DOE/SF/10737-1

SOLAR REPOWERING/INDUSTRIAL RETROFIT SYSTEMS

Category B: Solar Thermal-Enhanced Oil Recovery System

Final Report

July 1980

Work Performed Under Contract No. AC03-79SF10737

Martin Marietta Corporation
Denver, Colorado

U.S. Department of Energy

Solar Energy

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FOREWORD

This document is issued in accordance with the provisions of contract DE-AC03-79SF10737, Solar Repowering/Industrial Retrofit Systems. The contract was extended by the United States Department of Energy/San Francisco Operations Office to the Martin Marietta Corporation, spanning the period from 28 September 1979 through 15 July 1980. Contract manager was Mr. Fred Corona of DOE/SFO and the technical monitor was Mr. Jim Gibson of Sandia Laboratories/Livermore, California. Other major elements of the contractor team were Exxon Research and Engineering Advanced Energy Systems Laboratory, Exxon Enterprises Solar Thermal Systems Division, Foster Wheeler Development Corporation and Black and Veatch Consulting Engineers.

This report is organized into three general divisions. The executive summary, Section 1.0, provides a brief overview of the entire project for the reader who desires a quick understanding of the purpose, nature and significant results of the study. The body of the report, Sections 2.0 through 7.0, contains detailed descriptions of all activities and results. The conceptual design is completely described in Sections 4.0 and 5.0, and the pertinent economic evaluations are reported in Section 6.0. The appendices contain (1) detailed climatological data for the Bakersfield locale, (2) incident heat flux maps for the interior active surfaces of the receiver, and (3) the System Requirements Specification, which identifies specific design criteria, performance and operating requirements.

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GLOSSARY OF TERMS

AFUDC	Allowance for Funds Used During Construction
API	American Petroleum Institute
bbl	Barrel(s)
CCS	Collector Control Subsystem
EOR	Enhanced Oil Recovery
OCS	Operational Control Subsystem
ROR	Rate of Return
SRS	System Requirements Specification
STEAEC	Solar Thermal Electric Annual Energy Calculator
STEOR	Solar Thermal-Enhanced Oil Recovery
TDS	Total Dissolved Solids
TEOR	Thermal-Enhanced Oil Recovery
TMY	Typical Meteorological Year
TRASYS	Thermal Radiation Analysis System
UBC	Uniform Building Code

1.0 EXECUTIVE SUMMARY

The Martin Marietta Corporation, in association with Exxon Research and Engineering Advanced Energy Systems Laboratory, Foster Wheeler Development Corporation, and Black and Veatch Consulting Engineers, submits this final report to the United States Department of Energy in fulfillment of contract DE-AC03-79SF10737 entitled Solar Repowering/Industrial Retrofit Systems. The purpose of the DOE Solar Repowering/Industrial Retrofit project is to devise workable, economic concepts for the implementation of solar thermal power systems to reduce the consumption of fossil fuels in existing electric power generating and/or industrial process heat facilities. In accordance with Category B, Industrial Retrofit for Process Heat Applications, we have developed a conceptual design for a central receiver solar thermal system for a thermal-enhanced oil recovery (TEOR) process in Exxon's Edison oil field near Bakersfield, California. When installed and operational, this system will displace the comsumption of 6,852 m^3 [43,000 barrels (bbl)] of oil per year.

1.1 BACKGROUND AND APPROACH

The concept described in this report represents a unique opportunity to help alleviate the ever-increasing energy problem the United States faces by attacking the problem from two fronts simultaneously. Not only does the solar TEOR (STEOR) concept offer the potential to significantly augment the efforts in petroleum conservation by reducing the need for consumption, but also serves to increase domestic production of oil with the attendant benefit of reducing our dependency on foreign oil sources.

Crude oil is found in many forms, from a very light fluid that is easily pumped to an extremely heavy and viscous material such as tar. The geologic formations in which the crude oil resides also vary considerable in their physical nature, ranging form relatively loose, permeable sands to very hard, impenetrable shales. The preponderance of oil produced in the past, as well as that now being produced, is light crude having an API gravity rating above approximately 25°. Light crude is easily produced by the conventional pumping technique with normal ground pressure moving the crude to the well bottom. Oil from the middle east is mostly light crude, with an API rating of about 35°.

Although large portions of light crude sources in the United States have been depleted, vast quantities of heavy crude (below 20° API) remain. It has been estimated that perhaps 30 billion or more barrels of heavy crude oil deposits are contained in the states of California, Kentucky, New Mexico, Texas and Utah alone. Much of this resource remains untapped, but very large reserves exist where lighter crude was previously produced and depleted. In many cases oil fields have been abandoned when pumping ceased to be economically productive. Standard pumping methods can produce only a small portion (up to about 1/3) of the oil in most reservoirs.

The high viscosity of remaining crude, coupled with the decrease in ground pressure resulting from previous production and the high flow resistance of the formation, is the major factor that has caused many oil fields to become economically nonproductive.

As available crude oil reserves have been depleted and prices have escalated, several means of enhancing production rates have been conceived, including steam injection, chemical injection and in situ combustion. The most cost effective process, and that in use in the Edison field, is injection of steam into the ground. Crude oil-fired boilers generate steam (75 to 80% quality) at output temperatures in the range of 232 to 354°C (450 to 670°F). The steam is then injected into the ground in the "stimulation" mode (perodic injection, with recovery taking place between injection operations). As further field depletion occurs, the steam "drive" mode (in which injection is continuous and recovery occurs simultaneously from adjacent wells) may be implemented to maintain economical production rates.

This conventional steam injection process has two adverse characteristics that limit both economic and performance potentials. First, the steam generators consume large amounts of the very resource they are used to recover. Current estimates indicate that for every 0.48 m^3 (3 bbl) of oil produced by the thermal EOR process, up to 0.16 m^3 (1 bbl) is consumed in combustion to produce steam. Also, the Fuel Use Act of 1978 will further inhibit the use of conventional thermal recovery processes by requiring single boilers over 100 MBtu in size or multiple boiler installations of more than 250 MBtu to use coal or renewable fuels. Second, existing air quality standards, particularly in California, require costly methods of combustion gas treatment that further inhibit the efficiency of the process. From this standpoint, it is most unfortunate that virtually all heavy crude oil contains large amounts of sulphur--the oxides of which are among the most severe pollutants contained in combustion gases. It is believed that air quality and other environmental standards will become more stringent over the entire country and may ultimately prevent economical recovery of these vast reserves of crude oil unobtainable by conventional pumping technology.

The central receiver system described here was designed specifically for Exxon's field, but the potential utilization of this STEOR technology has much more far-reaching implications. Of the previously mentioned states containing abundant reserves of heavy crude oil only one--Kentucky--perhaps has insufficient insolation for the economical use of STEOR in the near future. The other four states are all located in the sun belt of the southwest where conditions are very conducive to effective implementation of solar thermal systems. Presently most of the nation's heavy crude production is taking place in California where over 500,000 barrels per day of crude in the 10 to 20° API range is produced. If only 20% of this production that now utilizes crude-fired boilers for steam injection is repowered by central receiver solar thermal systems, up to 12 million barrels of oil can be conserved each year.

1.2 SITE DESCRIPTION

The site selected for this design study is the Edison oil field in Kern County, California. The Edison field is located approximately 7 miles southeast of Bakersfield at the south end of the San Joaquin Valley. The latitude is about 35° north. Figure 1.2-1 shows the location relative to Bakersfield. The terrain is very flat (Fig. 1.2-2), is at an average elevation of 183 m (600 ft) above mean sea level and has a very slight slope of 1.5% from the northeast to the southwest.

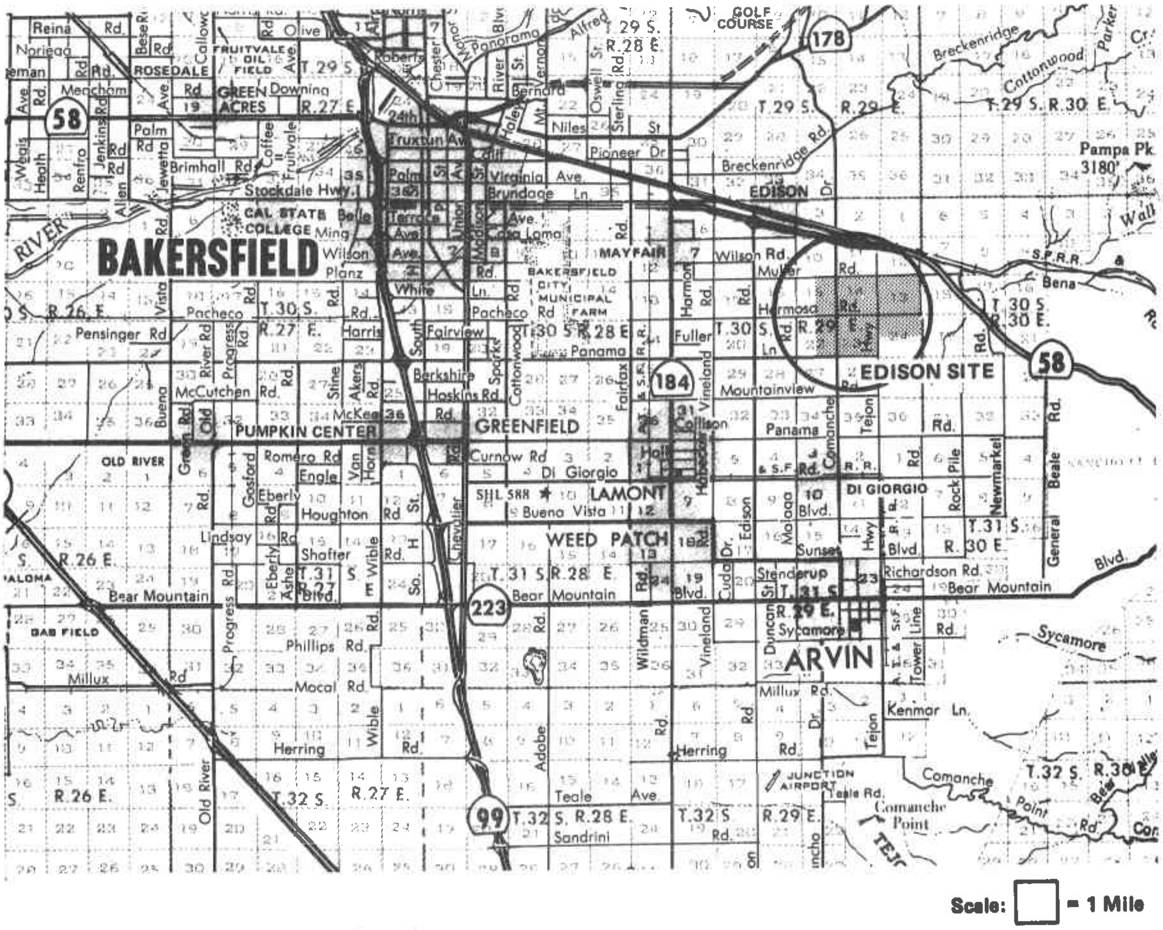


Figure 1.2-1 Bakersfield Area Map

A plat of the zone to be served by the STEOR system is shown in Figure 1.2-3. There are 121 producing wells on this site and another 121 are planned to be drilled. When the drilling program is complete, the average oil well density will be one well per 5059 m^2 (1.25 acres). The collector/receiver module will be located on lease 808794, which measures 805 m (2640 ft) by 402 m (1320 ft), and will also serve leases 808795, 808701 and 808699.

Figure 1.2-2 Exxon's Edison Field Looking South from Tank Battery Location

The annual average direct normal insolation in this general area of California ranges from 6 to 7 kW/m^2 per day. The closest location to the site for which detailed measured insolation data are available is Fresno, 174 km (108 miles) to the northwest, which averages 6.2 kW/m^2 per day. The climate is warm and semiarid. Average daily temperatures range from 9°C (48°F) in the winter to 29°C (84°F) in the summer. Cumulative precipitation averages 15 cm (5.8 in.) annually, nearly all of which is in the form of rain.

Exxon presently uses two crude oil-fired boilers, each rated at about 7.3 MWt (25 MBtu/h output power, in their steaming operations. The boilers, fuel and feedwater storage tanks and feedwater treatment module are all portable units that can be moved about the field. The system is presently operated in the steam stimulation mode. Steam is injected into a single well at a time continuously for about 7 days, then the well is capped and allowed to soak for about 4 days. After pumping is resumed, the initial production rate is several times greater than before the injection process (Fig. 1.2-4). The production rate declines with time until the next steaming cycle is performed. The interval between stimulations for any given well varies from one to several years. Exxon plans to double their steaming capacity and begin operating in the steam drive mode by 1986.

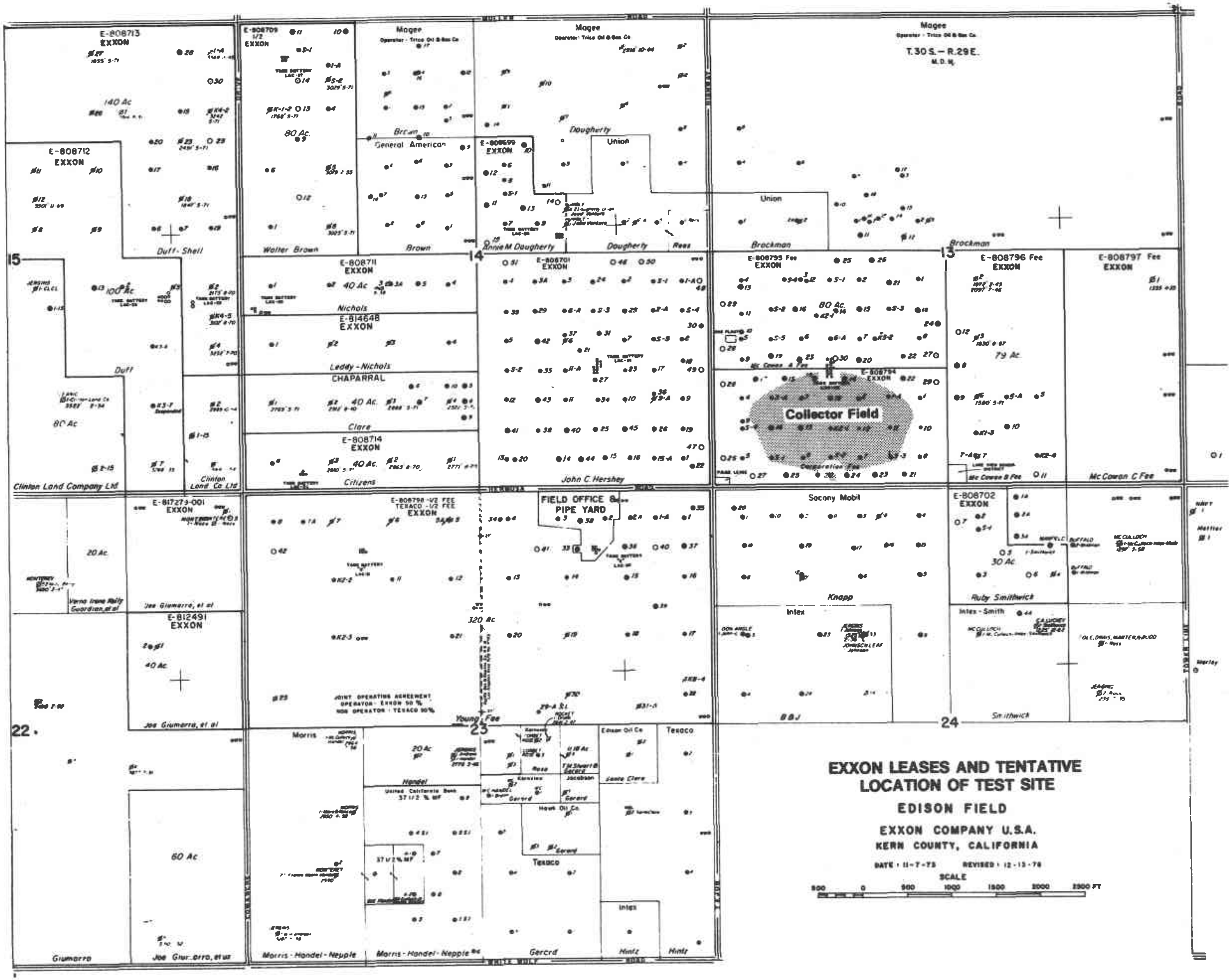


Figure 1.2-3 Edison Field Plat

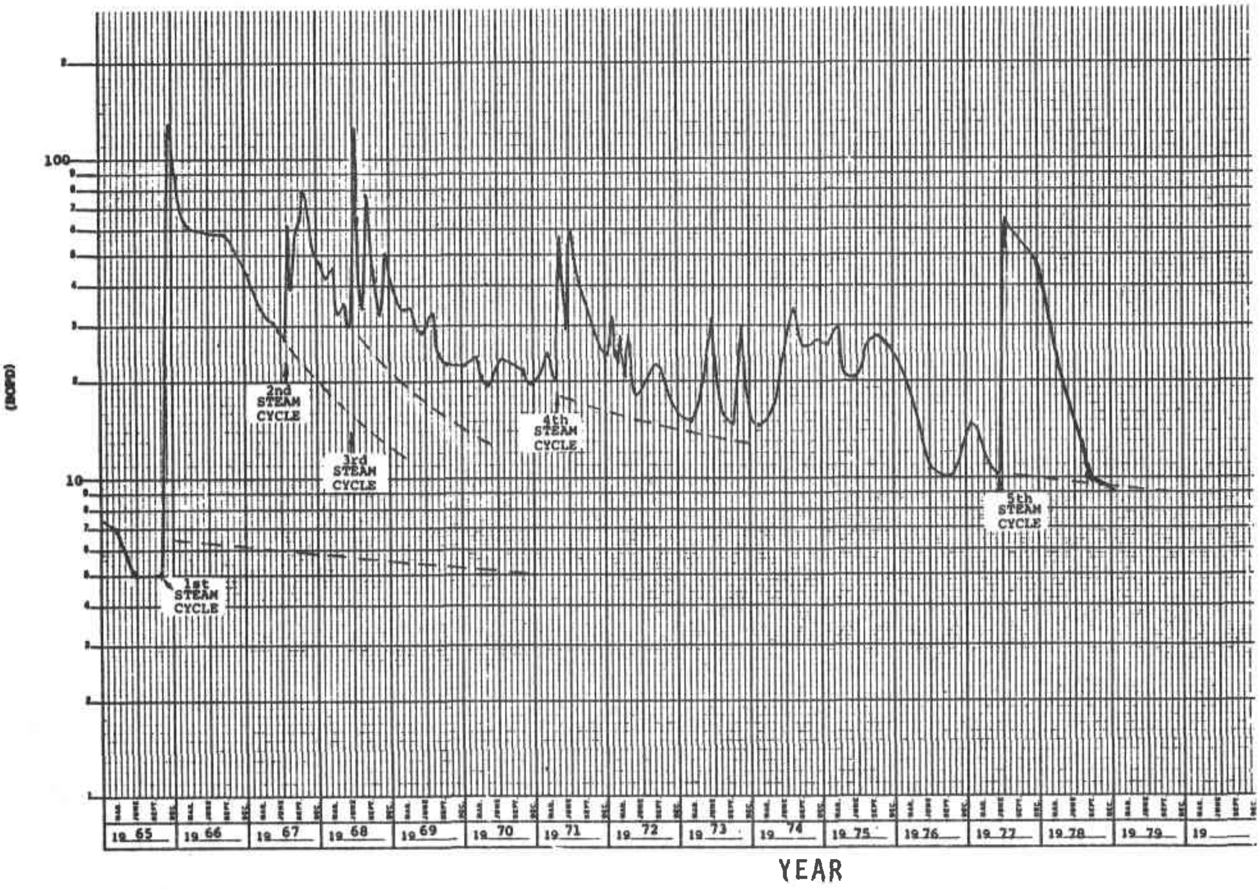


Figure 1.2-4 Typical Production History for Steam Stimulation Cycles

1.3 PROJECT SUMMARY

The concept of using central receiver solar thermal technology to power a steam injection-enhanced oil recovery process is very clearly in concert with the programmatic goals set for the DOE solar repowering industrial retrofit project. More specifically, our design for a solar thermal system installation at the Edison oil field will provide a valid demonstration of the feasibility of building and operating solar power hardware in an industrial environment, while at the same time offering a real potential for the economic displacement of significant petroleum comsumption in the near term.

The potential total energy requirements for steam injection EOR operations in this country are enormous. Exxon has estimated that in Kern County, California alone, there is a potential for 1670 MWt (5.7×10^9 Btu/h) of installed solar capacity by the year 2000. This compares with estimates of over 9000 MWt (30.7×10^9 Btu/h) of total steaming capacity necessary by that time. The proposed Edison installation will provide less than 0.1% of that requirement. When considering the total steaming capacity necessary to support heavy crude production in the rest of California and the other states of the sun belt, one can reasonably project an ultimate power requirement on the order of 100,000 MWt (341×10^9 Btu/h).

From a technical standpoint, EOR is a most compatible application for central receiver solar thermal systems. Thermal storage will not generally be required for such installations, eliminating what is normally a costly and complex part of solar thermal systems. Likewise the operational requirements of the STEOR process are simple and not stringent as compared with electrical utility and many other process heat applications. From an installation standpoint, the oil field environment is generally well-suited to central receiver technology. Locations are predominantly in nonurban areas with little or no activities of potential interference involved. Large areas of relatively flat, uncongested land are normally available. Clearances for wellhead pumps, equipment and operational access are easily accommodated in the collector field layout. A clear illustration of this compatibility is the active agricultural operations that are frequently carried on in producing oil fields, including Edison.

The solar energy conversion process we have conceived is based on sound, proven technology and presents virtually no risk to implementation of an operational system by 1985. The development of reliable, low-cost heliostats is well under way, and the ability to operate and control an entire collector field has been demonstrated by the operational Central Receiver Test Facility (CRTF) at Albuquerque. By 1981, the Barstow Central Receiver Solar Thermal Power System Demonstration plant will be operational, adding even more experience and maturity to heliostat and control-system technical state of the art. The natural-circulation steam generator in our cavity receiver concept is backed by many years of design and operational experience in commercial applications and has been successfully demonstrated through the design, fabrication, and operation (under both infrared simulated and actual solar conditions) of 1- and 5-MWt prototypes.

In assessing the cost and economic issues related to implementation of an operational central receiver solar thermal system at Edison, we have tried to be realistic in identifying and including all items of design, procurement, fabrication and operation. We are well aware that the ultimate acceptance by, and penetration into, the commercial market place will depend entirely on a visible demonstration that the capital and O&M cost projections can be met. To generate and publish a cost estimate that is overly optimistic would be counterproductive to our long-range interests in the creation and participation in a viable, productive solar thermal power equipment industry.

We are most encouraged that our realistic costing approach has shown that a central receiver STEOR system is favorably competitive with the present crude oil combustion process even in the near term (see Section 1.5). At an installed cost of $14.0 million, and using the SNLL fuel cost escalation rate of 12%, our solar thermal system exhibits a break-even period of 13.5 years as compared to the existing fossil system. Considering a lower fuel escalation rate of 10%, the break-even point moves out to 18.5 years and the annualized costs of power are approximately $24/MWt for the central receiver system as compared to $28 to $36/MWt (10% and 12% escalation respectively) for the fossil system.

It is important to note that the recently imposed windfall tax on oil production revenues, which is included in our economic projections, actually penalizes the solar alternative in these comparisons. Since the tax reduces the net return to the producer of oil sold, there is more of an economic incentive to consume the oil in process heat generation than there would be without the tax.

1.4 CONCEPTUAL DESIGN DESCRIPTION

This design concept utilizes the central receiver type of solar thermal power conversion technology to generate the steam necessary for recovery of the heavy crude oil at the Edison field. Major elements of the system are shown schematically in Figure 1.4-1. The absence of a need for thermal storage capability and the moderate steam temperature requirement for the TEOR process results in a relatively simple system with well-defined interfaces. The collector field consists of individually driven heliostats that reflect and concentrate the solar radiant power into a tower-mounted twin-cavity receiver. Water is pumped from an existing well at Edison, treated, then piped to the receiver where the radiant input power is absorbed by the generation of steam. Water enters the receiver at 15.6°C (60°F) and wet steam exits at 297°C (567°F) and 82% quality.

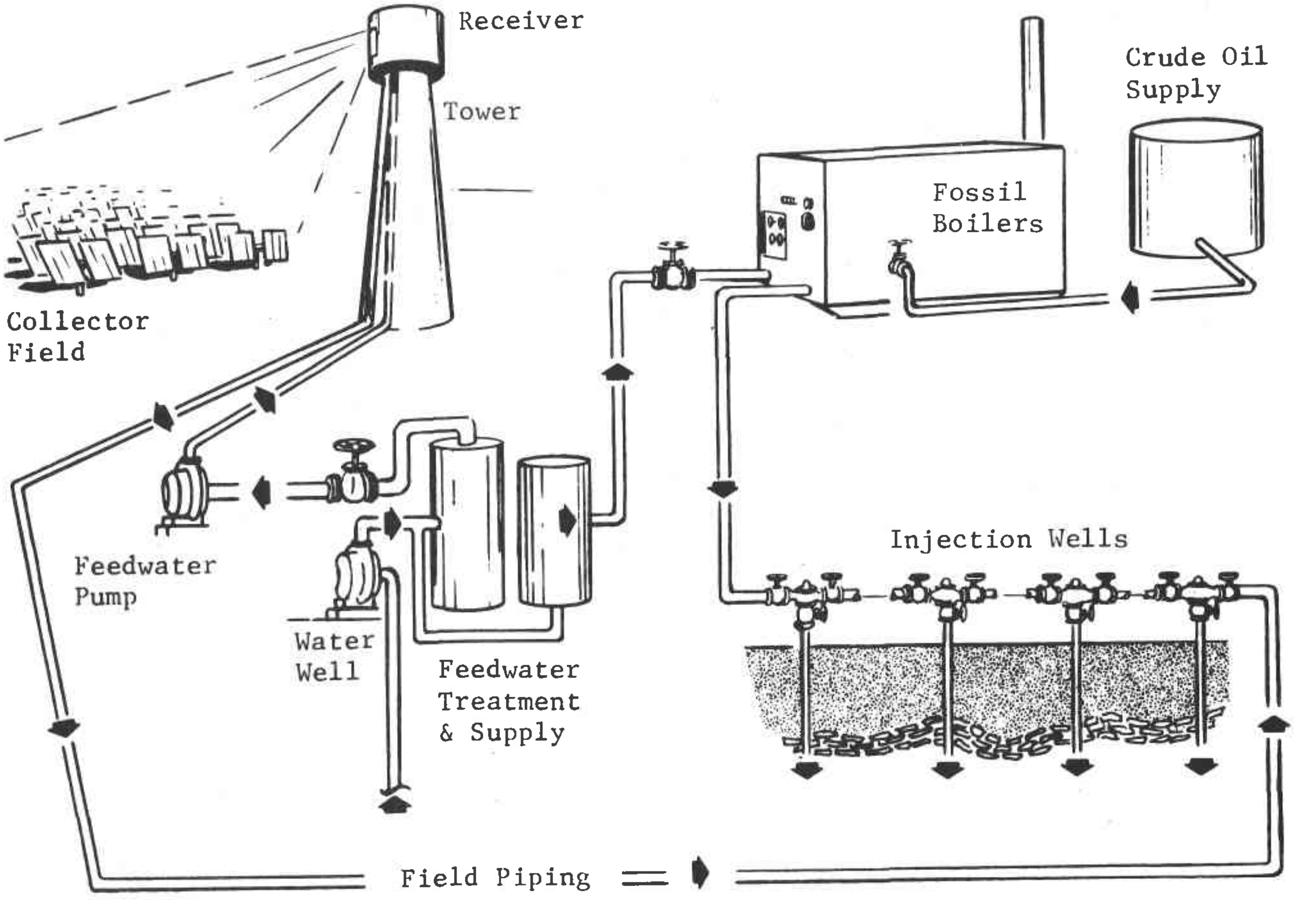


Figure 1.4-1 Process Schematic

The solar power system is sized to produce 29.3 MWt (100 MBtu/h) in the form of steam at the system design point (noon on February 27) at an insolation of 0.95 kW/m. This corresponds to an annualized average output of 6.4 MWt (21.8 MBtu/h) that will provide about 25% of the total planned steam requirement at Edison. The option of building an identical collector/receiver module on lease 808795 would increase the solar contribution to about 50% of the required process energy.

The collector field consists of 818 heliostats arranged on lease 808794 of the Edison oil field as shown in Figure 1.4-2. In the layout and placement of heliostats, adequate clearances are provided for oil well equipment and operational access. The heliostats are arranged generally in a 2.32 rad (150°) north circular sector to project power into a twin-cavity receiver. The quantity of 818 heliostats is based on a reflective area of 49.05 m^2 (528 ft^2), which was specified for this project. Heliostats of other sizes, such as the Martin Marietta second-generation unit at 56.9 m^2 (612 ft^2), could be used in this system without greatly affecting the indicated boundaries of the collector field or the receiver design. The Barstow pilot plant prototype unit (Fig. 1.4-3) illustrates a representative heliostat configuration.

Figure 1.4-2 Solar Enhanced Oil Recovery

The proposed receiver concept is a twin-cavity natural-circulation steam generator. Figure 1.4-4 shows a simplified plan view of the twin-cavity receiver. The side-opening cavities, equipped with aperture doors, have a high energy abosrption efficiency and low thermal

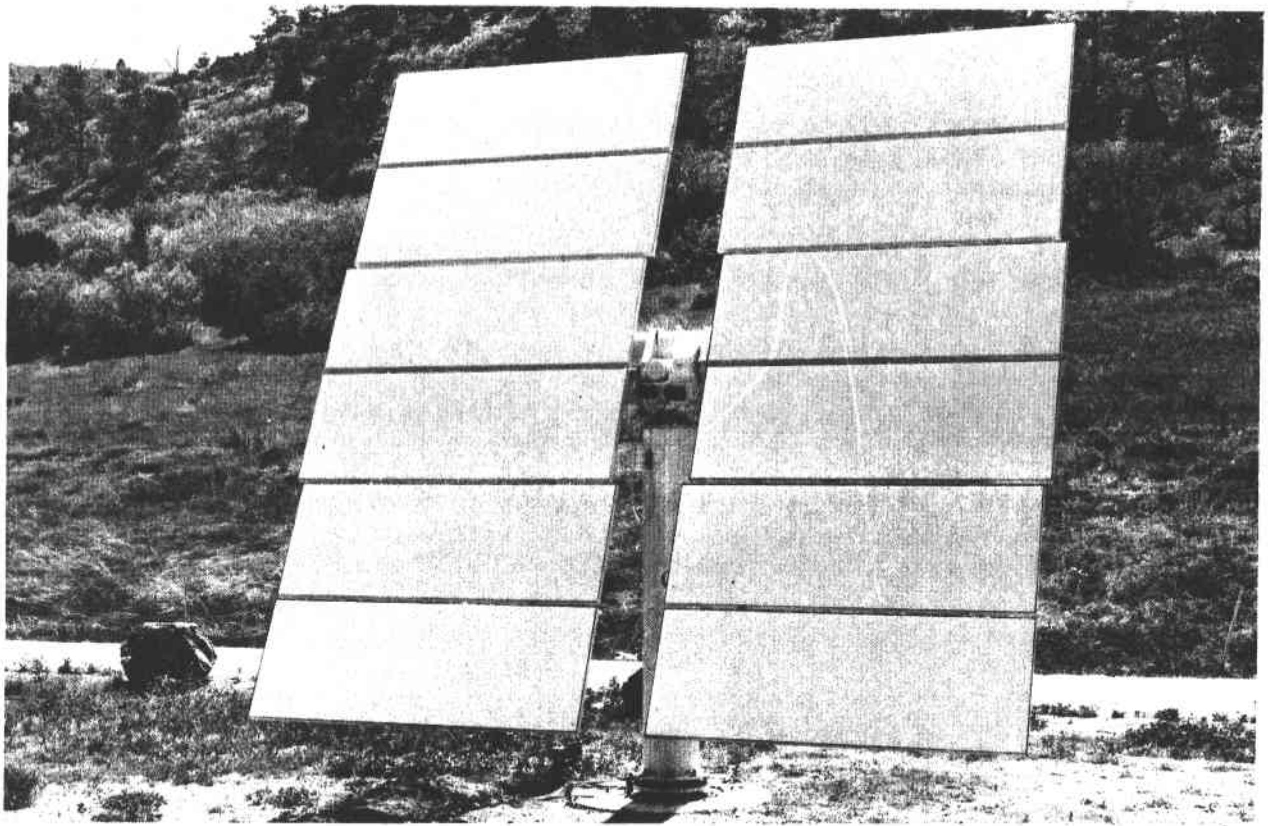


Figure 1.4-3 Prototype Barstow Heliostats

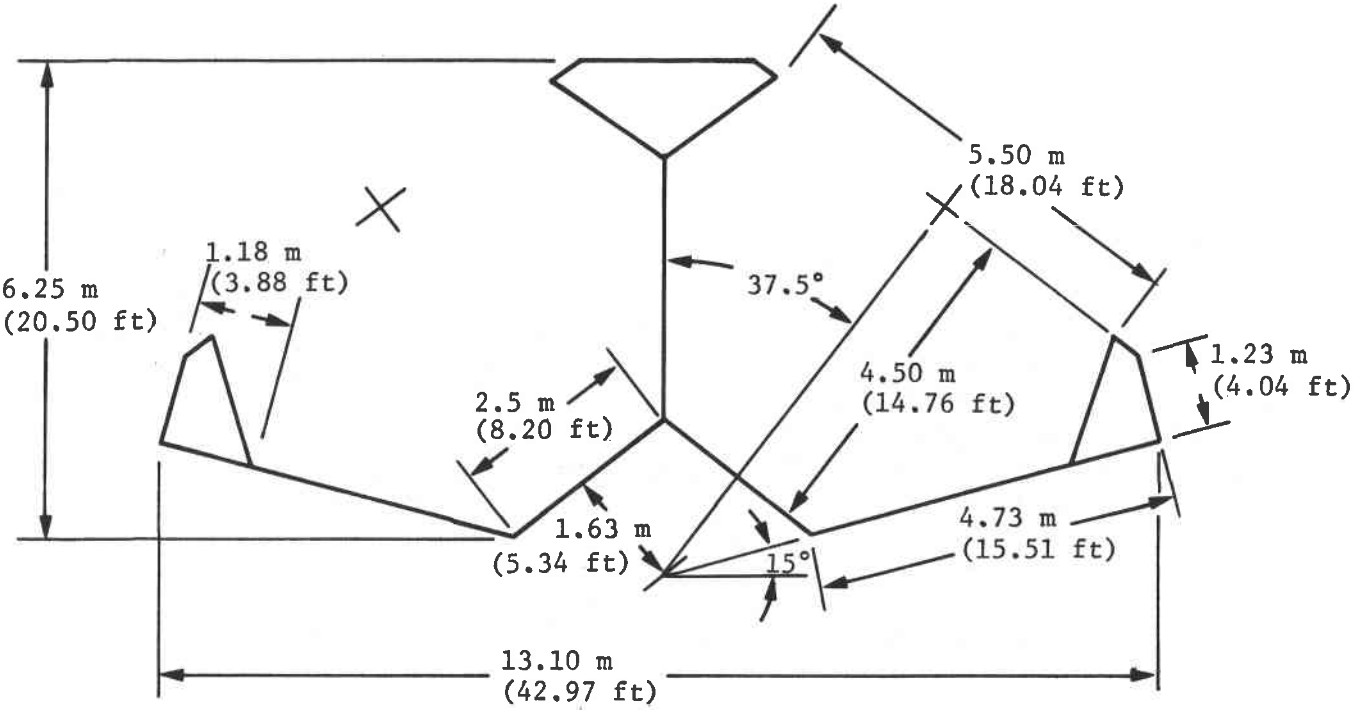


Figure 1.4-4 Simplified Plan View of Twin-Cavity Receiver

losses, both while in operation and overnight when the cavity doors are closed. Natural circulation was selected because it is simple and easily adapted to the given configuration. Also, natural circulation has a history of high reliability and eliminates the forced-circulation pump and associated costs. Natural circulation is inherently self-compensating for energy input variations. A natural-circulation receiver is also relatively tolerant of impure feedwater because of its large tubes, low tube-exit steam quality, large water inventory, and drum blowdown capability.

The natural-circulation type of solar receiver has been well-proved through the design, construction, and test of two complete working units with 1- and 5-MWt capacities. These receivers have amply demonstrated thermal and hydraulic stability as well as ease of control under very severe transient and steady-state operating conditions. Both receivers have been operated using infrared lamp radiation to simulate solar imput, and the 1-MWt unit was operated very successfully in the environment of the CNRS solar furnace at Odeillo, France.

The function of the field piping subsystem is to transport steam from the receiver outlet to the injection wellheads. Approximately 12 wells will be injected in parallel at any given time. This injection pattern will move gradually through the oil field at the rate of about 3 wells per year over the 26-year operational life of the system. The feeder lines to the wells connect to a common manifold that is fed by both the solar thermal system and the three fossil boilers. The routing of the trunk line from the receiver and the progression of the injection well pattern have been established on the basis of minimizing total installed length of pipe. Pipe diameters and insulation design were selected on the basis of minimizing costs, while maintaining reasonable pressure drop and heat loss characteristics.

Some of the key features of the STEOR system are summarized in Table 1.4-1.

1.5 SYSTEM PERFORMANCE AND ECONOMIC FINDINGS

Performance of the STEOR system was evaluated using three validated computer models--MIRVAL, TRASYS and STEAEC. The MIRVAL and TRASYS programs were extensively used to calculate the design point (noon, day 58) and off-design point performance of the collector and receiver subsystems. Performance parameters were developed from these performance estimates for input to the STEAEC system simulation model to evaluate the annual performance of the STEOR system with insolation and weather data representative of the Edison site.

Table 1.4-1 Conceptual Design Summary

1. Prime Contractor: Martin Marietta Corporation
2. Major Subcontractors: Exxon Research & Engineering, Foster Wheeler Development, Black & Veatch Consulting Engineers
3. Site Process: Thermal-Enhanced Oil Recovery Using Steam at 270 - 285°C (518 - 545°F)
4. Site Location: Edison Oil Field - Bakersfield, California
5. Design Point: Noon on February 27, Insolation of 0.95 kW/m^2
6. Receiver

   Receiver Fluid: Water/Steam
   Configuration: Twin Cavity
   Type: Natural Circulation
   Elements: Preheater and Boiler
   Output Fluid Temperature: 297°C (567°F)
   Output Fluid Pressure: 8274 kPa (1200 psia)
   Tower Height: 90m (259 ft)

7. Heliostats

   Number: 818
   Individual Mirror Area: 49.05 m^2 (528 ft^2)
   Cost: \$230/m^2 (\$21.36/ft^2)
   Type: Generic - Second Generation
   Field Configuration: 2.62 rad (150°) North Field

8. Storage: None
9. Total Project Cost: \$14,033,467 (\$230/m^2 Heliostat Cost)
10. Construction Time: 1.5 Years
11. Solar Plant Contribution at Design Point: 29.3 MWt
12. Solar Fraction - Annual: 25.1%
13. Annual Fossil Energy Saved: 44,058 Barrels at 5.800 x 10^6 Btu/Barrel
14. Type of Fuel Displaced: Heavy Crude Oil at 5.93 x 10^6 Btu/Barrel

14a. Annual Energy Produced: 55,870 MWh$_t$ (190,684 MBtu)

15. Ratio of $\frac{\text{Annual Energy Produced}}{\text{Total Heliostat Field Area}}$: 1.39 MWht/m^2
16. Ration of $\frac{\text{Capital Cost}}{\text{Annual Fuel Displaced}}$: $\frac{\$\ 14{,}033{,}467}{74{,}301\ \text{MWht}}$ = \$188.87 MWht
17. Site Insolation (direct normal)

    Annual Average: 2.26 MWh/m^2
    Source: SOLMET TMY for Fresno, Ca
    Site Measurements: Start Date: 1/1/80, Continuing
    Total Horizontal Insolation Sensor
    Direct Normal Insolation Sensor

The STEOR system design point output is 29.3 MWt (100 MBtu/h), based on a reference insolation level of 950 W/m^2. The overall design point system efficiency, defined by power available to the injection wells divided by 950 W/m^2 times the mirror area, is calculated at 76.9%. This high efficiency is due to the north field configuration (field efficiency = 81.7%) and the cavity receiver configuration (receiver efficiency = 94.2%).

The annual system performance was calculated using the SOLMET typical meteorological year (TMY) insolation and weather data for Fresno, CA, the nearest SOLMET station and typical of San Joaquin weather patterns. The average daily insolation, based on the SOLMET data, is 6.21 kWh/m^2. The annual STEOR system stairstep is shown in Figure 1.5-1. As depicted on the stairstep, the STEOR system has an average annual efficiency of 61.5%, providing a total of 55,870 MWht (190,684 MBtu) to the injection wells.

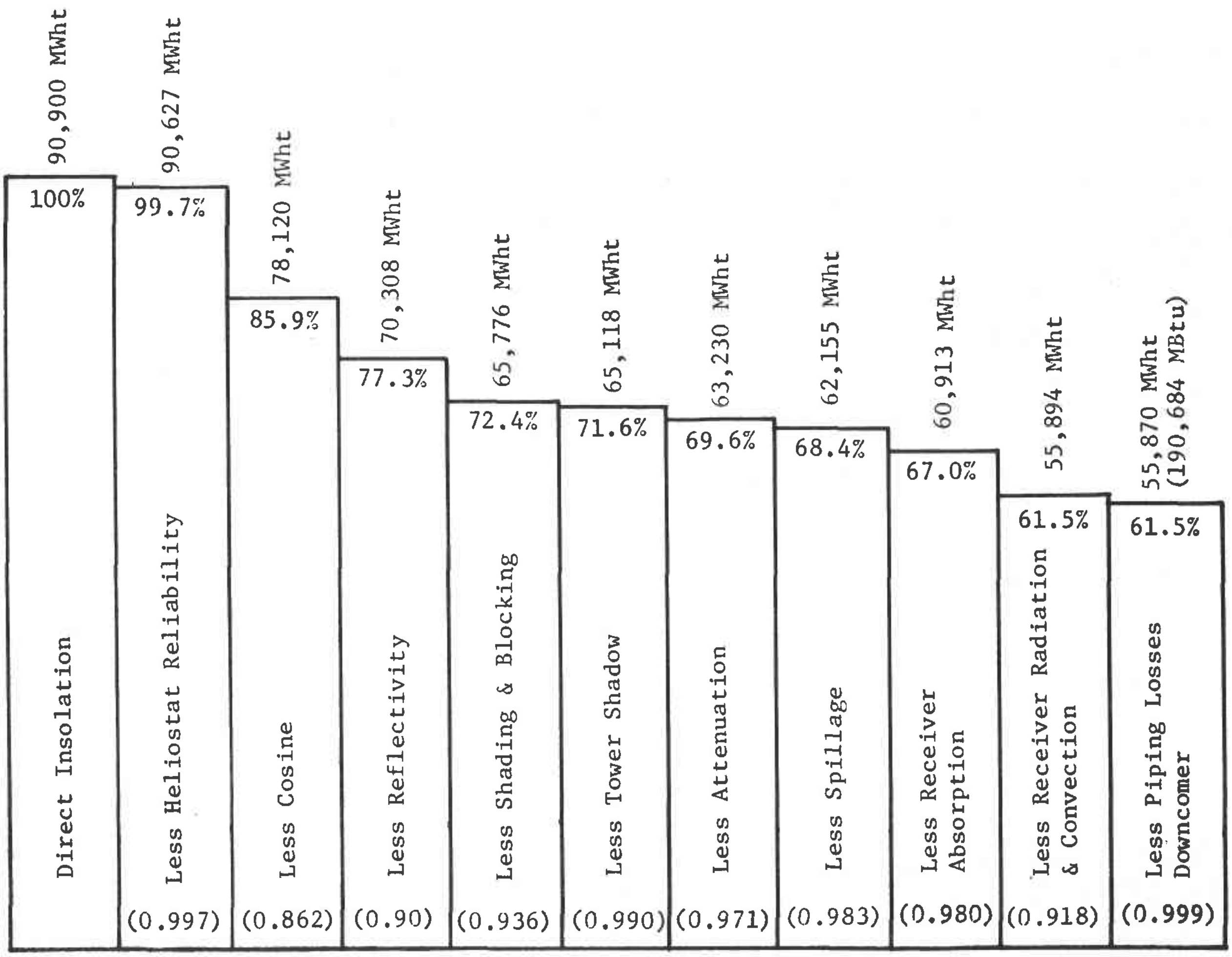


Figure 1.5-1 Annual System Efficiencies

The yearly output from the STEOR system is equivalent to displacing 685 m^2 (43,092 bbl) of oil burned in a conventional boiler of the type currently used in TEOR operations. Over the 26-year projected operating period, a total of over 178,000 m^3 (1.1 million bbl) of oil would be displaced, in addition to the heavy oil production resulting from the solar-produced steam injected.

With the steadily increasing price of oil, this oil displacement enables near-term economic viability of solar thermal EOR systems, even with heliostat costs in the \$230 to \$275/m^2 range. Installed heliostat costs of \$230/m^2 were used as a baseline "post-Barstow" heliostat cost, with a total STEOR system cost of just over \$14,000,000 as shown in Figure 1.5-2. The STEOR system was then compared to a conventional oil-fired steamer using two fuel cost scenarios. The first of these fuel cost scenarios assumed that the oil produced at the site (and burned in the steamer) was valued at the present world oil price, \$5.06/MBtu (\$30.00/bbl), escalating at 2.8% over a base inflation rate of 7%, and subject to all applicable ad valorem, royalty and windfall profits taxes. The second fuel cost was provided by Sandia Laboratories, calling for a fuel cost of \$4.00/MBtu, escalating at 4% over the base rate of inflation, given as 8% per year.

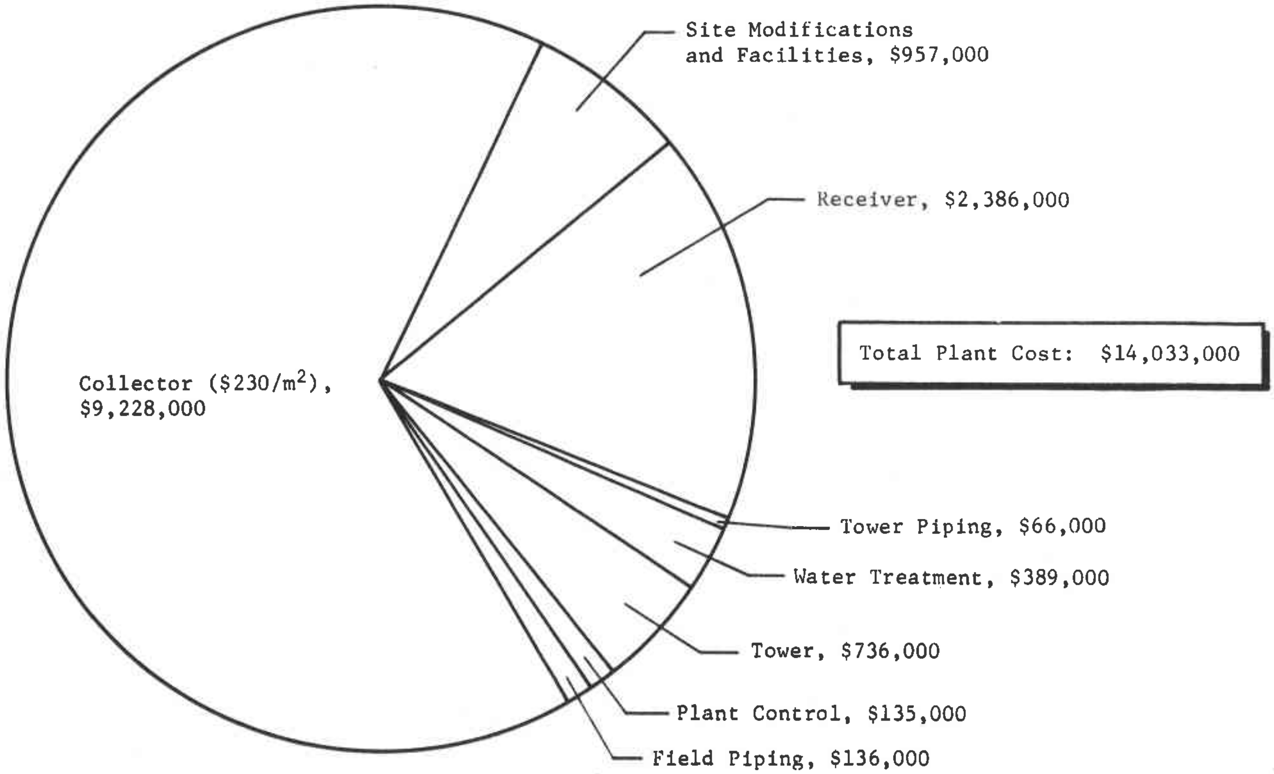


Figure 1.5-2 STEOR Construction Cost Estimate (1980\$)

Table 1.5-1 shows the significant (15 to 30%) reduction in the levelized cost of energy achieved with the STEOR over the 26-year operating life.

Table 1.5-1
Levelized Cost of Energy Results, Baseline Economics, 1980$

	Conventional Oil-Fired Steamer	Solar Thermal System
World Oil Price Economics	\$27.88/MWht (\$8.17/MBtu)	\$23.89/MWht (\$7.00/MBtu)
Sandia-Supplied Fuel Costs	\$35.53/MWht (\$10.41/MBtu)	\$24.26/MWht (\$7.11/MBtu)

Using the world oil price economics, the STEOR break-even operating period of 18.5 years is less than the projected (baseline) steam drive operating period of 26 years; using Sandia-supplied fuel costs and escalation, the STEOR system breaks even in just over 13 years.

The near-term economic viability of the STEOR system is perhaps better illustrated in Figures 1.5-3 and 1.5-4, examining both heliostat break-even costs and break-even oil escalation rates. As shown in the first

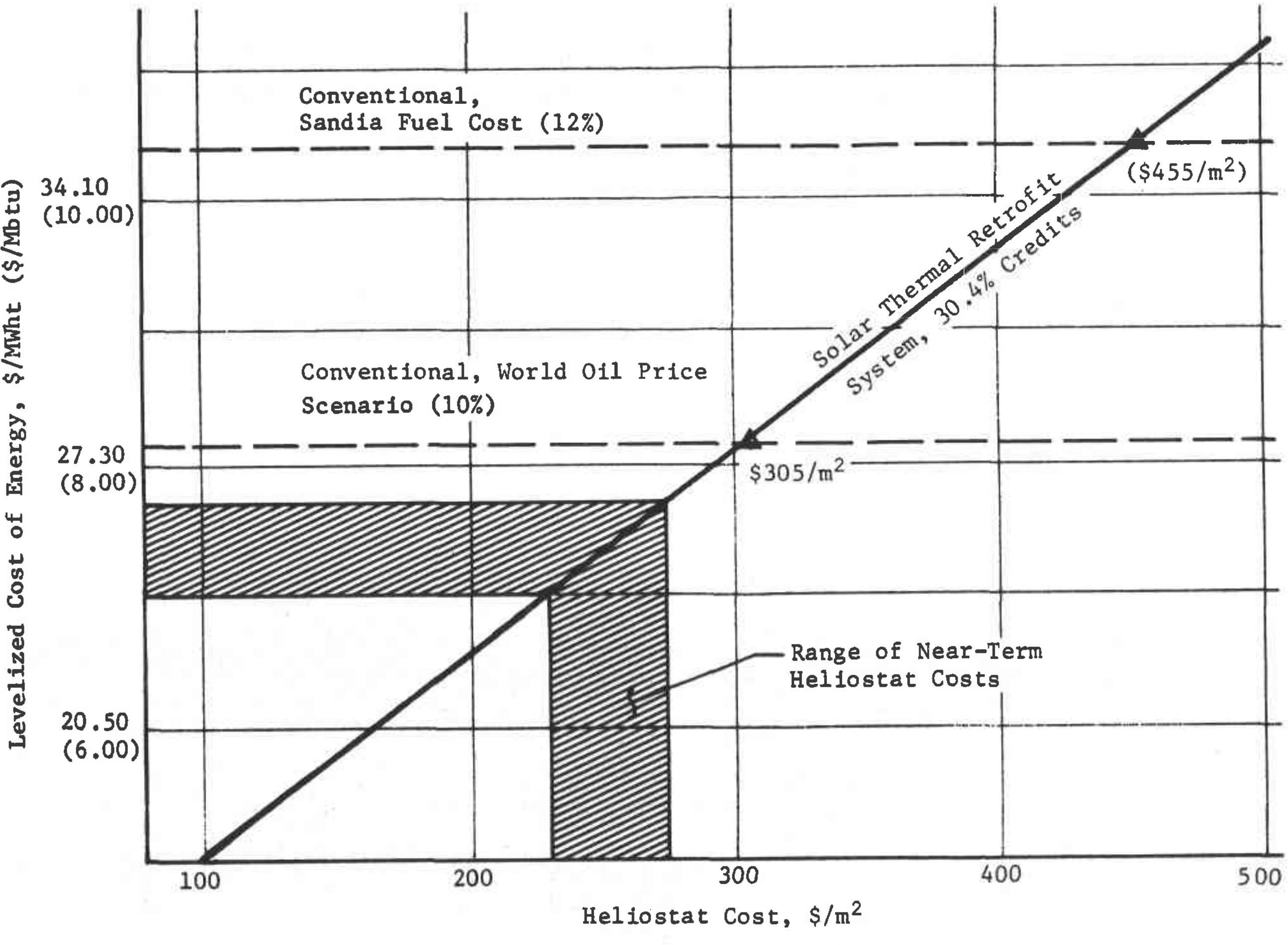


Figure 1.5-3 Effect of Heliostat Cost on Energy Cost

figure, the STEOR system remains economically viable with heliostat costs as high as \$450/m^2 using an oil escalation rate of 12%. Although the break-even heliostat cost (including 15% rate of return) is reduced to \$305/m^2 using the more conservative world oil price scenario, it is still above the range of the realistic post-Barstow heliostat costs shown in the figure.

The interrelationship of break-even heliostat cost and oil escalation rates is shown in Figure 1.5-4. For both fuel cost scenarios, the break-even oil escalation rate can be easily determined: for the baseline \$230/m^2 heliostat cost, the STEOR system remains viable for escalation rates as low as 8.6%.

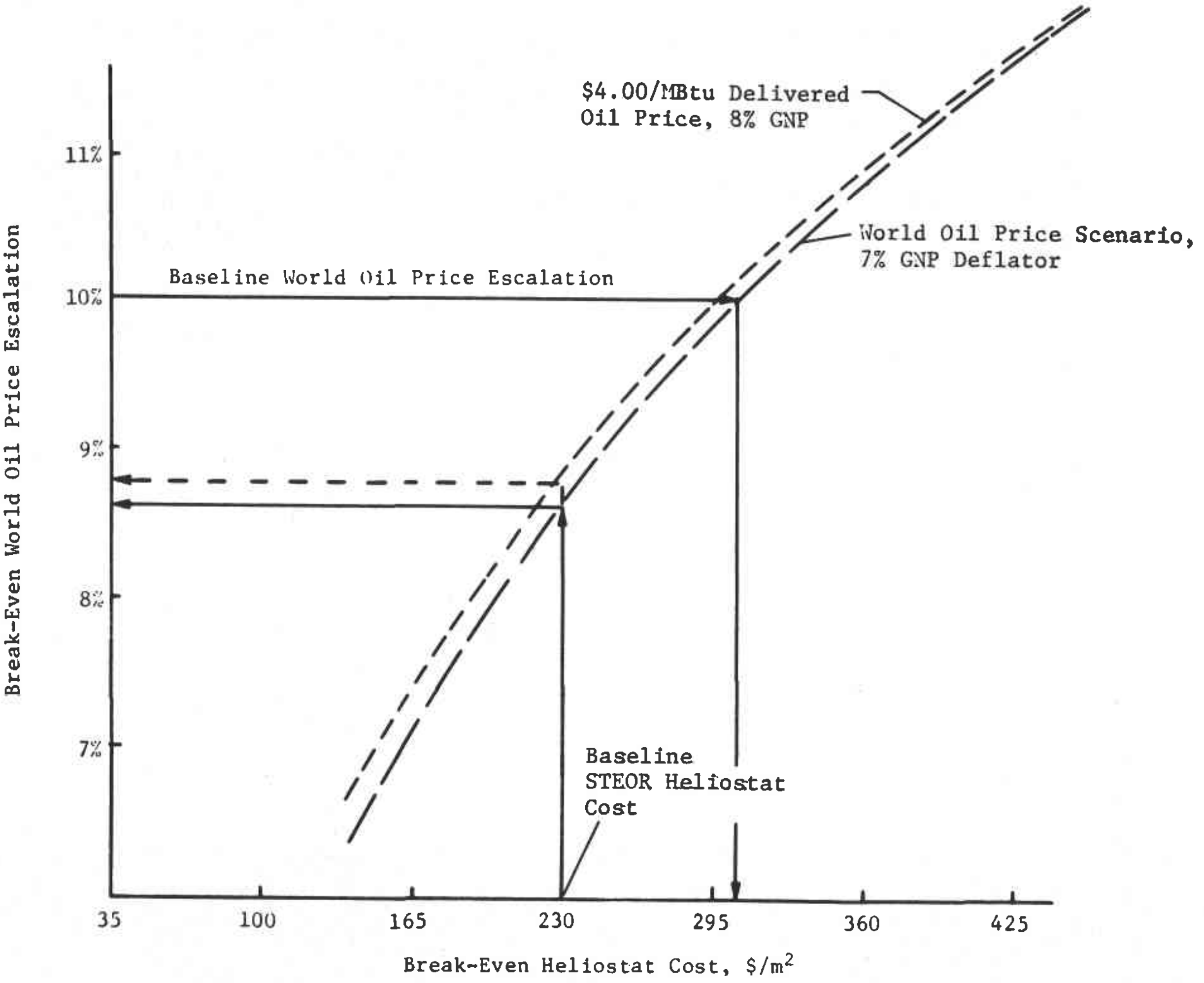


Figure 1.5-4 Break-Even Heliostat Cost/Oil Escalation Rate

The overall result of these economic analyses can only lead to a single conclusion--using realistic near-term heliostat costs, the solar thermal EOR system described in this study is an economically viable alternative to conventional oil-fired TEOR systems.

1.6 DEVELOPMENT PLAN

The development plan represents a guideline for evolving the solar thermal-enhanced oil recovery system from its present state of a conceptual design to a fully installed and operating hardware system at the Edison field. System development will be implemented as a joint Exxon/DOE project, and is consistent with the basic objectives and milestone criteria presented in the DOE Solar Repowering/Industrial Retrofit Plan issued by the San Francisco Operations Office in January 1980.

The word "development" as used this report is construed to include not only the kinds of activities related to resolution of design, hardware and/or process uncertainties, but also the tasks of detailed design, procurement, fabrication, installation and checkout that are necessary to produce an operational facility. It is significant that no hardware or process technologies are involved in this conceptual design that have not been demonstrated in operating systems. Only two test activities are included in the development plan. The first is a steam drive evaluation to be performed at the Edison field to determine the optimum operational strategy for future TEOR production. This will be conducted even if solar hardware is not to be installed. The second test planned is an operational demonstration of the Martin Marietta 5-MW receiver using the same feedwater quality found at the Edison site.

A schedule of the key milestones contained in the development plan is shown in Figure 1.6-1.

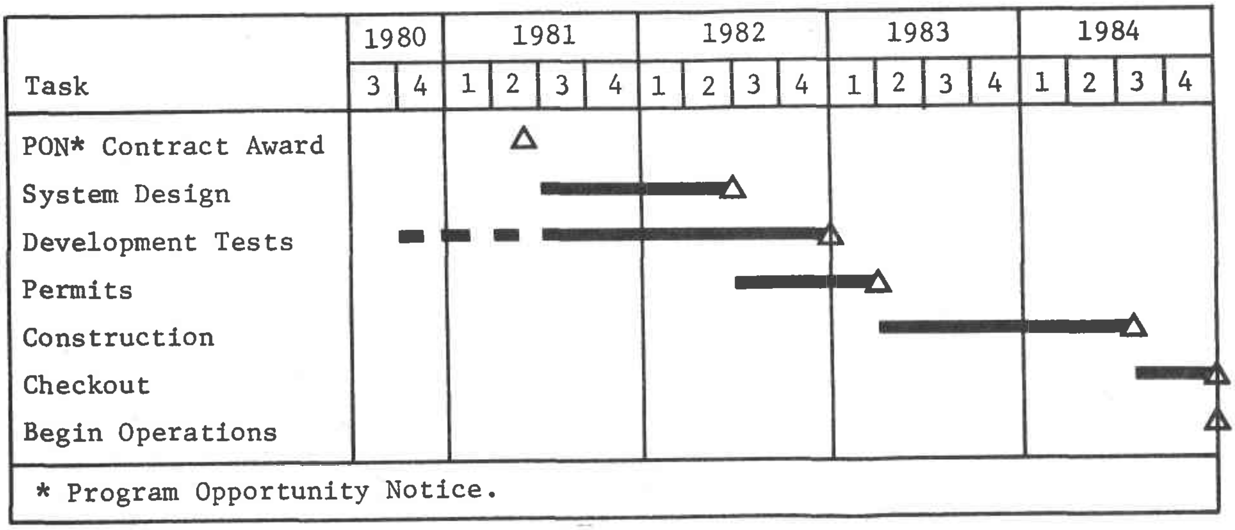


Figure 1.6-1 Development Schedule

1.7 SITE OWNER'S ASSESSMENT

In spite of the conceptual nature of this study and the paucity of operational and cost data, Exxon believes that the solar central receiver technology should be feasible for use at the Edison field. A technical central receiver system demonstration in an operational environment is necessary for users to have confidence in the performance, cost, and reliability of this system. Then, if as projected, a reasonable return on capital expended can be achieved, the solar thermal-enhanced oil recovery systems should make a significant penetration into the enhanced oil recovery operations.

While Exxon has no other active TEOR sites in California, we have estimated as part of DOE contract DE-AC03-79CS30307 that a solar potential of 1670 MWt (5700 MBtu/h) of installed steam capacity will exist in the Kern County area alone by the end of this century to help recover known heavy oil reserves.

Further opportunities will exist in other heavy oil-producing areas including Texas and Venezuela. At the Edison field, it may be possible to more than double the size of the heliostat field as demand for steam increases, depending on economic and geologic factors that have yet to be determined.

The conceptual design presents no severe or unusual safety or operational requirements and can be accommodated in the oil field production environment. The STEOR system should result in reduction of total ultimate atmosphere emissions, with the only negative impact being the loss of some 80 acres of farmland.

Two restrictions on energy use face Exxon at the Edison site--restrictions imposed by the California Air Resources Board on emissions from fossil-fired steamers, and restrictions on use of oil imposed by the Fuel Use Act of 1978. Solar systems could assist in meeting both of these restrictions as an increased demand for heavy oil causes an increase in the use of TEOR in California.

The development plan and schedule presented are technically feasible and do not involve any special problems. Exxon would prefer to have the project continue using a variety of tax incentives or accelerated depreciation schedules in the manner of the currently available, but time-limited, tertiary incentive revenue program rather than as a series of DOE contracts. This would permit private industry to take the lead in the project with government assistance in sharing the risk of a new and largely operationally unproven but very promising technology.

2.0 INTRODUCTION

This document describes the conceptual design study for a Solar Thermal-Enhanced Oil Recovery (STEOR) system. This work was performed for the Department of Energy San Francisco Operations Office under contract DE-AC03-79SF10737, entitled Solar Repowering/Industrial Retrofit Systems - Category B: Industrial Retrofit for Process Heat Application. This contract was performed at a cost of $409,300 during the period from 28 September 1979 through 15 July 1980. Department of Energy project direction was provided by Fred Corona, and Jim Gibson of Sandia Laboratories was technical monitor. The Martin Marietta prime contract was managed by David Gorman. The Martin Marietta mailing address is

Martin Marietta Corporation
PO Box 179
Denver, Colorado 80201

Other contributing organizations were Exxon Research and Engineering, under the management of Eugene Elizinga and George Yenetchi, Foster Wheeler Development Corporation, managed by S. F. Wu, and Black & Veatch Consulting Engineers, managed by John Harder.

2.1 STUDY OBJECTIVES

The objective of the sponsoring DOE procurement for this project was to develop site-specific conceptual designs that (1) provide practical and effective use of solar energy for repowering of electric power and/or industrial retrofit for process heat plants, (2) have the potential for construction and operation by 1985, (3) make maximum use of existing solar thermal technology, and (4) provide the best possible economics for the overall plant application. More specifically, the objective of this particular project was to develop a conceptual design of a solar thermal-enhanced oil recovery (STEOR) system for Exxon's Edison oil field near Bakersfield, California.

The United States, and particularly southern California, contains very large reserves of heavy crude oil that cannot be economically recovered by conventional pumping methods. The injection of steam to heat and pressurize the oil-bearing formations is a well-established method of attaining profitable production from these reserves. However, there are two significant limitations to the ecomomic and performance potentials of this process. First, the steam generators consume large amounts of the very resource they are used to recover. Current estimates indicate that for every 0.48 m^3 (3 bbl) of oil produced by the thermal EOR process, up to 0.16 m^3 (1 bbl) is consumed in combustion to produce steam. Second, existing air quality standards, particularly in California, require costly methods of combustion gas treatment that further inhibit the eficiency of the process. The use of a solar thermal power system to generate the needed steam would remove both of those limitations, thereby providing more domestic petroleum to meet demands of the market while at the same time providing for improvements in quality of the air.

2.2 TECHNICAL APPROACH AND PROCESS SELECTION

Several important criteria were considered in conceptual development of the STEOR system. The prime concern was to ensure compatibility of the solar hardware with physical and operational features of the crude oil production process in general, and the Edison field site in particular. Other major factors include the potential for minimizing the cost of energy conversion and utilization of mature solar thermal technology. The first step was to develop an understanding of the characteristics and requirements of the thermal-enhanced oil recovery process at the Edison field. The nominal steam conditions required, the allowable range of deviation in steam conditions, alternative operating strategies, physical constraints at the site, design and operating characteristics of the existing fossil steam generators, and the nature of ongoing operational activities were among the kinds of information developed early in the study.

The central receiver type of solar thermal power system is ideally suited to this application for several reasons. The steam conditions required for the TEOR process are well within central receiver capability. Since the process steam is not superheated, the receiver design is simplified and low-cost carbon steel can be used throughout the steam generator circuitry. Also, the absence of superheater panels eliminates the need for steam temperature controls, and output steam conditions can be established with only a simple pressure regulation device. The normal spacing of heliostats necessary for physical clearance and minimizing shadowing and blocking provides more efficient operational access to the oil field than a contiunuous distributed system. Finally, the capability for high solar concentration and low thermal losses offers the highest potential for minimizing energy conversion costs.

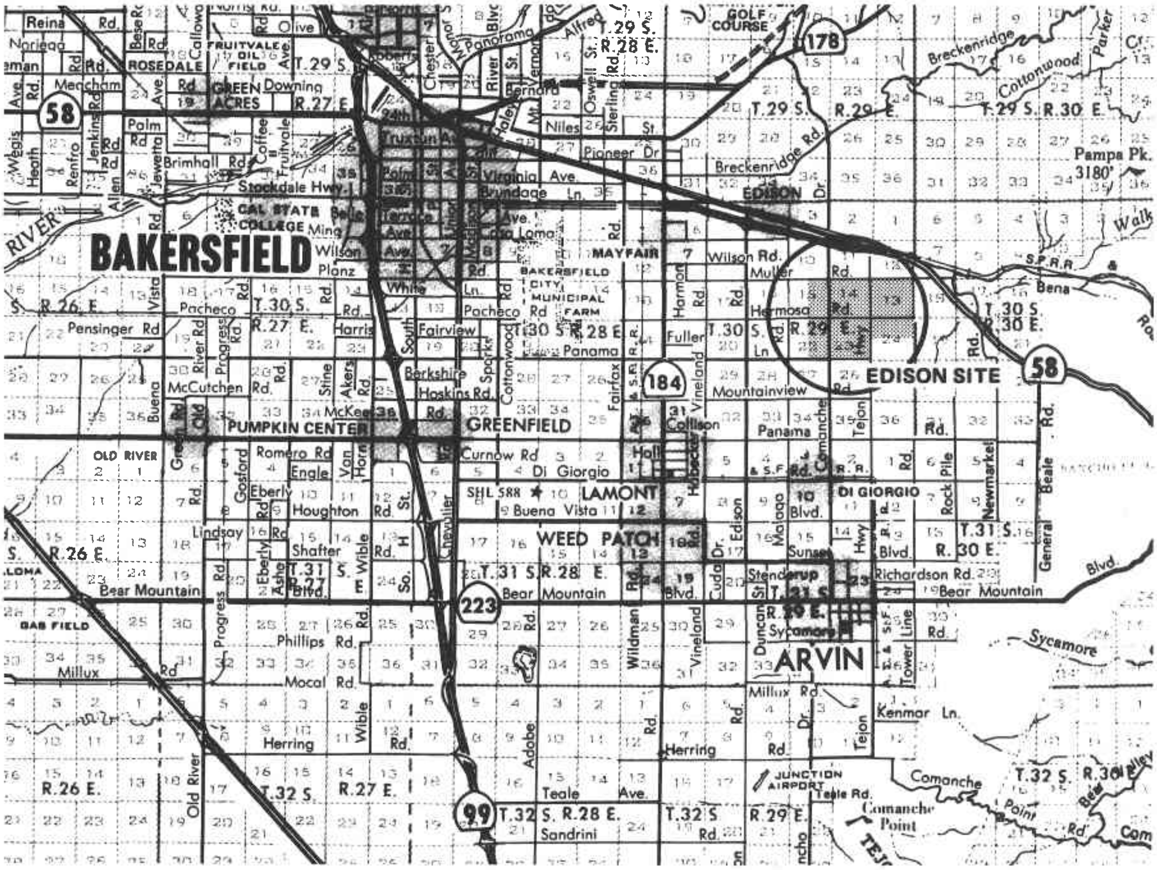
The central receiver solar thermal system selected for Edison includes a collector subsystem, a receiver subsystem and a field piping subsystem. Two subsystems commonly found in solar thermal power systems are notable for their absence in this conceptual design--the thermal storage and master control subsystems. The need for thermal storage is negated by two factors. First, the actual underground process of stimulating the flow and production of heavy crude oil does not require a constant or continuous injection of steam. The oil-bearing formation itself is a very effective natural thermal storage device, having an exceedingly large thermal capacity and a low conductance for heat loss. Existing TEOR operations at Edison demonstrate that enhanced recovery continues at a diminishing rate for periods up to a year after termination of steam injection into a particular zone.

Second, the planned operational mode for the solar thermal system will be to supplement the continuously operating fossil boilers whenever sufficient insolation is available.

A totally integrated master control system is not required because there are no requirements of a critical nature for synchronization, sequencing or coordination of activities between the solar thermal system and the power-consuming process as occurs in an electrical utility or perhaps a more demanding process heat application. The fluctuations in steam flow rate and injection pressure that occur as the solar thermal system cycles in response to insolation changes do not affect either the TEOR process or operation of the fossil boilers.

2.3 SITE LOCATION

Exxon's Edison field is located in parts of sections 13, 14, 15, 18, 19, 22, 23 and 24 of Kern County, California. The field is located on the east side of the San Joaquin Valley 11.3 km (7 mi) southeast of Bakersfield. Principal access is by California Highways 58 and 99 (Fig. 2.3-1).



Scale: ☐ = 1 Mile

Figure 2.3-1 Bakersfield Area Map

Figure 2.3-2 is a plot plan showing the Exxon leases at Edison and the location of the STEOR site. The site extends due east of Tejon Highway and is in Exxon lease 808794. It is approximately 0.3 km (1/2 mi) from the Exxon field office on Hermosa Road. The site area is approximately 327,756 m^2 (80 acres) and encompasses 25 operating wells. Access to the wells is from the west off Tejon Highway.

2.4 SITE GEOGRAPHY

At the proposed STEOR site, lease 808794, both the surface and mineral rights are owned by Exxon. There are few zoning and no other use restrictions on this and surrounding land. It is 8 km (5 mi) to the outskirts of Bakersfield and no extensive residential or commercial activities are anticipated during the period while oil is being produced. Present-day residential and commercial activities in the Bakersfield area are expanding to the southwest of the city away from the intensive oil-producing activities in Kern County. Access to the site is by publicly owned roads adjacent to the site.

It is not anticipated that any structures sufficiently large enough to interfere with solar operations would ever be considered in the area. The closest lease to the south of the site is owned by Mobil and is in active oil production

Figures 2.4-1. 2.4-2 and 2.4-3 are photographs from a central point in the site showing the surface features as viewed to the southeast, south and southwest, respectively. Figure 2.4-4 is an aerial view from 305 m (1000 ft) showing the lack of prominent natural and man-made structures on the field and surrounding land.

Kern County Airport is located approximately 32 km (20 mi) to the northwest of the site, which is outside the airport control zone.

Several structures already exist at the field. The principal building is the Exxon field office located on Hermosa Road. This building has available 65 m^2 (700 ft^2) of office space, 27.9 m^2 (300 ft^2) of locker and shower facilities and a small shop.

Shipments to the Edison field area can be made by truck, plane or railroad. The weight limitation on California Routes 58 and 99 and on local roads is 100 tons. Items measuring 3.7 by 30.5 m (12 by 100 ft) or larger can be shipped by truck but must be escorted. Heavy and bulky equipment is usually shipped by rail (Southern Pacific Railroad) to the freight depot at Edison, which is 8 km (5 mi) northwest of the field. There are no overpasses on the roads between the depot and the field.

The Edison site is a flat, alluvial plain ranging in elevation from about 0.21 km (700 ft) in the northeast to 0.15 km (500 ft) in the southwest (Fig. 2.4-5). The area is free of standing water and is not subject to flooding. After heavy rains of one to two days' duration, it is sometimes necessary to wait one to five days before heavy equipment can be moved on the field. Since there are no steep slopes in the area, no slides should occur.

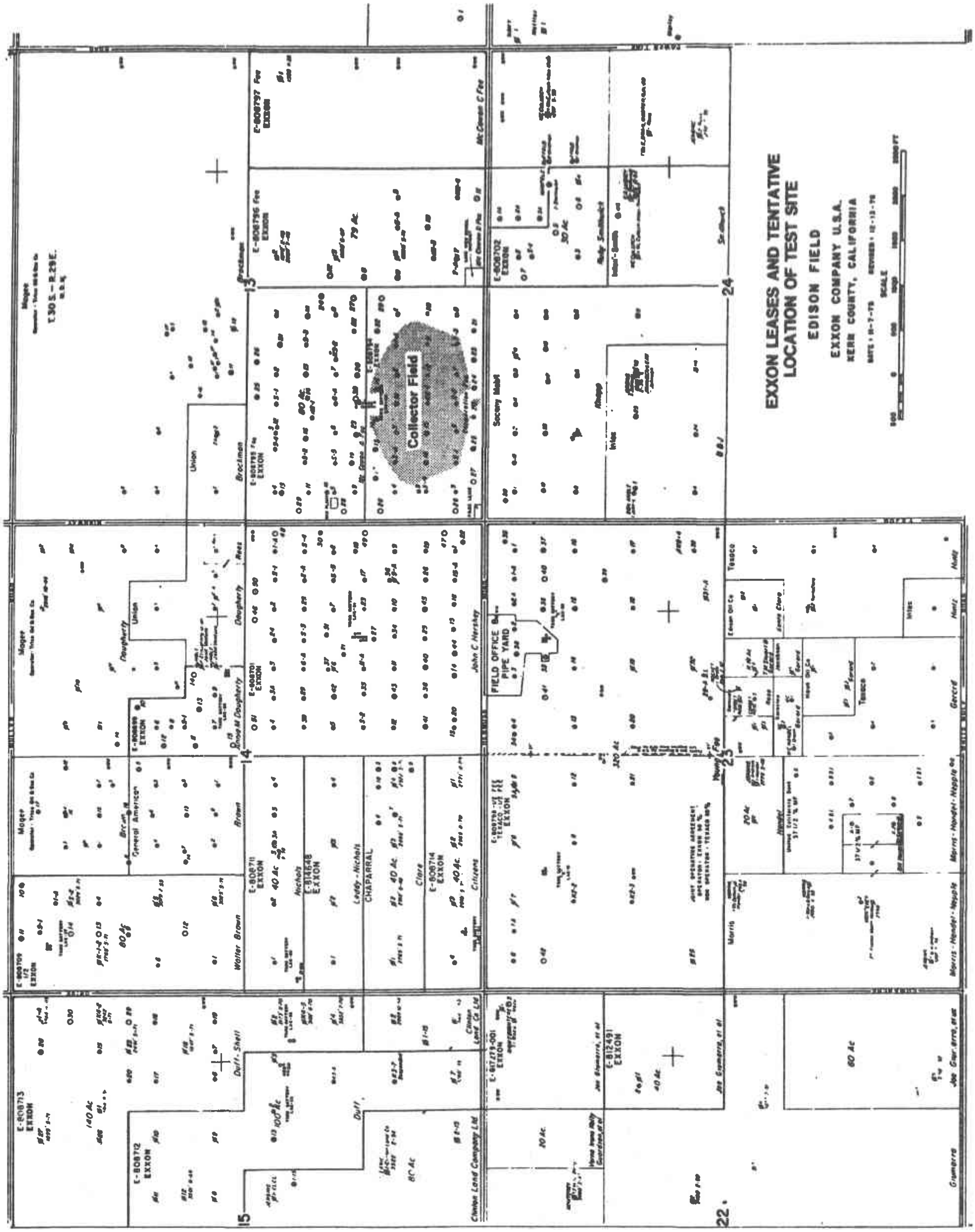


Figure 2.3-2 Exxon Field Plat

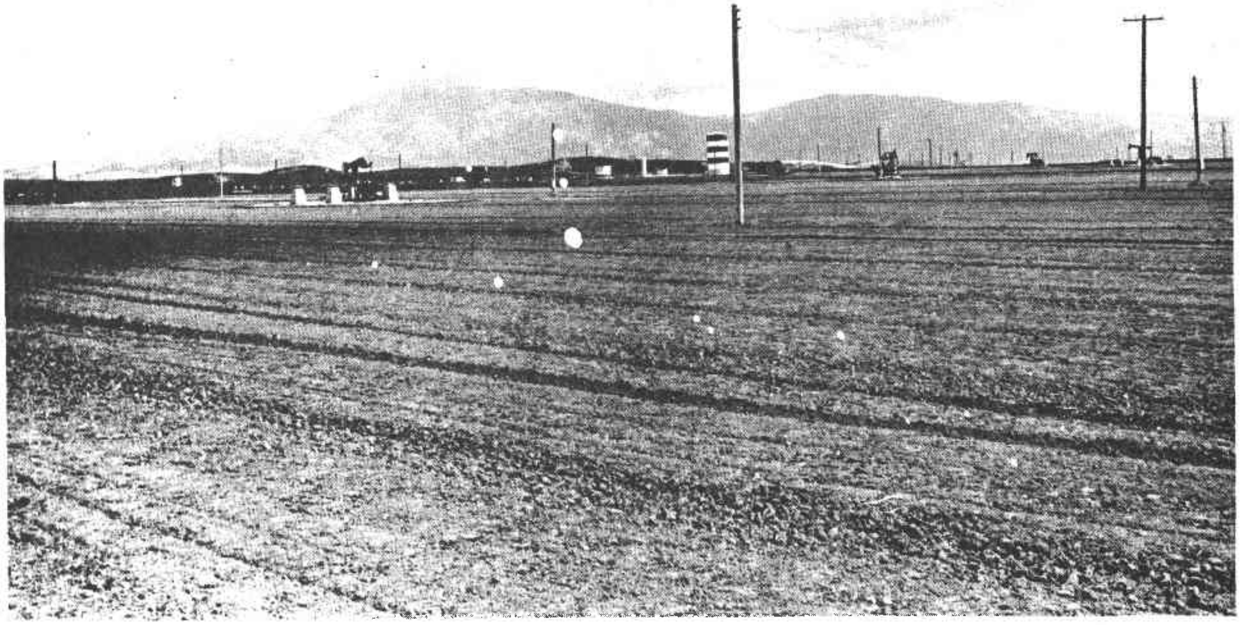


Figure 2.4-1 View of the Site Looking to the Southeast

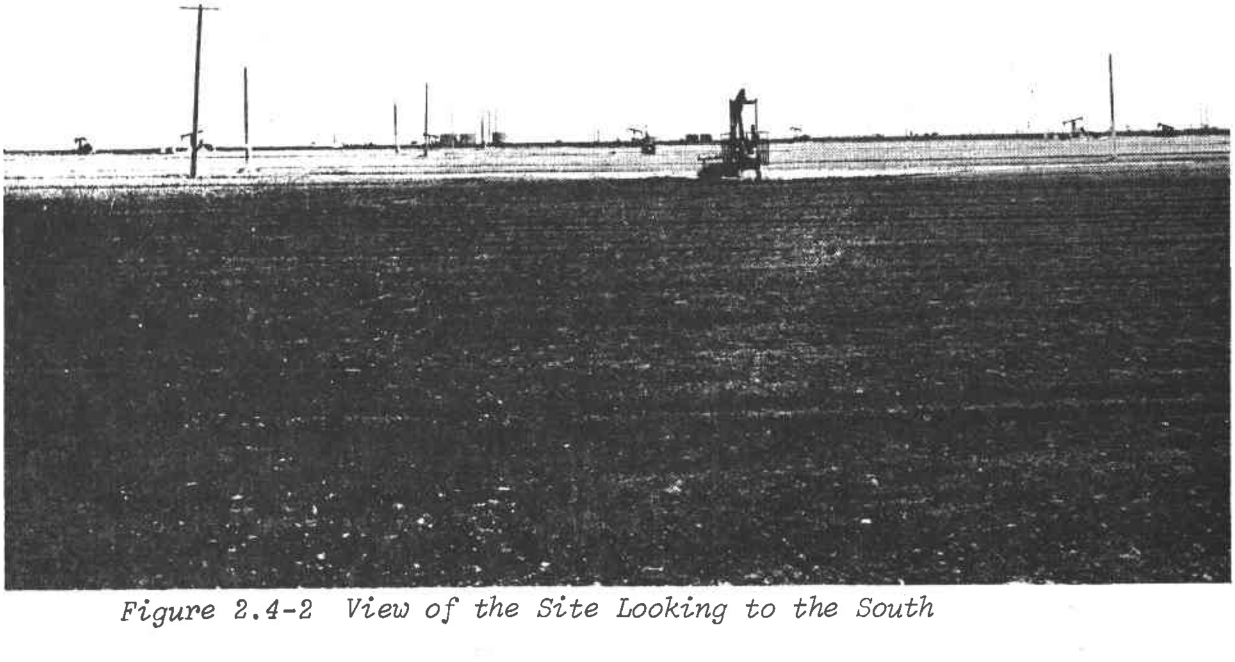


Figure 2.4-2 View of the Site Looking to the South

Figure 2.4-3 View of the Site Looking to the Southwest

Bakersfield is considered a high earthquake risk area. It is classified Zone 4 in the Uniform Building Code and structures must be designed to appropriate specifications. The last major quake was in 1952 and measured 7.5 to 7.7 on the Richter scale. The Uniform Building Code puts the soil of the Edison field in Class 4 (SC), sand and clay.

The dominant geologic structure in the Main area is the uplifted, southwesterly tilted fault block in the basement complex. Overlying sediments overlap and buttress against the high-relief structure, Figures 2.4-6 and 2.4-7.

Oil accumulation and migration limits result from:

1) Sand lenticularity and faulting in the nonmarine Kern River zone;

2) Interconnected fractures in the metamorphic Schist zone with capping by overlying sediments.

The producing zones in the Main area include the Kern River--Chanac, Santa Margarita, Wicker, Nozu, Freeman-Jewett, Walker and Schist. The Kern River and Schist are the two most prolific.

The Kern River is the shallowest producing zone and ranks first in productivity. Over the approximately 4.05 x 10^6 m^2 (1000 acres) on Exxon property, depth averages about 0.34 km (1000 ft) below sea level. Net sand thickness varies from 9 to 61 m (30 to 200 ft) in a gross interval. The nearly "dead" oil is produced by solution gas drive with limited water drive likely. Reservoir and oil characteristics for the Kern River formation are given in Table 2.4-1.

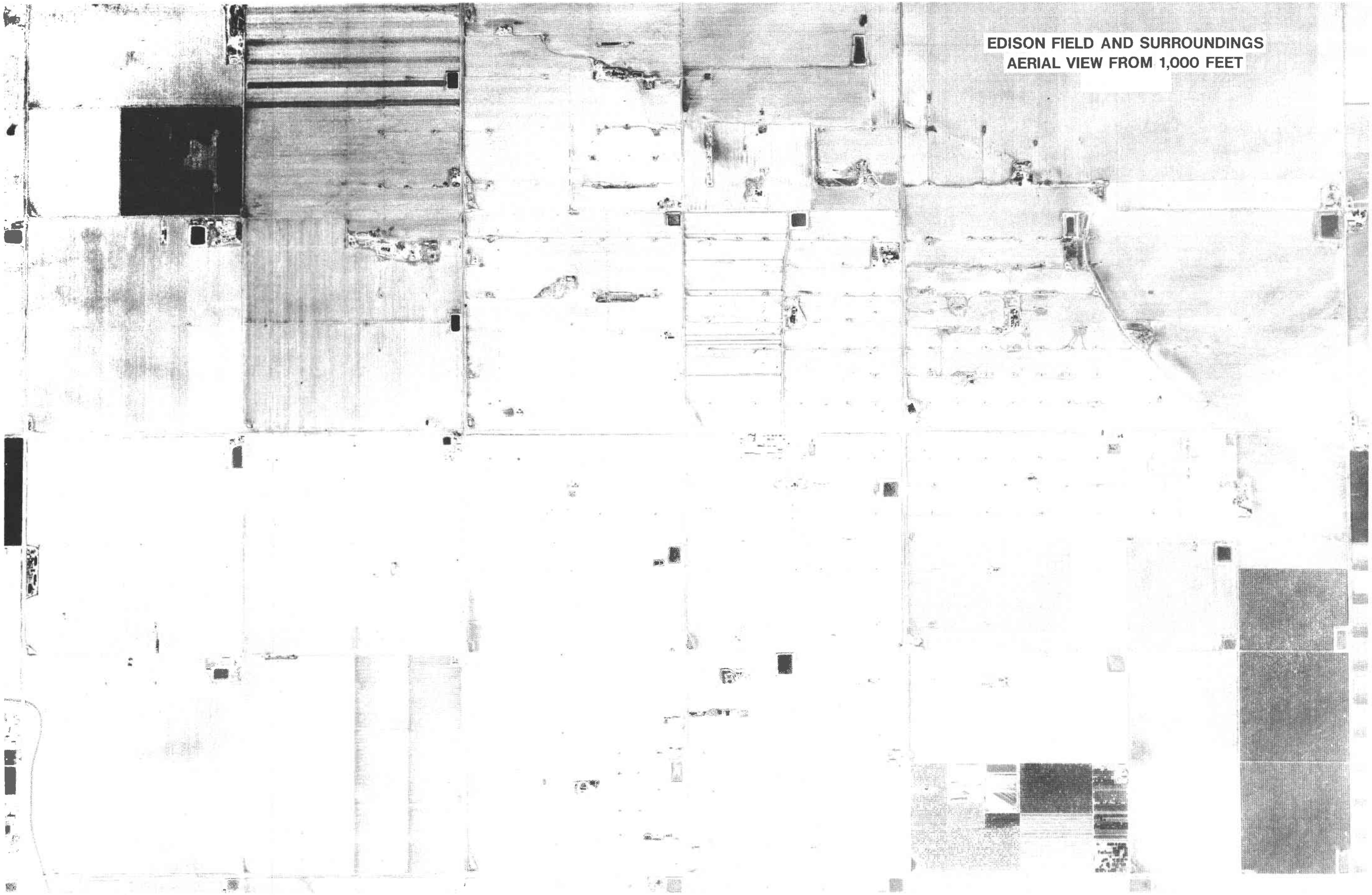
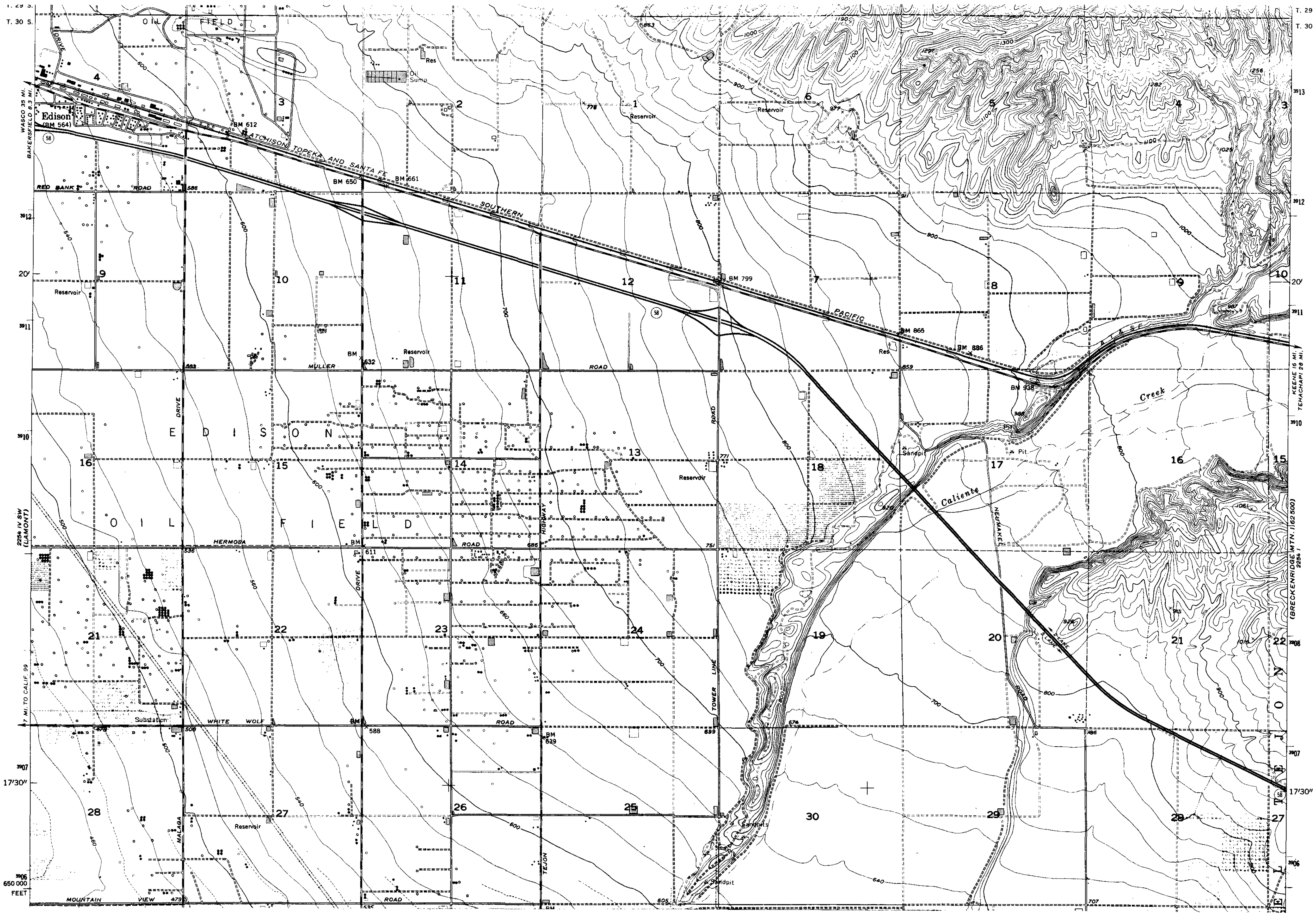
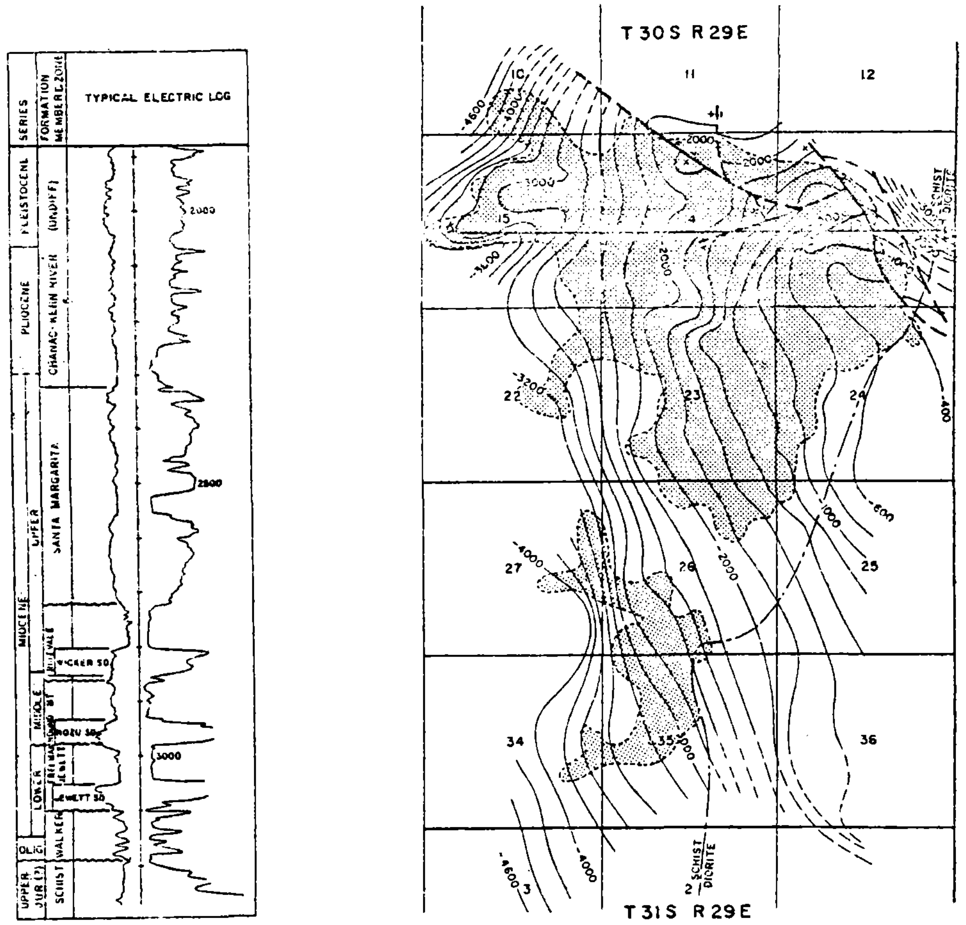


Figure 2.4-4 Edison Field and Surroundings - Aerial View from 1000 ft



GEOLOGICAL SURVEY MAP OF EDISON FIELD

Figure 2.4-5 Geological Survey Map of Edison Field



CONTOURS ON TOP OF BASEMENT COMPLEX

EDISON H. FIELD

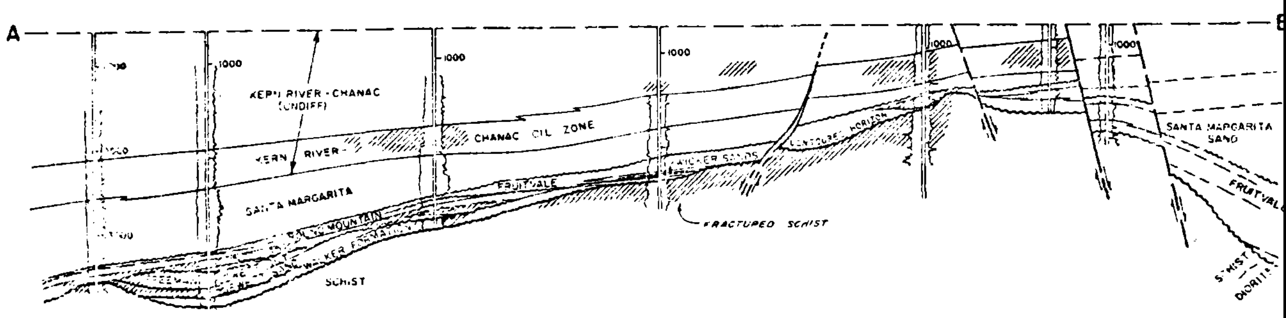


Figure 2.4-6 Geology of Main Area

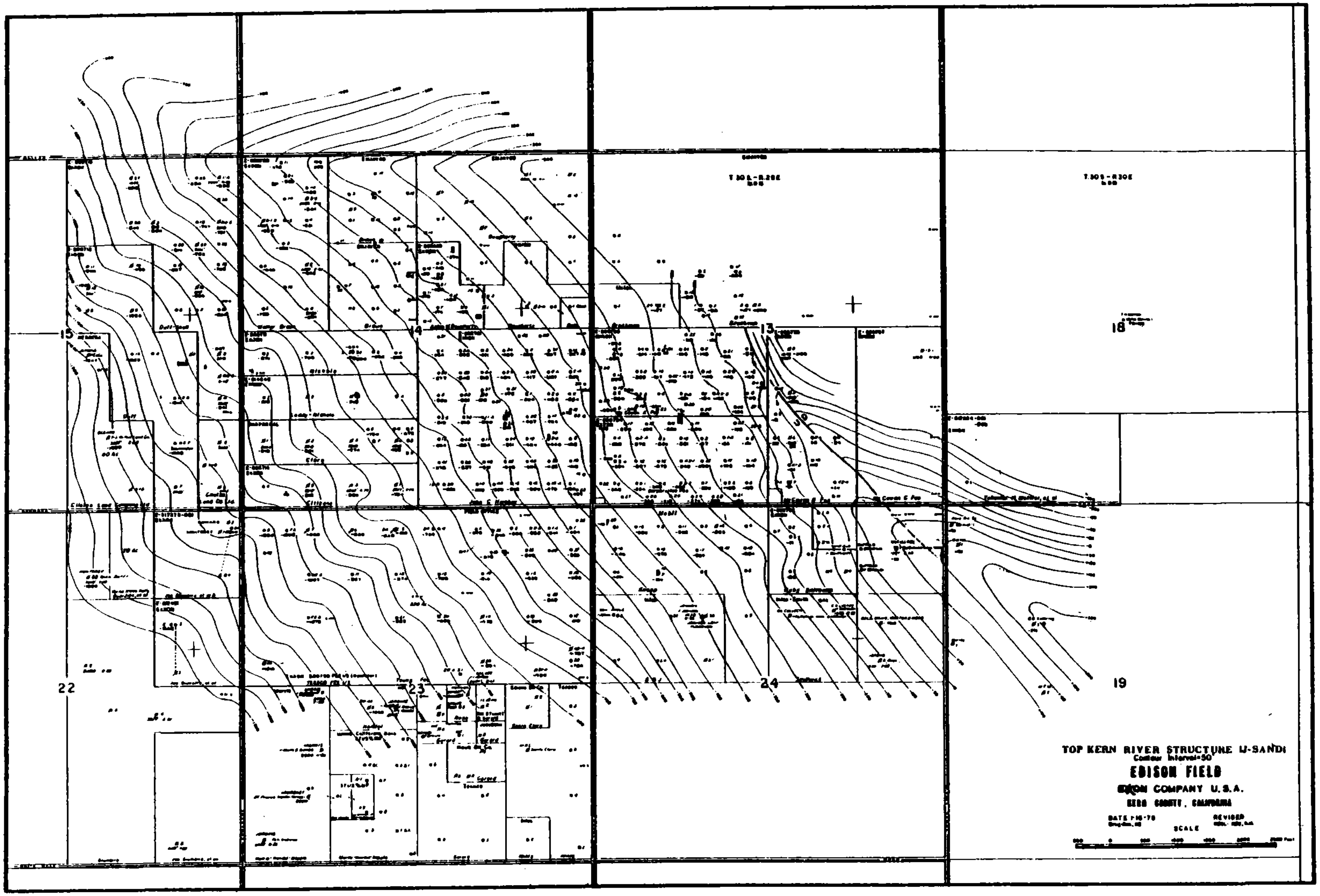


Figure 2.4-7 Top of Kern River Structure

Figure 2.4-7

Table 2.4-1 Summary of Reservoir Data

	Kern River Sand Edison Field
Depth to formation top, m (ft)	335.3 (1100)
Oil gravity, °API	16-19
Current reservoir pressure, MPa (psig)	1.034 (150.0)
Average net sand thickness, m (ft)	24.4 (80.0)
Reservoir temperature, °C (°F)	35 (95)
Oil viscosity at reservoir temperature, Pa-s (cp)	0.310 (310.0)
Average permeability to air, md	1500
Average porosity, %	27
Average oil content, bbl/AF	1150
Average oil saturation, % PV	55
Formation dip, rad (deg)	0.14-0.17 (3-10)
Pattern size, m (acres)	10,117-20,235 (2.5-5.0)

The Schist is he deepest producing zone and ranks second in productivity. Over the approximately 2.8 x 10^6 m^2 (700 acres) on Exxon property, depth varies from 9 m (30 ft) to over 610 m (2000 ft) below sea level. The primary production mechanism is water influx, although solution gas drive and gravity drainage have been important in the past.

The water supply for steam generation is provided from an Exxon-owned and operated well. This well draws water from a depth of 305 m (1000 ft) at a rate of 9.464 x 10^{-3} m/s (150 gpm). Water is distrubuted to the stimulation site by portable lines. Water is treated in portable units containing ion exchange beds. Table 2.4-2 contains water quality information before and after treatment. No problems are anticipated with the quantity of incremental water required for the solar-derived steam.

Table 2.4-2 Water Quality Data - Impurities in ppm

Impurities	As Produced from Well	After Treatment
Calcium	54.4	<0.5
Magnesium	12.6	<0.5
Sodium	50.6	210.0
Bicarbonates	298.9	≃0
Chlorides	36.1	326.0
Sulphates	2.2	≃0
Nitrates	0.44	≃0
Total Hardness as $CaCO_3$	187.66	<0.5

Produced water is separated from oil in the separator tanks distributed throughout the field and indicated in Figure 2.3-2. This water, along with the waste water from the water treating plants, is reinjected into the Schist zone through wells on the Young Fee. The reinjected water currently averages 684 m^3/day (4300 bbl/d).

Other wastes are handled as follows. Sanitary water is treated in the privately maintained septic system. Solid wastes, i.e., sludge from the gas scrubbing and oily waste, are trucked to a landfill operated by the town of Bakersfield.

Electric power produced by Pacific Gas and Electric services the field. An existing substation shown in Figure 2.3-2 at the southwest corner of section 13 is rated for 1900 kW. Currently the maximum load is 500 kW. The additional requirements for STEOR will be easily accommodated. Electric power is brought to the site by an overhead cable on utility poles along Hermosa Road.

2.5 CLIMATE

The overall climate at Bakersfield is warm and semiarid. Average temperature is 18°C (65°F) and varies from 9°C (48°) in winter to 29°C (84°F) in summer. Annual precipitation averages 15 cm (5.8 in.). Snow is rare and no accumulations of greater than 4 cm (1.5 in.) have been recorded. Southeasterly winds, originating in the Tehachapi Mountains can, at times, reach velocities of 26.82 mps (60 mph). The most recent severe wind storm occurred in December 1977, with gusts to 33.53 mps (75 mph). A complete summary of the local climatic conditions is given in Appendix A.

Annual average direct normal insolation read from available solar radiation charts lies between 6 and 7 kWh/m^2/day. However, the degree to which local conditions influence this value is unknown. Local factors include the intensive agricultural operations in the San Joaquin Valley and winter fogs that can be trapped in the area bound by the coast ranges to the west, the Tehachapi Mountains to the south and the Sierra Nevadas to the northeast.

2.6 EXISTING PLANT DESCRIPTION AND PERFORMANCE SUMMARY

The Edison field is currently in steam stimulation. The steam soaking approach is in use, a batch operation in which the following steps are taken (Fig. 2.6-1):

1) Saturated steam at 260 to 288°C (500 to 550°F) and 75 to 80% quality is injected into a well for 5 to 7 days. The steam flow rate is about 3.155×10^{-3} m^3/s (50 gpm) of water equivalent;

2) The well is closed and "steam-soaked" for about 4 days. The injected steam permeates and heats the oil/rock/sand formation and reduces the viscosity of the oil;

3) The well is opened and oil is pumped out for about the next 50 to 70 weeks, after which the steam soak process is repeated.

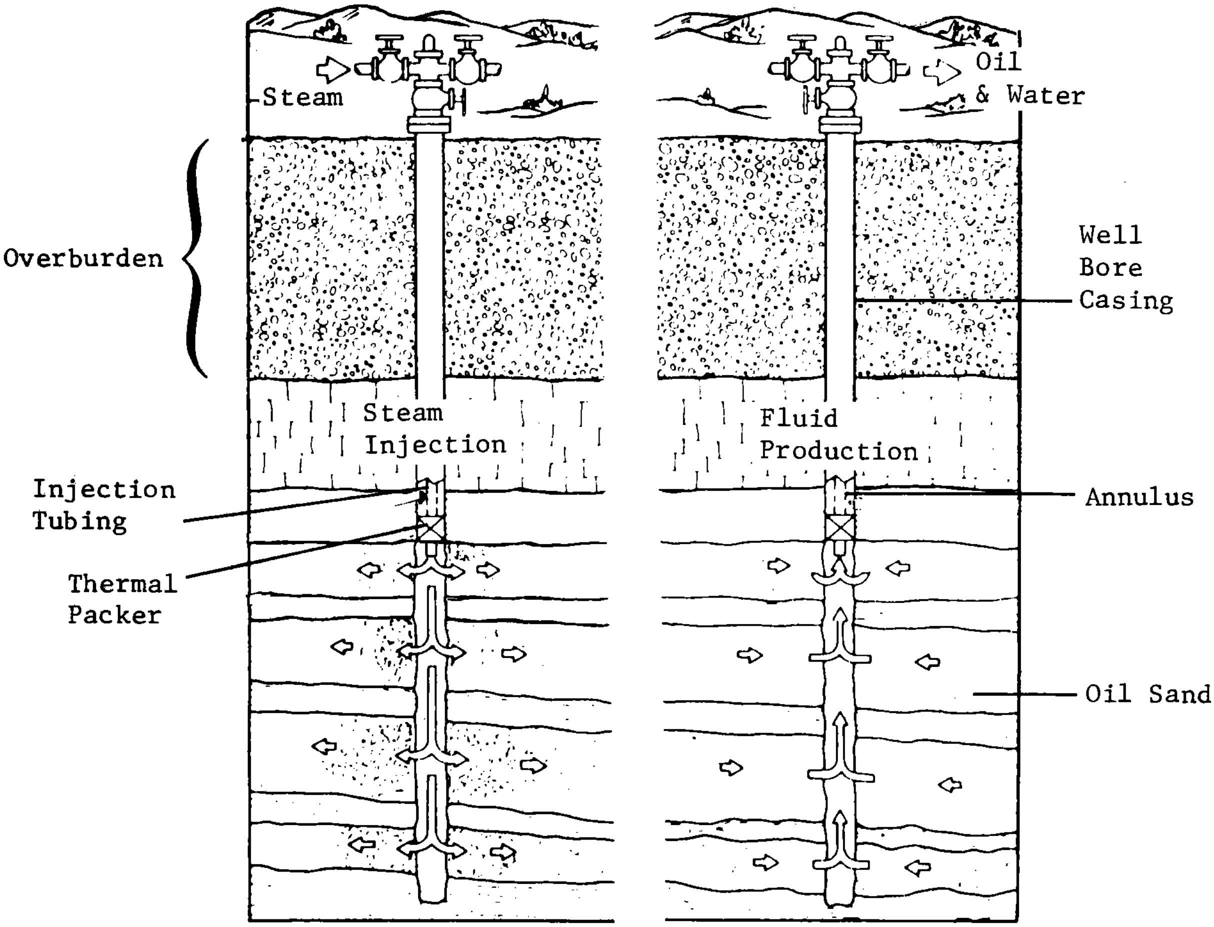


Figure 2.6-1 Steam Stimulation

Currently two crude oil-fueled boilers (one put into operation in 1965, the other in 1979) are being used at Edison. Their characteristics are listed in Table 2.6-1. For each well stimulation, a boiler, portable Thermiotics water treating plant, and portable water, boiler fuel, and diesel fuel tanks (Fig. 2.6-2) are moved to the well site.

In a typical operation, 1590 m^3 (10,000 bbl) of water will be converted to steam and injected into the well (plus an additional 9 to 10% for the scrubber). To accomplish this, about 115 m^3 (724 bbl) of crude oil will be burned (about 106 m^3 of oil would be required if no scrubber were used). An annualized energy diagram for this system is shown in Figure 2.6-3.

The portable steamers currently in use at Edison are in service on an average 80% of the time. The remaining 20% is divided between 3% for maintenance and 15% for moving and reinstallation. Unscheduled downtime occurs rarely when an automatic overpressure or overtemperature sensor shuts down the steamer. In these cases the shutdown is discovered and the steamer restarted within a few hours.

Table 2.6-1 Steam Generator Design Data for Struthers Thermoflood® 25 Steamer

Design Steam Pressure	10.343 MPa (1500 psig)
Design Steam Quality	80%
Design Steam Flow to Well	11,564.6 kg/h (25,500 lb/h)
Design Steam Flow to Oil Burner	72.56 kg/h (160 lb/h)
Condensate to Drain	18.14 kg/h (40 lb/h)
Design Steam Flow at Heater Outlet	11,655.3 kg/h (25,700 lb/h)
Heat to Well (Above 80°F Feed Temperature)	7.27 MW (24,797,808 Btu/h)
Heat to Produce Atomizing Steam	59.09 kW (201,600 Btu/h)
Heat to Preheat Fuel Oil (Recirculate)	37.44 kW (127,750 Btu/h)
Design Total Heat Output of Heater	7.91 MW (26,999,408 Btu/h)
Thermal Efficiency of Heater	89.99% (LHV Basis)
Thermal Efficiency of Process	89.12% (LHV Basis)
Burner Type	North American 5131-FA
Burner Heat Release	8.14 MW (27,777,778 Btu/h)
Fuel	Crude Oil
Fuel Net Heating Value	156.41 W/m^3 (141,000 Btu/gal)
Fuel Consumption	0.746 m^3/h (197 gal/h)
Pilot Fuel	Natural Gas or LPG
Combustion Air 11,900.2 kg/h (26,240 lb/h)	Flue Gas 12,598.6 kg/h (27,180 lb/h)
Flue Gas Temperature	190.6°C (375°F) at 20% Excess Air

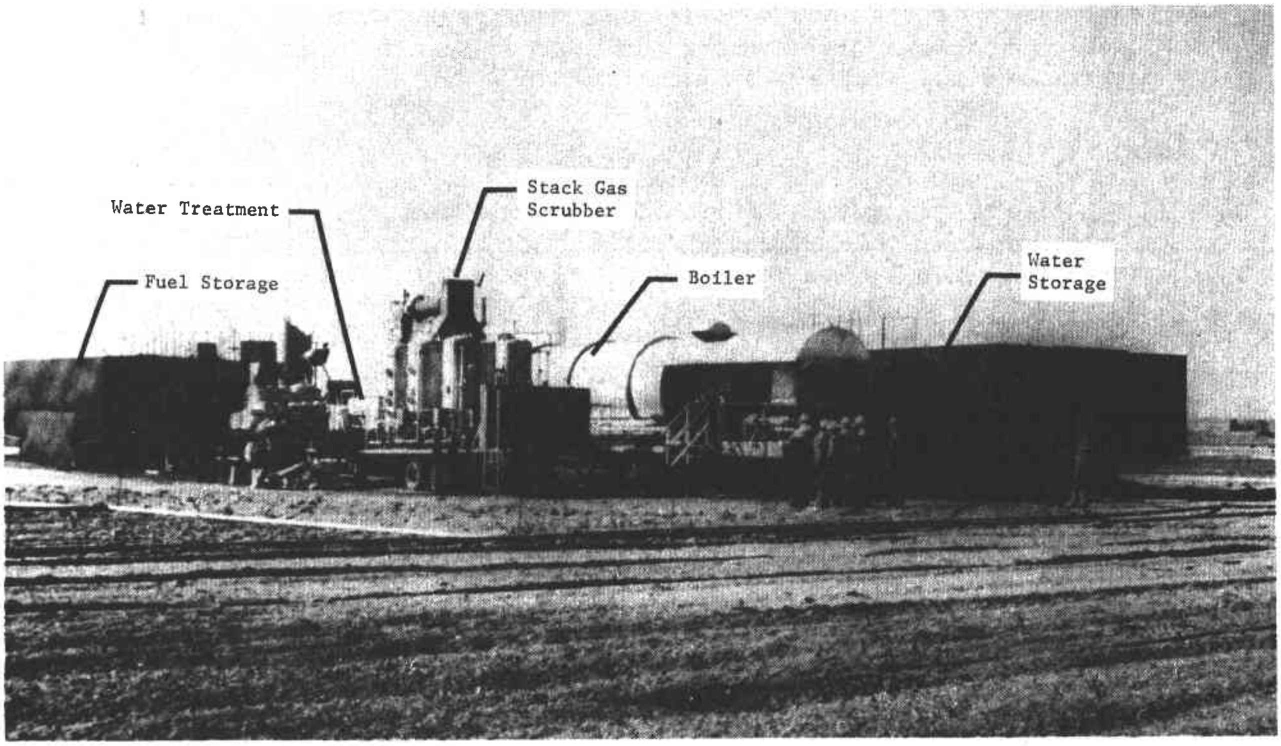


Figure 2.6-2 Steam Drive Operation at Edison Field

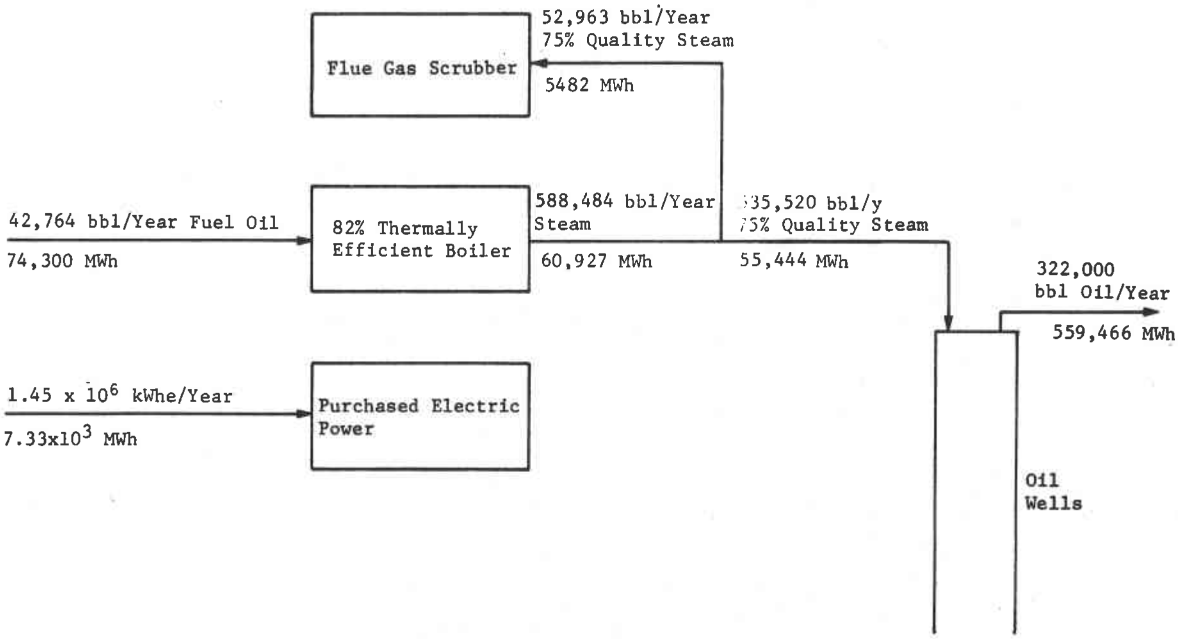


Figure 2.6-3 Annual Energy Flow Diagram, New 7.33 MWt Boiler

2.7 PROJECT ORGANIZATION

This conceptual design study was performed by a team consisting of Martin Marietta Corporation, Exxon Research and Engineering, Wheeler Development Corporation, and Black and Veatch Consulting Engineers, Incorporated. The organization and functional responsibilities are illustrated in Figure 2.7-1.

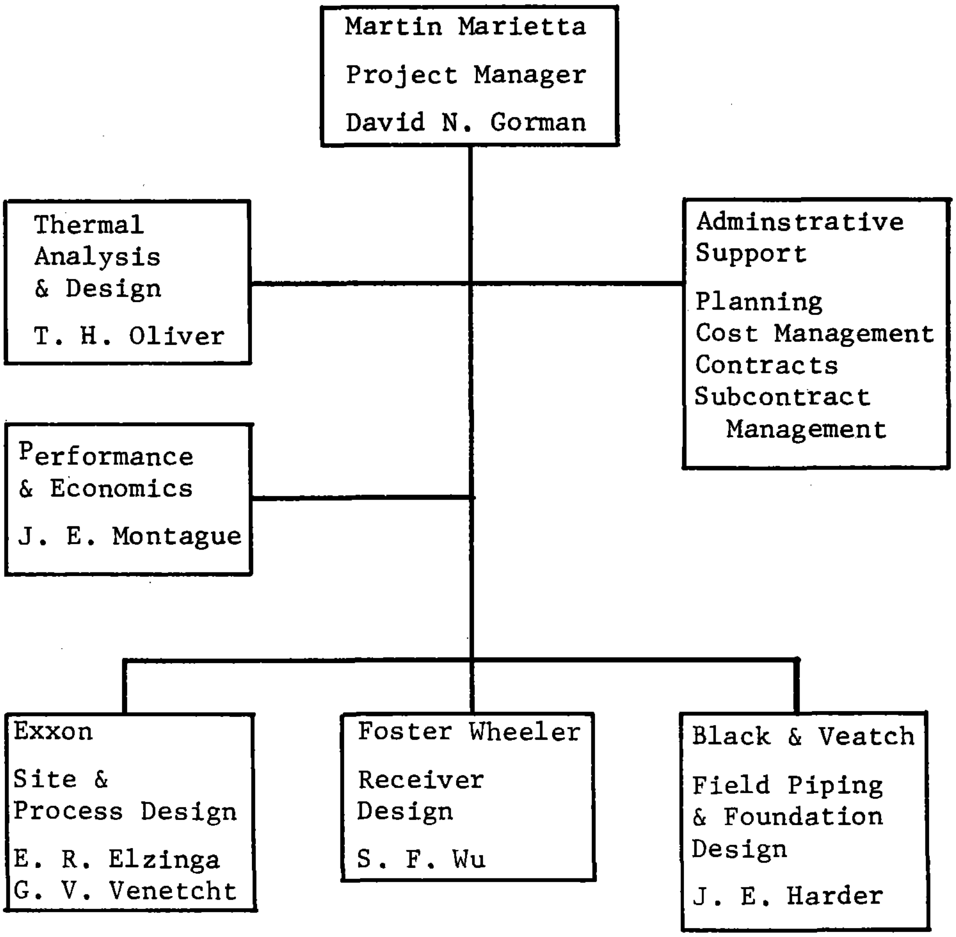


Figure 2.7-1
Solar Thermal-Enhanced Oil Recovery Project Organization

As prime contractor, Martin Marietta provided overall management for the project, serving as the focal point for technical coordination, reviews and documentation. Martin Marietta also made significant contributions to the development of specifications, thermal performance analyses, system selection and conceptual design, plant performance analyses and economic studies.

Exxon is the owner/operator of the specific thermal-enhanced oil recovery process application and site on which this entire project was based, and provided the necessary technical expertise, ecomomic understanding and operational knowledge of the oil production process. Exxon provided significant inputs to the system specifications, generated the development plan and performed process analyses and economic estimates. If it is decided to continue toward the development of an operational system, Exxon will provide team leadership and direction for the subsequent detailed design, development, construction and operational activities.

Foster Wheeler had the overall responsibility for conceptual design of the receiver. This included the structural concept, boiler circuitry and controls. Foster Wheeler performed the necessary analyses to ensure that the receiver design was consistent with applicable codes and criteria for steam boilers, and also performed transient operating analyses to establish startup capabilities.

Black and Veatch was responsible for the arrangement and design of the field piping subsystem. This included defining routing, pipe sizing, selection of major components, design of insulation and the supporting analyses of flow characteristics and heat loss. Black and Veatch also provided helpful evaluation of available soil data and conceptual designs for foundations for the heliostats and the receiver tower.

2.8 FINAL REPORT ORGANIZATION

This report is organized into three general divisions. The executive summary, Section 1.0, provides a brief overview of the entire project for the reader who desires a quick understanding of the purpose, nature and significant results of the study. The body of the report, Sections 2.0 through 7.0, contain the detailed descriptions of all activities and results. A complete description of the conceptual design is contained in Sections 4.0 and 5.0, and the pertinent economic evaluations are reported in Section 6.0. The appendices contain (1) detailed climatic data for the Bakersfield locale, (2) incident heat flux maps for the interior active surfaces of the receiver, and (3) the System Requirements Specification, which identifies specific design criteria, performance and operating requirements.

3.0 SELECTION OF PREFERRED SYSTEM

The process of selecting the preferred system configuration was highly influenced by the specific application and site chosen for this central receiver system design. The availability and configuration of land owned by Exxon, existing equipment and facilities, future expansion anticipated for the TEOR operations and projected response of the reservoir were all important factors. Some of the specific studies that led to the final design concept are discussed in this section.

3.1 TRADEOFF STUDIES

Several tradeoff studies were performed to aid in selecting a preferred configuration for the STEOR system concept. A comprehensive evaluation of collector field arrangements was performed to determine optimum layouts considering system power capacity, site limitations and possible receiver configurations. Then, more detailed studies were conducted to optimize the receiver cavity design. Other studies discussed in this section include layout and sizing of the field piping subsystem and some preliminary assessments of tower foundation concepts.

3.1.1 Collector Field/System Sizing Parametric Analyses

The objective of these analyses was to identify the most cost effective solar subsystem size and resulting collector field layout for the Edison enhanced oil recovery retrofit concept. An additional output from these analyses was the cavity receiver configuration; i.e., the number of apertures and their orientation. The collector field optimization and system sizing were combined in these analyses because of (1) the land constraints imposed by the site selection, and (2) the absence of thermal storage to act as a "buffer" between the collector field size and the rating of the process. This subsection will describe the methodology used, assumptions made and the results of these parametric analyses.

3.1.1.1 Approach - The overall approach to these analyses is shown in Figure 3.1-1. The range of system sizes to be analyzed was first defined. From previous studies, it was determined that the available land would be sufficient for a maximum solar system size of approximately 70 MWt peak (240 MBtu/h), and the minimum acceptable retrofit size to the site owner was about 20 MWt (68 MBtu/h). Over this range of power levels, four different cavity receiver configurations were considered--single-, 2-, 3- and 4-aperture systems.

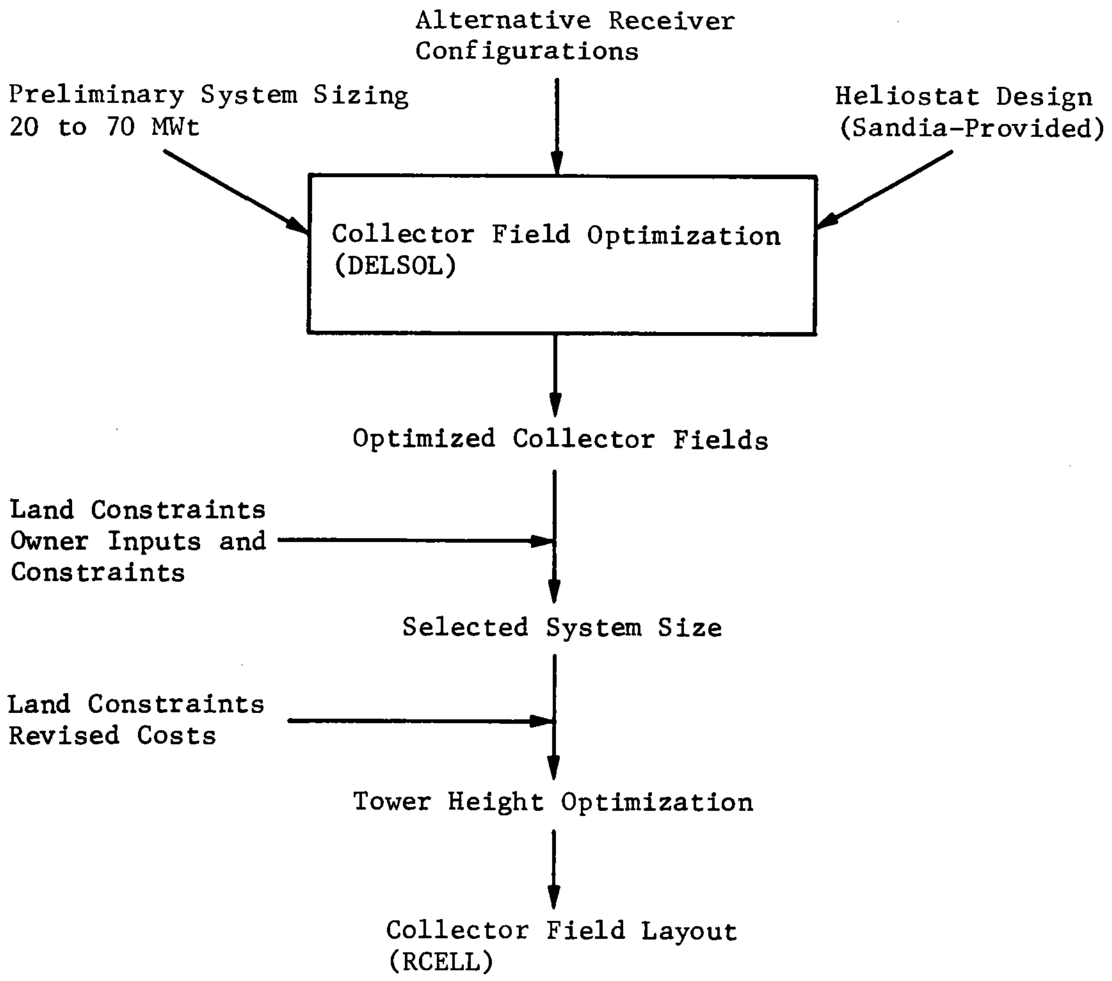


Figure 3.1-1
Collector Field/System Sizing Parametric Analysis Approach

The Sandia Laboratories DELSOL program was then used to optimize collector field size, receiver size and tower height for 11 discrete system sizes (power levels) between 20 and 70 MWt inclusive for each receiver configuration. This optimization was based on minimization of the levelized cost of energy, expressed by DELSOL in terms of mills/kWhe. This levelized cost of energy for the STEOR system considered the collector field cost (heliostats, wiring), tower cost, receiver cost and pump and piping cost. The total capital cost is levelized and divided by the net annual energy output. Consequently, the levelized cost of energy in this situation is in terms of mills/kWh (or equivalently, dollars/MWh) for the net thermal energy supplied to the wellhead.

After the optimization process was completed, the existing land constraints were imposed on the optimized collector fields for the range of system sizes considered. This analysis also incorporated the site owner's considerations and constraints and the programmatic considerations that resulted in selection of a preferred system size of 30 MWt (peak). At this power level, using the revised tower cost model provided by Sandia Laboratories in Technical Memo 6, January 18, 1980 and the strict land constraints, the tower height and field configuration was reoptimized, again using DELSOL. With the optimum tower height from this analysis, the heliostat spacings and layout were optimized using the University of Houston collector field optimization programs RCVR, RCELL and LAYOUT.

3.1.1.2 Collector Field Optimization/System Sizing Criteria - The DELSOL model requires a complete definition of the heliostat, tower, receiver and balance-of-plant performance and cost parameters to perform the optimization. This subsection will highlight the major criteria used in the parametric studies.

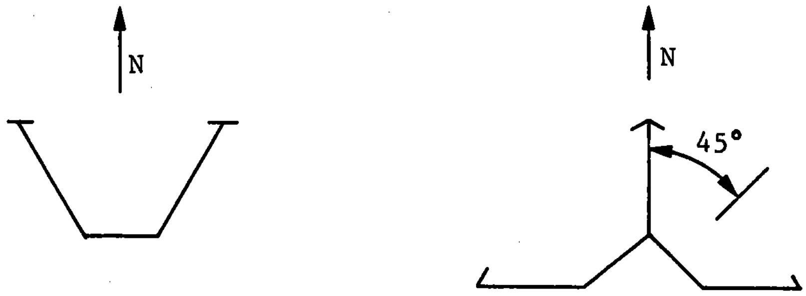
Heliostat - The baseline heliostat parameters used in these studies were provided by Sandia Laboratories in a November 6, 1979 memo, Technical Assumptions for the Repowering/Industrial Retrofit Conceptual Design Studies. The major heliostat parameters are summarized in Table 3.1-1.

Table 3.1-1 Heliostat Design Parameters

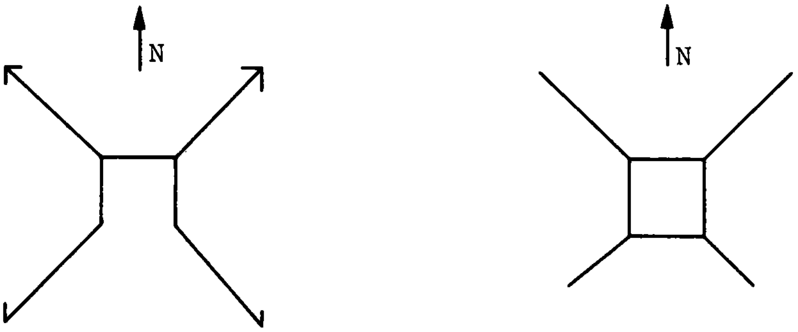
- Solar Central Receiver Heliostat
  - 12-facet glass/steel inverting stow design
  - 49.05-m^2 (528-ft^2) reflective surface
  - 7.416 x 7.378-m (24.33 x 24.20-ft) overall dimensions, 10.5-m (34.44-ft) minimum spacings
- Performance
  - 0.90 reflectivity
  - 0.75 mrad elevation axis error (1 sigma)
  - 0.75-mrad azimuth axis error (1 sigma)
  - 1.00-mrad single-axis mirror aberration error (1 sigma)
  - canted and focused at slant range
- Cost
  - \$230/m^2 (\$21.37/ft^2) first plant installed cost (1980\$)

The cost of heliostats includes the heliostat, installation, wiring and foundation, control system and all indirects and contingencies associated with the collector system. Land acquisition costs were assumed to be zero because no additional land would be required.

Receiver - An important advantage of the DELSOL program is the capability to model singleand multiple-aperture cavity receivers. In these analyses, single-, 2-, 3- and 4-aperture cavity receivers were considered, with the orientations shown in Figure 3.1-2. For performance calculations, the receiver reflection losses (effective absorptivity) for all cavities was a constant 2% of incident power (absorptivity = 0.98). Radiation and convection losses are scaled from an input reference receiver thermal efficiency of 0.985 as calculated by TRASYS. No attempt was made in the study to limit flux levels on the active surfaces of the cavities because prior work has shown that acceptable flux levels can be achieved by smart aiming strategies without increasing optimum aperture sizes or spillage.



(a) Single-Cavity (b) Two-Cavity



(c) Three-Cavity (d) Four-Cavity

Figure 3.1-2 Cavity Configurations Considered

The receiver cost model inherent in DELSOL is for external receivers, where the cost is assumed to scale exponentially (<1.0) with the absorber area. Since the absorber area is not calculated in the code for cavity receivers, modifications were made so the receiver cost scaled exponentially with the design point input power (RTHP). The model used can be expressed as

$$\text{Receiver cost} = \$1.8\text{M} \times \left(\frac{\text{RTHP}}{30.9}\right)^{0.8}$$

where the reference receiver cost of $1.8M was for a single-cavity receiver with a design point power input of 30.9 MWt.

Tower - For the range of system sizes considered, the optimum tower heights ranged between 50 and 105 m. To accurately reflect the cost data derived by Stearns-Roger in contract 18-8446, Tower Cost Data for Solar Central Receivers and modeled by the Sandia tower cost equations, a curve fit on steel tower costs between 50 and 105 m was used in the DELSOL tower cost model. The DELSOL tower cost model is of the form

$$\text{Tower cost} = a + b\,(\text{tower height}) + c\,(\text{tower height})^2 + d\,(\text{receiver weight})$$

where the default values of c and d were used, and the values of a = 4206 and b = 123.5 were calculated by curve-fit on the Stearns-Roger/ Sandia equations.

Balance-of-Plant - Since the STEOR concept does not include any of the equipment normally associated with a solar power plant, e.g., storage, heat exchangers and EPGS, all the cost models associated with the balance-of-plant were set to zero. Similarly, the performance efficiencies associated with storage and the EPGS were input as 1.0, resulting in the system output expressed in terms of thermal energy rather than electrical output.

3.1.1.3 Collector Field/System Sizing Analysis Results - Using the approach detailed in 3.1.1.1 and the criteria discussed in 3.1.1.2, the DELSOL program was used to calculate the optimum collector field size, receiver dimensions, tower height and resulting levelized cost of energy for system sizes between 20 and 70 MWt. The overall results are plotted in Figure 3.1-3 for the various cavity receiver configurations considered. As shown in the figure, the optimum STEOR configuration would be a 70-MWt (peak) system using a single north-facing cavity receiver. However, one could expect a lower cost of energy system at power levels higher than 70 MWt. The continuously decreasing cost of energy is due to the economies of scale being realized in the receiver and tower costs, as illustrated in Figure 3.1-4. The tower cost is slightly lower for 2-, 3- and 4-aperture systems due to lower tower heights than the single-aperture system; however, because of the receiver cost model used, with constant cost at a given power level for the various numbers of apertures, the receiver cost does not vary between configurations.

The levelized energy cost advantage of the single-aperture configuration is due to the increased system efficiencies, as shown in Figure 3.1-5. The decreasing system efficiencies with increasing number of apertures, especially at these small system sizes, are due to reduced field cosines with heliostats in the more southerly portions of the field, and increased radiation and convection losses with increasing aperture areas.

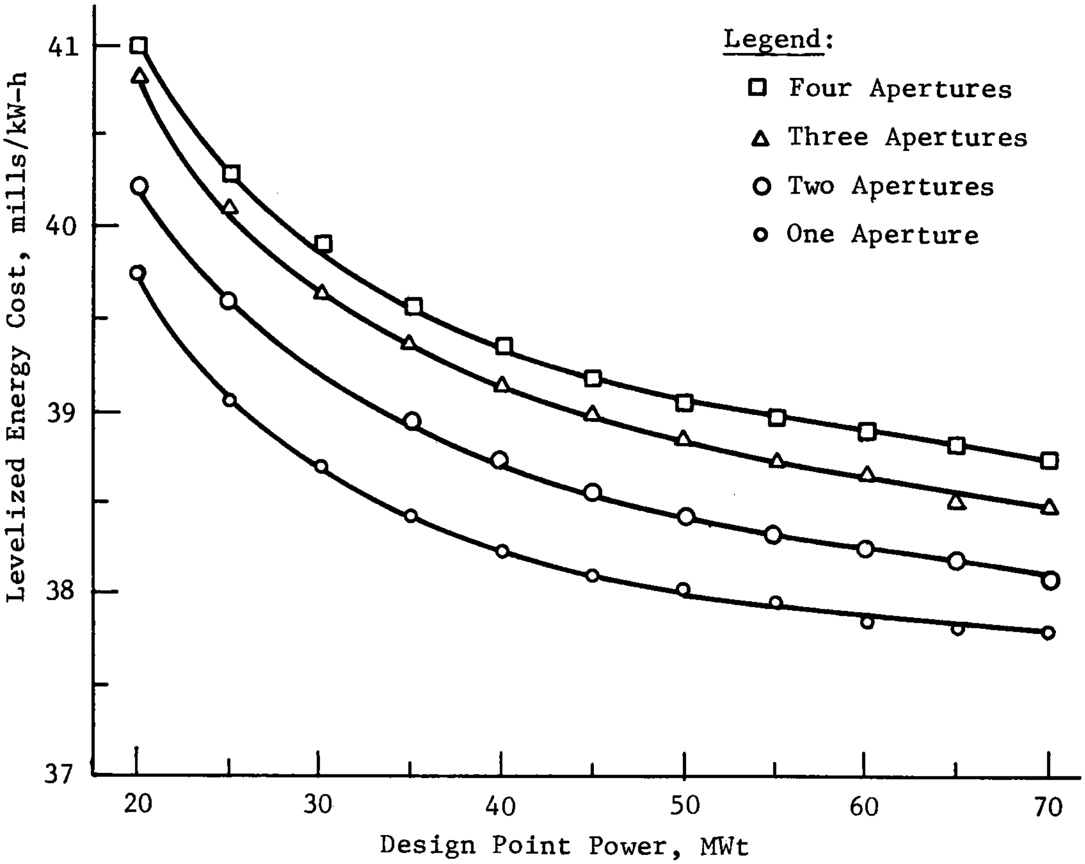


Figure 3.1-3 DELSOL Results - System Sizing Analysis

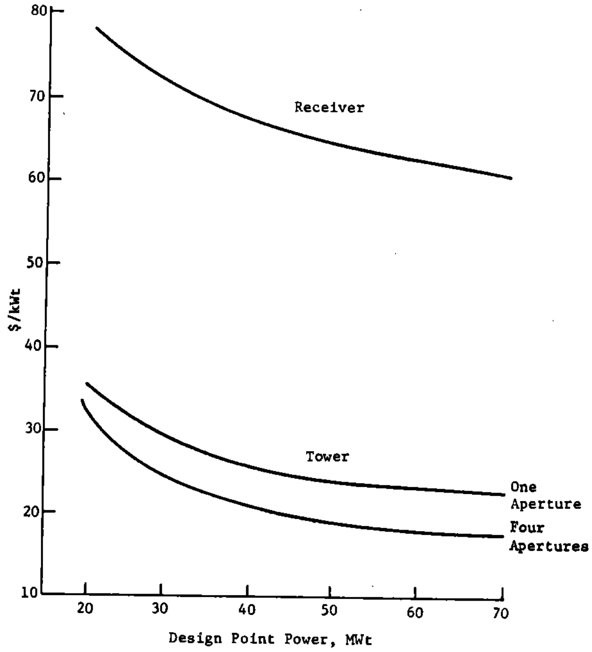


Figure 3.1-4 Economies of Scale

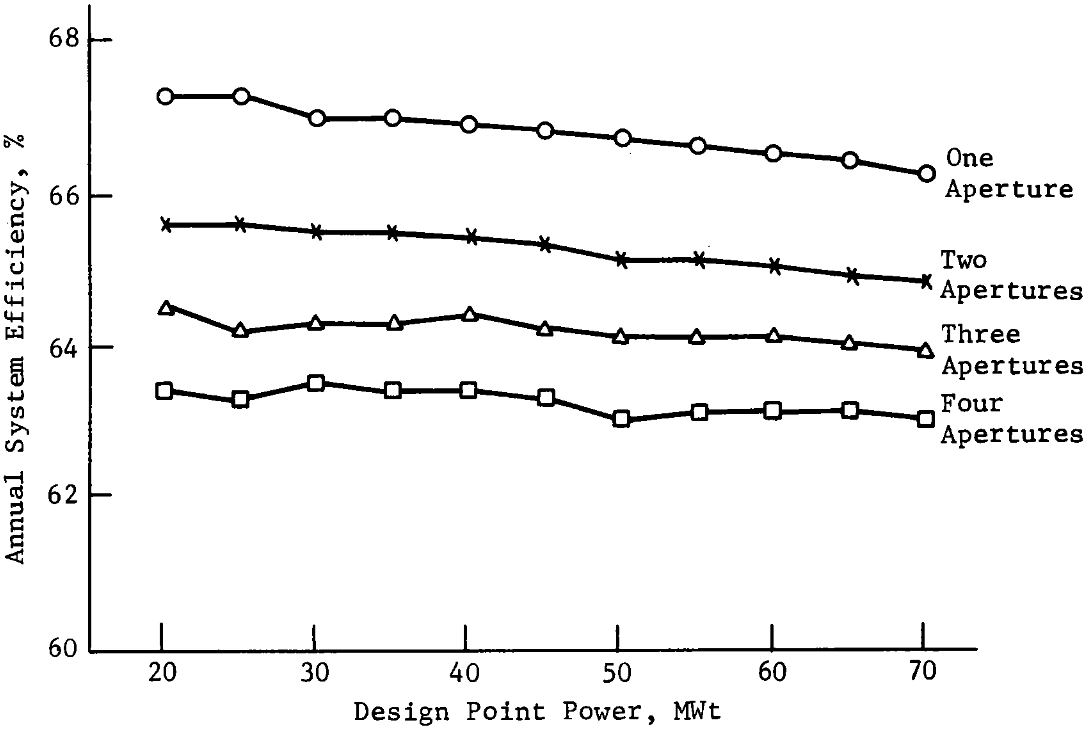
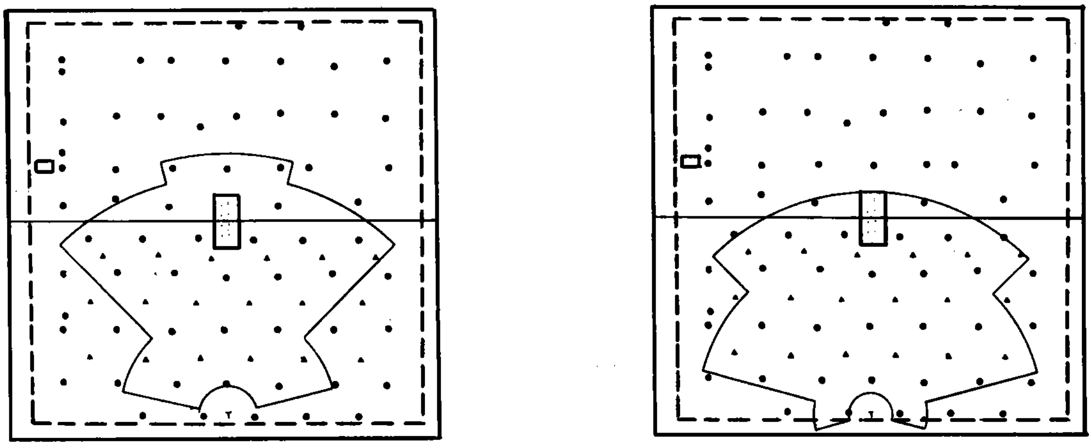


Figure 3.1-5 DELSOL Results - System Efficiencies

System Size Selection - The Edison field site imposes a strict constraint on the size and shape of the collector field. However, since the version of DELSOL used for this analysis could not impose land constraints on the optimization, it was necessary to manually impose the site constraints on the results presented in the previous discussion. This was accomplished by superimposing the heliostat field boundary as calculated by DELSOL on the plot plan of the site, examples of which are shown in Figure 3.1-6 for 30-MWt fields. These analyses of the land constraints only considered the overall dimensions of the site and did not consider the necessary easements around the wells, tank farm or gas plant. However, the consideration of land availability was sufficient to significantly constrain the system site selection as shown in Figure 3.1-7.

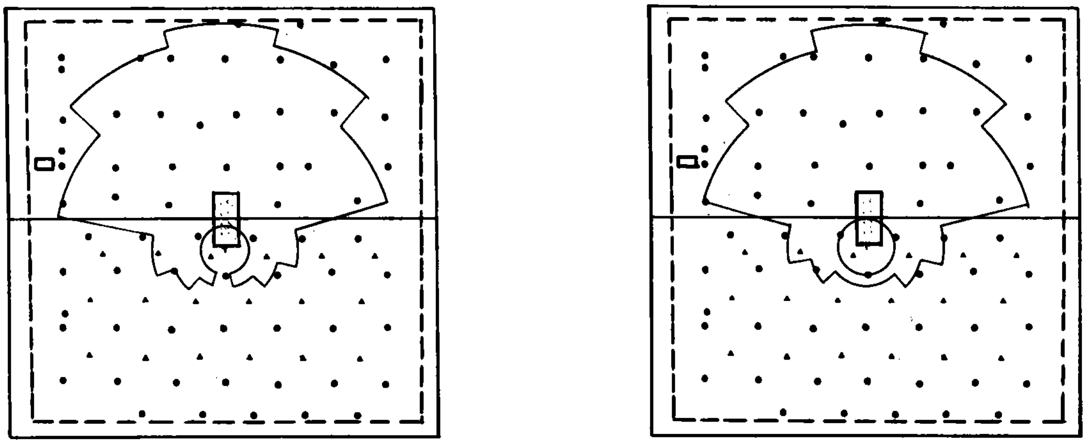
At this point in time, partially based on the results presented and partially on other operational EOR considerations, a solar retrofit size of 29.3-MWt (100-MBtu/h peak) system size was selected. This choice represented a 2% increase in the cost of energy over a 60-MWt (205-MBtu/h) solar size while reducing the projected capital investment by 49%.

From an operational point of view, the 29.3-MWt (100-MBtu/h) size represents the anticipated peak thermal requirements for steaming operations in the projected steam drive mode. The selection of the smaller size also allows construction of the collector field totally within the southern half of the site, thereby avoiding interference with the tank farm located in the middle of the site.



(a) One Aperture, 7 x 7 m, 70-m Tower Height, 38.7 mills/kWht

(b) Two Apertures, 6.5 x 6.5 m, 60-m Tower Height, 39.2 mills/kWht



(c) Three Apertures, 5.5 x 5.5 m, 60-m Tower Height, 39.7 mills/kWht

(d) Four Apertures, 5.5 x 5.5 m, 65-m Tower Height, 40.0 mills/kWht

Figure 3.1-6 DELSOL Heliostat Fields at Site, 30 MWt

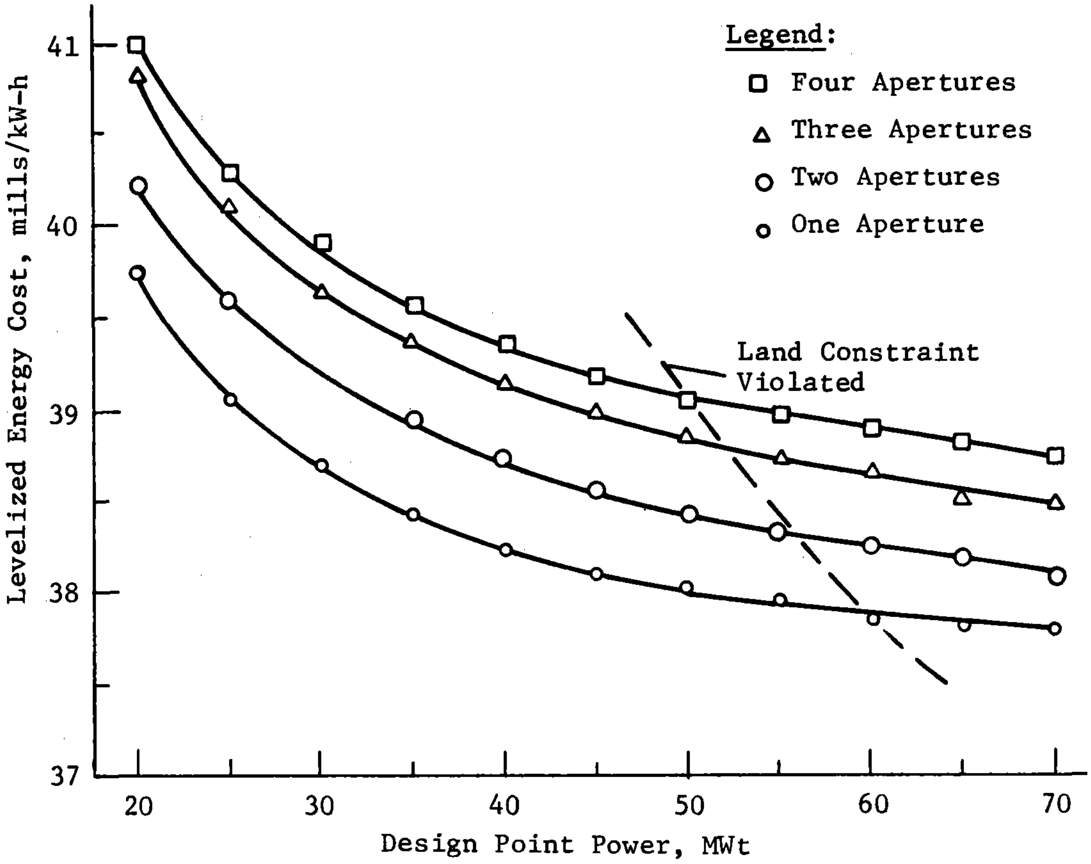


Figure 3.1-7 DELSOL Results - System Sizing Analysis

3.1.1.4 Land-Constrained Collector Field Optimization - Given the desired system size of 29.3 MWt (100 MBtu/h) and the land constraint of the southern half of the site, the tower height and final collector field layout were optimized. Based on the 30-MWt optimum collector fields shown in Figure 3.1-6, a two-cavity receiver was used for this optimization because the resulting collector field configuration provides maximum utilization of the rectangular land area. The final choice between a single-cavity and twin-cavity receiver was made after the final collector field configuration was determined, as discussed in Subsection 3.1.2. The tower height optimization involved inputting the collector field cells that did not violate the land constraints for a given tower height and using DELSOL to calculate the performance of the field. This procedure was followed for tower heights of 60, 70, 80 and 90 m, using the optimum aperture sizes (6.0 x 6.0 m) from the previous analysis. For all four tower heights, the collector field boundaries did not violate the land constraints and met the 29.3-MWt design point requirement.

An additional site constraint considered in this analysis was the required clearances around each injection and production well. This required clearance was determined to be approximately 9 m (30 ft). There are 28 wells at the site, with an additional 18 wells planned.

A simplified calculation was made to determine the number of heliostats in the collector field that would be displaced due to the minimum well clearance and moved to the outer radius of the field. Depending on the distance from the tower (and resulting field density), it was determined that between two and five heliostats would be displaced by each well. For each tower height, then, the total number of heliostats displaced was calculated and these were added to the outer radius of the field. However, these heliostats are less efficient than in their original position, thus reducing the total field efficiency. To achieve the desired design point power of 29.3 MWt, additional heliostats were added to the field, and the total number of heliostats (and cost) was calculated. Finally, the tower cost was calculated using the Sandia tower cost equations for a steel tower, assuming a constant receiver weight and size.

The results of this land-constrained optimization are summarized in Table 3.1-2. As the table shows, the minimum-cost configuration is the 90-m tower height, with the resultant heliostat field boundary shown in Figure 3.1-8.

Table 3.1-2 Two-Aperture Land-Constrained Optimization

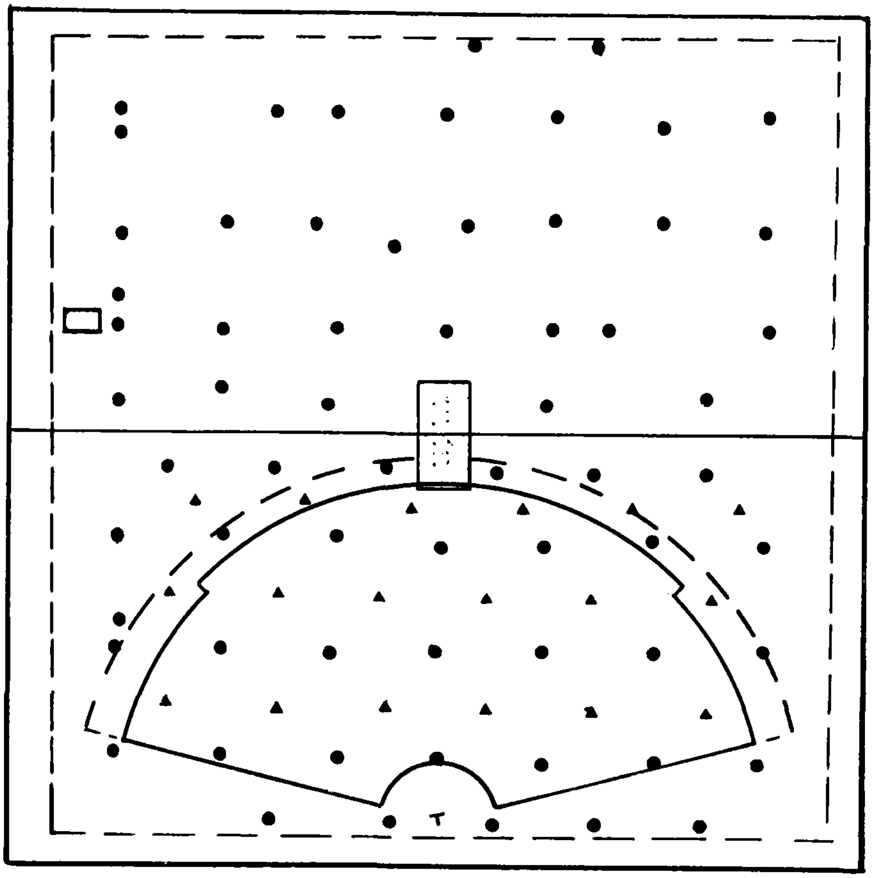
Tower Height, m (ft)	Number of Heliostats	Heliostats Displaced	Revised Number Heliostats*	Heliostat Cost, \$ x 10^3	Tower Cost†, \$ x 10^3	Total Cost, \$ x 10^3
60 (197)	831	97	838§	9,453.9	860.9	10,314.8
70 (230)	812	86	819§	9,239.5	914.8	10,154.3
80 (262)	805	75	810	9.138.0	980.0	10,118.0
90 (295)	803	65	805	9,018.6	1,052.0	10,084.6

* Accounting for well displacements.
† Revised tower cost equation, steel tower.
§ Land constraint violated.

The final task performed to arrive at the final collector field design described in Section 5.0 and in Appendix C was optimization of the heliostat spacings and the layout of the heliostat locations. To optimize the heliostat spacings, the University of Houston RCELL optimizer package was exercised for a 90-m tower height and a 6.0-m receiver size, with the heliostat design parameters given previously in Table 3.1-2. The resultant heliostat field radial coefficients were then input to the RCELL LAYOUT program to provide the coordinates of the individual heliostats for the collector field.

3.1.2 Receiver Cavity Arrangement

Two receiver configurations were considered for the 2.62-rad (150°) collector field--a single-cavity and a twin-cavity arrangement.



Note:
90-m tower,
6.0 x 6.0-m apertures.

Figure 3.1-8
Final DELSOL Two-Aperture Field Configuration (90-m Tower Height)

The single-cavity arrangement, as shown in Figure 3.1-9, has an aperture that faces north and is 18 m (50 ft) in width and 6.3 m (20.7 ft) in height. The single-cavity configuration required that the aperture width be stretched to capture the energy projected from the heliostats in the southern corners of the collector field. This increase in the aperture width resulted in a total cavity width of 22 m (72 ft).

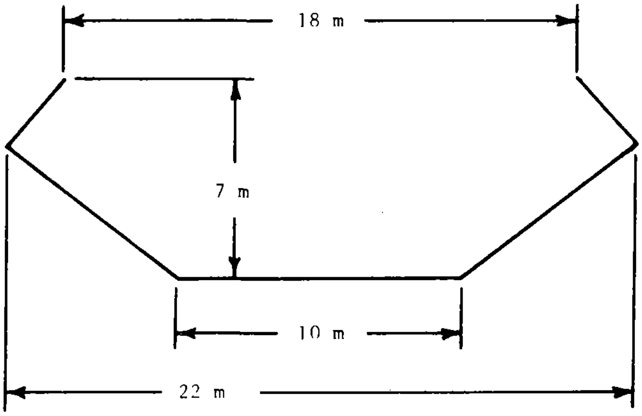


Figure 3.1-9 Single-Cavity Configuration

The twin-cavity arrangement has two 5.5 x 5.5-m (18 x 18-ft) apertures that are displaced 37.5° from the north axis, as shown in Figure 3.1-10. The two adjacent cavities have a combined width of 12 m (42.6 ft).

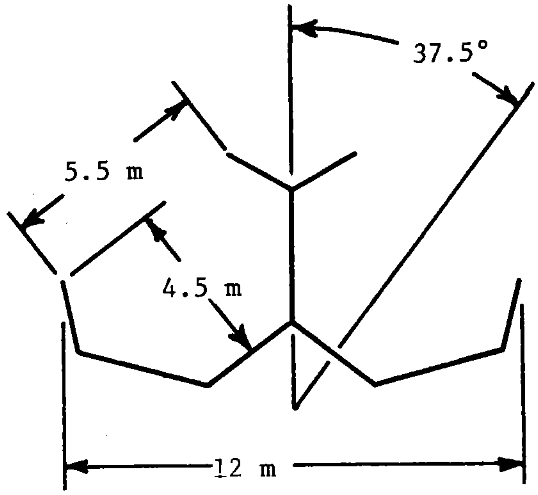


Figure 3.1-10 Twin-Cavity Configuration

The twin-cavity arrangement was found to be a more efficient and compact receiver and more compatible with the 2.62-rad (150°) field. The twin cavity was selected over the single cavity because of its higher efficiency as shown in Table 3.1-3. The higher losses from the single cavity are due to its larger aperture area, 113.4m^2 (1220.7 ft) for the single cavity, as opposed to 60.5 m^2 (651.3 ft^2) for both apertures of the twin cavity.

Table 3.1-3 Cavity Comparisons

	Design Point Lossess			
	Reflection,%	Radiation, %	Convection, %	Total, %
Single-Cavity	2.10	5.64	2.68	10.42
Twin-Cavity	1.56	1.51	2.41	5.48

3.1.2.1 Aperture Sizing - The apertures for the twin-cavity receiver were optimized by summing the cavity losses out the aperture with the spillage at the apertures. Cavity losses include radiation, convection, and reflection out the aperture. The optimum aperture size was found to be 5.5 x 5.5 m (18 x 18 ft) as shown in Figure 3.1-11.

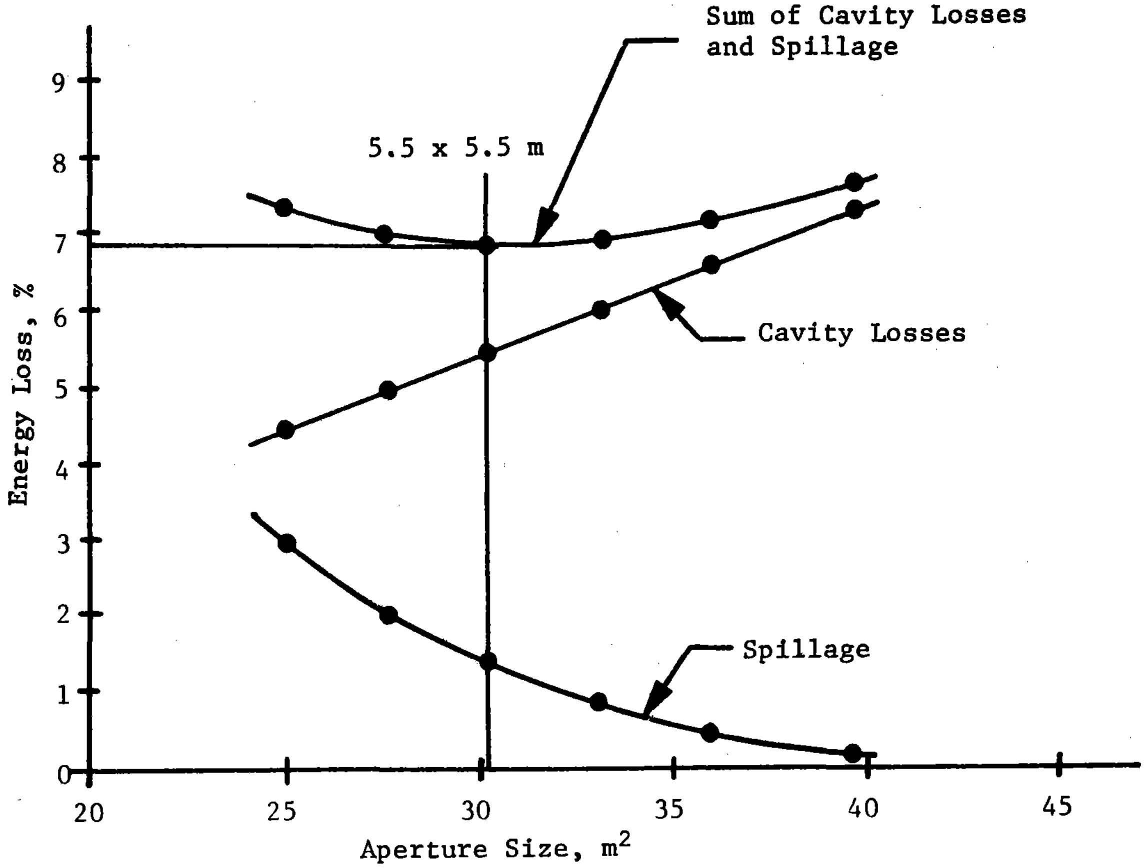


Figure 3.1-11 Aperture Sizing

3.1.2.2 Aperture Frame Heat Flux - The area around the aperture was checked for peak heat fluxes at various times of day and at various times of the year. The peak heat flux for the east aperture frame was found to occur at 10:00, day 172 along the top of the aperture as shown in Figure 3.1-12. Stainless steel with a low absorbtivity paint can tolerate an absorbed heat flux of 6.31 W/cm^2, which is well above the maximum absorbed heat flux of 4.02 W/cm^2. Therefore stainless steel can serve as a protective material around the aperture to protect the receiver structure.

3.1.3 Receiver Design Studies

Various tradeoff studies were performed to define and/or optimize key features of the receiver design. These studies are briefly summarized in this subsection.

3.1.3.1 Surface Arrangement - It is necessary to preheat the feedwater from an ambient level of about 16°C (60°F) to 149°C (300°F) to preclude excessive thermal stresses from occurring in the zone where the feedwater pipe enters the steam drum. Based on predictions of power input distributions and knowledge of the necessary preheat/boiling power apportionment, several configurations of preheat/boiler panel

Absorbed Flux, W/cm^2

0.0	0.0	0.0	0.0	0.0	0.03	0.03	0.82	1.03	0.87	0.54	0.26	0.08	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.02	0.07	0.10	0.06	0.01	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.08	0.80	2.33	3.58	4.02	3.42	2.14	0.96	0.32	0.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.07	0.58	1.83	2.49	1.86	0.82	0.23	0.01	0.0	0.0	0.0	0.0
0.0	0.0	0.0												0.02	0.0	0.0	0.0	0.0	0.0												0.0	0.0	0.0
0.0	0.0	0.10												0.10	0.0	0.0	0.0	0.0	0.0												0.03	0.0	0.0
0.0	0.03	0.38												0.31	0.02	0.0	0.0	0.0	0.0												0.13	0.01	0.0
0.01	0.08	0.72												0.63	0.07	0.0	0.0	0.0	0.07												0.28	0.02	0.0
0.01	0.13	0.98												0.93	0.12	0.01	0.0	0.0	0.22												0.38	0.03	0.0
0.0	0.14	1.06												1.09	0.14	0.0	0.0	0.02	0.35												0.38	0.02	0.0
0.0	0.11	0.93												1.02	0.13	0.0	0.0	0.02	0.36												0.24	0.01	0.0
0.0	0.06	0.65												0.73	0.07	0.0	0.0	0.01	0.26												0.07	0.0	0.0
0.0	0.02	0.35												0.36	0.02	0.0	0.0	0.0	0.12												0.0	0.0	0.0
0.0	0.01	0.13												0.09	0.0	0.0	0.0	0.0	0.02												0.0	0.0	0.0
0.0	0.0	0.0												0.0	0.0	0.0	0.0	0.0	0.0												0.0	0.0	0.0
0.0	0.0	0.0	0.04	0.21	0.62	1.30	1.95	2.25	2.04	1.35	0.50	0.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.12	0.34	0.65	0.76	0.51	0.13	0.01	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.02	0.08	0.19	0.30	0.34	0.24	0.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Day: 172
Time: 10:00
Insolation: 912 W/m^2 (289.30 Btu/h-ft^2)

Figure 3.1-12 Aperture Frame Heat Flux, 10:00 am Day 172

arrangements were evaluated. The optimum arrangement places preheater panels on the forward portion of the common vertical wall separating the two cavities, and on the horizontal ceilings of both cavities.

3.1.3.2 Steam Drum - Since the steam injection application does not require dry saturated steam, mechanical separators can be eliminated from the drum internals to effect a cost savings. Based on the operating pressure and steam loading, drums with different inside diameters and lengths were compared. A 1.22-m (48-in.) ID drum was selected for both the single- and twin-cavity configurations.

3.1.3.3 Boiler Circulation - A simplified analytical computer model was set up to check the adequacy of boiler circulation. It consisted of circuits representing downcomers, feeders, vertical boiler panels and risers. Different sizes of boiler tubes were analyzed for the different heat absorption conditions. Tubes of 50.8-mm (2.0-in.) OD were found adequate for all boiler panels. The results of this study were used to generate the boiler circuitry for the conceptual design.

3.1.3.4 Preheater Circuit - Tube size, width and orientation of flow passes, heat flux variation, and pressure drop were the key parameters considered in the design of the preheater flow circuit. Tubes of 25.4-mm (1.0-in.) OD were chosen for all preheater panels. The pressure drop through the preheater was estimated to be less than 207 kPa (30 psi).

3.1.3.5 Seismic Design Requirements - The lateral accelerations at the top of the receiver tower were calculated using the correlations recommended by Sandia Laboratories. An average peak ground acceleration of 0.5 g for UBC Seismic Zone 4 was used. The corresponding lateral tower-top acceleration is 0.82 g for a 90-m (295-ft) concrete tower, and 0.62 g for a steel tower of the same height.

3.1.4 Field Piping Study - The purpose of this study was to develop the most economical piping scheme for transporting the steam produced in the receiver to the injection wells.

3.1.4.1 System Arrangement - Assuming 12 wells are to be injected simultaneously, a well pattern that to the extent possible would be similar throughout the field was selected. The well injection pattern and the field piping arrangement are shown in Figures 3.1-13 and 3.1-14, respectively. For this field arrangement, piping generally runs parallel to the field boundaries. New injection wells can be added by taking wells out of service at one end of the well pattern and adding wells to the other end. This arrangement also lends itself to a complete relocation of the well pattern mainly by adding or removing lengths of main header piping.

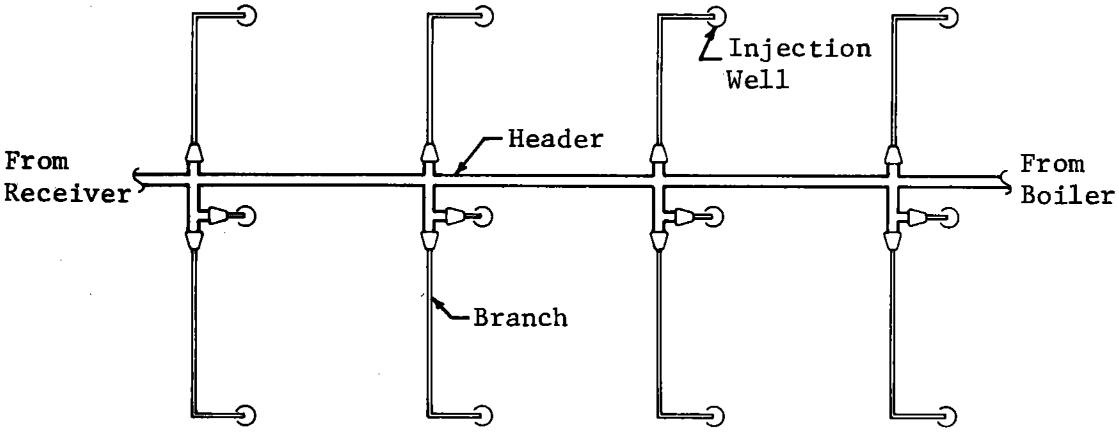


Figure 3.1-13 Well Injection Arrangement

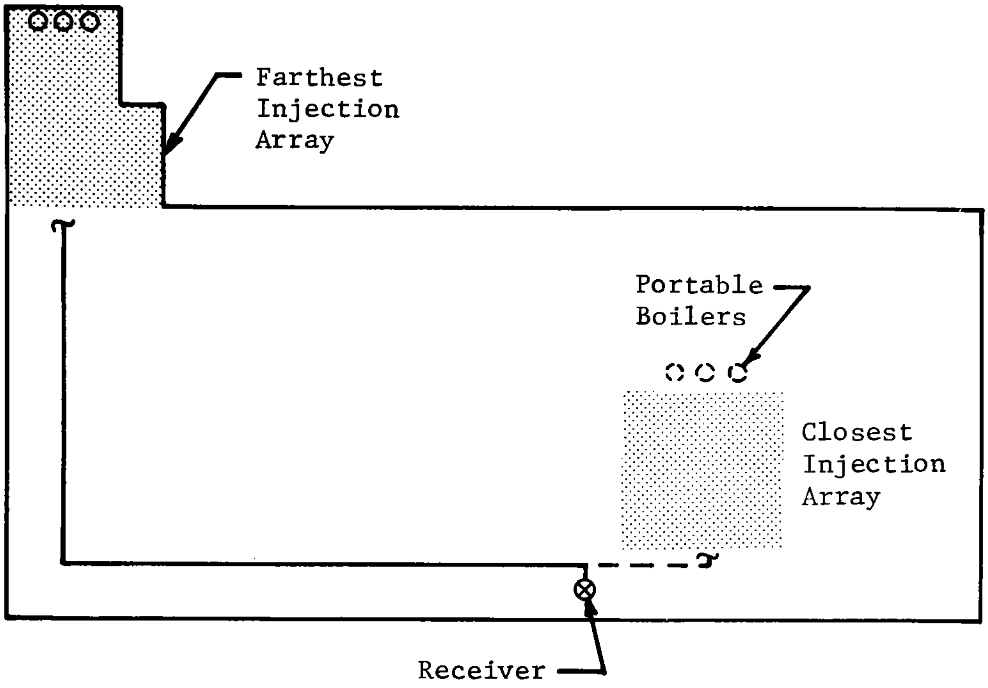


Figure 3.1-14 Field Arrangement

<u>3.1.4.2 Pipe Sizes</u> - Pipe sizes were selected using the following two criteria:

1) The steam pressure at any wellhead should not be less than 5.62 MPa (800 psig). Thus, with 7.00-MPa (1000-psig) steam pressure available at the nearest well, a maximum pressure loss of 1.38 MPa (200 psi) was established for the additional piping system necessary to reach the farthest well;

2) A maximum steam velocity of approximately 12.0 m/min/mm (1000 ft/min/in.) ID was selected as a reasonable value to minimize pipe erosion.

The piping system consists of two principal sections:

1) Main header - Header pipe from the receiver to a point just ahead of the injection well pattern;

2) Branch - Pipe from the main header to the injection wells.

The design steam flow is 43,540 kg/h (96,000 lb/h); this flow consists of 36,010-kg/h (79,400-lb/h) steam produced by the receiver and 7,580 kg/h (16,700 lb/h) of receiver blowdown (which is injected in the main header just downstream of the receiver). This steam quality is approximately 82%. With this steam flow, the selection of minimum pipe size was based on velocity. As can be seen in Table 3.1-4, a check of pressure loss with the minimum pipe size [150-mm (6-in.) main header and 80-mm (3-in.) branch] indicates a loss of approximately 1.45 MPa (210 psi). For the two pipe sections considered, one nominal pipe size above and below the minimum was also evaluated to see the effect on total system cost due to decreasing pressure loss by increasing pipe size.

Table 3.1-4 Comparison of Alternatives

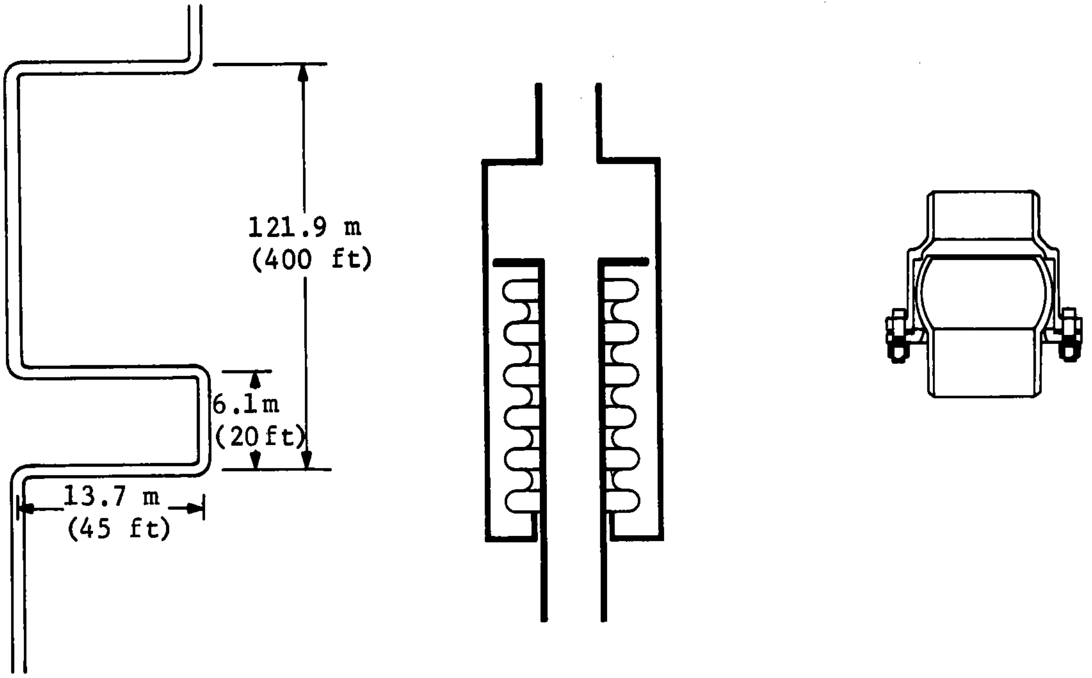
	Main Header						Branch		
	Farthest Array			Closest Array					
Pipe Size, mm (in.)	100 (4)	150 (6)	200 (8)	100 (4)	150 (6)	200 (8)	50 (2)	80 (3)	100 (4)
Pipe Cost, $1,000	318.6	402.7	487.4	37.7	47.6	58.1	128.1	144.0	166.4
Expansion Method, $1,000									
Pipe Loops	51.9	84.4	133.4	3.7	6.0	8.1	25.4	33.1	44.5
Bellows	51.6	55.4	76.2	3.7	4.0	5.4	23.3	39.3	44.2
Barco Joints	15.2	31.1	45.5	1.1	2.2	3.3	8.9	12.7	19.5
Insulation Cost, $1,000									
Bellows or Barco Joints	54.5	66.5	92.8	6.4	7.8	10.8	24.1	27.2	33.2
Pipe Loops	63.4	80.4	114.4	7.0	8.8	12.4	28.9	33.8	42.5
Total Cost, $1,000									
Pipe Loops	433.9	567.5	715.2	48.4	62.4	78.6	182.4	210.9	253.4
Bellows	424.7	524.6	656.4	47.8	59.4	74.3	180.3	210.5	253.1
Barco Joints	388.3	500.3	625.7	45.2	57.6	72.2	161.1	183.9	219.1
Total Pressure Drop, kPa (psi)									
Pipe Loops	11,473 (1664)	1,544 (224)	386 (56)	1,269 (184)	172 (25)	41 (6)	476 (69)	62 (9)	14 (2)
Bellows	10,598 (1537)	1,420 (206)	359 (52)	1,207 (175)	165 (24)	41 (6)	421 (61)	55 (8)	14 (2)
Barco Joints	10,514 (1525)	1,386 (201)	345 (50)	1,186 (172)	159 (23)	34 (5)	421 (61)	55 (8)	14 (2)

<u>3.1.4.3 Thermal Expansion</u> - For the pipe sizes considered, the three methods of compensating for thermal expansion shown in Figure 3.1-15 were evaluated:

1) Pipe expansion loops;

2) Metal bellows expansion joints;

3) Barco joints (swivel ball joints).



(a) Pipe Loop (b) Metal Bellows (c) Barco Joint

Figure 3.1-15 Expansion Device Detail

To simplify the piping support system, movement of the pipe at any location due to thermal expansion was limited to approximately 416 mm (16 in.). This requires a method of accommodating the expansion at intervals of approximately 122 m (400 ft). The cost of each of these techniques is listed in Table 3.1-4.

3.1.4.4 Insulation - To complete the piping study, insulation costs were developed based on the following criteria:

1) Wind speed = 18.5 km/h (11.5 mph) - Specified in United States Speed and Wind Power Duration tables by months, October 1975;

2) Ambient temperature = 18.3°C (65°F) - Annual mean value (Appendix A);

3) Energy cost = \$0.20/Btu/h - Estimated approximate cost to compensate for operating heat losses.

A preliminary evaluation was performed comparing heat loss cost and capital cost for the following types of insulation:

1) Thermo 12;

2) Epitherm 12-0;

3) Super Caltemp;

4) Kaylo 10;

5) Kaowool 2600;

6) Micro-lok 650;

7) Celotex 1500.

The three least expensive types of insulations (Epitherm 1200, Kaowool 2600, and Micro-lok (650) were further evaluated to determine the most economical insulation type and thickness for each size pipe. The results of this analysis for a representative pipe size [150 mm (6 in.)] is shown in Table 3.1-5. For this case it is apparent that the evaluated cost decreases sharply with increasing insulation thickness until a thickness of 89 mm (3.5 in.) is reached. For all pipe sizes, 89 mm (3.5 in.) of Micro-lok 650 was either the optimum or the point at which additional thickness resulted in insignificant cost savings. These results appear as the insulation cost in Table 3.1-4.

3.1.4.5 Conclusion - The principal conclusion of the study is that the most economical piping system would be:

1) 150-mm (6-in.) main header with Barco joints and 89 mm (3.5 in.) of Micro-lok insulation;

2) 80-mm (3-in.) injection piping with Barco joints and 89 mm (3.5 in.) of Micro-lok insulation.

3.1.5 Tower Foundation Study

The objective of this study was to identify the most cost effective foundation design for support of the receiver tower.

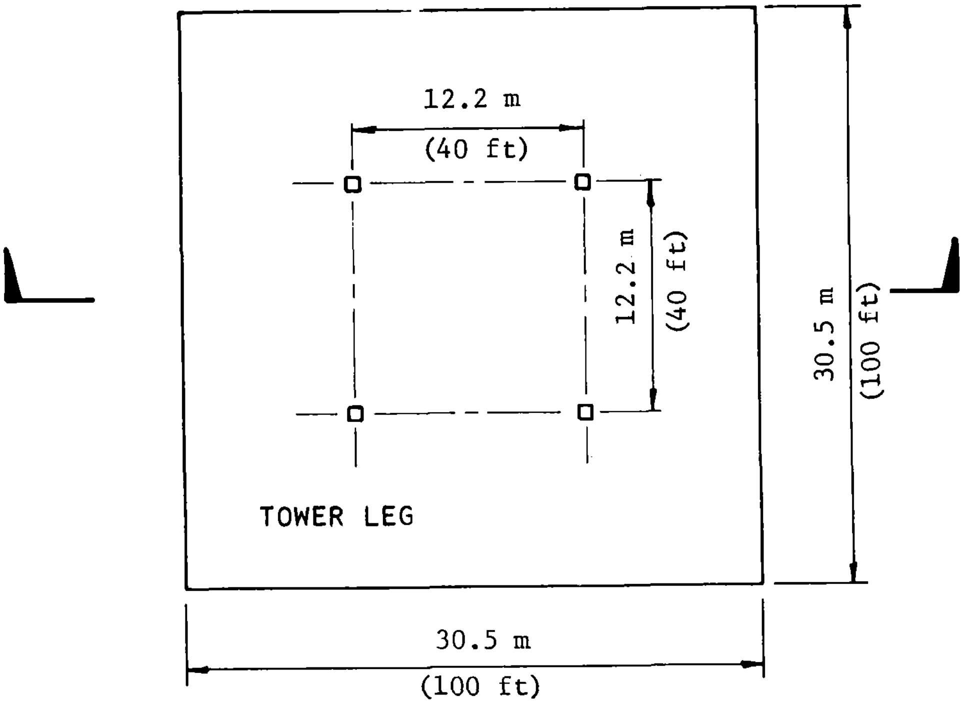
3.1.5.1 Site Soil Conditions - Sufficient soil data to facilitate a detailed foundation study were not available. Therefore for the conceptual design, it was assumed that the soil is Class 4, type SC (i.e., sandy with some clay) for which the 1979 edition of the Uniform Building Code provides the tabulated foundation design data. These pressures may be increased with depth, in accordance with the Code, up to the maxima tabulated.

	At the Surface	Maximum
Allowable Bearing Pressure	72 kPa (1500 psf)	215 kPa (4500 psf)
Allowable Lateral Pressure	7.2 kPa (150 psf)	108 kPa (2250 psf) for tower 14.4 kPa (300 psf) for tower
Lateral Sliding Coefficient	0.25	

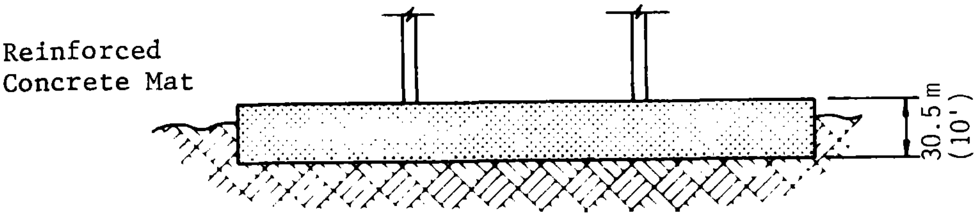
Table 3.1-5 Insulation Comparative Cost (Pipe Size - 150 mm (6") Sch 80)

Insulation Type and Thickness (in.)	W/M Heat Loss, (Btu/h/ft)	Heat Cost, $/m ($/ft)	Capital Cost, $/m ($/ft)	Total Cost, $/m ($/ft)
Epitherm 1200				
2.0	187.9 (195.5)	128.29 (39.10)	22.21 (6.77)	150.50 (45.87)
2.5	158.0 (164.4)	107.88 (32.88)	25.03 (7.63)	132.91 (40.51)
3.0	137.9 (143.5)	94.16 (28.70)	28.58 (8.71)	122.74 (37.41)
3.5	118.3 (123.1)	80.78 (24.62)	39.44 (12.02)	120.22 (36.64)
4.0	109.8 (114.3)	75.00 (22.86)	45.41 (13.84)	120.41 (36.70)
4.5	102.5 (106.7)	70.02 (21.34)	50.04 (15.25)	120.06 (36.59)
5.0	97.1 (101.0)	66.28 (20.20)	55.65 (16.96)	121.93 (37.16
Micro-lok 650				
2.0	198.7 (206.8)	135.70 (41.36)	23.52 (7.17)	159.22 (48.53)
2.5	167.0 (173.8)	114.05 (34.76)	27.99 (8.53)	142.04 (43.29)
3.0	145.8 (151.7)	99.55 (30.34)	32.19 (9.81)	131.74 (40.15)
3.5	122.3 (127.3)	83.53 (25.46)	36.35 (11.08)	119.88 (36.54)
4.0	115.2 (119.9)	78.68 (23.98)	40.49 (12.34)	119.17 (36.32)
4.5	108.4 (112.8)	74.02 (22.56)	44.99 (13.71)	119.01 (36.27)
5.0	102.3 (106.4)	69.82 (21.28)	49.12 (14.97)	118.94 (36.25)
Kaowool 650				
2.0	161.4 (167.9)	110.18 (33.58)	32.38 (9.87)	142.56 (43.45)
2.5	135.7 (141.2)	92.66 (28.24)	40.65 (12.39)	133.31 (40.63)
3.0	119.5 (124.4)	81.63 (24.88)	48.26 (14.71)	129.89 (39.59)
3.5	101.8 (105.9)	69.49 (21.18)	56.24 (17.14)	125.73 (38.32)
4.0	94.4 (98.2)	64.44 (19.64)	67.72 (20.64)	132.16 (40.28)
4.5	88.0 (91.6)	60.11 (18.32)	78.78 (24.01)	138.89 (42.33)
5.0	82.6 (86.0)	56.43 (17.20)	89.80 (27.37)	146.23 (44.57)

3.1.5.2 Receiver Tower Foundation - For the study of alternative receiver tower foundations, the three configurations shown in Figure 3.1-16 were investigated--mat, pile, and pier. The loads assumed for the study were based on Trial Tower Design No. 33 provided in the final report, Tower Cost Data for Solar Central Receiver Studies, prepared for Sandia Laboratories by Stearns-Roger Engineering Company, June 1979. A mat design, such as evaluated by Stearns-Roger, although good for transmitting the seismic shear and wind shear to the soil, was rejected as being too costly for the Exxon site. A driven pile foundation may be feasible but the requirements for predetermining pile length and long-lead time make this alternative unattractive. A preliminary conceptual design of the drilled pier foundation appears to be the best alternative; drilled piers offer the advantages of using local contractors, low mobilization costs, rapid construction, no formwork requirements for the piers themselves (although the pier cap requires formwork), practical reinforcement of the piers, a choice of pier diameters, and significantly, the embedment depth need not be accurately predetermined.



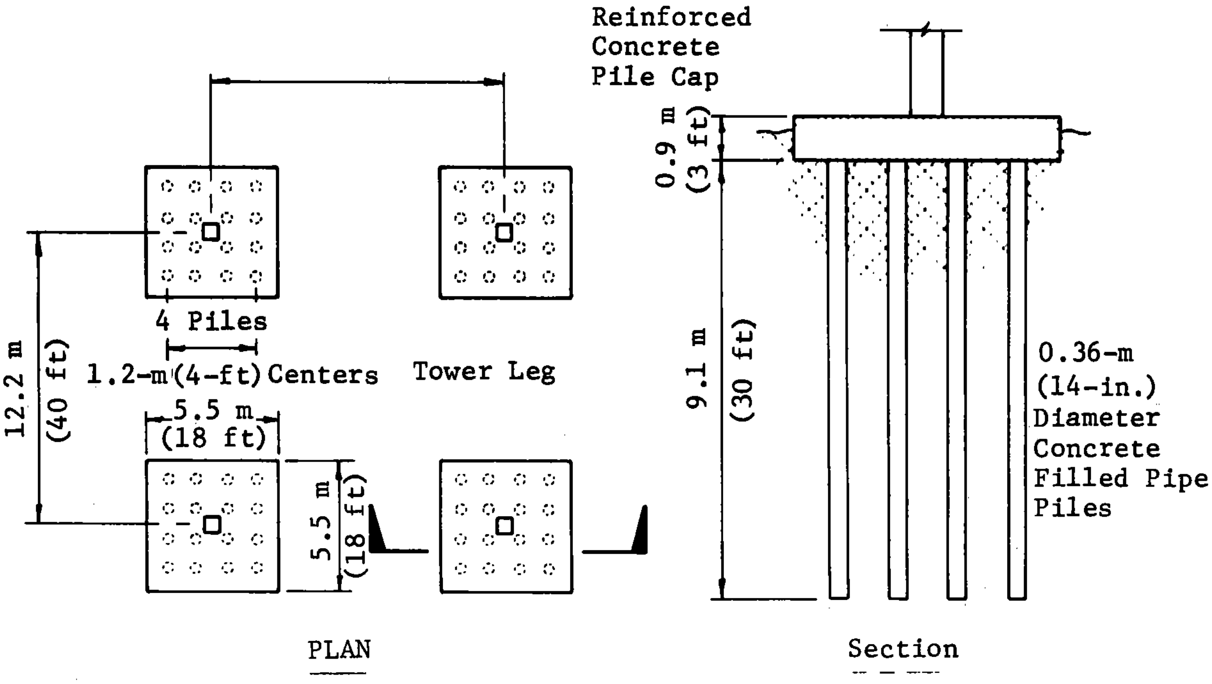
Plan



(a) Mat Foundation

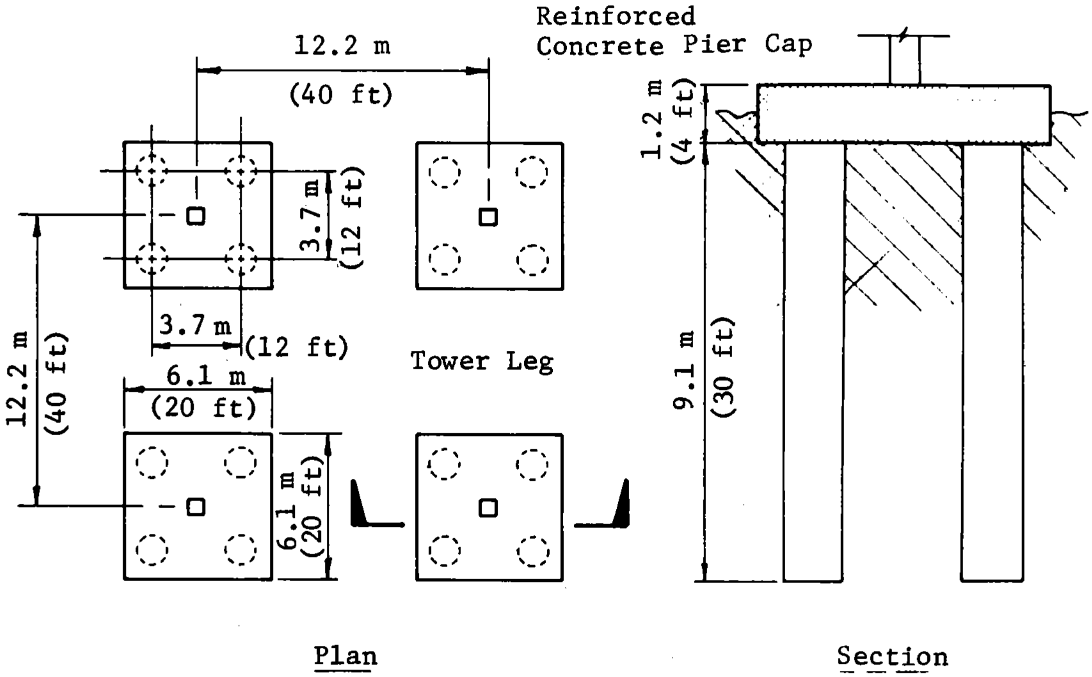
Section

Figure 3.1-16 Alternative Tower Foundations



(b) Driven Pile Foundation

Figure 3.1-16 (cont)



(c) Drilled Pier Foundation

Figure 3.1-16 (concl)

3.1.5.3 Conclusions - The optimal alternative foundation design consists of four piers under each of the four legs of steel tower; each pier would be 1.2 m (4 ft) in diameter and approximately 9-m (30-ft) long. The pier cap would be approximately 6-m (20-ft) square and 0.9-m (3-ft) thick.

3.2 SYSTEM SIZE

The conceptual design solar power system is sized to produce, on an annual average, the same amount of energy as one 7.3-MWt (25-MBtu/h) fossil boiler.

The projected requirement for steam at Edison for steam drive operations is to steam 121 injection wells over a period of 26 years in leases E868699, E808701, E808794 and E808795. Four 7.3-MWt fossil boilers would be required. The level of retrofit has thus been set at 25%.

The nature of the steam drive process has much to do with the selection of this retrofit level. The oil sand region is rather insensitive to variations of the steam injection rate over time because of its large thermal mass and relatively low thermal conductivity. In general it is thought that within wide limits the total amount of steam injected over a period of time is a far more important determining factor of total oil production than the instantaneous steam injection rate. An upper limit for an acceptable steam injection rate exists. If steam is injected too quickly, steam channels will be formed near the top of the oil sand formation. The steam will simply pass through the channel to the producing well and very little oil will be produced. Channeling is apt to occur if the steam injection rate is increased to about three or more times the normal continuous injection rate. (It must be stressed that there is enormous variation in the geology of oil formations not only between different fields, but also between different areas of the same field. Thus, when field behavior is discussed it must be understood to be only an approximate description of the behavior of any given set of wells. The only dependable method for determining the behavior of a given group of wells in steam drive is to perform a long-term test.) Conversely, if the injection rate drops to zero on a regular basis (as in diurnal solar-only operation without storage), well bore heat loss can result in considerable thermal stress and strain in the steel injection tubing. This may cause the thermal packer to be dragged along the sides of the well bore. The packer usually will fail after only a few of these cycles, requiring replacement at a significant cost in time and money. Sand infiltration of the well bore may also result from cyclic injection.

We have therefore decided that the TEOR operation should be designed to provide steam continuously to the wells for temperature maintenance and to limit the maximum steam injection rate to prevent channeling. This requires either a solar system with a significant amount of storage or a hybrid solar/fossil system.

At Edison, two fossil boilers that have already received operating permits are in use. Work has already begun to acquire and permit a third boiler. Since this process represents a considerable effort, it is felt that a solar system is best designed to supplement rather than displace existing capacity.

The selection of this size solar system in a hybrid configuration in which all steam produced goes into a common header will result in steam flow rates of:

1) 30,400 kg/h (67,000 lbm/h) from the three fossil boilers operating alone;

2) 43,600 kg/h (96,100 lbm/h) solar peak;

3) 9680 kg/h (21,350 lbm/h) solar average.

The steam rate during peak operation is low enough to preclude channeling. Since we are dealing with 82% quality steam, the daily variation in flow rates requiring variation of pressure will result in some temperature cycling. However, the effect is expected to be less than 28°C (50°F) over the course of a day, which will not produce significant thermal strain in the injection piping. Higher solar percentages were considered, but they would all require turndown of some heliostats or the use of thermal storage to reduce the peak noon steaming rates to acceptable levels.

As part of our development plan, we propose experimental steam drive operations to investigate the effects of variable diurnal steam injection at Edison. This would be in addition to the steam drive simulation analysis and testing already being conducted by Exxon.

3.3 TECHNOLOGY

The receiver fluid chosen is water/steam. This is logical since 82% quality steam is the desired end product and since required temperatures and pressures are relatively low so there is little to be gained by the use of an intermediate fluid loop. Solar-powered natural-recirculation water boilers of this type have been successfully tested at Sandia and Odeillo, France by Martin Marietta.

3.4 SYSTEM CONFIGURATION

The central receiver solar thermal system selected for Edison includes a collector subsystem, a receiver subsystem and a field piping subsystem. Two subsystems notable for their absence in this conceptual design are thermal storage and master control subsystems. The need for thermal storage is negated by two factors. First, the actual underground process of stimulating the flow and production of heavy crude oil does not require a constant or continuous injection of steam. The oil-bearing formation itself is a very effective natural thermal storage device, having an exceedingly large thermal capacity and a low conductance for heat loss. Existing TEOR operations at Edison have demonstrated that enhanced recovery continues at a diminishing rate for periods up to a year after termination of steam injection into a particular zone. Second, the planned operational mode for the solar thermal system will be to supplement the continuously operating fossil boilers whenever sufficient insolation is available.

A totally integrated master control system is not required because there are no requirements of a critical nature for synchronization, sequencing or coordination of activities between the solar thermal system and the power-consuming process, as occurs in an electrical utility or perhaps a more demanding process heat application. The fluctuations in steam flow rate and injection pressure that occur as the solar thermal system cycles in response to insolation changes do not affect either the TEOR process or operation of the fossil boilers.

The configuration of the collector field, the tower elevation and receiver geometry are mutually interrelated and were established in consideration of performance, economic and site-dependent factors. This process was described in some detail in Subsections 3.1.1 and 3.1.2.

The selected receiver concept is a twin-cavity natural-circulation steam generator. The side-opening cavities, equipped with aperture doors, have a high energy absorption efficiency and low thermal losses, both while in operation and overnight when the cavity doors are closed. Natural circulation was selected because it is simple and easily adapted to the given cavity configuration. Also, natural circulation has a history of high reliability and eliminates the forced-circulation pump and associated costs. Natural circulation is inherently self-compensating for energy input variations, while a once-through design may have to rely on a complicated valving and control system to adjust the flows among the circuits. A natural-circulation receiver is also relatively tolerant of impure feedwater because of its large tubes, low tube-exit steam quality, large water inventory, and drum blowdown capability.

The natural-circulation type of solar receiver has been well-proved through the design, construction, and test of two complete working units with 1- and 5-MWt capacities. These receivers have amply demonstrated thermal and hydraulic stability as well as ease of control under very severe transient and steady-state operating conditions. Both receivers have been operated using infrared lamp radiation to simulate solar input, and the 1-MWt unit was operated very successfully in the environment of the CNRS solar furnace at Odeillo, France.

The function of the field piping subsystem is to transport steam from the receiver outlet to the injection wellheads. Approximately 12 wells will be injected in parallel at any given time. This 12-well pattern will move gradually through the oil field at the rate of about 3 wells per year over the 26-year operational life of the system. The feeder lines to each well connect to a common manifold that is fed jointly by the solar thermal system and the three fossil boilers. The routing of the trunk line from the receiver and the progression of the injection well pattern have been established on the basis of minimizing total installed length of pipe. Pipe diameters and insulation design were selected on the basis of minimizing costs while maintaining reasonable pressure drop and heat loss characteristics.

4.0 CONCEPTUAL DESIGN

This section discusses all aspects of our concept for a solar thermal-enhanced oil recovery system at the Edison field. The total system will be described and the functional aspects, requirements, operational characteristics and performance, will be discussed. System costs, safety, environmental and regulatory issues and potential limiting considerations of system implementation will also be presented.

4.1 SYSTEM DESCRIPTION

This design concept utilizes the central receiver type of solar thermal power conversion technology to generate the steam necessary for recovery of the heavy crude oil at the Edison field. The major elements of the system are shown in Figure 4.1-1. The absence of a need for thermal storage and the moderate steam temperature required for the TEOR process results in a relatively simple system with well-defined interfaces. The collector field consists of individually driven heliostats that reflect and concentrate the solar radiant power into a tower-mounted receiver. Water is pumped from an existing well at Edison, treated, and then piped to the receiver where the radiant input power is absorbed by the generation of steam. Water enters the receiver at 15.6°C (60°F) and steam exits at 297°C (567°F) with an 82% quality.

The solar thermal system will be operated in parallel with existing crude oil-fired boilers. The planned operating mode is to use the crude oil-fired boilers continuously, and add receiver steam whenever sufficient insolation is available. Control and operation of the solar and fossil system will be essentially independent of one another, with the only physical interface being at the injection manifold. An alternative mode could totally decouple the operation by using separate supply headers to service different groups of injection wells from the solar and fossil systems.

The solar power system is sized to produce 29.3 MWt (100 MBtu/h) in the form of steam at the system design point (noon on February 27) at an insolation of 0.95 kW/m^2. The cumulative annual energy production of 55.87 x 10^3 MWht (190.674 MBtu) will provide about 25% of the total planned steam requirement at Edison. The option of building an identical collector/receiver module on lease 808795 would increase the solar contribution to about 50% of the required process energy.

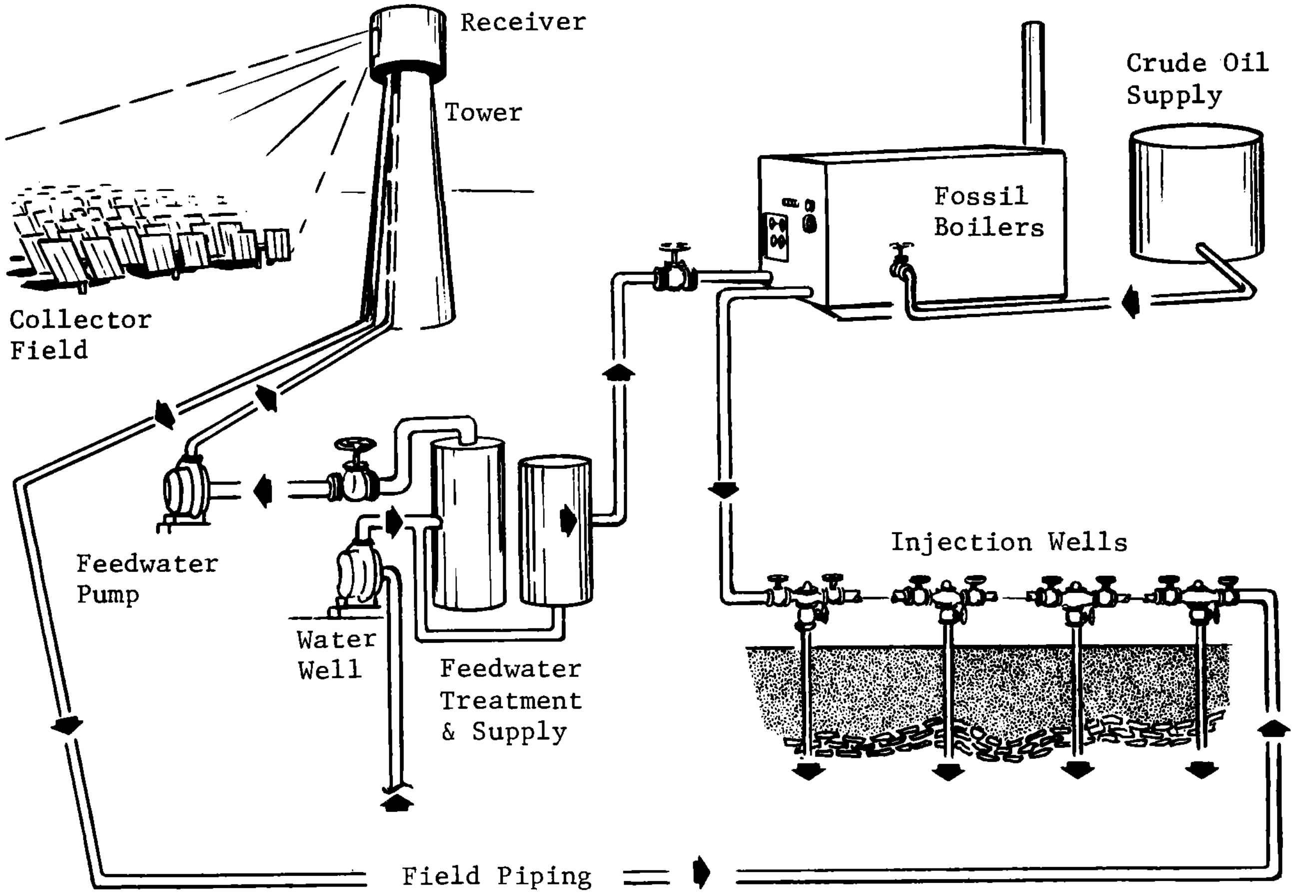


Figure 4.1-1 Process Schematic

The collector field consists of 818 heliostats arranged on lease 808794 of the Edison oil field as shown in Figure 4.1-2. In the layout and placement of heliostats, it was necessary to include adequate clearances for oil well equipment and operational access. The heliostats are arranged generally in a 150° north circular sector to project power into a twin-cavity receiver. The quantity of 818 heliostats is based on the reflective area of 49.05 m^2 (528 ft^2) that was specified for this project. Heliostats of other sizes could be used in this system without greatly affecting the indicated boundaries of the collector field or the receiver design. For instance, if Martin Marietta's second-generation heliostat design at 56.9 m^2 (612.5 ft^2) in size were used, only about 705 units would be required, spaced at slightly greater intervals. However, 982 of the 40-m^2 (430.6-ft) Barstow heliostats would be necessary, but would be installed at a smaller spacing. The ultimate selection of a heliostat for this project will be made on the basis of the most proven and cost effective design available at the time the construction decision is made.

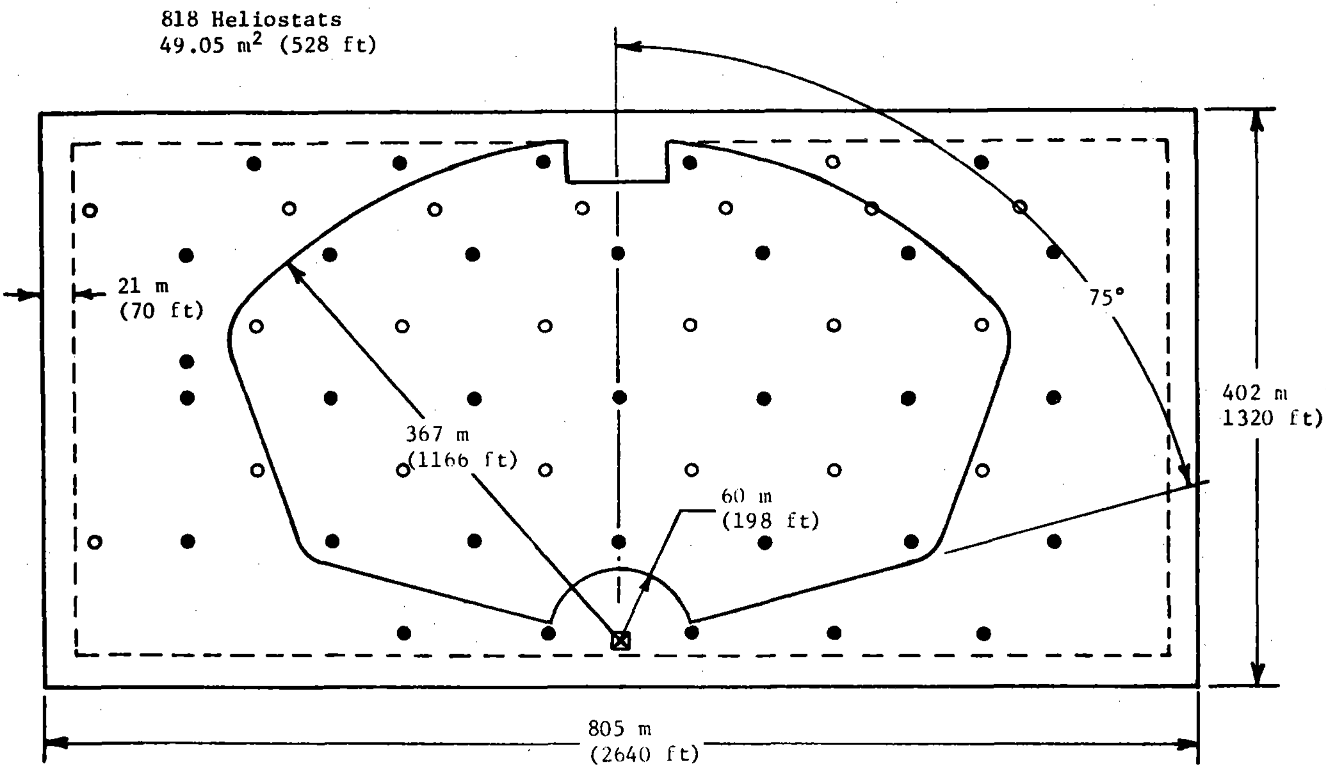


Figure 4.1-2 Collector Field Boundary

The receiver consists of a natural-circulation boiler configured in a twin-cavity arrangement as shown in the simplified plan view of Figure 4.1-3. The interior surfaces of the receiver consist of tube panels for water preheat and boiling. Each of the two apertures is 5.5-m (18-ft) square and accepts power from half the collector field. The normal to each aperture is displaced by 0.65 rad (37.5°) to each side of the north direction. The external surfaces are completely insulated to minimize heat loss. Insulated doors are provided to close over the apertures for heat retention during overnight shutdown and cloudy periods, thereby enabling morning startups to be initiated from a hot standby condition. The receiver is mounted on a 90-m (297-ft) steel tower located at the apex of the southern boundary of the collector field.

A field piping subsystem serves to transport steam from the receiver to the reservoir injection points and to interface with the crude oil-fired boilers. The piping concept combines fixed trunk lines with a minimum total length and cost. The piping is sized for optimum pressure drop, is insulated to limit thermal loss and includes accommodation for expansion and contraction with temperature changes.

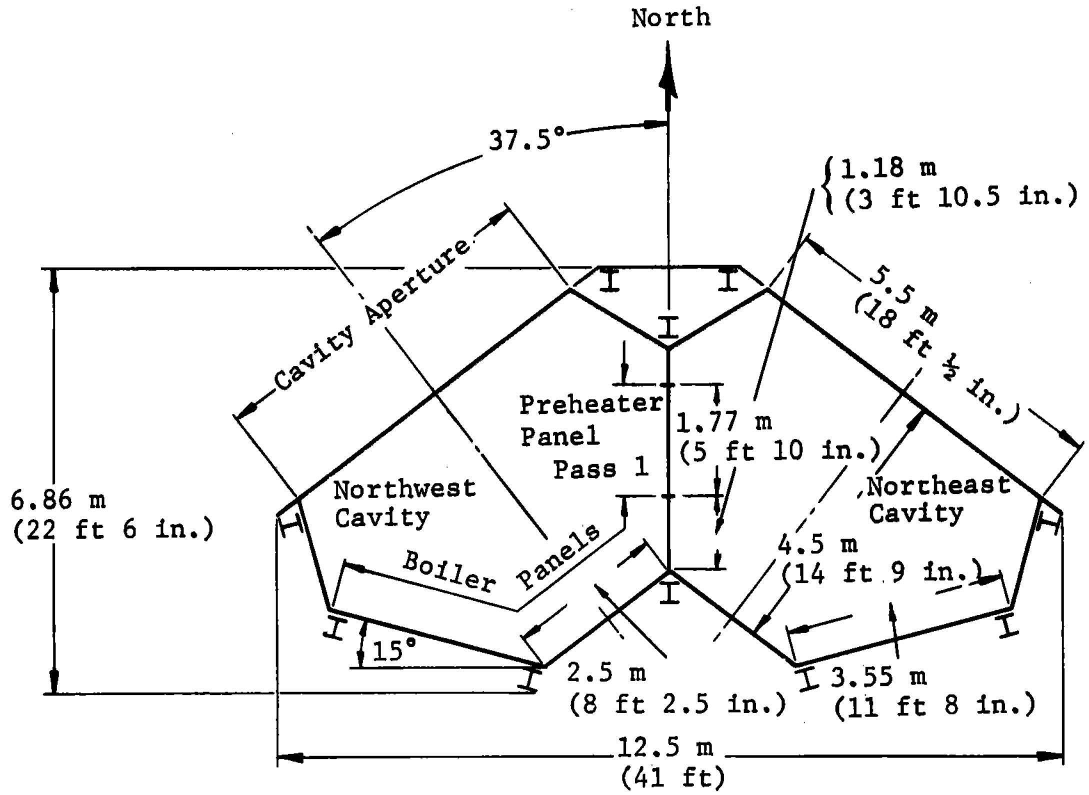


Figure 4.1-3 Twin-Cavity Arrangement Plan View

4.2 FUNCTIONAL REQUIREMENTS

The fundamental requirement for the solar thermal power system is to supply steam at a pressure between 5516 and 6895 kPa (800 and 1000 psia) to a pattern of injection wells to enhance the rate of crude oil production at the Edison field. Temperature of the steam delivered will range between 270 and 285°C (518 and 545°F) and the quality must be between 75 and 100%. Peak power output in the form of steam must be 29.3 MWt (1000 MBtu/h) at the design point of noon on February 27 at an insolation of 0.95 kW/m^2.

Since this system will operate in conjunction with existing crude oil-fired boilers and the EOR process is insensitive to diurnal variation in steam injection rates, it is not necessary that solar-generated power be available at night or during cloudy periods. Therefore no thermal storage system is required or provided. The system must be reliably available to operate whenever the insolation is at a sufficient level (above 0.1 kW/m^2). The system must respond to insolation transients during clear and intermittently cloudy days and must function, with minimal maintenance and repair, for the 26-year design lifetime. All equipment must endure the climatic and seismic environments that occur in the Bakersfield locale.

It is very important that the system can be installed and operated in concert with the normal ongoing activities at the Edison field. There should be a minimal impact on existing methods of operation and provisions should be included for future planned activities at the site. All hardware, including collector field, receiver and field piping, must be designed and located to not interfere with the operation or access to process equipment and to minimize the probability of damage being incurred by process equipment and personnel. In the design and/or selection of hardware, employing the existing skills found at the Edison site for maintenance, repair and operation of the solar power system should be considered as far as possible.

Instrumentation and controls for operating the solar power system should be of normal commercial technology. Control functions and procedures should be uncomplicated and require minimum personnel. Physical and operational interfaces between the solar and oil-fired power systems should be minimized. The system should be fully controllable in an automatic mode, with an operator override capability where desirable or necessary. Adequate provisions for caution and warning alarms and corrective actions in response to system malfunctions must be included.

A complete definition of the detailed requirements is contained in Appendix C. Table 4.2-1 briefly summarizes the significant quantitative requirements and operating parameters.

Table 4.2-1 Solar System Design/Operating Characteristics

Receiver Type	Natural Circulation
Fluid	Water/Steam
Output Capacity	29.3 MWt (100 x 10^6 Btu/h)
Material	Carbon Steel
Absorber Area	135.3 m^2 (1457 ft^2)
Boiler Area	81.1 m^2 (873 ft^2)
Preheater Area	54.2 m^2 (584 ft^2)
Peak Incident Flux, Boiler	69.7 W/cm^2 (220,900 Btu/h-ft^2)
Peak Tube Temperature, Boiler	390°C (734°F)
Steam Design Outlet Conditions	
Temperature	297°C (567°F)
Pressure	827 MPa (1200 psia)
Flow Rate	43.59 mg/h (96.1 x 10^3 lb/h)
Tower Type	Structural Steel
Height	90 m (295 ft)
Heliostats	
Field Configuration	2.62 rad (150°) North, Radial Staggered Array
Size	49.05 m^2 (528 ft^2)
Number	818
Field Piping	
Header Piping Size	15.2 cm (6 in.)
Branch Piping Size	7.6 cm (3 in.)
Thermal Expansion Type	Barco

4.3 DESIGN AND OPERATING CHARACTERISTICS

4.3.1 General Process Characteristics

The solar-generated steam will be used in parallel with crude-fired boilers for the steam drive operations scheduled to begin in 1985-1986. The crude-fired boilers will operate continuously, while the solar central receiver will produce steam whenever there is sufficient insolation. In steam drive, approximately 67.6 to 75.5 m^3 (425 to 475 bbl) of water per day in the form of steam is injected into each of a pattern of injection wells. Production wells are interspersed among the injection wells in 1012-m^2 (2 1/2-acre) 5-spot patterms (Fig. 4.3-1). This will require considerable infilling of new wells at Edison as illustrated in Figure 4.3-2.

The steam lowers crude oil viscosity and increases formation pressure, causing oil to flow out of the production wells (Fig. 4.3-3). At Edison it is estimated that each pattern would produce all oil recoverable by this technique in about three years. Then the steam lines would be installed on an adjacent pattern and the process repeated until the field is depleted. The performance of the process is quite sensitive to local variations in geology.

This process of steam drive (also called steam flooding) is basically a displacement process within the oil-bearing formation (Fig. 4.3-4). When steam is injected into the ground, a steam-saturated zone is formed near the injection point. A thermal packer (Fig. 4.3-3) blocks the annular space between the injection tube and the well casing, thus preventing the steam from escaping back up the well bore. As the steam permeats the formation, mixing with crude oil and forcing it along, heat loss causes condensation to begin to take place. A hot zone will extend radially outward to the point where essentially all the steam has been condensed, beyond which the temperature will begin to decrease with continuing heat loss. In the hot zone some of the lighter crude oil components may be distilled; the resulting gas then assists in the drive process. The condensate mixes with the oil, further reducing its viscosity. The water/oil mixture continues to be forced outward by the inflow of steam until it approaches a production well where the mixture is extracted. The mixture is routed to settling tanks where it is separated; the oil is transported to a refinery and the water is returned to the ground via a waste-water well. The enhancement of heavy crude oil recovery is actually a combination of several effects. The changes in reservoir temperature, pressure, viscosity and permeability brought about by the steam injection process are all important factors.

Current plans for Edison call for steaming the most productive section of the field (Fig. 4.3-2) at a rate of 954 m^3/day (6000 bbl water/day) of steam into 12 to 14 injection wells at a time over a period of 26 years. Using current oil-fired boiler technology, approximately 11.9 m^3 (75 bbl) of crude oil are required to produce 159 m^3 (1000 bbl) of steam for injection. In addition, 0.85 m^3 (5.2 bbl) of

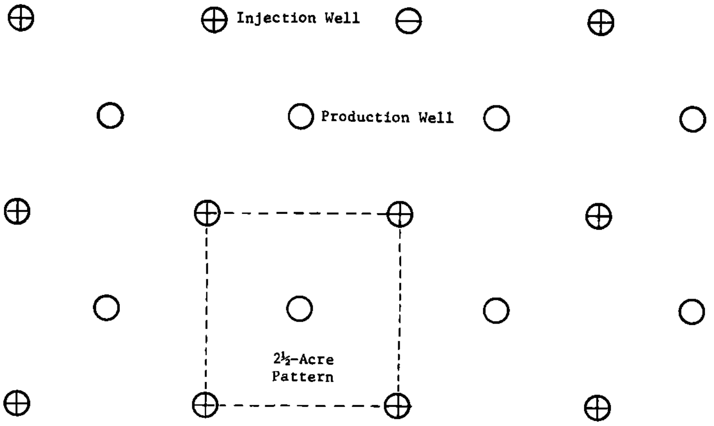
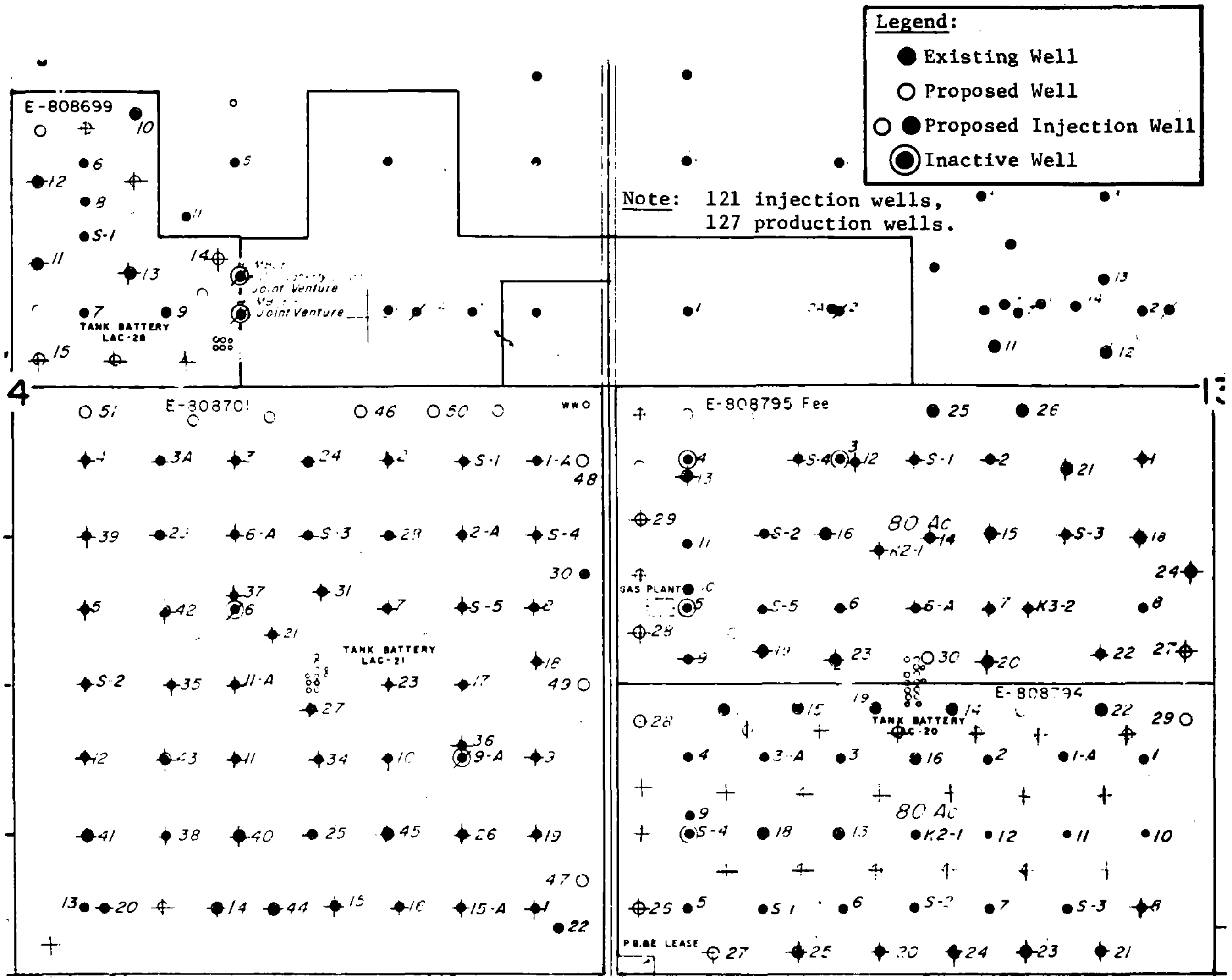


Figure 4.3-1 Steam Drive at Edison



Note: 121 injection wells, 127 production wells.

Figure 4.3-2 Areas of Operation

diesel fuel or 4800 kWh of electricity are consumed for every 159 m^3 (1000 bbl) of steam injected. This does not include energy for water purification or raw material transport, which would be similar for both fossil and solar systems. This steaming rate would require the use of four fossil-fired 7.33-MWt (25-MBtu/h) boilers operating at an anticipated 95% service factor.

4.3.2 Operating Modes and Controls

Among the advantages of using solar thermal power technology in TEOR applications is the relative physical and operating independence between the solar and the fossil power conversion systems. With the absence of thermal storage (other than the oil reservoir itself) and no critical process conditions to maintain on a precise schedule, devising sophisticated control sequences is not necessary.

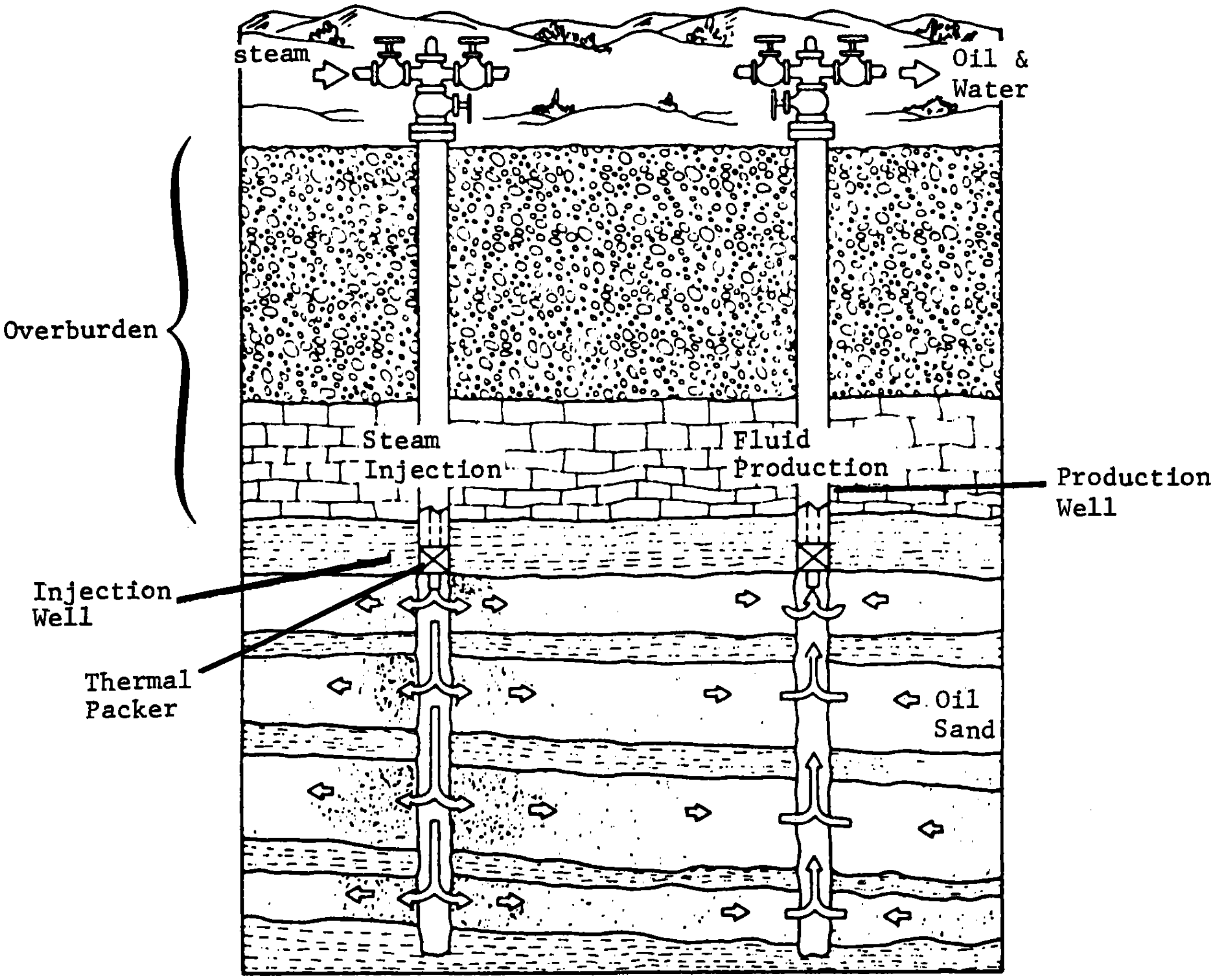


Figure 4.3-3 Steam Drive

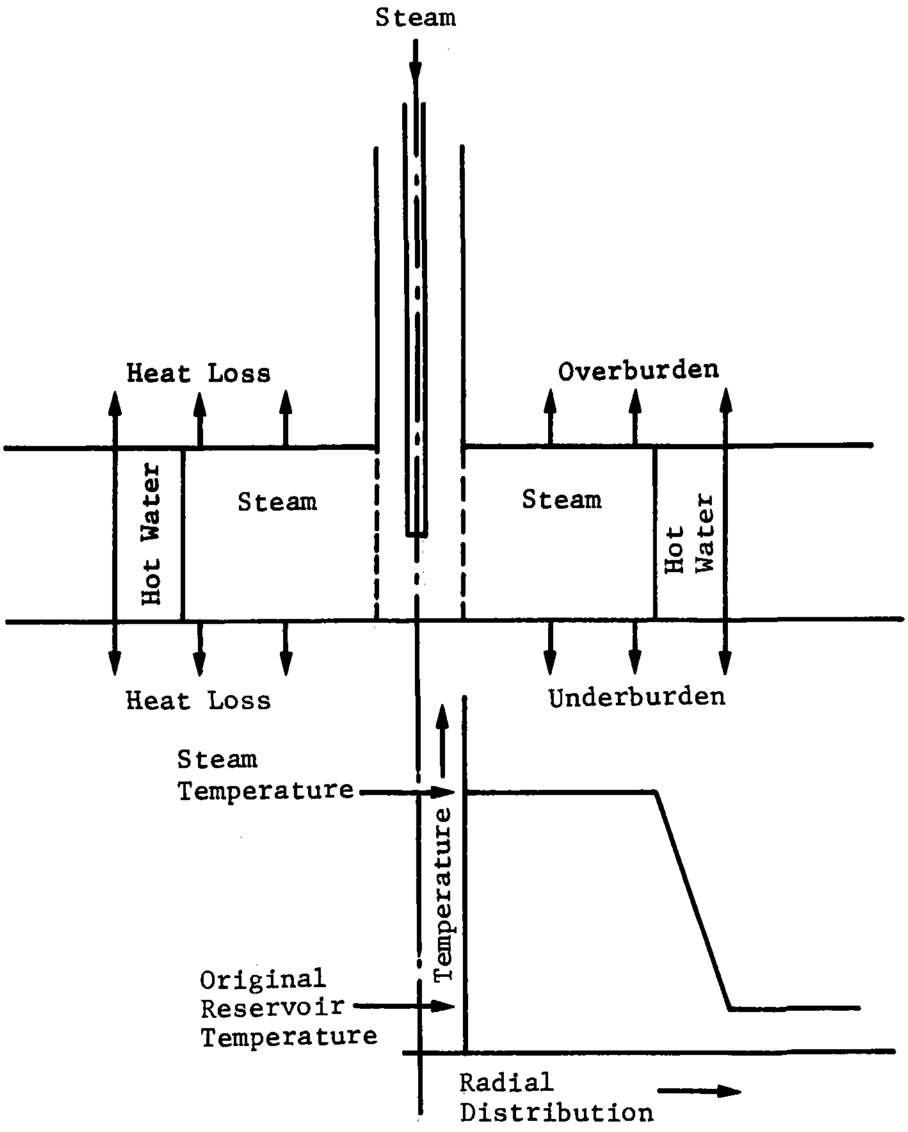


Figure 4.3-4
Schematic Diagram of Steam Injection and Approximate Distribution of Formation Temperature

The system schematic shown in Figure 4.3-5 illustrates the necessary system-level controls and is useful in describing the various operating modes. Normal operation of the process will entail the following basic operating modes for the solar power system:

1) Cold startup - The system is started when the receiver is at near-ambient pressure and temperature after an extended shutdown due to multiple sunless days or equipment repair. Solar power must be brought on gradually in a defined sequence;

2) Hot startup - This is the dominant mode of startup on a daily basis. After a single night of shutdown, the insulated receiver remains in a hot, pressurized condition the next morning and can immediately react to full solar input at startup;

3) Steady-state operation - This mode begins when nominal operating pressure and temperature are reached after either a cold or hot startup has been completed, and continues until either a normal or an emergency shutdown is initiated. During steady-state operation the system will react to the normal insolation transients occurring over a typical day;

4) Normal shutdown - The system is brought to an anticipated shutdown brought about by insufficient insolation at the end of a day, cloudiness or by a noncritical malfunction somewhere in the system. The shutdown terminates in the normal stow condition for all subsystems;

5) Emergency shutdown - The system is brought to an unanticipated shutdown caused by a critical malfunction. The collector field is directed to a safe standby condition, which removes all heat flux from receiver and tower;

6) Standby - This mode defines a condition in which the collector system is fully operational but the receiver is shut down. The collector field is tracking two points in space--half the heliostats track a point slightly to the east of the receiver and half track a point just west of the receiver. This is an intermediate mode from which insolation can be quickly applied to the receiver or from which the collector system can proced to the stow condition.

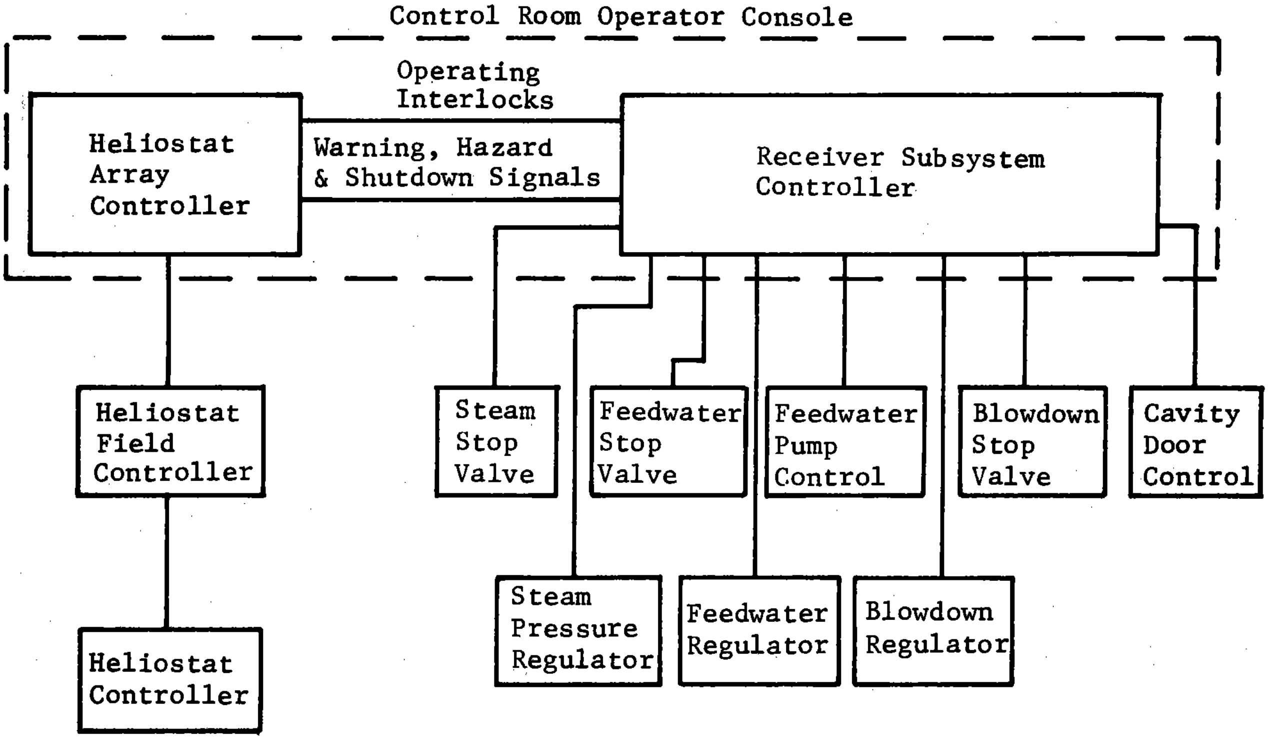


Figure 4.3-5 System Control Functions

The instrumentation and control functions necessary to monitor and maintain the various operating modes are relatively uncomplicated as compared to an electric power plant or a more complex industrial process application coupled to a solar thermal power system. First of all the fossil and solar power systems will be controlled independently from one another, precluding the need for an integrated master control system. Each fossil boiler, being a self-contained packaged unit, will operate continuously and be controlled by its own independent control system as is now done. As shown in Figure 4.3-5, the only interface between the fossil boilers and the receiver is the steam injection manifold. Each steam source--the receiver and each of the three fossil boilers--is connected to the manifold through an isolation valve, allowing independent shutdown and startup of each unit. The steam drive process within the oil reservoir is unaffected by the fluctuations in flow as the solar power system cycles up and down each day.

Although the receiver and collector field controls will both be located within the system support building and will be operated by a single solar equipment operator, these two subsystems will be operated largely independent of one another. The collector controls govern operation of heliostat drive motors in response to computer commands as dictated by the operating mode. Proper collector control software will assure that radiant power is brought onto the receiver in an acceptable sequence during system startup. The receiver controls consist of elements to govern feedwater flow, drum blowdown rate and output pressure. Each of these functions is automatically controlled in accordance with input set points. The control panel will also include provisions for actuation of the cavity doors just before startup and at completion of shutdown.

Coupling between the collector and receiver controls is necessary primarily for emergency action purposes. For instance, an overpressure condition sensed within the receiver must initiate an immediate reaction in the collector controls to drive the heliostats off the receiver to standby. A more indepth evaluation of control philosophy will be performed during the system detail design to determine the advisability of additional coupling of receiver and collector controls during normal operating modes. Such activities as aperture door actuations and isolation valve operations could be integrated with collector field sequencing during startup and shutdown of the system if economic and/or safety benefits can be derived.

Instrumentation will be provided to sense the various parameters necessary for operation of the solar power system controls. Collector subsystem instrumentation consists of azimuth and elevation position encoders for each heliostat. Within the receiver, transducers will be installed to monitor the feedwater flow rate, steam output flow rate, drum water level, drum blowdown flow rate, steam outlet pressure and the position of all control valves. In the field piping subsystem, pressure will be sensed at the steam injection manifold.

4.4 SITE REQUIREMENTS

The site as it now exists is almost ideally suited to installation of a central receiver solar thermal power system. The only modification of any consequence required is the removal of an overhead electric power line, which can be rerouted entirely or reinstalled in a ground-level conduit. The terrain is flat, with a slight tilt of 0.015 rad (0.36°), and will require no grading or surface preparation. No existing facilities must be modified to accommodate the solar power system. New facilities will include the collector field, the towermounted receiver, the field piping and a system support building that will house a control room along with maintenance and storage areas.

A plot plan of lease 808794 containing the collector/receiver module is shown in Figure 4.1-2. Constraints for location of solar equipment include the requirement for a 21-m (70-ft) setback observance for property boundaries and the tank farm located at the north central edge. Also, a clearance radius of 9.1 m (30 ft) must be maintained around each producing and injection well for maintenance access.

4.5 SYSTEM PREFORMANCE

The design point and annual performance of the selected STEOR retrofit conceptual design has been evaluated using three computer models--MIRVAL, TRASYS and STEAEC. The performance of the individual solar subsystems were modeled separately, with the results input into the STEAEC system simulation program, together with insolation and weather data, to model the annual performance of the system.

As discussed further in Section 5.1, the collector subsystem performance was evaluated using the MIRVAL Monte Carlo computer program. The collector field performance, as defined by the ratio of solar radiation entering the receiver to the total available insolation incident on the collector area, was calculated for a matrix of seven sun azimuth angles and six sun elevation angles, as well as for the sun position at noon, day 58 for the site. As discussed further in Section 5.2, the receiver losses were evaluated using the TRASYS thermal radiation analysis model, again for the design point and off-design cases. Based on the field piping and insulation optimization studies, thermal losses in the downcomer and field piping were also estimated.

The resulting design point system performance stairstep is shown in Figure 4.5-1. Assuming a reference direct normal insolation value of 950 W/m^2 (301.22 Btu/h ft^2), the system efficiency at the design point is 76.9%.

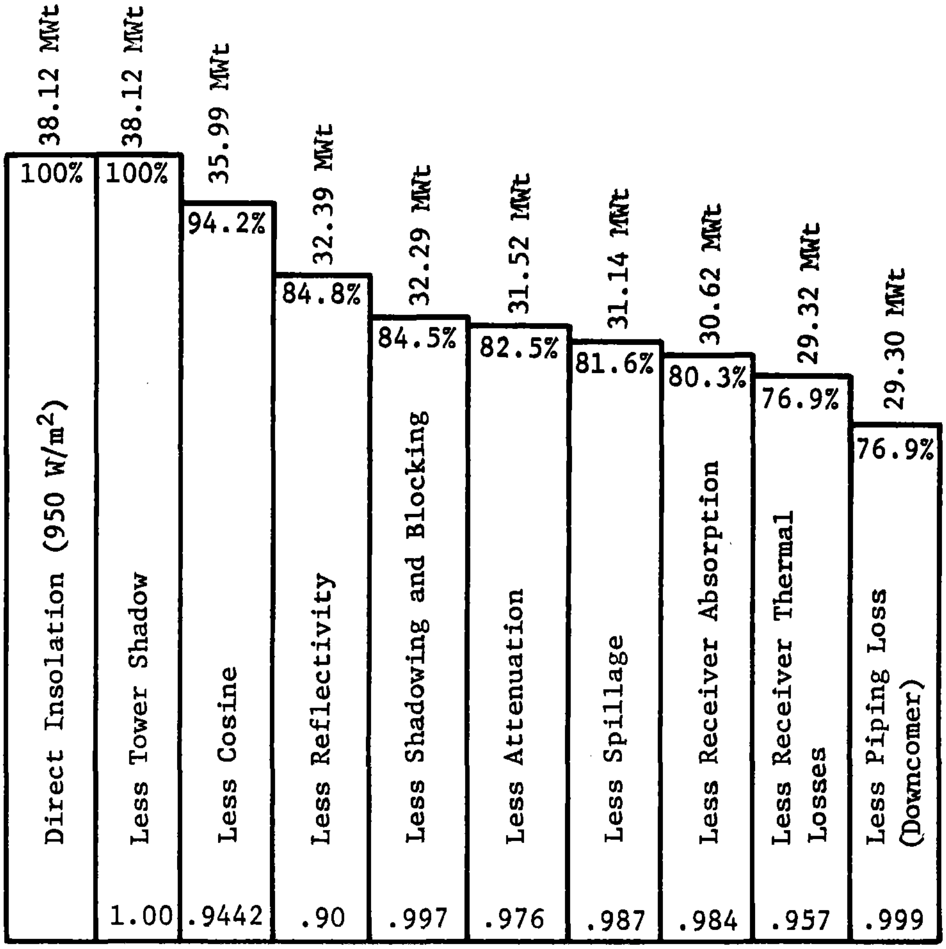


Figure 4.5-1
Design Point Efficiencies, 950 W/m^2 Insolation (Day 58, Noon)

The annual system performance was evaluated using the STEAEC system model, which simulates the performance of the system using 15-minute time steps and a site weather data tape. For the site weather data (insolation, wind speed and direction, temperature and pressure), the SOLMET typical meteorological year (TMY) weather data base was chosen. Because no TMY exists for the Bakersfield, CA area, the TMY data tape for Fresno, CA was used. As discussed in Section 2.5, Fresno is approximately 100 mi northeast of the selected retrofit site, but is nontheless representative of the San Joaquin Valley region. This assumption has been validated for a single day using total horizontal and direct normal insolation measurements currently being taken at the site by Exxon. For a typical clear day (2/2/80), the daily direct normal insolation was measured at 6.24 kWh/m^2, as compared with a SOLMET TMY clear February day value of 6.14 kWh/m^2. The SOLMET data, recorded on the tape at 1-hour intervals, were converted to 15-minute interval data using linear interpolation techniques before input to the STEAEC model for a more realistic evaluation of system performance. These SOLMET data yield an average daily direct normal insolation value of 6.21 kWh/m^2/day. The annual system performance stairstep is shown in Figure 4.5-2.

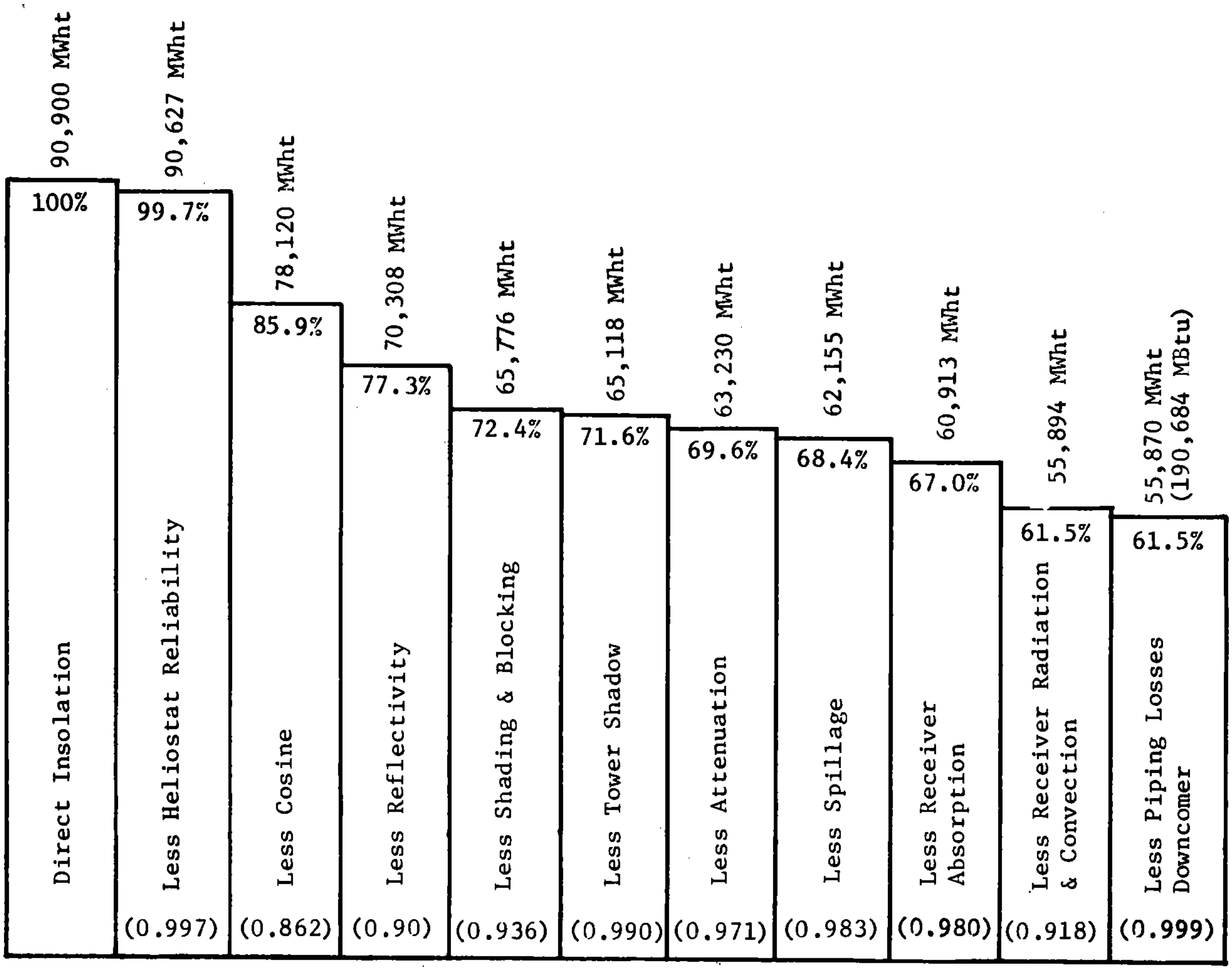


Figure 4.5-2 Annual Efficiencies, Fresno Insolation

The annual energy derived from the solar subsystem and delivered to the injection wells, as shown in the figure, is 55.870 MWt (190,684 MBtu), yielding an annual net solar system efficiency of 61.5%.

As will be discussed further in Section 6.0, this annual output of 55,870 MWht is equivalent to 85.7 x 10^6 kg (189 Mlbm) of steam injected in the field. Using conventional oil-fired steamer technology as typified by the Struthers Thermoflood® 25 with scrubbers, 6852 m^3 (43,092 bbl) per year of oil would be consumed to produce an equal amount of injection steam of the same quality.

4.6 PROJECT CAPITAL COST SUMMARY

This section presents a summation of the capital cost estimates developed for the solar thermal EOR retrofit concept. As the validity of the capital cost estimates is reflected directly in the economic viability of the concept design, detailed cost worksheets have been made for each major component to ensure realistic estimates.

These cost worksheets can be found in Section 5.3 of the System Requirements Specification (SRS), Appendix C, to this report, as well as detailed definitions of the various direct and indirect cost accounts.

4.6.1 Costing Ground Rules

A STEOR cost account breakdown is provided in Table 4.6-1. This account structure has fewer major accounts than most solar power projects since the STEOR system does not require any provision for additional fossil energy equipment (5600), energy storage (5700) or an electric power generation subsystem (5800). The major cost accounts are further illustrated in Figure 4.6-1, describing the major functional costing boundaries, and additional definition of the major equipment in each account is contained in Section 5.3 of Appendix C.

Table 4.6-1 STEOR Cost Accounts

5000	Solar Retrofit System Construction Cost
5100	Site Modifications
5200	Site Facilities
5300	Collector Subsystem
5400	Receiver Subsystem
5500	Plant Control Subsystem
5900	Process Heat Subsystem

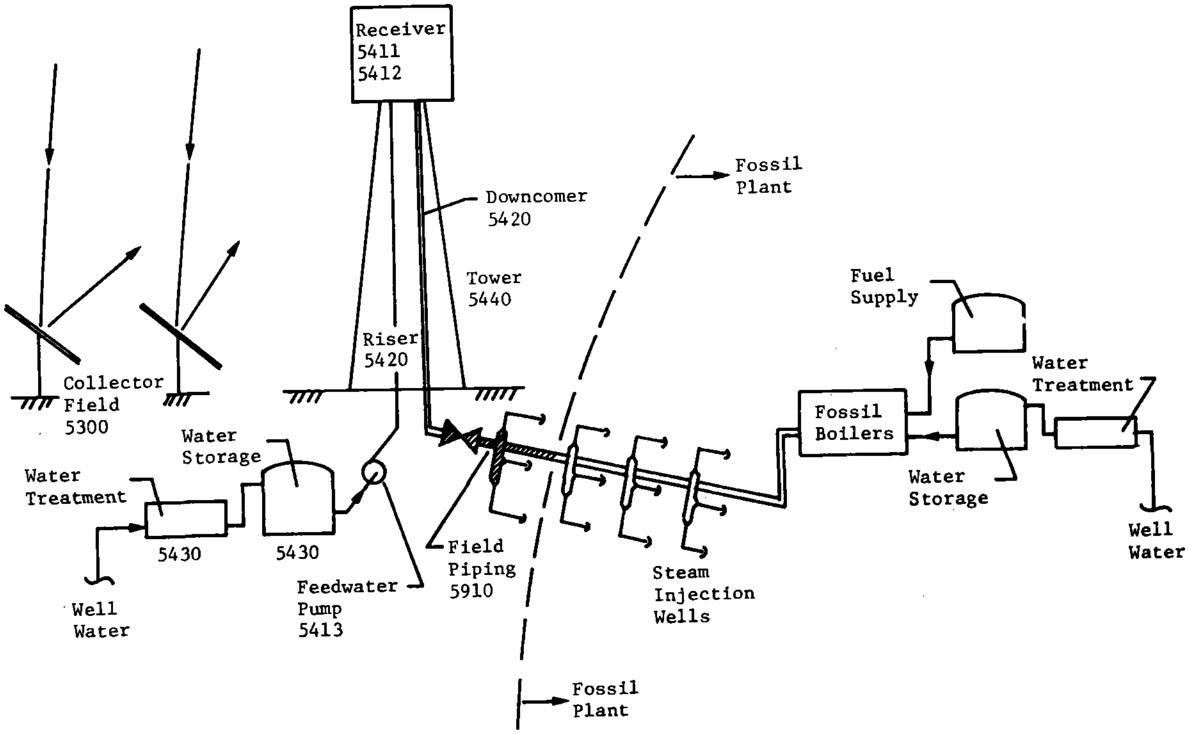


Figure 4.6-1 Major Equipment Cost Accounts

A detailed listing of the criteria used in estimating the construction cost can also be found in Appendix C. Table 4.6-2 summarizes the major assumptions made in the costing task.

Table 4.6-2 Cost Estimate Ground Rules

- All costs expressed in 1980$.
- Plant costing location is Bakersfield, CA for material prices and wage rates.
- All cost estimates are for installed and checked out equipment.
- Sales taxes and allowance for funds during construction (AFDC) not included.
- Design contingency not included in estimate.
- All indirects included per SRS worksheets.

4.6.2 Project Capital Cost Estimate

Based on the ground rules discussed in the SRS and the previous subsection, a construction cost of $14,033,467 has been estimated for the STEOR retrofit project. The account breakdown of this estimate is shown by major subsystem in Figure 4.6-2 and is tabulated to an expanded cost account structure in Table 4.6-3.

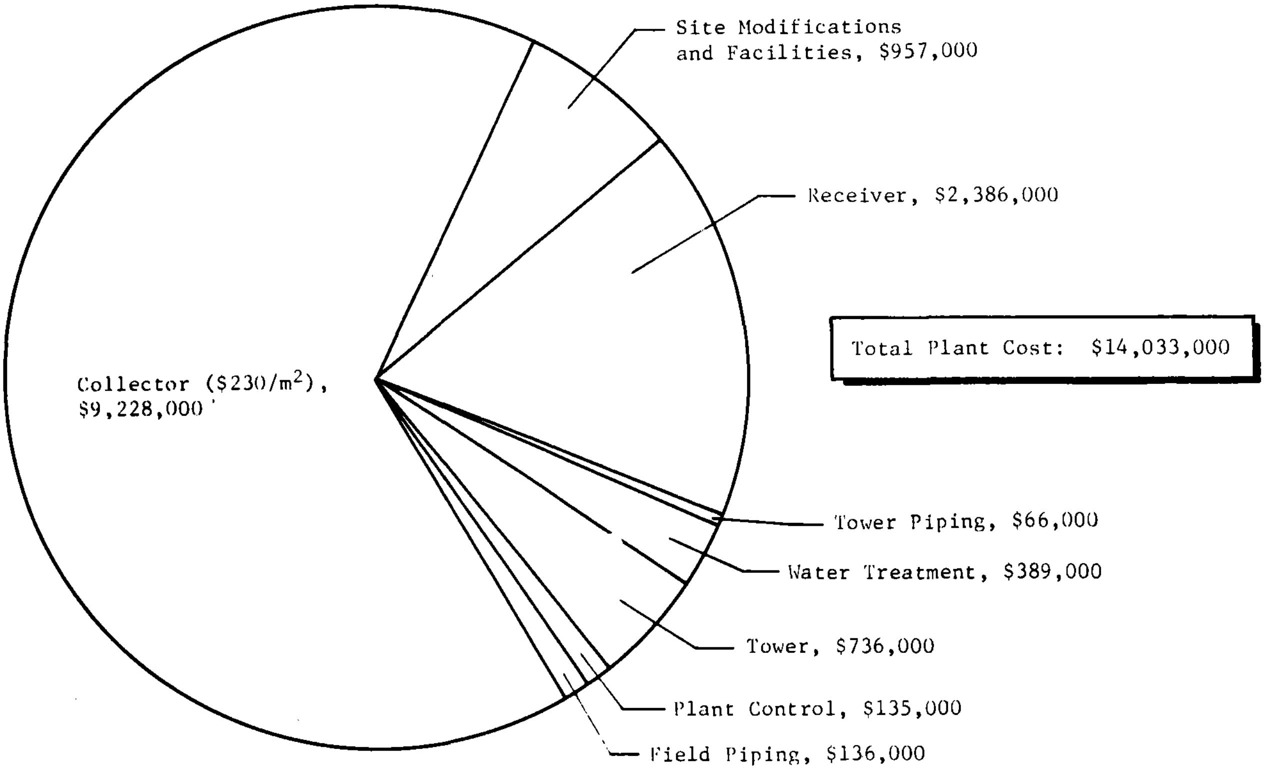


Figure 4.6-2 STEOR Construction Cost Estimate (1980$)

Table 4.6-3 STEOR Cost Estimate (1980$)

5100	Site Modification			$ 56,066
	5120	Yard Work	56,000	
5200	Site Facilities			$ 901,185
	5210	Operations and Maintenance	675,285	
	5220	Security	225,900	
5300	Collector Subsystem ($230/m)			$ 9,228,267
5400	Receiver Subsystem			$ 3,577,336
	5410	Receiver Unit	2,386,233	
	5420	Tower Piping	66,178	
	5430	Water Treatment	388,622	
	5440	Tower	736,303	
5500	Plant Control Subsystem			$ 135,250
5900	Process Heat Subsystem			$ 135,363
	5910	Field Piping	135,363	
5000	Plant Construction Cost			$14,033,467

As Figure 4.6-2 shows, over 65% of the STEOR total cost is the collector subsystem, using an installed cost of $230/m^2, or $11,281.50/ heliostat. This cost includes all heliostat-related costs such as foundations, installation, wiring and computers as provided by Sandia Laboratories in a November 6, 1979 memorandum, Technical Assumptions for the Repowering/Industrial retrofit Conceptual Design Studies. There is some thought that a more realistic heliostat cost would be $260 to $275/m^2; however, the economic analyses discussed in Section 6.0 show STEOR heliostat break-even costs (including 15% rate of return) above $300/m^2.

All costs shown in Table 4.6-3 and Figure 4.6-2 include field indirects, home office costs, contingency and fee. The detailed cost worksheets for each cost account and subaccount are contained in Section 5.3 of Appendix C, System Requirements Specification.

4.7 OPERATING AND MAINTENANCE COSTS AND CONSIDERATIONS

This section presents a summation of the annual operation and maintenance cost estimate for the solar thermal EOR system at the Edison site. As with the capital cost estimates, the validity of the economic analyses to be discussed in Section 6.0 depends to a large extent on realistic estimates of operating and maintenance costs. To achieve accurate cost estimates, the personnel required for operating and maintaining the STEOR system, as well as the operating consumables and maintenance materials, have been estimated and costed separately on the cost worksheets given in Section 5.3 of Appendix C.

The annual operating and maintenance cost estimates are summarized in Table 4.7-1. The estimates include a 7% overhead charge assessed on all recurring costs at the Edison site. Each of the major recurring cost items will be discussed in the following subsections.

Table 4.7-1
STEOR Operations and Maintenance Cost Summary (1980$)

OM100	Operations		$283,304
	OM110 Operating Personnel	203,856	
	OM120 Operating Consumables	79,448	
OM200	Maintenance Materials		$ 30,698
	OM210 Spare Parts and Materials	30,698	
OM300	Maintenance Labor		$ 66,361
	OM310 Scheduled Maintenance	66,361	
Total Yearly Operations and Maintenance			$380,363

4.7.1 Operating Personnel

The manning requirements for the STEOR system are identified as operating personnel and maintenance personnel. A level of 1.5 operators for two shifts (one per shift, and one overlapping) each day of the year (including holidays) was estimated to be required for system operations, plus an additional two maintenance personnel working standard 40-hour weeks for maintenance tasks.

4.7.2 Operating Consumables

The cost estimate for this account is split approximately evenly between chemicals for water treatment and electricity consumption for normal STEOR system operations.

4.7.3 Maintenance Materials

In addition to normal spare parts and maintenance materials, this account includes the field piping that must be added to the steam network due to steaming pattern movement (i.e., from the nearest injection array to the farthest array over the life of the field).

4.7.4 Scheduled Maintenance

This account includes two subcontracted periodic maintenance operations--heliostat washing and heliostat removal/replacement for well operations. Heliostat washing frequency is an unknown at this stage of the study; however, based on existing literature on heliostat washing costs, an estimate of $50/heliostat/year for washing was included. Because the site is a working oil field, provisions have been made for removal of heliostats from their foundations to allow sufficient clearance around wells in the heliostat field for well operations, including the infilling of new steam injection wells during the first three years of operations. The level of heliostat removal/replacement is expected to fall drastically after infilling is completed; however, to allow for unforeseen well operations over the life of the plant, the annual maintenance cost was not decreased.

4.8 SYSTEM SAFETY

The potential system safety implications can be subdivided into hazards to operating and maintenance personnel and hazards to the general public. In each of these cases the type of hazards can be identified as:

1) Visual hazards of reflected solar energy;

2) Releases of pressurized water and steam;

3) Catastrophic failure of equipment including pressure vessels.

To minimize the danger of stray reflected solar energy, an "always focused" operations strategy similar to that used at the CRTF would be employed. This strategy also results in limiting the area of concentrated energy to no more than twice the tower height, thus eliminating danger to aircraft (Fig. 4.8-1).

A fence surrounding the site will shield the two adjoining local roads (Hermosa Road and Tejon Highway) from glare and restrict unauthorized access to the site.

During operations, plant personnel will be excluded from the field and tower area. All nonemergency maintenance and operating activities in these areas will be done at night. Goggles and protective clothing will be worn whenever personnel must be present in an operating or unstowed field.

The receiver fluid (water) poses no toxic threat. Failure of receiver pressure parts during operation poses little danger since personnel will not be present. All equipment and pressure parts will be designed and built in strict accordance with the ASME Boiler and Pressure Vessel Code to minimize the possibility of failure. The failure of a tube in the receiver would release pressurized water that would flash and cool before hitting the ground.

Safety valves, overpressure alarms, a low-water-level sensor in the steam drum, and overtemperature alarms will be used to alert the operator to take appropriate action or to initiate automatic corrective action.

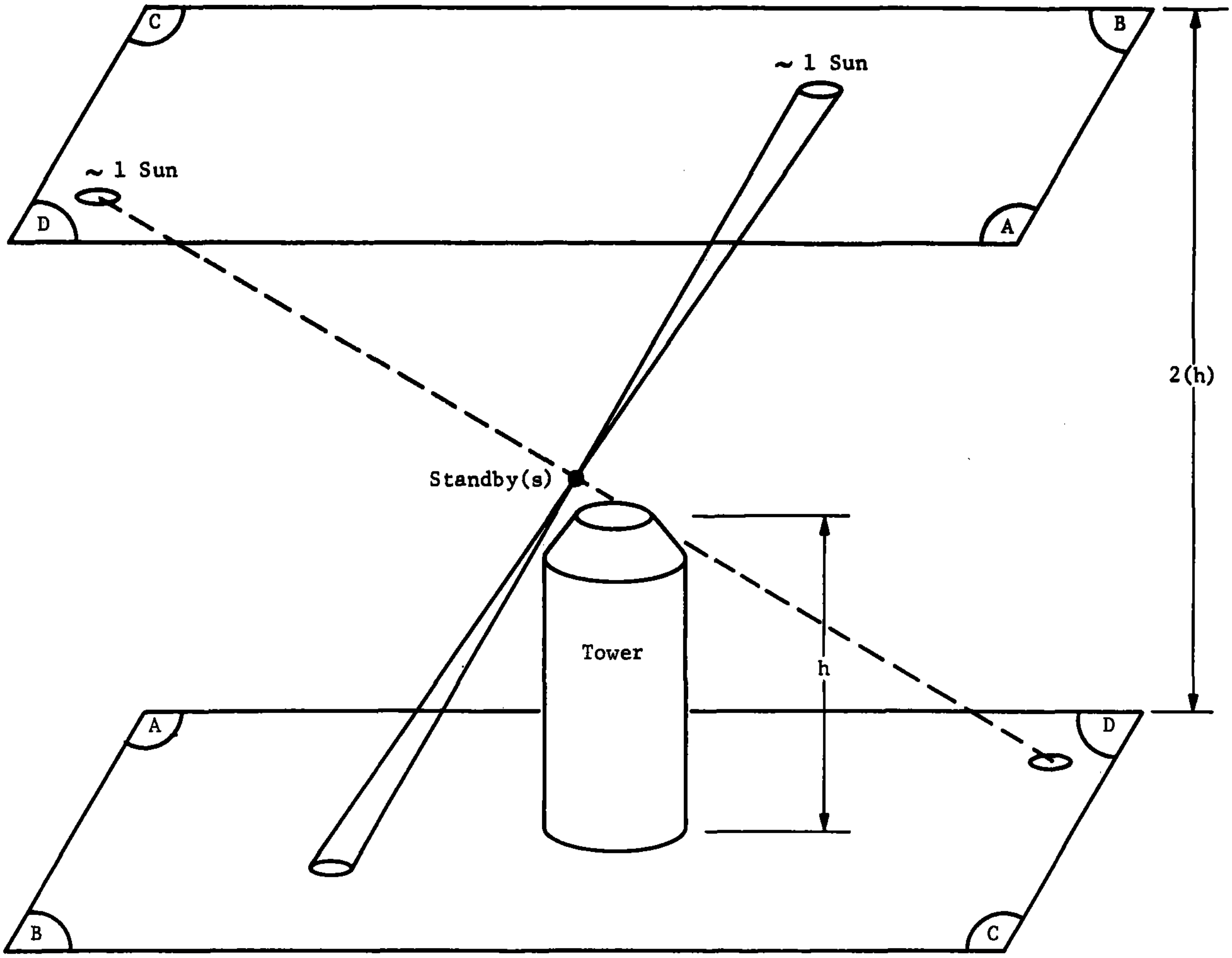


Figure 4.8-1 Collector Field Standby Condition

In the receiver tower, ample platforms, stairways, and ladders will be provided in accordance with OSHA regulations to permit convenient access to all areas requiring regular maintenance.

The tower will be lighted in accordance with FAA regulations. Oil well and field maintenance operations will only be carried out during periods when the solar system is not operating.

4.9 PROJECT ENVIRONMENTAL IMPACT ESTIMATE

The proposed site is currently in active oil production. The land surface is also being used for agricultural purposes.

The primary land use effect would be to remove about 80 acres of farmland from production. Ground water currently available and being used for steam stimulation activities at the site is sufficient for the proposed steam drive operations.

The use of this solar power system will eliminate one fossil-fueled boiler, out of four planned for the site, and reduce air pollution emissions accordingly. This will also reduce the particulate emissions associated with agricultural operations at the site.

The chief visual impact will be the receiver tower, which will stand out against the flat landscape and be visible for several miles.

The effect on local society will be minimal. Bakersfield, a large industrial city, is only a few miles distant and is well able to support the extra people and services the facility would require.

After the construction phase is completed, the system will produce little noise.

Accidental release of the receiver fluid, water, will have no adverse effects.

4.10 INSTITUTIONAL AND REGULATORY CONSIDERATIONS

The regulatory bodies who have authority at the site have been contacted. Copies of mentioned forms are included in Appendix C. In addition to those listed, a Federal Environmental Impact Report would be required if government funds were involved:

1) The receiver tower will require a zone variance from the Kern County Planning Department. Two forms are required. The application requires a description of the project, of the property, three copies of a plot plan, and submittal of an Environmental Assessment form;

2) The FAA must approve any construction greater than 61 m (200 ft) above ground level. FAA form 7460-1 must be filed 30 days before the application to construct is filed. A map showing the relationship of the site to the nearest airport is required;

3) Building permits are required by the Kern County Building Inspection Office for the operator's building/heliostat structures and the tower. Two sets of design and plot plans approved by a California registered civil engineer must be included for the heliostat foundation and the tower.

The following agencies do not require permits to be issued:

1) Division of Oil and Gas:

2) Kern County Air Pollution Central Board:

3) California Air Resources Board.

5.0 SUBSYSTEM CHARACTERISTICS

5.1 COLLECTOR SUBSYSTEM

This section details the key design and operation characteristics of the collector subsystem design developed for the STEOR system at the Edison field. The collector subsystem consists of:

1) Heliostats, including reflective surface, structural support, drive units, control sensors, pedestals, foundations, and cabling;

2) Controllers, including heliostat, heliostat array, field controllers, interface electronics, and power supplies;

3) Support equipment for alignment, washing, operations and maintenance, and installation and removal.

The collector subsystem design for the STEOR project is the result of collector/receiver configuration tradeoff studies and further collector field optimizations based on the results of configuration tradeoff studies.

5.1.1 Collector Subsystem Requirements

The primary requirement for the collector subsystem is to direct solar radiation onto the receiver absorber surfaces during all insolation periods in a cost effective manner that satifies the receiver incident heat flux requirements. For the selected STEOR system configuration, a design point requirement of not less than 31.2 MWt of redirected solar energy inside the receiver apertures at a reference insolation level of 950 W/m^2 (301.22 Btu/h-ft^2) has been imposed to enable calculation of the collector subsystem size.

The collector subsystem must also execute alternative drive modes in response to commands from the master control subsystem for emergency defocusing of the reflected energy or to protect the heliostat array against environmental extremes. The heliostat must be properly positioned for repair or maintenance in response to either master control or local commands. Heliostat design must provide for a stowed or safe position for use at night, during periodic maintenance and during adverse weather conditions.

The heliostats, cabling and controllers must meet all environmental/ operational requirements detailed in the Collector Subsystem Requirements, Rev C, A10772.

5.1.2 Collector Subsystem Design Description

The collector subsystem conceptual design description has been divided into two components for discussion. The first component is the heliostat design, including wiring, control and support equipment. The second component is the final collector field configuration, which has been optimized using the heliostat design characteristics and based on the tower height and receiver configuration selected on the basis of the parametric analysis results discussed in Subsection 3.1.1.

5.1.2.1 Heliostat Design Description - Because this study was intended to examine the design of the solar subsystems peculiar to the particular repowering/retrofit application, the heliostat design characteristics were provided by Sandia Laboratories (Livermore) early in the study. The key heliostat characteristics, as given in the November 6, 1979 memo, Technical Assumptions for Repowering/Industrial Retrofit Conceptual Design Studies, are shown in Table 5.1-1.

Table 5.1-1 Heliostat Design Characteristics

- 12-Facet, Glass/Steel, Inverting Stow Design
- Pedestal Foundation
- 49.05 m^2 (528 ft^2) Reflective Area
- 7.416 m (24.33 ft) x 7.378 m (24.20 ft) Overall Dimensions

- Performance Parameters
  - 0.90 Reflectivity
  - 2.0-mrad Beam Quality (Reflected Beam, 1 sigma)
  - 1.5-mrad Pointing Error (Reflected Beam, 1 sigma)

5.1.2.2 Collector Control Subsystem - The collector control subsystem (CCS) will be based on the technology for the Barstow 10-MWe pilot plant collector subsystem. Modifications will be in terms of fewer heliostats, larger heliostats, different field layout, and different interfaces with other plant subsystems. The CCS general characteristics are given in Table 5.1-2. The CCS control philosophy is automatic with a direct-control override capability. The control console includes color video displays and keyboard input and the CCS uses all digital data bus communications. There are external displays, flashing displays on the video screen, and audio alarms for warning purposes.

The primary interface will be with the receiver substystem to initiate standby mode in the event of a receiver shutdown or overpressure condition. The collector controls must also be capable of initiateing emergency heliostat stow whenever wind velocity exceeds operational limits. Local (CCS console) modes include:

1) Field activation;
2) Stow;
3) Position for wash;
4) Position for beam characterization;
5) Position for maintenance;
6) Emergency actions.

Table 5.1-2 Collector Control Subsystem Characteristics

- All Operator's Console Displays Alphanumerics
- Auxiliary Displays of Total Field Status and Selectable Field Segment Status
- Collector Field Divided into Segments, Rings, and Wedges
- Operator's Console Displays - Alarms, Warnings, Status and Commands
- Time Base Included
- Redundant Modcomp Computers
- MAXNET IV Operating System
- Asynchronous Data Links
- Data Logging via Disk and Hardcopy
- One Major Data Dump to Data Acquisition System Each Day

The heliostats can also be controlled individually at their site by a portable controller called a stimulator. This technique is used during maintenance. The computations related to beam characterization will be performed in the OCS minicomputer.

5.1.2.3 Collector Field Design Description - The final collector field layout is the result of using the RCELL collector field optimization programs to calculate the optimum heliostat spacings and superimposing physical site constraints (i.e., oil wells) to determine the permissible heliostat locations.

The University of Houston RCELL optimizer was run to calculate the optimum heliostat spacings using the optimum 90 m tower height determined during the parametric analyses, and modeling the receiver as a 6.0 m radius cylindrical receiver. The RCELL optimization output included the radial and azimuthal field coefficients, which were then input to the LAYOUT program, resulting in the heliostat coordinates for a surrounding field. This field was then trimmed to a 2.62 rad (150°) north field consisting of 812 heliostats.

The location (coordinates) of the heliostats as calculated by the LAYOUT program provides sufficient spacing between the heliostats for elimination of mirror physical interference and permits access by service vehicles and maintenance personnel. The minimum spacing between any two adjacent heliostat foundations in the fields is 10.77 m (35.33 ft), allowing a 0.3-m (1.0-ft) clearance between the reflective surfaces in any orientation, as shown in Figure 5.1-1.

However, the hiliostat spacings as output by LAYOUT do not account for the minimum clearance requirement of 9 m (30 ft) around each production or injection well. The well locations were superimposed on the heliostat, with the heliostats violating well clearances displaced to unused locations on the periphery of the field with a corresponding reduction in heliostat efficiency. To overcome the resulting reduced power input to the receiver due to a lower average field efficienty, six heliostats were added, again to the periphery of the field, to satisfy the design point power requirement.

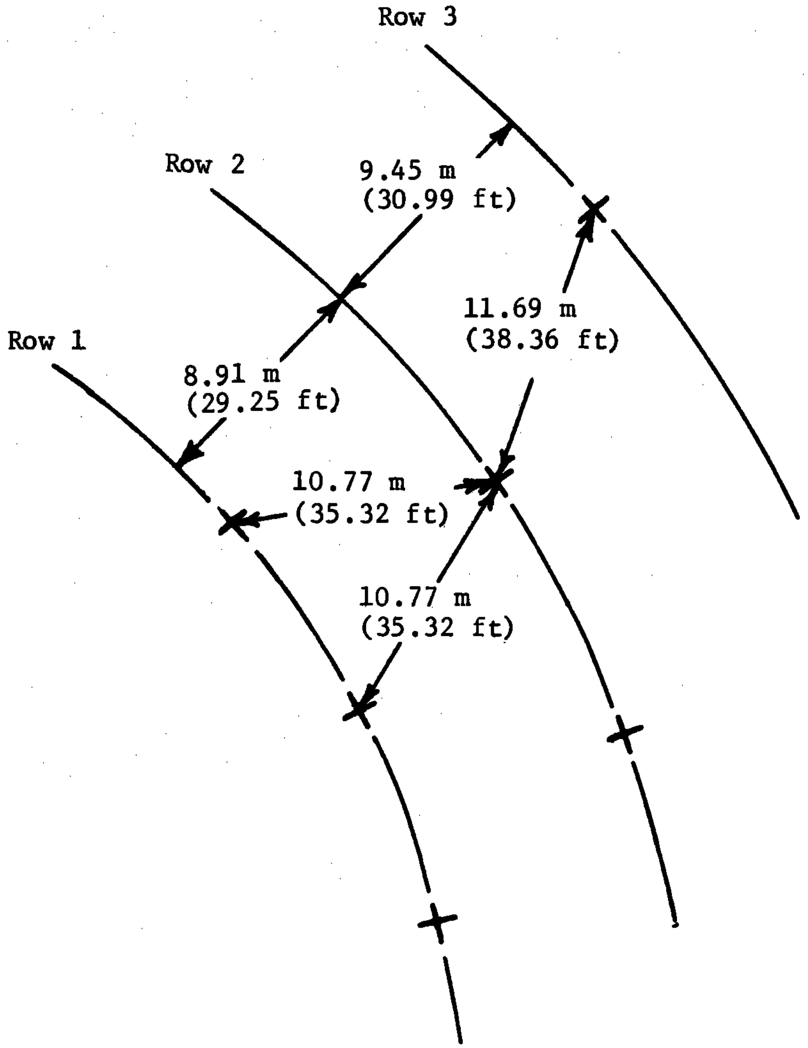


Figure 5.1-1 Access Clearance

In addition to well clearance, roads are required to provide normal oil well servicing. These roads are 9-m (30-ft) wide. Rather than use east-west roads, which would displace many heliostats, roads would be established between heliostat rows. Only one area does not meet the 9-m (30-ft) road requirement and that is the space between rows 1 and 2 as shown in Figure 5.1-1. This does not present any problem because there are no wells between these two rows.

The final collector field configuration, consisting of a single 2.62-rad (150°) north field with 818 heliostats (total reflective area of 40123 m^2 (431,880 ft^2) is shown if Figure 5.1-2. The X-Y coordinates of the heliostat locations are tabulated in the Systems Requirements Specification, Appendix C, with the origin of the coordinate system at the centerline base of the tower. The distance to the innermost row of the field from the tower is 60 m (198 ft), with the outer row being 367 m (1166 ft) from the tower.

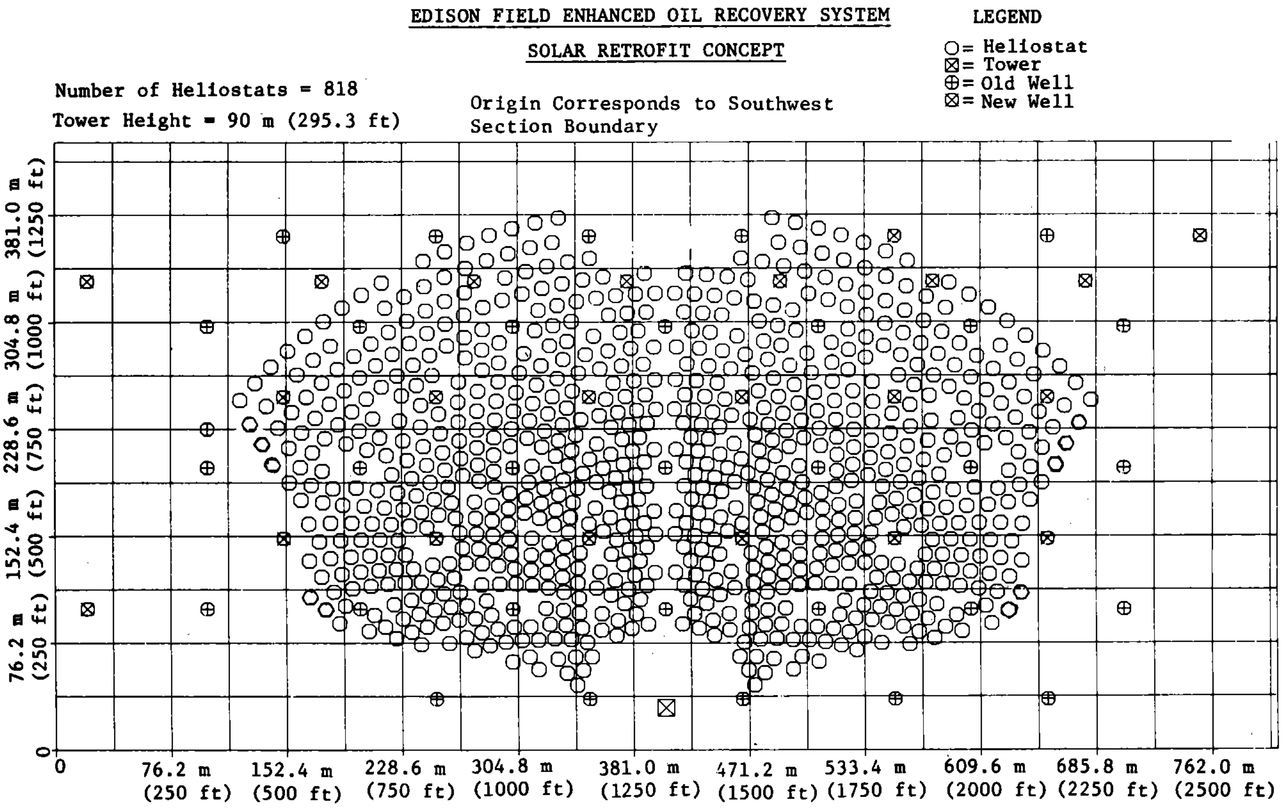


Figure 5.1-2 Collector Field Arrangement

5.1.3 Collector Field Performance

The performance of the collector field subsystem was analyzed using the MIRVAL computer code, with the following parameters considered:

1) Collector field layout;

2) Heliostat design parameters;

3) Receiver aperture sizes/orientation;

4) Heliostat aiming strategy;

5) Site location.

Receiver aperture sizes of 5.5 x 5.5 m (18.04 x 18.04 ft) with aperture normal orientations of 0.65 ± rad (37.5°) from due north were internally programmed in the MIRVAL code because the program will not accept cavities that are not oriented due north, east, west or south as input. The code was also revised to allow input aiming strategies dependent on heliostat slant range. The aiming strategy described in Subsection 5.2.1 was input for all performance analyses.

The final collector field efficiency values for various sun azimuth and elevation angles are shown in Table 5.1-3. Field efficiency is defined as the product of tower shadow, average field cosine efficiency, reflectivity (= 0.90), shading and blocking, atmospheric attenuation as calculated using the Martin Marietta atmospheric attenuation model (ABSORB = 0.099931) and spillage. The spillage losses include any losses due to heliostat tracking errors and beam quality.

Table 5.1-3 Collector Field Efficiencies

Sun Elevation [Horizontal = 0 rad (0°)]	Sun Azimuth [South = 0 rad (0°)]						
	0 rad (0°)	0.52 rad (30°)	1.05 rad (60°)	1.31 rad (75°)	1.51 rad (90°)	1.92 rad (110°)	2.27 rad (130°)
0.09 rad (5°)	0.250	0.240	0.239	0.233	0.220	0.150	0.125
0.26 rad (15°)	0.575	0.542	0.506	0.488	0.461	0.380	0.330
0.44 rad (25°)	0.717	0.682	0.638	0.613	0.582	0.516	0.450
0.78 rad (45°)	0.818	0.791	0.747	0.716	0.683	0.640	0.592
1.13 rad (65°)	0.795	0.785	0.757	0.735	0.715	0.684	0.654
1.56 rad (89.5°)	0.730	0.730	0.729	0.729	0.725	0.705	0.690

The collector field performance was also calculated for the noon, day 58 design point, again using MIRVAL and the inputs previously referenced. The design point efficiencies are shown in Table 5.1-4.

Annual field efficiencies were calculated using the STEAEC program with Fresno SOLMET TMY insolation and the field efficiency matrix given in Table 5.1-3. Using the ratio of "yearly energy to receiver" to "yearly energy to collector field," an annual average field efficiency of 68.4% was calculated.

Table 5.1-4
Design Point Collector Subsystem Performance
(MIRVAL Analysis)

Tower Shadow	0.9995
Cosine	0.9442
Reflectivity	0.90
Shading	0.9970
Blocking	1.00
Atmospheric Attenuation	0.9759
Spillage	0.9883
Total Field Efficiency	81.7%
818 Heliostats, Sun Elevation Angle: 0.8034 rad (46.03°) Sun Azimuth Angle: 0.0 rad (0°)	

5.2 RECEIVER SUBSYSTEM

5.2.1 Requirements

The receiver subsystem includes the receiver unit and the supporting tower. The receiver will convert the incident radiant flux energy from the collector subsystem into steam suitable for use in the enhanced oil recovery process. The tower will support the receiver, piping, and other elements of the receiver subsystem. The receiver and tower will be designed for the anticipated dead, wind and seismic loads. Adequate provisions will be made to ensure crew safety at all times for required operations, inspection, maintenance, and repair. Appropriate design standards and ASME boiler codes will be followed in the receiver design. The service life of the receiver subsystem will be at least 26 years.

The receiver is sized to absorb 29.3-MWt heat input from the collector subsystem. At the design point, with a reference insolation of 950 W/m^2(301.22 Btu/h-ft^2), the required steam outlet conditions are 8.27 MPa (1200 psia) and 297°C (567°F). A preheater section will be included to heat the feedwater from 15.6°C (60°F) to 148.9°C (300°F) under normal operating conditions.

The detailed requirements specification is presented in Appendix C of this report. The major requirements that directly guide design of the selected twin-cavity receiver are summarized in Table 5.2-1.

The boiler section of the receiver has a maximum absorbed heat flux limitation of 69.4 W/cm^2 (220,000 Btu/h-ft^2), and the preheat section has a maximum of 34.7 W/cm^2 (110,000 Btu/h-ft^2). To stay within these requirements and maintain a 4.5-m (14.76-ft) cavity depth, a simple aiming strategy had to be developed to lower peak flux to an acceptable level. The aiming strategy for both cavities are the same (Table 5.2-2). The coordinate system for the aiming strategy is in meters with the center point of the aperture being the origin.

Table 5.2-1 Summary of Receiver Requirement

Site Location	:	Edison Oil Field Kern County, California
Design Point	:	Noon, Day 58 (Insolation = 0.95 kW/m^2)
Thermal Input	:	31.2 MW (107.5 MBtu/h)
Thermal Output	:	29.3 MW (100.0 MBtu/h)
Feedwater Input		
Pressure	:	10.34 MPa (1500 psia)
Temperature	:	15.6°C (60°F)
Receiver Output		
Pressure	:	8.27 MPa (1200 psia)
Temperature	:	297°C (567°F)
Quality	:	82% by weight
Flow Rates		
Feedwater	:	43.59 Mg/h (96.1 klb/h)
Saturated Steam	:	36.02 Mg/h (79.4 klb/h)
Drum Blowdown	:	7.58 Mg/h (16.7 klb/h)
Peak Absorbed Heat Flux	:	694 kW/m^2 (220 $kBtu/h\text{-}ft^2$)
Preheater Duty	:	6.05 MW (20.7 MBtu/h)
Environments		
Ambient Temperature Range	:	-6.7 to 46°C (20 to 115°F)
Winds	:	40 m/s (90 mph)
Seismic Zone	:	UBC Zone 4
Ground Acceleration	:	0.3 g (minimum); 0.5 g (average)

Table 5.2-2 Aiming Strategy

Aim Point Number	Aim Point, m*			
	X	Y	Z	Rows
1	0.0	0.0	0.0	1-11, 21-29
2	0.0	0.0	1.5	12-13
3	0.0	0.0	1.25	14
4	0.0	0.0	1.0	15-16
5	0.0	0.0	-1.0	17-18
6	0.0	0.0	-0.5	19-20

* 3.281 ft = 1 meter.

The resulting incident heat fluxes (as calculated using TRASYS) with the aiming strategy for 8:00, 10:00, 12:00, 14:00 16:00 for days 58, 80, 172, and 355 are found in Appendix B. Heat fluxes are only shown for the east cavity because the west is a mirror image of the east. To account for the effects of reflections, a more detailed cavity node model was developed and run for noon day 58. The foldout in Figure 5.2-1 shows the node breakdown for cavity reflection calculations in

Table 5.2-3. The heat fluxes in parentheses represent the flux on a node after reflections inside the cavity while the fluxes without parentheses are the incident heat flux on that node. Both heat fluxes are in W/cm^2.

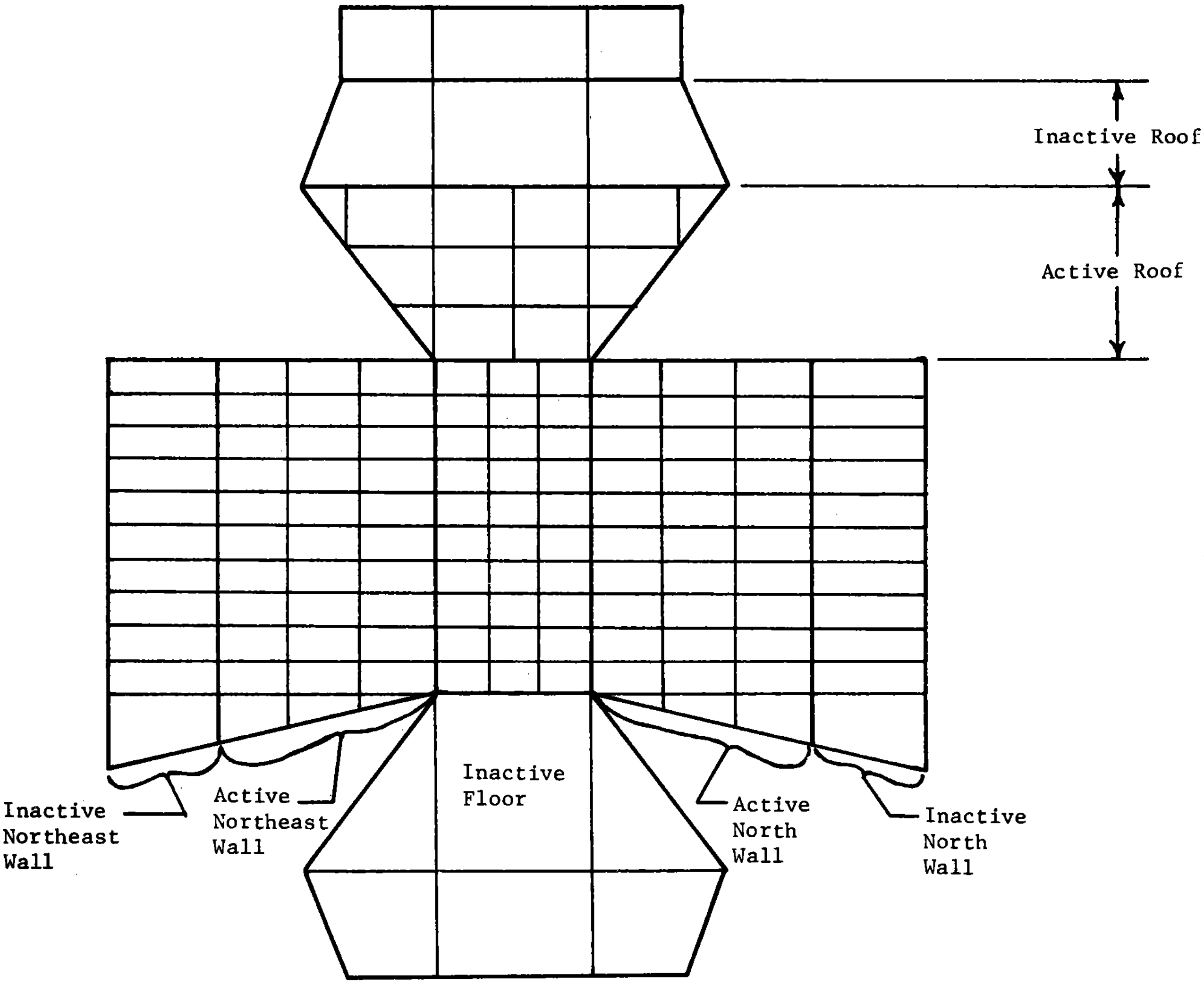


Figure 5.2-1 Northeast Receiver Cavity Foldout

5.2.1.1 Receiver Thermal Losses - The thermal losses from solar central receivers consist of spillage, solar reflection, infrared radiation convection, and conduction. Solar reflection losses were based on TRASYS grey-body calculations. The solar reflection loss for the design point is 1.56%.

The infrared radiation, convection, and conduction for the design point were calculated based on an ambient air temperature of 4.4°C (40°F). The infrared radiation loss was determined to be 1.51%. The convection loss was also based on the wind velocity in both cavities being 20% of the freestream. The freestream velocity at the receiver height was 4.9 m/s (16.1 ft/s). The convection loss was calculated to be 2.41%. The conduction loss was found to be 0.4% based on 10.16 cm (4 in.) of mineral wool insulation.

Table 5.2-3 Northeast Receiver Cavity Heat Fluxes, Noon Day 58

Northeast Wall				Backwall			North Wall			
In-active	Active						Active			In-active
0.0 (0.21)	1.29 (1.63)	23.1 (22.6)	41.9 (40.9)	49.8 (48.3)	51.0 (49.3)	43.2 (41.9)	31.3 (30.8)	19.9 (19.7)	2.86 (3.22)	0.01 (0.25)
0.0 (0.22)	2.79 (3.12)	31.9 (31.0)	49.3 (47.8)	56.6 (54.6)	58.8 (56.7)	48.9 (47.2)	35.5 (34.8)	23.8 (23.4)	3.84 (4.21)	0.03 (0.25)
0.02 (0.23)	4.88 (5.11)	36.1 (34.9)	51.8 (50.1)	60.3 (58.1)	62.1 (59.7)	52.0 (50.1)	36.4 (35.6)	24.5 (24.0)	4.40 (4.73)	0.03 (0.25)
0.11 (0.26)	7.42 (7.51)	38.0 (36.7)	54.4 (52.6)	66.1 (63.6)	66.1 (63.4)	55.7 (53.6)	36.3 (35.5)	23.1 (22.6)	4.55 (4.84)	0.03 (0.24)
0.23 (0.29)	9.86 (9.81)	40.2 (38.7)	57.7 (55.7)	71.1 (68.3)	69.7 (66.8)	58.6 (56.3)	36.2 (35.3)	21.5 (21.1)	4.60 (4.85)	0.04 (0.24)
0.31 (0.30)	11.0 (10.8)	39.6 (38.1)	54.5 (52.5)	66.1 (63.4)	64.8 (62.1)	53.9 (51.8)	33.0 (32.2)	19.5 (19.1)	4.45 (4.68)	0.07 (0.23)
0.29 (0.28)	9.41 (9.32)	32.3 (31.1)	41.4 (40.0)	48.7 (46.8)	48.7 (46.7)	40.4 (38.8)	25.3 (24.8)	15.6 (15.3)	3.80 (4.03)	0.08 (0.22)
0.18 (0.23)	5.86 (5.92)	19.9 (19.3)	23.8 (23.1)	27.2 (26.3)	28.1 (27.1)	23.3 (21.5)	15.3 (15.2)	10.2 (10.2)	2.52 (2.78)	0.06 (0.20)
0.07 (0.18)	2.36 (2.56)	8.69 (8.63)	9.47 (9.43)	10.4 (10.2)	11.2 (11.0)	9.18 (9.06)	6.57 (6.73)	4.92 (5.09)	1.07 (1.37)	0.02 (0.17)
0.01 (0.14)	0.44 (0.71)	1.99 (2.23)	2.02 (2.29)	2.43 (2.63)	2.63 (2.83)	1.91 (2.13)	1.11 (1.48)	1.06 (1.39)	0.19 (0.50)	0.0 (0.15)
0.0 (0.12)	0.01 (0.29)	0.21 (0.52)	0.45 (0.77)				0.23 (0.60)	0.05 (0.40)	0.0 (0.31)	0.0 (0.13)

	Roof					
Inactive	0.03 (0.19)		0.29 (0.30)		0.38 (0.30)	
Active	0.28 (0.67)	4.94 (5.45)	11.2 (11.5)	11.3 (11.6)	8.28 (8.61)	1.06 (1.45)
		19.9 (20.0)	25.5 (25.5)	23.9 (23.8)	17.9 (18.0)	
		29.3 (29.3)	29.0 (29.1)	27.0 (27.0)	22.4 (22.5)	

Noon
Day 58
Insolation 950 W/m^2

Floor Inactive		
0.0 (0.15)	0.01 (0.19)	0.0 (0.14)
0.0 (0.11)	0.01 (0.13)	0.0 (0.11)

Total Incident Power
15.6 MWt/Cavity

Total Power After
Reflected Losses
15.4 MWt/Cavity

5.2.1.2 Receiver Overnight Cooldown - Overnight cooldown was analyzed using the finalized "wet" receiver heat capacity, a 286°C (546°F) receiver temperature, and a -6.7°C (20°F) ambient air temperature at shutdown on the night of December 21. The winter solstice represents the longest nighttime duration, assuming a constant -6.7°C (20°F) temperature would provide a more severe cooldown condition than some shorter but colder nights. Figure 5.2-2 shows the cooldown rate and after 14.5 hours the receiver only experiences a 70.6°C (127°F) temperature drop. The final fluid conditions are sufficient for a rapid morning startup.

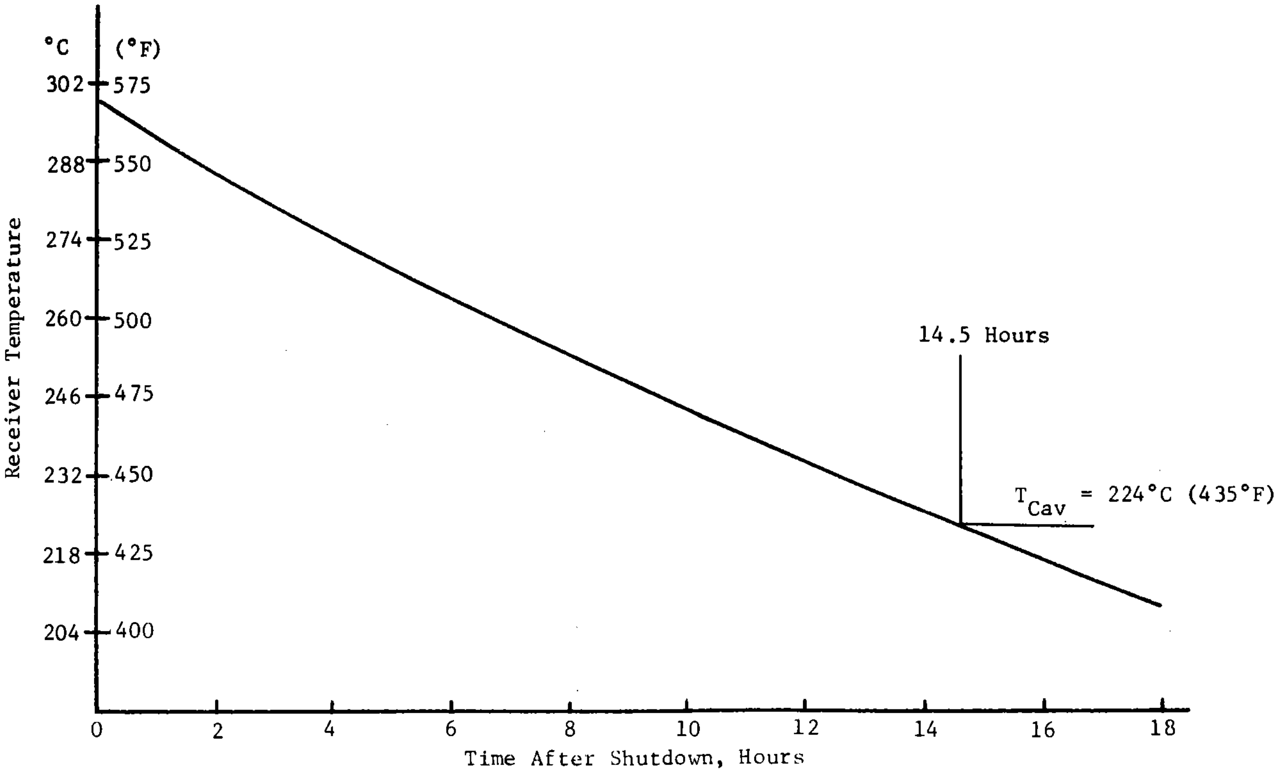


Figure 5.2-2 Receiver Overnight Cooldown

5.2.2 Description

5.2.2.1 Receiver Unit - The selected receiver concept is a twin-cavity, natural-circulation steam generator with separate preheater circuitry. This integrated twin-cavity receiver was devised for a 150° north collector field. The front elevation and plan views of this concept are given in Figure 5.2-3. As shown in the Section A-A view, the receiver is symmetric with respect to a north-south line passing through the common wall that partitions the two cavities. The aperture of each cavity is 5.5 x 5.5 m (18.04 x 18.04 ft) with its centerline extending at an angle of 37.5° from the common wall. The allocations of preheater and boiler surfaces on cavity walls are also shown in this view. The first pass of the preheater is located at the central portion of the common wall. The inboard portion of the common wall, two rear walls and two side walls are lined with boiler panels. Since considerable incident solar energy falls on the cavity roof, a large portion of the roof is covered by two serpentine panels of the preheater, as shown in the top plan view of the figure. All preheater and boiler panels are made of carbon steel tubes that are joined along their length by continuous-weld integral fins to form flat Monowalls ™. This type of panel is structurally rigid, can be handled in shipment and during erection with relative ease, and is impenetrable to incident solar flux.

As shown in the elevation views, feedwater enters at the lower header of the vertical preheater panel (pass 1), and flows upward inside the tubes while being heated by the incident heat flux along the length of the pass. Water is collected at the upper header and piped to the inlet header of the roof preheater panels. After traversing back and forth through the serpentine panel (pass 2) on the roof of the northwest cavity, heated water is collected and routed by a transfer pipe to the roof panel (pass 3) in the northeast cavity. There water is further heated until it exits from the outlet header and discharges into the drum.

From the drum, boiler water flows through five downcomers and branching feeders to the lower headers of the boiler, where the flow is divided among the various upflow boiler panels. As the water flows upward through the tubes, a portion is converted into steam by the absorbed heat. The resultant mixture of water and steam leaving the tubes is collected in the upper boiler headers and carried back to the steam drum through risers. A rear elevation view of the receiver is presented in Figure 5.2-4, illustrating the locations of headers and downcomers. The two plan views in this figure depict the routing of boiler feeders and risers respectively.

In the drum, the water is separated from steam by density differences and, after mixing with incoming feedwater, enters the downcomers for another trip around the boiler circuits. Saturated steam from the drum is piped down to the bottom of the receiver. Because of the dissolved solids in the feedwater, a substantial amount of continuous blowdown from the drum is necessary to maintain the total dissolved solids in the boiler water within tolerable limits. This hot blowdown water is recombined with the saturated steam at the outlet of the receiver to salvage the heat in the blowdown water. The arrangement of injecting the blowdown water into the saturated steam stream is shown schematically in Figure 5.2-4. The resulting wet steam (approximately 82% quality) is then piped down the tower to field distribution headers.

The shell of the receiver consists of preheater and boiler panels, cavity floor and roof plates, enclosure and stiffeners. Interior surfaces of the cavity that are not covered with preheater or boiler panels are lined with either flat steel plates or corrugated Incoloy plates coated with reflective material. Outside surfaces of the receiver, as well as drum and exterior piping, are insulated to reduce thermal losses to the ambient environment. The aperture of each cavity is provided with an insulated door that can be closed to minimize heat loss and resultant cooling of the receiver during overnight shutdown.

The conceptual support structure for the receiver is shown in Figure 5.2-5. The entire receiver is suspended from a structural-steel framework attached to the support columns. All pressure parts of the receiver are free to expand laterally and down. The structural framework also supports the enclosure. The preheater and boiler panels that receive solar energy from only one side can be held in position and braced at the back against thermal stress and wind and seismic loads by conventional structural-steel buckstays. The panels that form the partition wall between the two cavities are heated by radiant flux from both sides during operation. This reduces the circumferential temperature gradients of the tubes and results in much less thermal stresses in the tubes. Since the length of these panels is only about 6.7 m (22 ft), preliminary calculations indicate that no intermediate horizontal support in the heating zone is required.

5.2.2.2 Tower - The tower supports the receiver at the proper elevation to optimize optical performance and cost of the collector/receiver module (see Subsection 3.1.1 for details). The tower must also provide access to the receiver and accommodate routing of feedwater and steam piping as well as the instrumentation and control cabling from ground level to the receiver.

Although indepth tower design studies were beyond the scope of this project, certain physical characteristics were evaluated as a result of the collector/receiver optical performance optimization and the use of the Sandia Laboratories tower cost model. The tower height is 90 m (295 ft) from ground level to the base of the receiver. It is constructed of steel with four major vertical columns. For seismic conditions corresponding to zone 4 of the UBC, the resultant moment is 7.90

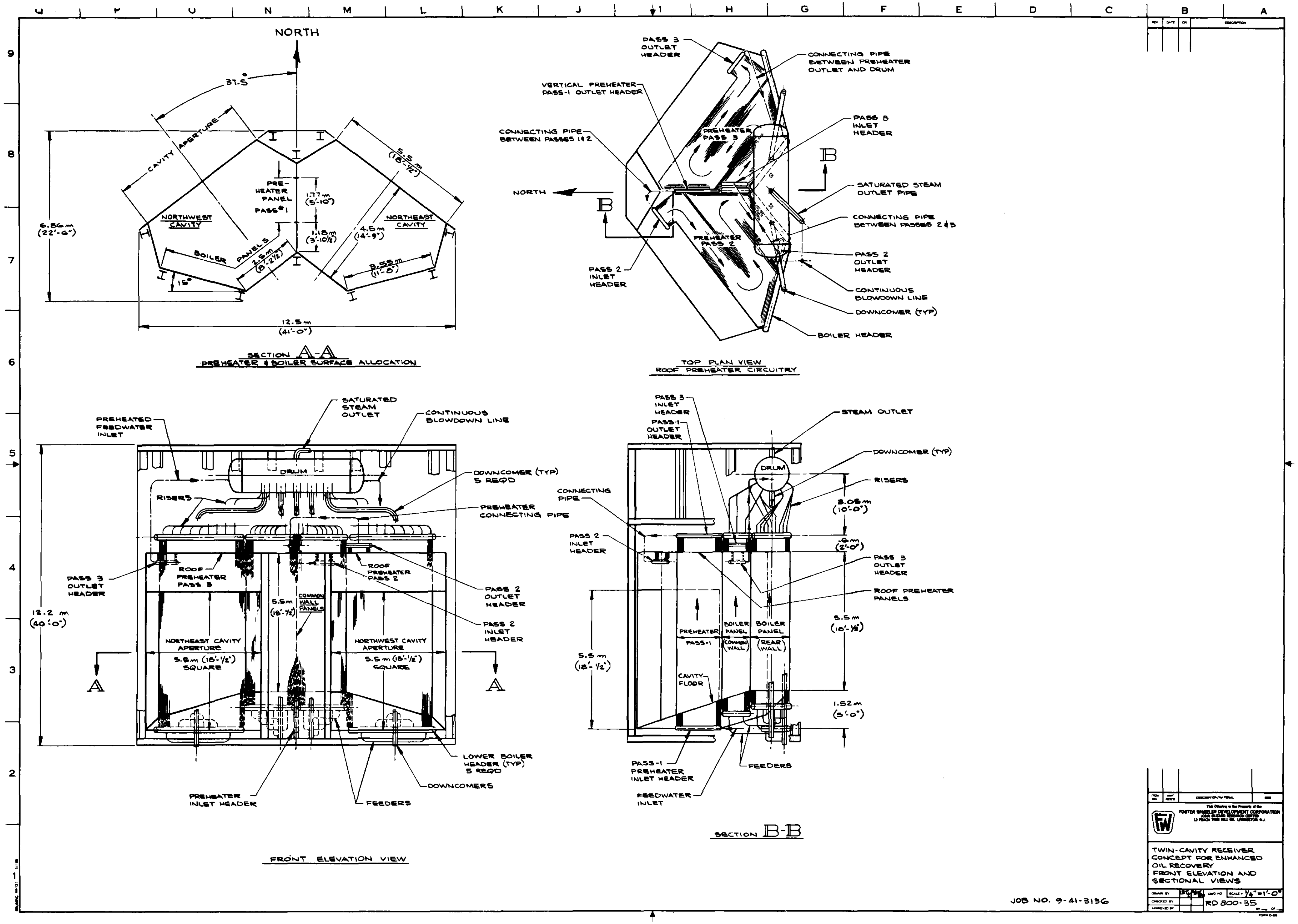


Figure 5.2-3 Twin-Cavity Receiver Concept for Enhanced Oil Recovery - Front Elevation and Sectional Views

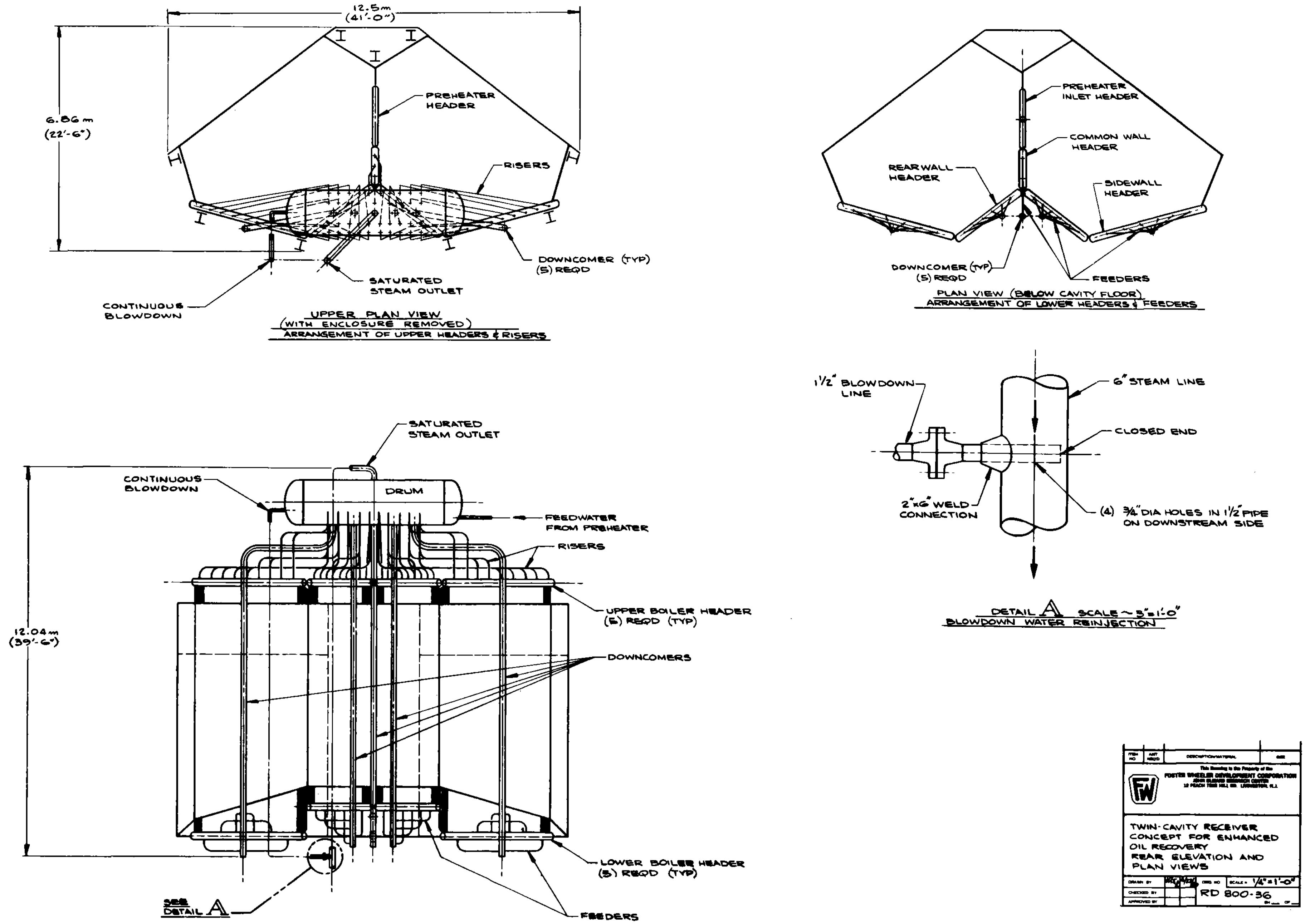


Figure 5.2-4 Twin Cavity Receiver Concept for Enhanced Oil Recovery - Rear Elevation and Plan Views

$\times 10^7$ Nm (58.3×10^6 ft-lbf) and peak tower top acceleration is 0.62 g. The maximum wind moment was calcualted to be 6.26×10^7 Nm (46.2×10^6 ft-lbf).

The foundation for the tower is designed to resist combinations of gravitational and seismic or wind forces. As discussed in Subsection 3.1.5, mat, pile, and pier foundations were considered and the pier concept proved to be the most cost effective. In the conceptual design, several pier quantity-diameter-length combinations were studied. The conceptual design, in accordance with ACI 336-72, requires three piers under each tower leg; each pier is 0.91 m (3 ft) in diameter and 13.7 m (45 ft) in length. A triangular pier cap, as shown in Figure 5.2-6, is most economical. The reinforcing for the piers and the pier caps is designed by the strength method using factored loads and allowables in accordance with ACI 318-77.

5.2.3 Performance and Operating Characteristics

5.2.3.1 Thermal/Hydraulic - Detailed thermal/hydraulic design and analyses were performed for the selected twin-cavity receiver. The results obtained for both preheater and boiler are described in this subsection.

Preheater - Feedwater must be preheated to reduce the temperature gradient across the thermal sleeve that protects the feedwater pipe joint and the drum. To preheat the feedwater from 16°C (60°F) to 149°C (300°F), approximately 21% of the total absorbed power is needed. The preheater consists of one vertical and two serpentine roof panels. At the design point heat flux conditions, this arrangement supplies the required fraction of receiver thermal duty. Calculations were also made for a range of days and times, and the results show that this fraction remains virtually constant.

Temperatures of water and tube wall along the three preheater passes were calculated for the design point flux distributions. In calculating these temperatures, the following effects were considered;

1) Absorbed heat flux variations among tubes of the same pass;

2) Manufacturing variations in tube wall thickness (+10%, -0% on minimum wall);

3) Flow imbalance because of connecting headers and unequal tube length.

The results are shown in Figure 5.2-7. The maximum mean tube wall temperature was based on the worst combination of heat flux and flow conditions (i.e., the highest heat flux and lowest flow among tubes of the same pass).

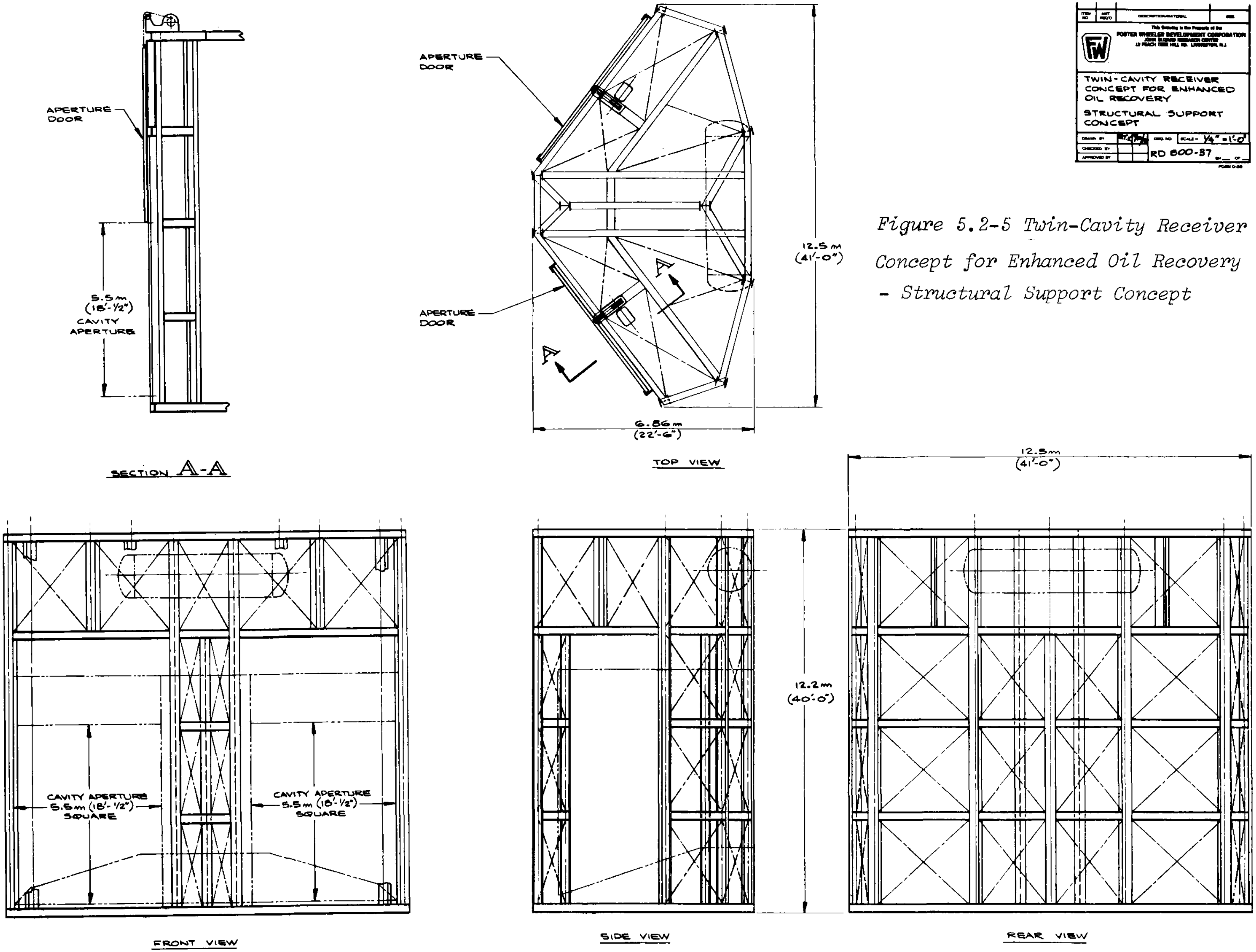


Figure 5.2-5 Twin-Cavity Receiver Concept for Enhanced Oil Recovery - Structural Support Concept

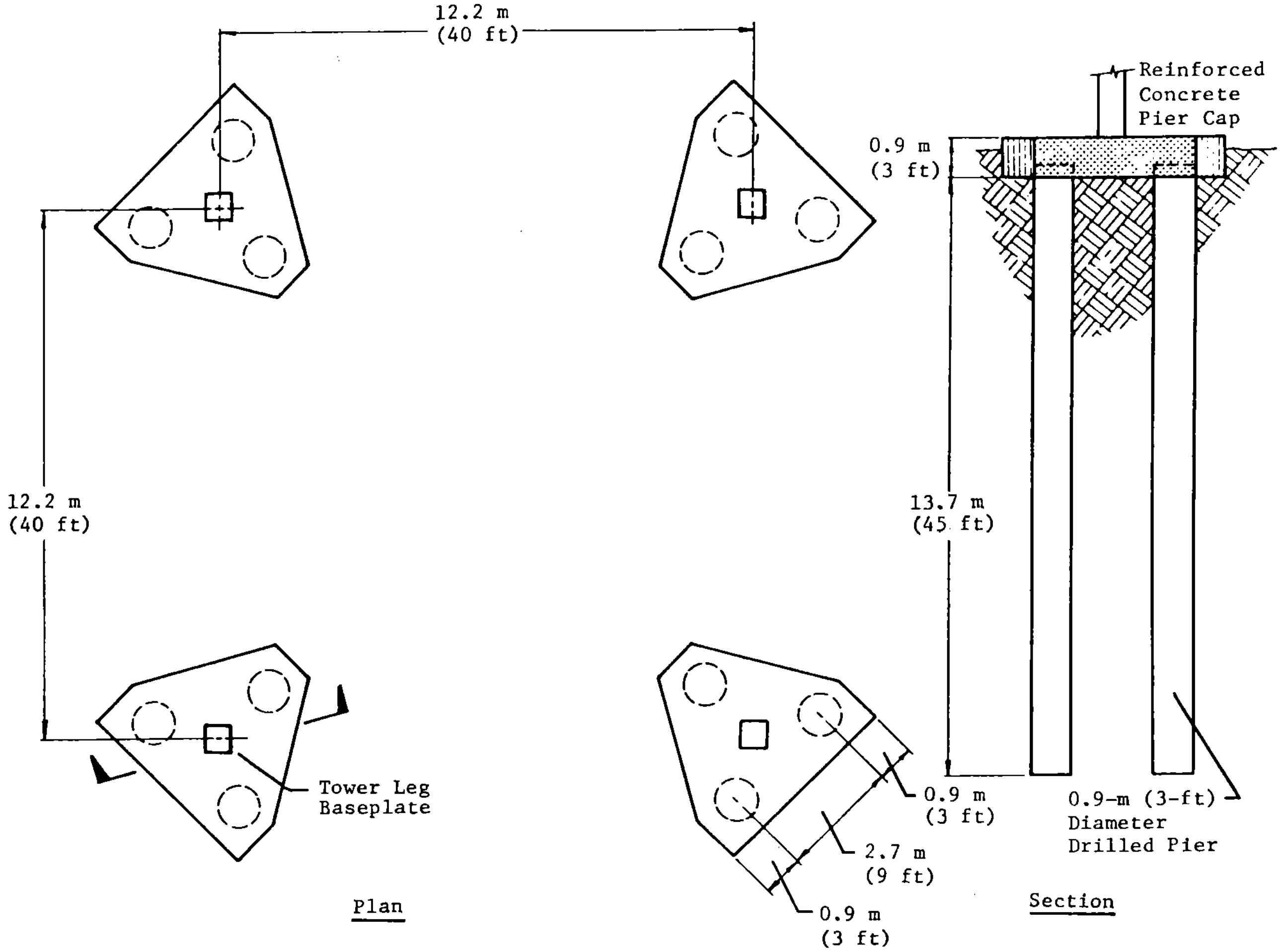


Figure 5.2-6 Receiver Tower Foundation

The total pressure drop from the inlet to the outlet of the preheater is approximately 207 kPa (30 psi). The frictional losses, including those through connecting piping, account for 117 kPa (17 psi) and the remaining drop is due to elevation difference.

Boiler - The selected receiver concept uses the natural-circulation principle. In a natural-circulation system, the rate of flow that can be produced is governed by flow resistances and differences in density between the downcomer circuits and the upward heated circuits. Control of these resistances enables the designer to apportion an adequate flow of water to parallel circuits. For the circulation analysis, the boiler section was divided into different circuits having similar heat absorption characteristics. After several repetitive calculations, during which changes were made to the number and size of tubes, feeders and risers in the individual circuits, an acceptable arrangement was obtained.

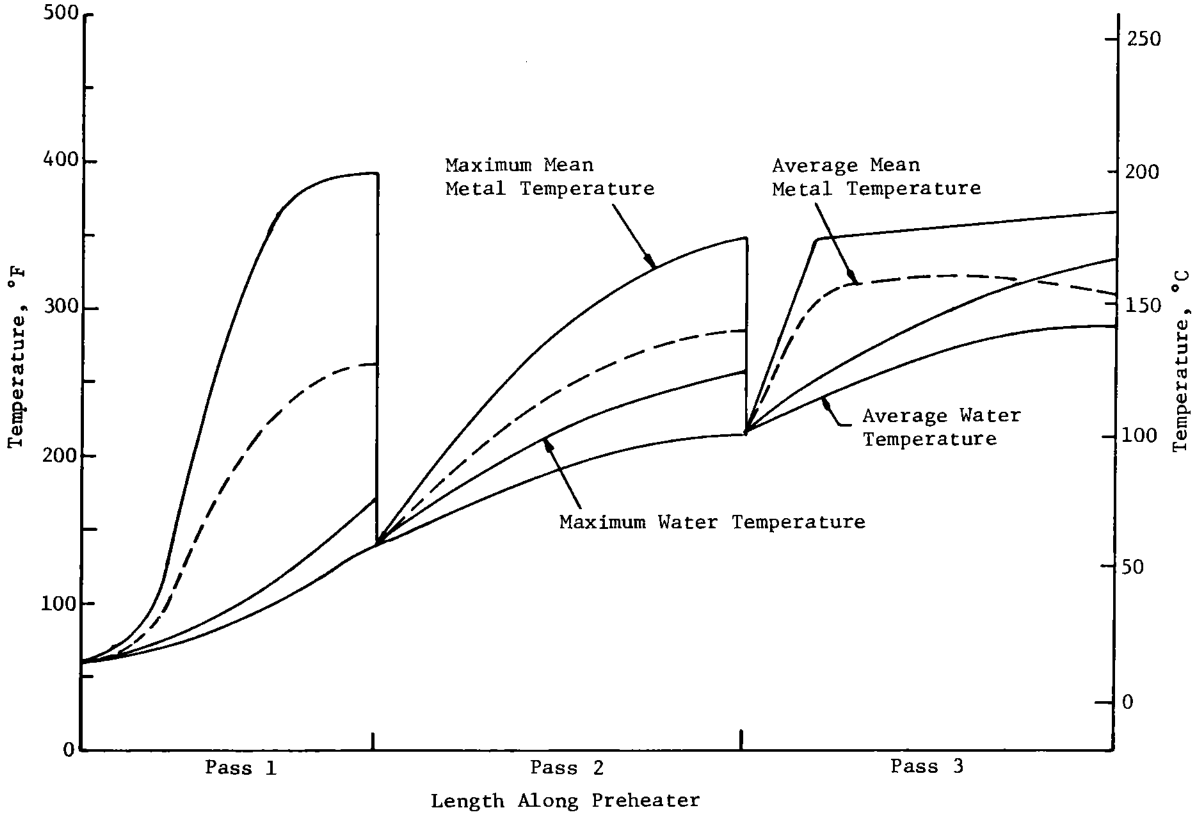


Figure 5.2-7 Preheater Temperature Profiles at the Design Point

Table 5.2-4 lists the number and sizes of the selected boiler circuits. Since the heat flux distributions on the side wall panels vary considerably in the horizontal direction from inboard to outboard tubes, the side walls were further divided into three parallel circuits for the circulation analysis. Table 5.2-5 summarizes the results for the design heat input conditions. As shown in this table, the ratio of the total circulating flow rate to the total steam-generating rate (overall circulation ratio) is 12:1. It was also found that all circuits satisfied the circulation design criteria imposed on the entrance velocity, steam quality, and absorbed heat flux.

Table 5.2-4 Summary of Boiler Circuitry

	Tube		Feeder		Riser		Downcomer	
Description	No.	OD, mm (in.)	No.	OD, mm (in.)	No.	OD, mm (in.)	No.	OD, mm (in.)
Common Wall	20	50.8 (2.0)	2	76.2 (3.0)	3	101.6 (4.0)	1	168.3 (6.625)
Rear Wall	86	50.8 (2.0)	12	76.2 (3.0)	18	76.2 (3.0)	2	168.3 (6.625)
Side Wall	124	50.8 (2.0)	12	76.2 (3.0)	18	76.2 (3.0)	2	168.3 (6.625)

Table 5.2-5 Boiler Circulation Summary

Description	Circulation Flow, Mg/h (klb/h)	Exit Quality, % by Weight	Steam Generated, Mg/h (klb/h)	Velocity Entering, m/s (ft/s)
Common Wall	56.7 (125)	8.9	5.0 (11.1)	1.1 (3.6)
Rear Wall	204.6 (451)	8.8	18.0 (39.7)	1.1 (3.7)
Side Wall 1	77.6 (171)	10.3	8.0 (17.6)	1.3 (4.3)
Side Wall 2	72.6 (160)	6.4	4.6 (10.2)	1.2 (4.0)
Side Wall 3	24.0 (53)	1.4	0.4 (0.8)	0.5 (1.5)

Note:

Total circulation rate = 435.5 Mg/h (960 klb/h),
steam generation rate = 36.0 Mg/h (79.4 klb/h),
continuous blowdown rate = 7.6 Mg/h (16.7 klb/h),
overall quality, % by weight = 8.3,
overall circulation ratio = 12.1,
heat input condition = Noon, Day 58.

5.2.3.2 Structural - The structural design requirements can be divided into two categories. First is the area of concern relating to internal pressure and temperature distribution. The second refers to external influences such as wind and seismic loading. This subsection describes the structural design studies of the receiver panel and other pressure components such as risers, feeders, downcomers, headers and the drum. The methods used in structural analysis, the computer programs, the criteria used in the evaluation and the important results are described.

Applicable Codes and Standards - The requirements of the ASME Boiler and Pressure Vessel Code, Section I* are fully met in the receiver design. The design philosophy of Section I is to set the wall thickness necessary to keep the hoop stress due to pressure below the tabulated allowable stress. Section I does not require a detailed evaluation of the higher, more localized stresses known to exist, but instead allows for these by the safety factor and a set of design rules. Section I also has no criteria to evaluate thermal stresses and fatigue. Experience shows that this approach has worked reasonably well in the case of fossil-fired power boilers. However, the loading conditions in the solar receiver are different from those of the conventional boilers be

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*ASME Boiler and Pressure Vessel Code. Section I (Rules for Construction of Power Boilers). ASME, New York, 1977 Edition.

cause the solar receiver is subjected to diurnal startup and shutdown cycles. The fatigue asociated with thermal cycling is an important failure mode in a solar receiver, but Section I does not have explicit criteria to evaluate this failure mode. In this study, Section I was supplemented with appropriate criteria from Section VIII, Division 2.* This approach is consistent with the proposed Interim Structural Design Standard for Solar Energy Applications.+,#

Receiver Panel - One of the critical components (in terms of structural integrity and fatigue life) in the receiver is the boiler panel. The panel is composed of 50.8-mm (2-in.) OD carbon steel boiler tubes on 57.2-mm (2.25-in.) centers using Monowall TM construction in which the tubes are joined together along their length by continuous welded integral fins to form a flat panel.

The tube thickness was calculated from the Section I formula for seamless tubes. The temperature and the stress distributions were determined by using the finite element program ANSYS.** The finite element model used is shown in Figure 5.2-8. Because of symmetry, only onehalf of the tube and the fin is analyzed. Generalized plane-strain conditions are assumed in the tube. Because of the intermediate and end suppports and the axial variation of flux, the problem is three-dimensional in nature. However, a study conducted by J. Jones of Sandia-Livermore has demonstrated that the two-dimensional generalized plane-strain model reflects the state of stress and strain accurately.++ Generalized plane-strain analysis is accomplished by first performing a plane-strain analysis and then relaxing the axial forces at the ends. A postprocesser computer program was specially written.

The postprocessor can also calculate the bending stresses and peak stress in the tube. The parameters considered in the analysis are shown in Table 5.2-6. The following criteria are used in evaluating the stresses:

1) Limit the primary stresses due to pressure to the allowable stress given in ASME Code Section I;

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*ASME Boiler and Pressure Vessel Code. Section VIII, Division 2 (Rules for Construction of Pressure Vessels - Alternative Rules). ASME, New York, 1977 Edition.

+I. Berman, et al.: An Interim Structural Design Standard for Solar Energy Applications. Report SAND-79-8183, Sandia Laboratories, Livermore, April 1979.

#T.V. Narayanan, et al.: "Structural Design of a Superheater for a Central Solar Receiver." Transactions of ASME, Journal of Pressure Vessel Technology, Vol 101, February 1979.

**ANSYS Engineering Analysis System User's Manual. Swanson Analysis Systems, Incorporated, 1974.

++J.Jones: "Absence of Bending Effects on Solar-Receiver-Tube Fatigue," Journal of Energy, AIAA, Vol 3, No. 3, May-June 1979.

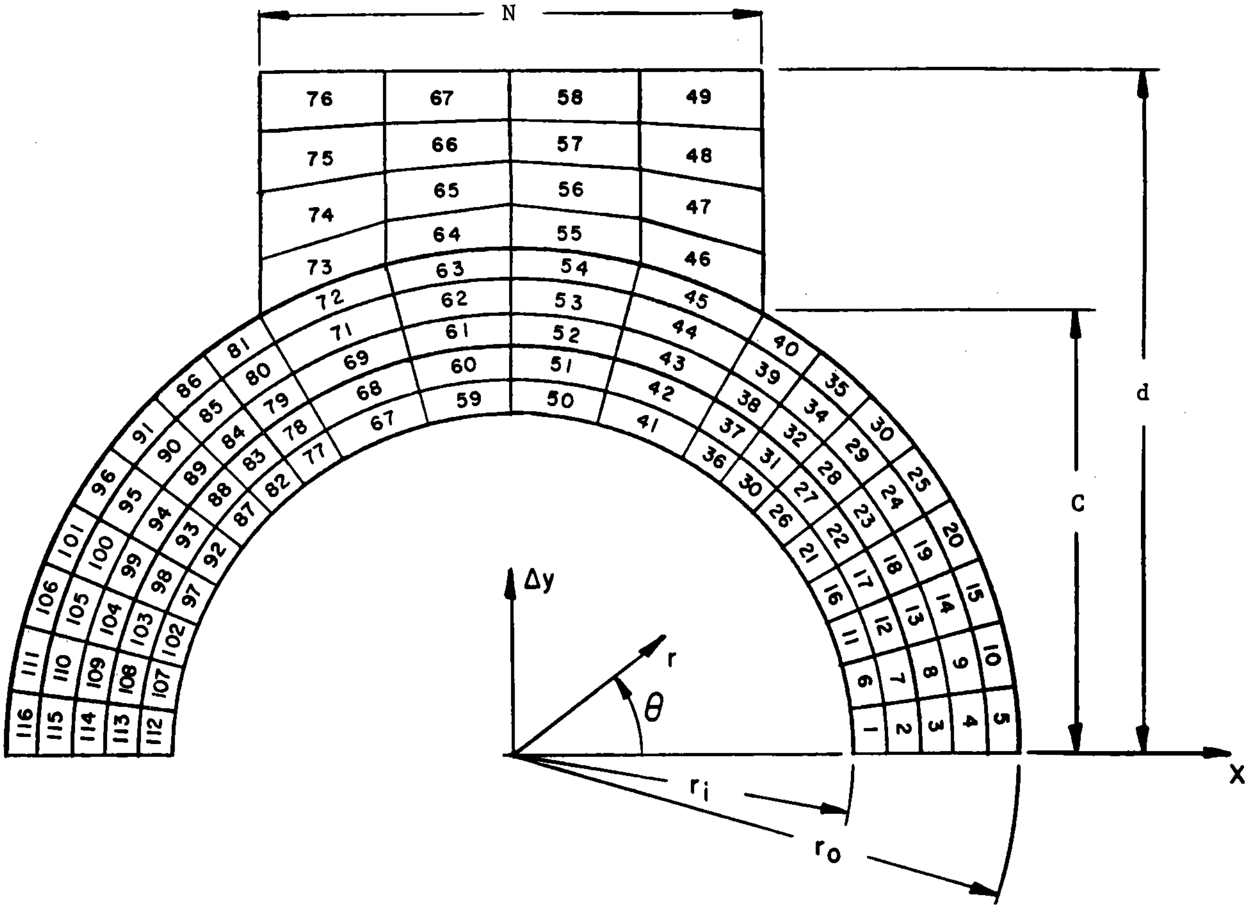

Figure 5.2-8 Finite Element Model of Boiler Tube

2) Limit the primary plus secondary stresses (thermal **stresses**) to twice the yield stress;

3) Evaluate the fatigue life using Section VIII Division 2.

This approach is consistent with that of Berman and Narayanan. The first of the above criteria is automatically satisfied by using the appropriate Section I formula in the thickness calculation. The second criterion is intended to ensure that shakedown occurs and continued plastic cycling does not occur. Fatigue is an important failure mode in solar receivers because of the diurnal startups and shutdowns as well as cloud-induced shutdowns. Since the design temperature is below 371°C (700°F), creep effects are negligible. Table 5.2-6 shows the appropriate stress intensities and allowable stresses.

The allowable value for primary plus secondary stress, i.e., 3 S_m (twice yield stress) is taken from Section VIII, Division 2. Fatigue life was evaluated using the Section VIII, Division 2 fatigue curves. The inplane axial stress in the panel due to the temperature differential across the panel was conservatively estimated as 68.97 MPa (10 ksi) and has been included in calculating the secondary and peak stresses. From Table 5.2-6, it is clear that the panel is structurally adequate and has an ample design margin for fatigue.

Table 5.2.6 Stress Intensities and Allowable Stress in the Panel

Peak Heat Flux q" = 0.694 MW/m^2 (220,000 Btu/h-ft^2)
Film Coefficient h = 29 kW/m^2°C (5100 Btu/h-ft^2-°F)
Thermal Conductivity k = 45.32 W/m°C (26.2 Btu/h-ft-°F)
Fluid Temperature T_f = 297°C (567°F)
Coefficient of Thermal Expansion α = 15.03 x 10^{-6}/°C (8.35 x 10^{-6}/°F)
Modulus of Elasticity E = 1.772 x 10^5 MPa (25.7 x 10^6 psi)
Poisson's Ratio ν = 0.31

Terms Defined In ASME Code Section VIII, Div 2	Stress Intensity, MPa (ksi)	Allowable Stress, MPa (ksi)
Primary Stress Intensity P_M	55.8 (8.1)	99.3 (14.4)
Primary Plus Secondary Stress Intensity $P_L + P_B + Q$	142.0 (20.6)	3 S_m = 312.4 (45.3)
Peak Stress Intensity $P_L + P_B + Q + F$	243.1 (35.26)	Fatigue Life 100,000 Cycles

Note:

Peak metal temperature = 390°C (734°F),
Design Temperature = 371°C (700°F).

Other Pressure Parts - Other pressure parts such as the downcomer, headers, feeders and risers, steam drum, etc were sized according to the requirements of ASME Code Section I.

Support Structure Design - The general arrangement of the support structure is shown in Figure 5.2-5. The support structure consists of 10 columns interconnected by beams and braces. The loading on the support structure is as follows:

1) Dead load - For the first iteration, the dead load was assumed to be 1.38 x 10 N (310 kips);

2) Wind load - The survival wind speed is 40 m/s (90 mph) at a reference height of 10 m (30 ft). The corresponding wind pressure at the centerline of the receiver is estimated as 2.16 kPa (45 psf) according to ANSI A58.1* The operational wind speed at a reference height of 10 m (30 ft) is 16 m/s (35 mph). The corresponding wind pressue at the centerline of the receiver is 0.41 kPa (8.5 psf);

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*ANSI A58.1-1972. Building Code Requirements for Minimum Design Loads in Buildings and Other Structures.

3) Seismic load - The equivalent static g values at the top of the steel tower are shown in Table 5.2-7.

Table 5.2.7 Equivalent Static-g Values for Steel Tower

	Ground Acceleration, $\ddot{X}_g$ (g)	Tower Top Vertical Acceleration, $\ddot{X}_{TT}$ (g)	Tower Top Lateral Acceleration, $\ddot{X}_{TT}$ (g)
Operational	0.30	0.90	0.38
Survival	0.50	1.50	0.62

The support structure was designed to withstand the above loads and other applicable loads such as snow, rain, ice, etc.

Operational Wind and Seismic Load on the Common-Wall Panels - The stresses caused by these loads on the common-wall panels were evaluated. The wind loads were found to govern the design. Since the wind loads cause primary bending stresses, the allowables are 1.5 k S, where k is 1.2 (Section VIII, Div 2) and S is the allowable stress given in Section I. The preheater panel was also found to be more critical than the boiler panel. The stresses in the preheater panel due to the operational wind load of 0.41 kPa (8.5 psf) was calculated to be 121.35 MPa (17.6 ksi). Since the allowable stress is 149.0 MPa (21.6 ksi), the design is acceptable.

5.2.3.3 Instrumentation and Control - Instrumentation is required for the receiver control system. The measurements include temperatures, pressures, flow rates and drumwater level. The receiver control system consists of a feedwater regulator, an output pressure regulator, and a continuous-blowdown regulator. A schematic flow diagram illustrating the essential instrumentation, valving, and controls of the receiver is shown in Figure 5.2-9. Feedwater is controlled by a feedwater regulator that matches feedwater flow to the total flow leaving the receiver, with a trimming override in response to drum level. The total flow leaving the receiver is determined by measurements of the blowdown flow and the saturated steam flow. The blowdown flow is regulated by a preset blowdown ratio with reference to the measured feedwater flow.

5.2.3.4 Feedwater Supply and Boiler Blowdown - The water supply for the receiver is provided from Exxon-owned and -operated wells. The wells draw water from a depth of 304.8 m (1000 ft). Water is treated in units containing ion exchange beds, the same commercial type currently used at the site. A booster pump at the bottom of the tower delivers the treated water to the preheater inlet of the receiver. Water quality information before and after treatment is shown in Section 3.4.2 of the System Requirements Specification (Appendix C). Because of the dissolved solids in the feedwater, a substantial amount of continuous blowdown from the drum is necessary to maintain the total dissolved solids (TDS) in the boiler water at the tolerable level. The combination of this hot blowdown water with the saturated steam from the drum results in a wet steam at the receiver outlet.

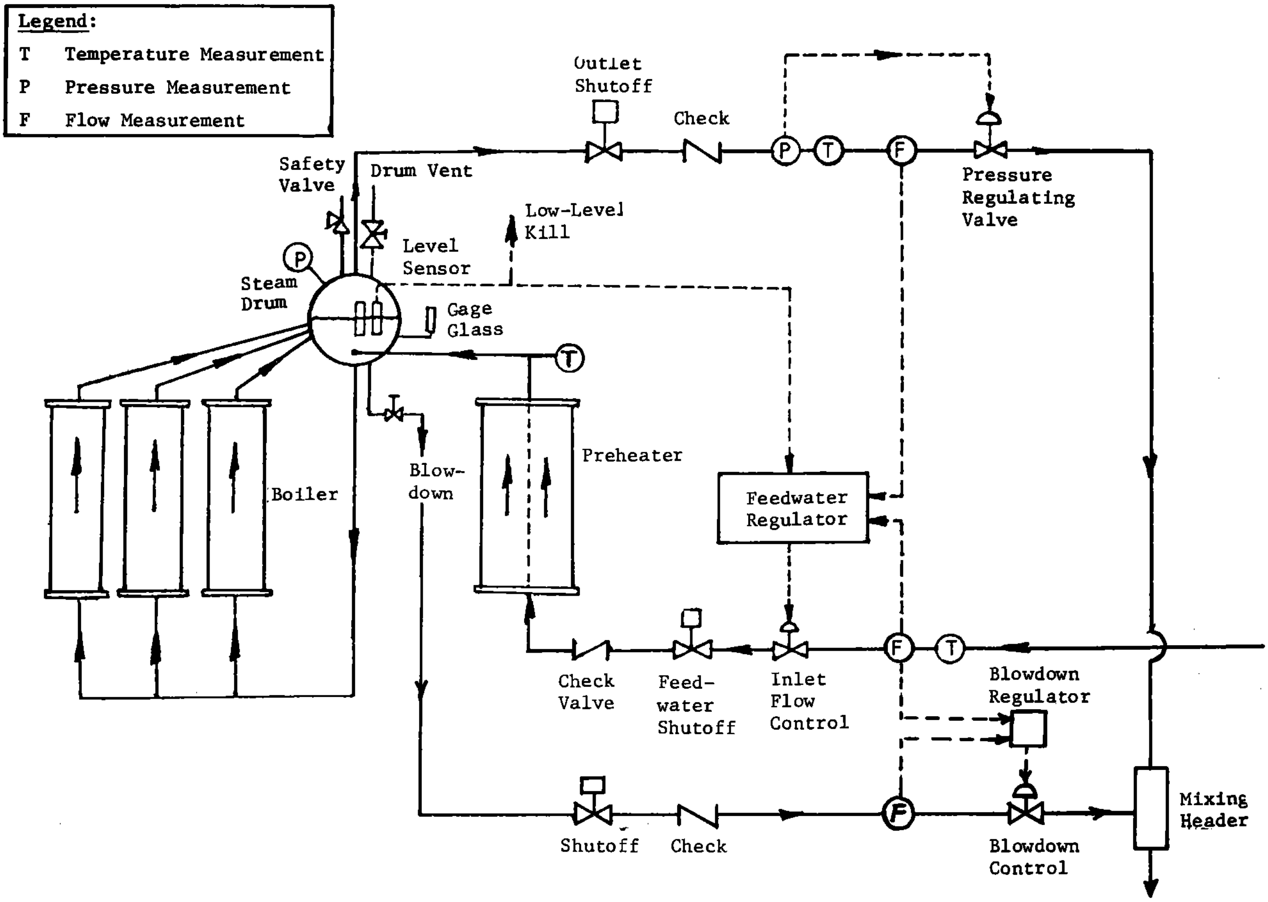

Figure 5.2-9 Receiver Schematic

The outlet steam quality (percent by weight) is determined by the ratio of blowdown-to-feedwater flow as illustrated in Figure 5.2-10. The TDS in the boiler water is a function of the TDS contained in the feedwater and the ratio of blowdown to feedwater. Curves generated for three different concentrations in the feedwater are also given in Figure 5.2-10.

From the water quality data, the total dissolved solids in the feedwater after treatment were found to be approximately 540 ppm. With a selected blowdown rate equal to 17.5% of the feedwater flow, the steam quality after mixing is 82% by weight, and the total dissolved solids in the boiler water amount to approximately 2500 ppm. These two operating points are shown in Figure 5.2-9. The 82% quality steam is acceptable for the enhanced oil recovery application because the existing oil-fired, once-through steamers generate the steam of a quality from 75 to 80%. For the operating pressure of 8.27 MPa (1200 psia), the American Boiler Manufacturer's Association (ABMA) recommends that the boiler water be limited to 1000 ppm TDS. However, this recommendation is based solely on the ability of the drum to deliver dry steam. Since the dryness of the steam is not required for this application, a higher concentration of TDS in the boilier water is tolerable. Another con-

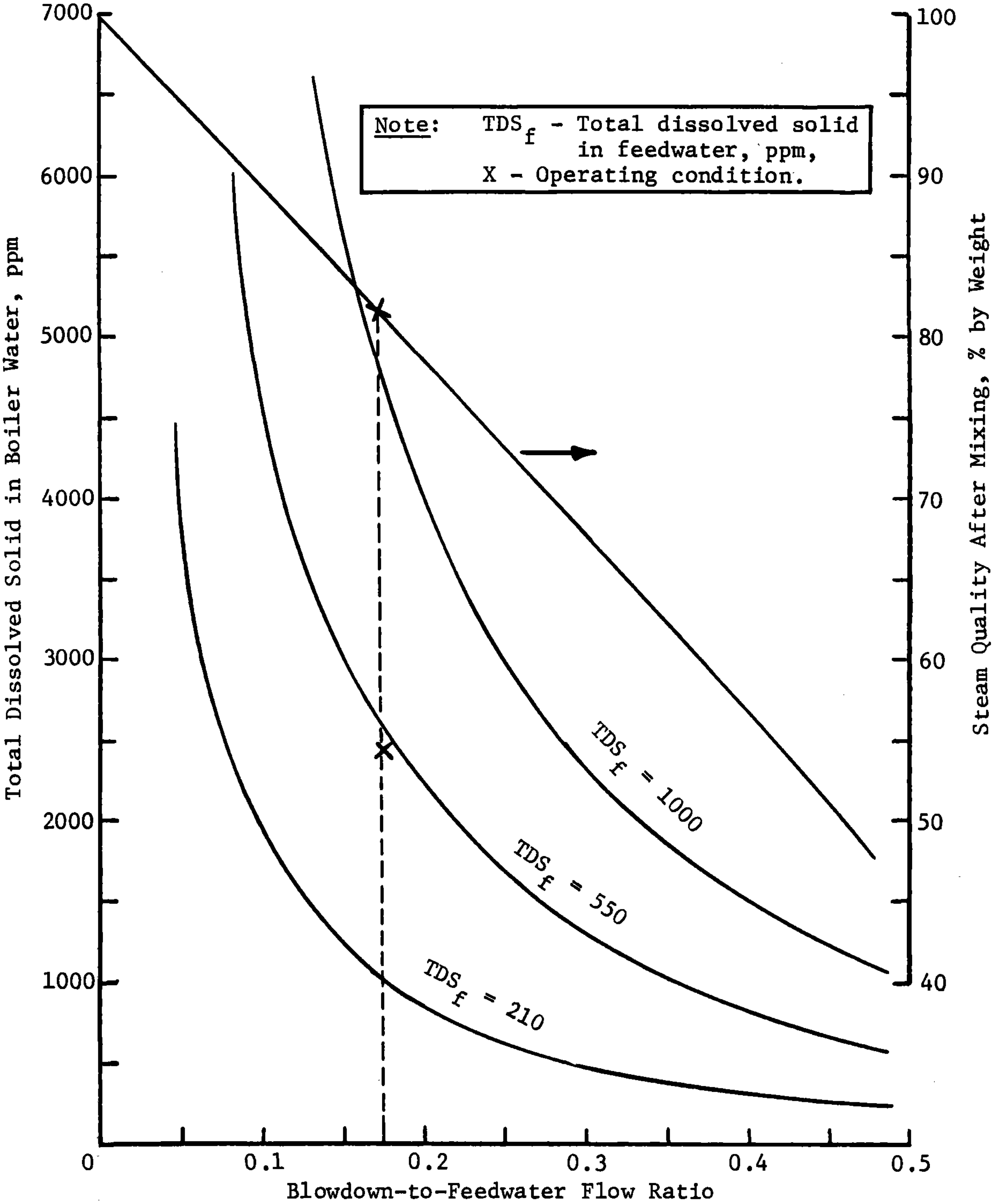

Figure 5.2-10
Blowdown Ratio vs Outlet Steam Quality and Concentrations of Total Dissolved Solids

cern is that high-TDS water could cause foaming and film boiling in boiler tubes and result in tube failures. Tube failures have been observed in large fossil-fueled, natural-circulation boilers built for the EOR application. High TDS was partly responsible for some tube failures because the boiler water was concentrated five times, resulting in 15,000 to 25,000 ppm TDS. While test data and empirical correlations are lacking in this area, it is generally regarded as a safe operation to limit the TDS concentration in the boiler water to 3000 ppm for this application. Field tests of a scaled-down receiver with the specified water quality and operating conditions are recommended.

5.2.3.5 Operating Modes - During normal operation the receiver delivers steam to the field distribution piping system at controlled outlet conditions of 8.27 MPa (1200 psia) and 297°C (567°F). The amount of steam generated at any instant is a function of the incident energy and receiver losses, assuming quasi-steady-state operation. Steady-state is never totally achieved because the incident energy is constantly changing as the sun's angle changes throughout the day. Therefore there is some thermal capacitance lag between incident energy and rate of steam generation.

A comparison of startup and shutdown transients shows that the receiver system can accommodate the latter much easier than the former. During a shutdown transient when the incident heat flux to the receiver is cut off, heat exchange occurs between the boiler, preheater, and cavity interior surfaces and from the receiver exterior surfaces to the surroundings. The closed cavity doors and insulated walls minimize heat loss from the receiver. Heat soaks back into the boiler section at a moderate rate, and any slight overpressure caused by this heat flow in the initial period of the transient can be either vented from the steam drum or regulated by the outlet pressure regulator. The tube panels, when experiencing gradual decreases in temperature level and front-to-back wall temperature gradients, are subjected to a stress condition no more severe than that encountered during steady-state operation. Therefore analytical studies were concentrated on startup transients only.

The selected receiver concept was evaluated for both hot and cold startup operations. A computer program developed for transient overall receiver heat balance calculation was used in this analysis. This program models the entire receiver by lump-mass nodes, uses a sequence of steady-state intervals to approximate a transient period, and performs a simplified heat balance calculation for each time interval.

The hot startup considered was a typical diurnal morning startup of the receiver after overnight shutdown. Analysis shows that after a 14.5-hour overnight cooldown with the aperture doors closed, the receiver experiences only a 70.6°C (127°F) saturation temperature drop. Consequently the receiver can be restarted each morning from a relatively hot standby state. The sunrise-to-noon incident energy rate to the receiver used in this analysis was derived from summer solstice, Barstow insolation data. The available power absorbed by the receiver for this condition is shown in Figure 5.2-11 as a function of time. The results of an acceptable summer solstice hot startup are depicted in Figure 5.2-12. The drum starting pressure of 2.63 MPa (367 psia) corresponds to the 70.6°C (127°F) overnight saturation temperature drop. As shown from this figure, the drum can be raised to full pressure in 30 minutes.

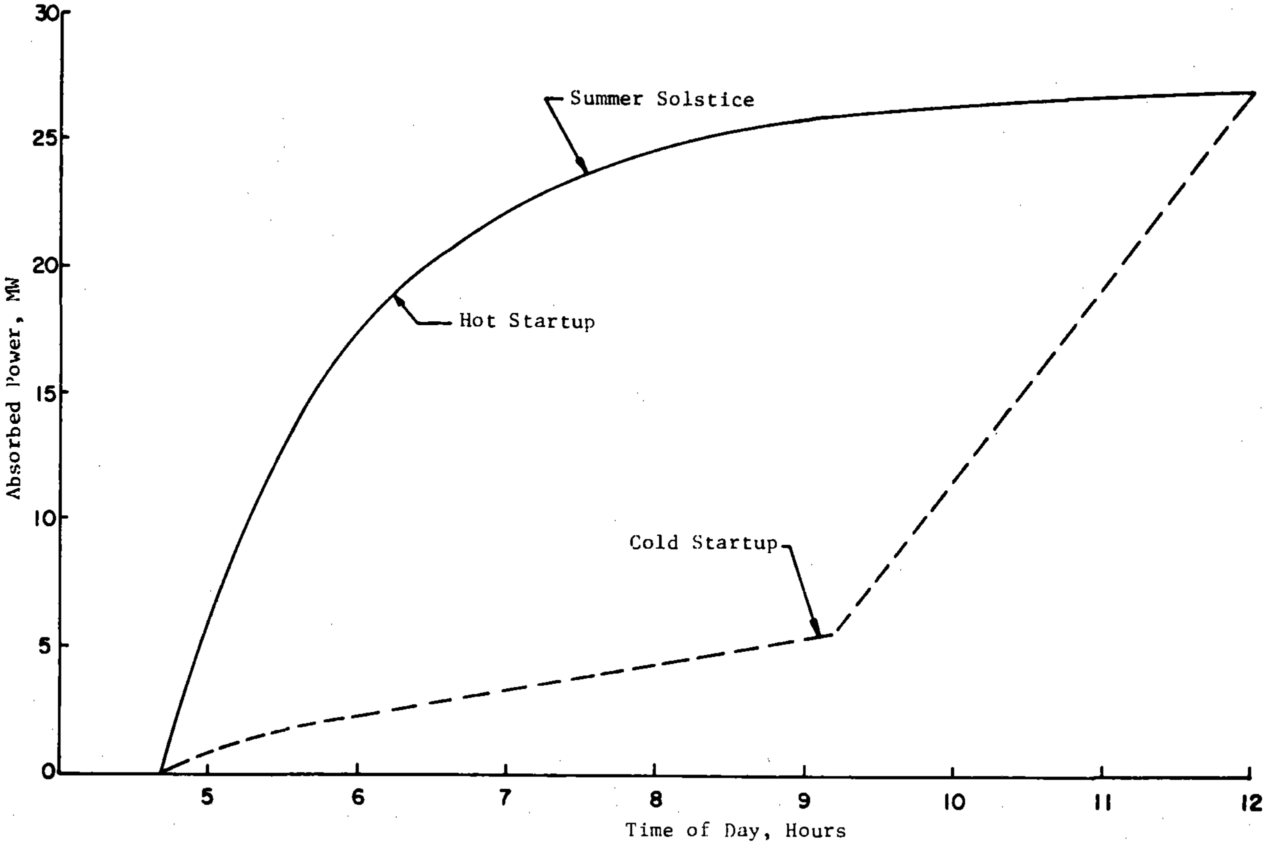

Figure 5.2-11 Rates for Hot and Cold Startups

Cold startup is anticipated when the receiver is first put into operation or is started after a prolonged shutdown period. The receiver is assumed to be at the ambient condition before starting. When starting from this condition, the receiver cannot absorb the fully concentrated solar energy without overheating components, especially during the early period of startup when no steam is being generated.

Thus the incident energy to the receiver must be greatly reduced by defocusing the heliostats. Pertinent results of a typical cold startup are shown in Figure 5.2-13. As indicated in the figure, it takes 60 minutes from sunrise for the receiver to start generating steam, and a total of 270 minutes to reach the full pressure. The energy incident of the receiver was assumed to increase gradually in the early stage of the transient and more rapidly during the later portion as shown in Figure 5.2-11.

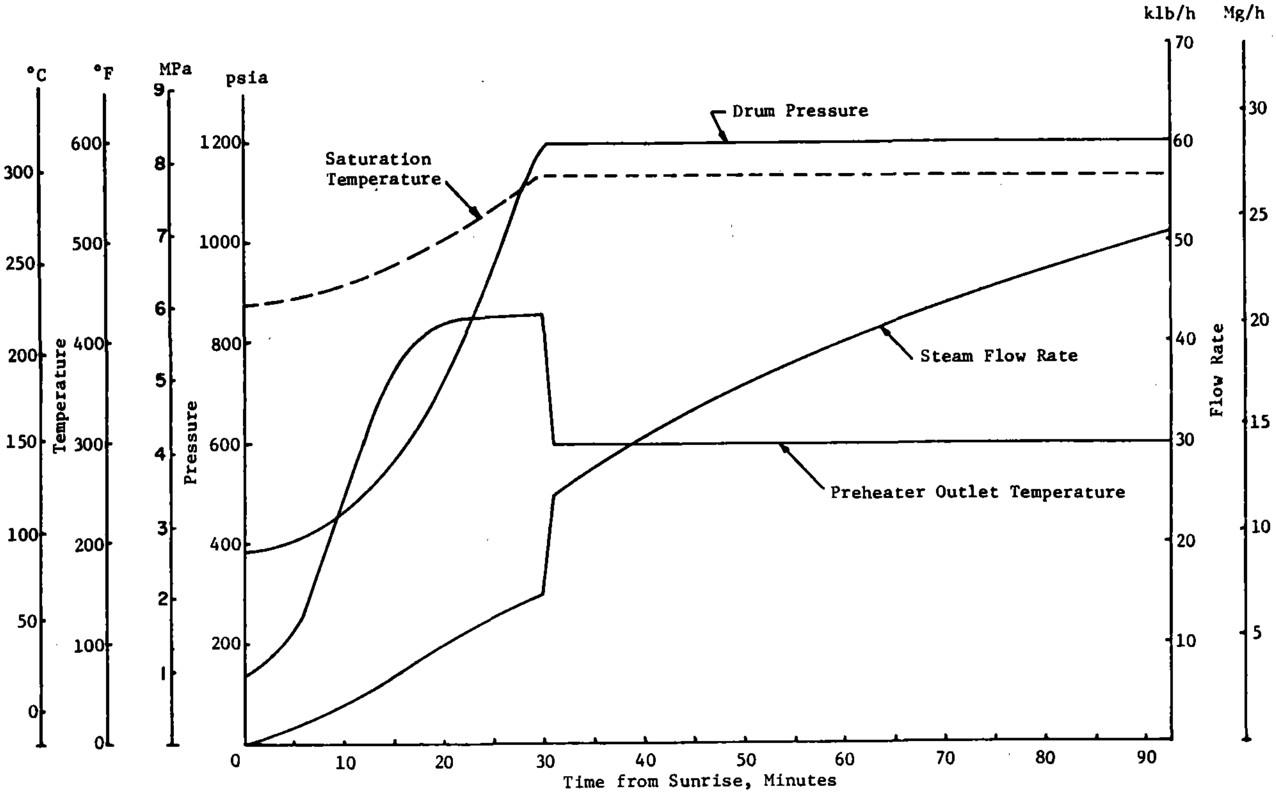

Figure 5.2-12 Receiver Hot Startup Predictions

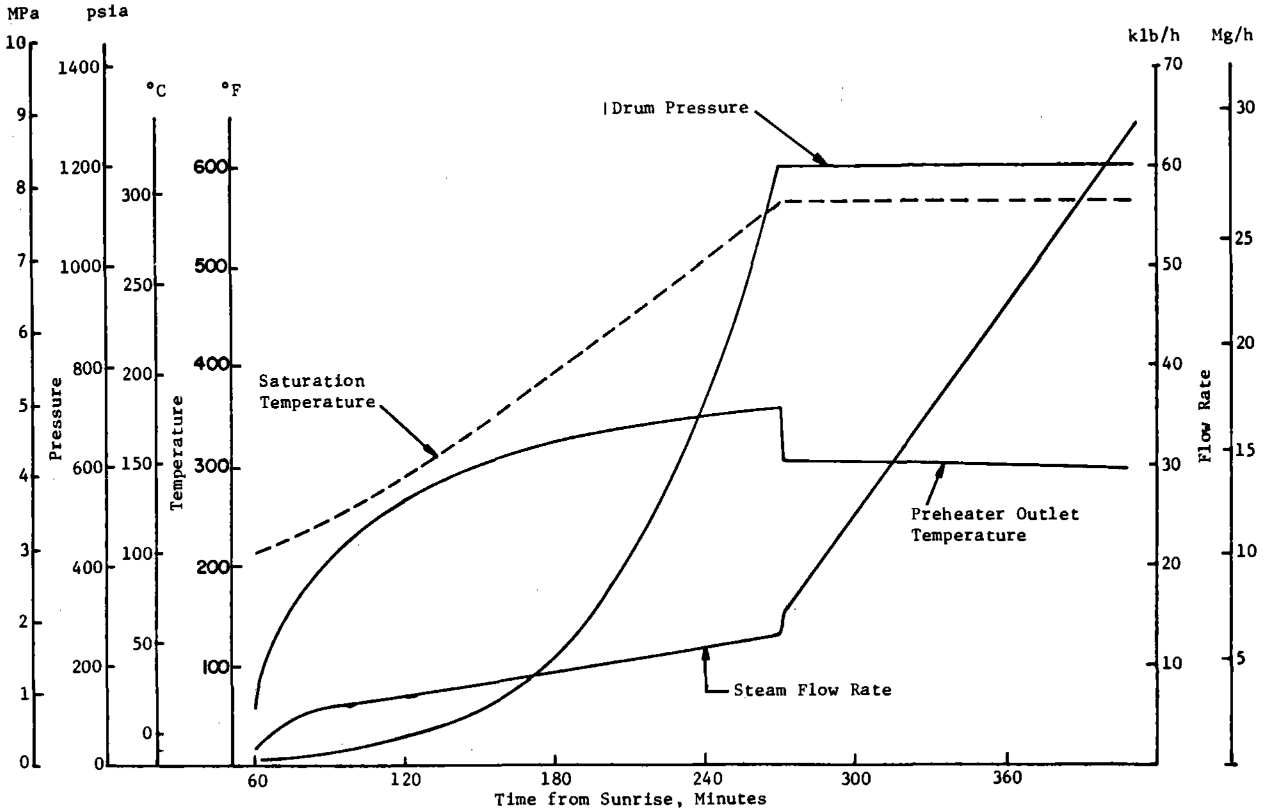

Figure 5.2-13 Receiver Cold Startup Predictions

5.2.3.6 Receiver Weights - The weights of the receiver key components were calculated. Table 5.2-8 summarizes the weights and selected materials for these compontents. The total estimated weight of the receiver is 139.4 Mg (307.3 klb).

Table 5.2.8
Summary of Material and Estimated Weight of the Selected Receiver Concept

	Material	Weight, kg x 10^3 (lb x 10^3)	
1. Pressure Parts			
Steam Drum	SA-516 Gr 70	13.11 (28.9)	
Downcomers	SA-106 C	2.31 (5.1)	
Boiler Panels	SA-210 A-1	8.44 (18.6)	
Boiler Headers	SA-106 C	2.63 (5.8)	
Feeders & Risers	SA-210 A-1	1.09 (2.4)	
Preheater Panels	SA-210 A-1	3.04 (6.7)	
Preheater Headers	SA-106 C	0.45 (1.0)	
Connecting Piping	SA-106 C	1.36 (3.0)	
Subtotal Pressure Parts			32.4 (71.5)
2. Cavity Enclosure & Doors			
Casing Plate & Stiffeners	Carbon Steel	21.00 (46.3)	
Insulation	Mineral Wool	6.49 (14.3)	
Lagging	Aluminum	2.54 (5.6)	
Subtotal Enclosure & Doors			30.0 (66.2)
3. Structural Steel	Carbon Steel		43.1 (95.0)
4. Platforms & Ladders	Carbon Steel		9.1 (20.0)
5. Miscellaneous Accessories			13.6 (30.0)
Total Receiver Dry Weight			128.2 (282.7)
Contained Water Weight at 15.6°C (60°F)			11.2 (24.6)
Total Estimated Weight			139.4 (307.3)

5.3 FIELD PIPING SUBSYSTEM

The field piping subsystem distributes the steam produced by the solar receiver and fossil boilers to the injection wells. The distribution is accomplished by crosstying the discharges of the receiver and fossil boilers with header piping and then branching from the header to the selected injection wells. Since only a few of the total wells on the site will be injected simultaneously, the subsystem is designed to accommodate relocation of the injection well pattern by addition and deletion of wells throughout the expected production life of the site. Selection of the field piping subsystem was primarily based on satisfying the functional requirements (as described later in this subsection) with a system of high reliability and low capital cost.

5.3.1 Major Components, Functional Elements and Physical Location

The major components include header and branch piping, pipe supports, insulation and lagging, piping accessories to accommodate thermal expansion, valves, and instrumentation.

The header piping interfaces the receiver outlet with the fossil boilers. Figure 5.3-1 shows the header piping arrangement to both the nearest and farthest injection well patterns. The header piping interfaces with the receiver at the receiver outlet near the top of the tower. It extends down to the base of the tower and then runs horizontally aboveground through the operating injection well pattern and to the fossil boilers. The offsets shown in Figure 5.3-1 indicate points in the header piping where provisions are made to accommodate thermal expansion.

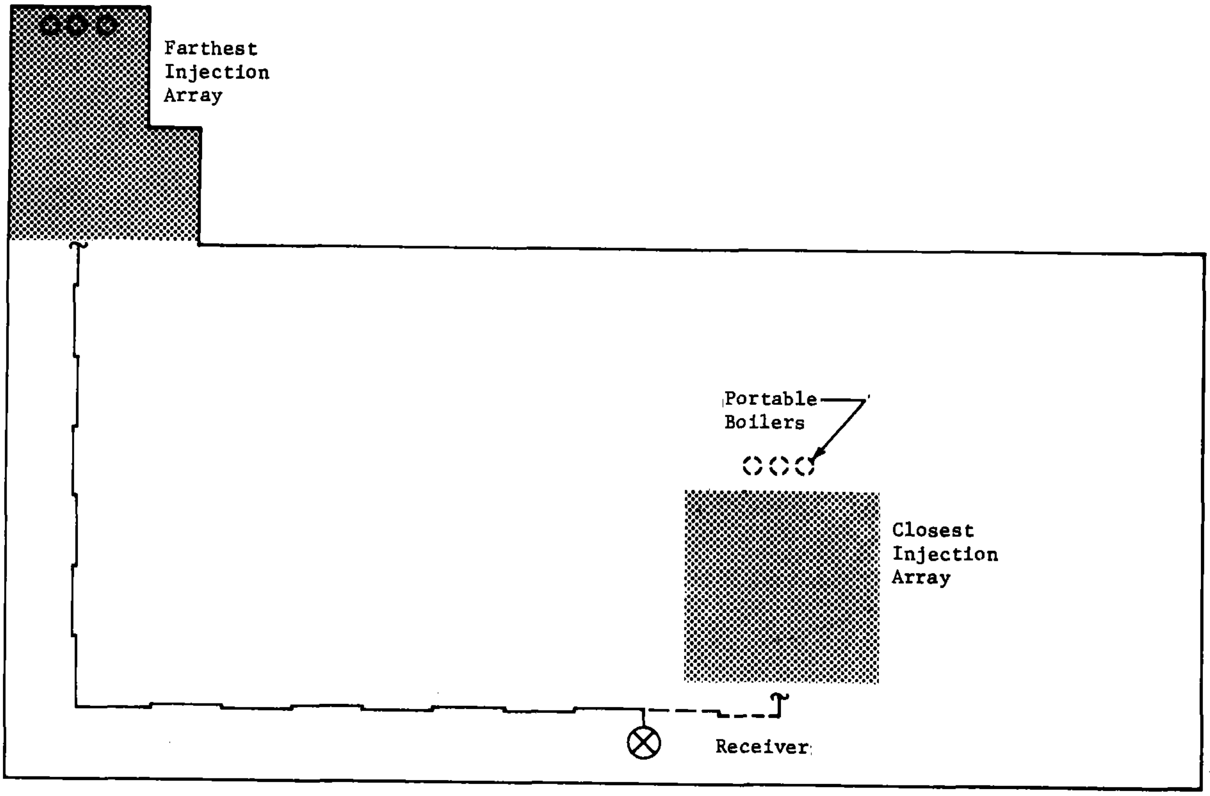

Figure 5.3-1 Header Piping Layout

The branch piping for a typical injection well pattern is shown in Figure 5.3-2. In this typical pattern, 12 wells are injected simultaneously; the approximate average distance between wells is 100 m (330 ft). As the injection well pattern is moved throughout the field, branch piping to the three wells located nearest the solar receiver is cut and capped near the header. This branch piping is further cut into sections manageable for relocation (approximately 15 m (50 ft) in length). The header piping is cut near the fossil boilers and the portable fossil boilers are then moved just beyond the three new in jection wells. A new section of piping is then welded into place to connect the header to the fossil boilers. The branch pipe previously cut from the system is used to the maximum extent possible in connecting the new wells to the header.

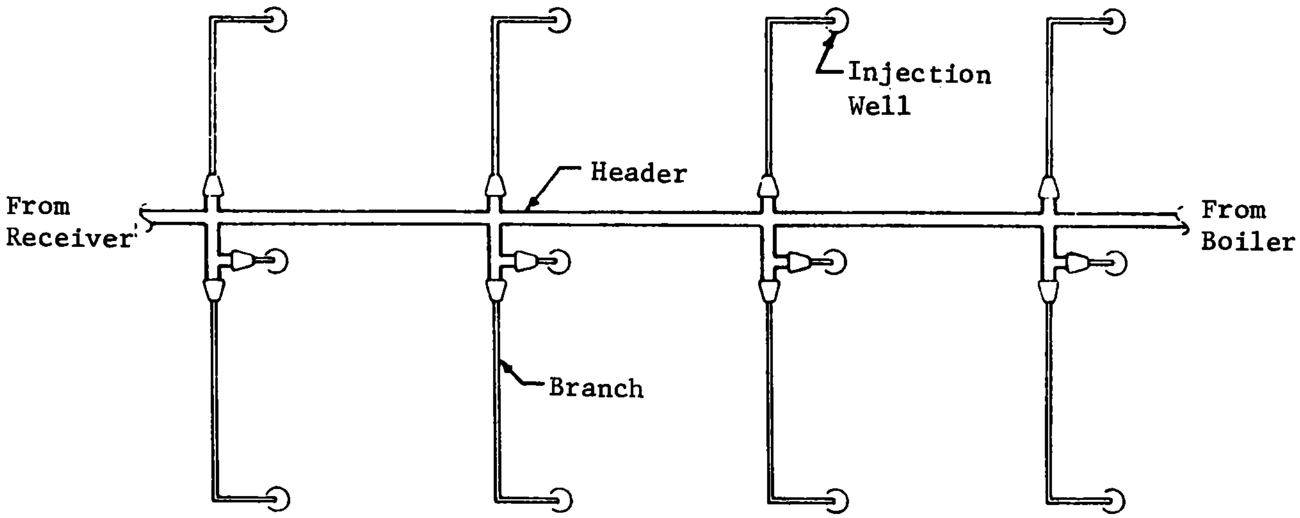

Figure 5.3-2 Well Injection Arrangement

Field piping is typically supported aboveground as shown in Figure 5.3-3. The exception to this approach occurs at roads where the piping is at ground level and mounded with soil to permit vehicle crossing. By locating the pipe aboveground, cathodic protection is not required.

Insulation is provided for all piping to reduce heat loss to the atmosphere. In addition, lagging and a moisture barrier are used to protect the insulation as shown in Figure 5.3-4.

A method of accommodating thermal expansion is also provided. The method utilizes offset piping swivel ball joints to allow for thermally induced pipe movement.

The field piping subsystem provides for isolation and overpressure protection of the wells with an isolation valve and relief valve for each well branch.

To monitor the well steam supply pressure, a pressure transmitter is located on the header pipe at the approximate center of the well pattern. This transmitter is moved periodically as the well patterns shift.

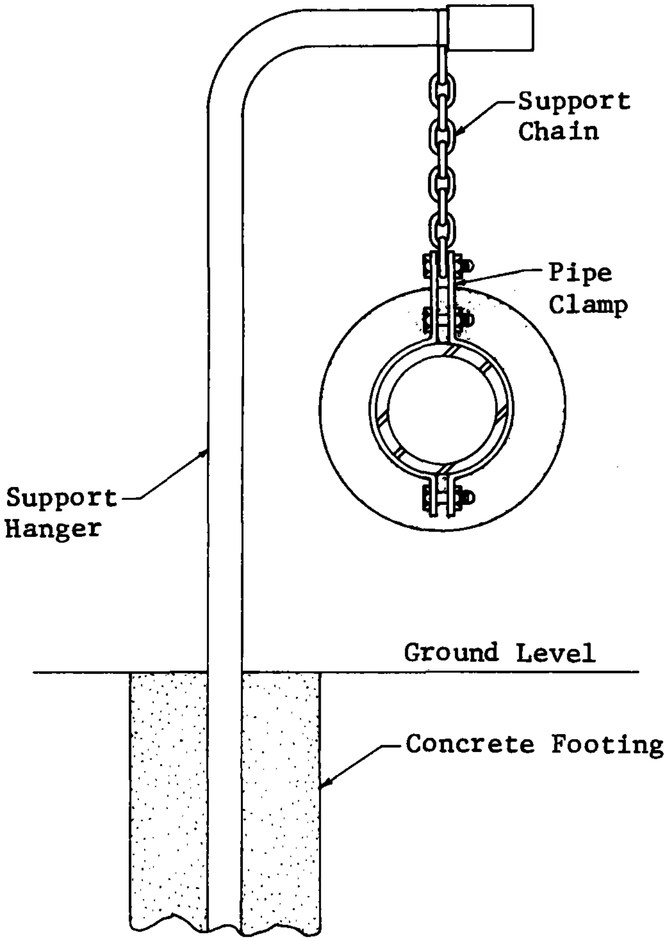

Figure 5.3-3 Typical Pipe Support

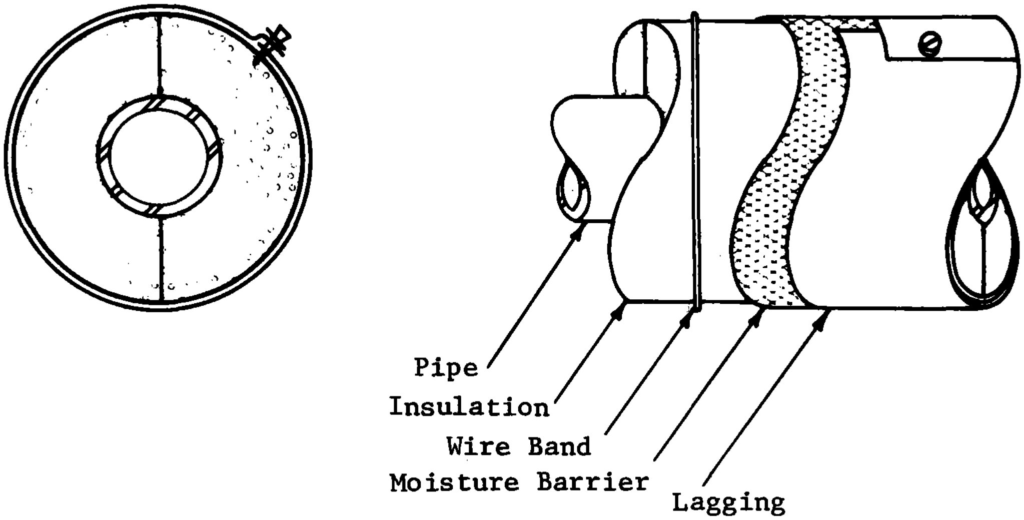

Figure 5.3-4 Typical Pipe Section

5.3.2 Functional Requirements

The field piping subsystem is designed to:

1) Deliver steam to any injection well at a pressure within the acceptable limits;

2) Limit heat loss from the piping system to an economical minimum;

3) Provide ruggedness (as required by the outdoor installation) and dependability with a minimum of routine maintenance.

To provide sufficient driving steam force in the formation, a minimum steam pressure of 5.62 MPa (800 psig) is required. To avoid fracturing the formation, the maximum well operating pressure is 7.00 MPa (1000 psig). Thus if the nearest well is supplied with steam at the maximun operating pressure, the piping pressure drop to the farthest well must not be greater than 1.38 MPa (200 psi) above the pressure loss to the nearest well.

Piping heat loss is limited to the economical minimum by optimizing the insulation thickness as described in the tradeoff studies (see Subsection 3.1.4).

The field piping system is designed for reliability by providing;

1). Lagging and moisture barrier for insulation protection;

2) An adequate corrosion/erosion allowance for the pipe wall thickness;

3) A proven, low-maintenance method of allowing for thermal expansion.

5.3.3 Design

The specific design of the major components of the field piping subsystem are described in terms of materials, sizes, and trade names (where appropriate).

All piping is ASTM A53 grade B schedule 80 seamless carbon steel pipe. Schedule 80 pipe allows for 3.81 mm (0.15 in.) of corrosion/erosion on the pipe wall thickness; corrosion of the internal pipe wall occurs during system shutdown and erosion occurs as the wet steam flows through the pipe.

Both the header and branch piping are insulated with 8.9 cm (3.5 in.) of Micro-lok 650 insulation. This insulation thickness and type was selected from the optimization analysis conducted in the tradeoff studies (see Subsection 3.1.4). Micro-lok 650 is a rigid, lightweight, heavy-density fiberglass pipe insulation designed for temperatures up to 370°C (650°F). The insulation, which is held in place by wire loops, is protected by aluminum jacketing with a thickness of 0.51 mm (0.020 in.). An asphalt and kraft paper moisture barrier is atached to the inside surface of the jacketing. All jacketing joints are over lapped and placed to shed water. Joints that cannot be effectively sealed by overlapping are weatherproofed by application of an aluminum pigmented sealer.

The method of accommodating the thermal expansion, which occurs when the piping system is heated from ambient temperature to 288°C (550°F), utilizes Barco joints piping ball joints with an angular flexing capability of 15° as well as 360° swiveling characteristics. In this application, the joints are used primarily as swivel joints. Figure 5.3-5 shows a detail of the expansion method for the header pipe using two joints at each expansion point. Thermal expansion at the wellhead is provided for with three joints as shown in Figure 5.3-6. Referring to Figure 5.3-5, as the pipe length increases due to thermal expansion, the distance between the pipe runs changes slightly because of a difference in the angle of the offsetting section relative to the pipe. The pipe support system (Fig. 5.3-3) allows for this small lateral pipe movement. However, since the wellhead is stationary, three joints are required at the well connection to accommodate thermal expansion without transmitting a force or movement to the wellhead.

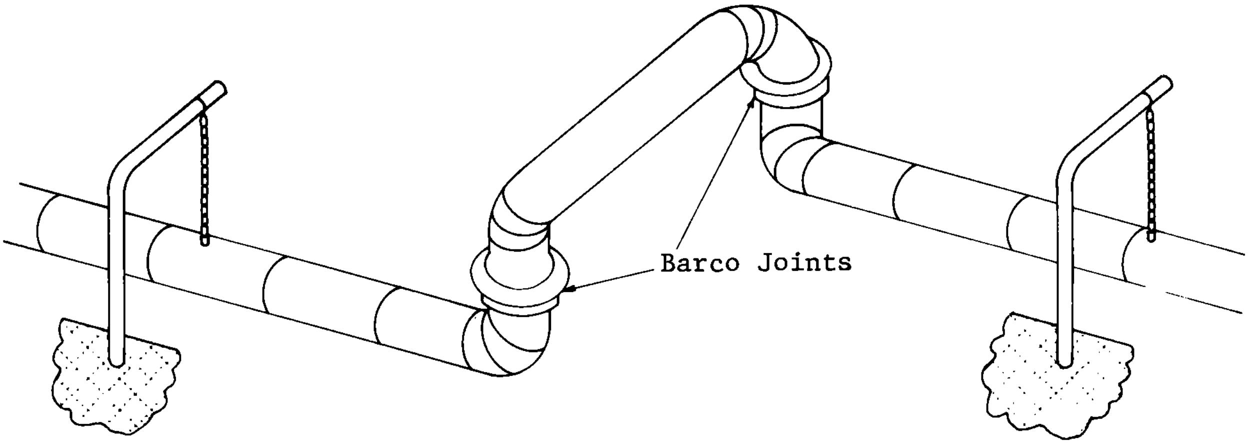

Figure 5.3-5 Thermal Expansion Technique for Header Piping

This type of support, currently used in oil fields, was chosen because of its simplicity and low cost. The support consists of a section of 80-mm (3-in.) pipe with the end embedded in a concrete footing approximately 1-m (3-ft) deep by 0.3-m (1-ft) diameter. A standard pipe clamp and chain are used to support the pipe from the hanger. The pipe supports are spaced 6-m (20-ft) apart.

5.3.4 Operating Characteristics

The field piping subsystem is designed to transport 43,590 kg/h (96,100 lb/h) of steam generated in the solar receiver to the injection wells at a wellhead pressure between 5.51 and 6.90 MPa (800 to 1000 psi). The branch piping to each well is designed for a flow of 6164 kg/h (13,591 lb/h) of steam.

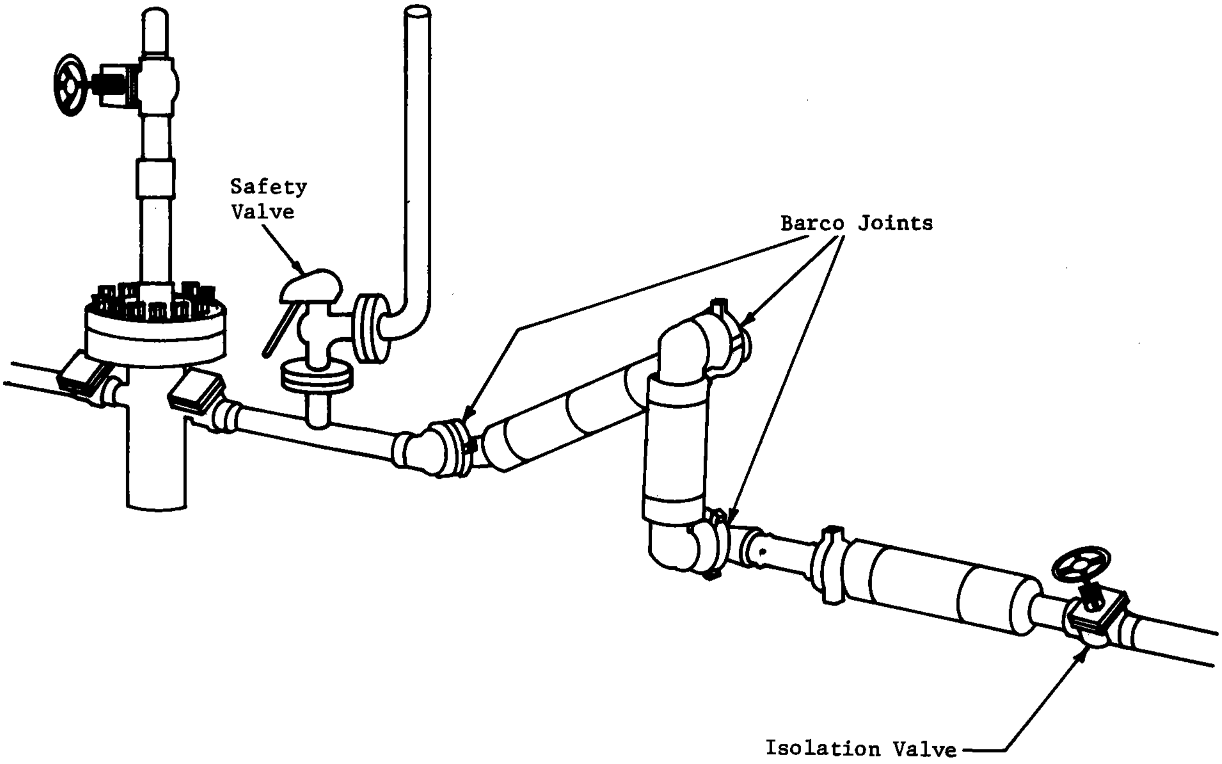

Figure 5.3-6 Thermal Expansion Technique for Well Piping

In the morning as solar energy becomes available, the receiver pressure begins to rise. As the pressure becomes sufficient to supply steam to the wells, a receiver control valve opens and steam begins to flow. Additional flow to the wells is provided by the fossil-fired boilers, which have a total capacity of 30,390 kg/h (67,000 lb/h). As insolation declines near dusk and receiver pressure begins to decay, the pressure control valve begins to close. At night the entire injection load is maintained by the fossil boilers. The fossil boilers provide the additional service of pressurizing the main header while the receiver is not in use. This prevents an induction of air that would cause corrosion in the piping system.

The injection array is moved at a rate of three wells each year. After cutting the header and branches as described earlier, the ends are beveled in accordance with ANSI butt weld end preparations for the particular size and schedule of pipe involved. As the header length increases with each additional array, Barco joints are added as shown in Figures 5.3-1 and 5.3-5.

The Barco joint gasket life is a function of the number of rotational and flexing cycles they perform and, in this installation, leakage at the gaskets may occur at a rate of approximately one-third of the joints in service per year. Gasket repair is accomplished by adding packing. The packing comes in tubes and is injected through the packing connections located on each Barco joint.

5.3.5 System Performance

The field piping subsystem performance can be evaluated from the perspective of pressure loss and heat loss. Figures 5.3-7 and 5.3-8 show pressure loss and heat loss respectively as a function of main header length. Predicted values of these parameters can be determined by reading the header loss on the solid line and the total head and branch loss on the dotted line for any header length from the receiver to the farthest injection array of approximately 1890 m (6200 ft).

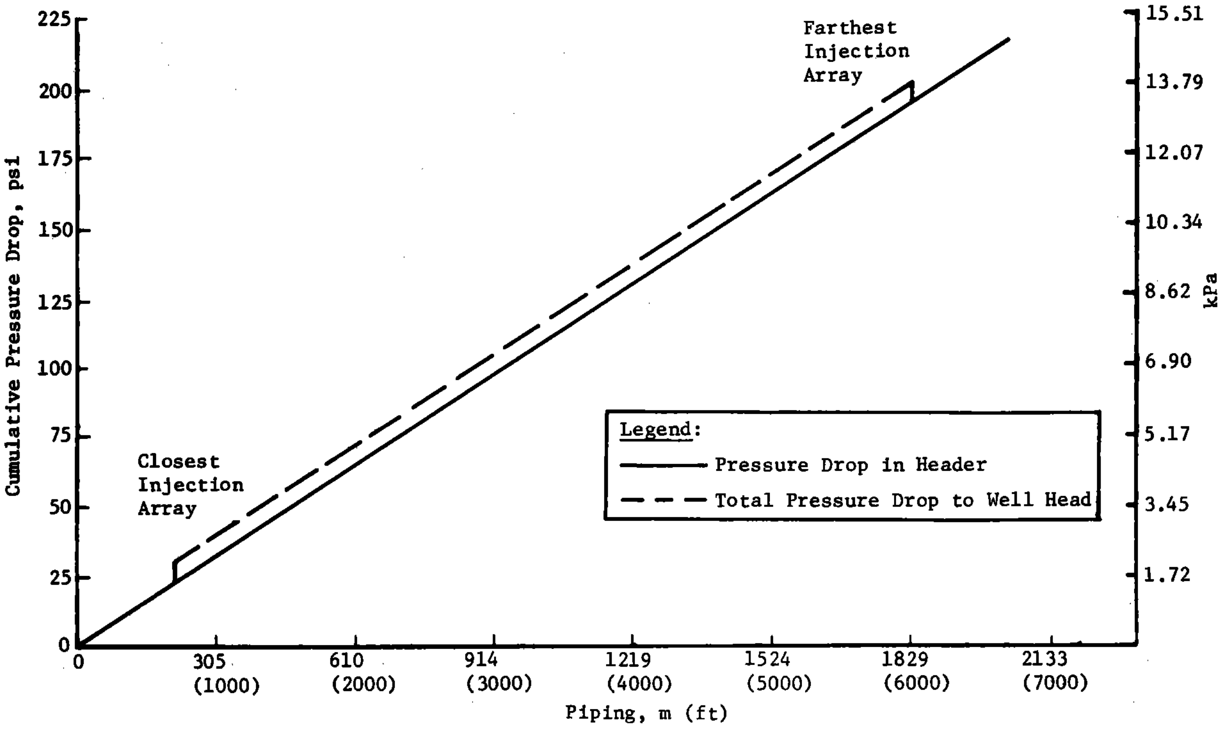

Figure 5.3-7 Pressure Drop - Receiver to Well Head

The maximum pressure loss is to the farthest well and is 1.45 MPa (210 psi). The minimum pressure loss is to the nearest well and is 0.21 MPa 930 psi). Thus with the nearest wellhead steam pressure of 6.9 MPa (1000 psi), the farthest wellhead pressure is 5.65 MPa (820 psi). These values are within the wellhead pressure constraints of 5.51 to 6.9 MPa (800 to 1000 psi). The pressure loss analysis is based on empirical friction factors and equations and the Darcy formula.

The field piping subsystem heat loss was analyzed by a two-dimensional series heat transfer model. The results of this analysis, showing the cumulative heat loss at any point in the piping system, are shown in Figure 5.3-8. For a given main header length, the heat loss in the header can be read from the solid line and total loss to the well can be read from the dashed line. Specific empirical data on the conductivity of the pipe, insulation and lagging as a function of temperature were used. Internal convective coefficients were determined by pressure, temperature and velocity of the steam at several points along the pipe. External convective coefficients included a design wind velocity of 4.9 m/s (11 mph) at an ambient temperature of 18.3°C (65°F). Also included were radiation losses, which assumed an emissivity for the aluminum lagging. The heat loss shown is for 150-mm (6-in.) schedule 80 header and 80-mm (3-in.) schedule 80 branch piping, both with 95 mm (3.5 in.) of Micro-lok 650 insulation, moisture barrier and lagging.

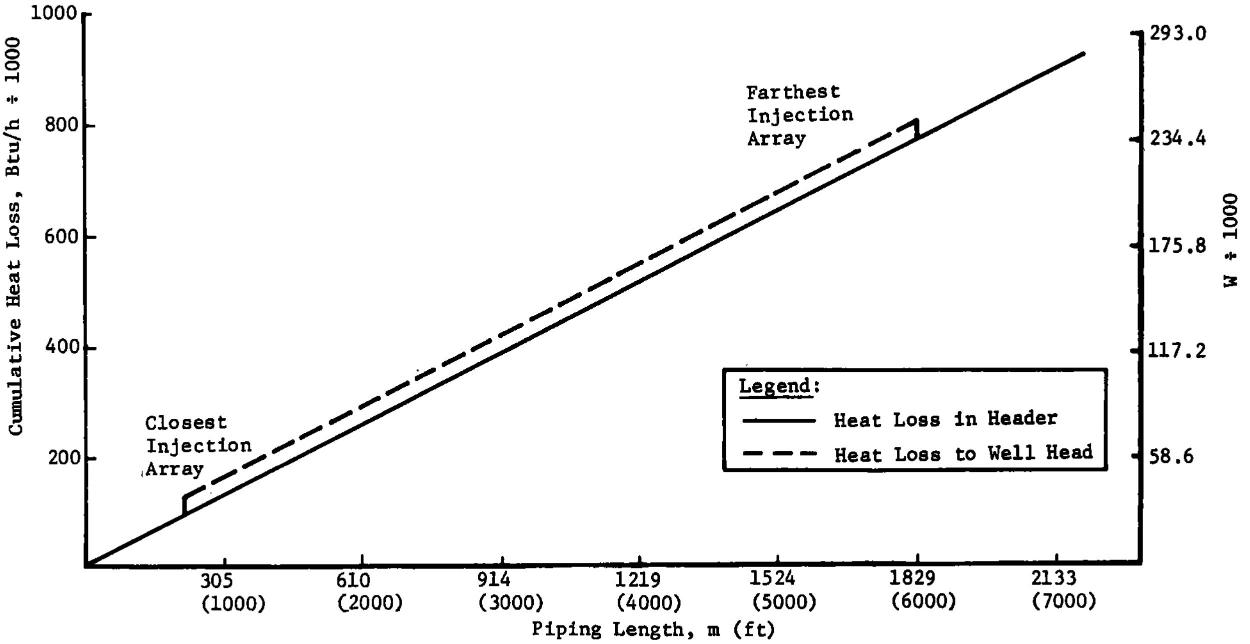

Figure 5.3-8 Heat Loss - Receiver to Well Head

6.0 ECONOMIC ANALYSIS

A major consideration in the economic analysis of the central receiver STEOR conceptual design was to assess the near-term economic viability to the potential user, Exxon. Therefore the assessment of the STEOR system has been made using all available user economic parameters, and a methodology modified to accurately reflect the commercial environment. The analysis has shown that this STEOR concept is a viable alternative to conventional TEOR processes, both economically and in terms of fuel displacement, with present heliostat costs.

6.1 METHODOLOGY

The methodology used in the assessment of the STEOR retrofit concept differs from the "traditional" required revenue methodology that is customarily used for evaluation of solar thermal systems in the utility environment. The required revenue methodology is used to calculate a levelized busbar energy cost ($\overline{BBEC}$) that the utility must charge for energy to recover all cost incurred, including taxes on that revenue. However, in this commercial EOR application, only the costs incurred by the user are considered. The required revenue methodology, as described in The Cost of Energy from Utility-Owned Solar Electric Systems, was modified to calculate an "after-tax" levelized energy cost in terms of dollars per MWht ($/MBtu) of output.

The levelized energy cost is calculated by

$$\overline{EC} = \left[\left(\overline{FCR} \times CI_{PV}\right) + (1 - \tau)(CRF)\left(OM_{PV} + Elect_{PV} + Fuel_{PV}\right)\right] \Big/ \text{Annual Output}$$

where FCR is the levelized fixed charge rate, CRF the capital recovery factor, and τ the applicable corporate tax rate. CI_{PV} accounts for all capital expenditures prior to commercial operation; OM_{PV}, $Elect_{PV}$ and $Fuel_{PV}$ are the present values of all recurring costs incurred during operation over the system life, namely operations and maintenance (OM), electricity purchases (Elect) and any fuel burned (Fuel). The levelized fixed charge rate (FCR) is a value that, when applied to the capital investment over the life of the plant, expressed the constant fixed charges required to recover the investment, allowing for depreciation and investment tax credit effects. For this project, the FCR is calculated by

$$FCR = [1 - \tau(DPF) - \alpha]\ CRF + (1 - \tau)\ (\beta_1 + \beta_2)$$

where DPF is the depreciation factor for the applicable depreciation method and period, α is the investment tax rate percentage, and $\beta_1 + \beta_2$ is the combined insurance and property tax rate.

The economic analysis performed for this study is a straightforward comparison of the costs of the proposed STEOR system and cost of a conventional Struthers Thermoflood® steamer currently in use at the site. This approach was chosen because in the anticipated steam drive operations at the Edison field, the STEOR system would be installed in lieu of a conventional 25 MBtu/h steamer. The projected annual steam output of the solar system using Fresno insolation data is very close to the steam output of a conventional steamer (within 1%) and, consequently, instead of four conventional steamers used for steam drive, three conventional steamers and the solar system would be used. Since the methodology has been developed to calculate the levelized cost of energy, this economic analysis involves comparing the levelized cost of producing injection steam from both the solar and conventional systems in terms of $/MWht ($/MBtu).

6.2 ECONOMIC ENVIRONMENT FOR ASSESSMENT

As mentioned in the introduction to this section, a primary consideration in the economic analysis is to assess the economic viability to the STEOR concept to the user, Exxon USA. The economic parameters used in the analysis, developed with Exxon, are shown in Table 6.2-1.

Table 6.2-1 Economic Parameters

System Life	26 Years
Initial Year of Operation	1985
Rate of Return (Discount Factor)	15%
Depreciation Period	11 Years
Depreciation Method	ADR
Federal Income Tax Rate	46%
State Income Tax Rate	9%
Composite Tax Rate	50.86%
Investment Tax Credits (Solar)	30.4%
Investment Tax Credits (Fossil)	10%
Insurance and Property Tax	2.25%

The depreciation method, accelerated depreciation ratio (ADR), is a composite accelerated depreciation calculation where the double-declining method is used for the first two calendar years, sum-of-the years digits are used for the next nine calendar years, with the residual (if startup occurs midyear) taken in the last year of operation. The depreciation factor (DPF) used in the FCR equation can be calculated using a $1 investment in midyear 1985, and is equal to 0.5891. The composite tax rate of 50.86% is not a direct addition of the federal and state tax rates but accounts for the deduction of the state tax during calculation of the federal tax.

The solar investment tax credit of 30.4% comprises several separate state and federal tax credits, again accounting for some complex interrelationships. Simplified, this credit is made up of the standard 10% federal investment tax credit, 15% federal energy tax credits as specified by the 1980 Windfall Profits Tax Act, and 5.4% California tax credits. The actual California tax credit rate applicable to this project is 25%, a portion of which is not allowed if federal credits are taken. This value of 30.4% tax credits is believed the most realistic to be in effect in 1985. However, different expectations of the various tax credits can be found, yielding possible alternative tax credit levels between 25.0 and 33.1%. Since the baseline credit is near the midpoint of these two alternative levels, it is believed to be a reasonable choice.

6.2.1 Fuel Costs

To quantify the value of the oil displaced by the STEOR system, realistic oil costs and escalation rates must be defined. This task is complicated by two factors: (1) the oil currently burned in the steamers is heavy crude oil produced at the Edison field, and (2) the value of the oil is subject to the recently enacted windfall profits tax, other taxes and royalties. With the assistance of Exxon, the following fuel cost computation has been developed to provide a realistic value for the oil displaced by the STEOR system.

First, tertiary recovered oil is sold at a price based on the world oil price, which was $5.01/MBtu ($29.72/bbl) as of February 29, 1980,* and was rounded to $5.06/MBtu ($30.00/bbl) for this study. Since heavy oil must be refined further than light crude and is usually higher in sulfur content, there is a 10% quality debit assessed on the price of heavy oil, i.e., it sells for 90% of the world oil price. Thus oil produced at the Edison field can be sold at (0.90) (5.06) = $4.55/MBtu ($27.00/bbl). However, the producer must pay taxes on oil sold that are not levied on oil burned at the site. Thus the cost to Exxon of oil burned in the steamers is less than the $4.55/MBtu price.

The first of these taxes is an ad valorem tax of approximately 6%, yielding an oil cost after ad valorem taxes of $4.28/MBtu ($25.38/bbl). The windfall profits tax must also be calculated. It is believed this project will be classified as an "incremental tertiary project, tier 3 heavy oil," which is subject to a tax rate of 30% on the difference between the price of the oil after ad valorem taxes and a base price of $2.79/MBtu ($16.55/bbl) that escalates at the GNP deflator plus 2%. This formula equates to a tax of $0.45/MBtu ($2.65/bbl) in 1980, which yields an oil cost of $3.83/MBtu. The windfall profits tax is due to be phased out in 1991 (assuming a tax revenue target has been met) and this must be taken into account in the energy cost analysis. Finally, all oil sold from the Edison field is subject to a royalty interest of 7%, which again is not assessed on oil burned at the site.

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*EIA weekly petroleum status report, March 31, 1980.

Thus the effective value of oil burned in the steamers at 1980 prices is (0.93) (3.83), or \$3.56/MBtu (\$21.14/bbl). As can be seen, the sum effect of the windfall profits tax and the other levies is to lower the price of fuel burned from \$4.55 to \$3.56, or a difference of \$0.99/MBtu (\$5.86/bbl) as compared to burning heavy oil purchased on the market.

As for escalation rates for oil, capital and O&M, as well as the GNP deflator, various sources were consulted. A real oil escalation rate of 2.8% above the GNP deflator of 7% was used for this study, as forecasted by the U.S. government in "Rules for Life-Cycle Costing, Federal Energy Projects," published in the Federal Register on January 23, 1980, resulting in a total oil escalation rate of 10%. Capital and O&M costs were assumed to escalate at the same rate as the GNP deflator. Finally, an electricity price escalation rate of 9% was assumed, based on recent experience. This set of fuel and escalation parameters will be referred to as the "world oil price" scenario. The economic analysis of the STEOR system was also performed using fuel costs and escalation rates supplied by Sandia for the repowering/retrofit studies. All of the applicable fuel costs and escalation rates discussed here are summarized in Table 6.2-2.

Table 6.2-2 Fuel Cost/Escalation Assumptions, 1980\$

	World Oil Price Scenario	Sandia Fuel Costs
Rate of General Inflation	7%	8%
Capital Escalation Rate	7%	8%
O&M Escalation Rate	7%	8%
Fuel Cost (Oil)*	\$3.56/MBtu	\$4.00/MBtu
Oil Escalation Rate	10%	12%
*Delivered to process consumption.		

Figure 6.2-1 shows the variation of the 26-year levelized cost of fuel burned for the two sets of assumptions for a range of oil escalation rates. The levelized cost of fuel burned includes tax deductibility effects and the 15% discount factor, but not boiler efficiencies. Although the base world oil price is significantly higher than the Sandia fuel cost (\$5.06/MBtu vs \$4.00/MBtu), the effect of royalties and taxes serves to equalize the levelized costs. The two curves begin to converge at higher oil escalation rates due to increasing windfall profits taxes resulting from a greater difference between the world oil price and base price.

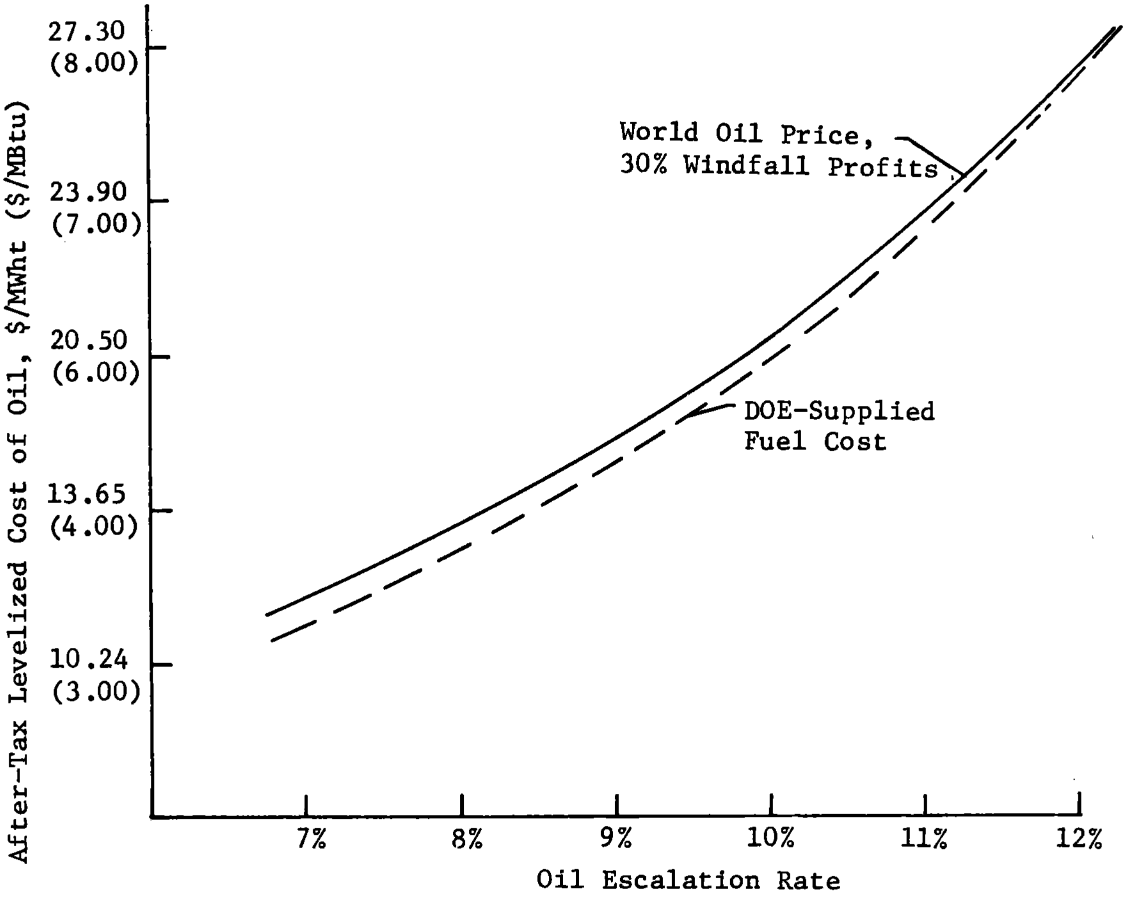

Figure 6.2-1 Fuel Cost Assumptions, 26 Year System Life

6.3 PLANT AND SYSTEM SIMULATION MODELS

As discussed in Section 4.5, the performance of the STEOR system has been analyzed using three computer models--MIRVAL, TRASYS, and STEAEC. The MIRVAL and TRASYS programs were used to model the performance of the collector field and receiver, respectively, from which performance parameters were developed for input to the STEAEC system simulation model.

The MIRVAL computer code, developed by Pat Leary and J.D. Hankins at Sandia Laboratories-Livermore, is a Monte Carlo model that evaluates collector field performance. The model evaluates tower shadow, field cosines, reflectivity losses, shading and blocking, atmospheric attenuation and spillage losses, taking into account heliostat error parameters and aperture sizes and orientations. Internal modifications were made to the code, with the assistance of Pat Leary, to account for the 0.65 rad (+37.5°) from north orientations of the apertures.

The Thermal Radiation Analysis System (TRASYS) model, a Martin Marietta CDC program, was used to calculate receiver reflection losses. The program models the reflected beam from the heliostat field and calculates incident and absorbed heat fluxes on active surfaces defined by user input nodes.

The annual system performance and energy output were evaluated using the STEAEC program also developed by Sandia Laboratories-Livermore. This program simulates the system performance at 15-minute intervals using site insolation and weather data as input. For the site weather data, the SOLMET TMY data tape for Fresno, CA was converted to a compatible format for input to STEAC.

The results of these analyses are further detailed in Section 4.5, with the net annual output summarized in Table 6.4-1 of the following section.

6.4 ECONOMIC ANALYSIS RESULTS AND CONCLUSIONS

As discussed in Section 6.1, the evaluation performed during the economic analysis and presented here is a levelized cost of energy comparison between the STEOR system and a conventional Struthers Thermoflood® oil-fired steamer. Table 6.4-1 summarizes the capital cost, yearly operating costs and annual output from each technology.

Table 6.4-1 Cost and Performance Summary, 1980$

	Conventional Oil-Fired Steamer	Solar Retrofit System
Capital Cost	$667,240	$14,033,467
Operations and Maintenance	$49,230	$301,024
Operating Consumables	$98,099	$40,927
Electric Purchases	$55,772	$38,520
Net Annual Output	55,444 MWht (189,230 MBtu)	55,870 MWht (190,684 MBtu)
Fuel Burned	253,951 MBtu (42,764 bbl)	-0-

The capital cost of the conventional oil-fired steamer consists of the following components: Thermoflood® 25 unit ($203,000), water treatment equipment ($192,000), flue gas desulphurization ($151,000) and miscellaneous support equipment ($121,000). The costs and performance of the STEOR system are discussed in Sections 4.5 through 4.7, with detailed cost estimate worksheets contained in the System Requirements Specification. All operations and maintenance expenses shown in the table include a 7% overhead charge charged at the site.

Using the methodology, economic parameters and fuel costs discussed in the previous sections, the levelized cost of thermal energy from the STEOR and conventional systems was evaluated. The significant results and overall conclusions are discussed in the following sections.

6.4.1 Levelized Cost of Energy

The baseline case is defined by the parameters shown in Table 6.2-1. The levelized cost of energy results in terms of \$/MWht (\$/MBtu), using the two alternative fuel and escalation scenarios previously discussed, are shown in Table 6.4-2. The STEOR system exhibits significant cost advantages over the conventional steamer units--a 15% reduction in the levelized cost of thermal energy using the world oil prices escalating at 10% per year. Using the Sandia-supplied delivered fuel cost of \$4.00/MBtu escalating at 12% per year, the STEOR system supplies steam at a levelized cost 30% less than a conventional steamer. The rate of return (ROR) for the STEOR system has also been calculated by determining the discount factor that would be applied to the solar system that would yield the same system net present value as the conventional system with a 15% rate of return. For the baseline case of world oil price economics the STEOR has a 18.2% ROR, and using Sandia fuel costs, a 24.2% ROR.

Table 6.4-2 Levelized Cost of Energy Results, Baseline Economics, 1980\$

	Conventional Oil-Fired	Solar Thermal System
World Oil Price Economics	\$27.88/MWht (\$8.17/MBtu)	\$23.89/MWht (\$7.00/MBtu)
Sandia-Supplied Fuel Costs	\$35.53/MWht (\$10.41/MBtu)	\$24.26/MWht (\$7.11/MBtu)

6.4.2 Sensitivity Analyses

To completely evaluate the cost effectiveness of the STEOR system, sensitivities of the levelized cost of energy to the major economic assumptions were examined. Each of the major sensitivities are examined in the following paragraphs.

6.4.2.1 System Life - The STEOR components are designed for a 30-year life. However, the actual operating life of the system will be dictated by the oil production from the field resulting from steam drive operations. It is currently estimated that the Edison field will be productive for approximately 26 years with steam drive although reservoir analysis is still an inexact science. Therefore the levelized cost of energy for the STEOR system and conventional systems has been calculated for varying operating periods, with the results depicted in Figure 6.4-1. As the figure shows, the STEOR concept with \$230/m^2 heliostats is cost effective with operating periods much less than 26 years. The break-even period is less than 19 years using the world oil price assumptions, and only 13.5 years using the Sandia-supplied fuel cost and 12% escalation.

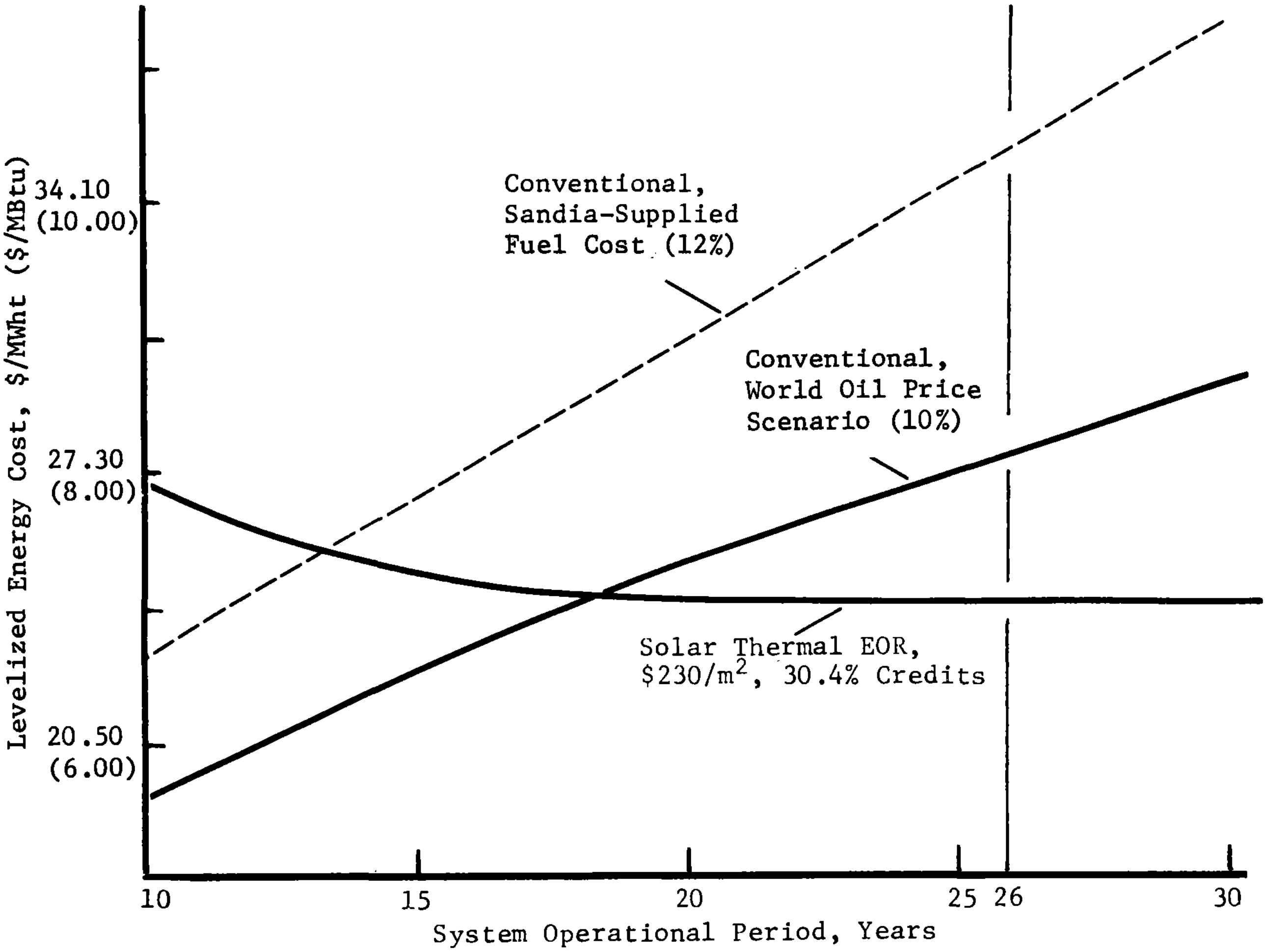

Figure 6.4-1 Effects of System Operating Period on Energy Cost

6.4.2.2 Solar O&M Expense - As a commercial solar central receiver EOR system has yet to be built or operated, there is some uncertainty as to the actual yearly operations and maintenance costs incurred. The baseline estimate of $342,000 (2.75% of the plant capital cost) has been reviewed and is considered to be realistic. However, as shown in Figure 6.4-2, the yearly O&M expense could be close to 5% of the capital cost, or $695,000 per year, and still break even with conventional systems using world oil price economics. Using Sandia-supplied fuel costs, yearly STEOR O&M expenses could be over 8% of the capital cost without exceeding the conventional system energy cost.

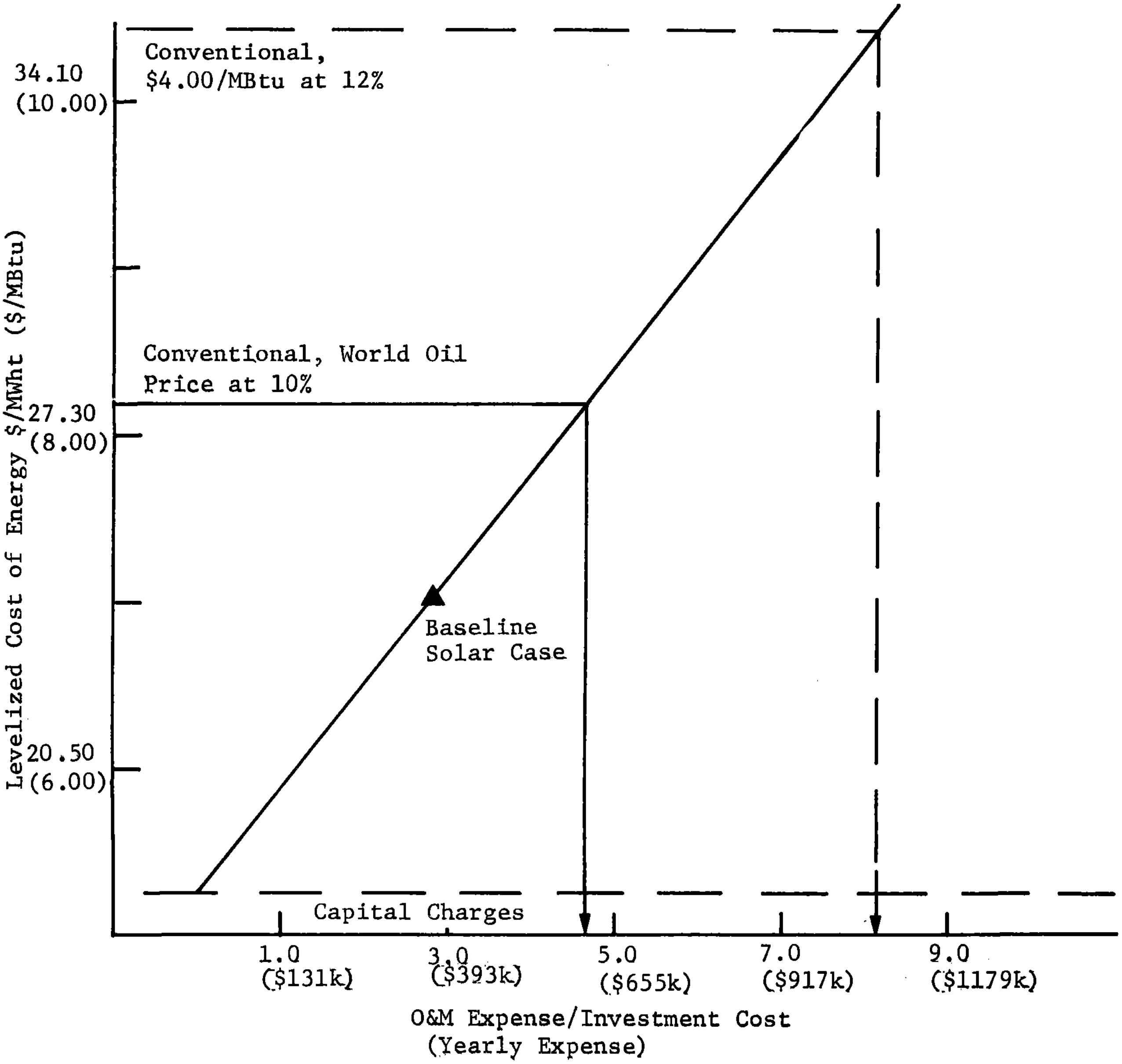

Figure 6.4-2 Effect of STEOR O&M Expense on Energy Cost

6.4.2.3 Heliostat Cost - As discussed in Section 4.6, a value of $230/m^2 (installed) has been used as a realistic near-term heliostat cost. However, there is some controversy as to what heliostats will cost in the near future. Therefore the levelized cost of energy from the STEOR system has been plotted against varying heliostat costs in Figure 6.4-3 for the baseline 26-year system life. Break-even heliostat costs (including 15% rate of return) of $305/m^2 and $455/m^2 can be calculated by plotting conventional system costs with world oil pricing and Sandia fuel cost/escalation assumptions, respectively. The shaded area, with energy costs ranging from $7.00 to $7.70/MBtu, corresponds with near-term ("post-Barstow") heliostat costs of $230 to $275/m^2. Over this entire range of heliostat costs, STEOR remains competitive.

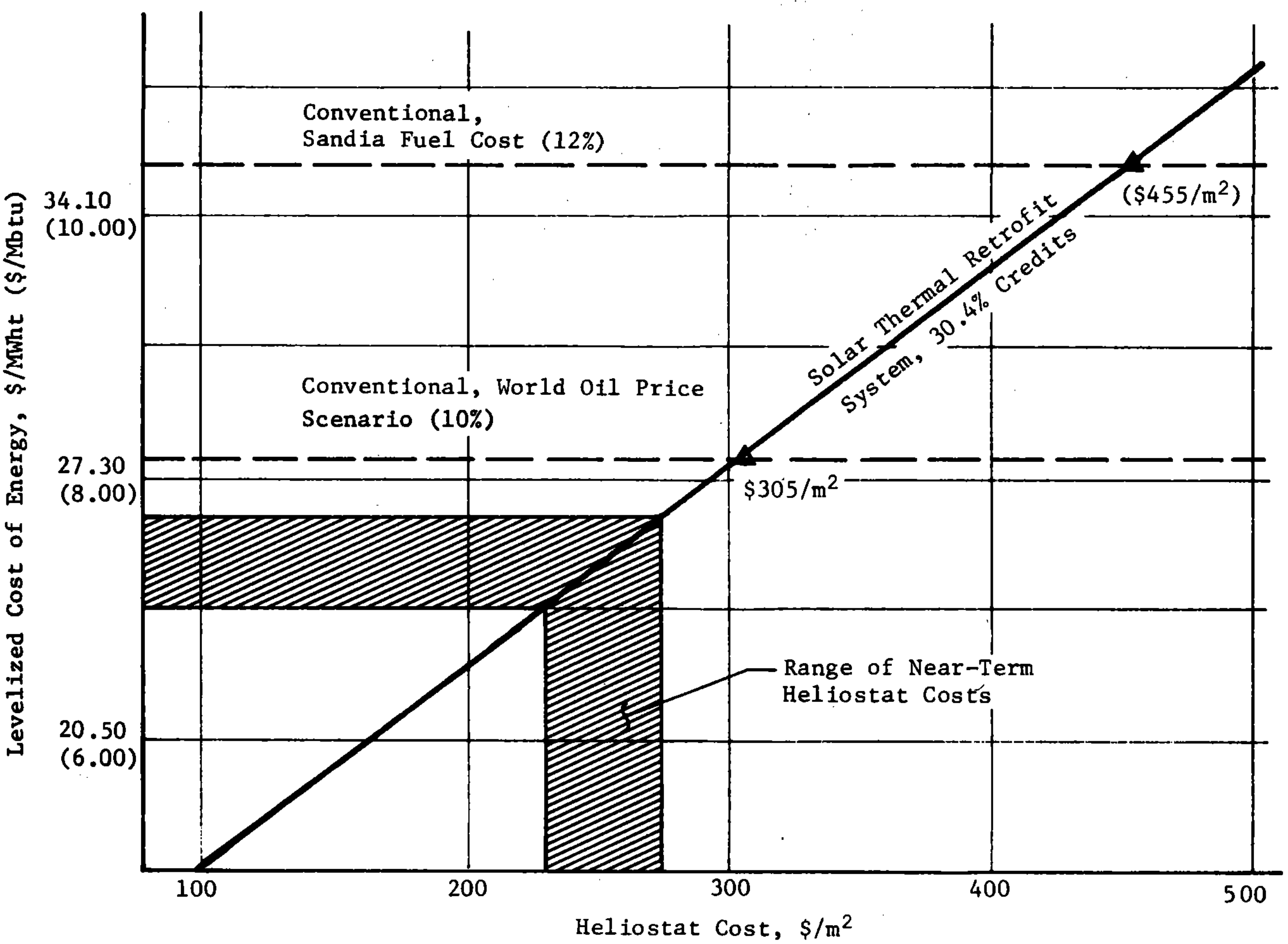

Figure 6.4-3 Effect of Heliostat Cost on Energy Cost

6.4.2.4 Oil Escalation Rate - The effects of heliostat cost variations and oil escalation rate uncertainties have been combined in a single relationship shown in Figure 6.4-4. Using this graph one can determine the break-even oil escalation rate for any given heliostat cost; conversely, given an oil escalation rate, the break-even heliostat cost can be found. So for the baseline $230/m^2 heliostat cost, the break-even oil escalation rate is 8.6% using the world oil pricing assumptions, or 8.8% using the Sandia-supplied oil costs. Similarly, given the baseline oil escalation rate of 10% using the world oil pricing assumptions, the break-even heliostat cost is $305, as was shown in Figure 6.4-3.

6.4.3 Fuel Savings

The annual and cumulative fuel savings is an important measure of the effectiveness of the solar thermal EOR system, particularly in view of the growing shortage of petroleum supplies. At the projected annual output of 55,870 MWht (190,684 MBtu) from the STEOR system, 6852 m^3 (43,092 bbl) of oil will be displaced. Using the world oil pricing assumptions, the first year oil displacement would be worth over $1.3M (1980$). Over the projected 26-year life of the system, over 178,000 m^3 (1.1 million bbl) of oil would be displaced.

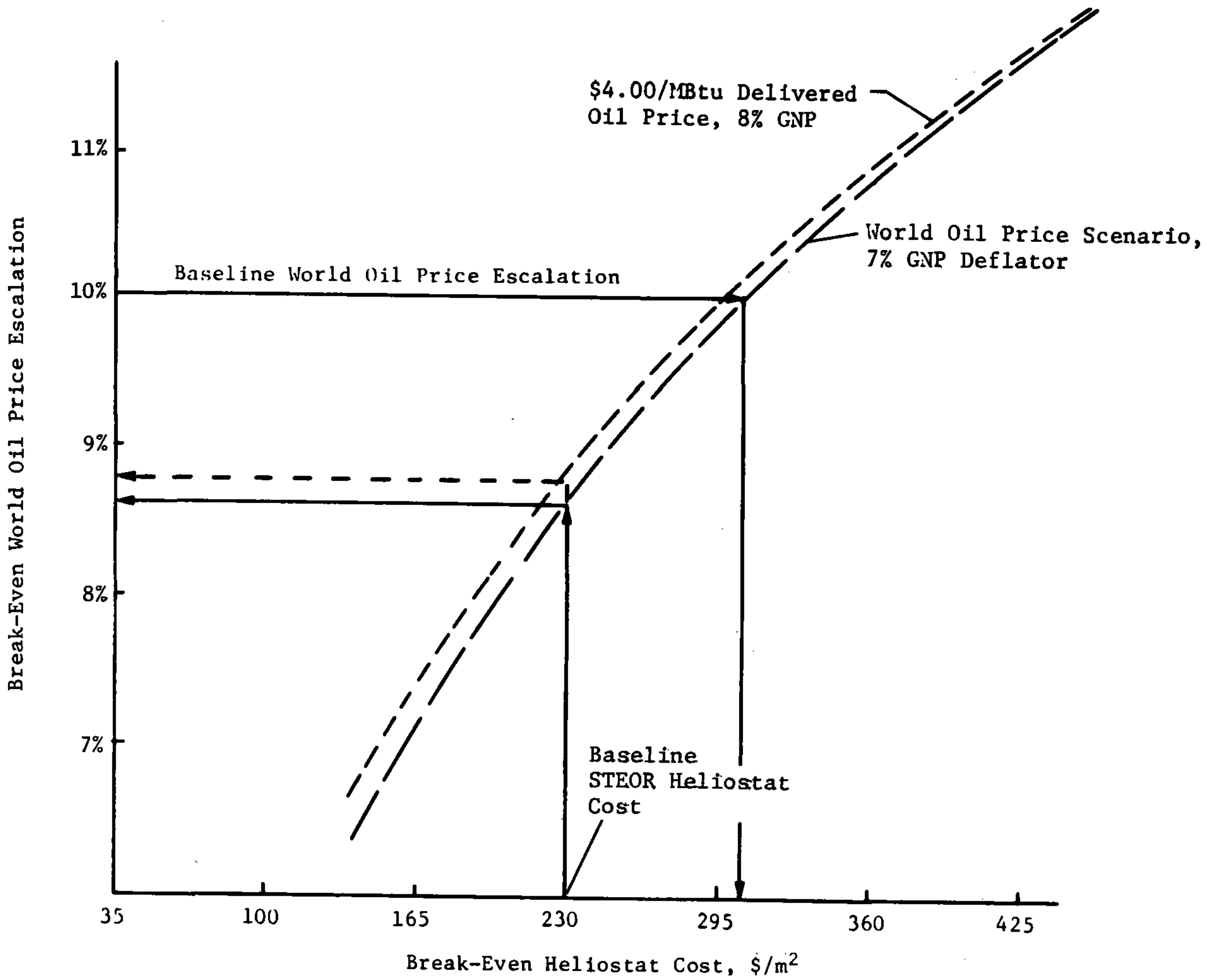

Figure 6.4-4 Break-Even Heliostat Cost/Oil Escalation Rate

6.4.4 Economic Analysis Conclusions

The previous analyses have shown significant economic advantages of the STEOR system described in this report over conventional oil-fired steamers for thermally enhanced oil recovery operations at the Edison field. These cost advantages range from a 15 to 30% reduction in the levelized cost of energy from conventional systems using a $\$230/m^2$ heliostat cost. The STEOR system retains its cost competitiveness even at heliostat costs as high as $\$300$ to $\$450/m^2$, depending on the oil escalation scenario assumed. In addition, significant critical fuel (i.e., oil) displacement is achieved, along with increased production of proven heavy oil reserves.

7.0 DEVELOPMENT PLAN

This development plan is for a joint DOE-Exxon project for the design, construction and operation of a solar field at Edison. It is consistent with the schedule presented in the Department of Energy Solar Repowering/Industrual Retrofit Program Element Plan.

7.1 DESIGN PHASE

The design phase begins after completion of the conceptual design and includes development tests, system detail design, and work needed to obtain the necessary legal permits before construction can begin.

Three principal development tests have been identified as necessary before detail design can be completed. The first of these is a steam drive pilot at the Edison field. This test would confirm the suitability of the field for steam drive operations. This pilot operation is already planned by Exxon and preliminary work is underway. These tests will run through 1981 and 1982 and are required whether or not a solar field is envisioned. The second test is to determine the effects of intermittent diurnal steam injection by an actual field well experiment. This test will be useful for determining the effects of part-time injection so the final solar design will be appropriate, and will be run concurrently with the steam drive pilot.

The third experiment will test a natural-recirculation receiver using Edison feedwater at design fluxes. The purpose of this test is to ensure that the specified blowdown flow rate is sufficient to prevent serious fouling of the tubes by the Edison feedwater. This test can be accomplished using the existing 5-MWt water steam receiver already tested at Sandia, Alburquerque by Martin Marietta. This receiver can be made to simulate our design by disconnecting the superheater section. The test could be conducted either at the CRTF (if available) or at the IR test facility.

The detailed design work will use information from these tests as well as construction information from the Solar One (Barstow) program to produce a detailed engineering design for the solar facility. This would include all aspects of the system, including controls, collectors, tower, receiver, piping and site, as well as a plan for installation, startup, testing and operation. This design will provide the information required to obtain the construction permit and tower zoning variance.

Following completion of the detail design and in anticipation of actual construction, applications will be filed for the necessary permits for construction. Sufficient time has been allowed for this purpose in the schedule.

.2 CONSTRUCTION PHASE

Following signing of the contract extension for the construction option, construction begins with site preparation and ordering of materials for component fabrication. Then heliostat foundations are installed in parallel with construction of the control building, with preliminary electrical work following. Fabrication of the heliostats and receiver is then begun and work on the tower started. Heliostat delivery will be phased so they can be installed on arrival at the field. The receiver components will be delivered when the tower is ready for its installation. When most of the hardware is in place, the piping and control system will be installed and final system interconnections accomplished.

7.3 SYSTEM CHECKOUT AND STARTUP PHASE

After final interconnections, the system will be run through a series of tests designed to check all the normal and emergency operating modes. This will include separate tests of the heliostat field, receiver, and control systems.

Following successful checkout, initial operation of the system will follow. The system will be carefully monitored during this phase to ensure that design operating conditions are met.

7.4 SYSTEM PERFORMANCE VALIDATION PHASE

After successful startup the system will be operated in its normal modes. Sufficient data will be taken to demonstrate successful operations.

7.5 JOINT USER/DOE OPERATIONS PHASE

This phase will include the first five years of normal operations, after which the system will revert to private ownership. During this period, data regarding O&M costs, scheduled and unscheduled downtime, equipment failures, cost of operations and energy produced will compiled.

7.6 SCHEDULE AND MILESTONES

The project schedules and milestones are shown in Figure 7.6-1. Final design will be completed by June 1982. Permits and zone variances will be in hand by March 1983 so construction can begin by May 1983. System installation will be complete by September 1984, with normal operations beginning in January 1985 following the checkout and startup phases.

This schedule follows the procurement schedule given in the Solar Repowering/Industrual Retrofit Program Element Plan draft, January 1980. It would be possible to tighten the early design phases of this project to achieve an earlier operating data.

7.7 ROLES OF SITE OWNER, GOVERNMENT AND INDUSTRY

Exxon will be the owner-operator of the solar field and will act as overall project manager. As increased steam capacity at the Edison field is warranted, Exxon would be willing to invest up to the total incremental cost of purchasing and operating additional conventional steamer capacity. This assumes that the risk premiums of using a new technology such as solar were borne by the government, and any higher costs above those required for conventional technology were covered by some type of tax-incentive program. Thus Exxon would act as project manager and the government would act to reduce the risk of the project to Exxon. Industry would provide engineering services and solar equipment under contract.

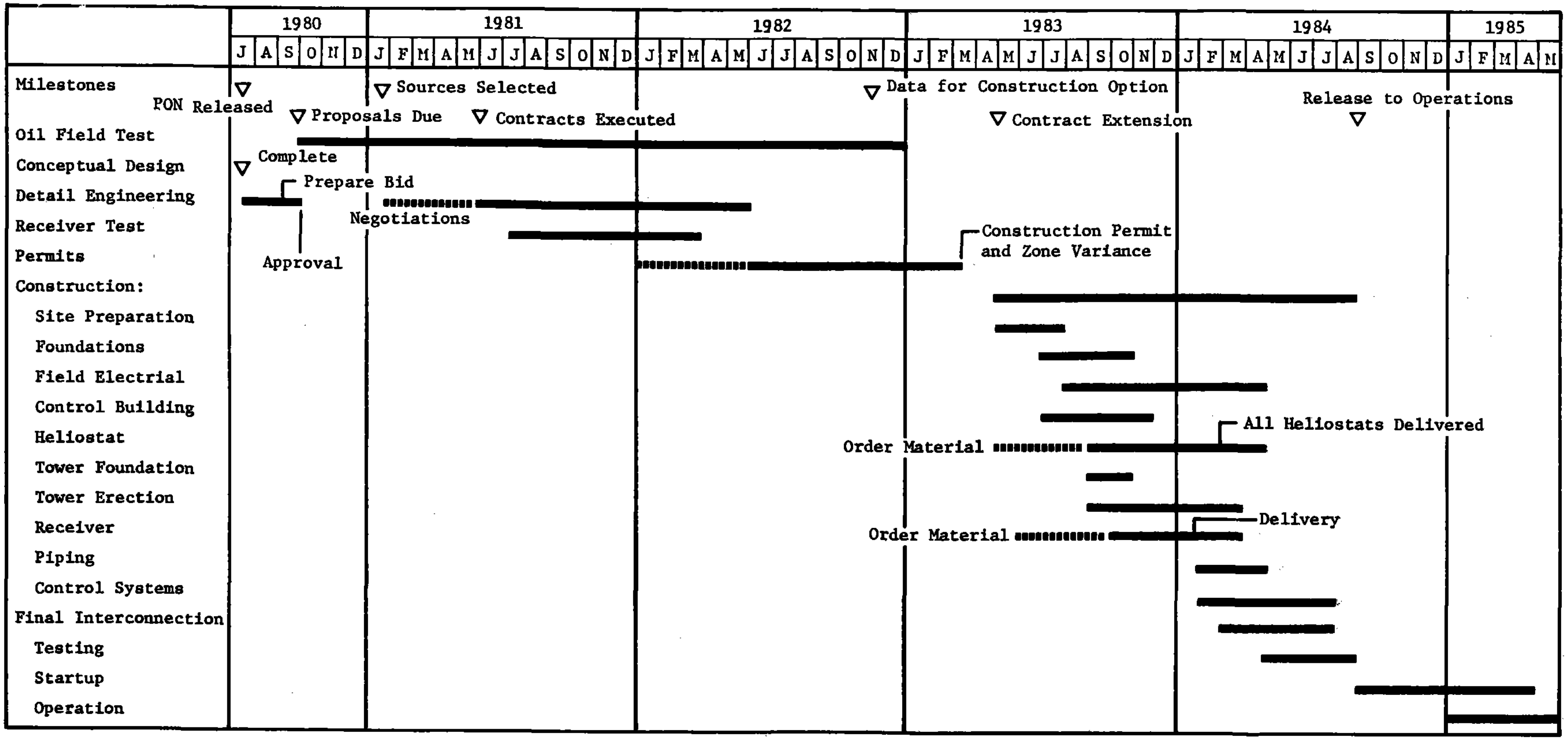

Figure 7.6-1 Development Schedule

Local Climatological Data

Annual Summary With Comparative Data

1978

BAKERSFIELD, CALIFORNIA

DEPARTMENT OF COMMERCE ★ UNITED STATES OF AMERICA ★

Narrative Climatological Summary

Bakersfield, situated in the extreme south end of the great San Joaquin Valley, is partially surrounded by a horseshoe-shaped rim of mountains with an open side to the northwest and the crest at an average distance of 40 miles.

The Sierra Nevadas to the northeast shut out most of the cold air that flows southward over the continent during winter. They also catch and store snow, which provides irrigation water for use during the dry months. The Tehachapi Mountains, forming the southern boundary, act as an obstruction to northwest wind, causing heavier precipitation on the windward slopes, high wind velocity over the ridges and, at times, prevailing cloudiness in the south end of the valley after skies have cleared elsewhere. To the west are the coast ranges, and the ocean shore lies at a distance of 75 to 100 miles.

Because of the nature of the surrounding topography, there are large climatic variations within relatively short distances. These zones of variation may be classified as Valley, Mountain, and Desert areas. The overall climate, however, is warm and semi-arid. There is only one wet season during the year, as 90 percent of all precipitation falls from October through April, inclusive. Snow in the valley is infrequent, with only a trace occurring in about one year out of seven. Thunderstorms also seldom occur in the valley.

Summers are cloudless, hot and dry. The average length of the growing season is 265 days; the valley area is suitable for Mediterranean and specialized types of agriculture. Cotton, potatoes, grapes, and cattle are the principal agricultural products. There are considerable amounts of deciduous fruits, citrus, grain and various vegetables. There are actually more than 90 farm crops grown commercially. Certain crops are planted or harvested every month of the year. Severe freezes seldom occur and there are occasional years with no frost at all in certain warm areas.

Winters are mild and semi-arid, yet fairly humid. December and January are characterized by frequent fog, mostly nocturnal, which prevails when marine air is trapped in the valley by a high pressure system. In extreme cases this fog may last continuously for two or three weeks. Its depth is usually less than 3,000 feet and the same condition that produces it also causes clear skies with mild temperatures in the surrounding mountain and desert areas.

Another local characteristic is the occasionally warm, dry, southeast chinook wind that spills through the Tehachapi Pass during winter. This wind usually attains velocities of 30 to 40 miles an hour, sometimes reaching as high as 60 miles an hour. Its path is approximately 30 miles wide and the stream flows in a curving course around the south end of the valley, turning northward and rising; it is seldom manifest on the floor of the valley for a distance of more than 50 miles.

During summer months northwest sea breezes frequent the Bakersfield area about twice weekly. When above normal temperatures prevail for several days, the gradient builds up sufficiently to draw in cooler air from the coastal section. During prolonged periods of drought this late afternoon breeze may carry varying amounts of dust, and thermal instability sometimes causes it to rise as high as 7,000 feet.

noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / ENVIRONMENTAL DATA AND INFORMATION SERVICE / NATIONAL CLIMATIC CENTER ASHEVILLE, N.C.

Meteorological Data For The Current Year

Station: BAKERSFIELD, CALIFORNIA # 23155 KERN COUNTY AIR TERMINAL Standard time used: PACIFIC Latitude: 35° 25' N Longitude: 119° 03' W Elevation (ground): 475 feet Year: 1978

Month	Temperature °F Averages Daily maximum	Temperature °F Averages Daily minimum	Temperature °F Averages Monthly	Temperature °F Extremes Highest	Date	Temperature °F Extremes Lowest	Date	Degree days Base 65 °F Heating	Degree days Cooling	Precipitation in inches Water equivalent Total	Greatest in 24 hrs.	Date	Snow, Ice pellets Total	Greatest in 24 hrs.	Date	Relative humidity, pct. Hour 04 (Local time)	Hour 10	Hour 16	Hour 22	Wind Resultant Direction	Resultant Speed m.p.h.	Average speed m.p.h.	Fastest mile Speed m.p.h.	Fastest mile Direction	Date	Percent of possible sunshine	Average sky cover, tenths, sunrise to sunset	Number of days Sunrise to sunset Clear	Partly cloudy	Cloudy	Precipitation .01 inch or more	Snow, Ice pellets 1.0 inch or more	Thunderstorms	Heavy fog, visibility ¼ mile or less	Temperature °F Maximum (b) 90° and above	Maximum 32° and below	Minimum 32° and below	Minimum 0° and below	Average station pressure mb Elev. 492 feet m.s.l.
JAN	62.7	46.8	54.8	73	13	32	25	311	0	1.21	0.55	16-17	0.0	0.0		84	77	66	78	09	1.4	6.4	26	13	9		7.8	4	7	20	11	0	0	12	0	0	1	0	1000.3
FEB	64.7	47.7	56.2	79	4	40	3	241	3	4.68	3.02	9-10	0.0	0.0		83	77	63	79	05	1.1	6.7	32	16	5		7.6	2	9	17	9	0	1	7	0	0	0	0	999.3
MAR	71.6	53.5	62.6	84	17	45	13	82	14	2.00	0.65	21	0.0	0.0		83	71	57	76	02	1.9	6.4	21	14	31		7.4	4	7	20	11	0	0	1	0	0	0	0	998.0
APR	72.0	50.7	61.4	85	11	42	5	124	23	0.88	0.50	6-7	0.0	0.0		80	58	46	71	35	3.3	7.5	29	16	15		6.3	4	14	12	6	0	2	0	0	0	0	0	998.0
MAY	87.2	59.1	73.2	101	29	47	16	13	273	0.02	0.02	1	0.0	0.0		54	35	23	38	33	3.7	7.7	20	31	14		2.3	22	6	3	1	0	0	0	13	0	0	0	995.9
JUN	93.7	66.0	79.9	107	7	60	16	0	451	0.00	0.00		0.0	0.0		52	36	22	33	33	4.7	6.9	20	31	26		1.3	25	4	1	0	0	0	0	22	0	0	0	996.6
JUL	99.6	72.1	85.9	108	22	61	3	0	655	0.00	0.00		0.0	0.0		47	34	21	32	31	4.0	6.9	16	31	25		.3	31	0	0	0	0	0	0	28	0	0	0	994.2
AUG	97.5	72.5	85.0	111	8	60	24	0	628	0.00	0.00		0.0	0.0		54	37	24	39	32	3.9	7.0	17	31	9		1.1	28	3	0	0	0	0	0	25	0	0	0	995.3
SEP	88.7	64.7	76.7	104	2	49	19	0	358	0.74	0.63	5-6	0.0	0.0		62	45	34	51	34	2.5	6.4	20	34	17		2.3	23	3	4	3	0	0	0	11	0	0	0	995.9
OCT	88.7	61.7	75.2	102	14	47	31	9	332	0.00	0.00		0.0	0.0		56	42	28	46	35	1.1	5.2	14	15	30		2.5	22	5	4	0	0	0	0	16	0	0	0	997.6
NOV	68.8	45.6	57.2	83	7	35	15	236	11	0.21	0.12	13	0.0	0.0		68	57	43	64	05	0.9	4.9	18	28	21		4.0	18	4	8	4	0	0	3	0	0	0	0	1000.7
DEC	54.4	37.9	46.2	70	16	25	8	578	0	0.57	0.28	1	0.0	0.0		78	70	58	73	04	0.2	4.2	16	34	19		6.7	7	8	16	5	0	0	4	0	0	5	0	1003.4
YEAR	79.1	56.5	67.8	111	AUG 8	25	DEC 8	1594	2748	10.31	3.02	FEB 9-10	0.0	0.0		67	53	40	57	34	2.0	6.4	32	16	FEB 5		4.1	190	70	108	50	0	3	27	115	0	6	0	997.9

Normals, Means, And Extremes

Month	Temperatures °F Normal Daily maximum	Normal Daily minimum	Normal Monthly	Extremes Record highest	Year	Extremes Record lowest	Year	Normal Degree days Base 65 °F Heating	Cooling	Precipitation in inches Water equivalent Normal	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Snow, Ice pellets Maximum monthly	Year	Maximum in 24 hrs.	Year	Relative humidity pct. Hour 04 (Local time)	Hour 10	Hour 16	Hour 22	Wind Mean speed m.p.h.	Prevailing direction	Fastest mile Speed m.p.h.	Fastest mile Direction	Year	Pct. of possible sunshine	Mean sky cover, tenths, sunrise to sunset	Mean number of days Sunrise to sunset Clear	Partly cloudy	Cloudy	Precipitation .01 inch or more	Snow, Ice pellets 1.0 inch or more	Thunderstorms	Heavy fog, visibility ¼ mile or less	Temperatures °F Max. (b) 90° and above	Max. 32° and below	Min. 32° and below	Min. 0° and below	Average station pressure mb. Elev. 492 feet m.s.l.
(a)				41		41					41		41		41		41		41		15	15	15	15	39	15	30	30			33	38	38	38	41	41	41	41	15	15	15	15	6
J	57.5	37.4	47.5	79	1974	20	1963	543	0	0.96	2.87	1943	T	1972	1.09	1954	T	1973	T	1973	83	75	61	78	5.2	NW	35	02	1960		6.3	8	8	15	6	0	*	8	0	0	4	0	1002.7
F	63.3	41.4	52.4	85	1977	26	1949	353	0	1.03	4.68	1978	0.03	1967	3.02	1978	T	1953	T	1953	77	66	50	70	5.8	ENE	44	29	1960		5.8	8	8	12	6	0	*	3	0	0	1	0	1001.8
M	68.6	44.5	56.6	92	1969	31	1966	266	6	0.83	4.61	1938	T	1972	1.68	1938	1.5	1974	1.5	1974	70	55	40	60	6.6	NW	38	36	1973		5.2	11	9	11	6	*	*	*	*	0	*	0	998.9
A	75.5	49.9	62.7	98	1965	35	1955	140	71	0.85	2.65	1967	0.00	1966	1.00	1943	0.0		0.0		64	46	32	53	7.2	NW	40	29	1958		4.3	13	9	8	4	0	1	*	2	0	0	0	998.3
M	83.6	56.0	69.8	107	1976	40	1950	22	171	0.19	2.39	1971	0.00	1970	1.40	1971	0.0		0.0		55	37	24	40	8.0	NW	38	32	1951		3.0	19	8	4	2	0	*	*	11	0	0	0	995.6
J	91.5	62.3	76.9	114	1976	45	1953	0	362	0.06	1.11	1972	0.00	1978	1.10	1972	0.0		0.0		51	34	23	35	8.0	NW	41	15	1972		1.6	24	4	2	*	0	*	0	19	0	0	0	994.5
J	99.1	68.7	83.9	115+	1950	53	1948	0	586	0.02	0.30	1965	0.00	1978	0.30	1965	0.0		0.0		48	32	20	33	7.2	NW	25	29	1950		1.1	27	3	1	*	0	*	*	29	0	0	0	994.5
A	96.5	66.6	81.6	112	1950	52	1942	0	515	0.01	1.03	1977	0.00	1978	1.03	1977	0.0		0.0		52	36	23	37	6.8	NW	30	06	1972		1.2	26	4	1	*	0	*	*	26	0	0	0	994.9
S	91.1	62.1	76.6	112	1955	45	1948	0	348	0.08	1.06	1976	0.00	1977	0.63	1978	0.0		0.0		57	41	27	43	6.3	WNW	35	14	1976		1.5	25	4	1	1	0	*	*	17	0	0	0	995.0
O	80.5	53.3	66.9	103	1947	29	1971	55	114	0.26	1.82	1974	0.00	1978	1.51	1940	0.0		0.0		62	46	33	52	5.6	NW	31	32	1970		2.8	20	7	4	2	0	*	*	6	0	*	0	998.1
N	67.8	44.2	56.0	91	1949	28	1941	276	6	0.69	3.04	1960	0.00	1959	1.54	1960	0.0		0.0		75	63	49	68	5.1	ENE	30	34	1975		4.8	13	7	10	3	0	*	3	*	0	*	0	1001.5
D	57.4	38.4	47.9	82	1939	21	1962	530	0	0.74	1.80	1977	T	1962	1.15	1974	T	1968	T	1968	83	75	61	79	5.0	ENE	46	13	1977		6.4	8	7	16	5	0	*	8	0	0	4	0	1003.3
YR	77.7	52.1	64.9	115	JUL 1950	20	JAN [illegible]	2185	2179	5.72	4.68	FEB 1978	0.00	OCT 1978	3.02	FEB 1978	1.5	MAR 1974	1.5	MAR 1974	65	50	37	54	6.4	NW	46	13	DEC 1977		3.7	202	78	[illegible]	34	*	3	22	110	0	10	0	998.2

Means and extremes above are from existing and comparable exposures. Annual extremes have been exceeded at other sites in the locality as follows: Highest temperature 118 in July 1908; lowest temperature 13 in December 1905; maximum monthly snowfall 4.0 in December 1932; maximum snowfall in 24 hours 4.0 in December 1932.

(a) Length of record, years, through the current year unless otherwise noted, based on January data.
(b) 70° and above at Alaskan stations.
* Less than one half.
T Trace.

NORMALS - Based on record for the 1941-1970 period.
DATE OF AN EXTREME - The most recent in cases of multiple occurrence.
PREVAILING WIND DIRECTION - Record through 1963.
WIND DIRECTION - Numerals indicate tens of degrees clockwise from true north. 00 indicates calm.
FASTEST MILE WIND - Speed is fastest observed 1-minute value when the direction is in tens of degrees.

Average Temperature

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
1939	47.8	47.6	56.9	67.0	70.8	78.4	83.6	83.4	76.1	64.5	57.6	51.0	65.4
1940	51.0	54.5	59.9	69.8	74.4	82.8	82.2	82.1	72.2	66.9	53.1	53.9	66.4
1941	51.8	55.6	57.5	59.0	70.4	74.6	84.4	79.2	72.4	63.8	58.0	50.4	64.8
1942	49.6	49.7	56.2	61.2	66.3	76.8	85.4	82.8	74.3	66.9	55.2	46.4	64.2
1943	47.6	53.2	57.4	62.2	70.5	72.4	82.2	79.0	78.5	66.6	57.5	50.1	64.8
1944	48.8	50.3	56.4	60.2	70.4	73.4	82.4	81.4	78.0	69.0	54.4	50.2	64.6
1945	45.6	52.7	57.6	63.4	68.4	77.8	87.2	82.0	78.3	68.8	55.6	50.9	65.3
1946	46.6	51.0	56.9	64.8	69.6	75.5	86.0	83.5	76.7	62.8	51.9	46.6	64.2
1947	42.0	53.2	60.4	65.5	74.8	77.8	80.2	78.8	78.8	66.0	51.9	46.2	64.7
1948	52.8	50.2	54.2	62.2	66.4	77.0	81.2	79.6	76.0	66.4	54.2	45.6	63.8
1949	40.4	48.6	56.0	66.8	69.6	80.0	83.0	77.8	77.3	65.2	61.0	46.4	64.3
1950	45.2	54.9	56.4	65.5	71.3	76.0	86.1	82.7	74.7	68.1	60.7	52.6	66.2
1951	48.0	52.8	57.6	64.1	71.4	78.4	82.6	81.1	77.9	65.1	56.9	46.8	65.2
1952	47.1	52.4	52.2	62.7	72.2	71.8	84.1	81.6	77.7	70.3	53.8	49.2	64.6
1953	51.7	50.8	56.0	61.2	64.4	72.5	85.1	77.2	77.2	65.4	56.4	47.2	63.8
1954	48.5	52.1	55.3	66.7	72.6	74.6	84.1	77.2	74.3	66.2	54.5	46.3	64.4
1955	44.7	50.0	57.3	58.7	69.5	75.6	79.6	83.6	77.6	68.0	53.8	52.5	64.2
1956	51.2	47.7	57.0	62.4	70.3	77.7	83.0	78.8	77.5	64.1	56.8	47.3	64.5
1957	44.7	55.6	57.9	63.3	68.0	81.0	83.4	79.8	77.6	64.8	54.6	47.6	64.8
#1958	48.3	56.9	55.9	61.4	72.0	75.4	82.4	85.7	76.9	71.5	56.1	52.4	66.1
1959	51.6	51.7	60.5	68.3	67.1	79.6	86.6	81.1	74.5	68.9	58.0	49.3	66.4
1960	48.9	51.9	59.5	62.4	68.7	83.7	86.1	81.5	77.9	65.7	53.8	45.4	65.4
1961	45.7	54.2	55.2	64.1	65.8	82.0	85.2	83.5	74.4	66.3	54.0	45.3	64.5
1962	42.6	49.6	59.5	65.8	66.0	77.7	82.8	80.5	75.9	65.7	56.6	49.5	63.8
#1963	44.9	58.4	55.8	57.4	69.2	74.8	79.8	79.9	77.2	66.6	54.7	41.5	63.4
1964	46.4	51.0	54.8	62.0	67.6	76.9	84.1	82.7	74.0	71.0	51.2	50.7	64.4
1965	47.2	50.4	57.1	61.9	69.3	73.3	82.0	82.5	72.2	69.6	57.3	42.8	63.8
1966	46.8	49.0	57.5	67.3	72.6	78.0	81.4	84.7	74.8	67.1	57.7	46.3	65.2
1967	46.6	49.7	56.1	52.7	70.5	75.2	86.7	87.7	80.4	69.0	61.0	45.3	65.1
1968	47.9	58.9	59.8	65.4	70.2	81.2	86.6	79.8	76.9	66.2	55.7	47.0	66.3
1969	48.9	51.1	56.7	63.5	74.3	76.7	86.3	86.2	80.8	64.6	58.3	51.1	66.6
1970	54.0	56.5	58.8	60.0	74.0	80.3	88.3	84.8	77.5	67.5	59.0	49.1	67.4
1971	47.6	49.8	57.8	61.9	67.9	77.7	87.0	86.0	76.6	64.1	53.8	45.4	66.7
1972	41.7	54.9	63.4	63.4	72.4	80.3	85.0	82.8	75.2	65.8	52.6	43.6	65.1
1973	47.9	57.4	54.3	64.5	76.7	82.4	85.0	83.4	76.6	68.4	56.6	50.0	66.9
1974	51.6	52.9	59.6	63.9	73.2	81.6	89.8	84.6	83.0	70.5	56.7	46.8	67.5
1975	46.8	54.4	57.1	58.8	73.5	81.1	84.5	83.0	82.6	66.6	54.7	48.0	65.9
1976	49.5	55.5	57.4	61.3	75.3	79.7	85.5	79.1	78.1	71.0	59.4	51.1	67.0
1977	46.7	56.9	54.2	67.6	67.2	83.9	85.7	85.3	78.9	71.2	59.5	57.1	67.8
1978	54.8	56.2	62.6	61.4	73.2	79.9	85.9	85.0	76.7	75.2	57.2	46.2	67.8
RECORD MEAN	47.3	52.6	57.0	62.6	70.0	77.6	83.8	81.7	75.7	66.6	55.8	48.0	64.9
MAX	57.4	64.2	69.3	75.8	84.1	92.8	99.9	97.8	91.1	81.1	68.9	58.6	78.4
MIN	37.1	41.0	44.7	49.5	55.8	62.2	67.7	65.6	60.5	52.0	42.6	37.4	51.3

Heating Degree Days

BAKERSFIELD, CA

Season	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Total
1958-59	0	0	0	7	264	385	406	367	140	14	41	0	1624
1959-60	0	0	3	33	204	483	492	372	185	118	31	0	1921
1960-61	0	0	0	60	333	600	656	296	296	93	33	0	2367
1961-62	0	0	0	107	324	607	687	424	349	58	62	2	2620
1962-63	0	0	0	44	257	472	618	179	276	223	14	1	2084
#1963-64	0	0	0	41	303	722	568	399	323	138	67	2	2563
1964-65	0	0	1	17	407	438	546	405	241	186	45	7	2299
1965-66	0	0	0	18	232	681	557	443	236	46	6	1	2220
1966-67	0	0	1	32	222	572	566	422	271	361	48	7	2502
1967-68	0	0	0	5	137	604	523	177	181	81	24	0	1732
1968-69	0	0	3	34	277	553	492	384	274	88	13	0	2118
1969-70	0	0	0	45	207	426	337	239	195	158	15	0	1622
1970-71	0	0	0	55	184	486	532	420	225	117	30	3	2052
1971-72	0	0	16	163	329	597	717	286	97	82	25	0	2312
1972-73	0	0	0	59	362	657	521	205	324	87	3	0	2218
1973-74	0	0	0	24	263	461	409	333	174	92	20	0	1776
1974-75	0	0	0	26	244	558	559	294	244	192	30	0	2147
1975-76	0	0	0	73	304	521	463	272	243	140	0	0	2016
1976-77	0	0	0	13	193	424	559	229	333	31	37	0	1819
1977-78	0	0	0	12	162	237	311	241	82	124	13	0	1182
1978-79	0	0	0	9	236	578							

Cooling Degree Days

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
1969	0	0	25	49	308	360	668	663	401	43	13	0	2610
1970	2	0	9	13	300	466	727	621	385	140	11	0	2674
1971	0	0	7	32	126	389	691	660	372	144	0	0	2421
1972	0	0	52	42	261	466	627	559	313	90	0	0	2410
1973	0	0	0	79	371	528	624	580	355	137	18	0	2692
1974	0	0	12	63	281	505	651	616	549	206	0	0	2883
1975	0	0	7	14	299	490	606	564	538	130	1	0	2649
1976	0	6	15	34	326	447	643	445	406	204	32	0	2558
1977	0	10	2	115	113	577	651	635	423	211	4	1	2742
1978	0	3	14	23	273	451	655	620	358	332	11	0	2740

Precipitation

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
1939	1.12	1.00	2.37	0.31	0.35	0.03	0.00	0.00	0.48	0.22	T	0.19	6.07
1940	1.81	2.58	0.75	1.20	0.00	0.00	0.00	0.00	0.00	1.51	0.03	1.67	9.55
1941	1.54	2.28	2.39	2.13	0.06	T	0.00	T	0.00	0.53	0.49	1.54	10.96
1942	0.47	0.19	0.60	1.03	0.19	0.00	0.00	0.01	0.00	0.24	0.20	1.33	4.26
1943	2.87	1.55	0.80	2.39	0.25	0.00	T	0.00	0.00	0.05	0.09	1.38	9.38
1944	0.71	1.18	0.76	0.63	0.23	0.13	0.00	0.00	0.00	0.14	1.70	0.60	6.08
1945	0.82	1.91	1.15	0.64	0.26	0.14	0.00	T	0.07	0.58	0.28	1.48	7.33
1946	0.46	0.82	1.01	0.02	0.42	0.00	0.23	0.04	T	0.48	1.14	1.33	5.95
1947	0.24	0.12	1.02	0.54	T	0.00	0.00	0.07	T	0.02	0.01	0.66	2.68
1948	0.01	0.49	1.27	1.13	0.18	0.60	0.00	0.00	0.00	0.14	T	0.50	4.32
1949	0.47	1.10	1.12	0.07	0.66	T	T	0.01	0.00	T	0.51	0.57	4.51
1950	1.75	1.04	0.51	0.47	0.02	0.00	0.03	0.00	0.61	0.22	0.58	0.32	5.55
1951	1.61	0.55	0.36	0.87	0.06	0.00	T	0.00	0.00	0.17	0.33	1.76	5.71
1952	2.47	0.27	2.39	1.29	0.00	0.00	0.10	T	T	T	1.32	1.80	9.64
1953	0.62	0.26	1.22	0.54	0.53	T	T	T	0.00	0.02	0.80	0.18	4.17
1954	1.86	0.25	1.24	0.06	T	T	0.00	0.00	0.00	0.00	0.50	0.57	4.48
1955	1.51	0.85	0.25	0.80	0.16	0.00	0.00	0.00	0.00	0.00	0.51	0.50	4.58
1956	0.90	0.65	T	0.94	0.40	0.00	T	0.00	T	1.46	0.00	0.05	4.40
1957	0.82	0.70	0.16	0.96	0.23	0.32	T	0.00	T	0.78	0.57	1.02	5.56
#1958	0.93	1.55	2.05	2.23	0.88	T	0.00	0.01	0.56	T	0.38	0.02	8.61
1959	0.32	0.88	0.02	0.23	0.03	0.00	0.00	T	0.04	T	0.00	0.35	1.87
1960	1.42	1.56	0.16	0.77	T	0.00	0.00	0.00	T	0.08	3.04	T	7.03
1961	0.39	0.12	0.38	0.04	0.02	0.00	T	0.02	T	T	0.67	0.34	1.98
1962	0.59	4.42	0.31	0.02	0.07	0.00	0.00	0.00	0.02	0.23	T	T	5.66
1963	0.12	1.54	1.25	0.85	0.26	0.28	0.00	T	0.83	0.73	0.94	0.08	6.88
1964	0.27	0.41	0.57	0.56	0.20	0.01	T	0.17	T	0.67	0.46	0.70	4.02
1965	0.74	0.17	1.17	1.65	0.02	T	0.30	T	0.10	0.00	1.05	1.60	6.80
1966	0.70	1.14	0.29	0.00	T	T	T	T	0.03	T	0.88	1.58	4.62
1967	0.96	0.03	0.52	2.65	0.28	0.20	T	0.00	0.11	0.00	1.76	0.54	7.05
1968	0.49	0.56	1.01	0.64	0.06	0.00	T	T	0.00	1.29	0.40	0.67	5.14
1969	2.12	2.83	0.29	1.10	0.08	T	T	T	T	T	0.42	0.16	7.00
1970	0.57	1.56	0.48	0.16	0.00	T	T	0.00	0.00	T	1.70	0.71	5.18
1971	0.53	0.35	0.42	0.56	2.39	0.00	0.00	0.12	0.02	0.09	0.12	1.17	5.77
1972	T	0.27	T	0.08	0.02	1.11	T	T	0.02	0.54	1.55	0.66	4.25
1973	2.07	0.49	2.49	0.18	T	0.00	0.00	0.00	0.00	0.16	0.64	0.79	6.82
1974	1.16	0.13	1.53	0.70	T	0.00	T	0.00	0.00	1.82	0.51	1.19	7.04
1975	0.06	1.60	0.60	0.93	T	0.00	0.00	0.05	T	0.48	0.25	0.13	4.10
1976	0.05	1.64	0.44	0.76	0.55	0.02	T	T	1.06	0.11	0.31	0.13	5.07
1977	0.58	0.07	1.28	T	0.59	0.06	0.02	1.03	0.00	T	0.09	1.80	5.52
1978	1.21	4.68	2.00	0.88	0.02	0.00	0.00	0.00	0.74	0.00	0.21	0.57	10.31
RECORD MEAN	1.02	1.03	0.99	0.63	0.31	0.07	0.02	0.02	0.12	0.34	0.54	0.81	5.90

Snowfall

Season	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Total
1970-71	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1971-72	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1972-73	0.0	0.0	0.0	0.0	0.0	0.0	T	0.0	0.0	0.0	0.0	0.0	T
1973-74	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	1.5
1974-75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1975-76	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1976-77	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1977-78	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1978-79	0.0	0.0	0.0	0.0	0.0	0.0							
RECORD MEAN	0.0	0.0	0.0	0.0	0.0	T	T	T	T	0.0	0.0	0.0	T

# Indicates a station move or relocation of instruments. See Station Location table.

Record mean values above are means through the current year for the period beginning in 1911 for temperature, 1889 for precipitation, and 1938 for snowfall. Data are from Cooperative locations through September 1937 and from Airport locations thereafter.

STATION LOCATION

Location	Occupied from	Occupied to	Airline distance and direction from previous location	Latitude North	Longitude West	Elevation above										Remarks
						Sea level	Ground									
						Ground at temperature site	Wind instruments	Extreme thermometers	Psychrometer	Telepsychrometer	Tipping bucket rain gage	Weighing rain gage	8" rain gage	Hygrothermometer		
COOPERATIVE																
Santa Fe Rwy. Station 14th & F Street	1/1889	9/1937		35° 22'	119° 00'	401		5					3			
AIRPORT																
Administration Building Kern Co. Airport #1	9/08/28	3/10/58	4 mi. NNW	35° 25'	119° 03'	489	a65	5	5			b4	3			a - 38 feet to 1/20/40. b - Installed 1/20/40.
Kern County Air Terminal Meadows Field	3/10/58	Present	1500 ft. WNW	35° 25'	119° 03'	f475	c20	5	d5			d5	3	e5		c - 60 feet to 6/19/60. d - 4 feet to 2/24/61. e - Commissioned 1600 feet SE of thermometer site 12/6/63. f - 494 feet to 12/6/63.

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I certify that this is an official publication of the National Oceanic and Atmospheric Administration, and is compiled from records on file at the National Climatic Center, Asheville, North Carolina 28801.

Daniel B. Mitchell
Director, National Climatic Center

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JANUARY 1979
BAKERSFIELD, CALIFORNIA
NATIONAL WEATHER SERVICE OFC
KERN COUNTY AIR TERMINAL

Local Climatological Data

MONTHLY SUMMARY

JANUARY 1979 BAKERSFIELD, CALIFORNIA

LATITUDE 35° 25 ′N LONGITUDE 119° 03 ′W ELEVATION (GROUND) 475 FT. STANDARD TIME USED: PACIFIC WBAN #23155

DATE	TEMPERATURE °F MAXIMUM	TEMPERATURE °F MINIMUM	TEMPERATURE °F AVERAGE	TEMPERATURE °F DEPARTURE FROM NORMAL	TEMPERATURE °F AVERAGE DEW POINT	DEGREE DAYS BASE 65° HEATING (SEASON BEGINS WITH JUL.)	DEGREE DAYS BASE 65° COOLING (SEASON BEGINS WITH JAN.)	WEATHER TYPES ON DATES OF OCCURRENCE 1 FOG 2 HEAVY FOG 3 THUNDERSTORM 4 ICE PELLETS 5 HAIL 6 GLAZE 7 DUSTSTORM 8 SMOKE, HAZE 9 BLOWING SNOW	SNOW, ICE PELLETS OR ICE ON GROUND AT 04AM IN.	PRECIPITATION WATER EQUIVALENT IN	PRECIPITATION SNOW, ICE PELLETS IN.	AVG. STATION PRESSURE IN. ELEV. 492 FEET M.S.L.	WIND RESULTANT DIR.	WIND RESULTANT SPEED M.P.H.	WIND AVERAGE SPEED M.P.H.	WIND FASTEST MILE SPEED M.P.H.	WIND FASTEST MILE DIRECTION	SUNSHINE MINUTES	SUNSHINE PERCENT OF POSSIBLE	SKY COVER TENTHS SUNRISE TO SUNSET	SKY COVER TENTHS MIDNIGHT TO MIDNIGHT	DATE
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	61	26*	44	-2	24	21	0	1 8	0	0	0	29.86	14	7.5	12.9	29	15			5	4	1
2	68	40	54	8	24	11	0		0	0	0	29.76	12	4.6	7.6	17	32			10	9	2
3	61	35	48	2	32	17	0	8	0	0	0	29.59	30	1.6	5.5	10	28			9	6	3
4	70	45	58	12	34	7	0	8	0	T	0	29.57	01	1.4	5.9	14	16			7	9	4
5	63	51	57	11	37	8	0		0	.15	0	29.36	15	15.9	16.4	28	13			10	10	5
6	63	49	56	10	47	9	0		0	T	0	29.47	36	3.1	5.8	13	04			9	8	6
7	63	46	55	8	46	10	0	1 8	0	T	0	29.61	34	.9	3.3	9	04			10	7	7
8	70	46	58	11	45	7	0	1 8	0	.06	0	29.64	11	3.4	6.5	16	05			9	8	8
9	62	50	56	9	50	9	0	1	0	.40	0	29.67	33	4.8	6.5	10	32			8	7	9
10	63	47	55	8	46	10	0		0	0	0	29.76	02	1.4	5.0	7	28			8	6	10
11	71*	53	62*	15	51	3	0		0	.02	0	29.61	35	1.8	5.3	15	31			9	10	11
12	65	47	56	9	50	9	0		0	.01	0	29.61	34	6.3	8.3	17	34			7	6	12
13	59	44	52	5	45	13	0		0	0	0	29.63	04	1.5	5.0	7	06			10	8	13
14	61	49	55	8	41	10	0		0	.18	0	29.38	11	4.1	5.8	13	06			9	7	14
15	60	48	54	7	46	11	0		0	.46	0	29.31	09	3.8	9.5	17	11			10	9	15
16	52	50	51	4	47	14	0	2 8	0	.07	0	29.42	30	3.0	4.3	10	31			10	10	16
17	61	48	55	8	45	10	0	1 8	0	.06	0	29.37	11	.6	2.2	17	28			7	7	17
18	58	43	51	4	42	14	0		0	.04	0	29.53	36	3.7	6.3	17	28			5	5	18
19	59	39	49	1	40	16	0	8	0	0	0	29.74	05	1.1	3.7	8	24			4	4	19
20	60	39	50	2	41	15	0	1 8	0	0	0	29.71	25	.8	3.6	8	28			10	7	20
21	61	44	53	5	45	12	0	2 8	0	0	0	29.49	27	1.0	5.3	12	15			10	8	21
22	58	42	50	2	44	15	0	2 8	0	0	0	29.48	10	.8	3.3	6	12			8	8	22
23	60	39	50	2	43	15	0	2 8	0	0	0	29.48	02	.7	2.6	9	33			10	10	.3
24	53	48	51	3	43	14	0	1 8	0	0	0	29.28	35	3.7	4.0	12	35			10	10	24
25	53	40	47	-2	38	18	0	1 8	0	.03	0	29.25	32	6.8	7.8	18	32			6	6	25
26	53	33	43	-6	31	22	0		0	0	0	29.64	14	1.6	4.5	8	22			0	1	26
27	60	29	45	-4	29	20	0		0	0	0	29.64	05	2.1	5.6	10	32			2	3	27
28	48	37	43*	-6	36	22	0		0	.10	T	29.41	13	4.4	6.0	10	02			9	6	28
29	56	33	45	-4	28	20	0		0	0	0	29.53	11	2.8	3.7	8	12			6	4	29
30	59	40	50	0	29	15	0		0	.11	0	29.43	12	16.3	16.5	30	12			10	10	30
31	60	43	52	2	38	13	0		0	.11	0	29.32	15	7.9	10.4	18	16			10	9	31
	SUM	SUM				TOTAL	TOTAL			TOTAL	TOTAL	FOR THE MONTH:						TOTAL	%	SUM	SUM	
	1871	1323				410	0	NUMBER OF DAYS		1.80	T	29.53	10	1.4	6.4	30	12		FOR	247	220	
	AVG.	AVG.	AVG.	DEP.	AVG.	DEP.	DEP.	PRECIPITATION		DEP.						DATE: 30		POSSIBLE	MONTH	AVG.	AVG.	
	60.4	42.7	51.6	4.1	40	-133	0	≥ .01 INCH	14	0.84										8.0	7.1	

				SEASON TO DATE		SNOW, ICE PELLETS							
NUMBER OF DAYS				TOTAL	TOTAL	≥ 1.0 INCH	0	GREATEST IN 24 HOURS AND DATES				GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE	
MAXIMUM TEMP.		MINIMUM TEMP.		1233	0	THUNDERSTORMS	0	PRECIPITATION		SNOW, ICE PELLETS			
≥ 90°	≤ 32°	≤ 32°	≤ 0°	DEP.	DEP.	HEAVY FOG	4	.80	14-15	T	28	0	
0	0	2	0	-171	0	CLEAR 2	PARTLY CLOUDY 8	CLOUDY 21					

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT
+ ALSO ON AN EARLIER DATE, OR DATES.
HEAVY FOG: - VISIBILITY 1/4 MILE OR LESS.
FIGURES FOR WIND DIRECTIONS ARE TENS OF DEGREES CLOCKWISE FROM TRUE NORTH. 00 = CALM.
DATA IN COLS. 6 AND 12-15 ARE BASED ON 7 OR MORE OBSERVATIONS PER DAY AT 3-HOUR INTERVALS.
FASTEST MILE WIND SPEEDS ARE FASTEST OBSERVED ONE-MINUTE VALUES WHEN DIRECTIONS ARE IN TENS OF DEGREES. THE / WITH THE DIRECTION INDICATES PEAK GUST SPEED.
ANY ERRORS DETECTED WILL BE CORRECTED AND CHANGES IN SUMMARY DATA WILL BE ANNOTATED IN THE ANNUAL SUMMARY

SUMMARY BY HOURS

HOUR LOCAL TIME	AVERAGES SKY COVER TENTHS	AVERAGES STATION PRESSURE IN.	AVERAGES TEMPERATURE AIR °F	AVERAGES TEMPERATURE WET BULB °F	AVERAGES TEMPERATURE DEW PT. °F	AVERAGES RELATIVE HUMIDITY %	AVERAGES WIND SPEED M.P.H.	RESULTANT WIND DIRECTION	RESULTANT WIND SPEED M.P.H.
01	7	29.54	48	44	39	78	4.2	07	1.5
04	6	29.53	46	43	39	78	4.7	10	2.1
07	7	29.54	45	42	38	79	5.3	11	2.7
10	8	29.58	51	46	40	69	6.9	15	1.7
13	8	29.52	57	49	41	58	8.3	30	.9
16	7	29.50	58	50	41	56	7.7	29	1.1
19	7	29.52	52	46	40	66	7.5	08	2.2
22	6	29.54	49	45	40	74	6.8	10	3.9

HOURLY PRECIPITATION (WATER EQUIVALENT IN INCHES)

DATE	A. M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	P. M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	DATE
1																									1
2																									2
3																									3
4					T																				4
5		.01	T	.01	.06	.02									.01	.01	T	T	T	T	T	.01	.01	.01	5
6	T																								6
7														T											7
8																				T	.04	.02	T		8
9	.04	.02	.09	.15	.07	.01	T	.02			T	T	T												9
10																									10
11																		T	T	.02	T		T		11
12		.01	T				T	T																	12
13																									13
14										T	.01	.07	.10	T											14
15				.06	.18	.18	T				T	.02	.02	T	T		T					T		T	15
16	.01	.02	.03	.01	T	T	T		T				T		T	T									16
17																							T	.06	17
18	.02	T			.01	.01																			18
19																									19
20																									20
21																									21
22																									22
23																									23
24																									24
25		T	T		.02	.01							T	T											25
26																									26
27																									27
28									.07	.01	T	.02	T												28
29																									29
30																			T	T	.09	T		.02	30
31	.02	.02	.03		T										.01	.02		.01	T	T		T	T	T	31

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noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / ENVIRONMENTAL DATA AND INFORMATION SERVICE

Daniel B. Mitchell
DIRECTOR, NATIONAL CLIMATIC CENTER

USCOMM--NOAA--ASHEVILLE 03/07/79 400

OBSERVATIONS AT 3-HOUR INTERVALS

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
DAY 01											
01	0	UNL	7			35	33	30	82	09	5
04	0	UNL	7			33	31	28	82	00	0
07	1	UNL	2		GF	29	28	26	89	34	3
10	4	UNL	2	8	KH	41	38	35	79	28	6
13	3	UNL	4		KH	54	46	38	55	30	10
16	8	UNL	15			58	45	29	33	13	18
19	10	250	15			57	39	05	12	14	24
22	3	UNL	10			53	36	02	12	14	24
DAY 02											
01	5	UNL	15			47	37	20	34	04	4
04	7	UNL	10			41	36	30	65	34	4
07	10	250	10			48	40	28	46	12	7
10	10	250	15			56	41	18	22	14	14
13	10	100	15			65	44	13	13	12	14
16	10	150	30			60	47	31	34	00	0
19	10	150	20			53	40	19	28	11	5
22	10	150	15			44	40	35	71	28	5
DAY 03											
01	0	UNL	15			43	39	34	71	33	7
04	0	UNL	10			39	38	36	89	33	4
07	10	150	7			36	33	28	73	27	3
10	8	UNL	5		KH	54	43	30	40	19	6
13	9	150	5		KH	57	45	31	37	32	3
16	7	250	10			60	48	34	38	24	7
19	3	UNL	15			50	42	32	50	06	4
22	10	120	10			47	41	33	58	08	4
DAY 04											
01	10	90	10			48	42	36	63	29	4
04	10	90	10			47	42	35	63	11	8
07	3	UNL	5		KH	45	40	33	63	09	5
10	6	UNL	7			60	46	29	31	12	3
13	10	UNL	10			68	49	26	21	27	9
16	10	150	5		KH	64	49	34	33	30	7
19	10	150	8		KH	56	47	38	51	36	5
22	10	130	5		KH	51	46	39	64	01	4
DAY 05											
01	10	130	7			61	43	17	18	16	8
04	10	100	5		R	62	48	32	32	16	18
07	10	70	30			53	47	40	62	13	23
10	8	250	30			58	49	41	53	18	12
13	10	80	15			60	50	40	48	17	15
16	10	80	7		RW	55	49	43	64	15	12
19	10	80	7		RW	54	48	42	64	15	18
22	10	80	7		RW	55	48	41	59	15	8
DAY 06											
01	10	65	30			52	48	46	80	34	6
04	8	65	15			50	47	45	83	00	0
07	10	70	15			52	48	45	77	04	11
10	9	75	8			53	49	46	77	00	0
13	8	UNL	15			62	55	49	63	27	8
16	10	250	15			63	54	47	56	35	5
19	7	UNL	7			54	50	47	77	36	5
22	10	250	7			54	50	47	77	12	5
DAY 07											
01	7	UNL	7			50	47	44	80	00	0
04	10	120	10			50	47	45	83	05	4
07	10	150	3		KH	46	44	42	86	00	0
10	10	150	3		KH	55	51	47	75	26	3
13	10	120	6		KH	60	53	48	65	31	6
16	10	60	7			63	55	49	60	36	5
19	8	250	7			56	51	46	69	00	0
22	0	UNL	7			52	49	46	80	16	5
DAY 08											
01	7	80	7			50	47	45	83	00	0
04	3	UNL	5		FH	50	46	43	77	12	6
07	3	UNL	3		FH	46	44	42	86	12	4
10	7	UNL	20			58	51	44	60	21	6
13	10	UNL	20			66	55	45	47	23	4
16	10	80	10			69	55	44	41	18	3
19	10	50	7			64	54	46	52	10	8
22	10	50	5		RF	56	53	50	80	05	14
DAY 09											
01	10	25	3		RWF	55	52	50	83	30	4
04	10	25	2	8	RF	55	53	51	86	35	5
07	10	10	0	8	F	54	52	51	90	32	7
10	10	20	7			54	52	50	86	32	7
13	10	40	10			56	53	51	83	34	7
16	3	UNL	10			61	54	49	65	33	6
19	1	UNL	7			55	51	46	77	36	4
22	7	UNL	7			50	48	46	86	13	5
DAY 10											
01	3	UNL	10			50	48	46	86	07	5
04	0	UNL	10			50	47	45	83	04	5
07	9	UNL	30			42	42	42	100	12	4
10	7	UNL	30			54	50	47	77	23	4
13	8	UNL	30			61	54	48	63	31	4
16	6	UNL	15			63	54	47	56	28	6
19	8	100	7			57	53	50	78	36	3
22	8	80	7			53	49	46	77	08	4
DAY 11											
01	10	120	10			54	51	48	80	10	6
04	8	80	10			54	50	47	77	00	0
07	10	45	30			54	51	49	83	02	4
10	10	41	30			57	52	48	72	14	5
13	8	120	15			67	57	50	55	02	3
16	9	150	20			71	60	53	53	00	0
19	10	26	5		R	64	60	58	81	32	12
22	10	65	7			61	58	56	84	28	7
DAY 12											
01	10	65	7			60	57	55	84	09	4
04	10	90	7			59	56	54	84	10	5
07	10	38	7		RW	58	55	53	84	32	8
10	8	UNL	15			59	55	52	78	35	13
13	7	40	20			62	54	48	60	32	12
16	4	UNL	30			63	54	47	56	33	14
19	0	UNL	30			55	50	45	69	35	4
22	0	UNL	30			48	45	43	83	00	0
DAY 13											
01	0	UNL	30			47	45	42	83	08	5
04	0	UNL	15			46	44	41	83	00	0
07	1	UNL	30			44	42	40	86	06	5
10	10	250	30			50	47	45	83	11	5
13	10	130	30			57	52	47	69	31	6
16	10	120	15			58	53	48	70	27	5
19	10	120	15			54	50	47	77	08	6
22	10	120	10			50	48	47	89	27	3
DAY 14											
01	10	UNL	10			51	48	45	80	00	0
04	10	120	30			51	45	39	64	08	5
07	10	100	30			58	46	32	37	13	8
10	10	90	20			61	47	32	34	22	6
13	10	50	10		RW	52	48	45	77	08	10
16	5	UNL	30			58	52	46	65	15	4
19	3	UNL	30			52	49	46	80	00	0
22	1	UNL	30			49	45	40	71	10	7
DAY 15											
01	10	90	15			55	47	38	53	13	10
04	10	50	15		RW	52	48	45	77	34	8
07	10	45	7			51	47	44	77	12	11
10	10	65	20			51	48	46	83	10	9
13	10	60	7		RW	55	52	49	80	10	7
16	10	60	15			56	53	50	80	31	6
19	8	90	20			53	51	49	86	34	7
22	9	90	15		RW	52	50	49	90	13	6
DAY 16											
01	10	90	10		R	52	49	47	83	12	3
04	10	90	10		R	52	49	47	83	00	0
07	10	75	2		FKH	50	48	47	89	28	4
10	10	2	0	4	FKH	50	48	47	89	29	7
13	10	50	1	8	F	51	49	47	86	34	6
16	10	9	4		F	50	48	47	89	32	4
19	10	10	5		F	50	48	46	86	26	4
22	10	5	3		F	50	48	47	89	00	0
DAY 17											
01	10	17	3		F	50	48	46	86	00	0
04	10	10	2		F	49	47	46	89	00	0
07	10	22	3		FKH	50	48	46	86	00	0
10	8	22	4		FKH	51	49	47	86	00	0
13	8	25	5		KH	57	51	45	64	20	3
16	0	UNL	10			60	52	45	58	18	4
19	0	UNL	10			53	49	45	74	02	4
22	2	UNL	7			48	45	42	80	07	4
DAY 18											
01	10	35	7		RW	50	47	45	83	36	5
04	9	45	10			49	46	42	77	11	6
07	10	45	10			47	44	40	77	10	3
10	7	40	10			53	47	42	66	03	8
13	4	UNL	20			56	49	42	60	32	8
16	7	50	20			58	50	42	55	31	10
19	0	UNL	30			49	45	41	74	01	4
22	0	UNL	30			45	42	39	80	00	0
DAY 19											
01	10	180	7			44	41	38	80	01	4
04	7	65	7			42	40	38	86	00	0
07	1	UNL	3		KH	40	38	36	86	00	0
10	1	UNL	5		KH	48	45	41	77	14	3
13	3	UNL	7			55	48	41	59	12	4
16	6	38	10			57	49	41	55	23	5
19	2	UNL	10			50	46	41	71	36	4
22	0	UNL	10			47	44	40	77	04	6
DAY 20											
01	0	UNL	7			42	40	38	86	00	0
04	0	UNL	10			39	38	36	89	16	4
07	6	UNL	5		KH	39	37	34	82	00	0
10	9	UNL	7			48	45	41	77	22	3
13	10	250	4		KH	54	50	46	75	30	6
16	10	250	5		KH	57	52	47	69	22	4
19	10	160	7			51	48	45	80	35	4
22	10	250	7			48	46	43	83	09	4
DAY 21											
01	0	UNL	3		F	47	45	44	89	36	5
04	4	UNL	2		F	44	43	41	89	27	5
07	10	1	0	2	F	44	43	42	93	15	10
10	10	250	0	12	F	48	46	45	89	00	0
13	10	UNL	3		KH	60	54	49	67	26	7
16	10	120	5		KH	59	54	49	70	32	8
19	10	120	4		KH	53	50	48	83	00	0
22	8	250	2	8	F	48	46	44	86	08	4
DAY 22											
01	3	UNL	2	4	F	44	43	41	89	00	0
04	10	0	0		F	44	43	42	93	10	4
07	10	11	0	10	F	48	46	45	89	00	0
10	10	12	1		F	50	48	46	86	18	3
13	9	14	1	8	KH	53	49	45	74	28	4
16	4	UNL	1	8	KH	57	52	47	69	12	4
19	3	UNL	3		KH	46	44	41	83	33	4
22	3	UNL	3		KH	47	45	42	83	08	4
DAY 23											
01	10	2	0	3	F	42	41	39	89	00	0
04	3	UNL	1	8	F	43	42	40	89	00	0
07	10	0	0		F	43	42	40	89	11	4
10	10	15	0	12	F	47	45	43	86	20	4
13	10	15	3		KH	54	49	45	72	36	4
16	10	250	3		KH	56	51	46	69	35	6
19	10	14	3		KH	51	47	44	77	00	0
22	10	18	3		KH	50	47	44	80	00	0
DAY 24											
01	10	18	2	8	KH	50	47	45	83	00	0
04	10	17	3		FKH	49	46	44	83	00	0
07	10	19	1	8	FKH	48	45	43	83	00	0
10	10	23	2	8	KH	50	47	44	80	36	5
13	10	25	3		KH	53	47	42	66	34	5
16	10	22	3		KH	53	48	43	69	32	5
19	10	28	3		KH	50	46	43	77	35	9
22	10	35	3		KH	49	45	41	74	04	4
DAY 25											
01	10	35	3		KH	48	45	43	83	30	3
04	10	16	2		FH	47	45	42	83	26	4
07	6	15	2		F	42	41	39	89	32	4
10	10	35	7			46	43	38	77	34	10
13	7	120	10		RW	50	44	37	61	30	13
16	3	UNL	15		RW	53	43	32	45	32	9
19	0	UNL	15			45	40	34	65	36	6
22	1	UNL	15			43	39	34	71	01	5
DAY 26											
01	10	55	15			42	39	35	76	09	4
04	0	UNL	30			39	36	33	79	01	4
07	4	UNL	30			36	33	28	73	00	0
10	0	UNL	30			44	37	28	53	24	5
13	0	UNL	30			50	42	31	48	18	4
16	0	UNL	30			53	43	30	41	26	3
19	0	UNL	15			47	40	31	54	12	5
22	0	UNL	15			40	36	30	68	12	6
DAY 27											
01	0	UNL	30			36	33	28	73	13	3
04	0	UNL	30			34	31	26	73	08	5
07	0	UNL	30			32	30	25	75	00	0
10	0	UNL	30			45	39	31	58	14	9
13	2	UNL	30			56	44	28	34	27	4
16	3	UNL	30			59	45	28	31	02	9
19	10	90	15			47	41	33	58	36	6
22	8	70	15			45	41	35	68	35	3
DAY 28											
01	4	UNL	15			44	40	36	74	01	4
04	1	UNL	15			39	36	33	79	09	5
07	9	50	15			40	37	34	79	16	5
10	10	40	8			41	39	37	86	13	6
13	10	40	10			45	41	37	74	12	4
16	3	UNL	15			46	42	38	74	15	8
19	4	UNL	15			42	39	36	79	19	4
22	8	80	15			40	38	35	82	09	6
DAY 29											
01	0	UNL	15			38	36	33	82	00	0
04	0	UNL	15			35	33	30	82	00	0
07	0	UNL	30			33	31	28	82	11	5
10	3	UNL	30			46	40	32	58	19	6
13	9	UNL	30			52	42	30	43	12	5
16	9	UNL	30			54	41	21	28	00	0
19	8	UNL	30			45	37	26	47	07	4
22	1	UNL	30			41	35	27	58	08	6
DAY 30											
01	8	UNL	30			41	35	26	55	14	4
04	10	100	30			45	37	25	46	10	6
07	10	90	30			45	37	26	47	12	8
10	10	90	30			55	44	30	39	10	10
13	10	90	30			59	46	32	36	12	17
16	10	100	15			56	44	30	37	12	22
19	10	41	7		RW	53	43	30	41	13	23
22	6	90	30			48	41	33	56	12	25
DAY 31											
01	10	45	7		RW	47	43	38	71	13	10
04	10	35	7			46	42	38	74	13	12
07	8	90	30			43	40	37	79	00	0
10	8	250	30			50	45	40	69	11	7
13	10	40	30			60	48	35	39	13	15
16	10	45	10		RW	47	44	40	77	24	8
19	10	90	15		RW	50	43	35	57	18	16
22	10	55	10		RW	48	43	38	68	25	4

NOTES

CEILING

UNL INDICATES UNLIMITED

WEATHER

*	TORNADO
T	THUNDERSTORM
Q	SQUALL
R	RAIN
RW	RAIN SHOWERS
ZR	FREEZING RAIN
L	DRIZZLE
ZL	FREEZING DRIZZLE
S	SNOW
SP	SNOW PELLETS
IC	ICE CRYSTALS
SW	SNOW SHOWERS
SG	SNOW GRAINS
IP	ICE PELLETS
A	HAIL
F	FOG
IF	ICE FOG
GF	GROUND FOG
BD	BLOWING DUST
BN	BLOWING SAND
BS	BLOWING SNOW
BY	BLOWING SPRAY
K	SMOKE
H	HAZE
D	DUST

WIND

DIRECTIONS ARE THOSE FROM WHICH THE WIND BLOWS. INDICATED IN TENS OF DEGREES FROM TRUE NORTH: I.E., 09 FOR EAST, 18 FOR SOUTH, 27 FOR WEST. ENTRY OF 00 IN THE DIRECTION COLUMN INDICATES CALM.

SPEED IS EXPRESSED IN KNOTS; MULTIPLY BY 1.15 TO CONVERT TO MILES PER HOUR.

STATION	YEAR & MONTH
BAKERSFIELD CALIFORNIA	79 01

U.S. DEPARTMENT OF COMMERCE
NATIONAL CLIMATIC CENTER
FEDERAL BUILDING
ASHEVILLE, N.C. 28801

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE
COM-210

U.S.MAIL

FIRST CLASS

FEBRUARY 1979
BAKERSFIELD, CALIFORNIA
NATIONAL WEATHER SERVICE OFC
KERN COUNTY AIR TERMINAL

Local Climatological Data

MONTHLY SUMMARY

LATITUDE 35° 25 ′N LONGITUDE 119° 03 ′W ELEVATION (GROUND) 475 FT. STANDARD TIME USED: PACIFIC WBAN #23155

DATE	TEMPERATURE °F MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	AVERAGE DEW POINT	DEGREE DAYS BASE 65° HEATING (SEASON BEGINS WITH JULY)	COOLING (SEASON BEGINS WITH JAN.)	WEATHER TYPES ON DATES OF OCCURRENCE 1 FOG 2 HEAVY FOG 3 THUNDERSTORM 4 ICE PELLETS 5 HAIL 6 GLAZE 7 DUSTSTORM 8 SMOKE, HAZE 9 BLOWING SNOW	SNOW, ICE PELLETS OR ICE ON GROUND AT 04AM IN.	PRECIPITATION WATER EQUIVALENT IN	SNOW, ICE PELLETS IN.	AVG. STATION PRESSURE IN. ELEV. 492 FEET M.S.L.	WIND RESULTANT DIR.	RESULTANT SPEED M.P.H.	AVERAGE SPEED M.P.H.	FASTEST MILE SPEED M.P.H.	FASTEST MILE DIRECTION	SUNSHINE MINUTES	PERCENT OF POSSIBLE	SKY COVER TENTHS SUNRISE TO SUNSET	MIDNIGHT TO MIDNIGHT	DATE
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	58	44	51	1	42	14	0	1 8	0	.18	0	29.45	08	.6	6.3	14	27			9	8	1
2	55	44	50	0	40	15	0		0	T	0	29.49	02	2.9	6.2	12	30			10	9	2
3	57	38	48	-2	38	17	0	1 8	0	0	0	29.74	10	1.3	5.8	8	15			1	2	3
4	60	36	48	-3	36	17	0	8	0	0	0	29.71	09	1.0	4.5	12	33			0	0	4
5	63	38	51	0	38	14	0	8	0	0	0	29.70	02	1.7	5.6	10	30			4	4	5
6	65	40	53	2	38	12	0	8	0	0	0	29.74	10	3.1	5.0	9	08			8	3	6
7	66	39	53	2	41	12	0		0	0	0	29.72	11	1.6	5.8	8	02			7	6	7
8	63	40	52	1	43	13	0	8	0	0	0	29.72	10	1.2	4.3	9	15			9	7	8
9	56	35*	46*	-6	43	19	0	2 8	0	0	0	29.76	01	.8	2.7	9	14			9	7	9
10	62	40	51	-1	43	14	0	1 8	0	0	0	29.66	16	1.8	3.7	7	12			7	8	10
11	70	41	56	4	43	9	0	8	0	0	0	29.64	03	1.6	5.6	14	30			6	4	11
12	79*	45	62	10	45	3	0	8	0	0	0	29.54	03	.4	5.0	12	29			8	6	12
13	68	55	62*	10	44	3	0		0	.26	0	29.41	09	5.2	8.9	16	13			10	10	13
14	61	46	54	2	45	11	0		0	T	0	29.53	33	5.5	7.6	17	27			6	5	14
15	59	40	50	-3	42	15	0		0	0	0	29.59	08	1.2	3.5	9	32			5	3	15
16	60	43	52	-1	43	13	0		0	.01	0	29.64	04	2.6	7.3	13	31			6	4	16
17	62	43	53	0	45	12	0	8	0	0	0	29.73	03	2.0	4.0	9	01			5	4	17
18	61	42	52	-1	45	13	0	1 8	0	0	0	29.62	09	1.7	4.6	9	13			9	6	18
19	58	48	53	0	49	12	0	1 8	0	.15	0	29.56	33	2.6	3.7	9	31			9	8	19
20	54	45	50	-3	46	15	0	1	0	.41	0	29.47	09	1.9	6.6	15	33			10	8	20
21	60	48	54	0	46	11	0		0	.12	0	29.35	26	4.5	9.6	18	27			8	9	21
22	59	41	50	-4	43	15	0		0	.18	0	29.48	14	1.7	4.6	14	34			7	7	22
23	59	44	52	-2	45	13	0		0	.04	0	29.59	36	3.7	5.8	16	35			4	4	23
24	62	39	51	-3	43	14	0		0	0	0	29.73	36	.9	5.0	10	03			10	7	24
25	70	44	57	3	48	8	0		0	0	0	29.62	30	2.2	5.2	10	34			9	7	25
26	62	43	53	-1	46	12	0		0	.04	0	29.61	35	5.5	7.5	18	33			8	6	26
27	61	43	52	-2	44	13	0		0	0	0	29.69	02	3.3	5.5	9	08			9	5	27
28	63	41	52	-2	44	13	0	8	0	.02	0	29.48	06	2.0	3.5	8	25			6	6	28

SUM	SUM	—	—	—	TOTAL	TOTAL		TOTAL	TOTAL	FOR THE MONTH:						TOTAL	% FOR MONTH	SUM	SUM
1733	1185	—	—	—	352	0	NUMBER OF DAYS	1.41	0	29.61	03	1.2	5.5	18	33			199	163
AVG.	AVG.	AVG.	DEP.	AVG.	DEP.	DEP.	PRECIPITATION	DEP.	—	—	—	—	—	DATE: 26+		POSSIBLE		AVG.	AVG.
61.9	42.3	52.1	-0.3	43	-1	0	≥ .01 INCH 10	0.38	—	—	—	—	—	—				7.1	5.8

				SEASON TO DATE		SNOW, ICE PELLETS	
NUMBER OF DAYS				TOTAL	TOTAL	≥ 1.0 INCH	0
MAXIMUM TEMP.		MINIMUM TEMP.		1585	0	THUNDERSTORMS	0
≥ 90°	≤ 32°	≤ 32°	≤ 0°	DEP.	DEP.	HEAVY FOG	1
0	0	0	0	-172	0	CLEAR 2	PARTLY CLOUDY 11 CLOUDY 15

GREATEST IN 24 HOURS AND DATES PRECIPITATION		SNOW, ICE PELLETS	GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE	
.51	20-21	0	0	

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT
+ ALSO ON AN EARLIER DATE, OR DATES.
HEAVY FOG: - VISIBILITY 1/4 MILE OR LESS.
FIGURES FOR WIND DIRECTIONS ARE TENS OF DEGREES CLOCKWISE FROM TRUE NORTH. 00 = CALM.
DATA IN COLS. 6 AND 12-15 ARE BASED ON 7 OR MORE OBSERVATIONS PER DAY AT 3-HOUR INTERVALS.
FASTEST MILE WIND SPEEDS ARE FASTEST OBSERVED ONE-MINUTE VALUES WHEN DIRECTIONS ARE IN TENS OF DEGREES. THE / WITH THE DIRECTION INDICATES PEAK GUST SPEED.
ANY ERRORS DETECTED WILL BE CORRECTED AND CHANGES IN SUMMARY DATA WILL BE ANNOTATED IN THE ANNUAL SUMMARY

SUMMARY BY HOURS

HOUR LOCAL TIME	AVERAGES SKY COVER TENTHS	STATION PRESSURE IN.	TEMPERATURE AIR °F	WET BULB °F	DEW PT. °F	RELATIVE HUMIDITY %	WIND SPEED M.P.H.	RESULTANT WIND DIRECTION	SPEED M.P.H.
01	4	29.61	47	45	43	85	4.8	07	3.0
04	5	29.60	46	43	41	88	4.1	11	1.6
07	6	29.63	44	42	40	89	4.5	11	2.0
10	8	29.65	52	48	44	76	4.9	17	1.6
13	8	29.60	58	51	45	62	7.1	31	3.0
16	7	29.57	61	52	44	55	7.0	32	6.0
19	6	29.59	54	49	45	71	5.3	02	3.1
22	5	29.60	50	47	44	80	6.1	08	3.6

HOURLY PRECIPITATION (WATER EQUIVALENT IN INCHES)

DATE	A.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	P.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	DATE
1			T				.09											.04	.05						1
2														T	T	T									2
3																									3
4																									4
5																									5
6																									6
7																									7
8																									8
9																									9
10																									10
11																									11
12																									12
13										T	T	T	.02	T		.03	.07	.02		T	.01	.03	.04	.04	13
14	T																								14
15																									15
16									T	.01	T	T													16
17																									17
18																									18
19	T	.02	T		T	.04	.05	.01	.02	.01															19
20										T	T	.03	.03	.01	T	T	T	.01				.10	.16	.07	20
21		.04	.04	.02	T							T	.02	T											21
22																T			T	.10	.07	.01			22
23				.01	.01	.02																			23
24																									24
25																									25
26					.02	.01		T	.01		T														26
27																									27
28																					T	T	.02		28

I CERTIFY THAT THIS IS AN OFFICIAL PUBLICATION OF THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, AND IS COMPILED FROM RECORDS ON FILE AT THE NATIONAL CLIMATIC CENTER, ASHEVILLE, NORTH CAROLINA 28801.

noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / ENVIRONMENTAL DATA AND INFORMATION SERVICE

Daniel B. Mitchell
DIRECTOR, NATIONAL CLIMATIC CENTER

USCOMM--NOAA--ASHEVILLE 03/30/79 400

OBSERVATIONS AT 3-HOUR INTERVALS

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
DAY 01											
01	10	50	15			46	44	41	83	30	8
04	10	7	7			45	44	42	89	12	6
07	10	5	1		RWF	45	44	42	89	16	3
10	9	UNL	5		KH	48	46	44	86	09	5
13	4	UNL	7			54	49	44	69	28	6
16	8	70	15			55	47	39	55	33	6
19	10	75	30			48	45	41	77	09	4
22	9	65	15			46	43	40	80	13	6
DAY 02											
01	10	65	30			46	43	40	80	08	5
04	8	65	30			45	43	40	83	11	4
07	8	50	30			45	43	40	83	10	5
10	10	80	15			51	45	38	61	00	0
13	10	80	15			53	47	41	64	34	8
16	9	85	20			53	46	38	57	02	7
19	10	90	20			50	46	43	77	01	7
22	10	40	20			49	46	42	77	26	7
DAY 03											
01	0	UNL	10			42	40	38	86	10	5
04	4	UNL	7			42	40	38	86	14	5
07	2	UNL	0	12	F	38	37	36	93	31	4
10	0	UNL	4		KH	47	43	39	74	15	7
13	4	UNL	4		KH	52	46	40	64	24	3
16	0	UNL	6			56	48	40	55	30	5
19	0	UNL	15			49	44	39	69	04	5
22	0	UNL	10			44	40	36	74	06	5
DAY 04											
01	0	UNL	7			41	38	34	76	04	4
04	0	UNL	7			38	36	33	82	13	4
07	0	UNL	7			36	34	32	85	00	0
10	0	UNL	7			53	45	37	55	18	6
13	0	UNL	7			56	48	39	53	18	3
16	0	UNL	8			59	50	41	51	33	10
19	0	UNL	10			50	44	37	61	00	0
22	0	UNL	7			45	42	38	77	10	4
DAY 05											
01	0	UNL	10			42	40	37	83	10	7
04	0	UNI	7			40	38	35	82	00	0
07	3	UNL	4		KH	38	36	34	86	10	5
10	8	UNL	7			55	47	39	55	32	3
13	1	UNL	7			61	51	42	50	30	9
16	8	UNL	10			63	51	40	43	30	6
19	9	UNL	15			54	47	39	57	04	4
22	4	UNL	10			48	44	39	71	09	5
DAY 06											
01	0	UNL	10			45	42	39	80	07	4
04	0	UNL	10			42	40	37	83	08	5
07	1	UNL	7			40	37	34	79	15	5
10	10	UNL	6		KH	51	44	37	59	12	3
13	7	UNL	5		KH	60	50	41	50	10	4
16	5	UNL	7			62	49	35	37	26	5
19	3	UNL	10			52	46	40	64	10	4
22	3	UNL	10			47	43	38	71	08	5
DAY 07											
01	0	UNL	10			44	41	38	80	12	5
04	0	UNL	10			42	40	38	86	09	4
07	3	UNL	10			39	38	37	93	09	5
10	8	UNL	10			55	48	41	59	21	4
13	8	UNL	8			61	52	43	52	22	5
16	10	UNL	7			64	53	43	47	29	5
19	10	UNL	10			54	49	44	69	02	7
22	10	UNL	10			48	45	43	83	11	5
DAY 08											
01	4	UNL	10			45	43	41	86	00	0
04	7	UNL	10			43	42	40	89	12	5
07	7	UNL	4		KH	41	39	37	86	00	0
10	10	UNL	4		KH	51	47	42	71	15	8
13	8	UNL	3		KH	60	53	46	60	29	3
16	9	UNL	3		KH	63	54	47	56	33	5
19	4	UNL	4		KH	55	50	46	72	02	5
22	1	UNL	3		KH	48	46	45	89	12	4
DAY 09											
01	4	UNL	4		FKH	44	43	42	93	00	0
04	3	UNL	2	8	FKH	41	41	40	96	00	0
07	10	0	0		F	35	35	35	100	00	0
10	10	4	0	6	F	42	42	42	100	12	6
13	9	9	1		F	50	48	47	89	06	3
16	10	30	1	8	KH	56	51	47	72	32	4
19	10	30	3		KH	54	50	47	77	31	6
22	8	30	3		KH	51	48	46	83	00	0
DAY 10											
01	3	UNL	2		FH	45	44	43	93	00	0
04	3	UNL	2		FH	43	42	41	93	16	5
07	4	UNL	0	12	FH	40	39	38	93	00	0
10	9	UNL	1		FH	49	47	45	86	25	3
13	10	250	2		KH	57	51	45	64	17	5
16	5	UNL	2	8	KH	62	53	45	54	27	4
19	5	UNL	3		KH	52	48	45	77	11	3
22	6	UNL	5		KH	50	46	43	77	09	8
DAY 11											
01	0	UNL	5		KH	46	44	41	83	06	6
04	0	UNL	5		KH	44	42	40	86	00	0
07	7	UNL	3		KH	41	40	38	89	12	4
10	2	UNL	4		KH	54	49	44	69	19	5
13	8	UNL	4		KH	64	55	47	54	28	6
16	10	120	3		KH	69	58	46	44	34	7
19	3	UNL	5		KH	57	51	45	64	02	6
22	0	UNL	5		KH	52	48	44	74	09	5
DAY 12											
01	9	100	5		KH	49	47	45	86	12	5
04	10	120	5		KH	49	47	45	86	34	5
07	10	120	2	8	KH	45	44	43	93	12	5
10	10	120	15			59	52	46	62	00	0
13	10	120	4		KH	70	57	46	42	23	4
16	2	UNL	6		KH	79	59	44	29	31	6
19	10	120	5		KH	63	53	45	52	18	3
22	10	120	7			63	55	49	60	05	5
DAY 13											
01	8	120	7			60	52	44	56	09	6
04	10	100	10			63	47	28	27	12	7
07	10	100	30			59	47	35	41	28	7
10	10	90	30		RW	63	51	40	43	09	4
13	10	80	20		RW	62	55	50	65	05	10
16	10	80	7		RW	65	58	52	63	03	6
19	10	75	7			60	55	52	75	08	11
22	10	75	7		RW	57	53	49	75	16	9
DAY 14											
01	10	65	20			55	52	50	83	00	0
04	4	UNL	30			55	52	50	83	30	15
07	10	80	30			52	48	45	77	32	7
10	10	30	30			53	49	46	77	32	10
13	7	50	30			57	51	46	67	06	4
16	2	UNL	20			61	51	42	50	33	7
19	0	UNL	20			53	47	42	66	02	5
22	0	UNL	7			47	45	42	83	08	5
DAY 15											
01	3	UNL	30			46	44	42	86	00	0
04	2	UNL	10			42	41	40	93	00	0
07	8	UNL	15			40	40	39	96	09	4
10	0	UNL	7			48	46	45	89	18	4
13	8	40	8			55	49	44	67	32	7
16	9	35	15			59	50	42	54	00	0
19	0	UNL	15			54	48	42	64	08	3
22	0	UNL	15			48	45	42	80	09	8
DAY 16											
01	0	UNL	15			44	42	40	86	16	5
04	10	UNL	15			44	42	40	86	09	8
07	10	120	15			45	43	40	83	09	6
10	10	45	7		RW	50	48	46	86	12	5
13	9	40	10			57	51	46	67	32	4
16	2	UNL	15			60	52	44	56	31	11
19	0	UNL	30			52	49	46	80	02	7
22	0	UNL	30			46	44	42	86	35	5
DAY 17											
01	0	UNL	15			44	43	42	93	11	3
04	10	28	7			43	42	42	96	00	0
07	2	UNL	4		KH	43	42	42	96	15	5
10	6	UNL	5		KH	52	49	47	83	00	0
13	3	UNL	7			60	53	47	62	36	5
16	6	UNL	10			62	53	46	56	33	4
19	4	UNL	15			54	50	47	77	01	8
22	0	UNL	15			51	48	46	83	07	3
DAY 18											
01	0	UNL	10			47	45	44	89	09	6
04	0	UNL	7			45	44	42	89	00	0
07	6	UNL	2		F	42	41	40	93	20	3
10	10	250	3		KH	49	47	46	89	14	6
13	10	32	4		KH	59	53	47	65	36	7
16	10	UNL	8		KH	61	53	46	58	25	4
19	10	250	10			57	52	47	69	00	0
22	3	UNL	10			51	48	46	83	07	7
DAY 19											
01	10	90	10		R	51	49	48	90	30	4
04	10	45	2		F	51	50	49	93	00	0
07	10	5	0	8	RLF	50	50	50	100	00	0
10	10	50	0	12	F	50	50	50	100	32	5
13	10	30	7			57	53	49	75	31	7
16	9	65	10			57	52	48	72	33	5
19	4	UNL	15			57	52	47	69	00	0
22	0	UNL	5		KH	49	48	47	93	08	5
DAY 20											
01	0	UNL	7			47	46	45	93	09	6
04	0	UNL	7			46	45	44	93	18	5
07	7	UNL	15			46	44	43	89	11	6
10	10	50	7			52	47	43	72	25	4
13	10	45	4		RWF	53	50	47	80	10	12
16	10	45	7		RW	53	50	47	80	00	0
19	9	45	15			53	52	51	93	00	0
22	10	38	5		RW	51	49	48	90	33	13
DAY 21											
01	10	50	10			51	50	49	93	10	5
04	10	50	15		RW	50	49	48	93	28	5
07	5	UNL	30			48	47	47	96	12	8
10	10	55	30			52	50	48	86	13	6
13	10	50	15		RW	60	53	47	62	27	16
16	8	80	30			59	52	45	60	28	13
19	10	70	30			54	48	43	67	28	10
22	9	45	30			53	48	44	72	27	4
DAY 22											
01	4	UNL	30			48	45	43	83	02	6
04	2	UNL	30			44	43	41	89	00	0
07	3	UNL	20			41	40	39	93	06	5
10	3	UNL	30			52	47	41	66	19	5
13	10	70	30			56	48	40	55	20	4
16	10	50	20			57	50	43	60	22	4
19	10	45	20		RW	56	51	46	69	13	4
22	10	50	10			50	49	48	93	13	4
DAY 23											
01	7	65	30			51	49	48	90	00	0
04	10	45	10		RW	48	47	47	96	00	0
07	3	UNL	30			48	47	46	93	06	4
10	10	50	20			52	50	48	86	29	6
13	5	UNL	20			57	50	43	60	34	9
16	2	UNL	30			58	49	40	51	32	8
19	0	UNL	30			51	48	45	80	02	6
22	0	UNL	30			48	44	40	74	07	7
DAY 24											
01	0	UNL	30			45	43	40	83	09	5
04	0	UNL	30			41	40	38	89	12	4
07	10	UNL	30			43	40	37	79	00	0
10	10	UNL	30			52	46	40	64	25	4
13	10	250	20			58	52	47	67	28	5
16	10	UNL	30			62	54	48	60	32	7
19	10	250	30			56	52	49	80	34	4
22	10	250	20			53	50	47	80	10	6
DAY 25											
01	8	250	20			49	47	46	89	00	0
04	10	200	20			50	48	47	89	00	0
07	10	250	15			46	45	44	93	22	6
10	10	250	10			54	52	50	86	31	6
13	9	120	20			66	57	48	49	27	4
16	8	UNL	30			70	56	48	46	34	9
19	10	UNL	20			61	54	49	65	23	4
22	4	UNL	20			55	51	48	77	06	7
DAY 26											
01	1	UNL	20			52	49	47	83	03	10
04	6	90	15			53	47	41	64	13	4
07	10	55	10			50	49	48	93	36	4
10	10	32	10			52	50	49	90	00	0
13	9	32	10			58	54	51	78	30	12
16	3	UNL	20			61	53	48	58	35	15
19	2	UNL	20			52	48	45	77	34	7
22	0	UNL	30			45	44	42	89	00	0
DAY 27											
01	8	45	30			46	45	45	96	32	6
04	0	UNL	10			44	43	42	93	12	4
07	4	UNL	7			44	43	43	96	07	5
10	10	50	7			53	50	47	80	00	0
13	10	UNL	15			59	50	41	51	34	5
16	10	80	15			61	52	43	52	33	6
19	1	UNL	7			54	49	44	69	02	6
22	0	UNL	7			49	46	43	80	07	6
DAY 28											
01	0	UNL	7			46	44	42	86	08	5
04	4	UNL	7			42	42	41	96	36	4
07	8	UNL	7			44	43	42	93	13	3
10	2	UNL	5		KH	51	48	45	80	17	4
13	9	32	8			59	51	44	58	11	3
16	8	UNL	7			63	53	45	52	00	0
19	8	250	7			56	52	48	75	00	0
22	10	86	7		RW	56	52	48	75	04	5

NOTES

CEILING

UNL INDICATES UNLIMITED

WEATHER

•	TORNADO
T	THUNDERSTORM
Q	SQUALL
R	RAIN
RW	RAIN SHOWERS
ZR	FREEZING RAIN
L	DRIZZLE
ZL	FREEZING DRIZZLE
S	SNOW
SP	SNOW PELLETS
IC	ICE CRYSTALS
SW	SNOW SHOWERS
SG	SNOW GRAINS
IP	ICE PELLETS
A	HAIL
F	FOG
IF	ICE FOG
GF	GROUND FOG
BD	BLOWING DUST
BN	BLOWING SAND
BS	BLOWING SNOW
BY	BLOWING SPRAY
K	SMOKE
H	HAZE
D	DUST

WIND

DIRECTIONS ARE THOSE FROM WHICH THE WIND BLOWS. INDICATED IN TENS OF DEGREES FROM TRUE NORTH; I.E., 09 FOR EAST, 18 FOR SOUTH, 27 FOR WEST. ENTRY OF 00 IN THE DIRECTION COLUMN INDICATES CALM.

SPEED IS EXPRESSED IN KNOTS; MULTIPLY BY 1.15 TO CONVERT TO MILES PER HOUR.

STATION

BAKERSFIELD CALIFORNIA

YEAR & MONTH

79 02

U.S. DEPARTMENT OF COMMERCE
NATIONAL CLIMATIC CENTER
FEDERAL BUILDING
ASHEVILLE, N.C. 28801

AN EQUAL OPPORTUNITY EMPLOYER

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE
COM-210

FIRST CLASS

MARCH 1979
BAKERSFIELD, CALIFORNIA
NATIONAL WEATHER SERVICE OFC
KERN COUNTY AIR TERMINAL

Local Climatological Data

MONTHLY SUMMARY

LATITUDE 35° 25′ N LONGITUDE 119° 03′ W ELEVATION (GROUND) 475 FT. STANDARD TIME USED: PACIFIC WBAN #23155

DATE	TEMPERATURE °F MAXIMUM	TEMPERATURE °F MINIMUM	TEMPERATURE °F AVERAGE	TEMPERATURE °F DEPARTURE FROM NORMAL	TEMPERATURE °F AVERAGE DEW POINT	DEGREE DAYS BASE 65° HEATING (SEASON BEGINS WITH JULY)	DEGREE DAYS BASE 65° COOLING (SEASON BEGINS WITH JAN.)	WEATHER TYPES ON DATES OF OCCURRENCE 1 FOG 2 HEAVY FOG 3 THUNDERSTORM 4 ICE PELLETS 5 HAIL 6 GLAZE 7 DUSTSTORM 8 SMOKE, HAZE 9 BLOWING SNOW	SNOW, ICE PELLETS OR ICE ON GROUND AT 04AM IN.	PRECIPITATION WATER EQUIVALENT IN	PRECIPITATION SNOW, ICE PELLETS IN.	AVG. STATION PRESSURE IN. ELEV. 492 FEET M.S.L.	WIND RESULTANT DIR.	WIND RESULTANT SPEED M.P.H.	WIND AVERAGE SPEED M.P.H.	WIND FASTEST MILE SPEED M.P.H.	WIND FASTEST MILE DIRECTION	SUNSHINE MINUTES	SUNSHINE PERCENT OF POSSIBLE	SKY COVER TENTHS SUNRISE TO SUNSET	SKY COVER TENTHS MIDNIGHT TO MIDNIGHT	DATE
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	56	37	47*	-8	43	18	0	1	0	.27	0	29.28	01	5.5	8.5	23	34			8	7	1
2	58	37*	48	-7	39	17	0		0	0	0	29.57	11	2.4	4.9	9	08			5	4	2
3	66	40	53	-2	41	12	0		0	0	0	29.72	02	4.0	6.3	12	03			4	2	3
4	62	43	53	-2	48	12	0	8	0	0	0	29.77	32	1.7	6.0	14	33			5	5	4
5	65	53	59	4	52	6	0	1 8	0	0	0	29.81	29	2.4	4.2	12	18			9	8	5
6	76	49	63	8	53	2	0	1 8	0	0	0	29.76	08	1.3	4.3	8	08			0	2	6
7	80	55	68	13	55	0	3	1 8	0	0	0	29.60	03	1.7	5.0	9	32			0	1	7
8	80	56	68	13	55	0	3	8	0	0	0	29.39	02	1.5	3.7	8	10			6	4	8
9	80*	55	68*	12	55	0	3	8	0	0	0	29.38	08	1.9	4.2	9	07			9	6	9
10	77	55	66	10	56	0	1	2 8	0	0	0	29.58	35	3.4	3.7	12	34			5	4	10
11	71	56	64	8	57	1	0	2 8	0	0	0	29.61	03	.7	4.6	8	05			9	7	11
12	75	56	66	10	56	0	1	2 8	0	0	0	29.46	36	2.6	3.9	8	32			9	9	12
13	72	59	66	10	54	0	1	3 8	0	.01	0	29.50	01	4.9	6.6	13	02			8	9	13
14	69	54	62	6	54	3	0	8	0	.23	0	29.65	01	2.4	5.3	9	06			9	8	14
15	68	48	58	2	50	7	0	1 3 8	0	T	0	29.47	31	4.9	7.8	23	28			8	7	15
16	62	46	54	-2	44	11	0		0	.16	0	29.46	34	4.4	6.2	12	33			7	8	16
17	58	48	53	-4	47	12	0		0	.16	0	29.48	13	.1	5.2	14	32			10	8	17
18	62	47	55	-2	45	10	0		0	.24	0	29.45	17	2.1	4.6	14	34			7	8	18
19	58	48	53	-4	46	12	0		0	.35	0	29.28	20	1.4	4.9	9	05			10	10	19
20	60	45	53	-4	48	12	0	2	0	.01	0	29.27	11	2.0	5.0	14	08			9	8	20
21	61	49	55	-2	48	10	0		0	0	0	29.38	06	4.8	5.6	14	04			9	8	21
22	66	52	59	1	46	6	0		0	0	0	29.57	02	8.5	8.9	15	02			6	6	22
23	68	48	58	0	48	7	0		0	0	0	29.68	01	4.2	5.8	9	35			6	7	23
24	71	50	61	3	49	4	0	8	0	0	0	29.67	28	1.4	3.0	8	17			0	1	24
25	72	48	60	2	49	5	0		0	0	0	29.50	08	1.7	3.2	10	01			1	2	25
26	71	50	61	3	49	4	0	8	0	.01	0	29.32	14	2.5	6.5	23	16			10	8	26
27	72	54	63	5	46	2	0		0	.18	0	29.20	12	7.5	10.9	26	17			9	8	27
28	63	52	58	0	48	7	0		0	.35	0	29.26	31	2.0	9.1	13	29			9	9	28
29	62	47	55	-4	47	10	0		0	0	0	29.54	33	2.5	5.3	9	33			9	7	29
30	60	45	53	-6	47	12	0		0	0	0	29.69	35	1.9	5.6	9	31			9	5	30
31	67	44	56	-3	47	9	0	8	0	0	0	29.72	01	1.5	5.9	8	09			3	3	31
	SUM	SUM				TOTAL	TOTAL			TOTAL	TOTAL	FOR THE MONTH:						TOTAL	%	SUM	SUM	
	2088	1526				211	12	NUMBER OF DAYS		1.97	0	29.52	02	1.6	5.6	26	17		FOR	208	190	
	AVG.	AVG.	AVG.	DEP.	AVG.	DEP.	DEP.	PRECIPITATION		DEP.						DATE:	27	POSSIBLE	MONTH	AVG.	AVG.	
	67.4	49.2	58.3	1.7	49	-55	6	≥.01 INCH	11	1.14										6.7	6.1	

NUMBER OF DAYS				SEASON TO DATE			
MAXIMUM TEMP.		MINIMUM TEMP.		TOTAL	TOTAL	SNOW, ICE PELLETS ≥ 1.0 INCH	0
≥ 90°	≤ 32°	≤ 32°	≤ 0°	1796	12	THUNDERSTORMS	2
				DEP.	DEP.	HEAVY FOG	4
0	0	0	0	-227	6	CLEAR 5 PARTLY CLOUDY 9 CLOUDY 17	

GREATEST IN 24 HOURS AND DATES				GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE	
PRECIPITATION		SNOW, ICE PELLETS			
.54	18-19	0		0	

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT
+ ALSO ON AN EARLIER DATE, OR DATES.
HEAVY FOG: - VISIBILITY 1/4 MILE OR LESS.
FIGURES FOR WIND DIRECTIONS ARE TENS OF DEGREES CLOCKWISE FROM TRUE NORTH. 00 = CALM.
DATA IN COLS. 6 AND 12-15 ARE BASED ON 7 OR MORE OBSERVATIONS PER DAY AT 3-HOUR INTERVALS.
FASTEST MILE WIND SPEEDS ARE FASTEST OBSERVED ONE-MINUTE VALUES WHEN DIRECTIONS ARE IN TENS OF DEGREES. THE / WITH THE DIRECTION INDICATES PEAK GUST SPEED.
ANY ERRORS DETECTED WILL BE CORRECTED AND CHANGES IN SUMMARY DATA WILL BE ANNOTATED IN THE ANNUAL SUMMARY

SUMMARY BY HOURS

HOUR LOCAL TIME	AVERAGES SKY COVER TENTHS	AVERAGES STATION PRESSURE IN.	AVERAGES TEMPERATURE AIR °F	AVERAGES TEMPERATURE WET BULB °F	AVERAGES TEMPERATURE DEW PT. °F	AVERAGES RELATIVE HUMIDITY %	AVERAGES WIND SPEED M.P.H.	RESULTANT WIND DIRECTION	RESULTANT WIND SPEED M.P.H.
01	5	29.51	54	51	49	83	5.8	09	3.0
04	6	29.50	52	50	48	87	4.5	07	2.4
07	7	29.53	51	49	48	89	4.2	05	1.4
10	7	29.55	58	53	49	75	5.3	25	1.2
13	7	29.52	64	56	49	59	5.8	31	4.3
16	7	29.48	67	57	49	54	6.8	33	3.6
19	6	29.49	60	55	50	69	6.3	01	3.3
22	5	29.53	56	53	49	78	6.5	07	3.7

HOURLY PRECIPITATION (WATER EQUIVALENT IN INCHES)

DATE	A.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	P.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	DATE
1	.02	.04	.01	.01	.06	.06	.06	.01	T	T															1
2																									2
3																									3
4																									4
5																									5
6																									6
7																									7
8																									8
9																									9
10																									10
11																									11
12																									12
13					T	T								T	T	T	T	.01	T						13
14		.22	T			.01		T																	14
15														T	T										15
16																		T	T	.07	.05	.01		.03	16
17	.10	.04	T						.02	T	T						T								17
18								T	.06	T												T	.06	.12	18
19	.08	.07	.06	.03	.02	.01	.02	.01	.03	.02	T	T										T	T		19
20															T	T	.01	T							20
21																									21
22																									22
23																									23
24																									24
25																									25
26																				.01	T				26
27			T	.04	.04	.09	.01																		27
28	T	.15	.03	.01	.03	.05	.01	T							T			T	.01	.01	.03	.02	T		28
29																									29
30																									30
31																									31

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Daniel B. Mitchell
DIRECTOR, NATIONAL CLIMATIC CENTER

USCOMM--NOAA--ASHEVILLE 04/25/79 400

OBSERVATIONS AT 3-HOUR INTERVALS

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
					DAY 01											DAY 02											DAY 03						
01	10	55	7		RW	54	52	50	86	12	6	0	UNL	30			39	38	36	89	08	5	0	UNL	30			48	44	39	71	09	7
04	10	38	10		RW	53	51	50	90	22	3	0	UNL	30			37	37	36	96	09	5	0	UNL	30			42	40	37	83	01	5
07	10	32	7		RW	47	46	45	93	36	11	0	UNL	30			37	36	35	92	07	4	0	UNL	30			43	40	37	79	06	5
10	10	35	15			46	44	41	83	03	10	10	45	20			47	44	41	80	15	5	0	UNL	30			57	47	37	47	29	4
13	10	35	20			51	47	42	71	29	7	8	40	20			54	47	40	59	22	6	9	UNL	30			63	52	42	46	30	7
16	7	40	20			55	46	37	51	36	12	3	UNL	20			58	49	40	51	27	3	7	UNL	30			66	53	42	42	00	0
19	3	UNL	30			47	43	38	71	02	5	0	UNL	20			53	47	40	62	00	0	3	UNL	30			58	52	47	67	03	7
22	0	UNL	30			42	40	37	83	03	5	0	UNL	7			50	46	41	71	09	6	0	UNL	30			54	50	46	75	03	9
					DAY 04											DAY 05											DAY 06						
01	0	UNL	10			50	47	45	83	12	4	10	35	7			54	53	52	93	33	4	7	UNL	6		KH	55	52	50	83	13	4
04	0	UNL	10			47	45	43	86	07	5	10	35	7			55	53	52	90	29	4	7	UNL	3		KH	53	51	49	86	08	5
07	0	UNL	7			44	43	42	93	30	4	10	12	1	8	F	53	52	51	93	29	3	7	UNL	0	12	F	49	48	47	93	09	5
10	0	UNL	5		KH	55	51	48	77	20	5	9	10	2	4	F	56	54	52	87	17	4	0	UNL	3		KH	62	56	52	70	00	0
13	8	250	3		KH	58	54	51	78	32	11	10	30	3		KH	63	57	52	68	33	9	0	UNL	3		KH	71	61	55	57	22	3
16	8	38	4		KH	62	55	49	63	16	4	4	UNL	4		KH	65	58	52	63	00	0	0	UNL	4		KH	76	64	56	50	31	4
19	6	35	7			54	52	51	90	34	5	10	35	6		KH	61	56	53	75	22	5	0	UNL	4		KH	67	61	57	70	28	4
22	10	45	7			55	53	52	90	32	4	9	UNL	6		KH	59	55	52	78	00	0	0	UNL	7			62	58	55	78	07	5
					DAY 07											DAY 08											DAY 09						
01	0	UNL	5		KH	58	56	54	87	10	6	0	UNL	4		KH	60	56	53	78	12	4	0	UNL	4		KH	62	58	56	81	09	4
04	3	UNL	2	8	KH	56	54	52	87	00	0	0	UNL	4		KH	59	55	52	78	08	5	0	UNL	4		KH	61	56	53	75	10	5
07	0	UNL	3		KH	55	52	50	83	04	4	6	UNL	3		KH	56	54	52	87	10	3	10	UNL	3		KH	56	54	52	87	00	0
10	0	UNL	1	8	KH	63	59	56	78	24	5	1	UNL	5		KH	68	60	54	61	00	0	10	UNL	4		KH	66	58	53	63	16	4
13	0	UNL	3		KH	75	63	55	50	00	0	9	UNL	5		KH	77	64	56	48	34	6	8	UNL	4		KH	76	63	54	47	24	3
16	1	UNL	3		KH	79	65	57	47	30	7	10	UNL	5		KH	79	65	56	45	31	4	10	UNL	4		KH	79	65	57	47	34	5
19	1	UNL	5		KH	70	63	58	66	01	6	5	UNL	5		KH	69	62	57	66	32	4	8	UNL	4		KH	72	62	56	57	07	4
22	0	UNL	6		KH	65	60	58	73	08	7	0	UNL	5		KH	65	60	58	73	00	0	7	UNL	4		KH	66	61	57	73	06	4
					DAY 10											DAY 11											DAY 12						
01	0	UNL	4		KH	62	58	55	78	00	0	3	UNL	3		KH	61	59	57	87	14	2	7	35	3		KH	60	58	56	87	08	4
04	0	UNL	3		KH	59	56	53	81	00	0	7	UNL	2	8	KH	57	55	54	90	13	4	10	32	3		KH	60	58	56	87	00	0
07	10	0	0	2	F	55	53	52	90	00	0	10	3	0	8	F	59	57	56	90	21	3	10	30	0		F	57	55	54	90	00	0
10	10	2	0	8	F	58	57	57	96	00	0	10	2	0	4	F	60	58	57	90	32	3	9	UNL	1	8	KH	65	60	57	75	29	4
13	0	UNL	3		KH	71	63	58	64	32	7	10	10	1	12	KH	67	62	58	73	28	4	10	250	3		KH	71	62	56	59	07	3
16	3	UNL	4		KH	76	65	59	56	35	9	10	30	2		KH	71	62	57	61	35	6	10	250	3		KH	73	63	57	57	33	5
19	3	UNL	5		KH	65	61	58	78	35	5	3	UNL	3		KH	65	60	57	75	03	5	8	250	3		KH	67	61	57	70	36	6
22	3	UNL	4		KH	64	60	57	78	03	5	3	UNL	3		KH	61	58	56	84	12	5	10	UNL	3		KH	60	57	55	84	36	5
					DAY 13											DAY 14											DAY 15						
01	10	UNL	3		KH	62	58	56	81	09	5	10	38	10			60	57	54	81	26	6	10	UNL	7			57	55	53	87	08	5
04	10	45	4		KH	61	58	56	84	00	0	10	45	10			58	55	53	84	06	6	10	UNL	7			55	53	52	90	00	0
07	10	35	4		KH	60	57	55	84	01	5	10	15	8			58	56	54	87	00	0	10	80	7			57	54	52	83	13	4
10	8	85	10			66	58	53	63	35	6	10	38	7			60	57	54	81	30	4	7	UNL	10			63	57	53	70	28	7
13	6	70	10			71	60	53	53	34	8	9	25	7			64	59	55	73	03	3	10	90	10			67	57	50	55	00	0
16	9	250	10			67	60	56	68	02	10	9	25	7			66	60	55	68	31	5	8	45	7			68	58	50	53	28	16
19	10	35	10		RW	61	57	54	78	31	8	8	55	7			63	58	55	75	03	5	1	UNL	20			53	50	47	80	32	10
22	10	80	10			61	56	52	72	08	4	4	UNL	7			58	55	53	84	08	6	8	75	30			51	47	44	77	33	12
					DAY 16											DAY 17											DAY 18						
01	7	80	15			48	46	44	86	34	4	10	50	7		RW	51	50	49	93	28	5	2	UNL	20			48	46	44	86	10	5
04	7	80	15			48	46	44	86	36	6	10	45	10			50	48	46	86	09	7	8	45	15			48	47	46	93	34	2
07	7	250	30			48	46	43	83	00	0	10	30	15			50	48	46	86	00	0	10	35	10			50	47	44	80	16	4
10	2	UNL	30			55	49	43	64	28	4	10	35	10		RW	52	50	48	86	23	4	9	80	10			50	49	49	96	18	8
13	9	90	30			61	50	39	44	30	8	10	40	10			54	51	48	80	33	8	5	UNL	15			58	52	46	65	24	4
16	10	55	20			61	50	40	46	32	5	9	20	10			58	52	46	65	19	3	4	UNL	15			62	53	45	54	00	0
19	10	55	7		RW	57	52	47	69	36	10	7	90	7			55	50	46	72	16	4	10	250	7			59	50	42	54	06	4
22	4	UNL	7			52	50	48	86	08	6	0	UNL	7			49	47	46	89	08	5	10	26	7		RW	52	49	47	83	22	5
					DAY 19											DAY 20											DAY 21						
01	10	38	7		RW	50	48	47	89	17	5	10	55	7			52	52	52	100	00	0	1	UNL	30			49	47	46	89	04	4
04	10	45	7		R	49	47	46	89	00	0	7	90	7			50	48	47	89	00	0	10	35	30			51	49	47	86	06	3
07	10	22	7		R	48	47	46	93	15	5	10	0	0		F	46	46	46	100	35	4	10	32	20			53	50	48	83	12	4
10	10	11	7		R	49	47	46	89	20	4	9	85	7			53	50	48	83	18	6	10	41	20			54	51	48	80	08	6
13	10	200	15			54	49	45	72	25	4	8	80	7			58	53	48	70	31	4	10	85	20			59	53	48	67	05	4
16	8	250	15			58	52	46	65	28	5	10	65	15		RW	57	53	49	75	08	11	10	35	20			60	54	49	67	05	5
19	6	90	15			55	50	46	72	03	6	4	UNL	15			53	50	47	80	16	6	10	45	15			58	54	51	78	09	4
22	10	50	15		RW	53	51	49	86	19	3	1	UNL	15			52	50	49	90	10	4	8	50	15			53	50	48	83	02	9
					DAY 22											DAY 23											DAY 24						
01	4	UNL	15			52	48	45	77	02	12	4	UNL	15			52	48	45	77	01	8	0	UNL	10			53	51	49	86	09	4
04	10	45	15			53	48	44	72	03	10	4	UNL	15			48	46	44	86	11	4	2	UNL	10			51	49	48	90	00	0
07	3	UNL	15			52	48	44	74	02	9	6	UNL	15			50	48	47	89	09	3	0	UNL	20			50	49	48	93	00	0
10	8	250	15			58	51	44	60	00	0	8	UNL	15			58	53	48	70	33	7	0	UNL	7			60	55	52	75	23	4
13	8	30	10			63	54	46	54	34	6	4	UNL	15			64	55	48	56	32	3	1	UNL	7			68	57	49	51	31	6
16	7	70	15			66	56	47	51	03	9	8	30	10			68	57	49	51	01	7	0	UNL	7			71	59	49	46	24	4
19	3	UNL	15			58	52	47	67	03	9	8	70	10			62	56	52	70	36	4	2	UNL	7			66	57	50	57	31	3
22	6	65	15			53	50	47	80	35	7	2	UNL	10			57	53	49	75	05	4	0	UNL	7			60	54	49	67	00	0
					DAY 25											DAY 26											DAY 27						
01	0	UNL	7			57	53	50	78	12	4	0	UNL	7			56	52	49	78	09	6	10	60	7			61	51	42	50	14	20
04	0	UNL	7			53	50	48	83	00	0	0	UNL	7			51	49	48	90	21	4	10	30	15		RW	54	52	51	90	03	14
07	0	UNL	7			50	49	49	96	00	0	10	250	5		H	50	49	49	96	00	0	9	30	15			54	52	50	86	11	9
10	0	UNL	10			60	54	50	70	19	3	10	120	5		KH	60	55	51	72	15	6	8	200	30			63	54	47	56	14	5
13	0	UNL	10			69	58	49	49	00	0	9	120	7			70	57	47	44	24	4	10	250	30			70	55	42	36	17	3
16	1	UNL	10			72	58	47	41	01	8	10	120	10			71	57	46	41	03	6	7	250	30			72	58	46	40	23	5
19	5	UNL	10			65	57	50	59	00	0	10	100	10			64	57	52	65	35	5	2	UNL	30			65	53	43	45	13	10
22	5	UNL	10			60	54	50	70	09	7	10	40	10			60	53	47	62	16	14	9	55	30			61	53	46	58	13	10
					DAY 28											DAY 29											DAY 30						
01	10	40	30		RW	60	57	55	84	14	8	10	65	20			52	49	46	80	00	0	1	UNL	30			50	48	46	86	00	0
04	10	40	7		RW	54	52	51	90	12	5	4	UNL	20			47	45	44	89	11	6	0	UNL	30			46	45	45	96	27	7
07	10	30	15		RW	53	51	49	86	24	9	10	65	20			49	48	48	96	33	6	7	13	10			46	45	45	96	35	5
10	9	25	30			56	53	50	80	30	7	8	70	15			57	53	49	75	33	6	10	38	10			53	50	47	80	34	7
13	9	50	30			61	53	45	56	32	7	9	41	20			61	53	46	58	30	6	10	28	15			55	51	47	75	34	6
16	10	250	30			62	53	44	52	29	10	10	50	30			62	53	45	54	26	4	5	UNL	15			60	53	48	65	12	4
19	10	45	20		RW	56	50	44	64	35	7	9	65	30			60	54	49	67	32	5	7	250	10			57	52	48	72	14	6
22	10	45	20		RW	52	49	47	83	07	10	2	UNL	30			56	52	49	78	08	4	2	UNL	10			52	50	48	86	05	4
					DAY 31																												
01	5	UNL	10			48	47	46	93	34	6																						
04	6	50	10			47	46	46	96	13	4																						
07	1	UNL	5		KH	48	47	46	93	07	4																						
10	4	UNL	8			58	53	48	70	16	4																						
13	8	35	8			64	55	48	56	34	7																						
16	3	UNL	12			66	55	46	49	27	6																						
19	0	UNL	20			60	53	46	60	35	5																						
22	0	UNL	15			54	50	46	75	11	5																						

NOTES

CEILING

UNL INDICATES UNLIMITED

WEATHER

•	TORNADO
T	THUNDERSTORM
Q	SQUALL
R	RAIN
RW	RAIN SHOWERS
ZR	FREEZING RAIN
L	DRIZZLE
ZL	FREEZING DRIZZLE
S	SNOW
SP	SNOW PELLETS
IC	ICE CRYSTALS
SW	SNOW SHOWERS
SG	SNOW GRAINS
IP	ICE PELLETS
A	HAIL
F	FOG
IF	ICE FOG
GF	GROUND FOG
BD	BLOWING DUST
BN	BLOWING SAND
BS	BLOWING SNOW
BY	BLOWING SPRAY
K	SMOKE
H	HAZE
D	DUST

WIND

DIRECTIONS ARE THOSE FROM WHICH THE WIND BLOWS. INDICATED IN TENS OF DEGREES FROM TRUE NORTH; I.E., 09 FOR EAST, 18 FOR SOUTH, 27 FOR WEST. ENTRY OF 00 IN THE DIRECTION COLUMN INDICATES CALM.

SPEED IS EXPRESSED IN KNOTS; MULTIPLY BY 1.15 TO CONVERT TO MILES PER HOUR.

STATION

BAKERSFIELD CALIFORNIA

YEAR & MONTH

79 03

U.S. DEPARTMENT OF COMMERCE
NATIONAL CLIMATIC CENTER
FEDERAL BUILDING
ASHEVILLE, N.C. 28801

AN EQUAL OPPORTUNITY EMPLOYER

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE
COM-210

U.S.MAIL

FIRST CLASS

APRIL 1979
BAKERSFIELD, CALIFORNIA
NATIONAL WEATHER SERVICE OFC
KERN COUNTY AIR TERMINAL

Local Climatological Data

MONTHLY SUMMARY

APRIL 1979 BAKERSFIELD, CALIFORNIA

LATITUDE 35° 25 ′ N LONGITUDE 119° 03 ′ W ELEVATION (GROUND) 475 FT. STANDARD TIME USED: PACIFIC WBAN #23155

DATE	TEMPERATURE °F MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	AVERAGE DEW POINT	DEGREE DAYS BASE 65° HEATING (SEASON BEGINS WITH JULY)	COOLING (SEASON BEGINS WITH JAN.)	WEATHER TYPES ON DATES OF OCCURRENCE 1 FOG 2 HEAVY FOG 3 THUNDERSTORM 4 ICE PELLETS 5 HAIL 6 GLAZE 7 DUSTSTORM 8 SMOKE, HAZE 9 BLOWING SNOW	SNOW, ICE PELLETS OR ICE ON GROUND AT 04AM IN.	PRECIPITATION WATER EQUIVALENT IN	SNOW, ICE PELLETS IN.	AVG. STATION PRESSURE IN. ELEV. 492 FEET M.S.L.	WIND RESULTANT DIR.	RESULTANT SPEED M.P.H.	AVERAGE SPEED M.P.H.	FASTEST MILE SPEED M.P.H.	FASTEST MILE DIRECTION	SUNSHINE MINUTES	PERCENT OF POSSIBLE	SKY COVER TENTHS SUNRISE TO SUNSET	MIDNIGHT TO MIDNIGHT	DATE
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	70	47	59	0	46	6	0		0	0	0	29.59	05	2.8	6.2	12	32			3	2	1
2	71	45	58	-2	42	7	0		0	0	0	29.55	36	4.3	6.5	16	35			0	0	2
3	73	46	60	0	43	5	0		0	0	0	29.63	04	3.4	6.3	10	34			0	0	3
4	81	48	65	5	47	0	0		0	0	0	29.60	07	2.1	5.9	12	32			0	0	4
5	88*	53	71	11	47	0	6		0	0	0	29.44	35	4.6	8.3	14	31			1	1	5
6	68	50	59	-2	48	6	0		0	0	0	29.49	01	3.0	6.6	12	36			9	5	6
7	70	48	59	-2	49	6	0	1 8	0	0	0	29.55	12	2.4	6.2	9	13			8	7	7
8	79	49	64	3	49	1	0		0	0	0	29.52	08	2.3	5.8	10	30			1	2	8
9	70	52	61	0	44	4	0		0	0	0	29.44	33	11.4	11.9	16	35			8	7	9
10	69	42	56	-5	35	9	0		0	0	0	29.46	35	7.2	9.1	17	36			2	1	10
11	62	47	55*	-7	46	10	0		0	0	0	29.47	17	1.3	5.5	9	12			10	7	11
12	77	47	62	0	48	3	0		0	0	0	29.54	05	3.1	5.2	12	30			2	2	12
13	79	52	66	4	50	0	1		0	0	0	29.51	06	.4	3.0	9	32			3	1	13
14	81	52	67	5	51	0	2		0	0	0	29.43	07	.7	3.9	10	33			0	0	14
15	83	52	68	5	50	0	3		0	0	0	29.42	14	2.3	5.0	12	14			1	2	15
16	82	57	70	7	50	0	5		0	0	0	29.35	33	9.6	11.9	24	32			6	6	16
17	71	50	61	-2	40	4	0		0	0	0	29.44	33	12.4	13.2	20	34			6	5	17
18	67	44	56	-7	36	9	0		0	0	0	29.58	34	4.8	6.3	10	34			6	4	18
19	73	42*	58	-5	39	7	0		0	0	0	29.63	01	2.4	4.3	10	34			0	0	19
20	77	45	61	-3	41	4	0		0	0	0	29.58	19	1.9	4.3	10	04			2	1	20
21	80	50	65	1	42	0	0		0	0	0	29.47	30	.7	4.2	8	03			4	2	21
22	80	53	67	3	43	0	2		0	0	0	29.44	34	7.4	9.2	20	31			1	1	22
23	75	50	63	-1	43	2	0		0	0	0	29.48	33	6.8	9.4	14	32			5	3	23
24	74	48	61	-4	42	4	0		0	0	0	29.51	30	2.2	6.2	12	27			1	1	24
25	80	52	66	1	45	0	1		0	0	0	29.48	17	.6	4.0	10	30			9	7	25
26	86	64	75*	10	52	0	10		0	T	0	29.48	02	4.2	7.2	15	32			8	6	26
27	78	59	69	4	54	0	4		0	0	0	29.56	35	7.1	8.6	15	32			4	3	27
28	78	53	66	0	50	0	1		0	0	0	29.54	32	4.4	7.6	12	32			6	4	28
29	80	54	67	1	48	0	2		0	0	0	29.44	30	2.3	6.5	10	26			4	2	29
30	82	54	68	2	46	0	3		0	0	0	29.39	34	4.1	6.3	14	32			3	2	30

SUM	SUM				TOTAL	TOTAL		TOTAL	TOTAL	FOR THE MONTH:						TOTAL	%	SUM	SUM
2284	1505				87	40	NUMBER OF DAYS	T	0	29.50	35	3.1	6.8	24	32		FOR	113	84
AVG.	AVG.	AVG.	DEP.	AVG.	DEP.	DEP.	PRECIPITATION	DEP.						DATE: 16		POSSIBLE	MONTH	AVG.	AVG.
76.1	50.2	63.2	0.5	45	-53	-31	> .01 INCH 0	-0.85										3.8	2.8

NUMBER OF DAYS				SEASON TO DATE					
				TOTAL	TOTAL	SNOW, ICE PELLETS > 1.0 INCH 0	GREATEST IN 24 HOURS AND DATES		GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE
MAXIMUM TEMP.		MINIMUM TEMP.		1883	52	THUNDERSTORMS 0	PRECIPITATION	SNOW, ICE PELLETS	
> 90°	< 32°	< 32°	< 0°	DEP.	DEP.	HEAVY FOG 0	T 26	0	0
0	0	0	0	-280	-25	CLEAR 16 PARTLY CLOUDY 8 CLOUDY 6			

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT
+ ALSO ON AN EARLIER DATE, OR DATES.
HEAVY FOG: - VISIBILITY 1/4 MILE OR LESS.
FIGURES FOR WIND DIRECTIONS ARE TENS OF DEGREES CLOCKWISE FROM TRUE NORTH. 00 = CALM.
DATA IN COLS. 6 AND 12-15 ARE BASED ON 7 OR MORE OBSERVATIONS PER DAY AT 3-HOUR INTERVALS.
FASTEST MILE WIND SPEEDS ARE FASTEST OBSERVED ONE-MINUTE VALUES WHEN DIRECTIONS ARE IN TENS OF DEGREES. THE / WITH THE DIRECTION INDICATES PEAK GUST SPEED.
ANY ERRORS DETECTED WILL BE CORRECTED AND CHANGES IN SUMMARY DATA WILL BE ANNOTATED IN THE ANNUAL SUMMARY

SUMMARY BY HOURS

HOUR LOCAL TIME	AVERAGES SKY COVER TENTHS	STATION PRESSURE IN.	TEMPERATURE AIR °F	WET BULB °F	DEW PT. °F	RELATIVE HUMIDITY %	WIND SPEED M.P.H.	RESULTANT WIND DIRECTION	SPEED M.P.H
01	1	29.51	56	51	46	69	6.0	01	3.8
04	2	29.51	53	49	45	74	4.2	02	1.4
07	4	29.54	55	50	46	71	5.7	13	1.0
10	4	29.55	65	55	46	51	6.7	31	2.5
13	4	29.50	73	58	46	40	6.6	31	3.5
16	4	29.45	75	58	45	35	10.1	32	7.2
19	2	29.45	67	55	45	47	7.6	35	6.0
22	1	29.49	61	53	45	57	7.7	04	5.6

HOURLY PRECIPITATION (WATER EQUIVALENT IN INCHES)

DATE	A. M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	P. M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	DATE
1																									1
2																									2
3																									3
4																									4
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30																									30

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noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / ENVIRONMENTAL DATA AND INFORMATION SERVICE

Daniel B. Mitchell
DIRECTOR, NATIONAL CLIMATIC CENTER

USCOMM--NOAA--ASHEVILLE 05/21/79 400

OBSERVATIONS AT 3-HOUR INTERVALS

DAY 01

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	15			50	47	45	83	12	6
04	0	UNL	10			49	47	45	86	10	6
07	7	UNL	10			49	47	46	89	10	3
10	3	UNL	10			59	53	48	67	23	5
13	3	UNL	15			66	55	45	47	02	5
16	2	UNL	20			70	55	42	36	34	6
19	0	UNL	20			60	53	47	62	01	8
22	0	UNL	20			54	50	46	75	05	4

DAY 02

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	30			48	46	44	86	00	0
04	0	UNL	30			48	46	44	86	11	4
07	1	UNL	30			49	46	44	83	11	5
10	0	UNL	20			61	51	42	50	36	6
13	1	UNL	20			66	53	42	42	32	8
16	1	UNL	25			71	55	40	33	36	13
19	0	UNL	20			59	48	38	46	33	9
22	0	UNL	20			54	48	42	64	00	0

DAY 03

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	20			50	46	42	74	08	6
04	0	UNL	20			48	44	40	74	12	4
07	0	UNL	30			52	46	40	64	10	5
10	0	UNL	30			64	53	44	48	32	8
13	0	UNL	20			71	57	46	41	34	6
16	0	UNL	20			73	57	43	34	02	6
19	1	UNL	20			64	54	46	52	33	3
22	0	UNL	20			58	52	46	65	08	6

DAY 04

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	20			53	49	46	77	08	4
04	0	UNL	20			49	46	43	80	12	4
07	0	UNL	30			52	48	44	74	14	6
10	0	UNL	30			69	55	44	41	19	4
13	0	UNL	30			75	59	46	36	33	5
16	0	UNL	20			81	62	48	32	32	6
19	0	UNL	20			70	60	52	53	03	5
22	0	UNL	20			64	57	52	65	08	7

DAY 05

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	20			60	55	52	75	08	7
04	0	UNL	20			59	54	49	70	08	5
07	0	UNL	30			58	54	49	70	16	4
10	5	UNL	30			74	59	47	38	32	5
13	0	UNL	30			85	64	49	28	35	4
16	0	UNL	15			88	65	49	26	31	12
19	1	UNL	20			74	57	44	34	33	10
22	0	UNL	30			67	53	40	37	01	11

DAY 06

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	30			55	48	40	57	31	5
04	10	100	10			55	52	50	83	33	8
07	10	14	7			53	50	48	83	32	5
10	10	20	7			58	53	49	72	15	7
13	10	30	7			62	55	50	65	34	4
16	5	UNL	7			68	57	49	51	02	8
19	3	UNL	7			62	55	49	63	07	4
22	0	UNL	7			57	53	49	75	09	5

DAY 07

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	5	UNL	10			55	52	49	80	36	2
04	7	55	10			51	49	48	90	30	6
07	10	250	5		F	50	49	48	93	32	4
10	10	14	5		KH	58	54	50	75	09	6
13	7	35	7			66	57	49	54	16	6
16	9	35	7			69	57	48	47	15	6
19	7	250	10			64	56	49	58	13	8
22	7	UNL	10			59	54	49	70	09	5

DAY 08

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	7			57	52	48	72	08	6
04	0	UNL	7			52	49	47	83	14	5
07	0	UNL	7			58	53	48	70	10	4
10	0	UNL	10			69	57	48	47	16	6
13	0	UNL	10			75	60	48	39	30	4
16	0	UNL	20			79	61	48	34	36	6
19	10	UNL	20			70	59	51	51	36	5
22	0	UNL	30			64	57	51	63	08	4

DAY 09

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	10	90	7			60	55	51	72	34	12
04	8	60	30			57	50	44	62	34	13
07	10	65	20			57	51	46	67	30	8
10	10	25	10			60	54	49	67	31	6
13	8	45	10			65	56	49	56	32	10
16	6	50	7			68	53	40	36	35	13
19	8	UNL	10			61	48	36	39	32	13
22	0	UNL	15			53	45	37	55	35	8

DAY 10

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	30			51	45	38	61	36	10
04	0	UNL	30			46	43	39	77	04	3
07	0	UNL	30			50	45	40	69	17	3
10	2	UNL	30			60	48	34	38	33	9
13	2	UNL	15			66	49	30	26	30	10
16	7	UNL	10			69	51	32	25	36	15
19	0	UNL	10			60	48	34	38	02	8
22	0	UNL	15			54	45	36	51	01	5

DAY 11

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	20			50	45	39	66	27	4
04	8	100	10			51	46	41	69	00	0
07	10	20	10			52	49	46	80	26	5
10	10	22	10			58	53	48	70	28	6
13	10	20	10			62	54	48	60	08	5
16	10	50	10			61	54	48	63	16	7
19	2	UNL	15			59	53	48	67	15	5
22	1	UNL	30			53	50	48	83	08	6

DAY 12

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	2	UNL	30			54	50	47	77	04	4
04	0	UNL	20			50	49	48	93	00	0
07	2	UNL	15			55	51	48	77	12	5
10	2	UNL	15			66	57	50	57	36	4
13	2	UNL	20			74	60	49	41	12	5
16	1	UNL	20			77	60	47	35	32	5
19	1	UNL	30			69	58	49	49	02	5
22	0	UNL	30			62	55	49	63	07	8

DAY 13

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	30			58	53	48	70	00	0
04	0	UNL	30			54	50	47	77	00	0
07	1	UNL	10			55	52	49	80	00	0
10	7	70	10			64	57	51	63	13	3
13	3	UNL	10			74	61	52	46	29	5
16	1	UNL	10			79	63	52	39	14	4
19	0	UNL	15			70	60	52	53	34	5
22	0	UNL	15			64	57	52	65	09	4

DAY 14

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	15			60	55	52	75	00	0
04	0	UNL	15			54	51	49	83	00	0
07	0	UNL	10			59	55	51	75	13	7
10	0	UNL	10			70	58	51	51	16	3
13	0	UNL	12			77	63	53	43	00	0
16	0	UNL	15			81	62	49	33	30	7
19	0	UNL	30			73	59	49	43	34	4
22	0	UNL	30			67	57	50	55	07	6

DAY 15

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	30			62	56	52	70	10	3
04	0	UNL	30			54	51	48	80	00	0
07	3	UNL	30			60	54	49	67	16	5
10	1	UNL	30			70	57	47	44	18	7
13	1	UNL	20			78	62	50	38	19	4
16	0	UNL	30			83	63	50	32	24	4
19	7	UNL	30			75	60	50	42	01	4
22	6	UNL	30			68	59	52	57	08	8

DAY 16

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	30			62	56	52	70	10	7
04	10	UNL	30			59	54	49	70	36	5
07	10	UNL	20			64	57	51	63	35	6
10	10	UNL	15			72	60	51	48	33	9
13	0	UNL	20			78	62	51	39	28	6
16	6	50	10			79	62	50	36	31	18
19	7	50	10			64	55	47	54	33	20
22	10	75	20			62	54	48	60	32	12

DAY 17

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	10	38	30			59	52	45	60	34	15
04	10	45	10			55	50	45	69	30	8
07	9	45	25			55	50	45	69	31	5
10	7	50	30			63	50	38	40	01	7
13	6	50	30			69	53	37	31	33	15
16	6	50	30			67	52	37	33	30	15
19	1	UNL	30			61	47	32	34	32	10
22	0	UNL	15			56	47	37	49	34	17

DAY 18

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	30			48	43	37	66	36	8
04	4	UNL	30			46	41	36	68	36	4
07	10	50	30			48	43	37	66	32	4
10	10	38	20			55	46	37	51	31	5
13	5	UNL	20			62	49	35	37	29	7
16	2	UNL	20			66	50	33	29	31	8
19	0	UNL	20			60	48	34	38	02	4
22	0	UNL	20			53	45	35	51	08	4

DAY 19

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	30			47	42	36	66	36	5
04	0	UNL	30			45	41	36	71	00	0
07	0	UNL	15			47	42	37	68	14	6
10	0	UNL	15			59	49	39	48	00	0
13	0	UNL	15			68	53	38	33	33	5
16	0	UNL	15			73	56	40	30	35	6
19	0	UNL	15			63	53	44	50	34	4
22	0	UNL	20			58	49	41	53	06	4

DAY 20

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	20			49	45	41	74	00	0
04	0	UNL	20			52	46	40	64	00	0
07	0	UNL	7			52	46	40	64	15	5
10	0	UNL	10			64	52	40	42	23	4
13	2	UNL	10			72	56	42	34	17	4
16	10	UNL	10			76	57	42	30	23	8
19	2	UNL	10			68	54	42	39	35	4
22	0	UNL	10			63	52	42	46	10	5

DAY 21

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	10			55	49	43	64	34	5
04	0	UNL	10			55	49	43	64	00	0
07	7	UNL	10			57	49	41	55	14	5
10	0	UNL	10			68	54	41	38	26	4
13	5	UNL	10			75	58	44	33	22	4
16	7	UNL	10			80	59	42	26	30	5
19	2	UNL	10			75	57	41	30	00	0
22	0	UNL	10			64	52	41	43	06	6

DAY 22

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	15			63	51	40	43	02	7
04	0	UNL	15			58	49	39	48	04	4
07	7	UNL	20			60	51	43	54	32	7
10	0	UNL	15			70	57	46	42	34	8
13	0	UNL	15			77	58	44	31	26	7
16	0	UNL	15			80	56	40	24	34	9
19	0	UNL	15			70	56	45	41	31	10
22	0	UNL	30			61	54	48	63	01	12

DAY 23

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	30			58	52	47	67	36	10
04	0	UNL	30			51	47	44	77	28	4
07	0	UNL	30			57	52	47	69	14	5
10	4	UNL	30			68	55	44	42	31	12
13	10	250	30			72	56	43	35	28	5
16	8	UNL	30			75	56	39	27	31	10
19	1	UNL	45			67	52	38	35	34	11
22	0	UNL	30			59	49	38	46	01	8

DAY 24

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	20			53	47	42	66	36	6
04	0	UNL	20			49	45	40	71	07	4
07	0	UNL	30			53	47	42	66	00	0
10	2	UNL	30			62	52	42	48	24	6
13	1	UNL	30			71	56	44	38	24	6
16	1	UNL	30			74	57	42	32	27	10
19	0	UNL	30			67	54	42	40	35	6
22	0	UNL	30			62	51	40	45	08	5

DAY 25

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	30			57	49	42	57	00	0
04	1	UNL	30			55	49	44	67	00	0
07	10	100	30			55	49	44	67	14	6
10	5	UNL	30			66	55	45	47	18	4
13	10	200	30			78	60	46	32	00	0
16	10	100	20			79	60	46	31	28	9
19	10	200	30			74	58	46	37	01	4
22	7	200	20			71	58	47	43	10	5

DAY 26

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	10	90	20			70	58	48	46	00	0
04	7	75	20			67	56	47	49	10	5
07	8	70	15			67	57	49	53	15	4
10	4	UNL	15			79	61	48	34	08	7
13	6	250	15			86	64	50	29	01	4
16	10	80	15		RW	74	65	60	62	32	13
19	4	UNL	30			70	63	59	68	02	7
22	2	UNL	30			68	62	58	71	02	10

DAY 27

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	30			62	58	56	81	02	7
04	3	UNL	30			60	57	55	84	36	6
07	8	UNL	30			60	56	53	78	34	12
10	3	UNL	20			68	61	56	66	36	9
13	4	UNL	20			75	63	55	50	27	6
16	0	UNL	20			78	63	53	42	30	6
19	2	UNL	20			70	60	53	55	34	6
22	0	UNL	30			68	59	52	57	03	8

DAY 28

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	3	UNL	30			60	55	52	75	28	8
04	2	UNL	30			55	52	50	83	26	5
07	9	70	15			58	54	50	75	32	5
10	6	28	15			63	56	50	63	30	5
13	6	45	15			72	60	51	48	12	7
16	3	UNL	20			77	61	49	37	33	9
19	0	UNL	20			71	59	51	49	35	5
22	0	UNL	30			67	56	48	51	01	9

DAY 29

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	30			55	50	46	72	33	6
04	0	UNL	30			55	50	45	69	13	4
07	1	UNL	25			60	52	45	58	15	6
10	4	UNL	15			71	58	48	44	31	4
13	10	250	10			79	62	51	38	29	8
16	4	UNL	15			80	62	50	35	28	8
19	0	UNL	20			74	60	50	43	32	4
22	0	UNL	30			69	58	49	49	07	5

DAY 30

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	30			64	56	50	61	05	4
04	0	UNL	20			58	54	50	75	10	2
07	0	UNL	20			60	54	50	70	13	4
10	0	UNL	10			70	57	46	42	29	6
13	6	UNL	15			79	61	47	32	33	6
16	9	UNL	20			82	61	44	26	34	11
19	1	UNL	30			72	55	41	33	34	6
22	0	UNL	30			63	52	41	45	32	5

NOTES

CEILING

UNL INDICATES UNLIMITED

WEATHER

*	TORNADO
T	THUNDERSTORM
Q	SQUALL
R	RAIN
RW	RAIN SHOWERS
ZR	FREEZING RAIN
L	DRIZZLE
ZL	FREEZING DRIZZLE
S	SNOW
SP	SNOW PELLETS
IC	ICE CRYSTALS
SW	SNOW SHOWERS
SG	SNOW GRAINS
IP	ICE PELLETS
A	HAIL
F	FOG
IF	ICE FOG
GF	GROUND FOG
BD	BLOWING DUST
BN	BLOWING SAND
BS	BLOWING SNOW
BY	BLOWING SPRAY
K	SMOKE
H	HAZE
D	DUST

WIND

DIRECTIONS ARE THOSE FROM WHICH THE WIND BLOWS. INDICATED IN TENS OF DEGREES FROM TRUE NORTH: I.E., 09 FOR EAST, 18 FOR SOUTH, 27 FOR WEST. ENTRY OF 00 IN THE DIRECTION COLUMN INDICATES CALM.

SPEED IS EXPRESSED IN KNOTS: MULTIPLY BY 1.15 TO CONVERT TO MILES PER HOUR.

STATION: BAKERSFIELD CALIFORNIA

YEAR & MONTH: 79 04

U.S. DEPARTMENT OF COMMERCE
NATIONAL CLIMATIC CENTER
FEDERAL BUILDING
ASHEVILLE, N.C. 28801

AN EQUAL OPPORTUNITY EMPLOYER

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE
COM-210

U.S.MAIL

FIRST CLASS

MAY 1979
BAKERSFIELD, CALIFORNIA
NATIONAL WEATHER SERVICE OFC
KERN COUNTY AIR TERMINAL

Local Climatological Data

MONTHLY SUMMARY

MAY 1979 BAKERSFIELD, CALIFORNIA

LATITUDE 35° 25 ′N LONGITUDE 119° 03 ′W ELEVATION (GROUND) 475 FT. STANDARD TIME USED: PACIFIC WBAN #23155

DATE	TEMPERATURE °F MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	AVERAGE DEW POINT	DEGREE DAYS BASE 65° HEATING (SEASON BEGINS WITH JULY)	COOLING (SEASON BEGINS WITH JAN.)	WEATHER TYPES ON DATES OF OCCURRENCE 1 FOG 2 HEAVY FOG 3 THUNDERSTORM 4 ICE PELLETS 5 HAIL 6 GLAZE 7 DUSTSTORM 8 SMOKE, HAZE 9 BLOWING SNOW	SNOW, ICE PELLETS OR ICE ON GROUND AT 04AM IN.	PRECIPITATION WATER EQUIVALENT IN	SNOW, ICE PELLETS IN.	AVG. STATION PRESSURE IN. ELEV. 492 FEET M.S.L.	WIND RESULTANT DIR.	RESULTANT SPEED M.P.H.	AVERAGE SPEED M.P.H.	FASTEST MILE SPEED M.P.H.	FASTEST MILE DIRECTION	SUNSHINE MINUTES	PERCENT OF POSSIBLE	SKY COVER TENTHS SUNRISE TO SUNSET	MIDNIGHT TO MIDNIGHT	DATE
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	76	54	65	-1	47	0	0		0	T	0	29.35	33	8.8	9.2	21	32			8	7	1
2	75	57	66	-1	49	0	1		0	0	0	29.40	33	3.1	5.5	12	31			7	5	2
3	87	57	72	5	52	0	7		0	0	0	29.46	34	3.7	6.8	13	28			2	1	3
4	87	58	73	6	53	0	8		0	0	0	29.51	35	2.4	5.8	9	29			5	3	4
5	85	56	71	4	49	0	6		0	0	0	29.44	33	7.9	10.2	23	28			5	4	5
6	76	56	66	-2	43	0	1		0	0	0	29.41	33	13.9	14.4	21	34			5	5	6
7	73	53	63	-5	46	2	0		0	T	0	29.38	33	10.3	11.2	21	31			9	8	7
8	72	49*	61*	-7	39	4	0		0	T	0	29.36	34	9.4	11.2	22	32			6	7	8
9	75	50	63	-5	40	2	0		0	0	0	29.43	34	3.8	6.9	14	28			4	4	9
10	82	52	67	-1	38	0	2		0	0	0	29.56	36	1.2	6.0	13	26			0	0	10
11	90	54	72	3	40	0	7		0	0	0	29.57	06	1.8	6.9	13	32			0	0	11
12	95	60	78	9	43	0	13		0	0	0	29.52	01	1.6	6.5	13	30			0	0	12
13	99	64	82	13	44	0	17		0	0	0	29.41	30	.2	6.6	14	33			0	0	13
14	102*	67	85	16	43	0	20		0	0	0	29.31	33	1.3	7.9	14	03			0	0	14
15	96	64	80	10	37	0	15		0	0	0	29.30	36	4.7	7.5	21	33			0	0	15
16	88	60	74	4	45	0	9		0	0	0	29.34	31	3.8	6.6	14	31			0	0	16
17	94	62	78	8	48	0	13		0	0	0	29.35	32	.9	6.0	13	33			0	0	17
18	98	68	83	13	52	0	18		0	0	0	29.33	34	2.3	6.6	15	32			5	4	18
19	99	73	86	15	52	0	21		0	0	0	29.27	35	6.1	8.5	16	31			1	1	19
20	92	66	79	8	53	0	14		0	0	0	29.33	32	7.0	7.9	14	30			0	0	20
21	86	62	74	3	55	0	9		0	0	0	29.50	32	6.0	7.8	12	36			3	2	21
22	85	63	74	3	57	0	9		0	0	0	29.52	31	5.6	6.9	13	34			10	7	22
23	91	69	80	9	52	0	15		0	0	0	29.46	36	4.4	7.1	12	32			7	6	23
24	90	63	77	5	51	0	12		0	0	0	29.39	32	7.1	7.9	15	30			0	0	24
25	99	69	84	12	51	0	19		0	0	0	29.33	02	1.5	5.8	14	32			1	1	25
26	101	72	87*	15	50	0	22		0	0	0	29.29	36	3.3	7.6	13	31			1	1	26
27	95	69	82	10	48	0	17		0	0	0	29.26	31	6.9	8.2	17	33			2	1	27
28	86	60	73	1	48	0	8		0	0	0	29.34	33	7.4	8.2	17	03			5	3	28
29	85	60	73	0	43	0	8		0	0	0	29.38	32	6.5	7.9	13	33			0	0	29
30	91	62	77	4	44	0	12		0	0	0	29.33	35	.7	6.0	14	25			0	0	30
31	98	67	83	10	46	0	18		0	0	0	29.30	33	5.0	8.6	15	35			0	0	31
	SUM	SUM				TOTAL	TOTAL			TOTAL	TOTAL	FOR THE MONTH:						TOTAL	%	SUM	SUM	
	2748	1896				8	321	NUMBER OF DAYS		T	0	29.39	33	4.6	7.7	23	28		FOR	86	70	
	AVG.	AVG.	AVG.	DEP.	AVG.	DEP.	DEP.	PRECIPITATION		DEP.						DATE:	05	POSSIBLE	MONTH	AVG.	AVG.	
	88.6	61.2	74.9	5.1	47	-14	150	≥.01 INCH	0	-0.19										2.8	2.3	

NUMBER OF DAYS				SEASON TO DATE			
MAXIMUM TEMP.		MINIMUM TEMP.		TOTAL	TOTAL	SNOW, ICE PELLETS ≥ 1.0 INCH	0
≥ 90°	≤ 32°	≤ 32°	≤ 0°	1891	373	THUNDERSTORMS	0
				DEP.	DEP.	HEAVY FOG	0
16	0	0	0	-294	125	CLEAR 19 PARTLY CLOUDY 9 CLOUDY 3	

GREATEST IN 24 HOURS AND DATES PRECIPITATION		SNOW, ICE PELLETS		GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE	
T	8+	0		0	

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT
+ ALSO ON AN EARLIER DATE, OR DATES.
HEAVY FOG: - VISIBILITY 1/4 MILE OR LESS.
FIGURES FOR WIND DIRECTIONS ARE TENS OF DEGREES CLOCKWISE FROM TRUE NORTH. 00 = CALM.
DATA IN COLS. 6 AND 12-15 ARE BASED ON 7 OR MORE OBSERVATIONS PER DAY AT 3-HOUR INTERVALS.
FASTEST MILE WIND SPEEDS ARE FASTEST OBSERVED ONE-MINUTE VALUES WHEN DIRECTIONS ARE IN TENS OF DEGREES. THE / WITH THE DIRECTION INDICATES PEAK GUST SPEED.
ANY ERRORS DETECTED WILL BE CORRECTED AND CHANGES IN SUMMARY DATA WILL BE ANNOTATED IN THE ANNUAL SUMMARY

SUMMARY BY HOURS

HOUR LOCAL TIME	AVERAGES SKY COVER TENTHS	STATION PRESSURE IN.	TEMPERATURE AIR °F	WET BULB °F	DEW PT. °F	RELATIVE HUMIDITY %	WIND SPEED M.P.H.	RESULTANT WIND DIRECTION	SPEED M.P.H.
01	2	29.40	67	56	47	51	6.0	35	3.9
04	1	29.41	64	55	47	56	5.5	04	2.0
07	4	29.44	68	57	48	50	6.5	11	.7
10	3	29.44	77	60	48	38	6.9	29	3.9
13	3	29.38	85	63	47	29	9.3	31	7.8
16	2	29.34	88	63	45	24	11.1	32	10.0
19	2	29.34	81	61	47	32	8.7	34	7.8
22	1	29.39	74	58	46	40	8.2	36	5.8

HOURLY PRECIPITATION (WATER EQUIVALENT IN INCHES)

DATE	A. M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	P. M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	DATE
1																		T	T						1
2																									2
3																									3
4																									4
5																									5
6																									6
7																			T	T					7
8							T	T																	8
9																									9
10																									10
11																									11
12																									12
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29																									29
30																									30
31																									31

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Daniel B. Mitchell
DIRECTOR, NATIONAL CLIMATIC CENTER

USCOMM--NOAA--ASHEVILLE 06/25/79 400

OBSERVATIONS AT 3-HOUR INTERVALS

DAY	HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
DAY 01	01	0	UNL	30			56	51	46	69	36	5
	04	0	UNL	30			56	51	46	69	00	0
	07	9	75	20			60	53	47	62	35	7
	10	8	80	20			65	55	47	52	36	4
	13	8	90	20			71	58	48	44	33	8
	16	9	80	20			74	58	45	36	32	11
	19	8	65	20			68	58	49	49	31	11
	22	10	65	20			64	56	50	61	32	18
DAY 02	01	10	90	20			60	54	50	70	29	6
	04	3	UNL	20			58	52	47	67	34	5
	07	10	35	15			60	54	49	67	00	0
	10	10	45	15			66	57	51	59	31	7
	13	9	65	10			71	58	50	48	27	4
	16	2	UNL	30			75	60	49	40	36	5
	19	0	UNL	30			70	58	49	47	35	4
	22	0	UNL	30			65	56	49	56	10	7
DAY 03	01	0	UNL	30			62	55	49	63	09	7
	04	0	UNL	30			60	53	48	65	00	0
	07	7	UNL	15			63	56	50	63	00	0
	10	0	UNL	10			78	63	52	40	31	8
	13	0	UNL	10			82	64	53	37	27	10
	16	0	UNL	10			87	66	53	31	33	9
	19	0	UNL	10			79	64	54	42	36	5
	22	0	UNL	10			75	62	53	46	04	8
DAY 04	01	0	UNL	30			62	57	53	73	34	5
	04	0	UNL	30			61	56	53	75	09	8
	07	10	UNL	10			62	56	52	70	00	0
	10	9	UNL	10			70	61	54	57	05	4
	13	0	UNL	10			82	65	55	40	29	8
	16	0	UNL	10			87	66	53	31	31	7
	19	0	UNL	10			80	63	52	38	30	4
	22	0	UNL	10			75	61	51	43	09	4
DAY 05	01	0	UNL	10			64	57	51	63	32	9
	04	0	UNL	10			60	55	52	75	36	7
	07	7	UNL	10			61	56	53	75	13	5
	10	8	UNL	10			70	60	52	53	27	3
	13	3	UNL	10			81	61	45	28	35	11
	16	0	UNL	15			83	59	38	20	30	10
	19	6	UNL	15			72	60	51	48	30	11
	22	0	UNL	15			66	57	49	54	34	15
DAY 06	01	10	65	30			63	55	49	60	32	17
	04	10	65	15			60	53	46	60	34	20
	07	9	UNL	20			59	52	45	60	31	12
	10	9	UNL	20			66	54	43	43	32	14
	13	4	UNL	20			76	56	38	25	32	10
	16	0	UNL	25			75	56	38	26	32	10
	19	2	UNL	25			68	53	40	36	36	9
	22	0	UNL	20			59	51	43	56	34	8
DAY 07	01	0	UNL	20			54	49	44	69	33	7
	04	4	UNL	20			56	51	46	69	33	7
	07	10	55	30			60	54	49	67	31	8
	10	9	55	30			66	56	47	47	28	6
	13	10	55	30			71	57	45	39	33	13
	16	9	56	30			71	57	45	39	01	14
	19	10	60	30		RW	64	56	47	54	32	8
	22	10	65	30			61	53	46	58	34	15
DAY 08	01	10	90	20			55	48	42	62	31	10
	04	10	90	20			53	47	42	66	30	5
	07	10	45	15		RW	54	48	42	64	34	6
	10	7	35	20			60	50	39	46	32	11
	13	8	40	30			72	54	37	28	30	16
	16	5	UNL	10			70	52	34	27	01	15
	19	1	UNL	15			63	50	38	40	01	9
	22	4	UNL	15			55	46	37	51	04	6
DAY 09	01	10	40	30			57	49	42	57	34	5
	04	8	65	30			53	47	41	64	28	4
	07	10	55	30			57	49	42	57	08	4
	10	7	55	30			61	51	41	48	03	4
	13	3	UNL	30			70	54	40	34	27	9
	16	2	UNL	30			75	55	36	24	35	10
	19	0	UNL	30			68	52	37	32	34	7
	22	0	UNL	30			62	50	38	41	10	5
DAY 10	01	0	UNL	20			58	48	38	48	09	5
	04	0	UNL	20			52	46	40	64	15	8
	07	0	UNL	30			60	50	41	50	10	4
	10	0	UNL	30			72	55	40	31	24	4
	13	0	UNL	30			78	57	40	26	34	5
	16	0	UNL	30			82	57	33	17	32	10
	19	0	UNL	30			74	54	35	24	34	6
	22	0	UNL	30			70	52	34	27	00	0
DAY 11	01	0	UNL	30			60	49	37	43	06	4
	04	0	UNL	30			56	48	38	48	12	6
	07	0	UNL	15			63	51	38	41	13	8
	10	0	UNL	15			77	57	40	27	22	5
	13	0	UNL	20			84	60	42	23	36	8
	16	0	UNL	30			90	61	38	16	28	7
	19	0	UNL	30			82	59	41	23	02	6
	22	0	UNL	30			75	55	41	29	06	4
DAY 12	01	0	UNL	30			66	53	42	42	06	3
	04	0	UNL	30			62	51	41	46	12	3
	07	0	UNL	15			71	55	42	35	14	5
	10	0	UNL	15			82	61	45	27	24	3
	13	0	UNL	20			92	65	46	20	34	7
	16	0	UNL	30			95	65	43	17	30	11
	19	0	UNL	20			88	62	41	19	03	6
	22	0	UNL	30			80	59	43	27	12	5
DAY 13	01	0	UNL	30			71	57	46	41	00	0
	04	0	UNL	30			67	55	45	45	14	5
	07	0	UNL	15			76	60	47	36	13	6
	10	0	UNL	15			85	64	50	30	18	7
	13	0	UNL	15			98	65	42	15	29	4
	16	0	UNL	20			98	65	40	13	28	9
	19	0	UNL	30			91	61	37	15	02	9
	22	0	UNL	30			79	59	43	28	34	4
DAY 14	01	0	UNL	30			75	57	42	31	03	4
	04	0	UNL	30			70	55	42	36	13	6
	07	0	UNL	15			77	59	45	32	13	7
	10	0	UNL	15			88	64	47	24	21	5
	13	0	UNL	15			97	66	44	16	25	5
	16	0	UNL	20			101	66	39	12	28	7
	19	0	UNL	30			89	63	44	21	31	9
	22	0	UNL	30			81	58	39	22	02	12
DAY 15	01	0	UNL	30			77	57	40	27	36	10
	04	0	UNL	30			68	54	41	38	00	0
	07	0	UNL	20			74	56	40	29	13	5
	10	0	UNL	15			86	59	37	18	13	3
	13	0	UNL	20			93	61	32	11	07	5
	16	0	UNL	20			95	62	34	12	32	5
	19	0	UNL	20			82	58	41	23	33	14
	22	0	UNL	20			76	54	32	20	36	10
DAY 16	01	0	UNL	30			62	50	38	41	29	5
	04	0	UNL	30			62	52	42	48	04	4
	07	0	UNL	15			65	54	45	49	23	4
	10	0	UNL	15			74	61	51	45	36	3
	13	0	UNL	10			85	64	49	29	29	11
	16	0	UNL	15			88	62	43	21	32	9
	19	0	UNL	20			81	62	48	32	33	9
	22	0	UNL	20			76	59	45	33	12	5
DAY 17	01	0	UNL	15			67	56	46	47	16	2
	04	0	UNL	15			67	56	47	49	08	4
	07	0	UNL	10			71	58	48	44	14	6
	10	0	UNL	10			81	63	50	34	21	4
	13	0	UNL	10			88	65	49	26	28	7
	16	0	UNL	10			93	65	45	19	31	10
	19	0	UNL	15			86	64	50	29	36	5
	22	0	UNL	15			80	62	49	34	09	4
DAY 18	01	0	UNL	15			75	60	49	40	00	0
	04	0	UNL	15			70	59	50	49	11	5
	07	2	UNL	10			78	61	49	36	14	5
	10	5	UNL	10			86	65	52	31	15	5
	13	8	UNL	10			94	68	53	25	35	5
	16	7	150	10			98	69	52	21	32	13
	19	8	250	15			91	67	52	28	30	6
	22	2	UNL	15			81	66	56	42	34	7
DAY 19	01	0	UNL	15			77	64	56	48	07	6
	04	0	UNL	15			73	61	52	48	00	0
	07	2	UNL	10			77	63	53	43	14	4
	10	1	UNL	10			90	66	51	26	33	13
	13	0	UNL	15			94	67	51	23	34	8
	16	3	UNL	15			97	68	50	20	34	10
	19	1	UNL	15			88	66	53	32	32	10
	22	0	UNL	15			80	62	50	35	03	8
DAY 20	01	0	UNL	15			74	60	50	43	36	5
	04	0	UNL	15			68	58	51	55	00	0
	07	0	UNL	10			73	61	53	50	31	6
	10	0	UNL	10			80	65	56	44	26	7
	13	0	UNL	10			88	68	58	34	32	7
	16	0	UNL	15			92	67	52	26	33	11
	19	0	UNL	15			80	64	54	41	32	10
	22	0	UNL	30			72	61	53	51	35	9
DAY 21	01	0	UNL	30			67	58	52	59	36	8
	04	0	UNL	20			63	57	52	68	36	8
	07	10	30	15			65	58	53	65	31	9
	10	2	UNL	15			72	62	55	55	27	5
	13	0	UNL	10			80	66	57	45	24	5
	16	0	UNL	10			86	68	58	39	29	7
	19	2	UNL	10			82	66	57	43	33	7
	22	0	UNL	10			75	64	57	54	36	5
DAY 22	01	0	UNL	10			68	60	55	63	30	5
	04	0	UNL	10			65	60	56	73	36	6
	07	10	UNL	8			67	60	56	68	30	6
	10	10	UNL	8			74	64	57	55	28	5
	13	10	UNL	10			81	66	57	44	31	5
	16	10	UNL	7			85	68	58	40	28	10
	19	10	UNL	7			82	67	58	44	30	5
	22	3	UNL	10			78	66	58	50	02	5
DAY 23	01	8	250	10			72	64	59	64	34	5
	04	10	250	10			72	61	54	53	01	10
	07	10	150	10			71	62	56	59	14	7
	10	8	200	10			79	64	55	44	09	4
	13	10	UNL	20			87	63	47	25	34	7
	16	2	UNL	20			91	65	48	23	32	8
	19	0	UNL	20			86	64	48	27	36	4
	22	0	UNL	20			80	62	50	35	36	6
DAY 24	01	0	UNL	20			68	59	52	57	29	4
	04	0	UNL	30			67	58	52	59	01	4
	07	0	UNL	30			73	61	53	50	34	6
	10	0	UNL	30			79	63	52	39	30	10
	13	0	UNL	30			85	65	52	32	31	8
	16	0	UNL	30			90	66	51	26	30	13
	19	0	UNL	15			85	63	48	28	34	6
	22	0	UNL	15			76	60	46	32	01	4
DAY 25	01	0	UNL	30			74	61	51	45	00	0
	04	0	UNL	30			71	59	50	48	13	6
	07	0	UNL	30			79	62	50	36	11	4
	10	0	UNL	30			86	65	51	30	15	4
	13	4	UNL	15			93	68	53	26	28	5
	16	2	UNL	15			99	69	52	21	34	8
	19	1	UNL	15			93	68	52	25	03	8
	22	0	UNL	20			80	63	52	38	31	5
DAY 26	01	0	UNL	20			77	64	55	47	12	4
	04	0	UNL	20			74	61	51	45	10	5
	07	0	UNL	30			77	63	53	43	12	8
	10	0	UNL	30			90	66	51	26	30	4
	13	2	UNL	20			98	68	50	20	31	11
	16	2	UNL	20			101	69	49	17	35	8
	19	1	UNL	30			94	65	46	19	35	7
	22	0	UNL	30			82	62	47	29	34	6
DAY 27	01	0	UNL	20			80	62	49	34	00	0
	04	0	UNL	20			72	59	49	44	00	0
	07	0	UNL	30			76	62	52	43	26	6
	10	0	UNL	30			82	63	51	34	25	4
	13	1	UNL	20			92	66	50	24	29	13
	16	9	UNL	15			92	64	43	18	33	14
	19	7	UNL	20			82	61	46	28	33	13
	22	0	UNL	15			72	58	46	40	36	7
DAY 28	01	0	UNL	15			68	56	45	44	36	8
	04	0	UNL	15			65	54	44	47	00	0
	07	7	UNL	30			71	56	44	38	02	5
	10	8	UNL	20			76	60	47	36	32	7
	13	10	UNL	20			82	63	51	34	30	10
	16	3	UNL	20			85	64	50	30	34	12
	19	1	UNL	20			82	63	49	32	35	6
	22	0	UNL	30			71	59	50	48	31	9
DAY 29	01	0	UNL	30			62	55	49	63	33	6
	04	0	UNL	30			63	55	48	58	00	0
	07	0	UNL	30			68	56	46	45	28	8
	10	0	UNL	30			72	54	38	29	30	8
	13	0	UNL	15			79	58	39	24	28	9
	16	0	UNL	15			85	60	40	20	33	11
	19	0	UNL	15			80	59	42	26	33	7
	22	0	UNL	20			75	57	42	31	04	6
DAY 30	01	0	UNL	15			65	54	44	47	18	2
	04	0	UNL	15			64	53	44	48	14	4
	07	0	UNL	20			70	55	43	38	12	7
	10	0	UNL	15			78	59	43	29	28	5
	13	0	UNL	15			87	62	44	22	01	8
	16	0	UNL	15			91	64	44	20	26	7
	19	0	UNL	15			85	63	48	28	03	6
	22	0	UNL	15			79	59	44	29	06	5
DAY 31	01	0	UNL	15			74	58	45	36	34	4
	04	0	UNL	15			68	57	48	49	13	7
	07	0	UNL	10			76	59	46	35	12	4
	10	0	UNL	15			86	63	46	25	30	9
	13	0	UNL	15			94	65	46	19	30	10
	16	1	UNL	15			98	66	45	16	34	10
	19	1	UNL	20			91	63	43	19	36	8
	22	0	UNL	20			78	60	47	34	32	8

NOTES

CEILING

UNL INDICATES UNLIMITED

WEATHER

■	TORNADO
T	THUNDERSTORM
Q	SQUALL
R	RAIN
RW	RAIN SHOWERS
ZR	FREEZING RAIN
L	DRIZZLE
ZL	FREEZING DRIZZLE
S	SNOW
SP	SNOW PELLETS
IC	ICE CRYSTALS
SW	SNOW SHOWERS
SG	SNOW GRAINS
IP	ICE PELLETS
A	HAIL
F	FOG
IF	ICE FOG
GF	GROUND FOG
BD	BLOWING DUST
BN	BLOWING SAND
BS	BLOWING SNOW
BY	BLOWING SPRAY
K	SMOKE
H	HAZE
D	DUST

WIND

DIRECTIONS ARE THOSE FROM WHICH THE WIND BLOWS. INDICATED IN TENS OF DEGREES FROM TRUE NORTH: I.E., 09 FOR EAST, 18 FOR SOUTH, 27 FOR WEST. ENTRY OF 00 IN THE DIRECTION COLUMN INDICATES CALM.

SPEED IS EXPRESSED IN KNOTS: MULTIPLY BY 1.15 TO CONVERT TO MILES PER HOUR.

STATION

BAKERSFIELD CALIFORNIA

YEAR & MONTH

79 05

U.S. DEPARTMENT OF COMMERCE
NATIONAL CLIMATIC CENTER
FEDERAL BUILDING
ASHEVILLE, N.C. 28801

AN EQUAL OPPORTUNITY EMPLOYER

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE
COM-210

U.S.MAIL

FIRST CLASS

JUNE 1979
BAKERSFIELD, CALIFORNIA
NATIONAL WEATHER SERVICE OFC
KERN COUNTY AIR TERMINAL

Local Climatological Data

MONTHLY SUMMARY

LATITUDE 35° 25 ′N LONGITUDE 119° 03 ′W ELEVATION (GROUND) 475 FT. STANDARD TIME USED: PACIFIC WBAN #23155

DATE	TEMPERATURE °F MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	AVERAGE DEW POINT	DEGREE DAYS BASE 65° HEATING (SEASON BEGINS WITH JULY)	COOLING (SEASON BEGINS WITH JAN.)	WEATHER TYPES ON DATES OF OCCURRENCE 1 FOG 2 HEAVY FOG 3 THUNDERSTORM 4 ICE PELLETS 5 HAIL 6 GLAZE 7 DUSTSTORM 8 SMOKE, HAZE 9 BLOWING SNOW	SNOW, ICE PELLETS OR ICE ON GROUND AT 04AM IN.	PRECIPITATION WATER EQUIVALENT IN	SNOW, ICE PELLETS IN.	AVG. STATION PRESSURE IN. ELEV. 492 FEET M.S.L.	WIND RESULTANT DIR.	RESULTANT SPEED M.P.H.	AVERAGE SPEED M.P.H.	FASTEST MILE SPEED M.P.H.	FASTEST MILE DIRECTION	SUNSHINE MINUTES	PERCENT OF POSSIBLE	SKY COVER TENTHS SUNRISE TO SUNSET	MIDNIGHT TO MIDNIGHT	DATE
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	102	69	86	13	43	0	21		0	0	0	29.32	01	3.8	7.6	17	33			2	1	1
2	104	72	88	15	42	0	23		0	0	0	29.30	27	1.2	7.9	15	28			0	0	2
3	102	72	87	13	45	0	22		0	0	0	29.31	34	5.5	6.8	16	33			0	0	3
4	100	71	86	12	46	0	21		0	0	0	29.31	35	3.2	5.2	10	32			3	2	4
5	98	71	85	11	50	0	20		0	0	0	29.30	35	3.7	6.6	13	28			1	0	5
6	100	76	88	14	49	0	23	8	0	0	0	29.20	35	5.4	8.6	18	32			0	0	6
7	90	69	80	5	41	0	15		0	0	0	29.25	34	5.1	8.2	17	32			0	0	7
8	95	68	82	7	35	0	17		0	0	0	29.40	05	2.4	7.1	13	33			0	0	8
9	100	69	85	10	37	0	20		0	0	0	29.51	33	2.1	5.9	15	33			2	2	9
10	105	71	88	13	42	0	23		0	0	0	29.46	01	1.3	6.9	17	32			0	0	10
11	109	70	90	14	45	0	25		0	0	0	29.41	35	2.6	6.2	14	32			0	0	11
12	110*	75	93*	17	41	0	28		0	0	0	29.39	34	3.4	7.3	15	36			0	0	12
13	101	73	87	11	40	0	22		0	0	0	29.41	30	5.9	9.1	15	33			9	6	13
14	89	63	76	0	33	0	11		0	0	0	29.47	34	7.1	7.9	14	31			0	1	14
15	90	60	75	-2	41	0	10		0	0	0	29.45	34	6.8	7.8	15	32			0	0	15
16	87	60	74	-3	44	0	9		0	0	0	29.39	33	8.3	8.6	18	33			0	0	16
17	78	57	68*	-9	43	0	3		0	0	0	29.45	34	8.9	9.9	16	34			2	1	17
18	82	57*	70	-7	42	0	5		0	0	0	29.50	33	6.0	7.6	16	32			1	0	18
19	88	60	74	-4	45	0	9		0	0	0	29.49	30	3.0	6.3	13	28			0	0	19
20	94	65	80	2	46	0	15		0	0	0	29.46	28	2.4	6.6	14	28			0	0	20
21	92	66	79	1	45	0	14		0	0	0	29.52	33	4.1	6.6	15	31			0	0	21
22	91	63	77	-2	46	0	12		0	0	0	29.49	31	4.2	7.8	15	32			0	0	22
23	98	68	83	4	48	0	18		0	0	0	29.39	05	.9	7.2	15	31			0	0	23
24	102	69	86	7	50	0	21		0	0	0	29.35	35	4.1	6.8	13	31			0	0	24
25	97	70	84	4	48	0	19		0	0	0	29.46	33	6.6	7.2	14	31			8	6	25
26	93	67	80	0	53	0	15		0	0	0	29.54	32	4.7	8.8	15	28			8	6	26
27	93	69	81	1	52	0	16		0	0	0	29.52	26	3.8	7.2	14	26			5	3	27
28	97	68	83	3	50	0	18		0	0	0	29.49	32	4.1	7.5	14	32			6	4	28
29	91	66	79	-2	49	0	14		0	0	0	29.49	32	4.1	7.6	12	30			3	2	29
30	88	64	76	-5	49	0	11		0	0	0	29.44	32	3.5	7.1	14	28			0	0	30
	SUM	SUM				TOTAL	TOTAL			TOTAL	TOTAL	FOR THE MONTH:						TOTAL	%	SUM	SUM	
	2866	2019				0	500	NUMBER OF DAYS		.00	0	29.41	33	3.9	7.3	18	33		FOR	50	34	
	AVG.	AVG.	AVG.	DEP.	AVG.	DEP.	DEP.	PRECIPITATION		DEP.						DATE:	16+	POSSIBLE	MONTH	AVG.	AVG.	
	95.5	67.3	81.4	4.5	45	0	138	≥.01 INCH	0	-0.06										1.7	1.1	

				SEASON TO DATE			
NUMBER OF DAYS				TOTAL	TOTAL	SNOW, ICE PELLETS ≥ 1.0 INCH	0
MAXIMUM TEMP.		MINIMUM TEMP.		1891	873	THUNDERSTORMS	0
≥ 90°	≤ 32°	≤ 32°	≤ 0°	DEP.	DEP.	HEAVY FOG	0
24	0	0	0	-294	263	CLEAR 25 PARTLY CLOUDY 2 CLOUDY 3	

GREATEST IN 24 HOURS AND DATES PRECIPITATION		SNOW, ICE PELLETS		GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE	
0		0		0	

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT
+ ALSO ON AN EARLIER DATE, OR DATES.
HEAVY FOG: - VISIBILITY 1/4 MILE OR LESS.
FIGURES FOR WIND DIRECTIONS ARE TENS OF DEGREES CLOCKWISE FROM TRUE NORTH. 00 = CALM.
DATA IN COLS. 6 AND 12-15 ARE BASED ON 7 OR MORE OBSERVATIONS PER DAY AT 3-HOUR INTERVALS.
FASTEST MILE WIND SPEEDS ARE FASTEST OBSERVED ONE-MINUTE VALUES WHEN DIRECTIONS ARE IN TENS OF DEGREES. THE / WITH THE DIRECTION INDICATES PEAK GUST SPEED.
ANY ERRORS DETECTED WILL BE CORRECTED AND CHANGES IN SUMMARY DATA WILL BE ANNOTATED IN THE ANNUAL SUMMARY

SUMMARY BY HOURS

HOUR LOCAL TIME	AVERAGES SKY COVER TENTHS	STATION PRESSURE IN.	TEMPERATURE AIR °F	WET BULB °F	DEW PT. °F	RELATIVE HUMIDITY %	WIND SPEED M.P.H.	RESULTANT WIND DIRECTION	SPEED M.P.H.
01	0	29.42	73	57	44	37	4.8	35	1.9
04	1	29.43	69	56	45	44	4.9	06	2.3
07	1	29.46	75	59	47	38	5.8	13	2.2
10	2	29.46	84	62	46	27	7.5	30	3.7
13	2	29.42	92	64	44	20	8.9	31	7.9
16	2	29.36	95	65	44	18	11.5	32	10.7
19	1	29.36	89	63	44	21	8.1	34	7.1
22	0	29.40	80	59	43	28	7.1	01	5.3

HOURLY PRECIPITATION (WATER EQUIVALENT IN INCHES)

DATE	A.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	P.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	DATE
1																									1
2																									2
3																									3
4																									4
5																									5
6																									6
7																									7
8																									8
9																									9
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25																									25
26																									26
27																									27
28																									28
29																									29
30																									30

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I CERTIFY THAT THIS IS AN OFFICIAL PUBLICATION OF THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, AND IS COMPILED FROM RECORDS ON FILE AT THE NATIONAL CLIMATIC CENTER, ASHEVILLE, NORTH CAROLINA 28801.

noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / ENVIRONMENTAL DATA AND INFORMATION SERVICE

Daniel B. Mitchell
DIRECTOR, NATIONAL CLIMATIC CENTER

USCOMM--NOAA--ASHEVILLE 07/23/79 400

OBSERVATIONS AT 3-HOUR INTERVALS

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
DAY 01											
01	0	UNL	30			75	58	45	34	06	4
04	0	UNL	30			71	57	45	39	11	5
07	0	UNL	15			76	59	46	35	17	4
10	0	UNL	15			87	63	46	24	25	5
13	1	UNL	15			97	66	46	17	02	5
16	7	150	20			101	66	39	12	33	15
19	0	UNL	30			94	63	38	14	02	9
22	0	UNL	30			87	61	41	20	03	6
DAY 02											
01	0	UNL	20			76	59	45	33	20	4
04	0	UNL	30			74	58	45	36	12	6
07	0	UNL	20			80	61	47	31	15	7
10	0	UNL	15			89	63	45	22	14	3
13	0	UNL	15			98	66	43	15	28	13
16	0	UNL	15			103	67	40	11	33	10
19	0	UNL	20			96	63	36	12	01	8
22	0	UNL	20			85	59	37	18	20	4
DAY 03											
01	0	UNL	20			77	60	47	35	00	0
04	0	UNL	20			73	58	45	37	00	0
07	0	UNL	30			80	61	46	30	12	4
10	0	UNL	20			91	64	46	21	34	9
13	0	UNL	20			97	66	45	17	31	10
16	0	UNL	20			101	67	43	14	34	10
19	0	UNL	20			94	64	41	16	34	7
22	0	UNL	30			83	62	47	28	36	7
DAY 04											
01	0	UNL	30			77	60	47	35	02	6
04	0	UNL	20			74	59	48	40	00	0
07	0	UNL	15			78	61	48	35	11	5
10	0	UNL	15			91	63	43	19	27	6
13	0	UNL	20			97	65	43	16	35	5
16	8	UNL	20			97	65	42	15	34	7
19	5	UNL	30			92	65	47	21	36	7
22	0	UNL	25			78	60	46	32	00	0
DAY 05											
01	0	UNL	20			78	61	48	35	06	2
04	0	UNL	20			72	59	50	46	14	4
07	0	UNL	10			76	62	52	43	09	6
10	2	UNL	10			87	67	54	32	32	8
13	0	UNL	15			94	67	50	22	32	10
16	0	UNL	15			98	69	53	22	32	7
19	0	UNL	20			93	68	48	21	35	5
22	0	UNL	20			84	63	48	29	03	4
DAY 06											
01	0	UNL	15			78	62	50	36	08	5
04	0	UNL	15			79	62	50	36	08	5
07	0	UNL	15			86	65	52	31	11	4
10	0	UNL	15			92	67	51	25	34	12
13	0	UNL	10			96	69	53	23	29	8
16	0	UNL	7			100	69	50	19	35	11
19	0	UNL	7			92	63	41	17	33	10
22	0	UNL	7			75	59	46	36	30	5
DAY 07											
01	0	UNL	30			73	56	40	30	09	6
04	0	UNL	30			71	55	40	33	09	7
07	0	UNL	20			78	57	40	26	32	14
10	0	UNL	10			81	58	39	22	30	9
13	0	UNL	7			88	61	41	20	36	4
16	0	UNL	7			90	62	40	17	33	10
19	0	UNL	10			82	61	45	27	32	7
22	0	UNL	10			74	58	45	36	00	0
DAY 08											
01	0	UNL	15			75	55	37	25	06	4
04	0	UNL	15			70	55	41	35	09	6
07	0	UNL	10			80	58	38	22	12	6
10	0	UNL	15			87	58	31	13	18	6
13	0	UNL	30			94	61	33	12	33	7
16	0	UNL	30			93	61	35	13	30	7
19	0	UNL	30			89	59	31	12	01	7
22	0	UNL	20			81	56	31	16	07	6
DAY 09											
01	0	UNL	20			71	53	36	28	12	5
04	0	UNL	20			71	54	38	30	10	5
07	0	UNL	15			77	56	38	25	00	0
10	7	UNL	20			88	61	38	17	21	4
13	6	UNL	20			97	63	37	12	29	8
16	0	UNL	20			100	65	38	12	33	12
19	0	UNL	20			93	62	36	13	36	7
22	0	UNL	20			86	59	36	17	00	0
DAY 10											
01	0	UNL	20			77	57	40	27	00	0
04	0	UNL	20			74	56	41	31	16	6
07	0	UNL	20			80	58	40	24	14	7
10	0	UNL	10			89	63	44	21	18	4
13	0	UNL	15			99	67	46	16	32	10
16	0	UNL	15			104	69	45	14	34	10
19	0	UNL	15			98	64	39	13	36	6
22	0	UNL	30			87	60	39	18	08	5
DAY 11											
01	0	UNL	20			78	60	46	32	00	0
04	0	UNL	20			74	58	46	37	12	4
07	0	UNL	15			82	62	47	29	15	5
10	0	UNL	10			92	65	46	20	22	4
13	0	UNL	10			103	69	47	15	34	4
16	0	UNL	10			109	70	44	11	32	10
19	0	UNL	30			99	66	44	15	01	7
22	0	UNL	30			89	61	38	17	01	9
DAY 12											
01	0	UNL	20			84	58	36	18	31	4
04	0	UNL	20			76	57	41	29	09	7
07	0	UNL	20			82	60	43	25	13	5
10	0	UNL	10			94	66	47	20	26	5
13	0	UNL	10			106	68	42	11	00	0
16	0	UNL	10			107	69	43	11	30	12
19	0	UNL	15			95	65	44	17	34	8
22	0	UNL	15			87	57	29	12	01	10
DAY 13											
01	0	UNL	30			75	56	37	25	30	5
04	0	UNL	30			75	55	37	25	34	5
07	7	UNL	15			79	59	44	29	20	4
10	9	UNL	15			87	62	42	21	17	8
13	10	UNL	15			98	66	45	17	30	11
16	10	UNL	8			100	67	45	15	26	5
19	10	UNL	10			91	63	43	19	31	12
22	0	UNL	20			79	55	30	17	33	13
DAY 14											
01	0	UNL	15			70	53	37	30	00	0
04	8	UNL	15			68	52	36	31	02	8
07	0	UNL	25			69	52	35	29	32	7
10	0	UNL	19			81	56	32	17	33	10
13	0	UNL	20			86	58	31	14	34	7
16	0	UNL	20			87	58	31	13	31	9
19	2	UNL	20			83	56	31	15	33	6
22	0	UNL	15			77	54	30	18	02	8
DAY 15											
01	0	UNL	20			68	53	40	36	34	4
04	0	UNL	25			60	52	44	56	02	5
07	0	UNL	20			68	55	44	42	00	0
10	0	UNL	15			78	59	43	29	32	8
13	0	UNL	15			85	60	40	20	29	9
16	0	UNL	15			90	61	38	18	32	13
19	0	UNL	20			85	60	40	20	36	6
22	0	UNL	20			78	57	40	26	02	9
DAY 16											
01	0	UNL	20			63	53	44	50	33	4
04	0	UNL	20			61	54	48	63	34	5
07	0	UNL	15			70	57	47	44	00	0
10	0	UNL	15			78	59	44	30	27	4
13	0	UNL	15			84	59	39	20	33	11
16	0	UNL	20			86	60	39	19	33	12
19	0	UNL	25			80	59	43	27	32	14
22	0	UNL	15			72	58	48	43	33	10
DAY 17											
01	0	UNL	30			62	53	46	56	32	7
04	5	UNL	30			57	52	47	69	30	6
07	0	UNL	30			61	53	47	60	34	11
10	2	UNL	30			69	55	44	41	34	8
13	2	UNL	30			74	57	42	32	30	12
16	0	UNL	30			78	57	38	24	36	10
19	0	UNL	30			74	56	40	29	36	10
22	0	UNL	30			68	53	40	36	02	5
DAY 18											
01	0	UNL	20			60	50	39	46	36	5
04	0	UNL	20			60	50	41	50	00	0
07	2	UNL	30			61	53	46	58	30	5
10	0	UNL	30			71	58	47	43	32	7
13	0	UNL	30			76	59	43	29	31	9
16	0	UNL	30			81	59	41	24	32	14
19	0	UNL	30			78	57	40	26	33	7
22	0	UNL	30			71	54	39	31	09	6
DAY 19											
01	0	UNL	30			68	54	42	39	10	5
04	0	UNL	30			61	51	41	48	00	0
07	0	UNL	20			69	55	44	41	30	5
10	0	UNL	15			78	58	44	30	12	4
13	0	UNL	15			84	62	45	26	26	6
16	0	UNL	15			88	64	47	24	28	11
19	0	UNL	20			84	63	49	30	29	6
22	0	UNL	20			76	60	47	36	36	7
DAY 20											
01	0	UNL	30			70	55	42	36	24	3
04	0	UNL	30			67	55	45	45	16	4
07	0	UNL	15			73	58	46	38	15	5
10	0	UNL	10			83	63	48	30	16	4
13	0	UNL	15			90	65	49	24	28	10
16	0	UNL	15			94	66	47	20	29	7
19	0	UNL	20			88	63	45	22	35	5
22	0	UNL	20			79	61	47	32	35	8
DAY 21											
01	0	UNL	25			71	58	47	43	00	0
04	0	UNL	30			67	57	50	55	10	4
07	0	UNL	20			74	60	50	43	18	4
10	0	UNL	20			81	59	40	23	29	7
13	0	UNL	20			88	61	40	18	33	8
16	0	UNL	20			92	64	43	18	31	10
19	0	UNL	20			87	63	46	24	34	6
22	0	UNL	20			79	59	43	28	36	7
DAY 22											
01	0	UNL	20			70	57	48	42	32	8
04	0	UNL	20			64	54	46	52	00	0
07	0	UNL	30			73	59	48	41	12	7
10	0	UNL	20			82	61	45	27	32	13
13	0	UNL	15			87	63	45	23	31	6
16	2	UNL	15			91	64	45	20	30	10
19	0	UNL	15			86	62	45	24	29	5
22	0	UNL	20			78	59	45	31	12	5
DAY 23											
01	0	UNL	30			75	57	41	30	12	7
04	0	UNL	30			70	55	42	36	07	5
07	0	UNL	10			75	59	47	37	14	4
10	0	UNL	10			85	62	44	24	18	7
13	0	UNL	10			95	67	49	21	32	7
16	0	UNL	10			98	67	46	17	31	10
19	0	UNL	15			90	66	50	25	32	4
22	0	UNL	15			83	63	48	30	08	6
DAY 24											
01	0	UNL	20			79	61	48	34	07	5
04	0	UNL	10			74	59	47	38	02	5
07	0	UNL	7			78	62	51	39	14	3
10	0	UNL	7			87	66	53	31	12	3
13	0	UNL	10			98	69	51	20	34	9
16	0	UNL	10			102	70	51	18	32	10
19	0	UNL	15			95	66	48	20	36	5
22	0	UNL	20			80	82	50	35	31	7
DAY 25											
01	0	UNL	20			75	59	46	36	33	4
04	0	UNL	20			72	58	48	43	01	5
07	2	UNL	20			77	62	51	40	00	0
10	8	250	15			84	64	50	31	36	8
13	10	250	20			93	64	44	18	31	10
16	10	250	20			97	66	46	17	32	11
19	10	UNL	20			88	65	50	26	30	5
22	0	UNL	15			80	62	50	35	32	7
DAY 26											
01	3	UNL	15			72	62	55	55	30	6
04	3	UNL	15			70	61	54	57	32	6
07	10	UNL	10			72	62	55	55	15	5
10	10	UNL	10			81	66	57	44	34	4
13	10	250	10			90	66	50	25	28	3
16	1	UNL	10			93	68	52	25	30	10
19	10	UNL	15			89	65	50	26	34	8
22	0	UNL	15			82	64	52	35	01	5
DAY 27											
01	0	UNL	15			72	62	55	55	29	6
04	0	UNL	15			69	60	54	59	36	6
07	7	UNL	10			73	63	57	57	16	6
10	10	UNL	10			82	66	57	43	27	5
13	6	UNL	10			90	66	51	26	22	6
16	0	UNL	10			93	65	47	21	26	12
19	0	UNL	10			90	65	48	24	24	5
22	0	UNL	20			83	62	47	28	04	4
DAY 28											
01	0	UNL	20			78	61	48	35	00	0
04	6	UNL	20			70	60	52	53	26	4
07	8	UNL	10			75	62	53	46	13	8
10	4	UNL	10			85	67	56	37	28	6
13	5	UNL	10			92	66	48	22	30	9
16	7	UNL	10			96	67	49	20	31	8
19	2	UNL	10			88	64	48	25	33	7
22	1	UNL	10			82	60	43	25	01	10
DAY 29											
01	0	UNL	10			70	58	48	46	35	6
04	0	UNL	10			70	58	48	46	05	6
07	0	UNL	30			74	60	50	43	11	4
10	0	UNL	20			83	62	47	28	30	10
13	7	UNL	20			86	64	49	28	27	8
16	2	UNL	20			91	64	46	21	28	8
19	3	UNL	15			87	65	51	29	27	5
22	0	UNL	15			81	63	51	35	02	6
DAY 30											
01	0	UNL	20			72	61	53	51	30	10
04	0	UNL	20			68	59	52	57	00	0
07	0	UNL	30			70	59	50	49	13	5
10	1	UNL	30			78	60	47	34	18	4
13	0	UNL	20			85	63	47	27	29	7
16	0	UNL	30			88	64	48	25	32	10
19	0	UNL	30			86	64	49	28	33	6
22	0	UNL	30			78	59	46	31	04	7

NOTES

CEILING

UNL INDICATES UNLIMITED

WEATHER

■	TORNADO
T	THUNDERSTORM
Q	SQUALL
R	RAIN
RW	RAIN SHOWERS
ZR	FREEZING RAIN
L	DRIZZLE
ZL	FREEZING DRIZZLE
S	SNOW
SP	SNOW PELLETS
IC	ICE CRYSTALS
SW	SNOW SHOWERS
SG	SNOW GRAINS
IP	ICE PELLETS
A	HAIL
F	FOG
IF	ICE FOG
GF	GROUND FOG
BD	BLOWING DUST
BN	BLOWING SAND
BS	BLOWING SNOW
BY	BLOWING SPRAY
K	SMOKE
H	HAZE
D	DUST

WIND

DIRECTIONS ARE THOSE FROM WHICH THE WIND BLOWS. INDICATED IN TENS OF DEGREES FROM TRUE NORTH; I.E., 09 FOR EAST, 18 FOR SOUTH, 27 FOR WEST. ENTRY OF 00 IN THE DIRECTION COLUMN INDICATES CALM.

SPEED IS EXPRESSED IN KNOTS; MULTIPLY BY 1.15 TO CONVERT TO MILES PER HOUR.

STATION	YEAR & MONTH
BAKERSFIELD CALIFORNIA	79 06

U.S. DEPARTMENT OF COMMERCE
NATIONAL CLIMATIC CENTER
FEDERAL BUILDING
ASHEVILLE, N.C. 28801

AN EQUAL OPPORTUNITY EMPLOYER

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE
COM-210

U.S.MAIL

FIRST CLASS

JULY 1979
BAKERSFIELD, CALIFORNIA
NATIONAL WEATHER SERVICE OFC
KERN COUNTY AIR TERMINAL

Local Climatological Data

MONTHLY SUMMARY

LATITUDE 35° 25 ′N LONGITUDE 119° 03 ′W ELEVATION (GROUND) 475 FT. STANDARD TIME USED: PACIFIC WBAN #23155

DATE	TEMPERATURE °F MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	AVERAGE DEW POINT	DEGREE DAYS BASE 65° HEATING (SEASON BEGINS WITH JULY)	COOLING (SEASON BEGINS WITH JAN.)	WEATHER TYPES ON DATES OF OCCURRENCE 1 FOG 2 HEAVY FOG 3 THUNDERSTORM 4 ICE PELLETS 5 HAIL 6 GLAZE 7 DUSTSTORM 8 SMOKE, HAZE 9 BLOWING SNOW	SNOW, ICE PELLETS OR ICE ON GROUND AT 04AM IN.	PRECIPITATION WATER EQUIVALENT IN	SNOW, ICE PELLETS IN.	AVG. STATION PRESSURE IN. ELEV. 492 FEET M.S.L.	WIND RESULTANT DIR.	RESULTANT SPEED M.P.H.	AVERAGE SPEED M.P.H.	FASTEST MILE SPEED M.P.H.	DIRECTION	SUNSHINE MINUTES	PERCENT OF POSSIBLE	SKY COVER TENTHS SUNRISE TO SUNSET	MIDNIGHT TO MIDNIGHT	DATE
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	96	66	81	0	47	0	16		0	0	0	29.30	33	4.3	7.8	18	02			0	0	1
2	86	66	76	-6	48	0	11		0	0	0	29.31	35	10.9	11.8	23	33			0	0	2
3	86	61	74	-8	50	0	9	8	0	0	0	29.41	33	5.8	7.5	13	29			5	3	3
4	86	61	74*	-8	54	0	9		0	0	0	29.46	32	6.7	7.1	14	30			2	2	4
5	88	66	77	-6	54	0	12		0	0	0	29.47	32	7.2	7.8	15	31			1	1	5
6	89	63	76	-7	52	0	11		0	0	0	29.53	31	3.9	5.2	14	32			0	0	6
7	89	61*	75	-8	52	0	10		0	0	0	29.53	30	3.7	6.0	12	32			8	6	7
8	91	63	77	-6	54	0	12		0	0	0	29.53	29	1.8	4.3	9	28			10	8	8
9	96	65	81	-3	56	0	16		0	0	0	29.46	30	5.0	7.2	14	31			1	1	9
10	90	65	78	-6	58	0	13		0	0	0	29.51	31	5.6	7.5	13	33			0	0	10
11	89	65	77	-7	54	0	12		0	0	0	29.47	31	6.1	7.3	15	32			0	0	11
12	94	71	83	-1	55	0	18		0	0	0	29.37	31	1.5	5.8	14	28			0	0	12
13	101	76	89	5	59	0	24		0	0	0	29.28	23	2.3	5.8	12	28			0	0	13
14	106	78	92	8	60	0	27		0	0	0	29.27	31	3.4	6.9	14	30			0	0	14
15	106	76	91	7	59	0	26		0	0	0	29.31	32	6.4	7.2	15	30			0	0	15
16	110*	75	93	9	57	0	28		0	0	0	29.42	29	3.6	7.2	13	30			0	0	16
17	107	75	91	6	57	0	26		0	0	0	29.48	29	3.3	6.2	13	27			0	0	17
18	104	75	90	5	53	0	25		0	0	0	29.39	31	3.4	4.8	12	31			0	0	18
19	108	78	93	8	58	0	28		0	0	0	29.24	32	2.2	4.6	14	28			3	2	19
20	100	82	91	6	61	0	26		0	0	0	29.29	14	6.2	7.9	18	13			9	7	20
21	96	75	86	1	63	0	21		0	0	0	29.41	30	7.6	10.1	18	33			1	2	21
22	95	70	83	-2	64	0	18		0	0	0	29.45	32	5.0	6.3	13	31			4	3	22
23	102	78	90	5	62	0	25		0	0	0	29.38	32	2.6	6.2	12	30			2	1	23
24	104	75	90	5	60	0	25		0	0	0	29.33	32	3.0	5.2	13	30			0	0	24
25	109	78	94*	9	58	0	29		0	0	0	29.28	34	2.9	6.0	15	30			0	0	25
26	105	77	91	7	52	0	26		0	0	0	29.30	31	7.3	8.2	15	33			0	0	26
27	97	71	84	0	54	0	19		0	0	0	29.35	29	4.2	5.8	14	32			0	0	27
28	100	70	85	1	54	0	20		0	0	0	29.35	35	3.3	6.6	14	30			0	0	28
29	100	70	85	1	52	0	20		0	0	0	29.36	29	2.5	7.2	16	33			0	0	29
30	104	75	90	6	54	0	25		0	0	0	29.36	29	2.8	6.8	17	31			0	0	30
31	108	76	92	8	57	0	27	8	0	0	0	29.42	29	2.4	3.9	14	30			0	0	31
	SUM	SUM	—	—	—	TOTAL	TOTAL			TOTAL	TOTAL	FOR THE MONTH:						TOTAL	%	SUM	SUM	
	3042	2203	—	—	—	0	614	NUMBER OF DAYS		.00	0	29.39	31	3.8	6.7	23	33		FOR	46	36	
	AVG.	AVG.	AVG.	DEP.	AVG.	DEP.	DEP.	PRECIPITATION		DEP.	—	—	—	—	—	DATE: 02		POSSIBLE	MONTH	AVG.	AVG.	
	98.1	71.1	84.6	0.7	56	0	28	≥.01 INCH	0	-0.02	—	—	—	—	—	—				1.5	1.2	

NUMBER OF DAYS				SEASON TO DATE			
				TOTAL	TOTAL	SNOW, ICE PELLETS ≥ 1.0 INCH	0
MAXIMUM TEMP.		MINIMUM TEMP.		0	1487	THUNDERSTORMS	0
≥ 90°	≤ 32°	≤ 32°	≤ 0°	DEP.	DEP.	HEAVY FOG	0
24	0	0	0	0	281	CLEAR 26 PARTLY CLOUDY 2 CLOUDY 3	

GREATEST IN 24 HOURS AND DATES				GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE	
PRECIPITATION		SNOW, ICE PELLETS			
0		0		0	

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT
+ ALSO ON AN EARLIER DATE, OR DATES.
HEAVY FOG: - VISIBILITY 1/4 MILE OR LESS.
FIGURES FOR WIND DIRECTIONS ARE TENS OF DEGREES CLOCKWISE FROM TRUE NORTH. 00 = CALM.
DATA IN COLS. 6 AND 12-15 ARE BASED ON 7 OR MORE OBSERVATIONS PER DAY AT 3-HOUR INTERVALS.
FASTEST MILE WIND SPEEDS ARE FASTEST OBSERVED ONE-MINUTE VALUES WHEN DIRECTIONS ARE IN TENS OF DEGREES. THE / WITH THE DIRECTION INDICATES PEAK GUST SPEED.
ANY ERRORS DETECTED WILL BE CORRECTED AND CHANGES IN SUMMARY DATA WILL BE ANNOTATED IN THE ANNUAL SUMMARY

SUMMARY BY HOURS

HOUR LOCAL TIME	AVERAGES SKY COVER TENTHS	STATION PRESSURE IN.	TEMPERATURE AIR °F	WET BULB °F	DEW PT. °F	RELATIVE HUMIDITY %	WIND SPEED M.P.H.	RESULTANT WIND DIRECTION	SPEED M.P.H
01	0	29.38	77	63	54	46	4.6	34	2.5
04	1	29.40	73	62	55	54	3.9	05	.9
07	1	29.43	78	64	56	47	4.8	15	2.3
10	1	29.43	87	67	56	36	6.3	28	3.5
13	1	29.39	93	70	56	30	9.5	30	8.8
16	2	29.35	97	71	55	25	11.4	31	9.9
19	2	29.34	90	69	57	33	7.4	31	6.4
22	1	29.38	83	66	56	40	5.6	01	4.1

HOURLY PRECIPITATION (WATER EQUIVALENT IN INCHES)

DATE	A.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	P.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	DATE
1																									1
2																									2
3																									3
4																									4
5																									5
6																									6
7																									7
8																									8
9																									9
10																									10
11																									11
12																									12
13																									13
14																									14
15																									15
16																									16
17																									17
18																									18
19																									19
20																									20
21																									21
22																									22
23																									23
24																									24
25																									25
26																									26
27																									27
28																									28
29																									29
30																									30
31																									31

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I CERTIFY THAT THIS IS AN OFFICIAL PUBLICATION OF THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, AND IS COMPILED FROM RECORDS ON FILE AT THE NATIONAL CLIMATIC CENTER, ASHEVILLE, NORTH CAROLINA 28801.

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / ENVIRONMENTAL DATA AND INFORMATION SERVICE

Daniel B. Mitchell
DIRECTOR, NATIONAL CLIMATIC CENTER

USCOMM--NOAA--ASHEVILLE 08/30/79 400

OBSERVATIONS AT 3-HOUR INTERVALS

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
DAY 01											
01	0	UNL	20			72	58	48	43	34	4
04	0	UNL	20			68	57	48	49	09	4
07	0	UNL	20			75	60	49	40	15	5
10	0	UNL	10			83	63	49	31	23	5
13	0	UNL	10			91	64	45	20	29	6
16	0	UNL	15			98	66	45	17	34	13
19	0	UNL	20			84	63	48	29	34	12
22	0	UNL	30			76	59	45	33	36	5
DAY 02											
01	0	UNL	30			75	57	42	31	02	16
04	0	UNL	30			67	55	44	44	00	0
07	0	UNL	30			70	55	43	38	04	5
10	0	UNL	20			81	63	50	34	35	11
13	0	UNL	15			85	64	51	31	33	13
16	0	UNL	8			84	64	51	32	33	20
19	0	UNL	8			75	60	50	42	34	10
22	0	UNL	15			68	58	50	53	34	7
DAY 03											
01	0	UNL	30			66	55	46	49	34	5
04	0	UNL	30			63	55	49	60	02	7
07	0	UNL	15			72	60	51	48	15	4
10	7	UNL	7			76	61	51	42	30	6
13	6	UNL	7			83	64	51	33	32	7
16	7	UNL	10			86	65	51	30	32	10
19	6	UNL	10			83	64	51	33	32	6
22	0	UNL	20			74	61	52	46	33	7
DAY 04											
01	0	UNL	30			69	61	55	61	32	7
04	0	UNL	30			62	56	52	70	32	6
07	0	UNL	20			68	60	54	61	32	6
10	0	UNL	10			75	63	55	50	00	0
13	1	UNL	15			82	65	55	40	30	12
16	3	UNL	20			85	66	55	36	32	7
19	7	UNL	20			82	65	55	40	34	7
22	6	UNL	20			76	63	54	47	36	4
DAY 05											
01	1	UNL	30			71	61	55	57	32	10
04	3	UNL	30			67	60	56	68	34	5
07	3	UNL	30			69	61	55	61	30	7
10	2	UNL	10			78	63	54	44	30	5
13	0	UNL	20			83	65	53	36	29	7
16	0	UNL	30			88	66	52	28	36	7
19	0	UNL	30			84	65	53	34	32	5
22	0	UNL	20			74	61	52	46	32	8
DAY 06											
01	0	UNL	30			67	56	48	51	30	5
04	0	UNL	30			64	57	52	65	00	0
07	0	UNL	15			69	60	54	59	18	3
10	0	UNL	15			77	64	55	47	00	0
13	0	UNL	20			85	66	55	36	30	10
16	0	UNL	20			88	65	51	28	31	9
19	0	UNL	30			84	64	51	32	31	6
22	0	UNL	30			78	63	52	39	05	3
DAY 07											
01	0	UNL	30			69	60	53	57	32	5
04	0	UNL	30			64	58	53	68	33	4
07	10	UNL	30			70	60	53	55	20	6
10	3	UNL	20			76	62	53	45	18	5
13	10	UNL	20			85	65	52	32	32	9
16	10	UNL	25			89	66	52	28	32	6
19	9	UNL	25			86	64	49	28	30	7
22	3	UNL	30			80	63	51	36	00	0
DAY 08											
01	0	UNL	20			74	60	50	43	10	2
04	8	UNL	20			64	57	52	65	30	7
07	10	UNL	30			68	61	56	66	00	0
10	10	UNL	30			78	64	56	47	14	4
13	10	UNL	30			86	67	55	35	24	3
16	10	UNL	30			90	67	53	28	30	7
19	10	UNL	30			87	67	56	35	28	4
22	4	UNL	30			79	64	55	44	05	3
DAY 09											
01	3	UNL	30			75	62	53	46	00	0
04	3	UNL	30			67	62	58	73	00	0
07	2	UNL	20			72	62	55	55	18	5
10	1	UNL	20			82	65	55	40	26	7
13	0	UNL	15			90	69	57	33	28	9
16	0	UNL	15			96	70	55	25	31	12
19	0	UNL	15			90	68	56	32	33	8
22	0	UNL	15			81	66	56	42	35	9
DAY 10											
01	0	UNL	30			70	62	57	64	20	7
04	0	UNL	30			69	60	54	59	36	3
07	0	UNL	30			73	63	56	55	31	5
10	0	UNL	30			80	66	57	45	32	6
13	0	UNL	30			85	68	58	40	33	11
16	0	UNL	30			88	70	60	39	28	8
19	0	UNL	30			87	68	58	37	31	7
22	0	UNL	30			80	68	61	52	34	5
DAY 11											
01	0	UNL	30			74	65	60	62	32	7
04	0	UNL	30			67	60	55	66	29	6
07	0	UNL	20			72	62	55	55	31	4
10	1	UNL	30			79	63	53	41	29	10
13	0	UNL	20			85	66	55	36	30	8
16	0	UNL	20			89	69	57	34	32	8
19	0	UNL	20			85	64	50	30	30	4
22	0	UNL	20			80	62	49	34	09	4
DAY 12											
01	0	UNL	15			74	61	51	45	00	0
04	0	UNL	15			73	60	51	46	10	5
07	0	UNL	15			80	62	49	34	16	4
10	0	UNL	20			87	67	54	32	35	7
13	0	UNL	20			88	68	56	33	28	8
16	0	UNL	20			94	70	57	29	30	7
19	0	UNL	20			91	70	59	34	25	4
22	0	UNL	20			84	68	59	43	08	5
DAY 13											
01	0	UNL	15			80	67	58	48	12	5
04	0	UNL	15			77	65	57	50	00	0
07	0	UNL	10			84	68	58	41	14	6
10	0	UNL	7			90	69	58	34	26	7
13	0	UNL	10			95	71	58	30	29	8
16	0	UNL	10			100	74	60	27	24	5
19	0	UNL	10			96	72	60	30	25	5
22	0	UNL	30			88	70	60	39	11	4
DAY 14											
01	0	UNL	30			85	68	58	40	09	5
04	0	UNL	30			80	66	58	47	00	0
07	0	UNL	10			84	69	60	44	15	5
10	0	UNL	10			93	72	61	34	24	5
13	0	UNL	10			100	74	61	28	29	9
16	0	UNL	10			105	75	60	23	31	11
19	0	UNL	10			98	73	61	29	34	7
22	0	UNL	10			87	69	60	40	34	6
DAY 15											
01	0	UNL	10			81	67	58	46	34	5
04	0	UNL	10			78	66	58	49	01	5
07	0	UNL	7			83	68	60	46	00	0
10	0	UNL	7			91	71	60	35	24	4
13	0	UNL	7			100	75	62	29	31	11
16	0	UNL	10			106	74	57	20	32	12
19	0	UNL	30			95	72	60	31	33	7
22	0	UNL	20			85	68	58	40	33	6
DAY 16											
01	0	UNL	30			82	65	56	40	28	5
04	0	UNL	30			76	65	59	56	16	5
07	0	UNL	7			85	67	56	37	16	5
10	0	UNL	7			92	70	59	33	28	4
13	0	UNL	7			101	75	63	29	26	8
16	0	UNL	10			109	74	55	17	30	11
19	0	UNL	15			102	69	49	17	01	6
22	0	UNL	30			88	69	59	38	34	6
DAY 17											
01	0	UNL	30			85	62	44	24	35	5
04	0	UNL	30			76	62	53	45	00	0
07	1	UNL	7			82	66	57	43	14	5
10	1	UNL	7			90	70	60	37	00	0
13	0	UNL	7			100	75	63	30	27	9
16	0	UNL	15			105	75	60	23	27	11
19	0	UNL	15			98	72	59	27	27	5
22	0	UNL	15			90	70	59	35	01	8
DAY 18											
01	0	UNL	15			86	67	55	35	00	0
04	0	UNL	15			78	67	61	56	00	0
07	0	UNL	15			82	68	61	49	15	4
10	0	UNL	12			94	63	39	15	35	7
13	0	UNL	20			101	68	47	16	31	8
16	0	UNL	20			103	71	51	18	31	10
19	0	UNL	20			96	70	56	26	29	4
22	0	UNL	20			90	66	51	26	00	0
DAY 19											
01	0	UNL	20			81	66	57	44	00	0
04	0	UNL	20			78	64	56	47	13	6
07	0	UNL	7			85	66	54	35	07	3
10	2	UNL	7			97	71	58	27	33	4
13	4	UNL	7			102	75	63	28	29	7
16	5	UNL	8			107	73	55	18	32	8
19	3	UNL	10			97	74	64	34	32	4
22	3	UNL	10			95	70	57	28	00	0
DAY 20											
01	0	UNL	30			86	68	57	37	00	0
04	4	UNL	4		BD	89	71	61	39	13	15
07	8	250	20			89	70	60	38	16	8
10	6	UNL	30			95	72	60	31	12	10
13	10	80	30			100	74	60	27	32	5
16	10	80	20			97	73	62	31	15	12
19	10	80	20			93	72	62	36	15	5
22	3	UNL	30			86	72	65	50	00	0
DAY 21											
01	4	UNL	20			79	67	61	54	34	6
04	8	80	20			77	67	61	58	36	6
07	0	UNL	10			80	67	60	51	25	8
10	0	UNL	10			85	70	62	46	24	6
13	1	UNL	10			92	74	65	41	30	11
16	2	UNL	10			96	75	65	38	31	15
19	1	UNL	15			85	73	67	55	32	13
22	0	UNL	15			77	69	65	67	20	5
DAY 22											
01	0	UNL	15			75	68	64	69	35	8
04	0	UNL	15			72	66	63	73	32	6
07	0	UNL	7			75	67	63	66	14	3
10	0	UNL	7			83	70	64	53	28	4
13	2	UNL	10			89	73	65	45	33	4
16	8	UNL	10			93	73	63	37	31	9
19	10	UNL	15			90	73	65	44	28	5
22	7	UNL	20			85	72	65	51	35	5
DAY 23											
01	0	UNL	30			83	71	65	55	13	4
04	0	UNL	30			79	67	61	54	00	0
07	0	UNL	7			84	70	63	49	16	5
10	0	UNL	7			90	73	65	44	30	6
13	0	UNL	10			97	75	66	36	30	5
16	1	UNL	10			101	72	56	22	31	9
19	5	UNL	15			94	72	61	33	32	6
22	0	UNL	15			88	68	57	35	04	8
DAY 24											
01	0	UNL	15			83	67	58	43	00	0
04	0	UNL	15			81	67	59	47	10	4
07	0	UNL	8			84	69	60	44	00	0
10	0	UNL	8			93	72	62	36	22	3
13	0	UNL	10			100	74	60	27	30	11
16	0	UNL	10			103	74	60	24	32	9
19	0	UNL	10			98	73	61	29	29	4
22	0	UNL	10			90	70	60	37	03	5
DAY 25											
01	0	UNL	10			86	69	59	40	00	0
04	0	UNL	10			80	68	61	52	00	0
07	0	UNL	7			83	68	59	44	12	7
10	0	UNL	10			93	69	56	29	07	3
13	0	UNL	10			102	71	54	20	28	8
16	0	UNL	10			108	73	54	17	36	6
19	0	UNL	15			97	74	63	33	30	7
22	0	UNL	20			88	67	55	33	35	11
DAY 26											
01	0	UNL	20			80	60	44	28	27	4
04	0	UNL	20			79	62	50	36	00	0
07	0	UNL	20			86	65	52	31	00	0
10	0	UNL	20			94	68	52	24	27	11
13	0	UNL	15			102	70	51	18	32	10
16	0	UNL	15			103	70	50	17	31	12
19	0	UNL	25			92	69	57	31	30	12
22	0	UNL	30			81	66	56	42	36	8
DAY 27											
01	0	UNL	30			76	62	52	43	00	0
04	0	UNL	30			76	63	55	48	00	0
07	0	UNL	10			79	66	58	49	00	0
10	0	UNL	10			85	66	55	36	28	6
13	0	UNL	10			93	67	50	23	25	10
16	0	UNL	20			97	70	54	24	30	12
19	0	UNL	20			89	68	56	33	30	8
22	0	UNL	30			84	65	53	34	04	6
DAY 28											
01	0	UNL	20			75	64	57	54	36	4
04	0	UNL	20			73	64	58	59	18	4
07	0	UNL	10			76	65	58	54	12	6
10	0	UNL	10			88	68	56	34	30	5
13	0	UNL	20			95	67	50	22	35	7
16	0	UNL	30			100	68	46	16	31	4
19	0	UNL	30			88	66	52	29	32	7
22	0	UNL	20			85	64	51	31	02	9
DAY 29											
01	0	UNL	20			76	62	52	43	06	2
04	0	UNL	20			72	59	49	44	15	4
07	0	UNL	20			80	63	51	36	11	5
10	0	UNL	20			90	67	53	28	25	6
13	0	UNL	20			96	68	52	23	30	11
16	0	UNL	20			100	71	53	21	30	13
19	0	UNL	20			92	69	55	29	32	4
22	0	UNL	20			84	63	49	30	11	5
DAY 30											
01	0	UNL	30			78	63	52	40	00	0
04	0	UNL	30			77	62	52	42	09	4
07	0	UNL	15			81	64	52	37	13	6
10	0	UNL	10			83	68	52	25	19	6
13	0	UNL	10			100	71	55	22	30	12
16	0	UNL	10			104	73	56	20	30	14
19	0	UNL	20			93	70	58	31	32	5
22	0	UNL	10			86	67	55	35	00	0
DAY 31											
01	0	UNL	20			84	66	54	36	12	4
04	0	UNL	20			79	64	54	42	00	0
07	0	UNL	7			88	66	53	30	00	0
10	0	UNL	5		KH	95	71	58	28	25	6
13	0	UNL	7			104	75	60	24	00	0
16	3	UNL	5		KH	106	74	57	20	30	10
19	0	UNL	15			92	72	62	37	32	7
22	0	UNL	20			85	69	61	45	00	0

NOTES

CEILING

UNL INDICATES UNLIMITED

WEATHER

*	TORNADO
T	THUNDERSTORM
Q	SQUALL
R	RAIN
RW	RAIN SHOWERS
ZR	FREEZING RAIN
L	DRIZZLE
ZL	FREEZING DRIZZLE
S	SNOW
SP	SNOW PELLETS
IC	ICE CRYSTALS
SW	SNOW SHOWERS
SG	SNOW GRAINS
IP	ICE PELLETS
A	HAIL
F	FOG
IF	ICE FOG
GF	GROUND FOG
BD	BLOWING DUST
BN	BLOWING SAND
BS	BLOWING SNOW
BY	BLOWING SPRAY
K	SMOKE
H	HAZE
D	DUST

WIND

DIRECTIONS ARE THOSE FROM WHICH THE WIND BLOWS. INDICATED IN TENS OF DEGREES FROM TRUE NORTH; I.E., 09 FOR EAST, 18 FOR SOUTH, 27 FOR WEST. ENTRY OF 00 IN THE DIRECTION COLUMN INDICATES CALM.

SPEED IS EXPRESSED IN KNOTS; MULTIPLY BY 1.15 TO CONVERT TO MILES PER HOUR.

STATION

BAKERSFIELD CALIFORNIA

YEAR & MONTH

79 07

U.S. DEPARTMENT OF COMMERCE
NATIONAL CLIMATIC CENTER
FEDERAL BUILDING
ASHEVILLE, N.C. 28801

AN EQUAL OPPORTUNITY EMPLOYER

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE
COM-210

U.S.MAIL

FIRST CLASS

AUGUST 1979
BAKERSFIELD, CALIFORNIA
NATIONAL WEATHER SERVICE OFC
KERN COUNTY AIR TERMINAL

Local Climatological Data

MONTHLY SUMMARY

LATITUDE 35° 25 ′N LONGITUDE 119° 03 ′W ELEVATION (GROUND) 475 FT. STANDARD TIME USED: PACIFIC WBAN #23155

DATE	TEMPERATURE °F MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	AVERAGE DEW POINT	DEGREE DAYS BASE 65° HEATING (SEASON BEGINS WITH JUL. 1)	COOLING (SEASON BEGINS WITH JAN. 1)	WEATHER TYPES ON DATES OF OCCURRENCE 1 FOG 2 HEAVY FOG 3 THUNDERSTORM 4 ICE PELLETS 5 HAIL 6 GLAZE 7 DUSTSTORM 8 SMOKE, HAZE 9 BLOWING SNOW	SNOW, ICE PELLETS OR ICE ON GROUND AT 04AM IN.	PRECIPITATION WATER EQUIVALENT IN	SNOW, ICE PELLETS IN.	AVG. STATION PRESSURE IN. ELEV. 492 FEET M.S.L.	WIND RESULTANT DIR.	RESULTANT SPEED M.P.H.	AVERAGE SPEED M.P.H.	FASTEST MILE SPEED M.P.H.	FASTEST MILE DIRECTION	SUNSHINE MINUTES	PERCENT OF POSSIBLE	SKY COVER TENTHS SUNRISE TO SUNSET	MIDNIGHT TO MIDNIGHT	DATE
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	112*	76	94*	10	50	0	29		0	0	0	29.41	34	2.6	4.8	9	36			0	0	1
2	109	77	93	9	50	0	28		0	0	0	29.32	33	4.9	5.9	13	33			0	0	2
3	107	75	91	8	49	0	26		0	0	0	29.26	33	2.5	5.3	12	03			0	0	3
4	101	73	87	4	50	0	22		0	0	0	29.33	33	7.7	8.6	15	30			0	0	4
5	97	69	83	0	52	0	18		0	0	0	29.41	27	3.3	4.2	8	30			1	2	5
6	100	73	87	4	53	0	22		0	0	0	29.40	29	2.8	6.8	10	31			7	6	6
7	103	74	89	6	52	0	24		0	0	0	29.38	34	4.1	6.5	13	34			2	2	7
8	102	74	88	5	46	0	23		0	0	0	29.41	34	4.2	5.5	12	35			0	0	8
9	100	70	85	2	52	0	20		0	0	0	29.42	32	2.4	6.3	15	32			5	3	9
10	103	71	87	5	54	0	22		0	0	0	29.39	34	3.3	6.8	14	31			2	3	10
11	100	78	89	7	56	0	24		0	0	0	29.29	28	1.4	8.5	15	14			10	10	11
12	95	71	83	1	50	0	18		0	0	0	29.24	34	7.5	9.6	15	33			8	6	12
13	86	64	75	-7	52	0	10		0	0	0	29.42	34	6.6	7.8	13	33			1	1	13
14	86	60*	73*	-9	56	0	8		0	0	0	29.47	31	5.4	7.3	14	31			0	0	14
15	89	65	77	-5	57	0	12		0	0	0	29.41	33	2.4	3.7	10	32			0	0	15
16	92	65	79	-3	57	0	14		0	0	0	29.41	30	2.9	5.0	14	31			1	2	16
17	94	68	81	0	57	0	16		0	0	0	29.43	32	4.7	6.5	15	30			10	8	17
18	99	73	86	5	54	0	21		0	0	0	29.39	35	2.6	8.1	14	33			8	6	18
19	95	70	83	2	51	0	18		0	0	0	29.38	34	6.3	7.5	16	35			0	0	19
20	89	63	76	-5	54	0	11		0	0	0	29.43	32	6.9	7.3	15	33			0	0	20
21	87	64	76	-5	55	0	11		0	0	0	29.47	34	4.9	6.2	15	29			0	0	21
22	87	63	75	-6	58	0	10		0	0	0	29.50	27	3.9	5.6	9	32			0	0	22
23	88	64	76	-5	59	0	11		0	0	0	29.47	32	2.9	5.2	10	30			6	4	23
24	88	64	76	-4	57	0	11		0	0	0	29.41	26	2.4	5.6	10	30			10	8	24
25	91	64	78	-2	54	0	13		0	0	0	29.33	34	3.5	5.9	14	31			1	1	25
26	89	63	76	-4	53	0	11		0	0	0	29.36	31	3.7	5.8	12	31			0	0	26
27	93	70	82	2	55	0	17		0	0	0	29.31	34	1.0	5.3	12	30			0	0	27
28	93	72	83	3	57	0	18		0	0	0	29.24	33	4.7	5.8	13	33			2	2	28
29	87	70	79	-1	58	0	14		0	0	0	29.25	32	6.5	8.6	14	31			4	3	29
30	85	65	75	-5	59	0	10		0	0	0	29.36	31	5.2	7.2	13	32			1	1	30
31	89	64	77	-3	58	0	12		0	0	0	29.33	32	1.9	5.0	12	30			0	0	31
	SUM	SUM				TOTAL	TOTAL			TOTAL	TOTAL	FOR THE MONTH:						TOTAL	%	SUM	SUM	
	2936	2132				0	524	NUMBER OF DAYS		.00	0	29.37	32	3.8	6.4	16	35		FOR	79	68	
	AVG.	AVG.	AVG.	DEP.	AVG.	DEP.	DEP.	PRECIPITATION		DEP.						DATE: 19		POSSIBLE	MONTH	AVG.	AVG.	
	94.7	68.8	81.8	0.2	54	0	9	>.01 INCH	0	-0.01										2.5	2.2	

				SEASON TO DATE		SNOW, ICE PELLETS				
NUMBER OF DAYS				TOTAL	TOTAL	≥ 1.0 INCH	0	GREATEST IN 24 HOURS AND DATES		GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE
MAXIMUM TEMP.		MINIMUM TEMP.		0	2011	THUNDERSTORMS	0	PRECIPITATION	SNOW, ICE PELLETS	
≥ 90°	≤ 32°	≤ 32°	≤ 0°	DEP.	DEP.	HEAVY FOG	0	0	0	0
19	0	0	0	0	300	CLEAR 22	PARTLY CLOUDY 4	CLOUDY 5		

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT
+ ALSO ON AN EARLIER DATE, OR DATES.
HEAVY FOG: - VISIBILITY 1/4 MILE OR LESS.
FIGURES FOR WIND DIRECTIONS ARE TENS OF DEGREES CLOCKWISE FROM TRUE NORTH. 00 = CALM.
DATA IN COLS. 6 AND 12-15 ARE BASED ON 7 OR MORE OBSERVATIONS PER DAY AT 3-HOUR INTERVALS.
FASTEST MILE WIND SPEEDS ARE FASTEST OBSERVED ONE-MINUTE VALUES WHEN DIRECTIONS ARE IN TENS OF DEGREES. THE / WITH THE DIRECTION INDICATES PEAK GUST SPEED.
ANY ERRORS DETECTED WILL BE CORRECTED AND CHANGES IN SUMMARY DATA WILL BE ANNOTATED IN THE ANNUAL SUMMARY

SUMMARY BY HOURS

HOUR LOCAL TIME	AVERAGES SKY COVER TENTHS	STATION PRESSURE IN.	TEMPERATURE AIR °F	WET BULB °F	DEW PT. °F	RELATIVE HUMIDITY %	WIND SPEED M.P.H.	RESULTANT WIND DIRECTION	SPEED M.P.H
01	1	29.38	75	62	53	47	4.7	34	3.4
04	1	29.38	72	61	54	56	4.3	36	2.2
07	3	29.42	75	63	54	50	4.6	10	1.7
10	3	29.42	83	68	54	38	6.1	28	3.8
13	2	29.38	90	68	55	31	8.5	31	7.3
16	3	29.32	94	69	54	27	10.2	31	9.3
19	2	29.32	86	67	55	36	6.4	32	4.9
22	2	29.36	80	64	53	41	6.3	01	4.8

HOURLY PRECIPITATION (WATER EQUIVALENT IN INCHES)

DATE	A. M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	P. M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	DATE
1																									1
2																									2
3																									3
4																									4
5																									5
6																									6
7																									7
8																									8
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28																									28
29																									29
30																									30
31																									31

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noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / ENVIRONMENTAL DATA AND INFORMATION SERVICE

Daniel B. Mitchell
DIRECTOR, NATIONAL CLIMATIC CENTER

USCOMM--NOAA--ASHEVILLE 09/26/79 400

OBSERVATIONS AT 3-HOUR INTERVALS

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
					DAY 01											DAY 02											DAY 03						
01	0	UNL	20			84	62	47	28	33	4	0	UNL	30			82	61	46	28	00	0	0	UNL	30			81	61	46	29	01	5
04	0	UNL	20			77	65	58	52	00	0	0	UNL	30			82	61	46	28	00	0	0	UNL	30			77	63	53	43	00	0
07	0	UNL	7			86	67	55	35	14	3	0	UNL	7			89	65	50	26	09	3	0	UNL	10			82	63	51	34	12	4
10	0	UNL	8			96	68	52	23	18	4	0	UNL	15			97	67	49	20	30	5	0	UNL	8			92	68	53	27	00	0
13	0	UNL	8			104	72	53	18	29	4	0	UNL	15			102	69	49	17	31	9	0	UNL	15			103	68	44	13	27	4
16	0	UNL	20			111	71	46	11	34	8	0	UNL	15			108	72	51	15	33	11	0	UNL	15			104	72	54	19	28	10
19	0	UNL	30			102	67	42	13	01	5	0	UNL	20			96	69	54	24	34	5	0	UNL	15			93	69	56	29	30	4
22	0	UNL	30			87	63	47	25	36	6	0	UNL	30			86	66	53	32	36	8	0	UNL	15			88	60	37	16	03	10
					DAY 04											DAY 05											DAY 06						
01	0	UNL	30			80	57	35	20	01	5	0	UNL	20			75	64	58	56	34	6	8	150	25			77	64	55	47	30	4
04	0	UNL	30			79	60	46	31	02	8	0	UNL	20			71	61	54	55	21	2	2	UNL	30			75	62	54	48	35	5
07	0	UNL	20			83	63	48	30	00	0	0	UNL	15			75	63	56	52	00	0	10	130	30			77	65	57	50	17	5
10	0	UNL	20			89	66	55	32	31	9	0	UNL	15			84	63	49	30	24	6	9	130	25			87	65	50	28	20	6
13	0	UNL	15			98	70	55	24	31	11	0	UNL	15			92	66	49	23	27	6	8	130	25			92	67	52	26	23	7
16	0	UNL	15			100	70	52	20	32	10	2	UNL	20			97	68	51	21	28	5	7	130	20			96	68	52	23	32	8
19	0	UNL	15			90	68	56	32	32	8	3	UNL	30			90	67	52	27	27	4	2	UNL	20			88	66	51	27	28	5
22	0	UNL	15			84	66	55	37	36	9	5	UNL	30			83	63	49	31	00	0	1	UNL	20			85	64	50	30	02	7
					DAY 07											DAY 08											DAY 09						
01	7	100	20			80	65	55	42	00	0	0	UNL	15			76	57	40	27	00	0	0	UNL	30			81	63	51	35	03	4
04	3	UNL	15			76	64	56	50	30	3	0	UNL	15			74	55	38	27	06	5	0	UNL	30			72	62	56	57	00	0
07	0	UNL	7			80	66	57	45	14	5	0	UNL	15			81	61	45	28	00	0	2	UNL	10			77	63	54	45	16	4
10	0	UNL	7			89	68	55	32	11	3	0	UNL	7			89	65	50	26	26	4	7	UNL	10			87	67	56	35	16	5
13	3	UNL	10			99	69	52	21	32	9	0	UNL	15			98	68	49	19	34	8	7	UNL	10			95	69	53	24	32	12
16	3	UNL	15			102	69	49	17	34	9	0	UNL	20			102	68	46	15	31	8	8	UNL	10			98	67	48	18	30	11
19	0	UNL	10			89	65	49	25	33	10	0	UNL	20			92	66	49	23	36	6	2	UNL	15			86	64	49	28	31	4
22	0	UNL	30			84	58	39	20	36	6	0	UNL	30			80	64	54	41	34	6	0	UNL	25			83	63	49	31	09	4
					DAY 10											DAY 11											DAY 12						
01	0	UNL	30			80	63	52	38	08	6	8	UNL	15			81	66	57	44	30	7	7	250	30			83	61	45	26	04	8
04	0	UNL	30			75	60	50	42	13	3	10	UNL	15			82	64	53	37	12	6	3	UNL	30			81	61	47	30	03	7
07	0	UNL	8			78	63	53	42	12	5	10	130	10			81	65	54	39	08	4	10	250	15			82	62	48	31	03	6
10	0	UNL	10			89	68	55	32	00	0	10	200	10			89	68	55	32	29	4	9	250	15			87	66	53	31	33	11
13	0	UNL	8			98	71	57	26	31	6	10	UNL	10			96	70	55	25	31	10	8	250	15			92	68	53	27	32	10
16	4	UNL	10			103	71	51	18	31	11	10	250	15			100	73	59	26	31	11	9	250	20			91	65	48	23	30	7
19	9	UNL	10			91	69	57	32	33	6	10	250	20			94	71	59	31	15	10	1	UNL	25			86	65	52	31	29	10
22	7	UNL	10			84	67	56	38	34	10	10	250	20			88	69	58	36	16	7	0	UNL	30			76	61	50	40	33	8
					DAY 13											DAY 14											DAY 15						
01	0	UNL	30			69	59	51	53	36	7	0	UNL	20			65	59	55	70	34	7	0	UNL	30			74	63	56	54	00	0
04	0	UNL	30			65	57	51	61	36	4	0	UNL	20			62	58	55	78	30	4	0	UNL	20			70	62	57	64	00	0
07	3	UNL	30			67	59	53	61	34	11	0	UNL	10			67	61	57	70	17	3	0	UNL	8			68	62	57	68	00	0
10	0	UNL	15			76	63	54	47	01	5	0	UNL	10			75	64	57	54	29	5	0	UNL	10			78	65	57	49	26	4
13	0	UNL	15			81	64	53	38	25	6	0	UNL	10			82	66	57	43	30	10	0	UNL	10			85	67	57	39	30	8
16	0	UNL	25			86	65	52	31	33	11	0	UNL	11			86	68	57	37	31	12	0	UNL	10			89	68	56	33	33	7
19	0	UNL	25			78	62	50	38	31	4	0	UNL	15			80	65	56	44	30	6	0	UNL	10			84	67	57	40	35	5
22	0	UNL	20			71	61	54	55	34	6	0	UNL	30			77	64	56	48	08	4	0	UNL	20			79	65	56	45	08	4
					DAY 16											DAY 17											DAY 18						
01	0	UNL	20			72	62	56	57	30	5	3	UNL	15			75	62	54	48	29	4	3	UNL	30			77	61	50	39	24	3
04	0	UNL	20			66	60	56	70	29	5	8	250	15			68	62	58	68	34	2	7	120	30			75	63	55	50	12	8
07	0	UNL	10			70	62	57	64	20	4	10	120	15			74	64	58	58	16	3	7	250	10			76	64	57	52	13	7
10	0	UNL	10			78	65	57	48	26	4	10	250	15			82	66	56	41	23	4	8	UNL	15			84	66	54	36	22	6
13	0	UNL	10			86	69	59	40	23	3	9	250	15			90	69	58	34	36	7	9	UNL	10			93	71	59	32	36	8
16	2	UNL	10			92	68	53	27	02	9	10	250	10			91	69	58	31	32	12	10	250	10			98	70	55	24	33	12
19	6	250	10			83	67	57	41	30	5	8	250	15			86	69	59	40	31	6	6	250	15			90	67	52	27	02	7
22	7	250	15			80	66	57	45	00	0	8	UNL	15			80	66	58	47	33	7	3	UNL	15			83	63	48	30	34	7
					DAY 19											DAY 20											DAY 21						
01	0	UNL	30			78	60	47	34	34	9	0	UNL	30			70	61	54	57	30	7	0	UNL	20			67	58	52	59	35	5
04	0	UNL	30			75	60	49	40	00	0	0	UNL	30			68	60	55	63	34	7	0	UNL	20			66	58	52	61	02	5
07	0	UNL	30			77	61	49	37	13	4	0	UNL	45			70	58	51	51	00	0	0	UNL	20			70	60	53	55	32	8
10	0	UNL	30			85	64	49	29	31	5	0	UNL	45			78	62	52	43	32	6	0	UNL	10			76	64	56	50	24	3
13	0	UNL	20			92	67	52	26	35	8	0	UNL	20			85	67	56	37	28	7	0	UNL	15			82	66	57	43	35	9
16	0	UNL	20			94	69	54	26	34	12	0	UNL	20			89	68	56	33	31	9	0	UNL	15			87	68	57	36	33	8
19	1	UNL	20			86	66	54	33	35	5	1	UNL	20			81	66	57	44	33	7	0	UNL	20			80	67	59	49	33	7
22	1	UNL	30			78	62	50	38	34	9	1	UNL	30			72	61	54	53	34	8	0	UNL	30			77	65	57	50	06	4
					DAY 22											DAY 23											DAY 24						
01	0	UNL	30			71	63	58	64	00	0	0	UNL	20			75	65	59	58	08	4	0	UNL	20			71	63	58	64	32	5
04	0	UNL	30			63	59	56	78	32	8	2	UNL	10			70	63	58	66	00	0	8	UNL	20			66	61	57	73	36	6
07	0	UNL	15			67	60	56	68	16	5	7	UNL	10			68	61	56	66	33	4	10	250	15			70	62	56	61	16	6
10	0	UNL	15			75	64	57	54	25	7	9	250	7			78	66	58	50	28	3	10	250	15			78	64	55	45	20	7
13	0	UNL	15			83	67	58	43	31	7	8	120	7			86	69	59	40	27	6	10	160	15			84	66	55	37	30	8
16	0	UNL	15			86	69	59	40	28	7	3	UNL	15			88	69	59	38	31	9	10	200	15			87	68	58	37	24	7
19	0	UNL	15			82	67	59	46	26	5	9	250	15			82	68	60	47	31	5	10	200	15			81	68	60	49	00	0
22	0	UNL	20			78	66	58	50	00	0	0	UNL	20			80	67	59	49	07	5	8	200	15			76	64	56	50	00	0
					DAY 25											DAY 26											DAY 27						
01	0	UNL	30			74	63	55	52	09	4	0	UNL	20			72	62	55	55	30	5	0	UNL	20			74	61	52	46	00	0
04	0	UNL	30			71	61	54	55	09	3	0	UNL	30			66	59	54	65	00	0	0	UNL	20			71	59	50	48	10	6
07	0	UNL	15			75	63	55	50	00	0	0	UNL	30			73	62	55	53	07	4	0	UNL	30			79	63	52	39	09	5
10	0	UNL	10			82	66	57	43	36	4	0	UNL	30			82	63	51	34	31	10	0	UNL	30			86	66	54	33	31	3
13	0	UNL	15			88	66	53	30	31	10	0	UNL	30			87	67	54	32	28	8	0	UNL	20			90	68	56	32	30	8
16	3	UNL	20			91	66	50	25	28	8	0	UNL	30			89	66	52	28	30	4	0	UNL	20			92	69	57	31	32	7
19	1	UNL	20			85	65	52	32	33	6	0	UNL	30			80	64	54	41	29	5	0	UNL	20			87	68	57	36	24	4
22	0	UNL	20			78	63	52	40	02	8	0	UNL	30			76	62	52	43	08	4	0	UNL	15			82	67	58	44	12	4
					DAY 28											DAY 29											DAY 30						
01	0	UNL	30			78	64	55	45	00	0	0	UNL	30			75	68	61	62	34	7	5	UNL	30			72	63	58	62	34	6
04	0	UNL	30			73	64	58	59	00	0	1	UNL	30			70	64	61	73	33	7	2	UNL	20			66	62	59	78	30	8
07	0	UNL	20			77	65	57	50	11	3	10	50	20			72	63	57	59	36	9	0	UNL	20			70	63	58	66	35	5
10	0	UNL	20			86	67	56	36	32	11	10	50	30			82	66	56	41	24	10	2	UNL	20			76	65	58	54	28	6
13	0	UNL	20			89	68	55	32	31	5	0	UNL	20			85	68	59	41	31	12	0	UNL	15			82	67	58	44	24	4
16	4	UNL	30			93	69	56	29	32	8	0	UNL	20			87	69	59	39	27	6	0	UNL	15			84	68	59	43	28	8
19	8	UNL	30			83	68	60	46	34	5	0	UNL	30			81	65	54	39	34	4	0	UNL	20			77	66	59	54	32	6
22	0	UNL	30			80	67	59	49	36	8	0	UNL	30			73	64	59	62	36	5	0	UNL	30			76	65	59	56	04	7
					DAY 31																												
01	0	UNL	15			71	64	59	66	00	0																						
04	0	UNL	15			65	61	58	78	34	6																						
07	0	UNL	10			68	62	58	73	12	7																						
10	0	UNL	8			78	66	58	52	22	4																						
13	0	UNL	10			85	68	58	40	03	4																						
16	0	UNL	10			88	69	58	36	30	10																						
19	0	UNL	10			81	67	58	46	30	4																						
22	0	UNL	10			77	64	56	48	00	0																						

STATION

BAKERSFIELD CALIFORNIA

YEAR & MONTH

79 08

NOTES

CEILING

UNL INDICATES UNLIMITED

WEATHER

*	TORNADO
T	THUNDERSTORM
Q	SQUALL
R	RAIN
RW	RAIN SHOWERS
ZR	FREEZING RAIN
L	DRIZZLE
ZL	FREEZING DRIZZLE
S	SNOW
SP	SNOW PELLETS
IC	ICE CRYSTALS
SW	SNOW SHOWERS
SG	SNOW GRAINS
IP	ICE PELLETS
A	HAIL
F	FOG
IF	ICE FOG
GF	GROUND FOG
BD	BLOWING DUST
BN	BLOWING SAND
BS	BLOWING SNOW
BY	BLOWING SPRAY
K	SMOKE
H	HAZE
D	DUST

WIND

DIRECTIONS ARE THOSE FROM WHICH THE WIND BLOWS. INDICATED IN TENS OF DEGREES FROM TRUE NORTH: I.E., 09 FOR EAST, 18 FOR SOUTH, 27 FOR WEST. ENTRY OF 00 IN THE DIRECTION COLUMN INDICATES CALM.

SPEED IS EXPRESSED IN KNOTS; MULTIPLY BY 1.15 TO CONVERT TO MILES PER HOUR.

U.S. DEPARTMENT OF COMMERCE
NATIONAL CLIMATIC CENTER
FEDERAL BUILDING
ASHEVILLE, N.C. 28801

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE
COM-210

U.S.MAIL

FIRST CLASS

SEPTEMBER 1979
BAKERSFIELD, CALIFORNIA
NATIONAL WEATHER SERVICE OFC
KERN COUNTY AIR TERMINAL

Local Climatological Data

MONTHLY SUMMARY

LATITUDE 35° 25' N LONGITUDE 119° 03' W ELEVATION (GROUND) 475 FT. STANDARD TIME USED: PACIFIC WBAN #23155

DATE	TEMPERATURE °F: MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	AVERAGE DEW POINT	DEGREE DAYS BASE 65°: HEATING (SEASON BEGINS WITH JULY)	COOLING (SEASON BEGINS WITH JAN. 1)	WEATHER TYPES ON DATES OF OCCURRENCE 1 FOG 2 HEAVY FOG 3 THUNDERSTORM 4 ICE PELLETS 5 HAIL 6 GLAZE 7 DUSTSTORM 8 SMOKE, HAZE 9 BLOWING SNOW	SNOW, ICE PELLETS OR ICE ON GROUND AT 04AM IN.	PRECIPITATION: WATER EQUIVALENT IN	SNOW, ICE PELLETS IN.	AVG. STATION PRESSURE IN. ELEV. 492 FEET M.S.L.	WIND: RESULTANT DIR.	RESULTANT SPEED M.P.H.	AVERAGE SPEED M.P.H.	FASTEST MILE: SPEED M.P.H.	FASTEST MILE: DIRECTION	SUNSHINE: MINUTES	PERCENT OF POSSIBLE	SKY COVER TENTHS: SUNRISE TO SUNSET	MIDNIGHT TO MIDNIGHT	DATE
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	92	67	80	1	57	0	15		0	0	0	29.29	32	2.9	4.9	12	30			0	0	1
2	90	65	78	-1	61	0	13		0	0	0	29.38	31	1.1	4.9	12	29			0	0	2
3	90	68	79	0	60	0	14		0	0	0	29.38	31	3.3	5.3	10	32			0	0	3
4	89	66	78	-1	60	0	13		0	0	0	29.33	31	4.2	5.8	10	34			0	0	4
5	92	69	81	2	58	0	16		0	0	0	29.37	33	1.0	5.9	12	32			0	0	5
6	96	70	83	4	58	0	18		0	0	0	29.38	25	1.1	4.8	12	32			0	0	6
7	105	71	88	9	59	0	23	8	0	0	0	29.29	33	2.7	4.8	10	32			0	0	7
8	92	72	82	4	59	0	17		0	0	0	29.35	29	3.2	6.2	14	31			0	0	8
9	90	71	81	3	59	0	16		0	0	0	29.32	30	1.5	4.3	10	31			0	0	9
10	94	73	84	6	59	0	19		0	0	0	29.26	29	1.4	3.5	12	26			0	0	10
11	104	72	88	10	60	0	23		0	0	0	29.21	31	1.8	6.2	13	28			0	0	11
12	107*	75	91	13	59	0	26		0	0	0	29.24	33	1.8	6.2	13	31			1	0	12
13	105	79	92	15	56	0	27		0	0	0	29.27	29	1.9	6.6	14	29			2	2	13
14	104	74	89	12	51	0	24		0	0	0	29.33	01	.5	4.3	12	29			0	0	14
15	106	77	92*	15	49	0	27		0	0	0	29.34	33	2.5	7.1	13	32			0	0	15
16	104	75	90	13	53	0	25		0	0	0	29.36	34	1.6	5.0	12	32			0	0	16
17	105	76	91	14	49	0	26		0	0	0	29.38	01	3.1	5.8	9	04			0	0	17
18	95	62	79	3	46	0	14		0	0	0	29.46	32	.5	4.6	10	31			1	1	18
19	92	65	79	3	50	0	14		0	0	0	29.43	23	1.8	5.2	10	26			4	2	19
20	92	65	79	3	51	0	14		0	0	0	29.33	18	.9	4.3	9	24			0	0	20
21	98	65	82	6	52	0	17		0	0	0	29.31	36	.4	5.3	12	31			0	0	21
22	101	67	84	9	50	0	19		0	0	0	29.38	36	4.3	6.3	15	34			0	0	22
23	101	65	83	8	52	0	18		0	0	0	29.39	30	1.5	3.3	12	30			0	0	23
24	96	66	81	6	56	0	16	3	0	.21	0	29.38	36	4.6	8.2	17	36			6	4	24
25	83	60	72	-2	55	0	7		0	0	0	29.56	33	3.9	6.0	12	36			0	0	25
26	84	59*	72*	-2	55	0	7		0	0	0	29.50	30	1.2	6.2	10	03			6	4	26
27	87	63	75	1	58	0	10	8	0	0	0	29.41	31	1.7	4.8	9	32			10	7	27
28	91	62	77	4	55	0	12	8	0	0	0	29.43	03	.8	3.2	9	02			3	3	28
29	89	67	78	5	57	0	13	3	0	.02	0	29.51	36	2.3	7.9	15	06			8	7	29
30	83	67	75	2	62	0	10	3 8	0	.12	0	29.47	12	.2	4.6	14	30			9	8	30
	SUM	SUM				TOTAL	TOTAL			TOTAL	TOTAL	FOR THE MONTH:						TOTAL	%	SUM	SUM	
	2857	2053				0	513	NUMBER OF DAYS		.35	0	29.37	33	1.6	5.4	17	36		FOR	50	38	
	AVG.	AVG.	AVG.	DEP.	AVG.	DEP.	DEP.	PRECIPITATION		DEP.						DATE: 24		POSSIBLE	MONTH	AVG.	AVG.	
	95.2	68.4	81.8	5.2	55	0	165	≥ .01 INCH	3	0.27										1.7	1.3	

				SEASON TO DATE	
NUMBER OF DAYS				TOTAL	TOTAL
MAXIMUM TEMP.		MINIMUM TEMP.		0	2524
≥ 90°	≤ 32°	≤ 32°	≤ 0°	DEP.	DEP.
24	0	0	0	0	465

SNOW, ICE PELLETS ≥ 1.0 INCH 0
THUNDERSTORMS 3
HEAVY FOG 0
CLEAR 24 PARTLY CLOUDY 3 CLOUDY 3

GREATEST IN 24 HOURS AND DATES				GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE	
PRECIPITATION		SNOW, ICE PELLETS			
.21	24	0		0	

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT
+ ALSO ON AN EARLIER DATE, OR DATES.
HEAVY FOG: - VISIBILITY 1/4 MILE OR LESS.
FIGURES FOR WIND DIRECTIONS ARE TENS OF DEGREES CLOCKWISE FROM TRUE NORTH. 00 = CALM.
DATA IN COLS. 6 AND 12-15 ARE BASED ON 7 OR MORE OBSERVATIONS PER DAY AT 3-HOUR INTERVALS.
FASTEST MILE WIND SPEEDS ARE FASTEST OBSERVED ONE-MINUTE VALUES WHEN DIRECTIONS ARE IN TENS OF DEGREES. THE / WITH THE DIRECTION INDICATES PEAK GUST SPEED.
ANY ERRORS DETECTED WILL BE CORRECTED AND CHANGES IN SUMMARY DATA WILL BE ANNOTATED IN THE ANNUAL SUMMARY

SUMMARY BY HOURS

HOUR LOCAL TIME	AVERAGES: SKY COVER TENTHS	STATION PRESSURE IN.	TEMPERATURE: AIR °F	WET BULB °F	DEW PT. °F	RELATIVE HUMIDITY %	WIND SPEED M.P.H.	RESULTANT WIND: DIRECTION	SPEED M.P.H.
01	0	29.37	75	63	55	52	3.7	03	2.0
04	0	29.37	71	61	55	58	3.0	09	1.6
07	1	29.41	73	62	55	55	4.3	13	3.7
10	1	29.41	84	66	56	40	5.4	24	3.0
13	2	29.36	92	69	56	31	8.4	31	7.2
16	2	29.32	94	69	55	28	9.1	30	7.8
19	1	29.33	84	67	56	40	4.7	36	2.9
22	1	29.37	80	65	56	45	4.4	06	2.0

HOURLY PRECIPITATION (WATER EQUIVALENT IN INCHES)

DATE	A. M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	P. M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	DATE
1																									1
2																									2
3																									3
4																									4
5																									5
6																									6
7																									7
8																									8
9																									9
10																									10
11																									11
12																									12
13																									13
14																									14
15																									15
16																									16
17																									17
18																									18
19																									19
20																									20
21																									21
22																									22
23																									23
24													T				.03	.14	.04						24
25																									25
26																									26
27																									27
28																									28
29							T	T	T							T	.02	T	T						29
30			.07	.01				T										T	.04	T	T	T			30

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noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / ENVIRONMENTAL DATA AND INFORMATION SERVICE

Daniel B. Mitchell
DIRECTOR, NATIONAL CLIMATIC CENTER

USCOMM--NOAA--ASHEVILLE 10/30/79 400

OBSERVATIONS AT 3-HOUR INTERVALS

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
DAY 01											
01	0	UNL	25			74	64	58	58	06	3
04	0	UNL	20			70	62	57	64	00	0
07	0	UNL	7			73	63	57	57	16	3
10	0	UNL	7			83	68	59	44	27	4
13	0	UNL	7			90	69	58	34	30	4
16	0	UNL	7			92	69	56	30	30	10
19	0	UNL	20			84	67	57	40	36	5
22	0	UNL	30			80	65	56	44	36	5
DAY 02											
01	0	UNL	30			75	68	65	71	36	6
04	0	UNL	30			66	61	58	76	30	5
07	0	UNL	30			71	64	60	68	16	4
10	0	UNL	30			78	68	62	58	17	3
13	2	UNL	20			86	69	60	42	19	4
16	0	UNL	20			90	70	60	37	30	5
19	0	UNL	20			84	69	61	46	33	3
22	0	UNL	20			80	67	59	49	06	4
DAY 03											
01	0	UNL	20			76	65	58	54	00	0
04	0	UNL	20			68	63	60	76	34	6
07	0	UNL	20			71	65	61	71	13	4
10	0	UNL	20			80	68	61	52	24	6
13	0	UNL	20			87	69	59	39	31	9
16	0	UNL	30			90	70	60	37	32	8
19	0	UNL	30			84	68	59	43	36	4
22	0	UNL	30			79	67	60	52	00	0
DAY 04											
01	0	UNL	30			73	65	61	66	32	7
04	0	UNL	30			68	63	60	76	33	5
07	0	UNL	30			72	65	61	68	11	4
10	0	UNL	30			78	67	60	52	35	4
13	0	UNL	30			86	68	58	39	28	6
16	0	UNL	25			88	69	59	38	29	9
19	0	UNL	30			82	68	61	49	31	5
22	0	UNL	25			80	68	61	52	00	0
DAY 05											
01	0	UNL	30			72	63	57	59	33	5
04	0	UNL	20			71	63	58	64	12	4
07	0	UNL	10			72	64	59	64	15	4
10	0	UNL	8			81	67	59	47	16	5
13	0	UNL	15			89	69	57	34	32	10
16	0	UNL	20			92	69	56	30	31	8
19	0	UNL	20			84	68	58	41	00	0
22	0	UNL	30			80	66	57	45	10	5
DAY 06											
01	0	UNL	30			77	64	56	48	06	6
04	0	UNL	20			71	61	55	57	00	0
07	0	UNL	7			76	65	58	54	16	5
10	0	UNL	10			84	68	58	41	20	5
13	0	UNL	10			94	72	60	32	24	7
16	0	UNL	15			96	71	58	28	32	10
19	0	UNL	15			89	71	61	39	00	0
22	0	UNL	20			82	67	58	44	00	0
DAY 07											
01	0	UNL	15			79	66	58	49	08	4
04	0	UNL	15			76	65	58	54	00	0
07	0	UNL	10			77	65	57	50	00	0
10	0	UNL	7			90	69	58	34	24	4
13	0	UNL	7			98	74	62	31	33	5
16	0	UNL	10			104	73	56	20	29	9
19	0	UNL	15			87	71	63	45	32	4
22	0	UNL	15			87	68	58	37	02	7
DAY 08											
01	0	UNL	20			75	66	60	60	31	5
04	0	UNL	30			74	65	60	62	12	5
07	0	UNL	30			75	65	59	58	17	3
10	0	UNL	30			85	67	56	37	31	12
13	0	UNL	30			88	69	58	36	32	9
16	0	UNL	20			92	70	58	32	22	5
19	0	UNL	20			86	70	61	43	26	4
22	0	UNL	30			82	68	61	49	00	0
DAY 09											
01	0	UNL	20			78	67	60	54	00	0
04	0	UNL	20			71	64	59	66	00	0
07	1	UNL	20			72	65	60	66	16	3
10	0	UNL	20			80	66	57	45	27	5
13	0	UNL	20			88	70	60	39	36	6
16	1	UNL	20			90	70	59	35	31	8
19	0	UNL	30			86	69	60	42	19	4
22	0	UNL	30			82	67	58	44	08	3
DAY 10											
01	0	UNL	30			77	66	59	54	00	0
04	0	UNL	30			74	66	61	64	00	0
07	0	UNL	20			75	64	58	56	10	5
10	0	UNL	10			85	69	60	43	25	4
13	0	UNL	10			93	71	60	33	31	5
16	0	UNL	15			93	70	57	30	26	6
19	0	UNL	15			88	69	59	38	36	4
22	0	UNL	15			81	68	61	51	00	0
DAY 11											
01	0	UNL	15			77	65	57	50	09	5
04	0	UNL	15			75	64	57	54	00	0
07	0	UNL	15			77	65	58	52	14	4
10	0	UNL	10			88	71	62	42	24	5
13	0	UNL	10			98	74	62	31	32	9
16	0	UNL	12			102	75	61	26	26	11
19	0	UNL	12			89	72	63	42	36	4
22	0	UNL	12			88	70	60	39	04	5
DAY 12											
01	0	UNL	15			81	68	60	49	06	2
04	0	UNL	15			77	66	60	56	08	6
07	2	UNL	10			78	66	58	49	09	4
10	1	UNL	8			94	71	58	30	25	5
13	0	UNL	8			103	75	61	25	28	9
16	1	UNL	8			105	74	58	21	32	8
19	1	UNL	8			90	71	62	39	33	5
22	0	UNL	8			85	67	56	37	12	4
DAY 13											
01	0	UNL	8			82	66	56	41	11	4
04	3	UNL	10			81	67	58	46	13	5
07	7	100	7			83	67	57	41	16	4
10	2	UNL	7			94	71	58	31	29	5
13	0	UNL	7			104	72	55	20	29	12
16	1	UNL	8			104	71	52	18	31	9
19	0	UNL	10			91	67	53	27	32	3
22	0	UNL	10			83	66	55	38	12	4
DAY 14											
01	0	UNL	30			80	63	52	38	00	0
04	0	UNL	30			77	63	53	43	12	5
07	1	UNL	10			77	63	54	45	11	4
10	0	UNL	7			90	67	54	29	00	0
13	0	UNL	7			103	68	44	13	30	8
16	0	UNL	15			102	69	47	16	29	7
19	0	UNL	15			90	66	50	25	06	2
22	0	UNL	20			84	65	52	33	09	4
DAY 15											
01	0	UNL	15			78	61	49	36	10	5
04	0	UNL	20			78	60	47	34	10	5
07	0	UNL	15			82	61	45	27	08	3
10	0	UNL	12			93	67	50	23	23	5
13	0	UNL	10			102	70	50	17	31	10
16	0	UNL	10			105	71	50	16	33	10
19	0	UNL	15			88	63	46	23	36	5
22	0	UNL	15			83	64	52	34	26	6
DAY 16											
01	0	UNL	15			82	63	51	34	10	5
04	0	UNL	15			76	61	50	40	09	5
07	0	UNL	15			80	62	50	35	00	0
10	0	UNL	10			92	66	50	24	20	4
13	0	UNL	10			99	72	58	26	30	7
16	0	UNL	10			104	72	53	18	32	10
19	0	UNL	20			89	68	55	32	36	4
22	0	UNL	20			83	67	58	43	00	0
DAY 17											
01	0	UNL	20			79	65	56	45	00	0
04	0	UNL	20			78	63	54	44	09	5
07	0	UNL	20			81	64	53	38	10	4
10	0	UNL	15			94	68	53	25	24	4
13	0	UNL	15			100	70	51	19	34	8
16	0	UNL	15			105	69	45	13	36	6
19	0	UNL	25			92	61	36	14	04	8
22	0	UNL	30			82	60	42	24	32	5
DAY 18											
01	0	UNL	30			76	57	40	27	11	4
04	0	UNL	30			63	50	36	37	00	0
07	2	UNL	20			72	59	50	46	11	5
10	2	UNL	7			79	65	56	45	24	3
13	0	UNL	15			92	67	51	25	31	9
16	0	UNL	20			95	64	42	16	27	6
19	0	UNL	30			84	64	50	31	00	0
22	0	UNL	30			77	59	45	32	07	5
DAY 19											
01	0	UNL	20			67	55	45	45	00	0
04	0	UNL	20			68	58	50	53	15	4
07	0	UNL	7			70	58	48	46	16	5
10	0	UNL	7			82	63	50	33	26	6
13	9	UNL	10			89	66	51	27	28	5
16	10	UNL	15			91	67	53	27	28	9
19	0	UNL	15			83	64	52	34	07	3
22	0	UNL	15			76	61	50	40	09	4
DAY 20											
01	0	UNL	15			74	61	51	45	00	0
04	0	UNL	15			68	58	50	53	09	4
07	0	UNL	8			69	58	50	51	14	7
10	0	UNL	7			79	62	51	38	18	5
13	0	UNL	7			90	67	52	27	34	7
16	0	UNL	10			91	66	50	25	25	7
19	0	UNL	15			84	66	54	36	00	0
22	0	UNL	15			78	62	50	38	00	0
DAY 21											
01	0	UNL	15			71	58	50	48	00	0
04	0	UNL	15			70	59	50	49	08	4
07	0	UNL	7			71	59	49	46	00	0
10	0	UNL	7			85	65	52	32	17	6
13	0	UNL	7			94	69	54	26	30	8
16	0	UNL	7			97	71	57	26	30	9
19	0	UNL	15			85	65	53	33	08	4
22	0	UNL	10			80	64	53	39	10	6
DAY 22											
01	0	UNL	15			77	62	52	42	05	4
04	0	UNL	15			71	60	52	61	00	0
07	0	UNL	7			73	60	51	46	10	4
10	0	UNL	7			87	66	53	31	30	4
13	0	UNL	10			99	68	48	18	33	4
16	0	UNL	15			100	68	46	16	33	11
19	0	UNL	30			88	65	50	27	35	9
22	0	UNL	30			84	64	50	31	06	8
DAY 23											
01	0	UNL	30			75	60	50	42	00	0
04	0	UNL	30			74	60	50	43	00	0
07	0	UNL	20			73	59	49	43	13	3
10	0	UNL	20			82	63	51	34	20	4
13	0	UNL	20			98	69	53	22	34	8
16	2	UNL	20			101	71	53	20	28	4
19	0	UNL	30			85	65	53	33	31	4
22	0	UNL	30			79	64	55	44	00	0
DAY 24											
01	0	UNL	30			79	62	50	36	36	6
04	0	UNL	30			72	59	50	46	00	0
07	0	UNL	20			74	62	53	48	09	7
10	2	UNL	20			86	66	54	33	24	4
13	8	100	20			92	68	57	31	18	6
16	10	70	20			89	70	59	36	35	11
19	8	70	20		T	79	72	68	69	36	11
22	1	UNL	15			69	61	55	61	36	12
DAY 25											
01	0	UNL	15			65	59	54	68	36	10
04	0	UNL	15			61	56	53	75	36	6
07	0	UNL	10			65	59	55	70	12	5
10	0	UNL	15			75	63	55	50	30	5
13	0	UNL	15			81	65	55	41	33	5
16	0	UNL	15			83	65	54	37	29	7
19	0	UNL	20			72	62	55	55	28	4
22	0	UNL	20			70	61	55	59	00	0
DAY 26											
01	0	UNL	15			63	58	54	73	26	4
04	0	UNL	15			61	56	53	75	00	0
07	0	UNL	15			61	57	55	81	14	6
10	6	UNL	10			73	63	56	55	21	7
13	10	250	10			80	65	55	42	30	5
16	10	UNL	10			83	66	56	40	29	7
19	5	UNL	10			75	63	56	52	01	6
22	0	UNL	20			73	63	56	55	05	8
DAY 27											
01	0	UNL	20			67	60	56	68	02	3
04	0	UNL	20			65	60	56	73	00	0
07	10	UNL	7			65	59	55	70	00	0
10	10	UNL	7			75	64	57	54	17	4
13	10	UNL	5		KH	83	67	57	41	30	7
16	10	UNL	7			86	68	57	37	33	8
19	10	UNL	8			78	63	54	44	02	5
22	7	UNL	10			74	63	55	52	20	6
DAY 28											
01	0	UNL	15			70	62	56	61	12	3
04	0	UNL	15			67	60	55	66	00	0
07	2	UNL	4		KH	65	59	54	68	18	4
10	1	UNL	7			78	63	54	44	00	0
13	3	UNL	7			86	67	55	35	33	5
16	5	UNL	8			90	67	53	28	35	6
19	3	UNL	10			83	65	54	37	00	0
22	8	140	10			78	66	59	52	09	4
DAY 29											
01	3	UNL	10			74	63	56	54	35	5
04	3	UNL	10			67	60	56	68	14	4
07	10	45	10		RW	71	62	57	61	19	3
10	9	90	10			83	65	53	36	06	11
13	4	UNL	15			88	64	48	25	32	12
16	10	70	10		TRW	85	67	56	37	30	6
19	9	100	10			74	68	64	71	10	8
22	10	100	10			72	67	64	76	28	6
DAY 30											
01	7	100	10			71	67	65	81	00	0
04	4	UNL	10			68	64	62	81	00	0
07	9	120	7			71	65	62	73	14	4
10	9	120	10			79	67	60	52	24	3
13	10	90	10			81	68	61	51	32	9
16	9	90	10			80	67	59	48	02	6
19	8	120	30			76	66	61	60	14	5
22	5	UNL	20			75	67	63	66	16	5

NOTES

CEILING

UNL INDICATES UNLIMITED

WEATHER

*	TORNADO
T	THUNDERSTORM
Q	SQUALL
R	RAIN
RW	RAIN SHOWERS
ZR	FREEZING RAIN
L	DRIZZLE
ZL	FREEZING DRIZZLE
S	SNOW
SP	SNOW PELLETS
IC	ICE CRYSTALS
SW	SNOW SHOWERS
SG	SNOW GRAINS
IP	ICE PELLETS
A	HAIL
F	FOG
IF	ICE FOG
GF	GROUND FOG
BD	BLOWING DUST
BN	BLOWING SAND
BS	BLOWING SNOW
BY	BLOWING SPRAY
K	SMOKE
H	HAZE
D	DUST

WIND

DIRECTIONS ARE THOSE FROM WHICH THE WIND BLOWS. INDICATED IN TENS OF DEGREES FROM TRUE NORTH; I.E., 09 FOR EAST, 18 FOR SOUTH, 27 FOR WEST. ENTRY OF 00 IN THE DIRECTION COLUMN INDICATES CALM.

SPEED IS EXPRESSED IN KNOTS; MULTIPLY BY 1.15 TO CONVERT TO MILES PER HOUR.

STATION

BAKERSFIELD CALIFORNIA

YEAR & MONTH

79 09

U.S. DEPARTMENT OF COMMERCE
NATIONAL CLIMATIC CENTER
FEDERAL BUILDING
ASHEVILLE, N.C. 28801

AN EQUAL OPPORTUNITY EMPLOYER

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE
COM-210

U.S.MAIL

FIRST CLASS

OCTOBER 1979
BAKERSFIELD, CALIFORNIA
NATIONAL WEATHER SERVICE OFC
KERN COUNTY AIR TERMINAL

Local Climatological Data

MONTHLY SUMMARY

LATITUDE 35° 25 ′N LONGITUDE 119° 03 ′W ELEVATION (GROUND) 475 FT. STANDARD TIME USED: PACIFIC WBAN #23155

DATE	TEMPERATURE °F MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	AVERAGE DEW POINT	DEGREE DAYS BASE 65° HEATING (SEASON BEGINS WITH JULY)	COOLING (SEASON BEGINS WITH JAN.)	WEATHER TYPES ON DATES OF OCCURRENCE 1 FOG 2 HEAVY FOG 3 THUNDERSTORM 4 ICE PELLETS 5 HAIL 6 GLAZE 7 DUSTSTORM 8 SMOKE, HAZE 9 BLOWING SNOW	SNOW, ICE PELLETS OR ICE ON GROUND AT 04AM IN.	PRECIPITATION WATER EQUIVALENT IN	SNOW, ICE PELLETS IN.	AVG. STATION PRESSURE IN. ELEV. 492 FEET M.S.L.	WIND RESULTANT DIR.	RESULTANT SPEED M.P.H.	AVERAGE SPEED M.P.H.	FASTEST MILE SPEED M.P.H.	FASTEST MILE DIRECTION	SUNSHINE MINUTES	PERCENT OF POSSIBLE	SKY COVER TENTHS SUNRISE TO SUNSET	MIDNIGHT TO MIDNIGHT	DATE
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	92	65	79	7	58	0	14		0	0	0	29.41	36	1.9	5.8	12	31			1	0	1
2	93*	64	79	7	57	0	14		0	0	0	29.44	35	6.8	7.9	12	33			2	3	2
3	88	68	78	6	58	0	13	8	0	0	0	29.50	08	.8	4.3	8	30			9	7	3
4	92	65	79	8	59	0	14	8	0	0	0	29.53	36	2.9	5.8	9	33			7	6	4
5	90	68	79*	8	55	0	14	8	0	0	0	29.57	27	.7	4.8	8	32			5	6	5
6	88	67	78	7	54	0	13	8	0	0	0	29.48	16	.9	4.0	10	27			1	1	6
7	85	65	75	5	53	0	10		0	0	0	29.43	33	3.1	5.9	15	33			0	1	7
8	78	59	69	-1	54	0	4		0	0	0	29.45	34	4.2	5.5	10	34			3	2	8
9	83	55	69	0	53	0	4	8	0	0	0	29.46	01	2.9	4.6	10	34			6	4	9
10	84	63	74	5	53	0	9	8	0	0	0	29.55	28	1.2	2.5	7	25			7	5	10
11	85	63	74	5	54	0	9	8	0	0	0	29.49	02	.6	4.6	8	32			2	2	11
12	84	61	73	5	54	0	8	8	0	0	0	29.42	02	1.5	5.0	8	33			8	6	12
13	83	64	74	6	54	0	9	8	0	0	0	29.36	32	.9	4.9	10	35			9	6	13
14	84	66	75	7	57	0	10		0	0	0	29.44	34	4.6	7.1	12	36			2	3	14
15	82	65	74	7	57	0	9		0	0	0	29.53	01	2.6	4.2	12	33			8	6	15
16	82	66	74	7	58	0	9	8	0	0	0	29.54	28	2.7	4.6	8	28			6	6	16
17	82	64	73	6	56	0	8	8	0	0	0	29.45	34	2.2	4.6	9	35			5	4	17
18	83	61	72	6	50	0	7	8	0	0	0	29.41	04	2.5	4.3	9	34			9	7	18
19	81	67	74	8	51	0	9		0	0	0	29.36	33	3.8	7.5	20	28			9	9	19
20	74	57	66	1	52	0	1		0	.20	0	29.34	34	8.3	10.5	17	34			3	6	20
21	73	50	62	-3	50	3	0		0	0	0	29.54	35	3.4	5.5	8	02			2	1	21
22	78	51	65	0	49	0	0		0	0	0	29.56	32	.3	3.9	8	24			8	4	22
23	81	54	68	4	48	0	3	8	0	0	0	29.47	08	1.6	5.9	9	36			5	3	23
24	85	55	70	6	46	0	5	8	0	0	0	29.38	02	2.7	5.9	10	33			0	0	24
25	84	57	71	7	50	0	6	1	0	.08	0	29.42	02	1.5	6.5	15	35			3	4	25
26	71	60	66	3	57	0	1	1 8	0	0	0	29.59	33	3.6	7.6	15	30			9	9	26
27	75	58	67	4	55	0	2	8	0	0	0	29.60	27	2.3	2.8	8	28			3	5	27
28	74	54	64	1	50	1	0		0	0	0	29.56	34	5.4	5.6	15	30			8	6	28
29	68	42*	55*	-7	39	10	0		0	0	0	29.57	18	1.0	4.0	10	22			0	0	29
30	72	48	60	-2	37	5	0		0	0	0	29.57	19	3.6	4.3	7	09			0	0	30
31	74	50	62	1	43	3	0		0	0	0	29.47	05	2.3	5.2	10	30			6	4	31
	SUM	SUM				TOTAL	TOTAL			TOTAL	TOTAL	FOR THE MONTH:						TOTAL	%	SUM	SUM	
	2528	1852				22	205	NUMBER OF DAYS		.28	0	29.48	35	2.0	5.3	20	28		FOR	146	126	
	AVG.	AVG.	AVG.	DEP.	AVG.	DEP.	DEP.	PRECIPITATION		DEP.						DATE: 19		POSSIBLE	MONTH	AVG.	AVG.	
	81.5	58.7	70.8	3.7	52	-33	91	≥ .01 INCH	2	0.02										4.7	4.1	

NUMBER OF DAYS				SEASON TO DATE		SNOW, ICE PELLETS		GREATEST IN 24 HOURS AND DATES			GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE	
MAXIMUM TEMP.		MINIMUM TEMP.		TOTAL	TOTAL	≥ 1.0 INCH	0	PRECIPITATION		SNOW, ICE PELLETS		
≥ 90°	≤ 32°	≤ 32°	≤ 0°	22	2729	THUNDERSTORMS	0	.20	20	0	0	
4	0	0	0	DEP.	DEP.	HEAVY FOG	0					
				-33	556	CLEAR 14	PARTLY CLOUDY 8	CLOUDY 9				

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT
+ ALSO ON AN EARLIER DATE, OR DATES.
HEAVY FOG: - VISIBILITY 1/4 MILE OR LESS.
FIGURES FOR WIND DIRECTIONS ARE TENS OF DEGREES CLOCKWISE FROM TRUE NORTH. 00 - CALM.
DATA IN COLS. 6 AND 12-15 ARE BASED ON 7 OR MORE OBSERVATIONS PER DAY AT 3-HOUR INTERVALS.
FASTEST MILE WIND SPEEDS ARE FASTEST OBSERVED ONE-MINUTE VALUES WHEN DIRECTIONS ARE IN TENS OF DEGREES. THE / WITH THE DIRECTION INDICATES PEAK GUST SPEED.
ANY ERRORS DETECTED WILL BE CORRECTED AND CHANGES IN SUMMARY DATA WILL BE ANNOTATED IN THE ANNUAL SUMMARY

SUMMARY BY HOURS

HOUR LOCAL TIME	AVERAGES SKY COVER TENTHS	STATION PRESSURE IN.	TEMPERATURE AIR °F	WET BULB °F	DEW PT. °F	RELATIVE HUMIDITY %	WIND SPEED M.P.H.	RESULTANT WIND DIRECTION	SPEED M.P.H.
01	3	29.49	65	58	52	64	4.7	04	1.9
04	3	29.48	63	57	52	69	4.7	02	1.5
07	5	29.51	63	57	52	69	4.9	08	1.7
10	5	29.52	73	61	53	51	4.8	25	2.5
13	5	29.47	79	63	53	41	6.5	32	4.6
16	4	29.44	81	63	52	37	7.6	32	6.2
19	4	29.46	73	61	52	47	5.3	01	3.5
22	3	29.48	69	59	53	57	4.3	05	1.6

HOURLY PRECIPITATION (WATER EQUIVALENT IN INCHES)

DATE	A.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	P.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	DATE
1																									1
2																									2
3																									3
4																									4
5																									5
6																									6
7																									7
8																									8
9																									9
10																									10
11																									11
12																									12
13																									13
14																									14
15																									15
16																									16
17																									17
18																									18
19																									19
20				.02	.10	.08	T																		20
21																									21
22																									22
23																									23
24																									24
25																T	T	T	T	T	.03	.05	T	T	25
26																									26
27																									27
28																									28
29																									29
30																									30
31																									31

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noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / ENVIRONMENTAL DATA AND INFORMATION SERVICE

Daniel B. Mitchell
DIRECTOR, NATIONAL CLIMATIC CENTER

USCOMM--NOAA--ASHEVILLE 11/28/79 400

OBSERVATIONS AT 3-HOUR INTERVALS

DAY 01

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	30			71	65	62	73	09	7
04	0	UNL	30			71	63	58	64	08	5
07	0	UNL	15			70	63	59	68	02	3
10	0	UNL	10			82	67	58	46	28	4
13	1	UNL	10			89	68	57	34	34	8
16	1	UNL	15			91	71	60	35	32	8
19	0	UNL	20			83	64	52	34	20	5
22	0	UNL	20			76	63	55	48	00	0

DAY 02

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	30			72	63	58	62	36	5
04	0	UNL	20			68	61	57	68	34	4
07	8	250	15			73	62	55	53	02	9
10	4	UNL	15			77	64	56	48	30	9
13	0	UNL	15			89	69	57	34	33	7
16	0	UNL	15			93	70	58	31	32	7
19	7	UNL	10			84	66	59	43	02	9
22	7	UNL	10			78	64	56	47	01	5

DAY 03

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	3	UNL	10			71	61	55	57	34	5
04	7	UNL	10			71	62	56	59	12	6
07	5	UNL	5		KH	72	63	58	62	00	0
10	10	100	7			78	66	58	50	18	6
13	10	100	8			84	68	59	43	00	0
16	9	250	10			88	69	59	38	31	4
19	6	120	15			80	67	60	51	03	5
22	6	UNL	15			78	67	60	54	12	4

DAY 04

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	15			73	64	59	62	13	3
04	0	UNL	15			69	63	59	71	04	4
07	0	UNL	5		KH	71	62	57	61	11	4
10	8	UNL	5		KH	82	67	58	44	27	5
13	10	250	7			89	70	59	36	02	5
16	8	250	8			92	70	58	32	33	8
19	10	250	15			82	68	60	47	03	6
22	10	250	10			80	67	60	51	32	5

DAY 05

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	8	250	10			74	61	51	45	28	4
04	10	UNL	15			70	62	56	61	00	0
07	8	UNL	5		KH	70	62	56	61	13	5
10	3	UNL	6		KH	79	65	56	45	22	6
13	5	UNL	6		KH	86	68	57	37	02	4
16	10	UNL	7			90	68	55	31	30	7
19	2	UNL	10			82	64	53	37	02	3
22	0	UNL	10			77	65	57	50	13	4

DAY 06

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	6	UNL	10			72	62	56	57	00	0
04	0	UNL	10			68	61	57	68	13	5
07	4	UNL	7			70	61	54	57	14	5
10	5	UNL	7			79	64	55	44	24	4
13	0	UNL	7			87	67	55	34	04	4
16	0	UNL	7			88	66	52	29	26	7
19	1	UNL	10			80	63	52	38	06	3
22	0	UNL	10			75	62	54	48	00	0

DAY 07

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	10			67	59	53	61	00	0
04	4	UNL	10			67	59	53	61	12	7
07	0	UNL	10			69	59	52	55	00	0
10	0	UNL	8			75	62	53	46	28	5
13	3	UNL	10			83	64	52	34	30	6
16	0	UNL	12			85	65	53	33	34	6
19	0	UNL	15			77	62	52	42	02	8
22	0	UNL	30			69	60	54	59	31	9

DAY 08

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	30			63	57	53	70	29	6
04	5	UNL	30			61	56	53	75	34	5
07	6	40	7			62	57	53	73	31	6
10	4	UNL	8			72	61	53	51	36	4
13	4	UNL	8			78	63	54	47	32	4
16	0	UNL	10			78	63	54	44	36	5
19	0	UNL	15			71	61	54	55	03	5
22	0	UNL	20			70	61	54	57	07	3

DAY 09

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	20			62	56	52	70	01	5
04	0	UNL	15			61	55	51	70	00	0
07	2	UNL	5		KH	62	58	51	67	05	4
10	1	UNL	6		KH	74	62	53	48	15	3
13	9	250	7			80	64	53	39	34	4
16	9	UNL	15			83	65	54	37	32	7
19	7	UNL	20			74	62	54	50	01	5
22	2	UNL	20			72	60	52	50	08	4

DAY 10

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	20			66	58	52	61	00	0
04	0	UNL	20			64	57	52	65	00	0
07	4	UNL	5		KH	64	57	52	65	30	3
10	7	150	5		KH	75	62	53	46	00	0
13	8	250	6		KH	81	65	54	39	27	6
16	8	UNL	7			84	66	54	36	33	4
19	5	UNL	7			78	63	53	42	00	0
22	7	UNL	10			72	62	56	57	14	4

DAY 11

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	10	250	10			72	61	54	53	06	4
04	6	250	10			65	58	52	63	31	5
07	2	UNL	7			64	58	53	68	09	4
10	8	UNL	5		KH	74	62	54	50	18	4
13	0	UNL	6		KH	81	66	56	42	24	3
16	0	UNL	7			85	66	55	36	32	7
19	1	UNL	15			77	63	54	45	00	0
22	0	UNL	15			73	62	55	53	10	5

DAY 12

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	15			69	60	54	59	33	4
04	0	UNL	15			63	58	54	73	12	4
07	10	200	7			61	57	54	78	12	5
10	10	120	5		KH	74	63	55	52	25	3
13	8	UNL	7			82	65	54	38	02	4
16	3	UNL	8			84	65	53	34	33	7
19	7	UNL	10			75	62	53	46	36	4
22	8	UNL	10			71	60	53	53	12	4

DAY 13

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	10			69	60	54	59	10	5
04	0	UNL	10			66	58	53	63	00	0
07	9	100	6		H	67	59	53	61	13	6
10	10	120	7			75	62	53	46	23	6
13	10	120	7			80	65	55	42	31	8
16	9	120	8			83	65	53	36	01	3
19	10	120	15			79	64	54	42	00	0
22	3	UNL	30			73	64	58	59	33	5

DAY 14

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	30			71	63	58	64	35	4
04	6	50	30			71	63	58	64	01	10
07	5	UNL	30			66	61	58	76	22	3
10	0	UNL	30			78	67	60	54	22	4
13	3	UNL	20			83	67	57	41	32	6
16	0	UNL	30			83	66	55	38	31	8
19	0	UNL	30			77	64	55	47	04	7
22	2	UNL	30			73	63	57	57	36	7

DAY 15

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	2	UNL	30			69	62	57	66	05	5
04	0	UNL	20			65	60	56	73	03	6
07	10	15	7			67	62	58	73	00	0
10	6	UNL	7			73	64	59	62	00	0
13	10	UNL	10			80	66	58	47	30	5
16	9	UNL	20			82	66	57	43	31	4
19	9	UNL	20			75	64	57	54	36	5
22	0	UNL	20			74	64	57	55	10	4

DAY 16

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	7	60	20			68	61	56	66	30	2
04	8	80	10			68	61	57	68	34	6
07	10	55	8			68	62	58	71	12	5
10	9	UNL	5		KH	75	65	59	58	00	0
13	6	250	7			82	67	58	44	26	6
16	1	UNL	7			82	66	57	43	28	7
19	8	50	7			78	66	58	49	27	6
22	0	UNL	10			73	63	57	57	00	0

DAY 17

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	10			64	59	56	75	28	4
04	6	45	10			68	62	58	71	21	3
07	7	55	5		KH	66	61	57	73	00	0
10	9	UNL	5		KH	76	64	57	52	01	3
13	6	UNL	7			81	65	55	41	35	8
16	0	UNL	7			82	65	55	40	33	6
19	1	UNL	8			76	62	53	45	02	3
22	0	UNL	10			70	61	55	59	12	5

DAY 18

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	10			68	59	54	65	10	5
04	0	UNL	10			64	58	53	68	00	0
07	8	140	4		KH	62	57	53	73	13	6
10	8	UNL	6		KH	72	59	50	46	00	0
13	10	UNL	7			81	64	52	37	00	0
16	10	UNL	7			83	62	46	27	35	7
19	10	120	10			74	57	44	34	02	7
22	9	80	10			74	57	44	34	36	5

DAY 19

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	8	80	30			70	50	28	21	03	6
04	10	40	30			69	56	45	42	01	4
07	10	35	30			68	61	57	68	08	7
10	10	45	30			74	64	57	55	22	6
13	9	40	20			80	66	58	47	33	13
16	9	40	20			80	66	58	47	30	11
19	1	UNL	20			71	60	53	53	27	5
22	10	60	30			71	60	53	53	00	0

DAY 20

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	10	90	30			71	60	52	51	05	6
04	10	45	10		R	65	61	59	81	36	10
07	9	40	30			62	60	58	87	30	8
10	3	UNL	30			68	60	55	63	33	11
13	5	UNL	30			71	60	53	53	34	15
16	0	UNL	30			72	57	45	38	34	11
19	6	70	20			63	53	45	52	01	5
22	5	UNL	30			59	54	50	72	31	7

DAY 21

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	30			55	52	50	83	32	6
04	0	UNL	30			51	49	48	90	28	5
07	5	UNL	20			53	51	50	90	04	5
10	3	UNL	7			62	57	53	73	00	0
13	0	UNL	10			70	58	48	46	33	3
16	0	UNL	10			72	58	48	43	31	7
19	0	UNL	20			63	56	50	63	02	7
22	0	UNL	30			61	55	51	70	09	5

DAY 22

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	30			57	53	50	78	09	5
04	0	UNL	15			55	51	48	77	00	0
07	3	UNL	20			55	51	47	75	07	6
10	9	UNL	10			68	58	51	53	27	6
13	10	250	7			76	61	50	40	00	0
16	10	250	7			78	59	45	31	24	7
19	6	250	12			70	59	50	49	36	3
22	0	UNL	12			63	56	50	63	00	0

DAY 23

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	12			60	54	50	70	11	7
04	0	UNL	12			55	51	48	77	28	3
07	3	UNL	5		KH	56	52	48	75	07	4
10	4	UNL	7			71	58	48	44	21	5
13	2	UNL	7			78	60	47	34	26	4
16	9	120	7			81	61	46	29	38	8
19	8	120	10			74	58	47	38	11	3
22	0	UNL	10			66	57	49	54	08	7

DAY 24

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	10			63	55	48	58	04	3
04	0	UNL	10			59	54	49	70	09	6
07	0	UNL	6		KH	58	52	46	65	11	4
10	0	UNL	6		KH	75	56	45	34	33	4
13	0	UNL	7			83	62	47	28	30	8
16	0	UNL	7			85	61	43	23	32	6
19	0	UNL	12			74	57	44	34	08	6
22	0	UNL	15			69	56	46	44	05	9

DAY 25

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	15			65	55	47	52	12	4
04	0	UNL	15			59	52	45	60	11	5
07	0	UNL	7			58	52	47	67	09	4
10	0	UNL	7			71	59	49	46	17	6
13	2	UNL	8			83	61	44	25	31	3
16	9	70	10		RW	81	61	46	29	01	8
19	10	35	10		RW	71	62	57	61	34	9
22	10	4	2		RWF	65	62	61	87	28	6

DAY 26

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	10	7	4		F	65	62	61	87	34	10
04	10	8	3		F	63	61	60	90	30	13
07	10	8	5		F	60	58	56	87	29	9
10	10	10	7			63	58	55	75	33	6
13	10	10	5		H	66	61	58	76	08	8
16	8	12	7			70	62	58	61	11	3
19	5	UNL	10			67	60	56	68	14	4
22	10	45	10			67	61	57	70	00	0

DAY 27

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	8	45	10			65	60	57	75	00	0
04	10	45	7			59	57	55	87	00	0
07	10	40	7			60	57	54	81	00	0
10	0	UNL	5		KH	68	60	55	63	20	4
13	1	UNL	5		KH	74	62	54	50	30	6
16	1	UNL	6		KH	75	62	54	48	26	7
19	10	45	10			68	61	56	66	29	3
22	2	UNL	10			61	56	53	75	00	0

DAY 28

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	7	45	15			62	57	54	75	00	0
04	1	UNL	7			57	54	52	83	00	0
07	10	45	7			60	55	51	72	01	4
10	10	28	7			66	60	55	68	32	6
13	9	20	10			72	61	54	53	33	8
16	8	25	10			73	61	53	50	35	9
19	0	UNL	20			63	52	41	45	34	9
22	0	UNL	30			54	48	42	64	33	3

DAY 29

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	30			52	47	42	69	12	5
04	0	UNL	30			50	45	40	69	00	0
07	0	UNL	30			49	44	38	66	29	3
10	0	UNL	30			60	50	40	48	00	0
13	0	UNL	30			66	52	39	37	22	8
16	0	UNL	30			65	49	33	30	30	4
19	0	UNL	20			59	48	37	44	12	3
22	0	UNL	30			55	48	40	57	09	5

DAY 30

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	30			50	45	40	69	18	6
04	0	UNL	30			49	44	38	66	20	4
07	0	UNL	30			50	44	37	61	19	5
10	0	UNL	10			65	51	37	36	18	6
13	0	UNL	10			69	52	36	30	16	3
16	0	UNL	20			72	53	34	25	26	6
19	0	UNL	20			65	51	38	37	00	0
22	0	UNL	10			58	49	39	49	00	0

DAY 31

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	AIR °F	WET BULB °F	DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
01	0	UNL	10			52	45	38	59	00	0
04	4	UNL	10			53	45	37	55	11	6
07	10	45	10			58	49	39	49	10	4
10	9	50	7			66	53	40	39	16	3
13	2	UNL	7			73	58	45	37	34	8
16	2	UNL	20			73	58	48	41	35	5
19	0	UNL	30			62	54	48	60	01	8
22	0	UNL	15			59	53	47	65	12	4

NOTES

CEILING

UNL INDICATES UNLIMITED

WEATHER

■	TORNADO
T	THUNDERSTORM
Q	SQUALL
R	RAIN
RW	RAIN SHOWERS
ZR	FREEZING RAIN
L	DRIZZLE
ZL	FREEZING DRIZZLE
S	SNOW
SP	SNOW PELLETS
IC	ICE CRYSTALS
SW	SNOW SHOWERS
SG	SNOW GRAINS
IP	ICE PELLETS
A	HAIL
F	FOG
IF	ICE FOG
GF	GROUND FOG
BD	BLOWING DUST
BN	BLOWING SAND
BS	BLOWING SNOW
BY	BLOWING SPRAY
K	SMOKE
H	HAZE
D	DUST

WIND

DIRECTIONS ARE THOSE FROM WHICH THE WIND BLOWS. INDICATED IN TENS OF DEGREES FROM TRUE NORTH: I.E., 09 FOR EAST, 18 FOR SOUTH, 27 FOR WEST. ENTRY OF 00 IN THE DIRECTION COLUMN INDICATES CALM.

SPEED IS EXPRESSED IN KNOTS; MULTIPLY BY 1.15 TO CONVERT TO MILES PER HOUR.

STATION	YEAR & MONTH
BAKERSFIELD CALIFORNIA	79 10

U.S. DEPARTMENT OF COMMERCE
NATIONAL CLIMATIC CENTER
FEDERAL BUILDING
ASHEVILLE, N.C. 28801

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U.S.MAIL

FIRST CLASS

NOVEMBER 1979
BAKERSFIELD, CALIFORNIA
NATIONAL WEATHER SERVICE OFC
KERN COUNTY AIR TERMINAL

Local Climatological Data

MONTHLY SUMMARY

LATITUDE 35 °25 'N LONGITUDE 119 °03 'W ELEVATION (GROUND) 475 FT. STANDARD TIME USED: PACIFIC WBAN #23155

DATE	TEMPERATURE °F MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	AVERAGE DEW POINT	DEGREE DAYS BASE 65° HEATING (SEASON BEGINS WITH JULY)	COOLING (SEASON BEGINS WITH JAN.)	WEATHER TYPES ON DATES OF OCCURRENCE 1 FOG 2 HEAVY FOG 3 THUNDERSTORM 4 ICE PELLETS 5 HAIL 6 GLAZE 7 DUSTSTORM 8 SMOKE, HAZE 9 BLOWING SNOW	SNOW, ICE PELLETS OR ICE ON GROUND AT 04AM IN.	PRECIPITATION WATER EQUIVALENT IN	SNOW, ICE PELLETS IN.	AVG. STATION PRESSURE IN. --- ELEV. 492 FEET M.S.L.	WIND RESULTANT DIR.	RESULTANT SPEED M.P.H.	AVERAGE SPEED M.P.H.	FASTEST MILE SPEED M.P.H.	FASTEST MILE DIRECTION	SUNSHINE MINUTES	PERCENT OF POSSIBLE	SKY COVER TENTHS SUNRISE TO SUNSET	MIDNIGHT TO MIDNIGHT	DATE
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	74	48	61	0	47	4	0	8	0	0	0	29.52	12	1.6	5.0	8	29			4	2	1
2	79	51	65	4	46	0	0	8	0	0	0	29.51	04	3.2	4.9	9	32			5	4	2
3	77	50	64	4	48	1	0	8	0	.03	0	29.43	32	3.4	7.3	24	30			6	4	3
4	72	51	62	2	49	3	0		0	T	0	29.57	36	3.3	5.2	12	34			6	5	4
5	74	42	58	-2	45	7	0		0	0	0	29.58	02	2.1	6.2	12	36			7	6	5
6	78	53	66*	7	45	0	1		0	0	0	29.43	35	2.3	4.9	10	34			9	8	6
7	74	52	63	4	45	2	0		0	T	0	29.28	15	4.9	5.9	21	17			10	8	7
8	74	50	62	3	45	3	0		0	0	0	29.38	04	2.4	6.2	10	25			2	2	8
9	72	46	59	1	46	6	0		0	0	0	29.50	04	2.6	4.2	9	17			3	2	9
10	72	46	59	1	46	6	0	8	0	0	0	29.54	04	1.2	5.3	10	32			0	0	10
11	74	50	62	5	47	3	0	8	0	0	0	29.58	29	1.2	5.2	10	29			7	4	11
12	77	46	62	5	47	3	0	1 8	0	0	0	29.64	01	1.8	5.8	8	31			4	3	12
13	74	45	60	3	46	5	0	1 8	0	0	0	29.58	02	1.9	3.5	10	28			7	4	13
14	77	45	61	5	44	4	0	1 8	0	0	0	29.49	34	1.2	4.2	8	28			3	2	14
15	82	42	62	6	39	3	0	1 8	0	0	0	29.58	34	.6	3.5	7	34			1	1	15
16	82*	47	65	9	33	0	0	8	0	0	0	29.50	02	2.2	4.8	16	32			10	7	16
17	68	55	62	7	55	3	0		0	13	0	29.47	32	3.2	6.5	16	33			8	8	17
18	64	45	55	0	48	10	0	2	0	0	0	29.63	33	6.9	7.3	10	34			7	4	18
19	60	42	51	-4	38	14	0		0	0	0	29.74	02	2.1	3.5	9	33			4	2	19
20	61	35	48*	-6		17	0		0	0	0	29.85	08	1.6	4.8	9	33			1	1	20
21	68	31*	50	-4	28	15	0		0	0	0	29.89	12	3.4	5.6	7	25			1	1	21
22	64	39	52	-2	33	13	0		0	0	0	29.83	11	1.5	3.0	12	09			9	7	22
23	64	48	56	2	42	9	0		0	0	0	29.77	30	1.2	4.6	10	30			6	5	23
24	65	40	53	0	46	12	0	2 8	0	0	0	29.80	10	2.5	3.7	7	13			5	5	24
25	70	52	61	8	50	4	0	8	0	0	0	29.64	27	1.1	4.2	10	03			7	6	25
26	72	47	60	7	49	5	0	1 8	0	T	0	29.54	33	4.8	8.5	20	34			7	5	26
27	63	42	53	1	38	12	0		0	0	0	29.73	33	1.0	4.2	7	07			2	1	27
28	70	40	55	3	38	10	0	8	0	0	0	29.75	11	1.2	3.6	9	36			8	4	28
29	66	42	54	2	40	11	0	8	0	0	0	29.76	12	2.3	3.5	7	07			7	3	29
30	65	42	54	3	43	11	0	8	0	0	0	29.74	19	.5	5.0	9	26			2	2	30
	SUM	SUM	—	—	—	TOTAL	TOTAL			TOTAL	TOTAL	FOR THE MONTH:						TOTAL	%	SUM	SUM	
	2132	1364	—	—	—	196	1	NUMBER OF DAYS		.16	0	29.61	02	1.1	5.0	24	30		FOR	158	116	
	AVG.	AVG.	AVG.	DEP.	AVG.	DEP.	DEP.	PRECIPITATION		DEP.	—	—	—	—	—	DATE: 03		POSSIBLE	MONTH	AVG.	AVG.	
	71.1	45.5	58.3	2.3		-80	-5	≥.01 INCH	2	-0.53	—	—	—	—	—	—				5.3	3.9	

				SEASON TO DATE		SNOW, ICE PELLETS		
NUMBER OF DAYS				TOTAL	TOTAL	≥ 1.0 INCH	0	
MAXIMUM TEMP.		MINIMUM TEMP.		218	2730	THUNDERSTORMS	0	
≥ 90°	≤ 32°	≤ 32°	≤ 0°	DEP.	DEP.	HEAVY FOG	2	
0	0	1	0	-113	551	CLEAR 9	PARTLY CLOUDY 15	CLOUDY 6

GREATEST IN 24 HOURS AND DATES				GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE	
PRECIPITATION		SNOW, ICE PELLETS			
.13	17	0		0	

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT
+ ALSO ON AN EARLIER DATE, OR DATES.
HEAVY FOG: - VISIBILITY 1/4 MILE OR LESS.
FIGURES FOR WIND DIRECTIONS ARE TENS OF DEGREES CLOCKWISE FROM TRUE NORTH. 00 = CALM.
DATA IN COLS. 6 AND 12-15 ARE BASED ON 7 OR MORE OBSERVATIONS PER DAY AT 3-HOUR INTERVALS.
FASTEST MILE WIND SPEEDS ARE FASTEST OBSERVED ONE-MINUTE VALUES WHEN DIRECTIONS ARE IN TENS OF DEGREES. THE / WITH THE DIRECTION INDICATES PEAK GUST SPEED.
ANY ERRORS DETECTED WILL BE CORRECTED AND CHANGES IN SUMMARY DATA WILL BE ANNOTATED IN THE ANNUAL SUMMARY

DEW POINT DATA MISG. NOV. 20TH.

SUMMARY BY HOURS

HOUR LOCAL TIME	AVERAGES SKY COVER TENTHS	STATION PRESSURE IN.	TEMPERATURE AIR °F	WET BULB °F	DEW PT. °F	RELATIVE HUMIDITY %	WIND SPEED M.P.H.	RESULTANT WIND DIRECTION	SPEED M.P.H
01	2	29.61	52	48	43	72	4.2	07	2.2
04	3	29.61	50	47	43	77	3.3	08	2.0
07	5	29.63	48	45	41	77	3.9	09	3.0
10	6	29.65	60	52	45	58	3.8	22	1.8
13	5	29.59	69	56	44	42	7.1	31	4.0
16	5	29.57	69	56	44	42	7.6	30	5.0
19	4	29.59	59	51	43	58	5.3	02	3.8
22	3	29.62	55	49	44	67	4.6	08	2.5

HOURLY PRECIPITATION (WATER EQUIVALENT IN INCHES)

DATE	A. M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	P. M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	DATE
1																									1
2																									2
3																.01	.02								3
4				T		T	T																		4
5																									5
6																									6
7															T										7
8																									8
9																									9
10																									10
11																									11
12																									12
13																									13
14																									14
15																									15
16																									16
17	.02	.06	.02	.02				T	.01		T	T	T	T											17
18																									18
19																									19
20																									20
21																									21
22																									22
23																									23
24																									24
25																									25
26								T																	26
27																									27
28																									28
29																									29
30																									30

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noaa NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / ENVIRONMENTAL DATA AND INFORMATION SERVICE

Daniel B. Mitchell
DIRECTOR, NATIONAL CLIMATIC CENTER

USCOMM--NOAA--ASHEVILLE 12/21/79 400

OBSERVATIONS AT 3-HOUR INTERVALS

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
					DAY 01											DAY 02											DAY 03						
01	0	UNL	15			53	49	45	74	03	5	2	UNL	10			58	52	47	67	10	5	0	UNL	10			55	50	45	69	00	0
04	0	UNL	15			52	48	45	77	12	4	0	UNL	10			55	50	46	72	04	5	0	UNL	10			52	48	44	74	00	0
07	0	UNL	7			50	47	45	83	13	3	0	UNL	6		KH	56	50	45	67	05	5	1	UNL	7			54	48	43	67	10	6
10	4	UNL	5		KH	62	55	50	65	17	5	9	UNL	6		KH	69	57	48	47	00	0	4	UNL	5		KH	69	56	46	44	17	3
13	7	UNL	4		KH	71	59	49	46	18	3	10	UNL	6		KH	76	59	46	35	34	5	6	100	7			75	60	49	40	30	13
16	5	UNL	7			72	58	48	43	29	7	6	UNL	8			79	60	45	30	35	7	10	50	1		RW	66	58	52	61	30	20
19	2	UNL	7			63	54	47	56	07	3	2	UNL	10			69	55	43	39	08	3	3	UNL	30			61	59	57	87	04	6
22	0	UNL	10			58	52	46	65	10	5	0	UNL	10			60	53	47	62	12	4	2	UNL	30			56	53	51	83	08	3
					DAY 04											DAY 05											DAY 06						
01	10	45	30			58	53	49	72	34	5	0	UNL	30			53	49	46	77	13	5	8	120	20			56	51	47	72	16	4
04	10	45	30			57	54	51	80	35	5	3	UNL	30			50	47	44	80	10	3	8	UNL	20			54	50	47	77	10	2
07	8	55	30			56	54	52	87	00	0	10	UNL	30			46	43	41	83	14	3	10	120	10			56	51	47	72	06	4
10	8	50	30			63	57	52	68	03	3	9	UNL	10			63	54	46	54	24	4	8	150	10			68	57	49	51	28	3
13	8	35	30			69	57	48	47	31	6	3	UNL	15			72	57	45	38	36	10	9	120	10			76	58	43	31	30	5
16	3	UNL	45			70	58	48	46	34	6	6	250	30			71	58	48	44	31	8	10	120	15			78	57	40	26	32	5
19	0	UNL	30			60	53	47	62	04	6	10	250	20			61	53	46	58	01	5	10	120	15			67	55	44	44	36	6
22	0	UNL	30			55	51	47	75	13	5	8	120	20			60	53	47	62	07	5	9	120	15			62	52	43	50	36	5
					DAY 07											DAY 08											DAY 09						
01	4	UNL	15			59	52	45	60	08	7	4	UNL	30			60	53	46	60	05	5	0	UNL	30			55	49	44	67	09	5
04	10	UNL	15			55	50	45	69	00	0	3	UNL	30			54	50	46	75	09	4	0	UNL	30			52	47	43	72	00	0
07	9	40	15			54	49	45	72	00	0	6	120	30			52	48	45	77	08	7	2	UNL	20			50	46	42	74	07	4
10	10	250	15			66	55	46	49	14	6	2	UNL	30			64	55	47	54	14	3	4	UNL	7			62	54	48	60	00	0
13	10	100	30			73	56	40	30	18	8	2	UNL	30			71	57	45	39	24	6	5	UNL	7			70	58	49	47	02	4
16	10	60	7			69	55	44	41	17	13	0	UNL	30			73	57	44	35	33	7	2	UNL	7			71	58	48	44	31	5
19	10	80	15			63	53	45	52	16	7	0	UNL	30			64	54	45	50	04	7	0	UNL	10			61	53	45	56	02	7
22	10	65	30			63	54	46	54	00	0	0	UNL	30			55	50	45	69	32	4	0	UNL	10			57	51	46	67	11	4
					DAY 10											DAY 11											DAY 12						
01	0	UNL	10			55	50	45	69	08	6	0	UNL	7			54	50	46	75	22	5	0	UNL	5		KH	52	49	46	80	14	3
04	0	UNL	10			47	44	41	80	00	0	4	UNL	7			52	49	46	80	00	0	0	UNL	5		KH	48	45	43	83	10	5
07	0	UNL	5		H	48	45	42	80	10	4	10	UNL	5		H	52	48	44	74	13	5	4	UNL	3		FKH	49	46	44	83	08	5
10	0	UNL	5		H	61	53	47	60	26	5	10	UNL	5		H	65	55	46	50	16	4	3	UNL	3		KH	63	55	49	60	29	4
13	0	UNL	7			72	58	47	41	34	8	10	UNL	5		H	73	59	48	41	32	6	3	UNL	4		KH	73	59	48	41	31	6
16	0	UNL	5		H	72	58	48	43	29	5	0	UNL	6		H	72	59	49	44	29	9	9	UNL	4		KH	75	60	49	40	31	7
19	2	UNL	6		H	61	53	47	60	09	4	0	UNL	7			62	54	48	60	02	7	6	UNL	6		KH	62	54	48	60	01	6
22	0	UNL	7			57	52	48	72	12	5	0	UNL	7			57	52	48	72	00	0	0	UNL	7			58	52	47	67	11	4
					DAY 13											DAY 14											DAY 15						
01	0	UNL	7			51	47	43	74	00	0	3	UNL	3		FH	51	48	45	80	12	3	0	UNL	15			51	46	41	69	00	0
04	0	UNL	5		FH	48	45	43	83	00	0	0	UNL	3		FH	47	44	41	80	00	0	0	UNL	10			48	44	39	71	10	5
07	0	UNL	3		FH	46	44	41	83	08	5	3	UNL	1	8	FH	46	43	40	80	09	5	2	UNL	2		FKH	45	42	39	80	00	0
10	2	UNL	2		KH	63	55	48	58	13	3	5	UNL	2		KH	62	54	48	60	00	0	0	UNL	4		KH	66	55	45	47	27	3
13	10	UNL	3		KH	74	59	47	38	36	5	4	UNL	3		KH	75	60	48	39	28	7	2	UNL	5		KH	76	57	40	27	33	5
16	10	UNL	3		KH	71	59	50	48	30	5	2	UNL	4		KH	77	58	43	30	31	6	1	UNL	7			81	58	37	21	31	6
19	5	UNL	4		KH	60	54	49	67	02	6	0	UNL	7			58	49	41	53	31	4	0	UNL	10			65	49	31	28	00	0
22	3	UNL	4		KH	54	50	46	75	00	0	0	UNL	7			55	49	43	64	07	4	0	UNL	10			59	48	38	46	13	5
					DAY 16											DAY 17											DAY 18						
01	0	UNL	15			56	46	34	44	00	0	10	50	7		R	63	59	56	78	33	6	3	UNL	10			54	52	51	90	36	5
04	0	UNL	10			55	44	32	42	08	6	10	50	7			61	59	57	87	18	4	10	35	10			56	54	52	87	34	8
07	10	UNL	20			50	42	33	52	01	5	10	48	30			60	58	56	87	17	4	3	UNL	1		F	47	46	46	96	30	5
10	10	250	20			66	49	29	25	00	0	10	38	12			63	60	58	84	24	3	9	45	7			56	53	50	80	30	6
13	10	250	7			80	56	33	18	24	4	9	60	10			68	60	55	63	31	12	6	UNL	15			63	54	47	56	34	9
16	10	UNL	10			80	56	32	17	18	3	4	UNL	10			66	60	55	68	35	9	3	UNL	15			63	54	46	54	33	7
19	8	UNL	7			65	50	33	30	07	3	9	45	10			59	56	54	84	31	3	2	UNL	30			56	52	48	75	36	4
22	8	UNL	7			68	51	34	29	36	12	7	UNL	10			55	53	52	90	05	4	3	UNL	30			50	48	46	86	32	7
					DAY 19											DAY 20											DAY 21						
01	0	UNL	30			46	43	40	80	34	5	0	UNL	20			43				10	5	0	UNL	10			41	37	31	67	09	5
04	0	UNL	30			43	42	40	89	09	5	0	UNL	20			42				10	5	0	UNL	10			38	35	31	76	06	5
07	4	UNL	30			45	43	40	83	00	0	8	40	20			39	36	32	76	14	3	0	UNL	7			32	30	27	82	11	6
10	1	UNL	30			55	48	40	57	08	4	4	UNL	8			52	45	38	59	23	5	0	UNL	8			51	43	34	52	16	4
13	3	UNL	20			58	47	36	44	01	6	0	UNL	10			59	48	37	44	00	0	1	UNL	10			65	46	20	18	14	4
16	3	UNL	20			59	48	36	42	31	4	0	UNL	10			60	48	35	39	32	5	3	UNL	15			67	46	19	16	25	6
19	0	UNL	30			51	44	37	59	00	0	0	UNL	10			49	43	35	59	01	5	2	UNL	10			55	44	31	40	14	4
22	0	UNL	20			46	42	38	74	00	0	0	UNL	10			45	41	35	68	08	5	0	UNL	8			47	40	32	56	09	5
					DAY 22											DAY 23											DAY 24						
01	0	UNL	10			45	39	32	60	00	0	10	50	10			56	48	39	53	00	0	0	UNL	15			47	45	42	83	09	5
04	0	UNL	10			43	38	32	65	00	0	10	35	10			56	50	45	67	29	4	0	UNL	5		F	45	44	43	93	12	5
07	8	UNL	10			40	35	27	60	09	10	7	UNL	10			50	44	37	61	05	3	7	UNL	0	4	F	40	40	40	100	00	0
10	10	150	15			55	44	31	40	00	0	10	60	10			59	52	46	62	29	3	10	3	0	8	F	49	48	48	96	10	4
13	7	UNL	7			62	49	36	38	26	5	4	UNL	7			63	51	39	41	20	6	0	UNL	3		H	59	53	48	67	11	3
16	10	UNL	15			64	49	34	33	15	3	1	UNL	7			62	53	45	54	30	9	0	UNL	5		H	64	55	47	54	20	3
19	10	250	10			54	45	34	47	00	0	1	UNL	7			54	49	44	69	06	3	10	38	7			60	53	48	65	36	4
22	10	120	10			55	47	38	53	09	3	0	UNL	10			51	47	44	77	10	4	10	30	7			59	53	48	67	12	2
					DAY 25											DAY 26											DAY 27						
01	7	45	7			55	51	47	75	00	0	0	UNL	10			56	53	50	80	09	6	3	UNL	10			47	43	38	71	34	6
04	10	26	7			58	53	49	72	00	0	0	UNL	10			52	50	48	86	11	3	0	UNL	15			46	43	39	77	00	0
07	10	25	4		H	58	53	49	72	00	0	10	50	5		FH	55	52	50	83	09	4	1	UNL	30			43	40	36	76	00	0
10	10	35	4		H	63	55	49	60	23	4	3	UNL	5		H	64	57	52	65	23	3	1	UNL	10			53	45	37	55	22	5
13	3	UNL	7			69	59	52	55	26	9	8	30	8			71	61	54	55	32	12	5	UNL	10			60	49	38	44	30	4
16	8	UNL	12			70	59	51	51	30	3	9	23	7			64	58	53	68	34	15	0	UNL	10			62	51	40	45	22	4
19	0	UNL	15			60	54	50	70	03	8	10	32	7			59	50	41	51	31	10	0	UNL	20			53	46	39	59	04	4
22	2	UNL	15			57	53	50	78	14	5	3	UNL	7			52	46	40	64	30	6	0	UNL	20			40	39	38	93	07	6
					DAY 28											DAY 29											DAY 30						
01	0	UNL	15			46	43	39	77	14	3	2	UNL	10			48	44	39	71	00	0	0	UNL	5		KH	47	44	41	80	08	5
04	0	UNL	15			43	41	38	83	06	4	0	UNL	10			45	42	39	80	00	0	0	UNL	5		KH	45	43	40	83	12	4
07	4	UNL	15			43	40	37	79	12	3	10	UNL	7			49	44	39	69	12	4	2	UNL	3		KH	43	41	38	83	00	0
10	10	UNL	10			52	46	39	61	22	3	10	250	4		KH	54	48	41	62	23	4	1	UNL	4		KH	56	48	40	55	25	5
13	8	UNL	8			68	54	41	38	08	3	3	UNL	5		KH	64	53	42	45	13	4	3	UNL	3		KH	64	55	47	54	26	8
16	3	UNL	8			68	52	36	31	18	4	3	UNL	4		KH	66	53	42	42	14	4	4	UNL	2	8	KH	63	55	48	58	29	3
19	0	UNL	20			55	47	38	53	35	5	1	UNL	7			53	47	40	62	05	4	3	UNL	3		KH	55	51	48	77	04	5
22	3	UNL	10			57	48	39	51	00	0	2	UNL	7			49	45	41	74	11	4	3	UNL	3		KH	51	48	45	80	14	5

NOTES

CEILING
UNL INDICATES UNLIMITED

WEATHER

*	TORNADO
T	THUNDERSTORM
Q	SQUALL
R	RAIN
RW	RAIN SHOWERS
ZR	FREEZING RAIN
L	DRIZZLE
ZL	FREEZING DRIZZLE
S	SNOW
SP	SNOW PELLETS
IC	ICE CRYSTALS
SW	SNOW SHOWERS
SG	SNOW GRAINS
IP	ICE PELLETS
A	HAIL
F	FOG
IF	ICE FOG
GF	GROUND FOG
BD	BLOWING DUST
BN	BLOWING SAND
BS	BLOWING SNOW
BY	BLOWING SPRAY
K	SMOKE
H	HAZE
D	DUST

WIND

DIRECTIONS ARE THOSE FROM WHICH THE WIND BLOWS, INDICATED IN TENS OF DEGREES FROM TRUE NORTH; I.E., 09 FOR EAST, 18 FOR SOUTH, 27 FOR WEST. ENTRY OF 00 IN THE DIRECTION COLUMN INDICATES CALM.

SPEED IS EXPRESSED IN KNOTS; MULTIPLY BY 1.15 TO CONVERT TO MILES PER HOUR.

BAKERSFIELD CALIFORNIA 79 11

U.S. DEPARTMENT OF COMMERCE
NATIONAL CLIMATIC CENTER
FEDERAL BUILDING
ASHEVILLE, N.C. 28801

AN EQUAL OPPORTUNITY EMPLOYER

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE
COM-210

FIRST CLASS

DECEMBER 1979
BAKERSFIELD, CALIFORNIA
NATIONAL WEATHER SERVICE OFC
KERN COUNTY AIR TERMINAL

Local Climatological Data

MONTHLY SUMMARY

DECEMBER 1979 BAKERSFIELD, CALIFORNIA

LATITUDE 35 °25 'N LONGITUDE 119 °03 'W ELEVATION (GROUND) 475 FT. STANDARD TIME USED: PACIFIC WBAN #23155

	TEMPERATURE °F					DEGREE DAYS BASE 65°		WEATHER TYPES ON DATES OF OCCURRENCE 1 FOG 2 HEAVY FOG 3 THUNDERSTORM 4 ICE PELLETS 5 HAIL 6 GLAZE 7 DUSTSTORM 8 SMOKE, HAZE 9 BLOWING SNOW	SNOW, ICE PELLETS OR ICE ON GROUND AT 04AM IN.	PRECIPITATION		AVG. STATION PRESSURE IN. - - - ELEV. 492 FEET M.S.L.	WIND					SUNSHINE		SKY COVER TENTHS		
DATE	MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	AVERAGE DEW POINT	HEATING (SEASON BEGINS WITH JULY)	COOLING (SEASON BEGINS WITH JAN.)			WATER EQUIVALENT IN	SNOW, ICE PELLETS IN.		RESULTANT DIR.	RESULTANT SPEED M.P.H.	AVERAGE SPEED M.P.H.	FASTEST MILE SPEED M.P.H.	FASTEST MILE DIRECTION	MINUTES	PERCENT OF POSSIBLE	SUNRISE TO SUNSET	MIDNIGHT TO MIDNIGHT	DATE
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	70	40	55	4	45	10	0	1 8	0	0	0	29.66	02	.5	5.0	9	33			2	3	1
2	75	45	60	9	44	5	0	1 8	0	0	0	29.63	07	3.3	3.7	12	09			9	8	2
3	83*	53	68*	18	34	0	3	8	0	0	0	29.74	11	3.3	5.8	9	09			9	7	3
4	71	45	58	8	39	7	0	8	0	0	0	29.82	07	.5	5.3	9	27			5	5	4
5	67	44	56	6	43	9	0	8	0	0	0	29.67	08	1.3	3.6	7	08			2	1	5
6	69	44	57	7	41	8	0	1 8	0	0	0	29.44	08	.9	4.2	8	28			1	0	6
7	74	43	59	10	42	6	0	8	0	0	0	29.41	32	1.7	4.3	12	31			0	1	7
8	77	45	61	12	45	4	0	8	0	0	0	29.60	35	1.2	4.6	8	31			1	1	8
9	74	44	59	10	45	6	0	1 8	0	0	0	29.66	27	.5	3.9	9	24			2	1	9
10	59	45	52	3	49	13	0	1 8	0	0	0	29.56	35	.7	4.6	8	12			10	8	10
11	57	41	49	1	37	16	0	1 8	0	0	0	29.57	30	3.1	5.2	13	30			7	6	11
12	61	37	49	1	34	16	0	8	0	0	0	29.68	12	2.1	5.8	9	31			0	0	12
13	63	37	50	2	36	15	0	8	0	0	0	29.76	36	1.1	4.9	10	28			2	1	13
14	63	36	50	2	38	15	0	1 8	0	0	0	29.74	11	1.6	3.7	7	09			1	1	14
15	63	37	50	2	38	15	0	1 8	0	0	0	29.65	32	1.2	4.9	9	28			2	1	15
16	68	36	52	4	39	13	0	1 8	0	0	0	29.67	01	2.1	4.2	13	33			2	1	16
17	68	34	51	4	39	14	0	1 8	0	0	0	29.68	03	1.8	3.3	7	08			2	1	17
18	75	37	56	9	37	9	0	1 8	0	0	0	29.54	05	2.4	6.5	10	09			2	2	18
19	66	45	56	9	37	9	0	8	0	T	0	29.57	08	1.7	5.2	10	02			9	5	19
20	66	41	54	7	41	11	0	8	0	T	0	29.57	23	.6	3.5	9	36			3	5	20
21	65	47	56	9	49	9	0	3 5 8	0	.17	0	29.49	36	.7	6.8	32	35			7	7	21
22	57	43	50	3	46	15	0	1 8	0	.02	0	29.56	35	2.5	5.6	10	34			9	6	22
23	64	40	52	5	34	13	0		0	0	0	29.49	13	5.9	8.8	20	14			10	8	23
24	64	57	61	14	38	4	0	8	0	.03	0	29.44	15	13.4	17.8	30	15			10	9	24
25	65	45	55	8	47	10	0		0	0	0	29.65	01	6.2	7.8	14	04			8	5	25
26	54	40	47	1	42	18	0		0	0	0	29.67	35	1.0	6.0	9	18			6	5	26
27	61	34	48	2	38	17	0	1	0	0	0	29.70	05	1.1	5.3	9	25			0	0	27
28	57	33*	45*	-1	39	20	0	1 8	0	0	0	29.75	31	2.3	6.3	14	30			9	7	28
29	64	36	50	4	41	15	0	2 8	0	0	0	29.64	14	1.9	4.2	9	28			6	5	29
30	71	42	57	11	43	8	0	1 8	0	0	0	29.57	03	4.2	6.5	16	03			10	8	30
31	72	50	61	15	51	4	0		0	T	0	29.64	01	2.3	6.2	14	32			10	9	31
	SUM	SUM	—	—	—	TOTAL	TOTAL	—		TOTAL	TOTAL	FOR THE MONTH:						TOTAL	%	SUM	SUM	
	2063	1296	—	—	—	334	3	NUMBER OF DAYS		.22	0	29.62	06	.9	5.6	32	35		FOR	156	127	
	AVG.	AVG.	AVG.	DEP.	AVG.	DEP.	DEP.	PRECIPITATION		DEP.	—	—	—	—	—	DATE: 21		POSSIBLE	MONTH	AVG.	AVG.	
	66.5	41.8	54.2	6.3	41	-196	3	> .01 INCH	3	-0.52	—	—	—	—	—	—				5.0	4.1	

				SEASON TO DATE							
NUMBER OF DAYS				TOTAL	TOTAL	SNOW, ICE PELLETS > 1.0 INCH	0	GREATEST IN 24 HOURS AND DATES			GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE
MAXIMUM TEMP.		MINIMUM TEMP.		552	2733	THUNDERSTORMS	1	PRECIPITATION		SNOW, ICE PELLETS	
> 90°	< 32°	< 32°	< 0°	DEP.	DEP.	HEAVY FOG	1	.19	21-22	0	0
0	0	0	0	-309	554	CLEAR 15	PARTLY CLOUDY 5	CLOUDY 11			

* EXTREME FOR THE MONTH - LAST OCCURRENCE IF MORE THAN ONE.
T TRACE AMOUNT
+ ALSO ON AN EARLIER DATE, OR DATES.
HEAVY FOG: - VISIBILITY 1/4 MILE OR LESS.
FIGURES FOR WIND DIRECTIONS ARE TENS OF DEGREES CLOCKWISE FROM TRUE NORTH. 00 = CALM.
DATA IN COLS. 6 AND 12-15 ARE BASED ON 7 OR MORE OBSERVATIONS PER DAY AT 3-HOUR INTERVALS.
FASTEST MILE WIND SPEEDS ARE FASTEST OBSERVED ONE-MINUTE VALUES WHEN DIRECTIONS ARE IN TENS OF DEGREES. THE / WITH THE DIRECTION INDICATES *PEAK GUST SPEED.*
ANY ERRORS DETECTED WILL BE CORRECTED AND CHANGES IN SUMMARY DATA WILL BE ANNOTATED IN THE ANNUAL SUMMARY

SUMMARY BY HOURS

	AVERAGES							RESULTANT WIND	
			TEMPERATURE						
HOUR LOCAL TIME	SKY COVER TENTHS	STATION PRESSURE IN.	AIR °F	WET BULB °F	DEW PT. °F	RELATIVE HUMIDITY %	WIND SPEED M.P.H.	DIRECTION	SPEED M.P.H
01	3	29.62	49	45	40	75	4.3	09	3.0
04	3	29.61	46	43	39	79	5.2	09	2.5
07	4	29.64	44	41	38	79	4.8	11	2.1
10	5	29.66	55	48	41	62	4.6	18	1.5
13	5	29.60	64	53	43	49	6.6	29	4.7
16	5	29.59	64	53	43	48	7.2	28	2.6
19	4	29.61	55	49	43	66	6.4	04	3.6
22	3	29.63	51	47	42	72	5.5	09	3.5

HOURLY PRECIPITATION (WATER EQUIVALENT IN INCHES)

	A. M. HOUR ENDING AT												P. M. HOUR ENDING AT												
DATE	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	DATE
1																									1
2																									2
3																									3
4																									4
5																									5
6																									6
7																									7
8																									8
9																									9
10																									10
11																									11
12																									12
13																									13
14																									14
15																									15
16																									16
17																									17
18																									18
19														T	T										19
20																				T	T				20
21						T										.10	.07	T							21
22		.01	.01																						22
23																									23
24										T	T		T	T	T	.02	T			.01					24
25																									25
26																									26
27																									27
28																									28
29																									29
30																									30
31																	T								31

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION / ENVIRONMENTAL DATA AND INFORMATION SERVICE

Daniel B. Mitchell
DIRECTOR, NATIONAL CLIMATIC CENTER

USCOMM--NOAA--ASHEVILLE 01/31/79 400

OBSERVATIONS AT 3-HOUR INTERVALS

HOUR	SKY COVER TENTHS	CEILING HNDS. OF FT.	VISIBILITY WHOLE MILES	VISIBILITY 16THS MILE	WEATHER	TEMPERATURE AIR °F	TEMPERATURE WET BULB °F	TEMPERATURE DEW PT. °F	REL. HUM. %	WIND DIR	WIND SPEED KNOTS
DAY 01											
01	2	UNL	3		KH	50	46	43	77	09	5
04	2	UNL	3		KH	45	43	41	86	08	4
07	2	UNL	2		KH	42	40	38	86	16	3
10	1	UNL	1	8	KH	62	54	48	60	33	8
13	2	UNL	2		KH	66	56	48	52	25	5
16	7	UNL	2		KH	67	57	49	53	23	5
19	3	UNL	2	8	KH	57	51	46	67	05	5
22	2	UNL	2	8	KH	52	48	45	77	00	0
DAY 02											
01	2	UNL	2	8	KH	50	47	45	83	06	6
04	4	UNL	2	8	KH	50	47	45	83	09	10
07	3	UNL	7			48	45	41	77	00	0
10	10	250	3		KH	61	53	47	60	00	0
13	10	250	3		KH	72	57	45	38	00	0
16	10	250	3		KH	70	56	45	41	09	3
19	10	UNL	4		KH	62	53	45	54	36	3
22	10	UNL	5		KH	61	51	42	50	08	4
DAY 03											
01	10	UNL	7			57	48	39	51	08	7
04	10	UNL	10			53	46	38	57	00	0
07	2	UNL	30			55	45	33	43	08	8
10	9	UNL	30			68	52	37	32	23	4
13	10	UNL	30			80	55	30	16	16	5
16	10	UNL	30			79	55	30	17	25	4
19	7	UNL	30			63	49	34	34	09	7
22	0	UNL	30			61	46	28	29	12	5
DAY 04											
01	0	UNL	30			55	44	32	42	33	3
04	0	UNL	30			48	41	31	52	07	4
07	2	UNL	30			47	40	32	56	11	5
10	8	250	7			62	51	40	45	30	5
13	3	UNL	3		KH	69	56	46	44	25	6
16	10	UNL	3		KH	69	56	45	42	23	4
19	6	UNL	3		KH	58	50	43	58	07	6
22	10	UNL	4		KH	53	47	41	64	10	4
DAY 05											
01	6	UNL	4		KH	51	46	41	69	00	0
04	0	UNL	7			50	45	40	69	00	0
07	1	UNL	3		KH	44	41	38	80	36	5
10	1	UNL	3		KH	59	50	41	51	18	3
13	2	UNL	2	8	KH	65	56	48	54	31	4
16	2	UNL	2	8	KH	67	56	47	49	13	4
19	1	UNL	3		KH	57	51	46	67	10	5
22	0	UNL	4		KH	51	47	43	74	08	4
DAY 06											
01	0	UNL	4		KH	50	46	41	71	09	4
04	0	UNL	4		FKH	45	43	40	83	10	5
07	0	UNL	4		KH	45	42	38	77	10	4
10	1	UNL	4		KH	59	49	40	50	00	0
13	1	UNL	4		KH	67	55	44	44	28	7
16	0	UNL	6		KH	68	54	41	38	22	4
19	0	UNL	7			57	50	43	60	03	5
22	0	UNL	7			52	47	42	69	00	0
DAY 07											
01	0	UNL	7			47	43	38	71	00	0
04	0	UNL	7			46	43	40	80	00	0
07	0	UNL	5		KH	46	43	39	77	17	4
10	1	UNL	3		KH	59	51	43	56	11	3
13	0	UNL	4		KH	72	58	46	40	31	10
16	0	UNL	4		KH	71	57	46	41	30	6
19	0	UNL	7			55	49	43	64	33	4
22	3	UNL	6		KH	55	49	44	67	08	3
DAY 08											
01	0	UNL	6		KH	52	47	43	72	00	0
04	0	UNL	5		KH	50	46	43	77	00	0
07	0	UNL	4		KH	46	44	42	86	10	4
10	0	UNL	4		KH	62	53	46	56	24	3
13	2	UNL	3		KH	75	60	48	39	31	7
16	2	UNL	3		KH	74	59	48	40	27	6
19	0	UNL	5		KH	62	54	47	58	02	6
22	0	UNL	4		KH	57	51	46	67	09	6
DAY 09											
01	0	UNL	4		KH	53	49	45	74	00	0
04	1	UNL	3		KH	50	46	43	77	35	5
07	1	UNL	4		KH	50	46	41	71	10	3
10	3	UNL	2		KH	59	52	46	62	20	4
13	2	UNL	3		KH	71	58	47	43	00	0
16	2	UNL	3		KH	70	58	48	46	24	5
19	0	UNL	4		KH	60	53	47	62	03	6
22	0	UNL	4		KH	56	51	46	69	22	4
DAY 10											
01	2	UNL	2	8	KH	47	45	43	86	00	0
04	2	UNL	2	8	FKH	46	44	43	89	14	5
07	10	4	0	10	F	50	49	48	93	15	5
10	10	26	0	12	F	54	52	51	90	15	3
13	10	25	1	4	F	59	55	52	78	30	4
16	10	25	1	8	FKH	58	54	51	78	36	4
19	10	25	4		FKH	55	53	51	86	35	6
22	10	32	7			56	53	51	83	32	5
DAY 11											
01	10	32	7			55	52	50	83	00	0
04	10	5	2	8	FH	52	51	50	93	30	5
07	10	20	10			48	41	33	56	31	9
10	6	25	20			49	41	32	52	27	6
13	9	25	10			55	44	31	40	24	4
16	1	UNL	5		H	56	46	34	44	26	4
19	0	UNL	7			46	41	34	63	36	3
22	0	UNL	7			43	39	34	71	08	5
DAY 12											
01	0	UNL	7			41	38	34	76	11	5
04	0	UNL	10			38	36	32	79	12	5
07	0	UNL	8			37	35	31	79	11	5
10	0	UNL	6		H	50	42	32	50	12	3
13	0	UNL	6		H	57	47	36	46	25	6
16	0	UNL	6		H	58	48	38	48	26	6
19	0	UNL	7			48	42	36	63	03	5
22	0	UNL	7			44	40	35	71	11	5
DAY 13											
01	0	UNL	7			41	38	33	73	00	0
04	0	UNL	7			39	37	34	82	10	4
07	6	UNL	5		H	38	36	32	79	10	4
10	3	UNL	4		H	50	43	34	54	23	4
13	0	UNL	4		H	60	49	38	44	31	7
16	0	UNL	4		H	61	50	40	46	27	5
19	0	UNL	7			51	45	39	64	01	5
22	0	UNL	7			46	42	38	74	06	5
DAY 14											
01	0	UNL	7			41	39	36	82	11	4
04	0	UNL	5		H	40	38	35	82	00	0
07	1	UNL	3		H	38	36	33	82	11	3
10	2	UNL	2	8	H	51	45	38	61	00	0
13	1	UNL	3		H	59	49	40	50	17	4
16	1	UNL	3		H	61	51	41	48	24	4
19	0	UNL	5		H	51	45	39	64	02	6
22	0	UNL	6		H	45	42	39	80	10	5
DAY 15											
01	0	UNL	6		H	43	40	37	79	00	0
04	0	UNL	5		FH	40	38	35	82	00	0
07	2	UNL	2		F	37	36	35	92	13	5
10	2	UNL	2		H	53	46	39	59	29	6
13	2	UNL	2	8	H	62	52	42	48	28	8
16	2	UNL	2	8	H	62	51	41	46	30	4
19	0	UNL	4		H	52	46	40	64	03	6
22	0	UNL	4		H	46	42	38	74	10	5
DAY 16											
01	0	UNL	5		KH	46	43	39	77	00	0
04	0	UNL	5		KH	39	37	35	86	00	0
07	5	UNL	1	8	F	37	36	34	89	12	4
10	1	UNL	3		H	50	44	38	64	00	0
13	2	UNL	2	8	H	67	54	43	42	34	8
16	1	UNL	3		H	64	53	42	45	30	7
19	0	UNL	4		H	51	46	40	66	04	5
22	0	UNL	4		H	46	42	38	74	07	5
DAY 17											
01	0	UNL	3		H	43	40	37	79	01	5
04	0	UNL	3		H	40	38	35	82	09	5
07	4	UNL	1	4	FH	37	36	34	89	00	0
10	2	UNL	1		FH	51	46	40	66	00	0
13	2	UNL	2		H	63	53	43	48	00	0
16	2	UNL	2		H	66	54	43	43	28	4
19	1	UNL	3		H	53	47	42	66	36	4
22	0	UNL	3		H	47	44	40	77	08	5
DAY 18											
01	0	UNL	3		H	45	42	39	80	10	5
04	1	UNL	2	8	FH	44	42	39	83	12	5
07	1	UNL	2	8	FH	43	41	38	83	07	4
10	2	UNL	1	4	H	54	48	41	62	31	7
13	0	UNL	3		H	71	54	38	30	27	6
16	4	UNL	4		H	73	53	34	24	36	6
19	5	UNL	7			60	48	35	39	09	7
22	0	UNL	7			55	45	33	43	06	5
DAY 19											
01	0	UNL	7			55	43	29	37	00	0
04	0	UNL	7			51	43	33	50	12	4
07	6	250	3		H	50	44	37	61	11	6
10	10	120	7			60	47	33	36	14	3
13	10	120	6		H	66	50	33	29	15	5
16	5	UNL	20			63	52	42	46	35	8
19	5	UNL	30			57	50	44	62	33	7
22	6	75	10			55	49	43	64	11	3
DAY 20											
01	3	UNL	10			50	46	42	74	00	0
04	0	UNL	10			46	42	38	74	13	4
07	1	UNL	5		H	41	39	36	82	29	3
10	0	UNL	4		H	55	48	41	59	16	5
13	1	UNL	4		H	65	52	40	40	23	4
16	9	140	6		H	65	52	40	40	30	4
19	10	90	7			59	50	41	51	02	4
22	10	55	7			56	52	48	75	00	0
DAY 21											
01	10	45	7			56	53	50	80	04	7
04	9	41	7			54	52	51	90	14	5
07	8	65	3		H	52	49	47	83	15	4
10	8	60	4		H	60	54	49	67	00	0
13	7	70	10			63	55	49	60	28	9
16	8	45	8		TRW	58	54	50	75	02	8
19	4	UNL	7			50	49	48	93	26	9
22	4	UNL	7			49	48	48	96	10	5
DAY 22											
01	5	UNL	10			49	47	46	89	04	5
04	5	UNL	6		FH	46	46	46	100	30	5
07	10	30	2	8	FH	45	45	45	100	31	5
10	10	22	4		FH	50	49	48	93	28	3
13	10	14	5		FH	54	51	48	80	36	6
16	10	38	20			55	50	46	72	30	5
19	2	UNL	8			49	46	44	83	11	4
22	0	UNL	7			45	44	43	93	09	6
DAY 23											
01	0	UNL	10			45	42	38	77	07	7
04	0	UNL	10			42	40	37	83	00	0
07	10	250	30			42	40	38	86	31	7
10	10	120	30			51	45	39	64	11	6
13	10	90	30			61	50	38	43	11	3
16	10	100	30			64	47	28	26	13	10
19	10	75	20			59	45	27	29	15	13
22	10	120	7			60	45	26	27	15	15
DAY 24											
01	10	120	7			64	46	22	20	15	20
04	10	90	7			63	45	22	21	14	26
07	10	80	2		BD	63	46	26	25	14	20
10	10	60	5		RBD	63	50	38	40	16	22
13	10	60	5		RBD	61	53	46	58	27	9
16	10	55	10		R	59	53	48	67	14	15
19	10	55	30		R	60	53	47	62	17	4
22	10	41	30		R	57	55	53	87	34	8
DAY 25											
01	10	45	30			57	54	51	80	02	6
04	0	UNL	30			54	50	47	77	04	12
07	3	UNL	30			47	46	46	96	00	0
10	7	UNL	10			56	53	50	80	09	5
13	9	UNL	10			63	54	46	54	33	10
16	8	UNL	20			64	54	46	52	34	8
19	4	UNL	20			53	49	46	77	01	8
22	6	40	30			48	47	46	93	32	5
DAY 26											
01	10	25	7			50	50	50	100	32	4
04	7	25	30			48	47	47	96	32	8
07	3	UNL	7			41	41	40	96	00	0
10	10	12	8			46	44	42	86	36	5
13	10	20	10			50	45	40	69	30	5
16	1	UNL	15			53	47	40	62	18	8
19	0	UNL	15			46	43	40	80	12	6
22	0	UNL	15			43	41	38	83	08	6
DAY 27											
01	0	UNL	15			40	39	37	89	07	5
04	0	UNL	5		F	36	35	34	92	34	4
07	0	UNL	30			35	34	32	89	11	4
10	0	UNL	30			49	43	37	63	16	4
13	0	UNL	15			57	49	41	55	30	6
16	0	UNL	15			59	50	42	54	28	5
19	0	UNL	20			48	45	42	80	05	5
22	0	UNL	20			45	43	40	83	12	4
DAY 28											
01	0	UNL	10			40	39	37	89	10	5
04	0	UNL	7			36	36	35	96	32	4
07	2	UNL	7			34	33	32	92	00	0
10	6	UNL	4		H	48	44	40	74	17	6
13	10	150	4		H	53	48	43	69	31	10
16	10	150	7			57	49	42	57	26	10
19	10	80	3		FH	45	44	42	89	34	3
22	10	5	1	8	FH	45	44	43	93	02	6
DAY 29											
01	3	UNL	1		FH	41	41	41	100	12	4
04	6	UNL	0	12	F	41	41	41	100	12	6
07	10	0	0		F	40	40	40	100	23	3
10	10	0	0		F	40	40	40	100	00	0
13	1	UNL	3		H	55	49	43	64	30	4
16	7	UNL	7			62	51	41	46	18	5
19	0	UNL	5		H	49	46	42	77	06	4
22	1	UNL	5		H	48	45	41	77	14	3
DAY 30											
01	4	UNL	5		FH	45	43	40	83	12	5
04	2	UNL	7			49	42	34	56	04	6
07	9	50	30			47	43	38	71	00	0
10	8	70	30			55	48	40	57	00	0
13	10	55	30			67	56	46	47	32	10
16	10	55	30			71	59	49	46	36	10
19	10	45	30			59	54	50	72	08	8
22	6	45	30			58	53	48	70	03	6
DAY 31											
01	4	UNL	30			55	51	47	75	10	5
04	9	150	30			54	50	47	77	00	0
07	10	120	30			53	49	46	77	35	3
10	10	200	30			63	55	48	58	14	6
13	10	UNL	30			70	58	49	47	33	7
16	10	70	20			71	62	56	59	32	12
19	10	250	15			58	57	56	93	35	4
22	10	UNL	20			60	58	57	90	10	6

NOTES

CEILING
UNL INDICATES UNLIMITED

WEATHER

*	TORNADO
T	THUNDERSTORM
Q	SQUALL
R	RAIN
RW	RAIN SHOWERS
ZR	FREEZING RAIN
L	DRIZZLE
ZL	FREEZING DRIZZLE
S	SNOW
SP	SNOW PELLETS
IC	ICE CRYSTALS
SW	SNOW SHOWERS
SG	SNOW GRAINS
IP	ICE PELLETS
A	HAIL
F	FOG
IF	ICE FOG
GF	GROUND FOG
BD	BLOWING DUST
BN	BLOWING SAND
BS	BLOWING SNOW
BY	BLOWING SPRAY
K	SMOKE
H	HAZE
D	DUST

WIND

DIRECTIONS ARE THOSE FROM WHICH THE WIND BLOWS, INDICATED IN TENS OF DEGREES FROM TRUE NORTH: I.E., 09 FOR EAST, 18 FOR SOUTH, 27 FOR WEST. ENTRY OF 00 IN THE DIRECTION COLUMN INDICATES CALM.

SPEED IS EXPRESSED IN KNOTS; MULTIPLY BY 1.15 TO CONVERT TO MILES PER HOUR.

BAKERSFIELD CALIFORNIA 79 12

U.S. DEPARTMENT OF COMMERCE
NATIONAL CLIMATIC CENTER
FEDERAL BUILDING
ASHEVILLE, N.C. 28801

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE
COM-210

U.S.MAIL

FIRST CLASS

Day: 58

Time: 08:00

Average Cosine: 0.7037

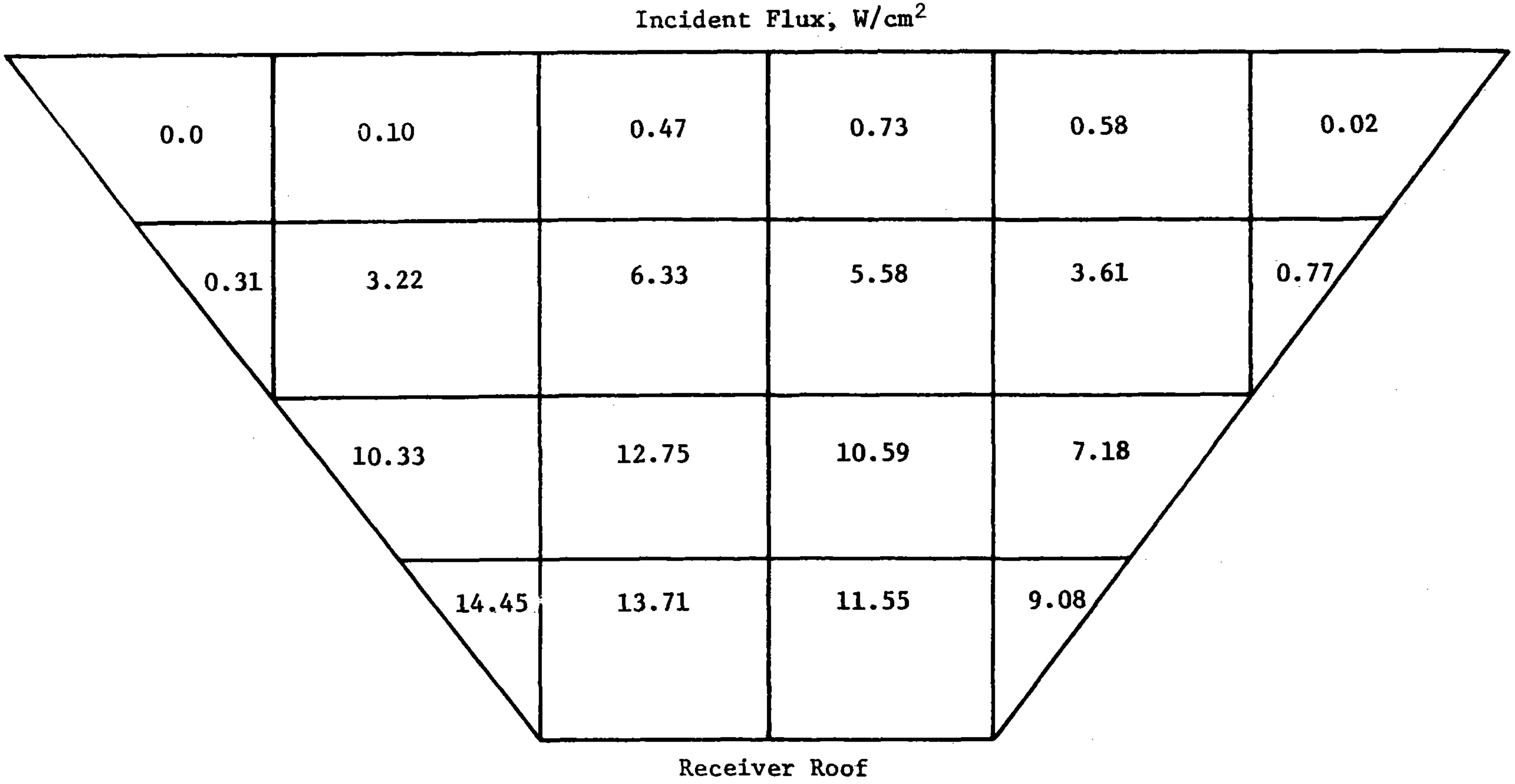
Total Incident Power: 7.31 MW

Incident Flux, W/cm^2

	0.0	1.27	13.0	21.36	24.01	22.93	18.87	12.43	7.71	1.63	0.04
	0.03	2.84	18.02	25.53	28.38	27.22	22.03	14.26	9.27	2.20	0.07
	0.16	4.57	20.28	27.22	30.95	29.29	23.55	14.54	9.42	2.47	0.09
	0.30	6.05	21.04	27.66	31.81	29.49	23.44	13.77	8.66	2.40	0.08
	0.33	6.21	19.00	23.74	26.93	24.98	19.70	11.44	7.24	2.10	0.08
	0.21	4.43	12.84	15.00	16.77	16.03	12.63	7.53	4.99	1.53	0.07
	0.06	1.85	5.70	6.10	6.68	6.77	5.30	3.42	2.57	0.79	0.03
	0.0	0.28	1.08	0.99	1.09	1.11	0.81	0.52	0.56	0.16	0.0
	0.0	0.0	0.02	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0
	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Node Area	0.833 m^2 (8.968 ft^2)				0.587 m^2 (6.324 ft^2)			0.833 m^2 (8.968 ft^2)			

Receiver Walls

Figure B-1 Receiver Cavity Heat Fluxes, 8:00 Day 58



0.0	0.10	0.47	0.73	0.58	0.02
0.31	3.22	6.33	5.58	3.61	0.77
	10.33	12.75	10.59	7.18	
	14.45	13.71	11.55	9.08	

Figure B-1 (concl)

Day: 58

Time: 1000

Total Incident Power: 13.18 MW

Average Cosine: 0.8488

Incident Flux, W/cm^2

	0.0	1.50	21.87	37.51	43.11	43.07	35.92	25.49	16.28	2.50	0.03
	0.02	3.58	30.44	44.27	49.79	50.19	41.34	28.83	19.29	3.41	0.05
	0.18	6.37	33.73	47.07	55.12	54.18	44.77	29.09	18.76	3.75	0.05
	0.40	9.16	35.95	49.83	59.40	56.99	46.91	28.50	17.06	3.76	0.09
	0.43	9.69	33.18	43.35	50.52	48.71	39.67	24.00	14.43	3.46	0.11
	0.25	6.52	21.44	25.72	29.08	28.96	23.53	14.86	9.61	2.44	0.07
	0.06	2.30	8.26	8.95	9.85	10.35	8.31	5.62	4.18	0.94	0.01
	0.0	0.24	1.16	1.18	1.34	1.45	1.06	0.61	0.53	0.09	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Node Area	0.833 m^2 (8.968 ft^2)				0.587 m^2 (6.324 ft^2)			0.833 m^2 (8.968 ft^2)			

Receiver Walls

Figure B-2 Receiver Cavity Heat Fluxes, 10:00 Day 58

Figure B-2 (concl)

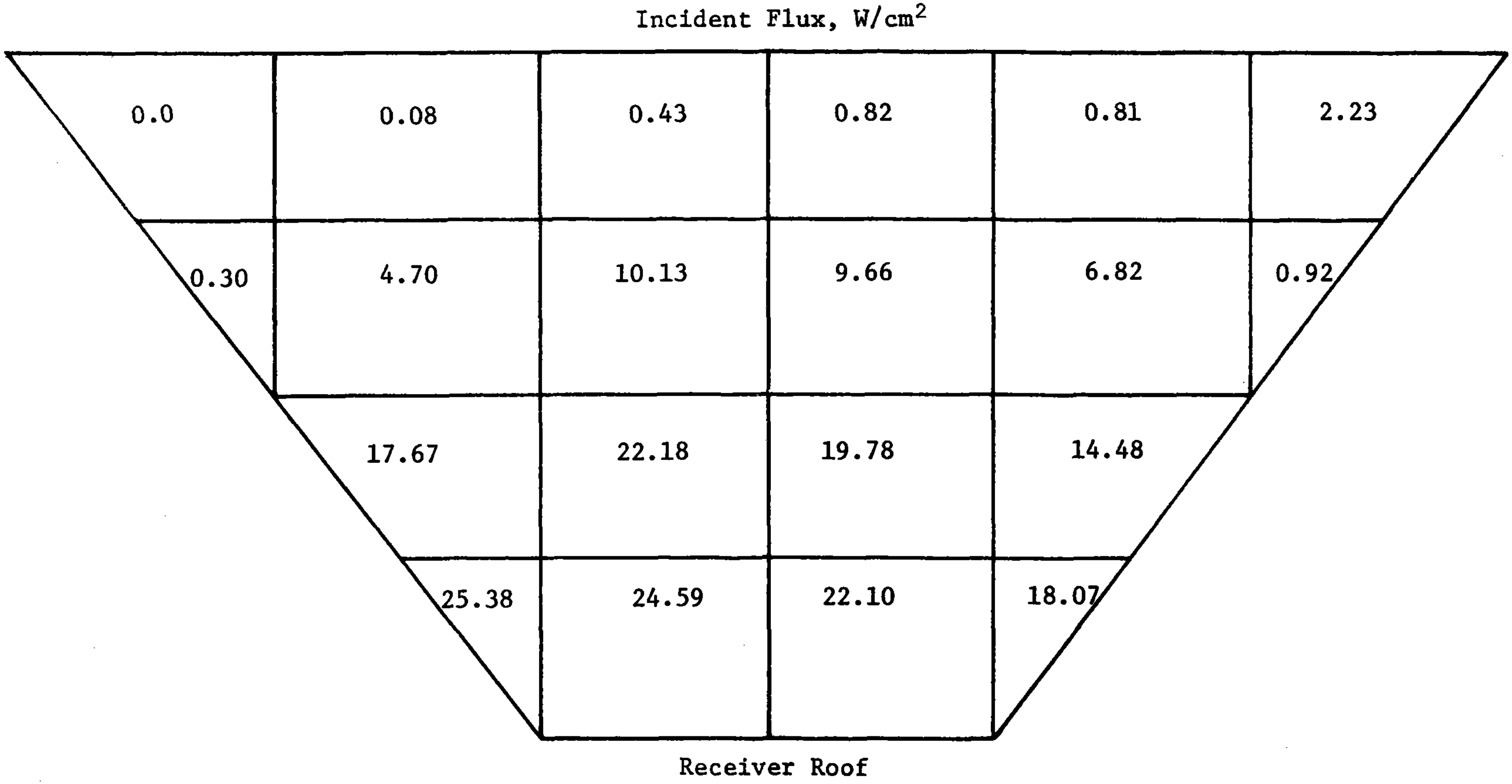


Figure B-2 (concl)

Day: 58

Time: 1200

Total Incident Power: 15.660 MW

Average Cosine: 0.9437

Incident Flux, W/cm^2

	0.0	1.40	24.41	43.05	50.75	52.58	44.30	33.31	21.80	2.48	0.0
	0.01	3.47	33.94	50.43	57.68	60.38	49.99	36.94	25.56	3.40	0.01
	0.16	6.48	37.40	53.87	64.84	65.54	55.47	37.02	23.63	3.54	0.0
	0.39	9.68	40.57	58.79	72.73	71.91	61.18	38.03	21.52	3.73	0.03
	0.42	10.36	37.97	51.46	61.74	61.66	51.90	32.56	18.68	3.69	0.05
	0.24	6.75	23.79	29.16	33.38	34.14	28.34	18.65	11.87	2.41	0.03
	0.05	2.20	8.42	9.11	9.86	10.51	8.34	5.76	4.18	0.66	0.00
	0.0	0.19	1.01	1.03	1.12	1.19	0.84	0.43	0.26	0.22	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Node Area	0.833 m^2 (8.968 ft^2)				0.587 m^2 (6.324 ft^2)			0.833 m^2 (8.968 ft^2)			

Receiver Walls

Figure B-3 Receiver Cavity Heat Fluxes, 12:00 Day 58

Figure B-3 (concl)

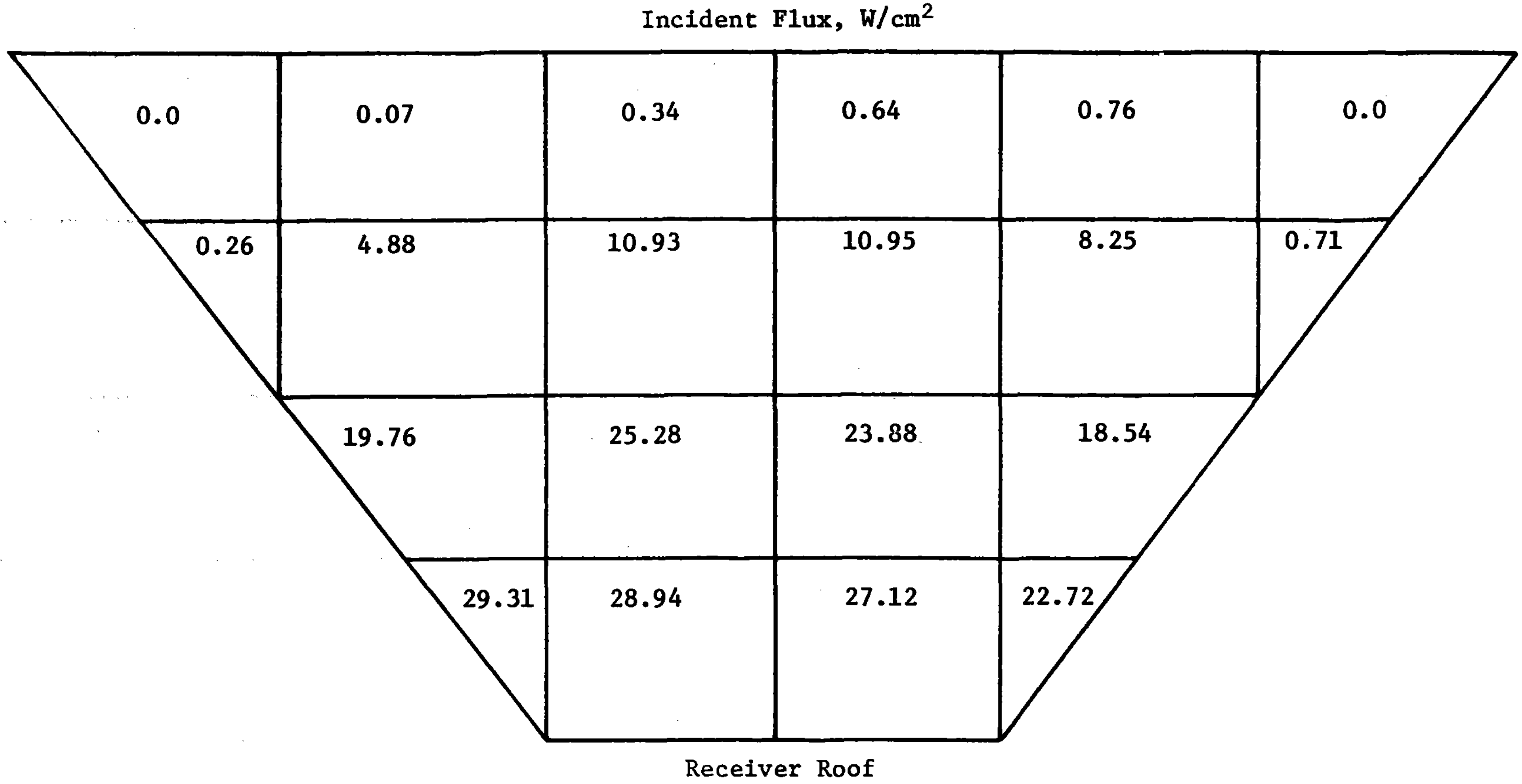


Figure B-3 (concl)

Day: 58

Time: 1400

Total Incident Power: 15.282 MW

Average Cosine: 0.9798

Incident Flux, W/cm^2

	0.0	1.39	22.25	40.06	48.67	51.68	44.12	34.65	23.26	2.14	0.0
	0.01	3.33	31.00	47.00	55.33	59.29	49.47	38.05	27.05	2.94	0.0
	0.16	6.09	34.46	50.69	62.85	64.97	56.08	38.06	24.11	2.89	0.0
	0.38	8.99	37.50	55.81	71.58	73.03	63.98	40.59	22.14	3.18	0.01
	0.41	9.55	34.98	48.77	60.64	62.52	54.12	35.13	19.79	3.33	0.02
	0.23	6.25	21.92	27.40	32.00	33.34	28.02	18.93	11.97	2.01	0.01
	0.05	2.09	7.80	8.43	8.96	9.49	7.35	5.01	3.48	0.40	0.0
	0.0	0.19	0.95	0.93	0.94	0.96	0.64	0.29	0.12	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Node Area	0.833 m^2 (8.968 ft^2)				0.587 m^2 (6.324 ft^2)			0.833 m^2 (8.968 ft^2)			

Receiver Walls

Figure B-4 Receiver Cavity Heat Fluxes, 14:00 Day 58

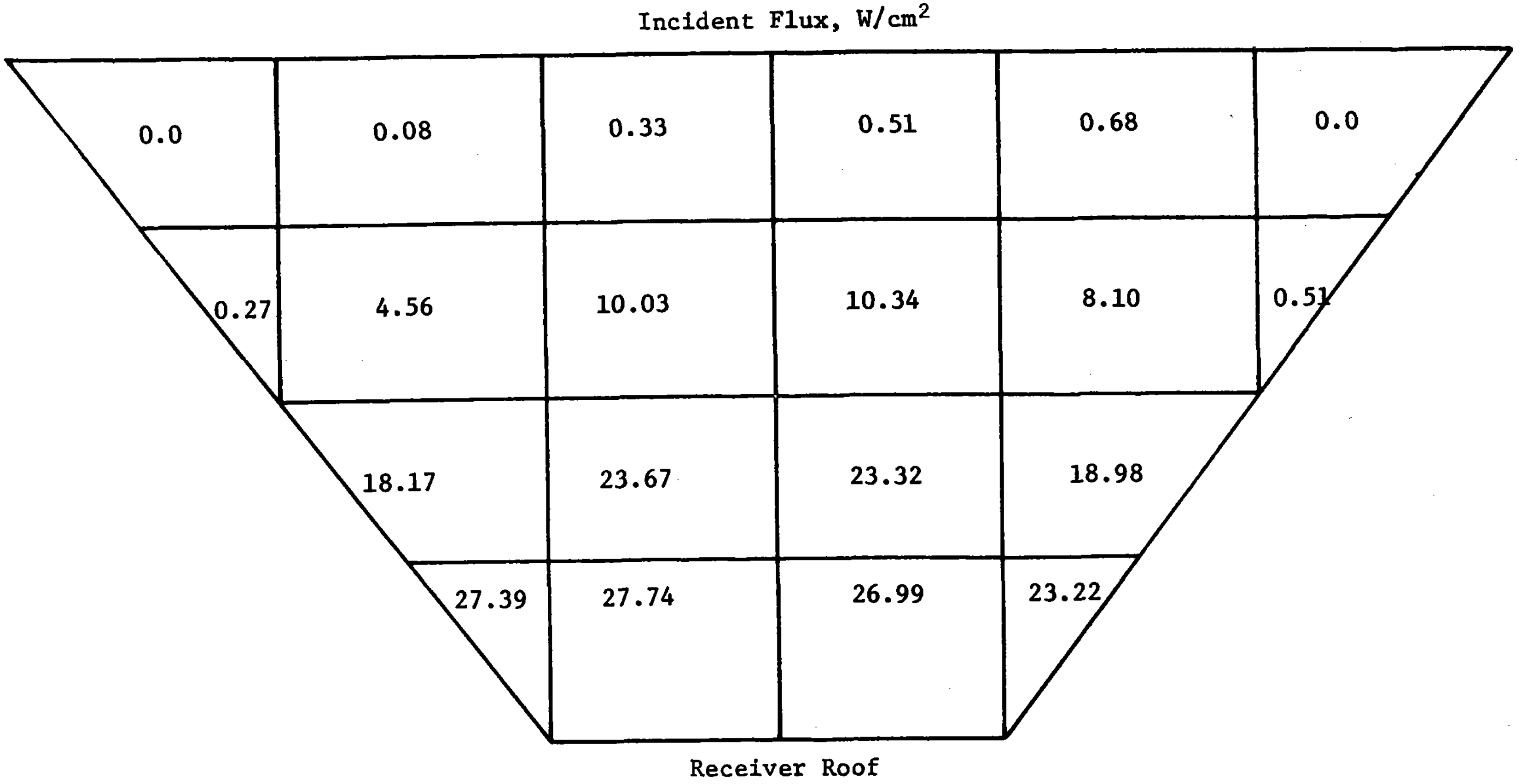


Figure B-4 (concl)

Day: 58

Time: 1600

Total Incident Power: 10.033 MW

Average Cosine: 0.9543

Incident Flux, W/cm^2

	0.0	1.14	13.51	24.66	31.16	33.54	29.30	23.63	16.11	1.42	0.0
	0.02	2.53	18.91	29.29	36.07	39.01	33.24	26.06	18.77	1.95	0.0
	0.14	4.28	21.52	32.05	41.11	43.35	38.09	26.23	16.65	1.87	0.0
	0.29	5.94	23.18	34.72	46.12	48.47	43.52	28.25	15.42	2.08	0.0
	0.32	6.19	21.30	30.18	39.06	41.41	36.72	24.48	13.91	2.22	0.01
	0.19	4.22	13.74	17.49	21.15	22.36	19.01	13.02	8.29	1.31	0.0
	0.05	1.59	5.34	5.83	6.24	6.53	4.99	3.33	2.26	0.24	0.0
	0.0	0.19	0.78	0.71	0.69	0.69	0.44	0.18	0.06	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Node Area	0.833 m^2 (8.968 ft^2)				0.587 m^2 (6.324 ft^2)			0.833 m^2 (8.968 ft^2)			

Receiver Walls

Figure B-5 Receiver Cavity Heat Fluxes, 16:00 Day 58

Figure B-5 (concl)

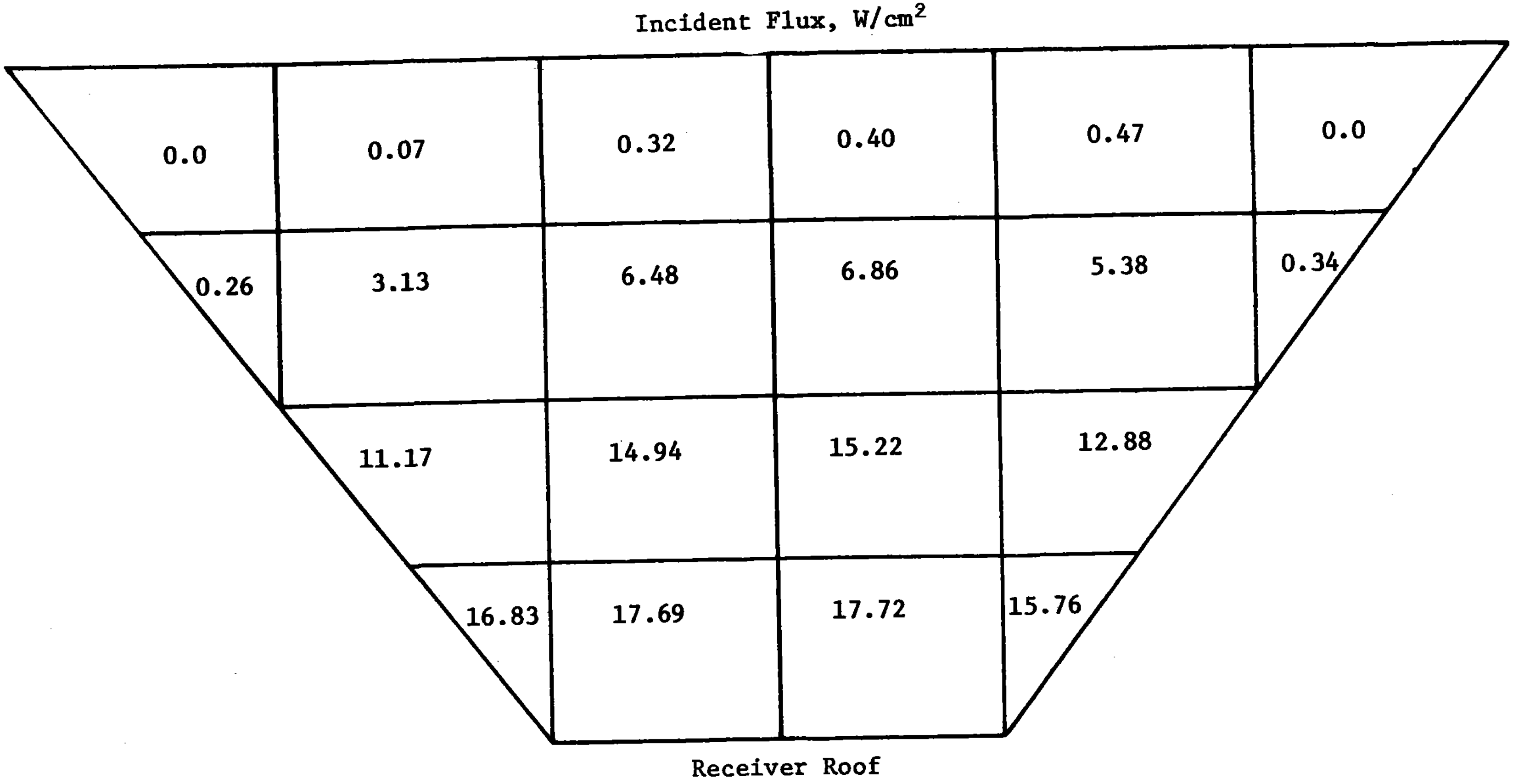


Figure B-5 (concl)

Day: 80

Time: 0800

Total Incident Power: 7.864 MW

Average Cosine: 0.6865

Incident Flux, W/cm^2

	0.0	1.45	14.07	23.02	25.91	24.79	20.49	13.64	8.57	1.80	0.04
	0.03	3.19	19.42	27.83	30.47	29.23	23.75	15.52	10.24	2.44	0.07
	0.19	5.05	21.72	28.96	32.89	31.18	25.13	15.56	10.30	2.73	0.09
	0.35	6.57	22.31	29.11	33.49	31.11	24.80	14.68	9.38	2.63	0.09
	0.38	6.71	20.02	24.93	28.34	26.32	20.81	12.17	7.79	2.28	0.09
	0.24	4.84	13.67	15.94	17.87	17.05	13.47	8.06	5.40	1.67	0.08
	0.08	2.10	6.25	6.66	7.30	7.36	5.77	3.72	2.82	0.88	0.03
	0.0	0.35	1.26	1.13	1.19	1.21	0.88	0.58	0.64	0.19	0.0
	0.0	0.0	0.02	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Node Area	0.833 m^2 (8.968 ft^2)				0.587 m^2 (6.324 ft^2)			0.833 m^2 (8.968 ft^2)			

Receiver Walls

Figure B-6 Receiver Cavity Heat Fluxes, 8:00 Day 80

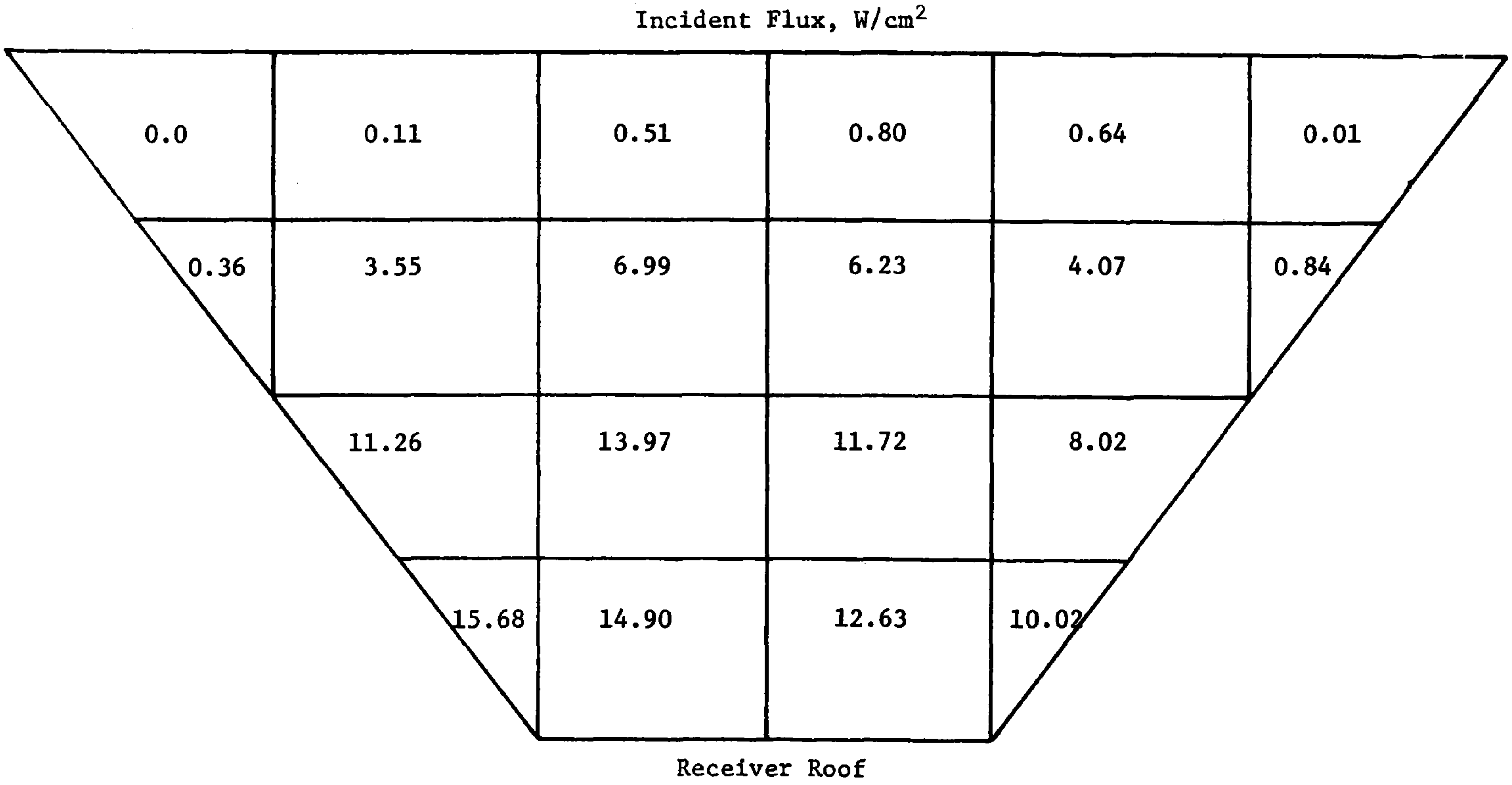


Figure B-6 (concl)

Figure B-6 (concl)

Day: 80

Time: 1000

Total Incident Power: 13.078 MW

Average Cosine: 0.8362

Incident Flux, W/cm^2

	0.0	1.56	21.77	37.21	42.85	42.89	35.92	25.68	16.57	2.52	0.02
	0.02	3.71	30.17	43.74	49.36	49.82	41.18	29.0	19.57	3.46	0.05
	0.20	6.47	33.28	46.22	54.18	53.38	44.24	29.0	18.91	3.79	0.05
	0.41	9.15	35.10	48.43	57.85	55.70	46.04	28.17	17.06	3.79	0.08
	0.45	9.64	32.27	42.07	49.24	47.60	38.94	23.72	14.39	3.50	0.11
	0.27	6.58	21.09	25.28	28.71	28.61	23.33	14.77	9.63	2.48	0.07
	0.07	2.42	8.38	9.07	9.98	10.47	8.39	5.67	4.236	0.10	0.01
	0.0	0.27	1.26	1.24	1.41	1.53	1.12	0.64	0.57	0.09	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Node Area	0.833 m^2 (8.968 ft^2)				0.587 m^2 (6.324 ft^2)			0.833 m^2 (8.968 ft^2)			

Receiver Walls

Figure B-7 Receiver Cavity Heat Fluxes, 10:00 Day 80

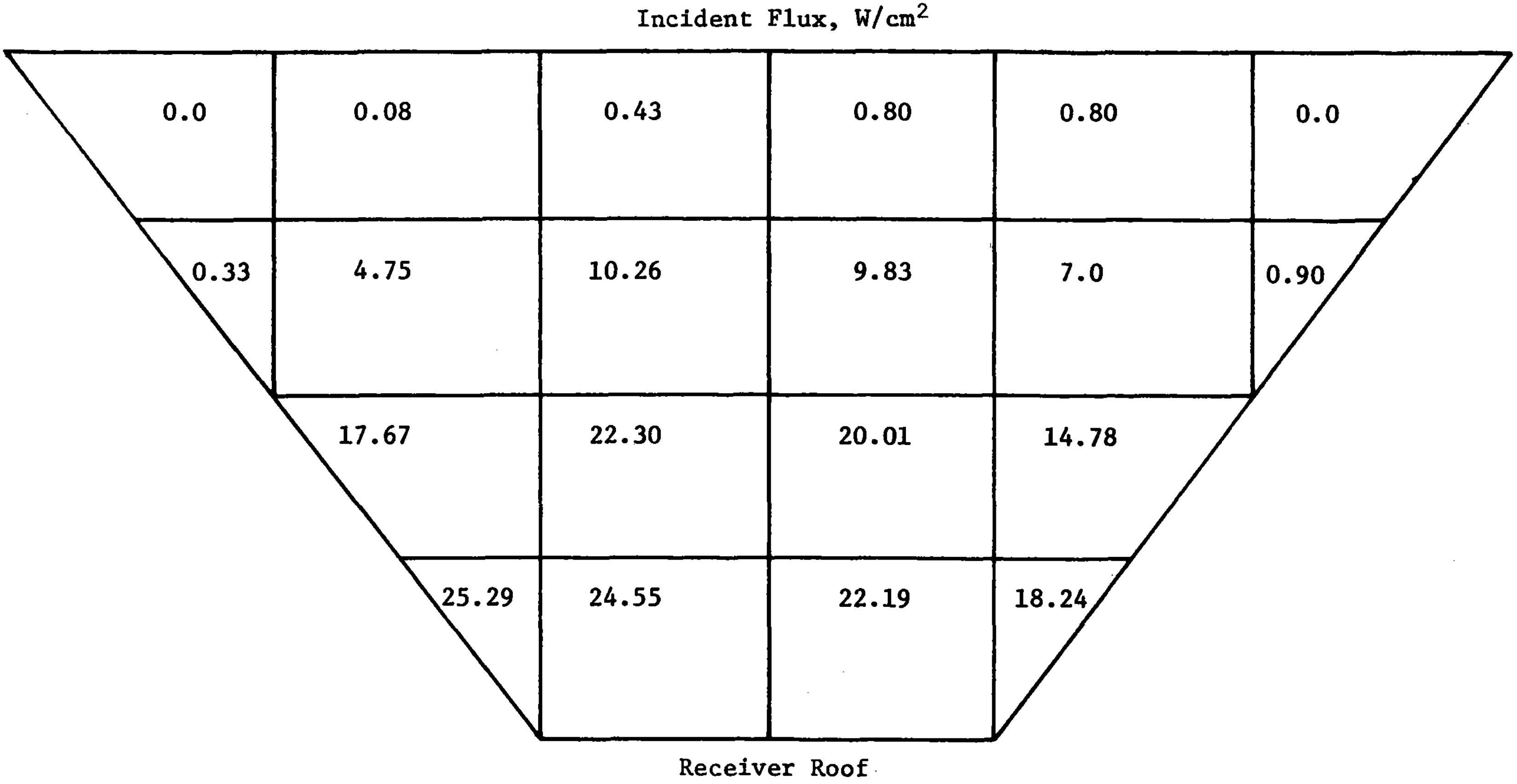


Figure B-7 (concl)

Figure B-7 (concl)

Day: 80

Time: 1200

Total Incident Power: 15.482 MW

Average Cosine: 0.9333

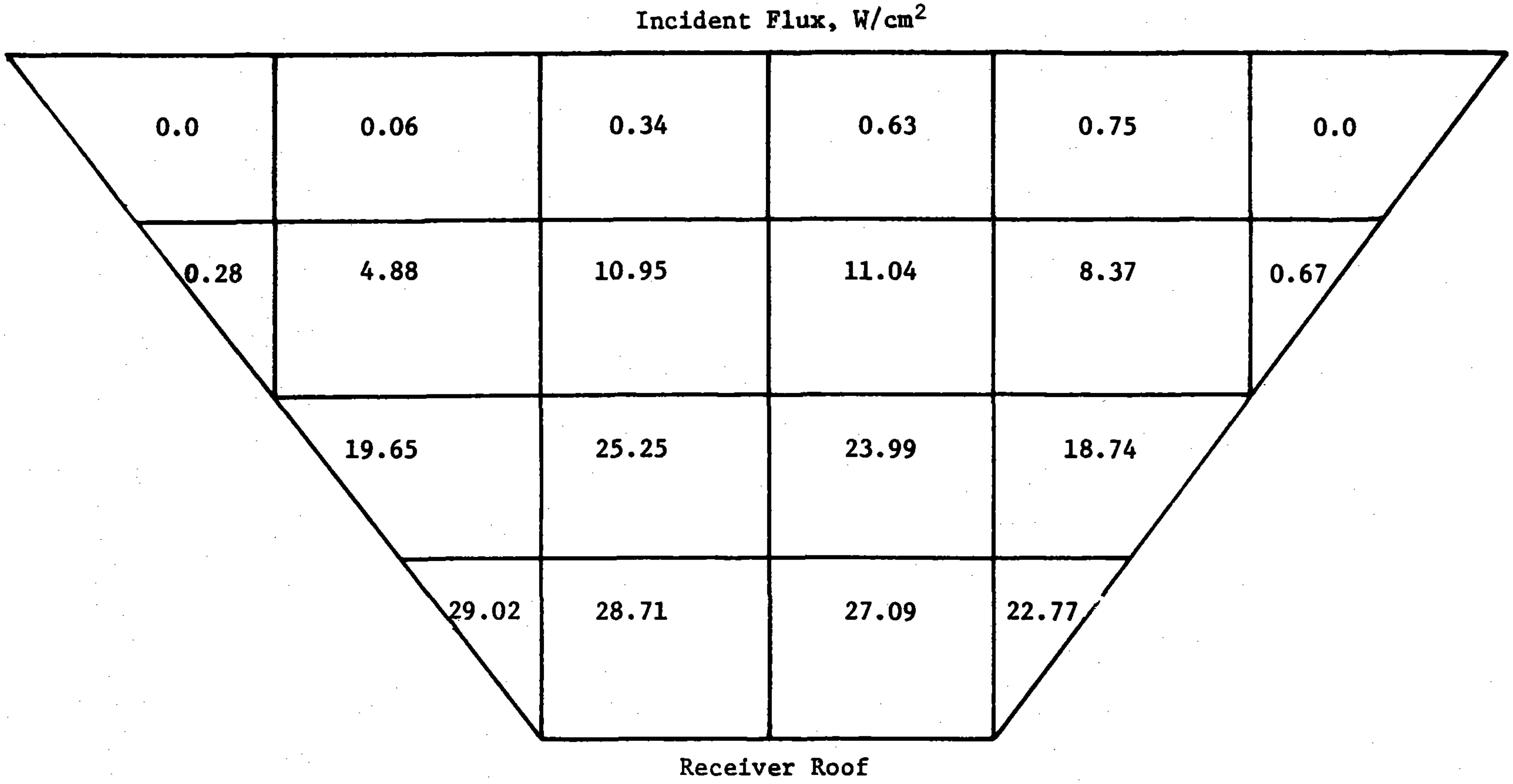
Incident Flux, W/cm^2

	0.0	1.47	24.16	42.49	50.28	52.17	44.15	33.41	22.01	2.46	0.0
	0.02	3.57	33.48	49.62	57.01	59.79	49.66	36.98	25.78	3.41	0.01
	0.18	6.54	36.75	52.69	63.60	64.49	54.73	36.77	23.70	3.56	0.0
	0.40	9.64	39.47	56.94	70.72	70.19	59.99	37.56	21.44	3.74	0.03
	0.44	10.28	36.78	49.80	60.09	60.23	50.94	32.16	18.62	3.70	0.05
	0.25	6.78	23.30	28.60	32.91	33.71	28.08	18.54	11.88	2.43	0.02
	0.06	2.29	8.50	9.22	10.01	10.62	8.43	5.82	4.23	0.67	0.0
	0.0	0.22	1.09	1.10	1.19	1.25	0.88	0.45	0.27	0.02	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Node Area	0.833 m^2 (8.968 ft^2)				0.587 m^2 (6.324 ft^2)			0.833 m^2 (8.968 ft^2)			

Receiver Walls

Figure B-8 Receiver Cavity Heat Fluxes, 12:00 Day 80

Figure B-8 (concl)



0.0	0.06	0.34	0.63	0.75	0.0
0.28	4.88	10.95	11.04	8.37	0.67
	19.65	25.25	23.99	18.74	
	29.02	28.71	27.09	22.77	

Figure B-8 (concl)

Day: 80

Time: 1400

Total Incident Power: 15.247 MW

Average Cosine: 0.9701

Incident Flux, W/cm^2

	0.0	1.45	22.15	39.86	48.66	51.78	44.39	35.05	23.69	2.13	0.0
	0.02	3.47	30.78	46.62	55.20	59.29	49.64	38.42	27.52	2.93	0.0
	0.18	6.21	34.11	50.00	62.19	64.54	55.92	38.21	24.36	2.91	0.0
	0.39	9.00	36.74	54.50	70.25	72.02	63.42	40.52	22.27	3.22	0.01
	0.43	9.54	34.16	47.58	59.61	61.72	53.71	35.10	19.94	3.38	0.02
	0.26	6.34	21.64	27.10	31.88	33.27	28.06	19.02	12.10	2.05	0.0
	0.06	2.20	7.93	8.60	9.18	9.70	7.52	5.10	3.55	0.41	0.0
	0.0	0.22	1.03	0.10	1.01	1.03	0.68	0.31	0.13	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Node Area	0.833 m^2 (8.968 ft^2)				0.587 m^2 (6.324 ft^2)			0.833 m^2 (8.968 ft^2)			

Receiver Walls

Figure B-9 Receiver Cavity Heat Fluxes, 14:00 Day 80

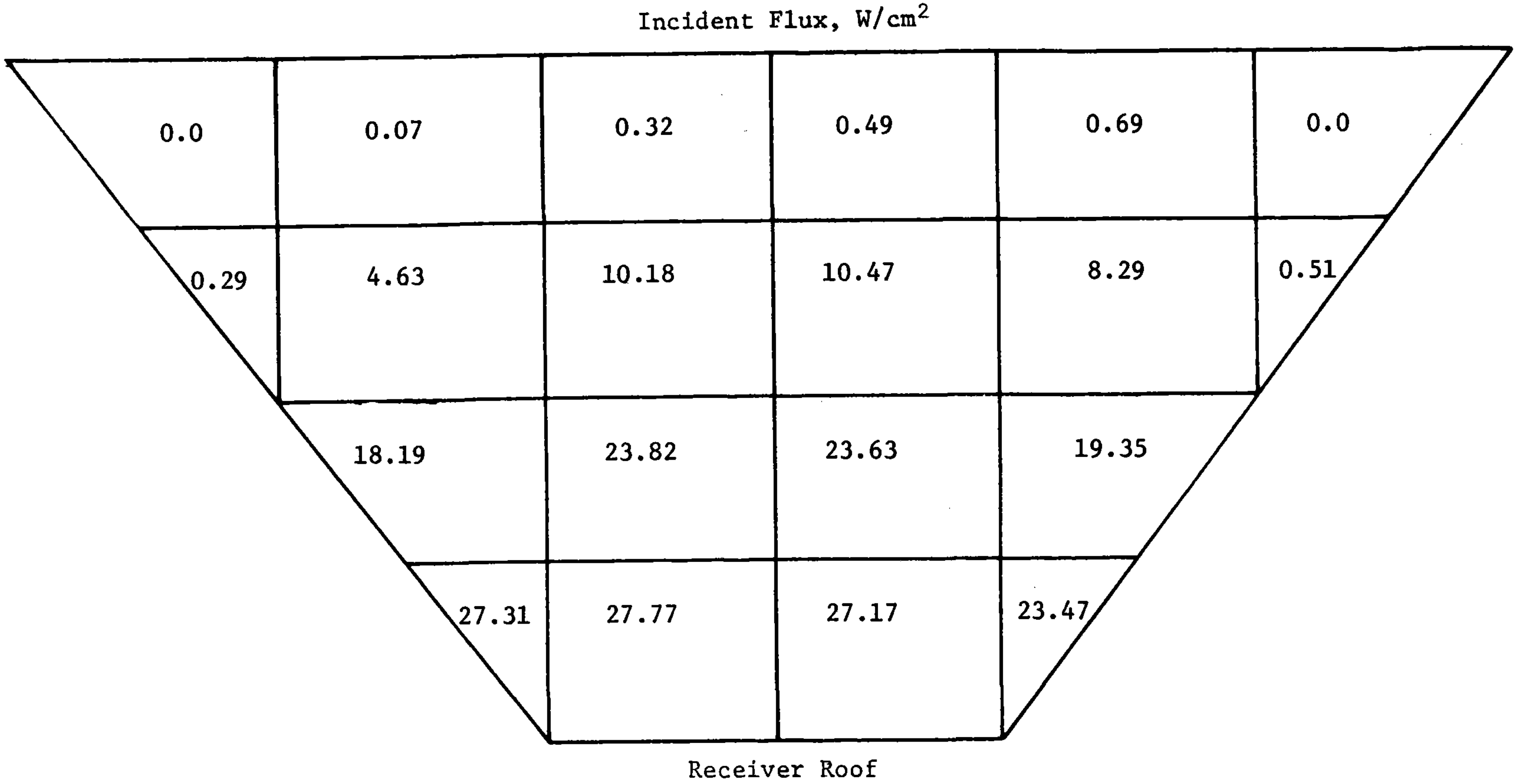


Figure B-9 (concl)

Figure B-9 (concl)

Day: 80

Time: 1600

Total Incident Power: 10.955 MW

Average Cosine: 0.9438

Incident Flux, W/cm²

	0.0	1.30	14.70	26.80	34.06	36.77	32.27	26.19	17.98	1.55	0.0
	0.03	2.86	20.48	31.73	39.35	42.70	36.55	28.83	20.94	2.12	0.0
	0.17	4.75	23.22	34.51	44.50	47.14	41.63	28.86	18.47	2.06	0.0
	0.33	6.49	24.79	37.04	49.50	52.32	47.28	30.92	17.0	2.31	0.0
	0.36	6.74	22.70	32.10	41.98	44.73	39.93	26.81	15.37	2.48	0.01
	0.23	4.66	14.79	18.87	23.03	24.42	20.85	14.33	9.18	1.45	0.0
	0.07	1.81	5.91	6.48	6.98	7.29	5.60	3.71	2.53	0.26	0.0
	0.0	0.24	0.92	0.82	0.80	0.51	0.22	0.07	0.0	0.0	0.0
	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Node Area	0.833 m² (8.968 ft²)				0.587 m² (6.324 ft²)			0.833 m² (8.968 ft²)			

Receiver Walls

Figure B-10 Receiver Cavity Heat Fluxes, 16:00 Day 80

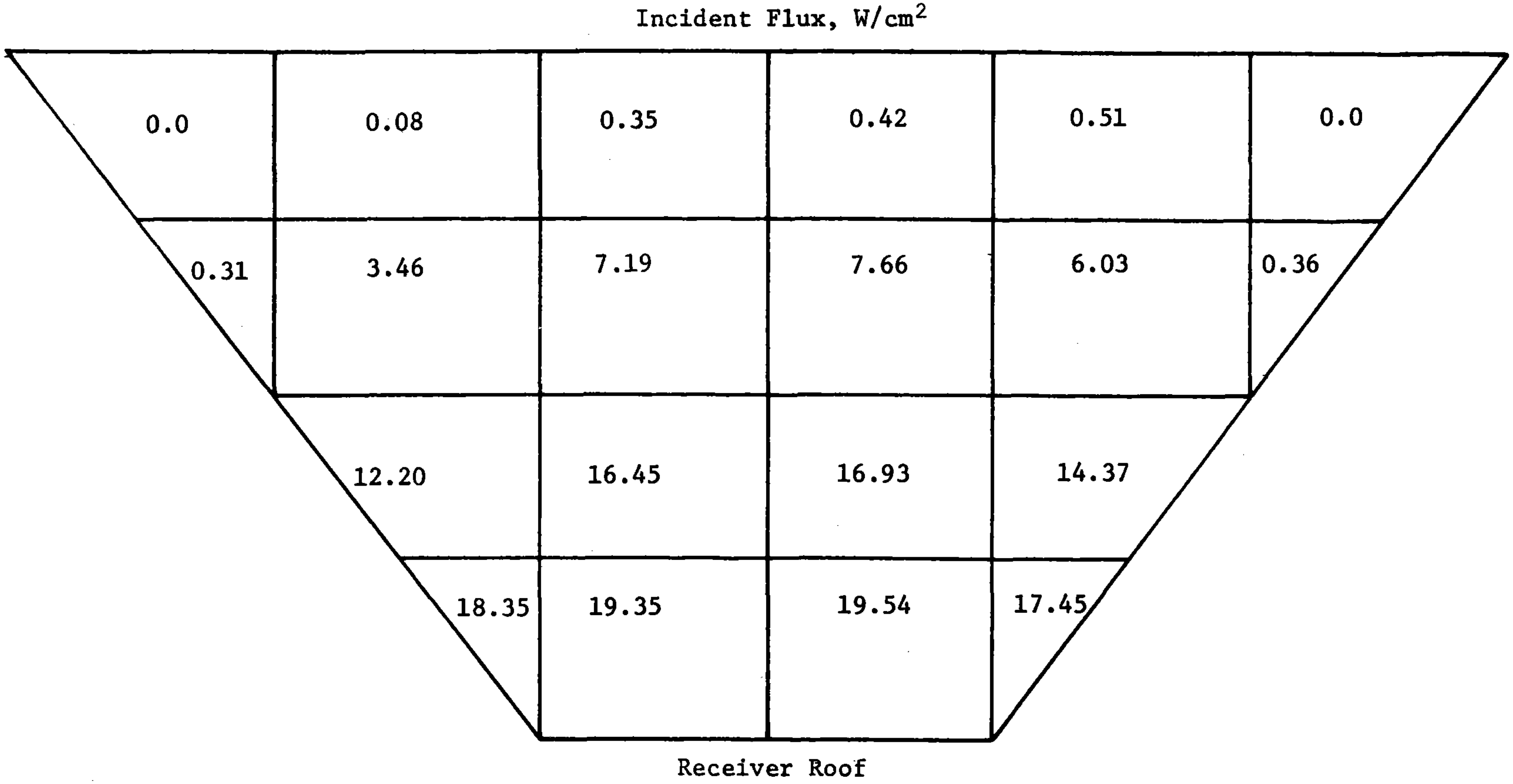


Figure B-10 (concl)

Figure B-10 (concl)

Day: 172

Time: 0800

Total Incident Power: 8.389 MW

Average Cosine: 0.6405

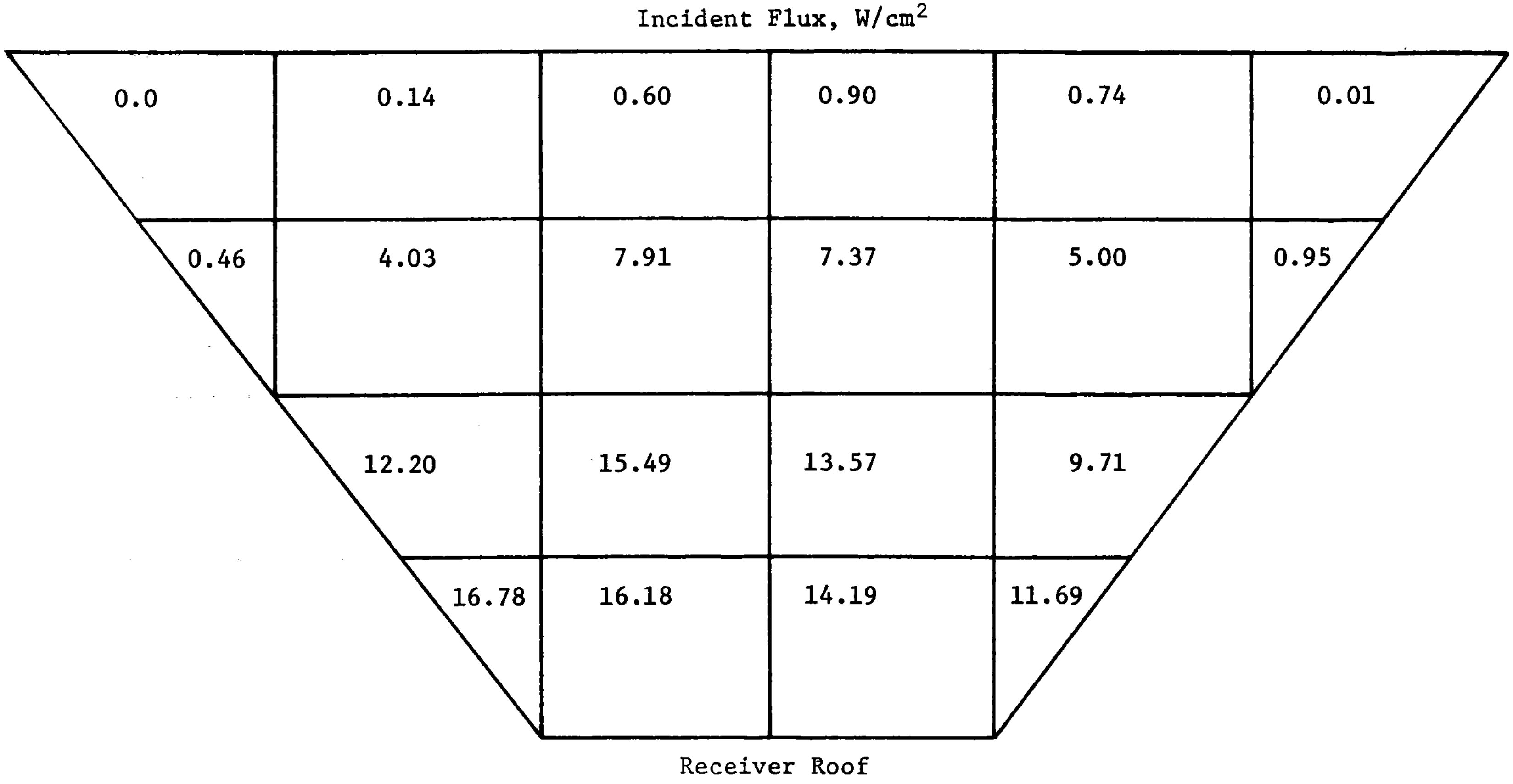
Incident Flux, W/cm^2

	0.0	1.82	14.91	24.15	27.65	26.76	22.66	15.79	10.37	2.11	0.04
	0.07	3.84	20.26	28.31	32.01	31.05	25.80	17.66	12.21	2.89	0.08
	0.26	5.72	22.30	29.33	33.67	32.33	26.62	17.36	11.97	3.20	0.10
	0.43	7.05	22.26	28.62	33.35	31.49	25.73	15.87	10.59	3.02	0.10
	0.48	7.07	19.69	24.32	28.16	26.57	21.54	13.04	8.68	2.60	0.11
	0.34	5.27	13.79	16.04	18.34	17.64	14.22	8.73	6.03	1.93	0.09
	0.12	2.55	6.82	7.23	7.97	8.0	6.32	4.15	3.23	1.04	0.04
	0.01	0.56	1.64	1.37	1.30	1.31	0.98	0.68	0.77	0.23	0.0
	0.0	0.02	0.04	0.0	0.0	0.0	0.0	0.0	0.01	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Node Area	0.833 m^2 (8.968 ft^2)				0.587 m^2 (6.324 ft^2)			0.833 m^2 (8.968 ft^2)			

Receiver Walls

Figure B-11 Receiver Cavity Heat Fluxes, 8:00 Day 172

Figure B-11 (concl)



0.0	0.14	0.60	0.90	0.74	0.01
0.46	4.03	7.91	7.37	5.00	0.95
	12.20	15.49	13.57	9.71	
	16.78	16.18	14.19	11.69	

Figure B-11 (concl)

Day: 172

Time: 1000

Total Incident Power: 12.443 MW

Average Cosine: 0.7862

Incident Flux, W/cm^2

	0.0	1.84	20.61	34.82	40.71	41.04	35.03	25.73	17.06	2.57	0.02
	0.04	4.16	28.15	40.61	46.73	47.37	39.81	28.76	20.0	3.56	0.04
	0.25	6.72	30.80	42.20	50.01	49.80	41.90	28.25	19.10	3.91	0.05
	0.47	8.93	31.50	42.76	51.78	50.64	42.65	26.86	16.89	3.88	0.08
	0.51	9.22	28.47	36.87	44.07	43.18	36.06	22.51	14.13	3.56	0.12
	0.32	6.58	19.28	23.13	26.84	26.87	22.73	14.31	9.59	2.57	0.07
	0.10	2.78	8.48	9.18	10.17	10.54	8.48	5.77	4.38	1.06	0.01
	0.01	0.44	1.60	1.44	1.61	1.71	1.25	0.72	0.66	0.11	0.0
	0.0	0.0	0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Node Area	0.833 m^2 (8.968 ft^2)				0.587 m^2 (6.324 ft^2)			0.833 m^2 (8.968 ft^2)			

Receiver Walls

Figure B-12 Receiver Cavity Heat Fluxes, 10:00 Day 172

Figure B-12 (concl)

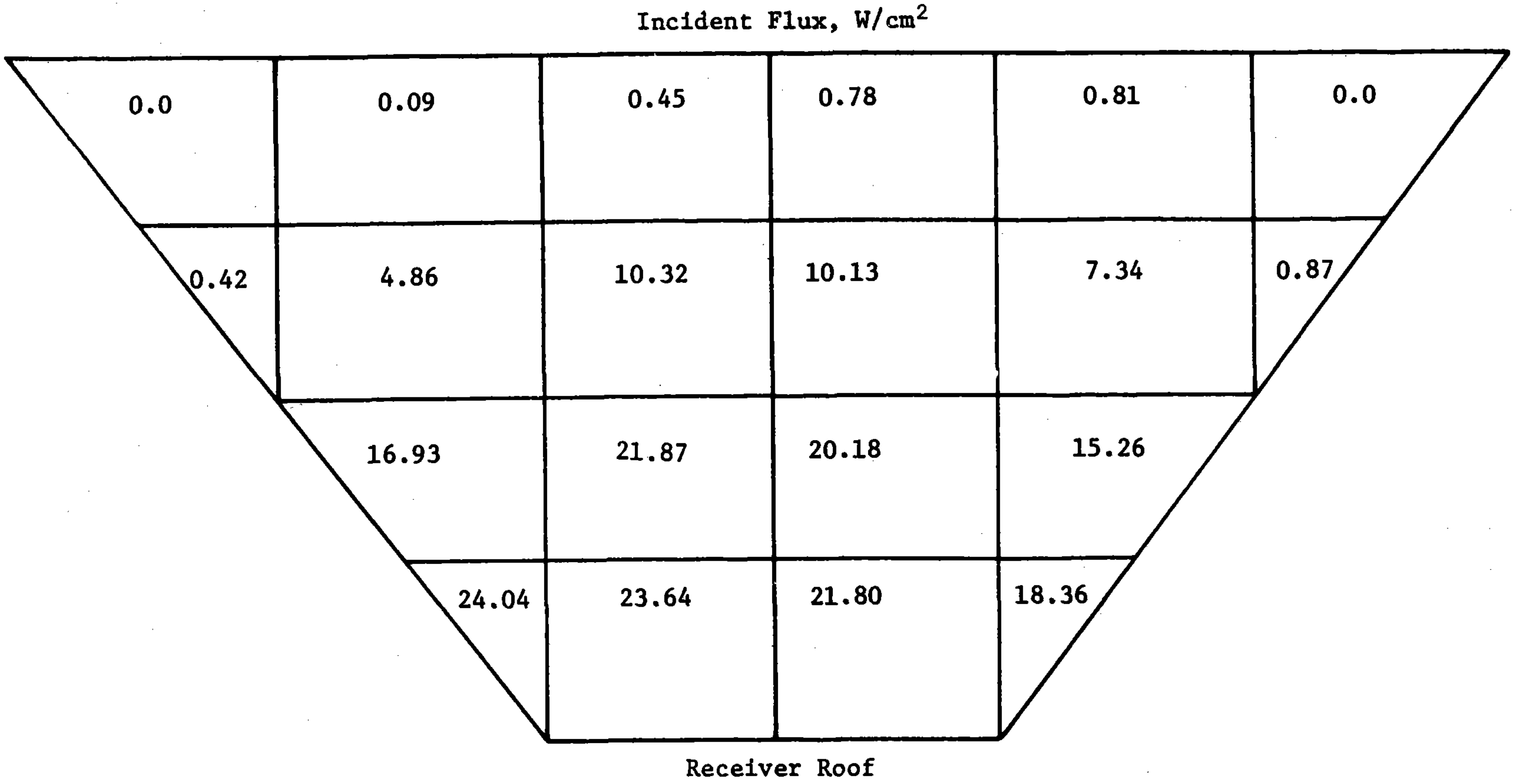


Figure B-12 (concl)

Day: 172

Time: 1200

Total Incident Power: 14.573 MW

Average Cosine: 0.8802

Incident Flux, W/cm^2

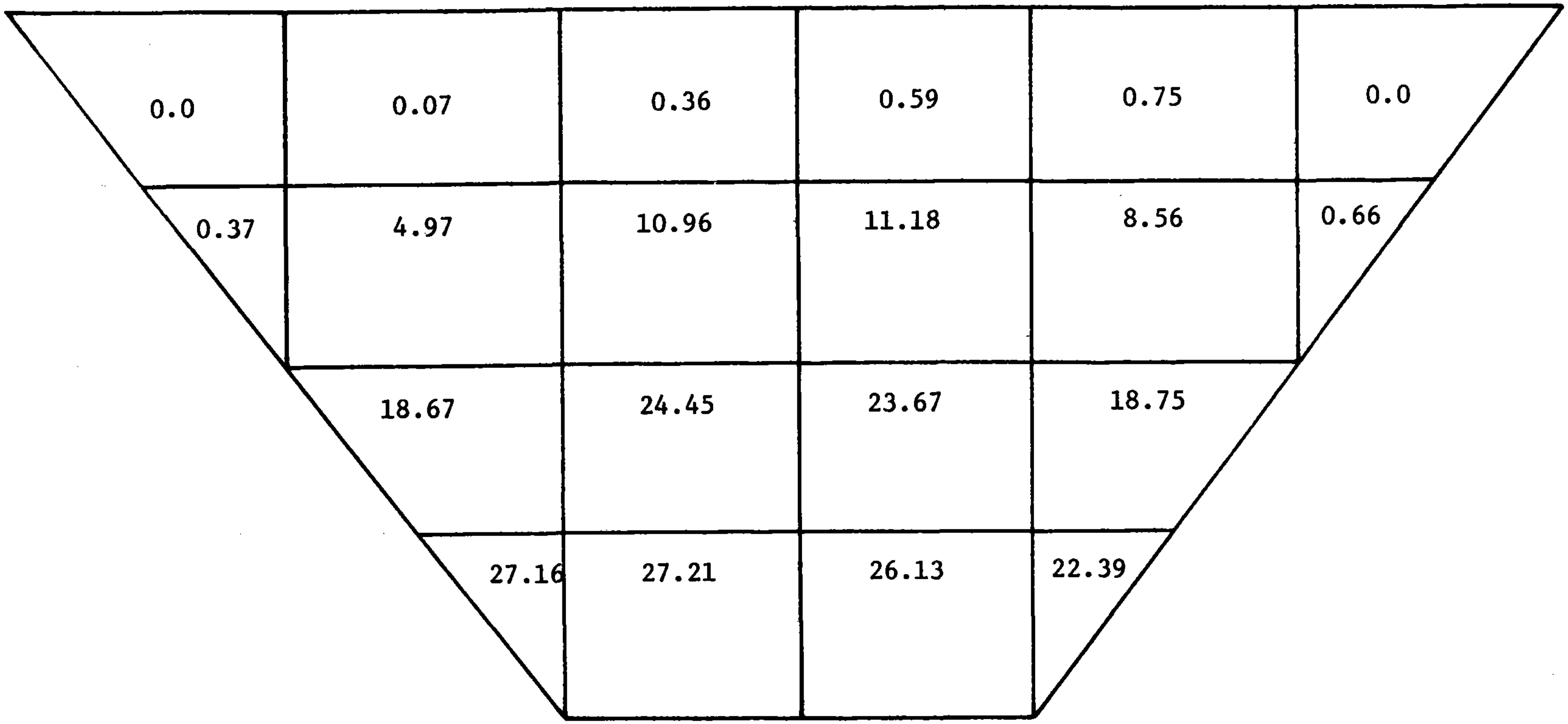
	0.0	1.74	22.58	39.38	47.25	49.23	42.36	32.63	21.95	2.48	0.0
	0.04	4.05	30.97	45.74	53.65	56.39	47.59	36.02	25.67	3.45	0.01
	0.24	6.79	33.80	47.82	58.34	59.80	51.36	35.30	23.45	3.66	0.01
	0.46	9.38	35.16	49.84	62.67	63.15	54.81	35.19	20.88	3.84	0.03
	0.51	9.81	32.19	43.29	53.44	54.19	46.62	30.03	18.01	3.78	0.06
	0.32	6.83	21.26	26.14	30.82	31.71	26.73	17.83	11.71	2.54	0.03
	0.09	2.66	8.71	9.48	10.45	10.97	8.77	6.02	4.44	0.75	0.0
	0.0	0.36	1.42	1.33	1.41	1.49	1.04	0.55	0.36	0.03	0.0
	0.0	0.0	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Node Area	0.833 m^2 (8.968 ft^2)				0.587 m^2 (6.324 ft^2)			0.833 m^2 (8.968 ft^2)			

Receiver Walls

Figure B-13 Receiver Cavity Heat Fluxes, 12:00 Day 172

Figure B-13 (concl)

Incident Flux, W/cm^2



0.0	0.07	0.36	0.59	0.75	0.0
0.37	4.97	10.96	11.18	8.56	0.66
	18.67	24.45	23.67	18.75	
	27.16	27.21	26.13	22.39	

Receiver Roof

Figure B-13 (concl)

Day: 172

Time: 1400

Average Cosine: 0.9155

Total Incident Power: 14.577 MW

Incident Flux, W/cm^2

	0.0	1.73	21.04	37.51	46.50	49.66	43.29	34.60	23.73	2.22	0.0
	0.04	3.94	28.91	43.66	52.85	56.86	48.43	37.93	27.63	3.06	0.0
	0.25	6.51	31.85	46.09	58.09	60.92	53.38	37.18	24.48	3.10	0.0
	0.46	8.87	33.26	48.43	63.25	65.74	58.72	38.39	22.01	3.41	0.01
	0.51	9.24	30.41	42.04	53.88	56.41	49.90	33.18	19.52	3.56	0.02
	0.32	6.45	20.07	25.20	30.45	31.96	27.31	18.67	12.16	2.22	0.01
	0.10	2.57	8.22	9.01	9.86	10.34	8.12	5.48	3.90	0.51	0.0
	0.0	0.36	1.36	1.22	1.25	1.30	0.88	0.41	0.19	0.01	0.0
	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Node Area	0.833 m^2 (8.968 ft^2)				0.587 m^2 (6.324 ft^2)			0.833 m^2 (8.968 ft^2)			

Receiver Walls

Figure B-14 Receiver Cavity Heat Fluxes, 14:00 Day 172

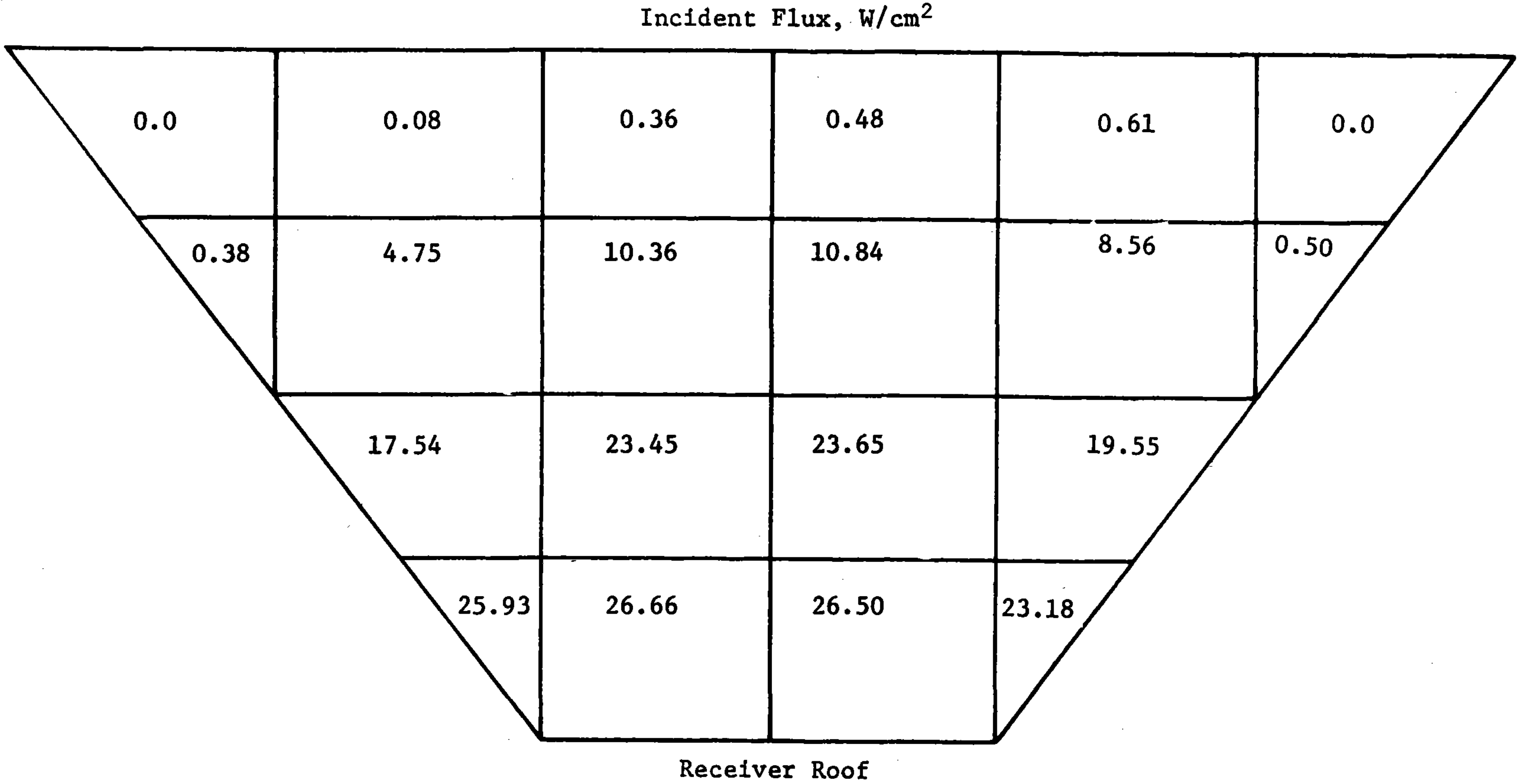


Figure B-14 (concl)

Day: 172

Time: 1600

Total Incident Power: 11.831 MW

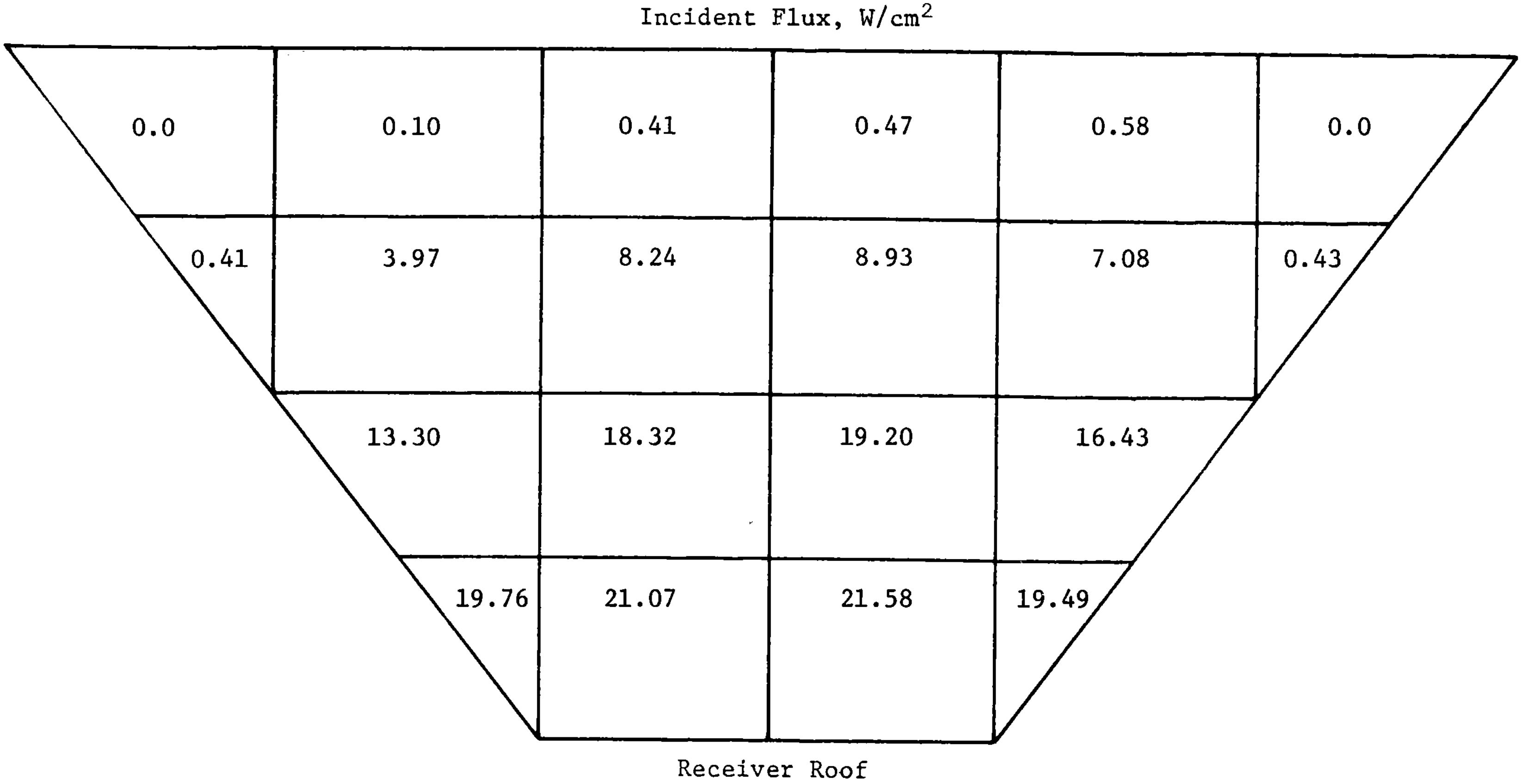
Average Cosine: 0.8895

Incident Flux, W/cm^2

	0.0	1.65	15.75	28.42	36.75	39.92	35.63	29.22	20.34	1.81	0.0
	0.06	3.53	21.65	33.46	42.49	46.27	40.32	32.21	23.73	2.51	0.0
	0.24	5.50	24.33	35.76	46.83	50.19	44.90	31.77	20.95	2.50	0.0
	0.41	7.14	25.24	37.12	50.37	53.98	49.47	33.09	19.00	2.80	0.0
	0.46	7.28	22.82	32.00	42.84	46.20	41.96	28.63	16.99	2.97	0.01
	0.31	5.24	15.37	19.68	24.72	26.43	22.95	15.92	10.45	1.81	0.0
	0.11	2.29	6.75	7.49	8.37	8.78	6.85	4.56	3.19	0.36	0.0
	0.01	0.41	1.29	1.10	1.10	1.13	0.73	0.33	0.14	0.0	0.0
	0.0	0.01	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Node Area	0.833 m^2 (8.968 ft^2)				0.587 m^2 (6.324 ft^2)			0.833 m^2 (8.968 ft^2)			

Receiver Walls

Figure B-15 Receiver Cavity Heat Fluxes, 16:00 Day 172



0.0	0.10	0.41	0.47	0.58	0.0
0.41	3.97	8.24	8.93	7.08	0.43
	13.30	18.32	19.20	16.43	
	19.76	21.07	21.58	19.49	

Figure B-15 (concl)

Figure B-15 (concl)

Day: 355

Time: 0800

Total Incident Power: 4.803 MW

Average Cosine: 0.7315

Incident Flux, W/cm²

	0.0	0.77	8.35	13.89	15.65	14.97	12.29	8.03	4.90	1.03	0.02
	0.01	1.73	11.71	16.75	18.65	17.94	14.52	9.32	5.95	1.39	0.04
	0.09	2.87	13.31	18.09	20.67	19.61	15.76	9.65	6.12	1.57	0.05
	0.19	3.89	14.04	18.68	21.58	20.05	15.93	9.29	5.72	1.54	0.05
	0.20	4.02	12.74	16.08	18.27	17.00	13.39	7.75	4.82	1.35	0.05
	0.12	2.81	8.49	9.98	11.15	10.72	8.45	5.04	3.30	0.98	0.04
	0.03	1.11	3.61	3.89	4.26	4.36	3.42	2.22	1.66	0.48	0.02
	0.0	0.14	0.62	0.59	0.67	0.70	0.51	0.32	0.33	0.09	0.0
	0.0	0.0	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Node Area	0.833 m² (8.968 ft²)				0.587 m² (6.324 ft²)			0.833 m² (8.968 ft²)			

Receiver Walls

Figure B-16 Receiver Cavity Heat Fluxes, 8:00 Day 355

Figure B-16 (concl)

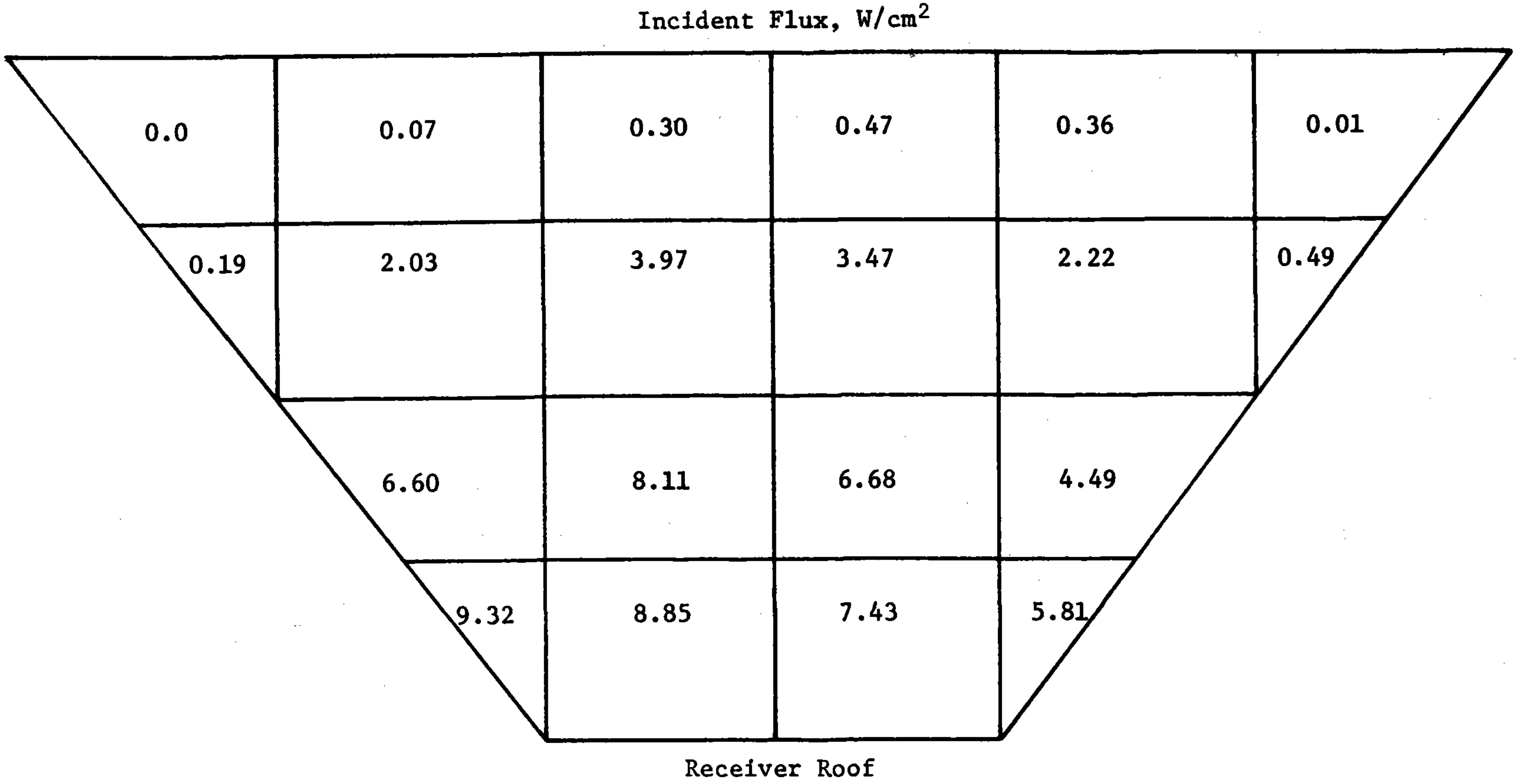


Figure B-16 (concl)

Day: 355

Time: 1000

Total Incident Power: 13.116 MW

Average Cosine: 0.8629

Incident Flux, W/cm^2

	0.0	1.41	21.56	37.17	42.62	42.53	35.32	24.79	15.63	2.46	0.03
	0.01	3.39	30.18	44.13	49.57	49.90	40.96	28.26	18.64	3.31	0.05
	0.15	6.17	33.76	47.49	55.63	54.55	44.95	28.90	18.33	3.65	0.05
	0.37	9.03	36.48	50.97	60.70	58.04	47.59	28.63	16.89	3.68	0.08
	0.40	9.60	33.83	44.39	51.51	49.58	40.21	24.15	14.33	3.38	0.11
	0.23	6.34	21.56	25.91	29.16	29.06	23.56	14.81	9.48	2.36	0.06
	0.05	2.13	8.00	8.68	9.54	10.11	8.09	5.49	4.05	0.89	0.01
	0.0	0.19	1.04	1.07	1.24	1.33	0.97	0.56	0.49	0.08	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Node Area	0.833 m^2 (8.968 ft^2)				0.587 m^2 (6.324 ft^2)			0.833 m^2 (8.968 ft^2)			

Receiver Walls

Figure B-17 Receiver Cavity Heat Fluxes, 10:00 Day 355

Figure B-17 (concl)

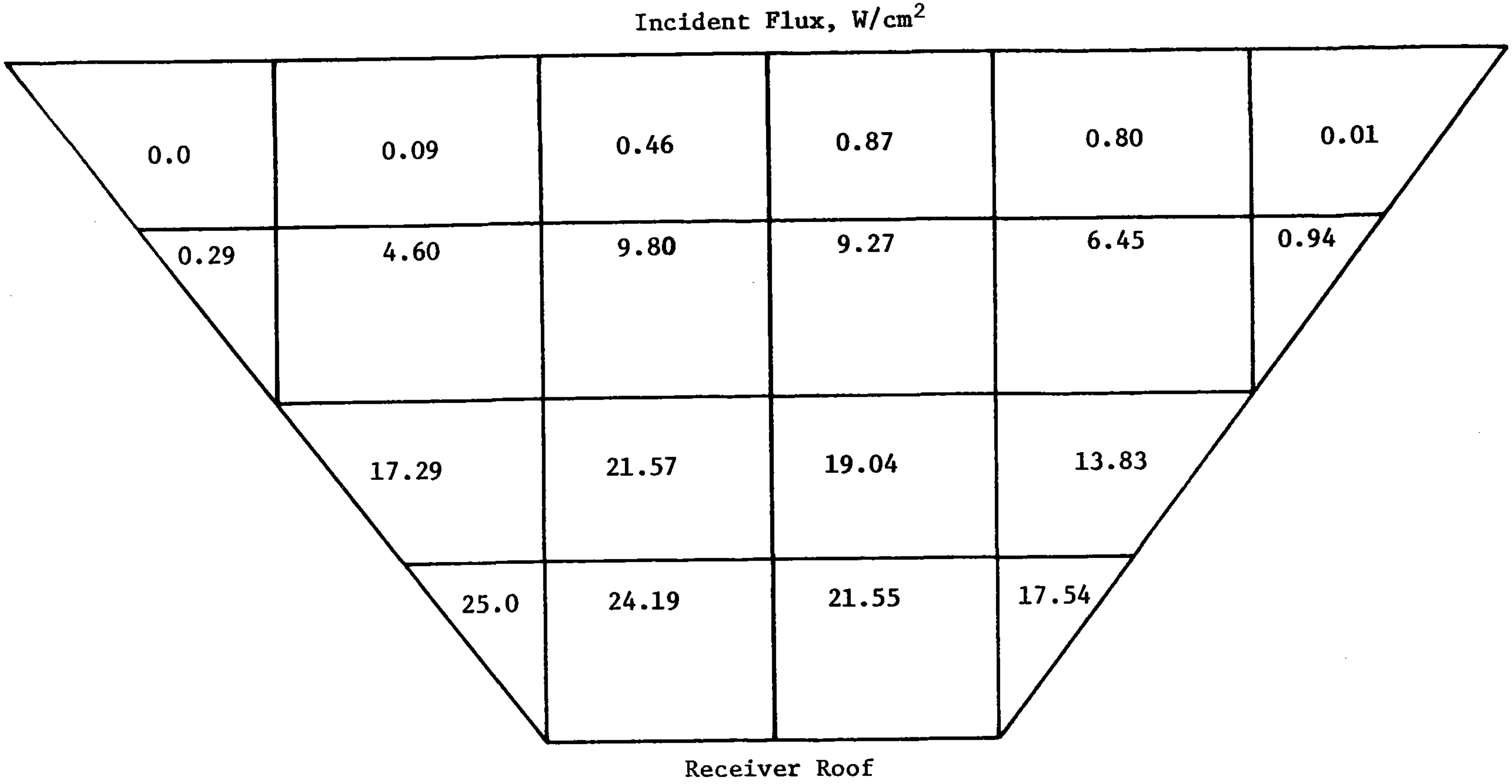


Figure B-17 (concl)

Day: 355

Time: 1200

Average Cosine: 0.9502

Total Incident Power: 15.769 MW

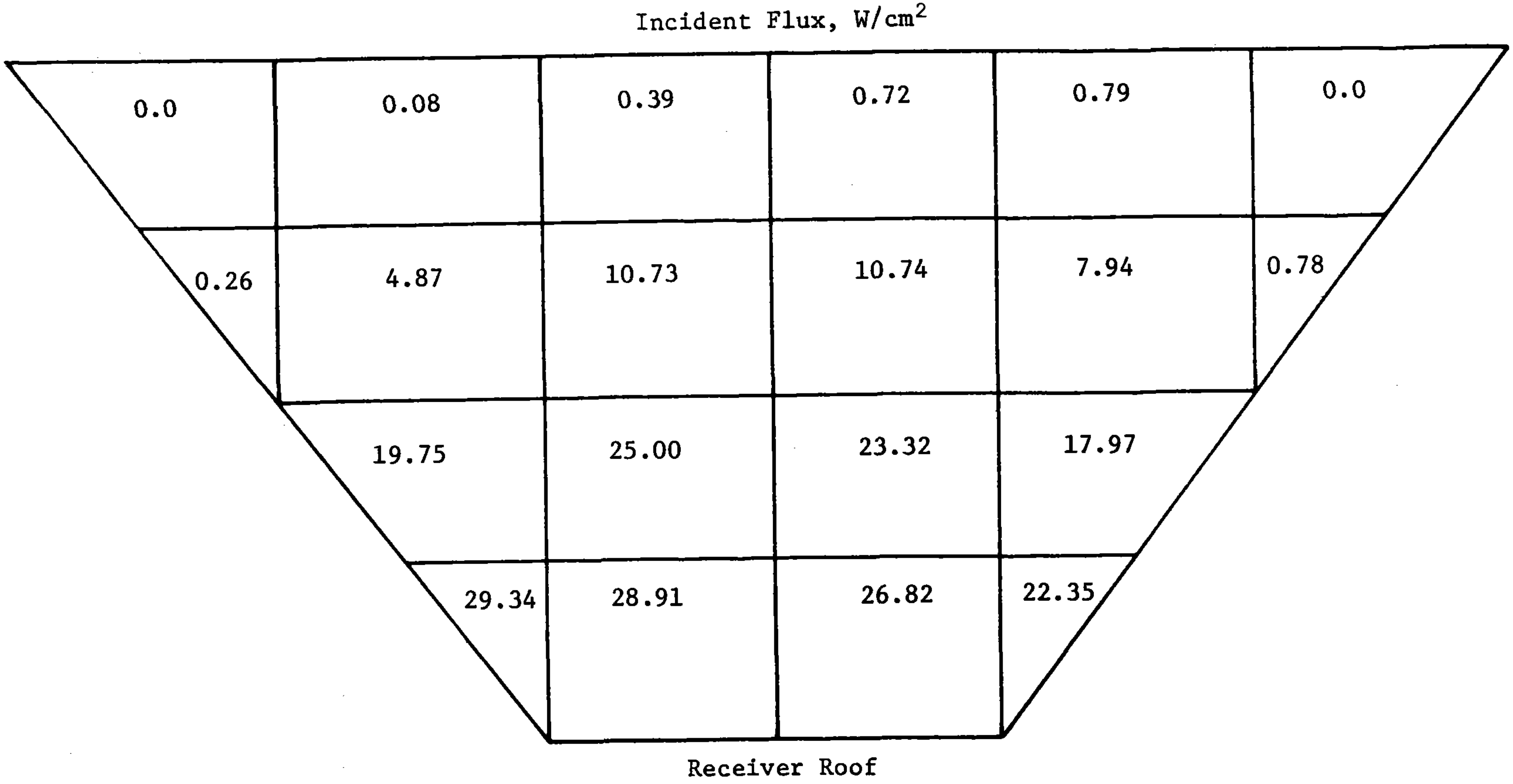
Incident Flux, W/cm^2

	0.0	1.36	24.50	43.29	50.83	52.43	44.03	32.76	21.17	2.53	0.0
	0.01	3.35	34.25	51.00	58.16	60.62	50.05	36.55	24.90	3.43	0.01
	0.14	6.41	38.03	55.06	66.16	66.57	56.08	37.04	23.34	3.58	0.01
	0.36	9.75	41.81	60.83	74.87	73.65	62.23	38.31	21.47	3.73	0.03
	0.41	10.44	39.25	53.23	63.43	63.05	52.70	32.74	18.64	3.66	0.06
	0.22	6.69	24.27	29.74	33.82	34.55	28.56	18.68	11.80	2.38	0.03
	0.04	2.08	8.32	8.99	9.73	10.42	8.26	5.73	4.14	0.65	0.0
	0.0	0.15	0.91	0.96	1.07	1.14	0.80	0.40	0.26	0.03	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Node Area	0.833 m^2 (8.968 ft^2)				0.587 m^2 (6.324 ft^2)			0.833 m^2 (8.968 ft^2)			

Receiver Walls

Figure B-18 Receiver Cavity Heat Fluxes, 12:00 Day 355

Figure B-18 (concl)



0.0	0.08	0.39	0.72	0.79	0.0
0.26	4.87	10.73	10.74	7.94	0.78
	19.75	25.00	23.32	17.97	
	29.34	28.91	26.82	22.35	

Figure B-18 (concl)

Day: 355

Time: 1400

Total Incident Power: 15.014 MW

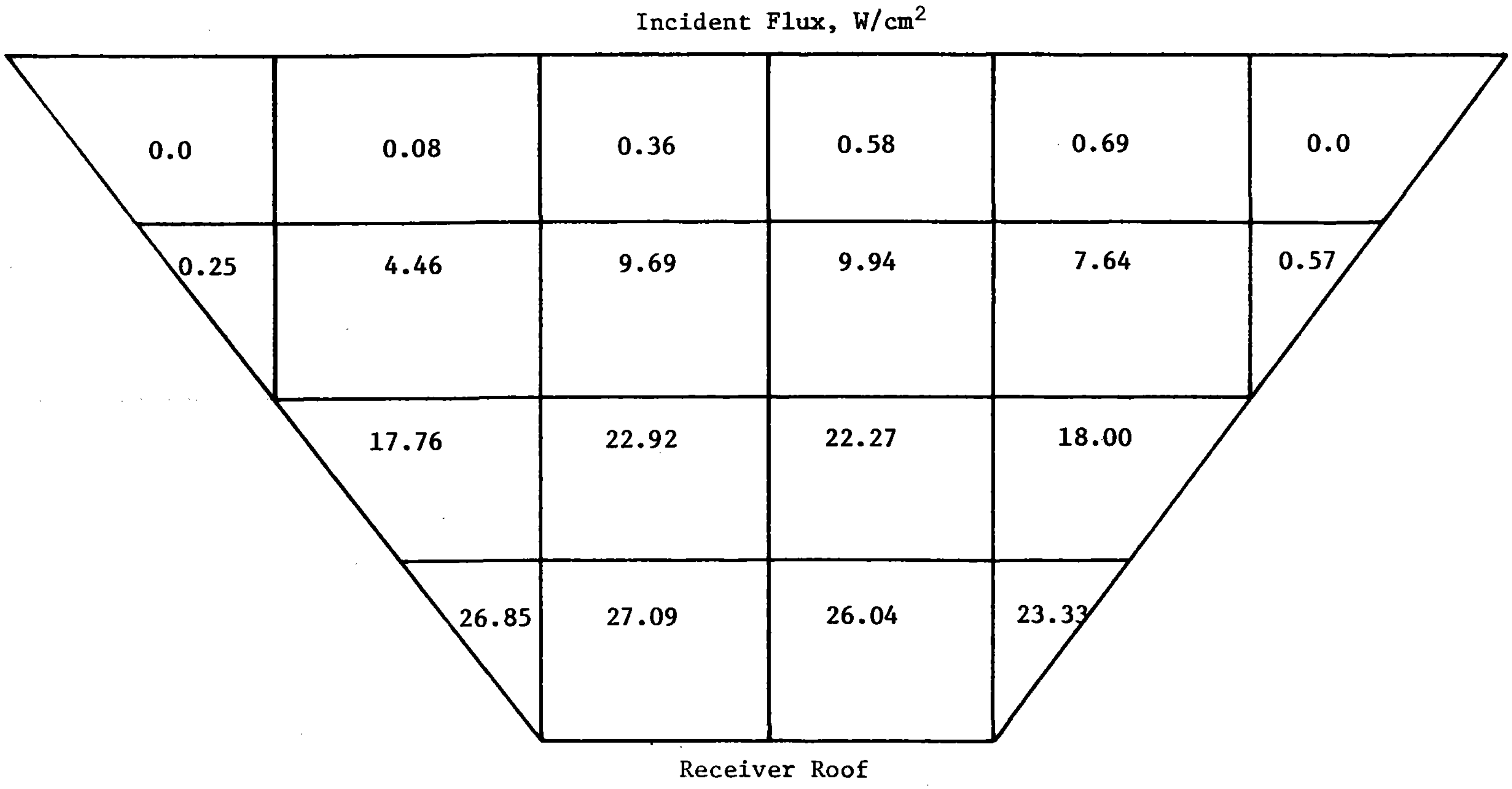
Average Cosine: 0.9838

Incident Flux, W/cm^2

	0.0	1.32	21.88	39.45	47.60	50.25	42.75	33.17	21.95	2.16	0.0
	0.01	3.16	30.66	46.55	54.44	57.99	48.27	36.64	25.65	2.94	0.0
	0.14	5.90	34.35	50.71	62.54	64.25	55.19	37.08	23.21	2.89	0.0
	0.35	8.85	37.84	56.42	71.80	72.69	63.12	39.63	21.48	3.15	0.01
	0.38	9.43	35.42	49.30	60.68	62.12	53.30	34.20	19.13	3.24	0.02
	0.21	6.09	21.92	27.33	31.65	32.87	27.49	18.45	11.59	1.97	0.01
	0.04	1.95	7.55	8.17	8.65	9.19	7.13	4.90	3.41	0.41	0.0
	0.0	0.16	0.84	0.84	0.87	0.90	0.61	0.28	0.12	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Node Area	0.833 m^2 (8.968 ft^2)				0.587 m^2 (6.324 ft^2)			0.833 m^2 (8.968 ft^2)			

Receiver Walls

Figure B-19 Receiver Cavity Heat Fluxes, 14:00 Day 355



0.0	0.08	0.36	0.58	0.69	0.0
0.25	4.46	9.69	9.94	7.64	0.57
	17.76	22.92	22.27	18.00	
	26.85	27.09	26.04	23.33	

Figure B-19 (concl)

Figure B-19 (concl)

Day: 355

Time: 1600

Average Cosine: 0.9605

Total Incident Power: 6.372 MW

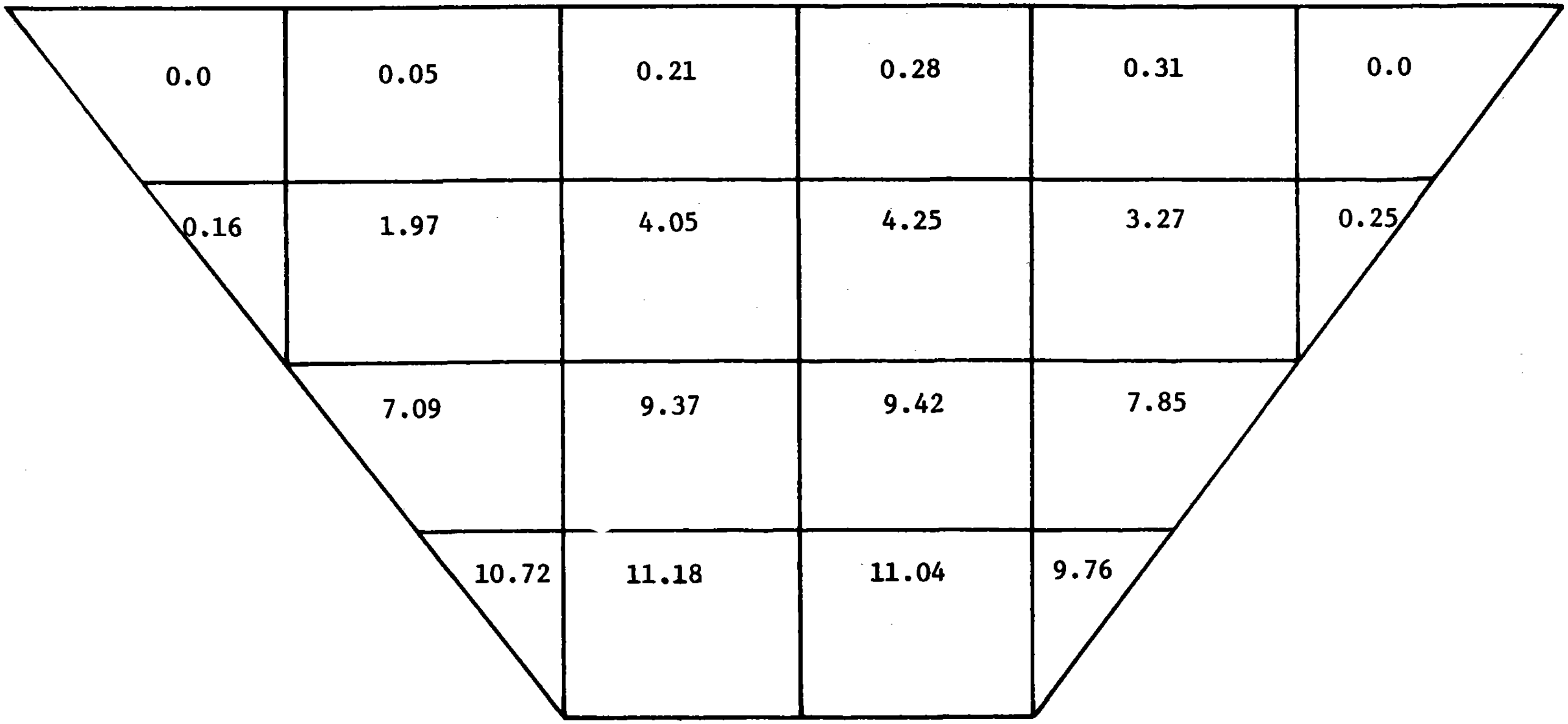
Incident Flux, W/cm^2

	0.0	0.69	8.65	15.78	19.73	21.08	18.32	14.56	9.80	0.93	0.0
	0.01	1.55	12.18	18.86	22.98	24.67	20.92	16.17	11.45	1.26	0.0
	0.08	2.68	13.96	20.82	26.47	27.68	24.15	16.45	10.33	1.21	0.0
	0.18	3.80	15.22	22.81	29.96	31.16	27.68	17.75	9.63	1.33	0.0
	0.19	3.98	14.05	19.81	25.33	26.59	23.33	15.33	8.65	1.44	0.01
	0.11	2.67	8.94	11.33	13.54	14.23	12.03	8.17	5.16	0.83	0.0
	0.03	0.95	3.36	3.65	3.88	4.07	3.12	2.10	1.44	0.16	0.0
	0.0	0.10	0.45	0.42	0.41	0.41	0.27	0.11	0.04	0.00	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Node Area	0.833 m^2 (8.968 ft^2)				0.587 m^2 (6.324 ft^2)			0.833 m^2 (8.968 ft^2)			

Receiver Walls

Figure B-20 Receiver Cavity Heat Fluxes, 16:00 Day 355

Incident Flux, W/cm^2



0.0	0.05	0.21	0.28	0.31	0.0
0.16	1.97	4.05	4.25	3.27	0.25
	7.09	9.37	9.42	7.85	
	10.72	11.18	11.04	9.76	

Receiver Roof

Figure B-20 (concl)

Figure B-20 (concl)

1.0 GENERAL

1.1 SCOPE

This specification defines the system and subsystem characteristics, design requirements, system environmental requirements, and plant conceptual design data requirements for a Solar Thermal Central Receiver Enhanced Oil Recovery System.

1.2 SYSTEM DESCRIPTION

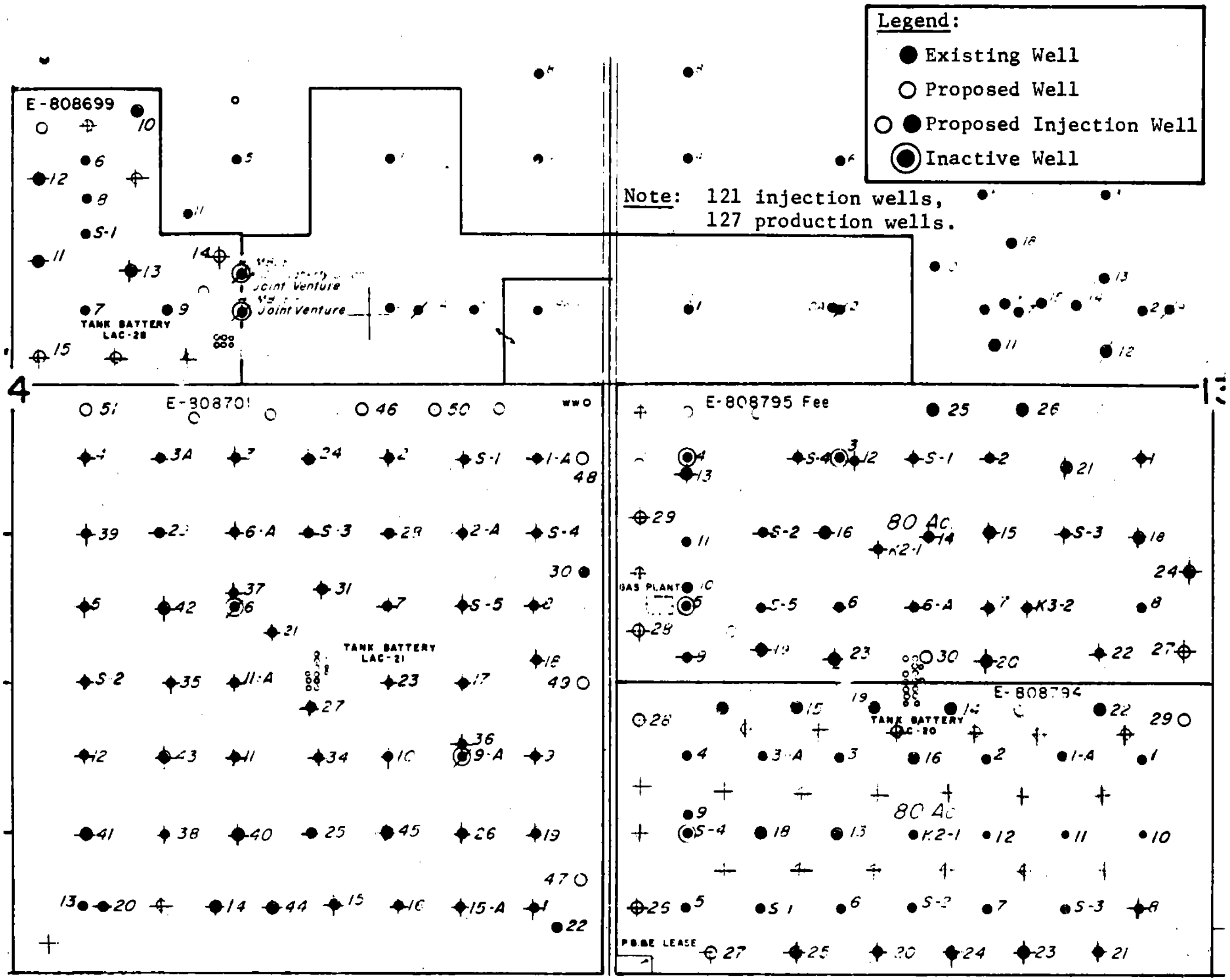
For the purpose of the Exxon Edison Field Solar Thermal-Enhanced Oil Recovery (STEOR) conceptual design project, solar retrofit will consist of the following major elements:

1) Site;
2) Site facilities;
3) Collector subsystem;
4) Receiver subsystem;
5) Fossil energy subsystem;
6) Field piping subsystem;
7) Modes of operation.

1.2.1 Site

The site chosen for installation of the heliostat field is Exxon Corporation's lease E-808794. This lease is located at the intersection of Tejon Highway and Hermosa Road in Edison, California, and is totally owned and operated by Exxon. The lease covers an area of 323,717 m^2 (80 acres) and is 402.32 x 804.63 m (1320 x 2640 ft) in size. There are 32 existing wells in the field (Fig. C-1). For steam drive operations, 24 additional wells will be drilled (Fig. C-1).

To permit normal oil field operations, a 9.1-m (30-ft) wide access road is required along each row of wells (Fig. C-2). When additional wells are drilled, a 30.48 x 60.96-m (100 x 200-ft) space will be required around the planned well site to allow for drilling operations. Heliostats in this space will be removed for drilling operations and replaced after the wells have been drilled. A distance of 21.33 m (70 ft) must be allowed from the center of Tejon Highway and Hermosa Road.



(*Figure C-1 Areas of Operation*

The site is flat, free from rock, and well drained. The Uniform Building Codes put the soil of the site in Class 4 (SC), sand and clay.

There are no zoning or other use restrictions on the site. Kern County Airport is located approximately 32.2 km (20 mi) to the northwest of the site. The site is outside the airport control zone. Figure C-3 shows the major access highways in the Bakersfield area.

1.2.2 Site Facilities

The site facilities for the Edison field solar industrial retrofit are described in this subsection.

- Area To Be Free of Equipment
  - Road Clearance for Tejon Hermosa - 0.258×10^5 m^2 (0.277×10^6 ft^2)
  - Access Roads to Wells = 0.589×10^5 m^2 (0.634×10^6 ft^2)
  - Access Around New Wells = 0.286×10^5 m^2 (0.308×10^6 ft^2)
- Total Lease Area = 3.237×10^5 m^2 (3.485×10^6 ft^2)
- Typical Location of New Wells in Relation to Existing Wells:

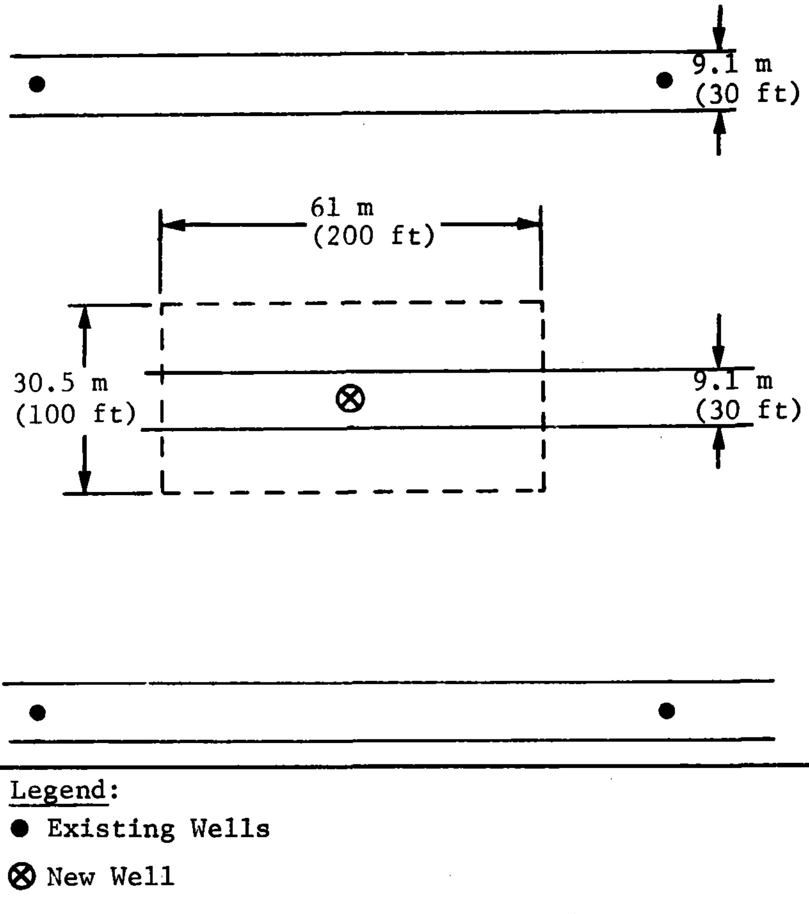


Figure C-2 Required Access and Open Area on Corporation Fee E-808794

The Operations building will provide an area for the display, control and data acquisition equipment related to the solar system for control and data acquisition support and maintenance personnel. The Operations building will also provide space for storage and maintenance of the solar system equipment.

A security fence will be installed around the outer perimeter of the solar system. The fence will also serve as a shield against stray reflected glare.

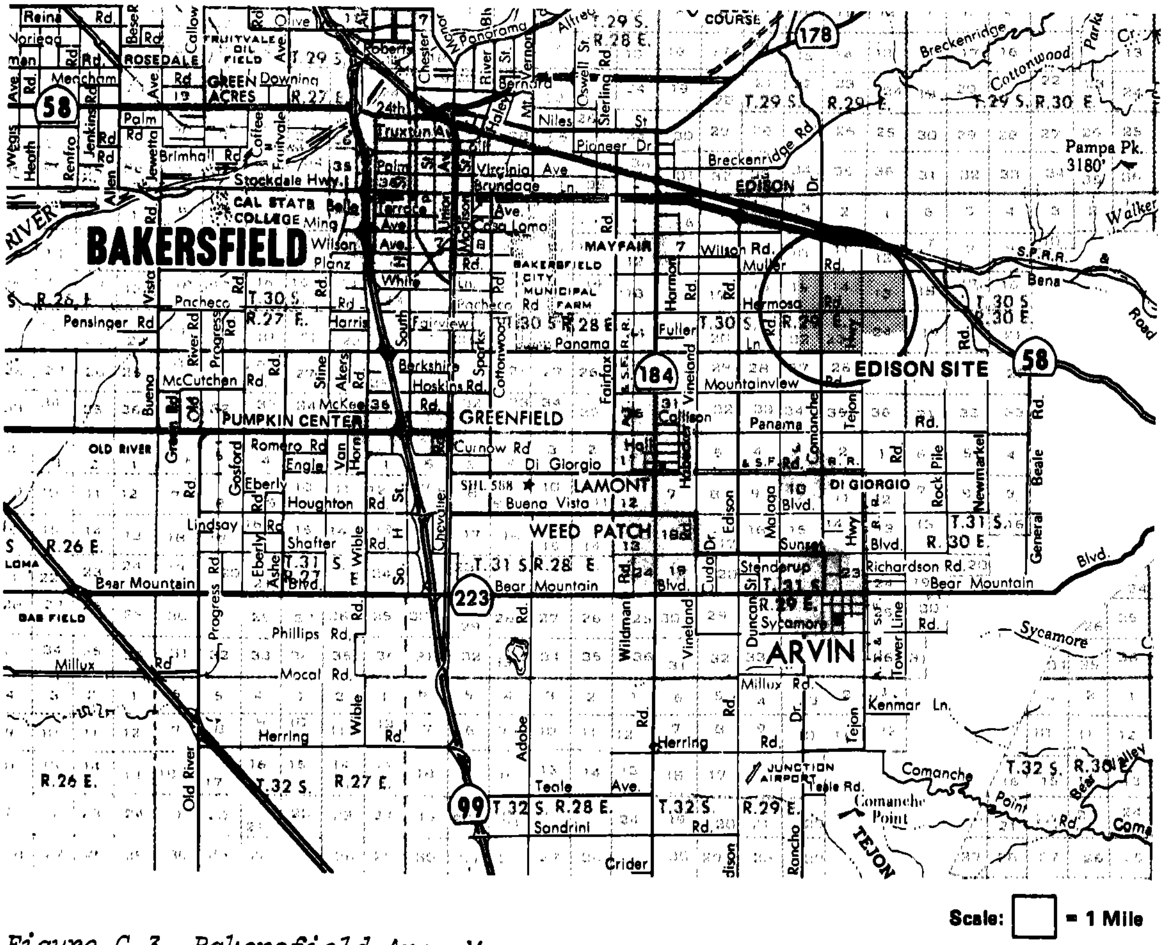


Figure C-3 Bakersfield Area Map

The utility serving the field is Pacific Gas and Electric Co. An existing substation at the southwest corner of section 13 is rated for 1900 kW. Currently the maximum load is 500 kW. Incremental requirements for STEOR will be easily accommodated. Electric power is brought to the site by overhead cable on utility poles along Hermosa Road.

1.2.3 Collector Subsystem

The collector subsystem is composed of an array of heliostats for the concentration of solar thermal radiation on the receiver and includes the following equipment:

1) Heliostats, including reflective surface, structural support, drive units, control sensors, pedestals, foundations, cabling, and cable array installations;

2) Electromechanical and electrical controllers, including individual heliostat and heliostat field controllers, control system interface electronics, and power supplies.

The primary requirement for the collector subsystem is to direct solar radiation onto the receiver absorber surfaces in a cost effective manner consistent with receiver incident heat flux requirements. The collector subsystem includes a heliostat array containing 818 second-generation heliostats in a radial staggered pattern as shown in Figure C-4. The heliostat can be considered as a 12-facet, glass/steel, inverting stow unit with a reflective area of 49.05 m^2 (528 ft^2). Interruptions in the heliostat spacing resulted from a requirement to provide a clearance of 9.1 x 9.1 m (30 x 30 ft) around all oil wells for normal maintenance and operations access. In the normal operating mode, each heliostat rotates in azimuth and elevation angles to aim reflected insolation on the receiver.

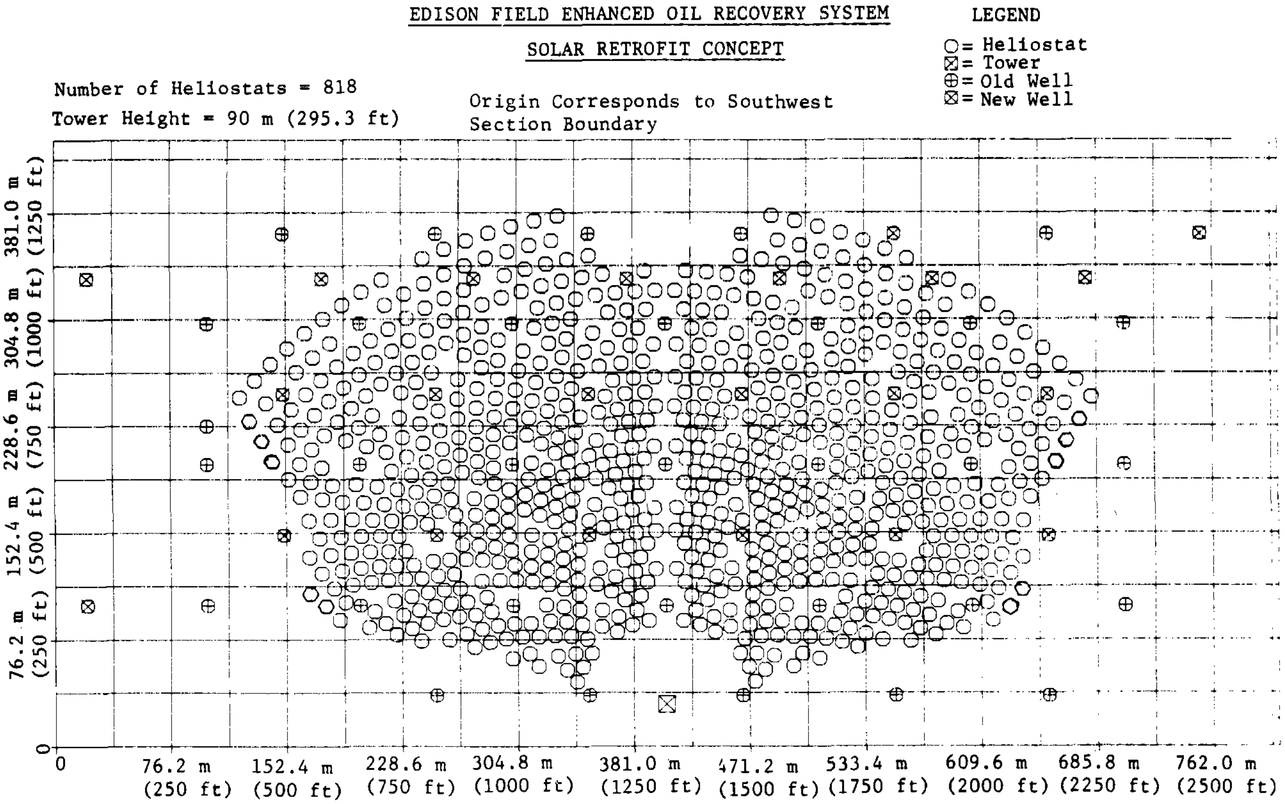


Figure C-4 Collector Field Arrangement

The collector subsystem can also execute alternative drive modes in response to commands from the control system for emergency defocusing of the reflected energy or to protect the heliostat array against environmental extremes. The heliostats will require vertical positioning to provide access for normal well servicing. A complete specification for the heliostat is contained in Section 3.3.2.

1.2.4 Receiver Subsystem

The receiver subsystem provides a means of transferring the incident radiant flux energy from the collector subsystem into a suitable receiver fluid. The receiver consists of an elevated receiver to intercept the radiant flux reflected from the collector and a steel tower structure to support the receiver. Water enters the preheat panels of the receiver at 15.6°C (60°F) and is heated to 148.9°C (300°F). The heated water then enters the steam drum where it circulates through the boiler section to generate steam at 8.27 MPa (1200 psia) and 297°C (567°F). The receiver also includes the pumps, valves and control system within the tower structure necessary to regulate the fluid flow, temperature and pressure, and the control system components necessary for safe and efficient operation, startup, shutdown, and standby.

A twin-cavity type receiver will be mounted on a steel tower. The receiver apertures are offset 0.65 rad (37.5°) from the north axis and have a square opening of 5.5 m (18 ft). Figure C-5 shows a plan view and a cross section of the twin-cavity receiver. The receiver apertures are sized to provide the best combination of spillage and thermal losses. The cavity is insulated and aperture doors will be provided to reduce the receiver cooldown during nonoperating periods.

Access to the receiver equipment will be provided for maintenance and inspection, provisions will be made for user safety, and the design will be consistent with the intent of the appropriate ASME boiler codes. Maintenance and personnel safety will be considered throughout the conceptual design. Piping and valves will be located to allow access for maintenance and removal. All platforms and openings will be protected by rails or safety chains. Lightning protection will be provided.

1.2.5. Field Piping Subsystem

The field piping subsystem is composed of the piping and piping-related items required to transport the steam produced by the solar receiver to the injection wells (including receiver tower piping). The piping-related items include:

1) Pipe insulation;

2) Pipe supports;

3) Valves;

4) Items required to accommodate thermal expansion.

The field piping subsystem will be designed so the pressure at any well is within acceptable limits and so the piping heat loss is the economical minimum.

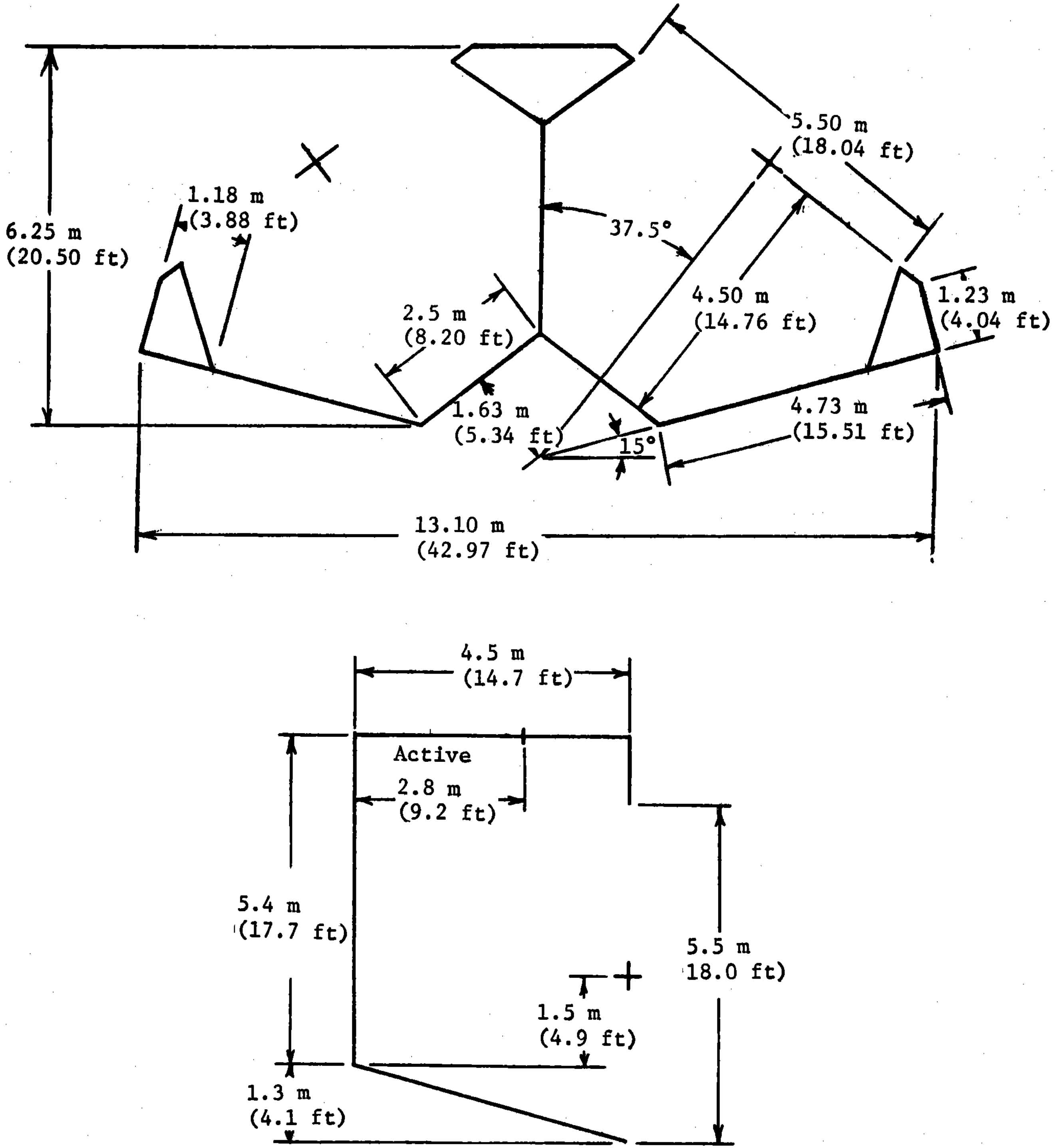


Figure C-5 Simplified Plan View and Cross Section

1.2.6 Modes of Operation

Operation of the solar power system in a TEOR application where there is no EPGS or storage (other than the oil reservior itself) is relatively simple. Normal operation of the process will entail the following basic operating modes for the solar power system:

1) Cold startup - The system is started when the receiver is at near-ambient pressure and temperature after an extended shutdown due to multiple sunless days or equipment repair. Solar power must be brought on gradually in a defined sequence;

2) Hot startup - This is the dominant mode of startup on a daily basis. After a single night of shutdown, the insulated receiver remains in a hot, pressurized condition the next morning and can immediately react to full solar input at startup;

3) Steady-state operation - This mode begins at the time nominal operating pressure and temperature are reached after either a cold or hot startup has been completed and continues until either a normal or an emergency shutdown is initiated. During steady-state operation the system will react to the normal insolation transients occurring over a typical day;

4) Normal shutdown - The system is brought to an anticipated shutdown that is caused by insufficient insolation at the end of a day or cloudiness or by a noncritical malfunction somewhere in the system. The shutdown terminates in the normal stow condition for all subsystems;

5) Emergency shutdown - The system is brought to an unanticipated shutdown due to a critical malfunction. The collector field is directed to a safe standby condition, which removes all heat flux from receiver and tower;

6) Standby - This mode defines a condition in which the collector system is fully operational but the receiver is shut down. The collector field is tracking two points in space--half the heliostats track a point slightly to the east of the receiver and half track a point just west of the receiver. This is an intermediate mode from which insolation can be quickly applied to the receiver or from which the collector system can proceed to the stow condition.

1.3 DEFINITION OF TERMS

Beam Pointing Error - The angular difference between the aim point and the beam centroid of the heliostat.

Capacity Factor, Annual, Nonsolar+ - Annual nonsolar MWh divided by the product of 8760 h and plant or unit rating* in MW.

Capacity Factor, Annual, Overall+ - Annual solar MWh plus annual nonsolar MWh divided by the product of 8760 h and plant or unit rating* in MW.

Capacity Factor, Annual, Solar+ - Annual solar MWh divided by the product of 8760 h and plant or unit rating* in MW.

Concentration Ratio - The ratio of the received energy on a small area from multiple surfaces with perfect reflectivity to that arriving from the sun often measured in "suns." Commonly used to refer to the ratio of aperture-to-receiver areas.

Demand - The power versus time profile of the energy required to satisfy the energy needs of the end use consuming process.

Design Point - The time and day of the year at which the system is sized with reference insolation, wind speed, temperature, humidity, dewpoint, and sun angles.

Direct Insolation - Nonscattered solar flux falling on a surface of given orientation (W/m^2).

Enhanced Oil Recovery - Use of any of a variety of techniques to remove oil from a reservoir after the natural rate of flow has become uneconomical.

Fluid, Receiver - The fluid used to cool the solar receiver and distribute the absorbed solar energy to other parts of the system; heat transport fluid of the receiver.

Fluid, Working - The fluid used in the turbine or other prime mover.

Geometric Concentration Ratio - The ratio of the projected area of a reflector system (on a plane normal to the insolation) divided by absorber area.

Heavy Crude Oil - Although no uniform definition exists, almost all TEOR production in the U.S. has an API gravity below 20°. Typical TEOR production is in the range of 12° to 17° API.

Hybrid System - A combination of solar and nonsolar technology to provide a single plant system that is capable of continuous operation.

+Note: For utility applications, MWh electrical net from respective source. For industrial process heat, MWh net, thermal.

*Usually nameplate unless otherwise specified. Additional reference, EPRI PS-1201-SR, Special Report, July 1979.

Injection/Production Tubing - Steel pipe inserted into well bore for injecting steam or removing oil.

Levelized Energy Cost - The cost per unit of energy that, if held constant throughout the life of the system and multiplied by the total system energy output, exactly expresses the after tax expenses encurred, including return on investment.

Oil/Steam Ratio - Number of barrels of oil produced per barrel of steam injected.

Overburden - Nonoil-bearing geologic zone above oil bearing zone.

Payback Period - A traditional measure of the economic viability of an investment project. A payback period is defined in several ways, one being the number of years required to accumulate fuel savings that exactly equal the initial capital cost of the system. Payback often does not give an accurate representation of total life-cycle values.

Pointing Error - The difference between the aim point and the measured beam centroid for any tracking aim point (on target or at standby) under the specified operating conditions.

Present Value - The present value of capital and operating costs (or annual savings) brought back over a given time period, such as the life of the plant, is a single value of the costs or savings at a reference time accounting for economic factors such as escalation rates and rate of return on the capital.

Process Heat - Thermal energy that is used in industrial operations.

Receiver Efficiency - Ratio of thermal power from the output of the receiver to incident solar power on the receiver.

Repowered/Industrial Retrofit Plant - A plant that uses central receiver technology and solar energy to partially replace nonrenewable (fossil) fuels.

Solar Flux - The amount of solar energy per unit of time flowing across a given area. Often imprecisely used to refer to irradiance (W/m^2) or total incident insolation (J/m^2 or $kW\text{-}h/m^2$).

Solar Fraction, Annual - Ratio of solar energy to the process divided by the total energy consumption (annual average) measured at process heating end-use device inlet.

Solar Fraction, Design Point - As above, at design point.

Solar Multiple - Defined at the design point as thermal power from receiver(s) after downcomer and piping losses divided by thermal power, prime mover, (defined under Thermal Power later).

Steam Drive - Also called steam flooding. Steam is continuously injected into a pattern of injection wells to lower viscosity and increase pressure, pushing oil out of a number of interspersed production wells. Normally steam drive operations are begun after steam soak operations have ceased to be economical.

Steam Soak - Also called steam stimulation. Steam is pumped into a well for 7 to 10 days. This reduces oil viscosity, increasing production rates. A typical Bakersfield well would be steamed once every 12 to 18 months.

Thermal-Enhanced Oil Recovery - Use of heat to lower oil viscosity and increase reservoir pressure. Methods include steam soak, steam drive, hot water flood, and *in situ* combustion.

Thermal Packer - Plug used to provide tight seal between bottom of injection tubing and well bore so steam does not escape upward.

Thermal Power, Fossil Heater Output - Thermal power input to working or transport fluids from the fossil heater after stack and miscellaneous losses.

Thermal Power, Prime Mover - Thermal power input to turbine or other prime mover at the design point.

Thermal Power, Receiver Output - Thermal power derived from the receiver. Does not include electrical parasitic or downcomer thermal losses.

Well Bore - Well and casing, typically 9 to 10 in. in diameter.

2.0 REFERENCES

The following documents, of the issue in effect on the date of the contract award, form a part of this specification to the extent stated herein.

2.1 Standards and Codes

Uniform Building Code - 1976 Edition by International Conference of Building Officials

Occupational Safety and Health Act (OSHA) Regulations

- OSHA Title 29, Part 1910 - Occupational Safety and Health Standards.

American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code

- Section I - Power Boilers.
- Section II - Materials Specifications.
- Section VIII - Unfired Pressure Vessels.

American National Standard Institute (ANSI)

- B31.1 - Power Piping.
- B31.3 - Chemical Plant and Petroleum Refining Piping.

Nuclear Regulatory Commission (NRC) Regulatory Guide 1.60.

(NRC) Regulatory Guide 1.61

Institute of Electrical and Electronic Engineers (IEEE) Codes, as applicable.

National Fire Protection Association (NFPA).

National Fire Codes - 1975.

Human Engineering Design Criteria

- MIL-STD-810C.
- MIL-STD-1472.

Design, Construction and Fabrication Standards

- Standards of American Institute of Steel Construction (AISC).

- Standards of American Concrete Institute (ACI).
- Standards of Tubular Exchanger Manufacturer's Association (TEMA).
- Standard 650 of American Petroleum Institute (API)--Welded Steel Tanks for Oil Storage.

2.2 OTHER PUBLICATIONS AND DOCUMENTS

Environmental Legislation

- National Environmental Policy Act (NEPA).
- Collector Subsystem Requirements Spec A10772, Issue C, November 1979.

2.3 LICENCES AND PERMITS

Construction of the Solar-Enhanced Oil Recovery system will require the following licences, and permits:

- California Department of Transportation--Division of Aeronautics permit;
- Kern County building permits for each structure with structure specification for the tower and heliostats;
- Kern County Planning Office requires a zoning variance for any structure over 54.9 m, (180 ft) high;
- Site leveling requires a permit.

2.4 APPLICABLE LAWS AND REGULATIONS

- National Energy Conservation Policy Act of 1978.
- Power Plant and Industrial Fuel Act of 1978.
- Public Utilities Regulatory Policy Act.
- Natural Gas Act of 1978.
- Decontrol Exise Tax Act of 1980.

- Federal Aviation Administration (FAA) permit and special lighting for 100-m (328.1-ft) structure.
- Regional Water Control Board investigation of erosion into local streams.

3.0 REQUIREMENTS

The solar repowered plant shall be designed to meet the performance requirements of this section. This specification is applicable as a design requirement only to the new or modified portions of the plant.

3.1 SITE PREPARATION

Little special site preparation will be required because of the flat nature of the land. Some existing overhead utility lines must be rerouted and/or buried.

3.2 SITE FACILITIES

This section defines the requirements for site facilities (other than those described under collector, receiver, and field piping subsystems) that must be added for solar retrofit. These areas include, but are not limited to, the general class of facilities described in the following subsections.

3.2.1 Operations Building

Includes collector and receiver controls, instrumentation and alarms. Also provides space for spares storage and maintenance.

3.2.2 Security Fence

Prohibits unauthorized access and protects passing motorists from reflected glare.

3.3 COLLECTOR SUBSYSTEM

The collector subsystem shall reflect solar radiation onto the receiver subsystem in a manner that satisfies receiver incident power and heat flux requirements. The collector subsystem shall also respond to commands from the collector control subsystem for emergency defocusing of the reflected energy. The heliostats shall be properly positioned for repair or maintenance in response to either collector control or manual commands. Heliostat design shall provide for a stowed or safe position for use at night, during periodic maintenance and during adverse weather conditions. The collector subsystem shall be designed in coordination with receiver design and to provide energy to the receiver fluid consistent with the end energy requirements of the plant.

3.3.1 Collector Field

The collector field design shall provide an optimum heliostat layout considering

1) Heliostat capital cost;
2) Operating and maintenance cost;
3) Field wiring cost;
4) Land availability;
5) Land cost;
6) Heliostat performance;
7) Receiver aperture size;
8) Receiver tower height;
9) Reliability;
10) Shading and blocking;
11) Atmospheric attenuation;
12) Sun position.

The collector field in Figure C-4 was derived by using RCELL and relocating heliostats that were displaced by oil wells. The collector field contains 818 49.05-m² (528-ft²) heliostats located within a 3.62-rad (150°) segment to the north of the receiver.

3.3.2 Heliostat Performance, Reference Collector Subsystem Requirements No. A10772

There are some differences in environmental conditions at the Bakersfield site from the conditions at the site stated in the Collector Subsystem Requirements (CSR). The different conditions are tabulated.

	Bakersfield Site	CSR Site
Seismic	Zone 4	Zone 3
Temperature	-6.7 to 46°C (20 to 115°F)	0 to 50°C (32 to 122°F)
Rain - Average Annual	150 mm (5.8 in.)	750 mm (30 in.)
Maximum 24-h Rate	40 mm (1.68 in.)	75 mm (3 in.)
Snow Loads	3.81 kg/m² (0.78 lb/ft²)	24.4 kg/m² (5 lbs/ft²)

3.3.3 Collector Control

The collector control shall function as appropriate for all steady-state modes of plant operation. This shall include the capability of controlling the number of heliostats in the tracking mode to vary the redirected flux to the receiver between zero and the maximum achievable level.

3.4 RECEIVER SUBSYSTEM (INCLUDING TOWER)

The receiver subsystem shall provide a means of converting the incident radiant flux energy from the collector subsystem into steam suitable for use in the STEOR process. The supporting steel tower is also considered to be a part of the receiver subsystem. The receiver and tower shall be designed to provide access for maintenance and inspection of tower structure receiver, receiver fluid, instruments and controls, power conversion equipment that may be located on the tower, utilities, etc. Adequate provisions shall be made to ensure crew safety at all times for required operations, inspection, maintenance, and repair. The receiver design shall be consistent with the intent of appropriate ASME boiler codes.

3.4.1 Configuration

The twin-cavity configuration has two 5.5 x 5.5-m (18 x 18-ft) apertures that are rotated 0.65 rad (37.5°) from the north axis as shown in Figure C-5. Each cavity is 4.5 m (14.8 ft) in depth and shares a common wall that is on the north-south axis. Portions of the common wall and ceiling are preheat panels while the remainder of the cavity walls are boiler panels.

3.4.2 Receiver Fluid Specifications

The water supply for steam generation is provided from an Exxon-owned and -operated well. This well draws water from a depth of 304.8 m (1000 ft). The water is treated in units containing ion exchange beds. Water quality before and after treatment is tabulated.

Impurities	As Produced from Well, ppm	Posttreatment, ppm
Calcium	54.4	0.5
Magnesium	12.6	0.5
Sodium	50.6	210.0
Bicarbonates	298.9	0
Chlorides	36.1	326
Sulphates	2.2	0
Nitrates	0.44	0
Total Hardness as $CaCO^3$	187.66	0.5
pH	7.4	9.0

The posttreatment water quality is to be used for receiver design.

Approximately 238.4 m^3 (1500 barrels) of water per day will be required for the solar system.

3.4.3 Receiver Criteria

The receiver shall be a natural-circulation boiler, twin-cavity type designed to use water/steam as the receiver fluid and sized to deliver 29.3 MWt (100 $x10^6$ Btu/h) to the field piping subsystem at the design point (noon day 58). However, the receiver can operate on as low as a 3.52-MWt (12 x 10^6-Btu/h) flux from the collector subsystem. The peak allowable absorbed heat flux on the boiler panels is 69.4 W/cm^2 (220,000 $Btu/h\text{-}ft^2$), while the preheat panels have an allowable peak absorbed heat flux of 34.7 W/cm^2 (110,000 $Btu/h\text{-}ft^2$).

Power distribution within the receiver at the system design point is shown in Table C-1. Under normal operating conditions water enters the preheat section at 15.6°C (60°F) and exists the preheat section into the steam drum at 148.9°C (300°F). The boiler section then converts the water into saturated steam at a pressure of 8.27 MPa (1200 psia) and a temperature of 297°C (567°F). Continuous drum blowdown is required to maintain acceptable boiler water purity. The drum blowdown steam is injected into the steam outlet line, resulting in a receiver steam outlet quality of 82%.

The receiver was designed to meet the ASME boiler and pressure vessel codes called out in Section 2. The total dry receiver weight, including support structure and enclosure, is 128.2 Mg (282.7 klb).

3.4.4 Tower Criteria

The tower that supports the receiver, piping, and other elements of the receiver subsystem shall have the following characteristics:

1) Tower height, 90 m (295 ft);

2) Structural type, Steel, 4 support legs, 12.2-m (40-ft)

3) Environmentally induced structural criteria,
   - Wind-induced moment, 1.263 x 10^8 Nm (93,200 kip-ft),
   - Seismic-induced moment, 9.228 x 10^7 Nm (68,100 kip-ft);

4) Maximum weight to support, 139.4 Mg (307,300 lb).

3.4.5 Receiver Control

The receiver control consists of a feedwater regulator, an output pressure regulator, and a blowdown regulator. Figure C-6 shows the receiver schematic with the control subsystem.

Table C-1 Design Point Heat Fluxes, Noon, Day 58

Incident Heat Flux, W/cm^2										
Northeast Wall				Back Wall			North Wall			
Inactive	Active						Active			Inactive
0.0	1.29	23.1	41.9	49.8	51.0	43.2	31.3	19.9	2.86	0.01
0.0	2.79	31.9	49.3	56.6	58.8	48.9	35.5	23.8	3.84	0.03
0.02	4.88	36.1	51.8	60.0	62.1	52.0	36.4	24.5	4.40	0.03
0.11	7.42	38.0	54.4	66.1	66.1	55.7	36.3	23.1	4.55	0.03
0.23	9.86	40.2	57.7	71.1	69.7	58.6	36.2	21.5	4.60	0.04
0.31	11.0	39.6	54.5	66.1	64.8	53.9	33.0	19.5	4.45	0.07
0.29	9.41	32.3	41.4	48.7	48.7	40.4	25.3	15.6	3.80	0.08
0.18	5.86	19.9	23.8	27.2	28.1	23.3	15.3	10.2	2.52	0.06
0.07	2.36	8.69	9.47	10.4	11.2	9.18	6.57	4.92	1.07	0.02
0.01	0.44	1.99	2.02	2.43	2.63	1.91	1.11	1.06	0.19	0.0
0.0	0.01	0.21	0.45				0.23	0.05	0.0	0.0
Insolation = 950 W/m^2										

Incident Heat Fluxes, W/cm^2						
Roof						
Inactive		0.03	0.29		0.38	
Active	0.28	4.94	11.2	11.3	8.28	1.06
		19.9	25.5	23.9	17.9	
		29.3	29.0	27.0	22.4	
Insolation 950 W/m^2						
Total Incident Power 15.6 MWt (per Cavity)						

Floor Inactive		
0.0	0.01	0.0
0.0	0.01	0.0

Feedwater is controlled by a feedwater regulator that matches feedwater flow to the total flow leaving the receiver, with a trimming override in response to drum level. The total flow leaving the receiver is determined by measurements of the blowdown flow and the saturated steam flow. The blowdown flow is regulated by a preset blowdown ratio with reference to the measured feedwater flow. Output pressure is maintained by a control valve in accordance with a feedback signal from a pressure sensor. All receiver controls can be operated either in a fully automatic mode or by manned override at the operator's discretion.

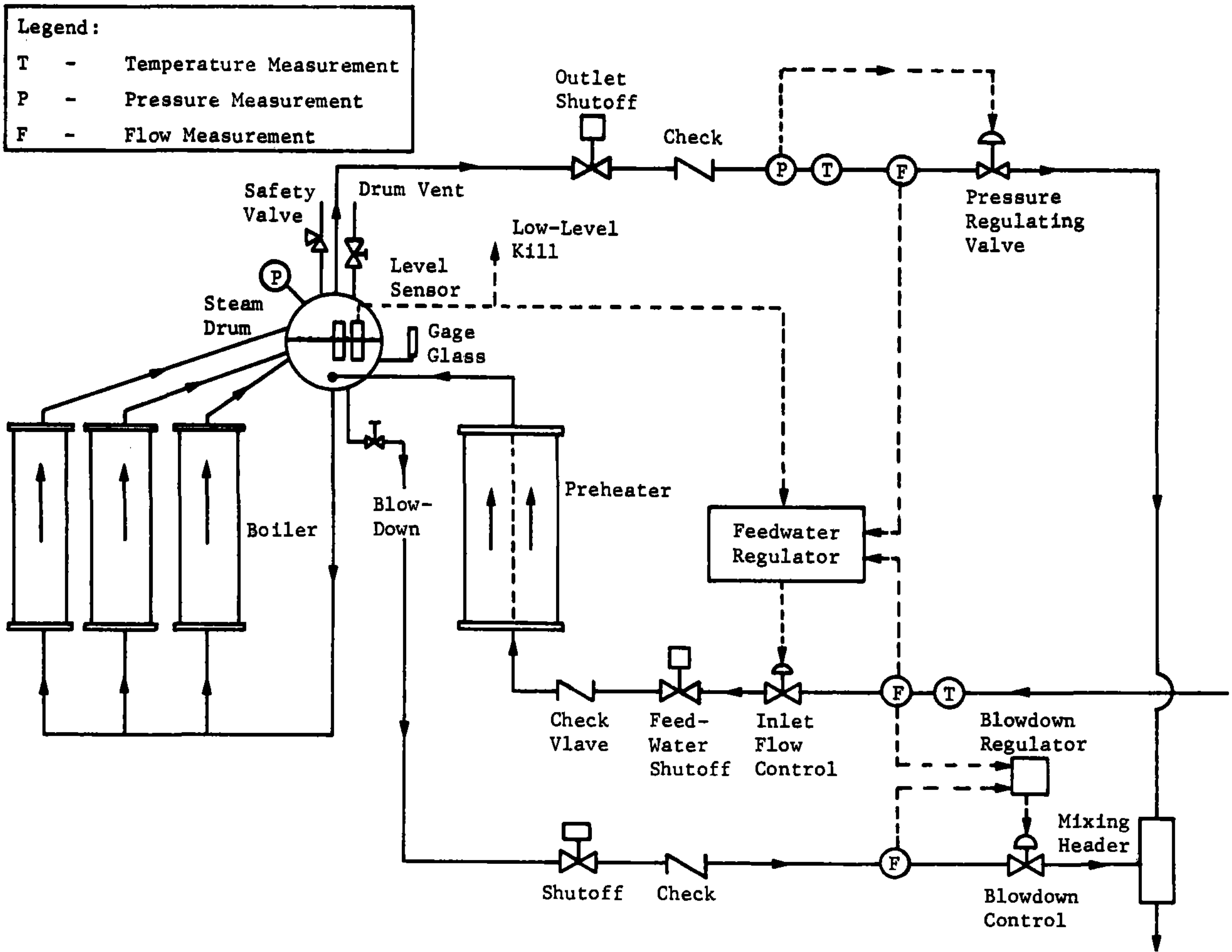


Figure C-6 Receiver Schematic

If the receiver should reach a critical condition, an emergency shutdown signal is sent to the collector subsystem to put it in a standby mode. From the standby mode the collector field can either be stowed or returned to normal tracking, depending on the condition of the receiver.

3.5 FIELD PIPING

The field piping must transport and distribute steam from the receiver to the injection well at a pressure in the range from 5.5 to 6.7 MPa (800 to 1000 psia) and a maximum heat loss of about 1% of the design power.

3.6 SERVICE LIFE

The solar power system shall be designed for a 26-year service life with only minimal repair and maintenance.

3.7 PLANT AVAILABILITY AND RELIABILITY

The system shall be designed for 95% plant availability, based on documented reliability and maintainability assessment, exclusive of insolation condition. In the design, consideration shall be given to achieving high reliability by providing design and operating margins and utilizing sound engineering design practices.

3.8 MAINTAINABILITY

The solar repowered plant modifications and new installations shall be designed to be compatible with normal plant maintenance and practices. Potential maintenance locations shall be easily reached and components such as electronic units, motors, drivers, valves, sensors, etc readily replaceable. Elements subject to wear and damage, such as supporting wheels, gears, seals, etc shall be easily serviced or replaced. The plant shall be capable of being serviced with a minimum of specialized equipment and tools. Preventive maintenance procedures shall be scheduled for performance during nighttime or other nonoperative periods.

3.9 SPECIALIZED EQUIPMENT

Specialized equipment will be required for the removal and reinstallation of heliostats for the drilling of wells. A standard forklift will be used with a special lifting device to hold the heliostats.

3.10 SPECIALIZED REQUIREMENTS

A solar power system in a production oil field creates a special requirement. When wells are drilled, an area around the drilling site will need to be cleared of heliostats for the drilling operation. After the drilling is completed the heliostats will be reset at their former location. Six wells will be drilled each year for three years in the heliostat field. Also normal oil well operations (well casing replacement) will require the removal of heliostats to service the wells periodically over the life of the field.

3.11 DESIGN AND CONSTRUCTION

All governing codes will be used during the design and construction of the solar power system.

3.12 MATERIALS, PROCESSES AND PARTS

To the maximum extent possible, standard materials and processes and off-the-shelf components shall be used. Wherever possible, commercial specifications shall be employed. All noncommercially available parts shall be defined and documented in deliverable documents.

3.13 ELECTROMAGNETIC RADIATION

The master control subsystem wiring shall be designed to minimize susceptibility to electromagnetic interference and to minimize the generation of conducted or radiated interference.

3.14 FLAMMABILITY

In the high-temperature low-humidity environment of a typical desert, the solar equipment shall not be vulnerable to extensive fire damage.

Should a fire exist in any part of the equipment, the fire should not damage any other equipment that is not directly adjacent to the fire by burning of the equipment or wiring. If any equipment or any part of the equipment burns for any reason, the fire should not spread to other parts of the solar system due to blowing winds, component explosions, or any other means.

3.15 NAMEPLATES AND PRODUCT MARKING

All major elements and assemblies shall be labeled with a permanent nameplate, listing as a minimum the manufacturer, part number, serial number, and date of manufacture.

3.16 WORKMANSHIP

The level of workmanship shall conform to practices defined in the codes, standards, and specifications applicable to the Edison site and Exxon, USA. Where specific skill levels or certifications are required, current certification status shall be maintained with evidence of the status available for examination. All work shall be finished in a manner that presents no unintended hazard to operating and maintenance personnel, is neat and clean, and presents a uniform appearance.

3.17 INTERCHANGEABILITY

Items with a common function shall have a common part number and be interchangeable. Components with a similar appearance, but different functions, shall incorporate protection against inadvertent erroneous installation.

3.18 SAFETY

The solar system shall be designed to minimize safety hazards to operating and service personnel, the public, and equipment. Electric components shall be insulated and grounded. All components with elevated temperatures shall be insulated against contact with personnel. Any moving elements shall be shielded to avoid entanglements and safety override controls/interlocks shall be provided for servicing.

3.19 HUMAN ENGINEERING

The solar system shall be designed to facilitate the manual operation, adjustment, and maintanance needed and provide the optimum allocation of functions between personnel and automatic control. The solar system design shall provide electrical and electronic packaging that ensures rapid repair and replacement, placarding of hazardous work areas, and equipment for item removal and handling. MIL-STD-1472, Human Engineering Design Criteria, shall be used as a guide in designing equipment.

4.0 ENVIRONMENTAL CRITERIA

The environmental criteria of this section are to be used in establishing the system design, operating, maintenance, performance, and reliability characteristics of the equipment described in Section 3.

4.1 OPERATING

The system will be capable of operating in appropriate combinations of the following environments:

1) Temperature--The plant will be capable of operating efficiently within the ambient temperature range of -6.7 to 46°C (20 to 115°F), which is an extreme temperature range for the Bakersfield area;

2) Wind--The plant shall be capable of operating with a wind speed of 16 m/s (35 mph).

3) Earthquake--Peak operational ground acceleration for UBC Zone 4 are 0.30 g. This peak ground acceleration is combined with the response spectrum given by NRC Regulation Guide 1.60 and the damping values given for the operating basis earthquake in NRC Regulation Guide 1.61.

4.2 SURVIVAL

The system shall be capable of surviving appropriate combinations of the following environments:

1) Wind--The plant shall survive winds with a maximum speed, including gusts of 40 m/s (90 mph), without damage. A local wind vector variation of +10° from the horizontal shall be assumed for the survival conditions;

2) Snow--The plant shall survive a static snow load of 3.81 kg/m^2 (0.78 lb/ft^2) and a snow deposition rate equal to the maximum on record of 0.04 m (1.5 in.);

3) Rain--The plant shall survive the rainfall conditions of average annual of 0.15 m (5.8 in.) and maximum 24-h rate of 0.04 m (1.68 in.);

4) Ice--The plant shall survive freezing rain and ice deposits in a layer 50-mm (2-in.) thick;

5) Earthquake--Peak survival ground acceleration for UBC Zone 4 is 0.50 g. This peak ground acceleration is combined with the response spectrum given by NRC Regulation Guide 1.60 and the damping values given for the survival basis earthquake in NRC Regulation Guide 1.61;

6) Sandstorm environment--The plant shall survive after being exposed to flowing dust comparable to the conditions described by Method 510 of MIL-STD-810C or any other more appropriate condition;

7) Lightning--The plant shall have a lightning protection system. It need not prevent the total distruction of a single heliostat and its controller when subjected to a direct hit, but the damage to an adjacent heliostat should be minimized. The central controller and the local controllers of heliostats adjacent to a direct lightning strike must be protected or alternative control methods must be provided to minimize the loss of collector subsystem control.

4.3 ENVIRONMENTAL STANDARDS

The plant shall meet the emission requirements of Kern County, the State of California and the National Standards for each contaminant. The air quality emission limits include:

1) Sulfur--For units constructed after 2/21/79, the limit is 0.027 kg (0.06 lb) sulfur and 0.054 kg (0.12 lb) SO_2 per MBtu of heat unit, set by CARB.* Kern County (Rule 407) sets a limit of 2000 ppm SO_x in gas discharge from any source using fossil fuel regardless of size;

2) NO_x--The plant will meet the controls for NO_x on oil field generators now being considered by CARB. The county emision regulations correspond to approximately 350 volumetric ppm NO_2 in the flue gas at 20% excess air;

3) Hydrocarbons--Kern County has a regulation that requires 93% recovery of all condensable hydrocarbons from steam drive production wells. This corresponds to 550 ppm for hydrocarbons as for particulates, in the flue gas at 20% excess gas;

4) CO--The county has a carbon monoxide limit for oil field steam generators of 68 kg/h (150 lb/h) maximum discharge;

5) For oil field steam generators, there is a maximum discharge limit set by county Rule 210.1 of 6.8 kg/h (15 lb/h) for each contaminant including SO_x, NO_x, particulates and hydrocarbons.

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*California Air Regulatory Board.

4.3.1 Water Pollution Standards

The plant will comply with any regulations the government may set for waste water. Today they are satisfied with the water being pumped back into the ground and have not established limits.

5.0 CONCEPTUAL DESIGN DATA SUMMARY

The data for the conceptual design are summarized in this section.

5.1 PLANT CHARACTERISTICS AND PERFORMANCE DATA

The following technical data will be used in determining system performance and technical characteristics.

5.1.1 Collector Design Characteristics Data

The collector field is a 2.62-rad (150°) north field as shown in Figure C-7, with the outermost row 367 m (1166 ft) from the tower centerline and the innermost row 60m (198 ft.) from the tower centerline. The origin for the heliostat coordinates in Table C-2 is the tower centerline, with east being positive X and north being positive Y. The collector field consists of 818 heliostats.

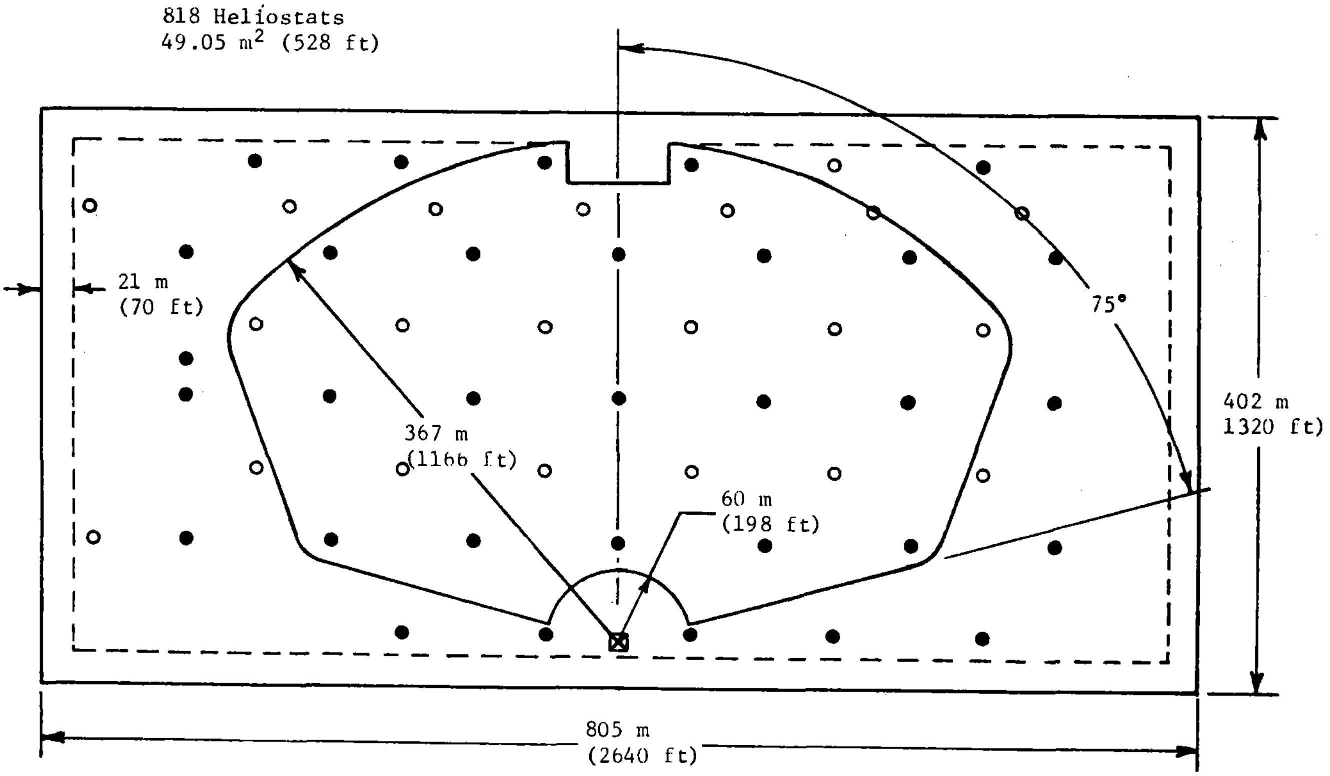

Figure C-7 Collector Field Boundary

Table C-2 Heliostat Coordinates

	X	Y
Row 1	58.29 m (191.24 ft)	15.77 m (51.75 ft)
	54.35 m (178.32 ft)	26.32 m (86.34 ft)
	48.52 m (159.20 ft)	35.94 m (117.93 ft)
	32.07 m (105.32 ft)	51.16 m (167.86 ft)
	22.02 m (72.25 ft)	56.23 m (184.48 ft)
	11.20 m (36.76 ft)	59.34 m (194.68 ft)
	-11.50 m (-36.76 ft)	59.34 m (194.68 ft)
	-22.02 m (-72.25 ft)	56.23 m (184.48 ft)
	-32.07 m (-105.32 ft)	51.16 m (167.86 ft)
	-48.52 m (-159.20 ft)	35.94 m (117.93 ft)
	-54.35 m (-178.32 ft)	26.32 m (86.34 ft)
	-58.29 m (-191.24 ft)	15.77 m (51.75 ft)
Row 2	64.92 m (212.99 ft)	24.25 m (79.58 ft)
	59.29 m (194.52 ft)	35.88 m (117.72 ft)
	51.60 m (169.30 ft)	46.26 m (151.78 ft)
	42.12 m (138.19 ft)	55.03 m (180.56 ft)
	31.18 m (102.29 ft)	61.89 m (203.06 ft)
	19.15 m (62.83 ft)	66.60 m (218.52 ft)
	-19.15 m (-62.83 ft)	66.60 m (218.52 ft)
	-31.18 m (-102.29 ft)	61.89 m (203.06 ft)
	-42.12 m (-138.19 ft)	55.03 m (180.56 ft)
	-51.60 m (-169.30 ft)	46.26 m (151.78 ft)
	-59.29 m (-194.52 ft)	35.88 m (117.72 ft)
	-64.92 m (-212.99 ft)	24.25 m (79.58 ft)
Row 3	70.87 m (232.54 ft)	34.32 m (112.59 ft)
	62.16 m (203.96 ft)	48.33 m (158.58 ft)
	54.81 m (179.84 ft)	56.53 m (185.49 ft)
	41.82 m (137.22 ft)	66.72 m (218.90 ft)
	27.00 m (88.58 ft)	73.97 m (242.70 ft)
	16.41 m (53.85 ft)	77.01 m (252.68 ft)
	-16.41 m (-53.85 ft)	77.01 m (252.68 ft)
	-27.00 m (-88.58 ft)	73.97 m (242.70 ft)
	-41.82 m (-137.22 ft)	66.72 m (218.90 ft)
	-54.81 m (-179.84 ft)	56.53 m (185.49 ft)
	-62.16 m (-203.96 ft)	48.33 m (158.58 ft)
	-70.87 m (-232.54 ft)	34.32 m (112.59 ft)
Row 4	83.59 m (274.27 ft)	26.86 m (88.13 ft)
	72.91 m (239.23 ft)	48.91 m (160.49 ft)
	65.38 m (214.50 ft)	58.61 m (192.30 ft)
	56.56 m (185.57 ft)	67.16 m (220.35 ft)
	35.80 m (117.46 ft)	80.17 m (263.05 ft)
	24.26 m (79.60 ft)	84.38 m (276.86 ft)

Table C-2 (cont)

	12.25 m (40.20 ft)	86.94 m (285.26 ft)
	-12.25 m (-40.20 ft)	86.94 m (285.26 ft)
	-24.26 m (-79.60 ft)	84.38 m (276.86 ft)
	-35.80 m (-117.46 ft)	80.17 m (263.05 ft)
	-56.56 m (-185.57 ft)	67.16 m (220.35 ft)
	-65.38 m (-214.50 ft)	58.61 m (192.30 ft)
	-72.91 m (-239.23 ft)	48.91 m (160.49 ft)
	-83.59 m (-274.27 ft)	26.86 m (88.13 ft)
Row 5	89.52 m (293.71 ft)	35.85 m (117.62 ft)
	83.64 m (274.43 ft)	47.99 m (157.45 ft)
	76.13 m (249.77 ft)	59.19 m (194.20 ft)
	67.12 m (220.23 ft)	69.23 m (227.15 ft)
	56.81 m (186.38 ft)	77.92 m (255.66 ft)
	45.38 m (148.89 ft)	85.09 m (279.17 ft)
	33.06 m (108.48 ft)	90.59 m (297.21 ft)
	20.10 m (65.95 ft)	94.31 m (309.44 ft)
	6.74 m (22.13 ft)	96.19 m (315.61 ft)
	-6.74 m (-22.13 ft)	96.19 m (315.61 ft)
	-20.10 m (-65.95 ft)	94.31 m (309.44 ft)
	-33.06 m (-108.48 ft)	90.59 m (297.21 ft)
	-45.38 m (-148.89 ft)	85.09 m (279.17 ft)
	-56.81 m (-186.38 ft)	77.92 m (255.66 ft)
	-67.12 m (-220.23 ft)	69.23 m (227.15 ft)
	-76.13 m (-249.77 ft)	59.19 m (194.20 ft)
	-83.64 m (-274.43 ft)	47.99 m (157.45 ft)
	-89.52 m (-293.71 ft)	35.85 m (117.62 ft)
Row 6	100.73 m (330.49 ft)	32.37 m (106.20 ft)
	94.40 m (309.74 ft)	47.77 m (156.72 ft)
	88.88 m (291.61 ft)	57.39 m (188.31 ft)
	78.78 m (258.47 ft)	70.62 m (231.72 ft)
	66.73 m (218.93 ft)	82.11 m (269.39 ft)
	57.75 m (189.49 ft)	88.65 m (290.85 ft)
	43.14 m (141.53 ft)	96.61 m (316.97 ft)
	27.45 m (90.07 ft)	102.18 m (335.24 ft)
	16.59 m (54.44 ft)	104.49 m (342.83 ft)
	-16.59 m (-54.44 ft)	104.49 m (342.83 ft)
	-27.45 m (-90.07 ft)	102.18 m (335.24 ft)
	-43.14 m (-141.53 ft)	96.61 m (316.97 ft)
	-57.75 m (-189.49 ft)	88.65 m (290.85 ft)
	-66.73 m (-218.93 ft)	82.11 m (269.39 ft)
	-78.78 m (-258.47 ft)	70.62 m (231.72 ft)
	-88.88 m (-291.61 ft)	57.39 m (188.31 ft)
	-94.40 m (-309.74 ft)	47.77 m (156.72 ft)
	-100.73 m (-330.49 ft)	32.37 (106.20 ft)
Row 7	105.09 m (344.79 ft)	46.41 m (152.28 ft)
	99.64 m (326.93 ft)	57.17 m (187.58 ft)
	77.03 m (252.74 ft)	85.23 m (279.63 ft)

Table C-2 (cont)

	67.67 m (222.04 ft)	92.83 m (304.57 ft)
	57.57 m (188.90 ft)	99.41 m (326.17 ft)
	35.59 m (116.76 ft)	109.23 m (358.38 ft)
	23.94 m (78.56 ft)	112.36 m (368.64 ft)
	12.04 m (39.50 ft)	114.25 m (374.84 ft)
	-12.04 m (-39.50 ft)	114.25 m (374.84 ft)
	-23.94 m (-78.56 ft)	112.36 m (368.64 ft)
	-35.59 m (-116.76 ft)	109.23 m (358.38 ft)
	-57.57 m (-188.90 ft)	99.41 m (326.17 ft)
	-67.67 m (-222.04 ft)	92.83 m (304.57 ft)
	-17.03 m (-252.74 ft)	85.23 m (279.63 ft)
	-99.64 m (-326.93 ft)	57.17 m (187.58 ft)
	-105.09 m (-344.79 ft)	46.41 m (152.28 ft)
Row 8	115.57 m (379.17 ft)	43.95 m (144.20 ft)
	110.32 m (361.97 ft)	55.82 m (183.14 ft)
	87.60 m (287.43 ft)	87.25 m (286.27 ft)
	77.98 m (255.85 ft)	95.95 m (314.81 ft)
	67.48 m (221.45 ft)	103.59 m (339.89 ft)
	56.27 m (184.61 ft)	110.10 m (361.23 ft)
	32.08 m (105.26 ft)	119.41 m (391.77 ft)
	19.39 m (63.62 ft)	122.11 m (400.65 ft)
	6.49 m (21.29 ft)	123.47 m (405.11 ft)
	-6.49 m (-21.29 ft)	123.47 m (405.11 ft)
	-19.39 m (-63.62 ft)	122.11 m (400.65 ft)
	-32.08 m (-105.26 ft)	119.41 m (391.77 ft)
	-56.27 m (-184.61 ft)	110.10 m (361.23 ft)
	-67.48 m (-221.45 ft)	103.59 m (339.89 ft)
	-77.98 m (-255.85 ft)	95.95 m (314.81 ft)
	-87.60 m (-287.43 ft)	87.25 m (286.27 ft)
	-110.32 m (-361.97 ft)	55.82 m (183.14 ft)
	-115.57 m (-379.17 ft)	43.95 m (144.20 ft)
Row 9	125.73 m (412.52 ft)	40.40 m (132.56 ft)
	120.80 m (396.36 ft)	53.36 m (175.06 ft)
	114.55 m (375.83 ft)	65.72 m (215.63 ft)
	98.33 m (322.63 ft)	88.16 m (289.24 ft)
	88.55 m (290.54 ft)	97.97 m (321.45 ft)
	77.80 m (255.25 ft)	106.71 m (350.13 ft)
	66.19 m (217.16 ft)	114.28 m (374.95 ft)
	40.91 m (134.23 ft)	125.57 m (411.98 ft)
	27.53 m (90.32 ft)	129.16 m (423.78 ft)
	13.84 m (45.41 ft)	131.33 m (430.91 ft)
	-13.84 m (-45.41 ft)	131.33 m (430.91 ft)
	-27.53 m (-90.32 ft)	129.16 m (423.78 ft)
	-40.91 m (-134.23 ft)	125.57 m (411.98 ft)
	-66.19 m (-217.16 ft)	114.28 m (374.95 ft)
	-77.80 m (-255.25 ft)	106.71 m (350.13 ft)
	-88.55 m (-290.54 ft)	97.97 m (321.45 ft)
	-98.33 m (-322.63 ft)	88.16 m (289.24 ft)

Table C-2 (cont)

	-114.55 m (-375.83 ft)	65.72 m (215.63 ft)
	-120.80 m (-396.36 ft)	53.36 m (175.06 ft)
	-125.73 m (-412.52 ft)	40.40 m (132.56 ft)
Row 10	130.97 m (429.71 ft)	49.81 m (163.42 ft)
	125.03 m (410.22 ft)	63.26 m (207.55 ft)
	117.71 m (386.31 ft)	76.01 m (249.40 ft)
	109.10 m (357.95 ft)	87.93 m (288.50 ft)
	99.28 m (325.74 ft)	98.88 m (324.42 ft)
	88.37 m (289.95 ft)	108.74 m (356.77 ft)
	76.49 m (250.96 ft)	117.40 m (385.19 ft)
	63.76 m (209.21 ft)	124.77 m (409.37 ft)
	50.34 m (165.16 ft)	130.77 m (429.04 ft)
	36.36 m (119.29 ft)	135.32 m (443.99 ft)
	21.98 m (72.10 ft)	138.39 m (454.05 ft)
	7.35 m (24.12 ft)	139.93 m (459.10 ft)
	-7.35 m (-24.12 ft)	139.93 m (459.10 ft)
	-21.98 m (-72.10 ft)	138.39 m (454.05 ft)
	-36.36 m (-119.29 ft)	135.32 m (443.99 ft)
	-50.34 m (-165.16 ft)	130.77 m (429.04 ft)
	-63.76 m (-209.21 ft)	124.77 m (409.37 ft)
	-76.49 m (-250.96 ft)	117.40 m (385.19 ft)
	-88.37 m (-289.95 ft)	108.74 m (356.77 ft)
	-99.28 m (-325.74 ft)	98.88 m (324.42 ft)
	-109.10 m (-357.95 ft)	87.93 m (288.50 ft)
	-117.71 m (-386.21 ft)	76.01 m (249.40 ft)
	-125.03 m (-410.22 ft)	63.26 m (207.55 ft)
	-130.97 m (-429.71 ft)	49.81 m (163.42 ft)
Row 11	142.10 m (486.24 ft)	45.66 m (149.82 ft)
	135.73 m (445.33 ft)	62.09 m (203.72 ft)
	130.43 m (427.93 ft)	72.58 m (238.12 ft)
	120.97 m (396.89 ft)	87.44 m (286.88 ft)
	109.82 m (360.32 ft)	101.08 m (331.65 ft)
	101.53 m (333.11 ft)	109.41 m (358.97 ft)
	87.93 m (288.49 ft)	120.61 m (395.72 ft)
	73.10 m (239.85 ft)	130.13 m (426.96 ft)
	62.64 m (205.52 ft)	135.48 m (444.50 ft)
	46.24 m (151.71 ft)	141.91 m (465.62 ft)
	29.19 m (95.78 ft)	146.38 m (480.26 ft)
	17.59 m (57.71 ft)	148.22 m (486.30 ft)
	-17.59 m (-57.71 ft)	148.22 m (486.30 ft)
	-29.19 m (-95.78 ft)	146.38 m (480.26 ft)
	-46.24 m (-151.71 ft)	141.91 m (465.62 ft)
	-62.64 m (-205.52 ft)	135.48 m (444.50 ft)
	-73.10 m (-239.85 ft)	130.13 m (426.96 ft)
	-87.93 m (-288.49 ft)	120.61 m (395.72 ft)
	-101.53 m (-333.11 ft)	109.41 m (358.97 ft)
	-109.82 m (-360.32 ft)	101.08 m (331.65 ft)
	-120.97 m (-396.89 ft)	87.44 m (286.88 ft)

Table C-2 (cont)

	-130.43 m (-427.93 ft)	72.58 m (238.12 ft)
	-135.73 m (-445.33 ft)	62.09 m (203.72 ft)
	-142.10 m (-466.24 ft)	45.66 m (149.82 ft)
Row 12	146.31 m (480.04 ft)	60.08 m (197.13 ft)
	141.13 m (463.04 ft)	71.41 m (234.28 ft)
	135.07 m (443.18 ft)	82.29 m (269.98 ft)
	120.50 m (395.35 ft)	102.45 m (336.14 ft)
	112.07 m (367.69 ft)	111.61 m (366.20 ft)
	102.94 m (337.74 ft)	120.08 m (393.99 ft)
	82.83 m (271.77 ft)	134.74 m (442.08 ft)
	71.98 m (236.15 ft)	140.84 m (462.09 ft)
	60.67 m (199.07 ft)	146.06 m (479.23 ft)
	37.02 m (121.45 ft)	153.77 m (504.53 ft)
	24.81 m (81.39 ft)	156.21 m (512.52 ft)
	12.44 m (40.82 ft)	157.67 m (517.33 ft)
	-12.44 m (-40.82 ft)	157.67 m (517.33 ft)
	-24.81 m (-81.39 ft)	156.21 m (512.52 ft)
	-37.02 m (-121.45 ft)	153.77 m (504.53 ft)
	-60.67 m (-199.07 ft)	146.06 m (479.23 ft)
	-71.98 m (-236.15 ft)	140.84 m (462.09 ft)
	-82.83 m (-271.77 ft)	134.74 m (442.08 ft)
	-102.94 m (-337.74 ft)	120.08 m (393.99 ft)
	-112.07 m (-367.69 ft)	111.61 m (366.20 ft)
	-120.50 m (-395.35 ft)	102.45 m (336.14 ft)
	-135.01 m (-443.18 ft)	82.29 m (269.98 ft)
	-141.13 m (-463.04 ft)	71.41 m (234.28 ft)
	-146.31 m (-480.04 ft)	60.08 m (197.13 ft)
Row 13	160.71 m (527.30 ft)	44.75 m (146.81 ft)
	156.70 m (514.12 ft)	57.25 m (187.83 ft)
	151.71 m (497.75 ft)	69.40 m (227.69 ft)
	145.78 m (478.29 ft)	81.12 m (266.14 ft)
	138.95 m (455.88 ft)	92.33 m (302.94 ft)
	131.25 m (430.64 ft)	102.97 m (337.86 ft)
	122.74 m (402.72 ft)	112.98 m (370.69 ft)
	113.48 m (372.32 ft)	122.29 m (401.22 ft)
	102.51 m (339.60 ft)	130.83 m (429.26 ft)
	92.90 m (304.79 ft)	138.57 m (454.65 ft)
	81.71 m (268.08 ft)	145.45 m (477.31 ft)
	70.01 m (229.71 ft)	151.42 m (496.82 ft)
	57.88 m (189.92 ft)	156.46 m (513.35 ft)
	45.40 m (148.95 ft)	160.53 m (526.70 ft)
	32.63 m (107.06 ft)	163.60 m (536.78 ft)
	19.66 m (64.50 ft)	165.66 m (543.54 ft)
	-19.66 m (-64.50 ft)	165.66 m (543.54 ft)
	-32.63 m (-107.06 ft)	163.60 m (536.78 ft)
	-45.40 m (-148.95 ft)	160.53 m (526.70 ft)
	-57.88 m (-189.92 ft)	156.46 m (513.35 ft)

Table C-2 (cont)

	-70.01 m (-229.71 ft)	151.42 m (496.82 ft)
	-81.71 m (-268.08 ft)	145.45 m (477.21 ft)
	-92.90 m (-394.79 ft)	138.57 m (454.65 ft)
	-103.51 m (-339.60 ft)	130.83 m (429.26 ft)
	-113.48 m (-372.32 ft)	122.29 m (401.22 ft)
	-122.74 m (-402.72 ft)	112.98 m (370.69 ft)
	-131.25 m (-430.64 ft)	102.97 m (337.86 ft)
	-138.95 m (-455.88 ft)	92.33 m (302.94 ft)
	-145.78 m (-478.29 ft)	81.12 m (266.14 ft)
	-151.71 m (-497.75 ft)	69.40 m (227.69 ft)
	-156.70 m (-514.12 ft)	57.25 m (187.83 ft)
	-160.71 m (-527.30 ft)	44.75 m (146.81 ft)
Row 14	166.89 m (547.57 ft)	53.63 m (175.95 ft)
	162.15 m (532.03 ft)	66.59 m (218.48 ft)
	156.42 m (513.20 ft)	79.14 m (259.65 ft)
	149.70 m (491.18 ft)	91.20 m (299.22 ft)
	142.07 m (466.12 ft)	102.69 m (336.93 ft)
	133.55 m (438.18 ft)	113.55 m (372.55 ft)
	124.20 m (407.51 ft)	123.70 m (405.86 ft)
	114.09 m (374.32 ft)	133.09 m (436.66 ft)
	103.27 m (338.82 ft)	141.65 m (464.75 ft)
	91.80 m (301.21 ft)	149.33 m (489.96 ft)
	79.71 m (261.73 ft)	156.09 m (512.14 ft)
	67.25 m (220.64 ft)	161.88 m (531.13 ft)
	54.30 m (178.17 ft)	166.67 m (546.85 ft)
	41.02 m (134.60 ft)	170.43 m (559.17 ft)
	27.49 m (90.20 ft)	173.13 m (568.03 ft)
	13.79 m (45.24 ft)	174.75 m (573.36 ft)
	-13.79 m (-45.24 ft)	174.75 m (573.36 ft)
	-27.49 m (-90.20 ft)	173.13 m (568.03 ft)
	-41.02 m (-134.60 ft)	170.43 m (559.17 ft)
	-54.30 m (-178.17 ft)	166.67 m (546.85 ft)
	-67.25 m (-220.64 ft)	161.88 m (531.14 ft)
	-79.77 m (-261.73 ft)	156.09 m (512.14 ft)
	-91.80 m (-301.21 ft)	149.33 m (489.96 ft)
	-103.27 m (-338.82 ft)	141.65 m (464.75 ft)
	-114.09 m (-374.32 ft)	133.09 m (436.66 ft)
	-124.20 m (-407.51 ft)	123.70 m (405.86 ft)
	-133.55 m (-438.18 ft)	113.55 m (372.55 ft)
	-142.07 m (-466.12 ft)	102.69 m (336.93 ft)
	-149.70 m (-491.18 ft)	91.20 m (299.22 ft)
	-156.42 m (-513.20 ft)	79.14 m (259.65 ft)
	-162.15 m (-532.03 ft)	66.59 m (218.48 ft)
	-166.89 m (-547.57 ft)	53.63 m (175.95 ft)
Row 15	177.06 m (580.94 ft)	49.30 m (161.75 ft)
	172.63 m (566.41 ft)	63.07 m (206.94 ft)
	167.14 m (548.38 ft)	76.46 m (250.86 ft)
	160.61 m (526.95 ft)	89.37 m (293.21 ft)
	153.08 m (502.25 ft)	101.73 m (333.76 ft)

Table C-2 (cont)

	135.23 m (443.69 ft)	124.47 m (408.40 ft)
	125.02 m (410.19 ft)	134.72 m (442.03 ft)
	114.04 m (374.15 ft)	144.14 m (472.93 ft)
	102.34 m (335.79 ft)	152.66 m (500.89 ft)
	90.02 m (295.35 ft)	160.24 m (525.76 ft)
	77.14 m (253.08 ft)	166.83 m (547.36 ft)
	63.77 m (209.24 ft)	172.38 m (565.57 ft)
	50.02 m (164.10 ft)	176.86 m (580.28 ft)
	35.95 m (117.95 ft)	180.25 m (591.39 ft)
	21.66 m (71.06 ft)	182.51 m (598.83 ft)
	7.24 m (23.74 ft)	183.65 m (602.51 ft)
	-7.24 m (-23.74 ft)	183.65 m (602.57 ft)
	-21.66 m (-71.06 ft)	182.51 m (598.83 ft)
	-35.95 m (-117.95 ft)	180.25 m (591.39 ft)
	-50.02 m (-164.10 ft)	176.86 m (580.28 ft)
	-63.77 m (-209.24 ft)	172.38 m (565.57 ft)
	-77.14 m (-253.08 ft)	166.83 m (547.36 ft)
	-90.02 m (-295.35 ft)	160.24 m (525.76 ft)
	-102.34 m (-335.79 ft)	152.66 m (500.89 ft)
	-114.04 m (-374.15 ft)	144.14 m (472.93 ft)
	-125.02 m (-410.19 ft)	134.72 m (442.03 ft)
	-135.23 m (-443.69 ft)	124.47 m (408.40 ft)
	-153.08 m (-502.25 ft)	101.73 m (333.76 ft)
	-160.61 m (-526.95 ft)	89.37 m (293.21 ft)
	-167.14 m (-548.38 ft)	76.46 m (250.86 ft)
	-172.63 m (-566.41 ft)	63.07 m (206.94 ft)
	-177.06 m (-580.94 ft)	49.30 m (161.75 ft)
Row 16	184.33 m (604.79 ft)	57.24 m (187.80 ft)
	178.55 m (585.81 ft)	73.32 m (240.57 ft)
	171.36 m (562.23 ft)	88.83 m (291.45 ft)
	165.82 m (544.05 ft)	98.79 m (324.12 ft)
	138.09 m (453.08 ft)	134.85 m (442.45 ft)
	125.62 m (412.16 ft)	146.54 m (480.80 ft)
	112.16 m (368.01 ft)	157.08 m (525.38 ft)
	87.84 m (288.19 ft)	171.87 m (563.91 ft)
	72.29 m (237.17 ft)	178.97 m (587.19 ft)
	61.60 m (202.10 ft)	182.92 m (600.17 ft)
	45.71 m (148.21 ft)	187.65 m (615.69 ft)
	28.39 m (93.16 ft)	190.91 m (626.39 ft)
	17.08 m (56.03 ft)	192.26 m (630.80 ft)
	-17.08 m (-56.03 ft)	192.26 m (630.80 ft)
	-28.39 m (-93.16 ft)	190.91 m (626.39 ft)
	-45.71 m (-148.21 ft)	187.65 m (615.69 ft)
	-61.60 m (-202.10 ft)	182.92 m (600.17 ft)
	-72.29 m (-237.17 ft)	178.97 m (587.19 ft)
	-87.84 m (-288.19 ft)	171.87 m (563.91 ft)
	-112.16 m (-368.01 ft)	157.08 m (515.38 ft)
	-125.62 m (-412.16 ft)	146.54 m (480.80 ft)
	-138.09 m (-453.08 ft)	138.85 m (442.45 ft)
	-165.82 m (-544.05 ft)	98.79 m (324.12 ft)

Table C-2 (cont)

	-171.36 m (-562.23 ft)	88.83 m (291.45 ft)
	-178.55 m (-585.81 ft)	73.32 m (240.57 ft)
	-184.33 m (-604.79 ft)	57.24 m (187.80 ft)
Row 17	195.22 m (640.51 ft)	54.35 m (178.33 ft)
	191.67 m (628.86 ft)	65.78 m (215.82 ft)
	182.58 m (599.05 ft)	87.93 m (288.43 ft)
	177.07 m (580.98 ft)	98.53 m (323.28 ft)
	170.95 m (560.89 ft)	108.81 m (357.01 ft)
	156.94 m (514.91 ft)	128.20 m (420.61 ft)
	149.10 m (489.19 ft)	137.24 m (450.27 ft)
	140.74 m (461.76 ft)	145.80 m (478.36 ft)
	122.58 m (402.17 ft)	161.37 m (529.44 ft)
	93.64 m (307.22 ft)	168.32 m (552.26 ft)
	81.41 m (267.09 ft)	185.57 m (608.86 ft)
	70.31 m (230.69 ft)	190.05 m (623.56 ft)
	58.97 m (193.48 ft)	193.87 m (636.09 ft)
	35.71 m (117.18 ft)	199.47 m (654.46 ft)
	23.88 m (78.35 ft)	201.23 m (660.24 ft)
	11.96 m (39.24 ft)	202.29 m (663.71 ft)
	-11.96 m (-39.24 ft)	202.29 m (663.71 ft)
	-23.88 m (-78.35 ft)	201.23 m (660.24 ft)
	-35.71 m (-117.18 ft)	199.47 m (654.46 ft)
	-58.97 m (-193.48 ft)	193.87 m (636.09 ft)
	-70.31 m (-230.69 ft)	190.05 m (623.56 ft)
	-81.41 m (-267.09 ft)	185.57 m (608.86 ft)
	-93.64 m (-307.22 ft)	168.32 m (552.26 ft)
	-122.58 m (-402.17 ft)	161.37 m (529.44 ft)
	-140.74 m (-461.76 ft)	145.80 m (478.36 ft)
	-149.10 m (-489.19 ft)	137.24 m (450.27 ft)
	-156.94 m (-514.91 ft)	128.20 m (420.61 ft)
	-170.95 m (-560.89 ft)	108.81 m (357.01 ft)
	-177.07 m (-580.98 ft)	98.53 m (323.28 ft)
	-182.58 m (-599.05 ft)	87.93 m (288.43 ft)
	-191.67 m (-628.86 ft)	65.78 m (215.82 ft)
	-195.22 m (-640.51 ft)	54.35 m (178.33 ft)
Row 18	193.92 m (636.26 ft)	86.41 m (283.52 ft)
	188.49 m (618.42 ft)	97.71 m (320.58 ft)
	182.39 m (598.42 ft)	108.66 m (356.52 ft)
	175.66 m (576.34 ft)	119.24 m (391.22 ft)
	168.31 m (552.24 ft)	129.40 m (424.55 ft)
	160.38 m (526.22 ft)	139.11 m (456.41 ft)
	151.89 m (498.36 ft)	148.33 m (486.67 ft)
	142.87 m (468.77 ft)	157.04 m (515.24 ft)
	133.36 m (437.54 ft)	165.20 m (542.01 ft)
	123.37 m (404.79 ft)	172.78 m (566.89 ft)
	112.96 m (370.62 ft)	179.76 m (589.79 ft)
	102.15 m (335.17 ft)	186.11 m (610.64 ft)
	90.99 m (298.54 ft)	191.82 m (629.35 ft)

Table C-2 (cont)

	79.51 m (260.87 ft)	196.85 m (645.88 ft)
	67.75 m (222.30 ft)	201.20 m (660.15 ft)
	55.76 m (182.95 ft)	204.85 m (672.12 ft)
	43.57 m (142.96 ft)	207.79 m (681.75 ft)
	31.23 m (102.47 ft)	209.99 m (688.99 ft)
	18.78 m (61.63 ft)	211.47 m (693.84 ft)
	6.27 m (20.57 ft)	212.21 m (696.27 ft)
	-6.27 m (-20.57 ft)	212.21 m (696.27 ft)
	-18.78 m (-61.63 ft)	211.47 m (693.84 ft)
	-31.23 m (-102.47 ft)	209.99 m (688.99 ft)
	-47.57 m (-142.96 ft)	207.79 m (681.75 ft)
	-55.76 m (-182.95 ft)	204.85 m (672.12 ft)
	-67.75 m (-222.30 ft)	201.20 m (660.15 ft)
	-79.51 m (-260.87 ft)	196.85 m (645.88 ft)
	-90.99 m (-298.54 ft)	191.82 m (629.35 ft)
	-102.15 m (-335.17 ft)	186.11 m (610.64 ft)
	-112.96 m (-370.62 ft)	179.76 m (589.99 ft)
	-123.37 m (-404.79 ft)	172.78 m (566.89 ft)
	-133.36 m (-437.54 ft)	165.20 m (542.01 ft)
	-142.87 m (-468.77 ft)	157.04 m (515.24 ft)
	-151.89 m (-498.36 ft)	148.33 m (486.67 ft)
	-160.38 m (-526.22 ft)	139.11 m (456.41 ft)
	-168.31 m (-552.24 ft)	129.40 m (424.55 ft)
	-175.66 m (-576.34 ft)	119.24 m (391.22 ft)
	-182.39 m (-598.42 ft)	108.66 m (356.52 ft)
	-188.49 m (-618.42 ft)	97.71 m (320.58 ft)
	-193.92 m (-636.26 ft)	86.41 m (283.52 ft)
Row 19	214.63 m (704.21 ft)	59.76 m (196.07 ft)
	210.73 m (691.41 ft)	72.32 m (237.29 ft)
	206.10 m (676.20 ft)	84.63 m (277.68 ft)
	200.74 m (658.63 ft)	96.65 m (317.11 ft)
	194.68 m (638.76 ft)	108.33 m (355.43 ft)
	187.95 m (616.67 ft)	119.63 m (392.51 ft)
	180.56 m (592.43 ft)	130.52 m (428.23 ft)
	172.54 m (566.12 ft)	140.95 m (462.45 ft)
	163.93 m (537.84 ft)	150.89 m (495.06 ft)
	154.73 m (507.68 ft)	160.30 m (525.94 ft)
	145.00 m (475.76 ft)	169.15 m (554.99 ft)
	134.77 m (442.17 ft)	177.42 m (582.10 ft)
	124.06 m (407.04 ft)	185.06 m (607.18 ft)
	112.92 m (370.50 ft)	192.06 m (630.15 ft)
	101.39 m (332.66 ft)	198.39 m (650.92 ft)
	89.50 m (293.66 ft)	204.03 m (669.42 ft)
	77.31 m (253.64 ft)	208.95 m (685.58 ft)
	64.84 m (212.73 ft)	213.15 m (699.36 ft)
	39.27 m (128.83 ft)	219.31 m (719.55 ft)
	26.25 m (86.14 ft)	221.24 m (725.90 ft)
	13.15 m (43.15 ft)	222.41 m (729.72 ft)
	-13.15 m (-43.15 ft)	222.41 m (729.72 ft)
	-26.25 m (-86.14 ft)	221.24 m (725.90 ft)

Table C-2 (cont)

	-39.27 m (-128.83 ft)	219.31 m (719.55 ft)
	-64.84 m (-212.73 ft)	213.15 m (699.36 ft)
	-77.31 m (-253.64 ft)	208.95 m (685.58 ft)
	-89.50 m (-293.60 ft)	204.03 m (669.42 ft)
	-101.39 m (-332.66 ft)	198.39 m (650.92 ft)
	-112.92 m (-370.50 ft)	192.06 m (630.15 ft)
	-124.06 m (-407.04 ft)	185.06 m (607.18 ft)
	-134.77 m (-442.17 ft)	177.42 m (582.10 ft)
	-145.00 m (-475.76 ft)	169.15 m (554.99 ft)
	-154.73 m (-507.68 ft)	160.30 m (525.94 ft)
	-163.93 m (-537.84 ft)	150.89 m (495.06 ft)
	-172.54 m (-566.12 ft)	140.95 m (462.45 ft)
	-180.56 m (-592.43 ft)	130.52 m (428.23 ft)
	-187.95 m (-616.67 ft)	119.63 m (392.51 ft)
	-194.68 m (-638.76 ft)	108.33 m (355.43 ft)
	-200.74 m (-658.63 ft)	96.65 m (317.11 ft)
	-206.10 m (-676.20 ft)	84.63 m (277.68 ft)
	-210.73 m (-691.41 ft)	72.32 m (237.29 ft)
	-214.63 m (-704.21 ft)	59.76 m (196.07 ft)
Row 20	222.83 m (731.11 ft)	69.19 m (227.02 ft)
	218.36 m (716.44 ft)	82.22 m (269.77 ft)
	213.12 m (699.26 ft)	94.97 m (311.59 ft)
	207.15 m (679.65 ft)	107.38 m (352.32 ft)
	200.45 m (657.67 ft)	119.42 m (391.82 ft)
	193.05 m (633.40 ft)	131.04 m (429.95 ft)
	184.98 m (606.92 ft)	142.21 m (466.59 ft)
	176.26 m (578.32 ft)	152.88 m (501.60 ft)
	166.93 m (547.71 ft)	163.02 m (534.86 ft)
	157.02 m (515.19 ft)	172.58 m (566.25 ft)
	146.56 m (480.87 ft)	181.55 m (595.67 ft)
	135.59 m (444.87 ft)	189.89 m (623.02 ft)
	124.15 m (407.32 ft)	197.56 m (648.19 ft)
	112.27 m (368.35 ft)	204.54 m (671.10 ft)
	100.00 m (328.10 ft)	210.81 m (691.67 ft)
	87.38 m (386.71 ft)	216.35 m (709.83 ft)
	74.46 m (244.31 ft)	221.12 m (725.51 ft)
	61.28 m (201.06 ft)	225.14 m (738.67 ft)
	34.32 m (112.62 ft)	230.79 m (757.22 ft)
	20.64 m (67.73 ft)	232.41 m (762.54 ft)
	6.89 m (22.60 ft)	233.22 m (765.21 ft)
	-6.89 m (-22.60 ft)	233.22 m (765.21 ft)
	-20.64 m (-67.73 ft)	232.41 m (762.54 ft)
	-34.32 m (-112.62 ft)	230.79 m (757.22 ft)
	-61.28 m (-201.06 ft)	225.14 m (738.67 ft)
	-74.46 m (-244.31 ft)	221.12 m (725.51 ft)
	-87.38 m (-286.71 ft)	216.35 m (709.83 ft)
	-100.00 m (-328.10 ft)	210.81 m (691.65 ft)
	-112.27 m (-368.35 ft)	204.54 m (671.10 ft)
	-124.15 m (-407.32 ft)	197.56 m (648.19 ft)
	-135.59 m (-444.87 ft)	187.89 m (623.02 ft)

Table C-2 (cont)

	-146.56 m (-480.87 ft)	181.55 m (595.67 ft)
	-157.02 m (-515.19 ft)	172.58 m (566.25 ft)
	-166.93 m (-547.71 ft)	163.02 m (534.86 ft)
	-176.26 m (-578.32 ft)	152.88 m (501.60 ft)
	-184.98 m (-606.92 ft)	142.21 m (466.59 ft)
	-193.05 m (-633.40 ft)	131.04 m (429.95 ft)
	-200.45 m (-657.67 ft)	119.42 m (391.82 ft)
	-207.15 m (-679.65 ft)	107.38 m (352.32 ft)
	-213.12 m (-699.26 ft)	94.97 m (311.59 ft)
	-218.36 m (-716.44 ft)	82.22 m (269.77 ft)
	-222.83 m (-731.11 ft)	69.19 m (227.02 ft)
Row 21	231.51 m (759.59 ft)	79.45 m (260.69 ft)
	226.42 m (742.88 ft)	92.98 m (305.07 ft)
	220.54 m (723.58 ft)	106.18 m (348.38 ft)
	213.89 m (701.76 ft)	119.01 m (390.48 ft)
	206.49 m (677.48 ft)	131.43 m (431.22 ft)
	198.37 m (650.85 ft)	143.39 m (470.46 ft)
	189.56 m (621.95 ft)	154.85 m (508.05 ft)
	180.09 m (590.88 ft)	165.76 m (543.87 ft)
	169.99 m (557.75 ft)	176.10 m (577.80 ft)
	159.30 m (522.67 ft)	185.83 m (609.71 ft)
	148.06 m (485.77 ft)	194.91 m (639.50 ft)
	136.29 m (447.18 ft)	203.31 m (667.06 ft)
	124.06 m (407.03 ft)	211.00 m (692.29 ft)
	111.39 m (365.46 ft)	217.95 m (715.11 ft)
	98.33 m (322.62 ft)	224.15 m (735.43 ft)
	84.93 m (278.65 ft)	229.56 m (753.19 ft)
	71.23 m (233.71 ft)	234.17 m (768.32 ft)
	57.28 m (187.95 ft)	237.97 m (780.78 ft)
	43.14 m (141.54 ft)	240.94 m (790.51 ft)
	28.84 m (94.63 ft)	243.06 m (797.48 ft)
	14.45 m (47.40 ft)	244.34 m (801.68 ft)
	-14.45 m (-47.40 ft)	244.34 m (801.68 ft)
	-28.84 m (-94.63 ft)	243.06 m (797.48 ft)
	-43.14 m (-141.54 ft)	240.94 m (790.51 ft)
	-57.28 m (-187.95 ft)	237.97 m (780.78 ft)
	-71.23 m (-233.71 ft)	234.17 m (768.32 ft)
	-84.93 m (-278.65 ft)	229.56 m (753.19 ft)
	-98.33 m (-322.67 ft)	224.15 m (735.43 ft)
	-111.39 m (-365.46 ft)	217.95 m (715.11 ft)
	-124.06 m (-407.03 ft)	211.00 m (692.29 ft)
	-136.29 m (-447.18 ft)	203.31 m (667.06 ft)
	-148.06 m (-485.77 ft)	194.91 m (639.50 ft)
	-159.30 m (-522.67 ft)	185.83 m (609.71 ft)
	-169.99 m (-557.75 ft)	176.10 m (577.80 ft)
	-180.09 m (-590.88 ft)	165.76 m (543.87 ft)
	-189.56 m (-621.95 ft)	154.85 m (508.05 ft)
	-198.37 m (-650.85 ft)	143.39 m (470.46 ft)
	-206.49 m (-677.48 ft)	131.43 m (431.22 ft)
	-213.89 m (-701.76 ft)	119.01 m (390.48 ft)

Table C-2 (cont)

	-220.54 m (-723.58 ft)	106.18 m (348.38 ft)
	-226.42 m (-742.88 ft)	92.98 m (305.07 ft)
	-231.51 m (-759.59 ft)	79.45 m (260.69 ft)
Row 22	234.50 m (769.40 ft)	104.49 m (342.84 ft)
	227.92 m (747.82 ft)	118.15 m (387.66 ft)
	220.55 m (723.64 ft)	131.40 m (431.12 ft)
	212.41 m (696.93 ft)	144.19 m (473.08 ft)
	203.53 m (667.79 ft)	156.47 m (513.39 ft)
	183.68 m (602.64 ft)	179.37 m (588.50 ft)
	172.77 m (566.86 ft)	189.90 m (623.05 ft)
	161.26 m (529.09 ft)	199.76 m (655.42 ft)
	149.19 m (489.49 ft)	208.93 m (685.50 ft)
	136.60 m (448.17 ft)	217.37 m (713.20 ft)
	123.53 m (405.30 ft)	225.06 m (738.41 ft)
	110.03 m (361.01 ft)	231.95 m (761.04 ft)
	96.15 m (315.46 ft)	238.04 m (781.02 ft)
	81.93 m (268.81 ft)	243.30 m (798.28 ft)
	67.43 m (221.23 ft)	247.71 m (812.75 ft)
	52.69 m (172.87 ft)	251.26 m (824.40 ft)
	37.77 m (123.91 ft)	253.93 m (833.16 ft)
	22.71 m (74.52 ft)	255.72 m (839.02 ft)
	7.58 m (24.87 ft)	256.62 m (841.96 ft)
	-7.58 m (-24.87 ft)	256.62 m (841.96 ft)
	-22.71 m (-74.52 ft)	255.72 m (839.02 ft)
	-37.77 m (-123.91 ft)	253.93 m (833.16 ft)
	-52.69 m (-172.87 ft)	251.26 m (824.40 ft)
	-67.43 m (-221.73 ft)	247.71 m (812.75 ft)
	-81.93 m (-268.81 ft)	243.30 m (798.28 ft)
	-96.15 m (-315.46 ft)	238.04 m (781.02 ft)
	-110.03 m (-361.01 ft)	231.95 m (761.04 ft)
	-123.53 m (-405.30 ft)	225.06 m (738.41 ft)
	-136.60 m (-448.17 ft)	217.37 m (713.20 ft)
	-149.19 m (-489.49 ft)	208.93 m (685.50 ft)
	-161.26 m (-529.09 ft)	199.76 m (655.42 ft)
	-172.77 m (-566.86 ft)	189.90 m (623.05 ft)
	-183.68 m (-602.64 ft)	179.37 m (588.50 ft)
	-203.53 m (-667.79 ft)	156.47 m (513.39 ft)
	-212.41 m (-696.93 ft)	144.19 m (473.08 ft)
	-220.55 m (-723.64 ft)	131.40 m (431.12 ft)
	-227.92 m (-747.82 ft)	118.15 m (387.66 ft)
	-234.50 m (-769.40 ft)	104.49 m (342.84 ft)
Row 23	234.83 m (770.47 ft)	130.67 m (428.72 ft)
	225.64 m (740.31 ft)	145.97 m (478.92 ft)
	218.95 m (718.37 ft)	155.82 m (511.23 ft)
	196.38 m (644.31 ft)	183.45 m (601.90 ft)
	188.06 m (617.03 ft)	191.97 m (629.84 ft)
	174.90 m (573.85 ft)	204.03 m (669.41 ft)
	160.97 m (528.14 ft)	215.19 m (706.04 ft)

	136.21 m (446.89 ft)	231.66 m (760.07 ft)
	120.52 m (395.44 ft)	240.19 m (788.07 ft)
	109.77 m (360.16 ft)	245.29 m (804.80 ft)
	93.24 m (305.93 ft)	252.04 m (826.94 ft)
	76.31 m (250.36 ft)	257.67 m (845.42 ft)
	64.82 m (212.68 ft)	260.80 m (855.68 ft)
	47.36 m (155.40 ft)	264.53 m (867.91 ft)
	29.70 m (97.43 ft)	267.09 m (876.31 ft)
	17.84 m (58.54 ft)	268.14 m (879.77 ft)
	-17.84 m (-58.54 ft)	268.14 m (879.77 ft)
	-29.70 m (-97.43 ft)	267.09 m (876.31 ft)
	-47.36 m (-155.40 ft)	264.53 m (867.91 ft)
	-64.82 m (-212.68 ft)	260.80 m (855.68 ft)
	-76.31 m (-250.36 ft)	257.67 m (845.42 ft)
	-93.24 m (-395.93 ft)	252.04 m (826.94 ft)
	-109.77 m (-360.16 ft)	245.29 m (804.80 ft)
	-120.52 m (-395.44 ft)	240.19 m (788.07 ft)
	-136.21 m (-446.89 ft)	231.66 m (760.07 ft)
	-160.97 m (-528.14 ft)	215.19 m (706.04 ft)
	-174.90 m (-573.85 ft)	204.03 m (669.41 ft)
	-188.06 m (-617.03 ft)	191.97 m (629.84 ft)
	-196.38 m (-644.31 ft)	183.45 m (601.90 ft)
	-218.95 m (-718.37 ft)	155.82 m (511.23 ft)
	-225.64 m (-740.31 ft)	145.97 m (478.92 ft)
	-234.83 m (-770.47 ft)	130.67 m (428.72 ft)
Row 24	239.92 m (787.19 ft)	147.78 m (484.87 ft)
	233.15 m (764.95 ft)	158.26 m (519.25 ft)
	225.91 m (741.21 ft)	168.43 m (552.61 ft)
	210.12 m (689.42 ft)	187.75 m (616.02 ft)
	201.60 m (661.46 ft)	196.87 m (645.94 ft)
	192.69 m (632.21 ft)	205.61 m (674.60 ft)
	173.74 m (570.05 ft)	221.85 m (727.89 ft)
	163.75 m (537.26 ft)	229.32 m (752.41 ft)
	153.43 m (503.42 ft)	236.35 m (775.46 ft)
	131.92 m (432.84 ft)	249.00 m (816.96 ft)
	120.77 m (396.25 ft)	254.59 m (835.32 ft)
	109.38 m (358.87 ft)	259.69 m (852.05 ft)
	85.97 m (282.08 ft)	268.35 m (880.46 ft)
	74.01 m (242.82 ft)	271.89 m (892.08 ft)
	61.90 m (203.08 ft)	274.90 m (901.96 ft)
	37.33 m (122.49 ft)	279.30 m (916.39 ft)
	24.93 m (81.79 ft)	280.68 m (920.92 ft)
	12.48 m (40.94 ft)	281.51 m (923.63 ft)
	-12.48 m (-40.94 ft)	281.51 m (923.63 ft)
	-24.93 m (-81.79 ft)	280.68 m (920.92 ft)
	-37.33 m (-122.49 ft)	279.30 m (916.39 ft)
	-61.90 m (-203.08 ft)	274.90 m (901.96 ft)
	-74.01 m (-242.82 ft)	271.89 m (892.08 ft)
	-85.97 m (-282.08 ft)	268.35 m (880.46 ft)
	-109.38 m (-358.87 ft)	259.69 m (852.05 ft)

Table C-2 (cont)

	-120.77 m (-396.25 ft)	254.59 m (835.32 ft)
	-131.92 m (-432.84 ft)	249.00 m (816.96 ft)
	-153.43 m (-503.42 ft)	236.35 m (775.46 ft)
	-163.75 m (-537.26 ft)	229.32 m (752.41 ft)
	-173.74 m (-570.05 ft)	221.85 m (727.89 ft)
	-192.69 m (-632.21 ft)	205.61 m (674.60 ft)
	-201.60 m (-661.46 ft)	196.87 m (645.94 ft)
	-210.12 m (-689.42 ft)	187.75 m (616.02 ft)
	-225.91 m (-741.21 ft)	158.43 m (552.61 ft)
	-239.92 m (-787.19 ft)	147.78 m (484.87 ft)

Row 25	247.60 m (812.36 ft)	160.18 m (525.54 ft)
	240.26 m (788.29 ft)	170.98 m (560.99 ft)
	232.45 m (762.68 ft)	181.45 m (595.35 ft)
	224.19 m (735.57 ft)	191.57 m (628.53 ft)
	215.49 m (707.02 ft)	201.31 m (660.49 ft)
	203.36 m (677.08 ft)	210.65 m (691.14 ft)
	196.84 m (645.82 ft)	219.58 m (720.45 ft)
	186.92 m (613.28 ft)	228.08 m (748.33 ft)
	176.64 m (579.55 ft)	236.14 m (774.76 ft)
	166.01 m (544.67 ft)	243.72 m (799.66 ft)
	155.05 m (508.73 ft)	250.84 m (822.99 ft)
	143.79 m (471.79 ft)	257.46 m (844.71 ft)
	132.26 m (433.93 ft)	263.57 m (864.77 ft)
	120.45 m (395.21 ft)	269.17 m (883.14 ft)
	83.73 m (274.72 ft)	282.75 m (927.71 ft)
	71.13 m (233.38 ft)	286.18 m (938.96 ft)
	58.39 m (191.57 ft)	289.05 m (948.38 ft)
	45.53 m (149.39 ft)	291.35 m (955.93 ft)
	32.59 m (106.92 ft)	293.08 m (961.61 ft)
	19.58 m (64.23 ft)	294.24 m (965.40 ft)
	6.53 m (21.43 ft)	294.82 m (967.30 ft)
	-6.53 m (-21.43 ft)	294.82 m (967.30 ft)
	-19.58 m (-64.23 ft)	294.24 m (967.30 ft)
	-32.59 m (-106.92 ft)	293.08 m (961.61 ft)
	-45.53 m (-149.39 ft)	291.35 m (955.93 ft)
	-58.39 m (-191.57 ft)	289.05 m (948.38 ft)
	-71.13 m (-233.38 ft)	286.18 m (938.96 ft)
	-83.73 m (-274.72 ft)	282.75 m (927.71 ft)
	-120.45 m (-395.21 ft)	269.17 m (833.14 ft)
	-132.26 m (-433.93 ft)	263.57 m (864.77 ft)
	-143.79 m (-471.79 ft)	257.46 m (844.71 ft)
	-155.05 m (-508.73 ft)	250.84 m (822.99 ft)
	-166.01 m (-544.67 ft)	243.72 m (799.66 ft)
	-176.64 m (-579.55 ft)	236.14 m (774.76 ft)
	-186.92 m (-613.28 ft)	228.08 m (748.33 ft)
	-196.84 m (-645.82 ft)	219.58 m (720.45 ft)
	-206.36 m (-677.08 ft)	210.65 m (691.14 ft)
	-215.49 m (-707.02 ft)	201.31 m (660.49 ft)
	-224.19 m (-735.57 ft)	191.57 m (628.53 ft)

	-232.45 m (-762.68 ft)	181.45 m (595.35 ft)
	-240.26 m (-788.29 ft)	170.98 m (560.99 ft)
	-247.60 m (-812.36 ft)	160.18 m (525.54 ft)
Row 26	255.78 m (839.22 ft)	173.62 m (569.66 ft)
	247.84 m (813.17 ft)	184.78 m (606.26 ft)
	239.42 m (785.53 ft)	195.57 m (641.67 ft)
	230.52 m (756.35 ft)	205.98 m (675.83 ft)
	221.18 m (725.68 ft)	215.99 m (708.65 ft)
	211.40 m (693.59 ft)	225.57 m (740.09 ft)
	201.20 m (660.14 ft)	234.71 m (770.08 ft)
	190.61 m (625.40 ft)	243.39 m (798.55 ft)
	179.65 m (589.42 ft)	251.59 m (825.46 ft)
	168.33 m (552.30 ft)	259.30 m (850.75 ft)
	156.68 m (514.08 ft)	266.49 m (874.37 ft)
	144.73 m (474.86 ft)	273.17 m (896.27 ft)
	132.49 m (434.71 ft)	279.31 m (916.42 ft)
	120.00 m (393.71 ft)	284.90 m (934.77 ft)
	107.26 m (351.93 ft)	289.94 m (951.29 ft)
	94.32 m (309.47 ft)	294.40 m (965.94 ft)
	54.49 m (178.77 ft)	304.30 m (998.42 ft)
	40.96 m (134.38 ft)	306.42 m (1005.36 ft)
	27.35 m (89.73 ft)	307.93 m (1010.32 ft)
	13.69 m (44.91 ft)	308.84 m (1010.30 ft)
	-13.69 m (-44.91 ft)	308.84 m (1013.30 ft)
	-40.96 m (-134.38 ft)	306.42 m (1005.36 ft)
	-54.49 m (-178.77 ft)	304.30 m (998.42 ft)
	-67.91 m (-222.80 ft)	301.59 m (989.53 ft)
	-81.19 m (-266.39 ft)	298.29 m (978.69 ft)
	-94.32 m (-309.47 ft)	294.40 m (965.94 ft)
	-107.26 m (-351.93 ft)	289.94 m (951.29 ft)
	-120.00 m (-393.71 ft)	284.90 m (934.77 ft)
	-132.49 m (-434.71 ft)	279.31 m (916.42 ft)
	-144.73 m (-474.86 ft)	273.17 m (896.27 ft)
	-156.68 m (-514.08 ft)	266.49 m (874.37 ft)
	-168.33 m (-552.30 ft)	259.30 m (850.75 ft)
	-179.65 m (-589.42 ft)	251.59 m (825.46 ft)
	-190.61 m (-625.40 ft)	243.39 m (798.55 ft)
	-201.20 m (-660.14 ft)	234.71 m (770.08 ft)
	-211.40 m (-693.59 ft)	225.57 m (740.09 ft)
	-221.18 m (-725.68 ft)	215.99 m (708.65 ft)
	-230.52 m (-756.35 ft)	205.98 m (675.83 ft)
	-239.42 m (-785.53 ft)	195.57 m (641.67 ft)
	-247.84 m (-813.17 ft)	184.78 m (606.26 ft)
	-255.78 m (-839.22 ft)	173.62 m (569.66 ft)
Row 27	263.53 m (864.64 ft)	187.54 m (615.33 ft)
	254.97 m (836.55 ft)	199.03 m (653.01 ft)
	245.91 m (806.82 ft)	210.12 m (689.41 ft)
	236.36 m (775.50 ft)	220.80 m (724.46 ft)

Table C-2 (cont)

	226.35 m (742.66 ft)	231.05 m (758.08 ft)
	215.90 m (708.37 ft)	240.85 m (790.22 ft)
	205.02 m (672.68 ft)	250.17 m (820.81 ft)
	193.75 m (635.68 ft)	259.00 m (849.79 ft)
	182.09 m (597.43 ft)	267.33 m (877.11 ft)
	170.07 m (558.00 ft)	275.13 m (902.70 ft)
	157.72 m (517.49 ft)	282.39 m (926.52 ft)
	145.07 m (475.96 ft)	289.10 m (948.53 ft)
	132.12 m (433.49 ft)	295.24 m (968.67 ft)
	118.92 m (390.17 ft)	300.80 m (986.92 ft)
	105.48 m (346.09 ft)	305.77 m (1003.22 ft)
	91.84 m (301.33 ft)	310.14 m (1017.56 ft)
	78.02 m (255.98 ft)	313.90 m (1029.91 ft)
	64.04 m (210.13 ft)	317.05 m (1040.23 ft)
	49.49 m (163.86 ft)	319.57 m (1048.52 ft)
	-49.94 m (-163.86 ft)	319.52 m (1048.52 ft)
	-64.04 m (-210.13 ft)	317.05 m (1048.23 ft)
	-78.02 m (-255.98 ft)	313.90 m (1029.91 ft)
	-91.84 m (-301.33 ft)	310.14 m (1017.56 ft)
	-105.48 m (-346.09 ft)	305.77 m (1003.22 ft)
	-132.12 m (-433.49 ft)	295.24 m (968.67 ft)
	-145.07 m (-475.96 ft)	289.10 m (948.53 ft)
	-157.72 m (-517.49 ft)	282.39 m (926.52 ft)
	-170.07 m (-558.00 ft)	275.13 m (902.70 ft)
	-182.09 m (-597.43 ft)	267.33 m (877.11 ft)
	-193.75 m (-635.68 ft)	259.00 m (849.79 ft)
	-205.02 m (-672.68 ft)	250.17 m (820.81 ft)
	-215.90 m (-708.37 ft)	240.85 m (790.22 ft)
	-226.35 m (-742.66 ft)	231.05 m (758.08 ft)
	-236.36 m (-775.50 ft)	220.80 m (724.46 ft)
	-245.91 m (-806.82 ft)	210.12 m (689.41 ft)
	-254.97 m (-836.55 ft)	199.03 m (653.01 ft)
	-263.53 m (-864.64 ft)	187.54 m (615.33 ft)

Row 28	271.80 m (891.76 ft)	202.64 m (664.86 ft)
	262.56 m (861.45 ft)	214.47 m (703.69 ft)
	242.55 m (795.82 ft)	236.86 m (777.14 ft)
	231.83 m (760.63 ft)	247.37 m (811.62 ft)
	220.65 m (723.94 ft)	257.39 m (844.50 ft)
	184.60 m (605.67 ft)	284.36 m (932.97 ft)
	171.83 m (563.77 ft)	292.25 m (958.88 ft)
	158.77 m (520.76 ft)	299.57 m (982.90 ft)
	145.30 m (476.73 ft)	306.31 m (1004.99 ft)
	131.59 m (431.76 ft)	312.44 m (1025.11 ft)
	117.63 m (385.95 ft)	317.96 m (1043.23 ft)
	103.44 m (339.38 ft)	322.86 m (1059.29 ft)
	89.04 m (292.14 ft)	327.12 m (1073.28 ft)
	74.47 m (244.33 ft)	330.74 m (1085.16 ft)
	-74.47 m (-244.33 ft)	330.74 m (1085.16 ft)
	-89.04 m (-292.14 ft)	327.12 m (1073.28 ft)
	-103.44 m (-339.38 ft)	322.86 m (1059.29 ft)

Table C-2 (concl)

	-117.63 m (-385.95 ft)	317.96 m (1043.23 ft)
	-131.59 m (-431.76 ft)	312.44 m (1025.11 ft)
	-145.30 m (-476.73 ft)	306.31 m (1004.99 ft)
	-158.72 m (-520.76 ft)	299.57 m (982.90 ft)
	-171.83 m (-563.77 ft)	292.25 m (958.88 ft)
	-184.60 m (-605.67 ft)	284.36 m (932.97 ft)
	-220.65 m (-723.94 ft)	257.39 m (844.50 ft)
	-231.83 m (-760.63 ft)	247.37 m (811.62 ft)
	-242.55 m (-795.82 ft)	236.86 m (777.14 ft)
	-262.56 m (-861.45 ft)	214.47 m (703.69 ft)
	-271.80 m (-891.76 ft)	202.64 m (664.86 ft)
Row 29	280.09 m (918.96 ft)	218.63 m (717.33 ft)
	270.13 m (886.29 ft)	230.82 m (757.32 ft)
	259.64 m (851.89 ft)	242.55 m (795.82 ft)
	243.65 m (815.82 ft)	253.81 m (832.76 ft)
	237.17 m (778.15 ft)	264.57 m (868.07 ft)
	225.22 m (738.95 ft)	274.83 m (901.67 ft)
	212.83 m (698.30 ft)	284.52 m (933.51 ft)
	200.02 m (656.28 ft)	293.66 m (963.51 ft)
	186.82 m (612.97 ft)	302.23 m (991.62 ft)
	159.35 m (522.84 ft)	317.57 m (1041.96 ft)
	145.14 m (476.19 ft)	324.32 m (1064.09 ft)
	130.63 m (428.61 ft)	330.43 m (1084.13 ft)
	115.87 m (380.18 ft)	335.89 m (1102.05 ft)
	100.89 m (331.01 ft)	340.69 m (1117.80 ft)
	85.71 m (281.20 ft)	344.82 m (1131.36 ft)
	70.35 m (230.83 ft)	348.28 m (1142.70 ft)
	-70.35 m (-230.83 ft)	348.28 m (1142.70 ft)
	-85.71 m (-281.20 ft)	344.82 m (1132.36 ft)
	-100.89 m (-331.01 ft)	340.69 m (1117.80 ft)
	-115.87 m (-380.18 ft)	335.89 m (1102.05 ft)
	-130.63 m (-428.61 ft)	330.43 m (1084.13 ft)
	-145.14 m (-476.19 ft)	324.32 m (1064.09 ft)
	-159.35 m (-522.84 ft)	317.57 m (1041.96 ft)
	-173.26 m (-568.46 ft)	310.21 m (1017.79 ft)
	-186.82 m (-612.97 ft)	302.23 m (991.62 ft)
	-200.02 m (-656.28 ft)	293.66 m (963.51 ft)
	-212.83 m (-698.30 ft)	284.52 m (933.51 ft)
	-225.22 m (-738.95 ft)	274.82 m (901.67 ft)
	-237.17 m (-778.15 ft)	264.57 m (868.07 ft)
	-248.65 m (-815.82 ft)	253.81 m (832.76 ft)
	-259.64 m (-851.89 ft)	242.55 m (795.82 ft)
	-270.13 m (-886.29 ft)	230.82 m (757.32 ft)

5.1.2 Receiver Design Characteristics Data

The receiver is sized to acccept 29.3 MWt at the design point (noon day 58) and is a twin-cavity geometry as shown in Figure C-5. The receiver material and mass (dry) is 128.2 x 10^3 kg (282.7 x 10^3 lb). The receiver working fluid output conditions will be 29.3 MW (100,000,000 Btu/h) 82% quality steam at 8.27 x 10^6 MPa (1200 psia) 297°C (567°F) with a flow rate of 43,590 kg/h (96,100 lb/h).

The material for all absorber panels is carbon steel. The absorber panel, number, size, type, material and mass are tabulated.

			Tube Size		
Type of Absorber Panel	No. of Panels	Total No. of Tubes	OD, mm (in.)	Minimum Thickness, mm (in.)	Dry Weight Including Headers, kg (lb)
Vertical Preheater	1	56	25.4 (1.0)	3.76 (0.148)	1,290 (2,840)
Roof Preheater	2	56	25.4 (1.0)	3.76 (0.148)	2,190 (4,820)
Boiler	5	210	50.8 (2.0)	3.76 (0.148)	11,080 (24,430)

The material for all valves is carbon steel. The receiver valves are tabulated.

Location	Type	No.	Nominal Size, in.	Weight, kg (lb)
Main Feed	Feed Check Valve	1	3	45.4 (100)
	Feed Stop Valve	1	3	68.0 (150)
	Inlet Control Valve	1	3	90.7 (200)
Drum	Safety Valve Set at 1275 psia	1	1-1/2	45.4 (100)
	Safety Valve Set at 1313 psia	1	1-1/2	45.4 (100)
	Vent Valve	2	1	45.4 (100)
	Steam Gage Shutoff	1	1/2	22.7 (50)
	Steam Gage Test	2	1/2	45.4 (100)
	Water Gage Shutoff	2	1	113.4 (250)
	Water Gage Drain	2	1/2	45.4 (100)
	Remote Level Indicatro Shutoff	2	1	22.7 (50)
	Water Level Control	2	1	136.1 (300)
	Water Sampling	1	1	90.7 (200)
	Blowdown	1	1-1/2	68.0 (150)
Preheater	Vent	2	1	45.4 (100)
	Drain	4	1	90.7 (200)
Waterwalls	Drain	10	1	226.8 (500)
	Drain Manifold	2	1	45.4 (100)
Saturated Steam Outlet	Outlet Shutoff	1	6	362.9 (800)
	Check	1	6	226.8 (500)
	Pressure Regulating	1	6	272.2 (600)
Continuous Blowdown	Blowdown Shutoff	1	1-1/2	68.0 (150)
	Check	1	1-1/2	45.4 (100)
	Isolation	1	1-1/2	45.4 (100)
	Blowdown Control	1	1-1/2	45.4 (100)

The material for all piping is carbon steel. The pipes information is tabulated.

Description	Nominal Size	Weight, kg (lb)
Feedwater	3-in. Sch 40	72.6 (160)
Blowdown	1-1/2-in. Sch 40	63.5 (140)
Steam Outlet	6-in. Sch 80	816.5 (1800)
Connecting	4-in. Sch 40	136.1 (300)
Miscellaneous	1/2- & 1-in. Sch 40	272.2 (600)

The receiver heat transfer coefficients are tabulated.

		kW/m^2-°C (Btu/h-ft^2-°F)
Preheater	- Pass 1 (Vertical Panel)	4.5 (800)
	- Pass 2 (Roof Panel)	11.1 (1950)
	- Pass 3 (Roof Panel)	13.3 (2350)
Boiler	- Common Wall Panel	30.2 (5320)
	- Rear Wall Panel	29.0 (5100)
	- Side Wall Panel	23.3 (4110)

The receiver system pressures and flow rates are tabulated.

Pressure	kPa, (psia)
Receiver Inlet	8481 (1230)
Drum Operating	8274 (1200)
Receiver Outlet	8267 (1199)
Flow Rate	**Mg/h, (klb/h)**
Feedwater	43.59 (96.1)
Saturated Steam	36.015 (79.4)
Drum Blowdown	7.575 (16.7)

The absorber panels will be coated with flat black Pyromark Series 2500 with an absorptivity of 0.95 and an emissivty of 0.90. The inactive wall of the receiver will be coated with white Pyromark Series 2500 with an absorptivity of 0.32 and an emissivty of 0.84.

The 15-cm (6-in.) steam line that ties the solar receiver outlet to the ground-level field piping system is supported at several locations by the receiver tower.

The support tower for the receiver shall be constructed of structural steel, 90 m (295 ft) to the receiver support level (top of tower itself), with four support legs on 12.2-m (40-ft) spacing. Foundations for each support leg shall comprise three drilled piers 0.9 m (3 ft) in diameter and 13.7 m (45 ft) in length. The pier cap shall be triangular in plan, 4.6 m (15 ft) on each leg of the triangle, and 0.9-m (3-ft) thick. Each pier will have a full reinforcing cage. It is expected that casings will not be required during pier drilling.

The feedwater pump will provide a flow rate of 43.59 Mg/h (96,100 lb/h) and a pressure of 9.653 MPa (1400 psia) at the feedwater control valve.

The major operating characteristics are:

1) The receiver input power at the design point is 31.2 MWt;
2) The receiver total absorbed power is 29.3 MWt;
3) The design point flux as shown in Table C-1;
4) Peak material temperature, working stress, fatigue life, number of cycles, and equivalent operation life (Table C-3);
5) Predictions of receiver hot and cold startups as shown in Figures C-8 and C-9, respectively.

Table C-3 Design Point Stress Conditions

Terms Defined In ASME Code Section VIII, Div 2	Stress Intensity, MPa (ksi)	Allowable Stress, MPa (ksi)
Primary Stress Intensity P_M	55.8 (8.1)	99.3 (14.4)
Primary Plus Secondary Stress Intensity $P_L + P_B + Q$	142.0 (20.6)	$3S_m$ = 312.4 (45.3)
Peak Stress Intensity $P_L + P_B + Q + F$	243.1 (35.26)	Fatigue Life 100,000 Cycles
Note: Peak metal temperature = 390°C (734°F), design temperature = 371°C (700°F).		

The receiver losses are tabulated.

	Conduction	Radiation	Convection	Reflection	Spillage	Total
Design Point	0.4%	1.51%	2.41%	1.56%	1.3%	6.98%

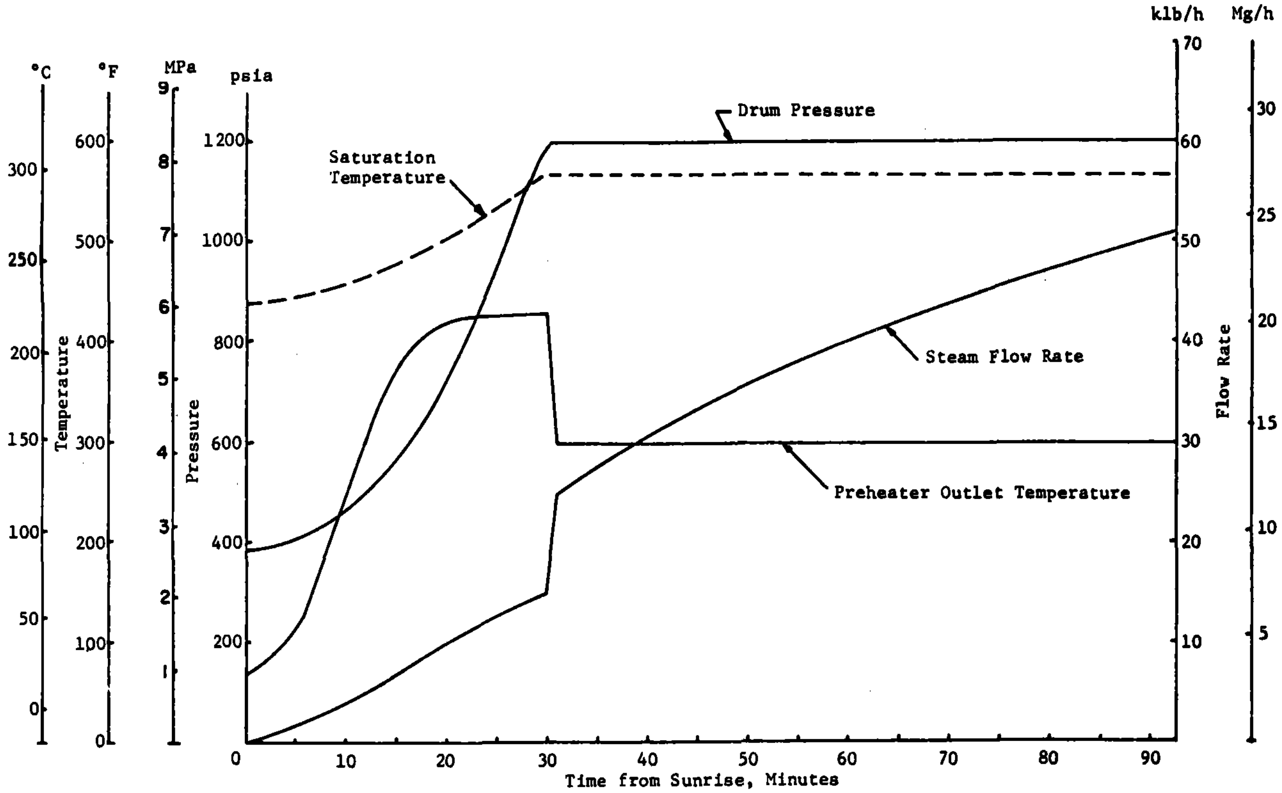

Figure C-8 Receiver Hot Startup Predictions

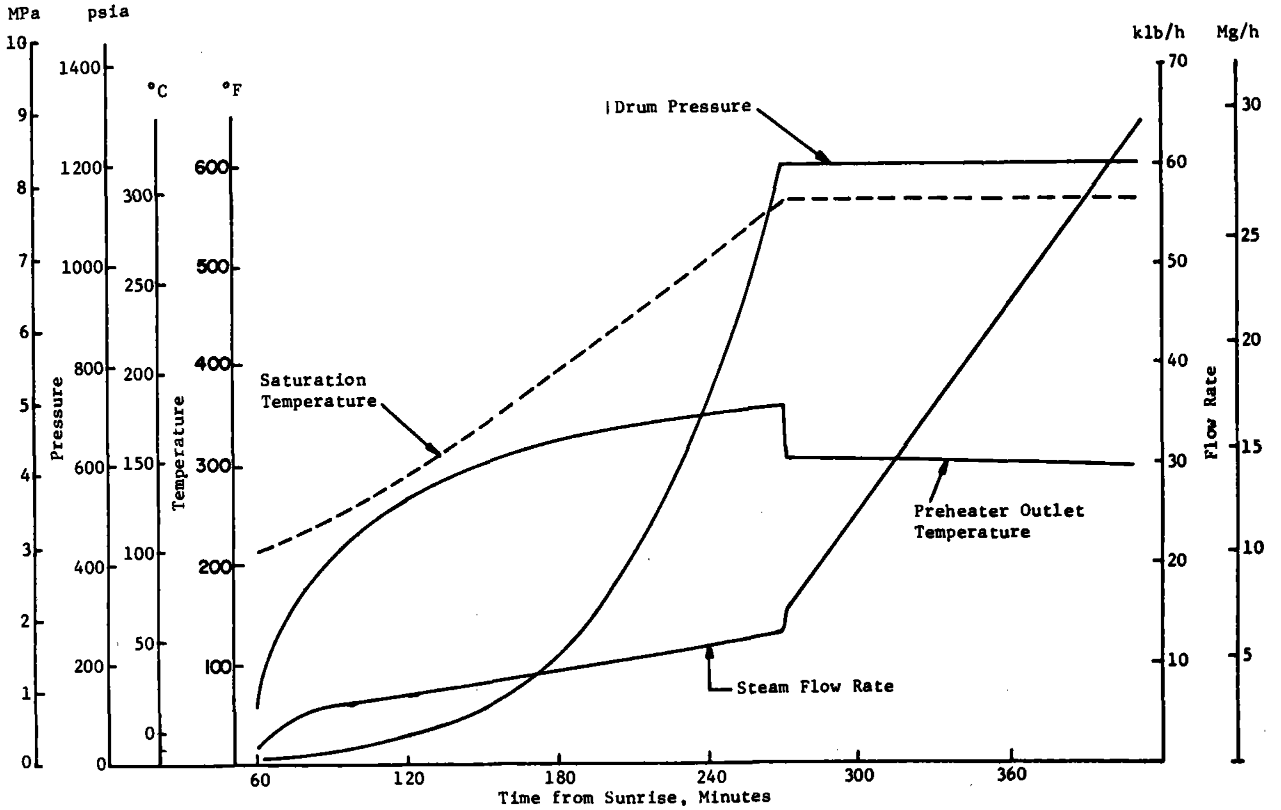

Figure C-9 Receiver Cold Startup Predictions

5.1.3 Field Piping* Design Characteristics Data

The header piping from the receiver is 150-mm (6-in.) Schedule 80 carbon steel pipe designed to pass 43,590 kg/h (96,100 lb/h) of wet steam at a quality of 82%.

The piping from the fossil boilers is 150-mm (6-in.) Schedule 80 carbon steel pipe designed to pass 30,375 kg/h (66,976 lb/h) of wet steam at a quality of 75 to 80%.

Branch piping to each well is 80-mm (3-in.) Schedule 80 carbon steel pipe designed to pass 6164 kg/h (13,591 lb/h) of wet steam (1/12 of the total steam flow).

The piping system design pressure = 7.2 MPa (1050 psig); design temperature = 293°C (560°F).

A corrosion/erosion allowance of 3.8 mm (0.15 in.) is applied to the piping wall thickness.

Field pipe supports are spaced at 6-m (20-ft) intervals.

5.2 EXISTING EQUIPMENT DATA

There are two existing steamers and water softeners. The steamers provide 11.16 Mg/h (24,600 lb/h) of 80% quality steam at 313°C (596°F). Table C-4 shows the steam generator design data for the Struthers Thermoflood® 25 steamer. The water softeners are portable units that contain ion exchange beds that can provide 0.315×10^{-3} m^3/s (50 gpm) of treated water continuously.

Table C-4 Steam Generator Design Data for Struthers Thermoflood® 25 Steamer

Design Steam Pressure	10.343 MPa (1500 psig)
Design Steam Quality	80%
Design Steam Flow to Well	11,564.6 kg/h (25,500 lb/h)
Design Steam Flow to Oil Burner	72.56 kg/h (160 lb/h)
Condensate to Drain	18.14 kg/h (40 lb/h)
Design Steam Flow at Heater Outlet	11,655.3 kg/h (25,700 lb/h)
Heat to Well (Above 80°F Feed Temperature)	7.27 MW (24,797,808 Btu/h)
Heat to Produce Atomizing Steam	59.09 kW (201,600 Btu/h)
Heat to Preheat Fuel Oil (Recirculate)	37.44 kW (127,750 Btu/h)
Design Total Heat Output of Heater	7.91 MW (26,999,408 Btu/h)
Thermal Efficiency of Heater	89.99% (LHV Basis)
Thermal Efficiency of Process	89.12% (LHV Basis)
Burner Type	North American 5131-FA
Burner Heat Release	8.14 MW (27,777,778 Btu/h)
Fuel	Crude Oil
Fuel Net Heating Value	156.41 W/m^3 (141,000 Btu/gal)
Fuel Consumption	0.746 m^3/h (197 gal/h)
Pilot Fuel	Natural Gas or LPG
Combustion Air 11,900.2 kg/h (26,240 lb/h)	Flue Gas 12,598.6 kg/h (27,180 lb/h)
Flue Gas Temperature	190.6°C (375°F) at 20% Excess Air

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*All piping is ASTM A53 grade B.

5.3 COST DATA

5.3.1 Construction Cost Data

The construction cost of the STEOR system has been estimated based on the construction cost codes defined in Tables C-5 and C-6. The basis for the STEOR retrofit construction cost estimate is enumerated in Table C-7 and all costs are provided in 1980 dollars.

A total plant construction cost estimate of $14,033,467 has been developed based on the ground rules in Tables C-5 through C-7, with a breakdown by cost account shown in Table C-8.

Figure C-9 provides the cost summary sheets for each major cost account given in Table C-5, with accompanying cost backup worksheets.

5.3.2 Owner's Cost Data

In addition to the estimated construction costs, some projects incur certain other costs as part of the overall project cost. The following owner's cost considerations have been identified:

1) Land, including cost of canceling existing surfaces leases. No cost is incurred with 60 days notice of cancellation of the lease;

2) Water rights are currently owned;

3) No recreational area or landscaping required;

4) No site studies required with existing data;

5) No archeological artifacts at site;

6) Environmental studies not anticipated to the required;

7) Public relations activities will not be charged to the plant;

8) Cost of obtaining necessary permits estimated to be negligible (<$1000);

9) Dealings with public agencies, etc not charged directly to plant;

10) Owner's "home-office costs" not known at this level of design;

11) Plant consumable supplies included in operating and maintenance estimate;

12) Property taxes during construction charged to existing facilities;

13) Sales tax not costed;

14) Project would most likely be financed with retained earnings (internal funds), therefore no allowance for funds used during construction (AFUDC) charges.

Table C-5 Construction Cost Code Definitions for Solar Thermal-Enhanced Oil Recovery Project

5100			Land, Yark Work
	5110		Land required for retrofit application provided by site owner.
	5120		Yard work includes any necessary grading, compacting and surfacing of area around tower, control and storage building, and collector field.
5200			Site Facilities
	5210		Operations and Maintenance
		5211	A single structure will be used for control rooms, and storage and maintenance area.
		5212	Miscellaneous equipment includes communications, machine shop equipment, instrument repair, air systems, emergency power supply, and transportation and maintenance equipment.
	5220		Security
		5221	Security/eye hazard fincing around collector field to prevent unauthorized personnel entry and offsite glint.
		5222	Security lighting around tower area.
5300			Collector Subsystem
5400			Receiver Subsystem
	5410		Receiver Unit
		5411	Pressure parts include all components from interface with the riser at the top of the tower to junction with the field piping. This junction is at the base of the receiver, immediately after the blowdown outlet.
		5412	Support structure includes tower/receiver interface, pressure parts support, external enclosure, cavity doors and mechanisms, platforms and ladders, insulation, etc.
		5413	Receiver circulation equipment consists of the feedwater pump(s) and associated motors and valving.
		5414	Instrumentation and control includes tracer lines, controls and door actuators.
	5420		Tower piping is from the outlet of the FW water storage tank/water treatment facility to the top of the tower/base of receiver, and from base of receiver to base of tower.
	5430		Water treatment equipment includes all hardware used to treat incoming well water, and storage tank.
	5440		Tower, including foundation and all necessary accessories such as access, lighting, machinery and equipment.
5500			Plant control subsystem includes the displays, alarms, and data recording equipment for the receiver and field piping subsystems. All controls and displays for the heliostat field are included in account 5300.
5910			Field piping includes the steam piping from the outlet of the receiver to the stream injection wells. For construction cost, only that piping required to the initial three injection wells will be costed. Insulation, supports and control valves are to be included.

Table C-6 Indirect Cost Account Definitions

Account	Description
L	Temporary Construction Facilities Includes temporary buildings, sheds, trailers, work areas, bays, roads, walks, parking, signs, railroads, unloading docks, utilities, personnel protection, camps, cleaning services, maintenance services, utility bills, and site maintenance.
M	Construction Services, Supplies and Expenses Services Includes cleanup, nonproductive time, medical examinations, doctor's fees, move on and off, and construction equipment maintenance and servicing. Small Tools Supplies Includes welding rod, oxygen, acetylene, rags and other consumables. Field Office Supplies Includes office machines, telephone, telegraph, postage, computer rental, stationary, furniture.
N	Field Staff, Subsistence and Expense Field Staff Includes superintendents, field engineers, cost engineers, field administration, warehouseman, purchaser, nurse, safety engineer, timekeeper, accountant, clerks, Q/A control, watchman, and security service. Field Staff Subsistence Includes travel, subsistence, transportation, and relocation for field staff. Field Staff Burdens Includes vacation, sick leave, and holiday allowance.
P	Field Craft Benefits, Payroll Burdens and Insurance Field Craft Benefits Includes required contributions to funds for vacation, welfare, education, apprentice, retirement, holidays, etc. Field Craft Travel, Transportation or Subsistence Payroll Burdens for Field Craft and Field Staff Includes social security, workman's compensation, comprehensive PL & PD, state unemployment insurance, federal unemployment insurance. Insurance Includes builder's risk, performance bonds, and marine insurance.
Q	Equipment Rental Construction Equipment Rental Special Equipment Rental Note: Special rigging equipment included in the direct field accounts.
R	Engineering Plant Engineering - Prime contractor to design plant, subcontract construction, and start up plant. R&D - For anticipated research and development required to design and produce special equipment that is not currently manufactured.
S	Equipment Procurement by Prime Contractor
T	Construction Management by Prime Contractor
U	Labor Productivity Includes adjustment for the difference in labor efficiency in Houston to the jobsite.
V	Contingency Construction Cost Contingency - This represents normal construction uncertainties in an estimate that is based on a given design.
W	Prime Contractors Fee Material Markups Fee on Labor and Indirects Fee on Subcontracted Work Excludes Design Contingency

Table C-7 Basis for Construction Cost Estimate

1. Structure of construction costs estimate will be:
   1) Construction cost codes per Table C-4;
   2) Construction cost accounts, A thru W;
   3) Construction cost backup sheets.
2. A/E performs as an engineer and constructor and is the prime Contractor responsibile for:
   1) Plant design;
   2) Quality control;
   3) Construction;
   4) Subcontracting construction;
   5) Procuring major equipment;
   6) Construction management.
3. Labor wages rates = base wage rate at Bakersfield, CA, 1980.
4. Labor manhours per Bakersfield, CA.
5. Material priced to job location, 1980.
6. Field indirects and engineering will be Table C-4.
7. The following two items are not to be included in construction costs:
   1) Sales tax;
   2) Cost of money, AFDUC.
8. Design contingency not to be included in total for construction cost.
9. Any unique equipment not built at the construction site is to be treated as if it were for this cost estimate.

Table C-8 STEOR System Cost Estimate (1980$)

5100	Site Modification		$ 56,066
	5120 Yard Work	56,066	
5200	Site Facilities		901,185
	5210 Operations and Maintenance	675,285	
	5220 Security/Safety	225,900	
5300	Collector Subsystem ($230/m)		9,228,267
5400	Receiver Subsystem		3,577,336
	5410 Receiver Unit	2,386,233	
	5420 Tower Piping	66,178	
	5430 Water Treatment	388,622	
	5440 Tower	736,303	
5500	Plant Control		135,250
5900	Process Heat Subsystem		135,363
	5910 Field Piping	135,363	
	5000 Plant Construction Cost		$14,033,467

Table C-9 Construction Cost Estimate

CLIENT ____

LOCATION BAKERSFIELD, CA

PROJECT STEOR RETROFIT

DESCRIPTION 5000
PLANT COST

SUMMARY

CONT. NO. ____

MADE BY ____

APPROVED ____

A/C NO.	ITEM & DESCRIPTION	MAN HOURS	ESTIMATED COST			
			LABOR	SUBCONTRACTS	MATERIALS	TOTALS
A	Excavation & Civil			185,990		185,990
B	Concrete	587.5	10,152	36,234	11,285	57,671
C	Structural Steel	930	23,060	287,500	30,500	341,060
D	Buildings			350,000		350,000
E	Machinery & Equipment	1300	32,000	602,300	245,000	879,300
F	Piping	14,912	345,520	241,000	145,375	731,895
G	Electrical			96,500		96,500
H	Instruments		100	100,000	650	100,750
J	Painting					
K	Insulation		9,430	20,200	12,290	41,920
	FIELD ERECTION, A-K	16,000	392,000			392,000
	DIRECT FIELD COSTS	34,230	812,262	1,919,524	445,100	3,176,886
	AVE WAGE = $23.73/hr					
L	Temporary Construction Facilities					
M	Construction Services, Supplies & Expense					
N	Field Staff, Subsistence & Expense					
~~P~~	~~Craft Benefits, Payroll Burdens & Insurance~~	IN WAGE RATE				
Q	Equipment Rental					
	INDIRECT FIELD COSTS					167,238
	TOTAL FIELD COSTS					3,344,124
R	Engineering					
	Design & Engineering					
	Home Office Costs					
	R & D					
S	Major Equipment Procurement					
T	Construction Management					
	TOTAL OFFICE COSTS					643,285
	TOTAL FIELD & OFFICE COSTS					3,987,409
	G&A EXPENSES					118,121
U	Labor Productivity					
V	Contingency					395,789
W	Fee					303,881
	COLLECTOR SUBSYSTEM					9,228,267
	TOTAL CONSTRUCTION COST					$14,033,467

DATE ____ REVISION NO. ____ REVISION DATE ____ PAGE NO. 9-1

Table C-9 (cont)

CONSTRUCTION COST ESTIMATE

CLIENT

LOCATION BAKERSFIELD, CA

PROJECT STEOR

DESCRIPTION 5100

LAND, GENERAL SITE PREPARATION

CONST. NO.

MADE BY

APPROVED

A/C NO.	ITEM & DESCRIPTION	MAN HOURS	ESTIMATED COST			
			LABOR	SUBCONTRACTS	MATERIALS	TOTALS
A	Excavation & Civil			46,750		46,750
B	Concrete					
C	Structural Steel					
D	Buildings					
E	Machinery & Equipment					
F	Piping					
G	Electrical					
H	Instruments					
J	Painting					
K	Insulation					
	DIRECT FIELD COSTS			46,750		46,750
L	Temporary Construction Facilities					
M	Construction Services, Supplies & Expense					
N	Field Staff, Subsistence & Expense					
P	Craft Benefits, Payroll Burdens & Insurances					
Q	Equipment Rental					
	INDIRECT FIELD COSTS					–
	TOTAL FIELD COSTS					46,750
R	Engineering					
	Design & Engineering					
	Home Office Costs					
	R & D					
S	Major Equipment Procurement					
T	Construction Management @ 2.5%					1170
	TOTAL OFFICE COSTS					1170
	TOTAL FIELD & OFFICE COSTS					47,920
U	Labor Productivity					
V	Contingency @ 10%					4792
W	Fee 7%					3354
	TOTAL CONSTRUCTION COST					56,066

DATE ________ REVISION NO. ________ REVISION DATE ________ PAGE NO. 9-2

Table C-9 (cont)

CONSTRUCTION COSTS

CLIENT

LOCATION BAKERSFIELD, CA

PROJECT STEDR

BY [illegible] **CHKD.** **APVD.**

A/C NO.	ITEM & DESCRIPTION	QUAN.	UNIT	MANHOURS PER UNIT	MANHOURS TOTAL	MANHOURS RATE	COST/UNIT LABOR	COST/UNIT SUB CONTR.	COST/UNIT MAT'L.	COSTS ( ) LABOR	COSTS ( ) SUB CONTRACT	COSTS ( ) MATERIAL	COSTS ( ) TOTAL
5100	LAND, GENERAL Site Preparation												
5120	YARD WORK												
A	EXCAVATION & CIVIL												
A1	PLANT ACESS AND PAVED WORK AREA	2500	SY					10.70$			26,750		26,750
	125' x 180' = 22,500 SF												
	6" ASPHALT PAD + BASE												
	@ $1.50/SY LABOR, $9.20/SY MATERIAL												
A2	DRAINAGE	ALLOW									20,000		20,000

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Table C-9 (cont)

CONSTRUCTION COST ESTIMATE

CLIENT

LOCATION: BAKERSFIELD, CA

PROJECT: STEOR

DESCRIPTION 5200

SITE FACILITIES

CONT. NO.

MADE BY

APPROVED

A/C NO.	ITEM & DESCRIPTION	MAN HOURS	ESTIMATED COST			
			LABOR	SUBCONTRACTS	MATERIALS	TOTALS
A	Excavation & Civil			138,000		138,000
B	Concrete					
C	Structural Steel					
D	Buildings			350,000		350,000
E	Machinery & Equipment	1600	28,000		177,000	205,000
F	Piping					
G	Electrical			50,000		50,000
H	Instruments					
J	Painting					
K	Insulation					
	DIRECT FIELD COSTS	1600	28,000	538,000	177,000	743,000
L	Temporary Construction Facilities					
M	Construction Services, Supplies & Expense			30%		
N	Field Staff, Subsistence & Expense					
~~P~~	~~Craft Benefits, Payroll Burdens & Insurance~~	IN LABOR RATE				
Q	Equipment Rental					
	INDIRECT FIELD COSTS					8400
	TOTAL FIELD COSTS					751,400
R	Engineering					
	Design & Engineering					
	Home Office Costs					
	R & D					
S	Major Equipment Procurement					
T	Construction Management 2.5%					18,785
	TOTAL OFFICE COSTS					18,785
	TOTAL FIELD & OFFICE COSTS					770,185
U	Labor Productivity					
V	Contingency 10%					77,000
W	Fee 7%					54,000
	TOTAL CONSTRUCTION COST					901,185

DATE

REVISION NO.

REVISION DATE

PAGE NO. 9-4

Table C-9 (cont)

CONSTRUCTION COSTS

CLIENT

LOCATION BAKERSFIELD, CA

PROJECT STEOR RETROFIT

BY Jom **CHKD.** **APVD.**

A/C NO.	ITEM & DESCRIPTION	QUAN.	UNIT	MANHOURS			COST/UNIT			COSTS (1980 $)			
				PER UNIT	TOTAL	RATE	LABOR	SUB CONTR.	MAT'L.	LABOR	SUB CONTRACT	MATERIAL	TOTAL
5210	SITE FACILITIES												
D	BUILDINGS												
D1	CONTROL/ADMIN/WAREHOUSE	10,000	SF					35			350,000		350,000
	10,000 SF, 170,000 FT³ - BUTLER-TYPE												
E	MACHINERY & EQUIPMENT												
E1	MISCELLANEOUS EQUIPMENT CRANES, HOISTS, MACHINE TOOLS, WELDING EQUIP & AIR COMPRESSORS	1	LOT							25,000		150,000	175,000
E2	DIESEL GENERATOR, 150 KW	1								3000		27,000	30,000
										28,000	350,000	177,000	555,000
5220	SECURITY												
A	CIVIL												
A1	SECURITY FENCING 12' CHAIN LINK W/3 STRANDS WIRE, VISUM SHIELD INTERWOVEN	6500	LF					20			130,000		130,000
G	LIGHTING												
G1	SECURITY LIGHTING (PERIMETER)	ALLOW									50,000		50,000

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Table C-9 (cont)

CONSTRUCTION COST ESTIMATE

CLIENT

LOCATION BAKERSFIELD, CA

PROJECT STEOR RETROFIT

DESCRIPTION 5410 RECEIVER SUBSYSTEM (SUMMARY)

CONT. NO.

MADE BY FW | Jom

APPROVED

A/C NO.	ITEM & DESCRIPTION	MAN HOURS	ESTIMATED COST			
			LABOR	SUBCONTRACTS	MATERIALS	TOTALS
A	Excavation & Civil					
B	Concrete					
C	Structural Steel	930	23,060	112,500	30,500	166,060
D	Buildings					
E	Machinery & Equipment	200	4,000	30,000	68,000	102,000
F	Piping	12,190	279,030	178,500	96,300	553,830
G	Electrical			46,500		46,500
H	Instruments					
J	Painting					
K	Insulation			20,000		20,000
	FIELD ERECTION, A-K	16,000	392,000			392,000
	DIRECT FIELD COSTS	29,320	698,090	387,500	194,800	1,280,390
L	Temporary Construction Facilities					
M	Construction Services, Supplies & Expense					20,000
N	Field Staff, Subsistence & Expense					41,000
~~P~~	~~Craft Benefits, Payroll Burdens & Insurances~~	IN LABOR RATE				
Q	Equipment Rental					40,000
	INDIRECT FIELD COSTS					101,000
	TOTAL FIELD COSTS					1381,390
R	Engineering	16,750	469,040		20,000	489,040
	Design & Engineering					
	Home Office Costs					
	R & D					
S	Major Equipment Procurement					
T	Construction Management	1500	54,750			54,750
	TOTAL OFFICE COSTS	18,250	523,790		20,000	543,790
	TOTAL FIELD & OFFICE COSTS	47570	1,221,880	387,500	214,800	1,925,180
	G & A EXPENSES @ 6.2%					118,121
U	Labor Productivity					
V	Contingency @ 10%					190,519
W	Fee @ 8%					152,414
	TOTAL CONSTRUCTION COST					2,386,233

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Table C-9 (cont)

CONSTRUCTION COSTS

CLIENT

LOCATION BAKERSFIELD, CA

PROJECT STEOR RETROFIT

BY FW CHKD. APVD.

A/C NO.	ITEM & DESCRIPTION	QUAN.	UNIT	MANHOURS			COST/UNIT			COSTS ( )			
				PER UNIT	TOTAL	RATE	LABOR	SUB CONTR.	MAT'L.	LABOR	SUB CONTRACT	MATERIAL	TOTAL
5411	RECEIVER PRESSURE PARTS												
F	PIPING (SHOP FABRICATION)												
F1	DRUM				2640	24.80				65,470		26,000	91,470
F2	DOWNCOMERS				490					12,150		4,800	16,950
F3	HEADERS				2380					59,020		14,500	73,520
F4	RISERS & FEEDERS				710					17,610		9,200	26,810
F5	TUBE PANELS				5640	20.90				117,880		37,800	155,680
F6	JUMPER TUBES				330	20.90				6,900		4,000	10,900
F7	VALVES AND FITTINGS										80,000		80,000
F8	OTHER SHOP COSTS												
	TOOLING										35,000		35,000
	HEAT TREAT										4,000		4,000
	MOCKUP										6,000		6,000
	SHIPPING FIXTURES										15,000		15,000
	FREIGHT & INS										27,500		27,500
	MISCELLANEOUS										6,000		6,000
					12,190					279,030	173,500	91,300	548,830

DATE REVISION NO. REVISION DATE PAGE NO. 9-9 OF

Table C-9 (cont)

CONSTRUCTION COSTS

CLIENT
LOCATION BAKERSFIELD, CA
PROJECT STEOR RETROFIT

BY FW **CHKD.** **APVD.**

A/C NO.	ITEM & DESCRIPTION	QUAN.	UNIT	MANHOURS PER UNIT	MANHOURS TOTAL	MANHOURS RATE	COST/UNIT LABOR	COST/UNIT SUB CONTR.	COST/UNIT MAT'L.	COSTS ( ) LABOR	COSTS ( ) SUB CONTRACT	COSTS ( ) MATERIAL	COSTS ( ) TOTAL
5412	RECEIVER STRUCTURE AND ACCESSORIES												
C	STRUCTURAL STEEL												
C1	CAVITY ENCLOSURE										16,500		16,500
C2	PLATFORM & LADDERS										14,000		14,000
C3	SUPPORT STRUCTURAL STEEL										82,000		82,000
C4	DOORS				930	24.80				23,060		30,500	53,560
										23,060	112,500	30,500	166,060
F	PIPING												
F1	CONNECTING PIPING										5,000		5,000
K	INSULATION												
K1	INSULATION & SHEATHING										20,000		20,000
					930					23,060	137,500	30,500	191,060

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Table C-9 (cont)

CONSTRUCTION COSTS

CLIENT

LOCATION BAKERSFIELD, CA

PROJECT STEDR - RETROFIT

BY Jom CHKD. APVD.

A/C NO.	ITEM & DESCRIPTION	QUAN.	UNIT	MANHOURS			COST/UNIT			COSTS ( )			
				PER UNIT	TOTAL	RATE	LABOR	SUB CONTR.	MAT'L.	LABOR	SUB CONTRACT	MATERIAL	TOTAL
5413	RECEIVER CIRCULATION EQUIPMENT												
E	MACHINERY AND EQUIPMENT												
E1	RECEIVER FEEDWATER PUMP	1			200	20	4000		68,000	4000		68,000	72,000
	BYRON JACKSON MODEL DVMX3,4,9B 200 gpm, 3500 ft HEAD (1500 psi)												

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Table C-9 (cont)

CONSTRUCTION COSTS

CLIENT

LOCATION Bakersfield, CA

PROJECT STEOR

BY Fw/Jen CHKD. APVD.

A/C NO.	ITEM & DESCRIPTION	QUAN.	UNIT	MANHOURS			COST/UNIT			COSTS ( )			
				PER UNIT	TOTAL	RATE	LABOR	SUB CONTR.	MAT'L.	LABOR	SUB CONTRACT	MATERIAL	TOTAL
5414	RECEIVER INSTRUMENTATION & CONTROL												
E	MACHINERY AND EQUIPMENT												
E1	CAVITY DOOR ACTUATORS	2	ea					15,000			30,000		30,000
G	ELECTRICAL												
G1	CONTROLS AND INSTRUMENTS (RECEIVER)										40,000		40,000
G2	(FW PUMP)										6,500		6,500
											46,500		46,500

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Table C-9 (cont)

CONSTRUCTION COST ESTIMATE

PROJECT: Solar Industrial Retrofit System for EOR

LOCATION: Edison Field, Bakersfield, California

DESCRIPTION: Receiver Subsystem Only, Not Including Support Tower and Tower Downcomer and Riser

A/C NO	Item & Description	Man Hours	Labor ($)	Estimated Cost $		
				Sub-contracts	Materials	Totals
5400	Receiver					
A	Shop Fabrication	13,120	302,090		126,800	428,890
B	Other Shop Cost					93,500
C	Subcontracted Fabrication			137,500		137,500
D	General Accessories				130,000	130,000
E	Home Office Costs	17,750	509,790		20,000	529,790
F	Field Erection	16,000	392,000		115,000	507,000
	Total Shop, Office & Field Costs					1,826,680
G	Contingency (10% of ΣA to F)					182,670
	ΣA to G					2,009,350
H	G&A (6.2% of ΣA to G)					124,580
	ΣA to H					2,133,930
I	Fee (8% of ΣA to H)					170,710
	Total Construction Cost					2,304,640

Table C-9 (cont)

/c :o.	ITEM & DESCRIPTION	QUAN.	UNIT	MANHOURS			COST UNIT			COSTS ($)			
				PER UNIT	TOTAL	* RATE	LABOR	SUB CONTR	MAT'L	LABOR	SUB CONTRACT	MATERIAL	TOTAL
200	Receiver Subsystem												
A	Shop Fabrication												
	1. Drum				2640	24.80				65,470		26,000	91,4
	2. Downcomers				490	"				12,150		4,800	16,9
	3. Headers				2380	"				59,020		14,500	73,5
	4. Risers & Feeders				710	"				17,610		9,200	26,8
	5. Tube Panels				5640	20.90				117,880		37,800	155,6
	6. Jumper Tubes				330	"				6,900		4,000	10,9
	7. Doors				930	24.80				23,060		30,500	53,5
	A/C "A" Total				13120					302,090		126,800	428,8
B.	Other Shop Costs												
	1. Tooling												35,
	2. Heat Treat												4,
	3. Mock-up												6,
	4. Shipping Fixtures												15,
	5. Freight & Insurance												27,
	6. Miscellaneous												6,
	A/C "B" Total												93,5
C	Sub-Contract Fabrication												
	1. Cavity Enclosure										16,500		16,5
	2. Platforms & Ladders										14,000		14,0
	3. Support Structure Steel										82,000		82,0
✓	4. Insulating & Sheathing										20,000		20,0
✓	5. Connecting Piping										5,000		5,0
	A/C "C" Total										137,500		137,5

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Note: * Manhour rate includes labor and overhead

Table C-9 (cont)

/c o.	ITEM & DESCRIPTION	QUAN.	UNIT	MANHOURS PER UNIT	MANHOURS TOTAL	MANHOURS * RATE	COST UNIT LABOR	COST UNIT SUB CONTR	COST UNIT MAT'L	COSTS ( ) LABOR	COSTS ( ) SUB CONTRACT	COSTS ( ) MATERIAL	COSTS ( ) TOTAL
D.	General Accessories												
	1. Valves & Fitting	✓										80,000	80,00
	2. Controls & Instrumentation											20,000	20,00
	3. Cavity Door Actuators											30,000	30,00
	A/C "D" Total											130,000	130,00
E.	Home Office Cost												
	1. Project Management				1500	36.50				54,750	✓		54,7
	2. Engineering				2500	37.80				94,500			94,5
	3. Design & Drafting				8850	29.20				258,420			258,4
	4. Mechanical Detailing				3650	16.80				61,320			61,3
	5. Manufacturing Engineering				400	35.90				14,360			14,3
	6. Welding Engr. QC&QA				250	37.90				9,480			9,4
	7. Contract Administration				350	33.60				11,760			11,7
	8. Estimating				250	20.80				5,200			5,2
	9. Reproduction											5,000	5,00
	10. Travel & Living Expense											10,000	10,00
	11. Computer											5,000	5,00
	A/C "E" Total				17,750					509,790		20,000	529,79
F.	Field Erection												
	1. Field Labor				16,000	24.50				392,000			392,00
	2. Tools & Equip. Rental												40,00
	3. Consumable												20,00
	4. Field Supervision											115K	41,00
	5. Home Office Management												14,00
	A/C "F" Total												507,00

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Table C-9 (cont)

CONSTRUCTION COST ESTIMATE

CLIENT

LOCATION BAKERSFIELD, CA

PROJECT STEOR

DESCRIPTION 5420
TOWER PIPING

CONT. NO.

MADE BY JDM

APPROVED

A/C NO.	ITEM & DESCRIPTION	MAN HOURS	ESTIMATED COST			
			LABOR	SUBCONTRACTS	MATERIALS	TOTALS
A	Excavation & Civil					
B	Concrete					
C	Structural Steel					
D	Buildings					
E	Machinery & Equipment					
F	Piping	1124	28,140		13,925	42,065
G	Electrical					
H	Instruments					
J	Painting					
K	Insulation		1,720		2,320	4,040
	DIRECT FIELD COSTS	1124	29,860		16,245	46,105
L	Temporary Construction Facilities				30%	
M	Construction Services, Supplies & Expense					
N	Field Staff, Subsistence & Expense					
~~P~~	~~Craft Benefits, Payroll Burdens & Insurance~~	IN LABOR RATE				
Q	Equipment Rental					
	INDIRECT FIELD COSTS					8958
	TOTAL FIELD COSTS					55,063
R	Engineering					1500
	Design & Engineering					
	Home Office Costs					
	R & D					
S	Major Equipment Procurement					
T	Construction Management					
	TOTAL OFFICE COSTS					1500
	TOTAL FIELD & OFFICE COSTS					56,563
U	Labor Productivity					
V	Contingency 10%					
						5656
W	Fee 7%					
						3959
	TOTAL CONSTRUCTION COST					66,178

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Table C-9 (cont)

CONSTRUCTION COSTS

CLIENT

LOCATION BAKERSFIELD, CA

PROJECT STEOR

BY **CHKD.** **APVD.**

A/C NO.	ITEM & DESCRIPTION	QUAN.	UNIT	MANHOURS			COST/UNIT			COSTS ( )			
				PER UNIT	TOTAL	RATE	LABOR	SUB CONTR.	MAT'L.	LABOR	SUB CONTRACT	MATERIAL	TOTAL
5420	TOWER PIPING												
F	PIPING												
F1	RISER	450	LF	1.2	540	24			9.68	12,960		4356	17,136
	4" CARBON STEEL sch 40												
	INCL SUPPORTS												
F2	DOWNCOMER	365	LF	1.6	584	26			26.21	15,180		9570	24,750
	6" CARBON STEEL sch 80												
	INCL EXP. LOOPS & SUPPORTS												
K	INSULATION												
K1	3½" MICRO LOK INSULATION, INCL CASING	365	LF				4.72		6.36	1,720		2,320	4,040
	DOWNCOMER ONLY												

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Table C-9 (cont)

CONSTRUCTION COST ESTIMATE

CLIENT

DESCRIPTION 5430 WATER TREATMENT

LOCATION BAKERSFIELD, CA

CONT. NO.

MADE BY [illegible]

PROJECT STEOR

APPROVED

A/C NO.	ITEM & DESCRIPTION	MAN HOURS	ESTIMATED COST			
			LABOR	SUBCONTRACTS	MATERIALS	TOTALS
A	Excavation & Civil			745		745
B	Concrete	375	6375		5625	12,000
C	Structural Steel					
D	Buildings					
E	Machinery & Equipment			255,000		255,000
F	Piping			62,500		62,500
G	Electrical					
H	Instruments					
J	Painting					
K	Insulation					
	DIRECT FIELD COSTS	375	6375	318,245	5625	330,245
L	Temporary Construction Facilities					
M	Construction Services, Supplies & Expense				30%	
N	Field Staff, Subsistence & Expense					
~~P~~	~~Craft Benefits, Payroll Burdens & Insurance~~					
Q	Equipment Rental					
	INDIRECT FIELD COSTS					1912
	TOTAL FIELD COSTS					332,157
R	Engineering					
	Design & Engineering					
	Home Office Costs					
	R & D					
S	Major Equipment Procurement					
T	Construction Management					
	TOTAL OFFICE COSTS					—
	TOTAL FIELD & OFFICE COSTS					332,157
U	Labor Productivity					
V	Contingency 10%					33,215
W	Fee 7%					23,250
	TOTAL CONSTRUCTION COST					$ 388,622

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Table C-9 (cont)

CONSTRUCTION COSTS

CLIENT

LOCATION BAKERSFIELD, CA

PROJECT STEOR

BY JON CHKD. APVD.

A/C NO.	ITEM & DESCRIPTION	QUAN.	UNIT	MANHOURS			COST/UNIT			COSTS ( )			
				PER UNIT	TOTAL	RATE	LABOR	SUB CONTR.	MAT'L.	LABOR	SUB CONTRACT	MATERIAL	TOTAL
5430	WATER TREATMENT FACILITY												
A	EXCAVATION & CIVIL												
A1	FOUNDATION EXCAVATION	75	CY					9.90			743		743
B	CONCRETE												
B1	FOUNDATION	75	CY	5	375	17			75	6375		5625	12,000
E	MACHINERY & EQUIPMENT												
E1	THERMOTICS WATER SOFTENER, w/ DEEP BED FILTER 75 gpm CAPACITY	1						255,000			255,000		255,000
	DELIVERED AND INSTALLED												
F	PIPING												
F1	WATER STORAGE, 100,000 gal. CAPACITY 30'D x 19'H CYLINDRICAL TANK	1									62,500		62,500

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Table C-9 (cont)

CONSTRUCTION COST ESTIMATE

CLIENT

LOCATION BAKERSFIELD, CA

PROJECT STEOR RETROFIT

DESCRIPTION 5440 TOWER

CONT. NO.

MADE BY [illegible]/BN

APPROVED

A/C NO.	ITEM & DESCRIPTION	MAN HOURS	ESTIMATED COST			
			LABOR	SUBCONTRACTS	MATERIALS	TOTALS
A	Excavation & Civil			495		495
B	Concrete	190	3327	36234	4850	44,412
C	Structural Steel			175,000		175,000
D	Buildings					
E	Machinery & Equipment			317,300		317,300
F	Piping					
G	Electrical					
H	Instruments					
J	Painting					
K	Insulation					
	DIRECT FIELD COSTS	190	3327	529,029	4850	537,206
L	Temporary Construction Facilities					
M	Construction Services, Supplies & Expense					
N	Field Staff, Subsistence & Expense		15% OF	A-C		
~~P~~	~~Craft Benefits, Payroll Burdens & Insurance~~					
Q	Equipment Rental					
	INDIRECT FIELD COSTS					32,985
	TOTAL FIELD COSTS					570,191
R	Engineering					
	Design & Engineering					
	Home Office Costs		10% OF DFC			53,721
	R & D					
S	Major Equipment Procurement					
T	Construction Management					
	TOTAL OFFICE COSTS					53,721
	TOTAL FIELD & OFFICE COSTS					623,912
U	Labor Productivity					
V	Contingency 10%					62,391
W	Fee 5%					50,000
	TOTAL CONSTRUCTION COST					736,303*

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* AS COMPARED to $879,549 TOWER COST USING SLL TOWER COST MODEL

Table C-9 (cont)

CONSTRUCTION COSTS

CLIENT

LOCATION BAKERSFIELD, CA

PROJECT STEOR RETROFIT

BY **CHKD.** **APVD.**

A/C NO.	ITEM & DESCRIPTION	QUAN.	UNIT	MANHOURS PER UNIT	MANHOURS TOTAL	MANHOURS RATE	COST/UNIT LABOR	COST/UNIT SUB CONTR.	COST/UNIT MAT'L.	COSTS (1980 $) LABOR	COSTS (1980 $) SUB CONTRACT	COSTS (1980 $) MATERIAL	COSTS (1980 $) TOTAL
5440	TOWER												
C	STRUCTURAL STEEL												
C1	TOWER STRUCTURE, STEEL, W/4 LEGS - SUPPORTING RECEIVER WT OF 310,000 lb; SURVIVAL WIND OF 75 mph.	1	EA					175,000			175,000		175,000
		Approx	200T	A36	STEEL								
			1632	mh LABOR	× 19.02	/mh	= 31,040						
	REF: TOWER COSTS FOR SOLAR CENTRAL RECEIVERS, LIEBENBERG & GRANT, 1/7/80												
	REF: STEARNS-ROGER "TOWER COST DATA FOR SOLAR CENTRAL RECEIVER STUDIES" JUNE 1979												
E	MACHINERY AND EQUIPMENT												
E1	ELEVATOR, LIGHTING, LIGHTNING PROTECTION, SERVICE PLATFORM												
	ELEVATOR, 900 lb CAPACITY, 300'							119,400					
	OBSTRUCTION LIGHTING							102,670					
	STAIRS, 30 IN							25,500					
	SAFETY LADDER							11,400					
	LIGHTNING PROTECTION							17,300					
	PLATFORM (1000 FT^2)							30,000					
	PAINT, $20/TON × 200 T							4,600					
	LIGHTING							6,500					
								317,300			317,300		317,300
	REF: STEARNS-ROGER												

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Table C-9 (cont)

CONSTRUCTION COSTS

COST CODE 5400 -
RECEIVER SUBSYSTEM

CLIENT MARTIN MARIETTA
LOCATION BAKERSFIELD, CA.
PROJECT SOLAR RETROFIT

BY BV **CHKD.** **APVD.**

A/C NO.	ITEM & DESCRIPTION	QUAN.	UNIT	MANHOURS PER UNIT	MANHOURS TOTAL	MANHOURS RATE	COST/UNIT LABOR	COST/UNIT SUB CONTR.	COST/UNIT MAT'L.	COSTS LABOR	COSTS SUB CONTRACT	COSTS MATERIAL	COSTS TOTAL
5440	TOWER ~~FOUNDATION~~												
A	EXCAVATION & CIVIL												
A1	Tower Foundation Excavation for Pier Caps including Mobilization, with backhoe.	50	CY					9.90			495		495
B	CONCRETE												
B1	Piers - 3'ø x 45' long, 3/cap including mobilize (from Bakersfield or LA) drilled in stable ground with no casings, full rebar cage.	540	LF					67.10			36,234		36,234
B2	Pier Caps - 3 Triangular Δ 18', 3' deep, including form work and reinforcement.	47	CY				70.80		103.20	3,327.60		4,850.40	8,178
													$ 44,907*

* NOTE: THIS CAN BE COMPARED TO A FOUNDATION COST OF $ 310,405 USING THE SANDIA MODEL FOR A MAT FOUNDATION

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Table C-9 (cont)

CONSTRUCTION COST ESTIMATE

CLIENT ____________________

LOCATION BAKERSFIELD, CA

PROJECT STEOR

DESCRIPTION 5500
PLANT CONTROL SUBSYSTEM

CONT. NO. ____________________

MADE BY [illegible]

APPROVED ____________________

A/C NO.	ITEM & DESCRIPTION	MAN HOURS	ESTIMATED COST			
			LABOR	SUBCONTRACTS	MATERIALS	TOTALS
A	Excavation & Civil					
B	Concrete					
C	Structural Steel					
D	Buildings					
E	Machinery & Equipment					
F	Piping					
G	Electrical					
H	Instruments			100,000		100,000
J	Painting					
K	Insulation					
	DIRECT FIELD COSTS			100,000		100,000
L	Temporary Construction Facilities					
M	Construction Services, Supplies & Expense					
N	Field Staff, Subsistence & Expense					
P	Craft Benefits, Payroll Burdens & Insurances					
Q	Equipment Rental					
	INDIRECT FIELD COSTS					—
	TOTAL FIELD COSTS					100,000
R	Engineering 15%					15,000
	Design & Engineering					
	Home Office Costs					
	R & D					
S	Major Equipment Procurement					
T	Construction Management					
	TOTAL OFFICE COSTS					15,000
	TOTAL FIELD & OFFICE COSTS					115,000
U	Labor Productivity					
V	Contingency 10%					11,500
W	Fee 7%					8,750
	TOTAL CONSTRUCTION COST					$135,270

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Table C-9 (cont)

CONSTRUCTION COSTS

CLIENT

LOCATION BAKERSFIELD, CA

PROJECT STEOR

BY JDM CHKD. APVD.

A/C NO.	ITEM & DESCRIPTION	QUAN.	UNIT	MANHOURS			COST/UNIT			COSTS ( )			
				PER UNIT	TOTAL	RATE	LABOR	SUB CONTR.	MAT'L.	LABOR	SUB CONTRACT	MATERIAL	TOTAL
5500	PLANT CONTROL SUBSYSTEM												
	INCLUDES ONLY DISPLAYS FOR RECEIVER, PUMP, PIPING AND WATER TREATMENT CONTROLS INCLUDED IN COMPONENT ACCOUNTS.												
	HELIOSTAT CONTROLS IN 5300												
H	INSTRUMENTS												
H1	PANEL DISPLAY AND CONTROL BOARD SIMILAR CONFIGURATION to BTG BOARD IN POWER PLANT										100,000		100,000
	BUDGETARY ESTIMATE PROVIDED by JOHNSON CONTROLS. INCL. INSTALLATION & hook-up												

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Table C-9 (cont)

CONSTRUCTION COST ESTIMATE

CLIENT

LOCATION Bakersfield, CA

PROJECT STEOR Retrofit

DESCRIPTION 5900
Field piping

CONT. NO.

MADE BY B&V

APPROVED

A/C NO.	ITEM & DESCRIPTION	MAN HOURS	ESTIMATED COST			
			LABOR	SUBCONTRACTS	MATERIALS	TOTALS
A	Excavation & Civil					
B	Concrete	22.5	450		810	1260
C	Structural Steel					
D	Buildings					
E	Machinery & Equipment					
F	Piping	1598	38,350		35,150	73,500
G	Electrical					
H	Instruments		100		650	750
J	Painting					
K	Insulation		7,710		9,970	17,680
	DIRECT FIELD COSTS	1620.5	46,610		46,580	93,190
L	Temporary Construction Facilities					
M	Construction Services, Supplies & Expense					
N	Field Staff, Subsistence & Expense			30%		
~~P~~	~~Craft Benefits, Payroll Burdens & Insurance~~					
Q	Equipment Rental					
	INDIRECT FIELD COSTS					13,983
	TOTAL FIELD COSTS					107,173
R	Engineering 10% of DFC					9,319
	Design & Engineering					
	Home Office Costs					
	R & D					
S	Major Equipment Procurement					
T	Construction Management					
	TOTAL OFFICE COSTS					9,319
	TOTAL FIELD & OFFICE COSTS					116,492
U	Labor Productivity					
V	Contingency 10% of TFC					10,717
W	Fee 7%					8,154
	TOTAL CONSTRUCTION COST					135,363

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Table C-9 (concl)

CONSTRUCTION COSTS

CLIENT

LOCATION BAKERSFIELD, CA

PROJECT STEOR RETROFIT

BY B&V CHKD. APVD.

A/C NO.	ITEM & DESCRIPTION	QUAN.	UNIT	MANHOURS			COST/UNIT			COSTS ( )			
				PER UNIT	TOTAL	RATE	LABOR	SUB CONTR.	MAT'L.	LABOR	SUB CONTRACT	MATERIAL	TOTAL
5900	FIELD PIPING												
B	CONCRETE												
	FOOTINGS FOR PIPE SUPPORTS	90	ea	.25	22.5	20.	5.00		9.00	450		810	1260
F	PIPING												
	6" MAIN HEADER sch 80 C.S.	1050	LF	.95	998	24			10.85	23,950		11,390	35,340
	BARCO JOINTS	4	ea						1112	①		4,450	4,450
	PIPE SUPPORT SYSTEM												
	PIPE CLAMPS	52							25.71	①		1,340	1,340
	SUPPORTS	52							66.00	①		3,430	3,430
	3" BRANCH PIPING sch 80 CS.	750	LF	.80	600	24			3.97	14,400		2,980	17,380
	BARCO JOINTS	9							354	①		3,190	3,190
	GATE VALVE	3							400	①		1,800	1,800
	RELIEF VALVE	3							1200	①		3,600	3,600
	PIPE SUPPORT SYSTEM												
	PIPE CLAMPS	38							12.10			460	460
	SUPPORTS	38							66.00			2,510	2,510
H	INSTRUMENTS												
	PRESSURE TRANSMITTER	1							650	100		650	750
	(INCL. SIPHON TANK, LOCAL INDICATOR & SHUTOFF VALVE)												
K	INSULATION												
	(3½" micro-lok, lagging incl.)												
	6" MAIN HEADER PIPE	1050	LF				9.72		6.36	4,960		6,680	11,640
	3" Branch pipe	750	LF				3.66		4.38	2,750		3,290	6,040

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5.3.3 Operating and Maintenance Cost Data

The operations and maintenance costs for the first year of operation of the STEOR system are shown in Table C-10. The estimates include a 7% overhead charge assesed on all recurring costs at the Edison site. Table C-11 shows the cost breakdown for each cost account and Table C-12 gives the material cost for field piping additions.

Table C-10 STEOR Operations and Maintenance Cost Summary (1980$)

OM100	Operations		$283,304
	OM110 Operating Personnel	203,856	
	OM120 Operating Consumables	79,448	
OM200	Maintenance Materials		$ 30,698
	OM210 Spare Parts and Materials	30,698	
OM300	Maintenance Labor		$ 66,361
	OM310 Scheduled Maintenance	66,361	
	Total Yearly Operations and Maintenance		$380,363

5.4 PLANT ECONOMIC EVALUATION DATA

For the Exxon solar thermal EOR project, the plant economic data are shown in Table C-13.

In addition to the factors shown in Table C-13 describing the economic environment of the plant owner, economic factors describing the overall economy seen by the user are also required. These factors are shown in Table C-14.

5.4.1 Fuel Cost Assumptions

The fuel savings realized from operation of the solar portion of the plant is an important parameter of the cost effectiveness of the STEOR project. Accurate estimates of the displaced fuel costs at the site are required. These fuel costs are to be expressed in 1980$. For the Exxon Kern River enhanced oil recovery project, crude oil is the fuel to be displaced, with the expected cost and escalation shown in Table C-15. Electrical energy is also used at the site, for both conventional and solar processes, with the costs and escalation shown in Table C-16.

5.4.2 Alternative Fuel Cost Assumptions (Sandia-Suplied)

To facilitate comparison of system economics between alternative sites and owners, a standard set of fuel costs and escalation rates have been supplied by Sandia Laboratories (Livermore). These fuel costs are given in Table C-16.

Table C-11 Operating and Maintenance Cost Worksheets

OM100 Operations

OM110 Operations Personnel
OM110A Operations
1 Supervisor/Operator (1 shift)
1 Technician (2 shifts)
2 men x 1.5 shifts/day x 365 days x 8 h/shift = 8760 man-hours (mh)
x $17/mh*
$148,920

Om110B Maintenance
2 maintenance personnel for receiver, collector and piping
2 men x 1 shift/day x 260 days/yr x 8 hr/shift = 4160 mh
x $10/mh
$ 41,600

Total OM110 = $190,520

OM120 Operating Consumables
OM120A Water Treatment Chemicals
$360/10,000 bbl water x 750,000 bbl water/yr = $27,000
OM120B Water
$150/10,000 bbl x 750,000 bbl = $11,250
OM120C Electricity
Feedwater Pump: 266 kW x 3140 h/yr = 835,240 kWh
Heliostats: Avg 480 Wh/helio/day = 143,313 kWh
978,553 kWh/yr
Use 1,000 MWh/yr
x $36/MWh
$36,000/yr

Total OM120 = $74,250

OM200 Maintenance Materials

OM210 Spare Parts and Material for Repairs
OM212 Collector
0.1% of initial cost/helio/yr = $12.75/helio/yr x 818 = $10,430
OM213 Receiver Subsystem
0.1% of initial cost/yr = $12,600
OM215 Process Heat Subsystem
Additional pipe, fittings, joints for steam line relocation
See Table C-12 for cost backup = $ 5,560
Replacement packing for Barco joints = $ 100

Total OM210 = $28,690/yr

OM300 Maintenance Labor

OM310 Scheduled Maintenance
Subcontracted service for heliostat washing at $50/heliostat/yr x 818 heliostats
= $40,900
Removal and reemplacement of heliostats for well drilling operations
= $21,120/yr for years 1 thru 3.

Total OM300 = $62,020

OM310 Removal and Replacement of Heliostats for Well Drilling
To remove/replace ∿4 hours w/crew of 4
Crew: 1 lead heliostat man
2 normal maintenance men (from OM210)
1 heavy equipment operator
4 hours x 2 men x $17/hour = $136 Labor
Forklift rental at $1200/mo = $ 40
$176 per heliostat removal or replacement

Over first 3 years, 18 wells will be drilled in heliostat field, requiring removal and replacement of ∿180 heliostats.

180 helio x $176/helio x 2 operators = $63,360 total cost

$\frac{63,360}{3}$ = $21,120/yr over 1st 3 years

Continuing at ∿ same level for years 4 thru 26 to account for periodic well operations (further drilling, casing work, etc).

* Labor rate includes shift premiums

Table C-12 Development of Yearly Material Cost for Field Piping Additions

CONSTRUCTION COSTS

CLIENT ____________

LOCATION BAKERSFIELD, CA

PROJECT STEOR

BY ______ CHKD. ______ APVD. ______

A/C NO.	ITEM & DESCRIPTION	QUAN.	UNIT	MANHOURS			COST/UNIT			COSTS ( )			
				PER UNIT	TOTAL	RATE	LABOR	SUB CONTR.	MAT'L.	LABOR	SUB CONTRACT	MATERIAL	TOTAL
OM215	FIELD PIPING												
B	CONCRETE												
	FOOTINGS FOR PIPE SUPPORTS	258	ea				5		9	1290		2322	3612
F	PIPING												
	6" MAIN HEADER (sch 80)	5150	LF	.95	4892	24			10.85	117,240		55,877	173,297
	BARCO JOINTS	22	ea						1112			24,464	24,464
	PIPE SUPPORT SYSTEM												
	PIPE CLAMPS	258	ea						25.71			6633	6633
	SUPPORTS	258	ea						66.00			17,028	17,028
K	INSULATION (3½" thick)												
	6" MAIN header	5150	LF				4.72		6.36	24,308		32,754	57,062
	TOTAL COST OF STEAM HEADER EXTENSIONS OVER 26 YEARS									142,838		139,078	282,096
	ANNUAL COST, 25 YEARS									5713		5,560	11,283
										INCLUDED IN OM100 personnel		TO ACCT OM215	

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Table C-13 Site-Specific STEOR Economic Parameters

System Life	26 years
Initial Year of Operation	1985
Rate of Return (Discount Factor)	15%
Depreciation Period	11 years
Depreciation Method	ADR
Levelized Depreciation Factor	0.5891
Federal Income Tax Rate	46%
State Income Tax Rate	9%
Composite Tax Rate	50.86%
Investment Tax Credits (Solar)	30.4%
Investment Tax Credits (Fossil)	10%
Insurance and Property Tax	2.25%

Table C-14 STEOR General Economic Factors

Rate of General Inflation	7%
Capital Escalation Rate	7%
Operations and Maintenance Escalation Rate	7%

Table C-15 Fuel Cost Assumption

World Oil Price, 1980	$506/MBtu ($30.00/bbl)
Quality Debit	10%
Ad Valorem Tax Rate	6%
Windfall Profits Tax Rate	30%*
Royalties	7%
"As-Burned" Oil Cost	$3.56/MBtu ($21.11/bbl)
Oil Escalation Rate	10%
Electricity Cost	$36.00/MWhe
Electic Escalation Rate	9%

* The windfall profits tax is levied on the difference of the Edison price after ad valorem taxes and the base price of $2.79/MBtu ($16.55/bbl) escalating at the GNP deflator + 2%, and is assumed to expire in 1991.

Table C-16 Sandia-Supplied Fuel Cost Assumptions (1980$)

Nuclear	$0.85/MBtu
Coal	$1.25/MBtu
Oil	$4.00/MBtu*
Natural Gas	$2.50/MBtu
Fuel Escalation Rates	
General Inflation	8%/year
Nuclear	1%/year above General Inflation
Coal	2%/year above General Inflation
Oil	4%/year above General Inflation
Natural Gas	3%/year above General Inflation

*Delivered fuel cost.

5.5 SIMULATION MODELS

This section describes the simulation models used in calculating performance of the selected solar system and in the studies performed the selection of that system.

5.5.1 Insolation Models

To perform yearly energy production calculations, the SOLMET typical meteorological year (TMY) insolation and weather data base was used because no TMY data exist for the Bakersfield, CA area, the TMY data tape for Fresno, CA was selected. Fresno is approximately 100 mi northeast of the site, but was chosen as being representative of the San Joaquin Valley region. The typical meteorological years selected for each month for the Fresno data are shown in Table C-17. The average daily insolation calculated from the Fresno data is 6.21 kWh/m^2/day.

Table C-17 Typical Meteorological Years for Fresno, CA

January 1964	July 1954
February 1975	August 1973
March 1968	September 1968
April 1953	October 1966
May 1968	November 1974
June 1962	December 1968

5.5.2 Performance Models

The following models will be used in designing and evaluating the system performance:

1) DELSOL - Calculates the optical performance, field layout and optical system design for solar central receiver plants;

2) RCELL - Optimizes heliostat spacings and tower heights and provides heliostat foundation coordinates;

3) MIRVAL - Calculates heliostat field performance by Monte Carlo analysis for STEAEC analysis;

4) TRASYS - Models receiver performance and calculates incident and absorbed heat fluxes on active surfaces and reflection losses;

5) STEAEC - Models system performance with SOLMET insolation data to provide yearly energy output.

5.5.3 Economic Models

The models used in evaluating the system economics are:

1) BUCKS - A required revenue analysis model for calculating the levelized cost of energy;

2) STEORE - A net present value analysis model for calculating the net present value of the solar retrofit system.

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