GL03081 - 2 of 6

# PLAN OF OPERATION,

## INJECTION

Lease Nos. CA 966 and CA 1903
Sec. 25, T15S, R16E; Secs. 19,20,28,29 and 30
T15S, R17E, SB B&M

East Mesa, Imperial County, California

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Proposal to commence injection operations at Well Nos. 18-28, 52-29 and 56-29 to dispose of geothermal liquids produced during well testing and production activities for a 10 Mw power plant.

Estimated Starting Date: Date of Approval

Estimated Completion Date: Indefinite

REPUBLIC GEOTHERMAL, INC.

PLAN OF OPERATION, INJECTION
10 Mw POWER PLANT

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REPUBLIC GEOTHERMAL, INC.

PLAN OF OPERATION, INJECTION
UNITED STATES GEOTHERMAL LEASE NOS. CA 966 AND CA 1903
EAST MESA, IMPERIAL COUNTY, CALIFORNIA

## A. PROPOSED PLAN OF OPERATION

Republic Geothermal, Inc. proposes herein to commence injection operations as part of the initial stages of geothermal development on Lease Nos. CA 966 and CA 1903. This Plan of Operation, Injection is submitted in accordance with 30 CFR 270.34 and draft GRO Order No. 5, and covers proposed subsurface injection to dispose of geothermal liquids produced during well testing and production activities for a 10 Mw power plant, to recharge the reservoir, and to minimize the possibility of surface subsidence due to withdrawal of geothermal fluids.

Three injection wells (No. 18-28, existing; Nos. 52-29 and 56-29, proposed) and five production wells (Nos. 16-30, 56-30 and 16-29, existing; Nos. 36-30 and 76-30, proposed) are to be used for the proposed power plant. Related pipelines, access roads, well testing and production operations, and other surface activities are discussed in Republic's Plan of Operation, Development which is being submitted simultaneously.

Draft GRO Order No. 5 requires duplicate information for the Plan of Operation, Development and the Plan of Operation, Injection, particularly in regard to injection well location and drilling operations. Republic has followed the outline of necessary information as closely as possible; thus there is some repetition. To avoid confusion, however, Republic requests that the proposed injection well locations and attendant surface facilities (pad construction, roads, pipelines, etc.) be evaluated and approved as part of the Plan of Operation, Development, and that the proposed liquid disposal program and subsurface injection operations be evaluated and approved as part of this Plan of Operation, Injection. Republic believes that this request is consistent with the intent and purpose of the separation of the two Plans in draft GRO Order No. 5.

In addition, three alternative power plant sites are shown in this Plan of Operation to provide a perspective of overall development. The site selection and details of the power plant operation will be contingent upon evaluation and approval of Republic's Plan of Utilization, which will be submitted to the Supervisor in accordance with proposed amendments to 30 CFR, Section 270 and 43 CFR, Part 3208.

## B. DETAILS OF PROPOSED PLAN

### 1. Location and Placement of Proposed Operations

#### a. Maps

Attached hereto and made a part hereof as Exhibit A is our Drawing No. 199-10, East Mesa Geothermal Project Vicinity Map, which shows the topography, drainage patterns, cultural features and existing roads and wells. The Vicinity Map also shows existing and proposed transmission lines for informational purposes.

Attached hereto and made a part hereof as Exhibit B is our Drawing No. 199-11, East Mesa Geothermal Project Development Plan-10 Mw Power Plant, which shows the proposed location and spacing of wells, existing and proposed access roads and alternative power plant sites. Pipelines will be located along the existing and proposed access roads.

#### b. Justification for Proposed Location and Spacing of Wells

The location of the eight wells (five producers, three injectors) devoted to the proposed 10 Mw power plant must be viewed in relation to the overall resource development plan for justification. Figure 1 shows conceptual well locations for a 48 Mw net project having 19 interior producers and 9 peripheral injectors. Sufficient well control and geophysical evidence exists to indicate that this is a reasonable minimum interpretation of the ultimate project scope. Wells devoted to the 10 Mw plant can be seen to be an integral part of the overall plan.

Peripheral injection (Figure 1) into the interval 2000$\pm$ to 5000$\pm$ feet and production from a central group of producers completed

# CONCEPTUAL WELL LOCATION PLAN
# FUTURE 48 NET MW PROJECT

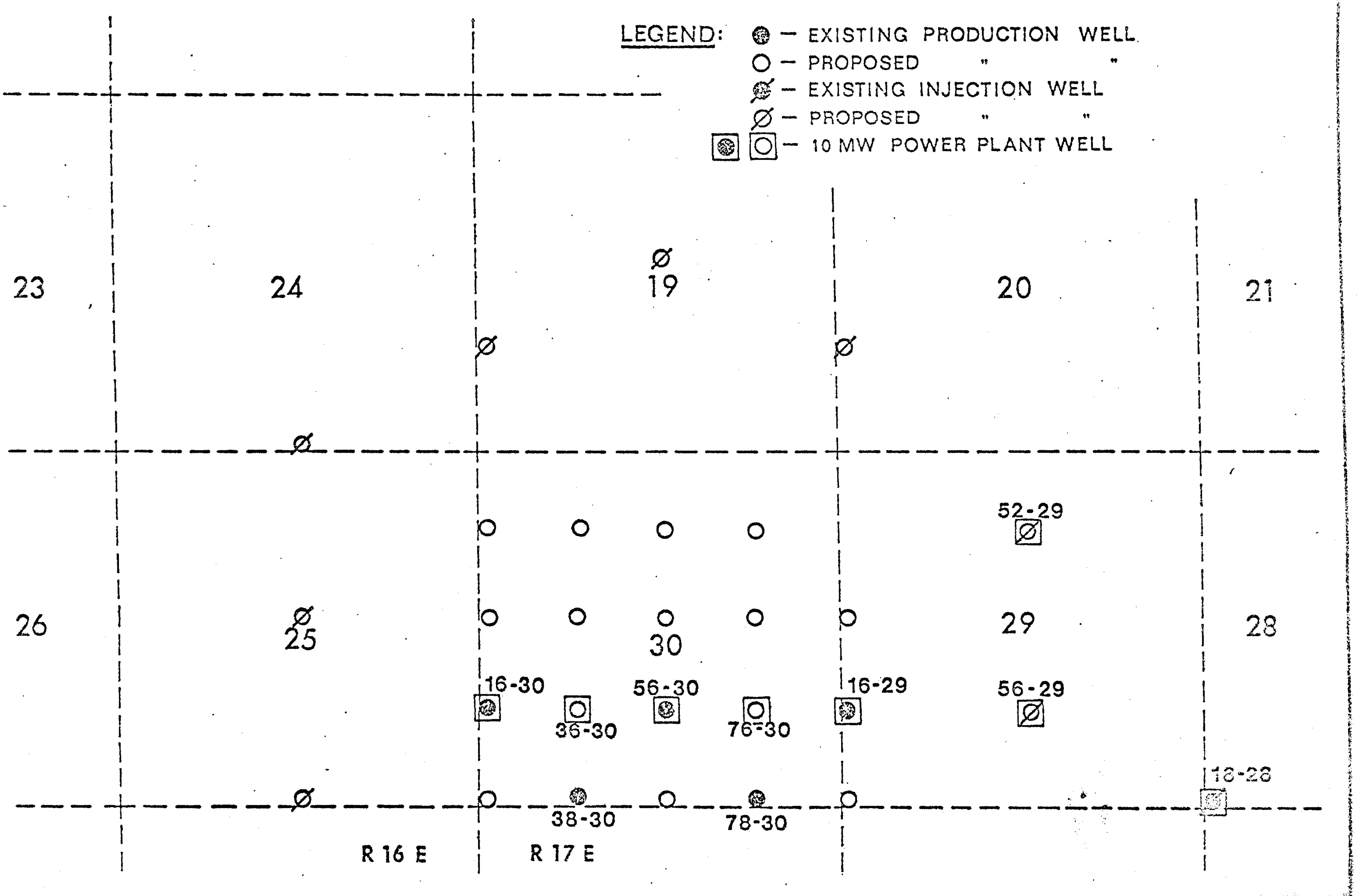


Figure 1

in the interval 5500± to 7500± feet is currently considered to be the most advantageous manner in which to develop the East Mesa reservoir. Such a pattern maximizes the time and path of travel of the cooler reinjected waters between the injectors and producers. The longer the reinjected water is in contact with the hot reservoir rock, the hotter it will be when it arrives back at the producers. Thus, the life of the resource will be much greater with such a pattern relative to that which would be expected with any interior reinjection pattern alternative.

Injection into the shallower sands rather than directly into the productive reservoir is also advantageous economically and environmentally. Because the shallower sands have a much higher permeability than those of the reservoir, it should be possible to inject the water from two producers into a single injector using a low surface pressure. Thus, well costs, energy costs (pump power), and surface usage will be minimized relative to a deep interior reinjection pattern.

Good vertical communication below 2000± feet is the key to the success of such a shallow peripheral reinjection plan. Preliminary reservoir simulation work shows that with vertical communication, pressure can be maintained in the interior producing area when aided by a minor amount of aquifer influx. The required influx need only be enough to replace evaporative losses at the plant, and will certainly exist during operation of the 10 Mw plant by itself. When the larger plant(s) comes on line, the natural influx may or may not have to be supplemented, and that determination will require several years of full-scale production experience.

Substantial evidence exists that good vertical communication and hot water influx from depth are present at East Mesa, as is detailed in later sections. The convective nature of the temperature profiles below 2000+ feet indicates both vertical communication and water influx. Hot water influx from below the producing interval is also indicated by the silica and alkalai chemical equilibrium temperatures of the produced fluids. Well logs and geologic correlations show essentially sand-on-sand contacts throughout the vertical sequence below 2000+ feet. Finally, pressure interference testing by Lawrence Berkeley Laboratories shows that USBR Well Nos. 6-1 and 6-2, and USBR Well No. 31-1 and Republic Well No. 38-30 communicate, even though the completion intervals of each well pair do not overlap vertically.

The foregoing discussion is intended to justify the well location concept for overall development and, indirectly, for the 10 Mw plant. Similarly, well spacing must also be viewed in the context of an overall plan. An acceptable spacing of 40-acres per well as shown on Figure 1 was established with a reservoir simulation study (discussed in more detail in a later section). For this study, the most conservative conditions of "no influx" and "no vertical communication" were assumed. Under these conditions, interior five-spot pattern reinjection may be required for pressure maintenance.

Results of the 40-acre spacing five-spot simulations show that pressure can easily be maintained, but that some produced fluid temperature decline will be experienced after 12+ years. This is illustrated in Figure 2. While this amount of temperature decline is tolerable and easily compensated for by a few make-up wells, closer spacings which were investigated (i.e., 20-acres and 10-acres per well), resulted in earlier breakthroughs and more precipitous temperature declines. This would require a substantially greater number

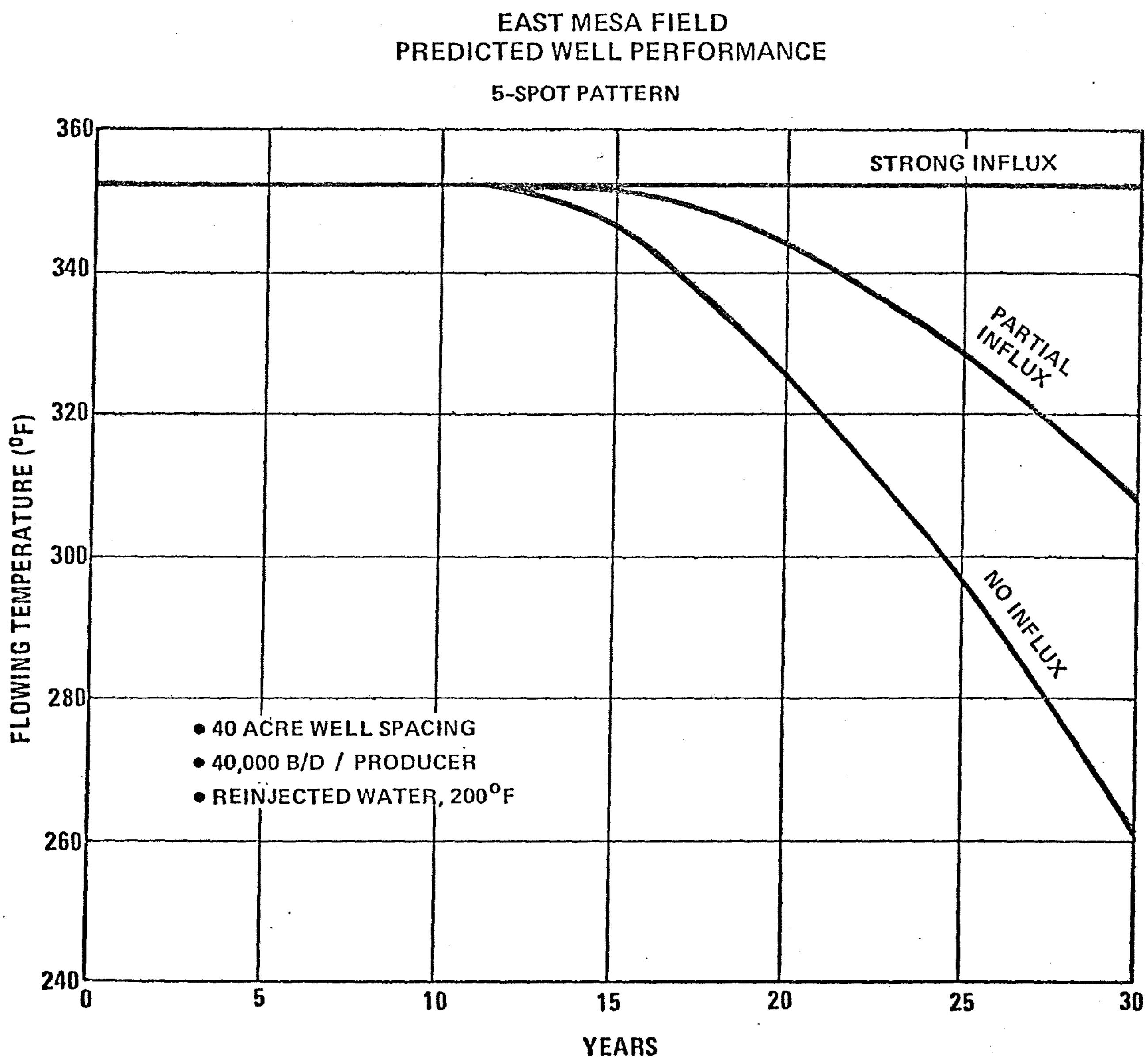
EAST MESA FIELD
PREDICTED WELL PERFORMANCE
5-SPOT PATTERN
STRONG INFLUX
PARTIAL INFLUX
NO INFLUX
• 40 ACRE WELL SPACING
• 40,000 B/D / PRODUCER
• REINJECTED WATER, 200°F
FLOWING TEMPERATURE (°F)
YEARS
360
340
320
300
280
260
240
0
5
10
15
20
25
30

Figure 2

of make-up wells to sustain a 25- to 30-year plant life. Thus, 40-acres per well spacing has been established as an acceptable spacing in the event that an interior five-spot reinjection pattern must be resorted to in order to maintain pressure.

It should be emphasized that five-spot reinjection is not the expected mode of operation. Evidence thus far available indicates that the peripheral injection scheme discussed above will be successful, and that production well spacing will be of little importance to efficient development of the resource.

In addition, topographic features, drainage patterns and current land uses were considered in well spacing. The topography at East Mesa is essentially level. Surface water is limited to one short section of the East Highline Canal, and the leases are devoid of obvious stream channels. Land in the area of the proposed development is open space desert. The dominant plant species is that of the creosote bush (Larrea divaricata). Immediately southwest of the southwestern corner of the leasehold is an orange orchard which occupies less than one section of land.

None of the above factors presents an environmental concern which would determine or limit the location of wells or roads within the boundaries of the leases. Thus the wells are spaced at 40-acre intervals for maximum efficiency and utilization of the resource based on the data briefly discussed earlier and described in more detail in a later section.

2. Discussion of Proposed Operations

Republic proposes to dispose of waste geothermal fluids from development and production activities by injecting the fluids into proposed injection Well Nos. 18-28, 52-29 and 56-29. Fluid to be injected will consist primarily of produced fluids from testing of Well Nos. 16-30, 36-30, 56-30, 76-30 and 16-29, and spent liquids produced from these same wells which have been utilized during the operation of a 10 Mw power plant.

In addition, Republic proposes to use the injection wells for temporary waste disposal of geothermal fluids produced during production testing of exploratory wells in other parts of the leasehold, until such time that sufficient data exist to submit and approve subsequent Plans of Operation, Development and Injection. Republic anticipates the volume of these fluids will be relatively small. Republic also believes this flexibility will encourage the orderly and timely development of the resource.

Republic recognizes that prior to commencing any of the operations mentioned above, specific details must be submitted to the Area Geothermal Supervisor and explicit approval obtained.

3. Resource Data

a. Lithology

Cores, cuttings and geophysical logs from 14 wells drilled to depths of 6,000-10,000 feet provide a means to understand the subsurface lithology at East Mesa, with optical and x-ray diffraction techniques having been used to examine the cores and cuttings.

The stratigraphy at East Mesa is a sedimentary section composed of a lacustrine and deltaic sequence of alternating sandstones, siltstones, and mudstones of Plio-Pleistocene age, covered by a 100-150 ft. surficial layer of dune sand deposits. Immediately below these dune sands and above the deltaic sediments is a 1700-1900 ft. thick lacustrine interval that contains a significant to dominant percentage of clay-rich mudstones, particularly between the depths of 600 ft. and 1000 ft. These mudstones effectively separate the overlying fresh water sands from the more saline waters in the predominantly sandstone-siltstone sediments of the Colorado River delta sequence.

The proposed disposal zone is below 2000 feet, within the deltaic sandstones. Lithologically these sandstones are medium to fine-grained, moderately to moderately-well sorted, and quartz-rich. Detrital clasts include lithic fragments, feldspars, chert, and the usual accessories. Authigenic carbonate and quartz can occur as partial porefilling, replacement and vein materials, particularly at depths below 4000 ft. Interbedded with the sandstones are more thinly developed siltstone-mudstone lithologies. These finer-grained units progressively change in color and clay mineral content with increasing depth, starting as tan, montmorillonite- and kaolinite-rich units at shallower depths, and becoming gray, illite- and chlorite-rich units at greater depths.

A detailed overall examination of the deltaic sequence as specifically displayed in the relatively closely-spaced Republic wells at East Mesa indicates that singular lithologic units are typically 10 to 60 feet in thickness, that sandstone units are predominant, and that individual units maintain a moderate degree of lateral sedimentologic continuity.

b. Subsurface Maps and Cross-Section

The geophysical well logs from the six Republic wells and the USBR Well No. 31-1 have been examined in detail to provide an interpretation of the existing stratigraphic and structural conditions in the northern part of the East Mesa field.

In addition, the results of a recent Vibroseis reflection seismology program have been reviewed and used to expand the structural interpretation. The Vibroseis data is published in an ERDA Report titled "Utilization of Seismic Exploration Technology for High Resolution Mapping of a Geothermal Reservoir", by P. L. Goupillaud and J. T. Cherry, April, 1977.

The Plio-Pleistocene deltaic sedimentary rock sequence, present at all depths drilled below 1800-2100 ft., contains both the proposed fluid disposal zones and the underlying productive geothermal reservoir sands. The top of this deltaic assemblage of sandstones, siltstones and mudstones (shales) is represented by a distinctive and correlative shale-sand horizon that is now designated "$A_1$". The underlying succession of lithologic units has been correlated from well to well, with 58 specific horizons similarly designated and spaced throughout the total stratigraphic section to a depth of about 7500 feet.

Drawing No. 199-12, attached hereto and made a part hereof as Exhibit C, displays a sequence of three subsurface structure contour maps and a structural cross section through this part of the East Mesa field. As seen in the east-west cross section, a broad anticlinal axis is present near Republic Well No. 16-30. The western flank of this structure is relatively steep, with dips of as much as 35° observed in USBR Well No. 31-1. The structure dips more gently to the east, with a broad synclinal axis being present between Republic Well Nos. 16-29 and 18-28.

A series of normal growth-type faults traverses the structure. These faults strike NE-SW, dip to the NW, and cause the lithologic units to be vertically displaced by as much as 200-500 ft. at depths of about 6000 ft. Displacement decreases toward shallower depths, as the sequence of growth faults appears to have been generated at a time nearly contemporaneous with deposition of the deltaic units. It is consequently highly unlikely that they create any displacement in the overlying lacustrine beds above a depth of 1000-1500 ft.

In addition to the normal faults, two lateral faults are interpreted to be present in this area. These faults appear as a conjugate set, with the NW-SE trending fault probably being the so-called East Mesa fault referred to in recent publications on observed seismicity at East Mesa. There is no known nor suspected evidence of recent activity on any of the other faults in the area.

The combined stratigraphic and structural interpretation indicates that both horizontal and vertical fluid communication exist between the depths of 2000-7500 ft. in this portion of the East Mesa field. At least four factors have contributed to create this condition. The sand-dominated deltaic depositional environment has provided a primary horizontal stratigraphic continuity, with sufficient cut and fill present to interrupt the thinner shale interbeds. Second, the system of penecontemporaneous normal growth faults has vertically disturbed and dislocated the sediments, thereby increasing the means for vertical fluid communication. Third, the post-depositional folding and doming in this area has undoubtedly promoted the propagation of vertical tensional cracks. Finally, the more recent near-vertical lateral faults have further vertically disrupted the dominantly sandstone-siltstone lithologic assemblage. These lateral faults may actually result in some local reduction in horizontal fluid communication as they develop due to horizontal compression. In contrast, the more prevalent normal faults should be expected to have no noticeable adverse effect on horizontal fluid movement as they are formed in response to a tensional condition present during deposition.

c. Fluid Chemistry

Produced fluids from Republic's wells at East Mesa average less than 1900 ppm total dissolved solids (TDS) and less than four ppm of total hardness (calcium). This is the lowest salinity and hardness found in any geothermal field in the Imperial Valley. Furthermore, this water is remarkably free of heavy metals which often cause environmental problems for disposal of geothermal fluids. Somewhat higher salinities have been found in the central and southern part of the East Mesa field, with a maximum of 26,000 ppm present in the Bureau of Reclamation's Well No. 6-1.

A summary of the produced water analyses data is shown in Table 1 for the three earlier Republic wells plus the shallow water supply well. The three recently completed wells (Nos. 16-30, 56-30 and 78-30), have not yet been flowed sufficiently to yield meaningful samples uncontaminated by drilling mud filtrate. The analyzed fluids from the first three deep geothermal wells are similar and are characterized by low hardness, moderate pH, high bicarbonate, and low TDS. The most notable differences between these waters and the ground water represented by the water well analysis are the lower bicarbonate, flouride and boron content of the ground water.

Only the marginally high TDS, arsenic, flouride and boron contents prevent the geothermal water from being suitable for agriculture, livestock, and human consumption. Therefore, the risk of accidental harm to the surrounding ecosystem from water spillage is minimal.

TABLE 1

EAST MESA WELL FLUID COMPARISON (mg/l)

(Unflashed Samples)

| Parameter | RGI 38-30 | RGI 16-29 | RGI 18-28 | RGI (450') Water Well |
|---|---|---|---|---|
| Total Dissolved Solids | 1860 | 1761 | 1727 | 1600 |
| Silica | 148.5 | 149.6 | 86.5 | 10 |
| Iron | 0.04 | .04 | .07 | 0.1 |
| Calcium | 2.1 | 2.6 | 3.2 | 68 |
| Magnesium | 0.3 | .1 | .2 | 19 |
| Sodium | 548 | 506 | 515 | 410 |
| Potassium | 28 | 28.5 | 14.8 | 12 |
| Bicarbonate | 530 | 530 | 537 | 76 |
| Carbonate | 0 | 0 | 0 | 4 |
| Sulfate | 150 | 83 | 165 | 9 |
| Chloride | 450 | 461 | 401 | 760 |
| Fluoride | 2.8 | 3.3 | 4.0 | 0.5 |
| Arsenic | .11 | .10 | .10 | N/A |
| Boron | 2.1 | 3.0 | 1.7 | 0.9 |
| Bromide | 0.25 | 0.17 | .31 | N/A |
| pH (pH units) | 7.7 | 7.7 | 8.2 | 8.3 |

However, no surface use is contemplated at this time since it is planned that all the water, with the exception of that needed for cooling water, will be returned to the reservoir by injection. The analysis in Table 1 is for produced water without steam flash, and it is nearly representative of the residual plant waters which will be injected. The anticipated differences are those associated with the evaporation losses which will occur in the plant processing.

A chemical analysis of the flashed steam from Well No. 16-29 is shown in Table 2. The non-condensables are only 0.64 weight percent of the steam and consist primarily of carbon dioxide. Only minute concentrations of hydrogen sulfide have yet been detected in the steam. There are two major implications of this analysis. The first is that any possible environmental problems associated with flashing to the atmosphere are negligible. The second is that the low level of noncondensables makes it feasible to utilize a flashed steam process to drive the power plant turbines.

d. Reservoir Properties

(1) Log Analyses

Analyses of the geophysical well logs from Republic Well Nos. 38-30, 16-29 and 18-28 have been completed. Analyses of logs from the more recently completed wells (Nos. 16-30, 56-30 and 78-30) are currently underway. The principal results of the completed analyses were a determination of porosity, permeability salinity, and net sand present at each well location versus depth. The permeability - posity - log relationships are calibrated with core data from USBR Well No. 5-1. An improved relation may be possible when lab results from recent tests on the core from Republic Well No. 78-30 become available.

TABLE 2

CHEMICAL ANALYSIS OF
FLASHED STEAM - REPUBLIC WELL NO. 16-29

| | | |
|---|---|---|
| Total Noncondensables | - | 0.64 wt. % of steam |
| Constitutents | | |
| Carbon dioxide | - | 91.4 vol. % of noncondensables |
| Nitrogen | - | 4.3 |
| Methane | - | 3.9 |
| Alkanes | - | 0.4 |
| Hydrogen sulfide | - | None detected |

Tables 3, 4 and 5 provide a summary of the individual well data for each 250-foot increment of depth. These data generally show an excellent amount of sand development in the wells, with a gradual decrease in reservoir properties and salinity with depth. The porosity, net sand, and permeability in the producing interval, 5500± to 7500± feet, are sufficiently high to permit large flow rates with relatively minor pressure drawdowns. The validity of these calculations has been confirmed by both pressure buildup analyses and by interference testing, as discussed later.

Note that the permeabilities in the proposed injection interval, 2000± to 5000± feet (Table 3), are relatively much higher than those of the productive interval. This should allow high-volume shallow injection at low pressures as previously noted. The higher salinity of the water in the injection interval relative to the salinity in the productive interval provides assurance that injection will not degrade the shallow zone waters. Contamination of the ground water above 1000± feet will be prevented by the "shale barrier" between 1000± and 2000± feet (discussed previously in the lithology section) coupled with an adequate injection well leak monitoring system.

(2) Temperatures

The temperatures measured in each well versus depth are illustrated in Figures 3 and 4. Well Nos. 38-30, 16-29, and 18-28 have been flowed and surveyed sufficiently during the 2± years since completion to be assured that the data represents true static temperature profiles. The data from the recently completed wells

TABLE 3

REPUBLIC GEOTHERMAL WELL NO. 38-30

ZONE SUMMARIES

| | Thickness (ft) | | | | Permeability (md) | | Salinity * |
|---|---|---|---|---|---|---|---|
| Interval | Gross | Net Sand | % Sand | $\bar{\phi}$ | $\bar{K}$ (h) Arith | $\bar{K}$ (h) Geo | ppm NaCl |
| 1350-1500 | 151 | 125 | 83 | .35 | 1174 | 913 | 8,216 |
| 1501-1750 | 250 | 223 | 89 | .34 | 1023 | 757 | 8,091 |
| 1751-2000 | 250 | 140 | 56 | .32 | 756 | 456 | 10,317 |
| 2001-2250 | 250 | 155 | 62 | .34 | 1064 | 721 | 10,237 |
| 2251-2500 | 250 | 166 | 66 | .31 | 573 | 321 | 10,818 |
| 2501-2750 | 250 | 161 | 64 | .31 | 467 | 256 | 10,113 |
| 2751-3000 | 250 | 214 | 86 | .36 | 1645 | 1315 | 7,500 |
| 3001-3250 | 250 | 214 | 86 | .33 | 897 | 534 | 8,043 |
| 3251-3500 | 250 | 171 | 68 | .28 | 149 | 102 | 7,585 |
| 3501-3750 | 250 | 181 | 72 | .29 | 322 | 134 | 6,556 |
| 3751-4000 | 250 | 166 | 66 | .31 | 473 | 243 | 5,569 |
| 4001-4250 | 250 | 111 | 44 | .31 | 714 | 286 | 6,117 |
| 4251-4500 | 250 | 145 | 58 | .29 | 263 | 148 | 5,471 |
| 4501-4750 | 250 | 195 | 78 | .30 | 432 | 186 | 3,006 |
| 4751-5000 | 250 | 189 | 76 | .28 | 367 | 115 | 3,223 |
| 5001-5250 | 250 | 162 | 81 | .30 | 595 | 205 | 3,029 |

* Produced **fluid** salinity 1860 ppm from the interval 6383' to 8898'

TABLE 3
(Continued)
REPUBLIC GEOTHERMAL WELL NO. 38-30
ZONE SUMMARIES

| | Thickness (ft) | | | | Permeability (md) | | Salinity * |
|---|---|---|---|---|---|---|---|
| Interval | Gross | Net Sand | % Sand | $\bar{\phi}$ | $\bar{K}$ (h) Arith | $\bar{K}$ (h) Geo | ppm NaCl |
| 5251-5500 | 250 | 210 | 84 | .30 | 570 | 187 | 2,564 |
| 5501-5750 | 250 | 201 | 80 | .23 | 101 | 22 | 2,508 |
| 5751-6000 | 250 | 162 | 65 | .23 | 63 | 23 | 3,250 |
| 6001-6250 | 250 | 183 | 73 | .28 | 312 | 90 | 2,834 |
| 6251-6500 | 250 | 227 | 91 | .31 | 645 | 266 | 2,134 |
| 6501-6750 | 250 | 219 | 88 | .31 | 826 | 229 | 2,670 |
| 6751-7000 | 250 | 153 | 61 | .25 | 287 | 36 | 3,318 |
| 7001-7250 | 250 | 76 | 30 | .16 | 9 | 2 | 4,140 |
| 7251-7500 | 250 | 86 | 34 | .19 | 17 | 6 | 5,814 |
| 7501-7700 | 200 | 115 | 58 | .18 | 14 | 5 | 4,428 |
| 7701-8000 | 300 | 122 | 41 | .22 | 106 | 18 | 3,915 |
| 8001-8250 | 250 | 93 | 37 | .11 | 1.5 | .6 | 4,378 |
| 8251-8500 | 250 | 111 | 44 | .10 | .9 | .4 | No Data |
| 8501-8750 | 250 | 63 | 25 | .11 | 16 | .6 | 1,199 |
| 8751-8900 | 150 | 26 | 17 | .07 | .2 | .1 | No Data |

* Produced fluid salinity 1860 ppm from the interval 6383' to 8898'

TABLE 4

REPUBLIC GEOTHERMAL WELL NO. 16-29
ZONE SUMMARIES

| Interval | Thickness (ft) Gross | Net Sand | % Sand | $\bar{\phi}$ | Permeability (md) $\bar{K}$ (h) Arith | $\bar{K}$ (h) Geo | Salinity * ppm NaCl |
|---|---|---|---|---|---|---|---|
| 4800-5000 | 250 | 175 | 70 | .26 | 190 | 54 | No Data |
| 5001-5250 | 250 | 182 | 73 | .25 | 130 | 43 | |
| 5251-5500 | 250 | 181 | 72 | .22 | 56 | 18 | |
| 5501-5750 | 250 | 206 | 82 | .22 | 33 | 15 | |
| 5751-5925 | 174 | 125 | 72 | .22 | 81 | 16 | |
| 5926-6000 | 250 | 52 | 21 | .27 | 140 | 64 | |
| 6001-6250 | 250 | 211 | 84 | .25 | 112 | 44 | |
| 6251-6500 | 250 | 219 | 88 | .27 | 263 | 78 | |
| 6501-6750 | 250 | 175 | 70 | .25 | 95 | 39 | |
| 6751-7000 | 250 | 163 | 65 | .19 | 16 | 6 | |
| 7001-7050 | 50 | 3 | 6 | .14 | 2 | 1 | |
| 7051-7250 | 200 | 40 | 20 | .14 | 32 | 1 | |
| 7251-7500 | 250 | 143 | 57 | .22 | 37 | 13 | |
| 7501-7750 | 250 | 155 | 62 | .21 | 54 | 11 | |
| 7751-7900 | 150 | 90 | 60 | .22 | 34 | 16 | |

* Produced fluid salinity 1761 ppm from the interval 6413' to 7996'

TABLE 5

REPUBLIC GEOTHERMAL WELL NO. 18-28
ZONE SUMMARIES

| | Thickness (ft) | | | | Permeability (md) | | Salinity * |
|---|---|---|---|---|---|---|---|
| Interval | Gross | Net Sand | % Sand | $\bar{\Phi}$ | $\bar{K}$ (h) Arith | $\bar{K}$ (h) Geo | ppm NaCl |
| 5100-5250 | 250 | 88 | 35 | .25 | 306 | 34 | No Data |
| 5251-5500 | 250 | 226 | 90 | .29 | 458 | 146 | |
| 5501-5750 | 250 | 226 | 90 | .29 | 658 | 134 | |
| 5751-6000 | 250 | 193 | 77 | .29 | 529 | 136 | |
| 6001-6250 | 250 | 183 | 73 | .22 | 42 | 15 | |
| 6251-6400 | 250 | 59 | 24 | .23 | 86 | 18 | |
| 6401-6500 | 100 | 28 | 28 | .22 | 30 | 17 | |
| 6501-6750 | 250 | 202 | 81 | .22 | 29 | 16 | |
| 6751-7000 | 250 | 136 | 54 | .22 | 127 | 18 | |
| 7001-7250 | 250 | 84 | 34 | .23 | 213 | 24 | |
| 7251-7500 | 250 | 94 | 38 | .27 | 994 | 85 | |
| 7501-7750 | 250 | 92 | 36 | .22 | 198 | 13 | |
| 7751-7900 | 150 | 55 | 37 | .15 | 2 | 2 | |

* Produced fluid salinity 1727 ppm from the interval 6413' to 7996'

EQUILIBRATED STATIC TEMPERATURE SURVEYS,
EAST MESA WELLS

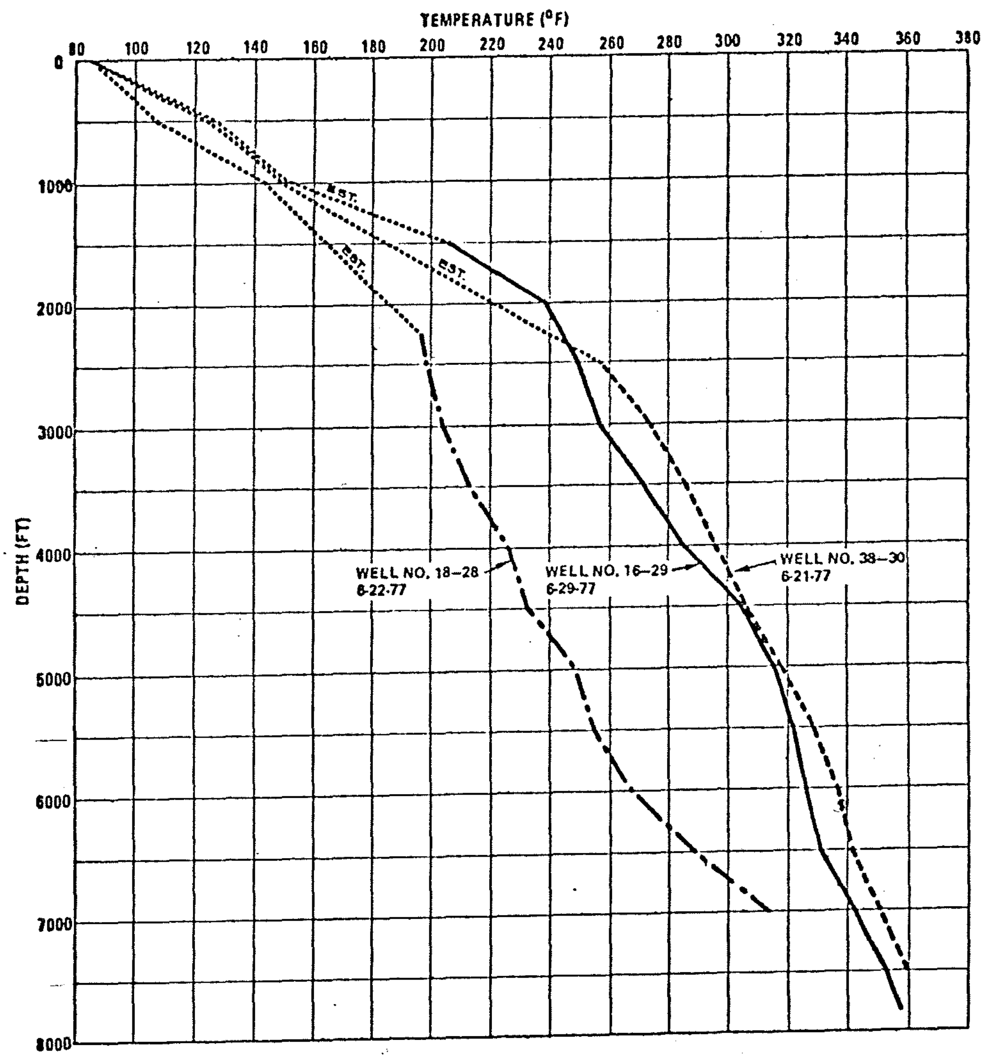


Figure 3

PRELIMINARY STATIC TEMPERATURE SURVEYS
EAST MESA WELLS

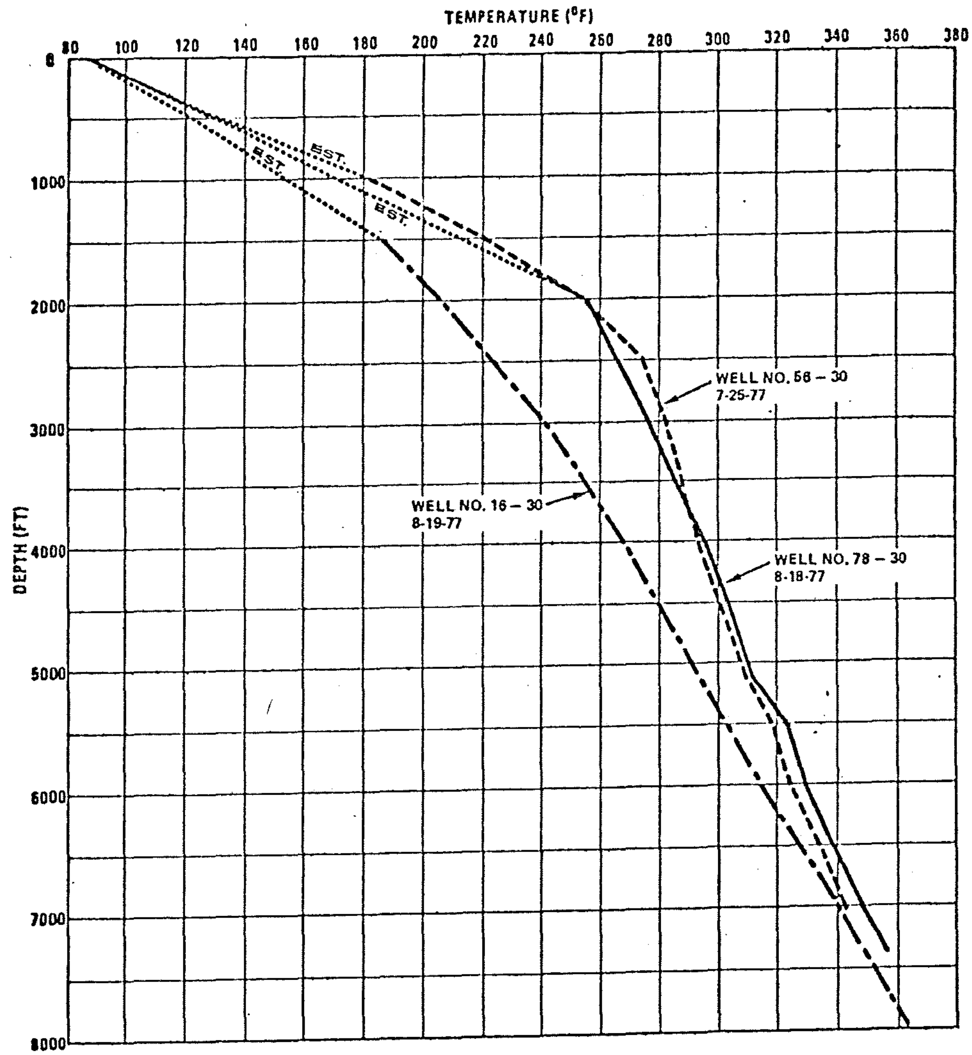


Figure 4

(Nos. 16-30, 56-30, and 78-30), however, were taken shortly after drilling and are undoubtedly at less than equilibrium temperatures.

Note the increase in slope present in all the wells except Well No. 18-28 in the interval 2500± to 3500± feet. This is indicative of convective vertical fluid flow in the reservoir and hot water influx from depth. In general, the temperature in the productive interval (5500± to 7500± feet) may be seen to range between 320°F and 360°F, while the range in the proposed injection interval (2000± to 5000± feet) is between 235°F and 310°F.

Minimum bottom-hole flowing temperatures (above the completion interval) of 338°F and 332°F have been established in Well Nos. 38-30 and 16-29, respectively, during short term flow tests. These values are very important in that they represent the volumetric average temperature of the producing interval. Such data has not yet been obtained during long term production tests, but the values can be expected to be higher, if anything, in the future. At low production rates, it may take many months for the surface produced fluid temperatures to approach the downhole flowing temperatures due to well bore heat losses. At the expected pumped rates of 800,000 + $lb_m$/hr, rates expected of East Mesa producers being pumped, however, preliminary calculations indicate "equilibration" between bottom-hole and surface temperatures will occur within a few days.

(3) Pressures

Bottom-hole pressure drawdown and buildup tests were run in Well Nos. 38-30, 16-29, and 18-28. The more recent wells (Nos. 16-30, 56-30, and 78-30), have, thus far, only been short-term production tested without bottom-hole instrumentation. The data were analyzed using conventional Horner plot, Miller-Dyes-Hutchinson and superposition techniques to estimate the permeability-thickness (kh) of the producing interval, and to determine if formation damage exists around the well bore. In addition, an indication of boundaries was sought, which could be combined with geophysical, petrophysical and other data to help delineate the East Mesa reservoir. A tabulation of the input data and principal results obtained from the buildup analyses are given in Table 6.

Lawrence Berkeley Laboratory has also conducted a series of interference tests between various pairs of wells in the field. A summary of the permeability and permeability-thickness data calculated by three methods (i.e., log analysis, pressure buildup, and interference testing) is given in Table 7, along with the maximum observed flow rates. Well No. 38-30 has a buildup permeability of 84 md, which is the highest of any well in the group. The permeability of 42 md found in Well No. 16-29, yields an average 63± md for this area. The highest permeability USBR well is No. 31-1 (30 md), located immediately adjacent to the Republic leases. The interference kh between Republic's Well No. 38-30 and the USBR Well No. 31-1 is 29.8 Darcy-feet, which is in excellent agreement with the average buildup kh of 32.3 Darcy-feet between the two wells.

More recent Lawrence Berkeley Laboratory/ Republic Geothermal interference and drawdown/falloff pressure testing

TABLE 6

PRESSURE BUILDUP DATA AND RESULTS

| Test Data | RGI WELLS 18-28 | 16-29 | 38-30 |
|---|---|---|---|
| Flow duration, hrs | 21.5 | 5.53 | 5.47 |
| Shut-in time, hrs | 9.3 | 22.40 | 24.39 |
| Cumulative production STB | 1,264 (1) | 4,525 | 5,907 |
| Last rate before shut-in, STB/D | 2,517 | 19,668 | 25,462 |
| Producing time, hrs | 17.05 | 5.902 | 6.097 |
| **Reservoir and Fluid Property Data** | | | |
| Water viscosity, μ | 0.210 | 0.185 | 0.185 |
| Water FVF, RB/STB | 1.078 | 1.085 | 1.088 |
| Porosity, fraction | 0.220 | 0.223 | 0.249 |
| Total compressibility, $psi^{-1}$ | $7.570 \times 10^{-6}$ | $7.904 \times 10^{-6}$ | $8.202 \times 10^{-6}$ |
| Well bore radius, ft | 0.375 | 0.443 | 0.510 |
| Estimated net thickness, ft | 77 | 827 | 499 |
| Perforated intervals, ft | 6105-6210 | 6413-6984 | 6383-7022 |
| | 6440-8000 (2) | 7231-7996 | 7271-7485 (3) |
| | | | 7869-7998 |
| | | | 8297-8384 |
| | | | 8640-8898 |
| **Results** | | | |
| Average permeability, md | 81.94 | 41.96 | 83.50 |
| Flow capacity, md-ft | 6,309 | 34,698 | 41,666 |
| Formage damage (skin) | -0.91 | -2.28 | -2.81 |
| Distance to nearest boundary, ft | 451 | 893 | 692 |

(1) Estimated
(2) Spinner survey showed no fluid entry
(3) Fill to 7022'

TABLE 7

COMPARISON OF PERMEABILITY AND
FLOW CAPACITY OF EAST MESA WELLS

| Well | Max. observed flow rate, B/D | Avg. Permeability from buildup (md) | Permeability-Thickness (Darcy-ft) | |
|---|---|---|---|---|
| | | | Buildup | Logs |
| public Geothermal | | | | |
| 38-30 | 50,300 | 84 | 41.7 | 44 |
| 16-29 | 31,400 | 42 | 34.7 | 30 |
| 18-28 | 15,600 | 82 | 6.3 | 14 |
| reau of Reclamation | | | | |
| 31-1 | 21,200 | 30 | 22.2 | N/A |

wrence Berkeley Laboratory Interference Results:

-30 and 31-1 pair: kh = 29.8 Darcy-ft

involving all six Republic wells has yet to be analyzed. This current effort involves a large amount of data which is still being digitized preparatory to computer aided analysis. However, an initial approximate "by hand" analysis generally confirms the earlier interpretations.

Static reservoir pressures are approximately hydrostatic plus 75± psig. For example, the static pressure in Well No. 38-30 at 6100 feet is 2576± psig. (The average hydrostatic gradient at 38-30 temperature conditions is 0.41 psi/ft; 6100 ft. x .041 psi/ft = 2501 psig; 2501 psig + 75 psig = 2576 psig). Because of the incremental 75± psig over hydrostatic, shut-in wellhead pressures are positive an equivalent amount. Artesian flow of the wells is thus possible even in the absence of steam flash.

In summary, it is important to note the good agreement between all three methods of measuring reservoir productive properties, as well as their correlation with maximum observed flow rates. This lends additional credibility to applying the permeability calculation results to the reservoir performance model and to the well performance predictions.

e. Production/Injection Experience

A summary of key well data and available initial production test data is given in Table 8. The three recently completed wells (Nos. 16-30, 56-30 and 78-30) have been flowed only a few hours to clean out drilling fluid. Preliminarily it can be stated that Well Nos. 56-30 and 78-30 perform as well as or better than Well No. 38-30, and Well No. 16-30 appears to be similar to Well

TABLE 8

EAST MESA WELL DATA

| Well | T.D. | Est. Temp. @ T.D. | Flowing Downhole Temp. (2) | Maximum Observed Flow Rate $lb_m$/hr | Maximum Observed Flow Rate $10^6$ BTU/day | Completion Date |
|---|---|---|---|---|---|---|
| 38-30 | 9009' | 387°F (1) | 338°F | 670,000 (3) | 5,000 | 10/75 |
| 16-29 | 7998' | 361°F | 332°F | 419,000 (3) | 3,060 | 12/75 |
| 18-28 | 8001' | 346°F | 310°F (est.) | 208,000 (3) | 1,400 | 1/76 |
| 16-30 | 8000' | 364°F (4) | N/A | N/A | N/A | 7/77 |
| 56-30 | 7520' | 352°F (4) | N/A | N/A | N/A | 6/77 |
| 78-30 | 7442' | 358°F (4) | N/A | N/A | N/A | 8/77 |

(1) Fill at 6910' (348°F)

(2) Above producing interval

(3) Liquid rate only. Vapor phase (12±%) not measured.

(4) Preliminary (non-equilabrated) measurements.

No. 16-29. Detailed data from recent long term tests of Well Nos. 38-30 and 16-29 are currently being tabulated and will be available in the near future.

The highest natural flow rate measured thus far was 670,000 $lb_m$/hr (760,000 $\pm$ $lb_m$/hr including steam flash) while flowing Well No. 38-30 directly into the storage basin. During the more recent long term testing, this well demonstrated a sustained natural flow capability of about 400,000 $lb_m$ /hr against 30$\pm$ psig backpressure with only a 200$\pm$ psi bottom-hole drawdown. Subsequently, the well was pumped continuously for more than thirty days using a line-shaft turbine pump set at 420+ feet. The maximum rate of about 475,000 $lb_m$/hr attained during pumping was limited due to the disposal system capacity.

Well No. 16-29 flowed to the basin at a maximum rate of 419,000 $lb_m$/hr (475,000$\pm$ $lb_m$/hr including steam flash). A sustained natural flow capability of about 335,000 $lb_m$/hr against 30 psig backpressure was achieved in the more recent tests. Continuous pressure/temperature profiles, observed during flow with experimental instruments from Denver Research Institute, suggest that cold water influx at the intermediate casing shoe may be occurring. This could have a substantial constraining influence on flow capability. Confirmation testing is underway, with remedial work planned if indicated, prior to resumption of long term testing.

Two high volume line-shaft turbine pumps designed for 1000$\pm$ foot setting depths are currently on order and should be ready for testing by May 1978. It is anticipated that the five producers for the 10 Mw plant (including Well Nos. 16-29, 56-30 and 16-30 already drilled) should be capable of 800,000 to 900,000 $lb_m$/hr each when equipped with such pumps. This will be an adequate supply for the plant which requires 4,300,000± $lb_m$/hr of 335°F water initially to generate 10 Mw. After integration with the planned 48 net Mw plant in early 1980, the efficiency of the 10 Mw plant will be nearly twice as great (i.e., about half as much feed water required) due to the addition of a second stage flash.

Well No. 18-28 was found to be on the flank of the thermal anomaly and it is too cold to be an economic producer. It was capable of only 208,000 $lb_m$/hr artesian flow and was ultimately converted to injection service. During the recent long term testing of Well Nos. 38-30 and 16-29, it was possible to inject about 300,000 $lb_m$/hr at 400 psig wellhead pressure on a sustained basis into Well No. 18-28. Initial plugging problems were overcome by acid treatment and installation of finer filters (10 μ rather than 50 μ) to prevent suspended $CaCO_3$ precipitates from entering the well bore.

Profile surveys showed that less than 200 feet of the 1800 feet of perforations open in Well No. 18-28 were actually taking fluid. Presumably this was due to an inability to flow the well at high enough rates to remove the initial drilling mud wallcake. Current plans are to plug back the well and jet perforate about 1200 feet of the proposed shallow injection zone. Long term testing of the producers will then resume.

It is anticipated that the three injectors for the 10 Mw plant (including Well No. 18-28) will be able to handle the residual 4,000,000 + $lb_m$/hr water at very low wellhead injection pressures due to the high permeability sands present in the 2,000± to 5000± foot injection zone.

4. Representative Injection Well Drilling Program

a. Zone of Completion

Injection wells will be completed in the Borrego Formation described in the geological section. The completion interval will be from approximately 2000 feet to 4500 feet (all depths referenced to Kelly Bushing), which averages approximately 52 feet above mean sea level.

b. Casing and Cementing Program

The casing program will be one of the following:

| | Depth | Program 1 | Program 2 |
|---|---|---|---|
| Conductor | 90' | 20" | 24" |
| Surface Casing | 2000' | 13-3/8" | 16" |
| Injection Liner | 4500' | 9-5/8" | 11-3/4" |

The two casing size programs are proposed since the injectivities are not yet adequately known. The larger program may be necessary to reach the necessary injection rates. Details of the two casing programs are presented in the attached table.

The wellheads will consist of a 13-3/8" S.O.W. x 12" - 400# RTJ Model SU casing head with two 2" flanged side outlets; two 12" - 600# ANSI series manual gate valves with 400# RF flanges; a 12" tee with 400# RTJ flanges; a 6" - 400# RTJ flanged crown valve and two 12" series 400# manual gate valves for the wing valves.

The surface casing will be cemented to the surface using API class "G" cement mixed 1:1

with Perlite plus 2% gel and 35% silica flour. The slurry density will be 95#/ft$^3$. A tail slurry of 200 sacks of class "G" cement with 35% silica flour with a density of 117#/ft$^3$ will be used for additional strength around the casing shoe. After waiting on cement for eight hours, the casing will be slacked off and the casing pressure tested to 100 psi for 30 minutes.

c. Mud Program

The mud program from surface to TD will be lightweight (8.8-9.2 PPG), low solids, fresh water, clay base drilling fluid treated with lignite for temperature stability, and bicarbonate of soda for cement combination. Desanders and desilters will be run in order to keep the solids as low as possible. A cooling tower will be installed in the mud system and the mud pumped through this cooling tower when the return mud temperature exceeds 160°F (71.1°C).

d. Safety Provisions

After setting surface casing, an API class 300 psi double hydraulic pipe and blind ram blowout preventer will be installed above a 12" gate valve with 400# RTJ flanges which will be just above the casing head. On those wells drilled with the large casing program, a single blind run will be installed instead of the 12" gate valve. The casing head will have two side outlets with two flanged valves on each outlet. One side will be connected to the rig choke manifold, the other side will be connected to a pumping unit as a kill line with a back pressure valve in the line for pumping into the well if necessary. A fill-up line will be installed above the BOP equipment so that the hole can be filled during trips, and the amount of fluid pumped into the well while tripping will be monitored.

The hydraulic control unit for the BOP equipment will have two operating stations, one on the rig floor and one at least 50 feet from the wellhead. At all times the mud flow line temperature and the mud pit level will be monitored. A pit level warning device will be installed. Gases in the mud return will be monitored. Special provisions for handling hydrogen sulfide have not been made since it has not been found in the exploration and delineation wells at the East Mesa KGRA.

The BOP equipment will be pressure tested to 1000 psi when installed and at least once every seven days thereafter. This will include testing of all drill string back pressure valves, full opening valves, standpipe and choke manifold.

A drill string back pressure valve along with a full opening safety valve will be maintained on the rig floor with adequate subs to fit all connections in the drill string.

Each drilling crew will be instructed in blowout control procedures and the contractor will be required to have at least one pit drill per crew per week.

In the event of an emergency, the drilling contractor will have the names and telephone number of the appropriate company personnel to notify. Please refer to Section E, Emergency Contingency Plan, of this Plan of Operation for more detailed emergency procedures.

5. Proposed Downhole and Surface Injection Equipment

No downhole injection equipment is proposed beyond that described in Section B-6 above.

The surface injection equipment will consist of pumps, various facilities for water treatment or clarification as required for maintaining adequate injectivity, and metering facilities located at the plant site with individual injection lines running along roadways to each injection well. It is proposed that a continuous record of total injection volume be kept with volumes for individual wells recorded daily.

The nominal capacity for the injection pumps will be approximately 360,000 barrels of water per day. The pipelines will be designed and tested at 1.5 times the normal expected operating pressure which at this time is expected to be 150 psig at the injection wellhead.

The injection lines will be installed on the surface with expansion loops placed as necessary to prevent mechanical damage to the pipe from thermal expansion.

6. Proposed Injection Well Surveys

Injection well surveys will be run routinely to detect major changes in injection profiles. Additional surveys will be run as needed, especially when significant changes occur in the injection rate or pressure. A routine survey will be run on each injector within one month of the beginning of injection and once annually thereafter. The most effective types of surveys for this purpose are the spinner survey, the radioactive tracer survey and the shut-in temperature/differential temperature survey. A selection of one of these will be made consistent with specific well conditions and with minimum disruption of field operations. The normal survey interval will be from the surface to the bottom of the deepest major injection interval.

7. Hydrology of the Area

a. Surface Water

Republic's East Mesa leases are devoid of any obvious stream channels. Surface water is presently confined within the one-half mile section of the East Highline Canal located in the extreme southwestern portion of Lease CA 966. The East Highline Canal flows northward and contains water diverted from the Colorado River via the All American Canal. Irrigated farmlands lie to the west of the Canal, covering almost all of the Imperial Valley. To the east of the Canal is the East Mesa, which is essentially desert with only a few dry washes active only after heavy rains (usually in the winter). All drainage is toward the Salton Sea.

b. Ground Water

The major source of shallow ground water at East Mesa is seepage from the All American, Coachella and East Highline Canals which enclose the mesa on the south, northeast and east, respectively. The major ground water gradient is downslope to the west-southwest, although seepage from the East Highline Canal has created a small localized ground water mound. According to the U. S. Bureau of Reclamation, the ground water level immediately underlying Republic's proposed area of operations has apparently undergone very little change since the installation of the canals.

The quality of the shallow ground water is generally equivalent to the anticipated water quality of the geothermal fluid that will be produced. In some areas, as at the USBR geothermal test site, the shallow ground water is in fact of lower quality than the geothermal fluid previously produced from Republic's East Mesa wells. Water produced from Republic's shallow water well has a salinity of 1600 mg/l, very similar to the geothermal fluid. In addition, Schlumberger electric logs run in all of Republic's wells indicate the presence of a shale aquaclude, generally at depths from 1000-2000 feet, separating the geothermal reservoir from the shallow ground water aquifers. Further evidence of this hydrologic separation is the lack of any surface manifestations (hot springs, fumeroles, alteration, etc.) of the underlying geothermal system and the existence of conductive heat flow to depths of approximately 2000 feet, as shown by the temperature profiles of all deep wells drilled in the East Mesa area. The underlying convective heat flow is indicative of vertical permeability, whereas conductive heat flow demonstrates a lack of vertical permeability.

Republic's injection plans call for reinjection of the spent fluids at 150-500 psi over and above static reservoir pressures into the reservoir between the depths of 2000 and 4500 ft. This pressure is well below the overburden pressure at 2000 feet, which is approximately 2000 psi. It is also below the expected vertical fracture pressure of 1600± psi. That pressure would have to be exceeded to allow injection fluids to penetrate the overlying sediments, including the shale aquiclude.

Based on the above data, Republic believes it can state there will be no effect of the spent fluid reinjection on the present shallow ground water system.

8. <u>Source of Water Supply and Road Building Material</u>

In accordance with Section 270.34, water for operations will be supplied by the previously approved well, WW-1, a shallow water well located in the northwest corner of Republic's East Mesa maintenance yard. Source of road building material for access roads is discussed in the Plan of Operation, Development.

9. <u>Additional Information</u>

Additional information regarding surface disturbance for injection and development operations can be found in Republic's Plan of Operation, Development submitted simultaneously with this plan.

The following, submitted by Republic Geothermal to the Area Geothermal Supervisor, are incorporated herein and made a part hereof by reference:

a. Plan of Operation, approved as effective September 12, 1975 (EA 12).

b. Supplemental Plan of Operation, approved as effective December 15, 1975 (EA 29).

c. Plan of Operation, approved as effective December 1, 1976 (EA 61).

d. Supplemental Plan of Operation, approved as effective September 16, 1977 (EA 81).

e. Amended Plan of Operation, submitted June 14, 1977 (EA 86).

f. Program for Collection of Environmental Baseline Data, Federal Geothermal Leases CA 966, CA 967 and CA 1903, submitted August 3, 1977.

C. ENVIRONMENTAL PROTECTION

The following measures will be taken for protection of the environment:

1. Fire

a. All local, state and federal fire protection standards applicable to Republic's activities will be observed.

b. Vegetation on the lease is sparse and low-level. It will be cleared only to the extent needed for proper operation. Smoking will be allowed only in designated areas.

c. Water and fire extinguishers will be available at each site during drilling activities and at a central location during testing and production activities in the unlikely event a fire should occur.

2. Soil Erosion

Due to the essentially level topography at East Mesa, the infrequent rainfall and the lack of surface water, soil erosion is not anticipated to be a problem. The proposed injection operations do not entail activities which would have effect on soil erosion. Potential soil erosion resulting from operations which disturb the surface has been fully discussed in Republic's Plan of Operation, Development.

3. Pollution of the Surface and Ground Water

a. Surface Water

Surface waters within Republic's East Mesa leasehold are limited to one very short section of the East Highline Canal in the extreme southwestern corner of Lease No. CA 966. The remainder of the area is devoid of easily recognizable stream channels.

The low salinity of the geothermal fluids produced from Republic's East Mesa wells, lease stipulations which restrict drilling within one-quarter mile of the canal, and the distance to the nearest well proposed under this Plan of Operation from the canal all indicate that the proposed development will have no deleterious effect on the quality of water in the East Highline Canal.

b. Ground Water

There are no natural ground water sources such as springs or seeps within Republic's East Mesa leases. The California Regional Water Quality Control Board considers the ground water in the vicinity of Republic's leases saline and not beneficially used.

All of Republic's previously approved Plans of Operation on East Mesa have been conducted under approved Orders No. 76-35 and No. 76-64 (Revised) of the California Regional Water Quality Control Board, Colorado River Basin Region. These Orders have been previously submitted to the USGS-AGS.

The Board has determined that Republic's discharge of geothermal fluids into unlined temporary storage basins is acceptable for fluids of less than 2300 mg/l. They have approved the discharge of geothermal fluids onto roads and well sites in an amount not to exceed 126,000 gallons per day or 232 acre-feet for the life of the project. This Order also permits the disposal of geothermal waste fluids by subsurface injection into the zone of extraction or into zones which contain a total dissolved solids content that is equal to or greater than that contained in the zone of extraction.

Republic shall also protect the area's ground water by using well drilling and casing programs in compliance with the provisions of

GRO Order No. 2 or exceptions to this Order as approved by the Area Geothermal Supervisor for East Mesa and the conditions of approval for Republic's Plan of Operation, Injection.

For more detailed information on the effects of reinjection on the shallow ground water system in the vicinity, please refer to Section B.7, Hydrology, of this Plan.

4. <u>Fish and Wildlife</u>

a. There are no fish in the area.

b. Potential habitat degradation resulting from construction of the injection well location and attendant surface facilities has been discussed in Republic's Plan of Operation, Development. The proposed injection operations will not disturb additional habitat beyond that discussed in the above referenced Plan.

5. <u>Air and Noise Pollution</u>

a. Air

Air quality should not be affected by the proposed injection operations, since injection does not involve emissions to the atmosphere. Effects of drilling and testing on air quality is discussed in the Plan of Operation, Development. Republic will conduct all operations with the approval of the Imperial County Air Pollution Control District.

Dust from cleared roads used for vehicles necessary to injection operations will be suppressed by distribution of geothermal fluids on these areas, as evaluated and approved by the California Regional Water Quality Control Board.

b. Noise

Noise resulting from injection operations at

East Mesa is expected to be of minor concern. The main source of noise during injection testing will be a pump located at the well site. During production an injection pump will be located at the plant site. Noise levels will be maintained within the limits prescribed by the County of Imperial, the Bureau of Land Management and the Occupational Safety and Health Administration.

Noise impacts on wildlife at East Mesa will probably be minimal because of the relatively low intensity and steady, continuous nature of most of these noise emissions. The East Mesa area itself is also very isolated from any human receptors. The extant ambient noise levels on East Mesa are usually very low, but are frequently punctuated by the sounds of aircraft overflights and explosions from the nearby military gunnery range. Occasional off-road vehicle use of the area also adds to the ambient noise levels.

6. <u>Hazards to Public Health and Safety</u>

Public health and safety shall be ensured through the use of appropriate equipment, operating procedures and notices. Supervisory personnel will be on site during testing and production activities. All equipment will be secured within a maintenance yard encircled by a chain-link fence when not in use. During testing activities the location pad will be surrounded by a locked chain-link fence. During production the wells will be chained and locked behind a chain-link enclosure and all other necessary injection equipment will be located at the power plant site.

7. <u>Section 270.34, (i) and (j)</u>

a. Methods for Disposal of Waste Materials

Portable chemical sanitary facilities will be used by personnel during testing. These will be maintained and the wastes disposed of by a local contractor. Permanent sanitary facilities will be located at the power plant site after construction is complete.

b. Delineation of Potential Environmental Impacts

Republic anticipates that there should be only negligible environmental impacts from these proposed operations over and above those from existing approved operations.

c. Environmental Monitoring and Any Additional Information

Geothermal fluids will be monitored in accordance with the requirements of Order No. 76-64(Revised) of the California Regional Water Quality Control Board, Colorado River Basin Region.

Noncondensable gases will be monitored in accordance with the requirements of the Imperial County Air Pollution Control District.

Republic has submitted to the Supervisor a Program for Collection of Environmental Baseline Date for Federal Geothermal Leases CA 966, CA 967 and CA 1903 at East Mesa, in accordance with 270.34 (k).

Republic is prepared to submit, upon notification to do so, any further information not included herein which the Supervisor may require. Republic is also prepared to carry out provisions for monitoring deemed necessary by the Supervisor to ensure compliance with the regulations and to participate in the collection of data concerning the existing air and water quality, noise, seismic and land subsidence activities, and ecological systems in the vicinity of the site.

d. Approximate Crew Size, Probable Type and Location of Housing and Support Facilities

Approximately twelve to fifteen people may be working on the location during injection activities, although during normal operations, the number will be considerably less. No housing or special support facilities will be required on-site during these operations due to proximity of existing facilities.

## D. DISCUSSION OF ADDITIONAL ENVIRONMENTAL CONCERNS

### 1. Seismicity

The Imperial Valley has long been known as a region of high natural seismicity. This has led the USGS to establish an extensive seismographic network in the valley both to detect seismic events and to determine their epicenters. The Imperial Valley Environmental Project (IVEP) has added to this network near the Salton Sea geothermal field. They are also in the process of detonating a number of calibration explosions within the valley in an attempt to reduce the ambiguity of the focal depth determinations. On East Mesa, the Bureau of Reclamation (USBR) is maintaining an independent network of six seismographic stations designed to detect microseismic activity. Republic believes that the existing seismographic networks are at present more than adequate to monitor seismic activity for the level of development on East Mesa.

Increased fluid pressure within a fluid-filled reservoir is associated with reduced frictional resistence along fracture planes and has occasionally resulted in increased seismic activity. However, Republic intends to employ a low pressure injection system which, together with the permeable sediments of the injection zone, mitigates the unlikely possibility of induced seismicity. If analyses of data from USBR stations indicate that induced seismicity is attributable to Republic's injection operations, Republic will cooperate with the Supervisor in taking any appropriate actions.

### 2. Subsidence

The possibility of localized subsidence induced by withdrawal of geothermal fluids is recognized, although no actual case history of subsidence due to geothermal development is documented. After careful review of all existing subsidence prediction models, Lawrence Berkeley Laboratory (LBL) determined that none of the currently available models could adequately predict the magnitude or location of subsidence induced by the extraction of geothermal fluids. Because Republic plans peripheral injection of all the waste geothermal fluid, only a slight decrease in the reservoir pressure is expected; thus, surface subsidence should be minimal.

The dual flash power cycle to be used by Republic at East Mesa will employ steam condensate for cooling water which will be cooled in forced draft towers. Evaporative losses are expected to be approximately 10 percent by volume of the produced geothermal fluid. It is expected that influx from the very large surrounding aquifer will be adequate to make up for this small deficiency. Therefore, reservoir pressure depletion and possible resulting subsidence are expected to be negligible. Since no adequate theoretical models exist to make a quantitative prediction, empirical observations must be relied upon.

Further, because East Mesa is not within a developed agricultural portion of the Imperial Valley, there are no irrigation canals or tile drains in the immediate vicinity to be disrupted should subsidence occur. Similarly, no significant detrimental effects on the existing desert environment are anticipated should localized subsidence occur.

Republic's Program for Collection of Environmental Baseline Data, East Mesa, has already been submitted to the Area Geothermal Supervisor. It contains a thorough description of the existing subsidence monitoring network in the area and describes Republic's efforts to improve the network at all well sites. Should significant surface subsidence occur as a result of development of the geothermal resource, Republic will take the necessary actions to remedy the problem.

## E. EMERGENCY CONTINGENCY PLAN

If any emergency develops or is determined to be impending, appropriate control procedures will be initiated. The specific procedures will vary greatly depending on the nature of the problem. Examples of possible emergencies are: a well control problem (well blowing steam, hot water or other well effluent with loss of means to shut in or divert the flow); a spill of geothermal fluid; fire; accidents or injuries; etc. The following measures will be taken:

1. If any injuries have occurred, arrangements will be made to care for the injured party(ies).

   Chalfont Service Corporation
   496 W. Euclid Road
   El Centro, California 92243
   (714) 352-2711

   First aid supplies will be available at the drillsite during drilling operations as well as at the power plant site during all other operations. At least one person on each crew will be trained in first aid. In addition, copies of Republic's comprehensive booklet, "Safety Begins With You: A Handbook of Safe Industrial Practices and Fundamental First Aid Techniques" will be available at the drillsite and/or plant site.

2. If there is a threat to local residents, the Sheriff will be notified as soon as possible.

   Imperial County Sheriff's Department
   150 S. 9th
   El Centro, California 92243
   (714) 352-3111

3. The Field Production Superintendent will be notified and consulted immediately.

   Carl E. Fisher
   El Centro, California 92243
   (714) 352-4434, Unit 4176
   Home: (714) 353-4434

4. The Vice President, Production, will be advised and consulted as soon as practicable.

Dr. James Barkman
Vice President, Production
11823 E. Slauson, Suite One
Santa Fe Springs, California 90670
(213) 945-3661

5. Field supervisory personnel will contact the Staff Drilling Engineer or Senior Facilities Engineer and consult with him as to any further or supplemental steps which may be necessary or advisable.

Dr. Robert Nicholson
Staff Drilling Engineer
11823 E. Slauson, Suite One
Santa Fe Springs, California 90670
(213) 945-3661

Michael J. Walker
Sr. Facilities Engineer
11823 E. Slauson, Suite One
Santa Fe Springs, California 90670
(213) 945-3661

6. The Vice President, Land, will be advised and consulted as soon as practicable. He may consult with Republic's environmental staff.

Timothy M. Evans
Vice President, Land
11823 E. Slauson, Suite One
Santa Fe Springs, California 90670
(213) 945-3661

7. All prescribed safety practices and procedures will be followed. All members of the drilling, well testing, construction or field operations crews will perform duties assigned for the specific purpose, following specified safety practices and procedures.

8. Every effort will be made to minimize possible deleterious environmental effects of the emergency and the operations performed to control the emergency.

9. A pump truck will be in the vicinity, and earth moving equipment may be obtained from local contractors, if necessary.

Henry Abeyta
360 W. El Dorado Road
El Centro, California
(714) 3522545

Ryerson Ditch-Liners
50 East Highway 80
El Centro, California
(714) 352-4341

Merrill Ditch-Liners, Inc.
51 East Highway 80
El Centro, California
(714) 353-0193

10. The Staff Drilling Engineer or Senior Facilities Engineer will:

(a) Brief his immediate supervisor (Vice President, Production) on the situation and course of action underway.

Dr. James Barkman
Vice President, Production
11823 E. Slauson, Suite One
Santa Fe Springs, California 90670
(213) 945-3661

(b) Contact the following agencies or regulatory bodies as soon as practicable and in the following order:

U. S. Geological Survey
Conservation Division
Western Region
345 Middlefield Road
Menlo Park, California 94025
(415) 323-8111, Ext. 2845

Bureau of Land Management
1695 Spruce
Riverside, California 92507
(714) 787-1462

(c) If the emergency involves a well control problem or other well operations, he will also notify the following agency:

Department of Conservation
State of California
Division of Oil and Gas
Geothermal Unit
1416 Ninth Street
Sacramento, California 95814
(916) 445-9686

11. The Vice President, Land, or Republic's environmental personnel will notify as soon as possible the following additional state and local agencies:

California Regional Water Quality Control Board
Colorado River Basin Region
73-271 Highway 111
Suite 21
Palm Desert, California 92260
(714) 346-7491

Imperial County Air Pollution Control District
935 Broadway
El Centro, California 92243
(714) 352-3610

Imperial County Planning Department
Courthouse
El Centro, California 92243
(714) 352-8184

Resources Agency
State of California
Department of Fish and Game
Region No. 5
350 Golden Shore
Long Beach, California 90802
(213) 435-7741

U. S. Fish and Wildlife Service
2800 Cottage Way
Sacramento, California 95825
(916) 484-4657