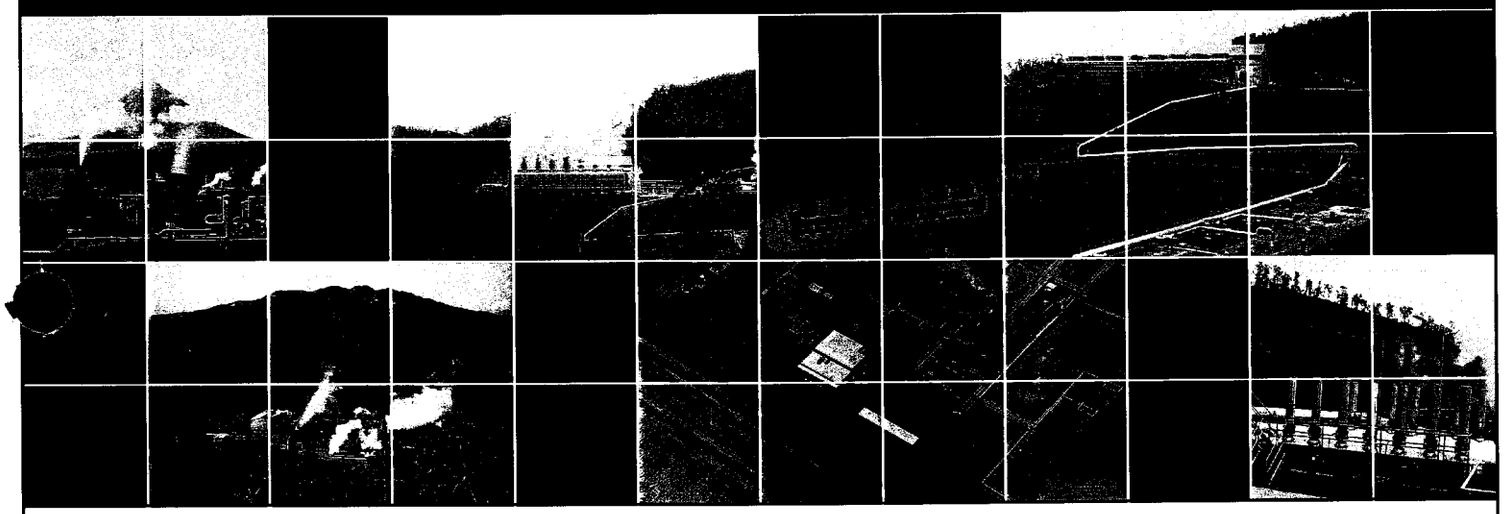

Feasibility Study Report for the Germencik Geothermal Power Plant

Submitted by

Shaw® Stone & Webster International, Inc.

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SUBMITTAL LETTER

gürmat

ELEKTRİK ÜRETİM A.Ş.

Ankara,26 August 2005
GU-DIG-098

U.S. Trade and Development Agency
1000 Wilson Blvd, Suite 1600
Arlington, VA 22209-3901

Attention : Ms.Marian Bassett
Subject : USTDA Grant Feasibility Study for Germencik Geothermal Project, Aydın Province, Turkey

Reference:

Appropriation No.:	**113/41001**
Activity No.	**2004-80036B**
Reservation No.	**04836414**
Grant No.	**GH04836414**

Dear Ms.Bassett,
With reference to the USTDA Grant Ageement No. GH04836414 for the Feasibility Study for the Germencik Geothermal Power Plant, we would like to inform you that together with Stone and Webster International,Inc. we have completed the study and the report.

We hereby confirm that we approved the Feasibility Study Report for the Germencik Geothermal Power Plant which was prepared by Stone and Webster International,Inc. and will soon be submitted to you.

We would like to present our gratitute to USTDA for sharing its financial, technical and administrative support during the development of this project.

Thank you for your kind interest.

We, of course, remain at your disposal to provide any further information necessary.

Sincerely Yours,

Ali KARADUMAN
General Manager

C.C.MS.JENNIFER SNYDER Fax : 0 312 466 6082
MRMC CO 3037417670

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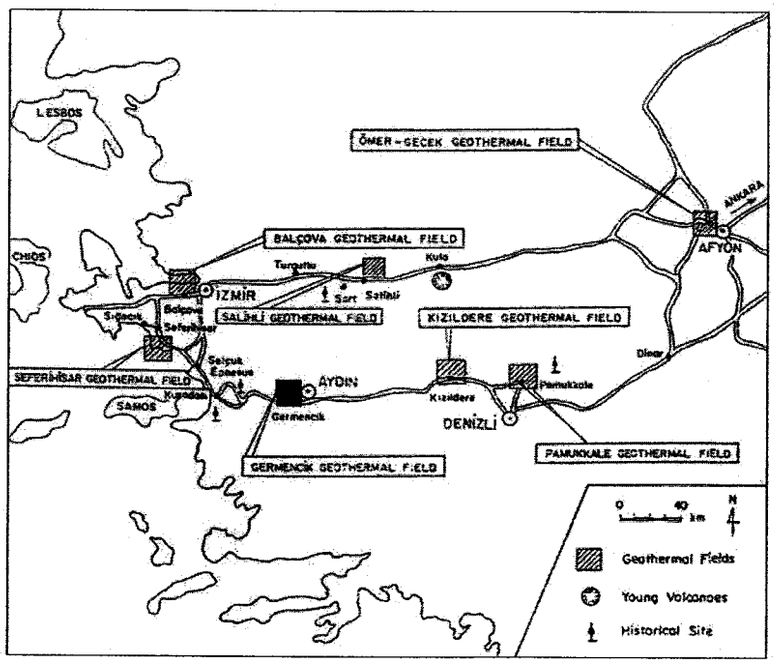
GÜRİŞ KURULUŞUDUR

EXECUTIVE SUMMARY

The following report details the Feasibility Study for a 25.2 MW geothermal power plant in Aydin Province, Turkey. The study was conducted by Stone & Webster International, Inc. of Denver, Colorado and its subcontractors Geologica and Veizades and Associates of San Francisco, California and Global Power Solutions of Evergreen, Colorado. This work was supported by a grant from U. S. Trade and Development Agency. The in-country sponsoring Client is Gurmat Uretrim A.S. of Ankara, Turkey.

In the early 1960s the Mineral Investigation Research General Administration (MTA) began investigations into the exploitation of geothermal energy in Turkey. The first economic geothermal area was explored in 1968 in the Denizli-Kizildere region of southeastern Turkey (See Figure 2-1). A power plant was constructed by Turkiye Elektrik Kurumu (TEK) in this region and began operations in February, 1984.

Figure 2-1 Aydin – Denizli Geothermal Fields



The Germencik geothermal field is located at the west end of the Byuku Menderes Graben extending in the east-west directions approximately 50 km from the Aegean Sea in West Anatolia province of Turkey.

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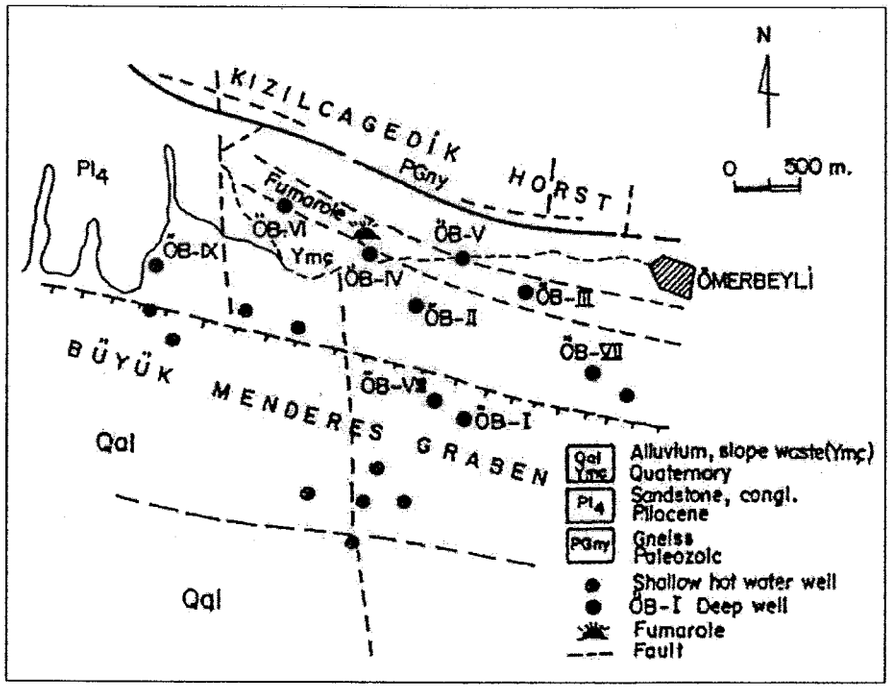
Subsequently, between 1983 and 1986, seven more geothermal wells (OB-3 through OB-9) were drilled in order to determine the layout of the reservoirs and their characteristics. The tests and studies conducted show that the geothermal fluid available is suitable for power generation. The location of the Kizildere and Germencik geothermal fields and the nine geothermal wells that were drilled in the Germencik geothermal field are shown on Figures 2-1 and 2-2 respectively.

Figure 2-2 Location of Existing Wells, Germencik Geothermal Field



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life of the project. The limits of the resource are still undefined. At a minimum, there is sufficient acreage for additional make-up wells as the resource declines during production and exploration. In addition, further testing is expected to identify additional resource capacity to sustain more than the initial planned power generation. Sufficient geothermal fluid can be supplied by two existing and two newly drilled wells and the injection capacity for accepting waste brine can be provided by one existing and three additional wells. Critical development issues that have plagued other Turkish geothermal projects such as scaling and brine injection can be addressed with standard geothermal industry technologies.

Reservoir Characteristics

The primary permeability of the Germencik geothermal resource occurs in fractured metamorphic rocks of Menderes Massif. Permeability is present in fractures related to the steeply dipping splays of the Omerbeyli fault along the range front of the Kizilcagedik Horst. Although there is a range of permeability (permeability-thickness indexes in the range of 18,750 to 41,250 millidarcy-feet OB-8 and OB-9, and 322,400 for OB-6),within the field, the permeability is very high in the vicinity of OB-6 possibly as a result of fault interactions or splays of the Omerbeyli fault. Low to moderate permeabilities occur elsewhere in the field. Vertical fluid flow may be limited to steeply dipping graben faults while lateral flow may occur along older thrust shear zones or contacts between metamorphic units.

Static reservoir pressures are over 100 barg at 1000 m and static reservoir temperatures are approximately 220°C, within an isothermal zone several hundred meters thick. Existing wells have identified a reservoir volume of at least 6.4×10^9 m^3 based on temperature, but the margins of the field have not been defined and additional exploration may identify additional resource capacity beyond the current assumed limits of the Germencik Geothermal Field. Although the first production zone of the reservoir is typically approximately 800 meters below the surface, a central upflow zone and very shallow high temperatures occur around OB-4. The estimates of the maximum depth of the resource are limited by existing drilling to 2000 meters. Temperature reversals below 1300 meters in outlying wells may establish the western edge of the field. Based on a Monte Carlo simulation and using known and interpreted temperature distributions, there is a 90% probability that the resource potential is greater than 34.1 MW gross for a 40 year project period and a 50% probability that the resource potential is greater than 72.6 MW gross for a 40 year project period.

Geothermal Fluid Chemistry

Preliminary indications of reservoir chemistry from field measurements suggest that the Germencik reservoir fluids have a relatively high gas content around 1 ½ % by weight and moderate salt content of approximately 5,000 mg/kg based on brine conductivity measurements. Evaluation of laboratory results indicates that Germencik reservoir chemistry is typical for a robust liquid-dominated geothermal field at temperatures

approximately 210 to 220°C in equilibrium with calcite and quartz. Brine chemistry is fairly benign and with appropriate phase separation, brine carryover is unlikely to create problems with steam purity or corrosion.

Non-condensable gas pressures make up over half of the total reservoir pressure and gas concentrations in the Germencik reservoir of approximately 1.6 weight percent are higher than most geothermal fields but are not singularly unique. Carbon dioxide is the predominant non-condensable gas is with trace amounts of hydrogen sulfide and other gases. Almost all of the non-condensable gas will partition into the high pressure steam which will have approximately 14.8% by weight non-condensable gas which is 99.8% carbon dioxide and 263 parts per million by weight hydrogen sulfide. Low pressure steam will have approximately 0.14 % non-condensable gas by weight which is almost all carbon dioxide. Rising geothermal fluids in the Germencik reservoir become two phase deeper than most geothermal fluids of equal temperature. The depth of top of the reservoir at which the temperature gradient changes from conductive to convective coincides with the gas-corrected boiling point to depth curve suggesting that boiling-related mineralization may seal the top of the reservoir.

Calcite scale mitigation will be required below the depth of boiling in production wells because the produced fluids will become saturated with calcite initiating precipitation. Long term development strategy includes minimizing boiling (and calcite deposition) in the reservoir and down-hole injection of scale inhibitors. Silica scaling is unlikely to require a separate mitigation system, but some additional injection of inhibitors may be required prior to injection.

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Recent production tests confirmed the productive capacity of the field and the commercial viability of three existing wells: OB-6, OB-8 and OB-9. Earlier tests in the 1980's proved commercial productivity ranging from 125 t/hr to 455 t/hr of total mass flow. Three recently tested wells, OB-3, OB-5, and OB-7 are either marginally commercial or non-commercial because of low permeability or mechanical problems

with each wellbore, although OB-3 may be a useful after remediation (scale removal) for condensate-cooling tower blowdown disposal. Based on recent test results, downhole productivity indices vary between 9.9 (at OB-8) and 145.8 (at OB-6) t/hr/bar for the existing commercial wells The average enthalpy of OB-6 and OB-9 is 890 kJ/kg and these existing wells are proposed as production wells for the current development. ,

Production (1864 t/hr at 901 kJ/kg) and brine injection requirements (1492 t/hr at 105°C and 35.5 barsg) based on power plant heat balance calculations combined with known reservoir characteristics suggest that the optimal development strategy for Germencik includes extracting primary production from the northwest part of the field, around wells OB-6 and OB-9 and injecting brine into the area around OB-8 and OB-7. The resource is capable of supplying geothermal fluids for the planned project using two existing wells (OB-6 and OB-9) and two additional wells (OB-6A and OB-10) with larger diameter configurations. One will be drilled near OB-6 (OB-6A) and one (OB-10) will be drilled from a new pad near the proposed power plant.

Wellbore flow simulations indicate that the existing and planned new wells will be able to supply the required 1864 t/hr of brine at 20 to 25 kg/cm^{2}g flowing wellhead pressure. Initially, wells will be throttled and, as the reservoir declines, wellhead valves will be opened to increase flow. The throttled flow represents the additional capacity required for start-up. Well OB-6 exhibits choked flow at higher flow rates and based on wellbore simulations, the maximum production rate is limited by the size of its wellbore. Larger diameter wells would be more productive. Consequently, new production wells are planned with larger diameter casing.

The reservoir is capable of receiving waste brine by subsurface injection using one existing well (OB-8) and approximately three additional appropriately designed and located injection wells. The optimal number of wells requires a balance between the competing parameters of injection pressure, wellbore configuration and drilling costs. Using an injection pressure of 35.5 barg, approximately three new large diameter wells will be required. Assuming an approximate industry average of 4% decline, wellhead pressures will reach a minimum of 10 kg/cm^{2}g after approximately eight years of production. One new well will be required at that time and an additional well will be required approximately every seven years afterwards. Approximately five addition production wells may be required to maintain geothermal fluid supply to the plant over the life of the project.

Wellfield Development Cost Estimate

Large diameter wells are the optimum production and injection configuration based on an iteration of wellbore productivity, injectivity and well costs relative to casing size. Estimated costs for wellfield development are approximately $17.7 million US dollars with average annual resource operation and maintenance of approximately $1.0 million US dollars. The cost of well drilling is the primary wellfield development cost, and drilling costs have increased dramatically in the last few years (approximately 25% in the

last year). As the oil and steel markets stabilize and more drilling rigs are made available to satisfy the demand, these costs may level off. Additional drilling engineering will allow for competitive drilling bids, procuring expendable materials at reasonable costs and refining drilling budgets.

Gurmat Electric Uretrim A.S. has a corporate commitment to the development of the resource for the generation of electricity. Gurmat currently has an Energy Sales Agreement (ESA) with TEAS and a Contract with MTA for the use of the wells. These arrangements have been carried out in accordance with the legislation of the Turkish Energy Market Regulatory Board – Enerji Piyasasi Duzenleme Kurulu (EPDK).

Gathering System

The resource gathering system addresses the transportation of geothermal brine to flash tanks and polishing separators located close to the power generating facilities. The main consideration in transporting hot two-phase brine is pipeline flexibility. This is achieved by using the topographical features of the area and by offsets in the piping alignment such as expansion loops. In addition to the pipelines, the gathering system scope will include new well pads, improvements to existing well pads, a river crossing of the Alangullu River, improved access roads, some new access roads, new steam separation equipment and the attendant electrical and control systems for the wells.

Injection System

After steam energy is released by the brine, the excess brine draining from the low pressure separator will be transported to injection wells where it will be injected into the resource. This provides several advantages including replenishment of the fluid to the resource as well as avoiding the environmental problems encountered in releasing the brine above ground either to the river or elsewhere. Cooling tower overflow will be injected at a separate well.

Pipelines

Two-phase flow lines generally perform well when installed level or run downslope. For upsloping flow lines, the velocities must be controlled to avoid flow conditions that would generate either slug flow or wavy flow. It is desirable to size two-phase pipes so that the two-phase flow falls either under annular or dispersed regimes. Changes in vertical alignment should be gradual and as minimal as possible. The total two-phase pressure drop is comprised of friction, gravitation, and acceleration components. The frictional pressure drop is generally the primary contributor to the total pressure drop, particularly in relatively flat terrain. The pressure drops attributed to gravitation and acceleration may be generally neglected without introducing large errors.

Based on power plant requirements for the generation of 25.2 MW net, the steam flows at both the high pressure and low pressure dictated pipeline sizing to maintain a reasonable pressure drop in the pipeline. Line loss pressure drop was limited to less than 1 bar (~15 psi) between the turbine inlet and the furthest well head.

Flash Vessels and Separators

Flash vessel and separator flow sizing for this evaluation is based on mass flow. The preliminary design for flash vessels and polishing separators was performed utilizing the separator inlet pressure, steam flow, brine outlet flow, and pressure drop through the vessel. A 0.14 bar pressure drop was assumed to size the separators. All design parameters were based on flow data inputted in to VAI's pressure drop analysis from the PFD provided by Stone & Webster.

Steam Release Facilities

The steam release facility in a geothermal plant is required for start-up and for venting during turbine trips. In addition it takes the discharge from rupture disks during over-pressure relief of piping and pressure vessels such as separators. The steam release facility at Germencik will consists of a single-cell rock muffler with 100% vent capacity that is expected to be a 6.1m x 4.9m rectangular structure.

The rock muffler works on the basis concept of subjecting the vented steam to a tortuous path through hard durable volcanic angular rock. The steam follows the path of least resistance and is forced to enter and exit the rock fill by partial plugs installed in the expanded metal flow cylinders. Depending on the design capacity, the steam passes through the rock fill between 3 and 5 times. Each path reduces the potential energy of the steam and the rock absorbers and deadens the sound.

Gathering System Cost Estimate

The cost of the gathering system is anticipated to be approximately $14 million US dollars with average annual operation and maintenance cost of approximately $0.5 million US dollars.

Power Plant

The team selected a double flash unit for this project as we considered this to be the best balance between cost and efficient performance. This is the most common arrangement used in the industry for a liquid dominated resource at the demonstrated temperature and pressure. In addition we decided on a top discharge turbine with the condenser mounted beside the turbine. For a unit of this size this is a practical approach which avoids having to build an expensive turbine pedestal. Three manufacturers have provided quotations for the turbine and all have experience with turbines of this general design.

The resource at Germencik is very similar to the resource at Kizildere, a neighboring geothermal plant. The resource is very low in dissolved salts but high in non-condensable gases. Large quantities of non-condensable gases, particularly CO_2, will flash off the brine with the high pressure steam. This gas will be carried through the turbine into the condenser and will be removed from the condenser by a combination of steam jet ejectors and vacuum pumps. These will send the gases to the cooling tower where they will be disbursed in the atmosphere with the cooling tower vapor. Because of the quantity of gas to be handled, the ejectors and vacuum pumps will be large and expensive. Ultimately, the best way to handle the gas would be to send it to a gas bottling plant. This however is in the future.

After the high pressure steam has been flashed from the brine, the residual brine will be taken to a low pressure flash tank to remove additional energy in the form of low pressure steam for the turbine. After both low and high pressure steam have been flashed, there is still an appreciable amount of thermal energy left in the brine. This energy may be used in the future to provide heat to a greenhouse or other user. With the present design, the brine will be taken to injection wells for injection into the resource.

The additional innovative use of non-condensable gas and thermal energy described above could provide additional revenue streams for the Owner in the future.

The equipment for the power plant is all readily available on the market and there are no special requirements. Materials will be standard with no exotic alloys required. Stainless steel will be used in some applications but nothing more exotic such as Hastelloy or Inconel which are required in some liquid dominated applications.

Three manufacturers were requested to furnish bids on the turbine-generator, Fuji, Toshiba and Ansaldo. All replied with reasonable proposals. Pricing and delivery was approximately the same for all three. For simplicity we have chosen to present data and information based on the Fuji submittal. The schedule for delivering the Turbine-Generator appears to be a bit long however, we believe we can negotiate a better delivery once the project is authorized. In addition we suggest that a source of funding be identified early which would support a program to negotiate for the turbine supply and allow the selected turbine manufacturer to proceed with their engineering as soon as possible. The turbine supplier may be willing to do a limited amount of work at his own risk.

As has been stated as conclusions in the resource and gathering system sections of this report, we believe that the resource is well suited to development for the generation of electrical energy. Long term testing will be required to provide the information necessary to determine the maximum available energy from the resource and to define the resource boundaries. These tests are planned to begin in late 2005. There are no apparent insurmountable obstacles to transporting the brine from the wells to the plant site for separation.

The need for new wells, both production and injection has been discussed elsewhere. Again we see no apparent obstacles to extracting the energy necessary for providing the power plant with steam for the generation of 33 MW gross which will be required to produce 25.2 MW net.

Geotechnical

Borings were taken at three potential sites for the power plant. Our assessment of the available subsurface data indicates that the soils at two of the sites are suitable for a shallow foundation scheme. Both sites should provide reasonable bearing capacity, level topography, and deep ground water levels. These factors will enhance the excavation and construction process. The third site area appears to be less favorable for a shallow foundation scheme due to the looser soil conditions and correspondingly lower allowable bearing capacity. Additionally, excessive settlement resulting from soil densification during earthquake is possible in the vicinity of this site. Deep foundations or soil improvement measures would be necessary to reduce settlements and increase bearing capacity in this area. This area is also located adjacent to an area of steeper terrain, where slope instability and areas of slope incision due to surface run-off were observed during the December 14, 2004 site visit. These factors also make this area a less desirable site.

Soil liquefaction due to the assumed earthquake conditions appears unlikely at all the investigated areas based on a preliminary assessment of the available data. Installation of monitoring wells is recommended at the selected site in order to confirm the seasonal water levels. Higher water levels could contribute to the liquefaction potential in zones that are currently assumed to be non-liquefiable.

The measured temperatures of the groundwater in the borings range from 40.8 to 52.6 C°. Though these temperatures are somewhat elevated, the temperatures and groundwater levels would not contribute to near surface boiling conditions. Temperature wells should be constructed in the existing borings. It is recommended that temperature measurements continue be taken periodically at various elevations to confirm the thermal profile.

Additional borings will be necessary for the selected site in order to refine the geotechnical design criteria for the design stage. The borings should be adequately spaced to define vertical and lateral changes in the soil profile, particularly at key structures. Care should be taken to ensure that the drilling observations record layers of gravel that may bias the recorded N values and result in artificially high N values and un-conservative soil parameters. Estimates of the fine content in accordance with the Unified Soil Classification System are also strongly recommended in order to better define liquefaction resistance. Laboratory testing of site soils are also necessary during the design investigation stage to determine gradation and compaction characteristics, index properties, and the chemical constituents of the soil and groundwater.

Overall

Information which has been gathered evaluated to date indicates that the hot brine resource can supply the energy necessary to produce the 33 MW gross, 25.2 MW net, for this project. No unusual obstacles are anticipated in transporting the brine to the power plant where steam separation will occur. The design of the power plant is based on existing Stone & Webster designs which have been in successful operation for several years.

The Germencik geothermal project will provide many socio-economic benefits to the country, the region, and local towns. The benefits include development of new infrastructure, employment, technology transfer, environmental, economic, and perhaps food production.

The project will provide a source of clean, reliable, economical, indigenous electric power. It will reduce the country's reliance on foreign oil and gas for power generation, and in so doing, should help Turkey's balance of trade and their currency value.

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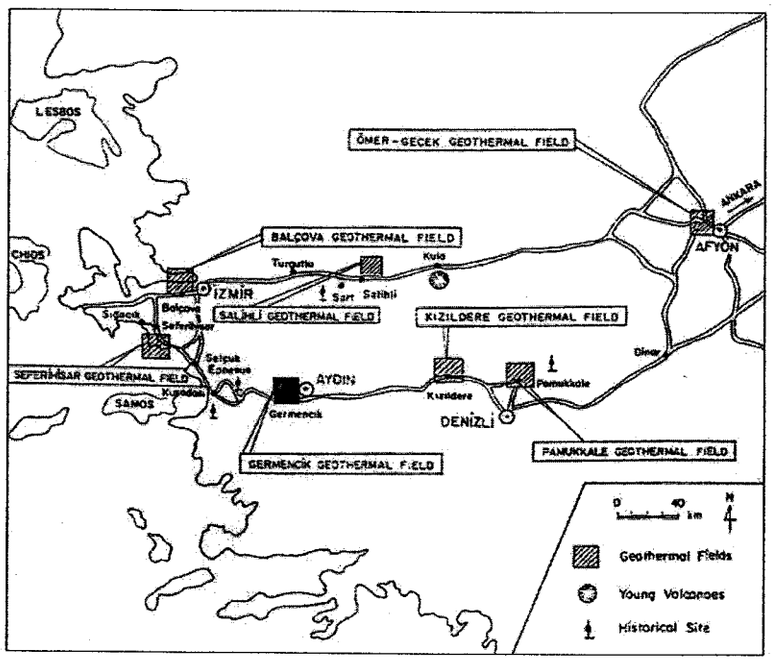

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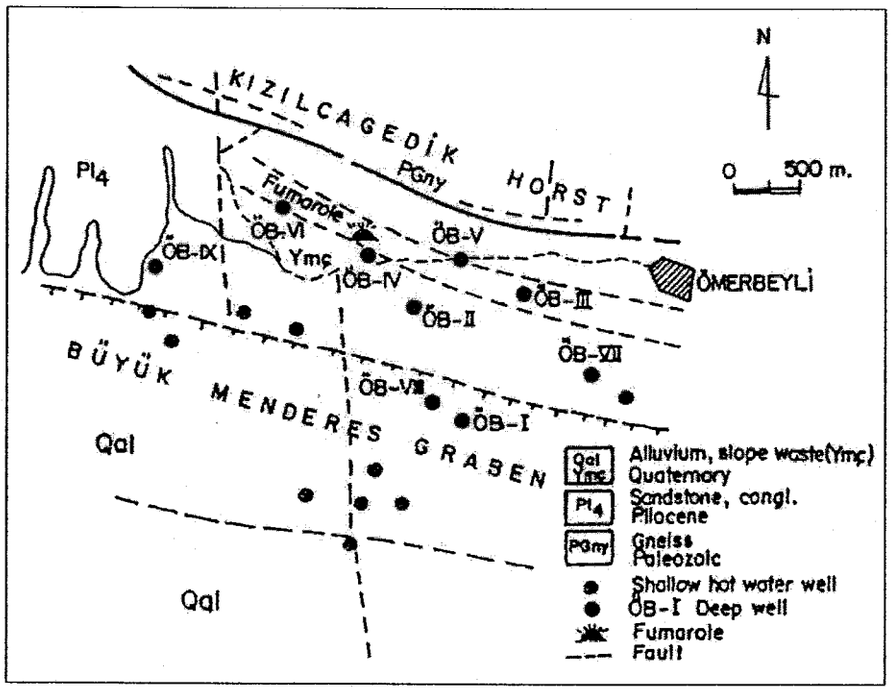

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Recent production tests confirmed the productive capacity of the field and the commercial viability of three existing wells: OB-6, OB-8 and OB-9. Earlier tests in the 1980's proved commercial productivity ranging from 125 t/hr to 455 t/hr of total mass flow. Three recently tested wells, OB-3, OB-5, and OB-7 are either marginally commercial or non-commercial because of low permeability or mechanical problems

with each wellbore, although OB-3 may be a useful after remediation (scale removal) for condensate-cooling tower blowdown disposal. Based on recent test results, downhole productivity indices vary between 9.9 (at OB-8) and 145.8 (at OB-6) t/hr/bar for the existing commercial wells The average enthalpy of OB-6 and OB-9 is 890 kJ/kg and these existing wells are proposed as production wells for the current development. ,

Production (1864 t/hr at 901 kJ/kg) and brine injection requirements (1492 t/hr at 105°C and 35.5 barsg) based on power plant heat balance calculations combined with known reservoir characteristics suggest that the optimal development strategy for Germencik includes extracting primary production from the northwest part of the field, around wells OB-6 and OB-9 and injecting brine into the area around OB-8 and OB-7. The resource is capable of supplying geothermal fluids for the planned project using two existing wells (OB-6 and OB-9) and two additional wells (OB-6A and OB-10) with larger diameter configurations. One will be drilled near OB-6 (OB-6A) and one (OB-10) will be drilled from a new pad near the proposed power plant.

Wellbore flow simulations indicate that the existing and planned new wells will be able to supply the required 1864 t/hr of brine at 20 to 25 kg/cm^{2}g flowing wellhead pressure. Initially, wells will be throttled and, as the reservoir declines, wellhead valves will be opened to increase flow. The throttled flow represents the additional capacity required for start-up. Well OB-6 exhibits choked flow at higher flow rates and based on wellbore simulations, the maximum production rate is limited by the size of its wellbore. Larger diameter wells would be more productive. Consequently, new production wells are planned with larger diameter casing.

The reservoir is capable of receiving waste brine by subsurface injection using one existing well (OB-8) and approximately three additional appropriately designed and located injection wells. The optimal number of wells requires a balance between the competing parameters of injection pressure, wellbore configuration and drilling costs. Using an injection pressure of 35.5 barg, approximately three new large diameter wells will be required. Assuming an approximate industry average of 4% decline, wellhead pressures will reach a minimum of 10 kg/cm^{2}g after approximately eight years of production. One new well will be required at that time and an additional well will be required approximately every seven years afterwards. Approximately five addition production wells may be required to maintain geothermal fluid supply to the plant over the life of the project.

Wellfield Development Cost Estimate

Large diameter wells are the optimum production and injection configuration based on an iteration of wellbore productivity, injectivity and well costs relative to casing size. Estimated costs for wellfield development are approximately $17.7 million US dollars with average annual resource operation and maintenance of approximately $1.0 million US dollars. The cost of well drilling is the primary wellfield development cost, and drilling costs have increased dramatically in the last few years (approximately 25% in the

last year). As the oil and steel markets stabilize and more drilling rigs are made available to satisfy the demand, these costs may level off. Additional drilling engineering will allow for competitive drilling bids, procuring expendable materials at reasonable costs and refining drilling budgets.

Gurmat Electric Uretrim A.S. has a corporate commitment to the development of the resource for the generation of electricity. Gurmat currently has an Energy Sales Agreement (ESA) with TEAS and a Contract with MTA for the use of the wells. These arrangements have been carried out in accordance with the legislation of the Turkish Energy Market Regulatory Board – Enerji Piyasasi Duzenleme Kurulu (EPDK).

Gathering System

The resource gathering system addresses the transportation of geothermal brine to flash tanks and polishing separators located close to the power generating facilities. The main consideration in transporting hot two-phase brine is pipeline flexibility. This is achieved by using the topographical features of the area and by offsets in the piping alignment such as expansion loops. In addition to the pipelines, the gathering system scope will include new well pads, improvements to existing well pads, a river crossing of the Alangullu River, improved access roads, some new access roads, new steam separation equipment and the attendant electrical and control systems for the wells.

Injection System

After steam energy is released by the brine, the excess brine draining from the low pressure separator will be transported to injection wells where it will be injected into the resource. This provides several advantages including replenishment of the fluid to the resource as well as avoiding the environmental problems encountered in releasing the brine above ground either to the river or elsewhere. Cooling tower overflow will be injected at a separate well.

Pipelines

Two-phase flow lines generally perform well when installed level or run downslope. For upsloping flow lines, the velocities must be controlled to avoid flow conditions that would generate either slug flow or wavy flow. It is desirable to size two-phase pipes so that the two-phase flow falls either under annular or dispersed regimes. Changes in vertical alignment should be gradual and as minimal as possible. The total two-phase pressure drop is comprised of friction, gravitation, and acceleration components. The frictional pressure drop is generally the primary contributor to the total pressure drop, particularly in relatively flat terrain. The pressure drops attributed to gravitation and acceleration may be generally neglected without introducing large errors.

Based on power plant requirements for the generation of 25.2 MW net, the steam flows at both the high pressure and low pressure dictated pipeline sizing to maintain a reasonable pressure drop in the pipeline. Line loss pressure drop was limited to less than 1 bar (~15 psi) between the turbine inlet and the furthest well head.

Flash Vessels and Separators

Flash vessel and separator flow sizing for this evaluation is based on mass flow. The preliminary design for flash vessels and polishing separators was performed utilizing the separator inlet pressure, steam flow, brine outlet flow, and pressure drop through the vessel. A 0.14 bar pressure drop was assumed to size the separators. All design parameters were based on flow data inputted in to VAI's pressure drop analysis from the PFD provided by Stone & Webster.

Steam Release Facilities

The steam release facility in a geothermal plant is required for start-up and for venting during turbine trips. In addition it takes the discharge from rupture disks during over-pressure relief of piping and pressure vessels such as separators. The steam release facility at Germencik will consists of a single-cell rock muffler with 100% vent capacity that is expected to be a 6.1m x 4.9m rectangular structure.

The rock muffler works on the basis concept of subjecting the vented steam to a tortuous path through hard durable volcanic angular rock. The steam follows the path of least resistance and is forced to enter and exit the rock fill by partial plugs installed in the expanded metal flow cylinders. Depending on the design capacity, the steam passes through the rock fill between 3 and 5 times. Each path reduces the potential energy of the steam and the rock absorbers and deadens the sound.

Gathering System Cost Estimate

The cost of the gathering system is anticipated to be approximately $14 million US dollars with average annual operation and maintenance cost of approximately $0.5 million US dollars.

Power Plant

The team selected a double flash unit for this project as we considered this to be the best balance between cost and efficient performance. This is the most common arrangement used in the industry for a liquid dominated resource at the demonstrated temperature and pressure. In addition we decided on a top discharge turbine with the condenser mounted beside the turbine. For a unit of this size this is a practical approach which avoids having to build an expensive turbine pedestal. Three manufacturers have provided quotations for the turbine and all have experience with turbines of this general design.

The resource at Germencik is very similar to the resource at Kizildere, a neighboring geothermal plant. The resource is very low in dissolved salts but high in non-condensable gases. Large quantities of non-condensable gases, particularly CO_2, will flash off the brine with the high pressure steam. This gas will be carried through the turbine into the condenser and will be removed from the condenser by a combination of steam jet ejectors and vacuum pumps. These will send the gases to the cooling tower where they will be disbursed in the atmosphere with the cooling tower vapor. Because of the quantity of gas to be handled, the ejectors and vacuum pumps will be large and expensive. Ultimately, the best way to handle the gas would be to send it to a gas bottling plant. This however is in the future.

After the high pressure steam has been flashed from the brine, the residual brine will be taken to a low pressure flash tank to remove additional energy in the form of low pressure steam for the turbine. After both low and high pressure steam have been flashed, there is still an appreciable amount of thermal energy left in the brine. This energy may be used in the future to provide heat to a greenhouse or other user. With the present design, the brine will be taken to injection wells for injection into the resource.

The additional innovative use of non-condensable gas and thermal energy described above could provide additional revenue streams for the Owner in the future.

The equipment for the power plant is all readily available on the market and there are no special requirements. Materials will be standard with no exotic alloys required. Stainless steel will be used in some applications but nothing more exotic such as Hastelloy or Inconel which are required in some liquid dominated applications.

Three manufacturers were requested to furnish bids on the turbine-generator, Fuji, Toshiba and Ansaldo. All replied with reasonable proposals. Pricing and delivery was approximately the same for all three. For simplicity we have chosen to present data and information based on the Fuji submittal. The schedule for delivering the Turbine-Generator appears to be a bit long however, we believe we can negotiate a better delivery once the project is authorized. In addition we suggest that a source of funding be identified early which would support a program to negotiate for the turbine supply and allow the selected turbine manufacturer to proceed with their engineering as soon as possible. The turbine supplier may be willing to do a limited amount of work at his own risk.

As has been stated as conclusions in the resource and gathering system sections of this report, we believe that the resource is well suited to development for the generation of electrical energy. Long term testing will be required to provide the information necessary to determine the maximum available energy from the resource and to define the resource boundaries. These tests are planned to begin in late 2005. There are no apparent insurmountable obstacles to transporting the brine from the wells to the plant site for separation.

The need for new wells, both production and injection has been discussed elsewhere. Again we see no apparent obstacles to extracting the energy necessary for providing the power plant with steam for the generation of 33 MW gross which will be required to produce 25.2 MW net.

Geotechnical

Borings were taken at three potential sites for the power plant. Our assessment of the available subsurface data indicates that the soils at two of the sites are suitable for a shallow foundation scheme. Both sites should provide reasonable bearing capacity, level topography, and deep ground water levels. These factors will enhance the excavation and construction process. The third site area appears to be less favorable for a shallow foundation scheme due to the looser soil conditions and correspondingly lower allowable bearing capacity. Additionally, excessive settlement resulting from soil densification during earthquake is possible in the vicinity of this site. Deep foundations or soil improvement measures would be necessary to reduce settlements and increase bearing capacity in this area. This area is also located adjacent to an area of steeper terrain, where slope instability and areas of slope incision due to surface run-off were observed during the December 14, 2004 site visit. These factors also make this area a less desirable site.

Soil liquefaction due to the assumed earthquake conditions appears unlikely at all the investigated areas based on a preliminary assessment of the available data. Installation of monitoring wells is recommended at the selected site in order to confirm the seasonal water levels. Higher water levels could contribute to the liquefaction potential in zones that are currently assumed to be non-liquefiable.

The measured temperatures of the groundwater in the borings range from 40.8 to 52.6 C°. Though these temperatures are somewhat elevated, the temperatures and groundwater levels would not contribute to near surface boiling conditions. Temperature wells should be constructed in the existing borings. It is recommended that temperature measurements continue be taken periodically at various elevations to confirm the thermal profile.

Additional borings will be necessary for the selected site in order to refine the geotechnical design criteria for the design stage. The borings should be adequately spaced to define vertical and lateral changes in the soil profile, particularly at key structures. Care should be taken to ensure that the drilling observations record layers of gravel that may bias the recorded N values and result in artificially high N values and un-conservative soil parameters. Estimates of the fine content in accordance with the Unified Soil Classification System are also strongly recommended in order to better define liquefaction resistance. Laboratory testing of site soils are also necessary during the design investigation stage to determine gradation and compaction characteristics, index properties, and the chemical constituents of the soil and groundwater.

Overall

Information which has been gathered evaluated to date indicates that the hot brine resource can supply the energy necessary to produce the 33 MW gross, 25.2 MW net, for this project. No unusual obstacles are anticipated in transporting the brine to the power plant where steam separation will occur. The design of the power plant is based on existing Stone & Webster designs which have been in successful operation for several years.

The Germencik geothermal project will provide many socio-economic benefits to the country, the region, and local towns. The benefits include development of new infrastructure, employment, technology transfer, environmental, economic, and perhaps food production.

The project will provide a source of clean, reliable, economical, indigenous electric power. It will reduce the country's reliance on foreign oil and gas for power generation, and in so doing, should help Turkey's balance of trade and their currency value.

STONE & WEBSTER
POWER PLANT

Shaw® Stone & Webster International, Inc.

FEASIBILITY REPORT

GERMENCIK GEOTHERMAL POWER PLANT

Prepared by

Shaw
Stone & Webster International

For

US Trade and Development Agency

And

Gurmat Electric
Ankara, Turkey

August 25, 2005

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FEASIBILITY STUDY

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1.0 INTRODUCTION

1.1 Purpose and Scope

The purpose of the Feasibility Study was to assess the viability of the resource at Germencik, to determine the costs of developing the resource and building a power plant to produce 25.2 net MWe, and to prepare documentation which would allow the Client (Gurmat) to obtain the financing to build the project.

Shaw/Stone & Webster and its subcontractors reviewed existing data, confirmed the significant parameters such as achievable brine pressures, temperatures and flow rates through review of test data taken at Aydin-Germencik and operational experience at Kizildere.

From this review the team determined the optimum thermal cycle for the proposed plant. Parameters to be studied included the number of steam flashes, steam flash pressures, optimum turbine design, and cooling system design. Scaling caused by precipitation of calcium carbonate in the well pipes and in surface equipment was addressed and the solution selected.

In the early stages of the study, the Client decided to conduct new well tests and have the results analyzed to verify that the test data which had been developed several years ago were still valid. On this basis, the study was delayed for several months in order to take advantage of the new data. Well tests were conducted under a separate program and did not impact the USTDA study financially.

As part of the Feasibility Study, the project team reviewed the existing reports and old and new data available for the reservoir and wells. These were used to characterize the reservoir and to make recommendations for additional drilling and testing. In addition, Geologica studied the issue of the high well gas content and made recommendations for its treatment as well as treatment of the accompanying scaling problem.

Geologica assessed the capacity of the Germencik geothermal resource to estimate the total geothermal power generation which can be expected over the life of the project. They also assessed major environmental issues related to resource development and geothermal power generation from this resource. The resource and environmental assessment is based on the latest data gathered during recent well testing. Geologic and geophysical data have been reviewed to identify field boundaries, permeability distribution and probable reservoir configuration. Geochemical data have been evaluated to identify fluid characteristics, reservoir characteristics such as temperatures and connectivity, and scaling potential as well as production processes to control steam quality and scale development and manage gas loading. Well test data have been reviewed to establish individual well production capacity and estimate production strategies and maximum reservoir capacity over the short and long term.

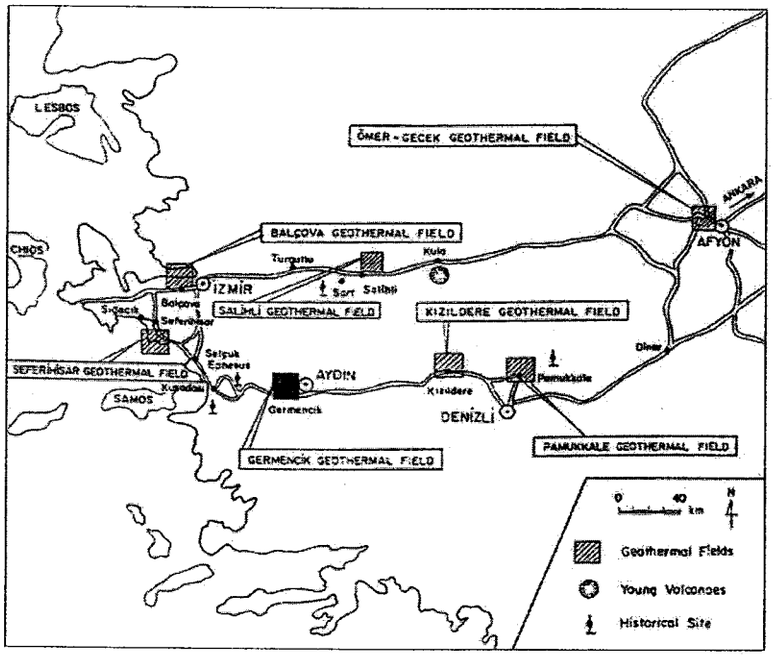
Geologica and Veizades have worked with Gurmat to plan a future long term well test program which will verify well condition, resource condition and total resource capacity. The long term plan is to develop ~100 MW at this site.

1.2 History

In the early 1960s the Mineral Investigation Research General Administration (MTA) began investigations into the exploitation of geothermal energy in Turkey. The first economic geothermal area was explored in 1968 in the Denizli-Kizildere region of southeastern Turkey (See Figure 2-1). A power plant was constructed by Turkiye Elektrik Kurumu (TEK) in this region and began operations in February, 1984.

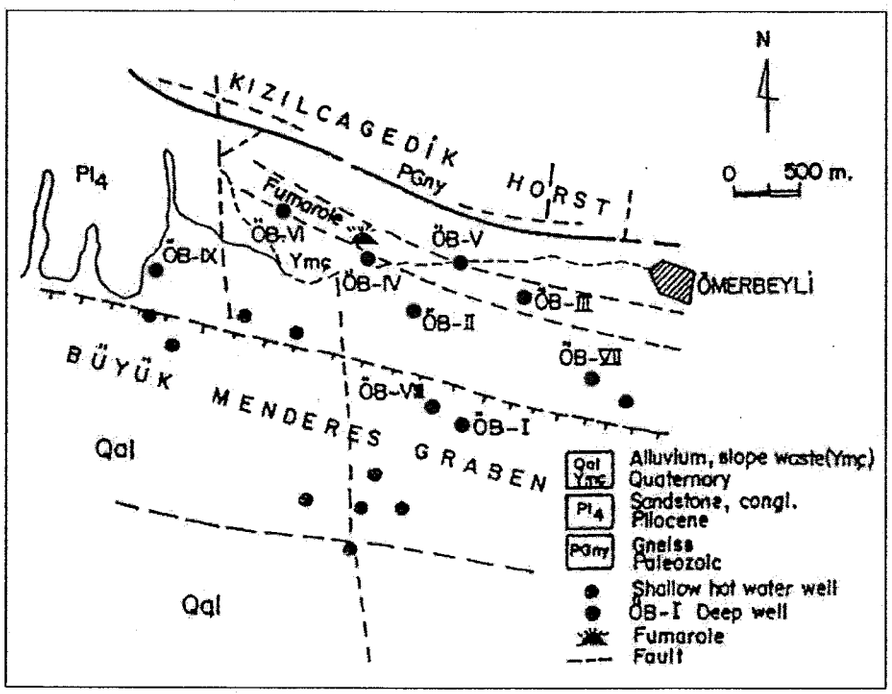
The first studies of the Germencik geothermal resource area were started in 1967. In 1970 shallow drilling was done (167 meters) and a temperature of 105° C was measured at 97 meters. Between 1978 and 1982 the Buyuk Menderes Graben was studied and evaluated for geothermal power generation capability. This graben extends through the Kizildere and the Germencik areas. Detailed studies to evaluate geothermal capability were conducted and in 1982 two wells were drilled. The first well OB-1was drilled to a depth of 1002 meters and geothermal fluid at 203° C was produced. This is in what is termed as the first reservoir. An additional well OB-2 was drilled and penetrated into a second reservoir and produced geothermal fluid at 232° C.

Figure 2-1 Aydin – Denizli Geothermal Fields



Subsequently, between 1983 and 1986, seven more geothermal wells (OB-3 through OB-9) were drilled in order to determine the layout of the reservoirs and their characteristics. The tests and studies conducted show that the geothermal fluid available is suitable for power generation. The location of the Kizildere and Germencik geothermal fields and the nine geothermal wells that were drilled in the Germencik geothermal field are shown on Figures 2-1 and 2-2 respectively

Figure 2-2 Location of Existing Wells, Germencik Geothermal Field



Since that time, numerous pre-feasibility studies have been conducted or proposed, but no further commercial development has occurred. Since 1985, a number of additional studies and testing programs have been conducted on the Germencik geothermal resource. These are discussed briefly below.

1.3 Previous Studies

In 1985, Mitsubishi Heavy Industries of Japan and Bureau de Recherches Geologiques et Minieres (BRGM) of France proposed to TEK that they form a consortium to develop the wellfield and build a power plant at the Germencik geothermal field. They proposed to review existing test data developed by MTA and to do additional well testing and analysis to characterize each well for: mass flow rates; well head pressures; enthalpy; static and dynamic pressures and temperatures; and, re-injection characteristics. Based on existing data for both

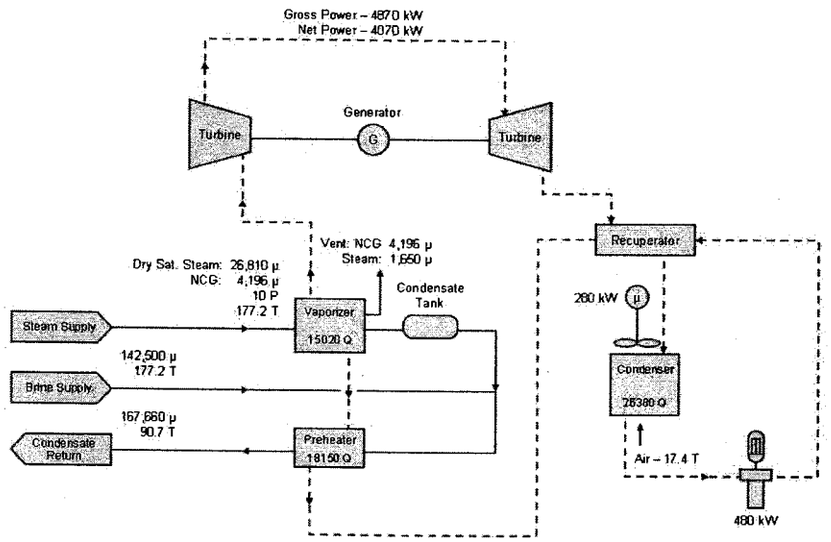
reservoirs, they anticipated total electrical generation of 110 MW (Mitsubishi (1985)). The overall schedule for the entire process was estimated at 43 months.

In 1988 a pre-feasibility study and report prepared by Dr. Sakir Simsek and Abdullah Gulgor evaluated and expanded on previous studies of the Aydin-Germencik-Omerbeyli geothermal field (MTA (1988)). Their work evaluated the geological, geophysical, geochemical, drilling and test work in this field identified the geological makeup of the field including the high seismicity of the area, defined the boundary of the field, identified the additional drilling requirements, verified the reservoir temperatures (203° C-232° C), verified the amount of dissolved solids in the brine (~5000 ppm), verified the amount of non-condensable gas, suggested the use of double flash units, and suggested additional uses for residual heat in the brine after flashing steam for electricity generation. Simsek and Gulgor estimated the electrical power value of the resource at 120 MW. They discussed the handling of the high CO_2 content of the brine and its penchant for combining with Ca^{++} to cause well and surface equipment scaling.

Simsek and Gulgor determined that the output of the existing viable wells totaled 23 MW. They estimated that 20 wells would be required at each reservoir site and recommended that well pipes be driven below 900 meters which they believe will mitigate the scaling effects. Simsek and Gulgor suggested other treatments for scaling including mechanical cleaning and acidification with hydrochloric acid.

A Feasibility Study and Report was prepared by Mitsubishi (1990) further testing and characterizing the reservoirs and wells in the Germencik field. This report records some raw well log data for wells OB-6, OB-8 and OB-9 (see Figure 2-2).

Figure 2-3 Typical Organic Binary Cycle



Based upon the MTA (1988) report Guris (1994 and 1999) prepared feasibility reports with the assistance of Ormat. Again the characteristics of the reservoirs and wells were reviewed and a power generation facility was introduced which used binary cycle type units to generate 24 Mwe gross. This organic binary system is based on the closed loop Rankine power cycle. Organic motive fluid is vaporized by heat from the geothermal fluid flowing through a vaporizer. The resultant motive fluid vapor expands as it flows through the turbine that is coupled to a generator that in turn produces electrical power. The cycle is shown in Figure 2-3. This approach has been put aside primarily because of the costs associated with the need to use four binary units to generate 24 MW.

1.4 Project Site

The Germencik geothermal field is located at the west end of the Byuku Menderes Graben extending in the east-west directions approximately 50 km from the Aegean Sea in West Anatolia province of Turkey. The site location can be seen on Figure 2-2. Gurmat currently has an Energy Sales Agreement (ESA) with TEAS and a Contract with MTA for the use of the wells. These arrangements have been carried out in accordance with the legislation of the Turkish Energy Market Regulatory Board – Enerji Piyasasi Duzenleme Kurulu (EPDK).

Good road and rail transportation are available in close proximity to the site. Some road improvement to the site is anticipated. There is a 34.5 kV transmission line passing through the site which can be used for construction power. In addition, groundwater or water from nearby Alangullu Creek may be used for construction water. A source of potable water is available from shallow wells on the west side of the Alangullu Creek. Requirements for infrastructure improvements will also be evaluated. A plan for road improvements is discussed in Appendix A of the Gathering System Report Section.

The interface point for the regional 154 kV transmission system is approximately 3.5 km from the proposed power plant location.

A proposed Site plan is shown in Attachment 1.1 – SITE PLAN.

2.0 TECHNICAL

2.1 Resource

The resource has been evaluated from historical data and from short term well tests rub in February and March of 2005. These tests were conducted by Gurmat under a separate effort. The results of the resource assessment effort indicate tha Germencik is a good hot water dominated geothermal resource capable of sustaining the fluid production and injection required for 33 MW gross electrical output for the 40 year life of the project. Details are given in Part B of this report prepared by Geologica.

2.2 Brine Gathering and Injection

The brine gathering system wellpads and pipelines have been laid out as shown on the development plan which is Appendix A to Part C of this Report prepared by Veizades and Associates. Civil work for the pipelines, roadwork and pads has also been addressed. Included with the gathering system are requirements for the flash vessels, polishing separators, and injection system.

2.3 Power Plant

2.3.1 Thermal Cycle Study and Equipment

General

The Germencik geothermal resource has an average temperature of over 210°C, which is best utilized with a dual flash plant. Dual flash is the most common technology for liquid-dominated resources. They are well understood, reliable, and cost effective. Based on numerous previous studies, other cycle configurations do not appear to be attractive enough to justify a detailed study of alternatives for Germencik.

The designs of other geothermal units similar to the Germencik plant were studied to determine which would be the most appropriate cycle to use for this design. The Germencik plant most closely resembled two plants with which we were familiar; East Mesa a 20 MW dual flash unit and Dixie Valley, a proposed 25 MW unit. Brine and steam conditions were close to those at Germencik. The plant we have proposed, therefore closely resembles these plants.

The plant will use a dual flash steam cycle, which is very common in the geothermal power industry, particularly for resources with enthalpies similar to Germencik. Two-phase geothermal fluids flow to the plant, where steam will be separated at two pressures and sent to two turbine admission points. The steam will expand through the turbine, creating power in the spinning shaft, which turns the generator. The turbine exhaust steam will be condensed in a direct-contact condenser, which is cooled by water from a cooling tower. The cooling tower transfers heat to

the atmosphere primarily by evaporation. The large quantities of non-condensable gas admitted to the turbine with the steam are removed from the condenser by a system comprised of steam jet ejectors and liquid ring vacuum pumps. The fraction of geothermal fluid that is not evaporated is pumped to injection wells.

The heat balance diagram in Attachment 2.1 shows how the plant is expected to perform under design conditions, producing 25,200 kW net. Under these conditions, the plant will be supplied with 2,040 t/h of geothermal fluid and 1,652 t/h will need to be injected. The generator will produce 32,300 kW, but approximately 7,100 kW will be consumed by the plant equipment. The plant's internal consumption is relatively high because of the power required to remove the high levels of gas in the steam and the high power required by the pumps to develop the pressure required to inject the fluid back into the ground.

The water balance can be determined from the Floe Diagrams attached. At the present time, an accurate Material Balance cannot be completed since there is little or no information on the composition or quantity of chemicals to be used for the plant such as anti-scalant injected into the wells and chemicals required for other water treatment purposes.

Gurmat has determined that water is available either from the nearby Alangullu River or fresh water wells which can be drilled on the property acquired by Gurmat.

A preliminary Mechanical and Electrical Equipment List is included as Attachment 2.3.1-1

Turbine – Generator

The turbine will be a single-flow design with two steam admission points (HP and LP). The last-stage blades will be relatively large to allow a high flow rate and capacity. The unit will be shipped mounted on a low level foundation, with turbine exhaust exiting the turbine upward and flowing to the adjacent condenser via a crossover duct. The turbine and generator will both operate at 3,000 rpm.

For the HP steam inlet there will be two swing check type stop valves, two governor valves, and two steam strainers. For the Low pressure side there will be 4 butterfly type stop valves, 4 governor valves and two steam strainers.

Turbine control will be a Woodward 505 digital governor. Turbine protective devices will include mechanical overspeed protection, a mechanical thrust bearing wear trip device, low vacuum trip device, solenoid trip device, emergency manual trip device, lubricating oil pressure low-low trip device, control oil pressure low-low trip device, and a vacuum breaker valve.

The gland steam system will include a pneumatically operated valve with block and bypass features.

The lube oil system will include a main lube oil pump, a D-C emergency lube oil pump, a jacking oil pump, an oil reservoir, an oil vapor extractor fan, duplex oil filter, accumulator, electric heater, lube oil cooler, lube oil temperature control system, and an oil conditioner system.

Test devices shall be local manual and include a test devices for the main steam stop valve, the governor valve, oil trip test device for the emergency governor, and oil pump auto test systems.

The 13.8 kV synchronous generator shall be three-phase, 50 Hz, able to operate at 0.90 leading and lagging power factor. The generator will be fully enclosed, water to air cooled, using brushless excitation. Three 33.4% generator coolers will be provided. Also included will be a shaft grounding brush, space heater, cooling water leakage alarm system, six main terminals, earth terminals, 304 stainless steel lube oil piping, resistance temperature detectors (RTDs) for stator windings, temperature elements for bearings, thermometer for bearing lube oil return temperatures, full enclosure, and a generator cover for outdoor use.

The excitation system will include a brushless exciter, digital Automatic Voltage Regulator (AVR), backup Manual Voltage Regulator (MVR), and field grounding protection.

Auxiliary equipment by the turbine supplier will include:

- Generator PT/SA cubicle
- Generator neutral cubicle
- Current transformers
- Motor starter for emergency oil pump

Control and monitoring equipment will include:

- Turbine control and supervisory system
- Turbine trip logic
- Required pressure, temperature and level instruments
- Vibration sensors (Bently Nevada 3300 series)
- Shaft position sensor
- Expansion differential sensor and monitor

The package will be supplied with all the auxiliary equipment required for operation. The equipment will be designed for flexible, stable operation that is typical of utility-grade power plants.

Preliminary Turbine generator Data Sheets are in Attachment 2.3.1-0.

Condenser

Steam is condensed by exposing the turbine exhaust steam to the cooling water, which is drawn into the condenser through from the cooling tower by the vacuum in the condenser. The

condenser pressure will be about 135 mbara at the design point, but will vary with load and ambient wet bulb temperature.

The condensed steam and cooling water fall to the hotwell at the bottom of the condenser, where they are removed by the hotwell pumps. The condenser level is controlled by valves at the discharge of the hotwell pumps.

The condenser also cools the gas that is removed by the gas removal system. This is done in the gas cooling section of the condenser. The cooling is important because it reduces the water vapor in the gas, thereby reducing the load on the gas removal system.

Preliminary Sketches of the condenser are shown in Attachments 2.3.1-2 and 2.3.1-3.

Cooling Tower

The cooling tower will be a four-cell, wet, mechanical draft tower with counter-flow fill. The hotwell pumps will pump the cooling water to the distribution system in the top of the tower, where the water is sprayed over the top of the fill material. Four fans atop the tower draw air through the fill, where heat is transferred from the water to the air via evaporative and sensible heat transfer mechanisms.

The cooling tower is sized to cool 2.33 m^3/s of cooling water from 46.7 °C to 22.2 °C with an ambient wet bulb temperature of 15.6 °C. The four fan motors will jointly consume approximately 800 kW of power.

The cooling tower will be of fiberglass construction with plastic fill material. Stainless steel will be used for connections, fasteners, etc. due to the corrosive environment. The tower will rest atop a concrete basin.

Circulating Water

The circulating water system carries water between the cooling tower, condenser, the gas removal system and other components that require cooling water. The system is sized for a flow of 2.1 m^3/s between the cooling tower and the condenser. The cooling water is drawn from the cooling tower basin by the vacuum in the condenser. Auxiliary cooling water and component cooling water umps will supply cooling water to the gas removal system and component cooling water heat exchangers.

Draind from small condensers and miscellaneous drains are brought to the condenser where they add to the inventory in the hotwell created by the condensed steam and circulating water. The two hotwell pumps operate continuously to remove the fluid and maintain level in the hotwell.

The two hotwell pumps are each capable of handling 50% of the maximum required capacity. The pump flow is controlled by a control valve at the pump discharge, operating to control the

hotwell level. The pumps will operate at constant-speed, with each of the two motors consuming approximately 400 kW. The pumps will be vertical can pumps with a total capacity of 2.33 m^3/s at 27 m of head.

Refer to Flow Diagram 111113-DJ-03.

Gas Removal

The gas removal system will draw the non-condensable gas (NCG) from the condenser, along with the associated water vapor contained in the NCG. The compression of the gas from the condenser pressure of approximately 135 mbara to atmospheric pressure will be accomplished in two stages. The first stage will us steam jet ejectors and the second stage will use liquid ring vacuum pumps, with an inter-condenser between the two stages.

Due to the very high amount of gas (approximately ten times normal amount normally experienced at a geothermal power plant), the gas removal system will be large and expensive and will consume large amounts of steam and power.

The first stage will be comprised of two 37.5% capacity jets and two 25% capacity jets. This gives a total capacity of 125% of the expected gas flow while providing part-load flexibility. The steam jets will consume approximately 30,000 kg/hr of motive steam at the design condition.

The steam jets will discharge into a single inter-condenser, where the motive steam will be condensed. The inter-condenser will be a direct-contact heat exchanger, supplied with water from the cooling tower.

The NCG will be drawn from the inter-condenser by the four liquid ring vacuum pumps, each with a capacity of 25%. There will also be a parallel steam jet with 25% capacity for startup and to operate when a vacuum pump is out of service. The vacuum pumps will draw total power of approximately 2,800 kW.

Additional Technical Data can be found in Attachment 2.3.1. Also refer to Flow Diagram 111113-DJ-05.

2.3.2 Other Mechanical Equipment/Systems

Compressed Air System

Two 100% oil free air compressors will supply compressed air to the plant. Air dryers will be provided to dry the compressed air for the plant service and instrument air users. Two air receivers, one for service air and one for instrument air will be installed, each sized to provide uninterrupted air supply to the plant. The compressed air equipment will be modularized and

skid mounted for easy shipping and installation. Compressors, dryers, and air filters will be mounted on a common skid. The compressed air system will be sized for 135 psig.

Dry instrument air will be distributed throughout the plant wherever control valves and instrumentation are installed which requires a supply of instrument air. Stainless steel or equal piping will be used in the instrument air system.

Service air will be delivered to quick action air hose connections in the following general areas: Turbine area, steam flash system area, cooling tower area, and any maintenance buildings. Service air will be available at a pressure and flow rate sufficient to operate most common air tools needed for maintenance and repair operations. Carbon steel piping will be used in the service air system.

Sizing of the compressors and air receivers will be performed at a later stage.

Fire Protection System:

A dedicated fire water storage tank will supply water for fire fighting purposes. Distribution of fire water will be through underground piping, with hydrants and hose stations at strategic locations. Buildings will be equipped with fire suppression sprinkler systems, smoke detectors, and pull stations.

It is anticipated that fire hydrants and fire suppression systems will be installed in the following general areas of the plant: steam turbine, generator, generator lube oil system, pump lube oil systems, maintenance and office buildings, chemical and fuel storage facilities, warehouse and shop areas.

Fire water from the dedicated fire water storage tank will be supplied to the plant fire hydrants by means of a fire pump station. The pump station consists of one each electric motor driven pump, one fire water jockey pump, and as a backup a diesel driven pump.

Auxiliary Cooling System:

Condensate / circulating water will be used for component cooling water. Circulating water will be taken from the cooling tower discharge and fed to two 100% capacity component cooling water pumps.

The component cooling water pumps supply cooling water to the following plant systems: Generator lube oil coolers, generator air coolers, turbine lube oil coolers, and miscellaneous pump lube oil coolers. Additionally, cooling water is supplied to the turbine gland steam condenser, the gas removal system intercooler, liquid ring vacuum pumps, as well as the pump

seal water system. If water cooled air compressors are selected, cooling water will be supplied to these, as well.

Hot cooling water, downstream of all component coolers, will be returned to the cooling tower.

Refer to Flow Diagram 111113-DJ-04

Chemical System / Water Treatment:

A chemical system will be designed to treat water used in the plant. Condensate, which is also used as circulating water will receive biocide injection to prevent cooling tower fouling.

Component cooling water will receive corrosion and scale inhibiting additives to protect the equipment cooling heat exchangers.

2.3.3 Electrical Power and Distribution Study and Equipment

General

Several geothermal units similar in size were studied. These studies were used to model the electrical system for Germencik. Electrical load lists from other plants were analyzed and an electrical load list was developed for the Germencik plant. This is Attachment 2.3.3-1 to this report. Single-Line diagrams were developed from this load list.

The generator is connected to the generator circuit breaker which in turn is connected to the low side of the generator step-up transformer (GSU). The high side of the GSU is connected to the switchyard. With the generator breaker in the closed position, power flows from the generator through the GSU to the switchyard. In addition, power flows to the generating plant auxiliaries, through the unit auxiliary transformer (UAT) and the medium and low - voltage distribution systems. The auxiliaries consist of all a-c electrical equipment and electrically-driven mechanical equipment, including the electrical auxiliary systems such as lighting, miscellaneous power, etc. that are required to provide a fully functional, operable plant.

At startup, power is fed to the auxiliary loads from the switchyard through the Generator Step-Up Transformer (GSU) and the Unit Auxiliary Transformer) UAT with the generator circuit breaker in the open position. Once the turbine is brought up to speed, the unit is synchronized to the switchyard and the generator breaker is closed. The unit is then on line.

The major components of the ac power system are as follows:

- Generator Step-up Transformer

- Unit Auxiliary Transformer
- Non-Segregated Phase (or Cable) Bus
- Generator Breaker
- Medium Voltage Distribution System
- Low Voltage Distribution System

The function of the AC Power Supply System is to supply the transmission network with a source of reliable generator output power and to provide a reliable source of power to the plant electrical auxiliary systems. The overall design of the AC Power Supply System is based on connecting to a high voltage transmission system with a usual voltage swing of plus or minus 5% and supplying minimum required voltage to the equipment. During project design, AC Load Flow and Short Circuit Calculations will be conducted to verify proper voltage at equipment under design operating conditions and maximum fault current is within the equipment ratings.

AC System Protection

The transmission system, generator, transformers, cables, medium and low voltage distribution system are protected from:

- System fault current and over load conditions by the selection of equipment ratings, relays and relay coordination.
- Lightning and switching surges by proper application of surge arrestors and selection of equipment BIL.

Generator Step-Up Transformer

The generator step-up transformer is sized to supply the maximum generator design output at the specified generator lagging and leading power factors to the switchyard at the rated operating voltage and under design operating conditions and temperatures. The transformer is sized based on the heat balances obtained for the turbine-generator output at the maximum design temperature.

The impedance shall be selected to limit short circuit duties to within design values and to provide acceptable voltage regulation. The range of manufacturers' standard impedances will be considered when making this selection.

The low voltage winding is based on the generator voltage rating and the high voltage rating is based on the switchyard voltage.

Data for the Generator Step up Transformer are given in Table 2.3.3a.

Unit Auxiliary Transformer

The unit auxiliary transformer supplies power to the medium voltage distribution system. The leads to this transformer will consist of cable bus. The auxiliary transformer shall be designed to carry the maximum design load of the medium voltage distribution system switchgear at the rated operating voltage and under the design operating conditions. Transformer rating will be 6/8 MVA OA/FA cooling and based on 65° C temperature rise.

The transformer impedance shall be sized to provide the following:

- Small enough to provide adequate voltage regulation for the equipment and allow starting of the large motors.
- Large enough so that the short circuit current rating of the connected switchgear is not exceeded.

The high voltage winding rating for the Unit Auxiliary Transformer is based on the generator voltage rating and the low voltage winding rating is based on the switchgear nominal voltage rating.

Data for the Unit Auxiliary Transformer are given in Table 2.3.3b.

Non-Segregated Phase Bus

The non-segregated phase bus connects the generator to the generator circuit breaker and the generator circuit breaker to the generator step-up transformer. This is referred to as the main bus. The bus will be of aluminum construction rated at 1600 amperes, 15 kV. Bus will be self cooled. The Unit Auxiliary transformer will also be connected to the 6.3 kV switchgear bus with 1200 amp rated non-segregated phase or cable bus. Bus shall be suitable for indoor and outdoor service.

Bus duct housings shall be primed and painted to resist corrosion. Hardware shall be 316 stainless steel.

Generator Breaker

During plant startup, the generator breaker is open and the plant electrical auxiliaries are supplied with power from the 154 kV System through the step-up transformer and auxiliary transformer. When the generator is up to speed, it is synchronized to the utility system across the generator breaker, the breaker is closed, and the plant electrical system is supplied from the generator. After start-up and during normal plant operation the plant electrical auxiliaries are supplied directly from the generator through the unit auxiliary transformer connected to the medium voltage distribution system.

Generator Circuit Breaker Data are shown in Table 2.3.3c.

13.8 kV System

The 13.8 kV System consists of the Generator, Generator Circuit Breaker, Generator Step-Up Transformer, Unit Auxiliary Transformer, Non-Segregated Phase Bus and the protection and metering systems.

Protection will be provided by a system of voltage and current transformers providing signals to a solid state integrated protective relay such as a Beckwith M-3520 and/or M-3530. Both relays may be applied to provide redundant protection for the generator and the transformers, however only the M-3520 is shown on the one-line. In addition, differential protective relaying will be provided for each transformer. Metering will be by Scientific Columbus or equal.

The 13.8 kV System is shown on One Line Diagram 111113-DE-101A and a typical outline of a protective relay panel is shown in Figure 2.3.2a.

6.3 kV Medium Voltage Distribution System

The 6.3 kV medium voltage distribution system consists of metal-clad switchgear lineups, with each lineup consisting of main supply circuit breakers, feeder breakers and / or metal-enclosed fused contactors. The medium voltage system supplies power to all medium voltage equipment, including medium voltage motors generally rated 200 kW and larger, the medium to low voltage unit substation transformers, and other large loads. Circuit breakers shall be rated for the requirements of the plant under all normal and fault conditions. Breakers shall be rated at 500 MVA at 7.2 kV.

Fused contactors shall be furnished for motor starting duty. They shall be of the vacuum contactor type. Contactors shall be of robust design rated for full voltage starting of squirrel cage type motors. Contactors shall be of 400 amp or 720 amp rating as appropriate. GE Multilin 369 or 469 protective relays will be applied as required.

The arrangement of the 6.3 kV distribution is shown on One-Line Diagram 111113-DE-102A

Low Voltage Distribution System

The low voltage distribution system consists of the following:

- Low voltage secondary unit substations

Each secondary unit substation consists of a medium voltage to low voltage transformer which supplies power to the 380V switchgear. The metal-enclosed switchgear consists of a main supply circuit breaker, feeder circuit breakers and a tie breaker to interconnect with another secondary

unit substation. Protection will be provided by the manufacturer's standard static protection system.

Refer to One-Line Diagram 111113-DE-103A

- Motor Control Centers

Motor control centers consist of bus breakers and starters to provide power to motors and smaller loads. Typically, low voltage substations supply loads from 100 kW to 200 kW and motor control centers feed loads from 0.75 kW to 100kW. Protection will be provided by GE Multilin Relays selected for the application.

Refer to One-Line Diagrams 111113-DE-104A through DE-107A

Switchyard
The Generator Step-Up Transformer will be located adjacent to the power plant to minimize the length of the non-segregated phase bus between the generator and the transformer. A dead-end structure will be placed outside the transformer and leads from the transformer high voltage bushing will be terminated on insulators on the dead-end structure. The switchyard will contain another dead-end structure for overhead line connection, 154 kV SF_6 Circuit Breakers, disconnect switches for circuit breaker isolation, metering equipment (voltage and current transformers), a control house and miscellaneous other equipment as required. The switchyard shall be surrounded by a ten foot chain link fence topped with razor ribbon wire. A gate in the fence shall be suitably sized to admit maintenance vehicles. A grounding system shall be installed to account for step-and touch potentials. The grounding system shall be properly connected to the plant grounding system. The substation shall be paved with six inches of gravel.

2.3.4 Control System

The primary control system shall be a Distributed Control System (DCS). The input/output (I/O) cabinets of the control system shall be distributed throughout the plant and the steam field. Operator work stations shall be located in the plant control room and shall be used for supervision and monitoring of the entire plant including start-up, synchronizing the unit to the transmission system, loading the unit and shutdown.

The DCS shall provide an operator interface to any separate controls such as the turbine EHC system and generator automatic voltage regulator. The DCS includes, but will not necessarily be limited to the following functions:

Condenser hotwell level monitoring and control
Cooling tower basin level monitoring and control
Re-injection flow control
Circulating water control
Turbine run-up, synchronizing, loading and shut-down controls

Steam field controls
Auxiliary equipment operation
Electrical protection alarms
Alarm management and event recording
Revenue metering recording
Sequence of Events logging
On line performance calculations
On line trending
Historical data storage and retrieval
Operation and production reporting

2.3.5 Geotechnical

Subsurface Investigations

A preliminary geotechnical investigation was conducted between July 14 and July 20, 2005 in order to evaluate subsurface conditions at three potential power plant locations in the Germencik Geothermal Project area. The main objective of the investigation was to collect basic subsurface information in order to characterize the engineering properties of site soils and to approximate the groundwater levels and temperatures. This information is necessary to conceptualize plant foundation types and to evaluate the liquefaction resistance of site soils during earthquake conditions. The temperature data is useful in identifying potentially unfavorably high thermal zones that could lead to foundation instability.

The geotechnical investigation consisted of six borings (SK1 to SK6) drilled to depths ranging from 15 to 50 m. The boring locations are shown on Attachment 2.3.5-1 – Boring Location Plan (sketch 111113-DW-101-A). Drilling and sampling was conducted using standard penetration test methods in accordance with ASTM D 1586. The borings were advanced using rotary drilling techniques with water. Steel casing was advanced to stabilize the boreholes. Groundwater levels were measured in each boring during drilling and water temperatures were measured in all borings except SK1. A boring inspector monitored the drilling operations and prepared boring logs that describe the recovered soils and record drilling observations. The boring logs are Attachments 2.3.5-2a-f.

Borings SK3 and SK6 were drilled in the vicinity of Alternative Site 1, located about 500 m west of well ÖB-2. Borings SK2 and SK4 were drilled in the vicinity of Alternative Site 2 which is situated about 500 m west-northwest of Alternative Site 1. This site is approximately midway between geothermal wells ÖB-2 and ÖB-9. Borings SK1 and SK5 were drilled to evaluate a third area located between Alternative Sites 1 and 2. This third area is located approximately 200 m northwest of Alternative Site 1 and 200 m northeast of Alternative Site 2.

The boring investigations indicate that the subsurface materials consist mainly of inter-layered sand and gravel with varying amounts of silt and clay sized particles in the three investigated areas. These findings are consistent with site observations made by Stone & Webster's

geotechnical engineer on December 14, 2004. Stone & Webster visited the sand and gravel quarry near well ÖB-9 where vertical cuts exposed alluvial deposits that mainly consist of sub-horizontal bedded sandy gravels. These deposits are inter-layered with large irregular lenses of fine sand and silty sand. In general, the sandy gravel layers at the quarry contain sub-rounded material up to 15 cm in length with most particles ranging between 1.25 and 5 cm. The sand size material occurring with the sandy gravel is mainly coarse. The sand layers and lenses consist mainly of fine sand. The rapid lateral changes between the fine sand layers and coarse gravels observed in the quarry excavation illustrate the variability of these deposits in the subsurface. The actual percentage of silt, clay, sand and gravel size particles are not known at this time but can be determined from laboratory testing on the recovered samples.

Groundwater levels measured during the drilling operations provide an estimate of groundwater depths. More accurate groundwater levels, reflecting seasonal variations, can be determined from groundwater monitoring wells installed during a later investigation phase. The depths indicate that groundwater levels range from 12.5 to 17 m below ground surface. The measured groundwater depths, elevations, and temperatures are shown in the table below.

Boring Number	Ground Surface Elevation (m)	Goundwater Depth (m)	Groundwater Elevation (m)	Goundwater Temperature (C°)
SK1	71	17	54	Not Available
SK2	69	16	53	52.6
SK3	60	12.5	47.5	50.2
SK4	67.5	13.8	53.7	51.5
SK5	68	14.2	53.8	40.8
SK6	64	13	51	41.2

Foundation Conditions

The limited boring data collected at each of the three investigated areas allows for a preliminary assessment of foundation conditions. More detailed subsurface evaluation will be necessary during later design stages in order to better define the engineering properties and uniformity of the subsurface at the selected site. The soil types observed in the sand and gravel quarry and those described in the borings typically provide adequate bearing capacity, liquefaction resistance, and tolerable settlements for shallow foundations if the materials are sufficiently dense. The preliminary boring investigation indicates that the materials at Alternative Sites 1 and 2 are suitable for a shallow foundation scheme such as spread footings. The intermediate area of investigation at borings SK1 and SK5 indicates somewhat less favorable shallow foundation conditions than those at Alternative Sites 1 and 2.

The standard penetration test N values recorded in borings SK3 and SK6 at Alternative Site 1 and in borings SK2 and SK4 at Alternative Site 2 indicate medium dense to dense soil conditions. Typical allowable bearing capacities for the observed soils are around 200 kPa (2 tsf) for standard shallow foundation footing widths. The anticipated elastic settlements under static

conditions should be less than 2.5 cm (1 inch) for this bearing pressure. The N values recorded at borings SK1 and SK5 indicate looser soil conditions in this area. In particular, boring SK1 soil conditions are classified as loose to medium dense based on the N counts. Allowable bearing capacity at this site considering the looser soil condition is estimated to be around 100 kPa (1 tsf). The recommended allowable bearing pressures used in the foundation design will depend on the actual foundation dimensions, depths, and a more accurate understanding of soil conditions.

The Germencik Geothermal Project is located within an area of high seismicity. A review of the seismic hazard literature suggests that an earthquake with a 10% probability of exceedance in 50 years (equivalent to a return period of 475 years) can result in a peak ground acceleration of about 0.43 g in the site area. Loose, saturated, cohesionless soils can be subject to soil liquefaction under earthquake conditions. Additionally, settlement can result in those soils above the water table due to soil densification during an earthquake.

A preliminary evaluation of liquefaction potential indicates that the soil and groundwater conditions at all three investigated areas are not conducive to liquefaction, based on the available data. A magnitude 6.5 earthquake is assumed in the liquefaction evaluation. A key factor affecting liquefaction potential is the location of the groundwater table. The groundwater table is about 17 m below ground surface at SK1. This depth is below the depth of the loosest soils sampled in the investigation.

Settlement, due to soil densification during the assumed earthquake is estimated to be negligible at Alternative Sites 1 and 2. Potential settlement resulting from densification of the unsaturated loose soils at boring SK1 is estimated to be in excess of about 4 cm (1.6 inches).

Conclusions and Recommendations

Our assessment of the available subsurface data indicates that the soils at Alternative Sites 1 and 2 are suitable for a shallow foundation scheme. Both sites should provide reasonable bearing capacity, level topography, and deep ground water levels. These factors will enhance the excavation and construction process. The third site area, in the vicinity of boring SK1 appears to be less favorable for a shallow foundation scheme due to the looser soil conditions and correspondingly lower allowable bearing capacity. Additionally, excessive settlement resulting from soil densification during earthquake is possible in the vicinity of boring SK1. Deep foundations or soil improvement measures would be necessary to reduce settlements and increase bearing capacity in this area. This area is also located adjacent to an area of steeper terrain, where slope instability and areas of slope incision due to surface run-off were observed during the December 14, 2004 site visit. These factors also make this area a less desirable site.

Soil liquefaction due to the assumed earthquake conditions appears unlikely at all the investigated areas based on a preliminary assessment of the available data. Installation of monitoring wells is recommended at the selected site in order to confirm the seasonal water

levels. Higher water levels could contribute to the liquefaction potential in zones that are currently assumed to be non-liquefiable.

The measured temperatures of the groundwater in the borings range from 40.8 to 52.6 C°. Though these temperatures are somewhat elevated, the temperatures and groundwater levels would not contribute to near surface boiling conditions. Temperature wells should be constructed in the existing borings. It is recommended that temperature measurements continue be taken periodically at various elevations to confirm the thermal profile.

Additional borings will be necessary for the selected site in order to refine the geotechnical design criteria for the design stage. The borings should be adequately spaced to define vertical and lateral changes in the soil profile, particularly at key structures. Care should be taken to ensure that the drilling observations record layers of gravel that may bias the recorded N values and result in artificially high N values and un-conservative soil parameters. Estimates of the fine content in accordance with the Unified Soil Classification System are also strongly recommended in order to better define liquefaction resistance. Laboratory testing of site soils are also necessary during the design investigation stage to determine gradation and compaction characteristics, index properties, and the chemical constituents of the soil and groundwater.

2.3.6 Contractor Contacts

Contractor contact information is shown in Attachment 2.3.6-1.

2.3.7 Power Plant Design Criteria

The Design Criteria for the Power Plant are given in Attachment 2.3.7-1.

3.0 CONSTRUCTABILITY REVIEW

The construction department of Shaw/Stone & Webster (SSW) performed a constructability review of the Germencik Geothermal Power Plant located in Aydin Province in Turkey and determined that the power plant can be built safely and in the time frame allowed.

A constructability analysis at this stage of the project is a practical, positive, and cost effective way of ensuring the project can be built as designed and construction problems and delays can be minimized.

Utilizing their construction knowledge and experience in planning and field construction operations to achieve overall project objectives the following items were looked at:

1. Overall project configuration
2. Construction sequence
3. Personnel access
4. Crane access
5. Maintenance of equipment
6. Access and interferences for staging
7. Modular and preassembly fabrication

Building arrangement and layout dramatically impacts construction sequence, bulk material quantities, staging of construction activities, and access for construction maintenance. The proposed layout of the equipment allows for construction, operation, and maintenance requirements including horizontal and vertical access for installation, pull spaces and removal for repairs.

The site layout, while compact, also allows access for cranes and other construction equipment for the installation of the permanent equipment without having an impact on the schedule. The layout and construction sequencing should also minimize access restrictions and safety problems resulting from open ditches and excavations.

There is sufficient area to store and stage equipment and material as it arrives. Most of the equipment may be set directly on the foundations as it arrives. Piping, miscellaneous mechanical equipment and material and electrical bulk material will have to be stored and staged as necessary.

The schedule was reviewed to ensure the sequencing of construction activities is tied to equipment delivery dates and sequenced in the proper order to ensure optimum use of construction equipment and labor. In addition, the construction sequence and duration supports the commissioning schedule.

4.0 ECONOMIC ANALYSIS

4.1 General

An analysis was conducted to determine the economic feasibility of the project, resulting in cash flow projections for the expected project life of 37 years. The cash flow projections and related assumptions are included in Attachment 4.1.

In the analysis, all payments are denominated in U.S. dollars, even though most will be paid in Turkish lira. This is based on the assumption that the relationship between the buying power of the dollar and the lira will not change on the average over the term considered by the study. It was assumed that revenues escalate at 3.0% per year in dollar terms and that most expenses escalate at 2.5% per year in dollar terms.

The analysis calculates the net present value and internal rate of return on the project's pre-tax cash flow for thirty years of operation. The analysis is based on project cash flows, not income and therefore includes the cost of debt financing, but excludes depreciation and income tax. Debt service coverage ratios (DSCRs) are calculated to determine how well the project can repay the debt.

4.2 Operating Assumptions

The plant is designed to produce 25,200 kW of net capacity initially. It was assumed that the output would degrade at 0.25% per year as an allowance for modest resource decline and degradation of plant equipment. The plant is assumed to operate at a capacity factor of 93.7%, calculated from reasonable assumptions for outages and dispatch, which are shown in the cash flow assumptions. This plant performance is achievable with proper operation and maintenance practices.

The geothermal resource is assumed to produce at the flow and enthalpy necessary to produce the assumed plant output, with the forecast well maintenance and drilling to ensure that the production and injection capacities are adequate. Estimated well maintenance, workovers, and drilling costs are included in the analysis.

4.3 Revenues

4.3.1 Power Sales

The output of the plant will be sold to the Turkish electricity trading company, TETTAS. Power sales will be at rates set by the government, which was recently equivalent to 6.32 US cents per kilowatt-hour. This value was assumed as the rate for 2005, escalating at 3.0% per year. All production from the plant is assumed to be sold, but is reduced by 3.02% for transmission losses, as recommended by Guris.

4.3.2 Heat & Carbon Dioxide Sales

There are potential opportunities to sell both heat and/or carbon dioxide. This would require additional equipment at the plant, which would add to the overall project cost. Such revenues and expenses are not included in the cash flow projections.

4.4 Project Cost

The project costs to achieve commercial operation were estimated based on conceptual designs, equipment price quotations, and past experience. A summary of the estimate is shown in Table 4-1, with explanations following the table.

Table 4-1
Summary Total Project Cost Estimate ($1000)

Production Wells & Startup	$6,550
Injection Wells	$11,010
Gathering & Injection Systems	$14,051
Power Plant	$45,000
VAT	$1,000
Development Costs	$1,300
Financing Fees & Interest	$16,892
Total Project Cost	$95,803

4.4.1 Capital Costs

A capital cost estimate was prepared for production and injection wells, geothermal fluid handling systems, and the power plant. This includes the costs that would be paid to contractors to complete all critical aspects of the project, including startup and testing.

The $6.55 million cost for production wells includes drilling and completing two wells, as well as other necessary expenses related to the wellfield. These other expenses include long-term flow testing, individual well testing and logging, start-up, production engineering and reservoir management, instrument and chemistry laboratory setup, and environmental report update.

The $11.01 million is included for drilling three large-diameter injection wells, which appears to be the optimum configuration. The injection pressure is still expected to be high, resulting in unusually high injection pumping power. Future injection testing will provide additional information that might allow the injection well cost and pumping power to be reduced.

The $14.05 million gathering and injection system costs include the costs to install all wellfield piping, separators, pumps, etc. necessary to deliver steam to the power plant and return the spent fluid to the injection wells.

The power plant cost was estimated at $45.00 million, including all costs for engineering, design, procurement, construction, startup, and testing. The plant design would be a dual flash, single turbine configuration.

Guris advised that VAT would apply to certain costs incurred in Turkey, but that the total amount would not exceed $1.0 million, which was used in the analysis.

4.4.2 Development Costs

Development costs were estimated based on Stone & Webster's experience with other projects. The assumed costs are summarized below:

Table 4-2
Summary Development Cost Estimate ($1000)

Land	$180
Consultants	$50
Legal	$150
Permits & Fees	$100
Management	$100
Lender's Independent Engineer	$150
Lender's Legal Counsel	$300
Clerical staff	$30
Office expense	$50
Telecommunications	$40
Miscellaneous	$100
General & Administrative	$50
Total	$1,300

4.4.3 Financing Costs

The financing costs include interest on the construction loan and lender's fees. The lender's costs for an independent engineer and legal counsel for due diligence are included in the development costs.

The interest expense is calculated using an assumed fixed loan rate of 5.00 percent on the outstanding loan amount, which increases as construction expenditures occur over two years. The project is assumed to be financed with 70 percent debt.

Lender's exposure fees were estimated to be 20.17% of the total loan amount, based on US ExIm's fee for this project. It would accrue as the funds are drawn and the fees would be capitalized. Additional arrangement and commitment fees of 0.50% and 0.125% per year are also included.

4.4.4 Operating Costs

Labor

The labor cost for the plant was estimated by assumed staff levels and labor rates, based on discussions with Guris, which intends to operate the plant. These are summarized in Table 4-3.

Table 4-3
Labor Cost Summary

Position	Qty	Annual Cost
Plant Manager	1	$57,000
O&M Supervisor	4	$92,160
Plant Engineer	1	$33,600
Production Engineer	1	$33,600
Secretary	1	$13,860
Lead Operator	5	$99,000
Roving Operator	10	$158,400
Mechanic	3	$35,640
Electrician	2	$27,720
I&C Technician	2	$31,680
Chemistry Technician	1	$13,860
Laborer	5	$27,000
Delivery / Pickup	1	$5,400
Total	37	$628,920

O&M Expenses

Annual non-labor costs for routine operation and maintenance were determined from input from Guris and Stone & Webster's experience. The assumed costs are listed in the table below in 2005 dollars and are assumed to escalate at 2.5%.

Table 4-4
O&M Cost Summary ($1000)

Consultants	$100
Chemicals	$75
Permits & Fees	$20

Routine Maintenance	$50
Performance Monitoring	$100
Chemical Monitoring	$50
Scale Inhibitor	$108
Production & Injection Management	$100
Environmental Management	$25
Well Workovers	$250

Capital Expenditures

Allowances have been included for plant overhauls and production well drilling. Production wells are assumed to be needed in the fifth year of operation and then every eighth year thereafter. The estimated cost is $2.95 million in 2005, escalating at 2.5%.

Turbine overhauls are expected to occur every five years and it is assumed that some vehicles and other equipment will be replaced at the same time. A cost of $1.2 million every five years was assumed in 2005, escalating at 2.5%.

A reserve fund was included in the cash flow projections to provide for the capital expenditures. Each capital expenditure is assumed to be funded by three equal contributions to the reserve beginning two years before the expenditure. The calculations include interest accruing on the balance at a rate of 3.0%.

4.4.5 Overhead Costs

The estimated annual overhead costs are listed in the table below:

Table 4-5
Overhead Cost Summary ($1000)

Office expense	$40
Telecommunications	$30
Bank Engineering & Legal	$50
General & Administration	$40
Miscellaneous	$50
Transmission	$323
MTA Fee	$286
MTA Land Lease	$35
Insurance	$383

Miscellaneous	$100

These expenses are based on input from Guris and Stone & Webster's experience. They are assumed to escalate at 2.5% per year, except for the MTA fee and land lease, which Guris stated would be constant.

The analysis includes an expense for a royalty payment equal to 1.5% on gross revenues, based on input from Guris.

A transmission credit is also due to Guris during the first three years of operation, which is deducted from the transmission cost in the cash flow projections. The credit is estimated to be $333,000 per year in 2005 dollars, escalating at 2.5%.

4.5 Financing Expense

The project was assumed to be funded with 70% debt and minimum 30% equity. It was assumed that the equity would be contributed before the debt funding in the two-year development period. Interest during the development period was calculated and included in the project cost.

Debt financing was assumed to be in the form of a 15-year note with guarantees provided by the U.S. Export Import Bank. It would be drawn over the two-year development period and repaid with repayment over the subsequent 15 years with equal principal payments each period. The interest rate was assumed to be 5.00 percent, based on current fixed rates.

Debt service coverage ratios were calculated for each year by dividing the cash flow from operations by the amount owed for principal, interest, and fees. This measure is one of the primary measures that lenders will consider in evaluating the lending risk. Lenders will expect that the project cash flows will be greater than certain minimum and average DSCRs of at approximately 1.2 and 1.8, respectively.

4.6 Economic Performance

The projected cash flows are shown in Attachment 4.1.

The before-tax net present value (NPV) and internal rate of return (IRR) for the equity participants were calculated for 20, 30, and 37 years of operation. The weighted average cost of capital (8.9%) was used for calculating the NPV.

Debt service coverage ratio was calculated to determine the adequacy of the cash flows for payments to the lenders, using two amortization scenarios: 1) constant principal payments, and 2) constant total payments.

The economic performance of the project is measured by the calculated DSCR, NPV, and IRR. The levelized cost of energy is also calculated as a basis to compare to other power supply options.

4.7 Economic Conclusions

Pre-tax equity returns are shown below for 20, 30, and 37 years of operation:

Term (years)	20	30	37
Net Present Value ($M)	$24	$43	$50
Internal Rate of Return (%/yr)	16%	17%	18%

The minimum and average debt service coverage ratios were calculated to be 1.29 and 1.95, respectively.

The economic returns and DSCRs indicate that the project is economically feasible. However, the project could be made stronger by any of the following:

- Reduce transmission losses
- Negotiate better power sales rates
- Negotiate sales of heat and carbon dioxide
- Conduct injection testing and try to reduce injection pressure

5.0 FINANCIAL

5.1 Financial Borrowing Structure

A project company, Gurmat Energy, Investment and Trade Co., Ltd. (Gurmat) has been formed to own and operate the grassroots Germencik Geothermal Electric Power Project. Gurmat is owned 50% by Guris Construction and Engineering Company, Inc., and 50% by Guris Holding Inc., a Turkish conglomerate involved in construction, manufacturing, trading and various manufacturing undertakings. The Project is to utilize geothermal wells under a long-term 45 year lease agreement with the Turkish government agency MTA – Mineral Research and Exploration Institute, under the Ministry of Energy and Natural Resources. Power from the plant will be sold to the government grid via TETTAS, the government owned electricity trading company.

The Project will be financed as either (A) a limited recourse Project Finance off-balance sheet undertaking, or (B) a Corporate Risk on-balance sheet borrowing utilizing the corporate financial resources of the Guris Group. Under a Project Finance scenario the project company-Gurmat, may serve as Borrower to lenders, with creditworthiness dependent on project cash flows, project financial strength, equity structure, and off-take pricing to the electric power grid. Under a Corporate Risk borrowing, Gurmat may serve as borrower, or alternatively Guris Construction as borrower, with the financial backing or guarantee of the parent company, Guris Holding Inc.

Under the Project Financing approach a significant number of interrelated and sound contractual arrangements are key to a successful completion and operation of the project. Lenders are expected to require at least a 75% debt/25% equity structure for the project under a Project Finance structure. Under a Corporate Risk structure Gurmat may elect to borrow 100% of project costs.

Discussion:

The various lenders contacted by The Shaw Group/Stone & Webster made the following observations.

Although the nature of the project, as a grassroots/greenfield geothermal electric power project, does often lend itself to a limited recourse Project Finance structure, the estimated total project costs of $50 million, and imported/3rd country costs of $25 million to $35 million, may be relatively low for Export Credit Agencies (ECA's) to consider Project Financing support. ECA's often have minimum threshold amounts for this type of financing. It should be pointed out that Project Financing can be very complex and time consuming to structure, to perform financial, economic and legal due diligence, and could involve a process that could take in excess of one year to complete.

ExIm Bank officials also reported that although in the past Turkey's Undersecretariat of the Treasury stood behind or backed up Project Finance IPP/PPA structures, that no longer is the case as a requirement of the IMF. ExIm Bank and other ECA's do need that type of backing however, it was reported.

ECA support for a Project Finance type of structure will need to be carefully examined. The Shaw Group/Stone & Webster will work with Gurmat to fully explore this type of financing. The turnaround time on a Corporate Risk approach would be expected to be shorter than Project Financing.

Information Needs:

Under the Project Financing approach the project company would enter into financing arrangements and inter-creditor agreements which would require certain financial covenants and the pledging/liens on certain project assets as collateral to lenders. Lenders will require a full understanding of the particulars of the project.
Lenders will perform a very thorough financial analysis of the proposed project, the project's projected financial statements, balance sheets, profit and loss statements, and cash flow statements. Geothermal reserve assessments, offtake arrangements, power purchase agreements, shareholders agreements and government undertakings and approvals, to include the lease agreement for the geothermal field, will, among other items, be closely reviewed.

A Corporate Risk approach may include much of the above information plus relevant financial information on the Guris Group.

5.2 Financial Sources – General Background

The Shaw Group/Stone & Webster has contacted certain prospective international financial institutions to discuss possible financing assistance for this project.

Three groups of lenders may play a significant role in the financing of the geothermal electric power project (Financial Sources) : (A) Official Government Export Credit Agencies (ECA's); (B) Commercial Banks (Commercial Lenders); and (C) Multilateral Development Banks (MDB's).

(A) The ECA's are government finance agencies which offer programs of loans, guarantees and export credit insurance that can assist in financing the geothermal electric power project. ECA's belong to the OECD Arrangement on Export Credits and have Corporate Risk and Project Finance programs that are available for infrastructure project lending. Sources of equipment and services procurement for the project will include the countries of the U.S., Japan and Europe, and ECA's from those countries would be expected to provide financing support.

Each ECA provides similar financing terms, but may co-lend or co-finance to a project depending on the source of supply of procurement. The ECA's also have cooperative agreements among themselves whereby one ECA may "front" for other lenders to the project, providing for a minimum of loan agreements for the project.

(B) Commercial Lenders. U.S. or European Commercial Lenders (private commercial banks) will assist in covering certain balance of funding for the project. The Commercial Lenders may serve as direct lending institutions on behalf of ECA's as required, that is where the ECA's do not lend directly to the project but instead provide guarantees or export credit insurance to the lenders ('Covered") risks. Commercial Lenders will also fund certain "Uncovered" risks of the project, for instance the 15% cash payment required for long-term ECA financing, and certain in-country Turkish costs possibly not already covered by the ECA.

Commercial Lenders' terms and conditions are dependent on their respective financing role in the project, whether they are funding "Covered" or "Uncovered" risks. For the "Covered" portion backed by the ECA, Commercial Lenders would lend on repayment terms established by the ECA, and have relatively tight interest rate margins over Libor (London Interbank Offered Rate). For the "Uncovered" portion the Commercial Lenders would lend on shorter repayment terms with higher fees and spreads over Libor.

(C) MDB's . MDB's are international lending institutions owned by member countries that play an active role in funding and supporting third world countries economic development. The World Bank is the largest of the MDB's and has a global focus. The World Bank will typically require the sovereign guarantee for its lending activities. The World Bank's private sector lending arm, the International Finance Corporation (IFC), provides Project Financing assistance and equity investments for projects such as the Guris geothermal project. The World Bank recently established a Renewable Energy Special Purpose Debt Facility (SPDF) with Turkey. In addition the World Bank administers the Global Environment Facility (GEF) which can provide supplemental assistance to renewable energy projects in the form of contingent loans and grants.

Another MDB is the European Bank for Reconstruction and Development (EBRD), located in London, which can provide support for infrastructure projects. However, as a founding member of the EBRD, Turkey is not an operating country having a borrower/lending relationship with the EBRD.

Two other International Financial Institutions (IFI's) conducting lending activities with Turkey are the European Investment Bank (EIB), Brussels, Belgium and the Black Sea Trade and Development Bank, Greece.

5.3 Financial Plan

(A) ECA's

The Shaw Group/Stone & Webster contacted U.S. ExIm Bank and other official government ECA's. These institutions are open for Turkey and available to provide support for the project.

U.S. ExIm Bank programs are fully open for Turkey. ExIm Bank is very interested in providing support and is prepared to consider an application for the geothermal project for US goods and services, as well as local Turkish costs up to 15%. ExIm Bank would perform its due diligence on the project typically under a Project Finance approach, and/or a due diligence on the financial condition of the Guris Group, depending on the entity that serves as the borrower, or guarantor (Corporate Risk). ExIm Bank would offer up to possibly 15 year repayment terms following completion of construction of the project. ExIm Bank would offer funding support in the form of a long-term fixed US dollar loan to the project company, Gurmat (Project Financing), or the appropriate Guris entity (Corporate Risk), or a financial guarantee to a Commercial Lender which would provide funding at a floating US dollar Libor rate. ExIm Bank would charge a commitment fee and exposure fee (credit risk premium) for the financing (greater than 10 % exposure fee which could be rolled into the financing). ExIm Bank, in keeping with OECD ECA rules, would cover 85% of US costs, with 15% cash payment to be funded by the Commercial Lenders. ExIm Bank will also provide a 15% local cost guarantee. The interest rate on an ExIm Bank direct loan is currently 4.94%; this interest rate will be fixed at the time of final approval of an ExIm Bank direct loan and would depend on the repayment term approved for the transaction. A commitment fee of ½% is charged on a loan, or alternatively 1/8% on a financial guarantee.

ExIm Bank reported that although in the past Turkey's Undersecretariat of the Treasury stood behind or backed up Project Finance IPP structures, that no longer is the case as a requirement of the IMF. ExIm Bank and other ECA's do need that type of backing, however, it was reported. A Corporate Risk structure could be viable, however with the Guris Group backing, and/or a securitization of the project revenue streams, that would require creditworthy customers to pay directly into specific bank accounts which would apply first to debt repayment to the lenders.

Third country sourcing for the project could include the countries of Italy, France or Japan. The ECA's from those countries are all open to consider new project opportunities in Turkey.

U.S. ExIm Bank and the other ECA's would cooperate and provide co-financing for the project. One ECA could "front" for the other ECA which would minimize the loan agreements and application processing.

(B) Commercial Lenders.

U.S. or European Commercial Lenders will assist in covering certain balance of funding for the project. The Commercial Lenders may serve as direct lending institutions on behalf of the ECA's, and their terms and conditions are dependent on their respective financing role in the project, that is where they are funding "Covered" or "Uncovered" risks, covered or not covered by the ECA.

The Commercial Lenders, for the "Covered" portions of the project supported by the ECA's, would be expected to provide Libor dollar based funding at spreads of 30 to 50 basis points, with a repayment term as authorized by the ECA of possibly 15 years, following completion of construction. For the "Uncovered" portion, the Commercial Lenders would offer spreads of 150 to 250 basis points above Libor with a repayment term of approximately 5 years. The Commercial Lenders will also charge commitment and arrangement fees.

Note- the U.S. ExIm Bank program is open to work with U.S. or non-U.S. Commercial Lenders, as are the other ECA's.

(C) MDB's

The Shaw Group/Stone & Webster contacted the World Bank and the IFC, as well as other international financial institutions.

The World Bank recently established a Renewable Energy Special Purpose Debt Facility (SPDF) with Turkey. This is a multilayered on-lending Facility (requiring multiple lending reviews and decisions) in which the World Bank lends to the Government of Turkey through its Treasury, the Undersecretariat of the Treasury, who on-lends to two designated Turkish banks, Turkiye Sinai Kalkinma Bankasi (TSKB), the Turkish Industrial Development Bank (private), and the Turkiye Kalkinma Bankasi (TKB), the Turkish Development Bank (government).TSKB and TKB on-lend to the end-user, the renewable energy project. This Facility requires international competitive bids (ICB) in most cases, meaning that US companies will bid against other global suppliers from Europe or Japan for the Turkish project. The terms of the Facility are also not necessarily competitive with ECA finance. TSKB and TKB establish the terms of repayment and interest rate spreads depending on their risk evaluation of the project. As reported by the World Bank, it is anticipated that the Facility terms will include a repayment term of 6 years and 2 years grace, or longer, and interest rate spreads of 300 to 350 basis points, or less. The Guris/Gurmat project principals will need to carefully examine and compare this Facility with other forms of financing, including ECA financing, in terms of the all-in cost of financing, the processing time and timing of project approvals, and the World Bank's ICB procedures and requirements. In theory, the SPDF could supplement ECA support on a co-financing basis. This may however, not be practical in the subject project given the specific requirements, expectations, and timing needs.

The Global Environment Facility (GEF) is a financial mechanism for the United Nations Framework Convention on Climate Change (UNFCCC). The GEF can provide additional/supplemental support and leverage co-financing funding availability. The GEF can provide a "sweetener" to top up funding for a project through grants and contingent loans. Renewable energy projects in Turkey are eligible. The World Bank administers the GEF. The GEF fund is used to lower barriers to the consideration of renewable energy projects, where there

may be a lack of a clear policy environment, and to provide a significant and sustainable favorable economic impact. The World Bank's Renewable Energy SPDF has not been used to mix with GEF funds. Also ECA's have specific rules on the mixing and concessionality levels of grant funds being combined with ECA funds. The World Bank's ICB procedures and requirements will be in effect for US companies pursuing the Guris/Gurmat geothermal project. Guris/Gurmat will need to examine the applicability of the GEF fund.

Another fund, the Prototype Carbon Fund (PCF), was established by the World Bank to address the issues of climate change and mobilize resources as a source of financing for sustainable development in the energy, industrial, waste management and renewable energy fields. The PCF is not currently available for Turkey however, as that country has not ratified the Kyoto Convention.

The Black Sea Trade and Development Bank (BSTDB), Thessaloniki, Greece, is an International Financial Institution (IFI) that supports economic development and regional cooperation by providing trade and project financing, guarantees and equity for development projects supporting both public and private enterprises in its member countries (includes Turkey). The Shaw Group/Stone & Webster contacted the BSTDB who indicated that they would be open to consider support for the Gurmat/Guris project. Indicative terms were given as: maximum support – up to $20 million; maximum contribution per project – 35%; minimum financing support- $3 million; repayment term – up to 10 years, but more normally 5 to 7 years; grace period – 2 years; interest rate – fixed or floating in any major currency, with interest rate pricing subject to project appraisal; commitment fee- up to 1%; front end commission – up to 1% on undisbursed amount; other fees, financial covenants, and security – negotiable. BSTDB financing would be conditional on the project appraisal, the overall financing plan, and satisfactory project arrangements. ICB rules may apply, however suppliers and contractors from member countries, such as Turkey, may receive a margin of preference on a case by case basis.

Another IFI, the European Investment Bank (EIB), Luxembourg, finances various types of capital infrastructure projects in the EU, Central and Eastern Europe, the FSU and elsewhere, including Turkey. The Shaw Group/Stone & Webster contacted the EIB who reported that they are looking at supporting renewable energy projects which should have a minimum total project cost of EUR 20 million. The EIB has financed in Turkey certain municipal water infrastructure projects, a gas storage project, an education loan, various transportation projects, and a TEAS interconnection project with Syria. The EIB provides long-term financing of 7 to 12 years maturity including 2 to 3 years grace period.

(D) Equity

Lenders under a Project Finance approach are expected to require at least a 75% debt/ 25% equity structure. Equity is to be provided by the Guris Group and possibly by 3rd party investors. Assuming a 25% equity component for this project, the equity portion would approximate $ 12.5

million. Alternatively, Gurmat, the project company, may elect to borrow 100% of project costs under a Corporate Risk approach, and thus not require equity support from outside investors.

Two international financial institutions that support or back-stop equity investments are OPIC and MIGA. These institutions could support 3rd party cross-border investors to the project.

The Overseas Private Investment Corporation (OPIC) is a U.S. government agency that offers financing and equity investment insurance. OPIC insurance covers generally against political violence, expropriation and currency inconvertibility. OPIC insures equity investments by U.S. investors and supports equity investment funds. The Shaw Group/Stone & Webster contacted OPIC which said that they would be interested in supporting the project.

An equity investment fund supported by OPIC and available for projects in Turkey is the Soros Investment Capital, Ltd. Fund. The fund would need to review the particulars of the subject project and determine expected equity returns to its investors. This fund is managed by Soros Private Funds Management LLC who are also organizing a new fund which would be available for projects in Turkey; this fund is to be called the Soros-Bedminster Fund.

Another international finance agency that may be of assistance to the project in raising equity is MIGA – Multilateral Investment Guarantee Agency, an arm of the World Bank. MIGA promotes private investment in developing countries and specific projects by offering support to equity investments in new start up companies and projects, or expansions, modernizations or privatizations. MIGA is open to support investments in Turkey by cross-border investors. For investments less than $25 million an application fee of $5,000 is charged. MIGA's premium would be established upon the completion of an analysis of the project, but a range of 50 basis points to 2% could be anticipated. A stand-by commitment fee of 30% of the premium is charged on the undrawn balance of the equity funds to be invested. MIGA covers investors against defined political risks which include expropriation, political violence, civil disturbance and currency transfer risks. The Shaw Group/Stone & Webster contacted MIGA which said that they would be interested in supporting the project.

5.4 Summary and Conclusion

The Financial Plan developed by The Shaw Group/Stone & Webster presents a comprehensive program for the proposed geothermal project. The Shaw Group/Stone & Webster contacted official Export Credit Agencies, Multilateral Development Banks, Commercial Lenders, International Financial Institutions and potential Equity participants; their expected terms and conditions are stated herein. The most viable and time sensitive financing strategy would indicate a Corporate Risk structure utilizing the financing programs of the ECA's, Commercial Lenders, and possibly supplemental financing from an MDB/IFI such as the Black Sea Trade and Development Bank. The Shaw Group/Stone & Webster has developed a Financial Plan which recommends the most efficient financing strategy in order to proceed with the geothermal

electric power project. Financial institution funding sources and amounts will be dictated by respective country sourcing of engineering, equipment and services.

6.0 POLITICAL VIABILITY

6.1 Turkish Energy Policy

There were many changes at energy market in Turkey in a few years period and a new law as a number of 4628 is in force. The objective of this law is to establish a financially viable, stable, transparent and competitive energy market, which will function as per the provisions of private law and ensure independent regulation and supervision of the market in order to provide sufficient electricity in a good quality, at low cost, in a reliable and environment friendly manner.

The Electricity Market Regulatory Authority was established as per Law no. 4628 and it was later on renamed as Energy Market Regulatory Authority as per the provisions of Natural Gas Market Law no. 4646. Members of the Energy Market Regulatory Board assumed duty on November 19, 2001.

The Electricity Market Law[1] (The Law) has created the necessary legal framework for the introduction of a competitive environment to ensure the adequate, efficient, and continuous provision of high quality, low cost electricity to consumers. In this regard, the Law foresees the establishment of a market model based on bilateral contracts between market participants and a balancing and settlement mechanism.

The realization of the market model envisaged in the Law necessitates a privatization process in line with the market objectives and the formation of a freely negotiable supply margin. Within this context, the establishment of a non-discriminatory, competitive and transparent market structure is of central importance. As market risks are minimized through regulations, confidence is established and the market is liberalized gradually based on a schedule, it will become more appealing for foreign and domestic private investors.

Overview of the Market Structure

The Law envisages a bilateral contracting market complemented by the Market Financial Reconciliation Center. Licensing is the method chosen for market entry. System access is regulated.

Bilateral contracts, which are one of the major components of the market model, are agreements whose terms and duration are freely determined by parties and are subject to the provisions of private law.

[1] Electricity Market Law No 4628, Effective date 3 March 2001.

In reaching the goals envisaged for the competitive market, it is crucial that liberalization is realized not only on the supply side but also on the consumption side. The purpose of the bilateral contracts is for the customer's entire electric energy needs to be met by the supplier. This should also account for the changes in the customers' electricity demand over time. For this reason, it is necessary that the bilateral contracts are structured in a way as to match the customer's load profile as closely as possible.

No matter how sensitive an estimate is made in the beginning, the supply-demand balance foreseen in the bilateral contract may be disrupted due to changing conditions and unforeseen situations concerning either side. In this case, the transmission system operator (National Load Dispatch Center) shall ensure the final physical balance by making giving orders to generators to load or de-load, based on bids and offers submitted by generators. The Market Financial Reconciliation Center charges market participants for the balancing and settlement costs they caused.

Market Activities and Market Entrance

A license is an authorizing document that a legal entity should obtain from the EMRA in order to operate in the market. In order to operate in the market, legal must obtain the relevant license for each market activity and for each facility. Those legal entities who wish to be engaged in electricity generation in more than one facility under a single legal entity's name, may obtain only one of the generation, auto producer or auto producer group license types.

According to the Law, licensees may be engaged in the following market activities:

- Generation
- Transmission
- Distribution
- Wholesale
- Retail
- Retail Service
- Import and Export

The import and export activities to be undertaken by wholesale licensees and import activities to be undertaken by the retail licensees shall be regulated within the scope of their wholesale or retail licenses and no separate license shall be required.

Retail services and retail activities can be performed through a single license provided that the relevant provisions are included in the retail license.

The rights of the licenses within the scope of its license may not be transferred to third parties without Energy Market Regulatory Board (the Board) approval.

All legal entities who are subject to private law and applying for a license in order to operate in the market, are required to have been established as joint stock or limited liability companies in

accordance with the provisions of the Turkish Commercial Code no: 6762, and, if established as joint stock companies, all shares of the company must be registered.

Generation

The generation activity shall be performed by the state-owned Electricity Generation Company (EUAS), its affiliates, private generation companies, auto producers and auto producer groups.

The generation licensees may sell the generated electricity and/or capacity to wholesale licensees, retail licensees and eligible consumers through bilateral contracts.

EUAS and its affiliates: The state-owned legal entity, EUAS and its affiliates shall maintain the ownership of and operate all state-owned generation facilities. In compliance with the Provisional Article 6 of the Law, they shall sell the generated electricity to the Turkish Electricity Trading and Contracting Co. (TETAS) for a period of not longer than 5 years.

Private sector generation companies: are private sector legal entities subject to private law, that are engaged in the generation and sale of electricity at generation facility(ies) they own or have acquired through financial leasing or a transfer of operating rights. They may establish affiliate relationships with private sector distribution companies, without forming a control relationship. The total market share of any private sector generation company and its affiliates may not exceed twenty per cent of Turkey's total installed capacity published for the previous year.

Auto producers and auto producer groups: shall operate essentially to meet their own needs. However, they may be entitled to sell a certain amount, to be determined by the Board and not exceeding twenty percent of the total electricity they have generated in the previous calendar year, in the competitive market.

Transmission

The transmission activity in the market shall be performed by the Turkish Electricity Transmission Company (TEIAS). Holding the ownership of all transmission assets, TEIAS shall serve as the transmission system operator and the market operator. In this context, TEIAS shall be responsible for;

- Taking over all state-owned transmission facilities,
- Preparing transmission investment plans and executing them,
- Operating, repairing and maintaining the national transmission system,
- Providing transmission services on a non-discriminatory basis,
- Forming an infrastructure suitable for a competitive environment to ensure the formation and sustainability of an efficient, stable and economical system in the market,
- Safeguarding system access rights while meeting the third party demands for connection to and use of the transmission system,
- Preparing generation capacity projections,

- Operation of the Market Financial Reconciliation Center,
- Procurement of ancillary services,
- Determining the measures to be taken for emergency cases, making preparations for such cases, coordinating the preparations and instructing the related licensees through an emergency statement,
- Preparing and submitting the transmission and connection tariffs to EMRA within the framework of the provisions of the Electricity Market Tariffs Regulation[2] and the relevant communiqués,
- Carrying out international interconnection works.

Distribution

The distribution activity shall be performed by the Turkish Electricity Distribution Company (TEDAS), its affiliates and private sector distribution companies in the regions specified in their licenses. The responsibilities of distribution licensees are the following:

- The preparation of distribution investment plans for new distribution facilities,
- The construction, operation, enhancing, repair and maintenance of the new distribution facilities in compliance with the applicable legislation,
- Providing distribution services on a non-discriminatory basis,
- Safeguarding system access rights while meeting the third party demands for connection to and use of the distribution system,
- Keeping a database of updated records on consumers in their regions,
- Preparation of demand forecasts,
- In case there are consumers in their region who are unable to purchase electricity and/or capacity from another supplier, obtaining a retail license and providing retail sale and retail services to them,
- In case there is an eligible consumer who is being served by a supplier other than that region's distribution company with a retail license, and in case the activities of that other supplier are temporarily suspended or terminated because of legal reasons, providing energy and/or capacity to that eligible consumer until the consumer reaches an agreement on a bilateral contract with a new supplier,
- Preparing and proposing distribution and connection tariffs to EMRA within the framework of the provisions of the Electricity Market Tariffs Regulation and the relevant communiqués,
- Procurement and provision of ancillary services,
- In addition to the common provisions above, other provisions that a distribution licensee shall comply with are the following:
- TEDAS and its affiliates: In the initial period following the opening of the market, distribution and retail sale activities shall be mainly performed by the state-owned enterprise,

[2] Electricity Market Tariffs Regulation published in the Official Gazette dated August 11, 2002 numbered 24843.

TEDAS and its affiliates. But, TEDAS and its affiliates shall be reorganized as defined in the new market model and shall keep separate accounts for distribution and retail sale activities.

- Private sector distribution companies: Provided that they obtain a generation license, private sector distribution companies may set up generation facilities in the region specified in their licenses on the condition that the amount of the annual electricity they generate does not exceed 20 percent of the total amount of electricity offered for consumption in the relevant region within the previous year, or may establish joint ventures with legal entities holding generation licenses. However, private sector distribution companies may not purchase electricity from the generating company(ies) they own, or the generating company(ies) they are affiliated with, at an amount exceeding 20 percent of the total amount of electricity offered for consumption in the relevant region within the previous year.
- Distribution licensees may provide retail sale and/or retail services provided that they obtain a retail license.

Wholesale

The wholesale activity shall be performed by TETAS and private sector wholesale companies. The activities that wholesale licensees may perform within the scope of their licenses are the following:

- Wholesale of electricity and/or capacity and its direct sale to eligible consumers,
- Carrying out import and export activities in the market provided that their licenses include the relevant provisions.
- Along with these activities, a wholesale licensee shall be obliged to comply with other provisions:
- TETAS; is a public company that is assigned for addressing the stranded costs arising form arrangements under the previous regime. The responsibilities of TETAS within the scope of its license are;
- Operating in the market in a non-discriminatory manner,
- Taking over existing supply contracts for consumers directly connected to the transmission system, until the consumers choose their suppliers to sign bilateral contracts,
- Taking over import and export contracts,
- To offer contracts to cover its firm purchasing obligations
- Submission of offers and bids to the balancing and settlement market,
- Tendering for leasing of hydroelectric capacity,
- In case of an inability to meet its energy sales obligations, making new purchasing contracts based on least cost offers.
- As TETAS will initially have a dominant position in the market, it will be necessary for most of its activities to be regulated. Per Provisional Article 6 of the Law, regarding stranded costs, TETAS shall purchase electricity and/or capacity from EUAS and/or its affiliates via vesting contracts, for a period not exceeding five years, and sell energy and/or capacity to all legal entities and real persons in a non-discriminatory manner. The following items related to TETAS are subject to regulation;

- The bilateral contracts with distribution companies holding a retail license, retail and wholesale companies,
- Bids and offers made to the balancing and settlement market,
- If the need arises, that the additional energy is purchased from the most economical source,
- Private sector wholesale companies: The total share of any private sector wholesale company that is not subject to regulation, together with its affiliates may not exceed ten percent of the total energy consumed in the market in the previous year.

Retail and Retail Services

Retail and/or Retail Services are performed by retail companies and distribution companies holding a retail license.

The activities that may be performed by retail licenses are stated below:
- Sale of electricity and/or capacity to consumers in the market,
- Engaging in retail services,
- Engaging in import of electricity and/or capacity at the distribution level provided that their licenses contain the relevant provisions.

Retail licensees may be engaged in retail and retail services without any limitation of region.

Retail licensees, while purchasing energy for sales to non-eligible consumers, are obliged to purchase primarily from generation facilities based on renewable resources, if the price of the energy generated by such a facility is less than or equal to TETAS's wholesale price and a cheaper supplier cannot be found.

6.2 Renewable Resources

It is one of the duties of the BOARD to take the necessary measures for encouraging the utilization of renewable energy sources. In this respect, under Electricity Market License Regulation; 1- The legal entities applying for licenses for construction of facilities based on domestic natural resources and renewable energy resources shall only pay 15 of total licensing fee, 2- the generation facilities based on renewable energy resources shall not pay annual license fees for the first eight years following the facility completion date approved in their respective licenses. 3- TEIAS and distribution licenses shall give priority in system connection of generation facilities based on renewable resources.

In the framework of new marked model, alternatives for the encouragement of renewable resources has been established by a separate law (YEK law). By YEK law; 1- distribution companies have to take the renewable energy up to 8% of their capacity. 2-energy sale price will be the TETAS sell price and government has the right to increase this price up to 20%. 3- Some advantages for land lease are improved to the benefit of renewable energy sources.

6.3 Long Term Energy Demand

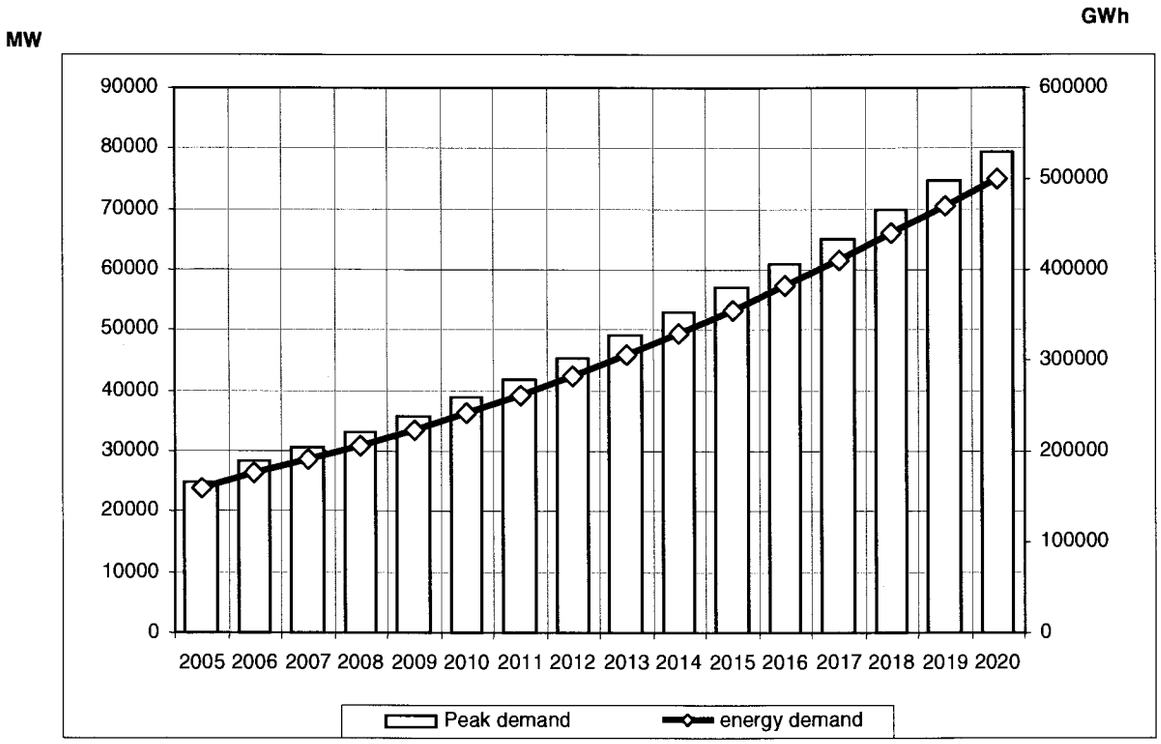
The studies carried out by Ministry of Energy and Natural Sources for future energy demand and capacity planning is indicated in the following table and the graph. In this study the generation of plants under construction and licensed by EMRA to be completed from 2005 up to 2010 are

considered. Those plants are considered to be operated in full capacity from starting date of commissioning.

Table1 : Future Energy Demand

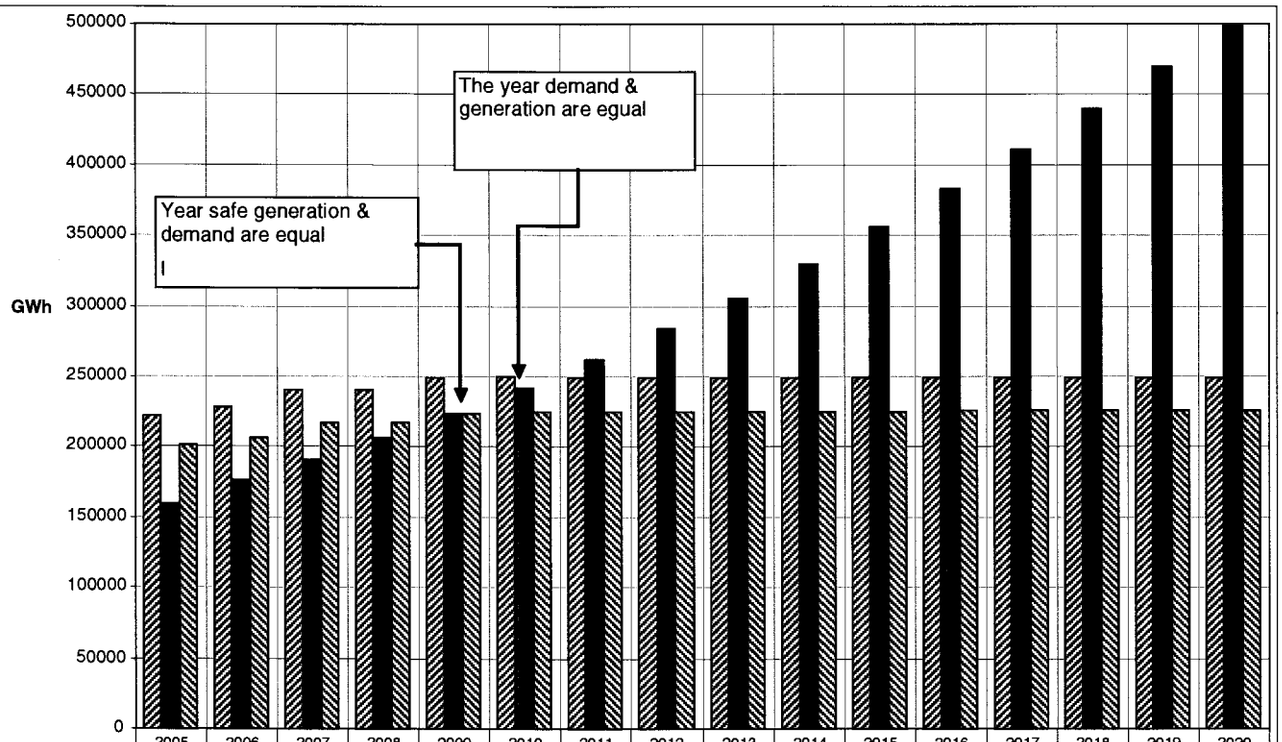
YEAR	PİG DEMAND		ENERGY DEMAND	
	MW	İncrease (%)	GWh	İncrease (%)
2005	25000	-	159650	-
2006	28270	13,1	176400	10,5
2007	30560	8,1	190700	8,1
2008	33075	8,2	206400	8,2
2009	35815	8,3	223500	8,3
2010	38785	8,3	242020	8,3
2011	41965	8,2	262000	8,3
2012	45410	8,2	283500	8,2
2013	49030	8,0	306100	8,0
2014	52905	7,9	330300	7,9
2015	57050	7,8	356200	7,8
2016	60845	6,6	383000	7,5
2017	65245	7,2	410700	7,2
2018	69835	7,0	439600	7,0
2019	74585	6,8	469500	6,8
2020	79350	6,4	499490	6,4

Figure 1: Energy Demand



The planned energy need is considered to be met by the existing generating units and the plants under construction and the plants licensed. The following figures show the generation and demand conditions and the capacity increase plan of future projection.

Figure 2: The influence of safe production capacity of existing, licensed , under construction plants to the energy demand.

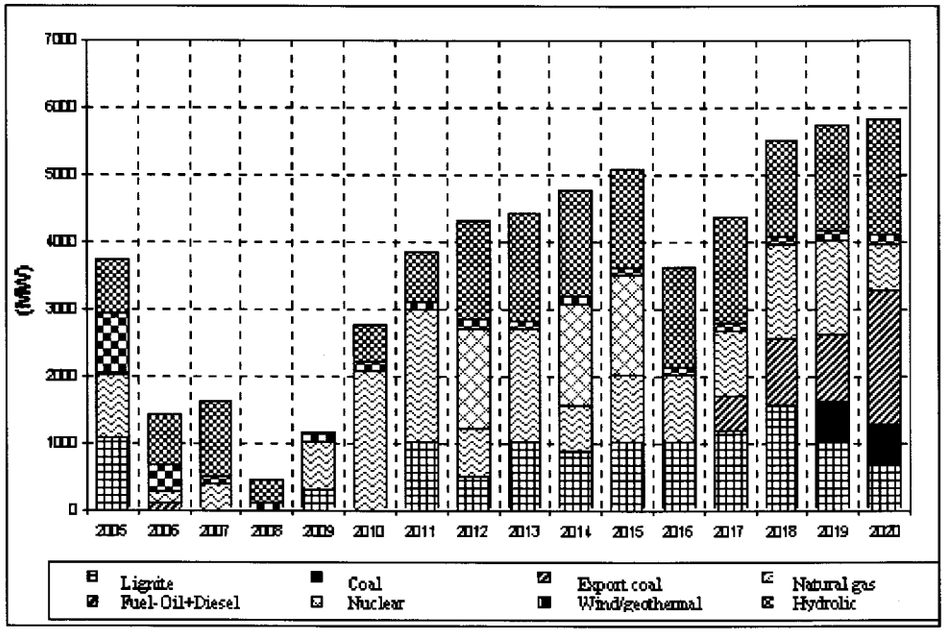


	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Production capacity	222371	228512	240426	240864	249278	249869	249058	249356	249356	249356	249356	249356	249356	249356	249356	249356
Demand	159650	176400	190700	206400	223500	242020	262000	283500	306100	330300	356200	383000	410700	439600	469500	499490
Safe production capacity	201168	206457	216821	217166	223957	224708	224071	224545	224720	224895	225070	225245	225420	225595	225770	225945

Renewable wind/geothermal energy is considered to be reached to a capacity of 1750Mw including already licenced capacity of 1269MW.

The proposed additional generation capacity and the classification of these capacities according to primary energy sources are shown by the following Figure 3 .

Figure 3: Additional generation capacity and the classification of these capacities



7.0 LICENSES AND PERMITS

The following licenses and permits are required for the execution of the project. Gurmat will obtain the necessary documents.

LICENSE / PERMITS AND GENERAL CLASSIFICATION

1 **EMRA LICENSE**

2 **MILITARY PERMIT**

3 **EIA APPROVAL**

4 **CIVIL WORKS PERMITS**

A **Jobsite Permits**
- A.1 Opening of Job Site
- A.2 Excavation-Road-Canal Opening
- A.3 Temporary Site Buildings,
- A.4 Facilities/Site Waste Water

B **Mapping Permits**
- B.1 Topographical Map
- B.2 Shore Line

C **Plan Changes and Site Survey**
- C.1 1/25000Coastal Area Plan Change
- C.2 1/5000 Master Plan
- C.3 Geotechnical Report
- C.4 1/1000 Application Plan
- C.5 Off-Shore Structures and Integral Parts Plan
- C.6 1/1000Parcellation Plan

D **Building Permits**
- D.1 Examption of Technical Buildings from Construction Permit
- D.2 T Road Connection
- D.3 Drawing Approval (MENS)
- D.4 Construction Permit of the non-technical buildings
- D.5 Off-shore Structures Building Permit

5 **MINISTRY OF HEALTH PERMITS**

A **Job Site Waste Water**

B **Job Site Solid Waste**

C **Site Selection**
D **Preliminary Emission**
E **Facility Permit**
F **Cooling Water Discharge**
G **Waste Water Discharge**

6 **OTHER PERMITS**

A **JOB SITE UTILILITIES PERMITS**
A.1 Under Ground Water Permit
A.2 Telephone Connection
A.3 Diesel Station
A.4 Temporary Electric Connection
A.5 Wireless Communication

B **WORK & RESIDENCE PERMIT**

C **OVERHEADLINE PERMITS**
E.1 OHL EIA Approval
E.2 OHL Expropriation Works
E.3 OHL Project Approval

The EMRA License listed above is required by the Turkish energy regulatory authorities to build an energy generating plant and to sell electricity.

The Military Permit is required to indicate that there is no military restriction on the jobsite.

The EIA Approval is required to show that all environmental regulations have been identified and will be met.

Other items in the table above are self explanatory.

8.0 SCHEDULE

A schedule is included as Attachment 8.1 and is also Appendix J to the Brine Gathering section of the report. As shown, the long lead item will be the Turbine Generator. Quoted delivery to the site is approximately 16 months after receipt of order. It is imperative that work begin very soon on the procurement phase of this equipment if the Client's deadline of June 23, 2007 for commercial operation. As can be seen, other efforts are also necessary to insure that the schedule is met. These include the project financing effort, long term well testing, procurement of the Main Generator Step-Up Transformer and procurement of the brine injection pumps.

9.0 COST ESTIMATE

The cost estimate has been deleted from this copy.

10.0 IMPLEMENTATION PLAN

A three day meeting was held on August 10-12, 2005 at the offices of Stone & Webster International in Denver, Colorado to review the Draft Feasibility Report and to plan a future course of action for the project. Attendees at the meeting included representatives from Gurmat, Stone & Webster International and its subcontractors Geologica, Veizades, and Global Power Solutions. The draft report was reviewed and cost estimates and cash flow analyses were discussed.

An implementation plan for actions to be taken in the 90 days following the meeting future was outlined. This plan includes the following tasks:

Gurmat will immediately begin to acquire the land necessary for the power plant as well as that for the pipelines. In addition, Gurmat will apply for the permits listed in Section 7 of the Stone & Webster part of this report. Gurmat will also begin to acquire the equity funds necessary to finance the near term work.

The project team will develop proposals to support the following activities:

- Long Term Flow Tests – The requirements and plan for long term flow testing of the wells is described in Appendix H of the Geologica part of this report. A proposal to execute this plan is in preparation.

- Environmental Document Modification – The existing EIA (environmental report) is based on building a binary type power plant. This document must be updated for the dual flash unit proposed. A proposal for this work will be sent to Gurmat.

- Geotechnical Report – Although some borings were taken and the results analyzed to support this study effort, a more complete geotechnical study and report will be required before the exact site for the facilities can be characterized to allow proper foundation design.

- EPC Contract – An EPC Contract must be developed for the design and construction of this 25.2 MW net (33 MW gross) power plant, gathering system and resource development including drilling of new wells.

Gurmat, with the assistance of Stone & Webster will be seeking project financing in the next 90 day period. In the meantime, it is expected that interim financing will be necessary to support the above activities as well as the following:

- Early selection of a turbine vendor and authorization for such supplier to proceed with early engineering and placement of an order for the material for the turbine rotor forging

- Early selection of other long lead equipment
- Start of Engineering and Design activities on the part of the project team.

11.0 DEVELOPMENTAL IMPACT ASSESSMENT

The Germencik geothermal project will provide many socio-economic benefits to the country, the region, and local towns. The benefits include development of new infrastructure, employment, technology transfer, environmental, economic, and perhaps food production.

The project will provide a source of clean, reliable, economical, indigenous electric power. It will reduce the country's reliance on foreign oil and gas for power generation, and in so doing, should help Turkey's balance of trade and their currency value.

The project will also bring the country forward in the development of its geothermal resources, in which case it could be a catalyst for further development, having similar benefits. The success of this project should reduce the perceived risk of development elsewhere in Turkey. This power plant will provide voltage support to the power grid in the region and improve reliability of the power supply. In the future, the power generation from this resource could increase to nearly 100 MW.

The project will provide employment for many years. Construction of the project will employ many laborers, both skilled and unskilled for approximately 18 months, with a peak demand for personnel as high as 100 people. The project will then need a staff of 30 to 40 people of various trades to operate for 37 years. In addition, other services will be needed in the form of consultants and temporary workers.

The project will be a state-of-the-art geothermal facility, based on technologies developed around the world to make geothermal plants very efficient and reliable sources of electric power. Engineers and others in Turkey can learn from this plant how to build other facilities that are equally efficient and reliable.

The project provides a very clean source of power, with relatively low emissions. This has advantages to Turkey vis-à-vis the Kyoto Protocol. Adding geothermal plants will aid the country environmentally, by allowing it to eventually retire units in the electrical system that have higher emissions.

The project has the potential to provide heat for a greenhouse or similar agricultural facility. This would support food production and economic gains in the region. A greenhouse can extend the growing season and increase crop yields, thereby providing more produce at a lower cost and of higher quality.

12.0 SUMMARY AND CONCLUSIONS FOR POWER PLANT

The team selected a double flash unit for this project as we considered this to be the best balance between cost and efficient performance. This is the most common arrangement used in the industry for a liquid dominated resource at the demonstrated temperature and pressure. In addition we decided on a top discharge turbine with the condenser mounted beside the turbine. For a unit of this size this is a practical approach which avoids having to build an expensive turbine pedestal. Three manufacturers have provided quotations for the turbine and all have experience with turbines of this general design.

The resource at Germencik is very similar to the resource at Kizildere, a neighboring geothermal plant. The resource is very low in dissolved salts but high in non-condensable gases. Large quantities of non-condensable gases, particularly CO_2, will flash off the brine with the high pressure steam. This gas will be carried through the turbine into the condenser and will be removed from the condenser by a combination of steam jet ejectors and vacuum pumps. These will send the gases to the cooling tower where they will be disbursed in the atmosphere with the cooling tower vapor. Because of the large quantity of gas, the ejectors and vacuum pumps will be large and expensive. Ultimately, the best way to handle the gas would be to send it to a gas bottling plant. This however is in the future.

After the high pressure steam has been flashed from the brine, the residual brine will be taken to a low pressure flash tank to remove additional energy in the form of low pressure steam for the turbine. After both low and high pressure steam has been flashed, there is still an appreciable amount of thermal energy left in the brine. This energy may be used in the future to provide heat to a greenhouse or other user.

The additional innovative use of non-condensable gas and thermal energy described above, could provide additional revenue streams for the Owner in the future.

The equipment for the power plant is all readily available on the market and there are no special requirements. Materials will be standard with no exotic alloys required. Stainless steel will be used in some applications but nothing more exotic such as Hastelloy or Inconel which are required in some liquid dominated applications.

Three manufacturers were requested to furnish bids on the turbine-generator, Fuji, Toshiba and Ansaldo. All replied with reasonable proposals. Pricing and delivery was approximately the same for all three. For simplicity we have chosen to present data and information based on the Fuji submittal. The schedule for delivering the Turbine-Generator appears to be a bit long, however, we believe we can negotiate a better delivery once the project is authorized.

The turbine will be the longest lead item for the power plant and the completion schedule will revolve around this item. For this reason we suggest that a source of funding be identified early which would support a program to negotiate for the turbine supply and allow the selected turbine

manufacturer to proceed with their engineering as soon as possible. The turbine supplier may be willing to do a limited amount of work at his own risk.

As has been stated as conclusions in the resource and gathering system sections of this report, we believe that the resource is well suited to development for the generation of electrical energy. Long term testing will be required to provide the information necessary to determine the maximum available energy from the resource and to define the resource boundaries. These tests are planned for late 2005. There are no apparent insurmountable obstacles to transporting the brine from the wells to the plant site for separation.

The need for new wells, both production and injection has been discussed elsewhere. Again we see no apparent obstacles to extracting the energy necessary for providing the power plant with steam for the generation of 33 MW gross which will be required to produce 25.2 MW net.

and partitioned rooms with hollow walls shall be flush mounted in outlet boxes, with coverplates to match other hardware.

Local switches shall be specification grade for lighting circuits in offices, laboratories, control room, and partitioned rooms.

Receptacles shall be specification grade, duplex, two-pole, three-wire, grounding type for 125v, 20A Service.

Photoelectric cells shall be designed for automatic quick response switching of outdoor lighting loads or contactor coils. Operating level will be preset for turn-on at 1.5 ±0.6fc and turn-off at 6 to 10 fc when the control voltage is 120v. The enclosure shall be fitted with locking type plug and shall be of non-corroding, nonconductive material.

4.3.3.7 Installation

Installation of the lighting system shall be in accordance with the installation specification and the latest edition of the National Electrical Code, unless otherwise noted.

The lighting shall be designed for early installation to facilitate the use of portions of the permanent system during construction.

Fluorescent fixtures may be hung on chains attached to each end of the fixture. The cord from the fixture shall be hard wired.

Fixtures shall be placed away from critical equipment.

Recessed fluorescent fixtures shall be double-suspended, i.e., from suspended ceiling and from structure.

Sufficient interleaving and inter-spacing of both parallel a-c lighting and parallel emergency a-c lighting shall be provided to prevent the total loss of lighting in critical areas.

4.3.3.8 System Voltage Range

The a-c lighting system will be designed to operate with a ±10 percent voltage variation.

4.3.3.9 System Operation

The normal and emergency a-c lighting system is normally operating during all modes of plant operation including the relay, switchgear rooms and adjacent related areas. On loss of normal a-c power, a-c emergency lighting remains energized, and is transferred to the emergency source.

4.3.3.10 Safety Considerations

Emergency lighting shall meet the requirements of NEC article 700-D.

The levels of illumination listed in the lighting tables (Appendix 8.4-3) provide greater than the minimum levels required where safety is related to seeing conditions.

4.3.4 Maintenance

The Constructor shall maintain the system until final turnover.

Preventive maintenance should include group re-lamping of areas before the end of the average rated life of the lamps, instead of spot re-lamping only as individual lighting elements burn out. Also periodic cleaning of lens, fixtures, lamps and tubes can maintain the average light intensity at the design level. All maintenance and cleaning of lighting system components will be done in accordance with manufacturers' recommendations.

Design of the lighting systems shall permit routine testing without disrupting normal service. The self-contained units shall be provided with local test switches to simulate loss of normal a-c power.

Lighting Tables

The following tables show the illumination level* and type of fixture by building and area:

Switchgear and Related Areas	I
Turbine Building	II
Misc. Buildings and Areas	III
Outdoor Areas	IV

* Illumination level is shown as the minimum foot-candles required for a task and as average foot-candles for an area.

TABLE I

Control Building (PDC)

Area	Foot-Candles	Fixtures
Levels and Landings	5	Fluorescent
Switchgear Room	35	Fluorescent
Relay Room	80	Fluorescent
HVAC Area	20	Fluorescent
Battery Room	20	Fluorescent

TABLE II

Turbine Building

Area	Foot-Candles	Fixtures
Levels, Landings, and Corridors	5	(Enclosed & Gasketed) HPS
Ground Floor	20	(Enclosed & Gasketed) HPS
Turbine Oil Room	20	(Enclosed & Gasketed) HPS
Operating Level	35	(Enclosed & Gasketed) HPS

TABLE III

Miscellaneous Buildings and Areas

Location	Foot-Candles	Fixture
Circulating Water Pump Area	30	(Enclosed & Gasketed) HPS

TABLE IV

Outdoor Areas

Location	Foot-Candles	Fixture
Main Entrance	5	(Enclosed & Gasketed) HPS
Roadways	1	(Enclosed & Gasketed) HPS
Parking Areas	2	(Enclosed & Gasketed) HPS
Switchyard (General) (Disconnects)	 0.2 2.0	(Enclosed & Gasketed) HPS
Tanks	1	(Enclosed & Gasketed) HPS
Cooling Tower	5	(Enclosed & Gasketed) HPS

4.4 Grounding System

The grounding system will consist of the interconnected grounding conductors and ground electrodes necessary to provide an adequate electrical connection to earth. The grounding system will minimize shock hazards to personnel and will provide a ground path for a-c system faults and direct stroke lightning currents.

The plant and switchyard will have a ground grid designed to IEEE standards.

The turbine structure and PDC will have a ground system installed which will be tied by two ground conductors to the substation grid.

The metal enclosure or frame of all electrical equipment, the air terminals of lightning protection systems, building steel and other metallic objects which could become energized will be connected to the grounding system.

This section also includes methods to be used for the grounding of instruments.

The grounding system layout shall be approved by the Owner.

DEFINITIONS

Ground	-	A conducting connection, whether intentional or accidental, by which an electrical circuit or equipment is connected to the earth or to some conducting body of relatively large extent that serves in place of the earth.
Grounded	-	Connected to earth or to some extended conducting body that serves in place of the earth, whether the connection is intentional or accidental.
Ground connection	-	A connection used in establishing a ground and consisting of a grounding conductor, a grounding electrode, and the earth (soil) which surrounds the electrode.
Ground conductor	-	A conductor providing an electric connection between part of a system, or the frame of a machine or piece of apparatus, and a ground electrode or a ground bar.
Ground electrode	-	A conductor or group of conductors in intimate contact with the earth for the purpose of providing a connection with the ground.
Ufer Ground	-	A system used in establishing a ground by utilizing steel reinforcing bars in concrete foundations.
Ground grid	-	A system of grounding electrodes consisting of interconnected bare cables buried in the earth to provide a common ground for electric devices and metallic structures.

4.4.1 System Requirements

4.4.1.1 Codes and Standards

The grounding and lightning protection systems will be designed and installed in conformance with the latest versions of the following codes and standards:

National Electrical Code Article 250	Grounding
NFPA No. 78	Lightning Protection Code
IEEE 80	Safety in a-c Substation Grounding
IEEE 142	Grounding of Industrial and Commercial Power Systems
NESC	National Electric Safety Code

4.4.1.2 System Grounding

System grounding consists of the connection of the neutral or one of the normal current-carrying conductors of the power system to ground, for the purpose of enhancing overvoltage and short circuit protection. Such connections will be effected at various points and they may be connections of no intentional impedance such as solid grounding, resistance such as low or high resistance grounding, or inductance such as reactance grounding.

The 13.8 kV generator will be resistance grounded through a distribution transformer.

4.4.1.3 Medium Voltage System-6.3 KV

The medium voltage system grounding will consist of low resistance grounding of the system neutral. Each of the medium voltage source neutrals, such as transformers, will be connected to ground through a resistor.

The low-resistance method will have the advantage of immediate and selective clearing of the grounded circuit but also will require that the minimum ground-fault current be large enough (400A) to positively actuate the applied ground-fault relay.

4.4.1.4 380V System

The 380 V 3-phase, 3-wire system will be wye connected and low or high resistance grounded.

Individual motors less than 25 kw will be grounded through the raceway system. Where this is impractical, or fault current could exceed raceway current rating, a separate ground conductor will be installed. Where motors are remote from the station grounding system, a ground rod will be installed.

4.4.1.5 220/380V System

The 308/220 V three-phase system neutral will be solidly grounded at the various sources of supply.

4.4.1.6 D-C System

The d-c system will be ungrounded. Ground tracing features will be used to detect and alarm unintentional connections to ground.

4.4.1.7 Main Generator Neutral

The unit-connected main generator neutral will be grounded through a high-resistance arrangement. This method consists of connecting the generator neutral to the primary winding of a sealed, dry type, two-winding, single-phase distribution transformer, with a primary rating equal to the generator line-to-neutral voltage nearest standard voltage rating, and a low voltage, high-current resistor connected to the transformer secondary winding.

4.4.1.8 Structural Steel

Structural steel will be grounded in accordance with NEC. Steel structural members which will be isolated from ground because of the building design will be connected to the nearest grounded structural steel member or directly to the grounding system by cable.

Where overhead high voltage conductors and ground wires are secured to a building, ground cable will be installed from the station grounding system to each point of cable attachment on the building.

4.4.1.9 Motors

All local motors 25 kw or smaller will use the conduit system for ground fault current return. When conduit is not used, a ground conductor equal in ampacity to the phase leads will be provided for motor frame grounding. In addition, 6.3 Kv motors and remotely located motors will have a driven ground rod. In addition, they will be grounded to the raceway, where feasible. Where non-metallic raceway is used, the cable feeder to the motor shall have a fourth grounding conductor (half size) to which the motor frame shall be grounded.

4.4.1.10 Switchgear

The ground bus in metal-clad switchgear, load centers, and motor control centers will be connected to the station grounding system at each end by ground cables. Switchgear, load centers, and motor control centers will be provided with a fault current return path grounding conductor; rigid conduit or the ground cable in the cable tray will be used.

4.4.1.11 Raceways

A ground cable (No. 4/0 AWG copper) will be laid in all trays containing power cables. The ground cable will be fastened to tray rungs in the same manner and at the same intervals as the power conductors. The ground cables will be routed through wall and floor sleeves, as required, to make a continuous run. Where a metallic sleeve is used to enclose a grounding conductor, each end of the sleeve will be connected to the ground conductor.

Sections of the tray shall be jumpered with a green insulated wire to provide ground continuity in the tray system. The connection of the jumper wire to the tray shall be given special consideration as a point of possible corrosion.

In the non-remote areas, hot dipped galvanized conduit between equipment or between cable tray and equipment will provide a ground fault current return path when properly connected. Conduit ground connections to equipment will be made with a threaded hub, boss, or two locknuts, one on either side of the box or cabinet. Conduit ground connections to cable tray will be made with a non-insulating type grounding bushing on the conduit and a bonding jumper to the ground conductor within the tray. The size of the bonding jumper will be the largest the bushing can accommodate. All flexible conduits will be jumpered with a bare conductor, using a green insulated wire.

Conduits shall be bonded to metallic tray, or to the copper ground conductor the tray.

Each duct bank containing power cables will have two bare tinned copper grounding conductors laid on top of the duct enclosure.

4.4.1.12 Piping and Tanks

Metallic underground piping and fixed piping of the fire extinguishing systems will not be connected to the station grounding system, unless cathodic protection is required.

Metal tanks shall use a ground rod with PVC protected copper, 4/0 cable attached to above ground steel.

4.4.1.13 Fence and Rail

4.4.1.13.1 Fences for the substation will be connected to the grounding system. Fence posts will be connected at intervals of approximately 50ft to a parallel tinned copper ground conductor buried 3ft outside the fence. Posts on each side of a gate or removable fence section will be bonded together below grade. For each permanent gate, a potential grid will be installed.

Crane rails will be connected to ground and rail joints and will be jumpered.

4.4.1.14 Building Lightning Protection and Grounding

The following lightning protection and grounding requirements shall apply:

1) Turbine Structure

- Shall be protected from lightning by Air Terminals located on light poles and tied directly to the ground system.
- Grounding shall be by redundant conductors to the switchyard mat.
- Stator housing and neutral grounding transformer downcomers on turbine pedestal shall be grounded to the substation grid via cable in PVC conduit.

2) Cooling Tower

- Lightning protection shall be provided by properly located air terminals.
- All motors shall be provided with adequate ground connections. Each motor will carry a ground conductor routed through tray.

3) Modular Equipment Buildings

- No lightning protection is required.
- The PDC will be surrounded by a ground loop which will in turn be grounded with two ground rods and connected to the switchyard grid.

4) Vessels

- No lightning protection is required.

- Vessels shall use a ground rod with a 4/0 copper cable (insulated) tied to above ground steel. 19 mm PVC shall be used to protect the cable. (This alternative is necessary because of epoxy coated rebar.)

5) Pipe Racks

- Ufer grounded, every other column. Rebar may be tied directly to anchor bolts.

6) Switchyard

- Lightning protection shall be by static wires.

- An underground ground-grid shall provide ground protection The ground grid shall consist of 316 stainless steel, one inch diameter ground rods, 10 feet in length tied together with tinned copper ground conductors. All connecting points shall be coated.

4.4.1.15 Disconnect Switches

The operating position for the 154 kV hand-operated disconnect switch will be protected from voltage potentials arising between the switch handle and ground by a copperweld wire mesh grounding mat buried 100 mm. below grade, or a metal grating located at or above finished grade where a person stands to operate the switch. No point within the protected area will be more than 75 mm from the mat. The mat will be connected to the grounding grid at the same point as the switch supporting structure.

4.4.1.16 Electronic Control Systems

The following procedure will be implemented unless manufacturer's instructions are to the contrary.

Terminal cabinets, control panels and consoles involved with electronic signals will require two grounding systems as follows:

1. Safety Ground: Grounding bus is attached to cabinet and panel structures.

2. Signal Ground: Instrument cable shielding and instrument signal reference ground attached to this bus.

In loops containing multiple instruments, the shields of all cables used in the loop should be connected together and connected at only one point to the shield ground bus, at the signal source cabinet. Intermediate terminal boxes for signal wiring are unacceptable.

The signal ground shall be isolated from the safety ground with the exception of a single point of connection. The design shall prevent ground loops in the signal ground system.

Grounding of the equipment ground bus will be made by directly connecting to the station grounding system. System specifications should advise the manufacturers of the intent to ground shields and cabinets in this manner.

4.4.1.17 Lighting

All lighting circuits will be grounded in accordance with the National Electrical Code.

4.4.1.18 Miscellaneous

All miscellaneous items not included in these criteria will be grounded in accordance with the National Electric Code.

4.4.1.19 Component Design

The size of each medium voltage (6.3 KV) system neutral grounding resistor will be such as to limit the fault current through the source neutrals to a minimum of 400A.

The station grounding system cable shall be tinned copper for underground and bare copper for indoor applications. For outdoor applications above ground, the grounding system cable shall be stranded, insulated copper. Where a grounding cable is used for both indoor and outdoor applications, the entire cable shall be as dictated by the outdoor application.

Ground rods shall be 3 m in length and 25 mm in diameter, 316 stainless steel.

Ground wells shall consist of 316 stainless steel50 mm, schedule 160 pipe. For convenient access the pipe shall be installed in a 250mm concrete pipe or plastic box with removable cover, standard water meter box is acceptable. No coke breeze fill shall be utilized.

Where ground cable in concrete crosses expansion joints, the cable shall be wrapped with burlap and painted with asphaltum or wrapped with polyethylene. The ground cable shall be wrapped a distance of 460 mm. either side of the expansion joint.

All grounding connections shall be by the compression type, or of a clamping or crimping type approved by the Owner.

4.4.1.20 Arrangement

The station grounding system's general arrangement shall be shown on the drawings.

4.4.1.21 Construction Notes

Continuity of the station grounding system shall be verified during construction. After construction, ground resistance to remote earth will be measured and compared with computed value, and proper corrective action shall be taken by the Constructor, should the measured value be substantially higher than one ohm.

4.4.1.22 System Reliability

The reliability of the system shall be ensured over the life of the plant, as long as the conductors are of adequate size, all joints are made up tightly, and scheduled testing is performed.

4.4.2 System Limitations, Set Points and Precautions

Resistance of the station grounding system to remote earth shall be a maximum of one ohm.

4.4.3 Operation

The station grounding system is passive. No human, mechanical, or electrical control or operation will be required. Its functions are protective, preventing harm to personnel and damage to equipment or structures.

4.4.4 Safety Considerations

Electric shock accidents are caused by the coincidence of the following unfavorable factors:

1. High ground fault current in relation to ground resistivity.

2. Distribution of ground fault current such that high potential differences are possible.

3. Presence of an individual at such a place and time and in such a position that his body bridges two points of high potential difference.

4. Absence of sufficient contact resistance or other series resistance to limit current to a safe value.

5. Duration of the fault and body contact for a sufficient time to cause harm at the given current intensity.

Accidents of this nature are infrequent because of the low probability of coincidence of all five conditions. The probability of coincidence will be lowered in the following manner. The ground grid shall have a low enough resistance such that the maximum short circuit current results in a ground grid potential below safe values. All metallic structures or equipment which might accidentally become energized shall be connected to the grid in order to prevent the possibility of high potential differences. Clearing of faults shall be provided in a reasonably fast time to limit the duration of current flow. Where it is impractical to eliminate the possibility of excessive potential differences during faults, personnel access shall be barred or limited.

4.4.4.1 Ground Fault Risks

The following situations are considered potentially dangerous in terms of personal ground fault risks, and receptacle circuits in these areas should be protected by GFCIs:

- All outdoor locations accessible from grade level
- Brine Processing Area
- At outside transformers and switchyard area
- Cooling tower
- Rooms with metal floors

EQUIPMENT GROUNDING

Service	Number Required	Wire Type
Medium Voltage A-c Motors	1	120 mmcopper
Load Centers and MCCs	2	120 mm
Medium Voltage Switchgear	2	120 mm
Power and Control Cable Tray	1	120 mm copper
Instrument Cable Tray	1	120 mm Main Step-up
Transformer	2	120 mm copper
Station Service Transformer	1	120 mm copper
Auxiliary Transformers	1	120 mm
Lighting Transformers	1	70 mm
Structural Steel Column	1	120 mm
Main Generator	4	120 mm
Non-Segregated Phase Bus (Following mfr's instructions)	1	120 mm copper
Control and Relay Boards	2	120 mm

Lighting Panels	1	70 mm
Crane Rails, Fences	1	120 mm Tank and
Pressure Vessels	1	120 mm
Computer and Other Electronic Control	1	70 mm Signal Systems
	1	120 mm
Stairways, Handrails, Gratings (If isolated)	1	120 mm
Lightning Arresters (per pole)	1	No. 336.4 KMC
Lightning Rods and Air Terminals	2	No. 336.4 KMC
Inverters	1	70 mm
Chargers	1	70 mm
Small Low Voltage Loads	1	16 mm

4.5

Communications System

Communication shall be by telephone, internet connection and radio.

4.6 Metering and Relaying

4.6.1 System Requirements

The station electrical protection consists of protective devices or relay systems which monitor the electrical characteristics of the station equipment and/or power system to assure operation consistent with designed parameters, as follows:

1. Initiate the removal from service of any piece of equipment which has sustained a short circuit.

2. Provide automatic supervision of manual and/or automatic operations which could jeopardize the safe operation of the station.

3. Initiate automatic operations and/or switching which may be required for the continued safe operation or shutdown of the station.

The station electrical protection described in these criteria applies to the main generator, transformers, and auxiliary station service system for a geothermal, steam-turbine generating plant and shall be shown on the one-line diagrams by the Engineer.

The station electrical protection shall be designed to accept a single assumed failure so that the failure does not result in the loss of the capability of the protection to perform its desired functions.

The station electrical protection shall be designed to provide minimal clearing times in order to limit short circuit damage and minimize the effects of abnormal operating conditions on the station and/or the power system.

The structural and mechanical requirements for all relay panels and switchgear equipment on which station protection is mounted shall be outlined in detailed specifications by the Engineer.

The station electrical protection equipment shall be mounted such that the mounting structure will not amplify or attenuate the input signal or relay action.

The station electrical protection shall be designed with overlapping and redundant zones of protection. This may be in the form of a duplicate protection scheme or in the form of time coordinated steps of protection. The electrical protection shall be designed so as to remove a minimum of equipment from service and readily identify the faulted equipment or system.

The station electrical protection provides a high-speed scheme of protection for major equipment in the station. This would include, shall but not be limited to, the main generator, and the generator step-up transformer.

Where possible, the station electrical protection shall maintain sufficient separation so as to eliminate the common failure mode. The common failure mode is defined as a mechanism by which a single event can cause redundant equipment to be inoperable.

The station electrical protection shall be designed and assembled to provide access to the individual components of the various protective schemes for maintenance purposes. This requirement shall not be

limited to the protective relays but would also include the input current and/or voltage devices, output devices and their associated wiring.

The station electrical protection shall make use of terminal blocks on the entry of all protection current and/or voltage circuits entering the relay panels or switchgear to ease maintenance of these circuits.

The station electrical protection shall be designed to permit in-service testing of the individual protective schemes. The in-service testing of one particular protective scheme shall not jeopardize the remaining system protection in any manner.

All protective relays shall preferably be mounted in drawout type cases equipped with current-shorting switches on all active current circuits or shall be equipped with independent current-shorting test switches to facilitate testing.

The trip contacts of all protective schemes shall be wired in series with a single-pole test switch to open trip circuits during in-service testing. The test switches shall be front-of-panel mounted with covers which cannot be replaced with switches open.

The station electrical protection shall be sufficiently independent from metering and voltage regulating equipment so as not to affect protection during testing of the metering and voltage regulating equipment.

The d-c voltage to all protective schemes will be monitored and an alarm provided for low voltage.

Control wiring and all auxiliary control devices shall be of such quality as to assure high reliability with due consideration given for published codes and standards, fire hazards, current-carrying capacity, voltage drop, insulation level, mechanical strength, shielding, grounding, and environment.

Sufficient instrumentation and metering shall be provided to allow safe and reliable operation of the station for such functions as synchronizing and live bus transfer.

Reliable operation of the station electrical protection is enhanced by the redundancy in design. Short circuits in the generating station shall be detected by at least two different schemes of protection.

4.6.2 Generator Protection

4.6.2.1 Differential Protection

Differential protection of the generator stator shall be provided by a high-speed generator differential relay (Device 87G). This relay has adequate frequency response down to 20Hz and will detect three-phase and phase-to-phase faults in the stator winding. Since the current transformers for the differential relay have very high ratios, the differential relay will be insensitive to phase-to-ground faults. The relay has a variable percentage characteristic to provide high sensitivity at light loads and avoid incorrect relay operation during heavy external faults. Turn-to-turn protection of the stator winding is not required since modern synchronous generators employ single turn construction. The relay shall trip and lock out the main generator breaker, trip and lock out the generator field, trip the turbine, and annunciate through a generator lock out relay. A similar differential relay shall protect the generator step up transformer.

4.6.2.2 Primary Ground Protection

Phase-to-ground primary protection of the generator stator shall be provided by a generator neutral ground relay. The generator is essentially high-resistance grounded through a distribution transformer, thereby limiting ground fault current to approximately 10 amperes. This relay consists of a time-overvoltage element which is frequency-tuned to operate on the 50 Hz voltage drop across the secondary

resistor, resulting from the flow of ground fault current in the distribution transformer primary winding. The ground relay protects approximately 95percent of the stator winding and must coordinate in pickup and time with the generator voltage transformer fuses. This relay shall trip and lock out the generator breaker, trip and lock out the generator field, trip the turbine, and annunciate through the generator lock out relay.

4.6.2.3 Backup Ground Protection

Backup protection against ground faults in the generator stator, the generator bus and the delta windings of connected generator step-up and normal station service transformers shall be provided by a second time-overvoltage relay. The backup ground relay shall detect the presence of voltage across the broken-delta secondary of a set of wye-delta connected auxiliary voltage transformers. During un-faulted operation no voltage will be developed across the relay; however, during a single phase-to-ground fault, the voltage will be 3V, or approximately 200 volts with 69 volt secondary windings. The relay shall have a 16 volt pickup and a 199 volt continuous rating, which shall detect fairly high resistance faults. This relay shall trip and lock out the 13.8 kV GSU XFMR Loadside Breaker, trip and lock out the generator field, trip and lock out the main generator breaker, trip the turbine, trip the 154 KV line breaker, and annunciate through the unit lock out relay. This relay shall be supervised by a voltage balance relay to prevent undesired tripping due to blown potential transformers.

4.6.2.4 Field and Exciter Protection

The generator field circuit shall be ungrounded to provide reliability; therefore, a single ground in this circuit would not require taking the generator out of service immediately. The continued operation of the generator must be weighed against the possibility of a second ground which could result in unbalanced torques on the rotor and possible shaft damage. The following discussion covers the protection schemes for the brushless excitation system.

4.6.2.5 Brushless Excitation System

The generator field circuit with the brushless excitation system consists of the generator field, the field diodes, the exciter armature mounted on the generator rotor shaft, and a permanent magnet generator mounted to the generator rotor shaft.

Since the brushless exciter possesses no external field leads from the generator, conventional ground detector relays cannot be applied. Instead, an Automatic Ground Detector (AGD) will be provided to initiate a ground test every 24 hr, or upon manual initiation. If a ground exists, an alarm is given and the operator will initiate a normal shutdown of the generator. The automatic ground detector accomplishes this test by lowering brushes onto slip rings.

The field and exciter protection are provided by the generator manufacturer as part of the exciter package.

4.6.2.6 Loss-of-Excitation Protection

Decrease or loss-of-excitation on a synchronous generator can result in thermal damage to the generator, or can cause system instability due to low-voltage conditions. Absence of field current in the rotor reduces the magnetic coupling between the rotor and stator. With a constant mechanical input, the rotor accelerates, runs above synchronous speed, and the machine operates as an induction generator. The machine will draw inductive power from the system through the stator windings. These stator currents induce heavy currents in the rotor teeth and wedges which may damage the machine.

A two-zone scheme shall be used to provide loss-of-excitation protection with the following advantages:

1. Reduced sensitivity to stable system swings due to the time-delay associated with the zone 2 element.

2. High-speed clearing is retained for valid loss-of-excitation conditions with the zone 1 element.

3. The zone 2 element provides backup protection for a valid loss-of-excitation condition.

The setting of the two-zone protection provides for a zone1 characteristic with a negative offset setting equal to one-half of the direct-axis transient reactance (1/2X'dv). The diameter of the mho circle is equal to 1.0 per unit reactance and operates with no intentional time-delay. The zone2 setting has the same negative offset and a mho circle diameter equal to the synchronous reactance (Xd), however, a time-delay of 1second or more is used to prevent operation on stable swings.

The loss-of-excitation relay shall trip and lock out the generator breaker, the generator field, trip the turbine, and annunciate through the generator back-up lock out relay. Since loss of relaying potential may permit undesired operation of the loss-of-excitation relay, it will be supervised by a voltage balance relay.

4.6.2.7 Negative Sequence Protection

Unbalanced three-phase stator currents cause double-system-frequency (120Hz) currents to be induced in the rotor iron, which tend to flow in the surface of the rotor's solid forging, and in the nonmagnetic wedges and retaining rings. The IR losses will quickly cause rotor overheating and serious damage if the generator is allowed to continue operating in this unbalanced condition.

Negative sequence protection shall be provided by a negative phase sequence current relay applied to detect the presence of negative phase sequence current in the stator windings. The relay alarms at low values of negative phase sequence current. The relay shall initiate trip and lock out of the generator breaker, trip and lock out of the generator field, trip the turbine, and annunciate through the generator backup lock out relay if the current increases to a higher value.

4.6.2.8 Phase Fault Backup Protection

Phase fault backup protection shall be provided to prevent exceeding the thermal limit of the stator winding as specified in ANSI C50.13 for faults remote from the generator zone. This protection is primarily for three-phase fault protection but may provide phase-to-phase protection as well.

The relays shall be induction disc overcurrent relays with voltage restraint. Each relay shall provide a trip output when the current exceeds the current setting and the voltage is less than the voltage setting. Since the loss of a single potential transformer will cause the relays to trip for loss of potential, the trip outputs shall be supervised by the voltage balance relay, described in 8.4.6.2.12.

The time dial settings for these relays shall be coordinated with the time delay and line distance settings of the distance relays discussed in more detail in Section 8.4.6.11.1.

These relays with the generator step-up transformer overcurrent relays shall constitute the primary 3 phase fault protection for the 13.8kV bus. There shall be no 3 phase fault backup protection for this bus.

These relays shall trip and lock out the generator breaker, trip and lock out the exciter breaker, trip the turbine, and annunciate through the unit primary lock out relay.

Since the relay is dependent on voltage sensing, a loss of relaying potential may appear as a fault to the relay and cause undesired operation. For this reason, a voltage-balance relay shall be used to supervise the distance relay. A more detailed description of the voltage-balance relay is given in Section 8.4.6.2.12.

The relay shall trip and lock out the generator breaker, trip and lock out the generator field, trip the turbine, and annunciate through generator backup lock out relay.

4.6.2.9 Anti-motoring Protection

Loss of steam, with the main generator breaker closed and with the generator field applied, will result in the generator running as a motor connected to the high-voltage system. From the electrical point of view, this usually presents no problem. However, when the steam supply to the prime mover is removed and the generator begins motoring, the absence of steam passing through the turbine to carry away the heat that will be produced by windage loss results in overheating and quite possibly damage to the low pressure turbine blades. The length of time that a turbine can withstand this condition varies with the type of turbine, steam conditions, and turbine back-pressure.

Antimotoring protection shall be provided by a reverse power relay to electrically sense the real power (kW) flow into the machine which may be as low as 1/2 of 1 percent of generator rating. The reverse power relay is insensitive to var flow so that the generator is capable of accepting reactive power from the system without relay operation. The power directional unit of this relay shall be supervised with the main generator circuit breaker "a" contacts to prevent intermittent closing of the power sensing unit of the relay prior to synchronizing. The timing circuit shall be provided to override transient power flow into the generator that might occur during synchronizing. This relay shall trip and lock out the generator breaker, trip and lock out the generator field, trip the turbine, and annunciate through the generator backup lock out relay.

Backup anti-motoring protection shall be provided by a turbine valve limit switch circuit. This circuit shall produce a trip when all four turbine inlet ports are closed. This circuit shall trip and lock out the generator breaker, trip and lock out the exciter breaker, trip the turbine and annunciate through the generator primary lock out.

4.6.2.10 Blown Fuse Protection

The failure of the generator voltage transformers could result in undesired operation of some of the generator control and protection circuits. If the voltage to the regulator sensing circuit is lowered by a blown voltage transformer fuse or a transformer failure, the automatic voltage regulator will sense this lowered voltage and attempt to raise the terminal voltage of the generator. If voltage is lost to certain relays, such as the backup ground and the loss of excitation relays, undesired tripping could occur.

Blown fuse protection shall be provided by two voltage-balance relays applied to monitor the two sets of generator voltage transformers.

Both relays shall annunciate blown fuses in either set of fuses. One of the relays shall trip the generator automatic regulator to manual. Both relays shall be used to supervise protective type relays.

4.6.2.11 Synchronizing Supervision

The closing of the generator circuit breaker when the generator voltage is out-of-phase with the system voltage could have adverse consequences. With the generator voltage 180 degrees out-of-phase with respect to the system voltage, the winding stresses could approach twice those of a three-phase short circuit.

Supervision of manual synchronizing of the generator shall be provided to prevent the operator from closing the generator circuit breaker with the generator more than 10 degrees out-of-phase with the system. A synchronizing check relay to limit the angle at which the operator may close the generator breaker. A zero degree cutoff shall be provided in this scheme to block closing after the in-phase position has been exceeded until the next approaching in-phase condition. In order for breaker closing to be

initiated, the synchronizing check relay must operate, then the operator must close the control switch before the machine reaches the in-phase position with the system, and the machine must be running faster than the system.

4.6.2.12 Frequency Protection

At other than the designed frequency limits, the turbine generator is limited to the degree of over- or under- frequency operation. As the departure from rated frequency increases, the withstand time of the turbine generator decreases.

Frequency relays shall be applied to the generator voltage transformer to detect operation at increased or reduced frequencies. These relays will trip and lock out the 92 KV breaker, and trip and lock out the 13.8 kV XFMR load side breaker, initiate run back to station service load and annunciate through the line lockout relay.

4.6.2.13 Generator Metering

The plant will have electrical generation metering separate from the utility's revenue metering. It will also have its own potential and current sources.

These meters shall be redundant to the revenue metering and will be used to verify calibration but will not be used for re-calibration. They shall be located on the 154 KV system.

The 154 kV meters for the plant shall provide the operator with accurate visual indication as to the electrical characteristics of the net output of the plant. This indication shall be located in the control room. This shall include the following:

a. Phase Current
b. Watts
c. Vars
d. Voltage

In addition electrical meters shall be provided to maintain an accurate account of the net electrical output of the plant over extended periods of time as follows:

e. Watt hours in
f. Watt hours out
g. Var hours in
h. Var hours out

The main generator shall be provided with the necessary metering to provide the operator in the control room with accurate visual indication as to the electrical characteristics of the machine. These meters shall be located on the 13.8 kV system. This shall include the following:

a. Generator Phase Current (3 phase)
b. Generator Watts (3 phase)
c. Generator Vars (3 phase)
d. Generator Voltage (3 phase)
e. Generator Frequency
f. Generator Power Factor

In addition, electrical meters will be provided to maintain accurate account of the electrical output of the machine over extended periods of time as follows:

g. Generator Watt hours (3 phase)
h. Generator Var hours (3 phase)

Test switches shall be provided to remove portions of the metering circuits from service without rendering all instrumentation inoperative.

A Var transducer and a Watt transducer from both the 154 kV and 13.8 kV meters shall be provided with inputs to the DCS.

4.6.2.14 Overexcitation Protection

Overexcitation (excessive volts/Hertz) describes a condition where excess flux saturates the core of a wound device and flows into the adjacent structure, causing high eddy current losses in the core and adjacent conducting materials. The heat from these losses may quickly damage the insulating materials if the overexcitation condition is severe. The overexcitation withstand capability of the generator and the connected transformers has an inverse characteristic.

Dual-level overexcitation protection shall be provided for protection of the generator and its connected transformers. In some instances, this equipment may be provided as part of the excitation equipment furnished by turbine-generator manufacturer. In any case, it is suggested that one relay be set at 110 percent volts/Hertz with a time delay of 45 seconds. The second relay would be set at 118 percent volts/Hertz with a time delay of 2 seconds. Both relays would trip and lock out the 92KV breaker, trip and lock out the main generator breaker, trip and lock out the generator field, trip the turbine, and annunciate through the generator backup lock out relay.

4.6.3 Generator Step-up Transformer Protection

Differential protection of the generator step-up transformer shall be provided by three high-speed, harmonic-restrained, percentage-differential relays applied to provide sensitive protection against internal three-phase and phase-to-phase faults. This protection shall also detect phase-to-ground faults in the high-voltage winding of the transformer. The relays shall trip and lock out the 154 kV line breaker, trip and lock out the transformer loadside breaker, initiate runback to station service load and shall annunciate through the transformer lock out relay.

Sudden pressure protection for internal faults of the generator step-up transformer shall be provided by a sudden pressure relay. The sudden pressure relay responds to the increase in internal pressure generated by the arcing of turn-to-turn or phase-to-ground faults inside the transformer. This relay shall trip and lock out the 154 kV line breaker, trip and lock out the transformer loadside breaker, initiate runback to station service load and shall annunciate through the transformer lock out relay.

The high-voltage winding of the generator step-up transformer shall be solidly grounded thereby providing a source of ground current during line-to-ground fault conditions on the high-voltage system. Line-to-ground faults on the high-voltage system which are external to the unit zone of protection would normally be cleared by the switchyard or transmission line protection. In the event that system protection fails, a ground backup overcurrent relay shall be applied to a current transformer in the neutral bushing of the generator step-up transformer. This relay must coordinate with the system protection and initiate trip and lock out of the 154 kV line breaker, the GSU XFMR Loadside breaker, and annunciates through the transformer lock out relay.

Three time and instantaneous relay functions provide overcurrent protection for the generator step-up transformer. These same three relay functions, with the generator voltage restrained overcurrent relays, also constitute the primary 3 phase fault protection for the 13.8kV bus. There is no backup three phase fault protection for this bus. These relays shall trip and lock out the 154 kV line breaker, trip and lock out the GSU transformer loadside breaker, initiate runback, and annunciate through the GSU transformer lock out relay.

4.6.4 Normal Station Service Transformers Protection

4.6.4.1 Differential Protection

Differential protection of the normal station service transformer is not required.

4.6.4.2 Sudden Pressure Protection

Sudden pressure protection for internal faults of the transformer shall be provided by a sudden pressure relay. The sudden pressure relay responds to the increase in internal pressure generated by the arcing of turn-to-turn or phase-to-ground faults inside the transformer.

4.6.4.3 Phase Overcurrent Protection

Phase overcurrent protection for the normal station service transformers shall be provided by three time and instantaneous overcurrent relays.

4.6.4.4 Ground Protection

A phase-to-ground fault on the 6.3 kVvoltage system shall be limited to 400 amperes and a phase-to-ground fault on the 380V system shall be limited to 3.5 amperes.

4.6.5 Metering

The station service power shall be monitored at the 1200A, 13.8 kV feeder breakers in the PDC, by watt-hour meters and ammeters connected to the current transformers on the 13.8 kV feeder buses. The potential circuit shall be supplied from the 13.8 kV feeder bus.

4.6.6 6.3 kV and 380 V Switchgear

4.6.6.1 6.3 kV and 380 V Bus Supply Protection

Protection for the bus supply feeders from the transformers shall be provided by time-overcurrent relays applied in the bus feeder breakers.

Phase overcurrent protection shall be provided for the 6.3 kV bus by three time-overcurrent relays applied to each of the bus supply breakers. These relays shall provide three-phase and phase-to-phase fault protection for the bus by tripping and lock out of the bus supply breaker.

4.6.6.2 6.3 kV Motor Feeder Protection

All 6.3 kV motors shall be fed by medium voltage starters. Each starter will be equipped with motor protection relaying Multilin.

All 6.3 kV motors shall be equipped with six 100ohm RTD's embedded in the stator windings. These RTD's will provide high temperature alarm and high-high trp signals to the DCS system.

Motors 1500 kw and larger shall have differential protection across the windings and surge protection at the motor terminals.

4.6.6.3 6.3 kV and 380 V Switchgear Metering

A voltmeter and a voltmeter selector switch shall be provided on the 6.3 kVbus and at each incoming breaker to allow local inspection of the three line-to-line voltages at the bus and at the breakers.

The switchgear for the power plant and the Minerals Recovery Facility shall have individual watt hour metering for accounting purposes.

Phase overcurrent protection shall be provided for MCC feeders consisting of low-voltage air circuit breakers containing overcurrent direct-trip devices with adjustable long-time and short-time trip elements. The long-time delay unit shall be set to pickup at a value higher than the expected full load current and less than the rated current carrying capacity of the cable, with sufficient time delay to coordinate with the maximum overload device setting in the motor control center. The short-time delay unit shall be coordinated with the maximum instantaneous setting in the motor control center.

The MCC feeder breakers shall also be provided with negative sequence voltage relaying protection.

4.6.7 Motor Control Centers (MCC)

4.6.7.1 Motor Loads

The 380 Vmotor control centers shall be supplied from the 380 V station service transformers. The loads fed from the MCC shall be limited to motors up to and including 50 kw as well as other small miscellaneous loads.

Phase overcurrent protection shall be provided for motor feeders consisting of motor circuit protectors (MCP and contactor overload relays. The molded-case breakers with instantaneous magnetic elements shall provide short-circuit protection, while the contactor overload relays shall provide thermal protection.

The magnetic elements of the MCPs shall be set to provide short-circuit protection for both continuous and intermittent duty motors.

The contactor overload relays for continuous duty motors will be selected 115-125 percent of rated full load current. The contactor overload heaters for the intermittent duty motors shall be selected between 80 to 150 percent of rated full load current.

4.6.7.2 Non-motor Loads

Phase and ground overcurrent protection shall be provided for non-motor feeders consisting of molded-case breakers with long-time thermal trip elements to provide overload or low current fault protection, and instantaneous magnetic trip elements to provide short-circuit protection.

The rating of the thermal element shall be approximately 150 percent of rated full load current and the pickup of this element is nonadjustable. The magnetic element may or may not be adjustable; however, in either case the pickup of this element shall vary between 500 and 1,500 percent of the thermal rating.

All current transformers used in the station protection shall have relaying accuracy ratings in accordance with ANSI C58.4.13, and their performance at high current levels shall be compatible with the protection requirements.

All voltage transformers used in the station protection shall have accuracy ratings in accordance with ANSI C58.4.13 and shall have sufficient thermal capabilities for the associated protection.

Current and voltage circuit lengths shall be designed to minimize burden requirements. The routing of these circuits will provide adequate separation of redundant zones of protection.

The station electrical protection shall be applied with the intent of providing overlapping zones of protection for high-speed clearing of the major items. This principle shall also apply to the control circuitry for the station. Similar high-speed zones of protection shall initiate clearing of the fault by means of separate auxiliary lock out relays. Station protection, which shall provide time-delayed clearing of faults, shall initiate clearing by means of a third auxiliary lock out relay.

The d-c control power for the 6.3 kV switchgear as well as the 380V MCC supply breakers shall be provided by the 110 V d-c power system. Motor starters shall be self-powered a-c controlled.

The control power for all motor controllers or contactors at the 380 V motor control center (MCC) level shall be provided by 308-120Vcontrol transformers. Each control transformer shall be connected to its associated 380 V MCC branch circuit. Therefore, the a-c control power for 380 V MCC shall be provided by the a-c power system. The secondaries of all 380-120 V control transformers shall be fused and grounded.

4.6.8 System Operation

The station electrical protection shall be in service at all times and shall automatically initiate corrective action upon inception of a fault or abnormal condition which may be detrimental to the safe operation of the station and/or the system.

In some instances, the station protection shall lock out the affected equipment to prevent re-energizing. In these cases, it shall be necessary to manually reset the auxiliary lock out relay before re-energizing.

It shall be necessary to indicate to the station operator the occurrence of certain undesired conditions. These conditions shall include, but not necessarily be limited to, a blown fuse on the generator voltage transformers, grounds on the d-c battery system, loss of d-c control power to the station protection schemes, loss of d-c control power to circuit breakers, and over-excitation of the unit.

4.6.9 Safety Features for Potential Emergencies

Because of its requirements, the station protection physically encompasses a large area. The a-c current and voltage sensing circuits, as well as the d-c control circuits are exposed to the natural elements such as heat, moisture, dust, etc., which could cause insulation failure.

During certain conditions, significant voltages could exist on the a-c current and voltage circuits due to differences in ground potential.

Current, voltage, and control circuits which extend to the high-voltage switchyard may be subjected to induced high-voltage as a result of mutual coupling to the high-voltage conductors.

The inadvertent opening of a current transformer secondary circuit could result in extremely high-voltages at the current transformer secondary.

Because of the reliability in past current transformer design and the criticality of current circuits, no fuses or interrupting devices shall be applied. The insulation shall be resistant to the natural elements. The reliability of the current and voltage circuits, as well as the d-c control circuitry, shall be stressed in the design of duct runs and cable trays. Since the a-c voltage and the d-c control circuitry are much more complicated and are not as critical as the current circuits, fusing will be permitted, and the circuits shall be monitored to detect the blown fuse.

The location of the station protection shall be in a designated area where only qualified personnel shall be permitted. The location of relays on control panels and switchgear shall be such as to minimize vibration.

The grounding of each a-c current and voltage circuit shall be at the relay panels or the switchgear and shall be grounded in one location only.

The current transformer secondary circuits shall be wired to current-shorting type terminal blocks or test switches in cases where metering and relaying circuits are combined.

4.6.10 System Maintenance

The station electrical protection shall be designed to permit easy access for the removal or replacement of the individual relays which make up the protective systems

All fault-detecting relays shall have mechanical or electrical targets to readily identify the relay responsible for interruption. These targets shall be visible without dismantling any of the protection.

Drawout-type construction of the fault-detecting relays shall provide easy removal of the relay for bench maintenance and also provide for injection of current and/or voltage for in-place testing.

4.6.11 154 kV Line Protection

4.6.11.1 Primary Line Protection

The first zone distance relay provides 3 phase and phase to phase fault protection for 90% of the line length to the utility substation.

The second zone distance relay provides time delayed 3 phase and phase to phase fault protection for 125% of the line length to the utility substation.

The directional/ground overcurrent relay provides time and instantaneous ground overcurrent for the line.

These relays trip and lock out the 154 kV line breaker, trip and lock out the GSU load side breaker, initiate runback to station service load, and annunciate through the 154 kV line lock out.

4.6.11.2 Backup Line Protection

The directional phase overcurrent relays provide time overcurrent protection for the 154 kV line. These relays trip and lock out the154 kV breaker, trip and lock out the 154 kV breaker, trip and lock out the GSU transformer, initiate runback to station service load and annunciate through the 154 kV line lockout relay.

The backup ground protection for the 154 kV line is the neutral overcurrent relay on GSU transformer. It is described in Section 8.4.5. The Engineer shall coordinate the 154 kV protection scheme with the utility.

4.7 Medium And Low Voltage Power Systems

The medium and low voltage power systems shall consist of 13.8 kV and 6.3 kV metal-clad switch gear, 6.3 kV motor controllers and 380 V motor control centers. The station service transformers shall step the voltage down from the 13.8 kV generator voltage to the 6.3 kV or 380 V bus voltage.

380 volt loads and motors up to and including 200 kw shall be powered from motor control centers (MCCs) located in controlled air environments within the PDC. Motors larger than 200 kw shall be powered from 6.3 kV motor controllers.

The 6.3 kV switchgear and motor controllers, as well as the 380 volt MCCs shall be designed with adequate space capacity to anticipate future load growth.

4.7.1 System Requirements

The function of the a-c power system shall be to supply reliable a-c power to all electrical equipment.

The ac power system shall include transformers, switchgear, motor control centers, motors, conductors, and associated instrumentation and controls.

A nominal system voltage of 6.3 kV, 3 phase, 50 Hz shall be provided to supply large motors (over 200 kw).

A nominal system voltage of 380 V, 3 phase, 50 Hz shall be provided to supply small motors (1/2 kw through 200 kw) and non-motor loads less than, or equal to, 300 kW.

A nominal system voltage of 220 V, single phase, 50 Hz shall be provided to supply fractional horsepower motors (1/2 kw and smaller) and small single phase loads.

The voltage at the terminals of motor leads during start shall not be allowed to dip below 80 percent.

Thekilowatt ranges stated above, that will be assigned to each voltage level, are intended as a guide. There may be instances of overlap, where the Engineer may assign a motor to a bus not in accordance with the above. Assignment of motors to a bus shall take into consideration availability of power source and increases or decreases in motor rating after switchgear is purchased.

The 6.3 kV system shall be grounded at the wye-connected secondary windings of each unit and reserve station service transformer through a resistor to limit the maximum line-to-ground fault current to approximately 400 amperes. The 380 Vsystem will be high and low resistance grounded. Lighting and outlet circuits requiring a solidly grounded neutral will be supplied from a 380V-220 V transformer with its secondary solidly grounded.

Oil-filled transformers shall be located outdoors. Non-segregated phase bus duct shall be located both outdoors and indoors. Motors shall be located both outdoors and indoors as required. All other equipment such as switchgear, air-cooled dry-type transformers, silicon filled transformers, MCCs, and distribution cabinets shall be located indoors, in the controlled environment of the Power Distribution Center (PDC).

The equipment shall be arranged to facilitate repair and removal for maintenance. Metal-clad switchgear and transformers shall be arranged to facilitate uniform phasing. Standard transformer connections shall be used (wherever possible). Incoming and outgoing feeder conductors for switchgear, and MCCs shall be identified (as viewed from the front), as phase A, B, and C, left to right and top to bottom, or front to back, as applicable.

Periodic maintenance shall be performed on components of the a-c power system. This maintenance shall be consistent with the manufacturer's recommendations. In addition, adequate floor space shall be provided around the equipment for proper maintenance.

Testing and inspection shall be provided for all normal a-c systems. The particular tests and inspections and their frequency will depend upon the specific components installed, their function, and their environment. These tests and inspections shall be directed at detecting the deterioration of the system toward an unacceptable condition and to demonstrate that standby power equipment and other components that are not running during normal operation are operable.

The normal a-c power system instrumentation and control shall consist of the following:

1. 13.8 kV station service power supply breaker control
2. 6.3 kV feeder breaker control
3. 380 V feeder control

The 154 kV, 13.8 kV, 6.3 kV and 380 V breaker control shall:

1. Be powered from a d-c source (when not prohibited by distance).
2. Provide control from the control room and switchgear for the 154 kV breaker and generator breaker. All other breakers will be controlled locally at the switchgear.
3. Provide protective interlocks.

The DCS inputs shall record that a breaker is tripped.

4.7.2 System Design

Connections of the power supply feeders and busing arrangements of the ac power system are shown on the main one-line diagram.

During normal operation, while the plant is generating, the main power source shall be from the unit turbine-generator. A 13.8 kV non-segregated phase bus shall connect the generator to the 13.8 kV terminals of the generator breaker and the 13.8 kV terminals of the station service transformer.

Voltage at the motor terminals at any voltage level shall not be less than 80 percent of rated motor voltage during starting. The voltage at the terminals of any power transformer shall not exceed 110 percent of

rated voltage under no-load conditions when the high voltage supply from the 154 kV line is 102.5 percent of rated nominal voltage.

The system frequency shall not exceed 50 Hz, ±5 percent. The maximum system frequency decay rate shall not exceed 5 Hz per sec.

The generator step-up transformer shall consist of a two winding three phase transformer. The transformer shall be fed from the non-segregated phase bus leads connected to the generator breaker.

The station service transformers shall be located outdoors, near the power distribution centers (PDC). The station service transformers shall be two winding three phase transformers.

The 6.3 kV and 380 Vswitchgear equipment shall be located in the power distribution centers which will also be a controlled environment area.

The 380/220 V buses will be located in the environmentally controlled areas of the PDC. The respective transformers shall be oil filled and located adjacent to the PDC.

An automatic fire suppression system will be furnished for the PDC. Smoke detectors and temperature sensors provided by the Constructor will also alarm in the control room. There will be a fire extinguisher located at each end of each P.D.C.

4.7.3 Component Design

4.7.3.1 Main Turbine Generator

The main generator shall be rated 25.2 MVA, three-phase, 3000 rpm, 13.8 kV, 50 Hz, 0.90 leading and lagging power factor. The generator will be wye-connected and will be capable of operating with a neutral grounding device having ahigh impedance which will limit the maximum phase current. The neutral terminal enclosure shall be furnished with the generator, with provisions for the Engineer's conduit for the grounding lead. The Generator Step-Up Transformer shall have a no load tap changer providing ±10% voltage control.

Each of the stator terminals shall be equipped with bushing type current transformers of suitable rating. All current transformers shall have 5 amp secondaries. The main terminals shall be arranged for non-segregated phase bus duct connections. The generator excitation system shall be capable of regulating the generator voltage from 95 to 105 percent of the rated voltage at any load level up to the generator nameplate rating. Suitable excitation switchgear shall be furnished for control of the generator exciter.

The generator shall be supplied complete with all the auxiliary equipment required for the successful operation of the generator.

4.7.3.2 Non-Segregated Phase Bus

The non-segregated phase bus shall connect the main generator to the main generator breaker located **at the west end of the turbine structure** and from the main generator breaker to the generator step up transformer. It shall be self-cooled and rated to carry the maximum generator output. It will be fully insulated. The bus shall be designed for outdoor operation at maximum ambient temperature.

The non-segregated phase bus shall include the following:

1. The main bus leads including metal enclosure
2. Supporting structures

The bus duct shall be of the totally enclosed type with galvanized steel comprising the formed duct and bolted, gasketed covers.

4.7.3.3 Generator Step-up Transformer

The three phase transformer for the generator step-up transformer shall have full capacity no-load taps on the high voltage winding and shall be rated to deliver the MVA output of the turbine generator at rated frequency. The transformer winding insulation shall be operated at no higher temperatures than it would be subjected to if operated in a standard ambient. The transformer shall be connected delta-wye, and shall; be solidly grounded on the high voltage wye connected side.

4.7.3.4 Station Service Transformer

The station service transformer impedance values shall be selected to satisfy the following criteria:

1. Be low enough to provide good plant voltage regulation down to the 220 V a-c level.
2. Be low enough to successfully start large ac motors. (In general, the voltage, upon starting large motors, will be limited to not less than 80 percent of nominal.)
3. Be large enough that the interrupting rating of connected switchgear is not exceeded.

The station service transformers shall be three phase with full capacity no-load taps on the primary winding. Transformers shall be rated to carry the connected normal bus load at maximum ambient temperature. Transformers shall be connected delta-wye resistance grounded and provided with ground resistors on the secondary neutral. The transformers shall be oil filled, rated to supply the normal load on the bus, three-phase, with class H (220 C) insulation with full capacity no-load taps on the primary windings.

4.7.3.5 Switchgear

The switchgear shall be rated for interrupting capacity based on maximum short-circuit availability at its location. The switchgear bus full-load ampere rating shall be sized to have the standard available bus ratings above the maximum coincidental load. The buses shall be braced to withstand the maximum momentary short-circuit current, taking into consideration the fault contribution of all connected rotating machines and source transformers and making proper allowance for system X/R ratio at the point of fault.

The vacuum breakers, if used, shall be selected with a maximum symmetrical interrupting rating (kA) which will exceed that available from the power system at the point of application. This shall take into consideration all the contribution of connected induction motors.

4.7.3.6 Motor Control Centers

Motor control centers shall be rated 380 V, 3 phase, 50 Hz, utilizing combination motor starters and molded case circuit breakers for motor branch circuit protection. The motor branch circuit breakers, as well as those for feeders, shall have a minimum symmetrical interrupting rating of 42,000 A.

4.7.3.7 Motors

All motors shall be sized to develop sufficient horsepower to drive the connected load under runout or maximum expected flow or pressure, whichever is larger, and permit the driven equipment to develop its specified capacity without exceeding the temperature limits of the motor. Motors shall be specified with the following special features:

a. All motors not located in a clean dry area protected from the atmosphere, shall be totally enclosed and will be specified with a 1.15 service factor. Motors located indoors may be furnished with drip-proof enclosures and have a 1.15 service factor.

b. During normal operation, no encroachment on the service factor will be permitted.

c. During infrequent and short periods in an emergency, such as runout operation, exceeding of the service factor rating will not be permitted.

d. Motor insulation shall be specified as Class F with a 90°C rise at service factor load for a ***later*** °C average ambient, and with an 80°C rise at service factor load for site maximum ambient. Although motors are to be specified with a Class F insulation system, they shall be sized on the basis of Class B temperature rises.

e. A minimum torque margin of 15 percent of rated full load torque from standstill to speed at which breakdown torque occurs at specified minimum starting voltage shall be specified to assure rapid acceleration.

f. A minimum locked rotor thermal limit time equal to the minimum voltage acceleration time shall be specified for the rated voltage condition.

g. For all low voltage motors non-hygroscopic type insulation shall be specified. Motors to be run from variable frequency drives shall be designed and specified for the application.

For all medium voltage motors, VPI Insulation systems shall be specified. Medium voltage motors shall be furnished with six duplex 100 ohm Platinum stator RTDs.

h. Coil ends of open motors shall be provided with abrasion protective coats to resist wear, such as a resilient silicone rubber spray coat.

i. All anti-friction bearings shall be specified with a minimum L-10 life of 50,000 hr. Motors with anti-friction bearings shall be furnished with duplex thermocouples on each bearing. Sleeve bearings shall be furnished with duplex 100 ohm Platinum RTDs

4.7.3.8 13.8 kV and 6.3 kV Metal-clad Switchgear

The 13.8 kV and 6.3 kV switchgear vacuum circuit breakers shall be of the electrically operated drawout type with stored energy mechanisms. Switchgear breaker control d-c power shall be supplied from batteries of the 110 V d-c power system.

13.8 kV circuit breakers shall have the capability of being manually operated at the switchgear and remotely from the new mimic panel in the control room.

The 6.3 kV fused vacuum contactors shall feed 6.3 kV motors. They shall be both manually operated locally or remotely from the DCS.

Open and closed positions of all 13.8 kV and 6.3 kV circuit breakers and the contactors shall be indicated at the switchgear, and in the control room. 13.8 kV positions shall be indicated by lights on the mimic panel. 6.3 kV breaker and contactor positions shall be indicated in the DCS. All trip functions shall be alarmed through the DCS.

An Ammeter and Ammeter Switch shall provide local indication of 6.3 kV loads and an amp transducer will be provided for remote monitoring at the DCS.

4.7.3.9 380 V Load Center Type Breakers

If required, 380 V load center type air circuit breakers shall be provided with d-c control power supplied from batteries of the 125 V d-c power system.

Load center type air-magnetic circuit breakers applied as MCC feeders shall be manually operated at the MCC lineup.

Tripping and closing positions of the main 380 V circuit breakers shall be indicated at the switchgear, tripping will be alarmed in the control room through the DCS.

4.7.3.10 380 V Motor Control Centers (MCC)

For motor starters, heater feeders, or other load feeders, 380-110 V control power transformers shall be connected to the load side of the circuit breakers to supply control power to the starter or contactor. Loss of ac supply power to a starter or contactor shall cause it to fail open, disconnecting the load. However, the 380 V system shall be designed such that the voltage at the MCCs will be within the starter pickup voltage rating.

The MCC distribution and miscellaneous feeders shall be provided with manual control at the circuit breakers. Motor and heater feeder breakers shall be provided with automatic and/or remote control, as required.

4.7.4 System Limitations and Set Points

The components of the a-c power systems shall be loaded only within their nameplate ratings. Loads in excess of this will cause reduced life expectancy and may cause automatic disconnection of the loaded circuit. Electrical equipment shall be sized and load groupings shall be assigned such that the maximum coincidental load falls within the rating of each ac power system component.

4.7.4.1 Set Points

Various components of the ac power system shall have set points which are discussed in the following paragraphs:

4.7.5 Switchgear and Relay Panels

4.7.5.1 Protective relays

Protective relay settings shall represent the most desirable compromise between equipment protection and continuity of station service. Examples of the parameters which must be set are current pickup, current tap settings, and time dial positions.

4.7.5.1.1 Time delay relays

Time delay relays shall be set to delay actuation of a device in order to accomplish a particular function. Relays of the fixed timer type shall be set to agree with the time settings given on elementary diagrams to be developed by the Engineer.

4.7.6 Motor Control Centers

4.7.6.1.1 Overload relay selection

Overload relays shall be selected and installed by the Constructor to protect motors or connected equipment from overload for excessive periods of time. They shall be selected to protect the specific load in question, taking into consideration the ambient temperature in which the relay operates.

4.7.6.1.2 Adjustable trip settings

If required, in order to more closely match the heater characteristics with the protected equipment or to prevent false tripping, the relay pickup point may be changed through the range of 90 to 110 percent of the stamped rating on the bimetallic heater element.

4.7.7 Power Transformers

Oil-filled transformers shall be equipped with liquid temperature devices (top oil) and/or winding temperature devices (top oil temperature augmented by a heat generating current proportional to load). These devices shall function to alarm, start radiator fans, or start oil circulating pumps, where applicable.

Air-cooled transformers, if supplied, shall be equipped with thermostatic devices which automatically turn on cooling fans at a particular temperature setting and alarm at a higher temperature setting.

The setting of the temperature devices shall be the responsibility of the respective transformer manufacturer and shall be a function of the transformer design.

4.7.8 System Operation

4.7.8.1 Start-Up and Shutdown

The Project shall be designed so that power required for start-up will be provided from the Utility at the Owner's option. A 13.8 kV feed shall be installed to connect to future units. Once the turbine is operational, the load will be transferred to the Unit generator and the breaker to the utility will be opened. At this point, the Unit can be synchronized to the system.

4.7.8.2 Normal Operation

Adequate power will be supplied to the ac system during normal operation to energize all required loads for this mode of operation. The power source during normal operation will be the main turbine-generator.

4.7.9 System Maintenance

4.7.9.1 Maintenance Approach

The maintenance program for the ac power system will consist of periodic testing following the pre-operational and initial system tests and inspections. A complete schedule of manufacturer's recommendations concerning components of the system will be maintained as well as an outline of various problems, their causes, diagnostic indications, and recommended corrective action. All instruments and equipment required to inspect, test, and maintain the system components will be part of the plant stock supply.

4.7.9.2 Preventive Maintenance

Routine preventive maintenance will be performed on components of the system in accordance with manufacturer's recommended procedures.

The station maintenance program will include testing requirements for all ac systems following the pre-operational and initial system tests and inspections. The particular tests and the frequency of these tests will depend upon the specific components installed, their function, their environment, and the fact that they are on the station maintenance program. These tests will be directed at detecting the deterioration of the system toward an unacceptable condition and will demonstrate that standby power equipment and other components that are not running during normal operation are operable.

4.7.9.3 Testing

During the pre-operational stage with all components of the ac power system installed, tests shall demonstrate that all components are correct and are properly mounted, all connections are verified as being correct and continuous, all components are operational, and all metering and protective devices are properly calibrated and adjusted.

Following satisfactory checkout of all components of a system, the initial system test will be performed with all components installed. The initial system test will be operational tests conducted to demonstrate that the equipment operates within design limits and that the system is operational and meets its performance specifications.

The 6.3 kV and 380 V circuit breakers and associated devices will be tested while individual equipment is shut down or not in service. Protective relays will be tested under a simulated overload or fault condition, and their calibration will be verified. The breaker opening and closing capabilities can also be demonstrated. Availability of breaker control power will be indicated by breaker indicating lights.

The in-service periodic testing requirements of the loads will be met in part by actual operation of the active normal components of the system. The capability of the distribution circuits of the normal system to transmit sufficient energy to start and operate all required loads will be confirmed during these periodic tests of the loads themselves. These tests will also confirm the capability of the supply breakers to operate and transmit the required energy upon receipt of a control input.

4.7.9.4 Inspection

Typical inspections will include visual inspection of switchgear, metering, and surveillance equipment. Availability of breaker control power will be shown by breaker indicating lights at the main control room DCS console and at the switchgear.

4.7.9.5 Corrective Maintenance

Corrective maintenance will be performed on components of the ac power system, as required. The specific maintenance action will depend on the type of equipment, type of correction to be made, and manufacturer's recommendations on the subject.

CODES AND STANDARDS

The normal ac power system will be designed and constructed in accordance with the latest versions of the following codes and standards:

American National Standards Institute

ANSI C37	Power Switchgear
ANSI C50	Rotating Electrical Machinery
ANSI C57	Transformer, Regulators, and Reactors

Institute of Electrical and Electronics Engineers

ANSI C38.4.96	Guide for Induction Motor Protection

National Electrical Manufacturer's Association

NEMA AB-1	Molded Case Circuit Breakers
NEMA E12	Instrument Transformers
NEMA FU1	Low-Voltage Cartridge Fuses
NEMA ICS	Industrial Controls and Systems
NEMA PB-1	Panelboards
NEMA PB-2	Dead-Front Distribution Switch-boards
NEMA SG3	Low Voltage Power Circuit Breakers
NEMA SG4	AC High Voltage Power Circuit Breaker
NEMA SG5	Power Switchgear Assemblies
NEMA SG6-1974	Power Switching Equipment
NEMA TR-1	Transformers, Regulators, and Reactors
NEMA MG1	Motors and Generators

Miscellaneous

NFPA No. 78	Lightning Protection Code
UL 96A	Installation Requirements - Master Labeled Lightning Protection System
Title 24, CAC	California Administrative Code Title 24California Building Code

4.8 D.C. Systems

The d-c power system shall consist of one 110 V d-c battery, distribution panels and associated equipment. The d-c power system will supply d-c power for the operation and control of equipment and d-c loads. The d-c power system nominal voltage shall be 110 V d-c, ungrounded.

4.8.1 System Requirements

The 110 V d-c power system will supply d-c power for the operation and control of equipment, d-c motors, and other loads. The UPS System shall be supplied at 110 Vd-c from a separate battery.

The d-c power system will include power supplies and distribution systems arranged to provide d-c electric power to all d-c loads. The power supply will consist of one 110 V d-c battery, and one battery charger. The distribution system will consist of all equipment in the distribution circuits from the supply devices to their loads. Components of each system will be marked for easy identification.

A nominal voltage of 110 V d-c will be provided from a 50-cell station battery to supply power and control loads for two hours following a loss of normal power. The voltage at the terminals of the d-c electrical equipment fed from this battery may vary between 117 and 87.5 V d-c.

System equipment will be housed in the PDC Building. The batteries will be enclosed in a separate ventilated room. Under normal conditions, the d-c buses will be supplied from battery chargers. On loss of ac power, the batteries will supply power to the d-c buses for a minimum of two hours.

Periodic maintenance will be performed on components of the d-c power system. This maintenance will be consistent with manufacturer's recommendations. In addition, adequate floor space will be provided around the equipment including the station batteries for proper maintenance.

Testing will be provided for the d-c power system. The particular tests and inspections and their frequency will depend upon the specific components installed, their function, and their environment. These tests will be directed at detecting the deterioration of the system toward an unacceptable condition and to demonstrate that backup power equipment and other components that are not running during normal operation are operable.

In general, the testing requirements will be met in part by actual operation of the active components of the system. The capability of the distribution circuits of the d-c power system to transmit sufficient energy to start and operate all required loads will be confirmed during these periodic tests and inspections of the loads themselves. These tests will also confirm the capability of the supply breakers to operate and transmit the required energy upon receipt of a control input.

The normal d-c power system instrumentation will consist of battery, battery charger, and d-c bus monitoring, as well as annunciation in the control room so that corrective action may be initiated to restore the system to normal operation.

The following functions will be monitored or controlled:

Battery Monitoring output/input current

Charger Monitoring and Control

Output current and voltage

High output voltage

AC power failure to battery charger

Control for float and equalize charge

D-C Bus Monitoring

Voltage

Ground detection

Local indication will be provided.

The DCS will monitor sufficient parameters to alert the control room operators that corrective action is required to restore the system to normal operation.

The d-c system will be operated at a normal float charge voltage level to maintain the batteries in a fully charged condition. The battery charger associated with each battery will be rated to supply the largest combined demands of the various steady state loads and the charging capacity to restore the battery from the design minimum charge state to the fully charged state.

4.8.2 System Design

Under normal conditions, 380V motor control centers shall supply power to the d-c bus through a battery charger. In the event of loss of a-c power the battery shall directly feed the d-c bus.

The d-c power system shall be operated at a normal float charge voltage level to maintain the battery in a fully charged state.

All auxiliary electrical equipment connected to the 125 V d-c power system shall be capable of operating on a voltage range of 140 to 101 V d-c.

The batteries shall be housed in a separate room from the battery chargers and main distribution panels.

The principal components of the d-c power system shall consist of one 50-cell battery, one 110 V static battery charger, and distribution panels as required for D.C. loads.

4.8.2.1 Battery Room

A separate battery room shall be provided as part of the PDC for the batteries of the d-c power system. The room will provide a well ventilated, clean, cool, and dry place so that the cells will not be affected by sources of radiant heat such as sunshine, steam pipes, or heating units.

The battery room shall have a designed ambient temperature of 77 ±5°F (25 ±2.8°C) year round to provide optimum battery life, ease of maintenance, and low cost of operation. Since variations in electrolyte temperature between cells of more than 5°F (2.8°C) may cause the warmer cells to become unequal, proper battery location, ventilation and cell arrangement shall be provided to keep this variation within the above limits, and prevent deterioration of the positive plates thus prolonging battery life. The battery temperature shall not exceed 90°F for more than 1% of the year, nor exceed the range of 60 to 120°F at any time.

The battery room shall be ventilated to maintain the design temperature and prevent accumulation of hydrogen. The room air shall be changed a minimum of 5 times an hour, which is more than sufficient to keep hydrogen liberated from battery cells from exceeding the maximum allowable concentration of less than 2 percent by volume. A separate exhaust fan shall be provided for the battery room.

The battery room shall not be provided with permanent flush or wash facilities. However, in compliance with OSHA 1910.132, neoprene or rubber gauntlet gloves, chemical eye protection goggles, and eye wash units such as plastic squeeze bottles containing clean water, readily available to flush the eyes shall be provided close-by outside the battery room. The requirement for rubber aprons, safety shoes, etc., will depend on the operator's tasks.

The battery room shall be provided with adequate aisle space for inspection, maintenance, testing, and cell replacement. Space shall also be provided above the cells to allow for operation of lifting equipment, addition of water, and taking measurements (e.g., temperature, specific gravity, etc.). The battery room floor shall have an acid resistant coating.

4.8.2.2 Batteries

The battery shall be lead-calcium, power-station type. The battery shall be sized per IEEE 485 for ampere-hour capacity suitable for supplying all connected for a minimum period of two-hours, in the event of loss of all ac power and without the use of battery chargers. At no time during the two hour period will the battery terminal voltage drop below 1.75 V per cell. The characteristics of each load, the time duration each load is required and the basis used to establish the power required for each load will be used to establish the combined load demand to be connected to the d-c power supply during the "worst" operating conditions.

Intercell and terminal connectors shall consist of lead-plated copper connectors.

The battery shall be provided with a battery disconnect switch for maintenance and safety. Annunciation shall be provided in the control room when disconnect switch and/or breaker are "open" to indicate the battery is disconnected from the d-c bus.

The battery shall be mounted on battery racks constructed of steel rails, frames, and braces. The racks shall be provided with acid resistant insulated channels on which the battery cells will rest, and noncombustible, moisture and acid-resistant spacers between the cells to keep them aligned. The metal surfaces of all racks shall be coated with acid-resistant enamel paint and shall be solidly connected to the

station grounding system. The Seller shall design the rack to ensure that it will withstand the seismic forces encountered at the plant site.

4.8.2.3 Battery Charger

The static type battery charger shall have ample capacity to supply the steady state loads under any plant condition, while recharging the battery to a fully charged condition from the design minimum charged state within 24 hours.

The static battery chargers connected to the 125 V d-c buses shall have a nominal output float voltage of 130 to 135 V d-c, with an input of 380 V ac, 3-phase, and shall limit the output ripple voltage under full load without the battery attached, to 1 percent rms or less.

4.8.2.4 D-C Distribution

The battery shall be connected to a d-c distribution panel which will supply the appropriate d-c loads. The battery distribution panel shall be equipped with a battery main air circuit breaker with only long-time and short-time trip attachments. In addition, ground detection equipment shall be provided consisting of a zero-center voltmeter and a center tapped resistor connected across the bus. The negative meter terminal shall be connected to the resistor tap and the positive meter terminal to the ground. With a ground the meter shall indicate positive or negative voltage depending on which side of the bus is grounded, with no ground the meter shall indicate zero. Meters shall be provided with alarm contacts that will be used to annunciate a ground in the control room.

4.8.2.5 Other Considerations for System Design

All branch circuits shall have overcurrent protection on both wires.

The average ambient temperature of the area in which the battery distribution panel will be located, shall be maintained at less than 90° F (32.2° C) year round.

All d-c motors shall be capable of delivering adequate power so that the driven equipment will perform its intended function properly when the voltage at the motor terminals varies between 140 V and 105 V d-c. All equipment specifications shall state these requirements.

Auxiliary electrical equipment such as motor starters, breakers, and relays used in the 125 V d-c power system shall be capable of operating between 140 V and 105 V d-c.

Motor starters shall be single-pole of the reduced-inrush type, using step starting resistors and timers to limit the current to safe values during acceleration.

Motor starters shall be located close to the battery rather than near the motor and separate leads will be run to the motor shunt fields. This will minimize the voltage drop problem due to high inrush currents which may result in unsatisfactory starting performance because of low field excitation levels.

The d-c power system instrumentation shall consist of measuring the battery output current to the d-c distribution system, and displaying the battery voltage at the distribution panel. Battery voltage shall also be continuously monitored in the control room through voltage-to-current transducers. Undervoltage relays shall alarm for low voltage and critical low voltage conditions.

Main circuit breakers shall be provided for each battery and with only long-time and short-time trip attachments.

Ground detection shall be provided for the d-c bus consisting of a voltmeter containing auxiliary contacts to alarm for a ground on the bus. The alarms shall be annunciated in the control room.

The battery charger shall be provided with an output voltmeter and ammeter, as well as pilot lights to indicate that input voltage is available. In addition, relays shall be provided to alarm on low power ac input voltage on any phase, and high d-c output voltage. The charger input ac and the output d-c shall also be provided with circuit breakers sized not to trip with the output short circuited. A manually adjustable timer shall also be included to automatically control the duration of equalizing charge cycles. An interruption of timer supply during a charging cycle shall not result in return of output voltage to float level on restoration of power supply.

4.8.3 System Limitations, Set Points, and Precautions

The d-c power system shall be operable with or without ac power. It shall supply all normal d-c loads for a minimum of two hours without ac power, and continuously with ac power.

Low, critical low and high battery bus voltage, high battery current, ac failure, and ground detection shall be annunciated in the control room.

The low, critical low, and high voltages that shall be annunciated for the 125 V d-c bus will be 125 V, 108 V, and 140 V, respectively.

4.8.4 System Operation

During unit start-up, the d-c power system will receive d-c power through the battery charger. The battery charger will be supplied from the 380 V motor control centers.

During normal plant operations and shutdown, the d-c power system will receive d-c power through the battery charger to supply all required loads for these mode of operation.

During an abnormal condition, when ac power is lost to the battery charger, the d-c system will receive d-c power directly from the batteries. When ac power is restored, the d-c system will again receive d-c power through the battery charger.

4.8.5 System Maintenance

The station maintenance program will include preventive maintenance, periodic testing and inspections and corrective maintenance.

A complete schedule of manufacturer's recommendations concerning components of the system will be maintained as well as an outline of various problems, their causes, diagnostic indications, and recommended corrective action. All instruments and equipment required to inspect, test, and maintain the system components will be part of the plant stock supply.

Routine preventive maintenance, including routine replacement of components which may be susceptible to common mode failure near the end of their expected life, will be performed on the system in accordance with manufacturer's recommended procedures.
During preventive maintenance circuit breakers will afford the opportunity of component isolation from an energized condition to a de-energized state.

Maintenance performed on the d-c equipment will be done only by qualified personnel who are familiar with the component maintenance manuals and plant operational testing procedures.

4.8.6 Testing

The station maintenance program will include periodic testing for the d-c system following the pre-operational and initial system tests and inspections. The particular tests and the frequency of these tests will depend upon the specific components installed, their function, their environment, and the fact that they are on the station maintenance program.

During the pre-operational stage with all components of the d-c power system installed, tests shall demonstrate that all components are correct and properly mounted, all connections are verified as being correct and continuous, all components are operational, and all metering and protective devices are properly calibrated and adjusted.

4.8.6.1 Initial Start-up System Tests

Following satisfactory checkout of all system components as described above, the initial system start-up tests shall be performed with all components installed. The initial start-up system tests will consist of operational tests conducted to demonstrate that the equipment operates within design limits and that the system is operational and meets its performance specifications. These operational tests will demonstrate:

1. That the normal d-c loads can be operated from the ac power source through the battery charger supplied from the load center, and

2. That upon the loss of the normal ac power source, the battery can supply the design load.

Pre-operational testing of the d-c power system will include the following:

1. The backup features of the battery and battery charger system will be checked out.

2. The capacity of the battery and the voltage profile will be verified by acceptance test per IEEE Standard 450, Section 5.5.1.

3. The recharging of a discharged battery within a specified period will also be verified. (This is a maximum time of 24 hr.)

4. Instruments will be calibrated; also, relays, breakers, and interlocks will be checked.

4.8.6.2 Acceptance Tests

Acceptance tests shall be made in accordance with IEEE 450, Sections 4.1, 5.4.1, and 5.5.1, at the factory. Onsite performance tests will be made in accordance with IEEE 450, Sections 4.2, 5.4.1, and 5.5.1. A battery service test, described in Sections 4.3 and 5.6 of IEEE 450, will be performed during a scheduled plant outage, with intervals between tests not to exceed 18 months.

Corrective maintenance will be performed on components of the d-c power system in accordance with IEEE Standard 450, Section 3.4.

CODES AND STANDARDS

The d-c power system will be designed and constructed in accordance with the latest versions of the following codes and standards:

American National Standards Institute

ANSI C37	Power Switchgear

Institute of Electrical and Electronics Engineers

IEEE Std 484	Recommended Practice for Installation of Large Lead Storage Batteries for Generating Stations and Substations
IEEE Std 450	Recommended Practice for Maintenance, Testing, and Replacement of Large Lead Storage Batteries for Generating Stations and Substations
IEEE Std 485	IEEE Recommended Practice for Sizing Large Lead Storage Batteries for Generating Stations and Substations.

National Electrical Manufacturer's Association

NEMA AB-1	Molded Case Circuit Breakers
NEMA FU1	Low-Voltage Cartridge Fuses
NEMA ICS	Industrial Controls and Systems
NEMA PB-1	Panelboards
NEMA PB-2	Dead-Front Distribution Switchboards

4.9

Fire Stops And Seals

Fire stops and seals shall be provided where raceways penetrate walls, floors and equipment, and require a barrier against smoke, dust, water and airborne contaminants. A fire stop has a fire rating and a seal does not.

Penetration Fire Stop - A sealed cable penetration through a fire barrier wall or floor. The rating of the fire stop is equal to the required fire rating of the barrier.

Penetration Seal - A sealed cable penetration through non-fire rated wall or floor. The "Penetration Seal" is not required to have a fire rating. It may, however, provide a dust, moisture, or pressure seal.

4.9.1 System Requirements

Normal design practice dictates that the openings around cables passing through floor and walls be sealed.

The seals are required to perform two distinct functions:

1. Act as a fire stop
2. Act as a seal

When cables penetrate a fire barrier, the seal is a penetration fire stop and must fulfill the following requirements:

a. Must have a fire rating equal to or greater than the required fire rating of the fire barrier it penetrates. Performance must be proven by test.

b. Satisfy insurance company requirements.

c. Be compatible with cable insulation and jacket material.

d. Consider derating, if any, of power cables.

e. Prevent passage of flame and smoke for a time interval equal to or greater than the fire rating of the wall it penetrates.

f. Allow future addition or removal of cables.

When cables penetrate a nonfire rated wall, the following requirements must be met:

a. Be compatible with cable jacket material.

b. Consider derating, if any, of power cables.

c. Allow future addition or removal of cables.

Fire stops and penetration seals shall be suitable for use in environmental conditions encountered. These requirements are:

1. Temperature, ambient, 93° F
   Temperature, max, 120° F
2. Pressure, 15 psia
3. Humidity, 90 %
4. Chemical compatibility

The seals around cables penetrating walls and floors shall provide adequate mechanical strength to provide necessary pressure barrier and seal against 15 psi.

The seal shall facilitate the removal or addition of cables and be capable of being resealed so as to retain the original integrity of the seal.

The following materials shall be used as fire stops and seals for raceway penetrations:

Dow Corning Silicone Foam Q3-6548

Thomas & Betts flame safe

No normal maintenance is anticipated during the useful life of a fire stop/seal. After installation, periodic inspections should be made to determine any obvious deterioration, such as holes not originally noted or discoloration.

4.9.2 Design

The cable penetrations shall be designed as a system, taking into consideration the size of the opening, depth of the opening, type of cable insulation, and jacket, etc.

The cable shall penetrate the floors and walls through round metallic sleeves or rectangular slots.

Cable trays shall not be carried through fire barrier walls, to minimize the transfer of heat.

4.9.3 Maintenance

Fire stops which have been breached (to add or remove cables) shall be restored to their original design integrity shortly after the work is complete.

4.10 Uninterruptible Power System

The Engineer shall design, specify, and furnish the uninterruptible a-c system.

The uninterruptible power system shall provide control and instrument power to critical systems in the plant. The uninterruptible power system shall supply reliable, stable, and regulated 120 V a-c, three phase, 50 Hz control and instrument power. It will be ungrounded.

4.10.1 System Requirements

The function of the uninterruptible power system will be to supply continuous, regulated, and reliable single phase ac control and instrument power to the DCS System, critical instrumentation and protection circuits during all modes of plant operation.

A voltage of 120 V ±2 percent will be maintained at the 120 V ac bus. The frequency of the inverter output will be maintained at 50 Hz ±0.3Hz. The frequency of the regulating transformer output will vary with that of its input power.

In general, the testing and inspection requirements may be met in part by actual operation of the active components of the system. The capability of the distribution circuits of the uninterruptible power system to transmit sufficient control and instrument power to operate all required loads will be confirmed during these periodic tests and inspections of the loads themselves.

These tests and inspections will ensure the capability of the uninterruptible power system to furnish control and instrument power, and will be performed at scheduled intervals to demonstrate the operability of the uninterruptible power system.

The uninterruptible power system instrumentation and controls will consist of battery charger, battery, inverter and ac panel local monitoring as well as monitoring in the control room so that corrective action may be initiated.

The static inverter will be provided with indicators to monitor voltage, current, and frequency, with input and output protection with alarm relays.

The essential 120 V ac distribution panels will be provided with incoming and feeder protection.

The annunciators will monitor sufficient parameters to alert the control room operator that corrective action is required to restore normal system operation.

Local instrumentation will be furnished to monitor sufficient parameters to:

1. Assist in determining system operation for any annunciated malfunction.

2. Monitor system equipment performance so that long term deterioration of performance can be detected.

The system is normally connected to a battery and rectifier/charger through the static inverter, and to the ac power system through a regulating transformer used during inverter maintenance.

4.10.2 System Design

The uninterruptible power system shall supply 120 V ac control and instrument power to critical systems and certain control building emergency lighting loads. The uninterruptible power system shall consist of a power system with adequate capacity to supply its own essential loads.

The 120 V ac vital bus shall provide power for critical instrumentation and protection circuits. The bus shall be fed from a 125 V battery and battery charger through a static inverter, or from a 380 V bus through a regulating transformer when the inverter is out of service. The 120 V ac and 125 V d-c systems shall be shown on the 125 V d-c and 120 V ac vital bus one-line diagrams prepared by the Engineer.

The output of the static inverter shall be connected to a vital bus distribution cabinet through a normally closed circuit breaker. The regulating transformer shall supply an ac input to the 120 V ac vital bus when the associated inverter is down for maintenance.

A manual by-pass switch will be provided to connect the regulating transformer to the vital bus distribution cabinet. When this switch is in this "alternate", or bypass position, this condition shall be alarmed.

The distribution cabinets for the 120 V ac vital bus system shall have 15 and 20 ampere branch fused disconnects to feed protection and other instrument loads.

The 120 V ac vital bus system shall constitute a very reliable electrical system with independent conversion equipment. This system shall provide a stable instrument power supply to critical equipment and shall guarantee supply to this equipment. Spurious shutdowns shall be minimized as a result of the reliability and stability of the 120 V ac system.

The 120 V ac vital bus voltage shall be maintained at 120 $\pm$2.0 V. When the vital bus is fed from the inverter source the system frequency variation shall not exceed 50 Hz, $\pm$0.3 Hz.

The 120 V ac vital bus regulating transformer shall be located in the electrical equipment and control building near the static inverter.

The 120 V ac vital bus shall be located in the same area of the plant as the inverter and regulating transformer.

The static inverter shall be suitable for input voltage range of 105 V to 140 V d-c, and output voltage maintained at 120 V $\pm$2 percent from no load to full load. Harmonic distortion of output voltage shall not exceed 5 percent, and its frequency shall be maintained to within $\pm$0.3 Hz over the full range of load and input voltage. The inverter shall be current limiting at 150 percent of full load and shall permit indefinite operation at that level. Upon sudden application or removal of full load, output voltage undershoot or overshoot shall be corrected to a level that will not cause damage or improper operation of the inverter. In addition, voltage shall recover to within 2 percent of steady state within 0.1 sec after the occurrence of this event.

The inverter shall operate in continuous synchronism with a 50 Hz, 380 V ac sine wave reference power system.

The yearly average ambient temperature of the area where the static inverter is located shall be maintained at less than 82° F.

The voltage regulating transformer shall be suitable for input voltage range of 417 to 528 V, ac, three phase, 50 Hz, $\pm$.3 Hz and output voltage maintained at 120 V $\pm$2 percent from no load to full load with output adjustability of $\pm$10 percent. Harmonic distortion of output voltage shall not exceed 5 percent. The regulating transformer shall have current capability to withstand high in-rush load currents and momentary overloads. Specifications for the transformers shall include the above requirements. The yearly average ambient temperature of the area where the regulating transformers are located shall be maintained at less than 82° F.

Instrumentation and control for the uninterruptible power system shall consist of inverter control and instrumentation, as well as control and instrumentation of the critical 120 V ac bus and loads.

The static inverter ac output shall be provided with a voltmeter, an ammeter, and a frequency meter. Abnormal conditions existing for at least 0.05 sec will be alarmed. These shall include output low voltage, overload, opening of any fuse, and reduced air flow when forced air cooling is used. Local indicators shall be provided for the abnormal signals, with signals for alarm in the control room.

The distribution panel shall be provided with three-pole disconnecting type fuses suitable for 120 V service.

The uninterruptible power system shall normally interface with the static inverter and with the ac power system through the voltage regulating transformer during inverter maintenance.

4.10.3 System Limitations, Set Points, and Precautions

The components of the uninterruptible power system can be loaded only within their nameplate ratings. Loads in excess of this will cause reduced life expectancy and may cause automatic disconnection of the loaded circuit. Electrical equipment shall be sized and load groupings shall be assigned such that the maximum coincidental load falls within the rating of each uninterruptible power system component.

To prevent unnecessary unit tripping, all testing of vital bus loads must be withheld, whenever the system inverter fails or is being taken out of service, until the 120 V a-c vital bus is fed through the regulating transformer.

4.10.4 System Operation

The 120 V vital bus shall be normally energized through a static inverter. An alternate source of power will be from the ac power system through a regulating transformer. The transformer will be used during periods of maintenance on the inverter.

The 120 V vital bus will be energized to supply adequate power to the uninterruptible power system during start-up by energizing all required loads for this mode of operation.

Adequate power will be supplied to the uninterruptible power system during normal operation to energize all required loads for this mode of operation.

For a normal plant shutdown, adequate power shall be supplied to the uninterruptible power system for this mode of operation.

In the event of an inverter failure, the corresponding voltage regulating transformer can be temporarily connected to provide power to the bus.

4.10.5 System Maintenance

The maintenance program for the uninterruptible power system will include preventive maintenance, periodic testing, inspection, and corrective maintenance.

Complete schedule of manufacturer's recommendations concerning components of the system will be maintained as well as an outline of various problems, their causes, diagnostic indications, and recommended corrective action. All instruments and equipment required to inspect, test, and maintain the system components will be part of the plant stock supply.

Routine preventive maintenance will be performed on components of the system in accordance with manufacturer's recommended procedures. These procedures will be directed at detecting the deterioration of the system toward an unacceptable condition and demonstrating that standby equipment and other components that are not exercised during normal operation are operable.

During preventive maintenance circuit breakers afford the opportunity of component isolation from an energized condition to a de-energized state.

Any maintenance performed on the system equipment will be done only by qualified personnel who are familiar with the component maintenance manuals and plant operational testing procedures.

The station maintenance program will include periodic testing for the uninterruptible power system following the pre-operational and initial system tests and inspections. The particular tests and the frequency of these tests will depend upon the specific components installed, their function, their environment, and the fact that they are on the station maintenance program. These tests will be directed at detecting the deterioration of the system toward an unacceptable condition and will demonstrate that standby power equipment and other components that are not running during normal operation are operable.

During the pre-operational stage with all components of the uninterruptible system installed, tests will demonstrate that all components are correct and properly mounted, all connections are verified as being correct and continuous, all components are operational, and all metering and protective devices are properly calibrated and adjusted.

Following satisfactory checkout of all system components as described above, the initial system start-up tests will be performed with all components installed. The initial start-up system tests will consist of operational tests conducted to demonstrate that the equipment operates within design limits and that the system is operational and meets its performance specifications.

Typical inspections will include visual inspection of inverter, metering, and surveillance equipment.

Each static inverter will be given a thorough periodic inspection following the manufacturer's recommendations.

Corrective maintenance will be performed on components of the uninterruptible power system as required. The specific maintenance action will depend on the type of equipment, type of correction to be made, and manufacturer's recommendations on the subject.

CODES AND STANDARDS

The uninterruptible power system will be designed and constructed in accordance with the latest versions of the following codes and standards:

American National Standards Institute

ANSI C57	Transformer, Regulators, and Reactors

National Electrical Manufacturer's Association

NEMA AB-1	Molded Case Circuit Breakers
NEMA FU1	Low-Voltage Cartridge Fuses
NEMA ICS	Industrial Controls and Systems
NEMA PB-1	Panelboards
NEMA TR-1	Transformers, Regulators, and Reactors
NEMA WC5-1973	Thermoplastic - Insulated Wire and Cable

Miscellaneous

NFPA No. 70	National Electrical Code
NFPA No. 78	Lightning Protection Code
UL 96A	Installation Requirements -

Master Labeled Lightning

Protection System

1.

5. Instrumentation and Controls Design Criteria

5.1 General

5.1.1 Guidelines

The Instrumentation and Control (I&C) Design Criteria are prepared to present guidelines that will be followed in the design and installation of the I&C systems for the Germencik Geothermal Project (the Project). It is intended that this document shall be used by the Engineer as input to equipment specifications, installation drawings and instructions.

The design criteria are based upon the following design objectives:

1. Maintain the plant in a safe condition at all times. Automatic protection and plant trips shall be provided so that if a potentially dangerous situation should occur, the plant will be maintained in a safe and undamaged condition without the need for any operator action.
2. Prevent the violation of environmental regulations concerning air, land, and water quality requirements.
3. Provide for smooth startup and shutdown of the power plant and auxiliary systems in accordance with pre-planned operating procedures with a minimum of operator intervention.
4. Provide for efficient steady-state control of the power plant and auxiliary systems.
5. Provide reliable steady power plant operation at the full range of possible operating capacity levels.
6. Minimize the effects of abnormal process conditions, load upsets, and equipment malfunctions on power plant operations.
7. Provide operator interfaces that minimize the potential for operator error.
8. Minimize the number of plant forced outages and spurious trips.
9. Provide for reliable, economical/optimum operation of the turbine generator and related systems.
10. Provide for ease of construction.
11. Provide a control system that allows for maximum flexibility to expand the system and/or modify control functions that affect the performance of the unit during initial startup, testing and operation.
12. Minimize the effects of corrosion and scaling through proper equipment and material selection, equipment location, environmental control, and on-line maintenance capability.

5.1.1.1 Control System

In general, during normal operation of the plant all control and monitoring functions will be performed from the control room, however, startup and shutdown of equipment for maintenance will be performed locally at the equipment using a hand/off/auto select switch along with start/stop push buttons. These controls shall be wired directly into the MCC, eliminating the need for the DCS, should it be down. DCS control shall only be enabled if the H-O-A select switch is in the auto position. The circuits within the hardwired controls shall incorporate all necessary interlocks for safe operation of the equipment utilizing process mounted switches. The DCS shall not be used for these interlocks.

5.2 Main Control Room And Power Distribution Center

5.2.1 Control Room Area

The control room locared in the PDC, will be designed in accordance with human factors engineering principles to the maximum extent possible for the comfort and efficiency of operations personnel. Control items not requiring operator attention such as protective relays, computer hardware, EHC and excitation control cabinets, will be located in a separate area of the modular Power Distribution Center (PDC) adjacent to the turbine building.

The main control panel serves as the operator/plant interface, and it is essential that information be presented to the operator in a clear and simple form and in order of priority. The following design guidelines will be observed:

1. The control room area will be designed to permit two control room operators to control and monitor plant operation and identify plant abnormalities for the brine flashing operation and power generation facilities. This will be accomplished by optimizing the length of the control panel and by minimizing the number of display devices which must be continuously monitored during plant operation.
2. Although the panel will be designed to permit two operators to monitor plant operation, the size and arrangement of the new panels will accommodate additional operators, if necessary, during test operations or other periods of unusual operating conditions.
3. Testing and maintenance procedures involving control panel-mounted equipment will be possible with minimal interference with the plant operation.
4. All alarm functions will be handled by the DCS. No separate annunciator system will be provided.
5. One (1) additional color CRT's with keyboards will provide the operator interface with the plant distributed control system (DCS). All primary control and monitoring functions for the process will be done through the DCS. All of the CRT's will have access to the same data base.
6. The main control panel will be a bench type panel which will house the CRT stations alarm and operations keyboards.
7. A fire protection monitoring panel for the plant shall be located in the control room area.
8. Two graphic capable, laser jet type printers will be provided as part of the distributed control system. One printer shall be dedicated to alarm printing; one dedicated to event logging.

In general, cables shall enter equipment from the bottom of the panels. There shall be no exposed conduits or cable tray in the control room.

Ambient temperature will be controlled at 24° ±1°C. Relative humidity will be controlled to 50% ±10°%.

Non-electric signals of plant instrumentation and control shall not be connected direct to control room equipment.

5.2.2 Power Distribution Center (PDC)

The PDC shall be placed on concrete pillars with 6'-0" clearance between ground elevation and floor of the PDC. In order to minimize the effects of corrosion on sensitive control equipment, the PDC environmental conditions will be controlled using redundant air conditioning units.

These rooms will also be designed to minimize the amount of unnecessary traffic and maintain the highest practical level of cleanliness.

Ambient temperature will be controlled at 24° ±1°C. Relative humidity will be controlled to 50% ±10°%.

Non-electric signals of plant instrumentation and control shall not be connected direct to the PDC equipment.

In general, cables shall enter the cabinets from the top.

The following equipment shall be located in this room:

- DCS process control units and other equipment not otherwise required in the control room
- Vibration monitoring racks
- Turbine Generator governor controls

5.3 Distributed Control System

5.3.1 General

The plant will generally be operated via a distributed control system (DCS). The DCS shall be complete with all necessary hardware and software.

The DCS shall be provided with the following hardware and software accessories.

1. Sequential and discrete digital logic for motor control and interlocking as well as analog control for modulating control loops.
2. Sequence of events capability shall be provided within the DCS with time resolution of 1 msec.
3. All unit devices capable of communicating with one another on a redundant data highway.
4. CRT interactive graphics with dynamic data updating.
5. Efficiency calculation, custom report generation, and long term data archiving. This may be done in the DCS or in an auxiliary computer system dedicated to any or all of these function. Data archiving shall be done on optical disks. Any I/O points or internal alarms shall be capable of being logged.
6. Spare rack space containing approximately 20% spare I/O hardware for each type of I/O will be provided.
7. The system should have the capability for future expansion.
8. The system should have the capability to interface through a modem with a personal computer for transfer of report data.

The alarm reporting system shall have the capability to group and prioritize incoming alarms as well as to disable individual or groups of alarms.

The system will have the capability to interface with the major brands of programmable logic controllers. Following summarizes the PLCs that could be expected on site:

- Modicon
- Bentley
- Woodward 509

5.3.2 Turbine Generator Governor / DCS Interface

The DCS will make provisions for the necessary I/O and displays to interface with the Turbine Generator control system.

All T/G controls and monitoring necessary for operation of the T/G shall be incorporated into the DCS. The DCS operator shall interface with the governor system through graphic displays on the DCS.

A separate T/G control interface shall be provided in the control room. The primary purpose of this panel is to monitor the governor system. This panel shall not contain the actual governor controls, but will only be a monitoring window to them.

The T/G controls shall allow:

- Isochronous Control Mode
- Speed Control Mode
- Load Control Mode
- Pressure Control Mode
- Have provisions for Droop control.

The DCS shall indicate and alarm all T/G alarms.

5.3.3 DCS Requirements

5.3.3.1 General

The DCS will be separate from the hard wired Station Electrical Protection, Metering System and the Turbine Generator control system, but will have access to select variables within these systems. (Refer to Electrical Design Criteria and the Turbine Governor Specification).

The DCS shall be capable of handling any normal logic complexity associated with plant interlocks and shall also be capable of being programmed in the field with minimum effect on plant operations. The application software (firmware) shall be non-volatile.

The DCS shall be designed and constructed so that it will not be affected by transient or continuous electro-magnetic interferences. This will include the capability to continue normal operations with RF emission from a hand held FM transceiver keyed adjacent to DCS equipment, including the process control units and the operator interface stations. Credit may be taken requiring DCS enclosure doors to be closed. The engineering work station is exempt from this requirement.

All trips shall be alarmed on the operator interface and printed at the operations printer

DCS control nodes shall be equipped with dual power supplies and redundant control processors.

The DCS shall be of modular design, with a fault tolerant, redundant architecture such that the failure of one section will not affect the operation of other sections of the equipment. The reliability of each constituent part of the system, and the system as a whole shall be such as to meet the overall plant performance criteria. This shall be achieved by suitable levels of redundancy on the equipment.

Critical I/O shall be duplicated implemented with redundant inputs. Digital inputs shall utilize a "1 out of 2" voting system to propagate the condition. Analog signals shall utilize a select feature, and the ability to switch primary controlling signal. An alarm shall be generated if redundant analog signals deviate by more than 10% of span.

There should be no process change resulting from the failure of a controller.

The final fully configured system shall have a total round-trip time for a command to be processed, including display of the feedback signal from the local processor, of less than 2 seconds.

5.3.3.2 I/O Requirements

5.3.3.2.1 Analog Input

The DCS shall be capable of accepting the following analog signals:

- Current inputs 4 to 20 mA with individual A/D conversion. The system shall be capable of supplying the 24 V d-c loop power for 4 to 20 mA 2-wire or 3-wire transmitters.
- Current inputs of -1.2 - 0 - +1.2 mA (nominal) from standard SCADA compatible metering and relaying devices,
- Voltage inputs within the range of -10 Vd-c to +10 V d-c.

The choice of field or system power shall be user selectable for each point. Inputs shall be via a low-pass filter to reject high frequency interference. Common mode noise rejection shall be a minimum of 110 dB at 50 Hz. Normal mode rejection shall be a minimum 60 dB at 50 Hz. Accuracy shall be ±0.2% of full span or better.

As an option, the Engineer may utilize SMART field communications between field transmitters and the DCS. The Engineer may daisy-chain multiple transmitters one a single field bus type loop. Use of SMART communications must be done in such a way as to be fault tolerant (e.g.; ring topology).

5.3.3.2.2 Analog Output

The DCS shall be capable of driving 600 ohm standard or up to 750 ohms total loop resistance at 4 - 20 mA. The system shall be capable of supplying the 24 V D-C loop power. The choice of field or system power shall be user selectable for each point. The system shall also be capable of providing a user selectable default output state for each individual point in the event of an error. Accuracy shall be ±0.2 % of full span or better.

As an option, the Engineer may utilize SMART field communications between field devices and the DCS. The Engineer may daisy-chain multiple transmitters and/or final control elements on a single field bus type loop. Use of SMART communications must be done in such a way as to be fault tolerant (e.g.; ring topology).

5.3.3.2.3 Digital Input

The DCS shall be capable of receiving the following signals:

- 24 Vd-c,
- 48 Vd-c,
- 220 Vac or
- 110 Vd-c

All digital inputs shall be available with selectable filtering from 2 to 20 milliseconds.

Inputs shall be high impedance type.

5.3.3.2.4 Digital Output

The DCS shall provide isolated contact rated at110 V d-c, 3A and 220 V a-c and user selectable as normally open or normally closed, momentary or maintained.

The system shall be capable of providing a user selectable default output state for each point in the event of an error.

5.3.3.2.5 Temperature Inputs

The DCS shall be capable of receiving the following temperature detector inputs:

- RTD Input: Capable of receiving 100 ohm platinum resistance temperature detectors (RTDs) inputs directly. Lead length compensation for 3-wire RTDs shall be provided. Other types of RTDs such as 10 ohm copper RTDs shall not be used due to the presence of hydrogen sulphide.
- T/C Input apable of receiving all types of thermocouple inputs directly. Cold junction reference compensation and open circuit detection shall be provided. Millivolt input ranges of -100 to +100 mV and 0 to +100 mV shall also be provided. Thermocouple reference junction temperature compensation shall be provided. The thermocouple reference junction temperature compensation value shall be available for display to the operator and shall have alarm limits.

5.3.3.2.6 Pulse Input

The DCS shall be capable of receiving square wave or contact input of 1-10 volts and a pulse rate of up to 25 kHz.

5.3.3.3 General Guidelines

In general, the following signal standards shall be used:

- Analog input signals shall be 4 to 20 mA.
- Analog output signals shall be 4 to 20 mA.
- Digital inputs interrogated by the DCS shall be 24 Vd-c.
- MCC monitoring and interrogation shall utilize MCC control power and shall be 220 V a-c or 110 V d-c as appropriate.
- Turbine trip circuitry shall be 110 V d-c.
- Field cables shall not terminate directly onto electronic circuit boards.
- For each analog input and output, two terminals plus isolated ground connection shall be provided.
- For digital inputs, a minimum of one common terminal for each four digital inputs shall be provided. Common terminals supplying outgoing field power shall be individually fused.

5.3.3.4 Spare Capacity

The DCS shall have spare capacity after the Unit is fully commissioned as follows:

- Multi-loop controller - 50% of total processing capacity per module.
- I/O - 20% of I/O per process control unit.
- Cabinet space for expansion - 25%.
- All spare I/Os shall be active and wired to terminations and clearly shown on the termination drawings.
- The DCS shall allow for system expansion through the addition of controllers, operator work stations and I/O modules while system is on line.

5.3.3.5 Distributed Control System Cabinets

A 19 inch rack mounting shall be provided for all DCS modules, modular power systems and terminations. The cabinets shall be able to accommodate either top or bottom cable entry. The cabinets shall provide front and rear doors to provide easy access for installation and maintenance of power systems and mounting assemblies.

5.3.3.6 Power Supplies and System Power Feeds

The DCS components within the power plant shall be supplied from two secure 220 V a-c sources: one from an uninterruptible power supply (UPS) and the second from a reliable 220 V a-c bus. The DCS shall monitor alarms from the internal power supplies.

Redundant power supplies shall be provided to power process control modules and field termination devices. The power supply output voltages shall be well regulated and not fluctuate more than ± 1% with input voltages of 220 V a-c ± 10%.

5.3.3.7 Operator Work Stations

One (1) Operator work stations (OWS) and an engineering work station (EWS) shall be supplied and installed in a control desk to be located in the power plant control room. The engineering work station shall be used primarily for system maintenance, engineering and configuration functions.

5.3.3.8 Control Desk

All operator work stations shall be installed in the control room in a suitably designed control desk. The control desk design shall incorporate at least 2 work surfaces, each equal in floor space to the area allowed for an OWS, to provide workspace for plant operators.

5.3.3.9 Data Storage

At least two high density optical disk drives shall be supplied for redundant storage and retrieval of historical and trend data, system software, and system configuration files. Software shall be provided to allow easy transfer of archived data into MicroSoft compatible database or spreadsheet format.

Tape Drives are not acceptable as backup devices.

5.3.3.10 Printers

Two industry standard non-impact, laser jet type printers shall be provided. This printer shall be a high resolution laser jet single color suitable for printing A4 and A3 paper. These shall be desktop mounted in the Control Room on suitable furniture with space for paper, toner cartridges and other supplies. The printers shall include paper trays and feeders.

The 2 printers shall be utilized as follows:

- One dedicated to alarm printing
- One dedicated to event logging.

The minimum print speed acceptable is 300 characters/second.

Printers shall operate without sound hoods in a quiet control room environment and printer noise level shall not exceed 47 dBA at distance of 1 m from printer.

Sufficient toner cartridge set(s) for each printer suitable for one year's operation of the power plant shall be supplied with the equipment. Printers shall use commercially available printer paper which is readily available.

Printouts shall be spooled, and printouts intended for a printer which has failed shall be able to be re-routed to the other printer.

Each printer shall be able to be accessed via any operator work station. Printers shall be network interfaced. Printer "Failover Switches" shall not be used.

5.3.3.11 Operator Workstation Software/Display Subsystem

The system software shall be designed by the DCS provider. It shall be design in such a way as to provide a seamless, transparent connection to the existing plant. Graphics shall be designed with similar symbology, colors and styles.

5.3.3.12 Historical Data Storage and Retrieval System

The system shall include a comprehensive historical storage and retrieval system for long term archiving of predefined digital and analog process data in a series of disk files. The number and the size of the disk files shall be user configurable. This data shall be stored on a large capacity optical disk for long term storage. Disk capacity shall include at least two years storage of historical data collected from the system.

It shall be possible to view the data logged to disk search for any desired portion of the file. Software shall be provided to allow easy transfer of archived data into MicroSoft compatible database or spreadsheet format.

Facilities shall be provided to both archive and restore log files to and from floppy or other backup media without taking the system off-line.

The data recorded by the historian shall be selected through the "event log" database.

5.3.3.13 Reports

The DCS shall generate the following reports

5.4 Instrument Application

5.4.1 General Technical Requirements

No process or instrument air lines associated with any instrumentation shall be brought into the control room area or adjacent electrical/electronic equipment rooms.

No electrical voltages in excess of 220 V nominal associated with any instrumentation shall be brought into the main control room area.

Instruments or other devices containing mercury shall not be used in any system.

Prime consideration will be given to the effects of corrosion and scaling on instrument selection and installation. Materials selection will be based on conditions of service and will be indicated on individual instrument data sheets. Bronze and other copper bearing alloys shall be avoided.

Engraved phenolic tags engraved with the instrument tag number shall be permanently attached to all instruments.

Outdoor electrical enclosures shall have a NEMA 4X rating and shall generally be of nonmetallic construction.

All instruments and control equipment will be readily available from U.S. suppliers and shall be approved by a national testing agency such as FM or UL.

All control and instrumentation items and associated valves shall be located for easy access by operating and maintenance personnel from a floor, permanent platform or walkway.

Portions of the process will contain fluids that are highly susceptible to precipitation of salts. The Engineer is responsible for the design and installation of heat tracing for instrument sensing lines as required to prevent precipitation.

5.4.2 Instrument Electric Supply Systems

Electric power for all instruments shall be supplied from an Uninterruptible Power Supply (UPS) system.

Dual redundant instrument power supplies shall be provided and have the capability of being replaced on-line without affecting the operation of the instruments. The output of the instrument power supplies shall be 24 V d-c.

Field instrumentation shall be standardized as much as practical.

Redundancy for sensors as controls shall be provided to meet the design availability requirements for the Plant.

Multiple sensors shall be used in instances where a single sensor cannot be expected to provide an average true value because of conditions or where a single instrument cannot cover the expected range.

Generally, individual transmitters and controllers will be installed to permit isolation without upsetting the process.

Separate test taps or thermowells shall be provided as required for performance or acceptance testing.

Instruments dials and scales shall be white with black markings. The number of markings on all instruments dials shall be kept to a minimum consistent with easy reading to the required accuracy. All instrument dials shall be at least 100 mm diameter. Instrument ranges shall be selected so that the dial pointer is at the 2 o'clock position under normal operating conditions.

Measuring devices shall be complete with all necessary condensation chambers, isolating valves and seal pots.

One pair of tapping points with isolating valves only shall be made in the pipeline and any multiplication of signal output shall be carried out elsewhere.

Bellows-type meters shall be capable of taking full line pressure on one side only, without damage or loss of calibration.

Snubbers will be added only after their installation is shown to be required.

5.4.3 Instrumentation Design Implementation

5.4.3.1 General

In general, alarm contacts from field devices should be open during normal operation and close to alarm. The exception to this is in the case of fail safe items such as turbine tripping schemes.

Alarms shall generally be generated within the DCS off of the analog signal measuring the process variable.

In cases where additional reliability orredundancy of signals are required, the trip signals should be generated off of process switches.

Process switches monitoring critical process variables (such as liquid levels protecting against turbine water induction), redundant switches will be used in a 1 out of 2 switching scheme. Analog signals shall utilize a select feature, and the ability to switch primary controlling signal. An alarm shall be generated if redundant analog signals deviate by more than 10% of span.

5.4.3.2 Valve Limit Switches

Limit switches from on/off control valves shall be wired such that both contact are closed in mid-travel.

The closed limit switch is that limit switch that changes state at the valve closed position. Similarly, the open limit switch is that limit switch that changes state at the valve open position

5.4.3.3 Initiating Devices

Trip signals shall be derived as directly as possible from the initiating device. Wherever possible, pending trip conditions shall be alarmed at the operator interface.

Critical process trip signal systems shall operate on a 2 out of 3 voting system basis. When one signal is locked out of service, the trip signal system shall operate on a 1 out of 2 voting system basis. Analog signals shall utilize a select feature, and the ability to switch primary controlling signal. An alarm shall be generated if redundant analog signals deviate by more than 10% of span.

5.4.3.4 System Safety

The control and plant protection systems shall be designed to ensure that the plant reverts to a safe state upon failure of any individual plant item or power supply, and that the operator is notified of the failure. The following means may be used to ensure a "safe" state:

- Automatic switching to a standby device or power supply
- Shutdown of the affected plant
- Locking of the control system at the settings prevailing immediately prior to the failure

5.4.3.5 Subsystems

Individual systems comprising this power generation plant may have equipment which requires some form of proprietary control or monitoring system. The distributed control system shall provide as much of this control and monitoring as possible. Separate specialized electronic controls dedicated to a particular control task or sub-system shall be utilized only when the specialized nature of the task or subsystem requires it (eg AVR, governor controls, vibration and temperature monitoring subsystems).

Where such specialized electronic controls are utilized, they shall be fully interfaced with the DCS, using compatible communication hardware and by the provision of communication software as necessary. The interface to the DCS shall be made at the node allocated for the control of that local plant / subsystem.

On/Off and start-up of back-up equipment shall generally be determined via discharge flow or pressure monitoring. Motor control circuit energized status shall be used where redundant motor/pumps combinations or other electrically driven redundant or standby equipment exists, or where discharge condition monitoring is inappropriate.

5.4.3.6 Electrical Noise

The field instrumentation performance shall not be affected by electro-magnetic or radio frequency interference up to 3 V/m and according to IEC 255-22.

In order to minimize the effects of generated or radiated electrical noise:

- The d-c power and signal cables shall not run parallel or in close proximity to ac power cables.
- The d-c and ac control and instrumentation cables of differing voltages shall be segregated.
- Proper grounding techniques shall be utilized
- Shields shall be terminated on the monitoring system end only, and only to an isolated ground.
- The primary a-c power source shall be noise free

5.4.4 Instruments Cables And Wiring

Power wiring to and from the instruments and power supply units shall be such that power supply units can be removed without total system shutdown.

Wire and cables of electronic instrument installation shall be single pair not less than 1.5 mm tinned copper conductors with PVC insulation, twisted, with aluminum shielded mylar tape separators with drain wire, extruded PVC inner sheath, wire braid or armor, and overall PVC jacket.

Single pair wires shall be run in separate trays from the various transmitting and control devices to centrally located field terminal junction boxes in the process area. From the centrally located junction boxes, 20 pair cable shall be run to the DCS termination cabinets. If all pairs within a particular cable is not utilized, they shall be identified as spare. Cable sizes of less than 20 pair connecting field junction boxes and the DCS shall not be utilized.

The ac power and signal wiring shall be separated by a minimum spacing of 100 mm in all cases, and shall not under any circumstance be run in the same wire way.

Wiring between terminals shall be point-to-point and free from wire splicing and T connections.

When shielded cables or wires are necessary, an insulating sheath shall be included. Provision for termination of shields, or means to maintain the continuity of isolated shields shall be provided as required.

In general, the plant electrical system will be designed, built, and tested in accordance with the most recent NEC Standards. The basic design philosophy shall provide the most effective measures to ensure high reliability and low maintenance.

5.4.5 Isolated Ground

Grounding of control systems and instrumentation equipment shall follow good industry practice and be such as to ensure that equipment operates reliably, safely and without damage in the presence of large electrical disturbances such as occur in power generation plant. A separate grounding system for control and instrumentation systems shall be established:

- The plant shall incorporate an isolated ground system for use by the instrumentation and control system
- The isolated ground system shall tie into the plant equipment ground system at only one point.
- The system shall be isolated from the power system
- The isolated ground system shall not have any ground loops.
- In general, shields shall be terminated in the rack or cabinet where the measurement is monitored. The shield at opposite end of the cable shall be cut and taped.

5.4.6 Instrument Requirements

5.4.6.1 Electronic Instruments

Electronic equipment offered shall be of a type having proven record of reliability under geothermal power station service conditions.

All remote control loops shall be solid state electronic and control signal transmission shall be current type, 4-20 milliamps d-c, and utilize a 2-wire circuit (ISA Type 2).

Dual-auctioneered, regulated power supplies shall be used in the distributed control system I/O cabinets and shall operate on 220V a.c., 50 HZ house power (with isolation transformer) and from the plant UPS.

Field mounted transmitters shall have a minimum load resistance capability of 300-800 ohms at a corresponding power supply voltage of 23-32.7V d.c. (ISA Class U). Accuracy shall be 0.25% of calibrated span or better, including repeatability, linearity, and hysteresis.

Signal reference and cable shielding ground connections shall be made at one point only and that point shall be the isolated grounding bus in the appropriate electronic cabinet in the relay room unless otherwise specified. The field end of the shielded cable shall have the shielding clipped off close to the outer layer of insulation and an insulating tape applied to assure that the shielding does not touch the local instrument or appurtenances at any point. (Refer to Electrical Design Criteria for additional details).

5.4.6.2 Transmitters and Transducers

All transmitters shall be as much as possible of the SMART variety and shall conform to the HART protocol requirements.

In general, the range for an analog input shall be sized such that the maximum process value is approximately 85% of the range. The range shall always be rounded to a convenient number such as 50, 100, 800, 1000, etc.

Accuracy shall be 0.10% of calibrated span or better, including repeatability, linearity, and hysteresis.

All wetted parts of the transmitter shall be at least 316 stainless steel construction.

Transmitter fill fluid, if used, shall be silicone.

Transmitters shall be provided with flange adapter kits and mounting brackets.

Transmitters shall be housed in a NEMA 4X rated enclosure.

A hand-held SMART transmitter calibrator shall be provided with the transmitters.

Diaphragm seals shall be used where corrosive liquids are in the process and require process isolation from the transmitter element. Seals shall be standardized as much as possible for interchangability.

Analog measurements from process plant and electrical power supply systems for remote indication and control purposes shall be transmitted as 4-20 mA d-c output signal. Alternately, the Engineer may utilize SMART field bus type communications.

Transmitters and transducers shall be solid state electronic devices suitably designed for the location and services required.

Appropriate measures shall be taken to prevent any impurities in the fluid being measured from affecting transmitter and transducer operations. This shall generally be achieved by providing double diaphragm seals.

5.4.6.3 Pneumatic Instruments

All modulating control valves and dampers, unless otherwise specified, shall be air operated. The conversion from an electronic control signal to a pneumatic control signal will be made at the final control element with a current to pneumatic (I/P) transducer with pneumatic valve positioner where necessary.

Critical final control elements will have a local pneumatic loading station for testing or emergency operation.

Pneumatic valve positioners shall have the following design features as required on a case by case basis:

- Characterizeable (feedback cams).
- Useable for double or single acting service.
- Direct or Inverse action.

- High capacity pilot valves.
- Suitable for linear or rotary movement.

All pneumatic instruments shall be fitted with inlet filters.

All vents off of pneumatic instruments shall be fitted with bug screens.

All pneumatic instruments shall be mounted in separate, non-metallic enclosures with an air purge from the instrument air supply.

Instrument air will be supplied In accordance with section 10.16. Instruments shall be designed to operate over an air supply pressure range of 5-9 bar. Pressure reduction to the level required by the instrument or valve will be done locally at the instrument.

Where appropriate for multiple runs of tubing, trays and/or tube bundles will be utilized.

5.4.6.4 Process Switches

Process switches, e.g. pressure, temperature, flow, limit, shall contain a minimum of two isolated Form C contacts, unless otherwise specified. Switches shall be snap-acting type.

The switch element shall be located in a hermetically sealed enclosure which prevents exposure of contacts to atmosphere.

Switch contact ratings for specific applications will be shown on the respective technical data sheets.

5.4.6.5 Temperature

5.4.6.5.1 Resistance Temperature Detectors (RTD)

For general process applications, three lead, 100 ohm @ 0°C platinum RTD shall be used. These devices shall not be used for temperatures in excess of 340°C. They shall be duplex, sheathed, ungrounded, and ceramic insulated. The sheath O.D. shall be 6.mm. They shall be furnished with terminal blocks and grounding lug.

Manufacturer supplied copper RTD's, (10 ohm @ 25°F), are not acceptable.

RTDs monitoring process fluids shall be mounted in suitable thermowells.

5.4.6.5.2 Thermocouples

For applications not suitable for RTD's, chromel-constantan (Type E) thermocouples shall be used. These shall be duplex, sheathed, grounded, and ceramic or magnesium oxide insulated. They shall be furnished with terminal blocks and grounding lug. The sheath O.D. shall be 6 mm. Thermocouple extension wire, of the same material as the attached thermocouple, shall always be used to interconnect the thermocouple to its transducer.

Thermocouples monitoring process fluids shall be mounted in suitable thermowells.

5.4.6.5.3 Bimetallic Thermometers

For local temperature indication, not requiring high accuracy, bimetallic type thermometers with a universal angled, 125 mm nominal diameter dial and 6 mm" O.D. stem shall be used. These shall be inserted in a thermowell.

5.4.6.5.4 Filled Thermal Systems

In general, filled thermal systems shall not be used. In those applications where no other technology is practical, filled instruments may be used. Instruments using filled systems include the sensor bulb and the readout device or switch as a complete system. The class of the system and bulb diameter are generally determined by temperature range, length of capillary required and whether a uniform scale is required if there is a readout device. Thermowells compatible with a specific type of bulb will be specified with the thermal system.

5.4.6.5.5 Thermowells

Thermowells for use with filled thermal systems are not included in the scope of this section. (See previous Subsection on filled thermal systems.)

There shall be two means of attachment:

- Socketweld - 25 mm socketweld shall be preferentially utilized for clean, low pressure and temperature service.
- Flanged - The flanged means of attachment shall be used on all vessels and for all services where socketweld wells are not appropriate. In general, 38 mm RF flanged wells will be used.

Thermowells shall be constructed of the following materials:

- Water and other benign fluids: 316SS
- Steam and Brine service: Alloy 625/Hastelloy C, or 2205 flange welded to Alloy 625/Hastelloy C probe.

5.4.6.5.6 Test Wells

Test wells, where required, shall meet all the criteria for material, design, construction and certification specified for thermowells. Each test well shall be furnished with a stainless steel extension nipple and screwed cap. Extension nipple length shall be as determined by the manufacturer, unless otherwise specified by the A/E.

5.4.6.6 Pressure

Local pressure indicators shall be bourdon tube type with an accuracy of ±0.5% of span. Dials shall be white with black markings and shall be 115 mm diameter with a dial arc of 270° unless otherwise specified. Units of measurement shall be indicated on the dial face and the pointer shall be externally adjustable from the front of the gauge. The gauges shall be a solid front, blow-out back, hermetically sealed type. Gauge movements shall be stainless steel, geared type and the bourdon tubes and sockets ANSI 316 SS (Refer to ANSI B40.1-1974 for application guidelines).

Pressure gauges shall be Ashcroft or 3D gauges. 3D gauges shall be used on vibrating platforms such as near pumps and level control valves.

5.4.6.7 Flow

5.4.6.7.1 General

For general flow measurement applications, head type flowmeters shall be used. Where higher, wide range accuracies are required, or special operating conditions exist that preclude the use of head type meters, other types of metering systems will be specified. All steam flow measurements shall have associated pressure and temperature measurements to be used for mass flow calculation in the DCS.

Differential pressure primary elements in hot liquid services shall be under sufficient hydrostatic head to prevent flashing at the lowest pressure point in the element outlet.

Differential pressure type flowmeters shall be fitted, as a minimum, with 5-valve manifolds including an equalizing valve for zero check.

Primary flow elements shall be readily accessible for maintenance or calibration.

5.4.6.7.2 Orifice Plates

Orifice plates shall be of the sharp, square-edged, thin plate, concentric bore, paddle type with flange taps. The differential pressure at design flow shall generally be 250 cm wc. Diameter ratio (Beta Ratio) shall not exceed 0.70. Sizing and installation practice will be in accordance with the American Gas Association (ANSI/API 2530). Plates shall be of alloy 625 or C-276 for SA, LA services. Plates shall be 316L for all other applications except steam service. All steam service plates will be the same as for SA and LA services.

Vent and drain holes shall be provided in orifice plates to prevent the build-up of vapor pockets in liquid service pipes and condensate in vapor service pipes.

5.4.6.7.3 Wedge Flow Meters

Wedge flow meter may be used where low loss and pluggage concerns exist. Wedge flow meter shall be used in brine service. Wedge flow meters shall have a H/D ratio between 0.2 and 0.5 with a nominal differential pressure at the taps at rated flow between 125 cm and 500 cm H2O. Flow meters shall be calibrated prior to installation. Wedge flow meters shall have an accuracy of 0.75% or better when operated within the calibrated range.

5.4.6.7.4 Magnetic Flow Meters

Magnetic flow meters may be used for slurry flows or other difficult flow measurements. Magnetic flow meters will be installed with a minimum of 10 diameters of straight pipe upstream and 2 diameters downstream. Lining and electrode materials shall be compatible with the requirements of the fluid. The electronics shall be separately mounted in a non-corrosive NEMA 4X enclosure. Meters shall be fed from the UPS should the meter require external power.

Magnetic flow meters shall be used for measurement of hotwell condensate, scrubber drain rates, purge water flow rates. Mag meters will be Krohne.

5.4.6.7.5 Mass Flow Meters

For applications where measurement of mass flow is required, the use of direct mass flow (Coriolis Effect) meters or thermal dispersion type will be considered.

5.4.6.7.6 Velocity Averaging Pitot Tubes / Annubar (Dieterich Standard Corp.)

These type meters may be used only with prior approval of the Owner. In general, the rangeability and accuracy of this element is comparable to an orifice plate. The permanent pressure loss is significantly less than orifice plates in most applications and the installation cost is less than an orifice plate. In particular, these devices may be used where permanent pressure loss is an important factor, where removal of the element for inspection and/or maintenance is required without interrupting flow in a process line, or where line size may make orifice plates uneconomical. Flow elements shall be calibrated prior to installation.

Annubars shall be of Hastalloy C material construction for all steam and non-condensible gas applications. They shall be either retractable or have a purge style head with purge water hooked up via 316L instrument tubing to periodically flush the Annubar. Due to the unique service and history, the only approved supplier of Annubars is Dieterich Standard Annubars.

5.4.6.7.7 Flow Test Ports

The flow test port (where required) consists of a single 25 mm) pipe branch, (100 mm) long with a (25 mm) full port ball valve ((38 mm) pipe and (38 mm) ball valve with (25 mm) minimum bore on lined pipe). The pipe branch shall be located just upstream of the flow element or meter. It shall be perpendicular to the main pipe axis and shall be positioned on the circumference such that nothing obstructs the insertion of the Pitot tube.

The ball valve materials shall be compatible with the fluid in the main line. On unlined pipe the full port ball valve shall be threaded. On lined pipe the ball valve shall be flanged.

5.4.6.7.8 Venturi Flow Elements

A steam flow measuring device, which shall be a venturi flow meter shall be installed after the interface point isolation valve. This device shall be connected to the Power Plant monitoring system and shall be used for measurement of steam flow during normal operation of the Power Plant and during performance testing. Performance testing of the plant shall be carried out using the calibrated Venturi meter installed in the main steam line. The venturi meter and its installation shall comply with relevant ISA standards sufficient to give flow measurement with at least ±0.5% accuracy. Refer to Section 10.24.2.2 for additional requirements concerning venturi flow elements.

5.4.6.8 Level Measurement

Suitable bosses, stub pipes and isolating valves shall be provided on all tanks, and vessels where level measurements are required.

Wherever practical an external level bridle shall be provided wherever turbulence or other undesirable conditions are present to enable representative and stable level measurements to be made. Where a level bridle cannot be incorporated, a stilling well shall be provided for this service.

Wherever possible, liquid level measurements will have a gage glass for direct visual observation as well as transmitters or switches. Gages shall normally be of the armored reflex type, except that armored transparent type will be used for brine service.

In general, level measurements shall be made using electronic differential pressure transmitters. In applications where the differential pressure transmitter is undesirable, displacers, bubbler, capacitance or ultrasonic beam based devices may be used. Flange ratings shall be in accordance with vessel specifications. For multiple instruments connected to a vessel an external stand pipe will be utilized. Flange ratings shall be in accordance with vessel specifications.

Differential pressure type level transmitters shall be fitted, as a minimum, with 5-valve manifolds including an equalizing valve for zero check.

For fluids with high solids content, high temperature, or other service conditions where float mechanisms are not appropriate, hydrostatic head, electric probes, or sonic type level measurements may be utilized. Where feasible, purging of level taps will be considered to prevent pluggage.

In general, sonic or RF probes shall be used for solids level detection.

5.4.6.9 Level Switches

Locally mounted liquid level gauges shall be used for sight monitoring and measurement purposes. Locally mounted magnetic coupling glandless level switches shall be used for alarm and control purposes.

5.4.6.10 Chemical Analysis Equipment

Where specified for conductivity or pH measurement, the instruments shall be of the immersed electrode type, in-line for pipe measurement and dip type for measurement in open vessels. The measurement electrode, reference electrode and temperature compensation shall all be contained in the same probe.

5.4.7 Final Control Elements

5.4.7.1 Air Operated Control Valves - RPF Service

Control valves and all required accessories shall be provided as a complete assembly by the valve manufacturer. This shall include all solenoid valves, limit switches, valve actuators, valve position transmitters and other accessories as required by the installation. Where air actuation is not feasible and economically justifiable electric, hydraulic or electro-hydraulic actuators shall be used for modulating service.

The control valves shall be installed to the manufacturer's recommendations for minimum length of straight pipe upstream and downstream of the valve as well as the location of pipe reducers.

Except where specified or approved by the Owner, all control valves shall have upstream and downstream isolation valves. A bypass valve of a capacity equal to or greater than the control valve shall also be provided, where required by the mechanical design (refer to Section 8.6.10.3). The upstream and downstream connections of the bypass valves shall be made outside the isolation valves provided for the control valve. This would enable the bypass line to be placed in service while the control valve is isolated and serviced. In addition, a 19 mm drain line and valve (ball or gate) shall be installed upstream and downstream of all control valves mid-way between the control and isolation valve in an accessible area. Hydraulic and Motor operated valves shall have the same block, bypass and drain features.

Control Valves shall be designed to fail in the position that is safest for the process as defined by the P&IDs.

Unless the process requires otherwise, control actuators shall be pneumatic. Electric, hydraulic or electro-hydraulic may be used where necessary and where life-cycle costs show them to be competitive.

All drain valves in the RPF must be 38 mm min. size for both steam and brine service.

Control valves or control valve accessories requiring air pressure tanks must meet all state requirements for pressure tanks (e.g.; safety valve, pressure indication).Eccentric disk type valves (Masoneilan Camflex II or equivalent) will be utilized for brine and steam services. Masoneilan Camflex II control valves must be used in flashing and cavitating services for brine and condensate. Refer to the pipe class specification sheets for additional valve specifications.

5.4.7.2 Air Operated Control Valves - PGF Service

Unless otherwise specified on the data sheets, all control valves shall have flanged ends or be lugged wafer type for insertion between line flanges. Minimum flange rating shall be 300 lb class for sizes 4" and under.

During the normal range of operating conditions the sound level at any point 1 m. radially from the surface of the downstream pipe at a distance of 1 m. downstream of the valve outlet should not exceed 85 dBA. Body outlet velocity should not exceed MACH 0.3. Should sound levels exceed 90 dBA, the valve vendor shall provide recommendations for mitigation of the problem.

The maximum allowable seat leakage must be determined from process design considerations and for a particular valve is dependent on body and trim construction. The permissible leakage rates shall be in accordance with ANSI FCI 70-2 1976, Classes 1-6 and will be specified on the valve data sheet.

Instrument air supplied to the air operated control valves will be at 6.9 barg nominal and a minimum of 5.2 barg. Air pressure reduction, as required for operation, will be accomplished at the valve location.

Control valves shall normally be sized with normal flow at approximately 70% of valve capacity. Pressure drop across the valve should be at least 25% of total system frictional losses or 10% of total system pressure whichever is greater. All sizing calculations will be verified by the valve manufacturer. Minimum size shall be 25 mm.

Safe failure modes will be determined at the time of system design and indicated on the valve data sheets.

5.4.7.3 Valve Accessories

Local control valve accessories shall be mounted on the valve unless otherwise specified. Accessory items include the following:

- I/P transducer /Positioner Unit with gauges
- Air Pressure Regulator and Filter
- Solenoid Valve(s)
- Limit Switch(es) (on on/off service DCS controlled valves only)
- Volume Booster (as required)
- Position Transmitter (on DCS controlled modulating valves only)

Double acting cylinder actuators shall be provided with air accumulators when required to achieve required failure positions.

Solenoid enclosures shall be corrosion resistant IP 66 (NEMA 4X) unless otherwise specified.

Solenoid coils shall be Class H high temperature construction, at (220 V a-c) and shall be suitable for continuous duty.

Three-way direct acting solenoid valves shall normally be used to actuate control valves when interlocked with fail safe or shutdown circuits, or when used for on/off service type control valves. Universal (reversible ports) are preferred.

The valve bodies for two-way solenoid valves shall follow the piping specification in the Mechanical Design Criteria when used in process lines.

I/P and hand stations shall be mounted in a NEMA 4X enclosure.

The coil shall be molded design with waterproof housing and shall be furnished to meet area electrical code classifications.

Outdoor installations shall be weatherproof.

Solenoid vents shall have bug screens.

Those solenoids that have top mounted vents shall be piped so that moisture does not enter the valve.

5.4.7.4 Limit Switches

Limit switches shall be supplied as an integral part of the valve-actuator assembly.

All limit switches shall be snap acting type limit switches and shall be provided and installed at the factory with mounting brackets and associated hardware. Switches shall have two normally open and two normally closed contacts and a corrosion resistant IP66 (NEMA 4X) enclosure.

5.4.7.5 Pressure Gauges

Gauges for control air supply and signal pressures integral to the instrument shall be in accordance with the control manufacturer's standards. All other gauges shall be as specified herein.

5.4.7.6 Motor Operated Valves

All motor operated valves shall be equipped with a non-relaxing gear train and non-rotating handwheel during electric operation. A minimum of eight independently set limit switches shall be provided.

Torque seating and/or torque back seating requirements shall be determined by the type of valve and application. In general all valves, except rotary valves, will be torque seated.

If position indication is required, it shall be by resistance to current or angle to current (4-20 mA) 2 wire.

5.4.7.7 Safety Relief Valves

In general, line and vessel protection shall be accomplished by the use of rupture disks. However, for applications protecting against thermal expansion and low flows, safety relief valves may be used.

Safety relief valves shall:

1. Conform to the requirements of ASME VIII, Division 1, Pressure Vessel Code.
2. Be top guided.
3. Be supplied with lifting levers for steam and air service.
4. Be suitable for use on ANSI B31.1 piping.
5. The seat leakage test for all valves will be as follows:
6. Air and vapor service as per API-Std-RP-527.
7. Liquid service - 2.5 cc/hr per cm of valve size at 90 percent set pressure.
8. Bodies shall be constructed of 316 Stainless Steel with Stellite seats.
9. Relief valves shall be supplied with gags.
10. Bellows shall be specified where back pressures could affect proper operation.

For location and piping criteria see Mechanical Design Criteria.

5.5 Equipment Installation And Service Connection

5.5.1 Instrument Tubing and Accessories

5.5.1.1 General

This criteria applies to all piping, tubing, fittings, and valves required for primary instrument, sampling, air supply, and pneumatic control systems in ANSI B31.1 installations.

Class, size, routing and valving shall be as shown on Stone & Webster Engineering Corporation Drawings, Standards, Technical Data Sheets, and Specifications. Instrument process connections will generally be 19 mm with 75 mm connections for level bridles.

Compression fittings and connections shall be used for all stainless steel primary sensing, air supply, and control tubing. Transition from welded to compression fittings will be made at the instrument root valve.

Instrument locations and connections shall be designed for maximum accessibility and for ease of operations and servicing. Instruments shall be close coupled in scaling or corrosive service. When several instruments are located in close proximity they will be grouped together on an instrument rack. In the resource production facility area these racks shall be nonmetallic closed cabinets with gasketed doors.

Instrument process connections shall be designed to be roddable and root and isolation valves shall have removable seats and straight through flow paths for ease of maintenance.

Nonmetallic tubing may be considered for services with severe vibration or corrosion problems.

5.5.1.2 Instrument Valves

Blowdown and drain valves are required in the connecting lines to all transmitters and instruments used on water, steam and condensable vapor services.

The method of attaching isolating valves to instruments shall be such that it is possible to disconnect the instrument from the connecting pipe without having to drain the pipe.

Manifold Valves - Differential pressure type flowmeters shall be fitted, as a minimum, with 3-valve manifolds including an equalizing valve for zero check.

5.5.1.3 Instrument Pipework And Fittings

Instrument root connections at the process piping or process vessel shall generally be (19.mm). The Mechanical Design Criteria will detail the requirements for both the connections at the process piping and process vessel and the vessel instrument isolation valve associated with these connections.

Monel tubing, fittings, valves, and manifolds shall be used for all brine piping. Stainless steel tubing, fittings, valves, and manifolds shall be used for all other primary piping.

The Instrument Installation Diagrams will show the physical requirements for mounting and routing of the instrument tubing.

5.5.1.4 Instrument Fittings and Tubing Support

All tubing shall be (6 mm), 9.3 mm), or 12.5 mm) stainless steel; other sizes of tubing shall not be provided.

All tubing and capillaries shall be supported and protected from external damage using TubeTrack or similar product. Tubing support components shall be manufactured from materials which are suitable for the harsh chemical environments likely to be encountered. Tubing support systems shall be routed so as not to impede removal of adjacent equipment. Tubing support systems shall be mounted to structure only, not to equipment.

Flexible hoses or conduit shall be used to ensure that movement between actuator devices and stationary devices are absorbed in the flexible hose and not in the rigid tubing or conduit.

Ports for flushing instrument sensing lines shall be provided as required.

5.5.1.5 Primary Instrument Tubing Requirements

Compression fittings shall be used for all primary instrument sensing tubing.

Tubing runs greater than 15 m should be avoided.

All tubing for this service shall have a minimum outside diameter of 12 mm and shall conform to the following requirements:

- ASTM A-213 Grade TP316 (S31600)
- Seamless Stainless Steel
- Cold Drawn Fully Annealed
- 3 m. Lengths or Longer

Dimensions:

Actual O.D. Inches	Wall Thickness Inches	I.D. Inches	MWP @1,000F
3/8*	0.049	0.291	4,261
½	0.049	0.402	3,070
5/8	0.072	0.481	2,690
¾	0.083	0.584	2,575

*3/8-inch tubing may be used only for those parts of sampling systems that are located within a panel or a rack.

Weld repairs shall not be allowed on the tubing.

The supplier of the tubing shall verify that all requirements of the material specifications have been complied with and that the tubing meets these requirements.

5.5.1.6 Instrument Air Supply and Pneumatic Control Tubing Design

316 Stainless steel tubing, fittings, and valves shall be used for all instrument air and control pneumatic tubing.

Instrument and pneumatic pipe routing shall maintain adequate distances from outside walls, doorways, and areas of extreme heat to minimize ambient effects on control lines.

Lines in the instrument air supply distribution system shall be sized such that the maximum pressure drop from the air dryer to the most remote air user does not exceed .35 bard with a 6.9 barg supply when all users are taking air at approximately .06 to .14 scmm.

Instruments requiring air shall generally be supplied from a branch instrument air header. The maximum number of instrument air users that shall be taken off a (12 mm) branch shall be four. The maximum number of instrument air users that shall be taken off a (25 mm) header shall be twenty. Separate connections shall be taken off the main instrument air header for instruments requiring large amounts of air for operation with a (12 mm) minimum line being used. Shutoff valves at the instruments shall be swing-out ball valves with compression fittings.

A separate reducing filter regulator shall be furnished for each instrument requiring a source of instrument air.

All tubing for this service shall have a minimum outside diameter of 12 mm (except as noted in the table below) and shall conform to the following requirements:

- ASTM A-213 Grade TP316 (S31600)
- Seamless Stainless Steel
- Cold Drawn Fully Annealed
- 3 m. Lengths or Longer

The supplier of the tubing shall verify that all requirements of the material specification have been complied with and that the tubing meets these requirements.

The requirements for all instrument air piping above 12 mm is covered in the Mechanical Design Criteria.

5.5.2 Material

5.5.2.1 Stainless Steel Fittings

5.5.2.1.1 Compression Type Fittings

This type of fitting shall be used for all of the following connections:

- Connection of a primary sensing line or sampling line from the root valve transition fitting to an instrument.
- Connection of an individual instrument air supply line between the air supply header shut-off valve and the instrument.
- Connection of instrument air supply headers assembled from stainless steel tubing (Not pipe).
- Connection of a pneumatic control line to an instrument, control valve, control drive or accessory device.

Compression fitting shall be furnished with the following specifications:

- Tube Size, O.D: 6 mm, 9 mm, 12 mm, 16 mm, 19 mm
- Type: Compression
- Material: 316 Stainless Steel
- Manufacturer: Crawford "Swagelok"

9 mm tube fittings may be used only for those parts of sampling systems that are located within a panel and/or a rack.

Manufacturers recommended tools and installation procedures shall be strictly followed.

5.5.2.1.2 Socket Weld Fittings (Primary Sensing & Sample Lines)

Socket weld fittings shall have full annular stops, a straight bore and shall be furnished in accordance with the following specifications:

- Tube size, O.D.: 9 mm, 12 mm
- Manufacturer: Cajon Company* or equal

*Swagelok to weld fittings are also available from Cajon which provide easy transition from welded to non-welded tubing systems.

5.5.2.2 Stainless Steel Valves

The valves applicable to this section are the instrument valve, blowdown valve, test valve, backup root valve (when specified) and sample regulating valves. The valves for these applications shall be furnished in accordance with the following specifications:

- Style: Ball, full port
- Rating: 400 bar @ 38C
- Body Design: Replaceable seat roddable
- Body Material: 316 Stainless Steel, except for brine service which shall be Alloy 20.
- Construction: Union Bonnet, 316 Stainless Steel
- Stem: Stainless Steel
- Seat: Reinforced TFE
- Packing: Reinforced TFE
- End Connections: NPT or Compression Tube Fittings

Exception: Low pH root valves shall be C276 or Inconel 625.

In general, 19 mm valves shall be used.

9 mm valves may be used only for those parts of sampling systems that are located within a panel and/or a rack.

Weld repair of defects on the pressure boundaries of a valve body shall not be allowed.

5.5.2.3 Instrument Air Supply Valves

The valves applicable to this section are the individual instrument air supply shut-off valves. They shall be furnished in accordance with the following specifications:

- Style: Ball, full port
- Working Pressure: 200 bar @ 38C
- Body Material: 316 Stainless Steel
- Body Construction: Ball
- Construction: Screwed Bonnet
- Stem: Stainless Steel
- Sizes: 6, 9, 12 mm
- End Connections: Pipe to pipe, pipe to tube, tube to tube
- Manufacturer: Whitey Co., "43" Series, or equal

5.5.2.4 Manifolds

Three valve manifolds shall be supplied as follows:

- Body Design: Removable Seat, Roddable
- Body and Bonnet Material: 316 Stainless Steel
- Stem Material: 316 Stainless Steel
- Seat: Reinforced TFE
- Packing: Reinforced TFE
- Process and Instrument
- Port Connections: 1/2 Inch NPT
- Manufacturer: HEX VALVE HM452 Series, or equal

5.6 Racks And Panels

5.6.1 Field Enclosures

Unless otherwise specified, all indicating instruments shall have dust and moisture proof cases to NEMA 4X. All enclosures shall be specified to be corrosion resistant.

Enclosures will protect the field instrumentation from solids, hazardous conditions and washdowns with high pressure hoses. The enclosures will be designed to permit in-place calibration of instrumentation and instrumentation removal from the enclosure front. In all cases corrosion-resistant housings (NEMA 4X) are required with stainless steel or non-corroding hinge material.

In addition to the above requirements, panels will be provided with replaceable corrosions resistance ion emitters

An instrument air purge shall be provided on electrical or control enclosures with an interior volume greater than .03 m^3. Design of panel purge and purge flow rates shall be sufficient to provide positive pressure within the enclosure under all conditions

5.6.2 Local Control Panels

Local control panels shall meet the same requirements as for field instrument enclosures. The construction and finish of all local control panels shall conform to the requirements of the ambient conditions. In all cases corrosion-resistant housings (NEMA 4X) are required with stainless steel or non-corroding hinge material.

5.6.3 Terminal Blocks

Terminal blocks shall be rated at 600 volts and shall be provided for all external connections to cabinets and consoles. Terminations to compression type terminal blocks shall include a metal ferrule, compressed over all conductor strands. Termination of bare wires in compression terminal blocks is not acceptable. Alternately, terminations may be made to terminal blocks accepting locking ring tongue compression type lugs.

Thermocouple terminal blocks shall be of the same material as the thermocouple extension wire.

5.6.4 Control Panels And Relay Panels

In addition to the requirements set forth above, all control panels and relay panels shall have lights and receptacles installed within the cabinet. The lights and receptacles shall be wire to separate power entry terminal blocks such that a separate feed may be used to power these loads. Cabinets which are installed as a unit, such as the DCS, should have a single feed connection point for all the cabinets in the set.

5.6.5 Local Push Button Stations

All motors and loads controlled via the DCS will have an auxiliary local push button control station located adjacent to the equipment for local control of the equipment. The push button station will have controls for start and stop of the equipment, as well as a local/remote select switch that enables DCS control of the load. The local start/stop control shall be wired directly into the associated MCC, along with the appropriate field instrumentation interlocks, to allow complete pump operation apart for the DCS. Modulating valves shall have local manual loading stations.

Design implementation of the local controls will provide for bumpless transfer from DCS to field control and from field control to the DCS. This includes motor on/off control stations as well as valve manual loading stations.

Local panels shall be NEMA 4X rated and constructed of stainless steel.

Mechanical Design Criteria

6.1 General

The geothermal power plant receives geothermal steam and brine from the wells designated as ***later***. After energy is extracted from the brine, the brine is routed to injection pumps which pump the brine to injection wells designated as ***later*** .

6.2 Operating Modes

The Project will operate as a base load plant.

6.3 Reliability

The Project shall de designed with installed spare capacity, redundancy, and other features to achieve high reliability during normal operation.

The design of systems and equipment shall provide maximum reliability. All rotating equipment shall be provided with installed spare capacity unless otherwise specified.

6.4 Power Cycle

The power cycle is shown on the General Process Flow diagram included in ***the report***. The power cycle uses geothermal steam at two different pressures. Steam at two pressures is delivered to a condensing steam turbine generator. The turbine exhausts to a direct contact condenser located below the turbine. Steam condensate from the condenser is pumped to the main cooling water system as makeup. Additional makeup is available from water wells on the property. The cooling water system uses a wet, mechanical draft cooling tower to reject waste heat to the environment. Hotwell pumps deliver water from the condenser to the cooling tower. Condenser vacuum will deliver cooling water back to the condenser.

Geothermal steam contains non-condensable gas that must be removed from the condenser. Gas removal steam jet ejectors and vacuum pumps remove the gas from the condenser and an intercondenser and an aftercondenser cool it to a pressure and temperature so that the gas can be sent to the cooling tower for dispersion or is useable by a future adjacent bottling and dry ice plant. Should the gas plant be out of service, the compressors will deliver the gas to the cooling tower for release to the environment with the cooling tower plume. The gas contains Carbon Dioxide and trace amounts of Hydrogen Sulfide. Hydrogen Sulfide abatement is not required beyond dispersion through the cooling tower.
Plant auxiliary equipment is cooled with water from the cooling tower basin.
Geothermal brine is pumped to, and through, two levels of cascading steam separators to generate high pressure and low pressure steam. From the steam separators the brine is delivered to a brine injection system .

6.5 Cycle Heat Balance

The Engineer has developed a Heat and Material Balance diagram for the Project. This diagram is included in the report.

6.6 Materials of Construction

The geothermal fluids are extremely corrosive to standard materials of construction. The Engineer's material selections are represented on the Station Materials Diagram included in Attachment ***later*** .

Products which contain asbestos are prohibited. This prohibition includes items such as packing or gaskets even though the item is encapsulated or the asbestos fibers are impregnated with binder material.

6.7 Seismic Design

Equipment and anchorages shall be designed to withstand a seismic event as specified ***later***. All process equipment shall remain operative after being subjected to the design seismic event without loss of performance or structural integrity.

Analysis shall be made using the equivalent lateral force (ELF) method. A value of 2/3 of the ELF shall be simultaneously imposed as a vertical force on the equipment. No credit for friction shall be taken in designing the anchorage system to resist lateral loads. The seismic load shall be included with the normal operating loads of the equipment.

6.8 Vibration

Vibration shall be minimized by good design and by the adoption of high standards of balancing of both components and rotating assemblies during manufacture.

Except where otherwise specified the vibration amplitude of rotating equipment when measured on the bearing housings under steady state conditions shall not exceed the middle values of the bands designated "brauchbar" (satisfactory) in VDI 2056 for the class of machine concerned.

Steam turbines and generators shall be installed with proximity transducers on all bearing housings. The transducers shall measure x & z direction vibration on all housings and y direction (axial) vibration on thrust bearings. Vibration limits for turbines and generators shall comply with the relevant sections of API 612 and API 546 respectively. Design and installation of vibration monitoring equipment shall comply with the requirements of API 670.

Continuous vibration monitoring equipment shall be provided for turbines, generators and circulating water pumps. Equipment shall be Bentley-Nevada 3300 series or approved equal. All vibration signals shall be brought to a monitoring panel. The panel shall provide relay access for hook up of spectrum analyzing equipment. Summary indication and alarm signals shall be connected to the DCS.

Should vibration levels exceed the above limits, the Constructor shall reduce the vibration to within the defined limits.

6.9 Fluid Velocities

The Engineer's design is based on the following fluid velocities at design flow conditions. Deviation from these fluid velocities may be permitted for intermittent operation or transient conditions. Any deviation above the maximum specified fluid velocities requires approval by the Owner. Non-condensable gas piping is sized based on pressure drop, not velocity.

Fluid	Recommended Velocity
HP Steam	30-43 m/sec
LP Steam	37-49 m/sec
Brine, single phase	1.5-2.7 m/sec
HP Brine, two phase	30 m/sec
LP Brine, two phase	37 m/sec
Water and oil	3 mt/sec
Pump suction and drain lines	2 m/sec

General service	5 m/sec
Condensate pump suction	1 m/sec

6.10 Pumps

6.10.1 Centrifugal Pumps

Particular attention shall be paid to the selection of pumps and their materials of construction for the specific application.

Horizontal shaft pumps shall be either horizontal split casing or back pull out

Pumps shall be capable of operating continuously over their full operating range without overheating, cavitating, excessive noise or vibration, surging or instability when operating in single or in parallel with other pumps. Pumps shall be selected for maximum efficiency at the design condition and shall have a head/flow curve that rises steadily from rated flow to shut off. Pumps shall either be installed with a flooded suction or shall be self priming.

Mechanical seals shall be used on all power generation cycle pumps. Pumps shall be self flushing with process fluid wherever possible. Where flushing with the process fluid is not possible, a seal flushing system including pumps where necessary shall be provided to supply suitable quality seal flushing water to the mechanical seals. All seal flushes shall be fitted with flow indication. Seal water flush will be routed to the local drain system by way of stainless steel tubing on discharge side of the seal.

Pumps and motors above 15 kW shall be coupled and assembled on a common base. Integral pump motor units are preferred for smaller pumps.

All pumps, with the exception of the hotwell pumps, shall be specified with a 10% flow margin above the design flow as set out on the heat and material balance diagram. Hotwell pumps shall be specified with a margin of at least 5% flow margin above the design flow as set out on the heat and material balance diagram.

Pumps shall be installed with an adequate margin to ensure that the pump operates without cavitating over the full range of flows and suction level conditions. Motors shall have power ratings, including service factor at least equal to the power required at runout flow.

For continuous duty, pumps driven at no more than 4-pole speed (1500 rpm) are preferred. All pumps shall be close coupled without gearboxes.

All pump bearing housings, shall be fitted with surfaces suitable for the fitting of portable vibration sensing transducers.

6.10.2 Diaphragm Pumps

Diaphragm pumps for chemical transfer service shall be double diaphragm pumps. Diaphragm pumps shall be powered from the Service Air System.

The materials of construction shall be compatible with the system fluid.

6.10.3 Metering Pumps

Metering pumps for chemical injection service shall be positive displacement type pumps. The pumps shall be capable of supplying an infinitely variable feed rate from zero to the maximum capability of the

pump. Metering pump installation shall include calibration pipes. The pump, or system shall include a pulsation damper to eliminate pulsing of the flow at the injection nozzle. The pumps shall have an internal relief valve for overpressure protection.

The materials of construction shall be compatible with the system fluid.

6.11 Valves

Valve selection guide lines are included in Attachment ***later.***
All valves in brine service shall have the capability of applying grease to the stem.

6.11.1 Manual Isolation Valves

Valves shall be located to minimize the dead leg areas of brine piping.

For valves 8" and under, secondary isolation valves at easily accessible spots shall be considered in lieu of the addition of valve access platforms, as long as the primary valve is not a frequent service or maintenance item. Primary valves of this nature must have access by way of a man basket.

Butterfly valves may be considered for primary isolation in steam service for line sizes greater than 600 mm. Valves shall be triple offset high performance design. The valves shall be type 316L stainless steel or better construction, metal seated, with replaceable seats on the body. Seats should be Stellite, Inconel 625, or Hastelloy C. Stems shall be Inconel 625. Accommodation in design must be made to allow for a drop out spool and/or a slip blind downstream of all butterfly valves in steam service upstream of the turbine.

For 150 mm and under size line (and some 200 mm Type 316L stainless steel ball valves are the preferred means of isolation for steam, condensate, and some brine services. Valves shall be a two piece flanged design, and use PEEK seats.

6.11.2 Motor Operated Valves

Motor operators shall be Limitorque or Engineer approved equal.

6.11.3 Control Valves

Refer to Section 8.5.4.7 for specific requirements for control valves.

Not all control valves will require full bypasses. The function of the bypass can be designed into the valve sizing criteria where parallel valve systems will exist such as on brine vessel level control and dump systems, steam scrubber and demister level control systems. Bypasses shall be installed on systems where a malfunction of the control valve would result in a critical system shutdown in order to perform maintenance on the item.

6.11.4 Vent and Drain Valves

Manual high point vent valves and low point drain valves shall be provided as required for system fill and drain purposes. Valves shall be sized to permit efficient venting and draining. Vent and drain valves shall be full port ball valves.

6.12 Strainers

Permanent strainers shall be installed where necessary to protect equipment or pumps from damage. Differential pressure instrumentation shall be provided to monitor strainer operation.

Provisions are to be made to blow down the strainer of accumulated debris and condensate. Local pressure gauges are required upstream and downstream of the strainer, and all strainers in steam, and water services in critical systems.

Where permanent pump suction strainers are not installed, pump suction piping shall include startup strainers that can be easily installed and removed.

A strainer shall be installed in the steam inlet line to steam jet ejectors. Strainer basket shall be of C-276 or Alloy 625. The strainer body shall be carbon steel.

6.13 Expansion Joints

Elastomer expansion joints shall follow the construction details outlined in the Rubber Expansion Joint Technical Handbook. The overall design including the selection of materials, shall be as recommended by the Engineer for the intended service. The expansion joints shall not crack, peel, or show any evidence of deterioration from exposure to the system fluids or the ambient conditions.

The expansion joints shall provide for a maximum of 12 mm of lateral and 25 mm of axial displacement and a maximum of one degree of torsional or angular displacement to accommodate erection misalignment.

The outside surface of all expansion joints shall be resistant to ozone, aging, and sunlight. Cover protection, if painted, shall be completely bonded to the cover and shall not crack or peel.

The expansion joints shall be full face flange type, with integral flanges, and shall be furnished complete with split retaining rings backing the flanges. Flanges and retaining rings shall have the same pressure rating as the piping system it is installed in.

The tube and cover shall be full thickness throughout and the bolt holes sealed to completely cover the carcass fabric. Flange thickness shall be even over all parts of the flange.

Arch fillers, when specified, shall be permanently attached to prevent dislodgement from the arch.

Sufficient clearance shall be provided between the arches and the retaining rings to allow for use of nuts to standard heavy hexagon dimensions, ANSI B18.2.2.

Control units, when specified, shall conform to the dimensions of Appendix C of the Rubber Expansion Joint Technical Handbook.

All expansion joints shall be visually inspected by the Seller for damage and defects. The surfaces finish on all parts of the joint shall be smooth and free from cuts, gouges or other detrimental defects. Repairs shall not be made without the Engineer's approval.

6.14 Vessels

Vessel nozzles in brine service shall be no less than 100 mm. Vessel nozzles in steam service shall be no less than 75 mm. Vessel nozzles in clean services shall not be less than 50 mm. All vessels shall be equipped with at least one manhole. Manholes shall be at least 600 mm in diameter.

Vessels in the HP steam system shall have a design pressure of 12 barg. Vessels in the LP steam systems shall have a design pressure of 6.7 barg.

Drain nozzles for steam scrubbers, demisters, and turbine casing drains shall be made of Alloy 625 or Hast. C material. Carbon steel to alloy weld of the nozzle to the vessel shall be of the same material as of

the alloy. Valves for level taps, drains, and other nozzles for these vessels may be type 316L stainless steel ball valve with PEEK seats.

6.15 Cranes and Hoists

A gantry crane shall be installed over the turbine generator. The gantry crane shall have one main hook and one auxiliary hook. Crane lift capability shall not be less than 110% of the heaviest component plus rigging to be lifted during maintenance. The gantry crane shall be designed, fabricated, and tested in accordance with CMAA 70. Both hooks on the gantry crane shall be capable of lifting any turbine or generator component from grade level up to any required assembly or disassembly height.

The Engineer shall provide maintenance hoists for the following:

- Cooling water pump intake structure screen and stop logs
- Cooling tower mechanical equipment removal
- Maintenance hoists for other equipment that is not accessible to a mobile crane

7. Piping Design Criteria

7.1 General

Brine handling and steam production piping shall be designed, fabricated, installed, and tested in accordance with ANSI B31.3 Process Piping. All other piping shall be designed, fabricated, installed, and tested in accordance with ANSI B31.1, Power Piping. Materials for piping systems shall be as shown on the Station Materials Diagram. All piping shall be in accordance with the Piping Material Specifications included in Attachment ***later.***

In general, yard water mains, circulating water pipe, water fire lines connecting hydrants, and sewers shall be underground. All other lines shall be aboveground except for special conditions where underground piping may be desirable. Buried metallic piping shall be coated and wrapped to resist corrosion.

38 mm drains shall be considered standard size for equipment, vessels, and piping over 100 mm diameter unless otherwise noted. 38 mm drain valves shall be provided on both sides of tubular heat exchangers, coolers, and condensers unless otherwise indicated on the drawings.

Process vents and drains shall be identified during design development and shown on P&ID's as required on high and low points of piping systems. Unless otherwise specified piping shall have 19 mm minimum vents and drains.

Piping around equipment and heat exchangers shall be arranged and supported to permit ready access for maintenance and inspection.

Radiographic examination (RT) of welds shall be performed as specified in the individual pipe classes. All Alloy 625/Hast. C piping larger than 50 mm will be 100% radiographed and interpreted as per B31.1. All fillet welds of these alloys will be inspected with LP. Weld maps are required for pressure vessels.

All steam and brine process vessels shall be designed with short drop-out spools on the upstream and downstream ends of the vessels to facilitate isolation and inspection for maintenance.

Alloy 625/Hast. C piping (SA pipe class) shall be designed such that the pipe spools are easily removable for inspection and cleaning. One 90 deg. elbow fitting or one tee fitting is permitted per removable spool piece. This design will facilitate shop fabrication of alloy spool pieces. Field fabrication of alloy components shall be kept to a minimum.

7.2 Pipe

Minimum pipe size shall be 19 mm.

Unless otherwise specified in the individual Piping Material Specifications, all pressures specified are positive pressures.

The design of G-cement lined steel piping systems shall take into account the specific requirements necessary for this type of piping, including the following features:

> Flanges will have 3 mm 2205 rings welded to the surface of the flange, protruding 12 mm into the ID of fitting. Welds are seal welded to ID and the OD of the flange, and finished with a 125 to 250 RMS finish suitable for gasketing. This added dimension must be accounted for in the piping design.
>
> All elbows are flanged on each end.
>
> All tees are flanged on each end.
>
> All reducers are flanged on end.
>
> One drop out spool (a 13 m flanged spool) is required per every straight run and/or every 97 m for inspection and repair purposes. Clamp on galvanized pipe shoes are required. Gussets on the pipe shoes are not permitted.
>
> Drains, sample ports, TI's, PI's are made using Alloy 625/Hast C nipples. These protrude 12 mm into the pipe and are seal welded on both ends. These must be located at the end of a flanged run or on flanged elbow/tee/reducer such that hand patching of the area can be accommodated.

Additional detail design and fabrication requirements for Inconel Alloy 625 and Hastelloy C piping and fittings and cement lined piping are included in Attachment ***later.***

7.3 Steam Piping

All branch lines shall be from the top or side of horizontal headers.

Branches from the main steam line to the other services shall be taken off at the top of the pipe. All branch lines off of a primary steam line shall be isolated as close to the branch connection as possible. Should access to the isolation valve be difficult, consideration shall be given to placing a second isolation valve at a readily accessible area, as opposed to the construction of a permanent access platform at the branch connection isolation point. All low spots shall be equipped with systems to remove condensate as it collects.

Galvanized clamp-on pipe shoes shall be used on all alloy steam piping where pipe shoes are required. Gussets on pipe shoes are not permitted. Pipe shoes will be either 100 or 150 mm in height, the 150 mm shoes are used where 75 or 100 mm of insulation thickness is required.

Galvanized clamp-on pipe shoes shall be used on all primary steam process lines. Welded on shoes have proved to be a source of preferential corrosion.

Where weld seam pipe is used, the pipe system shall be designed to place the seam at 10:00 or 2:00 position when the line is overhead, or otherwise direct the seam away from work areas.

There shall be no steam traps used in corrosive service. In non-corrosive service the following shall apply.

- Steam traps shall be installed at low points and dead ends of saturated steam systems.
- Traps should be installed on long runs of steam piping for sufficient condensate removal to ensure dry quality steam at its destination.
- Drip lines from steam headers or equipment, operating at different pressures, should be independently trapped.
- An isolation valve shall be installed upstream of the trap.
- All valves at steam traps shall be trap size, but not less than 19 mm.
- A union shall be provided on each side of steam traps to permit their removal.
- Where several traps discharge into a single header which is, or may be under pressure, a stop valve and a check valve shall be provided in the discharge line from each trap. (B31.1 Par 102.2.5, B).
- A Y-type strainer with blowoff valve shall be installed ahead of each steam trap.

Before-seat and after-seat turbine stop valve drains shall be piped to the main condenser.

It is preferred that steam piping be run overhead because access for cleaning is not usually required. Dead legs shall be avoided by proper location of valves. Condensate and gas buildup which may occur in such dead legs can produce water hammer and accelerated corrosion.

7.4 Piping at Condenser Auxiliaries

Condenser water box drains shall be 75 mm. minimum and equipped with adequate hose connections

7.5 Cooling Water Piping

Where bearings are provided with water jackets in the top and bottom halves, cooling water shall be piped in series through the bottom half and top half in that order, unless manufacturer specifies that parallel circuits are needed. Exit piping shall be higher than the highest point of the bearing cooler to ensure a complete fill.

Valves in cooling water lines to oil coolers, cylinder jackets, and compressor aftercoolers, shall not be less than 19 mm. ball type. Individual connections to small pump bearings may be smaller. Where solenoid valves are provided in cooling water lines, suitable bypasses shall be provided.

Open cooling water outlets shall be visible from a point within reach of regulating valves. When discharging into a funnel, the end of the cooling water outlet line shall be no more than 12 mm. below the top of the funnel. When a number of drain lines discharge into a funnel, they shall be arranged so the flow from each is clearly visible.

Ball valves (75 mm and under) or butterfly valves (100 mm and up) shall be used at the inlet and outlet connections to air, oil, seal oil, etc., coolers.

All flanged rubber expansion joints shall be provided with limit rods and shall be capable of withstanding system hydrostatic test pressure. Minimum face to face dimensions for flanged rubber expansion joints for any service shall be as follows:

Size, mm.	Minimum Face to Face Dimension, mm
50 to 300	150
350 to 400	200
450 to 900	250
1200 to 1500	275
1650	600

Cooling water piping shall be 316L or FRP for above ground pipe. Below ground pipe may be 316L, FRP.

Valves may be 316L, Teflon lined, rubber lined, FRP.

7.6 Lubricating Oil Piping

Where a common suction line is provided for two or more hydraulic coupling oil pumps, a separate strainer shall be provided inside the suction gate valve at each pump.

7.7 Piping at Pumps

Hotwell pump suction lines shall be as direct as possible and shall be arranged to permit removal of the pump impeller without removing the suction valve.

When a reducer is required between the pump suction nozzle and the line, an eccentric reducer shall be used if the pump has a horizontal suction. The reducer shall be installed so that air pockets do not exist. Reducing flanges shall not be used.

When a check valve is installed in the centrifugal pump discharge it shall be installed upstream of the pump discharge shutoff valve. No check valves will be used in corrosive service.

The hotwell pump discharge check valves shall be submerged below the normal hotwell level so a standby pump can be maintained completely filled by gravity from the hotwell when the pump suction and discharge vents are open.

Vertical hotwell pumps shall be fitted with suction and discharge vents unless such vents are known to be integral with the pump casing and the pump manufacturer approves such omission. Each vent from each pump shall be run to the condenser separately.

Brine pump suction piping from the separator vessel outlet nozzles to the injection pump suction shall be as direct as possible. The use of inline expansion joints may be required. When eccentric reducers are used on pump suctions, the flat side should be on top. Strainers are not required for injection pumps.

When more than one level is required in yard pipe racks, a minimum of 450 mm vertical clearance shall be maintained between pipe banks.

Preferred minimum clearance from walls, floors, columns, etc. are listed below:

Pipe Diameter	Clearance
Up to 300 mm	225 mm
300 mm to 400 mm	300 mm
450 mm and larger	375 mm

Piping run in horizontal layers shall have a minimum of 450 mm between layers.

7.8 Maintenance

Equipment, structures and piping shall be arranged to permit maintenance and service by means of mobile equipment. Permanent facilities shall be provided where maintenance by mobile equipment is impractical.

Exchangers with removable tube bundles shall have maintenance clearance equal to the bundle length plus 1.5 m' measured from the tube sheet.

Piping at all equipment flanges shall have provisions for drop out isolation spools as the primary means of providing for maintenance isolation. If this can not be reasonably achieved, then provisions will be made for maintenance blinds. The blind thickness will be per ANSI B31.1. Maintenance blinding may be provided either by sufficient flexibility in the piping to allow installation of maintenance blind or installed spectacle blind.

7.9 Personnel Protection

Eye wash and emergency showers shall be provided in areas where operating personnel are subject to hazardous sprays or spills, such as acid, caustic, etc. The system design shall account for solar heating and the high ambient temperatures.

Personnel protection shall be provided at uninsulated lines and equipment operating above 66°C, when they constitute a hazard to the operators during normal operation. Lines which are infrequently used such as relief valve discharges do not require insulation.

Valve and flange shields, if required, shall be noted in the piping material specifications.

7.10 Branch Connections

Where reinforcement of pipe to pipe branch connections, is required for external forces. The reinforcing pad shall have a thickness not less than 1 1/2 times the pipe run thickness and a diameter twice the branch pipe diameter.

The Constructor shall determine the need for, and provide, pipe to pipe branch reinforcement for internal pressure in accordance with Code rules. Duplication of reinforcement for both internal pressure and external forces is not required.

Forged tees are recommended and fabricated stub-in type branch connections are to be minimized. Use of weldolets is acceptable.

Branch reinforcement of alloy piping (Alloy 625/Hast C) may be Type 316L stainless steel. Design of the reinforcement pad must take into account differences in strength of the material. Full size reinforcing pads are required on all Alloy branch connections for the following services:

- Steam service pipe.
- Two-phase brine service.
- Branches on the single phase brine side of the LCV's of the two-phase brine service.

Pulled tees are acceptable for Alloy piping. Pulled tees may be designed with integral reinforcing pads as part of the pull process. This work can be performed by Northwest Copperworks, in Portland Oregon.

7.11 Flanges

In pipe classes which specify 10.6 kg/cm^2 flanges, any required orifice flanges shall be 21.2 kg/cm^2. 37 mm and smaller orifice flanges shall be socket weld.

Raised face weldneck flanges to be used on 50 mm pipe or larger except for alloy pipe, or where space requirements dictate otherwise.

Welding-neck pipe flanges shall be specified with bore to match mating butt-welding fittings, or pipe.

Lap joint flanges shall be used in alloy applications.

Spiral wound gaskets shall be used in all brine and steam service.

Welding-neck orifice flanges shall be specified with bore to match mating pipe. Orifice flanges in brine service shall have 19 mm NPT threaded taps.

Overlaid RFSO flanges may be used in lieu of lap joint flanges provided they have a square ID with no notch or internal crevice or bevel on the ID of the alloy pipe. The overlay shall be an 3.mm minimum, and be of the same material type of the pipe. The Engineer must review any proposed use and design of the overlaid flanges prior to fabrication. This technique has also been used to create flange tapped orifice flanges out of carbon steel RFSO for alloy 625 systems. This type of work has been done by Northwest Copperworks, in Portland Oregon.

7.12 Fittings and Bends

Weld-o-lets shall be used for alloy piping. Thread-o-lets and sock-o-lets shall not be used for alloy piping.

Welding elbows shall be long radius elbows.

Weldolets and threadolets are commonly used for connecting small diameter piping to larger diameter piping as opposed to collars, sockolets, or saddles.

7.13 Threaded Connections

Piping 2" and smaller may be threaded or welded depending on the service. Seal welding of threaded connections is not allowed. Small diameter piping in high temperature, pressure, or corrosive service shall be welded.

7.14 Brine Handling and Steam Production Piping

The following additional criteria shall apply to the brine handling and steam production piping.

7.14.1 Brine

Pressurized brine piping on the outlet of separators is at its bubble point pressure plus the head supplied due to the liquid level in the vessel. Vertical loops shall not be used and the number of fittings minimized to keep bubbles from forming in the brine upstream of meters and control valves which are adversely affected by upstream flashing. Only one elbow shall exist between flanged connections.

Atmospheric brine is at its bubble point pressure plus any available head. The piping design shall prevent flashing due to local pressure drops in pump suctions and at meters.

Brine piping ID shall be designed to accommodate 25 mm thickness of rough, hard scale adhering to the pipe walls with an absolute roughness factor of 0.03 to 0.125 inch.

Two phase flow will exist between the upstream vessel LCV and the inlet of the downstream vessel.. This pipe is very sensitive to design.

Piping calculations shall be based on 3 mm scale inside the alloy two phase pipe, and 3 mm of scale for brine dump piping to the steam relief.

For alloy brine and steam pipe in single phase flow conditions, alloy expansion joints shall be considered. Expansion joints shall be of Alloy 625/Hast. C pipe, sleeve, and bellows. Provisions shall be made such that the space between the sleeve and the bellows can be filled with an inert material to prevent accumulation of brine in a static area.

Drains line terminations on brine pipe shall be placed at an non-perpendicular angle to the ground such that when drains are used under pressure, or when they require rod out, that brine does not splash up to the operator. An angle of 60 to 75 deg. Shall be used.

Drain valves in brine service shall be 37 mm Hast C ball valves. Sample valves in brine service shall be 25 mm Hast C ball valves.

Instrument taps, level bridle isolation valves, level taps, and other valves that are in a normally open position during operation may be Type 316L stainless steel ball valves with PEEK seats. This is also true for steam service.

7.14.2 Steam Piping

Steam piping shall be sized for normal flow rates, unless otherwise indicated.

Dead legs should be avoided.

Piping shall be designed to avoid water hammer.

7.15 Pipe Stress Analysis

This section provides basic pipe stress design criteria and design guidelines for analysis of 67 mm and larger piping for the Brine Handling and Steam Production equipment.

Brine piping shall be analyzed for the operating design density of the brine, with the line full.

Two phase piping will be for the operating density of flashed brine, but pipe and supports must be capable of a full hydrostatic condition. Springs and hangers must be designed per operating conditions, not the full hydrostatic condition.

Steam pipe 600 mm in diameter and under should be designed such that a hydrotest of the system can be accomplished. Springs and hangers must also be designed for the operating conditions.

Steam pipe above 750 mm diameter is not required to be hydrotested if in design the hydrotest loads become the dominant loads for the pipe support system, support spacing, and the wall thickness of the pipe. Alloy pipe will be 100% radiographed. All bolt torquing will documented if a hydrotest is not required. An inspection for leaks during initial operation will then be required.

7.15.1 Design, Operating, and Test Conditions

The Engineer shall specify the design conditions for the systems in accordance with ANSI B31.1 or ANSI B31.3.

Where systems have multiple operating modes, sufficient thermal cases (in addition to the normal operating case) shall be analyzed to insure that the maximum range of thermal movements is obtained.

Any fluid transient loadings shall be included in the design of the systems.

7.15.2 Restraint and Anchor Stiffness

Equipment anchor stiffness shall be provided by the manufacturer. For cylindrical vessels and similar equipment such as heat exchangers, nozzle stiffness shall be approximated using Welding Research Council Bulletin #297 or using Fourier Series Formulas developed and published by P.P. Bijlaard.

7.15.3 Thermal Analysis

All piping systems149C or greater shall be computer analyzed. For piping systems less than 149°F, judgment shall be used as to when a computer analysis, hand analysis, or no analysis should be performed. This judgment shall be based on piping configuration, temperature, allowable reactions on equipment, etc.

7.15.4 Allowable Nozzle Loadings

Allowable nozzle loads for major equipment shall be provided by the equipment vendor. Where the Vendor is not able to provide allowable loads, the actual loads shall be transmitted for approval.

7.15.5 Considerations for Process Piping

Physical properties for polymer concrete-lined pipe or alloy pipe shall be considered.

Where two-phase flow is expected and pipe fittings require overlay, the change in flexibility and weight of the fittings shall be taken into consideration.

When the process fluid is brine or slurry, actual brine or slurry densities shall be used in the analysis.

7.16 Pipe Supports

This section provides basic pipe support design criteria and design guidelines for the design of pipe supports.

All pipe supports shall be verified for adequate capacity under the design loading conditions.

Anchoring on pipe supports with pipe shoes shall be accomplished by using 3 mm gaps on the guides and limit stops on all four sides of the shoe, as opposed to a rigidly welded out anchor system. Stress analysis shall take advantage of this gap for these anchor types, as lower support load often will result, and the pipe rack loads will be reduced.

Clips and guides shall be hot dipped galvanized and shall be cold galvanized after installation.

7.16.1 Pipe Support Analytical Methods

Load Combinations and Allowable Stresses

The following load combinations shall be considered in the design of pipe support supplemental steel, welds, and bolts:

Case	Loads	Allowable
Normal	DL + Therm + P	AISC Part 5
Occasional	DL + P + Therm (Max) + |OCC|	Sect. 1.5 & 1.6
	DL + P + Therm (Min) + |OCC|	
Test	DL + P	Sect. 1.5 & 1.6

Where:

DL	=	Dead Load
Therm	=	Thermal Load (zero thermal load shall also be considered when all thermal loads are of the same sign)
P	=	Unbalanced pressure load due to expansion joints
OCC	=	Occasional Load = SRSS (Wind or Earth with Ft)
Wind	=	wind load
Earth	=	earthquake load (X or Z)
FT	=	Fluid transient load

For pipe support standard components, the manufacturer's catalog allowable loads shall be used.

Loads from Computer Analyzed Piping

Pipe support loads from computer analyzed piping shall be combined as shown in the previous section. Pipe support locations shall be per pipe stress ISO.

Hand Calculated Pipe Support Loads

Non-computer analyzed piping shall be supported using the following methodology or other good engineering practice:

1. Place supports near each horizontal change in direction.

2. Support long risers (preferably at the top). No more than one rigid support shall be used in a riser.

3. Place supports near valves and other concentrated weights or reduce the maximum pipe span.

4. Place supports to maintain maximum suggested spans shown in ANSI B31.1 Table 121.5.

5. Locate supports at existing steel wherever possible.

6. Locate lateral supports for seismic piping by the following criteria:

    a. In general, every 3rd support should be a guide.

    b. Long straight runs of pipe should have one axial restraint or a restraint immediately after a change in direction.

    c. Place guides near valves or valve stations where possible, especially MOV's.

7. Operating temperatures of the piping should be considered when locating guides to avoid restricting thermal expansion.

Support loads shall be determined by standard engineering methods using appropriate piping fluid, component weights, and seismic accelerations.

For seismically qualified piping, the horizontal acceleration is shown in the Structural Design Criteria.

Standard support loads will be developed based on pipe size and should be used to the greatest extent.

Piping near equipment shall be supported so as to meet the manufacturer's specified maximum nozzle loads. Where piping is connected to rotating machinery such as pumps or compressors, the use of a spring hanger at the first support shall be used where practical.

Calculation Requirements for Supports

A pipe support calculation shall be produced for each high energy piping system. The calculation shall serve as documentation for support loads. In addition, the calculation shall include the analysis for all computer analyzed pipe supports and other complex supports. No calculation is necessary for relatively simple supports where the support component loads are easily obtainable. Where integral attachments are welded to piping, determination of local piping stresses shall be included in the calculation.

In addition to piping loads, the following items shall be considered in the design and analysis of supports.

1. Self-weight load for large structures.

2. Friction loads for hot systems.

3. All supplemental steel spanning existing floor beams shall be considered pinned irrespective of welding.

Support Configuration Sketches

Support configuration sketches shall be produced for all large bore piping. The sketches should provide the following information:

1. General configuration with existing steel and elevations.

2. Interference check/clearances.

3. Pipe data and support location plan.

4. Piping loads and movements.

5. A detailed design for complex supports.

The sketches should also show standard hanger components and supplemental steel including end connections for rod and spring hangers. All sketches shall include the initials and date of preparer and reviewer, and associated node point number for computer analyzed piping. Sketches shall utilize standard forms wherever feasible.

The sketches shall be numbered as follows:

XXX-YYYY-###

Where:

XXX is the system designation (MSS, CCW)
YYYY is the support type
PSRH for rod hanger
PSSH for spring hanger
PSST for sway strut
PSSP for snubber/shock suppressor
PSR for other restraints
PSG for guides (two-way lateral restraint)

PSA for anchor
PSS for sliding support

is a unique number associated with the support.

This shall serve as the support mark number.

Copies of support sketches shall be included with the piping stress analysis calculations.

Special Considerations for Support Design

1. Local attachments and integral welds shall be designed and shown on the support sketches. The design shall insure that piping stresses remain within allowable limits.

2. Removable supports requiring supplemental steel shall be bolted with ASTM A193 Gr. B8 bolts and A194 Gr. 8 nuts. This information shall be included on the sketches.

3. Sliding supports shall include the effect of friction from deadweight and thermal loads only. The coefficient of friction shall be 0.30 for steel on steel and 0.15 for dry lubricant bonded surfaces such as Teflon or Lubrite.

4. U-bolts may be used as guides for 100 mm and under piping when the applied side load is below allowable limits.

5. Preferential corrosion has occurred on weld on type pipe shoes and other components. This has not been observed with clamp on shoes.

7.17 Valves

Butterfly valves shall not be used for isolation in brine service. They may be used for isolation in steam service only as outlined in the pipe specification sheets.

All valves (except wafer type butterfly valves) adjacent to towers, exchangers or vessels or expansion joints shall be attached directly to the nozzles where possible.

Position of stems of all valves 3 in and larger shall be indicated on the design drawings.

All operating valves shall be accessible for operation and maintenance. Valves shall not be located in the interior of piping bundles.

All safety valves, control valves, check valves, rupture discs, and equipment, which may require servicing shall be located so they are readily accessible from permanent platforms or ground level.

Generally, globe valves shall be installed with pressure under the seat, except for globe valves in lines under vacuum, in which case the valves shall have vacuum under the seat.

Infrequently used isolation valves shall be accessible but may be located more than 2 m above the operating level with a permanent access platform. Portable access platforms must be approved by the Owner

Operating valves shall be oriented to optimize the manual operation of the valve. Overhead valves shall be oriented so that the handwheels are approximately 1.5 m above the operating level or access platform.

This orientation may be increased to 2 m maximum provided that the valve can be opened or closed in this position.

Where valves are to be locked in an open or closed position, they shall be provided with a suitable locking device, and shall be so noted on the P&IDs.

Operating valves located underground or in trenches or below platforms shall be provided with extension stems or otherwise arranged so the handwheels will be above the surface of the ground or grating, and in such position as to be readily reached and operated. Bonnet, yoke, and stem of rising stem gate valves, when below grade and not in trenches, shall be protected with valve boxes or other suitable means. Above grade valve extensions shall be protected from damage by vehicular traffic.

Wafer type butterfly valves shall not be installed directly on equipment nozzles.

The gate valve adjacent to a power control valve shall have flanged inlet and outlet connections to permit removal of and repairs in the shop to both the gate valve and the power control valve.

7.18 Instruments and Controls

Control valves, block valves, and bypass valves around control valves shall be individually sized by the Engineer and sizes noted on the flow diagrams or drawings. In general, block and bypass valves will be line size for lines 50 mm. and smaller, and where line size is 67 mm. and larger, bypass and block valves may be one size smaller than line size, but in no case smaller than the control valve.

Bypass valves shall be ball valves in sizes up to and including 75 mm. Above this size, use type of valve as specified in the piping class of the line.

Control valves shall be installed with block valves and bypass valves. Block and bypass valves shall not be installed where redundant control valves are installed. Control valves shall be installed with the valve stem vertical where possible. Butterfly control valves in brine service shall be oriented with the shaft horizontal.

Manifold shall be arranged to permit easy removal of the control valve while line is in operation and should also provide clearance for removing inner valve from above or below, while valve body remains in place, if possible.

Block and bypass valves may be omitted if the control valves are equipped with manual operators (handjacks). Bypass valves may be omitted where manual control of the process is not possible.

Carbon steel flanged control valves shall have the same rating as the piping class in which they are installed. 100 mm control valve flanges and below shall be rated 21.2 kg/cm^2 minimum.

A drain and bleeder valve shall be provided between the upstream block valve and control valve for draining and pressure blowdown.

Unless otherwise specified, where flashing occurs through control valves located in control valve stations, the control valve shall be located as close as possible to the downstream end of the line, in order to minimize erosion.

First shutoff valves for all instrument connections shall be shown on P&IDs.

Main turbine vacuum trip feeler line shall be taken from a separate connection in the main condenser neck and shall not be valved.

Each level control standpipe shall be provided with a 19 mm. valved vent and 19 mm. valved drain.

Each level controller and level switch shall be provided with a 12 mm. valved vent and a 12 mm. valved drain.

Orifice flanges shall be a minimum size and rating of 37 mm, 300 lb ANSI standard.

Thermometers in overhead lines shall be installed on the lower quadrant of the pipe (but not on the bottom) for improved visibility.

Gage glass drains shall not be smaller than the size of the tapped connection on the gage glass (usually 12 mm.).

Pressure gage connections on pump discharge piping shall be located on pump side of check and block valves.

Instrument connections shall be arranged so the line and valve are roddable.

For instrument branch connections, the first fitting and valve, if required, shall be as follows:

Instrument	Connection Size, (mm.)
Conductivity (cell inserted in line)	30
Flanged tap orifice	12
Flowmeter line taps	19
Level	
External chamber controller	50
Switches	25
Differential pressure transmitters	19
Standpipes or multiple gage glass columns	50 (with 100 mm. stand- pipes)
Pressure	19
Sample	37
Temperature well	37

Liquid level controllers and level glasses shall be located to be accessible from grade, platform or permanent ladder. The level glass shall be readable from grade wherever practical.

7.19 Relief Devices

Relief line layout should avoid low spots where brine, condensate, or slurry can accumulate. All relief lines shall have a 6 mm sentry hole downstream of the relief device. Drains are to be installed when low spots cannot be avoided. The minimum drain size is 37 mm. For piping normally in service, roddable vents (37 mm) shall be supplied on the side or top of the pipe in conjunction with the drain. Clearance, on the order of 36" for pressurized lines and 18" for atmospheric lines, in the direction the valve points, is recommended to enable rod-out (hot-tap) of a plugged valve.

Steam safety device vent lines shall not be manifolded, but shall be run independently to atmosphere.

Relief devices shall be accessible. Wherever feasible, they should be located at platforms which are functional for other purposes. Relief devices with a centerline elevation over 5 m above high point of finish surface shall be accessible from platform or permanent ladder.

a. 25 mm and smaller thermal relief devices may be installed in a horizontal position when it is impractical to install in the vertical. 37 mm and larger relief devices shall be installed in a vertical position.

b. Relief devices discharging to a closed system shall normally be installed higher than the collection header. There should be no pockets in the discharge line. Where economics dictate, relief devices may be lower than the collection header.

c. Relief devices discharging to atmosphere shall have tail pipes extended to a minimum of 2.5 m above the nearest operating platform within a radius of 7.5 m unless otherwise approved by the Engineer.

7.19.1 Orifice Runs

Orifice runs should be located in the horizontal. Vertical orifice runs may be used with the approval from the Engineer. Orifice flanges with a centerline elevation over 5 m above the high point of finish surface, except in pipeways, shall be accessible from a platform or permanent ladder.

a. Orifice taps shall be located as follows:

1. Air and Gas - Top vertical centerline (preferred)

   - 45° above horizontal centerline (alternate)

2. Liquid and Steam - Horizontal centerline (preferred)

   - 45° below horizontal centerline (alternate)

3. Isometrics shall show the required tap orientations.

7.19.2 Temperature Instrument Accessibility and Visibility

a. Temperature test wells located less than 5 m above high point finish surface shall be accessible from grade or a portable ladder. Those located in a pipe way shall be considered accessible by portable ladder. Those located over 5 m above high point of finish surface shall be accessible from a platform or permanent ladder.

b. Temperature indicators shall be visible from grade, ladder or platform.

c. Thermocouple and temperature indicators located less than 5 m above high point of finish surface shall be accessible from grade or a portable ladder. Those located in a pipe way shall be considered accessible by portable ladder. Those over 5 m above high point of finish surface shall be accessible from a platform or permanent ladder.

Local pressure indicators shall be visible from grade, permanent ladder or platform. Those located less than 5 m above high point of finish surface shall be accessible from grade or a portable ladder. Those located in a pipe way shall be considered accessible by portable ladder. Those over 5 m above high point of finish surface shall be accessible from a platform or permanent ladder.

7.20 Strainers

Stainless steel temporary start-up strainers, 50 mm nominal pipe size and larger shall meet the requirements in the individual Piping Material Specifications.

7.21 Vessels

Vessel design shall conform to ASME Section VIII. Where it will simplify and economize piping systems, nozzle flexibility should be taken into account for pipe stress analysis. Additional nozzle reinforcement should be considered to increase the allowable forces and moments for a particular nozzle. Vessel nozzles in brine service shall be 100 mm or greater.

7.22 Corrosion Allowances

Corrosion allowances not otherwise specified in the individual Piping Material Specifications shall be specified by the Engineer such that the component service life will meet or exceed the specified project life

7.23 Codes and Standards

As a minimum the Engineer's design shall comply with the current editions, at the Date of Notice to Proceed, of relevant internationally recognized Codes, Standards and Regulations and all applicable Codes, Standards, and Regulations of Turkey. Where conflicts exist between Standards, the more stringent requirements shall prevail. Deviations from relevant Standards shall only be implemented with the written approval of theEngineer.

Codes and specifications from the following list will be preferred over alternative codes:-

Codes & Standards

AASHTO American Association of State Highway and Transportation Officials
ACI American Concrete Institute
AFBMA Antifriction Bearing Manufacturer's Association
AGMA American Gear Manufacturer's Association
AISC American Institute of Steel Construction
ANSI American National Standards Institute
API American Petroleum Institute
ASHRAE American Society for Heating, Refrigeration and Air Conditioning Engineers
ASME American Society of Mechanical Engineers Boiler and Pressure Vessel Codes
ASNT American Society for Non-destructive Testing
ASTM American Society for Testing and Materials
AWS American Welding Society
AWWA American Water Works Association
BOCA Building Office Codes Association

CTI	Cooling Tower Institute
DIN	Deutsche Institut fur Normung
EJMA	Expansion Joint Manufacturer's Association
HEI	Heat Exchanger Institute
HI	Hydraulic Institute
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IPCEA	Insulated Power Cable Engineers Association
ISA	Instrument Society of America
ISO	International Organization for Standardization
JEC	Japanese Electrotechnical Committee
JEM	Japan Electrical Manufacturers' Association
JIS	Japanese Industrial Standards
NACE	National Association for Corrosion Engineers
NEC	National Electrical Code
NEMA	National Electrical Manufacturer's Association
NESC	National Electric Safety Code
NFPA	National Fire Protection Association
OSHA	USA Department of Labor Occupational Safety and Health Act
SSPC	Steel Structures Painting Council
TEMA	Tubular Exchanger Manufacturer Association
UBC	Uniform Building Code, 1997
UFC	Uniform Fire Code
UL	Underwriters Laboratories Inc.
UPC	Uniform Plumbing Code, International Association of Plumbing and Mechanic Officials

Specific dates and revisions of Codes, Standards and Regulations shall be identified on issued drawings and specifications.

ATTACHMENT 4.1 HAS BEEN DELETED FROM THIS COPY.

Attachment 6.1

Law on Utilization of Renewable Energy Resources for the Purpose of Generating Electrical Energy

Law No. 5346
Ratification Date: 10.05.2005
Enactment Date: 18.05.2005

SECTION ONE
Purpose, Scope, Definitions and Abbreviations

Purpose

Article 1– The purpose of this Law is to expand the utilization of renewable energy resources for generating electrical energy, to benefit from these resources in secure, economic and qualified manner, to increase the diversification of energy resources, to reduce greenhouse gas emissions, to assess waste products, to protect the environment and to develop the related manufacturing sector for realizing these objectives.

Scope

Article 2– This Law encompasses the procedures and principles for conservation of the renewable energy resource areas, certification of the energy generated from these resources and utilization of these resources.

Definitions and Abbreviations

Article 3– The terms used in this Law are defined as follows;

1. **The Ministry:** Ministry of Energy and Natural Resources,
2. **EMRA:** Energy Market Regulatory Authority,
3. **DSİ:** General Directorate of State Water Works,
4. **EİE:** General Directorate of Electrical Power Resources Survey and Development Administration,
5. **TEİAŞ:** Turkish Electricity Transmission Company Inc.,
6. **MTA:** General Directorate of Mineral Exploration and Research,
7. **TETAŞ:** Turkish Electricity Trading and Contracting Company Inc.,

8. **Renewable energy resources:** Non-fossil energy resources such as hydraulic, wind, solar, geothermal, biomass, biogas, wave, current and tidal energy,

9. **Biomass**: The fuels in solid, liquid or gaseous phase obtained from organic wastes and from the agricultural and forestry products including the waste products of agricultural harvesting and oil extraction from plants as well as from the by products formed after their processing,

10. **Geothermal resource**: The natural water, steam and gases comprising melted substances and gases with temperature permanently higher than the regional atmospheric average due to the natural heat in the earth crust and water as well as vapor and gases obtained from hot dry rocks,

11. **Renewable energy resources in the scope of this Law**: The electrical energy generation resources suitable for wind, solar, geothermal, biomass, biogas, wave, current and tidal energy resources together with hydraulic generation plants either canal or run of river type or with a reservoir area of less than fifteen square kilometers,

12. **Turkish average wholesale electricity price:** The average of the wholesale prices of electricity calculated by EMRA and applied in the country annually.

SECTION TWO
Identification, Conservation and Utilization of Renewable Energy Resource Areas and Certification of the Electrical Energy Generated from Renewable Energy Resources

Identification, conservation and utilization of the resource areas

Article 4- Following the effectiveness of this Law, no development plan affecting the utilization and efficiency of renewable energy resource areas shall be prepared in the public or Treasury territory. The procedures and principles for identification, conservation and utilization of geothermal resource areas for electrical energy generation shall be specified in regulation.

Renewable Energy Resource Certificate

Article 5– The legal entity holding generation license shall be granted by EMRA with a "Renewable Energy Resource Certificate" (RES Certificate) for the purpose of identification and monitoring of the resource type in purchasing and sale of the electrical energy generated from renewable energy resources in the domestic and international markets.

The procedures and principles of the RES Certificate shall be specified in the regulation.

SECTION THREE
The Implementation of Procedures and Principles in the Electrical Energy Generation from Renewable Energy Resources

Principles of Implementation

Article 6– The legal entities holding licenses to generate and transact electricity from the renewable energy resources in the scope of this Law are subject to the principles of implementation specified hereunder:

a) The electrical energy generated from the renewable energy resources in the scope of this Law shall be purchased by the legal entities holding retail sale license on the basis of bilateral agreements to be concluded in pursuance with the provisions of paragraphs (b), (c) and (d) of this article.

b) Within the framework of prepared projection by the Ministry, the relevant information on amount of RES certified electrical energy, which shall utilize the implementations in the scope of this Law, shall be issued by EMRA annually. Each legal entity holding retail sale license shall be entitled to purchase RES certified electrical energy in an amount declared by EMRA considering the proportion of the energy amount he has sold within the previous calendar year to the total electrical energy amount which all legal entities holding retail sale license offered for sale in Turkey.

In case the total electrical energy amount with RES certificate is sufficient, the legal entities holding retail sale license shall be entitled to purchase RES certified electrical energy not lower than eight per cent of the electrical energy they have sold in the previous calendar year.

c) Until the end of 2011, the applicable price for the electrical energy to be purchased in pursuance with this Law within each calendar year shall be the Turkish average wholesale electricity price in the previous year determined by EMRA. The Council of Ministers is entitled to raise this price up to 20 % at the beginning of each year.

d) As of the end of 2011, this pricing methodology shall not be applicable for the RES certified electrical energy generation plants which are under operation for more than seven years. The retail sale companies shall purchase the RES certified electrical energy, which they are obliged to purchase on the basis of the provisions of this Law, primarily from those plants which have not yet completed a business period of seven years, in accordance with the pricing methodology laid down in part (c) of this article, and in case the purchased amount of electrical energy is less than the ratio specified in part (b) of this article, they shall buy the remaining amount, until reaching the ratio referred hereof, through bilateral agreements at the price formed in the market without exceeding the Turkish average wholesale electricity price.

SECTION FOUR
Principles of Implementation Regarding Investment Period

Investment Period Implementations

Article 7–The real persons and legal entities establishing an isolated electricity generation plant and grid supported electricity generation plant by utilizing hydraulic resources with a maximum installed capacity of 1000 kW for meeting solely their own demands, shall not be claimed to pay the amounts of service for the projects, of which final designing, planning, master planning, preliminary surveying and first auditing were prepared by either DSİ or EİE.

Within the framework of this Law;

a) Investments on energy generation facilities;
b) Procurement of domestically manufactured electromechanical systems;
c) Investments on research and development and manufacturing in the scope of the electricity generation systems by utilizing solar cells and concentrated collectors;
d) Investments on research and development facilities for generation of electrical energy or fuels by utilizing biomass resources;

can benefit from the incentives determined by the Council of Ministers.

The heat energy needs of the residential areas in the boundaries of the province and municipalities in the regions with sufficient geothermal resources shall be met primarily by geothermal or solar thermal resources.

Implementations related to Acquisition of Land

Article 8– In case of utilization of all sorts of property which is under the possession of Forestry or Treasury or under the sovereignty of the State for the purpose of generating electrical energy from the renewable energy resources in the scope of this Law, these territories are permitted on the basis of its sale price, rented, given right of access or usage permission by Ministry of Environment and Forestry or Ministry of Finance. Fifty percent deduction shall be implemented for permission, rent, right of access and usage permission in the investment period. ORKOY and forestation special allowance revenue shall not be charged in forested land.

SECTION FIVE
Various Provisions

Coordination of the Implementations

Article 9– The Ministry shall provide coordination in implementation, steering, monitoring and assessment of the fundamental principles and obligations specified in this Law, and in planning the measures to be undertaken.

Sanctions

Article 10– The legal entities holding retail sale license who breach the provisions of Article 6 of this Law shall be charged administrative fine of 250 billion TL by EMRA and shall be warned to eliminate the violation in sixty days.

In case the activities that necessitate imposing a fine are not corrected or repeated, the amount of fine is doubled every time. If the same action is not taken in a two year period that necessitates imposing the same administrative fine, the preceding fines are not taken into account. But the increased fine that will be imposed if the action is taken more than once in two year period cannot be more than ten percent of the legal entity's gross income in the balance sheet. If the fine reaches to this level, EMRA may cancel the license.

Regulations

Article 11– The regulation related to 5th Article of this Law and the other regulations shall be prepared and put into force by the EMRA and the Ministry, respectively, within four months after the date of effectiveness of this Law.

Article 12 – The Annex Article 1, annexed to the Law on DSİ's Organization and Duties, dated 18/12/1953 and numbered 6200, under article 18 of the Law dated 22/02/2001 and numbered 4628 is changed as follows.

Additional Article 1 - The sections related with energy generation of the hydroelectric power stations, constructed, commissioned and to be commissioned by DSI and heir complementary immovables shall be transferred to the general management of Electricity Generation Company Inc., without payment, at the prices to be determined by considering their construction prices, their operation times, the repayments transferred to the Public Partnership Fund after such plants are completed and the financial liabilities arisen from foreign project credit facilities provided by the Treasury Under secretariat and allocated to DSI for such plants. A loan agreement shall be executed between the Treasury Under secretariat and the general management of Electricity Generation Company Inc. for the Electricity Generation Company Inc. to undertake the payments to be made by the Treasury Under secretarial during the years following the date of transfer for the portion of such foreign loans corresponding to energy generation purposes.

The procedures and principles of transfer shall be prepared by the Ministry of Energy and Natural Resources and the Treasury Undersecretariat and they shall be determined by a regulation to come into force upon a resolution by the Council of Ministers.

Transfer transactions shall be exempt from all kinds of taxes and duties.

Article 13 - Article 11 of the "Expropriation Law", dated 4/12/1984 and numbered 3096, is amended as follows:

Article 11. - Expropriation shall be carried out by the Ministry of Energy and Natural Resources under the Law 4650, pursuant to the approved application projects of the generation, transmission and distribution plants to be constructed by companies in charge, if expropriation is required, provided that the expropriation costs are covered by the company in charge, except for hydropower plants with a reservoir. Expropriation costs for such plants shall be covered by the Treasury from an allocation to be put in the budget of the Ministry.

The provision amended by this article shall apply to those projects, whose contracts have been executed under the law 3096, but not put into operation yet.

Provisional Article 1 – The legal entity that take place among the existing contracts, as defined by Electricity Market Law numbered 4628 and in the scope of the build – operate – transfer model, which is not in operation and which will generate electricity from renewable energy resources under this Law shall utilize the applications in this Law, provided that they should waive their rights arisen from existing contracts. EPDK shall grant generation licenses to such projects.

Provisional Article 2 – Public distribution companies holding a retail sale license shall be exempt from the purchase obligations under article 6 of this Law, up to 01.01.2007, except for the Ministry's and EMRA's existing regulations and applications. However, they shall contract electricity sales agreements with legal entities holding a RES–certified generation license, for purchase obligations, to be effective from 01.01.2007.

Provisional Article 3 – The projection stated in article 6 of this law shall be published by the Ministry within three months after effectiveness of this Law. However, such projection shall cover those projects, whose generation licenses have been granted by EMRA before effectiveness of this Law and those projects, among those existing contracted ones as defined in provisional article 1, whose licenses would be awarded under this law.

Provisional Article 4 – DSI energy contribution shares, shown in US$ in the contracts of build – operate – transfer model hydroelectric power stations, in operation under their existing contracts and their DSI contribution shares are paid by TETAŞ through tariff, shall be paid to DSI, in an amount as shown in the contract, at the foreign exchange rate of the Central Bank on the date of payment, at the end of every operation year.

The installation charges to be taken as basis in the calculation of the energy contribution share to be defined for hydraulic plants installed or to be installed under the law numbered 4628 and to be paid to DSI shall not exceed the 30 % of the first estimated value that forms basis to the tender which is the amount at the date of the agreement on water use updated by using Wholesale Price Index as a deflator. Of the amounts paid or to be paid in relation to the expropriations for the projects, the amount corresponding to energy share from the amount at the date of the agreement on water use, (updated by) using Wholesale Price Index as a deflator, shall be paid in whole by the company.

Effectiveness

Article 13– This Law shall be effective on the date of its publication.

Enforcement

Article 14– The provisions of this Law shall be enforced by the Council of Ministers.

ATTACHMENT 9.1 HAS BEEN DELETED FROM THIS COPY.

TABLES

Generator Step-Up Transformer Ratings
Table 2.3.3a

1)	**Type**	2 winding, 3 phase	
2)	**Frequency, Hz**	50	
3)	**Three-phase output (MVA), ONAN**	40	
4)	**Cooling method**	ONAN	
5)	**Impedance at rated 96MVA base**		8 %
		H-winding	**X- winding**
6)	**Rated voltage, kV**	154	13.8
7)	**Transformer Connections**	solid ground Wye	Delta
8)	**Impulse withstand voltage of windings, 1.2/50 microsec, kV, peak**	750	95
9)	**Impulse withstand voltage of neutral end, 1.2/50 microsec, kV, crest (winding BIL)**	110	N/A
10)	**1 minute power frequency withstand voltage , kV, rms**	325	38
11)	**Polarity**	Subtractive	
12)	**Phase relation**	YNd5	
13)	**Taps (full capacity)**	5 tap position	
	a. Number, percent volts,	+5% in 2.5% step	
	b. Number, percent volts below, rated voltage	-5% in 2.5% step	

Generator Step-Up Transformer Ratings
Table 2.3.3a

14) High voltage Bushing Electrical characteristics:

		H-winding	X-winding
a.	Voltage rating, kV	170	17.5
b.	Low frequency withstand voltage, 1 minute, kV	325	38
c.	Full wave impulse withstand voltage, kV, crest	750	95

15) No load loss at rated voltage less than 25 kW

16) Load loss on principal ratio at 1.0 PF less than 75 kW

17) Bushing Current transformer (Taps to be as ANSI C57.13)

a: Per each phase HV line bushing
400/5A CL. 0.5, 30VA
400/5A 5P15, 30VA
400/5A 5P15, 30VA
400/5A 5P15, 30VA

b: Per each phase LV line bushing
2000/5A CL. 0.5, 30VA
2000/5A 5P15, 30VA
2000/5A 5P15, 30VA
2000/5A 5P15, 30VA

18) Sound level, maximum dB According to NEMA TR-1 standard

19) High & low voltage bushing mounting Tank Cover

20) Annunciator type LED lamp type

21) Hot spot relay contact settings: LATER

22) Auxiliary power supplies

a. Rated voltage, phase, frequency 380/220V 3 phase 4 wire, 50Hz

b. Short-circuit capacity 40kA symmetrical

Unit Auxiliary Transformer Ratings
Table 2.3.3b

1.	**Rated power (MVA)**	9/12
2.	**Cooling method**	OA/FA
3.	**Installation (indoor/outdoors)**	Outdoors
4.	**Ambient**	Moderate
5.	**Temperature rise**	55/55° C
6.	**Insulation**	Oil
7.	**Number of phases**	3
8..	**H.V. winding**	
	kV	13.8
	Connection	Delta
	Full capacity taps	+5% in 2.5% Steps -5% in 2.5% Steps
	BIL	150
9.	**L.V. winding**	
	kV	6.3
	Connection	Wye- Res. Grd.
	BIL, kV	60
	Neutral connection, BIL	60
10.	**Rated frequency**	60 Hz
11.	**HV bushings**	
	kV	15
	BIL, kV	150
	Creepage distance, in.	Extra Creep
12.	**H.V. bushings shall be capable of accepting a cable connection**	
13.	**L.V. and L.V. neutral bushings**	
	kV	15
	BIL	60
	Creepage distance, in.	Extra Creep
14.	**H.V. side disconnect switch (yes/no)**	No
15.	**Impedance, base MVA**	By Contractor
16.	**Bushing current transformers**	
	HV Bushings	1 x 600/5A5P15, 30VA
	LV Bushings	2 x 1200/5A5P15

GENERATOR CIRCUIT BREAKER RATINGS
Table 2.3.3c

	UNITS	DATA
RATED VALUES OF CHARACTERISTICS:		
Number of Poles	3	3
Service Voltage	kV	13.8
Maximum Rated Voltage	kV	17.5
Rated Frequency	Hz	50
Insulation Level:		
Rated impulse withstand voltage	kV	95
Rated one-minute power frequency withstand voltage	kV	60
Rated Current	A	2000
Rated short-circuit breaking current	kA	63
Rated withstand current	kA	63
Rated duration of short-time current	sec	1
Rated out-of-phase breaking current	A	31500
Opening time (at rated interrupting capacity) including time for operation of any auxiliary contacts at 100% dc tripping voltage		45
Arc duration at 100% interrupting capacity	ms	80
Make-time at 100% dc closing voltage	ms	100
Maximum time from pre-arcing to arc extinction when closing on to a fault ignoring protection delays. All at 80%.		35
Dc closing and tripping voltage and minimum mechanism operating pressures at 100% rated capacity		110V, 275Kg/sec
CONSTRUCTIONAL FEATURES:		
Material of main contacts		Silver Plated Cu or Al
Type of arcing contacts and/or arc control device		
Material of arcing contacts		Tungsten Copper
Overall Dimensions:		
Height	mm	2390
Width	mm	2100
Length	mm	4130
Mass	kg	6500
Material of HV terminals		
SF_6 TYPES:		
Leakage rate of gas at normal pressure	% year	<1
OPERATING MECHANISMS:		
Are CB's trip free?	Yes/No	Yes
Normal operating voltage CB trip coil	V dc	110
Normal operating voltage CB close coil	V dc	110
Method of operating CB's, eg. Solenoid, Hydraulic or Spring:		
Closing		Hydraulic
Opening		Hydraulic
Time to recharge after CO cycle	Sec	60
Length of time CB design has been in commercial operation	Years	30
Length of time CB spares will be available	Years	6

GENERATOR CIRCUIT BREAKER RATINGS
Table 2.3.3c

MOTORIZED EARTHING SWITCH:	**UNITS**	**DATA**
Standard		IEEE C37.013
Number of Poles	3	3
Service Voltage	kV	13.8
Maximum Rated Voltage	kV	17.5
Rated Frequency	Hz	50
Rated Current	A	N/A
Insulation Level:		
Rated impulse withstand voltage	kV	95
Rated one-minute power frequency withstand voltage	kV	60
Rated short-circuit breaking current	A	N/A
Rated withstand current	kA	63
Rated duration of short-time current	sec	1
Motor rating, voltage	kW, V	0.8/AC220
Manual override		
Enclosure material	H_sS proof	Painted
Auxiliary contacts	H_sS proof	Painted
AUXILIARY LOADS:		
~~Compressors:Hydraulic Pumps~~		
Quantity		1
Rating	kW	0.75
Voltage	V ac	380
Phase	□	3
Heaters:		
Quantity		2
Rating	kW	0.2
Voltage	V ac	220
Phase	1 or 3	1

ONE-LINE DIAGRAMS

FEASIBILITY REPORT

GERMENCIK GEOTHERMAL POWER PLANT
AYDIN, TURKEY

FOR GATHERING SYSTEM EVALUATION
& DEVELOPMENT PLAN STUDY

TO
STONE & WEBSTER

Presented by:

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VEIZADES & ASSOCIATES, INC.
CONSULTING ENGINEERS

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FEASIBILITY REPORT
GERMENCIK GEOTHERMAL POWER PLANT
AYDIN, TURKEY
FOR
GATHERING SYSTEM EVALUATION AND DEVELOPMENT PLAN STUDY

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1. INTRODUCTION

Veizades & Associates (VAI) is pleased to present the Feasibility Report for the proposed Germencik Geothermal Power Plant (GGPP). The purpose of this report is to provide overall project scoping and conceptual design of the Resource Gathering System (RGS) at the GGPP. The basis for all data and siting/location information utilized in this report is information provided by Stone & Webster on the Preliminary Heat Balance drawing and on information we have gathered during the course of the well testing and recent site visits.

The Development Plan for this project and specifically the RGS is provided in Appendix A.

This report includes conceptual guidelines for the layout of the resource gathering system including line sizing and separation strategy. VAI utilized our proprietary flow model and other tools developed specifically for the design of resource gathering systems as well as our experience to develop these initial concepts. VAI has developed as part of the preliminary concepts, and provided in the Appendix, the Process and instrumentation drawings (P&ID) under Appendix B, the Process Flow Diagram under Appendix C, and vessel drawings under Appendix F through I, for critical components of the system. Geochemical considerations for the gathering system design, including scaling potential and brine carryover, are also included in the design approach.

In addition to the evaluation of the Gathering System VAI also evaluated the vent station at plant site, and the hot and cold injection facilities.

2. RESOURCE GATHERING SYSTEM LAYOUT & CIVIL WORK

The main consideration in selecting piping alignments for transporting hot geothermal fluids is flexibility.

Flexibility may be provided by following topographic features and by offsets in the piping alignment. Expansion loops are frequently used to provide needed flexibility.

The preliminary layout of the Germencik GRS as indicated on the Development Plan, Appendix A, is based on topography and existing access roads and keeping in mind pipeline flexibility and access for construction and maintenance.

In order to transport the resource from Well Pad OB-9 it will be necessary to construct a pipe crossing at the Alangullu River.

Scope of Civil Work:
The scope of work discussed in this report is limited to the following civil facilities:

- Two new well pads
- Improvements to three existing well pads
- One river crossing
- 550 meters of improved primary access road
- 2,400 meters of improved secondary access road
- 1,600 meters of new secondary access road

New pad construction

Well Pad OB-10

- Construct well pad and sump on fairly level ground adjacent to the power plant site. This site includes a 4,000,000 gallon sump for full-field testing. Assume approximately 20,000 cubic meters of earthwork.
- Place 0.15 meter of base rock on a 5400 square meter area.
- Place 0.75 meter thick clay liner in sump, requiring approximately 4300 cubic meters of clay. Alternatively, install 6000 square meters of 80 mil HDPE membrane liner.

Well Pad OB-12

- Construct well pad and sump on fairly level ground. Assume approximately 7500 cubic meters of earthwork.
- Place 0.15 meter of base rock on a 5000 square meter area.

- Place 0.75 meter thick clay liner in sump, requiring approximately 2300 cubic meters of clay. Alternatively, install 3200 square meters of 80 mil HDPE membrane liner.

Improvement & Expansion of Existing Pads

Well Pad OB-6

- Construct well pad and sump on relatively steep terrain. Assume approximately 15,000 cubic meters of earthwork.
- Place 0.15 meter of base rock on a 5000 square meter area.
- Place 0.75 meter thick clay liner in sump, requiring approximately 2300 cubic meters of clay. Alternatively, install 3200 square meters of 80 mil HDPE membrane liner.

Well Pad OB-8

- Construct well pad and sump on level ground. Assume approximately 7000 cubic meters of earthwork.
- Place 0.15 meter of base rock on a 5000 square meter area.
- Place 0.75 meter thick clay liner in sump, requiring approximately 2300 cubic meters of clay. Alternatively, install 3200 square meters of 80 mil HDPE membrane liner.

Well Pad OB-9

- Construct well pad and sump on fairly level ground. Assume approximately 7500 cubic meters of earthwork.
- Place 0.15 meter of base rock on a 5000 square meter area.
- Place 0.75 meter thick clay liner in sump, requiring approximately 2300 cubic meters of clay. Alternatively, install 3200 square meters of 80 mil HDPE membrane liner.

Pipe Bridge at Alangullu River crossing

Construction of a crossing of the Alangullu River for the primary access road and pipelines would involve:

- Providing temporary erosion and sedimentation protection facilities
- Constructing a cast-in-place concrete, multi-cell box culvert, approximately 17 meters long by 16 meters wide by 3 meters high, requiring about 400 cubic meters of concrete
- Constructing concrete wing walls on both sides of both the upstream and downstream ends of the box culvert, requiring approximately 80 cubic meters of concrete

- Placing dirt fill behind the wing walls and over the box culvert to bring the area up to match existing grade on each side of the river.
- Installing approximately 600 cubic meters of rip rap for permanent erosion control at the upstream and downstream ends of the box culvert

Primary Access Road:

This will require construction of approximately 550 meters of primary access road, essentially following an existing road from about 100 meters west of the river to the power plant site.

- Perform grading of existing road to widen it to 11 meters wide and smooth out grades. The 11 meter width will provide a 9 meter wide roadway (including ditches and/or berms) and a 2 meter wide pipeline right-of-way.
- Place 0.30 meter of base rock and 75 mm of asphalt concrete on 3850 square meters of roadway.
- Provide drainage facilities as required.

Improve Existing Secondary Access Roads:

Improvements will be required on approximately 700 meter of existing road from the power plant site to the existing OB-6 well pad and approximately 1,700 meters of existing road from the power plant site to the new well pad OB-12.

- Perform grading of existing road to widen it to 6.5 meters wide and smooth out grades. The 6.5 meter width will provide a 4.5 meter wide roadway (including a ditch or berm) and a 2 meter wide pipeline right-of-way.
- Place 0.15 meter of base rock and 50 mm of asphalt concrete on 8400 square meters of roadway.
- Provide drainage facilities as required.

New Secondary Access Roads:

This would involve construction of approximately 250 meters of new secondary access road around the power plant site, approximately 450 meters of new secondary access road to well pad OB-3, and approximately 900 meters of new secondary access road to well pad OB-8.

- Lay out the alignment of new roads.
- Perform grading required to construct a 4.5 meter wide roadway (including a ditch or berm) plus a 2 meter wide pipeline right-of-way.

- Place 0.15 meter of base rock and 50 mm of asphalt concrete on 5600 square meters of roadway.
- Provide drainage facilities as required.

3. RESOURCE GATHERING SYSTEM DESIGN CONCEPTS

Line Sizing

Resource gathering systems are designed to maximize the production of steam supply to the power plant at a minimum cost. Our approach to gathering system design includes the following considerations since the line sizing and design effort must be completed prior to the resource being fully developed. The RGS must be sized for minimum and maximum expected flow conditions and therefore it must be designed to an envelope of parameters rather than to a fixed set.

- Maximize utilization of the resource by minimizing pressure drop.
- Flexibility to accommodate minimum and maximum flow conditions.
- Construction costs over the life of the project.
- Appropriate steam quality objectives for turbine inlet.
- Consider operations and maintenance cost.
- Consider project expansion options or additional wellfield development required to compensate for wellfield decline.

When applied to a specific field, the following design criteria are developed in conjunction with resource development and power plant design:

- Line sizing.
- Separation strategy.
- Scaling and corrosion mitigation or accommodation.
- Piping alignment.
- Pressure control strategy.
- Metering and control system.

Pressure control, metering, and control systems are typically developed in close coordination with resource management and power plant design. Therefore, this report focuses on line and separator sizing. All other issues critical to this conceptual design are included in the P&ID's.

VAI utilized our spreadsheet-based computer model to perform a preliminary analysis of pressure drops and two-phase flow characteristics for sizing the pipelines in the proposed

Germencik RGS. The following is an introductory description of the model followed by a description of the results of the evaluation.

Geothermal Resource Gathering System Model

The resource gathering system model, for steam, is comprised of the single phase steam flow template which utilizes the Fritzche's equation. The calculations performed by the model are based on user-defined inputs such as well head pressure, resource enthalpy, turbine inlet pressure and equivalent lengths. The model includes curve-fit equations of several thermodynamic properties based on the Steam Tables such as Specific Volume, Enthalpy, Viscosity, and the Surface Tension. In order to minimize curve-fit related inaccuracies we have only curve-fitted the appropriate pressure ranges that apply to geothermal gathering systems. For example, we have performed separate curve fitting, with flowing pressure as the variable, for the high pressures and low-pressure ranges typically encountered in geothermal work. We have set our high pressure curve-fit range from 25 psia to 250 psia with an accuracy (as compared to steam table data) of ±0.05%, and the low pressure curve-fit range is set from 10 psia to 25 psia with an accuracy of ±0.05%.

Two-phase flow lines generally perform well when installed level or run downslope. For upsloping flow lines, the velocities must be controlled to avoid flow conditions that would generate either slug flow or wavy flow. It is desirable to size two-phase pipes so that the two-phase flow falls either under annular or dispersed regimes. Changes in vertical alignment should be gradual and as minimal as possible. The total two-phase pressure drop is comprised of friction, gravitation, and acceleration components. The frictional pressure drop is generally the primary contributor to the total pressure drop, particularly in relatively flat terrain. The pressure drops attributed to gravitation and acceleration may be generally neglected without introducing large errors.

For this preliminary evaluation, the equivalent lengths, between assigned nodes, required for frictional pressure drop calculations of for Germencik RGS were calculated based on the plan length, alignment as shown on the Development Plan, multiplied by a 1.2 factor to account for cross-country piping bends and fittings. The equivalent lengths required for frictional pressure drop calculations of piping components were calculated utilizing published flow resistance constants for valves and other fittings. To obtain accurate pressure drops for long pipelines, an iterative calculation of pressure drop was performed in order to modify and reflect the effect of pressure-based thermodynamic parameters as they change.

The user-defined inputs, described above, are usually either in the form of actual measured data at the wellhead, or derived from the deliverability curves. Anticipated wellhead pressure and corresponding flow data characteristics are retrieved from the deliverability curves. This forecast

of deliverability varies with anticipated resource enthalpy so deliverability data must be critically analyzed and entered in to the model to achieve a reasonably accurate performance of production wells used in the gathering system model.

The well quantities and flow rates were revised based on the following information received in July 2005. This in turn led to revisions in line sizing and total gathering system cost. The HP Steam Flow production was calculated to be approximately 197,960 kg/hr at the HP Separation pressure of 5.2 BarG and LP Steam Flow production was calculated to be approximately 187,890 kg/hr at the LP Separation pressure of 0.2 BarG.

Revised Production Well Flow Data

Well Name	**Two-Phase Well Flow [ton/hr]**	**Two-Phase Enthalpy [kJ/kg]**
OB-6	375.0	908.0
OB-6A	717.0	908.0
OB-9	282.0	872.0
OB-10	490.0	908.0
Total	**1,864.0**	**902.6**

The approach taken in this analysis was to allow for approximately 1.5 Bar maximum line losses between the furthest well pad header or maximum pressure downstream of the well line control valve and the 4.9 BarG turbine inlet pressure that has been defined in the Heat Balance. A typical gathering system will have approximately 1 to 2 psi pressure drop between the turbine inlet and the well head. In this pressure drop model, we limited the line loss pressure drop to less than 1 Bar with the RGS pipeline sizes as depicted on the Development Plan (See Appendix).

Results of the Resource Gathering System Model

The following table indicates the estimated well head pressures based on the turbine inlet pressure of 4.9 BarG.

Turbine Inlet: 4.9 BarG

Well	Calculated Pad Header Pressures [BarG]	DP (Turbine & Pad Header) Bar
OB-6 & OB-6A	5.8	0.93
OB-9	5.6	0.74
OB-10	5.5	0.60

Control valves are required on each production well to control and reduce the high flowing pressure of the resource.

4. EVALUATION OF HP & LP FLASH VESSELS

Sizing the Separators and Polishing Vessel

Separation strategy for the Germencik Field:

Separator sizing for this evaluation is based on mass flow. The preliminary design for separators and polishing vessels was performed utilizing the separator inlet pressure, steam flow, brine outlet flow, and pressure drop through the vessel. A 0.14 Bar pressure drop was assumed to size the separators. All design parameters were based on flow data inputted in to VAI's pressure drop analysis from the PFD provided by Stone & Webster. The sizing summaries for the H.P. and L.P. separators are as follows:

HP Separator:

a) Calculated Results of selected sizing options:

Option	Per separator		
Separator Diameter & Qty	**Pressure Drop in Bar**	**HP Steam Discharge in kg/hr**	**Steam discharge quality**
1.83m diam, 2 each	0.05 bar	101,355	98.9%
3.05m diam, 1 each	0.12 bar	202,711	99.5%

b) Selections:

HP Separator Dia (in)	**Inlet Dia**	**Steam Outlet Dia**	**Brine Outlet Dia**	**Dwg. #**
3.05m Single Sep	600mm	750mm	400mm	V-1, Appendix F

LP Separator:

a) Calculated Results of selected sizing options:

Option	Per separator		
Separator Diameter & Qty	**Pressure Drop in Bar**	**LP Steam Discharge in kg/hr**	**Steam discharge quality**
3.05m diam, 3 each	0.06 bar	56,458	98.1%
3.66m diam, 2 each	0.14 bar	84,687	98.3%

b) Selected qty and size:

LP Separator Dia	Inlet Dia	Steam Outlet Dia	Brine Outlet Dia	Dwg. #
3.66m diam, 2 each	600mm	750mm	400 mm	V-2, Appendix G

5. EVALUATION OF HP STEAM & LP STEAM POLISHING SEPARATORS

VAI has performed an evaluation of the sizing for a "Portatest" or recycling polishing separator based on the HP and LP Steam flowrates used previously for the HP and LP Flash Vessels sizing above.

The typical pressure drop design basis for a "Portatest" recycling separator ranges from 1.0 to 2.0 psi. The results of the evaluation are given below:

1) Design Parameters: Turbine inlet pressure of 4.5 BarG
   HP Steam Pressure = 5.2 BarG, LP Steam Pressure = 0.2 BarG

Calculated Results of selected sizing options:

Polishing Sep Size options	Pressure Drop (Bar)	Steam Flow (kg/hr)
HPS G54 (1350mm)	0.12	202,711
HPS G60 (1500mm)	0.08	202,711
LPS G78 (1950mm)	0.12	169,374
LPS G84 (2100mm)	0.09	169,374

2) Selected qty and size:

VAI has selected the G54 (1350mm) size for the HP Steam polishing vessel and the G78 (1950mm) for the LP Steam polishing vessel.

Type	Shell ID (mm)	Height (m)	Dwg. #
HPS G54	1372 mm	9.9m overall	V3A&B, Appendix H
LPS G78	1981 mm	13.87m overall	V4A&B, Appendix I

6. STEAM RELEASE FACILITIES- VENT STATION EVALUATION

The steam release facility in a geothermal plant is required for start-up and for venting during turbine trips. In addition they take the discharge from rupture disks during over-pressure relief of piping and pressure vessels such as separators.

The steam release facility at Germencik will consists of a single-cell rock muffler with 100% vent capacity rock muffler that is expected to be a 6.1m x 4.9m rectangular structure. The discussion below indicates the basic operation of a rock muffler.

Rock Muffler Principles of Operation

The rock muffler works on the basis concept of subjecting the vented steam to a tortuous path through hard durable volcanic angular rock. The steam follows the path of least resistance and is forced to enter and exit the rock fill by partial plugs installed in the expanded metal flow cylinders. Depending on the design capacity, the steam passes through the rock fill between 3 and 5 times. Each path reduces the potential energy of the steam and the rock absorbers and deadens the sound.

The required cross sectional areas are determined by flow velocities and are controlled by the expanded metal cylinders to minimize the potential of fluidizing the rock fill. Drains are incorporated in the bottom discharge chamber to keep the muffler free from condensate.

Diffuser design is critical to the success of the rock muffler. The diffuser is sized to limit the maximum flow to the design limit, while back-pressuring the vent valve. This passive control ensures that flow in excess of the design cannot happen.

The diffuser also serves as the primary steam let down device and channels the noise of the steam let down into the bottom chamber of the rock muffler. The chamber area is constructed with concrete for erosion and sound deadening qualities.

7. OVERPRESSURE RELIEF IN GEOTHERMAL GATHERING SYSTEMS

Rupture disks are installed in geothermal piping to prevent over pressuring the piping and separation facility vessels. Over pressuring can occur when wells are opened against a closed isolation valve (for example the plant motor operated isolation valve). Rupture disks or other overpressure devices are not required if the piping components are designed for the expected shut-in pressure of wells but this option is typically too costly to implement for the large diameter geothermal pipelines.

Pressure relief valves used as overpressure devices have not performed well in geothermal systems. Due to deposits a pressure relief valve would not reseat once activated. In general rupture disks have been found to be more effective. The rupture disks that have performed well are the reverse buckling type installed in safety heads with cutting blades. The specification of the rupture discs requires a zero manufacturing tolerance and an operating limit of 90% of the rated burst pressure to prevent spurious rupture disc operation.

A typical rupture disk installation incorporates 2x100% rupture disks with an isolation valve immediately upstream of the rupture disk. The flow is piped to a muffler for noise control. The function of this isolation valve is to be able to replace the rupture disk, either upon burst or during periodic maintenance replacement, without shutting down that portion of the gathering system. Such isolation valves are not allowed by the ANSI B31.1 code. A variance, however, from the authority responsible for safety monitoring of the installation must be obtained on a project specific basis provided the following conditions are met.

- The rupture disks are sized to relieve pressure at the maximum delivery of the wells connected upstream of the rupture disk station.
- An additional rupture disk, over and above the quantity required for 100% flow vent, is installed. This will ensure that when a rupture disk is taken out of service for maintenance the total number of rupture disks required are still open to the system.
- The isolation valves are chained and locked open and controlled by authorized personnel.
- Written and documented procedures have been developed for the replacement of rupture disks.

8. DISCUSSION OF PIPELINE PRESSURE PROTECTION DESIGN

The design of the pressure relief systems on geothermal pipelines has been evolving over the last 15 to 25 years based on a different perspective on the purpose of the vent station. In the early years the vent station design was more in keeping with a complete failsafe system where in any upset condition or loss of signal or air supply the vent station valves would go fully open.

In the late 70's to early 80's the operation and purpose of the vent station was reviewed due to the advent of geothermal pipeline distributed control systems. The control systems allowed an operator interface with the vent station controls that was not previously available and the control functions of the vent station were viewed in a new light. There was a basic separation of the rupture disc function to only protect the pipeline and its appurtenances and not include the rupture disc systems in the protection scheme of the steam turbine. This approach centered on the fact that the pipeline vessels and pipeline themselves were protected by rupture discs and that the vent station could have a control function using a pressure controller in the distributed control system. The changes that took place were the following:

- **Modulating Pressure Control Valves-** The vent valves became modulating pressure control valves with the primary control loop residing in the control system so that the header pressure at the turbine inlet could be closely monitored and the loop pressure set points were capable of being operator defined.

- **Fail In Last Position on Loss of Signal-**The vent valves on loss of signal were now set to fail in last position instead of fail open. Thus if the vent valves were closed when the DCS signal to the vent valves was lost the vent valves would stay closed and if they were open on loss of signal they would remain open.

- **Vent Valve Stroking Speed**- There was still a requirement to open the vent valves quickly to prevent over pressuring the system and bursting rupture discs. The change to modulating control required high capacity valve actuator positioners or volume boosters to allow large volumes of air into the diaphragm to stroke the valves. A design in one system used Bailey positioners that stroked opened 12-inch Fisher Design U Vee-Ball valves in less than 3 seconds. Another design incorporated pneumatic volume boosters that resulted in a similar actuation speed.

- **Fail Safe Design-** To minimize the deviation from a controlled venting event the system was designed to feature "graceful degradation". This meant that it was necessary to design the system with levels of backup so that it was "Fail Safe". This included stand-alone backup "Fisher Wizard" independent loop pressure controllers and the final mode of defense being a high pressure switch to trip the vent valves in the event either the control system loop or the Fisher Wizard pneumatic controller was incapable of sending a signal to open the vent valves. The Fisher Wizard pneumatic controller setpoints are set slightly higher than the control system loop setpoints and the high pressure switch trip point was set at the system design pressure limit.

- **Operator Interface-** The Control system loop pressure set points are adjustable. The operator is usually allowed the discretion of changing pressure control set points within

defined ranges. The use of pressure control loops allows the changing of the control constants for the pressure control valves which is beneficial when venting because the control for the initialization of a trip needs to be much quicker than during a stable venting period.

- **Refinement of Rupture Disc Specifications-** The rupture discs specified for geothermal service require a tighter tolerance because the pipeline rupture discs are located at the power plant and with the flowing pressure drop to the plant the outlying wells can have a line pressure that can be 1~1.5 Bar higher than the plant.

Operational Benefits

The benefits to this vent station design and operating philosophy are:

1. Pressure protection of the pipeline and pressure vessels is improved because of the layers of system protection.
2. Upset conditions are less severe and recovery from a turbine trip is usually faster than with solenoid operated trip valves. A typical hot restart from zero output to full load can be as short as 20 minutes. This is due to the maintenance of a constant header pressure. There is no increase in mass flow in the two-phase system, two-phase Separator liquid levels do not fluctuate as much and brine pump capacity is maintained. Our experience indicates rupture discs do not burst as often.
3. Flexible operation when venting conditions and turbine roll conditions must be maintained under close pressure control.
4. Allows controlled testing of vent valve operation (This is performed by putting the vent valve pressure control loop in manual and ramping the output to a specified % and visually confirming valve movement.).

There are several facilities that have implemented this pressure control philosophy and they have been in service for over 20 years. The most recent project that installed a pressure protection system with similar philosophy was the Miravalles III 27.5 MW plant in Costa Rica.

It must be noted that the pipeline overpressure protection system is used to protect over pressuring of the production piping and has no function in overpressure protection of the turbine.

9. INJECTION PUMP STATION & INJECTION FACILITIES DISCUSSION

The injection system consists of a cooling tower overflow injection system (cold injection system) and an LP brine injection system (Brine Injection System). The cold injection system disposes of excess cooling tower water, all rainwater falling on the power plant site, condensate drained from the plant steam piping, polishing separator drained condensate and other miscellaneous sources of geothermal steam condensate. The brine injection system handles the LP flash separator brine discharge to minimize cooling of the LP brine due to mixing which can lead to significant scaling issues in the brine injection pipeline. During upset conditions the brine dump pond will be pumped into the brine injection system upstream of the brine injection pumps. Based on the reservoir report, the Brine Injection System pumps will be required to have a minimum injection pressure at the injection well of 37.9 BarG (387m TDH). The cooling tower overflow pumps could possibly have a lower injection pressure due to higher wellbore density gradients but at this time it is premature to use a lower injection pressure.

Hotwell Condensate Injection

The cooling tower overflow injection system is a 200mm epoxy coated pipeline sized to handle a maximum injection flow of 0.126 cubic meters/sec. The cost estimate is based on 3 each 33-1/3% capacity pumps each with a 0.042 cubic meters/sec capacity at a TDH of 427 meters. It is anticipated a single pump will be capable of handling the cooling tower overflow under normal operating conditions.

The three vertical turbine pumps will be mounted on top of an overflow weir box with a control volume of approximately 18.9 cubic meters. The weir box allows level to be controlled by a control valve at the injection well. During rainfall periods when additional control volume may be required the weir box level and the cooling tower level can be allowed to equalize providing the larger control volume.

The cooling tower overflow injection well is approximately 2,150 meters from the plant. The injection well is assumed to have a magnetic flow meter, motor operated control valve, line pressure, wellhead injection pressure and wellhead temperature. No strainers are anticipated for this system.

Brine Injection System

The brine draining from the LP flash vessel drain typically has the highest dissolved solids and is required to be kept segregated from any steam derived condensate due to scaling issues of a mixed fluid stream. The Brine injection system has an estimated flowrate of 0.434 cubic meters/sec. We have assumed three-1/3 capacity multi-stage vertical turbine pumps at a TDH of

427 meters. The LP separator drains will be manifolded to the vertical turbine pumps with individual pump separator level control valves on the pump discharge piping.

The injection pipeline is a combination of approximately 650 meters long 500 mm nominal diameter pipe and a total of 2,150 meters of 400 mm nominal diameter pipeline to the OB-8 and OB-12 injection well pads. The brine injection wells will have manual butterfly control valves, venturi flow meters and isolation valves.

During upset conditions there will be emergency dump valves from the HP and LP flash separators discharging all brine into a sump. To retrieve this brine for injection back into the reservoir, two sump pumps with a total capacity of 0.032 cubic meters/sec and a TDH of 15 meters will be used to pump into the brine pump suction piping to drain the sump.

10. GEOCHEMICAL CONSIDERATIONS – SCALING & CORROSION MITIGATION

This section presents a preliminary review of geochemical issues related to RGS system design, construction and operations. This work is based on data from flow testing of wells OB-6, OB-9 and OB-4, provided by Guris and on previous geochemical evaluation of the Germençik Field performed in 1988, as part of a resource evaluation.

The primary fluid chemistry issues that can affect gathering system design criteria include scaling in well bores, pipelines, and the injection system, and the impacts of brine carryover on chemical steam quality. The primary design criteria affected are:

- Wellhead accommodation for downhole scale mitigation.
- High pressure and low pressure separation strategy (remote or single).
- Separation pressures.
- Design specifications for steam quality downstream of separators.
- Steam polishing units.

Downhole Scale Mitigation Facilities

The wellbore downhole facilities for injection of scale inhibitor consists of a capillary tubing string with a dispersion head hung from the wellhead to below the flash point in the wellbore. The capillary tubing is protected at the flow tee by a stinger that protrudes past the flow direction change. In high flow capacity (i.e. high velocity wells) a 2-7/8" (73mm) tubing string is hung from the wellhead to below the flash point and the capillary tubing is run into the wellbore inside the 2-7/8" (73mm) tubing string. The surface equipment consists of the capillary tubing spool, a peristaltic metering pump that dispenses the scale inhibitor in very precise small quantities and a

3,000 to 5,000 gallon cross linked polyethylene storage tank. Typically, all surface capillary tubing requires heat tracing in freezing climates with the pump and tank in a heated enclosure. A paper presented at the 2001 GRC meeting described this type of system in detail and is provided in Appendix L.

11. RGS ELECTRICAL DISTRIBUTION AND INSTRUMENTATION & CONTROLS

Electrical Distribution

The resource gathering system will be required to have electrical power at the well pad to operate control valves and for supplying power for control system components at the well pads. The electrical distribution system for the well field is typically fed from an auxiliary transformer in the plant switchyard on a pole line to all production and injection pads. The pole line stops at the edge of the pad where a manual disconnect switch and a pole-mounted step down transformer are installed. An air-conditioned building houses the electrical distribution panel and the control system remote terminal unit (RTU). The electrical wiring and the control system process instrumentation from the distribution panel to the equipment is installed underground or strapped along the pipeline to avoid interference with a drilling rig occupying the well pad.

At each pad we have assumed the electrical service are as follows:

- Control System RTU including communications equipment (1,000 watts)
- Control Building ½ ton Air Conditioning
- One-Three (3) horsepower air compressor with instrument air drier.
- One- One (1) horsepower control valve actuator per well with a total of 4 wells on a pad.
- One- fifty (50) horsepower brine transfer pump
- Miscellaneous Lighting (1,000 watts)

This list includes an air compressor for a well pad instrument air system, which may not be required if the control valve actuators are electric. We have specified a large quantity of motor operated actuators for control valves and have some issues on the high maintenance requirements. Air actuators have significantly less capital and maintenance costs and may prove to have benefits for this project.

To provide for any expansion we have typically installed a 200 kVA transformer at each well pad and the electrical distribution system is designed for this size of transformer.

Instrumentation and Controls

The resource gathering system for geothermal projects typically has a control system to adjust well flows and be able to adjust well flows to conserve resource and implement a reservoir management plan. The major function of the resource gathering system control is to provide for an accurate record of production to be able to evaluate individual well and reservoir performance for prediction and evaluation of infill well drilling or well decline due to wellbore problems. This requirement of historizing data is not typically a strong point of control systems and requires additional interface into a data base management system.

The communications link between the well pads and the power plant is a fiber optic system that would be installed on the power poles below the electrical power lines. The transceivers will be installed in the RTU at the pad building

We have assumed that a programmable logic controller (PLC) based system is installed that is compatible with the power plant control system. The operator station for the resource gathering system is typically integrated into the power plant control system with at least one operator station dedicated to the well field controls.

The function of the instrumentation and control system is as follows:

- Instantaneous measurement of process variables on a minimum 3 second update rate.
- Current output and position feedback status of all control valves.
- Alarm for all process variables with capability of direct action on a high-high alarm such as a separator liquid level high-high signal activates a dump valve.
- Allow manual and automated local loop control of well flow, separator level,
- Historization of process variables and the capability of providing hourly, daily and monthly cumulative and average values for a selected number of process variables. Monthly data to include wellhead pressure, temperature and flow for a minimum of thirty years on a daily average basis.
- Graphing capability for the above process variables and the defined time frame.

Costs Excluded From the Estimate

The costs excluded from the estimate for the electrical distribution and instrumentation and controls cost are as follows:

- Step up transformer at the switchyard and all power metering and protection devices and oil containment required for installation and control of the transformer.
- Control System Operator Station hardware and software development for displays.

12. RGS PROJECT CONSTRUCTION SCHEDULE

The RGS project construction schedule is provided in Appendix J.

13. RGS COST ESTIMATE

COST ESTIMATE INFORMATION HAS BEEN DELETED FROM THIS COPY.

- The civil works and road construction costs were allocated a factor of 120% for 2005 to account fuel cost rise and inflation.

- Pressure Vessels (72" HPS and 144" LPS & 54" HP Polishing and 78" LP Polishing Separators) cost is based July 2005 budgetary quote from Mark Steel Fabricators, Utah, USA.

- Hot Brine Injection Pumps cost is based on quotes received in 2004 from Goulds Pumps.

- Transmission Line costs from 2004 estimate for a 21KV wood pole line

- Electrical and Instrumentation Costs based on a standard configuration for a production and injection well developed in 2004.

- The Engineering, Construction Management and Outside Services cost for Gathering system, Vent Station, and a Separation and Pumping facility is based on a detailed June 2005 man-hour and task spreadsheet.

14. ANTICIPATED RGS OPERATING AND MAINTENANCE BUDGET

The resource gathering system operating and maintenance costs provided in Appendix M are based on the operational guidelines currently in practice at single facilities in the United States and might be somewhat different in Turkey due to differences in operational philosophy. The basic assumptions for developing these operation and maintenance costs are:

- All control functions required to operate the wellfield during normal and upset conditions will be provided in the supervisory control system located in the power plant control room.
- Operator rounds can be offset so either the plant operator or the field operator is in the control room at all times.
- The plant and field operator have been cross-trained sufficiently to be able to control upset conditions without risking the integrity of the plant and field facilities.
- One field operator on duty 24-hours a day in the control room.
- No start-up operational costs are included in this estimate of O&M costs. For discussion purposes 4 months of operation and maintenance costs ($382,250) should be used to estimate operational start up costs.
- No equipment or tool purchases are included in these costs. Typical equipment would consist of 2 mechanics utility bed ¾ ton or 1-ton trucks, 1 supervisor vehicle, a boom truck with a 20 foot flatbed, a backhoe and propane powered 4,500 kg capacity forklift or

Gradall telescoping boom. It is assumed all maintenance personnel are trained in the operation of the boom truck and other equipment. The total capital costs for this equipment is typically on the order $300,000.

- There is a periodic need for additional equipment such as graders, Link Belt cranes and excavators. This larger equipment is assumed to be rented or contracted out through a local equipment contractor and not purchased.
- A reservoir monitoring program is included in this O&M budget. The majority of the work is chemical sampling with wireline services being required annually.

APPENDICES

Appendix A – Development Plan

Appendix B – P&IDs

Appendix C – Process Flow Diagram

Appendix D – Production Well Piping

Appendix E – Injection Well Piping

Appendix F – V1 HPS Flash Separator-10ft (120")

Appendix G – V2 LPS Flash Separator- 12 ft (144") 2 required

Appendix H – V3A & V3B--G54 HPS Polishing Separator

Appendix I – V4A & V4B--G78 HPS Polishing Separator

Appendix J – Preliminary Construction Schedule

Appendix K – Preliminary Anticipated Project Cost Summary

Appendix L – Scale Mitigation Facilities Paper

Appendix M – Field Operating and Maintenance Costs

Appendix A
Development Plan

APPENDIX A

Development Plan

Appendix B
P&IDs

Gurmat Geothermal Project Short Term Flow Testing
Geochemical Field Measurements and Sample Records for Each Short Term Flow Test

	Test Conditions						Sampling Separator	Samp T (°C)	Field Measurements		Brine Samples					Steam Samples			Comments
Laboratory												Thermochem			IGNS	Thermochem		IGNS	
Analyte											anions	cations	SiO2	Hg	D, O18	NCG	Na,B,As	D, O18	
Well	Date	Time	LP (bars g)	LT (°C)	P (bars g)	T (°C)	Condenser	pH	conductivity	G/S (ppm wt)	1LUF	500ml FL+HNO3	250mlw/dilute nitric	125ml glass w/$K_2CR_2O_7$	60 ml vial	Evacuated Bottle w/NaOH	250mlUF	60 ml vial	
OB-3	7-Mar-05	17:20	4.0	145	4.0	145	16.6	7.44	6430	129014	OB3B1A	OB3B1B	OB3B1C	OB3B1D	OB3B1E	OB3S1C	OB3S1A	OB3S1B	NY/AK- good sampling
	8-Mar-05	8:20	2.5	125	2.5	125	15.6	8.45	7430	109053	OB3B2A	OB3B2B	OB3B2C	OB3B2D	OB3B2E	OB3S2C	OB3S2A	OB3S2B	NY/AK- good sampling
	8-Mar-05	14:10	3.5	140	3.0	140	12.2	8.54	7430	125229	OB3B3A	OB3B3B	OB3B3C	OB3B3D	OB3B3E	OB3S3C	OB3S3A	OB3S3B	NY/AK- good sampling
	9-Mar-05	8:50	3.0	135	2.5	135	11.1	8.50	7660	85912	OB3B4A	OB3B4B	OB3B4C	OB3B4D	OB3B4E	OB3S4C	OB3S4A	OB3S4B	NY/AK- good sampling
OB-5	11-Mar-05	9:15	5.5	159	5.5	159	10	7.74	6690	154287	OB5B1A	OB5B1B	OB5B1C	OB5B1D	OB5B1E	OB5S1C	OB5S1A	OB5S1B	NY/AK/SO
	11-Mar-05	13:10	5.5	155	5.5	155	8.9	6.83	6500	120194	OB5B2A	OB5B2B	OB5B2C	OB5B2D	OB5B2E	OB5S2C	OB5S2A	OB5S2B	NY/AK/SO
	11-Mar-05	16:35	5.5	155	5.5	155	16.66	7.83	6190	152798	OB5B3A	OB5B3B	OB5B3C	OB5B3D	OB5B3E	OB5S3C	OB5S3A	OB5S3B	NY/AK/SO
	12-Mar-05	8:55	5.0	155	5.0	155	4.44	8.61	6950	137042	OB5B4A	OB5B4B	OB5B4C	OB5B4D	OB5B4E	OB5S4C	OB5S4A	OB5S4B	NY/AK/SO
OB-6	26 Feb 05	15:40	5.1	148	5.05	150	15.6	7.5	6720	163000	OB6B1A	OB6B1B	OB6B1C	OB6B1D	OB6B1E	OB6S1C	OB6S1A	OB6S1B	wet weather sampling
	28 Feb 05	11:20	10.5	180	11	180	15.6	7.14	6720	193000	OB6B2A	OB6B2B	OB6B2C	OB6B2D	OB6B2E	OB6S2C	OB6S2A	OB6S2B	wet weather sampling
	28 Feb 05	16:50	9.5	175	9.5	175	20	7.02	6610	181000	OB6B3A	OB6B3B	OB6B3C	OB6B3D	OB6B3E	OB6S3C	OB6S3A	OB6S3B	wet weather sampling
	1-Mar-05	7:40	4.5	148	4.5	148	25.6	7.99	7520	154000	OB6B4A	OB6B4B	OB6B4C	OB6B4D	OB6B4E	OB6S4C	OB6S4A	OB6S4B	wet weather sampling
OB-7	18-Mar-05	18:35	6.0	160	6.0	160	19.89	7.15	5850	177347	OB7B1A	OB7B1B	OB7B1C	OB7B1D	OB7B1E	OB7S1C	OB7S1A	OB7S1B	NY/AK/SO
	19-Mar-05	9:30	5.9	160	5.9	160	15.55	6.48	6400	141848	OB7B2A	OB7B2B	OB7B2C	OB7B2D	OB7B2E	OB7S2C	OB7S2A	OB7S2B	NY/AK/SO
	19-Mar-05	13:50	5.5	150	4.2	150	20.00	8.19	7630	133773	OB7B3A	OB7B3B	OB7B3C	OB7B3D	OB7B3E	OB7S3C	OB7S3A	OB7S3B	NY/AK/SO
	19-Mar-05	18:00	4.2	150	4.2	150	23.88	8.03	8210	157097	OB7B4A	OB7B4B	OB7B4C	OB7B4D	OB7B4E	OB7S4C	OB7S4A	OB7S4B	NY/AK/SO
OB-8	14-Mar-05	17:55	7.2	165	7.2	165	15.55	6.72	6670	177774	OB8B1A	OB8B1B	OB8B1C	OB8B1D	OB8B1E	OB8S1C	OB8S1A	OB8S1B	SO/AK
	15-Mar-05	8:45	7.2	165	7.2	165	13.33	7.92	7000	192510	OB8B2A	OB8B2B	OB8B2C	OB8B2D	OB8B2E	OB8S2C	OB8S2A	OB8S2B	SO/AK
	15-Mar-05	12:30	6.9	165	6.9	165	25.55	7.67	7000	171122	OB8B3A	OB8B3B	OB8B3C	OB8B3D	OB8B3E	OB8S3C	OB8S3A	OB8S3B	SO/AK
	15-Mar-05	17:05	5.0	155	5.0	152	22.22	7.24	6980	144020	OB8B4A	OB8B4B	OB8B4C	OB8B4D	OB8B4E	OB8S4C	OB8S4A	OB8S4B	SO/AK
OB-9	4-Mar-05	17:45	8.5	172	8.7	172	22.2	7.12	6650	150000	OB9B1A	OB9B1B	OB9B1C	OB9B1D	OB9B1E	OB9S1C	OB9S1A	OB9S1B	NY/AK- good sampling
	4-Mar-05	9:00	4.4	148	4.5	148	22.2	7.4	6800	193000	OB6B2A	OB9B2B	OB9B2C	OB9B2D	OB9B2E	OB9S2C	OB9S2A	OB9S2B	NY/AK- good sampling
	4-Mar-05	15:20	6.1	160	6.2	160	21.1	6.98	6580	204000	OB6B3A	OB9B3B	OB9B3C	OB9B3D	OB9B3E	OB9S3C	OB9S3A	OB9S3B	NY/AK- good sampling
	5-Mar-05	9:50	4.4	150	4.5	150	21.1	7.4	6800	164000	OB6B4A	OB9B4B	OB9B4C	OB9B4D	OB9B4E	OB9S4C	OB9S4A	OB9S4B	NY/AK- good sampling

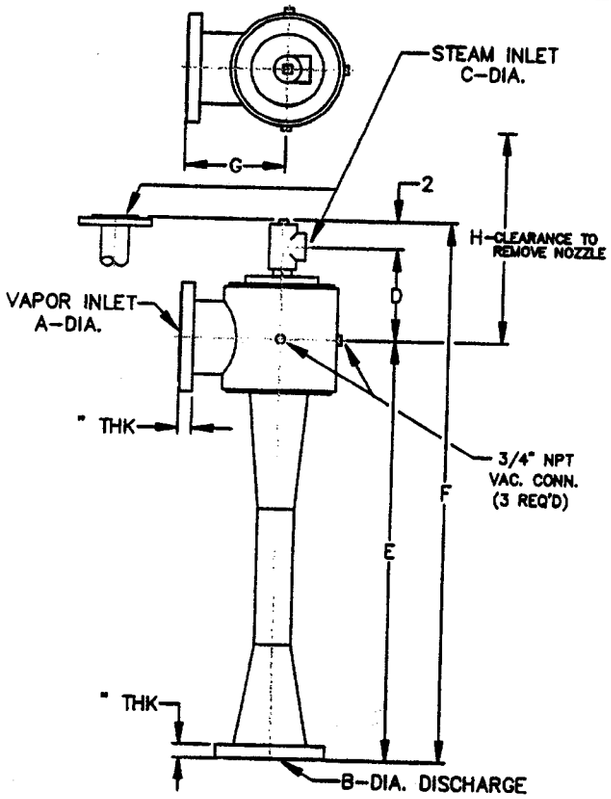
Gurmat Geothermal Project Short Term Flow Testing
Geochemical Sample Collection and Sample Submittal Record

	Test Conditions				Brine Samples										Steam Samples					
					Thermochem Lab										Thermochem Lab					
					Analytes										Analytes					
					anions*		cations**		SiO2		Hg		D, O18		NCG***		Na,B,As		D, O18	
Well	Date	Time	Line P (bar_g)	Line T (°C)	1LUF	Date submitted or Not Submitted (NS)	500ml FL+HNO3	Date submitted or Not Submitted (NS)	250mlw/dilute nitric	Date submitted or Not Submitted (NS)	250ml glass UFw/$K_2CR_2O_7$	Date submitted or Not Submitted (NS)	60 ml vial	Date submitted or Not Submitted (NS)	Evacuated Bottle w/NaOH	Date submitted or Not Submitted (NS)	250mlUF	Date submitted or Not Submitted (NS)	60 ml vial	Date submitted or Not Submitted (NS)
OB-3	7-Mar-05	17:20	4.0	145	OB3B1A	NS	OB3B1B	NS	OB3B1C	NS	OB3B1D	NS	OB3B1E	NS	OB3S1C	NS	OB3S1A	NS	OB3S1B	NS
	8-Mar-05	8:20	2.5	125	OB3B2A	NS	OB3B2B	NS	OB3B2C	NS	OB3B2D	NS	OB3B2E	NS	OB3S2C	NS	OB3S2A	NS	OB3S2B	NS
	8-Mar-05	14:10	3.5	140	OB3B3A	31-Mar-05	OB3B3B	31-Mar-05	OB3B3C	31-Mar-05	**OB3B3D**	31-Mar-05	OB3B3E	31-Mar-05	**OB3S3C**	31-Mar-05	OB3S3A	31-Mar-05	OB3S3B	31-Mar-05
	9-Mar-05	8:50	3.0	135	OB3B4A	31-Mar-05	OB3B4B	31-Mar-05	OB3B4C	31-Mar-05	OB3B4D	NS	OB3B4E	31-Mar-05	**OB3S4C**	31-Mar-05	OB3S4A	31-Mar-05	OB3S4B	31-Mar-05
OB-5	11-Mar-05	9:15	5.5	159	OB5B1A	NS	OB5B1B	NS	OB5B1C	NS	OB5B1D	NS	OB5B1E	NS	OB5S1C	NS	OB5S1A	NS	OB5S1B	NS
	11-Mar-05	13:10	5.5	155	OB5B2A	3/31/2005	OB5B2B	3/31/2005	OB5B2C	3/31/2005	OB5B2D	NS	OB5B2E	3/31/2005	**OB5S2C**	3/31/2005	OB5S2A	3/31/2005	OB5S2B	3/31/2005
	11-Mar-05	16:35	5.5	155	OB5B3A	3/31/2005	OB5B3B	3/31/2005	OB5B3C	3/31/2005	**OB5B3D**	3/31/2005	OB5B3E	3/31/2005	**OB5S3C**	3/31/2005	OB5S3A	3/31/2005	OB5S3B	3/31/2005
	12-Mar-05	8:55	5.0	155	OB5B4A	3/31/2005	OB5B4B	3/31/2005	OB5B4C	3/31/2005	OB5B4D	NS	OB5B4E	3/31/2005	**OB5S4C**	3/31/2005	OB5S4A	3/31/2005	OB5S4B	3/31/2005
OB-6	26 Feb 05	15:40	5.1	148	OB6B1A	NS	OB6B1B	NS	OB6B1C	NS	OB6B1D	NS	OB6B1E	NS	OB6S1C	NS	OB6S1A	NS	OB6S1B	NS
	28 Feb 05	11:20	10.5	180	OB6B2A	3/31/2005	OB6B2B	3/31/2005	OB6B2C	3/31/2005	OB6B2D	NS	OB6B2E	3/31/2005	**OB6S2C**	3/31/2005	OB6S2A	3/31/2005	OB6S2B	3/31/2005
	28 Feb 05	16:50	9.5	175	OB6B3A	3/31/2005	OB6B3B	3/31/2005	OB6B3C	3/31/2005	**OB6B3D**	3/31/2005	OB6B3E	3/31/2005	**OB6S3C**	3/31/2005	OB6S3A	3/31/2005	OB6S3B	3/31/2005
	1-Mar-05	7:40	4.5	148	OB6B4A	3/31/2005	OB6B4B	3/31/2005	OB6B4C	3/31/2005	OB6B4D	NS	OB6B4E	3/31/2005	**OB6S4C**	3/31/2005	OB6S4A	3/31/2005	OB6S4B	3/31/2005
OB-7	18-Mar-05	18:35	6.0	160	OB7B1A	NS	OB7B1B	NS	OB7B1C	NS	OB7B1D	NS	OB7B1E	NS	OB7S1C	NS	OB7S1A	NS	OB7S1B	NS
	19-Mar-05	9:30	5.9	160	OB7B2A	3/31/2005	OB7B2B	3/31/2005	OB7B2C	3/31/2005	OB7B2D	NS	OB7B2E	3/31/2005	**OB7S2C**	3/31/2005	OB7S2A	3/31/2005	OB7S2B	3/31/2005
	19-Mar-05	13:50	5.5	150	OB7B3A	3/31/2005	OB7B3B	3/31/2005	OB7B3C	3/31/2005	**OB7B3D**	3/31/2005	OB7B3E	3/31/2005	**OB7S3C**	3/31/2005	OB7S3A	3/31/2005	OB7S3B	3/31/2005
	19-Mar-05	18:00	4.2	150	OB7B4A	3/31/2005	OB7B4B	3/31/2005	OB7B4C	3/31/2005	OB7B4D	NS	OB7B4E	3/31/2005	**OB7S4C**	3/31/2005	OB7S4A	3/31/2005	OB7S4B	3/31/2005
OB-8	14-Mar-05	17:55	7.2	165	OB8B1A	NS	OB8B1B	NS	OB8B1C	NS	OB8B1D	NS	OB8B1E	NS	OB8S1C	NS	OB8S1A	NS	OB8S1B	NS
	15-Mar-05	8:45	7.2	165	OB8B2A	3/31/2005	OB8B2B	3/31/2005	OB8B2C	3/31/2005	OB8B2D	NS	OB8B2E	3/31/2005	OB8S2C	3/31/2005	OB8S2A	3/31/2005	OB8S2B	3/31/2005
	15-Mar-05	12:30	6.9	165	OB8B3A	3/31/2005	OB8B3B	3/31/2005	OB8B3C	3/31/2005	OB8B3D	3/31/2005	OB8B3E	3/31/2005	OB8S3C	3/31/2005	OB8S3A	3/31/2005	OB8S3B	3/31/2005
	15-Mar-05	17:05	5	155	OB8B4A	3/31/2005	OB8B4B	3/31/2005	OB8B4C	3/31/2005	OB8B4D	NS	OB8B4E	3/31/2005	OB8S4C	3/31/2005	OB8S4A	3/31/2005	OB8S4B	3/31/2005
OB-9	4-Mar-05	17:45	8.5	172	OB9B1A	3/31/2005	OB9B1B	3/31/2005	OB9B1C	3/31/2005	OB9B1D	NS	OB9B1E	3/31/2005	**OB9S1C**	3/31/2005	OB9S1A	3/31/2005	OB9S1B	3/31/2005
	4-Mar-05	9:00	4.4	148	OB6B2A	NS	OB9B2B	NS	OB9B2C	NS	OB9B2D	NS	OB9B2E	NS	OB9S2C	NS	OB9S2A	NS	OB9S2B	NS
	4-Mar-05	15:20	6.1	160	OB6B3A	3/31/2005	OB9B3B	3/31/2005	OB9B3C	3/31/2005	**OB9B3D**	3/31/2005	OB9B3E	3/31/2005	**OB9S3C**	3/31/2005	OB9S3A	3/31/2005	OB9S3B	3/31/2005
	5-Mar-05	9:50	4.4	150	OB6B4A	3/31/2005	OB9B4B	3/31/2005	OB9B4C	3/31/2005	OB9B4D	NS	OB9B4E	3/31/2005	**OB9S4C**	3/31/2005	OB9S4A	3/31/2005	OB9S4B	3/31/2005

* Chloride (Cl), Sulfate (SO4), bicarbonate (HCO3), carbonate (CO3), flouride (F), ammonium (NH4), pH, TDS
**sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), lithium (Li), boron (B), arsenic (As), iron (Fe), manganese (Mn)
***NCG=noncondensible gases, argon (Ar), oxygen (O2), nitrogen (N2), methane (CH4), hydrogen (H2), carbon dioxide (CO2), ammonia (NH3), hydrogen sulfide (H2S), total NCG G/S

Well	Date	Time	Line P bar g	Line T °C	H(res,tot) KJ/kg	Y	pH	cond-meas	G/S-meas	cond-res	Gas-res % by weight	gas-res well average	cond-res well average
	7-Mar-05	17:20	4.0	145		0.100	7.4	6430	129010	5787	1.29		
	8-Mar-05	8:20	2.5	125		0.119	8.5	7430	109050	6546	1.30		
	8-Mar-05	14:10	3.5	140		0.108	8.5	7430	125230	6628	1.35		
OB-3	9-Mar-05	8:50	3.0	135	840.7	0.112	8.5	7660	85910	6802	0.96	1.23	6441
	11-Mar-05	9:15	5.5	159		0.106	7.7	6690	154290	5979	1.64		
	11-Mar-05	13:10	5.5	155		0.112	6.8	6500	120200	5773	1.34		
	11-Mar-05	16:35	5.5	155		0.110	7.8	6190	152800	5507	1.69		
OB-5	12-Mar-05	8:55	5.0	155	911	0.117	8.6	6950	137040	6140	1.60	1.57	5850
	26 Feb 05	15:40	5.1	148		0.114	7.5	6720	163000	5957	1.85		
	28 Feb 05	11:20	10.5	180		0.057	7.1	6720	193000	6339	1.09		
	28 Feb 05	16:50	9.5	175		0.072	7.0	6610	181000	6136	1.30		
OB-6	1-Mar-05	7:40	4.5	148	907.8	0.126	8.0	7520	154000	6574	1.94	1.54	6252
	18-Mar-05	18:35	6.0	160		0.107	7.2	5850	177350	5224	1.90		
	19-Mar-05	9:30	5.9	160		0.109	6.5	6400	141850	5701	1.55		
	19-Mar-05	13:50	5.5	150		0.113	8.2	7630	133770	6770	1.51		
OB-7	19-Mar-05	18:00	4.2	150	916	0.129	8.0	8210	157100	7151	2.03	1.75	6211
	14-Mar-05	17:55	7.2	165		0.087	6.7	6670	177770	6089	1.55		
	15-Mar-05	8:45	7.2	165		0.089	7.9	7000	192510	6379	1.71		
	15-Mar-05	12:30	6.9	165		0.093	7.7	7000	171120	6350	1.59		
OB-8	15-Mar-05	17:05	5.0	155	904.6	0.111	7.2	6980	144020	6207	1.59	1.61	6256
	4-Mar-05	17:45	8.5	172		0.060	7.1	6650	155000	6249	0.94		
	4-Mar-05	9:00	4.4	148		0.104	7.4	6800	193000	6092	2.01		
	4-Mar-05	15:20	6.1	160		0.085	7.0	6580	204000	6021	1.73		
OB-9	5-Mar-05	9:50	4.4	150	872.3	0.105	7.4	6800	164000	6087	1.72	1.60	6112

MEAN of ALL SAMPLES	892					6187		1.55	6187
Standard Deviation	3%					7%		20%	3%
MEAN of OB-6, OB-8 and OB-9	895					6290		1.58	6207
Standard Deviation	2%					3%		21%	1%



SIZE	A	B	C NPT	STEAM INLET C	FLG RATING	D △	E	F △	G △	H	APPROX WEIGHT IN LBS
24x18	24	18				24	185.25	211.25	22.5	60	1850
24x20	24	20				24	205.25	231.25	22.5	60	2050
24x24	24	24				24	236.25	262.25	22.5	60	2400
30x20	30	20				29	209.00	240.00	26	75	2500
30x24	30	24				29	240.00	271.00	26	75	2900
30x30	30	30				29	289.00	320.00	26	75	3600
36x24	36	24				32	241.75	275.75	30	82	3500
36x30	36	30				32	290.75	324.75	30	82	4200
36x36	36	36				32	354.75	388.75	30	82	5300
42x30	42	30				34.5	293.25	329.75	33	90	4900
42x36	42	36				34.5	357.25	393.75	33	90	5900
42x42	42	42				34.5	414.25	450.75	33	90	7100
48x36	48	36				37	359.75	398.75	36	96	6800
48x42	48	42				37	416.75	455.75	36	96	7900
48x48	48	48				37	472.75	511.75	36	96	9200

NOTES:
1. FLANGES A & B CONFORM TO 150# ANSI DRILLING PATTERN – (C – CONFORMS TO RATING LISTED).
2. ALL DIMENSIONS IN INCHES.
3. FLANGE BOLT HOLES STRADDLE CENTERLINES.
4. ±1/4" TOLERANCE ON ALL DIMENSIONS.
5. SUPPORT CONNECTING PIPING SO THAT NO STRAIN IS IMPOSED ON EJECTOR.

☐ For Approval: Tentative shipping promise is established upon return of approved print:_____

☐ For Final Approval: This print covers equipment on which material has been ordered, however, no mfg. has started. Delivery is established upon return of final approved print:_____

☐ Certified for Construction: This print covers equipment on which mfg. has started. Any change is subject to price and shipping promise adjustment:_____

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REV	DESCRIPTION	DATE	APVD
4	CO. NAME CHANGE	3/03	
3	CO. NAME CHANGE	1/97	
2	CO. NAME CHANGE	1/87	
1	DIMENSION CHANGE	1/81	
0	ORIGINAL	6/74	

REVISIONS

nash_elmo™industries
ELIZABETH, PENNSYLVANIA 15037

TITLE: 24 x 18 THRU 48 x 48 DIAMETER FLANGED EJECTOR

PURCHASER: P.O. #
PROJ #
USER: S.O. #

SCALE: NONE | DRAWN BY: | APPVD BY: | DATE:

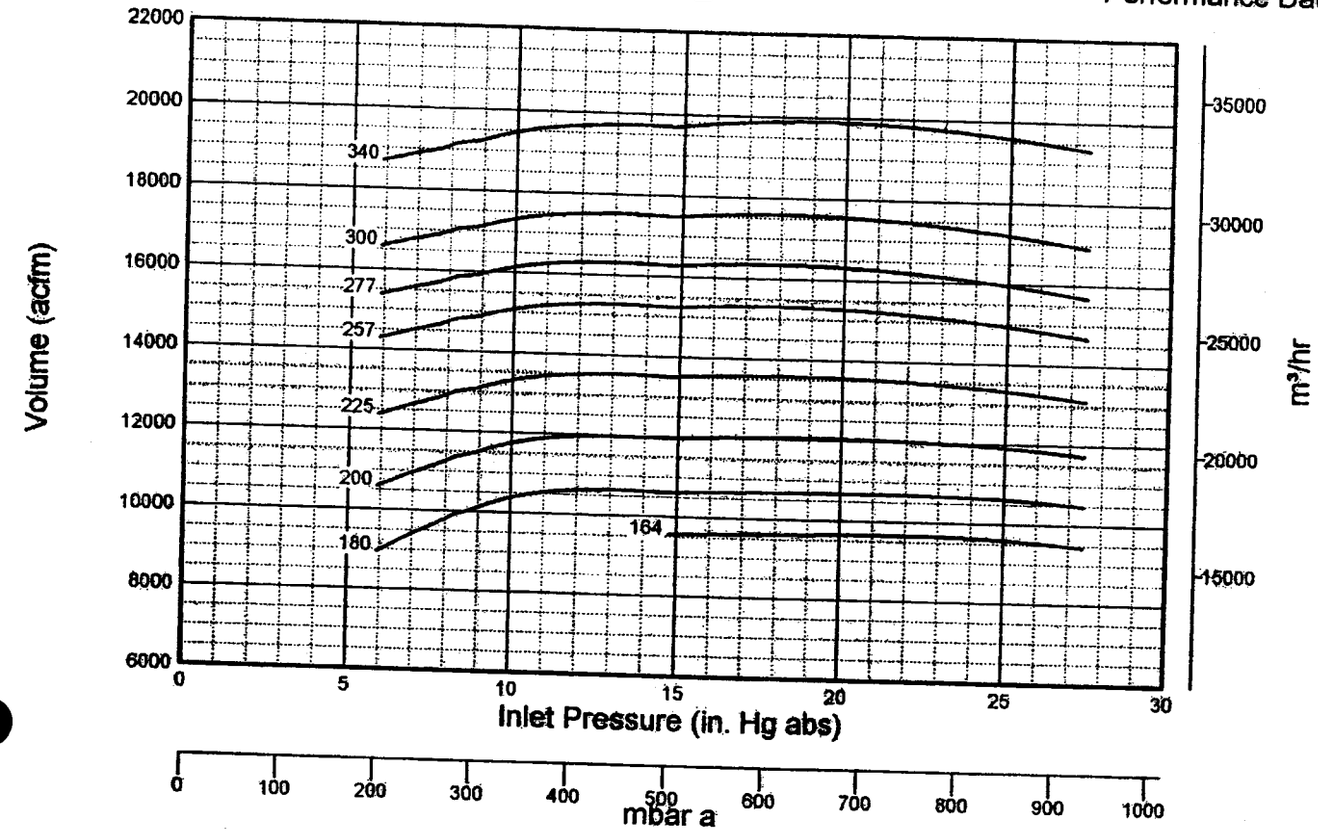
DRAWING NUMBER: A-100013 | REVISION: 4 | DATE:

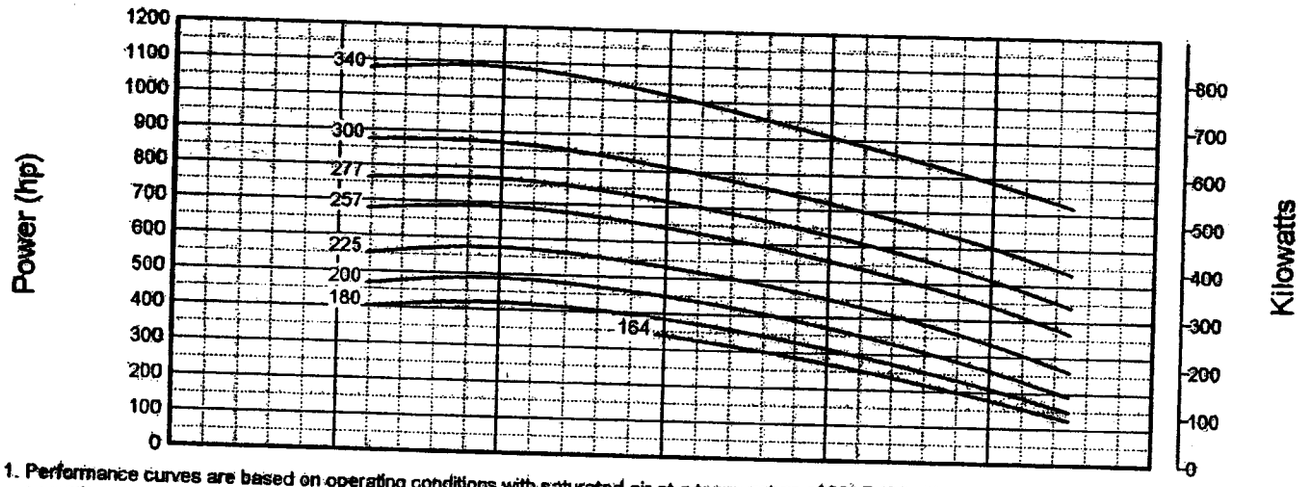
nash_elmo

Premier 2BE3 72 Vacuum Pump

L_series

Performance Data





1. Performance curves are based on operating conditions with saturated air at a temperature of 68° F (20° C), operating water at a temperature of 60° F (15° C) and a discharge pressure of 29.92 in. HgA (1013 mbar).
2. Tolerance to HEI / Pneurop standards.
3. Operating conditions other than those stated above may result in different capacities or power. Please contact the home office for details.
4. Reference Curve No. EN1406-001 rev A.

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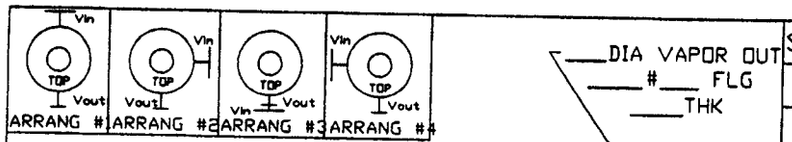
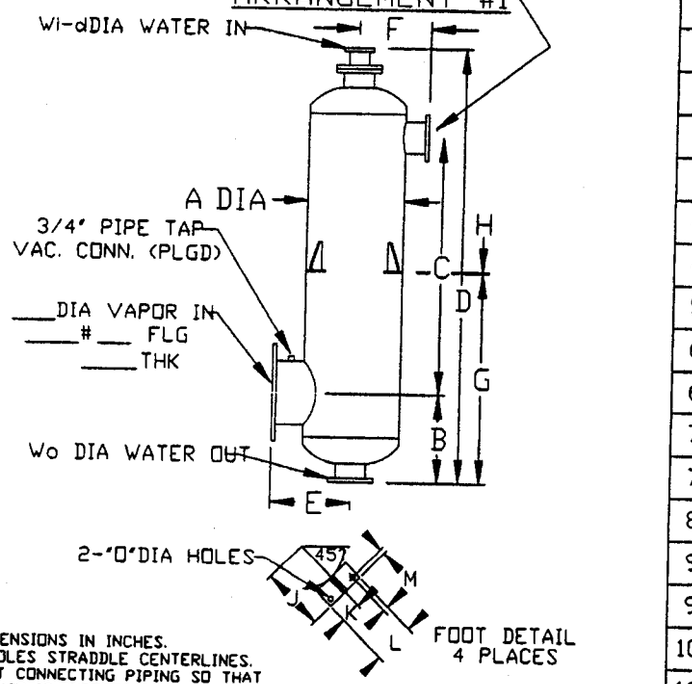


ARRANGEMENT #1



NOTES:
1. ALL DIMENSIONS IN INCHES.
2. BOLT HOLES STRADDLE CENTERLINES.
3. SUPPORT CONNECTING PIPING SO THAT NO STRAIN IS IMPOSED ON CONDENSER.
4. FLGS. 18" & SMALLER ARE 150#RF UNLESS OTHERWISE MARKED. FLGS. 20" & LARGER ARE EQUIVALENT OF 125#FF, EXCEPT FOR THICKNESS.
5. ±1/4" TOLERANCE ON ALL DIMENSIONS.
6. ARRANGEMENT#1 UNLESS OTHERWISE SPECIFIED.

SIZE	CAP. GPM	Wi	Wo	A	B	C	D	E	F	G	H	J	K	L	M	O	APPROX WT LBS EMPTY	FULL
18	183	3	6	18	18	57	94	15	13	35	3/4	12	3	6	1	7/8	800	1500
20	240	4	6	20	19	61	100	16	14	37	3/4	13	3	6	1	7/8	900	1850
24	385	4	8	24	21	71	113	19	16	43	3/4	15	3	6	1	7/8	950	2500
28	550	6	10	28	23	72	118	21	18	45	3/4	17	3	6	1	7/8	1350	3650
30	660	6	10	30	24	75	122	22	19	46	3/4	18	3	6	1	7/8	1475	4200
32	770	6	10	32	26	80	130	24	21	50	3/4	19	3	6	1	7/8	1600	4900
36	900	8	12	36	27	88	140	25	22	54	3/4	23	5	10	1 1/4	1 1/8	1950	6500
42	1250	8	14	42	31	98	156	28	25	60	3/4	26	5	10	1 1/4	1 1/8	2800	9800
48	1700	10	16	48	34	106	169	31	28	65	3/4	29	5	10	1 1/4	1 1/8	3400	13450
54	2200	10	18	54	37	116	184	34	33	71	3/4	32	5	10	1 1/4	1 1/8	4650	18550
60	2750	12	20	60	40	126	199	37	36	77	3/4	35	5	10	1 1/4	1 1/8	5550	24250
66	3300	14	24	66	43	132	210	40	39	82	3/4	38	5	10	1 1/4	1 1/8	6450	30450
72	3960	14	24	72	46	143	226	43	42	88	3/4	41	5	10	1 1/4	1 1/8	7450	38350
78	4620	16	30	78	49	155	243	47	45	95	1	45	6	12	1 1/2	1 3/8	8650	47900
84	5390	16	30	84	52	160	253	50	48	99	1	48	6	12	1 1/2	1 3/8	9600	57150
90	6160	18	30	90	56	170	269	53	51	105	1	51	6	12	1 1/2	1 3/8	11050	69300
96	7040	20	30	96	59	184	288	56	54	113	1	54	6	12	1 1/2	1 3/8	12600	84800
102	8030	20	36	102	62	189	298	59	57	117	1 1/4	57	8	16	1 3/4	1 5/8	17250	100600
108	8910	24	36	108	65	199	312	62	60	122	1 1/4	60	8	16	1 3/4	1 5/8	19250	117350
114	10000	24	36	114	68	207	325	65	63	128	1 1/4	63	8	16	1 3/4	1 5/8	21050	135100
120	11000	24	42	120	71	218	343	68	66	135	1 1/4	66	8	16	1 3/4	1 5/8	23250	157000

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REV	DESCRIPTION	DATE	APVD
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3	CO. NAME CHANGE	2/97	
2	ENGINEERING CHG	12/89	
1	CO. NAME CHANGE	1/87	
0	ORIGINAL	6/74	

REVISIONS

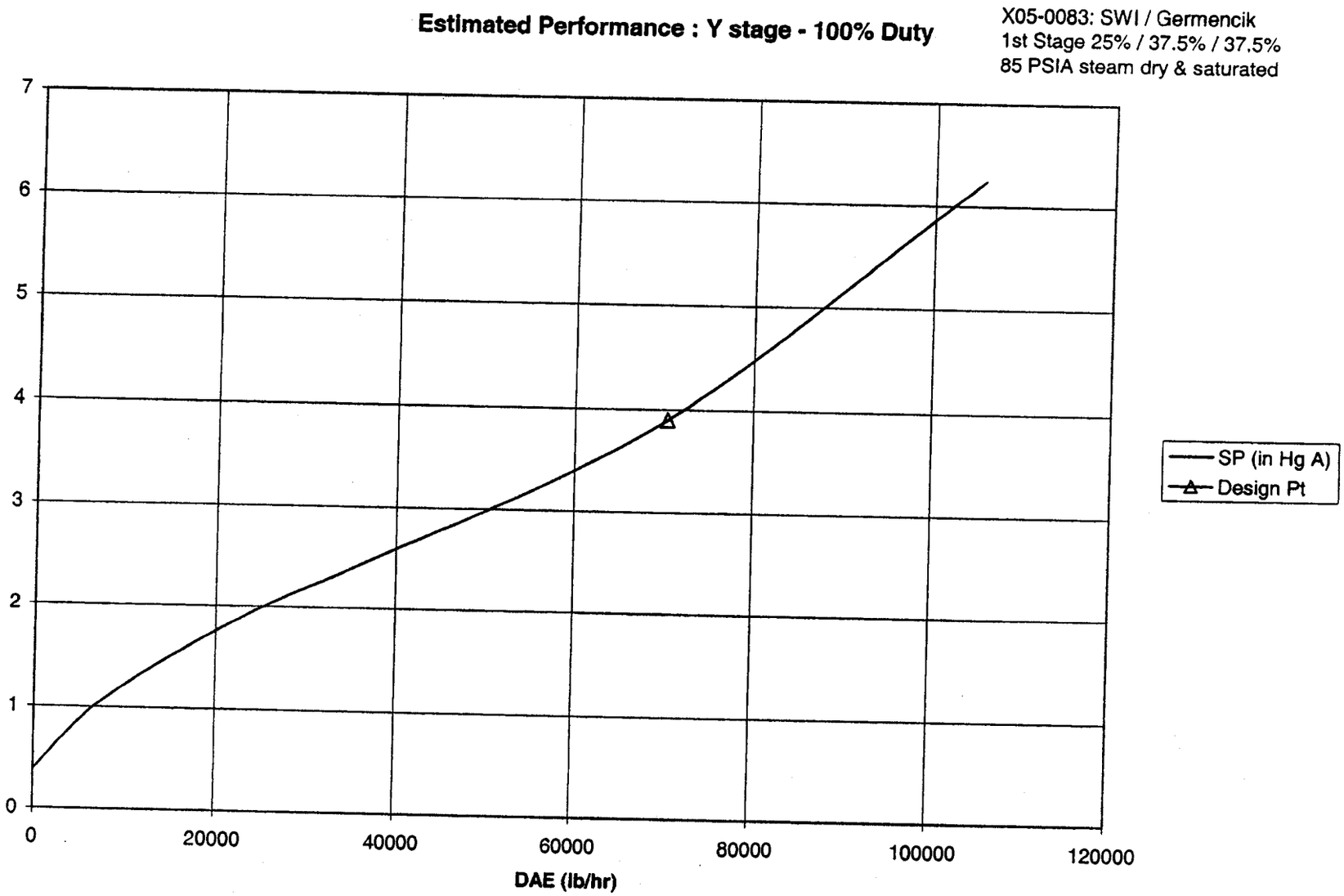
nash_elmo™industries
ELIZABETH, PENNSYLVANIA 15037

TITLE: 18" THRU 120" DIAMETER DIRECT CONTACT SPRAY NOZZLE - BAROMETRIC CONDENSER

PURCHASER: P.O. #
PROJ #
USER: S.O. #

SCALE:	DRAWN BY:	APPVD BY	DATE:
NONE			

DRAWING NUMBER:	REVISION:	DATE:
A-100037	4	


Estimated Performance : Y stage - 100% Duty
X05-0083: SWI / Germencik
1st Stage 25% / 37.5% / 37.5%
85 PSIA steam dry & saturated
7
6
5
4
3
2
1
0
0
20000
40000
60000
80000
100000
120000
DAE (lb/hr)
SP (in Hg A)
Design Pt

Appendix G
V2 LPS Flash Separator

APPENDIX G

V2 LPS Flash Separator- 12 ft (144")

Appendix K
Preliminary Anticipated Project
Cost Summary

APPENDIX K

Preliminary Anticipated Project Cost

APPENDIX K HAS BEEN DELETED FROM THIS COPY.

APPENDIX L

Scale Mitigation Facilities Paper

Calcium Carbonate Inhibition System for Production Wells at the Miravalles Geothermal Field

Paul Moya and Antonio Yock

Instituto Costarricense de Electricidad, UEN Proyectos y Servicios Asociados
C. S. Recursos Geotérmicos, Apartado Postal 10032-1000, San José, Costa Rica, Centro América
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Keywords

Inhibitiion system, Miravalles geothermal field, Costa Rica, inhibitor injection technology

ABSTRACT

The Miravalles Geothermal Field has been producing electric energy since March 1994. It has provided steam for Unit 1 (55 MWe) since 1994, a Well Head Unit (5 MWe) installed in 1995, Unit 2 (55 MWe) in 1998 and Unit 3 (27.5 MWe) in the year 2000. During the first production tests of wells in the Miravalles Geothermal Field it was found that the reservoir fluids are over-saturated with respect to calcium carbonate at the flashing zone, causing deposition of this mineral and obstruction of the production casing in few days. A test conducted in 1989 proved that systematic chemical inhibition inside the production wells could prevent the formation of calcite scale. The materials and equipment of the inhibition system are described in this article. Since 1994, the inhibition system has been used successfully in the production wells that supply steam to the generating Units. Experience has indicated that, with the injection of an appropriate dose of inhibitor, it is possible to incorporate the geothermal wells into production with no deposition of calcium carbonate and at a reasonable cost.

Introduction

The Miravalles geothermal field is located on the southwestern slope of the Miravalles volcano. The extent of the geothermal field already identified is greater than 21 km², of which about 16 km² are dedicated to production and 5 km² to injection. There are 51 geothermal wells (Figure 1), including observation, production and injection wells, whose depths range from 900 to 3,000 meters. The production wells produce between 3 and 12 MW each, and the injection wells each accept between 70 and 450 kg/s. The reservoir has a temperature of about 240°C and is water-dominated.

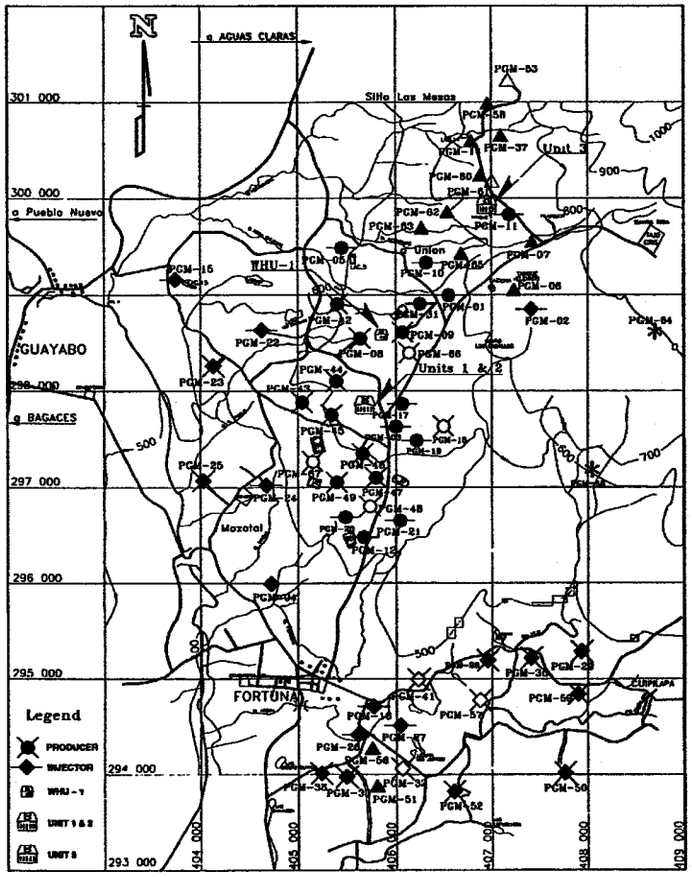

Figure 1. Location of production wells at the Miravalles Geothermal Field.

Seven separation stations supply the steam needed for Unit 1, Unit 2, Unit 3 and the Wellhead Unit (142.5 MWe installed capacity). Normally, two or three production wells supply two-phase flow to each separation station. The total steam flow to the plants is about 300 kg/s, and the residual geothermal water sent to the injection wells is about 1,350 kg/s.

Table 1. Geothermal units at the Miravalles Geothermal Field.

Plant Name	Start-up Date	Final Date	Power (MW)	Belongs to
Unit 1	3/1994	—	55.0	ICE
WHU-1	1/1995	—	5.0	ICE
WHU-2	9/1996	4/1999	5.0	CFE
WHU-3	2/1997	4/1998	5.0	CFE
Unit 2	8/1998	—	55.0	ICE
Unit 3	3/2000	—	27.5	ICE
Unit 5	9/2003	—	10 - 20	ICE

Notes:
ICE: Instituto Costarricense de Electricidad
CFE: Comisión Federal de Electricidad (México)
WHU Wellhead Unit

The Miravalles Geothermal Field has been producing since 1994. Table 1 shows the increments of generation during these first seven years, and also the expected future development. As indicated in Table 1, the wellhead units from the Comisión Federal de Electricidad (Mexico) were in operation while Unit 2 was being built. Unit 1 is currently capable of generating 60 MWe; therefore at present there is a need to supply enough steam to generate 60 MWe (Unit 1), 5 MWe (Wellhead Unit), 55 MWe (Unit 2) and 27.5 MWe (Unit 3), for a total of 147.5 MWe. This capacity will be increased to 157.5– 167.5 MWe when a bottoming second-flash unit or a binary plant comes online by the end of 2003.

Figure 2 shows the rate of mass extraction from the Miravalles Geothermal Field since production began. The steam extraction rate increased gradually from May 1994 (350 thousand tons/month) until August 2000 (820 thousand tons/month). Liquid mass and total mass extraction have behaved in basically the same way: there was an increase from March 1994 (1 million tons/month) to May 1995 (2.5 million tons/month); they then fluctuated within a narrow band (1.7 to 2.5 million tons/month) until April 1998. Thereafter, the total mass extraction increased from 3.4 to 4.9 million tons/month and the liquid mass also increased from 2.9 to 4.1 million tons/month. This last increment has been due to the start-up of Units 2 and 3. The behavior of the extraction curves matches quite well the increases in generation over these years as the different new units were commissioned. From September 2000 to February 2001 the

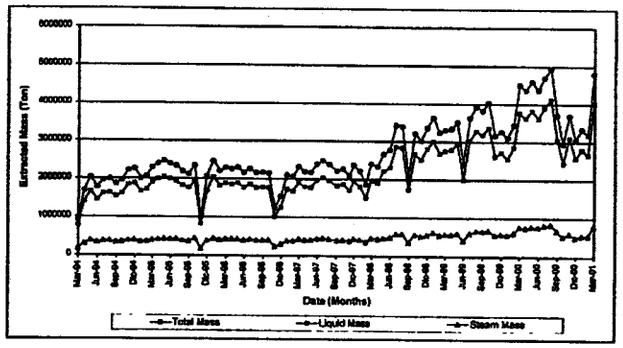

Figure 2. History of Mass Extraction.

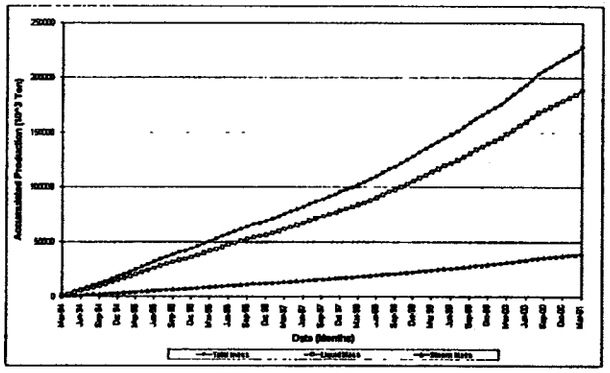

Figure 3. Cumulative Mass Extraction.

production of steam and liquid decreases due to the maintenance of the Units 1, 2 and 3.

Figure 3 shows the cumulative production of total, liquid and steam masses from the geothermal field. All of these masses increase linearly from March 1994 up to May 1998. When Units 2 and 3 started production the slope of the curves became steeper, but the increases were still nearly linear over those periods (from April 1998 to March 2000 and from April 2000 to March 2001). By March 2001, the accumulated production was approximately 39.5 million tons of steam, 188 million tons of liquid and 228 millions tons of total mass.

In order to supply the steam to the power plants, it was necessary to install a calcium carbonate scale inhibition system in each production well. Now there are 21 inhibitions systems operating 24 hours a day, 365 days a year at the Miravalles Geothermal Field. The formation of calcium carbonate, and the method and equipment used to control it, are described in the following sections.

Formation of Calcium Carbonate

Production wells at the Miravalles Geothermal Field showed a high potential for calcite deposition even before exploitation of the field began. The degree of calcite saturation (log Q/K) was evaluated for each production well using the Watch computer program (Arnórsson *et al.*, 1982; Bjarnason, 1994) and it was found that the pre-flashed reservoir fluids of neutral pH are below saturation levels. Arnórsson (1989) discussed two mechanisms by which calcium carbonate minerals can be formed from geothermal fluids. The first process occurs through hydrolysis, and the second takes place through boiling. In both mechanisms the important parameters that govern the deposition of calcite include P_{CO2} (fugacity or partial pressure of dissolved CO_2), pH, temperature, salinity and Ca^{+2} content.

In Miravalles, the second process of calcite precipitation (boiling) is the mechanism that affects the output of the production wells; this is supported by the fact that calcite deposition has occurred on the downhole capillary tubing near the flashing zone. As the hot brine rises towards the surface in a production well, equilibrium is reached between the pressure in the wellbore and boiling point of the brine, causing flashing inside the well.

When flashing occurs as the deep fluids are ascending to the wellhead, the fluid tends to to become supersaturated with calcite and hence there is a high potential for calcite to be deposited.

Under normal geothermal conditions, the concentration of aqueous carbonate (CO_3^{-2}) is low and most dissolved carbonate is in the form of carbonic acid (H_2CO_3) or bicarbonate (HCO_3^-) as shown by the following reactions:

$$CO_{2,(gas)} + H_2O = H_2CO_{3,(aq)} \quad (1)$$

$$H_2CO_{3,(aq)} = H^+_{(aq)} + HCO_3^-{}_{(aq)} \quad (2)$$

$$HCO_3^-{}_{(aq)} = H^+_{(aq)} + CO_3^{-2}{}_{(aq)} \quad (3)$$

By combining these equations, the following reaction is obtained:

$$2HCO_3^-{}_{(aq)} = CO_3^{-2}{}_{(aq)} + H_2O + CO_{2(gas)}\uparrow \quad (4)$$

Equation 4 indicates the reaction that takes place during boiling. When boiling occurs, it leads to a strong reduction in the partial pressure of CO_2 due to an effective transfer of CO_2 into the steam phase that forms during the flashing process. The carbonate ions (CO_3^{-2}) are then available to react with calcium ions to cause deposition of calcium carbonate. The following reaction is the simplest way to represent the formation of calcite:

$$Ca^{+2} + CO_3^{-2} = CaCO_3 \quad (5)$$

Adding equations 4 and 5 gives:

$$2HCO_3^-{}_{(aq)} + Ca^{+2} = CaCO_{3\,(sol)}\downarrow + H_2O + CO_{2(gas)}\uparrow \quad (6)$$

Equation 6 shows that the calcite precipitates by exsolution of CO_2 gas.

Several techniques to control calcite scaling have been used in Miravalles, including mechanical clean outs, acid stimulation and downhole injection of chemical inhibitor. Before Unit 1 was commissioned, mechanical clean outs were performed in wells PGM-01, PGM-03, PGM-05, PGM-10, PGM-11 and PGM-12. At present, an inhibition system using downhole injection is used in all production wells with good results, except in well PGM-03. In PGM-03 an inhibition system is installed, but because is not possible to place the dispersion head below the flashing zone, acid stimulation has been used from time to time to clean out the deposited calcite, especially when the output of the well has declined.

Basically, the downhole inhibition system consists of delivering the inhibitor chemical below the boiling zone by pumping, using a string of 6.35 mm capillary tubing with a dispersion head and a sinker bar. Several chemicals have been tested, but at present the polymers with carboxylic functional groups are highly utilized due to their greater thermal stability. This group includes polymers from acrilic acid, maleic anhydride, metyl acrilic acid and their copolymers. In Miravalles an aqueous solution of a polyacrylate is being used currently.

Inhibition Control

Once the dispersion head is placed below the boiling zone, two procedures must be carried out. The first is to determine the baseline in order to obtain the reference ratio, and the second is to monitor the inhibition every week in order to determine the inhibitor's effectiveness.

Sampling Procedure at Miravalles

The sampling procedure at Miravalles is as follows. The 2" valve on the pipe next to the wellhead is opened for 10 minutes in order to clean any deposits from around the valve. Three samples of 100 ml of water are collected at atmospheric pressure, allowing 15 minutes between each sample. For each sample the chloride concentration and calcium content are determined. The chloride concentration is measured by titration with AgNO3 using an auto-titrator, which is equipped with a specific chloride electrode. The calcium content is analyzed by titration with EDTA using an auto-titrator, which is equipped with an specific calcium electrode.

Baseline

In order to determine the baseline, at least 10 sets of samples must be taken before injecting the diluted inhibitor. While measuring the baseline, clean water must be injected through the capillary tubing. The time between sample sets is about 4 to 6 hours, and each set comprises three water samples. The baseline ratio $(R)_{BL}$ is calculated in order to avoid extensive boiling or mixing:

$$(R)_{BL} = (\text{ppm } Ca^{+2}/\text{ ppm } Cl^-)_S * (\text{ppm } Cl^-)_r \quad (7)$$

R = ratio, BL = baseline, S = sample, and r = reservoir.

Monitoring

In order to monitor the performance of the inhibition system, at least one set of samples must be collected each week. Each set comprises three water samples. For each water sample the chloride concentration and calcium content are determined, and the ratio is calculated in order to avoid extensive boiling or mixing:

$$(R)_{MC} = (\text{ppm } Ca^{+2}/\text{ ppm } Cl^-)_S * (\text{ppm } Cl^-)_r \quad (8)$$

R = ratio, MC = monitored control, S = sample, and r = reservoir

The comparison of these ratios (R_{BL} & R_{MC}) determines the inhibitor effectiveness. If the difference is grater than or equal to 3 units, the inhibition is working properly, but if the difference is less than 3 units, a problem may exist with the inhibition system, and therefore, an inspection of the inhibition system must be performed.

The condition of the production wells is dynamic; therefore, the inhibitor dosages in every well must be verified every two years. Also, the doses of the inhibitor must be checked if the weekly fluid monitoring shows variations in the chloride

and calcium concentrations, or if the bicarbonates monitored monthly show variations in their concentrations. The new doses are determined by a procedure similar to the one described above, the only difference being that, before taking the samples for the baseline, clean water is injected through the capillary tubing for 24 hours in order to eliminate the residual inhibitor inside the capillary tubing.

The optimal dosage determined by the tests was 3 ppm of Nalco 1340 HP, but when the geothermal field began production, the doses were increased to 4 ppm. At present the inhibitor rates range from 2.5 ppm to 0.5 ppm. In most of the wells the dosage is 0.75 ppm.

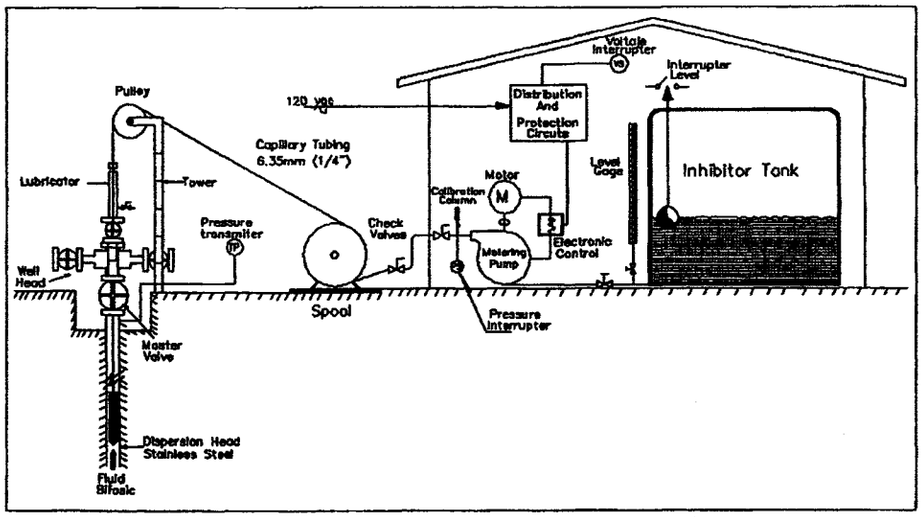

Figure 4. Inhibition System.

Inhibition System Equipment

The equipment used for the inhibition system is described in this section (Figure 4). The main components of the inhibition system are the dispersion head, the capillary tubing, the stinger, the tower, the lubricator, the spool, the metering pump and the tank. An inhibition plant and a truck are needed to implement the inhibition system.

Dispersion Head

The dispersion head is place inside the well at a specified depth. Normally the optimal depth is about 50 – 100 meters below the flashing point. The head is made of 304 stainless steel and has a length of 6 meters and a diameter of 2 or 3 inches. The diameter of the dispersion head depends upon the flow rate of the well; usually if the flow rate is greater than 100 kg/s a 3-inch diameter dispersion head is used (The production casing is 13 5/8").

Capillary Tubing

The capillary tubing strings used in the production wells are of 316 L stainless steel or Incoloy 825, and have a diameter of a 1/4" and a length of 1,300 or 1,500 meters. The length of the capillary tubing string depends upon the depth of the flashing point inside the well (Figure 4).

Lubricator

The lubricator is placed on top of the wellhead Christmas tree. It is made of 3" or 4" diamter steel pipe (A-53 gr B sch. 80) and has a length of about 6 meters. The lubricator is used to store the dispersion head before lowering it inside the well or after lifting it up from inside the well (Figure 4).

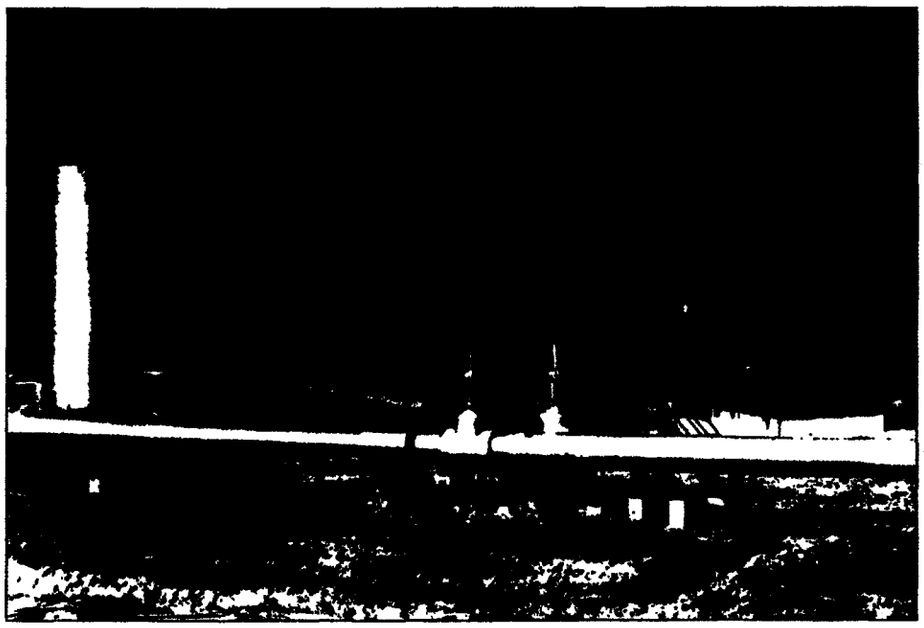

Figure 5. Inhibition System.

Stinger

The stinger is placed inside the cross at the Christmas tree. It protects the capillary tubing from bending at the cross. It also is made of 3" or 4" diameter steel pipe (A-53 gr B sch. 80) and has a length of about 1.2 meters. At its lower end it has a protective teflon coating that prevents contact of the capillary tubing with the steel pipe.

Tower

The tower is used to lower and raise the capillary tubing with a winch. At Miravalles the towers are between 10 and 12 meters high. Initially, steel beams were used to construct the towers, but, more recently, rejected drill pipe has been used (Figure 5).

Spool

The spools have an internal diameter of 1.0 meter to protect the capillary tubing from excessive bending. They are made of a common carbon steel (A36) and are used to roll and unroll the capillary tubing while lowering or lifting the dispersion head (Figure 4).

Metering Pump

The metering pump delivers the inhibitor through the capillary tubing from the tank (located at the surface) to the dispersion head (inside the well). The pumps operate 24 hours a day, 365 days a year, unless a well is taken out of production. The metering pumps at the Miravalles Field are of positive displacement type, with a capacity of 5 gph @ 1000 psi and a power supply of 110/220 VAC (Figure 4).

Tank

The tanks store the inhibitor at the well site. The capacity of the tanks ranges from 1,200 gallons to 2,400 gallons. The tanks are made of high-density polyethylene (Figure 4).

Truck

A truck is needed to deliver the diluted inhibitor to each well. Under normal operating conditions about 37,000 liters (4,780 kg) of diluted inhibitor are delivered to the wells each month.

Inhibition Plant

The inhibition plant consists of at least two tanks of 11,200-gallon capacity (at Miravalles there are six tanks) where the pure and diluted inhibitor can be stored before being distributed to the wells. At the inhibition plant the pure inhibitor is diluted to 11.1% v/v.

Conclusions

Currently there are 21 inhibition systems working 24 hours a day at the Miravalles Geothermal Field. These inhibitions systems have allowed constant supply of steam to the installed units, with little or no deposition of calcium carbonate inside the production wells during the first seven years of commercial operation.

The formation of calcium carbonate inside the wells at the Miravalles Field is caused by boiling; this is supported by the fact that calcite has deposited on the capillary tubing near the flashing zone.

The inhibitor controls at the Miravalles Field have been successfully implemented. This has been proven by the fact that there have been few mechanical clean-outs and the output from the production wells have been almost constant during these years of exploitation.

The optimal inhibitor dosage was initially estimated to be 3 ppm. When exploitation began at the Miravalles Field, the dosage was increased to 4 ppm, but since then it has been decreasing and now the dosage is between 2.5 and 0.75 ppm. In most of the wells the dosage is 0.75 ppm.

Under normal conditions, about 37,000 liters/month (4,780 kg/month) of diluted inhibitor (11% v/v) must be delivered to the field to feed the tanks at the well sites. Therefore, about 444,560 liters (57,390 kg) of diluted inhibitor are needed each year to operate the Miravalles Geothermal Field.

Appendix M
Field Operation and Maintenance Costs

APPENDIX M

Field Operating and Maintenance Costs

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Geothermal Resource Assessment

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August 20, 2005

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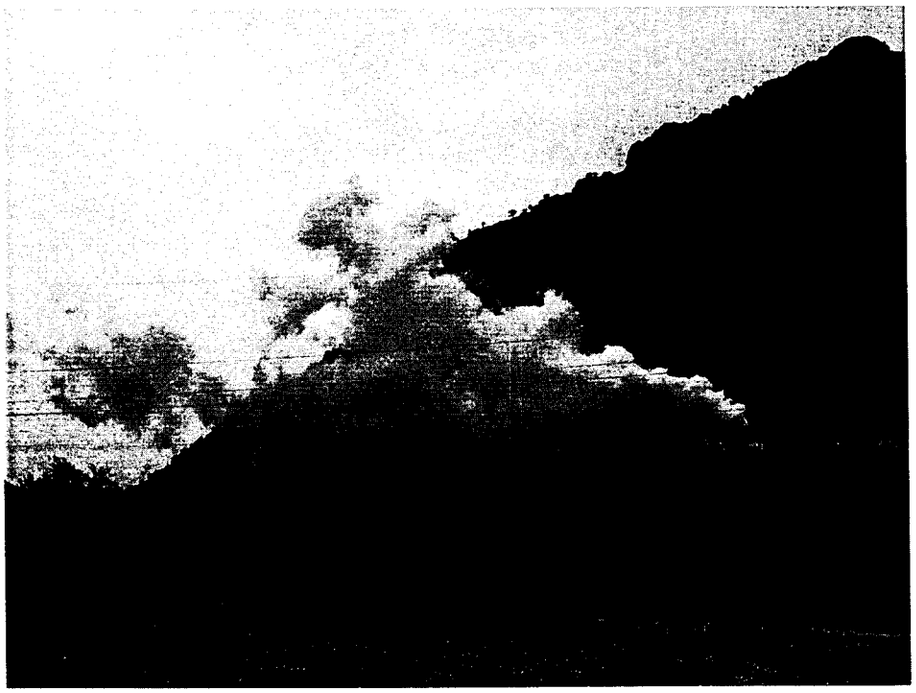

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G. Preliminary Drilling Plans and Cost Estimate
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1 Introduction

Gurmat Energy Generation Co. (Gurmat) is developing the Germencik Geothermal Project (the project) in order to produce an approximately 25 megawatt (MW) (net) power generation in Germencik, Aydin Province, Turkey. This Resource Assessment is part of a Feasibility Study for the 25 MW Power Generation Project at Germencik (Feasibility Study) which is being prepared by Stone & Webster. The Feasibility Study includes a technical, economic, financial and environmental analysis of the project. Stone & Webster will be submitting the Feasibility Study to both Gurmat and U.S. Trade Development Agency (USTDA). The Feasibility Study is funded by USTDA (70%) and the participating consultants including GEOLOGICA. This report provides an initial assessment of the Germencik geothermal resource and environmental conditions related to the project, a proposed resource development strategy and a preliminary cost estimate for implementing that strategy.

The Germencik Geothermal Field was discovered in the early 1970's west of the village of Omerbeyli in the Aydin-Germencik region during a period of extensive geothermal exploration in Turkey after the 1968 discovery of the first commercial Turkish geothermal field at Kizildere, approximately 50 km east. Nine deep exploration wells drilled in the mid-1980's all encountered temperatures approaching or exceeding 215°C within a kilometer of the surface. Flow testing and resource studies indicated that the field is capable of commercial production. Subsequent testing and evaluations during the 1990's (MTA-CFG) and recent well testing by Gurmat in 2005 established that Germencik is a viable geothermal resource capable of commercial production of 25 MW (net) 33 MW (gross) from the identified field. In addition, issues such as scaling and brine injection which have inhibited geothermal development at Kizildere appear to be manageable at Germencik with available technology.

An Environmental Evaluation Report was prepared for the Germencik Geothermal Project in 2001 in compliance with the Turkish 1993 Environmental Impact Assessment (EIA) Regulation. Based on the project description at that time, no significant environmental impacts from the project were identified and project was approved by the Turkish Ministry of the Environment and Forestry. Temporary soil loss, flora and fauna disturbance during construction were not considered significant. Additional environmental impacts related to the current project description will be evaluated in an addendum to the currently approved EER.

Geothermal fluid and brine disposal requirements for the project will require additional wellfield development. The wellfield development strategy described in this report seeks to optimize production and minimize well costs within the limitations of available data. Production strategies for addressing scaling potential and reservoir pressure maintenance are also discussed. As the project proceeds, additional information on the resource will become available as a result of drilling and testing wells and additional data interpretation. This information will allow this

preliminary resource assessment to be refined and the reservoir development strategy to be improved. Future development of the reservoir is currently estimated at approximately 100 MW but this capacity could be higher with application of additional information and experience of the initial development to optimizing the resource development.

This report presents a Preliminary Resource Assessment of the Omerbeyli-Germencik Geothermal Reservoir performed by GEOLOGICA including:

- an independent assessment of the data reviewed,
- geology, geochemistry and reservoir characteristics of the resource,
- an assessment of the environmental status of the project,
- proposes development strategy, and
- presents preliminary cost estimates to implement that strategy.

1.1 PURPOSE

This resource and environmental assessment is submitted by GEOLOGICA to Stone & Webster as part of a Feasibility Study for the Germencik Geothermal Project. The Feasibility Study is intended to provide a basis for financing a geothermal project based on an independent assessment of the technical, financial, economic, and environmental feasibility and preliminary cost of geothermal power development at Germencik.

1.2 SCOPE OF WORK

The evaluation of the capacity of the Germencik geothermal resource to support geothermal power generation over the 40 year life of the project is based on the available data and historical information compiled during the exploration and development of the Germencik geothermal field. Geologic and geophysical data were reviewed to identify field boundaries, permeability distribution and probable reservoir configuration. Geochemical data were evaluated to identify fluid characteristics, reservoir characteristics such as temperatures and connectivity, and scaling potential as well as production processes to control steam quality and scale development and manage gas loading. Well data test data were reviewed to establish individual production capacity, long-term production strategies and maximum reservoir capacity over the short and long term. Major environmental issues were assessed to evaluate resource development and geothermal power generation impacts.

The goal of the resource assessment is to establish the sustainable capacity of the resource and existing wells, and to formulate an optimal resource development strategy. The optimal resource development strategy is one that will maximize production and injection, manage reservoir pressures, and control facility configurations to minimize production problems and costs. Quantitative assessments of well productivity and potential reservoir capacity established how many additional wells are required to assure production from an approximately 25 MW net power plant at start-up, and over the approximately 40 year life of the project.

This Scope of Work was performed in the following Tasks:

Task 1 – Data Review and Preliminary Meeting
- Review the following based on available data and information
  - Geology
  - Geochemistry
  - Reservoir performance
- Prepare preliminary outline and identify data gaps
- Preliminary meeting

Task 2 – Site Visit and Field Investigation
- In-country data review
- Site visit
- Existing Development plans and Environmental Issues

Task 3 – Technical Analysis
- Geology
- Geochemistry
- Reservoir

Task 4 – Report
- Reservoir Assessment
- Environmental Assessment
- Development strategy
- Cost Estimate

2 Background of Germencik Geothermal Resource Development

The Germencik geothermal area is one of several geothermal areas within the Buyuk Mendres Graben of western Anatolia. The Turkish Ministry of Mineral Research and Exploration (MTA) began evaluating the geothermal potential of the region in 1962 initiating a series of geological, geophysical, geochemical and heat flow studies. Potential high-enthalpy geothermal systems were identified during the late 1960's and early 1970's at Kizildere near Denizli in the east and at Omerbeyli village near Aydin-Germencik in the western part of the Graben. The potential of the Germencik geothermal field was established in 1982 with the drilling of wells OB-1 and OB-2, which encountered temperatures of 200 to 232°C and produced hot water from two reservoir zones. A series of 7 additional productive wells were drilled between 1982 and 1986.

Flow test and resource studies during the 1980's established Gemencik as one of Turkey's most promising geothermal prospects. A total of seven productive Germencik wells ranged from 126 to 389 tons per hour (t/hr) of total mass flow at wellhead pressures ranging from 8.2 to 15 kg/cm^2.

The flow tests were relatively short-term but the initial results indicated that the existing operable exploration wells were capable of commercial geothermal production for 23 MW of electrical generation. An MTA pre-feasibility study estimated approximately 8 km^2 productive area within the Germencik field could sustain 55 MW of generation. The primary MTA development efforts during the late 1970's and 1980's were directed toward Kizildere and the potential of the Germencik field remained dormant.

The Turkish government explored the potential of privatizing portions of their geothermal resources during the 1980's. Exploration and evaluation efforts were launched between western energy companies and Turkish partners. A cooperative venture between Unocal Geothermal and Turkish Petroleum (TPAO) explored the country's potential by doing reconnaissance work and geochemical sampling in prospect areas across the country. More detailed geophysical and geochemical efforts were completed to develop specific exploration targets including the Germencik field as a high potential development area.

A consortium of MTA and Comission Francais pour le Development de la Geothermie et des Energies Nouvelles (CFG) initiated a program of additional well testing in 1989-90 with support from the French government. The tests confirmed the production capacity of the wells and expanded the estimated productive area of the field to approximately 15 km^2. The CFG recommended a conservative staged development approach with an initial installation of a 30 Mw generation facility. Based on standard well completion technologies, the potential development plans required six new production wells and 3 new injection wells.

West Japan Engineering Consultants (WJEC) reanalyzed the available data in 2002 and concluded that the Germencik field could conservatively sustain 30 Mw of generation. The WJEC evaluation was the first published study to suggest a combined cycle (conventional flash and binary) development scenario to optimize the resource utilization. The study also recognized that drilling had not established the lateral limits of the field and suggested additional geophysical surveys (CSAMT) could help identify field boundaries and target exploration areas.

After approximately fifteen years without significant activity at Germencik, Gurmat initiated additional well testing in 2005 to evaluate the individual well productivity and identify usable wells for an initial power generation project. In cooperation with Geologica, Veizades & Associates (Veizades), and MTA well tests were conducted on six wells, establishing the potential productivity of the field. Commercial productivity of at least three wells was verified suggesting that wellfield development would initially consist of a mix of new and established production within the system. The reservoir data from the test verified the productive capacity and usability of OB-6, OB-8 and OB-9 and the potential for over 30 MW gross productive capacity of the Germencik reservoir. Development scenarios are being initiated for further testing and drilling additional wells to assure production and address potential scaling problems.

3 Data Reviewed for this Work

Geologica reviewed the exploration data Gurmat provided on the geothermal resource and additional published background information on Anatolian geology and geothermal development.

3.1 GEOLOGICAL DATA

Data on the general geology and well data from the Germencik Geothermal Field were provided by Gurmat from previous work by MTA and MTA-CFG (Germencik Geothermal Field Feasibility Report, Part Two DRAFT July 1990, MTA, Mitsubishi, Ministry of Energy and Natural Resources, C.F.G). Additional information was obtained from general publications (Sengor, 1979; Windley, 1982; Ercan, 2000) or published reports on the Germencik field or geothermal development in the Buyuk Mendres Graben (Simsek and Gulgor, 1988; Demange and others, 1989).

3.2 GEOCHEMICAL DATA

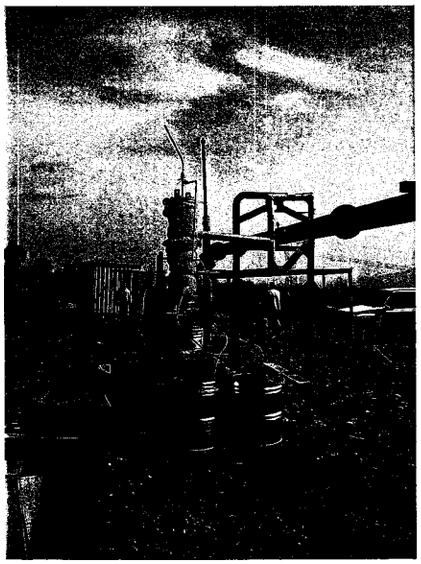
3.2.1 Previously Collected Data

Geochemical analysis of samples of geothermal fluids and cold water in the vicinity of the Germencik Geothermal Field were provided by Gurmat from previous work by MTA and MTA-CFG (Germencik Geothermal Field Feasibility Report, Part Two DRAFT July 1990, MTA, Mitsubishi, Ministry of Energy and Natural Resources, C.F.G). Additional analyses were obtained from the public domain (e.g. Filiz et al., 2000). Historical Data are summarized in Table 3.2.1-1.

3.2.2 Data Collected by Gurmat in 2005

Geochemical samples of steam and brine were collected during short term flow testing of all six wells at Germencik between 26 February and 19 March 2005. Four sets of samples were collected during each flow test and one or two samples were collected from each of approximately three or four flow testing periods as described in the Short Term Flow Testing Plan (Appendix A).

Steam and brine samples were collected from the well test flow line after careful separation using a sampling cyclone separator designed by Veizades and pictured below.



Field measurements of pH and conductivity of brine and noncondensible gas concentration in steam (Gas/Steam; see Short Term Flow Test Plan for methodology) were performed concurrently with the collection of four sets of steam and brine samples from each well. Selected samples from these four sets were analyzed as follows:

Fluid	Analytes	Sample Frequency	Laboratory
Steam	Gases: Ar, Air, N_2, CH_4, H_2, CO_2, NH_3, H_2S, Total NCG	2/well except OB-3	Thermochem
Steam condensate	B, As, Na	2/well except OB-3	Thermochem
Steam condensate	Stable isotopes of water Oxygen-18 and deuterium	1/well	Thermochem
Brine	Cl, SO_4, HCO_3, pH, TDS, NH_3, Na, K, Ca, Mg, Li, B, As, SiO_2, Na, K, Ca, Mg, Li, B, As, Hg	2/well	MTA and Thermochem
Brine	Stable isotopes of water Oxygen-18 and deuterium	1/well	IGNS

Results of laboratory analysis of selected samples and field measurements are summarized in Table 3.2-2a-Field Measurements, Table 3.2-2b-Brine Analysis, Table 3.2-2c-Noncondensible Gas Analysis, Table 3.2-2d Condensate Analysis, and Table 3.2-2e-Isotope Analysis.

The analytical results from the Short Term Flow Tests indicate that the sample quality is good. Condensate analysis suggest that except for one sample collected from OB-7, the separation of brine and steam was excellent, assuring good quality brine and steam samples. In addition, the amount of air leakage into the gas samples reported in the Gas analysis suggests that the samples are not contaminated. Although insufficient samples were collected to quantitatively evaluate

analytical reproducibility, the difference between geothermal reservoir concentrations calculated by correcting for variable sampling conditions is negligible for bicarbonate and sulfate and cations except calcium. Calcium is expected to be variable due to scaling. Differences between chloride and silica analysis by Thermochem and MTA are resolved by utilizing only the Thermochem results when there is an inconsistency.

3.3 RESERVOIR DATA

3.3.1 Initial Well Drilling and Testing by MTA

Results of the 1988 MTA flow tests were reviewed to establish the initial resource productivity. A brief summary of results is listed below for each well and the type of test performed. Water disposal limited the test operations and as a result, OB-6, OB-9, and OB-4 were tested with long term flow tests, while OB-2 and OB-3 were tested with short term flow tests and wells OB-5, OB-7, and OB-8 were only tested briefly with vertical James tubes.

1988 Results:

OB-1: Not tested due to drilling problems.

OB-2: Short term flow test with horizontal James tube, atmospheric separator, and weir box. The results were:
- Total flow = 144 t/hr, WHP = 8.2 kg/cm^2,g

OB-3: Short term flow test with horizontal James tube, atmospheric separator, and weir box. The results were:
- Total flow = 260 t/hr, WHP = 13.2 kg/cm^2,g

OB-4: 14 day flow test with horizontal James tube, atmospheric separator, and weir box. This well is a shallow well completed only in Reservoir #1. Initial production was 700 t/hr at WHP = 14.4 kg/cm^2,g with a bottom hole temperature of 217 deg C. After 14 days of production, it had declined to 214 t/hr at WHP = 11.1 kg/cm^2,g with a bottom hole temperature of 196 deg C.
- Total flow = 214 t/hr, WHP = 11.1 kg/cm^2,g

OB-5: Brief flow test with vertical James tube. The results were:
- Total flow = 241 t/hr, WHP = 16.0 kg/cm^2,g

OB-6: 75 day flow test with horizontal James tube, atmospheric separator, and weir box. The results were:
- Total flow = 389 t/hr, WHP = 15 kg/cm^2,g

OB-7: Brief flow test with vertical James tube. The results were:

- Total flow = 126 t/hr, WHP = 14.0 kg/cm^2,g

OB-8: Brief flow test with vertical James tube. The results were:
- Total flow = 357 t/hr, WHP = 13.2 kg/cm^2,g

OB-9: 35 day flow test with horizontal James tube, atmospheric separator, and weir box. The results were:
- Total flow = 332 t/hr, WHP = 15.0 kg/cm^2,g

3.3.2 Well Testing by CFG-MTA in 1990

Flow tests by CFG in 1990 were intended to test the short term performance of wells OB-6 and OB-9. Results are listed below for each well including the type of test performed and a brief summary of the results. Well OB-9 was given an initial short term injection test. Well OB-6 was then flowed for 17 days while OB-9 was used as an injection well for cold water disposal and well OB-8 was used as a monitoring well to gather interference data.

<u>1990 Short Term Testing Results</u>:

OB-6: Short term flow test with horizontal James tube, atmospheric separator, and weir box. The results at maximum tested flow were:
- Total flow = 410 t/hr, WHP = 23.4 kg/cm^2,g, and Enthalpy = 903.5 kJ/kg (enthalpy adjusted for NCG content).

OB-9: Short term flow test with horizontal James tube, atmospheric separator, and weir box. The results at maximum tested flow were:
- Total flow = 374 t/hr, WHP = 17.3 kg/cm^2,g, and Enthalpy = 913.6 kJ/kg (enthalpy adjusted for NCG content)

<u>1990 Longer Term Testing Results</u>:

OB-6: 17 day flow test with horizontal James tube, atmospheric separator, and weir box. These data and the description of the tests were not supplied in a form to allow results to be calculated.

OB-9: 17 day injection test with injection pump. Initial shut in WHP=20.4 kg/cm^2,g. Maximum rate of pump was 20 liters/sec (72 t/hr), with that injection rate, wellhead pressure stabilized at 14.3 kg/cm^2,g.

OB-8: Used as interference monitoring well during long term flow test of OB-6. No data or analyses are supplied.

3.3.3 Short Term Well Testing by Gurmat in 2005

Short term flow testing produced sufficient data to identify three wells (OB-6, OB-8, and OB-9) that are capable of commercial production. The flow test results provided the data needed for a preliminary assessment of the commercial potential and mechanical status of the six tested wells (OB-3, OB-5, OB-6, OB-7, OB-8, and OB-9). The short term flow testing at Germencik has shown that three of the six tested wells, OB-6, OB-8, and OB-9 are highly productive, commercial grade geothermal wells suitable for use in electricity production. The other three tested wells, OB-3, OB-5, and OB-7 are either marginally commercial or non-commercial.

The flow tests were conducted mostly accordance with the original test plan (attached in Appendix A) but each well had a slightly different flow schedule to balance equipment and manpower among the competing goals of starting each test as soon as equipment was moved and ready, collecting fluid samples, and performing dynamic surveys and pressure buildups in daylight. In all cases, the changes made in the flow test program served to enhance data quality. Each well's flow test contained at least three flow rate periods, one of which was the maximum (100%) total mass flow and the other tested rates were a portion (50% to 90%) of the maximum total flow. Each flow period lasted at least two hours, but most flow periods were four hours or longer.

In five of the six wells, all goals set forth in the original flow test plan were accomplished. The exception was well OB-7. In well OB-7, the dynamic pressure and temperature survey and pressure buildup survey could not be performed due to a blockage in the well. There was also a slight variation in the testing of OB-9. Due to a blockage in OB-9, the static pressure and temperature survey was run after the flow test, and all testing goals were completed for well OB-9. Although the static pressure survey in well OB-9 was not performed prior to the flow test, as set forth in the original plan, the survey obtained was representative of static conditions. Appendix A contains Table A.1 through A.6 which show the actual flow test schedule performed on each well. In addition, Appendix A also contains the text of the original flow test program.

Wireline surveys were performed in each well, in addition to flow testing. The raw data (in addition to graphical representations) of these surveys are shown in Appendix B (static surveys) and Appendix C (Dynamic surveys). The following surveys were performed:

1. Static Pressure and Temperature Survey
2. Dynamic Pressure and Temperature Survey
3. Downhole Pressure Buildup Survey

During each production flow period of each test, the following data were collected:

1. Static and Dynamic Wellhead pressure
2. Flow Line pressure
3. Flow Line temperature
4. James Tube pressure
5. Weir box water level

5. Weir box water level

Gurmat observed and manually recorded the flow test data on a 24-hour per day basis, on 60 minute intervals. GEOLOGICA observed and manually recorded flow test data on a 12-hour per day basis (daylight hours) on 10 to 60 minute intervals and was present to collect flow test data during all critical phases of the entire flow test. Both the Gurmat, and the GEOLOGICA data are presented in Appendix D. Data were also collected by MTA, but these data were not provided to GEOLOGICA and are not used in this report

Short Term Flow Testing of OB-6 Germencik Geothermal Project

Wells (OB-6, OB-8, and OB-9) are capable of commercial production based on the short term flow test data. Of the remaining wells tested (OB-3, OB-5, and OB-7), productivity may be increased by removing obstructions, perforating liners, or deepening except for OB-5 which may be completed in an area of low productivity. The commercial wells produce high maximum mass flows (321 to more than 450 t/hr) at moderate enthalpy (approximate average 900 kJ/kg) with moderate salinity and relatively high noncondensible gas levels.

4 Reservoir Assessment

4.1 GEOLOGY

The Germencik geothermal system comprises an area of approximately 8 km^2 in the western part of the Buyuk Mendres Graben of southwestern Turkey (Figure 4.1-1). The area is bounded by the Kizilcagedik Horst to the north (Figure 4.1-2). Geologic units in the Menderes area are divided into Paleozoic metamorphic rocks and late Cenozoic to Quaternary detrital sedimentary rocks of alluvial or lacustrine origin that filled the evolving grabens in western Anatolia (Figure 4.1-3).

4.1.1 Paleozoic Rocks

The Mendres metamorphic rocks comprise the principal deep geothermal reservoir at Germencik. The highest temperatures and the most productive wells are related to deep permeability within the metamorphic section. Earlier studies (Simsek and Gulgor, 1988; Demange and others, 1989) emphasized deformed and highly permeable marble units as primary production zones but several deformed or jointed zones within the gneiss and schist and the fault contacts between thrust blocks also appear to be permeable in some wells.

The Paleozoic metamorphic rocks of the Mendres Massif are a heterogeneous mixture of older gneiss, calcic and graphitic schists, marble and quartzite. Simsek and Gulgor (1988) divide the metamorphic units into an allocthonous (overthrust) unit and an underlying stable (autocthonous) unit based on pre-Cenozoic faulting that deformed and thickened the metamorphic section. Wells within the Germencik field penetrate the allocthonous gneiss and at least the upper part of the autothocnous schists, metasedimentary rocks. The autocthonous metamorphic rocks are generalized as a lower (older?) sequence of gneiss, a middle sequence of greenschist facies schists approximately 2000m thick, and an upper series of marble, calc schists, and graphitic schists with interbedded lenses of quartizite that may be 1000m thick. The allocthonous gneiss unit was emplaced over the younger schists along low-angle pre-Miocene thrust faults. The allocthonous unit varies in thickness from 414m near the Mendres Massif on the north in well OB-5 to 52m on the south in well OB-8 within the Mendres Graben.

4.1.2 Cenozoic Rocks

Cenozoic rocks are the allvial or lacustrine detrital material that filled the evolving basins of the Mendres Graben. Miocene conglomerates, sandstones and clays unconformably overlie the older Mendres metamorphic units and vary in thickness from 117 to 735m in Germencik wells. Well OB-1 penetrated 6m of Miocene lignite coal from 897 to 903m but coal seams appear to be discontinuous since no other coal units were logged in the other wells. Conglomerates at or near the base of the Miocene section appear to be permeable in some wells and are part of the shallow high temperature zone encountered in OB-1 and OB-4 wells.

Pliocene conglomerates, sandstones and clays are similar to Miocene units and in faulted areas, may also unconformably overlie the Mendres metamorphic rocks. Germencik wells penetrate as little as 27m close to the mountain front and as much as 236m of Pliocene rocks farther south in

the graben. Upper Pliocene units (designated Plio-Quaternary in earlier studies) include less indurated conglomerates and clays varying from 38m to 332m thick. A series of Pliocene basalts andesites and dacites occur north around Ortaklar and southwest around Soke in limited eroded eruptive centers along the Omerbayli fault (Cicekli, 1985). Early studies mention a basalt dike penetrated in OB-6 but the dike is not included on the general log of the well.

4.1.3 Quaternary Rocks

Quaternary rocks are generally poorly consolidated alluvium or talus varying in thickness between 12 to 54 meters in Germencik wells. Quaternary units represent the principal shallow aquifers in the region and include local travertine in and hot spring areas in Bozkoy and Gemus (Simsek and Gulgor, 1988).

4.1.4 Structure

Turkey is located at the active convergence boundary between the African, Arabian and Eurasian plates. In part, the African plate is being subducted northwards beneath the Eurasian plate resulting in compressional thrusts and crustal shortening seen in the Mendres metamorphic rocks through the Miocene. Post- Miocene movement of the Arabian plate complicates the tectonics of the eastern Mediterranean by wedging Turkey sideways to the west. The resulting convergence and oblique extension has produced an array of internal faults within the Anatolian crust (Sengor, 1979). The region remains one of the most seismically active parts of the Alpine-Himalyan belt (Windley, 1984). The high level of seismicity, predominant east-west rifts, north-south extensional faults, crustal thinning and high heat flow of the Mendres Graben are a direct response to the northward convergence and escape of Turkey westward.

The Mendres Graben is one of the most prominent tectonic rifts in western Turkey. The Kizilcagedik Horst, an uplift of Palezoic metamorphic rocks separating two parts of the Mendres Graben, is defined by a series of east-west oriented extensional faults that control the orientation of the graben and deeper permeability within the Germencik geothermal field.

4.1.5 Permeability

Fluid flow in the Germencik geothermal system is controlled by fracture zones within the older crystalline metamorphic rocks. Penetrative fault zones control deep recharge from higher elevations in the uplifted metamorphic blocks to the north. Deep circulation, heating and upflow occur along dipping graben-bounding faults at lower elevations to the south. The permeable deep source reservoir at Germencik is controlled by active east-west graben-bounding faults that penetrate deep into the metamorphic section of the Mendres Massif.

Temperatures within the Germencik geothermal reservoir illustrate vertical distribution of permeability controlled by splays of the steeply dipping Omerbeyli fault along the range front of the Kizilcagedik Horst (Figure 4.1-4). Shallow high temperature conditions around the OB-4 well apparently mark a central upflow zone within the Germencik geothermal system. Penetrative permeable faults apparently extend from the deeper resource (1000 m) to the upper part of the Germencik hydrothermal system (<100m). Downhole temperatures measured in the 1980s exceed

the boiling point-depth curve for pure water in OB-4 (Figure 4.1-5) and near boiling temperatures occur in the shallow subsurface (Figure 4.1- 6). In other Germencik wells, temperatures above 150°C occur at greater depths and permeable zones are penetrated deeper in the metamorphic section (Figures 4.1-7 through 4.1-10).

Vertical fluid flow may be limited to steeply dipping graben faults while lateral flow may occur along older thrust shear zones or contacts between metamorphic units. Earlier studies apparently inferred permeability from drilling fluid losses with the deeper metamorphic rocks. Circulation losses during drilling partially correlate with jointed or fractured marbles; however, many deeper permeable zones correlate with projected fault trends (OB-8) or intersections between predominant east-west faults and conjugate north-south faults related to regional tectonics (OB-6) (Figure 4.1-4). The range of permeability within the field may depend on fault interactions and position relative to splays of the Omerbeyli fault. More productive wells were drilled in the western part of the field (OB-6 and 9) along projections of conjugate north-south faults while less productive wells were drilled closer to the range front (OB-5) or to the eastern side of the field (OB-3 and 7).

The shallow lower enthalpy reservoir at Germencik is partly controlled by fracturing and by primary porosity within the younger shallow sedimentary rocks. Thermal fluids move vertically along steeply dipping faults or complex fault intersections into shallower permeable sedimentary units. Intersections with conjugate north-south faults control the location of thermal springs, warm water wells and regional alteration within the graben (Ercan, 2000) and in part control fractures that cut the underlying bedrock. Shallow thermal fluid discharge from hot springs and seeps is controlled by faults (Figure 4.1-2) and warm water wells south of the geothermal reservoir are controlled by outflow within poorly consolidated Quaternary alluvium.

4.1.6 Field Geometry

The boundaries of the Germencik geothermal system can only be inferred from limited exploration data. The Omerbeyli fault along the range front of the Kizilcagedik Horst is probably the northern limit of the producing reservoir at Germencik. The eastern, western and southern limits of the field have not been established by drilling. Early Schlumberger dc surveys identified a broad resistivity low correlating roughly with the basin deposits in the Mendres Graben with little lateral distinction and no apparent southern limit (Sahin and Senor, 1984). Detailed electromagnetic surveys were run during the late 1980's by Unocal and TPAO to identify the center of alteration and define the field limits but the data were not available for this review.

The probable minimum boundaries of the Germencik field can be inferred from temperature data. Conductive temperature profiles suggest that well OB-5 may be close to the northern margin of the field, or may be within a less permeable section. Convective profiles suggest that the easternmost well OB-7 is still within the field but mechanical problems apparently limit production leaving the eastern-most limit undefined. A deep temperature reversal of 9°C in the lower 300m of OB-8 may indicate that the well is on the margin of the convective reservoir. A similar deep temperature reversal may suggest that well OB-9 is on or near the western limit of the Germencik reservoir. Both wells are good producers and will contribute to the total production from the field but they

may be producing from the margins and not from the central portion of the reservoir. Further definition of the Germencik reservoir depends on gradient drilling, geophysics and exploration of the margins through deep drilling.

4.2 GEOCHEMISTRY

Reservoir conditions and operational issues related to the chemistry of the produced geothermal fluids are evaluated based on the results of geochemical analysis of geothermal fluids. The short term flow testing of OB-3, OB-5, OB-6, OB-7, OB-8 and OB-9 in 2005 provided sufficient data to reliably establish reservoir chemistry. This section discusses the reservoir chemistry and related reservoir properties as well as potential chemical issues related to producing the Germencik geothermal resource in the proposed double-flash system.

4.2.1 Reservoir Fluid Characteristics

The chemistry of the reservoir fluid is derived from separate steam and brine samples collected primarily during the short term flow testing performed in 2005. Supplemental information is obtained from surface and downhole samples collected by MTA during the 1980s. Reservoir fluid compositions were derived from analytical results of brine and steam samples by correcting for the fraction of steam (y) separated during sampling (concentration in reservoir = [y x concentration in steam sample] + [(1-y) x concentration in brine sample]). The amount of steam separated during sampling is based on obtaining reliable estimates of total enthalpy and the enthalpy of steam and brine at sampling conditions. Thermodynamic and chemical data collected during the 2005 short term flow testing were of sufficient quality to reliably calculate reservoir chemistry. The reservoir chemistry is presented in Table 4.2-1a-Reservoir Dissolved Constituents and 4.2-1b-Reservoir Gas Chemistry. Stable isotopic composition of reservoir fluids were presented in Table 3.2-2e.

The geothermal reservoir fluid at Germencik is a sodium chloride-bicarbonate brine. Although sodium is the predominant cation by a factor of ten (Figure 4.2-1), the concentrations of chloride and bicarbonate are approximately equivalent (Figure 4.2-2). The reservoir chemistry is similar to other geothermal fields (Figures 4.2-1 and 4.2-2). Total salinity (dissolved solids) of the reservoir fluid averages approximately 4900 mg/kg or 0.5% dissolved solids by weight (Table 4.2-1a). This salinity is relatively low to low-average for geothermal fluids world-wide.

In contrast to dissolved solids, noncondensible gas concentrations in the reservoir fluids are relatively high for a geothermal reservoir averaging approximately 1.6% by weight (Table 4.2-1b). Typical of most geothermal systems, the gas dissolved in the reservoir fluid is predominantly carbon dioxide, (CO_2; 99.6% by mole and 99.8% by weight) with lesser amounts of hydrogen sulfide and ammonia. Reservoir gases at these levels have been reported at only a few other geothermal resources such as Ngawha and Broadlands in New Zealand (1.2 and up to 5 weight %, respectively), parts of the northwest Geysers in California, USA (10 to 15% by weight in steam).

4.2.2 Reservoir Properties from Fluid Chemistry

The chemistry of the Germencik reservoir fluid is consistent with a moderate to high temperature liquid-dominated artesian geothermal reservoir, within carbonate-bearing reservoir host rocks.

Fluid chemistry varies in a limited range in wells completed up to three kilometers apart suggesting that the Germencik reservoir has sufficient permeability for lateral fluid movement. The most distinctive chemical feature of the resource is the high concentration of carbon dioxide (CO_2). The partial pressure of CO_2 exceeds 40 bar absolute (bara) on average whereas the liquid water pressure at saturation at reservoir temperature is only about 20- 23 bara, bringing the total vapor pressures to above 60 bara. These elevated pressures provide the drive for artesian flow in the wells and suppress the depth of boiling, lowering the boiling point to depth curve (Figure 4.2-3).

The gas-corrected depth of the boiling coincides with the approximate top of the reservoir as seen in the intersection of the change of temperature gradients from conductive (increasing with depth) to convective (vertical) of OB-6 and OB-9 (Figure 4.2-3). Since boiling in geothermal reservoirs is typically accompanied by mineral deposition such as calcite precipitation, this correlation suggests that the Germencik Geothermal Reservoir is at least partially capped with a mineral seal.

Reservoir fluid temperatures estimated from chemical geothermometers (Table 4.2-2) are slightly higher than temperatures measured during flowing temperature and pressure surveys. Variations across the field are slight but both temperatures from the quartz geothermometer and the cation geothermomer suggest that reservoir temperatures close to the north side of the field are higher (Figure 4.2-4). Temperatures of the total fluid flow within the wellbore average approximately 209 °C whereas the Na-K geothermometer of Fournier suggest the average temperature is 215 °C, the K-Mg suggests 222 °C and the quartz geothermometer indicates an average reservoir temperature of 228 °C. Although some temperature loss can be expected in the wellbore as the result of wellbore dynamics during flowing conditions, slight, differences between these temperature estimates suggest that a) widespread boiling is not occurring in the unexploited reservoir (no excess steam), there is some wellbore cooling during short term tests and temperatures may be slightly higher and possibly because the ultimate source fluid is below the existing well depths. More importantly, however, the calculated geothermometer temperatures support downhole measurements suggesting that the reservoir temperatures are above 210 °C, well within the range of commercial development.

The stable isotopes of Germencik reservoir water, oxygen-18 and deuterium, average -1.88 ‰ v SMOW and -39.0 ‰ v SMOW, respectively. The average steam-brine fractionation appears to have occurred at approximately 170 °C, representing an estimate of flowing boiling conditions. These reservoir values indicate a significant oxygen-18 shift (average +4 to +5 ‰) relative to meteoric water (Figure 4.3-5). Although the stable isotope values of reservoir fluids are relatively similar, there appears to be a slight increase in the oxygen-18 shift from OB-6 to OB-3, suggesting that the reservoir is more water-dominated (higher water/rock ratios) and/or lower in temperature in the vicinity of OB-6 relative to the area around OB-3. These results also suggest that the water source for the Germencik reservoir fluids is not local surface water but could be local meteoric water.

4.2.3 Production Issues

The chemistry of geothermal fluids can present challenges for scaling and corrosion, noncondensible gas loading, steam quality, and environmental impacts related to air emissions. The chemistry of the geothermal fluids at Germencik is relatively benign but it presents a few issues that require addressing with appropriate development strategy including:

1. calcite scaling in production wells,
2. possible silica scaling in the injection system, and
3. noncondensable gas loading.

Germencik resource chemistry does not appear to present problems with steam purity potentially affecting the turbine; toxic levels hydrogen sulfide gas emissions components in cooling tower drift that cannot be addressed with standard geothermal project facility design.

4.2.3.1 Scaling potential

The production of geothermal resources often involves flashing the geothermal fluid into steam and brine at a pressure below the reservoir pressure. This flashing typically occurs in the wellbore and is followed by steam and water separation at moderate pressure (known as the first or high pressure flash) and sometimes (as proposed for Germencik) a second stage of flashing separation at lower pressure (second or low pressure flash). The temperature drop and chemical changes that accompany the flashing can induce supersaturation with respect to minerals with which the geothermal fluids may have been in equilibrium or undersaturated in the reservoir. This supersaturation leads to two common geothermal scaling problems: calcite and silica scaling may be an issue during production of geothermal fluids at Germencik.

Germencik fluids appear to be in equilibrium with calcite in the reservoir; however, the currently proposed production scenario requires a high pressure (6.2 bara) and low pressure (1.2 bara) flash (boiling). The pH increase, loss of carbon dioxide and concentration of calcium in the liquid during flashing suggests that there is a high potential for calcite scaling after flashing (Figure 4.2-6). Because during the short term flow tests, samples for calcium analysis were collected after the fluids had at least partially boiled thereby removing some calcium by scaling, the exact scaling rate is uncertain at this time. Assuming an average of values derived from mineral equilibrium and downhole measurements by MTA, the calcite scaling rate at the maximum flow rate of OB-6 could be over 1 m^3/day. Most importantly, both the fluid chemistry at Germencik as well as experience in the nearby Kizildere field where the brine chemistry is similar suggest that calcite scaling should be addressed in order to prevent well bore damage and loss of formation permeability.

Fortunately, calcite scaling has been successfully mitigated using scale inhibitors especially designed for geothermal applications across the world. Downhole application of scale inhibitors has become routine in geothermal fields. The injection point is selected just below the flash point. Calcite scaling will be mitigated at Germencik by application of antiscalant, such as PowerChem's ***Geosperse 8466***, a severe-duty carbonate inhibitor directly into the single phase flowing brine (in the wellbore approximately 500 meters bgs). This scale inhibitor is selected because of its potential to mitigate low levels of silica scaling in the injection system. Because of the variability

of geothermal fluids, inhibitor concentrations and depths of application are typically determined on a site specific basis during field tests. Scale inhibitor rates and injection will be evaluated at Germencik during the long term flow testing scheduled to begin in late 2005 (see Appendix H).

Silica scaling potential is based on numerous factors including total silica concentration, flash conditions, pH, fluid dynamics and time which control the deposition of amorphous silica. The total silica concentration is controlled by reservoir temperature which controls total silica concentration based on equilibrium with quartz in almost all geothermal systems. The average Germencik reservoir fluid concentration (378 mg/kg) appears to be in equilibrium with quartz (Figure 4.2-7) above 230°C. Samples collected during the short term flow testing at pressures between 3 and 9 bars suggest that the fluids are still undersaturated with amorphous silica during sampling suggesting fluids have a low potential for silica scaling at the first flash at 6.2 bara. However, at the proposed low pressure flash, silica deposition may occur depending on the post flash pH, the flow dynamics and the time (kinetic-related) that the fluid remains above saturation.

These results suggest that silica scaling may potentially be an issue within in the brine discharge system from the 2nd flash and/or in the injection system. The borderline solubility suggests that an extensive silica scale mitigation program such as Brine Acidification is not indicated at this time. Calcite scale inhibitors capable of suppressing some silica scaling will be evaluated during additional flow testing. Elsewhere (e.g. East Mesa, California), minor silica scaling in the injection system is mitigated with an additional application of these scale inhibitors. During the long term flow testing, additional data on pH and silica scaling potential will be collected (Appendix H), and the need for silica scale mitigation will be evaluated at that time. This evaluation will be based on the long term flow test results, the sensitivity of injection pressures to silica scaling, and the potential impact to the project of injectivity (and related injection pressure). Additional scale mitigation upstream of the brine injection pumps could be included prior to wellfield start-up if testing indicates that it is required.

4.2.3.2 Gas Loading

The noncondensible gases dissolved in the reservoir fluids are a significant component of the high pressure steam flow to the turbine because they partition almost entirely into the vapor phase. The amount of gas in the vapor phase depends on the flash conditions affecting both the amount of steam produced and the gas partitioning. Based on gas partitioning at the proposed high pressure (6.2 bara) first flash and low pressure (1.24 bara) second flash of the brine discharged from the first flash, we anticipate the following gas concentrations:

Table 4.2-3 Estimated Gas Loading-Double Flash System

	Carbon Dioxide		Hydrogen Sulfide		Ammonia	
Weigh %	Steam	Brine	Steam	Brine	Steam	Brine
Reservoir (210-220 °C)	-	1.580	-	0.0029	-	0.0012
HP flash (160 °C)	14.8	0.014	0.0263	0.000086	0.011	0.00004
LP flash (105 °C)	0.14	0.000033	0.0008	0.000001	0.00035	not detectable

4.2.3.3 Steam purity

The steam purity to the turbine depends on the concentration of dissolved solids in the brine and the steam quality produced by the separators and steam polishing units which are proposed for the project. As discussed above, anticipated steam purity of the HP steam based on a phase separation efficiency of 0.1% liquid carryover would be 5 parts per million (ppm) total dissolved solids by weight and chloride will be approximately 1 to 1.5 ppm.
Brine carryover from the LP separation based on the same liquid carryover would produce approximately 6 ppm. These values can be readily reduced by steam polishing equipment and are unlikely to present an issue for turbine scaling or corrosion.

4.2.3.4 Hydrogen sulfide

Hydrogen sulfide is a colorless gas which is toxic to humans at high concentrations and is a common constituent of geothermal noncondensible gases. It is detectable by smell to most humans at 5 to 30 ppb and eye irritations can be detected at 10 ppm, eye damage at 47 ppm followed by respiratory failure and death at very high exposures (Air Quality guidelines Chapter 6.6 Hydrogen Sulfide, WHO, 2000). Hydrogen sulfide is a component of air pollution (especially when converted to Sulfur dioxide in air), however it presents a more immediate concern to the geothermal industry as a health and safety issue if inhaled at high concentrations. Fortunately, the circumstances which might produce is very rare. Hydrogen sulfide is primarily regulated by ambient air concentration. These Ambient Air Quality Standards are typically set at the odor threshold of 30 ppb (California OEHHA) or 5 ppb (WHO 2000) or at an a "no significant health risk" level of 100 ppb (WHO, 2000) although the total emission levels are sometimes regulated especially in urban areas of the U.S.

Although the total gas concentrations are relatively high at Germencik, the amount of hydrogen sulfide in the gas is very low. Hydrogen sulfide makes up 0.026 wt % of the HP steam and 0.0008 wt % of LP steam (see Table above in Section 4.3.2.2). Approximately 54.3 kg/hr (119 lbs/hr) from the high pressure steam and 1.5 kg/hr (3.32 lbs/hr) from low pressure steam will enter the condenser and less than 90 % of the total or less than 50 kg/hr will be vented through the cooling

tower. Natural air dispersion is most likely to disperse the hydrogen sulfide at these emission rates to nondetectable levels at the ground.

Concerns related to hydrogen sulfide are readily addressed within the geothermal industry by measuring ambient air concentrations in the vicinity of the power plant using simple portable or stationary ambient hydrogen sulfide monitors. These can also be used during flow testing to insure that workers are not exposed to hazardous levels of hydrogen sulfide. During February and March, 2005 flow testing when up to 13 kg/hr of hydrogen sulfide was being emitted from the silencer, no hydrogen sulfide odor was discernable suggesting that the concentrations were less than 30 ppb despite an emission height of less than one-third of the planned cooling tower height.

4.2.3.5 Potentially Corrosive Steam

The steam condensate in some geothermal systems is highly corrosive. The steam condensate in the Germencik Project is unlikely to be corrosive because: the reservoir temperature is moderate, steam/brine separation pressure is low (6.2 bara), and the steam lines are relatively short.

4.2.3.6 Cooling Tower Drift

The cooling tower drift is the emission of water droplets of circulating water directly from the top of the cooling tower. The proposed project cooling tower is estimated to have about 0.005% drift or 1000 kg/day of condensate will be emitted and dispersed through the top of the cooling tower. Only components of the steam condensate and any cooling tower treatment will be emitted. Because of the relatively low separation pressures, low brine salinity, the steam condensate is relatively benign. Boron and arsenic are semi-volatile components of the geothermal fluid that partition into steam and therefore end up in the cooling tower circulation water and are emitted in cooling tower drift. Although boron concentrations in brine might average above 70 mg/kg (after double flash, the steam condensate will be a fraction of that (probably averaging about 0.225 mg/kg, based on steam condensate samples from the short term flow test collect near HP flash conditions and undetectable concentrations predicted for LP steam). The cooling tower boron emissions based on these assumptions will be less than 10 grams/day. Arsenic emissions will be less than 0.25 grams/day. These levels are not unlikely to cause concern or to require additional drift elimination.

4.3 RESERVOIR

4.3.1 Reservoir Properties and Characteristics

Several favorable reservoir properties and characteristics are required for a geothermal resource to be a commercially viable reservoir suitable for the production of electricity. Among these are: reasonably high permeability at economically drillable depths; some level of permeability extending to depth or laterally; it is favorable if the reservoir is recharged by upwelling hot fluid or cooler encroaching fluids at the edges of the reservoir (or both); and in most cases the reservoir must contain a suitable volume of rock heated to suitable temperature. From the review of existing

data and the newly acquired data from the short term flow testing, Germencik was found to possess all of the needed properties and characteristics of a commercial geothermal reservoir. Furthermore, the properties and characteristics of the Germencik reservoir are consistent with commercial grade geothermal resources worldwide.

The static reservoir pressure at 1000 meters below sea level is fairly uniform through the field and averages 114.3 bar,g. The relative uniformity of the static reservoir pressure suggests that all wells intersect the same reservoir (or that there is some interconnection between different sub-reservoirs). The average maximum static reservoir temperature in the six tested wells is 218.6 deg C. During the flow tests of the six wells, the average flowing wellhead enthalpy was 892.2 kJ/kg.

The 2005 Short Term Flow Testing at Germencik provided static and dynamic well surveys of known quality and controlled flow which, in conjunction with previous static well surveys by MTA, provided data to base estimates of reservoir characteristics. For example, static temperature surveys helped to identify the top of the reservoir. The static temperature profiles change from a conductive gradient to an isothermal convective gradient at the top of the reservoir and remain mostly isothermal within the reservoir. The top of the conductive zone is thus an estimation of the top of the reservoir. During the dynamic temperature surveys during the flow testing, the first inflow into the wells occurs near the top, or below the top, of the reservoir. The reservoir is considered to be the entire volume of heated rock regardless of permeability. The production zone (inflow fracture) within the reservoir is a high permeability feature that allows the fluid in the reservoir to flow to the well.

In the existing wells, with one exception, the first inflow fracture is encountered at depths between 850 and 1300 meters. The exception is well OB-4 which encountered the top of the reservoir at less than 300 meters and may intersect a localized upflow zone. The top of the reservoir appears to be tilted, becoming deeper near well OB-8. Well OB-8 encounters the first production zone at approximately 1300 meters.

Similar to many geothermal reservoirs, Germencik exhibits a high degree of heterogeneity in reservoir properties such as permeability. The calculated downhole productivity indices for all the tested wells range over two orders of magnitude. The lowest productivity index was 1.6 tph/bar, measured at well OB-7, a fraction of the highest productivity index of 145.8 tph/bar measured at well OB-6. The test data allowed permeability estimates to be made for each of the six tested production wells. The productivity index for OB-7 translates into permeability-thicknesses of 2,650 md-feet. The productivity index for OB-6 translates into permeability-thicknesses of 322,400 md-feet. Generally, geothermal production wells with productivity indices below 10,000 md-feet are non-commercial. Of the existing Germencik wells only OB-6, OB-8, and OB-9 have permeability-thickness over 10,000 md-feet and can be considered commercial wells in their present condition.

Wells OB-3, OB-5, and OB-7 were non-commercial but showed some permeability. These wells are not likely useful in geothermal production, but they do serve to enhance the outlook of total reserves at Germencik. In addition, if some of the well-mechanics related problems in these wells

can be reversed and true permeabilities can be measured, they may be higher. Regardless, there is likely enough low level permeability in these areas to allow fluids to migrate over time to the commercial-grade production wells, thus provide long-term pressure support and reserves. The low level permeability areas also provide a heated buffer zone to heat cool waters that may migrate from the peripheral areas during long term commercial production.

Table 4.3.1 - 1
Germencik Reservoir Properties

Well	Productivity Index (tph/bar)	Permeability Thickness (md-feet)	Static Pressure (bar,g at 1000 meters)	Maximum Static Temperature (deg C)	Flowing Wellhead Enthalpy (kJ/kg)
OB-3	2.4	4,150	107.0	221.4	841
OB-5	1.7	2,850	106.2	212.9	911
OB-6	145.8	322,400	104.4	216.9	908
OB-7	1.6	2,650	109.2	223.3	916
OB-8	9.9	18,750	110.0	220.9	905
OB-9	20.8	41,250	108.3	216.4	872

4.3.2 Overall Reservoir Capacity

In addition to the individual well productivities evaluated during the Short Term Flow Testing, currently available temperature data indicate that the reservoir is sufficiently large (has sufficient capacity) to support the power plant over the life of the project. Additional data regarding the reservoir capacity will be provided during the long term multiple well interference testing (Appendix H) currently scheduled for late 2005 at Germencik. Long term multiple well testing will provide information about the interaction among the wells and the area of influence of the production wells, which will enable estimates of well density (how many wells can be drilled in the project area) and the long term capacity of the reservoir. Additional drilling and testing of production and injection wells for this project will also provide additional information about the size and capacity of the Germencik resource.

Full-field numerical reservoir simulation is the most widely accepted technique in the geothermal industry for estimating the overall capacity and the testing of various development plans for a

geothermal resource. The basis of a full-field reservoir simulation, among other information, is a significant database of production data and/or long term well test results. As is the case at Germencik, these items are usually not available at the feasibility stage of geothermal resource development. In lieu of a reservoir simulation, a Monte Carlo simulation was completed for this resource assessment to make an initial estimate of overall resource capacity of the Germencik geothermal resource.

The statistical Monte Carlo simulation process involves first making estimates of the ranges of volume of reservoir rock and other properties such as reservoir temperature, the ability to recover reservoir heat, and the efficiency of converting recovered heat into electrical power. The Monte Carlo approach utilizes initial estimates for these parameters which then vary over a range. Many simulations are made allowing the unknown variables to take random values within their respective ranges. Because the exploration of the Germencik Geothermal Reservoir has not defined the limits of the reservoir or the temperature anomaly (in either area or depth), the estimated reservoir area is assumed to range between one half and twice the area of known high temperatures (inside the 170° C contour). For the reservoir thickness, depths between 250 and 2000 meters were considered in the reservoir volume estimation. At each depth level (between 250 and 2000 meters), the area inside the 170° C contour was used as the reservoir boundary. Because the position of the 170° C contour is conservatively estimated, the approach used is considered to be conservative. Future exploration drilling may enlarge the area inside the 170° C contour and thus increase the estimate of resource capacity.

Figure 4.3.2 – 1 shows the frequency distribution of the 2000 realizations (N=2000) that were run for the Monte Carlo simulation. Figure 4.3.2 -2 shows the cumulative frequency of the Monte Carlo simulation results. Because the Monte Carlo approach is statistical, rather than deterministic, results are expressed in probabilistic terms.

The results of the Monte Carlo simulation for the Germencik resource indicate:

- There is a 90% probability that the resource potential is greater than 34.1 MW gross for a 40 year project period.

- There is a 50% probability that the resource potential is greater than 72.6 MW gross for a 40 year project period.

Table 4.3.2 - 1
Germencik Monte Carlo Simulation
Parameter Input and Probability Type

Parameter	Best Guess (Mode)	Probability Distribution (Type)	Minimum Value	Maximum Value
Rejection Temperature (deg C)	104.4	Single Valued	-	-
Total Project Life (years)	40	Single Valued	-	-
Plant Capacity Factor (fraction)	0.9	Single Valued	-	-
Reservoir Volume (cu. meters)	6.3826E+09	Triangular	3.1913E+09	1.2765E+10
Reservoir Specific Heat (kJ/kg-deg C)	0.9839	Uniform	0.9211	1.0467
Reservoir Rock Density (kg/cu.meter)	2656.6	Uniform	2600.4	2712.8
Average Reservoir Temperature (deg C)	204.4	Triangular	193.3	215.6
Heat Recovery Factor (fraction)	0.375	Triangular	0.250	0.500
Plant Conversion Factor (fraction)	0.115	Uniform	0.11	0.12

4.3.3 Well Characteristics

Well OB-1

Well OB-1 has 8 5/8-inch casing to 581 meters depth, 5 3/4-inch casing to 960 meters depth and 5 1/2-inch slotted liner from 960 meters to T.D. (Total Depth) of 1001 meters. This well was not tested in 1984 due to the noted well problems. Based on field observations in the summer of 2004, OB-1 is not capable of safe production as currently constructed. This well is not considered in either testing operations or future production/injection service. OB-1 was not tested in 2005.

Well OB-2

Well OB-2 has 9 5/8-inch casing to 729 meters depth and 7 3/4-inch slotted liner from 680 meters to T.D. (Total Depth) of 975 meters. OB-2 was not tested in 2005.

Well OB-3

OB-3 Static Pressure and Temperature

Well OB-3 has 8 5/8-inch casing to 657 meters depth and 5 3/4-inch slotted liner from 640 meters to T.D. (Total Depth) of 1196 meters. The static pressure and temperature survey of well OB-3 was completed by MTA on 2/18/2005 (Appendix B, Table B.1 and Figure B.1). The survey was completed to 1190 meters depth, which is near the T.D. of this well.

The static survey of OB-3 shows a thermally conductive zone from surface to approximately 800 meters. Below 800 meters, the static survey shows an isothermal zone with a temperature of

approximately 221 °C. An isothermal zone is a classic indication of a convective geothermal reservoir zone.

OB-3 Production Test Data

Well OB-3 was tested by flowing through a nominal 8" (20.3 cm) I.D. (Inner Diameter) James tube, into an atmospheric separator, and through a 61 cm square notch weir. The brine flowed out of the weir box into a temporary pipeline which drained by gravity into the river. The OB-3 flow test was conducted March 8 to 9, 2005 and was completed without any shut-downs. Data from the production portion of the test are presented in Appendix D (Tables D.1 and D.2).

Well OB-3 Production Test:
Total Flow Time = 48.1 hours
Static Pressure and Temperature Survey to 1190 meters, before flow test
Dynamic Pressure and Temperature Survey to 1190 meters, at 70% flow
Pressure Buildup Survey at 800 meters
Fluid Samples: Sample #1 at 100% flow, Sample #2 at 70% flow, Sample #3 at 90% flow, and Sample #4 at 100% flow.

OB-3 Dynamic Pressure and Temperature Surveys

The dynamic pressure and temperature survey on well OB-3 (Appendix C, Table C.1 and Figure C.1) was performed by MTA on March 9, 2005, which was near the end of the flow test. At the start of the survey, the well was throttled to approximately 70% of maximum flow. Well OB-3 has a 5 3/4-inch slotted liner completion (with the liner top at approximately 640 meters). There are two blank sections (no slots) in the slotted liner: one blank section from 640 to 722 meters, and another from 968 to 988 meters. During the dynamic survey, the well needed to be further throttled and then opened again in order to allow the tool to pass through these small I.D. sections.

The dynamic temperature survey shows an unstable, irregular temperature profile. One reason for this behavior is that the well was reacting to the additional throttling that was done to pass the survey tool through the blank liner sections. Another reason is that the wellhead pressure (and flow rate) was trending downward during the entire running of the dynamic survey, which was probably caused by the survey tool interfering with the flow. With an unstable flow rate, it was not possible to have a stabilized dynamic pressure and temperature survey.

The brine and steam flow rate during the dynamic survey (approximately 70% of maximum flow) is estimated to be 98.2 t/hr at a flowing wellhead pressure 17.40 kg/cm^2,g. At approximately 70% of maximum flow, approximately 201.5 °C single-phase water enters the well at 1150 meters and flows up the well to a flash depth of approximately 800 meters. At higher flow rates, and thus greater pressure drawdown, the flash depth would be deeper.

Comparing the static and dynamic pressure profiles on OB-3, there was approximately 40.1 bar of downhole pressure drawdown during the dynamic survey. Total mass flow during the dynamic

survey was approximately 98.2 t/hr. This indicates that OB-3 has a downhole formation productivity index of 2.4 t/h/bar. This is a low productivity index and indicates low formation permeability, plugged formation, plugged slotted liner, or possibly a combination of these effects.

OB-3 Well Capacity and Recommendations

The production test data and the pressure and temperature surveys for OB-3 were interpreted together and integrated make estimations of its production deliverability (Appendix E, Table E.1 and Figure E.1). OB-3 produces fluid with an average wellhead enthalpy of approximately 840.7 kJ/kg, which is equivalent to single-phase water at approximately 197.4 °C.

The maximum flow capacity of OB-3 is 125.2 t/hr of two-phase fluid at a wellhead pressure of 2.9 kg/cm^2,g. At this maximum flow rate, the flash depth would probably be close to the producing fracture, and may be flashing in the formation. Due to scaling potential in this field, it is unlikely that a well would continue to flow long-term with flashing in the formation. OB-3, if throttled to a lower flow rate (and higher wellhead pressure) may be suitable as a long-term production well at a modest level of production.

MTA informed Geologica that OB-3 was tested in the past and showed declining production due to scale. The well was cleaned and production was restored. MTA said the well was then further tested (without scale inhibitor) until it declined again. The tested was then stopped and the well remained in that condition until it was produced as part of the testing reported here. If OB-3 is scaled, cleaning the well may increase the productivity. Using the combination of geochemical sampling results from this testing and additional data from MTA on the level and duration of the previous flow period after the clean-out testing may allow for an evaluation of the potential level of damage related to scaling.

OB-4

Well OB-4 has 11 3/4-inch casing to 220.5 meters depth and 8 5/8-inch slotted liner from 210 meters to T.D. (Total Depth) of 285 meters. Based on field observations in the summer of 2004, OB-4 is not capable of safe production as currently completed and was not tested in 2005. The well has not been considered in either testing operations or future production/injection service. .

Well OB-5

OB-5 Static Pressure and Temperature

Well OB-5 has 8 5/8-inch casing to 930.5 meters depth and 7 3/8-inch open hole to T.D. of 1302 meters. The static pressure and temperature survey of well OB-5 (Appendix B, Table B.2 and Figure B.2) was completed by MTA on 2/19/2005. The static pressure and temperature survey could be completed to 1000 meters depth (similar to the 950 meter depth reached during a survey performed in the 1980s).

The static survey of OB-5 shows a thermally conductive zone from surface to approximately 600 meters. Below 600 meters, the static survey shows a transition to a more convective, isothermal reservoir zone. However, at the greatest depth surveyed (1000 meters), OB-5 is not yet isothermal, suggesting higher temperatures may occur below 1000 meters. The highest temperature measured in OB-5 was 212.9 °C at this depth.

OB-5 Production Test Data

Well OB-5 was tested by flowing through a nominal 6" (15.8 cm) I.D. James tube, into an atmospheric separator, and through a 61 cm square notch weir. The brine flowed out of the weir box into a temporary pipeline which drained by gravity into the river. The OB-5 flow test was conducted March 10 to 12, 2005 and was completed without any shut-downs. Data from the production portion of the test are presented in Appendix D (Tables D.3 and D.4).

Well OB-5 Production Test:
Total Flow Time = 44.4 hours
Static Pressure and Temperature Survey to 1000 meters, before flow test
Dynamic Pressure and Temperature Survey to 1000 meters, at 100% flow
Pressure Buildup Survey at 1000 meters
Fluid Samples: Sample #1 at 100% flow, Sample #2 at 70% flow, Sample #3 at 90% flow, and Sample #4 at 100% flow.

OB-5 Dynamic Pressure and Temperature Surveys

The dynamic pressure and temperature survey of OB-5 (Appendix C, Table C.2 and Figure C.2) was conducted by MTA on March 12, 2005 to a depth of 1000 meters. The flowing wellhead pressure during the survey was approximately 4.9 kg/cm^2,g and the total mass flow rate (100% of maximum flow) was approximately 135.5 t/hr.

The dynamic pressure survey of OB-5 (Figure C.2) shows that the well is has a two-phase fluid gradient down to the maximum depth of the survey which was 1000 meters. The flowing downhole pressure at 1000 meters is 24.4 bar,g at a flowing downhole temperature of 205.6 °C. Although this pressure is higher than the pure water bubble point for that temperature, this is probably the result of the high gas content. Fluids are flashing below the depth of the survey (1000 meters) and possibly in the formation.

Comparison of the static and dynamic pressure profiles of OB-5 indicates that there was approximately 81.8 bar of downhole pressure drawdown during the dynamic survey. The flow during the dynamic survey was approximately 135.5 t/hr indicating that OB-5 has a downhole formation productivity index of 1.7 t/hr/bar. This is a low productivity index and indicates low formation permeability, plugged formation, plugged slotted liner, or possibly a combination of these effects.

OB-5 Well Capacity and Recommendations

The production test data and the pressure and temperature surveys for OB-5 were interpreted together and integrated make estimations of its production deliverability (Appendix E, Table E.2 and Figure E.2). OB-5 produces fluid with an average wellhead enthalpy of approximately 911.0 kJ/kg, which is equivalent to single-phase water at approximately 212.9 °C.

The maximum flow capacity of OB-5 is 135.5 t/hr of two-phase fluid at a wellhead pressure of 4.9 kg/cm^2,g. At this maximum flow rate, the flash depth would probably be close to the producing fracture, and may be flashing in the formation. Due to scaling potential in this field, it is unlikely that a well would continue to flow long-term with flashing in the formation. OB-5 exhibits a low formation productivity and does not appear to be a commercial geothermal well for power generation.

Well OB-6

OB-6 Static Pressure and Temperature

Well OB-6 has 8 5/8-inch casing to 896.6 meters and 7 3/8-inch open hole to T.D. of 1100.1 meters. The static pressure and temperature survey of well OB-6 was completed by MTA on 2/22/2005 (Appendix B, Table B.3 and Figure B.3). The survey was completed to 1070 meters depth, which is near T.D. of this well.

The static survey of OB-6 shows a shallow temperature reversal at approximately 100 meters. Below 200 meters, the static temperature appears to be mostly conductive to 700 meters. At 700 meters, the static temperature shows an inflection point and becomes almost isothermal. Below 900 meters, the static temperature shows a classic reservoir zone isothermal section. The temperature in the isothermal zone below 900 meters is 216.8 °C.

OB-6 Production Test Data

Well OB-6 was tested by flowing through a nominal 8" (20.3 cm) I.D. James tube, into an atmospheric separator, and through a 61 cm square notch weir. The brine flowed out of the weir box into a cement-lined trench which drained by gravity into the river. The OB-6 flow test was conducted February 25 to March 1, 2005. During the OB-6 flow test, there were mechanical problems that caused two shut-down periods accounting for 44 hours of time. The flow test was continued and all testing goals were accomplished for this well. Data from the production portion of the test are presented in Appendix D (Tables D.5 and D.6).

<u>Well OB-6 Production Test:</u>
Total Flow Time = 47.2 hours
Static Pressure and Temperature Survey to 1070 meters, before flow test
Dynamic Pressure and Temperature Survey to 1070 meters, at 50% flow

Pressure Buildup Survey at 1000 meters
Fluid Samples: Sample #1 at 50% flow, Sample #2 at 100% flow, Sample #3 at 90% flow, and Sample #4 at 50% flow.

OB-6 Dynamic Pressure and Temperature Surveys

The dynamic pressure and temperature survey of OB-6 (Appendix C, Table C.3 and Figure C.3) was conducted by MTA on March 1, 2005 to a depth of 1070 meters. The flowing wellhead pressure during the survey was approximately 31.3 kg/cm^2,g and the total mass flow rate (50% of maximum flow) was approximately 204.1 t/hr.

The dynamic temperature survey of well OB-6 (Figure C.3) shows a temperature profile that indicates that OB-6 has a single fluid entry at 1000 meters. This entry supplies single-phase water at 216.3 °C. The pressure profile produced by the dynamic pressure survey of well OB-6 (Figure C.3) at 50% of maximum flow indicates single phase fluid flowing above from 1000 meters. At approximately 300 meters below the surface, the pressure profile shows a change in slope indicating a transition to two-phase flow (water and non-condensable gas).

There was approximately 1.4 bar of downhole pressure drawdown during the dynamic survey relative to the static survey. The flow rate during the dynamic survey was approximately 204.1 t/hr. This indicates that OB-6 has a downhole formation productivity index of 145.8 t/hr/bar. This is a high productivity index and indicates a commercial grade geothermal well.

OB-6 Well Capacity and Recommendations

The production test data and the pressure and temperature surveys for OB-6 were interpreted together and integrated in order to estimate well deliverability (Appendix E, Table E.3 and Figure E.3). OB-6 produces fluid with an average wellhead enthalpy of approximately 907.8 kJ/kg, which is equivalent to single-phase water at approximately 212.2 °C.

The maximum flow capacity of OB-6 is 455.3 t/hr of two-phase fluid at a wellhead pressure of 11.0 kg/cm^2,g, but this maximum production appears to be limited by the relatively small size of its casing (8 5/8-inch). At it higher flow rates, OB-6 exhibits the classic characteristics of choked two-phase flow. This condition is observed in geothermal wells with high reservoir pressure and high formation permeability, such as occurs in OB-6. Well OB-6 is a highly productive geothermal well, is the most productive well in the Germencik field, and is well suited for use in electricity production.

Well OB-7

OB-7 Static Pressure and Temperature

Well OB-7 has 9 5/8-inch casing to 1389.5 meters and 8 1/2-inch open hole to T.D. of 2398 meters. The static pressure and temperature survey of well OB-7 was completed by MTA on 2/20/2005. The static pressure and temperature survey on well OB-7 could be completed to 1515 meters depth, leaving only 125.5 meters of surveyed open hole.

The static survey of OB-7 shows a thermally conductive zone from surface to approximately 850 meters. Below 850 meters, the static survey shows a transition to isothermal. Below 1000 meters, the static survey of OB-7 shows an isothermal zone with a maximum temperature of 223.3 deg C. The upper approximately 400 meters of this isothermal zone is sealed behind the 9 5/8 inch casing.

OB-7 Production Test Data

Well OB-7 was tested by flowing through a nominal 6 inch (15.8 cm) I.D. James tube, into an atmospheric separator, and through a 61 cm square notch weir. The brine flowed out of the weir box into a cement-lined transfer pond built on location. The brine was then pumped into a temporary pipeline which drained into the river. The OB-7 flow test was conducted March 18 to 20, 2005 and was completed without any shut-downs. Data from the production portion of the test are presented in Appendix D (Tables D.7 and D.8).

Well OB-7 Production Test:
Total Flow Time = 44.4 hours
Static Pressure and Temperature Survey to 1515 meters, before flow test
Dynamic Pressure and Temperature Survey to 135 meters, at 70% flow (obstruction in well)
Pressure Buildup Survey not completed (obstruction in well)
Fluid Samples: Sample #1 at 100% flow, Sample #2 at 100% flow, Sample #3 at 90% flow, and Sample #4 at 70% flow.

OB-7 Dynamic Pressure and Temperature Surveys

The dynamic pressure and temperature survey of OB-7 (Appendix C, Table C.4 and Figure C.4) was conducted by MTA on March 20, 2005 to a depth of 135 meters. The flowing wellhead pressure during the survey was approximately 22.0 kg/cm^2,g and the total mass flow rate (70% of maximum flow) was approximately 99.8 t/hr.

The dynamic survey on OB-7 could not be completed due to a severe obstruction in the hole encountered at 135 meters. When running the dynamic pressure and temperature survey, MTA was unable to work past an obstruction at 135 meters. MTA then pulled out of the hole with the survey tool and re-entered the hole with only a sinker bar. The sinker bar became caught in the obstruction at 135 meters, the wire broke and the sinker bar was lost in the hole. MTA then rigged down the surveying equipment and shut the well down.

Because the dynamic survey could not be completed, a comparison of the static and dynamic pressure profiles on OB-7 is not possible. However, by projecting the OB-7 data from 135 meters to T.D., and using the shape of the other wells' surveys, an estimated was made of the downhole flowing pressure on OB-7. Using this method, there was approximately 64.3 bar of downhole pressure drawdown during the dynamic survey. The flow during the dynamic survey was approximately 99.8 t/hr. This indicates that OB-7 has a downhole formation productivity index of 1.6 tph/bar. This is a low productivity index and indicates low formation permeability, plugged formation, fill in the open hole, or possibly a combination of these effects. This low productivity index is also consistent with evidence from the static survey suggests that the lower 883 meters of the open hole is obstructed and that the upper 400 meters of the reservoir may be behind casing.

OB-7 Well Capacity and Recommendations

The production test data and the pressure and temperature surveys for OB-7 were interpreted together and integrated make estimations of its production deliverability (Appendix E, Table E.4 and Figure E.4). OB-7 produces fluid with an average wellhead enthalpy of approximately 916.0 kJ/kg, which is equivalent to single-phase water at approximately 214.0 deg C.

The maximum flow capacity of OB-7 is 148.0 t/hr of two-phase fluid at a wellhead pressure of 5.9 kg/cm^2,g. The analysis here is hindered by the fact that the dynamic survey could not be completed due to an obstruction in the well. Before the obstruction became apparent, OB-7 had the possibility of being a commercial production well. OB-8 and OB-9 both appear to produce from two and three productive zones respectively. In OB-7, the shallower zone (approximately 1300 meters below surface) that seems to contribute at least 50% to the flow of OB-8 appears to be cemented behind the 9 5/8 inch casing. It is possible that this zone could be jet-perforated to enhance the production from OB-7 increasing the productivity to commercial levels. Currently, with a severe obstruction at 135 meters OB-7 is not a commercial geothermal well.

Well OB-8

OB-8 Static Pressure and Temperature

Well OB-8 has 9 5/8-inch casing to 1298.7 meters and 7-inch slotted liner to T.D. of 2000 meters. The static pressure and temperature survey of well OB-8 was completed by MTA on 2/25/2005 to 1675 meters depth (a similar survey performed on OB-8 in 1990 reached a depth of approximately 1950 meters).

The static survey of OB-8 shows some fluctuations from surface to 400 meters. From 400 meters to 600 meters, the static survey shows a transition to a conductive gradient. The temperature profile of OB-8 is then conductive from 600 to 1300 meters. At 1300 meters, there is a peak temperature of 221 °C. From 1300 to 1400 meters, there is a temperature inversion. Below 1400 meters, the static temperature is approximately isothermal at approximately 214 °C.

OB-8 Production Test Data

Well OB-8 was tested by flowing through a nominal 8" (20.3 cm) I.D. James tube, into an atmospheric separator, and through a 61 cm square notch weir. The brine flowed out of the weir box into a cement-lined transfer pond built on location. The brine was then pumped into a temporary pipeline which drained into the river. The OB-8 flow test was conducted March 14 to 16, 2005 and was completed without any shut-downs. Data from the production portion of the test are presented in Appendix D (Tables D.9 and D.10).

Well OB-8 Production Test:
Total Flow Time = 47.9 hours
Static Pressure and Temperature Survey to 1675 meters, before flow test
Dynamic Pressure and Temperature Survey to 1675 meters, at 50% flow
Pressure Buildup Survey at 1300 meters
Fluid Samples: Sample #1 at 100% flow, Sample #2 at 100% flow, Sample #3 at 90% flow, and Sample #4 at 70% flow.

OB-8 Dynamic Pressure and Temperature Surveys

The dynamic pressure and temperature survey of OB-8 (Appendix C, Table C.5 and Figure C.5) was conducted by MTA on March 16, 2005 to a depth of 1675 meters. The flowing wellhead pressure during the survey was approximately 28.8 kg/cm^2,g and the total mass flow rate (50% of maximum flow) was approximately 138.3 t/hr.

The dynamic temperature survey of well OB-8 (Figure C.5) shows a temperature profile that indicates OB-8 has two single-phase fluid entries within the surveyed depth. Single-phase liquid at 210.8 °C is flowing up the well from below 1675 meters (the deepest point surveyed). At a depth between 1300 and 1400 meters, a second higher temperature fluid entry (approximately 221 °C) brings the mixed temperature up to 215.6 °C. The single-phase 215.6 °C single-phase fluid then travels up the well. At approximately 300 meters, the pressure profile shows a change in slope indicating a transition to two-phase flow (water and non-condensable gas).

Comparing the static and dynamic pressure profiles on OB-8, indicates that there was approximately 14.0 bar of downhole pressure drawdown during the dynamic survey. The flow during the dynamic survey was approximately 138.3 t/hr. This indicates that OB-8 has a downhole formation productivity index of 9.9 t/hr/bar. This is a moderately high productivity index and indicates a commercial grade geothermal well.

OB-8 Well Capacity and Recommendations

The production test data and the pressure and temperature surveys for OB-8 were interpreted together and integrated make estimations of its production deliverability (Appendix E, Table E.5 and Figure E.5). OB-8 produces fluid with an average wellhead enthalpy of approximately 904.6 kJ/kg, which is equivalent to single-phase water at approximately 211.5 °C. OB-8 appears to

produce from two zones one at approximately 221°C at 1300 to 1400 meters and one below 1675 meters below the surface at about 211 °C.

The maximum flow capacity of OB-8 is 321.8 t/hr of two-phase fluid at a wellhead pressure of 7.7 kg/cm^2,g. Well OB-8 is a highly productive geothermal well suitable for use in electricity production.

Well OB-9

OB-9 Static Pressure and Temperature

Well OB-9 has 9 5/8-inch casing to 896.3 meters depth and 7-inch slotted liner to T.D. of 1460 meters. The static pressure and temperature survey of well OB-9 was completed by MTA on 3/8/2005, three days after the end of the flow test. The static survey on OB-9 was conducted after the flow test because an obstruction prevented the logging tool from running down the hole. The flow test apparently loosened and cleared the obstruction in the well allowing surveys. The static survey was then completed to 1450 meters depth or approximately the T.D.

The static temperature survey of OB-9 shows temperature profile having some fluctuations from surface to 400 meters. The temperature profile is approximately conductive from 400 to 1000 meters. The maximum recorded temperature is 216 °C at 1000 meters which is an inflection point. The temperature gradient reverses to 1400 meters. Below 1400 meters, there appears to be a classic isothermal reservoir zone section at less than 200 °C.

OB-9 Production Test Data

Well OB-9 was tested by flowing through a nominal 8 inch (20.3 cm) I.D. James tube, into an atmospheric separator, and through a 61 cm square notch weir. The brine flowed out of the weir box into a temporary pipeline which drained by gravity into the river. The OB-9 flow test was conducted March 3 to 5, 2005. During the OB-9 flow test, there was a mechanical problem requiring a 2-hour shut-down. The OB-9 flow test was continued after 2 hours and all testing goals were accomplished. Data from the production portion of the test are presented in Appendix D (Tables D.11 and D.12).

<u>Well OB-9 Production Test:</u>
Total Flow Time = 47.5 hours
Static Pressure and Temperature Survey to 1450 meters, three days after flow
Dynamic Pressure and Temperature Survey to 1450 meters, at 50% flow
Pressure Buildup Survey at 1050 meters
Fluid Samples: Sample #1 at 100% flow, Sample #2 at 50% flow, Sample #3 at 70% flow, and Sample #4 at 50% flow.

OB-9 Dynamic Pressure and Temperature Surveys

The dynamic pressure and temperature survey of OB-9 (Appendix C, Table C.6 and Figure C.6) was conducted by MTA on March 8, 2005 to a depth of 1450 meters. The flowing wellhead pressure during the survey was approximately 27.5 kg/cm^2,g and the total mass flow rate (50% of maximum flow) was approximately 218.1 t/hr.

The dynamic temperature survey of well OB-9 (Figure C.6) shows a temperature profile that indicates OB-9 has three single-phase fluid entries within the surveyed depth. Single-phase liquid at 195.7 °C flows up the well from 1450 meters (the deepest point surveyed). At a depth between 1300 and 1400 meters, a second fluid entry supplies fluid bringing the mixed temperature up to 202.6 °C. At a depth between 900 and 1050 meters, a third fluid entry supplies fluid bringing the mixed temperature up to 208.5 °C. The single-phase 208.5 °C single-phase fluid then travels up the well. At approximately 300 meters, the pressure profile shows a change in slope indicating a transition to two-phase flow (water and non-condensable gas).

Comparing the static and dynamic pressure profiles on OB-9, there was approximately 10.5 bar of downhole pressure drawdown during the dynamic survey. The flow during the dynamic survey was approximately 218.1 t/hr. This indicates that OB-9 has a downhole formation productivity index of 20.8 t/hr/bar. This is a high productivity index and indicates a commercial grade geothermal well.

OB-9 Well Capacity and Recommendations

The production test data and the pressure and temperature surveys for OB-9 were interpreted together and integrated make estimations of its production deliverability (Appendix E, Table E.6 and Figure E.6). OB-9 produces fluid with an average wellhead enthalpy of approximately 872.3 kJ/kg, which is equivalent to single-phase water at approximately 204.4 °C. The well appears to produce fluid from three different entries.

The maximum flow capacity of OB-9 is 424.6 t/hr of two-phase fluid at a wellhead pressure of 9.5 kg/cm^2,g. Well OB-9 is a highly productive geothermal well suitable for use in electricity production.

4.3.4 Initial Production/Injection Rates

The short term flow testing at Germencik has shown that wells OB-6, OB-8, and OB-9 are highly productive, commercial grade geothermal wells suitable for use in electricity production. Wells, OB-1, OB-2, and OB-4 were not tested and are not believed to be capable of safe production. The other three tested wells, OB-3, OB-5, and OB-7 are either marginally commercial or non-commercial. Figure 4.3.4-1 shows an overlay plot with the preliminary deliverability curve for each of the six tested wells.

For each of the three non-commercial wells, there is an explanation and a possible way to increase production:

- Well OB-3 production (and associated wellhead pressure) may be increased to a commercial level by performing a well cleanout.
- Well OB-5 may be more productive if had it been drilled deeper and thus produced from more than one production zone.
- Well OB-7 production may be enhanced by jet-perforating the casing to allow production from shallower production zones as observed in OB-8 and OB-9. In the case of OB-7, the analysis is hindered by the lack of a dynamic pressure and temperature survey to total depth.

Of the three highly productive wells (OB-6, OB-8, and OB-9), well OB-6 is somewhat anomalous because the apparent formation permeability (as evidenced by formation productivity index) is much higher than in either OB-8 or OB-9. Well OB-6 is completed open-hole (without liner) while OB-8 and OB-9 have slotted liners. It is possible (but seems unlikely) that the slotted liners have affected the flow reducing apparent formation productivity (a skin effect). The maximum production flow rates of OB-6 and OB-9 were similar; however, OB-6, shows strong evidence of being in a two-phase choked flow condition at the higher flow rates (i.e. the production is limited by the casing I.D.). This phenomenon and the effect of larger casing was explored with wellbore simulation and is discussed later in this study.

OB-6 also produces from a single production zone whereas OB-8 produces from two zones and OB-9 produces from three zones. These zones appear to have only slightly different temperatures with the maximum temperatures at approximately 1000 meters (OB-6 and OB-9) and 1300 meters (OB-8) below the surface. It is not known at this time whether the multiple production zones represent multiple sub-reservoirs, or if they are simply vertically separated production zones within a single reservoir. Field measurements indicate that the reservoir fluids are chemically similar suggesting reservoir homogeneity. If future analysis of reservoir chemistry and geology verifies the presence of multiple reservoir zones, resource production and development potential may increase. Injection strategies could also be affected if multiple, unconnected reservoirs exist.

In summary, the short term flow testing identified three wells (OB-6, OB-8, and OB-9) capable of commercial production. Of the remaining wells tested (OB-3, OB-5, and OB-7), productivity is apparently limited by obstructions, less that optimum perforation placement, or shallow completion above the deeper reservoir. Well OB-5 is probably completed in an area of low productivity that may require additional drilling to confirm. Well productivity is summarized below. Formation productivity index is a measure of the total flow rate of a well per unit of downhole pressure drawdown. Formation productivity index is a function of several factors, such as the absolute permeability of the formation, density and viscosity of the fluid, and the resistance to flow of the completion of the well (slotted liner, screens, or formation damage).

Table 4.3.4 – 1
Productivity of Existing Germencik Wells

Well	Formation Productivity Index (t/hr/bar)	Estimated Wellhead Enthalpy (kJ/kg)	Equivalent Single-Phase Water Temperature (°C)	Maximum Total Flow Rate (t/hour)
OB-3	2.4	841	196	125
OB-5	1.7	911	213	135
OB-6	145.8	908	212	455
OB-7	1.6	916	214	148
OB-8	9.9	905	212	321
OB-9	20.8	872	204	424

4.3.5 Estimated Long Term Reservoir Performance

The deliverability of naturally flowing production wells in geothermal reservoirs world-wide tend to decline over time under long term production. If field-wide production deliverability falls below the level needed for the plant, a new production well must be drilled (or plant output will be reduced). Full field reservoir simulation is often used to estimate the long term rate of productivity decline, and how to manage it. Because full-field reservoir simulation is not available, a qualitative estimate of reservoir decline is used. Based on experience, the productivity decline is typically between 1% and 9% on an annual basis.

Based on an assumption of a moderate of 4% decline for Germencik, the first make up production well will need to be drilled in the eighth year of resource production. At project startup, the Germencik project will have excess production capacity and thus the production wells will be throttled at the wellhead valve. As the field gradually declines, the throttling will be reduced (the valves will be opened further). At some point, even with wells fully open, the minimum production requirements for the plant cannot be reached and the first make up production well will need to be drilled probably in the eighth year of the project. After the first drilled makeup well, an additional makeup well will be needed approximately every five to seven years.

5 Environmental Assessment

An Environmental Evaluation Report was prepared for the Germencik Geothermal project in 2001 in compliance with the Turkish 1993 Environmental Impact Assessment (EIA) Regulation. Based on the project description at that time, no significant environmental impacts were identified and the project was approved by the Turkish Ministry of the Environment and Forestry. Temporary soil loss, flora and fauna disturbance during construction were not considered significant. Additional environmental impacts related to the current project description will be evaluated in an addendum to the currently approved EER.

5.1 Regulatory Background

The main principles of environmental policy in Turkey include the management of natural resources and protection of human health while enabling continuous economic development. Turkish "Environment Law" was promulgated in 1983 establishing the general principles of this policy. The 1983 Environment Law (coded 2872) is intended to prevent and eliminate pollution, and to provide for the management of the natural and historical values and the land in such a way as to utilize and preserve resources for the future generations. The primary rules and regulations that affect this project are the Environmental Impact Assessment Regulation (EIAR) that became law on February 7,1993. The Turkish EIAR identified the administrative and technical principles governing the environmental impact assessment process. The primary environmental permitting and review process for industrial projects in Turkey is the preparation and approval of the project specific EIA. The EIA process evaluates possible impacts on environment of investment decisions and proposed activities of public or private organizations, institutions and agencies that may cause any harm to the environment and to asses the alternatives. The EIAR were updated in 1997 and 2003.

Other regulations complementary to the Environment Law and Public Health Law related' to electrical energy sector are:

- Air Quality Protection Regulation (AQPR) was formulated in line with the purpose and principles envisaged in the Environment Law and issued in November 1986
- Water Pollution Control Regulation
  Regulation set discharged limit values for different waste water streams
- Noise Control Regulation
- Control of Harmful Chemical Substances and Products Regulation
- Hazardous Waste Control Regulation

These regulations and related issues are addressed for new projects within the EIA process.

In addition to regulatory requirements, financial institutions considering investment in the project may require environmental assessment in order to comply with their procedures for managing environmental risks and liabilities and incorporating environmental and social considerations in

their investment process. Although there are commonalities, the specific environmental requirements for project financing vary for each institution. For example, International Finance Corporation (IFC; the World Bank institution dedicated to private industry) or the U.S. Export-Import (Ex-Im) Bank has specific environmental requirements which must be met in order to evaluate projects for investment or credit. The IFC requires that the Environmental Assessment (EA) of a project take into account natural environment (air, water, land flora and fauna), human health and safety; social aspects (involuntary resettlement, indigenous peoples, and cultural property); and global issues (climate change, ozone-depleting substances, pollution of international waters, impacts on biodiversity) that transcend national boundaries (IFC OP 4.01, October 1998) The Ex-Im Bank guidelines (Environmental Procedures and Guidelines Annex A) suggests that water use and quality, natural hazards, ecological resources, greenhouse gases, and socioeconomic and sociocultural framework be considered. Currently, Turkish EIAs focus on the major environmental issues and impacts (both positive and negative) and both human and biophysical environments of a specific project (Ilisu Engineering, April 2001).

Turkish EIA documents require seven major sections:

1. Purpose of the Project and Project Description,
2. Location of the Project
3. Existing Biophysical Environment
4. Existing Human Environment
5. Environmental Impacts and Mitigations
6. Public Participation
7. Summary

These are similar to the requirements of the IFC/World Bank EA which include:

1. Executive summary
2. Policy, legal, and administrative framework
3. Project description including the location and area of influence
4. Baseline Data Relevant physical, biological, and socioeconomic conditions before the project commences
5. Environmental impacts-positive and negative environmental impacts of the projects
6. Analysis of alternatives
7. Environmental action plan (EAP) including mitigation measures, monitoring and institutional strengthening

Environmental documentation prepared in compliance with the Turkish EIAR should address most of the components of environmental assessment required by the policies of international financial institutions. Upon review by financial agencies, some additional or updated evaluation are likely to be required in addition to the existing EIA documentation prepared for the Germencik project, but it is not anticipated to involve entirely new environmental studies. Specific additional concerns will depend on the financial institutions involved.

5.2 POTENTIAL ENVIRONMENTAL IMPACT ISSUES

The potential environmental issues related to the construction and operations of the Germencik Geothermal Project are relatively benign compared to other geothermal projects around the world for the following reasons:

- There are no surface manifestations directly related to the reservoir with existing use,
- The project area is currently developed and is not pristine,
- The chemistry of the geothermal fluid –both steam and brine – does not contain significant concentrations of toxic components present in other geothermal fluids such as hydrogen sulfide and heavy metals,
- Turkish energy and environmental policy is supportive of energy development and geothermal development,
- Jobs at the project are considered to be an important local economic benefit, and
- There do not appear to be any significant recreational, cultural or scenic sites near or within the project area.

The significance and risks of the major potential biophysical and human environmental issues related to the Germencik Geothermal Project are summarized in the following table. This is not meant to be a comprehensive list but rather a list of the major environmental issues typical of geothermal projects and their significance within the biophysical and human environmental setting at Germencik. Environmental Issues are divided into: 1) construction and drilling, and 2) operation and maintenance phases because the issues are significantly different. The environmental risk is characterized as low if there is no significant impact or if the impact is readily mitigated by standard geothermal industry practice, medium if it is a possibly significant issue and mitigation is possible but expensive or difficult, and high if the impact is significant and not mitigated.

Germencik Environmental Issues, Risks and Mitigations
Table 5.2-1

Construction and Drilling				
Environmental Issue	Environ-mental Risk	Proposed Mitigation	Issue identified in EER	Comment
Air Quality				
Drilling rigs and other heavy equipment-diesel emissions	low with mitigation	Proper equipment maintenance	yes	temporary impact
Dust	low with mitigation	dust control (water) as needed	yes	temporary impact
Steam venting (including brine carryover) during testing, blowdowns and start-up	low with mitigation	using low-carry over silencers and mufflers	no	temporary impact
Water Quality				
Brine Discharge to surface	low with	1. Limit surface	no	Project received

water during testing	mitigation	discharge to rainy season or inject, 2. groundwater monitoring (included in EER), 3. Discharge to sumps as possible		local and nation al State Water Directorate (DSI) permission to discharge 1 Oct 04-1 Apr 05
Spills	low with mitigation	1. Temporary Localized Spill Containment, 2. groundwater monitoring (included in EER)	no	
Subsurface leakage to groundwater during drilling	low with mitigation	1. Mud control/ cement casing program to maintain hole integrity, 2. groundwater monitoring (included in EER)	no	
Water Use	low	Groundwater monitoring (included in EER)	no	Use produced brine for drilling
Sump Leakage to groundwater	low with mitigation	Sump liner	no	
Biota				
Habitat disturbance	low		Yes but for less area	temporary, revised project increases area but type of impact
Biota disturbance/destruction	low	Fence off access	Yes without mitigation	temporary
Olive tree protection	low	Design to minimize tree destruction, replace as appropriate	yes	Project will comply with Turkish law and owner's request
Noise				
Construction	low	Proper equipment maintenance	yes	temporary impact
Drilling rigs and related machinery	low	International class drilling rigs contain noise control if needed, hearing	no	temporary impact

		protection provided for workers		
Flow Testing	low with mitigation	Hearing protection provided for workers	no	temporary impact
Geohazards				
Soil Loss/Erosion	low with mitigation	Minimize area of construction	Yes	
Induced Seismicity	low		Yes	Additional seismic activity unlikely-already active area
Hydrothermal Eruptions	low	Minimize construction in areas of shallow high temperature	No	Not likely due to geologic conditions
Subsidence	low		No	Not likely due to geologic conditions
Health & Safety and Hazardous Materials				
Spills	low with mitigation	Regulations will be followed	No	Few hazardous materials used
Worker Exposure	low with mitigation	Worker safety regulations will be followed	No	
Accidents	Low with mitigation	Worker safety regulations will be followed	yes	
Human Environment				
Land use	low with mitigation	Minimize use of agricultural land and surface area of all facilities	Yes	Revised project has additional impacts due to additional area such as for wellpad construction
Visual Impact	low with mitigation	Landscaping	Yes	Revised project has additional impacts due to cooling tower, larger plant and more well pads,piping, etc.
Employment	moderate		Yes	Temporary and long term job

				creation
Other Economic Factors	moderate		yes	Provides power from local resources, reduces air pollution for power generation
Project Operation-Transmission Line, Power Plant and Wellfield				
Air Quality				
Cooling Tower Gas Emission predominantly carbon dioxide with trace amounts of ammonia and hydrogen sulfide are emitted through the cooling tower with water vapor	low	Emitted with water vapor, rises in vapor/air plume. Cooling tower designed to maximumize dispersion	no	Can perform ambient air testing for hydrogen sulfide if concern is presented
Cooling Tower Drift Cooling tower circulation water droplets	low with mitigation	Include drift elimination Cooling tower designed to maximumize dispersion		Predominantly condensate low boron, arsenic
Steam venting at power plant during maintenance and upsets	low with mitigation	Use low emission vent mufflers, minimize duration		Predominantly steam with gas
Steam venting at well sites during testing, and upsets	low with mitigation	Use low emission silencers, minimize duration		Predominantly steam with gas and <1% brine carryover
Water Quality				
Brine Discharge to surface during testing, (otherwise brine injected back into the reservoir)	low with mitigation	Maintain sump capacity Limit surface discharge to rainy season or inject-groundwater monitoring	no	Project received permission to discharge 1 Oct 04-1 Apr 05 from local authorities
Spills	low	Sump liners, berm as needed, Groundwater monitoring	no	Use produced brine for drilling
Water Use	low with	Groundwater	no	Use produced

	mitigation	monitoring		brine for drilling
Injection Breakthrough to groundwater	low with mitigation	Production, Injection and Groundwater monitoring	no	Minimized by reservoir cap
Biota				
Habitat disturbance	low			No new construction
Biota destruction	low	Fence off dangerous areas		No new construction
Noise				
Standard construction equipment	low	Proper equipment maintenance		Limited to aintenance no new construction
Drilling	low	1. drilling rigs contain noise control if needed, 2. hearing protection provided for workers		Drilling limited to workovers one very two years-first replacement in 8 years and every 7 years afterwards
Flow Testing	low with mitigation	Hearing protection provided for workers and access limit	no	temporary impact
Geohazards				
Soil Loss/Erosion	low			Limited new construction
Induced Seismicity	low		yes	Additional seismic activity unlikely-already active area
Hydrothermal Eruptions	low	Injection to maintain pressures	No	Not likely due to geologic conditions
Subsidence	low	Injection to maintain pressures	No	Not likely due to geologic conditions
Health & Safety and Hazardous Materials				
Spills	low with	Regulations will	No	Few hazardous

	mitigation	be followed		materials used
Worker Exposure	low with mitigation	Worker safety regulations will be followed	No	
Accidents	low	Worker safety regulations will be followed	yes	
Human Environment				
Land use	low with mitigation	Minimize use of agricultural land and surface area of all facilities	yes	
Visual Impact	moderate	Maintain mitigating landscaping		
Employment	moderate		yes	Temporary and long term job creation
Other Economic Factors	moderate		yes	Provides power from local resources, reduces air pollution for power generation

5.3 Environmental Permitting Status and Issues

The existing environmental documentation includes an "Environmental Evaluation Report for Aydin Germencik Geothermal Plant & Transmission Lines" (EER) prepared for Gurmat Energy Generation Co. Inc. in 2001. This EER document was prepared in compliance with the 1993 EIAR. It includes:

1. Project summary
2. Project's Definition and Aim
3. Location of the Project
4. Economic and Social Dimensions of the Project
5. Current Environmental Characteristics within the Project's Area of Influence
6. Potential Impacts of the Project within the Area of Influence and Impact Mitigation Measures
7. Possible Impacts, Impacts, and Impact Mitigation after Project Closure
8. Project alternatives
9. Monitoring Program
10. Conclusion

The potential impacts to the human and biophysical environment described in the report include:

- Minor land disturbance for the power plant and transmission line construction.
- Land use will be changed from agricultural to industrial.
- Impacts to flora and fauna will occur during construction due to temporary construction activity and soil disturbance.
- Soil loss where earthwork is required.
- Visual appearance of the power plant (mitigated by landscaping)
- Employment of personnel during construction and operation will increase local incomes.
- Reliable indigenous energy supply benefits.

Environmental monitoring and mitigation will include compliance with relevant environmental rules and regulations, sampling and analysis of groundwater seasonally, equipment maintenance during construction to control noise, compliance with worker health and safety rules, sampling and analysis of production and injection wells. Several aspects of project were designed to mitigate potential environmental issues. These include

- brine injection,
- minimization of the area of disturbance,
- maximum effort to protect the olive trees from damage,
- sealed septic systems with off-site disposal to Germencik,
- closed geothermal fluid system (no air emissions), and
- no fluid discharge above ground.

This EER was originally submitted by Gurmat to the provincial environmental authorities in Aydin who regulate the Project area under the authority of the national Turkish Department of Environment and Forestry for approval. The local Aydin environmental authorities are concerned about surface discharge of geothermal brine as a result of many years of surface discharge at Kizildere. The local authorities reportedly ruled the document acceptable, however, they did not accept injection as an appropriate mitigation for brine disposal. Gurmat resubmitted the EER to the Department of the Environment and Forestry in Ankara and it was approved on August 20, 2003.

Since the document was approved the project has been modified in a few key aspects. These reportedly can be addressed in a supplemental document describing the existing environment, potential impacts and mitigations of the changes. The supplement will be submitted for approval to the Department of the Environment and Forestry in Ankara and will most likely be approved within 30 to 60 days. The primary project modifications that may produce environmental impacts and therefore which require consideration in a supplement are:

1. The currently proposed power plant is a dual flash plant rather than a binary plant and is no longer a closed system with regard to air quality. Air emissions from venting, testing, cooling tower drift and cooling tower vent gas will require consideration.
2. Additional drilling is required which was not considered previously. Drilling requires additional land disturbance, potential subsurface impacts, more employment, large equipment and several other issues.

3. This project will require a large power plant with more visual impact (cooling towers) and a large power plant site with more subsurface excavation and more land disturbance.

Similar environmental issues have been successfully addressed by the geothermal community in numerous projects around the world. The relatively non-toxic nature of the Germencik geothermal fluid will serve to minimize the impacts on air quality, drilling impacts will be similar to oil and gas drilling which is common in parts of Turkey, and the increase land disturbance can be minimized with readily available mitigations. Therefore, these additional issues are unlikely to impede environmental permitting of the project.

The key issue in the environmental process appears to be surface discharge of geothermal brine which is typically done into the Alangullu Brook which connects to the Buyuk River which flows to the west approximately 8 km south of the project area. In 2004, Gurmat was able to obtain permission to discharge to the Alangullu for the purposes of flow testing but the discharge was limited to approximately 1 October through 1 April. We anticipate that this permission would be available in the future albeit with a similar restriction.

6 Resource Development Strategies

Power plant heat balance calculations provided by Stone & Webster, indicate the wellfield will be required to deliver to the plant 1864 t/hr of total mass production (brine and steam) at an average plant inlet enthalpy of 901 kJ/kg, and must inject approximately 1492 t/hr of separated brine and 108 t/hr of condensate and cooling tower blowdown fluid. Although the nine existing exploration wells at Germencik indicate that sufficient reservoir temperatures are present at reasonable depths over most of the project area, permeability and productivity (and inferred injectivity) varies widely. The economics of reservoir production can be optimized by using commercially productive existing wells where possible, and drilling additional wells that are:

- Drilled directionally to take advantage of existing pads and minimum number of additional wellpads and piping,
- Configured for optimal productivity or injectivity relative to drilling costs,
- Separated sufficiently to prevent injection breakthrough in production wells, and
- Targeted for potential faults or fracture zones to maximize successful production opportunities.

A resource development strategy was designed for Germencik with the goals of specifying which existing wells would be used and whether to utilize them as producers or injectors. In addition, the development strategy specifies how many new wells are needed, approximate well configurations (for both injectors and producers), well locations and subsurface targets, and how they should be utilized. Additional well targets and locations are also identified beyond those that are anticipated for project start-up for contingency and for future make-up wells. The recommended strategy balances several (often competing) factors including:

- Production wells and injection wells are fundamentally different in that a production well requires both high permeability and high enthalpy, while an injection well requires only high permeability.

- The two best production wells (of the existing wells) in the field are wells OB-6 and OB-9 and these wells are relatively closely spaced, and therefore these wells should remain production wells in the development strategy.

- Between wells OB-6 and OB-9, well OB-6 is the better production well in terms of both permeability and enthalpy, and new production targets are located in the area around this well. Well OB-9 is a good production well but temperature profiles and geothermometer temperatures indicate that this well may be near the edge of the reservoir, and until more is known about the reservoir, new production will not be targeted immediately around this well.

- In a reservoir operation plan, injection provides the often needed pressure support to the production wells, but injection also poses the risk of thermal breakthrough thus cooling the production wells. Some pressure support will likely be needed for maintaining production at Germencik. Although the level is currently unknown, planned production is only moderate for a reservoir of this size which typically requires only a moderate amount of pressure support. Because the connectivity (risk of breakthrough) between wells is unknown, the development strategy calls for injection within the known reservoir (for pressure support), but as far away from the northwest production area (areas around OB-6 and OB-9) as possible (to lower risk of thermal breakthrough).

- The area around OB-8 and the area between OB-8 and OB-7 are suitable for injection because permeability is reasonably high and they are sufficiently distant from the northwest production area while still being within the known reservoir.

- In the future, if this injection strategy does not provide enough pressure support, the injection can be moved closer to the production wells. This approach is better than locating the injection too close to start, and being forced to move it farther away while suffering enthalpy loss at the producers.

This recommended resource development strategy for Germencik identifies existing wells OB-6 and OB-9 as production wells and the areas around OB-4, OB-6, and OB-9 (the northwest part of the presently known field) as the production area. Two new production wells, OB-6A, and OB-10, will be drilled in this area. Well OB-6A will be drilled from the OB-6 pad and OB-10 will be drilled near the plant site.

The areas between OB-8 and OB-7 (the southeast part of the presently known field) will be the brine injection area. Existing well OB-8 will be utilized as an injection well, in addition to three

newly drilled injection wells. One new injection well, OB-8A, will be drilled from the OB-8 pad. Two new injection wells, OB-12 and OB-12A, will be drilled in the area between OB-8 and OB-7. Condensate and cooling tower blowdown will be injected separately into OB-3.

Wellbore designs for new wells have been proposed to achieve optimum results. Sufficient drilling targets exist within the area of the reservoir defined by previous drilling. Results predicted for the initial production wells indicate that sufficient production capacity will be available to operate the proposed facility at 1864 t/hr for approximately eight years before any additional production wells are required. Initially, production wellhead valves will be throttled to limit production to the required amount of two-phase fluid at a wellhead operating pressure of at least 21 kg/cm^2. The new wells may be throttled at higher levels, depending on their productivity. As the wells' productivities gradually decline, the required production level can then be maintained by reducing wellhead pressures (i.e. opening the wellhead valves).

Total production of 1864 t/hr can be maintained by lowering wellhead pressures in response to anticipated reservoir decline to a minimum wellhead operating pressure of approximately 10 kg/cm^2. At an average reservoir production decline of approximately 4%/year, wellhead pressures would reach 10 kg/cm^2 in approximately eight years.

Productivity and injectivity can be maintained with available scale mitigation technology and workovers as needed to preserve wellbore integrity and formation permeability in the surrounding reservoir rock. Maintaining reservoir pressures with an appropriate brine injection strategy will prevent phase separation and minimize scaling-related permeability problems in the reservoir. For example, if reservoir pressures appear to be declining in production areas where enthalpy is not declining, injection can be moved closer to these areas to support reservoir pressures.

6.1 INITIAL PRODUCTION

The Germencik Geothermal Project will be supplied initially by four active production wells, two of which will be the existing commercial producers OB-6 and OB-9. The other two wells will be new production wells, OB-6A and OB-10. These four wells will be operated to produce 1864 t/hr of total flow to the plant while providing an appropriate reserve to accommodate contingencies such as well problems or surface equipment problems. Wells will be produced at wellhead pressures of approximately 20 to 25 bar,g. At these wellhead pressures, these wells will flow naturally, delivering a two-phase mixture of brine and steam at the wellhead. The locations and well configurations of the two new production wells are described in Section 6.1.1.

Wellbore flow simulations were performed to evaluate potential production and optimize the design of future wells. Known well configurations for OB-6 and OB-9 were input into the GWELL simulation program and data from the 2005 Short Term Flow Tests were modeled. The simulation parameters were adjusted to obtain reasonable matchs between the measured and simulated data. The design configurations for new wells were also modeled and the downhole properties were extrapolated from the known properties of wells OB-6 and OB-9. Simulated deliverability curves were then generated for each well for the conditions expected in the initial start-up of the

Germencik Geothermal Project (Figures 6.1-1 through 6.1-4) and for the entire field (Figure 6.1-5). For wells OB-6 and OB-9 (Figures 6.1-1 and 6.1-3), the simulations were based on actual data and are believed to be accurate. It is important to note that the wellbore simulation of OB-6 (Figure 6.1-1a) confirmed the existence of "choked" flow conditions for wellhead pressures lower than approximately 13 kg/cm^2 (at the high flow rates of 460 ton/hr), thus the flow rate from this well is limited only by the inner diameter of its wellbore.

The OB-6 casing is 8 5/8-inch whereas the design configuration for well OB-6A has stepped oversized casing (16-inch to 305 meters and 11 ¾-inch to 820 meters) allowing the largest possible inner diameter at each depth. The larger casing configuration provides at least double the cross sectional flow area as compared to well OB-6, effectively removing the choked flow condition. Wellbore simulation (with GWELL) was performed on OB-6A using large casing and OB-6 reservoir properties. This resulted in a simulated OB-6A flow of 1224 t/hr, more than double the production of OB-6.

A simulation was also completed for planned well OB-10 using the established downhole productivity index from well OB-9, and flowing enthalpy from OB-6 (Figure 6.1-4). Simulation indicated that an oversize diameter casing program for OB-10 would yield a maximum of 718 t/hr, nearly doubling the 424 t/hr measured during OB-9 flow tests.

The initial production requirement for the Germencik Geothermal project is 1864 t/hr corresponding to an initial average operating wellhead pressure of 22 kg/cm^2,g (Figure 6.1-5). At this pressure, the wells are throttled and reserve production is provided by reducing wellhead pressure to maintain flow rate. For example, at current reservoir conditions, if the wellhead pressure is lowered to approximately 10 kg/cm^2, the total flow would be approximately 2800 t/hr (Figure 6.1-5). The difference between the 2800 t/hr and 1864 t/hr constitutes a significant initial reserve capacity.

Table 6.1 -1
Initial Production

Well	Status	Initial WHP kg/cm^2,g.	Initial Production Rate (t/hr)	(t/hr)
Total Geothermal Fluid Production				**1864**
OB-6	existing	21	375	
OB-9	existing	21	282	
Total Existing Production				**657**
OB-6A	new	24.7	717	
OB-10	new	21.6	490	
Total New Production				**1207**

6.1.1 Drilling Additional Production Wells

Additional Germencik production wells will be drilled from multi-well pads to minimize land disturbance and maximize production potential from specific parts of the field. The new production wells are sited where the interpolated depth to the shallowest permeable zone within the reservoir is at least 800 meters deep. To prevent flashing in the reservoir if reservoir pressure declines, the casing shoe depth for well design used for estimating drilling costs will be approximately 200 meters deeper.

A generic well design (Figure 6.1-6 and Appendix G) was developed based on the estimated top of the reservoir and the completion of OB-6 because initial development will probably concentrate in the northwest portion of the field.

Planned casing depths and completion depths may vary depending on the location of the wellhead and drilling target. Actual casing depths will vary based on drilling conditions and the depths that permeable zones are encountered in an individual well.

All of the proposed wells will be completed with oversized casing to optimize flow potential. Approximately five make-up wells will be drilled over the life of the project. The actual number of wells will depend on the production capacity of each new well, and possibly interference effects among wells which is largely unknown until the long term flow test.

6.1.2 Production Well Targets

Initial new production wells will be directionally drilled to penetrate specific fault targets or to direct the well toward established production zones. Initial production designs include two additional wells: one from an expanded drilling pad at the OB-6 location, OB-6A, and one well at the anticipated power plant location designated OB-10 (Figure 6.1-7). Directional holes are directed to a specific bottomhole location at some horizontal distance from the surface location and vertical holes are undirected but would be allowed to vary within a 100m radius of the surface location.

Well Name	Production Casing Depth	Total Depth	Bottom Hole Location
OB-6A	750±50m	1500m	200±25m from the surface location S45°E
OB-10	650±30m	1250m	150±25m from the surface location N60°E

As the field is produced and well productivity declines, some additional or make-up wells will be required to maintain production. Based on an estimated annual decline of 4% and a 40 year project life, approximately five make-up wells will be required. Subsequent wells from each

drilling location are planned for specific fault targets or specific bottom-hole locations to maintain future production. Some of these may be vertical or near vertical wells. Possible locations are available within the existing field and planned wellpads (Figure 6.1-7).

6.2 INITIAL INJECTION

Approximately 80% of the produced geothermal fluid or 1492 t/hr will be injected as brine and approximately 5% or 108 t/hr will be injected as condensate. Brine will be injected into OB-8 and additional injection wells as needed (additional wells OB-8A, OB-12, and OB-12A). Condensate will be injected into OB-3. The following injection requirements can be anticipated for injection at the Germencik project:

Table 6.2-1
Initial Injection

Well	Status	Initial Injection Pressure bar,g.	Initial Injection Rate (t/hr)	(t/hr)
Total Geothermal Brine Injection Requirement				**1492**
OB-8	existing	35.5	355	
Total Existing injection Capacity				**355**
OB-8A	new	35.5	379	
OB-12	new	35.5	379	
OB-12A	new	35.5	379.	
Total New Injection Capacity				**1137**
Condensate Injection: Existing Well OB-3 will provide 100% of required capacity of 108 t/hr				

6.2.1 Injection well requirements

Additional injection wells will be required to obtain the additional 1137 t/hr of injection capacity required for the project. The number of additional wells required depends on the injection pressure, the existing injection capacity of OB-8 and the injection capacity of the new wells. Injection pressures were set relatively high at 35.5 bar to minimize the number of injection wells required while balancing the cost of pumping and transporting high pressure brine.

The injection capacity of OB-8 will be tested during the long term flow testing scheduled for late 2005 (Appendix H). For this present assessment however, the injectivity of OB-8 is estimated (Figure 6.2-1) based on a correlation developed to estimate injectivity indices from measured productivity indices. The productivity index of OB-8 was estimated based on the Short Term Flow Test results, (Section 4.3.4, above). This productivity index was then used as input into a correlation technique to estimate injectivity index as described below:

OB-9 is the only well in the field that has been tested by injection and production (that Geologica is aware of). The productivity index of OB-9 was calculated based on the recent Short Term Flow Test results. A preliminary injectivity curve from OB-9 was derived from limited cold water injection testing of OB-9 in 1990 by CFG-MTA, (Section 3.3.2, above), The two sets of data were used to develop a correlation relating productivity index to injectivity index for OB-9. The inputs into this correlation are productivity index and proposed injection temperature. The output is estimated downhole injectivity index.

When corrected for temperature, and allowing the assumption that the correlation between the productivity index and injectivity index at OB-8 is similar to this relationship in OB-9, an injectivity index for OB-8 was estimated (without actual injection testing). Applying the downhole injectivity index from this methodology with wellbore simulation using GWELL, existing well OB-8 can take approximately 359.2 t/hr of 105°C brine (at a wellhead pressure of approximately 35.5 barg). The project thus requires that approximately another 1137 t/hr of injection capacity be provided by new wells.

The injection capacity of a series of potential injection well configurations including OB-8 were evaluated using downhole injectivity indices as derived above as input into wellbore simulation (Figure 6.2-1, 6.2-2a and 6.2-2b). Results indicate that injectivity is affected by casing configuration and there is a significant difference between single and multiple (forked) completions. For the purposes of wellbore simulation, it was assumed that additional forks had one half of the injectivity index of the original leg. The injection well configurations were designed for 2000 meters depth to maximize the chances of encountering multiple permeable zones thus maximizing the potential injectivity of each injection well.

The drilling costs of providing the additional injection capacity were analyzed based on injection capacity of various well configurations, injection pressure, and the per well drilling costs of various injection well configurations:

Large Diameter = 16" casing to 1000m, 11.75" casing to 1300m and 10.625" open hole with 8.625" perforated liner to TD (2000m)-single wellbore or two-bore forked completions.

Medium Diameter = 11.75' casing to 1000m, 8.625" casing to 1300m and 7.875" open hole with 6.625" perforated liner to TD (2000m)-single wellbore or two-bore forked completions
OB-8 Type= 9.625" casing to 1300m and 8.5" open hole to TD

Results of the injection drilling cost analysis (Table 6.2-2) indicate that the drilling costs for injecting additional brine of 1137 t/hr are approximately US $11.01 million assuming three additional large-diameter injection wells are used based on current international drilling costs. Actual drilling costs may be lower when more detailed engineering is performed to produce drilling bid documents and obtain competitive bids.

6.2.2 Injection Well Targets

Additional Germencik injection wells will also be drilled from multi-well pads. A generic well design (Figure 6.2-3) was developed based on the casing size determined by the drilling cost analysis and the geologic setting of OB-8 because initial development will probably concentrate in the southern or southeast portion of the field. Approximately three additional wells will be required for start-up assuming an injection pressure of 35.5 bar,g. However, if more injection capacity is identified during long term testing (late 2005), fewer wells or smaller wells may be needed. Alternatively, if the same or more wells are drilled and injectivity is greater than predicted, the injection pressure could be reduced.

The initial well from each injection well pad location will be directed to specific fault targets or specific bottomhole locations to maintain injection capacity and minimize interference during injection. Subsequent wells from each injection drilling location would also be directionally drilled although one well from the OB-12-pad may be a vertical hole that would not be directed to a specific bottomhole location but would be allowed to vary within a 100m radius of the surface location. Injection well designs include one additional wells from an expanded drilling pad at the OB-8 location (OB-8A) and at least two new wells at a location designated OB-12 (OB-12 and OB-12A) (Figure 6.1-7). The capacity for additional wells exists in several areas of the field, some of which are identified as contingency wells (e.g. OB-8B, OB-12B and OB-12C).

Well Name	Production Casing Depth	Total Depth	Bottom Hole Location
OB-8A	1300±50m	2000m	150±25m from the surface location N40°E
OB-12	1300±50m	2000m	Undirected
OB-12A	1300±50m	2000m	300±25m from the surface location N60°E

6.3 EXTENDED PRODUCTION

Planning for field declines is difficult without long term testing or some production history. Long term testing planned for late 2005 will help identify the productivity decline characteristics of the Germencik resource. However, geothermal fields are known to decline with continued production and plans should be developed to establish some additional production capacity for the planned 40 year production life of the resource. Previous sections have discussed an average annual decline of 4%, which is based on an approximate industry average which is believed to be reasonable for the Germencik Geothermal Resource until long term testing is performed.

Previous discussions also suggested that the margins of the field could be expanded by exploration and drilling to establish the lateral limits to production or usable permeability for injection.

Exploration wells should be selected based on a rational exploration program that utilizes geology, geophysics and temperature gradient drilling to select the most reasonable locations. Preliminary step-out drilling locations are based solely on the current field data and may change considerably once the Germencik field is producing and exploration plans have been completed.

6.3.1 In-field and Step-out drilling

Drilling locations for future in-field make-up wells and step-out wells are designed to provide additional production and to test production capacity at Location Alt-D between wells OB-4 and 5 and the western extent of production along the Alangullu River at Location Alt-B (Figure 6.1-7). Based on an estimated annual decline of 4% and a 40 year project life approximately five make-up wells will be required. Sufficient in-field locations (OB-6B, OB-6C, OB-10A, OB-10B and OB-10C; Figure 6.1-7) are available from exiting pads to make-up the additional capacity from declining production Potential step-out well locations to the east are intended to establish the eastern field margin at and evaluate permeability to the southeast for additional injection capacity.

7 Initial Development Cost Estimate

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8 Resource Operation and Maintenance Cost Estimate

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9 Summary and Conclusions

The results of this resource assessment indicate that Germencik is a robust hot water dominated geothermal resource capable of sustaining the fluid production and injection required for a 33 Mw (gross) of electrical production for the projected 40 year generation life of the project. Additional conclusions include:

Reservoir Characteristics:

1. All nine exploration wells drilled in the 1980's discovered temperatures approaching or exceeding 220°C and 50 % of the wells proved commercial productivity ranging from 125 t/hr to 455 t/hr of total mass flow of two-phase high temperature fluid. Previous feasibility assessments based on these data indicated that the Germencik field is capable of over 50 MW of geothermal power generation.
2. Fractured metamorphic rocks of Mendres Massif form the primary permeable geothermal reservoir at Germencik.

3. Permeability is present in fractures related to the steeply dipping splays of the Omerbeyli fault along the range front of the Kizilcagedik Horst. Although there is a range of permeability (permeability-thickness indexes in the range of 18,750 to 41,250 md-feet OB-8 and OB-9, and 322,400 for OB-6),within the field, the permeability is very high in the vicinity of OB-6 possibly as a result of fault interactions or splays of the Omerbeyli fault. Low to moderate permeabilities occur elsewhere in the field.
4. Vertical fluid flow may be limited to steeply dipping graben faults while lateral flow may occur along older thrust shear zones or contacts between metamorphic units.
5. Although the top of the reservoir is typically approximately 800 meters below the surface, a central upflow zone and very shallow high temperatures occur around OB-4.
6. Existing wells have identified a reservoir volume of at least 6.4 x 10^9 m^3 based on temperature, but the edges of the field have not been defined and additional exploration may indicate that the Germencik Geothermal Field is larger than currently defined.
7. Based on a Monte Carlo simulation and using known and interpreted temperature distributions, there is a 90% probability that the resource potential is greater than 34.1 MW gross for a 40 year project period and a 50% probability that the resource potential is greater than 72.6 MW gross for a 40 year project period.
8. Static reservoir pressures are over 100 bar-g at 1000 m and static reservoir temperatures are approximately 220 °C, with an isothermal zone averaging several hundred meters thick.
9. Reservoir chemistry is typical for a robust geothermal field at temperatures approximately 210 to 220 °C in equilibrium with calcite and quartz.

Geothermal Fluid Chemistry

1. Brine chemistry is fairly benign and with appropriate phase separation, brine carryover is unlikely to create problems with steam purity or corrosion.
2. Noncondensible gas concentrations in the Germencik reservoir of approximately 1.6 weight percent are higher than most geothermal fields but are not singularly unique. Noncondensible gas pressures make up over half of the total reservoir pressure.
3. Germencik geothermal fluids rising within the reservoir become two phase deeper than most geothermal fluids of equal temperature. The depth of top of the reservoir at which the temperature gradient changes from conductive to convective coincides with the gas-corrected boiling point to depth curve suggesting that boiling- related mineralization may seal the top of the reservoir.
4. At the boiling point, producing fluids will become saturated with calcite and calcite scale mitigation will be needed below the depth of boiling in production wells. Long term development strategy includes minimizing boiling (and calcite deposition) in the reservoir and down-hole injection of scale inhibitors. Silica scaling is unlikely to require a separate mitigation system, but some additional injection of the inhibitor may be required prior to injection..

5. Noncondensible gas is primarily carbon dioxide with a trace amount of hydrogen sulfide and other gases. Almost all of the noncondensible gas will partition into the high pressure steam which will have approximately 14.8% by weight noncondensible gas which is 99.8% carbon dioxide and 263 parts per million by weight hydrogen sulfide. Low pressure steam will have approximately 0.14 % noncondensible gas by weight which is almost all carbon dioxide.

Environmental Assessment

1. An Environmental Evaluation Report (EER) was prepared for the Germencik Geothermal project in 2001 in compliance with the Turkish 1993 Environmental Impact Assessment (EIA) Regulation.
2. With minor mitigations, no significant environmental impacts were identified and the EER was approved.
3. The EER will require modification to address potential impacts of additional issues such as air emissions, additional land disturbance, and additional drilling as a result of modifications to the project since 2001. Additional environmental assessment may be required to address the issues of concern to specific international financing institutions.

Resource Development for Production and Injection

1. Recent production tests confirmed the productive capacity of the field and the commercial viability of OB-6, OB-8 and OB-9.
2. The other three recently tested wells, OB-3, OB-5, and OB-7 are either marginally commercial or non-commercial because of low permeability or mechanical problems with each wellbore, although OB-3 may be a useful after remediation (scale removal) for condensate-cooling tower blowdown disposal.
3. Average enthalpy of produced geothermal fluids will be approximately 901 kJ/kg at the wellhead, and the average enthalpy of the two existing wells proposed for use as production wells (OB-6 and OB-9) is 890 kJ/kg.
4. Downhole productivity index varies widely within the field and is between 9.9 (at OB-8) and 145.8 (at OB-6) t/hr/bar for the commercial wells,
5. Production (1864 t/hr at 901 kJ.kg) and brine injection requirements (1492 t/hr at 105 °C and 35.5 bars,g) and currently identified reservoir characteristics suggest that the optimal development strategy for Germencik includes extracting primary production from the northwest area of the field around and including using existing wells OB-6 and OB-9 and injecting brine into the area around OB-8 and OB-7 and including existing well OB-8.
6. The resource is capable of supplying geothermal fluids for the planned project using two existing wells (OB-6 and OB-9) and two additional wells (OB-6A and OB-10) with larger diameter configurations. One will be drilled near OB-6 (OB-6A) and one (OB-10) will be drilled from a new pad near the proposed power plant.

7. Wellbore simulations indicate that the maximum production flow rate of OB-6 is limited by the size of its wellbore (OB-6 in choked flow at higher flow rates) and that larger diameter wells would be more productive, therefore new production wells are planned with larger diameter casing.
8. The reservoir is capable of receiving waste brine by subsurface injection using one existing well (OB-8) and approximately three additional appropriately designed and located injection wells. The optimal number of wells requires balancing between the competing parameters of injection pressure, wellbore configuration and drilling costs. Using an injection pressure of 35.5 bar,g, approximately three new large diameter wells will be required.
9. Wellbore flow simulations indicate that the existing and planned new wells will be able to supply the required 1864 t/hr of brine at 20 to 25 kg/cm^2,g flowing wellhead pressure. Initially, wells will be throttled and as the reservoir declines, wellhead valves will be opened to increase flow. The throttled flow represents the additional capacity required for start-up
10. Assuming an approximate industry average of 4% decline, wellhead pressures will reach a minimum of 10 kg/cm^2,g after approximately eight years of production. One new well will be required at that time and an additional well will be required approximately every seven years afterwards. Approximately five addition production wells may be required to maintain geothermal fluid supply to the plant over the life of the project.

Wellfield Development Cost Estimate

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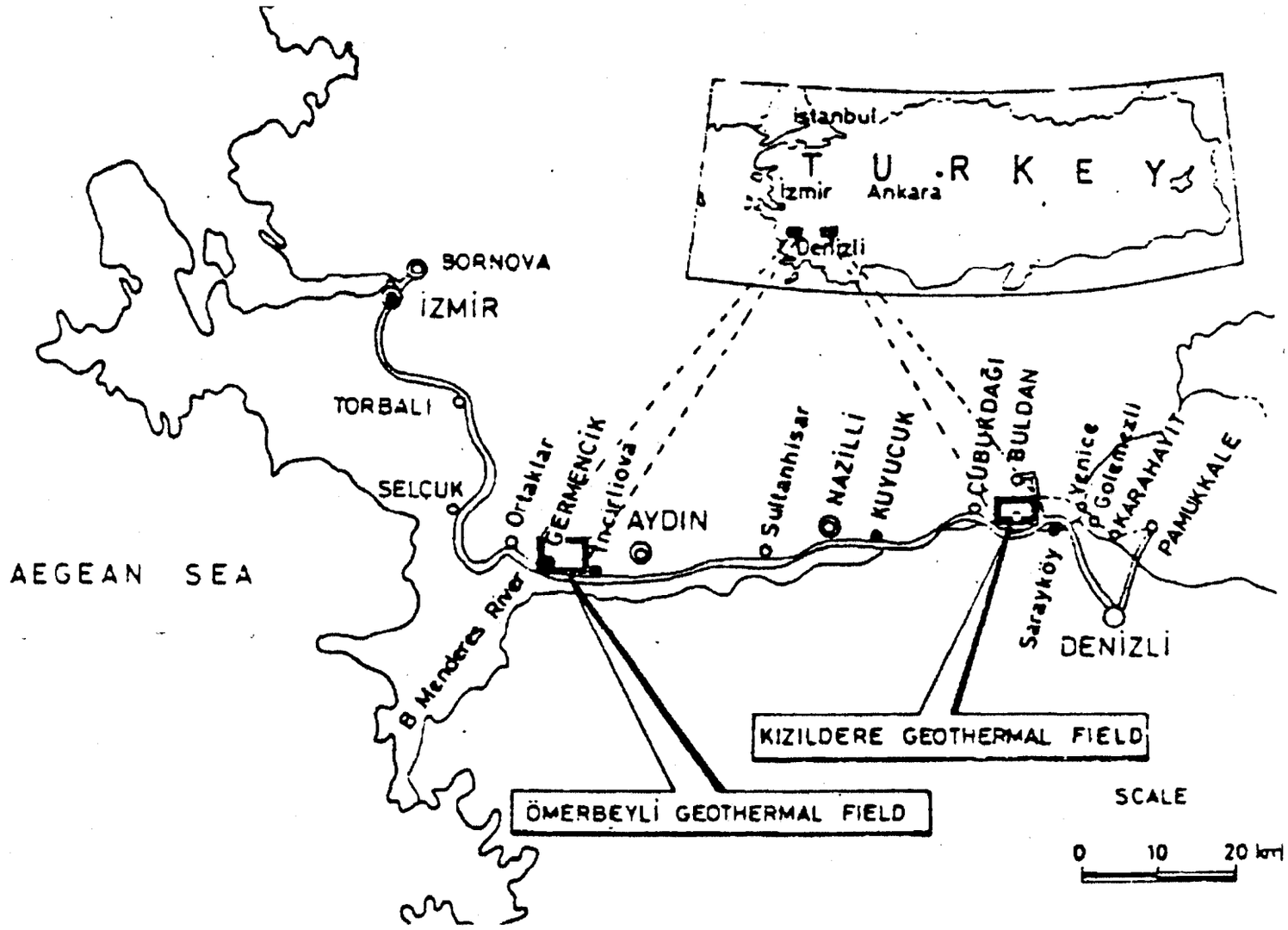

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Figure 4.1-1 Location map Western Anatolia

Western Anatolia Stratigraphy

Quaternary		Qal	*Alluvial fan and talus deposits*
Tertiary	Pliocene	Pl_4	*Poorly sorted, poorly consolidated alluvial conglomerates and sandstones with interbeds of siltsotne and clay*
		Pl_1	*Interbedded conglomerate, sandstone and claystone*
	Miocene (?)	M	Lacustrine siltstone with interbeds of conglomerate and sandstone and minor intercalations of coal (lignite). Basal conglomerate may be a shallow geothermal reservoir at Germencik.
Paleozoic	Mendres Metamorphic Group	P_{ms}	*Gneiss-quartzite-schist*
			Thrust shear zone
			Graphitic quartzite, marbles and calc-schist
			Marbles
		P_m	*Schists*
		P_q	*Quartzite*
		P_g	*Gneiss*

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Figure 4.1-3 Generalized Stratigraphic Units

Figure 4.1-4 Germencik Project
Reservoir Assessment
Schematic Cross-section

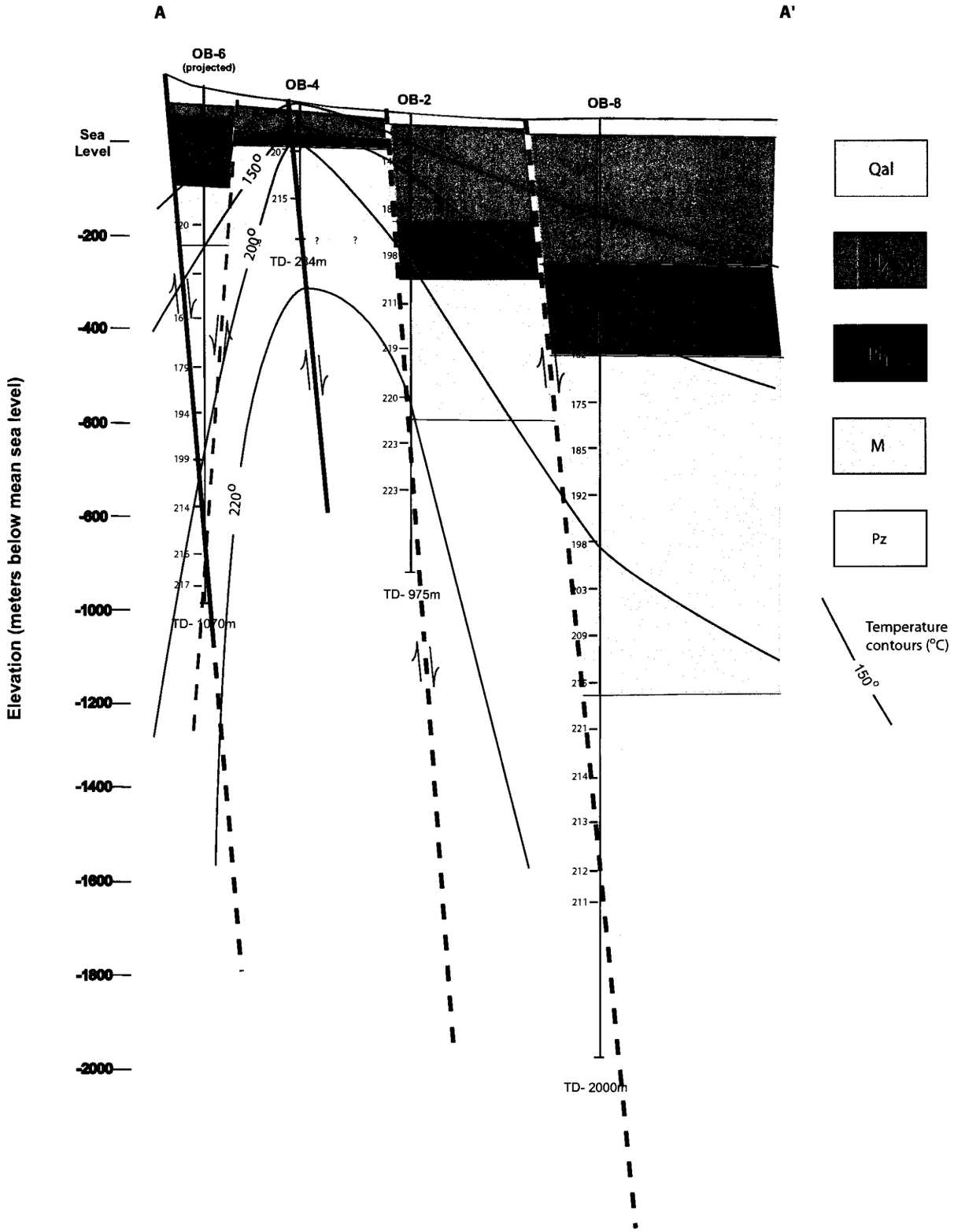

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Figure 4.1-5 Germencik Temperature Compilation

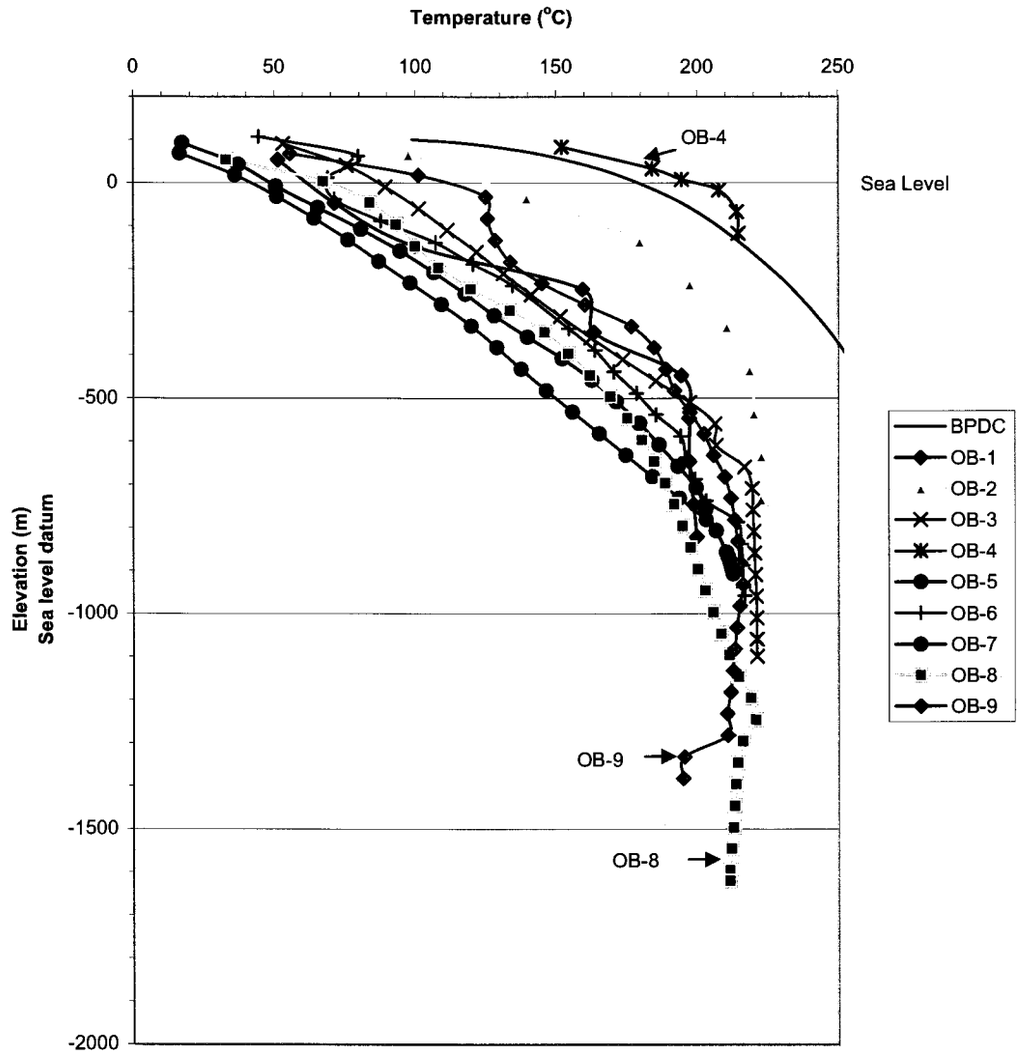

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Figure 4.2-1
Cation Trilinear Diagram

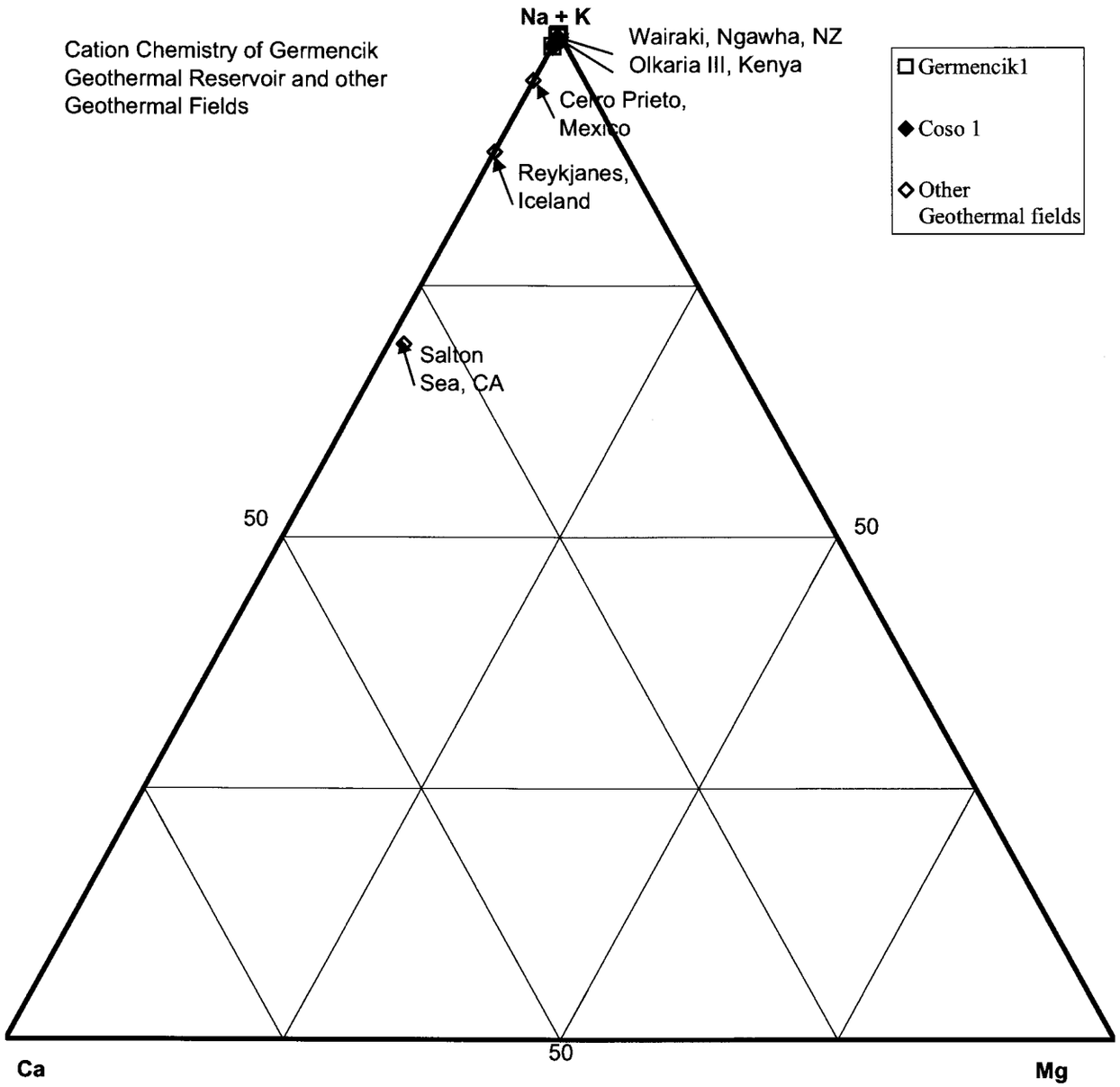

Figure 4.2-2
Anion Trilinear Diagram

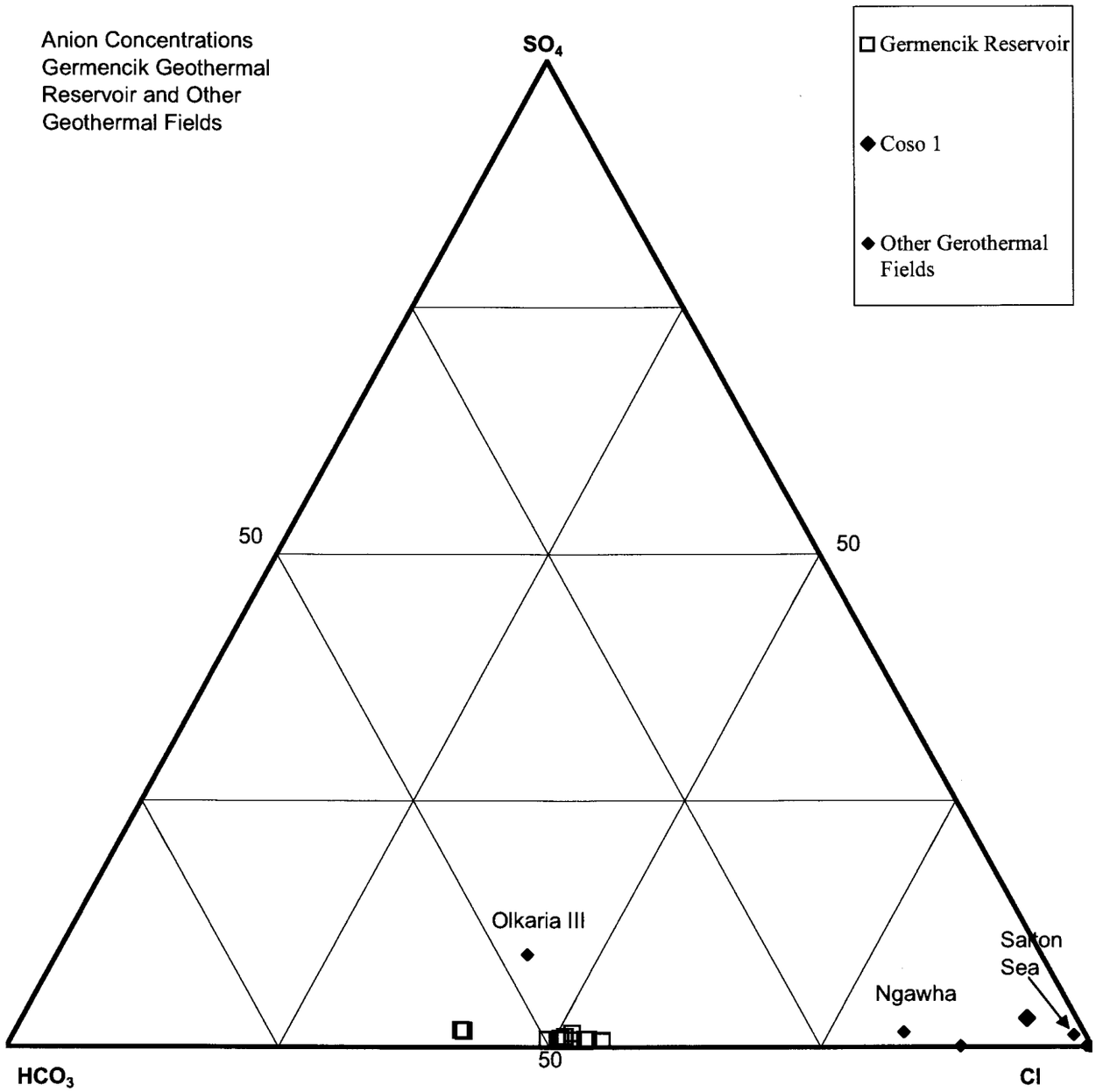

Figure 4.2-3

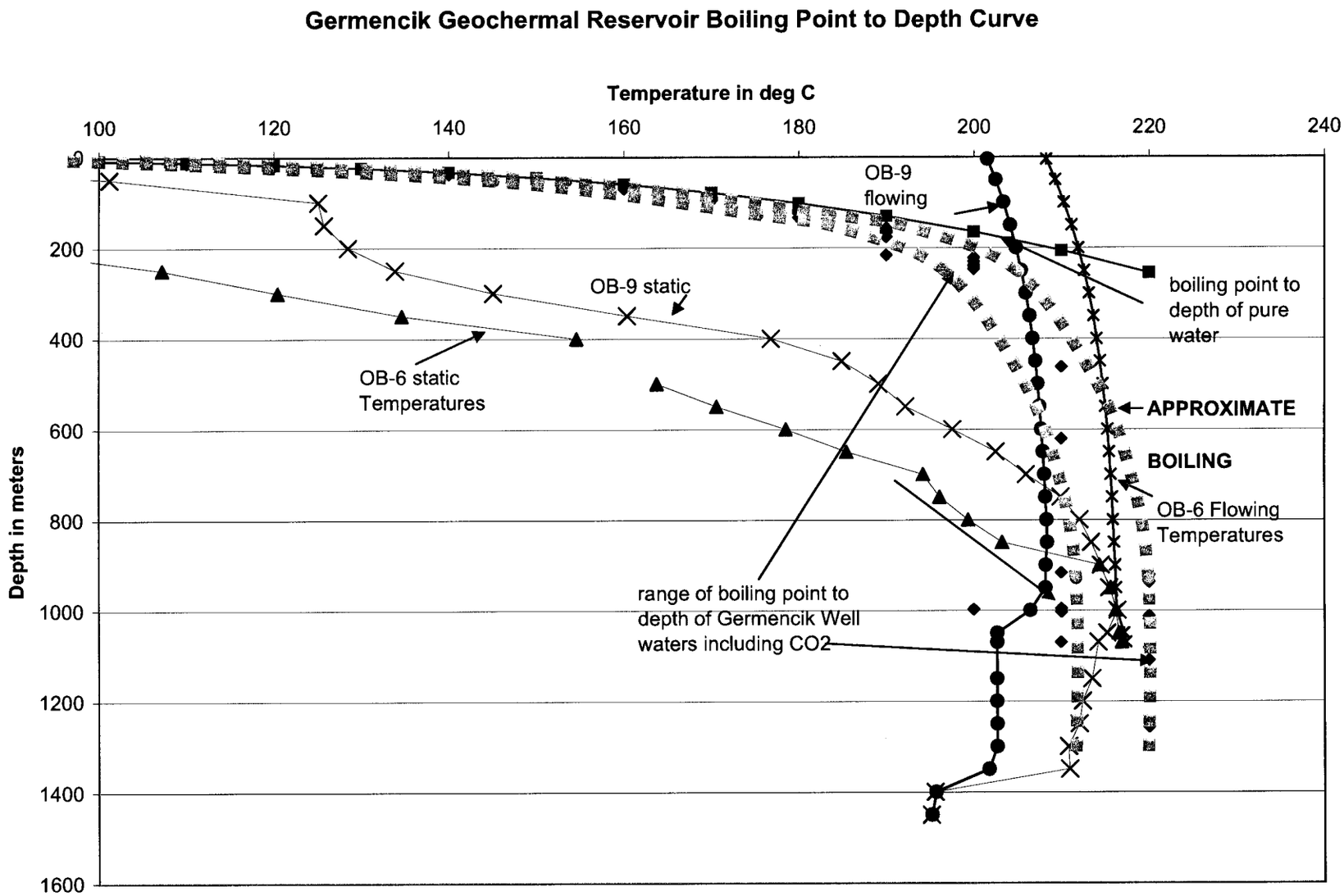

Figure 4.2-3
Resource Assessment
Germencik Geothermal Project
Draft Feasibility Report

Boiling Point to Depth Curves

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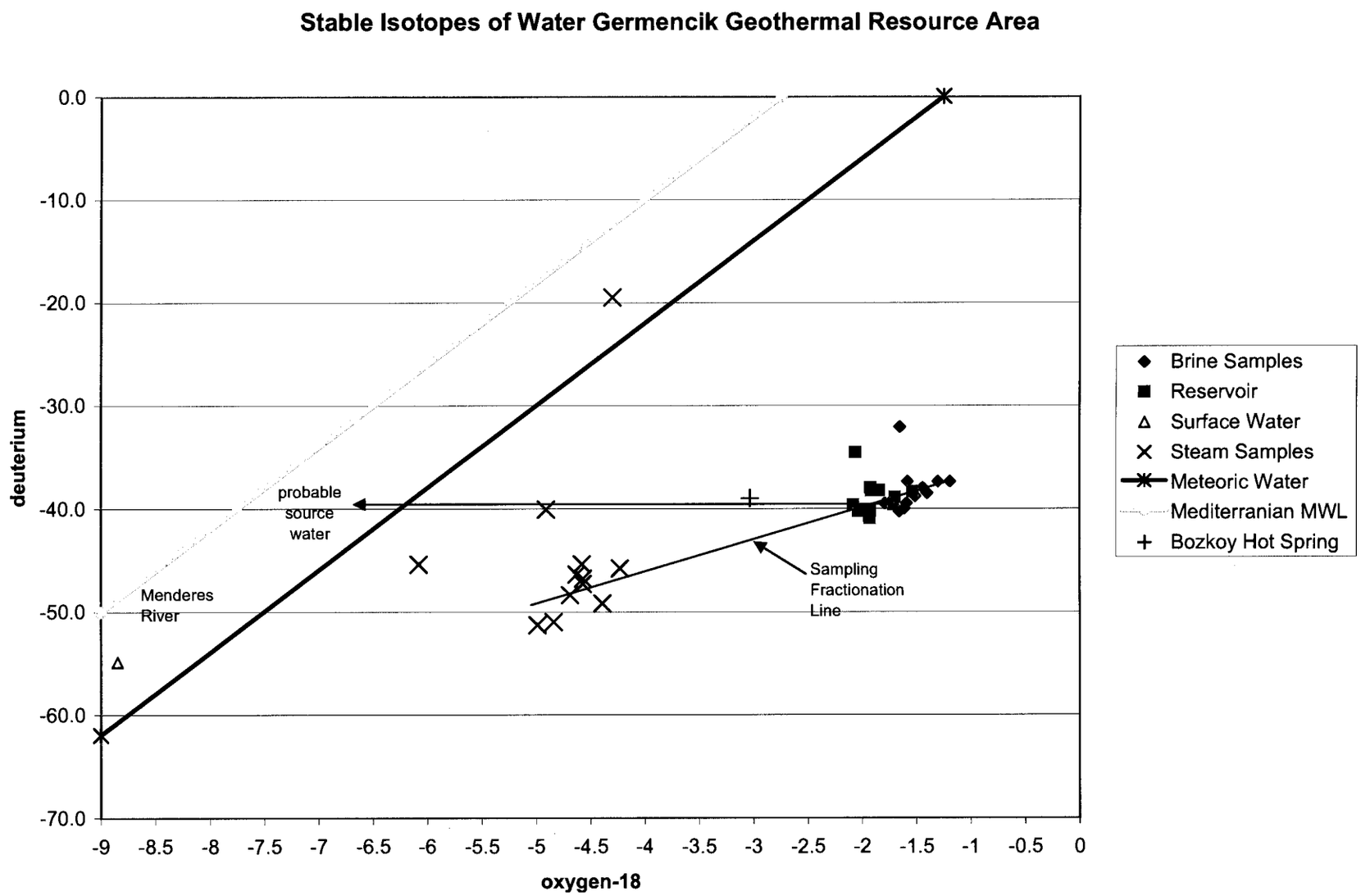

Figure 4.2-5
Resource Assessment
Germencik Geothermal Project

Stable Isotopes of Water

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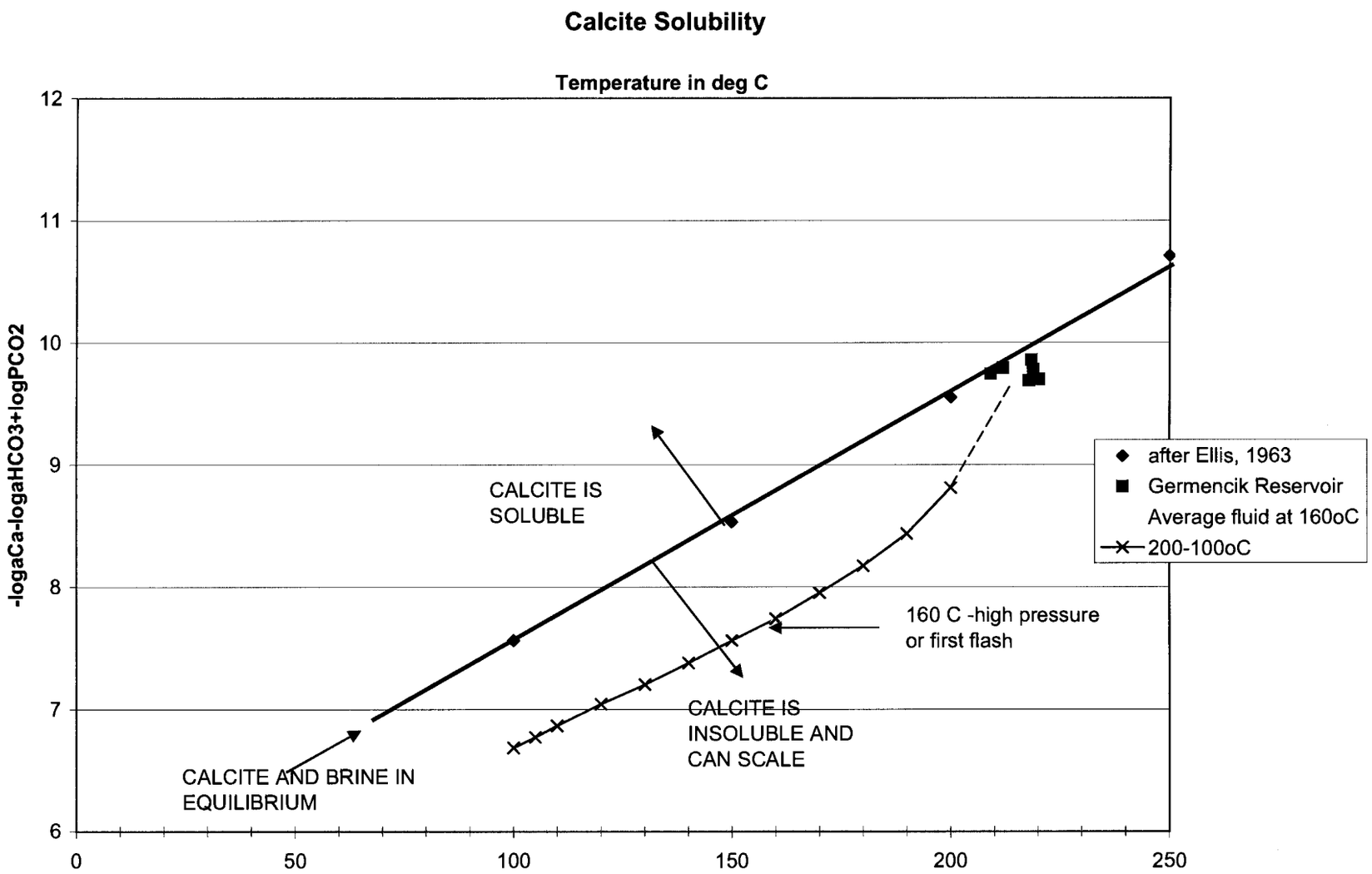

Figure 4.2-6
Resource Assessment
Germencik Geothermal Project

Calcite Solubility

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Silica Solubility Silica Concentrations Showing Reservoir Temperatures and Silica Scaling Potential

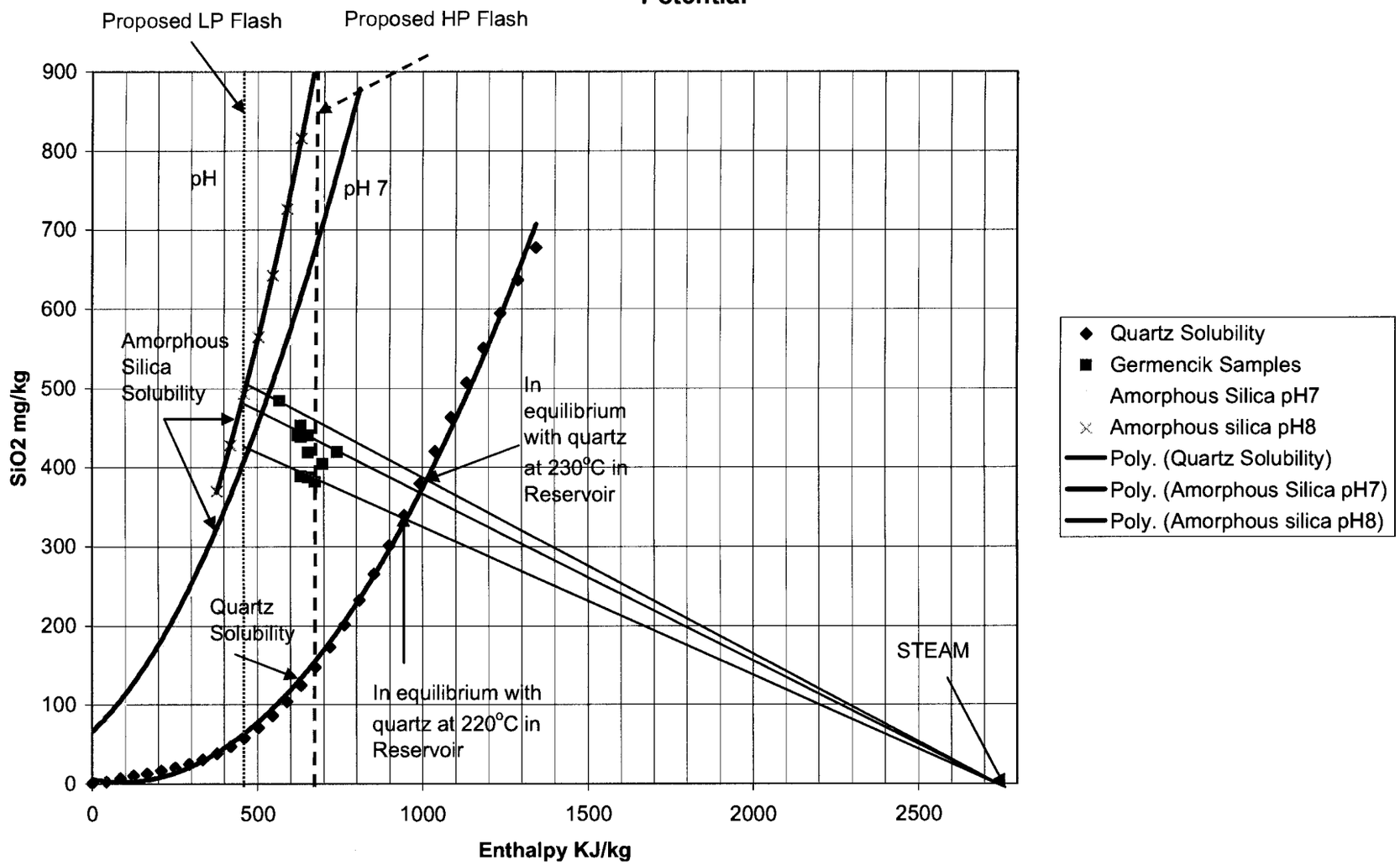

Figure 4.2-7
Resource Assessment
Germencik Geothermal Project

Silica Solubility

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Figure 4.3.2 - 1
Germencik Resource Monte Carlo Simulation
Frequency Distribution

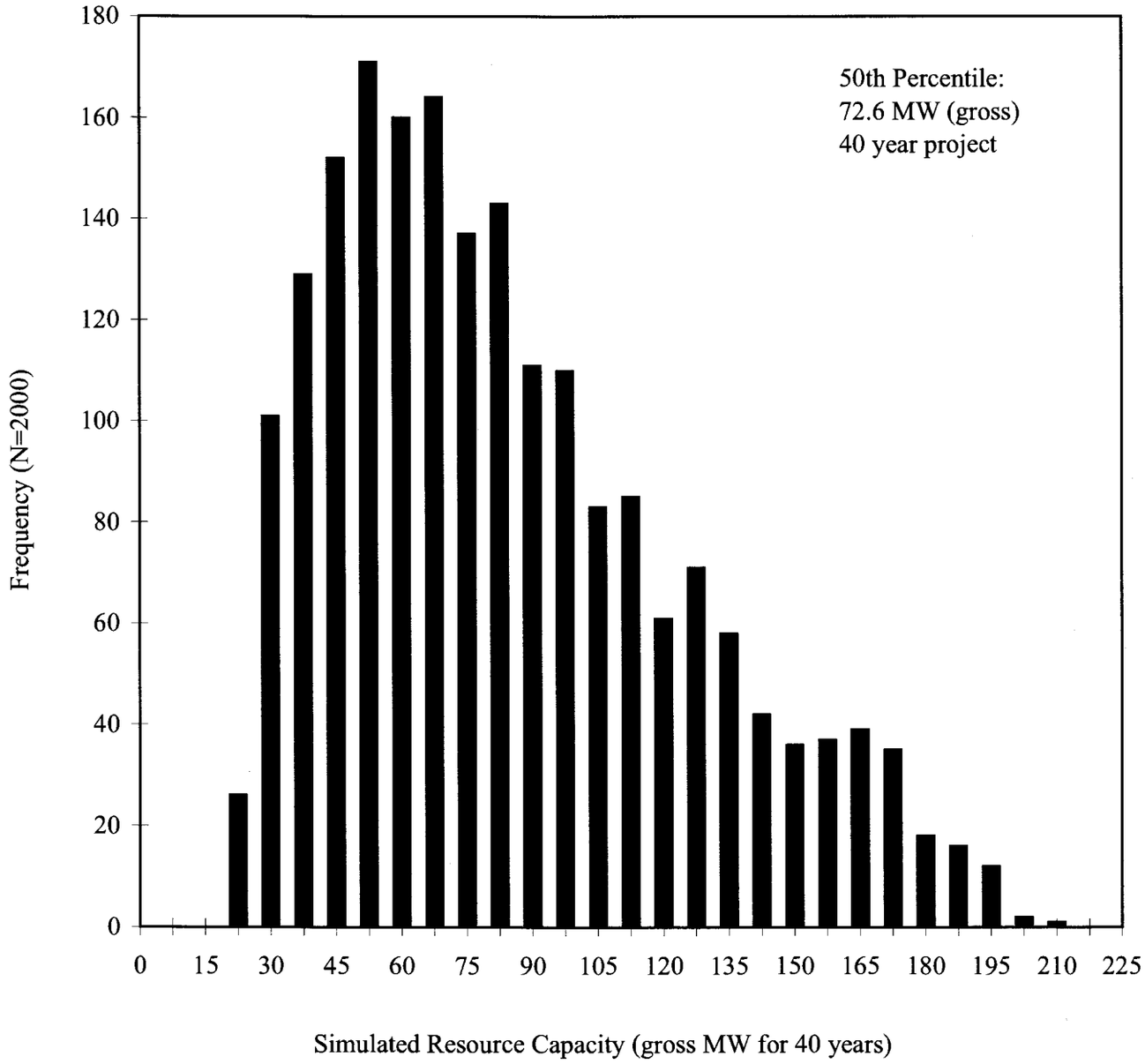

Figure 4.3.2 - 2
Germencik Resource Monte Carlo Simulation
Cumulative Frequency

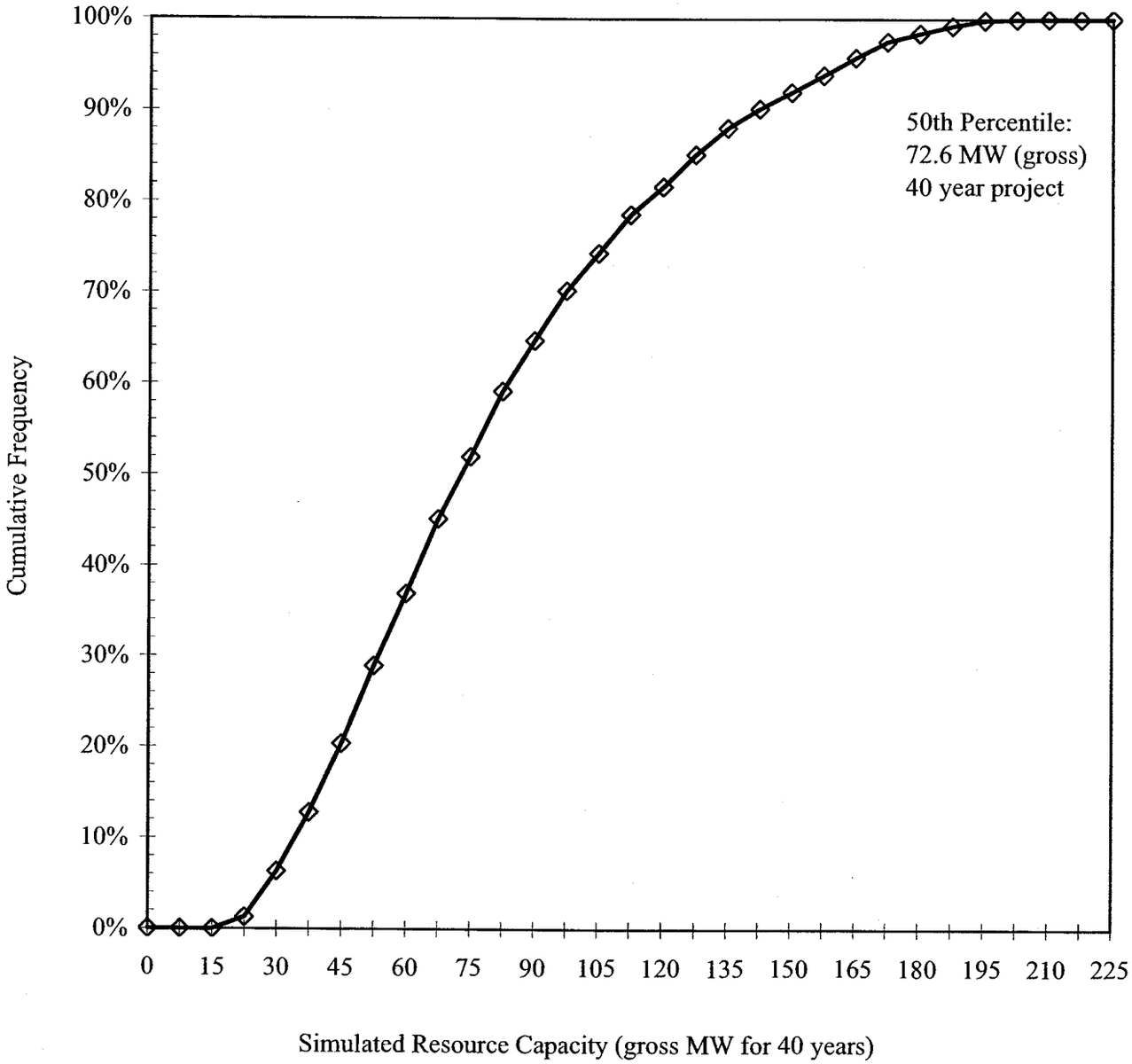

Figure 4.3.4 -1
Preliminary Deliverability Curves - Overlay Plot

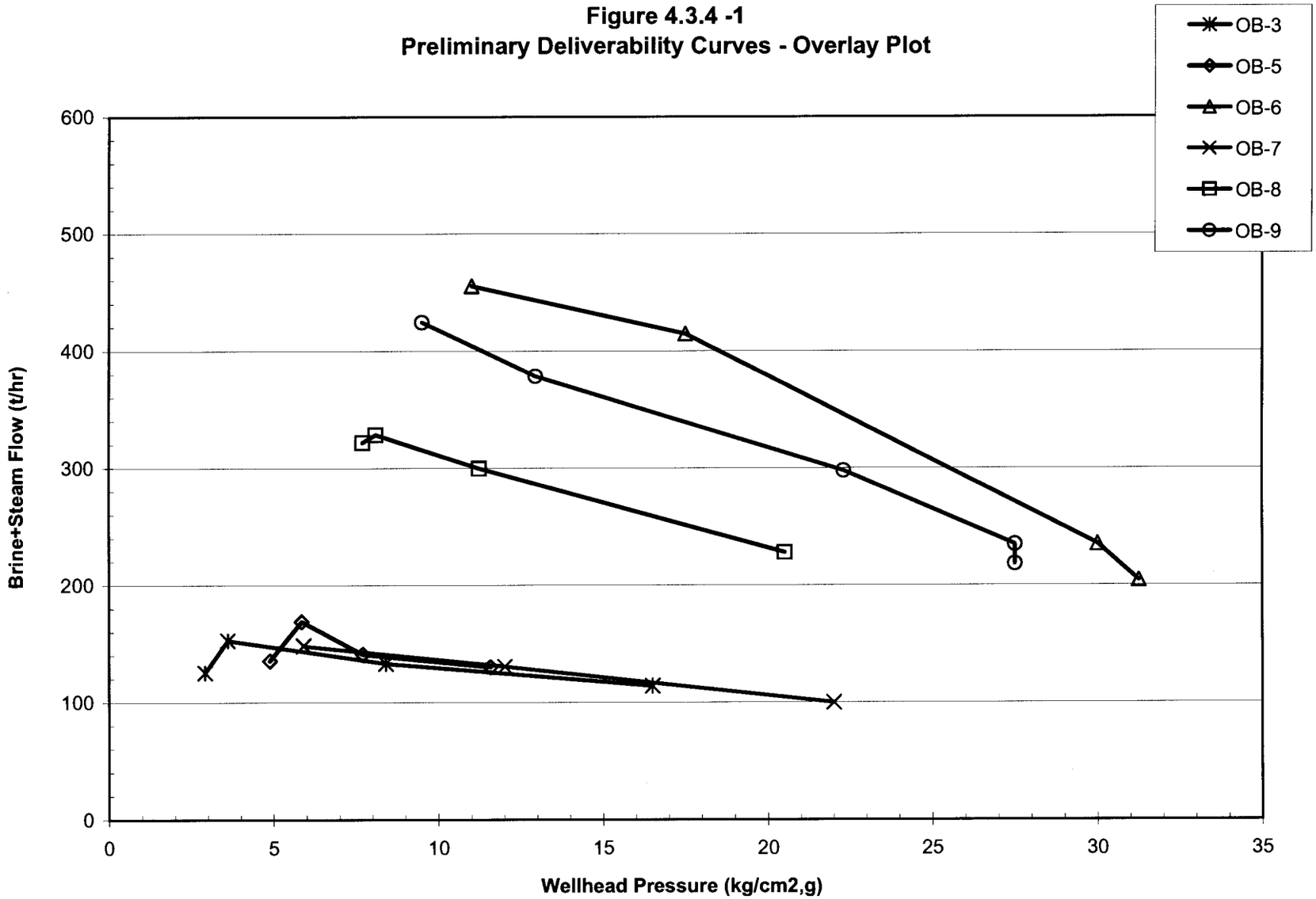

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Figure 6.2-1
Germencik Geothermal Project
Wellbore Simulation of OB-8 as Injection Well

Simulator: GWELL, File: IW-03.DAT

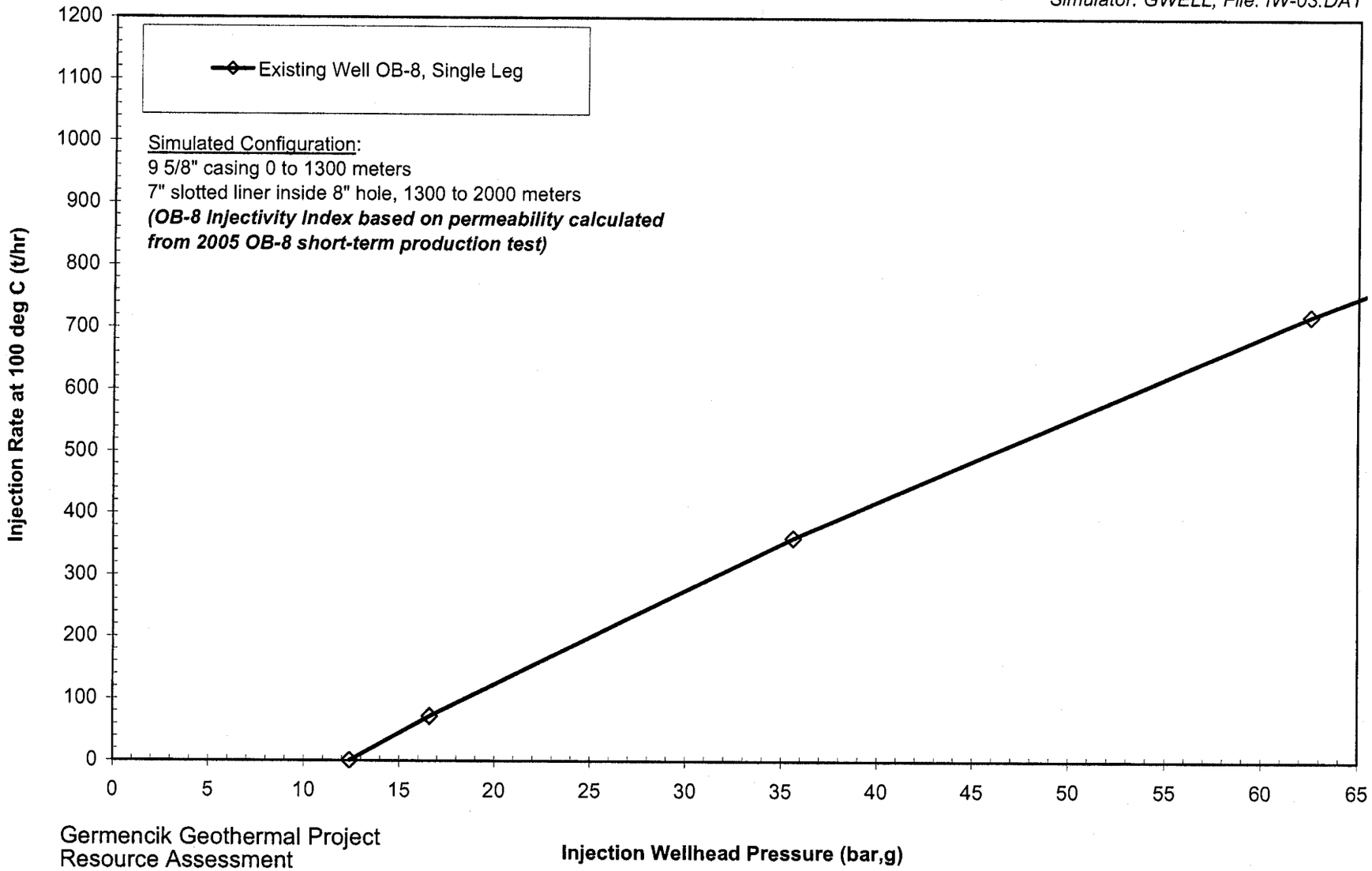

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Figure 6.2-2a
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Wellbore Simulation of "Medium" I.D. Injection Well

Simulator: GWELL, File: IW-02.DAT

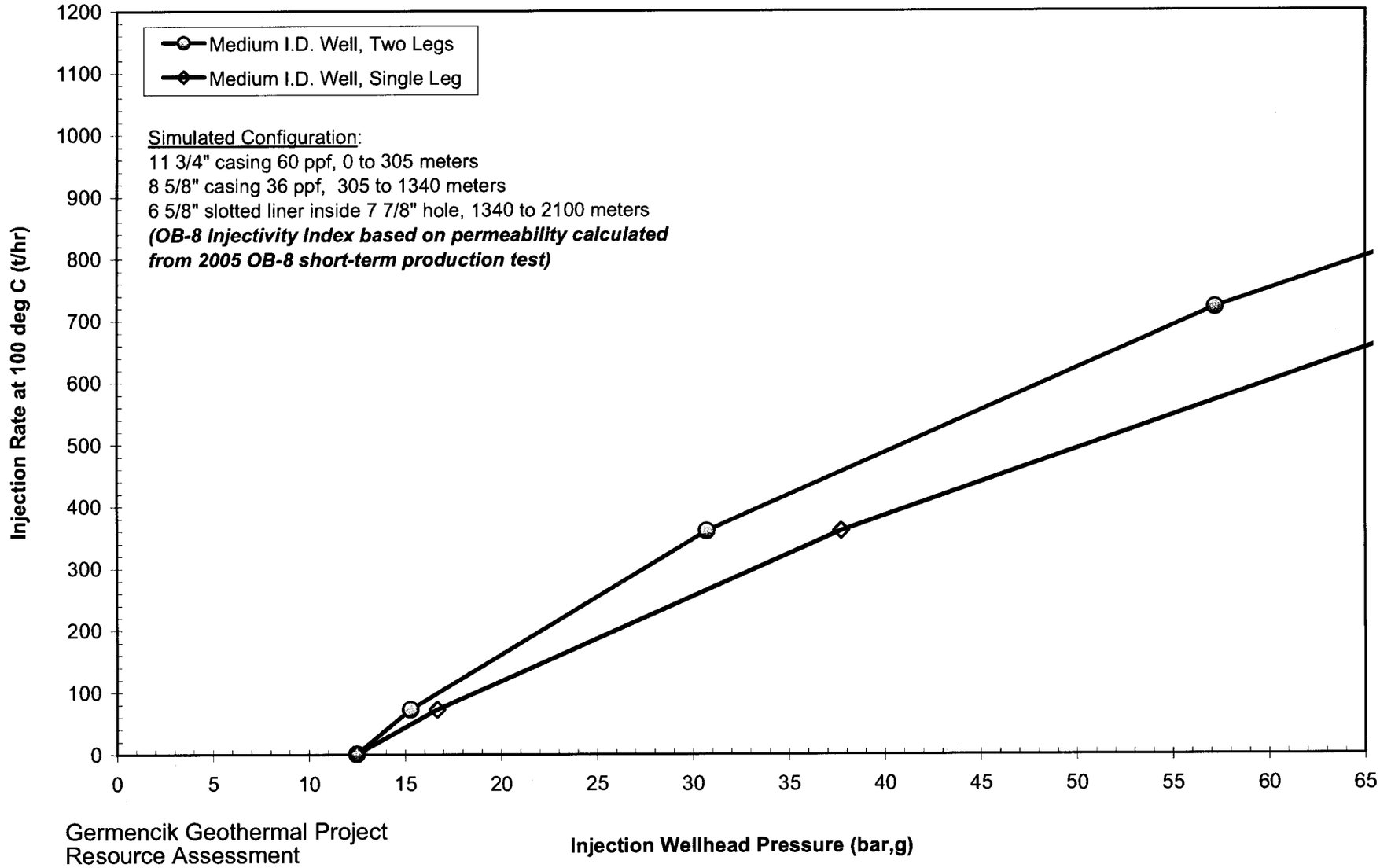

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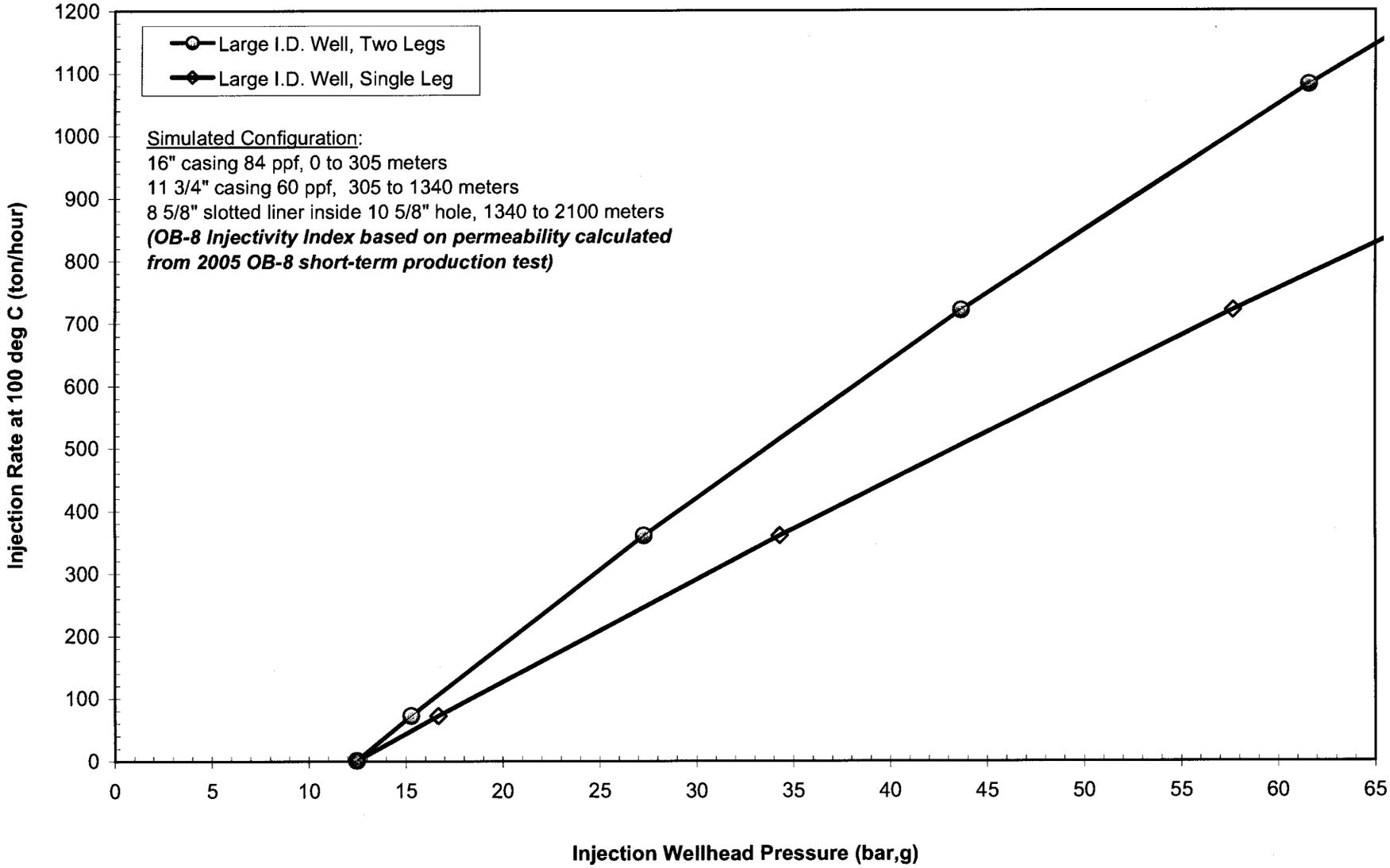
Figure 6.2-2b
Germencik Geothermal Project
Wellbore Simulation of "Large" I.D. Injection Wells

Simulator: GWELL, File: IW-01.DAT



R.Holt for Geologica, 8/18/2005

Figure 6.2-3 Germencik Injection Well Schematic

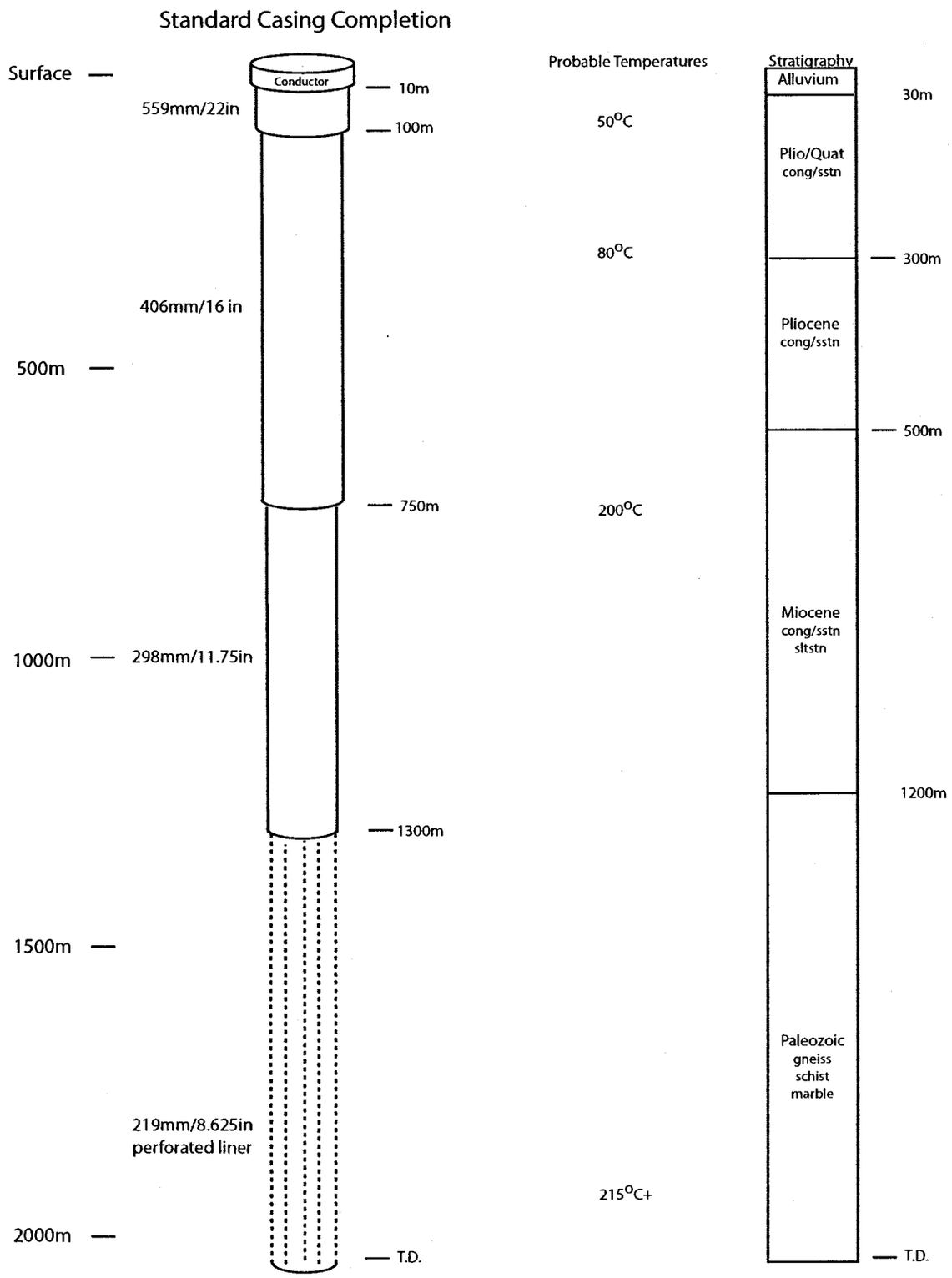


Figure 6.2-3 Germencik Injection Well Schematic

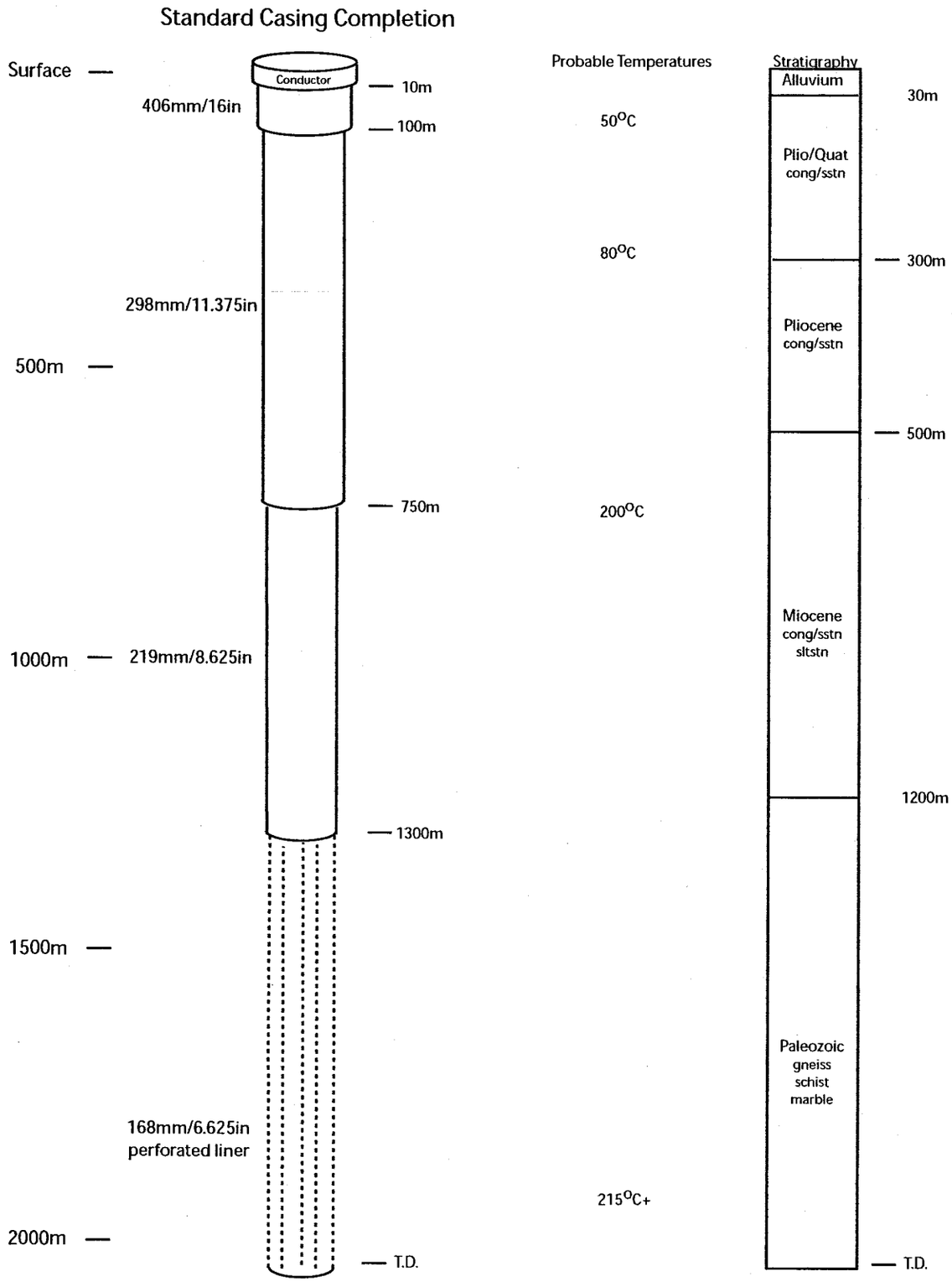


Figure 6.1 - 1
OB-6 Simulated Deliverability Curve

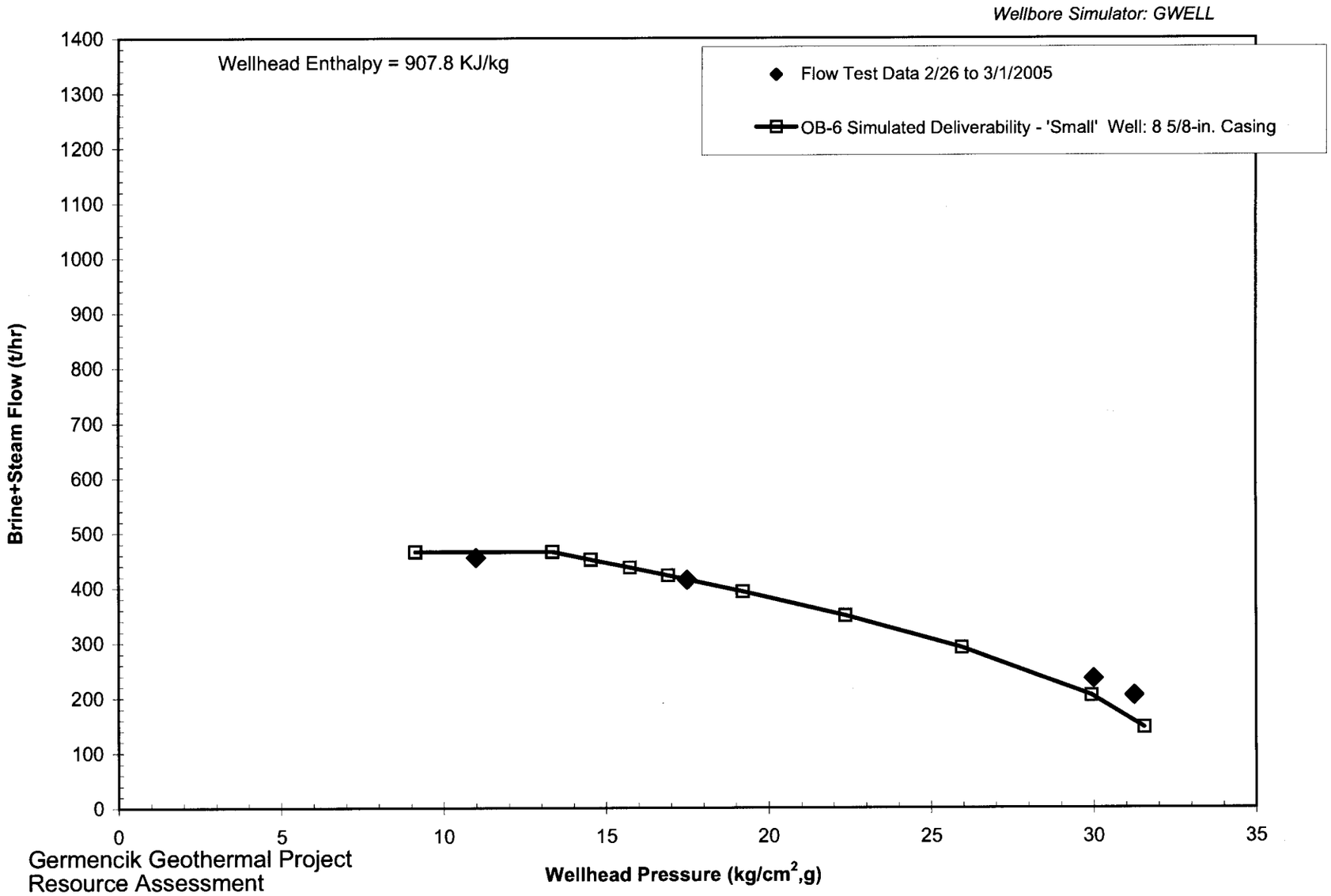


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Figure 6.1 - 1a
OB-6 Simulated Deliverability Curves

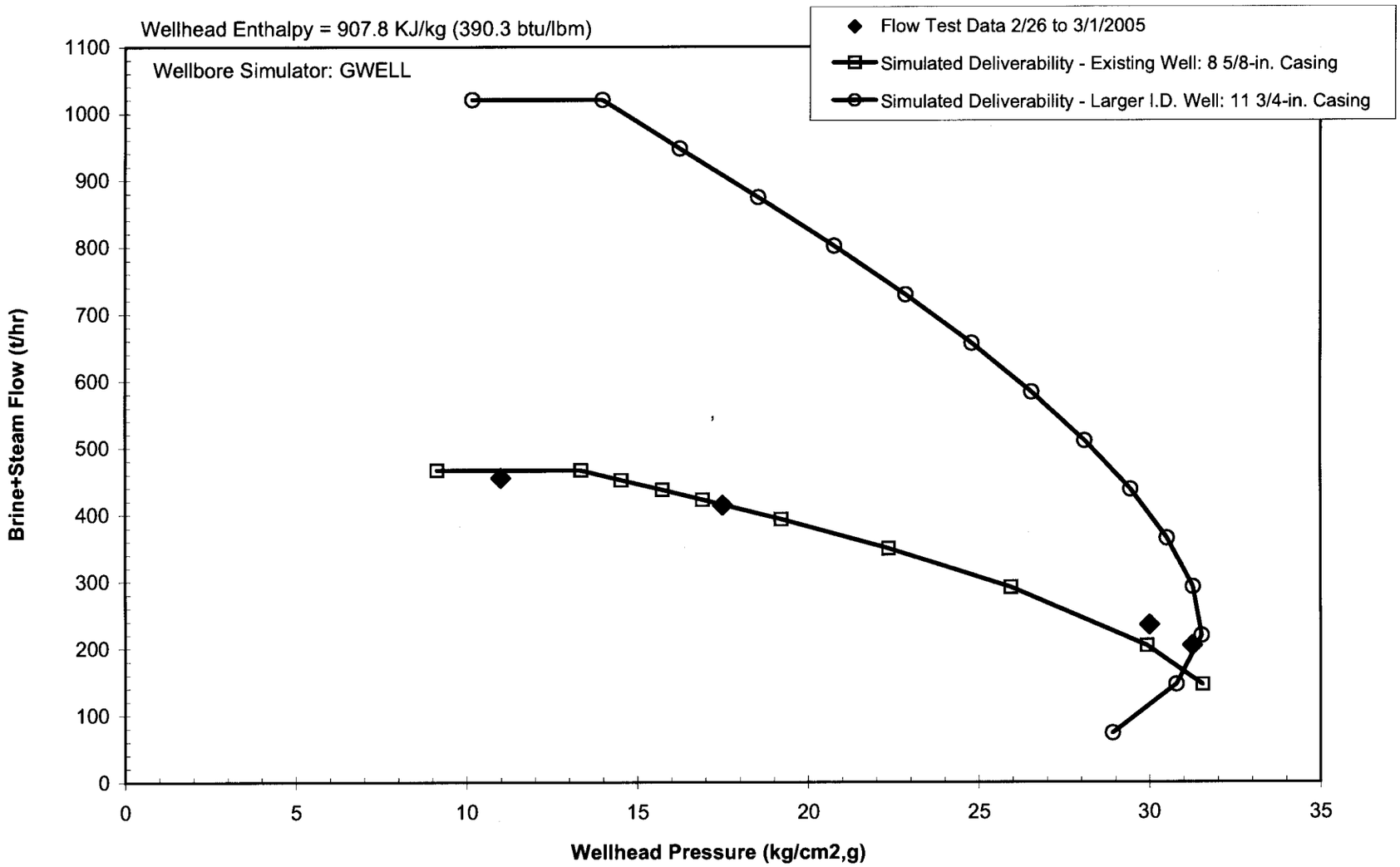

Figure 6.1 - 2
OB-6A Simulated Deliverability Curve

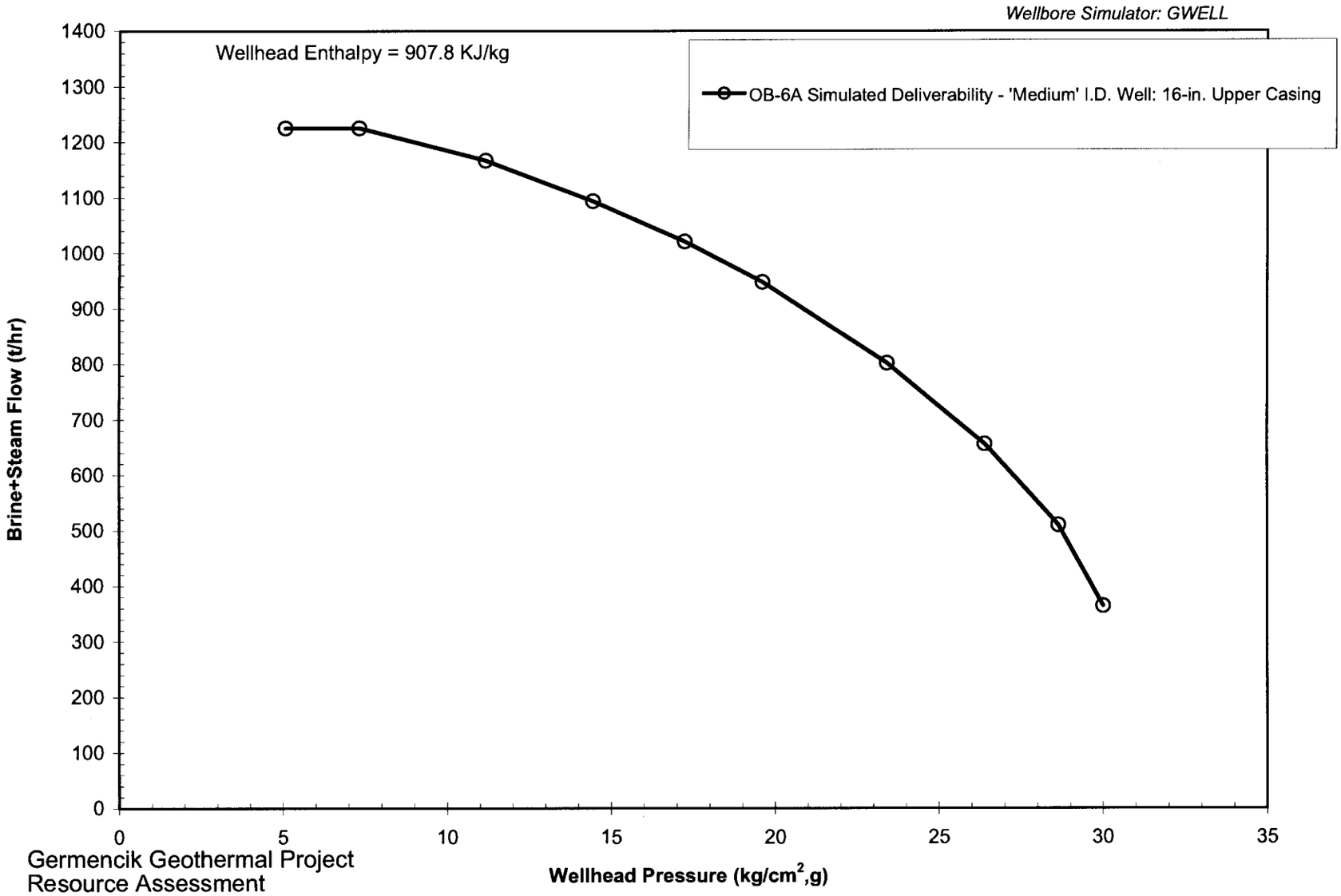

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Figure 6.1 - 3
OB-9 Simulated Deliverability Curve

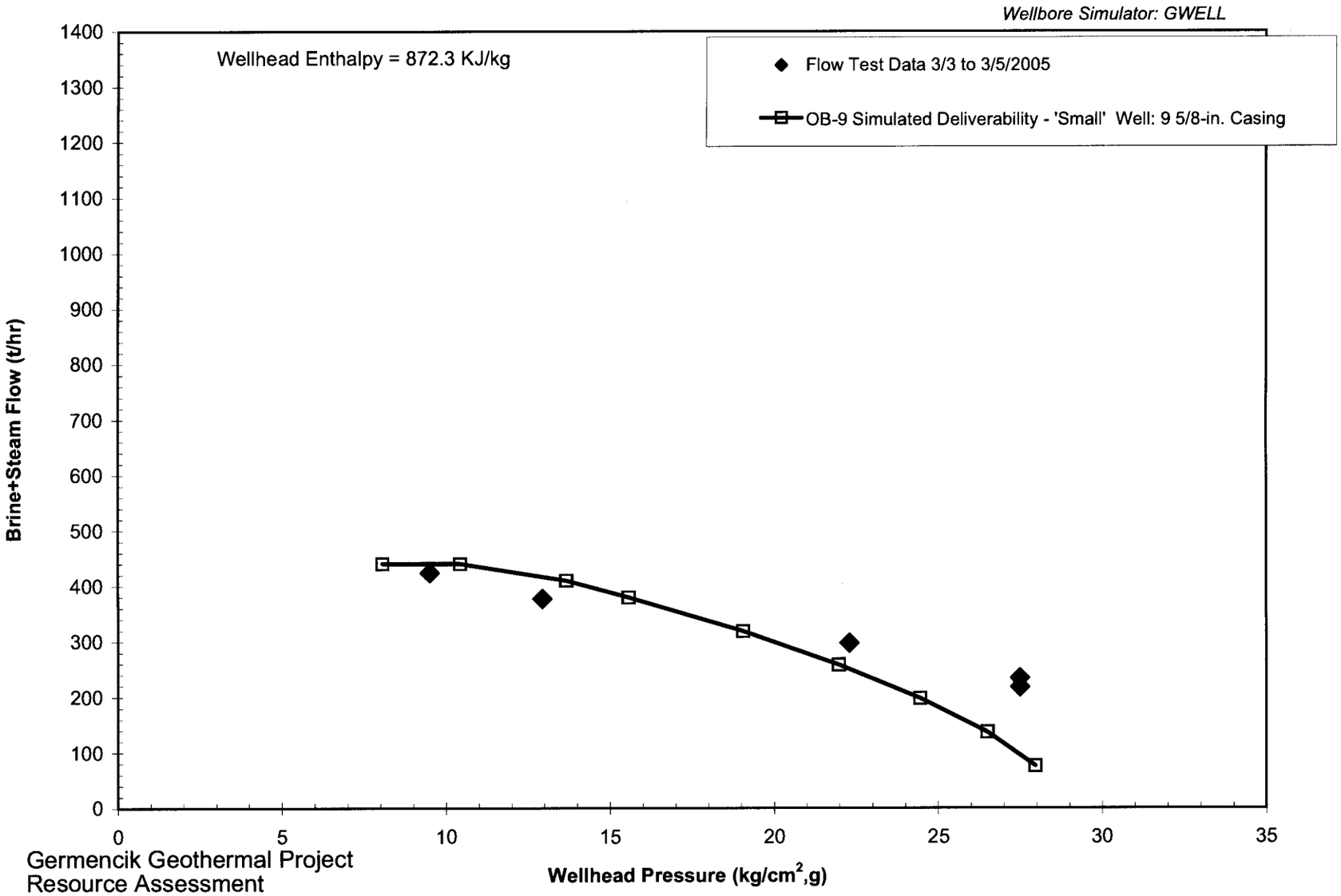

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Figure 6.1 - 4
OB-10 Simulated Deliverability Curve

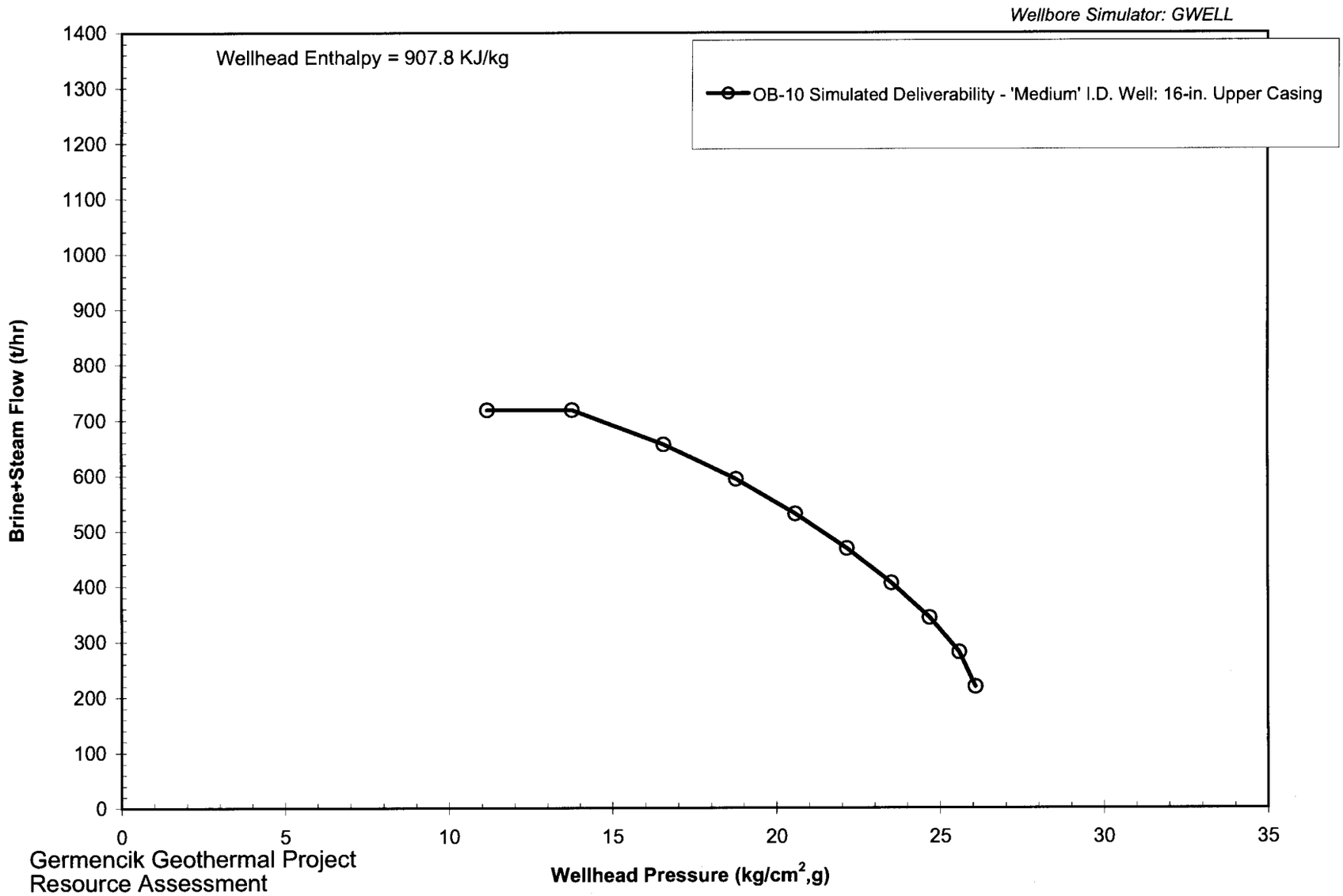

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Figure 6.1 - 5
Field Simulated Deliverability Curve

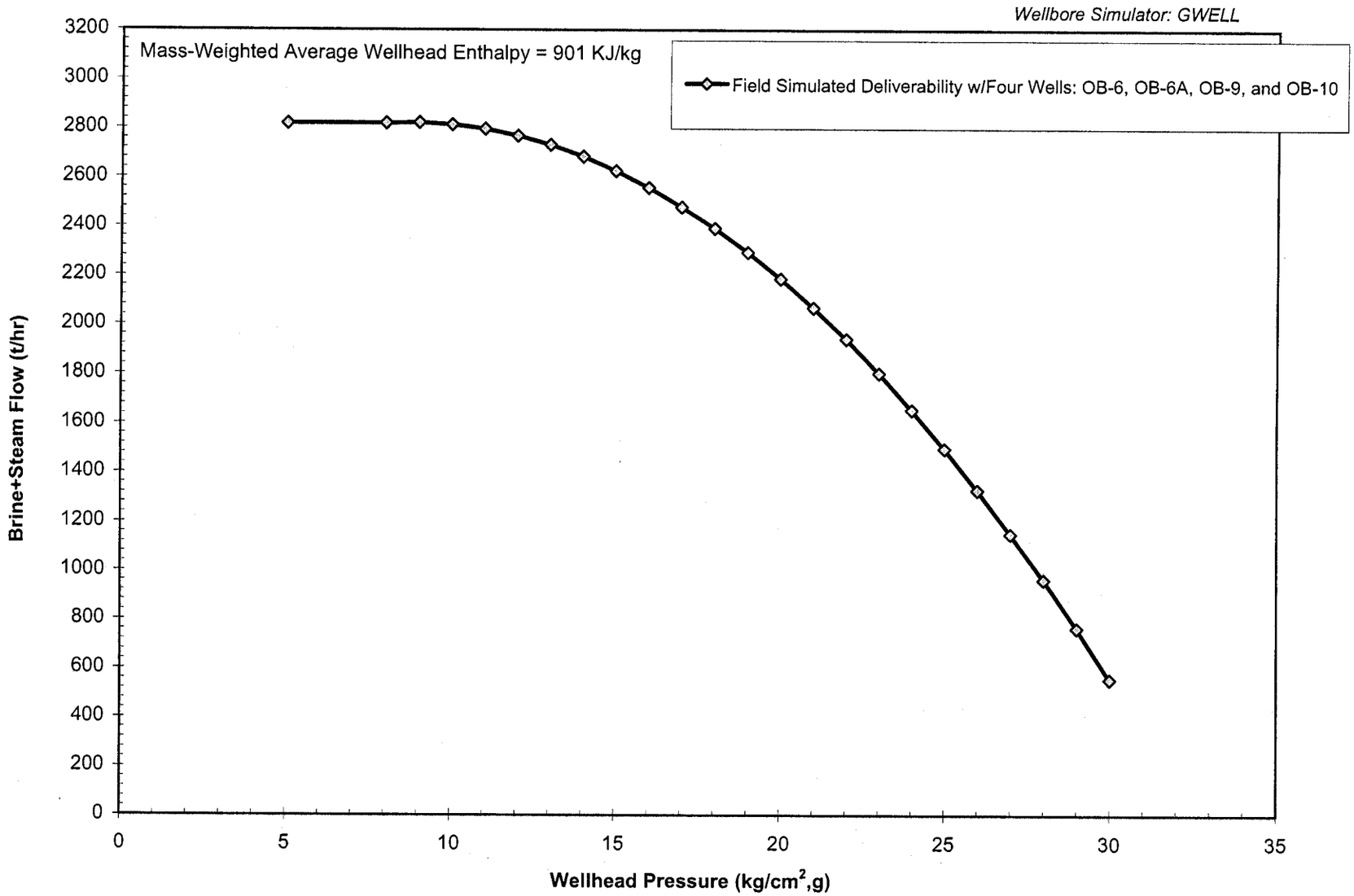
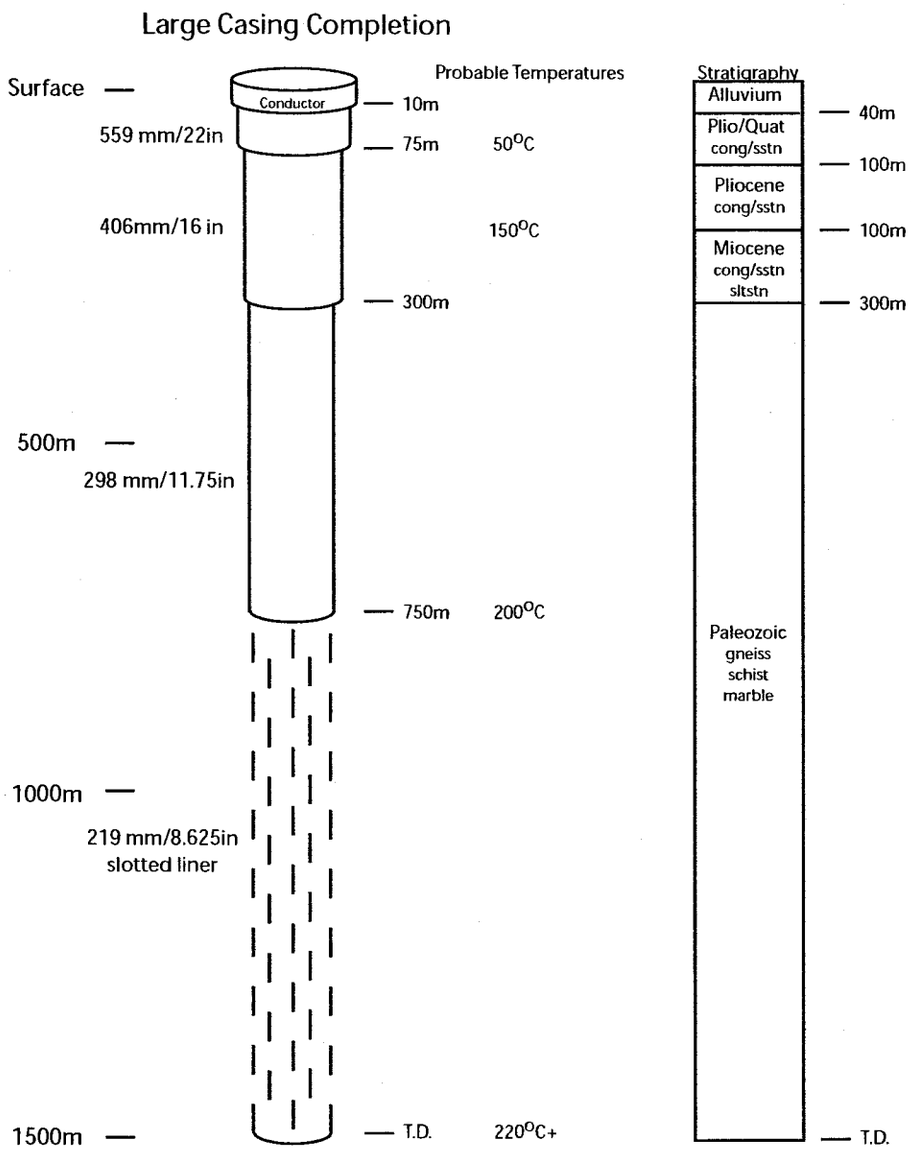


Figure 6.1-6 Germencik Production Well Schematic



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TABLES

Sampling Location		Date	pH	WHP	W (kg/s)	$H_{(tot)}$ kJ/kg	$T_{(samp}$ling) °C	$T_{(res)}$ °C	$T_{(Quartz)}$ °C	HSiO2 kJ/kg	Specific Cond. µmh/cm	TDS	Total Hard ness	K^+	Na^+	NH_4^+	Ca^{2+}	Mg^{2+}	Fe	As	B	HCO_3^-	CO_3^{2-}	SO_4^{2-}	Cl^-	F	NO_2^-	NO_3^-	CO_2	SiO_2	HS^-	RB	Li^+	Sr^{2+}	Mn^{2+}	Zn^{2+}	Cd^{2+}	Ni^{2+}	Cu^{2+}	Ba^{2+}	Al^{3+}	Comments
AlanGüllü	river-surface	18/08/2004	6.9				20.7				1082	738		12	86		66.6	53.6				479		26.30	83																	
Alangullu	Hot Spring-surface	1988	6.7				60				5838			125	1199		69	25			41	2426		66.00	1212					194												Khuyat, 1988
groundwater	cold	1988	7				17				1171	1111		28	112		38	77				653		78.00	75					50												Khuyat, 1988
OB1	"deep borehole"	03/11/1982							243	1050		4537	191	45	1355	3.81	50	16	<0.1	0.4	45	1172	84	37	1586	2.44	0.26	0.8		140												
OB1	weir box		8.5						218	931				45	1355	3.8	6.4	1			45	1324	246	37	1586					450			8									
OB1	weir box		8.5						218	931				85	2050		3.2	1			63	2123	438	66	1747					450			7.2									
OB2	"deep borehole"	07/06/1983	9						243	1050	7200	6017	4	89	1830	8.74	1.60	0.0	<0.1	0.59	71	1525	138	71	1359	8.25	0.0	0.0		160.0												
OB2	weir box			8.2	40	1110		232	218	931				191	2810		4.2	2			63	1531	204	168	1948					450.0			7.4									
OB2	2.reservoir		8.7						223	960				145	1600	9.3	6	1.2			50	900	280	24	1790					480.0			18									
OB-2b	wellhead sample	18/08/2004	6.5				35	220			6790	4688		130	1560		0	7.07				1391		28.80	1575																	reservoir temperatures are estimated
OB3	"deep borehole"	26/07/1984	8.8	13.2	72	1110			105		7100	5522	6	170	1775	4.8	1.6	0.5	<0.1	0.9	68	1342	204	74	1818	8.0	<0.01	<0.1	0.0	55												
ÖB-3b	wellhead sample	18/08/2004	6.7				54	220			6860	4664		135	1535		2.16	7				1440		31.20	1707																	reservoir temperatures are estimated
ÖB-3b	wellhead sample	18/08/2004	6.7				54	220			6860	4693		140	1580		3.96	5.9				1419		30.90	1580																	duplicate, reservoir temperatures are estimated
OB4	"deep borehole"	26/07/1984	7.7	11.1	119			200	183		5400	4793	35	35	1420	32.1	12	1.7	1.85	0.030	55	1440	0	37	1500	7.25	<0.01	<0.1	98	53												
OB5	"deep borehole"	08/01/1984	8.4	16	67				93		3000	4780		28	1387	9.6	8.4	6.8		0.01	56	1409	66	46	1454		<0.1			209												
OB6	"deep borehole"	05/03/1985	8.7	15	108	1084		224	225	970	6200	5516	9	80	1775	9.3	3.6	<1.0	<0.1	0.8	74	1202	288	64.2	1882		<0.01	<0.1	0	41												
OB6	"deep sampling"		6.1						224	965				132	1260		38.6	<0.5	-		45.2	1588		38.3	1420			-		367	0.5	0.026	8	2.93	0.8	0.3	0.62	3.2	32.2	1.2	-	
OB6	weir box		8.4						185					170	1850		0	<0.5	-		58.8	1868		27.8	1975			-		360	0.04	0.03	12	1.0	-	<0.1	<0.1	-	-	0.62	-	
OB7	"deep borehole"	14/04/1988	7.5	14	35				206	880	4200	4283	4	32	1100	1	19	6.1	7.6	0.05	56	1837	0.0	51	855		0.20	4.2		214												
OB8	"deep borehole"	22/07/1986	8.9	13.2	99				206	880	6600	4576	37.5	15	1550		8.02	2.43				1317	111	45.3	1528					286												
ÖB-8a	wellhead sample	18/08/2004	6.5				43	230			7030	4856		145	1600		0	9.82				1330		31.4	1690																	reservoir temperatures are estimated
OB9	"deep borehole"	12/05/1987	8.6						223	960	6500	5543	8.65	105	1750	11.3	4.8*	1.2*	<0.1	0.14	68	1376*	132	133	1819	7.3	0.01	1.0		286												
OB9	deep sampling		6.1	15	92	1047		224	203	880				100	1330		43.5	2.3	8.1		45.3	1586		35.7	1410			43.5		358	0.4	0.027	7.4	4.53	1	0.4	5.7	3.4	59.3	1.6	-	
OB9	deep sampling after injection test		###						-18					174	1870		6.8	<0.4	3.5		59.4	1871		37.2	2000			-		0.61	0.04	0.033	12	0.61	-	0	0.6	0.35	3.1	0.45	0.5	
OB9	weir box		8.3						214	920				130	1810		<0.5	<0.5	-		58.7	1768		30.2	1950			-		421	0.05	0.029	11	1.1	-	<0.5	<0.1	-	-	1.16	-	
ÖB-9a	wellhead sample	18/08/2004	6.5				39	230			6880	4693		145	1530		18.4	5.44				1482		30.80	1524																	reservoir temperatures are estimated

not analysed= blank box 407.6 1.07388

not detected= - 0.233

Table 3.2-1
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Historal Brine Analysis

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Well	Date	Time	Line P	Line T	H(res,tot)	Y	pH	cond-meas	G/S-meas	cond-res	Gas-res	gas-res	cond-res
			bar g	°C	KJ/kg						% by weight	well average	well average
	7-Mar-05	17:20	4.0	145		0.100	7.4	6430	129010	5787	1.29		
	8-Mar-05	8:20	2.5	125		0.119	8.5	7430	109050	6546	1.30		
	8-Mar-05	14:10	3.5	140		0.108	8.5	7430	125230	6628	1.35		
OB-3	9-Mar-05	8:50	3.0	135	840.7	0.112	8.5	7660	85910	6802	0.96	1.23	6441
	11-Mar-05	9:15	5.5	159		0.106	7.7	6690	154290	5979	1.64		
	11-Mar-05	13:10	5.5	155		0.112	6.8	6500	120200	5773	1.34		
	11-Mar-05	16:35	5.5	155		0.110	7.8	6190	152800	5507	1.69		
OB-5	12-Mar-05	8:55	5.0	155	911	0.117	8.6	6950	137040	6140	1.60	1.57	5850
	26 Feb 05	15:40	5.1	148		0.114	7.5	6720	163000	5957	1.85		
	28 Feb 05	11:20	10.5	180		0.057	7.1	6720	193000	6339	1.09		
	28 Feb 05	16:50	9.5	175		0.072	7.0	6610	181000	6136	1.30		
OB-6	1-Mar-05	7:40	4.5	148	907.8	0.126	8.0	7520	154000	6574	1.94	1.54	6252
	18-Mar-05	18:35	6.0	160		0.107	7.2	5850	177350	5224	1.90		
	19-Mar-05	9:30	5.9	160		0.109	6.5	6400	141850	5701	1.55		
	19-Mar-05	13:50	5.5	150		0.113	8.2	7630	133770	6770	1.51		
OB-7	19-Mar-05	18:00	4.2	150	916	0.129	8.0	8210	157100	7151	2.03	1.75	6211
	14-Mar-05	17:55	7.2	165		0.087	6.7	6670	177770	6089	1.55		
	15-Mar-05	8:45	7.2	165		0.089	7.9	7000	192510	6379	1.71		
	15-Mar-05	12:30	6.9	165		0.093	7.7	7000	171120	6350	1.59		
OB-8	15-Mar-05	17:05	5.0	155	904.6	0.111	7.2	6980	144020	6207	1.59	1.61	6256
	4-Mar-05	17:45	8.5	172		0.060	7.1	6650	155000	6249	0.94		
	4-Mar-05	9:00	4.4	148		0.104	7.4	6800	193000	6092	2.01		
	4-Mar-05	15:20	6.1	160		0.085	7.0	6580	204000	6021	1.73		
OB-9	5-Mar-05	9:50	4.4	150	872.3	0.105	7.4	6800	164000	6087	1.72	1.60	6112

MEAN of ALL SAMPLES	892					6187		1.55	6187
Standard Deviation	3%					7%		20%	3%
MEAN of OB-6, OB-8 and OB-9	895					6290		1.58	6207
Standard Deviation	2%					3%		21%	1%

Table 3.2-2a
Resource Assessment
Germencik Geothermal Project

Short term flow test Field Measurements

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9 July 2005

Germencik Short-term Flow Test Brine Analytical Results 2005

Sampling Location	Laboratory	Sampling P (bar_g)	Date	Time	pH	$T_{(sampling)}$ °C	$H_{(tot)}$ kJ/kg	$T_{(tot-meas)}$ °C	$T_{(silica)}$ °C	$T_{(Na-K)}$ °C	$T_{(Na-K)}$ °C	Specific Cond. µmh/cm	TDS	K^+	Na^+	NH_4^+	Ca^{2+}	Mg^{2+}	Fe	As	B total	HCO_3^-	CO_3^{2-}	SO_4^{2-}	Cl^-	SiO_2	Li^+	Sr^{2+}	Mn^{2+}	Ba^{2+}
OB-3	MTA	2.5	8-Mar-05	8:20	7.5	125	841	196	269	230	205	6850		198	1700	11	1.27	<1.0			71	1622	<10		1671	596				
OB-3	MTA	3.5	8-Mar-05	14:10	8	140	841	196	267	226	198	6930		190	1720	11	<1.0	<1.0			70	1657	<10		1704	583				
OB-3	MTA	3.0	9-Mar-05	8:50	8.2	135	841	196	259	227	200	6980		193	1720	11	<1.0	<1.0			72	1663	<10.		1713	535				
OB-3	Thermochem	3.0	9-Mar-05	8:55	8	135	841	196	249	219	190		6010	176	1720	10.1	0.909	<0.05	0.065	0.56	63.6	1670	<2	49.9	1820	484	10.5	0.93	0.01	1.13
OB-5	MTA	5.5	11-Mar-05	13:10	7.5	155	911	213	237	220	191	6380		165	1600	15	1.75	<1.0			66	1586	<10		1549	419				
OB5	MTA	5.5	11-Mar-05	16:35	6.9	155	911	213	239	220	191	6460		165	1600	14	1.66	<1.0			63	1598	<10		1558	430				
OB5	MTA	5.0	12-Mar-05	8:55	7.8	155	911	213	245	229	202	6640		183	1600	13	1.66	<1.0			67	1634	<10		1613	462				
OB5	Thermochem	5.5	11-Mar-05	16:40	7.59	155	911	213	241	214	184		5580	156	1610	13.3	1.33	<0.050	0.14	0.52	59	1610	<2	26.6	1660	440	9.45	0.89	0.01	1.05
OB5	Thermochem	5.0	12-Mar-05	8:55	7.76	155	911	213	236	216	187		5590	161	1620	13.3	1.52	<0.050	0.065	0.56	60.2	1650	<2	26.4	1640	418	9.41	0.91	0.01	1.08
OB-6	MTA	10.5	28 Feb 05	11:20	6.6	180	908	212	246	220	192	6860		158	1520	28	3.29	<0.1			64	2539	<10		1408	464				
OB-6	MTA	9.5	28 Feb 05	16:50	6.6	175	908	212	247	224	196	6830		158	1460	30	3.38	<0.1			66	2533	<10		1385	472				
OB-6	MTA	4.5	1-Mar-05	7:40	6.7	148	908	212	239	220	192	6840		158	1520	32	3.13	<1.0			69	2557	<10		1412	430				
OB-6	Thermochem	9.5	28 Feb 05	16:47	7.15	175	908	212	237	219	190		5460	156	1530	15.6	2.85	0.089	0.143	0.11	55.7	1590	<2	28.7	1660	419	8.96	0.8	0.01	0.83
OB-6	Thermochem	4.5	1-Mar-05	8:00	7.82	148	908	212	241	219	190		5750	166	1620	12.6	1.12	0.128	0.073	0.01	59.7	1660	<2	36.6	1760	440	9.63	0.8	0.01	0.9
OB-7	MTA	5.9	19-Mar-05	9:30	6.7	160	916	214	253	215	185	5540		143	1460	14	1.92	<1.0			73	1740	<10		1175	506				
OB-7	MTA	5.5	19-Mar-05	13:50	7.9	150	916	214	267	219	190	5760		150	1460	13	3.2	<1.0			75	1788	<10		1275	586				
OB-7	MTA	4.2	19-Mar-05	18:00	7.8	150	916	214	269	222	193	5760		150	1420	13	1.68	<1.0			76	1788	<10		1248	595				
OB-7	Thermochem	5.5	19-Mar-05	13:50	7.91	150	916	214	240	212	181		5210	135	1440	12.2	0.861	<0.050	0.065	0.65	61.6	1790		53.8	1280	438	8.02	0.73	0.01	0.95
OB-7	Thermochem	4.2	19-Mar-05	18:00	7.95	150	916	214	243	210	179		5330	137	1490	10.6	5	0.146	0.062	0.64	62.9	1810		53.2	1310	452	7.94	0.84	<0.005	0.85
OB8	MTA	7.2	15-Mar-05	8:45	7.6	165	905	212	259	206	173	6390		145	1660	14	1.5	<1.0			71	1426	<10		1622	535				
OB8	MTA	6.9	15-Mar-05	12:30	7.3	165	905	212	250	213	182	6340		145	1520	15	1.33	<1.0			69	1444	<10		1594	489				
OB8	MTA	5	15-Mar-05	17:05	7.2	155	905	212	254	210	179	6430		148	1600	15	1.68	<1.0			72	1474	<10		1613	510				
OB8	Thermochem	6.9	15-Mar-05	12:30	7.19	165	905	212	234	200	167		5380	130	1590	14.6	0.767	0.088	0.104	0.42	57.8	1460	<2	25.9	1690	404	8.63	1.09	0.01	0.83
OB8	Thermochem	5	15-Mar-05	17:05	7.22	155	905	212	230	202	169		5310	130	1560	15	0.835	0.097	0.06	0.42	57.1	1460	<2	25.6	1670	387	8.74	1.1	0.01	0.82
OB9	MTA	8.5	4-Mar-05	17:45	6.5	172	872.3	204	252	209	177	6110		138	1520	17	3.76	<1.0			61	1444	<10		1494	499				
OB9	MTA	6.1	4-Mar-05	15:20	7.6	160	872.3	204	246	208	177	6350		150	1660	15	1.79	<1.0			65	1509	<10		1567	465				
OB9	MTA	4.4	5-Mar-05	9:50	7.7	150	872.3	204	252	203	170	6440		138	1640	14	1.92	<1.0			67	1515	<10		1594	496				
OB9	Thermochem	6.1	4-Mar-05	15:30	7.66	160	872.3	204	229	203	170		5430	132	1570	12.5	1.53	0.2	0.117	0.37	58.5	1560	<2	23.2	1700	381	8.48	0.95	0.01	0.97
OB9	Thermochem	4.4	5-Mar-05	9:50	7.68	150	872.3	204	230	202	169		5370	130	1560	12.8	1.29	0.166	0.074	0.37	56.8	1530	<2	22.4	1670	388	8.46	0.93	0.01	0.96

	Field Measurements										Gas Analysis																
	Date	Time	LP	LT	H(res,tot)	Y	pH	G/S-meas	Gas-res		G/S		Carbon dioxide	Hydrogen sulfid	Ammonia	Argon	Nitrogen	Methane	Hydrogen	Carbon dioxide	Hydrogen sulfide	Ammonia	Argon	Nitrogen	Methane	Hydrogen	% Air
Well			bar g	°C	KJ/kg			ppmw	% by weight	well average	ppmw	mole/10^6 moles	Percent (%) by Volume in Dry Gas							Parts per Million by Weight							
	7-Mar-05	17:20	4.0	145		0.100	7.4	129010	1.29																		
	8-Mar-05	8:20	2.5	125		0.119	8.5	109050	1.30																		
	8-Mar-05	14:10	3.5	140		0.108	8.5	125230	1.35		125282									125000	208	73.9					
OB-3	9-Mar-05	8:50	3.0	135	840.7	0.112	8.5	85910	0.96	1.23	124512	58654	98.5	0.218	0.167	0.001	0.42	0.685	0.032	124000	211	0.813	1.37	315	291	1.69	0.025
	11-Mar-05	9:15	5.5	159		0.106	7.7	154290	1.64																		
	11-Mar-05	13:10	5.5	155		0.112	6.8	120200	1.34																		
	11-Mar-05	16:35	5.5	155		0.110	7.8	152800	1.69		132150	62835	98.4	0.214	0.141	0.001	0.48	0.766	0.034	131000	221	0.726	1.62	376	348	1.99	0.015
OB-5	12-Mar-05	8:55	5.0	155	911	0.117	8.6	137040	1.60	1.57	167309	82871	98.5	0.204	0.139	0.001	0.45	0.712	0.0313	166000	266	90.5	1.93	449	411	2.34	0.02
	26 Feb 05	15:40	5.1	148		0.114	7.5	163000	1.85																		
	28 Feb 05	11:20	10.5	180		0.057	7.1	193000	1.09																		
	28 Feb 05	16:50	9.5	175		0.072	7.0	181000	1.30		166922	82618	98.5	0.231	0.115	0.001	0.41	0.672	0.0558	166000	301	74.7	1.8	440	412	4.3	0.01
OB-6	1-Mar-05	7:40	4.5	148	907.8	0.126	8.0	154000	1.94	1.54	128713	60950	98.4	0.216	0.16	0.001	0.45	0.732	0.0379	128000	217	80.2	1.49	345	323	2.19	0.017
	18-Mar-05	18:35	6.0	160		0.107	7.2	177350	1.90																		
	19-Mar-05	9:30	5.9	160		0.109	6.5	141850	1.55																		
	19-Mar-05	13:50	5.5	150		0.113	8.2	133770	1.51		166375	82272	98.6	0.179	0.121	0.001	0.45	0.654	0.0334	165000	232	78.6	1.53	482	400	2.56	0.009
OB-7	19-Mar-05	18:00	4.2	150	916	0.129	8.0	157100	2.03	1.75	171394	85259	98.6	0.183	0.112	1E-03	0.45	0.653	0.0301	170000	245	74.6	1.57	492	411	2.38	0.012
	14-Mar-05	17:55	7.2	165		0.087	6.7	177770	1.55																		
	15-Mar-05	8:45	7.2	165		0.089	7.9	192510	1.71																		
	15-Mar-05	12:30	6.9	165		0.093	7.7	171120	1.59		175466	87761	98.5	0.202	0.106	0.001	0.45	0.711	0.043	174000	277	72.6	2	473	429	3.46	0.005
OB-8	15-Mar-05	17:05	5.0	155	904.6	0.111	7.2	144020	1.59	1.61	169687	84267	98.5	0.204	0.07	0.001	0.46	0.714	0.0426	168000	270	46.4	1.92	466	416	3.31	0.016
	4-Mar-05	17:45	8.5	172		0.060	7.1	155000	0.94																		
	4-Mar-05	9:00	4.4	148		0.104	7.4	193000	2.01																		
	4-Mar-05	15:20	6.1	160		0.085	7.0	204000	1.73		171736	85512	98.5	0.221	0.137	0.001	0.43	0.699	0.0391	170000	296	91.6	1.92	440	412	3.04	0.85
OB-9	5-Mar-05	9:50	4.4	150	872.3	0.105	7.4	164000	1.72	1.60	159243	78126	98.4	0.209	0.113	0.001	0.47	0.726	0.0408	158000	260	70	1.85	444	397	2.94	0.02

Condensate											
	Date	Time	LP	LT	H(res,tot)	Y	Condensate in mg/kg				%carryover
Well			bar g	°C	KJ/kg		Na	B	As	Na (brine)	Ccond=x*C brine + (1-x)Csteam
	7-Mar-05	17:20	4.0	145		0.100					
	8-Mar-05	8:20	2.5	125		0.119					
	8-Mar-05	14:10	3.5	140		0.108	0.266	0.348	<0.005		
OB-3	9-Mar-05	8:50	3.0	135	841	0.112	0.217	<0.180	<0.005	1720	0.013
	11-Mar-05	9:15	5.5	159		0.106					
	11-Mar-05	13:10	5.5	155		0.112					
	11-Mar-05	16:35	5.5	155		0.110	0.265	0.705	<0.005	1610	0.016
OB-5	12-Mar-05	8:55	5.0	155	911	0.117	0.48	0.583	<0.005	1620	0.030
	26 Feb 05	15:40	5.1	148		0.114					
	28 Feb 05	11:20	10.5	180		0.057					
	28 Feb 05	16:50	9.5	175		0.072	0.534	0.563	<0.005	1530	0.035
OB-6	1-Mar-05	7:40	4.5	148	908	0.126	0.079	0.234	<0.005	1620	0.005
	18-Mar-05	18:35	6.0	160		0.107					
	19-Mar-05	9:30	5.9	160		0.109					
	19-Mar-05	13:50	5.5	150		0.113	146	7.21	0.065	1440	10.139
OB-7	19-Mar-05	18:00	4.2	150	916	0.129	0.328	<0.180	0.016	1490	0.022
	14-Mar-05	17:55	7.2	165		0.087					
	15-Mar-05	8:45	7.2	165		0.089					
	15-Mar-05	12:30	6.9	165		0.093	0.406	0.689	<0.005	1590	0.026
OB-8	15-Mar-05	17:05	5.0	155	905	0.111	0.382	0.425	<0.005	1560	0.024
	4-Mar-05	17:45	8.5	172		0.060					
	4-Mar-05	9:00	4.4	148		0.104					
	4-Mar-05	15:20	6.1	160		0.085	0.071	0.242	0.0057	1570	0.005
OB-9	5-Mar-05	9:50	4.4	150	872	0.105	0.099	0.279	<0.005	1560	0.006

Stable Isotopes of Water Oxygen-18 (18O) and Deuterium (2H) Analytical Results and Calculated Reservoir Values

Well	Date	Descriptor	$\delta^{2}H$ (‰), H_2O V-SMOW [1]	$\delta^{18}O$ (‰), H_2O V-SMOW [1]	Steam Fraction, y	Separation Temp °C		Reservoir Values (‰)
OB3	8-Mar-05	Steam 3B 14:05	-51.3	-4.99	0.108	140	**D**	-38.90
OB3	8-Mar-05	Brine 3E 14:10	-37.4	-1.3	0.108	140	**O-18**	-1.70
OB3	9-Mar-05	Steam 4B 08:50	-45.8	-4.23	0.112	135	**D**	-38.34
OB3	9-Mar-05	Brine 4E 08:55	-37.4	-1.19	0.112	135	**O-18**	-1.53
OB5	11-Mar-05	Steam 3B 16:35	-46.8	-4.57	0.110	155	**D**	-40.75
OB5	11-Mar-05	Brine 3E 16:40	-40.0	-1.61	0.110	155	**O-18**	-1.94
OB5	12-Mar-05	Steam 4B 08:50	-40.1	-4.91	0.117	150	**D**	-38.24
OB5	12-Mar-05	Brine 4E 08:55	-38.0	-1.44	0.117	150	**O-18**	-1.84
OB6	28-Feb-05	Steam 3B 16:50	-19.5	-4.3	0.072	175	**D**	-37.97
OB6	28-Feb-05	Brine 3E 16:50	-39.4	-1.74	0.072	175	**O-18**	-1.92
OB6	1-Mar-05	Steam 4B 07:40	-45.4	-6.08	0.126	148	**D**	-39.63
OB6	1-Mar-05	Brine 4E 08:00	-38.8	-1.51	0.126	148	**O-18**	-2.08
OB7	19-Mar-05	Steam 3B 13:45	-45.4	-4.58	0.113	150	**D**	-38.30
OB7	19-Mar-05	Brine 3E 13:50	-37.4	-1.58	0.113	150	**O-18**	-1.92
OB7	19-Mar-05	Steam 4B 17:55	-51.0	-4.84	0.129	150	**D**	-34.54
OB7	19-Mar-05	Brine 4E 18:00	-32.1	-1.65	0.129	150	**O-18**	-2.06
OB8	15-Mar-05	Steam 3B 12:27	-47.3	-4.57	0.093	165	**D**	-40.95
OB8	15-Mar-05	Brine 3E 12:30	-40.3	-1.66	0.093	165	**O-18**	-1.93
OB8	15-Mar-05	Steam 4B 17:00	-46.4	-4.63	0.111	155	**D**	-40.26
OB8	15-Mar-05	Brine 4E 17:05	-39.5	-1.59	0.111	155	**O-18**	-1.93
OB9	4-Mar-05	Steam 3B 15:20	-48.4	-4.69	0.085	160	**D**	-40.26
OB9	4-Mar-05	Brine 3E 15:30	-39.5	-1.79	0.085	160	**O-18**	-2.04
OB9	5-Mar-05	Steam 4B 09:45	-49.2	-4.39	0.105	150	**D**	-39.62
OB9	5-Mar-05	Brine 4E 09:50	-38.5	-1.4	0.105	150	**O-18**	-1.71
Menderes R	1-Jun-80	cold water, FIKIZ	-54.9	-8.85	-	-		
Reservoir Mean			-38.98	-1.88				

1-parts per thousand relative to Standard Mean Ocean Water (SMOW)

Germencik Short-term Flow Test Reservoir Chemistry									Dissolved Constituents at Reservoir Conditions																	
Sampling Location	Laboratory	Sampling P (bar_g)	Date	Time	pH	$T_{(sampling)}$ °C	$H_{(tot)}$ kJ/kg	y	TDS	K^+	Na^+	NH_4^+	Ca^{2+}	Mg^{2+}	Fe	As	B total	HCO_3^-	CO_3^{2-}	SO_4^{2-}	Cl^-	SiO_2	Li^+	Sr^{2+}	Mn^{2+}	Ba^{2+}
OB-3	MTA	2.5	8-Mar-05	8:20	7.5	125	841	0.119		174	1498	9.7	1.12	-			62.6	1,429	-		1472	525		0.000	0.000	0.00
OB-3	MTA	3.5	8-Mar-05	14:10	8	140	841	0.108		169	1534	9.8	-	-			62.4	1,478	-		1520	520				
OB-3	MTA	3.0	9-Mar-05	8:50	8.2	135	841	0.112		171	1527	9.8	-	-			63.9	1,477	-		1521	475				
OB-3	Thermochem	3.0	9-Mar-05	8:55	8	135	841	0.112	5337	156	1527	9.0	0.81	-	0.058	0.500	56.5	1,483	-	44.3	1616	430	9.32	0.825	0.004	1.00
OB-5	MTA	5.5	11-Mar-05	13:10	7.5	155	911	0.112		147	1421	13.3	1.55	-			58.6	1,409	-		1376	372				
OB5	MTA	5.5	11-Mar-05	16:35	6.9	155	911	0.110		147	1424	12.5	1.48	-			56.1	1,422	-		1386	383				
OB5	MTA	5.0	12-Mar-05	8:55	7.8	155	911	0.117		162	1414	11.5	1.47	-			59.2	1,444	-		1425	408				
OB5	Thermochem	5.5	11-Mar-05	16:40	7.59	155	911	0.110	4965	139	1432	11.8	1.18	-	0.125	0.461	52.5	1,432	-	23.7	1477	391	8.41	0.791	0.007	0.93
OB5	Thermochem	5.0	12-Mar-05	8:55	7.76	155	911	0.117	4939	142	1431	11.8	1.34	-	0.057	0.491	53.2	1,458	-	23.3	1449	369	8.31	0.806	0.005	0.95
OB-6	MTA	10.5	28-Feb-05	11:20	6.6	180	908	0.057		149	1434	26.4	3.10	-			60.4	2,395	-		1328	438				
OB-6	MTA	9.5	28-Feb-05	16:50	6.6	175	908	0.072		147	1355	27.8	3.14	-			61.3	2,351	-		1286	438				
OB-6	MTA	4.5	1-Mar-05	7:40	6.7	148	908	0.126		138	1329	28.0	2.74	-			60.3	2,235	-		1234	376				
OB-6	Thermochem	9.5	28-Feb-05	16:47	7.15	175	908	0.072	5069	145	1420	14.5	2.65	0.083	0.133	0.103	51.7	1,476	-	26.6	1541	389	8.32	0.747	0.010	0.77
OB-6	Thermochem	4.5	1-Mar-05	8:00	7.82	148	908	0.126	5027	145	1416	11.0	0.98	0.112	0.064	0.005	52.2	1,451	-	32.0	1539	385	8.42	0.682	0.005	0.79
OB-7	MTA	5.9	19-Mar-05	9:30	6.7	160	916	0.109		127	1300	12.5	1.71	-			65.0	1,550	-		1047	451				
OB-7	MTA	5.5	19-Mar-05	13:50	7.9	150	916	0.113		133	1295	11.5	2.84	-			66.5	1,586	-		1131	520				
OB-7	MTA	4.2	19-Mar-05	18:00	7.8	150	916	0.129		131	1237	11.3	1.46	-			66.2	1,557	-		1087	518				
OB-7	Thermochem	5.5	19-Mar-05	13:50	7.91	150	916	0.113	4623	120	1278	10.8	0.76	-	0.058	0.575	54.7	1,588	-	47.7	1136	389	7.12	0.645	0.005	0.84
OB-7	Thermochem	4.2	19-Mar-05	18:00	7.95	150	916	0.129	4643	119	1298	9.2	4.36	0.127	0.054	0.560	54.8	1,577	-	46.3	1141	394	6.92	0.733	-	0.74
OB8	MTA	7.2	15-Mar-05	8:45	7.6	165	905	0.089		132	1513	12.8	1.37	-			64.7	1,299	-		1478	487				
OB8	MTA	6.9	15-Mar-05	12:30	7.3	165	905	0.093		132	1379	13.6	1.21	-			62.6	1,310	-		1446	444				
OB8	MTA	5	15-Mar-05	17:05	7.2	155	905	0.111		132	1423	13.3	1.49	-			64.0	1,311	-		1434	454				
OB8	Thermochem	6.9	15-Mar-05	12:30	7.19	165	905	0.093	4880	118	1442	13.2	0.70	0.080	0.094	0.380	52.4	1,324	-	23.5	1533	366	7.83	0.989	0.005	0.75
OB8	Thermochem	5	15-Mar-05	17:05	7.22	155	905	0.111	4722	116	1387	13.3	0.74	0.086	0.053	0.375	50.8	1,298	-	22.8	1485	344	7.77	0.978	0.005	0.73
OB9	MTA	8.5	3-Mar-05	17:45	6.5	172	872.3	0.060		130	1428	16.0	3.53	-			57.3	1,357	-		1404	469				
OB9	MTA	6.1	4-Mar-05	15:20	7.6	160	872.3	0.085		137	1519	13.7	1.64	-			59.5	1,381	-		1434	425				
OB9	MTA	4.4	5-Mar-05	9:50	7.7	150	872.3	0.105		124	1468	12.5	1.72	-			60.0	1,356	-		1427	444				
OB9	Thermochem	6.1	4-Mar-05	15:30	7.66	160	872.3	0.085	4969	121	1437	11.4	1.40	0.183	0.107	0.342	53.5	1,427	-	21.2	1556	349	7.76	0.868	0.005	0.89
OB9	Thermochem	4.4	5-Mar-05	9:50	7.68	150	872.3	0.105	4807	116	1397	11.5	1.15	0.149	0.066	0.329	50.8	1,370	-	20.1	1670	347	7.57	0.829	0.005	0.86

Table 4.2-1a
Resource Assessment
Germencik Geothermal Resource

Reservoir Chemistry-Dissolved Components

geologica
9 July 2005

	Field Measurements										Gas concentrations in reservoir Fluid														
	Date	Time	LP	LT	H(res,tot)	Y	pH	G/S-meas	Gas-res		Carbon dioxide	Hydrogen sulfide	Ammonia	Nitrogen	Methane	Hydrogen	Total gas	Carbon dioxide	Hydrogen sulfide	Ammonia	Nitrogen	Methane	Hydrogen	total gas	total gas
Well			bar g	°C	KJ/kg			ppmw	% by weight	well average	Total Concentration millimoles/kg							Total Concentration mg/kg							wt %
	7-Mar-05	17:20	4.0	145		0.100	7.4	129010	1.29																
	8-Mar-05	8:20	2.5	125		0.119	8.5	109050	1.30																
	8-Mar-05	14:10	3.5	140		0.108	8.5	125230	1.35		312.08	1.2033	0.4696				313.75	13732	40.91	7.98				13780	1.38
OB-3	9-Mar-05	8:50	3.0	135	840.7	0.112	8.5	85910	0.96	1.23	316.93	0.7053	0.0094	0.0017	0.0048	0.0018	317.66	13945	23.98	0.16	0.0475	0.0768	0.0036	13969	1.40
	11-Mar-05	9:15	5.5	159		0.106	7.7	154290	1.64																
	11-Mar-05	13:10	5.5	155		0.112	6.8	120200	1.34																
	11-Mar-05	16:35	5.5	155		0.110	7.8	152800	1.69		330.64	0.7337	0.0089	0.0019	0.0053	0.0019	331.39	14548	24.95	0.15	0.0529	0.0846	0.0038	14573	1.46
OB-5	12-Mar-05	8:55	5.0	155	911	0.117	8.6	137040	1.60	1.57	442.46	0.9317	1.1376	0.0019	0.0052	0.0018	444.54	19468	31.68	19.34	0.0528	0.0830	0.0036	19520	1.95
	26 Feb 05	15:40	5.1	148		0.114	7.5	163000	1.85																
	28 Feb 05	11:20	10.5	180		0.057	7.1	193000	1.09																
	28 Feb 05	16:50	9.5	175		0.072	7.0	181000	1.30		275.43	0.6722	0.8282	0.0011	0.0030	0.0020	276.93	12119	22.86	14.08	0.0295	0.0483	0.0040	12156	1.22
OB-6	1-Mar-05	7:40	4.5	148	907.8	0.126	8.0	154000	1.94	1.54	367.75	0.8167	1.0261	0.0020	0.0058	0.0024	369.60	16181	27.77	17.44	0.0567	0.0921	0.0048	16226	1.62
	18-Mar-05	18:35	6.0	160		0.107	7.2	177350	1.90																
	19-Mar-05	9:30	5.9	160		0.109	6.5	141850	1.55																0.00
	19-Mar-05	13:50	5.5	150		0.113	8.2	133770	1.51		425.19	0.7849	0.9574	0.0018	0.0046	0.0019	426.94	18708	26.69	16.28	0.0509	0.0738	0.0038	18752	1.88
OB-7	19-Mar-05	18:00	4.2	150	916	0.129	8.0	157100	2.03	1.75	500.86	0.9457	0.9724	0.0021	0.0053	0.0019	502.79	22038	32.15	16.53	0.0578	0.0843	0.0039	22087	2.21
	14-Mar-05	17:55	7.2	165		0.087	6.7	177770	1.55																
	15-Mar-05	8:45	7.2	165		0.089	7.9	192510	1.71																
	15-Mar-05	12:30	6.9	165		0.093	7.7	171120	1.59		371.22	0.7836	0.8523	0.0015	0.0041	0.0020	372.86	16334	26.64	14.49	0.0422	0.0661	0.0040	16375	1.64
OB-8	15-Mar-05	17:05	5.0	155	904.6	0.111	7.2	144020	1.59	1.61	425.67	0.8998	0.5691	0.0018	0.0049	0.0024	427.15	18729	30.59	9.68	0.0513	0.0791	0.0047	18770	1.88
	4-Mar-05	17:45	8.5	172		0.060	7.1	155000	0.94																
	4-Mar-05	9:00	4.4	148		0.104	7.4	193000	2.01																
	4-Mar-05	15:20	6.1	160		0.085	7.0	204000	1.73		331.71	0.7657	1.0186	0.0013	0.0037	0.0017	333.50	14595	26.03	17.32	0.0366	0.0595	0.0033	14639	1.46
OB-9	5-Mar-05	9:50	4.4	150	872.3	0.105	7.4	164000	1.72	1.60	378.74	0.8192	0.8235	0.0018	0.0048	0.0021	380.39	16665	27.85	14.00	0.0492	0.0761	0.0043	16707	1.67
Gurmat Geothermal Reservoir Average					892.0667					1.55	373.22	0.8385	0.7228	0.0017	0.0047	0.0020	374.79	16422	28.51	12.29	0.0479	0.0749	0.0040	16463	1.65

Reservoir Temperatures from Geothermometers

Sampling Location	T(tot-meas) °C	T(QTZ) °C	T(K2/Mg) °C	T(Na-K) °C Fournier	T(Na-K) °C Truesdell	D'Amore &Panichi
OB-3	196	257		230	205	
OB-3	196	256		226	198	
OB-3	196	248		227	200	
OB-3	196	239		219	190	318.5095
OB-5	213	227		220	191	
OB5	213	229		220	191	
OB5	213	234		229	202	
OB5	213	231		214	184	
OB5	213	226		216	187	301.5494
OB-6	212	240		220	192	
OB-6	212	241		224	196	
OB-6	212	227		220	192	
OB-6	212	230	238	219	190	
OB-6	212	229	229	219	190	305.2373
OB-7	214	243		215	185	
OB-7	214	256		219	190	
OB-7	214	256		222	193	
OB-7	214	230		212	181	
OB-7	214	231	216	210	179	296.9475
OB8	212	250		206	173	
OB8	212	242		213	182	
OB8	212	244		210	179	
OB8	212	225	228	200	167	
OB8	212	220	225	202	169	302.5378
OB9	204	247		209	177	
OB9	204	238		208	177	
OB9	204	242		203	170	
OB9	204	221	210	203	170	
OB9	204	221	212	202	169	304.859

Table 6.2-2 Additional Injection Capacity Drilling Cost Analysis - Injection Well Pressure, Configuration, and Number of Wells versus Drilling Costs

Additional Wells	Individual Wells					Two Additional Injection Wells (plus OB-8)					Three Additional Injection Wells (plus OB-8)					Four Additional Injection Wells (plus OB-8)				
Well Configuration	Large w/ Two Legs	Large w/ One Leg	Medium w/ Two Legs	Medium w/ One Leg	OB-8 Type	Large w/ Two Legs	Large w/ One Leg	Medium w/ Two Legs	Medium w/ One Leg	OB-8 Type	Large w/ Two Legs	Large w/ One Leg	Medium w/ Two Legs	Medium w/ One Leg	OB-8 Type	Large w/ Two Legs	Large w/ One Leg	Medium w/ Two Legs	Medium w/ One Leg	OB-8 Type
Drilling Costs (million $US)	4.83	3.67	4.35	3.3	3.3	9.66	7.34	8.7	6.6	6.6	14.49	11.01	13.05	9.9	9.9	19.32	14.68	17.4	13.2	13.2
Injection Wellhead Pressure (bar.g)	**Injection Rate (t/hr)**					**Injection Rate (t/hr)**					**Injection Rate (t/hr)**					**Injection Rate (t/hr)**				
20	187.2	127.2	156.4	116.3	123.8	498.3	378.2	436.7	356.4	371.5	685.5	505.3	593.1	472.6	495.4	872.8	632.5	749.5	588.9	619.2
21	211.3	143.8	174.6	130.2	139.4	562.1	426.9	488.6	399.9	418.2	773.4	570.7	663.1	530.1	557.6	984.7	714.5	837.7	660.4	697.0
22	235.3	160.3	192.6	144.1	154.9	625.4	475.5	540.0	443.1	464.6	860.7	635.9	732.6	587.3	619.4	1096.0	796.2	925.2	731.4	774.3
23	259.1	176.8	210.4	157.9	170.3	688.5	523.9	591.0	486.1	510.8	947.6	700.8	801.4	644.0	681.0	1206.7	877.6	1011.8	801.9	851.3
24	282.8	193.3	228.0	171.6	185.6	751.1	572.2	641.6	528.8	556.7	1033.9	765.5	869.7	700.4	742.3	1316.6	958.8	1097.7	872.1	927.9
25	306.3	209.7	245.5	185.2	200.8	813.4	620.2	691.8	571.3	602.4	1119.7	830.0	937.3	756.5	803.2	1426.0	1039.7	1182.8	941.7	1004.1
26	329.7	226.1	262.8	198.7	216.0	875.3	668.1	741.5	613.5	647.9	1205.0	894.2	1004.3	812.2	863.9	1534.7	1120.3	1267.1	1011.0	1079.9
27	352.9	242.4	279.9	212.2	231.1	936.9	715.8	790.9	655.4	693.2	1289.9	958.2	1070.8	867.6	924.2	1642.8	1200.6	1350.7	1079.7	1155.3
28	376.0	258.7	296.9	225.5	246.1	998.2	763.4	839.8	697.1	738.2	1374.2	1022.0	1136.7	922.6	984.3	1750.2	1280.7	1433.5	1148.1	1230.4
29	399.0	274.9	313.7	238.8	261.0	1059.0	810.8	888.3	738.5	783.0	1458.1	1085.6	1202.0	977.3	1044.0	1857.1	1360.5	1515.6	1216.0	1305.0
30	421.9	291.0	330.3	251.9	275.9	1119.6	858.0	936.4	779.7	827.6	1541.5	1149.0	1266.7	1031.6	1103.5	1963.3	1440.1	1597.0	1283.5	1379.4
31	444.6	307.2	346.7	265.0	290.7	1179.8	905.0	984.1	820.6	872.0	1624.4	1212.2	1330.8	1085.6	1162.6	2068.9	1519.3	1677.6	1350.6	1453.3
32	467.1	323.2	363.0	278.0	305.4	1239.7	951.9	1031.4	861.3	916.1	1706.8	1275.1	1394.4	1139.2	1221.5	2174.0	1598.4	1757.5	1417.2	1526.9
33	489.6	339.3	379.2	290.9	320.0	1299.2	998.6	1078.3	901.7	960.1	1788.8	1337.8	1457.5	1192.6	1280.1	2278.4	1677.1	1836.6	1483.4	1600.1
34	511.9	355.3	395.1	303.7	334.6	1358.4	1045.1	1124.8	941.9	1003.8	1870.3	1400.3	1520.0	1245.6	1338.4	2382.2	1755.6	1915.1	1549.2	1672.9
35	534.1	371.2	410.9	316.4	349.1	1417.3	1091.5	1171.0	981.8	1047.3	1951.4	1462.7	1581.9	1298.2	1396.3	2485.5	1833.8	1992.8	1614.6	1745.4
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
36	556.2	387.1	426.6	329.0	363.5	1475.8	1137.7	1216.7	1021.5	1090.5	2032.0	1524.7	1643.3	1350.6	1454.1	2588.2	1911.8	2069.9	1679.6	1817.6

APPENDICES

A. Short Term Flow Test Plan and Actual Flow Test Schedules

Appendix A

Actual flow Test Schedules and Original Short Term Flow Test Plan

Table A.1
Actual Flow Test Schedule
Well: OB-3

Start	End	Total Flow Hours	Shut-Down Hours	Approx. Flow Rate %	Samples	Surveys
		48.1	0.0			
3/7/05 13:30	3/7/05 19:00	5.50	0.0	100%	Sample 1: 3/7/05 17:00	
3/7/05 19:00	3/8/05 9:00	14.00	0.0	70%	Sample 2: 3/8/05 8:15	
3/8/05 9:00	3/8/05 15:00	6.00	0.0	90%	Sample 3: 3/8/05 13:45	
3/8/05 15:00	3/8/05 21:00	6.00	0.0	100%		
3/8/05 21:00	3/9/05 3:00	6.00	0.0	100%		
3/9/05 3:00	3/9/05 9:25	6.42	0.0	100%	Sample 4: 3/9/05 8:20	
3/9/05 9:25	3/9/05 13:35	4.17	0.0	70%		Flowing PT Survey: 3/9/05 11:10 Pressure Buildup Survey: 3/9/05 13:35

Table A.2
Actual Flow Test Schedule
Well: OB-5

Start	End	Total Flow Hours	Shut-Down Hours	Approx. Flow Rate %	Samples	Surveys
		44.4	0.0			
3/10/05 15:35	3/11/05 9:30	17.92	0.0	100%	Sample 1: 3/11/05 8:50	
3/11/05 9:30	3/11/05 13:15	3.75	0.0	70%	Sample 2: 3/11/05 12:40	
3/11/05 13:15	3/11/05 17:15	4.00	0.0	90%	Sample 3: 3/11/05 16:15	
3/11/05 17:15	3/12/05 9:15	16.00	0.0	100%	Sample 4: 3/12/05 8:35	
3/12/05 9:15	3/12/05 12:00	2.75	0.0	100%		Flowing PT Survey: 3/12/05 10:00 Pressure Buildup Survey: 3/12/05 11:45

Table A.3
Actual Flow Test Schedule
Well: OB-6

Start	End	Total Flow Hours	Shut-Down Hours	Approx. Flow Rate %	Samples	Surveys
		47.2	44.3			
2/25/05 15:35	2/25/05 16:45	1.17	0.00	50%		
2/25/05 16:45	2/26/05 12:45	0.00	20.00	0%		
2/26/05 12:45	2/26/05 13:45	1.00	0.00	100%		
2/26/05 13:45	2/26/05 22:00	8.25	0.00	50%	Sample 1: 2/26/05 15:00	
2/26/05 22:00	2/27/05 22:15	0.00	24.25	0%		
2/27/05 22:15	2/28/05 1:00	2.75	0.00	50%		
2/28/05 1:00	2/28/05 7:30	6.50	0.00	70%		
2/28/05 7:30	2/28/05 13:30	6.00	0.00	100%	Sample 2: 2/28/05 13:00	
2/28/05 13:30	2/28/05 19:30	6.00	0.00	90%	Sample 3: 2/28/05 6:40	
2/28/05 19:30	3/1/05 1:30	6.00	0.00	80%		
3/1/05 1:30	3/1/05 11:00	9.50	0.00	50%	Sample 4: 3/1/05 8:00	Flowing PT Survey: 3/1/05 9:00 Pressure Buildup Survey: 3/1/05 11:00

Table A.4
Actual Flow Test Schedule
Well: OB-7

Start	End	Total Flow Hours	Shut-Down Hours	Approx. Flow Rate %	Samples	Surveys
		44.4	0.0			
3/18/05 13:15	3/18/05 18:10	4.92	0.0	100%	Sample 1: 3/18/05 18:10	
3/18/05 18:10	3/19/05 9:40	15.50	0.0	100%	Sample 2: 3/19/05 9:10	
3/19/05 9:40	3/19/05 13:25	3.75	0.0	90%	Sample 3: 3/19/05 12:35	
3/19/05 13:25	3/19/05 17:10	3.75	0.0	70%	Sample 4: 3/19/05 17:00	
3/19/05 17:10	3/20/05 8:10	15.00	0.0	70%		Flowing PT Survey: 3/20/05 8:15
3/20/05 8:10	3/20/05 9:40	1.50	0.0	0%		

Table A.5
Actual Flow Test Schedule
Well: OB-8

Start	End	Total Flow Hours	Shut-Down Hours	Approx. Flow Rate %	Samples	Surveys
		47.9	0.0			
3/14/05 14:50	3/14/05 18:05	3.25	0.0	100%	Sample 1: 3/14/05 17:35	
3/14/05 18:05	3/15/05 8:55	14.83	0.0	100%	Sample 2: 3/15/05 8:15	
3/15/05 8:55	3/15/05 12:40	3.75	0.0	90%	Sample 3: 3/15/05 12:10	
3/15/05 12:40	3/15/05 17:15	4.58	0.0	70%	Sample 4: 3/15/05 16:45	
3/15/05 17:15	3/16/05 11:42	18.45	0.0	50%		Flowing PT Survey: 3/16/05 8:00
3/16/05 11:42	3/16/05 14:42	3.00	0.0	0%		Pressure Buildup Survey: 3/16/05 11:42

Table A.6
Actual Flow Test Schedule
Well: OB-9

Start	End	Total Flow Hours	Shut-Down Hours	Approx. Flow Rate %	Samples	Surveys
		47.5	2.0			
3/3/05 13:00	3/3/05 18:45	5.75	0.0	100%	Sample 1: 3/3/05 17:15	
3/3/05 18:45	3/4/05 0:00	5.25	0.0	50%		
3/4/05 0:00	3/4/05 2:00	0.00	2.0	0%		
3/4/05 2:00	3/4/05 10:00	8.00	0.0	50%	Sample 2: 3/4/05 9:00	
3/4/05 10:00	3/4/05 16:00	6.00	0.0	70%	Sample 3: 3/4/05 14:50	
3/4/05 16:00	3/4/05 22:30	6.50	0.0	80%		
3/4/05 22:30	3/5/05 3:45	5.25	0.0	90%		
3/5/05 3:45	3/5/05 14:30	10.75	0.0	50%	Sample 4: 3/5/05 9:25	Flowing PT Survey: 3/5/05 11:15 Pressure Buildup Survey: 3/5/05 14:30

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Innovative Strategies for Environmental and Natural Resource Management

Memorandum

To: Ali Kuraduman, Guris

From: Jill Haizlip, Geologica

CC: Henry Veizades, Veizades & Assoc

Date: 11/5/2004

Re: Germencik Geothermal Field: Short Term Flow Testing Program.

Introduction

GEOLOGICA INC. (GEOLOGICA) is pleased to submit this Germencik Geothermal Field Short Term Well Testing Plan to Guris Holding Inc. and Gurmat Energy, Investment and Trade Co., Ltd., their subsidiary (Guris). This Short Term Well Testing Plan provides a program for evaluating the existing wells for the Germencik Geothermal Project of which Guris is the project developer. This Short Term Well Testing Plan is being submitted to Guris in fulfillment of Task 1 of our Geothermal Resource Assessment services as described in our proposal to Guris dated July 19, 2004 and approved by Guris on July 27, 2004. This Plan is based on the Draft Plan submitted to Guris on August 30, 2004. No substantial changes to the Plan were provided by Guris and therefore we submit this final Plan. It includes a complete set of attachments and some minor edits.

The Germencik geothermal field is being evaluated for the feasibility of commercial electricity generation. Between 1982 and 1986, nine resource evaluation wells were drilled at Germencik. These wells are OB-1, 2, 3, 4, 5, 6, 7, 8, and 9. Some of these wells were tested to varying degrees after drilling and again during each of two testing periods, first in 1988 (by MTA), and then again in 1990 (by CFG). The results of our preliminary review of the previous well testing are presented in Attachment 1. Based on the information available, the wells have existed in an idle status since the testing done in 1990.

Based on a preliminary review of the well status during a site visit from August 15-19, the Short Term Flow Testing will be limited to wells OB-3, 5, 6, 7, 8, and 9. The purpose of the short term flow testing described in this program is to flow each well which can be safely produced, to collect the production and geochemical data needed to assess each well's productivity relative to the initial production tests as described in the following objectives:

1. Obtain a static wellbore temperature and pressure profile of each well before flow testing.

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2. Produce each well continuously in a step-rate flow test for 48 hours.
3. Collect fluid samples that are representative of each well's uncontaminated reservoir fluid.
4. Obtain a flowing wellbore temperature and pressure profile during each well's flow test.
5. Obtain downhole pressure data (a pressure buildup test) at the end of each well's flow test.

Short Term Flow Test Program

This short term flow testing is focused on collecting the data needed to make an updated assessment and verification of each well's productivity which will be compared to the results of the original production tests. Since the wells have been shut down for 14 years, their condition may have changed due to casing failure or scale deposition. The particular wells tested will be limited to those wells that can be safely produced with their current state of mechanical integrity which may include OB-3, 5, 6, 7, 8, and 9.

This short term flow test program provides the methodology for the flow testing of the Germencik wells. Two day flow tests will be conducted on each suitable well by flowing through a horizontal James tube that discharges into an atmospheric separator. The liquid discharge from the separator flows directly through a weir box and then into a channel. A preliminary list of equipment and sketches of the testing requirements for the well testing equipment have been provided to Veizades & Assoc. (Veizades) (Attachment 2). Veizades is designing specific flow testing apparatus including: wellhead configurations; flow line with valve, instrument and sample port locations, separator and weir box. When these designs are complete, a schematic of the flow testing apparatus and lay out will be provided and the instrumentation, valves, and other apparatus described in the following methodology will be identified. That schematic will provide further guidance for the flow test set up and operation.

1. Static TP Survey: Rig up wireline lubricator and run in the hole with a sinker bar to total depth or top of fill. Pull out of hole. Rig up tandem pressure and temperature wireline tool. Log down the hole recording pressure and temperature, making 50 meter (164 foot) stops, continuing to total depth or top of fill. Pull out of hole with logging tools.
2. Test Setup: Rig up test equipment. Install all gauges, sampling equipment and the appropriately sized James tube and weir box.. There will be two sizes of James tube available and the initial size will be selected by the onsite engineer based on prior well performance. Check the position of all valves and be sure that the transfer pump and/or injection pumps are ready to operate if appropriate. Record wellhead shut-in pressure and temperature.
3. Prepare for Flow: Set valves to bypass the separator while flow from the well is initiated. This will prevent sediments from clogging the separator if the well initially flows a lot of sediment. Therefore, close chemical sampling ports, open throttling valve, open bypass valve, close separator valve and open wellhead valve completely.
4. Initiate Flow: The well will flow through flow line from the flow T to an appropriately rated throttle valve (specifications provided by Veizades). This throttle valve will control the flow to the separator (avoid using the wellhead valve for throttling flow during the test).
   a. To initiate flow to the bypass, open the throttling valve enough to initiate a moderate flow. Approximately 20% opening of the throttling valve, depending on the well.
   b. Check the flow coming out of the bypass. If the flow is free of debris, then open the separator valve and close the bypass valve to direct flow through the test equipment.
   c. Open throttling valve to 100% open to flow full capacity (full capacity as test is configured, may not be the full capacity of well). After 10 minutes, check water level in weir box for 100% flow, and calculate weir box flow.
   d. Close throttling valve to a position that provides 50% of the weir box flow found in the step above to begin flow test.

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5. If Well Does Not Flow: If the well will not flow on its own, either attempt to induce flow (using a method below, or some other method) or declare the well non-commercial in its current state.
   a. Call in a coiled tubing unit and nitrogen pumper and rig up the coiled tubing injector on the wellhead. Run in hole with coil tubing to about 152.4 meters (500 ft) and begin pumping nitrogen at 500 scfm. Continue running deeper and increase nitrogen rate as necessary to keep well unloading steadily. When well begins flashing flow, shut off the nitrogen, wait to be sure that flow is sustained, and then pull out of hole with coil tubing and rig down unit.
   b. Call in a nitrogen pump and rig up to depress water column down the well with nitrogen pressure (pressure to be determined later). Wait six hours and open well.
6. If Well Does Flow, Begin Routine Data Acquisition: Data form will be provided.
   a. Record pressures, temperatures, and weir box water levels at least once every hour and more often when conditions are changing rapidly.
   b. Note the times of significant events such as rate changes.
   c. Perform routine equipment checks at least once every four hours checking for leaks and proper operations.
   d. Each morning, prepare a *daily operations report* to be transmitted. The report should cover the period of midnight to midnight of the preceding day.
7. Begin Flow Test: Maintain the throttling valve position that gives approximately 50% of the well's expected maximum flow rate based on weir box calculation. Begin recording data for wellhead pressure, wellhead temperature, James tube (lip) pressure, and weir box water level.
   a. 0 to 12 hours: Continue to operate the well at approximately 50% capacity for 12 hours. During this time, continue to monitor and record data checking for stability.
   b. 12 to 18 hours: Open the throttling valve near 100% of flow. Monitor data for 6 hours. Calculate weir box flow rate.
   c. 18 to 24 hours: Close the throttling valve near 90% of flow (based on weir box). Monitor data for 6 hours.
   d. 24 to 30 hours: Close the throttling valve near 80% of flow (based on weir box). Monitor data for 6 hours.
   e. 30 to 36 hours: Close the throttling valve near 70% of flow (based on weir box). Monitor data for 6 hours.
   f. 36 to 48 hours: Close the throttling valve near 50% of flow (based on weir box). Monitor data for 12 hours. Perform flowing TP survey during this segment.
8. Flowing TP Survey: Rig up wireline lubricator and run in the hole with a sinker bar to total depth or top of fill. Pull out of hole. Rig up tandem pressure and temperature wireline tool. Log down the hole recording pressure and temperature, making stops at 50 meter (164 foot) intervals, continuing to total depth or top of fill. Stop at total depth, or top of fill, and continue to record temperature and pressure.
9. Pressure Buildup Test (4 hours): With the wireline tool holding on bottom of the well, shut in the well with the throttling valve. The well should be closed in as quickly as is possible. The wireline tool with record the downhole pressure buildup for 4 hours. Continue to monitor and record wellhead pressure data from the wellhead gauge for 4 hours.
10. End of the Flow Test: At the end of the 4 hours buildup test, pull out of hole with the wireline tool. Then fully close the wellhead valve.

Injection Testing

Based on information provided, the previous testing did not test injection at high enough flow rates and pressures to predict injectivity at full scale injection conditions. For example the OB-9 testing was done with 72.1 t/hr (158.6 kph) at 14.3 kg/cm2,g (203 psig), which is 20% (or less) of the rate that this well would be injected into during the commercial phase (assuming this well is used).

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Geologica recommends setting up an injection system capable of injecting at up to 28 kg/cm2 (400 psi) at rates of 275-325 t/hr (600 to 700 kph), for at least short periods of time (2 to 4 hours). One well will be selected for injection testing at the end of the final tests.

1. Rig up wireline lubricator and run in the hole with a sinker bar to total depth or top of fill. Pull out of hole. Rig up tandem pressure and temperature wireline tool. Log down the hole recording pressure and temperature, making 50 meter (164 foot) stops, continuing to total depth or top of fill. Pull back 10-50 m (33 to 164 ft.) above bottom. Keep downhole temperature and pressure logging tool in the hole during injection and measure temperature and pressure.
2. Begin injection increasing the flow rate to approximately 300 t/hr (660 kph) (additional details depend on the final injection set up.
3. Measure WHP immediately before and after injection begins, and measure injection water flow rate and temperature.
   a. Use data record form for injection testing
   b. Record pressures and temperatures at least once every hour and more often when conditions are changing rapidly.
   c. Note the times of significant events such as rate changes.

Perform routine equipment checks at least once every four hours checking for leaks and proper operations.

Geochemical Testing

The geochemistry of geothermal fluids will be evaluated during flow testing by sample collection for laboratory analysis and limited field measurements. A thorough understanding of geothermal fluid chemistry is critical to the design of the power plant, specifically handling noncondensible gases and providing appropriate steam purity at the turbine inlet. It is also critical for scale management in the wells, production and injection pipelines and provides an important view of reservoir conditions. Some geochemical sampling of Germencik wells was performed during previous testing. The objectives of this geochemical testing are to confirm general chemistry, provide a more rigorous estimate of noncondensible gas chemistry and develop the geochemical basis for a scale inhibitor program.

Steam samples are collected for gas analysis in the laboratory and steam condensate samples are collected for stable isotope, boron, mercury and arsenic analysis. Liquid brine samples are collected for laboratory analysis of general minerals, physical properties, and stable isotopes. Field measurements are made on both the steam phase (gas/steam) and liquid phase (pH, conductivity, etc.).

Samples of steam and brine for both laboratory and field analysis are collected from a sampling separator (Figure 2) after flowing through a sampling condenser (Figure 3). The sampling separator is located on the well test line (Figure 1) and is operated at the same pressure. The sampling separator separates steam and liquid flows in order to collect pure steam and pure liquid samples. The steam and brine are separately cooled and sampled. Total fluid chemistry is calculated from steam analyses and brine analyses based on the fluid enthalpy.

This section describes the methodology and equipment set up for fluid sampling during a typical two-phase geothermal flow test. As specific details of the sampling equipment available for the short term flow testing of the Germencik geothermal wells become available, sampling apparatus diagrams and instructions specific to the Germencik testing will be provided as part of the flow test oversight.

Sampling Location and Equipment

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Samples are collected through a sampling separator attached to sampling ports located on the two-phase well test line. Figure 1 provides a typical configuration. The specific design for the well test line for Germencik will be provided by Veizades. When this design is complete, Figure 1 will be replaced.with a schematic of the specific flow line that will be used at Germencik. The sampling ports are ideally located where the flow is stratified and where there turbulent flow is minimized (at least eight (8) pipe diameters down stream and two (2) pipe diameters upstream of flow disturbances).

Because the flow regime during the short term testing will vary, and is not currently known, one sampling port should be located at the top of the pipeline with a dedicated sampling separator for steam sampling. One port should be located at the bottom or at a 45° angle from the bottom of the pipe with a dedicated sampling separator for brine sampling.

Sampling Equipment

The sampling equipment consists of two sampling separators and two dedicated sampling condensers, connecting sample hoses, brine filtration, miscellaneous gauges and valves and sampling containers.

The *sampling separators* are cyclone separators with pipe inlets tangential to the cylindrical body of the separator. Figure 2 provides a typical configuration. The specific design for the well test line for Germencik will be provided by Veizades. When this design is complete, Figure 2 will be replaced.with a schematic of the specific sampling separator that will be used at Germencik. The purpose of the sampling separator is to allow for a pure single phase to be sampled at a separation pressure equivalent to the pressure in the flow line. The cyclonic action removes the phase which is not being sampled from the sample stream and discharges brine through the bottom of the separator and steam from a pipe that runs from the top out the bottom. The steam or brine sample flows from the separator through a dedicated Teflon lined stainless steel braided hose or stainless steel tubing fitted with quick-connect fittings to separate *sampling condenser* (Figure 3). Condensers are filled with ice and water and approximately 5 kilograms (11 lbs.) of ice is required for each sample. The exit of the steam condenser is fitted with tygon tubing. The exit of the brine condenser is fitted with a filter.

In addition sample containers will be required for each sample of brine or steam. Field measurements will require additional equipment to measure the G/S in steam and pH and specific conductivity in brine.

A detailed Geochemical Sampling Equipment List is presented in Attachment 4.

Equipment Set up

After clearing the area around the sampling ports (Figure 1), open the sampling ports to clear debris and check for appropriate phases (steam from top port and brine from side or bottom port). Set up the separators as follows:

1. Install pipe nipples, with one part of the connecting hammer union attached, to the sample port. Use an elbow fitting and second nipple if the port is vertical. Length of nipples should be miniminzed.. Ports should be of sufficient diameter to support the weight of the separator and to allow sufficient flow.
2. Orient the nipple so it is pointing away from personnel and equipment, downwind if possible. Verify the path is clear, then open the sample valve to blow out any debris. A qualitative check on the amount of liquid and steam discharged can be made to verify your choice of sample port location. Close the valve.

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3. Connect each separator to the pipe nipples. Use the hammer to secure the unions tightly. Insulate the attached inlet piping and fittings one at a time.
4. Close all valves on the separator except the isolation valve to the pressure gauge.
5. Open the sample port valve completely and record the pressure reading. This pressure represents the static line pressure.
6. Slowly open the vent valve *(see #2 on Figure 2)*. Open the valve until the pressure on the gauge starts to drop, then shut the valve slightly so that the pressure is maintained at the original static line pressure. Maximize the vent without significantly dropping the pressure (<2% full reading), so that the relative heat loss between the pipeline and the separator is minimized.

Steam Sampling Procedures

1. Open the steam bleed valve ½ to 1 turn *(see #4 on Figure 2)*. Adjust the vent valve *(see #2 on Figure 2)* as needed to maintain pressure. Check the site glass to verify the liquid level is lower than the separator inlet. Let the separator level, pressure and temperature stabilize for 5 minutes. A transparent or bluish steam bleed indicates dry steam is exiting the valve. Excess moisture is usually visible as white spray or streaks in the steam plume.
2. Open the steam sample valve *(see #3 on Figure 2)*. Allow the steam to blow out any impurities, close the valve and connect the dedicated steam sample hose or tubing to this valve. Connect the other end of the hose or tubing to the condenser steam coils.
3. Open the steam sample valve 100% and throttle the sample flow using the regulating valve on the condenser. Adjust the vent valve as needed to maintain pressure. Allow the condensate to flush for 5 minutes through the condenser before sampling. Collect all samples as needed using the referenced methods. Perform field measurements of gas/steam ratio. Record the separator pressure and temperature before and after collecting samples and monitor during sampling.
4. Prior to and during sampling, the separator liquid level should remain below the separator inlet pipe. If this level rises, reduce the steam as much as possible without allowing a significant pressure drop. If the level still rises, another sample port location may be required.

Steam Double Stopcock Type Gas Bottle

Double stopcock bottles have an inlet nipple and valve for sample entry and a second outlet nipple with an additional stopcock valve to allow sample purge of the valve assembly. After the sample has purged for 30 seconds, the outlet nipple stopcock valve is closed and the container inlet stopcock valve is opened. These bottles are especially useful when long sample hose must be purged by a vacuum pump for low pressure sample sources.

1. Place Tygon tubing over the inlet nipple and open the outlet nipple valve, allowing sample to purge the valve assembly. Make sure the condenser valve us not set too high to cause over-pressuring of the tubing. Close the outlet nipple valve and open the container stopcock valve immediately before the tubing over-pressure.
2. Upon opening the valve, condensate and noncondensible gas will enter the container. The vacuum gauge will show an increase in vacuum usually much more than the stem type container because of the larger opening stopcock valves have compared to the small hole in the stem. The bottle valve can be throttled to reduce the sample rate and decrease the inlet vacuum.

It is desirable to maintain the bottle inlet pressure above atmospheric when sampling by adjusting the sample flowrate. This eliminates air in-leakage potential through the sampling train.

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3. Invert the container valve down to allow the gas and liquid to mix. Gently shaking the bottle will help dissolve much of the gas in the liquid and allow more sample to enter the container before the pressure increases.

If the sample flowrate is too low, bottle absorbing solution may backflow into Tygon tubing when the bottle is inverted. Increase flow or keep bottle upright.

4. As sampling progresses, condensate and gases fill container and the vacuum will slowly decrease back to zero or a slight positive pressure, sampling is completed at this point and the valve should be closed. If the vacuum does not return to zero or positive pressure, fill the container approximately ¾ full with total liquid, but no more than ¾ full. Slide the Tygon tubing off the nipple immediately after the bottle valve is closed. Those wells producing larger quantities of gas relative to steam pressurize the containers of gas relative to steam will pressurize the containers much faster and with less volume.

Steam Condensate

Steam condensate is collected in plastic or glass bottles. Sample bottles not containing preservatives are rinsed twice with sample and the end of Tygon tubing is rinsed with condensate from the bottle. The cap is rinsed twice with condensate before tightening onto the bottle. Often, acid or other preservatives are present in the bottles and care must be taken not to spill or over-fill the bottles. The condensate temperature should not exceed 26.7 °C (80°F) during collection, minimizing loss of dissolved gases and water vapor.

Field Measurements

Field Gas/Steam measurements will be performed every 2 hours as appropriate. Measurements will be made on the steam flow from the sampling separator as described in Attachment 5.

Brine Sampling Procedures

1. Open the steam bleed valve 100% (*see #4 on Figure 2)*. Adjust the vent valve *(see #2 on Figure 2)*as needed to maintain pressure. The separator liquid should rise and may flood the separator, venting liquid and steam from the steam bleed valve. This insures that pure liquid will be obtained from the water sample valve. Let the separator level, pressure, and temperature stabilize for 5 minutes.
2. Open the water sample valve, *(see #5 on Figure 2)*. Allow the water to blow out any impurities that may have settled there. Close the valve and connect one end of the dedicated brine sample hose to the valve.
3. Open the water sample valve 100% and throttle the sample flow using the condenser to flush for 5 minutes before collecting samples. Collect all samples as needed using the referenced methods. Record the separator pressure and temperature before and after sampling and monitor during sampling.

Brine

Brine sample bottles are filled in the same manner as steam condensate samples. Brine samples are normally filtered for SiO_2 and metals analysis. The high pressure stainless steel filter holder is assembled with a 0.45 µm polycarbonate or polyester membrane filter. Attach filter holder directly to Tygon tubing exiting brine condenser coils. Reduce the sample flowrate as needed to maintain the condenser pressure below 1.41 kg/cm^2,g (20 psig). In cases where the suspended matter to be removed may dissolve upon cooling through the condenser (calcite) or where precipitates may form upon cooling, the filter holder can be installed directly at the condenser inlet using stainless fittings

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and/or quick-connects. Only polyester membrane filters should be used on the high temperature side. In both cases, verify the filter has not ruptured during sampling and voided the samples by inspecting the membrane after the samples have been collected.

Dilution of brine samples with HNO_3 (1/10) may be required for silica analysis and provides a check on the analysis of other higher concentration metals.

Sampling Schedule

Fluid	Sample Container	Analytes	Sample Frequency	Notes
Steam	(1) Evacuated gas sample flasks w/ $NaOH/CdCl_2$ Methodology for gas flask prep will be forthcoming	Ar, O2, N_2, CH_4, H_2, CO_2, NH_3, H_2S, Total NCG	3/well	At high (100%), med (70%) and low flow rates (50%) after maximum period of stabilization within each flow period
Steam condensate	(1) 250 ml Plastic (polyethylene) Bottle Unfiltered	B, As, Na	3/well	At the same time as the gas samples
Steam condensate	(1) 60 ml Nalgene bottle w/Cu wire (stable isotopes)	Stable isotopes of water Oxygen-18 and deuterium	1/well	After maximum period of stabilization just before shut-in
Brine	(1) 1000 ml Plastic Bottle- Unfiltered (anions)	Cl, SO_4, HCO_3, pH, TDS, NH_3	2/well	At high (100%) and low flow rates (50%) after maximum period of stabilization within each flow period
Brine	(1) 500 ml Plastic Bottle w/ 10 ml HNO3- Filtered (Cations)	Na, K, Ca, Mg, Li, B, As	2/well	At high (100%) and low flow rates (50%) after maximum period of stabilization within each flow period
Brine	(1) 250 ml Plastic Bottle w/ 200 ml 0.1 N HNO3 - Filtered (SiO2)	SiO_2,	2/well	At high (100%) and low flow rates (50%) after maximum period of stabilization within each flow period
Brine	(1) 125 ml Glass Bottle w/ 25 ml HNO3/K2Cr2O7 (Mercury)	mercury	1/well	after maximum period of stabilization just before shut -in
Brine	(1) 60 ml Nalgene bottle w/Cu wire (stable isotopes)	Stable isotopes of water Oxygen-18	1/well	after maximum period of stabilization just before shut-in

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		and deuterium		

Field measurements of brine chemistry

Specific Conductivity and pH will be measured in the weir box hourly and every two hours in brine flow from the sampling separator after flow has stabilized up to two times/flow period. The specific conductivity and pH will be measured in brine collected in an open sampling container using a hand held meter. The meters will be calibrated daily. Meters are described in Attachment 4.

References

ASTM (1995) Standard Practice for Sampling Two-Phase Geothermal Fluid for Purposes of Chemical Analysis Designation E 1675-95

MTA (1988), "Aydin-Germencik Omerbeyli Geothermal Field Pre-Feasibility Report"

CFG (1990), "Germencik Geothermal Field, Feasibility Report Part Two: Reservoir and Well Test Analysis - DRAFT"

CFG (1994), "CFG – Pre-Feasibility Report of the Aydin-Germencik Geothermal Site"

Figures

1. Geochemical Sampling Port Locations
2. Two Phase Sampling Separator
3. Sampling Condenser

Attachments

1. Review of Previous Flow Test Results
2. Preliminary Production and Injection Curves
3. Preliminary Flow Testing Equipment List
4. Geochemical Sampling Equipment List including pH and conductivity measurements
5. Gas/Steam Methodology

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B. Static Pressure and
Temperature Surveys

Appendix B

Static Pressure and Temperature Surveys

Table B.1

WELL	ÖB-3	
DATE	02.18.2005	
TEST	Static Temp. and Pressure	
ELEMENT NO	G-5000	
WHP	19.2 kg/cm2	
Depth	*Pressure*	*Temperature*
(Meter)	*(Bar.g)*	*(° C)*
0	19.28	53.07
50	24.02	75.56
100	28.76	89.46
150	33.45	101.31
200	38.13	111.36
250	42.77	121.80
300	47.34	131.44
350	51.91	141.29
400	56.42	151.67
450	60.86	162.47
500	65.28	173.76
550	69.65	185.44
600	73.88	197.52
650	78.10	206.46
700	82.28	206.92
750	86.44	216.91
800	90.55	219.64
850	94.65	219.84
900	98.76	220.16
950	102.86	220.45
1000	106.95	220.77
1050	111.05	221.02
1100	115.13	221.20
1150	119.23	221.29
1190	122.50	221.37

Table B.2

WELL	*ÖB-5*	
DATE	*02.19.2005*	
TEST	Static Temp. and Pressure	
ELEMENT NO	*G-5000*	
WHP	*16.40 kg/cm2*	
Depth	*Pressure*	*Temperature*
(Meter)	*(Bar.g)*	*(° C)*
0	16.23	17.34
50	21.14	37.29
100	25.99	50.57
150	30.81	65.43
200	35.56	80.78
250	40.34	94.71
300	45.03	106.68
350	49.68	117.82
400	54.32	128.10
450	58.88	139.94
500	63.39	152.21
550	67.83	162.75
600	72.28	171.38
650	76.62	179.61
700	80.95	186.60
750	85.24	193.35
800	89.47	199.75
850	93.70	203.14
900	97.88	206.84
950	102.06	210.48
960	102.89	211.10
970	103.74	211.65
980	104.56	212.05
990	105.39	212.44
1000	106.20	212.89

Table B.3

WELL	*ÖB-6*	
DATE	*02.22.2005*	
TEST	Static Temp. and Pressure	
ELEMENT NO	*G 5000*	
WHP	*16.20 Kg/cm2*	
Depth	*Pressure*	*Temperature*
(Meter)	*(Bar.g)*	*(° C)*
5	15.76	44.45
50	20.51	79.76
100	25.27	68.94
150	30.08	71.32
200	34.82	87.82
250	39.51	107.24
300	44.15	120.47
350	48.76	134.62
450	57.82	154.58
500	62.28	163.78
550	66.70	170.59
600	71.07	178.55
650	75.40	185.44
700	79.67	194.22
750	83.93	196.09
800	88.14	199.35
850	92.32	203.23
900	96.48	214.31
950	100.52	215.59
1000	104.43	216.20
1050	108.31	216.51
1070	109.88	216.87

Table B.4

WELL	ÖB-7	
DATE	02.20.2005	
TEST	Static Temp. and Pressure	
ELEMENT NO	G-5000	
WHP	19.00 kg/cm2	
Depth	*Pressure*	*Temperature*
(Meter)	*(Bar.g)*	*(° C)*
0	18.58	16.37
50	23.49	36.04
100	28.32	50.88
150	33.17	64.11
200	37.97	76.14
250	42.71	87.17
300	47.44	98.23
350	52.14	109.37
400	56.80	119.95
450	61.42	129.05
500	65.99	137.74
550	70.55	146.64
600	75.03	155.92
650	79.48	165.39
700	83.87	174.79
750	88.23	184.21
800	92.49	193.84
850	96.72	203.35
900	100.92	209.40
950	105.08	213.89
1000	109.18	218.66
1050	113.29	219.22
1100	117.37	220.39
1150	121.43	221.51
1200	125.51	221.59
1250	129.60	221.17
1300	133.68	221.34
1350	137.74	221.77
1400	141.80	222.29
1450	145.82	222.78
1500	149.86	223.18
1515	151.08	223.31

Table B.5

WELL	ÖB-8	
DATE	2/25/2005	
TEST	STATİC Temperature & Pressure	
WHP	21.5 Kg/cm2	
ELEMENT	G 5000	
Depth	Pressure	Temperature
(Meter)	(Bar.g)	(C)
0	20.58	32.98
50	25.35	67.26
100	30.10	83.94
150	34.79	93.28
200	39.49	99.98
250	44.20	108.27
300	48.84	119.73
350	53.45	133.60
400	58.01	145.95
450	62.48	154.42
500	66.94	162.05
550	71.38	169.31
600	75.75	175.35
650	80.11	180.46
700	84.44	184.71
750	88.79	188.73
800	93.05	191.94
850	97.28	194.88
900	101.53	197.73
950	105.77	200.42
1000	109.97	203.08
1050	114.18	205.79
1100	118.40	208.63
1150	122.58	211.58
1200	126.72	214.78
1250	130.88	219.10
1300	134.98	220.87
1350	139.09	216.33
1400	143.23	214.50
1450	147.37	213.88
1500	151.49	213.35
1550	155.52	212.98
1600	159.49	212.23
1650	163.52	211.79
1675	165.59	211.74

Table B.6

WELL	ÖB-9	
DATE	8/3/2005	
TEST	STATİC Temperature & Pressure	
WHP	22 Kg/cm2	
ELEMENT	G 5000	
Depth	Pressure	Temperature
(Meter)	(Bar.g)	(C)
0	21.40	55.57
50	26.18	101.19
100	30.78	125.07
150	35.36	125.73
200	39.95	128.51
250	44.56	133.87
300	49.08	145.09
350	53.58	160.41
400	58.01	176.82
450	62.32	184.89
500	66.62	189.10
550	70.90	192.20
600	75.14	197.56
650	79.36	202.51
700	83.53	205.98
750	87.67	209.92
800	91.87	212.08
850	95.98	213.39
900	100.11	214.50
950	104.22	215.43
1000	108.33	216.37
1050	112.39	215.20
1100	116.49	214.21
1150	120.54	213.47
1200	124.56	212.83
1250	128.56	212.03
1300	132.53	210.78
1350	136.48	210.94
1400	140.46	195.57
1450	144.52	195.12

Figure B.1

Omerbeyli-Germencik Geothermal Project
Well OB-3 Static Pressure-Temperature Survey

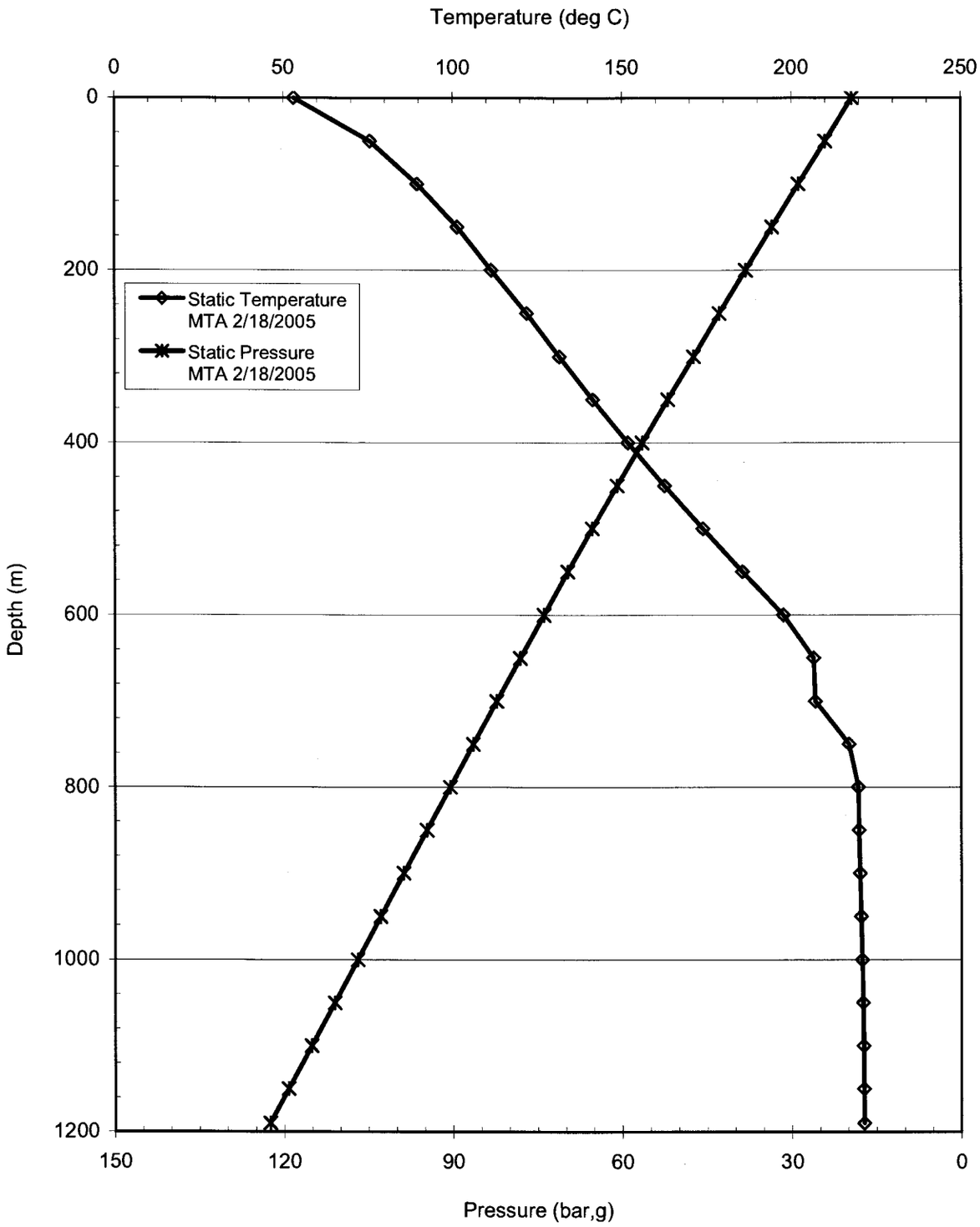

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Figure B.2

Omerbeyli-Germencik Geothermal Project
Well OB-5 Static Pressure-Temperature Survey

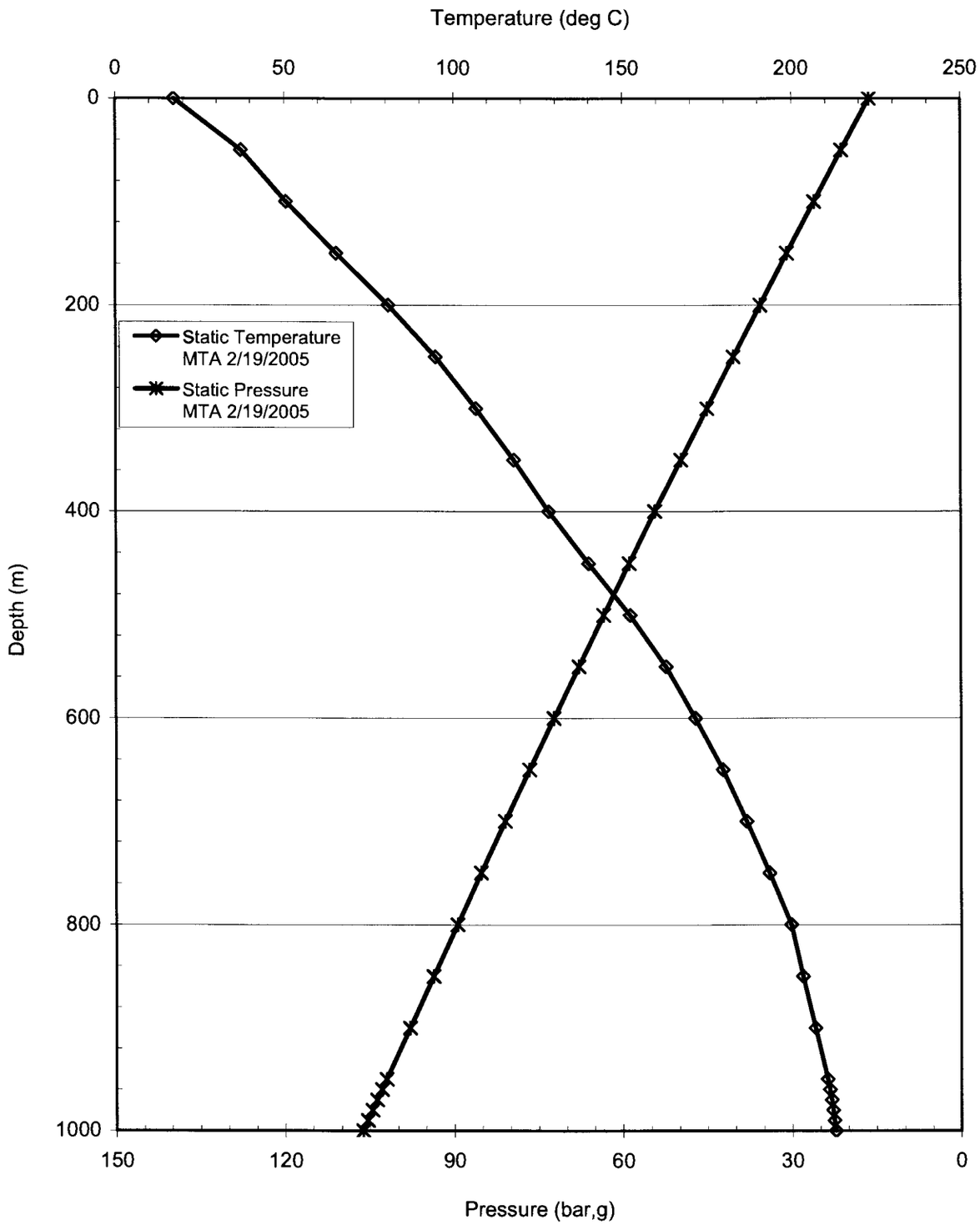

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Figure B.3

Omerbeyli-Germencik Geothermal Project
Well OB-6 Static Pressure-Temperature Survey

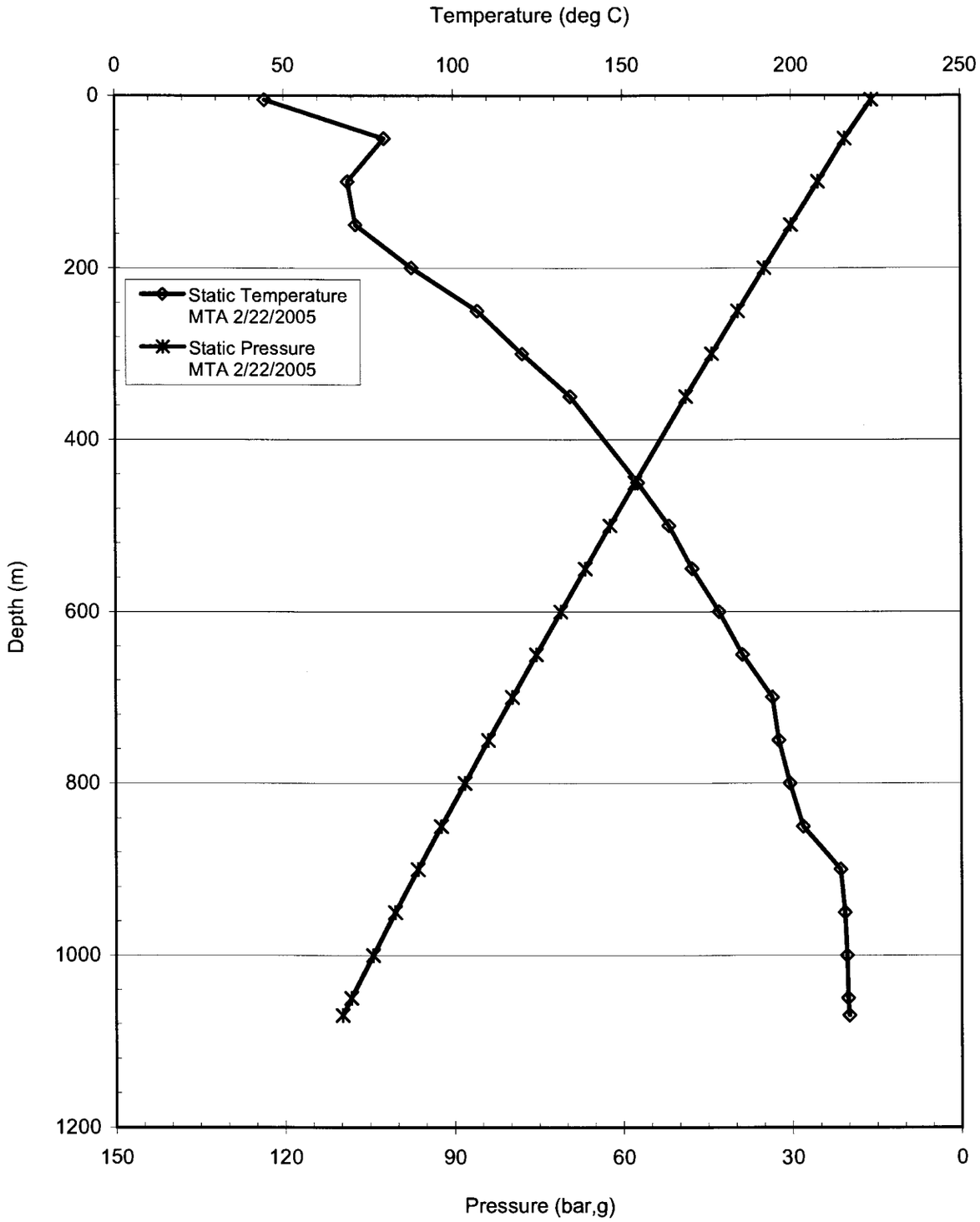

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Figure B.4

Omerbeyli-Germencik Geothermal Project
Well OB-7 Static Pressure-Temperature Survey

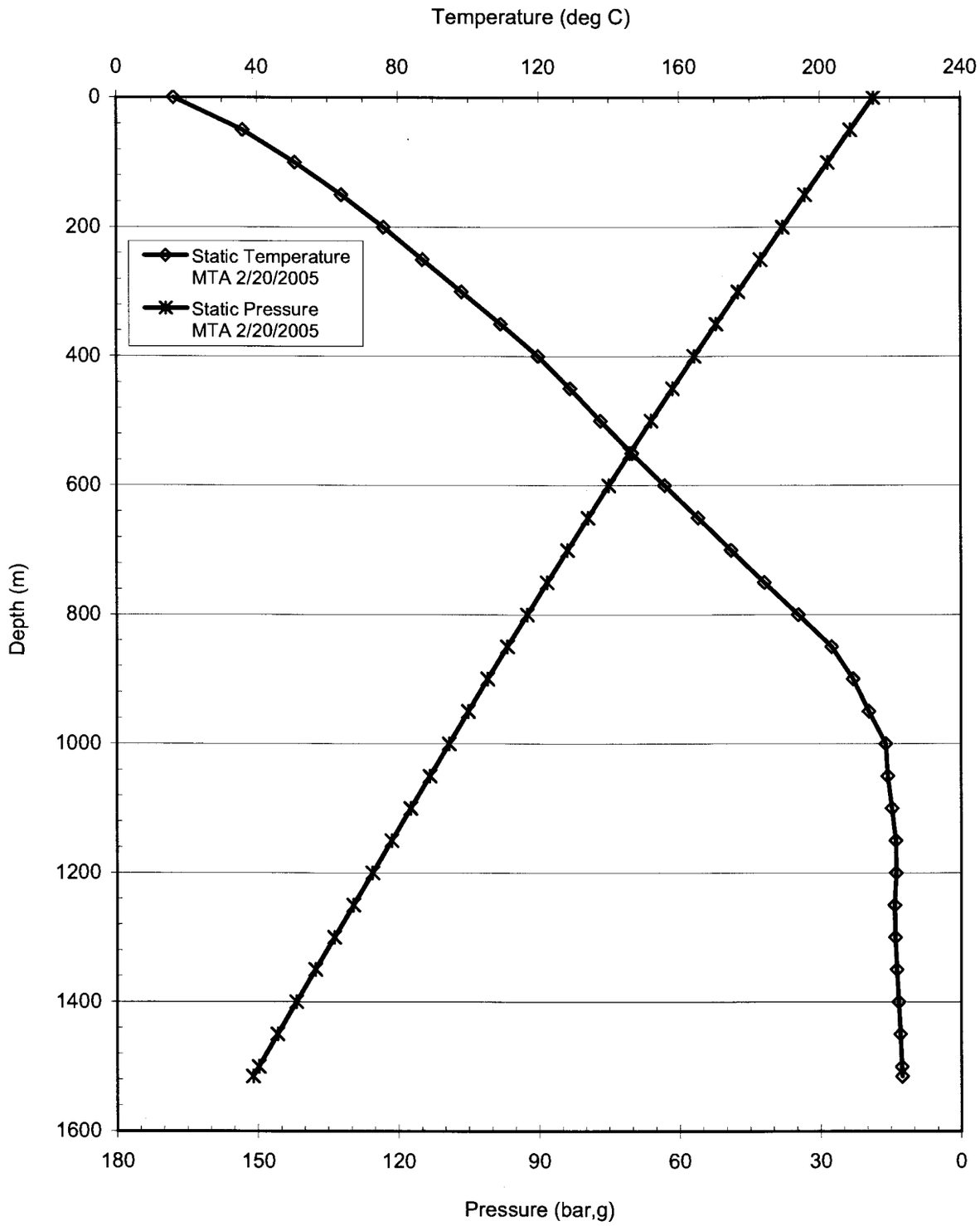

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Figure B.5

Omerbeyli-Germencik Geothermal Project
Well OB-8 Static Pressure-Temperature Survey

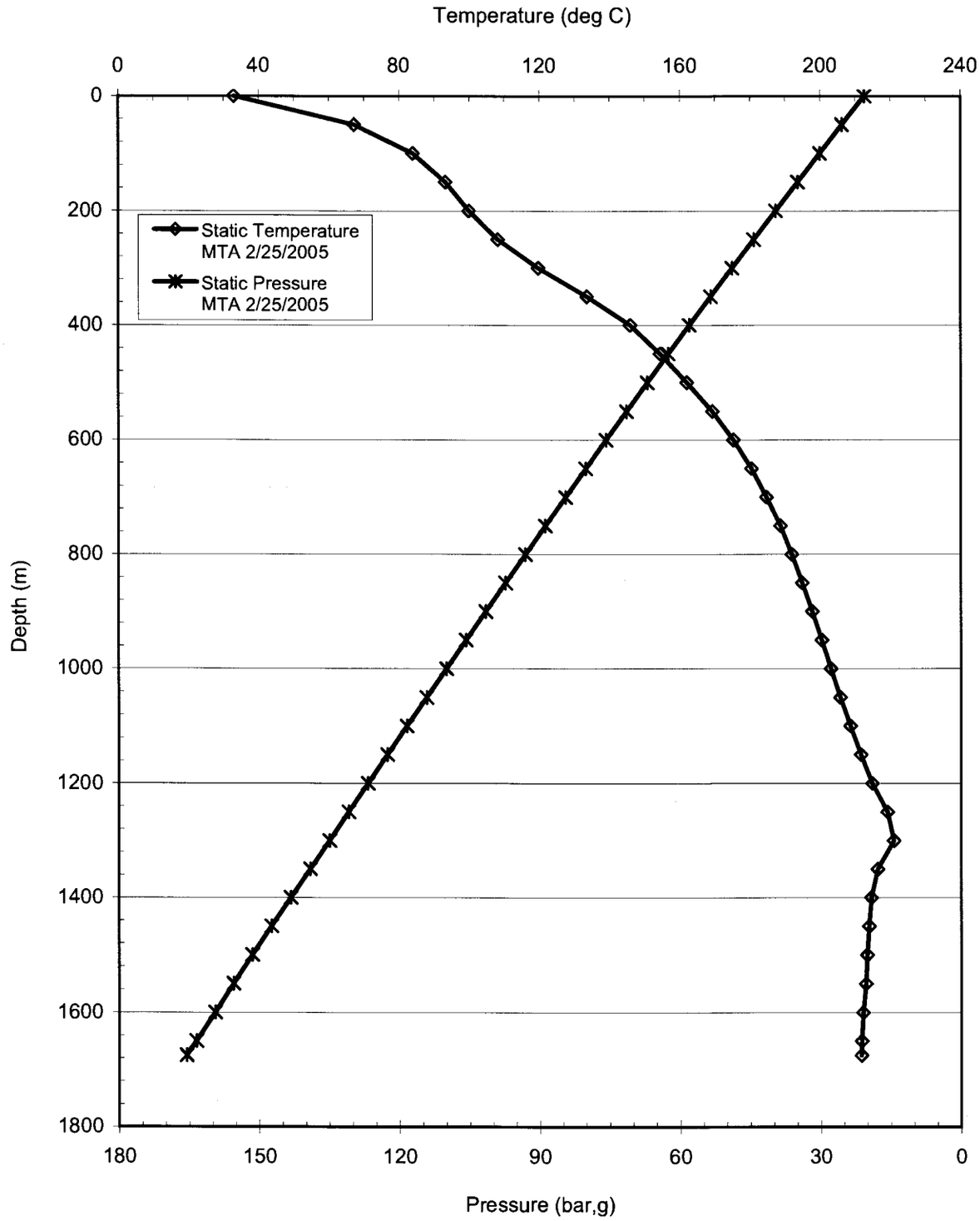

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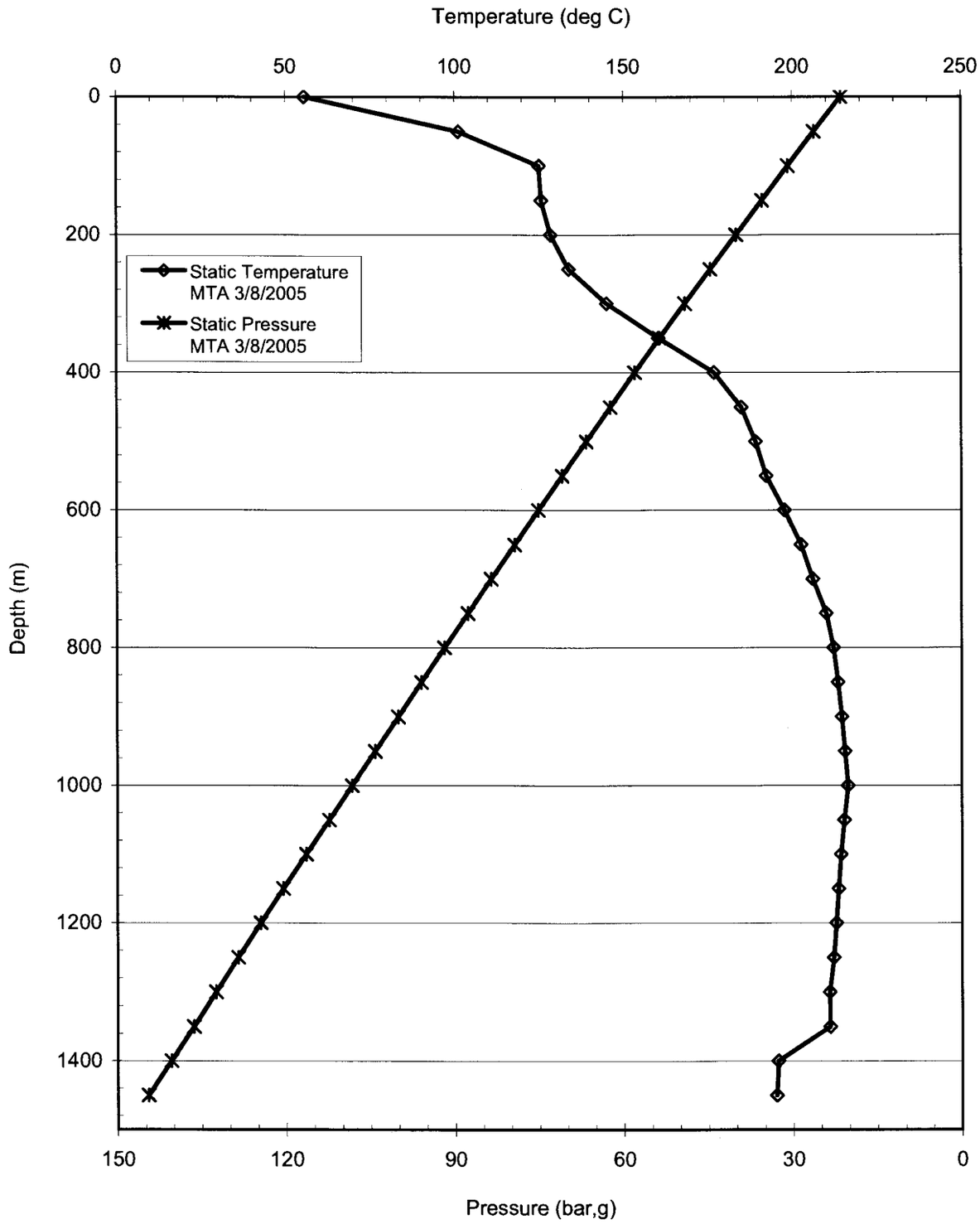
Figure B.6

Omerbeyli-Germencik Geothermal Project
Well OB-9 Static Pressure-Temperature Survey



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C. Dynamic Pressure and Temperature Surveys

Appendix C

Dynamic Pressure and Temperature Surveys

Table C.1

WELL	*ÖB-3*	
TEST	*Dynamic Temperature & Pressure*	
DATE	*03-09-05*	
ELEMENT	*G-5000*	
WHP	*13.5-17,5 Kg/cm2*	
Depth	*Pressure*	*Temperature*
(Meter)	*(Bar.g)*	*(C)*
5	13.39	181.81
50	14.26	183.58
100	15.31	185.01
150	16.33	186.34
200	17.39	187.49
250	18.53	188.74
300	19.67	189.61
350	20.92	190.06
400	22.19	190.08
450	23.48	189.60
500	24.90	188.39
550	26.42	189.24
600	28.04	190.33
650	30.08	194.00
700	32.87	193.94
750	37.81	196.06
800	44.85	196.45
850	51.44	195.89
900	56.54	197.64
950	61.20	199.12
1000	65.91	199.96
1050	70.47	199.68
1100	74.87	200.77
1150	79.32	201.51
1190	82.95	196.41

Table C.2

WELL	ÖB-5	
TEST	Dynamic Temperature & Pressure	
DATE	12/3/2005	
ELEMENT	G-5000	
WHP	4,8-5 Kg/cm2	
Depth	Pressure	Temperature
(Meter)	(Bar.g)	(C)
5	4.64	157.26
50	5.06	159.85
100	5.63	162.34
150	6.19	165.01
200	6.95	168.29
250	7.79	171.60
300	8.77	175.00
350	9.65	177.92
400	10.55	180.76
450	11.46	183.53
500	12.49	186.16
550	13.47	188.60
600	14.49	190.90
650	15.52	193.08
700	16.58	195.13
750	17.72	197.12
800	18.90	199.00
850	20.14	200.77
900	21.45	202.44
950	22.86	204.01
1000	24.38	205.55

Table C.3

WELL	ÖB-6	
TEST	Dynamic Temperature & Pressure	
DATE	1/3/2005	
ELEMENT	G-5000	
WHP	31.5 Kg/cm2	
Depth (Meter)	Pressure (Bar.g)	Temperature (C)
5	30.55	208.26
50	32.94	209.29
100	35.41	210.26
150	38.09	211.15
200	40.92	211.91
250	43.98	212.58
300	47.19	213.14
350	50.55	213.64
400	54.04	214.02
450	57.72	214.41
500	61.50	214.71
550	65.45	215.01
600	69.49	215.26
650	73.71	215.45
700	77.96	215.63
750	82.23	215.79
800	86.42	215.88
850	90.63	215.99
900	94.83	216.12
950	99.04	216.21
1000	103.12	216.30
1050	107.14	217.10
1070	108.72	217.33

Table C.4

WELL	*ÖB-7*	
TEST	*Dynamic Temperature & Pressure*	
DATE	*03.20.2005*	
ELEMENT	*G-5000*	
WHP	*23-23,40 Kg/cm2*	
Depth (Meter)	*Pressure (Bar.g)*	*Temperature (C)*
5	22.91	204.17
50	24.28	205.66
100	25.68	207.01
135	26.70	207.87

NOT: PT instrument was not able to be run down below 135 m.
To control the well, sinker bar was run down
but it stuck at the same depth. While trying to take that, wire broken.
Because of that PT measurement was not completed.

Table C.5

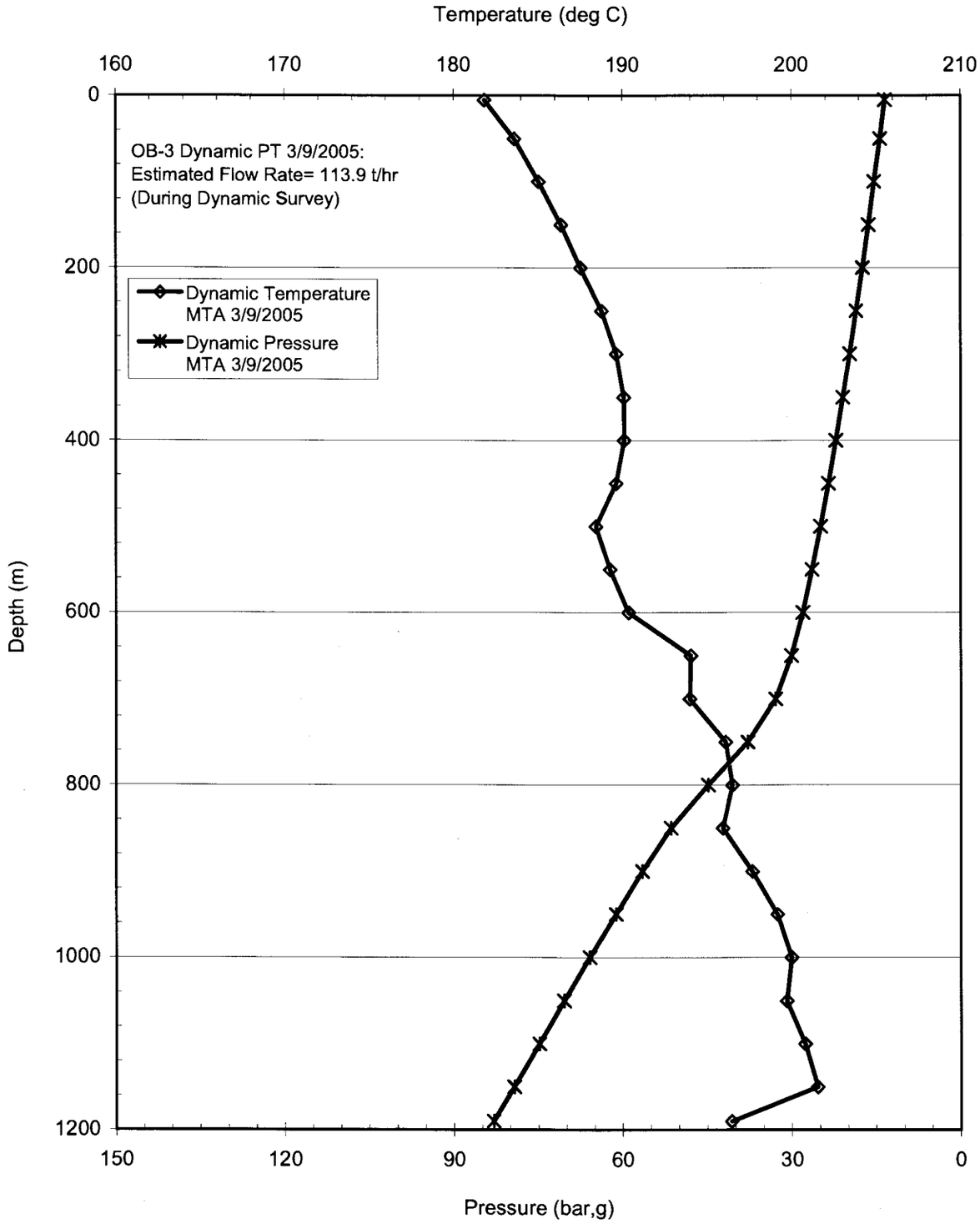
WELL	OB-8	
DATE	03.16.2005	
TEST	DYNAMIC PRESSURE & TEMPERATURE	
ELEMENT	G 5000	
WHP	29.50	
DEPTH	PRESSURE	TEMPERATURE
(Meter)	(Bar.g)	(C)
5	27.95	206.22
50	29.65	207.24
100	31.78	208.30
150	34.27	209.26
200	36.99	210.11
250	39.81	210.84
300	42.73	211.49
350	45.86	212.05
400	49.04	212.56
450	52.44	213.00
500	55.97	213.37
550	59.60	213.69
600	63.36	214.00
650	67.23	214.24
700	71.17	214.46
750	75.22	214.65
800	79.32	214.82
850	83.47	214.97
900	87.64	215.07
950	91.81	215.17
1000	95.97	215.28
1050	100.18	215.37
1100	104.35	215.46
1150	108.52	215.54
1200	112.69	215.63
1250	116.90	215.64
1300	121.31	215.46
1350	125.74	211.92
1400	130.02	210.77
1450	134.21	210.81
1500	138.25	210.84
1550	142.78	210.79
1600	147.14	210.79
1650	151.34	210.83
1675	153.89	210.88

Table C.6

WELL	ÖB-9	
TEST	Dynamic Temperature & Pressure	
DATE	5/3/2005	
ELEMENT	G-5000	
WHP	26,50 Kg/cm2	
Depth (Meter)	Pressure (Bar.g)	Temperature (C)
5	26.88	201.52
50	28.90	202.47
100	31.31	203.35
150	33.92	204.13
200	36.71	204.80
250	39.68	205.41
300	42.84	205.93
350	46.13	206.38
400	49.59	206.72
450	53.17	207.05
500	56.90	207.31
550	60.74	207.52
600	64.69	207.72
650	68.71	207.90
700	72.78	208.07
750	76.96	208.19
800	81.22	208.32
850	85.56	208.40
878	87.89	208.46
900	89.76	208.23
950	95.40	208.20
1000	98.26	206.47
1050	102.53	202.66
1100	106.77	202.65
1150	110.93	202.64
1200	115.09	202.64
1250	119.23	202.67
1300	123.34	202.66
1350	127.46	201.74
1400	131.42	195.66
1450	135.48	195.19

Figure C.1

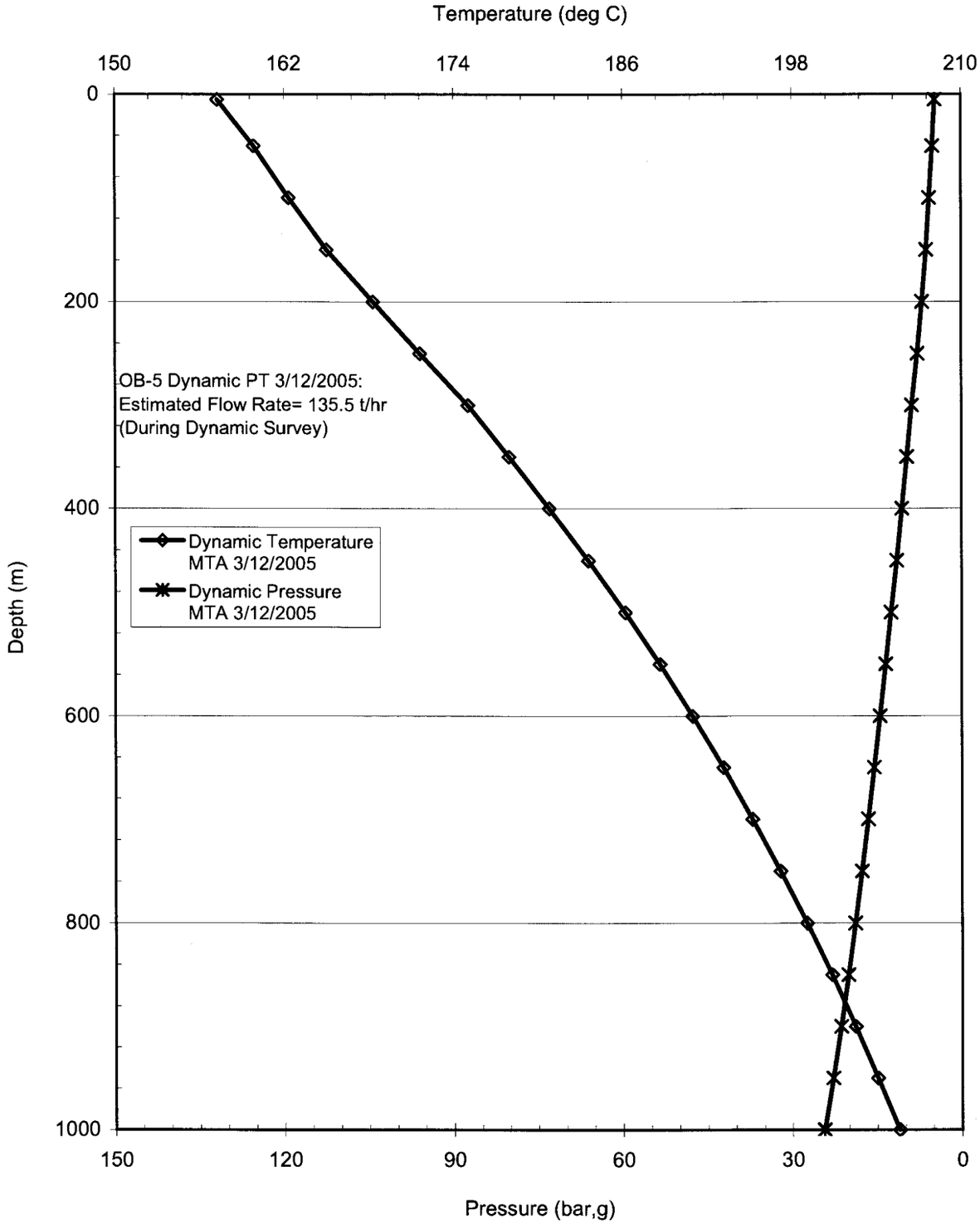
Omerbeyli-Germencik Geothermal Project
Well OB-3 Dynamic Pressure-Temperature Survey



Geologica, Inc.

Figure C.2

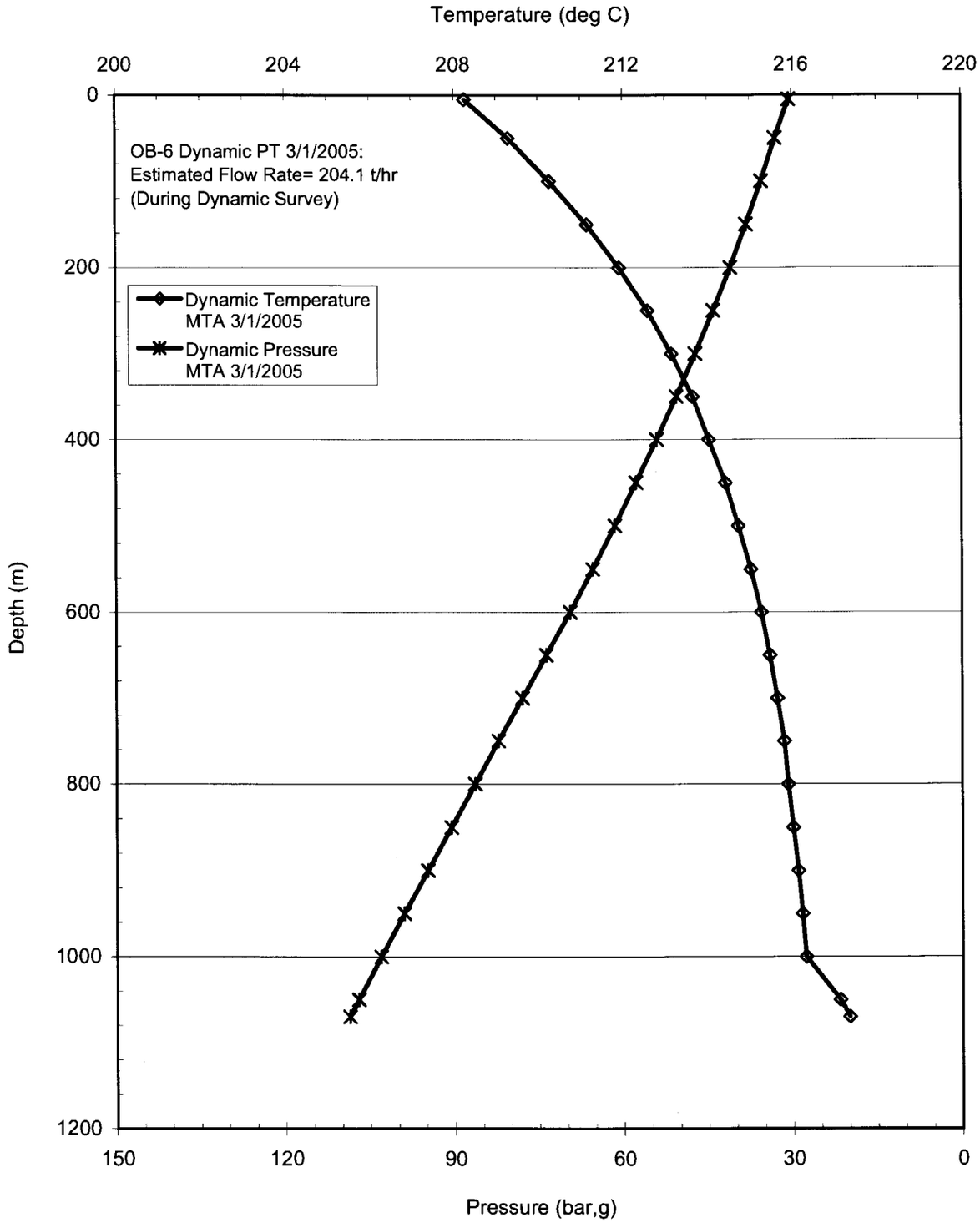
Omerbeyli-Germencik Geothermal Project
Well OB-5 Dynamic Pressure-Temperature Survey



Geologica, Inc.

Figure C.3

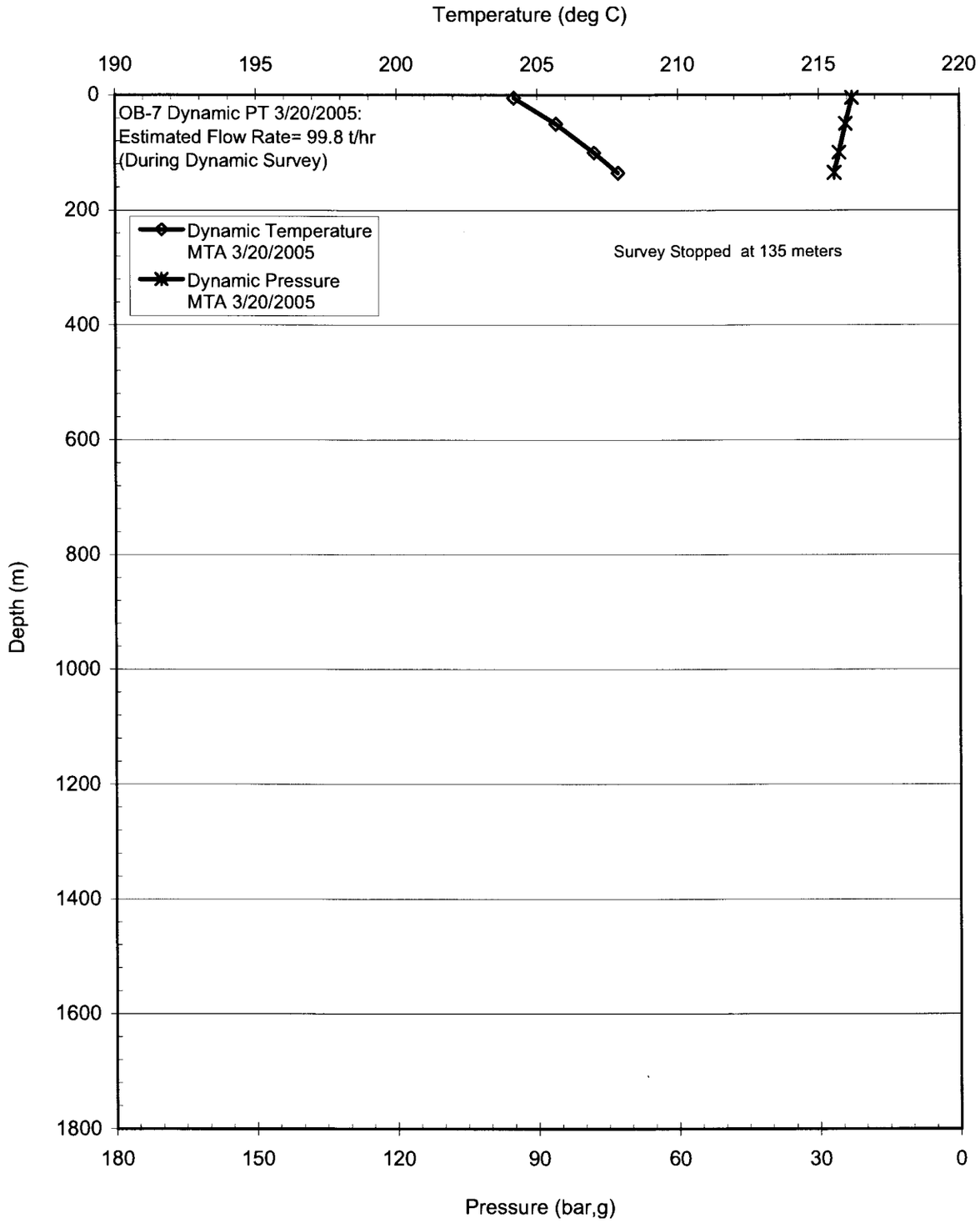
Omerbeyli-Germencik Geothermal Project
Well OB-6 Dynamic Pressure-Temperature Survey



Geologica, Inc.

Figure C.4

Omerbeyli-Germencik Geothermal Project
Well OB-7 Dynamic Pressure-Temperature Survey



Geologica, Inc.

Figure C.5

Omerbeyli-Germencik Geothermal Project
Well OB-8 Dynamic Pressure-Temperature Survey

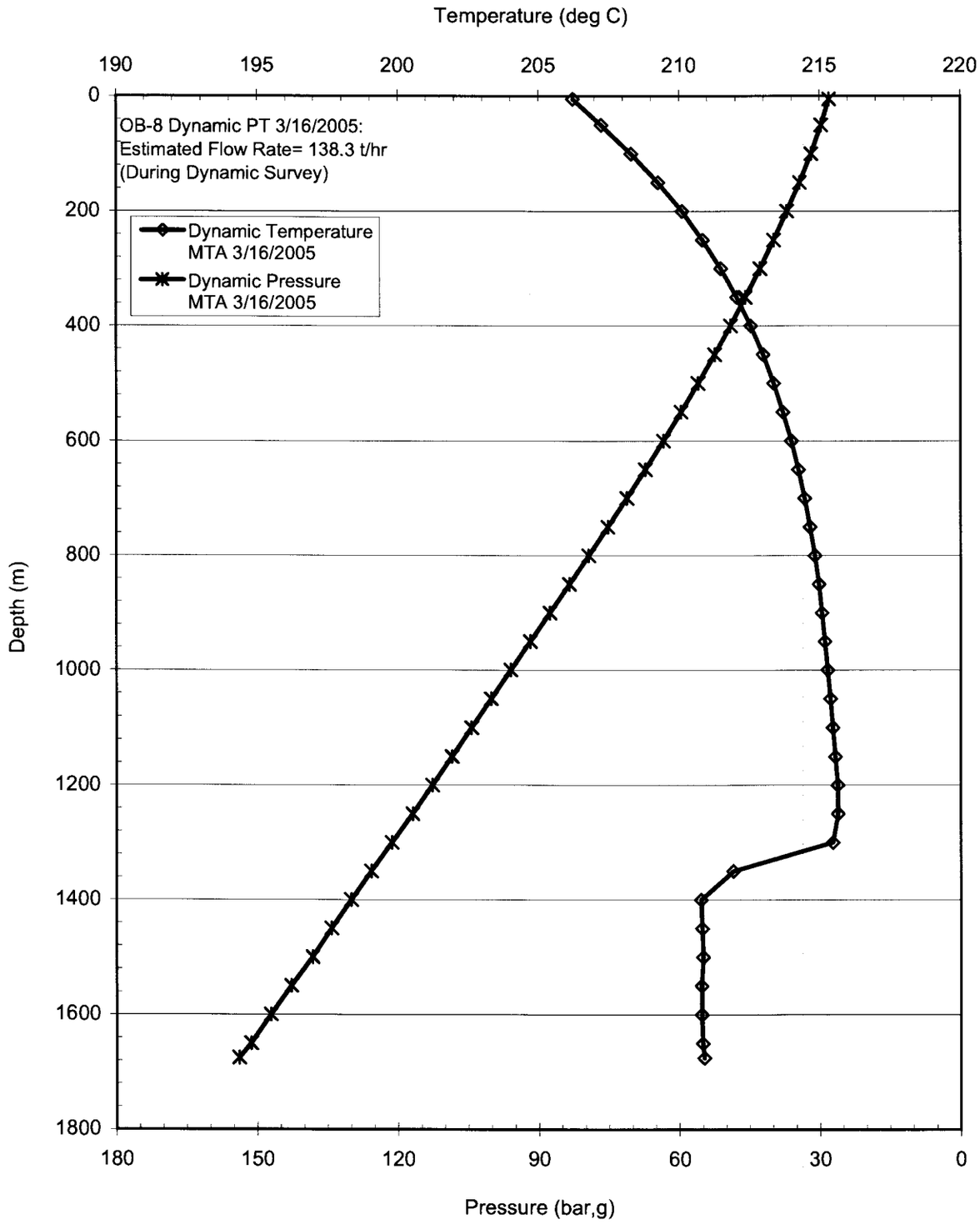


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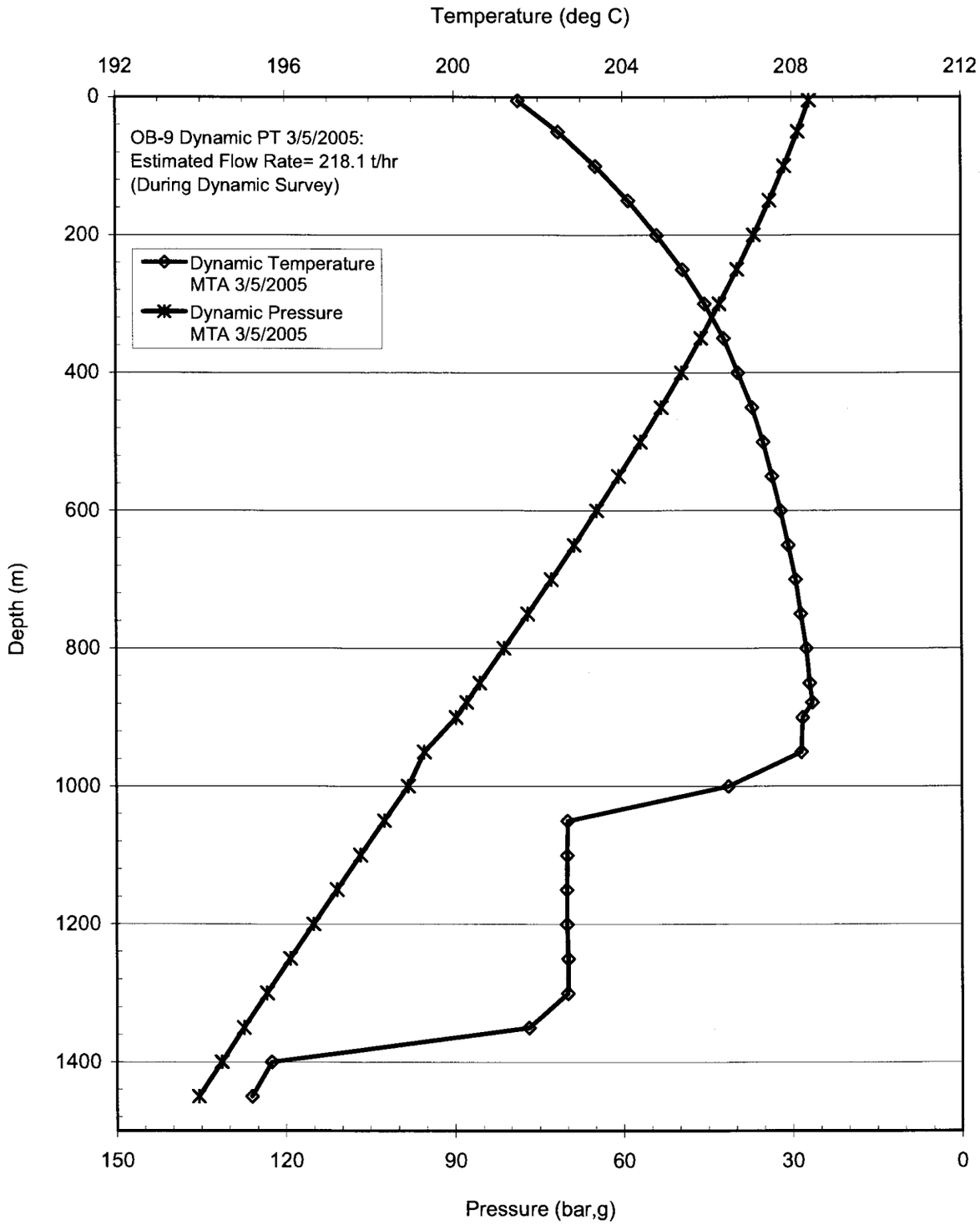
Figure C.6

Omerbeyli-Germencik Geothermal Project
Well OB-9 Dynamic Pressure-Temperature Survey



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D. Production Field Data

Appendix D

Production Field Data

Table D.1
Germencik Geothermal Field, Short-Term Flow Tests February-March 2005
Flow Test Data Collected by Geologica
Well: OB-3

Date	Time	Well	Approx. Flow %	WHP (kg/cm2,g)	Weir Box (net cm)	James Tube (psig)	Line Press (bar,g)	Line Temp (deg C)	Sep Press (bar,g)	Sep Temp (deg C)	Weir Square Notch (cm)	James Tube I.D. (cm)	Data Source	Notes
3/7/05	14:00	OB-3	100%	4.50	11.00	20.00	4.40				61.0	20.3	Geologica	Dirty water and rocks pinging in separator.
3/7/05	14:20	OB-3	100%	4.00	10.75	19.00	4.00				61.0	20.3	Geologica	
3/7/05	14:40	OB-3	100%	4.00	11.00	18.00	4.00				61.0	20.3	Geologica	
3/7/05	15:00	OB-3	100%	4.00	10.50	17.00	3.90				61.0	20.3	Geologica	
3/7/05	15:40	OB-3	100%	4.00	10.50	17.00	3.90				61.0	20.3	Geologica	Produced water is now clean
3/7/05	17:00	OB-3	100%	3.80	10.50	16.50	3.75		3.9	145.0	61.0	20.3	Geologica	Sample 1 at 100% 17:00 to 18:00
3/7/05	17:10	OB-3	100%	3.70	10.25	16.00	3.70		3.8	145.0	61.0	20.3	Geologica	
3/7/05	17:20	OB-3	100%	3.50	10.50	15.50	3.70		3.9	145.0	61.0	20.3	Geologica	
3/7/05	17:35	OB-3	100%	3.50	10.25	15.50	3.70		3.9	145.0	61.0	20.3	Geologica	
3/7/05	18:00	OB-3	100%	3.50	10.00	15.00	3.75				61.0	20.3	Geologica	
3/7/05	18:15	OB-3	100%	3.50	10.50	15.00	3.80				61.0	20.3	Geologica	
3/7/05	18:55	OB-3	100%	3.50	10.50	15.00	3.80				61.0	20.3	Geologica	
3/7/05	19:15	OB-3	70%	15.00	8.50	9.00	2.70				61.0	20.3	Geologica	Changed guage to lower range
3/8/05	8:15	OB-3	70%	16.50	8.25	9.50	2.50				61.0	20.3	Geologica	Sample 2 at 70% 8:15 to 9:00
3/8/05	8:30	OB-3	70%	16.50	8.50	9.50	2.50		2.7	133.0	61.0	20.3	Geologica	
3/8/05	8:45	OB-3	70%	16.50	8.50	9.50	2.60		2.7	133.0	61.0	20.3	Geologica	
3/8/05	9:00	OB-3	70%	16.50	8.50	9.50	2.60				61.0	20.3	Geologica	
3/8/05	13:45	OB-3	90%	8.50	9.25	13.00	3.20				61.0	20.3	Geologica	Sample 3 at 90% 13:45 to 14:20
3/8/05	14:00	OB-3	90%	8.50	9.50	12.75	3.30		3.3	140.0	61.0	20.3	Geologica	
3/8/05	14:10	OB-3	90%	8.30	9.25	12.50	3.20		3.0	139.0	61.0	20.3	Geologica	
3/8/05	14:30	OB-3	90%	8.30	9.50	12.50	3.20				61.0	20.3	Geologica	
3/8/05	15:30	OB-3	100%	3.40	10.00	14.50	3.40				61.0	20.3	Geologica	
3/8/05	15:45	OB-3	100%	3.40	9.75	14.50	3.40				61.0	20.3	Geologica	
3/8/05	16:10	OB-3	100%	3.30	10.00	14.50	3.40				61.0	20.3	Geologica	
3/8/05	16:35	OB-3	100%	3.30	9.75	14.50	3.40				61.0	20.3	Geologica	
3/8/05	18:35	OB-3	100%	3.30	9.75	14.00	3.40				61.0	20.3	Geologica	

Table D.1
Germencik Geothermal Field, Short-Term Flow Tests February-March 2005
Flow Test Data Collected by Geologica
Well: OB-3

Date	Time	Well	Approx. Flow %	WHP (kg/cm2,g)	Weir Box (net cm)	James Tube (psig)	Line Press (bar,g)	Line Temp (deg C)	Sep Press (bar,g)	Sep Temp (deg C)	Weir Square Notch (cm)	James Tube I.D. (cm)	Data Source	Notes
3/9/05	8:15	OB-3	100%	2.90	9.00	11.25	2.90				61.0	20.3	Geologica	Sample 4 at 100% 8:20 to 9:00
3/9/05	8:35	OB-3	100%	2.90	9.00	11.50	3.00				61.0	20.3	Geologica	Well declined overnight
3/9/05	9:00	OB-3	100%	2.90	9.00	11.50	3.00				61.0	20.3	Geologica	
3/9/05	9:35	OB-3	70%	12.25	8.25	6.00	2.25				61.0	20.3	Geologica	RU for Flowing PT and PBU
3/9/05	11:15	OB-3	70%	13.70	8.25	7.50	2.50				61.0	20.3	Geologica	RIH with Wireline for Flowing PT
3/9/05	11:30	OB-3	70%	13.70	8.25	7.50	2.50				61.0	20.3	Geologica	
3/9/05	11:45	OB-3	70%	13.70	8.50	7.50	2.50				61.0	20.3	Geologica	
3/9/05	12:35	OB-3	70%	14.80	7.75	5.75	2.30				61.0	20.3	Geologica	
3/9/05	13:00	OB-3	70%	17.00	7.50	5.00	2.20				61.0	20.3	Geologica	throttle to get past liner top
3/9/05	13:20	OB-3	70%	17.80	7.75	5.00	2.20				61.0	20.3	Geologica	
3/9/05	13:35	OB-3	0%										Geologica	Shut-in for PBU

Table D.2
Germencik Geothermal Field, Short-Term Flow Tests February-March 2005
Flow Test Data Collected by Guris
Well: OB-3

Date	Time	Well	Approx. Flow %	WHP (kg/cm2,g)	Weir Box (net cm)	James Tube (psig)	Line Press (bar,g)	Line Temp (deg C)	Sep Press (bar,g)	Sep Temp (deg C)	Weir Square Notch (cm)	James Tube I.D. (cm)	Data Source	Notes
3/7/05	13:40	OB-3	100%	22.5	9.5	10	3				61	20.3	GURIS Operators	
3/7/05	14:00	OB-3	100%	15.5	11	17	4.5				61	20.3	GURIS Operators	
3/7/05	14:20	OB-3	100%	4.5	11	20	4.3				61	20.3	GURIS Operators	
3/7/05	15:00	OB-3	100%	4	11	17	4				61	20.3	GURIS Operators	
3/7/05	16:00	OB-3	100%	4.5	11	18	4				61	20.3	GURIS Operators	
3/7/05	19:00	OB-3	100%	3.5	10.5	18	3.8				61	20.3	GURIS Operators	
3/7/05	20:00	OB-3	70%	15	8	10	2.7				61	20.3	GURIS Operators	
3/7/05	21:00	OB-3	70%	16.5	8	10	2.7				61	20.3	GURIS Operators	
3/7/05	22:00	OB-3	70%	16.5	8	10	2.7				61	20.3	GURIS Operators	
3/7/05	23:00	OB-3	70%	16.5	8	10	2.7				61	20.3	GURIS Operators	
3/8/05	0:00	OB-3	70%	16.5	8	10	2.7				61	20.3	GURIS Operators	
3/8/05	1:00	OB-3	70%	16.5	8	10	2.7				61	20.3	GURIS Operators	
3/8/05	2:00	OB-3	70%	16.5	8	10	2.7				61	20.3	GURIS Operators	
3/8/05	3:00	OB-3	70%	16.5	8	10	2.7				61	20.3	GURIS Operators	
3/8/05	4:00	OB-3	70%	16.5	8	10	2.7				61	20.3	GURIS Operators	
3/8/05	5:00	OB-3	70%	16.5	8	10	2.7				61	20.3	GURIS Operators	
3/8/05	6:00	OB-3	70%	16.5	8	10	2.7				61	20.3	GURIS Operators	
3/8/05	7:00	OB-3	70%	16.5	8	10	2.7				61	20.3	GURIS Operators	
3/8/05	8:00	OB-3	70%	16.5	8	11	2.7				61	20.3	GURIS Operators	
3/8/05	9:00	OB-3	70%	16.5	8	11	2.7				61	20.3	GURIS Operators	
3/8/05	9:30	OB-3	90%	9	10	16	3				61	20.3	GURIS Operators	
3/8/05	10:00	OB-3	90%	9	10	16	3.5				61	20.3	GURIS Operators	
3/8/05	11:00	OB-3	90%	8.5	10		3.3				61	20.3	GURIS Operators	
3/8/05	12:00	OB-3	90%	8.5	10	14	3.3				61	20.3	GURIS Operators	
3/8/05	13:00	OB-3	90%	8.5	10	14	3.3				61	20.3	GURIS Operators	
3/8/05	14:00	OB-3	90%	8.5	9.5	14	3.3				61	20.3	GURIS Operators	
3/8/05	14:30	OB-3	90%	8.5	9.5	14	3.2				61	20.3	GURIS Operators	
3/8/05	14:45	OB-3	100%	3.5	10	17.5	3.75				61	20.3	GURIS Operators	
3/8/05	15:00	OB-3	100%	3.4	10	14.5	3.4				61	20.3	GURIS Operators	

Table D.2
Germencik Geothermal Field, Short-Term Flow Tests February-March 2005
Flow Test Data Collected by Guris
Well: OB-3

Date	Time	Well	Approx. Flow %	WHP (kg/cm2,g)	Weir Box (net cm)	James Tube (psig)	Line Press (bar,g)	Line Temp (deg C)	Sep Press (bar,g)	Sep Temp (deg C)	Weir Square Notch (cm)	James Tube I.D. (cm)	Data Source	Notes
3/8/05	16:00	OB-3	100%	3.4	10	14.5	3.4				61	20.3	GURIS Operators	
3/8/05	17:00	OB-3	100%	3.3	10	14.5	3.4				61	20.3	GURIS Operators	
3/8/05	18:00	OB-3	100%	3.3	10	14.5	3.4				61	20.3	GURIS Operators	
3/8/05	19:00	OB-3	100%	3.3	10	14.5	3.4				61	20.3	GURIS Operators	
3/8/05	20:00	OB-3	100%	3.3	10	14.5	3.4				61	20.3	GURIS Operators	
3/8/05	21:00	OB-3	100%	3.3	10	14.5	3.4				61	20.3	GURIS Operators	
3/8/05	22:00	OB-3	100%	3.3	10	14.5	3.4				61	20.3	GURIS Operators	
3/8/05	23:00	OB-3	100%	3.3	10	14	3.4				61	20.3	GURIS Operators	
3/9/05	0:00	OB-3	100%	3.3	10	14	3.4				61	20.3	GURIS Operators	
3/9/05	1:00	OB-3	100%	3.3	10	14	3.4				61	20.3	GURIS Operators	
3/9/05	2:00	OB-3	100%	3.3	10	14	3.4				61	20.3	GURIS Operators	
3/9/05	3:00	OB-3	100%	3.3	10	14	3.4				61	20.3	GURIS Operators	
3/9/05	4:00	OB-3	100%	3.3	10	14	3.4				61	20.3	GURIS Operators	
3/9/05	5:00	OB-3	100%	3.3	10	13	3.4				61	20.3	GURIS Operators	
3/9/05	6:00	OB-3	100%	3.3	9	13	3.4				61	20.3	GURIS Operators	
3/9/05	7:00	OB-3	100%	3.3	9	13	3				61	20.3	GURIS Operators	
3/9/05	8:00	OB-3	100%	3	9	10.5	3				61	20.3	GURIS Operators	
3/9/05	9:00	OB-3	100%	3	9	11.5	3				61	20.3	GURIS Operators	
3/9/05	9:20	OB-3	70%	12.3	8.5	6	2.3				61	20.3	GURIS Operators	
3/9/05	10:00	OB-3	70%	12.5	8	8	2.3				61	20.3	GURIS Operators	
3/9/05	11:00	OB-3	70%	13.5	8	8	2.2				61	20.3	GURIS Operators	
3/9/05	12:00	OB-3	70%	13.8	8.5	8	2.2				61	20.3	GURIS Operators	
3/9/05	13:00	OB-3	70%	17.8	7.5	6	2.2				61	20.3	GURIS Operators	
3/9/05	13:30	OB-3	70%	17.5	8	6	2.2				61	20.3	GURIS Operators	
3/9/05			0%	31.5										

Table D.3
Germencik Geothermal Field, Short-Term Flow Tests February-March 2005
Flow Test Data Collected by Geologica
Well: OB-5

Date	Time	Well	Approx. Flow %	WHP (kg/cm2,g)	Weir Box (net cm)	James Tube (psig)	Line Press (bar,g)	Line Temp (deg C)	Sep Press (bar,g)	Sep Temp (deg C)	Weir Square Notch (cm)	James Tube I.D. (cm)	Data Source	Notes
3/10/05	15:35	OB-5	100%	17.10	9.50	25.00	5.25				61.00	15.80	Geologica	Fairly clean water
3/10/05	16:00	OB-5	100%	7.20	12.00	41.00	7.20				61.00	15.80	Geologica	Dirty water and rocks pinging in separator.
3/10/05	16:30	OB-5	100%	6.70	11.50	37.50	6.70				61.00	15.80	Geologica	
3/10/05	17:00	OB-5	100%	6.60	11.75	38.00	6.70				61.00	15.80	Geologica	
3/10/05	17:25	OB-5	100%	6.60	11.50	37.50	6.70				61.00	15.80	Geologica	water too dirty to sample
3/10/05	17:45	OB-5	100%	6.60	11.75	37.50	6.70				61.00	15.80	Geologica	
3/10/05	18:20	OB-5	100%	6.60	11.75	37.50	6.70				61.00	15.80	Geologica	
3/11/05	8:20	OB-5	100%	5.90	10.75	31.00	5.90				61.00	15.80	Geologica	water is clean
3/11/05	8:35	OB-5	100%	5.90	10.75	31.00	5.90				61.00	15.80	Geologica	Sample 1 100% 8:50 to 9:30
3/11/05	8:50	OB-5	100%	5.80	10.75	30.50	5.80				61.00	15.80	Geologica	
3/11/05	9:10	OB-5	100%	5.80	10.75	30.00	5.80		6.0	160.0	61.00	15.80	Geologica	
3/11/05	12:35	OB-5	70%	11.50	9.00	24.00	5.30				61.00	15.80	Geologica	Sample 2 70% 12:40 to 13:15
3/11/05	12:55	OB-5	70%	11.60	9.00	25.00	5.40		5.6	155.0	61.00	15.80	Geologica	
3/11/05	13:05	OB-5	70%	11.60	9.00	25.00	5.40				61.00	15.80	Geologica	
3/11/05	16:15	OB-5	90%	7.70	9.50	27.00	5.40				61.00	15.80	Geologica	Sample 3 90% 16:15 to 13:50
3/11/05	16:25	OB-5	90%	7.70	9.50	27.00	5.50		5.6	155.0	61.00	15.80	Geologica	
3/11/05	16:30	OB-5	90%	7.70	9.50	27.00	5.60				61.00	15.80	Geologica	
3/12/05	8:25	OB-5	100%	4.90	9.25	25.00	5.00				61.00	15.80	Geologica	Sample 4 100% 8:25 to 9:07
3/12/05	8:40	OB-5	100%	4.90	9.25	24.50	5.00		5.1	155.0	61.00	15.80	Geologica	
3/12/05	8:50	OB-5	100%	4.80	9.25	24.50	5.00				61.00	15.80	Geologica	
3/12/05	9:07	OB-5	100%	4.90	9.25	24.50	4.90				61.00	15.80	Geologica	
3/12/05	10:25	OB-5	100%	4.80	9.25	24.50	4.90				61.00	15.80	Geologica	RIH w/ wireline for flowing PT & PBU
3/12/05	11:00	OB-5	100%	4.80	9.25	24.50	4.90				61.00	15.80	Geologica	
3/12/05	11:30	OB-5	100%	4.80	9.25	24.50	4.90				61.00	15.80	Geologica	11:35 at 1000 m with wireline
3/12/05	11:40	OB-5	100%	4.80	9.25	24.50	4.90				61.00	15.80	Geologica	
3/12/05	11:45	OB-5	0%										Geologica	Shut-in for PBU 11:45 to 11:46

Table D.3
Germencik Geothermal Field, Short-Term Flow Tests February-March 2005
Flow Test Data Collected by Geologica
Well: OB-5

Date	Time	Well	Approx. Flow %	WHP (kg/cm2,g)	Weir Box (net cm)	James Tube (psig)	Line Press (bar,g)	Line Temp (deg C)	Sep Press (bar,g)	Sep Temp (deg C)	Weir Square Notch (cm)	James Tube I.D. (cm)	Data Source	Notes
3/12/05	11:46	OB-5	0%	8.90									Geologica	SIWHP
3/12/05	11:47	OB-5	0%	9.50									Geologica	SIWHP
3/12/05	11:50	OB-5	0%	11.50									Geologica	SIWHP
3/12/05	11:55	OB-5	0%	18.00									Geologica	SIWHP
3/12/05	11:57	OB-5	0%	23.50									Geologica	SIWHP
3/12/05	11:59	OB-5	0%	29.00									Geologica	SIWHP
3/12/05	12:00	OB-5	0%	29.90									Geologica	SIWHP

Table D.4
Germencik Geothermal Field, Short-Term Flow Tests February-March 2005
Flow Test Data Collected by Guris
Well: OB-5

Date	Time	Well	Approx. Flow %	WHP (kg/cm2,g)	Weir Box (net cm)	James Tube (psig)	Line Press (bar,g)	Line Temp (deg C)	Sep Press (bar,g)	Sep Temp (deg C)	Weir Square Notch (cm)	James Tube I.D. (cm)	Data Source	Notes
3/10/05	15:43	OB-5	100%	7	10	37.5					61	15.8	GURIS Operators	
3/10/05	16:00	OB-5	100%	7	11.5	37.5	7				61	15.8	GURIS Operators	
3/10/05	17:30	OB-5	100%	6.6	11.5	37	6.7				61	15.8	GURIS Operators	
3/10/05	18:00	OB-5	100%	6.6	11.5	37	6.7				61	15.8	GURIS Operators	
3/10/05	19:00	OB-5	100%	6.5	11.5	37	6.7				61	15.8	GURIS Operators	
3/10/05	20:00	OB-5	100%	6.5	11.5	37	6.7				61	15.8	GURIS Operators	
3/10/05	21:00	OB-5	100%	6.5	11.5	37	6.7				61	15.8	GURIS Operators	
3/10/05	22:00	OB-5	100%	6.5	11.5	37	6.7				61	15.8	GURIS Operators	
3/10/05	23:00	OB-5	100%	6.5	11.5	37	6.5				61	15.8	GURIS Operators	
3/11/05	0:00	OB-5	100%	6.5	11.5	37	6.5				61	15.8	GURIS Operators	
3/11/05	1:00	OB-5	100%	6.5	11.5	37	6.5				61	15.8	GURIS Operators	
3/11/05	2:00	OB-5	100%	6.5	11	35	6.3				61	15.8	GURIS Operators	
3/11/05	3:00	OB-5	100%	6.5	11	35	6.3				61	15.8	GURIS Operators	
3/11/05	4:00	OB-5	100%	6.5	11	35	6.3				61	15.8	GURIS Operators	
3/11/05	5:00	OB-5	100%	6.5	11	35	6.3				61	15.8	GURIS Operators	
3/11/05	6:00	OB-5	100%	6	11	35	6.3				61	15.8	GURIS Operators	
3/11/05	7:00	OB-5	100%	6	11	35	6.3				61	15.8	GURIS Operators	
3/11/05	8:00	OB-5	100%	6	11	33	6.3				61	15.8	GURIS Operators	
3/11/05	9:00	OB-5	100%	5.8	11	30	5.8				61	15.8	GURIS Operators	
3/11/05	9:50	OB-5	70%	11	8.5	24	5				61	15.8	GURIS Operators	
3/11/05	10:00	OB-5	70%	11.5	9.5	24	5.5				61	15.8	GURIS Operators	
3/11/05	11:00	OB-5	70%	11.5	9.5	24	5.5				61	15.8	GURIS Operators	
3/11/05	12:00	OB-5	70%	11.6	9	26	5.5				61	15.8	GURIS Operators	
3/11/05	13:00	OB-5	70%	11.5	9	26	5.5				61	15.8	GURIS Operators	
3/11/05	13:30	OB-5	70%	11.5	10	26	5.5				61	15.8	GURIS Operators	
3/11/05	14:00	OB-5	90%	7.7	10	28	5.7				61	15.8	GURIS Operators	
3/11/05	15:00	OB-5	90%	7.7	10	29	5.7				61	15.8	GURIS Operators	
3/11/05	16:00	OB-5	90%	7.5	9.5	28	5.6				61	15.8	GURIS Operators	
3/11/05	16:30	OB-5	90%	7.8	9.5	28	5.4				61	15.8	GURIS Operators	

Table D.4
Germencik Geothermal Field, Short-Term Flow Tests February-March 2005
Flow Test Data Collected by Guris
Well: OB-5

Date	Time	Well	Approx. Flow %	WHP (kg/cm2,g)	Weir Box (net cm)	James Tube (psig)	Line Press (bar,g)	Line Temp (deg C)	Sep Press (bar,g)	Sep Temp (deg C)	Weir Square Notch (cm)	James Tube I.D. (cm)	Data Source	Notes
3/11/05	17:00	OB-5	100%	6	10	33	6.3				61	15.8	GURIS Operators	
3/11/05	18:00	OB-5	100%	5.5	9.5	28	5.6				61	15.8	GURIS Operators	
3/11/05	19:00	OB-5	100%	5.5	9.5	28	5.6				61	15.8	GURIS Operators	
3/11/05	20:00	OB-5	100%	5.5	9.5	28	5.6				61	15.8	GURIS Operators	
3/11/05	21:00	OB-5	100%	5.5	9.5	28	5.6				61	15.8	GURIS Operators	
3/11/05	22:00	OB-5	100%	5.5	9.5	28	5.6				61	15.8	GURIS Operators	
3/11/05	23:00	OB-5	100%	5.5	9.5	28	5.6				61	15.8	GURIS Operators	
3/12/05	0:00	OB-5	100%	5.5	9.5	27	5.5				61	15.8	GURIS Operators	
3/12/05	1:00	OB-5	100%	5.5	9.5	27	5.5				61	15.8	GURIS Operators	
3/12/05	2:00	OB-5	100%	5.5	9.5	27	5.5				61	15.8	GURIS Operators	
3/12/05	3:00	OB-5	100%	5.5	9.5	27	5.5				61	15.8	GURIS Operators	
3/12/05	4:00	OB-5	100%	5.5	9.5	27	5.5				61	15.8	GURIS Operators	
3/12/05	5:00	OB-5	100%	5.5	9	25	5.3				61	15.8	GURIS Operators	
3/12/05	6:00	OB-5	100%	5	9	25	5.3				61	15.8	GURIS Operators	
3/12/05	7:00	OB-5	100%	5	9	25	5.3				61	15.8	GURIS Operators	
3/12/05	8:00	OB-5	100%	5	9	25	5.3				61	15.8	GURIS Operators	
3/12/05	9:00	OB-5	100%	5	9.5	24	5				61	15.8	GURIS Operators	
3/12/05	10:00	OB-5	100%	5	9.5	24	5				61	15.8	GURIS Operators	
3/12/05	11:00	OB-5	100%	5	9.5	24	5				61	15.8	GURIS Operators	
3/12/05	11:45	OB-5	100%	5	9.5	25	5				61	15.8	GURIS Operators	

Table D.5
Germencik Geothermal Field, Short-Term Flow Tests February-March 2005
Flow Test Data Collected by Geologica
Well: OB-6

Date	Time	Well	Flow %	WHP (kg/cm2,g)	Weir Box (net cm)	James Tube (psig)	Line Press (bar,g)	Line Temp (deg C)	Sep Press (bar,g)	Sep Temp (deg C)	Weir Square Notch (cm)	James Tube I.D. (cm)	Data Source	Notes
2/25/05	15:35	OB-6	100%		19	10					61	25.9	Geologica	Well Fully Open
2/25/05	15:42	OB-6	100%		19	10					61	25.9	Geologica	Water fairly clean
2/25/05	15:45	OB-6	50%		14.5	7					61	25.9	Geologica	
2/25/05	15:55	OB-6	50%		14.5	9					61	25.9	Geologica	
2/25/05	16:00	OB-6	50%	29.5	14	8					61	25.9	Geologica	
2/25/05	16:10	OB-6	50%	30	13.5	7					61	25.9	Geologica	
2/25/05	16:20	OB-6	50%	30	13.75	6					61	25.9	Geologica	
2/25/05	16:30	OB-6	50%	30	13.75	7.5					61	25.9	Geologica	Well is surging
2/25/05	16:40	OB-6	50%	20	19.5	25					61	25.9	Geologica	
2/25/05	16:42	OB-6	50%	20		22.5					61	25.9	Geologica	
2/25/05	16:42	OB-6	0%								61	25.9	Geologica	Shut-down for repairs/changes
2/26/05	12:45	OB-6	100%								61	20.3	Geologica	
2/26/05	13:27	OB-6	100%	26	16.5	43					61	20.3	Geologica	
2/26/05	13:30	OB-6	100%	21	21	57					61	20.3	Geologica	
2/26/05	13:35	OB-6	100%	18	20.5	67					61	20.3	Geologica	
2/26/05	13:37	OB-6	100%	17	21	72					61	20.3	Geologica	Well fully open, some splash out
2/26/05	13:40	OB-6	100%	15	19.5	75					61	20.3	Geologica	
2/26/05	13:42	OB-6	100%	14	20	73					61	20.3	Geologica	
2/26/05	13:55	OB-6	50%	29.5	14.5	29	5.5	145			61	20.3	Geologica	
2/26/05	14:10	OB-6	50%	30	13.5	29	5.5	145			61	20.3	Geologica	
2/26/05	14:25	OB-6	50%	30	13.5	28	5.5	147			61	20.3	Geologica	
2/26/05	14:35	OB-6	50%	30	13.5	28	5.3	145			61	20.3	Geologica	
2/26/05	14:50	OB-6	50%	30	13.5	28	5.3	145			61	20.3	Geologica	
2/26/05	15:05	OB-6	50%	30	13.5	28.5	5.3	145			61	20.3	Geologica	
2/26/05	15:30	OB-6	50%	30	13.5	28	5.1	145			61	20.3	Geologica	
2/26/05	15:45	OB-6	50%	30	13.5	28	5.1	145			61	20.3	Geologica	Sample 1 at 50% 15:40
2/26/05	16:00	OB-6	50%	30	13.5	28	5.1	145			61	20.3	Geologica	
2/26/05	16:40	OB-6	50%	30	14	28	5.2	145			61	20.3	Geologica	
2/26/05	17:05	OB-6	50%	30	13	27	5.1	145			61	20.3	Geologica	

Table D.5
Germencik Geothermal Field, Short-Term Flow Tests February-March 2005
Flow Test Data Collected by Geologica
Well: OB-6

Date	Time	Well	Flow %	WHP (kg/cm2,g)	Weir Box (net cm)	James Tube (psig)	Line Press (bar,g)	Line Temp (deg C)	Sep Press (bar,g)	Sep Temp (deg C)	Weir Square Notch (cm)	James Tube I.D. (cm)	Data Source	Notes
2/26/05	17:30	OB-6	50%	30	13.25	27.5	5.1	145			61	20.3	Geologica	
2/26/05	22:00	OB-6	0%		0						61	20.3	Geologica	Shut-down for repairs
2/27/05	22:45	OB-6	50%	30	14	26	4.9	140			61	20.3	Geologica	
2/28/05	0:15	OB-6	50%	30.4	14	26	5	141			61	20.3	Geologica	
2/28/05	0:35	OB-6	50%	30.5	13.75	25	5.1	140			61	20.3	Geologica	
2/28/05	0:50	OB-6	50%	30.5	13.75	25	4.9	140			61	20.3	Geologica	
2/28/05	1:10	OB-6	70%	25	18.5	48.5	7.7	155			61	20.3	Geologica	
2/28/05	2:00	OB-6	70%	24.8	18.5	48.5	7.7	160			61	20.3	Geologica	
2/28/05	2:45	OB-6	70%	24.8	18.5	48.5	7.7	160			61	20.3	Geologica	
2/28/05	3:15	OB-6	70%	24.8	18.5	48	7.6	160			61	20.3	Geologica	
2/28/05	3:40	OB-6	70%	24.5	18.5	48	7.7	160			61	20.3	Geologica	
2/28/05	4:25	OB-6	70%	24.8	18.25	47					61	20.3	Geologica	
2/28/05	5:30	OB-6	70%	24.7	18.5	48	7.7	160			61	20.3	Geologica	
2/28/05	5:40	OB-6	70%	24.8	18.5	47.5					61	20.3	Geologica	
2/28/05	6:40	OB-6	70%	24.8	18.5	48	7.7	160			61	20.3	Geologica	
2/28/05	7:10	OB-6	70%	24.5	18	47.5					61	20.3	Geologica	
2/28/05	7:15	OB-6	100%	11	21	72.5					61	20.3	Geologica	
2/28/05	18:10	OB-6	90%	17.8	20	62	9.5				61	20.3	Geologica	
2/28/05	20:10	OB-6	80%	23	18.5	52	7.9				61	20.3	Geologica	
2/28/05	20:30	OB-6	80%	23	19	51	7.9				61	20.3	Geologica	
2/28/05	21:00	OB-6	80%	23	18.75	51	7.8				61	20.3	Geologica	

Table D.6
Germencik Geothermal Field, Short-Term Flow Tests February-March 2005
Flow Test Data Collected by Guris
Well: OB-6

Date	Time	Well	Approx. Flow %	WHP (kg/cm2,g)	Weir Box (net cm)	James Tube (psig)	Line Press (bar,g)	Line Temp (deg C)	Sep Press (bar,g)	Sep Temp (deg C)	Weir Square Notch (cm)	James Tube I.D. (cm)	Data Source	Notes
2/26/05	13:50	OB-6	100%	14.5	21	74		150			61	20.3	GURIS Operators	
2/26/05	13:55	OB-6	50%	30	14	29	5.25				61	20.3	GURIS Operators	
2/26/05	15:00	OB-6	50%	30	14	28	5.25	145			61	20.3	GURIS Operators	
2/26/05	16:00	OB-6	50%	30	14	28	5.25	145			61	20.3	GURIS Operators	
2/26/05	17:00	OB-6	50%	30	13.5	28	5	145			61	20.3	GURIS Operators	
2/26/05	18:00	OB-6	50%	30	13.5	28	5	145			61	20.3	GURIS Operators	
2/26/05	19:00	OB-6	50%	30	13.5	28	5	145			61	20.3	GURIS Operators	
2/26/05	20:00	OB-6	50%	30	13.5	27	5	145			61	20.3	GURIS Operators	
2/26/05	21:00	OB-6	50%	31	13.5	26	4.9	140			61	20.3	GURIS Operators	
2/28/05	0:00	OB-6	50%	30.5	14	25	4.5	148			61	20.3	GURIS Operators	
2/28/05	0:30	OB-6	50%	30.5	14	25	4.9	148			61	20.3	GURIS Operators	
2/28/05	1:00	OB-6	50%	30.5	13.5	25	4.9	148			61	20.3	GURIS Operators	
2/28/05	1:00	OB-6	70%	24	17.5	49	7.5	155			61	20.3	GURIS Operators	
2/28/05	2:00	OB-6	70%	24	17.5	49	7.5	155			61	20.3	GURIS Operators	
2/28/05	3:00	OB-6	70%	24	17.5	49	7.5	155			61	20.3	GURIS Operators	
2/28/05	4:00	OB-6	70%	24	17.5	49	7.5	155			61	20.3	GURIS Operators	
2/28/05	5:00	OB-6	70%	24	17.5	49	7.5	155			61	20.3	GURIS Operators	
2/28/05	6:00	OB-6	70%	24	17.5	49	7.5	155			61	20.3	GURIS Operators	
2/28/05	7:00	OB-6	70%	24	17.5	49	7.5	155			61	20.3	GURIS Operators	
2/28/05	7:15	OB-6	100%	11	21	74	11	170			61	20.3	GURIS Operators	
2/28/05	8:00	OB-6	100%	11	21	74	11	170			61	20.3	GURIS Operators	
2/28/05	9:00	OB-6	100%	11	21	72	11	170			61	20.3	GURIS Operators	
2/28/05	10:00	OB-6	100%	11	21	72	11	170			61	20.3	GURIS Operators	
2/28/05	11:00	OB-6	100%	11	21	72	11	170			61	20.3	GURIS Operators	
2/28/05	12:00	OB-6	100%	11	21	72	11			180	61	20.3	GURIS Operators	
2/28/05	13:00	OB-6	100%	11	21	72	11			180	61	20.3	GURIS Operators	
2/28/05	13:30	OB-6	90%	17.5	20	62	9.2	165			61	20.3	GURIS Operators	
2/28/05	14:00	OB-6	90%	17.5	20	62	9.2	160			61	20.3	GURIS Operators	

Table D.6
Germencik Geothermal Field, Short-Term Flow Tests February-March 2005
Flow Test Data Collected by Guris
Well: OB-6

Date	Time	Well	Approx. Flow %	WHP (kg/cm2,g)	Weir Box (net cm)	James Tube (psig)	Line Press (bar,g)	Line Temp (deg C)	Sep Press (bar,g)	Sep Temp (deg C)	Weir Square Notch (cm)	James Tube I.D. (cm)	Data Source	Notes
2/28/05	15:00	OB-6	90%	17.5	20	62	9.2	160			61	20.3	GURIS Operators	
2/28/05	16:00	OB-6	90%	17.5	20	62	9.2				61	20.3	GURIS Operators	
2/28/05	17:00	OB-6	90%	17.5	20	62	9.2				61	20.3	GURIS Operators	
2/28/05	18:00	OB-6	90%	17.5	20	62	9.2				61	20.3	GURIS Operators	
2/28/05	19:00	OB-6	90%	17.5	20	62	9.2				61	20.3	GURIS Operators	
2/28/05	19:30	OB-6	80%	23	18	51	7.9				61	20.3	GURIS Operators	
2/28/05	20:00	OB-6	80%	23	18	51	7.9				61	20.3	GURIS Operators	
2/28/05	21:00	OB-6	80%	23	18	51	7.9				61	20.3	GURIS Operators	
2/28/05	22:45	OB-6	80%	23	18.5	53	8				61	20.3	GURIS Operators	
2/28/05	23:00	OB-6	80%	22.5	18.5	53	8				61	20.3	GURIS Operators	
3/1/05	0:00	OB-6	80%	22.5	18.5	53	8				61	20.3	GURIS Operators	
3/1/05	1:00	OB-6	80%	22.5	18.5	52	8				61	20.3	GURIS Operators	
3/1/05	1:30	OB-6	50%	31	12.5	21	4.4				61	20.3	GURIS Operators	
3/1/05	2:00	OB-6	50%	31	12.5	21	4.4				61	20.3	GURIS Operators	
3/1/05	3:00	OB-6	50%	31	12.5	21	4.4				61	20.3	GURIS Operators	
3/1/05	4:00	OB-6	50%	31	12.5	20	4.2				61	20.3	GURIS Operators	
3/1/05	5:00	OB-6	50%	31	12.5	20	4.2				61	20.3	GURIS Operators	
3/1/05	6:00	OB-6	50%	31	12.5	20	4.2				61	20.3	GURIS Operators	
3/1/05	7:00	OB-6	50%	31	12.5	20	4.2				61	20.3	GURIS Operators	
3/1/05	8:00	OB-6	50%	31.5	12	19	4.1				61	20.3	GURIS Operators	
3/1/05	9:00	OB-6	50%	31.5	12	18	4				61	20.3	GURIS Operators	
3/1/05	10:00	OB-6	50%	31.5	12	18	4				61	20.3	GURIS Operators	
3/1/05	11:00	OB-6	50%	31.5	12	18	4				61	20.3	GURIS Operators	

Table D.7
Germencik Geothermal Field, Short-Term Flow Tests February-March 2005
Flow Test Data Collected by Geologica
Well: OB-7

Date	Time	Well	Approx. Flow %	WHP (kg/cm2,g)	Weir Box (net cm)	James Tube (psig)	Line Press (bar,g)	Line Temp (deg C)	Sep Press (bar,g)	Sep Temp (deg C)	Weir Square Notch (cm)	James Tube I.D. (cm)	Data Source	Notes
3/18/05	13:30	OB-7	100%	5.50	9.80	28.00	6.00				61.00	15.80	Geologica	Well start-up dirty water
3/18/05	13:50	OB-7	100%	5.60	9.80	28.00	5.90				61.00	15.80	Geologica	
3/18/05	14:10	OB-7	100%	5.50	9.80	29.00	6.00				61.00	15.80	Geologica	
3/18/05	14:20	OB-7	100%	5.70	9.80	29.00	6.10				61.00	15.80	Geologica	
3/18/05	14:40	OB-7	100%	5.80	9.80	29.00	6.00				61.00	15.80	Geologica	
3/18/05	15:20	OB-7	100%	5.80	10.10	29.00	6.10				61.00	15.80	Geologica	
3/18/05	15:40	OB-7	100%	5.80	9.90	29.00	6.00				61.00	15.80	Geologica	
3/18/05	18:10	OB-7	100%	5.80	9.80	28.00	6.00				61.00	15.80	Geologica	Sample #1 at 100% 18:10 to 18:40
3/18/05	18:20	OB-7	100%	5.90	9.80	28.00	6.00				61.00	15.80	Geologica	
3/18/05	18:35	OB-7	100%	5.90	9.90	29.00	6.00				61.00	15.80	Geologica	
3/19/05	8:35	OB-7	100%	5.60	9.90	27.50	5.80				61.00	15.80	Geologica	Sample #2 at 100% 9:10 to 9:40
3/19/05	9:00	OB-7	100%	5.60	9.90	27.00	5.80				61.00	15.80	Geologica	
3/19/05	9:15	OB-7	100%	5.60	9.80	27.00	5.80				61.00	15.80	Geologica	
3/19/05	9:35	OB-7	100%	5.50	9.70	27.00	5.80				61.00	15.80	Geologica	

Table D.8
Germencik Geothermal Field, Short-Term Flow Tests February-March 2005
Flow Test Data Collected by Guris
Well: OB-7

Date	Time	Well	Approx. Flow %	WHP (kg/cm2,g)	Weir Box (net cm)	James Tube (psig)	Line Press (bar,g)	Line Temp (deg C)	Sep Press (bar,g)	Sep Temp (deg C)	Weir Square Notch (cm)	James Tube I.D. (cm)	Data Source	Notes
3/18/05	12:45	OB-7	100%	18.9	11	30	6				61		GURIS Operators	
3/18/05	13:21	OB-7	100%	6	10	28	6				61		GURIS Operators	
3/18/05	14:00	OB-7	100%	5.7	12	28	6.2				61		GURIS Operators	
3/18/05	15:00	OB-7	100%	6	12	28	6.2				61		GURIS Operators	
3/18/05	16:00	OB-7	100%	6	10	28	6.2				61		GURIS Operators	
3/18/05	17:00	OB-7	100%	5.6	9.7	28	6.2				61		GURIS Operators	
3/18/05	18:00	OB-7	100%	6	9.8	28	6.2				61		GURIS Operators	
3/18/05	18:40	OB-7	100%	6	9.7	28	6.2				61		GURIS Operators	
3/18/05	19:00	OB-7	100%	6	9.5	28	6.2				61		GURIS Operators	
3/18/05	20:00	OB-7	100%	6	9.5	28	6.2				61		GURIS Operators	
3/18/05	21:00	OB-7	100%	6	9.5	28	6.2				61		GURIS Operators	
3/18/05	22:00	OB-7	100%	6	9.5	28	6.2				61		GURIS Operators	
3/18/05	23:00	OB-7	100%	6	9.5	28	6.2				61		GURIS Operators	
3/19/05	0:00	OB-7	100%	6	9.5	28	6.2				61		GURIS Operators	
3/19/05	1:00	OB-7	100%	6	9.5	28	6.2				61		GURIS Operators	
3/19/05	2:00	OB-7	100%	6	9.5	28	6.1				61		GURIS Operators	
3/19/05	3:00	OB-7	100%	6	9.5	28	6.1				61		GURIS Operators	
3/19/05	4:00	OB-7	100%	6	9.5	28	6.1				61		GURIS Operators	
3/19/05	5:00	OB-7	100%	6	9.5	28	6.1				61		GURIS Operators	
3/19/05	6:00	OB-7	100%	6	9.5	28	6.1				61		GURIS Operators	
3/19/05	7:00	OB-7	100%	6	9.5	28	6.1				61		GURIS Operators	
3/19/05	8:00	OB-7	100%	6	9.5	28	6				61		GURIS Operators	
3/19/05	9:00	OB-7	100%	5.8	9.5	27	5.8				61		GURIS Operators	
3/19/05	9:30	OB-7	100%	5.6	9.5	27	5.7				61		GURIS Operators	
3/19/05	10:30	OB-7	90%	11.5	9	22	5.5				61		GURIS Operators	
3/19/05	11:00	OB-7	90%	12	9	25	5.5				61		GURIS Operators	
3/19/05	12:00	OB-7	90%	12	9	25	5.5				61		GURIS Operators	
3/19/05	12:30	OB-7	90%	12	9	25	5.5				61		GURIS Operators	
3/19/05	13:00	OB-7	90%	12	9	25	5.5				61		GURIS Operators	
3/19/05	14:00	OB-7	90%	12	9	25	5.5				61		GURIS Operators	

Table D.8
Germencik Geothermal Field, Short-Term Flow Tests February-March 2005
Flow Test Data Collected by Guris
Well: OB-7

Date	Time	Well	Approx. Flow %	WHP (kg/cm2,g)	Weir Box (net cm)	James Tube (psig)	Line Press (bar,g)	Line Temp (deg C)	Sep Press (bar,g)	Sep Temp (deg C)	Weir Square Notch (cm)	James Tube I.D. (cm)	Data Source	Notes
3/19/05	14:30	OB-7	70%	16.4	7.7	15	4.2				61		GURIS Operators	
3/19/05	14:40	OB-7	70%	19	7.5	14	4.2				61		GURIS Operators	
3/19/05	14:45	OB-7	70%	20.5	7.5	12	3.9				61		GURIS Operators	
3/19/05	15:00	OB-7	70%	21.9	8	13.5	4.3				61		GURIS Operators	
3/19/05	16:00	OB-7	70%	21.9	8	13.5	4.3				61		GURIS Operators	
3/19/05	17:00	OB-7	70%	22	7.5	14	4.2				61		GURIS Operators	
3/19/05	18:00	OB-7	70%	22	7.5	14	4.2				61		GURIS Operators	
3/19/05	19:00	OB-7	70%	22	7.5	14	4.2				61		GURIS Operators	
3/19/05	20:00	OB-7	70%	22.5	7.5	14	4.2				61		GURIS Operators	
3/19/05	21:00	OB-7	70%	22.5	7.5	14	4.2				61		GURIS Operators	
3/19/05	22:00	OB-7	70%	22.5	7.5	14	4.2				61		GURIS Operators	
3/19/05	23:00	OB-7	70%	22.5	7.5	14	4.2				61		GURIS Operators	
3/20/05	0:00	OB-7	70%	22.5	7.5	14	4.2				61		GURIS Operators	
3/20/05	1:00	OB-7	70%	22.5	7.5	14	4.2				61		GURIS Operators	
3/20/05	2:00	OB-7	70%	22.5	7.5	14	4.2				61		GURIS Operators	
3/20/05	3:00	OB-7	70%	22.5	7.5	14	4.2				61		GURIS Operators	
3/20/05	4:00	OB-7	70%	22.5	7.5	14	4.2				61		GURIS Operators	
3/20/05	5:00	OB-7	70%	22.5	7.5	14	4.2				61		GURIS Operators	
3/20/05	6:00	OB-7	70%	23	7.5	14	4.2				61		GURIS Operators	
3/20/05	7:00	OB-7	70%	23	7.5	12.5	4				61		GURIS Operators	
3/20/05	8:00	OB-7	70%	23.5	7.5	12.5	4				61		GURIS Operators	
3/20/05	9:00	OB-7	70%	23.5	7	12	4				61		GURIS Operators	

Table D.9
Germencik Geothermal Field, Short-Term Flow Tests February-March 2005
Flow Test Data Collected by Geologica
Well: OB-8

Date	Time	Well	Approx. Flow %	WHP (kg/cm2,g)	Weir Box (net cm)	James Tube (psig)	Line Press (bar,g)	Line Temp (deg C)	Sep Press (bar,g)	Sep Temp (deg C)	Weir Square Notch (cm)	James Tube I.D. (cm)	Data Source	Notes
3/14/05	14:50	OB-8	100%	25.3	11.6	15	3.3				61	20.3	Geologica	Well start-up, well not stable, dirty water
3/14/05	15:20	OB-8	100%	9	19.5	52	8				61	20.3	Geologica	
3/14/05	15:25	OB-8	100%	8.4	18	51	7.7				61	20.3	Geologica	
3/14/05	15:40	OB-8	100%	8.4	17.6	50	7.7				61	20.3	Geologica	
3/14/05	16:00	OB-8	100%	8.2	17.35	49.5	7.5				61	20.3	Geologica	
3/14/05	16:20	OB-8	100%	8	17.1	49	7.5				61	20.3	Geologica	
3/14/05	16:45	OB-8	100%	8.1	17.1	49	7.5				61	20.3	Geologica	
3/14/05	17:15	OB-8	100%	8.1	17.1	49	7.5				61	20.3	Geologica	water now clean - call for sample 1
3/14/05	17:35	OB-8	100%	8.1	16.9	49	7.4				61	20.3	Geologica	OB-8 Sample 1 (100%) 17:35 to 18:05
3/14/05	17:50	OB-8	100%	8.1	17.1	48.5	7.3				61	20.3	Geologica	
3/14/05	18:10	OB-8	100%	8.1	17.1	48	7.4		162	7.5	61	20.3	Geologica	
3/14/05	18:40	OB-8	100%	8.1	17.35	48.5	7.3				61	20.3	Geologica	
3/14/05	19:00	OB-8	100%	8.2	17.1	48	7.3				61	20.3	Geologica	
3/15/05	8:35	OB-8	100%	7.7	16.85	46.5	7.2		165	7.4	61	20.3	Geologica	OB-8 Sample 2 (100%) 8:15 to 8:55
3/15/05	8:45	OB-8	100%	7.7	16.725	46.5	7.2				61	20.3	Geologica	
3/15/05	12:10	OB-8	90%	11.3	15.85	43	6.8		162	7.1	61	20.3	Geologica	OB-8 Sample 3 (90%) 12:10 to 12:35
3/15/05	12:25	OB-8	90%	11.2	16	43	6.8				61	20.3	Geologica	
3/15/05	12:35	OB-8	90%	11.2	16.1	43	6.8				61	20.3	Geologica	
3/15/05	16:45	OB-8	70%	20.5	13.2	29	5.2		152	5	61	20.3	Geologica	OB-8 Sample 4 (70%) 16:45 to 17:10
3/15/05	16:55	OB-8	70%	20.5	13.3	29	5.2				61	20.3	Geologica	
3/15/05	17:05	OB-8	70%	20.5	13.2	29	5.2				61	20.3	Geologica	
3/15/05	18:00	OB-8	50%	26.5	10.3	16	3.5				61	20.3	Geologica	
3/15/05	18:20	OB-8	50%	26.8	10.1	16	3.6				61	20.3	Geologica	
3/15/05	18:35	OB-8	50%	26.9	10.2	16	3.6				61	20.3	Geologica	
3/16/05	8:40	OB-8	50%	28.1	10	12.5	3.2				61	20.3	Geologica	Flowing PT Survey

Table D.9
Germencik Geothermal Field, Short-Term Flow Tests February-March 2005
Flow Test Data Collected by Geologica
Well: OB-8

Date	Time	Well	Approx. Flow %	WHP (kg/cm2,g)	Weir Box (net cm)	James Tube (psig)	Line Press (bar,g)	Line Temp (deg C)	Sep Press (bar,g)	Sep Temp (deg C)	Weir Square Notch (cm)	James Tube I.D. (cm)	Data Source	Notes
3/16/05	9:00	OB-8	50%	28	9.85	12.5	3.2				61	20.3	Geologica	
3/16/05	9:20	OB-8	50%	28.4	9.9	12	3.1				61	20.3	Geologica	
3/16/05	10:05	OB-8	50%	28.5	9.6	11.5	3				61	20.3	Geologica	
3/16/05	10:30	OB-8	50%	28.5	9.85	11.5	3				61	20.3	Geologica	PT Survey at 1150 m
3/16/05	10:55	OB-8	50%	28.5	9.7	11	3				61	20.3	Geologica	
3/16/05	11:20	OB-8	50%	29.2	9.1	7	2.8				61	20.3	Geologica	
3/16/05	11:42	OB-8	0%	29.4							61	20.3	Geologica	SIWHP
3/16/05	11:43	OB-8	0%	32							61	20.3	Geologica	SIWHP
3/16/05	11:45	OB-8	0%	35.5							61	20.3	Geologica	SIWHP
3/16/05	11:46	OB-8	0%	35.6							61	20.3	Geologica	SIWHP
3/16/05	11:47	OB-8	0%	35.6							61	20.3	Geologica	SIWHP
3/16/05	11:48	OB-8	0%	35.7							61	20.3	Geologica	SIWHP
3/16/05	11:49	OB-8	0%	35.6							61	20.3	Geologica	SIWHP

Table D.10
Germencik Geothermal Field, Short-Term Flow Tests February-March 2005
Flow Test Data Collected by Guris
Well: OB-8

Date	Time	Well	Approx. Flow %	WHP (kg/cm2,g)	Weir Box (net cm)	James Tube (psig)	Line Press (bar,g)	Line Temp (deg C)	Sep Press (bar,g)	Sep Temp (deg C)	Weir Square Notch (cm)	James Tube I.D. (cm)	Data Source	Notes
3/14/05	15:10	OB-8	100%	8	16	51	7.5				61	20.3	GURIS Operators	
3/14/05	15:25	OB-8	100%	8.3	18	50	7.5				61	20.3	GURIS Operators	
3/14/05	15:40	OB-8	100%	8	17	49	7.4				61	20.3	GURIS Operators	
3/14/05	16:00	OB-8	100%	8	17.5	49	7.4				61	20.3	GURIS Operators	
3/14/05	17:00	OB-8	100%	8	17.5	48	7.4				61	20.3	GURIS Operators	
3/14/05	18:00	OB-8	100%	8	17.5	48	7.1				61	20.3	GURIS Operators	
3/14/05	19:00	OB-8	100%	8	17.5	48	7.1				61	20.3	GURIS Operators	
3/14/05	20:00	OB-8	100%	8.2	17.5	48	7.3				61	20.3	GURIS Operators	
3/14/05	21:00	OB-8	100%	8.3	17.5	48	7.3				61	20.3	GURIS Operators	
3/14/05	22:00	OB-8	100%	8.3	17.5	48	7.3				61	20.3	GURIS Operators	
3/14/05	23:00	OB-8	100%	8.3	17.5	48	7.3				61	20.3	GURIS Operators	
3/15/05	0:00	OB-8	100%	8.3	17.5	48	7.3				61	20.3	GURIS Operators	
3/15/05	1:00	OB-8	100%	8	17.5	48	7.3				61	20.3	GURIS Operators	
3/15/05	2:00	OB-8	100%	8	17.5	48	7.3				61	20.3	GURIS Operators	
3/15/05	3:00	OB-8	100%	8	17.5	48	7.3				61	20.3	GURIS Operators	
3/15/05	4:00	OB-8	100%	8	17.5	48	7.3				61	20.3	GURIS Operators	
3/15/05	5:00	OB-8	100%	8	17.5	48	7.3				61	20.3	GURIS Operators	
3/15/05	6:00	OB-8	100%	8	17.5	48	7.3				61	20.3	GURIS Operators	
3/15/05	7:00	OB-8	100%	8	17.5	48	7.3				61	20.3	GURIS Operators	
3/15/05	8:00	OB-8	100%	8	17.5	46	7.3				61	20.3	GURIS Operators	
3/15/05	8:40	OB-8	100%	8	17.5	46	7.3				61	20.3	GURIS Operators	
3/15/05	9:15	OB-8	90%	11	16	42	6.8				61	20.3	GURIS Operators	
3/15/05	10:00	OB-8	90%	11	16	43	6.8				61	20.3	GURIS Operators	
3/15/05	11:00	OB-8	90%	11	16	43	6.8				61	20.3	GURIS Operators	
3/15/05	12:00	OB-8	90%	11	16	43	6.8				61	20.3	GURIS Operators	
3/15/05	12:30	OB-8	90%	11	16	43	6.8				61	20.3	GURIS Operators	
3/15/05	13:00	OB-8	70%	19.5	13.7	29	5.2				61	20.3	GURIS Operators	
3/15/05	14:00	OB-8	70%	20	14	29	5.2				61	20.3	GURIS Operators	
3/15/05	15:00	OB-8	70%	20	14	29	5.2				61	20.3	GURIS Operators	

Table D.10
Germencik Geothermal Field, Short-Term Flow Tests February-March 2005
Flow Test Data Collected by Guris
Well: OB-8

Date	Time	Well	Approx. Flow %	WHP (kg/cm2,g)	Weir Box (net cm)	James Tube (psig)	Line Press (bar,g)	Line Temp (deg C)	Sep Press (bar,g)	Sep Temp (deg C)	Weir Square Notch (cm)	James Tube I.D. (cm)	Data Source	Notes
3/15/05	16:00	OB-8	70%	20.5	13.5	29	5.2				61	20.3	GURIS Operators	
3/15/05	17:00	OB-8	70%	20.5	13.5	29	5.2				61	20.3	GURIS Operators	
3/15/05	17:30	OB-8	70%	26.5	10.5	15	3.5				61	20.3	GURIS Operators	
3/15/05	18:00	OB-8	70%	26.7	10.5	16	3.6				61	20.3	GURIS Operators	
3/15/05	19:00	OB-8	70%	26.7	10.5	16	3.6				61	20.3	GURIS Operators	
3/15/05	20:00	OB-8	70%	27	10.5	16	3.5				61	20.3	GURIS Operators	
3/15/05	21:00	OB-8	70%	27	10.5	16	3.5				61	20.3	GURIS Operators	
3/15/05	22:00	OB-8	70%	27.5	10.5	15	3.5				61	20.3	GURIS Operators	
3/15/05	23:00	OB-8	70%	27.5	10.5	15	3.5				61	20.3	GURIS Operators	
3/16/05	0:00	OB-8	50%	27.5	10.5	15	3.5				61	20.3	GURIS Operators	
3/16/05	1:00	OB-8	50%	27.5	10.5	14	3.3				61	20.3	GURIS Operators	
3/16/05	2:00	OB-8	50%	28	10.5	14	3.3				61	20.3	GURIS Operators	
3/16/05	3:00	OB-8	50%	28	10.5	14	3.3				61	20.3	GURIS Operators	
3/16/05	4:00	OB-8	50%	28	10.5	14	3.3				61	20.3	GURIS Operators	
3/16/05	5:00	OB-8	50%	28	10.5	14	3.3				61	20.3	GURIS Operators	
3/16/05	6:00	OB-8	50%	28	10.5	13	3.3				61	20.3	GURIS Operators	
3/16/05	7:00	OB-8	50%	28	10.5	13	3.2				61	20.3	GURIS Operators	
3/16/05	8:00	OB-8	50%	28.2	10	12	3.2				61	20.3	GURIS Operators	
3/16/05	9:00	OB-8	50%	28.2	10	12	3.2				61	20.3	GURIS Operators	
3/16/05	10:00	OB-8	50%	28.5	9.5	11	3.2				61	20.3	GURIS Operators	
3/16/05	11:00	OB-8	50%	29.5	9.2	7	3.1				61	20.3	GURIS Operators	
3/16/05	11:30	OB-8	50%	29.5	9	7	2.8				61	20.3	GURIS Operators	

Table D.11
Germencik Geothermal Field, Short-Term Flow Tests February-March 2005
Flow Test Data Collected by Geologica
Well: OB-9

Date	Time	Well	Approx. Flow %	WHP (kg/cm2,g)	Weir Box (net cm)	James Tube (psig)	Line Press (bar,g)	Line Temp (deg C)	Sep Press (bar,g)	Sep Temp (deg C)	Weir Square Notch (cm)	James Tube I.D. (cm)	Data Source	Notes
3/3/05	13:25	OB-9	100%	28		20					61	20.3	Geologica	
3/3/05	13:30	OB-9	100%	26	15	28					61	20.3	Geologica	
3/3/05	13:35	OB-9	100%	18	19	55					61	20.3	Geologica	
3/3/05	13:40	OB-9	100%	12.5	19	54					61	20.3	Geologica	
3/3/05	13:42	OB-9	100%	14	20.5	55	8.5				61	20.3	Geologica	
3/3/05	13:45	OB-9	100%	10	20.5	61	10				61	20.3	Geologica	
3/3/05	14:05	OB-9	100%	9.5	20	58	9.5				61	20.3	Geologica	
3/3/05	14:17	OB-9	100%	9.5	21	60	9.5	170			61	20.3	Geologica	
3/3/05	15:45	OB-9	100%	9.5	21	58	8.5				61	20.3	Geologica	
3/3/05	16:00	OB-9	100%	9.5	20.75	58	8.6				61	20.3	Geologica	
3/3/05	16:15	OB-9	100%	9.5	19.5	59	8.5				61	20.3	Geologica	
3/3/05	16:20	OB-9	100%	9.5	21	58.5	8.5				61	20.3	Geologica	
3/3/05	16:35	OB-9	100%	9.5	19.5	58	8.5				61	20.3	Geologica	
3/3/05	16:50	OB-9	100%	9.75	20	59	8.5				61	20.3	Geologica	
3/3/05	17:00	OB-9	100%	9.5	19.5	58	8.5		9	170	61	20.3	Geologica	
3/3/05	17:15	OB-9	100%	9.5	19.5	59	8.5				61	20.3	Geologica	Sample 1 at 100% 17:15 to 18:00
3/3/05	17:25	OB-9	100%	9.5	19.5	59	8.5			170	61	20.3	Geologica	Splash Measured at 4.7 liters/sec by bucket
3/3/05	17:45	OB-9	100%	9.5	20.5	59	8.5				61	20.3	Geologica	
3/3/05	18:00	OB-9	100%	9.5	20	58	8.5				61	20.3	Geologica	
3/3/05	18:10	OB-9	100%	9.5	20	58	8.5				61	20.3	Geologica	
3/3/05	18:20	OB-9	100%	9.5		59	8.5				61	20.3	Geologica	
3/3/05	18:45	OB-9	100%	9.5		59	8.5				61	20.3	Geologica	
3/4/05	8:30	OB-9	50%	27.5	14	25	4.5				61	20.3	Geologica	
3/4/05	9:00	OB-9	50%	27.5	13.5	24.5	4.5				61	20.3	Geologica	Sample 2 at 50% 9:00 to 9:30
3/4/05	9:30	OB-9	50%	27.5	13.5	24.5	4.5				61	20.3	Geologica	Sinker bar tripped to bottom- no problems
3/4/05	10:15	OB-9	70%	24.25	15.5	35	5.5				61	20.3	Geologica	
3/4/05	14:40	OB-9	70%	22.5	16	35	6				61	20.3	Geologica	Sample 3 at 70% 14:50 to 15:30
3/4/05	15:00	OB-9	70%	22	16	35	6.1		6.2	160	61	20.3	Geologica	Splash Measured at 0.626 liters/sec by bucket
3/4/05	15:15	OB-9	70%	22.3	16	34.5	6.1				61	20.3	Geologica	

Table D.11
Germencik Geothermal Field, Short-Term Flow Tests February-March 2005
Flow Test Data Collected by Geologica
Well: OB-9

Date	Time	Well	Approx. Flow %	WHP (kg/cm2,g)	Weir Box (net cm)	James Tube (psig)	Line Press (bar,g)	Line Temp (deg C)	Sep Press (bar,g)	Sep Temp (deg C)	Weir Square Notch (cm)	James Tube I.D. (cm)	Data Source	Notes
3/4/05	15:30	OB-9	70%	22.4	16	34.5	6.1				61	20.3	Geologica	
3/4/05	16:00	OB-9	80%	18.5	18	45	7.5				61	20.3	Geologica	
3/4/05	16:20	OB-9	80%	18.3	17.5	45	7.4				61	20.3	Geologica	
3/4/05	16:45	OB-9	80%	18.5	17.25	45	7.3				61	20.3	Geologica	
3/4/05	17:10	OB-9	80%	18.4	17	45	7.3				61	20.3	Geologica	
3/4/05	17:30	OB-9	80%	18.3	16.75	45	7.3				61	20.3	Geologica	
3/4/05	18:00	OB-9	80%	18.3	17	45	7.3				61	20.3	Geologica	
3/4/05	18:30	OB-9	80%	18.4	17	45.5	7.2				61	20.3	Geologica	
3/4/05	19:00	OB-9	80%	18.5	16.875	45.5	7.2				61	20.3	Geologica	
3/5/05	9:25	OB-9	50%	27.5	13	21.5	4.4				61	20.3	Geologica	Sample 4 at 50% 9:25 to 10:00
3/5/05	9:45	OB-9	50%	27.5	13	21	4.5			150	61	20.3	Geologica	
3/5/05	10:00	OB-9	50%	27.5	13	21	4.5			150	61	20.3	Geologica	
3/5/05	10:30	OB-9	50%	27.5	13	21	4.4				61	20.3	Geologica	
3/5/05	11:00	OB-9	50%	27.5	13	20.75	4.4				61	20.3	Geologica	
3/5/05	11:15	OB-9	50%	27.5	13	20.5	4.4				61	20.3	Geologica	RU with wireline 11:15
3/5/05	11:30	OB-9	50%	27.5	13	20.5	4.4				61	20.3	Geologica	
3/5/05	12:00	OB-9	50%	27.6	13	20.5	4.4				61	20.3	Geologica	RIH with wireline 11:52
3/5/05	12:30	OB-9	50%	27.7	13	20.5	4.5				61	20.3	Geologica	
3/5/05	13:00	OB-9	50%	27.7	13	20.5	4.4				61	20.3	Geologica	
3/5/05	13:45	OB-9	50%	27.4	13.25	23	4.6				61	20.3	Geologica	Shut-down 13:10 to 13:30 wireline stuck liner
3/5/05	14:00	OB-9	50%	27.4	13.25	22.5	4.5				61	20.3	Geologica	14:10 Wireline at 1450 m TD for PBU
3/5/05	14:20	OB-9	50%	27.4	13.25	22.5	4.5				61	20.3	Geologica	14:20 Wireline at 1050 m fracture for PBU
3/5/05	14:31	OB-9	0%	33.5	shut-in						61	20.3	Geologica	Shut-in Throttle Valve for PBU 14:30
3/5/05	14:55	OB-9	0%	33	shut-in						61	20.3	Geologica	
3/5/05	15:02	OB-9	0%	32.8	shut-in						61	20.3	Geologica	
3/5/05	15:15	OB-9	0%	32	shut-in						61	20.3	Geologica	

Table D.12
Germencik Geothermal Field, Short-Term Flow Tests February-March 2005
Flow Test Data Collected by Guris
Well: OB-9

Date	Time	Well	Approx. Flow %	WHP (kg/cm2,g)	Weir Box (net cm)	James Tube (psig)	Line Press (bar,g)	Line Temp (deg C)	Sep Press (bar,g)	Sep Temp (deg C)	Weir Square Notch (cm)	James Tube I.D. (cm)	Data Source	Notes
3/3/05	13:00	OB-9	100%	23	0	0	8.5				61	20.3	GURIS Operators	
3/3/05	13:20	OB-9	100%	27.5	12	4	8.5				61	20.3	GURIS Operators	
3/3/05	14:00	OB-9	100%	9.5	20	58-60	8.5				61	20.3	GURIS Operators	
3/3/05	15:00	OB-9	100%	9.5	20-21	60	8.5				61	20.3	GURIS Operators	
3/3/05	16:00	OB-9	100%	9.5	20-21	58-59	8.5				61	20.3	GURIS Operators	
3/3/05	17:00	OB-9	100%	9.5	20-21	59	8.5				61	20.3	GURIS Operators	
3/3/05	18:00	OB-9	100%	9.5	20-21	58	8.5			170	61	20.3	GURIS Operators	
3/3/05	19:00	OB-9	100%	9.5	20-21	58	8.5				61	20.3	GURIS Operators	
3/3/05	19:00	OB-9	50%	25	13.5	25	5				61	20.3	GURIS Operators	
3/3/05	20:00	OB-9	50%	26	13.5	26	5				61	20.3	GURIS Operators	
3/3/05	21:00	OB-9	50%	26	13.5	26	5				61	20.3	GURIS Operators	
3/3/05	22:00	OB-9	50%	26.5	13.5	26	5				61	20.3	GURIS Operators	
3/3/05	23:00	OB-9	50%	26.5	13.5	26	5				61	20.3	GURIS Operators	
3/4/05	2:00	OB-9	50%	27.5	13.5	26	5				61	20.3	GURIS Operators	
3/4/05	3:00	OB-9	50%	27.5	13.5	26	5				61	20.3	GURIS Operators	
3/4/05	4:00	OB-9	50%	27.5	13.5	26	5				61	20.3	GURIS Operators	
3/4/05	5:00	OB-9	50%	27.5	13.5	26	5				61	20.3	GURIS Operators	
3/4/05	6:00	OB-9	50%	27.5	13.5	26	4.5				61	20.3	GURIS Operators	
3/4/05	7:00	OB-9	50%	27.5	13.5	26	4.5				61	20.3	GURIS Operators	
3/4/05	8:00	OB-9	50%	27.5	13.5	26	4.5				61	20.3	GURIS Operators	
3/4/05	9:00	OB-9	50%	27.5	13.5	26	4.5				61	20.3	GURIS Operators	
3/4/05	10:00	OB-9	50%	27.5	13.5	26	4.5				61	20.3	GURIS Operators	
3/4/05	10:30	OB-9	70%	22	16.5	39	6				61	20.3	GURIS Operators	
3/4/05	11:00	OB-9	70%	22	16.5	39	6				61	20.3	GURIS Operators	
3/4/05	12:00	OB-9	70%	22	16.5	38.5	6				61	20.3	GURIS Operators	
3/4/05	13:00	OB-9	70%	22	16.5	36	6				61	20.3	GURIS Operators	
3/4/05	14:00	OB-9	70%	22	16.5	36	6				61	20.3	GURIS Operators	
3/4/05	15:00	OB-9	70%	22	16	36	6				61	20.3	GURIS Operators	
3/4/05	15:30	OB-9	70%	22.5	16	36	6				61	20.3	GURIS Operators	

Table D.12
Germencik Geothermal Field, Short-Term Flow Tests February-March 2005
Flow Test Data Collected by Guris
Well: OB-9

Date	Time	Well	Approx. Flow %	WHP (kg/cm2,g)	Weir Box (net cm)	James Tube (psig)	Line Press (bar,g)	Line Temp (deg C)	Sep Press (bar,g)	Sep Temp (deg C)	Weir Square Notch (cm)	James Tube I.D. (cm)	Data Source	Notes
3/4/05	16:00	OB-9	80%	18.5	17.5	45	7.5				61	20.3	GURIS Operators	
3/4/05	17:00	OB-9	80%	18	17.5	45	7.4				61	20.3	GURIS Operators	
3/4/05	18:00	OB-9	80%	18.5	17.5	45	7.4				61	20.3	GURIS Operators	
3/4/05	19:00	OB-9	80%	18.5	17.5	45.5	7.4				61	20.3	GURIS Operators	
3/4/05	20:00	OB-9	80%	18.5	17.5	46	7.4				61	20.3	GURIS Operators	
3/4/05	21:00	OB-9	80%	18.5	17.5	46	7.4				61	20.3	GURIS Operators	
3/4/05	22:00	OB-9	80%	18.5	17.5	46	7.4				61	20.3	GURIS Operators	
3/4/05	22:30	OB-9	90%	13	19	57	8.5				61	20.3	GURIS Operators	
3/4/05	23:00	OB-9	90%	13	18.5	57	8.5				61	20.3	GURIS Operators	
3/5/05	0:00	OB-9	90%	13	18.5	57	8.5				61	20.3	GURIS Operators	
3/5/05	1:00	OB-9	90%	13	18.5	57	8.5				61	20.3	GURIS Operators	
3/5/05	2:00	OB-9	90%	13	18.5	57	8.5				61	20.3	GURIS Operators	
3/5/05	3:00	OB-9	90%	13	18.5	57	8.5				61	20.3	GURIS Operators	
3/5/05	3:45	OB-9	90%	12.75	18.5	56.75	8.5				61	20.3	GURIS Operators	
3/5/05	4:00	OB-9	50%	26.5	13	24.5	4.5				61	20.3	GURIS Operators	
3/5/05	5:00	OB-9	50%	26.5	13	24.5	4.5				61	20.3	GURIS Operators	
3/5/05	6:00	OB-9	50%	26.5	13	24.5	4.5				61	20.3	GURIS Operators	
3/5/05	7:00	OB-9	50%	27.5	13	23	4.5				61	20.3	GURIS Operators	
3/5/05	8:00	OB-9	50%	27.5	13	22	4.5				61	20.3	GURIS Operators	
3/5/05	9:00	OB-9	50%	27.5	13.5	22	4.5				61	20.3	GURIS Operators	
3/5/05	10:00	OB-9	50%	27.5	13.5	22	4.5				61	20.3	GURIS Operators	
3/5/05	11:00	OB-9	50%	27.5	13	20	4.5				61	20.3	GURIS Operators	
3/5/05	12:00	OB-9	50%	27.5	13	20	4.5				61	20.3	GURIS Operators	
3/5/05	13:00	OB-9	50%	27.5	13	20	4.5				61	20.3	GURIS Operators	
3/5/05	13:50	OB-9	50%	27.5	13	22.5	4.5				61	20.3	GURIS Operators	
3/5/05	14:00	OB-9	50%	27.5	13	22.5	4.5				61	20.3	GURIS Operators	
3/5/05	14:30	OB-9	50%	27.5	13	23	4.5				61	20.3	GURIS Operators	

E. Preliminary Production Deliverability

Appendix E

Preliminary Production Deliverability

Table E.1
Well OB-3
Preliminary Flow Calculations During Sampling Periods

Sample Number	Sample Time	Approx. Flow %	Wellhead Pressure (kg/cm^2,g)	Line Pressure (bar,g)	Calculated Brine+Steam Flow Rate (t/hr)	Calculated Steam Flow at Line Pressure (t/hr)
1	3/7/2005 17:00	100%	3.60	3.72	152.6	15.3
2	3/8/2005 8:15	70%	16.50	2.55	113.9	13.6
3	3/8/2005 13:45	90%	8.40	3.23	133.0	14.3
4	3/9/2005 8:20	100%	2.90	2.97	125.2	14.0

Notes:
Preliminary calculations as of 3/31/2005
Based on 197.4 deg C single-phase water
Preliminary Enthalpy = 840.7 KJ/kg (361.4 btu/lbm)

Table E.2
Well OB-5
Preliminary Flow Calculations During Sampling Periods

Sample Number	Sample Time	Approx. Flow %	Wellhead Pressure (kg/cm^2,g)	Line Pressure (bar,g)	Calculated Brine+Steam Flow Rate (t/hr)	Calculated Steam Flow at Line Pressure (t/hr)
1	3/11/2005 8:50	100%	5.85	5.85	169.0	18.0
2	3/11/2005 12:40	70%	11.57	5.37	130.2	14.6
3	3/11/2005 16:15	90%	7.70	5.50	141.0	15.5
4	3/12/2005 8:25	100%	4.88	4.98	135.5	15.8

Notes:
Preliminary calculations as of 3/312005
Based on 212.9 deg C single-phase water
Preliminary Enthalpy = 911.0 KJ/kg (391.7 btu/lbm) (based on single-phase liquid)

Table E.3
Well OB-6
Preliminary Calculations During Sampling Periods

Sample Number	Sample Time	Approx. Flow %	Wellhead Pressure (kg/cm^2,g)	Line Pressure (bar,g)	Calculated Brine+Steam Flow Rate (t/hr)	Calculated Steam Flow at Line Pressure (t/hr)
1	2/26/2005 15:40	50%	30.00	5.10	235.2	26.7
2	2/28/2005 11:20	100%	11.00	11.00	455.3	25.8
3	2/28/2005 16:47	90%	17.50	9.20	414.6	29.7
4	3/1/2005 7:40	50%	31.25	4.20	204.1	25.7

Notes:
Preliminary calculations as of 3/31/2005
Based on 212.2 deg C single-phase pure water
Preliminary Enthalpy = 907.8 KJ/kg (390.3 btu/lbm)

Table E.4
Well OB-7
Preliminary Flow Calculations During Sampling Periods

Sample Number	Sample Time	Approx. Flow %	Wellhead Pressure (kg/cm^2,g)	Line Pressure (bar,g)	Calculated Brine+Steam Flow Rate (t/hr)	Calculated Steam Flow at Line Pressure (t/hr)
1	3/18/2005 18:10	100%	5.90	6.00	148.6	15.9
2	3/19/2005 9:10	100%	5.90	5.80	148.0	16.2
3	3/19/2005 13:25	90%	12.00	5.50	130.6	14.7
4	3/19/2005 17:40	70%	22.00	4.20	99.8	12.9

Notes:
Preliminary calculations as of 3/31/2005
Based on 214.0 deg C single-phase water
Preliminary Enthalpy = 916.0 KJ/kg (393.8 btu/lbm) (based on single-phase liquid)

Table E.5
Well OB-8
Preliminary Flow Calculations During Sampling Periods

Sample Number	Sample Time	Approx. Flow %	Wellhead Pressure (kg/cm^2,g)	Line Pressure (bar,g)	Calculated Brine+Steam Flow Rate (t/hr)	Calculated Steam Flow at Line Pressure (t/hr)
1	3/14/2005 17:35	100%	8.10	7.37	328.4	28.6
2	3/15/2005 8:35	100%	7.70	7.20	321.8	28.6
3	3/15/2005 12:10	90%	11.23	6.80	299.6	27.8
4	3/15/2005 16:45	70%	20.50	5.20	227.9	25.2

Notes:
Preliminary calculations as of 3/31/2005
Based on 211.5 deg C single-phase water
Preliminary Enthalpy = 904.6 KJ/kg (388.9 btu/lbm) (based on single-phase liquid)

Table E.6
Well OB-9
Preliminary Flow Calculations During Sampling Periods

Sample Number	Sample Time	Approx. Flow %	Wellhead Pressure (kg/cm^2,g)	Line Pressure (bar,g)	Calculated Brine+Steam Flow Rate (t/hr)	Calculated Steam Flow at Line Pressure (t/hr)
1	3/3/2005 17:15	100%	9.50	8.50	424.6	25.6
2	3/4/2005 9:30	50%	27.50	4.50	234.7	24.4
3	3/4/2005 14:50	70%	22.30	6.08	297.6	25.3
4	3/5/2005 9:25	50%	27.50	4.45	218.1	22.9
X5	3/5/2005 3:45	90%	12.94	8.50	378.4	22.8

Notes:
Preliminary calculations as of 3/31/2005
Based on 204.4 deg C single-phase pure water at saturation
Preliminary Enthalpy = 872.3 KJ/kg (375.0 btu/lbm)
Point X5 is an extra flow calculation point only, no sample taken

Figure E.1
OB-3 Preliminary Deliverability Points

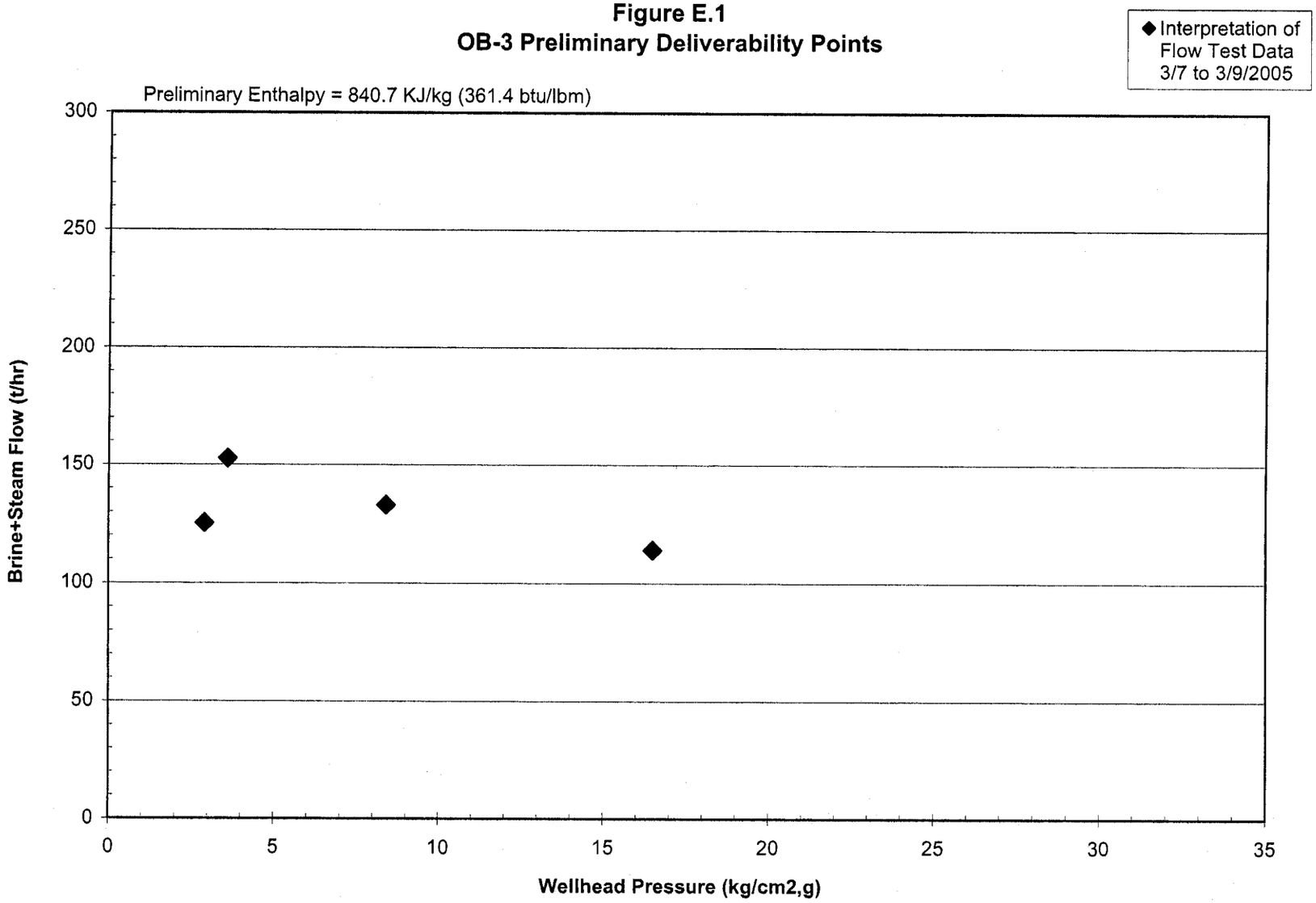

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Figure E.2
OB-5 Preliminary Deliverability Points

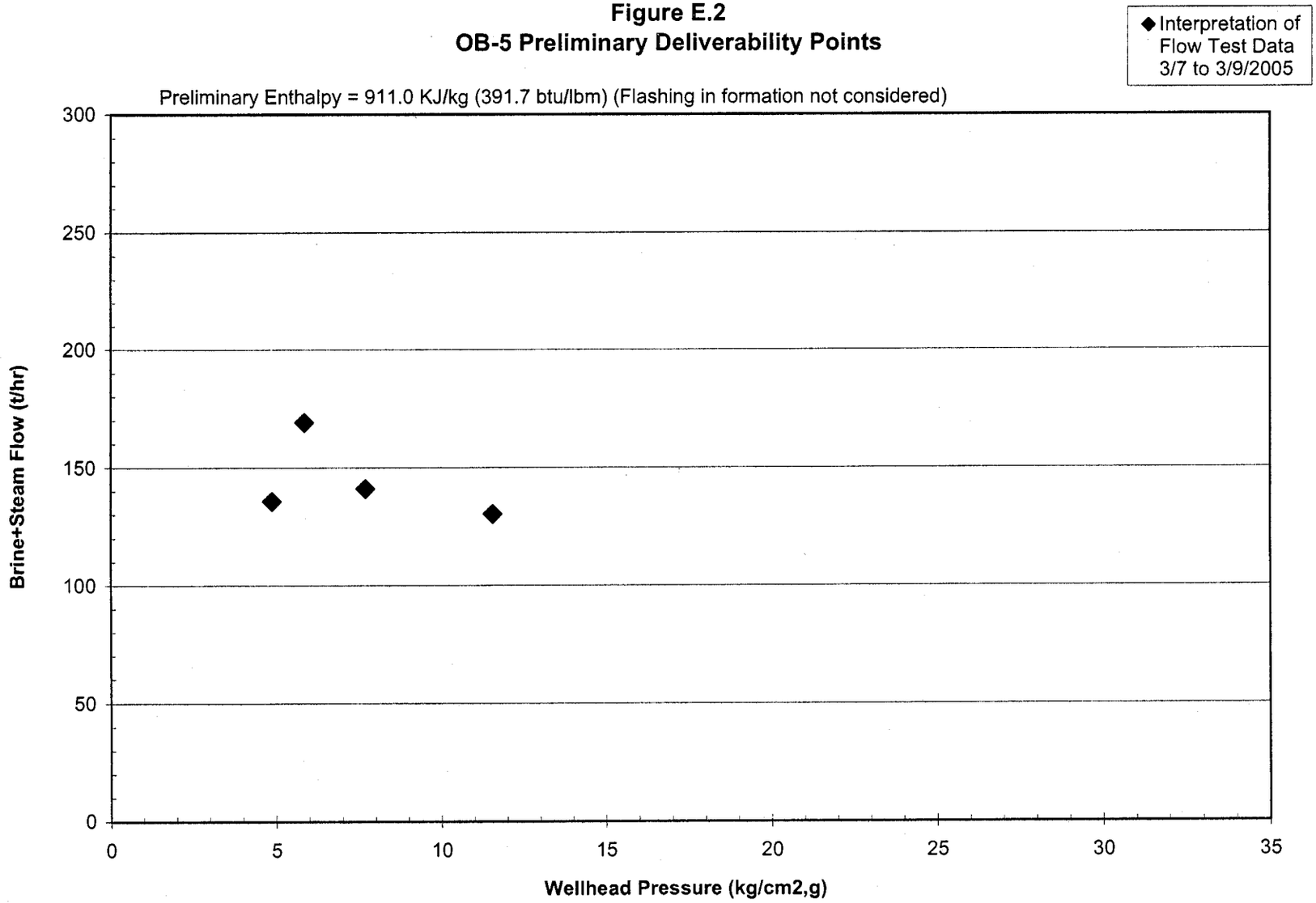

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Figure E.3
OB-6 Preliminary Deliverability Points

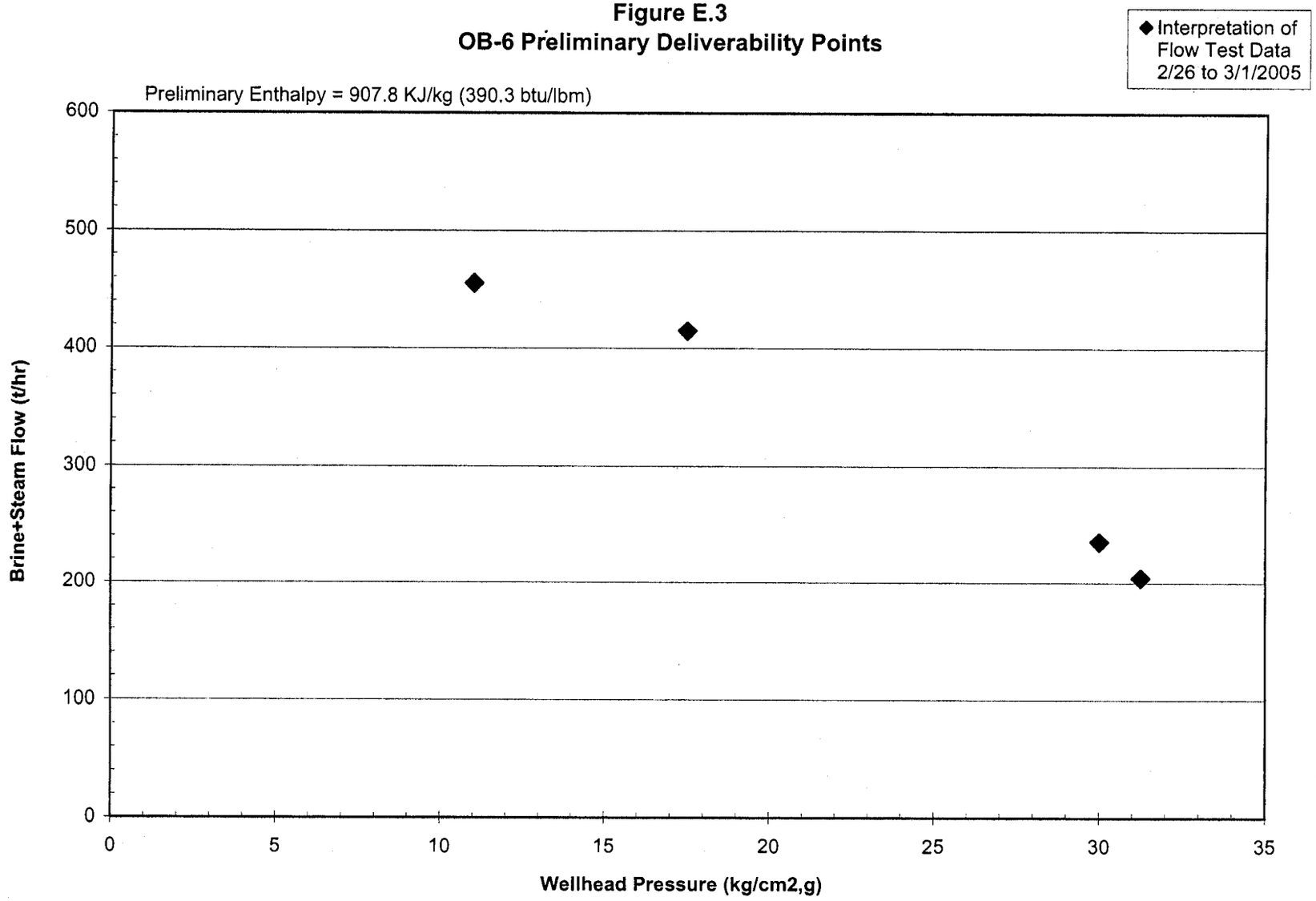

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Figure E.4
OB-7 Preliminary Deliverability Points

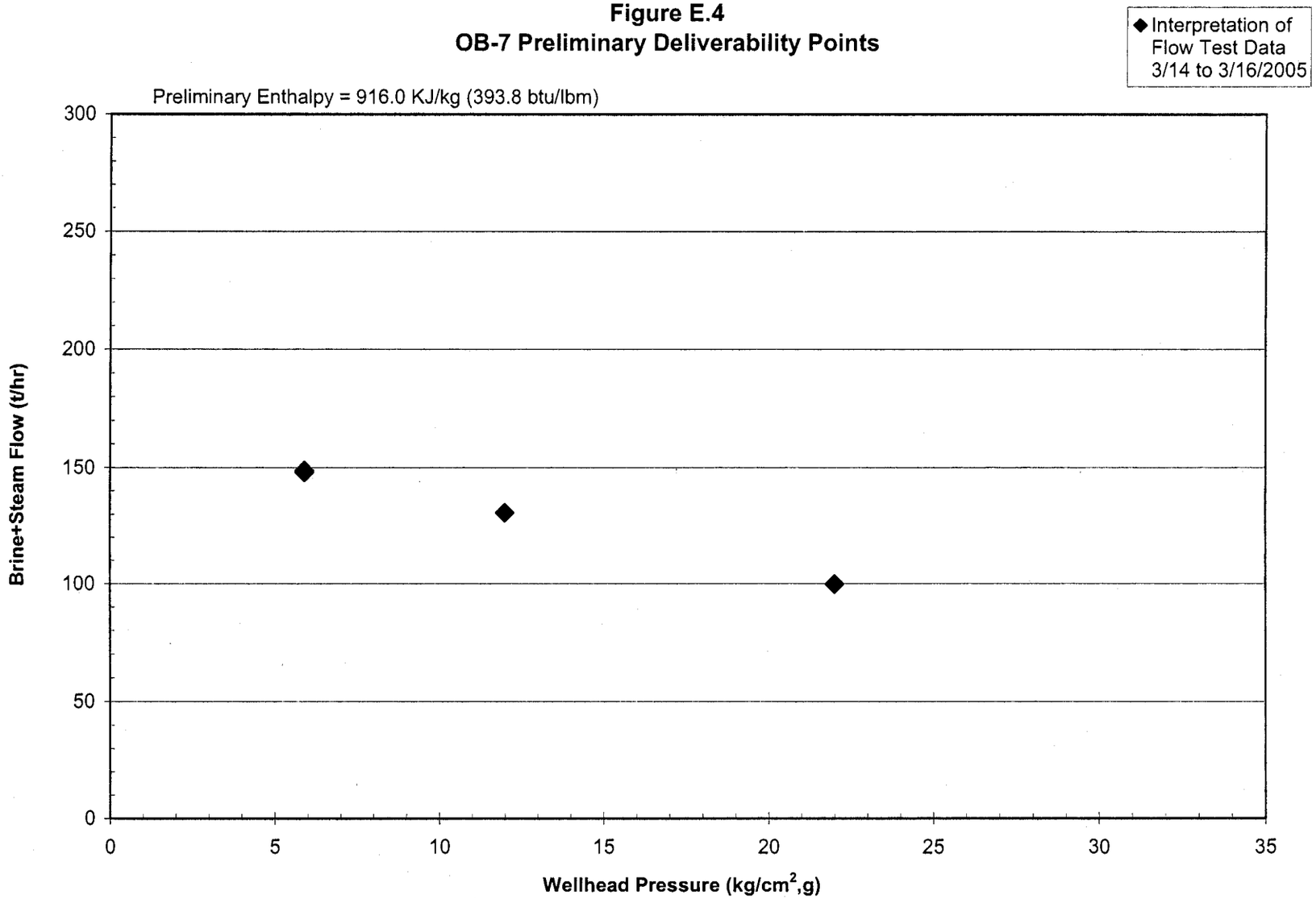

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Figure E.5
OB-8 Preliminary Deliverability Points

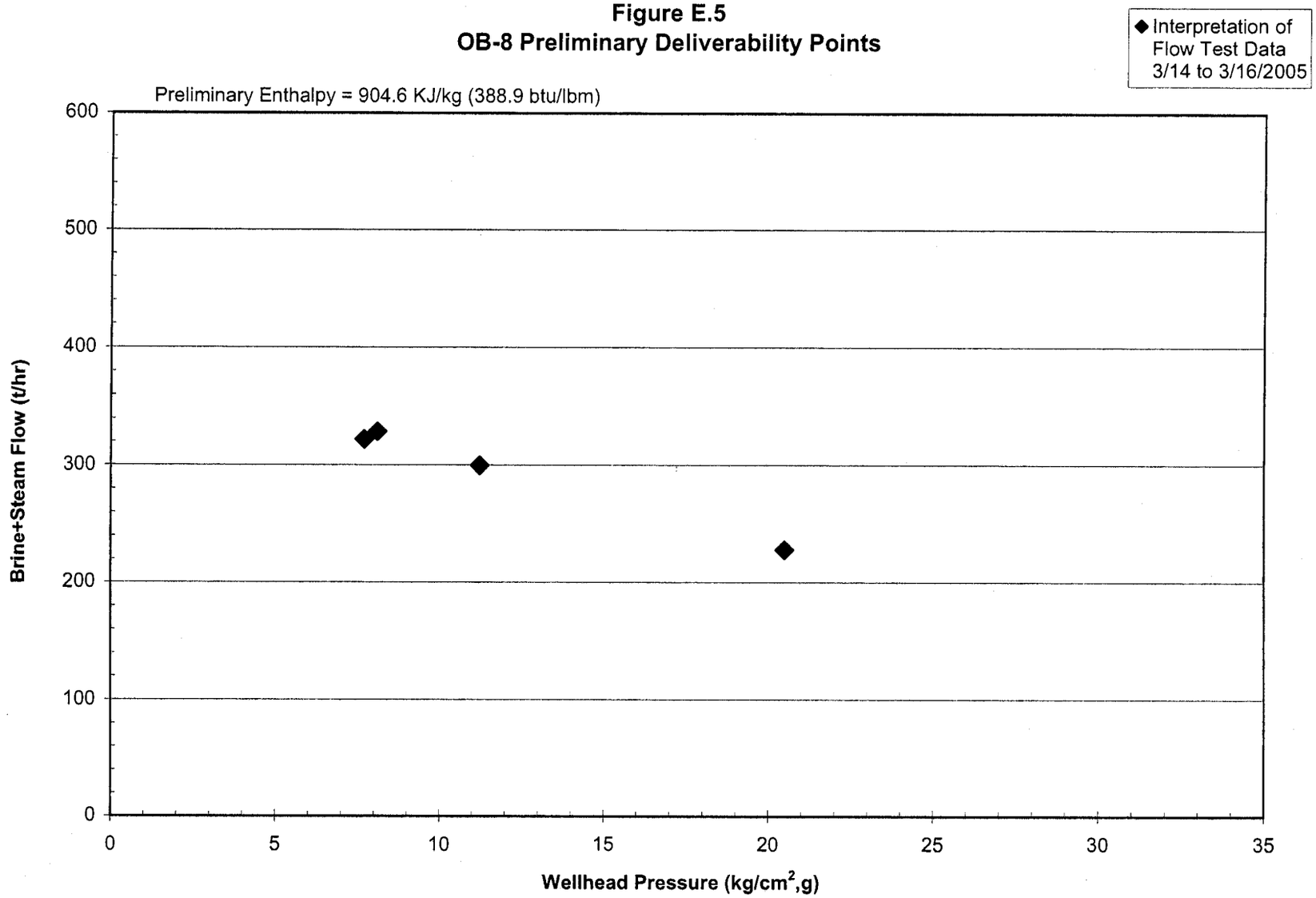

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Figure E.6
OB-9 Preliminary Deliverability Points

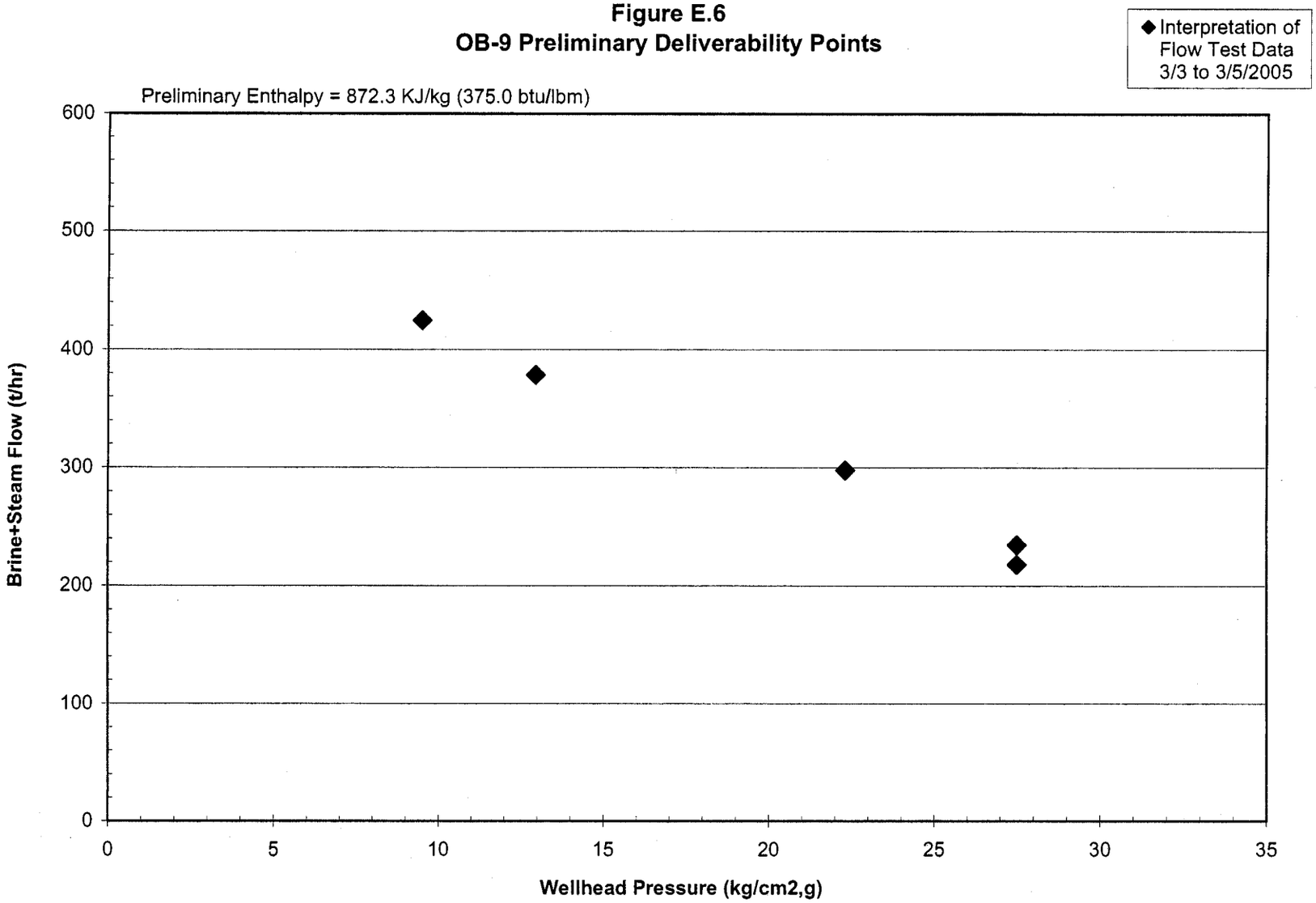

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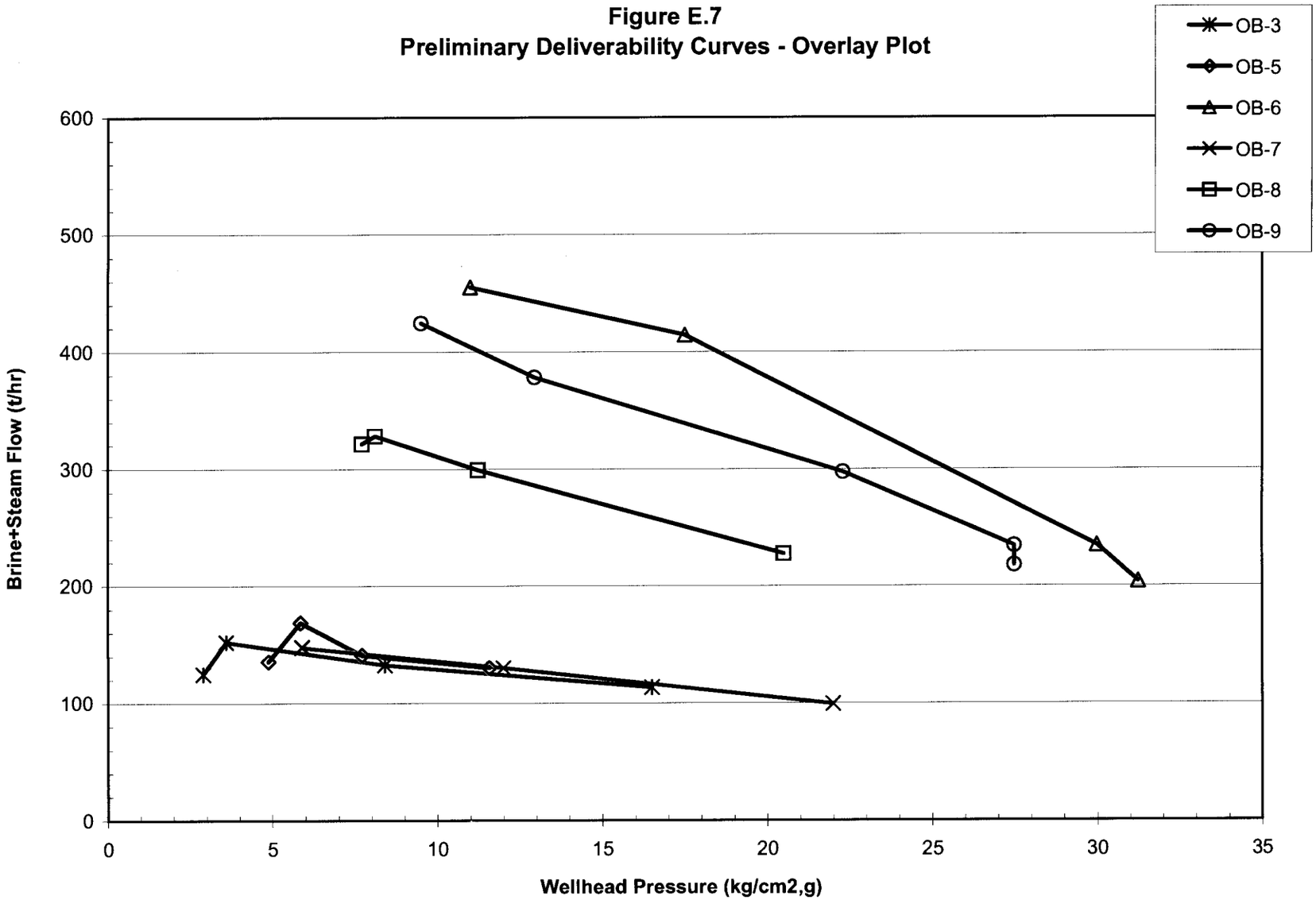
Figure E.7
Preliminary Deliverability Curves - Overlay Plot



Geologica, Inc

F. Geochemical Sampling Records

Appendix F

Geochemical Sampling and Field Measurements

F.1 Geochemical Sample and Field Data collection Record
F.2 Sample Laboratory Submittal Record
F.3 Field Data Table
F.4 Graphs of Field Geochemical Data and Sampling Conditions

Gurmat Geothermal Project Short Term Flow Testing
Geochemical Field Measurements and Sample Records for Each Short Term Flow Test

	Test Conditions				Sampling Separator		Samp T (°C)	Field Measurements			Brine Samples					Steam Samples			Comments
Laboratory											Thermochem				IGNS	Thermochem		IGNS	
Analyte											anions	cations	SiO2	Hg	D, O18	NCG	Na,B,As	D, O18	
Well	Date	Time	LP (bars g)	LT (°C)	P (bars g)	T (°C)	Condenser	pH	conductivity	G/S (ppm wt)	1LUF	500ml FL+HNO3	250mlw/dilute nitric	125ml glass w/$K_2CR_2O_7$	60 ml vial	Evacuated Bottle w/NaOH	250mlUF	60 ml vial	
OB-3	7-Mar-05	17:20	4.0	145	4.0	145	16.6	7.44	6430	129014	OB3B1A	OB3B1B	OB3B1C	OB3B1D	OB3B1E	OB3S1C	OB3S1A	OB3S1B	NY/AK- good sampling
	8-Mar-05	08:20	2.5	125	2.5	125	15.6	8.45	7430	109053	OB3B2A	OB3B2B	OB3B2C	OB3B2D	OB3B2E	OB3S2C	OB3S2A	OB3S2B	NY/AK- good sampling
	8-Mar-05	14:10	3.5	140	3.0	140	12.2	8.54	7430	125229	OB3B3A	OB3B3B	OB3B3C	OB3B3D	OB3B3E	OB3S3C	OB3S3A	OB3S3B	NY/AK- good sampling
	9-Mar-05	08:50	3.0	135	2.5	135	11.1	8.50	7660	85912	OB3B4A	OB3B4B	OB3B4C	OB3B4D	OB3B4E	OB3S4C	OB3S4A	OB3S4B	NY/AK- good sampling
OB-5	11-Mar-05	09:15	5.5	159	5.5	159	10	7.74	6690	154287	OB5B1A	OB5B1B	OB5B1C	OB5B1D	OB5B1E	OB5S1C	OB5S1A	OB5S1B	NY/AK/SO
	11-Mar-05	13:10	5.5	155	5.5	155	8.9	6.83	6500	120194	OB5B2A	OB5B2B	OB5B2C	OB5B2D	OB5B2E	OB5S2C	OB5S2A	OB5S2B	NY/AK/SO
	11-Mar-05	16:35	5.5	155	5.5	155	16.66	7.83	6190	152798	OB5B3A	OB5B3B	OB5B3C	OB5B3D	OB5B3E	OB5S3C	OB5S3A	OB5S3B	NY/AK/SO
	12-Mar-05	08:55	5.0	155	5.0	155	4.44	8.61	6950	137042	OB5B4A	OB5B4B	OB5B4C	OB5B4D	OB5B4E	OB5S4C	OB5S4A	OB5S4B	NY/AK/SO
OB-6	26 Feb 05	15:40	5.1	148	5.05	150	15.6	7.5	6720	163000	OB6B1A	OB6B1B	OB6B1C	OB6B1D	OB6B1E	OB6S1C	OB6S1A	OB6S1B	wet weather sampling
	28 Feb 05	11:20	10.5	180	11	180	15.6	7.14	6720	193000	OB6B2A	OB6B2B	OB6B2C	OB6B2D	OB6B2E	OB6S2C	OB6S2A	OB6S2B	wet weather sampling
	28 Feb 05	16:50	9.5	175	9.5	175	20	7.02	6610	181000	OB6B3A	OB6B3B	OB6B3C	OB6B3D	OB6B3E	OB6S3C	OB6S3A	OB6S3B	wet weather sampling
	1-Mar-05	07:40	4.5	148	4.5	148	25.6	7.99	7520	154000	OB6B4A	OB6B4B	OB6B4C	OB6B4D	OB6B4E	OB6S4C	OB6S4A	OB6S4B	wet weather sampling
OB-7	18-Mar-05	18:35	6.0	160	6.0	160	19.89	7.15	5850	177347	OB7B1A	OB7B1B	OB7B1C	OB7B1D	OB7B1E	OB7S1C	OB7S1A	OB7S1B	NY/AK/SO
	19-Mar-05	09:30	5.9	160	5.9	160	15.55	6.48	6400	141848	OB7B2A	OB7B2B	OB7B2C	OB7B2D	OB7B2E	OB7S2C	OB7S2A	OB7S2B	NY/AK/SO
	19-Mar-05	13:50	5.5	150	4.2	150	20.00	8.19	7630	133773	OB7B3A	OB7B3B	OB7B3C	OB7B3D	OB7B3E	OB7S3C	OB7S3A	OB7S3B	NY/AK/SO
	19-Mar-05	18:00	4.2	150	4.2	150	23.88	8.03	8210	157097	OB7B4A	OB7B4B	OB7B4C	OB7B4D	OB7B4E	OB7S4C	OB7S4A	OB7S4B	NY/AK/SO
OB-8	14-Mar-05	17:55	7.2	165	7.2	165	15.55	6.72	6670	177774	OB8B1A	OB8B1B	OB8B1C	OB8B1D	OB8B1E	OB8S1C	OB8S1A	OB8S1B	SO/AK
	15-Mar-05	08:45	7.2	165	7.2	165	13.33	7.92	7000	192510	OB8B2A	OB8B2B	OB8B2C	OB8B2D	OB8B2E	OB8S2C	OB8S2A	OB8S2B	SO/AK
	15-Mar-05	12:30	6.9	165	6.9	165	25.55	7.67	7000	171122	OB8B3A	OB8B3B	OB8B3C	OB8B3D	OB8B3E	OB8S3C	OB8S3A	OB8S3B	SO/AK
	15-Mar-05	17:05	5.0	155	5.0	152	22.22	7.24	6980	144020	OB8B4A	OB8B4B	OB8B4C	OB8B4D	OB8B4E	OB8S4C	OB8S4A	OB8S4B	SO/AK
OB-9	4-Mar-05	17:45	8.5	172	8.7	172	22.2	7.12	6650	150000	OB9B1A	OB9B1B	OB9B1C	OB9B1D	OB9B1E	OB9S1C	OB9S1A	OB9S1B	NY/AK- good sampling
	4-Mar-05	09:00	4.4	148	4.5	148	22.2	7.4	6800	193000	OB6B2A	OB9B2B	OB9B2C	OB9B2D	OB9B2E	OB9S2C	OB9S2A	OB9S2B	NY/AK- good sampling
	4-Mar-05	15:20	6.1	160	6.2	160	21.1	6.98	6580	204000	OB6B3A	OB9B3B	OB9B3C	OB9B3D	OB9B3E	OB9S3C	OB9S3A	OB9S3B	NY/AK- good sampling
	5-Mar-05	09:50	4.4	150	4.5	150	21.1	7.4	6800	164000	OB6B4A	OB9B4B	OB9B4C	OB9B4D	OB9B4E	OB9S4C	OB9S4A	OB9S4B	NY/AK- good sampling

Gurmat Geothermal Project Short Term Flow Testing
Geochemical Sample Collection and Sample Submittal Record
WELL _____
Test #OB3

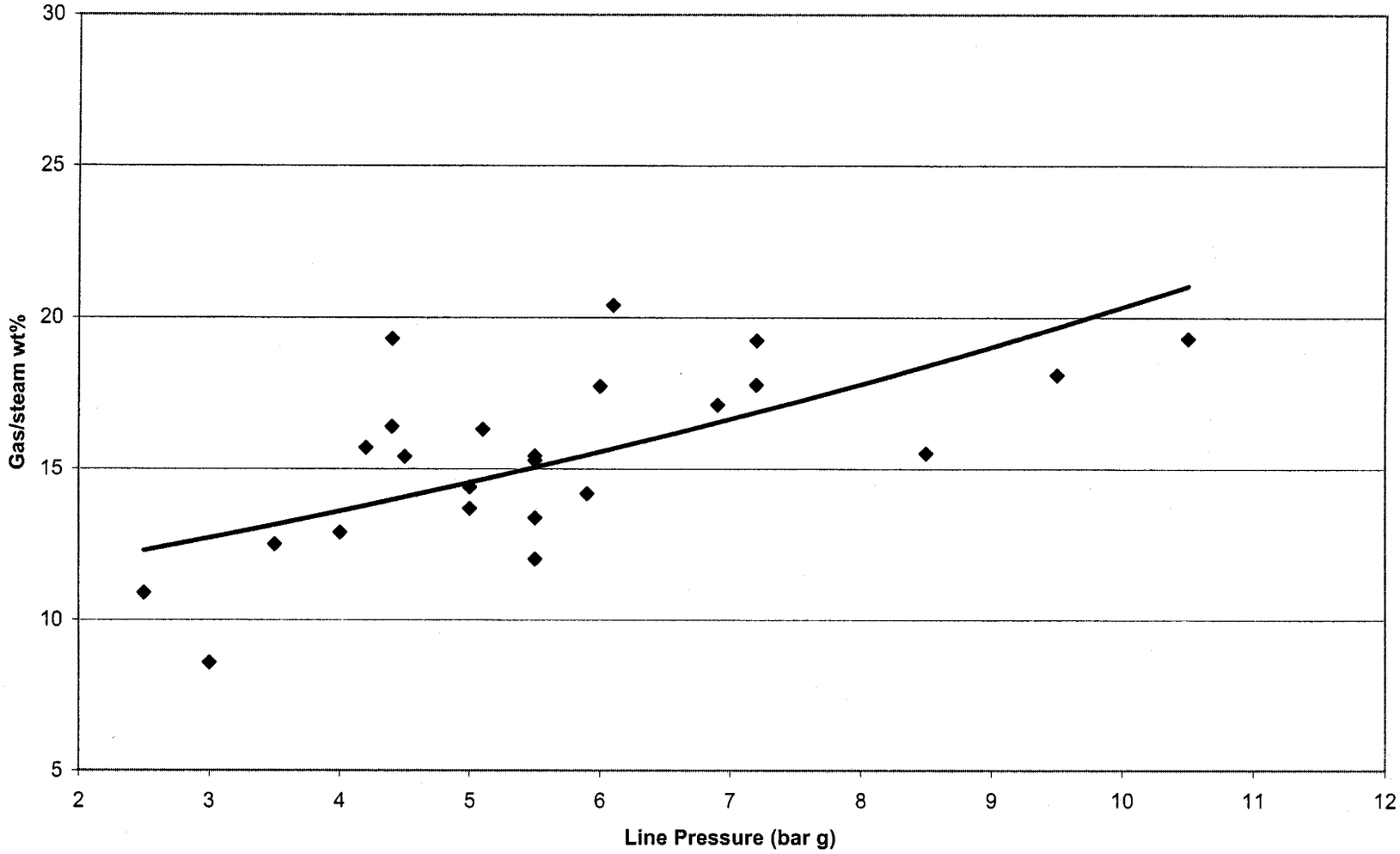
	Test Conditions				Brine Samples										Steam Samples					
					Thermochem Lab										Thermochem Lab					
					Analytes										Analytes					
					anions*		cations**		SiO2		Hg		D, O18		NCG***		Na,B,As		D, O18	
Well	Date	Time	Line P (bar_g)	Line T (°C)	1LUF	Date submitted or Not Submitted (NS)	500ml FL+HNO3	Date submitted or Not Submitted (NS)	250mlw/dilute nitric	Date submitted or Not Submitted (NS)	250ml glass UFw/K_2C R_2O_7	Date submitted or Not Submitted (NS)	60 ml vial	Date submitted or Not Submitted (NS)	Evacuated Bottle w/NaOH	Date submitted or Not Submitted (NS)	250mlUF	Date submitted or Not Submitted (NS)	60 ml vial	Date submitted or Not Submitted (NS)
OB-3	7-Mar-05	17:20	4.0	145	OB3B1A	NS	OB3B1B	NS	OB3B1C	NS	OB3B1D	NS	OB3B1E	NS	OB3S1C	NS	OB3S1A	NS	OB3S1B	NS
	8-Mar-05	08:20	2.5	125	OB3B2A	NS	OB3B2B	NS	OB3B2C	NS	OB3B2D	NS	OB3B2E	NS	OB3S2C	NS	OB3S2A	NS	OB3S2B	NS
	8-Mar-05	14:10	3.5	140	OB3B3A	31-Mar-05	OB3B3B	31-Mar-05	OB3B3C	31-Mar-05	**OB3B3D**	31-Mar-05	OB3B3E	31-Mar-05	**OB3S3C**	31-Mar-05	OB3S3A	31-Mar-05	OB3S3B	31-Mar-05
	9-Mar-05	08:50	3.0	135	OB3B4A	31-Mar-05	OB3B4B	31-Mar-05	OB3B4C	31-Mar-05	OB3B4D	NS	OB3B4E	31-Mar-05	**OB3S4C**	31-Mar-05	OB3S4A	31-Mar-05	OB3S4B	31-Mar-05
OB-5	11-Mar-05	09:15	5.5	159	OB5B1A	NS	OB5B1B	NS	OB5B1C	NS	OB5B1D	NS	OB5B1E	NS	OB5S1C	NS	OB5S1A	NS	OB5S1B	NS
	11-Mar-05	13:10	5.5	155	OB5B2A	3/31/2005	OB5B2B	3/31/2005	OB5B2C	3/31/2005	OB5B2D	NS	OB5B2E	3/31/2005	**OB5S2C**	3/31/2005	OB5S2A	3/31/2005	OB5S2B	3/31/2005
	11-Mar-05	16:35	5.5	155	OB5B3A	3/31/2005	OB5B3B	3/31/2005	OB5B3C	3/31/2005	**OB5B3D**	3/31/2005	OB5B3E	3/31/2005	**OB5S3C**	3/31/2005	OB5S3A	3/31/2005	OB5S3B	3/31/2005
	12-Mar-05	08:55	5.0	155	OB5B4A	3/31/2005	OB5B4B	3/31/2005	OB5B4C	3/31/2005	OB5B4D	NS	OB5B4E	3/31/2005	**OB5S4C**	3/31/2005	OB5S4A	3/31/2005	OB5S4B	3/31/2005
OB-6	26 Feb 05	15:40	5.1	148	OB6B1A	NS	OB6B1B	NS	OB6B1C	NS	OB6B1D	NS	OB6B1E	NS	OB6S1C	NS	OB6S1A	NS	OB6S1B	NS
	28 Feb 05	11:20	10.5	180	OB6B2A	3/31/2005	OB6B2B	3/31/2005	OB6B2C	3/31/2005	OB6B2D	NS	OB6B2E	3/31/2005	**OB6S2C**	3/31/2005	OB6S2A	3/31/2005	OB6S2B	3/31/2005
	28 Feb 05	16:50	9.5	175	OB6B3A	3/31/2005	OB6B3B	3/31/2005	OB6B3C	3/31/2005	**OB6B3D**	3/31/2005	OB6B3E	3/31/2005	**OB6S3C**	3/31/2005	OB6S3A	3/31/2005	OB6S3B	3/31/2005
	1-Mar-05	07:40	4.5	148	OB6B4A	3/31/2005	OB6B4B	3/31/2005	OB6B4C	3/31/2005	OB6B4D	NS	OB6B4E	3/31/2005	**OB6S4C**	3/31/2005	OB6S4A	3/31/2005	OB6S4B	3/31/2005
OB-7	18-Mar-05	18:35	6.0	160	OB7B1A	NS	OB7B1B	NS	OB7B1C	NS	OB7B1D	NS	OB7B1E	NS	OB7S1C	NS	OB7S1A	NS	OB7S1B	NS
	19-Mar-05	09:30	5.9	160	OB7B2A	3/31/2005	OB7B2B	3/31/2005	OB7B2C	3/31/2005	OB7B2D	NS	OB7B2E	3/31/2005	**OB7S2C**	3/31/2005	OB7S2A	3/31/2005	OB7S2B	3/31/2005
	19-Mar-05	13:50	5.5	150	OB7B3A	3/31/2005	OB7B3B	3/31/2005	OB7B3C	3/31/2005	**OB7B3D**	3/31/2005	OB7B3E	3/31/2005	**OB7S3C**	3/31/2005	OB7S3A	3/31/2005	OB7S3B	3/31/2005
	19-Mar-05	18:00	4.2	150	OB7B4A	3/31/2005	OB7B4B	3/31/2005	OB7B4C	3/31/2005	OB7B4D	NS	OB7B4E	3/31/2005	**OB7S4C**	3/31/2005	OB7S4A	3/31/2005	OB7S4B	3/31/2005
OB-8	14-Mar-05	17:55	7.2	165	OB8B1A	NS	OB8B1B	NS	OB8B1C	NS	OB8B1D	NS	OB8B1E	NS	OB8S1C	NS	OB8S1A	NS	OB8S1B	NS
	15-Mar-05	08:45	7.2	165	OB8B2A	3/31/2005	OB8B2B	3/31/2005	OB8B2C	3/31/2005	OB8B2D	NS	OB8B2E	3/31/2005	OB8S2C	3/31/2005	OB8S2A	3/31/2005	OB8S2B	3/31/2005
	15-Mar-05	12:30	6.9	165	OB8B3A	3/31/2005	OB8B3B	3/31/2005	OB8B3C	3/31/2005	OB8B3D	3/31/2005	OB8B3E	3/31/2005	OB8S3C	3/31/2005	OB8S3A	3/31/2005	OB8S3B	3/31/2005
	15-Mar-05	17:05	5	155	OB8B4A	3/31/2005	OB8B4B	3/31/2005	OB8B4C	3/31/2005	OB8B4D	NS	OB8B4E	3/31/2005	OB8S4C	3/31/2005	OB8S4A	3/31/2005	OB8S4B	3/31/2005
OB-9	4-Mar-05	17:45	8.5	172	OB9B1A	3/31/2005	OB9B1B	3/31/2005	OB9B1C	3/31/2005	OB9B1D	NS	OB9B1E	3/31/2005	**OB9S1C**	3/31/2005	OB9S1A	3/31/2005	OB9S1B	3/31/2005
	4-Mar-05	09:00	4.4	148	OB6B2A	NS	OB9B2B	NS	OB9B2C	NS	OB9B2D	NS	OB9B2E	NS	OB9S2C	NS	OB9S2A	NS	OB9S2B	NS
	4-Mar-05	15:20	6.1	160	OB6B3A	3/31/2005	OB9B3B	3/31/2005	OB9B3C	3/31/2005	**OB9B3D**	3/31/2005	OB9B3E	3/31/2005	**OB9S3C**	3/31/2005	OB9S3A	3/31/2005	OB9S3B	3/31/2005
	5-Mar-05	09:50	4.4	150	OB6B4A	3/31/2005	OB9B4B	3/31/2005	OB9B4C	3/31/2005	OB9B4D	NS	OB9B4E	3/31/2005	**OB9S4C**	3/31/2005	OB9S4A	3/31/2005	OB9S4B	3/31/2005

* Chloride (Cl), Sulfate (SO4), bicarbonate (HCO3), carbonate (CO3), flouride (F), ammonium (NH4), pH, TDS
**sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), lithium (Li), boron (B), arsenic (As), iron (Fe), manganese (Mn)
***NCG=noncondensible gases, argon (Ar), oxygen (O2), nitrogen (N2), methane (CH4), hydrogen (H2), carbon dioxide (CO2), ammonia (NH3), hydrogen sulfide (H2S), total NCG G/S

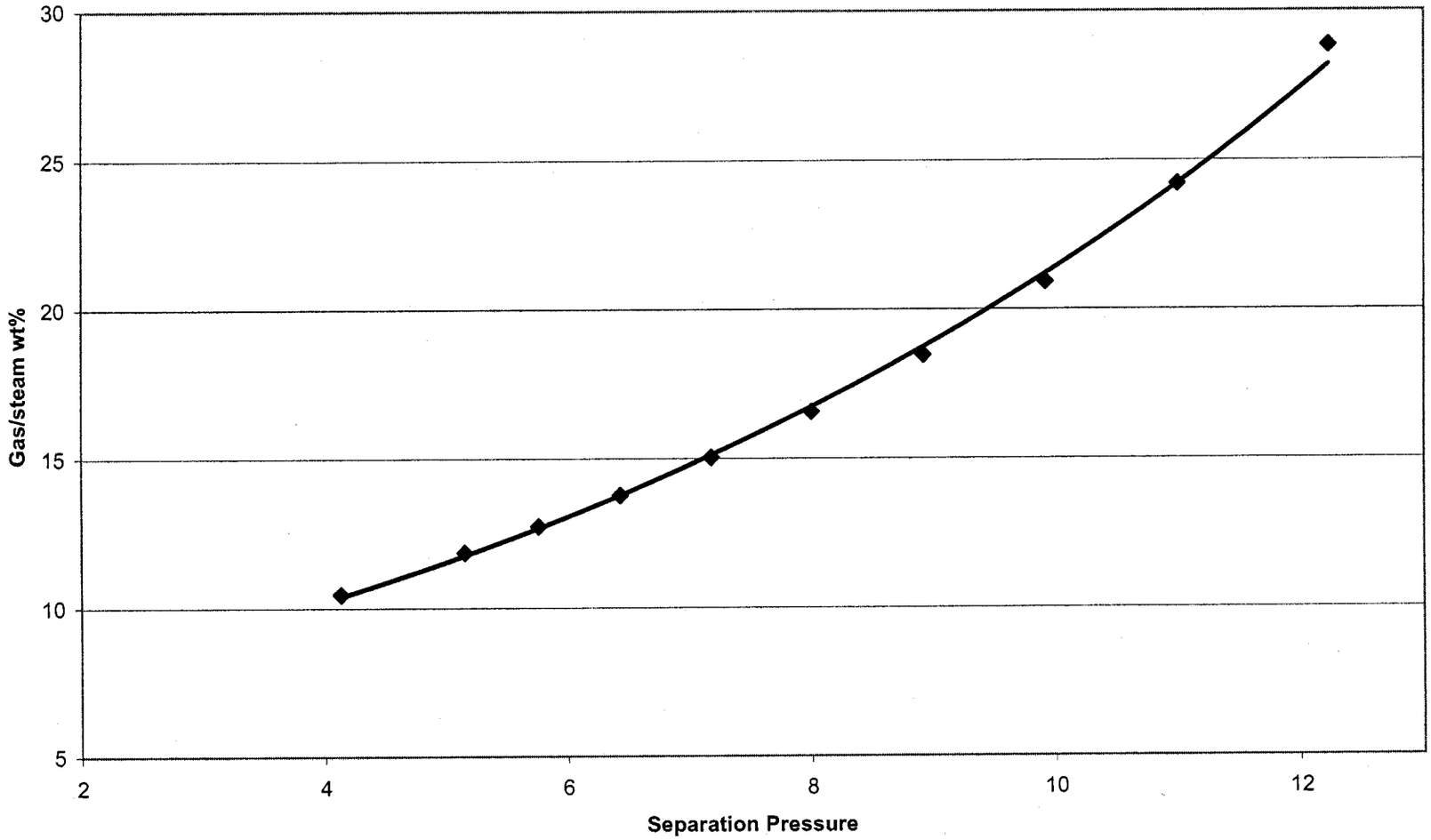
Well	Date	Time	Line P bar g	Line T °C	H(res,tot) KJ/kg	Y	pH	cond-meas	G/S-meas	cond-res	Gas-res % by weight	gas-res well average	cond-res well average
	7-Mar-05	17:20	4.0	145		0.100	7.4	6430	129010	5787	1.29		
	8-Mar-05	08:20	2.5	125		0.119	8.5	7430	109050	6546	1.30		
	8-Mar-05	14:10	3.5	140		0.108	8.5	7430	125230	6628	1.35		
OB-3	9-Mar-05	08:50	3.0	135	840.7	0.112	8.5	7660	85910	6802	0.96	1.23	6441
	11-Mar-05	09:15	5.5	159		0.106	7.7	6690	154290	5979	1.64		
	11-Mar-05	13:10	5.5	155		0.112	6.8	6500	120200	5773	1.34		
	11-Mar-05	16:35	5.5	155		0.110	7.8	6190	152800	5507	1.69		
OB-5	12-Mar-05	08:55	5.0	155	911	0.117	8.6	6950	137040	6140	1.60	1.57	5850
	26 Feb 05	15:40	5.1	148		0.114	7.5	6720	163000	5957	1.85		
	28 Feb 05	11:20	10.5	180		0.057	7.1	6720	193000	6339	1.09		
	28 Feb 05	16:50	9.5	175		0.072	7.0	6610	181000	6136	1.30		
OB-6	1-Mar-05	07:40	4.5	148	907.8	0.126	8.0	7520	154000	6574	1.94	1.54	6252
	18-Mar-05	18:35	6.0	160		0.107	7.2	5850	177350	5224	1.90		
	19-Mar-05	09:30	5.9	160		0.109	6.5	6400	141850	5701	1.55		
	19-Mar-05	13:50	5.5	150		0.113	8.2	7630	133770	6770	1.51		
OB-7	19-Mar-05	18:00	4.2	150	916	0.129	8.0	8210	157100	7151	2.03	1.75	6211
	14-Mar-05	17:55	7.2	165		0.087	6.7	6670	177770	6089	1.55		
	15-Mar-05	08:45	7.2	165		0.089	7.9	7000	192510	6379	1.71		
	15-Mar-05	12:30	6.9	165		0.093	7.7	7000	171120	6350	1.59		
OB-8	15-Mar-05	17:05	5.0	155	904.6	0.111	7.2	6980	144020	6207	1.59	1.61	6256
	4-Mar-05	17:45	8.5	172		0.060	7.1	6650	155000	6249	0.94		
	4-Mar-05	09:00	4.4	148		0.104	7.4	6800	193000	6092	2.01		
	4-Mar-05	15:20	6.1	160		0.085	7.0	6580	204000	6021	1.73		
OB-9	5-Mar-05	09:50	4.4	150	872.3	0.105	7.4	6800	164000	6087	1.72	1.60	6112

MEAN of ALL SAMPLES	892					6187		1.55	6187
Standard Deviation	3%					7%		20%	3%
MEAN of OB-6, OB-8 and OB-9	895					6290		1.58	6207
Standard Deviation	2%					3%		21%	1%

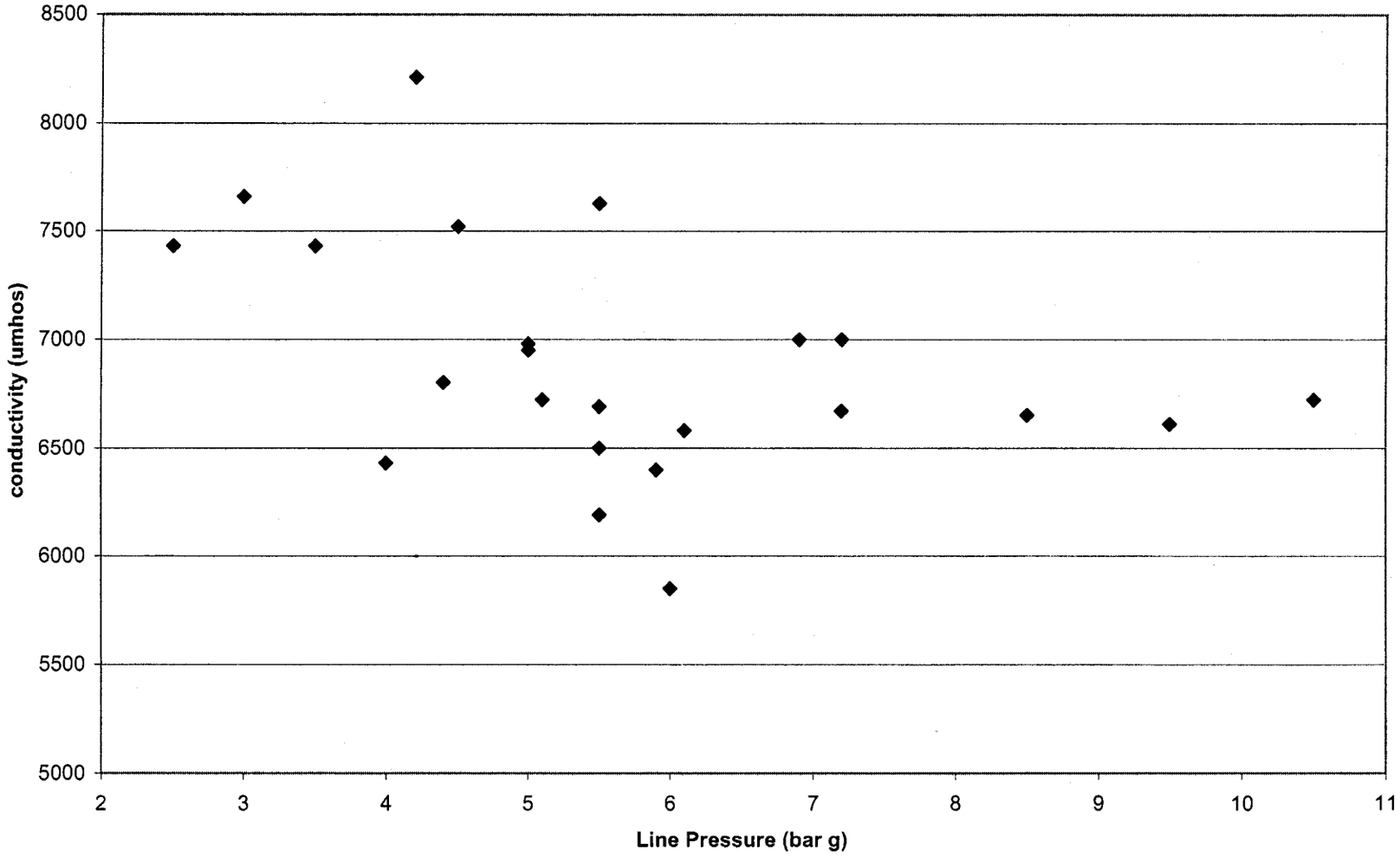
Germencik Flow Testing Gas/Steam Field Measurements V. Line Pressure All Wells



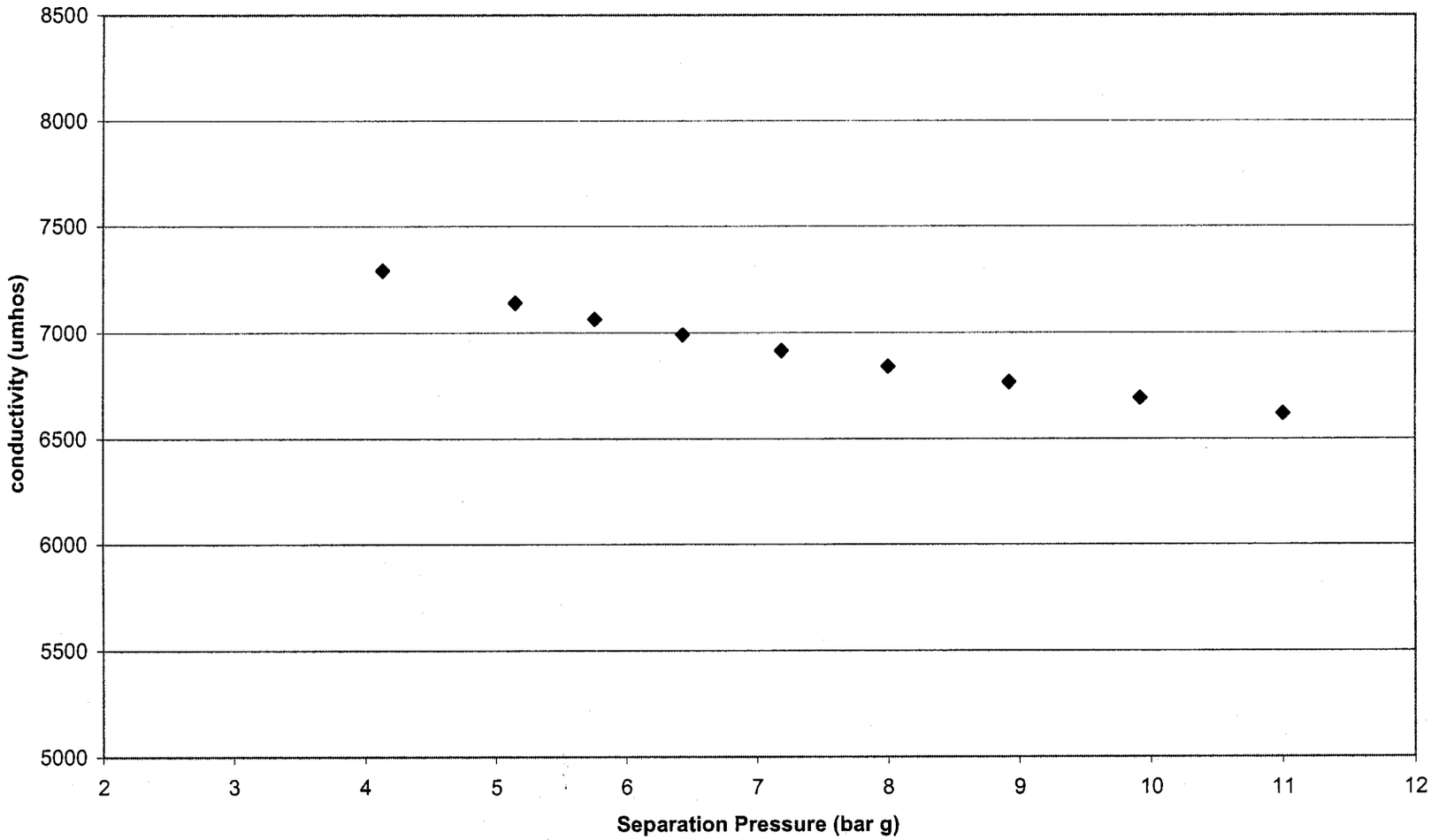
Germencik Flow Testing Calculated Gas/Steam V. Steam Fraction Using Average Reservoir Gas (1.55 wt%) and Total Enthalpy (895 kJ/kg)



Germencik Flow Testing Conductivity V. Line Pressure all wells



Germencik Flow Testing Calculated Brine Conductivity V. Separation Pressure - Average Reservoir Conductivity



G. Preliminary Drilling Plans
And Cost Estimate

Appendix G
Preliminary Drilling Cost Estimates
Medium-size Production Well and Various Injection Wells

APPENDIX G HAS BEEN DELETED FROM THIS COPY.

H. Long Term Flow Test Plan

Appendix H

Outline of Long Term Flow and Injection Testing

To: Ali Kindap
From: Richard Holt and Jill Haizlip
Date: May 13, 2005
RE: Outline of Germencik Long Term Well Test Program

Please find Geologica's recommendation for a long term flow test for the Germencik Geothermal project. This memorandum outlines the purpose and objectives of the long term testing, describes procedures, and identifies major pieces of equipment that will be required. The purpose of this memorandum is primarily to provide Guris with the information needed to begin organizing the resources, permits, and equipment for the long term flow test.

Purpose and Objectives:

The purpose of the long term flow tests is to evaluate the reservoir performance as a whole and to provide the data required to evaluate the overall size and potential capacity of the resource. While the short term flow tests evaluated the productivity of individual wells, the long term flow test evaluates the long term production performance (existence of deliverability decline), the long term injection performance (existence of injectivity decline), and pressure interference among the existing wells. This purpose will be addressed with the following objectives:

1. Flow one or more production wells for 30 to 60 days.
2. Inject into one well for 30 to 60 days.
3. Continuously monitor downhole pressure data in several wells.
4. Test the effectiveness of selected scale inhibitor for long term production and injection.
5. Run pressure-temperature-spinner surveys on flowing wells (production and injection) to quantify and evaluate the contributions of various zones.

Procedure:

The procedure for flowing the wells and collecting data will be similar to the procedures used in the short term flow test. The main differences are: longer flow periods, flowing two wells simultaneously, injection, pressure monitoring

in non-flowing wells, using spinner survey tools, and downhole use of chemical scale inhibitor. We propose to flow OB-6 and OB-9 simultaneously and inject into OB-8 as described below:

1. Flow Well OB-6 and OB-9 at (or near) wellhead pressure consistent with preliminary plant design for 30 to 60 days through flow elbow, James tube, into separator, and through weir box.

2. Assuming that OB-6 and OB-9 are each flowed at 90% capacity, there would be approximately 626 ton/hr of brine production. (OB-6 producing 324 ton/hr of brine, and OB-9 producing 302 ton/hr of brine)

3. Inject into Well OB-8 with an injection pump. The attached Figure shows the predicted wellhead injectivity for well OB-8 assuming 85 deg C water. OB-8's predicted injectivity at 35 bar,g wellhead pressure is approximately 322 ton/hr. At this level of pump capacity, OB-8 can dispose of half of the brine from two flowing wells, or all of the brine from one flowing well. It is recommended that this size of pump be investigated for feasibility and costs.

4. It is estimated that the wellhead pressure of OB-8 could be taken to a maximum or 52.5 bar,g before risking fracturing the formation at the casing shoe depth of 1298 meters. At this wellhead pressure, the injection flow is predicted to be 562 ton/hr. This injection rate is almost enough to handle a two well flow test. It is recommended that this size of pump be investigated for feasibility and costs.

5. Flow excess produced fluid into river. If two wells (OB-6 and OB-9) are produced near full capacity, depending on the final pump design and allowing for some uncertainty in the actual injectivity curve of OB-8, up to 300 ton/hr of brine may need to be flowed into the river.

6. Perform and test downhole inhibitor. Select optimal inhibitor/injection rate, set up injection, monitor calcium in brine using a field test, modify injection rate as appropriate. Sample brine at injection well for silica.

7. Sample production wells weekly for the last 3 to 4 weeks (depending on the length of the test and the change in producing conditions) including steam and brine field analysis and a complete set of samples as performed in the short term flow test.

8. Monitor downhole pressure on selected wells with capillary tubing set to approximately 900 meters recording data with a surface data logger. (Wells OB-3, OB-6, OB-7, OB-8, and OB-9)

9. Perform a pressure-temperature-spinner survey on wells OB-6, OB-8, and OB-9 during the first week of the long term flow test.

10. Perform a pressure-temperature-spinner survey on wells OB-6, OB-8, and OB-9 during the last week of the long term flow test.

11. Monitor and record flow test data on wells OB-6 and OB-9 (wellhead pressure, line pressure, James tube pressure, and water level).

12. Monitor and record injection data on wells OB-8 (wellhead pressure, line temperature, differential pressure on an orifice plate between pump and wellhead). Collect at least two samples of injectate for complete brine analysis.

Equipment:

Listed below are the major pieces of equipment required. We understand that additional engineering and design will be required in order to finalize this equipment list:

1. Two atmospheric separators (existing at site)

2. Two 8" (nominal) James tubes. Both James tubes should be equipped with a 1/4" diameter hole at a center distance of 1/4" from end of tube. End of tube should be cut square and deburred but not beveled. (This is important to follow exactly). Each equipped with pressure gauge.

3. Two 10" nominal flow lines with flow elbow to connect to wellhead and the appropriate capacity for chemical inhibitor injection. One additional to what already exists with appropriate temperature, pressure and sampling ports and temperature and pressure gauges.

4. Two 61 cm square notch weir boxes, one addition to what already exists.

5. Piping for the discharge from the weir box at OB-6 and/or OB-9 to OB-8 and/or the river.

6. Injection pump and generator capable of injecting either:
   i. 322 ton/hr at 35 bar,g, or
   ii. 562 ton/hr at 52.5 bar,g

7. A pressure-temperature-spinner survey tool. A spinner tool will need to be obtained and tested. Field personnel may need training in its operation.

8. Calibration should be performed on the existing temperature tool. The temperatures measured during the short term tests were systematically 9 deg C lower temperature than previous measurements. Either the old survey tool was reading temperatures too high, the new tool is 9 deg C too low, or the field has perhaps cooled. Calibration will remove one variable for this uncertainty.

9. Five downhole capillary tube setups with surface electronic data loggers to monitor downhole pressures at approximately 900 meters depth. Before purchase (or rental) of this equipment, an engineering decision will need to be made whether it is practical to having capillary tubing this deep in the flowing wells as they are large flow rates

10. Two downhole scale inhibitor infusion systems that can deliver below 300 meters below the wellhead.

11. Two phase sampling separator, condensers, sample bottles for steam and brine, field gas/steam and brine measuring equipment and other sampling equipment as used for the short term flow tests.

Please let us know if you have any questions or comments.