Technical Risk Assessment

Discipline:	EGS Energy Geothermal Drilling Operations	**Risk Assessment Ref:**	MDC/EGS/EP/RA-001
Assessment Team:	Richard Sands, James Sands, John Bateman and Philip Silk	**Date of Assessment:**	12/09/2013

Activity/Element	Potential Hazards	Preliminary L	Preliminary C	Preliminary R	Action to be Taken to Control and Mitigate Risk	Residual L	Residual C	Residual R	Residual Risks	Comments
Planning	Rig unsuitable for well construction. Wellhead design. Casing Design. Drill string design. Unsuitable downhole equipment from service providers. Directional profile leads to high torque and drag and compromising reaching well TD. Casing wear due to extended rotating through the casing leading to well barrier issues. Poor hole condition and geometry. Unsuitable mud systems. Unsuitable cement slurries. Incorrect bit choice and bit drive system reducing performance. Poor performance whilst drilling 26" / 24" hole. High cost over run.	4	4	16	Full rig specification derived for hoisting, rotation and pumping capabilities based on torque and drag and hydraulics modelling. Consider contingencies including turbines and diamond / matrix bits and sensitivities on rotational and drag friction coefficients. Model the well for drilling, hydraulic fracturing and production operations and confirm wellhead loads with manufacturer. Model the well for drilling, hydraulic fracturing and production operations and confirm casing fit for purpose. Utilise torque and drag modelling to confirm drill string specification. Include sensitivities on rotational and drag friction coefficients. Specify downhole tool operating conditions and pre qualify service providers to tender (specifically temperature). Create the smoothest directional profile with the lowest dog legs. Consider tools which will achieve this in practice e.g. rotary steerable systems. Develop a casing wear monitoring policy. Consider casing wear reduction accessories e.g. drill pipe rotating / non rotating centralisers. Ensure drill pipe hard banding is smooth. Utilise drill string tools to maintain hole gauge and profile e.g. roller reamers. Plan for high temperature application (model additional temperature increase due to extended circulation). Plan for friction reducers. Plan for high temperature application. Perform study and ensure suitable bits and drive systems available and planned contingencies e.g. motors, turbines. Consider drilling 26" / 24" hole prior to main rig arrival utilising air drilling, reverse circulation drilling etc. Well cost defined by drilling rate of penetration, bit longevity and rig tripping speeds. Scrutiny of offset wells and rig performance is essential.	2	4	8		
Mobilisation	Personnel onsite unaware of procedures and hazards. Injury to personnel/equipment. 3rd Party equipment arrival not in timely manner and unsuitable to lift. Insufficient lifting capability for rigging up. General traffic movement leading to accidents. Parking outside site leading to congestion or accidents. Traffic control to site. Site congestion. Personnel falling off trailers whilst unloading. Open cellar leading to people falling in. Control of access into and out of the site. Access to tourist attraction along same route. Public Right of Way across site entrance. Noise and light issues. Vehicles running out of hours and requiring to stop onsite. Site design and suitability. Insufficient safety equipment. SIMOPS. Shortfall in rig acceptance audit. Rig has not yet been determined and it's requirements therefore not understood.	4	4	16	All personnel to be inducted prior to commencing work onsite. All operations to be covered in a pre spud, capturing all crews. Correct slinging procedures in place. Lifts planned by AP and directed by slinger/signaller. Keep clear of tag lines when in use. Tools correct for application. All personnel to be made aware of ongoing operations. Relevant lifting certificates to be supplied by 3rd party. Move plan/schedule to be produced by rig contractor. Plan lifts into rig-up logistics. Banksman to direct vehicles. Designated parking area. Site layout to be agreed prior to rig move. Traffic movement onto wellsite to be controlled by site security, gate to be kept closed and only authorised personnel allowed access. Equipment to be unloaded with cranes and telehandler. If access to trailer is required, it is to be reviewed by Site Supervisor. Traffic Management Plan to be distributed to all service companies and reguarly reviewed. Security to manage and control access to and from the wellsite 24 hours a day. Clear segregation of PROW and Eden Project entrance when accessing entrance. Drivers to be made aware of PROW in TMP. Coordinate with Eden Project over peak periods. Grating to be installed over cellar. Designated holding areas to be identified prior to rig mobilisation and incorporated into TMP. Drivers to plan deliveries and avoid arriving on site out of hours. Identify a holding area nearby for their use. Site professionally designed and constrcted by comptent contractors. Details of ground loadings to be provided on completion of construction. Well handover process between construction contractor and drilling management team. Understand rig requirements and base on worst case scenario. Suitable welfare facilities to be provided for site personnel from commencement of operations. Continous environmental monitoring throughout. Liaison committee in place and a point of contact with project team. Agree scope of rig acceptance audit prior to commencement. Competent personnel completing audit. Rig visit and audit completed. Downtime records reviewed. Wellsite Supervisor to be onsite during the drilling rig mobilisation. Wellsite Supevisor to oversee and control all service company operations when the rig is onsite. No other wells onsite. PTW and PTRA in place for any SIMOPS. Suitable safety equipment to be provided for proposed operations. Defined in BSOR document. Information and handover meetings between all stakeholders. BSOR document including emergency procedures. Drinking water fountains to be placed as required. Legionalla assessment of all site units. Rig crew accomodation offsite (provided by rig contractor). Laundry facilities to be provided. Logistics plan.	2	4	8	Risks remain but mitigated.	Continual review of the logistics plan to confirm suitability and effectiveness.

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Auger 36" Surface Hole to 18 metres through Peat and unconsolidated Granite	Unable to drill through granite with auger. Verticality of wellbore. Drilling into local aquifer. Access over cellar. Limited information on near surface geology. Slow penetration rates. Hole collapse if unconsolidated. Auger becoming stuck in granite. Heat generated due to friction - circulating system required. Unable to reach TD with auger. Construction waste - brownfield site.	3	4	12	40" conductor to be installed during construction of cellar, will help with verticality and centralisation. Conductor to have fins installed and cemented into cellar base to prevent movement. Only WBM to be used. Monitor for losses to formation and ensure LCM available. Review of offset wells and any geotechnical boreholes drilled on the site. Understand requirements and ensure sufficient facilities available for setting up over cellar. Ensure rig has capability of circulating. Require additional information to be supplied by operator to understand near surface geology better. Once information received, review whether auguring is the most suitable methodology for the proposed objective. Backfill cellar if required for rig to sit over well. Site waste management plan.	2	3	6		
Run and install 30" conductor casing and cement to surface	Verticality of borehole. Potential for hole collapse preventing casing being run to bottom. If casing is run with rig - is it able to handle 30" casing and centralisers. Loss of cement to formation. No cement returns to surface. Handling of casing - lifting and RIH. Cement equipment and incompatibility with third parties if used. Lifting operations. Dropped objects. Vehicle movements around wellsite. Hot works. Casing floating and not able to be run to bottom. 50cm top up as per programme. Concrete not pumped to bottom. Inconsistent cement job.	4	4	16	Conduct verticality survey before running casing. Perform wiper trip prior to running casing. Rig yet to be determined and must be reviewed to assess its capabilities. Pump excess cement. Try to cure any losses prior to cementing. Consider running casing in dry hole. If significant losses to formation use bentonite pellets and pea gravel to isolate loss zones, before pumping cement on top. Cement basket installed on casing. Pre-operations discussions with contractor to plan operations. Lifting operations planned by AP. Certified lifting equipment to be used. Site logistics plan. Coded welders for making up casing. Sufficient facilities for welding. PTW system. Correct PPE for task being performed. Ability to wash casing down. Ability to fill casing whilst running. Sufficient access for height of casing to fill. Potential weak point in cement. Aim to pump in one with returns to surface. Consider use of grout rather than concrete. Use tremmie pipe to ensure cement is on bottom and chase up the outside of the casing. Ability to perform top up job - important to ensure cement is to surface on this section. Allow sufficient time between conductor and main rig operations to complete any remediation works on the well and site	2	3	6		
Drilling and installation of rathole and mousehole	Drilling fluid leakage into the environment. Starting to drill rathole and mousehole through concrete. Incorrect placement of rathole and mousehole during construction. Rig requirements not understood yet.	3	3	9	Ensure rathole and mousehole sock are leak free – no holes below ground level in the socks. Grout the holes to prevent loss of drilling fluids. Allow sufficient time for cement to cure. Water based fluids to be used when drilling mousehole and rathole. Leak test rathole and mousehole and cellar with water prior to commencing operations. Rig requirements to be understood prior to constructing site. Re-bar to be left out of sections for mousehole/rathole. Mousehole/rathole to be drilled by rig contractor if required.	2	1	2		

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Installation of Diverter	Injury whilst installing diverter. Damage to flange. Incompatible fittings. Spaceout under rig substructure. Orientation of diverter. Fouling of diverter with rig substructure. Diverter equipment not available. Confusion over diverter line position. Potential for diverter to kick/move. Dropped objects. Confined space. Rig koomey system unable to close diverter. Annular or valve not functional.	4	4	16	Correct slinging procedures. Keep clear of tag lines when in use. Certified lifting equipment. Specification reviewed during planning and design phase and detailed on load out list. Ensure flange is covered until last moment before installation. Diverter line to be secured. Defined location for diverter outlet detailed on site plan. Details specified in drilling program. Tie equipment off when working at height or over the well. PTW and confined space procedures. Check closing volume requirements for annular and valve with drilling contractor. Correct certification and function test prior to delivery to site.	1	3	3		
Drill 24" hole section to 300m through Granite	Inadequate well control. Hole instability. Losses whilst drilling unconsolidated granite. Poor cement job on 30" casing. 30" barrier leaking. Inadequate site supervision. Poor hole condition. Shallow gas. Hole verticality. Faults/fractures. Leaking well barriers - diverter system. Drill bits and associated equipment. Unsuitable service providers. Stuck pipe. Failure of critical equipment. NORMS. Waste disposal. Noise. Lighting. Groundwater contamination. Rig capabilities. Insufficient muds and additives. Extended time to complete operations with an unsuitable drilling unit.	4	4	16	Installation of diverter whilst drilling this section. Selection of suitable diverter. Stab in valve and crossover available on rig floor. Mud system monitored for losses. Mud system with hydrostatic overbalance. Industry best practice for tripping procedures. Mud engineer onsite 24 hrs. Offset well data reviewed. Ensure sufficient LCM material available on site. Water storage available onsite. Weighting agent to be availble on site. Pressure test casing and perform circulation test after drilling out shoe - monitor for losses. IWCF Site Supervisor with onshore experience. IWCF certificate to be held by Toolpusher and Driller. Maintain suitable mud system throughout section. Use of centrifuges as appropiate. Follow relevant industry standards for zoning and procedures. Ex equipment within zoned areas. Continous gas monitoring. Mud loggers onsite 24 hours. Working BA and escape sets available onsite. Emergency response procedures documented. Fire water tank. Regular surveys to be undertaken. Ensure provision is made for running surveys - sandline. Use of roller reamers. Pressure test diverter prior to commencing operations and casing. Drill bit and equipment optimisation to suit required well objectives. Pre-qualification of service providers and tender process. Suitable BHA design. Rig to have capability for sufficient overpull. Fishing equipment available. Sufficient cricital spares to be kept onsite. NORM's to be monitored. Services to be provided by specialist contractor. Use of licenced waste carriers. Site Waste Management Plan. Environmental Management Plan - reguarly reviewed and audited. Water based drilling fluids to be used. Ensure rig selection takes into consideration the sizes of equipment to be handled and run. Early discussions with contractors required. Load out list to include sufficent contingency of muds and additives. Consider using a dedicated rig to drill the 24" hole and run the 20" casing.	1	4	4		

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Run and install 20" casing and cement to surface	Well control. Surging formation leading to fluid losses. Handling equipment and procedures. Running practices. Verticality of borehole. Potential for hole collapse preventing casing being run to bottom. If casing is run with rig - is it able to handle 20" casing and centralisers. Sufficient room on rig floor for handling equipment. Loss of cement to formation. No cement returns to surface. Handling of casing - lifting and RIH. Cement equipment and incompatibility with third parties. Lifting operations. Dropped objects. Vehicle movements around wellsite. Hot works. Casing floating and not able to be run to bottom. Casing unable to be run to bottom. Casing held up off bottom. Incompatible working practices between rig contractor and Operator. Making up casing. Casing body or threads out of spec. Unable to space out with full joints. Inability to breakout and layout casing. Casing at surface set at wrong height (short) for planned stack up. Inadequate rathole below casing. Failure of non-return valve to open. Pack off in annulus whilst displacing slurry, leading to formation breakdown. Cement channelling. Failure of cement mixing equipment. Leak during casing pressure test.	4	4	16	Best practice procedures used when running casing. Swab and surge calculations to define acceptable running speeds. Suitable handling equipment to be available for running casing - discussions during pre-planning phase and specified in drilling program Monitor for fluid losses. Cement basket on casing. Consider use of stag cementing tool or inflatable packer (ESP). Ability to perform top up job - important to ensure cement is to surface on this section. Pump excess cement. Pre-operations discussions with contractor to plan operations. Lifting operations planned by AP. Certified lifting equipment to be used. Site logistics plan. Correct PPE for task being performed. Conduct verticality survey before running casing. Ability to wash casing down. Ability to rotate casing down. Requirement for longer bail arms to allow casing to be washed down. Perform wiper trip prior to running casing. Good hole cleaning prior to running casing. Ability to fill casing whilst running. Understand Rig contractors policies for running casing Tubular Running Services contractor required for making up casing Spare casing to be available onsite. Casing pup joints available for space out. Manufactured to API 5CT. Casing inspection performed. Correct length landing joint available. Casing tongs suitable size for operations. Planned in advance and stack up included in drilling program. Function test non-return valve prior to running. Tag bottom with casing and pull back leaving sufficient rat hole. Cement service provider also provides stab in stinger. Competent service provider and personnel. Slurry design by competent contractor. Pressure test temporary lines prior to operations commencing to mitigaten failure of equipment under pressure. Pressure test casing after BOP installation Mobilise packer to trace casing leak. Run CBL logs to confirm acceptability of cement jobs.	1	4	4		
BOP Installation	Injury whilst installing BOPs. Damage to flange. Incompatible fittings. Spaceout under rig substructure. Orientation of BOP's. Fouling of control lines and outlets etc. Dropped objects. Confined space.	4	3	12	Correct slinging procedures in place. Keep clear of tag lines when in use. Tools tied off and correct for application. Certified lifting equipment and competent personnel. Ensure wellhead flange is covered until last moment before installation. Specifications reviewed during planning phase and detailed on load-out list. Tie equipment off when working at height or over the well. PTW and confined space procedures.	1	3	3		

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BOP Pressure Testing	Failure of BOP/testing equipment resulting in injury. Failure of BOP test. Incorrect or no test tool. Koomey unit insufficient capacity to activate BOPS.	4	3	12	Barriers in place. Personnel stay clear of charged lines and BOP area whilst test is carried out. Whip checks installed on high pressure lines. All connections and hoses checked for integrity prior to use. All connection bolts etc, checked for correct torque and correct sizes. Spare rams and rubbers to be available. Spare seals to be checked. Rig contractor to review BOP specifications and ensure Koomey unit is sufficient. BOP's to be pressure tested offsite and delivered with certification.	1	2	2		
Drill out cement shoe and new formation, conduct FIT	Insufficient formation integrity. Poor cement at casing shoe.	3	3	9	Offset data to be reviewed. Small pressure test pump with accurate pressure measurement. FIT procedure to be followed. Perform circulation test after drilling out shoe - monitor for losses. Squeeze cement job planned in advance.	2	2	4		
Drill 17 1/2" hole to 1,400m through Granite	Inadequate well control. Hole instability. Losses. Poor cement job on 20" casing. 20" barrier leaking. Inadequate site supervision. Poor hole condition. Shallow gas. Hole verticality. Faults/fractures. Leaking well barriers - BOP system. Drill bits and associated equipment. Unsuitable service providers. Stuck pipe. Failure of critical equipment. NORMS. Waste disposal. Noise. Lighting. Groundwater contamination. Rig capabilities. Failed FIT. Poor drilling performance. Insufficient muds and additives available.	4	4	16	Installation of BOPs whilst drilling this section. Mud system monitored for losses. Mud system with hydrostatic overbalance. Industry best practice for tripping procedures. Mud engineer onsite 24 hrs. Offset well data reviewed. Ensure sufficient LCM material available on site. Water storage available onsite. Weighting agent to be available on site. Pressure test casing and perform circulation test after drilling out shoe - monitor for losses. IWCF Site Supervisor with onshore experience. IWCF certificate to be held by Toolpusher and Driller. Maintain suitable mud system throughout section. Use of centrifuges as appropriate. Follow relevant industry standards for zoning and procedures. Ex equipment within zoned areas. Continuous gas monitoring. Mud loggers onsite 24 hours. Working BA and escape sets available onsite. Emergency response procedures documented. Fire water tank. Regular surveys to be undertaken. Ensure provision is made for running surveys - sandline. Use of roller reamers to assist with hole condition. Pressure test BOPs prior to commencing operations. Drill bit and equipment optimisation to suit required well objectives. Pre-qualification of service providers and tender process. Suitable BHA design. Rig to have capability for sufficient overpull. Fishing equipment available. Sufficient critical spares to be kept onsite. NORM's to be monitored. Services to be provided by specialist contractor. Use of licenced waste carriers. Site Waste Management Plan. Environmental Management Plan - regularly reviewed and audited. Water based drilling fluids to be used. Ensure rig selection takes into consideration the sizes of equipment to be handled and run. Early discussions with contractors required. Load out list to include sufficient contingency of muds and additives.	2	4	8		

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Run electric line logs	Well control. Logging tools not reaching TD. Tools stuck in hole or lost. Breakdown of wireline equipment. Housekeeping. Slips,trips and falls. Compatability of equipment between contractors.	4	4	16	Well control procedure. Wire cutters to be availble on rig floor. Maintaining good hole condition. Wiper trip prior to logging. Consider using LWD. Fishing equipment availble onsite. Pre-qualification and tendering process to select competent contractor. Back up equipment to be available. Clear rig floor of excess equipment prior to commencing logging operations. Discussions during pre-planning stage to identify contractors requirements.	2	4	8		
Run and install 13 3/8" casing and cement to surface	Well control. Surging formation leading to fluid losses. Handling equipment and procedures. Running practices. Verticality of borehole. Potential for hole collapse preventing casing being run to bottom. If casing is run with rig - is it able to handle 13 3/8" casing and centralisers. Sufficient room on rig floor for handling equipment. Loss of cement to formation. No cement returns to surface. Handling of casing - lifting and RIH. Cement equipment and incompatibility with third parties. Lifting operations. Dropped objects. Vehicle movements around wellsite. Hot works. Casing unable to be run to bottom. Casing held up off bottom. Incompatible working practices between rig contractor and Operator. Making up casing. Casing body or threads out of spec. Unable to space out with full joints. Inability to breakout and layout casing. Casing at surface set with coupling at wrong position for wellhead. Sufficient rathole left below casing. Failure of non-return valve to open. Incompatibility of cement head. Cement plugs incompatible with cement head. Pack off in annulus whilst displacing slurry, leading to formation breakdown. Cement channelling. Failure of cementing equipment. Failure to bump plug. Leak during casing pressure test.	4	4	16	Best practice procedures used when running casing. Swab and surge calculations to define acceptable running speeds. Suitable handling equipment to be available for running casing - discussions during pre-planning phase and specified in drilling program. PTW system. Monitor for fluid losses. Cement basket on casing. Consider use of stag cementing tool or inflatable packer (ESP) Ability to perform top up job - important to ensure cement is to surface on this section. Pump excess cement. Pre-operations discussions with contractor to plan operations. Lifting operations planned by AP. Certified lifting equipment to be used. Site logistics plan. Correct PPE for task being performed. Conduct verticality survey before running casing. Ability to wash casing down. Ability to rotate casing down. Requirement for longer bail arms to allow casing to be washed down. Perform wiper trip prior to running casing. Good hole cleaning prior to running casing. Ability to fill casing whilst running. Understand Rig contractors policies for running casing. Tubular Running Services contractor required for making up casing. Spare casing to be available onsite. Casing pup joints available for space out. Manufactured to API 5CT. Casing inspection performed. Correct length landing joint available. Casing tongs suitable size for operations, including removing a coupling. Planned in advance and stack up included in drilling program. Function test non-return valve prior to running. Tag bottom with casing and pull back leaving sufficient rat hole. Cement service provider also provides cement plugs. Competent service provider and personnel. Slurry design by competent contractor. Pressure test temporary lines prior to operations commencing to mitigate failure of equipment under pressure. Pressure test casing after BOP installation. Mobilise packer to trace casing leak. Run centraliser simulation. Reciprocate casing whilst cementing. Run CBL logs to confirm quality of cement jobs.	2	4	8		

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Drill 12 1/4" hole section vertically before kicking off around 2,000m. Drill to 4,000m through Granite	Inadequate well control. Hole instability. Losses. Poor cement job on 13 3/8" casing. 13 3/8" barrier leaking. Inadequate site supervision. Poor hole condition. Gas and explosive atmospheres. Hole angle. Faults/fractures. Leaking well barriers - BOPs. Drill bits and associated equipment. Unsuitable service providers. Stuck pipe. Failure of critical equipment. NORMS. Waste disposal. Noise. Lighting. Groundwater contamination. Rig capabilities. Failed FIT. Handling of MWD equipment. Kick off direction. Rate of build too high Steering difficulties. Unable to drill out plugs. Difficulty maintaining directional path. Rotating with stabilisers. Poor drilling performance. Insufficient mud's and additives available. Mud temperature	4	4	16	BOP system installed. Operating procedures in place. Site evacuation procedures in place. Monitor pit volumes at all times whilst hole is open. Mud system to have minimum 100 psi overbalance. Industry best practice for tripping procedures. Mud engineer onsite 24 hrs. Offset well data reviewed. Ensure sufficient LCM material available on site. Cement any major loss zones before continuing to drill ahead. Water storage available onsite. Weighting agent to be available on site. Pressure test casing and perform circulation test after drilling out shoe - monitor for losses. IWCF Site Supervisor with onshore experience. IWCF certificate to be held by Toolpusher and Driller. Maintain suitable mud system throughout hole section. Use of centrifuges as appropriate. Follow relevant industry standards for zoning and procedures. Ex equipment within zoned areas. Continuous gas monitoring. Mud loggers onsite 24 hours. Working BA and escape sets available onsite. Emergency response procedures documented. Fire water tank. Regular directional surveys to be undertaken. Use of roller reamer to improve hole condition. Pressure test BOPs and and casing prior to commencing operations. Drill bit and equipment optimisation to suit required well objectives. Pre-qualification of service providers and tender process. Suitable BHA design. Rig to have capability for sufficient overpull. Fishing equipment available. Sufficient critical spares to be kept onsite. NORM's to be monitored. Services to be provided by specialist contractor. Use of licenced waste carriers. Site Waste Management Plan. Environmental Management Plan - regularly reviewed and audited. Ensure rig selection takes into consideration the sizes of equipment to be handled and run. Early discussions with contractors required. Follow recommended parameters for drilling out shoe track. Mud weight, volume and drilling parameters to be controlled and monitored. Monitor hydraulics, run surge analysis. Motor assembly to be run. Consider rotary steerable assembly. Ensure sufficient flow and pumps adequate. Increase low end mud viscosity. Only essential personnel to be on the rig floor during operations. Rotate drill string (maximum allowable with bend in motor). Monitor torque and drag. Specialist service providers to run MWD and directional equipment. Directional equipment to be scribed and witnessed by three people before being run. Gyro survey to be run. Use non-rotating cement plugs Threadlock shoe track. Confirm mud system suitable for expected temperature.	2	4	8		

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Drill 8 1/2" hole section to 4,800 m	Inadequate well control. Hole instability. Losses. Poor cement job on 13 3/8" casing. 13 3/8" barrier leaking. Inadequate site supervision. Poor hole condition. Shallow gas. Hole angle. Faults/fractures. Leaking well barriers - BOP system. Drill bits and associated equipment. Unsuitable service providers. Stuck pipe. Failure of critical equipment. NORMS. Waste disposal. Noise. Lighting. Groundwater contamination. Rig capabilities. Failed FIT. Handling of MWD equipment. Maintaining hole trajectory. Steering difficulties. Drilling rathole out of 12 1/4" hole. Mud Temperature. Suitability of mud's. Tool failure. Rotating with stabilisers. Poor drilling performance. Insufficient mud's and additives available.	4	4	16	Installation of BOPs whilst drilling this section. Mud system monitored for losses. Mud system minimum 100 psi overbalance. Industry best practice for tripping procedures. Mud engineer onsite 24 hrs. Offset well data reviewed. Ensure sufficient LCM material available on site. Cement any major loss zones before continuing to drill ahead. Water storage available onsite. Weighting agent to be available on site. Pressure test casing and circulate for 1 hour after new formation drilled. IWCF Site Supervisor with onshore experience. IWCF certificate to be held by Toolpusher and Driller. Maintain suitable mud system throughout hole section. Use of centrifuges as appropriate. Follow relevant industry standards for zoning and procedures. Ex equipment within zoned areas. Continuous gas monitoring. Mud loggers onsite 24 hours. Working BA and escape sets available onsite. Emergency response procedures documented. Fire water tank. Regular directional surveys to be undertaken. Use of roller reamer to assist with hole condition. Pressure test BOPs and casing prior to commencing operations. Drill bit and equipment optimisation to suit required well objectives. Pre-qualification of service providers and tender process. Suitable BHA design. Rig to have capability for sufficient overpull. Fishing equipment available. Sufficient critical spares to be kept onsite. NORM's to be monitored. Services to be provided by specialist contractor. Use of licenced waste carriers. Site Waste Management Plan Environmental Management Plan - regularly reviewed and audited Ensure rig selection takes into consideration the sizes of equipment to be handled and run. Early discussions with contractors required. Mud weight, volume and drilling parameters to be controlled and monitored. Monitor hydraulics, run surge analysis. Motor assembly to be run. Ensure sufficient flow. Increase low end mud viscosity. Only essential personnel to be on the rig floor during operations. Rotate drill string (maximum allowable with bend in motor). Monitor torque and drag. Specialist service providers to run MWD and directional equipment. Run stabilising string in 12 1/4" hole section. PPE appropriate to working with boiling fluids. Review of mud programme to account for expected temperature. Downhole tool selection for elevated temperatures.	2	4	8		
Place a sand plug in the 8 1/2" hole section	Abrasion of equipment. Inaccuracy during placement.	4	3	12	Specific mixing equipment required. Proper planning required.	2	4	8		

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Activity/Element	Potential Hazards	Preliminary L	Preliminary C	Preliminary R	Action to be Taken to Control and Mitigate Risk	Residual L	Residual C	Residual R	Residual Risks	Comments
Run and install 9 5/8" casing to 4,000m and cement	Well control. Surging formation leading to fluid losses. Handling equipment and procedures. Running practices. Verticality of borehole. Potential for hole collapse preventing casing being run to bottom. If casing is run with rig - is it able to handle 9 5/8" casing and centralisers. Sufficient room on rig floor for handling equipment. Loss of cement to formation. Handling of casing - lifting and RIH. Cement equipment and incompatibility with third parties. Lifting operations. Dropped objects. Vehicle movements around wellsite. Casing unable to be run to bottom. Casing held up off bottom. Incompatible working practices between rig contractor and Operator. Making up casing. Casing body or threads out of spec. Unable to space out with full joints. Inability to breakout and layout casing. Insufficient rathole left below casing. Failure of non-return valve to open. Incompatibility of cement head. Cement plugs incompatible with cement head. Pack off in annulus whilst displacing slurry, leading to formation breakdown. Cement channelling. Failure of cementing equipment. Failure to bump plug. Leak during casing pressure test. Temperature reaction with cement.	4	4	16	Industry best practice procedures used when running casing. Swab and surge calculations to define acceptable running speeds. Suitable handling equipment to be available for running casing - discussions during pre-planning phase and specified in drilling program. PTW system. Monitor for fluid losses. Cement basket on casing. Consider use of staged cementing tool or inflatable packer (ESP) Pump excess cement. Pre-operations discussions with contractor to plan operations. Lifting operations planned by AP. Certified lifting equipment to be used. Site logistics plan. Correct PPE for task being performed. Ability to wash casing down. Ability to rotate casing down. Requirement for longer bail arms to allow casing to be washed down. Perform wiper trip prior to running casing. Good hole cleaning prior to running casing. Ability to fill casing whilst running. Understand Rig contractors policies for running casing. Tubular Running Services contractor required for making up casing. Spare casing to be available onsite. Casing pup joints available for space out. Manufactured to API 5CT. Casing inspection performed. Correct length landing joint available. Casing tongs suitable size for operations, including removing a coupling. Function test non-return valve prior to running. Tag bottom with casing and pull back leaving sufficient rat hole. Cement service provider also provides cement plugs. Competent service provider and personnel. Slurry design by competent contractor. Pressure test temporary lines prior to operations commencing to mitigation failure of equipment under pressure. Pressure test casing. Mobilise packer to trace casing leak. Run centraliser simulation. Reciprocate casing whilst cementing. Cement contractor to design cement job taking account of high temperatures. Run CBL logs to confirm quality of cement jobs. Ensure cement plugs suitable for expected temperatures.	2	4	8	Contingencies in place.	
Drill out cement shoe and clean out sand to bottom	Mud cleaning system unable to maintain suitable mud conditions. Blinding shaker screens. Abrasion of circulating lines and tanks. Unable to drill out plugs.	4	3	12	Run centrifuges to remove sand. Controlled drilling parameters. Controlled circulating rates. Inspection of all pipework, tanks and pumps prior to any further work. Inspect equipment daily to identify any deterioration. Use non rotating plugs. Threadlock shoetrack.	2	3	6		

Technical Risk Assessment

Discipline:	EGS Energy Geothermal Drilling Operations	**Risk Assessment Ref:**	MDC/EGS/EP/RA-001
Assessment Team:	Richard Sands, James Sands, John Bateman and Philip Silk	**Date of Assessment:**	12/09/2013

Activity/Element	Potential Hazards	Preliminary L	C	R	Action to be Taken to Control and Mitigate Risk	Residual L	C	R	Residual Risks	Comments
Run 7" slotted liner to TD	Well control. Surging formation leading to fluid losses. Handling equipment and procedures. Running practices. Fluid loss whilst running casing. Potential for hole collapse preventing casing being run to bottom. If casing is run with rig - is it able to handle 7" liner and centralisers. Sufficient room on rig floor for handling equipment. Handling of casing - lifting and RIH. Lifting operations. Dropped objects. Vehicle movements around wellsite. Casing held up off bottom. Incompatible working practices between rig contractor and Operator. Making up casing. Casing body or threads out of spec. Unable to space out with full joints. Inability to breakout and layout casing.	4	4	16	Best practice procedures used when running liner. Special well control procedures. Swab and surge calculations to define acceptable running speeds. Suitable handling equipment to be available for running casing - discussions during pre-planning phase and specified in drilling program. Monitor for fluid losses. Pre-operations discussions with contractor to plan operations. Lifting operations planned by AP. Certified lifting equipment to be used. Site logistics plan. Correct PPE for task being performed. Ability to wash down. Ability to rotate liner down. Perform wiper trip prior to running liner. Good hole cleaning prior to running liner. Understand Rig contractors policies for running liner. Tubular Running Services contractor required for making up liner. Spare casing to be available onsite. Casing pup joints available for space out. Manufactured to API 5CT. 10% casing inspection performed. Correct size liner hanger available. Casing tongs suitable size for operations including removing a coupling. Run centraliser simulation. Liner hanger equipment suitable for temperature.	2	4	8		
Clean out well and displace to brine	Incorrect crossovers from casing scrapers to drill pipe. Incorrect space out of casing scrapers. Dirty KCl brine. Casing scrapers not suitable for casing weights. Scraping of 7" liner.	4	3	12	Correct space out checked by Drilling Supervisor and Toolpusher. Consider running 2 rotary scrapers in the string. Careful selection of scrapers suitable for casing weights. Ensure sufficient brine onsite to ensure well is suspended with clean fluid. Ensure space out of scraper correct to prevent entering 7" liner.	1	3	3	Contingencies in place.	
Suspension	Tubing incompatible with tubing hanger. Inability to pressure test tubing hanger seals. Damage to wellhead and tubing hanger during rig down. Inability to make up tubing hanger to kill string due to no pin x pin pup joint. Inability to run assemblies or casing through wellhead components. Inability to pressure test BPV.	4	3	12	Confirm threads on both. Spare seals available for tubing hanger and tie down bolts. Wellhead engineering support available. Install debris cap on wellhead after BOP removal. Ensure correct thread pup joint is available. Drift hangers and seal assemblies with the casing drift. Spare seals available for BPV.	1	3	3		

Technical Risk Assessment

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Activity/Element	Potential Hazards	Preliminary L	C	R	Action to be Taken to Control and Mitigate Risk	Residual L	C	R	Residual Risks	Comments
Rig down and move off	Personnel onsite unaware of procedures and hazards. Injury to personnel/equipment. 3rd Party equipment departure not in timely manner and unsuitable to lift. Insufficient lifting capability for rigging up. General traffic movement leading to accidents. Parking outside site leading to congestion or accidents. Traffic control to site. Site congestion. Traffic movement through local area during rig up and drilling ops leading to accidents. Personnel falling off trailers whilst unloading. Open cellar leading to people falling in. Control of access into and out of the site. Access to tourist attraction along same route. Public Right of Way across site entrance. Noise and light issues. Vehicles running out of hours and requiring to stop onsite. Insufficient safety equipment. SIMOPS.	4	4	16	All personnel to be inducted prior to commencing work onsite. Correct slinging procedures in place. Lifts planned by AP and directed by slinger/signaller. Keep clear of tag lines when in use. Tools correct for application. All personnel to be made aware of ongoing operations. Relevant lifting certificates to be supplied by 3rd party. Move plan/schedule to be produced by rig contractor. Plan lifts into rig-up logistics. Banksman to direct vehicles. Designated parking area. Traffic movement onto wellsite to be controlled by site security, gate to be kept closed and only authorised personnel allowed access. Equipment to be loaded with cranes and telehandler. If access to trailer is required, it is to be reviewed by Site Supervisor. Traffic Management Plan to be distributed to all service companies and regularly reviewed. Security to manage and control access to and from the wellsite 24 hours a day. Clear segregation of PROW and Eden Project entrance when accessing entrance. Drivers to be made aware of PROW in TMP. Coordinate with Eden Project over peak periods. Grating to be installed over cellar. Designated holding areas to be identified prior to rig demobilisation and incorporated into TMP. Drivers to plan collections and avoid arriving on site out of hours. Identify a holding area nearby for their use. Suitable welfare facilities to be provided for site personnel from commencement of operations. Continuous environmental monitoring throughout. Liaison committee in place and point of contact with project team. Wellsite Supervisor to be onsite during the drilling rig mobilisation. Wellsite Supervisor to oversee and control all service company operations when the rig is onsite. PTW and PTRA in place for any SIMOPS. Suitable safety equipment to be provided for proposed operations. Defined in BSOR document. Information and handover meetings between all stakeholders.	2	4	8		
General	Inexperienced / poor competence of personnel on site. Noise / smell / light pollution upsetting local population. Unsuitably constructed site with poor ground loadings. Protestors accessing wellsite.	4	4	16	CVs sent out from all 3rd party companies involved in operations. Ensure all lighting towers are positioned in suitable locations and light is directed onto the site to minimise light pollution. Be aware of the causes of strong smells that may be produced during drilling and completion phases. Environmental Management Plan in place. Noise monitoring to be conducted. Induct all rig site personnel to stop behavioural noise such as shouting. Good communication with local population to inform them of drilling times and location. Monitoring of campaign websites and liaison with local police. Emergency response procedures documented.	2	3	6	Risk remains but mitigated.	