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# *MEMORANDUM*

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***Date:*** 20 May 2005

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***From:*** Jim Lovekin

***Subject:*** Well Test Plan for Meager Creek Wells

This memo summarizes the anticipated sequence of well test activity at Meager Creek. It updates the GeothermEx memo on the same subject dated 10 May, based on drilling progress, new temperature-pressure surveys, and new cost estimates for some elements of the testing program. As of 20 May, MC-8 is drilling 12-1/4-inch hole at 2,090 meters and is expected to reach a total depth of about 2,130 meters tomorrow, when the current bit run is complete. There have been some losses of circulation below 2,000 meters and mud losses are about 3 to 4 cubic meters per hour. MC-6 is now at essentially initial-state temperatures (260°C on bottom, based on a survey conducted on 17 May), having heated up since its initial drilling and injection testing in November 2004. MC-7 is probably close to initial-state temperatures, after heating up since its initial drilling and injection testing in February 2005; its last survey (15 May) showed a maximum temperature of 253°C.

Based on presently available data, MC-6 seems to be the most promising of the three wells, with high temperatures and indications of permeability at several depths below about 1,800 meters. MC-7 appears less permeable but is almost as hot as MC-6. MC-8 is an unknown quantity; even if it is presumed to be as good or better than MC-6, it will probably require some period of heating up after initial drilling before it can be fully assessed.

The work required to evaluate these wells can be divided into three levels of incremental cost beyond the reaching of total depth in MC-8. The first level consists of testing that can be accomplished without any further stimulation of MC-6 or MC-8, i.e., initiating flow of these wells by air-lifting using the air compressors already mobilized for drilling operations. The second level of testing would involve injection of water into MC-6 to assess improvement in permeability, as well as a second attempt to air-lift MC-8 after period of heating up. The third level of testing would involve acid stimulation of MC-6 and/or MC-8, followed by a further period of heating up and air-lifting. This level of testing would entail mobilization of considerable equipment for the acidizing, including a coiled tubing unit. The hope is that the second or third levels of testing will not be needed, but budgetary provisions must be made for them in advance to assure continuity of operations and thorough evaluation of the wells.

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Note that the testing levels described above are for scenarios involving two production wells and one injection well. An injection well must be available for any testing scenario. The scenarios herein consider MC-7 as the injector, but any other well can be substituted as injector with minimal impact on the budget, depending on which two wells look the most promising after the completion of MC-8.

Table 1 describes the sequence of testing operations in detail, including the criteria of success that would determine whether further testing is warranted. Table 2 presents a budget for the well testing, broken down by incremental expenditures at each level. Table 3 shows the cost elements that form the basis for the well testing budget, as updated by recent estimates.

**Level 1 Testing**

Since mid-May, several attempts have been made to initiate flow from MC-6 by using an air cap, i.e., by injecting air into the wellhead to depress the liquid level to the shoe of the 13-3/8-inch casing, then releasing the air and allowing the upper part of the liquid column to boil. The air cap released from MC-6 on 18 May induced steam flow for about half an hour with a small amount of water, but so far the technique has not resulted in sustained flow. The results to date confirm our impression that air caps are a bit of a long shot for wells on this pad, because of the deep liquid levels. Still, since air compressors and other necessary pieces of equipment are already on site, the incremental cost of air caps is minimal, and a few more attempts on MC-6 are probably worth trying.

Figure 1 shows a scenario of production testing for MC-6 and MC-8, assuming that production from both wells can be initiated by air-lifting, without further stimulation. Figure 2 shows the result of wellbore simulation for MC-6, which indicates that the well could sustain flow at wellhead pressures in the range of 6 to 11 bars, as long as a threshold rate of about 170 t/hr can be achieved. At lower flow rates (points to the left of the broad maximum on the deliverability curve), the well would have difficulty lifting liquid out of the hole, and steady flow would not be sustained. Option 1 for evaluating MC-6 presumes that flow can be initiated by air lifting with drill pipe after moving the rig over MC-6. Option 2 (not depicted in Figure 1) would include removing the 9-5/8-inch liner from MC-6 and then attempting another air lift through drill pipe.

The testing of MC-8 could begin with an injection test, similar to the testing of MC-7 in February 2005. MC-8 could then be air lifted using 2-7/8-inch “stiff” tubing (as opposed to coiled tubing) installed with a crane.

If either MC-6 or MC-8 are successfully lifted with air, they should be treated with calcite scale inhibitor downhole for the duration of a one-month production test. This would entail installing a capillary tube and a dispersion chamber inside stiff tubing. A seat on the bottom of the stiff tubing would act as a retainer for the dispersion chamber. It would be wise to avoid extended periods of flow without scale inhibitor (especially when stiff tubing is in the well), because

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significant amounts of calcite could accumulate in just a few weeks. The well testing budget (Tables 2 and 3) includes cost estimates of scale inhibitor equipment (tubing and pumps) for two wells, plus a one-month supply of inhibitor chemical.

**Level 2 Testing**

Figure 3 shows the scenario in which a second level of testing is required to initiate flow. This would include injecting into MC-6 at the highest possible sustained rates for approximately three weeks. To accomplish this injection testing, the water supply from the stream source should be enhanced (possibly by twinning the existing line) to allow higher sustained injection rates than have been possible in the past. Step-rate injection tests should be conducted at the start of the MC-6 injection period and repeated at 1½ weeks and at 3 weeks, in order to assess improvement in the well's permeability. Ideally, the injection rates would be high enough to produce a positive wellhead pressure. If this is not possible, then pressures during step-rate tests would need to be measured with a downhole Kuster tool or capillary tube. By the end of June, the degree of improvement indicated by step-rate injection tests would determine whether to begin another heat-up period for MC-6 (as shown in Figure 3), or to continue with water injection, or to plan for an acid job.

Simultaneous with injection testing at MC-6, MC-8 would be heating up after its initial drilling and injection testing. MC-8 should be ready for an air-lift through the already-installed stiff tubing after about one month. Figure 3 shows mobilization of the air compressors in mid-July.

If MC-7 has not been used for injection in Level 1 testing, Level 2 testing would include an air lift of MC-7 through 2-7/8-inch tubing. The string of tubing intended for MC-6 would be available for this test of MC-7 while MC-6 undergoes injection testing. The air-lifts on MC-7 should be repeated several times to allow the maximum amount of heating of the upper wellbore. If MC-7 demonstrates sustained flow, it could inject into MC-6, substituting for water from the stream source. If airlifting MC-7 does not succeed in initialing flow, the well would be stimulated with water from the stream source, in parallel with the injection testing of MC-6 (as depicted in Figure 3).

**Level 3 Testing**

Level 3 testing would consist of acidization of one or two wells. Figure 4 shows a scenario in which both MC-6 and MC-8 would be acidized in early July. In Figure 4, the schedule includes pulling the 9-5/8-inch liner from MC-6 as part of Level 1 testing. However, even if the 9-5/8-inch liner has not been pulled, the period of injection into MC-6 during Level 2 testing will have helped cool the well down into a feasible range for acid treatment. It should be noted that the cost estimate for acid jobs in Tables 2 and 3 has increased substantially from our memo of 10 May (from $500,000 to $1,415,000 for 2 wells), based on a quote from a prospective service company. The acid jobs are projected to entail injecting a combination of hydrochloric (HCl)

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and hydrofluoric (HF) acid, with a total acid volume of about 100,000 gallons per well. After the acid jobs (which take about 1 day each of actual pumping time), the wells would be allowed to heat up for about two weeks. During this time, MC-7 could be receiving injection water from the stream source to enhance its permeability (assuming it did not respond to the air lift). In mid-July, MC-6 and MC-8 would be lifted with air through stiff tubing and put on simultaneous flow tests (assuming adequate injection capacity into KS-7). These flow tests would be anticipated to be completed by mid-August 2005.

**Table 1. Meager Creek Well Testing Activity**

**Level 1 - Production Testing of MC-6 and/or MC-8 Initiated Without Further Stimulation.**

**Criteria of Success:**

**Production test of MC-6 and/or MC-8 completed by end of June 2005.**

Complete drilling of MC-8 to apx 2,130 meters (projected total depth reached by 21 May 2005)

Evaluation of MC-8 will begin with injection test after rig has moved to MC-6,
followed by installation of 2-7/8" tubing with crane, and air lift through 2-7/8" tubing.
In this scenario, MC-8 completes testing at about the same time as MC-6 (late June 2005).

Evaluation of MC-6 proceeds by 2 options, both involving use of drill rig on MC-6):

Option 1: Use rig just for air lift with drill pipe (presumed successful).
Shut well in after 48 hrs, leave 9-5/8" liner in hole, and release rig (left in place over MC-6).
Then install 2-7/8" tubing with crane and air lift through tubing to initiate 1-month flow test.

Option 2: If initial air lift with drill pipe is not successful, pull 9-5/8" liner.
Then re-attempt air lift through drill pipe. If successful, flow 48 hrs and release rig (left in place over MC-6).
Then install 2-7/8" tubing with crane and air lift through tubing to initiate 1-month flow test.

MC-7 is used for injection from flow tests of MC-6 and MC-8.
Note: This is a 2-producer / 1-injector program. Any well can be substituted as injector,
after deciding which 2 wells look most promising for testing after completion of MC-8.

**Level 2 - Injection Testing of MC-6 and Heat-up of MC-8.**

**Criteria of Success:**

**Improved permeability in MC-6 and/or flow test of MC-8 by end of July 2005.**

Level 2 testing begins with installation of additional piping from steam source to allow 3-week injection test into MC-6.
MC-6 injection will include step-rate tests and pressure fall-off at start, at 1.5 weeks, and at three weeks (late-June 2005).
This will provide indication of whether MC-6 should continue injection, start heat-up, or have acid stimulation (Level 3).
Figure 3 presumes that improvement is seen from injection, such that heat up starts at end of June,
and flow test starts in second week of July, using air lift through 2-7/8" tubing.
If air lift allows MC-6 to sustain self-flow for 1-2 days, stop test long enough to install inhibitor tube inside stiff tubing.
Air lift MC-6 again and continue with flow test through end of July 2005.

Air lift of MC-8 through 2-7/8" tubing starts about 8 July, using air compressors re-mobilized for this purpose.
If air lift allows MC-8 to sustain self-flow for 1-2 days, stop test long enough to install inhibitor tube inside stiff tubing.
Air lift MC-8 again and continue with flow test through end of July 2005.

During Level 2 testing, MC-7 continues heating up through early June.
MC-7 may be lifted with air using the string of 2-7/8" tubing that is intended for MC-6, but that will be
available while MC-6 is undergoing injection testing.
Figure 3 illustrates a scenario in which an air lift of MC-7 is unsuccessful.
In that case, MC-7 is then stimulated by injection of water from the stream source.
Improvement is gauged by periodic step-rate tests, and by pressure fall-off tests at the beginning and end of July.

**Level 3 - Acidization, Heat-up, and Production Testing of MC-6 and/or MC-8.**

**Criteria of Success:**

**Extended production tests of MC-6 and/or MC-8 by mid-August 2005.**

Level 3 testing begins with the mobilization of a coiled-tubing rig and acidizing equipment in early July.

2-7/8" tubing is pulled from both MC-6 and MC-8 with crane prior to acid jobs, to be re-installed after acid jobs.

Equipment and supplies should be in place to allow acid treatments of both MC-6 and MC-8.

Estimated acid volume per well: 100,000 gallons of HF / HCL mix, pumped through coiled tubing.

Spent acid and reaction productes are immediately circulated back with air through coiled tubing.

If air lifting with coiled tubing yields sustained flow, flow test continues for one month (through mid-August 2005).

Wells on extended test should be equipped with calcite scale inhibitor installed in 2-7/8" tubing.

If air lifting with coiled tubing does not yield sustained flow, air compressors and coiled-tubing are demobilized,

and well(s) are allowed to heat back up for two weeks.

T&P surveys are run after 2 weeks to assess whether wells have heated up.

Then stiff tubing is installed with crane in candidate(s) for flow testing, and air compressors are remobilized.

Production flow testing is initiated with air lift through stiff tubing equipped with calcite scale inhibitor.

Anticipated duration of flow test: one month for each well, to be completed by mid-August.

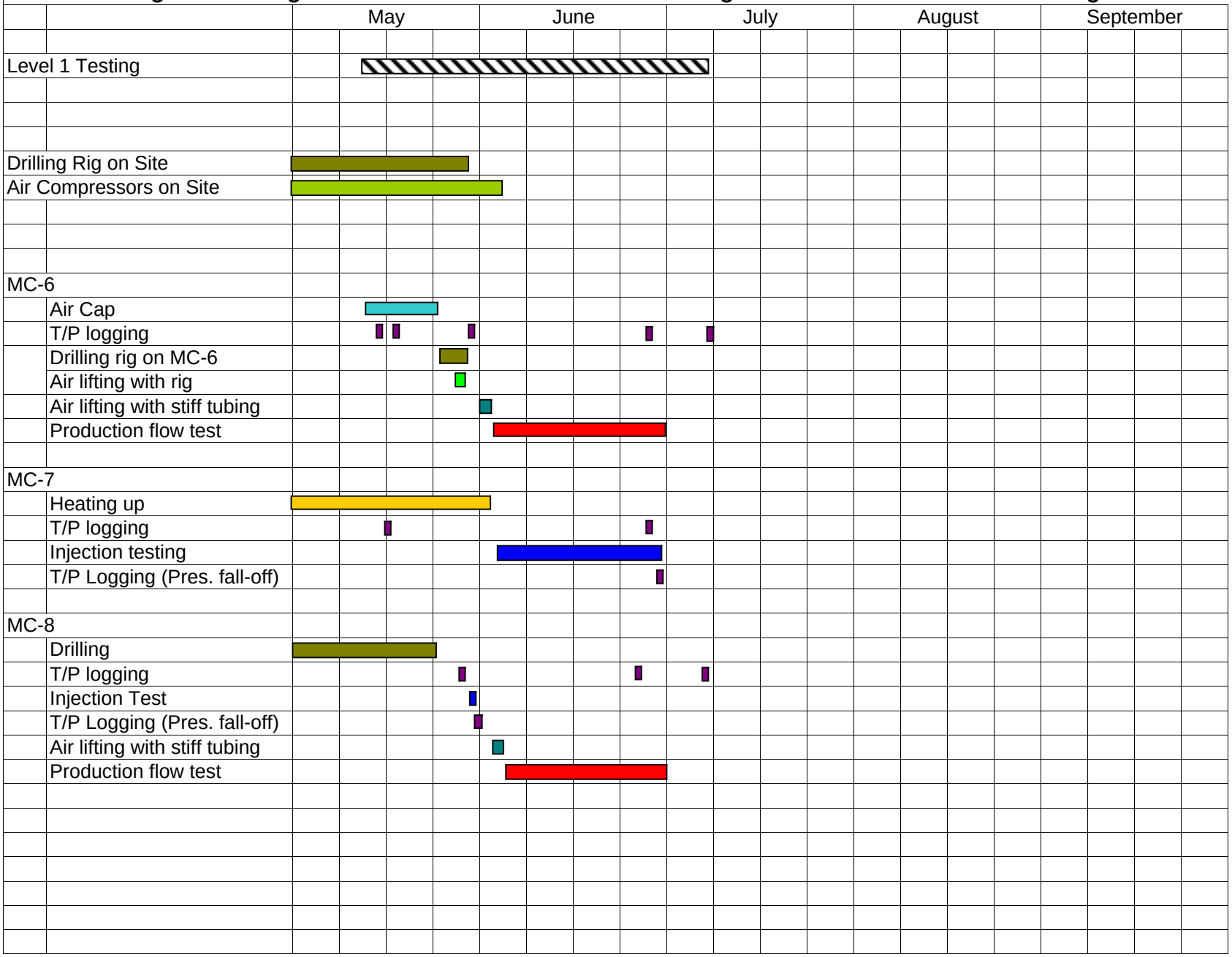
MC-6 and MC-8 may be tested simultaneously if there is adequate injection capacity in MC-7.

Otherwise, most promising well is tested first, and testing of second well is completed by mid-September.

| Table 2. Budget for Meager Creek Well Testing | | | |
|---|---|---|---|
| | Costs in Canadian Dollars | | |
| Base Costs (one-time costs incurred for any testing scenario) | | C$ 1000's | C$ 1000's |
| | Stiff tubing for 2 producers ($94K for 2 strings) | 94 | |
| | Capillary tubing to be installed inside stiff tubing for calcite scale inhibition - $20K/well | 40 | |
| | 1-month supply of calcite scale inhibitor chemical for flow tests of 2 wells | 4 | |
| | Geochem samples - 3 full suites for 2 wells, incl. sampling equipment & labor | 20 | |
| | Purchase wireline truck (Spicer) | 30 | |
| | Spinner logs for 2 producers and one injector (3 logs) | 10 | |
| | | | 198 |
| Level 1 Costs | | | |
| | Option 1: air lift MC-6 with rig, leaving 9-5/8" liner in hole (incl. camp thru end of May) | 375 | |
| | Option 2: pull 9-5/8" liner out of MC-6, followed by another air lift with rig | 1,074 | |
| | Camp & support for 1 month (June) after end of rig operations | 105 | |
| | T/P surveys: 12 surveys - see Figure 1 | 37 | |
| | Centrifugal pump: 1 month (June) | 4 | |
| | Subtotal Base Costs + Level 1 (Option 1) | | 719 |
| | Subtotal Base Costs + Level 1 (Option 2) | | 1,418 |
| Incremental Level 2 Costs | | | |
| | Camp & support for 1 month (July) | 105 | |
| | Incremental 10 T/P surveys - see Figure 3 | 30 | |
| | Air compressor: 1 mob/demob @ $30K (mid-July); 7 days @ $5K/day | 65 | |
| | Centrifugal pump: 1 month (July) | 4 | |
| | | | 204 |
| Incremental Level 3 Costs | | | |
| | Camp & support for 1 month (August) | 105 | |
| | Centrifugal pump: 1 month (August) | 4 | |
| | Acidization in mid-June: 2 jobs for $1,413K | 1,413 | |
| | Coiled tubing for acid jobs: 4 days (early July) @ 15K/day + $30K mob/demob | 90 | |
| | Air compressor: 1 mob/demob @ $30K in connection with acid job + 4 days @ $5K/day | 50 | |
| | Incremental 1 T/P survey - see Figure 4 | 3 | |
| | | | 1,665 |
| Total Costs Through Level 3 | | Option 1 | 2,588 |
| | | Option 2 | 3,287 |

| Table 3. Cost Elements for Meager Creek Well Testing | | | | | |
|---|---|---|---|---|---|
| Item | Testing Level (Base, 1, 2, or 3) | Purchase Price or Mob / Demob C$1,000s | Cost per Unit C$ | Number of Units | Probability of Success |
| "Stiff" tubing (2-7/8")<br>- as opposed to "coiled" tubing<br>- cost includes GST tax and trucking | Base | $94K for 2 strings (purchase) | 0 cost per day | 2 strings (MC-6 and -8) | High - for air lift & sheath for inhibitor tube |
| Inhibitor injection tube<br>- capillary with dispersion chamber<br>- estimated depth 1500 m<br>- cost includes inhibitor pump | Base | $20K per string (purchase) | 0 cost per day | 2 (MC-6 and -8) | High - for scale inhibition |
| Chemical inhibitor for calcite scale<br>- one-month supply incl. shipping | Base | $2K per well (purchase) | NA | 2 (MC-6 and -8) | High - for scale inhibition |
| Geochemical samples - 3 sets per well during 1-month flow test | Base | $10K per well (purchase) | NA | 2 (MC-6 and -8) | High - for analysis of reservoir fluid |
| Wireline truck | Base | $30K per truck (purchase) | NA | 1 | High - for conducting surveys |
| Spinner logs for 2 producers and one injector (3 logs) | Base | 0 (after purchase of truck) | $3K per well | 3 (MC-6, -7, and -8) | Medium - for identifying permeable zones |
| Drilling rig (Precision 620)<br>- Option 1: air lift of MC-6 with drill pipe, leaving liner in hole (air lift succeeds in initiating flow)<br>- Option 2: pull liner out of MC-6 after attempted air lift<br>- base rate for rig C$14,765/day | Level 1 | Option 1: $375K (mob $150K + 5 days at $45K/day); Option 2: $1,074.4K (all-in costs incl. mob, air lift, pulling liner & stacking rig) | $45K / day (all-in cost incl. camp) | Option 1: 5 days; Option 2: 10 days | Option 1: Medium - for initiating flow w/out pulling liner<br>Option 2: High - for initiating flow after pulling liner |
| Camp & support services<br>- in one-month increments<br>- based on C$3,500 / day | Levels 1, 2, & 3 | 0 | $105K / mo | 30 days | High |
| Wireline (Temperature & Pressure)<br>- Spicer memory tools | Levels 1, 2, & 3 | 0 (after purchase of truck) | $13,000 for 4 logs; $3,000 / log thereafter; ($3,000 / day) | depends on level of testing | High |
| Air Compressor<br>- incl. in rig cost for Level 1 | Levels 2 & 3 | $30K (mob/demob) | $5,000 / day incl. fuel | 1-week increments | High - for air-lifting wells |
| Centrifugal pump<br>- pumping water from source or from sump during injection tests | Levels 1, 2 & 3 | already on site | $3,500 / mo | 1 month in each Level | High |
| Acidizing Equipment and Supplies<br>- based on Sanjel quote 16 May 05 | Level 3 | incl. in job cost | 1 well: $774K<br>2 wells: $1,413 | 2 wells (MC-6 & MC-8) | Medium - for stimulating permeability |
| Coiled Tubing for Acidizing | Level 3 | $30K (mob/demob) | $15,000 / day | 1 week | High - for performing acid jobs |
| Steam Boiler - not used due to high fuel cost & low chance of success | Level 1 | $30K (mob/demob) | $15K / 2 wks + $22K / day for fuel | 2 weeks | Low - for heating upper wellbore |

## Figure 1: Meager Creek Well Test Schedule Assuming Production After Level 1 Testing



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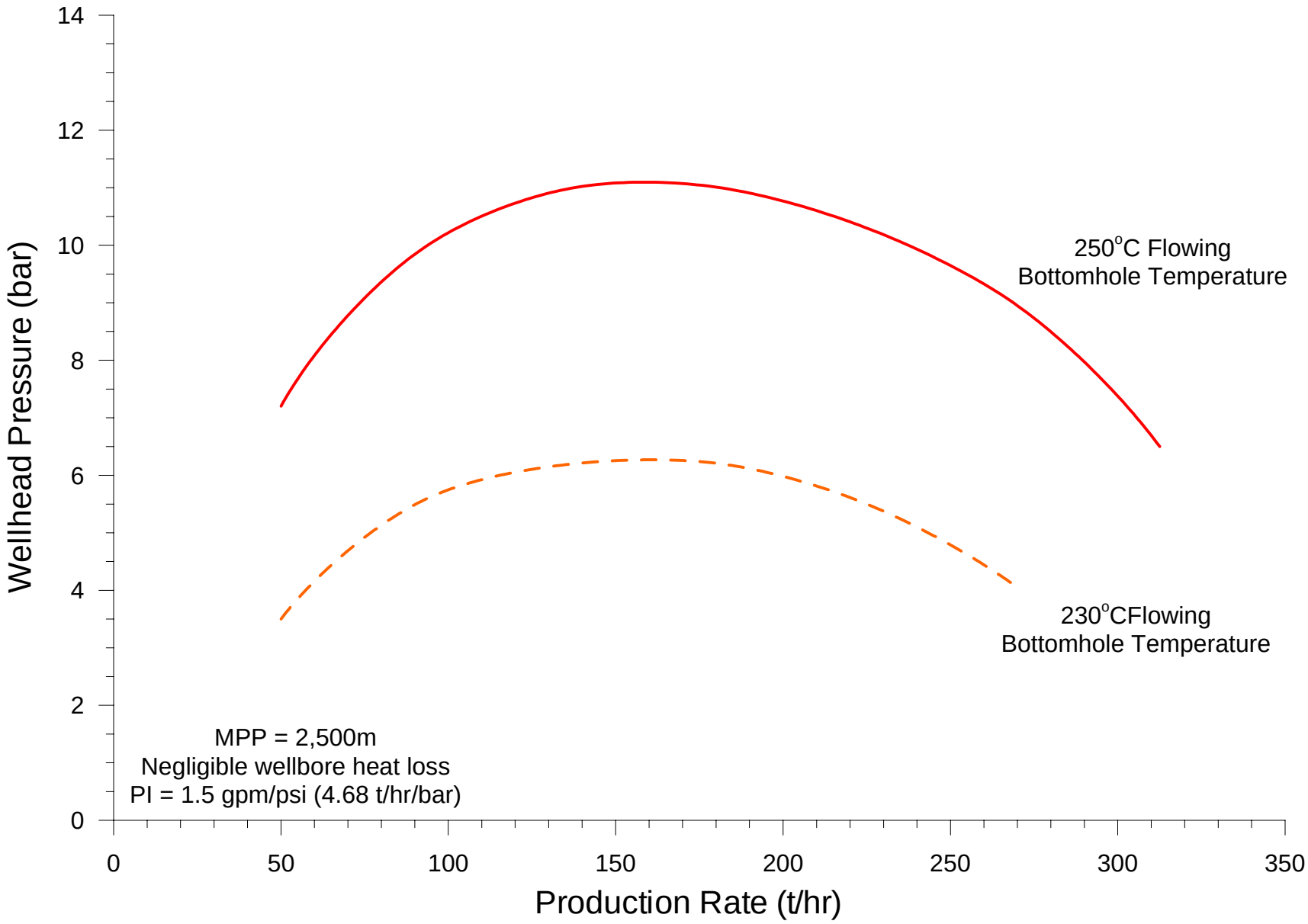
# Figure 2: Potential Production Capacity, Well MC-6

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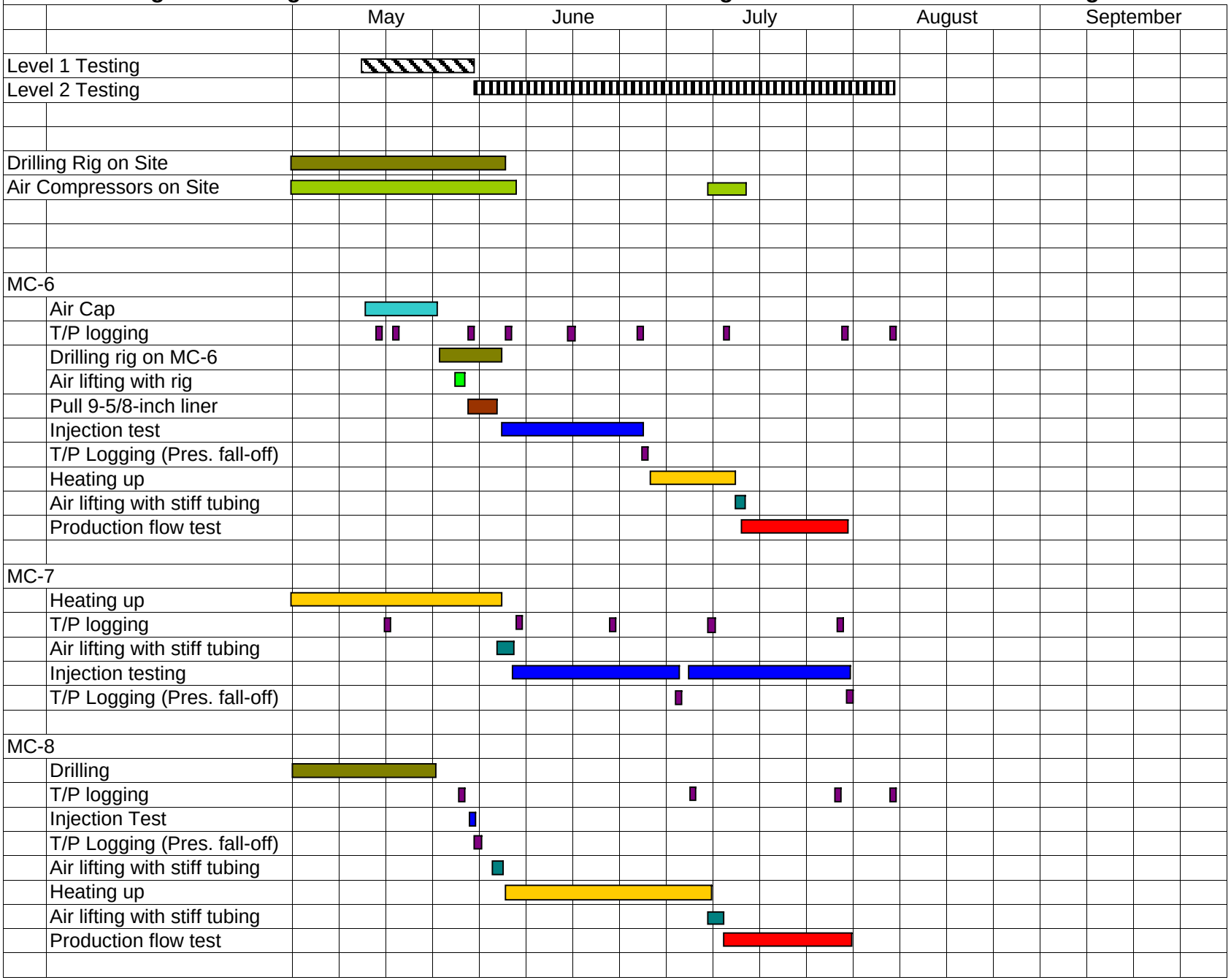
## Figure 3: Meager Creek Well Test Schedule Assuming Production After Level 2 Testing



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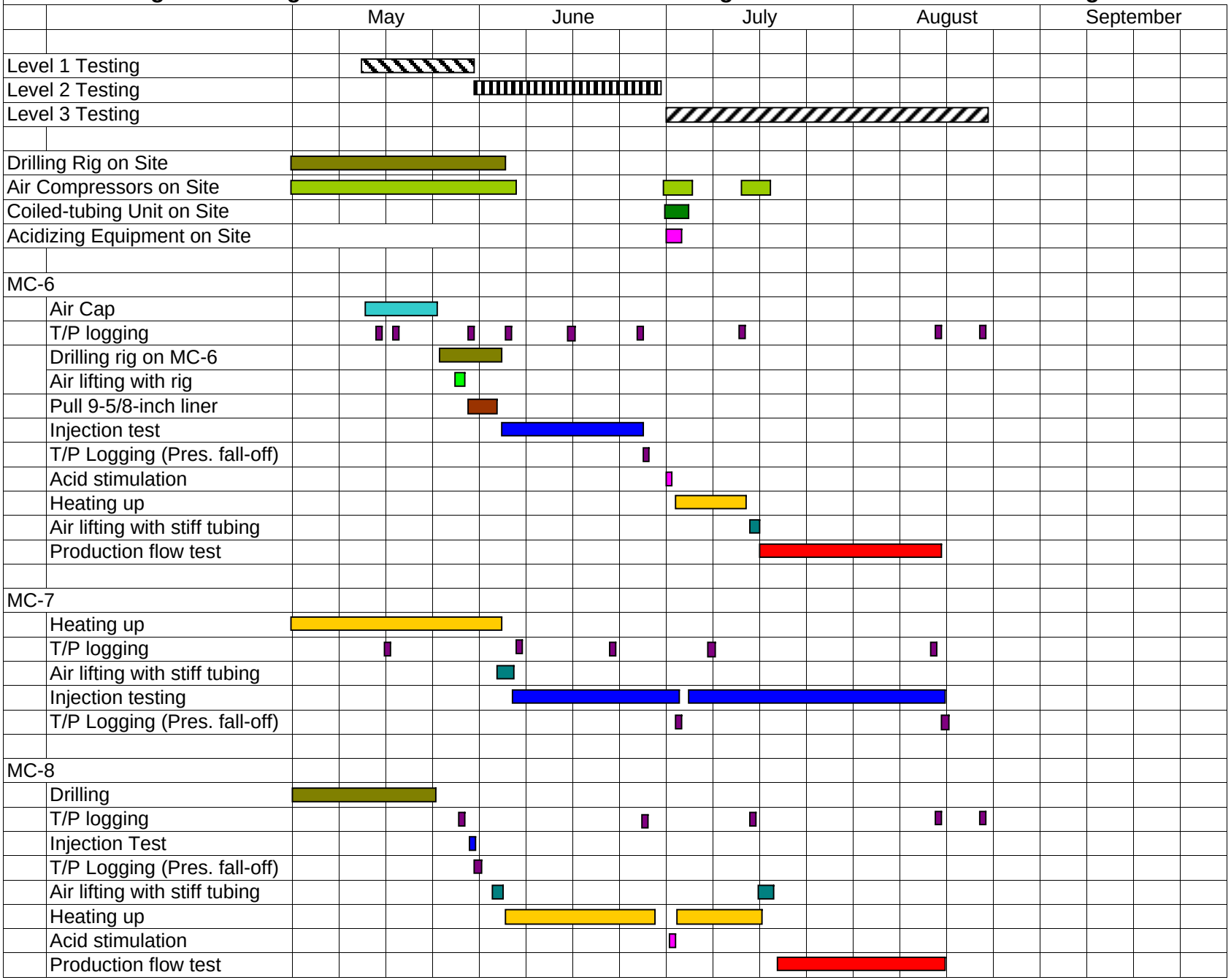
## Figure 4: Meager Creek Well Test Schedule Assuming Production After Level 3 Testing



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