INJECTION WELL PLUGGING PLAN
40 CFR 146.92(b)

PROJECT GOOSE LAKE

1.0 Facility Information

Facility name: Project Goose Lake

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[The information is Confidential Business Information per 5 U.S.C. § 552 (b)(4) and (b)(9).]

2.0 Planned Tests or Measures to Determine Bottom-Hole Reservoir Pressure

60-day notice will be provided prior to plugging operations. Adjustments to the plugging plan will be incorporated to meet guidance provided by the Underground Injection Control ("UIC") Program Director.

It is unlikely that a homogenous liquid will exist from the surface wellhead gauge down to the perforations. The homogenous liquid is required to accurately determine the downhole pressure at the perforations; a mixture of gas and super-critical phase CO_2 are not conducive to making accurate pressure calculations. Consequently, a wireline unit will deploy a tubing downhole pressure gauge with either surface read-out or recorded memory data, and the pressure at the perforations will be measured directly.

After determining the downhole pressure at perforations, the equivalent density of fluid to balance, this pressure will be calculated using the equation: Density = Pressure ÷ .052 ÷ TVD, where density is in pounds-per-gallon, pressure is psi, and TVD is feet.

A work fluid with the density calculated as above from the downhole pressure will be mixed from a freshwater base, with bentonite added for viscosity and barite added for weight. This fluid is robust at the expected temperatures and is compatible with common cement spacers and cements.

A work string likely consisting of 2-7/8 inch tubing will be run into the well using a workover rig. If the well has an existing tubing string with packer, the workover rig will make up a work joint to the existing tubing, pull tension to unseat the tubing hanger from the wellhead, and pull further tension to unseat the packer; if the packer has to be removed by milling, this can also be done with the work string. With the tubing work string in the hole or the existing tubing/packer unseated, the work fluid will be slowly pumped down the tubing towards the perforations. If fluid returns do not arrive back at surface, it may be necessary to add LCM (lost circulation material) to the work fluid to plug the formation porosity at the perforations until fluid returns do arrive at surface. Pumping rate will be low so that undue friction pressures are not exerted on the formation open at the perforations; the volume to be pumped will be on the order of 700 bbls.

3.0 Planned External Mechanical Integrity Test(s)

GCS will conduct at least one of the tests listed in Table 3.0-1 to verify external mechanical integrity prior to plugging the injection well as required by 40 CFR 146.92(a).

3.1 Procedures that will be followed for each type of test

At the end of injection activities, the (internal test) pressure test can be performed with the tubing in-place, still connected to the packer. [The information is Confidential Business Information per 5 U.S.C. § 552 (b)(9).] The other tests require that the tubing be pulled out of the way. The logs will be run inside the long string.

3.2 Gauges and/or other equipment

[The information is Confidential Business Information per 5 U.S.C. § 552 (b)(9).]

3.3 What constitutes a "pass" or "fail" for each test?

Cement bond log(s): significant (negative) deviation of the cement quality from the first cement bond logs run during well construction will provide an alert about this important external barrier between injection and underground sources of drinking water (USDW), but it is not necessarily a "fail". "Fail" will present itself if the subsequent acoustic log reveals moving fluids in the cemented space. "Pass" will be the result if the acoustic log does not detect fluid movement.

Pressure test and optional casing caliper log: "fail" if the long string if pressure does not hold at the applied test value, or if the caliper log reveals substantial corrosion/erosion which has decreased the wall thickness enough to likely result in a hole. "Pass" will be the opposite, a pressure test that holds steady, and a caliper log which does not reveal a condemning loss of wall thickness.

4.0 Information on Plugs

GCS will use the materials and methods noted in Table 4.0-1 to plug the injection well. The volume and depth of the plug or plugs will depend on the final geology and downhole conditions of the well as assessed during construction. The cement(s) formulated for plugging will be compatible with the carbon dioxide stream. The cement formulation and required certification documents will be submitted to the UIC Program Director with the well plugging plan. GCS will report the wet density and will retain duplicate samples of the cement used for each plug.

5.0 Methods used for volume calculations

[The information is Confidential Business Information per 5 U.S.C. § 552 (b)(9).] After running casing and cementing, a casing caliper log will be run as a baseline against which to measure future corrosive and/or erosive loss of wall thickness. Prior to plugging, casing i.d. data will be evaluated and compared to original baseline data. Calculations to determine cement plug and displacement

volumes will use the final casing i.d. values. Volume calculations will be based upon the final dimensions of the long string casing.

6.0 Notifications, Permits, and Inspections

In compliance with 40 CFR 146.92(c), GCS will notify the UIC Program Director at least 60 days before plugging the well and provide updated Injection Well Plugging Plan, if applicable.

7.0 Plugging Procedures

Plug-and-abandonment (P&A) cementing operations should occur when fluids in the wellbore are at balance with the exposed formation (in this case, via perforations in the long string). Water is the major component of the work fluid and is the liquid component of the cement, and water is effectively incompressible. A barrel of water introduced into a closed system will cause one barrel of water to be displaced out of the system.

All of the P&A plugs listed in Table 4.0-1 and planned for this well are to be placed by the Balance Method; the cement in fluid form will be precisely placed by accurately measuring the volumes of spacer, cement, and work fluid so that the cement height outside the work string will match the height inside the work string. As soon as the cement is in place, the work string will be slowly pulled from the still-fluid cement mixture, leaving a cement column of a known height.

The density difference between the work fluid and fluid cement will not cause disruption to the placement of cement, because the major component of water is incompressible, a barrel in leads to a barrel out. It is simply measurement of lengths, diameters, and volumes followed by math.

An example of the first P&A plug is provided in Figure 7.0-1. [The information is Confidential Business Information per 5 U.S.C. § 552 (b)(9).]

Salt can be an accelerator to the hydration process of cement, and it is possible that the work fluid might contain salt if it is made from the packer fluid used during the injection activities. To prevent cement from coming into contact with any salt in the work fluid, a fluid spacer containing no salt is pumped ("in the space") between cement and the work fluid. The standard cement plug placement thus consists of pumping accurate amounts of each of these three fluids: spacer, cement, work fluid.

Notes on plug placement:

- [The information is Confidential Business Information per 5 U.S.C. § 552 (b)(9).]
- Calculations to determine cement volume are performed first in barrels, then converted to ft^3, and finally ordered as sacks from the cement supplier. In practice, a calculation resulting in 152 sacks of cement required will typically be rounded-up to the next-highest unit of 10, in this case, 160 sacks.
- The desired top of cement (T.O.C.) may be, for example, 500 ft above the bottom of cement. By rounding-up the cement volume number, the calculated TOC may be higher than the perfect scenario of 500 ft. In reality, the spacer and cement are traveling face-to-face inside a tube for more than two miles, and there will be some mixing. The interface

between the spacer and cement normally leads to a certain amount of contaminated cement, which does not attain the desired properties of compressive strength/hardness. For deep-set cement plugs, it is very common to find the top 2 – 3 bbls of cement contaminated, even after WOC for a lengthy period of time. This contaminated cement can be circulated out of the wellbore prior to setting the next cement plug; it will be a viscous fluid. While performing this circulation, the work string tubing can be used to "tag" (i.e. land upon, touch) the hardened part of the cement plug.

Figure 7.0-1 details the calculation results for placement of the bottom P&A cement plug for the subject well.

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After displacing the cement plug to the balanced depth, the tubing work string will be slowly pulled to a point at least 500 ft above the top of cement, and the tubing work string will be circulated (the long way, down the tubing and up the annulus) to clear any excess cement out of the well; reciprocate and rotate the tubing continuously during this circulation. Wait-on-cement (W.O.C.) for 24 hours, with periodic short circulations down the tubing to ensure it remains open-ended. After W.O.C. 24 hours (or such time recommended by cementing contractor for plug to achieve 100 Bc or 1,000 psi compressive strength), run tubing work string slowly into well to tag the top of cement. Circulate through the work string during the final 90 ft (three joints) to ensure that the tubing remains open-ended when it encounters cement, and to begin to move contaminated, viscous cement up and out of the wellbore. Tagging the hardened cement top will determine the precise location of the cement compared to desired placement; set down 10,000 lbs of work string weight on top of the cement plug to prove its competency. The cross-sectional area of 2-7/8 inch tubing is approximately 2.7 in^2, and the force exerted on the cement top would be approximately 10,000 lbs ÷ 2.7 in^2 ≈ 3,700 psi.

After successfully tagging the cement plug top and proving its competency, immediately pick up the tubing work string and circulate through it to clear any cement from the open end and to circulate any contaminated cement out of the wellbore. Mix and pump via the balanced method another 500-ft cement plug similar to the first plug, placing it on top of the first plug. Repeat the process of pulling at least 500 ft above the calculated top of cement, circulating out any excess cement, W.O.C. while periodically circulating and tagging the top of second plug and proving its competency.

As a conservative approach, each of the plugs will be tagged using the method described. Tagging each plug will prove its location and competency, thus removing doubt about the suitability of the plugging process, and ensuring complete isolation of the USDW.

8.0 Contingency procedures/measures

Discussed above in the bulleted points concerning real-world implications of tubing lengths, cement volumes, and spacer/cement interface contamination.