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8. CLASS VI INJECTION WELL PLUGGING REPORT
40 CFR 146.92(d)

Heartland Greenway Storage Site NCV-6 Injection Well

8.1. Facility Information

Facility name:	Heartland Greenway Storage Site (HGSS) NCV-6
Facility Operator:	Heartland Greenway Carbon Storage, LLC (HGCS)
Facility Contact:	David Giles, President and COO 2626 Cole Ave., Dallas, Texas, USA 75204 Phone: (210) 880-6000; Email: dgiles@navco2.com
Well location:	Taylorville, Christian County, Illinois 39.654806 / -89.302665

At the end of life of the NCV-6 CO_2 injection well, Heartland Greenway Carbon Storage LLC (HGCS) will conduct well plugging and abandonment (P&A) operations in accordance with 40 CFR §146.92 in a manner that ensures USDW protection. HGCS has prepared this well plugging plan pursuant to 40 CFR §146.82 (c), as part of the Class VI permit application for the Heartland Greenway Storage Site. In accordance 40 CFR §146.92, HGCS will comply with this plugging plan for the NCV-6 CO_2 injection well, in addition to maintaining and updating the plan as required throughout the operational phase of the Heartland Greenway Storage Site (HGSS) project. HGCS will send a written notice documenting the intent to plug the NCV-6 well at least 60 days prior to plugging the well. Any proposed revisions to this plugging plan will only be incorporated into this plan and/or implemented in the field, upon approval from the Director and will be incorporated into the permit and are subject to the permit modification requirements of 40 CFR §144.39 or §144.41. After plugging operations are complete for the NCV-6 well, a plugging report will be submitted to the Director within 60 days of plugging, and HGCS will retain the well plugging report for 10 years following site closure.

8.2. Plugging and Abandonment Strategy

A generalized summary of plugging and abandonment approach and operations for the NCV-6 CO_2 injection well is as follows:

- HGCS will submit a written notice of intent to plug to the Director at least 60 days prior to the intended commencement of plugging and abandonment operations [40 CFR §146.91 (e) and §146.92 (c)].
- After the life cycle of the well is complete, bottom hole measurements will be made from downhole gauges to determine bottomhole reservoir pressure, necessary fluid density, and

the well will then be flushed with a kill weight brine fluid [40 CFR §146.92]. A minimum of three tubing volumes will be injected without exceeding fracture pressure.

- The well will undergo mechanical integrity testing to ensure internal and external mechanical integrity prior to commencement of P&A operations [40 CFR §146.89, 40 CFR §146.92]. If a mechanical integrity issue is encountered, remedial activities will be completed prior to proceeding with P&A activities.
- All casing in the HGSS CCS injection and monitoring wells(s) will be cemented to the surface during construction [40 CFR §146.86] and will not be retrievable at abandonment.
- Upon permanent conclusion of the lifecycle of wells, the tubing and packer will be removed.
- After removal of the tubing and packer, the balanced-plug placement method will be used to plug the well. If, after flushing, the tubing and packer cannot be released, an electric line with tubing cutter will be used to cut off the tubing above the packer and the packer will be left in the well, and the cement retainer method will be used for plugging the injection formation below the abandoned packer.
- All of the casing strings will be cut off at least 3 feet below the surface, below the plow line. A blanking plate with the required permit information will be welded to the top of the cutoff casing.
- All surface features associated with the plugged well and well-pad will be removed.
- A plugging report will be submitted within 60 days after plugging operations are completed to the Director [40 CFR §146.92].

8.3. Planned Tests or Measures to Determine Bottomhole Reservoir Pressure

HGCS will record bottom hole pressure measurements from a down hole pressure gauge and calculate kill fluid density prior to flushing the well [40 CFR §146.92].

8.4. Planned External MIT(s)

HGCS will conduct at least one of the MIT tests listed in **Table 8-1** to verify external mechanical integrity prior to plugging the well as required by [40 CFR §146.92]

Table 8-1. Planned MITs [as specified in 40 CFR §146.89].

Test Description	Location
DTS	Distributive temperature measurement across wellbore
Noise Log	Wireline well log
Oxygen Activation Log	Wireline well log

8.5. Information on Plugs

HGCS will use the plugging materials, details and methods noted in **Table 8-2** to plug the NCV-6 CO_2 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; this plan will be updated after well construction to determine the type and number of plugs to be used.

The cement(s) formulated for plugging wells which penetrate the CO_2 storage complex will be compatible with the carbon dioxide stream and will consist of EverCRETE or a similar product. Wells which do not penetrate the storage complex will be plugged with class A or H cement. The cement formulation and required certification documents will be submitted to the agency with the well plugging plan. The owner or operator will report the wet density and will retain duplicate samples of the cement used for each plug.

Table 8-2. Plug Information for the NCV-6 CO_2 Injection Well

Plug Attribute	Plug #1	Plug #2
Diameter of Boring in Which Plug Was Placed (inches)	12.25”, 17.5”	17.5”, 24”, 34”
Depth to Bottom of Tubing or Drill Pipe (ft)	6407	3407
Sacks of Cement Used (sks)	1101	1235
Slurry Volume that was Pumped (ft3)	1233	1400
Slurry Weight (ppg)	15.9	15.9
Top of Plug (ft)	3407	Surface
Bottom of Plug (ft)	6407	3407
Type of Cement or Other Material	EverCRETE	Class A
Method of Emplacement (e.g., balance method, retainer method, or two-plug method)	Balance Method	

8.6. Casing and Tubing Record after Plugging

Table 8-3. Casing and Tubing Specifications After Well Plugging for NCV-6

Tubular OD	Weight (lb/ft)	To be put in well (ft)	To be left in well (ft)	Diameter of boring
30" Casing	157.53	40	40	34
20" Casing	94	500	500	24
13.375" Casing	61	4789	4789	17.5
9.625" Casing	47	6407	6407	12.25
5.5" Tubing	17	5906	0	-

8.7. Description of Plugging Procedures

8.7.1. Notifications, Permits, and Inspections

In compliance with 40 CFR §146.92, HGCS will notify the Director at least 60 days before plugging the well and will provide the director with an updated injection well plugging plan, if applicable.

8.7.2. Plugging Procedures

1. Upon receiving written approval from the Director, well plugging and abandonment operations will commence.
2. Mobilize Rig (MR) and field staff to the HGSS and rig up (RU). All CO_2 pipelines will be marked and noted with rig supervisor prior.
3. Conduct and document a safety meeting to identify site specific occupational hazards.
4. Record bottom hole pressure from down hole gauge and calculate kill fluid density.
5. Open up all valves on the vertical run of the tree and check pressures.
6. Test the pump and line to 2,500 psi. Fill tubing with kill weight brine (9.5 ppg or determined by bottom hole pressure measurement). Bleeding off occasionally may be necessary to remove all air from the system. Test casing annulus to 1000 psi and monitor as in annual MIT. If there is pressure remaining on tubing rig to pump down tubing and inject two tubing volumes of kill weight brine. Monitor tubing and casing pressure for 1 hour. If both casing and tubing are dead, then nipple up blowout preventers (NU BOP's). Monitor casing and tubing pressures.
7. If the well is not dead or the pressure cannot be bled off of tubing, rig up (RU) slickline and set plug in lower profile nipple below packer. Circulate tubing and annulus with kill weight fluid until well is dead. After well is dead, nipple down tree, nipple up blow-out preventers (BOPs), and perform a function test. BOP's should have appropriately sized single pipe rams on top and blind rams in the bottom ram for tubing. Test pipe rams and

blind rams to 250 psi low, 3,000 psi high. Test annular preventer to 250 psi low and 3,000 psi high. Test all Texas Iron Works (pressure valve), BOP's choke and kill lines, and choke manifold to 250 psi low and 3,000 psi high. NOTE: Make sure casing valve is open during all BOP tests**.** After testing BOPs pick up tubing string and unlatch seal assembly from seal bore. Rig slick line and lubricator back to well and remove plug from well. Rig to pump via lubricator and circulate until well is dead.

8. Pull out of hole with tubing laying it down. NOTE: Ensure that the well is over-balanced so there is no backflow due to formation pressure and there are at least 2 well control barriers in place at all times.

9. Pull seal assembly, pick up work string, and trip in hole (TIH) with the packer retrieving tools. Latch onto the packer and pull out of hole laying down same. Next, confirm the well's mechanical integrity by performing one of the permitted external mechanical integrity tests listed in **Table 8-1**.

    a. ***Contingency:*** If unable to pull seal assembly, RU electric line and make cut on tubing string just above packer. Note: Cut must be made above packer at least 5-10 ft MD. If unable to pull the packer, pull the work string out of hole and proceed to next step. If problems are noted, update cement remediation plan (if needed) and execute prior to plugging operations.

10. TIH with work string to total depth (TD). Keep the hole full at all times. Circulate the well and prepare for cement plugging operations.

11. The lower section of the well will be plugged using CO_2-resistant cement from TD in the Precambrian basement to around 1000 ft above the top of the Eau Claire formation. This will be accomplished by placing plugs in 500 ft incremental lifts and using a density of 15.9 ppg slurry with a yield of 1.12 ft^3/sk for EverCRETE. It is anticipated that at 5-7 plugs of 500 feet in length will be necessary. No more than two plugs will be set before cement is allowed to set and plugs verified by setting work string weight down onto the plug. (*Example Calculations for NCV-1 CO_2 Injection Well:* Assume 9 5/8" 47 lb/ft casing for this interval 3000ft x .4110 ft^3ft^{-1} /1.12 ft^3sack =1101 sacks).

12. Circulate the well and ensure it is in balance. Place tubing just above cement top from previous day. Mix and spot 500 ft balanced plug in 9 5/8" casing (using a density of 15.9 ppg slurry a yield of 1.01 ft^3/sk for Class A). Pull out of plug and reverse circulate tubing. Repeat this operation until a total of 7-8 plugs have been set. If plugs are well balanced, then the reverse circulation step can be omitted until after each third plug. Lay down work string while pulling from well. If rig is working daylights only then pull 10 stands and rack back in derrick and reverse tubing before shutting down for night. After waiting overnight, trip back in hole and tag plug and continue. After required plugs have been set pull tubing from well and shut in for 12 hours. Trip in hole with tubing and tag cement

top. Pull tubing back out of well. Nipple down BOPs and cut all casing strings below plow line (min 3 feet below ground level or per local policies/standards). Trip in well and set final cement plug. Lay down all work string, etc. Rig down all equipment and move out. Clean cellar to where a plate can be welded with well name onto lowest casing string at 3 feet, or as per permitting agency directive. **(***Example Calculations for NCV-1:* assume 9 5/8" 47 lb/ft casing for this interval with no excess due to being inside the long string casing, 3600 ft x 0.4110 ft^3ft^{-1}/1.01 ft^3 sack =1465 sacks)

13. The procedures described above are subject to modification during execution as necessary to ensure a plugging operation that protects worker safety and is effective to protect USDWs, and any significant modifications due to unforeseen circumstances will be described in the Plugging report. Complete plugging forms and send in with charts and all lab information to the regulatory agency as required by permit. Plugging report shall be certified as accurate by HGCS and plugging contractor and shall be submitted to the Director within 60 days after plugging is completed in accordance with 40 CFR §146.92. A reference schematic for the plugging protocol mentioned above is shown in **Figure 8-2.**

8.8. Additional Information Attached

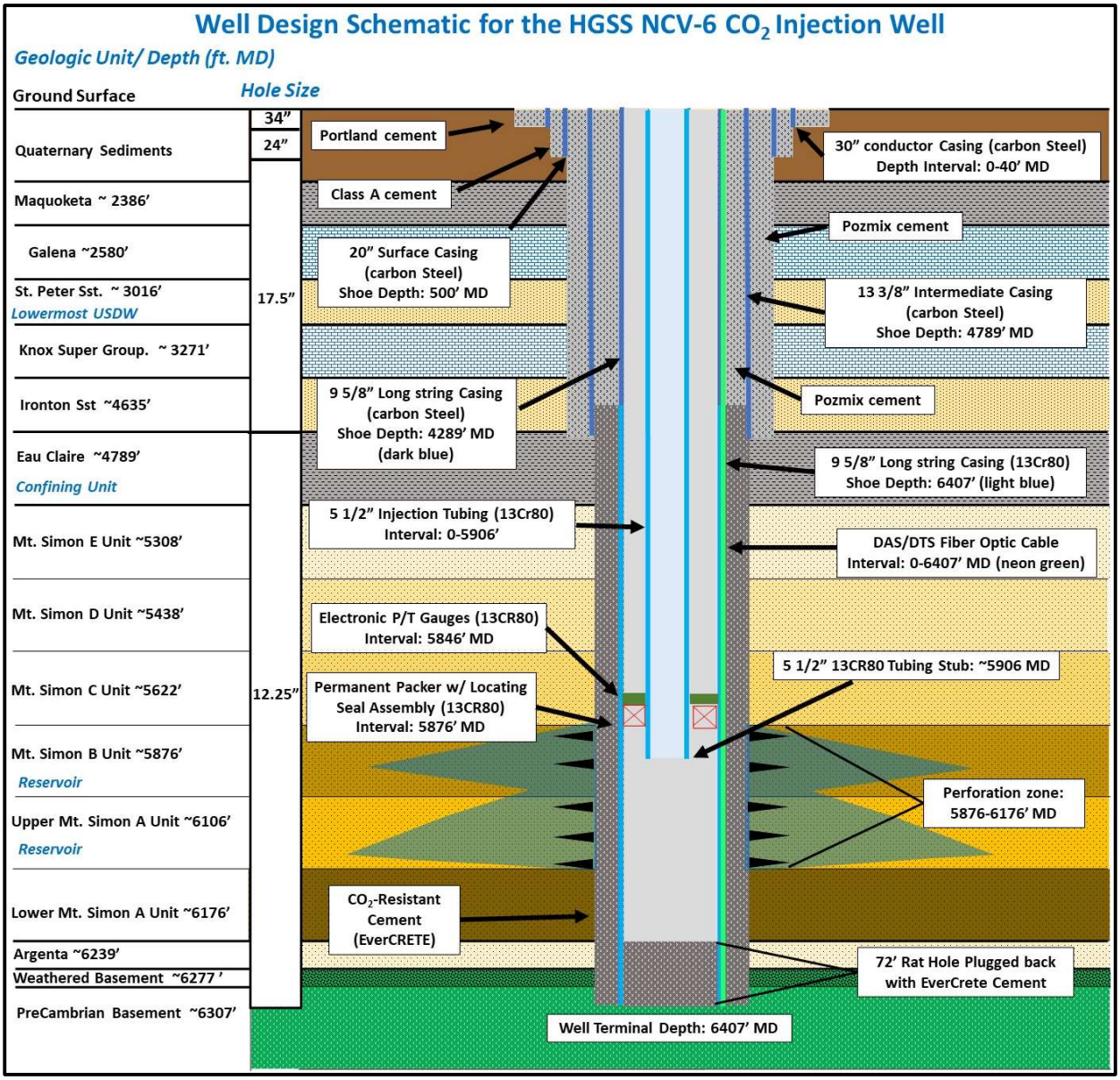

Figure 8-1. Well construction schematic detailing design specifications of the HGSS NCV-6 CO_2 injection well.

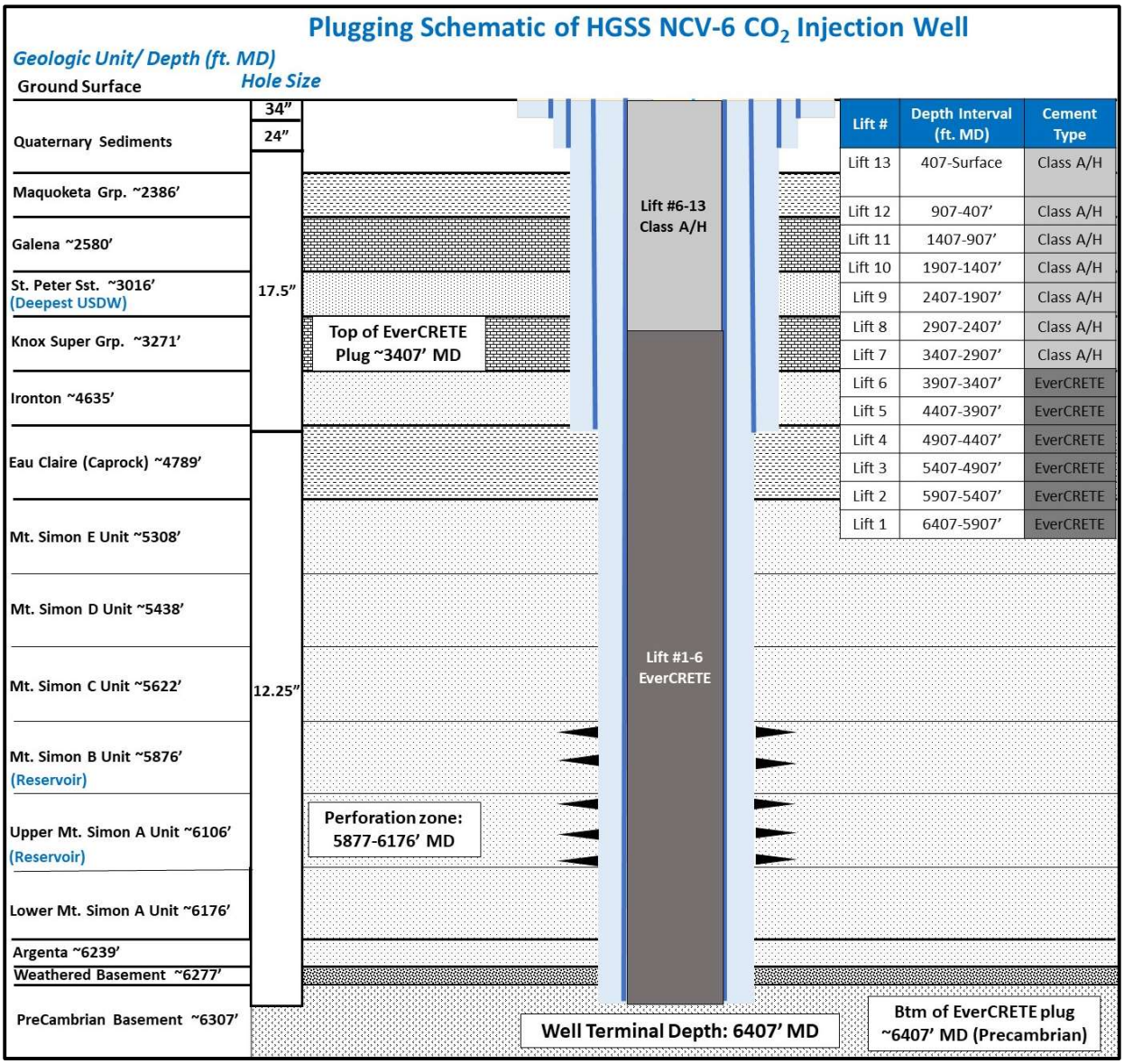

Figure 8-2. Plugging schematic detailing plug specifications for the HGSS NCV-6 CO_2 injection well.

8.9. Report Retention

A copy of this injection well plugging report will be retained by HGCS for 10 years following the date of site closure.