INJECTION WELL WORK PERMIT

Office of Conservation
Injection and Mining Division

MAILING ADDRESS
OFFICE OF CONSERVATION
Injection and Mining Division
P.O. Box 94275
Baton Rouge, LA 70804-9275

UIC-17 INVOICE # 1290438

Work Permit No.	04519
Operator's Name and Address:	Westlake US 2, LLC 2190 W. Burton St. Sulphur, LA 70663
Serial No.	67270
Operator Code:	W1039
Phone:	(337) 705-5717
Well Name and Number:	PPG Well No. 007-B
Fax:	
Field:	Sulphur Mines (8759)
Parish:	Calcasieu (10)
Sec.	029
Twp.	09S
Rng.	10W

DESCRIPTION OF WORK

MIRU on PPG No. 007-B. POOH with downhole pressure gauge. Reconfigure wellhead for fiber optics. Switch brine injection inlet point and install short protection tubing in wellhead. Run slickline gauge run to cavern TD. Deploy DAS and DTS single use Fiber optic cable. Monitor DTS/DAS data during acquisition period (estimated at 7 to 14 days) with continuous brine injection. For a period of 30 minutes during monitoring, ~250 bbls of warmed brine will be injected for modeling purposes. Cease data acquisition. Return brine injection to original inlet. Remove fiber optics deployment system from wellhead. Reconfigure wellhead back to original configuration (removing protection tubing). RIH with downhole pressure gauge. Install downhole gauge surface equipment and continue monitoring. RDMO.

Remark: Brine injection rate will continue as necessary to adhere to pressure maintenance strategy throughout the project.

Field Contact to Schedule Well Test :	Cayden Sessions	**Phone:**	832-381-8856
Permit Requested By:	Jorge Pacheco	**Date:**	05/16/2024
Signature:		**Email Address:**	jorge@lonquist.com
Permit Authorized By: **Stephen H. Lee, Director**		**Date:** 5/23/24	**Expiration Date:** 8/23/24

INSTRUCTIONS

A single application will suffice for one or combinations of the operations below provided that if more than one operation is requested on one form, such work must be performed consecutively. Once signed by an IMD Representative, this form will be sent to the operator and serve as the approved permit.

1. Plug and Abandon (Provide Well Schematic)	7. Back Wash, Acidize or Other Well Stimulation (Class I Wells Only)
2. Deepen	8. Pull Casing
3. Perforate	9. Replace Wellhead
4. Squeeze	10. Run a Liner
5. Plugback	11. Other (Any work requiring use of Workover Rig)
6. Pull Tubing/Packer	To Change Zone of Disposal/Completion submit Form UIC-32

Email all Injection Well Work Permit Applications to Injection-Mining@LA.gov, **OR** mail the application to the address provided in the upper right corner.

In accordance with RS 30:21, effective August 1, 2015, all Work Permit applications will be assessed a non-refundable $125 fee, due upon submittal of this form.

OFFICE OF CONSERVATION

To perform any of the above work types without first obtaining a work permit is a violation of the law (LAC43:XIX.105.), which carries with it possible civil and criminal penalties.

FORM UIC-17

HHH
5/23/24

MAY 16 2024 Rev 03/17

INJECTION & MINING DIVISION

OFFICE OF CONSERVATION

IMD REPORTING REQUIREMENTS >> Class II HSW & Class III Salt Cavern Wells

I. WORK PERMITS

Work Permit for an Existing Class II HSW or Class III Salt Cavern Well

At least 48 hours before beginning the well work, you must contact the Conservation Enforcement Specialist (CES) identified below. If you are unable to reach the CES, please call the Injection and Mining Division at (225) 342-5515 between the hours of 8:00 a.m. and 4:30 p.m., Monday through Friday.

Application No. **45219** Serial No. **67270**

CES Name **Billy Carnes (Area 6)** CES Phone No. **(225) 405-7470 (Area 6)**

Please forward all documents together in one submittal after completion of the activities authorized by the work permit and include the well's state Serial Number on all documents submitted. DO NOT SUBMIT DOCUMENTS SEPARATELY.

1. A *Well History and Work Résumé Report for Injection Wells* (Form UIC-WH1) with an original signature from an authorized representative of the operating company and two photocopies of the form, available at the following link: **http://www.dnr.louisiana.gov/assets/OC/im_div/UIC-WH1.pdf**. Describe the work performed on the back of the form.
2. Sonar caliper survey (if run).
3. Cavern pressure test / MIT (if performed).
4. One copy of all wireline logs run (Temperature, Density, Casing Inspection, Cement Bond Logs, etc.)
5. Results and/or analyses of any surveys or test performed.

II. CERTIFICATION AND SUBMISSION OF INFORMATION

All submittals including or comprising of the practice of engineering must be prepared, sealed, signed and dated by a licensed Professional Engineer (PE). All submittals including or comprising of geoscientific work must be prepared, sealed, signed and dated by a licensed Professional Geoscientist (PG). The PE or PG must be licensed to practice by and be in good standing with the Louisiana Professional Engineering and Land Surveying Board or Louisiana Board of Professional Geoscientists, respectively.

The staff of the Injection & Mining Division may be reached by phoning 225-342-5515. Submit all properly completed signed forms and required information to:

Street Address
Office of Conservation- 9th Floor
Injection & Mining Division
617 North 3rd Street
Baton Rouge, LA 70802

LONQUIST FIELD SERVICE

April 26, 2024

Stephen H. Lee, Director
Louisiana Department of Energy & Natural Resources
Injection and Mining Division
617 N. 3rd Street
Baton Rouge, Louisiana 70802

Re: Request to LDENR - Proposed Plan to Deploy Single-Use Fiber in Cavern 7
Westlake US 2, LLC – Well PPG No. 007B (SN 67270)
Sulphur Mines Salt Dome

Dear Mr. Lee,

This letter is submitted on behalf of Westlake US 2, LLC ("Westlake") to propose the installation of a single use fiber optic cable system on Well PPG No. 007B and within Cavern 7. This letter outlines the basis for the activity, general execution plan, active monitoring, and data analysis for the project.

Westlake is agreeable with proceeding with the project and believes the project may possibly provide valuable information as to the location of the brine egress area from Cavern 7. Westlake is seeking the approval of the Injection and Mining Division to execute this plan.

Basis of Proposed Plan & Request

The brine egress location from Cavern 7 has been speculated upon but is currently unknown. "In-Cavern" monitoring may reveal the depth and perhaps additional information about the egress area. Westlake proposes deploying a fiber optic cable in Cavern 7 and measuring both Distributed Temperature Sensing (DTS) and Distributed Acoustic Sensing (DAS) data. To perform this measurement, a Well-Sense Fiberline Intervention (FLI) bare fiber optic cable will be deployed via Well PPG No. 007B and into the entire height of Cavern 7. The installation will require some temporary wellhead modifications which are outlined in this document. The fiber is categorized as a "single-use" fiber meaning that it will deteriorate and dissolve after a period of time (believed to be no longer than 30-days for this project). After the project is completed the wellhead configuration will be reverted to the current configuration. The project has been designed so that it will not impact the overall brine injection and pressure maintenance operations of Cavern 7. It is anticipated that the fiber installation process will take approximately two days, and the data acquisition and monitoring process will take approximately 7 to 14 days. A data evaluation phase will then be conducted.

Technical Discussion - DAS and DTS Measured Using Single-Use Fiber Optic Cable

The Well-Sense bare fiber optic cable is deployed using a single-use FLI probe (Figure 1) with bare fiber optic lines wound inside. The FLI probe would be launched from the PPG No. 007B wellhead and would free-fall down the brine string to the base of Cavern 7, unspooling the optical fibers from the probe as it falls. Cavern operations (injection) will continue during the deployment and monitoring effort. Two single-mode fibers are included in the probe, allowing simultaneous Distributed Temperature Sensing (DTS) and Distributed Acoustic Sensing (DAS) data acquisition.

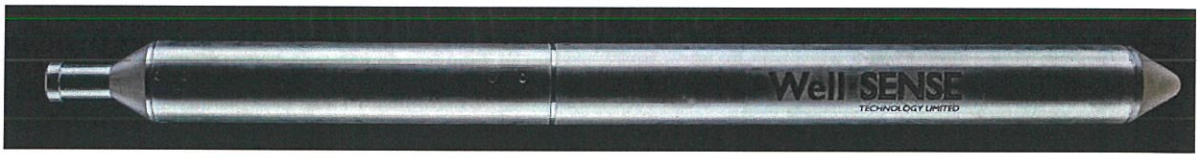


Figure 1. Example of a Well-Sense FLI probe. The bare fiber optic cables are spooled inside the probe. The probe is about 3 feet long.

The DAS and DTS data will be acquired continuously along the cable to allow for measurement of small fluctuations in temperature and/or acoustics along the entire length of the fiber in the cavern. Distributed fiber optic monitoring has been widely adapted in the oil industry to capture low-frequency strain associated with hydraulic fracture propagation on offset wellbores (Jin and Roy, 2017), as well as leak detection in wellbores, microseismic measurements, and borehole fluid measurements (Figure 2). DAS measures dynamic strain changes and can be used to measure both thermal or mechanical induced low-frequency strain, such as slow thermal slugging of fluid (Figure 2b), or microseismic events induced high-frequency strain (Figure 2a).

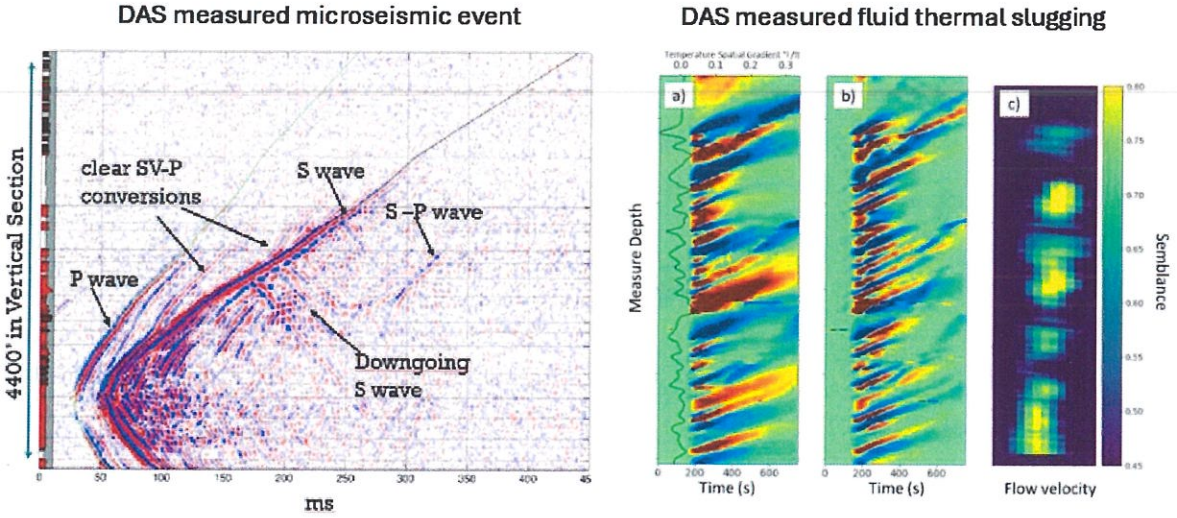


Figure 2. DAS based borehole measurements. On the left (2a) is a microseismic event recorded on a fiber optic vertical wellbore (from Hull et al., 2017). On the right (2b) is a low-frequency DAS plot of strain rate changes during a well opening event (Jin et al., 2019).

DAS and DTS interrogators monitor the cavern continuously during the data acquisition period. The DAS and DTS acquisition units will be located near the PPG No. 007B wellhead using a Well-Sense data acquisition system. The Well-Sense operation has a small footprint and is an efficient way to obtain both temperature (DTS) and acoustic/strain (DAS) data over the entire length of the wellbore and cavern. The single-use fiber optic cable will slowly deteriorate over time; estimates are from 2-3 weeks for the fiber to start to deteriorate, and subsequently, data acquisition will cease. A slug of warmed brine injection, likely for a period of ~30-minutes, is under consideration while the fiber is deployed to allow for soak

temperature contrast with the ambient brine in the cavern. The thermal anomaly created by the warmed brine slug will allow DAS and DTS measurements to track the thermal front to estimate flow velocity, as demonstrated in Jin et al. (2019). The flow velocity along the center line of the cavern will provide critical calibration of the computational flow dynamics ("CFD") models and support the possible identification of the egress area.

This project will use a newly developed product from Well-Sense, a "robust" single-use fiber designed with a special coating on the bare fiber line which has been tested to withstand the current injection rates (fluid velocities) in the brine string of Well PPG No. 007B. The current brine injection program will continue into Cavern 7 to maintain the cavern pressure, the new robust fiber should be able to withstand the continuous injection, but the continuous injection may hasten the demise of the fiber line. The FLI probe and fiber line will not be recovered after the deployment. The probe is constructed with light-weight materials that deteriorate over time and the fiber line will dissolve into the cavern brine.

There is only limited public information or published technical information available for DAS and DTS acquisition within a salt cavern (an example is provided within References). We cannot predict the chance of success of the in-cavern fiber optic monitoring effort. The monitoring will attempt to capture temperature fluctuations, acoustic noise sources, flow velocity distribution, and/or other phenomena within Cavern 7 that could help identify the depth and perhaps the nature of the brine egress area. The results may take time to analyze and interpret, and successful or conclusive results are not guaranteed. Dr. Ge Jin from Colorado School of Mines is assisting with the project. Dr. Jin is a widely recognized global expert in fiber optic acquisition, processing, and interpretation. The complex geometry of Cavern 7 (the hour-glass shape) and its wide diameter may complicate the interpretation of the results. The sheer size of the cavern may mask any subtle features at the egress area.

Operations Discussion

The deployment of the fiber cable system will require modifications to the wellhead assembly in order to protect the fiber from horizontal brine injection flow which is to remain continuous throughout the project. A current wellhead configuration is presented in Appendix A and a proposed fiber deployment wellhead configuration is presented in Appendix B. The proposed operational steps are outlined below in three phases.

Phase 1: The existing downhole pressure gauge will be removed. Currently, brine is being injected via Inlet A. Close Master Valve A, relieve trapped pressure above Master Valve A, and install a short protection string (2 3/8" tubing) in the upper section of the wellhead tree. The protection string will have a conventional mandrel-type hanger and tubing spool in which it is hung. A tubing head will be installed and above the tubing head, the new Master Valve C will be installed. Above Master Valve C will be a cross over flange to the pressure control lubricator and the Well-Sense fiber deployment system will be installed. Master Valve A, B, and C will be opened to the wellbore pressure. The proposed wellhead configuration and equipment will provide pressure containment (Appendix B).

Phase 2: The brine injection flow will be switched seamlessly to Inlet B. The fiber probe will be deployed into the well/cavern, and data acquisition will commence for approximately 7 to 14 days

(duration to be determined). Data and wellhead observation personnel will be on location 24-hours per day.

Phase 3: The data acquisition will cease either due to fiber optic cable failure or if it has been determined that enough data has been acquired. Master Valve C will be closed (if the fiber is still present, then the valve will cut the fiber). Brine injection flow will be switched seamlessly to Inlet A. Master Valve A will be closed and trapped pressure above the valve will be relieved. The Well-Sense assembly will be rigged down. The protection string will be removed from the wellhead, the downhole pressure gauge will be reinstalled, and the wellhead returned to the same configuration prior to this project (Appendix A).

It is planned for the brine injection rate into Cavern 7 to remain constant throughout the project, and wellhead pressure will be continuously monitored/recorded throughout the project.

Concluding Remarks

Westlake believes the project can be executed on Cavern 7 without interfering with the ongoing brine injection and cavern pressure maintenance operations. Westlake believes the data collected from this project may possibly aid in identifying the location of the brine egress area from Cavern 7. For clarity, there are no analogous projects to reference regarding expected data quality or the ability to identify an egress location. Therefore, Westlake cannot guarantee that the project will be conclusive or supportive.

Upon approval from the Injection and Mining Division, Westlake plans to begin execution of the project as soon as possible (tentatively scheduled for early June).

If there are any questions, please contact Josh Bradley (Westlake US 2, LLC) or Coleman Hale (Lonquist Field Service, LLC).

OFFICE OF CONSERVATION

Sincerely,

MAY 16 2024

R. Coleman Hale P.E.
Vice President / Sr. Petroleum Engineer
Lonquist Field Service, LLC

INJECTION & MINING DIVISION

STATE OF LOUISIANA
BEN H. BERGMAN
License No. 40184
4/30/2024
PROFESSIONAL ENGINEER

Certified By: Lonquist Field Service, LLC
Louisiana Registration No. EF5853

4/30/2024 P.E.

Ben H. Bergman P.E.
Senior Engineer
Louisiana Registration No. 40184
Date Signe: April 30th, 2024

APPENDICES LIST

A. Current Wellhead Diagram
B. Proposed Wellhead Diagram (Fiber Deployment)

REFERENCES

Well-Sense Website: https://www.well-sense.co.uk/

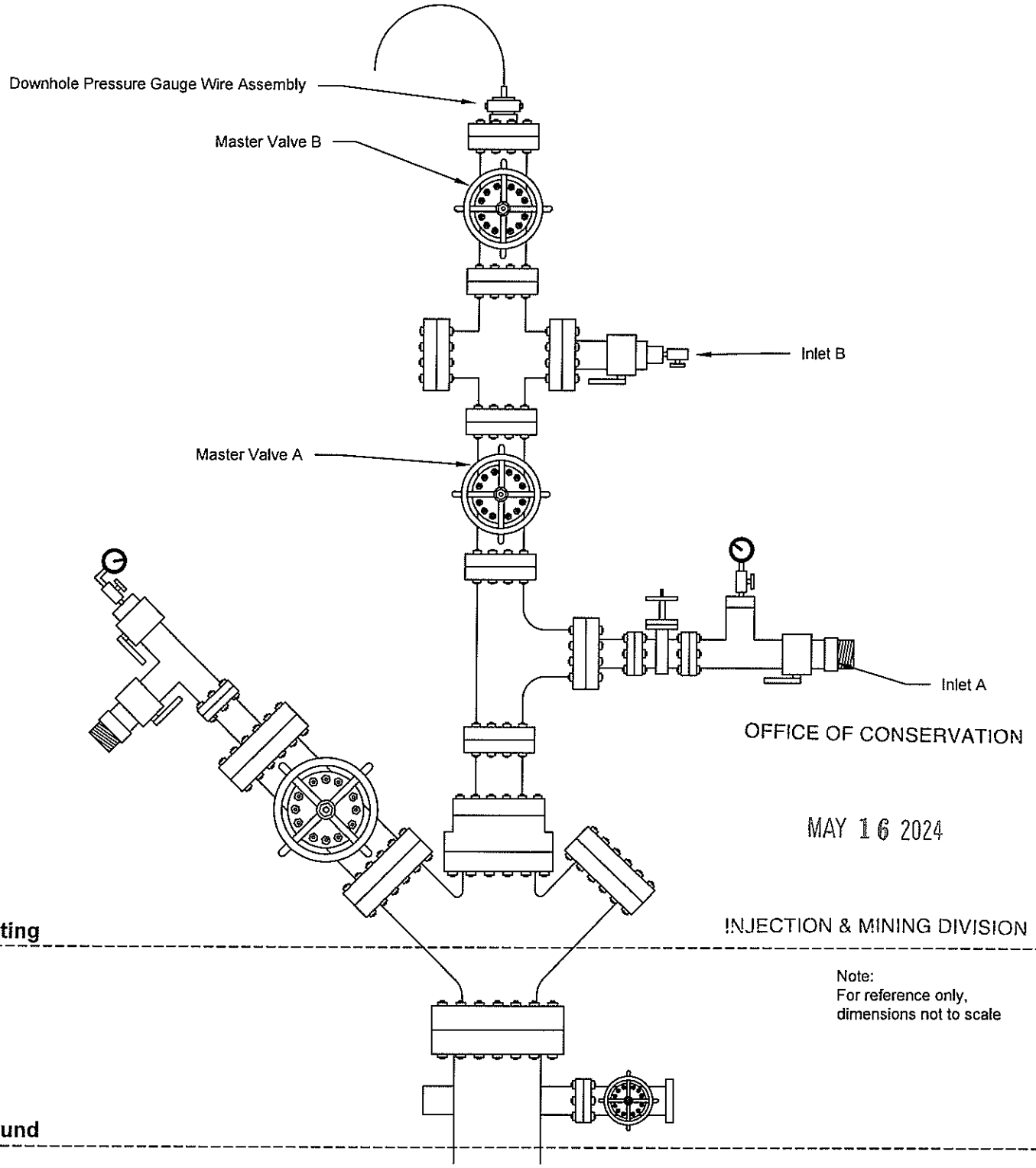
Hull, R., Meek, R., Bello, H., and D. Miller. "Case History of DAS Fiber-Based Microseismic and Strain Data, Monitoring Horizontal Hydraulic Stimulations Using Various Tools to Highlight Physical Deformation Processes (Part A)." Paper presented at the SPE/AAPG/SEG Unconventional Resources Technology Conference, Austin, Texas, USA, July 2017. doi: https://doi.org/10.15530/URTEC-2017-2695282

Jin, G., G. Ugueto, M. Wojtaszek , A. Guzik, , D. Jurick, K. Kishida, Novel Near-Wellbore Fracture Diagnosis for Unconventional Wells Using High-Resolution Distributed Strain Sensing during Production, *SPE J.* (2021;): doi: https://doi.org/10.2118/205394-PA

Jin, G., Friehauf, K., Roy, B., Constantine, J. J., Swan, H. W., Krueger, K. R., & Raterman, K. T. (2019). Fiber optic sensing-based production logging methods for low-rate oil producers. *Proceedings of the 7th Unconventional Resources Technology Conference*, 1183–1199.

Klafki, M., T. Wagler, S. Grosswig, A. Kneer. "Long-term downhole fibre optic temperature measurements and CFD-modeling for investigation of different gas cavern operating modes". Solution Mining Research Institute, Fall 2003 Conference 5-8 October, Chester, United Kingdom.

Appendix A – Current Wellhead Diagram



Note:
For reference only,
dimensions not to scale

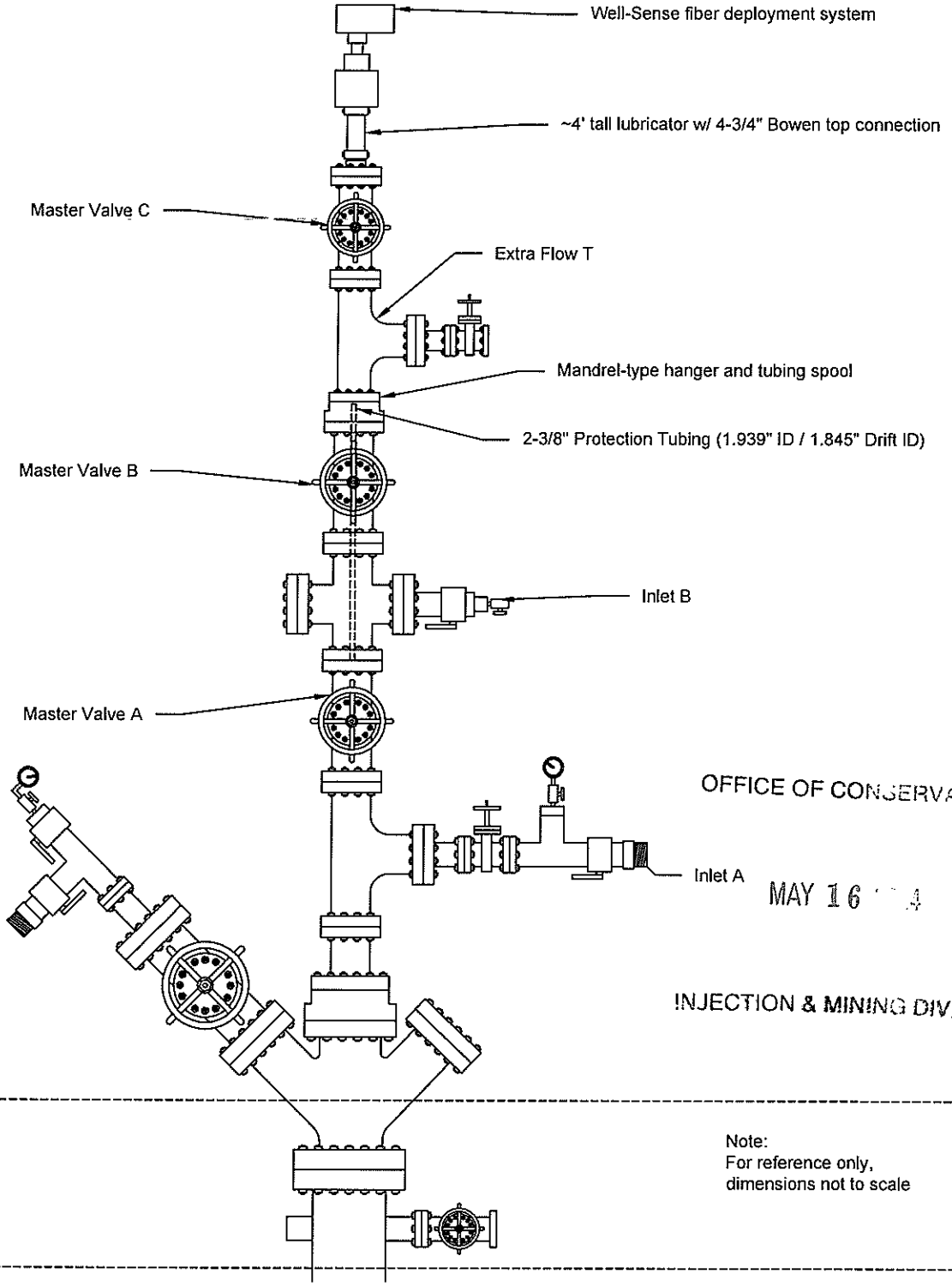
LONQUIST & CO. LLC
PETROLEUM ENGINEERS | ENERGY ADVISORS

Louisiana License EF-5853

1415 Louisiana St., Suite 3800
Houston, Texas 77002
Tel: 713.559.9950
Fax: 713.559.9959

Westlake US 2, LLC	PPG Well No. 007-B - Wellhead Schematic	
Country: USA	**State:** Louisiana	**Parish:** Calcasieu
Location: 12 mi. west of Lake Charles	**Site:** Sulphur Mines Brine Field	**Status:** Monitoring
Survey/STR: S-029 T-09S R-10W	**Field:** Sulphur Mines	**Serial No.:** 67270
Well API No: 17-019-04012	**Project No:** F2219.4	**Date:** 04/16/2024
Drawn: PJP	**Reviewed:** RCH	**Approved:** BHB
Rev No:	**Notes:**	

Appendix B – Proposed Wellhead Diagram (Fiber Deployment)



Note:
For reference only,
dimensions not to scale

LONQUIST & CO. LLC
PETROLEUM ENGINEERS | ENERGY ADVISORS
AUSTIN · HOUSTON | CALGARY · DENVER
DENVER | COLLEGE STATION | BAKERSFIELD | KENSINGTON

Louisiana License EF-5853

1415 Louisiana St., Suite 3800
Houston, Texas 77002
Tel: 713.559.9950
Fax: 713.559.9959

Westlake US 2, LLC	PPG Well No. 007-B - Proposed (Fiber Deployment)	
Country: USA	**State:** Louisiana	**Parish:** Calcasieu
Location: 12 mi. west of Lake Charles	**Site:** Sulphur Mines Brine Field	**Status:** Monitoring
Survey/STR: S-029 T-09S R-10W	**Field:** Sulphur Mines	**Serial No.:** 67270
Well API No: 17-019-04012	**Project No:** F2219.4	**Date:** 04/16/2024
Drawn: PJP	**Reviewed:** RCH	**Approved:** BHB
Rev No:	**Notes:**	

AFFIDAVIT OF NOTIFICATION
(Per Emergency Order No. EMERG 970-1)

I hereby certify, as counsel for Westlake US 2 LLC that notices regarding permit applications for work to be performed on Well 67270, a copy of which is attached as Exhibit "A," was duly served on the following Notice Recipients identified in the EMERG 970-1 Notification List provided by Injection and Mining Division, Office of Conservation, Louisiana Department of Natural Resources, via the email addresses provided by IMD in the EMERG 970-1 Notification List, pursuant to Emergency Order No. EMERG 970-1:

Operators and Counsel:

Boardwalk Louisiana Midstream, LLC
Austin Anderson
Austin.Anderson@bwpipelines.com

Liberty Gas Storage, LLC
Maurice Gilbert
713-206-6713
mgilbert@sempraglobal.com

Yellow Rock LLC
Jonathan Love
713-456-3011
jlove@bmfgco.com

Outside Counsel for Yellow Rock LLC
Thomas J. Madigan
tmadigan@shergarner.com

All operators responded that they have no objection to the proposed work.

OFFICE OF CONSERVATION

MAY 16 2024

INJECTION & MINING DIVISION

I declare under penalty of perjury that the foregoing is true and correct. Thus done, read, and signed in Baton Rouge, Louisiana, May 15, 2024. This notarial act was a remote online notarization.

TROY J. CHARPENTIER

Thus done and signed before me, undersigned Notary Public, this 15th day of May, 2024.

NOTARY PUBLIC
Print Name: Caroline Strohe Wampold
Notary ID: 170030/39354
My Commission Expires: At Death

Caroline C. Strohe
Bar Roll Number 39354
Notary ID Number 170030
Commission Expires at Death

OFFICE OF CONSERVATION

MAY 16 2024

INJECTION & MINING DIVISION

Signature Certificate

Reference number: IVQYJ-POQEF-XHZUQ-NTICQ

Signer	Timestamp	Signature
Caroline Wampold Email: caroline.wampold@keanmiller.com		
Sent:	15 May 2024 15:57:43 UTC	
Viewed:	15 May 2024 15:57:49 UTC	
Signed:	15 May 2024 15:58:12 UTC	
Recipient Verification:		IP address: 165.236.184.64
✔Email verified	15 May 2024 15:57:49 UTC	Location: Baton Rouge, United States

Document completed by all parties on:
15 May 2024 15:58:12 UTC

OFFICE OF CONSERVATION

MAY 16 2024

INJECTION & MINING DIVISION