Ameredev II, LLC
2901 Via Fortuna Suite 600 • Austin, Texas 78746 • Phone (737) 300-4700

August 28, 2023

NM Oil Conservation Division
Environmental Bureau
1220 South St. Francis Dr.
Santa Fe, NM 87505

RE: Ameredev Operating – Ike's Containment #1 C-147 Registration/Permit Application
Section 27, T26 S, R36 E, Lea County

Ameredev Operating respectfully resubmits registration/permit application for Ike's Containment #1 (inground) and recycling facility. The application (included in this package) was originally submitted, via email, to NMOCD in February of 2018, prior to the online submission process. The containment build was completed March 29, 2018. It was put into use in May of 2018 based on the understanding, as noted in original submission cover letter, that the containment could be put into use prior to receiving NMOCD approval.

An updated C 147 follows this cover letter and includes the final built location of the containment (within the "Fluid Containment Zone" mapped in original submission), liner details, and containment dimensions and volume. Also attached is the design with final dimensions of the built containment (Pettigrew) and the revised 3:1 outside slope and volume (Topographic). All other design details related to build, including leak detection design/anchor trench/fencing, are as shown in the conceptual design plan under Appendix A in the original submission.

The language of the original application discusses "equivalencies" which are considered "variances" by NMOCD. The original application package (cover letter, Design and Construction Plan) contains substantial information to support these variance requests, otherwise demonstrating compliance with the rule **(19.15.34.12 NMAC)** for containment design and construction specifications. Variances include:

- Fencing
- Avian Protection
- Secondary Liner

To support the information provided in the original submission for Siting Criteria compliance, we provide more recently available data for depth to water (DTW) and wellhead protection (Appendix F).

Appendix G contains the record of inground containment inspections.

Ameredev sent a communication to NMOCD regarding fluid use/disposition (including associated C-148s) in November 2018, but forms were not accepted as a facility number had not been assigned. Appendix H contains a copy of this communication and associated C-148 documents.

Ameredev tracks the total volume of water received for recycling, with the amount of fresh water received listed separately, and the total volume of water leaving the facility for disposition. This can be provided on monthly C 148s to NMOCD under separate cover (due to file size), please advise if you prefer these to be submitted by email or online.

This containment was initially intended for produced water for recycling but was transitioned to the storage of fresh and brackish water, obtained from water wells, in March of 2020. Residual produced water was used for drilling activities.

Ameredev respectfully requests to repurpose the Ike's Containment #1 for ongoing use as a freshwater storage containment. Ameredev understands that to assure no impact to human health or the environment, or to remediate any identified impact, it will close the containment according to closure plan for produced water containment, per 19.15.34.14 NMAC and 19.15.29 NMAC spill rule, when no longer in use. Please advise if this requires a request for extension of permit/registration, once approved.

Ameredev is committed to bringing all facilities into compliance with NMOCD rules. A modification for this permit/registration request is forthcoming to address the temporary use of 3 ASTs at this site, the last one currently being deconstructed. A closure report will demonstrate compliance with NMOCD 19.15.34.14 NMAC and 19.15.29 NMAC spill rule for the site. Design and construction details, inspection logs (including leak detection monitoring) and reports (C-148s) of monthly volumes of fluids received and their disposition will be provided.

Please let me know if you have any questions or if you require additional information.

Sincerely,

Shane McNeely

Shane McNeely
Ameredev II, LLC

August 28, 2023

State of New Mexico
Energy Minerals and Natural Resources
Department Oil Conservation Division
1220 South St. Francis Dr.
Santa Fe, NM 87505
https://www.emnrd.nm.gov/ocd/ocd-e-permitting/

Form C-147
Revised October 11, 2022

Recycling Facility and/or Recycling Containment

Type of Facility: ☑ Recycling Facility ☑ Recycling Containment*

Type of action: ☑ Permit ☑ Registration ☐ Modification ☐ Extension ☐ Closure ☐ Other (explain) _____

*** At the time C-147 is submitted to the division for a Recycling Containment, a copy shall be provided to the surface owner.**

Be advised that approval of this request does not relieve the operator of liability should operations result in pollution of surface water, ground water or the environment. Nor does approval relieve the operator of its responsibility to comply with any other applicable governmental authority's rules, regulations or ordinances.

1.

Operator: Ameredev II, LLC (For multiple operators attach page with information) OGRID #: 372224

Address: 2901 Vía Fortuna # 600, Austin, TX 78746

Facility or well name (include API# if associated with a well): Ike's Containment #1

OCD Permit Number: 1RF-508 (For new facilities the permit number will be assigned by the district office)

U/L or Qtr/Qtr D Section 27 Township 26 S Range 36 E County: Lea

Surface Owner: ☐ Federal ☐ State ☑ Private ☐ Tribal Trust or Indian Allotment

2.

☑ **Recycling Facility:**

Location of recycling facility (if applicable): Latitude 32.0191522 Longitude -103.2587185 NAD83

Proposed Use: ☑ Drilling* ☑ Completion* ☑ Production* ☑ Plugging *

****The re-use of produced water may NOT be used until fresh water zones are cased and cemented***

☐ Other, ***requires permit for other uses. Describe use, process, testing, volume of produced water and ensure there will be no adverse impact on groundwater or surface water.***

☑ Fluid Storage

☐ Above ground tanks ☑ Recycling containment ☐ Activity permitted under 19.15.17 NMAC explain type_____

☐ Activity permitted under 19.15.36 NMAC explain type:_____ ☐ Other explain _____

☐ For multiple or additional recycling containments, attach design and location information of each containment

☐ **Closure Report (required within 60 days of closure completion):** ☐ Recycling Facility Closure Completion Date:_____

3.

☑ **Recycling Containment:**

☐ Annual Extension after initial 5 years (attach summary of monthly leak detection inspections for previous year)

Center of Recycling Containment (if applicable): Latitude 32.0204733 Longitude -103.2583888 NAD83

☐ For multiple or additional recycling containments, attach design and location information of each containment

☑ Lined ☑ Liner type: Thickness Primary 60 mil ☐ LLDPE ☑ HDPE ☐ PVC ☐ Other Secondary 40 mil HDPE

☐ String-Reinforced

Liner Seams: ☑ Welded ☐ Factory ☐ Other _____ Volume: 774,891 bbl Dimensions: L 634 ft x W 438 ft x D 24.7 ft

☐ Recycling Containment Closure Completion Date:_____ Total volume below 3 ft freeboard 632,257 bbls

4.

Bonding:

☑ Covered under bonding pursuant to 19.15.8 NMAC per 19.15.34.15(A)(2) NMAC **(These containments are limited to only the wells owned or operated by the owners of the containment.)**

☐ Bonding in accordance with 19.15.34.15(A)(1). Amount of bond $_____ **(work on these facilities cannot commence until bonding amounts are approved)**

☐ Attach closure cost estimate and documentation on how the closure cost was calculated.

5.

Fencing:

☐ Four foot height, four strands of barbed wire evenly spaced between one and four feet

☑ Alternate. Please specify 6 foot chain link surrounding 40 acre parcel

6.

Signs:

☑ 12"x 24", 2" lettering, providing Operator's name, site location, and emergency telephone numbers

☐ Signed in compliance with 19.15.16.8 NMAC

7.

Variances:

Justifications and/or demonstrations that the proposed variance will afford reasonable protection against contamination of fresh water, human health, and the environment.

Check the below box only if a variance is requested:

☑ Variance(s): Requests must be submitted to the appropriate division district for consideration of approval. If a Variance is requested, include the variance information on a separate page and attach it to the C-147 as part of the application.

If a Variance is requested, it must be approved prior to implementation.

8.

Siting Criteria for Recycling Containment

Instructions: The applicant must provide attachments that demonstrate compliance for each siting criteria below as part of the application. Potential examples of the siting attachment source material are provided below under each criteria.

General siting

Ground water is less than 50 feet below the bottom of the Recycling Containment. NM Office of the State Engineer - iWATERS database search; USGS; Data obtained from nearby wells	☐ Yes ☑ No ☐ NA
Within incorporated municipal boundaries or within a defined municipal fresh water well field covered under a municipal ordinance adopted pursuant to NMSA 1978, Section 3-27-3, as amended. - Written confirmation or verification from the municipality; written approval obtained from the municipality	☐ Yes ☑ No ☐ NA
Within the area overlying a subsurface mine. - Written confirmation or verification or map from the NM EMNRD-Mining and Minerals Division	☐ Yes ☑ No
Within an unstable area. - Engineering measures incorporated into the design; NM Bureau of Geology & Mineral Resources; USGS; NM Geological Society; topographic map	☐ Yes ☑ No
Within a 100-year floodplain. FEMA map	☐ Yes ☑ No
Within 300 feet of a continuously flowing watercourse, or 200 feet of any other significant watercourse, or lakebed, sinkhole, or playa lake (measured from the ordinary high-water mark). - Topographic map; visual inspection (certification) of the proposed site	☐ Yes ☑ No
Within 1000 feet from a permanent residence, school, hospital, institution, or church in existence at the time of initial application. - Visual inspection (certification) of the proposed site; aerial photo; satellite image	☐ Yes ☑ No
Within 500 horizontal feet of a spring or a fresh water well used for domestic or stock watering purposes, in existence at the time of initial application. - NM Office of the State Engineer - iWATERS database search; visual inspection (certification) of the proposed site	☐ Yes ☑ No
Within 500 feet of a wetland. - US Fish and Wildlife Wetland Identification map; topographic map; visual inspection (certification) of the proposed site	☐ Yes ☑ No

9.
Recycling Facility and/or Containment Checklist:
Instructions: Each of the following items must be attached to the application. Indicate, by a check mark in the box, that the documents are attached.

- ☑ Design Plan - based upon the appropriate requirements.
- ☑ Operating and Maintenance Plan - based upon the appropriate requirements.
- ☑ Closure Plan - based upon the appropriate requirements.
- ☑ Site Specific Groundwater Data -
- ☑ Siting Criteria Compliance Demonstrations –
- ☑ **Certify that notice of the C-147 (only) has been sent to the surface owner(s)**

10.
Operator Application Certification:
I hereby certify that the information and attachments submitted with this application are true, accurate and complete to the best of my knowledge and belief.

Name (Print): Shane McNeely Title: Engineer

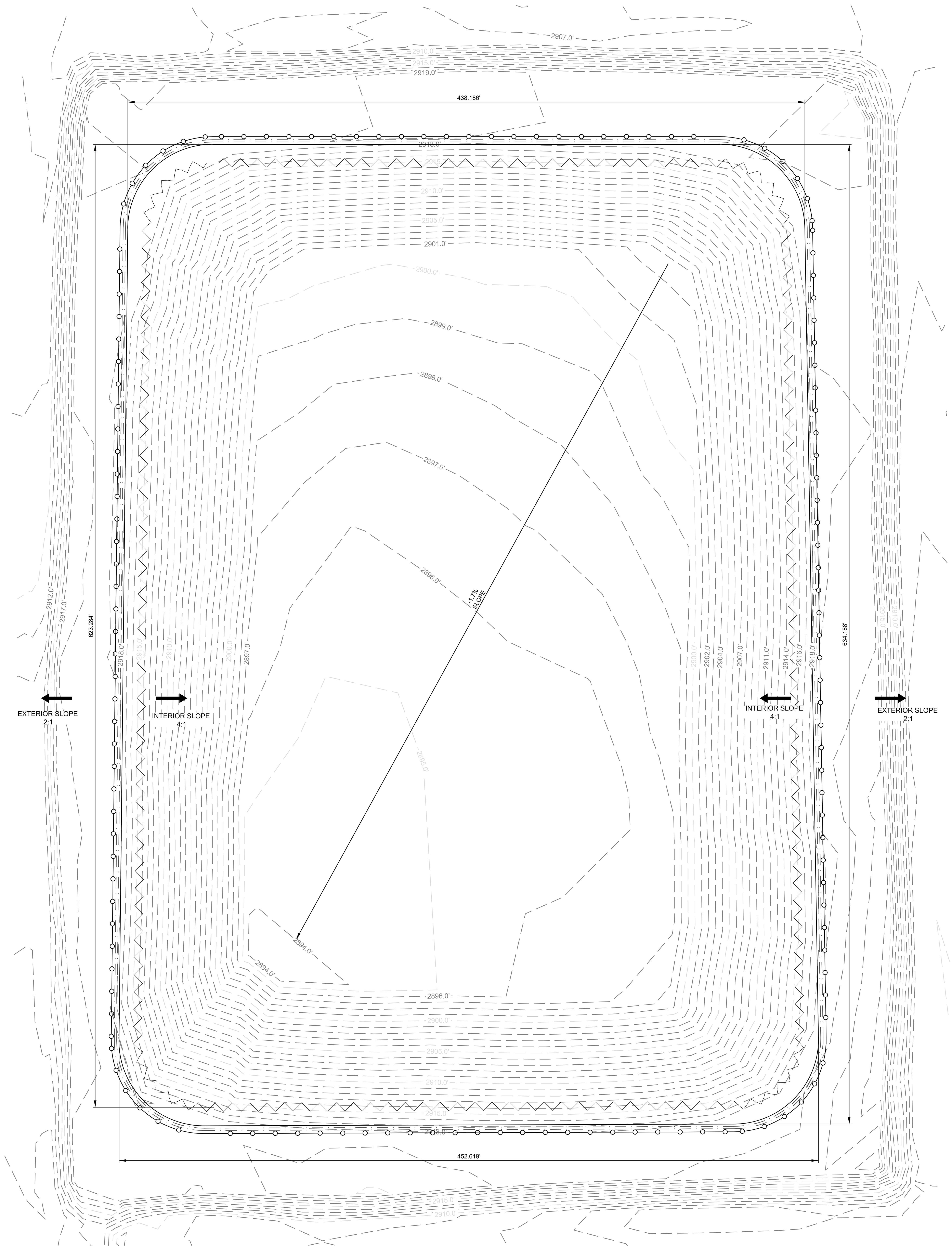
Signature: Shane McNeely Date: 8/28/2023

e-mail address: smcneely@ameredev.com Telephone: 737-300-4729

11.
OCD Representative Signature: Victoria Venegas **Approval Date:** 09/26/2023

Title: Environmental Specialist **OCD Permit Number:** 1RF-508

- ☒ OCD Conditions
- ☐ Additional OCD Conditions on Attachment

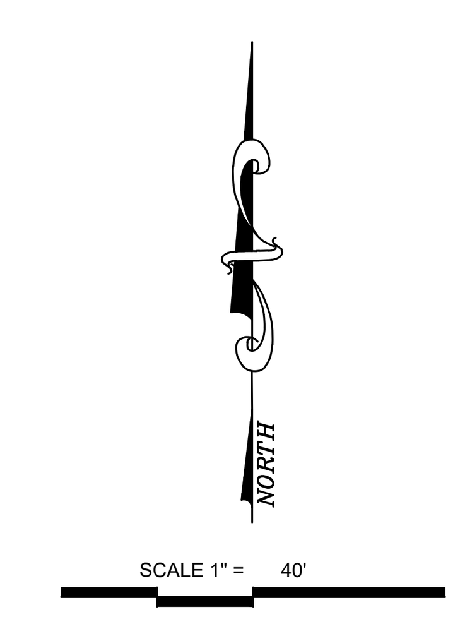


GENERAL NOTES

1. TOPOGRAPHIC INFORMATION OBTAINED FROM PETTIGREW & ASSOCIATES PA. ELEVATIONS ARE PROXIMATE AND MUST BE FIELD VERIFIED.
2. ALL CONSTRUCTION SHALL BE PERFORMED IN ACCORDANCE WITH THE PROJECT CONSTRUCTION PLANS OF THE REGISTRATION/PERMIT. NEW MEXICO STANDARD SPECIFICATIONS FOR PUBLIC WORKS CONSTRUCTION LATEST EDITION SHALL APPLY TO THIS PROJECT.
3. ALL DATA SHOWN HEREIN CONCERNING EXISTING PRIVATE AND/OR PUBLIC OWNED UTILITIES HAVE BEEN OBTAINED FROM THE OWNERS AND/OR FIELD OBSERVATIONS. THESE MAY OR MAY NOT BE ACCURATE. THE CONTRACTOR IS CAUTIONED THAT HE IS RESPONSIBLE FOR THE EXACT LOCATION AND PROTECTION OF ALL LINES DURING CONSTRUCTION. THE CONTRACTOR SHALL BE RESPONSIBLE FOR DETERMINING, IN ADVANCE OF HIS/HER CONSTRUCTION OPERATIONS, IF OVERHEAD UTILITY LINES, SUPPORT STRUCTURES, POLES, GUYS, ETC. ARE AN OBSTRUCTION TO CONSTRUCTION OPERATIONS. IF ANY OBSTRUCTION IS EVIDENT, THE CONTRACTOR SHALL BE RESPONSIBLE FOR COORDINATING WITH THE APPROPRIATE UTILITY OWNER TO REMOVE OR SUPPORT THE UTILITY OBSTRUCTION. ANY COST ASSOCIATED WITH THIS EFFORT IS INCIDENTAL TO THE PROJECT.
4. IT WILL BE THE CONTRACTOR'S RESPONSIBILITY TO SECURE AND SUPPLY WATER FOR THE PROJECT.
5. THE BOTTOM OF PIT SHALL BE SLOPED AT A MINIMUM 1.00%.
6. THE PERIMETER OF THE SITE SHALL BE ENCLOSED WITH GAME FENCE AS PRESCRIBED BY DESIGN/CONSTRUCTION PLAN IN REGISTRATION/PERMIT APPLICATION.
7. STRIP AND STOCKPILE TOP SOIL FOR FUTURE CLOSURE USE AND ENSURE EXCESS MATERIAL IS SEGREGATED FROM TOPSOIL MATERIAL. NEW MEXICO ADMINISTRATIVE CODE 19.15.34 AND (DESIGN AND CONSTRUCTION SPECIFICATIONS FOR A RECYCLING CONTAINMENT IN REGISTRATION/PERMIT) SHALL APPLY TO THIS PROJECT.
8. THE RECYCLING CONTAINMENT SHALL HAVE A PROPERLY CONSTRUCTED FOUNDATION AND INTERIOR SLOPES CONSISTING OF A FIRM, UNYIELDING BASE, SMOOTH AND FREE OF ROCKS, DEBRIS, SHARP EDGES OR IRREGULARITIES TO PREVENT THE LINER'S RUPTURE OR TEAR. GEOTEXTILE IS REQUIRED UNDER AND OVER THE LINER WHEN NEEDED TO REDUCE LOCALIZED STRESS-STRAIN OR PROTUBERANCES THAT OTHERWISE MAY COMPROMISE THE LINER'S INTEGRITY.
9. AS DESCRIBED IN THE DESIGN/CONSTRUCTION PLANS OF THE REGISTRATION/PERMIT, ALL PRIMARY (UPPER) LINERS IN A RECYCLING CONTAINMENT SHALL BE GEOMEMBRANE LINERS COMPOSED OF AN IMPERVIOUS, SYNTHETIC MATERIAL THAT IS RESISTANT TO ULTRAVIOLET LIGHT, PETROLEUM HYDROCARBONS, SALTS AND ACIDIC AND ALKALINE SOLUTIONS. ALL PRIMARY LINERS SHALL BE 60-MIL HDPE LINERS. SECONDARY LINERS SHALL BE 60-MIL HDPE. LINER COMPATIBILITY SHALL MEET OR EXCEED THE EPA SW-846 METHOD 9090A OR SUBSEQUENT RELEVANT PUBLICATIONS.
10. LINER SEAMS SHALL BE MINIMIZED AND ORIENTED UP AND DOWN, NOT ACROSS THE SLOPE.
11. EXPANSION WRINKLE SHALL BE INSTALLED IF NECESSARY INSIDE POND FOR THERMAL EXPANSION / CONTRACTION.
12. UNLESS DIFFERENTLY STATED IN THE CONSTRUCTION PLAN OF THE REGISTRATION PERMIT,THE OPERATOR SHALL ENSURE FIELD SEAMS IN GEOSYNTHETIC MATERIAL ARE THERMALLY SEAMED. PRIOR TO FIELD SEAMING, THE OPERATOR SHALL OVERLAP LINERS FOUR TO SIX INCHES. THE OPERATOR SHALL MINIMIZE THE NUMBER OF FIELD SEAMS AND CORNERS AND IRREGULARLY SHAPED AREAS. THERE SHALL BE NO HORIZONTAL SEAMS WITHIN FIVE FEET OF THE SLOPE'S TOE. QUALIFIED PERSONNEL HAVING MORE THAN 1,000,000 SQ.FT. EXPERIENCE SHALL PERFORM FIELD WELDING AND TESTING. DOCUMENTATION OF LINER WELDERS EXPERIENCE IS REQUIRED TO BE PRESENT.
13. AT POINTS OF DISCHARGE INTO OR SUCTION FROM THE RECYCLING CONTAINMENT, THE OPERATOR SHALL INSURE THAT THE LINER IS PROTECTED FROM EXCESSIVE HYDROSTATIC FORCE OR MECHANICAL DAMAGE. EXTERNAL DISCHARGE OR SUCTION LINES SHALL NOT PENETRATE THE LINER.
14. THE OPERATOR SHALL POST AN UPRIGHT SIGN NO LESS THAN 12 INCHES BY 24 INCHES WITH LETTERING NOT LESS THAN TWO INCHES IN HEIGHT IN A CONSPICUOUS PLACE ON THE FENCE SURROUNDING THE CONTAINMENT. THE OPERATOR SHALL POST THE SIGN IN A MANNER AND LOCATION SUCH THAT A PERSON CAN EASILY READ THE LEGEND. THE SIGN SHALL PROVIDE THE FOLLOWING INFORMATION: THE OPERATOR'S NAME, THE LOCATION OF THE SITE BY QUARTER-QUARTER OR UNIT LETTER, SECTION, TOWNSHIP AND RANGE, AND EMERGENCY TELEPHONE NUMBERS.
15. IT SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR TO CONTACT NEW MEXICO 811 (FORMERLY NEW MEXICO ONE CALL) A MINIMUM OF 48 HOURS BEFORE EXCAVATION. PRIOR TO CONSTRUCTION, THE CONTRACTOR SHALL EXCAVATE AND VERIFY THE HORIZONTAL AND VERTICAL LOCATIONS OF ALL DESIGNATED UNDERGROUND UTILITIES. SHOULD A CONFLICT EXIST, THE CONTRACTOR SHALL NOTIFY THE ENGINEER SO THAT THE CONFLICT CAN BE RESOLVED WITH A MINIMUM AMOUNT OF DELAY.
16. DURING CONSTRUCTION OF THE CONTAINMENT, THE CONTRACTOR WILL REPORT AND RESPOND TO ANY SPILLS OF HAZARDOUS MATERIALS SUCH AS GASOLINE, DIESEL, MOTOR OILS, SOLVENTS, CHEMICALS. TOXIC OR CORROSIVE SUBSTANCES, ETC. A SPILL IS DEFINED AS ANY RELEASE OF A CORROSIVE, HAZARDOUS, TOXIC OR RADIOACTIVE SUBSTANCE THAT MAY BE A THREAT TO PUBLIC HEALTH OR THE ENVIRONMENT. REPORTS OF SPILLS WILL BE MADE IMMEDIATELY TO BOTH THE NEW MEXICO ENVIRONMENT DEPARTMENT EMERGENCY RESPONSE TEAM (505-827-9329 OR 866-428-6535). THE CONTRACTOR WILL BE RESPONSIBLE FOR REPORTING AND CLEANUP OF ANY SPILL ASSOCIATED WITH PROJECT CONSTRUCTION. THE CONTRACTOR WILL BE RESPONSIBLE FOR REPORTING ANY DISCOVERIES OF PAST SPILLS OR CURRENT SPILLS NOT ASSOCIATED WITH CONSTRUCTION.
17. CONTRACTOR MUST OBTAIN CLIENT PERMISSION BEFORE SALVAGING ANY ITEMS SPECIFIED FOR REMOVAL AND DISPOSAL AFTER COMPLETION OF CONSTRUCTION OF THE CONTAINMENT.
18. THE CONTRACTOR SHALL BE RESPONSIBLE FOR OBTAINING DISPOSAL SITES THAT ARE ENVIRONMENTALLY SUITABLE FOR DISPOSAL OF ITEMS NOT SPECIFIED TO BE SALVAGED. THE CONTRACTOR IS EXPECTED TO ABIDE BY ALL FEDERAL, STATE, AND LOCAL LAWS AND REGULATIONS IN OBTAINING THE NECESSARY PERMITS FROM ALL APPLICABLE AGENCIES AND/OR PRIVATE PROPERTY OWNERS. ALL COSTS ASSOCIATED WITH OBTAINING THESE PERMITS SHALL BE INCIDENTAL TO THE COMPLETION OF THE PROJECT AND NO DIRECT MEASUREMENT OR PAYMENT SHALL BE MADE THEREFORE. THE CONTRACTOR SHALL PROVIDE THE ENGINEER WITH COPIES OF ALL PERTINENT INFORMATION, AGREEMENTS, AND PERMITS RELATED TO DISPOSAL SITES UTILIZED. BORROW MATERIAL, ROCK WASTE, AND VEGETATIVE DEBRIS SHALL NOT BE PLACED IN WETLANDS, ARROYOS, OR AREAS THAT MAY IMPACT THREATENED OR ENDANGERED SPECIES. ARCHEOLOGICAL AND ENVIRONMENTAL CLEARANCES MUST BE OBTAINED BEFORE DISPOSAL.
19. LINER INSTALLATION SHALL BE PERFORMED PER INDUSTRY BEST PRACTICES, STANDARDS AND OXY PROVIDED GUIDELINES.

RECYCLING CONTAINMENT	CONCEPTUAL	AS-BUILT	DIFFERENCE IN VOLUME
TOTAL CONTAINMENT VOLUME	1,533,079 BBL	746,334 BBL	786,745 BBL
TOTAL FLUID VOLUME BELOW 3' FREEBOARD ELEVATION	1,283,768 BBL	604,744 BBL	679,024 BBL
DEPTH OF POND	25.00 FT	23.00 FT	
DEPTH OF SUCTION SUMP	26.00 FT	24.00 FT	

NOTE : THE VOLUME CALCULATIONS HAVE BEEN OBTAINED FROM AUTOCAD CIVIL 3D.



PETTIGREW & ASSOCIATES PA
ENGINEERING | SURVEYING | TESTING
DEFINING QUALITY SINCE 1965
100 E. Navajo Drive Suite 100 Hobbs New Mexico 88240
T 575 393 9827 F 575 393 1543
Pettigrew.us

NOT FOR CONSTRUCTION
DRAFT
NOT FOR CONSTRUCTION

PROJECT ENGINEER:	DAVID ROYBAL, P.E.
PROJECT DESIGNER:	TT
DRAWN BY:	TT

LEGEND

- FINISH GRADE 1.0' CONTOUR
- FINISH GRADE 5.0' CONTOUR
- 3' FREEBOARD DEPTH
- 6' CHAIN LINK FENCE
- ANCHOR TRENCH

REVISIONS

No.	DATE	DESCRIPTION

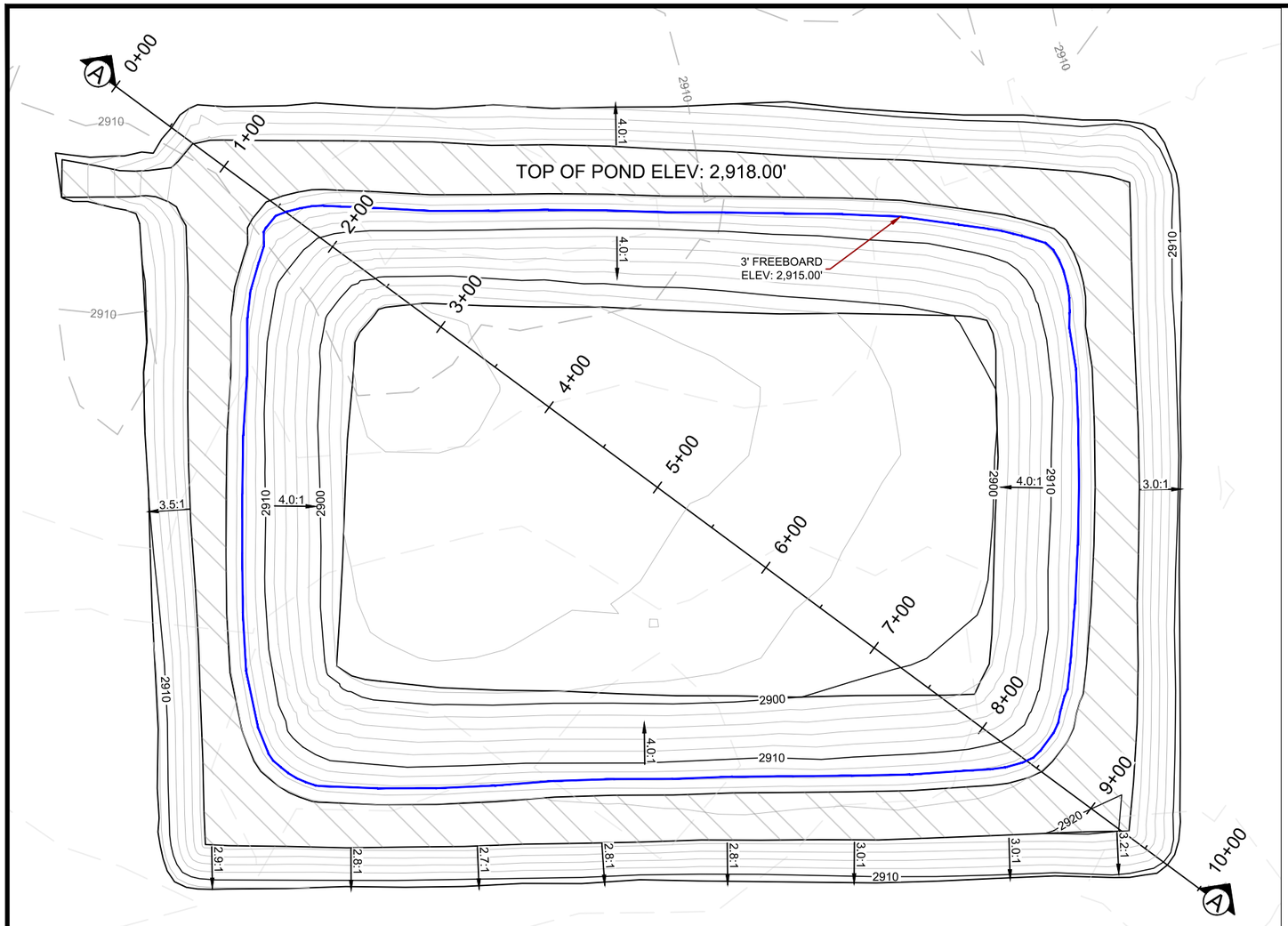
AS-BUILT PLAN

IKE'S RECYCLING CONTAINMENT #1 AND RECYCLING FACILITY

AMEREDEV OPERATING, LLC

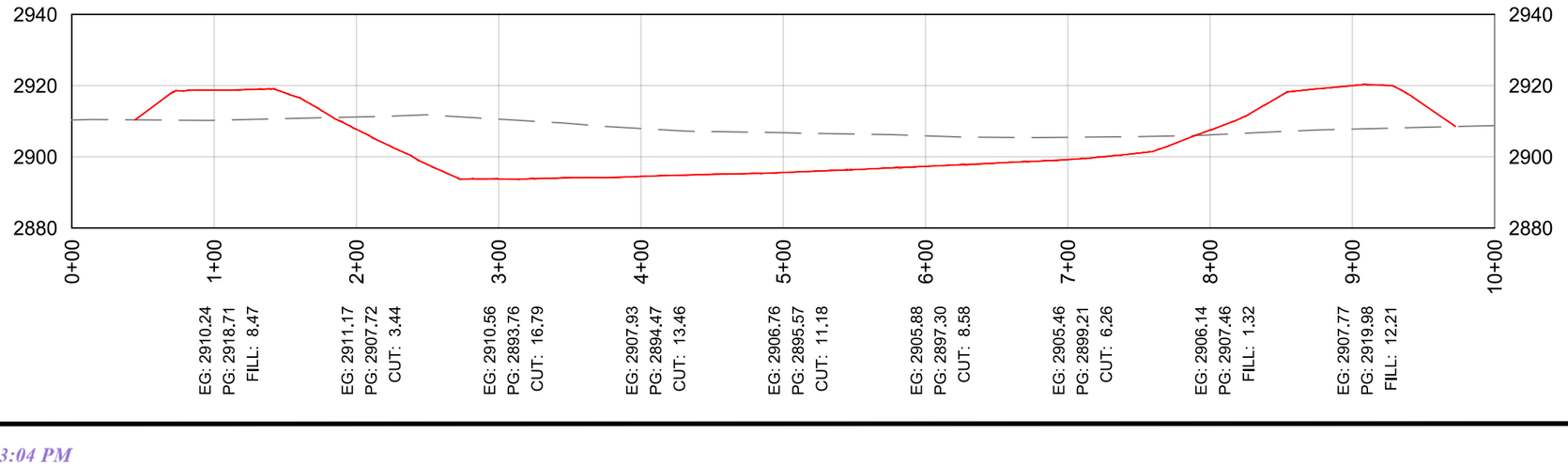
PROJECT NUMBER: 2018.1032

SHEET: CS-101



ELEV	DEPTH (FT)	AREA (ACRES)	VOLUME (BBLS)	VOLUME (ACRE FT)	VOLUME (CY)
2893.30	0.00	0.00	0.25	0.00	0.05
2893.80	0.50	0.15	230.46	0.03	47.92
2894.30	1.00	0.31	1091.81	0.14	227.04
2894.80	1.50	0.61	2804.75	0.36	583.24
2895.30	2.00	0.96	5824.34	0.75	1211.16
2895.80	2.50	1.32	10234.71	1.32	2128.29
2896.30	3.00	1.65	15989.52	2.06	3324.98
2896.80	3.50	1.92	22908.88	2.95	4763.85
2897.30	4.00	2.16	30789.46	3.97	6402.60
2897.80	4.50	2.41	39639.75	5.11	8243.00
2898.30	5.00	2.67	49485.05	6.38	10290.31
2898.80	5.50	2.91	60310.05	7.77	12541.34
2899.30	6.00	3.13	72031.55	9.28	14978.80
2899.80	6.50	3.30	84518.82	10.89	17575.50
2900.30	7.00	3.43	97568.26	12.58	20289.10
2900.80	7.50	3.53	111064.19	14.32	23095.55
2901.30	8.00	3.63	124948.78	16.11	25982.82
2901.80	8.50	3.72	139184.90	17.94	28943.19
2902.30	9.00	3.80	153751.49	19.82	31972.28
2902.80	9.50	3.88	168637.35	21.74	35067.76
2903.30	10.00	3.96	183839.40	23.70	38228.99
2903.80	10.50	4.05	199362.08	25.70	41456.90
2904.30	11.00	4.13	215202.78	27.74	44750.94
2904.80	11.50	4.21	231367.96	29.82	48112.45
2905.30	12.00	4.30	247859.63	31.95	51541.86
2905.80	12.50	4.39	264681.16	34.12	55039.85
2906.30	13.00	4.47	281834.69	36.33	58606.89
2906.80	13.50	4.56	299323.52	38.58	62243.66
2907.30	14.00	4.65	317148.90	40.88	65950.40
2907.80	14.50	4.73	335302.98	43.22	69725.50
2908.30	15.00	4.82	353782.00	45.60	73568.18
2908.80	15.50	4.90	372591.02	48.02	77479.47
2909.30	16.00	4.99	391725.20	50.49	81458.38
2909.80	16.50	5.07	411187.60	53.00	85505.54
2910.30	17.00	5.16	430974.48	55.55	89620.18
2910.80	17.50	5.24	451079.09	58.14	93800.89
2911.30	18.00	5.32	471492.20	60.77	98045.75
2911.80	18.50	5.40	492209.00	63.44	102353.76
2912.30	19.00	5.48	513227.93	66.15	106724.60
2912.80	19.50	5.57	534549.34	68.90	111158.34
2913.30	20.00	5.65	556178.77	71.69	115656.13
2913.80	20.50	5.75	578127.80	74.52	120220.38
2914.30	21.00	5.85	600421.28	77.39	124856.26
2914.80	21.50	5.95	623094.00	80.31	129571.00
2915.00	21.70	5.99	632257.26	81.49	131476.48
2915.30	22.00	6.04	646100.30	83.28	134355.11
2915.80	22.50	6.14	669421.45	86.28	139204.69
2916.30	23.00	6.21	693033.33	89.33	144114.73
2916.80	23.50	6.28	716875.66	92.40	149072.69
2917.30	24.00	6.33	740920.53	95.50	154072.77
2917.80	24.50	6.38	765153.02	98.62	159111.86
2918.00	24.70	6.39	774890.97	99.88	161136.84

3' FREEBOARD



SCALE: 1" = 100'

0' 50' 100'

TOPOGRAPHIC
LOYALTY INNOVATION LEGACY
1400 EVERMAN PARKWAY, Ste. 146 • FT. WORTH, TEXAS 76140
TELEPHONE: (817) 744-7512 • FAX (817) 744-7548
WWW.TOPOGRAPHIC.COM

AS-BUILT CALCULATIONS

IKE POND

FOR

AMEREDEV OPERATING LLC

REVISION:	
XXX	XX/XX/XXXX

DATE: 05/25/18

FILE: IKE_POND

DRAWN BY: ARG

REVIEWED BY: CCC

SCALE: 1" = 100'

SHEET : 1 OF 1

February 2018

C-147 Registration Package for Ike's Recycling Containment #1 and Recycling Facility Section 27 T26S R36E, Lea County

View to east-southeast from west-center area of the proposed containment showing the vegetated sand dunes. High magnification of this image revels the abandoned windmill east of County Road 32.

Prepared for:
Ameredev Operating LLC
Austin, Texas

Prepared by:
R.T. Hicks Consultants, Ltd.
901 Rio Grande NW F-142
Albuquerque, New Mexico

R. T. HICKS CONSULTANTS, LTD.
901 Rio Grande Blvd NW ▲ Suite F-142 ▲ Albuquerque, NM 87104 ▲ 505.266.5004 ▲ Fax: 505.266-0745

February 13, 2018

Ms. Olivia Yu
Mr. Bradford Billings
NMOCD District
1625 French Drive
Hobbs, NM 88240
Via E-Mail

RE: Ameredev Operating – Ike's Containment #1 C-147 Registration

Dear Ms. Yu and Mr. Billings:

On behalf of Ameredev Operating, Hicks Consultants submits the attached registration. Grading, compaction and geotechnical testing of the containment and liner foundation is complete. No variances from the Rule are necessary and this submittal demonstrates compliance with all mandates of the Rule for the containment. Since the recycling facility meets the criteria of 19.15.34.9.B.7, the facility also requires a registration. Thus, the Rule does not require approval by OCD in advance of using the containment. However, we understand that OCD desires to track the containments in New Mexico that do not employ the specific words or values in the Rule. To that end, the C-147 shows that the "permit" box is checked as is the "variance" box.

This submission includes the following elements that, for the purpose of OCD statistics, would be listed as variances:

1. An equivalency demonstration (variance) written by experts for the proposed 40-mil HDPE secondary liner. OCD has previously concurred that this material is equivalent to the 30-mil LLDPEr specified in the Rule for a secondary liner. We maintain that the language of the Rule is clear[1] and a variance is not required.
2. The proposed Avian Protection Plan is exactly the same as those approved by OCD for other containments. Thus, the plan meets the requirement of the rule that the "otherwise protective of wildlife, including migratory birds" and a variance is not required. For OCD statistics, this would be considered a variance.
3. Using a 6-foot high chain link fence in lieu of a 4-strand barbed wire fence is not a variance. Because feral pigs, javelena and deer are present in the area, a fence is required in order to comply with Section 19.15.34.12 D.1 of the Rule[2]. The specification for fencing provided in 19.15.34.12 D.2 contradicts D.1 because pigs will move beneath the lower strand of a 4-strand, 4-foot high barbed wire fence and deer will jump over. Thus, compliance with D.2 results in a violation of D.1. We maintain that compliance with D.1 is the critical component of the Rule and operators need not be required to submit a variance request in order to follow Best Management Practices and comply with the Rule. For OCD statistics, this would be considered a variance.

[1] Secondary liners shall be 30-mil LLDPE string reinforced or equivalent with a hydraulic conductivity no greater than 1 x 10-9 cm/sec

[2] The operator shall fence or enclose a recycling containment in a manner that deters unauthorized wildlife and human access and shall maintain the fences in good repair.

Site specific information demonstrates compliance with siting criteria for the location. Appendix A includes engineering design for the containment. This registration package includes design/construction, operating and maintenance, and closure plans in Appendices B, C and D. Additionally we include a site survey and photographs of the proposed containment area in Appendix E.

In compliance with 19.15.34.10 of the Rule, this submission is copied to Ameredev New Mexico LLC who is the surface owner of the private surface upon which the containment is constructed.

If you have any questions or concerns regarding this amendment to the registration or the attached C-147, please contact me. As always, we appreciate your work ethic and attention to detail.

Sincerely,
R.T. Hicks Consultants

Randall Hicks
Principal

Copy: Ameredev Operating, LLC
Ameredev New Mexico, LLC

Statement Explaining Why the Applicant Seeks Equivalency

The prescriptive mandates of the Rule that are the subject of this demonstration of equivalency are the following with *emphasis* added:

> **19.15.34.12 A. (4)** All primary (upper) liners in a recycling containment shall be geomembrane liners composed of an impervious, synthetic material that is resistant to ultraviolet light, petroleum hydrocarbons, salts and acidic and alkaline solutions. All primary liners shall be 30-mil flexible PVC, 45-mil LLDPE string reinforced or 60-mil HDPE liners. *Secondary liners shall be 30-mil LLDPE string reinforced or equivalent with a hydraulic conductivity no greater than 1 x 10-9 cm/sec.* Liner compatibility shall meet or exceed the EPA SW-846 method 9090A or subsequent relevant publications.

There are several reasons for requesting OCD agree that 40-mil HDPE for the secondary liner is equivalent to 30 mil LLDPEr. In addition to the reasons described in detail in the attached documents of support are the following logistical reasons:

1. The 30-mil LLDPEr is comprised of two 15-mil panels of LLDPE that are bonded together with the string mesh between. A minor concern is a puncture to the upper panel could allow fluid to wick along the string mesh. Thus, chemicals that may be slightly deleterious to 30-mil LLDPE can attack the 15-mil upper panel from the top surface and from the fluid in the wet mesh. A single layer of HDPE eliminates this potential problem.
2. Non-destructive testing of liner seams is not possible with the string-reinforced LLDPE material.
3. HDPE is more available in the market that LLDPEr

As the installed cost of the 30-mil LLDPEr is essentially the same as the smooth 40-mil HDPE, economics is not a factor in the decision to use HDPE in lieu of LLDPE.

We believe that the attached documents provide the demonstration that 40-mil HDPE is equivalent to 30-mil LLDPEr as a secondary liner. Some attributes of LLDPE superior to HDPE and some are inferior. On balance, we believe that performance is equivalent, based upon our reading of the attached documents and consideration of the logistical concerns listed above.

4898 Tarry Glen Drive
Suwanee, GA 30024

(404) 596-1838

November 3, 2017

Mr. Rod Kirch
Exterme Plastics Plus
15931 Interstate 35 Frontage Road
Moore, TX 78057

Project: Containment Liner

RE: Hydraulic Performance of HDPE

Dear Rod:

40-mil HDPE provides equal or better protection of fresh water, public health and the environment than 30-mil string reinforced LLDPE. Also the 40-mil HDPE liner has a hydraulic conductivity no greater than 1 x 10^{-9} cm/sec. Liner compatibility shall meet or exceed the EPA SW-846 method 9090A or subsequent relevant publications.

Respectfully,

Clay Reichert, P.E.
Technical Manager

R.K. FROBEL & ASSOCIATES
Consulting Engineers

Mr. Randall Hicks, PG
R.T. Hicks Consultants Ltd.
901 Rio Grande NW
Suite F-142
Albuquerque, New Mexico 87104

November 26, 2017

RE: Technical Memorandum
40 mil HDPE Geomembrane Equivalency as a Secondary Liner System
Merchant Recycling Containment and Recycling Facility
Lea County, New Mexico

Dear Mr. Hicks:

At your request, I have investigated the suitability of application for 40 mil HDPE geomembrane as an equivalent secondary liner to 30 mil scrim reinforced LLDPE (LLDPEr) in the Merchant Recycling Facility Containment Design. In summary, it is my professional opinion that the specified 40 mil HDPE geomembrane will provide a secondary liner system that is equal to or better than 30 mil scrim reinforced LLDPEr and will provide the requisite protection of fresh water, public health and the environment for many years and especially for the estimated design and operation life of the Merchant Recycling Containment.

I have reviewed your C-147 Registration Package and the Design documentation provided by R.T Hicks Consultants. It is understood that the lining system is composed of a 60 mil HDPE Primary liner, geonet drainage layer and a 40 mil HDPE Secondary liner. In consideration of the secondary lining system application, size of impoundment and depth, design details as well as the chemical nature of typical processed water, it is my professional opinion that the 40 mil HDPE geomembrane will provide the requisite barrier against processed water loss and will function effectively as a secondary liner. The following are discussion points that hopefully will exhibit the equivalency of a 40 mil HDPE secondary liner to that of a 30 mil LLDPEr.

The nature and formulation of the 40 mil HDPE resin is the same as the Primary 60 mil HDPE. The major difference is that the 40 mil HDPE is lower in thickness (more flexible and less puncture resistant). However, in covered conditions, HDPE will resist aging and degradation and remain intact for many decades. In fact, a secondary liner of 40 mil HDPE will outlast an exposed 60 mil HDPE liner. According to the Geosynthetic Research Institute (GRI) study on lifetime prediction (GRI Paper No. 6), the half life of HDPE (GRI GM 13) exposed is > 36 years and the half-life of HDPE covered or buried is greater than 100 years (the Merchant Recycling Facility life span is expected to be only 10 years maximum). It is understood that in order to ensure compliance of materials, the primary 60 mil HDPE to be used must meet or exceed GRI GM 13 Standards. Likewise, the secondary liner that is not exposed to the same environmental and chemical conditions must meet or exceed GRI GM 13 for non-reinforced HDPE. Adhering to the

minimum requirements of the GRI Specifications, 40 mil HDPE when used as a secondary liner will be equally as protective as the primary 60 mil HDPE liner (reference: www.geosynthetic-institute.org/grispecs) and equally as protective as a 30 mil scrim reinforced LLDPEr liner.

Durability of Geomembranes is directly affected by exposure conditions. Buried or covered geomembranes are not affected by the same degradation mechanisms (UV, Ozone, Chemical, Stress, Temperature, etc) as are fully exposed geomembranes. In this regard, the secondary liner material and thickness can be much less robust than the fully exposed primary liner which in this case is 60 mil HDPE. This is also the case for landfill lining systems where the secondary geomembrane in a bottom landfill cell may be 40 mil HDPE.

Thermal Fusion Seaming Requirements. Thermal seaming and QC seam test requirements for geomembranes are product specific and usually prescribed by the sheet manufacturer. Dual wedge thermal fusion welding is commonly used on HDPE and QC testing by air channel (ASTM D 5820) is fully acceptable and recognized as an industry standard. In this regard, there should be no exception requirement for seaming and QC testing as both the Primary and Secondary geomembranes are HDPE. This is fully covered in comprehensive specifications for both the Primary and Secondary geomembranes (Reference: www.ASTM.org/Standards).

Potential for Leakage through the Primary and Secondary Liners. Leakage through geomembrane liners is directly a function of the height of liquid head above any hole or imperfection. The geonet drainage media provides immediate drainage to a low point or sump and thus no hydrostatic head or driving gradient is available to push leakage water through a hole in the secondary liner. In this regard, secondary geomembrane materials can be (and usually are) much less in thickness and also polymer type. Hydraulic Conductivity through the 40 mil HDPE liner material is extremely low due to the polymer type, structure and crystallinity and exceeds requirements of EPA SW-846 Method 9090A.

Chemical Attack. Chemical attack to polymeric geomembranes is directly a function of type of chemical, temperature and exposure time. Again, the HDPE Primary provides the chemically resistant liner and is QC tested to reduce potential defects or holes. If there is a small hole, the geonet drain takes any leakage water immediately to the sump for extraction. Thus, exposure time is very limited on a secondary liner in addition to low temperature, little volume and virtually no head pressure. In this regard, a chemically resistant geomembrane material such as 40 mil HDPE can be specified for the secondary and is a fully acceptable alternate to 30 mil scrim reinforced LLDPEr.

Mechanical Properties Characteristics. Geomembranes of different polymer and/or structure (i.e., reinforced vs non-reinforced) can not be readily compared using such characteristics as tensile stress/strain, tear, puncture and polymer requirements. For a 40 mil HDPE liner material to function as a Secondary liner it should meet or exceed the manufacturers minimum requirements for Density, Tensile Properties, Tear, Puncture as

well as other properties such as UV resistance. The sheet material must also meet or exceed GRI GM 13 minimum requirements. In this regard, a 40 mil HDPE will be equivalent to a 30 mil LLDPEr as a secondary liner for the conditions listed below:

- The subgrade or compacted earth foundation will be smooth, free of debris or loose rocks, dry, unyielding and will support the lining system.
- The side slopes for the containment shall be equal to or less than 3H:1V.
- The physical properties and condition of the subgrade or liner foundation (i.e., density, slope, moisture) will be inspected and certified by a Professional Engineer that it meets or exceeds specification requirements.
- Immediately prior to installation, the installation contractor shall inspect and sign off on the subgrade conditions that they meet or exceed the HDPE manufacturer and installers requirements.
- A protective geotextile will be placed on the finished and accepted subgrade between subgrade and the 40 mil HDPE Secondary liner.
- A 200 mil geonet will be placed over the 40 mil HDPE Secondary Liner.
- A 60 mil HDPE Primary liner will be placed over the 200 mil geonet drainage layer.

If you have any questions on the above technical memorandum or require further information, give me a call at 720-289-0300 or email geosynthetics@msn.com

Sincerely Yours,

R K Frobel

Ronald K. Frobel, MSCE, PE

References:

C-147 Registration Package
Merchant Recycling and Containment
Section 35 T 21 SR 33 E Lea County
November 2016

Design Documents
Merchant Recycling and Containment

Geosynthetic Research Institute (GRI) Published Standards and Papers 2017
www.geosynthetic-institute.org

ASTM Geosynthetics Standards 2017
www.ASTM.org/Standards

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November 2, 2017

Attn: Mr. Rod Kirch

Project: Containment Liner

RE: UV Resistance and Chemical Resistance of HDPE

Dear Rod,

Polyethylene (PE) has a simple chain structure with a repeating unit,-(CH2)-. Its physical properties are greatly dependent upon the chain length, structure, and density. HDPE is a semi-crystalline polymer which consists of amorphous (disorder region) and crystalline (ordered structure phases). Due to the long linear chain structure, the degree of crystallinity of HDPE is much higher than LLDPE. The differences in crystallinity can affect the oxidation behavior partly because the diffusion of oxygen through the amorphous region is much easier than through the crystalline region.

Regarding the UV resistance of the two type of polyethylene, attached is the GRI White Paper #6, Geomembrane Lifetime Prediction: Unexposed and Exposed Condition. On page 10, the authors stated "The nature of the LLDPE resin and its formulation is very similar to HDPE. The fundamental difference is that LLDPE is a lower density, hence lower crystallinity, than HDPE;e.g., 10% versus 50%. This has theeffect of allowing oxygen to diffuse into the polymer structure quicker, and likely decreases Stages A and C. How much is uncertain since no data is available, but it is felt that the lifetime of LLDPE will be somewhat reduced with respect to HDPE." On page 23, Table 6, it listed the lifetime prediction of various types of geomembrane, including 1.5mm HDPE and 1.0mm LLDPE.

According to Geosynthetics from David I. Cook in Table 6, page 17, the chemical resistance of HDPE is rated "Excellent" and LLDPE is rated "Good". We also attached part of the report, p.15 to 18, for your information.

Please feel free to contact me if you have any question.

Sincerely,

Connie Wong, Ph.D.,
Support Engineer
cowong@gseworld.com

These EN requirement standards instruct manufacturers to declare the mean value and tolerance of certain product characteristics. The required characteristics depend on the end use and function (separation, filtration, etc.) of the fabric. These characteristics are determined by some of the test methods listed in **Table 3**. Some tests (referred to as H tests in the standards) are mandatory, i.e., required by Mandate M/107 issued by the European Community to the European standardisation committee for geotextiles, CEN 189. Some (referred to as A tests in the standards) are relevant to all conditions of use. The A tests are not legally required but are commercially important. A third test category (S) is relevant to specific conditions of use.

For more information and detail on the CPD and CE marking of geotextiles, the reader is recommended to consult a relevant and useful web site on quality and standardisation of geotextiles (www.vinci-quality.com).

It should be noted that 'geotextile related products' includes all other categories of geosynthetic except geomembranes and GCLs. The latter two groups are now known as 'geosynthetic barriers' and are in a separate CPD sector from geotextiles and related products.

The application standards for geosynthetic barriers are, at the time of writing, still at the provisional stage (prENs). There are five provisional geosynthetic barrier standards (www.vinci-quality.com):

- prEN 13361 reservoir and dam construction
- prEN 13362 canal construction
- prEN 13491 fluid barrier in tunnel and underground structures
- prEN 13492 liquid waste containment
- prEN 13493 solid and hazardous waste storage

4 Geomembranes

4.1 Description and Manufacturing

Geomembranes are thin, flexible sheets of material with very low permeability. They are manufactured from synthetic or bituminous products and may be strengthened with a fabric or film. Geomembranes are employed invariably as a barrier to prevent the passage of gases and fluids.

A commonly accepted definition of a geomembrane from the ASTM is:

> A geomembrane is a continuous membrane liner or barrier having sufficiently low permeability to control migration of fluids in a constructed project, structure or dam.

The original geomembranes were made of butyl rubber. Nowadays, polyvinyl chloride (PVC) or some form of polyethylene account for a high proportion of the total geomembrane useage. The different types of geomembrane polymer will be discussed in more detail later (Section 4.2).

The manufacture of geomembranes commences with the production of the raw materials, i.e., the polymer resin and a wide range of additives such as stabilisers, plasticisers, softeners, fillers, processing aids etc.

The raw materials can then be processed in three ways:

The first method produces the simplest type of geomembrane; single ply and non-reinforced. In this method the raw materials are blended and compounded before being extruded as sheets or cylinders. The extruder produces sheet material 0.1 to 5 mm thick and 1 to 5 m wide. Calendering, or pressing the sheets between counter rotating rollers, works them into uniform thickness and improves the mechanical properties. Full thickness sheets can also be blown into a large long bubble which is cut and opened into the final sheet form.

In the second method, multi-ply geomembranes are made by laminating several layers together. Laminated geomembranes can be non-reinforced or reinforced by inclusion of a fabric scrim between the layers. The scrim improves the mechanical properties (e.g., tensile and tear strength) of the composite material but does not reinforce the soil on which the geomembrane is placed.

The third production method is known as spread coating. In this method, a geotextile, usually a needle-punched non-woven, is used as a substrate on which the molten polymer is spread into its final thickness.

Geomembrane manufacturing methods are described in more detail in (a.9).

The surface of some geomembranes is roughened or textured, by spraying or embossing, to increase the soil/polymer friction (a.19). Three common techniques are coextrusion, lamination and impingement (a.20):

- Coextrusion uses a blowing agent in the extrudate which expands on cooling to cause a roughened surface.
- In lamination, a sheet containing a foam is adhered to a conventional sheet. The foaming agent provides a froth that produces a rough, textured laminate stuck to the smooth, solid sheet.
- Impingement is the projection of hot particles on to the smooth sheet.

A review of these texturing techniques and a discussion on characterisation of the surface topography has been presented by Zettler and co-workers (7).

4.2 Polymers

The vast majority of geomembranes are thin sheets of flexible thermoplastic or thermosetting polymeric materials. The main polymers used are (a.9):

Thermoplastic polymers

- Polyethylene (PE) – high density (HDPE), medium density (MDPE), linear low density (LLDPE), low density (LDPE), very low density (VLDPE)
- Polypropylene (PP)
- Polyvinyl chloride (PVC)
- Chlorinated polyethylene (CPE)
- Polyamide (PA)

Thermoset polymers

- Isoprene-isobutylene (IIR) or butyl rubber
- Epichlorohydrin rubber
- Ethylene-propylene-diene terpolymer (EDPM)
- Polychloroprene (Neoprene)
- Ethylene-propylene terpolymer (EPT)
- Ethylene-vinyl acetate (EVA)
- Ethylene interpolymer alloy (EIA)

Combination polymers

- PVC-nitrile rubber
- PE-EPDM
- PVC-EVA
- Crosslinked CPE
- Chlorosulfonated polyethylene (CSPE) 'Hypalon'

Others

- Bitumen impregnated geotextiles
- Elastomer impregnated geotextiles
- Aluminium foil coated geomembranes for protection against hydrocarbons (329).

Which geomembrane polymer to choose depends, as usual, on its properties, availability and, of course, on the application and structure in which the geomembrane is to be incorporated. The properties will be discussed in more detail in Section 4.4 (Testing).

No study appears to have been performed which compares the properties of all these polymers as geomembrane sheets. However, **Table 6** (a.21) provides a useful qualitative comparison of geomembrane liners made from eight polymers and, another type of geosynthetic barrier known as a geosynthetic clay liner (GCL). The attributes considered are physical properties, durability, installation damage, seaming and cost.

Table 6 refers to seaming methods, that is to say the techniques used to join together the membrane sheets either at the factory or on site. Production of a leak tight and durable seam is clearly vital otherwise the geomembrane's function as a fluid barrier is lost. There are several general seaming methods. The choice is governed by the polymer and site requirements.

- Solvent: A liquid solvent is brushed between two sheets of membrane followed by pressure to form the seal.
- Adhesive: A glue dissolved in a solvent is applied by brush or roller to the membrane sheets which are brought together after the surface becomes tacky.

Table 6 Geomembranes; comparison of polymers								
Attribute	**HDPE**	**LLDPE**	**PVC**	**EPDM**	**EIA**	**Reinforced CSPE**	**Flexible PP**	**GCL**
Chemical resistance	Excellent	Good	Fair	Good	Excellent (when cured)	Excellent	Excellent	Fair
Hydrocarbon resistance	Good	Good	Fair	Good	Excellent (when cured)	Good	Good	Poor
Weathering; UV resistance	Excellent	Fair	Poor	Excellent	Excellent (when cured)	Excellent	Excellent	Poor
Thermal stability	Poor	Poor	Good	Excellent	Good	Excellent	Good – excellent when reinforced	Good
Tensile properties	Good	Good	Good	Good	Excellent	Excellent	Good – excellent when reinforced	Good
Elongation; uniaxial	Excellent	Excellent	Good	Good	Fair	Good	Excellent	Fair
Elongation; multiaxial	Poor	Excellent	Excellent	Good	Fair	Good	Excellent	Fair
Puncture resistance	Fair	Excellent	Excellent	Good	Excellent	Good	Good	Good
Stress cracking	Fair	Good	Does not occur	Does not occur	Does not occur	Does not occur	Does not occur	Does not occur
Resistance to installation damage	Fair	Fair	Excellent	Excellent	Good	Good	Excellent	Good
Seaming methods	Thermal/ excellent	Thermal/ excellent	Thermal or solvent bonding/ good	Tape seams/good	Thermal/ excellent	Thermal or solvent bonding good	Thermal/ excellent	Laps only
Ease of repair in service	Good	Good	Good	Good	Good	Poor needs adhesives	Excellent	NA
Flexibility	Fair	Excellent	Good	Good	Good	Good	Excellent	NA
Roll cost	Low	Low/ medium	medium	Medium/ high	High	High	Medium	Medium
Reproduced with permission from M. Sadlier (a.21)								

- Thermal: There is a range of thermal methods in which the opposing surfaces are melted by some means such as hot air or electrically heated knife or wedge. The melted surfaces are pressed together by rollers.
- Mechanical: The usual mechanical joining methods are utilisation of sticky tapes or sewing. The sewn seams are subsequently waterproofed.

The solvent and adhesive methods tend to be used for thermoplastic polymers and elastomers such as PVC,

CPE, EDPM, and CSPE. Thermal methods can be employed for most thermoplastic polymers but are especially important for semi-crystalline polyethylene materials like HDPE and LDPE. A more detailed description of geomembrane seaming is given in Chapter 5 of Designing with Geosynthetics by Koerner (a.9).

Some further advantages and disadvantages of specific polymers are now given.

PVC (polyvinyl chloride)

- Tough without reinforcement
- Good seams by dielectric, solvent or heat
- Elasticised for flexibility, plasticiser leaches with time

CPE (chlorinated polyethylene)

- Seams easy to make by dielectric or solvent
- Plasticised with PVC

CSPE (chlorosulfonated polyethylene thermoplastic rubber)

- Good seams by heat or adhesive

Butyl

- Poor field seams
- Low gas permeability

CP (chloroprene/neoprene cured rubber)

- Fair field seams using solvent and tape

HDPE

- Good seams by thermal or extrusion methods
- Low friction surfaces
- High thermal expansion and contraction

MDPE, LDPE and VLDPE

- Good seams by thermal or extrusion methods
- Moderate thermal expansion and contraction

LLDPE

- High friction surface
- Good seams by thermal or extrusion methods
- Large variation in thickness

Further comparative properties are given in **Table 7** which has been generated from information in references a.9 and a.22.

Table 7 Geomembrane polymers: advantages and disadvantages

Factor	PVC	CPE	CSPE	Butyl	CP	HDPE	MDPE LDPE VLDPE	LLDPE
Cost	low	medium	medium	medium to high	high	low	low	medium
Chemical resistance	-	good	good	-	good	excellent	good	very good
Weathering	poor	good	excellent	fair to good	good	-	-	-
High temperature	poor	-	fair	good	good	-	-	-
Cold crack	poor	good	good	-	-	-	-	-
Stress crack	-	-	-	-	-	sensitive	none	none

CP = chloroprene rubber

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GRI White Paper #6

- on -

Geomembrane Lifetime Prediction:
Unexposed and Exposed Conditions

by

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Original: June 7, 2005

Updated: February 8, 2011

Geomembrane Lifetime Prediction: Unexposed and Exposed Conditions

1.0 Introduction

Without any hesitation the most frequently asked question we have had over the past thirty years' is "how long will a particular geomembrane last".* The two-part answer to the question, largely depends on whether the geomembrane is covered in a timely manner or left exposed to the site-specific environment. Before starting, however, recognize that the answer to either covered or exposed geomembrane lifetime prediction is neither easy, nor quick, to obtain. Further complicating the answer is the fact that all geomembranes are formulated materials consisting of (at the minimum), (i) the resin from which the name derives, (ii) carbon black or colorants, (iii) short-term processing stabilizers, and (iv) long-term antioxidants. If the formulation changes (particularly the additives), the predicted lifetime will also change. See Table 1 for the most common types of geomembranes and their approximate formulations.

Table 1 - Types of commonly used geomembranes and their approximate formulations (based on weight percentage)

Type	Resin	Plasticizer	Fillers	Carbon Black	Additives
HDPE	95-98	0	0	2-3	0.25-1
LLDPE	94-96	0	0	2-3	0.25-3
fPP	85-98	0	0-13	2-4	0.25-2
PVC	50-70	25-35	0-10	2-5	2-5
CSPE	40-60	0	40-50	5-10	5-15
EPDM	25-30	0	20-40	20-40	1-5

HDPE = high density polyethylene
LLDPE = linear low density polyethylene
fPP = flexible polypropylene
PVC = polyvinyl chloride (plasticized)
CSPE = chlorsulfonated polyethylene
EPDM = ethylene propylene diene terpolymer

* More recently, the same question has arisen but focused on geotextiles, geogrids, geopipe, turf reinforcement mats, fibers of GCLs, etc. This White Paper, however, is focused completely on geomembranes due to the tremendous time and expense of providing such information for all types of geosynthetics.

The possible variations being obvious, one must also address the degradation mechanisms which might occur. They are as follows accompanied by some generalized commentary.

- Ultraviolet Light - This occurs only when the geosynthetic is exposed; it will be the focus of the second part of this communication.
- Oxidation - This occurs in all polymers and is the major mechanism in polyolefins (polyethylene and polypropylene) under all conditions.
- Ozone - This occurs in all polymers that are exposed to the environment. The site-specific environment is critical in this regard.
- Hydrolysis - This is the primary mechanism in polyesters and polyamides.
- Chemical - Can occur in all polymers and can vary from water (least aggressive) to organic solvents (most aggressive).
- Radioactivity - This is not a factor unless the geomembrane is exposed to radioactive materials of sufficiently high intensity to cause chain scission, e.g., high level radioactive waste materials.
- Biological - This is generally not a factor unless biologically sensitive additives (such as low molecular weight plasticizers) are included in the formulation.
- Stress State – This is a complicating factor which is site-specific and should be appropriately modeled in the incubation process but, for long-term testing, is very difficult and expensive to acheive.
- Temperature - Clearly, the higher the temperature the more rapid the degradation of all of the above mechanisms; temperature is critical to lifetime and furthermore is the key to

time-temperature-superposition which is the basis of the laboratory incubation methods which will be followed.

2.0 Lifetime Prediction: Unexposed Conditions

Lifetime prediction studies at GRI began at Drexel University under U. S. EPA contract from 1991 to 1997 and was continued under GSI consortium funding until ca. 2002. Focus to date has been on HDPE geomembranes placed beneath solid waste landfills due to its common use in this particular challenging application. Incubation of the coupons has been in landfill simulation cells (see Figure 1) maintained at 85, 75, 65 and 55°C. The specific conditions within these cells are oxidation beneath, chemical (water) from above, and the equivalent of 50 m of solid waste mobilizing compressive stress. Results have been forthcoming over the years insofar as three distinct lifetime stages; see Figure 2.

Stage A - Antioxidant Depletion Time

Stage B - Induction Time to the Onset of Degradation

Stage C - Time to Reach 50% Degradation (i.e., the Halflife)

2.1 Stage A - Antioxidant Depletion Time

The dual purposes of antioxidants are to (i) prevent polymer degradation during processing, and (ii) prevent oxidation reactions from taking place during Stage A of service life, respectively. Obviously, there can only be a given amount of antioxidants in any formulation. Once the antioxidants are depleted, additional oxygen diffusing into the geomembrane will begin to attack the polymer chains, leading to subsequent stages as shown in Figure 2. The duration of the antioxidant depletion stage depends on both the type and amount of the various antioxidants, i.e., the precise formulation.

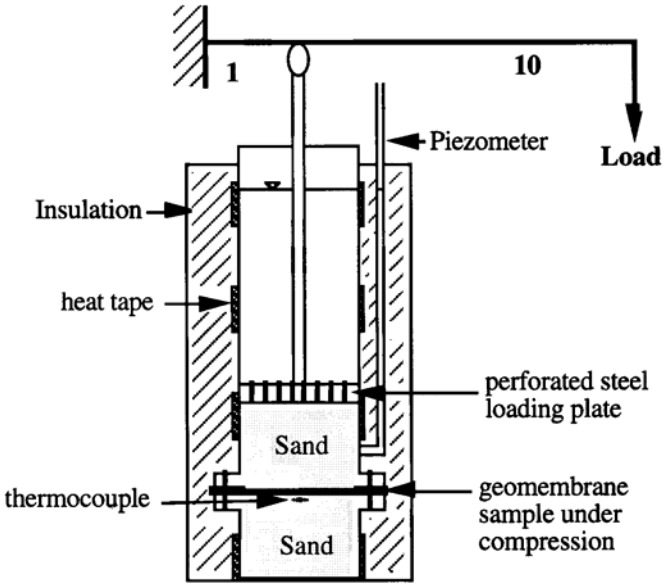


Figure 1. Incubation schematic and photograph of multiple cells maintained at various constant temperatures.

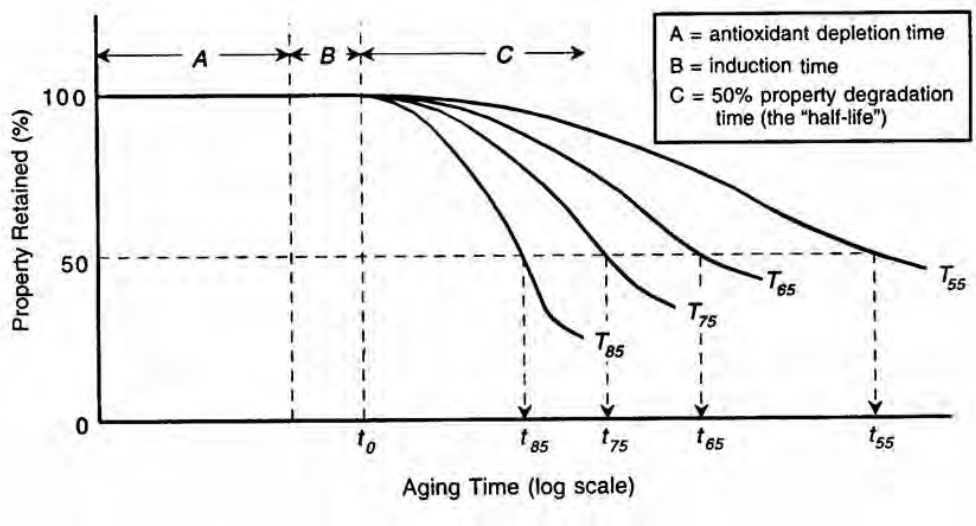


Figure 2. Three individual stages in the aging of most geomembranes.

The depletion of antioxidants is the consequence of two processes: (i) chemical reactions with the oxygen diffusing into the geomembrane, and (ii) physical loss of antioxidants from the geomembrane. The chemical process involves two main functions; the scavenging of free radicals converting them into stable molecules, and the reaction with unstable hydroperoxide (ROOH) forming a more stable substance. Regarding physical loss, the process involves the distribution of antioxidants in the geomembrane and their volatility and extractability to the site-specific environment.

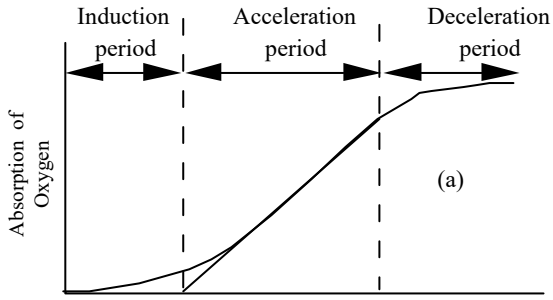
Hence, the rate of depletion of antioxidants is related to the type and amount of antioxidants, the service temperature, and the nature of the site-specific environment. See Hsuan and Koerner (1998) for additional details.

2.2 Stage B - Induction Time to Onset of Degradation

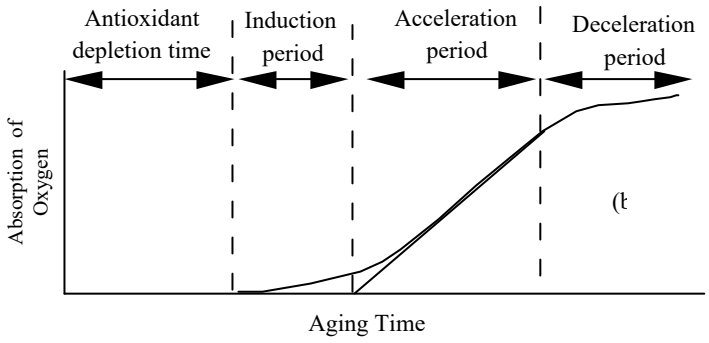
In a pure polyolefin resin, i.e., one without carbon black and antioxidants, oxidation occurs extremely slowly at the beginning, often at an immeasurable rate. Eventually, oxidation occurs more rapidly. The reaction eventually decelerates and once again becomes very slow.

This progression is illustrated by the S-shaped curve of Figure 3(a). The initial portion of the curve (before measurable degradation takes place) is called the induction period (or induction time) of the polymer. In the induction period, the polymer reacts with oxygen forming hydroperoxide (ROOH), as indicated in Equations (1)-(3). However, the amount of ROOH in this stage is very small and the hydroperoxide does not further decompose into other free radicals which inhibits the onset of the acceleration stage.

In a stabilized polymer such as one with antioxidants, the accelerated oxidation stage takes an even longer time to be reached. The antioxidants create an additional depletion time stage prior to the onset of the induction time, as shown in Figure 3(b).



(a) Pure unstabilized polyethylene



(b) Stabilized polyethylene

Figure 3. Curves illustrating various stages of oxidation.

$$RH \rightarrow R\bullet + H\bullet \quad (1)$$

(aided by energy or catalyst residues in the polymer)

$$R\bullet + O2 \rightarrow ROO\bullet \quad (2)$$

$$ROO\bullet + RH \rightarrow ROOH + R\bullet \quad (3)$$

In the above, RH represents the polyethylene polymer chains; and the symbol "•" represents free radicals, which are highly reactive molecules.

2.3 Stage C - Time to Reach 50% Degradation (Halflife)

As oxidation continues, additional ROOH molecules are being formed. Once the concentration of ROOH reaches a critical level, decomposition of ROOH begins, leading to a substantial increase in the amount of free radicals, as indicated in Equations (4) to (6). The additional free radicals rapidly attack other polymer chains, resulting in an accelerated chain reaction, signifying the end of the induction period, Rapopport and Zaikov (1986). This indicates that the concentration of ROOH has a critical control on the duration of the induction period.

$$ROOH \rightarrow RO\bullet OH\bullet \text{ (aided by energy)} \quad (4)$$

$$RO\bullet + RH \rightarrow ROH + R\bullet \quad (5)$$

$$OH\bullet + RH \rightarrow H2O + R\bullet \quad (6)$$

A series of oxidation reactions produces a substantial amount of free radical polymer chains (R•), called alkyl radicals, which can proceed to further reactions leading to either cross-linking or chain scission in the polymer. As the degradation of polymer continues, the physical and mechanical properties of the polymer start to change. The most noticeable change in physical properties is the melt index, since it relates to the molecular weight of the polymer. As for mechanical properties, both tensile break stress (strength) and break strain (elongation) decrease.

Ultimately, the degradation becomes so severe that all tensile properties start to change (tear, puncture, burst, etc.) and the engineering performance is jeopardized. This signifies the end of the so-called "service life" of the geomembrane.

Although quite arbitrary, the limit of service life of polymeric materials is often selected as a 50% reduction in a specific design property. This is commonly referred to as the halflife time, or simply the "halflife". It should be noted that even at halflife, the material still exists and can function, albeit at a decreased performance level with a factor-of-safety lower than the initial design value.

2.4 Summary of Lifetime Research-to-Date

Stage A, that of antioxidant depletion for HDPE geomembranes as required in the GRI-GM13 Specification, has been well established by our own research and corroborated by others, e.g., Sangram and Rowe (2004). The GRI data for standard and high pressure Oxidative Induction Time (OIT) is given in Table 2. The values are quite close to one another. Also, as expected, the lifetime is strongly dependent on the service temperature; with the higher the temperature the shorter the lifetime.

Table 2 - Lifetime prediction of HDPE (nonexposed) at various field temperatures

In Service Temperature (°C)	Stage "A" (years)			Stage "B" (years)	Stage "C" (years)	Total Prediction* (years)
	Standard OIT	High Press. OIT	Average OIT			
20	200	215	208	30	208	446
25	135	144	140	25	100	265
30	95	98	97	20	49	166
35	65	67	66	15	25	106
40	45	47	46	10	13	69

*Total = Stage A (average) + Stage B + Stage C

Stage "B", that of induction time, has been obtained by comparing 30-year old polyethylene water and milk containers (containing no long-term antioxidants) with currently

produced containers. The data shows that degradation is just beginning to occur as evidenced by slight changes in break strength and elongation, but not in yield strength and elongation. The lifetime for this stage is also given in Table 2.

Stage "C", the time for 50% change of mechanical properties is given in Table 2 as well. The data depends on the activation energy, or slope of the Arrhenius curve, which is very sensitive to material and experimental techniques. The data is from Gedde, et al. (1994) which is typical of the HDPE resin used for gas pipelines and is similar to Martin and Gardner (1983).

Summarizing Stages A, B, and C, it is seen in Table 2 that the halflife of covered HDPE geomembranes (formulated according to the current GRI-GM13 Specification) is estimated to be 449-years at 20°C. This, of course, brings into question the actual temperature for a covered geomembrane such as beneath a solid waste landfill. Figure 4 presents multiple thermocouple monitoring data of a municipal waste landfill liner in Pennsylvania for over 10-years, Koerner and Koerner (2005). Note that for 6-years the temperature was approximately 20°C. At that time and for the subsequent 4-years the temperature increased to approximately 30°C. Thus, the halflife of this geomembrane is predicted to be from 166 to 446 years within this temperature range. The site is still being monitored, see Koerner and Koerner (2005).

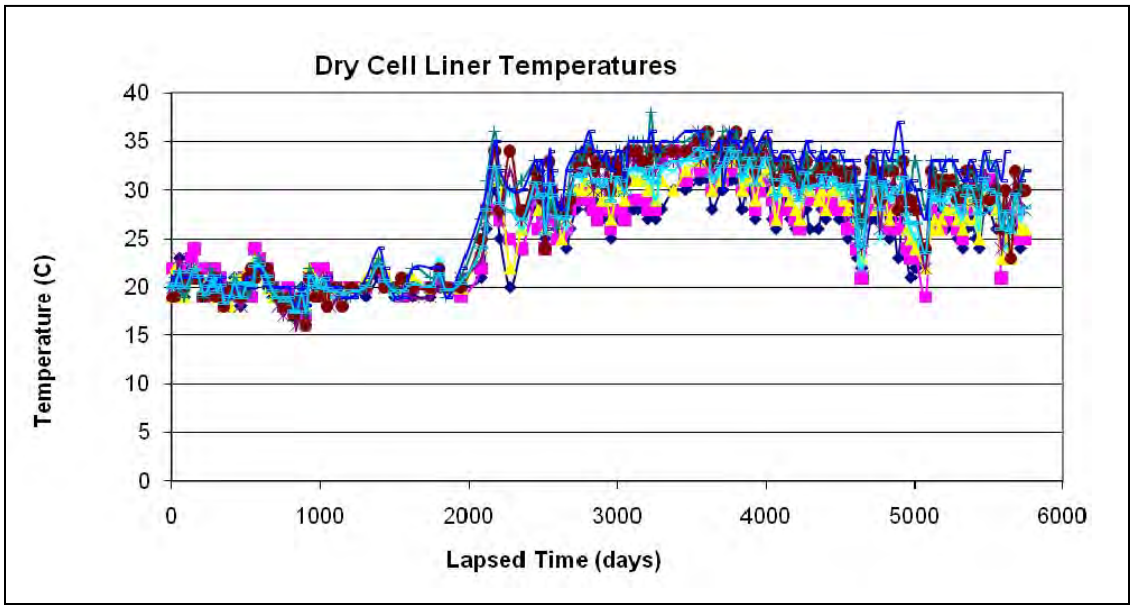


Figure 4. Long-term monitoring of an HDPE liner beneath a municipal solid waste landfill in Pennsylvania.

2.5 Lifetime of Other Covered Geomembranes

By virtue of its widespread use as liners for solid waste landfills, HDPE is by far the widest studied type of geomembrane. Note that in most countries (other than the U.S.), HDPE is the required geomembrane type for solid waste containment. Some commentary on other-than HDPE geomembranes (recall Table 1) follows:

2.5.1 Linear Low Density Polyethylene (LLDPE) geomembranes

The nature of the LLDPE resin and its formulation is very similar to HDPE. The fundamental difference is that LLDPE is a lower density, hence lower crystallinity, than HDPE; e.g., 10% versus 50%. This has the effect of allowing oxygen to diffuse into the polymer structure quicker, and likely decreases Stages A and C. How much is uncertain since no data is available, but it is felt that the lifetime of LLDPE will be somewhat reduced with respect to HDPE.

2.5.2 Plasticizer migration in PVC geomembranes

Since PVC geomembranes necessarily have plasticizers in their formulations so as to provide flexibility, the migration behavior must be addressed for this material. In PVC the plasticizer bonds to the resin and the strength of this bonding versus liquid-to-resin bonding is significant. One of the key parameters of a stable long-lasting plasticizer is its molecular weight. The higher the molecular weight of the plasticizer in a PVC formulation, the more durable will be the material. Conversely, low molecular weight plasticizers have resulted in field failures even under covered conditions. See Miller, et al. (1991), Hammon, et al. (1993), and Giroud and Tisinger (1994) for more detail in this regard. At present there is a considerable difference (and cost) between PVC geomembranes made in North America versus Europe. This will be apparent in the exposed study of durability in the second part of this White Paper.

2.5.3 Crosslinking in EPDM and CSPE geomembrnaes

The EPDM geomembranes mentioned in Table 1 are crosslinked thermoset materials. The oxidation degradation of EPDM takes place in either ethylene or propylene fraction of the co-polymer via free radical reactions, as expressed in Figure 5, which are described similarly by Equations (4) to (6).

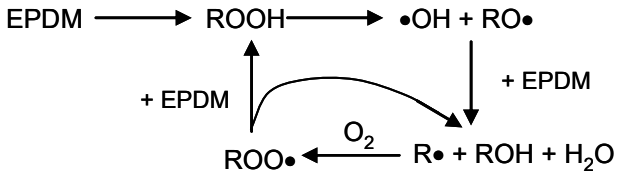


Figure 5. Oxidative degradation of crosslinked EPDM geomembranes, (Wang and Qu, 2003).

For CSPE geomembranes, the degradation mechanism is dehydrochlorination by losing chlorine and generating carbon-carbon double bonds in the main polymer chain, as shown in Figure 6.

The carbon-carbon double bonds become the preferred sites for further thermodegradation or cross-linking in the polymer, leading to eventual brittleness of the geomembrane.

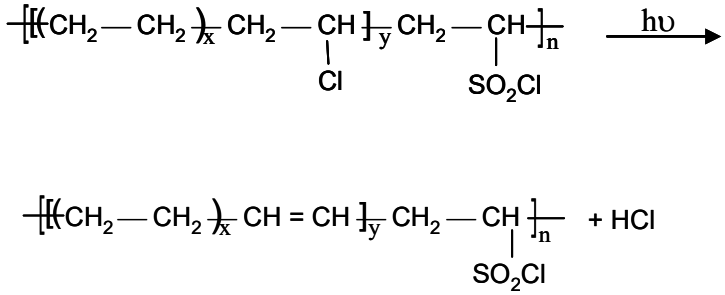


Figure 6. Dechlorination degradation of crosslinked CSPE geomembranes (Chailan, et al., 1995).

Neither EPDM nor CSPE has had a focused laboratory study of the type described for HDPE reported in the open literature. Most of lifetime data for these geomembranes is antidotal by virtue of actual field performance. Under covered conditions, as being considered in this section, there have been no reported failures by either of these thermoset polymers to our knowledge.

3.0 Lifetime Prediction: Exposed Conditions

Lifetime prediction of exposed geomembranes have taken two very different pathways; (i) prediction from anecdotal feedback and field performance, and (ii) from laboratory weathering device predictions.

3.1 Field Performance

There is a large body of anecdotal information available on field feedback of exposed geomembranes. It comes form two quite different sources, i.e., dams in Europe and flat roofs in the USA.

Regarding exposed geomembranes in dams in Europe, the original trials were using 2.0 mm thick polyisobutylene bonded directly to the face of the dam. There were numerous problems encountered as described by Scuero (1990). Similar experiences followed using PVC

geomembranes. In 1980, a geocomposite was first used at Lago Nero which had a 200 g/m^2 nonwoven geotextile bonded to the PVC geomembrane. This proved quite successful and led to the now-accepted strategy of requiring drainage behind the geomembrane. In addition to thick nonwoven geotextiles, geonets, and geonet composites have been successful. Currently over 50 concrete and masonry dams have been rehabilitated in this manner and are proving successful for over 30-years of service life. The particular type of PVC plasticized geomembranes used for these dams is proving to be quite durable. Tests by the dam owners on residual properties show only nominal changes in properties, Cazzuffi (1998). As indicated in Miller, et al. (1991) and Hammond, et al. (1993), however, different PVC materials and formulations result in very different behavior; the choice of plasticizer and the material's thickness both being of paramount importance. An excellent overview of field performance is recently available in which 250 dams which have been waterproofed by geomembranes is available from ICOLD (2010).

Regarding exposed geomembranes in flat roofs, past practice in the USA is almost all with EPDM and CSPE and, more recently, with fPP. Manufacturers of these geomembranes regularly warranty their products for 20-years and such warrants appear to be justified. EPDM and CSPE, being thermoset or elastomeric polymers, can be used in dams without the necessity of having seams by using vertical attachments spaced at 2 to 4 m centers, see Scuero and Vaschetti (1996). Conversely, fPP can be seamed by a number of thermal fusion methods. All of these geomembrane types have good conformability to rough substrates as is typical of concrete and masonry dam rehabilitation. It appears as though experiences (both positive and negative) with geomembranes in flat roofs should be transferred to all types of waterproofing in civil engineering applications.

3.2 Laboratory Weatherometer Predictions

For an accelerated simulation of direct ultraviolet light, high temperature, and moisture using a laboratory weatherometer one usually considers a worst-case situation which is the solar maximum condition. This condition consists of global, noon sunlight, on the summer solstice, at normal incidence. It should be recognized that the UV-A range is the target spectrum for a laboratory device to simulate the naturally occurring phenomenon, see Hsuan and Koerner (1993), and Suits and Hsuan (2001).

The Xenon Arc weathering device (ASTM D4355) was introduced in Germany in 1954. There are two important features; the type of filters and the irradiance settings. Using a quartz inner and borosilicate outer filter (quartz/boro) results in excessive low frequency wavelength degradation. The more common borosilicate inner and outer filters (boro/boro) shows a good correlation with solar maximum conditions, although there is an excess of energy below 300 nm wavelength. Irradiance settings are important adjustments in shifting the response although they do not eliminate the portion of the spectrum below 300 nm frequency. Nevertheless, the Xenon Arc device is commonly used method for exposed lifetime prediction of all types of geosynthetics.

UV Fluorescent devices (ASTM D7238) are an alternative type of accelerated laboratory test device which became available in the early 1970's. They reproduce the ultraviolet portion of the sunlight spectrum but not the full spectrum as in Xenon Arc weatherometers. Earlier FS-40 and UVB-313 lamps give reasonable short wavelength output in comparison to solar maximum. The UVA-340 lamp was introduced in 1987 and its response is seen to reproduce ultraviolet light quite well. This device (as well as other types of weatherometers) can handle elevated temperature and programmed moisture on the test specimens.

Research at the Geosynthetic Institute (GSI) has actively pursued both Xenon and UV Fluorescent devices on a wide range of geomembranes. Table 3 gives the geomembranes that were incubated and the number of hours of exposure as of 12 July 2005.

Table 5 - Details of the GSI laboratory exposed weatherometer study on various types of geomembranes

Geomembrane Type	Thickness (mm)	UV Fluorescent Exposure*	Xenon Exposure*	Comment
1. HDPE (GM13)	1.50	8000 hrs.	6600 hrs.	Basis of GRI-GM13 Spec
2. LLDPE (GM17)	1.00	8000	6600	Basis of GRI-GM-17 Spec
3. PVC (No. Amer.)	0.75	8000	6600	Low Mol. Wt. Plasticizer
4. PVC (Europe)	2.50	7500	6600	High Mol. Wt. Plasticizer
5. fPP (BuRec)	1.00	2745**	4416**	Field Failure at 26 mos.
6. fPP-R (Texas)	0.91	100	100	Field Failure at 8 years
7. fPP (No. Amer.)	1.00	7500	6600	Expected Good Performance

*As of 12 July 2005 exposure is ongoing
**Light time to reach halflife of break and elongation

3.3 Laboratory Weatherometer Acceleration Factors

The key to validation of any laboratory study is to correlate results to actual field performance. For the nonexposed geomembranes of Section 2 such correlations will take hundreds of years for properly formulated products. For the exposed geomembranes of Section 3, however, the lifetimes are significantly shorter and such correlations are possible. In particular, Geomembrane #5 (flexible polypropylene) of Table 3 was an admittedly poor geomembrane formulation which failed in 26 months of exposure at El Paso, Texas, USA. The reporting of this failure is available in the literature, Comer, et al. (1998). Note that for both UV Fluorescent and Xenon Arc laboratory incubation of this material, failure (halflife to 50% reduction in strength and elongation) occurred at 2745 and 4416 hours, respectively. The comparative analysis of laboratory and field for this case history allows for the obtaining of acceleration factors for the two incubation devices.

3.3.1 Comparison between field and UV Fluorescent weathering

The light source used in the UV fluorescent weathering device is UVA with wavelengths from 295-400 nm. In addition, the intensity of the radiation is controlled by the Solar Eye irradiance control system. The UV energy output throughout the test is 68.25 W/m^2.

The time of exposure to reach 50% elongation at break was as follows:

= 2745 hr. of light
= 9,882,000 seconds

Total energy in MJ/m^2 = 68.25 W/m^2 × 9,882,000
= 674.4 MJ/m^2

The field site was located at El Paso, Texas. The UVA radiation energy (295-400 nm) at this site is estimated based on data collected by the South Florida Testing Lab in Arizona (which is a similar atmospheric location). For 26 months of exposure, the accumulated UV radiation energy is 724 MJ/m^2 which is very close to that generated from the UV fluorescent weatherometer. Therefore, direct comparison of the exposure time between field and UV fluorescent is acceptable.

Field time = 26 Months vs. Fluorescent UV light time: = 3.8 Months **Thus, the acceleration factor is 6.8.**

3.3.2 Comparison between field and Xenon Arc weathering

The light source of the Xenon Arc weathering device simulates almost the entire sunlight spectrum from 250 to 800 nm. Depending of the age of the light source and filter, the solar energy ranges from 340.2 to 695.4 W/m^2, with the average value being 517.8 W/m^2.

The time of exposure to reach 50% elongation at break

= 4416 hr. of light
= 15,897,600 seconds

Total energy in MJ/m^2 = 517.8 W/m^2 × 15,897,600
= 8232 MJ/m^2

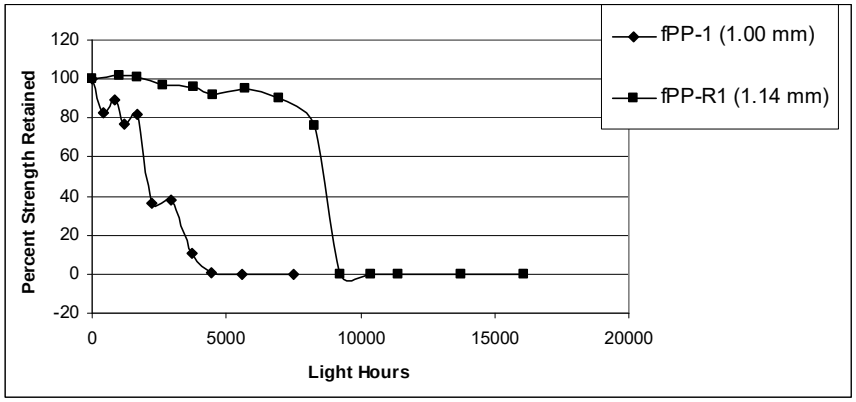
The solar energy in the field is again estimated based on data collected by the South Florida Testing Lab in Arizona. For 26 months of exposure, the accumulated solar energy (295-800 nm) is 15,800 MJ/m^2, which is much higher than that from the UV Fluorescent device. Therefore, direct comparison of halflives obtained from the field and Xenon Arc device is not anticipated to be very accurate. However, for illustration purposes the acceleration factor based on Xenon Arc device would be as follows:

Field = 26 Months vs. Xenon Arc = 6.1 Months : **Thus, the acceleration factor is 4.3.**

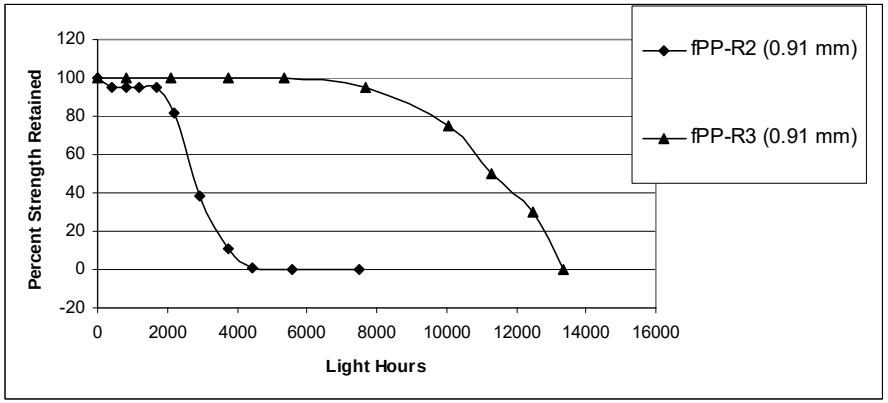
The resulting conclusion of this comparison of weathering devices is that the UV Fluorescent device is certainly reasonable to use for long-term incubations. When considering the low cost of the device, its low maintenance, its inexpensive bulbs, and ease of repair it (the UV Fluorescent device) will be used exclusively by GSI for long-term incubation studies.

3.3.3 Update of exposed lifetime predictions

There are presently (2011) four field failures of flexible polypropylene geomembranes and using unexposed archived samples from these sites their responses in laboratory UV Fluorescent devices per ASTM D7328 at 70°C are shown in Figure 5. From this information we deduce that the average correlation factor is approximately *1200 light hours ≃ one-year in a hot climate.* This value will be used accordingly for other geomembranes.



(a) Two Sites in West Texas



(b) Two Sites in So. Calif.

Lab-to-Field Correlation Factors
(ASTM D7238 @ 70°C)

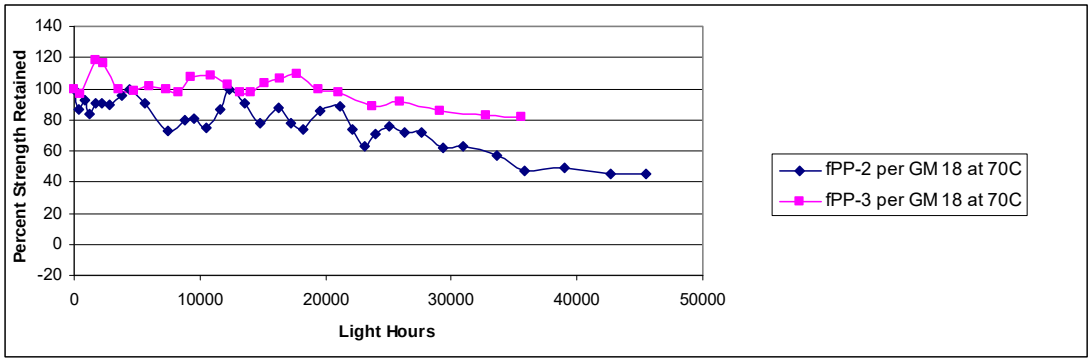
Method	Thickness (mm)	Field (yrs.)	Location	Lab (lt. hr.)	Factor (lt. hrs./1.0 yr.)
fPP-1	1.00	≃ 2	W. Texas	1800	900
fPP-R1	1.14	≃ 8	W. Texas	8200	1025
fPP-R2	0.91	≃ 2	So. Calif.	2500	1250
fPP-R3	0.91	≃ 8	So. Calif.	11200	1400
					1140*

*Use 1200 lt. hr. = 1.0 year in hot climates

Figure 5. Four field failures of fPP and fPP-R exposed geomembranes.

Exposure of a number of different types of geomembranes in laboratory UV Fluorescent devices per ASTM D7238 at 70°C has been ongoing for the six years (between 2005 and 2011) since this White Paper was first released. Included are the following geomembranes:

- Two black 1.0 mm (4.0 mil) unreinforced flexible polypropylene geomembranes formulated per GRI-GM18 Specification; see Figure 6a.
- Two black unreinforced polyethylene geomembranes, one 1.5 mm (60 mil) high density per GRI-GM13 Specification and the other 1.0 mm (40 mil) linear low density per GRI-GM17 Specification; see Figure 6b.
- One 1.0 (40 mil) black ethylene polypropylene diene terpolymer geomembrane per GRI-GM21 Specification; see Figure 6c.
- Two polyvinyl chloride geomembranes, one black 1.0 mm (40 mil) formulated in North America and the other grey 1.5 mm (60 mil) formulated in Europe; see Figure 6d.



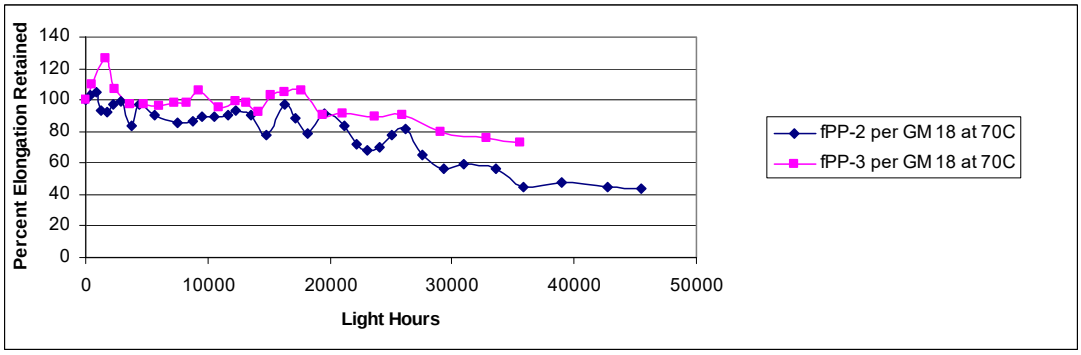
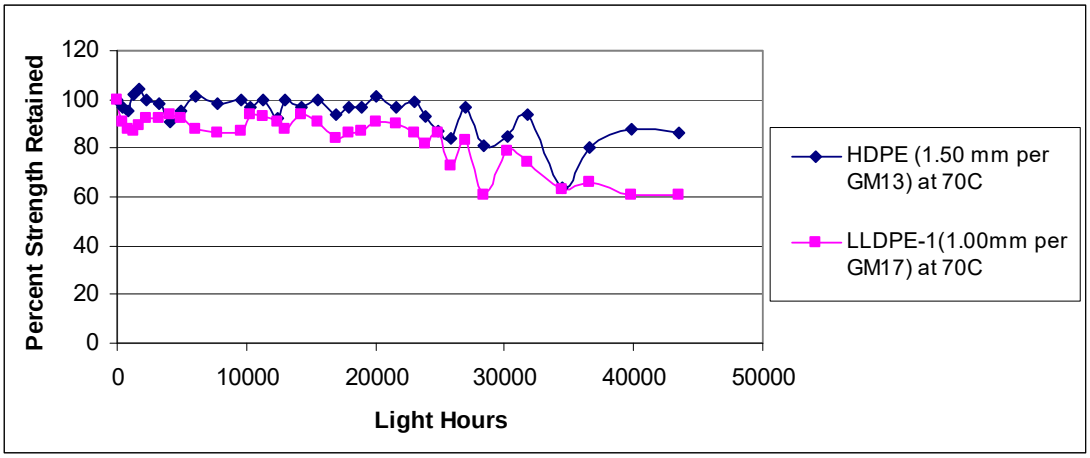


Figure 6a. Flexible polyethylene (fPP) geomembrane behavior.



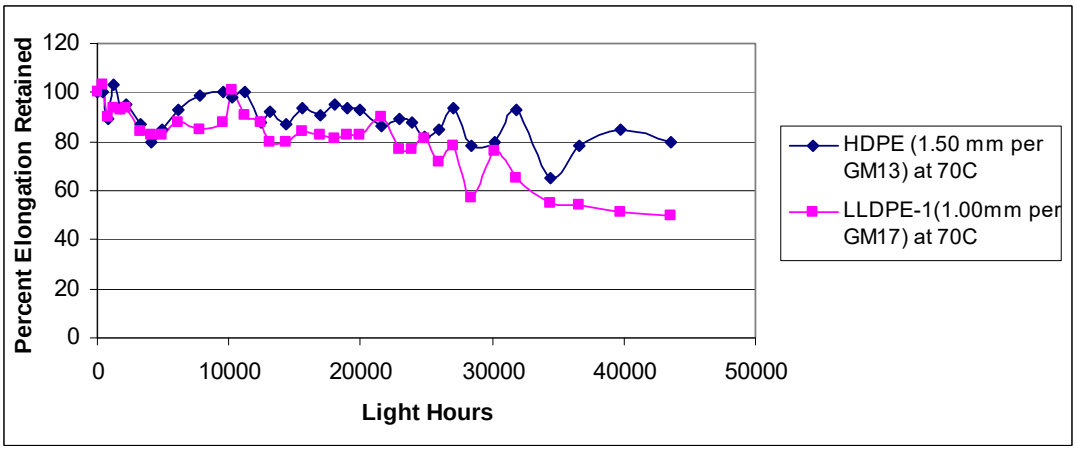
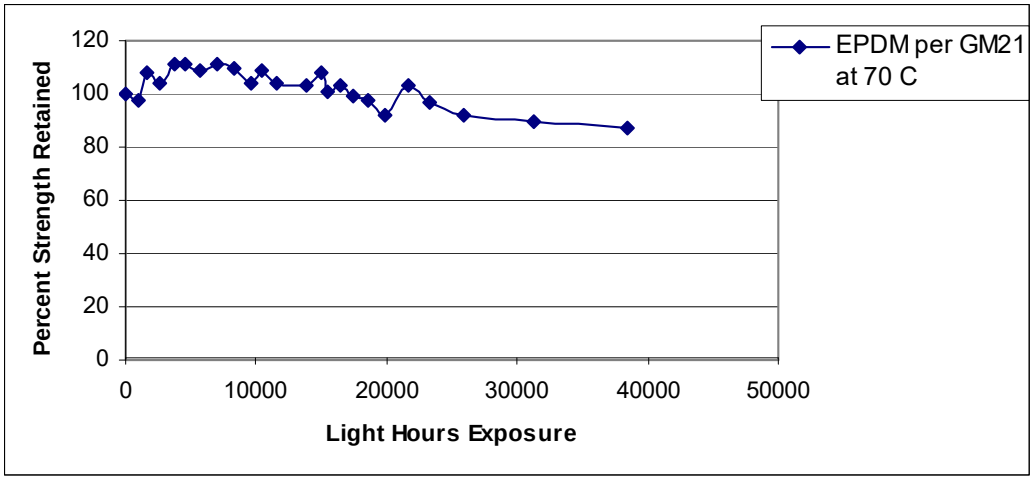


Figure 6b. Polyethylene (HDPE and LLDPE) geomembrane behavior.



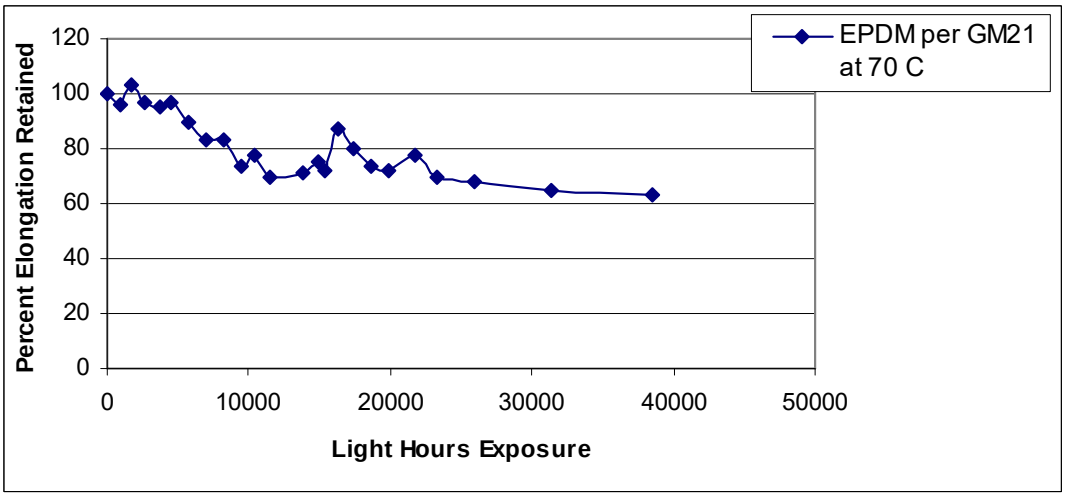


Figure 6c. Ethylene polypropylene diene terpolymer (EPDM) geomembrane.

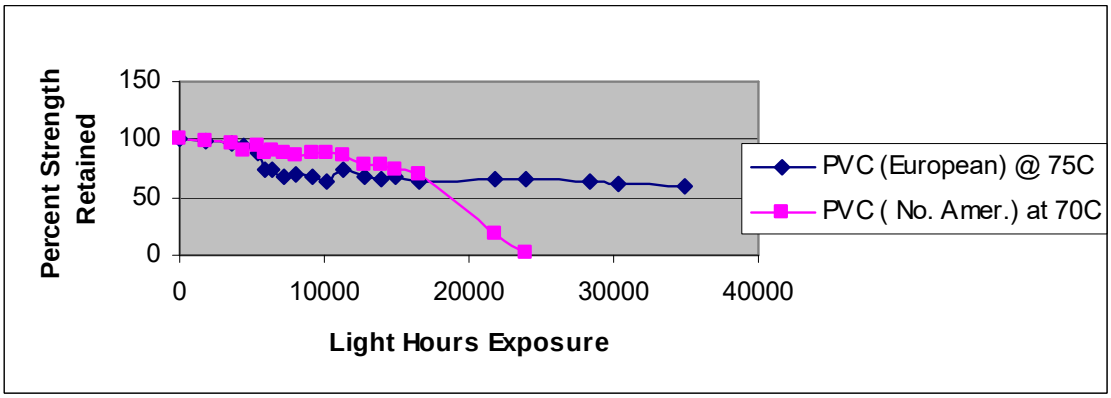


Figure 6d. Polyvinyl chloride (PVC) geomembranes.

From the response curves of the various geomembranes shown in Figure 6a-d, the 50% reduction value in strength or elongation (usually elongation) was taken as being the "halflife". This value is customarily used by the polymer industry as being the materials lifetime prediction value. We have done likewise to develop Table 6 which is our predicted values for the designated exposed geomembrane lifetimes to date.

Table 6 – Exposed lifetime prediction results of selected geomembranes to date

Type	Specification	Prediction Lifetime in a Dry and Arid Climate
HDPE	GRI-GM13	> 36 years (ongoing)
LLDPE	GRI-GM17	~ 36 years (halflife)
EPDM	GRI-GM21	> 27 years (ongoing)
fPP-2	GRI-GM18	~ 30 years (halflife)
fPP-3	GRI-GM18	> 27 years (ongoing)
PVC-N.A.	(see FGI)	~ 18 years (halflife)
PVC-Eur.	proprietary	> 32 years (ongoing)

4.0 Conclusions and Recommendations

This White Paper is bifurcated into two very different parts; covered (or buried) lifetime prediction of HDPE geomembranes and exposed (to the atmosphere) lifetime prediction of a number of geomembrane types. In the covered geomembrane study we chose the geomembrane type which has had the majority of usage, that being HDPE as typically used in waste containment applications. Invariably whether used in landfill liner or cover applications *the geomembrane is covered.* After ten-years of research Table 2 (repeated here) was developed which is the conclusion of the covered geomembrane research program. Here it is seen that HDPE decreases its predicted lifetime (as measured by its halflife) from 446-years at 20°C, to 69-years at 40°C. Other geomembrane types (LLDPE, fPP, EPDM and PVC) have had

essentially no focused effort on their covered lifetime prediction of the type described herein. That said, all are candidates for additional research in this regard.

Table 2 - Lifetime prediction of HDPE (nonexposed) at various field temperatures

In Service Temperature (°C)	Stage "A" (years)			Stage "B" (years)	Stage "C" (years)	Total Prediction* (years)
	Standard OIT	High Press. OIT	Average OIT			
20	200	215	208	30	208	446
25	135	144	140	25	100	265
30	95	98	97	20	49	166
35	65	67	66	15	25	106
40	45	47	46	10	13	69

*Total = Stage A (average) + Stage B + Stage C

Exposed geomembrane lifetime was addressed from the perspective of field performance which is very unequivocal. Experience in Europe, mainly with relatively thick PVC containing high molecular weight plasticizers, has given 25-years of service and the geomembranes are still in use. Experience in the USA with exposed geomembranes on flat roofs, mainly with EPDM and CSPE, has given 20^{+}-years of service. The newest geomembrane type in such applications is fPP which currently carries similar warranties.

Rather than using the intricate laboratory setups of Figure 1 which are necessary for covered geomembranes, exposed geomembrane lifetime can be addressed by using accelerating laboratory weathering devices. Here it was shown that the UV fluorescent device (per ASTM D7238 settings) versus the Xenon Arc device (per ASTM D 4355) is equally if not slightly more intense in its degradation capabilities. As a result, all further incubation has been using the UV fluorescent devices per D7238 at 70°C.

Archived flexible polypropylene geomembranes at four field failure sites resulted in a correlation factor of 1200 light hours equaling one-year performance in a hot climate. Using this

value on the incubation behavior of seven commonly used geomembranes has resulted in the following conclusions (recall Figure 6 and Table 6);

- HDPE geomembranes (per GRI-GM13) are predicted to have lifetimes greater than 36-years; testing is ongoing.
- LLDPE geomembranes (per GRI-GM17) are predicted to have lifetimes of approximately 36-years.
- EPDM geomembranes (per GRI-GM21) are predicted to have lifetimes of greater than 27-years; testing is ongoing.
- fPP geomembranes (per GRI-GM18) are predicted to have lifetimes of approximately 30-years.
- PVC geomembranes are very dependent on their plascitizer types and amounts, and probably thicknesses as well. The North American formulation has a lifetime of approximately 18-years, while the European formulation is still ongoing after 32-years.

Regarding continued and future recommendations with respect to lifetime prediction, GSI is currently providing the following:

(i) Continuing the exposed lifetime incubations of HDPE, EPDM and PVC (European) geomembranes at 70°C.

(ii) Beginning the exposed lifetime incubations of HDPE, LLDPE, fPP, EPDM and both PVC's at 60°C and 80°C incubations.

(iii) With data from these three incubation temperatures (60, 70 and 80°C), time-temperature-superposition plots followed by Arrhenius modeling will eventually provide information such as Table 2 for covered geomembranes. This is our ultimate goal.

(iv) Parallel lifetime studies are ongoing at GSI for four types of geogrids and three types of turf reinforcement mats at 60, 70 and 80°C.

(v) GSI does not plan to duplicate the covered geomembrane study to other than the HDPE provided herein. In this regard, the time and expense that would be necessary is prohibitive.

(vi) The above said, GSI is always interested in field lifetime behavior of geomembranes (and other geosynthetics as well) whether covered or exposed.

Acknowledgements

The financial assistance of the U. S. Environmental Protection Agency for the covered HDPE lifetime study and the member organizations of the Geosynthetic Institute and its related institutes for research, information, education, accreditation and certification is sincerely appreciated. Their identification and contact member information is available on the Institute's web site at <<geosynthetic-institute.org>>.

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C-147

R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW, Suite F-142
Albuquerque, NM 87104

District I
1625 N. French Dr., Hobbs, NM 88240
District II
811 S. First St., Artesia, NM 88210
District III
1000 Rio Brazos Road, Aztec, NM 87410
District IV
1220 S. St. Francis Dr., Santa Fe, NM 87505

State of New Mexico
Energy Minerals and Natural Resources
Department
Oil Conservation Division
1220 South St. Francis Dr.
Santa Fe, NM 87505

Form C-147
Revised April 3, 2017

Recycling Facility and/or Recycling Containment

Type of Facility: ☒ Recycling Facility ☒ Recycling Containment*

Type of action: ☒ Permit FOR OCD STATISTICS ☒ Registration
☐ Modification ☐ Extension
☐ Closure ☐ Other (explain) _____

*** At the time C-147 is submitted to the division for a Recycling Containment, a copy shall be provided to the surface owner.**

Be advised that approval of this request does not relieve the operator of liability should operations result in pollution of surface water, ground water or the environment. Nor does approval relieve the operator of its responsibility to comply with any other applicable governmental authority's rules, regulations or ordinances.

1.

Operator: : AMEREDEV OPERATING, LLC, OGRID #:__372224_____

Address: _____5707 Southwest Pkwy, Bldg 1, Austin, TX 78735 _____

Facility or well name (include API# if associated with a well): ____Ike's Containment #1_____

OCD Permit Number: _____(For new facilities the permit number will be assigned by the district office)

U/L or Qtr/Qtr ____D_____ Section ___27_____ Township __26S_____ Range ____36E_____ County: ____Lea_____

Surface Owner: ☐ Federal ☐ State ☒ Private ☐ Tribal Trust or Indian Allotment

2.

☐ **Recycling Facility:** Southeast Corner of Containment

Location of (if applicable): Latitude _32.01916_____ Longitude _-103.25714___ NAD83

Proposed Use: ☒ Drilling* ☒ Completion* ☒ Production* ☒ Plugging *

The re-use of produced water may NOT be used until fresh water zones are cased and cemented

☐ Other, ***requires permit for other uses. Describe use, process, testing, volume of produced water and ensure there will be no adverse impact on groundwater or surface water.***

☒ Fluid Storage

☐ Above ground tanks ☒ Recycling containment ☐ Activity permitted under 19.15.17 NMAC explain type_____

☐ Activity permitted under 19.15.36 NMAC explain type:_____ ☐ Other explain _____

☐ For multiple or additional recycling containments, attach design and location information of each containment

☐ **Closure Report (required within 60 days of closure completion):** ☐ Recycling Facility Closure Completion Date:_____

3.

☒ **Recycling Containment:**

☐ Annual Extension after initial 5 years (attach summary of monthly leak detection inspections for previous year)

Center of Recycling Containment (if applicable Latitude _32.01991_____ Longitude __-103.2592__ NAD83

☐ For multiple or additional recycling containments, attach design and location information of each containment

☒ Lined ☐ Liner type: Thickness __Secondary 40_mil Primary 60 mil ☐ LLDPE ☒ HDPE ☐ PVC ☐ Other _____

☐ String-Reinforced

Liner Seams: ☒ Welded ☐ Factory ☐ Other _____ Volume: __TBD_____bbl Dimensions: L_____ x W_____ x D_____

☐ Recycling Containment Closure Completion Date:_____

4.

Bonding:

☒ Covered under bonding pursuant to 19.15.8 NMAC per 19.15.34.15(A)(2) NMAC **(These containments are limited to only the wells owned or operated by the owners of the containment.)**

☐ Bonding in accordance with 19.15.34.15(A)(1). Amount of bond $_____ **(work on these facilities cannot commence until bonding amounts are approved)**

☐ Attach closure cost estimate and documentation on how the closure cost was calculated.

5.

Fencing:

☐ Four foot height, four strands of barbed wire evenly spaced between one and four feet

☒ Alternate. Please specify__6-foot chain link surrounding the 40-acre parcel_____

6.

Signs:

☒ 12"x 24", 2" lettering, providing Operator's name, site location, and emergency telephone numbers

☐ Signed in compliance with 19.15.16.8 NMAC

7.

Variances:

Justifications and/or demonstrations that the proposed variance will afford reasonable protection against contamination of fresh water, human health, and the environment.

Check the below box only if a variance is requested:

☒ Variance(s): Requests must be submitted to the appropriate division district for consideration of approval. If a Variance is requested, include the variance information on a separate page and attach it to the C-147 as part of the application.

If a Variance is requested, it must be approved prior to implementation. **BOX CHECKED FOR OCD STATISTICS ONLY.**

8.

Siting Criteria for Recycling Containment

Instructions: The applicant must provide attachments that demonstrate compliance for each siting criteria below as part of the application. Potential examples of the siting attachment source material are provided below under each criteria.

General siting

Ground water is less than 50 feet below the bottom of the Recycling Containment. NM Office of the State Engineer - iWATERS database search; USGS; Data obtained from nearby wells	☐ Yes ☒ No ☐ NA
Within incorporated municipal boundaries or within a defined municipal fresh water well field covered under a municipal ordinance adopted pursuant to NMSA 1978, Section 3-27-3, as amended. - Written confirmation or verification from the municipality; written approval obtained from the municipality	☐ Yes ☒ No ☐ NA
Within the area overlying a subsurface mine. - Written confirmation or verification or map from the NM EMNRD-Mining and Minerals Division	☐ Yes ☒ No
Within an unstable area. - Engineering measures incorporated into the design; NM Bureau of Geology & Mineral Resources; USGS; NM Geological Society; topographic map	☐ Yes ☒ No
Within a 100-year floodplain. FEMA map	☐ Yes ☒ No
Within 300 feet of a continuously flowing watercourse, or 200 feet of any other significant watercourse, or lakebed, sinkhole, or playa lake (measured from the ordinary high-water mark). - Topographic map; visual inspection (certification) of the proposed site	☐ Yes ☒ No
Within 1000 feet from a permanent residence, school, hospital, institution, or church in existence at the time of initial application. - Visual inspection (certification) of the proposed site; aerial photo; satellite image	☐ Yes ☒ No
Within 500 horizontal feet of a spring or a fresh water well used for domestic or stock watering purposes, in existence at the time of initial application. - NM Office of the State Engineer - iWATERS database search; visual inspection (certification) of the proposed site	☐ Yes ☒ No
Within 500 feet of a wetland. - US Fish and Wildlife Wetland Identification map; topographic map; visual inspection (certification) of the proposed site	☐ Yes ☒ No

9.
Recycling Facility and/or Containment Checklist:
Instructions: Each of the following items must be attached to the application. Indicate, by a check mark in the box, that the documents are attached.

- ☒ Design Plan - based upon the appropriate requirements.
- ☒ Operating and Maintenance Plan - based upon the appropriate requirements.
- ☒ Closure Plan - based upon the appropriate requirements.
- ☒ Site Specific Groundwater Data -
- ☒ Siting Criteria Compliance Demonstrations –
- ☒ **Certify that notice of the C-147 (only) has been sent to the surface owner(s)**

10.
Operator Application Certification:
I hereby certify that the information and attachments submitted with this application are true, accurate and complete to the best of my knowledge and belief.

Name (Print): Shane McNeely Title: Engineer

Signature: Shane McNeely Date: 2/13/18

e-mail address smcneely@umerenv.com Telephone: 737-300-4729

11.
OCD Representative Signature: _____ **Approval Date:** _____

Title: _____ **OCD Permit Number:** _____

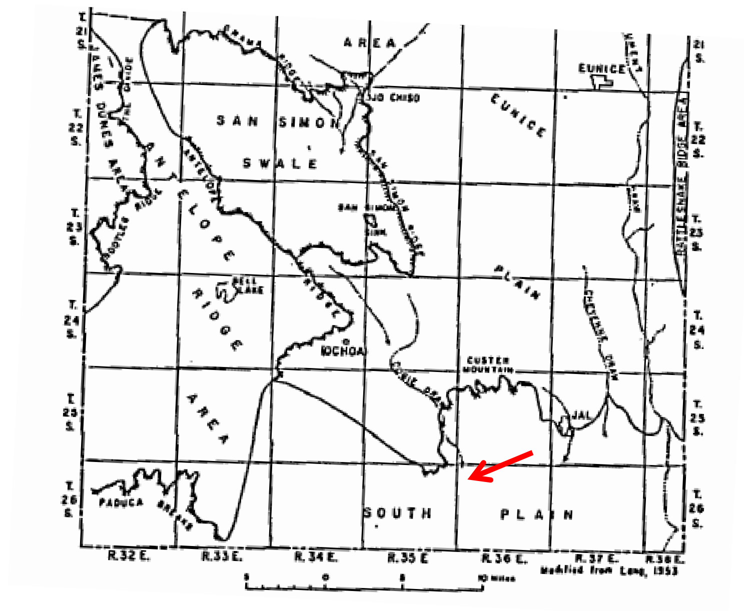
☐ OCD Conditions _____
☐ Additional OCD Conditions on Attachment

Site Specific Information

R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW, Suite F-142
Albuquerque, NM 87104

Geologic Setting of the Regional Fresh-Water Bearing Formations

The recycling containment site is located within the South Plain (see inset below, red arrow), which is in the High Plains Physiographic Province.



Groundwater in the area within the South Plain is found in in Mesozoic and Cenozoic Era rocks. The oldest of these are the Triassic age Dockum Group. They consist of conglomerates, cross-bedded sandstones, claystones, and siltstones that were deposited in a continental fluvial environment over the evaporites of the late Permian Ochoan Series, which had filled the Delaware Basin by that time. In much of the South Plain area, the Dockum Group (aka Chinle) is a secondary groundwater zone relative to the Ogallala.

Any Jurassic or Cretaceous age rocks that were deposited above the Triassic have subsequently been removed by erosion leaving an irregular surface on the Triassic rocks. Cenozoic Era rocks in the area consist of the Tertiary age Ogallala Formation and Quaternary age eolian and piedmont deposits. The Ogallala Formation consists of terrestrial sediments (sand with some clay, silt and gravel) that were deposited on the Triassic age rocks. The Quaternary deposits are generally thin veneers over the Ogallala in this area, except in larger drainages, such as Monument Draw.

The Ogallala and associated alluvial aquifers are the primary groundwater source where they are present, mainly in the eastern portion of the South Plain. All of water wells within the area of the containment that were measured by the USGS are considered "Alluvium" by the agency. Drillers and other experts, however, may consider the producing strata equivalent to the Ogallala (see Plate 1). Driller's logs of several of these wells suggest the water-bearing zone of the deeper wells (500-600 feet) tap the basal conglomerate of the Ogallala.

Distance to Groundwater

Figure 1, Figure 2, and the discussion presented below demonstrates that the depth to the groundwater surface at the location is approximately 145 feet. Assuming a maximum depth of the proposed containment of 25 feet, the distance between the bottom of the containment and groundwater is approximately 120 feet

Figure 1 is an area geologic base map that depicts regional topography and includes the water wells located nearest to the containment site for which information is available, regardless of how comprehensive or useful. It also shows:

1. The location of the 38-acre area in which the recycling containment is located as a blue rectangle. The "bite" from the rectangle in the southeast corner is due to the presence of an abandoned windmill that could be re-habilitated as a stock well. The "bite" allows the area to meet the setback criteria distance of 500 feet from a non-public water supply. The exact location of the containment within the 38± acre area will be submitted to OCD with the as-built engineering design.
2. Water wells from the USGS database as color-coded triangles that indicate the producing aquifer (see Legend).
3. Water wells from the New Mexico Office of the State Engineer (OSE) database as a small blue triangle inside a colored circle that indicates the well depth (see Legend). Please note, OSE wells are often miss-located in the WATERS database as older wells are plotted in the center of the quarter, quarter, quarter, of the Section Township and Range. Topographic maps and/or aerial photographs verified all of the OSE well locations included on this map.
4. Water wells, which are not documented in the public databases but were identified by field inspection or other published reports are shown as a dot inside a color-coded (depth) square.
5. Depth to water and gauging dates from the most recent and reliable measurement for each well is provided adjacent to the well symbol. It should be noted that in most cases the depth to water provided by the OSE database are from drillers log notes estimated at the time of completion, rather than actual field measurements.

Figure 2 is a regional geologic base map that depicts the potentiometric surface contours of the shallow-most aquifer surrounding the site. The potentiometric contours are labeled in feet above sea level (ASL). The water wells plotted include only the USGS database and published report water wells from Figure 1 for which a reliable depth to water measurement has been recorded. Figure 2 also shows:

1. The location of the containment as a blue rectangle with a "bite".
2. Groundwater elevations and gauging dates from the most recent available static water level measurement for each well.
3. USGS well 14287 shown south of the "abandoned windmill" could not be located in the field. We suspect the "abandoned windmill" is the same well as was measured by the USGS in 1970.

Site Geology

The proposed containment is located on what is mapped as Quaternary Age eolian and piedmont deposits (Qe/Qp on Figure 1). Aeolian deposits are fine-grained sands in vegetated low dunes (see site inspection photographs) that cover all but the southwest corner of the 40-acre parcel of

Ameredev-owned surface. In the southwest corner, the surface is characterized by fine soil and clay that appears to be the eastern margin of a relict lacustrine/playa deposits.

Surface drainage is not developed in northern and eastern ¾ of the 40-acre Ameredev-owned parcel where stabilized sand dunes are present. In the southwestern 10-acres surface water flows to the southwest toward a closed depression that is the relict playa lake (see Figure 3).

Water Table Elevation and Depth to Groundwater

Twelve measurements of water wells in the area surrounding the containment site provide a good estimate of the groundwater elevation in the area (see Figure 2). Figure 2 uses only data from the USGS, published reports, and field verified well information, which is generally considered reliable. As stated earlier, the groundwater elevations provided for these OSE wells are likely based on driller log notes after well completion rather than measurements made under static conditions.

Based on the potentiometric surface contours created using the available measurements from surrounding wells (Figure 2), we conclude that the groundwater elevation at the containment site is approximately 2,758 feet ASL. With a surface elevation of 2,903 feet ASL and a maximum depth of the containment of 25 feet, the depth to groundwater below the containment floor should be approximately (2903-2758-25=) 120 feet.

Distance to Surface Water

Figure 3 and the site visit demonstrates that the location is not within 300 feet of a continuously flowing watercourse, or any other significant watercourse, or within 200 feet of any lakebed, sinkhole, or playa lake (measured from the ordinary high-water mark). No continuously flowing watercourses exist within 300 feet of the location. The nearest surface feature (un-named lake/pond identified on the USGS quadrangle map) is located about ¾ mile to the east (Figure 3). Stabilized dune fields, like that which characterizes the location and much of the surrounding area, are seldom characterized by well-defined drainage patterns and that is the case in the area shown in Figure 3.

Several closed depressions are mapped in the area. During wetter times (during the Pleistocene and perhaps more recent), playa lakes probably occupied these depressions. Visual inspection of the depression that occupies a portion of the southwestern corner of the Ameredev-owned surface shows no evidence of historic intermittent water (see site photographs).

Distance to Permanent Residence or Structures

Figure 4 and the site visit demonstrates that the location is not within 300 feet from a permanent residence, school, hospital, institution, church, or other structure in existence at the time of initial application.

Distance to Non-Public Water Supply

Figures 1, 2, and 3 demonstrate that the location is not within 500 horizontal feet of a private, domestic fresh water well or spring that less than five households use for domestic

or stock watering purposes, or within 1000 horizontal feet of any other fresh water well or spring, in existence at the time of initial application.

- Figure 1 shows the locations of all mapped area water wells. The closest
    i. Mapped and active water supply wells are about 2 miles west of the proposed containment
    ii. Unmapped active windmill lies about 1 mile east of the proposed containment
    iii. An abandoned windmill is slightly more than 500 feet southeast of the proposed containment
- There are no known domestic water wells located within at least 1 mile of the proposed containment
- Figure 3 shows that no springs are identified within the mapping area and the field survey identified no evidence of springs.

Distance to Municipal Boundaries and Fresh Water Fields

Figure 5 demonstrates that the location is not within incorporated municipal boundaries or defined municipal fresh water well fields covered under a municipal ordinance adopted pursuant to NMSA 1978, Section 3-27-3, as amended.

- The closest municipality is Jal, NM approximately 7 miles to the northeast.
- The closest public well field is located west of Carlsbad or north of Maljamar

Distance to Wetlands

Figure 6 and the site visit demonstrates the location is not within 500 feet of wetlands.

- The nearest designated wetlands are about 3 miles east of the site and are considered freshwater ponds
- The site inspection identified no evidence of wetlands in the general area

Distance to Subsurface Mines

Figure 7 and our general reconnaissance of the area demonstrate that the nearest mine is caliche pit.

- Figures 3, 6 and 7 show the caliche pit about 1500 feet southeast of the edge of the Ameredev-owned surface

Distance to High or Critical Karst Areas

Figure 8 shows the location of the recycling containment with respect BLM Karst areas

- The proposed recycling containment is located within a "low" potential karst area.
- The nearest moderate potential karst area is located approximately 12 miles west of the site.
- We saw no evidence of unstable ground near the containment location during the site inspection.

Distance to 100-Year Floodplain

Figure 9 demonstrates that the location is within an area that has not yet been mapped by the Federal Emergency Management Agency with respect to the Flood Insurance Rate 100-Year Floodplain.

- Areas that are not mapped are designated as "Undetermined Flood Hazard" and are generally considered minimal flood risk.
- Our field inspection and examination of the topography permit a conclusion that the location is not within any floodplain.

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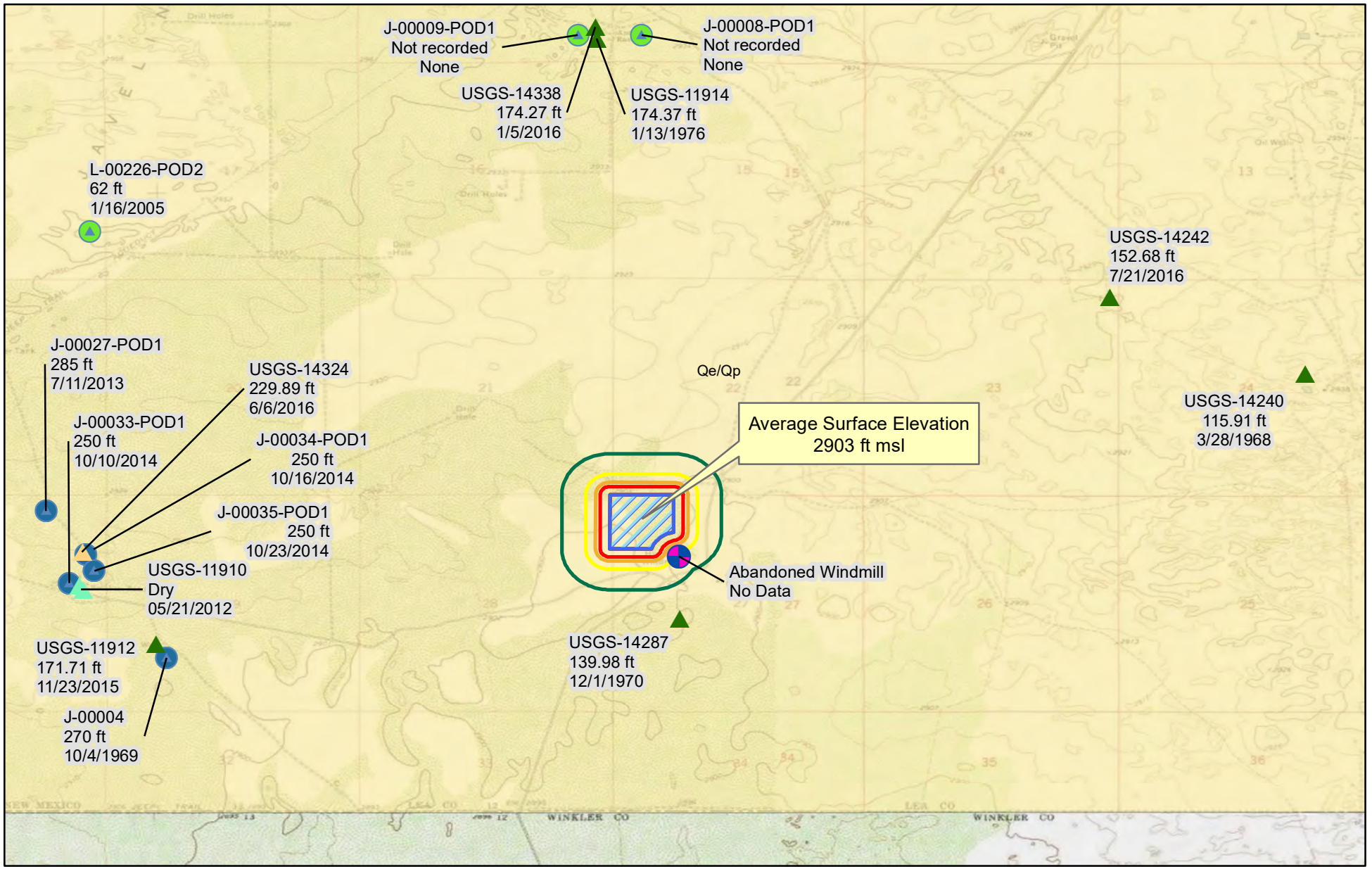

N W E S

0 0.5 1 Miles

R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	Depth To Water and Geology	Figure 1
	Ameredev Operating, LLC Fluids Containment Zone (nw/4 of nw/4, 27-T26N, R36E)	November 2017

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Legend

Fluid Containment Zone

40-Acre Tract (nw/4 of nw/4)

Fluid Containment Buffer (ft)

200 ft

300 ft

500 ft

1000 ft

Abandoned Windmill

OSE Water Wells (DTW, Date)

Well Depth (ft)

<= 150

151 - 350

351 - 500

501 - 1000

> 1000

USGS Gauging Station (DTW, Date)

Aquifer Code, Well Status

Alluvium

Alluvium/Bolsom

Alluvium/Bolsom, Site was dry (no water level was recorded).

NM Geology

Map Unit, Description

Qe/Qp, Quaternary-Eolian Piedmont Deposits

R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	Depth To Water and Geology	Figure 1 LEGEND
	Ameredev Operating, LLC Fluids Containment Zone (nw/4 of nw/4, 27-T26N, R36E)	November 2017

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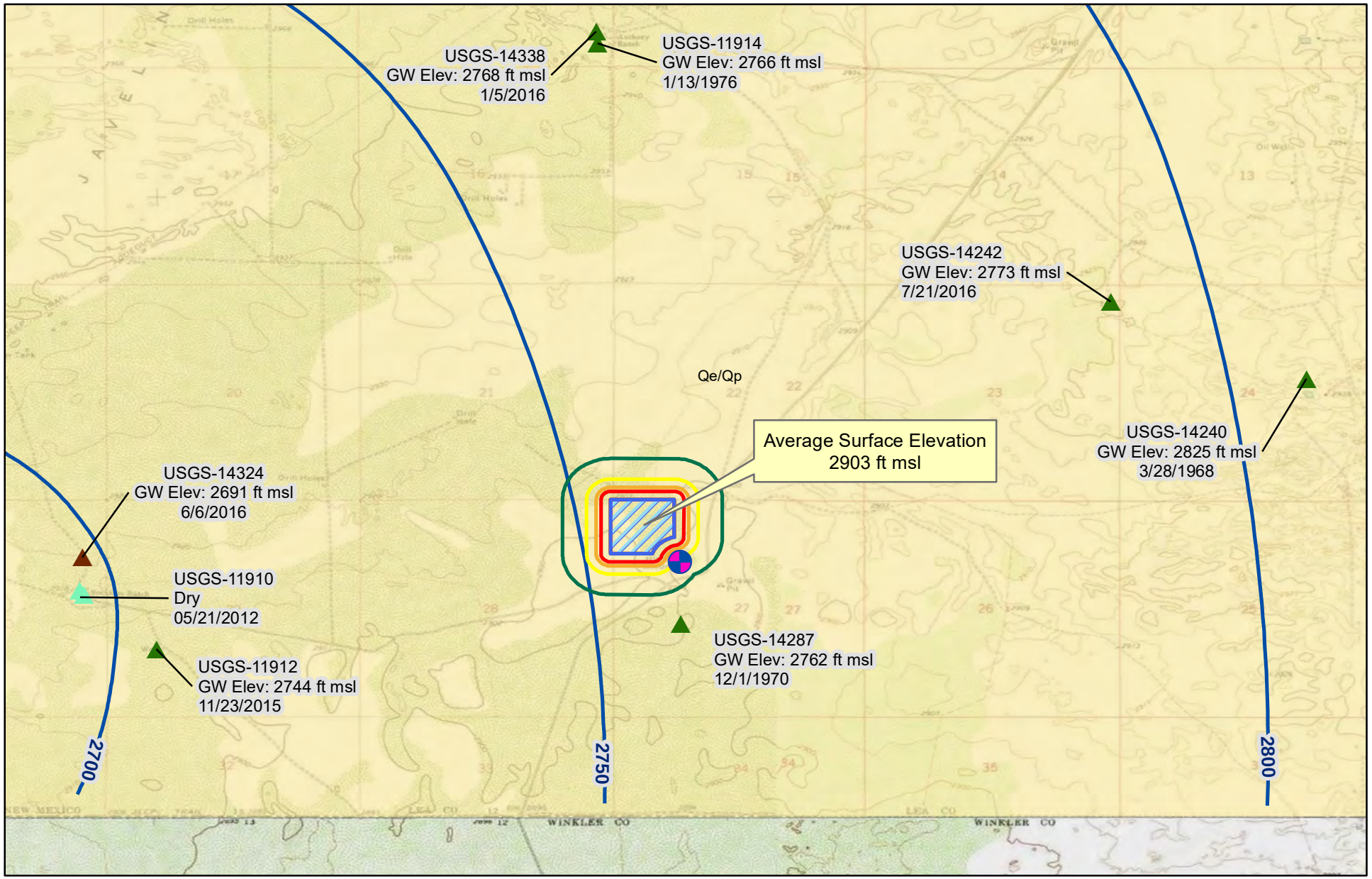

R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	Potentiometric Surface and Groundwater Elevation	Figure 2
	Ameredev Operating, LLC Fluids Containment Zone (nw/4 of nw/4, 27-T26N, R36E)	November 2017

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Legend

Fluid Containment Zone

40-Acre Tract (nw/4 of nw/4)

Fluid Containment Buffer (ft)

200 ft

300 ft

500 ft

1000 ft

Potentiometric Surface (ft msl)

Isocontours

Isocontour

USGS Gauging Station (GW Elev, Date)

Aquifer Code, Well Status

Alluvium

Alluvium/Bolsom

Alluvium/Bolsom, Site was dry (no water level was recorded).

Abandoned Windmill

NM Geology

Map Unit, Description

Qe/Qp, Quaternary-Eolian Piedmont Deposits

R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	Potentiometric Surface and Groundwater Elevation	Figure 2 LEGEND
	Ameredev Operating, LLC Fluids Containment Zone (nw/4 of nw/4, 27-T26N, R36E)	November 2017

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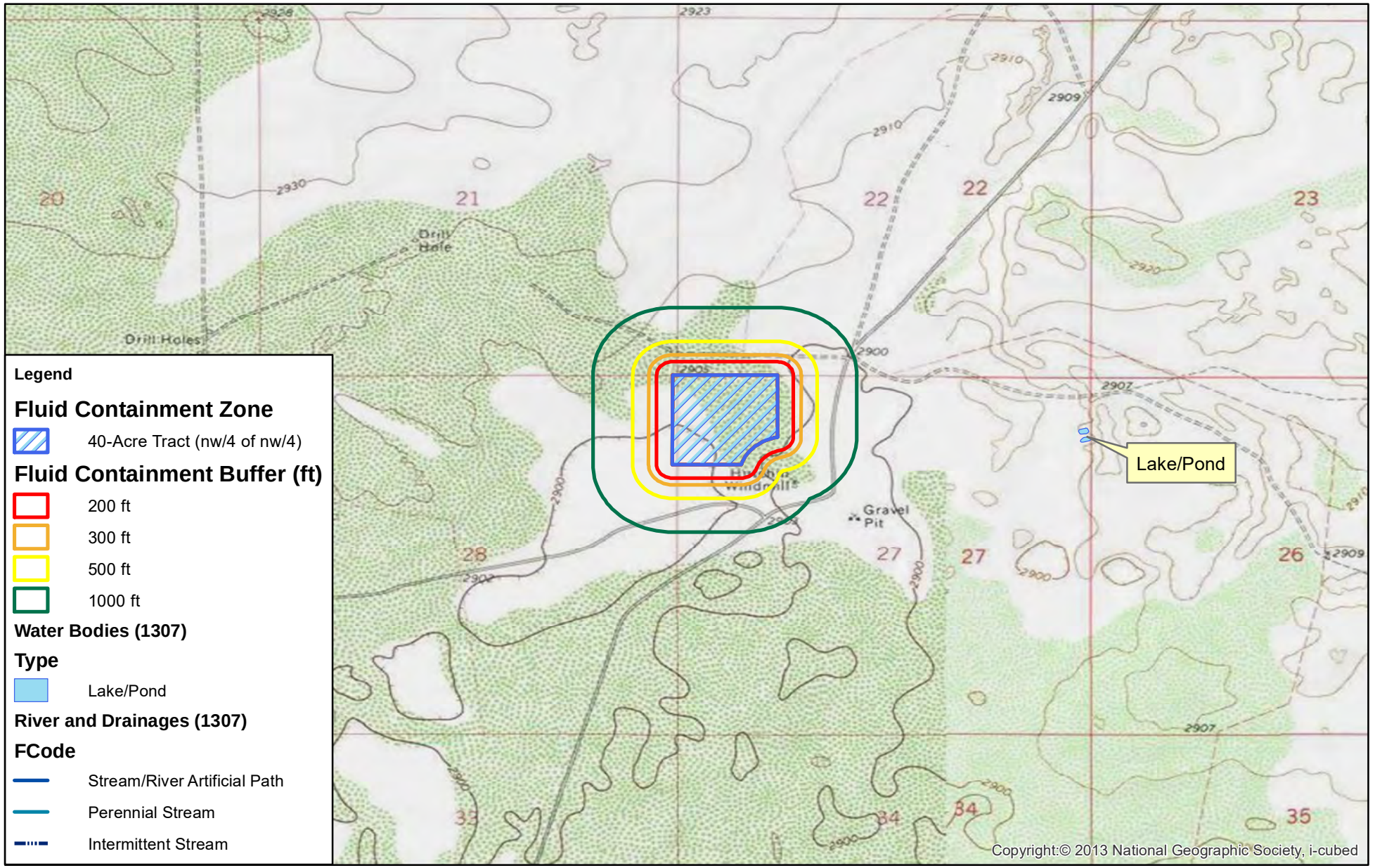

R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	Surface Water and Topography	Figure 3
	Ameredev Operating, LLC Fluids Containment Zone (nw/4 of nw/4, 27-T26N, R36E)	November 2017

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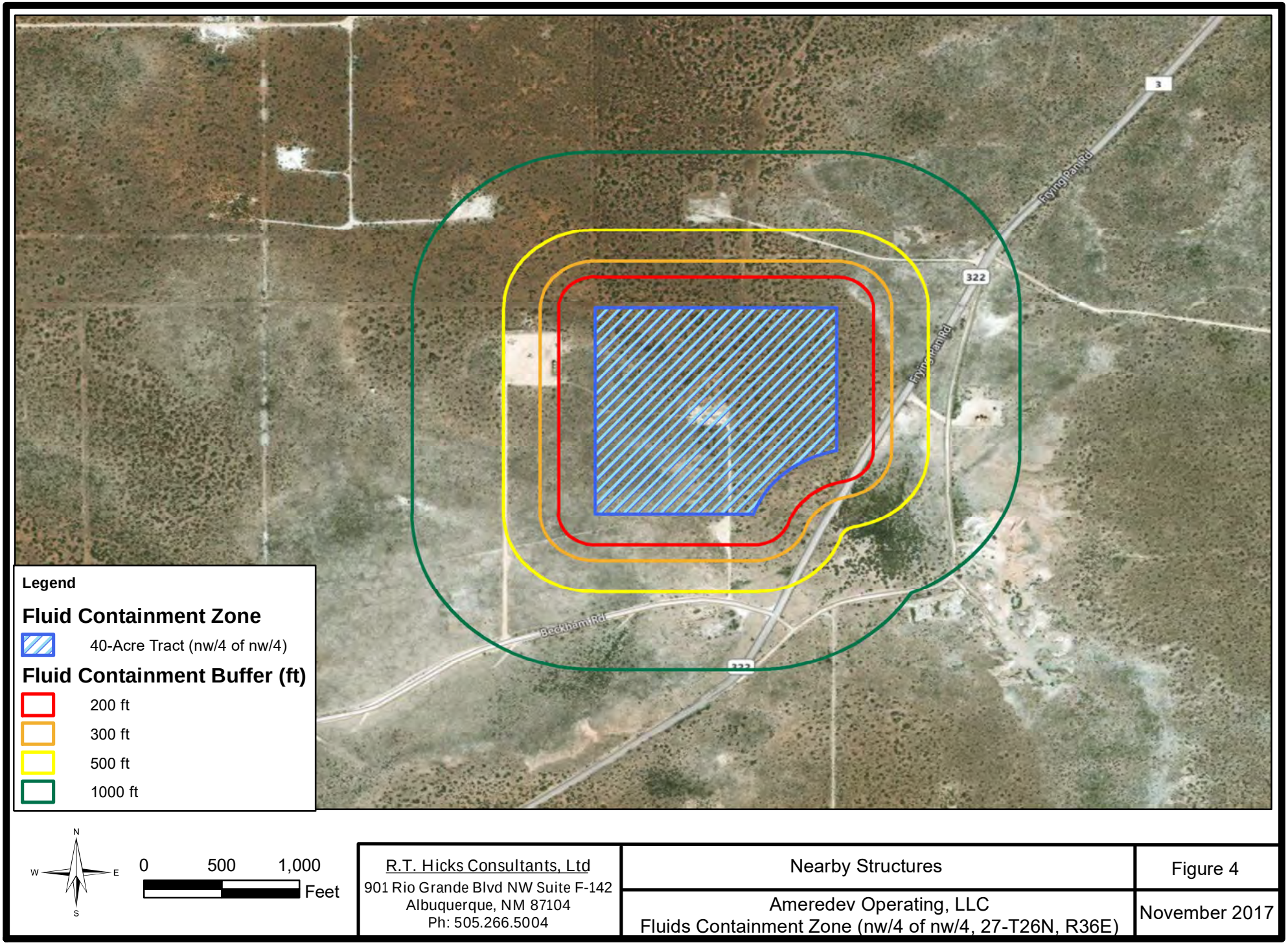

R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	Nearby Structures	Figure 4
	Ameredev Operating, LLC Fluids Containment Zone (nw/4 of nw/4, 27-T26N, R36E)	November 2017

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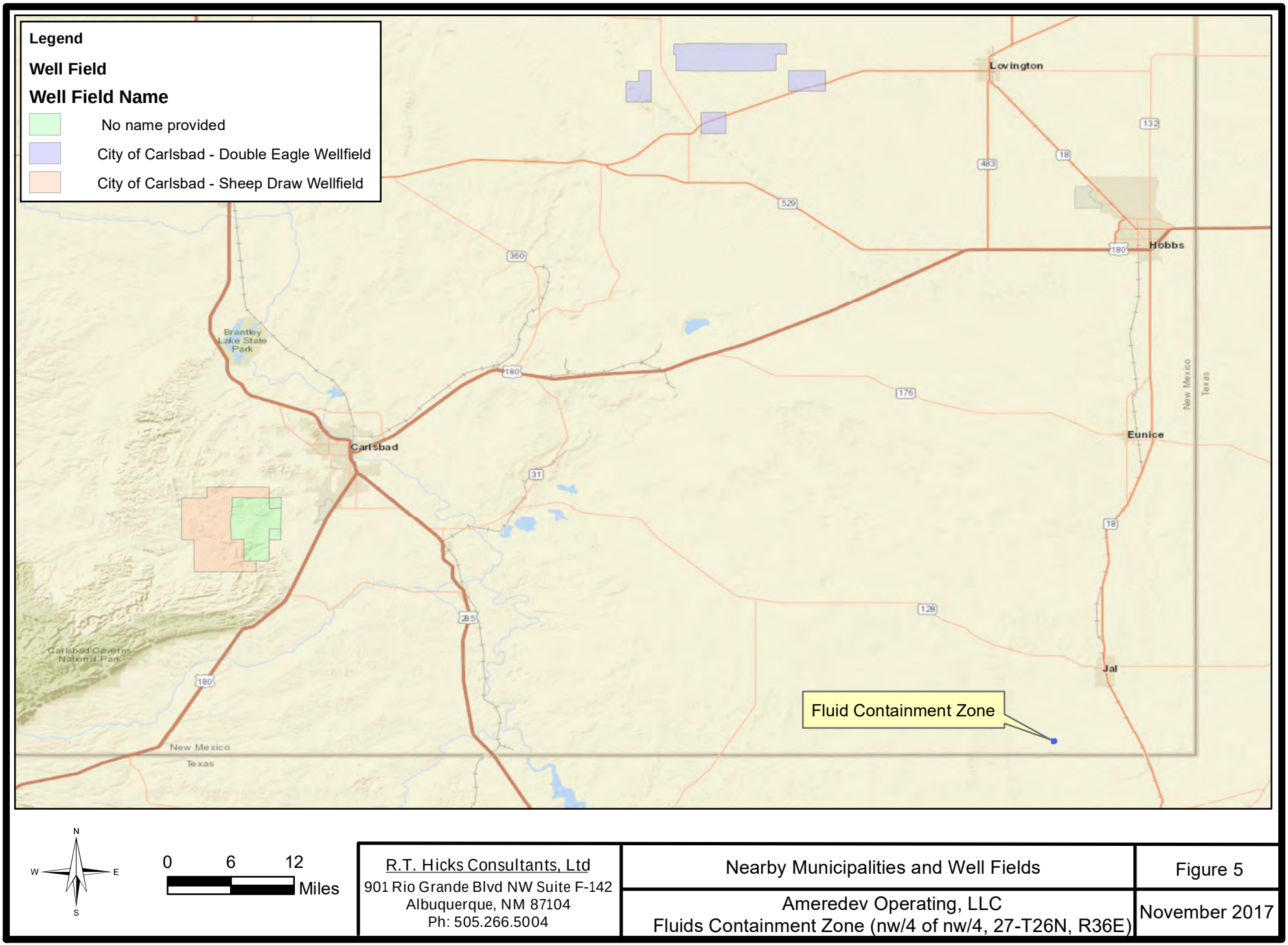

R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	Nearby Municipalities and Well Fields	Figure 5
	Ameredev Operating, LLC Fluids Containment Zone (nw/4 of nw/4, 27-T26N, R36E)	November 2017

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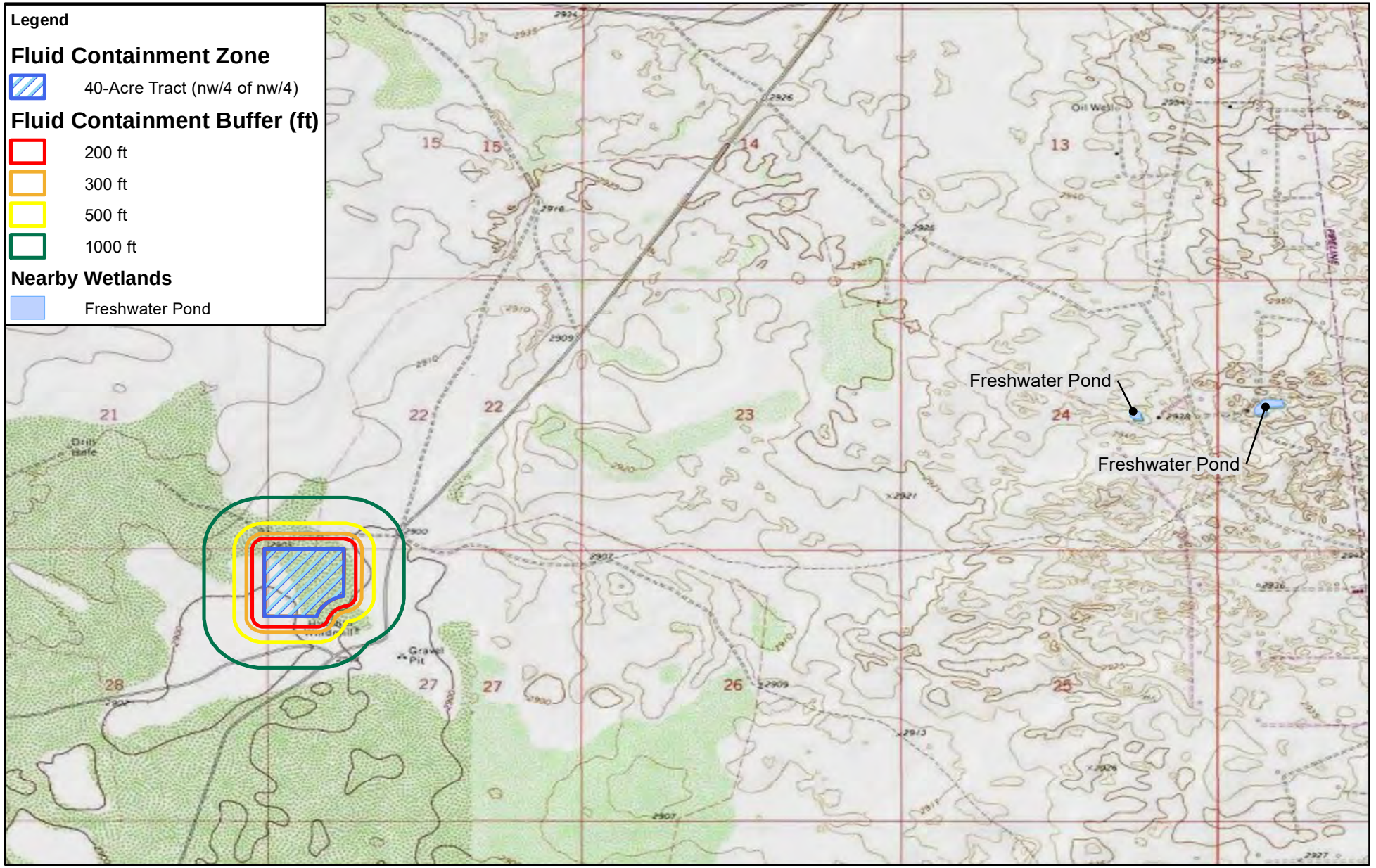

R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	Nearby Wetlands	Figure 6
	Ameredev Operating, LLC Fluids Containment Zone (nw/4 of nw/4, 27-T26N, R36E)	November 2017

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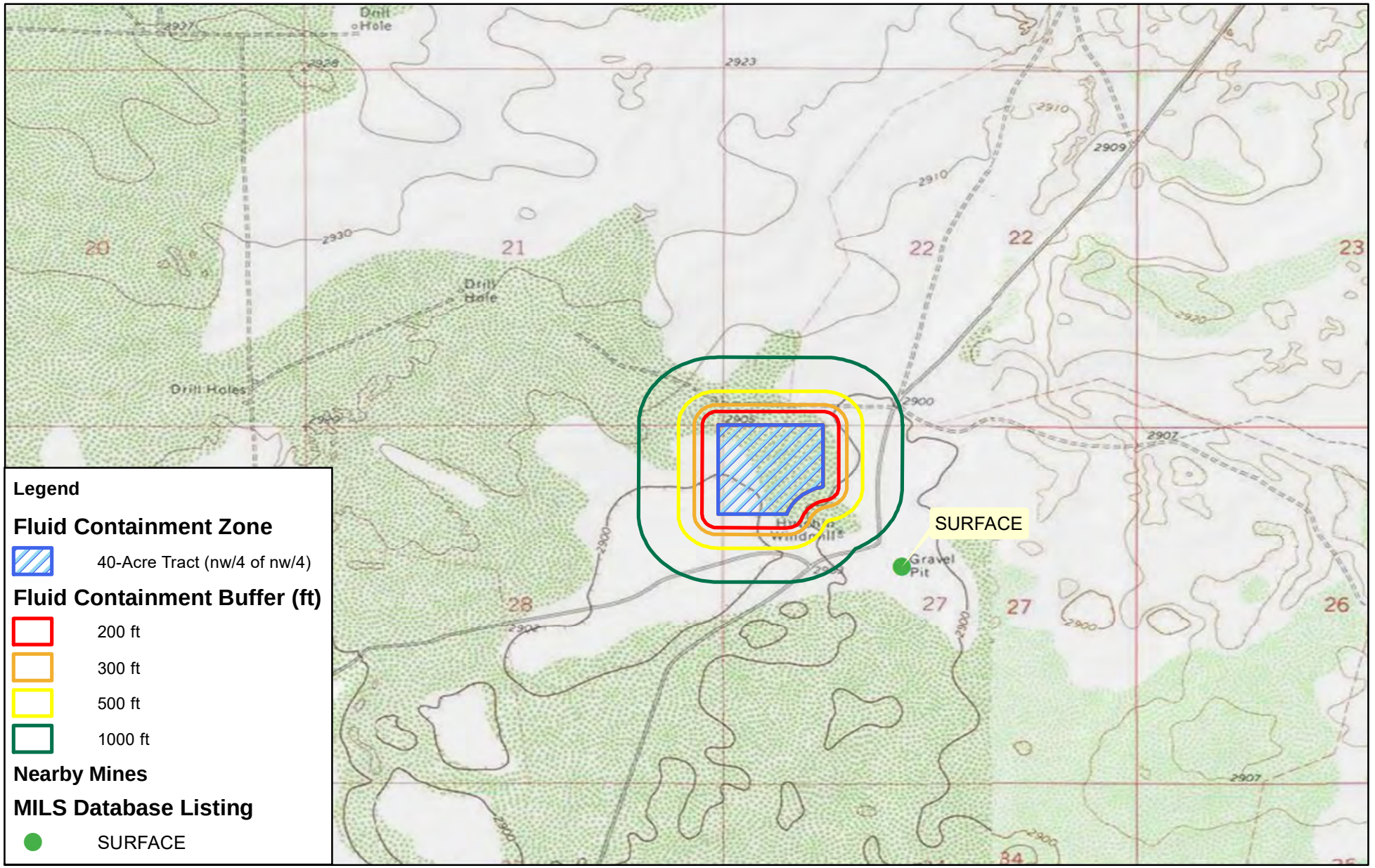
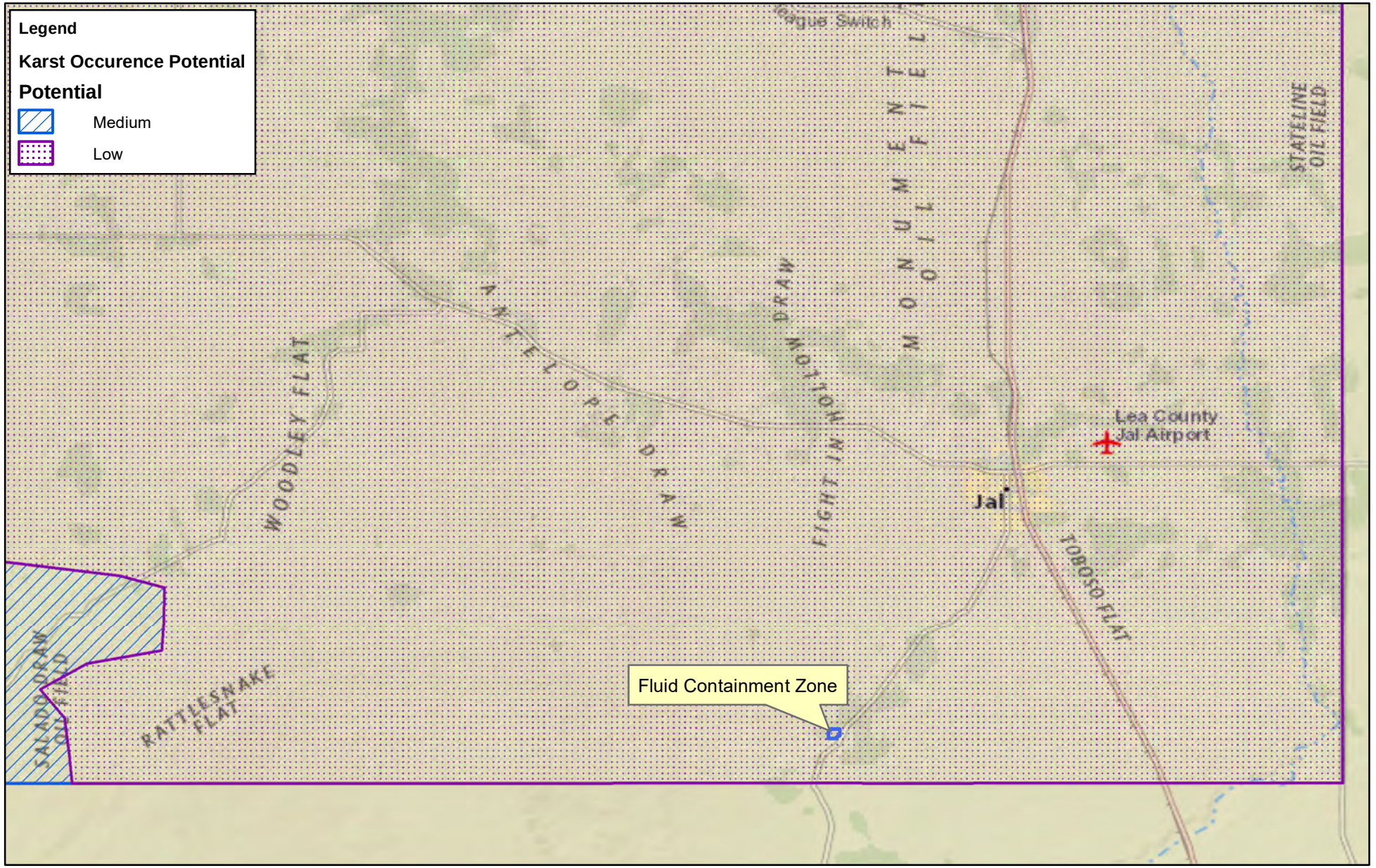


R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	Nearby Mines and Minerals	Figure 7
	Ameredev Operating, LLC Fluids Containment Zone (nw/4 of nw/4, 27-T26N, R36E)	November 2017

M:\Ameridev\containmentGIS_ap\Figures\figure8_karstPotential.mxd



R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	Karst Potential	Figure 8
	Ameredev Operating, LLC Fluids Containment Zone (nw/4 of nw/4, 27-T26N, R36E)	November 2017

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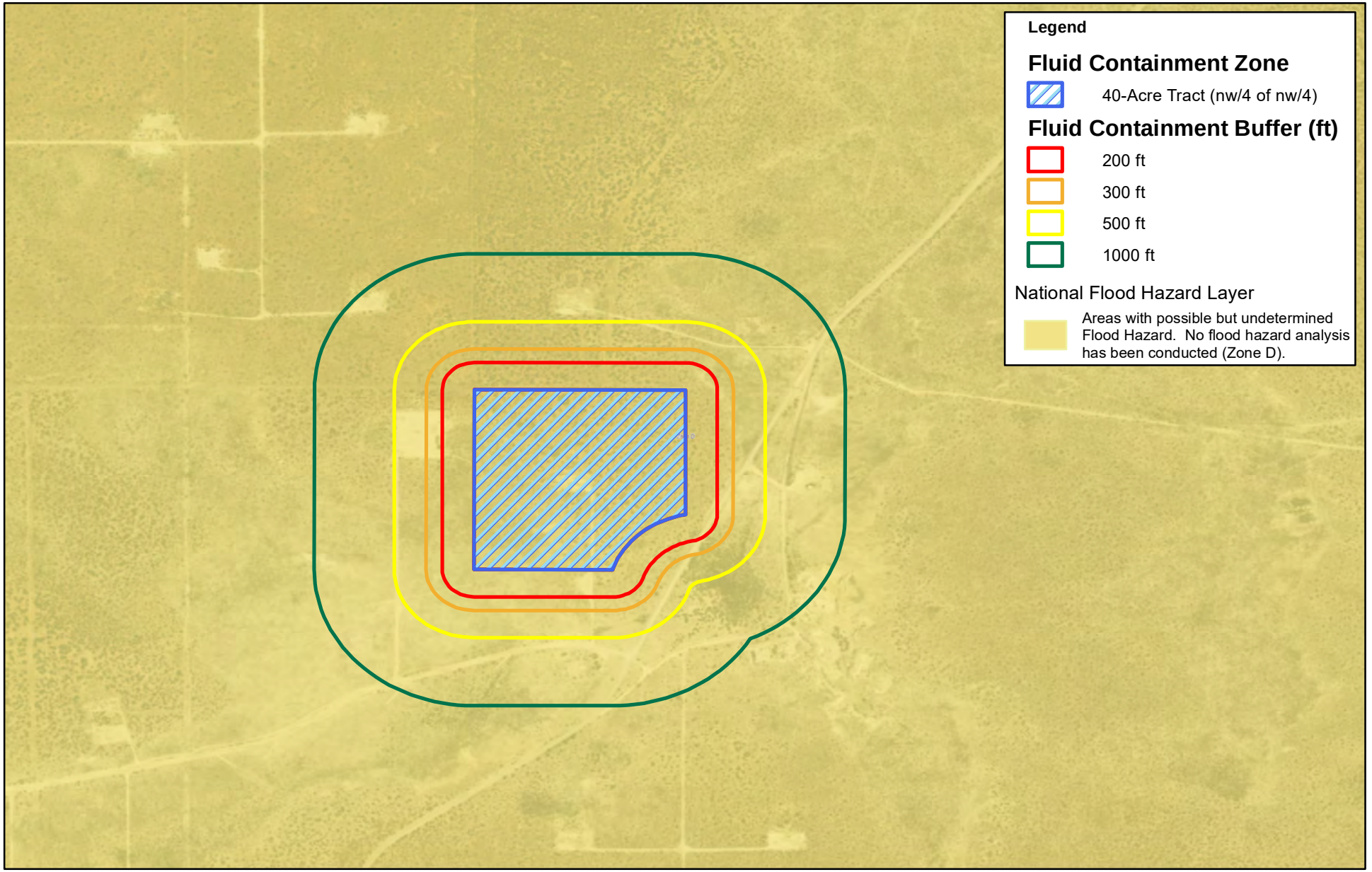
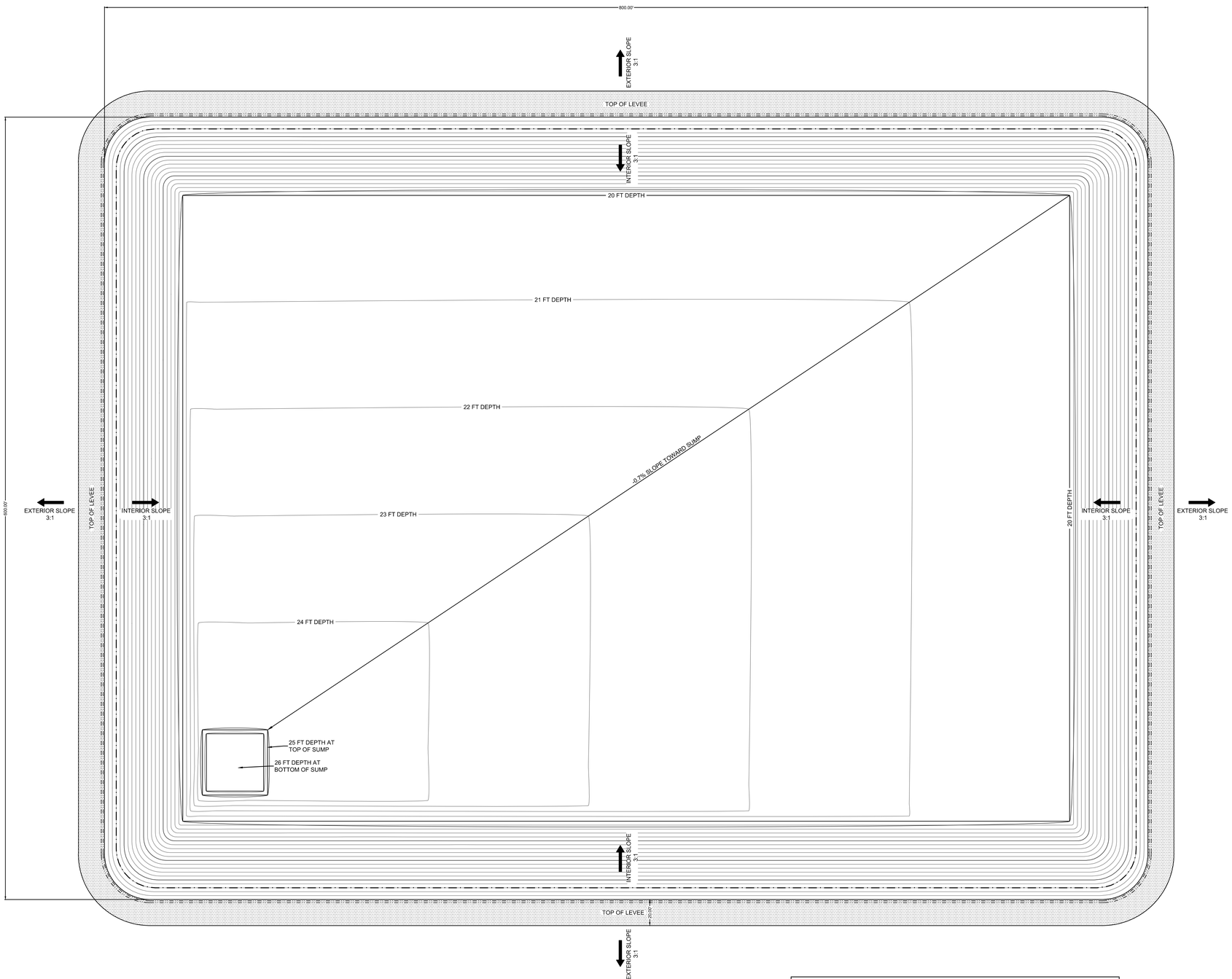


R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	FEMA Flood Map	Figure 9
	Ameredev Operating, LLC Fluids Containment Zone (nw/4 of nw/4, 27-T26N, R36E)	November 2017

Appendix A
Design Specifications



RECYCLING CONTAINMENT	
TOTAL CONTAINMENT VOLUME	1,533,079 BBL
TOTAL FLUID VOLUME BELOW 3' FREEBOARD ELEVATION	1,283,768 BBL

SCALE 1" = 40'
0' 20' 40' 80'

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PROJECT ENGINEER:	Jonathan Carey, PE
PROJECT DESIGNER:	Jonathan Carey, PE
DRAWN BY:	Jonathan Carey, PE

LEGEND

- FINISH GRADE 1.0' CONTOUR
- FINISH GRADE 5.0' CONTOUR
- DRIVING SURFACE
- ANCHOR TRENCH
- 3' FREEBOARD DEPTH

REVISIONS

No.	DATE	DESCRIPTION

CONCEPTUAL PLAN

IKE'S RECYCLING CONTAINMENT #1 AND RECYCLING FACILITY

AMEREDEV OPERATING, LLC

PROJECT NUMBER: 2018.1032

SHEET: CS-101

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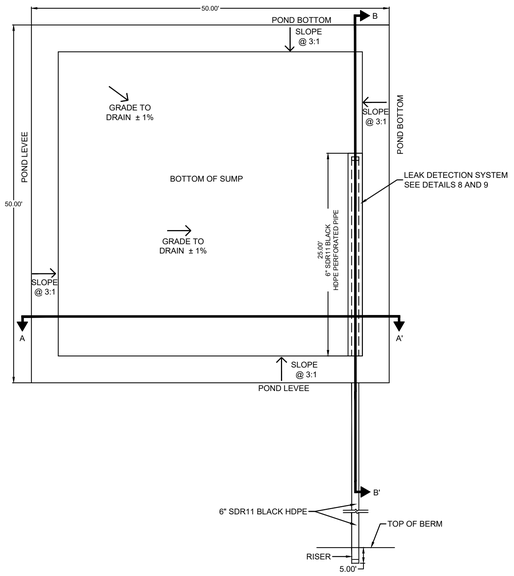
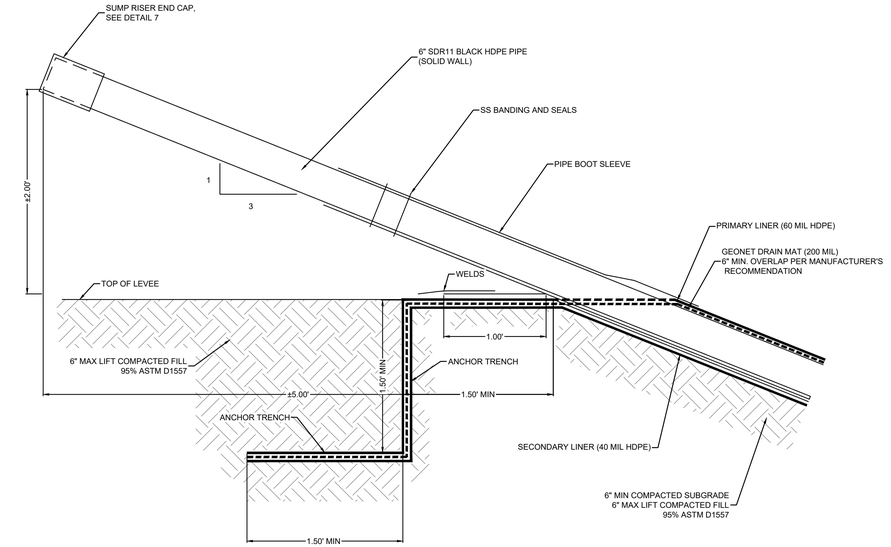
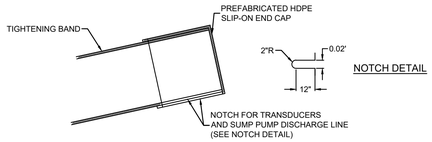


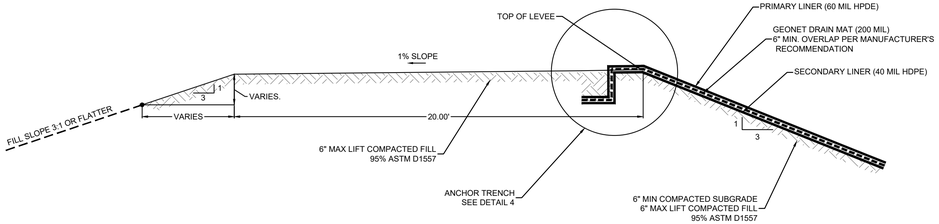
1 LEAK DETECTION SYSTEM
SUMP PLAN
SCALE: N.T.S.



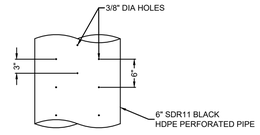
4 LEAK DETECTION SYSTEM
TYPICAL ANCHOR TRENCH AND RISER DETAIL
SCALE: N.T.S.

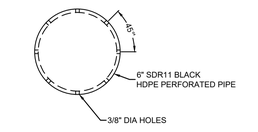


7 SUMP RISER END CAP
SCALE: N.T.S.

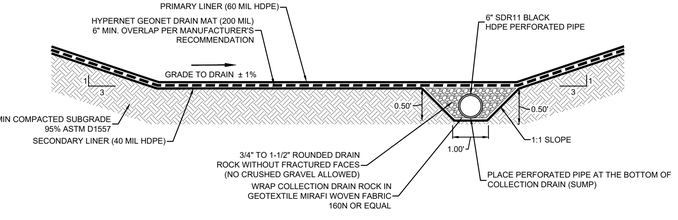


5 TOP OF LEVEE AND TYPICAL
CONTAINMENT EDGE DETAIL
SCALE: N.T.S.

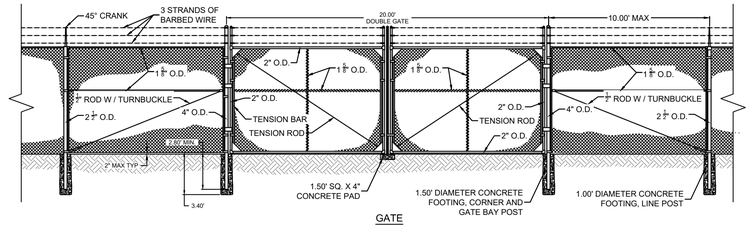




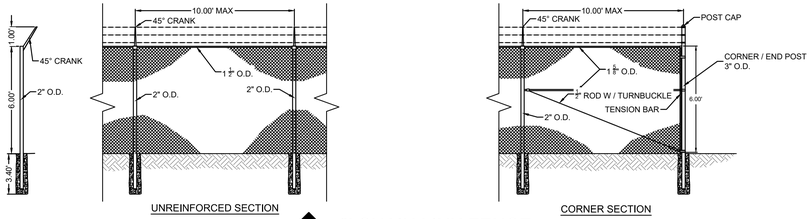
8 LEAK DETECTION SYSTEM
PIPE PERFORATION DETAIL
SCALE: N.T.S.



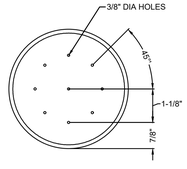
2 LEAK DETECTION SYSTEM SUMP DETAIL
SECTION A-A'
SCALE: N.T.S.



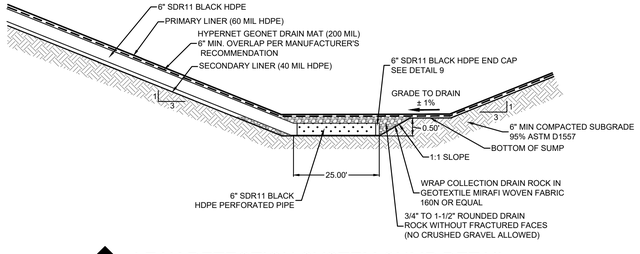
GATE



6 6' CHAIN LINK FENCE
SCALE: N.T.S.



9 LEAK DETECTION SYSTEM
PERFORATED END CAP DETAIL
SCALE: N.T.S.



3 LEAK DETECTION SYSTEM SUMP DETAIL
SECTION B-B'
SCALE: N.T.S.

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PROJECT ENGINEER:	Jonathan Carey, PE
PROJECT DESIGNER:	Jonathan Carey, PE
DRAWN BY:	Jonathan Carey, PE

REVISIONS

No.	DATE	DESCRIPTION

DETAILS

IKE'S RECYCLING CONTAINMENT #1 AND RECYCLING FACILITY

AMEREDEV OPERATING, LLC

PROJECT NUMBER: 2018.1032

SHEET: CS-501

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Appendix B
Construction Plan

C-147 Supplemental Information:Appendix B
Design and Construction Plan – Ike's Containment #1

Applicable mandates in Rule 34 are underlined. This plan addresses construction of the Ameredev Operating Ike's Containment #1. Appendix A contains the surveyed "as built" drawing of the containment prior to lining and liner and geotextile specifications are attached to this document.

Pettigrew Engineers provided the design of the containment will provide a geotechnical evaluation of the liner foundation and levees for the operator. Their design is included in this plan.

Dike Protection and Structural Integrity

The design and operation provide for the confinement of produced water, to prevent releases and to prevent overtopping due to wave action or rainfall. Additionally, the design prevents run-on of surface water as the containment is surrounded by an above-grade levee (a berm) and/or diversion ditch (between the levee and the soil stockpile) to prevent run-on of surface water.

Stockpile Topsoil

Where topsoil was present, prior to constructing containment, the operator stripped and stockpiled the topsoil for use as the final cover or fill at the time of closure.

Signage

The operator will place an upright sign no less than 12 inches by 24 inches with lettering not less than two inches in height in a conspicuous place on the fence surrounding the containment. The sign is posted in a manner and location such that a person can easily read the legend. The sign will provide the following information:

- the operator's name,
- the location of the site by quarter-quarter or unit letter, section, township and range, and
- emergency telephone numbers

Fencing

The operator will provide for a fence to enclose the recycling containment in a manner that deters unauthorized wildlife and human access. The perimeter fence around the entire 40-acre parcel owned by Ameredev is 6-foot high chain link fence rather than a a four foot fence that has at least four strands evenly spaced in the interval between one foot and four feet above ground level. Because feral pigs, javelena and deer are present in the area, a chain link or game fence is required in order to comply with Section 19.15.34.12 D.1 of the Rule[1]. The specification for fencing provided in 19.15.34.12 D.2 contradicts D.1 because pigs will move beneath the lower strand of a 4-strand, 4-foot high barbed wire fence and deer will jump over. Thus, compliance with D.2 results in a violation of D.1. Compliance with D.1 is the critical component of the Rule and operators need not submit a variance request in order to follow Best Management Practices and comply with the Rule. As stated

[1] The operator shall fence or enclose a recycling containment in a manner that deters unauthorized wildlife and human access and shall maintain the fences in good repair.

in the O&M plan, the operator will ensure that all gates associated with the fence are closed and locked when responsible personnel are not onsite.

Netting and Protection of Wildlife

The perimeter game fence will be effective in excluding stock and most terrestrial wildlife. If requested by the surface owner, the game fence can include a fine mesh from the base to 1 foot above the ground to exclude the small reptiles (e.g. dune sagebrush lizard).

The recycling containment will be protective of wildlife, including migratory birds through the implementation of an Avian Protection Plan, routine inspections and the perimeter fence.

The avian protection plan includes the use of a Bird-X Mega Blaster Pro[2] as a primary hazing program for avian species. The device will be equipped with sounds suitable for the Permian Basin environment. In addition to this sonic device, staff will routinely inspect the containment for the presence of avian species and, if detected, will use a blank cartridge or shell in a handgun, starter pistol or shotgun as additional hazing. Decoys of birds of prey may be placed on the game fence and other roosts around the open water to provide additional hazing.

The O&M plan calls for the operator to inspect for and, within 30 days of discovery, report the discovery of dead migratory birds or other wildlife to the appropriate wildlife agency and to the division district office in order to facilitate assessment and implementation of measures to prevent incidents from reoccurring.

Earthwork

The containment will have a properly constructed foundation and interior slopes consisting of a firm, unyielding base, smooth and free of rocks, debris, sharp edges or irregularities to prevent the liner's rupture or tear. Geotextile may be placed under the liner when needed to reduce localized stress-strain or protuberances that otherwise may compromise the liner's integrity.

Appendix A shows the

a) levee has inside grade no steeper than two horizontal feet to one vertical foot (2H: 1V).
b) levee outside grade is no steeper than three horizontal feet to one vertical foot (3H: 1V)
c) top of the levee is wide enough to install an anchor trench and provide adequate room for inspection and maintenance.
d) The containment floor design calls for a slope toward the sump in the northeast corner.

[2] https://bird-x.com/bird-products/electronic/sonic/mega-blaster-pro/

Liner and Drainage Geotextile Installation

The containment has a primary (upper) liner and a secondary (lower) liner with a leak detection system appropriate to the site's conditions.

The primary (upper) liner is a geomembrane liner composed of an impervious, synthetic material that is resistant to ultraviolet light, petroleum hydrocarbons, salts and acidic and alkaline solutions. It is 60-mil HDPE. The secondary liner is 40-mil HDPE and is equivalent to 30-mil LLDPEr. Liner compatibility meets or exceeds a subsequent relevant publication to EPA SW -846 method 9090A.

The recycling containment design has a leak detection system between the upper and lower geomembrane liners of 200-mil geonet to facilitate drainage. The leak detection system consists of a properly designed drainage and collection and removal system placed above the lower geomembrane liner in depressions and sloped to facilitate the earliest possible leak detection. The containment floor design calls for a slope toward the sump in the southeast corner. This slope combined with the highly transmissive geonet drainage layer provide for rapid leak detection.

The liners and drainage material will be installed consistent with the Manufacture's specifications. In addition to any specifications of the Manufacturer, protocols for liner installation include measures to:

i. minimizing liner seams and orient them up and down, not across, a slope of the levee.
ii. use factory-welded seams where possible.
iii. use field seams in geosynthetic material that are thermally seamed and prior to field seaming, overlap liners four to six inches.
iv. minimize the number of field seams and comers and irregularly shaped areas.
v. provide for no horizontal seams within five feet of the slope's toe.
vi. use qualified personnel to perform field welding and testing.
vii. avoid excessive stress-strain on the liner
viii. The edges of all liners are anchored in the bottom of a compacted earth-filled trench that is at least 18 inches deep

At points of discharge into the lined earthen containment the pipe configuration effectively protects the liner from excessive hydrostatic force or mechanical damage during filling.

The design shows that at any point of discharge into or suction from the recycling containment, the liner is protected from excessive hydrostatic force or mechanical damage. External discharge or suction lines do not penetrate the liner.

Pumping from the containment to hydraulic fracturing operations is the responsibility of stimulation contractors. Typically, lines are permanently placed in the containment with floats attached to prevent damage to the liner system. The containment may be equipped

with permanent HDPE stinger (supported by a sacrificial liner or geotextile) for withdrawal of fluid if the owner deems necessary during operations.

Leak Detection and Fluid Removal System Installation

The leak detection system, contains the following design elements

a. The 200-mil HyperNet Geonet drainage material between the primary and secondary liner that is sufficiently permeable to allow the transport of fluids to the observation ports (Appendix A).
b. The containment floor is sloped towards the monitoring riser pipe to facilitate the earliest possible leak detection of the containment bottom. A pump may be placed in the observation port to provide for fluid removal.
c. Piping will withstand chemical attack from any seepage; structural loading from stresses and disturbances from overlying water, cover materials, equipment operation or expansion or contraction (see Appendix A).

Appendix C

Operating and Maintenance Plan

R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW, Suite F-142
Albuquerque, NM 87104

Operating and Maintenance Procedures

In this plan, underlined text represents the language of the Rule.

The operator will operate and maintain the lined earthen containment to contain liquids and solids (blow sand and minimal precipitates from the treated produced water) and maintain the integrity of the liner system in a manner that prevents contamination of fresh water and protects public health and the environment as described below. The purpose of the lined earthen containment is to facilitate recycling, reuse and reclamation of produced water derived from nearby oil and gas wells. During periods when water for E&P operations is not needed, produced water will discharge to one of the injection wells in the operator's SWD system. The containment will not be used for the disposal of produced water or other oilfield waste.

The operation of the containment is summarized below.

A. Via pipeline, produced water generated from nearby oil and gas wells is delivered to a treatment system located as indicated in the C-147.
B. After treatment, the produced water discharges into the containment.
C. When required, treated produced water is removed from the containment for E&P operations. At this time, treated produced water will be used for drilling beneath the fresh water zones (beneath surface casing), for well stimulation (e.g. hydraulic fracturing) and other E&P uses as approved by OCD.
D. Whenever the maximum fluid capacity of the containment is reached, treatment and discharge to the containment ceases (see Freeboard and Overtopping Plan, below).
E. The operator will keep accurate records and shall report monthly to the division the total volume of water received for recycling, with the amount of fresh water received listed separately, and the total volume of water leaving the facility for disposition by use on form C-148.
F. The operator will maintain accurate records that identify the sources and disposition of all recycled water that shall be made available for review by the division upon request.
G. The containment shall be deemed to have ceased operations if less than 20% of the total fluid capacity is used every six months following the first withdrawal of produced water for use. The operator will report cessation of operations to the appropriate division district office. The appropriate division district office may grant an extension to this determination of cessation of operations not to exceed six months.

The operation of the lined earthen containment will follow the mandates listed below:

1. The operator will not discharge into or store any hazardous waste (as defined by 40 CFR 261 and NMAC 19.15.2.7.H.3) in the containments.
2. If the containment's primary liner is compromised above the fluid's surface, the operator will repair the damage or initiate replacement of the primary liner within 48 hours of discovery or seek an extension of time from the division district office.
3. If the primary liner is compromised below the fluid's surface, the operator will remove all fluid above the damage or leak within 48 hours of discovery, notify the division district office and repair the damage or replace the primary liner.
4. If any penetration of the containment liner is confirmed by sampling of fluid in the leak detection system (see Monitoring, Inspection, and Reporting Plan; below), the operator will:

a. Begin and maintain fluid removal from the leak detection/pump-back system,
b. Notify the district office within 48 hours (phone or email) of the discovery,
c. Identify the location of the leak, and
d. Repair the damage or, if necessary, replace the containment liner.

5. The operator will install, or maintain on site, an oil absorbent boom or other device to contain an unanticipated release and the operator will remove any visible layer of oil from the surface of the recycling containment.
6. The operator will report releases of fluid in a manner consistent with NMAC 19.15.29
7. The containment will be operated to prevent the collection of surface water run-on.
8. The operator will maintain the containment free of miscellaneous solid waste or debris.
9. The operator will maintain at least three feet of freeboard for the containment and will use a free-standing staff gauge to allow easy determination of the required 3-foot of freeboard.
10. As described in the design/construction plan, the injection or withdrawal of fluids from the containment is accomplished through hardware that prevents damage to the liner by erosion, fluid jets or impact from installation and removal of hoses or pipes.
11. The operator shall ensure that all gates associated with the fence are closed and locked when responsible personnel are not onsite.
12. The operator will maintain the fences in good repair.

Monitoring, Inspection, and Reporting Plan

The operator will inspect the recycling containment and associated leak detection systems weekly while it contains fluids. The operator shall maintain a current log of such inspections and make the log available for review by the division upon request.

Weekly inspections consist of:

- reading and recording the fluid height of staff gauges,
- recording any evidence that the pond surface shows visible oil,
- visually inspecting the containment's exposed liners, and
- checking the leak detection system for any evidence of a loss of integrity of the primary liner.

As stated above, if a liner's integrity is compromised, or if any penetration of the liner occurs above the water surface, then the operator will notify the District office within 48 hours (phone or email).

Monthly, the operator will:

A. Inspect diversion ditches and berms around the containment to check for erosion and collection of surface water run-on.
B. Inspect the leak detection system for evidence of damage or malfunction and monitor for leakage.
C. Inspect the containment for dead migratory birds and other wildlife. Within 30 days of discovery, report the discovery of dead migratory birds or other wildlife to the appropriate wildlife agency and to the division district office in order to facilitate assessment and implementation of measures to prevent incidents from reoccurring.
D. Report to the division the total volume of water received for recycling, with the amount of fresh water received listed separately, and the total volume of water leaving the facility for disposition by use on form C-148.
E. Record sources and disposition of all recycled water

The operator will maintain a log of all inspections and make the log available for the appropriate Division district office's review upon request. An example of the log is attached to this section of the permit application.

Freeboard and Overtopping Prevention Plan

The method of operation of the containment allows for maintaining freeboard with very few potential problems. When the capacity of the containment is reached (3-feet of freeboard), the discharge of treated produced water ceases and the produced water generated by nearby oil and gas wells is managed by an injection well(s).

If rising water levels suggest that 3-feet of freeboard will not be maintained, the operator will implement one or more of the following options:

I. Cease discharging treated produced water to the containment.
II. Accelerate re-use of the treated produced water for purposes approved by the Division.
III. Transfer treated produced water from the containment to injection wells.

The reading of the staff gauge typically occurs daily when treatment operations are ongoing and weekly when discharge to the containment is not occurring.

Protocol for Leak Detection Monitoring, Fluid Removal and Reporting

As shown in Appendix A, the leak detection system includes a monitoring system. Any fluid released from the primary liner will flow to the collection sump where fluid level monitoring is possible at the monitoring riser pipe associated with the leak detection system.

Staff may employ a portable electronic water level meter to determine if fluid exists in the monitoring riser pipe. Obtaining accurate readings of water levels in a sloped pipe beneath a containment can be a challenge. An electrician's wire snake may be required to push the probe to the bottom of the port and the probe may be fixed in a 2-inch pipe "dry housing" to avoid false readings due to water condensation on the pipe. There are many techniques to determine the existence of water in the sumps – including low flow pumps and a simple small bailer affixed to an electrician's snake. The operator will use the method that works best for this containment.

If seepage from the containment into the leak detection system is suspected by a positive fluid level measurement, the operator will:

1. Re-measure fluid levels in the monitoring riser pipe on a daily basis for one week to determine the rate of seepage.
2. Collect a water sample from the monitoring riser pipe to confirm the seepage is treated produced water from the containment via electrical conductivity and chloride measurements.
3. Notify NMOCD of a confirmed positive detection in the system within 48 hours of sampling (initial notification).
4. Install a pump into the monitoring riser pipe sump to continually (manually on a daily basis or via automatic timers) remove fluids from the leak detection system into the containment until the liner is repaired or replaced.
5. Dispatch a liner professional to inspect the portion of the containment

suspected of leakage during a “low water” monitoring event.

6. Provide NMOCD a second report describing the inspection and/or repair within 20 days of the initial notification.

If the point of release is obvious from a low water inspection, the liner professional will repair the loss of integrity. If the point of release cannot be determined by the inspection, the liner professional will develop a more robust plan to identify the point(s) of release. The inspection plan and schedule will be submitted to OCD with the second report. The operator will implement the plan upon OCD approval.

Containment Inspection Form

Month **Oct-14**

Day	Weekly	Low Water	Activity	Monthly	Staff Gauge	Comments
1 - Wed						
2	x				8.75	Gate unlocked upon arrival - notified Jerry Smith, no birds in pit
3					10	
4					12	
5			x			Water transfer to frac - pipes are good
6			x			Water transfer to frac - pipes are good
7		x			2.5	No visible liner problems
8					3	
9	x				4	All OK - no oil on surface, no birds in pit
10					5	
11					5	
12					6	
13					7	
14					7.5	
15				x	8	No fluid in leak detection, outer berm and stormater diversion OK, H2S - no alarm,
16					9	
17					9	
18					9.5	
19	x				10	All OK
20					11	
21					12	
22			x			Water transfer to frac - no problems
23			x			Water transfer to frac - no problems
24		x			1.75	No visible liner problems
25					2.25	
26	x				3.75	High wind -liner is good, no birds
27					4.75	
28					5.5	
29					6.75	
30					7.75	
31					8.5	

Appendix D

Closure Plan

R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW, Suite F-142
Albuquerque, NM 87104

In this plan, underlined text represents the language of the Rule.

After operations cease, the operator will remove all fluids within 60 days and close the containment within six months from the date the operator ceases operations from the containment for use.

The operator shall substantially restore the impacted surface area to

- the condition that existed prior to the construction of the recycling containment or
- to a condition imposed by federal, state trust land or tribal agencies on lands managed by those agencies as these provisions govern the obligations of any operator subject to those provisions,

As this containment will excavate caliche for future use and pay the surface owner (BLM) for the harvest and use of this material. We anticipate the surface owner will impose a closure design that conforms to one of a caliche mine rather than the condition that existed prior to construction. Until a change to closure as a caliche mine is required by BLM, the prescriptive mandates set forth in this plan will be in effect. The operator understands that a variance will be submitted to OCD to allow for any alternative closure protocol.

Excavation and Removal Closure Plan – Protocols and Procedures

The containment is expected to hold a small volume of solids, the majority of which will be windblown sand and dust with some mineral precipitates from the water

1. The operator will remove all liquids from the pits and either:
    a. Dispose of the liquids in a division-approved facility, or
    b. Recycle, reuse or reclaim the water for reuse in drilling and stimulation.
2. The operator will close the recycling containment by first removing all fluids, contents and synthetic liners and transferring these materials to a division approved facility.
3. After the removal of the pit contents and liners, soils beneath the containment will be tested by collection of a five-point (minimum) composite sample which includes stained or wet soils, if any, and that sample shall be analyzed for the constituents listed in Table I of 19.15.34.14.
4. After review of the laboratory results
    a. If any contaminant concentration is higher than the parameters listed in Table I, additional delineation may be required and the operator must receive approval before proceeding with closure.
    b. If all contaminant concentrations are less than or equal to the parameters listed in Table I, then the operator will proceed to
        i. backfill with non-waste containing, uncontaminated, earthen material. Or
        ii. undertake an alternative closure process pursuant to a variance request after approval by OCD

Reclamation and Re-vegetation

a. The operator will reclaim the containment's location to a safe and stable condition that blends with the surrounding undisturbed area.
b. Topsoils and subsoils shall be replaced to their original relative positions and contoured so as to achieve erosion control, long-term stability and preservation of surface water flow patterns.

c. The disturbed area shall then be reseeded in the first favorable growing season following closure of a recycling containment.

Closure Documentation

Within 60 days of closure completion, the operator shall submit a closure report on form C-147, including required attachments, to document all closure activities including sampling results and the details on any backfilling, capping or covering, where applicable. The closure report shall certify that all information in the report and attachments is correct and that the operator has complied with all applicable closure requirements and conditions specified in division rules or directives.

The operator shall notify the division when reclamation and re-vegetation are complete. Specifically the notice will document that all ground surface disturbing activities at the site have been completed, and a uniform vegetative cover has been established that reflects a life-form ratio of plus or minus fifty percent (50%) of pre-disturbance levels and a total percent plant cover of at least seventy percent (70%) of pre-disturbance levels, excluding noxious weeds.

Appendix E
Site Inspection and Survey

R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW, Suite F-142
Albuquerque, NM 87104

SKETCH

SECTION 27, T-26-E, R-36-E, N.M.P.M.
LEA COUNTY, NEW MEXICO
"NORTHWEST QUARTER OF NORTHWEST QUARTER OF SECTION 27 BOUNDARY"

SCALE: 1" = 100'
0' 50' 100'

LEGEND

- SECTION LINE
- PROPOSED SITE
- PROPOSED ROAD
- LIFT — PROPOSED GAS LIFT LINE
- GAS — PROPOSED GAS LINE
- PROPOSED EDGE OF EASEMENT
- TRACT BORDER
- C/L OF ROAD
- ROAD WAY
- X — FENCE LINE
- EXISTING PIPELINE
- OHE — OVERHEAD ELECTRIC
- IRON ROD SET
- MONUMENT
- NAIL FOUND
- GAS/OIL WELL
- PROPOSED WELL
- UTILITY/POWER POLE
- GUY ANCHOR

PROPOSED
AMEN CORNER STATE COM
BATTERY SITE

PROPOSED
PLAYER COMPRESSOR STATION
SITE

CATTLE GUARD

PROPOSED GAS LIFT LINE

PROPOSED GAS LINE

PROPOSED ROAD

PROPOSED ROAD

PROPOSED MAGNOLIA STATE COM 26-36-22 101H
PROPOSED MAGNOLIA STATE COM 26-36-22 111H

PROPOSED
AMEN CORNER STATE COM 26-36-27 111H
PROPOSED
AMEN CORNER STATE COM 26-36-27 121H

PROPOSED
AMEN CORNER STATE COM
PAD SITE

SECTION 21
SECTION 22
SECTION 28
SECTION 27

FND. BRASS CAP,
U.S. G.L.O. SUR.
1913
21 22
28 27

1/2" IRON ROD SET

PROPOSED ROAD

PROPOSED
OPTIONAL
PAD SITE

Produced Water Recycling Containment Placed in Northeast Portion of 40-acre Tract

NW4 OF NW4
OF SECTION 27

EXISTING WELL

EXISTING WELL

TELEPHONE LINE

LEASE RD.

LEASE RD.

JAL-3 ROFFRYNG PAN RD.

CATTLE GUARD

1/2" IRON ROD SET

60D NAIL

EXISTING
SITE

LEASE RD.

LEASE RD.

BORROW PIT

EXISTING WELL

S:\SURVEY\AMEREDEV_OPERATING_LLC\NW4_NW4_SEC_27_BOUNDARY\FINAL_PRODUCTS\SKETCH\SK_NW4_NW4_SEC27_BOUNDARY.DWG 11/7/2017 10:51:49 AM ccaston

Typical vegetation and low sand dunes characterize the northern and eastern ¾ of the Ameredev-owned surface where the containment will be built. The registration cover image also represents this area of the proposed containment.

This view to the southwest at the southwest corner of the Ameredev-owned surface is on the northeastern edge of the mapped closed depression shown in Figure 3. The area shows no historic evidence of a lake bottom, such as saline soils, wetland vegetation, ancient shorelines, etc.

The image below shows the nature of the vegetation and surface within the closed depression to the southwest of the Ameredev-owned surface. The corner stake in the image above is within the red circle. The surface is characterized by angular caliche clasts and possibly exposure of the underlying caliche layer.

The caliche pit shown below is located about 1500 feet southeast of the proposed containment area. The elevation of the pit suggests that caliche will be present in the bottom of the containment excavation.

Appendix F

Supplemental Site Information

901 Via Fortuna Suite 600 • Austin, Texas 78746

Supplemental Siting Criteria

Depth to Water

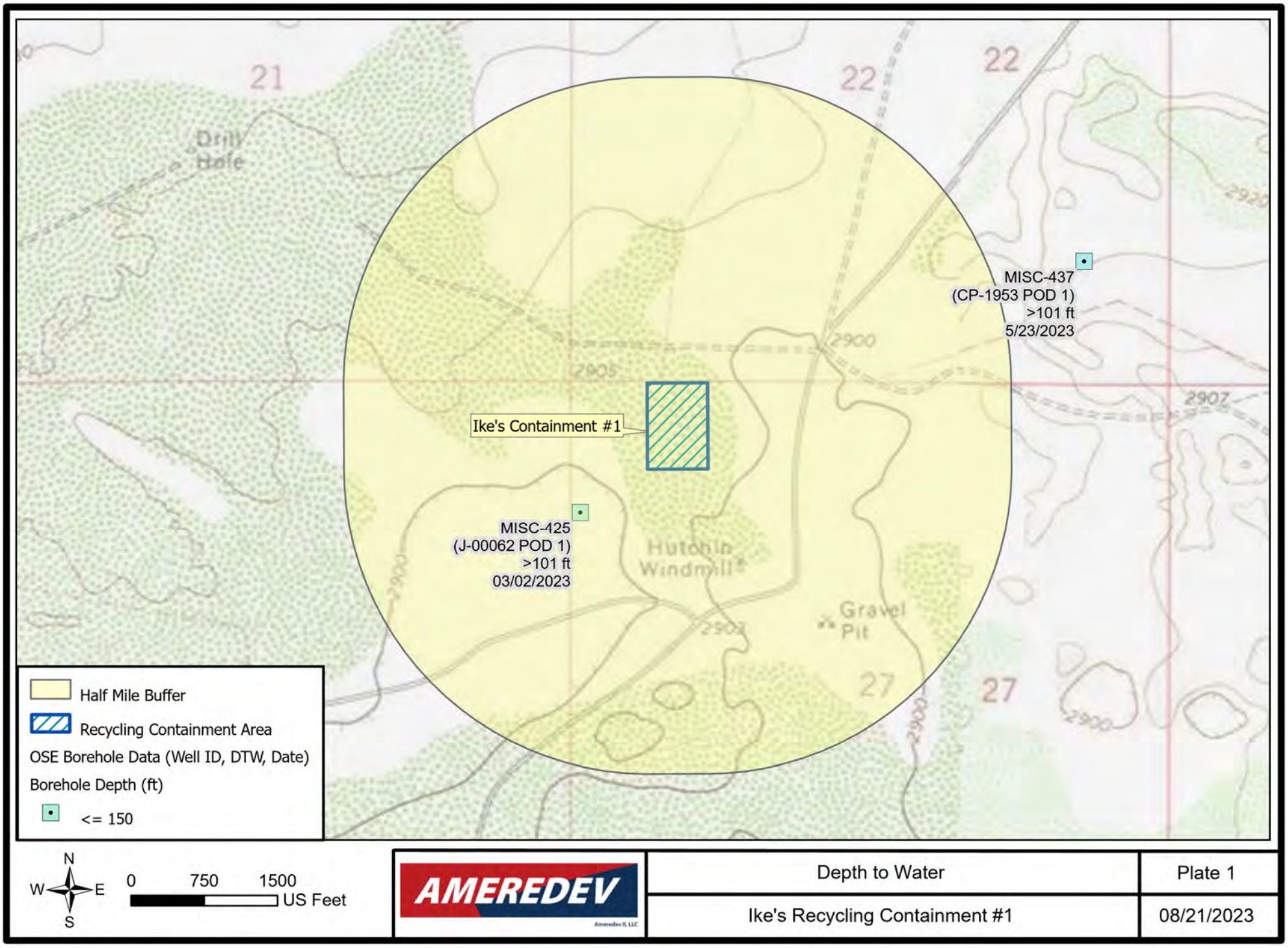
A depth-to-water borehole is mapped on Plate 1 followed by well log:

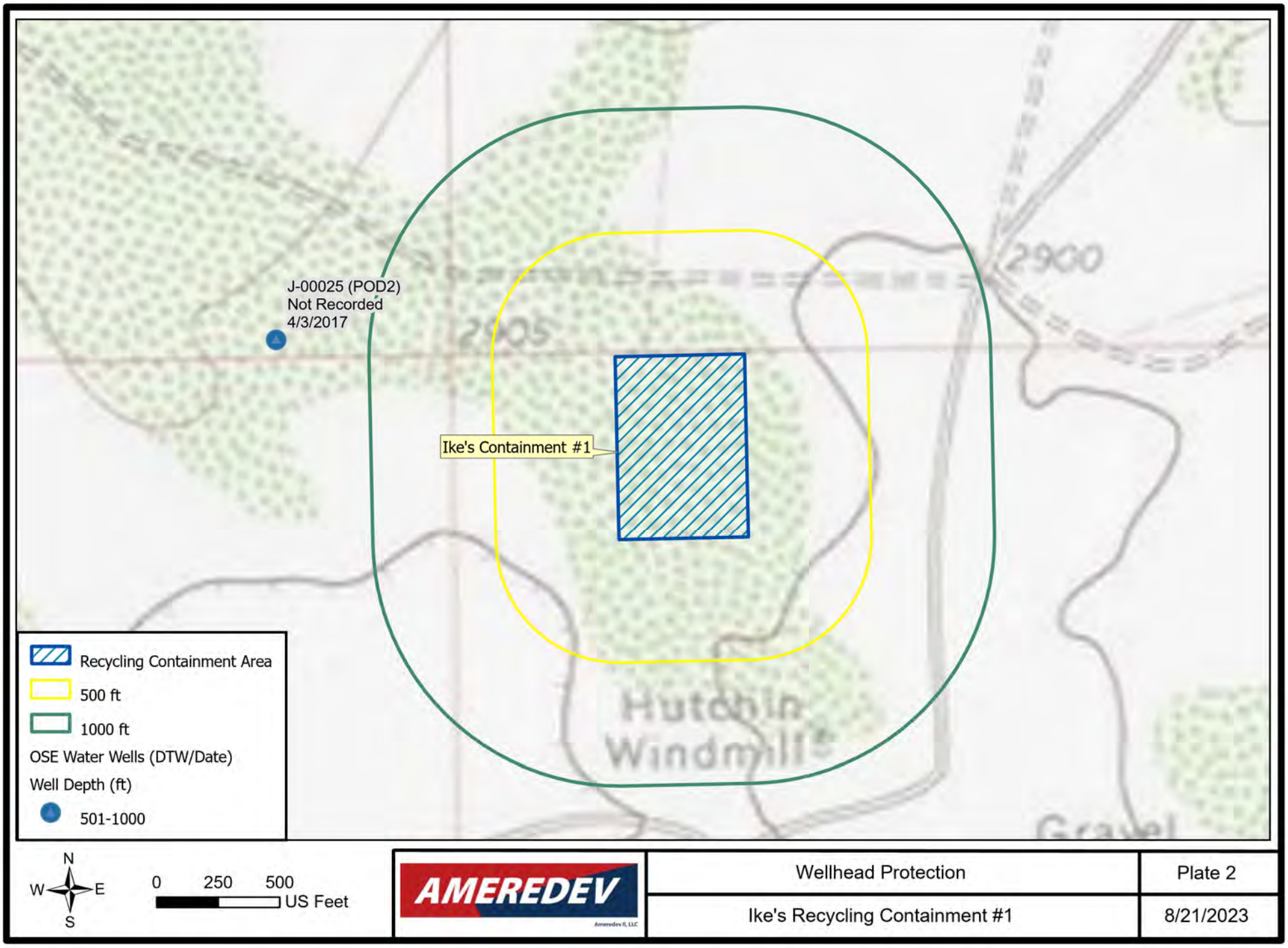
- MISC-425 (J-00062 POD 1) is located 0.15 miles to the southwest of Ike's Containment #1. Depth of the water is noted as >101-feet. This borehole has been plugged.

Wellhead Protection

Wellhead protection is maintained with no fresh water source within 500 ft from containment as seen Plate 2.

- An abandoned windmill (also discussed in body of registration package siting criteria), is located 900 ft to the southeast of the containment.


21
22
22
27
27
Drill Hole
Hutchin Windmill
Gravel Pit
2900
2905
2907
2925
MISC-437
(CP-1953 POD 1)
>101 ft
5/23/2023
Ike's Containment #1
MISC-425
(J-00062 POD 1)
>101 ft
03/02/2023
Half Mile Buffer
Recycling Containment Area
OSE Borehole Data (Well ID, DTW, Date)
Borehole Depth (ft)
<= 150
N
W
E
S
0
750
1500
US Feet
AMEREDEV
Depth to Water
Plate 1
Ike's Recycling Containment #1
08/21/2023


J-00025 (POD2)
Not Recorded
4/3/2017
Ike's Containment #1
2905
2900
Hutchin
Windmill
Gravel
Recycling Containment Area
500 ft
1000 ft
OSE Water Wells (DTW/Date)
Well Depth (ft)
501-1000
N
W
E
S
0
250
500
US Feet
AMEREDEV
Wellhead Protection
Plate 2
Ike's Recycling Containment #1
8/21/2023

Atkins ENGINEERING ASSOCIATES INC.
2904 W 2nd St.
Roswell, NM 88201
voice: 575.624.2420
fax: 575.624.2421
www.atkinseng.com

March 9, 2023

DII-NMOSE
1900 W 2nd Street
Roswell, NM 88201

Hand Delivered to the DII Office of the State Engineer

Re: Well Record J-00062 POD-1

To whom it may concern:

Attached please find a well log & record and a plugging record, in duplicate, for a one (1) soil borings, J-0062 POD-1

If you have any questions, please contact me at 575.499.9244 or lucas@atkinseng.com.

Sincerely,

Lucas Middleton

Enclosures: as noted above

WELL RECORD & LOG

OFFICE OF THE STATE ENGINEER

www.ose.state.nm.us

1. GENERAL AND WELL LOCATION

OSE POD NO. (WELL NO.)	WELL TAG ID NO.	OSE FILE NO(S).
POD-1	n/a	J-00062

WELL OWNER NAME(S)	PHONE (OPTIONAL)
Ameredev Operating, LLC	737-300-4700

WELL OWNER MAILING ADDRESS	CITY	STATE	ZIP
2901 Via Fortuna Suite 600	Austin	TX	78746

WELL LOCATION (FROM GPS)		DEGREES	MINUTES	SECONDS	
	LATITUDE	32	1	5.98	N
	LONGITUDE	103	15	39.71	W

* ACCURACY REQUIRED: ONE TENTH OF A SECOND
* DATUM REQUIRED: WGS 84

DESCRIPTION RELATING WELL LOCATION TO STREET ADDRESS AND COMMON LANDMARKS – PLSS (SECTION, TOWNSHIP, RANGE) WHERE AVAILABLE

SW NW NW Sec.27 T26S R36E NMPM

2. DRILLING & CASING INFORMATION

LICENSE NO.	NAME OF LICENSED DRILLER	NAME OF WELL DRILLING COMPANY
1249	Jackie D. Atkins	Atkins Engineering Associates, Inc.

DRILLING STARTED	DRILLING ENDED	DEPTH OF COMPLETED WELL (FT)	BORE HOLE DEPTH (FT)	DEPTH WATER FIRST ENCOUNTERED (FT)
2/21/23	2/21/23	temporary well material	±101	n/a

COMPLETED WELL IS: ☐ ARTESIAN ☑ DRY HOLE ☐ SHALLOW (UNCONFINED)

STATIC WATER LEVEL IN COMPLETED WELL (FT): n/a

DATE STATIC MEASURED: 3/2/2023

DRILLING FLUID: ☐ AIR ☐ MUD ADDITIVES – SPECIFY:

DRILLING METHOD: ☐ ROTARY ☐ HAMMER ☐ CABLE TOOL ☑ OTHER – SPECIFY: Hollow Stem Auger

CHECK HERE IF PITLESS ADAPTER IS INSTALLED ☐

DEPTH (feet bgl) FROM	DEPTH (feet bgl) TO	BORE HOLE DIAM (inches)	CASING MATERIAL AND/OR GRADE (include each casing string, and note sections of screen)	CASING CONNECTION TYPE (add coupling diameter)	CASING INSIDE DIAM. (inches)	CASING WALL THICKNESS (inches)	SLOT SIZE (inches)
0	101	6.25"	Soil Borning	--	--	--	--

3. ANNULAR MATERIAL

DEPTH (feet bgl) FROM	DEPTH (feet bgl) TO	BORE HOLE DIAM. (inches)	LIST ANNULAR SEAL MATERIAL AND GRAVEL PACK SIZE-RANGE BY INTERVAL	AMOUNT (cubic feet)	METHOD OF PLACEMENT

FOR OSE INTERNAL USE

WR-20 WELL RECORD & LOG (Version 01/28/2022)

FILE NO.	POD NO.	TRN NO.
LOCATION	WELL TAG ID NO.	PAGE 1 OF 2

4. HYDROGEOLOGIC LOG OF WELL

DEPTH (feet bgl) FROM	DEPTH (feet bgl) TO	THICKNESS (feet)	COLOR AND TYPE OF MATERIAL ENCOUNTERED - INCLUDE WATER-BEARING CAVITIES OR FRACTURE ZONES **(attach supplemental sheets to fully describe all units)**	WATER BEARING? (YES / NO)	ESTIMATED YIELD FOR WATER-BEARING ZONES (gpm)
0	24	24	Sand, very fine-grained, poorly graded, unconsolidated, Brown /Tan	Y ✓ N	
24	45	21	Sand, very fine-grained, poorly graded, slight consolidated, Tan	Y ✓ N	
45	101	56	Sand, fine-grained, poorly graded, unconsolidated, Tan	Y ✓ N	
				Y N	
				Y N	
				Y N	
				Y N	
				Y N	
				Y N	
				Y N	
				Y N	
				Y N	
				Y N	
				Y N	
				Y N	
				Y N	
				Y N	
				Y N	
				Y N	
				Y N	
				Y N	

METHOD USED TO ESTIMATE YIELD OF WATER-BEARING STRATA:

☐ PUMP ☐ AIR LIFT ☐ BAILER ☐ OTHER – SPECIFY:

TOTAL ESTIMATED WELL YIELD (gpm): 0.00

5. TEST; RIG SUPERVISION

WELL TEST — TEST RESULTS - ATTACH A COPY OF DATA COLLECTED DURING WELL TESTING, INCLUDING DISCHARGE METHOD, START TIME, END TIME, AND A TABLE SHOWING DISCHARGE AND DRAWDOWN OVER THE TESTING PERIOD.

MISCELLANEOUS INFORMATION: Removed temporary well material from soil boring, backfilled with drill cutting from total depth to 10 feet below ground surface, then placed hydrated bentonite from 10 feet to ground surface. See attached plugging record.
DTW-17

PRINT NAME(S) OF DRILL RIG SUPERVISOR(S) THAT PROVIDED ONSITE SUPERVISION OF WELL CONSTRUCTION OTHER THAN LICENSEE:

Shane Eldridge, Cameron Pruitt

6. SIGNATURE

THE UNDERSIGNED HEREBY CERTIFIES THAT, TO THE BEST OF HIS OR HER KNOWLEDGE AND BELIEF, THE FOREGOING IS A TRUE AND CORRECT RECORD OF THE ABOVE DESCRIBED HOLE AND THAT HE OR SHE WILL FILE THIS WELL RECORD WITH THE STATE ENGINEER AND THE PERMIT HOLDER WITHIN 30 DAYS AFTER COMPLETION OF WELL DRILLING:

Jack Atkins — Jackie D. Atkins — 3/9/2023

SIGNATURE OF DRILLER / PRINT SIGNEE NAME — DATE

FOR OSE INTERNAL USE — WR-20 WELL RECORD & LOG (Version 01/28/2022)

FILE NO.	POD NO.	TRN NO.	
LOCATION		WELL TAG ID NO.	PAGE 2 OF 2

PLUGGING RECORD

NOTE: A Well Plugging Plan of Operations shall be approved by the State Engineer prior to plugging - 19.27.4 NMAC

I. GENERAL / WELL OWNERSHIP:

State Engineer Well Number: J-00062 POD-1

Well owner: Ameredev Operating, LLC Phone No.: 737-300-4700

Mailing address: 2901 Via Fortuna Suite 600

City: Austin State: Texas Zip code: 78746

II. WELL PLUGGING INFORMATION:

1) Name of well drilling company that plugged well: Jackie D. Atkins (Atkins Engineering Associates Inc.)

2) New Mexico Well Driller License No.: 1249 Expiration Date: 04/30/23

3) Well plugging activities were supervised by the following well driller(s)/rig supervisor(s): Shane Eldridge, Cameron Pruitt

4) Date well plugging began: 3/2/2023 Date well plugging concluded: 3/2/2023

5) GPS Well Location: Latitude: 32 deg, 1 min, 5.98 sec
Longitude: 103 deg, 15 min, 39.71 sec, WGS 84

6) Depth of well confirmed at initiation of plugging as: 101 ft below ground level (bgl), by the following manner: water level probe

7) Static water level measured at initiation of plugging: n/a ft bgl

8) Date well plugging plan of operations was approved by the State Engineer: 1/26/23

9) Were all plugging activities consistent with an approved plugging plan? Yes If not, please describe differences between the approved plugging plan and the well as it was plugged (attach additional pages as needed):

Version: September 8, 2009
Page 1 of 2

10) Log of Plugging Activities - Label vertical scale with depths, and indicate separate plugging intervals with horizontal lines as necessary to illustrate material or methodology changes. Attach additional pages if necessary.

For each interval plugged, describe within the following columns:

Depth (ft bgl)	Plugging Material Used (include any additives used)	Volume of Material Placed (gallons)	Theoretical Volume of Borehole/ Casing (gallons)	Placement Method (tremie pipe, other)	Comments ("casing perforated first", "open annular space also plugged", etc.)
	0-10' Hydrated Bentonite	Approx. 15 gallons	15 gallons	Boring	
	10'-101' Drill cuttings	Approx. 145 gallons	145 gallons	Boring	

MULTIPLY		BY		AND OBTAIN
cubic feet	x	7.4805	=	gallons
cubic yards	x	201.97	=	gallons

III. SIGNATURE:

I, Jackie D. Atkins, say that I am familiar with the rules of the Office of the State Engineer pertaining to the plugging of wells and that each and all of the statements in this Plugging Record and attachments are true to the best of my knowledge and belief.

Jack Atkins — Signature of Well Driller

3/9/23 — Date

Version: September 8, 2009
Page 2 of 2

17-Well Record and Log-packet-forsign

Final Audit Report 2023-03-09

Created:	2023-03-09
By:	Lucas Middleton (lucas@atkinseng.com)
Status:	Signed
Transaction ID:	CBJCHBCAABAAzXuzWP53KQ1xK_g3D901wUVwqrF0rJrW

"17-Well Record and Log-packet-forsign" History

Document created by Lucas Middleton (lucas@atkinseng.com)
2023-03-09 - 5:46:44 PM GMT- IP address: 64.17.82.146

Document emailed to Jack Atkins (jack@atkinseng.com) for signature
2023-03-09 - 5:49:37 PM GMT

Email viewed by Jack Atkins (jack@atkinseng.com)
2023-03-09 - 7:24:12 PM GMT- IP address: 64.90.153.232

Document e-signed by Jack Atkins (jack@atkinseng.com)
Signature Date: 2023-03-09 - 7:24:27 PM GMT - Time Source: server- IP address: 64.90.153.232

Agreement completed.
2023-03-09 - 7:24:27 PM GMT

Adobe Acrobat Sign

Appendix G

Inspection Log

	Ike's Pond						Inspector Notes
Date	Leak Detection	Liner	Oil Visibility	Containment	Wild Life	Fencing	Comments
7/6/2018	Dry	Good	None	Good	None	Good	
7/13/2018	Dry	Good	None	Good	None	Good	
7/20/2018	Dry	Good	None	Good	None	Good	
7/27/2018	Dry	Good	None	Good	None	Good	
8/3/2018	Dry	Good	None	Good	None	Good	
8/10/2018	Dry	Good	None	Good	None	Good	
8/17/2018	Dry	Good	None	Good	None	Good	
8/24/2018	Dry	Good	None	Good	None	Good	
8/31/2018	Dry	Good	None	Good	None	Good	
9/7/2018	Dry	Good	None	Good	None	Good	
9/14/2018	Dry	Good	None	Good	None	Good	
9/21/2018	Dry	Good	None	Good	None	Good	
9/28/2018	Dry	Good	None	Good	None	Good	
10/5/2018	Dry	Good	None	Good	None	Good	
10/12/2018	Dry	Good	None	Good	None	Good	
10/19/2018	Dry	Good	None	Good	None	Good	
10/26/2018	Dry	Good	None	Good	None	Good	
11/2/2018	Dry	Good	None	Good	None	Good	
11/9/2018	Dry	Good	None	Good	None	Good	
11/16/2018	Dry	Good	None	Good	None	Good	
11/23/2018	Dry	Good	None	Good	None	Good	
11/30/2018	Dry	Good	None	Good	None	Good	
12/7/2018	Dry	Good	None	Good	None	Good	
12/14/2018	Dry	Good	None	Good	None	Good	
12/21/2018	Dry	Good	None	Good	None	Good	
12/28/2018	Dry	Good	None	Good	None	Good	
1/4/2019	Dry	Good	None	Good	None	Good	
1/11/2019	Dry	Good	None	Good	None	Good	
1/18/2019	Dry	Good	None	Good	None	Good	
1/25/2019	Dry	Good	None	Good	None	Good	
2/1/2019	Dry	Good	None	Good	None	Good	
2/8/2019	Dry	Good	None	Good	None	Good	
2/15/2019	Dry	Good	None	Good	None	Good	
2/22/2019	Dry	Good	None	Good	None	Good	
3/1/2019	Dry	Good	None	Good	None	Good	
3/8/2019	Dry	Good	None	Good	None	Good	
3/15/2019	Dry	Good	None	Good	None	Good	
3/22/2019	Dry	Good	None	Good	None	Good	
3/29/2019	Dry	Good	None	Good	None	Good	
4/5/2019	Dry	Good	None	Good	None	Good	
4/12/2019	Dry	Good	None	Good	None	Good	
4/19/2019	Dry	Good	None	Good	None	Good	
4/26/2019	Dry	Good	None	Good	None	Good	
5/3/2019	Dry	Good	None	Good	None	Good	
5/10/2019	Dry	Good	None	Good	None	Good	
5/17/2019	Dry	Good	None	Good	None	Good	
5/24/2019	Dry	Good	None	Good	None	Good	
5/31/2019	Dry	Good	None	Good	None	Good	
6/7/2019	Dry	Good	None	Good	None	Good	
6/14/2019	Dry	Good	None	Good	None	Good	
6/21/2019	Dry	Good	None	Good	None	Good	
6/28/2019	Dry	Good	None	Good	None	Good	
7/5/2019	Dry	Good	None	Good	None	Good	
7/12/2019	Dry	Good	None	Good	None	Good	
7/19/2019	Dry	Good	None	Good	None	Good	
7/26/2019	Dry	Good	None	Good	None	Good	
8/2/2019	Dry	Good	None	Good	None	Good	
8/9/2019	Dry	Good	None	Good	None	Good	
8/16/2019	Dry	Good	None	Good	None	Good	
8/23/2019	Dry	Good	None	Good	None	Good	
8/30/2019	Dry	Good	None	Good	None	Good	
9/6/2019	Dry	Good	None	Good	None	Good	
9/13/2019	Dry	Good	None	Good	None	Good	

	Ike's Pond						Inspector Notes
Date	Leak Detection	Liner	Oil Visibility	Containment	Wild Life	Fencing	Comments
9/20/2019	Dry	Good	None	Good	None	Good	
9/27/2019	Dry	Good	None	Good	None	Good	
10/4/2019	Dry	Good	None	Good	None	Good	
10/11/2019	Dry	Good	None	Good	None	Good	
10/18/2019	Dry	Good	None	Good	None	Good	
10/25/2019	Dry	Good	None	Good	None	Good	
11/1/2019	Dry	Good	None	Good	None	Good	
11/8/2019	Dry	Good	None	Good	None	Good	
11/15/2019	Dry	Good	None	Good	None	Good	
11/22/2019	Dry	Good	None	Good	None	Good	
11/29/2019	Dry	Good	None	Good	None	Good	
12/6/2019	Dry	Good	None	Good	None	Good	
12/13/2019	Dry	Good	None	Good	None	Good	
12/20/2019	Dry	Good	None	Good	None	Good	
12/27/2019	Dry	Good	None	Good	None	Good	
1/3/2020	Dry	Good	None	Good	None	Good	
1/10/2020	Dry	Good	None	Good	None	Good	
1/17/2020	Dry	Good	None	Good	None	Good	
1/24/2020	Dry	Good	None	Good	None	Good	
1/31/2020	Dry	Good	None	Good	None	Good	
2/7/2020	Dry	Good	None	Good	None	Good	
2/14/2020	Dry	Good	None	Good	None	Good	
2/21/2020	Dry	Good	None	Good	None	Good	
2/28/2020	Dry	Good	None	Good	None	Good	
3/6/2020	Dry	Good	None	Good	None	Good	
3/13/2020	Dry	Good	None	Good	None	Good	
3/20/2020	Dry	Good	None	Good	None	Good	
3/27/2020	Dry	Good	None	Good	None	Good	
4/3/2020	Dry	Good	None	Good	None	Good	
4/10/2020	Dry	Good	None	Good	None	Good	
4/17/2020	Dry	Good	None	Good	None	Good	
4/24/2020	Dry	Good	None	Good	None	Good	
5/1/2020	Dry	Good	None	Good	None	Good	
5/8/2020	Dry	Good	None	Good	None	Good	
5/15/2020	Dry	Good	None	Good	None	Good	
5/22/2020	Dry	Good	None	Good	None	Good	
5/29/2020	Dry	Good	None	Good	None	Good	
6/5/2020	Dry	Good	None	Good	None	Good	
6/12/2020	Dry	Good	None	Good	None	Good	
6/19/2020	Dry	Good	None	Good	None	Good	
6/26/2020	Dry	Good	None	Good	None	Good	
7/3/2020	Dry	Good	None	Good	None	Good	
7/10/2020	Dry	Good	None	Good	None	Good	
7/17/2020	Dry	Good	None	Good	None	Good	
7/24/2020	Dry	Good	None	Good	None	Good	
7/31/2020	Dry	Good	None	Good	None	Good	
8/7/2020	Dry	Good	None	Good	None	Good	
8/14/2020	Dry	Good	None	Good	None	Good	
8/21/2020	Dry	Good	None	Good	None	Good	
8/28/2020	Dry	Good	None	Good	None	Good	
9/4/2020	Dry	Good	None	Good	None	Good	
9/11/2020	Dry	Good	None	Good	None	Good	
9/18/2020	Dry	Good	None	Good	None	Good	
9/25/2020	Dry	Good	None	Good	None	Good	
10/2/2020	Dry	Good	None	Good	None	Good	
10/9/2020	Dry	Good	None	Good	None	Good	
10/16/2020	Dry	Good	None	Good	None	Good	
10/23/2020	Dry	Good	None	Good	None	Good	
10/30/2020	Dry	Good	None	Good	None	Good	

	Ike's Pond						Inspector Notes
Date	Leak Detection	Liner	Oil Visibility	Containment	Wild Life	Fencing	Comments
11/6/2020	Dry	Good	None	Good	None	Good	
11/13/2020	Dry	Good	None	Good	None	Good	
11/20/2020	Dry	Good	None	Good	None	Good	
11/27/2020	Dry	Good	None	Good	None	Good	
12/4/2020	Dry	Good	None	Good	None	Good	
12/11/2020	Dry	Good	None	Good	None	Good	
12/18/2020	Dry	Good	None	Good	None	Good	
12/25/2020	Dry	Good	None	Good	None	Good	
1/1/2021	Dry	Good	None	Good	None	Good	
1/8/2021	Dry	Good	None	Good	None	Good	
1/15/2021	Dry	Good	None	Good	None	Good	
1/22/2021	Dry	Good	None	Good	None	Good	
1/29/2021	Dry	Good	None	Good	None	Good	
2/5/2021	Dry	Good	None	Good	None	Good	
2/12/2021	Dry	Good	None	Good	None	Good	
2/19/2021	Dry	Good	None	Good	None	Good	
2/26/2021	Dry	Good	None	Good	None	Good	
3/5/2021	Dry	Good	None	Good	None	Good	
3/12/2021	Dry	Good	None	Good	None	Good	
3/19/2021	Dry	Good	None	Good	None	Good	
3/26/2021	Dry	Good	None	Good	None	Good	
4/2/2021	Dry	Good	None	Good	None	Good	
4/9/2021	Dry	Good	None	Good	None	Good	
4/16/2021	Dry	Good	None	Good	None	Good	1 AST Removed
4/23/2021	Dry	Good	None	Good	None	Good	
4/30/2021	Dry	Good	None	Good	None	Good	
5/7/2021	Dry	Good	None	Good	None	Good	
5/14/2021	Dry	Good	None	Good	None	Good	
5/21/2021	Dry	Good	None	Good	None	Good	
5/28/2021	Dry	Good	None	Good	None	Good	
6/4/2021	Dry	Good	None	Good	None	Good	
6/11/2021	Dry	Good	None	Good	None	Good	
6/18/2021	Dry	Good	None	Good	None	Good	
6/25/2021	Dry	Good	None	Good	None	Good	
7/2/2021	Dry	Good	None	Good	None	Good	
7/9/2021	Dry	Good	None	Good	None	Good	
7/16/2021	Dry	Good	None	Good	None	Good	
7/23/2021	Dry	Good	None	Good	None	Good	
7/30/2021	Dry	Good	None	Good	None	Good	
8/6/2021	Dry	Good	None	Good	None	Good	
8/13/2021	Dry	Good	None	Good	None	Good	
8/20/2021	Dry	Good	None	Good	None	Good	
8/27/2021	Dry	Good	None	Good	None	Good	
9/3/2021	Dry	Good	None	Good	None	Good	
9/10/2021	Dry	Good	None	Good	None	Good	
9/17/2021	Dry	Good	None	Good	None	Good	
9/24/2021	Dry	Good	None	Good	None	Good	
10/1/2021	Dry	Good	None	Good	None	Good	
10/8/2021	Dry	Good	None	Good	None	Good	
10/15/2021	Dry	Good	None	Good	None	Good	
10/22/2021	Dry	Good	None	Good	None	Good	
10/29/2021	Dry	Good	None	Good	None	Good	
11/5/2021	Dry	Good	None	Good	None	Good	
11/12/2021	Dry	Good	None	Good	None	Good	
11/19/2021	Dry	Good	None	Good	None	Good	
11/26/2021	Dry	Good	None	Good	None	Good	
12/3/2021	Dry	Good	None	Good	None	Good	
12/10/2021	Dry	Good	None	Good	None	Good	
12/17/2021	Dry	Good	None	Good	None	Good	

	Ike's Pond						Inspector Notes
Date	Leak Detection	Liner	Oil Visibility	Containment	Wild Life	Fencing	Comments
12/24/2021	Dry	Good	None	Good	None	Good	
12/31/2021	Dry	Good	None	Good	None	Good	
1/7/2022	Dry	Good	None	Good	None	Good	
1/14/2022	Dry	Good	None	Good	None	Good	
1/21/2022	Dry	Good	None	Good	None	Good	
1/28/2022	Dry	Good	None	Good	None	Good	
2/4/2022	Dry	Good	None	Good	None	Good	
2/11/2022	Dry	Good	None	Good	None	Good	
2/18/2022	Dry	Good	None	Good	None	Good	
2/25/2022	Dry	Good	None	Good	None	Good	
3/4/2022	Dry	Good	None	Good	None	Good	
3/11/2022	Dry	Good	None	Good	None	Good	
3/18/2022	Dry	Good	None	Good	None	Good	
3/25/2022	Dry	Good	None	Good	None	Good	
4/1/2022	Dry	Good	None	Good	None	Good	
4/8/2022	Dry	Good	None	Good	None	Good	
4/15/2022	Dry	Good	None	Good	None	Good	
4/22/2022	Dry	Good	None	Good	None	Good	
4/29/2022	Dry	Good	None	Good	None	Good	
5/6/2022	Dry	Good	None	Good	None	Good	
5/13/2022	Dry	Good	None	Good	None	Good	
5/20/2022	Dry	Good	None	Good	None	Good	
5/27/2022	Dry	Good	None	Good	None	Good	
6/3/2022	Dry	Good	None	Good	None	Good	
6/10/2022	Dry	Good	None	Good	None	Good	
6/17/2022	Dry	Good	None	Good	None	Good	
6/24/2022	Dry	Good	None	Good	None	Good	
7/1/2022	Dry	Good	None	Good	None	Good	
7/8/2022	Dry	Good	None	Good	None	Good	
7/15/2022	Dry	Good	None	Good	None	Good	
7/22/2022	Dry	Good	None	Good	None	Good	
7/29/2022	Dry	Good	None	Good	None	Good	
8/5/2022	Dry	Good	None	Good	None	Good	
8/12/2022	Dry	Good	None	Good	None	Good	
8/19/2022	Dry	Good	None	Good	None	Good	
8/26/2022	Dry	Good	None	Good	None	Good	
9/2/2022	Dry	Good	None	Good	None	Good	
9/9/2022	Dry	Good	None	Good	None	Good	
9/16/2022	Dry	Good	None	Good	None	Good	
9/23/2022	Dry	Good	None	Good	None	Good	
9/30/2022	Dry	Good	None	Good	None	Good	
10/7/2022	Dry	Good	None	Good	None	Good	
10/14/2022	Dry	Good	None	Good	None	Good	
10/21/2022	Dry	Good	None	Good	None	Good	
10/28/2022	Dry	Good	None	Good	None	Good	
11/4/2022	Dry	Good	None	Good	None	Good	
11/11/2022	Dry	Good	None	Good	None	Good	
11/18/2022	Dry	Good	None	Good	None	Good	
11/25/2022	Dry	Good	None	Good	None	Good	
12/2/2022	Dry	Good	None	Good	None	Good	
12/9/2022	Dry	Good	None	Good	None	Good	
12/16/2022	Dry	Good	None	Good	None	Good	
12/23/2022	Dry	Good	None	Good	None	Good	
12/30/2022	Dry	Good	None	Good	None	Good	
1/6/2023	Dry	Good	None	Good	None	Good	
1/13/2023	Dry	Good	None	Good	None	Good	
1/20/2023	Dry	Good	None	Good	None	Good	
1/27/2023	Dry	Good	None	Good	None	Good	
2/3/2023	Dry	Good	None	Good	None	Good	

	Ike's Pond						Inspector Notes
Date	Leak Detection	Liner	Oil Visibility	Containment	Wild Life	Fencing	Comments
2/10/2023	Dry	Good	None	Good	None	Good	
2/17/2023	Dry	Good	None	Good	None	Good	
2/24/2023	Dry	Good	None	Good	None	Good	
3/3/2023	Dry	Good	None	Good	None	Good	
3/10/2023	Dry	Good	None	Good	None	Good	
3/17/2023	Dry	Good	None	Good	None	Good	
3/24/2023	Dry	Good	None	Good	None	Good	
3/31/2023	Dry	Good	None	Good	None	Good	
4/7/2023	Dry	Good	None	Good	None	Good	
4/14/2023	Wet	Leak	None	Good	None	Good	Tear on West side of Pond. Drained Pond for repair
4/21/2023	Wet	Leak	None	Good	None	Good	
4/28/2023	Wet	Leak	None	Good	None	Good	
5/5/2023	Wet	Leak	None	Good	None	Good	
5/12/2023	Wet	Leak	None	Good	None	Good	
5/19/2023	Wet	Leak	None	Good	None	Good	
5/26/2023	Wet	Good	None	Good	None	Good	Liner Repaired and refilled.
6/2/2023	Dry	Good	None	Good	None	Good	
6/9/2023	Dry	Good	None	Good	None	Good	
6/16/2023	Dry	Good	None	Good	None	Good	
6/23/2023	Dry	Good	None	Good	None	Good	
6/30/2023	Dry	Good	None	Good	None	Good	
7/7/2023	Dry	Good	None	Good	None	Good	

Appendix H

Communications

901 Via Fortuna Suite 600 • Austin, Texas 78746

November 12, 2018

State Of New Mexico
Energy Minerals and Natural Resources Department
1220 South St. Francis Dr.
Santa Fe, NM 87504
ATTN: Randolph Bayliss

Re: C-148 – Ike's Containment #1 (Hobbs District: Sec 27, Township 26S, Range 36E in Lea County)

Attached are the monthly produced water volume C-148's. Below is a summary of what we have done with the containment at this point.

	Water Recycled	Water Utilized	Notes
May-18	5,357		
Jun-18	146,847		
Jul-18	141,775		
Aug-18	220,210		
Sep-18	212,856		
Oct-18	98,174	769,719	Red Bud State Com 25 36 32 105H & 105H Frac.

Please let me know if you need additional information.

Sincerely,

Shane McNeely
Engineer
Phone: 737-300-4729
Email: smcneely@ameredev.com

Form C-148

Revised March 31, 2015

District I
1625 N. French Dr., Hobbs, NM 88240
District II
811 S. First St., Artesia, NM 88210
District III
1000 Rio Brazos Road, Aztec, NM 87410
District IV
1220 S. St. Francis Dr., Santa Fe, NM 87505

State of New Mexico
Energy Minerals and Natural Resources
Department
Oil Conservation Division
1220 South St. Francis Dr.
Santa Fe, NM 87505

Operator Name Ameredev Operating, LLC

OGRID 372224

[X] I certify all recycling containments associated with our recycling facilities are using >20% of the containments' total fluid capacity every 6 months until closure in compliance with 19.15.34.13(C) NMAC.

Month/Year May - 2018

Admin. #	Produced water received*	Other fluid received*	Volume discharged for Recycling/Reuse*
	5,357		

*Report volumes in barrels

Form C-148

Revised March 31, 2015

District I
1625 N. French Dr., Hobbs, NM 88240
District II
811 S. First St., Artesia, NM 88210
District III
1000 Rio Brazos Road, Aztec, NM 87410
District IV
1220 S. St. Francis Dr., Santa Fe, NM 87505

State of New Mexico
Energy Minerals and Natural Resources
Department
Oil Conservation Division
1220 South St. Francis Dr.
Santa Fe, NM 87505

Operator Name Ameredev Operating, LLC

OGRID 372224

[X] I certify all recycling containments associated with our recycling facilities are using >20% of the containments' total fluid capacity every 6 months until closure in compliance with 19.15.34.13(C) NMAC.

Month/Year June - 2018

Admin. #	Produced water received*	Other fluid received*	Volume discharged for Recycling/Reuse*
	146,847		

*Report volumes in barrels

Form C-148

Revised March 31, 2015

District I
1625 N. French Dr., Hobbs, NM 88240
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District IV
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State of New Mexico
Energy Minerals and Natural Resources
Department
Oil Conservation Division
1220 South St. Francis Dr.
Santa Fe, NM 87505

Operator Name Ameredev Operating, LLC

OGRID 372224

[X] I certify all recycling containments associated with our recycling facilities are using >20% of the containments' total fluid capacity every 6 months until closure in compliance with 19.15.34.13(C) NMAC.

Month/Year July - 2018

Admin. #	Produced water received*	Other fluid received*	Volume discharged for Recycling/Reuse*
	141,775		

*Report volumes in barrels

Form C-148

Revised March 31, 2015

District I
1625 N. French Dr., Hobbs, NM 88240
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District III
1000 Rio Brazos Road, Aztec, NM 87410
District IV
1220 S. St. Francis Dr., Santa Fe, NM 87505

State of New Mexico
Energy Minerals and Natural Resources
Department
Oil Conservation Division
1220 South St. Francis Dr.
Santa Fe, NM 87505

Operator Name Ameredev Operating, LLC

OGRID 372224

[X] I certify all recycling containments associated with our recycling facilities are using >20% of the containments' total fluid capacity every 6 months until closure in compliance with 19.15.34.13(C) NMAC.

Month/Year August - 2018

Admin. #	Produced water received*	Other fluid received*	Volume discharged for Recycling/Reuse*
Aug - 18	220,210		

*Report volumes in barrels

Form C-148

Revised March 31, 2015

District I
1625 N. French Dr., Hobbs, NM 88240
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District III
1000 Rio Brazos Road, Aztec, NM 87410
District IV
1220 S. St. Francis Dr., Santa Fe, NM 87505

State of New Mexico
Energy Minerals and Natural Resources
Department
Oil Conservation Division
1220 South St. Francis Dr.
Santa Fe, NM 87505

Operator Name Ike's Containment - Ameredev Operating, LLC

OGRID 372224

[X] I certify all recycling containments associated with our recycling facilities are using >20% of the containments' total fluid capacity every 6 months until closure in compliance with 19.15.34.13(C) NMAC.

Month/Year September - 2018

Admin. #	Produced water received*	Other fluid received*	Volume discharged for Recycling/Reuse*
Sept - 18	212,856		

*Report volumes in barrels

Form C-148

Revised March 31, 2015

District I
1625 N. French Dr., Hobbs, NM 88240
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District IV
1220 S. St. Francis Dr., Santa Fe, NM 87505

State of New Mexico
Energy Minerals and Natural Resources
Department
Oil Conservation Division
1220 South St. Francis Dr.
Santa Fe, NM 87505

Operator Name Ike's Containment - Ameredev Operating, LLC

OGRID 372224

[X] I certify all recycling containments associated with our recycling facilities are using >20% of the containments' total fluid capacity every 6 months until closure in compliance with 19.15.34.13(C) NMAC.

Month/Year October - 2018

Admin. #	Produced water received*	Other fluid received*	Volume discharged for Recycling/Reuse*
Oct - 18	98,174		769,719

*Report volumes in barrels

Venegas, Victoria, EMNRD

From: Venegas, Victoria, EMNRD
Sent: Tuesday, September 26, 2023 9:34 AM
To: Laura Parker
Cc: Barr, Leigh, EMNRD
Subject: 1RF-508 - IKE's CONTAINMENT #1 FACILITY ID [fVV2326835427]
Attachments: C-147 1RF-508 - IKE's CONTAINMENT #1 FACILITY ID [fVV2326835427].pdf

1RF-508 - IKE's CONTAINMENT #1 FACILITY ID [fVV2326835427]

Good morning Ms. Parker,
NMOCD has reviewed the recycling containment permit application and related documents, submitted by [372224] AMEREDEV OPERATING, LLC Application ID 258103, for 1RF-508 - IKE's CONTAINMENT #1 FACILITY ID [fVV2326835427] in Unit Letter D, Section 27, Township 26S, Range 36E, Lea County, New Mexico. Note, the original application for this facility was submitted on 02/13/2018; this application included a recycling containment that was utilized for a period of time. The associated permit, 1RF-508, expired on 02/13/2023.

The modification request, C-147 Form submittal and related documents for the 1RF-508 - IKE's CONTAINMENT #1 FACILITY ID [fVV2326835427], is approved with the following conditions of approval:

- The closure plan included in Appendix D of the application is approved. [372224] AMEREDEV OPERATING, LLC will close 1RF-508 - IKE's CONTAINMENT #1 FACILITY ID [fVV2326835427] as proposed in the original application.
- At such time the operator decides to use the containment for produced water recycling purposes, [372224] AMEREDEV OPERATING, LLC must provide an inspection certified by a PE on the liner's design and integrity, use 1RF-508 to submit the C-148 monthly reports, recycle at a minimum of 20% of the total fluid capacity every six months, resume operation and inspections as required by 19.15.34.13 NMAC, and notify the OCD that the containment is no longer being utilized for only fresh water storage.

Please reference permit number 1RF-508 in all future communications, modifications, and notices related to 1RF-508 - IKE's CONTAINMENT #1 FACILITY ID [fVV2326835427].
Regards,

Victoria Venegas ● Environmental Specialist
Environmental Bureau
EMNRD - Oil Conservation Division
506 W. Texas Ave. Artesia, NM 88210
(575) 909-0269 | Victoria.Venegas@emnrd.nm.gov
https://www.emnrd.nm.gov/ocd/

District I
1625 N. French Dr., Hobbs, NM 88240
Phone:(575) 393-6161 Fax:(575) 393-0720
District II
811 S. First St., Artesia, NM 88210
Phone:(575) 748-1283 Fax:(575) 748-9720
District III
1000 Rio Brazos Rd., Aztec, NM 87410
Phone:(505) 334-6178 Fax:(505) 334-6170
District IV
1220 S. St Francis Dr., Santa Fe, NM 87505
Phone:(505) 476-3470 Fax:(505) 476-3462

State of New Mexico
Energy, Minerals and Natural Resources
Oil Conservation Division
1220 S. St Francis Dr.
Santa Fe, NM 87505

CONDITIONS

Action 258103

CONDITIONS

Operator:	OGRID:
AMEREDEV OPERATING, LLC 2901 Via Fortuna Austin, TX 78746	372224
	Action Number: 258103
	Action Type: [C-147] Water Recycle Long (C-147L)

CONDITIONS

Created By	Condition	Condition Date
vvenegas	The original application for this facility was submitted on 02/13/2018; this application included a recycling containment that was utilized for a period of time. The associated permit, 1RF-508, expired on 02/13/2023.The modification request, C-147 Form submittal for the 1RF-508 - IKE's CONTAINMENT #1 FACILITY[fVV2326835427], is approved with the following conditions: The closure plan included in Appendix D is approved. [372224] AMEREDEV will close 1RF-508 - IKE's CONTAINMENT as proposed in the original application. At such time the operator decides to use the containment for produced water recycling purposes, [372224] AMEREDEV must provide an inspection certified by a PE on the liner's design and integrity, use 1RF-508 to submit the C-148 monthly reports, recycle at a minimum of 20% of the total fluid capacity every six months, resume operation and inspections as required by 19.15.34.13 NMAC, and notify the OCD that the containment is no longer being utilized for only fresh water stor	9/26/2023