

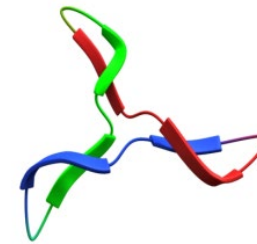
Kemper CO₂ Storage Complex: Pipeline and Surface Facility Design Considerations

***Presentation for Project ECO2S Workshop
at 2023 CLIMIT SUMMIT***

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Trimeric Corporation: Process engineering services

- Founded in 2003 in Buda, TX
- Diversified across industries, specialized in process engineering
- CO₂ capture & processing expertise
 - Pipeline flow analysis
 - Compression and dehydration
 - Pump skids for injection tests
 - Liquefaction and distillation
 - EOR facilities for Gas plant/recycle
 - Source assessments for Carbon SAFE



1 MM tonne/yr facility design. Blower (left) and compressor (right) skids

- Capture from Power Plants
- Capture from Industrial Sources
- Process simulation
- TEAs
- Food and beverage grade CO₂ facilities
- Process safety

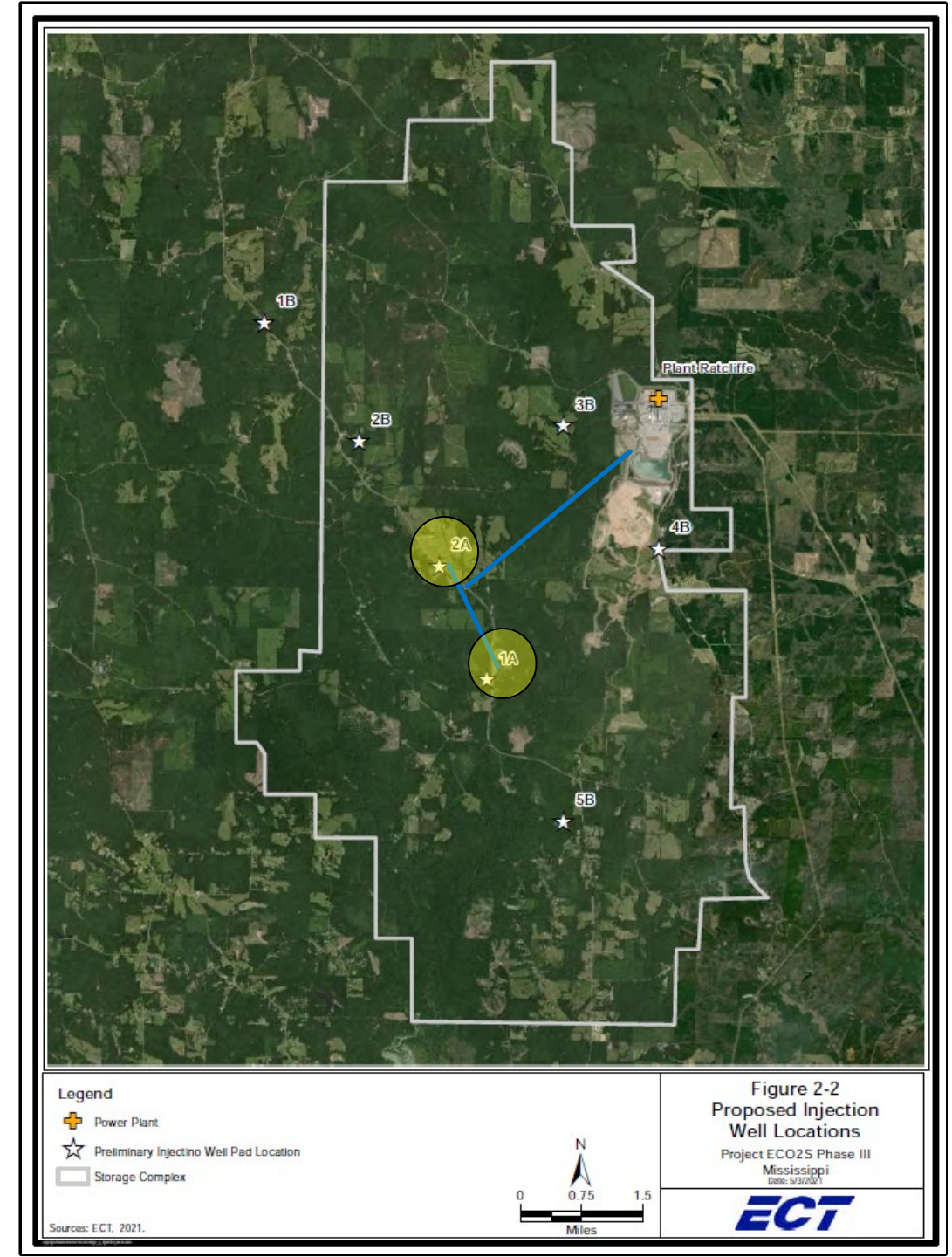
Plant Ratcliffe is closest CO₂ source to Kemper Storage Complex

- Southern Company, Mississippi Power
- NGCC: 2 CT x 1 ST
- 770 MWe nameplate
- Max CO₂ rate: 287 tonne/hr
- Max CO₂ rate: 6,888 t/d
- Min CO₂ rate: 133 tonne/hr
- 85% annual capacity factor
- 2.1 Mtpa
- 64 Mt over 30 years to Storage

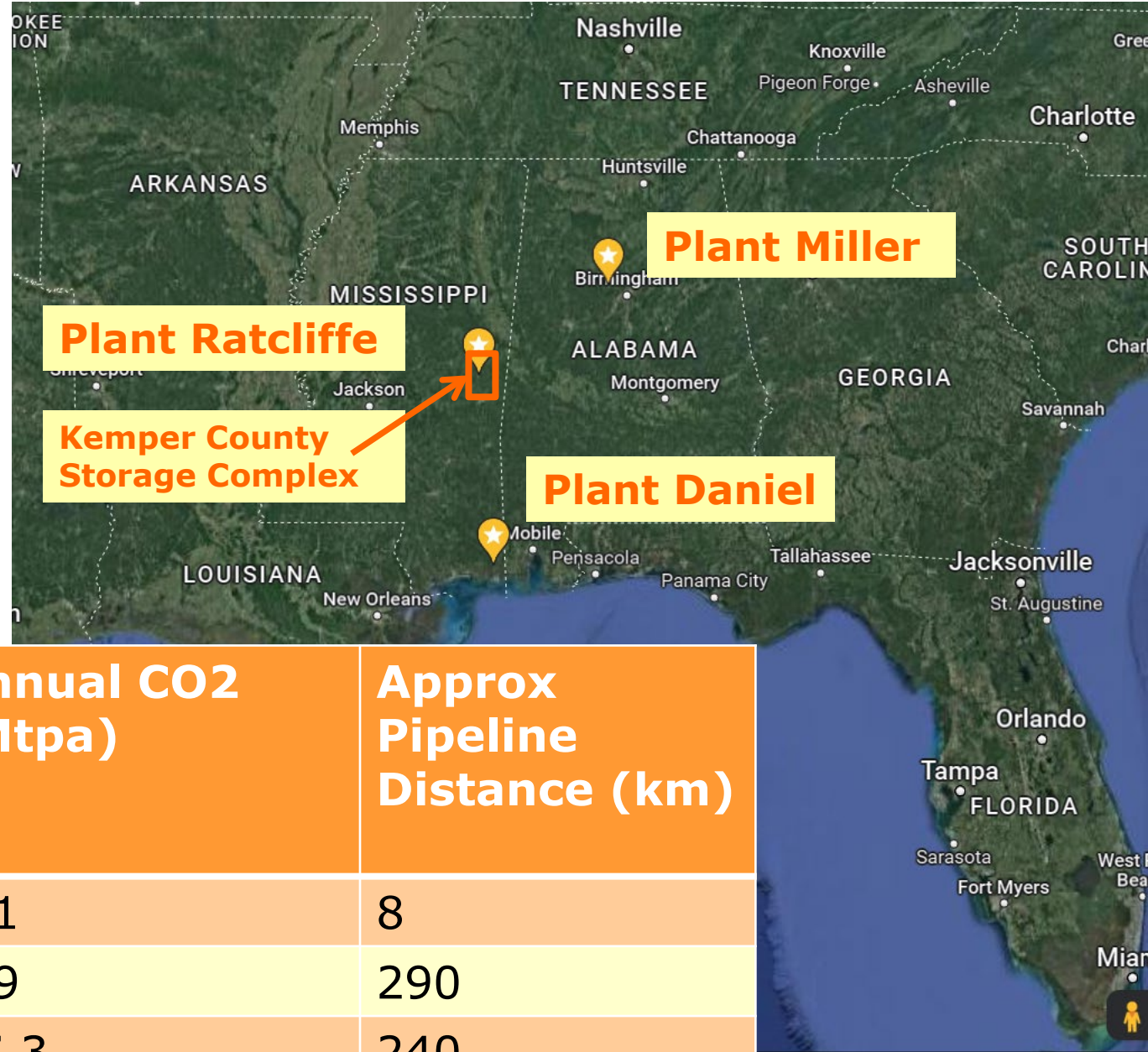


Initial build-out with 2 wells for Plant Ratcliffe

- Ratcliffe max CO₂: 6,888 t/d
- Injection wells at 1A and 2A
 - Each designed for 4,000 t/d
 - Required injection P
 - > 1,200 psig
 - > 8.4 MPa
 - > 84 bara

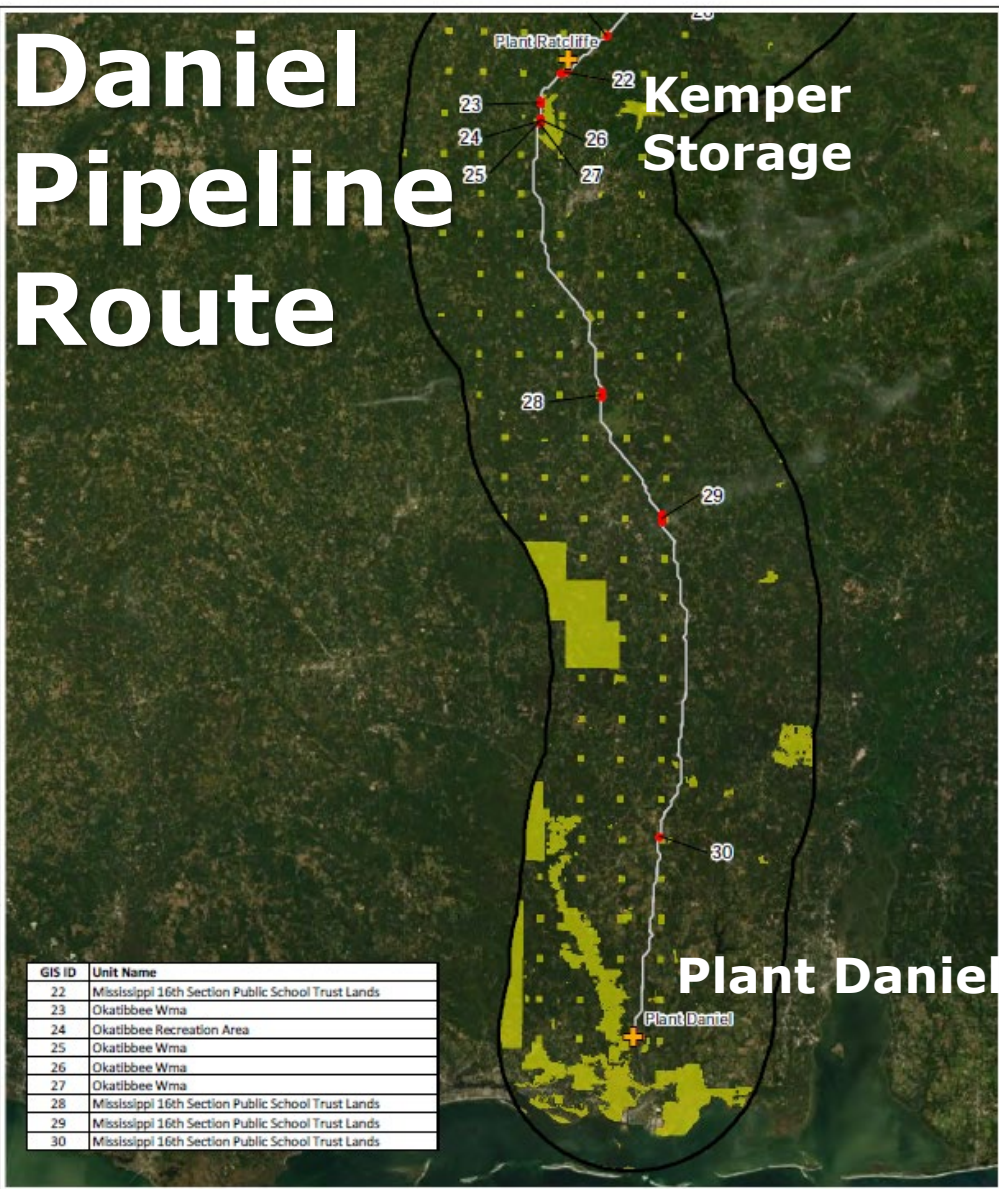


Kemper Storage Complex is near several other large CO₂ sources



Power Plant	Nameplate Generating Capacity (MWe)	Annual CO ₂ (Mtpa)	Approx Pipeline Distance (km)
Ratcliffe (NGCC)	770	2.1	8
Daniel (NGCC)	1,070	2.9	290
Miller (coal)	2,640	17.3	240

Daniel Pipeline Route



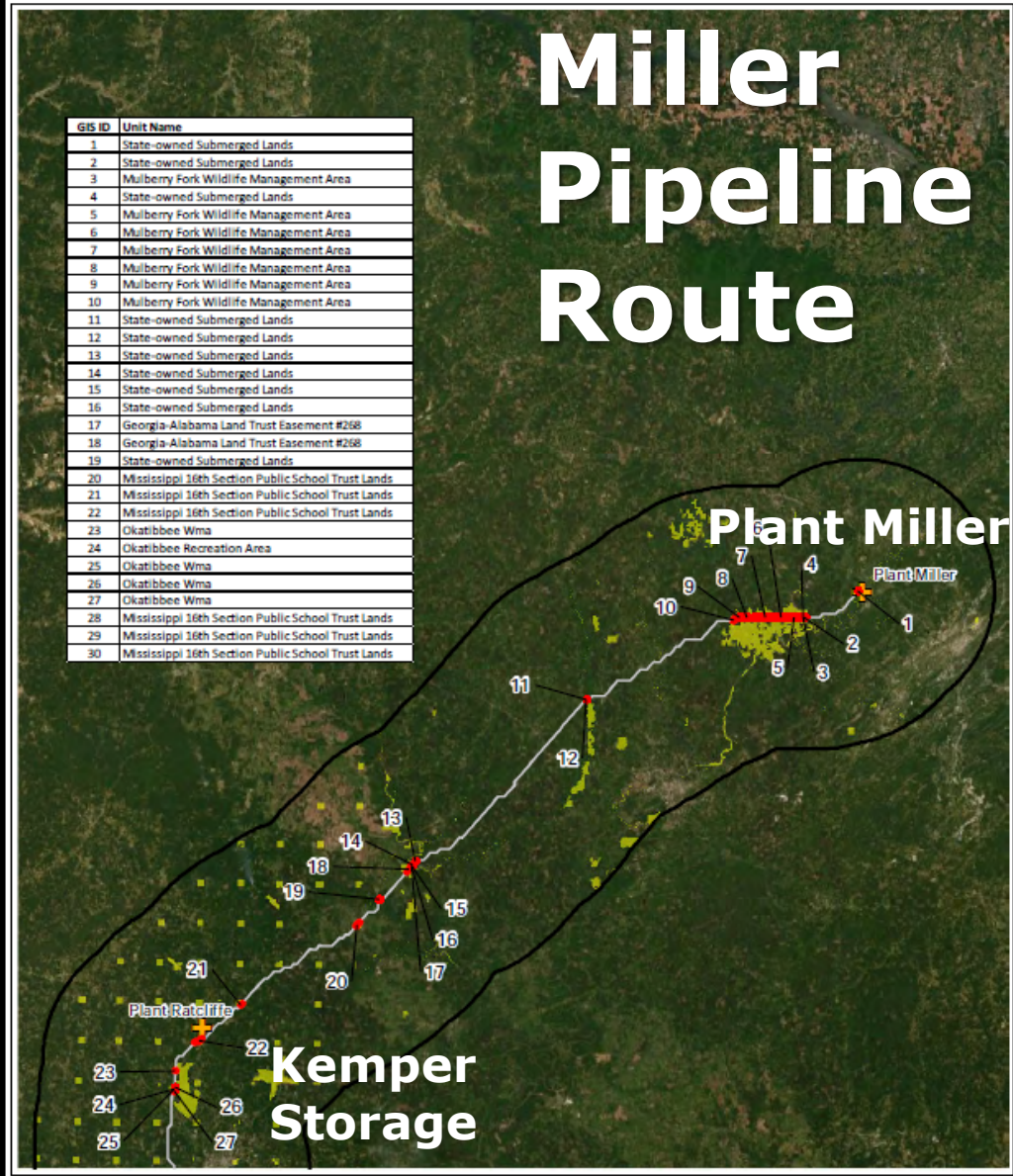
GIS ID	Unit Name
22	Mississippi 16th Section Public School Trust Lands
23	Okatibbee Wma
24	Okatibbee Recreation Area
25	Okatibbee Wma
26	Okatibbee Wma
27	Okatibbee Wma
28	Mississippi 16th Section Public School Trust Lands
29	Mississippi 16th Section Public School Trust Lands
30	Mississippi 16th Section Public School Trust Lands

Legend

- Power Plant
- 20 Mile Pipeline Buffer
- Protected Areas Within Corridor
- Pipeline Corridor (50 ft)
- US Protected Areas
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrub/Scrub

Figure 3-41
US Protected Areas Database
Daniel-Ratliffe
Pipeline Corridor
Project ECOS2S Phase III
Mississippi
Date: 4/29/2021
ECT

Miller Pipeline Route



GIS ID	Unit Name
1	State-owned Submerged Lands
2	State-owned Submerged Lands
3	Mulberry Fork Wildlife Management Area
4	State-owned Submerged Lands
5	Mulberry Fork Wildlife Management Area
6	Mulberry Fork Wildlife Management Area
7	Mulberry Fork Wildlife Management Area
8	Mulberry Fork Wildlife Management Area
9	Mulberry Fork Wildlife Management Area
10	Mulberry Fork Wildlife Management Area
11	State-owned Submerged Lands
12	State-owned Submerged Lands
13	State-owned Submerged Lands
14	State-owned Submerged Lands
15	State-owned Submerged Lands
16	State-owned Submerged Lands
17	Georgia-Alabama Land Trust Easement #268
18	Georgia-Alabama Land Trust Easement #268
19	State-owned Submerged Lands
20	Mississippi 16th Section Public School Trust Lands
21	Mississippi 16th Section Public School Trust Lands
22	Mississippi 16th Section Public School Trust Lands
23	Okatibbee Wma
24	Okatibbee Recreation Area
25	Okatibbee Wma
26	Okatibbee Wma
27	Okatibbee Wma
28	Mississippi 16th Section Public School Trust Lands
29	Mississippi 16th Section Public School Trust Lands
30	Mississippi 16th Section Public School Trust Lands

Legend

- Power Plant
- 20 Mile Pipeline Buffer
- Protected Areas Within Corridor
- Pipeline Corridor (50 ft)
- US Protected Areas
- 500' Buffer
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrub/Scrub

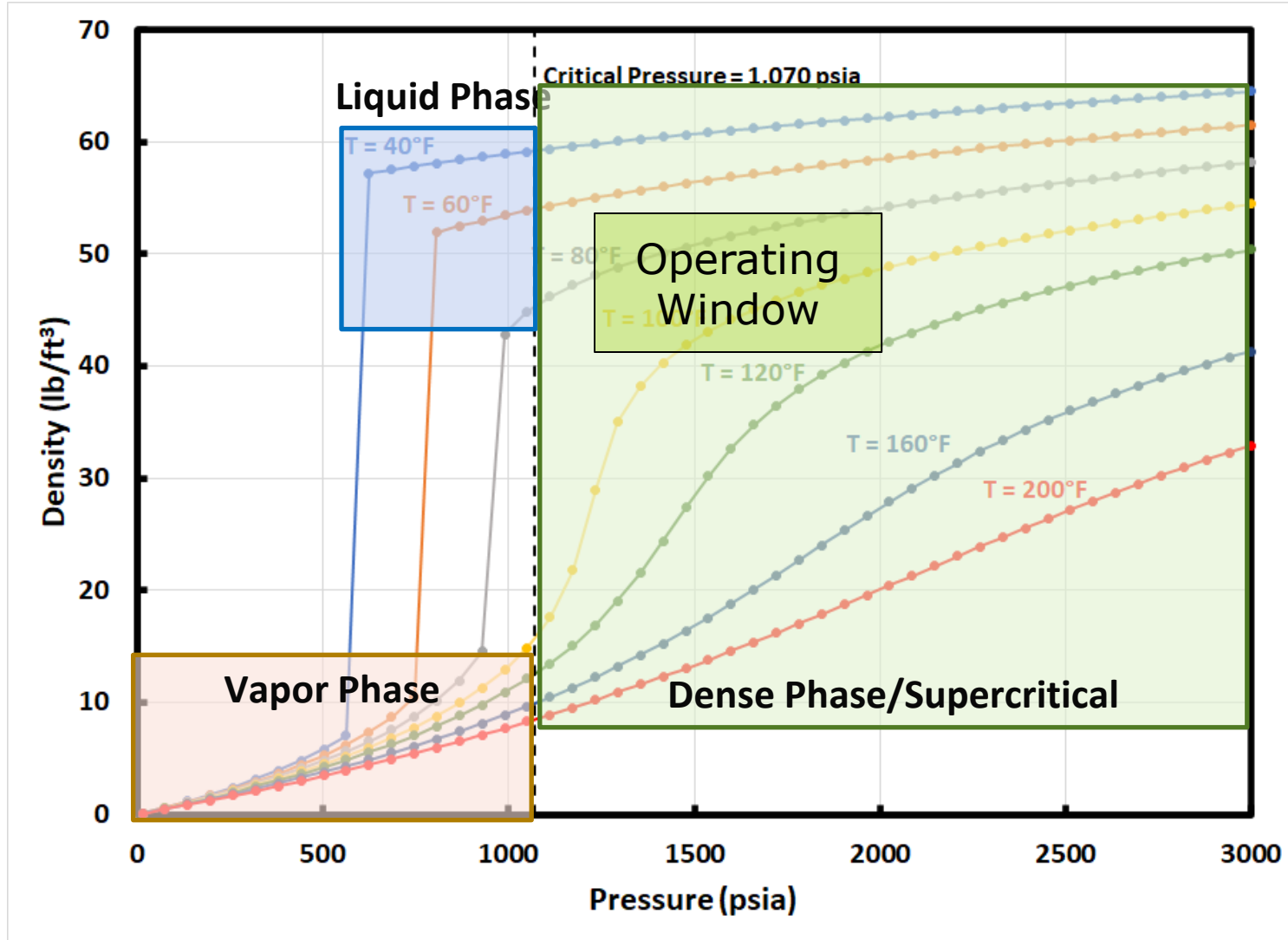
Figure 3-40
US Protected Areas Database
Kemper Regional Storage Complex-Miller
Pipeline Corridor
Project ECOS2S Phase III
Mississippi and Alabama
ECT
Date: 6/21/2021

CO₂ Specifications from Capture Plant

- Temperature ≤ 115°F (46°C)
- Available at 2,200 psig (152 bara) from Miller and Daniel
- Available at 1,700 psig (118 bara) from Ratcliffe
- Composition specification:

Component	Specification
CO ₂	> 95 vol%
H ₂ O	≤ 630 ppmv (30 lbs/MMCF)
H ₂ S	≤ 20 ppmv
Total Sulfur	≤ 35 ppmw
N ₂	≤ 4 vol%
Hydrocarbons	≤ 5 vol% & ≤ -20°F DewPoint
O ₂	≤ 10 ppmw
H ₂ S	≤ 20 ppmv
Glycol	< 0.3 gal/MMCF

Transport as Supercritical CO₂



- Supercritical/ Dense Phase
- No risk of phase transition above P_{critical} (74 bara)
- At ambient temperatures, densities approach liquid phase CO₂

Identified smallest pipeline diameter to meet preliminary design constraints

- Maximum pressure of 2,000 psig (139 bara)
- Trunkline delivery pressure $\geq 1,300$ psig (91 bara)
- CO₂ density > 40 lb/ft³ (for pump design)
- CO₂ velocity < 15 ft/s (typical guideline for economic design)
- Two cases:
 1. No booster pump station along route
 2. Booster pump station along route

Example Booster Pump Stations



**Pumps at 1,750 tph CO₂ Pipeline
Booster Pump Station**

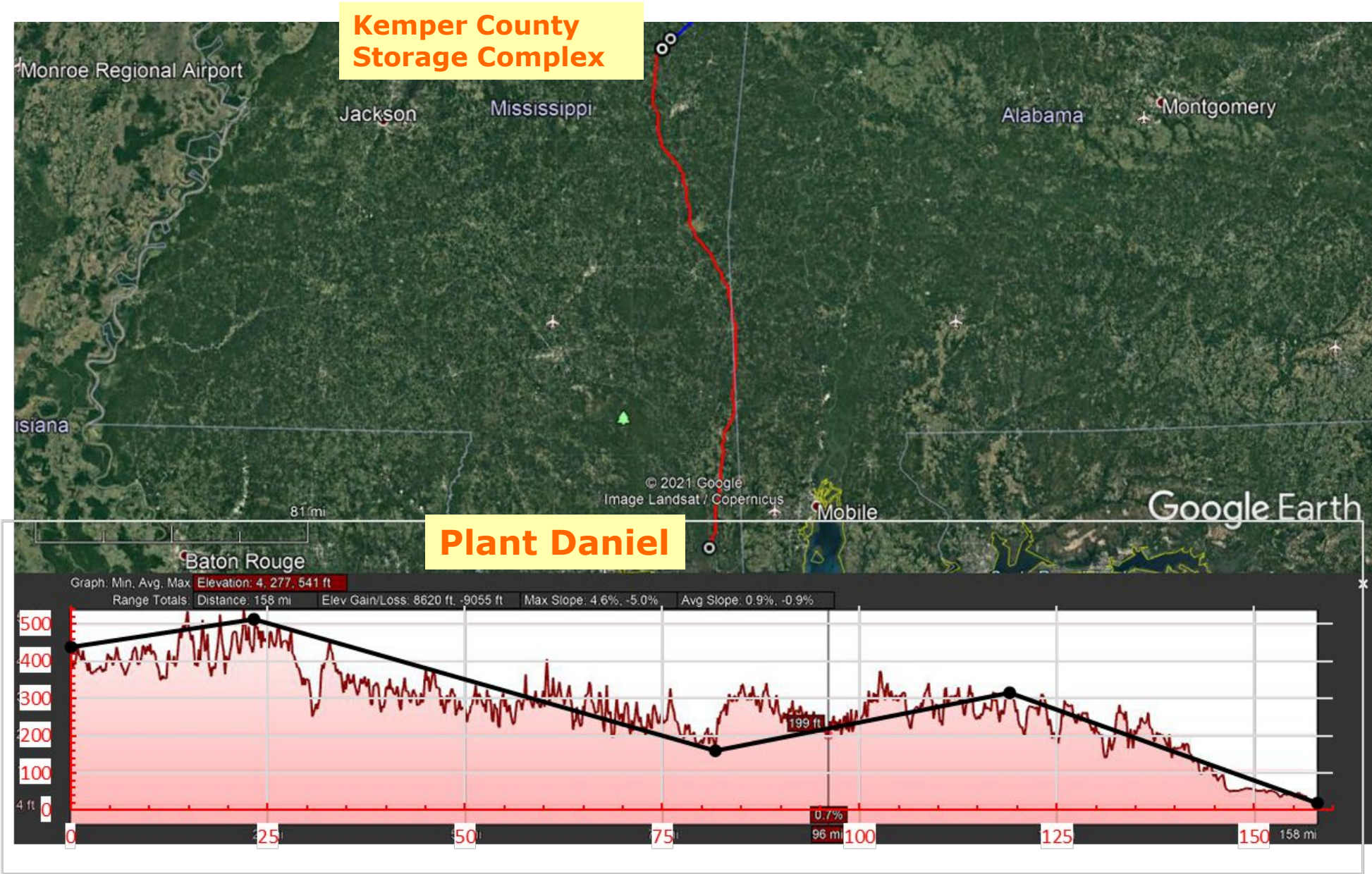


**Pumps at 1,425 tph CO₂ Pipeline
Booster Pump Station**

Simplified Hydraulic Model

- ❑ Simplified elevation profile
- ❑ Conservative pressure constraints
 - Max pipeline P of 2,000 psig vs. ANSI Class 900 rating of 2,220 psig
 - Deliver to Kemper at $> 1,300$ psig (91 bara)
 - Conservative pressure losses for fittings
- ❑ Simplified heat transfer model for buried uninsulated pipe
 - Reach ground temperature within 100 miles (160 km)
- ❑ Generic piping choices
 - Roughness, thickness, etc.

Simplified Elevation for Daniel Pipeline Analysis



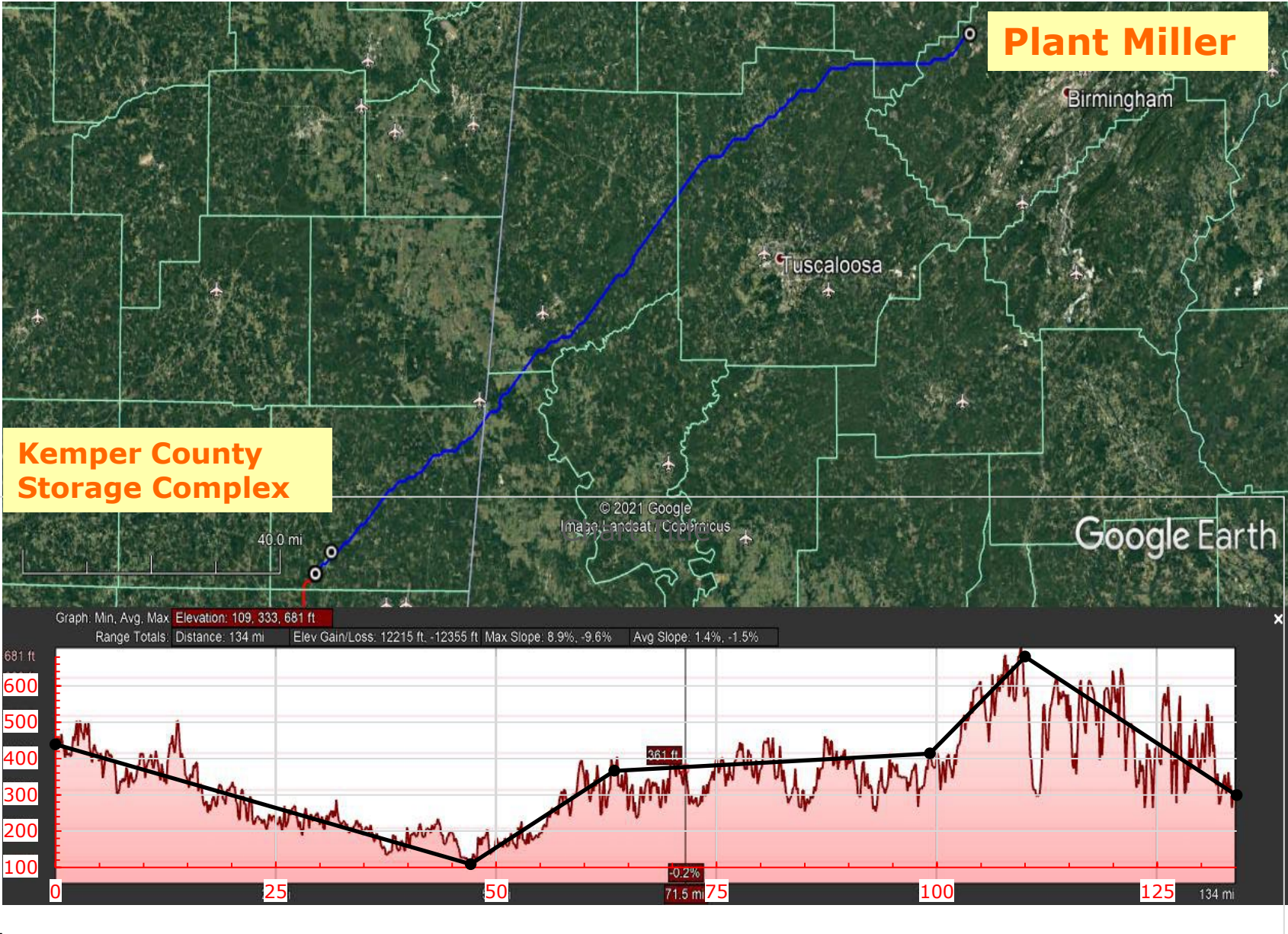
Plant Daniel

2.9 Mtpa

Nominal Pipeline Size (in)	# Booster Pump Stations	Distance from Source to Pump Station (km)	Source Pressure (bar)	Booster Pump Outlet Pressure (bar)	Trunkline Delivery Pressure to Kemper (bar)
20	0	-	139	-	110
18	0	-	139	-	98
16	1	234	139	94	91

Required trunkline delivery pressure of 91 bara

Simplified Elevation for Miller Pipeline Analysis



Plant Miller

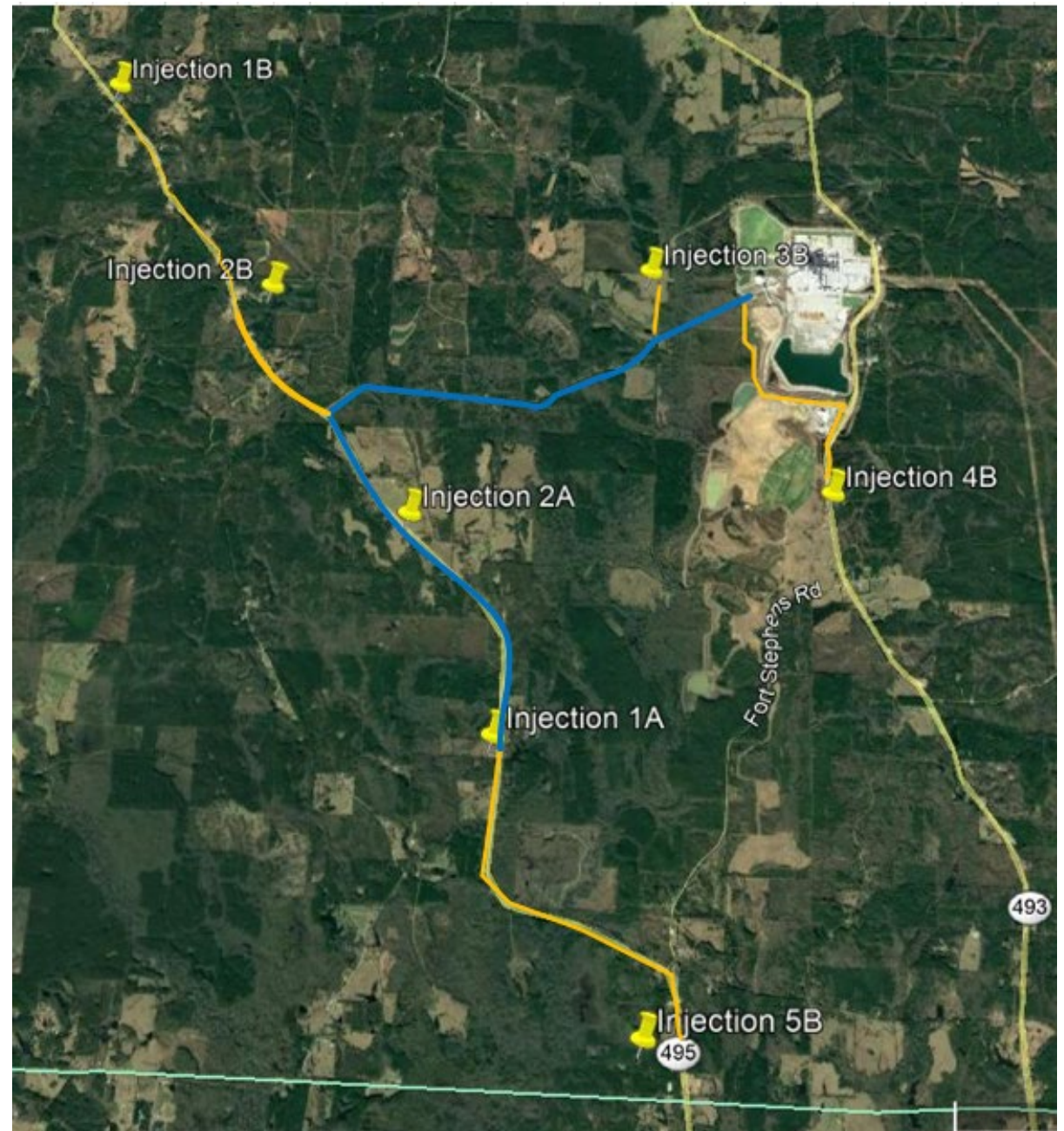
17.3 Mtpa

Nominal Pipeline Size (in)	# Booster Pump Stations	Distance from Source to Pump Station (km)	Source Pressure (bar)	Booster Pump Outlet Pressure (bar)	Trunkline Delivery Pressure to Kemper (bar)
36	0	-	139	-	110
34	0	-	139	-	99
30	1	184	139	114	91

Required trunkline delivery pressure of 91 bara

Phased Development of Kemper Storage Complex

- 7 pads x 3 wells/pad = 21 wells
 - Ratcliffe : 2 wells
 - Daniel: 3 wells
 - Miller: 16 wells
- All sources gathered near Ratcliffe
- Routing and size of header line from Ratcliffe to wells depends on future development plans



Next Step: Pipeline FEED Study

- FEED = Front-End Engineering and Design
- 13-km route at Kemper Complex: from Ratcliffe + future phases
- Early-phase, desktop study; no field survey
- Environmental Information already gathered by ECT:
 - Land use
 - Hydrologic and Geologic/Soil conditions
 - Vegetation and wildlife resources
 - Socioeconomic conditions
 - Historic/Cultural resources

Pipeline FEED Study Deliverables

- Basis of Design
- Permit Matrix
- Desktop route study
- Desktop geotechnical study
- Route map books
- Risk register
- Project management plan
- Project schedule
- Hydraulic analysis (primary and optional routes)
- P&IDs
- PFDs
- Bill of Materials
- Total Installed Cost (Class 3)
- Report narrative

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