Carbon Storage Potential in Chandeleur Sound, Louisiana

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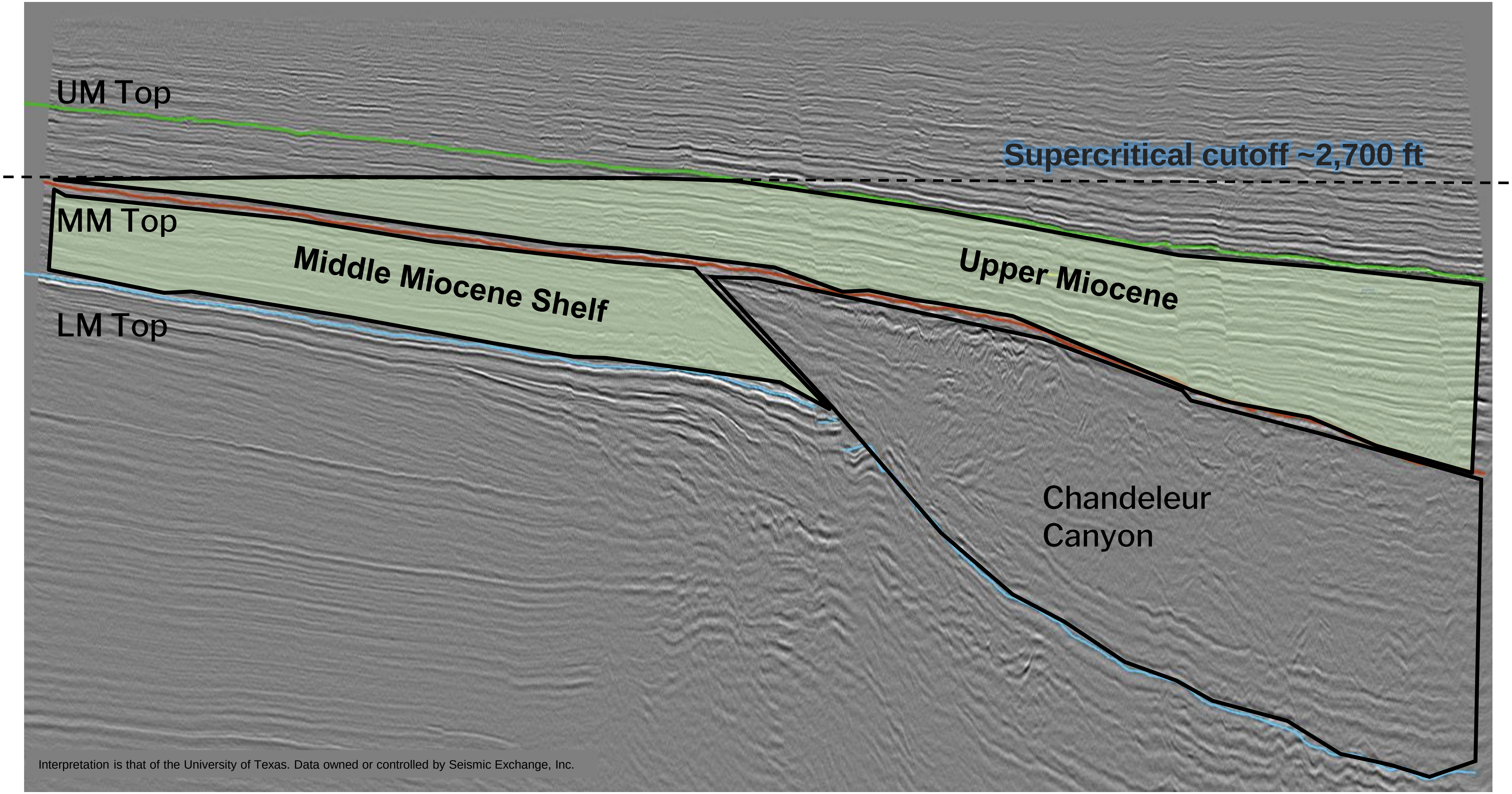
Project Introduction

Problem:

Is Chandeleur Sound geologically and economically viable for CCS?

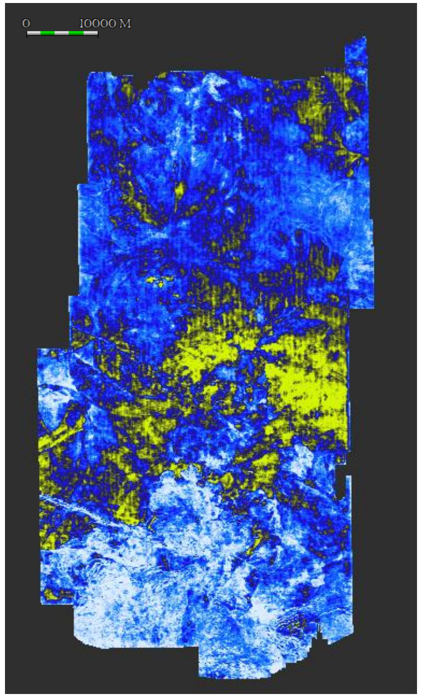
Major Steps:

- Geological characterization
- Storage capacity estimation
- Source-sink matching
- Pipeline regulations
- Pipeline routing and costs estimation

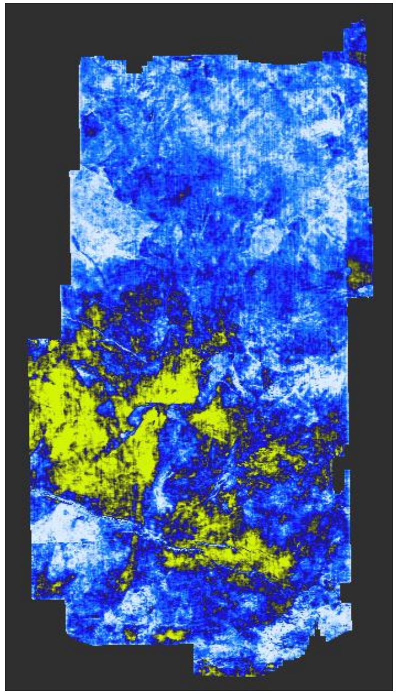


Vertical exaggeration: ~ 10

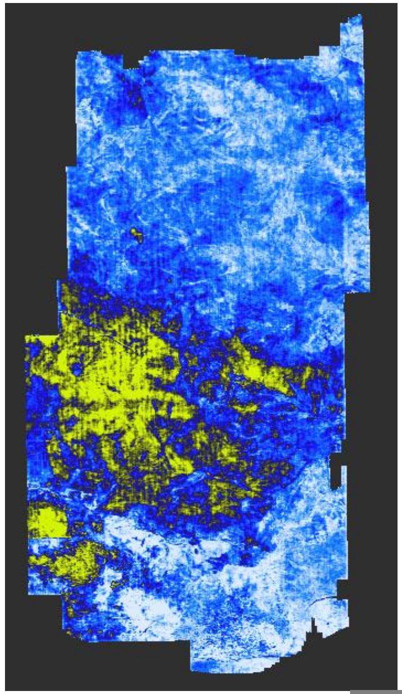
Sum Negative Amplitude – Upper Miocene



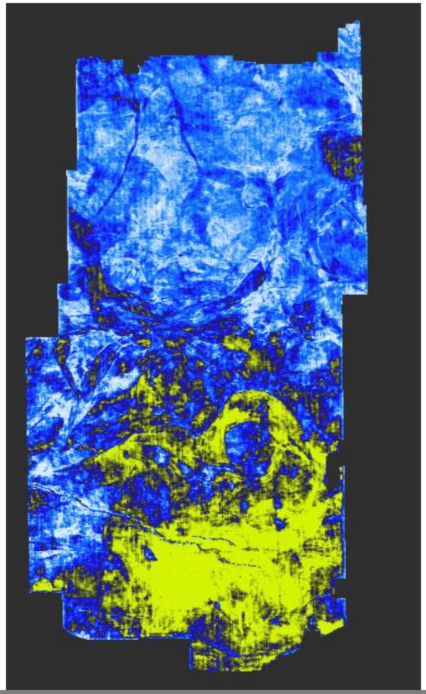
1500 ms



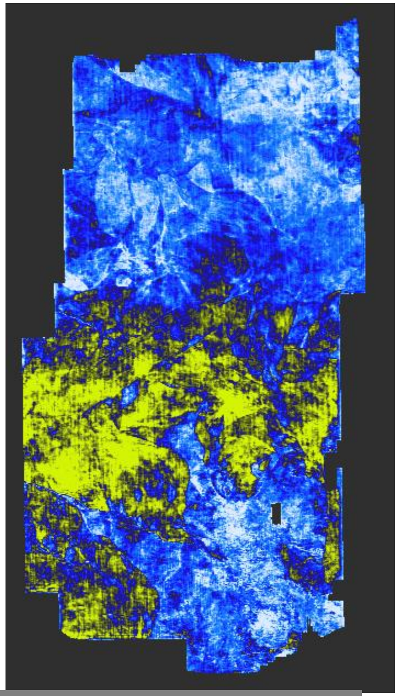
1730 ms



1600 ms

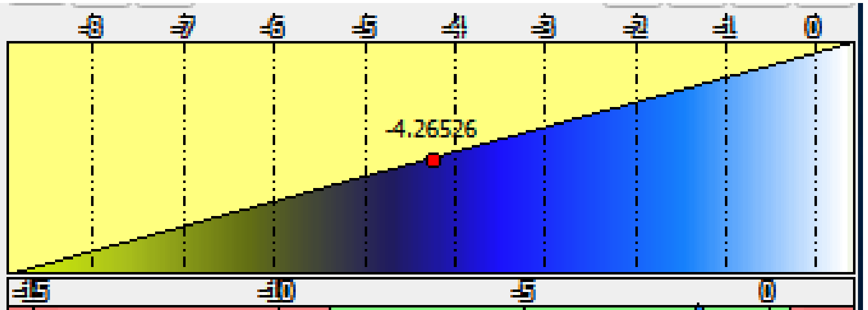


1700 ms



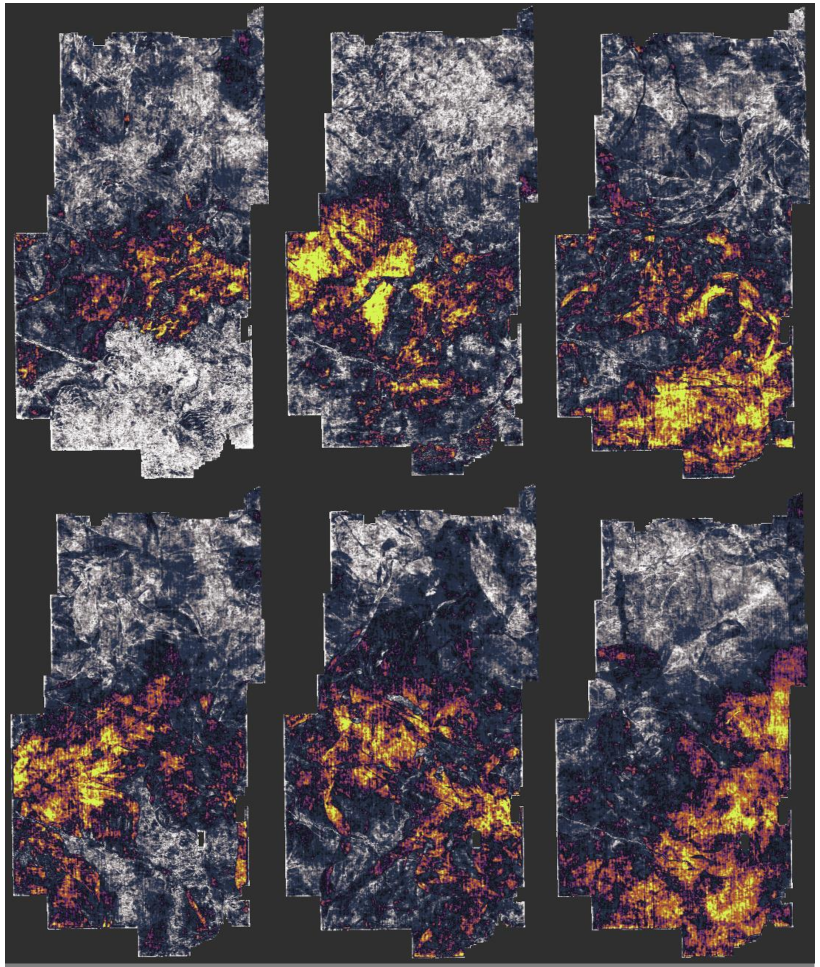
1400 ms

Time

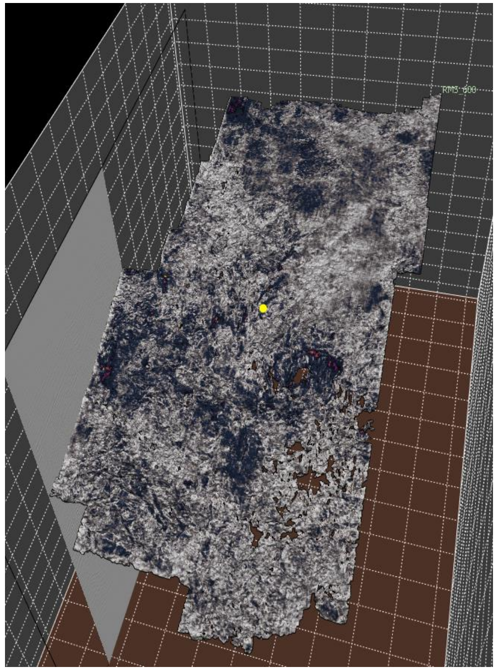


Yellow: trough, possibly sand

Root Mean Square (RMS) Amplitude



Interpretation is that of the University of Texas. Data owned or controlled by Seismic Exchange, Inc.



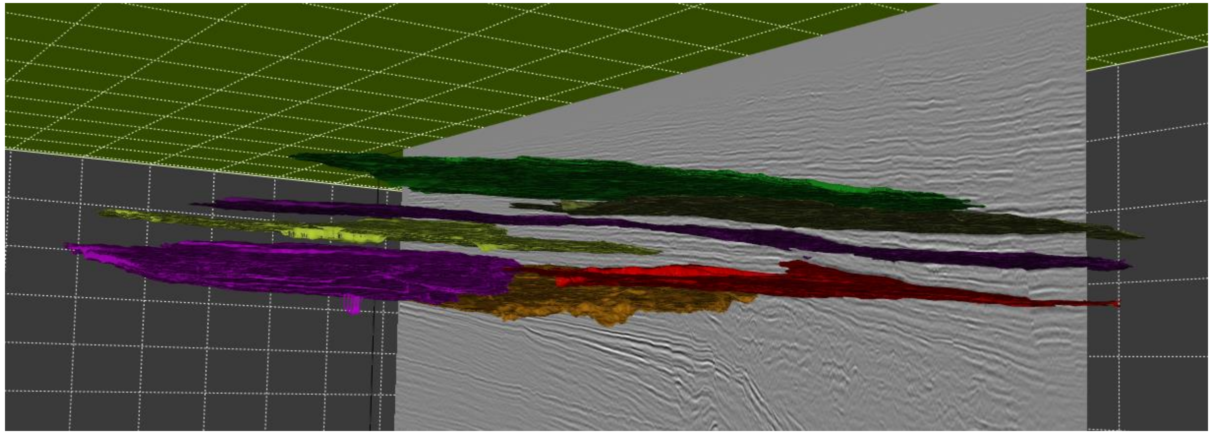
High amplitudes appear at:

- UM south

Low amplitudes appear at :

- UM north
- MM shelf

Geobodies extraction – from bright amplitude areas



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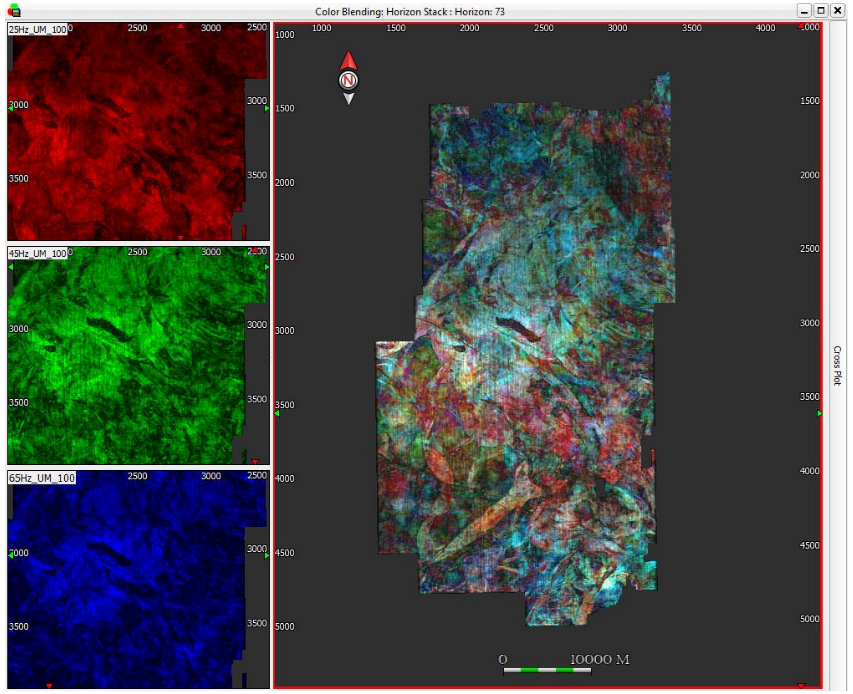
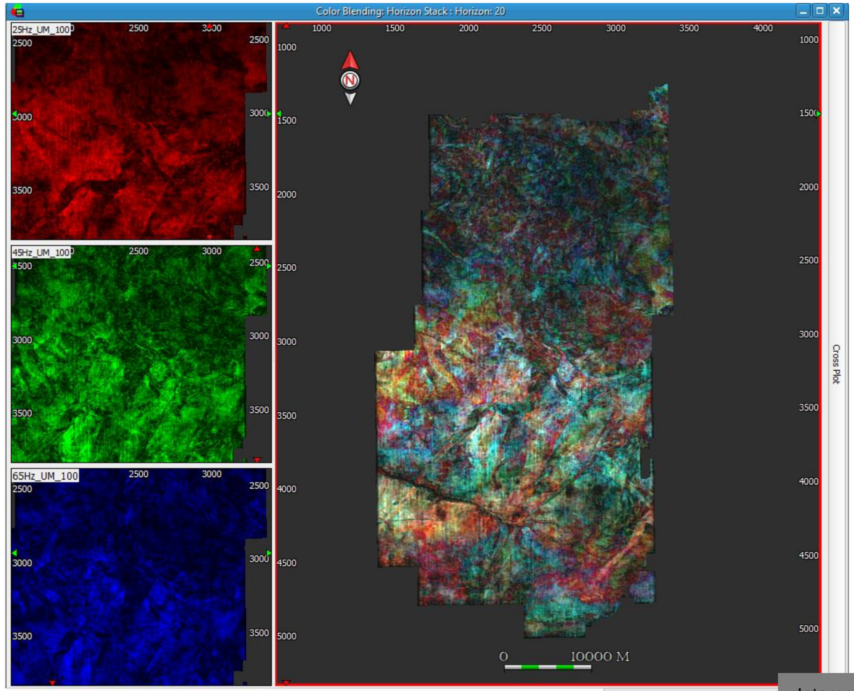
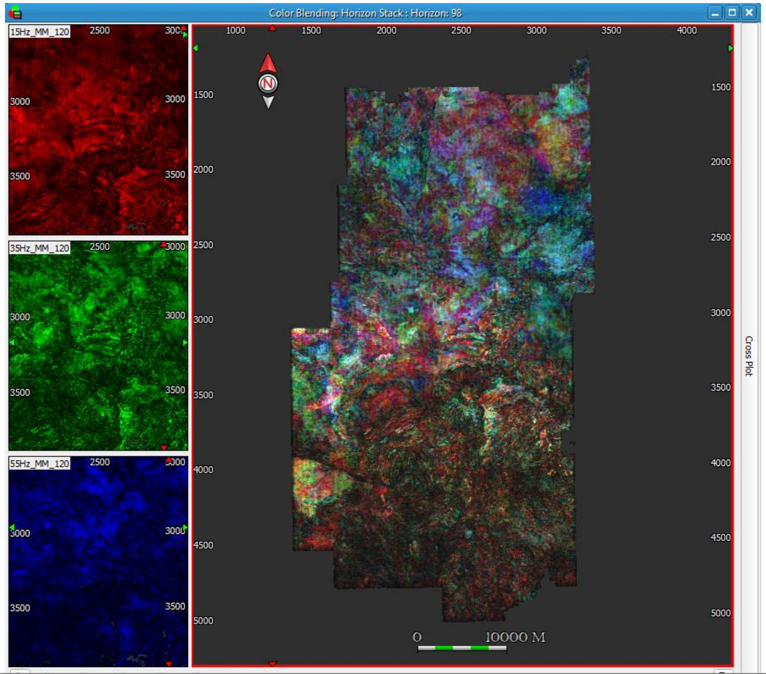
Spectrum Decomposition



upper UM



lower UM



MM

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- UM: 25, 45, 65 Hz (100 slices)
- MM: 15, 35, 55 Hz (120 slices)

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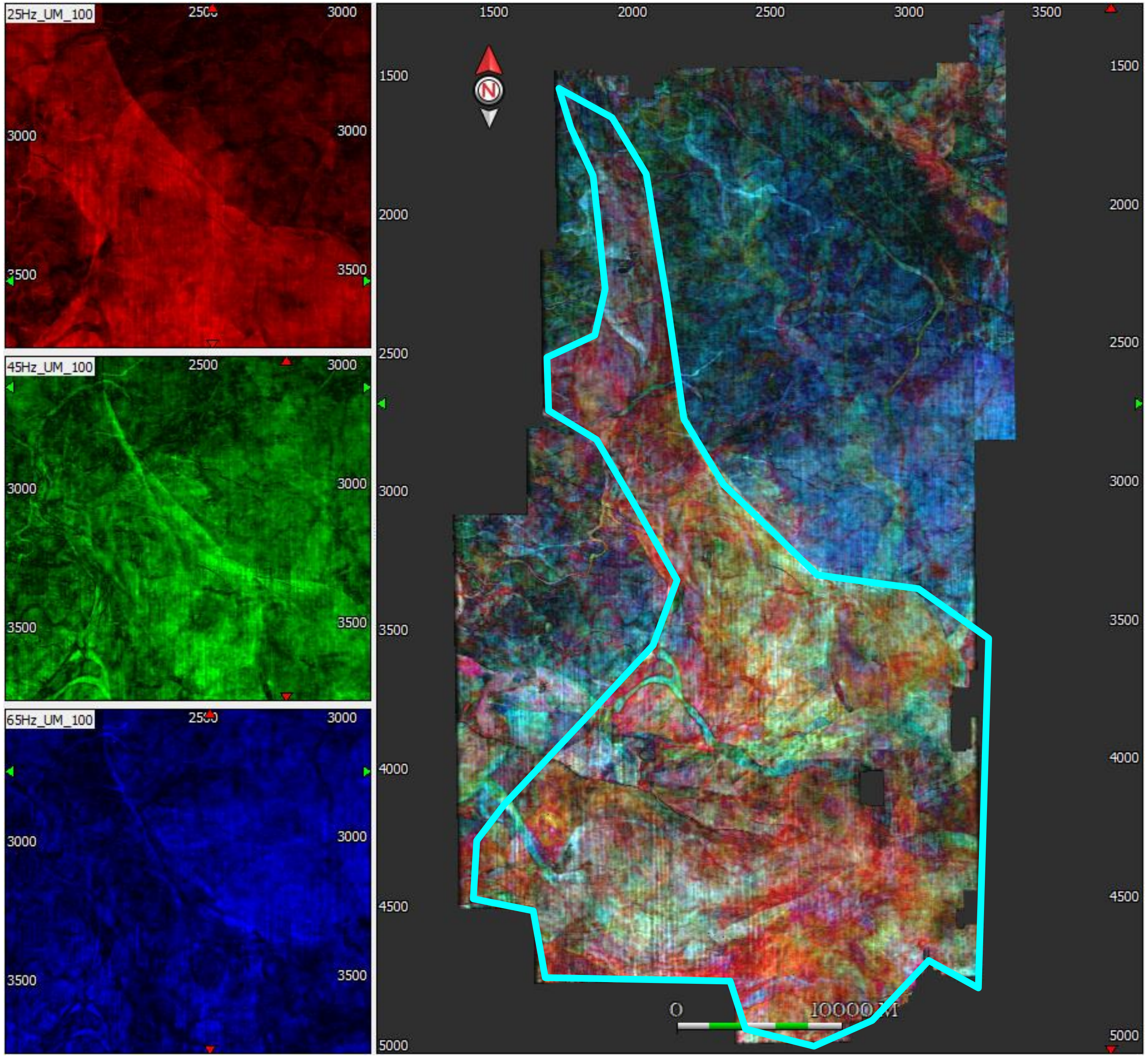
Major channel system appears near UM horizon, indicates possible sand flow.

Possible paleo Tennessee River distributary.



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Conclusions on CCS Viability outside of the Canyon

Most viable storage location:

- *UM shelf (south) - continuous sand*
- *Channel system near UM Top- massive, does not reach supercritical cut-off*

Not ideal:

- *MM shelf - low amplitude & lack of well control*
- *UM shelf (north) - above supercritical cutoff or lack of continuous seal*

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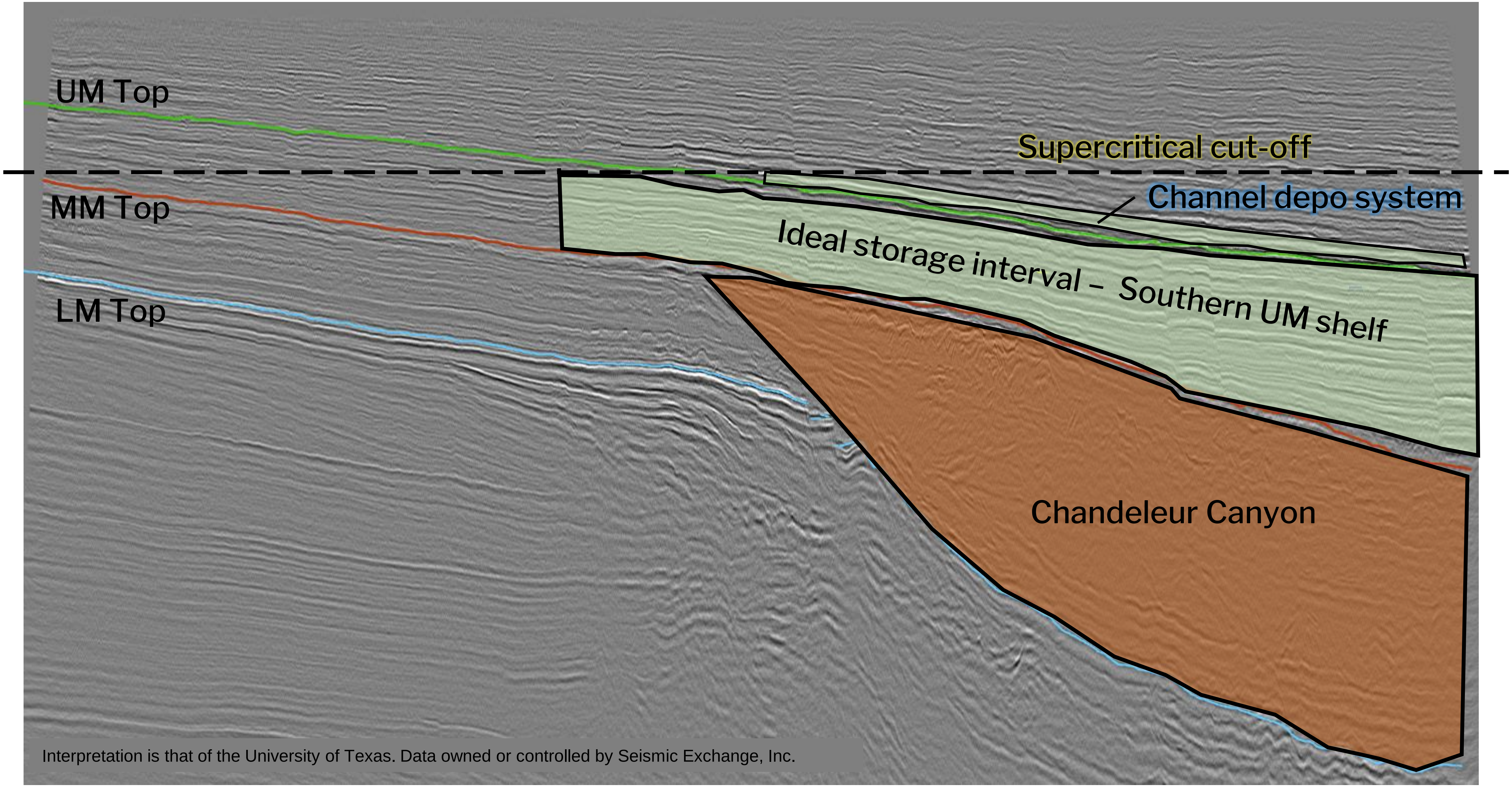

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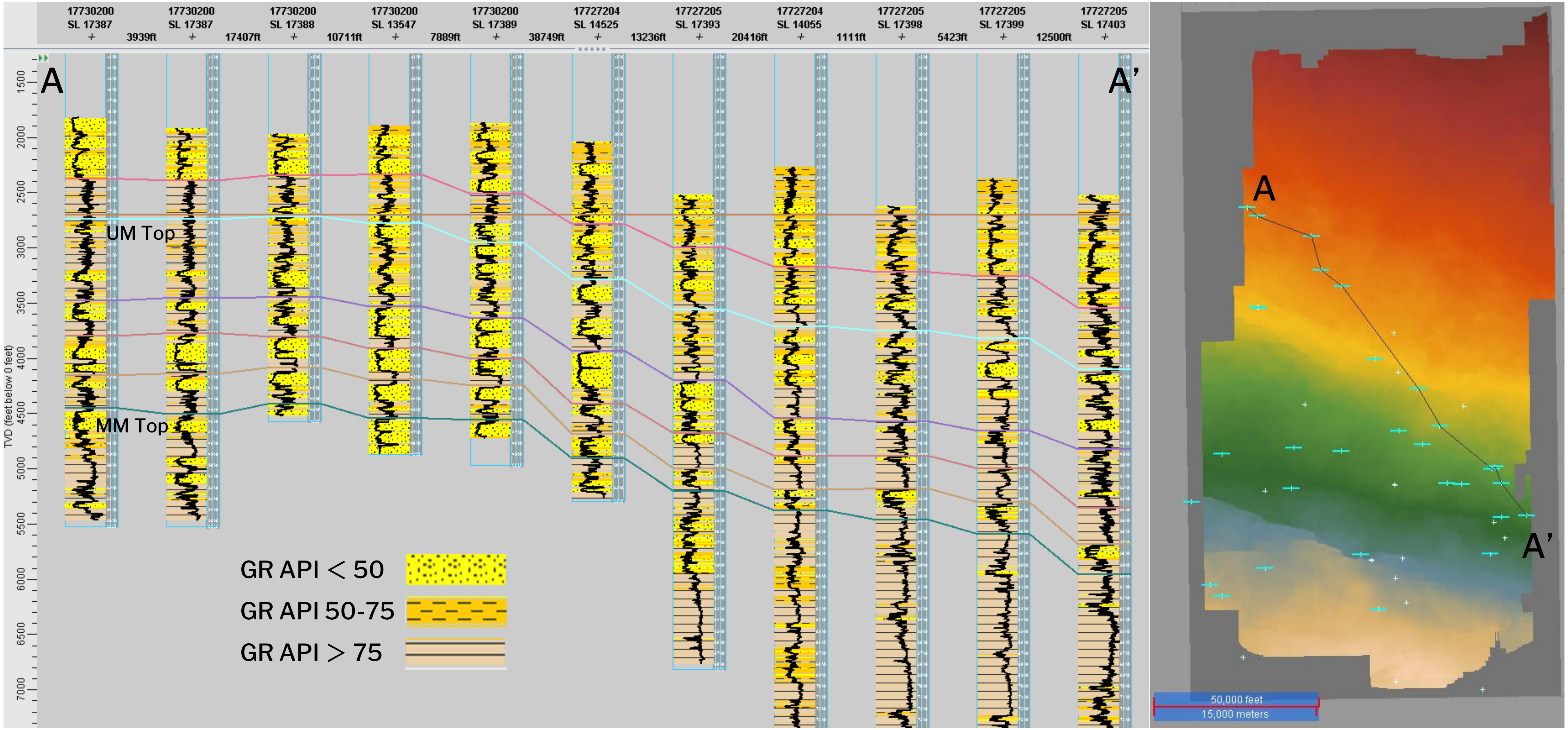
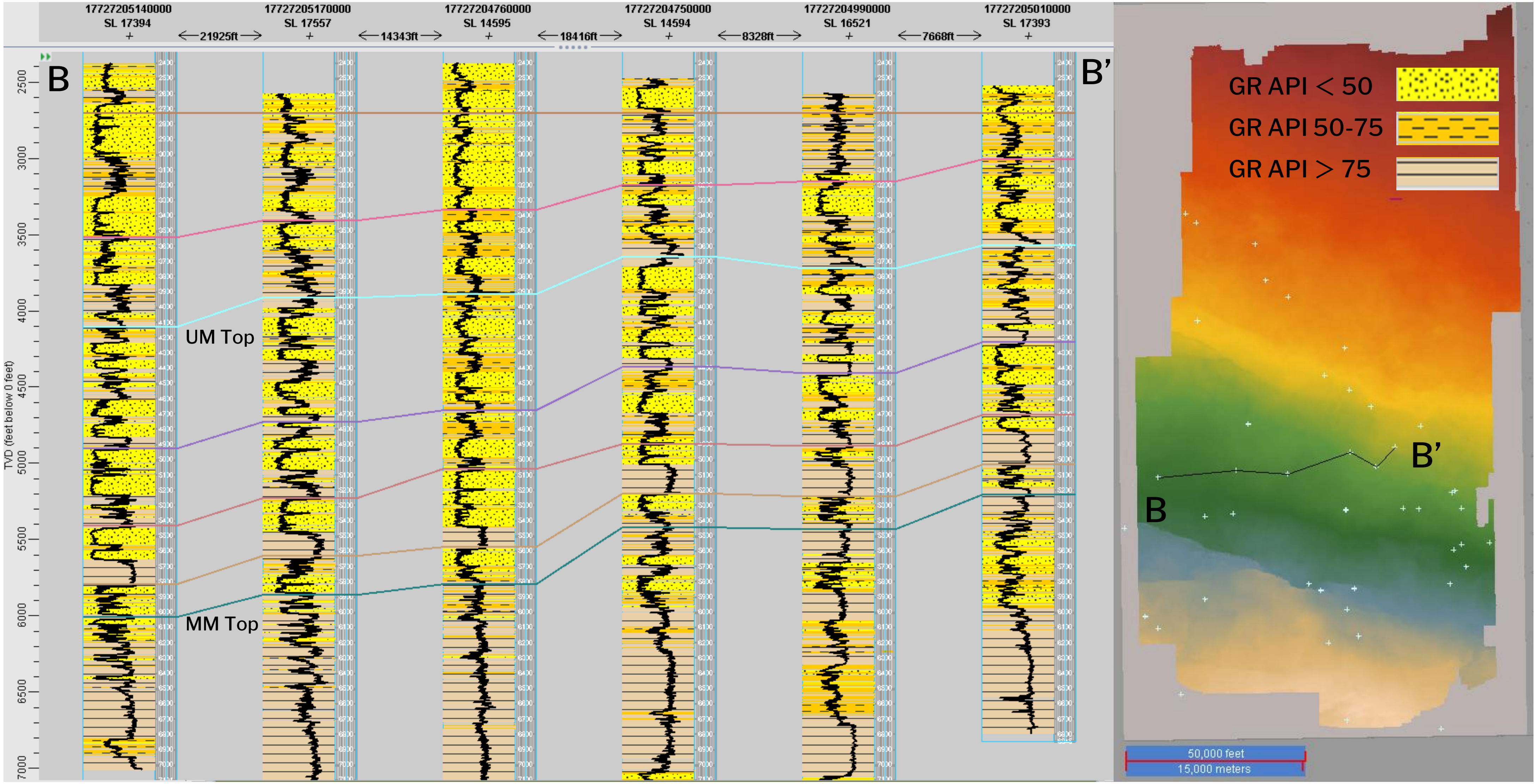
Well Analysis



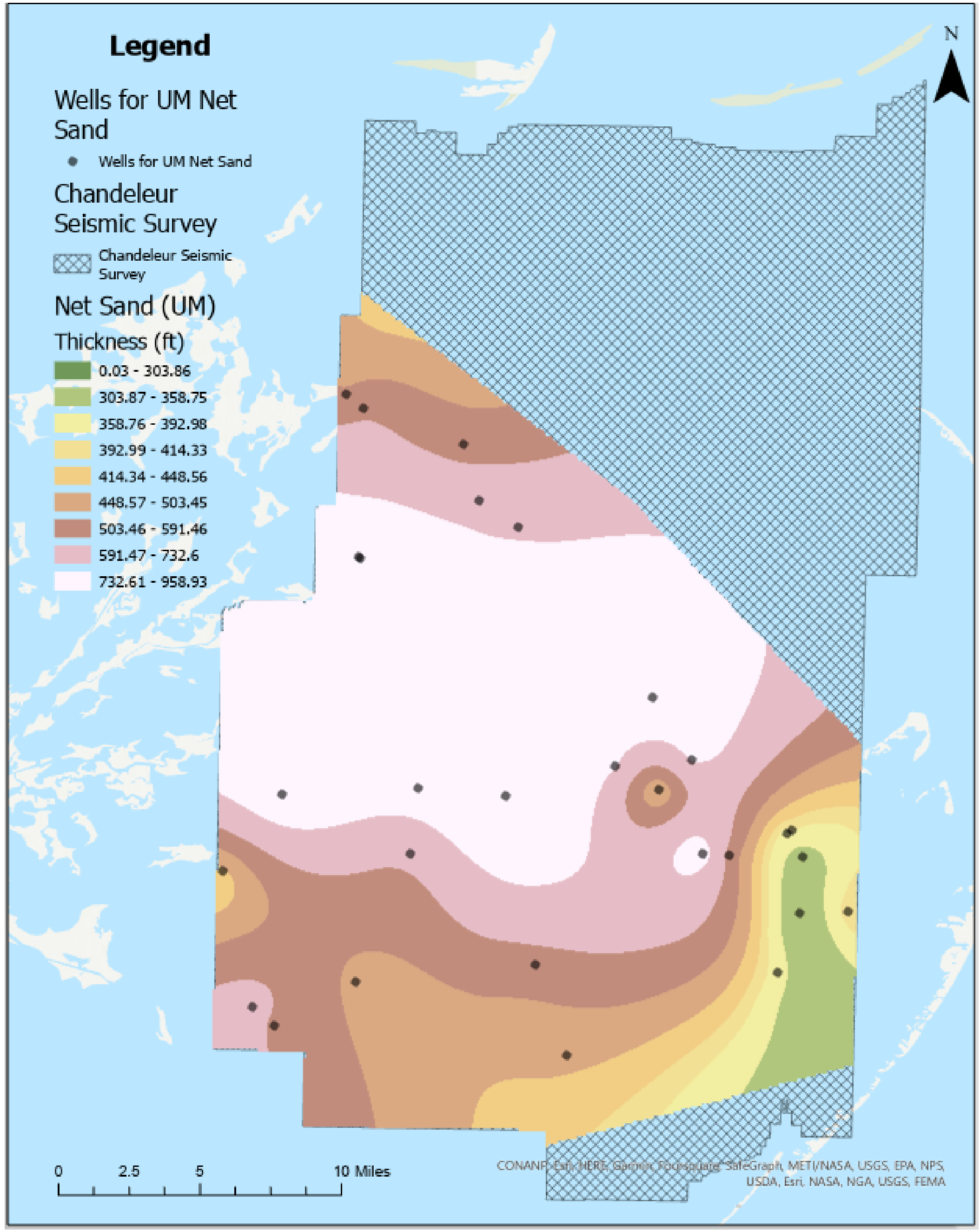

17727205140000
SL 17394
21925ft
17727205170000
SL 17557
14343ft
17727204760000
SL 14595
18416ft
17727204750000
SL 14594
8328ft
17727204990000
SL 16521
7668ft
17727205010000
SL 17393
B
B'
TVD (feet below 0 feet)
UM Top
MM Top
GR API < 50
GR API 50-75
GR API > 75
50,000 feet
15,000 meters

Net Sand Map

Net sand thickness of the whole UM interval

Measured using a Gamma Ray cut-off value of 50

Thickest at the Mid UM shelf (white color in the map), > 700 ft (214m) thick



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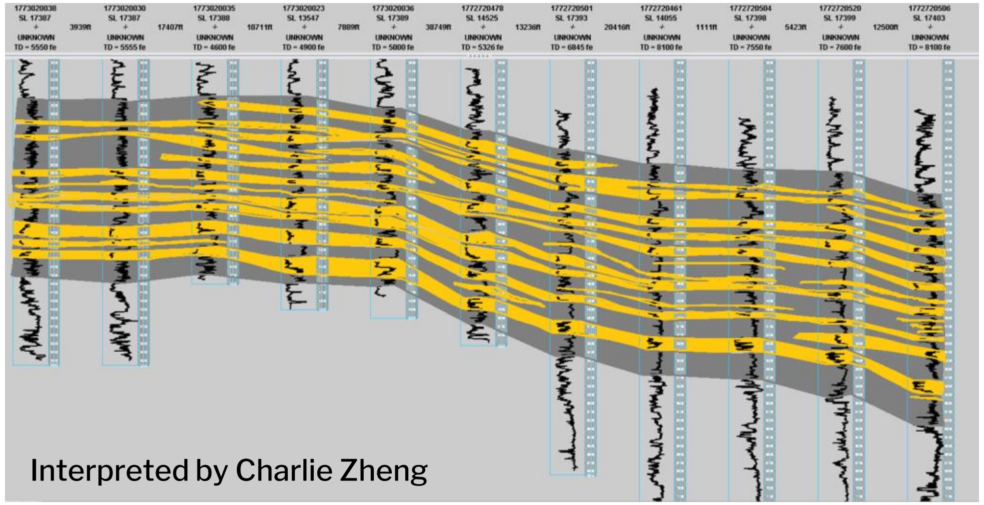
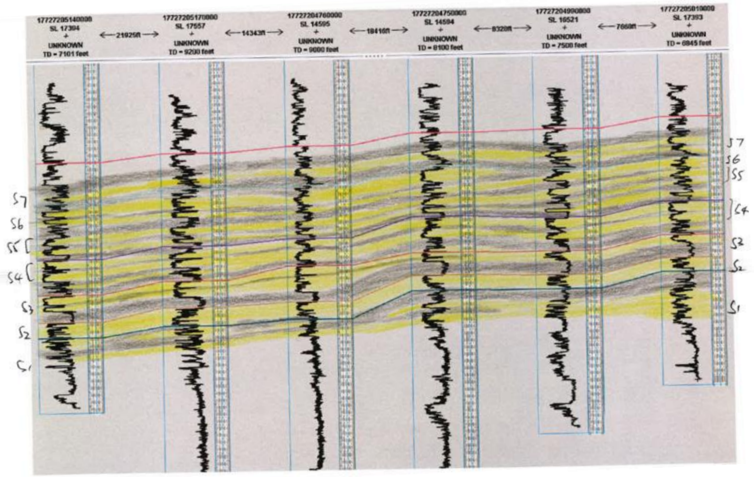
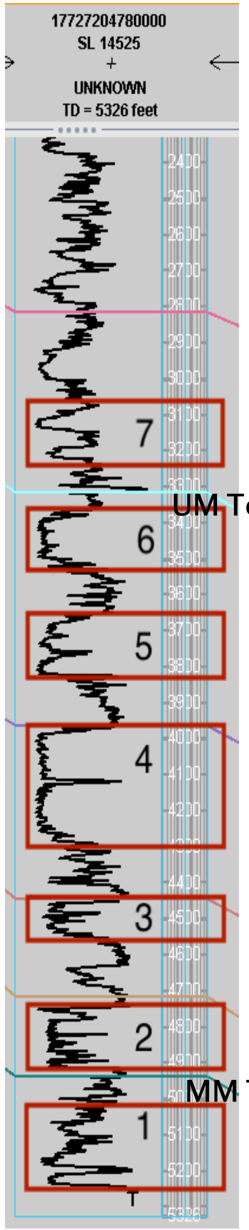
Reservoir Identification and Their Properties







Seven continuous sand bodies have been selected

Name	Depth (m)	Pressure (Mpa)	Temperature (C)	Porosity	Permeability (mD)	Thickness (m)	Area (km²)
S1	1694.84	17.79	57.36	0.27	77.01	42.16	278.59
S2	1694.48	16.53	54.36	0.23	11.32	53.34	283.51
S3	1473.84	15.48	51.85	0.25	36.84	49.02	301.02
S4	1359.75	14.28	48.99	0.26	168.01	64.01	261.81
S5	1242.23	13.04	46.06	0.29	216.19	61.72	477.52
S6	1188.36	12.48	44.71	0.31	362.24	47.55	450.55
S7	1099.29	11.54	42.48	0.31	451.92	47.85	405.78

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Static Storage Capacity Estimation

$$G_{CO2net} = A_t \, h_{net} \, \varphi_{tot} \, \rho \, E_{net}$$

A_t = Total area
h_{net} = Net sandstone thickness
φ_{tot} = Total porosity
ρ = CO_2 density
E_{net} = Net storage efficiency factor in a saline aquifer (using **2%** in this study)

Name	Density (kg/m^3)	Total Porosity	Thickness (m)	Area (km^2)	Estimated Capacity (Mt)
S1	703	33.46%	42.16	278.59	55.26
S2	700	33.28%	53.34	283.51	70.46
S3	696	34.87%	49.02	301.02	71.63
S4	691	34.37%	64.01	261.81	79.60
S5	685	34.68%	61.72	477.52	152.15
S6	681	35.39%	47.55	450.55	103.26
S7	673	36.54%	47.85	405.78	95.50
Total					627.86

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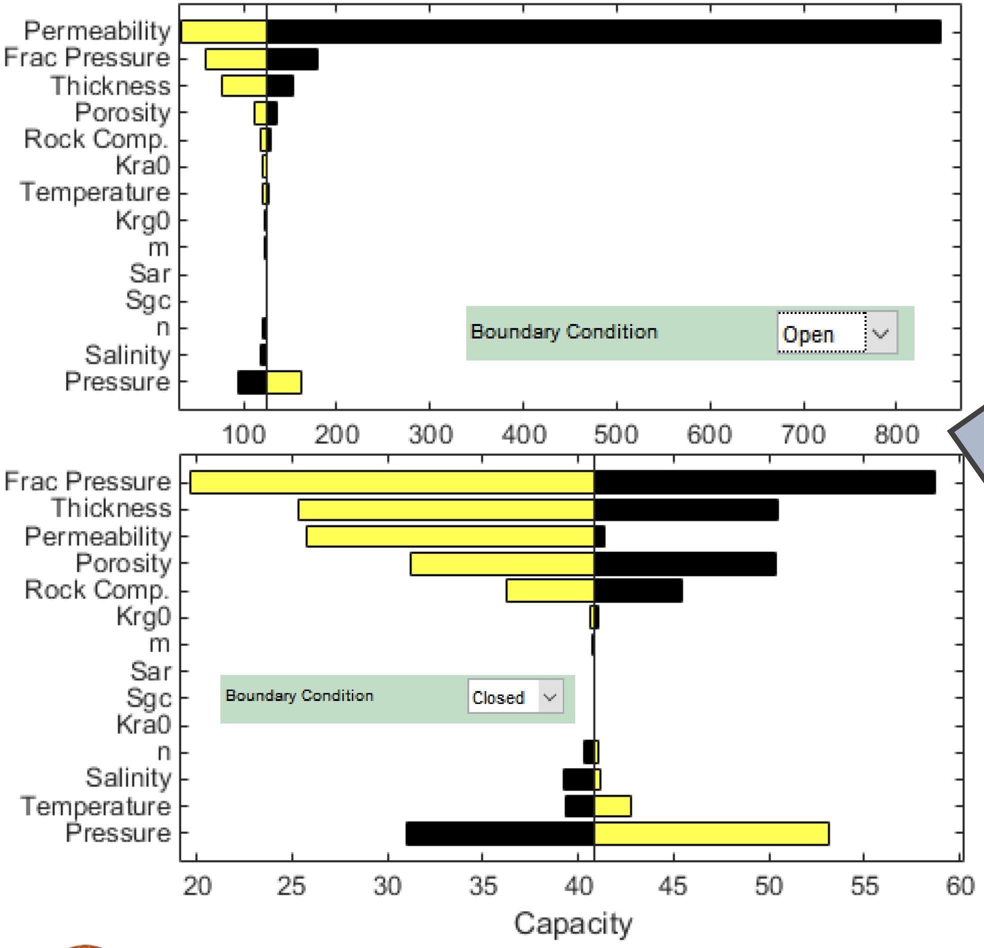
Static capacity equation, 2% as E_{net} value are from Goodman et al., 2011.

Dynamic Storage Capacity Estimation - EASiTool

Tornado diagrams for S3, with open and closed boundary conditions

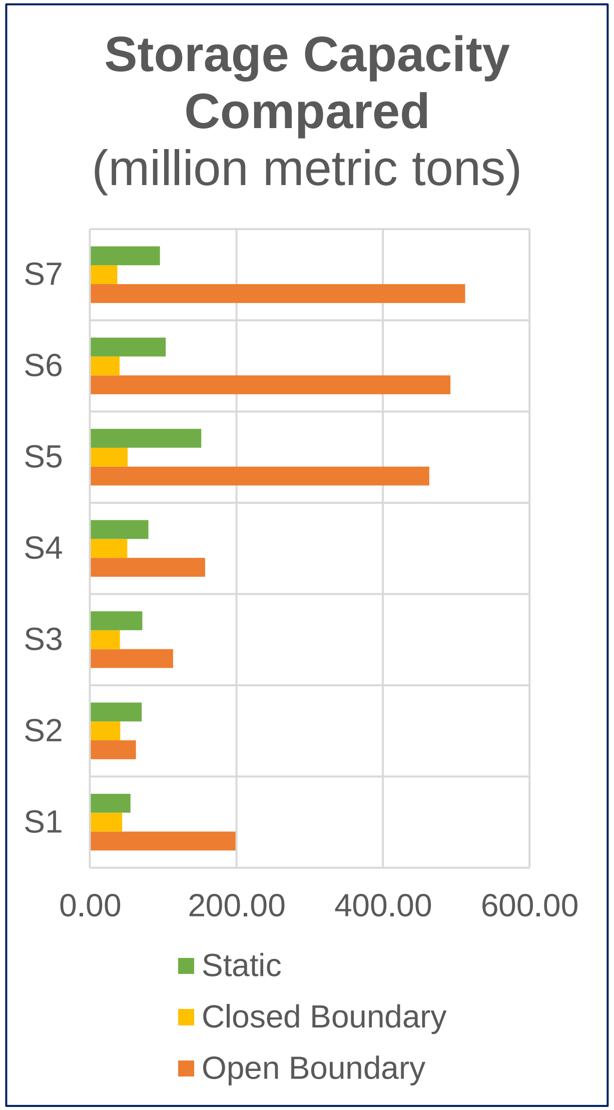


Capacity (Million metric tons)

	Open Boundary	Closed Boundary
S1	198.60	43.97
S2	62.71	41.14
S3	113.50	41.00
S4	157.00	50.77
S5	463.40	51.53
S6	492.10	40.27
S7	512.40	37.33
Total	**1999.71**	**306.01**

Largest effect on capacity (open boundary): permeability

Largest effect on capacity (closed boundary): frac pressure



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Economic Viability of Chandeleur Sound

- Large amount of carbon sources
  - Close to major industrial cities like: New Orleans, Baton Rouge, Pascagoula, etc.
  - Chemical corridor in LA
- Large, offshore, state water location
  - ~ 650 mi^2
  - Does not affect USDW

Transport method: pipeline

Source: EPA FLIGHT Database

Regulations on Pipeline Sitting

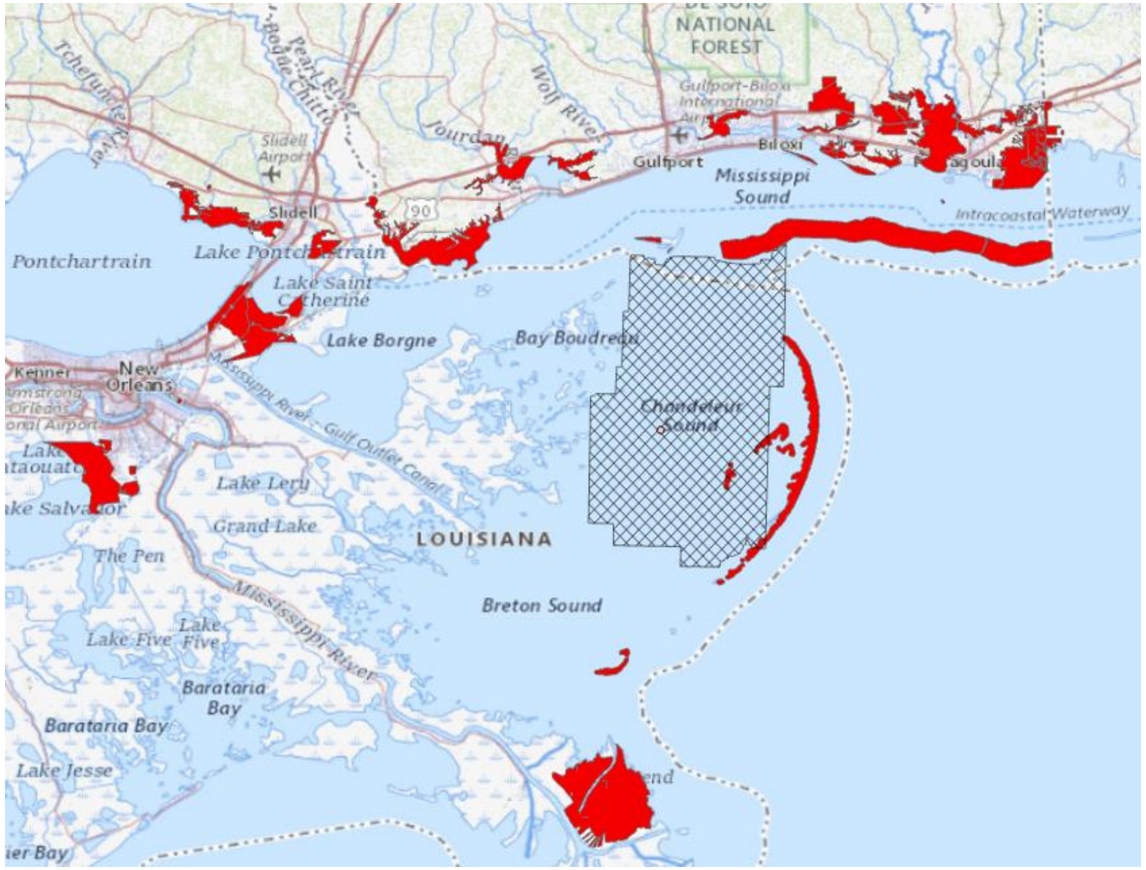
Regulatory agency:

Department of Transportation - United States Pipeline and Hazardous Materials Safety Administration (PHMSA)

Title: 49 C.F.R. §195

§ 195.210 Pipeline location.

- (a) Pipeline right-of-way must be selected to **avoid, as far as practicable, areas containing private dwellings, industrial buildings, and places of public assembly.**
- (b) No pipeline may be located within **50 feet (15 meters)** of any **private dwelling, or any industrial building or place** of public assembly in which persons work, congregate, or assemble, unless it is provided with at least 12 inches (305 millimeters) of cover in addition to that prescribed in § 195.248.
- Extra plans in High Consequence Areas (HCAs)
  - Commercially navigable waterways
  - High population areas (> 1,000 people per mi^2)
  - Other populated areas
  - Unusually Sensitive Areas (USAs)



Marine protected areas near Chandeleur Sound (NOAA, 2020)

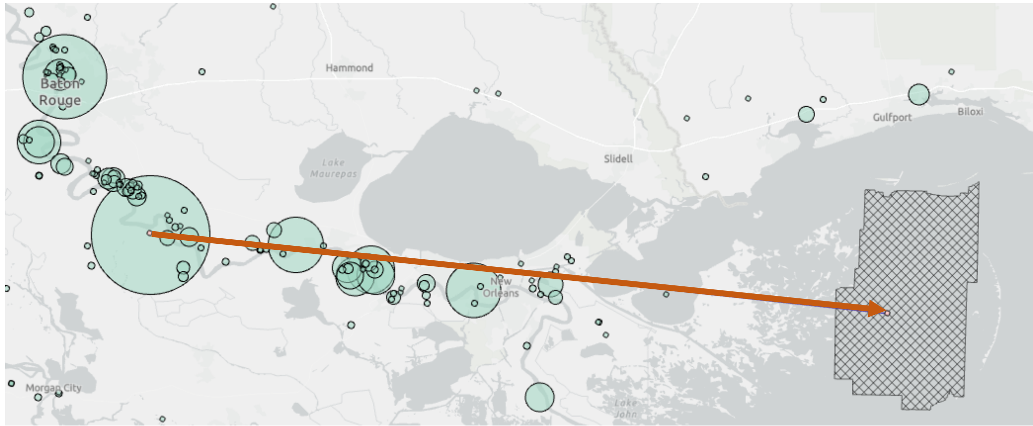
Pipeline Capital Costs – NETL Model

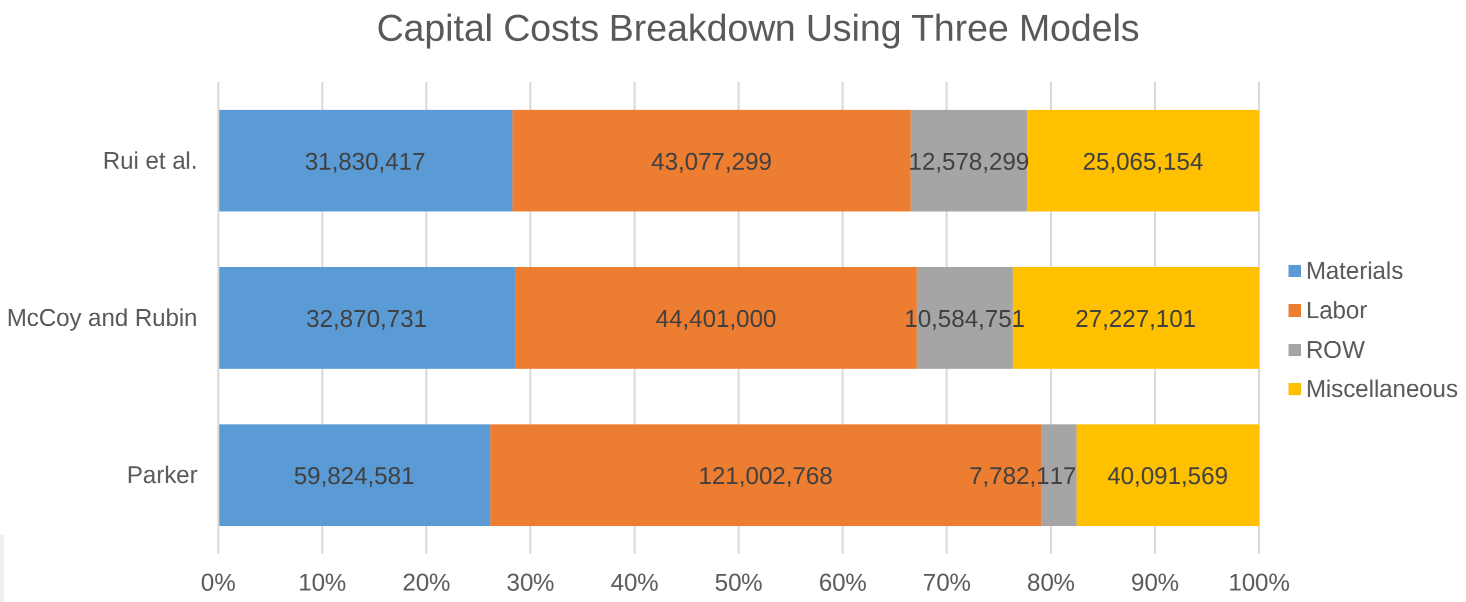
<u>Proposed pipeline route:</u>

CF Industries Nitrogen to Central Chandeleur Sound

- Pipeline length: 112.07 miles
- Average flow rate: 9 Mt/yr
- Diameter: 20 in
- Region: Southwest
- Injection period: 30 yr
- Construction period: 3 yr
- Capacity factor: 85%

Tool Used: FECM/NETL CO2 Transport Costs Model (2022)





Costs (2023$)	Parker	McCoy and Rubin	Rui et al.
Materials	59,824,581	32,870,731	31,830,417
Labor	121,002,768	44,401,000	43,077,299
ROW	7,782,117	10,584,751	12,578,299
Miscellaneous	40,091,569	27,227,101	25,065,154
CO2 Surge Tanks	1,616,184	1,616,184	1,616,184
Pipeline Control System	145,301	145,301	145,301
Pumps	6,923,719	6,923,719	6,923,719
Contingency	35,607,936	18,565,318	18,185,456
Capital Costs	272,994,174	142,334,104	139,421,829

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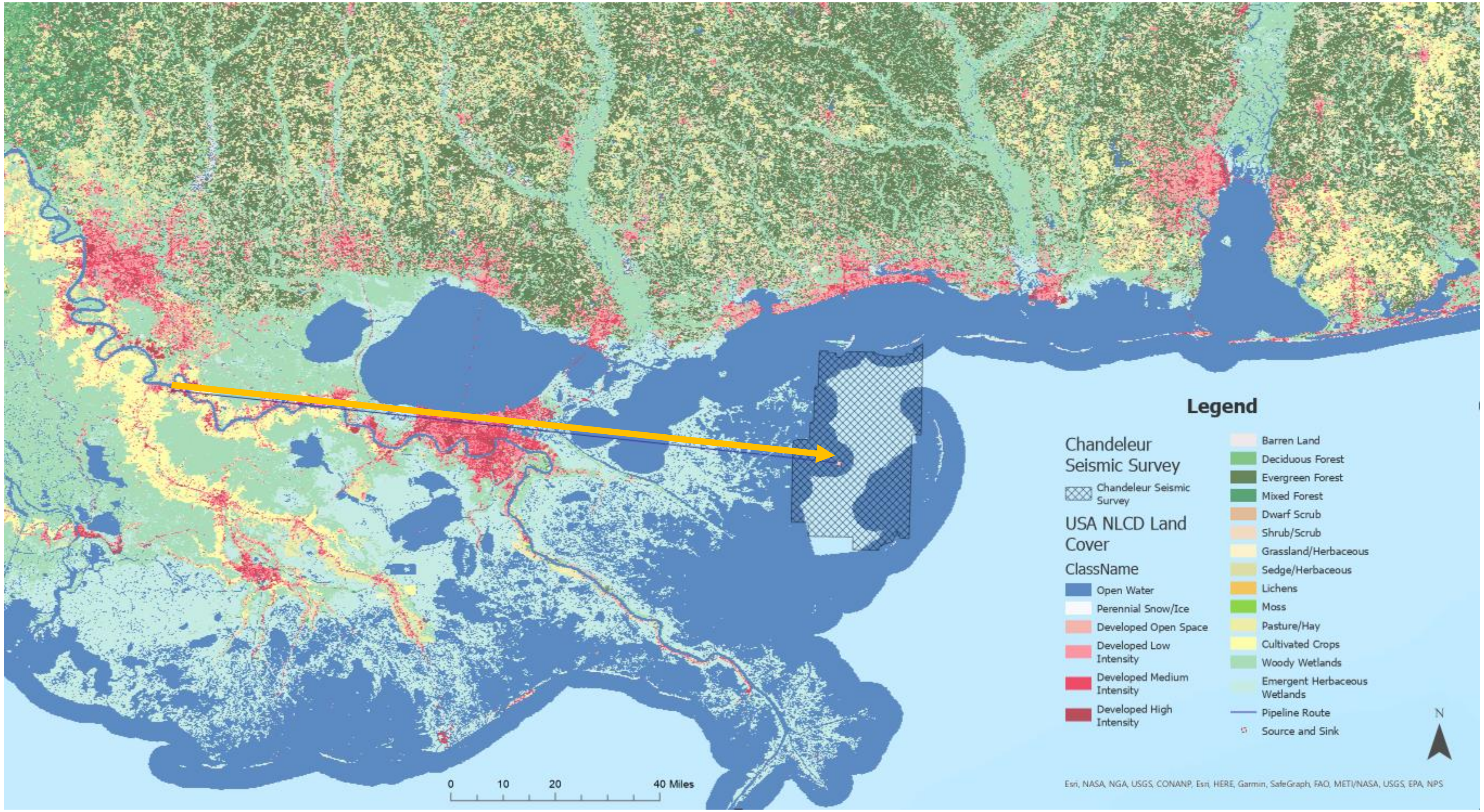
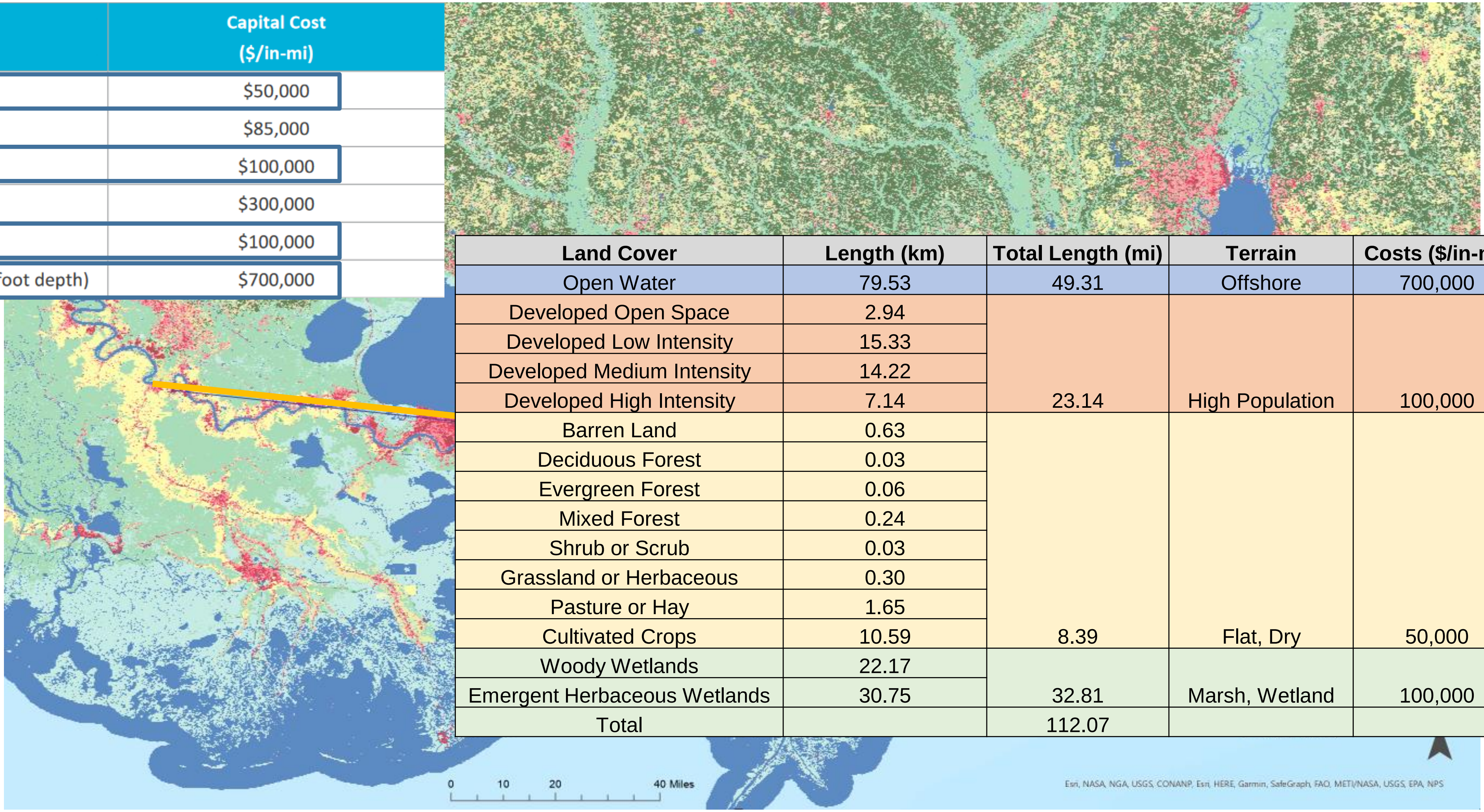
Pipeline Capital Costs – Terrain Based



Pipeline Capital Costs – Terrain Based

Terrain	Capital Cost ($/in-mi)
Flat, dry	$50,000
Mountainous	$85,000
Marsh, wetland	$100,000
River	$300,000
High population	$100,000
Offshore (150-foot [ft] – 200-foot depth)	$700,000



Land Cover	Length (km)	Total Length (mi)	Terrain	Costs ($/in-mi)	Total Costs
Open Water	79.53	49.31	Offshore	700,000	$ 690,320,389.40
Developed Open Space	2.94				
Developed Low Intensity	15.33				
Developed Medium Intensity	14.22				
Developed High Intensity	7.14	23.14	High Population	100,000	$ 46,276,800.07
Barren Land	0.63				
Deciduous Forest	0.03				
Evergreen Forest	0.06				
Mixed Forest	0.24				
Shrub or Scrub	0.03				
Grassland or Herbaceous	0.30				
Pasture or Hay	1.65				
Cultivated Crops	10.59	8.39	Flat, Dry	50,000	$ 8,388,600.08
Woody Wetlands	22.17				
Emergent Herbaceous Wetlands	30.75	32.81	Marsh, Wetland	100,000	$ 65,620,800.09
Total		112.07			$ 810,606,589.64

Cost ($/in-mi) is based on Kinder Morgan pipeline cost metrics (Layne, 2009)

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Future Work

Incorporate FECM/NETL model with terrain-based costs and regulatory restrictions

- Create a cost layer on ArcGIS, classified by land cover types
- Identify and overlay the Unusually Sensitive Areas (USAs) on top of the cost layer
- Identify and apply restriction level on the USAs (federal and state level)
- Generate pipeline route with the least capital costs and lowest restriction

Thank You!