



Pipelines – The Safest Way to Travel for CO₂

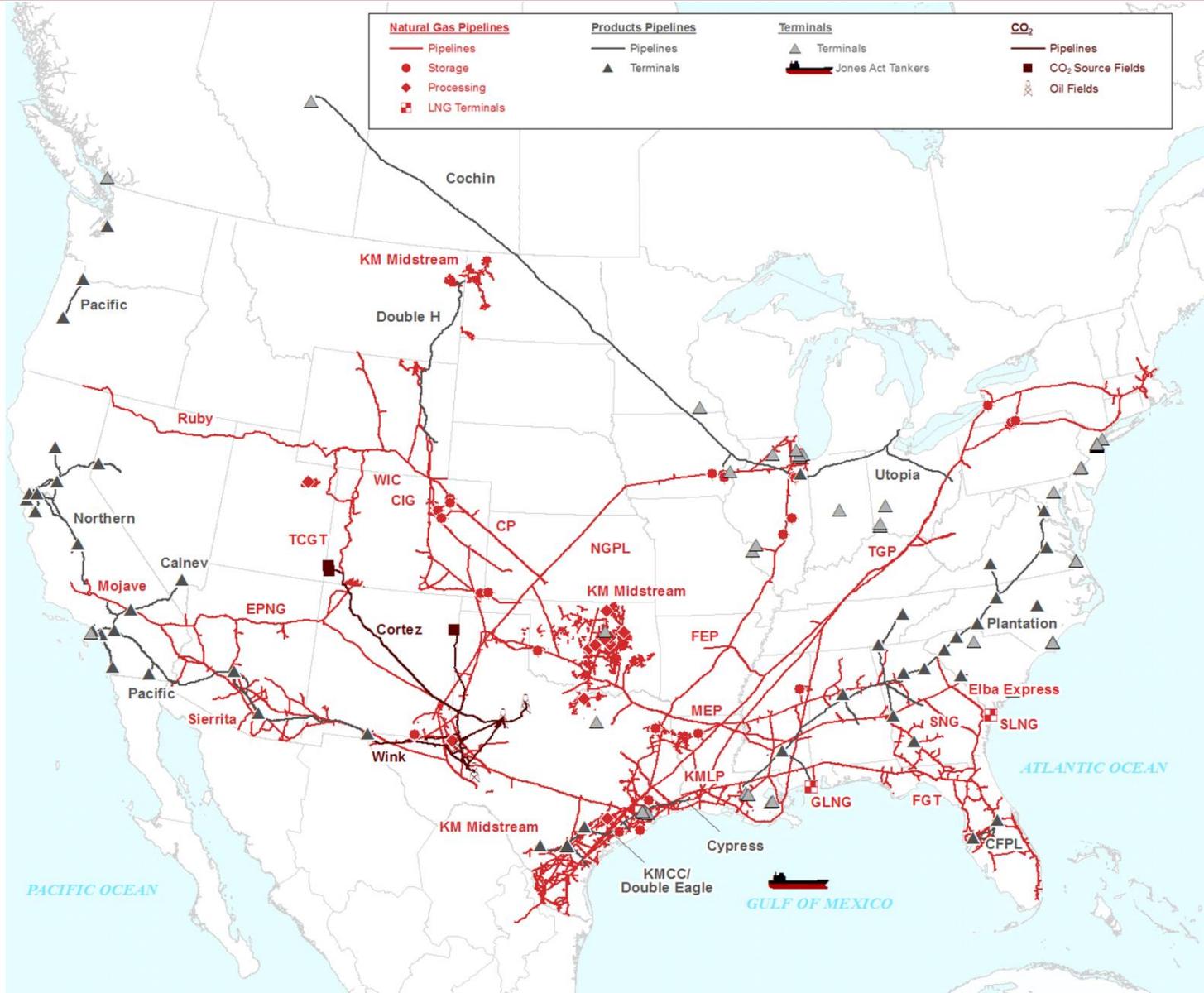
Whole Value Chain Carbon Capture, Utilization and Storage (CCUS)

October 16, 2018

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Kinder Morgan CO₂ Company



Kinder Morgan Assets



U.S. Energy Infrastructure

Pipelines move most of the energy resources we depend on in our daily lives.

Natural Gas

Nearly all natural gas is shipped via pipeline

Natural gas for consumer and industrial customers as well as power generation. 34% of all electricity in America is generated by natural gas.



Petroleum

Pipelines move 70% of petroleum products in the U.S.

Crude oil to refineries, gasoline and diesel fuel for consumers, jet fuel for airports and military bases.



NGL's

Most NGL's are shipped via pipeline

NGL's are used to make plastic, chemicals, fertilizer for agricultural uses, and propane.



CO₂ Segment's Asset Summary

Fully Integrated Asset Base in the Permian

S&T Asset Summary

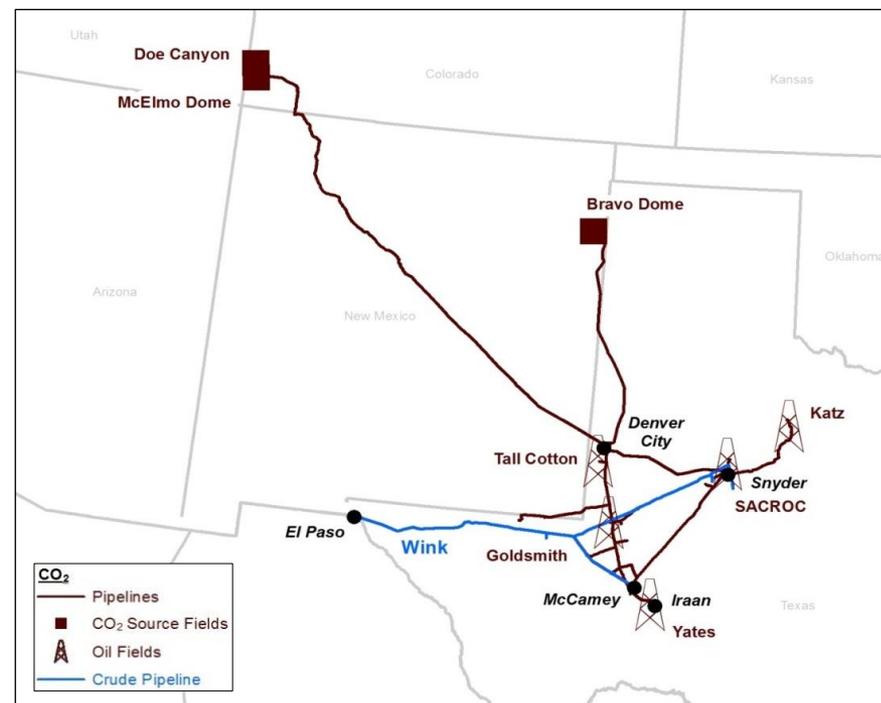
CO ₂ Reserves	KMI Interest	NRI	Location	Remaining Deliverability	OGIP (tcf)
McElmo Dome	45%	37%	SW Colorado	20+ years	22.0
Doe Canyon	87%	68%	SW Colorado	10+ years	3.0
Bravo Dome^(b)	11%	8%	NE New Mexico	10+ years	12.0

Pipelines	KMI Interest	Location	Capacity (mmcfpd)
Cortez	53%	McElmo Dome to Denver City	1,500
Bravo^(b)	13%	Bravo Dome to Denver City	375
Central Basin (CB)	100%	Denver City to McCamey	700
Canyon Reef	98%	McCamey to Snyder	290
Centerline	100%	Denver City to Snyder	300
Pecos	95%	McCamey to Iraan	125
Eastern Shelf	100%	Snyder to Katz	110
Wink (crude)	100%	McCamey to Snyder to El Paso	145 mbbl/d

Oil & Gas Production Asset Summary

Crude Reserves ^(a)	KMI Interest	NRI	Location	OOIP (billion bbls)
SACROC	97%	83%	West Texas	2.8
Yates	50%	44%	West Texas	5.0
Katz	99%	83%	West Texas	0.2
Goldsmith	99%	86%	West Texas	0.5
Tall Cotton	100%	88%	West Texas	0.7

Supplying CO₂ to the Permian, Permian EOR Prod.



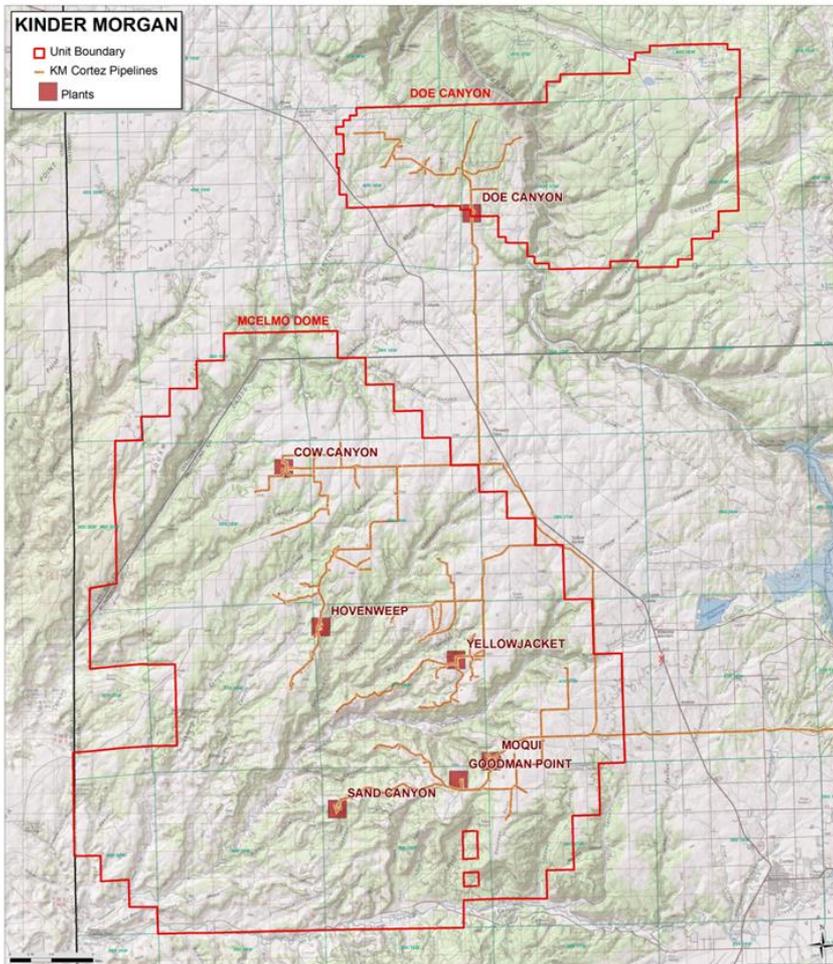
Note: In addition to KMI's interests above, KMI has a 22%, 51%, and 100% working interest in the Snyder gasoline plant, Diamond M gas plant and North Snyder plant, respectively.

(a) Reserve life -4 years based on current independent consultant reserve report.

(b) Not KM-operated.

SOURCE FIELDS – McElmo Dome and Doe Canyon

SW Colorado Source Fields



McElmo Dome

- 22 TCF OGIP
- 203,000 acre unit in Montezuma County, CO
- Majority of the unit is located under the Canyon of the Ancients National Monument
- First Production May 1984
- Production to date – 9.8 TCF
- 2018 Average Daily Production – 1,087 MMCFD

Doe Canyon

- 3 TCF OGIP
- 53,000 acre unit in Dolores County, CO
- First Production January 2008
- Production to date – 503 BCF
- 2018 Average Daily Production – 105 MMCFD

General Performance Characteristics

- Recovery efficiency - 10-15% OOIP
- Incremental oil prod. - 20-30% of cum. production (primary and secondary)
- Net utilization factor – 6-12 mcf/bbl oil
- Gross utilization factor - 10-30 mcf/bbl oil

Reservoir Criteria

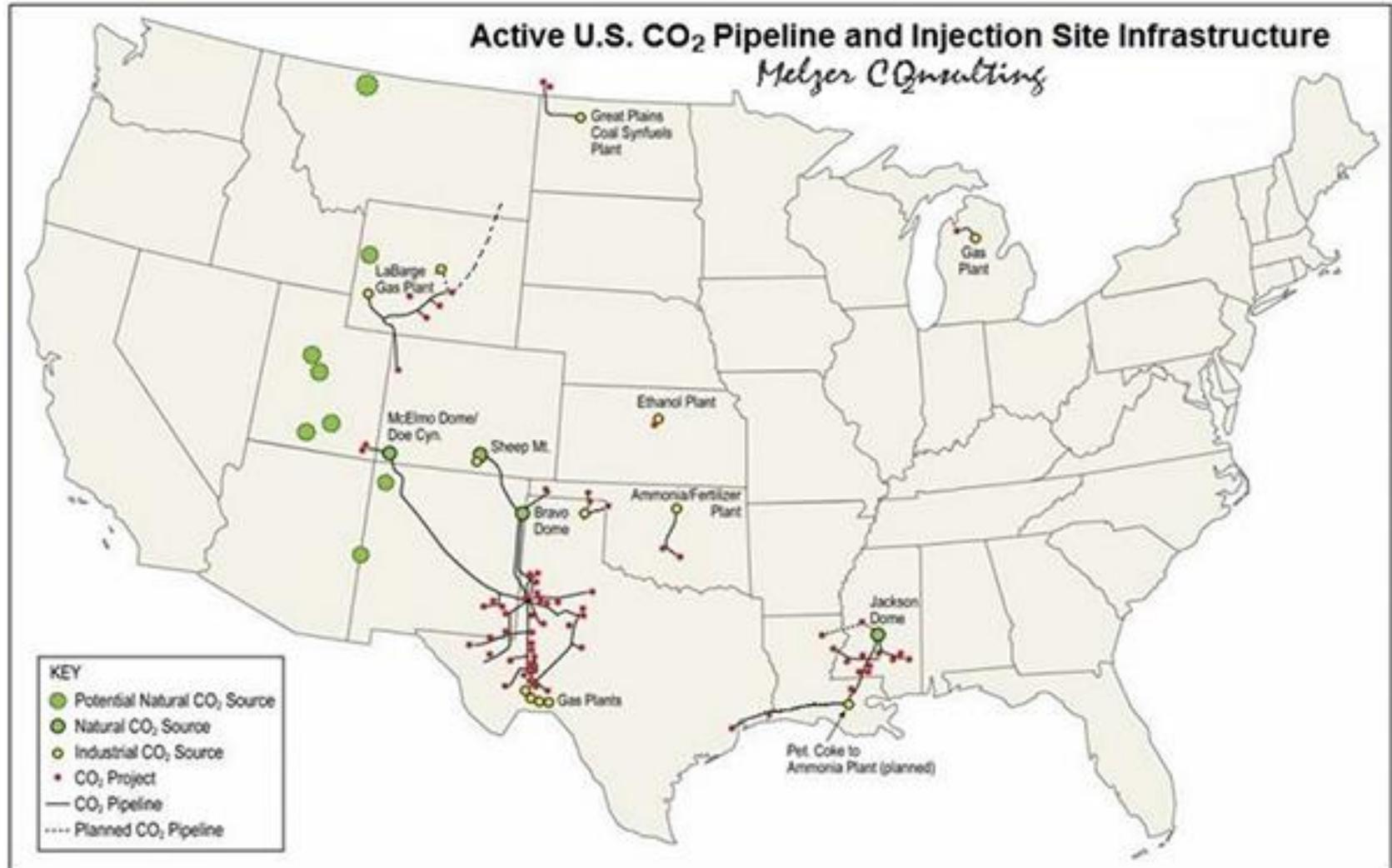
- Reservoir depth - 3000 ft or greater
- Oil gravity (API°) - 25 or greater
- High residual oil saturations
- Favorable water flood characteristics
 - Homogeneous reservoir
 - No fractures or thief zones

CO₂ - EOR The Impact

- Over 300,000 bpd produced in the U.S. due to CO₂-EOR.
- Seemingly small – BUT, equivalent to just over 110 shipments of crude per year from nearby markets. Saving energy in bunker costs and risk of spills as well as benefits of less shipping pollution.
- CO₂-EOR has an important niche in U.S. energy production. However, it requires incremental, readily available CO₂ supplies to grow.

CO₂ Pipeline - Design & Operations

CO₂ Pipelines in the US



- Use same steel metallurgy as Natural Gas Pipelines
 - Keep CO₂ dry
- Higher operating pressures
 - Gas – 600 psig to 1200 psig
 - CO₂ – 2000 to 3000 psig
 - Why? Maintain CO₂ in dense phase (>1300 psig) to allow pumping rather than compression.
- Pumps rather than compression
 - Energy savings
- CO₂ - PHMSA regulated under CFR Part 195, “Transportation of Hazardous Liquids by Pipeline”
- Natural Gas – PHMSA regulated under CFR Part 192, “Transportation of Natural and Other Gas by Pipeline”

CO₂ Pipeline Specifications

Quality specifications for CO₂ pipelines.

- a) Product. Contain at least 95 mole percentage of CO₂.
- b) Water. Contain no free water, and not more than thirty (30) pounds of water per mmcf in the vapor phase.
- c) Hydrogen Sulfide. Contain no more than 20 ppm, by volume, of H₂S.
- d) Total Sulfur. Contain no more than 35 ppm, by weight,
- e) Temperature. Shall not exceed 120°F.
- f) Nitrogen. Contain no more than 4 mole percent.
- g) Hydrocarbons. Contain no more than 5% mole percent and Dew point no more than -20°F.
- h) Oxygen. Contain no more than 10 ppm, by weight, of oxygen.
- i) Other. Contain no liquid glycol or no more than 0.3 gallons of glycol per MMcf.

Why are these specifications important?

- a) Product. Maintain dense phase
- b) Water. Free water causes corrosion and damages pump seals.
- c) Hydrogen Sulfide. Dangerous to health and safety of the public. Special requirements if > 99 ppm in Texas.
- d) Total Sulfur. Foul odor in product
- e) Temperature. Protect pipeline external coating
- f) Nitrogen. Maintain dense phase of product.
- g) Hydrocarbons. Maintain dense phase of product.
- h) Oxygen. Catalyst for other internal corrosion components. H₂S and O₂ form elemental sulfur in EOR piping
- i) Other. Glycol damages pump seals.

CO₂ Pipelines - Design

Engineering/Design

Engineering/Design

- Hydraulics
- CO₂ Quality
- H₂S
- Outside Diameter
- Wall Thickness
 - Barlow's Formula
 - Standard/Heavy Wall
- Ductile Fracture Analysis
 - Theoretical Charpy Numbers
 - Crack Arrestors
 - Operating Company risk tolerance
 - Design pipeline system in order to not add fracture arrestors
 - Wall thickness changes (crossings) to act like fracture arrestors

Lot Purchases from Vendor

- Review MTR's in detail before purchase
 - High Grade/High Strength
 - Approved Vendors/mills



CO₂ Pipelines-Pipe

Engineering/Design/Specification

Reference

- API Specification 5L; “Specification for Line Pipe” (45th Ed). PSL 2 Product Specification Level

Pipe Manufacturing Process and Grade:

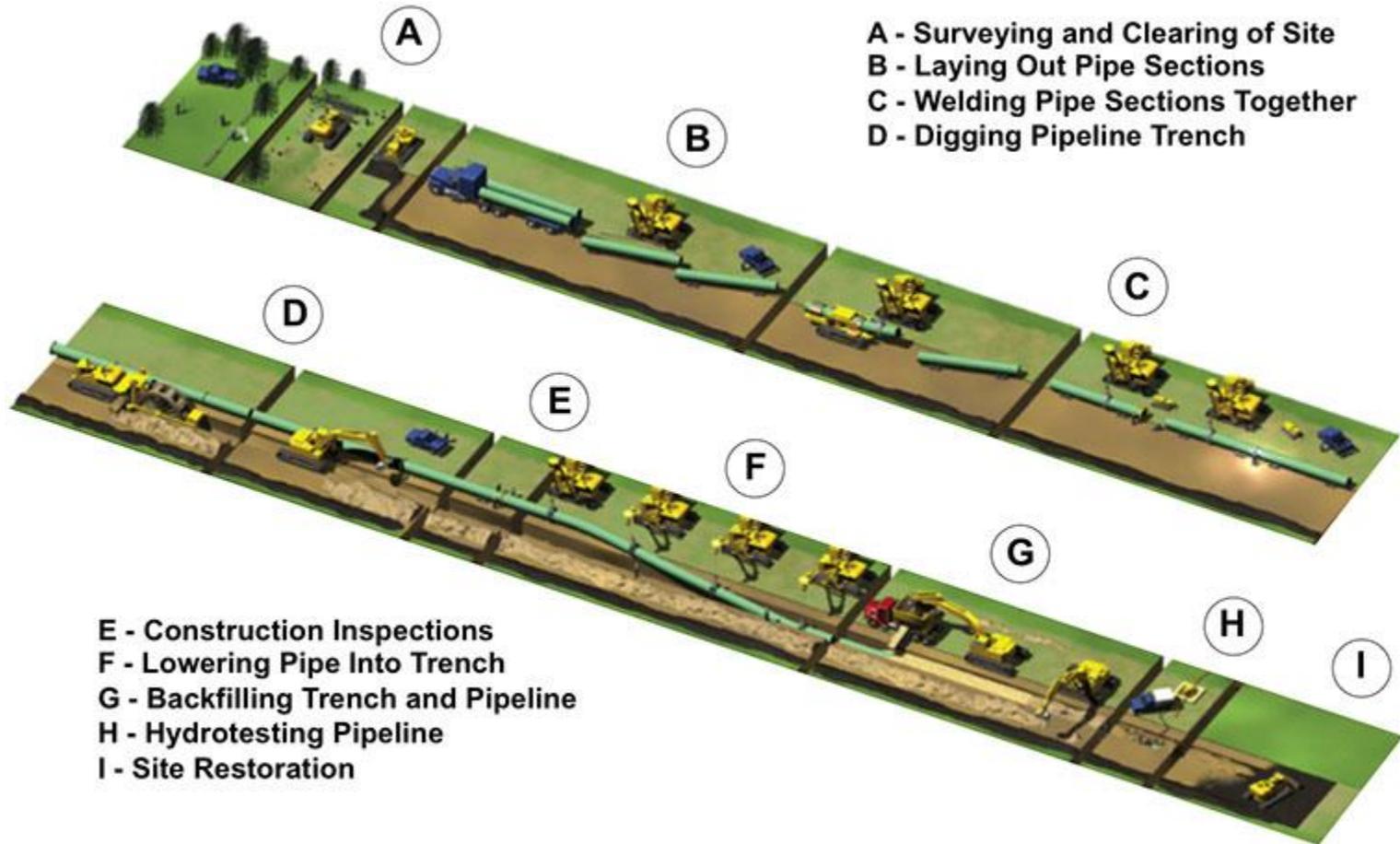
- Pipe Manufacturing Process and Grade:
 - High Frequency Electric Welded (**HFW**)
 - Electric Resistance Welding (**ERW**)
 - Double Submerged Arc Welding (**DSAW**) / Longitudinally submerged arc-welded pipes (**LSAW**)
 - **NO HSAW**
 - Preferred Grade: X65 or X70



CO₂ Pipelines-Coating

- Fusion Bonded Epoxy (FBE):
 - Standard Pipe
- FBE+ Abrasive Resistant Overlay (ARO)
 - Crossings (heavy Wall)
 - HDD/RRC/Highways/Roads/Water
- Powder Manufactures:
 - Valspar
 - Dupont
 - 3M

Pipeline Construction Sequence



CO₂ Pipelines - Regulations

- Regulated by Department of Transportation, Pipeline Hazardous Materials Safety Administration
- CO₂ Pipelines are regulated under 49 CFR Part 195 - Transportation of Hazardous Liquids by Pipeline
- Governs materials, design, construction, operations, and maintenance
- State Agencies may have additional regulations
- Regulations are specific/prescriptive or performance based
- Operations and Maintenance Manual
 - Operator interpretation and implementation of code
 - Provides uniform standard
 - Auditable procedures
 - Must follow plans and procedures as outlined in O&M Manual
 - Operators must comply with minimum standards from code or state
- Records prove compliance – types of records
 - Life of facility (includes construction, materials, repairs, testing, and MOP information)
 - Transient (includes tests, inspections, patrols, and surveys)
 - No records = did not do the work
- Pipeline Safety Management System – API RP 1173

Operations:

- ANSI 900/1,500 Pipeline System
- Minimum CO₂ Pressure: 1,300 psig
- Maximum Operating Pressure (MOP) varies per hydraulics/terrain
 - Typical: 2,160 psig / 2,220 psi
 - As high as 3,000+ psig
- Measurement – Orifice Measurement
- Cathodic Protection
 - Typical: Impressed Current System
- Remote Controlled by SCADA
- Pipeline Integrity Program
 - “Piggable”-Pigging program per CFR 195 and Kinder Morgan O&M
 - Anomaly Digs Per CFR 195 & O&M
- One Call Program
 - 811 Call Before You Dig Program



**Know what's below.
Call before you dig.**

CO₂ Pipelines – Operations

SCADA: Operational Control

Cortez, Colorado Control Center



System Control

- 24 hour monitoring and control of Pipeline Facilities
- Monitor pressures and flow at key points on the system
- Receive key alarms from field locations and callout employees in response
- Provides full remote control to:
 - Start/stop Pump Stations
 - Flow control of meter facilities to customers
 - Shut-down and closure of valves during normal operations and in an emergency

Kinder Morgan CO₂ Pipeline System

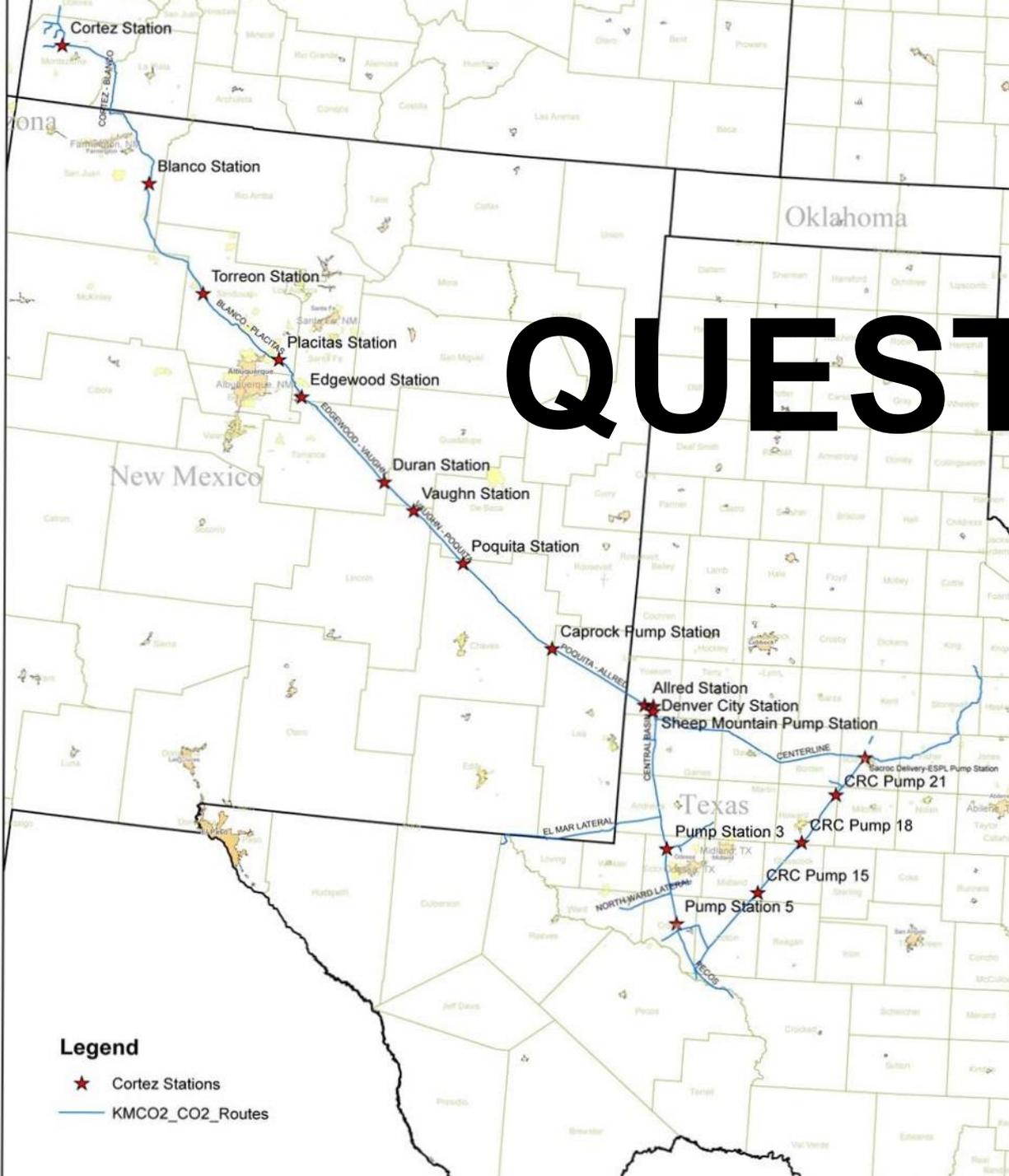
CO₂ Pipeline System



Pipeline Details

Name	Length (miles)	Diameter	Year Built
CRC PL	138	16"	1975
Cortez PL	502	30"	1984
Central Basin PL	143	26", 24", 20", & 16"	1985
Pecos PL	25	8"	1985
Centerline PL	112	16"	2002
Cogdell PL	4	10"	2003
Eastern Shelf PL	91	10"	2010
Total	1,298	4" to 30"	

QUESTIONS?



Legend

- ★ Cortez Stations
- KMC02_CO2_Routes