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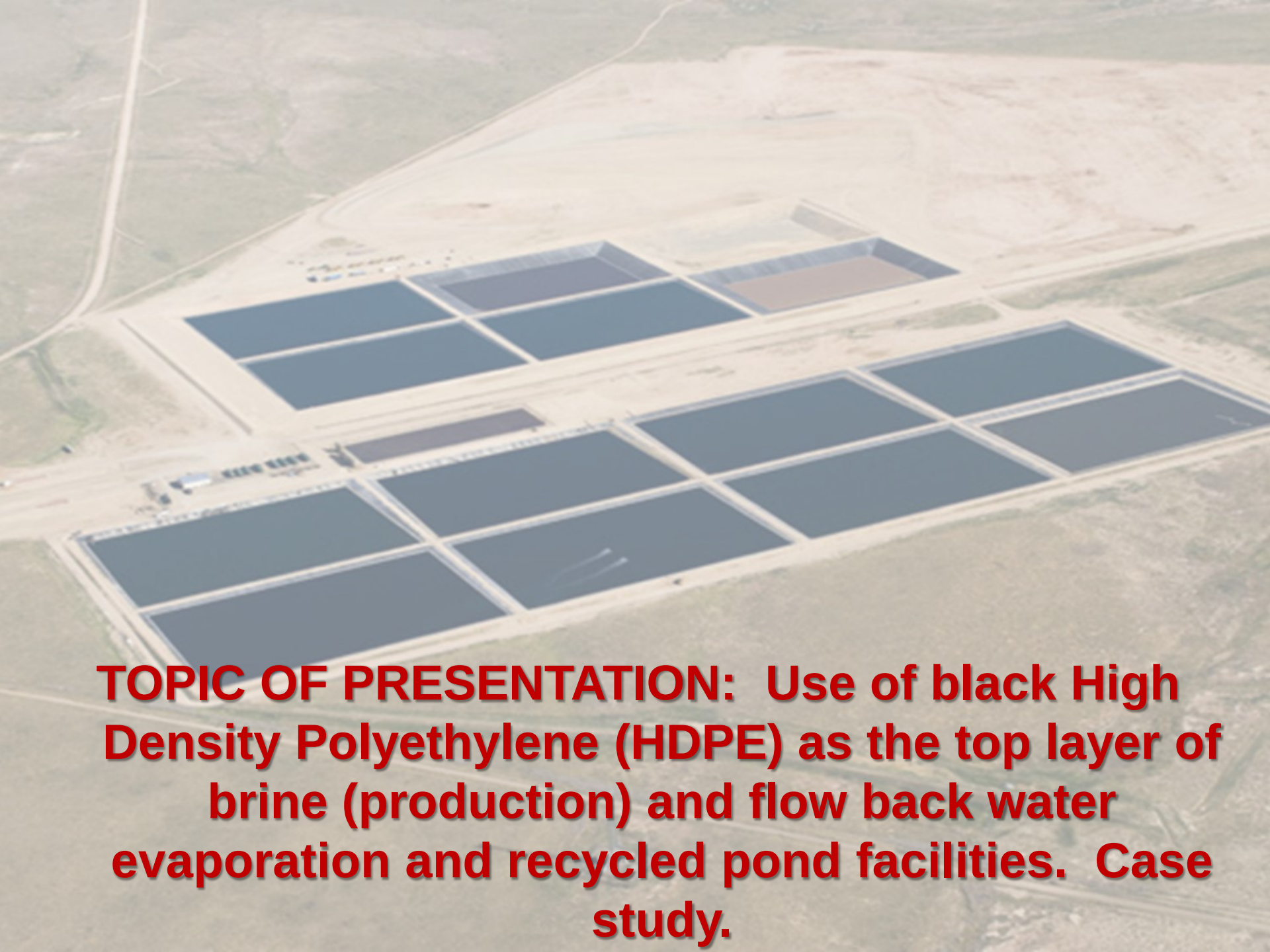
October 7-9 | San Antonio, Texas

High Density Polyethylene (HDPE) Lined Produced/Frac Flowback Water Recycled and Evaporation Ponds

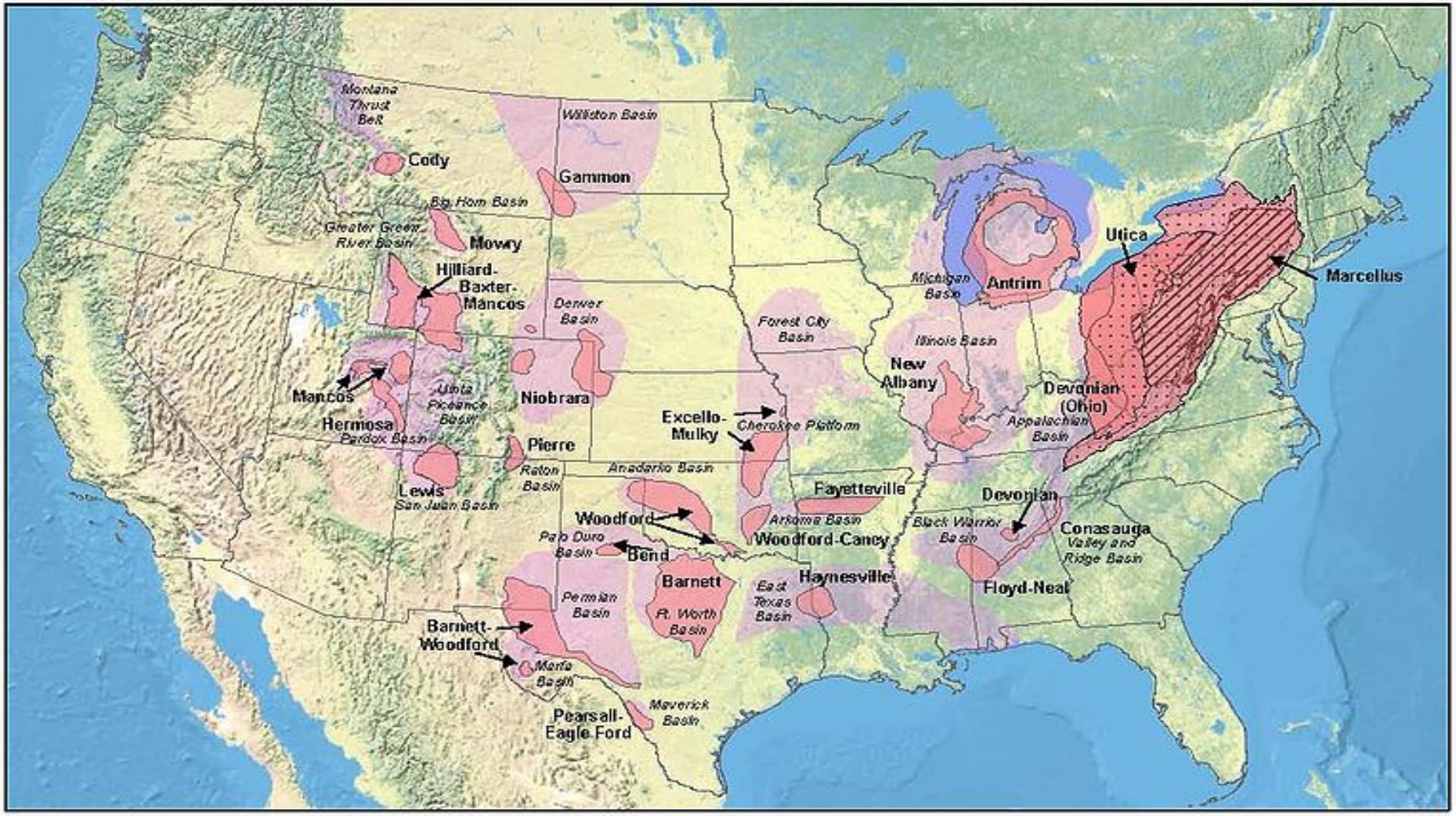
SCS ENGINEERS



TOPIC OF PRESENTATION: Use of black High Density Polyethylene (HDPE) as the top layer of brine (production) and flow back water evaporation and recycled pond facilities. Case study.

PURPOSE:

- Dispose of or recycle production water and flow back water generated from oil and gas development.
- Several **million** barrels of production water and flow back water are generated each year in many states.
- Varies from 1/2 to 8 bbls of water produced per barrel of oil (depends on formation).
- Other types of evaporation and disposal facilities exist.



United States Shale Gas Plays

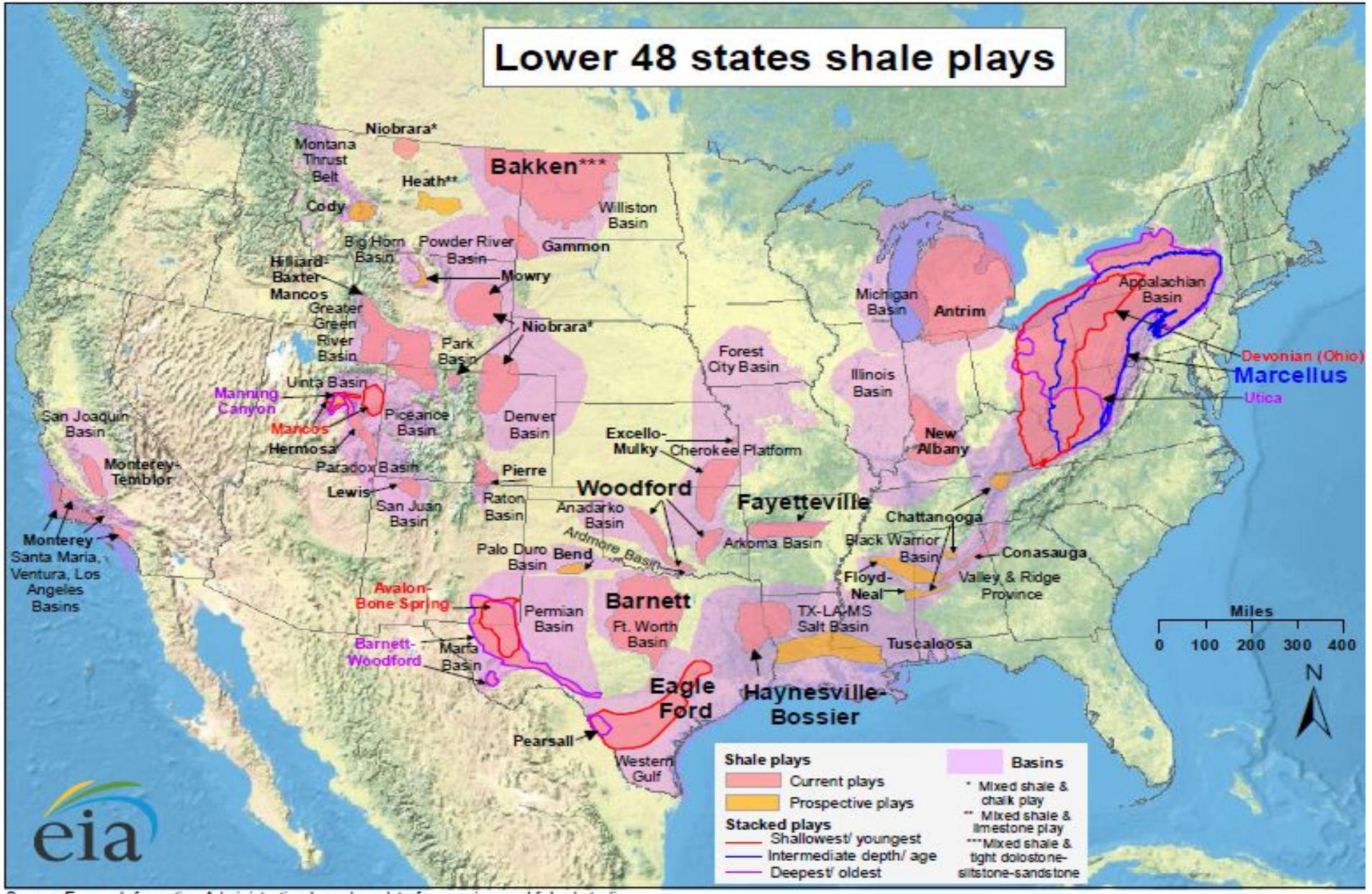
www.eia.doe.gov
Energy Information Administration
Office of Oil and Gas

Shale Gas Plays
Basins

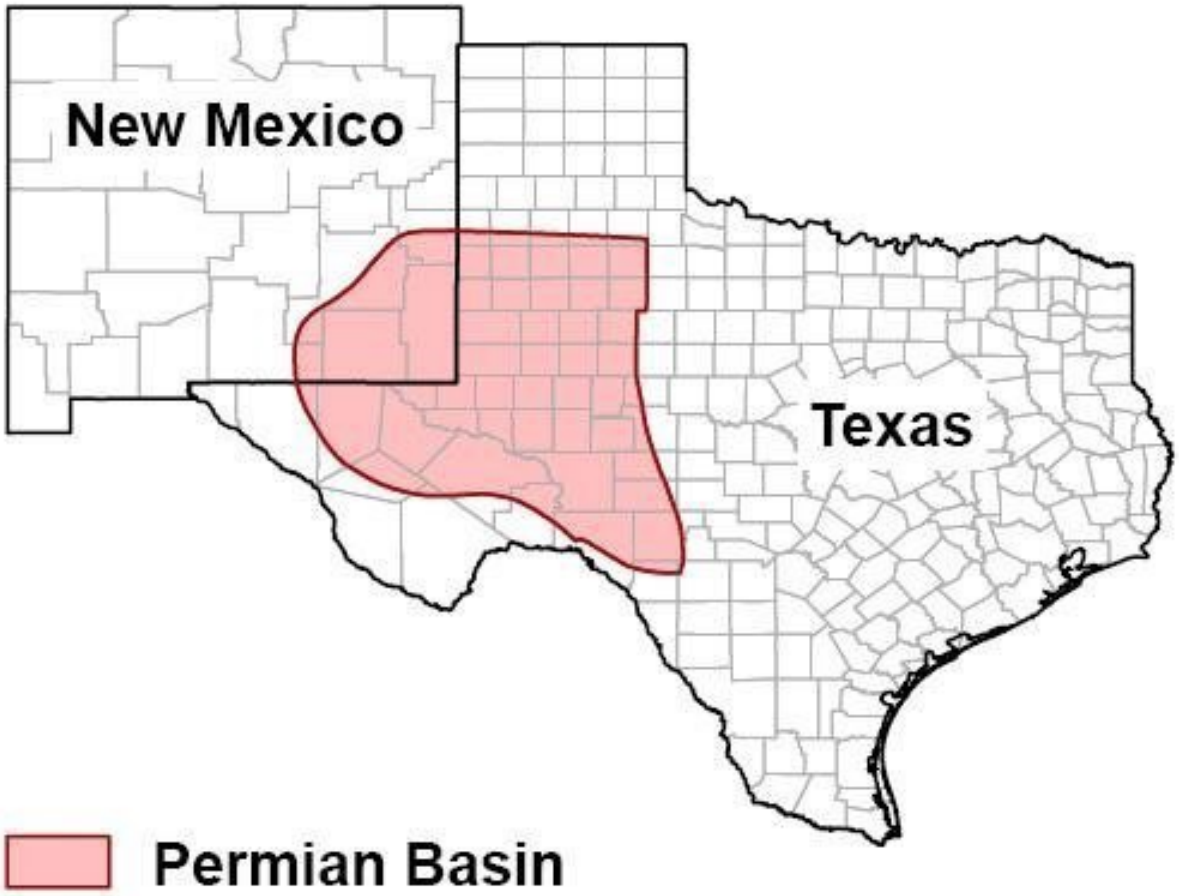
Stacked Appalachian Plays
Marcellus
Utica
Devonian (OH shale)

November 2008
Miles
0 150 300 600

N

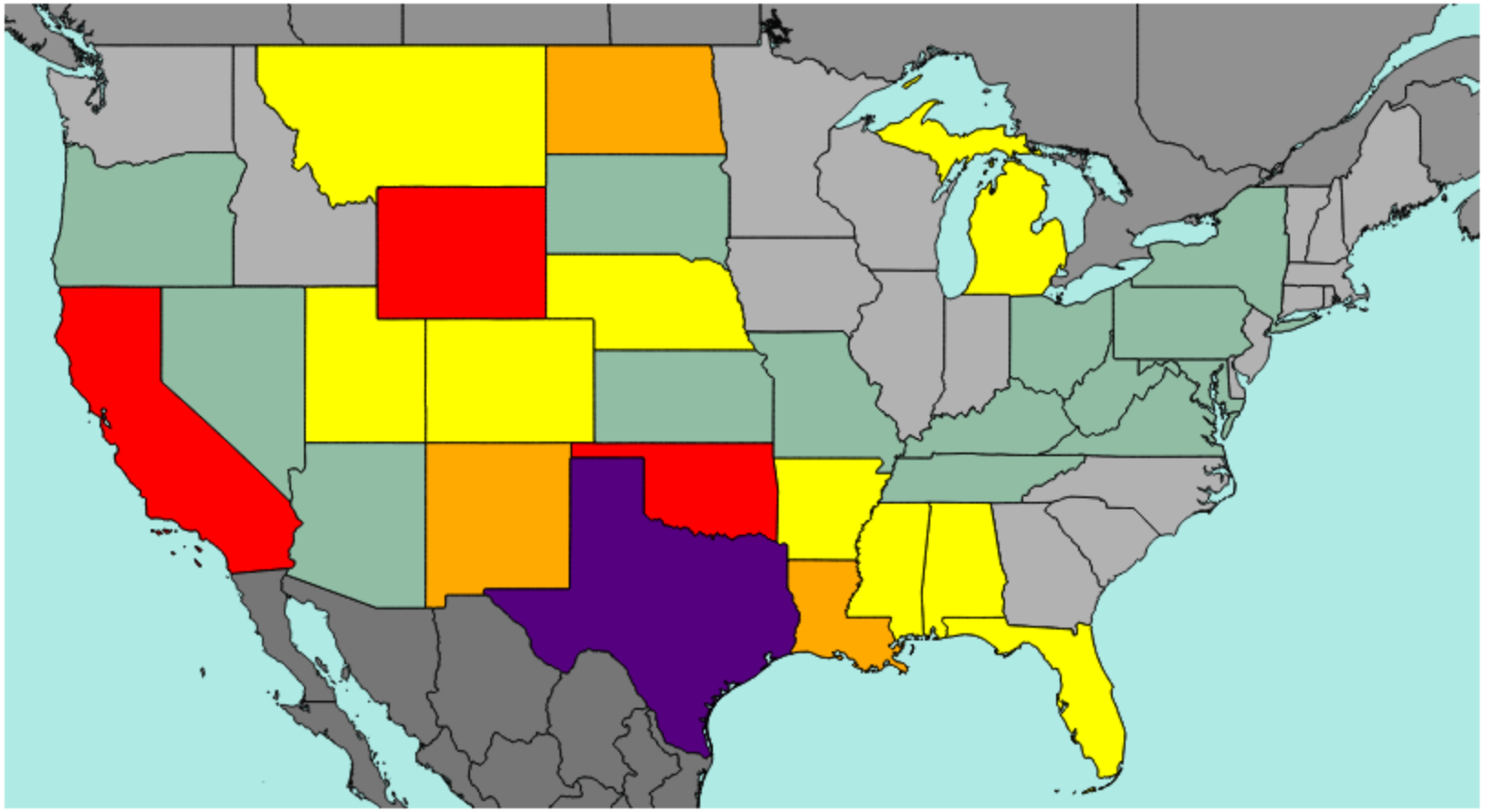


Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011


New Mexico
Texas
Permian Basin

BTU Analytics

Produced Water by State



> 18 MM bbls/d
5-10 MM bbls/d
1-5 MM bbls/d
0.1- 1.0 MM bbls/d
0-0.1 MM bbls/d
No Production

Oct. 2014

Source: BTU Analytics, Drilling Info

Produced Water

Generated per Barrel of Oil Equivalent (BOE)

Source: Digital H_2O, EIA

PRODUCED WATER

WHAT THE INDUSTRY IS SAYING

4B BBLS

2019 flows in the Permian Basin are enough to fill the Astrodome 535 times

Produced Water

IN 4 YEARS

Increased production in the Permian means double the water flow

Projected PW Flow

2X

PIPELINE

High costs associated with pipelines creates even more challenges

Cost per Mile

>30K

REGULATIONS

Changes in regulations for SWDs will negatively impact new well drilling

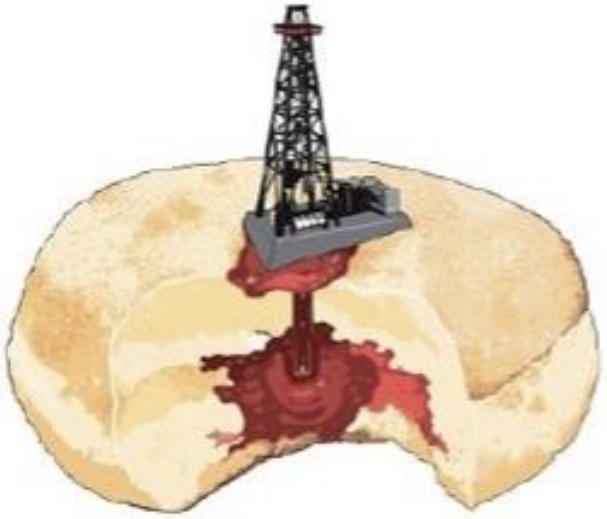
SWD Permitting

RECYCLE, REUSE, REPEAT!

Old Way of Drilling

Jelly Donut

Conventional Drilling
Basic Vertical Penetration
Limited Formation Contact



JELLY DONUT

Petroleum is like a jelly blob in the ground that flows out like using a straw

New Way of Drilling

Tiramisu

Unconventional Drilling
More Sophisticated Horizontal Penetration
Extensive Formation Contact

TIRAMISU

Natural gas is like cocoa powder between layers of rock, which is much harder to extract

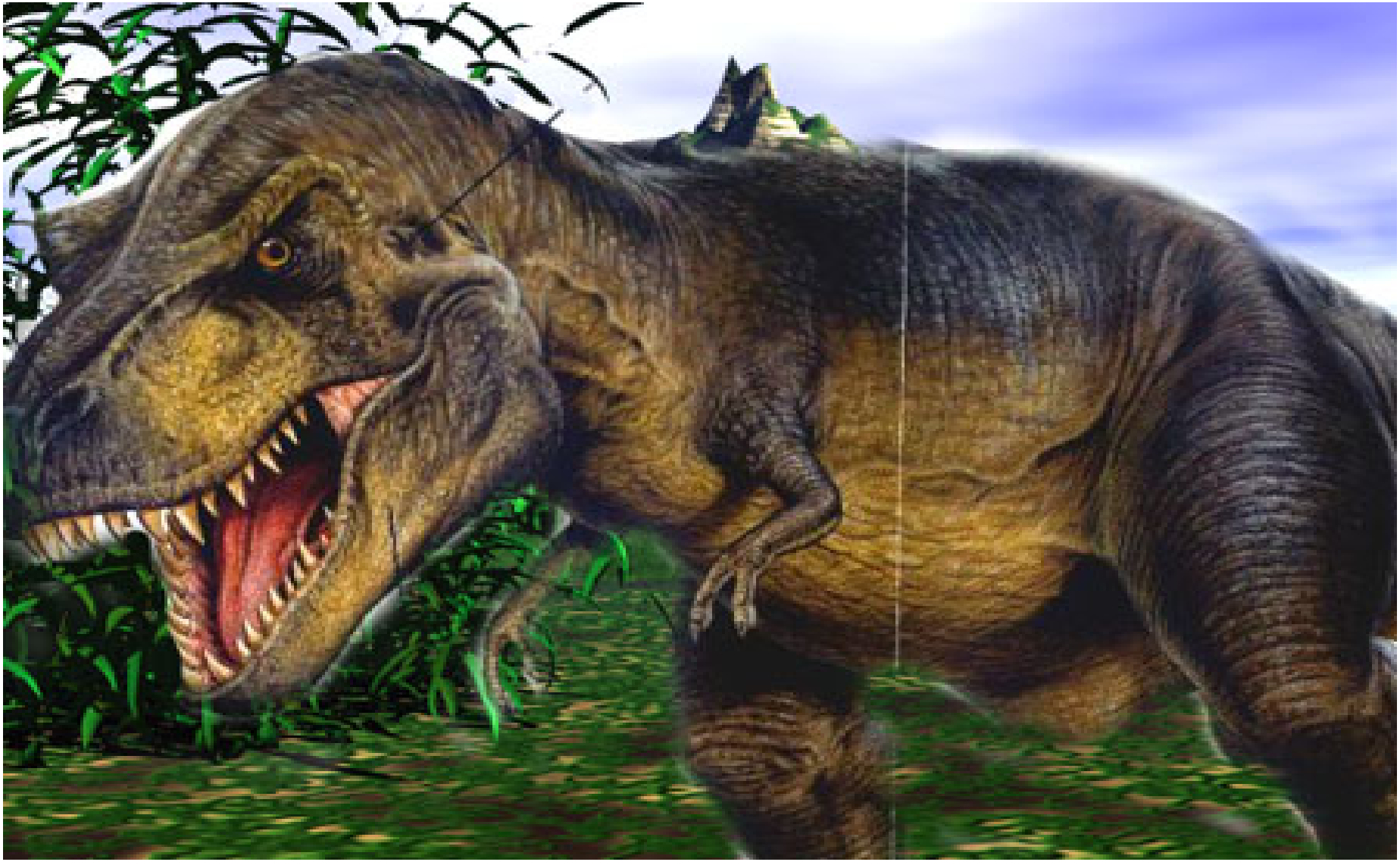
ENERGY STRONG

SELECTION OF TECHNOLOGY:

Technologies for managing production and flow back water:

- Disposal injection into acceptable zone
- Recycle/reuse
- “Frac” injection of the water into the production formation to enhance yield
- Treatment for surface discharge
- **Evaporation**

HDPE Lined Evaporation and Storage Ponds Not Extinct Yet?



DESIGN…WHY HDPE?:

60-mil thick HDPE for top liner of ponds not buried.

- Ultraviolet (UV) degradation resistance.
- Durability (20 plus years, *Ivy 2002*); ***Koerner 2016 stated 90 plus years (next slide).***
- Chemical resistance.
- Black color enhances evaporation of water.
- HDPE was chosen over clay liner and other geomembranes due to being the most compatible with site conditions and regulations (i.e. exposed to sunlight, desiccation, and hydrocarbons).
- Textured surface used to aid with traction if operations personnel fall into ponds, and to increase slope friction and stability.

RESULTS OF FIVE GEOMEMBRANE FIELD HALFLIFE PREDICTIONS IN PHOENIX, ARIZONA COMPARED TO PREVIOUS LABORATORY PREDICTIONS AT 20°C

Geomembranes (Various Resins)	**Thickness (mm)**	**Laboratory Predicted Half-life in Years**		**Phoenix, Arizona Predicted Half-life in Years**	
		Strength	Elongation	Strength	Elongation
HDPE (60-mil)	**1.5**	**76**	**69**	**97**	**91**
LLDPE	1.0	49	46	66	63
fPP	1.0	50	41	59	54
EPDM	1.0	60	70	74	56
PVC (Euro.)	2.5	54	54	72	55

From Geo-Americas April 2016, Lifetime Predictions of Exposed Geotextiles and Geomembranes by Bob Koerner, Grace Hsuan and George Koerner at Geosynthetic Institute/Drexel University.

High Density Polyethylene (HDPE) designed as the primary or top layer of the lined ponds in order to protect the groundwater and to enhance the evaporation of the production water within the ponds.

Geomembrane panels are welded together throughout the installation performed by trained and certified technicians.

Geomembrane panels are tested for strength throughout the installation performed by trained and certified technicians.

Ponds designed and constructed with one or two geomembranes over compacted clay or geosynthetic clay liner and a geonet leak layer in between to monitor the primary liner for leaks.

CONSTRUCTION

Ponds designed and constructed with two geomembranes over compacted clay or geosynthetic clay liner and a geonet and flat pipe leak layer in between to monitor the primary liner for leaks.

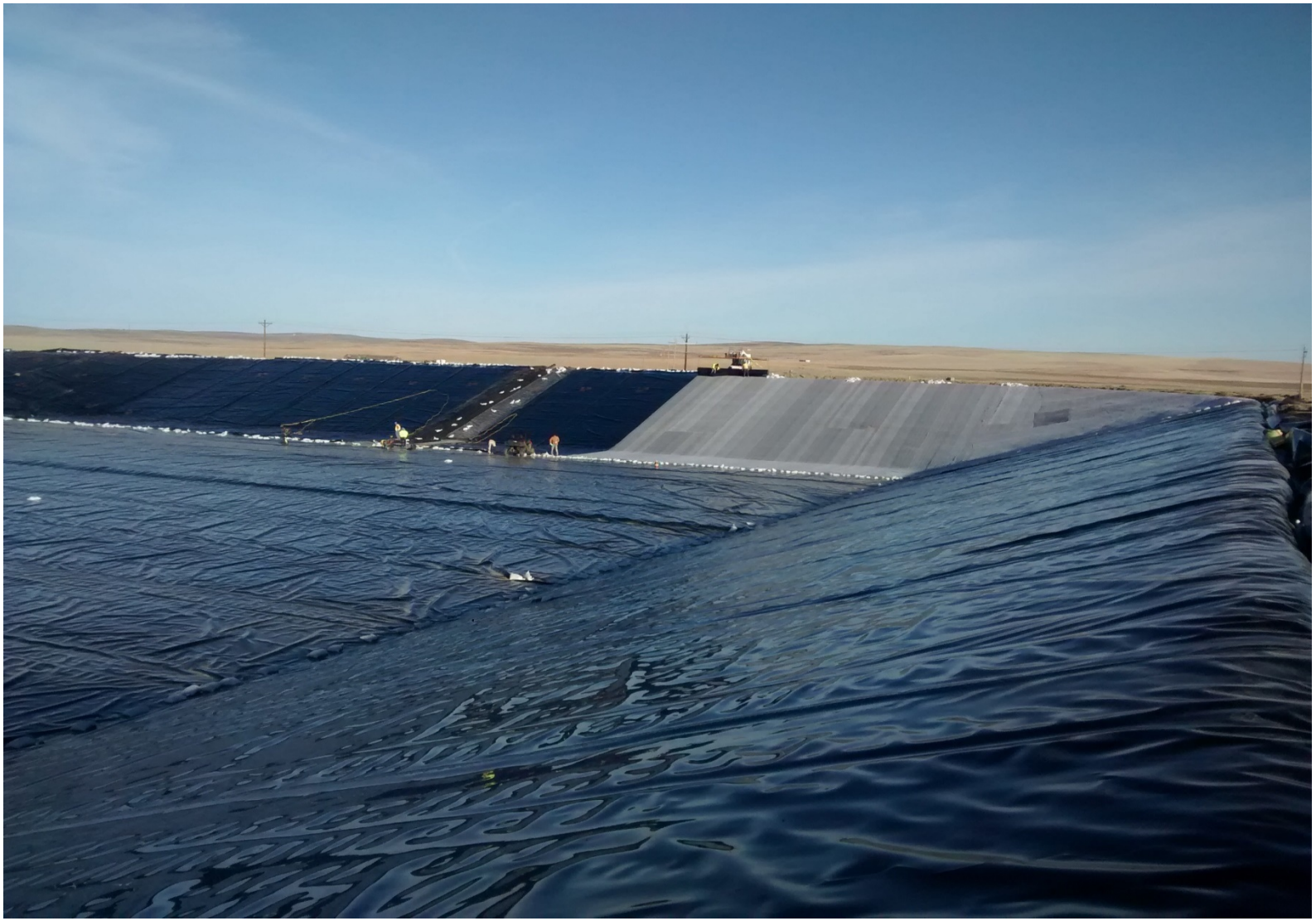
Permian Basin Recycled Water Ponds.

Danish Flats Utah, 14 ponds at 5 acres each, 70 acres of lined ponds and capacity = 6.5 million barrels.

Southern Cross with five ponds at 5 acres each and capacity = 2 million barrels operational (2014), including enhanced evaporation sprayers.

Silo Field under construction (2010) 3 ponds at 5 acres each.

Wright Facility under construction 2016, includes GCL, and double geomembrane with leak layer in between.



Bluegrass Water Wright, WY - ponds at 9 acres area and 1 million barrels capacity each, including enhanced evaporation sprayers. Currently Ponds #1 thru #6 operational = 6 million barrels total capacity.

Production water delivered to the sites via tanker trucks for disposal by evaporation

Truck receiving area/off-loading via hose and pipeline to initial phase separation in gun-barrel tanks.

At Danish Flats, off-gases from acceptance pits and gun barrel tanks are routed to a control device, which includes a thermal oxidizer and scrubber.

From gun-barrel tanks the water goes to

HDPE lined settlement/sludge pond

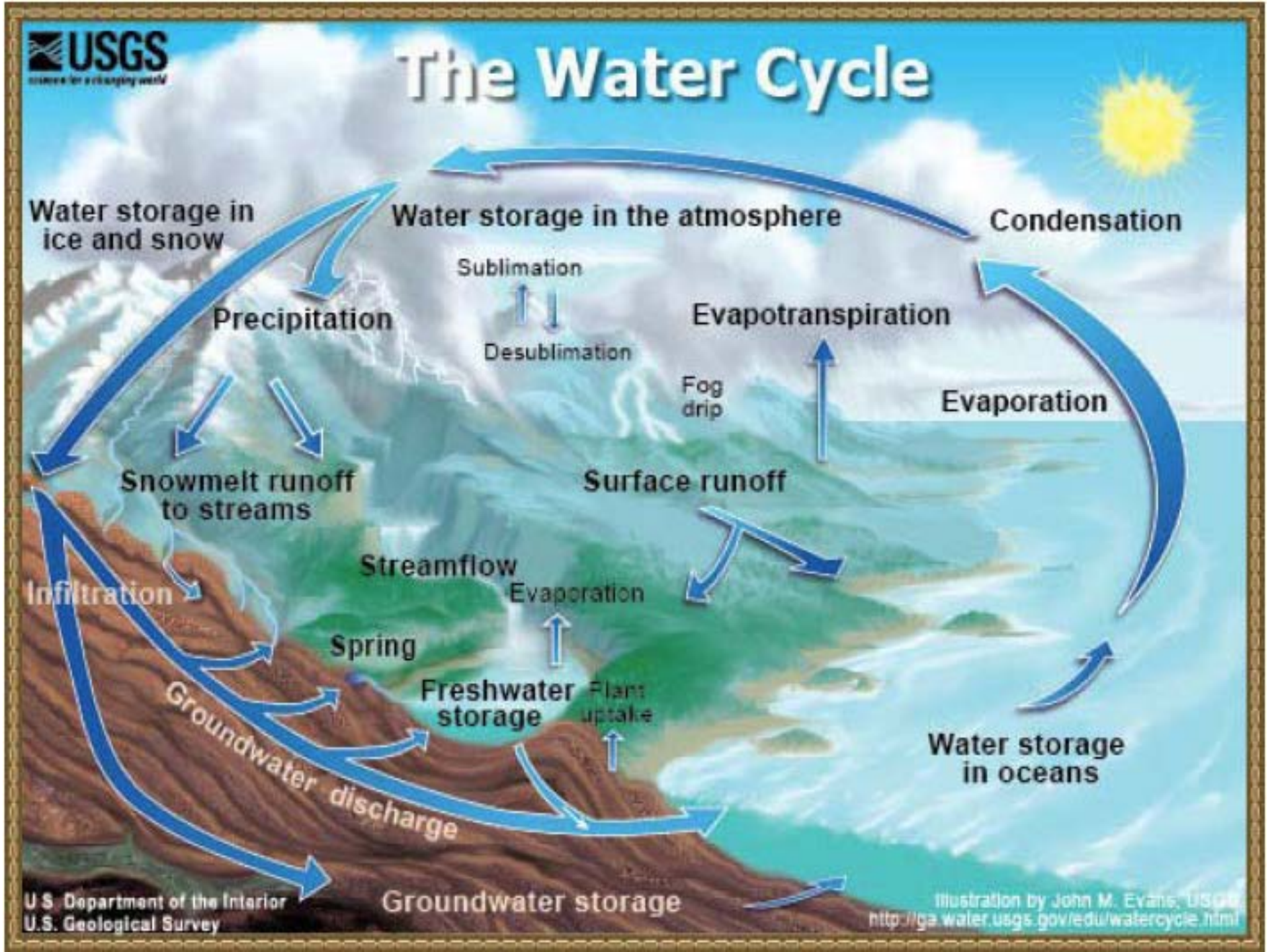
Last stage of hydrocarbon removal and collection that requires bird-netting to cover the water, which will likely have floating hydrocarbon.

These sludge ponds also are emission sources for volatile organic compounds (VOCs) if the floating product is not removed promptly.

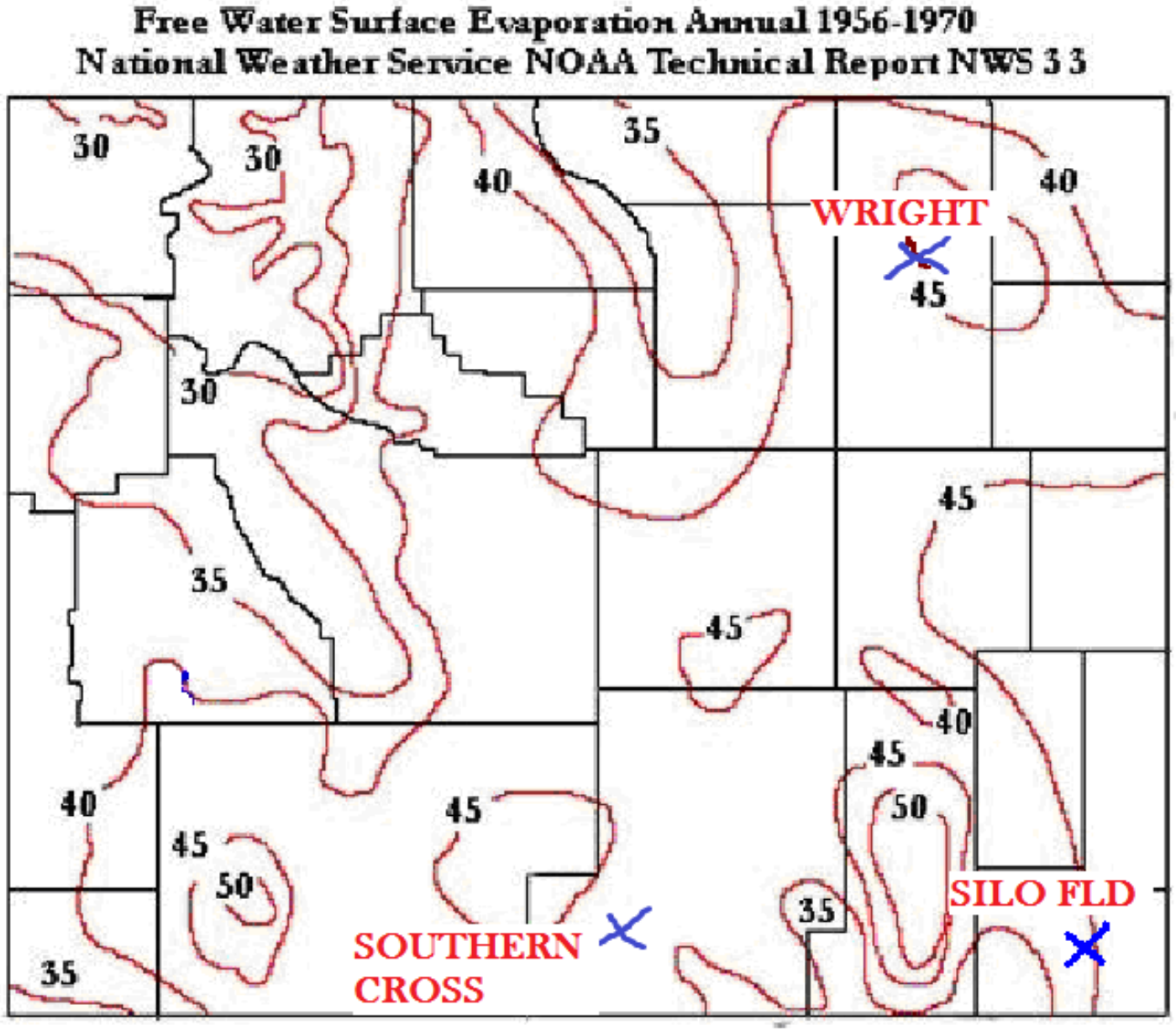
The water is fed by gravity or force main pipe to the evaporation ponds from the settlement/sludge pond or directly from the oil/water separation equipment.

EVAPORATION:

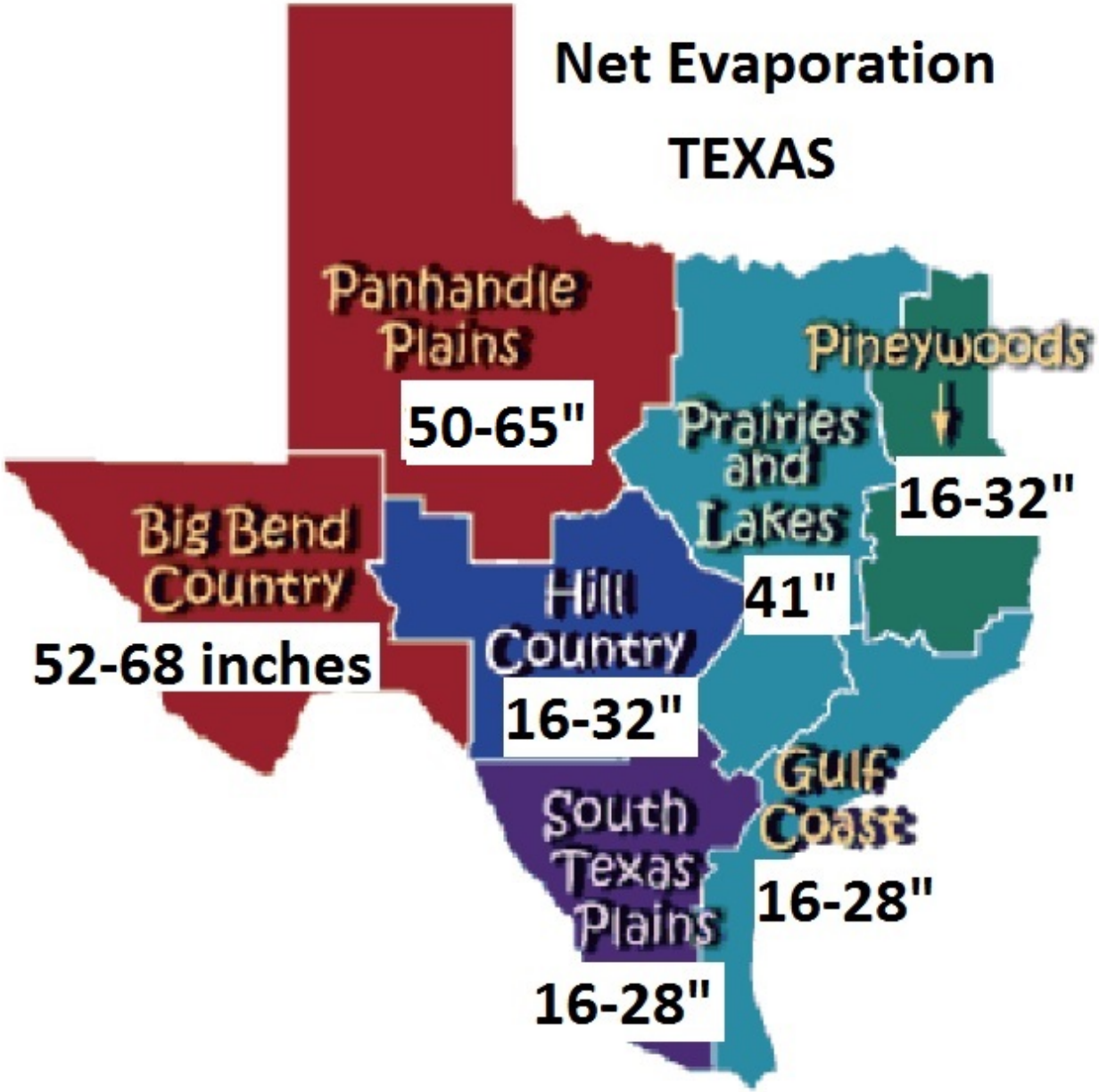
- Ponds designed to store and evaporate production and flow back water.
- Top layer of the pond liner is textured surface 60-mil HDPE.
- Climate at these sites is ideal in the semi-arid mountain west for evaporation during May through October.
- HDPE liner aided evaporation due to black color of surface.
- Water quality = 10,000 to 70,000 ppm TDS, mostly in the 30,000 ppm range.


USGS
The Water Cycle
Water storage in ice and snow
Water storage in the atmosphere
Condensation
Sublimation
Desublimation
Precipitation
Evapotranspiration
Fog drip
Evaporation
Snowmelt runoff to streams
Surface runoff
Streamflow
Infiltration
Evaporation
Spring
Freshwater storage
Plant uptake
Groundwater discharge
Water storage in oceans
Groundwater storage
U.S. Department of the Interior
U.S. Geological Survey
Illustration by John M. Evans, USGS
http://ga.water.usgs.gov/edu/watercycle.html

EVAPORATION:



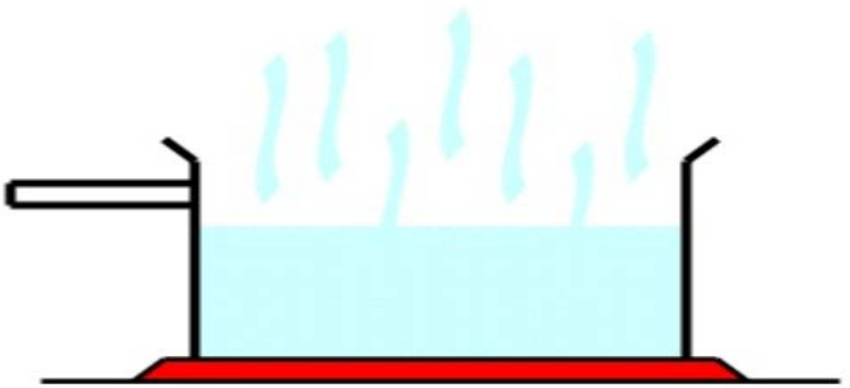
Net Evaporation - TEXAS



EVAPORATION:

- Annual design net evaporation rates estimated to be approximately:

Danish Flats = 50 inches
Southern Cross = 40 inches
Silo Field = 45 inches
Wright = 45 inches



- Danish Flats = actual annual evaporation encountered during 2008 was nearly 70 inches (an increase of nearly 30%); in 2009 and 2010 was nearly 60 inches (increase ~17%); and for 2012 was measured at 42 inches for only the period May through August.

- At Southern Cross in 2010 was approx. 55 inches (increase ~28%).

- At Silo Field was approximately 52 inches inches per year in 2014.

- At Wright was approximately = 30 inches in July 2017, including evaporation equipment.

Evaporation is enhanced using the surface of the HDPE geomembrane.

Evaporation is enhanced using atomizers that spray fine mist above the water…~5,000 bbls/day evaporated (depending).

Ideal conditions for evaporation occurs when:

- The air temperature is above 80 degrees Fahrenheit and sunny,
- Low humidity,
- The wind blows, and
- The level of water in a pond is not greater than 3 feet deep.

MAINTENANCE:

- After several years of operation (possibly 8 to 10 years), the “salt” from the production or brine water builds up as precipitate in the pond bottoms.

- Upon excessive build-up of sediments or upon closure, then all the water is evaporated and the sediments dried and either removed or the facility buried (closure).

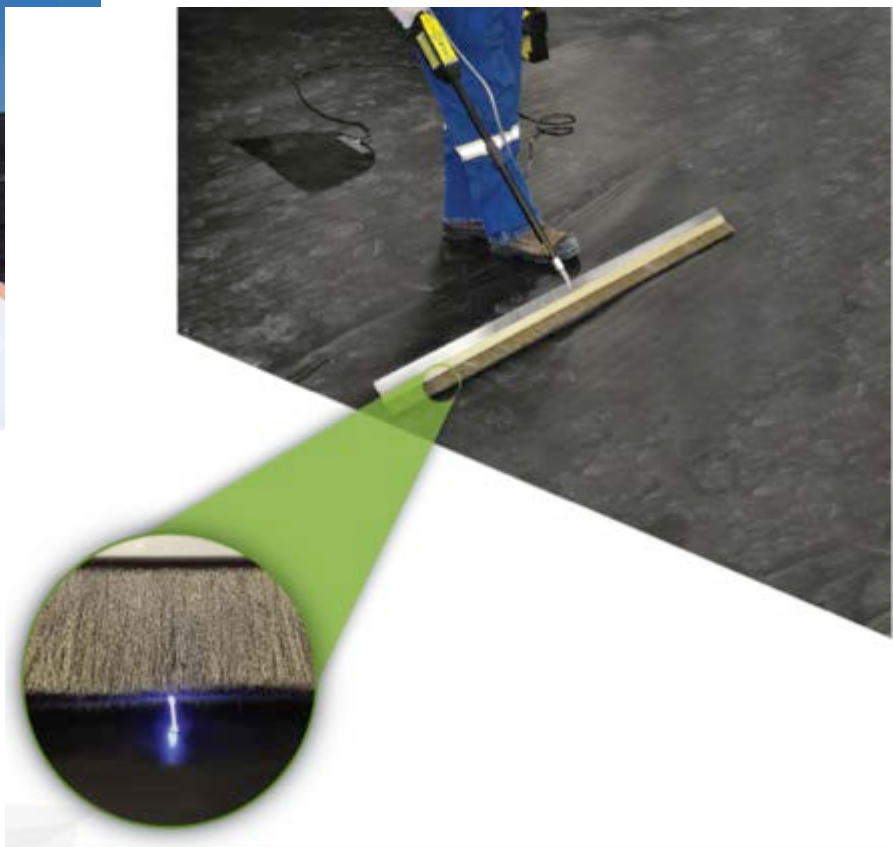
Wyoming - Sediments in pond bottoms after removal of water for liner repairs; pond operational 7 years. Water was 13,000 ppm to 66,000 ppm TDS.

Sediments removed by hand using shovels and power washer, then wheel barrow the sediments to the top of the pond. Load the dried sediments in waste trucks for disposal at oilfield waste landfills.

Liner can be “white” color instead of black in order to reduce evaporation. Also, reduces wrinkles due to less deformation due to heat/cold effects.

Ponds can be covered with a floating cover to minimize evaporation.

Liner can be conductive HDPE with white or black finish. Holes are found with wand.



Permian ponds from the air.

CONCLUSIONS:

- Evaporation and recycled facilities are serving a need of the region and the oil/gas industry.
- Evaporation of production/flow back water is a low cost method for disposal.
- Recycled water ponds saves fresh water usage.
- HDPE as the top layer is the right choice due to proven durability and resistance to UV and chemical degradation.
- HDPE improves the evaporative ability of the ponds with the black color of the liner.
- Ponds can be covered or liner can be white to reduce evaporation.


ELECTRIC VEHICLE CHARGING STATION
RUNNING ON DIESEL
ENERGY STRONG

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Questions are welcomed.
Thank you for your interest.

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