Risks Related to Water and Wastewater for an Oil and Gas Company

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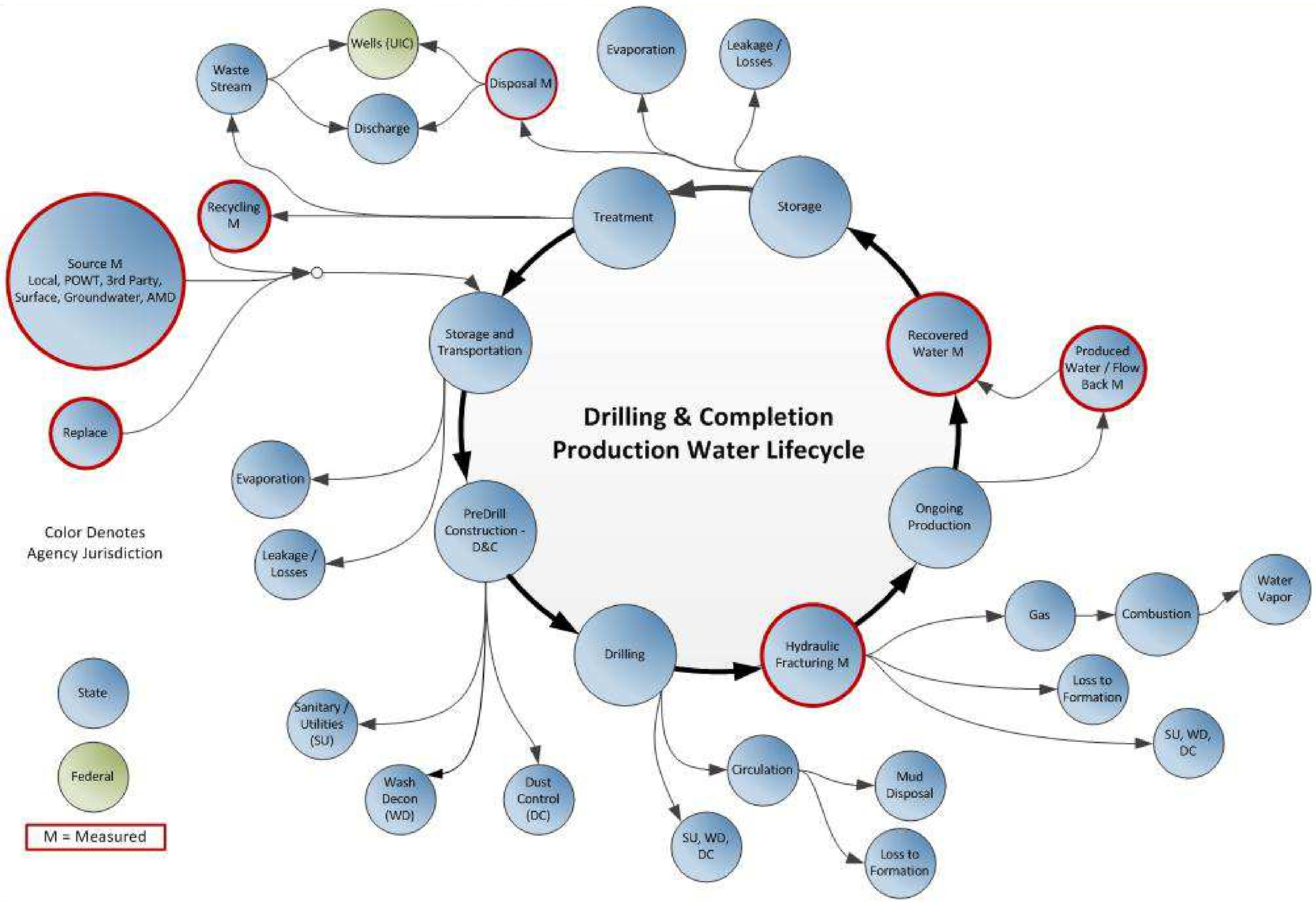
Topics for Discussion

- The water life cycle in oil and gas production
- Types of risks related to water
- Considerations for different stages of the water life cycle
- Volume of produced water generated and how is it managed
- Potential environmental impacts caused by produced water
- Evaluation of potential for impacts (risk assessment)
- Review of relevant water regulations

Imagine the Risk from Living Here

The Water Life Cycle in the Oil and Gas Industry

Water Lifecycle for Unconventional Oil & Gas



Source: Energy Water Initiative

Simplified List of Water Management Considerations

- Water
  - Source
  - Storage
  - Transportation
  - Water demands

- Wastewater
  - Volume
  - Characteristics
  - Storage
  - Transportation
  - Management
  - Residual management

Types of Water-Related Risk

Water-Related Risk Comes in Different Shapes and Sizes

- Environmental risk
  - Use of water for drilling/fracturing may conflict with other legitimate uses of water in the region
  - Wastewater management practices have a range of potential impacts
  - Air emissions from wastewater holding structures, trucking, and pumps
  - Spills and leaks
- Human health and safety risks
  - Large amount of water-hauling truck traffic on rural roads increases potential for accidents
  - Spills, leaks, drinking water contamination
  - Onsite worker safety

Types of Water-Related Risk (2)

- Business/operational risk
  - Ability to do business and conduct operations at your desired pace
  - Avoid bottlenecks caused by water supply or wastewater management
- Economic risk
  - Cost of procuring water supply and managing wastewater
    - These are relatively constant, but price of oil and gas fluctuates

Types of Water-Related Risk (3)

- Reputational/Legal risk
  - Outbidding other traditional users for water supply leads to bad relationships
  - Inappropriate wastewater management can lead to future liability and bad publicity, which harms company reputation
    - Adds incremental cost to the original wastewater management
  - Changes in state and federal regulations
  - Opponents are always on the lookout for opportunities to litigate
  - All oil and gas companies are perceived by the public to be equally bad
    - Need to do a good job on your own operations and work to improve performance of weakest performers through education and industry associations

Considerations Associated with Different Stages of the Water Life Cycle

Considerations for Water Sourcing and Demand

- Need to find water source(s) of sufficient volume and quality to meet operational needs
  - Fresh ground or surface water
  - Recycle your own wastewater
  - Municipal wastewater
  - Brackish groundwater
  - Underground mines or quarries (??)
- Availability and dependability over time
  - Consider different time frames for planning
  - Obtain permission/contracts to sustain water availability
- Cost of source water
- Compatibility of different water types
- Treatment may be required before use
- Monitoring, recordkeeping, reporting

Considerations for Water Transportation and Storage

- Distance from water source to well site
  - Direct delivery to well site vs. central impoundments within fields
- Movement of water in trucks vs. pipelines
  - Trucks pose safety and community relations issues
  - Pipes may be complicated to site and permit

Considerations for Water Transportation and Storage (2)

- Type of piping used for moving source water
  - Continuous welded pipe or jointed pipe sections
- Water storage facilities
  - Pits (lined or unlined)
  - Large centralized impoundments
  - Frac tanks
  - Other temporary tank types

Considerations for Wastewater Volume and Characteristics

- Wastewater volume
  - consistent or variable
  - rate of change (gradual vs. rapid)
  - consider both individual wells and all operating wells in a field/region
- Wastewater characteristics
  - consistent or variable
  - rate of change (gradual vs. rapid)
  - any constituents needing special attention and management

Shale Gas Wastewater - Flowback and Produced Water

- Some of the injected water returns to the surface over the first few hours to weeks. This ***frac flowback*** water has a high initial flow, but it rapidly decreases
  - Over the same period of time, the concentration of TDS and other constituents rises

TDS values (mg/L) in flowback from several Marcellus Shale wells

Location	Day 0*	Day 1	Day 5	Day 14	Day 90
A	990	15,400	54,800	105,000	216,000
B	27,800	22,400	87,800	112,000	194,000
C	719	24,700	61,900	110,000	267,000
D	1,410	9,020	40,700		155,000
E	5,910	28,900	55,100	124,000	

* Day 0 represents the starting frac fluid conditions

Source: Tom Hayes, 2009.

Considerations for Wastewater Storage and Transportation

- Wastewater storage facilities
  - Pits (lined)
  - Frac tanks
  - Other tank types

Considerations for Wastewater Storage and Transportation (2)

- Length of time storage is allowed onsite
- Movement of water
  - Transporting wastewater has more risks than transporting source water (higher level of contaminants)
- Type of piping used for moving wastewater may be restricted
- Monitoring, recordkeeping, data management relating to wastewater production and transportation
  - Internal systems
  - Agency requirements

Considerations for Wastewater Management and Residual Management

- How will wastewater be managed?
  - Inject
  - Discharge
  - Evaporation
  - Offsite disposal company
  - Recycle for oil and gas use
  - Reuse for other purpose
- Treatment may be required
  - Which parameters must be treated?
  - How much treatment is needed?
- Onsite vs. offsite treatment
  - Key consideration is what will be done next with the treated water
- Treatment processes often generate residuals (e.g., sludge, concentrated brines) that contain higher concentrations of contaminants than did the untreated wastewater
  - Make sure that the elevated concentrations do not create new risks to workers or for disposal

A New Technology For Managing Frac Residuals Discovered in Bolivia

Decision Criteria for Choosing a Wastewater Management Solution

Must be practical at your location

Must be allowed by the regulatory agency

Must be sustainable over time

Must pose low risk for future liability

Should be proven to give dependable performance over time

Must have affordable cost

Components Contributing to Total Cost of Wastewater Management

Category	***Cost Component (Some or all may be applicable)***
Prior to Operations	Prepare feasibility study to select option (in-house costs and outside consultants)
	Obtain financing
	Obtain necessary permits
	Prepare site (grading; construction of facilities for treatment and storage; pipe installation)
	Purchase and install equipment
	Ensure utilities are available
During Operations	Utilities
	Chemicals and other consumable supplies
	Transportation
	Debt service
	Maintenance
	Disposal fees
	Management of residuals removed or generated during treatment
	Monitoring and reporting
	Down time due to component failure or repair
	Clean up of spills
After Operations	Removal of facilities
	Long-term liability
	Site remediation and restoration

Upstream Oil and Gas Industry is Segmented into Many Niches

- Different production methods
- Different geographical plays
- Range of climates
- Federal and state regulations
- Availability of infrastructure
- Regional water supply availability

It is important to understand these differences when choosing a wastewater management technology

How Clean Must the Water Be (How Much Treatment Must Be Used)?

- What is the quality of the untreated water?
  - Types of constituents
  - Concentrations
  - Does it change over time?
- What will be done next with the water?
  - Disposal
    - Discharge
    - Injection
    - Evaporation
    - Send to third-party disposal company
  - Reuse
    - In oil and gas operations
    - Other

What Type of Criteria Determine How Clean the Water Must Be?

- Regulatory standards (set by government)
  - Discharge standards
    - Zero discharge
    - Limits on oil and grease, pH, TDS, metals, others
  - Air quality standards
    - Emissions from evaporation ponds or holding tanks
- Operational standards (set by operators)
  - Injection standards are designed to protect the injection formation from plugging
  - Reuse for drilling and frac fluids must meet criteria set by the oil and gas companies
  - Reuse for other purposes must meet the needs of those activities

Produced Water Volumes and Management Practices

Detailed Produced Water Inventory for the U.S.

- Clark, C.E., and J.A. Veil, 2009, *Produced Water Volumes and Management Practices in the United States*.
- The report contains detailed produced water volume data for 2007
  - ~21 billion bbl/year or 58 million bbl/day
  - 882 billion gallons/year or 2.4 billion gallons/day

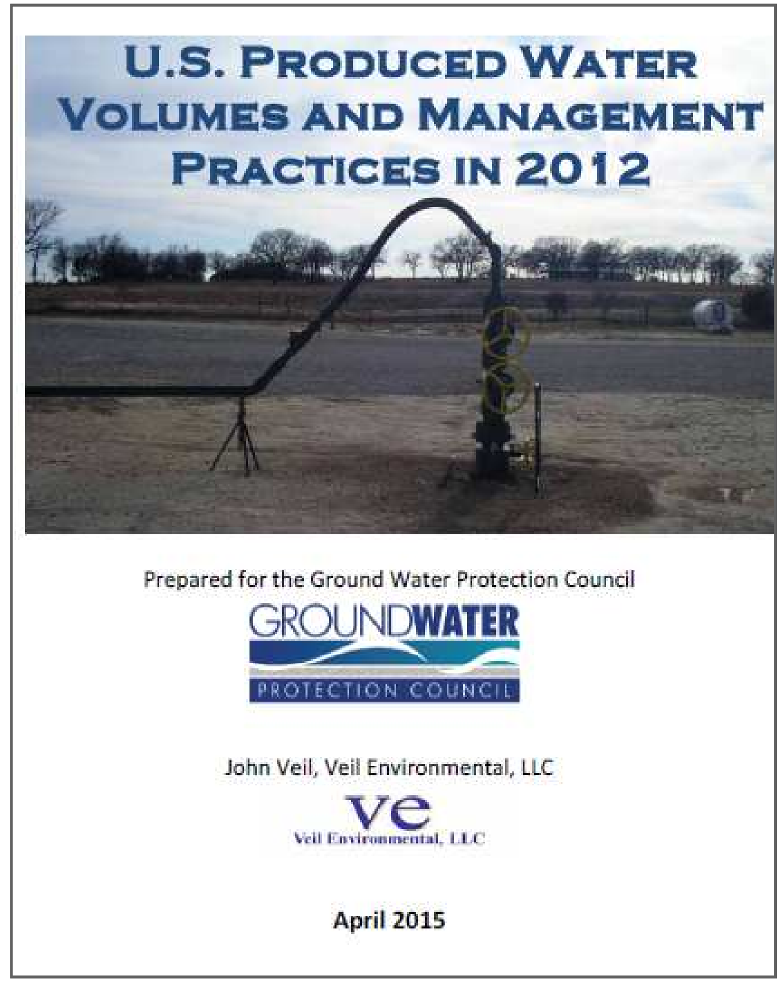
U.S. Produced Water Volume by Management Practice for 2007 (1,000 bbl/year)

	Injection for Enhanced Recovery	Injection for Disposal	Surface Discharge	Total Managed	Total Generated
Onshore Total	10,676,530	7,144,071	139,002	18,057,527	20,258,560
Offshore Total	48,673	1,298	537,381	587,353	587,353
Total	10,725,203	7,145,369	676,383	18,644,880	20,995,174

- Onshore – 98% goes to injection wells
  - 60% to enhanced recovery
  - 40% to disposal
- Offshore – 91% goes to discharge

Update to Detailed Produced Water Inventory for the U.S.

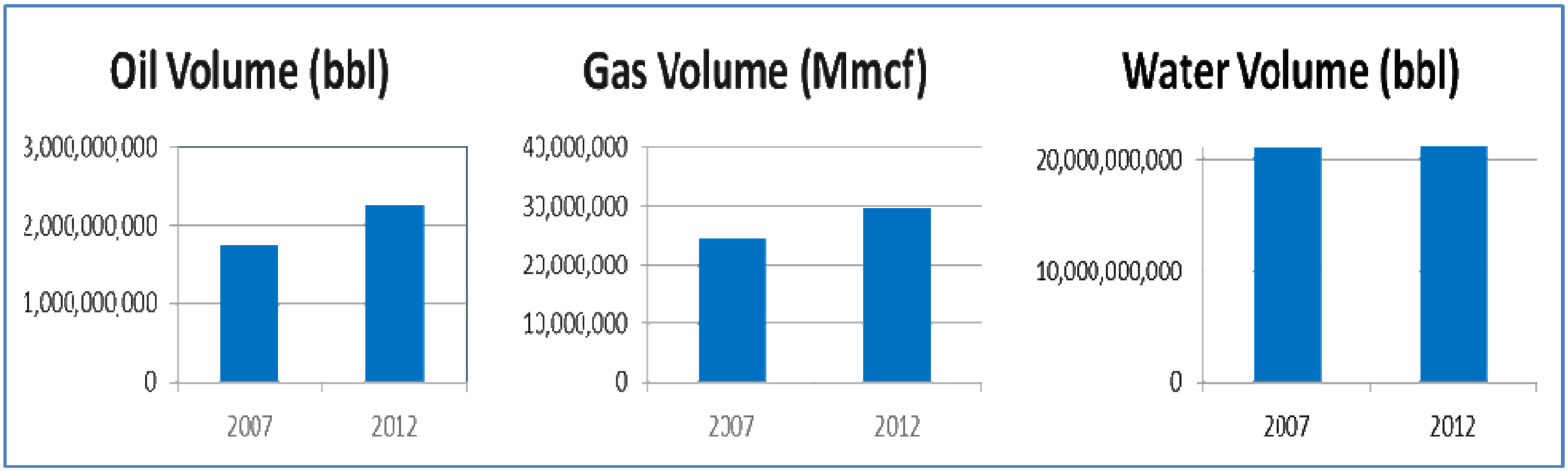
- GWPC contracted with Veil Environmental to update the earlier report using 2012 as the baseline year.
- Data were collected during the second half of 2014
- Report was published in April 2015



http://www.veilenvironmental.com/publications/pw/prod_water_volume_2012.pdf

Five Year Changes in Fluid Production

- Between 2007 and 2012
  - U.S. oil production increased by 29%
  - U.S. gas production increased by 22%
  - U.S. water production increased by <1%
    - 21.2 billion bbl vs. 21 billion bbl



Top Ten States in 2012 Water Production

Ranking	State	2012 Water (bbl/yr)	% of Total Water
1	Texas	7,435,659,000	35
2	California	3,074,585,000	15
3	Oklahoma	2,325,153,000	11
4	Wyoming	2,178,065,000	10
5	Kansas	1,061,019,000	5
6	Louisiana	927,635,000	4
7	New Mexico	769,153,000	4
8	Alaska	624,762,000	3
9	Federal Offshore	358,389,000	2
10	Colorado	320,191,000	2

Ratio of Water to Oil and Gas Production

- Not all states provided separate water from oil production and water from gas production
- The weighted average water-to-oil (WOR) for 21 states is 9.2 bbl water/bbl oil.
  - Two of the key water producing states (Texas and Oklahoma) were unable to distinguish the water generated from oil wells vs. water coming from gas wells. Both of those states have large numbers of older wells from mature fields that typically have very high WORs (much higher than the weighted average). It is very likely that if the wells from those states were averaged in, the national weighted average WOR would be higher than 10 bbl/bbl.
- The weighted average water-to-gas ratio (WGR) for 17 states is 97 bbl water/Mmcf gas.
  - The range of values from the different states was so large that using a WGR is not meaningful.

Why Did Oil and Gas Increase While Water Remained the Same?

Here is my hypothesis:

- Conventional production generates a small initial volume of water that gradually increases over time. The total lifetime water production from each well can be high
- Unconventional production from shales and coal seams generates a large amount of flowback and produced water initially but the volume drops off, leading to a low lifetime water production from each well
- Between 2007 and 2012, many new unconventional wells were placed into service and many old conventional wells (with high water cuts) were taken out of service
- The new wells generated more hydrocarbon for each unit of water than the older wells they replaced

Potential Environmental Risks from Produced Water

Potential Pathways for Produced Water to Impact the Environment

Spills and Leaks	Discharge to Surface Water
Underground Injection	Air Emissions

- The main constituent of produced water that causes impacts is salt
- Other constituents can create problems in certain settings

Spills and Leaks

- Salt can contaminate soils near wellheads, pipelines, and other facilities
  - Kills plants
  - Damages soils to impact future plant growth
- Large spills can move into surface water bodies
  - Salt problems in freshwater
  - Toxic compounds and oil and grease can damage aquatic life
- Leakage from tanks or impoundments can soak into the ground and enter groundwater
  - In addition to harming soils, large releases of produced water may soak deep into the ground and enter sources of drinking water
    - Impacts from salt, oil and grease, and from toxics

Discharge to Surface Water

- Discharges of salty produced water into fresh water bodies can cause damage to aquatic animals and plants
  - Discharge of salty water to the ocean does not cause salt-related harm
- Discharges of oil and grease and toxic chemicals can cause damage in both fresh and salt water
- Discharges of produced water are authorized by a regulatory agency through permits

Underground Injection

- Most onshore produced water is injected – this is generally safe
- Need to check the chemical compatibility of the injected produced water with the chemicals already found in the rock and the ground water
  - Incompatibility of the chemicals can cause precipitates to form that block pores and require additional injection pressure
  - Potential microbial problems can occur in the formation that lead to hydrogen sulfide generation

Underground Injection (2)

- Need to construct injection wells properly
  - Poor construction and bad cementing can create pathways for injected produced water to move to the surface or to a drinking water zone
  - Exceedance of operating pressure requirements can cause similar problems
- Extended injection can lead to seismic activities
  - Very low level seismic is common and does not pose any problems
- A small subset of injection wells are sited at locations with unexpected geological features
  - On occasion, these can cause seismic activities that can be felt at the surface
- In the U.S., 150,000 to 200,000 injection wells operate each day
  - Only a tiny proportion of these cause noticeable seismic activity

Air Emissions

- Movement and treatment of produced water requires much power (pumps, engines, etc.)
  - Operation of this type of equipment generates air emissions, including CO_2
- Evaporation pits and ponds or mechanical evaporators can create plumes of vapor that deposit on the ground down-wind of the site
  - The salty deposits can harm plants and soil

Source: BC Technologies

Source: Neil Nowak

Principles of Risk Assessment as Applied to Produced Water Management

Basics of Risk Assessment

- Risk assessment considers the hazard posed by an activity and the chemicals involved, as well as the likelihood of an event or exposure to humans or other animals that could cause harm
- Risk assessment involves 4 integrated tasks
  - Hazard identification
  - Exposure assessment
  - Toxicity (dose-response) assessment
  - Risk characterization

Hazard Identification

- What chemicals are likely to be present in produced water?
  - Salt
  - Oil and grease
  - Metals
  - Organics
  - NORM
  - Nutrients
  - High temperature

- The presence of specific chemicals and their concentrations varies greatly from place-to-place and over time

Exposure Assessment

- Evaluate the specific produced water management activity
  - Potential for releases via spills, leaks, and other accidents
- Identify release mechanisms
  - Broken valves
  - Corroded pipes
  - Bad cement job on injection well

- Identify potential receptors
  - Surface water
  - Ground water
  - Soil
  - Animals
  - Plants
  - People

Exposure Assessment (2)

- Identify the proximity of the produced water management facility to potential exposure/contact locations
  – How far away are sensitive environmental settings or sensitive animal, plant, or human populations?
- Assess the likelihood of exposure
  – Chemical reactions in a water body or in ground water may change the form or properties of chemicals or can produce new chemicals
  – Adsorption or geochemical reactions may bind chemicals in formation (less available)
  – Dilution/dispersion
- Estimate magnitude of exposure
  – Estimate concentrations at points of exposure
  – Estimate quantity of each chemical taken in by receptors

Toxicity (Dose-Response) Assessment

- Water
  - Water quality criteria and standards
    - Acute (short term exposure)
    - Chronic (long-term exposure)
  - Drinking water standards
- Soil
  - Clean up standards based on plant requirements
  - Agricultural soil standards
- Human health safe exposure levels
  - Cancer
  - Other non-cancer health affects
  - Ingestion vs. inhalation vs. skin contact

Risk Characterization: Human Health

- Compare estimates of exposure levels to the target (“acceptable”) values
  - Considers the probability of a sensitive area receiving an exposure
  - Amount of exposure
  - Duration of exposure

Risk Analysis for Class I Injection Well (used to inject hazardous wastes deep underground)

Source: William Rish, Hull and Associates, paper presented at 2003 Underground Injection Symposium

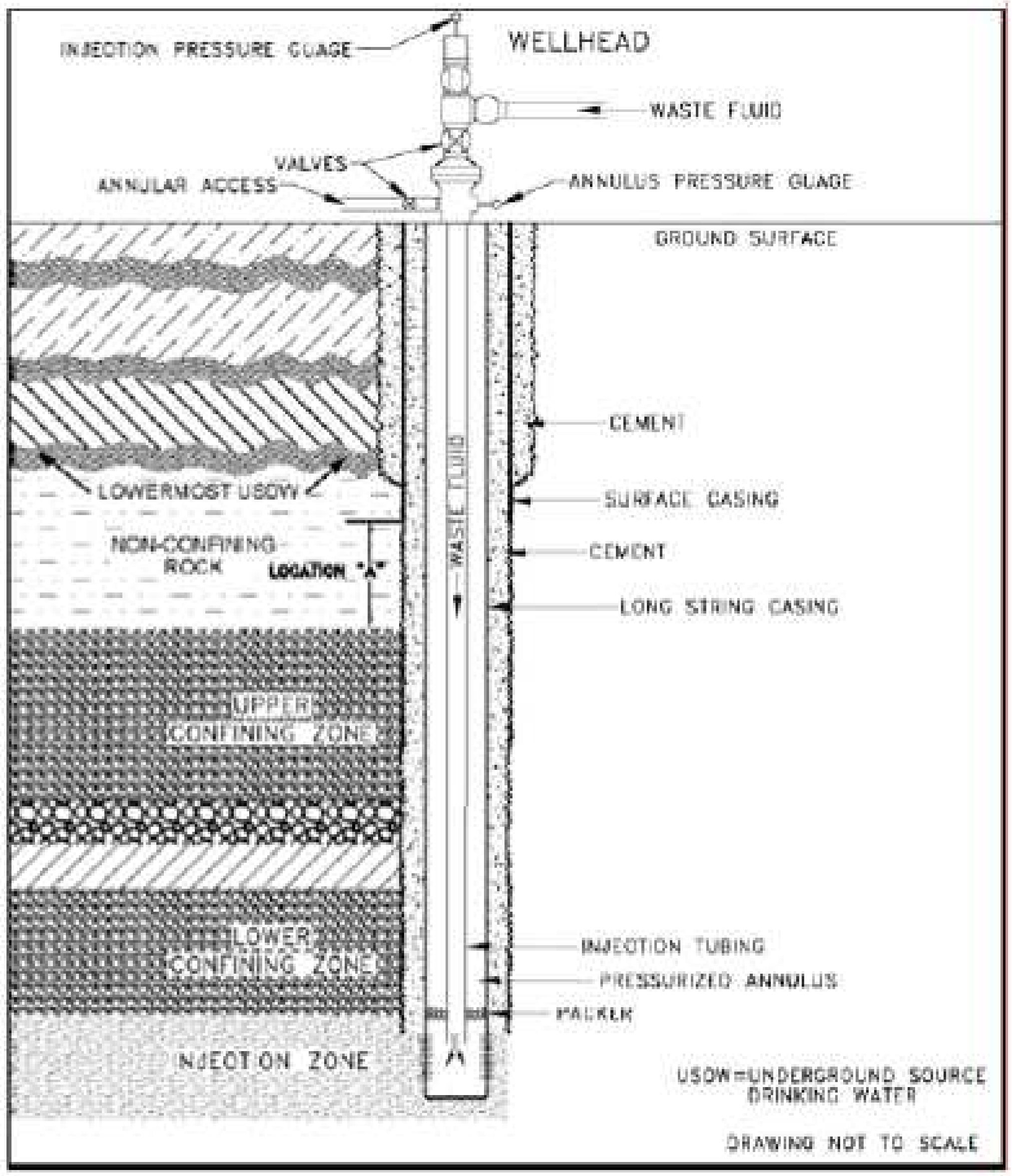


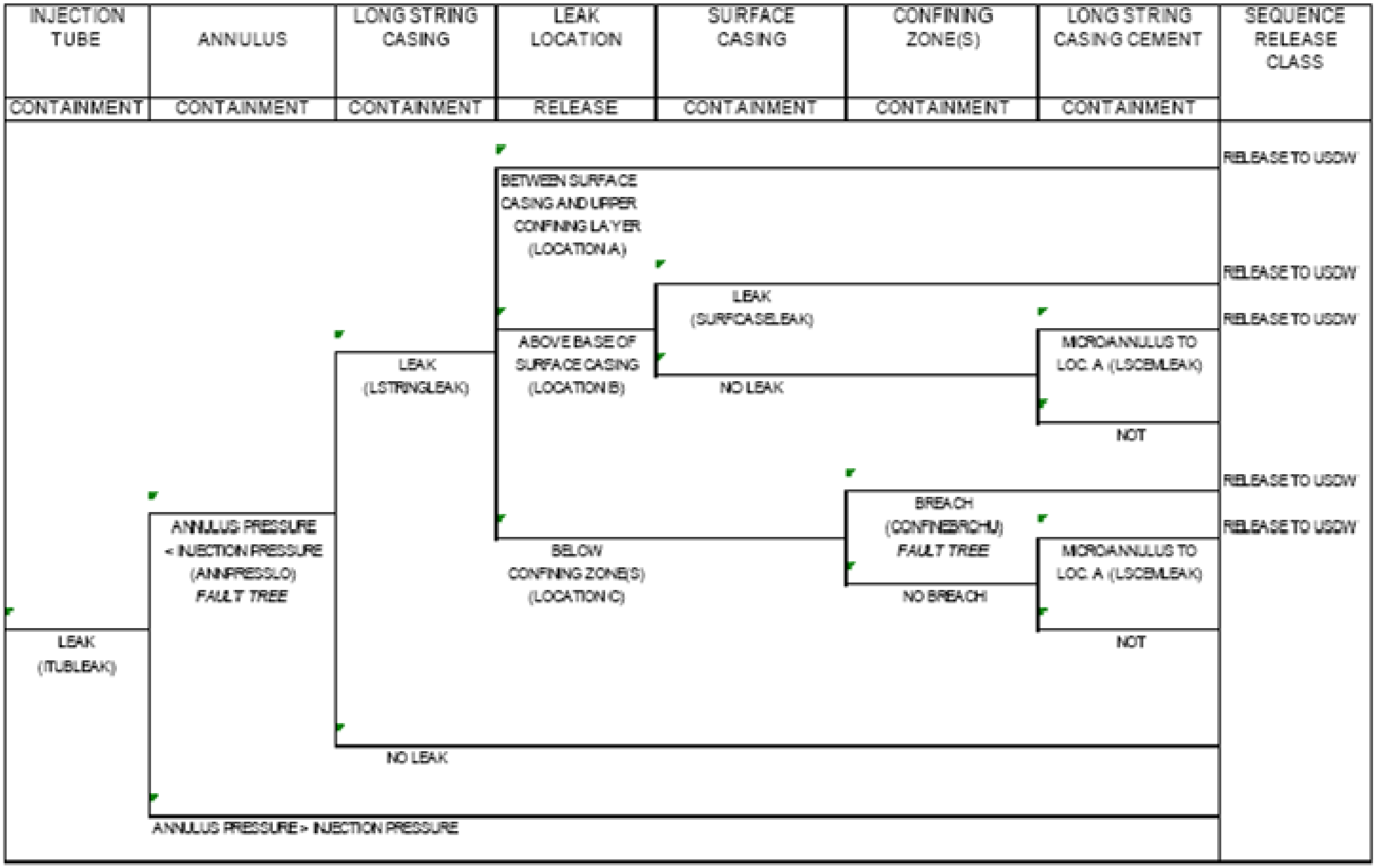
Figure 1 Simplified Class I Injection Well System Assumed for PRA

Event Probability Distributions -Class I Well Risk Analysis

EVENT NAME	DESCRIPTION	PROBABILITY DISTRIBUTION TYPE	LOWER BOUND	MEDIAN	UPPER BOUND
ALARM	Automatic alarm fails	Uniform	5E-05	3E-04	5E-04
ANNPRESSLO	Annulus pressure drops below injection pressure	From Fault Tree	9E-14	7E-12	8E-11
CAPLOSS	Loss of injection zone capacity results in overpressurization	Uniform	1E-05	1E-04	1E-03
CHECKPA	Annulus check valve fails open	Triangular	1E-04	3E-04	1E-03
CONFINEBRCHL	Transmissive breach occurs through lower confining zone	From Fault Tree	6E-04	3E-03	1E-02
CONFINEBRCHU	Transmissive breach occurs through upper confining zone	From Fault Tree	6E-04	3E-03	1E-02
CONTROLPA	Annulus pressure control system fails resulting in underpressurization	Uniform	1E-06	1E-05	1E-04
CONTROLPI	Injection pressure control system fails resulting in overpressurization	Uniform	1E-06	1E-05	1E-04
DETECTWELL	Failure to identify abandoned well in AOR	Uniform	1E-03	5E-03	1E-02
DISCONT	Presence of unidentified transmissive discontinuity	Uniform	1E-04	1E-03	1E-02
EXTRACT	Extraction of injection zone groundwater	Uniform	1E-05	1E-04	1E-03
FLUIDTEST	Testing fails to detect injection fluid migration along outside of long string casing	Uniform	5E-04	3E-03	5E-03
INCOMPWASTE	Waste injected that is chemically incompatible with geology or previously injected waste	Uniform	1E-05	5E-05	1E-04
ITUBFAIL	Sudden/major failure and breach of injection tube	Poisson	3E-07	6E-07	8E-07
ITUBLEAK	Injection tube leak	Poisson	3E-05	6E-05	8E-05
LBUOYANCY	Injected fluid is sufficiently buoyant to penetrate lower confining zone breach	Single Value	1E+00	1E+00	1E+00
LOCATION A	Long string casing leak is located between surface casing and uppermost confining zone	Uniform	1E-02	3E-02	5E-02
LOCATION B	Long string casing leak is located above base of surface casing	Uniform	1E-02	5E-02	1E-01
LOCATION C	Long string casing leak is located below confining zone(s)	Uniform	9E-01	9E-01	1E+00
LSCASEFAIL	Sudden/major failure and breach of long string casing	Poisson	2E-07	3E-07	5E-07
LSCEMLEAK	Long string casing cement microannulus allows fluid movement along casing	Poisson	2E-06	6E-06	1E-05
LSTRINGLEAK	Long string casing leak	Poisson	2E-05	3E-05	5E-05
MIGRATION_A	Waste migrates up microannulus to Location A between surface casing and upper confining zone	Uniform	1E-04	1E-03	1E-02
NORECOGNIZE	Failure to recognize that groundwater extraction is located within injection waste zone	Uniform	1E-03	5E-03	1E-02
OPERINJ	Operator fails to recognize changes in confining zone capacity	Uniform*	5E-05	3E-05	5E-04
OPERRDET	Operator fails to detect/respond to unnacceptable pressure differential	Uniform*	5E-05	3E-05	5E-04
OPERRFRAC	Operator error results in induced transmissive fracture through lower confining zone	Uniform*	5E-05	3E-04	5E-04
OPERRPA	Operator error causes annulus pressure below injection pressure	Uniform*	5E-05	3E-04	5E-04
OPERRPI	Operator error causes injection pressure above annulus pressure	Uniform*	5E-05	3E-04	5E-04

Source: Rish 2003

Example of Event Tree for Class I Well Failure



Source: Rish 2003

Examples of Good and Bad Water Management Practices from Marcellus Shale

(from my personal experience)

Example 1 - Large Producer - Planned Tour - October 2010

- A large gas company provided a tour of a well site in northeastern PA that was scheduled for a frac job on the following day.
- All equipment was in place
- Full pad was covered with gravel
- Central working area had geotextile liner and berm to collect any drips or spills
- It was raining that day, and workers were removing collected precipitation from the lined area using vacuum hoses. Collected wastewater went into vacuum trucks for offsite disposal.
- Company had a dedicated set of frac tanks to capture all flowback for subsequent reuse.




Example 2 - Very Small Producer - Unscheduled Visit - May 2010

- A small gas company that drilled only a few wells each year had fractured a vertical well in western PA on the previous day.
- A downhole tool got stuck in the well. The company brought in a coiled tubing rig to try to remove the tool.
- In the meantime, the well was flowing back to the surface. Some of the wastewater was collected in a small lined pit, then was pumped to a larger lined pit for subsequent treatment.
- A portion of the flowback sprayed from the top of a ~30 ft pipe. Depending on the wind direction, the spray moved to various sections of the well site. We received occasional flowback showers during our visit.

Normal Flowback Water Capture System

Unplanned Flowback Shower

Why Do Companies Change their Wastewater Management Practices?

Pennsylvania Flowback Management – 2009 vs 2013

2009	# individual entries (wells)	Bbls of wastewater	% of total wastewater managed using this method
Brine or Industrial Treatment Plant	233	3,437,556	37.6
Injection wells	1	14,530	0.2
Municipal Sewage Treatment Plant	111	2,038,227	22.3
Reuse	116	1,942,461	21.3
Other	106	1,703,936	18.6
Total	567	9,136,710	100

2013 (January-June)

Disposal Method	Total Volume (bbl)	% Using Method
Centralized Treatment Plant for Recycle	940,692	26.8
Injection Disposal Well	94888	2.7
Landfill	2186	0.1
Reuse Other Than Roadspreading	2,457,025	70.1
Storage Pending Disposal or Reuse	9,227	0.3
Centralized Treatment then Discharge	46	0.0
Total	3,504,064	100

Factors That Can Cause Sudden Changes to Water Management Practices

- Introduction of new technologies
  - Simple filtration in Marcellus
- New regulations/policy decisions
  - Notice from PA DEP to stop sending wastewater to POTWs and small industrial treatment plants
- Unexpected events
  - Earthquakes in Ohio, Arkansas, Texas, Oklahoma
- Shifts in supply and demand

Crossover Point

- The ability to reuse all the wastewater from a field depends on:
  - **How much wastewater is generated**
  - **The near-term and mid-term needs for drilling and fracturing new wells**
  - Relationship between point of generation and point of need for reuse
  - An infrastructure to collect, store, treat, and deliver water as needed
- Wastewater generation volumes (look at hypothetical analysis similar to Marcellus Shale; assumptions for the following analysis are underlined below)
  - Flowback water (first two weeks) – <u>one-time batch of 1 million gals/well</u>
  - Produced water (<u>as long as well is producing assume 250,000 gals/year/well</u>)
  - As more and more wells are drilled and begin production, the cumulative produced water volume increases continuously while the flowback volume stays relatively the same (assuming the same number of wells are drilled each year).

Crossover Point (2)

- Each new well requires about 5 million gals/well for drilling and fracturing
- In the early years of a field, there is much greater demand for water than supply
- Over time, with the steadily increasing produced water volume plus the constant flowback volume, the field reaches a point at which the volume of water generated matches the volume of water needed for drilling and fracturing
  - This is the **crossover point**
- After that point in the field's life, the total volume of produced water and flowback will exceed the demand for new wells. The excess water that cannot be recycled will need to be managed in some other way
- This is the point at which high level treatment (desalination) can play a more significant and growing role
- When will the crossover point be reached?

Hypothetical Data

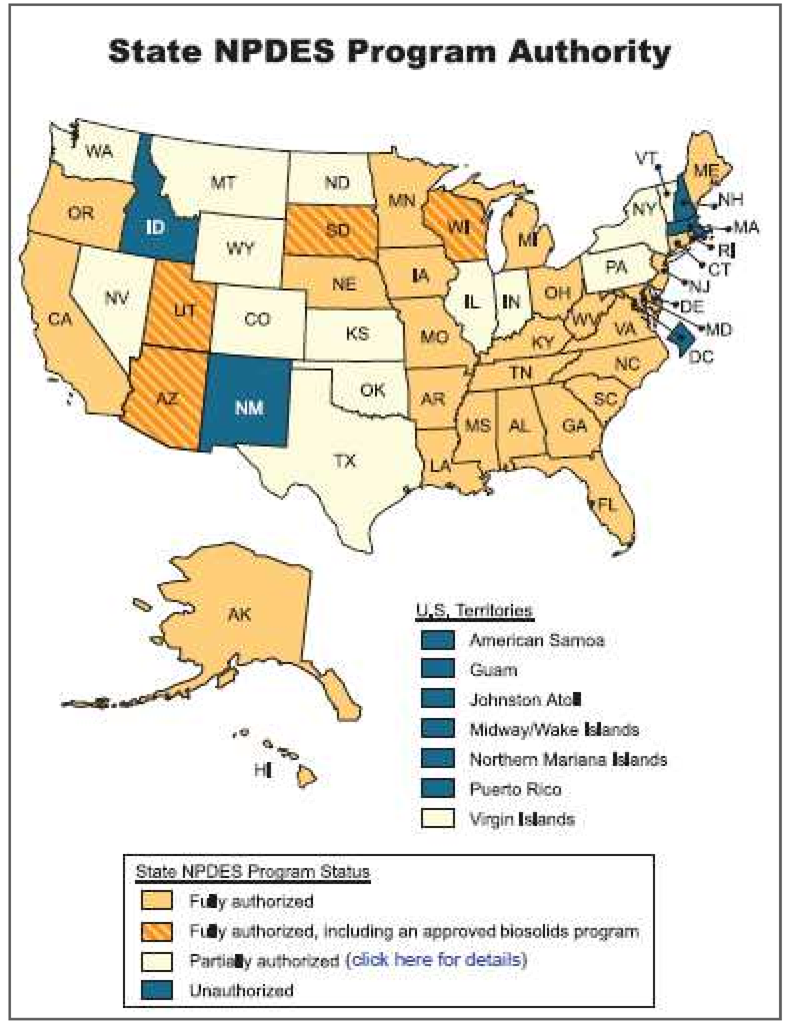
Year in life of field	No wells/year	Total Wells in Field	Flowback Volume (million gals)	Produced Water Volume (million gals)	Total Wastewater Generated (million gals)	Water needed (5 million gals/well)
1	100	100	100	25	125	500
2	500	600	500	150	650	2,500
3	1,000	1,600	1,000	400	1,400	5,000
4	1,500	3,100	1,500	775	2,275	7,500
5	2,000	5,100	2,000	1,275	3,275	10,000
6	2,000	7,100	2,000	1,775	3,775	10,000
7	2,000	9,100	2,000	2,275	4,275	10,000
8	2,000	11,100	2,000	2,775	4,775	10,000
9	2,000	13,100	2,000	3,275	5,275	10,000
10	2,000	15,100	2,000	3,775	5,775	10,000
11	2,000	17,100	2,000	4,275	6,275	10,000
12	2,000	19,100	2,000	4,775	6,775	10,000
13	2,000	21,100	2,000	5,275	7,275	10,000
14	2,000	23,100	2,000	5,775	7,775	10,000
15	2,000	25,100	2,000	6,275	8,275	10,000
16	1,800	26,900	1,800	6,725	8,525	9,000
17	1,600	28,500	1,600	7,125	**8,725**	**8,000**
18	1,400	29,900	1,400	7,475	**8,875**	**7,000**
19	1,200	31,100	1,200	7,775	**8,975**	**6,000**
20	1,000	32,100	1,000	8,025	**9,025**	**5,000**

Crossover point

U.S. Regulatory Requirements and How They Affect Water Management

State vs. Federal Authority

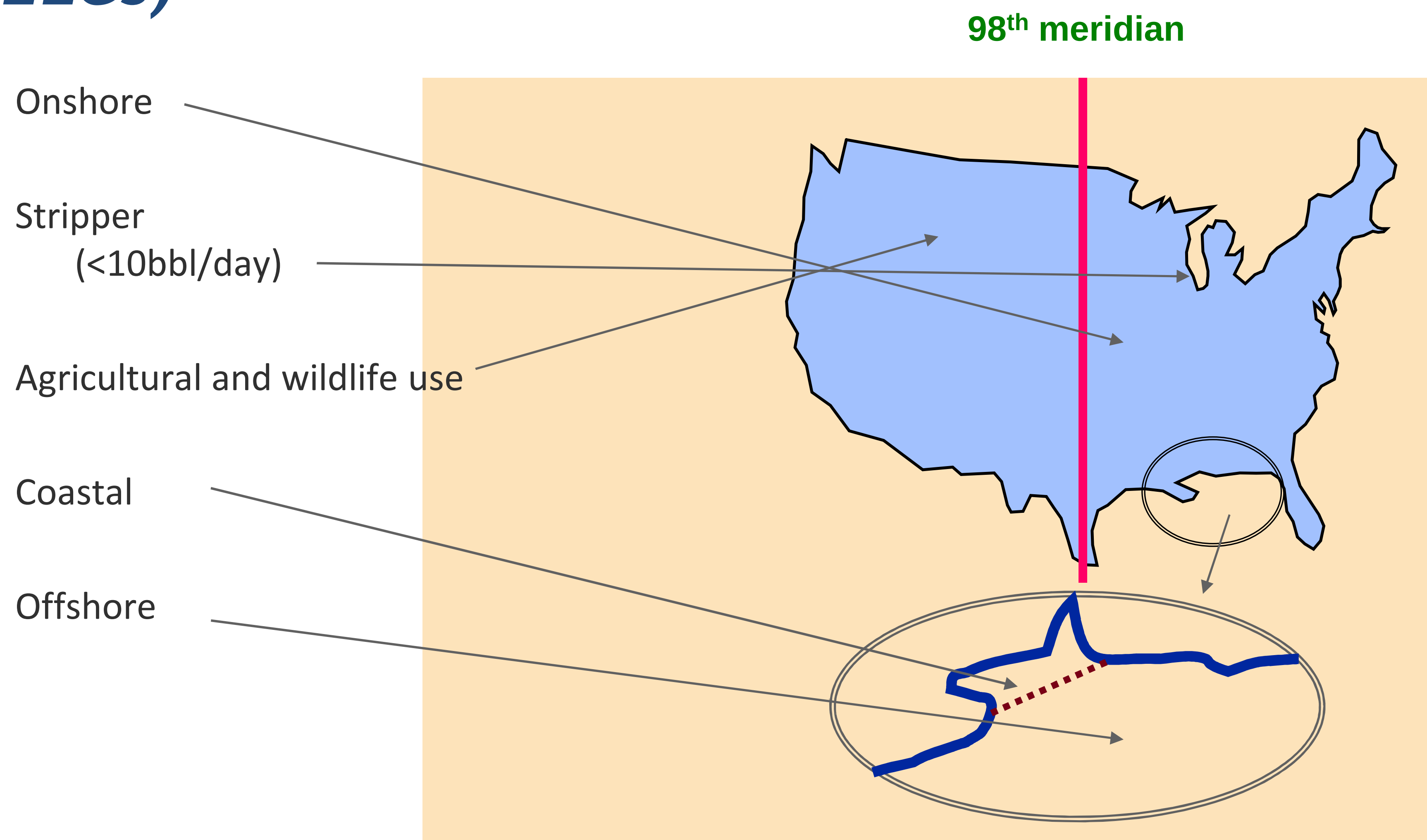
- Both discharge and injection are administered through regulatory programs
  - Major regulatory programs can be delegated
    - State can seek approval from the EPA for the day-to-day implementation and enforcement of programs
  - When states do not have delegated authority, programs are administered by EPA regional offices



Discharge Permits

- Discharge permits contain limits on several pollutants and give limits expressed as mg/L or pounds/day
  - Limits are based on national discharge standards and water quality protection
- Discharge permits require self-monitoring and reporting

EPA National Discharge Standards for Oil and Gas (Effluent Limitation Guidelines - ELGs)



Discharge Standards for Wells Located Onshore

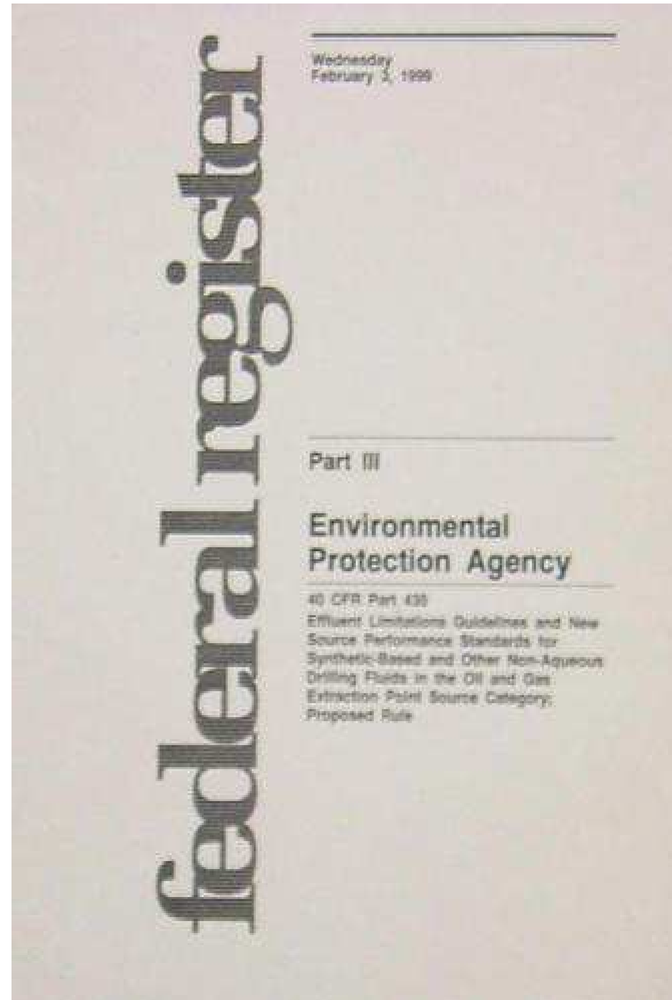
- Onshore subcategory
  - zero discharge

This is very important – it takes away a major water management option and drives companies to use injection

- Stripper subcategory
  - No national requirements
  - Jurisdiction left to state or EPA region
- Agricultural and Wildlife Use subcategory (not common)
  - produced water must have a use
    - Water must be of good enough quality for wildlife, livestock, or other agricultural use
  - Oil and grease limit of 35 mg/l maximum

Offshore and Coastal ELGs

- Best Available Technology (BAT) for offshore produced water:
  - Oil and grease limits before discharge
    - 29 mg/l monthly average
    - 42 mg/l daily maximum
- BAT for coastal produced water
  - zero discharge except in Cook Inlet, Alaska
  - Offshore limits are required there



Injection Permits

- Injection permits include requirements on:
  - Well location and construction
  - Operations
  - Monitoring
  - Pressure
  - Flow rate
  - Volume
  - Plugging and abandonment

Injection permits do not include standards on how clean the injected water must be. Any standards associated with injection are based on operational requirements to protect the formation.

Final Thoughts

- Water is a critical raw material to produce oil and gas
- Most types of oil and gas wells generate wastewater
- Companies must obtain water and manage wastewater in ways that allow operations to proceed on schedule, offer acceptable costs, and pose low risks
- There is no single “best practices” that can be used everywhere
- Prior planning and data collection help to minimize risks relating to water