

Practical Guidelines for Addressing Impacts of Produced Water Releases to Plants, Soil, and Groundwater

*API Produced Water Issues Group
Publication 4758, Sept. 2006*

J. A. Connor, P.E., P.G., D.E.E.
C. J. Newell, Ph.D., P.E., D.E.E.

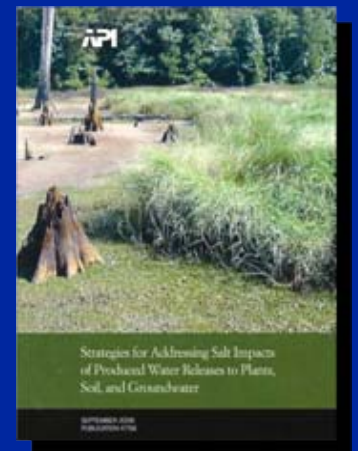
Groundwater Services, Inc.
Houston, Texas (713) 522-6300

Harley H. Hopkins
API, Washington, D.C.



Addressing Impacts of Produced Water

- **Effects on Soils, Plants, and Water**
- **Rules of Thumb: *Potential for Impacts***
- **Soils: *Remedy Selection and Implementation***
- **Groundwater: *Simple Modeling Tool***
- **Site Investigation Guidelines**



API 4758

Background on API Publication 4758

GOAL

Provide concise technical guidelines based on prior publications.

SCOPE

- 1) Will produced water release cause unacceptable impact?
- 2) Appropriate and effective response actions?

WHERE

www.api.org/produced_water

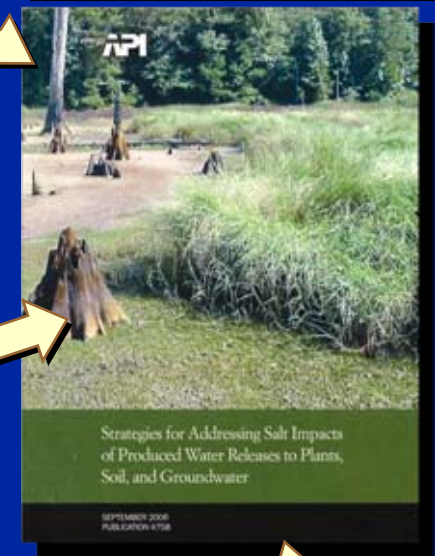


API 4663



API 4734

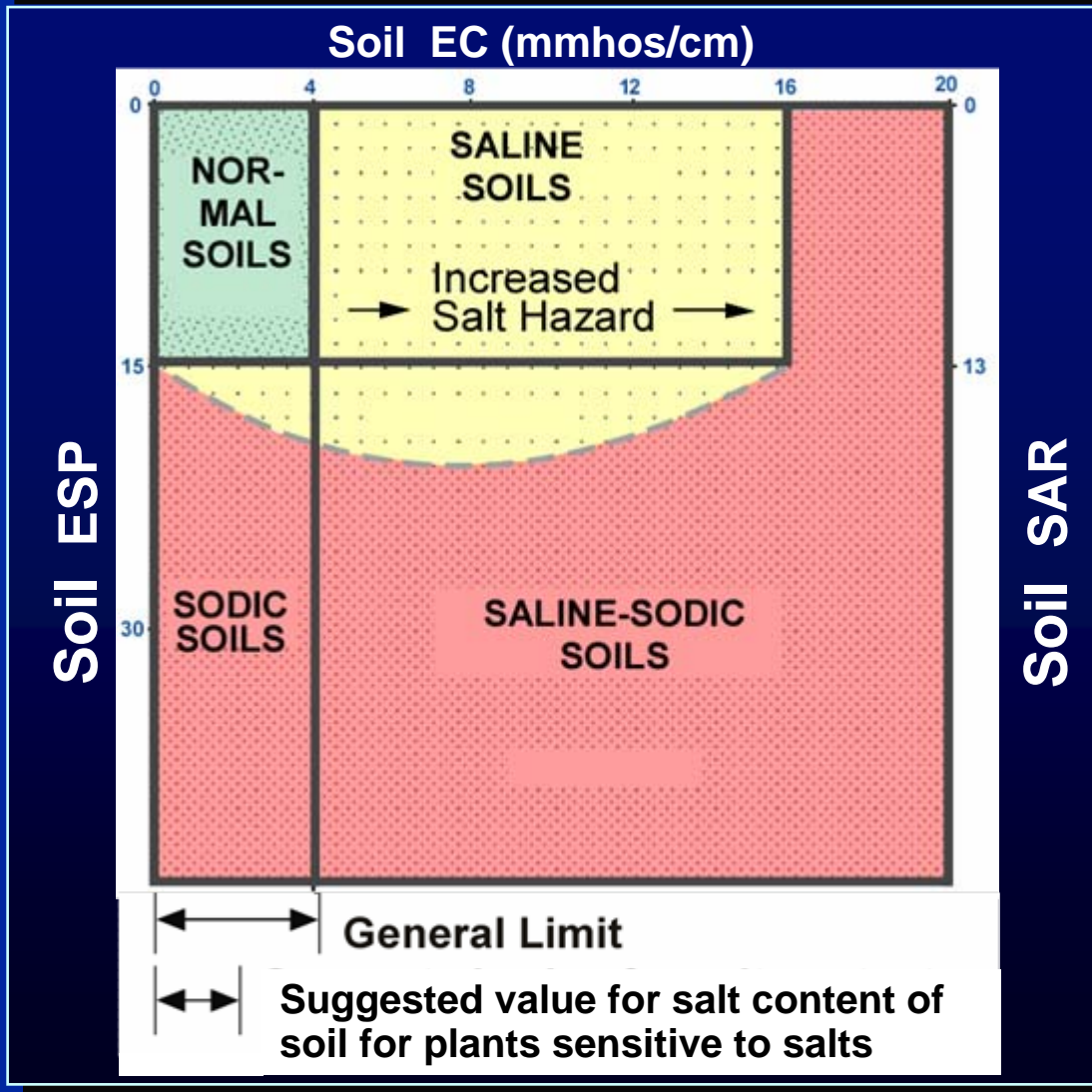
API 4758



Other
neat stuff

API 4758: Addressing Impacts of Produced Water

Salt Impacts to Plants



How:

High TDS in soil pore water prevents osmotic uptake, causing desiccation. Most sensitive at germination stage.

What:

Bare soils, stunted growth, deep blue-green foliage (not yellow), tip burn and cupping.

API 4758: Addressing Impacts of Produced Water

Salt Impacts to Plants: *East Texas Site, 2001*



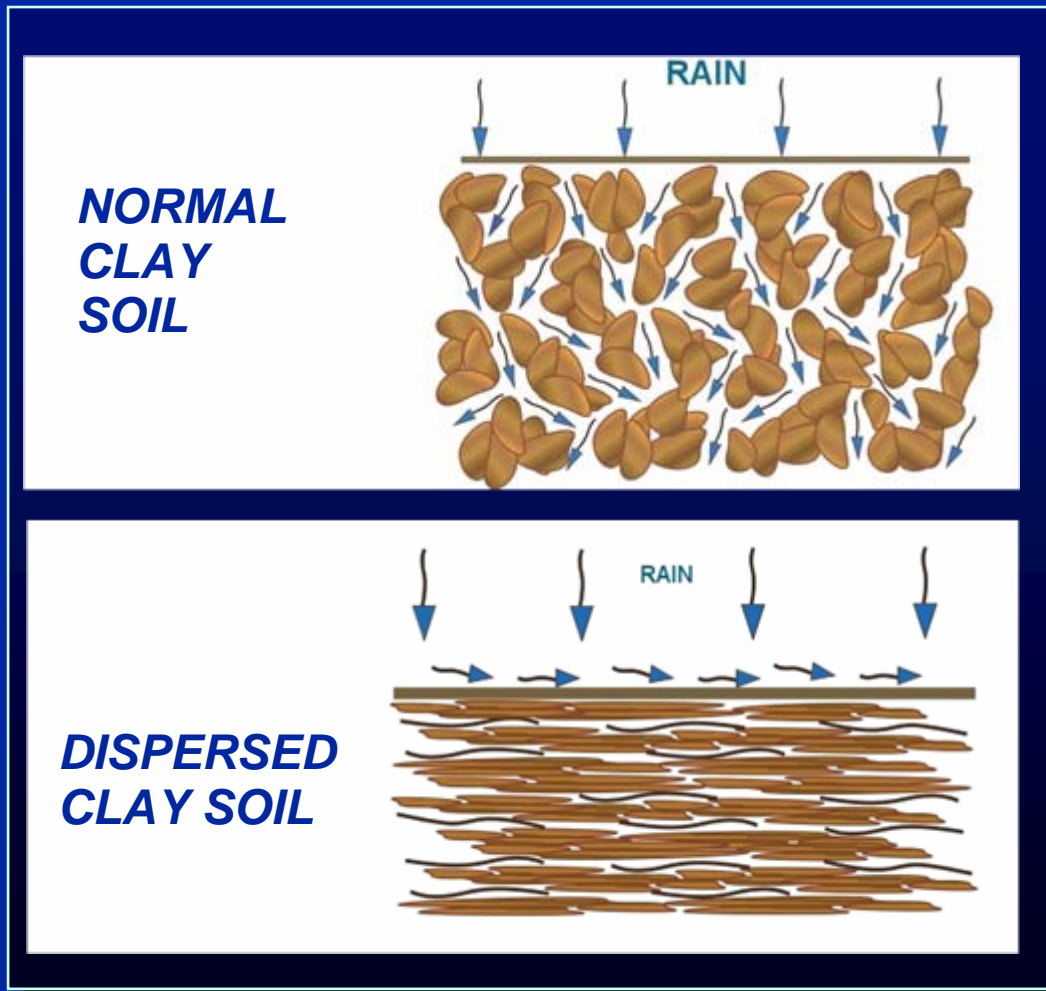
Releases at PW Injection Facility



Timber loss over 5-acres; growth of salt tolerant brush (*willow baccharis*)

API 4758: Addressing Impacts of Produced Water

Salt Impacts to Soils



Clay Soil Dispersion

How:

Sodium in PW exchanges with K, Ca, Mg in clay minerals.

What:

- Loss of soil cohesion
- Loss of permeability, drainage
- Increased erosion

When:

Affected soil ESP > 15%

Salt Impacts to Soils: *East Texas Site, 2001*



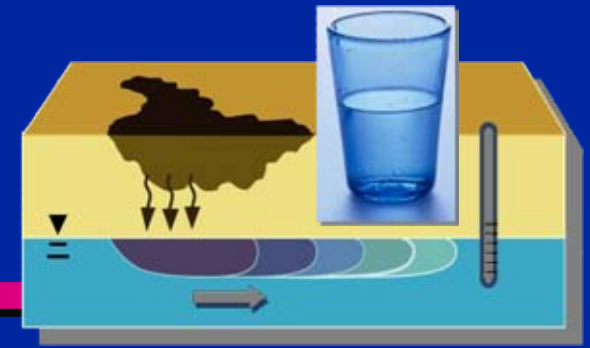
**High-sodium
brine spill to
lake causing
dispersion and
erosion of clay
soils in dam.**

Salt Impacts to Plants: *Former Brine Pit*



**Former brine pit
with vegetation
loss and surface
erosion.**

Salt Impacts to Water Resources



Salt loading can impair beneficial use of surface water or groundwater

BENEFICIAL USE CRITERIA

- ***Drinking Water:*** Secondary MCLs for TDS (500 mg/L) and chloride (250 mg/L).
- ***Aquatic Life:*** USEPA acute (860 mg/L) and chronic (230 mg/L) criteria for Cl. State criteria for TDS: 250 - 2500 mg/L.
- ***Irrigation:*** Salinity hazards above ~1,500 mg/L TDS.
- ***Livestock:*** Useable with TDS up to 3,200 mg/L, with some effects.

(In-situ photo of affected groundwater)

Rules of Thumb:

Will Soil be Impacted by PW Release?



Nope



Yep

***Affected Soil
Contains:***

ESP < 5%

EC < 4 mmhos/cm

ESP > 22 %



EC > 16 mmhos/cm

KEY POINT: For soil conditions between these extremes, must consider climate, drainage, vegetation, etc.

API 4758: Addressing Impacts of Produced Water

Rules of Thumb:

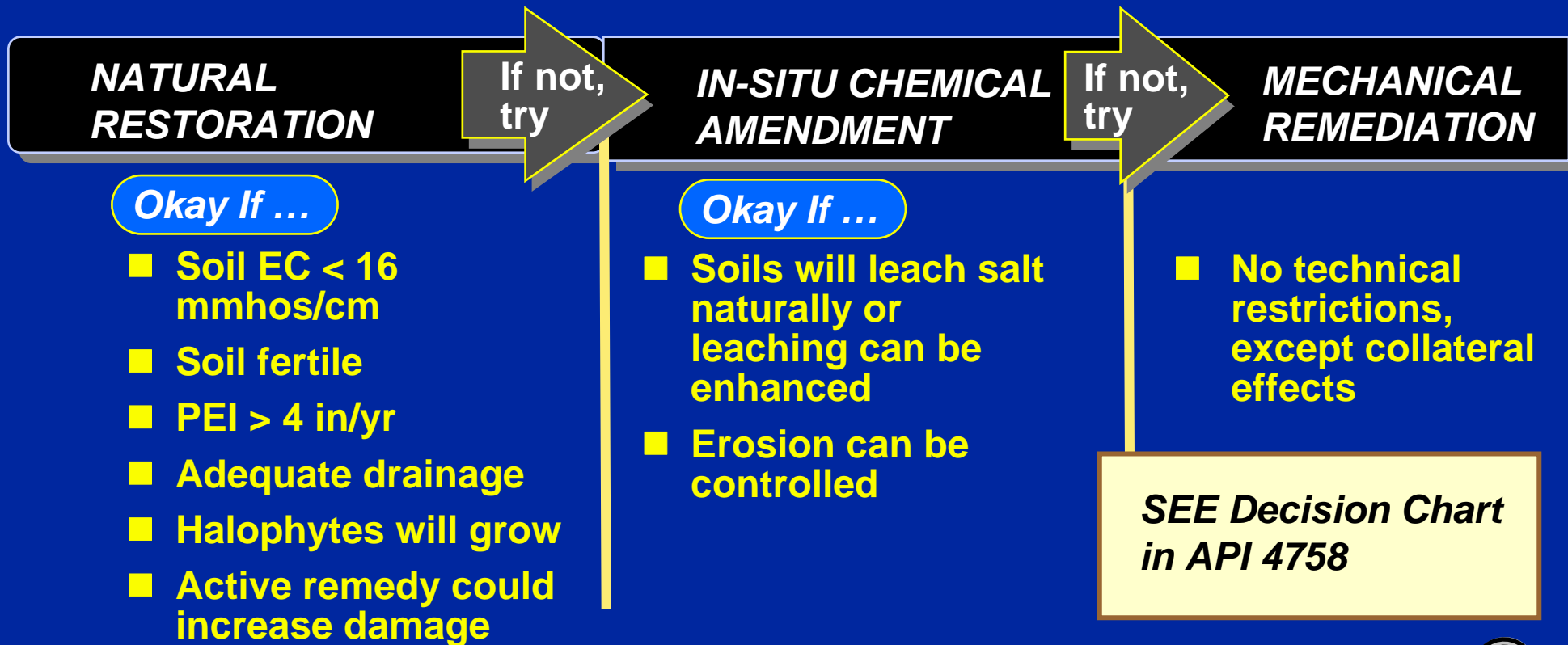
Will Groundwater be Impacted by PW Release?

SPILL SITE CONDITIONS:	 LESS LIKELY	 MORE LIKELY
Release Volume	< 100 bbls	> 100 bbls
Chloride Content	< 100,000 mg/L	>100,000 mg/L
Depth to GW	> 10 ft	< 10 ft
Soil Type	clayey	sandy
Spill Area (volume/area)	< 0.15 bbl/sq ft	

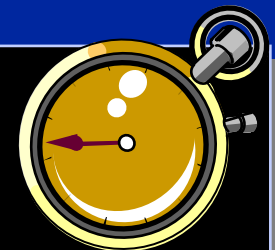
KEY POINT:

Most important variables for predicting groundwater impact = chloride mass, climate, soil type, depth to GW, aquifer thickness and flow.

Soil Remediation Options: *Will They Work?*



KEY POINT: If need rapid remedy, use chemical amendment or mechanical remediation.



Soil Remediation: *Natural Restoration*

Concept: Use plants and natural water flushing to restore salt-impacted soil.



Option A: Monitor natural revegetation process for 1 to 3 years.

Option B: Plant halophytic vegetation to restore affected area.

Rules of Thumb:

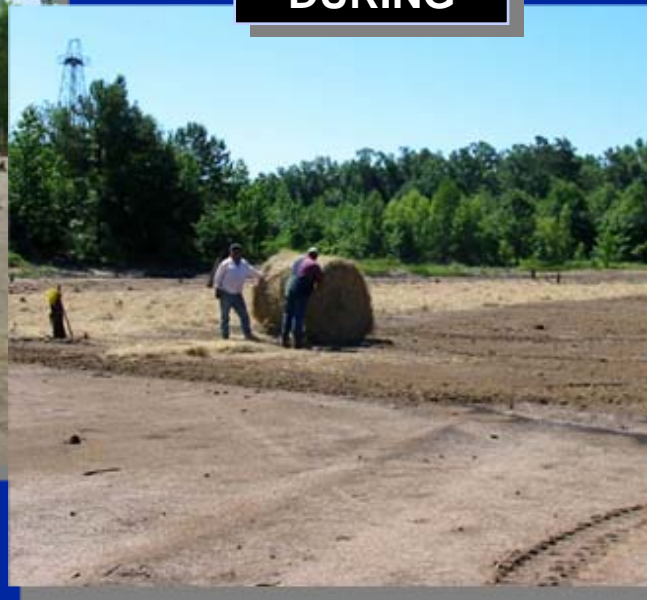
- ◆ **Mulch:** 2 to 4 inches
- ◆ **Fertilizer:** 28 lb per 1,000 sq ft of 13-13-13
- ◆ **Watering:** *Don't water clay soils!*

Soil Remediation: *Natural Restoration*

BEFORE



DURING



AFTER



Salt Remediation: *In-Situ Chemical Amendment*



ADDING GYPSUM

Concept: Add calcium to replace sodium and restore clay soil structure.

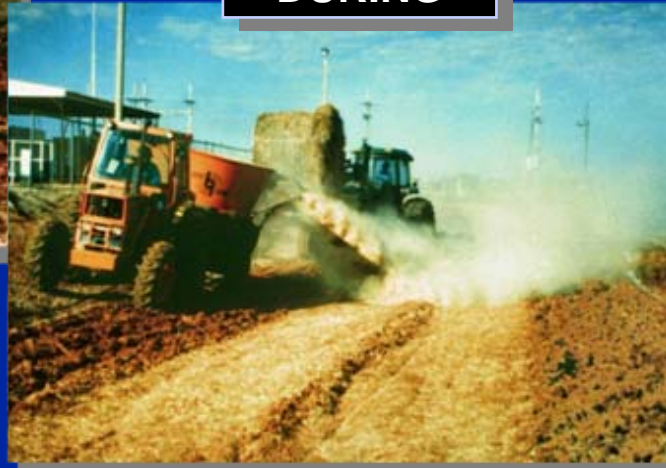
- **Drainage:** Improve as needed to leach Na.
- **Gypsum:** 13 lb/100 sq ft (or calculate per ESP, CEC, Na).
- **Mix:** Focus = upper 2 ft of soil. Add fertilizer and mulch if needed.
- **Irrigation:** Pulse flooding can reduce water requirements 50%. Perimeter berms improve infiltration.

Soil Remediation: *Chemical Amendment*

BEFORE



DURING



AFTER



Soil Remediation: *Mechanical Remediation*

BURIAL VAULT

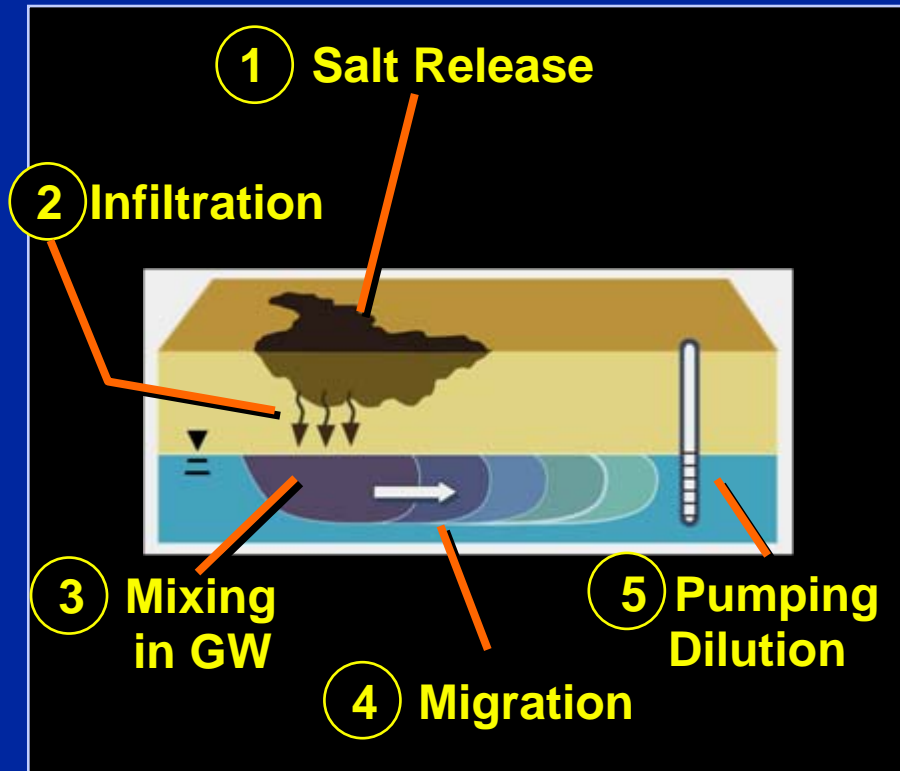


Concept: Optional methods for mixing, spreading, or relocating salt-impacted soil.

- **Land-spreading:** Mix affected soil with unaffected soil to reduce soil EC.
- **Burial:** Construct burial vault with capillary barrier; and gypsum, clay cover, and topsoil layers atop affected soil.
- **Road spreading** Use as roadbase per applicable regs.
- **Other:** Soil washing; landfill disposal.

API 4758: Addressing Impacts of Produced Water

Evaluating Groundwater Impacts: *Simple Modeling Tool*



API guide provides planning model to predict chloride impacts on GW

Step 1: Mass of chloride to soil

Step 2: Chloride infiltration to GW

Step 3: Chloride conc. in GW

Step 4: Chloride plume migration

KEY POINT:

■ All calcs based on simple nomographs
...no computer.



Site Investigation: *Data Needs*

Key Data Needs for Evaluation of Soil & GW Impacts

- **Soil Tests:**
EC, ESP (or SAR), CEC, Na, cleanup goal.
- **Soil Properties:** Hydr. cond., shrink-swell pot'l, slope, depth to GW, soil type (0-3 ft), unsat zone soil type.
- **Prod. Water:** Vol. and area of release Na, TDS, Cl levels.
- **Climate:** Annual rainfall, evaporation.
- **GW Data:** Source width, GW velocity, aquifer thickness, nearest well, cleanup goal.

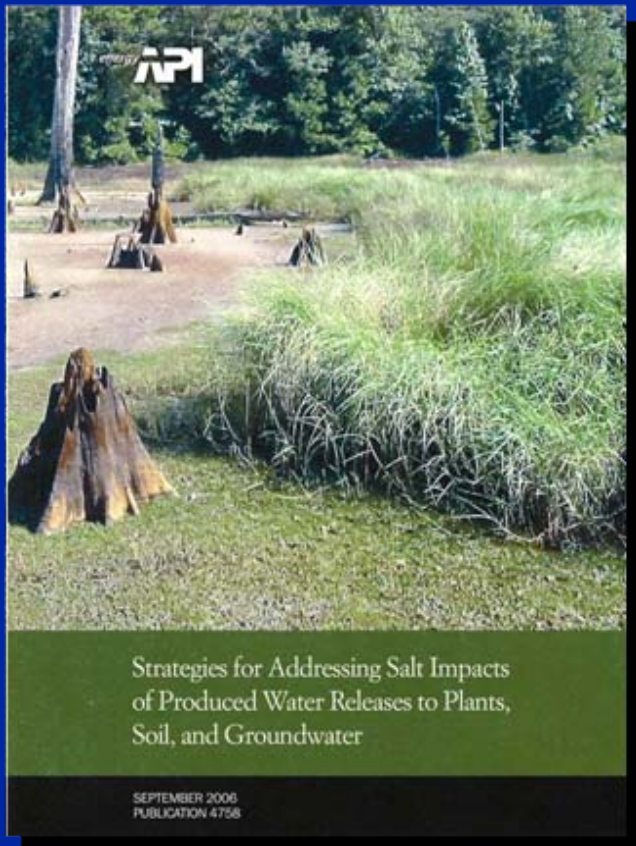


KEY POINT: API 4758 provides simple guidelines on data collection and field and lab analyses.

API 4758: Addressing Impacts of Produced Water

Where to Learn More

API 4758



*Download free
or buy fancy
printed version.*



www.api.org/produced_water

