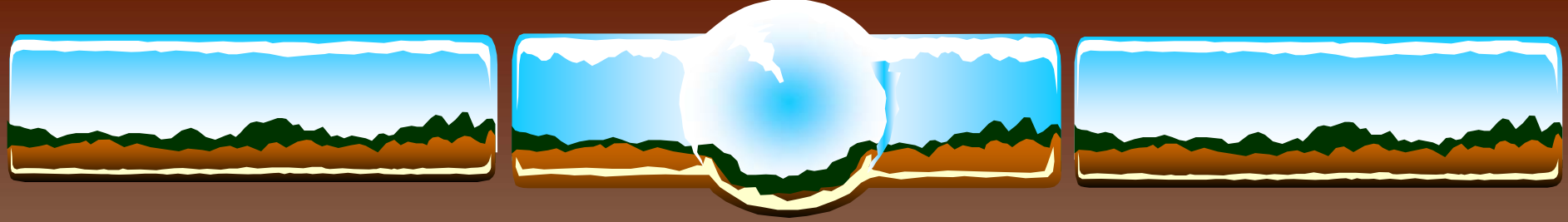


WDEQ/ Groundwater Program

CBM Impoundment Groundwater Quality Data Update 2007

Summary of Facility Information Powder River Basin

- Since new guideline in August 2004:
  - 30 operators using impoundments (reservoirs & pits) to discharge CBM produced water
  - 164 Pods (fed) & projects (non-fed) using impoundments to discharge CBM water
  - 1263 impoundments approved to discharge CBM water
  - 1371 borings to investigate these sites
  - 77 Chapter 3 permits issued to CBM operators for impoundments for groundwater compliance monitoring

Permitted Impoundments with Compliance Monitoring

- 164 impoundments have Ch 3 permits
  - Class I ……. 1 (before new policy)
  - Class II ……. 1 (before new policy)
  - Class III …….. 153
  - Class IV …….. 1 (near surface water)
- 183 compliance monitoring points
  - (several impoundments have multiple compliance monitoring point)

Exempt Impoundments

- 836 impoundments exempt from groundwater monitoring
  - Class IV ……..221
    - (example: > 5000 mg/L Total Dissolved Solids)
  - No groundwater ……586
    - (inc. < 0.5 gallons/minute groundwater yield)
  - Small capacity ……20
    - (less than 2 acre feet in capacity)

Other Ch 3 permit status information

- 121 investigated sites await regulatory action
- To date, operators elected to not use 88 sites which were investigated

Trigger Values for Total Dissolved Solids

- Since inception of required monitoring in Aug.,2004, 12 impoundments have exceeded their assigned trigger values for TDS
  - Compliance sampling is typically quarterly
  - Trigger value: “Compliance value < gw standard, which, if exceeded, ‘triggers’ monthly sampling”
- Eight impoundments currently exceed their trigger values (monthly sampling)
- Four have decreased to a value below the trigger value

Trigger Values for Sulfate

- A total of 11 impoundments have exceeded their assigned trigger values for sulfate at sometime or another
- Five currently exceed their trigger values
- Six have decreased again to below their trigger values

Trigger Values for Selenium

- A total of 8 impoundments have exceeded their assigned trigger value for Selenium at sometime or another
- Five currently exceed their trigger values
- Three have decreased again below their trigger values

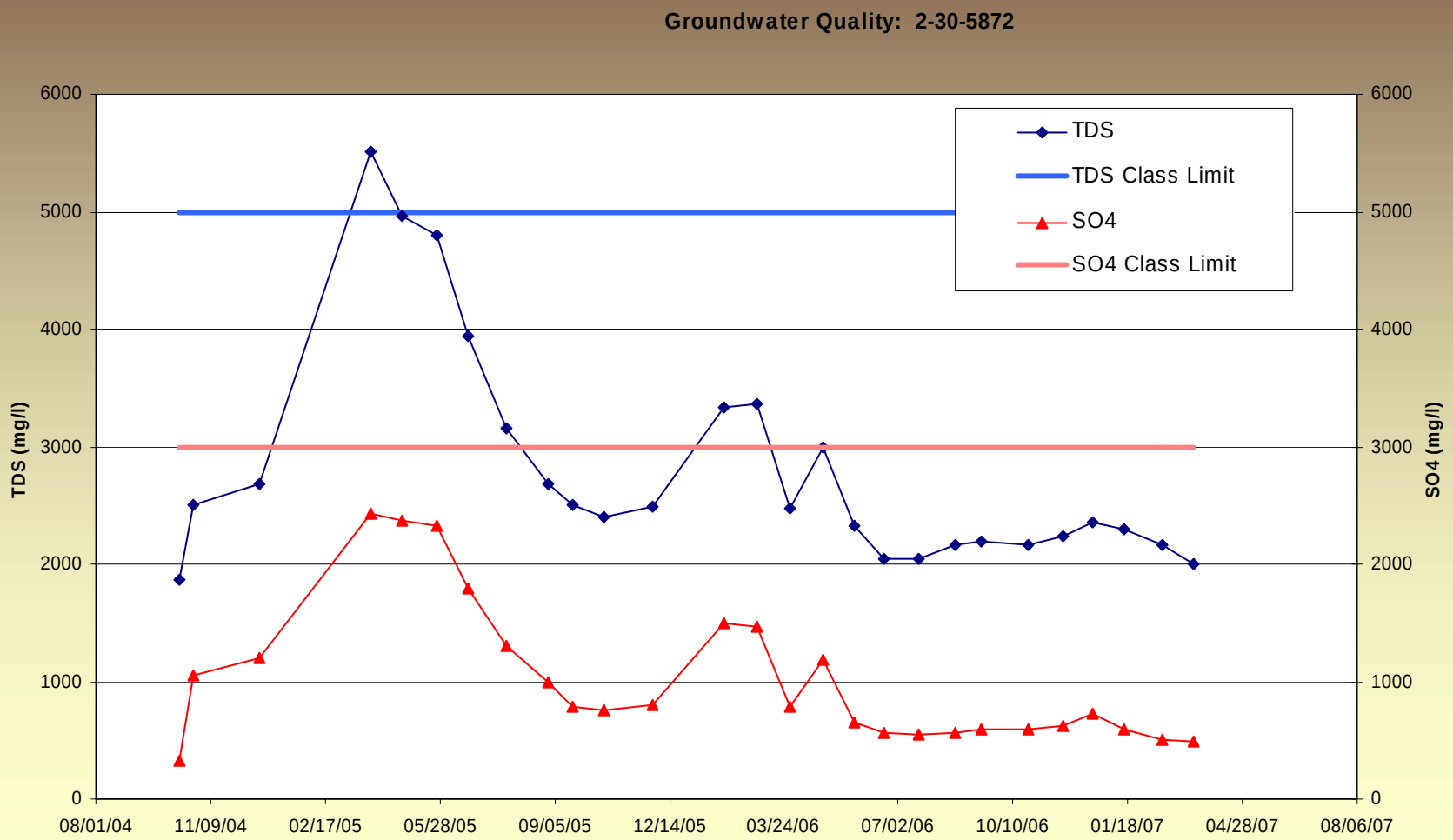
Trigger Values for Arsenic

- No impoundments have exceeded their assigned trigger values for Arsenic

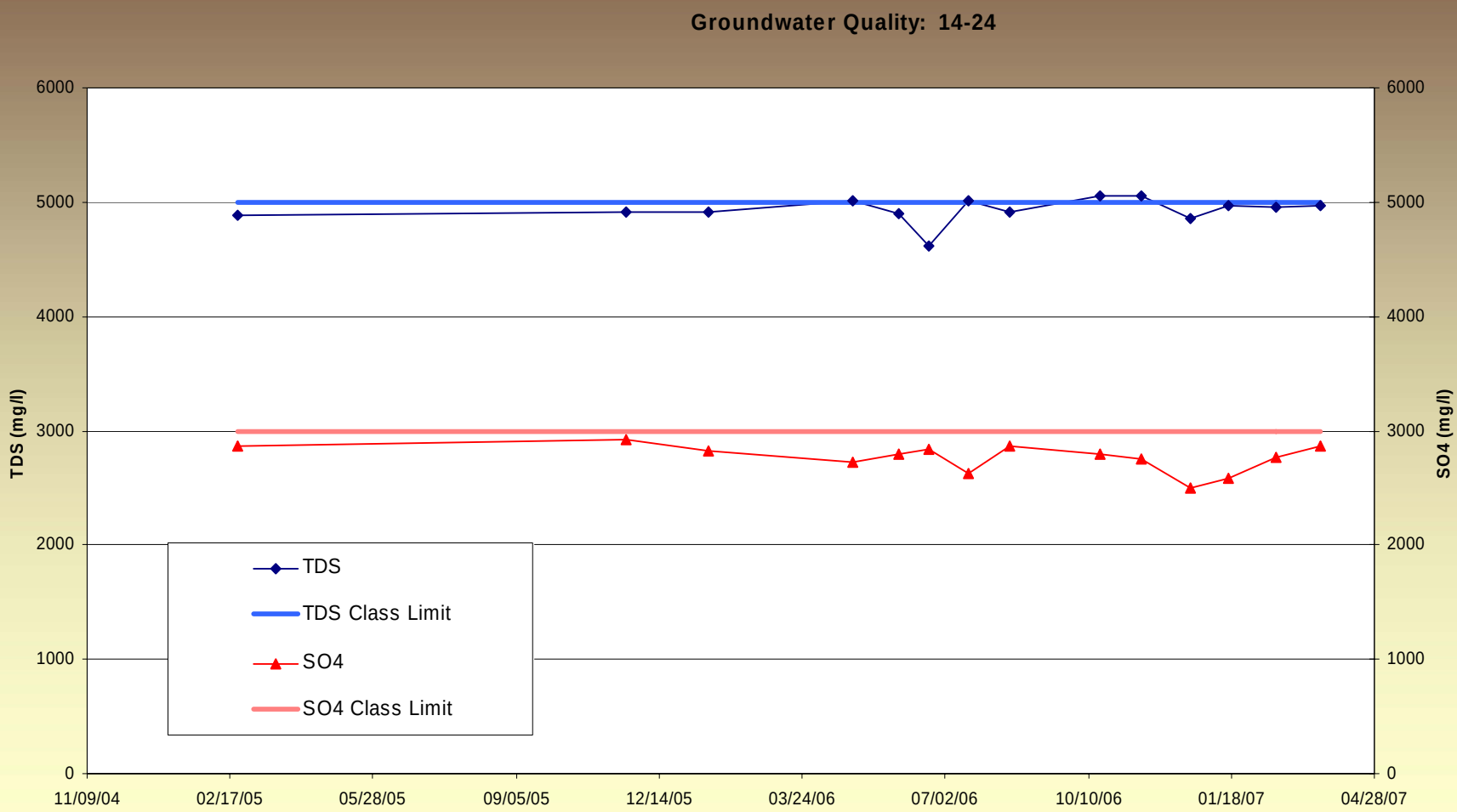
Impoundments that exceed Class of Use Standards

- Since inception of required monitoring in Aug.,2004, nine impoundments have exceeded the Class of use standard;
- Of these, only three currently exceed the assigned class of use
  - TDS: currently none exceed Class of Use
  - Sulfate: currently 1 exceeds Class of Use
  - Selenium: currently 2 exceed Class of Use

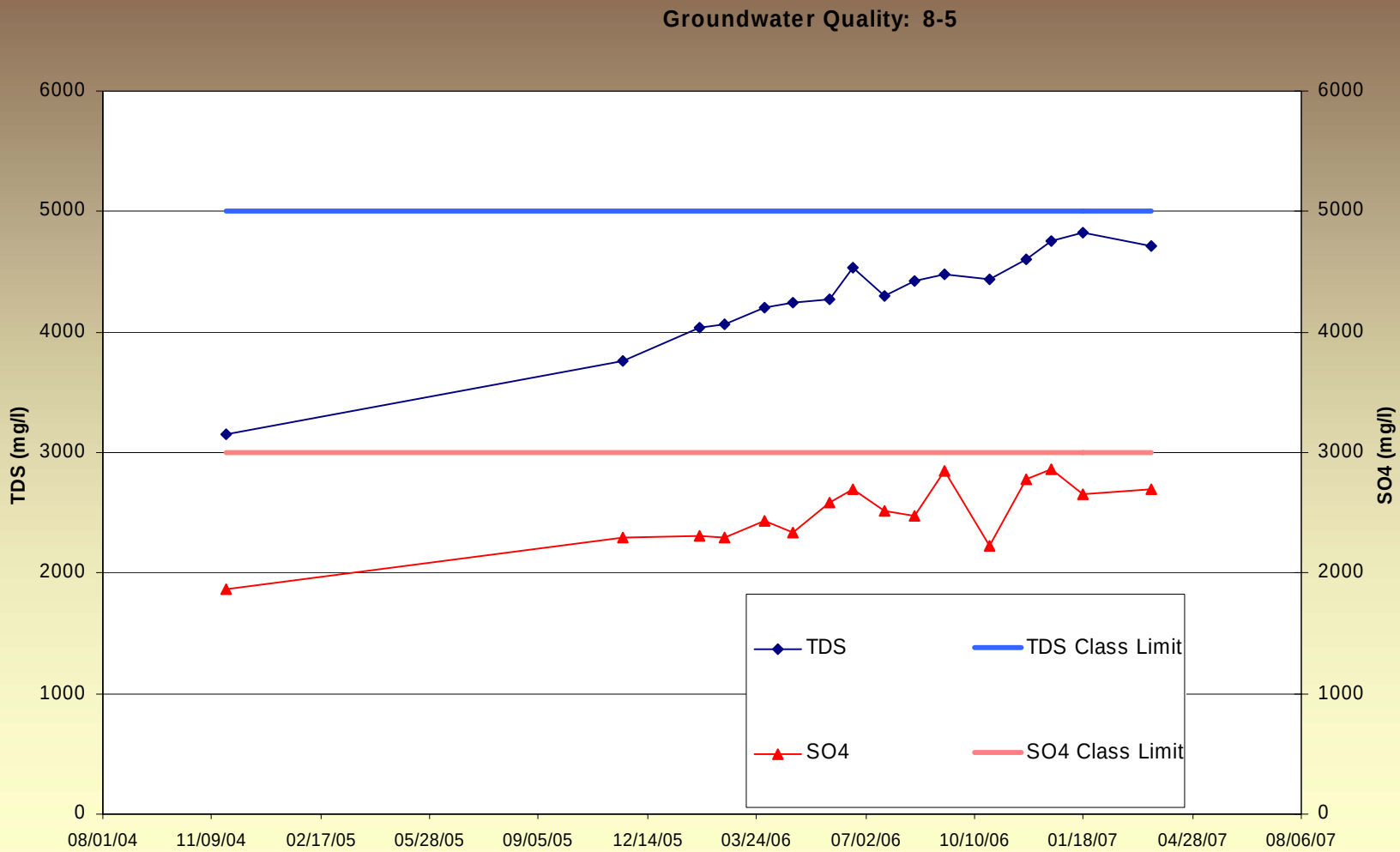
Groundwater Quality Example



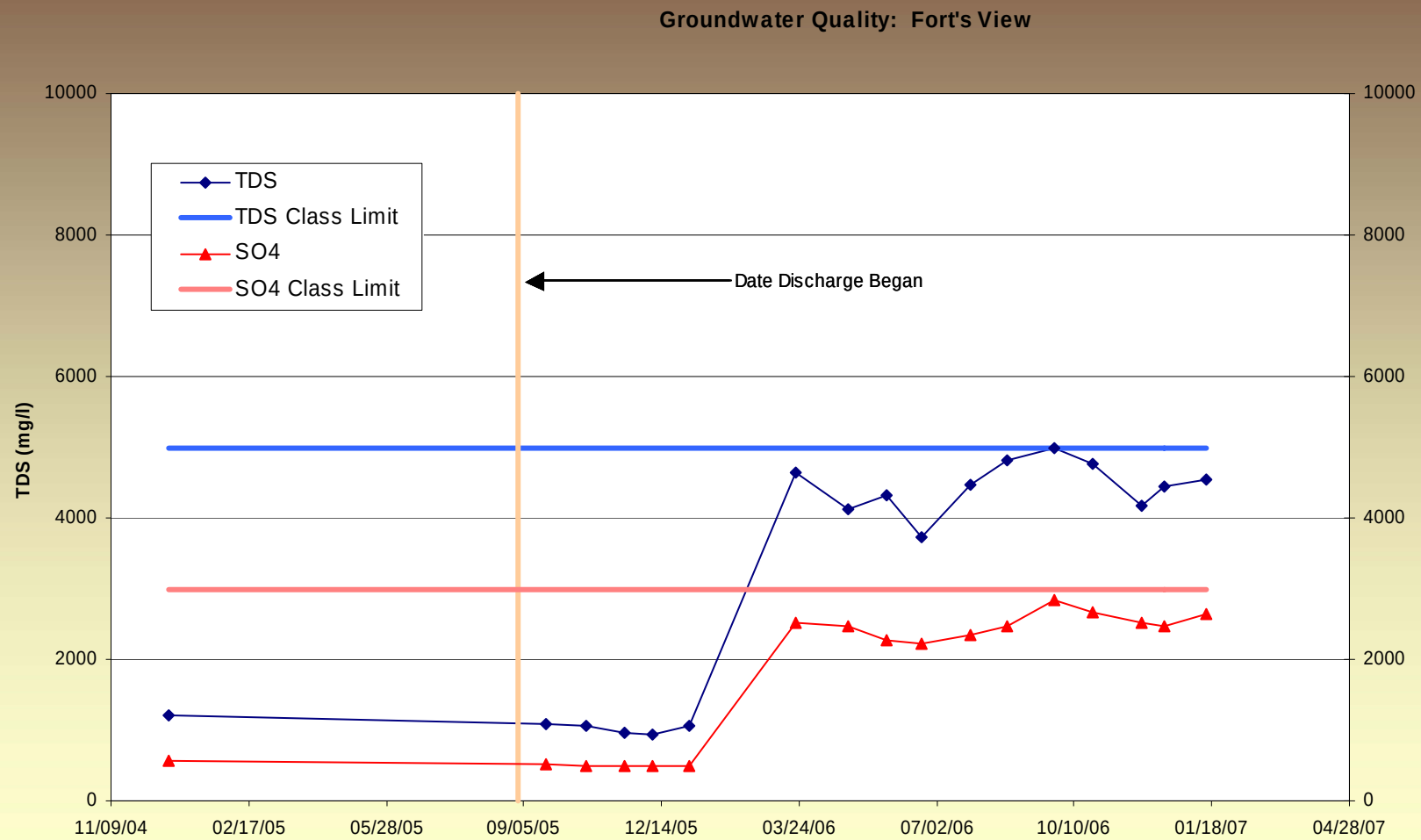
Groundwater Quality Example



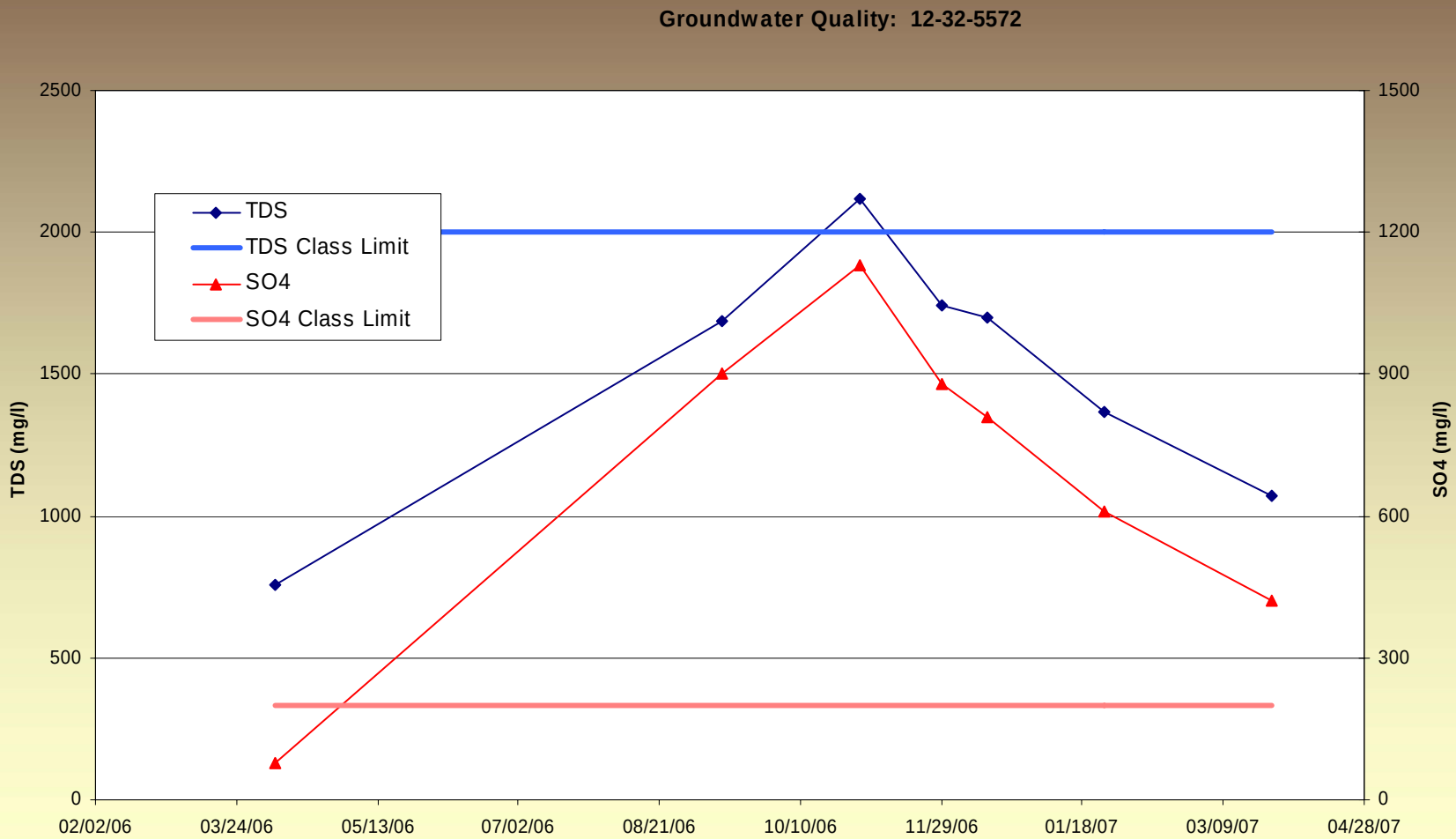
Groundwater Quality Example

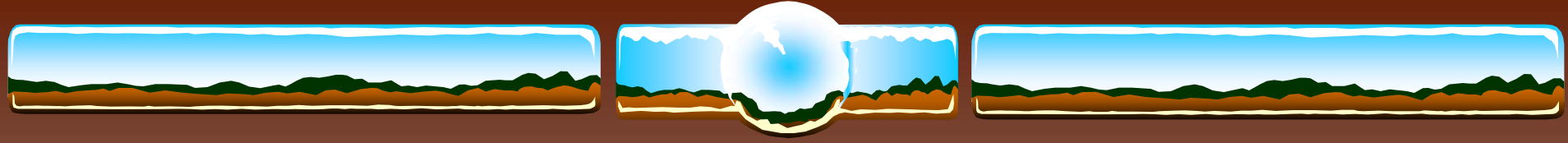


Groundwater Quality Example



Groundwater Quality Example





Discussion on current data set

- No large scale problems are evident to date
- Time for “flushing” of salts in vadose zone varies from site to site
- Need to establish fate of “salts” in groundwater downgradient from problem impoundments
- Need to establish time when discharge commenced into impoundment to get better handle on time of transport through the vadose zone
- Not enough data to date to draw definitive conclusions as to scale of impacts from infiltration impoundments

New Database

- New database being developed
  - Summer 2007
  - Internet &GIS Based
  - Includes locational & groundwater data for cbm impoundments, and all UIC facilities (vertical wells & subsurface irrigation systems)

Subsurface Drip Irrigation Systems (SDI's)

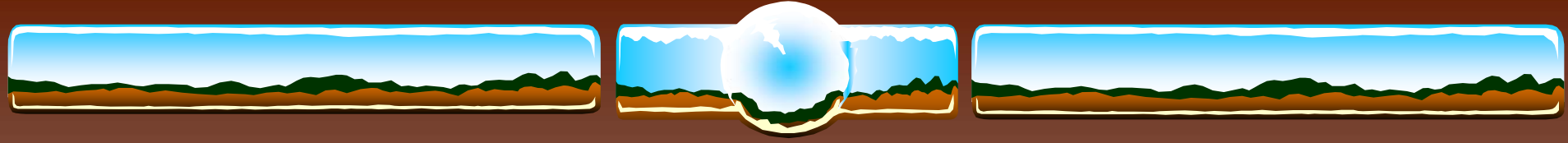
- Discharge of cbm water into shallow subsurface to grow crops or enhance native vegetation
  - Emitters typically 3 feet below ground surface
- 6 facilities have been permitted
- 14 more facilities have been proposed
  - Facilities vary from 30 acres to 600 acres (proposed)

Permit requirement

- WDEQ Chapter 16 UIC Permit Required
  - Compliance groundwater monitoring required
    - Groundwater protected to Class of Use
  - Surface water protection
    - CBM produced water cannot reach surface waters
      - Water balance (all facilities)
      - Groundwater models (proximal to perennial streams)
      - Visual inspections (ephemeral/intermittent streams)
- New guidance document late May, 2007

Beneficial Use of Water

- Hay crops: alfalfa yields 5-6 tons/acre at Perry Ranch on Prairie Dog Creek
- Water disposal 60-90 barrels/acre/day
- Disposal @ 65 barrels/acre/day (approx agronomic rates), 3000 irrigated acres would address over 71 million barrels of produced water/year



Further data needs

- Large scale (hundreds of acres) facilities proposed along major perennial streams
  - Need data on groundwater/surface water connectivity
    - Geophysical/electromagnetic profiles
- Need to establish ultimate fate of salts in soil profile (ie., Any long term impacts to soil?)
  - Recommend lab scale studies