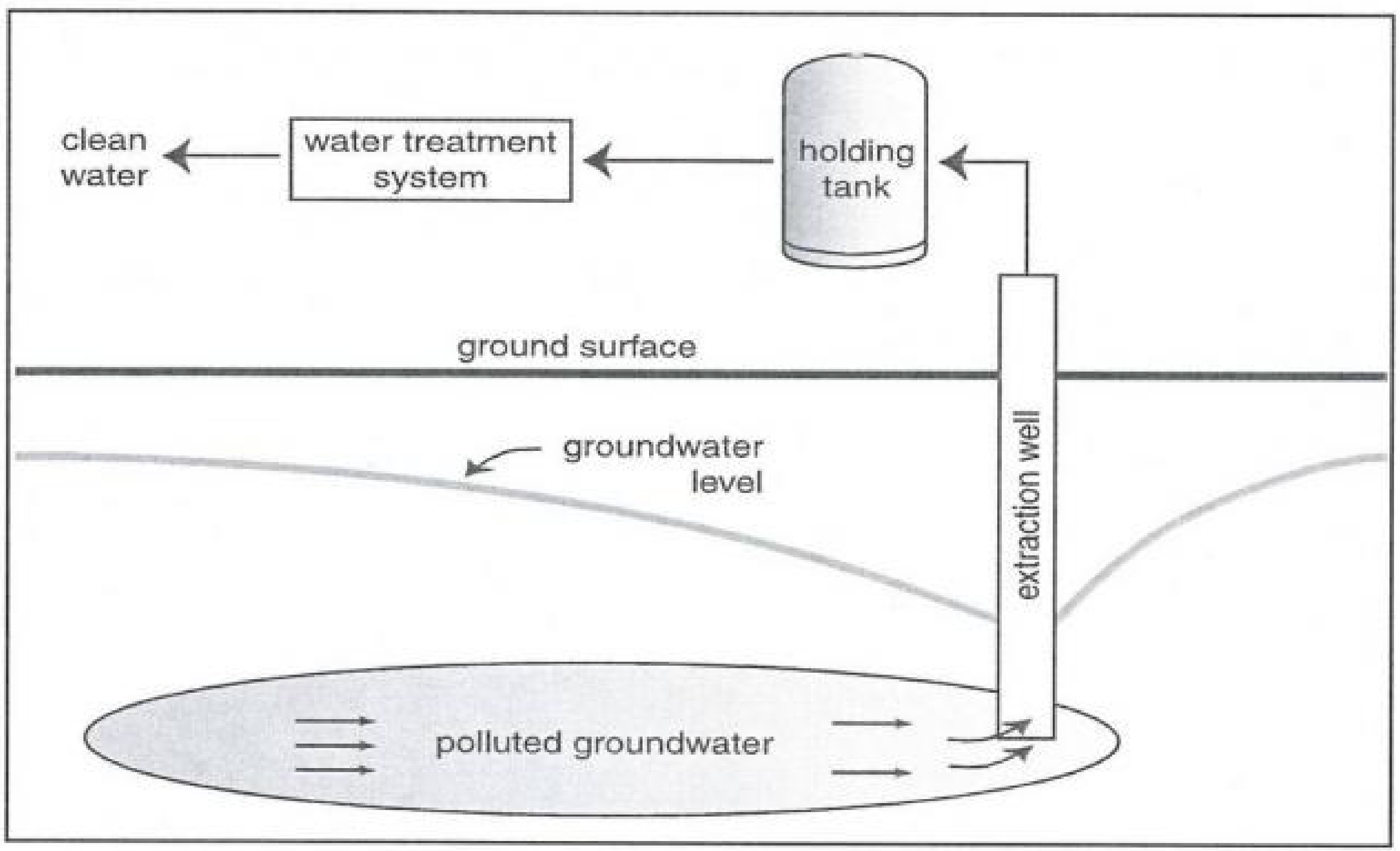
SB X2 1
Nitrate in Groundwater
Report to the Legislature

GROUNDWATER REMEDIATION

December 1, 2011

Pump and Treat

- Existing or new treatment facilities
- Remediation Basins



EPA, 2001b

Remediation Background

- The problem: Basin scale remediation of the groundwater quality.
- Basin scale remediation of groundwater quality has never been accomplished.
- Even plume scale remediation of groundwater has shown limited effectiveness.

Groundwater Volume Application Scale

Sub-Basin	Total Groundwater Volume in Study Area (Million AF)	Remediation Volume > ½ MCL (Million AF) [% of Total]	Remediation Volume > MCL (Million AF) [% of Total]
Tulare Lake Basin TOTAL	293	76.4 [26%]	32.2 [11%]
Salinas Valley Basin TOTAL	17.9	7.2 [41%]	3.4 [19%]
Study Area TOTAL	**311**	**83.6 [27%]**	**35.6 [11%]**

- Basin Scale
  - Have hypothetical examples based on plume scale methods; typical remediation options not practical for basin scale
  - Pump and fertilize potentially practical on basin scale
  - Remediation volume based on known nitrate levels
- Plume Scale
  - Remediation of known hot-spots
  - Plume size, boundary, depth and volume are site specific
  - Hypothetical plume characteristics

Width: 500 m	Depth: 75 m	Length: 2000 m
Span: 100 ha	Porosity: 0.1	Volume: 7.5 million m^3 (0.006 Million AF)

Remediation Options

- Pump and Treat - Basin-wide versus plume-scale application
  - Use of existing or new treatment facilities
  - Wood chip bioreactors
- *In situ* - Plume-scale application
  - In Situ Redox Manipulation (ISRM) - Injection of carbon source
  - Permeable Reactive Barriers (PRBs)
- Pump and Fertilize - Basin-wide application
  - Regional scale in situ removal of N via irrigation wells and irrigation of crops
  - Irrigation wells capture N-contaminated groundwater
  - Use crop irrigation and reduced fertilizer application to reduce N moving below root zone

Pump and Treat - Costs

Estimated Basin Scale Pump-and-Treat Water Treatment Costs Using Drinking Water Treatment Technologies:

	Total Remediation Cost (2010 $)			
	Biological Denitrification Treatment		Combined RO/IX Treatment	
	Scenario 1 (> ½ MCL)	Scenario 2 (> MCL)	Scenario 1 (> ½ MCL)	Scenario 2 (> MCL)
TLB	$29.4 billion	$12.4 billion	$65.5 billion	$27.6 billion
SV	$2.8 billion	$1.3 billion	$6.2 billion	$2.9 billion
TOTAL	**$32.1 billion**	**$13.7 billion**	**$71.6 billion**	**$30.5 billion**

Estimated Plume Scale Pump-and-Treat Water Treatment Costs Using Drinking Water Treatment Technologies:

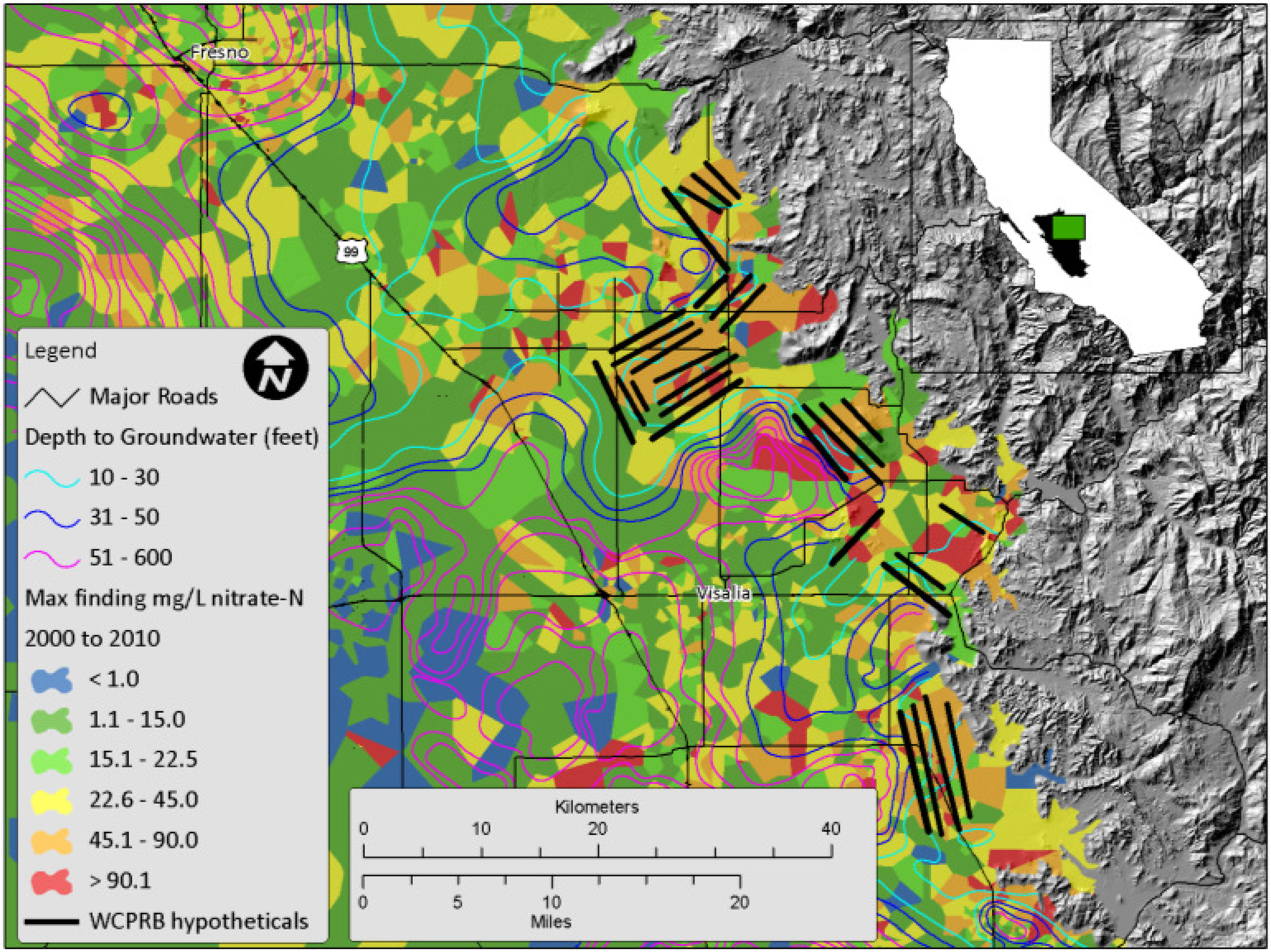
Total Remediation Costs:

Biological Treatment: **$2.3 million**

RO/IX Treatment: **$5.2 million**

NOTE: The above costs are presented as a hypothetical scenario for one time remediation, assuming no additional contamination. These costs include ONLY the treatment cost and do NOT include basin-wide infrastructure.

PRBs - Implementation



In situ Treatment - Costs

Case Studies: *In situ* remediation costs - PRBs

- *PRB costs depend on required depth*
- Mountain View, NM
  - Plume spans **>550 acres**, total volume of 1.6 billion gallons,
  - Nitrate levels as high as 300 mg/L N
  - Combination of PRB and ISRM – “biocurtain”/”biobarrier”
  - Project budgets **~$4 million** for multiple PRBs to address hot-spots
    - Removal of 450,000 lbs of nitrate over 4 years
    - Many years and considerable $$ has been invested in research (not included in cost above)
    - Currently in development

- Dover, DE
  - 10 gpm, ~5.3 million gallons per year
  - PRB depth: 39 ft, width: 68 ft, thickness: 4 ft, captures **50 ft of plume across 25 vertical feet**
  - Full-scale PRB at Dover AFB for CVOCs rather than nitrate
    - Capital Costs: Total Capital Cost: **$947,000**
    - O&M Costs: Total Annual O&M Cost: **$190,100**

- WCPRB Eastern TLB – estimated
  - 120 miles of WCPRB to treat 60 square miles of high-NO_3, shallow groundwater (~ 40,000 acft)
  - 1.6 million cu. yds chips (400,000 tons)
  - **$150 million + design/permitting/monitoring**

Pump & Fertilize Can Reduce Fertilizer Costs Enough to…

- For 6,000, 10,000 or 20,000 active wells in study area, nitrate data collection cost is $0.9 million, $1.5 million or **$3 million per year**.
- For a median nitrate concentration of 21 mg/L, 7.85 km^3 (6.1 million ac-ft) of irrigation water has potential for providing 35,000 MgN/yr.
- At current N fertilizer costs (>$1 per kg N; $0.50-$0.75/lb N), est. fertilizer value of irrigation water is >$35 million.
- If PAF can exploit at least 1/3 to ½ of the water fertilizer value, net savings in fertilizer costs could be on order of $10-$20 million.

Key Findings

- Remediation of basin-scale, nitrate-contaminated groundwater in the classical sense is not possible.
- Long-term improvement of groundwater quality is possible through the following actions:
  - Source reduction through recommended practices.
  - Clean up of N hot spots with plume-scale remediation methods.
  - Regional adoption of pump-and-fertilize methods.
  - Monitoring for performance assessment, and adjustments to the above as appropriate.
- Basin-scale management of groundwater quality is needed.
  - In turn, requires management of groundwater quantity, including the amounts and distributions of both ‘clean’ and ‘dirty’ recharge.
  - Groundwater quality management needs to be an ongoing process that uses both monitoring and modeling to adjust land and water management.

Pump and Fertilize (PAF)

- Could be done mainly with existing wells
- Requires farm- and field-scale monitoring of N in applied water AND management (reduction) of applied N in accordance with amount of N already in the water
- Some farmers already doing PAF and reaping lower fertilizer costs
- Pilot field projects and regional modeling needed to quantify benefits and project time frame for clean-up (likely many decades or more)

Cost of PAF

- Factors:
  - Type of irrigation
  - Combined groundwater and surface water sources of farm water
  - Numbers, locations and depths of irrigation wells on farm
  - Education, training and planning
  - On farm infrastructure changes and monitoring costs
  - Amount of N in the pumped groundwater (i.e., fertilizer value of the groundwater)

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