Western Nuclear Inc.
Split Rock Site
Analytical Transport Modeling of Nitrate

Presentation to NRC in Rockville, MD

October 12, 2016

Presentation Topics

- Problem Statement
- Purpose & Objectives
- Technical Approach
- Model Design
- Analytical Model Results
- Model Results Applied to Other Constituents
- Proposed LTSB
- Institutional Controls on Lands within LTSB
- Proposed License Amendment
- Questions and Next Steps

Problem Statement

Current groundwater concentrations of nitrate down gradient of the Southwest Valley point of compliance (POC) well MW-21 are greater than the approved alternate concentration limit (ACL) of 70.7 mg/L, which is not consistent with 10 CFR Part 40, Appendix A, Criterion 5B(1).

A technical basis is needed to rationalize a conservative point of exposure, which is commensurate with the LTSB, to support decision making and provide the requisite reasonable assurance of protection for the statutory compliance period for all hazardous constituents.

Purpose & Objectives

Purpose:

Provide a technical basis for amending radioactive material license SUA-056 to modify the approved nitrate alternate concentration limit ("ACL") in the Southwest Valley at the point of compliance (POC) well MW-21 from 70.7 mg/L to 500 mg/L.

Purpose & Objectives

Objectives:

Resolve the outstanding issues regarding:

- nitrate groundwater concentrations beyond the POC being higher than the approved ACL in conflict with 10 CFR 40 Appendix A, Criterion 5B(1); and

- uncertainty between measured groundwater concentrations at monitoring wells SWAB-2 and SWAB-1/1R, and modeled conditions and the impact of that uncertainty on the appropriate location for the proposed Long Term Surveillance Boundary (LTSB).

Technical Approach

Analytical Model

- ATRANS1, Version 1, a public domain software provided by S. S. Papadopulos.
- Simulates transient, three-dimensional advective-dispersive transport from a patch of specified concentration along the inflow boundary of an aquifer.
- Calculates exact solutions to the Advection-Dispersion Equation (ADE) using Laplace transforms.
- Computes concentrations at defined nodes (x,y,z,c) at specified times
- Computes time-concentration series at predefined points

Technical Approach (ATRANS1 Assumptions and Limitations)

- The aquifer is assumed to be semi-infinite, isotropic and homogenous.
- Aquifer is saturated
- Groundwater flow is steady-state
- Flow is uniform and one-dimensional along the x-axis
- Dispersion is assumed to be a Fickian process;
- The principal axes of the dispersion tensor are assumed to coincide with the directions parallel and transverse to groundwater flow
- Concentration patch source is assumed to be constant in time

Model Design

The ATRANS1 model was constructed to be consistent with the previous groundwater flow and transport models.

Flow Path

- Approximately 21,300 ft., from SWAB-2 to river.
  - Conservative, shorter than actual distance from POC to River
  - Consistent with mapped nitrate plume in 1996.
  - Consistent with 2003 modeling of uranium.
  - No dilution due to recharge infiltration
- Thickness (350 ft.)
  - Consistent with Upper Split Rock Formation thickness

Model Design (Continued)

Model Geometry

- The domain is discretized for the purpose of point calculation. Concentrations are calculated at each nodal point
- Model width = 10,000 ft. (nodes every 100 feet)
- Model Length = 21,310 ft. (nodes every 100 feet)
- Model Thickness = 350 ft. (nodes every 50 feet)
- Source patch is 2,000 feet wide x 350 feet thick
- Horizontal longitudinal velocity (q) calculated using Darcy's Law : $q = ki/\Theta$;
  - k = hydraulic conductivity
  - i = hydraulic gradient
  - Θ = effective porosity

Site Ownership Map with Groundwater Contours and Estimated Flow Path

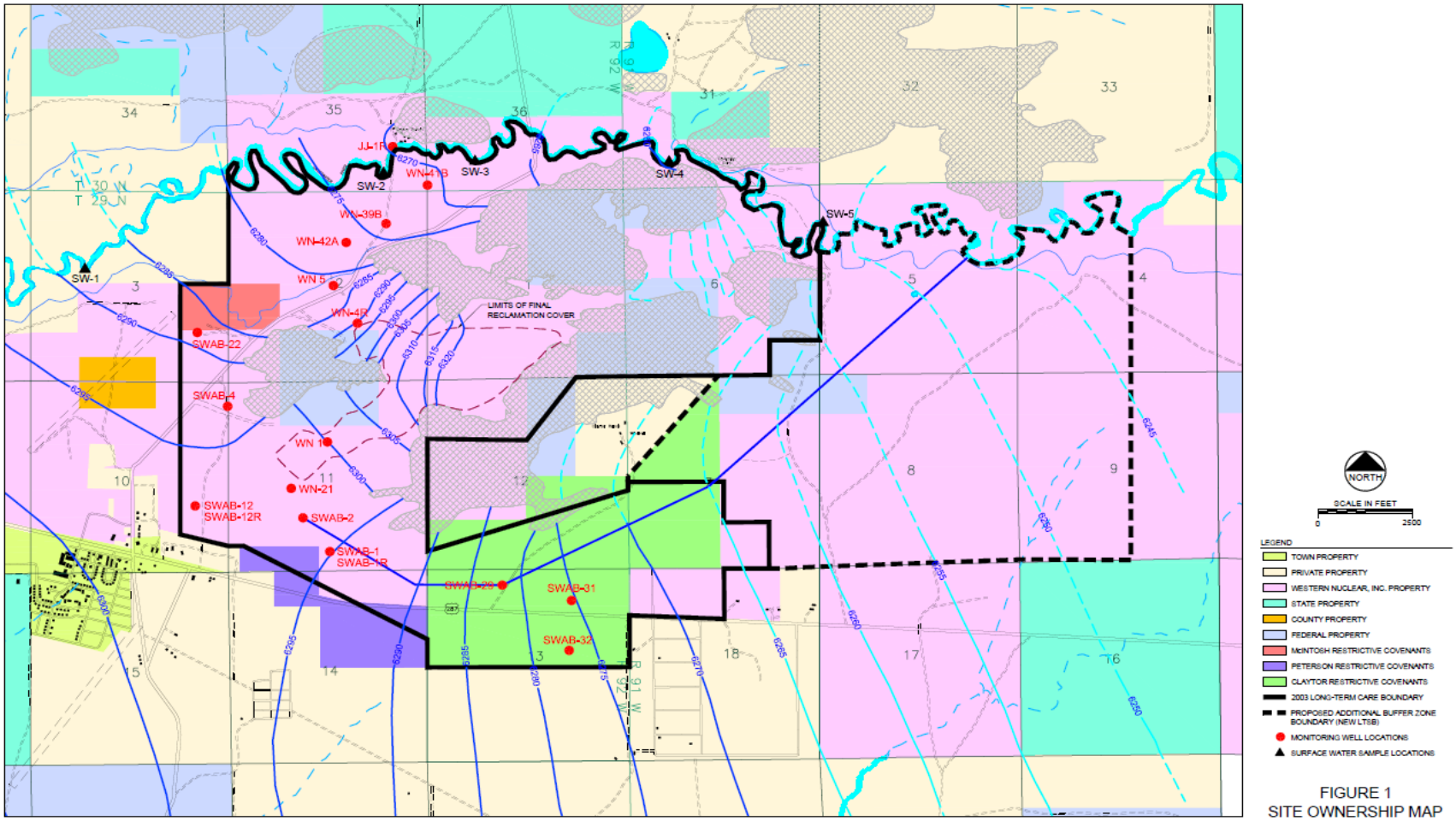


FIGURE 1
SITE OWNERSHIP MAP

Input Parameters & Basis

Flow Parameters

- Hydraulic Conductivity (K) = 5 ft/day
  - Higher than used in 1999 modeling (3.25 ft./day)
- Gradient (i) = 0.00244 ft./ft.
  - Head at SWAB-2 ≅ 6,292 ft. MSL (approx. 2016 level)
  - Head at Sweetwater River flow path axis conservatively assumed ≅ 6,240 ft. (actual elevation closer to 6,245 ft.)
  - Length of flow path 21,310 ft.

Input Parameters & Basis

Transport Parameters

- Source Concentration = Constant 500 mg/L applied at SWAB-2, conservative maximum
- Source Geometry

  2,000 x 350 feet full thickness of Upper Split Rock Formation; conservative…current observed plume is thinner at SWAB-2 (see Figure 29 from 1999 GWPP)
- Porosity (Θ) = 0.30
- Dispersivity (α)

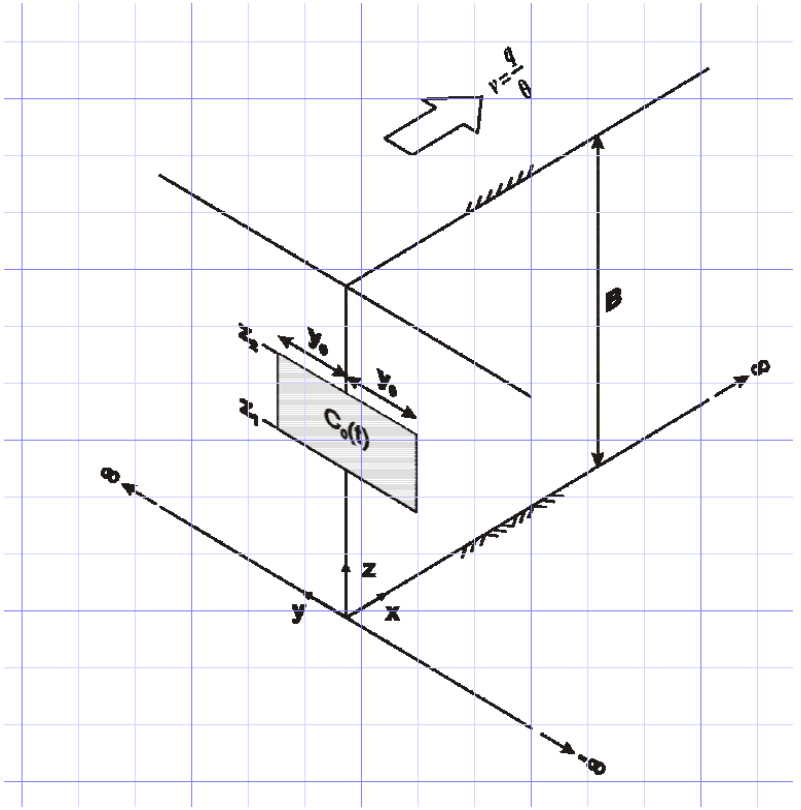
  αL= 200 ft, αT = 20 ft, αV = 2 ft.

  consistent with previous modeling
- Retardation = 1, treated as a conservative solute

Model Geometries And Input Parameters

Model Dimensions

X Dimensions	Y Dimensions	Z Dimensions
xmin= 0	ymin= -5,000	zmin=0
xmax=21,310	ymax=5,000	zmax=350
dx= 100	dy = 100	dz = 50



Parameter Assignment

h1 = head at SWAB-2 h2 = Head at Sweetwater River

Δh = h1 – h2

Δx = Distance from SWAB-2 to Sweetwater River

I = Δh/ Δx K = Hydraulic Conductivity

Θ = Effective Porosity

α_L, α_T, α_V = longitudinal, transverse and vertical dispersion

Model Parameters

H1 = 6,292 feet (SWAB-2)

H2 = 6,240 feet (River) Δh=52 feet

Δx = 21,310 feet (SWAB-2 to River)

i= 0.00244 feet/foot

K = 5 feet/day Θ = 0.3

Q = 0.0122 cubic feet/day v=0.0407 feet/day

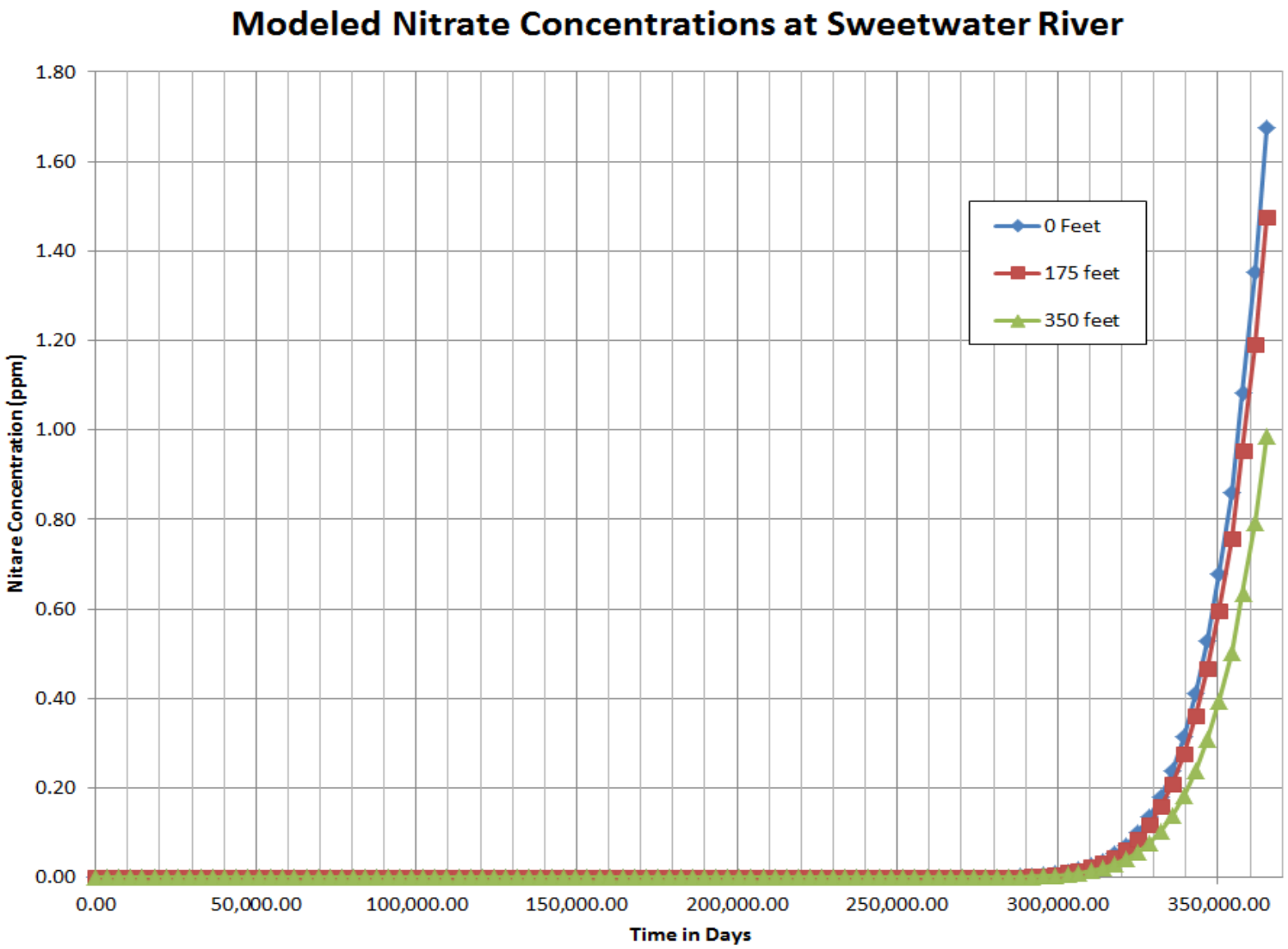
αL = 200 feet αT = 20 feet αV = 2 feet

Nitrate Source Parameters

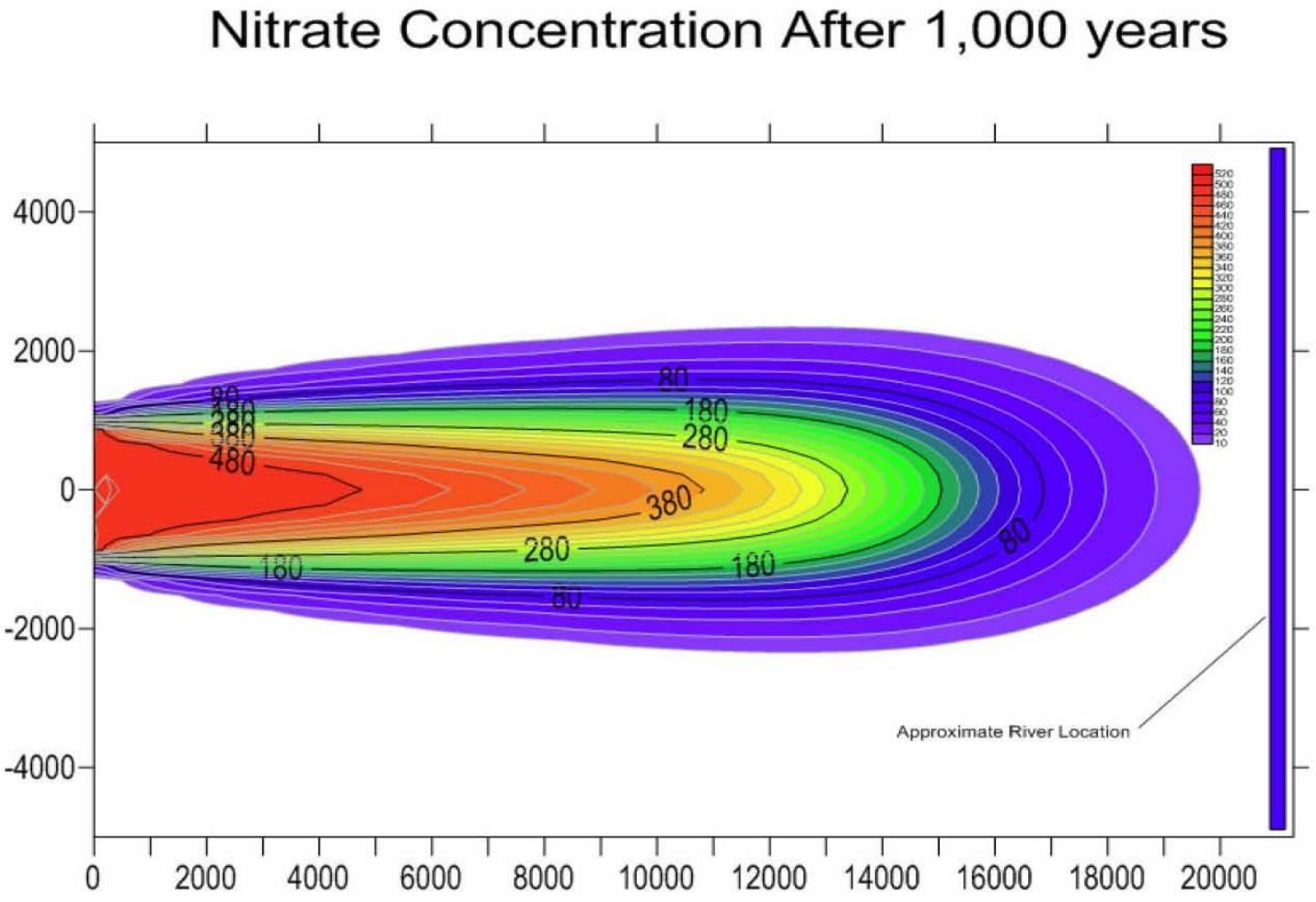
$C_0(t)$	500	mg/L
Z_0	0	feet
Z_1	350	Feet
Y_0	1,000	Feet

Analytical Model Results

Analytical Nitrate Transport Model Results at the Sweetwater River (ppm)



Nitrate (ppm)
Analytical Transport Model Results



TRANSPORT PARAMETERS

AVERAGE LINEAR GROUNDWATER VELOCITY = 4.070E-02
LONGITUDINAL DISPERSIVITY = 2.000E+02
HORIZONTAL TRANSVERSE DISPERSIVITY = 2.000E+01
VERTICAL TRANSVERSE DISPERSIVITY = 2.100E+00
EFFECTIVE DIFFUSION COEFFICIENT = 0.000E+00
AQUIFER THICKNESS = 3.500E+02

SOLUTE PROPERTIES

CONTAMINANT DECAY CONSTANT = 0.000E+00
RETARDATION FACTOR = 1.000E+00

SOLUTION PARAMETERS

NUMBER OF GAUSS POINTS = 60
NUMBER OF TERMS IN SERIES = 50

PATCH DIMENSIONS

SOURCE WIDTH = 2.000E+03
BOTTOM OF SOURCE LOCATED AT Z1 = 0.000E+00
TOP OF SOURCE LOCATED AT Z2 = 3.500E+02

INFLOW CONCENTRATION HISTORY

CONSTANT CONCENTRATION C0 = 5.000E+02

Analytical Model Results

- Source conditions highly conservative
  - constant source at 500 mg/L, never observed nor expected, diminishing source highly probable.
- Transport assumptions are conservative, no retardation, decay or degradation
- Modeled flow path conservative, shorter than POC to River
- Flow and transport assumptions consistent with previous models, analytical model neglects surfacial recharge

Analytical Model Results

- 10 mg/L nitrate plume contour does not reach the river in 1,000 years.
- 1.7 mg/L in groundwater at river edge in 1,000 years.
- Significant factor of safety in groundwater at LTSB
- Significant factor of safety with dilution by river.

Model Results Applied to Other Constituents

- Modeling results can also demonstrate that all other hazardous constituents will remain protective at the proposed LTSB for the period of compliance.
  - Modeling assumes purely conservative transport (no retardation, decay, or degradation)
  - Modeling would over predict any hazardous constituent that is not purely conservative in transport.
  - Therefore, observed dilution ratio (ratio of source concentration to modeled groundwater concentration at the LTSB) can be used to assess if any other hazardous constituent in the Southwest Valley groundwater will exceed protective levels in groundwater at the LTSB.

Ratio of Source Term to Protective Levels

- Nitrate Source Term = 500 mg/L
- Modeled nitrate concentration in groundwater at the river boundary in 1,000 years = 1.7 mg/L

Ratio of source to concentration in groundwater at the river boundary in 1,000 years:

500 mg/L to 1.7 mg/L = 294:1

Applying ratio 294:1 to the maximum Southwest Valley groundwater concentration ever measured for each hazardous constituent allows estimation of maximum potential groundwater concentration at the LTSB (in groundwater at the edge of the river), assuming purely conservative transport.

Ratio of Source Term to Estimated Levels

- The following table shows:
  - Maximum constituent conc. ever measured in POC well WN-21, SWAB-2, and SWAB-1/1R
  - Estimated concentrations in groundwater at LTSB given a ratio of 294:1 based on the maximum measured concentrations
  - Protective Values for each constituent
  - Background value for each constituent
  - Factors of Safety

	Max. Measured in WN-21	Max. Measured in SWAB-2	Max. Measured in SWAB-1/1R	[1]Estimated GW Conc. at LTSB with 294:1	Protective Value	[2]Factor of Safety	[3]Split Rock Formation Background	Units	Basis for Protective Value
Nitrate (NO_3+NO_2-N)	35.6	343	153	1.7	10	9	3.99	mg/L	MCLG
Uranium (Unat)	1.618	3.033	3.517	0.012	0.03	3	0.1264	mg/L	MCL
Ammonia (NH_3-N free)	0.5933	0.2159	0.0069	0.002	0.7	347	0.7	mg/L	Upper Split Rock Fm. Background
Manganese (Mn)	10.21	11.1	0.18	0.038	0.2	5	0.53	mg/L	WDEQ Class II
Molybdenum (Mo)	<0.1	<0.1	<0.1	<0.0003	0.004	>13	0.100	mg/L	EPA Health Assessment Level
Radium-226+228	4.7	10.6	1.6	0.036	5	139	5.30	pCi/L	MCL
Sulfate (SO_4)	1,053	2,630	1,940	8.9	250	28	133	mg/L	MCLG

[1] Using maximum concentration ever measured from WN-21 (POC well), SWAB-2 and SWAB-1/1R

[2] Factor of Safety = Estimated GW Concentration at LTSB ÷ Protective Value, does not account for constituent dilution in river

[3] Table F-5-15 Background Upper Prediction Limits for Split Rock Formation Groundwater, Appendix F to 1999 Ground Water Protection Plan (WNI, 1999)

Ratio of Source Term to Estimated Levels

- No hazardous constituent ever exceeds protective level at proposed LTSB for the period of compliance.
- Several of the constituents, (e.g., uranium, radium, manganese), are not conservative in transport but are known to be retarded in transport.
- Substantial factors of safety exist at the proposed LTSB.
- The factors of safety do not account for potential dilution in the river.

Proposed Long Term Surveillance Boundary

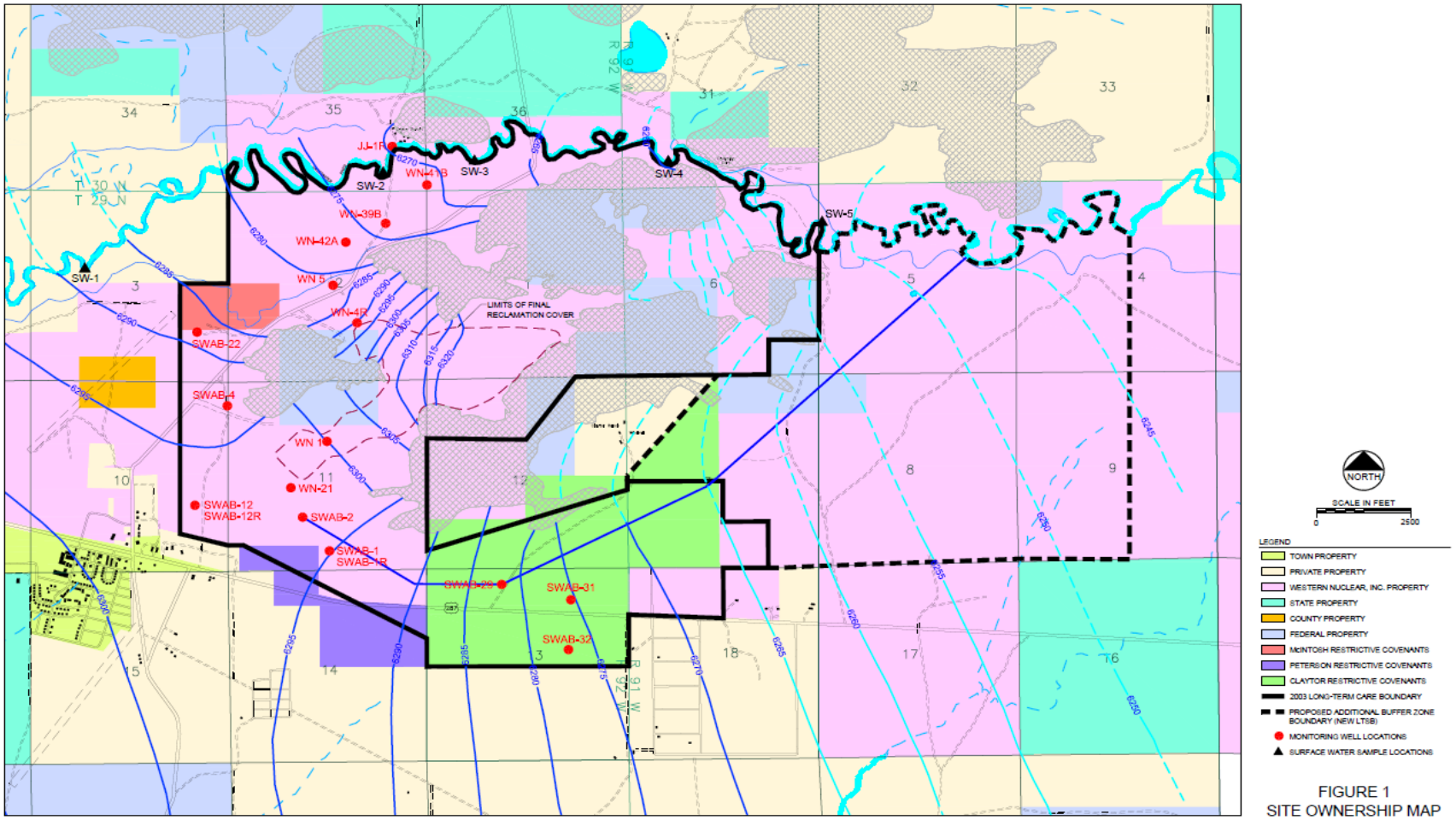


FIGURE 1
SITE OWNERSHIP MAP

Institutional Controls on Lands within the Proposed LTSB

- Rely on exactly the same controls previously proposed and assessed by NRC.
  - Full WNI ownership of surface and subsurface estates
  - Full Federal ownership of surface and subsurface estates
  - Claytor, Peterson, and McIntosh property restrictive covenants already acquired.

Proposed License Amendment

RML SUA-056

Condition 74. The licensee shall implement a compliance monitoring program containing the following:….

A. ……..(*no change*)

B. ……..(*no change*)

C.

…… ……..(*no change to Northwest Valley conditions*)

Comply with the following alternate concentration limits in the southwest valley at point of compliance Well 21, with background being recognized in Well 15:

ammonia = 0.84 mg/L, manganese = 35 mg/L, molybdenum = 0.22 mg/L, nitrate = ~~70.7~~ 500 mg/L, radium-226 and -228 = 19.9 pCi/L, and natural uranium = 3.4 mg/L.

Questions & Next Steps

- Questions?
- Next Steps
  - Finalize and submit modeling technical memorandum with a transmittal letter requesting:
    - Amendment to RML SUA-056 modifying the Southwest Valley POC well ACL for Nitrate from 70.7 mg/L to 500 mg/L; and proposed revised LTSB.
    - Approval of the requested amendment
    - Prompt initiation of DOE Development of LTSP
    - Prompt initiation of USACOE review
    - License termination.