Performance Assessments for EnergySolutions: History and Concepts

Loren Morton
Utah Division of Radiation Control
(lmorton@utah.gov)

EnergySolutions (ES) – Clive, UT
(~70 mi West of Salt Lake City)

ES Disposal Cells

- Uranium / Thorium Tailings:
  - Vitro
  - 11e.(2)
- Low-Level Radioactive Waste (LLRW)
  - LARW
  - Class A
  - Class A North
- Mixed Waste (LLRW + EPA RCRA)

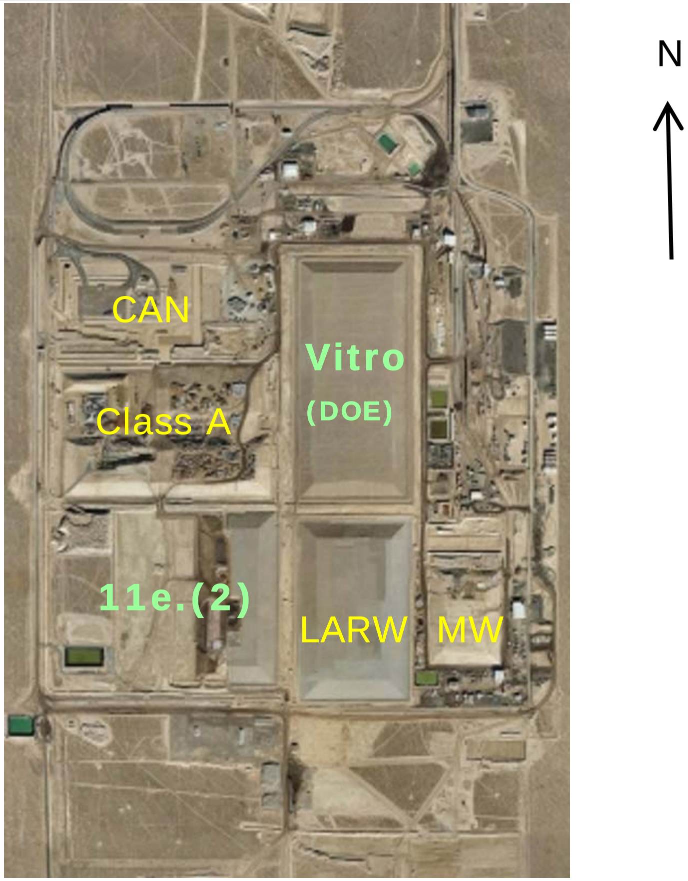


Photo: http://www.energysolutions.com/media-center

Performance Assessment (PA) Considerations – early 1990's

- LLRW - defined by what it is NOT
  - **NOT** (10 CFR 61.2):
    - High Level Radioactive Waste
    - Transuranic (TU) Waste (heavier than uranium)
    - Spent Nuclear Fuel
    - By-product material (e.g. uranium tailings)
    - Special Nuclear Material (fuel)
    - Uranium Ore
  - **IS:** catch all for everything else

PA Considerations – early 1990's

- Waste Classification: NRC / DRC Rules similar
  - **Class B & C Definitions** [10 CFR 61.55(a)(3)]
    - Basis #1: Half-Life (long-lived isotopes, Table 1)
      - C-14, Ni-59, Nb-94, Tc-99, I-129, Pu-241, Cm-242
      - Alpha emitting transuranics (TU), half-life > 5 years
      - Radium-226 (Utah rule only)
    - Basis #2: Concentration (short-lived isotopes, Table 2)
  - **Class A Waste = catch-all**
    - By default » all other LLRW

Note: uranium not defined as Class B / C

PA Considerations – early 1990's

- **By-Product Material:** Uranium / Thorium Recovery
  - Tailings
  - Mill Feed = ore / geologic deposits (usually)
  - Daughters?
    - Fully in-grown (over geologic time)
    - Ra-226 = **modern radon hazard**
  - NRC Rules (10 CFR 40, Appendix A)
    - No PA Required
    - Engineering Design Standard: Earthen Covers [Criterion 6(1)]
    - 200 – 1,000 year stability / durability
  - IRONY?

PA Considerations – early 1990's

- **Inadvertent Intruder** – Love Canal
  - NRC Rule [10 CFR 61.7(b)(3) and (4)]
  - Protection? » 2 Ways:
    - **Institutional Controls** – after site operations
      - Up to 100 years (ES surety)
    - **Engineered Barriers (EB)** - NRC
      - Class A and B Waste: EB **not** required
      - Class C Waste: EB **may** be required
        - EB Effective Life: **should** be 500 years (if required)
        - Burial Depth Option: **no** EB required if waste is ≥ 5 meters below top of cover [10 CFR 61.52(a)(2)]

PA Considerations – early 1990's

- Primary Waste Containment / Control
  - **Engineered Features** – examples:
    - Site Selection – gentle / flat topography
    - Waste form / package – @ disposal
      - Steel drums, concrete vaults, etc
    - Embankment cover / liner design – e.g.
      - Erosion resistance
      - Infiltration control
      - Minimize leachate generation
      - Radon gas control
      - Seismic resistance
    - Site Drainage – free flowing conditions

PA Considerations – early 1990's

- Secondary Waste Containment / Control
  - **<u>Site Characteristics</u>** <u>– examples:</u>
    - Remote location (few receptors)
    - Arid / Flat site (low erosion hazard)
    - Low seismic hazard (or appropriate design)
    - Limited Water Resources (availability / quality)
    - Long travel distance / time (to receptors)
      - Low velocity (advection)
      - Contaminant diffusion / dispersion
      - Soil / aquifer partitioning (K_d) [retardation]
      - Half-life (additional decay)

PA Considerations – early 1990's

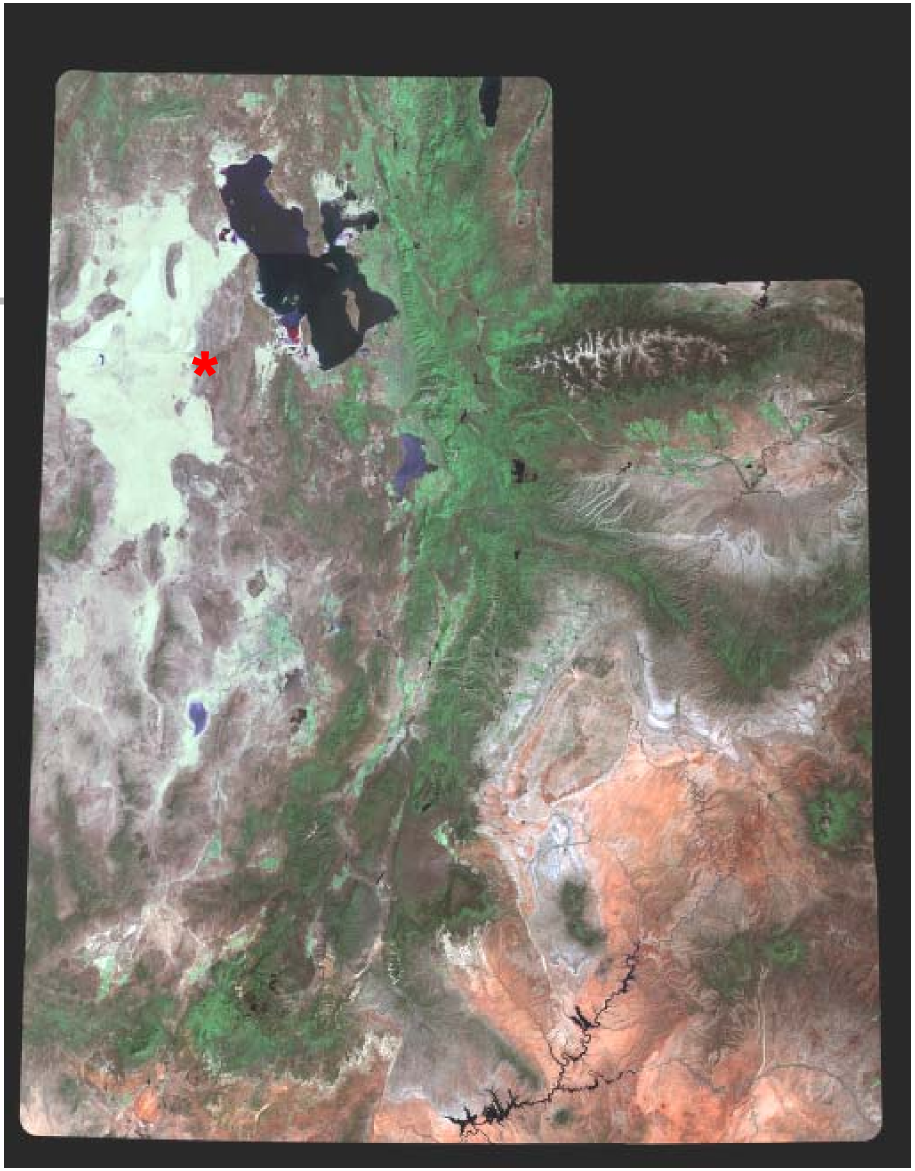
DRC Period of Performance - 500 yrs

Largely based on:

- **Remote Location** (few receptors)
- **Arid site** (limited erosion & surface / ground water resources)
- **LLRW Class C EB Effective Life** (500 yrs)
- **Uranium Tailings Design Standard** (200 – 1,000 yrs)
- **Site Characteristics** = safety factor
  - Multiple redundant and conservative factors in models
  - Pose additional reduction in future dose if / when engineered controls fail

PA Considerations
- early 1990's

- <u>Remote / Arid Location</u>
  - Near Salt Flats (few receptors)
  - Limited water resources
    - Little Surface Water
    - Saline Groundwater (GW) [Class IV]
  - Long Travel Time
    - To Great Salt Lake
    - Low GW velocity



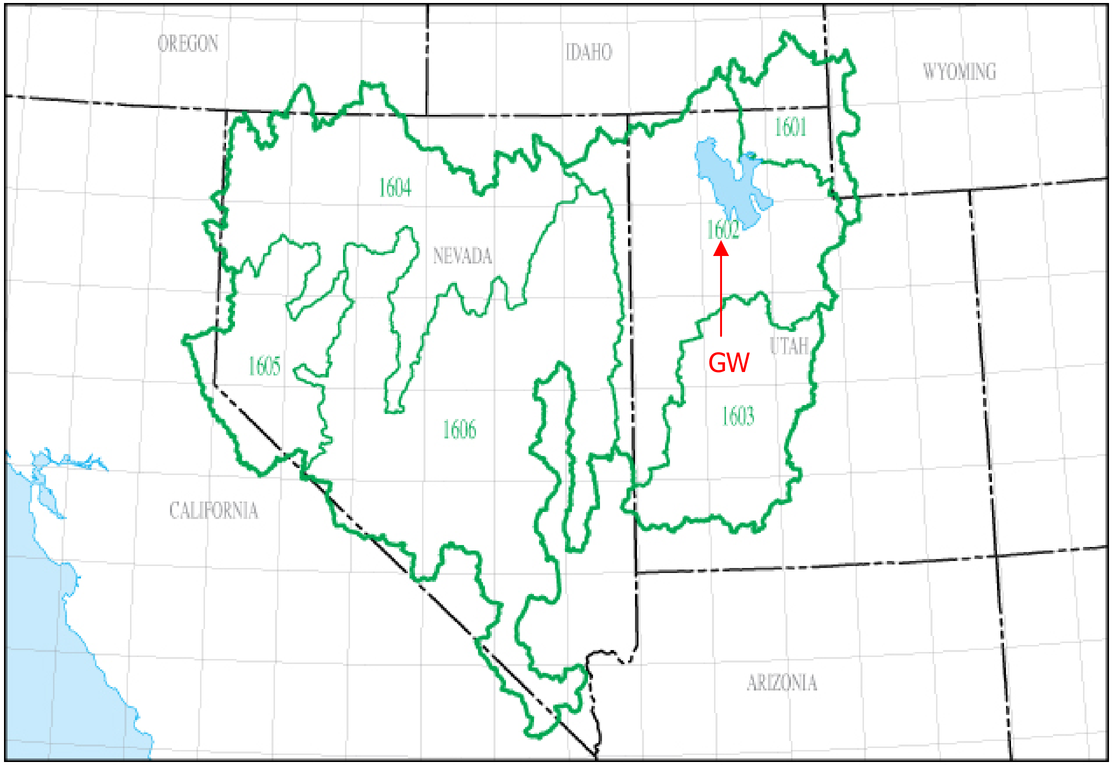
Landsat Image: http://earth.gis.usu.edu/landcover.html

PA Considerations – early 1990's

Great Basin Watershed
(sub-basins)

- Bear River
- West Desert
- Sevier River*
- GSL / Salt Flats = sink

* Groundwater in the Sevier River sub-basin drains to GSL



http://water.usgs.gov/wsc/reg/16.html

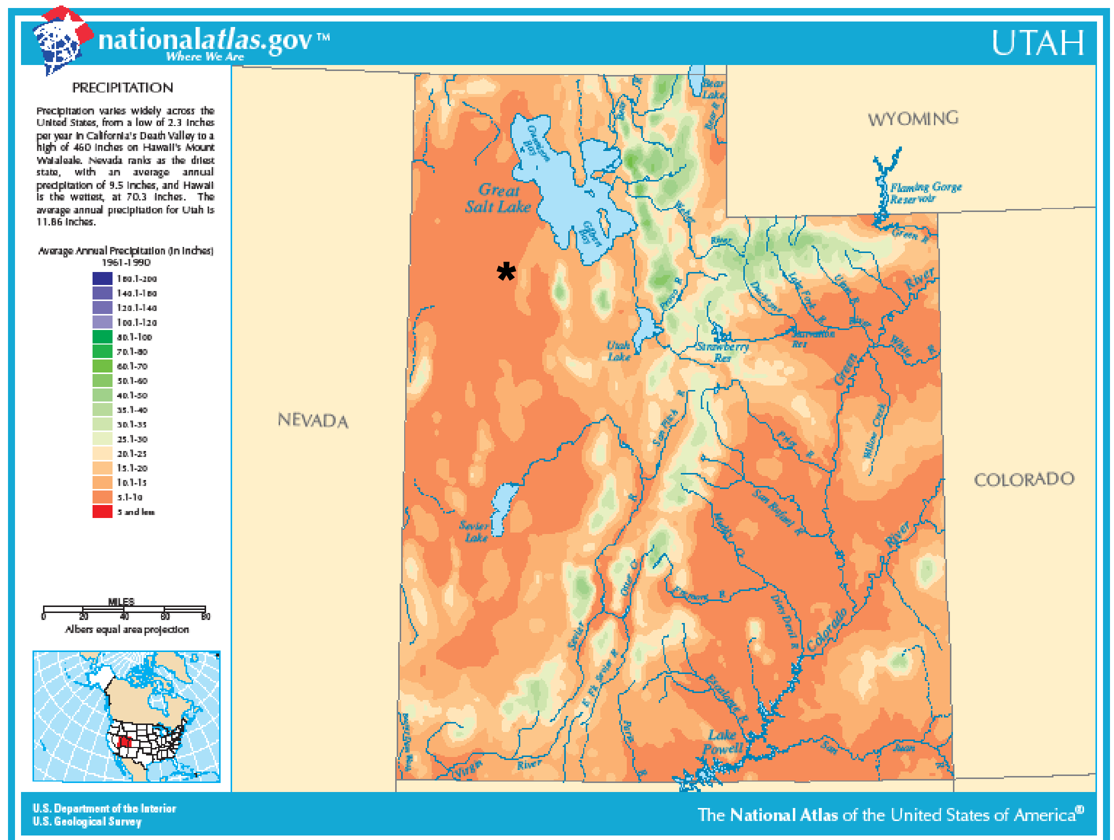
PA Considerations – early 1990's

Average Precipitation*

- Wasatch Front
  - 10 – 15 in/yr
- West Desert
  - 5 – 10 in/yr
- Clive[1] (1993 – 2009)
  - ~ 8 in/yr
- Wendover[2] (1911 – 2010)
  - 4.6 in/yr

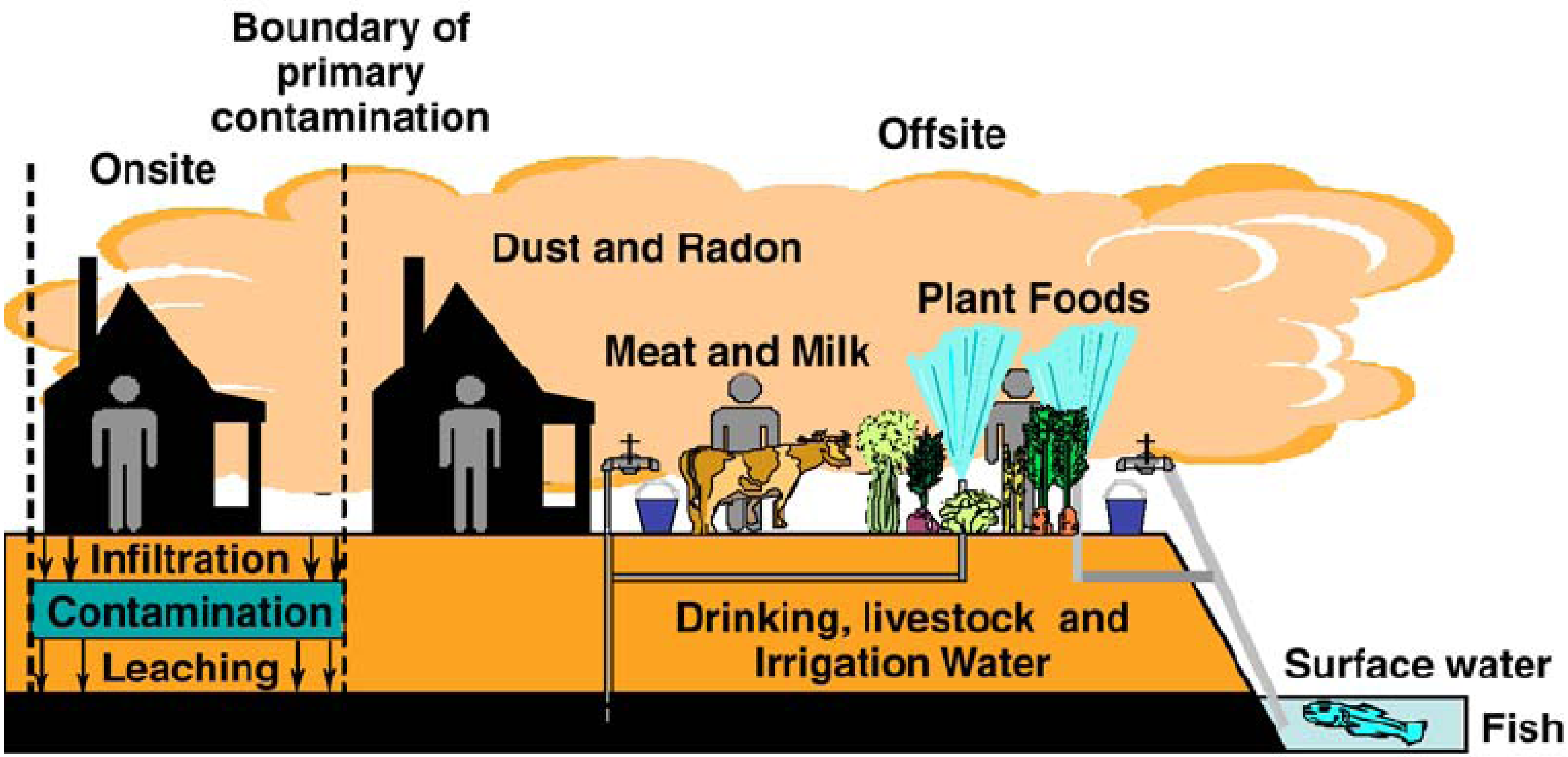
(1) 2/22/10 ES Report

(2) http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ut9382



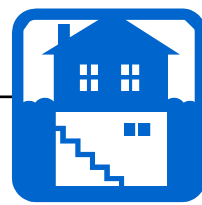
* Map= 1961 – 1990, found @ http://www.nationalatlas.gov/printable/precipitation.html#list

Performance Assessment Possible Pathways

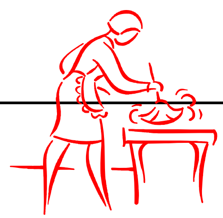


From NUREG/CR-6937, Fig. 1.1

DRC Pathway Findings – early 1990's

Location	Pathway	Description	Finding	Basis / Reasons
On-site	Inadvertent Intruder	Basement Excavation	Unlikely	Human habitation unlikely in future
				Arid site (~ 8 in/yr precipitation)
				Saline soil / water (for 1,000's of years)
				Better habitats elsewhere in Utah

DRC Pathway Findings – early 1990's

Location	Pathway	Description	Finding	Basis / Reasons
Off-site	Dust Inhalation	Exposed Waste	Unlikely	Human habitation unlikely in future, see above
				Armored cover system (erosion resistant, PMP)
				Cover & embankment = seismically robust
				No flowing streams nearby
				Flat topography – low erosion potential

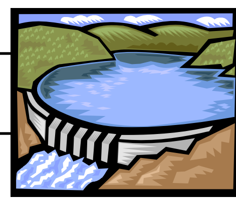
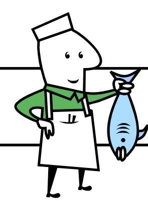
DRC Pathway Findings – early 1990's

Location	Pathway	Description	Finding	Basis / Reasons
Off-site	Radon Inhalation	Outdoor Air 	Unlikely	Radon Barrier – adequate engineering design
				Armored cover system (erosion resistant, PMP)
				Cover & embankment = seismically robust
				Cover system design: minimize bio-intrusion
				No residents expected
		Indoor Air	Unlikely	Human habitation unlikely in future, see above
				Other reasons, see above.

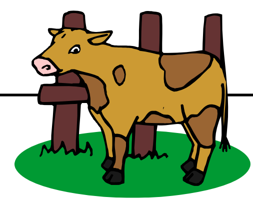
DRC Pathway Findings – early 1990's

Location	Pathway	Description	Finding	Basis / Reasons
Off-site	Ingestion: Drinking Water	Groundwater 	Unlikely	Poor quality GW - saline Site Total Dissolved Solids (TDS) ~ 30,000 – 60,000 mg/l Seawater ~ 30,000 mg/l
				Utah Drinking Water MCL: **TDS = 2,000 mg/l** [UAC R309-200-5(1)]
				Better water resources elsewhere in Utah

DRC Pathway Findings – early 1990's

Location	Pathway	Description	Finding	Basis / Reasons
Off-site	Ingestion: Drinking Water	Surface Water 	Unlikely	Arid site – little / no flowing or standing surface water
				Saline soils / water
				Better water resources elsewhere in Utah
	Ingestion: Fish	Meat 	Unlikely	Little / no surface water
				No aquatic habitat
				No freshwater resources

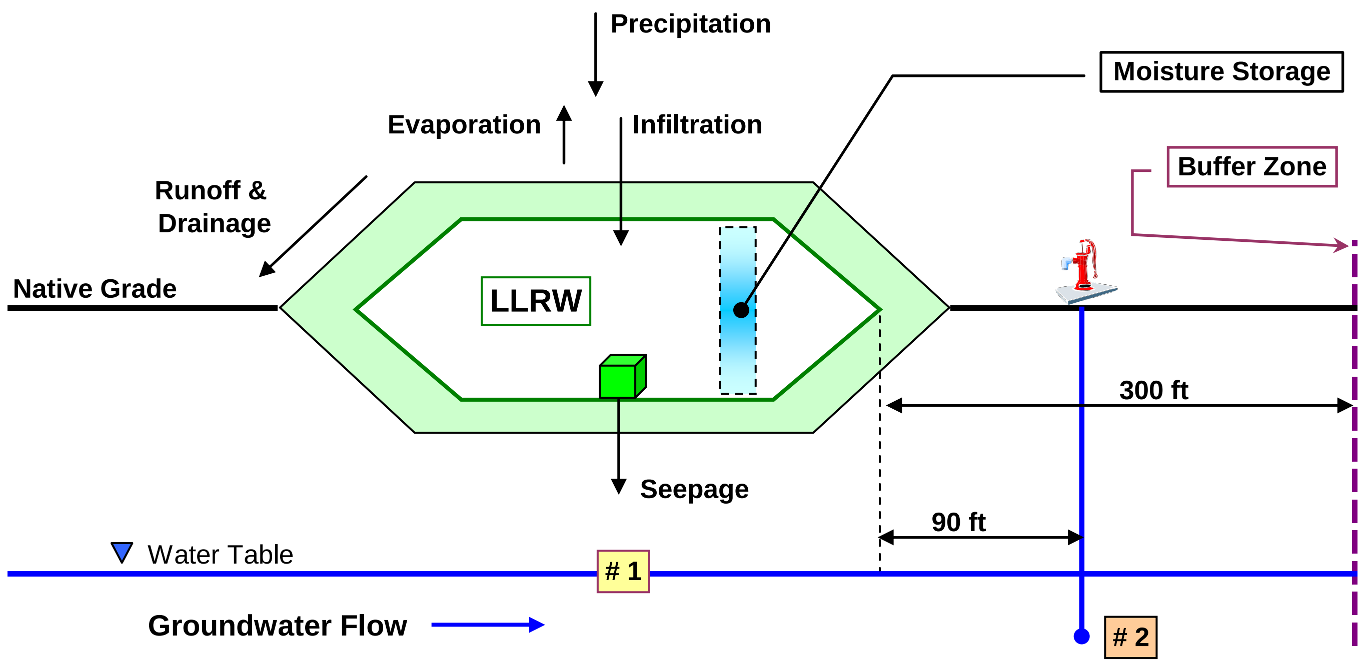
DRC Pathway Findings – early 1990's

Location	Pathway	Description	Finding	Basis / Reasons
Off-site	Ingestion: Plants	Crops Grown 	Unlikely	Saline soil / water resources
				Better agriculture areas elsewhere in Utah
	Ingestion: Livestock	Meat and Milk	Unlikely	Saline soils / water
				Feed / water would be imported – increased costs
				Better agriculture areas elsewhere in Utah

DRC PA Decision – early 1990's

- Critical Pathway: **Groundwater**
  - Protect as if **drinking water**
  - Points of Compliance
    - Pre-1998 = Water Table
    - Post-1998 = On-site Well, inside buffer zone
  - Apply Utah Groundwater Quality Standards (UAC R317-6-2)
    - Radiocontaminants ≥ 500 yrs (4 millrem/yr)
    - Nonradiologics ≥ 200 yrs (UT Drinking Water MCLs)

ES Performance Assessment – 1990s



	Points of Compliance			
Approach	Model Type	Early 1990's		Late 1990's
# 1	1-D	Water Table		
# 2	2-D			Monitor Well

ES Performance Assessment – 1990s

- Conservative Inputs / Assumptions - examples
  - Remote location
  - Arid site
  - Low GW velocity / long travel times
  - Point of Compliance (90 ft well)
  - GW = drinking water (assumed)
    - 4 millirem/yr (NRC = 25 / 75 /25 – all pathways)
  - Soil / Aquifer Kds
    - Pre-1998 = literature lows
    - Post-1998 = lab tests on Clive soil / GW
  - 2-D Model (quasi 2-D)
  - Waste Leaching Coefficients = soil Kd values