

Environmental Transport

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Purpose

- To present an overview of mechanisms which contribute to radionuclide transport *in*, and
- To consider the challenges inherent in predicting radionuclide migration *through*,
- The environment

en·vi·ron·ment

- \in-ˈvī-rə(n)-mənt
- The circumstances, objects, or conditions by which one is surrounded
- *The complex of physical, chemical, and biotic factors (as climate, soil, and living things) that act upon an organism or an ecological community and ultimately determine its form and survival*
- The aggregate of social and cultural conditions that influence the life of an individual or community

trans·port

- \tran(t)s-pört,
- To transfer or convey from one place to another <*transporting* radionuclides across a living membrane>

Overview

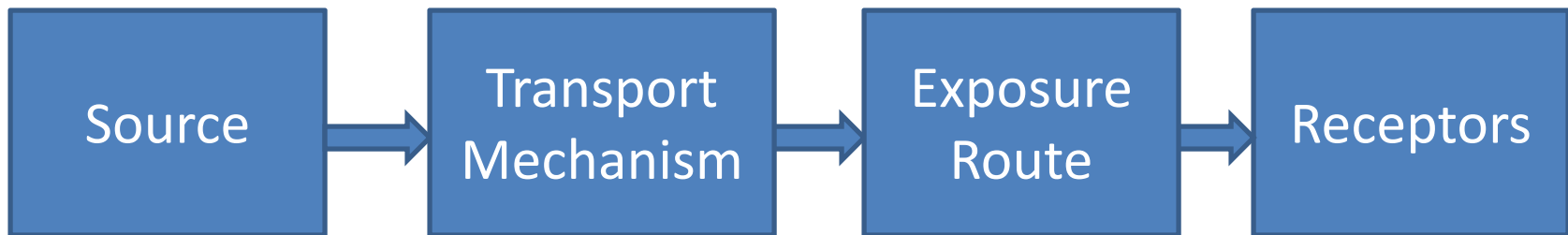
- Background – what constitutes environmental transport?
- Factors that limit transport
 - Waste Characteristics
 - Engineered Barriers
 - Natural Barriers

Overview, continued

- Factors that facilitate transport
 - Waste Characteristics
 - Water
 - Heat
 - Oxidizing/Reducing conditions
- How are transport calculations performed?
- Are there challenges?
- Summary

Environmental Transport

- Focus on radionuclides, but not exclusively
- Follow movement from a source of radionuclide to a specified point of interest
- “Compartmentalization” of system used to create conceptual & mathematical models:



- Real system inherently more complex

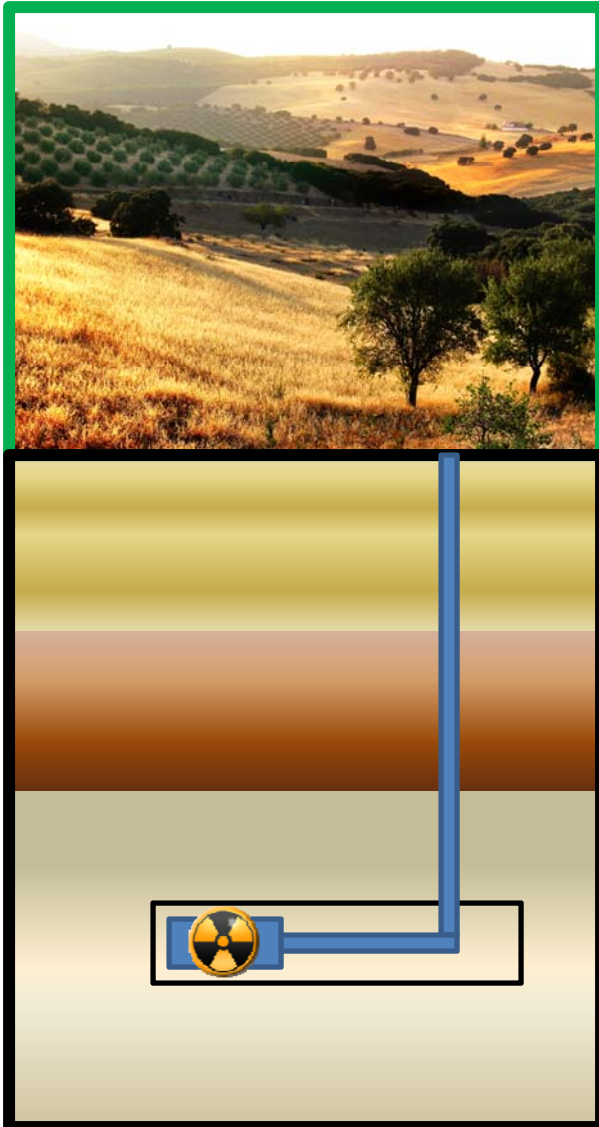
Conceptual Zones for Environmental Transport

- Near field
 - Encompasses waste form,
 - Any engineered barrier system, and
 - Disturbed zones (e.g., construction & access points)
- Far field (geosphere)
 - The geological mass surrounding the near field,
 - Includes natural barriers.

Conceptual Zones for Environmental Transport, continued

- Biosphere - the near surface, organic zone that contains life.
- *These definitions can apply to surface, near surface or sub surface disposal situations*

Example: Environmental Transport of Buried Radioactive Waste



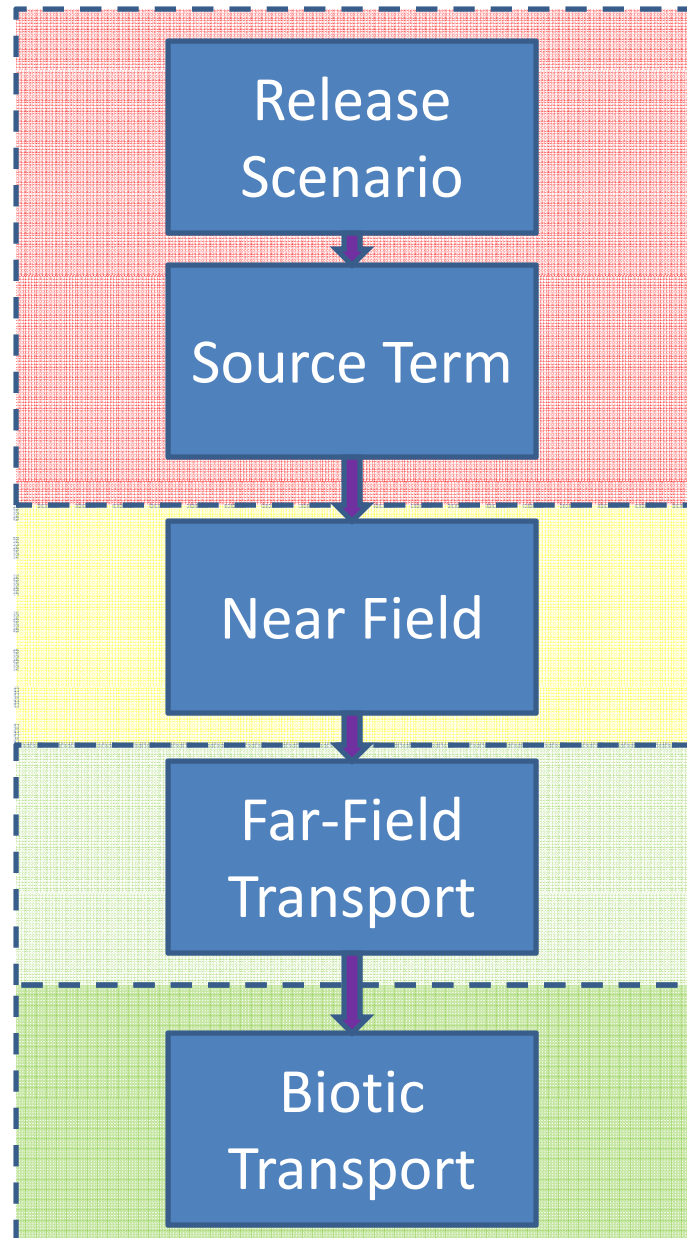
Biosphere

**Far field (geosphere incl.
natural barriers)**

Near field (engineered barrier)

After the illustration at
http://www.grimsel.com/general/bg_ebs.htm

Elements of Environmental Transport

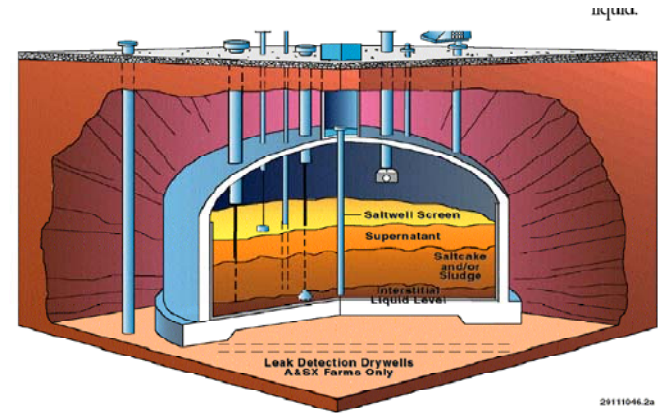


Elements of Release Scenario & Source Term

- Release scenario
 - Catastrophic event?
 - Chronic event?
 - Degradation?
- Time frame (years, decades, millennia?)
- Source term
 - Nuclides
 - Chemistry
 - Physical Properties

Source Term: Radionuclide Characteristics

- Inventory
- Solid?
- Liquid?
- Gaseous?
- Stabilized?
- Reactive?
- Corrosive?
- Explosive?
- Radiations emitted?



http://www.hanford.gov/hanford/files/TPA_HUSummer2007



Spent Fuel Assemblies in the K-East Basin

Engineered Barriers

- Designed to control movement of radionuclides from waste
- Includes
 - Facilities
 - Mill tailings piles
 - Low-level waste burial sites
 - Deep geologic repositories
 - ...
 - Includes materials:
 - Concrete, asphalt.....
 - Physical & chemical aspects



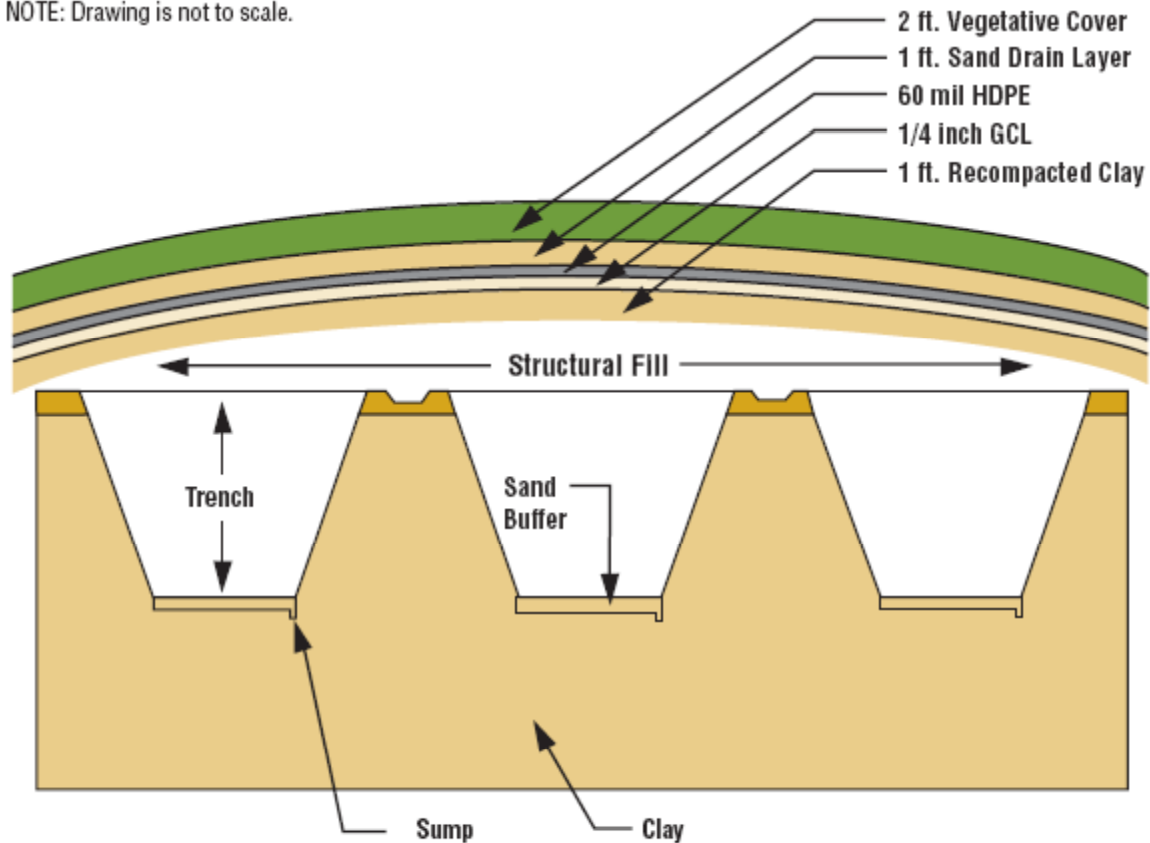
Uranium Mill Tailings Site
www.westernwaterandland.com/WWLProjects.htm

Engineered Barriers – Low Level Waste Sites

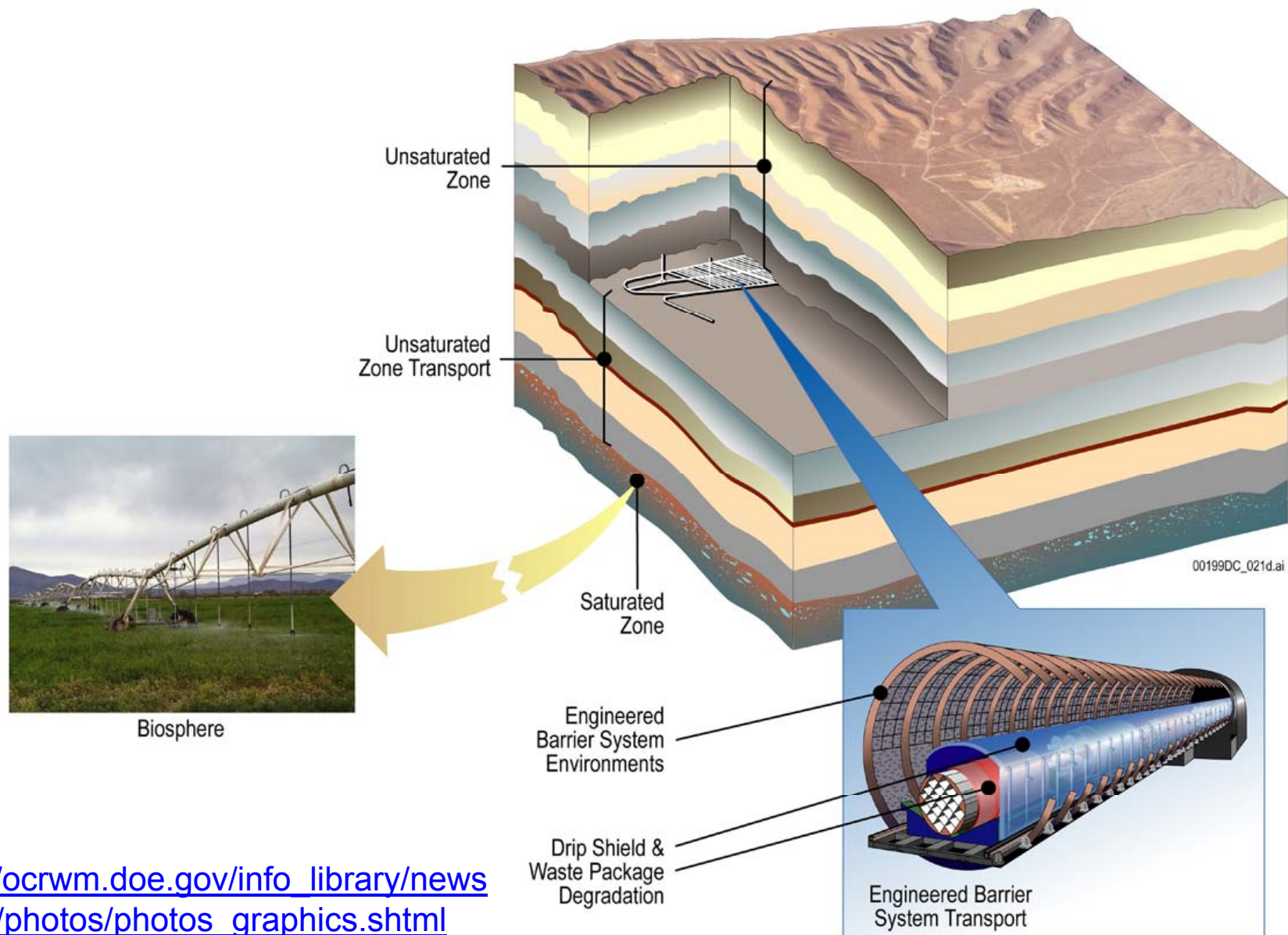
FIGURE 7

Enhanced Cover Construction Details

NOTE: Drawing is not to scale.

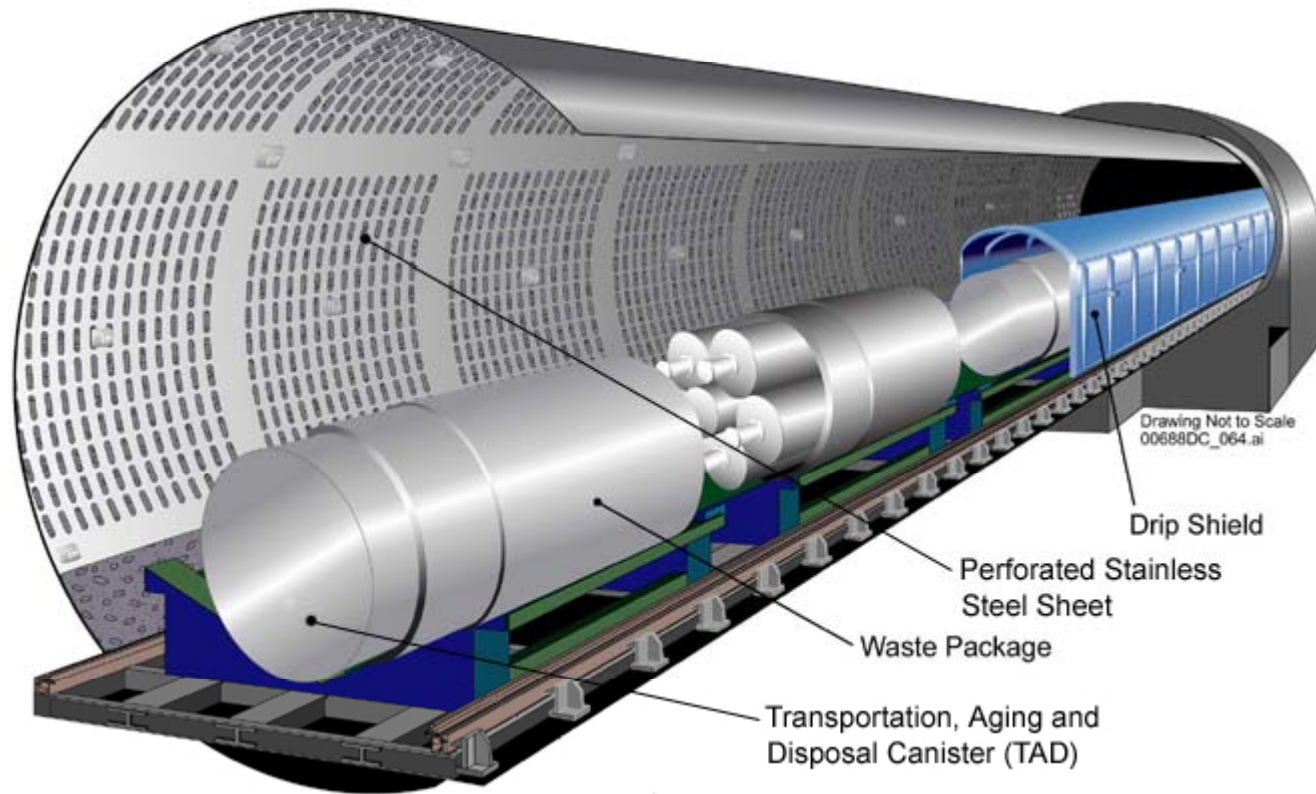


Example Facility: Yucca Mountain



http://ocrwm.doe.gov/info_library/newsroom/photos/photos_graphics.shtml

Example Engineered Barrier: Yucca Mtn



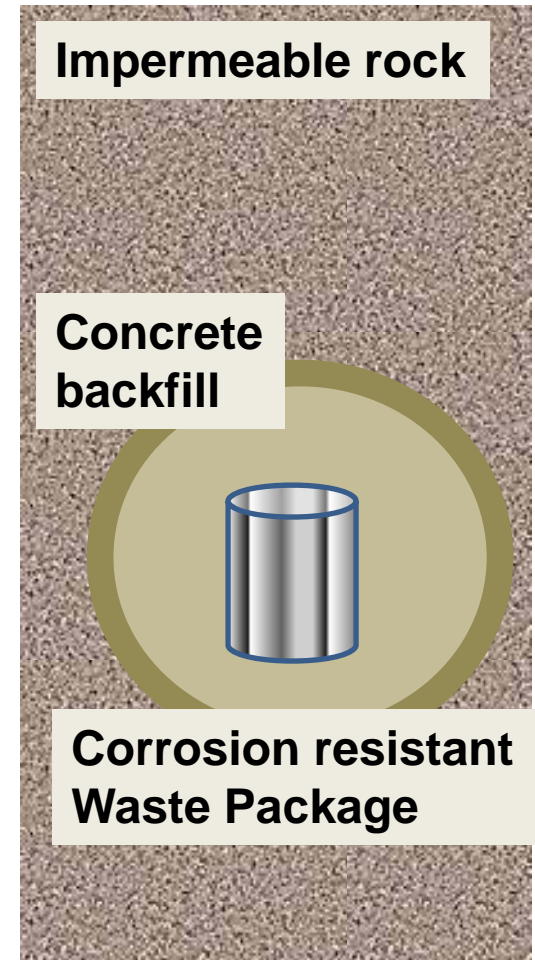
http://www.ocrwm.doe.gov/ym_repository/studies/engdesign/engbarriers_enlarge.htm

Barrier Functions

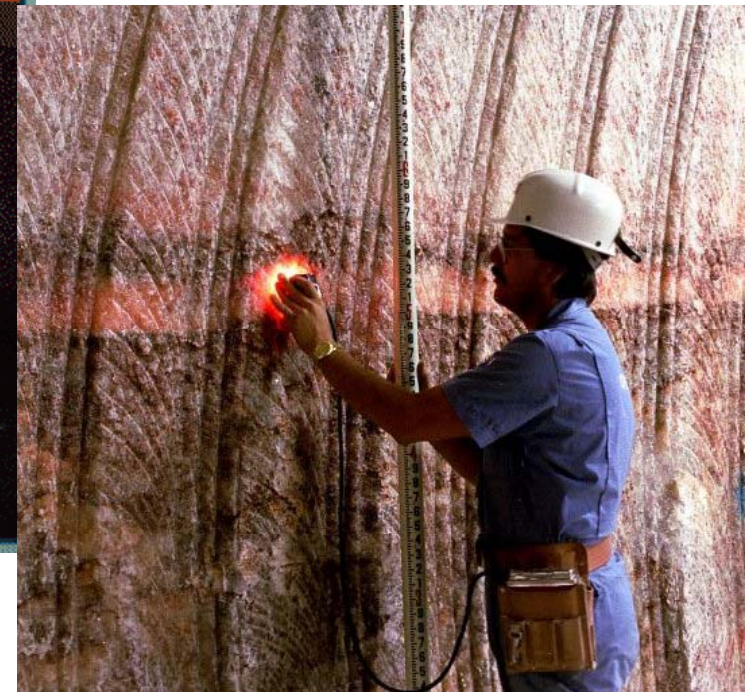
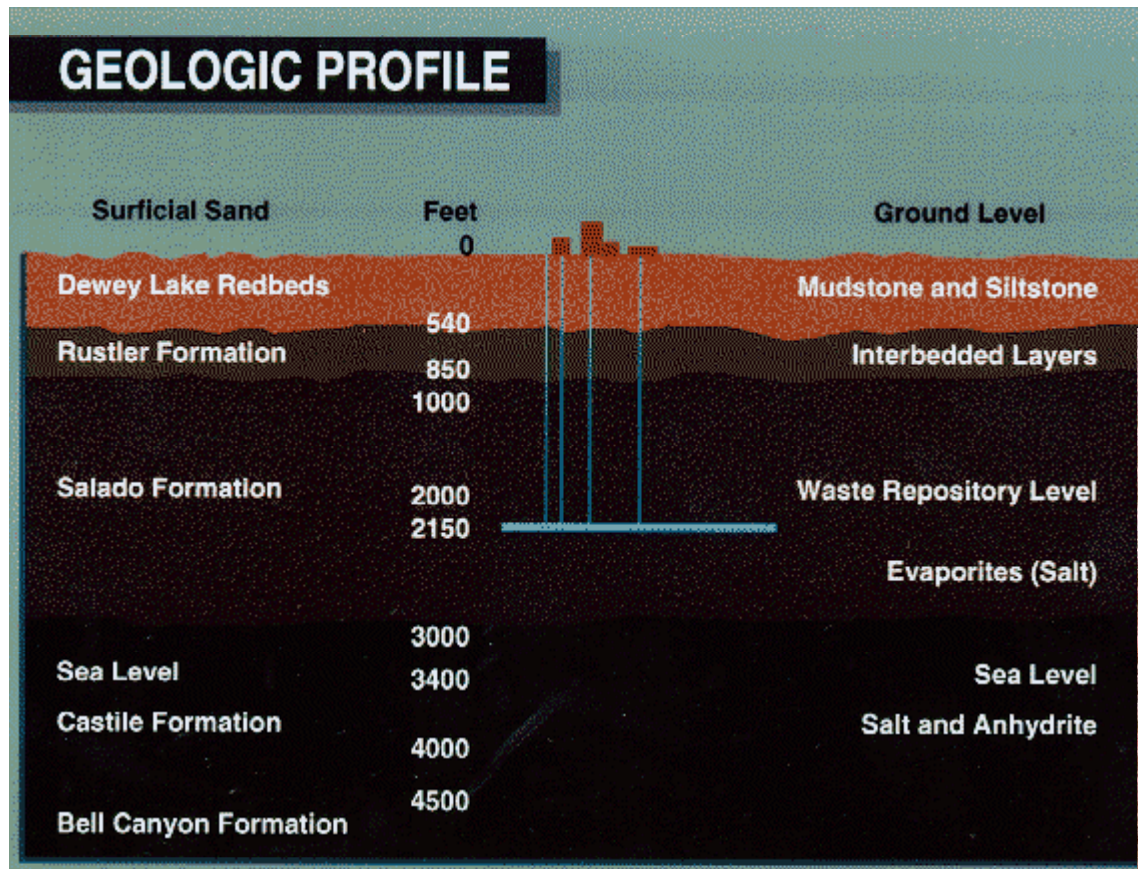
- Buy time
- Preclude water(!?)
- Provide structure
- Prevent biotic intrusion (human & animals)
- Stabilize chemistry (e.g. limit reactivity)
- Serve as radiation shield

Natural Barriers

- Many of same goals as engineered barriers
- Include
 - geologic formations, such as granitic rock, rock salt, or sedimentary rock which overlay or surround the radionuclides
 - Surface soils or topography which limit water infiltration
 - Climatic conditions which restrict water



Natural Barriers – WIPP Example



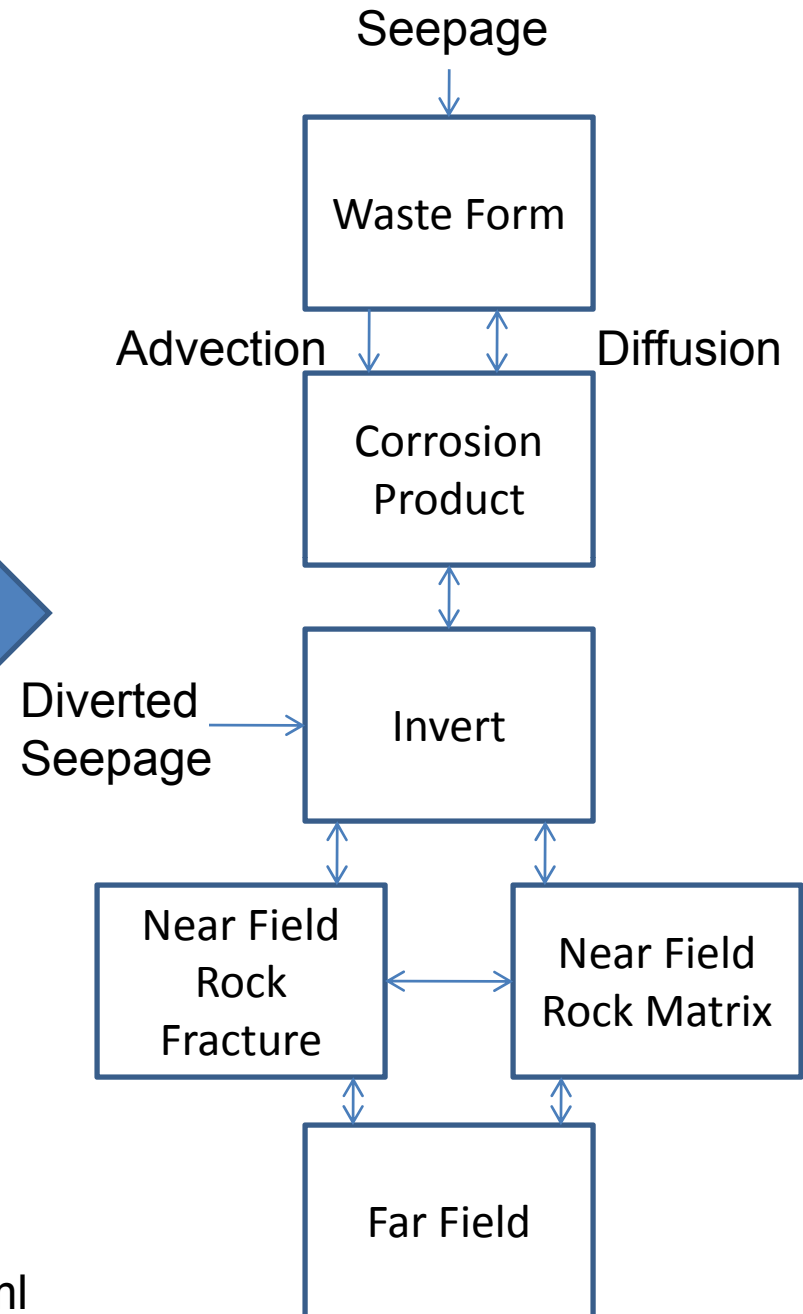
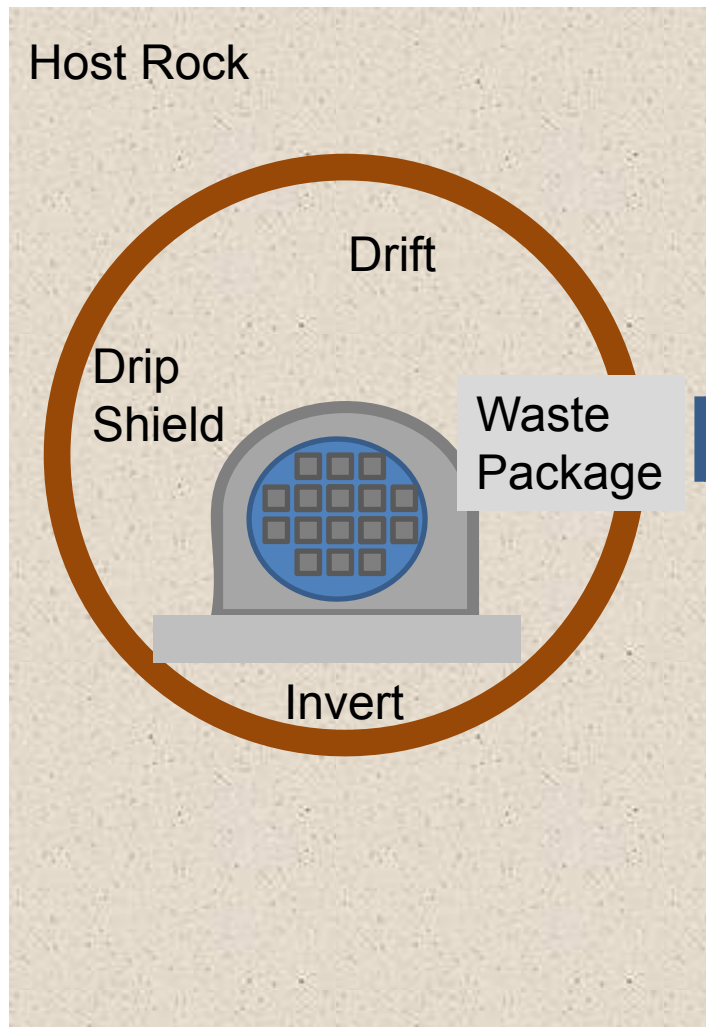
www.wipp.energy.gov/science/UG_Lab/cleansalt.htm

http://www.cardnm.org/repository_a.html

Considerations in Near Field for Radionuclide Transport

- Water balance
- Water infiltration
- Leaching
- Unsaturated/saturated zone behavior
- Advection
- Diffusion

Yucca Example

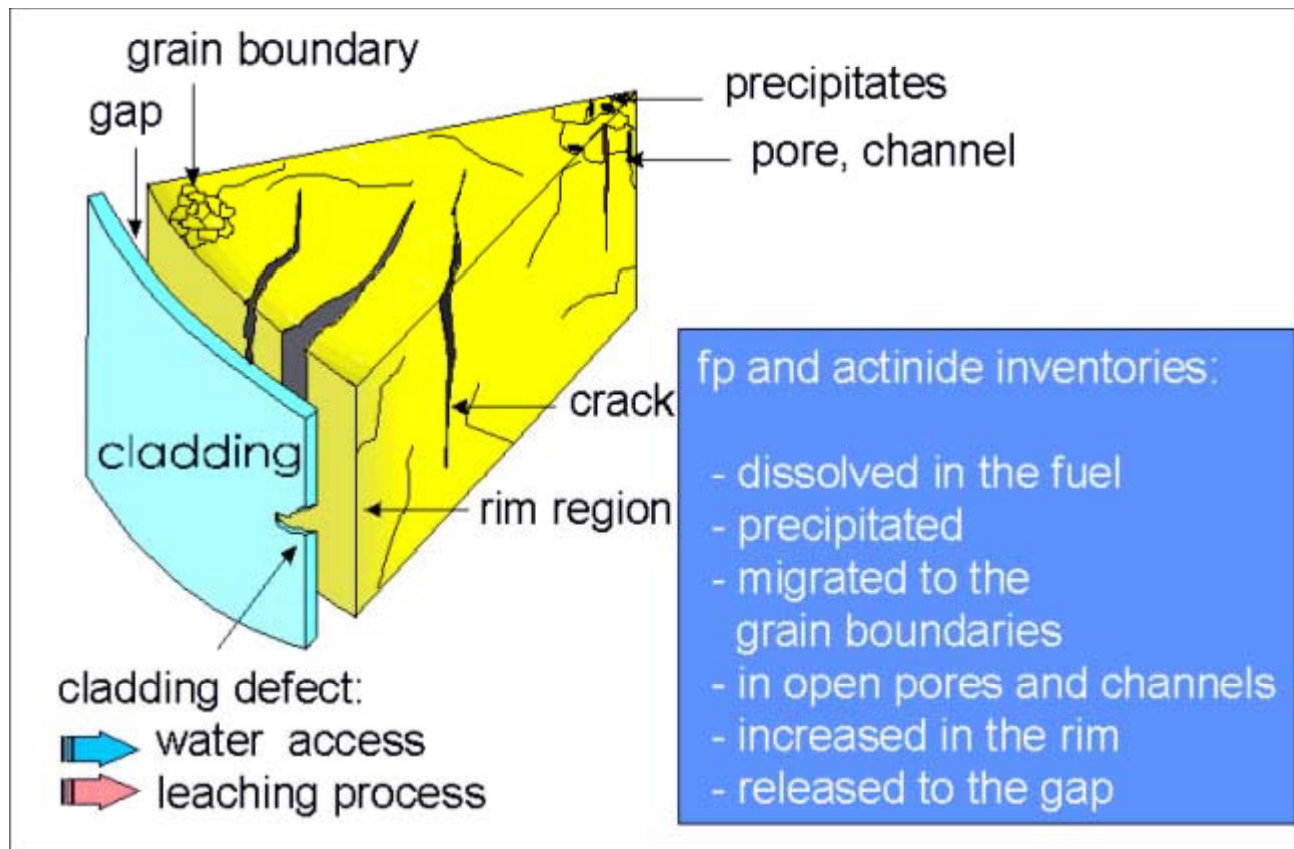


After <http://monitorsci.com/software/index.html>

Other Considerations in Near Field Performance Assessment

- Mechanical stresses
- Heat Flow
- Chemical Interactions
- Radiation-induced physical-chemical processes (gas evolution)
- Properties of host-rock

Example: Waste Form Degradation



Modeling Near Field: Heat Transfer Models

- Physics based
- Portray heat flow and changes in temperature
 - Temperature gradients are driving force in groundwater flow

Modeling Near Field: Thermochemical Models

- Physics based
 - Consider relationships between stress and strain
 - Difficult to extrapolate from laboratory to field
 - Inhomogeneity in host material
 - Fractures

Modeling Near Field: Chemical Models

- Consider interactions between waste and host rock, including:
 - Movement of fluids in vicinity
 - Corrosion of waste package (if any)
 - Dissolution of waste by groundwater
 - Sorption of radionuclides to rocks & engineered components
 - Absorption of radiation by waste
 - Alteration of chemical phases and properties in the vicinity of waste canister

Other Processes for Consideration

- Crustal-scale processes, such as volcanic activity and climate change,
- Temporal scales of thousands, if not tens of thousands, of years.
 - After Ewing and Macfarlane, 2002
- *And, ...what about INTRUSION???*

Far Field & Biotic Transport

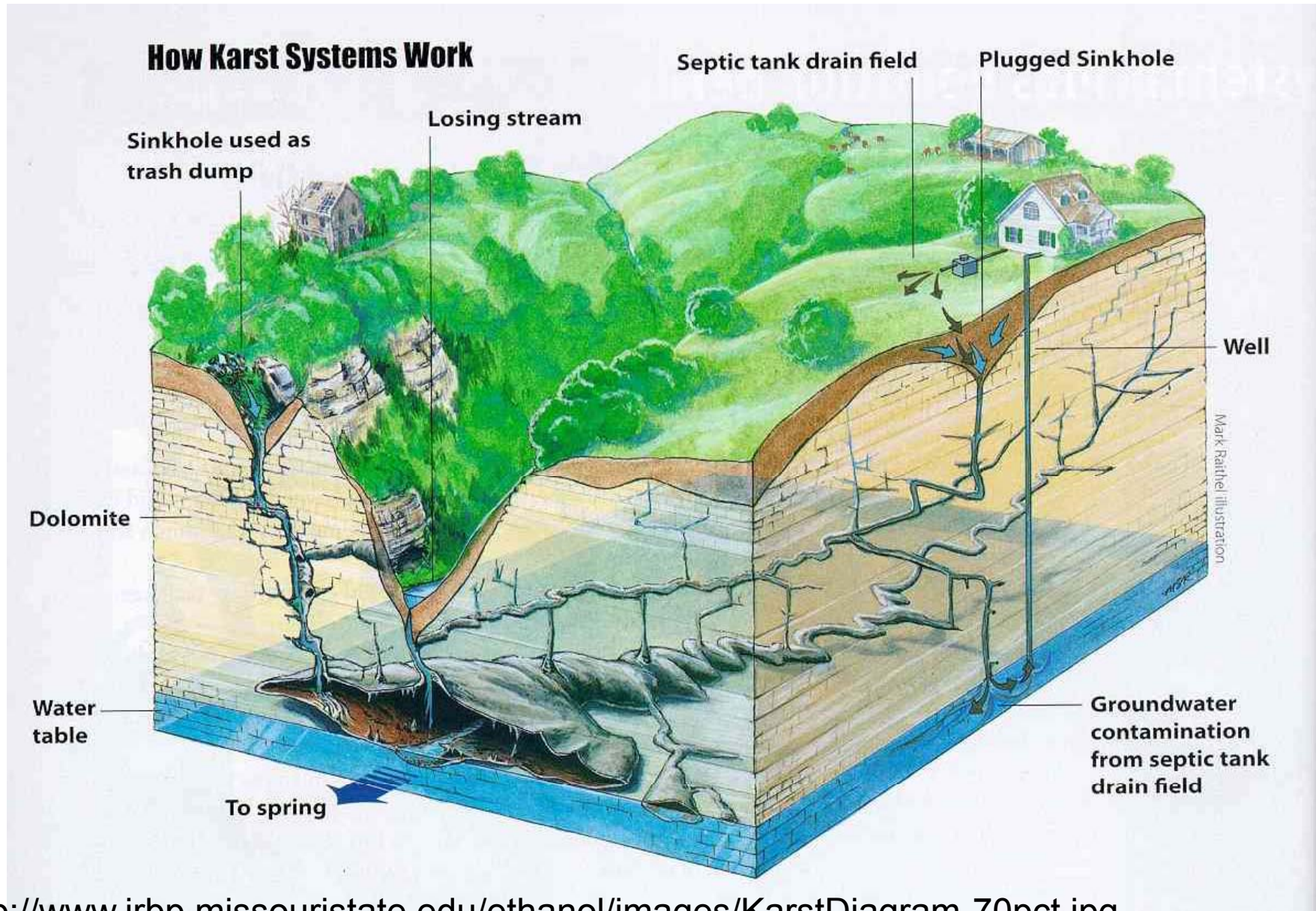
- Transport through geosphere
- Transport through biosphere



Modeling/Assessment Disconnects

- Near field & far field modeling
 - May be physico/chemically based
 - Subject to uncertainty analysis and bounding
 - Expert judgment may substitute for measurements
 - Risk defined as: probability x consequence

Inhomogeneity in Geosphere, another issue



<http://www.jrbp.missouristate.edu/ethanol/images/KarstDiagram-70pct.jpg>

Example – Far Field & Biotic Transport

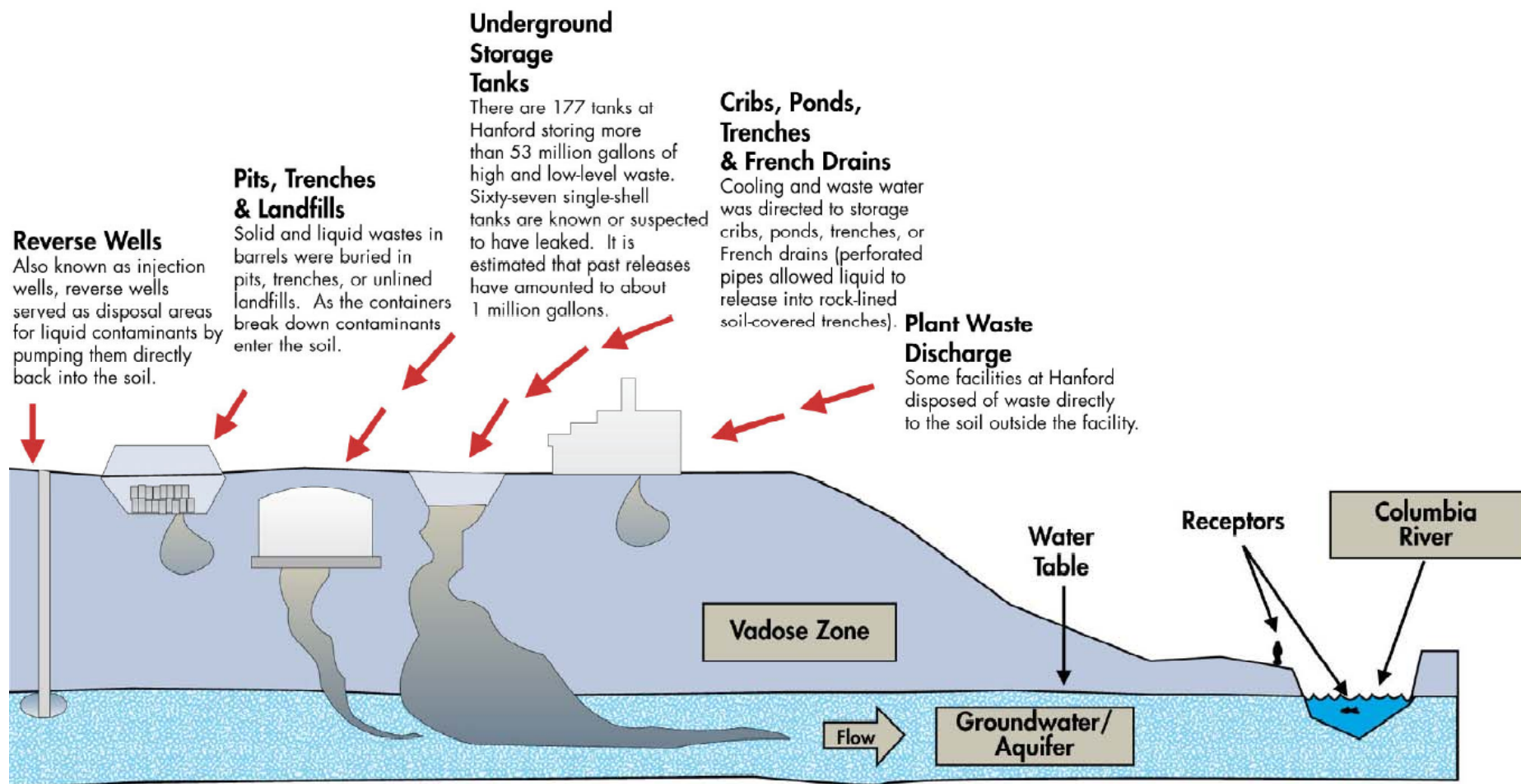
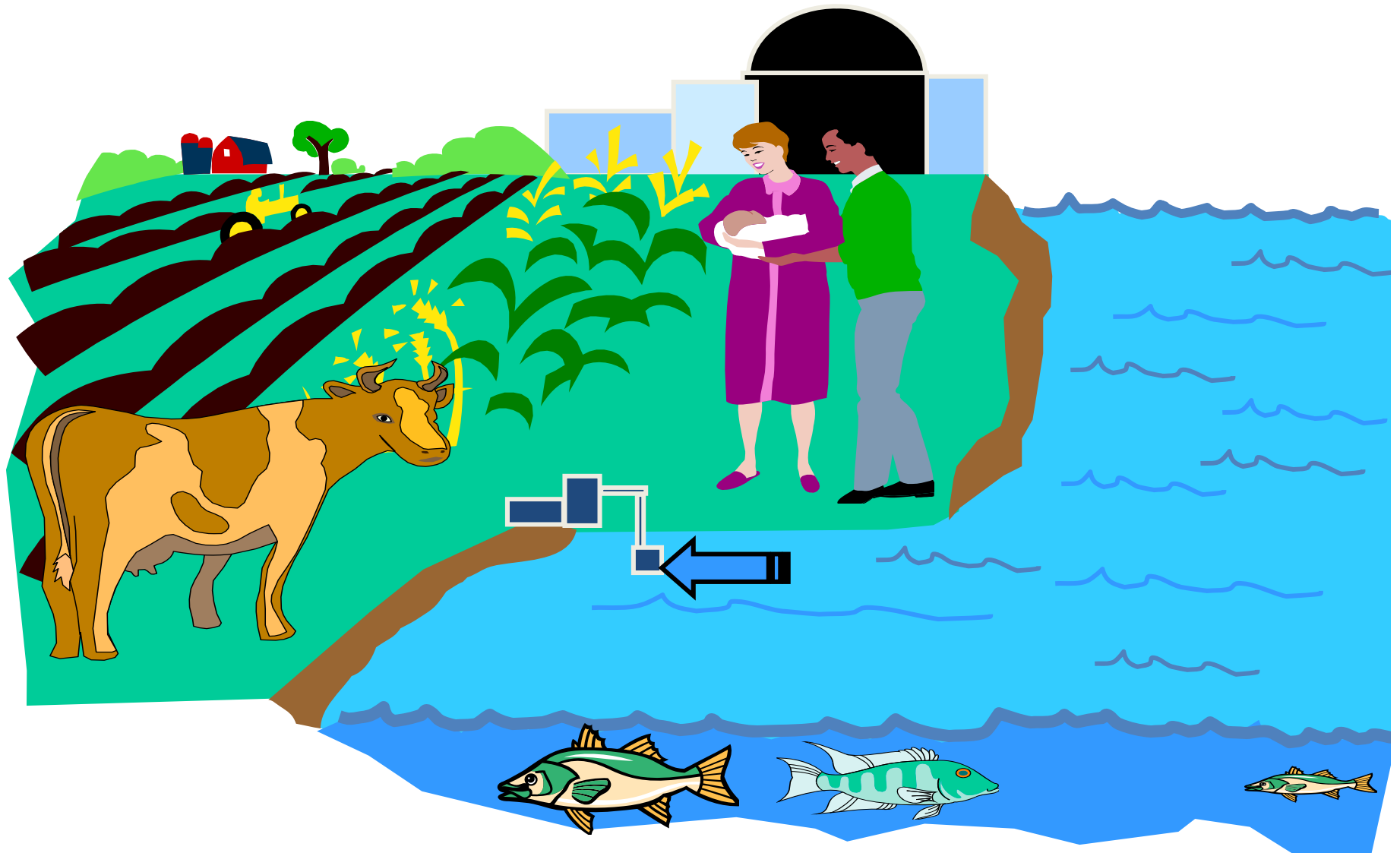


Figure 1.4. Sources of Hanford groundwater contamination.

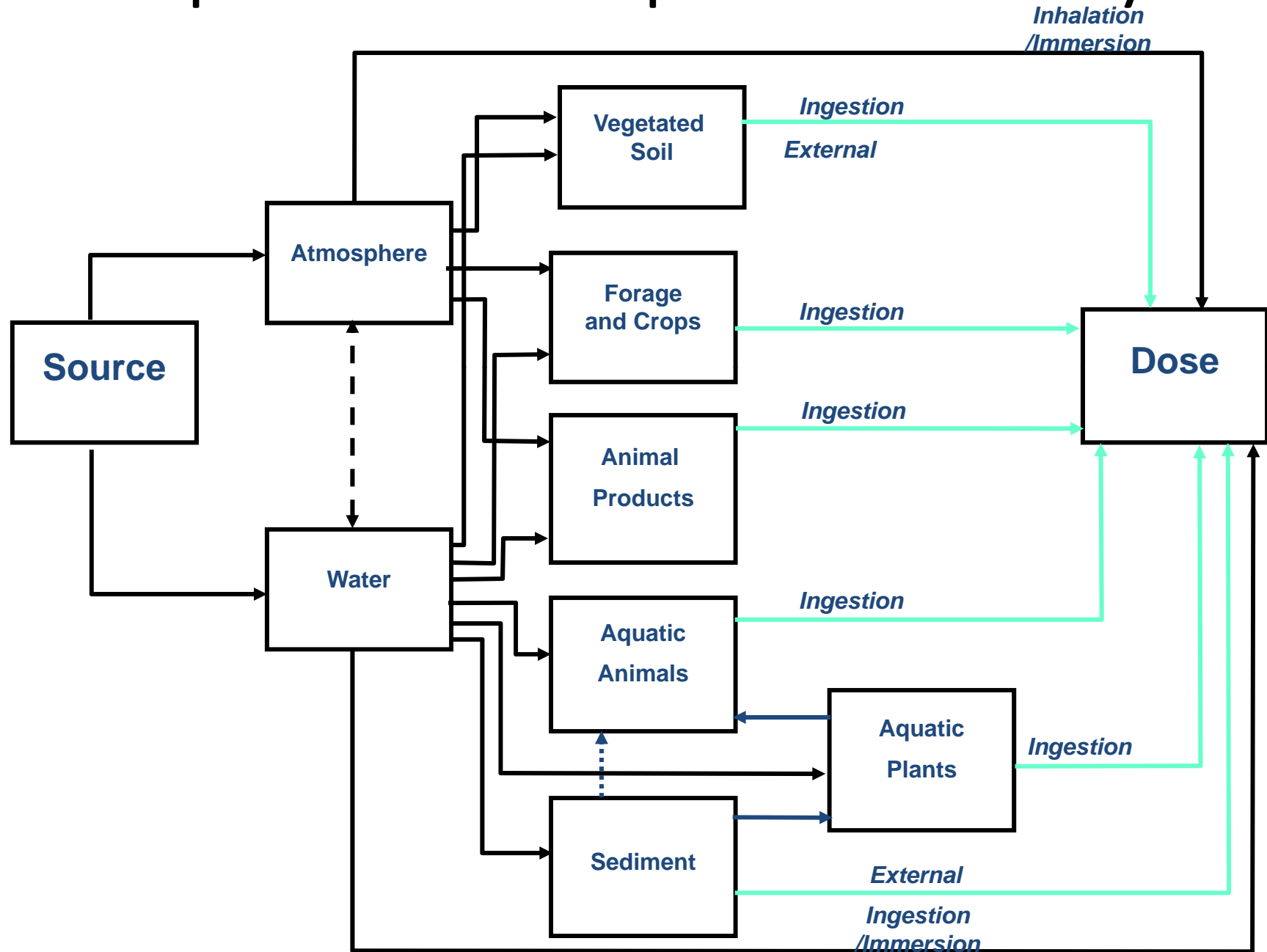
Modeling/Assessment Disconnects, continued

- Biotic transport, humans
 - Scenario based (behaviorally based)
 - Uncertainty focuses on variability in uptake/transfer parameters
 - Risk defined as: exposure x slope factors
 - Impacts typically projected at 95%

Human Exposure Pathways



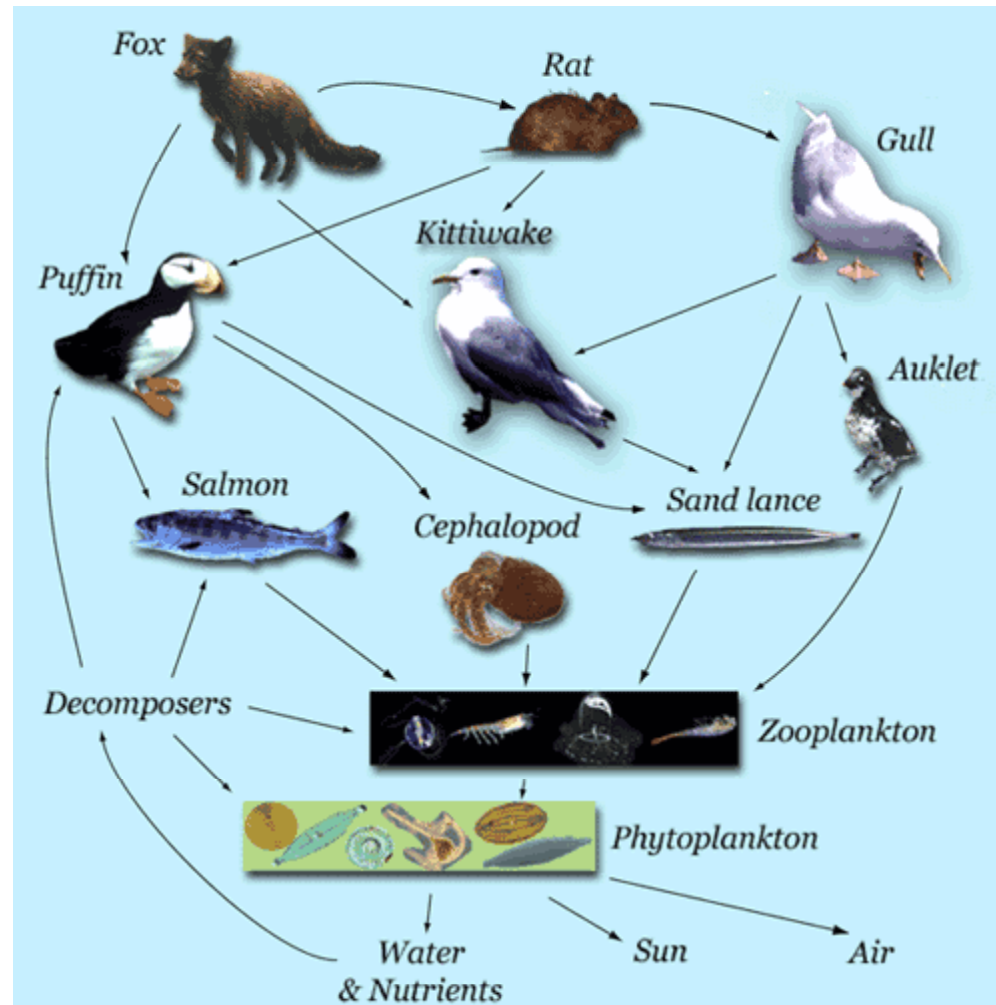
Example: Human Exposure Pathways



Modeling/Assessment Disconnects, continued

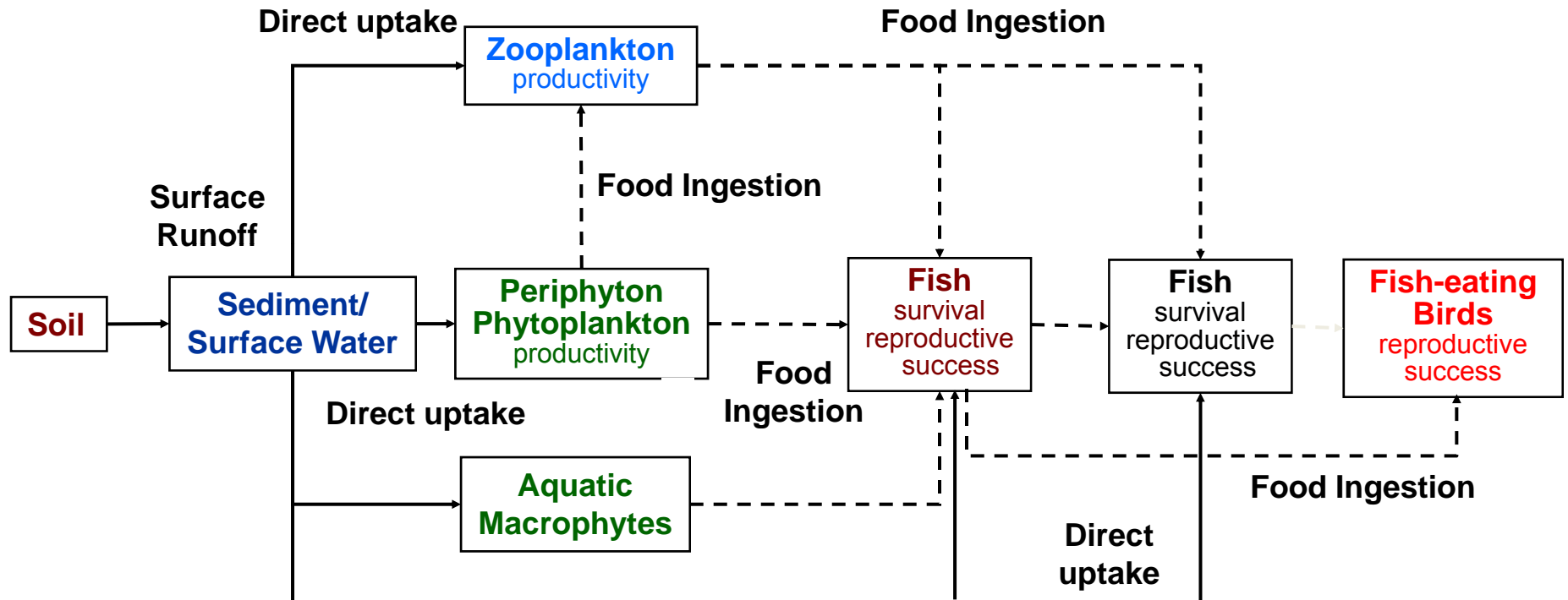
- Biotic transport, “non humans”
 - Still evolving
 - Ecosystem based
 - Sentinel species
 - Hazard quotients, or??

Food Web



http://www.absc.usgs.gov/research/seabird_foragefish/marinehabitat/images/Food_Web3.gif

Example: Non Human Biota

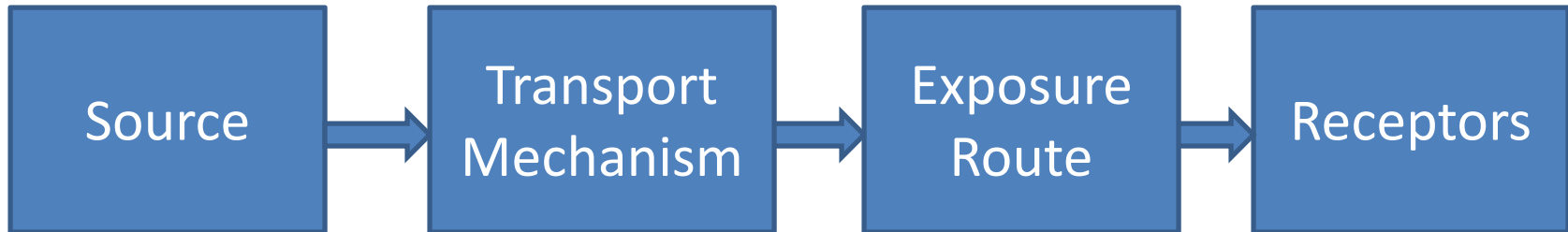


Assessment endpoint:
Maintenance of aquatic
macrophyte productivity
and abundance because
of importance as habitat

Assessment endpoint:
Maintenance of
phytoplankton,
zooplankton, and fish
productivity
because of importance
as food sources

Assessment endpoint:
Maintenance of fish-eating
bird survival and
reproduction because of
importance as top-level
predators

Summary



- Where does this leave us?
 - Reviewed factors influencing radionuclide transport
 - Presented near-field, far-field, and biosphere considerations
 - Discussed transport calculations and their challenges
- Still room for research!

Weblinks for Images

- http://www.grimsel.com/general/bg_ebs.htm
- <http://monitorsci.com/software/index.html>
- <http://www.merriam-webster.com/dictionary/environment>
- <http://www.merriam-webster.com/dictionary/transport>
- http://www.grimsel.com/general/bg_ebs
- http://www.hanford.gov/hanford/files/TPA_HUSummer2007.pdf
- www.westernwaterandland.com/WWLProjects.htm
- http://www.scdhec.net/environment/lwm/forms/commercial_low_level.pdf
- http://ocrwm.doe.gov/info_library/newsroom/photos/photos_graphics.shtml
- http://www.ocrwm.doe.gov/ym_repository/studies/engdesign/engbarriers_enlarge.htm
- http://www.cardnm.org/repository_a.html
- <http://www.nv.doe.gov/emprograms/images/pathway.jpg>
- www.wipp.energy.gov/science/UG_Lab/cleansalt.htm
- <http://itu.jrc.ec.europa.eu/index.php?id=169>
- <http://www.jrbp.missouristate.edu/ethanol/images/KarstDiagram-70pct.jpg>
- http://www.absc.usgs.gov/research/seabird_foragefish/marinehabitat/images/Food_Web3.gif