“Alternatives for Managing the Nation’s Complex Contaminated Groundwater Sites: NRC,2013; Key Findings, and Overview of Transition Assessments”

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Unlimited Use/Unrestricted Exposure

40CFR.300.430.4.ii, National Contingency Plan

If a remedial action is selected that results in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for ***unlimited use and unrestricted exposure****, the lead agency shall review such action no less often than every five years after initiation of the selected remedial action.*

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Technical Constraints: Contaminant Chemistry and Hydrogeology (NRC, 1994)

Contaminant Chemistry

Hydrogeology	Mobile, Dissolved (degrades/ volatizes)	Mobile, Dissolved	Strongly Sorbed, Dissolved (degrades/ volatizes	Strongly Sorbed, Dissolved	Separate Phase LNAPL	Separate Phase DNAPL
Homogeneous, single layer	1*	1-2	2	2-3	2-3	3
Homogeneous, multiple layers	1	1-2	2	2-3	2-3	3
Heterogeneous, single layer	2	2	3	3	3	4
Heterogeneous, multiple layers	2	2	3	3	3	4
Fractured Rock	3	3	3	3	4	4

*Relative ease of cleanup, where 1 is easiest and 4 is most difficult (NRC, 1994)

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Status of CERCLA Sites

http://www.epa.gov/superfund/sites/npl/status.htm

February 27, 2014

	Non-Federal	Federal	Totals
Proposed Sites	49	4	53
Final Sites	1,162	157	1,319
Deleted Sites	358	17	375
Construction Complete	1,085	73	1,158

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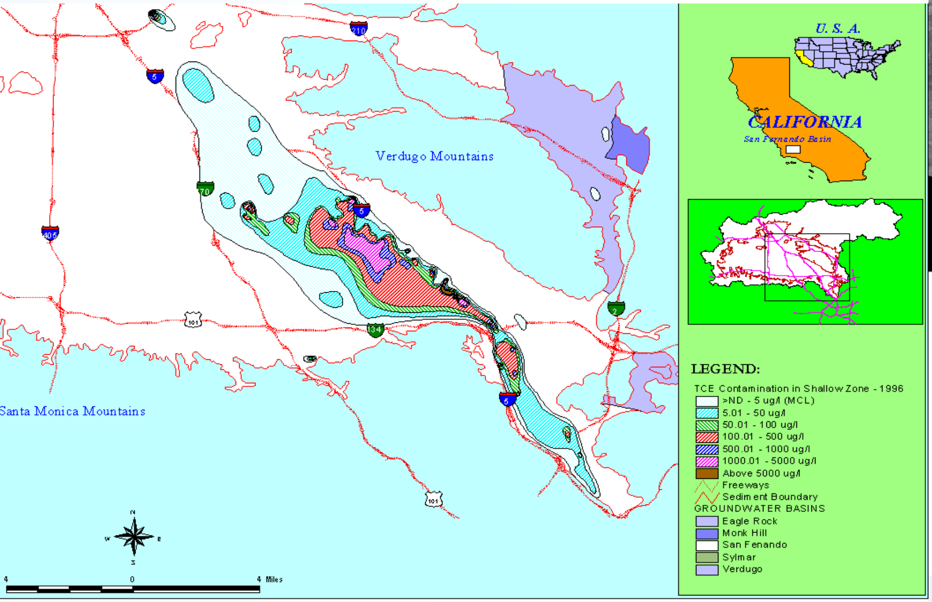
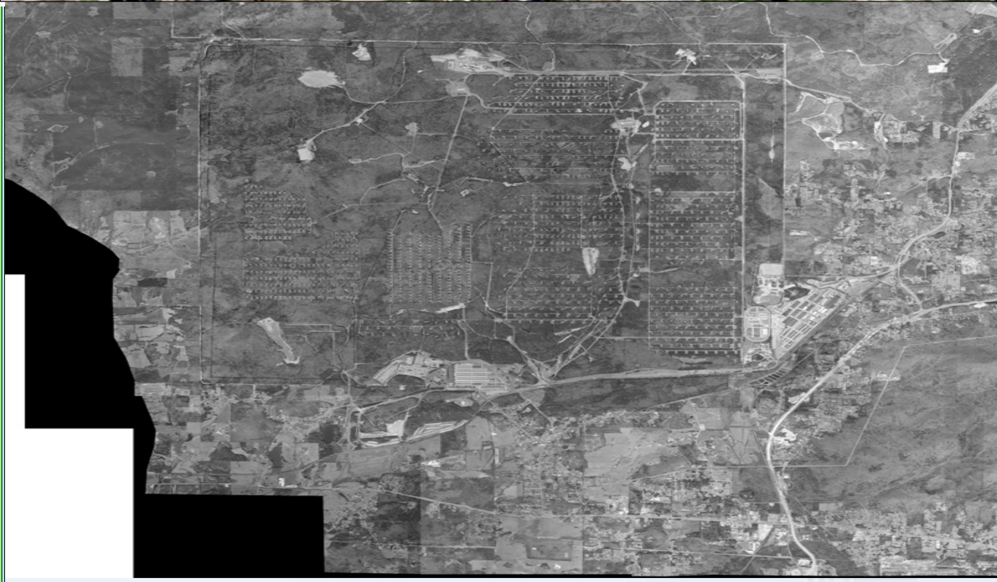
Examples of Complex Sites





Attributes of Highly "Complex Sites"

- Large releases of contaminants over long time frames
- Highly heterogeneous subsurface geologic environments
- Some contaminants recalcitrant and persistent
- Levels of contaminants several orders of magnitude above levels allowing for UU/UE (e.g., MCLs)
- Several years of remedial efforts with an indication of "asymptotic" performance – multiple 5-year reviews
- Life cycle costs to achieve restoration exceeding $20-$50 million

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Background: Overview of Groundwater Restoration
Unresolved Challenges of Groundwater Cleanup

- Many sites with groundwater contamination remain open and restoration to "unlimited use/unrestricted exposure" (UU/UE) and final "closure" uncertain in a "reasonable" timeframe.
- Long term management of orphan CERCLA sites transitioning to state responsibility following 10 years of operation.
  - 10-15 sites/year into the future according to Jim Woolford, (EPA, 2013).
- States financially constrained – long term management liabilities an issue.
- **The "complex site" problem**

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Conclusions – Size of the Problem

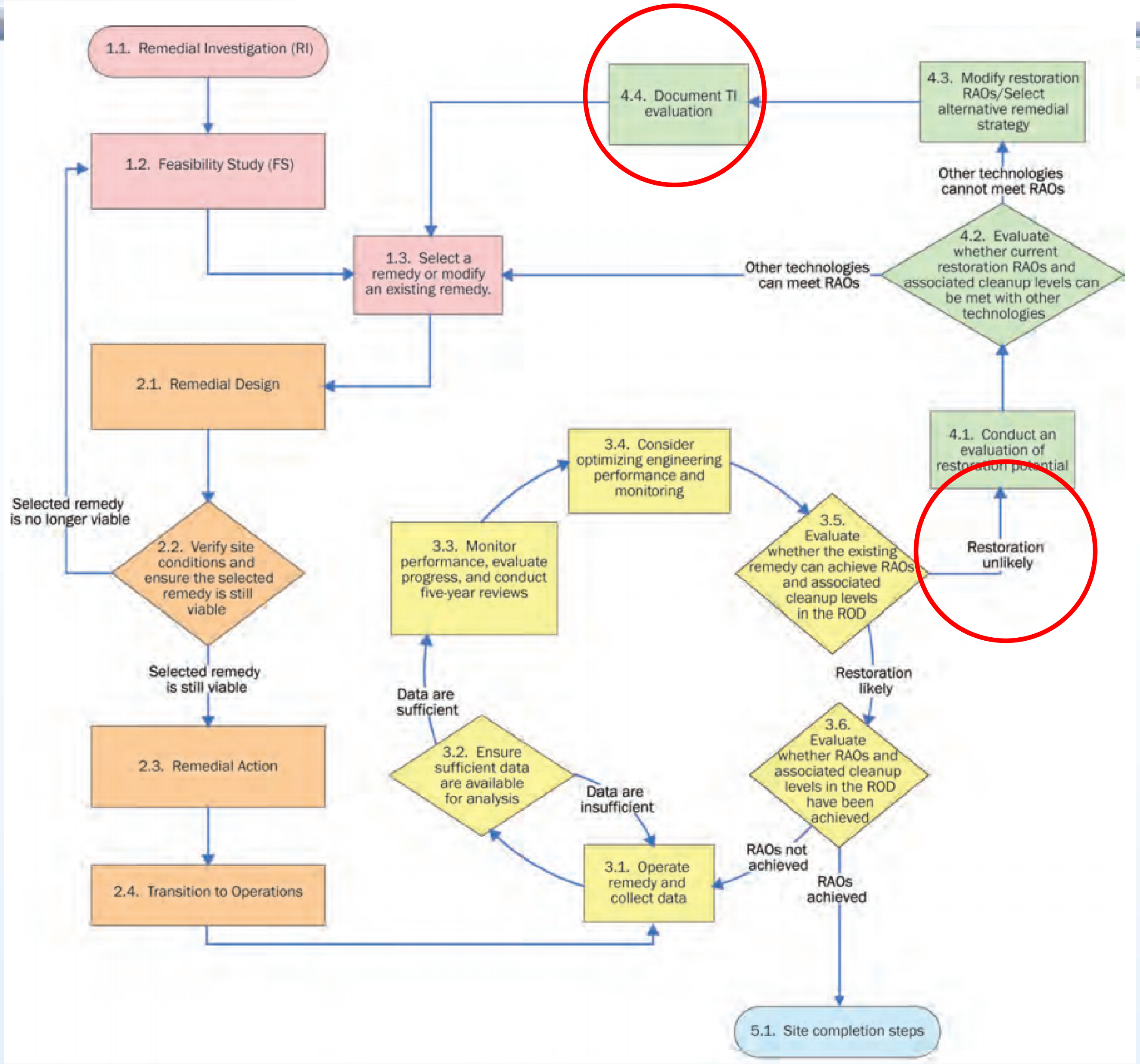
- 126,000 sites that have not yet reached closure is likely an underestimate
- Could not determine the total number of sites with residual contamination above levels allowing for UU/UE
  - Must be > 126,000
- Estimated future cost of $110-127 billion likely an underestimate

- More than 12,000 sites likely “complex”
  - This represents the approximate sum of high priority sites (CERCLA, DoD, DOE, RCRA CA)

Key Finding: Current Technical Capabilities to Achieve UU/UE

- *"Based on what is known about the effectiveness of remediation technologies (as described in this chapter [4]), the Committee concluded that regardless of the technology used, the complete removal (**<u>i.e., restoration</u>**) of contaminant mass at complex sites is unlikely. Furthermore, the Committee discovered no transformational remedial technology or combination of technologies that can overcome the current challenges associated with restoring contaminated groundwater at complex sites. At these sites, some amount of residual contamination will remain in the subsurface after active remedial actions cease, requiring long-term management." (page 114, NRC, 2013)*

EPA Recognizes Alternative Approaches Are Needed for Sites Where Restoration is Unlikely



EPA Roadmap July, 2011

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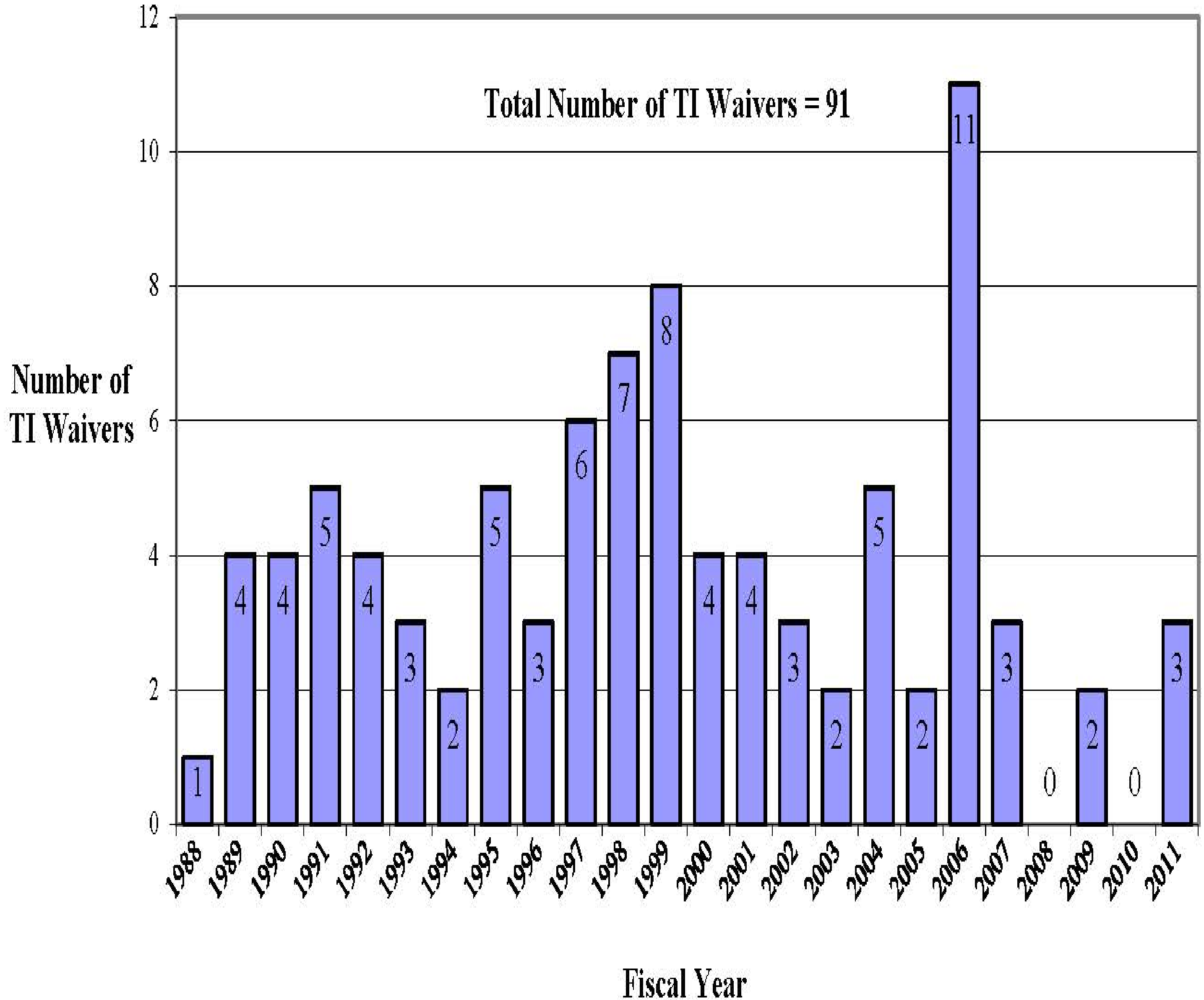
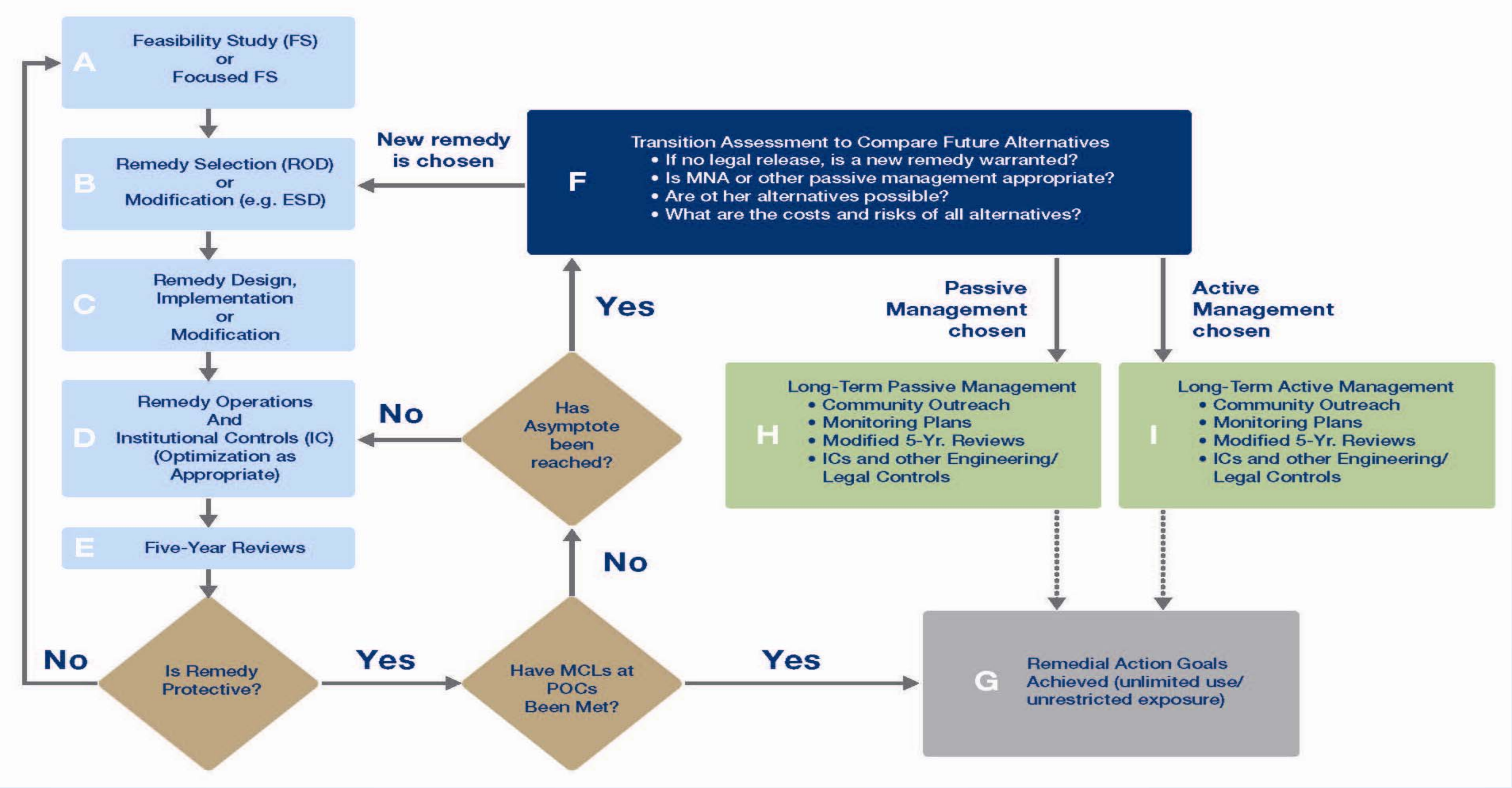
Figure 1: EPA TI Waivers by Fiscal Year (FY 1988 – 2011)



Decision Process Leading to Three Generic End States

- **Remedial Action Objectives Achieved**
  - This would include UU/UE but RAOs could deviate from UU/UE
- **Long-Term Active Management**
  - Operating remedy plus appropriate monitoring, reporting, 5-year reviews, institutional or legal controls, community outreach
- **Long-Term Passive Management**
  - No active remedy but appropriate monitoring, reporting, 5-year reviews, institutional or legal controls, community outreach
  - Consideration of factors to transition to no-monitoring requirements, where appropriate

Alternative Decision Making Process



Metrics to Support "Diminishing Returns" Hypothesis

- Statistical methods confirming declining trend in concentrations.
- Statistical confirmation of target reduction in mass flux/mass discharge.
- For LNAPL recovery, asymptotic performance based on LNAPL/water ratios.
- Risk reduction metric; cost per unit risk reduction.
- Exposure pathways eliminated and risks of residual contamination below threshold levels.
- Sustainability metrics; e.g. GHG emissions per unit mass removed.

Factors to be considered in a Transition Assessment – NRC 2013 Report

- Expanded analysis of costs and risk reduction for viable alternatives including containment.
- Sustainability assessments of options.
- Additional site characterization with advanced diagnostic tools (e.g. to estimate assimilative capacity of aquifer) if justified.
- Risk assessment and risk analysis of post-remedy conditions.
  - Particular focus on level of safety in any containment remedy, active or passive – a risk analysis of residual contamination.
- A risk-based or risk-informed decision process – (see "Science and Decisions" NRC, 1999)
- Expanded community outreach and education.

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EPA Risk Management: Aspirational Goals and Permitting Programs

- Aspirational Goals
  - UU/UE in CERCLA
  - MCLGs in SDWA
  - Fishable, swimmable waters in CWA
  - Delany clause -FDA

- Permitting Programs
  - NPDES in CWA
  - NAAQS – MACT Standards
  - RCRA – Containment of hazardous wastes

Empirical Safety Factors in Decision Making

- EPA human health risk assessments
  - Default values – factors from 1 to 1000
    - Linear extrapolation from animal studies for dose-response curve
    - Explicit defaults and missing defaults
  - Exposure assessments – Percentile default values (e.g. soil ingestion rate for children of 200 mg/day, 65th percentile)
- Establishing MCLs
  - MCLGs for potential human carcinogens; MCL based on risk management decision (e.g. analytical limitations)
- Food Quality Protection Act – factor of 10 to protect infants for pesticide limits.

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Geotechnical Engineers Methodology for Risk Analysis of Dams: Design Assumptions and Safety Factors

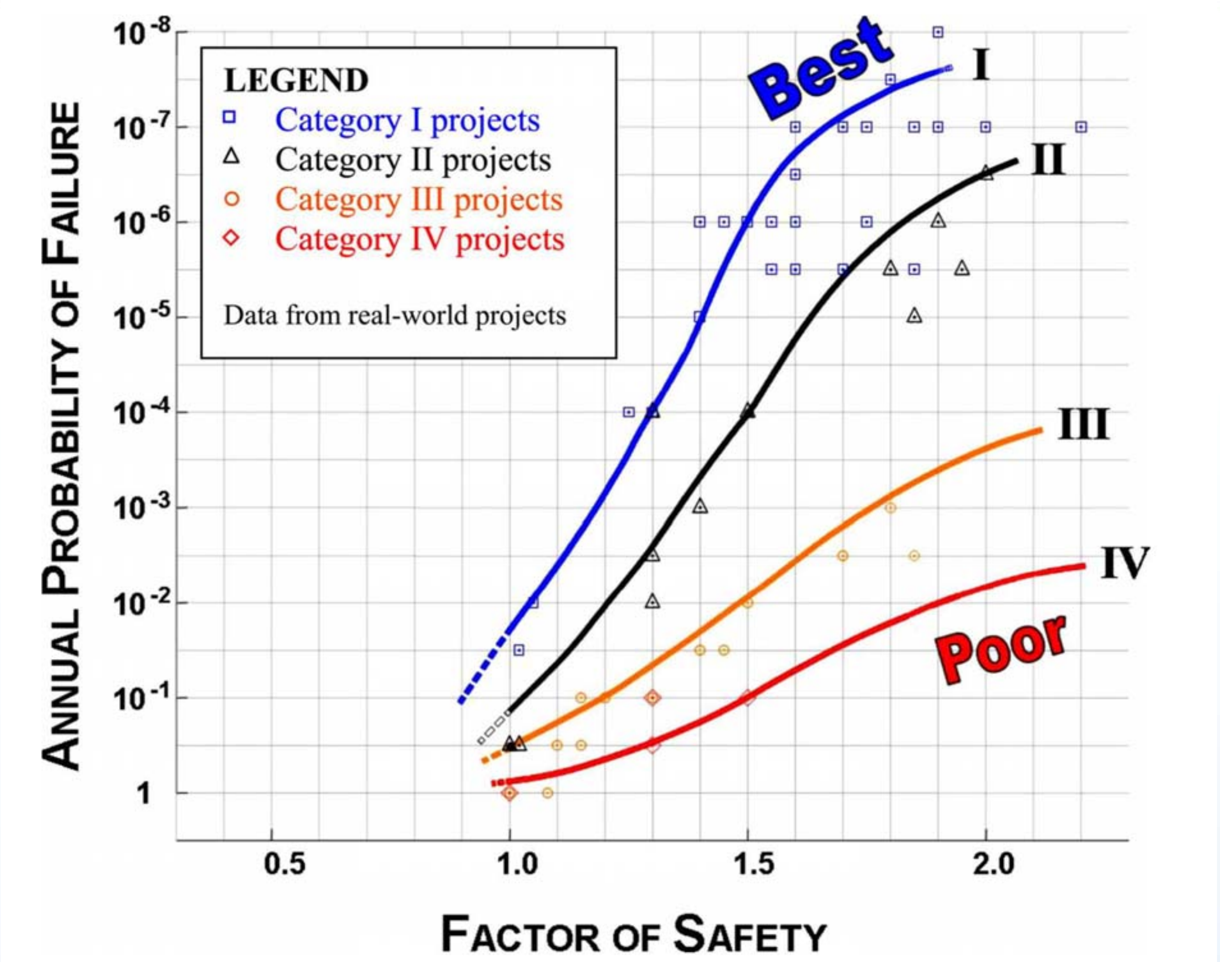

Fig. 1. Factor of safety versus annual probability of failure

F. Silva; T. Lamb; W. Marr, JOURNAL OF GEOTECHNICAL AND GEOENVIRONMENTAL ENGINEERING, Dec. 2008

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The Future: LTM as an Infrastructure Problem

- Goal of long-term management “end states”: minimize probability of failure and consequences of same
- A Geotechnical Engineering Perspective: Applying appropriate “best design practices” with “safety factors”

Risk Management Decision is a Trade Off Decision

Concluding Remarks

- **Central Theme of NRC 2013 Report**
  How nation should deal with residual contamination post-remedy at large number of sites – transition guidance needed.
- A persistent “tradeoff” problem requiring leadership and effective communications.
- Ultimately, from a sustainability perspective, there are limits to resource diversion for pursuing restoration. A pragmatic approach to an ethical problem – regulatory flexibility imbedded in all environmental regulations allowing for creative solutions.
- Research efforts needed to ensure that long term management infrastructure meets acceptable residual risk levels and that residual risk is allocated equitably.

Questions?

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