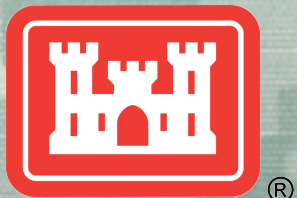
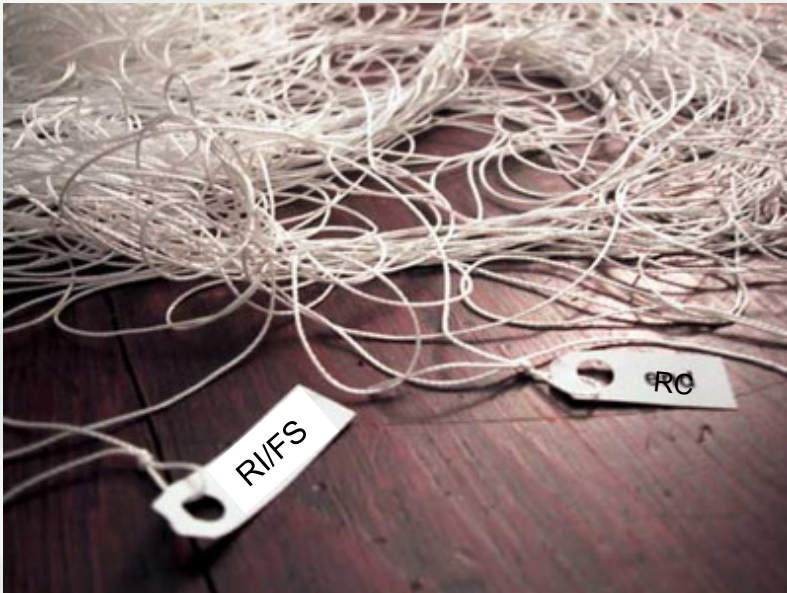


Demystifying RAOs, DQOs, CSMs....



US Army Corps of Engineers
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Discussion Points

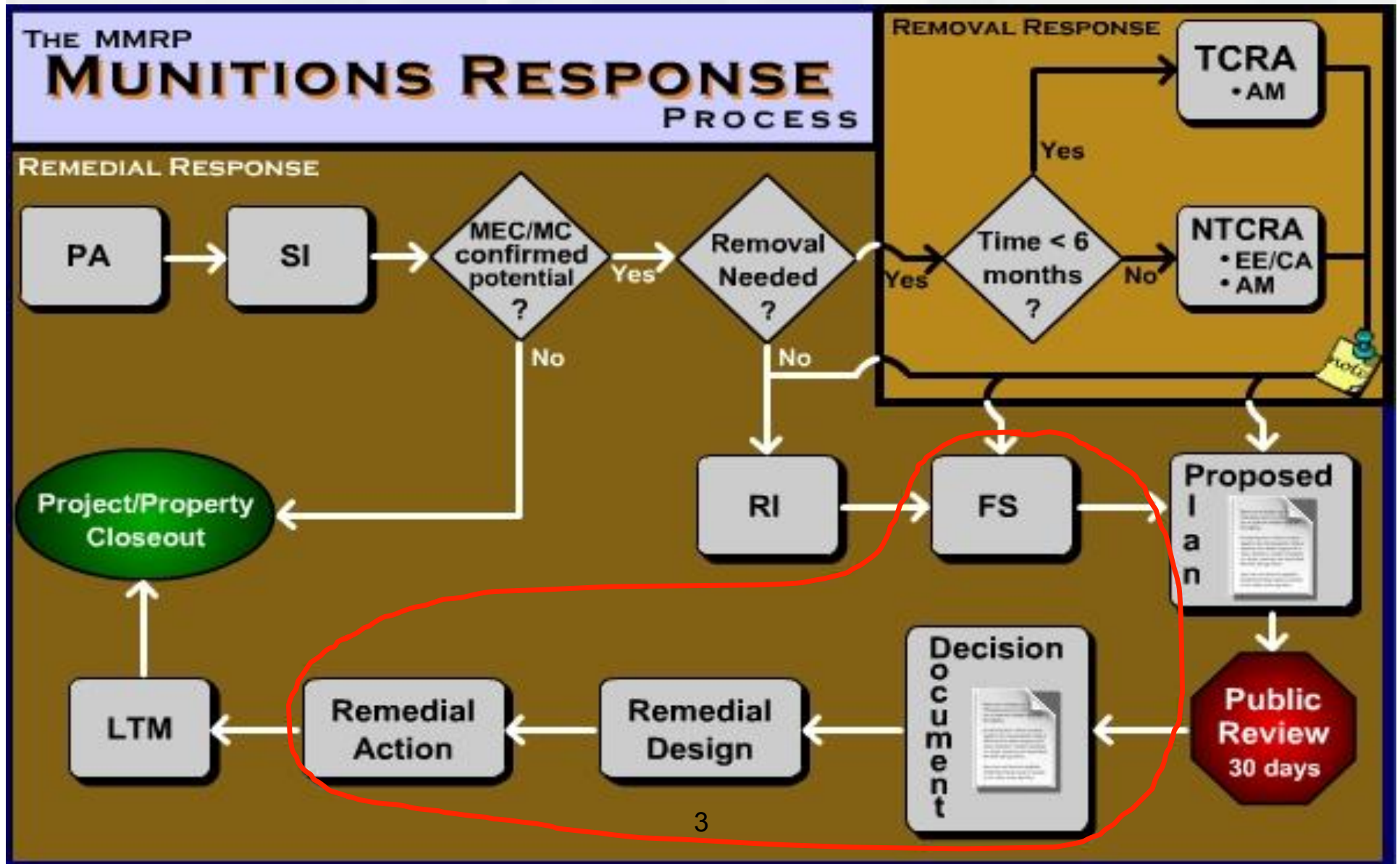


- Untangling
 - ▶ Conceptual Site Model
 - ▶ Remedial Action Objectives
 - ▶ Data Quality Objectives
 - ▶ General Response Actions
 - ▶ Alternatives

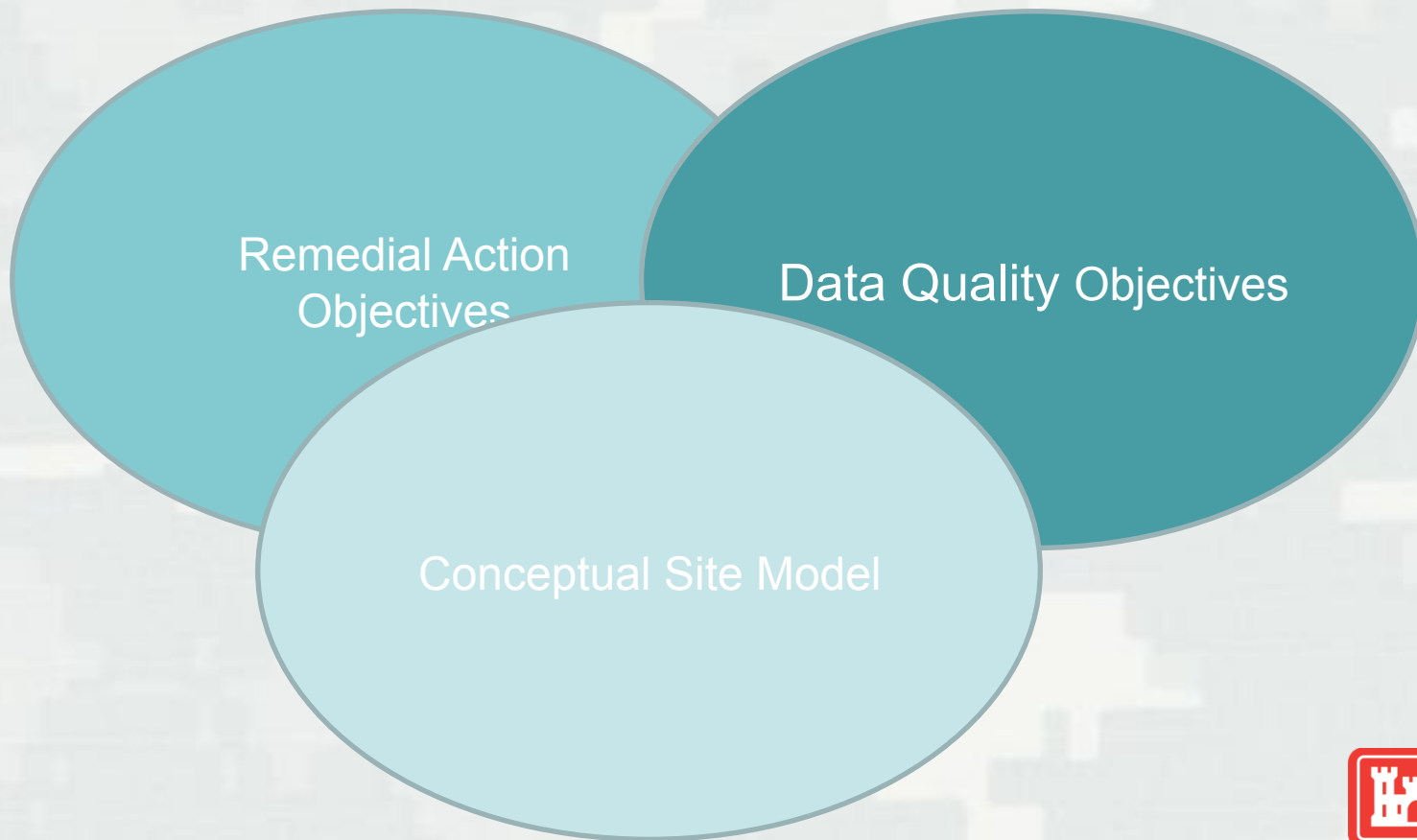
A lot of this is based on the FUDS MMRP Principles and Practices training course



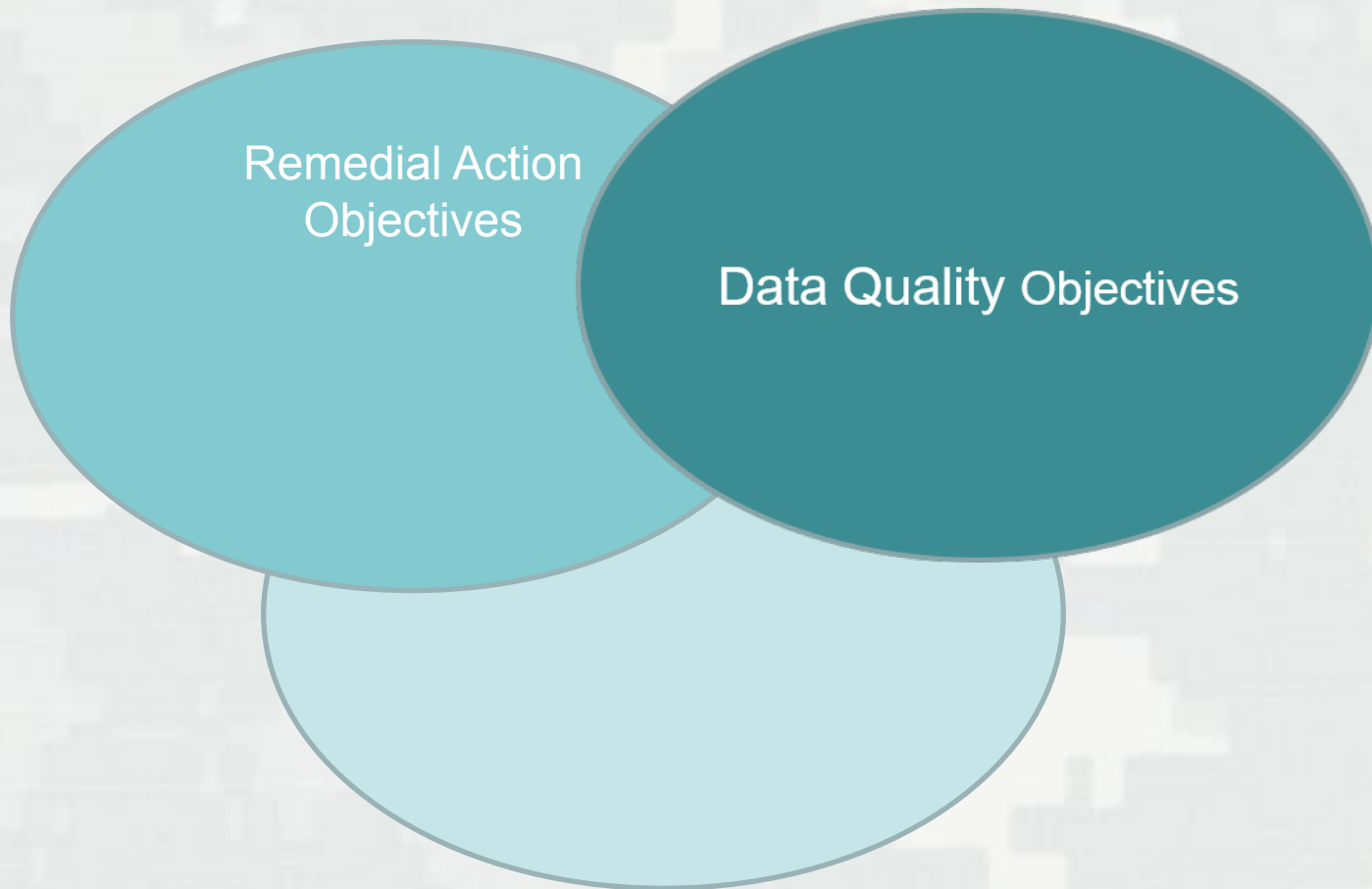
Context Focus For This Talk



RAO - DQO - CSM

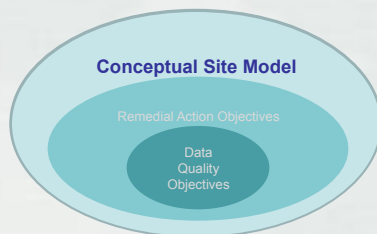


RAO - DQO - CSM



Conceptual Site Model (CSM)

- Written or Pictorial Representation of Current Site Conditions Based on Available Information
- Evolving Process
- Communication Tool
- Identify Data Needs



Conceptual Site Model (CSM)

The CSM is all-inclusive

- Physical descriptions
 - UXO/DMM
 - Geology
 - Topography
 - Vegetation
 - Etc.
- Land use descriptions

General Environmental Cleanup Steps	CSM Life Cycle	Best Management Practices		CERCLA - Superfund
		SPP	DWS/RTMT	
SITE ASSESSMENT	Preliminary CSM	Conceptual	Quantitative	Preliminary Assessment (PA)
	Baseline CSM			Site Inspection (SI)
SITE INVESTIGATION AND ALTERNATIVES EVALUATION	Characterization CSM Stage			Remedial Investigation/ Feasibility Study (RI/FS)
				Removal Actions - Emergency/ Time Critical/Non-Time-Critical
REMEDY SELECTION	Design CSM Stage			Proposed Plan
REMEDY IMPLEMENTATION	Remediation/ Mitigation CSM Stage			Record of Decision (ROD)
		Remedial Design (RD)		
POST-CONSTRUCTION ACTIVITIES	Post-Remedy CSM Stage	Remedial Action (RA) – Interim and Final		
		Operational & Functional Period		
SITE COMPLETION		Operation & Maintenance (O&M)		
		Long term monitoring (LTM)		
		Optimization		
		Long Term Response Action (Fund-lead groundwater/surface water restoration)		
		Construction Complete (CC)		
		Preliminary or Final Close Out Report (PCOR/FCOR)		
		Site Completion - FCOR		
		Site Deletion		
		O&M as appropriate		

Abbreviations:

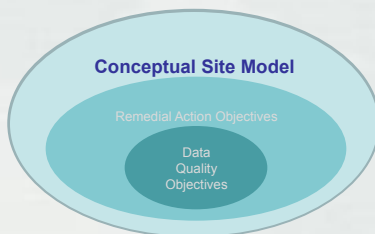
SPP = Systematic Project Planning

DWS = Dynamic Work Strategies

RTMT = Real Time Measurement Technologies

CERCLA = Comprehensive Environmental Response Compensation and Liability Act

RCRA = Resource Conservation and Recovery Act

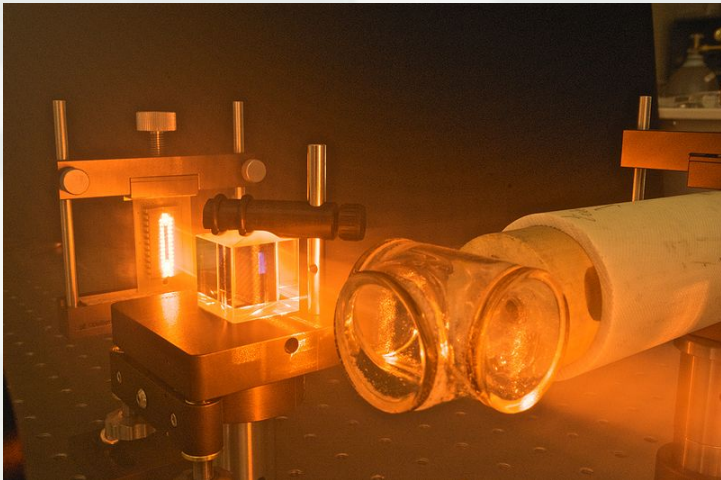
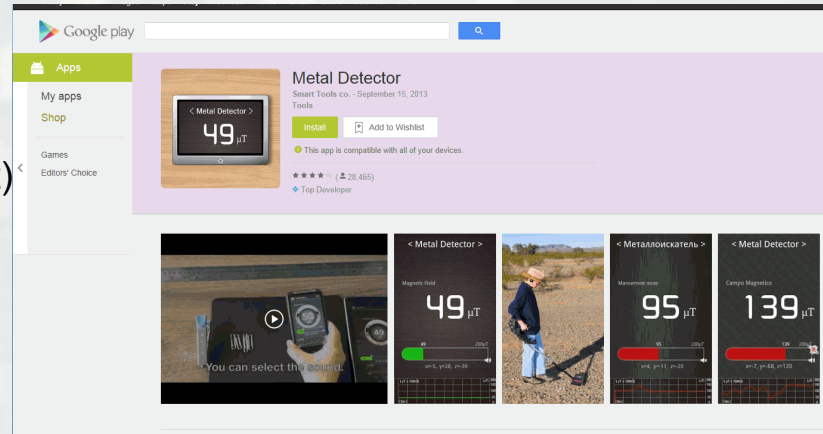


What Does the RAO Mean?

If RAO = "Recover UXO to Depth of Detection"

Then:

Metal Detector app for Android
Sensitivity: 300 nT/LSB (least significant bit)
(or 100# bomb to ~2ft)



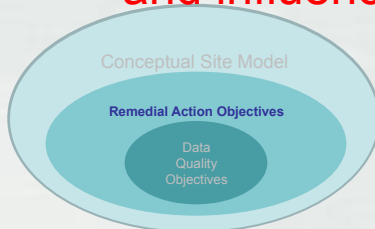
Spin Exchange Relaxation-Free magnetometer
Sensitivity: $0.00000054 \text{ nT Hz}^{-1/2}$
(or 100# bomb to little less than 1/3 mile)



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Remedial Action Objectives

- Munitions Response Site (MRS)-specific goals for protecting human health, safety, and the environment
- RAOs should:
 - ▶ identify contaminants/hazards of concern and media of concern
 - ▶ identify exposure pathways/routes and receptors
 - ▶ identify acceptable contaminant levels
- Examples:
 - ▶ Prevent human ingestion of groundwater with lead concentrations exceeding 15 parts per billion.
 - ▶ Prevent human interaction with surface and subsurface UXO/DMM to a depth of 1 foot under current recreational use activities.
 - ▶ Reduce the number of UXO to a level of not more than one per four acres and influence stakeholder behavior



From RAO To What Will Work

**From:
What We Must Achieve**



U.S. Army Corps of Engineers

FINAL

March 2013

Decision Document

Munitions Response Site
N-2/New Demolition Area

Former Kirtland AFB Precision Bombing Ranges

**To:
Making It Happen**



“The following RAO was developed as the basic requirement for the selected RA alternative at MRS N-2/NDA: prevent or reduce the potential for receptors to come in direct contact with MEC items potentially remaining in MRS N-2/NDA.”



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From EPA's FS Guidance (1988)

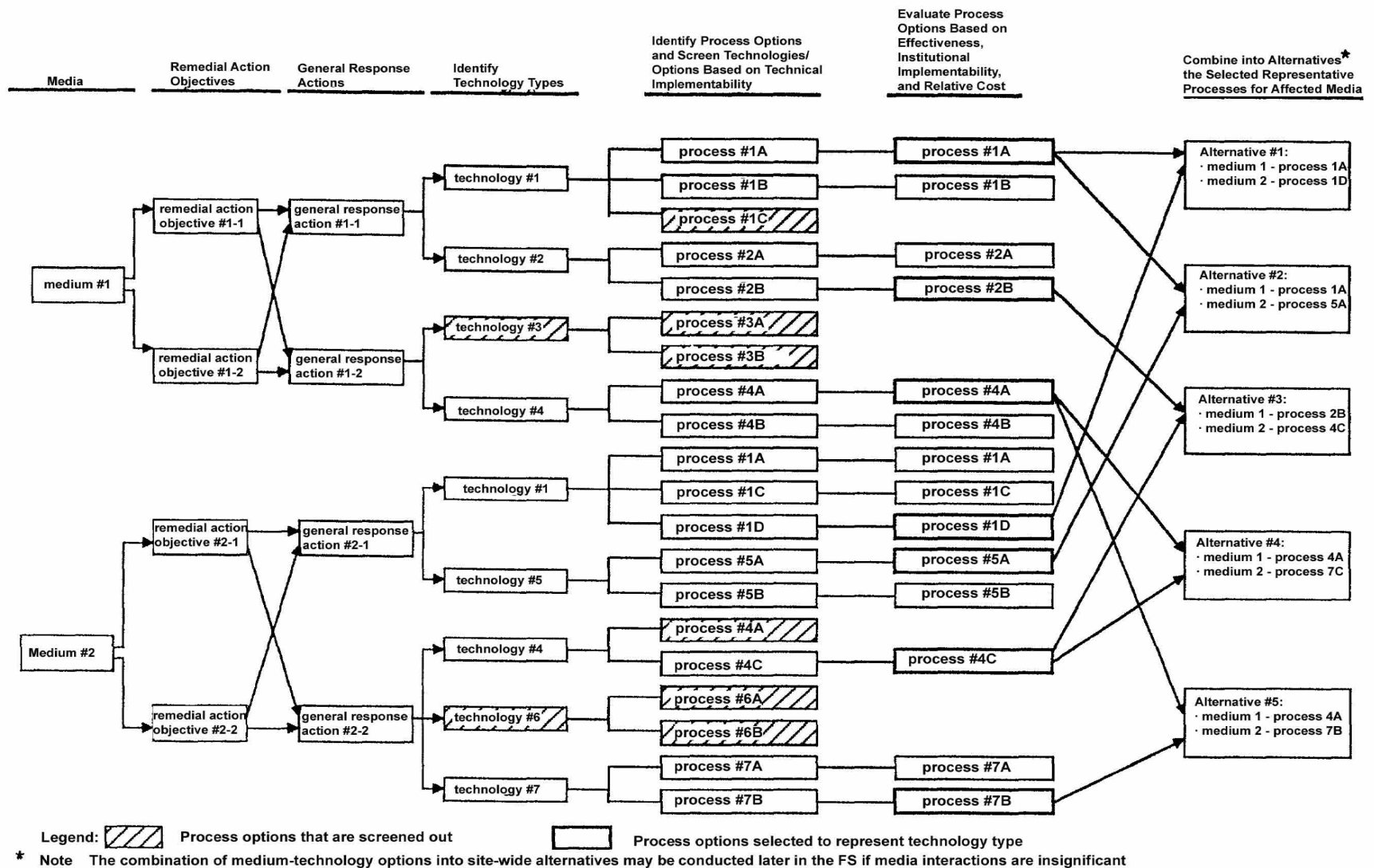


Figure 4-2. Generic alternative development process.

General Response Actions (cont)

- Gives the basic purpose and framework to help define data needs and project direction
- Majority of MRA's/MRS's will normally evaluate the following categories of GRAs:
 - ▶ **NFA (No Further Action)**
 - ▶ **Modify Behavior** = Land Use Controls (LUCs): educational programs, legal mechanisms
 - ▶ **Limit or Deny Access** = Land Use Controls (LUCs): Engineering controls, construction support
 - ▶ **Reduce or Eliminate Source** = Physical removal of hazards (UXO & DMM) and Active treatment



Common process options for each GRA

- No action
- **Limit or deny access**
 - Barriers
 - Use restrictions
 - policing
- **Modify behavior**
 - Education
- **Reduce or eliminate the source**
 - Dig & sift
 - Map and dig
 - Pick up off the surface



From RAO To GRA To What Will Work

From:

What We Must Achieve

- **Limit or deny access**
 - Barriers
 - Use restrictions
 - policing
- **Modify behavior**
 - Education
- **Reduce or eliminate the source**
 - Dig & sift
 - Map and dig
 - Pick up off the surface

To:

Making It Happen

LUC assemblies

- Fencing, pamphlets, deed notices, school programs, etc.

Clean-up technology assemblies

- Map, recover, dispose, etc.



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Remember:

Factor for Anticipated Future Land Use



Then



Now

- Land use impacts remedy selection
- Key factors to consider include:
 - ▶ What is the reasonably anticipated future land use?
 - ▶ Can the existing or anticipated future land use be changed to protect against potential MEC, CWM, or human health hazards?
 - ▶ Can LUCs protect against potential hazards from UXO, DMM, or MC?
 - ▶ Will they be effective



RAO - GRA - Alternatives

Remedial Action Objectives

- protectiveness statements
- clean-up statements

General Response Actions

- Modify Behavior
- Limit or Deny Access
- Reduce or Eliminate Source

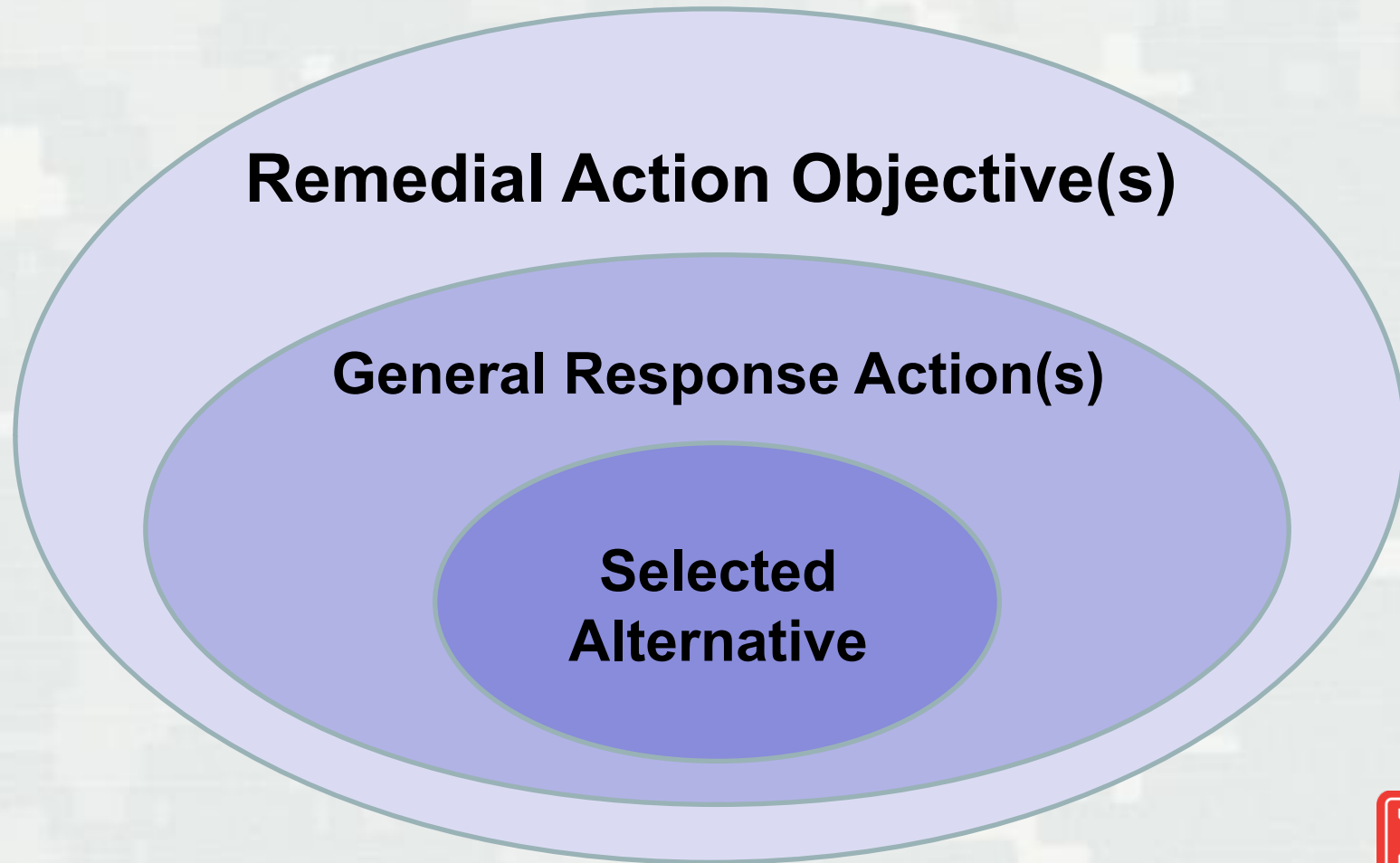
Alternatives

- Clean-up technology assemblies
- LUC assemblies



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RAO - GRA - Alternatives



Example Alternatives Work Flow

Media	RAO	General Response Actions	Technology Types & Options	Identify Process Options and Screen Technologies / Options based on technical implementability	Evaluate options based on effectiveness, intitutional implementability and relative cost			
Soil to 7'	Prevent or reduce the potential for receptors to come in direct contact with MEC items potentially remaining in MRS N-2/NDA.	Limit or Deny Access	physical barriers		fencing	Yes		
			police/guards		cover / fill	No		
			restrictions		patrols	Yes		
					use permits	Yes		
		Behavior Modification	education			School programs	No	
						Town meetings	No	
						signage	Yes	
						pamphlets	No	
						Internet Information	Yes	
		Reduce or eliminate source	detection	Analog	M&D or M&D		No	
					Digital magnetometers	airborne		No
						land borne man-		No
						land borne towed		Yes
						waterborne		No
				Analog EM	M&F or M&D		No	
					Digital EM	airborne array		No
						land borne man-		Yes
				land borne towed		Yes		
				classification	Digital EM	waterborne		No
			land borne man-			Yes		
land borne towed			Yes					
			Yes					
			Yes					
recovery	Excavation		Hand		No			
		Mechanised		Yes				
	Mass excavation and sifting		No					
	Magnetic recovery	electro-magnet		No				
rake & separate		No						
Disposal	Explosive	BIP		Yes				
		Consolidated detonations		No				
		with engineering controls		Yes				
		Contained detonation chamber		No				

using RAO:
 “prevent or reduce the potential for receptors to come in direct contact with MEC items potentially remaining in MRS N-2/NDA”



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Alternatives Work Flow

Build Alternatives

Media	RAO	General Response Actions	Technology Types & Options	Identify Process Options and Screen Technologies / Options based on technical implementability	Evaluate options based on effectiveness, intitutional implementability and relative cost		
Soil to 7'	Prevent or reduce the potential for receptors to come in direct contact with MEC items potentially remaining in MRS N-2/NDA.	Limit or Deny Access	physical barriers	fencing	Yes		
			police/guards	cover / fill	No		
			restrictions	patrols	Yes		
				use permits	Yes		
		Behavior Modification	education	School programs	No		
				Town meetings	No		
				signage	Yes		
				pamphlets	No		
		Reduce or eliminate source	detection	Analog	M&D or M&D	No	
					Digital magnetometers	airborne	No
						land borne man-	No
						land borne towed	Yes
				waterborne		No	
				Analog EM	M&F or M&D	No	
					Digital EM	airborne array	No
						land borne man-	Yes
			land borne towed			Yes	
			waterborne	No			
			classification	Digital EM	land borne man-	Yes	
					land borne towed	Yes	
recovery	Excavation		Hand	No			
			Mechanised	Yes			
	Magnetic recovery		Mass excavation and sifting	No			
			electro-magnet rake & separate	No			
Disposal	Explosive	BIP	Yes				
		Consolidated detonations	No				
		with engineering controls	No				
		Contained detonation chamber	No				

LUCs Only

- Fencing
- Patrols
- Permits
- Signage
- Web Info

DGM Only

- Towed Mag
- Backhoe excavation
- BIP

Classification Only

- Towed Mag detection
- MetalMapper Cued
- Backhoe excavation
- BIP

Etc...



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Example Alternatives Analysis

Using RAO “prevent or reduce the potential for receptors to come in direct contact with MEC items potentially remaining in MRS N-2/NDA”

Assume baseline MECHA level 1; UXO problem is the 100# HE bomb

Alternative	Effectiveness	Implementability	Cost	Stakeholder acceptance
NFA	Not	No issues	\$0	None
LUCs only	Meets threshold, MECHA would go to 2	City and airport agree to implement LUCs	\$0.4M	Will meet resistance as a standalone remedy
DGM only	Moderate to high, MECHA would go to 3	Will require significant airport shut down	\$5M	Little to no resistance expected
Classification only	Moderate to high, MECHA would go to 3	Minor issue, deep bombs difficult to classify	\$3M	Some resistance expected
Classification & LUCS	Moderate to high, MECHA would go to 3	Minor issue on technology, none on LUCs	\$3.4M	Full acceptance expected
Dig and sift	High, MECHA would go to 4	Minor dust issues	\$20M	Full acceptance expected

Example Alternatives Analysis

Using RAO “prevent or reduce the potential for receptors to come in direct contact with MEC items potentially remaining in MRS N-2/NDA”

Assume baseline MECHA level 1; UXO problem is the 100# HE bomb

- Lesson learned: one alternative is not “more protective” than another. There are no “degrees of protectiveness”
 - ▶ One alternative might be more implementable or more effective at achieving the desired level of protectiveness.



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Conceptual Site Model (CSM)

General Environmental Cleanup Steps	CSM Life Cycle	Best Management Practices		CERCLA - Superfund
		SPP	DWS/RTMT	
SITE ASSESSMENT	Preliminary CSM			Preliminary Assessment (PA) Site Inspection (SI) National Priorities List (NPL) No Further Remedial Action Planned (NFRAP)
	Baseline CSM			
SITE INVESTIGATION AND ALTERNATIVES EVALUATION	Characterization CSM Stage			Remedial Investigation/ Feasibility Study (RI/FS) Removal Actions - Emergency/ Time Critical/Non-Time-Critical
	Design CSM Stage			Proposed Plan Record of Decision (ROD)
REMEDY IMPLEMENTATION	Remediation/ Mitigation CSM Stage			Remedial Design (RD) Remedial Action (RA) – Interim and Final
Post-CONSTRUCTION ACTIVITIES	Post-Remedy CSM Stage			Operational & Functional Period Operation & Maintenance (O&M) Long term monitoring (LTM) Optimization Long Term Response Action (Fund-lead groundwater/surface water restoration)
SITE COMPLETION		Construction Complete (CC) Preliminary or Final Close Out Report (PCOR/FCOR) Site Completion - FCOR Site Deletion O&M as appropriate		

Abbreviations:

SPP = Systematic Project Planning

DWS = Dynamic Work Strategies

RTMT = Real Time Measurement Technologies

CERCLA = Comprehensive Environmental Re-
compensation and Liability Act

RCRA = Resource Conservation and Recovery

The CSM is all-inclusive

- Physical descriptions
 - UXO/DMM
 - Geology
 - Topography
 - Vegetation
 - Etc.
- Land use descriptions

But also:

- The RAO
- Remedial Action results
- Understanding of the Hazard Assessment



CSM - RAO - GRA – Alternative

Conceptual Site Model

Remedial Action Objective(s)

General Response Action(s)

**Selected
Alternative**

This is the Decision Document!



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We Have the RAOs and the Selected Alternative, Now What?

“...I’ll say...how do we know when we detect the UXO...then once we detect them, how do we know we cued them all...then once we cued them all how do we know we made the right dig decision..then once we make the dig decision how do we know we dug at the right place...then once we dug the hole how do we know we got everything out of it?”



This Is Where DQO's Fit In

DQOs are what you use to show:

- You detected the UXO over the entire site
- You cued them all
- You made the right dig decision,
- That you dug the hole at the correct location
- And that what you expected at that location got recovered



Example Inputs to Decisions

DD/RD→RIP/RC

UXO/DMM Clean-Up Design

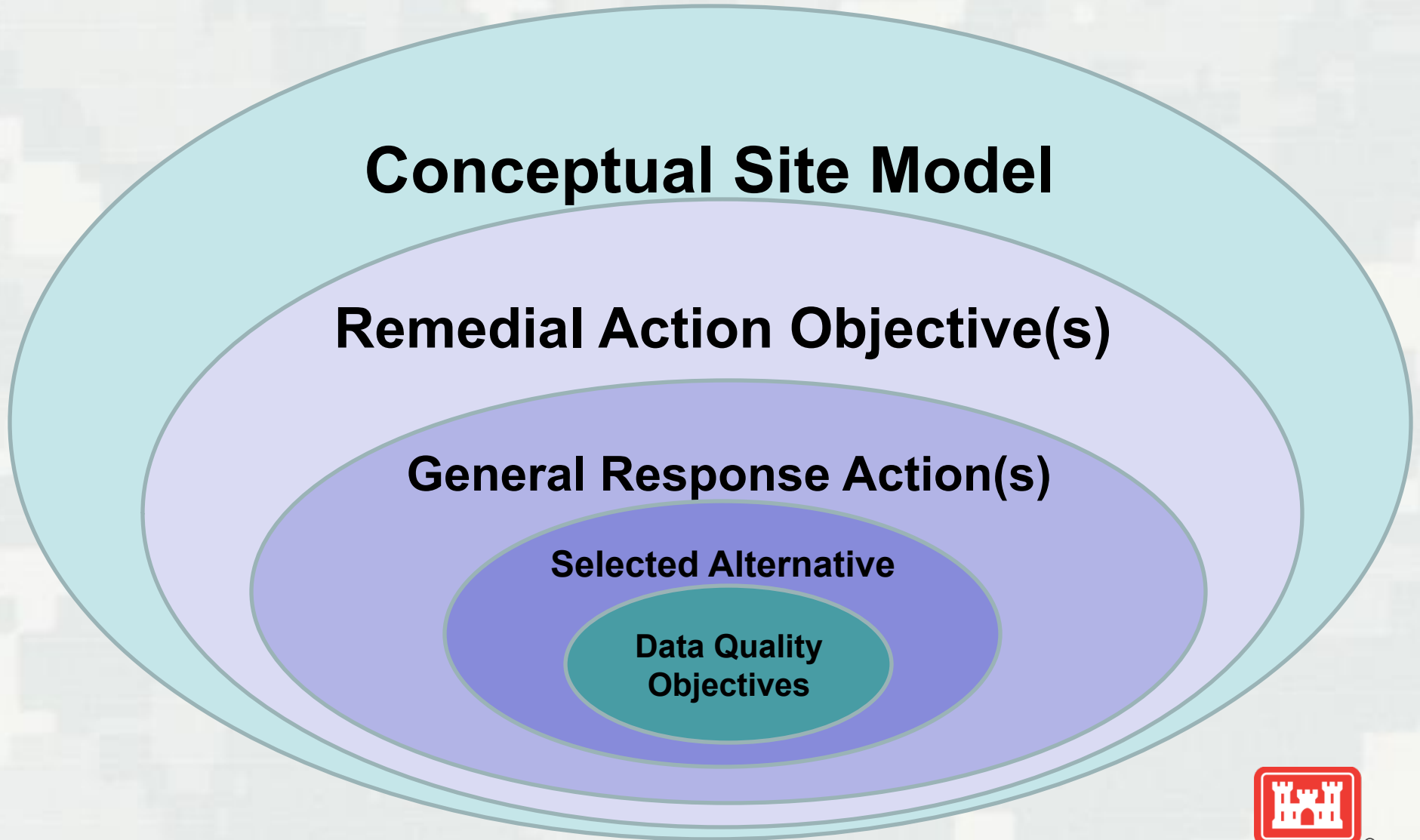
- How are UXO/DMM detected?
- How many are recovered and where?
- What is their depth distribution?
- What are the blind seed recovery rates?
- Is the quality control meaningful?

Residual Hazards Management

- What amount and types of residual hazard can be managed
- Do clean-up findings align with pre-cleanup CSM?
- Are LUCs implemented?
- Are cleanup findings communicated to stakeholders?



CSM - RAO - GRA – Alternatives -DQO



Examples of After-Action CSM pictorials

