Preliminary Assessment and Site Inspection (PA/SI) Process for Sites with General Radioactive Material (G-RAM)

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RITS 2025

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Information in this presentation is current as of May 22, 2025.

EXWC: Engineering and Expeditionary Warfare Center
NAVFAC: Naval Facilities Engineering Systems Command

Speaker Introduction

Rion Marcinko

CHP, RRPT

Health Physicist

Jacobs

Navy: Department of the Navy

- Bachelor of Science, Nuclear Energy Engineering Technology, Thomas Edison State College, Trenton, NJ
- Master of Science, Radiological Health Sciences Colorado State University, Fort Collins, CO
- CHP with over 12 years of experience in environmental assessment and remediation, licensing and regulatory requirements, decommissioning, shielding design, and operation and maintenance of military and civilian nuclear reactors
- Community of practice lead for the Jacobs Radiation Services group
- Former enlisted Navy “nuke” (Nuclear Propulsion Program), served on board the USS Kentucky, SSBN-737 in Silverdale (Bangor), WA

Presentation Overview

- Introduction
- Preliminary Assessment Development
- Site Inspection Process
- Case Studies
- Summary and Closing Statements

Section Overview

- Introduction
  - Previous RITS Presentations
  - Purpose
  - Applicability
  - Radiation 101
  - General Radioactive Material
  - Brief History of Radioactive Material and Regulators
  - Regulatory Authority and Responsibility

Previous RITS Presentations

2014	Rad 101: Everything you have been Curie-ous about…
2015	Multi-Agency Radiological Survey and Site Investigation Manual

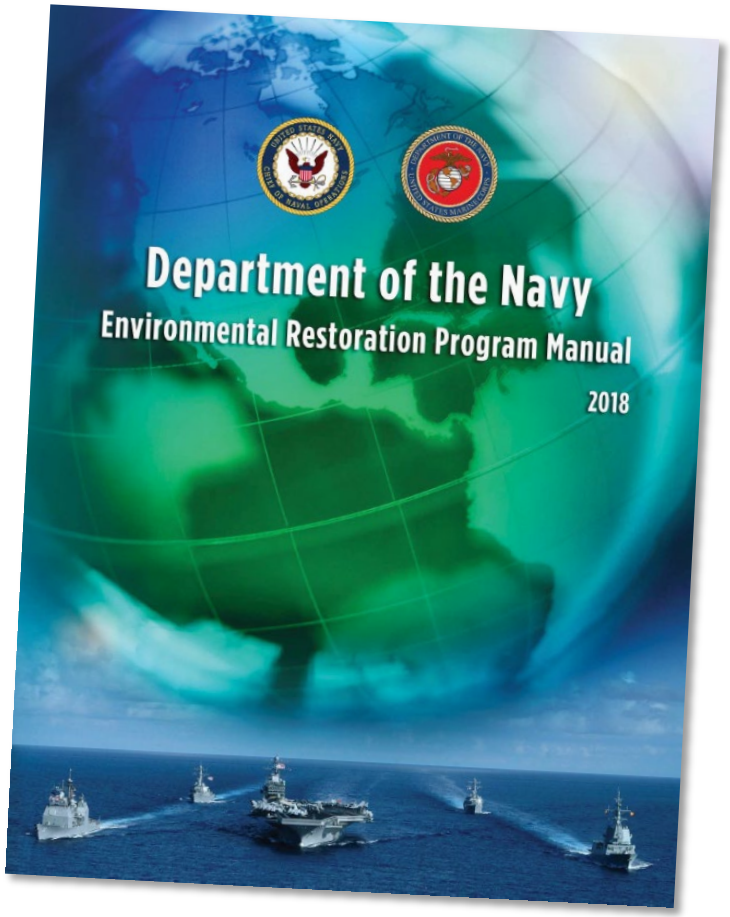
Purpose

- This presentation introduces G-RAM, its evaluation, and methodologies for investigation in the environment
- PA/SIs are commonplace for many COCs; however, G-RAM is a contaminant that presents unique challenges for investigation
- RPMs may be unfamiliar with G-RAM terminology and processes to evaluate environmental media
- Recently developed *Framework for Preliminary Assessments and Site Inspections at Radiological Sites* promulgated under EXWC for use by RPMs (Navy 2025)

CLEAN: Comprehensive Long-term Environmental Action—Navy
COC: contaminant of concern
RPM: Remedial Project Manager

Applicability

- Sites and areas identified with a suspicion or confirmed presence of G-RAM must meet eligibility criteria under NERP or ER,N (Navy 2018)
- G-RAM present within buildings are typically not ER,N eligible; however, releases to the environment from buildings (without an active source of contamination) or from foundations or piping remaining following building demolition are eligible

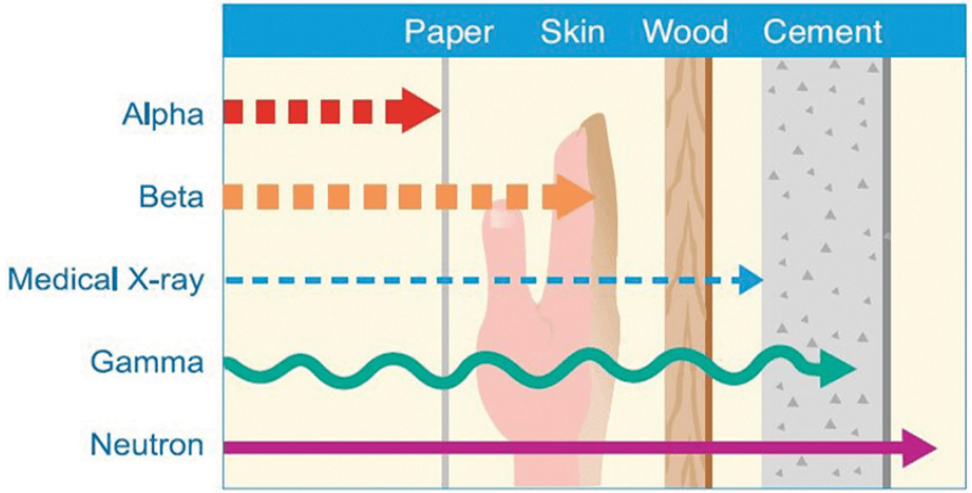


(Navy 2018)

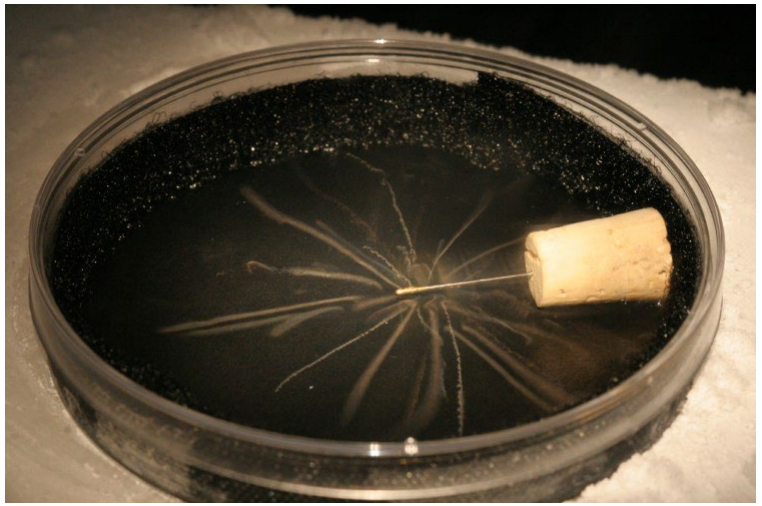
ER,N: Environmental Restoration, Navy
NERP: Navy Environmental Restoration Program

Radiation 101

- Key concept: Difference between *radiation* and *radioactive material*
- Radiation is all around us (cosmic, terrestrial sources)
- Three **primary** radiation types applicable to G-RAM:
  - Alpha (α)
  - Beta (β)
  - Gamma (γ)
- Hazards associated with different radiation types vary (e.g., external versus internal)



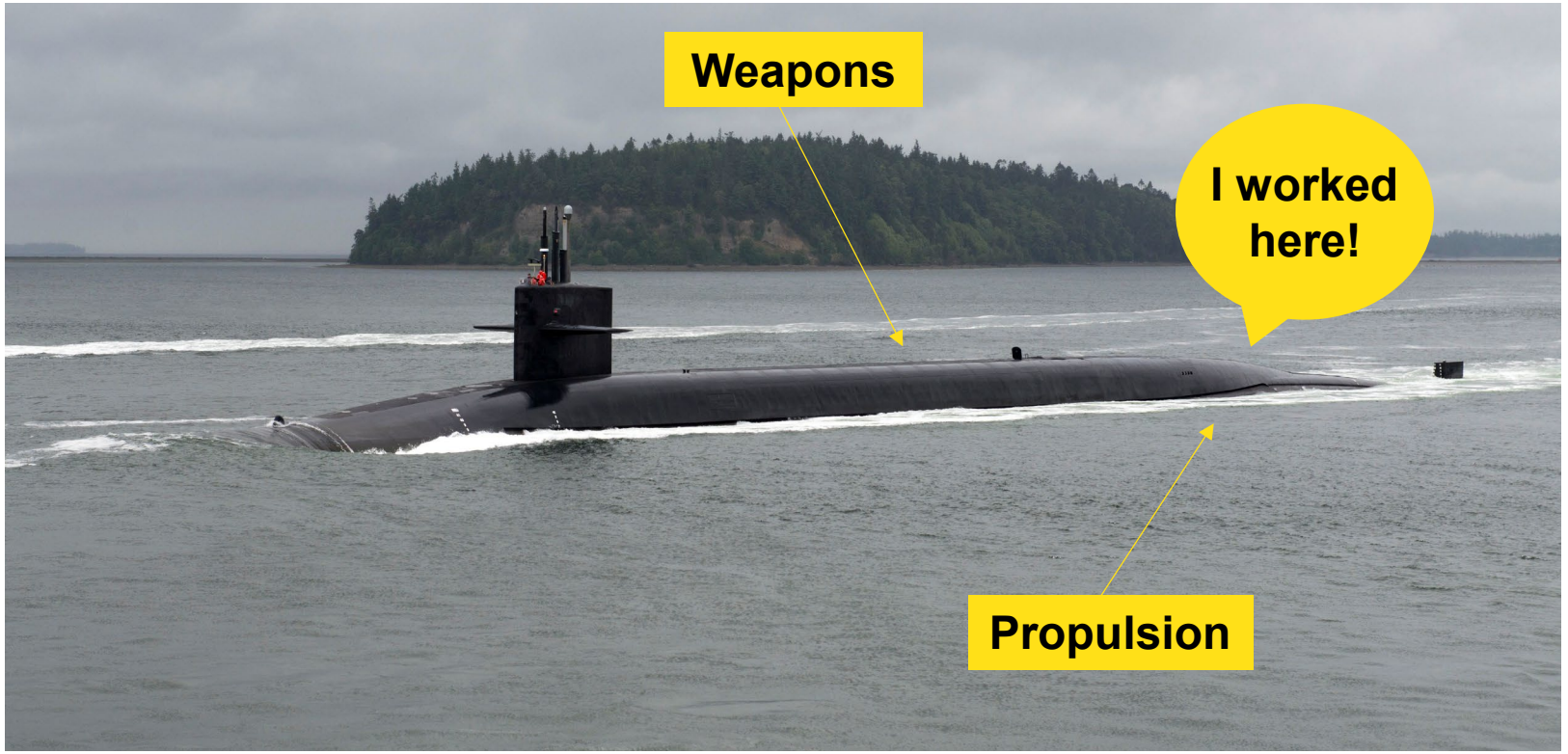
(NRC 2020)



(Jefferson Lab Resources 2025)

General Radioactive Material

*Term that describes Navy radioactive materials **excluding** Naval Nuclear Propulsion Program or Naval Nuclear Weapons Program radioactive materials*



(STRATCOM 2017)

General Radioactive Material

- **Includes**
  - Byproduct, source, and special nuclear materials
  - NORM
  - TENORM
  - NARM

KEY POINT

If radioactive material in question is not related to weapons or nuclear propulsion, it may be considered G-RAM!

Are x-ray machines considered G-RAM?

NARM: Naturally Occurring and Accelerator-produced Radioactive Material
NORM: Naturally Occurring Radioactive Material
TENORM: Technologically Enhanced Naturally Occurring Radioactive Material

Brief History of Radioactive Material and Regulators

- 1914: United States Radium Corporation founded
- 1946: AEA, AEC established
- 1954: AEA Revision (licensing and regulation of civilian use)
- 1963: Navy Bureau of Ships issues Instruction 5100.15, *Control of Contamination from Radioactive Luminescent Materials* (responsibilities eventually assigned to Naval Sea Systems Command)
- 1975: NRC established
- 1980: CERCLA and Superfund Program administered by EPA
- 1987: NRC grants Navy Master Materials License, NRMP established

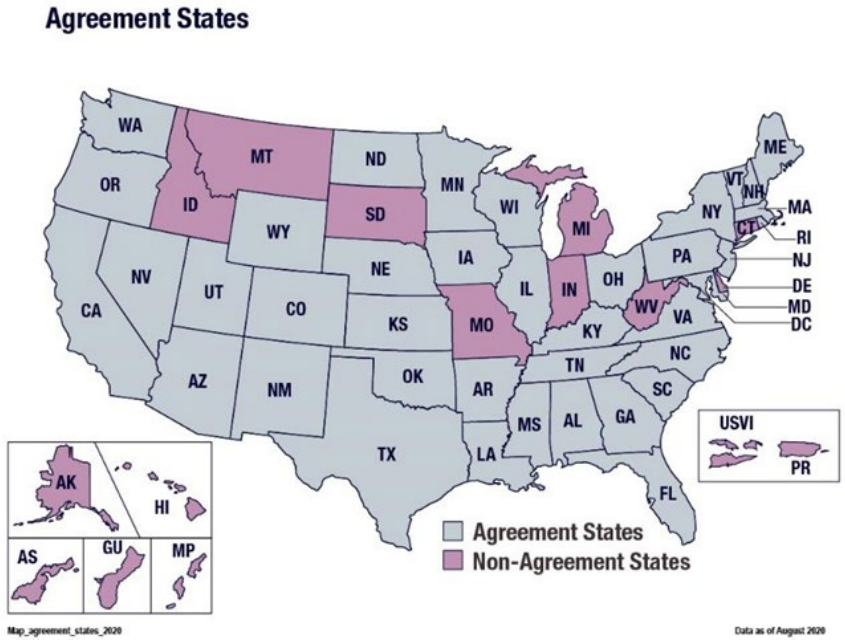
(DOE 1946)

(NRC 2024)

AEA: Atomic Energy Act
AEC: Atomic Energy Commission
CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act
EPA: United States Environmental Protection Agency
NRC: Nuclear Regulatory Commission
NRMP: Naval Radioactive Materials Permit Program

Regulatory Authority and Responsibility

- Regulatory authority is specific to each Installation and may differ for nearby properties (e.g., outlying fields or annexes)
- Installations listed under NPL will include EPA regional regulatory authority
- DoD maintains Memorandum of Understanding with NRC to avoid duplicative regulation and ensure responsibilities satisfied
- Non-NPL sites may include agreements with NRC or state environmental agencies (NRC Agreement States)
  - State may be engaged for NPL sites, too
- Consult your real estate or regulatory specialist for installation specific jurisdiction



(NRC 2020)

NPL: National Priorities List

Regulatory Authority and Responsibility

- The RPM is responsible for overall management and execution of work at DON ERP radiological sites
- RASO is the DON technical authority with cognizance for administering and enforcing G-RAM policies and requirements
- RASO will assign an individual EPM for PA/SI activities
- EPM will coordinate with NAVFAC on technical oversight and discussions with regulators (e.g., EPA, NRC, and State) and the public

(Navy 2020)

KEY POINT

Coordinate with your EPM *early* and *often* during the PA and SI process!

DON: Department of the Navy
EPM: Environmental Protection Manager
RASO: Radiological Affairs Support Office

(Navy 2010)

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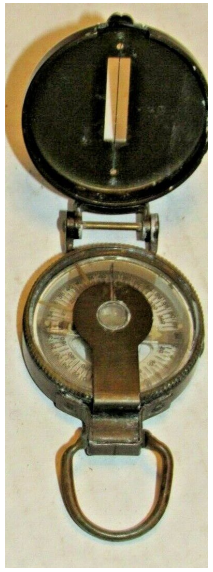
Section Overview

- **Preliminary Assessment Development**
  - Purpose of the Preliminary Assessment
  - Current Navywide Preliminary Assessment Status
  - Historical Radiological Assessments
  - Identifying Sites with General Radioactive Materials
  - Radionuclides of Potential Concern
  - Development of the Conceptual Site Model
  - Example Migration Pathways
  - Initial Site Classification
  - Preliminary Assessment Recommendations
  - Report Preparation

Preliminary Assessment Development

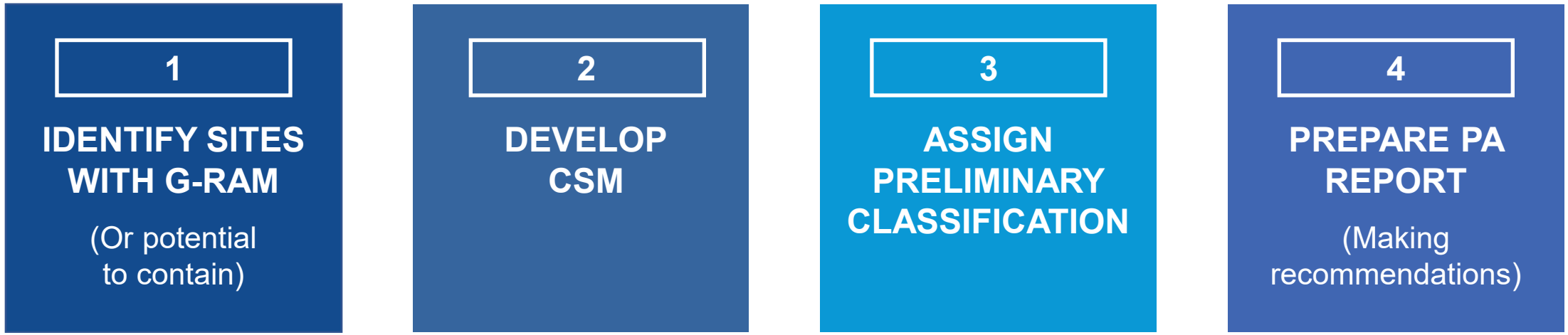
- Historical use of G-RAM through use of commodities, research radionuclides, and other military projects
- Commodities are most common form of G-RAM
  - Examples: Radioluminescent devices such as compasses, deck markers, signs, dials, and gauges; aircraft components such as engine exciters, structural metal alloys, and electronics systems; munitions; weaponry sights; and radar systems
- Many items were unregulated or permitted disposal by burial
- Regulations applicable to low-level radioactive waste were not implemented until early 1980s
- Legacy commodities (or residual radioactive material as the result of their use) may be present in environment



(US Army 2018)

Purpose of the Preliminary Assessment

- The PA team will gather information, evaluate environmental conditions, and provide recommendations to sites that warrant further investigation
- Accomplished through the following steps



- Methodology for completing each step is unique for sites with G-RAM

CSM: conceptual site model

(EPA 1991, Navy 2025)

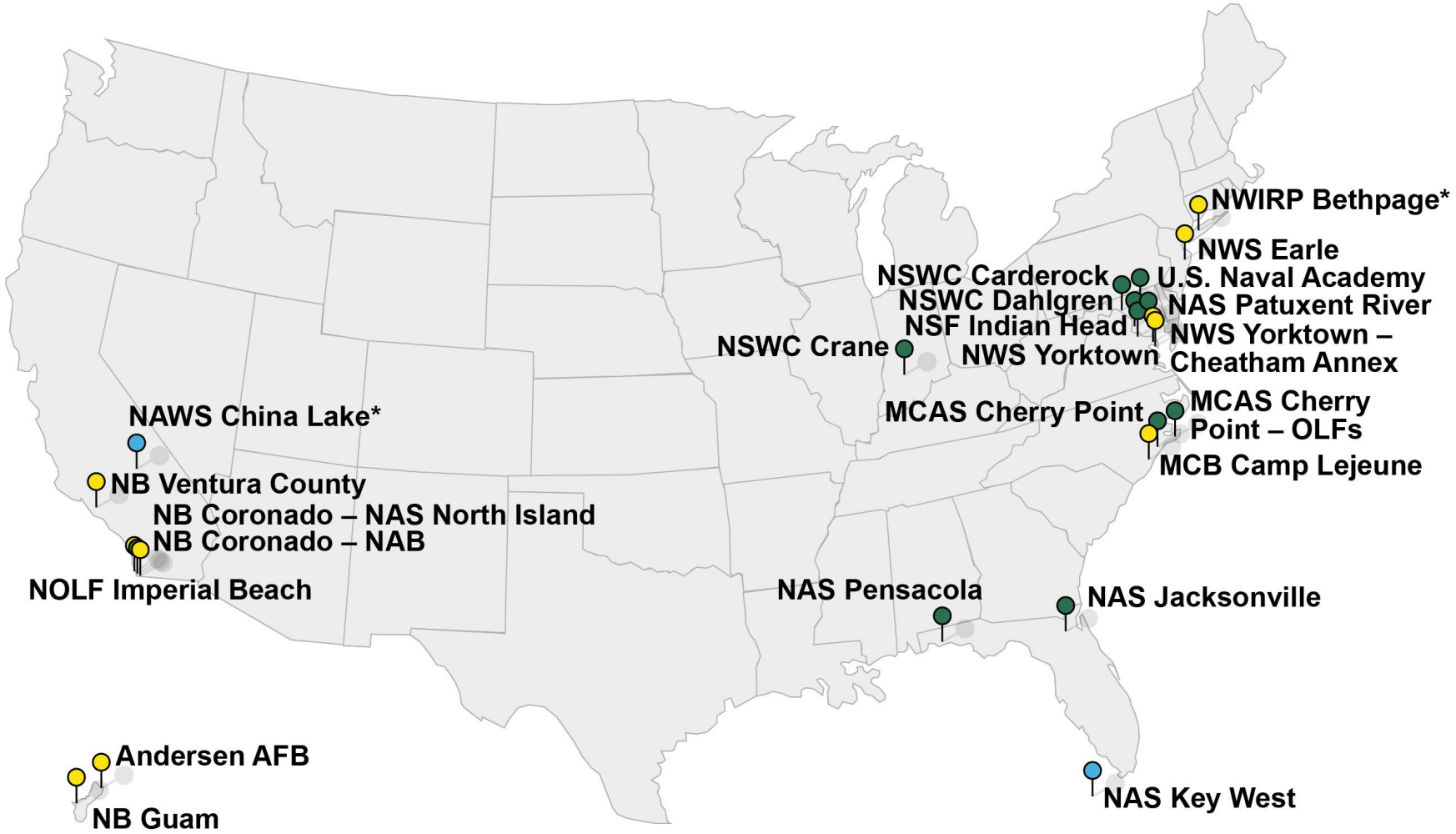
Historical Radiological Assessments

- What is an HRA, and was it completed at my installation?
  - Analog of CERCLA PA
  - Management tool developed by RASO to identify areas with radiological liabilities
  - In fiscal year 2015, RASO initiated series of modern HRAs
    - Shifted execution and support to NAVFAC and established consistency standards
  - Includes areas not ER,N eligible and materials or areas currently managed or regulated under NRMP
  - RPMs participate in performance and review
  - Includes same site classifications as PA
  - **Internal document – not added to administrative record**
  - Should not reference HRA directly in PA

HRA: Historical Radiological Assessment

(Navy 2022)

Current Navywide PA Status



LEGEND

- In progress
- Complete
- Planned
- * No HRA

AFB: Air Force Base
MCAS: Marine Corps Air Station
MCB: Marine Corps Base
NAB: Naval Amphibious Base
NAS: Naval Air Station
NAWS: Naval Air Weapons Station
NB: Naval Base
NOLF: Naval Outlying Landing Field
NSF: Naval Support Facility
NSWC: Naval Surface Warfare Center
NWIRP: Naval Weapons Industrial Reserve Plant
NWS: Naval Weapons Station

(Navy 2025)

Historical Radiological Assessments

Locations where modern HRA was completed

Installation	Year HRA Completed	Installation	Year HRA Completed
NAS Jacksonville	2016	NAS Key West	2020
NAS Pensacola	2016	Joint Region Marianas – Navy Base Guam	2021
NOLF Imperial Beach	2016	Joint Region Marianas – Andersen Air Force Base	2021
NRL Washington DC	2016	NAS Patuxent River	2020
NB Coronado; NAS North Island, NAB Silver Stand Training Complex	2019	MCAS Cherry Point	2021
NSA Crane	2018	NWS Earle	2022
NSWC Carderock	2018	NWS Yorktown	2022
NSF Dahlgren	2018	MCB Camp Lejeune	2023
US Naval Academy	2020	NB Ventura County	2018
NSF Indian Head	2018	NPGS, Monterey, CA	2017

(Navy 2022)

Identifying Sites with G-RAM

- If HRA is available, use information applicable to ER,N-eligible sites
  - Should not reference HRA directly
  - Download and review, applicable HRA references
- If HRA is not available
  - Compile comprehensive list of ER,N-eligible areas
  - Determine which sites have potential for G-RAM
- Conduct historical research
  - Desktop review
  - Site visit
  - Interviews
- Determine potential for G-RAM release to environment

(National Archives and Records Administration 2019)

(Navy 2025)

Identifying Sites with G-RAM

- Examples of sites with potential for G-RAM
  - Disposal sites (e.g., dumps, borrow pits, burn pits, and landfills)
  - DRMOs
  - Storage yards
  - Demolished aircraft hangars and aircraft rework shops
  - Aircraft boneyards
  - Aircraft crash sites
  - Former firefighting training areas where derelict aircraft were used for fire training exercises
  - Former ranges with use of aircraft, vehicle, or tank targets
  - Former radium paint shops (and surrounding areas)

(University of Guam 2017)

DRMO: Defense Reutilization and Marketing Office

(Navy 2025)

Radionuclides of Potential Concern

Radionuclide	Principal Radiation	Half-Life (years)	Common Uses
Cs-137	Beta	30	• Aircraft components (exciters: exciter boxes, engine exciters, and exciter assemblies) • Commodities
Ra-226	Alpha	1660	• Aircraft components (circuit breakers, numerous assorted gauges, and switches) • Radioluminescent devices (radioluminescent paint) • Commodities • Combat vehicle components (numerous assorted dials and switches) • Ground control approach radar units
Sr-90	Beta	29	• Aircraft components • Commodities
Th-232	Alpha	1.4×10^{10}	• Aircraft components (engine inlet frames, engine gear cases, gun sights, control pedals, and magnesium-Th coated structural pieces) • Thoriated glass optics (night vision lenses) • Commodities
U-238	Alpha	4.5×10^{9}	• DU ammunition • Aircraft components (DU counterweights)

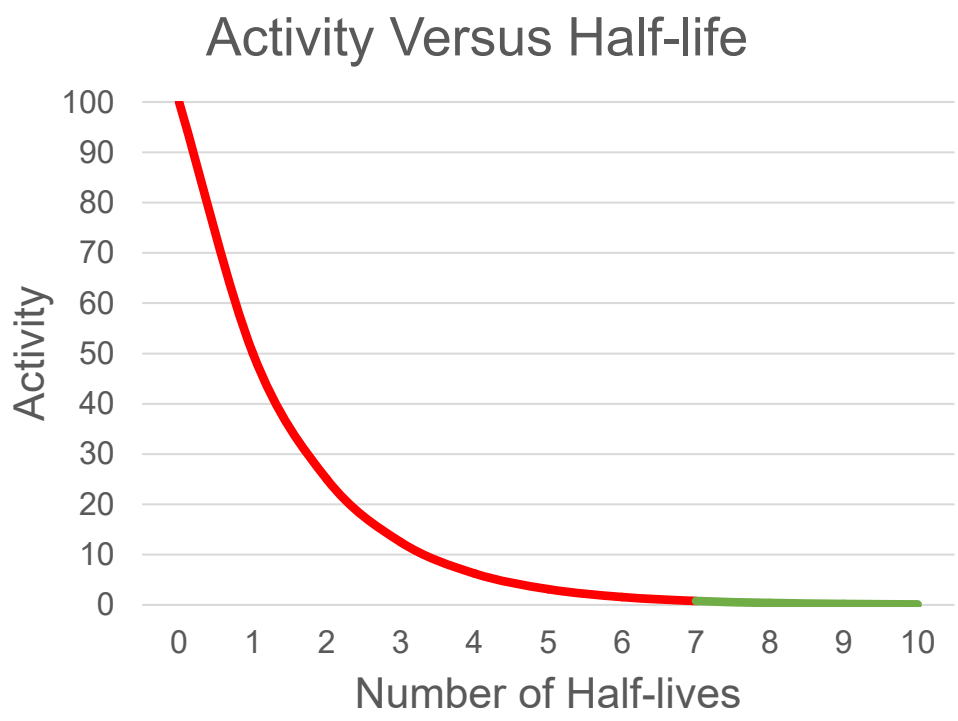
What about gamma radiation?

CS: cesium
DU: depleted uranium
Ra: radium
Sr: strontium
Th: thorium
U: uranium

(Navy 2025)

Radionuclides of Potential Concern

- What radionuclides are not typically added to our ROPC list, and why
  - Co-60
  - Pm-147
  - Tl-204
  - H-3 (tritium)
- Commercially regulated commodities may not be included as ROPCs
  - Th-232 in thoriated welding electrodes
  - U-238 in coal fly and bottom ash



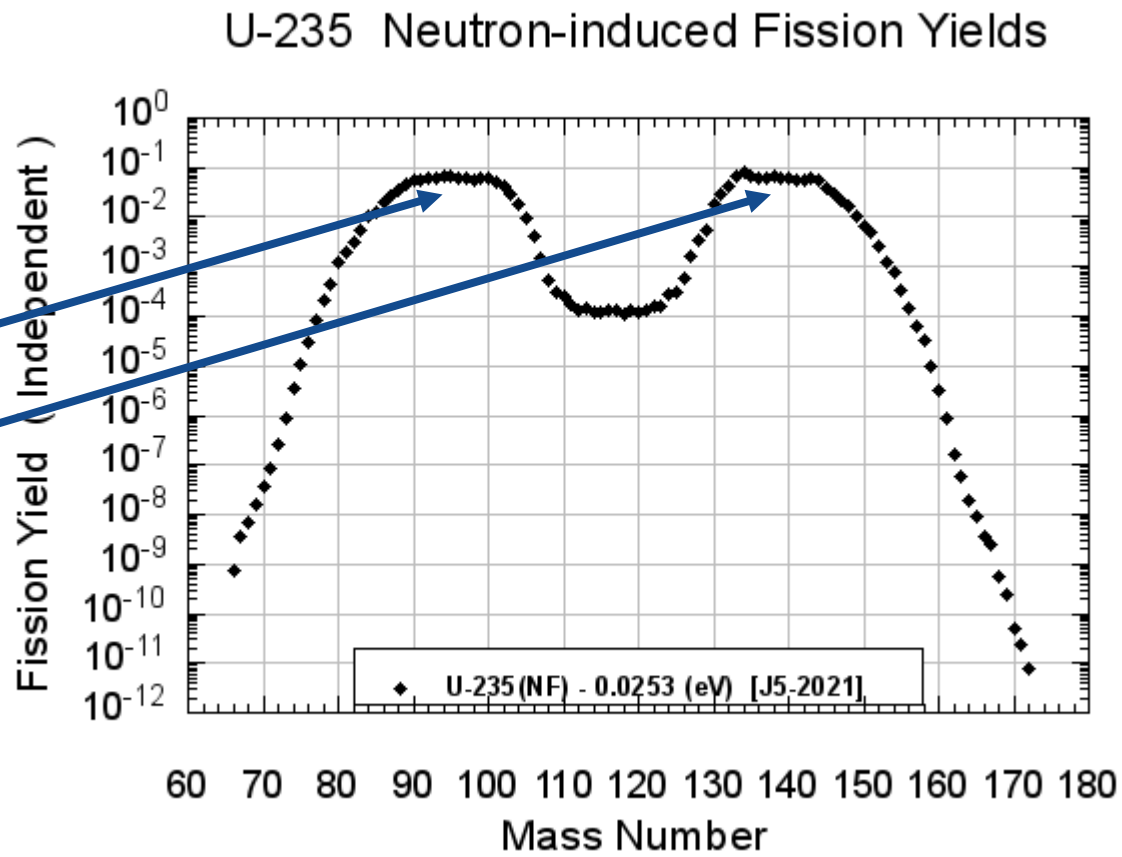
KEY POINT

ROPCs do not pose a significant risk after decaying beyond 7-10 half-lives

Co: cobalt
H: hydrogen
Pm: promethium
ROPC: Radionuclide of Potential Concern
Tl: thallium

Radionuclides of Potential Concern

- ROPCs present in background
  - U-238 (natural)
  - Ra-226 (natural)
  - Th-232 (natural)
  - Sr-90 (anthropogenic)
  - Cs-137 (anthropogenic)

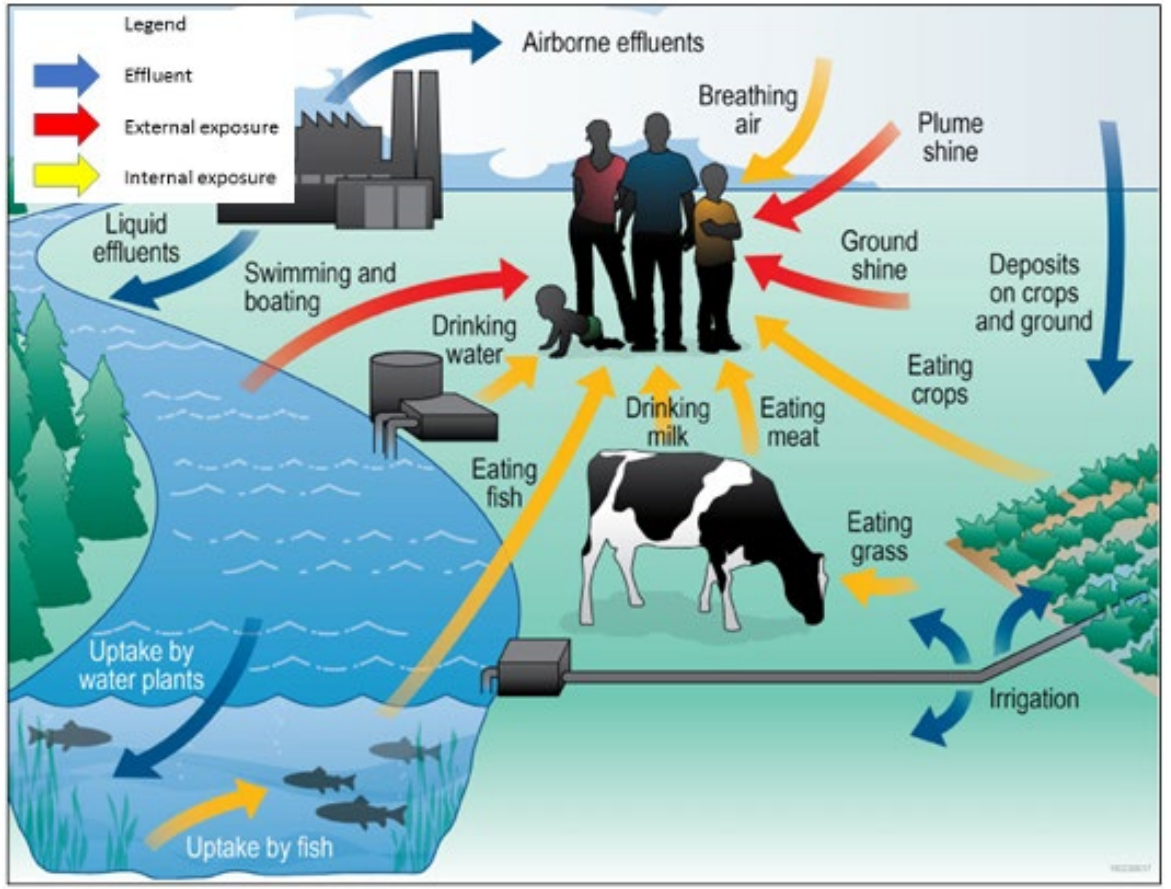


(Japan Atomic Energy Agency 2023)

(Oak Ridge Associated Universities 2025)

Development of Conceptual Site Model

- Common CSM elements
  - Site operational and investigation history
  - Site-specific geology and hydrology
  - Current site status
  - Historical radiological investigations
  - Potential or former historical radiological use and ROPCs
  - Identifying migration pathways and receptors
- How does CSM vary for sites with potential for G-RAM?

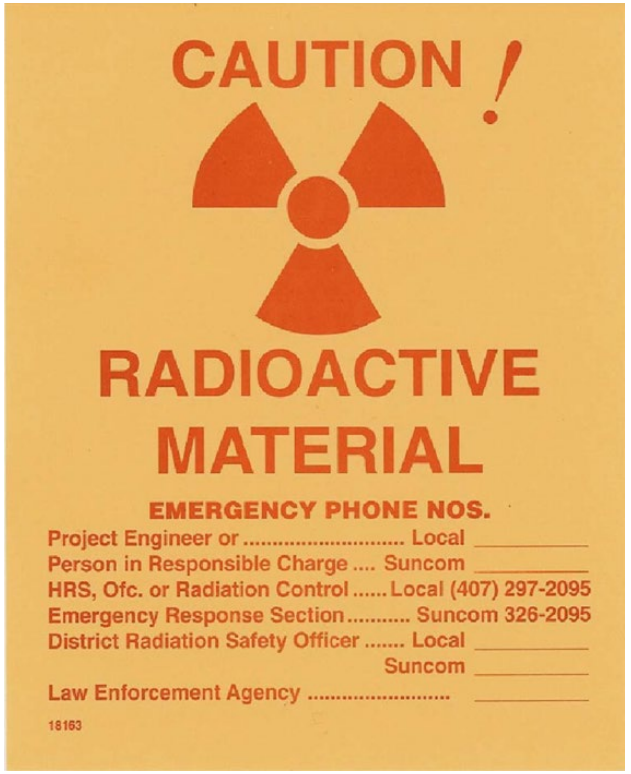


(Savannah River National Laboratory 2021)

(Navy 2025)

Example Migration Pathways

Media with G-RAM	Potential Migration Pathways
Debris on ground surface (e.g., disposal sites or crash sites)	• Surface soil • Subsurface soil (localized) • Surface water and sediment
Ash on ground surface (e.g., burn pits or crash sites)	• Surface soil • Subsurface soil (localized) • Surface water and sediment • Air (fugitive dust)
Buried debris (e.g., trench disposal sites and landfills)	• Subsurface soil • Groundwater (shallow leaching through infiltration)
Liquid G-RAM disposed onto ground surface (e.g., radium paint shop)	• Surface soil • Subsurface soil • Groundwater • Surface water and sediment



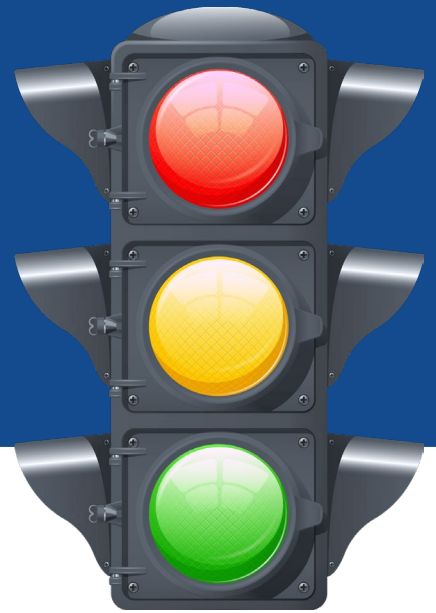
(Florida Department of Transportation 2008)

(Navy 2025)

Initial Site Classification

- Four site classifications are provided in HRA, based on MARSSIM and Navy definitions
  - Note: These classifications may dictate level of effort required in SI phase and should be carefully selected and agreed upon by all stakeholders

1. **Non-Impacted**
2. **Impacted**
3. **AOI**
4. **Previously Impacted**



Can a site classification change from HRA to PA?

AOI: Area of Interest
MARSSIM: Multi-Agency Radiation Survey and Site Investigation Manual

(Navy 2025)

Initial Site Classification

1. Non-Impacted: "Sites with **no reasonable possibility** or an **extremely low probability** for residual radioactive material based on area history, process knowledge, or survey information are determined to be non-impacted. They are identified through historical knowledge or previous survey information as areas where there is no reasonable possibility or extremely low probability for residual radioactive contamination."

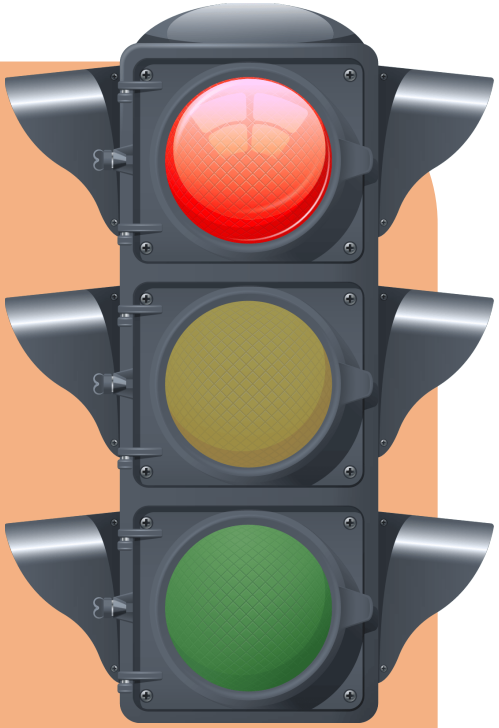
- Should later information identify radiological operations associated with a non-impacted area, the area can be reclassified as impacted
- Discovery of minimal radioactivity attributable to anthropogenic background radiation is not, in itself, cause for designation of an area as impacted

(Navy 2025)

Initial Site Classification

2. Impacted: "Site is either **known** to contain residual radioactive material based on radiological surveys or other documented evidence **or suspected with a high probability** to contain residual radioactive material based on historical information."

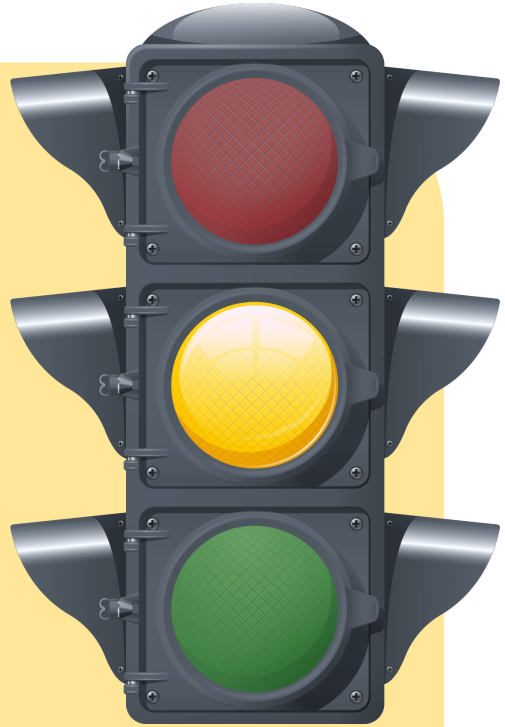
Evidence of an impacted area includes waste disposal areas likely to have received waste from a radioactive materials area, documented contamination or remediation, historically posted radioactivity areas, areas with specific descriptive names, or through sampling data.



(Navy 2025)

Initial Site Classification

3. AOI: "Sites that **cannot be classified as impacted or non-impacted** based on existing information are classified as AOIs. Following further evaluations, such as discovering new or additional information, performing investigations, or conducting interviews, AOIs are classified as impacted or are recommended for NFA for G-RAM because of the PA/SI. Areas initially identified as AOIs have a potential to contain residual radioactive materials from past operations that may have involved radioactive materials, but records may be unavailable to corroborate non-impacted status."

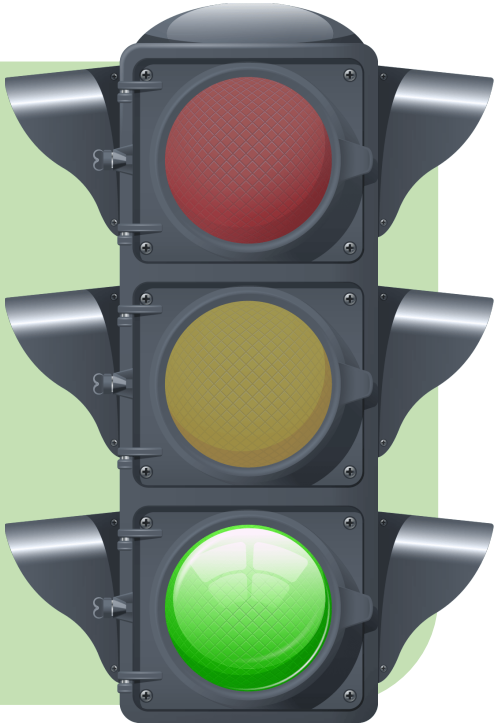


NFA: No Further Action

(Navy 2025)

Initial Site Classification

4. Previously Impacted: "Sites that were impacted, remediated, and surveyed, and adequate documentation exists supporting the area's **release for unrestricted use**." The area could also be categorized as non-impacted; however, it is given this specific designation, so the area's historical past is not overlooked.



- Release for unrestricted use is an official term that means the site has met all safety standards and has demonstrated through measurements that residual radiation levels are below the applicable, acceptable limits
- Equivalent to Unrestricted Use/Unlimited Exposure

(Navy 2025)

PA Recommendations

- Sites where sufficient evidence of a potential release is identified

- Sites where a known release occurred, risks to human health or ecological receptors have been identified, and time-sensitive actions may be recommended to stabilize or mitigate the threat from release

- Sites meeting the definition of Non-Impacted or Previously Impacted

FS: Feasibility Study
RI: Remedial Investigation
TCRA: Time-Critical Removal Action

(Navy 2025)

Report Preparation

- Report sections
  - Introduction
  - Regulatory Involvement
  - Installation Background and Environmental Setting
  - Radiological History of the Installation
  - Assessment Methodology
  - Findings and Recommendations
  - Conclusions
- Review stages
  - Preliminary Draft Report
    - Reviewers: NAVFAC RPM, RASO EPM, Installation Environmental Point of Contact
  - Draft Report
    - Reviewers: Regulatory agencies (e.g., EPA, State)
  - Draft Final Report
    - Reviewers: All prior reviewers (includes responses to comments)
  - Final Report
    - Reviewers: NAVFAC RPM, RASO EPM

(Navy 2025)

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Section Overview

- Site Inspection Process
  - Purpose
  - Current Navy-wide Site Inspection Status
  - MARSSIM Overview
  - Survey Basics
  - MARSSIM Survey Elements
  - Evaluation of Subsurface Soils
  - Evaluation of Groundwater
  - Planning Process
  - Data Quality Objectives
  - Data Quality Objective Example
  - Laboratory Analysis of Samples for G-RAM
  - Other Planning Documents
  - Report Preparation

Site Inspection Process

- Initiation based on recommendations presented in the PA
- SI does not involve a determination of nature or extent of contamination spread through migration pathways or site boundaries (EPA 1992)
- Instead, a strategic sampling approach and comparison to PSLs is performed
- Includes site specific DQOs; surveying, sampling, and laboratory analysis methods; evaluation of ROPCs present in background; and current and future anticipated use of the site
- Includes concurrence from all stakeholders

DQO: Data Quality Objective
PSL: Project Screening Level

Purpose

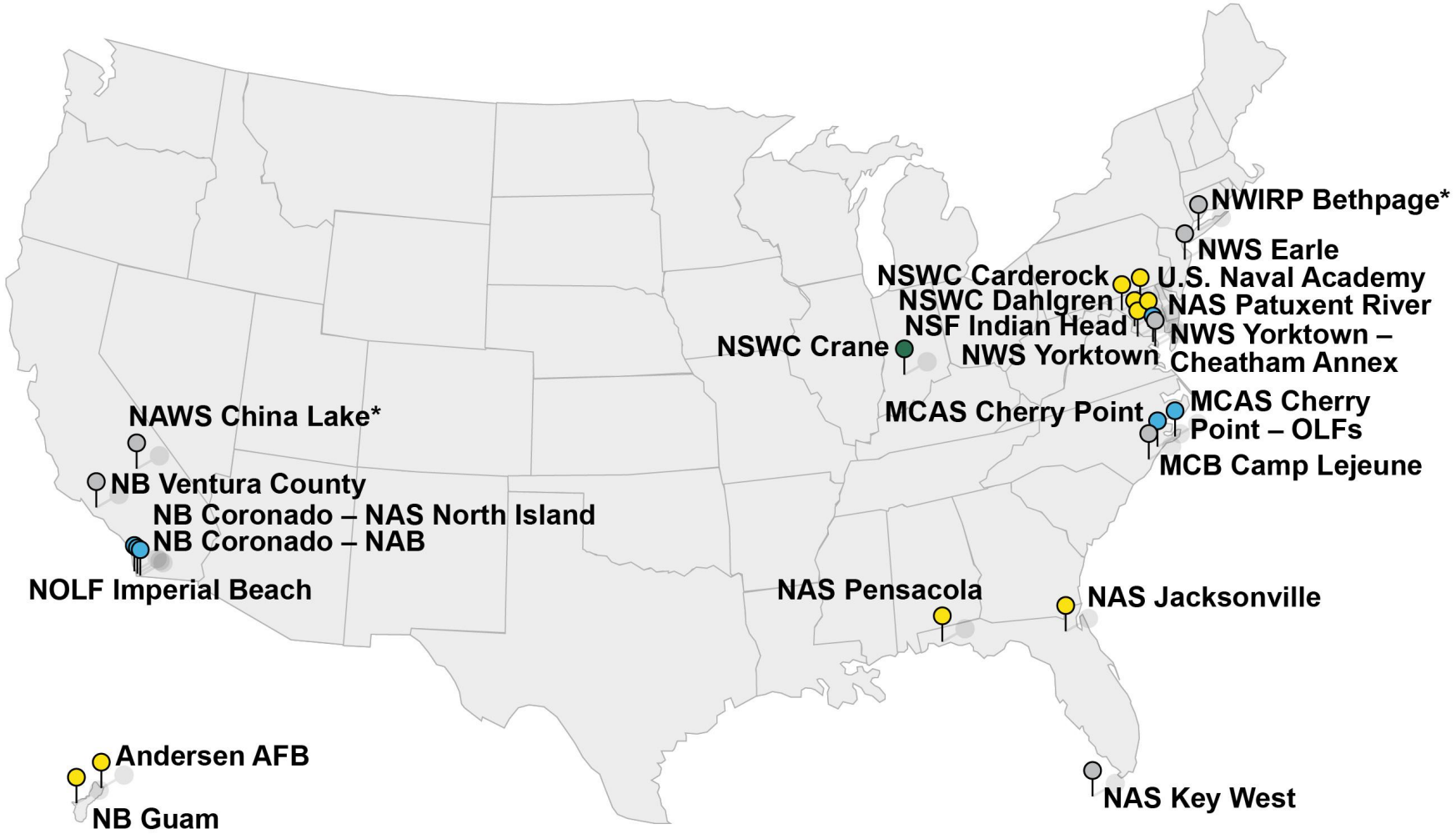
- Purpose of SI is to answer the following question

  Does G-RAM potentially pose an unacceptable risk to human health and the environment?

- Question is answered through
  - Use of standardized methods to evaluate ROPCs in environment
  - Development of **DQOs** to resolve SI question
  - Proposed recommendations including release for unrestricted use, NFA, or further evaluation in CERCLA process

(Navy 2025)

Current Navy-wide SI Status



LEGEND

- In progress
- Complete
- Planned
- To be determined
- * No HRA

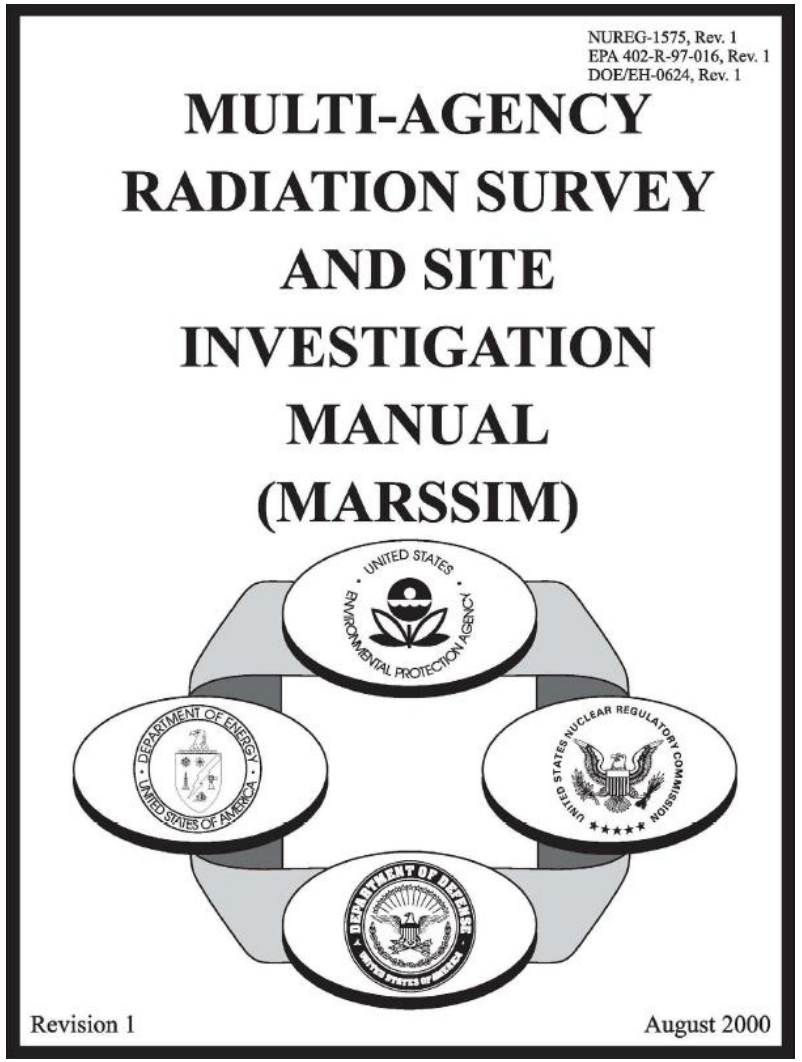
AFB: Air Force Base
MCAS: Marine Corps Air Station
MCB: Marine Corps Base
NAB: Naval Amphibious Base
NAS: Naval Air Station
NAWS: Naval Air Weapons Station
NB: Naval Base
NOLF: Naval Outlying Landing Field
NSF: Naval Support Facility
NSWC: Naval Surface Warfare Center
NWIRP: Naval Weapons Industrial Reserve Plant
NWS: Naval Weapons Station

(Navy 2025)

MARSSIM Overview

- MARSSIM Revision 1 (August 2000)
- Agency consensus document developed collaboratively by four federal agencies having authority and control over radioactive materials
  - DoD
  - DOE
  - EPA
  - NRC
- Objective to describe consistent approach for surveys and sampling while encouraging effective use of resources
- Basis for Radiological Site Management Toolkit for Navy Installations (Navy 2021), also known as EPM standards document

Guidance only!



(DoD et al. 2000)

DoD: Department of Defense
DOE: Department of Energy

MARSSIM Overview

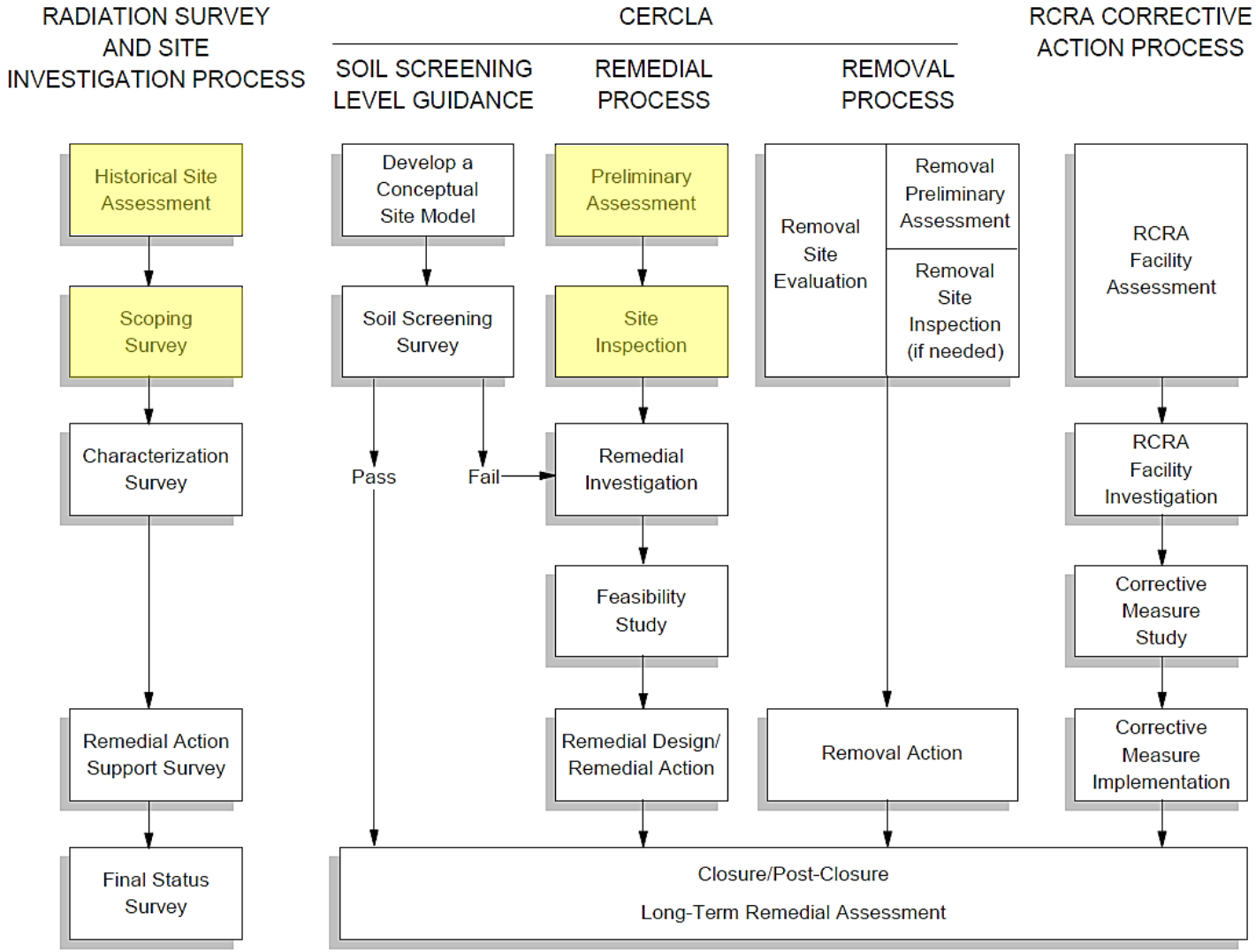
- Widely accepted; gold standard for radiological surveys
- Approach is only applied to surface soils and foundations (paved surfaces)
  - **Defined as top 15 centimeters (6 inches) of soils**
- Program comparison to CERCLA SI Process shows equivalency to a **Scoping Survey** (DoD et al. 2000)
- Other MARSSIM surveys defined as **FSS** which increase complexity (and cost)

MARSSIM	CERCLA REMEDIAL PROCESS
Historical Site Assessment Performed to gather existing information about radiation sites. Designed to distinguish between sites that possess no potential for residual radioactivity and those that require further investigation. Performed in three stages: 1) Site Identification 2) Preliminary Investigation 3) Site Reconnaissance	Preliminary Assessment Performed to gather existing information about the site and surrounding area. The emphasis is on obtaining comprehensive information on people and resources that might be threatened by a release from the site. Designed to distinguish between sites that pose little or no threat to human health and the environment and sites that require further investigation.
Scoping Survey Performed to provide a preliminary assessment of the radiological hazards of the site. Supports classification of all or part of the site as Class 3 areas and identifying non-impacted areas of the site. Scoping surveys provide data to complete the site prioritization scoring process for CERCLA or RCRA sites.	Site Inspection Performed to identify the substances present, determine whether hazardous substances are being released to the environment, and determine whether hazardous substances have impacted specific targets. Designed to gather information on identified sites in order to complete the Hazard Ranking System to determine whether removal actions or further investigations are necessary.

FSS: Final Status Survey(s)

(DoD et al. 2000)

MARSSIM Overview



(DoD et al. 2000)

RCRA: Resource Conservation and Recovery Act

Survey Basics

- Radiation detection instrumentation or “detectors” are used to survey or scan media to determine whether quantity of radiation exists above natural background range
- Typically, one of two types of detectors are used
  1. Gamma Detector (e.g., Ludlum Model 44-10) for soils
  2. Alpha-Beta Detector (e.g., Ludlum Model 43-93) for paved surfaces (e.g., building foundations)
- These detector types are simple counters, they cannot decipher between ROPCs
  - Instrumentation that can identify ROPCs (gamma spectroscopy) exists; however, it is typically impractical for use at this stage

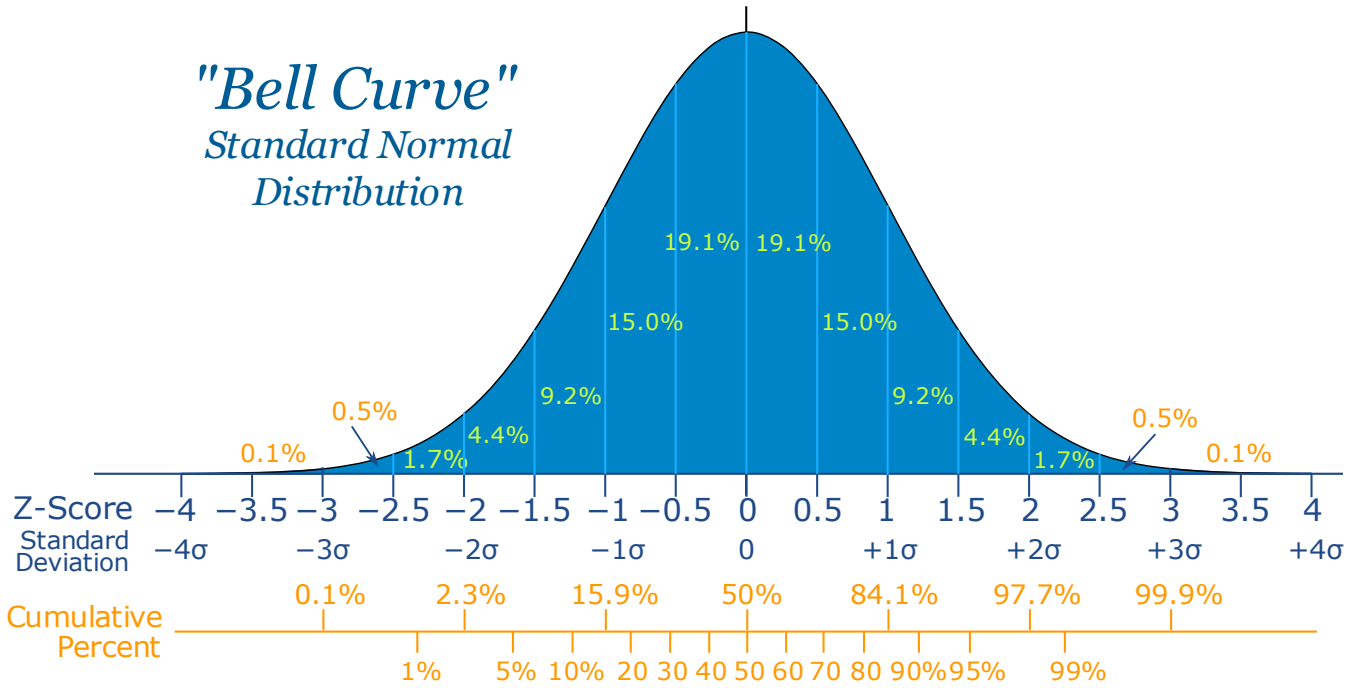
1, (γ)

2, (α-β)

(Ludlum Measurements 2024)

Survey Basics

- Before evaluation of radiation levels at site, a BRA survey is typically performed to establish IL
- IL is typically included as a count rate (e.g., counts per minute) and is instrument specific
- IL is applied to a survey of the site to identify locations for sampling



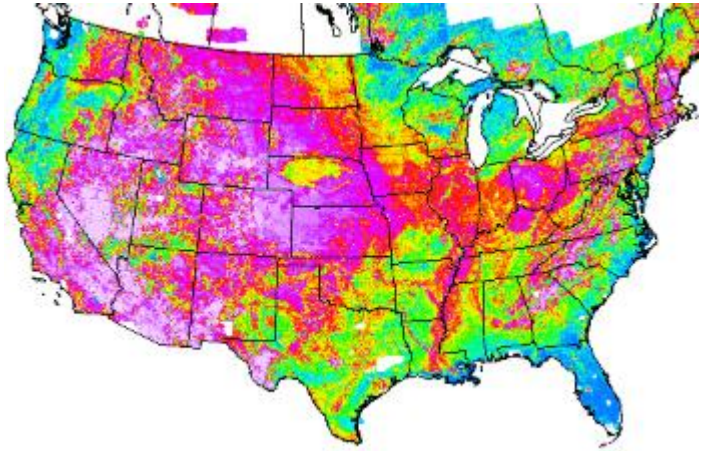
(Math is Fun 2025)

- Background radiation is assumed to follow normal distribution; therefore, IL may be selected at a value above the mean (e.g., +2 to 3σ)

σ: standard deviation
BRA: Background Reference Area
IL: Investigation Level

Survey Basics

- BRA
  - *"Area with similar physical, chemical, radiological, and biological characteristics as the site area but has not been contaminated by historical site activities. The distribution and concentration of background radiation in the BRA should be the same as that which would be expected on the site if that site had never been contaminated"* (DoD et al. 2000)
- May apply one BRA for multiple sites; however, proceed with caution because radiation levels can vary over short distances
- Recommended to use nearby, adjacent area
- Large enough to collect data for IL
- Depending on survey goals, may collect samples for comparison to site data and PSLs



(USGS 2005)

PSL: Project Screening Level

Survey Basics

- Surveys using a Gamma Detector (Instrument 1) may be coupled to a GPS device and additional software to create a precise heat map
  - Referred to as GWS
- Locations which exceed IL are easily identified and flagged for sampling
- Survey results **only** determine sampling locations, they do not make decisions on clearance
- May be applied during test pitting or to paved surfaces (conditions apply)

(ERG 2021)

RadScout GPS Gamma Survey System

GPS: Global Positioning System
GWS: Gamma Walkover Survey

Survey Basics

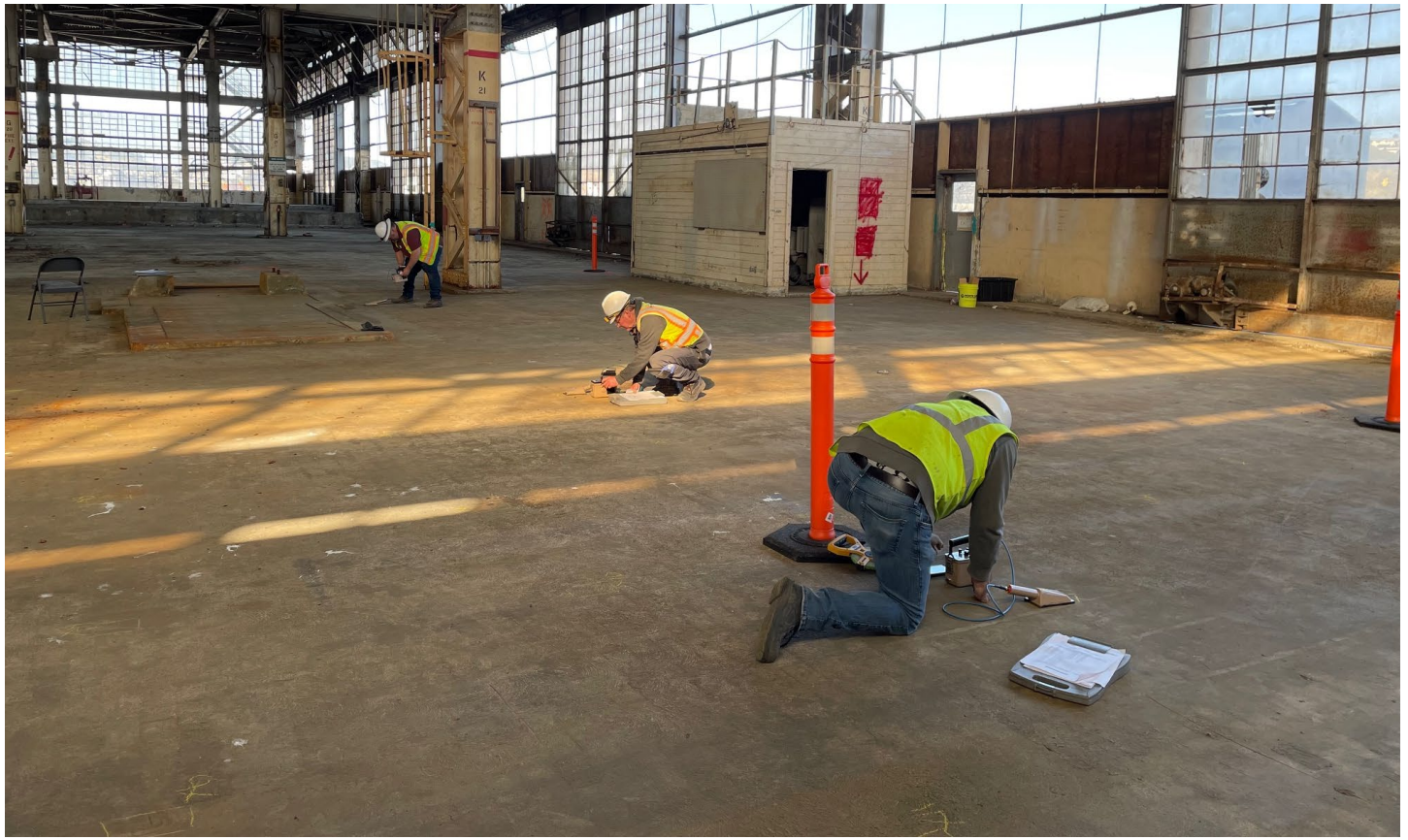
- Surveys using an Alpha-Beta detector (Instrument 2) may be used for scanning and, in lieu of sampling, for paved surfaces
- PSLs are typically expressed in values of surface activity (e.g., dpm per 100 square centimeters) and are separate for alpha and beta
- Since detector cannot decipher between ROPCs, the most limiting alpha or beta value is typically applied as the PSL

(Ludlum Measurements 2024)

dpm: Disintegrations Per Minute

Survey Basics

(Jacobs 2024)



(Jacobs/Perma-Fix 2022)

MARSSIM Survey Elements

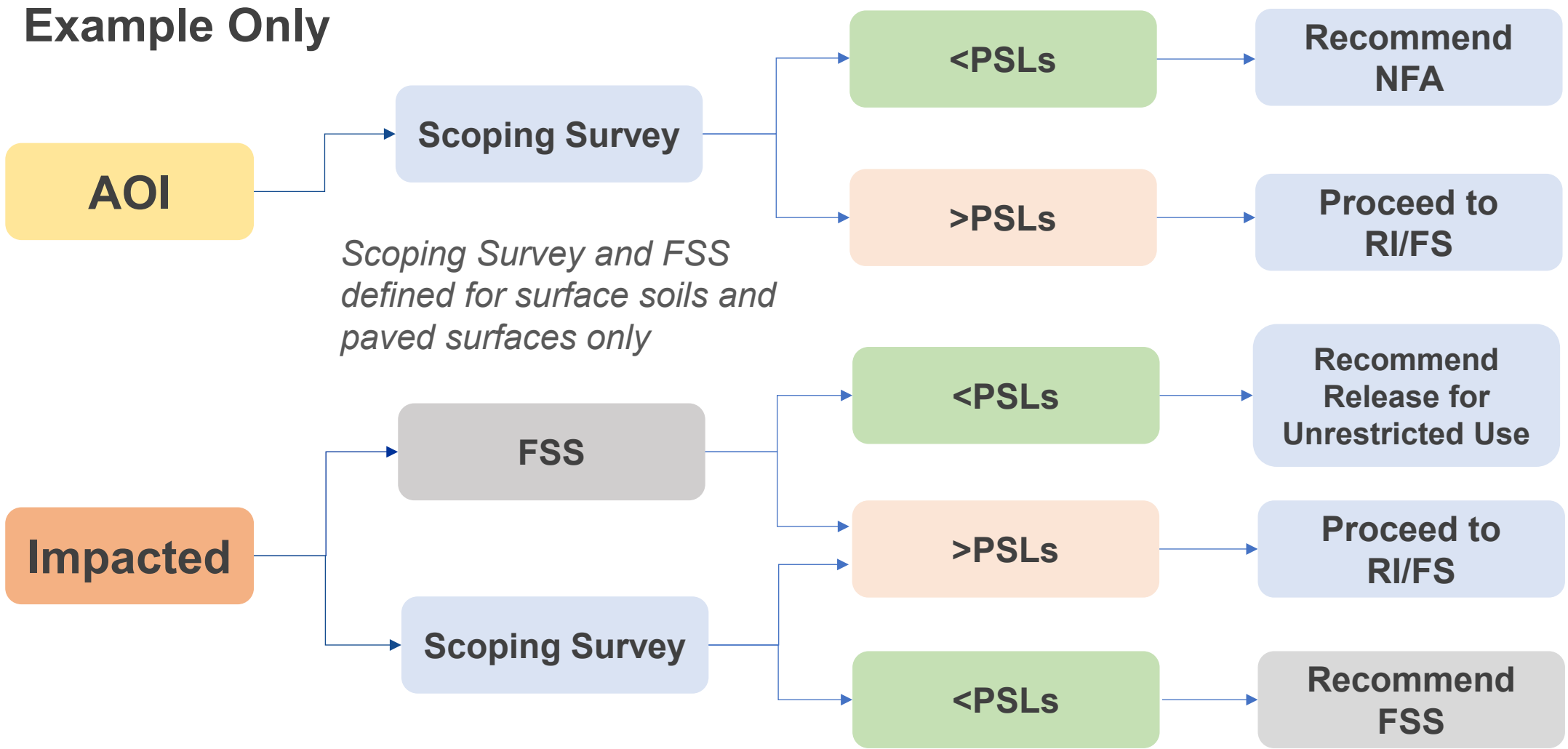
- **Scoping Survey**
  - If one or more ROPC present in background
    - BRA determination and survey
    - Collection of background data (e.g., GWS) and background soil samples
  - Determination of IL (e.g., 2 to 3σ above the mean background value)
  - Site survey (e.g., GWS)
  - Locations that exceed IL are flagged for **judgmental sampling** (soils) *or evaluation of paved surfaces*
    - Some sites may add random sampling, depending on objectives
  - Collection of samples for laboratory analysis
  - Evaluation of sample data against PSLs

(DoD et al. 2000)

MARSSIM Survey Elements

- **Final Status Survey**
  - Different FSS classes based on expected contamination levels or previous surveys documenting ROPCs
  - Same general methodology as a Scoping Survey, plus
  - Determination of a specific number of **random** or **systematic measurements**
    - Calculated based on differences between background and PSL
    - Problem: Large number of samples calculated when differences are small
  - May be performed in lieu of a Scoping Survey, or
  - May be performed following a Scoping Survey, depending on the results (after SI phase)
  - Provides official "*release for unrestricted use*" for surface soils or paved surfaces

MARSSIM Survey Elements



Evaluation of Subsurface Soils

- Subsurface investigations are outside of the scope of MARSSIM
- Limited guidance exists for subsurface investigations of G-RAM
  - *Soil Screening Guidance for Radionuclides: User's Guide* (EPA 2000)
    - Includes simple soil boring approach to determine if homogenous contamination exists
  - *Guidance on Surveys for Subsurface Radiological Contaminants, Draft Technical Letter Report* (SC&A 2021)
    - Draft not made final, many contractors still reference this information
  - NUREG 1757, Volume 2, Revision 2. *Consolidated Decommissioning Guidance. Characterization, Survey, and Determination of Radiological Criteria* (NRC 2022)
    - Recommends use of modeling for radiation dose

Evaluation of Subsurface Soils

- Soil borings
  - Problem: Depth and number of borings may not be enough to make conclusions regarding absence or presence of contamination, or to conclude site status
- Test pitting or excavation
  - Problem: Disposal areas may contain numerous COCs, unexploded ordnance, and other hazards
  - Digging into waste should be carefully planned
- Considerations for ROPCs suspected in subsurface waste
  - LUCs already in place to limit intrusive activities for other contaminants
  - Navy's anticipated future use for site
  - Possibility of simply removing and replacing waste
  - Investigation-derived waste concerns (additional, costly sampling)
  - Problems if large-scale contamination is unearthed

LUC: land use control

Evaluation of Groundwater

- No difference from sampling of GW for other contaminants
- Background (unaffected) GW sample should be collected
  - Upgradient of the site
- Site sample collection
  - Downgradient of the site

Tip: Laboratory analysis of GW samples may be accomplished by measuring gross alpha and beta activity and comparing to background sample. If consistent with background, no additional ROPC specific sampling may be needed (pending stakeholder concurrence).

KEY POINT

GW sampling preferably completed from previously installed wells. May also be able to install temporary wells based on scope and budget.

GW: groundwater

Planning Process

COLLABORATIONS

NAVFAC
RASO
Installation
Stakeholders

DOCUMENTS

Sampling and Analysis Plan

- Review Historical Records and PA Recommendations
- Refine Conceptual Site Model
- Prepare Sampling Plan
  - Prepare Worksheets (37)
    - Laboratory and Method Selection
    - Waste Management
    - Data Quality Objectives
      - **STEP 1:** State problem
      - **STEP 2:** Identify goal of SI
      - **STEP 3:** Identify information inputs
      - **STEP 4:** Define boundaries
      - **STEP 5:** Develop analytical approach
      - **STEP 6:** Screening criteria

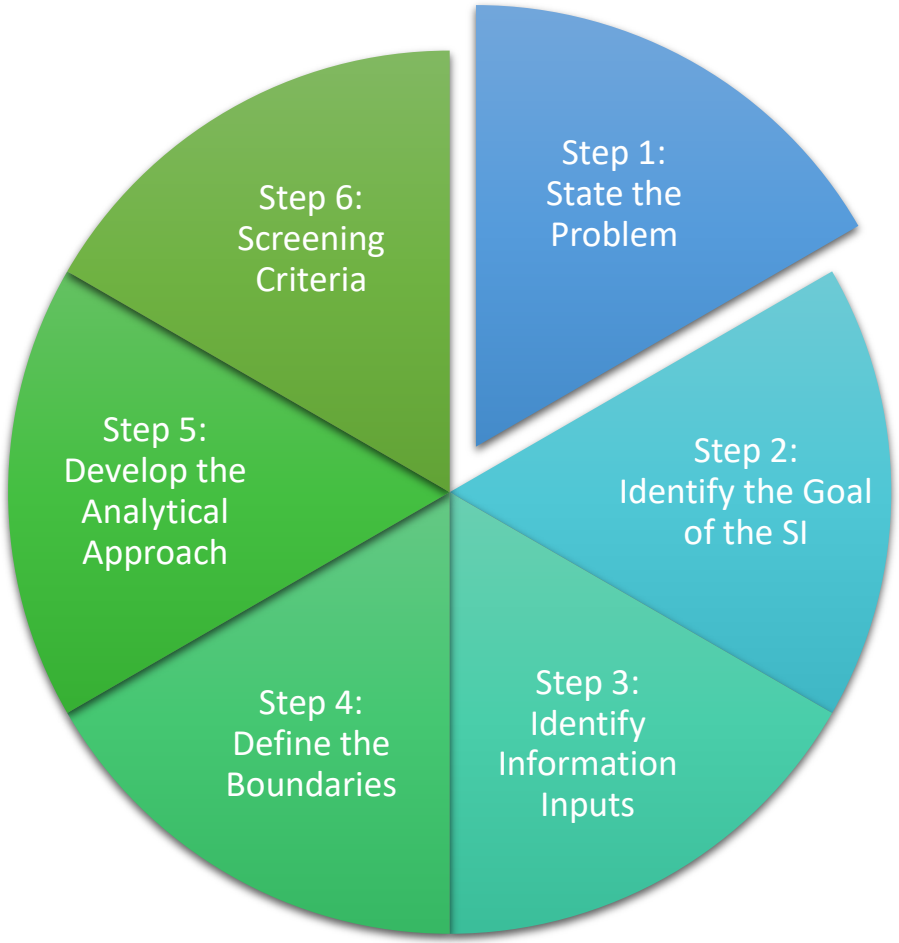
Health and Safety Plan

- Site-Specific Health and Safety Plan, Accident Prevention Plan, Radiological Protection Plan
- Radiological Management Plan
- Radioactive Materials License (if needed)

(Navy 2025)

Data Quality Objectives

- DQOs are site specific and must be developed separately for each site identified in PA
- Roadmap to completion of SI
- Define the type and number of measurements to collect, performance criteria, and decision points
- Seven dissimilar DQO steps developed by EPA (EPA 2006), MARSSIM (DoD et al. 2000), and the Toolkit (Navy 2021); harmonized within *Framework* to a total of six steps



(Navy 2025)

DQO Step 1: State Problem

- Statement may be taken directly from the CSM and recommendations from the PA
- Common problem for all sites with G-RAM
- ROPCs exist or have a potential to exist that may pose threat to human health and environment
- Knowledge of source of contamination is important to determine whether it is contained within the site or exists as a continuous release that may require a TCRA

KEY POINT

The problem statement should be simple enough such that the SI will provide a sufficient answer!

(Navy 2025)

DQO Step 2: Identify Goal of SI

- In determining goal, must collect enough data to sufficiently answer problem in Step 1
- Example goals include the following
  - Release site or a portion of the site for unrestricted use
  - Determine whether ROPCs are present and if there is an unacceptable risk to human health and environment
  - Determine whether a removal action is needed
  - Determine whether the ROPC(s) exist as a continuous or isolated source
- Other considerations include anticipated future land use and potentially affected populations

(Navy 2025)

DQO Step 3: Identify Information Inputs

- General data collection includes two methods
  - **Field Screening (Survey)**
    - Ensure detector can measure specific type or energy of radiation
    - Generally, does not distinguish between ROPCs
  - **Sampling (Laboratory Analysis)**
    - Can distinguish between ROPCs
    - Laboratory MDC must be less than PSL values for each ROPC
    - Minimum volume requirements
    - Samples should not require preservatives, may include in-growth of ROPC decay progeny at laboratory, typical turn around time of approximately 30 days

MDC: Minimum Detectable Concentration (Navy 2025)

DQO Step 4: Define Boundaries

- Scope, range, and delimitation of environmental media or conditions to be represented by the information inputs from Step 3
  - Water bodies (oceans, bays, and rivers) typically excluded from the scope of SI (also true for the HRA and PA)
- Lateral and vertical distribution determined by migration pathways in the CSM and other historical information, including where non-radiological COCs have been found
- General site boundaries (if not previously established) may be found using historic aerial photography
- Define BRA

DQO Step 5: Develop Analytical Approach

- Needs to answer the following
  - Type of survey (e.g., Scoping Survey or FSS)
  - Determination of ILs (e.g., 2 to 3σ above background)
  - Number of samples to be collected
    - Scoping Survey: Consider setting minimum and maximum number of samples to be collected
    - FSS: Determine decision error rates, PSLs, and background ROPC concentrations to determine minimum number of samples.
  - Evaluation of subsurface soils (if applicable)
  - Evaluation of GW (if applicable)
  - Decisions and recommendations based on the results of sampling

(Navy 2025)

DQO Step 5: Develop Analytical Approach

- Example scenarios presented based on site classification and survey type
- **Impacted sites:** If the site is Impacted in the PA and a Scoping Survey is performed, the following decisions **may be options**

  a) NFA with release of site for unrestricted use *(Unlimited Use/ Unrestricted Exposure)* for G-RAM based on completion of FSS

  b) Conduct removal action and FSS, then request release of site for unrestricted use for G-RAM

  c) Proceed to an RI/FS
- **AOIs:** If site is AOI in PA and a Scoping Survey is performed, the following decisions may be options

  a) NFA for G-RAM

  b) Proceed to an RI/FS

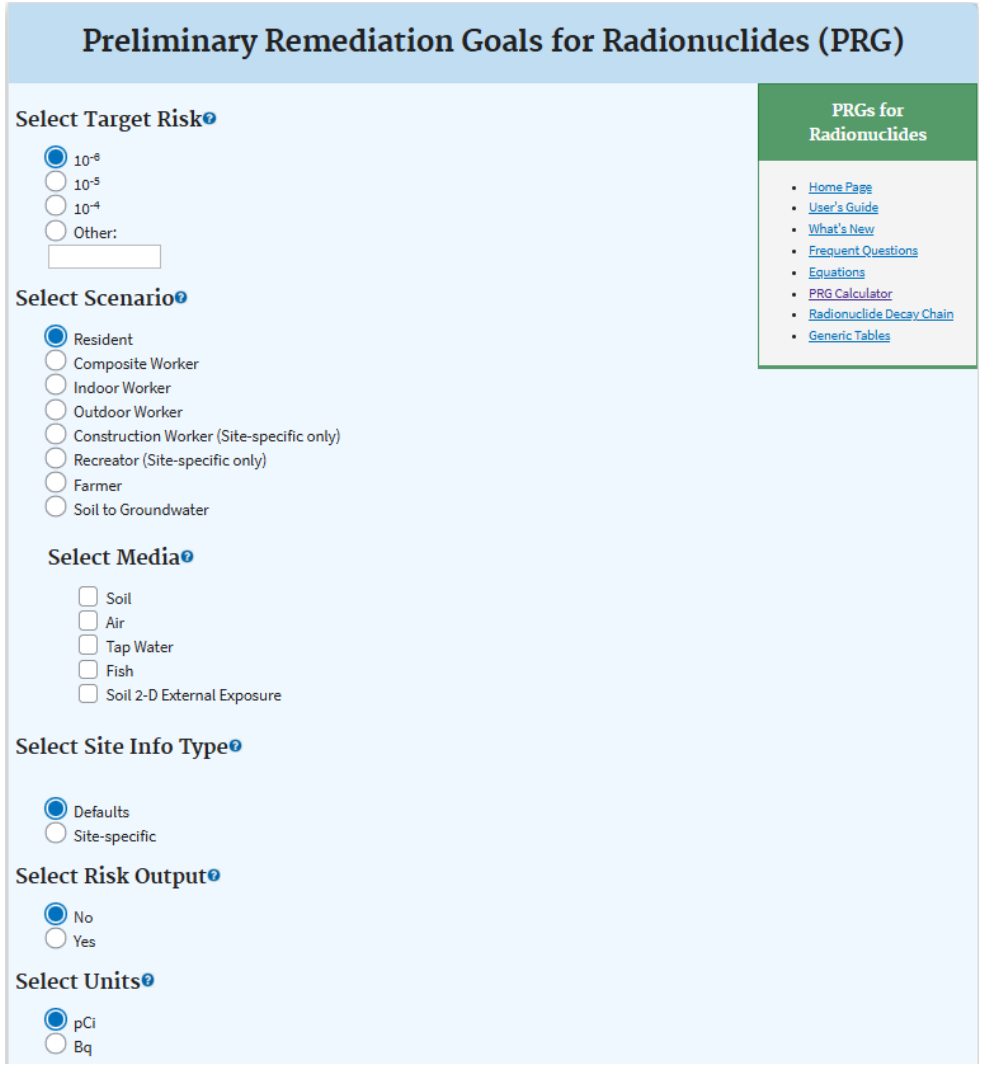
(Navy 2025)

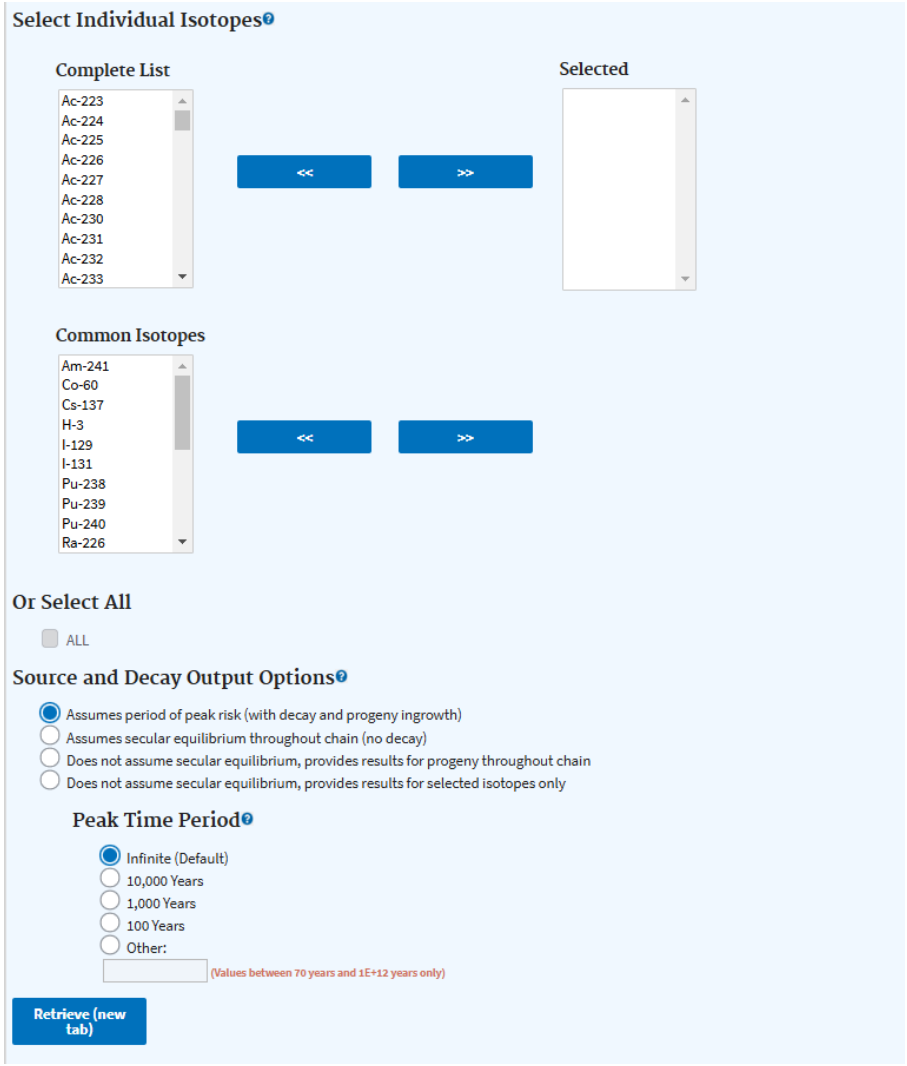
DQO Step 6: Specify Performance or Acceptance Criteria

- Cleanup and release criteria for radionuclides is complex and is not streamlined between regulatory agencies
- At NPL sites, a **risk-based** approach to screening criteria is typically used
- At non-NPL sites, a **dose-based** approach may be used (except in California)
- Example risk levels: 1×10^{-4} to 1×10^{-6}
- Conversion of risk to maximum activity concentration used for PSLs is most commonly accomplished through EPA PRG calculator or DOE (Argonne National Laboratory) RESRAD-ONSITE modeling tools
- Models use select exposure scenarios based on future site use (e.g., residential, industrial, farming, and recreation) over a set time period
- Exposure typically based on external radiation exposure, inhalation, and ingestion

PRG: Preliminary Remediation Goals for Radionuclides (Navy 2025)

DQO Step 6: Specify Performance or Acceptance Criteria

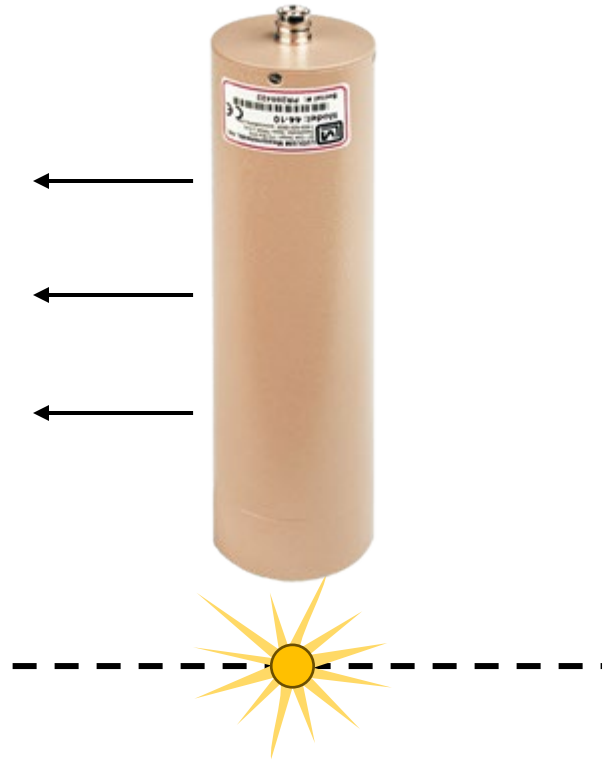




(EPA 2020)

DQO Step 6: Specify Performance or Acceptance Criteria

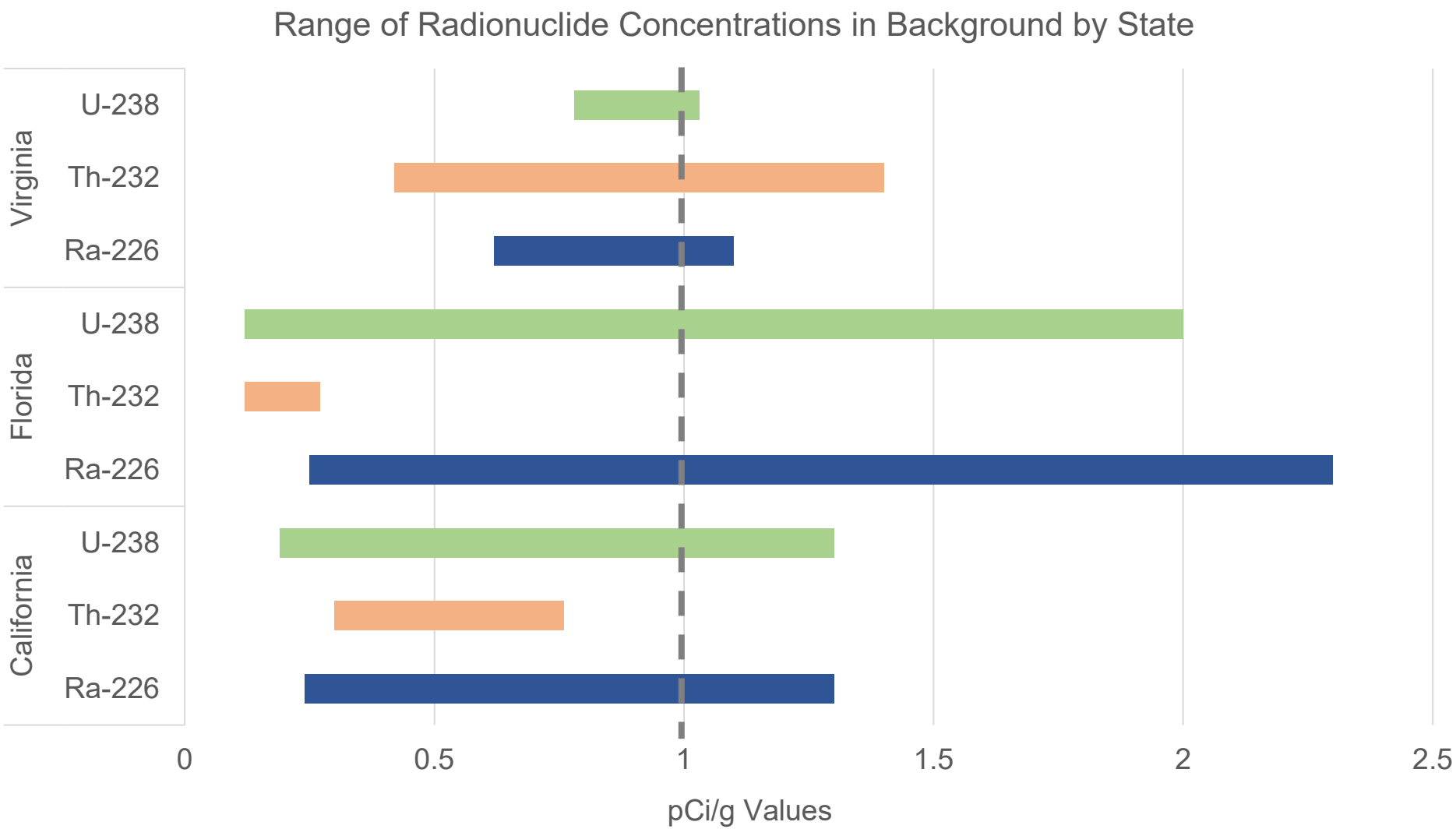
- Using multiple EPA PRG Calculator risk and scenario types, output PSL values for multiple radionuclides (e.g., Ra-226, Th-232) are typically **less than 1 pCi/g**
  - 1 pCi/g is equivalent to 2.22 dpm
  - Radiation emitted isotopically, losses >50%
  - Results in detector efficiency <20%
  - Detector is in motion, scan speed major variable
- Values include total concentration measured in soil and are *inclusive of background radionuclides*
- These values may be multiple orders of magnitude less than background
- Should be identified and rectified before initiation of SI activities



(Ludlum Measurements 2024)

pCi/g: picocurie(s) per gram

DQO Step 6: Specify Performance or Acceptance Criteria



(Oak Ridge National Laboratory 1981)

DQO Step 6: Specify Performance or Acceptance Criteria

- Summary of potential problems with EPA PRG Calculator
  - Assumes site is contaminated and needs remediated
  - Does not account for site-specific background
  - Sets extremely low screening criteria for some ROPCs
- Potential solutions
  - Title 40 CFR Part 192
    - Potentially applicable to CERCLA/Superfund sites
    - Limits surface soils to **5 pCi/g** (Ra-226 and Th-232)
  - Increase acceptable risk or use dose-based criteria
  - Change model parameters or modeling software
  - Discuss alternate solutions with RASO


DENVER RADIUM SUPERFUND SITE
COMPREHENSIVE REPORT

October 2014

Prepared by: City and County of Denver
Department of Environmental Health
Environmental Quality Division
200 W 14th Avenue, Suite 310
Denver, CO 80204

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Funded by EPA Grant V96802801

(Denver Department of Environmental Quality 2014)

CFR: *Code of Federal Regulations*

DQO Step 6: Specify Performance or Acceptance Criteria

- Consider detector performance in preparation for field screening
- Gamma Detector (Instrument 1) variants shown
- Example: FIDLER detector is best suited for U-238 (DU), but not remaining ROPCs

Table 6-5 NaI Scintillation Detector Scan MDCs for Common Radiological Contaminants—Example 1[a]

Radionuclide/Radioactive Material	1" × 1" NaI Detector		2" × 2" NaI Detector		3" × 3" NaI Detector		FIDLER	
	Scan MDC (pCi/g)	Weighted cpm/µR/h	Scan MDC (pCi/g)	Weighted cpm/µR/h	Scan MDC (pCi/g)	Weighted cpm/µR/h	Scan MDC (pCi/g)	Weighted cpm/µR/h
Am-241	57	3,701	39	12,710	27	27,870	5.6	47,540
Co-60	10	77	4.1	429	2.3	1,165	12	102
Cs-137	18	175	8.0	900	4.8	2,300	19	253
Th-230	3,200	2,633	2,100	9,082	1,500	19,920	420	31,860
Ra-226+C in equilibrium	6.0	179	3.0	841	1.8	2,087	2.9	582
Th-232+C in equilibrium	4.0	191	2.1	840	1.3	2,048	1.6	753
0.034% Depleted Uranium[b]	140	1,072	90	3,836	62	8,570	22	9,841
0.072% Natural Uranium[b]	140	1,130	92	3,836	63	8,996	25	9,379
3% Enriched Uranium[b]	150	1,212	96	4,328	66	9,567	34	8,186
20% Enriched Uranium[b]	180	1,408	110	5,027	80	11,060	49	7,218
50% Enriched Uranium[b]	220	1,431	140	5,106	98	11,230	62	7,085
75% Enriched Uranium[b]	250	1,437	160	5,129	110	11,270	71	7,067

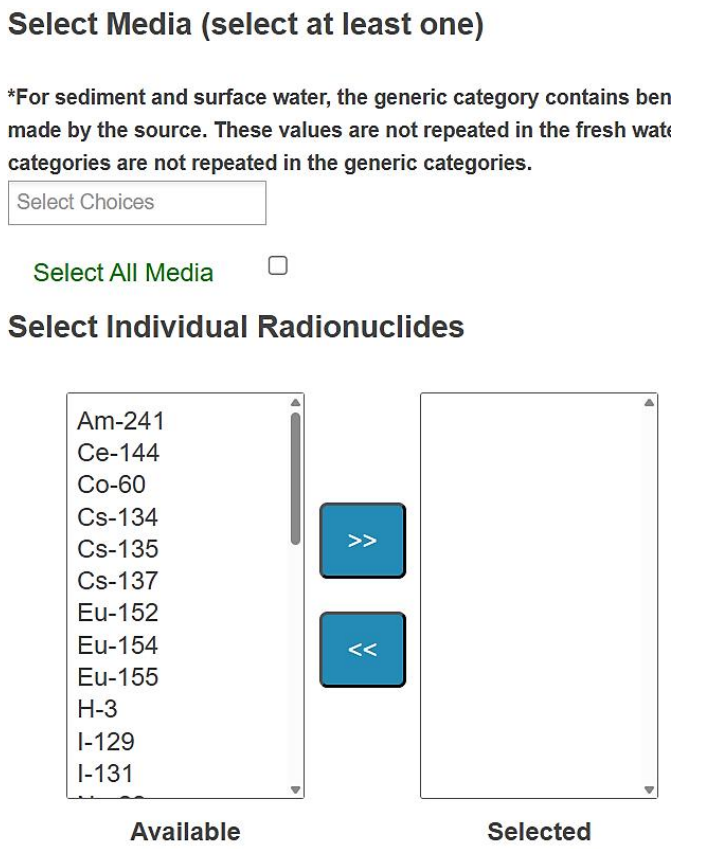
"+C" indicates the associated decay chain that ultimately results from the decay of the listed parent radionuclide.
[a]Refer to Section 6.2.5 of the text for complete explanation of factors used to calculate scan MDCs. For these examples, the following inputs were used:
Background levels = 1,800 cpm for the 1" × 1"; 9,750 for the 2" × 2"; 23,000 for the 3" × 3"; and 4,500 for the FIDLER
Observation interval (i) = 2 seconds
Index of sensitivity (d') = 2.32 for 0.95 true positive proportion and 0.25 false positive proportion (see Table 6-1)
Surveyor efficiency (p) = 0.5
[b]Scan MDC for uranium includes sum of U-238, U-235, and U-234.

NaI: Sodium Iodide

(NRC 2020)

DQO Step 6: Specify Performance or Acceptance Criteria

- Groundwater limits
  - Gross alpha/beta comparison
  - Determine groundwater use, consider drinking water limits for radionuclides
- Surface contamination limits
  - Applies to paved surfaces (e.g., storage lots and building foundations)
  - Also calculated using EPA PRG Calculator
  - Limits expressed as dpm per 100 square centimeters
- What about risks to the environment (biota)?
  - Los Alamos National Laboratory ECORISK Database (Release 4.4)
  - Selection of radionuclide and media type
  - Screening criteria likely exceeds risk or dose-based PSLs



(Oak Ridge National Laboratory 2024)

DQO Example

Step 1

STATE PROBLEM

Surface Dump Site 1
Dumping and disposal of hazardous materials, including potential (unconfirmed) radioluminescent devices documented from 1970 until 1985. Exact quantities and locations of dumped or disposed material are unknown. Various debris is assumed to be collocated within the top 15 centimeters of soils. The ROPC is Ra-226.

Step 2

IDENTIFY GOAL OF SI

Site is currently classified as an AOI. Based on future anticipated land use, the goal of the SI is to evaluate whether ROPCs are present in soil from historical activities exceeding the PSLs. Future anticipated land use includes development of a new military training facility.

Step 3

IDENTIFY INFORMATION INPUTS

Field screening will use a 2-inch by 2-inch gamma detector with positional correlation to perform a scan of professional judgment and accessible areas of the site. Laboratory MDC value is 1 pCi/g and is less than the PSL.

DQO Example

Step 4

DEFINE BOUNDARIES

Surveys will be performed within pre-established site boundaries based on a review of historical aerial photography of disturbed areas during site's estimated period of use.

Step 5

DEVELOP ANALYTICAL APPROACH

- Field screening will be completed in an adjacent BRA with the IL developed at 3 standard deviations above the mean background value
- At site, field screening exceeding the IL will be marked for judgmental sampling to a maximum of 10 samples
- If results of sampling do not indicate G-RAM is present exceeding screening criteria, site will be recommended for NFA for G-RAM
- If results of sampling indicate G-RAM is present and screening criteria is exceeded, site will proceed to RI
- No subsurface or groundwater sampling is recommended; sampling of subsurface soil may be recommended if elevated activity is identified in surface soil samples indicating a potential release that would impact subsurface or groundwater

Step 6

SCREENING CRITERIA

Screening criteria for Ra-226 is 3.96 pCi/g and are based on the EPA PRG Calculator using the Outdoor Worker scenario and an excess lifetime cancer risk of 1×10^{-4}

Laboratory Analysis of Samples for G-RAM

- EPA laboratory analysis methods, timelines, minimum sample volumes, and packaging requirements should be known and agreed upon before execution of SI
- Example analysis methods
  - Liquid scintillation counting
  - Gamma spectroscopy
  - Alpha spectroscopy
  - Gas flow proportional counting
- Laboratory MDCs should not exceed PSLs
  - MDCs are typically laboratory and contract specific
  - May reduce MDC by increasing sample count time (increases cost)
  - Most analysis methods should be ≤1 pCi/g

(Oak Ridge National Laboratory 2025)

(Navy 2025)

Other Planning Documents

- Radiological Protection Plan and Management Plans
  - Calibration and use of radiation detection instrumentation
  - Task-specific plans
  - Worker safety (personal protective equipment and stop points)
  - Training requirements
  - Handling requirements
  - Notification requirements
- Radioactive Materials License
  - If radioactive materials are unearthed, contractor shall be responsible for handling, storage, and disposal of those materials
  - Invocation of an NRC or Agreement State radioactive materials license, with reciprocity filed as appropriate, may be required (and should be verified prior to execution of the SI)

Report Preparation

- Report Sections
  - Introduction
  - Installation background and environmental setting
  - Field activities
  - Site-specific sections (including data review)
  - Conclusions and recommendations
- Review Stages
  - Same as PA
  - During review of SI report, any site that has a confirmed presence of G-RAM exceeding PSLs must include official RASO notification
  - These sites will be added to the IRP by applicable NAVFAC or installation procedures unless site has been recommended for NFA for G-RAM or released for unrestricted use

(Navy 2025)

Presentation Overview

- Introduction
- Preliminary Assessment Development
- Site Inspection Process
- Case Studies
- Summary and Closing Statements

Case Studies

- Example 1 (2022)
  - First SI executed (before completion of Framework)
  - 28 sites evaluated
  - Initially used **dose-based** PSLs (in conflict with EPA Region 4)
  - Re-evaluation of data against risk-based PSLs
  - **Nearly all ROPCs sampled exceeded new PSLs**
  - SI report not yet finalized

Case Studies

- Example 2 (2023, internal draft only)
  - 15 sites evaluated (all AOIs)
  - Risk based PSLs at 1×10^{-6} with residential and composite worker scenarios
  - Additional action levels set at 1×10^{-4} or 3×10^{-4}
  - **Nearly all ROPCs sampled exceeded PSLs for soil**
  - Background subtraction applied to site samples, sum of fractions applied to sites with multiple ROPCs, and results did not exceed action levels
  - Two sites recommended for further investigation, including a data gap SI, RI, or LUCs
  - Other areas not recommended for further investigation
  - SI report not yet finalized

Presentation Overview

- Introduction
- Preliminary Assessment Development
- Site Inspection Process
- Case Studies
- Summary and Closing Statements

Summary and Closing Statements

- G-RAM and its identification and evaluation in the environment is relatively new for many RPMs
- The PA compiles evidence needed to both classify a site and make recommendations for further action
- The SI is a complex process for evaluating ROPCs using field screening and laboratory sampling
- A harmonized DQO process allows for proper planning of SI and maintains a consistent approach; however, PSL development is site specific and needs to be carefully explored
- Recent PA/SI Framework should help RPMs and contractors succeed in efficiently evaluating sites with G-RAM

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Questions