THE TAO OF RAO

Remedial Action Objectives and Remediation Goals

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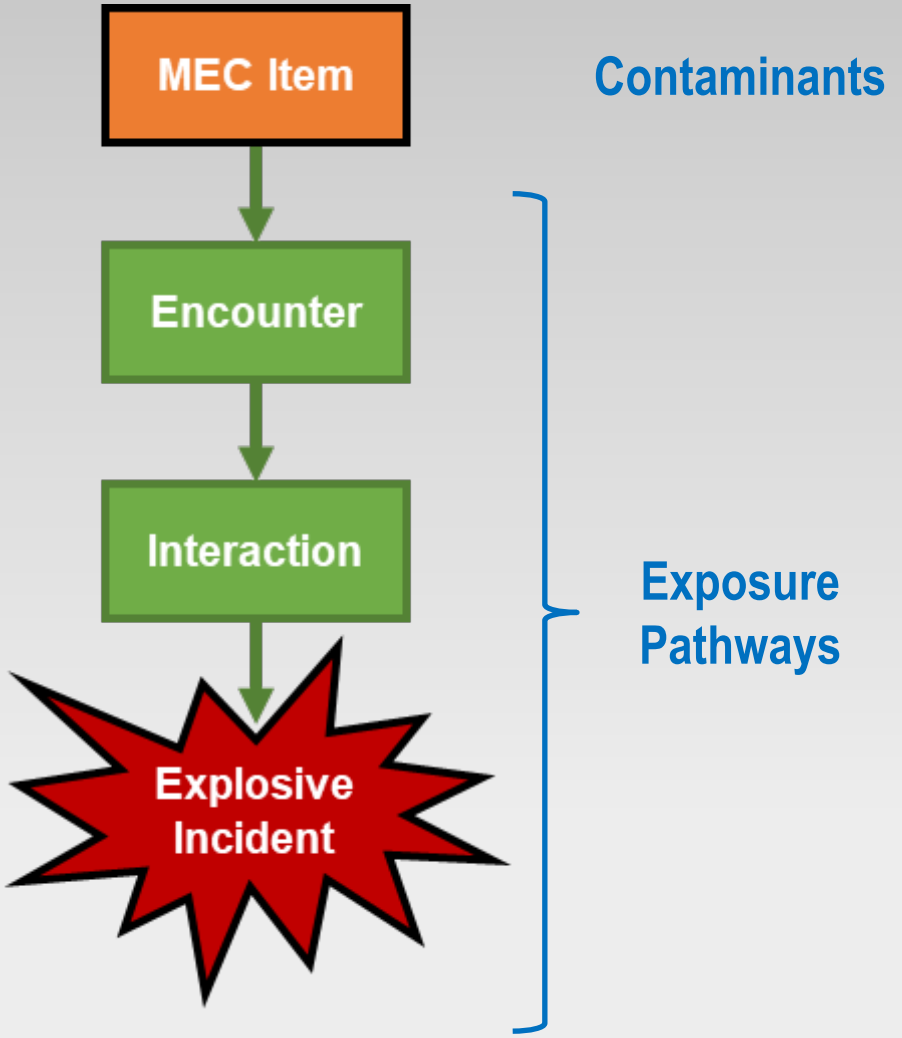
THE BASICS

- 40 CFR § 300.430 addresses the Remedial Investigation through Remedy Selection (RI → ROD)
  - 40 CFR Part 300.430(a)(1)(iii)(D)
    - EPA expects to use institutional controls such as water use and deed restrictions to supplement engineering controls as appropriate for short- and long-term management to ***prevent or limit*** exposure to hazardous substances, pollutants, or contaminants…
  - 40 CFR Part 300.430(e)(2)(i)
    - States the lead agency shall "Establish **remedial action objectives [RAOs]** specifying **contaminants and media of concern**, **potential exposure pathways**, and **remediation goals**."

THE BASICS, CONT'D.

- For RAOs on MEC projects
  - Contaminants and media of concern
    - Described in the CSM
  - Potential exposure pathways
    - Described in the CSM

- Remember the "risk scenarios" from the baseline MEC risk assessment…?



HOW RISK SCENARIOS CAN HELP WITH RAOs

❖ RAOs require

– Contaminants and Media of Concern

- Specific MEC types
- Specified horizontal boundary
- Depth related to current and future land use
- Depth of MEC determined during characterization (if less than land use)

– Potential Exposure Pathways

- Receptors
- Pathways

❖ RMM input data requires

– For MEC

- MEC Types

– Risk scenarios include

- Assessment Areas
- Receptor Activities
- Interaction Zones

It's all in there!

FOR EXAMPLE…

- MEC
  - MEC type(s)
    - 60mm HE mortars in soil to depths of 36 inches bgs
- Risk Scenario
  - Assessment Area
    - North Field Area (LUA)
  - Receptor Activities & Interaction Zones
    - Annual planting and harvesting activities to up to 18 inches bgs
    - Occasional fence installation to up to 36 inches bgs

- Possible RAO
  - "to reduce risk…

CONTAMINANTS AND MEDIA OF CONCERN

  - … due to presence of **60mm HE mortars in soil** within **the North Field Area (LUA) of the Example MRS** to a depth of **36 inches below surface**…

POTENTIAL EXPOSURE PATHWAYS

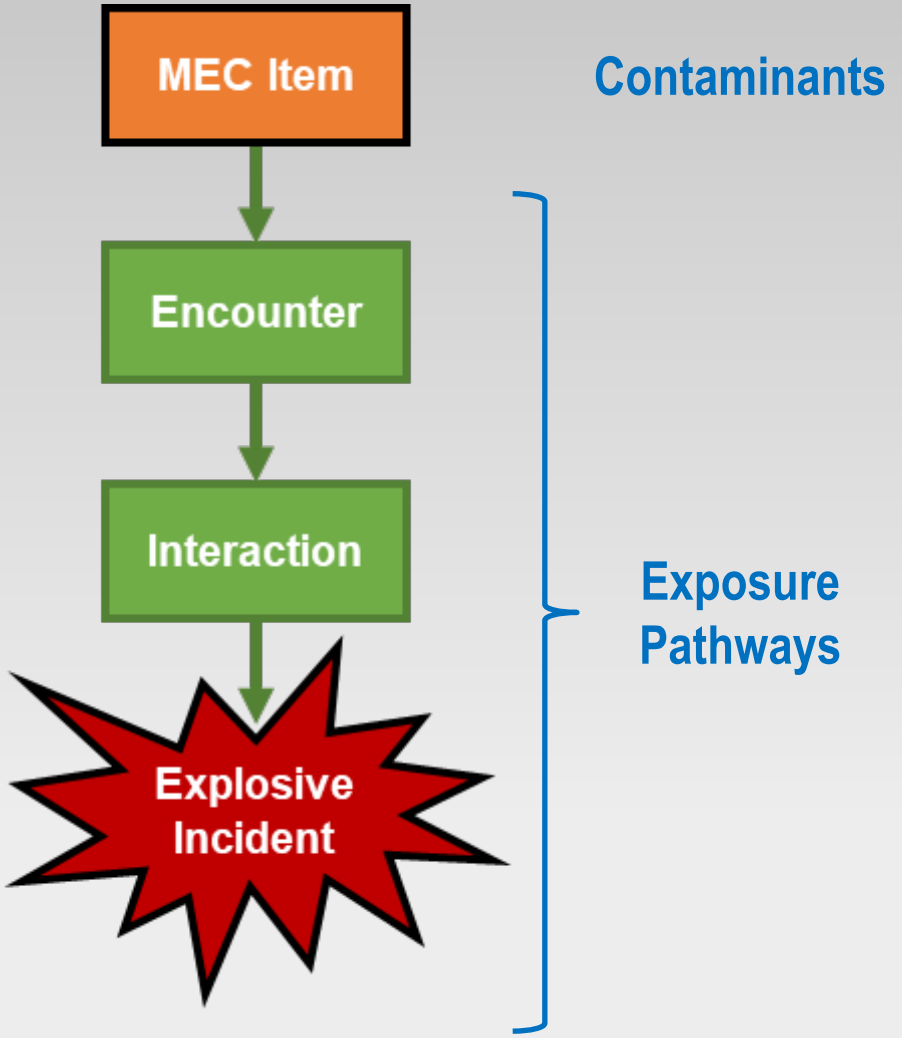
  - …to address likelihood of exposure to **agricultural workers** via **intentional or unintentional interactions during annual planting and harvesting activities to a depth of up to 18 inches bgs, and during occasional fence installations to a depth of 36 inches bgs**…

REMEDIATION GOAL

  - We'll discuss this next…

THE BASICS, CONT'D.

- For RAOs on MEC projects
  - Remediation goals
    - … is where it gets trickier
    - MEC risk is not easily quantifiable
    - There is no widely "acceptable" level of MEC exposures
      - » *Though we all agree any explosive incident is clearly unacceptable*
    - So, what can we do?

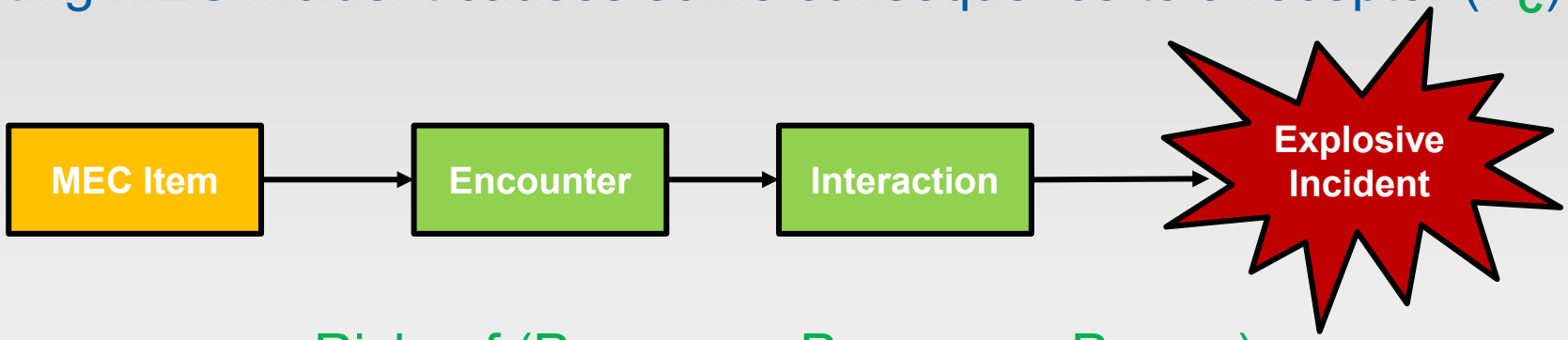


SOME QUICK DEFINITIONS

- Encounter
  - A receptor sees or is otherwise alerted to the location of a MEC item. An encounter does not include imparting energy to a MEC item.
- Interact/interaction
  - A receptor imparts energy to a MEC item where the amount of energy might cause the item to function or otherwise release energy that could potentially cause harm.
    - Interactions can be intentional or unintentional.
- Explosive Incident
  - A MEC item functions or otherwise releases energy that could potentially cause harm.
- Limit
  - To curtail or reduce in quantity or extent (Meriam Webster)
- Prevent
  - To keep from happening or existing (Meriam Webster)

RISKS FROM MEC HAZARDS

- To understand Remediation Goals, we need to understand how people can be at risk from MEC hazards
- MEC risk is the qualitative (though may be semi-quantitative) outcome from looking at all the probabilities that factor in to how someone might come to harm (1)
  - Risk is a function of the probability that a receptor
    - Encounters an explosively-configured UXO or DMM item (P_E) **AND THEN**
    - Imparts enough energy to that UXO or DMM that it functions (P_I) **AND THEN**
    - The resulting MEC incident causes some consequence to a receptor (P_C).

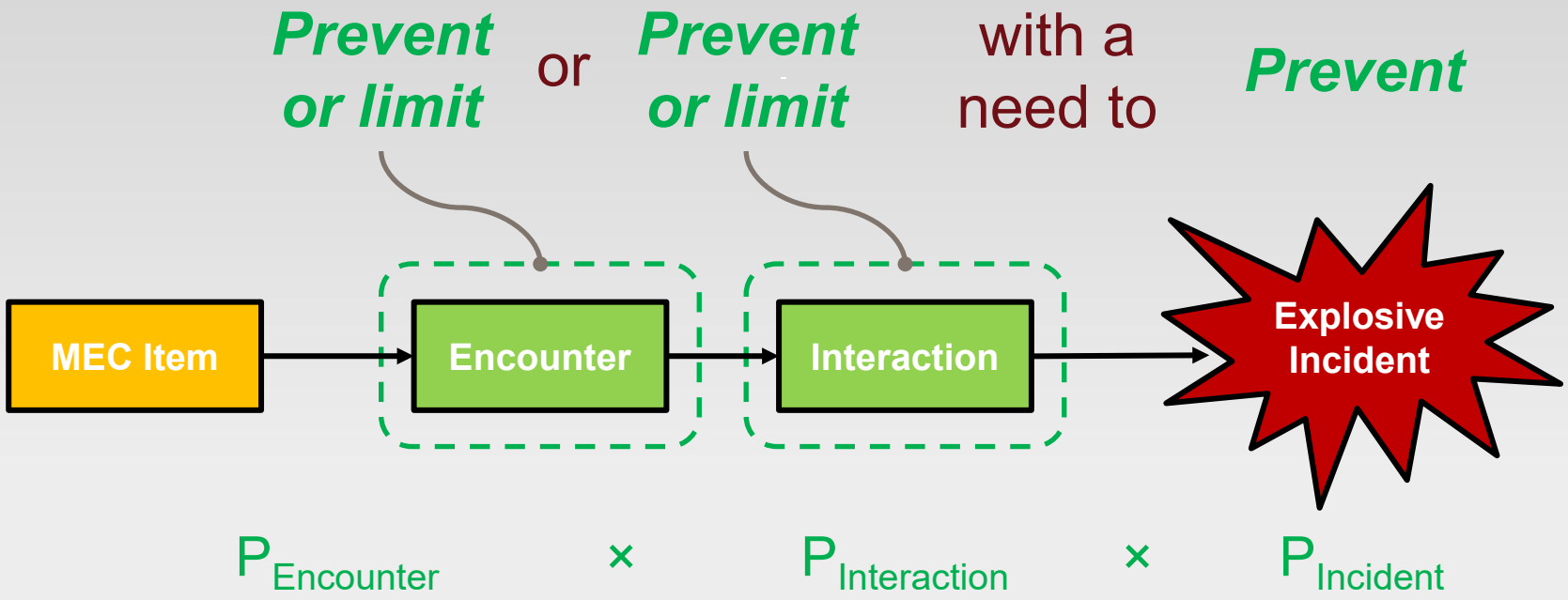


$$Risk = f\left(P_{Encounter} \times P_{Interaction} \times P_{Incident}\right)$$

1) *In probability theory, when the outcome of an event is the function of two or more individual probabilities, the probability of the event happening is the multiplication of the individual probabilities. e.g., the probability of tossing two coins and both landing heads is 0.5 (coin #1) x 0.5 (coin #2) = 0.25, or one in four tries of flipping both coins.*

REDUCING RISKS FROM MEC HAZARDS

- The NCP tells us that ***protectiveness*** is achieved when the MEC exposure pathway for, and risks to, all receptors is ***prevented or limited***
- Looking at the MEC exposure pathway, what can we 'prevent or limit'?



REMEDIATION GOALS

- Remediation goals for MEC projects
  - The purpose of the remediation goal is to clearly define the PDT's expectations for what the remedial response needs to achieve to be ***protective*** of human health and the environment
  - It set(s) a standard for the development and evaluation of remedial alternatives
    - i.e., it is "remedy-generic"
    - Must NOT be prescriptive (e.g., *require* MEC removal)
- What is does "protective" mean
  - Interpreting the NCP, ***protectiveness*** is achieved when the MEC exposure pathway for, and risks to, all receptors is ***prevented or limited***

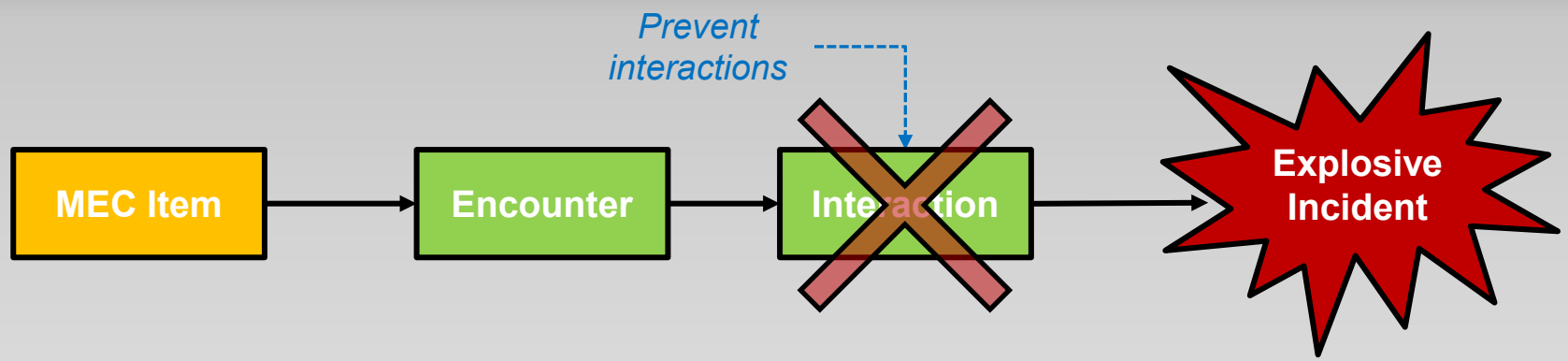
So, Remediation Goal = PDT's definition of "protectiveness"

OUTCOME NEEDED TO ACHIEVE PROTECTIVENESS

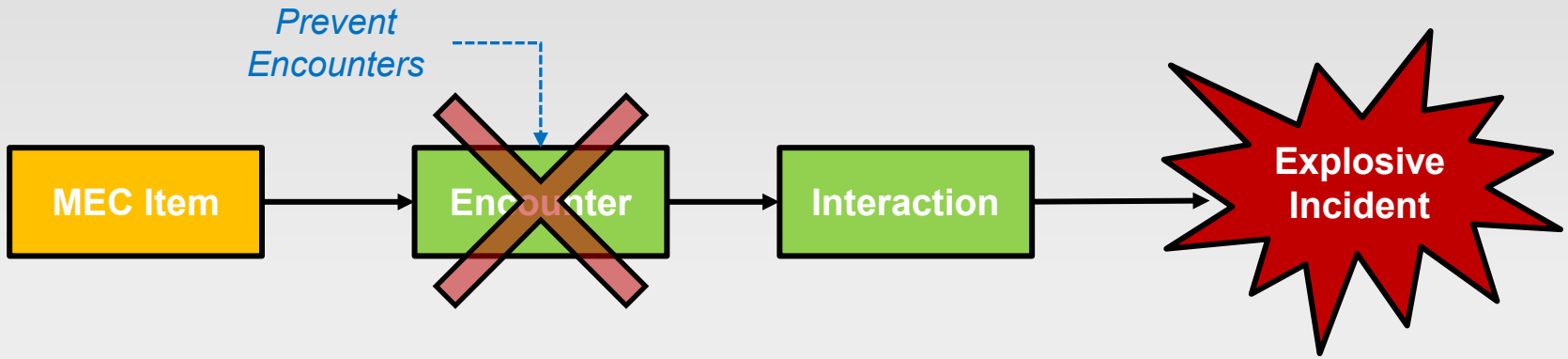
- So, if ***protectiveness*** is achieved when the MEC exposure pathway for all receptors is ***prevented or limited***, then we need to either
  - ****PREVENT**** the encounters or interactions leading to the unacceptable risk (i.e., *eliminating any likelihood of that type of exposure*)
    - Therefore, no amount of those exposures is considered acceptable
    - Further note that if actions taken to prevent risks results in removing all explosive hazards irrespective of interaction zones, then conditions for UU/UE are supported
  - ****LIMIT**** the encounters or interactions leading to the unacceptable risk (i.e., *significantly reducing the likelihood of that type of exposure*)
    - Note that while a goal of 'limiting' exposures is intended to reduce the number of exposures that present a risk, it is not aimed at completely removing (i.e., preventing) the exposure risk
      - This means some number of those exposures ***must be acceptable***, *and may even be expected*, as long as they are not anticipated to result in an explosive incident

→ From Slide 2, the concepts of "Prevent" and "Limit" are straight out of the NCP

TYPE OF EXPOSURE AND REMEDIATION GOAL



A remediation goal of preventing intentional or unintentional interactions could also be achieved by preventing or limiting encounters, such that explosive incidents are prevented



A remediation goal of preventing encounters would fail if a receptor simply encountered a MEC item, whether harm resulted from the encounter or not

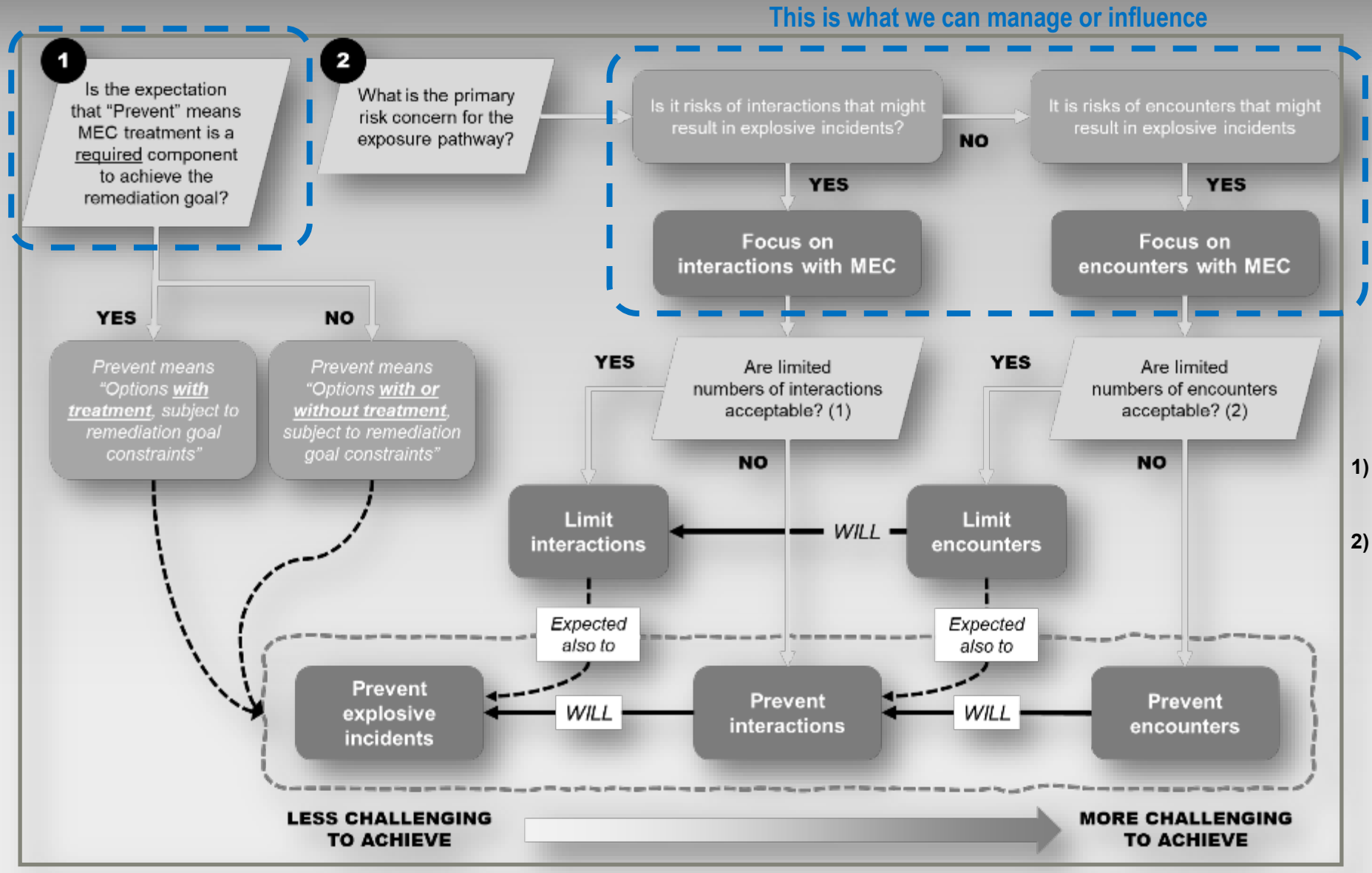
REMEDIATION GOALS AND *ACCEPTABLE* EXPOSURES

Remediation Goal	Goal is Based on No. of…	Acceptable Exposures	Failure Condition	Acceptable Exposure Levels (Nos. of interactions or encounters)
1) Limit MEC interactions	MEC interactions	X (must be >0)	**Explosive incidents >0** OR MEC interactions >X	MEC interactions ≤X OR Any number of MEC encounters
2) Prevent MEC interactions	MEC interactions	0	**Explosive incidents >0** OR MEC interactions >0	Any number of MEC encounters
3) Limit MEC encounters	MEC encounters	X (must be >0)	**Explosive incidents >0** OR MEC interactions >0 OR MEC encounters >X	MEC encounters ≤X
4) Prevent MEC encounters	MEC encounters	0	**Explosive incidents >0** OR MEC interactions >0 OR MEC encounters >0	None

Note: ***No number of explosive incidents is ever acceptable.***
Encounters and interactions do not always result in explosive incidents.

ROADMAP TO PROTECTIVENESS CONSENSUS

- Gets the dialogue started early
- Sets us up to answer Q#2 with common understanding



1) As long as there are no explosive incidents
2) As long as there are no explosive incidents or interactions

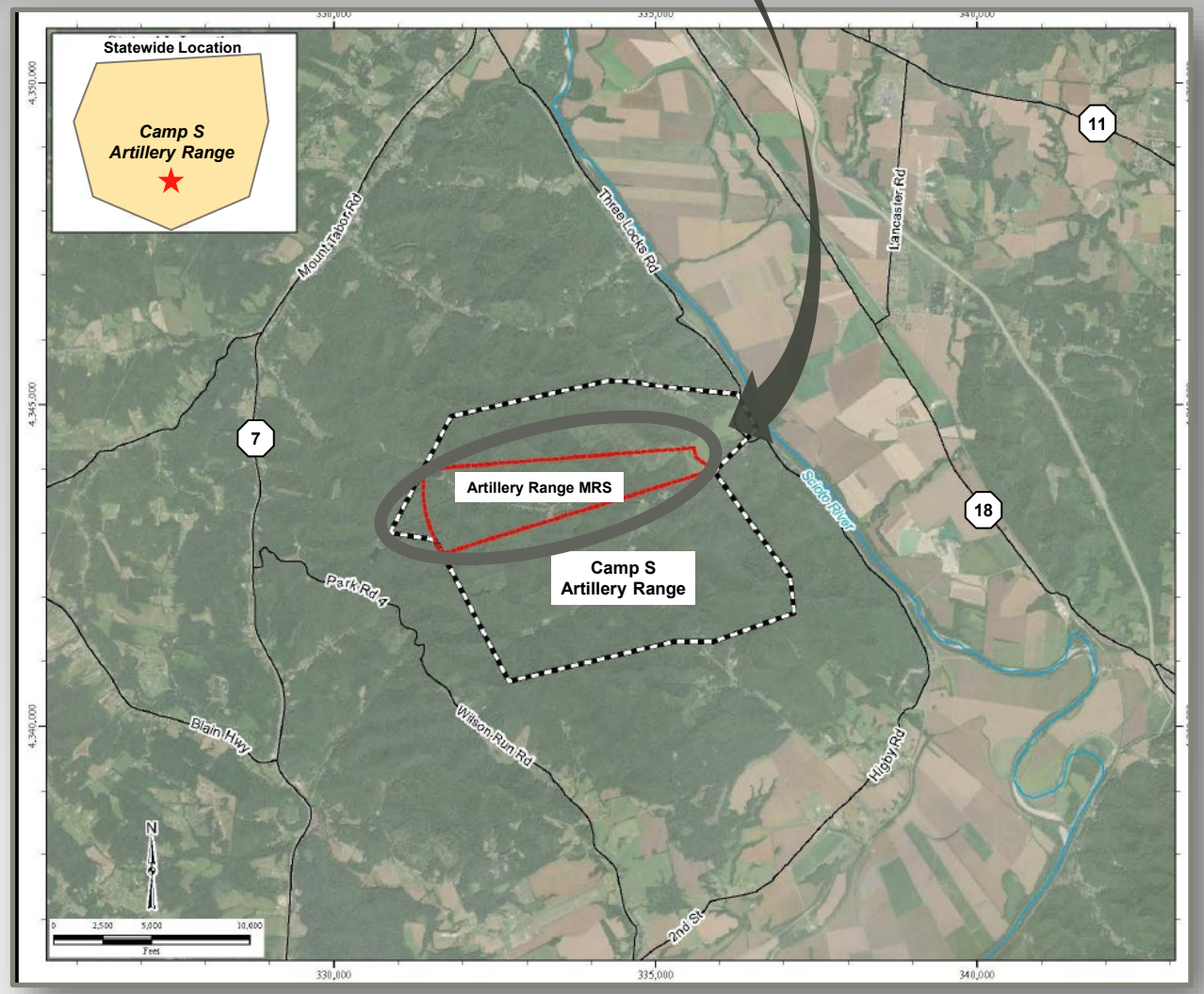
RAO FORMAT WITH NEW REMEDIATION GOALS

- "RAOs specifying **contaminants and media of concern**, **potential exposure pathways**, and **remediation goals**":
  - For RAOs where prevention of exposure is the goal
    - "The [assessment area(s)] is(are) anticipated to have [**contamination (MEC types)**] in [**media**] throughout the assessment area(s), with MEC expected to exist within [**depth profile(s)**]. [**Receptors**] in the assessment area could be exposed to MEC via [**exposure pathway(s)**] to [**exposure depth(s)**]. The remediation goal for the assessment area(s) is(are) to **PREVENT** [**receptors**] from [**type of exposure**] with MEC.
  - For RAOs where limiting exposure is the goal
    - "The [**assessment area(s)**] is(are) anticipated to have [**contamination (MEC types)**] in [**media**] throughout the assessment area(s), with MEC expected to exist within [**depth**] [**profile(s)**]. [**Receptors**] in the assessment area could be exposed to MEC via [**exposure pathway(s)**] to [**exposure depth(s)**]. The remediation goal for the assessment area(s) is(are) to prevent explosive incidents by **LIMITING** [**receptors**] to not more than [**acceptable exposure+type of exposure**] with MEC.

CONTAMINANTS AND MEDIA OF CONCERN | *POTENTIAL EXPOSURE PATHWAYS* | *REMEDIATION GOALS*

MRS	REMEDIAL ACTION OBJECTIVE						
	CONTAMINANT / MEDIUM	POTENTIAL EXPOSURE PATHWAY(S)			REMEDIATION GOAL		
		Assessment Area(s)	Receptors and Exposure Pathways	Depth of Exposure	Prevent / Limit?	Type of Exposure	Acceptable Exposure

EXAMPLE



From the Proposed Plan –

Currently used as state forest, farmland, and residential properties

Potential human receptors at the MRS include residents, site visitors/recreational users, on-site workers, and construction workers

Nothing more is written in the RI, FS or PP about land use or potential interactions

Known or suspected sources of MEC contamination :

- Projectile, 3-inch, HE and shrapnel
- Projectile, 4.7-inch, HE
- Projectile, 37mm, cast iron shell

"The RAO is to reduce risk due to presence of 3-inch shrapnel and HE shrapnel; 4.7-inch HE and shrapnel; and 37mm cast iron projectiles within Artillery Range MRS on the surface and in the subsurface at depths up to 60cm (~ 24"), 53cm (~ 21"), and 10cm (~ 4") bgs, respectively, to address likelihood of exposure to residents, outdoor workers, site visitors/recreational users, and utility workers via direct contact, such that an acceptable condition is achieved."

- What does that actually mean?
- Why the different depths?
- Do we need to keep some or all users from simply encountering MEC?
- Is it okay for them to unintentionally interact with MEC?
- Should we really treat all users the same?

EXAMPLE – INITIAL RAOs

Mapping those exposure descriptions to our new RAO model

From the RI/FS

- HUA-Regular (exposures)
- HUA-Often (exposures)
- HUA-Intermittent (exposures)
- LUA-Regular (exposures)
- LUA-Often (exposures)
- ~~LUA-Intermittent (exposures)~~
  → No unacceptable risk

MRS	REMEDIAL ACTION OBJECTIVE						
	CONTAMINANT / MEDIUM	POTENTIAL EXPOSURE PATHWAY(S)			REMEDIATION GOAL		
		Assessment Area(s)	Receptors and Exposure Pathways	Depth of Exposure	Prevent / Limit?	Type of Exposure	Acceptable Exposures
Camp S Artillery Range	MEC In Soil: ▪ Projectile, 4.7", HE, Mk4 (to 53cm bgs) ▪ Projectile, 3", HE and shrapnel (to 60cm bgs) ▪ Projectile, 37mm, cast iron (to 10cm bgs)	HUA-R	Residential properties, farmland, and areas near Caldwell Lake	*Not specified*	*Not specified*	*Not specified*	*"Acceptable condition"*
		HUA-O	Wooded and non-wooded areas with trails and roads or where recreational and maintenance activities often occur	*Not specified*	*Not specified*	*Not specified*	*"Acceptable condition"*
		HUA-I	Wooded and non-wooded areas where recreational activities intermittently occur	*Not specified*	*Not specified*	*Not specified*	*"Acceptable condition"*
		LUA-R	Residential properties, farmland, and areas near Caldwell Lake	*Not specified*	*Not specified*	*Not specified*	*"Acceptable condition"*
		LUA-O	Wooded and non-wooded areas with trails and roads or where recreational and maintenance activities often occur	*Not specified*	*Not specified*	*Not specified*	*"Acceptable condition"*

Who are the receptors?
What are they doing?

Still don't know!

???

How can we judge whether our remedies are "acceptable"?

How can we assess this during five-year reviews?

EXAMPLE – MORE COMPREHENSIVE RAOs

Using more detail about land use and receptors, plus the proposed method for remediation goals

MRS	REMEDIAL ACTION OBJECTIVE						
	CONTAMINANT / MEDIUM	POTENTIAL EXPOSURE PATHWAY(S)			REMEDIATION GOAL		
		Assessment Area(s)	Receptors and Exposure Pathways	Depth of Exposure	Prevent / Limit?	Type of Exposure	Acceptable Exposures
Camp S Artillery Range	MEC In Soil: ▪ Projectile, 4.7", HE, Mk4 (to 53cm bgs) ▪ Projectile, 3", HE and shrapnel (to 60cm bgs) ▪ Projectile, 37mm, cast iron (to 10cm bgs)	**State Forest Lands: Trail heads & parking areas, trails incl. 15m buffer, Lake area** HUA and LUA	Recreational users: hiking, walking, picnicking *Average of 25,000 visitors/year using the trails and 50,000 visitors/year using the lake area*	Surface mostly (15cm bgs rare)	Prevent	Encounter	0
			Site workers: road, parking area and trails: maintenance activities *Trail-head maintenance occurs once annually; trail maintenance is rare, occurring once per 10 years (approx.)*	55cm bgs	Prevent	Interactions	0
		State Forest Lands: off trail lands HUA	Recreational users: off trail hiking or walking *Off-trail use is rare, and is discouraged by the park owner*	Surface only	Prevent	Interactions	0
		State Forest Lands: off trail lands LUA	Recreational users: hiking, walking *Off-trail use is rare, and is discouraged by the park owner*	Surface only	Limit	Interactions	2/year
		Farmlands HUA and LUA	Farming users: planting crops, livestock grazing, haying *On average 100% of all tillable land is ploughed and disk harrowed once a year by 20 farm personnel*	60cm bgs	Prevent	Interactions	0
		Residential Areas HUA and LUA	Residential users: gardening/landscaping, installing fences *5% of individual yards are dug in to once a year by, on average, 200 residents. Digs are small diameter (~30cm) and locations are random*	30cm bgs	Prevent	Encounter	0
			Construction workers: road maintenance, utility installations & maintenance, septic installations *On average dirt roads are re-surfaced twice/year, paved roads every 15 years; power poles are replaced every 30 years; underground utilities are a potential replacement for currently above ground utilities*	160cm bgs	Prevent	Interactions	0

EXAMPLE – MORE COMPREHENSIVE RAOs

MRS	CONTAMINANT / MEDIUM	REMEDIAL ACTION OBJECTIVE					
		POTENTIAL EXPOSURE PATHWAY(S)			REMEDIATION GOAL		
		Assessment Area(s)	Receptors and Exposure Pathways	Depth of Exposure	Prevent / Limit?	Type of Exposure	Acceptable Exposures
Camp S Artillery Range	MEC In Soil: ▪ Projectile, 4.7", HE, Mk4 (to 53cm bgs) ▪ Projectile, 3", HE and shrapnel (to 60cm bgs) ▪ Projectile, 81mm, cast iron (to 10cm bgs)	**State Forest Lands: Trail heads & parking areas, trails incl. 15m buffer, Lake area** HUA and LUA	Recreational users: hiking, walking, picnicking *Average of 25,000 visitors/year using the trails and 50,000 visitors/year using the lake area*	Surface mostly (15cm bgs rare)	Prevent	Encounter	0
			Site workers: road, parking area and trails: maintenance activities *Trail-head maintenance occurs once annually; trail maintenance is rare, occurring once per 10 years (approx.)*	55cm bgs	Prevent	Interactions	0
		State Forest Lands: off trail lands HUA	Recreational users: off-trail hiking or walking *Off-trail use is rare, and is discouraged by the park owner*	Surface only	Prevent	Interactions	0
		State Forest Lands: off trail lands LUA	Recreational users: hiking, walking *Off-trail use is rare, and is discouraged by the park owner*	Surface only	Limit	Interactions	2/year
		Farmlands HUA and LUA	Farming users: planting crops, livestock grazing, haying *On average 100% of all tillable land is ploughed and disk harrowed once each year for farming purposes*	60cm bgs	Prevent	Interactions	0
		Residential Areas HUA and LUA	Residential users: planting gardens, installing fences *5% of individual yards are dug in to once a year by, on average, 200 residents. Digs are small diameter (~30cm) and locations are random*	30cm bgs	Prevent	Encounter	0
			Construction workers: road maintenance, utility installations & maintenance, septic installations *On average dirt roads are re-surfaced twice/year, paved roads every 15 years; power poles are replaced every 30 years; underground utilities are a potential replacement for currently above ground utilities*	160cm bgs	Prevent	Interactions	0

This allows us to evaluate whether a remedial method or an alternative can achieve our remediation goal.

For example, can a 3Rs pamphlet prevent encounters? *No.*

But can a 3Rs pamphlet limit interactions? *Absolutely.*

Also note how these remediation goals will help 5-year reviews

FINAL THOUGHTS

- This format for remediation goals
  - Facilitates evaluation of protectiveness for remedial methods and alternatives
    - Supports alternative design
    - Especially useful for LUCs
  - Allows evaluation of ongoing protectiveness during five-year reviews
  - Complies with the NCP
- Further described in imminent EM 200-1-15 update


ANY
QUESTIONS?