

Kirtland Air Force Base Fuel Leak Cleanup

Presenters: Kathryn Lynnes, HQE, Kirtland Air Force Base
Dr. Shannon Garcia, PhD, Risk Assessor/Toxicologist, Air
Force Civil Engineer Center
Cynthia Cheatwood, MSPH, EA Engineering, Science
and Technology, Inc., PBC
Rachel Hobbs, PG, Sundance Consulting, Inc.



Risk Assessment Deep Dive

November 14, 2017

Presenters

- Review Process: Dr. Shannon Garcia, PhD, Risk Assessor/Toxicologist, Air Force Civil Engineer Center
- General Risk Assessment Steps: Cynthia Cheatwood, MSPH, EA Engineering, Science and Technology, Inc., PBC
- BFF-Specific Risk Assessment Steps: Rachel Hobbs, PG, Sundance Consulting, Inc.

Deep Dive Outline

- Goal: Provide detailed explanation of BFF Risk Assessment and answer questions pertaining to the risk assessment
- Introduction
- Review Process
- General New Mexico risk assessment overview
- Human health risk assessment overview and results
- Ecological risk assessment overview and results

What is a Risk Assessment?

U.S. Environmental Protection Agency (EPA):

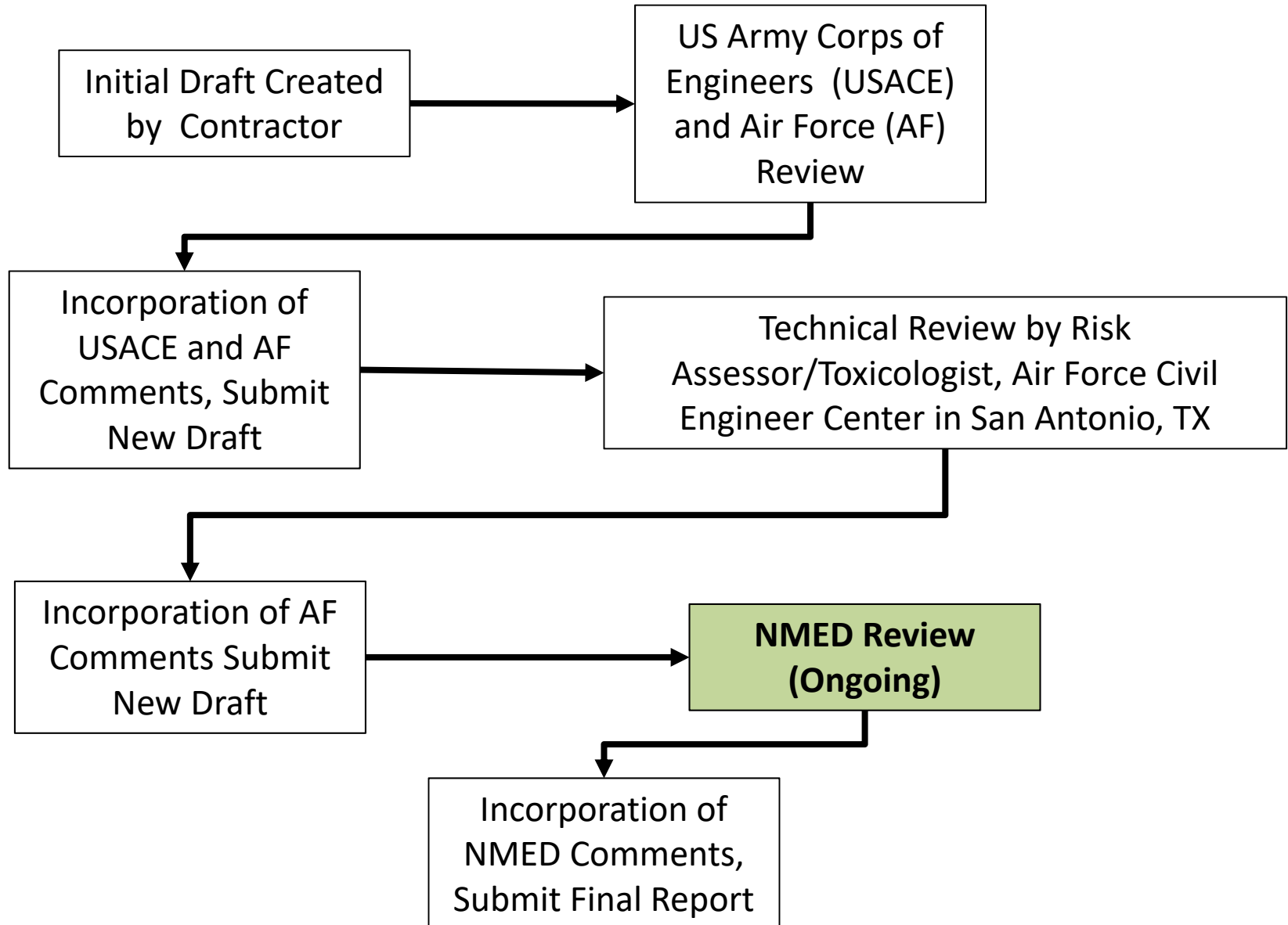
“A human health risk assessment (HHRA) is the process to **estimate the nature and probability of adverse health effects** in humans who may be exposed to chemicals in contaminated environmental media, now or in the future.”

“An ecological risk assessment is the process for evaluating **how likely it is that the environment may be impacted** as a result of exposure to one or more environmental stressors such as chemicals, land change, disease, invasive species and climate change.”

New Mexico Risk Assessment Guidance

- New Mexico Environment Department (NMED)
March 2017 Risk Assessment Guidance
(<https://www.env.nm.gov/hazardous-waste/guidance-documents/>)
 - Volume I - Screening Guidance for Human Health Risk Assessment
 - Volume II – Screening Guidance for Ecological Risk Assessments
- EPA screening levels are used when NMED has not established a screening level
(<https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide-june-2017>)

Risk Assessment Preparation Process

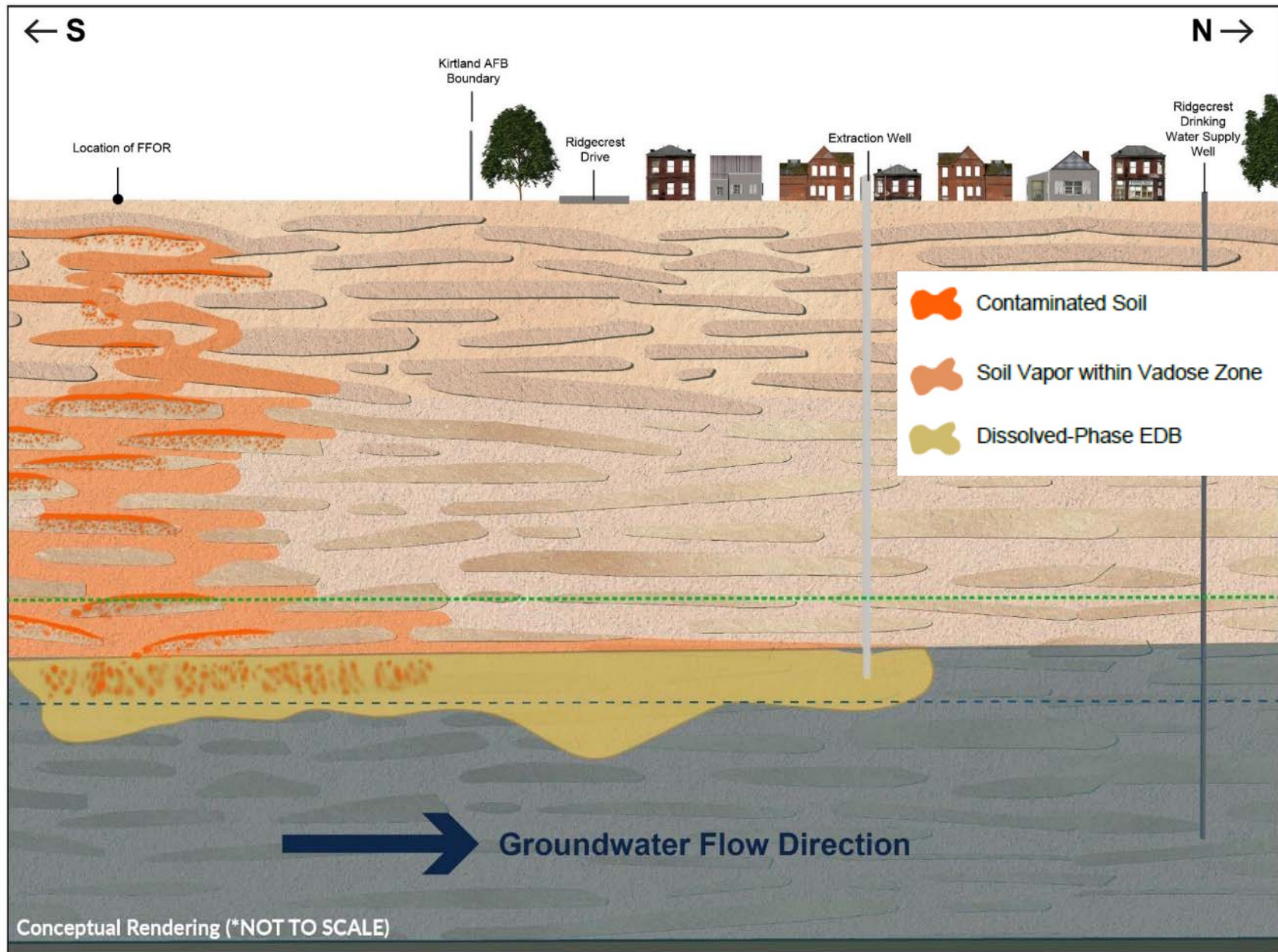


NMED Risk Assessment Overview

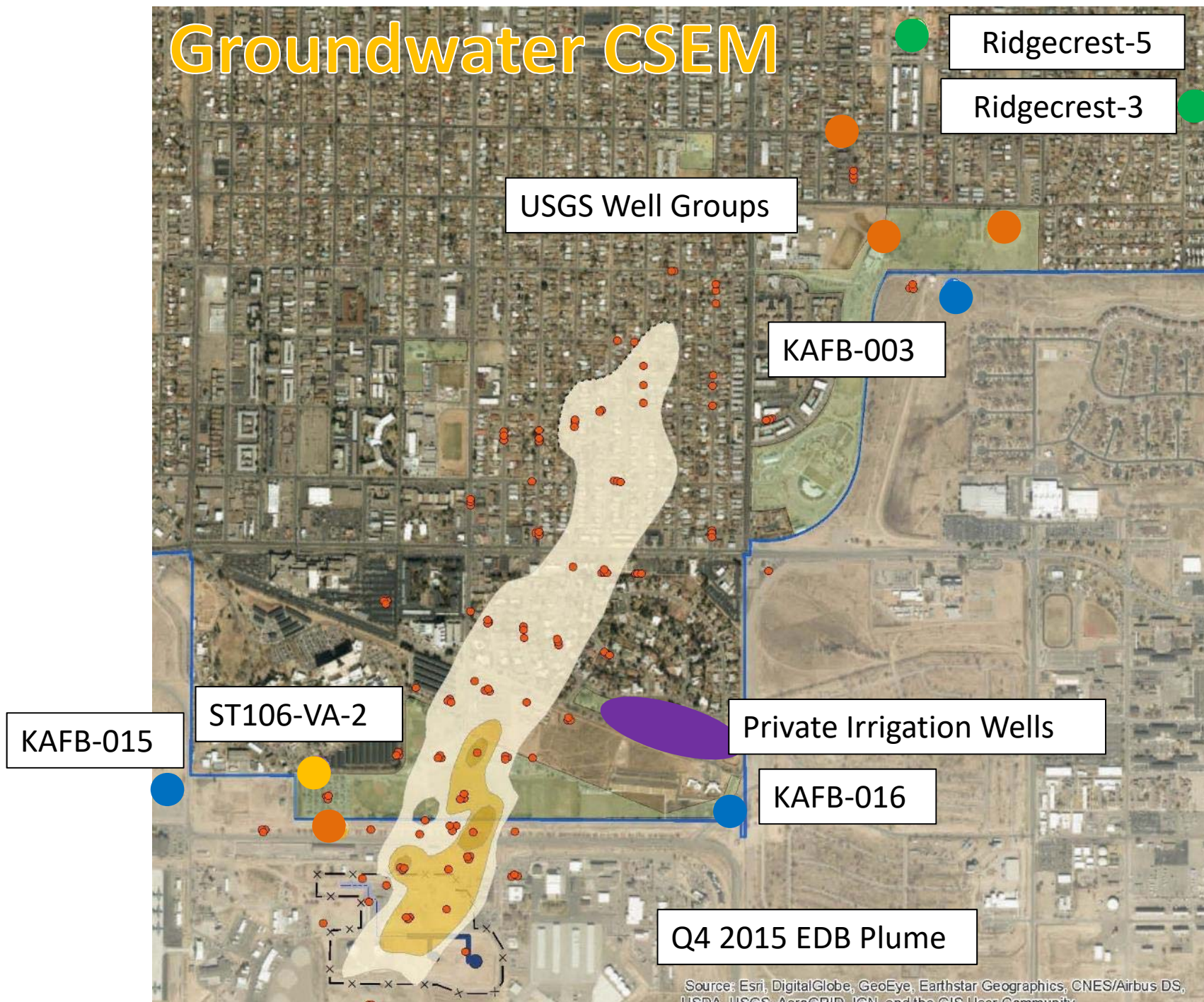
NMED Risk Assessment guidance follows EPA's 4-step process

- **Data Collection and Evaluation:** Collect reliable data for calculating risk
- **Exposure Assessment:** Estimate type and magnitude of exposures to chemicals of potential concern (COPCs)
- **Toxicity assessment:** Evaluate potential for adverse health effects
- **Risk Characterization:** Integrate Exposure Assessment and Toxicity Assessment to quantify risk

Conceptual Site Exposure Model



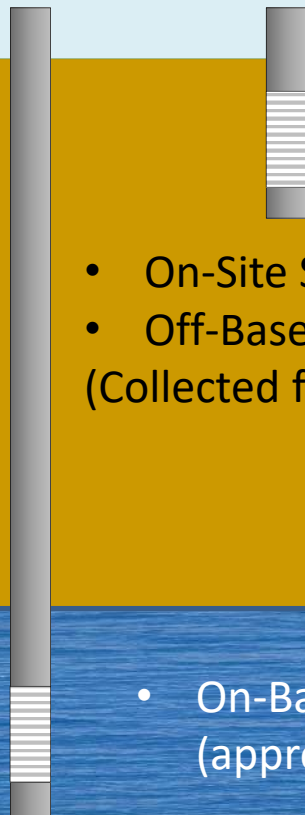
Groundwater CSEM



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Data Collection and Evaluation

- Chemical data collected from impacted media: soil, soil gas and groundwater
- Risk Assessment used data from RFI Report and Quarterly Monitoring Reports
- Conceptual site model refined based on data evaluation
- Chemical of potential concern identified (ex. Fuel constituents)



- On-Site Soil Gas Samples
- Off-Base Soil Gas Samples
(Collected from 25 feet bgs)

- On-Base/Off-Base Groundwater Samples
(approx. 480 feet bgs)

- Soil - On-site Soil Samples
0-1 foot below ground surface (bgs)
0-10 feet bgs
- No contaminated soil (0-10 feet bgs) off-Base
No off-Base soil samples evaluated



Fuel-Related Analytes

Chemicals of Potential Concern (COPCs)

COPCs	Soil	Soil Gas	Groundwater
1,2,4-Trimethylbenzene	✓	✓	✓
1,2-Dibromoethane (EDB)	✓	✓	✓
1,2-Dichloroethane	✓	✓	✓
1-Methylnaphthalene	✓		✓
2-Methylnaphthalene	✓		✓
Acetophenone			✓
Benzene	✓	✓	✓
Cyclohexane		✓	
Ethylbenzene	✓	✓	✓
Hexadecane	✓		
Isopropylbenzene (cumene)	✓		
Lead	✓		✓
m & p-Xylenes		✓	
MTBE	✓	✓	
n-Heptane		✓	
n-Hexane		✓	
Naphthalene	✓	✓	✓
o-Xylene		✓	
Toluene	✓	✓	✓
Xylenes (total)	✓	✓	✓

Exposure Assessment

- Evaluated current land use on Site and off Base
 - Current on-Site: Commercial/industrial at BFF
 - Current Off-Base includes:
 - Recreational (ex. Bullhead Park)
 - Residential (ex. North of Ridgecrest)
- Evaluated potential future land use
 - Future on-Site: Residential at BFF
 - Future off-Base: Residential at Bullhead Park
- Current land use controls
 - On-Site access at BFF restricted by approval process
 - Office of State Engineer restricts installation of private wells within a 500-ft buffer around EDB plume

Exposure Assessment Overview

Using Site data, Conceptual Site Model, and known land use the following steps were completed:

1. Receptors were identified on-Site and off-Base

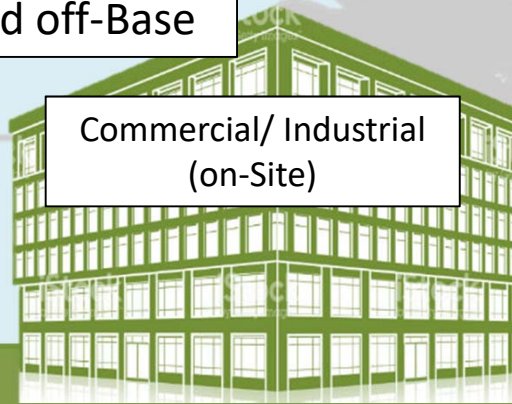
Construction Worker (on-Site)



Recreational (off-Base)



Commercial/ Industrial (on-Site)



Residential (on-Site and off-Base)



2. Exposure pathways/routes were evaluated to identify complete pathways

Outdoor Air
Inhalation

Soil: 0-10 ft bgs
Ingestion
Skin Contact
Inhalation

Tap Water
Ingestion
Skin Contact
Inhalation

Outdoor Air
Inhalation

Soil: 0-1 ft bgs
Ingestion
Skin Contact
Inhalation

Tap Water
Ingestion
Skin Contact
Inhalation

Indoor Air (Vapor Intrusion)
Inhalation

Soil: 0-1 ft bgs
Ingestion
Skin Contact
Inhalation

Tap Water
Ingestion
Skin Contact
Inhalation

Indoor Air (Vapor Intrusion)
Inhalation

Soil: 0-10 ft bgs
Ingestion
Skin Contact
Inhalation

Tap Water
Ingestion
Skin Contact
Inhalation

Complete and Incomplete Exposure Pathways

Off-Base

Current

Future

Recreational

Residential

Hypothetical residential houses in Bullhead Park



Outdoor Air

Indoor Air (Vapor Intrusion)

Indoor Air (Vapor Intrusion)

Incomplete Pathway:
Immediate dilution by ambient air

Incomplete pathway:
Currently no residential homes near impacted soil gas

Complete Pathway:
Assumes homes built in Bullhead Park or AF open space

Soil: 0-10 ft bgs

Soil: 0-10 ft bgs

Soil: 0-10 ft bgs

Incomplete Pathway:
No impacted soil off-base

Incomplete Pathway:
No impacted soil off-base

Incomplete Pathway:
No impacted soil off-base

Tap Water

Tap Water

Tap Water

Incomplete Pathway:
No drinking water wells in impacted groundwater

Incomplete Pathway:
No drinking water wells in impacted groundwater

Complete Pathway:
Assumes impacted groundwater detected at private or public wells

Complete or Incomplete Exposure Pathways on-Site

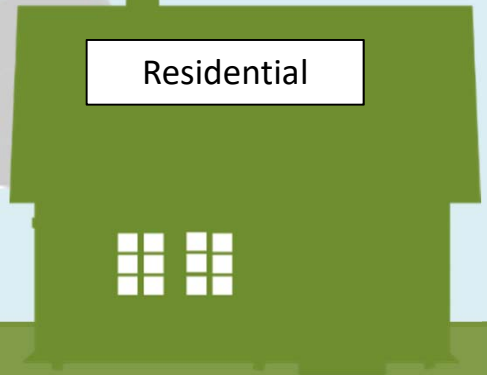
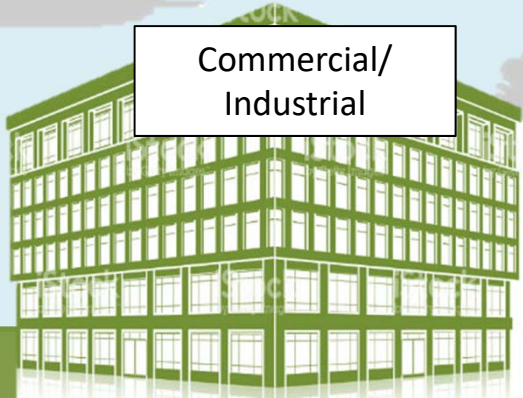
Current

Future

Construction Worker

Commercial/Industrial

Residential



Outdoor Air

Indoor Air (Vapor Intrusion)

Indoor Air (Vapor Intrusion)

Incomplete Pathway:
Immediate dilution by ambient air

Complete Pathway:
Occupied buildings near impacted soil gas

Complete Pathway:
Assumes homes built on-Site at BFF

Soil: 0-10 ft bgs

Soil: 0-1 ft bgs

Soil: 0-10 ft bgs

Complete Pathway:
Impacted soil on-Site

Complete Pathway:
Impacted soil on-Site

Complete Pathway:
Assumes homes built on-Site at BFF

Tap Water

Tap Water

Tap Water

Incomplete Pathway:
No drinking water wells in impacted groundwater

Incomplete Pathway:
No drinking water wells in impacted groundwater

Complete Pathway:
Assumes impacted groundwater detected at private or public wells

Residential Soil Screening Levels

Based on the following exposure scenario:



Includes children and adults

Assumes a person is at their home
24 hours/day, 350 days/year, for 26 years

Assumes resident exposed to impacted soil (0 to 10 feet bgs) during home activities

- Incidental soil ingestion
- Contact with skin
- Inhalation of particulates/dusts and/or volatile chemicals

Commercial/Industrial Soil Screening Levels

Based on the following exposure scenario:

Assumes the worker is present 225 days/year for 25 years

Only considers adult worker



Assumes long-term employee exposed to surface and shallow subsurface soils (0-1 ft bgs)

- Incidental ingestion
- contact with skin
- Inhalation of particulates or volatiles

Construction Worker Soil Screening Levels

Based on the following exposure scenario:

Assumes worker is present 250 days/year for 1 year

Only considers adult worker



Assumes worker may be exposed to soil during intrusive activities (0-10 ft bgs)

- Incidental ingestion
- Contact with skin
- Inhalation of particulates or volatiles

Tap Water Screening Levels

Based on the following exposure scenario:

Tap water screening levels (SLs) calculated based on residential exposure

Assumes groundwater used as a household water source or has impacted the drinking water supply

Includes children and adults

- Ingestion (ex. as drinking water)
- Skin contact (ex. during bathing/showering)
- Inhalation of volatiles during household use (ex. Showering or running a dishwasher)

Assumes resident exposed to impacted water from household use for 350 days/year for 26 years



Commercial/Industrial Vapor Intrusion Screening Levels

Residential Vapor Intrusion Screening Levels

Calculated from risk-based target indoor air concentration

Assumes a person is at work 8 hours/day, 225 days/year for 25 years

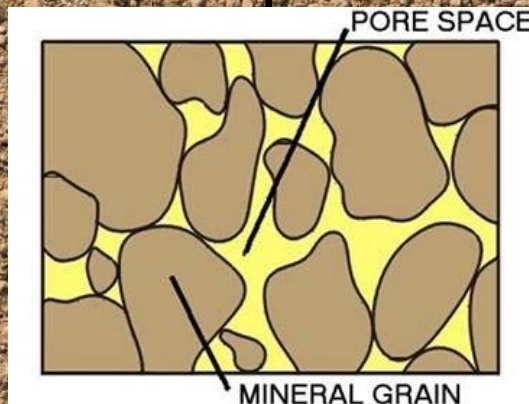
Assumes a person is at their home 24 hours/day, 350 days/year for 26 years

Considers adult workers only

Includes children and adults



Volatile compounds (as soil gas) may move upward through building foundation/slab from impacted soil and/or groundwater into indoor air. Impacted indoor air may be inhaled by workers or residents



Vapor intrusion SLs are applicable when buildings are present or may be built in the future. Incorporate attenuation factors based on conservative assumptions.

Toxicity Assessment

- NMED chemical-specific SLs incorporate toxicity values for COPCs
 - SLs available for Cancer and/or Noncancer effects
 - Cancer toxicity value = estimate of increased cancer risk (probability)
 - Noncancer toxicity value = estimate of exposure over a lifetime without appreciable risk of adverse effects
- SLs incorporate toxicity values based on EPA toxicity value hierarchy

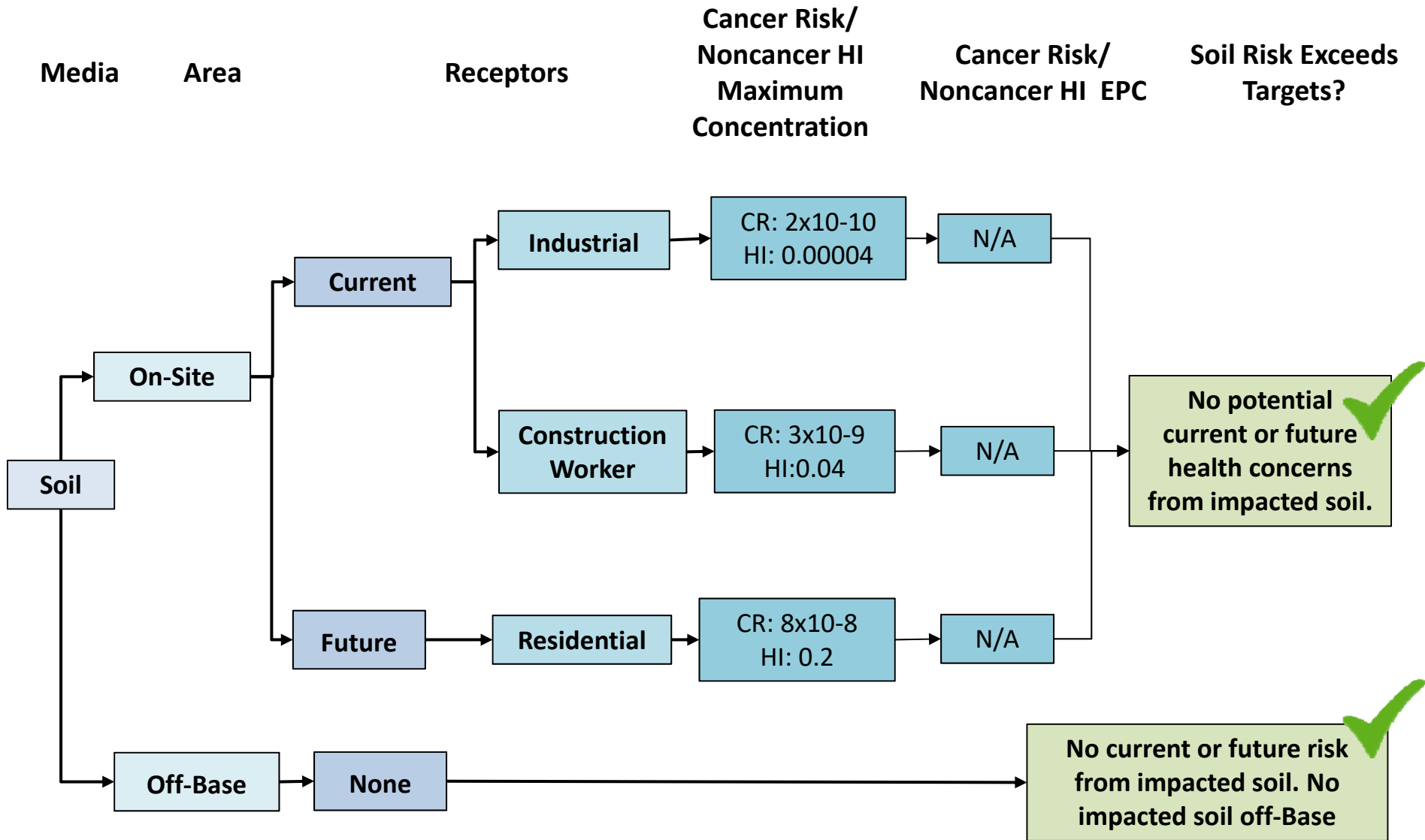
Risk Characterization

- Integrates toxicity and exposure assessments
- Use SL and exposure concentration to calculate chemical-specific risks
 - Used maximum concentrations (conservative)
 - Calculated total risk (all chemicals/each pathway)
 - Target cancer risk $\leq 1 \times 10^{-5}$
 - 1 in 100,000 probability that, over a lifetime, COPC exposure may cause cancer
 - Target non-cancer hazard index (HI) ≤ 1
 - If HI ≤ 1 then adverse effects unlikely due to COPC exposure

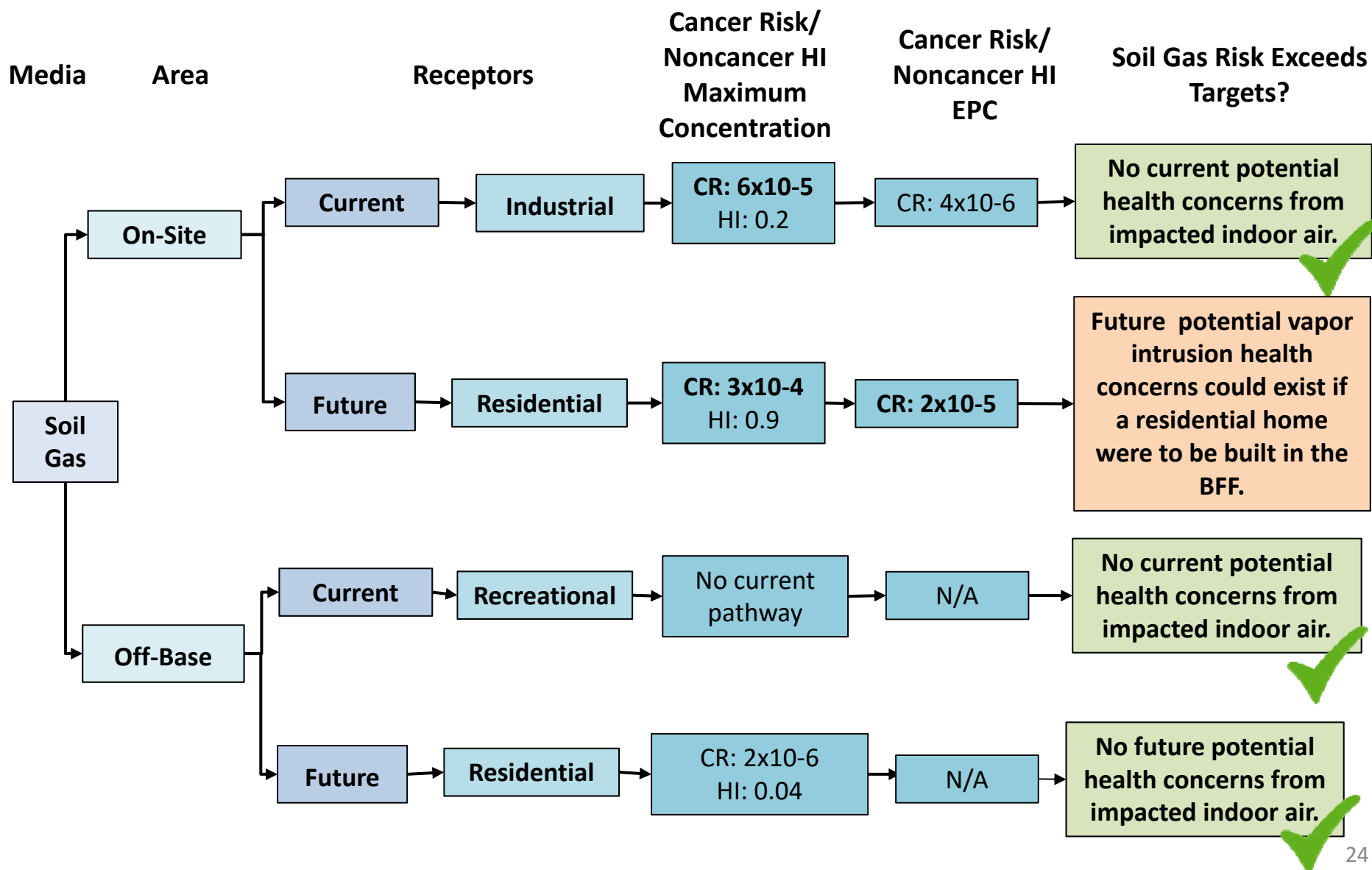
Risk Characterization Continued

- If total risk/hazard based on maximum concentrations exceeded target levels
 - Then calculated statistical exposure point concentration (EPC)
 - EPC = statistical value (average concentration across exposure area)
 - And re-calculated chemical-specific risks using statistical value using the EPC
 - Also re-calculated total risk (all chemicals/each pathway) and compared to target levels using the EPC

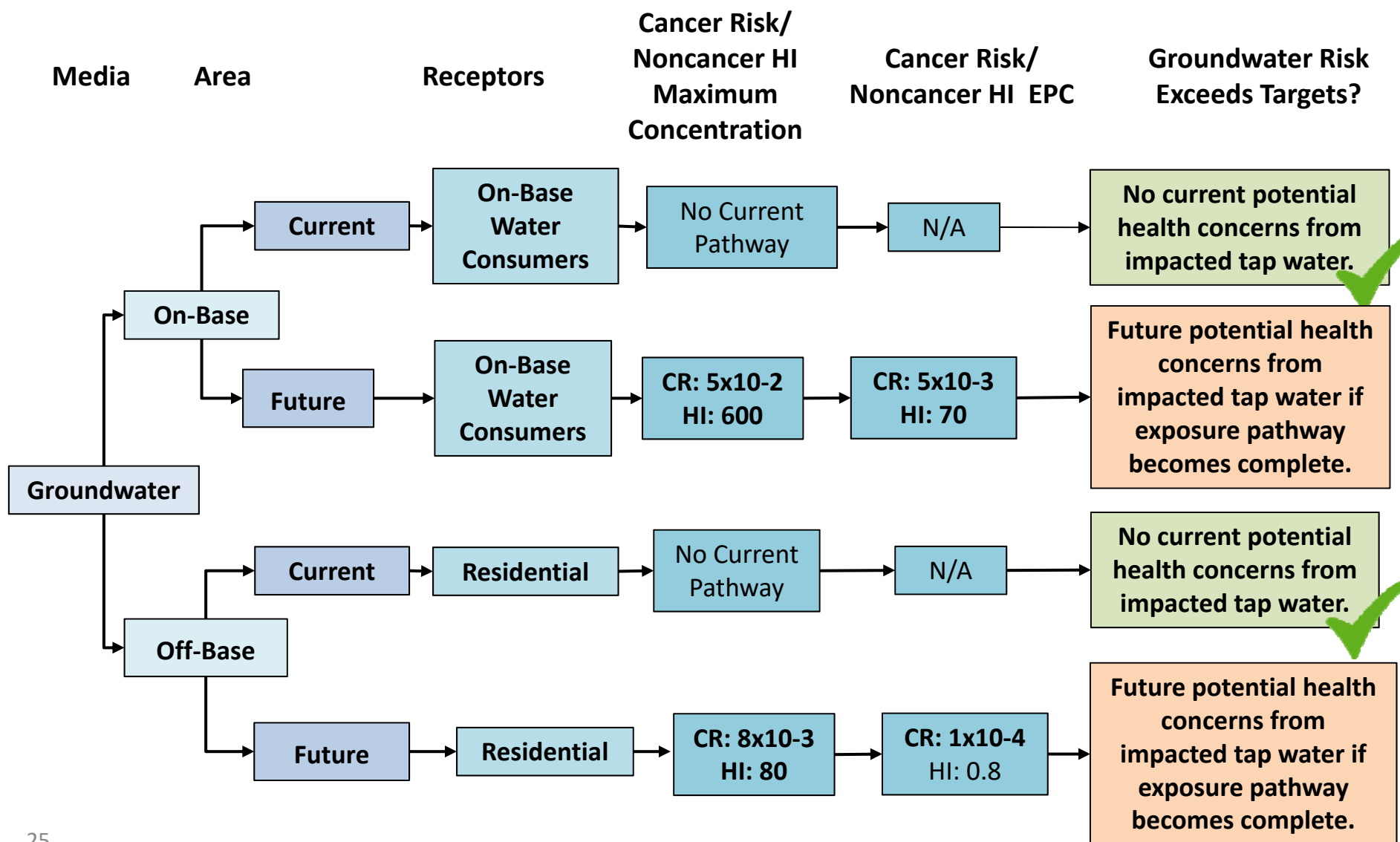
HHRA Results: Soil



HHRA Results: Soil Gas

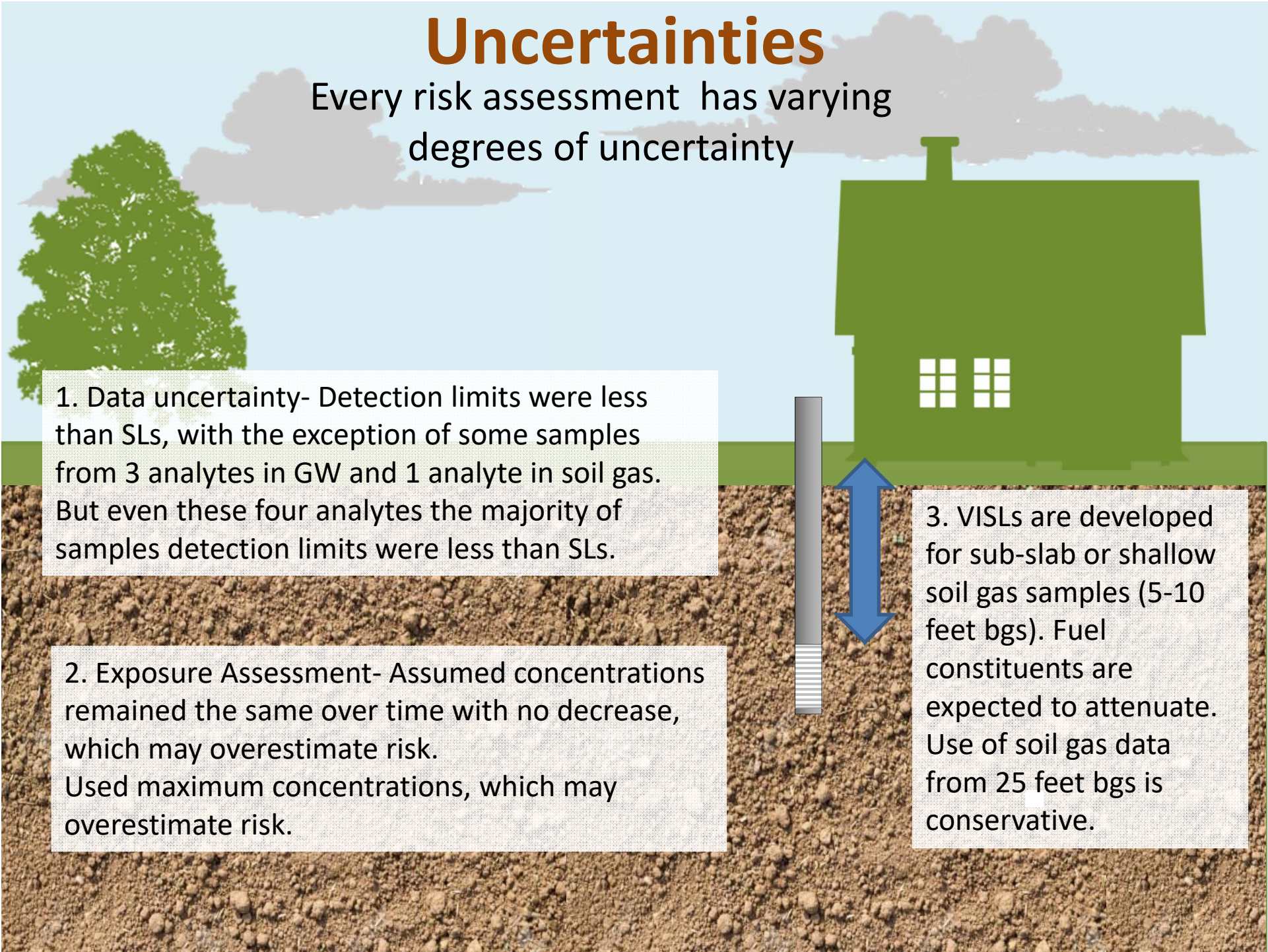


HHRA Results: Groundwater



Uncertainties

Every risk assessment has varying degrees of uncertainty



1. Data uncertainty- Detection limits were less than SLs, with the exception of some samples from 3 analytes in GW and 1 analyte in soil gas. But even these four analytes the majority of samples detection limits were less than SLs.

2. Exposure Assessment- Assumed concentrations remained the same over time with no decrease, which may overestimate risk. Used maximum concentrations, which may overestimate risk.

3. VISLs are developed for sub-slab or shallow soil gas samples (5-10 feet bgs). Fuel constituents are expected to attenuate. Use of soil gas data from 25 feet bgs is conservative.

HHRA Summary

- Current receptors: CR/HI < target levels
 - No current potential health concerns from impacted soil, soil gas, and groundwater
- Future receptors: CR/HI > target levels
 - On-site: Health concerns for soil gas, groundwater
 - Assumes residential use of BFF (unlikely)
 - Impacted groundwater migrates to drinking water supply well (unlikely-monitoring/interim measures in place)
 - Off-site: Health concerns for groundwater
 - Assumes installation of drinking water wells in impacted groundwater or that impacted groundwater migrates to drinking water supply well (unlikely-restricted well installation, monitoring, and interim measures in place)

Ecological Risk Assessment Overview

Same Site Data and CSEM as HHRA



Potential Receptors and Exposure Pathways

Aquatic Plants and Animals
Surface Water
Sediment

Invertebrates
Surface Soil

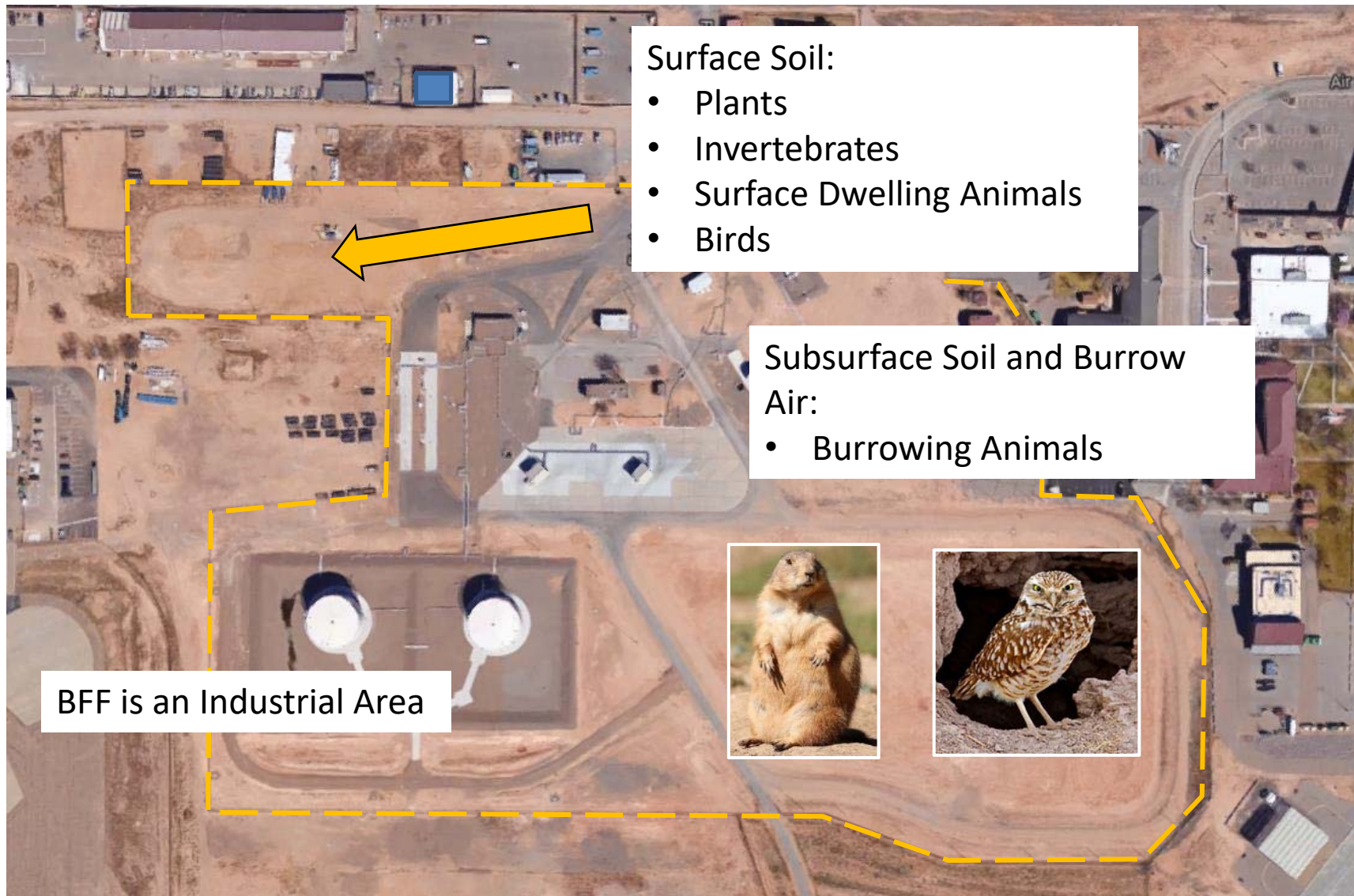
Terrestrial Animals
Surface Soil

Terrestrial Animals (Burrowing)
Surface Soil
Subsurface Soil
Burrow Air

Terrestrial Plants
Surface Soil

General examples of receptors for Ecological Risk Assessment- no surface water present on-Site

ERA: Receptors and Complete Exposure Pathways



Surface Soil:

- Plants
- Invertebrates
- Surface Dwelling Animals
- Birds

Subsurface Soil and Burrow Air:

- Burrowing Animals

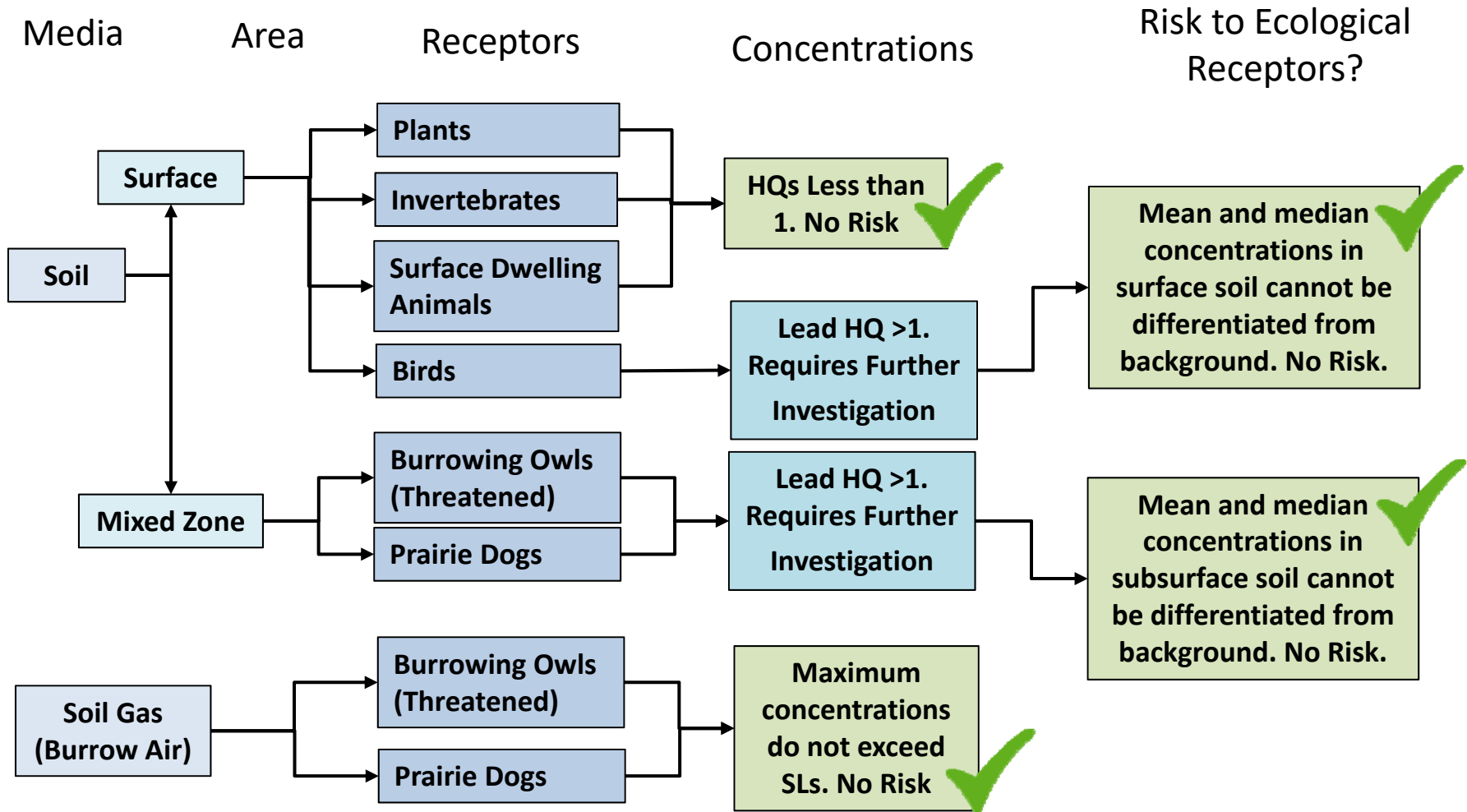
BFF is an Industrial Area



ERA Risk Calculations

- Do maximum concentrations of Site related chemicals exceed ecological screening levels (ESLs) for identified receptors?
- Evaluates concentrations to determine hazard quotient (HQ)
 - $HQ < 1$: most likely receptor is not at risk
 - $HQ > 1$: additional investigation necessary

ERA Results



ERA Summary

- No risk to ecological receptors
 - HQ <1 for all analytes and receptors with exception of lead
 - Soil lead concentrations equivalent to background

Next Steps

- NMED is currently reviewing risk assessment
- Risk Assessment a snapshot in time – used current site data
- Risk Assessment will be revisited during CME process to address:
 - New data in the RFI Addendum Report
 - Identify the need for formal land use controls to prevent exposure under scenarios with risks greater than target levels

Questions?



Photo Credit: Rebecca Cline

Kirtland AFB BFF Risk Assessment “Deep Dive”

Acronyms and Abbreviations

BFF – Bulk Fuels Facility	HHRA - Human Health Risk Assessment
COPC – Chemical of Potential Concern	HI – Hazard Index
CR -Cancer Risk Level	HQ – Hazard Quotient
CSEM – Conceptual Site Exposure Model	KAFB -Kirtland Air Force Base
EPA - Environmental Protection Agency	SL -Screening Level
EPC - Exposure Point Concentration	NMED – New Mexico Environment Department
ERA - Ecological Risk Assessment	VISL - Vapor Intrusion Screening Level
ESL - Ecological Screening Level	

Key Terms

Attenuate: Physical, chemical or biological processes that naturally reduce the mass, toxicity, mobility, volume or concentration of contaminants in the environment.

Cancer Risk Level: (From the EPA website: “The probability of contracting cancer over the course of a lifetime, assuming continuous exposure (assumed to be 70 years).”) Concentrations of chemicals that are carcinogenic are compared to NMED’s target risk level of 1×10^{-5} , or 1 person in 100,000. This represents the probability of developing cancer because of exposure to an environmental agent or mixture of agents averaged over a lifetime exposure (70 years).

Conceptual Site Exposure Model: A planning tool used to organize information about a site and to identify additional information needed to achieve project goals, such as cleanup. In a risk assessment, this involves identifying sources, media, receptors, fate and transport pathways, and exposure pathways.

Ecological Risk Assessment: The process for evaluating how likely it is that the environment may be impacted because of exposure to one or more environmental stressors such as chemicals, land change, disease, invasive species and climate change.

Exposure Pathway or Scenario: An *exposure pathway* is the link between a contaminant source and a receptor. A complete exposure pathway is one in which the stressor, or chemical can be traced or expected to travel from the source to a receptor that can be affected by that stressor¹.

Exposure Point Concentration: An average chemical concentration across an area where receptors may be exposed

Exposure Route: An *exposure route* is the way a chemical enters an organism upon contact. It is a point of contact/entry of a stressor or chemical from the environment into a human or ecological receptor (e.g., via ingestion, dermal absorption, or inhalation)¹

Hazard Index: the HI is used as a screening tool to determine if the concentrations of a chemical(s) in a location present a potential concern or impact to a receptor, (person, animal or plant). Potential impacts from chemical concentrations are determined by using the established levels at which a chemical or chemicals do not result in a negative effect to receptors. If the total of these values is less than 1, chemical concentrations typically do not result in any negative impacts. If the values are equal to or greater than 1, further evaluation is needed.

Human Health Risk Assessment: The process to estimate the nature and probability of adverse health effects in humans who may be exposed to chemicals in contaminated environmental media, now or in the future.

Receptor: A person, animal, or plant that could come into contact with a substance or chemical.

Screening Level: chemical concentrations that identify levels below which there are no concerns for human exposure

Soil Gas: Gaseous elements and compounds found in air space between soil particles. Such gases can be moved or driven out under pressure.

¹Definition from <https://www.epa.gov/ecobox/epa-ecobox-tools-exposure-pathways-exposure-pathways-era>