Magnitude and Relevance of the February 2014 Radiation Release Event at WIPP

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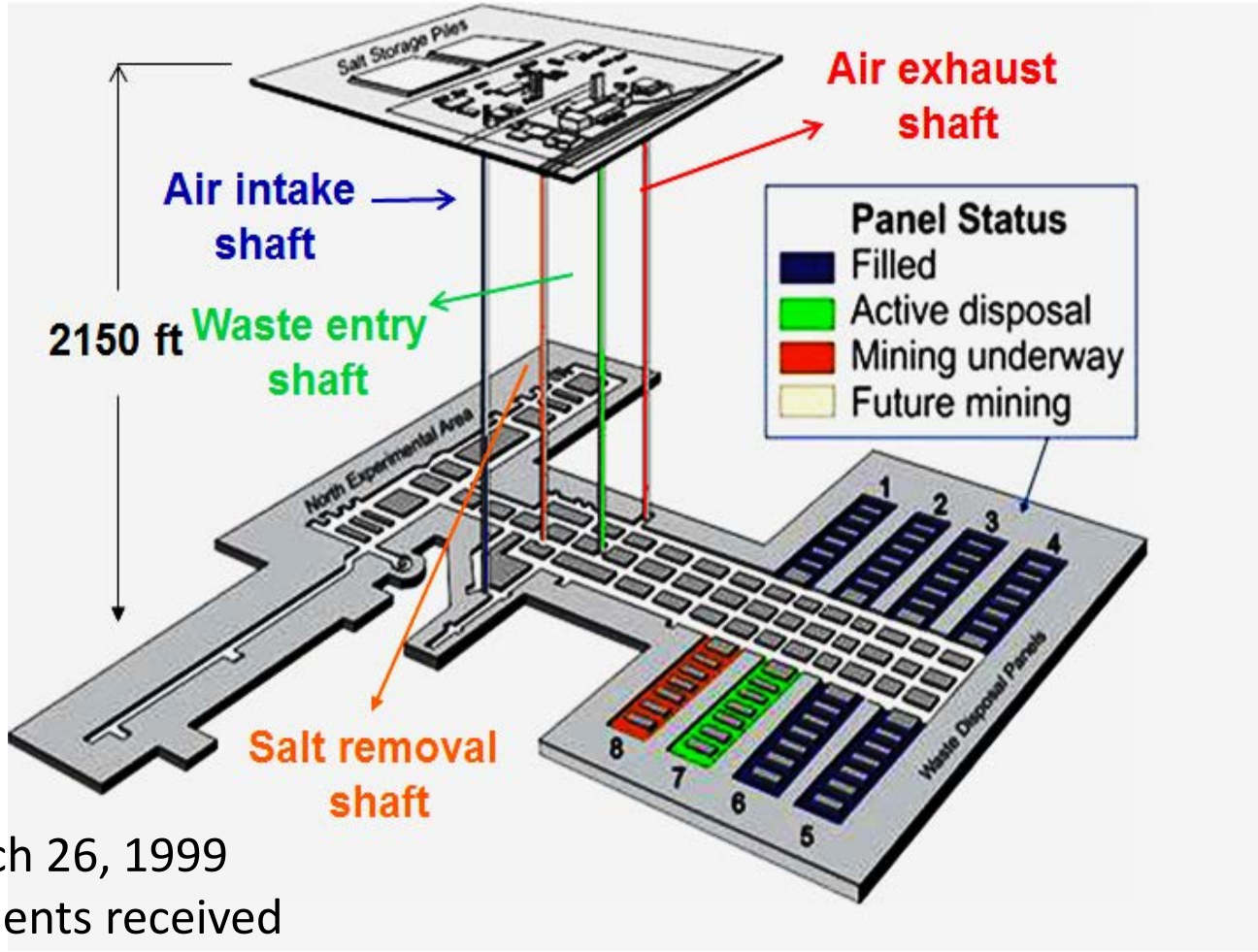
WIPP: A Working Repository

- 15 years of safe operations and permanent geological disposal of transuranic defense wastes [Intermediate-Level Long-Lived Waste by IAEA definition].
- Located in southeast New Mexico about 26 miles east of Carlsbad.
- TRU waste is man made radioactive elements that are heavier than uranium (Z>92).
- >100 nCi/g (>3700 Bq/g or ~1ppm) alpha emitting isotopes with t½ > 20 years.
- WIPP is also the first to recover from an accident and resume operations.

WIPP Layout



Quick Facts:

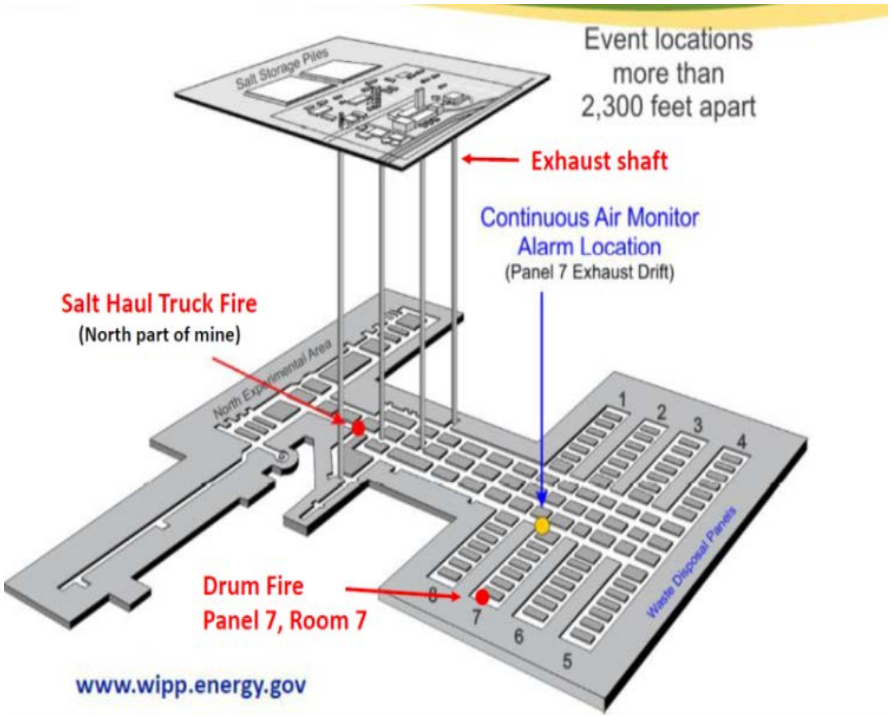
- Opened March 26, 1999
- 11,894 shipments received
- 90,983 cubic meters of waste disposed
- 171,064 containers disposed in the underground

CEMRC Role: Independent Environmental Monitoring

- Created in 1991 to conduct an independent environmental monitoring program of the WIPP
- Funded Primarily by the Department of Energy (DOE) through a grant (NOT a contract) that respects CEMRC independence
  - Current funding level $3m per year (~80% of total funding for CEMRC)
  - CEMRC monitoring and other work includes:
    - WIPP Underground Exhaust Air
    - Ambient Air
    - Drinking Water
    - Soil
    - Surface Water & Sediment
    - Whole Body Counting for Area Residents age 13+
    - R&D on monitoring methods and technologies

Recap of the Incidents at WIPP

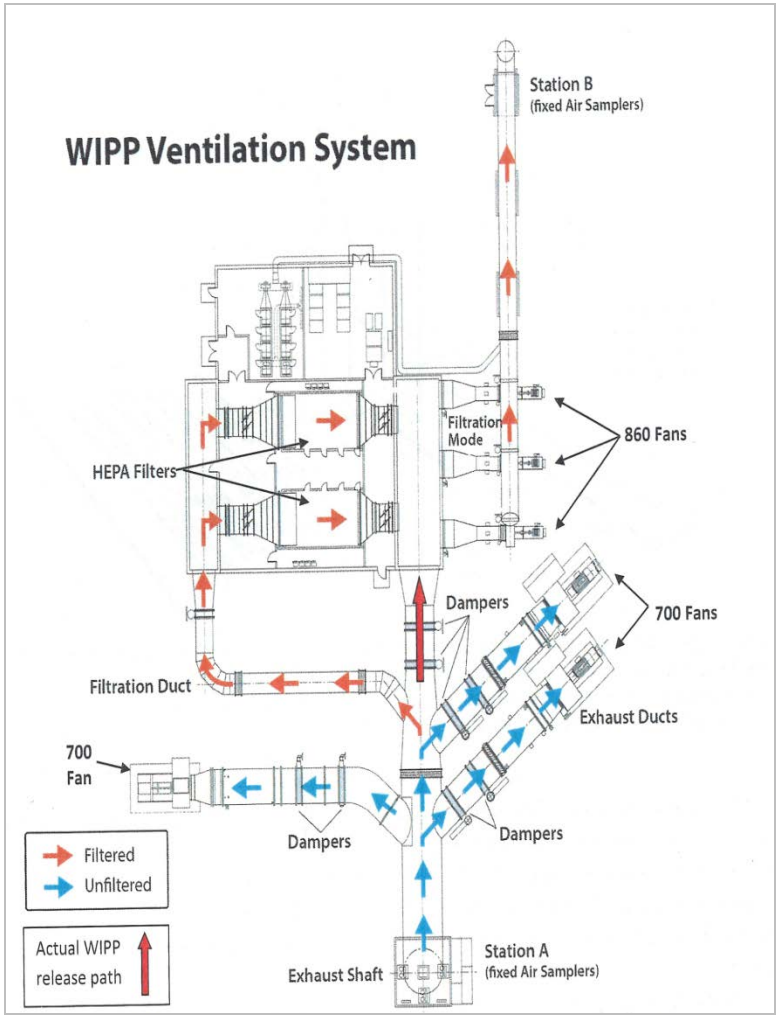
February 5 Underground Fire



→ **LANL, 68660 Drum with a lifted lid**

February 14, Radiation Release

Filtration bypass allowed some (minor) external contamination



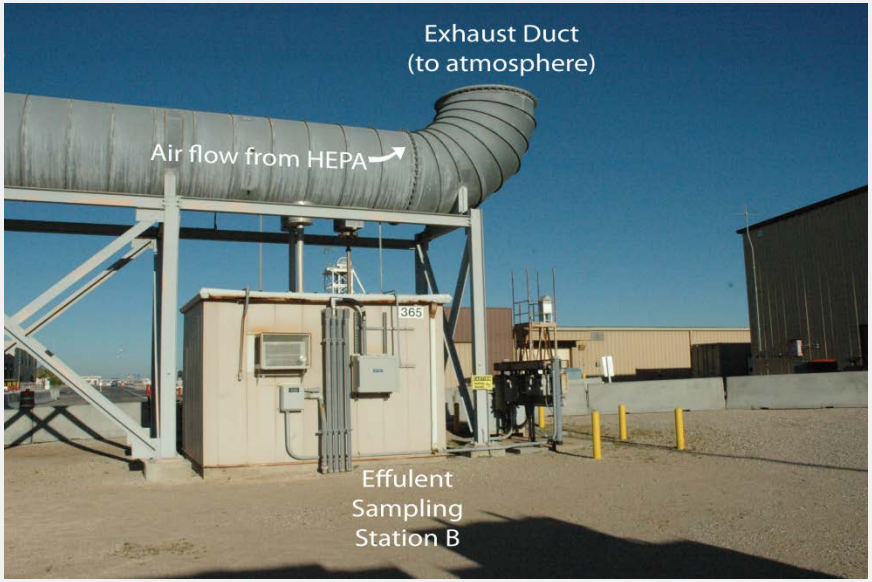
- Two leaking dampers allowed some contamination to bypass the filtration system
- Seal was imperfect due to salt buildup
- Foam was used to seal these dampers after the release

Consequence Assessment

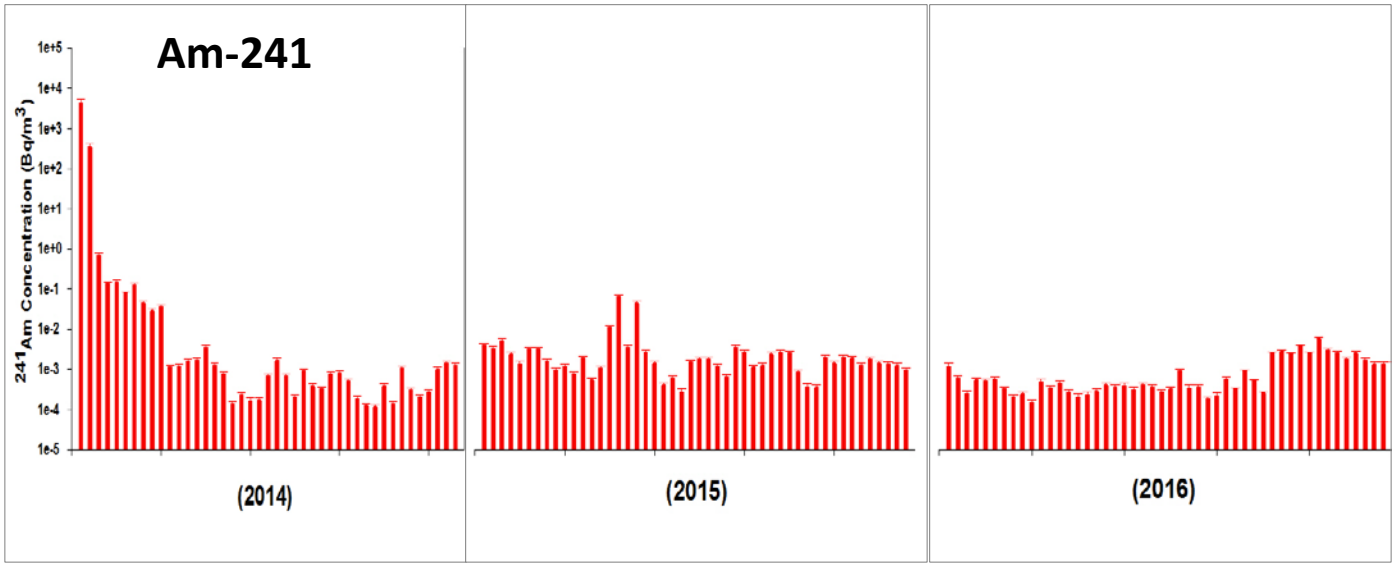
WIPP Underground Air Sampling Stations (A and B)

Station A, before filtration

Station B, at post-filtration outlet

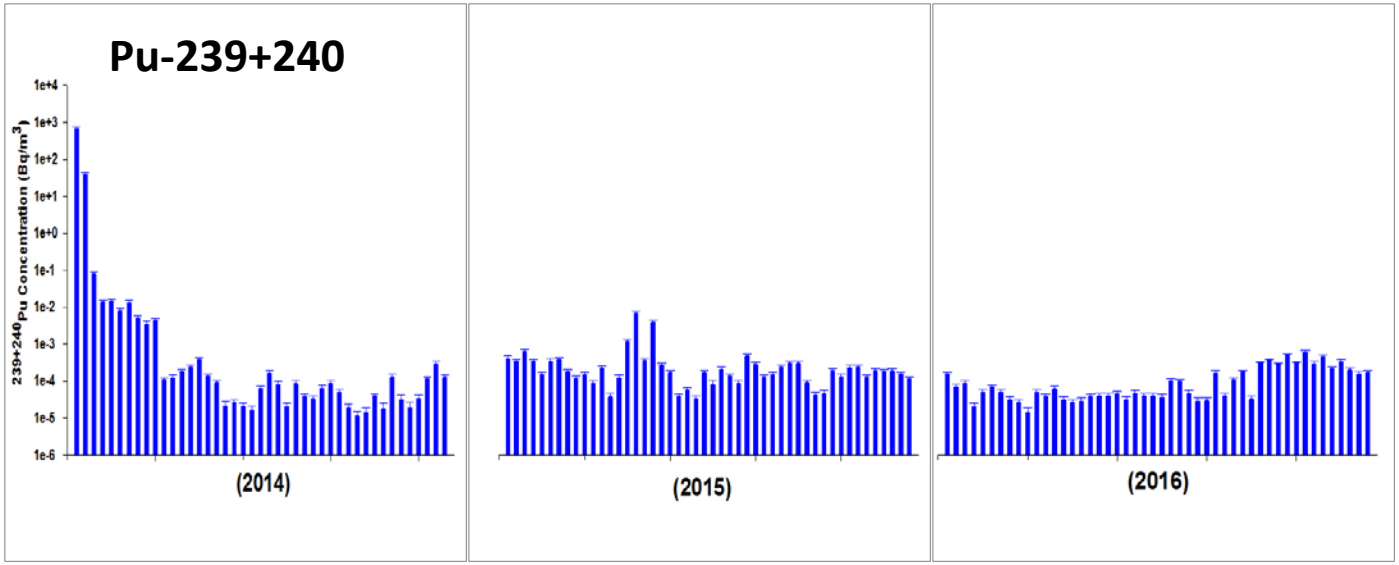


Radiation levels in the Underground Air (Station A)



4337 Bq/m^3

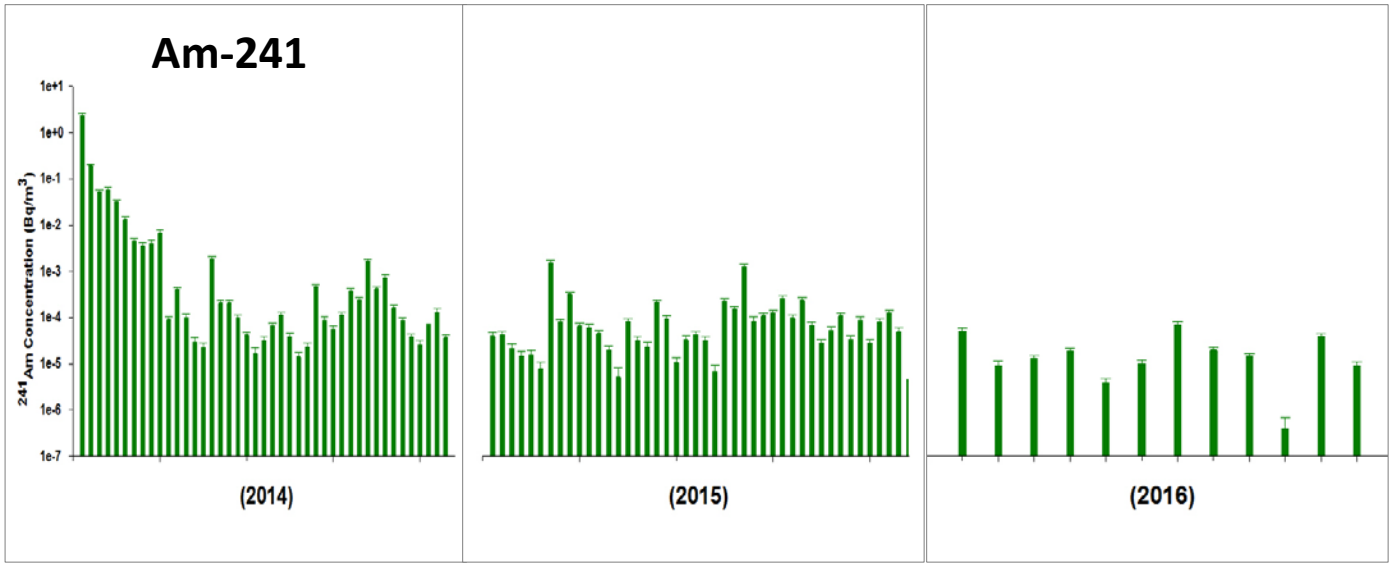
~ 0.002Bq/m^3



672 Bq/m^3

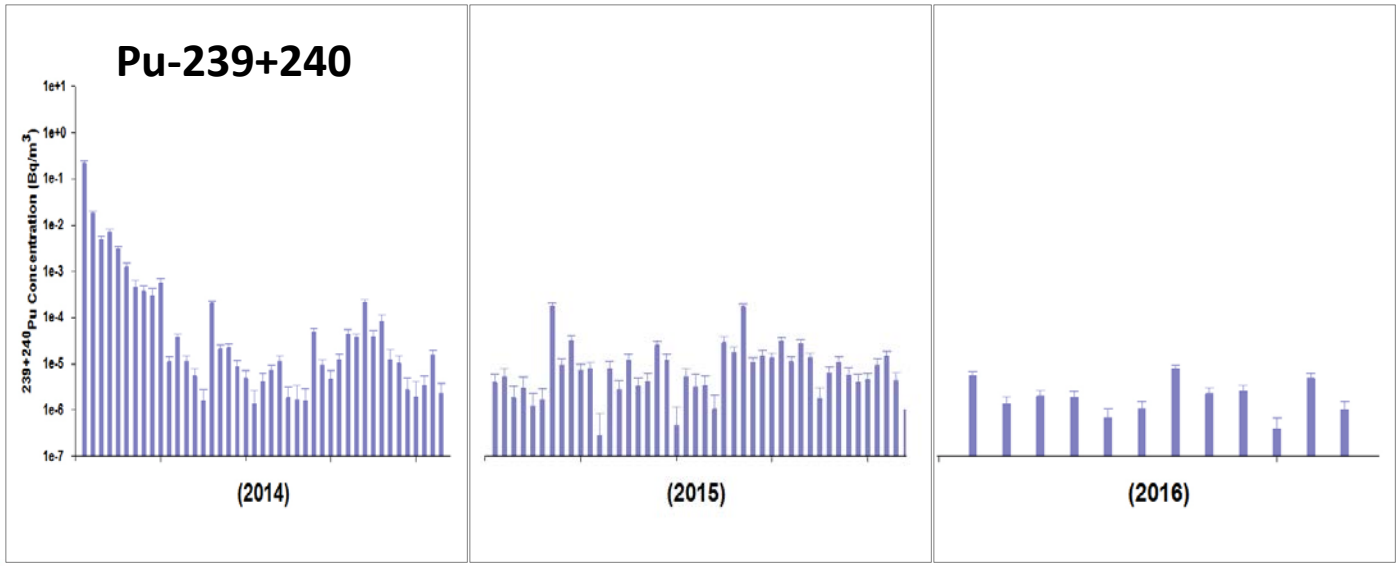
< 0.0002Bq/m^3

Radiation levels in the Underground Air (Station B)



2.3 Bq/m³

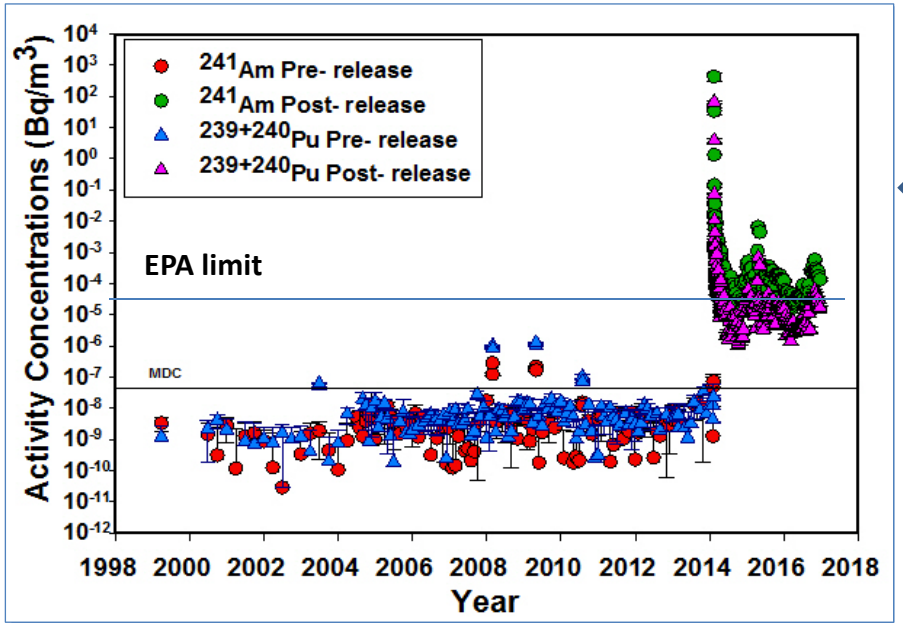
~ 2.5E-5 Bq/m³



~ 0.22 Bq/m³

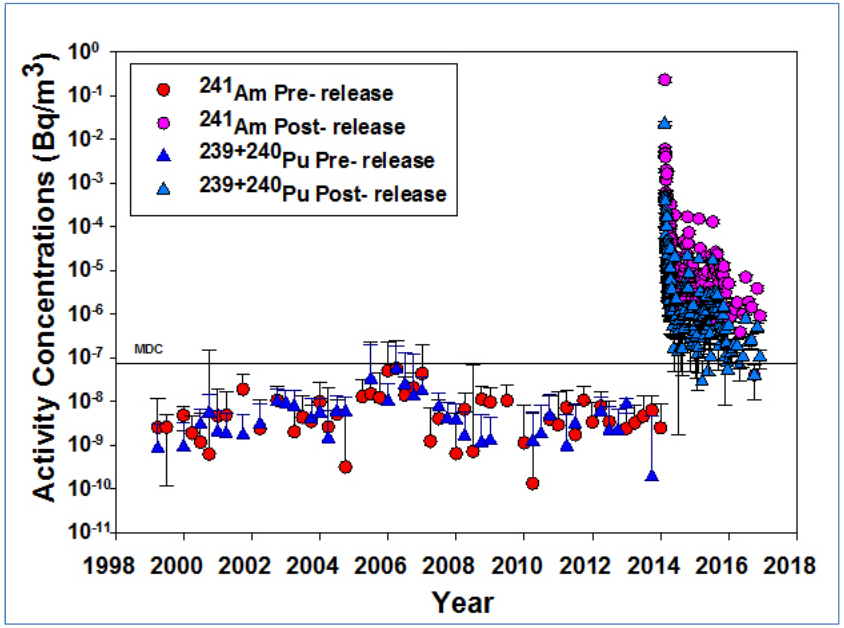
~ 2.6E-6 Bq/m³

Historical Radiation levels in the WIPP Underground Air



Station A, before filtration

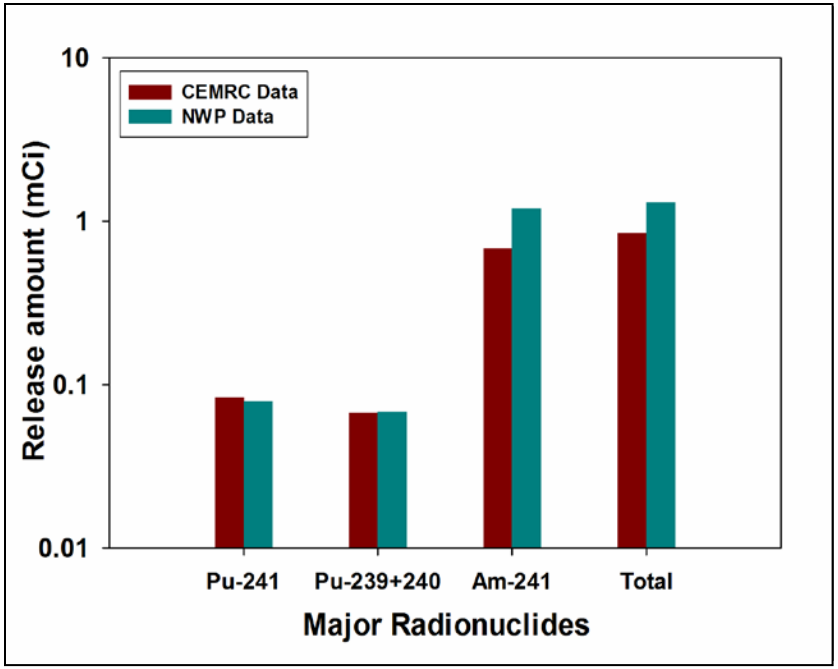
Station B, at post-filtration outlet



*EPA limit **~7.4E-5 Bq/m³** is from 40CFR 61 and corresponds to 10 mrem/year*

Estimating the total Environmental Release

- Station B (after filtration) results from both WIPP and CEMRC were used by each organization to estimate the total environmental release (~90% ^{241}Am)



CEMRC analyses:

0.72 mCi of ^{241}Am and

0.067 mCi of $^{239+240}$Pu

Total = (~1 mCi).

NWP analyses :

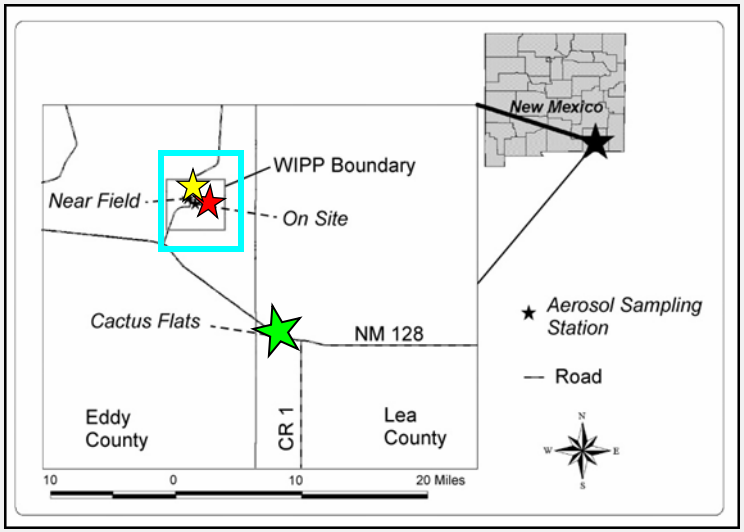
1.21 mCi of ^{241}Am and

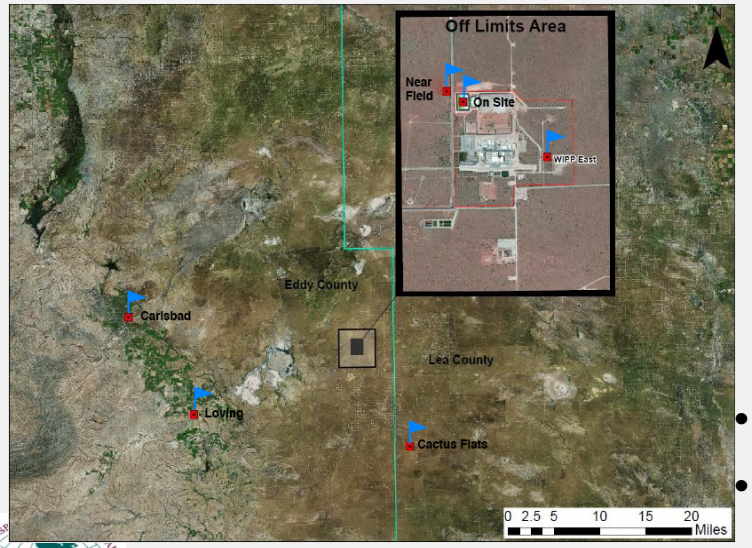
0.068 mCi of $^{239+240}$Pu

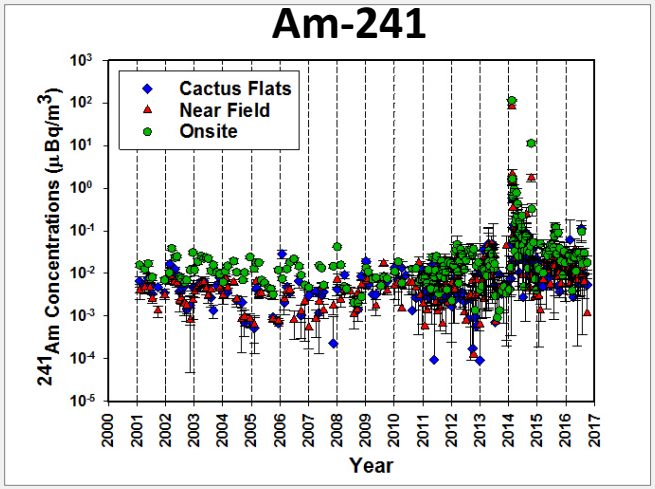
Total = (~1.3 mCi).

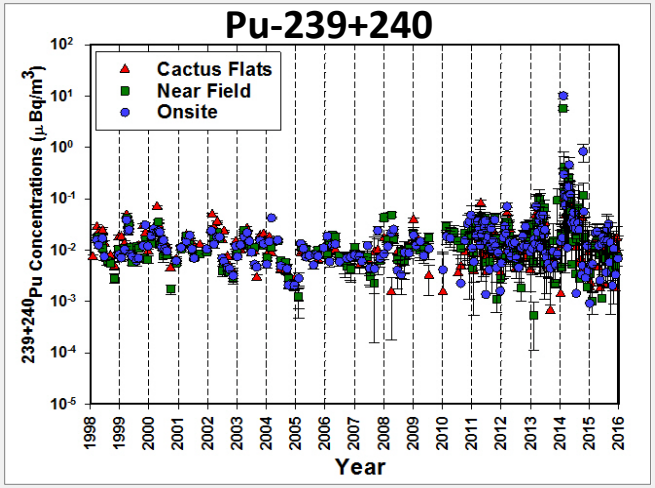
On site and Off Site Monitoring Stations

CEMRC Air sampling sites



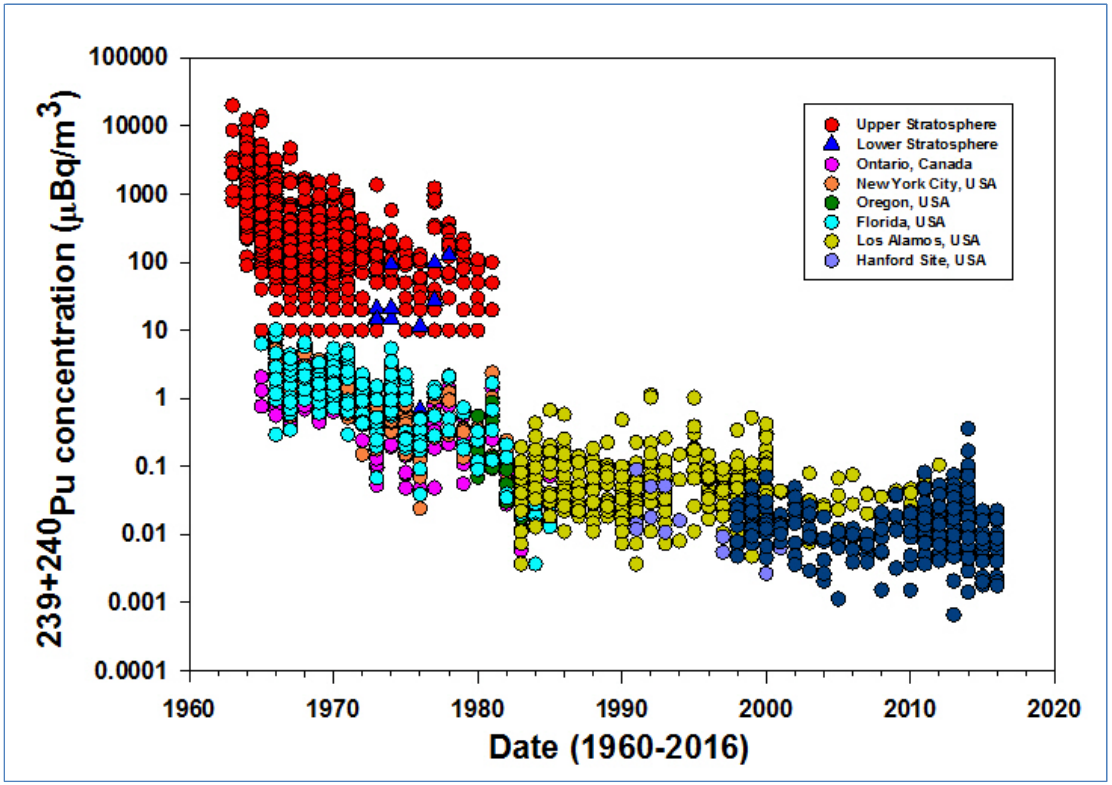






- **Onsite detection: 115 µBq/m^3 of ^{241}Am; 81.4 µBq/m^3**
- **No off-site hi-volume sampler detections were positively attributable to the WIPP release event.**

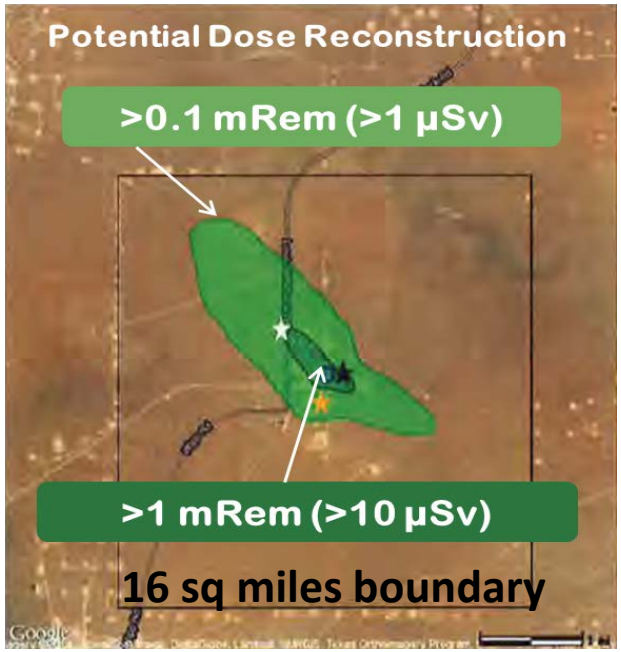
Plutonium Ambient Air Concentrations in the US

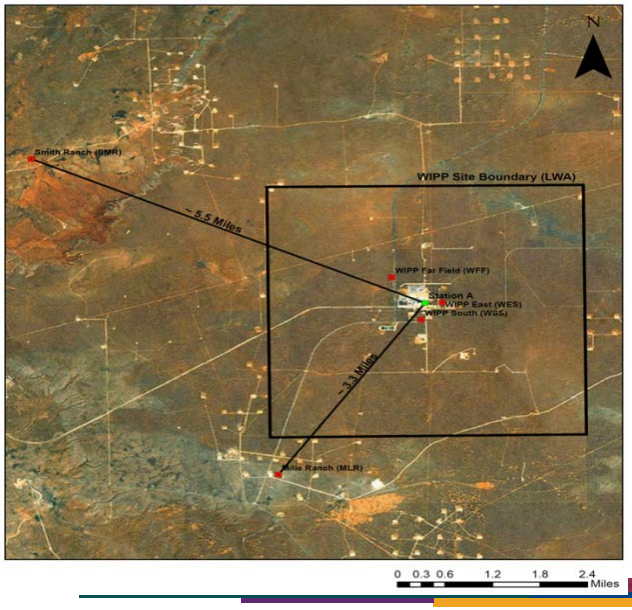


Modeling the atmospheric dispersion plume

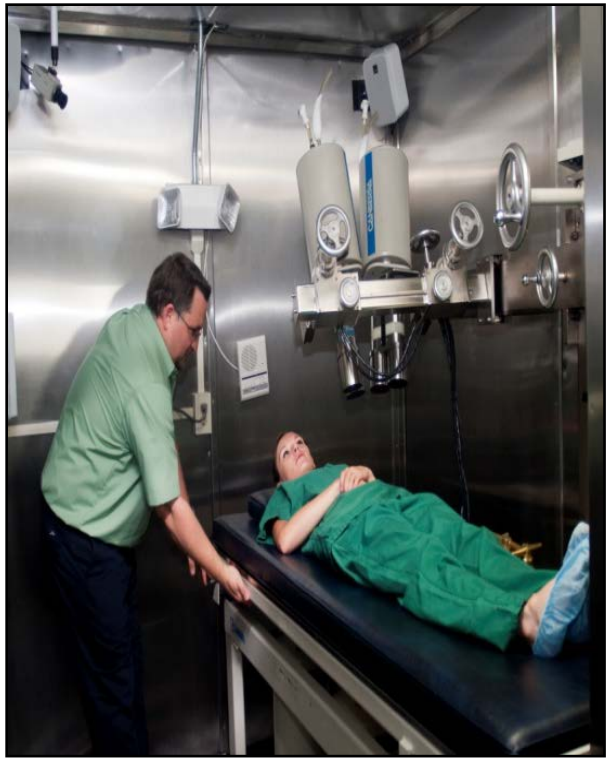
14-15 February 2015 release was modeled based on measured filter values and wind data in 15-minute increments

- **Inhalation doses constructed as if all alpha was only ^{239}Pu (conservative) and a hypothetical human breathed for entire duration of release.**
- **Inner darker green area >0.01 mSv**
- **Outer green area ranged from 0.01 to 0.001 mSv.**
- **Stars indicate sampling stations.**
- **Modeling of deposition in both green areas suggested none would be detectable on soil or vegetation (proven correct).**





Workers Exposer- Radio-bioassay



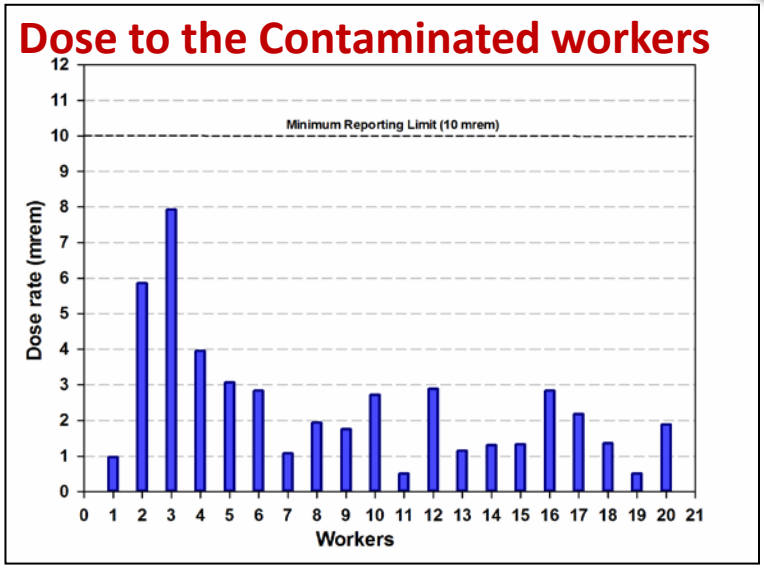
Fecal samples: 31

- 21 low-level positive
  - 21 positive for ^{241}Am
  - 7 positive for Pu
- 0.024 Bq (1.45 dpm) was highest total activity in a sample

Urine samples: 140

- 1 low-level ^{241}Am positive

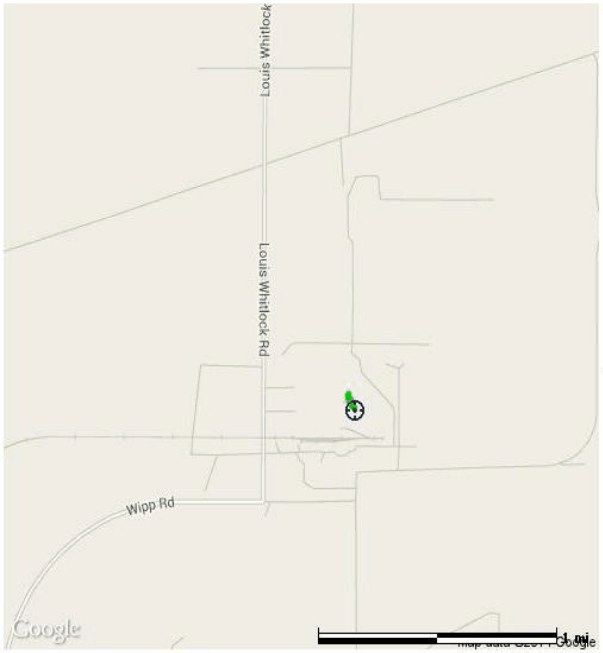
- Between Feb-July, 2014, 144 WIPP workers and 42 local citizens were counted.
- 0.1 nCi MDA for ^{241}Am
- ^{241}Am not detected.



Ground Contamination in the WIPP Vicinity

Both predicted and measured values of ground contamination are below detectable levels

NARAC Particle Animation at T+00:10

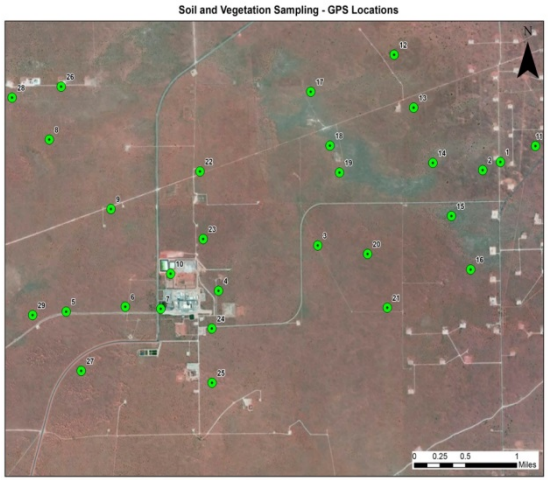


Contour Levels			
	Description	(dpm/100cm2) Extent Area	Population
	Below health effect guidelines. Possibly contaminated area. Use to confirm with monitoring surveys.	>1 9.9m 28.0m2	0
	Below health effect guidelines. Possibly contaminated area. Use to confirm with monitoring surveys.	>0.10 119m 2,476m2	0

Note: Areas and counts in the table are cumulative.
Population Source = LandScan USA V1.0.

APPROVED PRODUCT NARAC

Accumulated Deposition During First 12 hours



Soil Location

- **All results to date were either below Minimum Detectable Concentrations (MDCs) or, for Pu, at levels seen prior to the event**
- **Positive Pu detections did not have detectable Am, suggesting a non-WIPP event source, perhaps the nearby Gnome test's atmospheric release (1961)**

Underground Source Term Estimation

- The total radiological inventory in the drum was estimated to be around 9 Ci.
- It is estimated that between 5% and, at most, 20% of the drum inventory released into the WIPP underground.
- Source term estimation ~ 0.3-1.5 Ci of radioactivity released from the breached drum.
- The radiological constituents in the drum include: ^{241}Am, ^{243}Am, ^{237}Np, ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, and ^{242}Pu (>95% of activity).

Data source: CEMRC, NWP and Hunter & Viner 2015

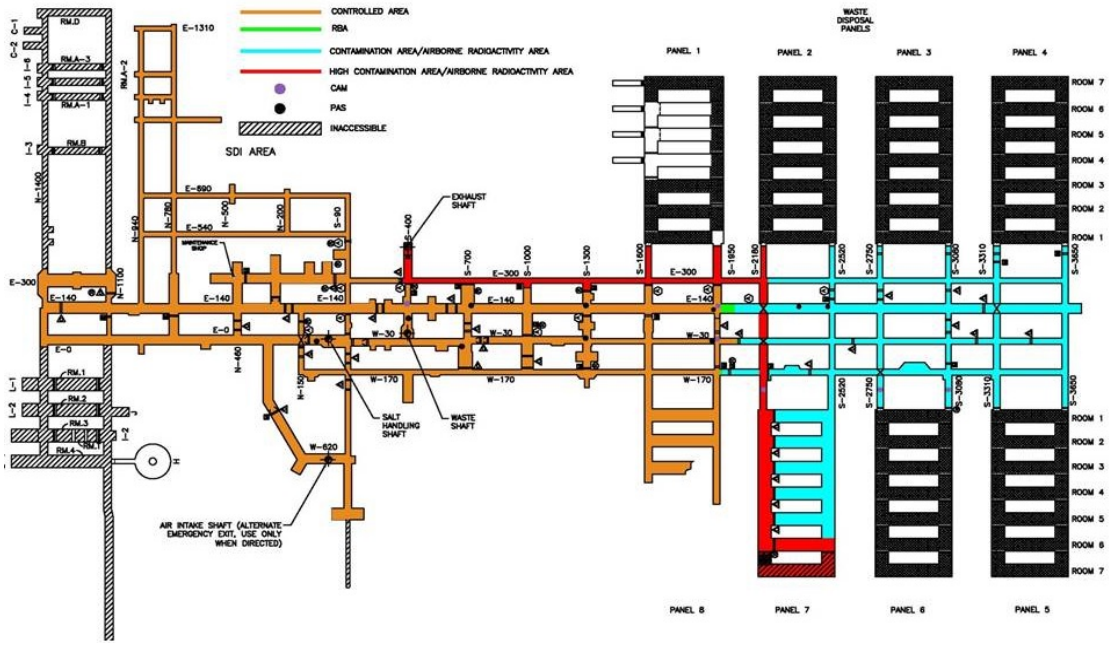
WIPP Underground –Contamination Status

A water spray is being used to remove and "fix" contamination from walls and ceilings.

When the salt recrystallizes, it encapsulates the contamination and prevents any resuspension of radioactive.

The highest concentration underground is 60 000 dpm (0.03 Ci) alpha

while in most areas of the mine, contamination is minimal at less than 200 dpm per m².



- Gray = filled waste disposal rooms
- Orange = controlled area--clean
- Green = Radiological Buffer Area (radiation boundary) – clean
- Red = high contamination area
- Light blue = contamination area

Map courtesy: CBFO, DOE

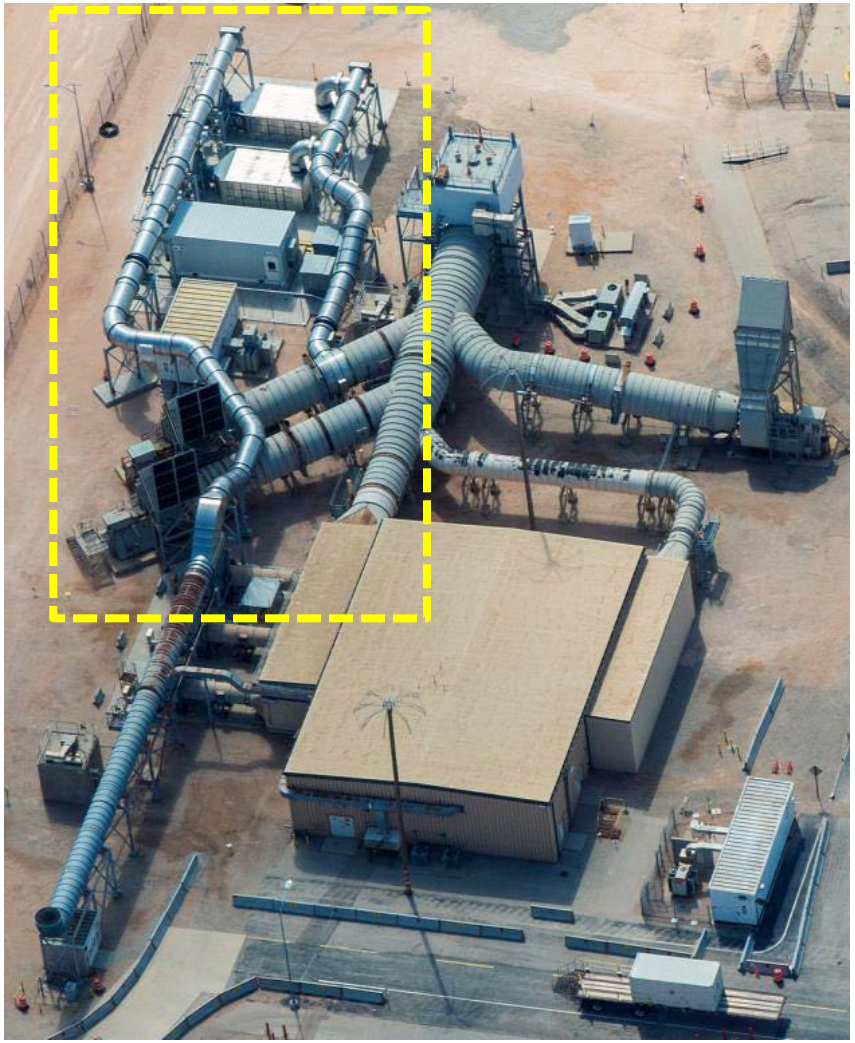
WIPP Ventilation Issues

Total Airflow (cfm)

Standard operations	**425,000**
WIPP Permit requirement	**260,000**
HEPA filtration	**60,000**
First phase: Interim skid-mounted ventilation	**114,000**
Second phase: Supplemental ventilation	**180,000**
Third phase: Permanent ventilation	**500,000**

Interim Ventilation System

- Interim Ventilation system is up and running since Aug, 25, 2016.
- It consists of two new fan (referred to as 960 fans)/filter units and ductwork.
- Provide adequate air flow at the waste phase –for resumption of waste placement.
- Increase airflow for ground control and maintenance operations.
- Ties into prior Ventilation System.



(target airflow ~118,000 cfm)

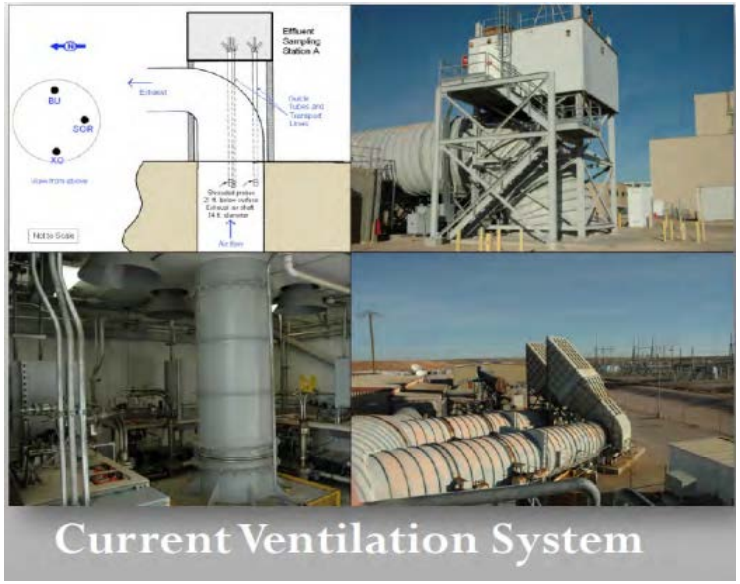
Supplemental Ventilation System

- Supplemental ventilation system not required for resumption of operations.
- Required for mining after waste operations resume.
- Scheduled to be operational in the early 2017.

(target airflow ~180,000 cfm)

Permanent Ventilation System

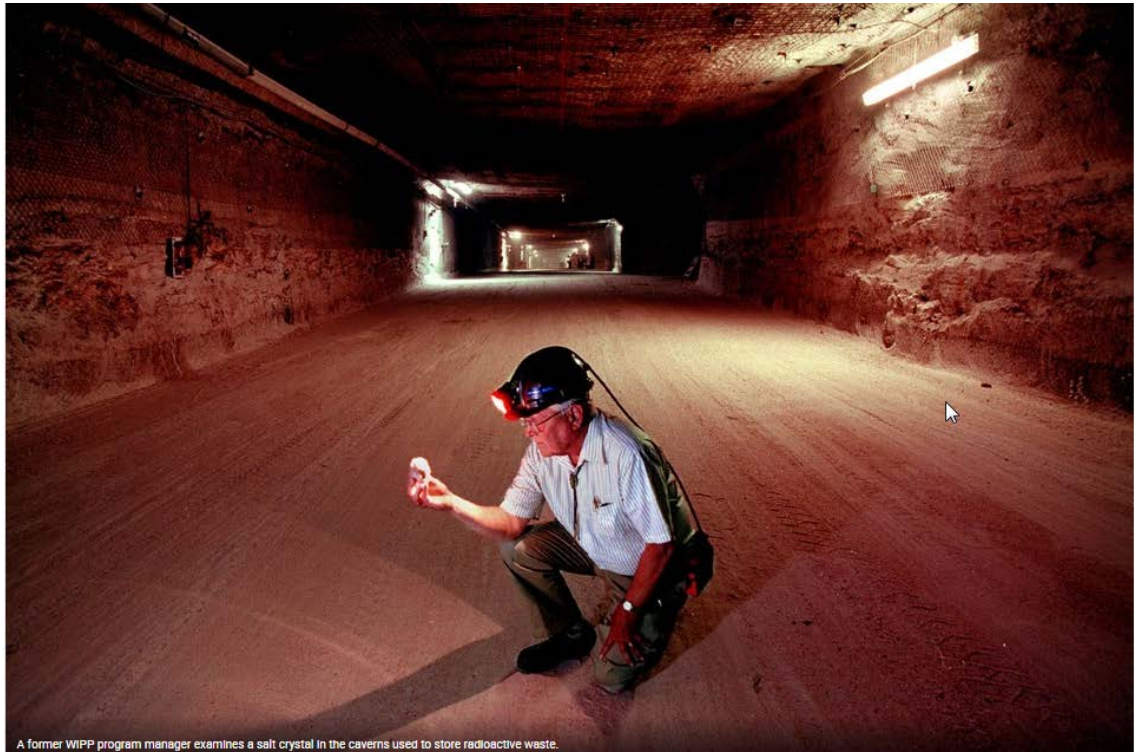
- New shaft and 55,000 sq. ft. ventilation building located east of the existing exhaust shaft
- Geotechnical Analysis is underway and consists of drilling multiple bore holes to various depths.
- Will provide sufficient airflow underground for mining and waste emplacement activities to occur concurrently.
- Operations in both “clean” and contaminated areas of the underground, targeting 500,000+ cfm airflow
- Provides operational flexibility
- Estimated to cost several hundred million dollars and will not be ready until 2021.



An alternative way to improve the Underground Ventilation is to:

Reverse the Policy of 100 % Filtration of Underground Air

WIPP underground is a radiation-deprived environment


A former WIPP program manager examines a salt crystal in the caverns used to store radioactive waste.

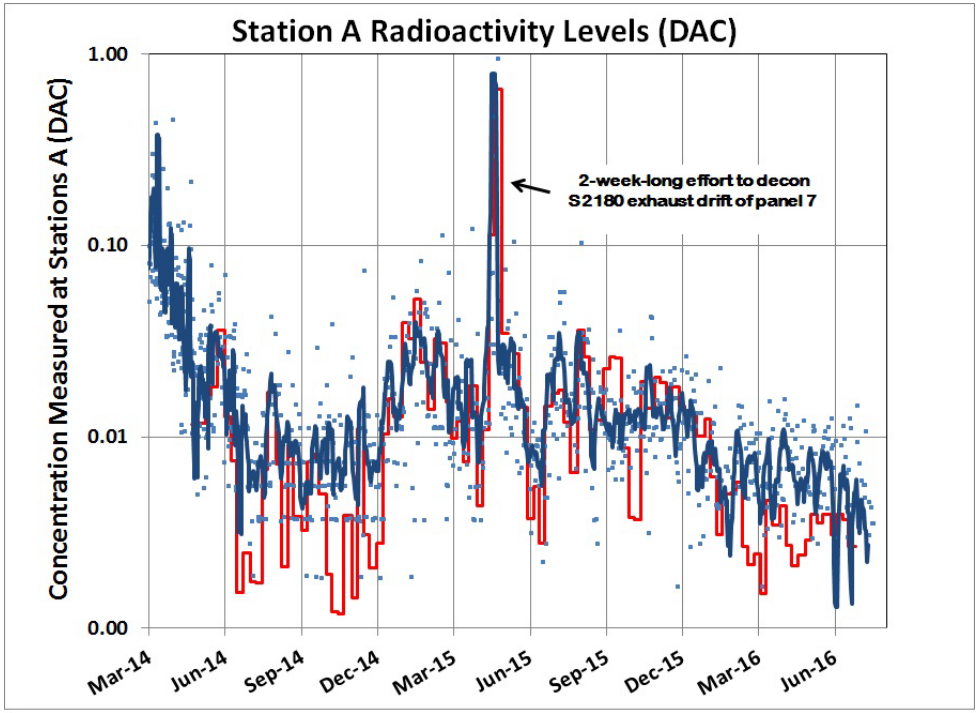
WIPP radiation levels average

- **0.031 µSv/h at the surface,**
- **0.006 µSv/h 655m underground or 2.2 µSv/year**

Source: G.B. Smith, et al., Health Physics,100: 263-265 (2011).

Derived Air Concentration (DAC)
estimates from Station A readings

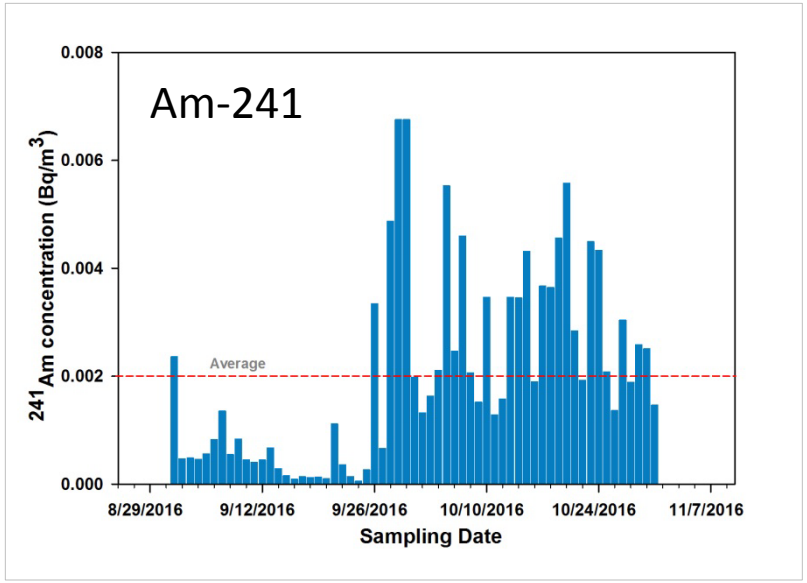
- DAC = concentration of radioactive material in air resulting in an annual intake limit if worker breathes that air 2,000 hours/year
- Small ~2% DAC peak at end of graph due to underground activity
- NWP=Nuclear Waste Partnership and independent monitoring organization (CEMRC) results shown
- Underground air relatively clean (but ALARA [=PPE] applied)

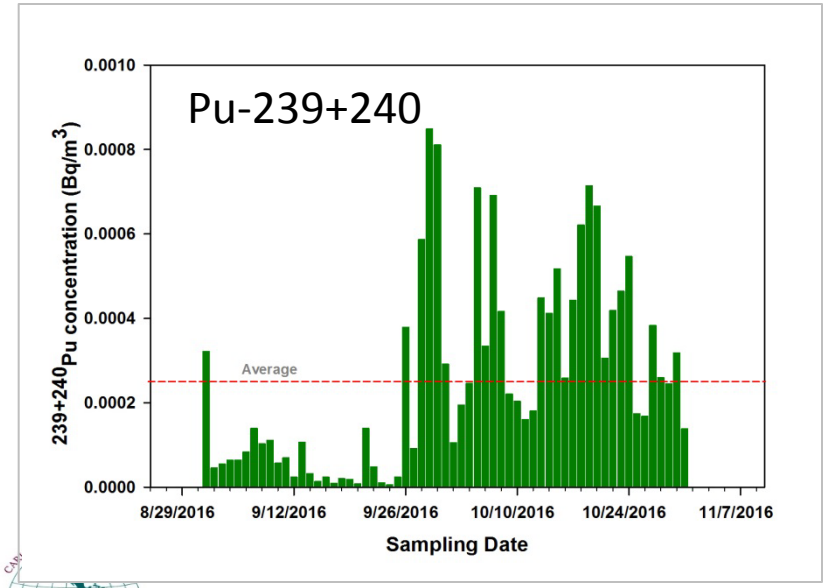


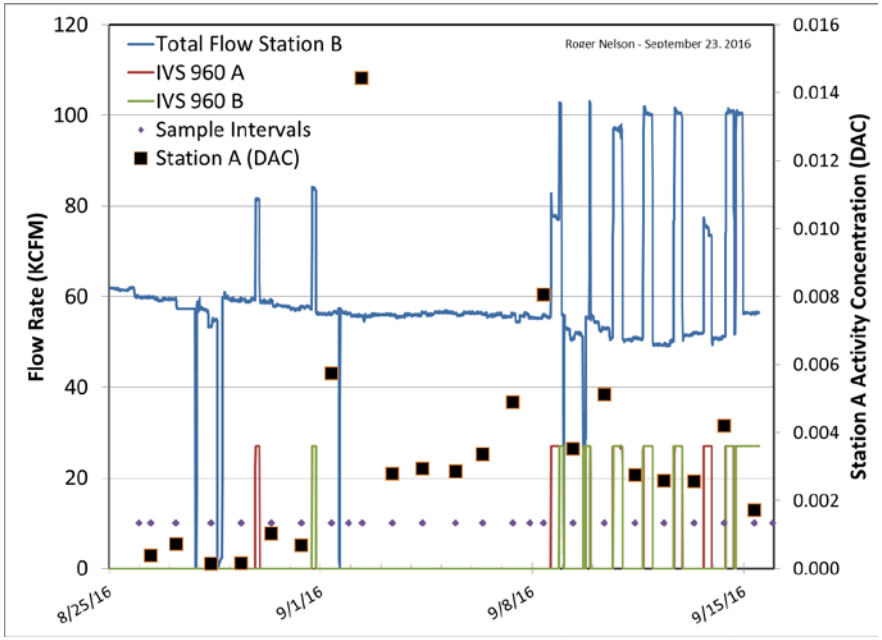
1 DAC ~ internal exposure of 50 mSV per work year, if a worker were continuously exposed for a full work year (2000 hours).

Graph courtesy: Roger Nelson

Increased Airflow could cause resuspension?







Graph courtesy: Roger Nelson

- **No relationship between flows starting and stopping, and the airborne levels.**
- **The fluctuations are more likely due to varying activities in different areas underground.**
- **Levels remain well below any threshold that might require filtration.**

Weighing Fears of Radiation

WIPP radiation release Event (>0.01 mSv)

Average annual US radiation dose (6.2 mSv)

1 average full-body CT scan (15 mSv)

Maximum annual dose for US radiation workers (50 mSv)

Lowest annual radiation dose linked to increased cancer risk (100 mSv)

Maximum allowed radiation dose for emergency workers (250 mSv)

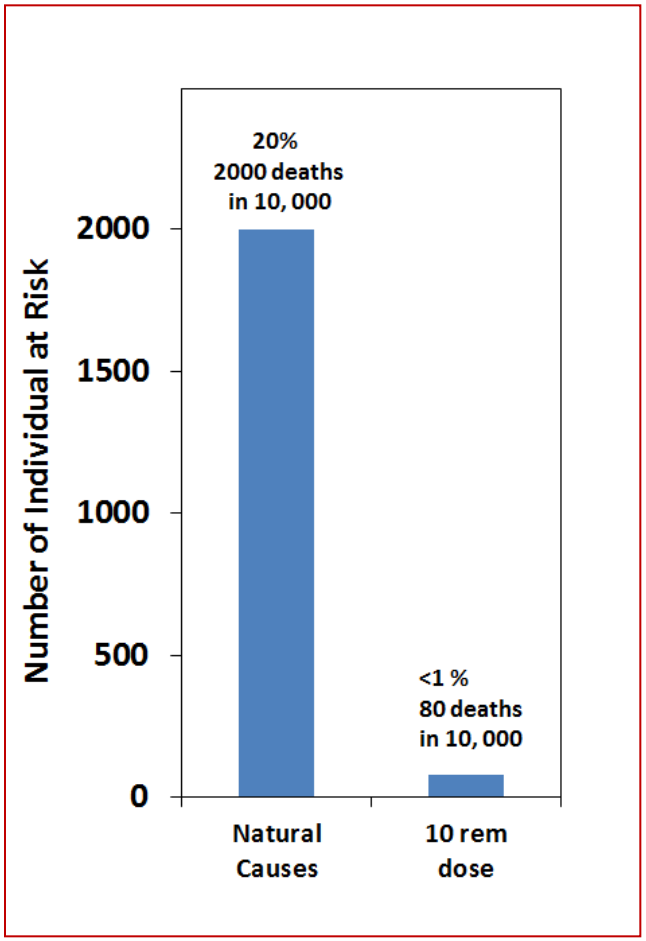
1600 m (~1 mile) from Hiroshima hypocenter (360 mSv)

Average thyroid radiation dose observed in Chernobyl evacuees (490 mSv)

Radiation Poisoning > 5 Sv

Underground Radiation and Risk

- The primary risk from occupational radiation exposure is an increased risk of cancer.
- The amount of risk depends on the amount of radiation dose received, and the body parts exposed.
- Although scientists assume low-level radiation exposure increases one's risk of cancer; medical studies have not demonstrated adverse health effects in individual exposed to small chronic radiation doses (up to 10 rem above background).
- If a person received a radiation dose of 10 rem to the entire body (above background), his or her chance of getting cancer would increase by 1%.



Estimated Cancer Risks to a population of 10,000

WIPP radiation Release Event in numbers

Accident	Type	Release of Radioactive materials	Populations Evacuated	Off-site dose	Estimated clean-up costs in million US$
Winscale 1957	Reactor fire	20,000 Ci, ^{131}I 594 Ci ^{137}Cs 0.02TBq Pu	No evacuation	10 time the Bkgd level	70,000 Complete by 2037
Three mile Island, 1979	Partial core melt	13-17 Ci ^{131}I 34,000 Ci ^{85}Kr	Voluntary short term evacuation of nearby communities due to misinformation.	0.08-1.0 mSv	~1000 12 years
Chernobyl, 1986	Runaway fission process destroying the reactor	1.4E+8 Ci	28, deaths, >300, 000 relocated	>20 mSv	250,000-500,000
Fukushima, 2011	Three reactor units severely damaged	1.2E+7 Ci	~160, 000 evacuated with prospects of return still unclear after 6 six years	~10 mSv	100,000-500,000
WIPP, 2014	Waste Drum breach	0.0013 Ci	No evacuation	1-10 µSv	500

Conclusions and Recommendations

- **The WIPP radioactive release event was serious:**
  - It stopped operations for almost three years
  - It cost up to a half billion dollars to recover the facility
- **The WIPP radiation release event was minor:**
  - In terms of exposures to workers (no doses assigned based on low and temporary bioassay results) and environmental contamination
  - There are no public health implications given such low off-site releases
- **The WIPP Underground air is relatively clean :**
  - The residual radioactivity levels in the underground no longer warrant HEPA filtration in order to meet either worker or environmental protection criteria
  - DOE should consider resumption of the unfiltered discharge of underground ventilation
- **Independent voice and communication extremely important**
  - With public and elected officials and also internally
  - Between site developer and regulator
  - Transparency; don't withhold information
- **Be Prepared**
  - Plan for a release, be able to measure it and mitigate it
  - Be able to tell public what the potential impact is-quickly and on a sustainable basis

Acknowledgement

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