Toxic Exposures in the Missile Environment

Missileers Ingested Carcinogens Due to the Materials Used and the Aging Infrastructure

If diesel fuel or hazardous materials, such as sodium chromate solution or polychlorinated biphenyls (PCBs), are spilled and not promptly contained, runoff to adjacent water bodies could have a significant adverse effect on surface water quality.

1. Diesel fuel was leaking underground and not promptly contained, due to lack of spill monitoring and water testing.
2. PCBs were leaking from the building materials and not promptly contained or removed.
3. Asbestos was not removed from inside the capsule and also likely leached into the drinking water.

Overview

- Assumptions
- Sources
- General Toxic Exposures
- Whiteman Decommissioning
- Unique to Malmstrom AFB
- Past Missed Opportunities
- Moving Forward

Assumptions

- Cancer is caused by ingesting toxic substances.
- Most major cancer clusters involve ingesting contaminated water (Camp Lejeune) or breathing contaminated air (mesothelioma and Navy personnel).
- The same types of chemicals are the culprits: petroleum-based volatile organic compounds, heavy metals, dioxin-based industrial chemicals, and asbestos to name a few.

Assumptions

- Missileers appear to have high levels of blood cancers, prostate cancers, thyroid issues, and autoimmune diseases.
- Malmstrom has higher levels of illnesses than other missile bases.
- Non-Hodgkins Lymphoma (NHL) is of particular concern for Malmstrom personnel. Missileers have different sub-varieties of NHL.
- Causes of NHL: pesticides/herbicides, volatile organic compounds (VOCs), bacteria from agricultural waste, PCBs. Dioxin-based products generally.
- Causes of prostate and brain cancer: PCBs, pesticides/herbicides.
- PCBs mimic various hormones in your body and can alter your immune function. Thyroid and autoimmune issues linked to PCBs, pesticides, and benzene.

Sources

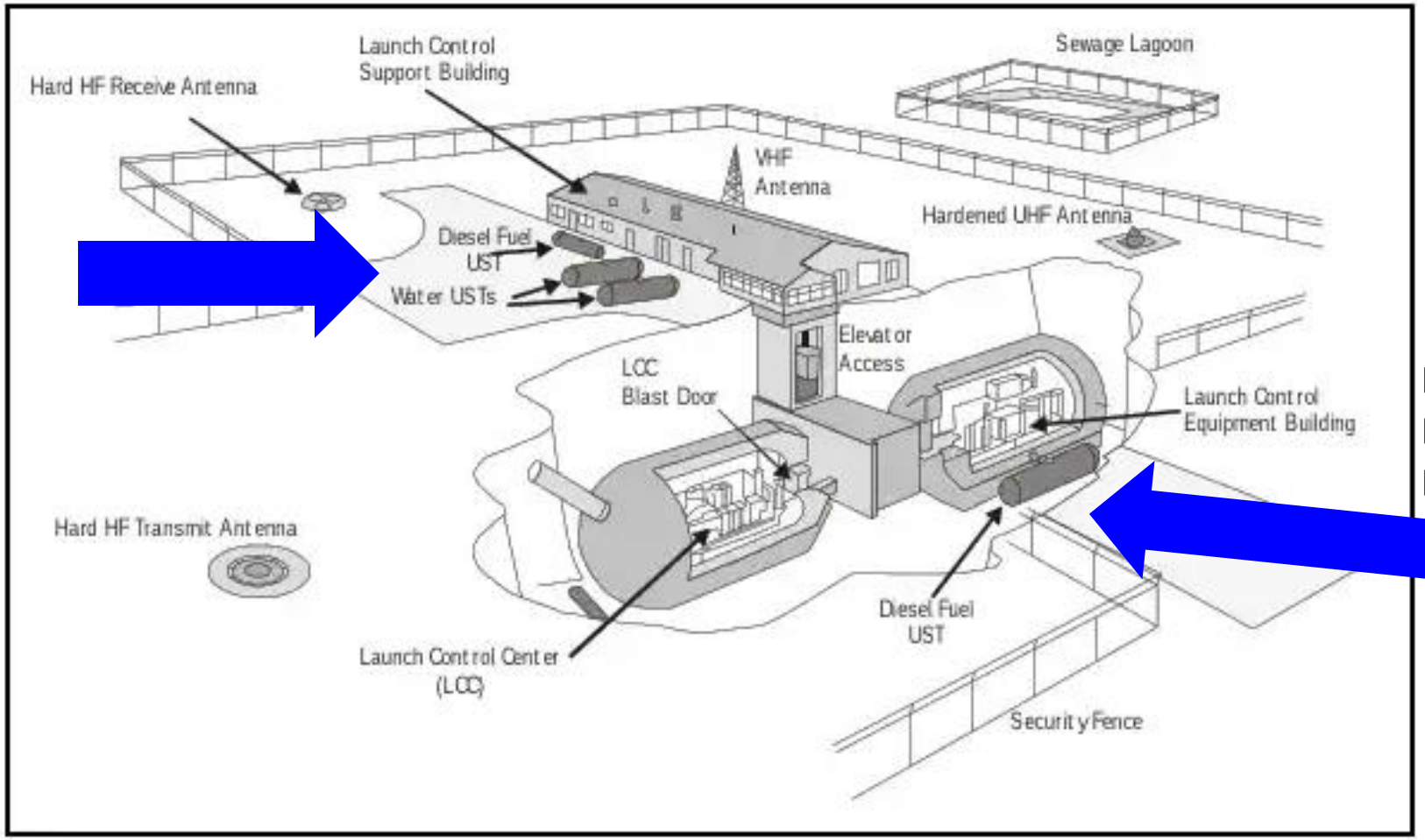
- 1985 Ellsworth AFB Installation Restoration Program
- 1992 Whiteman Missile Wing Deactivation EIS
- 2000 F.E. Warren Peacekeeper Deactivation EIS
- 2000, 2004, and 2005 Medical Study Reports for Malmstrom
- 2004 Environmental Assessment for Minuteman III Upgrades
- Missouri DNR Minuteman II Decommissioning Documents
- 2007 Malmstrom EIS for 564th Deactivation
- 2023 Sentinel EIS
- Montana State Environmental Underground Storage Tanks Data
- Contract data from www.usaspending.gov

General Toxic Exposures of Missileers

- Drinking Water for Missile Alert Facilities
- PCBs
- Petroleum Chemicals from Fuel Tanks
- Asbestos
- Lead & Heavy Metals
- Herbicides & Pesticides
- Nearby Farming or Manufacturing Pollution

General Toxic Exposures (Water)

Underground Water Tank (1,000 gallon) & Diesel Fuel (2,500 gallon) Next to Each Other (6-8 Feet Under)



Large (14,500 gallon) Diesel Fuel Tank (45 Feet Under)

Diagram of Underground Infrastructure (1960s)

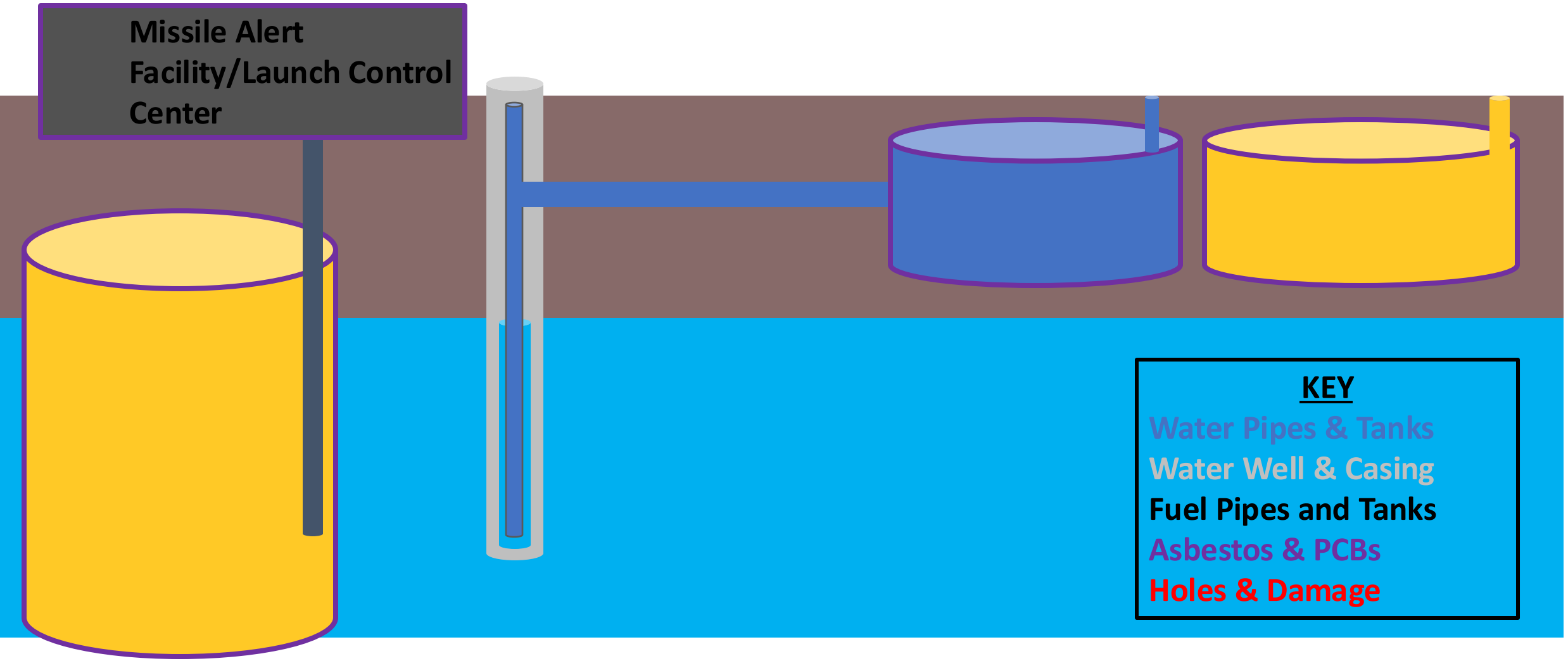
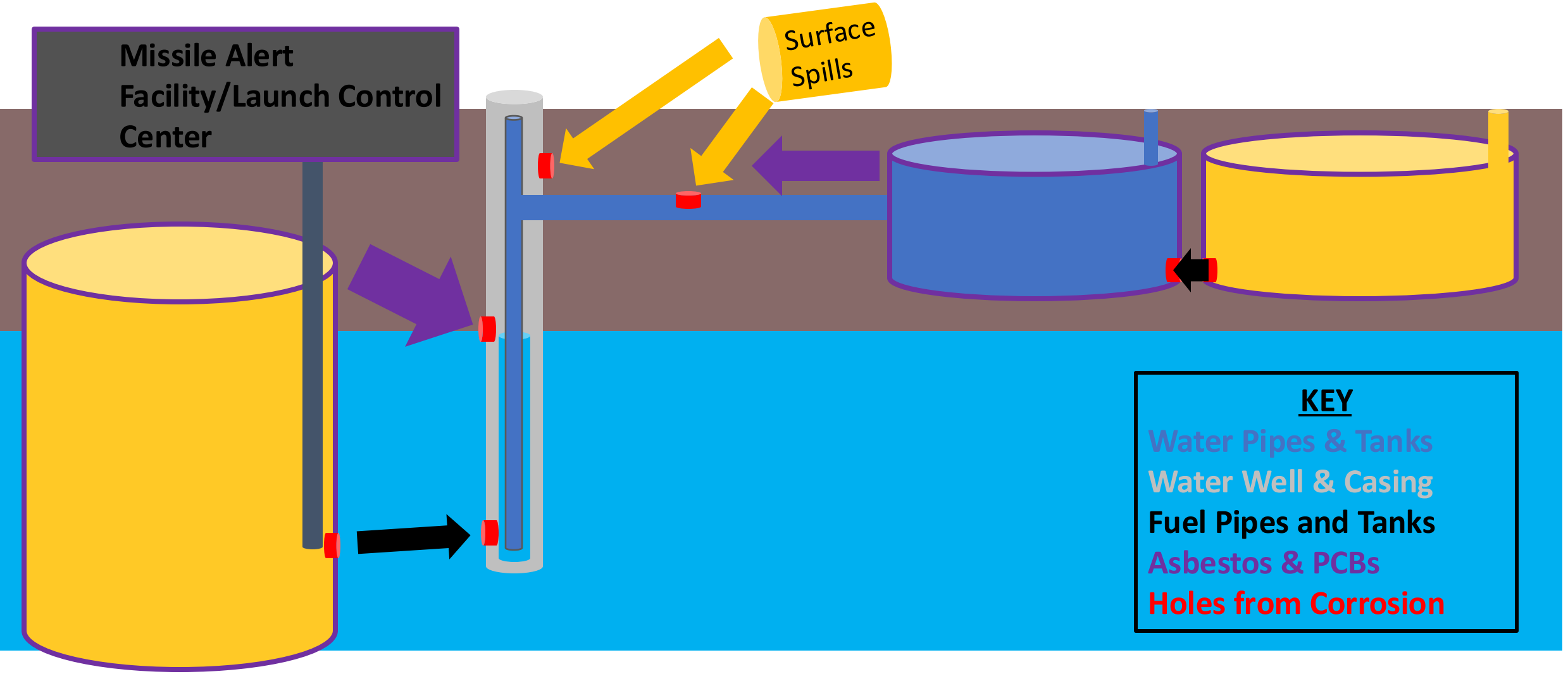


Diagram of Underground Infrastructure (2000s)



General Toxic Exposures (Water)

- Sources of Drinking Water for Missile Alert Facilities
  - Well water, surface water, public water companies, hauled water
  - All MAFs have a drinking water tank, likely coated in PCBs/asbestos.
- Malmstrom:
  - At least 7 MAFs at Malmstrom get drinking water from on-site, underground water wells. Historically, that number was greater.
- Minot: Unclear. “Most MAFs have drinking water wells.”
- F.E. Warren:
  - All 15 MAFs have drinking water wells, 14 of which are owned by the Air Force.
  - “Several of them have reverse osmosis units, and all have chlorination units to improve water quality. Many of the wells are in poor condition and need repair or replacement.” (Sentinel EIS)

General Toxic Exposures (Water)

- Bases do not have exact data on the depth of water wells or water table. Instead, they generally rely on depth of the water table.
  - Malmstrom
    - Water table depth of 20-100 feet.
  - F.E. Warren
    - 40-1,000 feet.
  - Minot
    - 120+ feet.
- Regulations on the testing and monitoring of private drink water sources have changed in the last 10-20 years. However, MAF water wells were likely not tested for water quality until the last 15 years.
- Today, many wells listed as providing water to a limited number of people, so testing not required, but mandated through command policy in 2010s.

General Toxic Exposures (Water)

- 1988: Congress passed a law calling for EPA to regulate underground storage tanks.
- 1998: EPA deadline for underground storage tanks to have spill monitors installed, otherwise tanks must be closed. Majority of MAF fuel tank leaks discovered around this time.
- Montana DEQ Database: 80+ leaking underground tanks on Air Force land. Most monitoring started in the late 1990s.
- During the 1960s, ground water wells would have utilized steel for well casing and pipes. Steel pipes are vulnerable to corrosion and have a life span of 20-30 years. Starting in the 1980s, these wells would have started allowing contaminated water into the casing and into the drinking water.
- MAF well water was unfiltered until the 2000s. Exact date is unclear.
- Around 2005-2007 at Minot, sites began receiving reverse osmosis systems. 2017-2019 for Malmstrom reverse osmosis systems.

General Toxic Exposures (Fuel Tanks)

- Original MAF single-wall, steel fuel tanks have life expectancy of 15-20 years, before leaking.
- MAFs and LFs each have several underground petroleum, oil, and lubricant (POL) tanks buried at depths ranging from 6 feet to 40 feet under the surface. Some of these tanks contain more than 10,000 gallons of diesel fuel for generator use.
- Importantly, these underground storage tanks (USTs) are at the water table level for Malmstrom. Minot and F.E. Warren water tables likely not as contaminated as Malmstrom, due to their depth.
- Numbers of known leaking USTs and other contamination according to Sentinel EIS:
  - Malmstrom: At least 170 LUSTs, 12 landfills, and 53 brownfields near MAFs.
  - Minot: At least 71 LUSTs, 20 landfills, and 10 brownfields.
  - F.E. Warren: At least 13 LUSTs and 11 leaking ASTs.

General Toxic Exposures (Fuel Tanks)

- Verification sampling of these leaks for the extent of the water contamination is not public record.
- 1998 is likely the first time many of these tanks were ever leak tested.
- Engineers recently noted that “trenching crews could encounter unexpected or undocumented contamination, such as fuel spills and agricultural waste.” (Sentinel EIS, 3-368).
- Some, but not all, of the tanks were replaced with double-walled tanks and spill monitors at some point prior to 2007. Metal pipesand casing from water source to MAFs also replaced due to cracks and leaks.

Fuel Tanks Leaks and Water Quality (MAFB, L-1)

gure 1: Site Map – MAF L-1

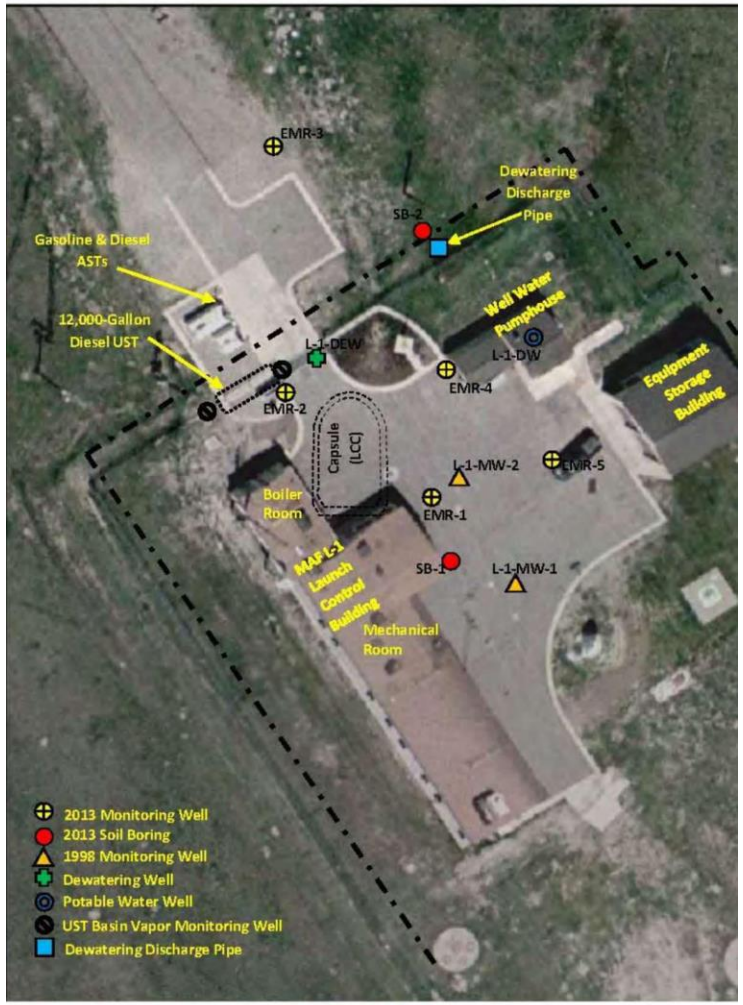


Table 3: Historic Fractionated Groundwater Analytical Table – MAF L-1

Sample ID	Date Sampled	C9-C18 Aliphatic Hydrocarbons	C19-C36 Aliphatic Hydrocarbons	C11-C22 Aromatic Hydrocarbons	Total Extractable Hydrocarbons (Post Fractionation)	Total Extractable Hydrocarbons (EPH Screen)
EMR-1	6/2013	**21,100 CCE, E**	**6,120 CCE, E**	**13,200**	43,400	**65,300 TEH, E**
	8/2013	**3,640 CCE, E**	623	**2,330**	6,590	**11,600 TEH, E**
	4/2015	**6,400**	**1,430**	**2,300**	10,100	**14,200 TEH**
	6/2015	**2,510**	**1,170**	**1,170**	4,840	**7,980 TEH**
EMR-4	8/2013	<55.3 U	186	<85.2 U	<239 U	**1,200 TEH**
	3/2015	<25.6 U	<36.0 U	<58.8 U	<120 U	**1,170 TEH**
DEQ Tier 1 RBSL (µg/L)		**1,000 (µg/L)**	**1,000 (µg/L)**	**1,000 (µg/L)**	**NE**	**NE**

NE – Groundwater Cleanup Target Level Not Available.
U – Analyte included in the analysis, but not detected at or above Method Detection Limit
E – This flag indicates the concentration for this analyte is an estimated value due to exceeding the calibration range or interferences resulting in a biased final concentration
CCE – Analyte concentration is flagged as estimated due to exceeding the calibration range or interferences. The sample is not over the calibration range for the target analytes and/or marker compounds that make up the range therefore not diluted further.
TEH – Total Extractable Hydrocarbons exceed criteria, fractionation is needed
U – Analyte was not detected at the Method Detection Limit
0.3 – Exceeds RBSL
Bold = Exceed the Tier 1 Risk Based Screening Level (RBSL)

Fuel Tanks Near MAFs (Malmstrom 2007 EIS)

The following sites are presently under RCRA investigation for the unintentional release of a hazardous substance (POL) from storage tanks in the past: B-1, C-1, D-1, E-1, F-1, G-1, H-1, L-1, N-1, P-0, Q-15, Q-18, and S-0 (U.S. Air Force, 2006g).

- *Note MAFs B, D, G, K, and N

Trucking in Water Begins in 2010s

2007

Table 3.4-2. Water Source and Usage at MAFs

MAF	Water Source	Average Annual Use (2002-2004) (gallons)
A-1	On-site well	300,443
B-1	On-site well	265,557
C-1	On-site well	270,417
D-1	Contracted (City of Denton)	344,200
E-1	On-site well	270,794
F-1	On-site well	219,523
G-1	On-site well	212,000
H-1	Tri-County Water District	305,188
I-1	Contracted (Prairie Water Company)	330,598
J-1	Tri-County Water District	286,849
K-1	On-site well	211,231
L-1	On-site well	276,914
M-1	On-site well	344,661
N-1	On-site well	317,225
0-1	Roy Water and Sewer District	264,927
P-0	City of Conrad	253,447
Q-0	Tiber County Water District	288,787
R-0	Tiber County Water District	328,009
S-0	Tiber County Water District	373,332
T-0	Lake Francis (pump)	249,041
MAF Average		285,657

MAF = Missile Alert Facility

Source: U.S. Air Force, 2003v; U.S. Air Force, 2006l.

2014

Table 1: MAF Drinking Water Summary (

MAF	Water Source
(b)(9)	Well (on-site)
	Delivered Water (Truck)
	Well (on-site)
	Delivered Water (Truck)
	Well (on-site)
	Delivered Water (Truck)
	Well (on-site)
	Connected to Tri-County Water District System
	Delivered Water (Truck)
	Connected to Tri-County Water District System
	Well (on-site)
	Well (on-site)
	Well (on-site)
	Delivered Water (Truck)
	Connected to Roy Water and Sewer District System

General Toxic Exposures (Pesticides)

- Various forms of herbicides and pesticides used at MAFs to clear vegetation. Limited research on safe ingestion levels of these chemicals.
- Agent Orange used for 1-2 years in the late 1970s. Toxic parts of Agent Orange (dioxin-based) can persist in ground soil for decades.
- MAFs located in heavily agricultural areas. Pesticides used on local farms likely seeped into drinking water. Regulations on pesticides limited until the 2000s.
- Surface uses of pesticides can easily permeate into groundwater.
- Pesticide usage stopped during 2010s, now the areas are mowed manually.

General Toxic Exposures (Asbestos)

- Asbestos used as an insulator and binding agent in missile facility building materials.
- Asbestos in MAF concrete that can leak into ground water.
- Asbestos insulation surrounds the underground drinking water holding tank.
- Asbestos fibers in insulation surrounding power generators.
- Asbestos used to insulate electrical wiring in parts of the capsule.

General Toxic Exposures (Interior Systems)

- Prior to 1980s, limited recordkeeping for spills of hazardous chemicals.
- Leaks and spills of hydrazine fuel & sodium chromate in the LFs occurred. Other chemicals used during missile maintenance, such as solvents or coolants.
- Use of sump pumps to pump dirty, contaminated water to the surface. This water would then trickle down to the groundwater.
- PCBs used in most industrial electrical wiring in the 1960s.
- PCBs in VDU and control console electronics.
- Lack of air circulation and filtration in the capsules. PCBs are aerosolized as they evaporate. Missileers would be exposed to PCBs in the air during their shift due to the lack of fresh air in the capsule.

Whiteman Decommissioning

- Required by START Treaty to implode missile silos.
- During an early implosion at Whiteman, PCB levels of 45,000 parts per million of PCBs were found in the nearby soil.
- EPA standard is 50 parts per million for PCBs. Whiteman had nearly 1,000x the legal limit in their groundwater and soil.
- PCBs used at MAFs for waterproofing. PCBs used in a tar-like substance to create a moisture barrier around the concrete walls and foundations.
- Ellsworth did not have the same issues with PCBs in soil due to different water table and lack of water contacting the moisture barrier.

Whiteman Decommissioning (cont.)

- Air Combat Command and Army Corps of Engineers studied soil conditions at Whiteman. Implosions of missile sites continued.
- Whiteman AFB re-deeded the missile site land back to local residents, with deed restrictions prohibiting drinking the groundwater or digging into the soil.
- In 1992, Whiteman did not have any tank leaks documented. No tank spill monitors had yet to be installed either. Whiteman's EIS called out the need for better sampling for leaks and contamination in the soil.

Unique to Malmstrom AFB

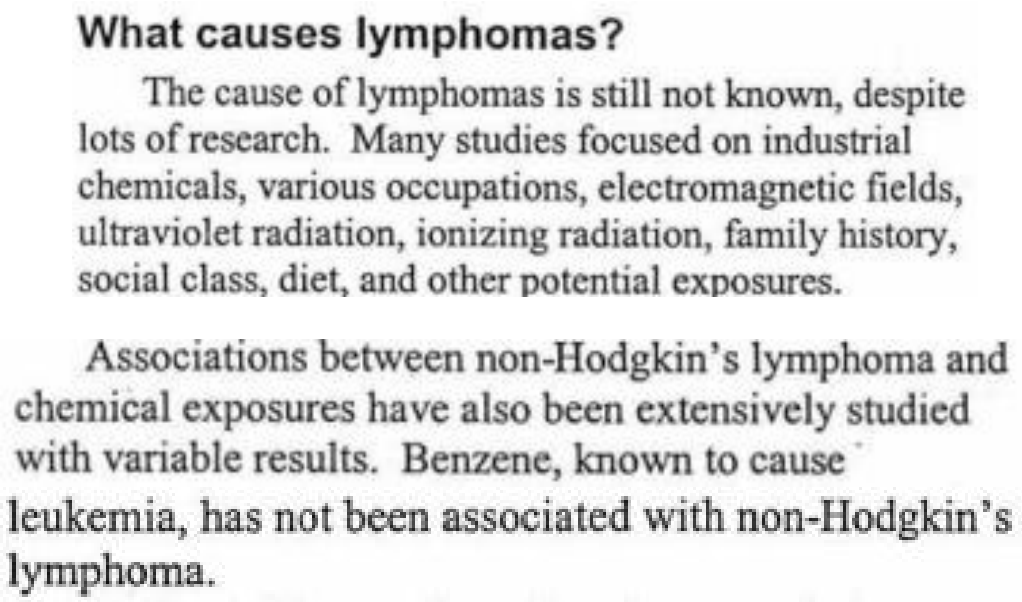
- Permeable soil:
  - Malmstrom has sandy soil that is permeable to surface water and the water table fluctuates due to agricultural uses. The Malmstrom EIS also noted the possibility that diesel fuel spilled on the surface could travel down 10 to 15 feet below the surface and reach the water table.
  - “The following sites are presently under RCRA investigation for the unintentional release of a hazardous substance (POL) from storage tanks in the past: B-1, C-1, D-1, E-1, F-1, G-1, H-1, L-1, N-1, P-0, Q-15, Q-18, and S-0.”
  - Spill monitoring was ongoing while drinking water went unfiltered.
- Number of leaking USTs at Malmstrom is much larger due to soil conditions and groundwater touching these tanks.

Unique to Malmstrom AFB

- Proximity to EPA Superfund sites:
  - Barker Hughesville Mining District: high levels of toxic heavy metals released into surface and ground water, causing fish and other life to die off.
    - A, B, C, D MAFs downstream of contaminated water. A-06 and A-05 on Superfund land.
  - ACM Smelter and Refinery: heavy metals contaminated land and Missouri River.
    - 12th MS within miles of a major Superfund site.
- Malmstrom AFB awarded millions of dollars in contracts for water well reconstruction in the 2010s.

Missed Opportunities

- **The 2000 Malmstrom Cancer Study Relied on Bad Science**: stated that benzene was not believed to cause lymphoma, in contrast to some scientific opinions at the time. This same study did not test for volatile organic compounds in water that would have provided for data on whether missileers were consuming petroleum-contaminated water.



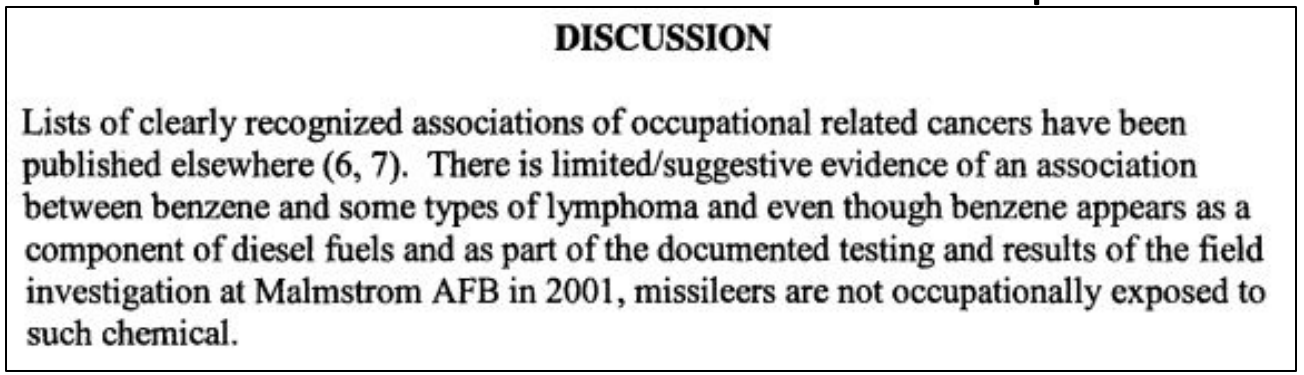
What causes lymphomas?

The cause of lymphomas is still not known, despite lots of research. Many studies focused on industrial chemicals, various occupations, electromagnetic fields, ultraviolet radiation, ionizing radiation, family history, social class, diet, and other potential exposures.

Associations between non-Hodgkin's lymphoma and chemical exposures have also been extensively studied with variable results. Benzene, known to cause leukemia, has not been associated with non-Hodgkin's lymphoma.

Missed Opportunities

- **The 2005 Malmstrom Study Spotted the Issue, But Wasn't Aware of Fuel Leaks**:
- It highlighted that benzene, a toxic chemical in petroleum, as a potential cause of lymphomas, but concluded that missileers were not exposed to such chemicals.



DISCUSSION

Lists of clearly recognized associations of occupational related cancers have been published elsewhere (6, 7). There is limited/suggestive evidence of an association between benzene and some types of lymphoma and even though benzene appears as a component of diesel fuels and as part of the documented testing and results of the field investigation at Malmstrom AFB in 2001, missileers are not occupationally exposed to such chemical.

- **The 2023 Missile Cancer Study Lacks Historical Context**: Sampling drinking water that's already been filtered. Inadequate soil sampling, only inches deep. Air sampling for only 7 varieties of PCBs, without knowing which types of PCBs are in the capsules.

Missed Opportunities

- **Malmstrom Deactivation Did Not Study PCBs in Ground Water, Due to False Assumptions**: "A weather sealing coating may be present on the exterior concrete of the LFSBs that contains solid PCB material. The USTs at the LF sites contained a coating that included a similar PCB material. The solid PCB coating on the USTs at the LF sites was sampled and analyzed, with results reported below laboratory reporting limits. Toxicity characteristic leaching procedure (TCLP) analysis indicated that the PCB material was not leachable (Toltest, 2007). Because the USTs were installed at the same time that the LFSBs were constructed, the coating used on the USTs is likely the same coating used on the exterior of the buried LFSB; therefore, the PCB concentration of the coating are also likely to be below reporting limits. Sampling of the coating on the LFSB had not been conducted. A 5-year groundwater monitoring effort that focused on potential PCB contamination has been conducted at dismantled LFs associated with Whiteman AFB, which contained solid PCB coatings. PCBs were not detected above laboratory reporting limits in any of the groundwater samples analyzed for the constituent, which further confirms that the solid PCB material is not leachable (U.S. Geological Survey, 2002)."

References

- Slide 2: Whiteman Minuteman II Deactivation EIS, pg 213
- Slide 8: Diagram pulled from Whiteman EIS. See back-up slides for tank sizes.
- Slide 11: Number of Malmstrom wells in Malmstrom 2007, see back-up slides. Sentinel EIS, pg 746 on number of wells at F.E. Warren. USTs coated in PCBs on pg. 54 of FE Warren EIS.
- Slide 12: F.E. Warren water depth on Sentinel EIS, pg. 803. For Minot, "Most MAFs have drinking water wells" on Sentinel EIS, pg 829. Colleague in Bioenvironmental confirmed that Malmstrom shows only one water source for routine testing, presumably installation water. Water sources from Whiteman EIS, pg 115. Remote ground water sites not monitored for water quality (Ellsworth 1984, pg 67).
- Slide 13: EPA RCRA overview: https://www.epa.gov/archive/epapages/newsroom_archive/newsreleases/184907499d0c3ccf852570d6005e7d17.html. Montana USTs and ARCGIS maps: https://deq.mt.gov/twr/Programs/ust. TD&H Engineering contracts for well repair: https://www.usaspending.gov/award/CONT_AWD_FA462618F3103_9700_FA462614D0002_9700
- Slide 14: Minot LUSTs at Sentinel EIS, pg. 514. Malmstrom LUSTs at Sentinel EIS, pg. 508. F.E. Warren LUSTs at Sentinel EIS, pg. 494. Diesel fuel tanks buried at 45 feet (Pg. 8 of FE Warren EIS).

References

- Slide 15: Testing done to meet 1998 EPA deadline, revealed leaks and piping fixed (Pg 102, FE Warren)
- Slide 16: Whiteman EIS pgs 73, 135
- Slide 17: Whiteman EIS, pgs 3-44/45.
- Slide 18: Ellsworth documents discuss sump pump usage. Ellsworth pg. 90 states: “A number of significant spill and leak events have occurred at Ellsworth AFB. The available written history of spills and leaks at Ellsworth AFB prior to 1980 is quite limited; therefore, the information on these events is primarily the result of personnel interviews with present and past base employees.” PCBs discussed in Whiteman, pg 3-45.
- Slide 19: See back-up slides. Comes from report on Whiteman de-activation.
- Slide 20: No spill monitors (Whiteman 136, 139). No documentation of leaks (Whiteman 139). Preparing a sampling plan to determine possible contamination (Whiteman 233). Deed restrictions information: https://dnr.mo.gov/waste-recycling/sites-regulated-facilities/federal/former-minuteman-ii-missile-sites
- Slide 21: Malmstrom EIS, Sentinel EIS. See back-up slides. Montana DNR website on leaks shows monitoring wells in place from 1998 on at sites that did not have water filtration until 2017. Malmstrom EIS also contains specific RCRA remediation sites in 2007.
- Slide 22: EPA website: https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.docdata&id=0801208
- Slide 25: Malmstrom EIS

Tanks (Pg. 102, FE Warren)

Table 3.3.4-1
Tanks at LFs and MAFs

Location	Depth in feet to top of tank	Contents	Capacity in gallons
LF - LCEB[1]	(in concrete vault, above ground)	Lube oil	60
LF - LCEB[1]	(in concrete vault, above ground)	Diesel (day tank)	315
LF	Shallow – about 3 to 4	Diesel	14,500
MAF underground[1]	35 to 45	Diesel	14,500
MAF underground[1]	3 to 4	Diesel	2,500
MAF above ground[1]	(in concrete vault, above ground)	MOGAS	2,000
MAF above ground[1]	(in concrete vault, above ground)	Diesel	1,000
MAF above ground[1]	(in concrete vault, above ground)	Diesel	1,000
MAF above ground[1]	(in concrete vault, above ground)	Diesel (day tank)	100
MAF above ground[1]	(in concrete vault, above ground)	Lube oil	65

[1] All tanks, unless otherwise noted, are steel. Most have non-liquid PCB containing coatings. The UST at LF Q-8 was recently replaced with a 4,000-gallon double-wall fiberglass tank.

Source: Zak, 1999

Whiteman Decommissioning

(U) **Silo Destruction** Demilitarizing and imploding Minuteman II silo launchers played a significant role in meeting START-I Treaty provisions under Rivet Dome. The counting rules under START-I did not make a distinction between empty silo launchers and those that contained a missile. Implosion, therefore, using procedures outlined in the START-I Conversion or Elimination Protocol, was the only method available to treaty signatories for removing silo launchers from accountability.[74]

Whiteman Decommissioning

(U) **PCB Contamination** The first Minuteman II silo launcher implosions occurred at Whiteman AFB on 8 and 21 December 1993, respectively. Unfortunately, Polychlorinated biphenyl (PCB) contamination discovered after the second of these, at 351st Missile Wing launch facility India-08, forced the command to temporarily suspend implosions at Whiteman and at Ellsworth. Testing at Whiteman showed PCB levels at 45,000 parts per million, well above an Environmental Protection Agency (EPA) standard of 50 parts per million. At Ellsworth, meanwhile, tests of soil samples showed only negligible amounts of PCB present on underground storage tanks and silo walls. Because the PCB was in a solid state and unlikely to migrate into the ground water, evaluators permitted silo implosions and removal of underground storage tanks at Ellsworth to continue. At Whiteman, however, the elimination of silos stopped for almost a year while Air Combat Command, the Army Corps of Engineers, the State of Missouri, and the EPA completed investigations.[75]

Whiteman Decommissioning

(U) On 1 July 1994, Colonel Mason explained how the PCB came to be present at Whiteman in a talking paper he prepared for the Twentieth Air Force commander. "It was discovered," he noted, "that a moisture prevention blanket was placed on the outside of the silos and underground storage tanks at Whiteman due to the high water table. [The] PCB is in a solid state and was used to seal this moisture blanket which was the normal industrial practice at the time the silos were constructed."[76]

Whiteman Decommissioning – Missouri DNR

The Problem

The USAF's 165 Minuteman II missile sites were decommissioned in the 1990's as the result of START I. During the closure process, the USAF discovered that waterproofing materials used in the construction of the missile silos and on underground storage tanks (USTs) contained polychlorinated biphenyls (PCBs).

Contaminants of Concern

The contaminants of concern for these sites are diesel fuel, PCBs and asbestos.

What's Been Done

Closure of the former Minuteman II missile sites included demolishing and capping silo structures and closing the USTs, which included removing soil contaminated with diesel fuel. Some diesel fuel may remain on-site at concentrations that are not a risk to human health. The remaining diesel fuel concentrations are decreasing through a process called natural attenuation, in which microorganisms in the soil break down the chemicals into nontoxic substances.

A groundwater investigation spanning five years confirmed that the PCBs remained trapped within asphaltic material that was buried during closure. The PCBs are not migrating into groundwater. Preventing human contact with PCBs is important because PCBs are toxic compounds that stay in the environment and do not break down over time.

What's Left

Department staff conduct follow-up visits at properties where the USAF's annual inspections indicate a change of land use or property ownership. Department staff assist the USAF with developing and implementing a system to update property ownership records, which helps in continued outreach with site owners.

Malmstrom Wells & Fuel Leaks