F-16 Training over the Gila

Community Input to the Environmental Impact Statement

FEBRUARY 2019

FLARES

Holloman Air Force Base proposes that F-16 fighter jets fire 15,000 defensive counter-measure flares annually into the air over Grant and Catron counties. This release would be authorized in existing Military Operations Areas (MOAs), as well as through the establishment of the Lobos MOA (Alternative #2 of the Air Force's Airspace Optimization project). The public is concerned about the use of flares over the Gila National Forest and wilderness areas due to wildfire risk and public safety. The Air Force should address these concerns in the Environmental Impact Statement for the expansion of military aircraft training over the Gila.

What is a countermeasure flare and how is it used?

Countermeasure flares, also known as decoy flares, are used to defend military aircraft from heat seeking missiles. The flares are fired individually or in salvos from the aircraft, which then takes extreme evasive maneuvers. Because the flares burn at temperatures that are significantly hotter than the engine exhaust of the aircraft, the missiles are deceived, locking on to the heat of the flares, and detonating away from the aircraft.

https://commons.wikimedia.org/wiki/File:F-16_releases_four_flares.jpg

Peaceful Gila Skies

A coalition of business and community leaders, sportsmen and concerned citizens, united in our goal of protecting the Gila Region from military aircraft training.

www.peacefulgilaskies.com | 575.538.8078 | peacefulgilaskies@gmail.com

How big are these flares and what are they made of?

The F-16s will use either the M-206 flare or the MJU-7AB. The M-206 is 1” x 1” X 8” and weighs 6.8 oz. The MJU-7AB is twice as big (1” x 2” x 8”) and weighs nearly twice as much (13 oz.). Both flares burn at 2,000 degrees for about 3.5 to 5 seconds, a duration designed to burn out within 150 to 400 feet of descent.

The combustible part of the flares is composed of Teflon, Magnesium, Fluorel binder, Boron, Potassium perchlorate, and Barium chromate. The assemblage is aluminum, Mylar, felt, and plastic or nylon.

https://www.ellsworth.af.mil/Portals/146/documents/AFD-141124-073.pdf

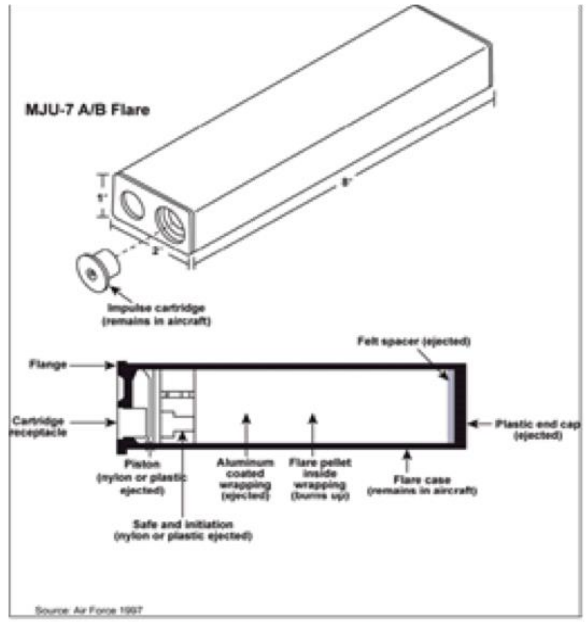


Figure D-7. MJU-7 A/B Flare

Does realistic F-16 training with decoy flares pose a hazard to people, plants, and animals living in an MOA? And to the land and water there?

The use of decoy flares pose serious, but uncommon, hazards. The hazards include the following:

- Wildland fires
- Injury from the accidental detonation of a “dud” flare
- Water contamination from repeated exposure to flare chemicals

Those hazards are reviewed in an Air Force report cited as: *Environmental Effects of Self-Protection Chaff and Flares. Final Report.* August 1997. Prepared for U.S. Air Force. Headquarters Air Combat Command. Langley Air Force Base. Virginia.

https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/PB98110620.xhtml

I. Wildland Fire

Decoy flares can start wildfires, although not very often, it seems. However, it's hard to tell exactly how often because fires started by military flares are not a category that is tracked in national and local databases.

A still-burning flare might reach the ground for a number of reasons:

- The flare could be released at too low an altitude with inadequate ground clearance.
- The flare could descend too rapidly due to vertical shear or wind burst.
- The flare could burn at an unexpectedly slow rate due to manufacture error.
- The igniter could malfunction, causing the flare to ignite late in the air or fall to the ground as a dud and ignite later.

Whether a still-burning flare will start a wildfire depends on the kind of "fuels" the flare lands in, how dry the fuels are, how much wind there is, etc. There are a lot of variables. Nevertheless, flares do sometimes start fires. Every military range surveyed for a 1997 Air Force report reported fires.

Wild Fire in the Gila Area

The Gila National Forest and its adjacencies are a fire-prone landscape.

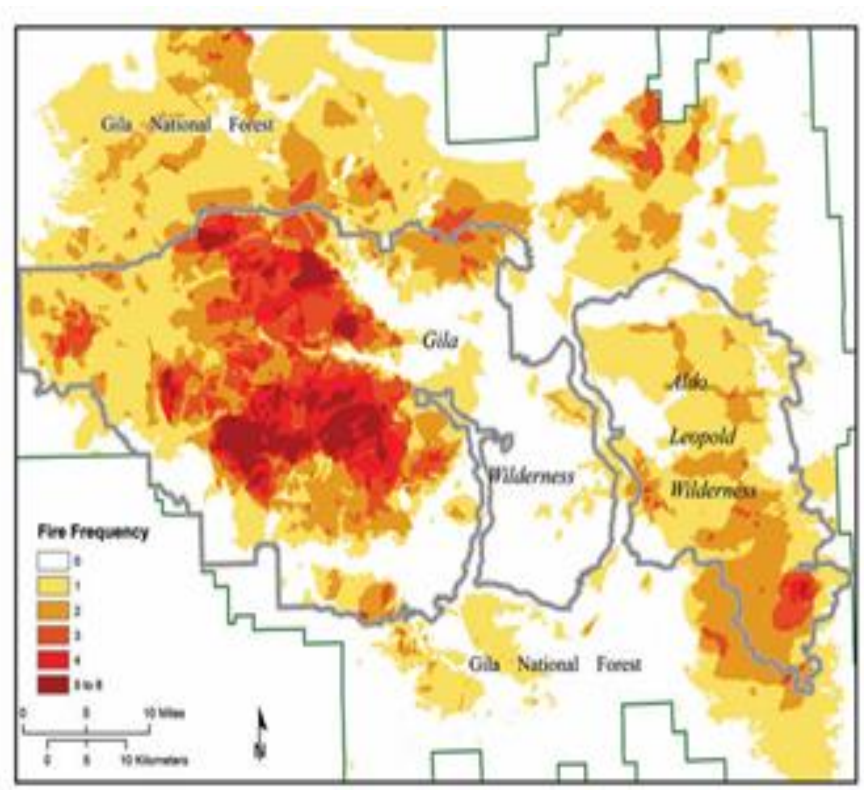


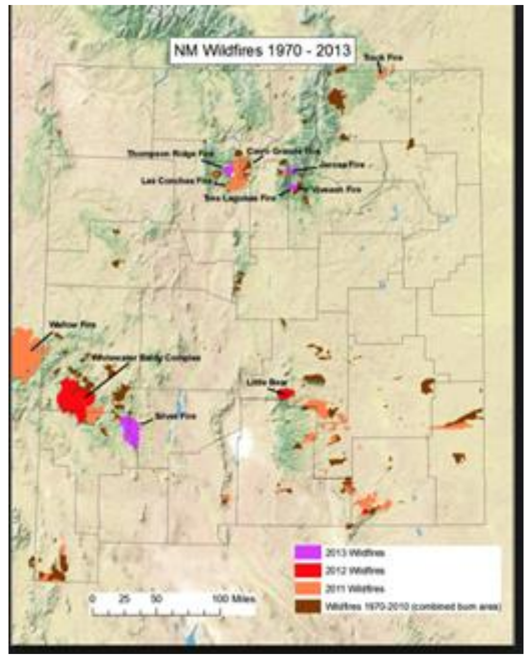
Figure 19—Fire frequency in the Gila Aldo Leopold Wilderness Complex from 1909 to 2013. Most of the pine and mixed conifer forest in the GALWC have burned at least once; hence, most of the unburned areas are dominated by pinyon-juniper. Some areas in the interior of these two wilderness areas have burned as many as eight times since 1909.

While the forest types in the Gila National Forest evolved with fire, the scale and intensity of fire has increased dramatically over the last several decades. There are two drivers effecting this change: fire suppression practices and climate change.

Fire Suppression Practices. Nearly a century of fire suppression practices has allowed fuel loads and fuel ladders to increase substantially over the natural condition of the forests. Where, previously, fires might burn at lower or more varied intensities and maintain the forest composition and structure, fires today can quickly surge to extraordinary intensities and scale with catastrophic results. (Note: Fuel ladder is a firefighting term for live or dead vegetation that allows a fire to climb up from the landscape or forest floor into the tree canopy. Common fuel ladders include tall grasses, shrubs, and tree branches, both living and dead. https://en.wikipedia.org/wiki/Fuel_ladder)

Climate Change. The other principal influence on the intensity and scale of wildfires in the Gila National Forest and throughout the Western US is climate change. The Union of Concerned Scientists issued a report (last updated in 2018) on the effects of global warming that noted:

> "Wildfires in the western United States have been increasing in frequency and duration since the mid-1980s. Between 1986 and 2003, wildfires occurred nearly four times as often, burned more than six times the land area, and lasted almost five times as long when compared to the period between 1970 and 1986."
>
> "US wildfire seasons—especially those in years with higher wildfire potential—are projected to lengthen, with the Southwest's season of fire potential lengthening from seven months to all year long. Additionally, the likelihood that individual wildfires become severe is expected to increase."
>
> https://www.ucsusa.org/global-warming/science-and-impacts/impacts/global-warming-and-wildfire.html#.XC1B6M9KjR
>
> https://www.env.nm.gov/swqb/Wildfire/



As the map above denotes, the increased scale of fires in the Gila area in recent years is notable.

Recent Wildfire in the Gila Area

The Whitewater-Baldy Fire in 2012 burned 297,845 acres. Fire suppression cost was $23,000,000. The residual effects post-fire and downstream continue to harm the following resources:

- **Soils**: Increased erosion
- **Water Quality**: Degradation due to ash and sediment deposition
- **Hydraulic Function**: Degradation due to vegetative cover loss - at least 25 years to recovery and a 25% increase in the spread of invasive plants
- **Riparian Habitat:** Degradation due to increased erosion and scour, as well as deposition of ash, sediment, and debris, including 294 miles of Outstanding Natural Resource Waters and 18 wetlands
- **Recreational Fishing Streams:** Impaired in the same manner
- **Threatened and endangered species:** Affected species include the Mexican Spotted Owl, Mexican Gray Wolf, Gila Trout, Gila Chub, Loach Minnow, Spikedace, Headwater Chub, Chiricahua Leopard Frog, Narrow-headed Garter Snake, Gila Spring snail
- **Cultural resources:** 168 archaeological sites located within the burn area

The images below were taken during and after the Whitewater-Baldy Complex Fire in the Gila National Forest.

http://www.kunm.org/post/are-megafires-new-normal

http://www.wildlife.state.nm.us/fishing/native-new-mexico-fish/gila-trout-recovery-angling/

The **Wallow Fire** in 2011 burned 522,642 acres in Arizona and 15,407 acres in New Mexico. The estimated cost was $109,000,000.

What precautions do the Air Force and Air National Guard take to prevent flares from starting wildfires?

The 1997 Air Force Report recommends several precautionary practices to reduce the risk of wildfires stemming from the use of flares:

- **Minimum Flare Release Altitudes**
- **Suspension of Flare Use** during periods of high fire danger
- **Emergency Fire Equipment and Trained Personnel on Standby** at the training location

Minimum Flare Release Altitude. A minimum altitude is set below which flares cannot be released. Here is an example of the logic: an M-206 or an MJU-7 A/B flare is designed to burn out within 150 to 400 feet; so "the likelihood of a flare-caused fire is substantially reduced" by setting a minimum release of altitude of 1,500 feet above ground level (AGL).
https://www.ellsworth.af.mil/Portals/146/documents/AFD-141124-073.pdf

This practice is universally employed. In the case of property not owned by the Department of Defense (DOD), such as military operations areas (MOAs), the minimums levels typically vary from 2,000 feet AGL to 5,000 feet AGL. But there are limits to the effectiveness of this practice. "In Nevada, flare fires have occurred in areas where minimum release altitudes are 5,000 feet AGL." A fire in Meadow Valley, for example, that burned 21,600 acres in 1993 was attributed to flare use by a BLM fire investigator.
https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/PB98110620.xhtml

Suspension of Flare Use. The suspension of flare release during periods of high fire danger is another precautionary practice recommended by the 1997 Air Force Report. The National Fire Danger Rating System is the most commonly-used metric of fire risk. It has five adjective class levels of danger:

- LOW - Fuels do not ignite readily from small firebrands, although a more intense heat source, such as lightning, may start fires in duff or light fuels.
- MODERATE - Fires can start from most accidental causes, but with the exception of lightning fires in some areas, the number of starts is generally low.
- HIGH - All fine dead fuels ignite readily and fires start easily from most causes.
- VERY HIGH - Fires start easily from all causes and, immediately after ignition, spread rapidly and increase quickly in intensity.
- EXTREME - Fires start quickly, spread furiously, and burn intensely. All fires are potentially serious.

These metrics help land management agencies such as the U.S. Forest Service determine appropriate use restrictions to minimize the danger of people accidently igniting wildfires. For example, during periods of high fire danger, campfires might be restricted to metal fire rings in developed campgrounds, or smoking cigarettes confined to enclosed vehicles, or fuel wood cutting restricted during hot periods of the day.

The 1997 Air Force Report expressly states that: "In all cases, flare use should be curtailed during periods identified as high or extreme fire risk." However, there is considerable variability in the implementation of this practice. Some units of the Air Force or Air National Guard suspend the use of flares but only at Very High or only at Extreme levels of danger. Some raise the minimum release altitude during periods of High Fire Danger and above but do not suspend use. Others do not curtail the use of flares at all regardless of the fire danger level.

The reason for this variability likely stems from a reluctance to interrupt training. For example, in rejecting a suspension of flare use linked to levels of fire danger, the Oregon Air National Guard observed that: "The inability to deploy flares, even if just for a few days a year, could delay or inhibit critical training for the Oregon ANG."
https://www.oregon.gov/OMD/Documents/Appendix%20I-Wildlife%20Hazard%20Analysis.pdf

There are inherent limits to the effectiveness of this practice, as well**.** The 1997 Air Force Report observes that: "Significant fires have occurred in times when fire danger was considered low or moderate."

Emergency Fire Equipment and Trained Personnel on Standby. This practice is employed at Military Ranges and other DOD properties. It is not feasible on MOAs where the Air Force or Air National Guard have no facilities.

Overarching Limitation of Precautionary Practices

The 1997 Air Force Report states that these practices appear to reduce the risk of fire stemming from the use of flares, but that fires still occasionally happen. Typically, an environmental analysis assessing the impact of flare balances this continued but reduced risk against the importance of not constraining the military training mission.

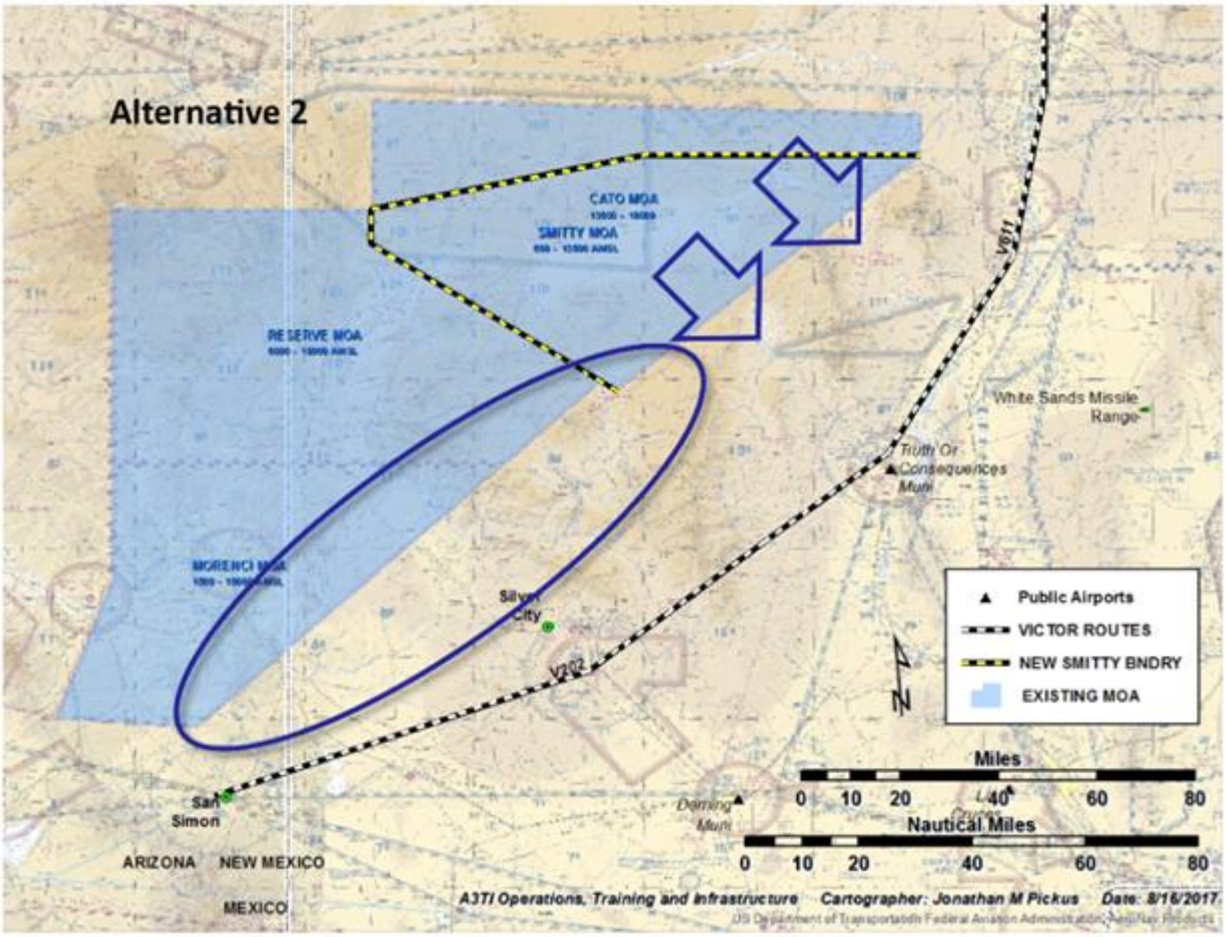
Wallow Fire cbs5az.com

Even as the 1997 Air Force Report was being drafted, however, the scale of fire spread and fire intensity was rising substantially in western forests. **The risk of catastrophic consequences is much higher now than previously observed twenty years ago, and the tradeoffs between risk to important natural resources and benefit of flare training need to be recalculated.**

Not all areas are equally suitable for that kind of use. This issue was anticipated in the 1997 Air Force Report as demonstrated in the following observations:

> **"While fire is a part of ecological cycles, fires originating from non-natural sources can be ill-timed and limit land managers' ability to implement fire management programs aimed at balancing ecological necessity with human safety."**
>
> **"Fires tend to spread and damage larger areas in timber and grassland environments, including specially protected areas such as Wilderness Areas, Wilderness Study Areas, Wild and Scenic Rivers, wildlife and habitat protection areas, and areas of designated outstanding visual quality. Areas specifically designated for preservation of natural qualities have low tolerance for changes brought on by non-ecological conditions, including litter and fires, and would be least suitable as flare training areas."**
> [Bold added for emphasis]

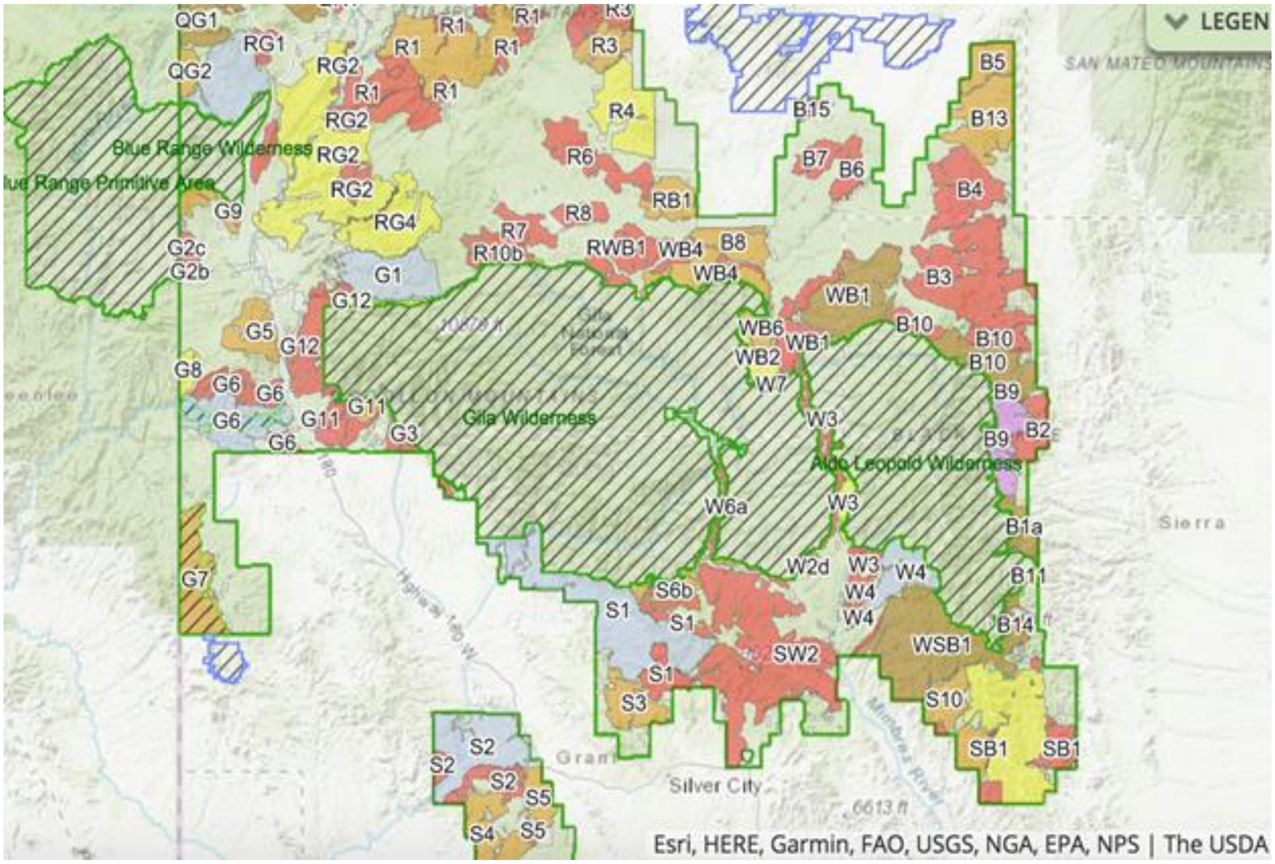
This statement is truer today than ever before, and certainly so for the proposed Lobos MOA.



The proposed Lobos MOA is currently denoted by the ellipse on the map above.

The Lobos MOA would potentially cover large areas of the Gila Wilderness, the Aldo Leopold Wilderness, and several Wilderness Study Areas. Even as planning for the Lobos MOA continues, new Wilderness Study Areas are being proposed in the Gila Area.

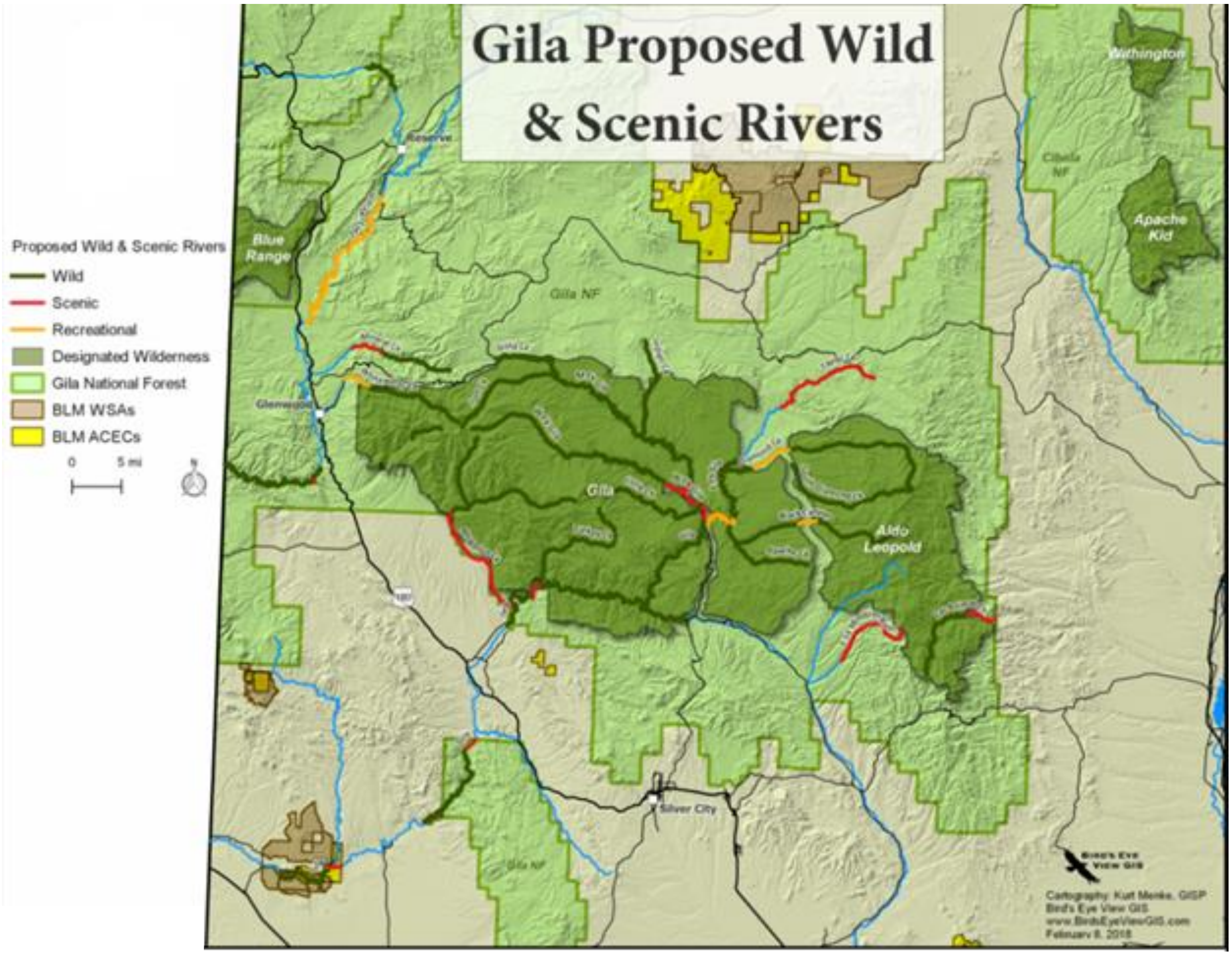
On the next page is a recent map of the new proposals. Established Wilderness Areas and established Wilderness Study Areas are denoted with cross-hatching. The colored sections with letters and numbers represent the new proposals.



Currently, the Gila National Forest is reviewing the proposals as part of the Forest Plan Revision, which is now underway. For information consult: Gila National Forest Plan Revision. *DRAFT Evaluation Report of Lands Inventoried for Potential Wilderness Characteristic.* DRAFT Report, June 2018 https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd584786.pdf

Not all of these proposals will be designated as suitable for wilderness status; but nearly 500,000 acres have already received high to outstanding ratings by the forest planners.

The Lobos MOA would most likely also cover large portions of the tributaries of rivers in the area that have been recently proposed for Wild and Scenic River Designation and hundreds of miles of Outstanding Resource Waters. (See map below)



II. Dud Flares

What is a dud flare?

A dud flare is a flare that did not ignite after ejection from the aircraft or only burned partially during its descent to the ground.

Are dud flares dangerous?

They can be very dangerous. Lying on the ground, exposed to time and weather and moisture, the explosive and pyrotechnic components of the decaying flare can become unstable and ignite if disturbed. The Air Force considers these flares to be UXO (unexploded ordnance) and dispatches trained personnel to safely dispose of the device when one is reported.

Often, people are unaware of this danger, however.
http://gilavalleycentral.net/fort-thomas-woman-burned-in-flare-explosion/

In 2017, a woman living near Fort Thomas, Arizona, (Jackal MOA) found a dud MJU-7A/B while walking. Not knowing what it was, she picked up the flare, which exploded in her hands. Here is the acute trauma care report:

> "There was a subsequent flare deflagration and the patient was seen running from the scene with her clothes on fire. The patient sustained a 49% of total body surface area burn including her head, bilateral upper and lower extremities and torso (Figures 1-4) [omitted here]. She was intubated in the field and transported to the Arizona Burn Center's intensive care unit. She underwent seven major operative skin excisions for her deep third degree burns coupled with initial cadaveric allograft coverage. These were later followed by wound closure with autografting using a split thickness skin graft technique. The patient was extubated on post-admission day 24. After being admitted for just over fifty days, she was discharged to a rehabilitation facility with burn clinic follow-up."

MJU-7 counter-measure flare

https://www.noao.edu/safety/fun_and_interesting_stuff/Beware%20of%20Military%20Flares%20and%20Ordnances.pdf

http://trauma-acute-care.imedpub.com/how-an-undeflagrated-flare-deployed-from-a-military-aircraft-caused-a-50tbsa-burn-injury.php?aid=19222

Are Dud flares common?

MJU-7A/B flares are believed to be 99% reliable—with a 95% confidence level. This assessment is based on a sampling program of flare lots. If 15,000 flares are discharged over the Lobos MOA each year, it would be reasonable to assume that 150 would be duds. Over ten years that would be 1,500 dispersed duds.

What precautions does the Air Force or the Air National Guard have to mitigate the risk of a dud flare on the ground injuring citizens?

Here are the observations of the 1997 Air Force report:

> "Dud flares, on the other hand, remain on the ground and could be found months or even years later, continuing to pose a potential hazard for an undetermined length of time. Therefore, as more flares are used, more duds will be produced, and the potential risk of injury will also increase. The cumulative level of risk cannot be precisely calculated."
>
> "Although the historic incident data do not indicate a risk, the potential for a dud flare to be picked up by a person who is subsequently injured should be taken into consideration for flare use over non-DOD land. Over DOD land, appropriate corrective actions could include educating all personnel on proper procedure when encountering a dud flare and ensuring that flare use areas are regularly surveyed by EOD personnel and all duds are disposed of properly."……
>
> "In areas where flares are regularly dispensed over non-DOD owned land frequented by the general public, a public information program could be employed to alert people of the risks associated with dud flares and safe procedures if a dud is found."

What would a public information program look like? The 1997 Air Force Report did not specify.

The Lobos MOA could include large areas of Wilderness, places "where the earth and its community of life are untrammeled by man." That these special places could be scheduled to regularly receive the dangerous falling detritus of unexploded flares for years on end at an unknown level of risk to the public seems not merely inappropriate but a grotesque misappropriation of purpose and benefit.

There are many other areas of scenic beauty, wildlife congregation, and public interest beyond the formally designated Wilderness Areas under the Lobos MOA. These should also be protected from the dangers of dud flares as well.

Beside the danger of inadvertent detonation, do dud flares pose other immediate dangers?

An MJU-7A/B flare weighs 13 oz. Falling from 2,000 feet AGL, the terminal velocity of a dud striking the ground would be over 100 mph. The dud would likely injure anything struck, but the likeliness of striking a person is exceedingly low in sparsely populated areas. The 1997 Air Force Report states that the odds are less than a million to one (10-6). For comparison, the lifetime odds of a person being struck by lightning are 12,000 to 1.

This issue typically receives more attention in the analyses of flare impacts to the environment. Perhaps because it is more easily quantified.

$$V_T = \left[\frac{2}{\rho}\left(\frac{W}{AC_D}\right)\right]^{1/2}$$

III. Flares and Chemical Pollution

Iconic signifiers of threat categories posed by flare chemicals

UO Wikipedi

How can decoy flares harm the quality of fresh water?
Decoy flares are pyrotechnic devices that are used in combat. There is no other purpose for them. They are munitions, and many of the chemicals that ignite are toxic.

There are two ways decoy flares pollute:

- Dud flares fall to the ground unignited, where they are considered unexploded ordinance (UXO) by the Air Force.
- Toxic flare ash and chemical residue fall to the ground after ignition

Dud Flares
The malfunction rate of decoy flares is 1%. Of 15,000 flares discharged annually by F-16s training over the proposed Lobos MOA and adjacent areas, 150 flares can be expected to fall to the ground. Perhaps a few will still be burning. The rest will fall without igniting. Some will fall into water. Over a ten-year period, 1,500 duds will fall, and eventually all of these duds will leach their chemicals into the environment. This release will happen more quickly and perhaps catastrophically if a dud is disturbed by a person or perhaps by an animal.

The chemicals of greatest concern in these flares are:

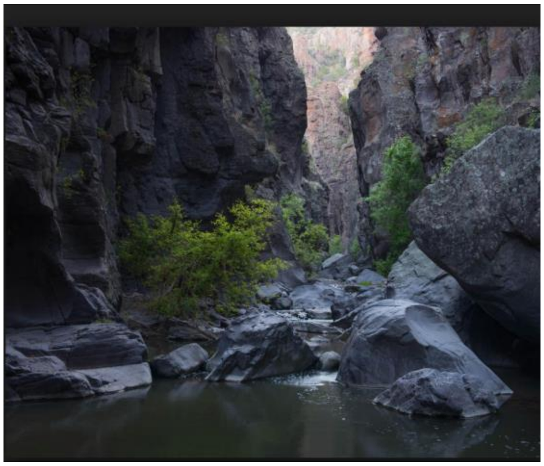
- **Barium Chromate ($BaCrO_4$)**, which is dangerous if swallowed, inhaled, or touched, and is very toxic to aquatic life and a long-term hazard to aquatic environments.

- **Boron (B),** which is toxic if swallowed and is a long-term hazard to aquatic life.

- **Potassium Perchlorate, ($KClO_4$)**, which irritates and can damage eyes, skin, respiratory systems as well as the thyroid, and is acutely hazardous to aquatic life and aquatic ecosystems, with long lasting effects.

- **Magnesium (Mg),** which in contact with water releases flammable gas that can ignite spontaneously. In a fire, it gives off irritating or toxic fumes (or gases). And with exposure to water (H_2O), Magnesium (Mg) produces Magnesium Oxide (MgO), which is *very toxic to aquatic life and aquatic environments with long-lasting effects.*

Gila Wilderness Image from The Wilderness Society



The professional Hazard Statements of these chemicals are listed at the end of this section

Fresh water in streams and pools and the aquatic life forms dependent on this water are notably vulnerable to the effects of these contaminants. Potassium perchlorate, for example, at very low doses (>0.004 mg/L) delays limb emergence in frogs, alters their gender ratios (0.06 mg/L), inhibits their metamorphosis (11.9 mg/L) and causes 50% mortality (329 mg/L over 96 hours). The effect on reptiles has apparently not been analyzed.

Wildlife Toxicity Assessment for Perchlorate. Final Report. February 2007. U.S. Army Center for Health Promotion and Preventive Medicine.
https://clu-in.org/download/contaminantfocus/perchlorate/Perchlorate-wildlife-toxicity.pdf

Perchlorate is also highly soluble. It remains in ponds, travels long distances in streams, and sinks into ground water. Canon AFB, Melrose Bombing Range, Fort Wingate, Holloman AFB and White Sands Missile Range all have surface or ground waters contaminated by perchlorate.

> **Note:** This problem of contamination is clearly an unintentional byproduct of military activities over long periods of time at a particular place. But with awareness comes a responsibility to actively avoid contaminating new areas of military activity—especially areas known for their pristine character.

In addition to specific toxicities noted in the bullets above and in the Hazard Statements below, flare chemicals raise the pH of water. A dud flare, for example, "falling into a small, confined pond could raise the pH and adversely affect aquatic life in the water." (p. 4-53) *Technical Reports on Chaff and Flares. Technical Report No. 5. Laboratory Analysis of Chaff and Flare Materials. November 1994. Prepared for: U.S. Air Force Headquarters Air Combat Command Langley Air Force Base, Virginia.* https://www.globalsecurity.org/military/library/report/enviro/1993-03-01608_rpt5.pdf

The probability of a dud falling into water is often dismissed as remote—but according to the 1997 Air Force report the method used to calculate hazard probability is "designed to assess the likely occurrence of discreet events and does not readily accommodate cumulatively increasing probabilities." (p. 4-25) In other words, while the odds of one dud landing in water are remote, as more duds fall over time (1,500 over 10 years), the odds increase but the cumulative level of risk is not calculable. Duds (or their chemical components exposed over time) that already lie on steep slopes or in arroyos might be carried (transported) into permanent water features by intense runoff from downpours.

Flare Ash and Chemical Residue

Of the 15,000 flares discharged annually by F-16s training over the proposed Lobos MOA and adjacent areas, 14,850 flares can be expected to ignite, and release ash and toxic residue into the air. This material will fall to the ground, and over a 10-year period the ash and residue of 148,500 flares will accumulate.

The chemicals of greatest concern in ash and residue are:

- **Chromium Oxide (Cr_2O_3)**, which is toxic if swallowed, causes skin reaction and eye damage, and may harm fertility or an unborn child. It may oxidize to Chromium (Cr) and Cr persists in the environment and has serious adverse effects on freshwater life forms. See for example:
  https://www.ncbi.nlm.nih.gov/pubmed/16297546
  https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2860883/

- **Barium,** which in contact with water releases flammable gas that may ignite spontaneously. It also causes skin burns, eye damage, and respiratory irritation.

- **Boron (B),** which is toxic if swallowed and may be a long-term hazard to aquatic life. See for example:
  https://www.researchgate.net/profile/Romana_HornekGausterer/publication/47699733_Effects_assessment_Boron_compounds_in_the_aquatic_environment/links/5a850de7aca272c99ac39432/Effects-assessment-Boron-compounds-in-the-aquatic-environment.pdf

- **Magnesium Chloride ($MgCl_2$)**, which is toxic if swallowed, causes skin irritation, serious eye damage, and respiratory irritation, and may harm aquatic life. See for example:
  https://www.researchgate.net/publication/316490087_Effects_of_magnesium_chloride_road_deicer_on_montane_stream_benthic_communities

- ***Magnesium Oxide (MgO)***, which causes skin irritation, serious eye irritation and possible damage, as well as possible respiratory irritation, and is very toxic to aquatic life and aquatic environments with long-lasting effects.

A common assumption that flare chemicals are entirely consumed during their ignition in the air is not correct. The 1997 Air Force report states that the burned mass of a flare condenses in the air as particulate. It adds: "Since information related to the condensation phenomena and/or the particulate size generated during condensation was not available, it would be hard to speculate whether respirable particles (PM_{10}) are produced." (p. 4-47)

Chiricahua Leopard Frog

Image by Steve Collins

The issue of harmful effects of flare ash on air quality is sidestepped with an observation that the use of flares occurs "over large areas and over long periods of time, and are therefore not expected to result in noncompliance with the NAAQS." (p. 4-47)

Of course, the distribution of ash could still be localized within a larger area. The stated reliance on wind to dilute ash and residue is conjectural and requires further analyses. Granted the distribution of ash falling to the ground is probably difficult to model. There are a lot of variables: the altitude of discharge, the wind speed at the time of discharge, the number of flares discharged. Nevertheless, the effects of a toxic cloud of particulate falling on a hapless hiker, or a bird, or a frog beneath a flare discharge by an F-16, should at least be considered. The probability of being struck by a falling dud flare was modeled, for example, and a dud flare has a much smaller profile than a cloud.

While effects of flare ash and residue on air quality have not been analyzed in any quantitative manner, a little study has been directed towards the potential harms to fresh water:

- The literature is sparse, however. A 1993 report observed that: “Virtually no information is available on the effects of flares and flare by-products on water resources.” (p. 5-34) The same report also noted that: “The majority of documents that address the use of flares contain conclusions of no impact to earth and water resources, although there is no scientifically sound data to support these conclusions.” (p. 5-34*)* *Technical Reports on Chaff and Flares. Technical Report No. l. March 1993. Prepared for: U.S. Air Force Headquarters Air Combat Command Langley Air Force Base, Virginia*. https://www.globalsecurity.org/military/library/report/enviro/1993-03-01608_rpt1.pdf

- Unfortunately, the statement above is still largely true. Only a few studies have been cited by the Air Force. And they are not definitive. The 1994 report, for example, concluded that the results of tests specifically performed to address the question of aquatic harms “are inconclusive with respect to potential effects from flare ash on sensitive aquatic habitats, primarily because the toxicity levels to some aquatic organisms are so low.” (p. 3-8). The report calls for more studies.

  Note: To accurately measure a small effect statistically, a large sample size is required. Without a greater investment of time and money, the study will be underpowered—and likely be inaccurate.

  Note: More recent laboratory research by others shows clear toxic effects of MgO on fish embryos. https://www.sciencedirect.com/science/article/pii/S0147651315300555 Updates to the Air Force research efforts and broader search parameters would be appropriate.

- Given the observed data limitations and the known toxicities of the flare chemicals, the 1997 report calls for additional site specific analyses whenever flares will be used in the vicinity of small, confined fresh water aquatic environments with sensitive species and water bodies with significant waterfowl use or protected species.

Wilderness, Wilderness Study Areas, Wild and Scenic Rivers

Many flare chemicals are known to be toxic, some persist in the environment for long periods of time, and there are uncertainties about how these chemicals disperse:

- particulate size of the condensed residue is not calculable,
- dispersal patterns of ash and residue from flares discharged in the air are not modeled,

- some flare chemicals convert with exposure to water or heat into more toxic forms,
- reported analyses of ash and residue dose thresholds for aquatic environments seem to be inconclusive and/or the sample sizes are small, and
- cumulative level of risk from 150,000 flare discharges over 10 years apparently cannot be calculated.

Given these uncertainties and the acknowledged sensitivity of land and waters managed for wilderness, it is prudent to avoid any levels of contamination with the toxic residue of flares. Instead of seeking the precise point where a toxin kills L50 (50% of the life form analyzed) or causes mutations or cancers, the management objective should be no flare contamination at all—especially by toxins that accumulate over time.

To avoid conflict in areas managed for pristine natural values, the 1993 report recommended that the Air Force "avoid releasing chaff or flares over Wilderness Areas, Wild and Scenic Rivers, National Parks and Monuments, PSD Class 1 areas, and areas identified as Class I Visual Resource Management (BLM) or Preservation (U.S. Forest Service)." (p. 6-6)

The Air Force should follow that recommendation.

<u>Principal Toxic or Dangerous Components of MJU-7A/B Flares</u>

- **Barium Chromate ($BaCrO_4$)**

GHS Hazard Statements (GHS = Globally Harmonized Classification System)

Aggregated GHS information provided by 335 companies from notifications to the ECHA C&L Inventory. Each notification may be associated with multiple companies.
H272 (14.33%): May intensify fire; oxidizer [Danger Oxidizing liquids; Oxidizing solids]
H301 (21.79%): Toxic if swallowed [Danger Acute toxicity, oral]
H302 (67.76%): Harmful if swallowed [Warning Acute toxicity, oral]
H317 (16.72%): May cause an allergic skin reaction [Warning Sensitization, Skin]
H332 (87.16%): Harmful if inhaled [Warning Acute toxicity, inhalation]
H350 (17.31%): May cause cancer [Danger Carcinogenicity]
H400 (12.54%): Very toxic to aquatic life [Warning Hazardous to the aquatic environment, acute hazard]
H410 (12.84%): Very toxic to aquatic life with long lasting effects [Warning Hazardous to the aquatic environment, long-term hazard]
https://pubchem.ncbi.nlm.nih.gov/compound/barium_chromate#section=GHS-Classification

- **Boron (B)**

GHS Hazard Statements

Of the 9 notification(s) provided by 162 of 270 companies with hazard statement code(s):
H302 (96.91%): Harmful if swallowed [Warning Acute toxicity, oral]
H413 (10.49%): May cause long lasting harmful effects to aquatic life [Hazardous to the aquatic environment, long-term hazard]
https://pubchem.ncbi.nlm.nih.gov/compound/boron#section=Hazards-Identification

- **Potassium Perchlorate ($KClO_4$)**

GHS Hazard Statements

Aggregated GHS information provided by 137 companies from 7 notifications to the ECHA C&L Inventory. Each notification may be associated with multiple companies.
H272: May intensify fire; oxidizer [Danger Oxidizing liquids; Oxidizing solids]
H315: Causes skin irritation [Warning Skin corrosion/irritation]
H319: Causes serious eye irritation [Warning Serious eye damage/eye irritation]
H335: May cause respiratory irritation [Warning Specific target organ toxicity, single exposure; Respiratory tract irritation]
H373: Causes damage to organs through prolonged or repeated exposure [Warning]
[Danger Flammable solids]
H250 (42.78%): Catches fire spontaneously if exposed to air [Danger Pyrophoric liquids; Pyrophoric solids]
H252 (26.65%): Self-heating in large quantities; may catch fire [Warning Self-heating substances and mixtures]
H260 (48.16%): In contact with water releases flammable gases which may ignite spontaneously [Danger Substances And Mixtures Which, In Contact With Water, Emit Flammable Gases]
H261 (51.69%): In contact with water releases flammable gas [Danger Substances And Mixtures Which, In Contact With Water, Emit Flammable Gases]
https://pubchem.ncbi.nlm.nih.gov/compound/magnesium#section=Chemical-Dangers

Toxic or Dangerous Components of Residue of MJU-7A/B Flare Combustion

- **Barium (Ba)**

GHS Hazard Statements

Of the 16 notification(s) provided by 251 of 291 companies with hazard statement code(s):
H260 (13.15%): In contact with water releases flammable gases which may ignite spontaneously [Danger Substances And Mixtures Which, In Contact With Water, Emit Flammable Gases]
H261 (84.46%): In contact with water releases flammable gas [Danger Substances And Mixtures Which, In Contact With Water, Emit Flammable Gases]
H302 (27.49%): Harmful if swallowed [Warning Acute toxicity, oral]
H314 (29.48%): Causes severe skin burns and eye damage [Danger Skin corrosion/irritation]
H315 (56.97%): Causes skin irritation [Warning Skin corrosion/irritation]
H318 (29.48%): Causes serious eye damage [Danger Serious eye damage/eye irritation]
H319 (56.97%): Causes serious eye irritation [Warning Serious eye damage/eye irritation]
H332 (27.09%): Harmful if inhaled [Warning Acute toxicity, inhalation]
H335 (56.57%): May cause respiratory irritation [Warning Specific target organ toxicity, single exposure; Respiratory tract irritation]
https://pubchem.ncbi.nlm.nih.gov/compound/barium#section=GHS-Classification

- **Boron (B)**

GHS Hazard Statements

Of the 9 notification(s) provided by 162 of 270 companies with hazard statement code(s):
H302 (96.91%): Harmful if swallowed [Warning Acute toxicity, oral]
H413 (10.49%): May cause long lasting harmful effects to aquatic life [Hazardous to the aquatic environment, long-term hazard]
https://pubchem.ncbi.nlm.nih.gov/compound/boron#section=Hazards-Identification

Chromium (III) Oxide (Cr_2O_3)

GHS Hazard Statements

Of the 17 notification(s) provided by 507 of 1213 companies with hazard statement code(s):
H302 (49.9%): Harmful if swallowed [Warning Acute toxicity, oral]
H317 (60.75%): May cause an allergic skin reaction [Warning Sensitization, Skin]
H319 (51.28%): Causes serious eye irritation [Warning Serious eye damage/eye irritation]
H360 (35.7%): May damage fertility or the unborn child [Danger Reproductive toxicity]
https://pubchem.ncbi.nlm.nih.gov/compound/Chromium_III__oxide#section=Safety-and-Hazard

- **Chromium (Cr)**

GHS Hazard Statements

Of the 17 notification(s) provided by 860 of 1558 companies with hazard statement code(s):
H317 (34.77%): May cause an allergic skin reaction [Warning Sensitization, Skin]
H319 (41.74%): Causes serious eye irritation [Warning Serious eye damage/eye irritation]
H334 (34.65%): May cause allergy or asthma symptoms or breathing difficulties if inhaled [Danger Sensitization, respiratory]
H400 (14.88%): Very toxic to aquatic life [Warning Hazardous to the aquatic environment, acute hazard]
H410 (10.81%): Very toxic to aquatic life with long lasting effects [Warning Hazardous to the aquatic environment, long-term hazard]
https://pubchem.ncbi.nlm.nih.gov/compound/chromium#section=GHS-Classification

- **Magnesium Chloride ($MgCl_2$)**

GHS Hazard Statements

Of the 11 notification(s) provided by 468 of 1113 companies with hazard statement code(s):
H290 (76.07%): May be corrosive to metals [Warning Corrosive to Metals]
H302 (75.85%): Harmful if swallowed [Warning Acute toxicity, oral]
H315 (94.44%): Causes skin irritation [Warning Skin corrosion/irritation]
H318 (75.85%): Causes serious eye damage [Danger Serious eye damage/eye irritation]
H319 (23.72%): Causes serious eye irritation [Warning Serious eye damage/eye irritation]
H335 (21.58%): May cause respiratory irritation [Warning Specific target organ toxicity, single exposure; Respiratory tract irritation]
https://pubchem.ncbi.nlm.nih.gov/compound/magnesium_chloride#section=Safety-and-Hazards

- ***Magnesium Oxide (MgO)***

GHS Hazard Statement

Of the 16 notification(s) provided by 127 of 1144 companies with hazard statement code(s):
H315 (37.01%): Causes skin irritation [Warning Skin corrosion/irritation]
H317 (25.98%): May cause an allergic skin reaction [Warning Sensitization, Skin]
H319 (57.48%): Causes serious eye irritation [Warning Serious eye damage/eye irritation]
H335 (31.5%): May cause respiratory irritation [Warning Specific target organ toxicity, single exposure; Respiratory tract irritation]
H410 (36.22%): Very toxic to aquatic life with long lasting effects [Warning Hazardous to the aquatic environment, long-term hazard]
https://pubchem.ncbi.nlm.nih.gov/compound/magnesium_oxide#section=Safety-and-Hazards