DEPARTMENT OF THE NAVY
NAVAL AIR WEAPONS STATION
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IN REPLY REFER TO:
5090
Ser PR241/279
June 21, 2022

Mr. Elly Daoud
Department of Toxic Substance Control
8800 Cal Center Drive
Sacramento, CA 95826-3200

Dear Mr. Daoud:

SUBJECT: UPDATED OPEN BURN/OPEN DETONATION ALTERNATIVES

Alternative Report for the Burro Canyon Treatment Facility has been updated as required by the Hazardous Waste Facility Permit of July 13, 2018 issued to China Lake, specifically Open Burn Unit Special Condition Number 7 and Open Detonation Unit Special Condition Number 9. Enclosure (1) provides an updated Open Burn/Open Detonation Alternatives at Burro Canyon, Naval Air Weapons Station, China Lake.

If you have any questions or require additional information, please contact Ms. Donna J. Ogilvie at 760-939-3213 or via email at donna.j.ogilvie2.civ@us.navy.mil.

Sincerely,

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D. J. OGILVIE
Director, Installation Environmental Program
By direction of the
Commanding Officer

Enclosure: Updated OB/OD Alternatives at NAWS China Lake

Updated OB/OD Alternatives at NAWS China Lake 2022

prepared by

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April 6, 2022

Enclosure

CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to be the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

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Kara Lormand
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Naval Air Warfare Center Weapons Division
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Updated OB/OD Alternatives at NAWS China Lake 2022

The Hazardous Waste Permit issued to the Naval Air Weapons Station (NAWS) China Lake to operate the Burro Canyon Open Burn (OB)/Open Detonation (OD) Facility requires the Navy to submit a report on the status of Open Burn alternatives every two years to the California Department of Toxic Substances Control. (Reference 1) A literature search was conducted to review the state of the art on conventional munitions demilitarization. There have been two recent publications that discuss alternatives to OB/OD. The United Nations has issued the Third Edition of International Ammunition Technical Guidelines (IATG) 10.10, "Demilitarization, destruction and logistic disposal of conventional ammunition" in March 2021. (Reference 2) These guidelines give an overview of disposal methods for conventional ammunition, including treatment alternatives to OB/OD. An article entitled "Alternatives to Open Burning and Open Detonation: The Disparity Between HMA and Commercial Best Practices" was published in *The Journal of Conventional Weapons Destruction* in 2021 and written on behalf of Norwegian People's Aid (NPA). (Reference 3) This article discusses the importance of selecting the appropriate environmentally-friendly and safe method for conventional weapons treatment in the context of humanitarian mine action (HMA), but does not discuss any specific alternatives to OB/OD. The 2019 National Academies of Science, Engineering, and Medicine report on *Alternatives for the Demilitarization of Conventional Munitions* remains the definitive analysis of the various alternatives to OB/OD. (Reference 4) No new, mature technologies have been identified since NAWS China Lake's last report under the previous permit. (Reference 5)

Several factors are important in reviewing technologies for use in treating energetic waste, in order of importance: personal safety, environmental impact, throughput capacity, and cost. The waste stream produced at China Lake is large and varied because it is a research, development, test, and evaluation (RDT&E) facility. As such, the treatment methods must be flexible or multiple methods must be used. The National Academies report, IATG 10.10, and even the NPA article acknowledge that OB/OD cannot be completely replaced at this time due to safety issues in treating unstable energetic waste. As a research facility, NAWS China Lake will invariably generate waste that should be treated with a minimum of handling and as such will only be suitable for treatment using OB or OD. The NPA article emphasizes the importance of properly selecting the appropriate treatment technology based on the disposal objectives and the available data (i.e., location, munition, environmental concerns, safety, cost).

Categories of energetic waste that are treated at the Burro Canyon facility are: Laboratory Scrap, Laboratory Samples, Laboratory Ordnance, Laboratory Solvent, Standard Munitions, Non-Standard Munitions, and Contributory Munitions. The Laboratory Scrap category includes leftovers from energetic material preparation. The Laboratory Samples category includes small samples held for testing and observation purposes. It also includes materials contaminated during energetic material operations. The Laboratory Ordnance category includes novel RDT&E ordnance items, including those that have been damaged during testing. The Laboratory Solvent Category includes liquid materials that are or have been contaminated with energetic materials.

The Standard Munitions category includes ordnance items that are designated as waste due to being expired or excessed. The Non-Standard Munitions category includes ordnance items that have been utilized in testing in some fashion and are likely damaged or modified. The Contributory Munitions category includes those items used to facilitate detonation or ignition of the operation at Burro Canyon. These items are also known as Donor Munitions. The breakdown of categories treated at Burro Canyon, including the explosive weight, over the time period from January 2021 to December 2021 are shown in Table 1.

Table 1. Treatment of Energetic Materials at Burro Canyon January 2021 to December 2021

	Explosive Weight (lb)	Percent	Percent w/o Donor
Donor Munitions	11,592.9	29.6%	42.0%
Standard Munitions	83.5	0.2%	0.3%
Non-Standard Munitions	8,159.2	20.8%	29.6%
Lab Ordnance	2,222.0	5.7%	8.1%
Lab Samples	7,324.4	18.7%	26.6%
Lab Scraps	9,338.3	23.8%	33.9%
Lab Solvents	444.4	1.1%	1.6%
Total	39,164.7	100.0%	142.0%
Total (w/o Donor)	27,571.8	70.4%	100.0%

The primary alternatives for replacing OB and OD are Contained Burn (CB) and Contained Detonation (CD). These technologies are similar to OB/OD, but the waste material is burned or detonated inside a vessel and the gaseous waste products from the process are treated by a pollution abatement system before being released. The isolated location of the Burro Canyon Facility as well as the groundwater and geologic nature of the area in which it is located removes some of the impetus for using a confined system. In 2007 a Health Risk Assessment (HRA) for the Burro Canyon facility was conducted that determined that OD and OB at Burro Canyon were did not exceed the risk thresholds for human health. (Reference 6) In fact, in most categories, logistics were the limiting factor in determining how much can be treated by a substantial amount. A 2014 review of the HRA determined that a re-accomplishment of the HRA using then-current Office of Environmental Health Hazard Assessment risk characterization processes would not change in the cancer, chronic, and acute health risk results. (Reference 7) Additionally, the 2014 HRA determined that greenhouse gas emissions from the Burro Canyon facility would not cause an impact as defined under the 2010 California Environmental Quality Act, even when operating at the maximum allowed amount permitted under the Resource Conservation and Recovery Act.

There are various different configurations used in CB and CD. The National Academies report cites various Department of Defense (DoD) or other facilities that use CB, including a

demonstration facility for treating large tactical rocket motors that was utilized at China Lake as a demonstration project prior to 2014. The burn chamber was 15 feet in diameter by 80 feet in length. The facility was shut down after the demonstration because China Lake does not generate or store many large tactical motors. The primary challenge with designing a CB treatment for a RDT&E facility is that they are not as flexible as OB or OD and work best when targeted toward a specific munition or class of munitions. This is particularly true of larger munitions that must be prepared by removing some or all of the inert materials, such as the casing, before treatment by CB or CD. The Naval Air Warfare Center Weapons Division (NAWCWD), the primary tenant command at NAWS China Lake, issued a report in 2004 on the feasibility of various CB, CD, and other treatment options at NAWS China Lake and concluded that none of them treated enough of China Lake's waste stream to be feasible. (Reference 8) The technologies considered in the 2004 report are shown in Table 2. The list of destruction technologies considered mature in the 2004 report are the same technologies considered mature in the National Academies report and IATG 10.10.

Table 2. Technologies Considered in 2004 NAWCWD Report (Reference 7)

Technology	Maturity
Destruction technologies	
Contained Detonation	G
Contained Burn #1, Solid Rocket Motors	G
Contained Burn #2, Confined Burn Facility	G
Contained Burn #3, Energetic Contaminated Wastes	G
Incineration, Rotary Kiln	G
Incineration, Plasma Arc	G
Incineration, Fluidized Bed	G
Oxidation, Base Hydrolysis	G
Oxidation, Supercritical Water (Hydrothermal Oxidation)	G
Oxidation, Molten Salt	G
Oxidation, Electrochemical	R
Oxidation, Peroxydisulfate	R
Oxidation, Adams Sulfur	R
Molten Metal	R
Oxidation, Wet Air	R
Hypergolic Non-Detonative Neutralization	R
Charged Particle Beam	R

Green: Advanced development or is in use, included for further evaluation.

Red: Conceptual, laboratory, or bench scale development for application to energetic wastes, eliminated from further evaluation at this time.

The 2004 report categorized the energetic waste differently than the Burro Canyon facility currently does (see Table 1). The 2004 report used the categories Bulk Energetics (28% of the then-current waste stream), Small Cased (5%), Medium Cased (13%), and Large Cased (54%). These categories deal with the form factor of the energetic waste and were chosen because they encapsulate the methods needed to treat the energetic waste, all other considerations being equal. The Burro Canyon facility's current categories deal with the source of the waste and are used because they inform the facility about the stability of the waste and the safety of handling it. Both methods of categorization are useful, but are not easily interchangeable without going through the list of items individually.

The 2004 report eliminated all the immature technologies. It also eliminated the oxidation technologies and the fluidized bed incineration technology for being only applicable to a portion of the bulk energetics waste stream, which were judged to be too small of a portion of China Lake's waste stream. The total bulk energetics waste stream was 28% at the time—it varies from year to year. Bulk energetics would fall into the Lab Samples and Lab Scraps categories in Table 1, but they also contain contaminated wastes that might require for some pre-treatment in order to be treated by these technologies. The 2004 report also eliminated the solid rocket motor CB technology because it treated too small a portion of the waste stream. The CB facility demonstrated at China Lake mentioned above was this type of facility sized for large motors and was discontinued after the demonstration due to lack of potential usage. This type of CB was also eliminated because it would not be appropriate for experimental ordnance (such as the Lab Ordnance in Table 1) or damaged ordnance (such as the Non-Standard Munitions in Table 1) because either of these types of wastes are potentially dangerous due to potential detonations or abnormal ignitions. The CB technology for energetic contaminated wastes was eliminated in the 2004 report because it was only useable for a small portion of the bulk energetics waste stream.

The 2004 report judged that using CD technology could treat 54% of the energetic waste and that 42% of the waste could be treated using CB, rotary kiln, or plasma arc incineration. However, these amounts would vary widely from year to year. In addition, only the Standard Munition category of waste (0.3% of the non-Donor waste in Table 1) could be shipped outside of NAWS China Lake to a facility that utilized one of these technologies. The other items, each unique due to the nature of RDT&E, require an Interim Hazard Classification (IHC) for each item, which is not only cost prohibitive to obtain, but causes unneeded safety concerns due to the added storage time needed to obtain each IHC. As mentioned, this value would fluctuate substantially from year to year. This can be seen by comparing the amount of non-Donor Standard Munitions in Table 1 (0.3%) to the value reported in the 2020 China Lake Alternative Technologies Report (24.8%). Even with an on-site facility, using laboratory or damaged ordnance in a confined system substantially increases the safety risk because the detonation and unintentional reaction risk increases substantially in a confined system versus an unconfined system. Bulk energetics could potentially be processed in such an on-site system, but only that

portion of the waste stream that is well-characterized in order to avoid detonations in a CB facility or excessive damage to a CD facility due to unexpected behavior of the waste items.

Other technologies are also required for CB/CD systems because the destruction takes place within a vessel of a fixed volume. Many ordnance items require additional handling to disassemble them or remove the energetic material prior to CB/CD. Doing this by hand increases the risk of personal safety. There are various technologies that can be used to more safely cut or break up energetic materials for treatment in smaller quantities. These include: cryo-fracture, liquid jet cutting, super-critical and fluid extraction. However, these methodologies need to be specialized for specific munitions or waste items and are not very adaptable to a waste stream made of a large number of various different, often unique, items.

There are a number of "non-incineration" methodologies for treating energetic hazardous wastes, some of which were examined in the 2004 report. These methodologies use a chemical and/or physical process other than combustion to break down energetic materials. These processes include: photocatalytic, ultrasonic, and bio-degradation treatments. Those technologies not mentioned in the 2004 report, but mentioned in the National Academies report, are in the early stages of development. They also require the energetic material be slurried in a liquid and are not suitable for use on raw munitions without sometimes extensive preparations to remove the hazardous material.

Also mentioned are explosive removal methods that "wash out" or "melt out" the explosive material from the munition. IATG 10.10 mentions microwave melt out in the footnotes as a new potential melt out method for meltable explosive material (e.g., TNT). These methods have the advantage of recovering some of the explosive material for reuse or easier treatment. However, these methods depend on the specific explosive material used in the munition and work best when a large number of identical munitions need to be treated. The RDT&E nature of NAWS China Lake generally precludes the feasibility of these methods as there are not a large number of identical munitions to operate upon. This is especially apparent when examining Table 1 where all types of Standard Munitions were only 0.3% of the energetic material treated at Burro Canyon in 2021.

In summary, no new alternative technology for treating energetic waste at China Lake is available. Re-examining older alternative technologies, there is no one alternative or set of alternatives that would completely replace OB/OD at China Lake. Furthermore, there is a substantial amount of the energetic waste generated at China Lake that could not be shipped off-site or treated using existing technology other than OB/OD. It is difficult to determine how much of China Lake's energetic waste stream could be treated by an alternative technology such as CB or CD because the type and amount of energetic material differs greatly from year to year, but a generous estimate places it at 54% with some heavy caveats based on the 2004 report, but it could be significantly lower some years. Based on the previous calendar year (January to

December 2021), only 0.3% of the energetic waste falls into the category of Standard Munition and may be suitable for off-site treatment.

References

[1] NAWS China Lake, Hazardous Waste Facility Permit. EPA ID Number CA2170023152. July 13, 2018.

[2] United Nations Office for Disarmament Affairs. March 2021. *International Ammunition Technical Guidelines 10.10: Demilitarization, destruction and logistic disposal of conventional ammunition.* Third Edition. http://data.unsaferguard.org/iatg/en/IATG-10.10-Demilitarization-destruction-logistic-disposal-IATG-V.3.pdf.

[3] Cottrell, Linsey and Dupuy, Kendra. "Alternatives to Open Burning and Open Detonation: The Disparity Between HMA and Commercial Best Practices." *The Journal of Conventional Weapons Destruction*. Vol 25. Iss 1. 2021. https://commons.lib.jmu.edu/cisr-journal/vol25/iss1/22.

[4] National Academies of Science, Engineering and Medicine. 2019. *Alternatives for the Demilitarization of Conventional Munitions.* Washington, DC: The National Academies Press. doi: https://doi.org/10.17226/25140.

[5] Goodman, Benjamin T. "Updated OB/OD Alternatives at NAWS China Lake." Attachment to Serial Letter D556400/2443. Naval Air Warfare Center Weapons Division. China Lake, CA. August 25, 2020.

[6] URS Group. "Burro Canyon Open Burn/Open Detonation Health Risk Assessment for Naval Air Weapons Station China Lake." Santa Ana, CA. August 2007.

[7] URS Group. "Naval Air Weapons Station China Lake Burro Canyon Treatment Facility Open Burn/Open Detonation Units Health Risk Assessment Report Greenhouse Gas Emissions Evalutation." Santa Ana, CA. January 2014.

[8] Naval Air Warfare Center Weapons Division. "Evaluation of Alternative Technologies to Open Detonation for Treatment of Energetic Wastes at the Naval Air Weapons Station, China Lake, California." NAWCWD TP 8559. China Lake, CA. January 2004.

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