

STATE OF SOUTH DAKOTA
OFFICE OF PROCUREMENT MANAGEMENT
523 EAST CAPITOL AVENUE
PIERRE, SOUTH DAKOTA 57501-3182

South Dakota's Mount Rushmore Fireworks Celebration
PROPOSALS ARE DUE NO LATER THAN 5:00 PM CST, MARCH 13, 2020

RFP #: 1936

BUYER: Wanda Goodman, South Dakota
Department of Tourism

EMAIL:
wanda.goodman@travelsouthdakota.com

READ CAREFULLY

FIRM NAME: _____ AUTHORIZED SIGNATURE: _____

ADDRESS: _____ TYPE OR PRINT NAME: _____

CITY/STATE: _____ TELEPHONE NO: _____

ZIP (9 DIGIT): _____ FAX NO: _____

FEDERAL TAX ID#: _____ E-MAIL: _____

PRIMARY CONTACT INFORMATION

CONTACT NAME: _____ TELEPHONE NO: _____

FAX NO: _____ E-MAIL: _____

1.0 GENERAL INFORMATION

1.1 PURPOSE OF REQUEST FOR PROPOSAL (RFP)

The State of South Dakota (State) is seeking proposals from qualified contractors to provide all materials and services necessary to produce an innovative, dynamic, and safe Independence Day aerial fireworks display at Mount Rushmore National Memorial on July 3, 2020, in accordance with the terms, conditions, and specifications contained in this Request for Proposals.

1.2 ISSUING OFFICE AND RFP REFERENCE NUMBER

The South Dakota Department of Tourism is the issuing office for this document and all subsequent addenda relating to it, on behalf of the State of South Dakota. The reference number for the transaction is RFP #1936. This number must be referred to on all proposals, correspondence, and documentation relating to the RFP.

1.3 SCHEDULE OF ACTIVITIES (SUBJECT TO CHANGE)

RFP Publication	February 14, 2020
Deadline for Scheduling of Site Visits	February 20, 2020 by 5 p.m. CST
Deadline for Completion of Site Visits	March 5, 2020
Deadline for Submission of Written Inquiries	March 9, 2020
Responses to Offeror Questions	March 11, 2020
Proposal Submission	March 13, 2020 by 5 p.m. CST
Oral Presentations/discussions (if required)	Week of March 23, 2020
Anticipated Award Decision/Contract Negotiation	Week of March 30, 2020

1.4 SITE VISITS

Site visits to Mount Rushmore National Memorial will be allowed up until March 5, 2020. To schedule a visit, offerors should contact Wanda Goodman at wanda.goodman@travelsouthdakota.com or 605-773-5328 by end of business on February 20.

1.5 SUBMITTING YOUR PROPOSAL

All proposals must be completed and received in the South Dakota Department of Tourism by the date and time indicated in the Schedule of Activities **(5:00 p.m. CST, March 13, 2020)**.

Proposals received after the deadline will be late and ineligible for consideration.

An original and 10 identical copies of the proposal shall be submitted.

The cost proposal must be in a separate sealed envelope and labeled “Cost Proposal”.

All proposals must be signed, in ink, by an officer of the responder, legally authorized to bind the responder to the proposal, and sealed in the form intended by the respondent. Proposals that are not properly signed may be rejected. The sealed envelope must be marked with the appropriate RFP Number and Title. The words “Sealed Proposal Enclosed” must be prominently denoted on the outside of the shipping container. **Proposals must be addressed and labeled as follows:**

**REQUEST FOR PROPOSAL #1936
PROPOSAL DUE MARCH 13, 2020
BUYER WANDA GOODMAN
SOUTH DAKOTA DEPARTMENT OF TOURISM
711 EAST WELLS AVENUE
PIERRE SD 57501**

All capital letters and no punctuation are used in the address. The Department of Tourism address as displayed should be the only information in the address field.

No proposal shall be accepted from, or no contract or purchase order shall be awarded to any person, firm or corporation that is in arrears upon any obligations to the State of South Dakota, or that otherwise may be deemed irresponsible or unreliable by the State of South Dakota.

1.6 CERTIFICATION REGARDING DEBARMENT, SUSPENSION, INELIGIBILITY AND VOLUNTARY EXCLUSION – LOWER TIER COVERED TRANSACTIONS

By signing and submitting this proposal, the offeror certifies that neither it nor its principals is presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from participation, by any Federal department or agency, from transactions involving the use of Federal funds. Where the offeror is unable to certify to any of the statements in this certification, the bidder shall attach an explanation to their offer.

1.7 NON-DISCRIMINATION STATEMENT

The State of South Dakota requires that all contractors, vendors, and suppliers doing business with any State agency, department, or institution, provide a statement of non-discrimination. By signing and submitting their proposal, the offeror certifies they do not discriminate in their employment practices with regard to race, color, creed, religion, age, sex, ancestry, national origin or disability.

1.8 RESTRICTION OF BOYCOTT OF ISRAEL

For contractors, vendors, suppliers, or subcontractors with five (5) or more employees who enter into a contract with the State of South Dakota that involves the expenditure of one hundred thousand dollars (\$100,000) or more, by submitting a response to this solicitation or agreeing to contract with the State, the bidder or offeror certifies and agrees that the following information is correct:

The bidder or offeror, in preparing its response or offer or in considering proposals submitted from qualified, potential vendors, suppliers, and subcontractors, or in the solicitation, selection, or commercial treatment of any vendor, supplier, or subcontractor, has not refused to transact business activities, has not terminated business activities, and has not taken other similar actions intended to limit its commercial relations, related to the subject matter of the bid or offer, with a person or entity on the basis of Israeli national origin, or residence or incorporation in Israel or its territories, with the specific intent to accomplish a boycott or divestment of Israel in a discriminatory manner. It is understood and agreed that, if this certification is false, such false certification will constitute grounds for the State to reject the bid or response submitted by the bidder or offeror on this project and terminate any contract awarded based on the bid or response. The successful bidder or offeror further agrees to provide immediate written notice to the contracting executive branch agency if during the term of the contract it no longer complies with this certification and agrees such noncompliance may be grounds for contract termination.

1.9 MODIFICATION OR WITHDRAWAL OF PROPOSALS

Proposals may be modified or withdrawn by the offeror prior to the established due date and time.

No oral, telephonic, telegraphic or facsimile responses or modifications to informal, formal bids, or Request for Proposals will be considered.

1.10 OFFEROR INQUIRIES

Offerors may submit inquiries concerning this RFP to obtain clarification of requirements. No inquiries will be accepted after the date and time indicated in the Schedule of Activities (**March 09, 2020**). Email inquiries must be sent to Wanda Goodman at Wanda.Goodman@TravelSouthDakota.com with the subject line "RFP #1936". No phone, fax or mail inquiries accepted.

All offerors will be informed of any inquiries and the State's response. Inquiries/questions and responses will be posted at www.SDVisit.com/RFP.

Offerors may not rely on any other statements, either of a written or oral nature, that alter any specification or other term or condition of this RFP. Offerors will be notified on the State's procurement website (<https://boa.sd.gov/central-services/procurement-management/procurement-management-vendorInfo.aspx>) regarding any modifications to this RFP. Click on the "Central Bid Exchange" link.

1.11 PROPRIETARY INFORMATION

The proposal of the successful offeror(s) becomes public information. Proprietary information can be protected under limited circumstances such as client lists and non-public financial statements. Pricing and service elements are not considered proprietary. An entire proposal may not be marked as proprietary. Offerors must clearly identify in the Executive Summary and mark in the body of the proposal any specific proprietary information they are requesting to be protected. The Executive Summary must contain specific justification explaining why the information is to be protected. Proposals may be reviewed and evaluated by any person at the discretion of the State. All materials submitted become the property of the State of South Dakota and may be returned only at the State's option.

1.12 LENGTH OF CONTRACT

The anticipated length of the contract is approximately **SIX (6)** months. The contract will commence on approximately April 6, 2020, and end on September 30, 2020, with customary provisions for early termination based upon performance.

1.13 GOVERNING LAW

Venue for any and all legal action regarding or arising out of the transaction covered herein shall be solely in the State of South Dakota. The laws of South Dakota shall govern this transaction.

1.14 DISCUSSIONS WITH OFFERORS (ORAL PRESENTATION/NEGOTIATIONS)

An oral presentation by an offeror to clarify a proposal may be required at the sole discretion of the State. However, the State may award a contract based on the initial proposals received without discussion with the Offeror. If oral presentations are required, they will be scheduled after the submission of proposals. Oral presentations will be made at the offeror's expense.

This process is a Request for Proposal/Competitive Negotiation process. Each Proposal shall be evaluated, and each respondent shall be available for negotiation meetings at the State's request. The State reserves the right to negotiate on any and/or all components of every proposal submitted. From the time the proposals are submitted until the formal award of a contract, each proposal is considered a working document and as such, will be kept confidential. The negotiation discussions will also be held as confidential until such time as the award is completed.

2.0 STANDARD CONTRACT TERMS AND CONDITIONS

Any contract or agreement resulting from this RFP will include the State's standard terms and conditions as listed below, along with any additional terms and conditions as negotiated by the parties:

- 2.1** The Contractor will perform those services described in the Scope of Work, attached hereto as Section 3 of the RFP and by this reference incorporated herein.
- 2.2** The Contractor's services under this Agreement shall commence on April 6, 2020, and end on September 30, 2020, unless sooner terminated pursuant to the terms hereof.
- 2.3** The Contractor will not use State equipment, supplies or facilities. The Contractor will provide the State with its Employer Identification Number, Federal Tax Identification Number or Social Security Number upon execution of this Agreement.
- 2.4** The State will make payment for services upon satisfactory completion of the services. The TOTAL CONTRACT AMOUNT is an amount up to, and not to exceed, \$350,000. The State will not pay Contractor's expenses as a separate item. Payment will be made pursuant to itemized invoices submitted with a signed state voucher. Payment will be made consistent with SDCL ch. 5-26.
- 2.5** The Contractor agrees to indemnify and hold the State of South Dakota, its officers, agents and employees, harmless from and against any and all actions, suits, damages, liability or other proceedings that may arise as the result of performing services hereunder. This section does not require the Contractor to be responsible for or defend against claims or damages arising solely from errors or omissions of the State, its officers, agents or employees.
- 2.6** The Contractor, at all times during the term of this Agreement, shall obtain and maintain in force insurance coverage of the types and with the limits as follows:
 - A. Commercial General Liability Insurance:**

The Contractor shall maintain occurrence based commercial general liability insurance or equivalent form with a limit of not less than \$1,000,000.00 for each occurrence. If such insurance contains a general aggregate limit it shall apply separately to this Agreement or be no less than two times the occurrence limit.
 - B. Professional Liability Insurance or Miscellaneous Professional Liability Insurance:**

The Contractor agrees to procure and maintain professional liability insurance or miscellaneous professional liability insurance with a limit not less than \$1,000,000.00.
 - C. Business Automobile Liability Insurance:**

The Contractor shall maintain business automobile liability insurance or equivalent form with a limit of not less than \$1,000,000.00 for each accident. Such insurance shall include coverage for owned, hired and non-owned vehicles.

D. Worker's Compensation Insurance:

The Contractor shall procure and maintain workers' compensation and employers' liability insurance as required by South Dakota law.

Before beginning work under this Agreement, Contractor shall furnish the State with properly executed Certificates of Insurance which shall clearly evidence all insurance required in this Agreement. The Contractor shall also add South Dakota state employees, officers, and assigns as additional named insureds. The Contractor shall also add Department of Interior and National Park Service employees, officers, and assigns as additional named insureds. In the event a substantial change in insurance, issuance of a new policy, cancellation or nonrenewal of the policy, the Contractor agrees to provide immediate notice to the State and provide a new certificate of insurance showing continuous coverage in the amounts required. Contractor shall furnish copies of insurance policies if requested by the State.

- 2.7** While performing services hereunder, the Contractor is an independent contractor and not an officer, agent, or employee of the State of South Dakota or the National Park Service.
- 2.8** Contractor agrees to report to the State any event encountered in the course of performance of this Agreement which results in injury to the person or property of third parties, or which may otherwise subject Contractor or the State to liability. Contractor shall report any such event to the State immediately upon discovery.
- Contractor's obligation under this section shall only be to report the occurrence of any event to the State and to make any other report provided for by their duties or applicable law. Contractor's obligation to report shall not require disclosure of any information subject to privilege or confidentiality under law (e.g., attorney-client communications). Reporting to the State under this section shall not excuse or satisfy any obligation of Contractor to report any event to law enforcement or other entities under the requirements of any applicable law.
- 2.9** This Agreement may be terminated by either party hereto upon thirty (30) days written notice. In the event the Contractor breaches any of the terms or conditions hereof, this Agreement may be terminated by the State at any time with or without notice. If termination for such a default is effected by the State, any payments due to Contractor at the time of termination may be adjusted to cover any additional costs to the State because of Contractor's default. Upon termination the State may take over the work and may award another party an agreement to complete the work under this Agreement. If after the State terminates for a default by Contractor it is determined that Contractor was not at fault, then the Contractor shall be paid for eligible services rendered and expenses incurred up to the date of termination.
- 2.10** This Agreement depends upon the continued availability of appropriated funds and expenditure authority from the Legislature for this purpose. If for any reason the Legislature fails to appropriate funds or grant expenditure authority, or funds become unavailable by operation of law or federal funds reductions, this Agreement will be terminated by the State. Termination for any of these reasons is not a default by the State nor does it give rise to a claim against the State.

- 2.11** This Agreement may not be assigned without the express prior written consent of the State. This Agreement may not be amended except in writing, which writing shall be expressly identified as a part hereof and be signed by an authorized representative of each of the parties hereto.
- 2.12** This Agreement shall be governed by and construed in accordance with the laws of the State of South Dakota. Any lawsuit pertaining to or affecting this Agreement shall be venued in Circuit Court, Sixth Judicial Circuit, Hughes County, South Dakota.
- 2.13** The Contractor will comply with all federal, state and local laws, regulations, ordinances, guidelines, permits and requirements applicable to providing services pursuant to this Agreement, and will be solely responsible for obtaining current information on such requirements.
- 2.14** The Contractor may not use subcontractors to perform the services described herein without the express prior written consent of the State. The Contractor will include provisions in its subcontracts requiring its subcontractors to comply with the applicable provisions of this Agreement, to indemnify the State, and to provide insurance coverage for the benefit of the State in a manner consistent with this Agreement. The Contractor will cause its subcontractors, agents, and employees to comply, with applicable federal, state and local laws, regulations, ordinances, guidelines, permits and requirements and will adopt such review and inspection procedures as are necessary to assure such compliance.
- 2.15** Contractor hereby acknowledges and agrees that all reports, plans, specifications, technical data, miscellaneous drawings, software system programs and documentation, procedures, or files, operating instructions and procedures, source code(s) and documentation, including those necessary to upgrade and maintain the software program, and all information contained therein provided to the State by the Contractor in connection with its performance of services under this Agreement shall belong to and is the property of the State and will not be used in any way by the Contractor without the written consent of the State. Papers, reports, forms, software programs, source code(s) and other material which are a part of the work under this Agreement will not be copyrighted without written approval of the State.
- 2.16** The Contractor certifies that neither Contractor nor its principals are presently debarred, suspended, proposed for debarment or suspension, or declared ineligible from participating in transactions by the federal government or any state or local government department or agency. Contractor further agrees that it will immediately notify the State if during the term of this Agreement Contractor or its principals become subject to debarment, suspension or ineligibility from participating in transactions by the federal government, or by any state or local government department or agency.
- 2.17** Any notice or other communication required under this Agreement shall be in writing and sent to the address set forth above. Notices shall be given by and to Wanda Goodman on behalf of the State, and by an authorized designee on behalf of the Contractor, or such authorized designees as either party may from time to time designate in writing. Notices or communications to or between the parties shall be deemed to have been delivered when mailed by first class mail, provided that notice of default or termination shall be sent by registered or certified mail, or, if personally delivered, when received by such party.
- 2.18** In the event that any court of competent jurisdiction shall hold any provision of this Agreement unenforceable or invalid, such holding shall not invalidate or render unenforceable any other provision hereof.
- 2.19** All other prior discussions, communications and representations concerning the subject matter of this Agreement are superseded by the terms of this Agreement, and except as specifically

provided herein, this Agreement constitutes the entire agreement with respect to the subject matter hereof.

3.0 PROPOSAL REQUIREMENTS, COMPANY QUALIFICATIONS, AND SCOPE OF WORK

Design and furnish a custom Aerial Fireworks Display (Display) at Mount Rushmore National Memorial, permitted by the National Park Service. The Display shall consist of a grand opening, aerial and/or proximate pyrotechnic display and grand finale. The Display to be provided by the vendor shall include all labor, equipment, materials and other miscellaneous items necessary to provide a first-class aerial firework display, and includes transportation, set-up, firing, and clean-up of the area. The offeror shall provide all services in a professional manner by trained, certified, and qualified employees. The offeror shall have primary responsibility for safety.

The offeror is cautioned that it is the offeror's sole responsibility to submit information related to the evaluation categories and that the State of South Dakota is under no obligation to solicit such information if it is not included with the proposal. The offeror's failure to submit such information may cause an adverse impact on the evaluation of the proposal.

Offeror's Contacts: Offerors and their agents (including subcontractors, employees, consultants, or anyone else acting on their behalf) must direct all their questions or comments regarding the RFP, the evaluation, etc. to the buyer of record indicated on the first page of this RFP. Offerors and their agents may not contact any state employee other than the buyer of record regarding any of these matters during the solicitation and evaluation process. Inappropriate contacts are grounds for suspension and/or exclusion from specific procurements. Offerors and their agents who have questions regarding this matter should contact the buyer of record.

The offeror may be required to submit a copy of their most recent audited financial statements upon the State's request.

3.1 COMPANY BACKGROUND AND STAFF

- 3.1.1** Provide a brief summary of the history of your company, including the number of years of pyrotechnic experience and a list of past pyrotechnic shows you have produced in the last five years.
- 3.1.2** Provide the resume of the Chief Pyrotechnic to be assigned to this display.
- 3.1.3** Provide the number of people who will be assigned to this display, and their qualifications.

3.2 REFERENCES

- 3.2.1** Provide the following information related to at least three previous and current service/contracts, performed by the offeror's organization, which are similar to the requirements of this RFP. Provide this information for any service/contract that has been terminated, expired or not renewed in the past three years.
 - a. Name, address and telephone number of client/contracting agency and a representative of that agency who may be contacted for verification of all information submitted;
 - b. Dates of the service/contract; and

- c. A brief, written description of the specific prior services performed and requirements thereof.

3.3 THE SHOW DESIGN PROCESS

- 3.3.1** The State of South Dakota and the contractor will collaborate to design the Display using the most cost-effective means by limiting the need for travel to South Dakota. There will be a need for an initial meeting between the prime contractor and the State to discuss ideas using the information from the contractor's proposal as well as for the State to lay out the minimum requirements by which the contractor shall abide. After the initial meeting, the contractor and the State may converse and discuss refining ideas by telephone, email and web meeting.
- 3.3.2** The Display may be influenced by a host of community leaders, government officials, corporate sponsors and a team of creative National Park Service (NPS) and State of South Dakota employees who will be coordinating the event. If there are any changes as a result of outside influences, these changes will be coordinated by the State team through a Contracting Officer (CO). As outside influences dictate, the State may request that the contractor make major revisions to the requirements and undertake many design evaluation processes. Therefore, the contractor must be flexible, innovative and adaptable to changing situations. The contractor may be called upon for professional information and guidance to aid the State team. Also, the contractor must be able to work and cooperate with other contractors and vendors.

3.4 FIREWORKS

- 3.4.1** Fireworks are to be conducted in support of and in conformance with the current requirements of National Park Service Guideline 53, Appendix 16, Exhibit 1, Special Park Uses: Special Events: Fireworks Displays; ANSI / NFPA 1123, Outdoor Display of Fireworks; NFPA 1124, Manufacture, Transportation and Storage of Fireworks; NFPA 1126, Pyrotechnics Before a Proximate Audience; and applicable requirements for the State of South Dakota and the Black Hills National Forest, which include SDCL 34-37 Fireworks and SDCL 34-35 Range and Forest Fire Prevention.
- 3.4.2** The State requires a firework display program, the objective of which shall be to create a spectacular, continuous, aerial fireworks display at Mount Rushmore National Memorial. To achieve this objective safely, the contractor must become familiar with and adhere to the following exhibits in the appendix. Any proposed deviation from these exhibits must be raised to the State and NPS for discussion prior to award.

Exhibit A – Mount Rushmore Fireworks & Pyrotechnics Code & Best Practices Evaluation
Exhibit B – Additional considerations for Mount Rushmore Fireworks contractor/operator
Exhibit C – Code recommendations and permit requirements

- 3.4.3** The firework display should have a patriotic theme in celebration of Independence Day.

3.5 MUSIC

- 3.5.1** The Display may be choreographed to music that is upbeat, contemporary and patriotic, and be choreographed so that the display complements the music. The music will be selected in conjunction with and approved by the State. The music for the show should be available in a digital medium that can be simulcast through an outdoor performance sound system. The music should be; mixed in accordance with industry standards, utilize

fade in/out where appropriate, music styles and tempos should be complementary as they transition (should not be abrupt), and the music should have a seamless and logical flow from beginning to end. At least four backup versions of the audio music files must be made available to the State in a digital format. The music selection will be based on final determination of a submitted sample, by the designated State representative.

3.6 PERFORMANCE REQUIREMENTS

- 3.6.1** The length of time for the July 3 display shall be no less than 15 minutes and no more than 30 minutes of continuous firing.
- 3.6.2** The Display shall include enough shells and other articles pyrotechnic to fill at least a 15-minute display period. Shells, mortars and other articles pyrotechnic shall follow the recommendations and restrictions brought forth in exhibits A and B, unless expressly permitted by the NPS. Innovation and creativity on the part of the contractor, contributing to the enhancement of the program, is encouraged.
- 3.6.3** Shells shall be distributed within the following segments: opening, main body, and finale, as requested by the State. Criteria for the show design will include the addition of color, variety and specialty shells.
- 3.6.4** Aerial fireworks shall be constructed of 100% biodegradable casings, tapes, glues and strings (paper, cardboard, wheat paste, cotton, flax, etc.).
- 3.6.5** Contractor will be required to provide Safety Data Sheets (SDS) for chemicals used in the park.
- 3.6.6** Substitutions shall not be made after award of the contract unless approved by the CO. Failure to provide exact brand, size, effect, country of origin, date of manufacture and quantity of shells as submitted in the final proposal may result in reduction in payment. Shells of a lesser value shall not be accepted unless approved by the CO.

3.7 OPERATIONAL SET UP

- 3.7.1** The contractor shall be responsible for the complete installation and cleanup of the display and supplying all necessary material in connection therewith.
- 3.7.2** The display shall be conducted in accordance with current: NFPA 1123, 1124, and other applicable codes of the National Fire Protection Association. The Contractor shall inform the CO of any deviations from NFPA 1123, 1124, and/or other applicable NFPA codes, or the suggested actions and specifications as listed in these guidelines. This modification shall be made if deviations occur in the original proposal and at any time after award.
- 3.7.3** Mortars shall be installed in heavy duty above ground, square tube metal frame mortar rack holders in accordance with current NFPA standards and as described on page 115 of Exhibit A, unless otherwise expressly permitted by the NPS.
- 3.7.4** No direct attachment to natural stone, vegetation, or infrastructure will be allowed, unless expressly permitted by the NPS.

3.8 FIREWORKS AREA

- 3.8.1 A proposed layout based on the approved launch sites in Exhibits A and B shall be included with the offeror's proposal. The fireworks launch sites shall be limited to the areas specified by the information in Exhibits A and B.
- 3.8.2 Should the State change the fireworks area, the final layout diagram will be provided to the contractor by the CO.
- 3.8.3 The contractor must submit for the approval of the CO, diagrams showing final layout at the fireworks area specified by exhibits A and B, indicating placement of mortars and plans showing construction details of mortar racks or mortar boxes and diagrams of electrical circuits from the power source to the electric matches.
- 3.8.4 No permanent changes shall be made to the area used as a firework launch site.

3.9 MORTAR SEPARATION DISTANCES

- 3.9.1 The safety zone surrounding the fireworks area for all aerial displays shall be a minimum of the current NFPA 1123, as applicable, for recommended distances from the various shell sizes to the edge of the display site. The State and NPS shall provide contractors with maps of spectator viewing areas and bulk fuel storage locations to be considered in determining minimum separation distance analyses.

3.10 PERFORMANCE TIME

- 3.10.1 The fireworks display shall commence at approximately **9:45 p.m., July 3, unless otherwise stated by the CO**. The exact firing time and command shall be given by the CO or Contracting Officer's Representative (COR) onsite.
- 3.10.2 In the event of inclement weather, the display will be cancelled and not rescheduled. The decision to cancel the display shall be made by the State and NPS Incident Command Team. An Incident Commander will be on site to communicate this decision.
- 3.10.3 In the event the display is cancelled due to circumstances beyond the NPS' or State's control, the contractor shall be notified through the CO, COR or Incident Commander.

3.11 CONTRACTOR REQUIREMENTS

- 3.11.1 Once a contract has been issued, the contractor is required to provide the performance bond for 100 percent of the price. Then the contractor is to provide the remaining deliverables for the show. Throughout the life of the contract the State may adjust the show.
- 3.11.2 Prospective offerors shall include, in their proposals, options for delivery, storage, set-up and execution of the fireworks. Additionally, all offers shall include proposals for cleaning debris resulting from the explosives from Mount Rushmore National Memorial and the debris field/fall-out area.
- 3.11.3 Identify the number of personnel and associated labor costs for contractor-provided staff to perform inspection (a.k.a. "sweep") and reporting to the NPS of unexploded ordnance or lack thereof of specified areas immediately following the conclusion of the display. Performance of this inspection and reporting must meet NPS requirements for providing clearance to the public watching the display to use area roadways and pedestrian

walkways to leave the affected areas of concern. A second inspection and reporting may be performed of designated areas the next day during specified daylight hours.

- 3.11.4 The contractor shall gather any other trash and debris generated by the contractor's personnel or activities and place in appropriate trash containers.
- 3.11.5 The contractor shall provide enough trained and rested employees to commence cleanup of Mount Rushmore National Memorial following the conclusion of the display so that the Memorial can be opened to the public the morning following the firing of the display.
- 3.11.6 Launch site(s) shall always be kept free of litter and debris.
- 3.11.7 No hazardous materials or hazardous waste shall be disposed of as refuse. The contractor is responsible for the proper removal of hazardous materials/waste from the site.
- 3.11.8 Debris and litter shall be picked up in the launch site(s). No litter and debris shall be on the grounds at the end of each set-up day.
- 3.11.9 The contractor shall return the site condition to as it was prior to taking control of the area.
- 3.11.10 All cleanup efforts shall be completed within five (5) days of the show or as directed by the CO.

3.12 TRANSPORTATION OF FIREWORKS

- 3.12.1 The transportation of fireworks shall be in compliance with NFPA 1124, applicable regulations of the U.S. Department of Transportation, 41CFR, Part 170-189 and Part 390-399, and all state and local motor vehicle laws and regulations applicable to the area through which the fireworks are transported. Any person importing, manufacturing for commercial use, dealing in, transporting or causing to be transported, or otherwise receiving display fireworks must obtain an ATF Federal explosives license or permit for the specific activity. Offeror would need a valid FEL to move fireworks. The State Fire Marshall's Office works closely with ATF in this regard and can verify compliance as necessary.

3.13 STORAGE

- 3.13.1 The NPS and the State will work with the Contractor to determine the date to bring live loads into Mount Rushmore National Memorial, as well as the appropriate route. Upon entering the Memorial, vehicle operators shall be responsible for the safety of the fireworks and all related equipment. Appropriate site security should be provided by the Contractor.
- 3.13.2 The number of vehicles allowed on site will be kept to a minimum. The contractor shall provide the number of vehicles needed on site and storage plans for surplus vehicles.

3.14 PERMITS

- 3.14.1 Pursuant to SDCL 34-37-13. **Permit for use of display fireworks at event--Purchase and use requirements--Violation as misdemeanor.** Nothing in this chapter prohibits

the use of display fireworks at a public or private event. A person using display fireworks at a public or private event shall obtain a permit from the governing body of the municipality, township, or county where the display fireworks are to be used. Display fireworks may only be purchased from a wholesaler licensee. Use of display fireworks at a public or private event shall comply with the National Fire Protection Association Standard 1123, 2018 edition. A violation of this section is a Class 1 misdemeanor.

- 3.14.2** An NPS Special Use Permit is required for the event. Materials to support the State's permit request are due to the State within 30 days of the award. The State and Contractor will work with NPS collaboratively to develop and refine the special use permit.
- 3.14.3** All special use permit materials must be provided no later than 60 days in advance of the event date.

3.15 GENERAL REQUIREMENTS

- 3.15.1** The Contractor shall comply with all safety and regulatory requirements and inspections of the National Park Service (NPS), U.S. Department of Transportation (USDOT), U.S. Alcohol, Tobacco, and Firearms (ATF), National Fire Protection Association (NFPA), State of South Dakota (State), U.S. Occupational Safety and Health Administration (OSHA), and other agencies with jurisdiction. Safety also includes collaborating with the NPS to protect park resources during all aspects of the Contractor's performance under the contract.
- 3.15.2** The Contractor shall provide necessary safety equipment/material and transportation and security for the fireworks. Fire extinguishers shall be in plain view when live loads are on-site. The number, type and size of fire extinguishers shall be adequate to the size of the display as determined by the State Fire Marshall and current NFPA 1123 and 1124. Vehicles used to transport/store fireworks, shall be placarded in accordance with DOT 49 CFR requirements.
- 3.15.3** The Contractor shall be responsible for the cleanup of the launch site(s) and the entire safety zone, to include: cleanup of shell fragments to include cardboard, plastic, burned time fuse, expended components; bits of fuse, string, tape, plastic, aluminum foil; nails, wood, sand; and all hazardous materials associated with the display located in the discharge site and safety zone.
- 3.15.4** The Contractor shall abide by all applicable Federal, State, county, and local laws and regulations pertaining to display fireworks.
- 3.15.5** The Contractor shall comply with all current local and federal codes, rules and regulations, and shall ensure the all current OSHA, NFPA, and industry standards are met.
- 3.15.6** In addition to Personnel Protective Equipment required during the firing of the display by provisions of NFPA 1123, all Contractor employees and all NPS personnel performing duties in the launch site will wear NFPA 1123 approved safety equipment.
- 3.15.7** Contractor will provide maps of fallout/standoff zones.

3.16 PROHIBITIONS

- 3.16.1 The State and NPS Incident Command Team will have in place a Go/No-Go plan for whether to present the display.
- 3.16.2 The State will not authorize any advanced payments to the Contractor for the financing of the purchasing of the supplies needed for the contract.
- 3.16.3 All administrative support for the contractor's personnel, as required to fulfill the tasks assigned under this contract, shall be the responsibility of the Contractor.
- 3.16.4 Under no circumstances will any aspect of the composition of the show itself be an endorsement or advertisement for the contractor or any of the Contractor's affiliates or subcontractors.
- 3.16.5 Upon award, the Contractor will be required to sign a non-disclosure agreement.

4.0 PROPOSAL RESPONSE FORMAT

- 4.1 An original and 10 copies shall be submitted.
 - 4.1.1 In addition, the offeror should provide one (1) copy of their entire proposal, including all attachments, in Microsoft Word or PDF electronic format. Offerors may not send the electronically formatted copy of their proposal via email.
 - 4.1.2 The proposal should be page numbered and should have an index and/or a table of contents referencing the appropriate page number.
- 4.2 All proposals must be organized and tabbed with labels for the following headings:
 - 4.2.1 **RFP Form.** The State's Request for Proposal form completed and signed.
 - 4.2.2 **Executive Summary.** The one- or two-page executive summary is to briefly describe the offeror's proposal. This summary should highlight the major features of the proposal. It must indicate any requirements that cannot be met by the offeror. The reader should be able to determine the essence of the proposal by reading the executive summary. Proprietary information requests should be identified in this section.
 - 4.2.3 **Detailed Response.** This section should constitute the major portion of the proposal and must contain at least the following information:
 - 4.2.3.1 A complete narrative of the offeror's assessment of the work to be performed, the offeror's ability and approach, and the resources necessary to fulfill the requirements. This should demonstrate the offeror's understanding of the desired overall performance expectations.
 - 4.2.3.2 A specific point-by-point response, in the order listed, to each requirement in the RFP. The response should identify each requirement being addressed as enumerated in the RFP.
 - 4.2.3.3 A clear description of any options or alternatives proposed.

- 4.2.4 Cost Proposal.** Cost will be evaluated independently from the technical proposal. Offerors may submit multiple cost proposals. All costs related to the provision of the required services must be included in each cost proposal offered.

The cost proposal must be submitted in a separate sealed envelope labeled "Cost Proposal" as outlined in section 1.5 of this RFP.

See section 6.0 for more information related to the cost proposal.

5.0 PROPOSAL EVALUATION AND AWARD PROCESS

- 5.1** After determining that a proposal satisfies the mandatory requirements stated in the Request for Proposal, the evaluator(s) shall use subjective judgment in conducting a comparative assessment of the proposal by considering each of the following criteria:
- 5.1.1** Specialized expertise, capabilities, and technical competence as demonstrated by the proposed approach and methodology to meet the project requirements;
 - 5.1.2** Resources available to perform the work, including any specialized services, within the specified time limits for the project;
 - 5.1.3** Record of past performance, including price and cost data from previous projects, quality of work, ability to meet schedules, cost control, and contract administration;
 - 5.1.4** Availability to the project locale;
 - 5.1.5** Familiarity with the project locale;
 - 5.1.6** Proposed project management techniques;
 - 5.1.7** Ability and proven history in handling special project constraints; and
 - 5.1.8** Cancellation policy
- 5.2** Experience and reliability of the offeror's organization are considered subjectively in the evaluation process. Therefore, the offeror is advised to submit any information which documents successful and reliable experience in past performances, especially those performances related to the requirements of this RFP.
- 5.3** The qualifications of the personnel proposed by the offeror to perform the requirements of this RFP, whether from the offeror's organization or from a proposed subcontractor, will be subjectively evaluated. Therefore, the offeror should submit detailed information related to the experience and qualifications, including education and training, of proposed personnel.
- 5.4** The State reserves the right to reject any or all proposals, waive technicalities, and make award(s) as deemed to be in the best interest of the State of South Dakota.
- 5.5 Award:** The requesting agency and the highest ranked offeror shall mutually discuss and refine the scope of services for the project and shall negotiate terms, including compensation and performance schedule.

- 5.5.1** If the agency and the highest ranked offeror are unable for any reason to negotiate a contract at a compensation level that is reasonable and fair to the agency, the agency shall, either orally or in writing, terminate negotiations with the contractor. The agency may then negotiate with the next highest ranked contractor.
- 5.5.2** The negotiation process may continue through successive offerors, according to agency ranking, until an agreement is reached, or the agency terminates the contracting process.

6.0 COST PROPOSAL

Below is a basic COST PROPOSAL to guide you as you prepare costs for the various components of the RFP. Please know that you can modify your cost proposal however you wish to fit your overall responses.

Cost of staff time
Cost of pyrotechnic materials and shells
Cost of additional supplies
Transportation costs
Cancellation fees
Additional costs not specified here

7.0 SCORING CRITERIA FOR EVALUATION OF WRITTEN PROPOSALS

7.1 The following scoring applies to all components:

7.1.1 Creativity and innovation (20 points)

- How well did the Offeror meet the objectives of the component?
- Related experience and capability.
- Does the Offeror show a depth of knowledge in pyrotechnics shows?
- Did the Offeror demonstrate unique, creative and innovative concepts?

7.1.2 Personnel experience (20 points)

- Did the Offeror demonstrate depth of team members with pyrotechnics show experience?
- Years of experience of team members.
- Company experience and current/past clients.

7.1.3 Example of product (15 points)

- Are the articles pyrotechnic American-made?
- Are the articles pyrotechnic as environmentally safe as possible?

7.1.4 Understanding of project (20 points)

- Is there evidence that the Offeror has a solid understanding of the needs of the project, including site challenges?
- Does the proposal clearly fit within the parameters established by the State and NPS? Which elements of the proposal will require further discussion with the NPS?

7.1.5 Cost of services (15 points)

- Are the fees and costs reasonable and within a normal range of what is a typical going rate for pyrotechnics services?

7.1.6 Philosophy and Methodology of services (15 points)

- Is the Offeror's approach to pyrotechnics shows appealing?
- Does the Offeror's methodology ensure a quality, consistent product?
- Does the Offeror have the ability to deliver world-class service and creative pyrotechnic show design?
- Is the Offeror's innovation evident and inspiring?
- Does the Offeror have a proven record of working well with other vendors/show producers?

7.1.7 Financial stability (10 points)

- Is there strength of evidence that the Offeror is financially suited to provide the pyrotechnics services?
- Does the record show consistent, positive financial standing and practices?

7.1.8 References (15 points)

- Were a sufficient number of references with complete contact information provided?
- Did past and/or present clients give the Offeror favorable reviews?

7.1.9 Cancellation Policy (10 points)

- Is the company's cancellation policy reasonable?

Mount Rushmore (MORU) Fireworks & Pyrotechnics Code & Best Practices Evaluation



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Weeth & Associates, LLC

www.pyro-pages.com

Updated by NPS to remove sensitive data: 1/30/2020

Author's Note

This report was prepared on behalf of, and for the National Park Service (NPS).

November 2019

Author's Note: This report is not a Formal Interpretation issued pursuant to National Fire Protection Association (NFPA) Regulations. Any opinion expressed is the personal opinion of the author and does not necessarily represent the official position of the NFPA or its Technical Committees.



Photo 1 A 2003 photo from below with 6" and larger color shells bursting above the carvings. [Photo credit: Cleveland.com]

Abstract

This Report is a professional evaluation of the proposed discharge sites for a fireworks display and/or proximate pyrotechnics Show at Mount Rushmore (MORU) National Memorial. These discharge sites have been evaluated for compliance with



Photo 2 A still photo of multicolor comets fired from angle cakes from the Tops of Carvings. Regular comets do not burst while splitting comets (Crossettes) burst. [Photo credit: South Dakota Tourism]

the relevant National Fire Protection Association (NFPA) codes and standards as well as best practices. The Report will be used to as part of the National Environmental Protection Act (NEPA) evaluation and decision process and inform the NPS and other authorities having jurisdiction (AHJs) in to approve and issue permits for a Show at MORU.

This Report is NOT an evaluation of the entertainment value, the logistical feasibility, the public service availability, or the economic viability of a Show at MORU. It will be up to the Sponsor(s) and the Operator¹ to determine the viewshed of the spectators in the Amphitheater to the MORU carvings together with the performance heights and dimensions of the fireworks and/or pyrotechnics in the sky from the proposed discharge sites, along with the mortar/tube angles in combination with the sizes, types and styles of fireworks and/or pyrotechnics to be fired from those discharge sites.

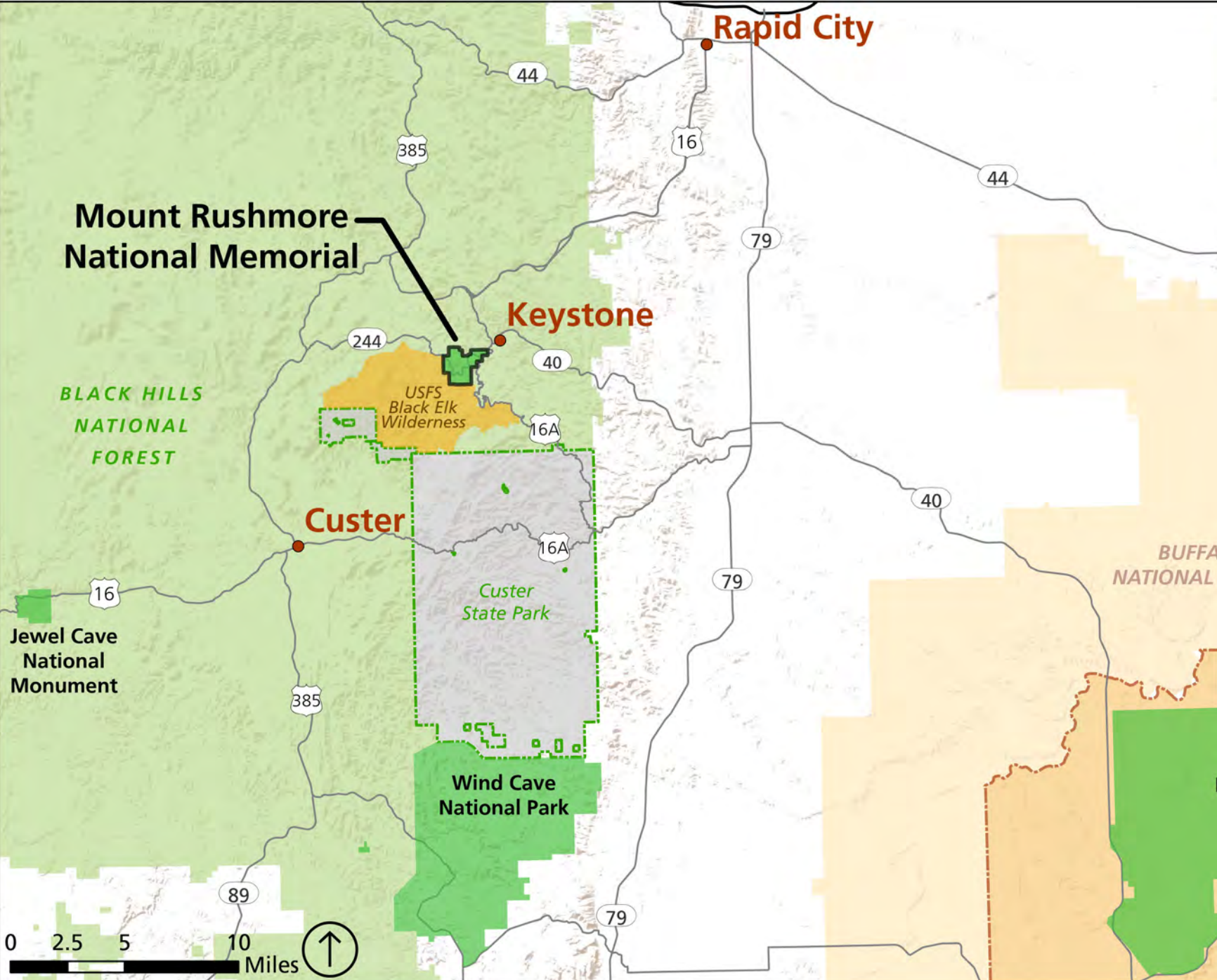
¹ NFPA 1123 3.3.39 **Operator:** The person with overall responsibility for the operation and safety of a fireworks display.



Regional Context

Montana	
Wyoming	
Nebraska	

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Introduction

The Mount Rushmore (MORU) National Memorial in the Black Hills of South Dakota is one of the most iconic national memorials administered by the National Park Service (NPS). It is the state's most popular attraction with about 3,000,000 annual visitors from around the world.

The carvings of MORU (Presidents Washington, Jefferson, Lincoln and T. Roosevelt) were blasted out of the smooth, fine grain granite by some 400 workers between 1927 and 1941. Each carving is about 60 feet tall on southeast side of the mountain, which is 5,725 feet above sea level and some 500 feet above the Amphitheater.

MORU consists of 1,278.45 acres of rocky hills covered with ponderosa pine forest and was designated a National Memorial in 1933. It is surrounded by the Black Hills National Forest, which consists of over 1.25 million acres and is managed by the U.S. Forest Service.

The original Visitor Center Complex completed in 1957 consisted of the Amphitheater, Grandview Terrace, and Avenue of Flags together with a gift shop, restaurant, information center and surface parking lot. There have been numerous improvements over the years with additional amenities such as a parking ramp, the Presidential Trail and the Lincoln Borglum Museum.

The Avenue of Flags and Grandview Terrace are currently being renovated and should be completed later in 2020. The Avenue of Flags, Grandview Terrace and Amphitheater are closed to the public during these renovations.

A new Administrative Building replaced the old building in the late 1990s and the original Maintenance Facilities have been updated over the years. There is also a Water Treatment Facility and Employee Dormitory.

Executive Summary

- From 1998 to 2001 and 2003 to 2009 a non-profit organization (NPO) that partners with the NPS at MORU sponsored a fireworks display on July 3rd.
- The fireworks displays were fired by a professional fireworks display company and consisted of thousands of aerial fireworks up to 12”² fired electrically from high density polyethylene (HDPE) mortars in above ground wood frame racks, as well as multiple tube devices (cakes) from the Hall of Records.
- In February 2009, NPS staff completed an internal report that addressed concerns with the feasibility of the location of the discharge site, to the manner in which fireworks display was set up and conducted, to the challenges with a fireworks display in a forest on steep slopes, to the safety and security of the spectators, to the compliance with national fire codes, as well as Federal and state laws.
- The 2010 fireworks display was cancelled based on the concerns raised in the 2009 NPS report and recent forest conditions that increased the fuel load
- On May 6, 2019, the Department of the Interior and the State of South Dakota signed a Memorandum of Agreement (MOA) “to work to return fireworks to Mount Rushmore National Memorial in a safe and responsible manner on July 3, July 4, or July 5, beginning in the year 2020”.
- In July 2019, staff from MORU and Regional NPS offices as well as from the South Dakota State Fire Marshal (SD SFM) and the Rapid City Fire Department

² 1123 4.1.1 Aerial shells, comets and mines are classified and described in terms of the inside diameter (ID) of the mortar from which they are fired (not their circumference)

(RC FD) surveyed potential discharge sites at MORU for a fireworks display in early July 2020. The group determined there were six potential discharge sites.

- On September 6, 2019 the NPS retained the Author to conduct a survey and evaluation of the potential discharge sites to comply with national fire codes and best practices, as well as Federal and state laws.
- The NPS provided the Author with the information available to date and the Author researched additional public information.
- The Author surveyed MORU and met with NPS staff as well as the SD SFM the week of October 7, 2019.
- The Author identified five additional potential discharge sites and divided one potential discharge site (Hall of Records) into five distinct portions
- The Author also consulted with NPS staff over the month of October and early November 2019, and researched additional information (See **References**)
- Based on the information available at this time, the Author has concluded that a fireworks display and/or pyrotechnic Show can be safely conducted at MORU and in compliance with national fire codes and best practices, as well as Federal and state laws, subject to the limitations and recommendations in this Report.
- Any such Show will be different from the previous fireworks displays, which were not in compliance with national fire codes and best practices, as well as Federal and state laws.
- It will be up to the Operator and Sponsor(s) to determine the entertainment value, the logistical feasibility, the public service availability, and the economic viability of a show at MORU.



Photo 3 Green grass and vegetation will burn easily if it receives sufficient heat or direct flame, especially if conditions are hot and dry. This is an example of a small grass fire that occurred during a battlefield reenactment using pyrotechnic and flammable gas special effects.

The fuel load was low, and winds were light, so the grass fire was slow moving. Firefighters with brush trucks and a ready source of water were on station, so it was not deemed a hazardous situation.

The reenactment continued for about an hour and after it concluded, the grass fire was extinguished.

Fireworks Displays at MORU 1998 - 2009

In 1998, a non-profit organization (NPO) that partners with the NPS at MORU sponsored a fireworks display from the Hall of Records canyon and on top of and behind the carvings. The NPO contracted with a professional fireworks company to perform the display on July 3rd.

The proposed display was deemed manageable by the NPS and other officials. Comprehensive operational and law enforcement plans to address issues with traffic control, fire protection, security and other issues were developed by the various Federal, state and local agencies in anticipation of the fireworks display.

The 1998 fireworks display was deemed a success by the NPO and tourism officials, so it was decided to continue it as an annual event. The July 3rd fireworks display continued until 2002 when it was cancelled due to drought conditions.

The July 3rd fireworks display picked up again in 2003 and the Federal, state and local officials continued to improve on their plans. At some point, NPS staff began to insist on changes to the display, such as reducing the sizes of the aerial shells from a maximum of 12” to 6” due to falling debris starting small fires in the forest below.



Photo 4 The actual Hall or Records was used by the crew to operate the firing control panel. Note there is no Means of Egress, Exit or Means of Escape. [Photo credit: NPS]

The last fireworks display was performed in the fog in 2009. The 2010 fireworks display was cancelled based on the concerns raised in the 2009 NPS Reconsideration of the Independence Day in Light of Updated Research and a recent pine beetle infestation that killed many ponderosa pines that increased the fuel load.

2009 NPS Reconsideration of the Independence Day in Light of Updated Research

In February of 2009, NPS staff at MORU issued an internal report that reviewed past experience with the fireworks displays and national fire codes and standards, Federal and state laws, as well as NPS policies. The NPS report concluded that many of the past practices were not in compliance national fire codes and standards, Federal and state laws, as well as NPS policies.

The 2009 NPS report concerns included:

- separation distances to spectator viewing areas from an elevated discharge site, especially with wind
- risks of aerial shells firing at steep angles, especially from an elevated discharge site
- potential for wildland fires and the limited fire prevention and fire protection resources
- difficulties with locating duds in a rocky forest fallout area
- hazards of aerial shells bouncing off of overhanging canyon walls
- safety of the crew firing from within the actual Hall of Records
- risks with chain fusing and rapid firing
- inability of mortar racks to withstand a catastrophic aerial shell malfunction in a mortar
- damage to the Memorial from burning cakes and fireworks malfunctions

The NPS Reconsideration concerns regarding the NPS policies, included:

- endangerment to property and critical utility infrastructure
- possible chemical hazards
- safe capacity and egress of the Visitor Center Complex for spectators
- perils to archaeological and natural resources



Photo 5 An example of a catastrophic aerial shell malfunction in a mortar. An 8" aerial shell functioned prematurely in an American made fiberglass mortar with a wood plug screwed into the bottom. The mortars were mounted in above ground wood frame racks.

The display site was in a park by a lake and fairly level. The mortar racks were located on a paved parking lot and nailed to each other for mutual support with 2" x 4" x 8' stringers. The show was computer fired and after the catastrophic aerial shell malfunction in the mortar, other 8" aerial shells continued to fire for many seconds before the show was stopped. Some shells flew down range well over 800 feet away into a grove of trees by some houses.

Note the remnant of mortar in the disintegrated rack in the center and the rack to the right that is missing all five of its mortars. The stringers supporting the group of mortar racks have been knocked off the racks. Not pictured is how this malfunction telegraphed down the line of mortar racks to the right, knocking other mortars loose and racks over as the computer continued to fire 8" shells.

Author Identified Concerns

In addition to the concerns identified in the 2009 NPS Reconsideration, the Author identified other issues, including:

- no record of any permit applications to the NPS or local fire officials by either the NPO or the professional fireworks company with diagrams of the discharge site, the fallout area and the spectator viewing areas for any years of the fireworks displays³
- no record of any permits issued by any Authority Having Jurisdiction (AHJ) to either the NPO or the professional fireworks company for any years of the fireworks displays⁴
- no information regarding the storage of the display fireworks in an approved Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) magazine for the days and weeks prior to the loading of the fireworks at the discharge site⁵
- no information regarding the storage or attendance by the Operator or any Assistants of the display fireworks loaded into the mortars and placed at the discharge site for the days prior to firing the display⁶
- the use of above ground wood frame mortar racks for 8” and larger aerial shells⁷
- no indication there were any Spotters around the Display Site watching the Fallout Area for normal or hazardous debris, duds, and blind stars or effects⁸

³ 1123 10.3

⁴ 1123 10.3

⁵ 1124 Chapter 5 and 27 CFR, Part 555, Subpart K Storage

⁶ 27 CFR, Part 555, Subpart K Storage

⁷ 1123 4.5.1* and 4.5.3

⁸ 1123 8.1.4.3

- no indication the Operator and/or Shooter was able to communicate with any of the Spotters or the AHJs, or vice versa⁹
- nothing to address the use of the Hall of Records as a limited egress discharge site and how the crew would be protected¹⁰

U. S. Geological Survey (USGS) Soil & Water Survey

In 2016, the U. S. Geological Survey (USGS) published the results of their soil and water survey conducted between 2011 and 2015 at MORU. These surveys began two years after the last fireworks display in 2009 and found fireworks debris on the ground.

The USGS determined that the past fireworks displays were the probable cause of elevated concentrations of perchlorate in groundwater and surface water. The concentrations are such that any further monitoring is advisable if there are fireworks displays in the future.

Fireworks compositions generally consist of a fuel, an oxidizer and a binder. Fireworks compositions create the bright colors and loud sounds due to the high heat and energy output of the fuel burning rapidly because of the higher levels of oxygen provided by the oxidizer (as opposed to combustible or flammable fuels that rely on the oxygen in the atmosphere to burn)

Potassium perchlorate (KClO₄) is the most common oxidizer used in display fireworks. It is more stable than potassium chlorate (KClO₃), which increases the sensitivity of fireworks compositions to ignition from impact or friction.

When fireworks stars and effects burn in the sky, the majority of the fuels and the oxidizers are consumed when heat and light are released, however any minute particles of

⁹ 1123 8.1.4.3.2

¹⁰ 1123 Chapter 7

compositions that are not burned will fall back down to the ground. The cardboard casings of aerial shells that burst apart in the sky and was in contact with the fireworks compositions will also fall back down to the ground with residual composition. Any duds or blind stars that failed to ignite in the sky will also fall down to the ground.

Over time, the remaining fuels and oxidizers that have come down to the ground in whatever form will eventually breakdown, thus resulting in potential contamination.

The level of contamination is based on the volume of unburned fireworks compositions that may come down over time, the type of soil and the volume of precipitation, and other factors.

Department of the Interior and South Dakota Memorandum of Agreement (MOA)

On May 6, 2019, the Department of the Interior and the State of South Dakota signed a Memorandum of Agreement (MOA). The MOA among other things called for the parties “to exercise their full authorities under State and Federal law to work to return fireworks to Mount Rushmore National Memorial in a safe and responsible manner on July 3¹¹, July 4, or July 5, beginning in the year 2020”.

This Evaluation is a part of this process.

¹¹ NPS Staff advised the Author that July 3rd was the only date supporting law enforcement, fire protection and other critical resources were available for a show at MORU



Photo 6 An example of an ideal display site. This display site is in an open, grassy field with no overhead obstructions. It is accessible by motor vehicles so the equipment and fireworks can be delivered to the discharge site.

The discharge site within the display site is 400 feet wide and 100 feet deep and it is in an area closed to the public and under 24-hour video surveillance with security patrols. The main spectator viewing area is in the grandstand another 150 feet behind the photographer.

The fireworks display consists of limited sizes, types and styles of aerial fireworks to minimize normal and hazardous debris, concussive effects, etc. All mortar racks are individually staked to the ground or supported by heavy duty steel frames.

There are fire hydrants as well as sprinklers near the discharge site for ready access to water if needed.

Display Sites, Discharge Sites, Fallout Areas and Spectator Viewing and Parking Areas

In order to understand this evaluation, it is helpful to first discuss the basic terms, code standards and best practices for Display Sites, Discharge Sites, Fallout Areas and Spectator Viewing and Parking Areas.¹²

Typically, a fireworks display has a single display site, discharge site and fallout area but many spectator viewing and parking areas. Some fireworks displays may have more than one display site, discharge site and fallout area as well.

A perfect display site for absolute safety would be fired remotely in a desert by robots with nobody and nothing around it that could be harmed or damaged in the event of a failure or

¹² See the definitions in Appendix A -Definitions and Standards

malfunction. Every other display site always has a number of compromises to absolute safety, starting with the fireworks crew that will handle, set up and operate the fireworks display to the supporting personnel and the spectators, to the property in and around the display site.

Display Sites

Ideally, a display site is a large open area that is relatively flat, and either in or near a public park, or some other facility such as a fairground, ball field, golf course, racetrack or the like where spectators can gather to watch the fireworks. Anything less than this ideal requires additional attention to detail by the Operator, Sponsor(s) and AHJ(s) to provide the safest fireworks display possible.

The design of the fireworks display will be based on the many variables of the display site, available resources, anticipated weather conditions and other factors. The design is critical to the safe conduct of the display because what is decided or not decided regarding the fireworks and the firing equipment before the fireworks display will determine the possible outcome in the event of a failure or malfunction during the fireworks display.

Essentially with a fireworks display, one is inviting thousands of people to attend an outdoor event, in the dark, which in and of itself presents many challenges. The spectators are as

close as permitted to see large projectiles fired into the sky, where they will explode with solid chemicals burning at 800-1,000° C while spreading out high in the sky.



This normal functioning of a fireworks display involves fireballs and firebrand near the ground where the fireworks

Photo 7 One of the factors to both the operation and the cost of a fireworks display is the amount of transportation and labor that is required to deliver the firing equipment and the fireworks to the display site, and then remove it all after the fireworks display. Larger, more complex shows at challenging venues require more resources, especially when working outside around the weather.

are fired from, followed by burning pieces of paper and cardboard falling back to the ground over many thousands of square feet. And this is what happens when there are no equipment failures or fireworks malfunctions.

The entire area around the exploding projectiles in the sky must be kept clear of unauthorized personnel. All public paths and roads must be closed and any bulk storage areas of materials that have a flammable, explosive or toxic hazard, and occupied dwelling buildings and structures must be accounted for as well, both during and after the display until this area can be cleared of any duds, and blind stars or effects.

This entire area also must have any potential combustible fuels, such as grass, trees and shrubs either be in a stage and condition that a wildland fire is not likely, or mitigation measures have been taken to reduce the chances of a wildland fire, or if possible, removed.

Discharge Sites

Selecting the appropriate discharge site is one of the most important facets to a safe fireworks display. Ideally it is reasonably flat and readily accessible with no or limited combustible vegetation and overhead objects. Also, of importance is a clear line of sight of the portion of the sky the fireworks will burst above the discharge site to the main spectator viewing area (otherwise there is no point to shoot the fireworks display).

The location of the discharge site in relationship to the main spectator viewing area will determine in part what fireworks can and should be used. Ideally the designer will choose the sizes, types and styles of fireworks that provide for the safest fireworks display possible, followed by what fireworks are most visible and entertaining to the spectators using the well understood design principles of scale, proportion, rhythm and pace.

Fallout Areas

The fallout areas are where the normal debris from a fireworks display is expected to land. It is also where any hazardous debris, duds, blind stars and effects are expected to land, provided the designer selected the right sizes, types and styles of fireworks for the display site and the anticipated weather conditions.

The fallout area is also where any aerial shells, comets or mines are likely to fire in the event of an equipment failure or fireworks malfunction, however this will depend in large part on sizes, types and styles of fireworks selected as well as the types of mortars and mortar racks, placement and securement methods, and fusing and firing methods.

It is possible that an errant fireworks can be fired at such an angle, especially from an elevated discharge site, that it can travel well outside the display site and then explode.

Spectator Viewing and Parking Areas

Essentially any place that spectators can view a fireworks display and park their cars while there to watch the show are spectator viewing and parking areas. However, from the perspective of the fire codes, the concern is primarily on spectator viewing and parking areas that are immediately adjacent to the display site. It is not uncommon that a fireworks display held for the benefit of a private audience at an outdoor venue may have an even larger audience outside of that venue.

Ideally, spectator viewing and parking areas are located in public parks, or some other facility such as a fairground, ball field, golf course, racetrack or the like that has the basic infrastructure to serve a large crowd at an outdoor event. Grandstand seating and/or open grassy areas are preferred for warm weather shows. A park or facility with permanent or temporary restrooms, food and beverage services and other amenities are often desired.

Separation Distances

In evaluating a potential display site, it is common that the first and sometimes the only consideration is the required minimum separation distances¹³ between the aerial shells to be fired in a proposed discharge site, and the proposed main spectator viewing and parking area. If noted,

¹³ 1123 5.1.3.1

but sometimes overlooked when evaluating a potential display site are bulk storage areas of materials that have a flammable, explosive or toxic hazard, and dwelling buildings and structures.

The distance will be measured and a determination often made that it will be “safe” to fire the largest aerial shells possible that meet the prescribed minimum separation distance.



Photo 8 An example of a computer firing control panel. These panels can fire thousands of cues in increments as fast as 1/10th of a second. They are proprietary and together with the design software, testers, junctions, firing modules and cables needed to make the entire system work, can cost tens of thousands of dollars

The reality is there are a host of other critical variables that can and should be taken into account before deciding on what sizes, much less what types and styles of fireworks can safely be fired at a particular display site. Many of these other critical variables are conditional and evaluating each in relationship to the others requires a thorough and thoughtful process.

Other Critical Variables

The Operator, Sponsor(s) and AHJ(s) must also evaluate and assess a number of other critical variables above and beyond just the separation distances. All of these variables must be considered along with the separation distances in order to develop a comprehensive show plan that provides for the safest possible fireworks display. These variables include:

- Aerial shell types and styles (Single break, multiple break, salutes, reports, inserts, comets, mines, splitting effects, bursting effects, falling or trailing effects, Roman candles, cakes, etc.)

- Display fireworks vs articles pyrotechnic
- Quality, reliability and consistency of the display fireworks and/or article pyrotechnic
- Quality, reliability and consistency of the mortars and mortar racks¹⁴
- Quality, reliability and consistency of the methods to secure mortars and mortar racks and securement (Steel or lightweight mortar materials¹⁵, buried in the ground, troughs or drums¹⁶, methods of bracing and securing above ground mortar racks¹⁷,
- Method(s) of ignition (manual, electrical or computer)
- Fusing type (Single shot vs. chain fused¹⁸)
- Pace of the show (slow, moderate or rapid fire)
- Combustible fuel types and loads (Grass, weeds, deciduous vs non- deciduous shrubs and trees, quantity of leaves and needles on the ground, etc.)
- Weather conditions prior to as well as potentially during the fireworks display (hot, dry, windy vs. cold, wet and calm)¹⁹
- Fire prevention (What needs to be done *beforehand* to mitigate potential for wildland fires vs. what can be done with the resources and time available)²⁰

¹⁴ 1123 4.5.4, 4.5.7* and 4.61*

¹⁵ 1123 4.3.8* and 4.3.10*

¹⁶ 1123 4.4

¹⁷ 1123 4.5

¹⁸ 1123 4.6.2 and 5.1.3.3.2

¹⁹ 1123 8.1.4.1 and 8.1.4.2*

²⁰ 1123 8.1.1*

- Fire protection (What needs to be done *during and after* to mitigate potential for wildland fires vs. what can be done with the resources and time available)²¹
- Ability of the Spotters to watch for normal or hazardous debris, duds, and blind stars or effects²²
- Ability of the Monitors to secure the display site²³
- Ability of the Spotters to communicate directly with the Shooter²⁴
- Ability to police the display site for duds, and blind stars or effects immediately after the fireworks display, and again at first light.²⁵
- Access and logistics to the discharge site (Haul the firing equipment and fireworks in and the firing equipment out)
- Ability to manage the spectator viewing and parking areas safely²⁶
- Ability to secure the discharge site(s) and fallout area(s) prior to²⁷, during²⁸ and after²⁹ the fireworks display
- Ability to mitigate the risks to the crew for a fireworks display from floating vessels and floating platforms³⁰ or a rooftop, other structure or other limited egress discharge site³¹

²¹ 1123 8.1.1*

²² 1123 7.6.4

²³ 1123 8.1.2.1 and 8.1.4.1

²⁴ 1123 8.1.4.3.2

²⁵ 1123 8.2.12*

²⁶ 1123 8.1.2*

²⁷ 1123 8.1.2.4

²⁸ 1123 8.1.2.1 and 8.1.4.1

²⁹ 1123 8.2.12*

³⁰ 1123 Chapter 6

³¹ 1123 Chapter 7

- Ability of the fire protection and emergency response personnel to respond to a situation³²
- Potential for hazardous condition given the variables of the fireworks display, the display site and the weather³³

Operator, Sponsor(s) and AHJ(s) Duties

Ultimately the decisions on how a fireworks display is planned, set up and operated and how the display site(s), discharge site(s), fallout area(s) will be decided by the Operator (there is only one) with the Sponsor(s) and the AHJ(s). The decisions that are made or not made will determine the likely outcome of any equipment failure or fireworks malfunction.

What happens in the event of an equipment failure or fireworks malfunction is likely to be almost instantaneous and unfold very rapidly and result in a series of hazardous situations that are potentially deadly to people and dangerous to property. The typical failures and malfunctions at a fireworks display occur so rapidly they are almost impossible for any human to react to, much less respond to, with any response too little, and too late to mitigate the hazardous situation. At that point, luck is the only potential mitigating factor.

This is why it is so important to design and plan a fireworks display anticipating the worst-case scenarios so the risks can be mitigated to an acceptable level of safety. The primary goal is to eliminate as many risks to life and property as possible, and mitigate the risks that cannot be eliminated.

³² 1123 8.1.4.4 and 8.1.5

³³ 1123 8.1.4



Photo 9 An example of a catastrophic aerial shell malfunction in a mortar. A 6" single break color shell has just burst inside a 6" HDPE mortar with a wood plug in an above ground wood frame rack. This photo was taken from over 100 feet away. Note an HDPE mortar from the mortar rack and pieces of the mortar rack flying up and out from the explosion with the fireball of the burst charge and burning stars, some of which landed still burning over 200 feet away.

Fireworks Failures and Malfunctions

There are a number of fireworks failures and malfunctions³⁴ that are worst-case scenarios that the Operator as well as the Sponsor(s) and AHJ(s) must consider. Here are a few:

- A catastrophic aerial shell malfunction of an aerial fireworks shell in a mortar is always a possibility. Such an event in a mortar made of lightweight mortar materials in an above ground wood frame rack, particularly of a larger, more powerful aerial shell can lead to devastating results. This type of malfunction can

³⁴ See Author's Terms for Malfunctions

be compounded by the methods that mortar racks are grouped or not, the materials and methods to secure the mortar racks and the elevation of the discharge site in relationship to the fallout areas and spectator viewing areas.

- A catastrophic aerial shell malfunction of an aerial fireworks shell in a mortar in a mortar rack containing chain fused aerial shells (or a blowout of a tube in a cake or finale box). Once ignited, the chained aerial shells or devices will continue to fire until it blows itself out, or it is spent.
- Failing to secure mortar racks properly or grouping them together so the mortar racks rely on each other for mutual support can result in mortars or mortar racks being realigned and firing aerial shells well outside the display site.
- Aerial shells that break low, especially over a fallout area with a substantial amount of fuel load, such as an area with lots of dry vegetation.
- Firing aerial shells at steep angles without adding additional fallout area to compensate.
- Failing to angle mortars and mortar racks away from the spectators and increasing separation distances in anticipation of winds blowing towards the spectators or over a sensitive part of the fallout zone.
- The Operator and AHJs being unable to communicate effectively with each other, as well as the Shooter and Spotters during the fireworks display
- Failing to recognize the difference between normal debris and hazardous debris.
- Selecting fireworks that are inappropriate for the display site and the conditions
- Failing to modify plans when things do not go as expected (they never do)

There are many others from possible incursions into the fallout area by a few spectators to the Shooter being unable to hear a call on the radio from a Spotter to a fire fighter overreacting to a few small pieces of glowing paper debris that helicopter outside the display site.

Applicable National Fire Protection Association (NFPA) Codes & Standards

The Author has identified the following National Fire Protection Association (NFPA) codes and standards that are applicable to a fireworks display/proximate pyrotechnic Show at MORU. These are:

- NFPA 1123, *Code for Fireworks Display* (2018)
- NFPA 1124, *Code for the Manufacture, Transportation, and Storage of Fireworks and Pyrotechnic Articles* (2017)
- NFPA 1126, *Standard for the Use of Pyrotechnics Before a Proximate Audience* (2016).
- NFPA 101, *Life Safety Code*[®] (2018) [Egress and other safety to life issues in an Assembly Occupancy]

Also applicable for a fireworks display/proximate pyrotechnic Show at MORU is:

- NFPA 1141, *Standard for Fire Protection Infrastructure for Land Development in Wildland, Rural, and Suburban Areas* (2017)
- NFPA 1143, *Standard for Wildland Fire Management* (2018)

Key NFPA 1123 Standards

The Operator

The most important standards in NFPA 1123 and NFPA 1126 are the definitions and requirements of the Operator/Pyrotechnic Operator. This one person is ultimately responsible for ensuring that all of the standards are followed and for the safe operation of the show. NFPA 1123 8.1.3 says it best: “**The Operator shall have primary responsibility for safety**”.

Minimum Required Radius of the Display Site

The minimum required radius of the Display Site is established in 1123 5.1.3.1. The formula is 70 feet per ID inch of mortar for the largest shell to be fired (in that discharge site). Other provisions, such as 5.1.4 and 5.2 modify this formula based on other factors, such as for using mines and comets, the bulk storage of hazardous materials, and elevations above the spectator viewing areas, etc.³⁵

³⁵ The *Display Fireworks Manual* (2010) and from Natural Resources Canada and the *Study Guide for Display Operator Training Program* (2017) from the Pyrotechnics Guild International, Inc. (PGI) address shell types and sizes, mortar placement and angle, elevated discharge site, wind speed and direction, and other factor in greater detail. Both documents provide for increased separation distances to spectator viewing areas based on these variables.



Photo 10 Flammable liquid and gas storage at different locations at MORU must be considered when establishing separation distances from discharge sites, in particular from any that are elevated.

However, the base formula in 5.1.3.1 is predicated on buried mortars that are vertical (90°) and firing single break color shells one at a time with a wind speed of zero. It does not take into account the use of lightweight mortar materials in above ground wood frame racks that cannot withstand a catastrophic malfunction. It does not take into account a group of these racks in close proximity to one another, relying on each other for mutual support, or angled to as much as 45°, or the potential for equipment failures or fireworks malfunctions.

It also does not take into account aerial shells that are chain fused³⁶ or the rapid pace a computer firing system can fire aerial shells, or wind speed and direction, and how these factor into separation distances in the event of equipment failures or fireworks malfunctions.

These factors are all up to the Operator to assess and determine using the applicable national fire codes and best practices³⁷ in consultation with the Sponsor(s) and the AHJ(s).

An experienced and prudent Operator understands these are the minimum separation distances³⁸, but will also know the worst case scenarios where mortars are knocked over from a catastrophic malfunction in a mortar or the failure of a mortar rack support, which can result in aerial shells firing at steep angles well beyond the designated fallout area.

An experienced and prudent Operator also understands that scale and proportion principles yield the optimum viewing of a show for the spectators. Generally, these are at distances greater than the minimums in the standards, especially for elaborate and complex pyromusicals.

³⁶ 1123 5.1.3.3.2 The minimum separation distances are doubled for “mortars, racks or other holders that are not sufficiently strong enough to prevent their being repositioned in the event of an explosive malfunction”

³⁷ Best practices in the fireworks trade are developed within each professional fireworks display company and vary significantly. Some companies have comprehensive professional development and safety programs, while others simply do what they’ve always done in the past and trust to luck. The trade tends to be secretive and very little is shared, much less published. What is published are such things as the *Display Fireworks Manual* (2010) and *Special Effects Manual* (2014) from Natural Resources Canada, the *Celebrate Safely* (DVD), American Pyrotechnics Association (APA), (2014), and the *Study Guide for Display Operator Training Program* (2017) from the Pyrotechnics Guild International, Inc. (PGI).

³⁸ The Canadian minimum separation distances are significantly greater than NFPA 1123 (Table 3-1), with formulas for increasing the distances to compensate for wind speeds and directions, as well as mortar angles (Table 3-2). These minimum distances are tripled “When mortars are not properly buried, placed in non-destructible racks or barricaded”

Overhead Projections and 25 Foot Clearance from Aerial Shell Trajectory

The issues of what constitutes an “overhead projection”³⁹ and the requirement for a 25-foot clearance from aerial shell trajectory is an essential standard when evaluating discharge sites at MORU. Every proposed discharge site at MORU has something that might be a potential “overhead projection”, depending on where mortars or tubes are placed. There are trees with branches, rock walls or stage walls that must be considered.



Photo 11 If a human can get to or stand on a location, some type of holder and fireworks or pyrotechnic device can be placed there. Whether it is safe and prudent for a human to get to that location, or place and use any particular type of fireworks or pyrotechnic device requires a serious evaluation of the various risks involved. [Photo credit: Seattle Space Needle]

This standard has been in NFPA 1123 since it was first adopted by in 1978. It has remained with the same exact wording ever since.

The purpose of the standard is twofold. First, protect property from potential damage from being struck by an aerial shell, and: second, protect the aerial shell from damage from an overhead object.

³⁹ 1123 5.1.4.7 The area selected for the discharge of aerial shells shall be located so that the trajectory of the shells shall not come within 25 ft. (7.6 m) of any overhead object.

At that time, fireworks displays were much smaller and typically fired from steel mortars buried in rows in the ground or troughs with the finale fired from cardboard mortars in above ground wood frame racks or finale boxes. The aerial shells were fired manually with fuses, portfires or other open flame sources, reloaded and fired multiple times.

The largest aerial shell size standard in the first two editions of NFPA 1123⁴⁰ was for 6” aerial shells (the separation distance and the fallout to the spectators was same at 150 feet, but 500 feet from hazardous materials, hospitals and penal facilities).

The buried mortars were angled slightly away from the Shooter and as the mortar was fired and reloaded over the course of the show, the recoil would often drive the mortar into the ground and/or change the angle of the mortar. Thus, the trajectory of the last shot could be very different than the first shot.

The vast majority of shows were then, and still are fired by volunteer groups in small communities across the country. They are often conducted in parks and ballfields and other public spaces with overhead wires, streetlamps, flagpoles, as well as trees and shrubs.

The standard is limited to only aerial shells. It does not include any other aerial fireworks such as comets, mines, Roman candles and cakes.

It is arbitrary because there is a single standard for all aerial shells no matter the size or type of the shell, or the mortar placement or angle. It is also the same for all overhead objects, no matter how tall or potentially sensitive to being damaged by an aerial shell, or causing damage to an aerial shell.

⁴⁰ NFPA 1123, Code for the Public Display of Fireworks (1978 and 1982)

A strict interpretation of the standard would treat any object that is within 25 feet of a mortar and taller by any measurement than that mortar as an overhead object. Thus, any mortar that is both taller than another mortar and within 25 feet would be considered an “overhead object” and one or the other mortar would be required to be moved further than 25 feet away.

Given that most fireworks displays now use lightweight mortars in above ground wood frame racks that are fired once and not reloaded, the concern over a mortar changing angles over the course of a show is no longer a concern; *provided that the mortar rack is securely placed*.

The intent of this standard is to prevent an aerial shell from striking and damaging an overhead object and/or being damaged by that overhead object. The distance needed to prevent this from happening is dependent on the size and type of the aerial fireworks, the type of mortar or tube and the method of placement, the angle of the mortar or tube in relationship to the overhead object, the height and type of overhead object, and the size and type of overhead object in combination with the potential for this event creating a hazardous situation.⁴¹

An example where 25 feet is more than is needed: A 3” aerial shell (round) is loaded into an HDPE mortar in an above ground wood frame rack that is at 85°. It is placed 5 feet away from a retaining wall in a park that is 50 feet tall and slopes away at 88°. The trajectory of a 3” aerial shell (round) will not be an issue with the retaining wall unless there is an incredibly strong wind towards the retaining wall at ground level.

An example where more than 25 feet is needed: A 12” aerial shell (round) is loaded into an HDPE mortar in an above ground drum filled with sand at 90°. It is placed 25 feet away from a cell phone tower that is 180 feet tall also at 90°. The trajectory of the 12” aerial shell (round)

⁴¹ Aerial shells can be fired through plywood sheets mounted a few feet above the mortar with little to no effect on their performance.

could possibly strike the cell phone tower, even if there is a slight breeze away from the cell phone tower. [50 feet would be a more prudent distance].

An Operator will need to determine exactly where in any of the proposed MORU discharge sites mortars and tubes can be placed in relationship to overhead objects, whether it is rock walls or tree branches, and exactly what size and type of fireworks or pyrotechnics can be safely fired from those locations.

An Operator will need to substantiate the location and angle choices according to 1123-1.3 Equivalency.



Photo 12 An example of troughs full of sand for 8", 10" and 12" mortars. Troughs and drums are often used where ground water levels are high and the soil is too soft to handle the recoil from large diameter mortars, or where the ground is too hard to bury the mortars.

AHJ Discretion

MORU is one of the more challenging venues one could pick for a fireworks display. The fact that it is a rocky mountain in a forest alone is enough of a challenge, but the many other variables, from the potential discharge sites at multiple elevations, to the angles needed to shoot bursting fireworks above the carvings, makes it incredibly complex.⁴²⁴³

The applicable fire codes for a show at MORU as adopted by the NPS and the South Dakota State Fire Marshal are NFPA 1123, 1124 and 1126. Each is applicable to specific portions of a show depending on the timing and location of the show.

The NPS and other AHJs both can and should give consideration to establishing specific minimum standards for a fireworks show at MORU based on their collective knowledge and experience to ensure public safety and protect the national treasure of MORU.



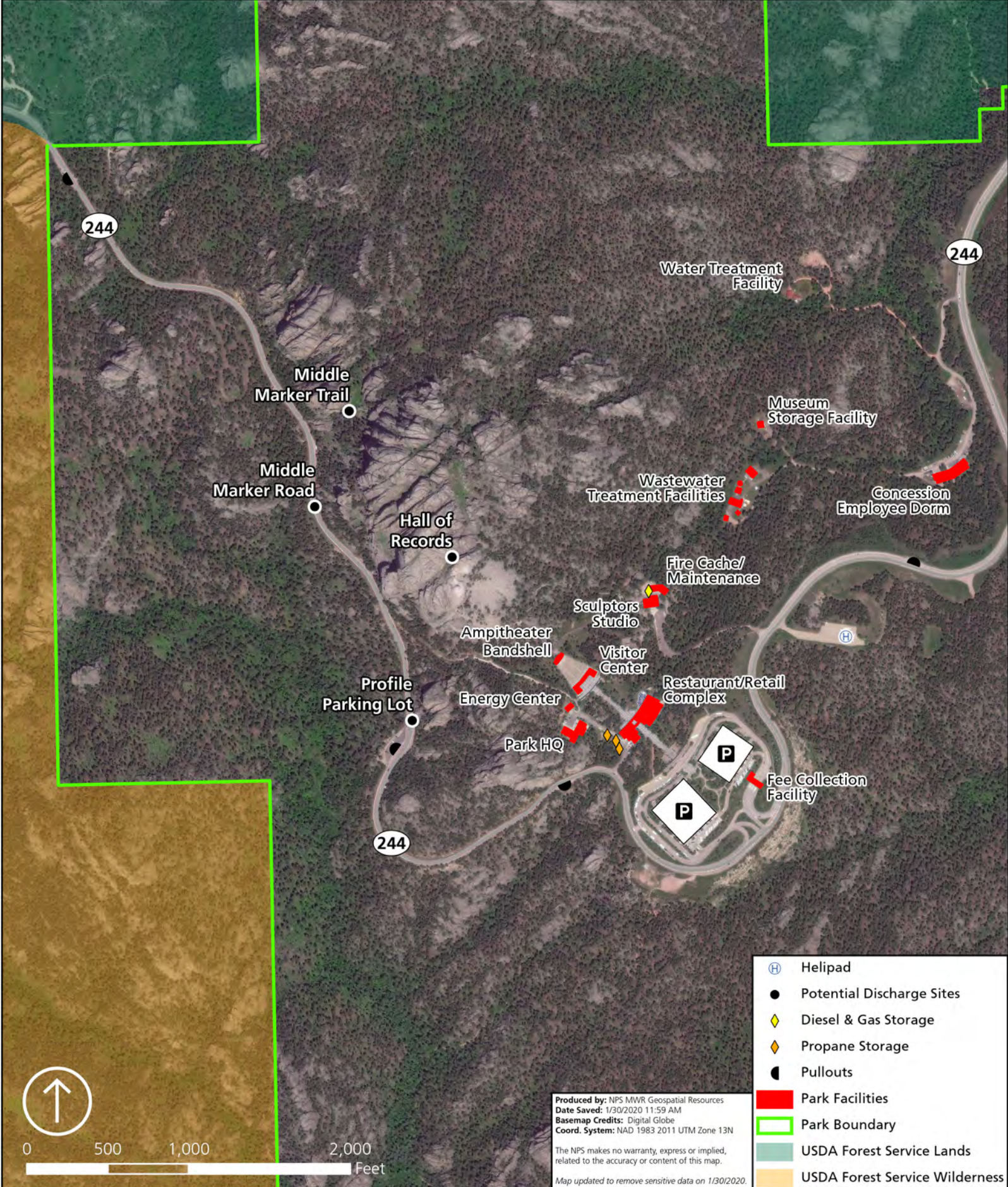
Photo 13 A 3" blowmolded HDPE mortar after a 3" single break salute shell was intentionally burst in the mortar. Note how the HDPE has stretched before failing in the classic banana peel deformation.

⁴² 1123 5.1.1 establishes additional criteria for the AHJ above and beyond the very broad definition of "Approved" for venues and situations just like MORU.

⁴³ 1123 5.2.2.1 in particular is applicable because MORU certainly has "unusual" and "safety-threatening conditions" no matter the weather or wildland fire conditions



Park Overview



Middle Marker Trail

Middle Marker Road

Hall of Records

Profile Parking Lot

Ampitheater Bandshell

Energy Center

Park HQ

Sculptors Studio

Visitor Center

Fire Cache/Maintenance

Water Treatment Facility

Wastewater Treatment Facilities

Museum Storage Facility

Concession Employee Dorm

Restaurant/Retail Complex

Fee Collection Facility

- Helipad
- Potential Discharge Sites
- Diesel & Gas Storage
- Propane Storage
- Pullouts
- Park Facilities
- Park Boundary
- USDA Forest Service Lands
- USDA Forest Service Wilderness

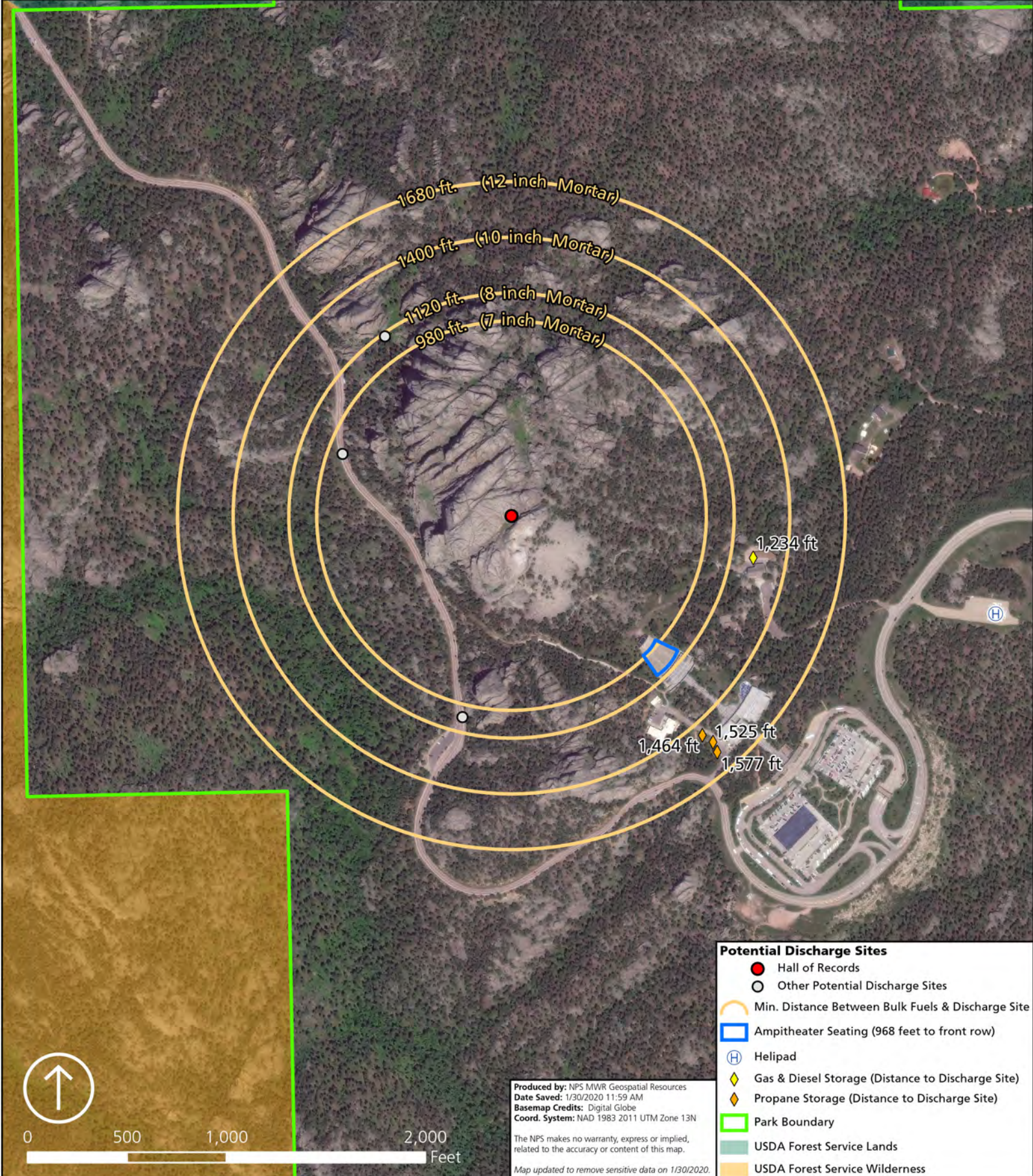
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Hall of Records Discharge Site

Minimum Distance Between Bulk Fuels & Discharge Site





Hall of Records Discharge Site

Minimum Distance Between Spectators & Discharge Site

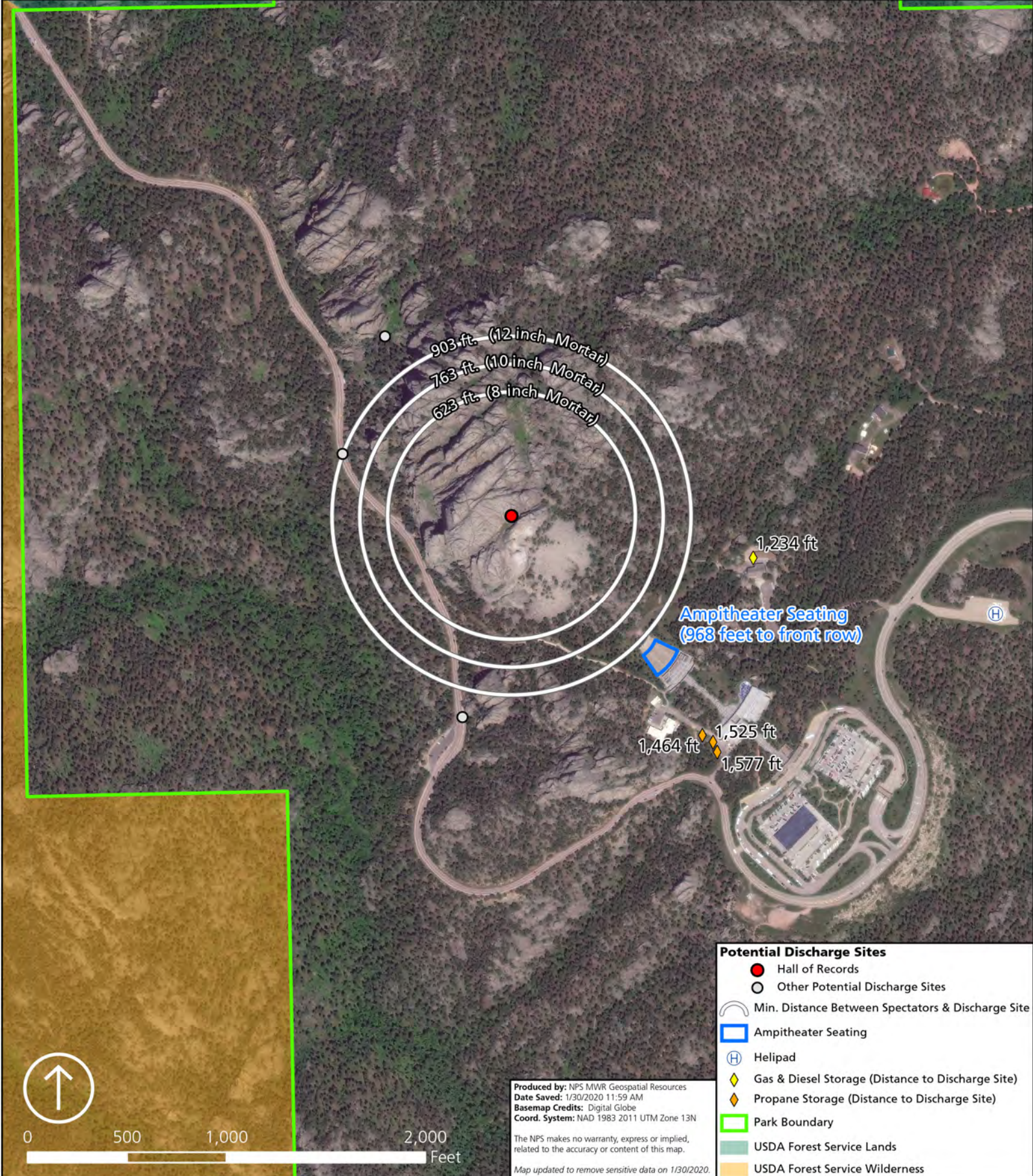




Photo 14 The Hall of Records Canyon, Entry and Ridge from the top of the steps of the Guard Shack. The actual Hall of Records is to the left of the Canyon and the Entry is to the right. The Ridge is to the top left (Note the wiring crew up in the rocks of the Ridge)

NPS Proposed Discharge Sites

In July 2019, staff from MORU and Regional NPS offices as well as from the South Dakota State Fire Marshal (SD SFM) and the Rapid City Fire Department (RC FD) met with at MORU and surveyed potential discharge sites for a July 3, 2020 fireworks display. The survey included taking photographs and geographic information system (GIS) measurements at the various potential discharge sites.

The group determined there were six potential discharge sites, which are as follows:

Hall of Records Discharge Site

The Hall of Records Discharge Site is the location used for the previous fireworks displays from 1998 to 2001 and 2003 to 2009. It is the logical first choice for a discharge site at MORU because it is directly behind the carvings and only about 1,000 feet from the spectators in the Amphitheater. Most aerial fireworks fired from this location will burst above the carvings and be readily visible⁴⁴ to the spectators in the Amphitheater.

This discharge site can only be reached by climbing the mountain or by helicopter.⁴⁵ Transporting the equipment and the fireworks here is extremely difficult. The area is mostly rocky but there are nearby forests, in particular below the mountain.

⁴⁴ What fireworks effects are readily visible from any discharge site or portion of a discharge site to the Spectators in the Amphitheater, especially those in the front rows with the backstage blocking the view of the carvings and in the Grand View Terrace to the sides with tree branches blocking the view of the carvings will be for the Operator to determine. This will require a viewshed analysis in combination with a detailed evaluation of the performance heights and widths of the various aerial shells, comets and mines.

⁴⁵ A Special Permit from the U. S. Department of Transportation (DOT), Pipeline and Hazardous Materials Safety Administration (PHMSA) for aircraft to carry Class 1 Explosives. See 49 *CFR*, Part 107, Subpart B - Special Permits

The Hall of Records Discharge Site is the most complex of the six NPS proposed discharge sites. It has multiple portions on different levels that must be considered when evaluating the potential for use as a discharge site. In order to better understand these differences, the Author divided the Hall of Records Discharge Site into five distinct portions in order to address the different issues presented in each portion.

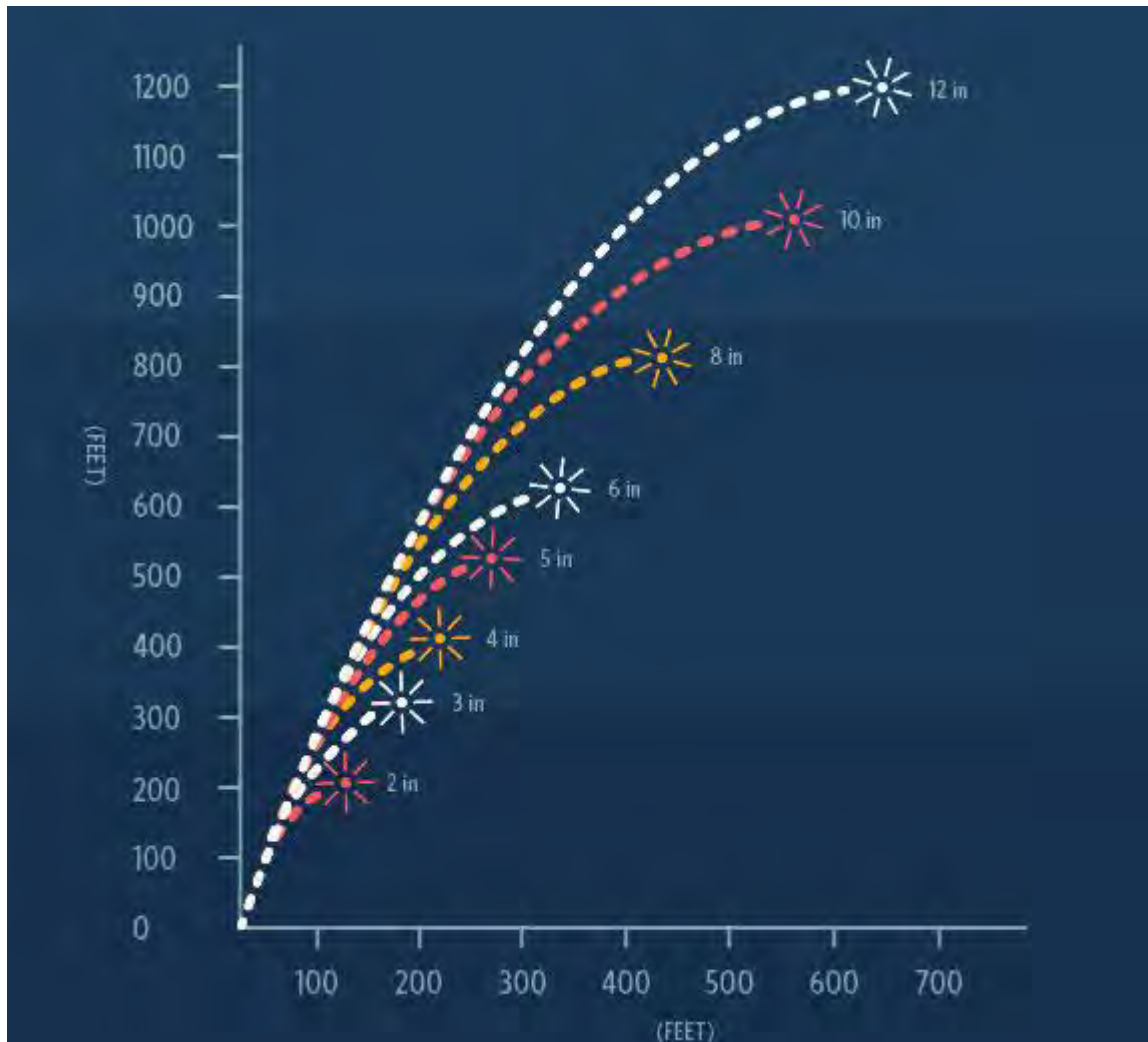


Photo 15 The rough rule of thumb for performance heights of most aerial shells. The actual performance heights can vary significantly depending on the type, style, manufacturer as well as the mortars and their placement. The performance heights for articles pyrotechnic are much more precise due to the higher quality of the various propellants and compositions combined with the tighter tolerances between the device and the mortar or tubes. [Chart credit: pyroinnovations.com]

Portions of the Hall of Records Discharge Site

The five distinct portions of the Hall of Records Discharge Site are as follows:

- Hall of Records - Canyon (The wide portion of the canyon immediately in front of the Hall of Records)
- Hall of Records - Entry (The narrow entry into the Canyon at the top of the metal staircase. It has a chain link fence and gate with concertina wire)
- Hall of Records - Top of Carvings (The platform and rock shelf behind and on top of the carvings)
- Hall of Records - Guard Shack Steps (The steps and landing to the Guard Shack)
- Hall of Records - Ridge (The top of the ridge behind the Hall of Records)

Description of the Hall of Records Discharge Site

At the base of the steel steps up to the Hall of Records is a chain link fence and gate with concertina wire. Within the Entry at the top of the steps is another fence and gate with concertina wire.⁴⁶

The Canyon and Entry vary in depth from about 80 to 120 feet. The Canyon walls tend to slope outward while the Entry walls tend to slope inward.

There is very little level ground in the Canyon or Entry. There are rocks of various sizes that jut out of the ground, as well as some sandy areas and vegetation. The remnant steel pipe used to power the air drills when MORU was carved from the rock remains in the Entry.

⁴⁶ The fences, gates and concertina wire are to keep people from climbing into the Hall of Records to reach the carvings



Photo 16 The Tops of Carvings. Note the burn marks on the granite rock from the cakes that were placed here 10 years earlier and the Visitor Center Complex in the background.

The Hall of Records was blasted out of the wall of the Canyon. It was never finished and considered a significant cultural and historic resource.

Another set of steel steps rises up from the Canyon floor to the Guard Shack. It has a steel deck landing.

The Top of Carvings is accessible only by climbing some of the rocks above the Guard Shack. There is a short deck behind Washington's head behind the carvings and a few level areas, but otherwise it is uneven fine grain granite.

The Ridge is behind the Hall of Records and is slightly above the carvings. It is solid granite and accessible only by climbing the rocks. It has limited locations for placing mortars or

mortar racks for display fireworks with heavier recoil, especially given the challenge to properly secure the mortars or mortar racks. It has more locations suitable for placing articles pyrotechnic that are 2” or smaller.

Means of Egress, an Exit or a Means of Escape

It should be noted that NO portion of the Hall of Records, other than the small area outside the fence in the Entry by the top of the steps, has anything that could be considered a Means of Egress, an Exit or a Means of Escape⁴⁷ during a fireworks display. Only the small area outside the fence in the Entry by the top of the steps could be considered a Means of Escape during a fireworks display; and then only for a limited number of authorized and ambulatory personnel behind a sturdy shield, and if the only way out (the steps) were illuminated.



Photo 17 Some of the plastic debris recovered in the Hall of Records during the survey of October 2019, ten years after the last fireworks display. These are a plastic time fuse tube from a large diameter aerial shell, plastic time fuse holders from medium diameter aerial shells, a spacer with a plastic time fuse holder from a Roman candle, and the remnant of a quickmatch leader fuse in a plastic casing with a plastic T connector for an electric match (Note the strands of still viable blackmatch fuse)

⁴⁷ See Other NFPA Key Definitions



Photo 18 The fence and gate with concertina wire in the Entry of the Hall of Records. The Shooter and Shooter's Assistant should be located outside of this gate, near the stairs behind a shield or barricade and with no mortars in the entry or within 75 feet of their position. 1123 – 7.3.3.1. [Photo credit: NPS]

Hall of Records Discharge Site – Limited Egress Discharge Site

The Hall of Records is the perfect example of a limited egress discharge site and the reason for the standards in NFPA 1123, Chapter 7. There is only one viable way into and out of the Hall of Records. It is challenging enough in the daylight for an ambulatory individual to climb up to or down from, let alone one that is wearing the personal protective equipment (Hard hat, safety glasses, and long sleeved natural fiber clothing) that may be attempting to escape the discharge site, in the dark, and in the event of equipment failures or fireworks malfunctions.

Each of the portions of the Hall or Records Discharge Site identified by the Author present their own unique possibilities and challenges for the placement of different types of fireworks or pyrotechnics. They vary in both footprint available for the placement of mortars and holders, the absence or presence of rock walls, and elevations.

Any 2” or larger aerial fireworks shells, mines or comets fired from the Canyon should be visible to spectators in the Amphitheater, but the smaller aerial fireworks that burst 200 feet above ground level (AGL) or less may just barely be visible, especially for those seated in the front rows of the Amphitheater.

Any articles pyrotechnic 2” or less fired from the Tops of Carvings and most aerial fireworks 2” or less fired from the Ridge would be visible to spectators in the Amphitheater, including those in the front rows of the Amphitheater.

Ground level fireworks fired from the Tops of Carvings would likely not be visible to spectators in the Amphitheater.

Past Fireworks Displays from the Hall of Records Discharge Site

The Author only has limited information on the past fireworks displays, but what is known is useful in evaluating the potential for a future fireworks display at MORU.

The first three portions of the Hall of Records Discharge Site were used in the previous displays. The entire Hall of Records Canyon and Entry were filled with mortar racks, while the Top of Carvings was used for cakes.

The crew used the actual Hall of Records to place the firing control panel and fire the display. It provided exceptional protection from any normal or hazardous debris, duds, and blind stars or effects, but would trap the crew in the event of a catastrophic malfunction of an aerial

shell in a mortar just a few feet away. Any muzzle breaks, low breaks or tipovers could also prove to be disastrous for the crew that was confined inside a hole in the rocky wall.

Past displays used a qualified rope line team⁴⁸ to transport the fireworks, mortar racks and firing equipment up and back down the mountain. It took about two weeks to get everything up for the show and well over a week to get everything back down after the show.

The fireworks crew had to climb up and down the mountain each day to set up the equipment, load the fireworks and then strike the equipment. The fireworks crew also had to climb down the mountain in the dark after the display.

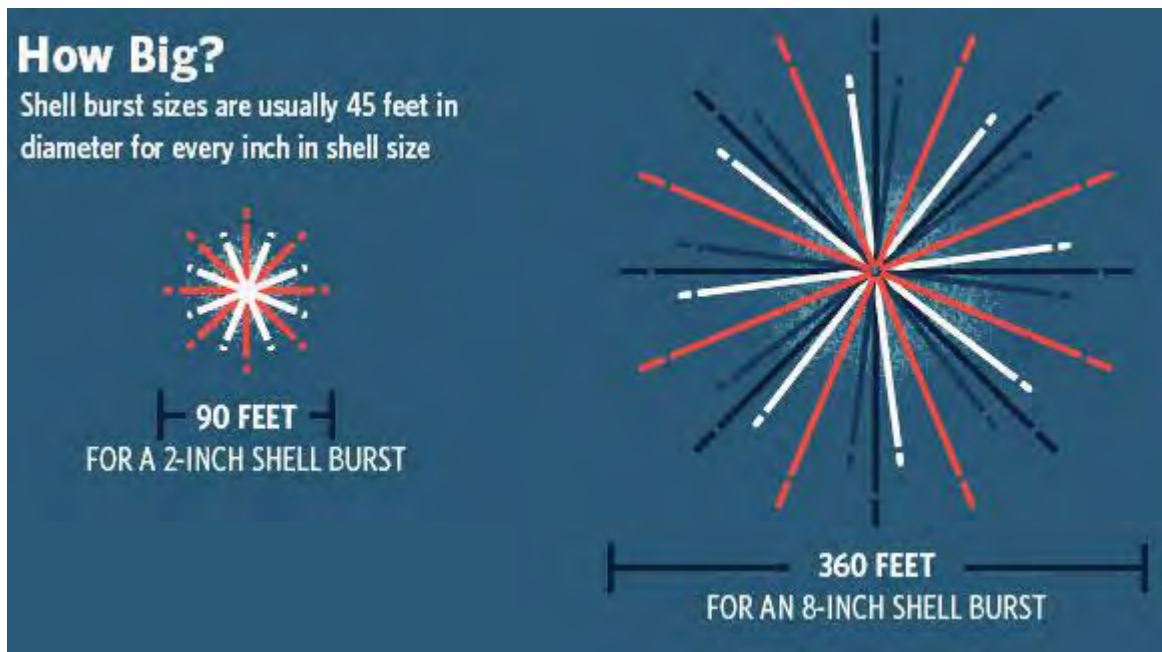


Photo 19 The burst size of aerial shells varies just like the performance height. Generally, the larger the aerial shell, the larger the burst pattern. This is a factor in both the design of a show for entertainment purposes as well as safety considerations.

⁴⁸ A qualified rope line team has the training and experience to setup and operate rope lines with trusses, hoists, pulleys, blocks and tackles, and other specialized equipment and technique to transport loads up and down steep hills, mountains, buildings and structures.

Issues: Hall of Records Discharge Site

The Hall of Records Discharge Site presents a number of significant issues, including:

- Requires climbing the mountain to access and a qualified rope line team or helicopters to bring equipment and fireworks up and back down.
- The entire discharge site is a limited egress discharge site subject to the requirements of NFPA 1123 Chapter 7.
- Nearby forest on steep, rocky ground, but with some open areas where Spotters could watch for duds, low breaks or hazardous debris.
- Nearby forest on steep, rocky ground, presents exceptional challenges for fire prevention and fire protection, especially at night.
- The only ready source of water for wetting down dry vegetation or to fight wildland fires is limited in capacity, and is only at the base on one side of the mountain, plus it is a great distance to the canyon and the top.



Photo 20 The Hall of Records Entry is narrow with walls that tend to slope inwards.



Photo 21 A dramatic segment from a show utilizing articles pyrotechnic mines and comets at multiple angles and 2” aerial shells fired vertically. These high-quality fireworks that are smaller allow for creative pyrotechnists to design and perform shows in venues that would be too small or otherwise too risky for larger aerial shells. Note the precise performance heights and effects diameters of the three different types of devices along with the uniformity of colors of each device. [Photo credit: Pirotecnia Ricardo Caballer S.A.]

- Most articles pyrotechnic 2” or less from the Top of Carvings and Ridge would be readily visible to spectators in all of the Amphitheater. Most aerial fireworks 2” to 5” would also readily visible to spectators in all of the Amphitheater.

Conclusion: Hall of Records Discharge Site

The Author’s conclusion is that using the Hall of Records Discharge Site to shoot aerial fireworks 2” to 5” can be done safely if in strict compliance with NFPA 1123 and best practices,

but only if wildland fire conditions⁴⁹ in July are low to moderate, with favorable wind speeds and directions, as well as dew points, and subject to the other recommendations in this Report.

Although the minimum separation distances may provide for larger aerial shells, the other factors at this display site, such as the elevated discharge site, the mountainous forest with a heavy fuel load, the likely conditions in early July, the challenges with spotting hazardous debris, the limitations on fire prevention and fire protection measures, and the potential for equipment failures and fireworks malfunctions, firing larger aerial shells pose a significant and unacceptable risk.

More specifically the Author concludes the following for the Hall of Records Discharge Site:

- The Canyon may be used for the types and styles of aerial fireworks 2” to 5” as recommended in this Report⁵⁰ that are fired straight up or angled to the sides, but not angled so that the trajectory of any aerial fireworks will hit or bounce off the canyon walls
- The Canyon may be used for placing mortars in racks that are perpendicular to the spectator viewing area and secured individually with ¾” plywood equilateral triangle screwed into the sides with at least six 2” deck screws or in groups

⁴⁹ Wildland fire conditions are described in Appendix B.

⁵⁰ These types and sizes of fireworks using the placement methods described here will meet the minimum separation distances in 1123 - 5.1.3.1 and 1123 - 5.1.4.3 as well as the best practices in *The Display Fireworks Manual* (2010) and from Natural Resources Canada, *Celebrate Safely* (DVD), American Pyrotechnics Association (APA), (2014, and the *Study Guide for Display Operator Training Program* (2017) from the Pyrotechnics Guild International, Inc. (PGI), subject to wind speeds and directions

secured by heavy duty steel frames, with all racks flat on the ground (loose sand or shims may be needed underneath given the uneven ground).

- The Entry may not be used for the placement of any mortars, tubes or other fireworks.⁵¹
- The Tops of Carvings may only be used for ground level fireworks and aerial fireworks or articles pyrotechnic that are 2” or less, and placed in metal holders with metal or wood bases, and on those areas that are reasonably flat and level, including the deck, but only on those areas approved by the NPS.
- The Guard Shack Steps may only be used for aerial fireworks or articles pyrotechnic 2” or less in custom metal holders that are securely attached to the sides of the steps, subject to approval by the NPS.



Photo 22 Articles pyrotechnic in metal holders and mounted on a truss. Article pyrotechnic are typically light enough and have low recoil so they can be placed in metal holders that can be mounted to almost any sturdy structure. [Photo credit: Pirotecnia Ricardo Caballer S.A.]

⁵¹ 1123 7.3.4.1

- The Ridge may only be used for aerial fireworks or articles pyrotechnic 2” or less in metal holders with metal or wood bases on those areas that are reasonably flat and level, but only on those areas approved by the NPS.⁵²



Photo 23 Article pyrotechnic in metal holders placed on top of a truss. These smaller mine and comets effects can be as dramatic or even more dramatic than aerial shells, yet they can be placed in many locations not suitable for mortars and much closer to the spectators. They also have almost no fallout and thus present less hazard to any nearby combustible materials. [Photo credit: Pirotecnia Ricardo Caballer S.A.]

- The firing control panel should be set up outside of the fence at the Entry.⁵³ The Shooter and the Shooter’s

Assistant, the only two people that need to be there during the show⁵⁴, may operate the firing control panel provided they are protected by a 4’ x 8’ x ¾” plywood and/or ¼” Lexan⁵⁵™ shield mounted on two equilateral triangle frames made of 2” x 4”, or equivalent.

⁵² The Ridge is about 100 feet above the Hall of Records canyon, necessitating additional separation distances to the spectators. It is solid granite with very few, level surfaces suitable for mortars or mortar racks with heavy recoil, especially given the difficulty in securing mortar or mortar racks properly at this location.

⁵³ 1123 7.3.3.1

⁵⁴ 1123 9.3.3

⁵⁵ 1123 – 6.2.3 (3) and 7.3.4.1 (3) ¾” plywood and ¼” Lexan™ have proven to be useful materials for protection from most, but not all, burning stars and fireworks debris. A combination of ¾” plywood with and ¼” Lexan™ window provides protection while allowing personnel to see through the shield. Shields that are angled deflect burning stars and debris better than shields that are vertical. Shields in limited egress discharge sites need to be placed away from the nearest mortars or effects according to 1123 – 7.3.3.1.

- The Entry steps should be illuminated during the display using solar lights or equivalent to provide for a Means of Escape.
- Fire prevention and protection for a show from this discharge site should address a show on the top of a steep, rocky mountain with the nearby forest. It would be essential to determine where to place Spotters to be able to watch for duds, blind stars, low breaks or hazardous debris. Planning where fire fighters should stage equipment and personnel in safe locations to respond to any potential wildland fires in the dark, would also a critical factor.
- Removal of the quickmatch leader fuses, a prohibition on chain fusing and cakes, together with the other recommendations in this report will reduce, but not entirely eliminate, the potential negative impact of any catastrophic aerial shell malfunction in a mortar or other malfunctions.

In order to protect against direct hits by aerial shells or large, powerful bursts in close proximity require heavier and sturdier barricades, such as sandbags, railroad ties, steel plate, etc.

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Indian Camp Discharge Site

The Indian Camp

Discharge Site is located

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]



The Indian Camp

Discharge Site is surrounded by a chain link fence with gates with concertina wire. The ground is relatively flat,

Photo 24 The Indian Camp Discharge Site is open but rocky and uneven with vegetation. It is surrounded by a fence and the [REDACTED]

[REDACTED]. but very rocky with some low vegetation. There are only a few nearby trees, but there are piles of fence material and other items left over from past efforts to secure the area.

The Indian Camp Discharge Site is another example of a limited egress location, depending on the number, type and placement of any mortars. The fence alone limits egress combined with the steepness and rough terrain just outside of the fence.

This discharge site can only be reached by [REDACTED] or by helicopter. Transporting the equipment and the fireworks here is extremely difficult (Moving the fence and other materials up here required a qualified rope line team that took [REDACTED]

[REDACTED].

The Indian Camp Discharge Site would support mortars buried in troughs or drums and mortars in above ground racks, but only in the open areas and only on the ground that was relatively flat.

Fireworks fired from this location can be angled slightly to burst [REDACTED], so it is likely the smallest aerial shells that would be visible to the spectators in the Amphitheater would be 6” aerial shells; however 6” aerial shells from this distance to the Amphitheater would look about the same size or smaller as 4” or 5” aerial shells fired from the Hall of Records.

Issues: Indian Camp Discharge Site

The Indian Camp Discharge Site presents a number of significant issues, including:

- Requires [REDACTED] to access and a [REDACTED] or helicopters to bring equipment and fireworks up and back down.
- Nearby forest on steep, rocky ground, but with some open areas where Spotters could watch for normal or hazardous debris, duds, and blind stars or effects
- Nearby forest on steep, rocky ground, presents exceptional challenges for fire prevention and fire protection, especially at night.
- The only ready source of water for wetting down dry vegetation or to fight wildland fires is limited in capacity, and is only at the base on one side of the mountain plus it is a great distance to the canyon and the top.
- The [REDACTED] would necessitate using aerial fireworks at least 6” and larger as anything smaller would likely be visible to spectators in the Amphitheater.

- The location [REDACTED] would necessitate compensating by moderate angling the mortars to have bursts above the carvings.
- The discharge site may need to meet the requirements of NFPA 1123, Chapter 7 and best practices for a limited egress location, which would limit the number, type and placement of any mortars.

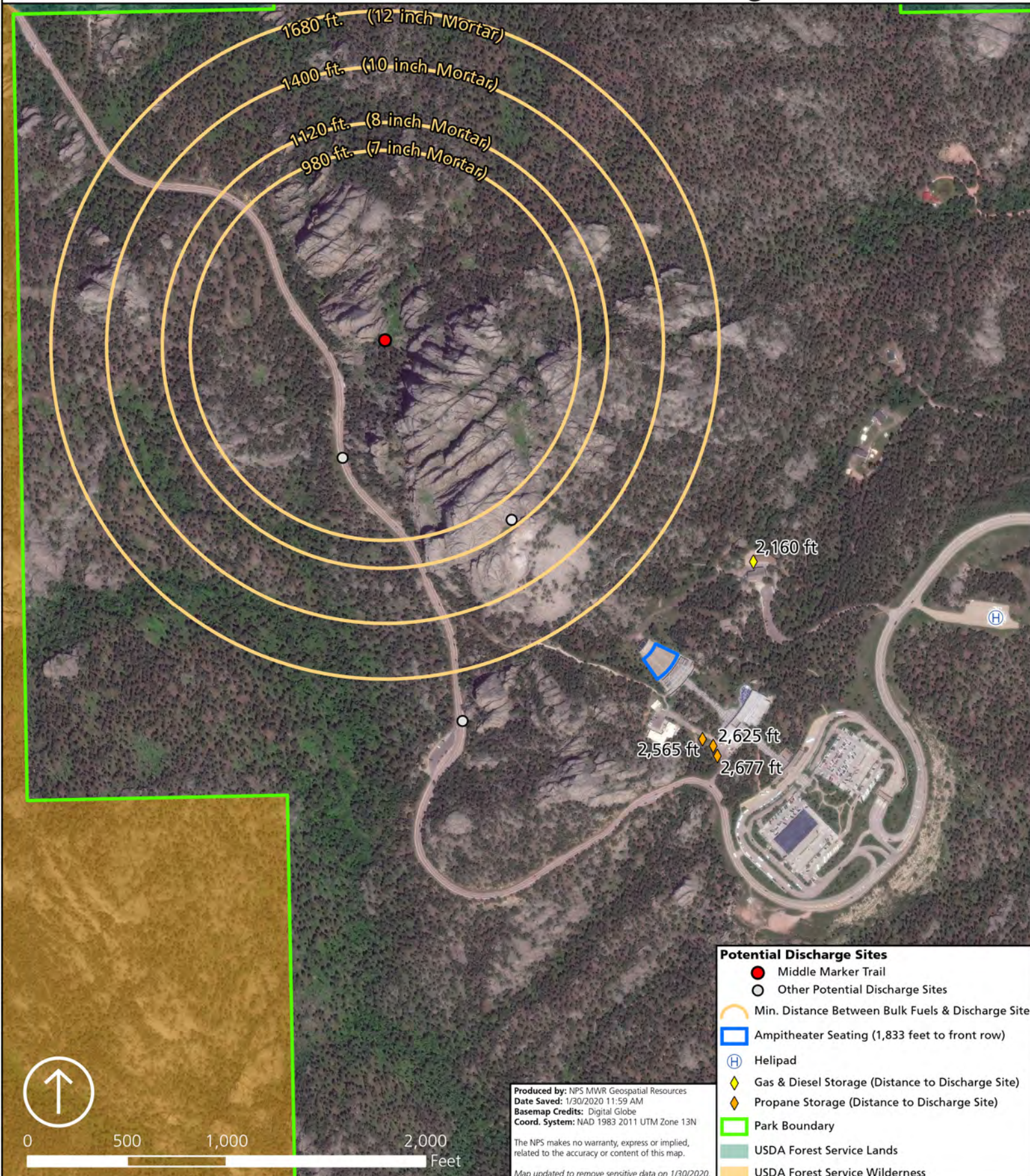
Conclusion: Indian Camp Discharge Site

The Author's conclusion is that using the Indian Camp Discharge Site to shoot aerial fireworks up to 6" can be done safely if in strict compliance with NFPA 1123 and best practices, but only if wildland fire conditions in July are low to moderate, with favorable wind speeds and directions, as well as dew points, and subject to the other recommendations in this Report.

Although the minimum separation distances may provide for larger aerial shells, the other factors at this display site, such as the elevated discharge site, the mountainous forest with a heavy fuel load, the likely conditions in early July, the challenges with spotting hazardous debris, the limitations on fire prevention and fire protection measures, and the potential for equipment failures and fireworks malfunctions, firing larger aerial shells pose a significant and unacceptable risk.



Middle Marker Trail Discharge Site Minimum Distance Between Bulk Fuels & Discharge Site



Potential Discharge Sites

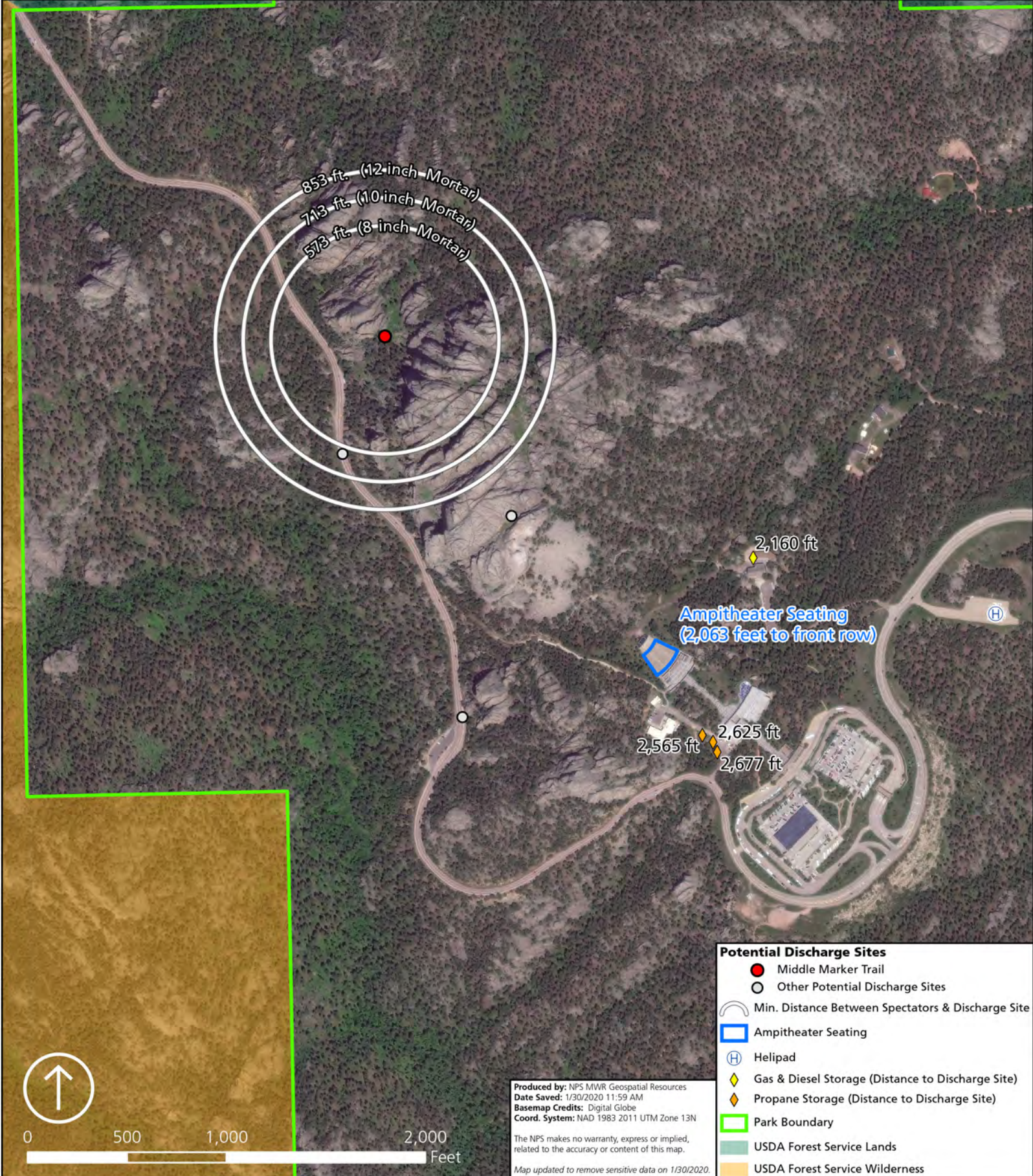
- Middle Marker Trail
- Other Potential Discharge Sites
- Min. Distance Between Bulk Fuels & Discharge Site
- Amphitheater Seating (1,833 feet to front row)
- Ⓜ Helipad
- ◆ Gas & Diesel Storage (Distance to Discharge Site)
- ◆ Propane Storage (Distance to Discharge Site)
- ▭ Park Boundary
- ▭ USDA Forest Service Lands
- ▭ USDA Forest Service Wilderness

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Middle Marker Trail Discharge Site

Minimum Distance Between Spectators & Discharge Site



Middle Marker Trail Discharge Site

The Middle Marker Trail Discharge Site is located about 1,100 feet behind the carvings and about 2,000 feet from the Amphitheater.

This discharge site is close to South Dakota Highway 244. It is on the backside of the mountain with the carvings. It would require substantial manual effort to haul the equipment and fireworks up to the open area. The ground is sloped and rocky, with many large ponderosa pine trees all about and up the slopes.

The Middle Marker Trail Discharge Site would support mortars buried in troughs or drums, but not large dumpsters. It would support mortars in above ground racks, but only in the open areas and only on the ground that was relatively flat.



Photo 25 The Middle Marker Trail Discharge Site is an open area in the rocky forest on the backside of the mountain. The distance and differences in elevation would require large diameter shells to possibly be visible to the spectators in the Amphitheater.

Issues: Middle Marker Trail Discharge Site

The Middle Marker Trail Discharge Site presents a number of significant issues, including:

- Surrounded by forest on steep, rocky ground making it difficult if not impossible for Spotters to watch for normal or hazardous debris, duds, and blind stars or effects.

- Surrounded by forest on steep, rocky ground making it difficult if not impossible for fire fighters to stage equipment and personnel in safe locations to respond to any potential wildland fires in the dark.



Photo 26 An example of wetting down combustible vegetation such as tall grass, even when it is green. This is a time-honored method to preventing potential grass fires from the normal or hazardous debris that come back down to the ground in a discharge site and fallout area. Doing so at MORU is a challenge given the limited water capacity and ability to pump water up a mountain, the type and volume of vegetation, and the size of the fallout areas from elevated discharge site(s).

- No ready source of water for wetting down dry vegetation or to fight wildland fires.
- The carvings between it and the Amphitheater would necessitate using aerial fireworks 8” or larger (probably only 10” and 12” would be visible at this distance) as aerial fireworks smaller than 8” would likely not be visible to spectators in the Amphitheater.
- The location and moderate slope to one side of the carvings would necessitate compensating by moderate angling the mortars in an attempt to have bursts above the carvings.
- Moderate angling of mortars may place tree branches unacceptably close to the trajectory of the aerial shells.

Conclusion: Middle Marker Trail Discharge Site

The Author's conclusion is that using the Middle Marker Trail Discharge Site to shoot some of the smallest of the articles pyrotechnic 2" or less might be done safely if in strict compliance with NFPA 1126 and best practices, but only if wildland fire conditions in July are ideal, and subject to the other recommendations in this Report; however there is no practical place for spectators to view such a show.

The to shoot aerial fireworks 2" or larger at the Middle Marker Trail Discharge Site cannot be done safely or in compliance with NFPA 1123 and best practices, and even if conditions in July are ideal.

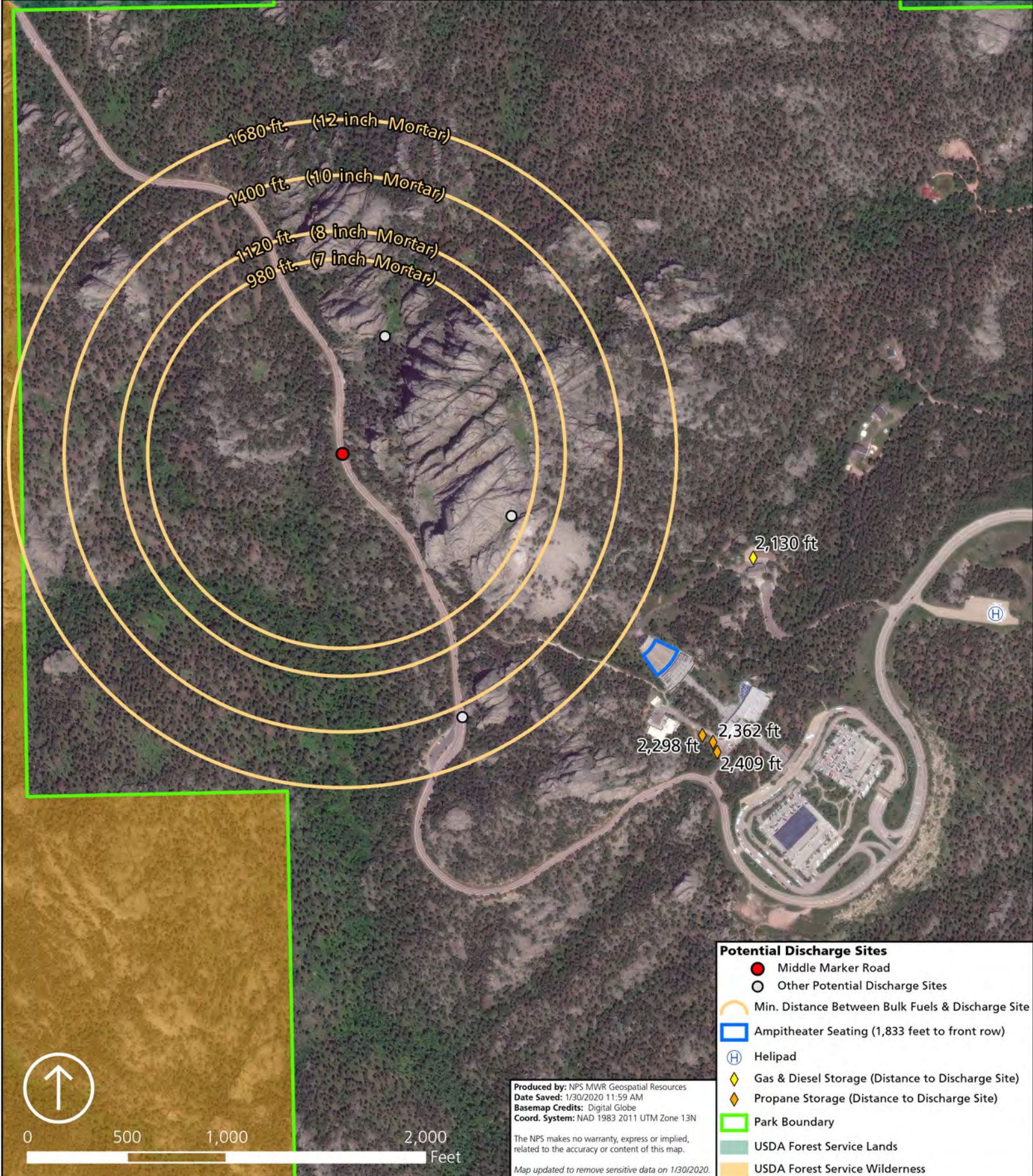
Although the minimum separation distances may provide for larger aerial shells, the other factors at this display site, the differences in elevations between this discharge site and the Amphitheater necessitating using larger diameter aerial shells, the mountainous forest with a heavy fuel load, the likely conditions in early July, the challenges with spotting hazardous debris, the limitations on fire prevention and fire protection measures, and the potential for equipment failures and fireworks malfunctions, firing larger aerial shells pose a significant and unacceptable risk.



Photo 27 The Amphitheater stage and backstage with the MORU carvings above could serve as a discharge site for some articles pyrotechnic. Any proximate pyrotechnics here would need to be designed around whatever other programs and entertainment are conducted here on the day of the Show. Note: The view of the carvings from venter of the first three rows is blocked by the backstage. Other locations have the view blocked by tree branches.



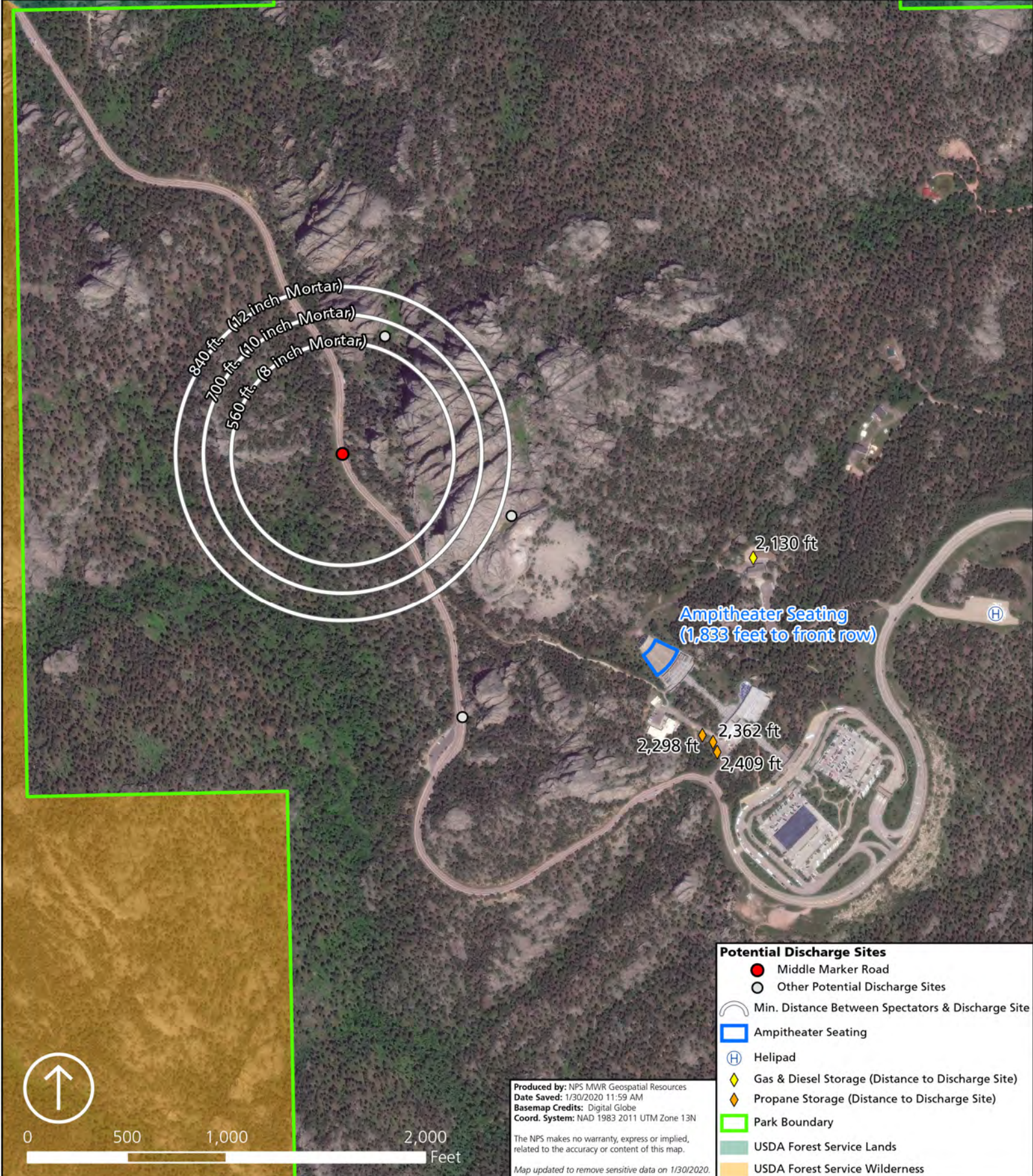
Middle Marker Road Discharge Site Minimum Distance Between Bulk Fuels & Discharge Site





Middle Marker Road Discharge Site

Minimum Distance Between Spectators & Discharge Site



Middle Marker Road Discharge Site

The Middle Marker Road Discharge Site is on South Dakota Highway 244 and located about 1,000 feet behind and slightly to one side of the carvings. It is over 1,700 feet from the Amphitheater.

This discharge site has road access and presents a good, hard, smooth surface, although the slope is both relatively steep and away from the carvings.

The Middle Marker Road Discharge Site would support mortars buried in troughs or drums, or in large dumpsters. It would support mortars in above ground racks, whether on the surface of the road or on trailers. Dumpsters or trailers could be set up at some other location and moved to this discharge site for loading and firing. It may also be feasible to load the mortars in the dumpsters and trailers at some nearby location, close the highway and move them to the discharge site the day of the show.



Photo 28 Middle Marker Road Discharge Site is a section of South Dakota Highway 244 behind the carvings

Issues: Middle Marker Road Discharge Site

The Middle Marker Road Discharge Site presents a number of significant issues, including:

- Requires road closure in order to set up the mortars and load the fireworks, or place the dumpsters or trailers with the mortars loaded with the fireworks.

- Surrounded by forest on steep, rocky ground making it difficult if not impossible for Spotters to watch for normal or hazardous debris, duds, and blind stars or effects.
- Surrounded by forest on steep, rocky ground making it difficult if not impossible for fire fighters to stage equipment and personnel in safe locations to respond to any potential wildland fires in the dark.
- No ready source of water for wetting down dry vegetation or to fight wildland fires.



Photo 29 Two flatbed trailers with drums filled with sand for large diameter mortars and heavy-duty metal frame racks for medium diameter mortars. A trailer or dumpster can be setup and the fireworks loaded at a secure location, and then the roads closed to the public for movement of the trailer or dumpster to the discharge site on the day of the show. [Photo credit: Fireworks FX, Inc]

- The carvings between it and the Amphitheater would necessitate using aerial fireworks 8” or larger as aerial fireworks smaller than 8” would likely not be visible to spectators in the Amphitheater.
- The moderate slope away from the carvings would necessitate compensating by moderate angling the mortars in an attempt to have bursts above the carvings.
- Moderate angling of mortars buried in dumpsters would require additional bracing with heavy material capable of withstanding the recoil.
- Moderate angling of mortars may place tree branches up the slope towards MORU unacceptably close to the trajectory of the aerial shells.

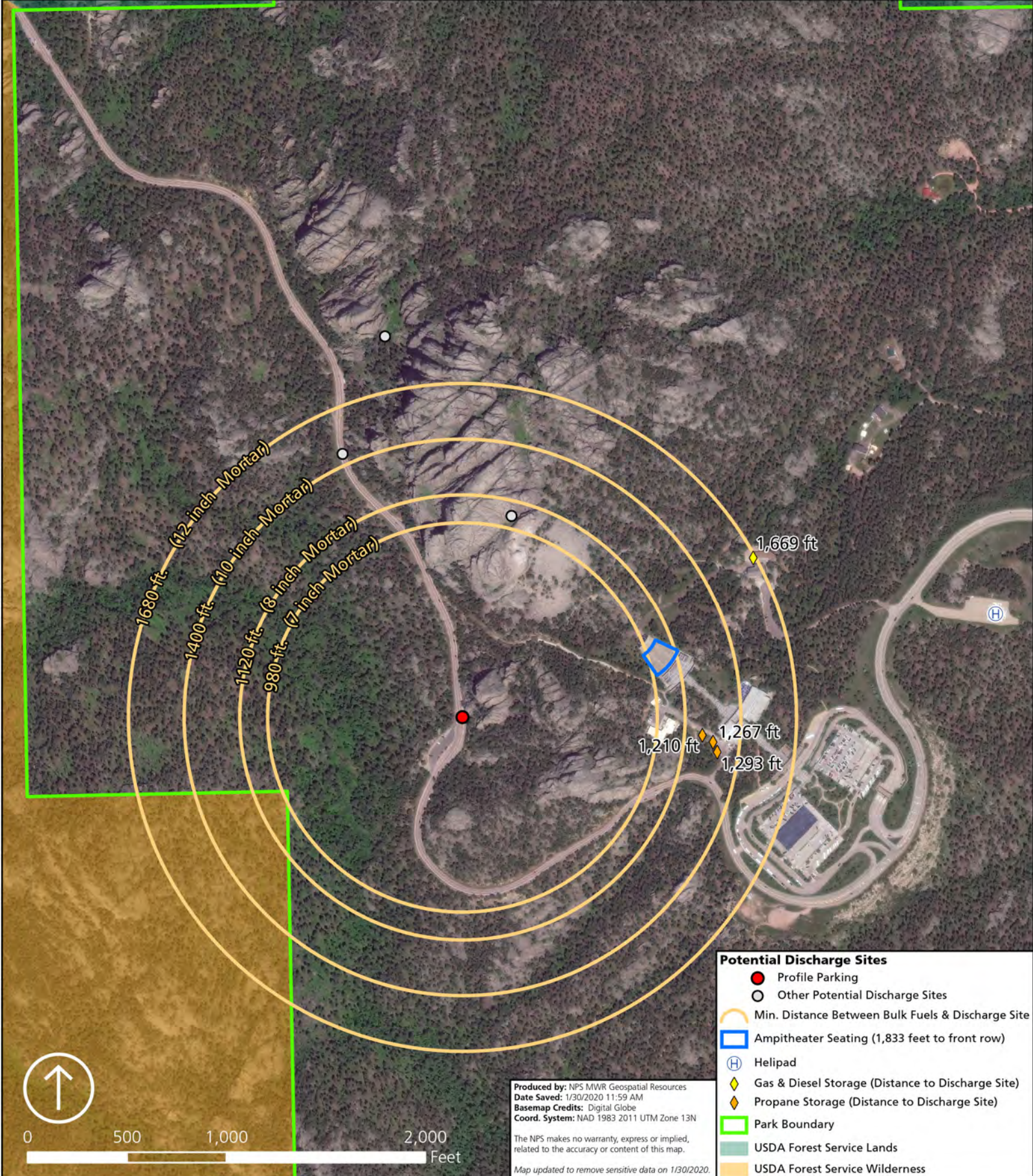
Conclusion: Middle Marker Road Discharge Site

The Author’s conclusion is that using the Middle Marker Road Discharge Site to shoot some articles pyrotechnic 2” or less might be done safely if in strict compliance with NFPA 1126 and best practices, but only if wildland fire conditions in July are ideal, and subject to the other recommendations in this Report; however the only practical place spectators could view such a show would be from the road.

Although the minimum separation distances may provide for larger aerial shells, the other factors at this display site, the differences in elevations between this discharge site and the Amphitheater necessitating using larger diameter aerial shells, the mountainous forest with a heavy fuel load, the likely conditions in early July, the challenges with spotting hazardous debris, the limitations on fire prevention and fire protection measures, and the potential for equipment failures and fireworks malfunctions, firing larger aerial shells pose a significant and unacceptable risk.



Profile Parking Discharge Site Minimum Distance Between Bulk Fuels & Discharge Site





Profile Parking Discharge Site Minimum Distance Between Spectators & Discharge Site



Profile Parking Discharge Site

The Profile Parking Discharge Site is located about 1,000 feet to the side (stage right, house left) and slightly in front of the carvings and about 1,000 feet from the Amphitheater.

This discharge site is adjacent to South Dakota Highway 244 and presents a good, hard, smooth surface, although the slope is both relatively steep and away from the carvings.

The Profile Parking Discharge Site would support mortars buried in troughs or drums, or in large dumpsters. It would support mortars in above ground racks, whether on the surface of the parking lot or on trailers. Dumpsters or trailers could be set up at some other location and moved to this discharge site for loading and firing. It may also be feasible to load the mortars in the dumpsters and trailers at some nearby location, close the highway and move them to the discharge site the day of the show.



Profile Parking Discharge Site is to the side and just in front of the carvings. It slopes steeply away from MORU.

Issues: Profile Parking Discharge Site

The Profile Parking Discharge Site presents a number of significant issues, including:

- Requires road closure in order to set up the mortars and load the fireworks, or place the dumpsters or trailers with the mortars loaded with the fireworks.

- Surrounded by forest on steep, rocky ground making it difficult if not impossible for Spotters to watch for normal or hazardous debris, duds, and blind stars or effects.
- Surrounded by forest on steep, rocky ground making it difficult if not impossible for fire fighters to stage equipment and personnel in safe locations to respond to any potential wildland fires in the dark.
- No ready source of water for wetting down dry vegetation or to fight wildland fires.
- The carvings between it and the Amphitheater would necessitate using aerial fireworks 8” or larger as aerial fireworks smaller than 8” would likely not be visible to spectators in the Amphitheater.
- The steep slope away from the carvings would necessitate compensating by severely angling the mortars in an attempt to have bursts above the carvings.
- Severe angling of mortars buried in dumpsters would require heavy bracing with concrete barricades or similar strong, heavy material capable of withstanding the recoil. (An equivalent method could be developed using heavy duty steel 2” square steel holders with reinforced concrete bracing capable of withstanding the recoil, but this would require significant development and testing).
- The location slightly in front of the carvings would necessitate compensating by severe angling the mortars to shoot aerial shells over a nearby rock formation in an attempt to have bursts behind and above the carvings.

- Aerial fireworks 8” or larger fired at these severe angles behind and above the carvings would likely not meet the separation distances required by 1123 - 5.1.3.1 and 1123 - 5.1.4.3 and best practices

Conclusion: Profile Parking Discharge Site

The Author’s conclusion is that using the Profile Parking Discharge Site to shoot some articles pyrotechnic 2” or less might be done safely if in strict compliance with NFPA 1126 and best practices, but only if wildland fire conditions in July are ideal, and subject to the other recommendations in this Report; however the only practical place spectators could view such a show would be from the road.

Although the minimum separation distances may provide for larger aerial shells, the other factors at this display site, the steep slope away from the carvings requiring offsetting mortar angles aimed towards the carvings combined with the distance necessitating using larger diameter aerial shells⁵⁶, the mountainous forest with a heavy fuel load, the likely conditions in early July, the challenges with spotting hazardous debris, the limitations on fire prevention and fire protection measures, and the potential for equipment failures and fireworks malfunctions, firing larger aerial shells pose a significant and unacceptable risk.

⁵⁶ It is quite likely that any such attempt to fire large diameter shells at such steep angles would result in the shells bursting on or striking the rock formations, the forest, the carvings and possibly even into the Amphitheater and surrounding areas with buildings and spectators. Any aerial fireworks 8” or larger that burst low or on the ground would likely result in starting a wildland fire in a multitude of locations over many hundreds of feet wide.

Amphitheater Discharge Site

The Amphitheater Discharge Site was identified by NPS staff as the primary location for spectators to view a show at MORU. It would be suitable only for articles pyrotechnics used according to NFPA 1126 and best practices.⁵⁷ It is located directly in front of and below the carvings (stage center, house center).



Photo 30 The Amphitheater and Grand View Terrace have many different elevations with the backstage or tree branches blocking the view of the carvings from some locations. [Photo credit: Eoin Care, NPS]

The Amphitheater Discharge Site consists of the stage and backstage, but not the area or road behind the Amphitheater.

The stage is slightly elliptical and approximately 73 feet wide and 24 feet deep. The backstage is in in two different levels, with the tallest level in the center and the shorter levels on either side.

The aisle between the front of the stage and the first row of seats is approximately 13 feet wide. It is approximately 38 feet from the front of the backstage to the first row of seats.

Issues: Amphitheater Discharge Site

The Amphitheater Discharge Site presents a number of issues, including:

⁵⁷ The *Special Effects Manual*, Natural Resources Canada, (2014) provides best practices that compliment NFPA 1126 for proximate pyrotechnics.

- It would be limited to articles pyrotechnics that comply with 1126 – 8.4 and best practices (proximate audience)
- Some articles pyrotechnic mounted on the stage or the backstage would likely not be visible to spectators behind the first few rows spectators in the Grand View Terrace.
- The view by the spectators of the carvings and any fireworks bursting above the carvings from the fireworks portion of a show would be obstructed by some articles pyrotechnic mounted on the stage or the backstage and fired at the same time during the show.

Conclusion: Amphitheater Discharge Site

The Author's conclusion is that the Amphitheater Discharge Site to shoot articles pyrotechnic (proximate audience) can be done safely subject to strict compliance with NFPA 1126 and best practices, if wildland fire conditions in July are low to moderate, with favorable wind speeds and directions, as well as dew points, and subject to the other recommendations in this Report.

Author Proposed Discharge Sites

The Author proposed additional discharge sites on the basis that fireworks devices and articles pyrotechnic could potentially be placed in these discharge sites and comply with NFPA 1123 and/or NFPA 1126 and best practices. The Author intended that no potential discharge site at MORU would be overlooked and evaluated, no matter how farfetched it might seem.

The Author proposed discharge sites are as follows:

Amphitheater Road Discharge Site

The Amphitheater Road Discharge Site was identified by the Author because it is a potential discharge site, but only for ground level fireworks and articles pyrotechnic 2” or less under NFPA 1126 and best practices given its proximity to the Amphitheater. It is just behind the Amphitheater and located directly in front of and below the carvings (stage center, house center), as well as to one side (stage left, house right).

The Amphitheater Road Discharge Site consists of a blacktop road and turn around circle. The area considered is approximately 100 feet long and 12 feet wide with a 40 feet wide in the turnaround circle. It is about 5 to 10 feet below the Amphitheater.

There are also open, grassy areas on either side of the road.

Issues: Amphitheater Road Discharge Site

The Amphitheater Discharge Road Site presents a number of issues, including:

- It would be limited to ground level fireworks and articles pyrotechnic 2” or less (proximate audience)
- Only some types of articles pyrotechnic 2” or less mounted on the road would shoot up high enough to be visible to most spectators in the Amphitheater, but



Photo 31 The Amphitheater Road Discharge Site likely will need to remain open and available for emergency access and fire equipment providing fire protection to MORU

those in the first few rows of the Amphitheater will only see the top portions of the effects.

- The view by the spectators of the carvings and any fireworks bursting above the carvings from the fireworks portion of a show would be obstructed by any articles pyrotechnic 2” or less mounted on the stage or the backstage and fired at the same time during the show.
- Strobe pots and perhaps some other types of illuminations on the road would be a useful effect at this location. Strobes pots would illuminate the forest and base of the mountain and build suspense and during quieter portions of any music track.

Conclusion: Amphitheater Road Discharge Site

The Author’s conclusion is that the Amphitheater Road Discharge Site to shoot some ground level fireworks and articles pyrotechnic 2” or less (proximate audience) can be done safely subject to strict compliance with NFPA 1126 and best practices, if wildland fire conditions in July are low to moderate, with favorable wind speeds and directions, as well as dew points, and subject to the other recommendations in this Report. Aggressive and comprehensive fire prevention measures to reduce the fuel load in the vicinity as well as fire prevention measures to mitigate the potential for wildland fires are essential. A thorough technical performance evaluation (performance height, spread, duration, trajectory, etc.) of every device in each specific location is also vital.

Presidential Trail Discharge Site

The Presidential Trail Discharge Site was identified by the Author because it is a potential discharge site, but only for ground level fireworks and some articles pyrotechnic 2” or less under NFPA 1123 and best practices. It meanders to and from the Visitor Center and across the base of the mountain.

The Presidential Trail Discharge Site consists of a concrete path and landings in combination with composite deck walkways with steps and landings. The area considered is approximately 400 to 500 feet from the Amphitheater and 600 feet long, however only the portions that have opening in the tree canopy are considered. Elevations also vary along the trail and range from about 50 to 100 feet above the Amphitheater.

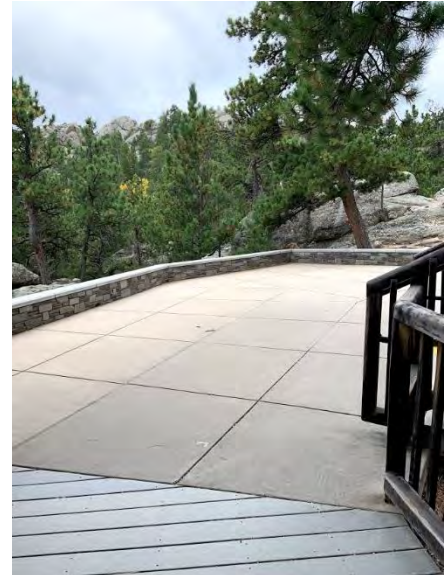


Photo 32 The Presidential Trail has a number of landings and a few segments along the trail with limited openings between the nearby the trees. These locations may serve well for strobe pots and articles pyrotechnic comets and mines up to 2”, provided there is due diligence with fire prevention and fire protection measures, a technical performance evaluation of the effects for each location, sufficient clearance from the trees, etc. and favorable conditions.

Issues: Presidential Trail Discharge Site

The Presidential Trail Discharge Site presents a number of issues, including:

- Anything other than ground level or articles pyrotechnic 2” or less that are mines or comets are likely not to comply with the Minimum Separation Distances in 1123 - 5.1.3.1 and 5.1.4.3 and best practices.
- The tree canopy limits the placement of articles pyrotechnic 2” or less to the openings along the trail, at the landings and a few other spots along the trail.

- All articles pyrotechnic 2” or less mounted on the trail should shoot up high enough to be visible to most spectators in the Amphitheater, but those in the first few rows of the Amphitheater may only see the top portions of the effects.
- The view by the spectators of the carvings and any fireworks bursting above the carvings from the fireworks portion of a show should not be obstructed by any articles pyrotechnic 2” or less mounted on the trail.
- Articles pyrotechnic 2” or less would need to be placed in metal holders with plywood or metal bases
- Ground level fireworks would need to be placed on metal plates or in pan mortars.

Conclusion: Presidential Trail Discharge Site

The Author’s conclusion is that the Presidential Trail Discharge Site to shoot ground level fireworks and some articles pyrotechnic 2” or less that are comets and mines can be done safely subject to strict compliance with NFPA 1123 and best practices, if wildland fire conditions in July are low to moderate, with favorable wind speeds and directions, as well as dew points, and subject to the other recommendations in this Report. Aggressive and comprehensive fire prevention measures to reduce the fuel load in the vicinity as well as fire prevention measures to mitigate the potential for wildland fires are essential. A thorough technical performance evaluation (performance height, spread, duration, trajectory, etc.) of every device in each specific location is also vital.

Forest Openings Discharge Site

The Forest Openings Discharge Site was identified by the Author because it is a potential discharge site, but only for ground level fireworks and some articles pyrotechnic 2” or less under NFPA 1123 and best practices. It is made up of the rocky and forested areas on both sides of the Presidential Trail at the base of the mountain.

The Forest Openings Discharge Site consists only of the areas with openings in the tree canopy. Elevations also vary and range from about 50 to 100 feet above the Amphitheater.



Photo 33 A burned tree trunk adjacent to the Presidential Trail serves as a reminder how fragile this National Memorial is, and how important it will be to make the correct decisions on a Show at MORU.

Issues: Forest Openings Discharge Site

The Forest Openings Discharge Site presents the same issues as the Presidential Trail Discharge Site, with the exception that the ground is rocky and uneven, and is covered with pine needles and other combustible vegetation.

Conclusion: Forest Openings Discharge Site

The Author’s conclusion is the same as for the Presidential Trail Discharge Site, with the exception that some rock formations may be used to place some ground level fireworks and articles pyrotechnic 2” or less. Any ground with pine needles and other combustible vegetation

would need additional protections, such as raking areas of pine needles and combustible vegetation, wetting down the immediate area, etc.

Talus Field Discharge Site

The Talus Field Discharge Site was identified by the Author because it is a potential discharge site, but only for ground level fireworks and some articles pyrotechnic 2” or less under NFPA 1123 and best practices. It is across the base of the mountain and roughly 500 feet wide and long, and 500 feet from the Amphitheater.

The Talus Field Discharge Site consists of the rock tailings from the blasting of the carvings with a few small trees at the base and along the sides. Elevations also vary from the top to the bottom and side to side. They range from about 100 to 400 above the Amphitheater.

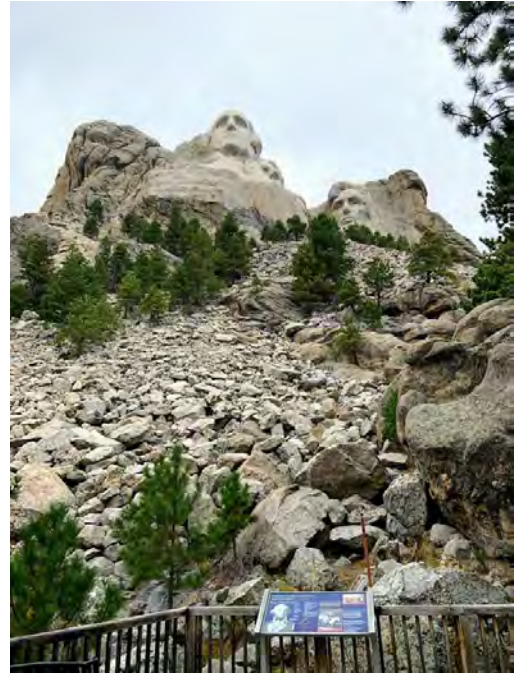


Photo 34 The Talus Field has some potential for articles pyrotechnic, however climbing it to place the devices poses significant risks. Strobe pots and 2” comets and mines at the lower levels that are safer to climb may be viable.

Issues: Talus Field Discharge Site

The Talus Field Discharge Site presents a number of issues, including:

- Anything other than ground level or articles pyrotechnic 2” or less that are mines or comets and placed in the lower portion of the Talus Field are likely not to comply with the Minimum Separation Distances in 1123 - 5.1.3.1 and 5.1.4.3.

- articles pyrotechnic 2” or less that are aerial shells and placed in the middle to the top of the Talus Field are likely to comply with the Minimum Separation Distances in 1123 - 5.1.3.1 and 5.1.4.3
- articles pyrotechnic 2” or less that are aerial shells and placed in the middle to the top of the Talus Field are likely to burst in front of the carvings
- The rock tailings are loose and unstable, and very difficult to climb.
- All articles pyrotechnic 2” or less mounted on the Talus Field should shoot up high enough to be visible to most spectators in the Amphitheater, but those in the first few rows of the Amphitheater may only see the top portions of the effects.

Conclusion: Talus Field Discharge Site

The Author’s conclusion is the same as for the Presidential Trail Discharge Site, with the exception that some portions of the lower talus field may be used to place some ground level fireworks and articles pyrotechnic 2” or less, and any ground with pine needles and other combustible vegetation would need additional protections, such as raking areas of pine needles and combustible vegetation, wetting down the immediate area, etc.

Sides of Carvings Discharge Site

The Sides of Carvings Discharge Site was identified by the Author because it is a potential discharge site, but only for ground level fireworks and some articles pyrotechnic 2” or less under NFPA 1123 and best practices. It is both sides of the carvings and roughly 100 feet below the top of the carvings. The Washington side (stage right, house left) of the carvings is

about 750 feet away from the Amphitheater and the Lincoln side (stage left, house right) of the carvings is about 850 feet away from the Amphitheater.

The Sides of Carvings Discharge Site consists of fine granite rock with a few small trees below. Elevations also vary from the about 500 feet at the top to about 400 feet at the bottom above the Amphitheater.



Photo 35 Waterfalls strung across the famous Edinburgh Castle create a fabulous and long lasting effect, however the rising smoke would obscure the carvings on the mountain and the sparks and hot dross would pose a hazard to the small trees below in the talus field. [Photo credit: Eoin Care, Allied Edinburgh Theater]

Issues: Sides of Carvings Discharge Site

The Sides of Carvings Discharge Site presents a number of issues, including:

- Anything other than ground level fireworks and article pyrotechnic 2” or less would be difficult to place and secure

- Niagara falls and some other illuminations would drop burning sparks or hot dross on the small trees below, and smoke would rise up in front of the carvings
- Anything that is hung over the side on ropes or cables and is not secured is likely to move about by any small breeze or updraft.
- Only skilled, capable rock climbers with the right equipment and support should rappel over the front of the mountain, and only subject to NPS approval
- All ground level fireworks and articles pyrotechnic 2” or less would be visible to most spectators in the Amphitheater, but those in the first few rows of the Amphitheater may not see any or all of the effects.

Conclusion: Sides of Carvings Discharge Site

The Author’s conclusion is that the Sides of Carvings Discharge Site to shoot ground level fireworks and articles pyrotechnic 2” or less can be done safely, if wildland fire conditions in July are low to moderate, with favorable wind speeds and directions, as well as dew points, and subject to the other recommendations in this Report.

In particular, only comets and mines with effects that could not reach the small trees below or that were aimed over the talus field should be used. No Niagara falls or other illuminations that could drop sparks or hot dross on the small trees below should be used.

General Author Conclusions

A fireworks display and/or proximate pyrotechnic Show can be done at MORU and comply with the applicable NFPA codes and standards as well as best practices, and the

recommendations in this Report; however in order to do so will require extraordinary due diligence by the Operator, Sponsor(s) and AHJ(s).

It is important to keep in mind that planning, preparing and scheduling a Show is one thing, but the weather and conditions at MORU can easily and quickly change everything, so all involved must be aware of that reality. Whatever is planned will change; and then change AGAIN!

Any Show at MORU that complies with the applicable NFPA codes and standards as well as best practices and the recommendations in this Report will be different than those performed from the Hall of Records in the past.⁵⁸



Photo 36 The Operator will need to conduct a detailed viewshed analysis that determines what aerial fireworks and articles pyrotechnic based on their performance heights and performance spread will be visible to the spectators in the Amphitheater

⁵⁸ The Author notes that many news reports and social media posts regarding the return of Independence Day fireworks to MORU in 2020 hint or even state that the show will be the same as in the past. The expectation also seems to be that anyone and everyone that wants to, will be able to drive to MORU to watch the show. Discussions with NPS staff and the South Dakota State Fire Marshal however indicate that there will be limits on the number of spectators in the Visitor Center Complex, as well as other controls due to security, traffic, parking, public safety and other concerns given the limitations of the infrastructure and resources.



Photo 37 A 4" catastrophic aerial shell malfunction in a cardboard mortar. This single break color shell has destroyed the above ground wood frame mortar rack and the sandbags that were used to brace it. Note the entire rack is coming up and out of the blast with the fireball, along with pieces of the mortar rack and the burning stars. Cakes and finale boxes with cardboard tubes, which are chain fused, will experience similar results in the event of a blowout, but because cakes and finale boxes are chain fused, they likely will continue to fire any remaining effects at steep angles until it blows itself out, or is spent.

Author Recommendations

The Author recommends the following:

Informational Package for Prospective Operators

Given the shortened timeline for a Show at MORU on July 3, 2020, to facilitate the process for soliciting bids in response to Requests for Proposals (RFPs) by the Sponsor(s), the NPS and other AHJs with the Sponsor(s) should develop an detailed MORU Fireworks Show Informational Package with the NPS criteria for a Show at MORU on July 3, 2020.

Prior to the Sponsor(s) awarding a contract to an Operator, the NPS should:

- hold an informational meeting with the other AHJs and explain what the NPS is considering, if any, for discharge site(s), operational limitations, resource limitations, expected resource needs, permit application requirements, etc. to develop the MORU Fireworks Show Informational Package
- hold an informational meeting with the Sponsor(s) and explain the MORU Fireworks Show Informational Package.
- after the Sponsor(s) decides what their goals and plans are for a show at MORU, the NPS should hold an informational meeting for prospective Operators to explain the MORU Fireworks Show Informational Package.
- schedule a walk through (when feasible) of the NPS approved discharge site(s) for the Sponsor(s) and prospective Operators.



Photo 38 Round stars are the most common type of stars used in display fireworks. There are also pumped stars that are conical in shape and cut stars that are cube in shape. Stars typically consist of a fuel, an oxidizer and a binder and burn at 800 to 1,000° C creating the bright colors we see in the sky.

Permit Application and Approval

The NPS as well as other AHJs should require a permit application from both the Operator and Sponsor(s) as required by NFPA 1123⁵⁹, NFPA 1126⁶⁰, Federal regulations⁶¹ and South Dakota state law.⁶²

MORU is in an incorporated area of Pennington County and a fireworks permit is required under § 34-37-13 would be issued by their Fire Administration.

Pennington County may need to revise their existing Fireworks Ordinance, which prohibits the use of fireworks under *SDCL* §34-37-19 and *SDCL* §34-36-7 because *SDCL* §34-

⁵⁹ 1123 10.3

⁶⁰ 1126 6.1

⁶¹ Title 36, *Code of Federal Regulations (CFR)* § 2.38 Explosives (b) Using or possessing fireworks and firecrackers is prohibited, except pursuant to the terms and conditions of a permit or in designated areas under such conditions as the superintendent may establish, and in accordance with applicable State law.

⁶² *South Dakota Codified Law (SDCL)* § 34-37-13 A person using display fireworks at a public or private event shall obtain a permit from the governing body of the municipality, township, or county where the display fireworks are to be used permit be issued.

36-7 has subsequently been repealed. The current language of the Fireworks Ordinance makes no mention of a permit for the use of fireworks and it may be prudent to establish a permit process.

MORU is also located within the Black Hills Fire Protection District. South Dakota state law prohibits the use of fireworks or pyrotechnics without a permit.⁶³

MORU is also surrounded by the Black Hills National Forest administered by the U.S. Forest Service. A Show at MORU presents issues they will need address because the laws of physics and chemistry are not governed by the invisible lines created by human beings.

The NPS may need to consult with the U.S. Forest Service, the SD SFM, the Black Hills Fire Protection District, and the Pennington County Fire Administration regarding the issuance of permits, waivers or a memorandum of understanding for a Show at MORU.

The NPS permit application and approval process should comply with NFPA 1, NFPA 101, NFPA 1123, NFPA 1124 and NFPA 1126 and best practices, as well as applicable NPS policies. The permit application should also require, the Operator and/or the Sponsor(s) provide the information in NFPA 1123 Appendix E Display Planning and Preparation and NFPA 1126 6.3 Content of Plans.

The NPS permit application and process should include the criteria the NPS and possibly other AHJs will consider for approval of a Show at MORU.

⁶³ *SDCL* §34-37-11 “No person may sell or cause to be sold, use, or cause to be used, any pyrotechnics of any description or any consumer fireworks within the exterior boundaries of the Black Hills Forest Fire Protection District. No person may use or cause to be used, any pyrotechnics or consumer fireworks within a zone that extends three hundred feet beyond the exterior boundaries of the Black Hills Forest Fire Protection District in this state. No person may sell or cause to be sold, use or cause to be used, any pyrotechnics of any description or any consumer fireworks within any national forest, national park, state forest, or any land owned or leased by the Department of Game, Fish and Parks without written authorization by the department permitting the use of pyrotechnics or consumer fireworks, pyrotechnic displays, sales, or exhibits on land owned or leased by the department, unless the department is otherwise prohibited by law from providing the written authorization.”

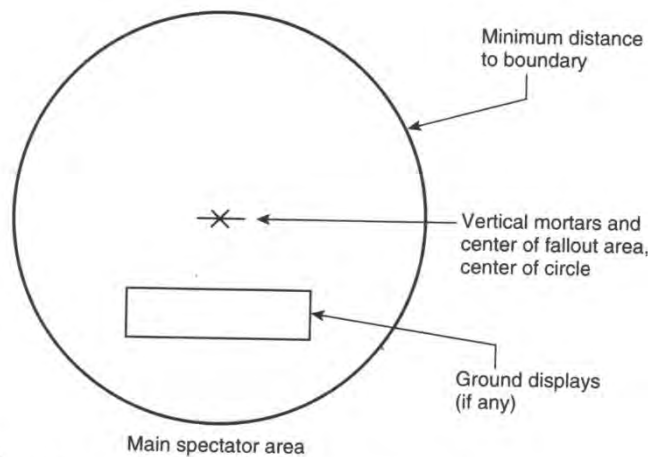


FIGURE A.5.2.1.1 Typical Layout for a Display Site with Vertically Positioned Mortars.

Photo 39 Figure A.5.2.1.1 from NFPA 1123 showing a very basic display site with a single discharge site for aerial fireworks and a single fallout area. This diagram assumes a level display site with single break shells fired from buried mortars that are vertical and with zero wind.

Permit Approval

The approval process of a permit application should include as a minimum:

- a mandatory personal survey by the permit applicant(s) of the potential discharge site(s) approved by the NPS AHJ and other AHJs.

Photo 40 Figure A.5.2.1.1 from NFPA 1123 showing a very basic display site with a single discharge site for aerial fireworks and a single fallout area. This diagram assumes a level display site with single break shells fired from buried mortars that are vertical and with zero wind.

- a detailed Display Site diagram with the discharge site(s), fallout area(s) and spectator viewing area(s) [The Display site].
- a detailed diagram showing storage area(s), preparation area(s), equipment staging areas(s), etc.

- detailed descriptions with specifications of the equipment (mortars, mortar racks, holders, securement and stabilization methods, shields and materials, firing system, etc.) to be used with photos,
- detailed descriptions of the fireworks and/or pyrotechnics to be used including brand names, sizes, effects descriptions, mortar and device locations with angles, durations, performance heights and performance spread
- a detailed viewshed analysis that determines what aerial fireworks and articles pyrotechnic based on their performance heights and performance spread will be visible to the spectators in the Amphitheater⁶⁴
- US Department of Transportation (DOT) Explosive number (EX#) with the manufacturer's applications listing the chemical compositions of all fireworks and articles pyrotechnic⁶⁵
- Safety Data Sheets (SDS) for all of all fireworks and articles pyrotechnic
- lists of other complex, large scale shows produced by the permit applicant with the contact names of the sponsors and the AHJs
- name, credentials, show experience, curriculum vitae (CV) of the Operator and key Assistants
- Proposed schedules

⁶⁴ Only a detailed viewshed analysis will determine with a high degree of accuracy what aerial fireworks and articles pyrotechnic will be visible to the spectators in the Amphitheater

⁶⁵ U. S. Department of Transportation (DOT) Explosive number (EX#) applications will list the approved chemical compositions for each fireworks or articles pyrotechnic effect, including the fuels, oxidizers and binders for the stars and burst charge.

Show Design

The safe performance of any show starts with the selection of both the discharge site(s) and the design of the show from that discharge site(s).

Anyone can design an impressive show that looks good on paper because of the volume of product used. A “shoot a hole in the sky” show also wows spectators with volley after volley of various sizes and types of fireworks, but this type of show requires more gear, which in turn requires more labor and logistics. This type of show generally relies on using large quantities of cheaper, lower quality product, which do not have the same vibrant colors and duration of higher quality fireworks; hence the need to rapidly fire larger numbers of fireworks devices.

More importantly, a “shoot a hole in the sky” show using large quantities of cheaper, lower quality product has a higher malfunction and failure rate, which in turn increases safety risks. Reducing the number of fireworks/pyrotechnic devices and using higher quality fireworks/pyrotechnic devices reduces, but does not eliminate, the odds of an equipment failure or fireworks malfunction, and thus reduces the risks of potential fires, property damage, injuries and even deaths.

Differences in the “Same” Fireworks

Compare a low quality 5” Chinese peony shell with a performance duration of about 1 second with a high quality American or Chinese 5” peony with a performance duration about 2 seconds. The low-quality Chinese peony colors will not be as vibrant and rich as the high quality American or Chinese peony simply because of the quality of the chemicals used and the better-quality controls in the manufacturing process.

The low-quality Chinese peony has only about 2/3 of the star composition by weight as a high quality American or Chinese peony. The low-quality Chinese peony may have a star ignition rate of only 90-95% while the high quality American or Chinese peony has a star ignition rate of 99.9%.

The more blind stars and effects that came down on the ground during a fireworks, the greater the potential for a hazardous situation. Blind stars and effects laying on the ground can still be ignited, provided there is sufficient fire transfer, such as from a direct and sustained flame from a prescribed burn or wildland fire. It may take weeks or months for blind stars and effects laying on the ground to dissolve to the point this hazard is diminished or mitigated.

Differences in the Show Pace

A “shoot a hole in the sky” generally has volley after volley of fireworks until the finale. Some volleys are a bit bigger or faster than others, but the pace of the show remains fairly constant until the finale. Sometimes the smoke from a show at this constant pace builds up to the point that the fireworks are obscured before the finale even begins.

The music is almost always continuous with shortened clips of songs that run one into the next. It is often mixed, so the beat is relatively constant from start to finish.

In the US and many other markets around the world, price is the dominant factor while in many other Western countries such as Japan, Canada, Australia and Western Europe quality is the dominant factor. Sponsors here tend to focus on how many “bangs for the buck” they get in a proposal rather than the entertainment value of the fireworks display.



Photo 41 An example of the volume of smoke generated from a small finale of cakes and chain fused 3” salutes on a very windy night. Note the burning stars going up as well as coming down from the cakes.

A show with a music mix of entire songs or at least portions of songs with an opening, a verse and a chorus with breaks between songs allows the spectators to clap and cheer between songs. It also builds anticipation, while allowing the smoke to dissipate.

The pace of each song remains as it was originally and the mix can go from hard and loud to soft and slow, back to hard and loud. Ebbs and flows to the music allow ebbs and flows to the fireworks, so one can shoot fewer, but higher quality fireworks and still entertain the spectators.

A show that tells a story, even one with narration between songs, can extend the show length and remain very entertaining. It just takes a bit of creativity.

Fireworks Alternatives: Lights, Lasers, Holograms and Drones

Some shows with the right venues, such as at theme parks and major attractions like the Eiffel Tower, the Seattle Space Needle and others utilize alternatives to fireworks, such as lights, lasers, holograms and now even squadrons of drones. Often these are used in conjunction with fireworks and articles pyrotechnic and enhance the story being told by the show, while allowing the smoke to clear from the fireworks.

MORU would be an ideal venue for some of these alternatives, especially projected lights and holograms onto the talus field and the carvings, which would serve as an excellent screen and backdrop. These alternatives may also prove to be as entertaining and cost effective as a much larger and longer fireworks display.

Fireworks Company Qualifications

Given the extreme challenges with any show at MORU, the fireworks/special effects company chosen should have extensive experience with similar challenging venues. The company should have the creativity to design a show that not only meets but exceeds the minimum standards in NFPA 1123 and/or NFPA 1126 and best practices.

The company should also have the experience and creativity to design a Show that is logistically feasible and entertaining, as well as on time and on budget.

Show Plan

Prior to the Show, the Fireworks Company and the Operator should develop a detailed show plan⁶⁶ that includes:

- schedule detailing each step in the Show from the acceptance by the Operator of the contract with Sponsor(s), meetings and communications with the MORU staff and AHJs, the planning and design, the preparation and loading of the equipment, fireworks and articles pyrotechnic for transport to MORU, the transport to MORU, the receiving at MORU, the preparation at MORU and the transport to the discharge site(s), the set up of the equipment and the loading, the testing, the sound check of the music and time code, the firing of the show, the policing for duds, the striking of the equipment, the transport from the discharge sites(a), and the loading and transport from MORU
- schedule with contingency plans and emergency plans.
- contact information including mobile phone numbers and email addresses of the Operator and key Assistants
- display site(s) diagram with the locations for all equipment, fireworks and articles pyrotechnic, the Operator⁶⁷, the Shooter(s) and the Shooter's Assistant(s), the Spotters and the Command Center with the AHJ(s) and the

⁶⁶ 1126 6.3 and 1123 – Appendix E as well as best practices in other documents provide guidance on what a comprehensive show plan should consider and contain.

⁶⁷ The Operator may be a Shooter, a Shooter's Assistant or a Spotter. It may be advisable for the Operator to be in the Command Center during the display to communicate with the AHJs, the Shooter(s), Shooter's Assistant(s) and Spotters as well as coordinate the music and time code feeds.

- diagram(s) with preparation areas, temporary fireworks storage, equipment storage, staging areas, etc.
- fireworks and article pyrotechnic inventory
- equipment inventory
- any other pertinent information the Operator, AHJs or Sponsor(s) deem necessary or useful (See NFPA 1123 Appendix E and 1126 6.3)
- reference best trade practices that meet the goals of a safe show

Operator & Crew Qualifications

The Operator the fireworks company chooses for any show at MORU should also have the experience, technical capability and creativity to make everything happen safely as well as on time and on budget. The Operator should have a clear understanding of NFPA 1123 and 1126 as well as best practices for every facet of a show from start to finish.

The key Assistants to the Operator should have similar experience, technical capability and creativity. The crew may contain less experienced Assistants for general labor and basic set up, however their roles should be limited.

The Operator and all Assistants must be physically and mentally capable of performing their respective duties.

The Operator and any Assistants that will set up, operate and strike the Show must be physically capable of climbing up and down to any discharge site(s) that is selected for the



Photo 42 The Shooter, who is the Operator for this fireworks display, controlling three computer firing panels as well as a computer with the music and the time code to the computer firing panels. This fireworks display has just under 1,000 cues with 1,400 fireworks devices and over 10,000 shots fired in 20 minutes to music.

show. The Operator and Assistants will also have a great number of responsibilities to address and must be capable of making the correct decisions.

Separation Distances from Discharge Sites

The Author recommends the following regarding the separation distances from the potential discharge sites to spectator viewing and parking area areas, bulk storage areas of materials that have a flammable, explosive or toxic hazard, and dwelling buildings and structures.

- At a minimum, the table of distances in 1123 5.1.3.1 as modified by the applicable provisions in Chapter 5 and best practices should be adhered to for all mortars and tubes that are vertical (90°) and with zero wind, with appropriate increases in distances for mortars that are angled ($\geq 60^\circ$) and in consideration of updrafts and wind.⁶⁸
- Under no circumstances should any mortars firing aerial shells be angled or aimed towards the spectator viewing areas, bulk storage areas of materials that have a flammable, explosive or toxic hazard, or dwelling buildings and structures.
- Mortars firing aerial shells should be vertical (90°) or angled slightly (85-80°) away from spectator viewing areas, bulk storage areas of materials that have a flammable, explosive or toxic hazard, or dwelling buildings and structures.

⁶⁸ The *Display Fireworks Manual* (2010) and from Natural Resources Canada and the *Study Guide for Display Operator Training Program* (2017) from the Pyrotechnics Guild International, Inc. (PGI) address many of the issues related to increasing or decreasing separation distances.

- Mortars firing aerial shells may be angled to the sides at angle as low as 60° and the separation distances to the sides should be increased accordingly.
- Mortars and tubes firing mines and comets may be angled to the sides at angle as low as 30° and the separation distances to the sides should be increased accordingly.



Photo 43 A 2004 still photo of the fireworks above the carvings. Note the trailing effects from the large diameter aerial shells coming down below ground level (hazardous debris) and the small tree (lower right) burning at the top of the Talus Field [Photo credit: NPS]

Fallout Area(s), Normal and Hazardous Debris, Duds, Blind Stars & Effects

The Author recommends following regarding the fallout area(s), normal and hazardous debris, and duds, blind stars and effects.

- Use aerial shells with comets to aid Spotters in tracking aerial shells to increase their ability to determine where any duds might land in the fallout area
- Fire aerial shells at a pace that Spotters can better track their trajectories to increase their ability to determine where any normal or hazardous debris, duds, and blind stars or effects might land in the fallout area(s)
- Place Spotters near the edges of the display site as well as elevated locations near the discharge site(s) to increase their ability to determine where any normal or hazardous debris, duds, and blind stars or effects might land in the fallout area(s)
- Place Spotters that are wearing the appropriate Personal Protective Equipment (PPE)⁶⁹ and that have been trained by the Operator in their duties⁷⁰ within the fallout area(s) in order to increase their ability to determine where any normal or hazardous debris, duds, and blind stars or effects might land in the fallout area(s)
- Use fluorescent spray paint on aerial shells to aid in finding duds in the fallout area(s)⁷¹

⁶⁹ 1123 8.1.3.4 establishes the PPE required for personnel in the discharge site. At the least American National Standards Institute (ANSI) rated head protection and eye protection should be worn by any authorized personnel in the display site.

⁷⁰ Spotters are generally instructed to mentally mark where any duds may have landed and not to approach until at least 15 minutes after the display. See 1123 8.2.12.1

⁷¹ Spray paint will only cover the top portion of an aerial shell. The outer wrapping for the lift charge and label will come off when the shell fires.

- Develop a plan for a grid search of duds in the fallout area(s) that can be safely and effectively policed in the dark after the display, as well as at first light the morning after⁷²
- Identify the portions of the fallout area(s) that can NOT be safely and effectively policed for duds and blind stars and effects in the dark after the display as well as at first light the morning after. Include provisions for addressing potential duds and blind stars and effects in locations that can NOT be accessed (Examples: rocky crevasses, steep slopes, etc.)⁷³
- Develop a plan for future utility servicing, security sweeps, vegetation mitigation, prescribed burns, surveys and any other entries into the fallout areas to address any duds or blind stars and effects that may be encountered
- Develop a plan for future prescribed burns and any wildland fires that may involve any duds or blind stars that may be encountered in the fallout area(s) to reduce risks to any personnel
- Develop a plan to provide for any emergency services in the fallout area(s)

⁷² 1123 – 8.2.12.3

⁷³ Locating duds and blind stars and effects may be a task better suited to bomb sniffing dogs



Photo 44 An example of Spotters just outside of the discharge site at a fireworks display.

Many fireworks displays are now fired by computer with thousands of devices launching many thousands of aerial devices into the sky. The rapid pace of these fireworks displays makes it difficult for the Shooter to keep an eye on the computer firing panel, the mortars and tubes, much less the effects flying and bursting into the sky.

These shows are often spread out over hundreds of feet as well, making it an even greater challenge. Multiple Spotters assist the Shooter by tracking certain portions of the show.

The Spotters here are wearing all the required PPE. They are perpendicular to the mortar racks, which are all individually secured to the ground and 100 feet or more away from the nearest devices.

Some of the Spotters are located near cable junctions between the computer firing panel and the firing modules that are connected to the electric matches on the aerial fireworks devices. The Spotters can alert the Shooter using LED lights to any problems. Spotters can also disconnect the cables to halt the firing of a specific portion of the display.

The Spotters also have pressurized water fire extinguishers or 5-gallon plastic buckets with a wet straw broom located around the discharge site to deal with any small fires that may need attention after the fireworks display. Spotters have been trained in their duties by the Operator. They are instructed NOT to enter the discharge site during the fireworks display.

Limited Egress Discharge Site(s)

The Author recommends following regarding the use of any limited egress discharge site(s).

- Analyze each potential discharge site for compliance with 1123 Chapter 7 and best practices
- Develop a plan to provide for the safe evacuation of the Shooter and an Assistant from a limited egress discharge site(s) in the event of a catastrophic malfunction or other similar event
- Develop a plan to provide for any emergency services to the Shooter and an Assistant in a limited egress discharge site(s) in the event of a catastrophic malfunction or other similar event

Monitor Wind Speeds and Directions

The Author recommends following similar methods of monitoring of wind speeds and directions at many of the leading venues with fireworks displays/pyrotechnic performances, such as theme parks, sports stadiums, etc. in order to more accurately gauge the possible negative impacts of high winds blowing towards spectator viewing area(s) from the discharge site(s) or the possible negative impact on potential wildland fire risk.

Place anemometers at key locations at MORU, including but not limited to:

- Hall of Records - On top of the carvings
- Hall of Records Ridge
- Indian Camp – tallest accessible rock formation
- Amphitheater – Backstage roof

- Talus field – Base above stairway of Presidential Trail
- Grandview Terrace - Top of columns
- Information Center – Top of building
- Sculptor’s Studio – Top of building
- Top of rock formation – Stage right/house left
- Other

Utilize a system that can record windspeeds and directions with software that can analyze and chart to determine any trends, such as windspeeds that tend to die down after sunset, updrafts by rock formations as the heat rises during the day and as the rocks cool in the evening, tunnel effects between rock formations, etc.

Wildland Fire Conditions for a Show

The Author recommends the MORU AHJ and other AHJs establish a bright line of the wildland fire conditions that could be approved for a show at MORU on July 3, 2020. The wildland fire conditions should be assessed at least weekly from now until the proposed date, with daily assessments starting in April or May.

The wildland fire conditions that could be approved for a show at MORU should include the fuel load in and around the MORU display site along with the temperature range, dew point range, wind speed(s) and directions, and other factors.



Photo 45 MORU has water access and capabilities, but it is limited to around the buildings at the base of the mountain.

It should be noted that weather is not the ONLY criteria in assessing wildland fire conditions. A wet fall and spring may prevent controlled burns and vegetation removal resulting in a much heavier fuel load going into the summer. A few warm sunny days in late June or early July, and suddenly even more fuel load can “appear”.

And most importantly, fireworks debris, in particular burning stars at 800-1,000° C, can and will easily ignite even the greenest of vegetation.

Potential Potassium perchlorate (KClO₄) and Other Chemical Contamination

The Author recommends the following regarding the potential for potassium perchlorate (KClO₄) and other chemical contamination:

- Limit the size and number of display fireworks with KClO₄ and use as many articles pyrotechnic that are nitrate based as possible⁷⁴
- Use higher quality display fireworks that are more likely to have fuller burn of compositions and less likely to result in duds and blind stars
- Use more articles pyrotechnics, which are usually even higher quality than display fireworks with far less normal debris and almost no hazardous debris

Show GO/NO GO Schedule

The Author recommends that the MORU AHJ and other AHJs establish a series of Show GO/NO GO criteria be established starting no later than May 1, 2020. The purpose is to facilitate

⁷⁴ Nitrate based compositions are not readily available in display fireworks, especially from China. The few nitrate based display fireworks and articles pyrotechnic available are from American, Japanese and Western European manufacturers.

planning, Show and fire prevention measures in advance to reduce the needless use of resources in the event conditions are such that the Show is likely to be cancelled.

Generally, if the wildland fire conditions are poor in April, May and early June, they are unlikely to improve by July 3, 2020. Weather and wildland fire conditions can change rapidly in the Black Hills so what might have been ideal conditions on June 26 can become poor if not unacceptable conditions on July 3

The Show GO/NO Schedule should at a minimum:

- Fuel load management schedule
- Fuel load mitigation (Prescribed burns, vegetation removal, etc.)
- Operator selects music and designs
- Operator selects fireworks and articles pyrotechnics
- Operator fuses and matches fireworks and articles pyrotechnics
- Operator loads and ships equipment to MORU
- Operator loads and ships fireworks and articles pyrotechnics to MORU
- Operator unloads and stages equipment at MORU
- Operator unloads and stores fireworks and articles pyrotechnics at MORU
- Operator transports and sets up equipment to discharge site(s)
- Operator transports and loads fireworks and articles pyrotechnic to discharge site(s)
- Operator finalizes continuity check of firing circuits
- July 1, 2020 @ 3:00 PM (Prior to evening TV news)
- July 2, 2020 @ 3:00 PM

- July 3, 2020 @ 6:00 AM (Prior to morning drive time radio news)
- July 3, 2020 @ 11:00 AM (Prior to Noon TV news)
- July 3, 2020 @ 3:00 PM (Prior to evening TV news)
- July 3, 2020 @ 5:30 PM (Prior to 6:00 PM TV news)
- July 3, 2020 @ 7:30 PM
- July 3, 2020 @ 8:30 PM
- July 3, 2020 @ 9:30 PM

Include Show GO/NO GO time lines for the following:

- Locations of traffic control devices around MORU
- Schedule for placement and removal of traffic control devices around MORU
- Road closures to MORU
- Deployment of fire prevention measures at MORU (Water cisterns, hoses, etc.)
- Muster of fire protection from supporting fire departments
- Deployment of fire protection from supporting fire departments
- Display site securement
- Deployment of Monitors and supporting fire fighters around display site
- Sound and time code check
- Final checks that all systems, equipment and personnel are ready
- Final check on weather and wildland fire conditions

Trail Improvements & Lighting

The Author recommends any natural trails to discharge site(s) be improved with temporary trail markings, such as survey flags or colored ropes to assist members of the fireworks crew and other authorized personnel find their way.

Temporary rock or wooden steps and climbing ropes tied to rocks and/or tree trunks should be placed at locations where the grade is particularly steep or slippery to reduce the potential for falls. These temporary steps and climbing ropes can be removed and return the natural trails to their former condition after the show.

Paths to dead ends or areas that are too steep or slippery should be marked with color ropes and small signs to prevent people from going into riskier areas, particularly after dark.

Solar lights should be placed along any natural and existing trails to assist the fireworks crew, fire fighters and other authorized personnel in and around the display site after dark.

Fireworks Transportation

The transportation of fireworks on public roads and highways are subject to Federal and state regulations regarding hazardous materials. There are also Federal regulations regarding the transportation of hazardous materials by air, such as by helicopter.⁷⁵

⁷⁵ Title 49, CFR, Parts 100-185, U. S. Department of Transportation (DOT), Pipeline and Hazardous Materials Safety Administration (PHMSA), Hazardous Materials Regulations (HMR) and Title 49, CFR, Parts 300-399, U.S. DOT, Federal Motor Carrier Safety Administration (FMCSA), General Regulations

Transportation by motor carrier of display fireworks that are classified as FIREWORKS UN0335 1.3G or FIREWORKS UN0333 1.1G generally requires the following:

The shipper of display fireworks must:

- be registered with the US DOT as a shipper of hazardous materials
- have a security plan
- train all employees on the proper identification, marking, labeling, packing and packaging of hazardous materials
- properly identify, mark, label, pack and package all shipments of hazardous materials
- properly prepare the bill of lading and all other shipping papers and documents, and maintain certain records for every shipment of hazardous materials
- provide the correct placards for the hazardous materials to the driver



Photo 46 Temporary fireworks storage prior to the show setup can be as simple as a truck or trailer that complies with the US DOT requirements for transportation and ATF requirements for temporary storage. It must be located in a secure area away [the distance will depend on the quantity of fireworks] from occupied buildings and public roads, along with other requirements to secure the vehicle from unauthorized movement.

The motor carrier of display fireworks must generally:

- register with the US DOT as a motor carrier

- carry \$5,000,000 minimum liability insurance ⁷⁶
- own or lease motor vehicles that meet the requirements for carrying Class 1 explosives
- verify and maintain driver licenses, TSA endorsements and DOT medical cards
- establish a random drug test program for all drivers
- maintain certain records for all vehicles and drivers

The driver of a commercial motor vehicle carrying display fireworks must:

- have a commercial driver license (CDL) with a hazmat "H" endorsement
- pass a Transportation Security Administration (TSA) background check and provide fingerprints
- pass a CDL physical and provide the carrier with DOT medical card
- have been issued an ATF responsible persons or employee possessor letter for that particular company that holds the ATF explosives license or user permit
- inspect the commercial motor vehicle before starting any trips
- inspect the load in the commercial motor vehicle before starting any trips
- properly placard the commercial motor vehicle before starting any trips
- review bill of lading and shipping papers, and sign receipt of the shipment
- stop to reinspect the commercial motor vehicle and the load during the trips
- stop and take the required breaks during the trip

⁷⁶ See DOT Form MCS-90 - Endorsement for Motor Carrier Policies of Insurance for Public Liability under Sections 29 and 30 of the Motor Carrier Act of 1980

- properly maintain a driver's daily log
- follow the requirements for hours of service (14 hours on duty, 11 hours driving, 10 hours off duty and no more than 60 hours on duty over 7 consecutive days)

The requirements for shippers of FIREWORKS UN0336 1.4G as well as ARTICLES PYROTECHNIC (for technical purposes) UN0341 1.4G or UN0432 1.4S are the same as for other Class 1 Explosives. The requirements carriers and drivers are similar as those described above, with a few differences.

Fireworks/Pyrotechnics Storage Prior to the Show Setup

The Author recommends that the temporary storage of the fireworks and/or pyrotechnics prior to the show comply with the applicable requirements of NFPA 1124, Chapter 5, as well as the applicable Federal and state laws and regulations.

Storage at a discharge site(s) prior to the show but during the set up should also meet the same standards.⁷⁷

Security & Attendance of the Fireworks Loaded at the Discharge Site(s)

The Author anticipates that fireworks will likely be loaded into the mortars and article pyrotechnics into holders at the discharge (s) many days in advance of the show. A discharge site

⁷⁷ The Ohio State Fire Marshal indicates what some of the best practices are with "Fireworks at the Exhibition Site"

with fireworks or articles pyrotechnics must be secured from unescorted public access⁷⁸ and best practices.

Any fireworks that are not stored in an ATF approved magazine or articles pyrotechnic that are not stored in appropriate locked storage must be attended to by authorized personnel or secured by some other means approved by the AHJ.⁷⁹

The Author recommends the Operator develop a security and attendance plan that secures any fireworks will likely be loaded into the mortars and article pyrotechnics into holders at the discharge (s) from the time they are loaded until the discharge site is secured after the show.⁸⁰

Mortars, Mortar Racks and Securement

The types of mortars, mortar racks and methods of securement have a major impact on the potential negative impacts if an aerial shell functions prematurely in a mortar. Mortars made of paper, high density polyethylene (HDPE) or fiberglass in above ground wood frame racks are the standard in the trade. Fiberglass mortars made in China are the most common, followed by HDPE and some fiberglass mortars made in the USA. Paper mortars are rarely used anymore.

⁷⁸ 1123 8.1.2.5

⁷⁹ 27 CFR, Part 555, Subpart K Storage. ATF considers storage to be anything other than: Fireworks in the process of manufacture; being physically handled in the operating process of a licensee or user; being used; or being transported to a place of storage or use by licensee or permittee or by a person who has lawfully acquired explosive materials under Sec. 555. 106.

⁸⁰ A discharge site that is enclosed by fences and monitored 24 hours a day by security cameras at a facility with limited public access could be approved, subject to other security provisions.

Above ground wood frame mortar racks are the typical type used in the trade. Some mortar racks are better than others in their design, materials and construction, however with the exception of the smaller 2" and 2.5" and perhaps some 3" aerial color shells that malfunction in HDPE mortars that are in an above ground wood frame rack with spacers between each mortar and the end boards, and that has been glued and screwed together with deck screws, with the holes drilled in the wood to prevent

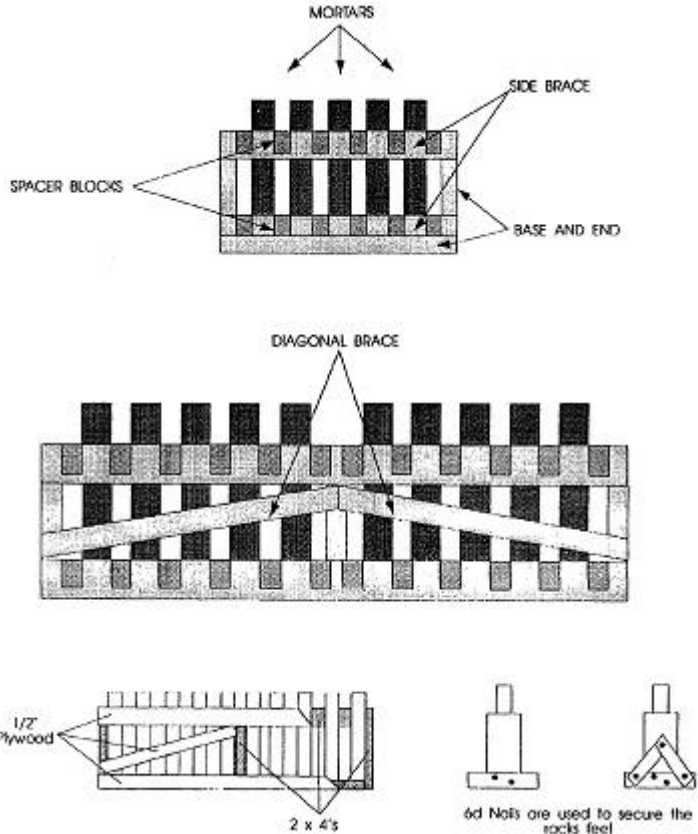


Photo 47 The California State Fire Marshal is one of the few AHJs that has published standards for mortar rack design and construction, as well as placement.

splitting, very few, if any other mortar racks – particularly for 5" and larger aerial shells, will withstand a catastrophic aerial shell malfunction in a mortar.⁸¹

If a group of above ground wood frame mortar racks are densely packed together and/or rely on the same supporting materials, such as wood stringers nailed or screwed to the sides of the racks, the whole assembly of mortar racks can be damaged or destroyed.

⁸¹ A.4.6.1 Aboveground wood frame mortar racks with lightweight mortar materials such as paper, HDPE, or fiberglass generally will not withstand a catastrophic aerial shell malfunction in a mortar

When a catastrophic aerial shell malfunction occurs in a mortar, it can cause other nearby mortars and/or mortar racks to tipover or realign. The fireball and effects from that shell and/or the firing system can fire other aerial shells, comets or mines in those mortars at steep angles at distances far greater than those in 5.1.3.1.

The research and experience of the Author and others with mortar designs, materials and construction methods indicate fiberglass, HDPE and paper are acceptable for use in fireworks displays, provided the mortars are constructed properly (the bases or plugs and fasteners are critical), the walls are the appropriate thickness, they are properly maintained, etc.

There are differences in how each type of mortar material combined with the plug and fasteners performs in the event of a premature aerial shell malfunction in the mortar, and how that can not only damage or destroy the mortar, but damage or destroy adjacent mortars, as well as nearby mortar racks.

Generally, fiberglass mortars are the strongest of the three materials, which also confines the blast of a premature aerial shell malfunction in the mortar making it a more powerful explosion. Fiberglass is also very brittle, so normal handling can cause hidden cracks and that weaken the mortar and especially the plug. A premature aerial shell malfunction in a fiberglass mortar tends to shatter it into many pieces.

Most of the trade now uses fiberglass mortars made in China. Quality can vary widely, with some mortars so poorly constructed they can fail on the first shot, especially larger diameter mortars such as 8", 10" and 12". The failure is usually due to the fiberglass tube and/or plug not having the right mix of fiberglass and resin and/or not having the plug secured well enough to the fiberglass tube.

HDPE mortars are only about 1/3 as strong as fiberglass, which lessens the confinement of the blast of a premature aerial shell malfunction in the mortar. HDPE is a thermoplastic that stretches before it fails, so the HDPE absorbs some of the energy of the blast in such an event. A premature aerial shell malfunction in an HDPE mortar tends to stretch the HDPE into a banana peel shape.

Paper mortars are also only about 1/3 as strong as fiberglass, which lessens the confinement of the blast of a premature aerial shell malfunction in the mortar. The blast from such an event is less powerful than in a fiberglass mortar, but a bit more powerful than an HDPE mortar. Paper breaks apart into a few large pieces (top and bottom with plug), with the portion of the paper mortar closet to the aerial shell shredded by the blast into many smaller piece



Photo 48 The metal steps up from the Hall of Records Canyon to the Guard Shack. Articles pyrotechnic holders could be secured to the outside of this structure.



Photo 49 An example of a heavy duty above ground metal frame rack with medium level mortars. Here a shell as just fired electrically from a Chinese fiberglass mortar Note: The sparks on the outside are from the leader fuse and the light of the lift charge illuminates the inside of the fiberglass mortar. This type of rack can withstand a catastrophic malfunction in a mortar from single break color shells. [Photo credit: Fireworks FX, Inc]

The Author recommends the use of heavy duty above ground, square tube metal frame mortar rack holders that can withstand a catastrophic malfunction in a mortar without repositioning the mortars in the rack, the mortar rack itself or other nearby mortar racks, or equivalent.

Weather Protection of the Fireworks

The Author anticipates it will take a number of days to load the fireworks for the show, thus the fireworks will need to be protected from the weather, even if no rain is forecast. Morning dew can accumulate inside mortars and tubes. Condensation can and will form over

mortars and tubes covered with plastic. Fog can roll in overnight and water droplets collect on cooler surfaces.

The Operator should have a detailed plan for how to protect the fireworks from the weather after the fireworks are loaded until the show. The plan should also take into account when and how whatever coverings are used will be removed before the fireworks display starts and/or and will be recovered after the fireworks display.

*Fireworks Types & Styles*⁸²

The Author recommends the use of the following types and styles of fireworks and articles pyrotechnic⁸³:

- Aerial fireworks and that are constructed of 100% biodegradable casings, tapes, glues and strings (paper, cardboard, wheat paste, cotton, flax, etc.)⁸⁴
- Single break aerial color shells with blackpowder break charges, with or without tails (Peonies, chrysanthemums, dahlias, gamoges, palm trees, patterns and rings, saturns, etc.)
- Aerial mines with non-bursting and non-splitting effects

⁸² Best practices in the trade are to use the types and styles as well as the sizes and power of the display fireworks and/or articles pyrotechnic that fit the unique features of the venue (occupied buildings with windows, tents, animals, air traffic, water traffic, combustible materials, hazardous materials, etc.) the potential weather conditions (windy, dry, wet, etc.), available resources (fire prevention, fire protection, traffic control, security, etc.) scheduling (other entertainment, construction, pedestrian and vehicular traffic demands, etc.), environmental sensitivity (forestland, grassland, golf course, stadium, historic site, etc.)

⁸³ The recommended types and styles of fireworks and articles pyrotechnic pose less of a potential hazard from normal functioning as well as potential malfunctions (See Author defined term Malfunction).

⁸⁴ These materials are generally considered to be biodegradable. The remnants of any ground level fireworks can be recovered after the fireworks display.

- Aerial comets with non-bursting and non-splitting effects
- Single shot aerial mines and comets with non-bursting and non-splitting effects
- Roman candles with non-bursting and non-splitting effects
- Illuminations (Flares, strobes, Bengal pots, lances, etc.)
- Gerbs and fountains



Photo 50 A handheld anemometer is useful for determining wind speeds at ground level; however, it cannot determine windspeeds above the discharge site or other locations around a display site. The larger the aerial shells, the larger the display site and the higher the bursts in the sky, making wind speed and direction both more critical and more difficult to assess in order to conduct a safe Show



Photo 51 A cutaway of a Chinese 6" single break peony with a pistil and rising tails shell. The leader fuse fits through a string loop at the top to the lift charge of black powder in a plastic bag at the bottom. Two time fuses with crossmatch are glued into place through the paper casing from the lift charge to the burst charge in the center, which consists of dry rice hulls coated with black powder. The smaller round stars in a circle inside the burst are the pistil round stars are the petals of the peony. The rising tails are glued on the outside top of the casing and ignited by the lift charge.

The Author recommends prohibiting the use of the following types and styles of aerial fireworks.⁸⁵

- Any aerial fireworks with plastic casings or components, or polyester based string or reinforced tape (Fuse holders, spacers, etc.)⁸⁶
- Single break salutes and artillery shells, and any aerial shells or mines with reports or siateens (Any shells with flash powder based concussive affects)⁸⁷
- Aerial mines with bursting or splitting effects
- Aerial comets with bursting or splitting effects
- Single shot aerial mines and comets with bursting or splitting effects
- Roman candles with bursting or splitting effects
- Single break color shells with any fine metallic powder enhanced break charges⁸⁸
- Aerial shells with inserts⁸⁹ (Whistles, hummers, serpents, fish, tourbillions, etc.)
- Multiple break canister, double bubble or peanut aerial shells (two round shells)

⁸⁵ The types and styles of fireworks and articles pyrotechnic recommended to be prohibited pose a greater potential hazard from normal functioning and/or malfunction because they are more complex and prone to malfunction, more powerful, produce more normal burning debris, produce trailing effects that may reach the ground, are chain fused (cakes), more prone to issues with blowouts (Roman candles and cakes), can burn longer and hotter, etc. (See Author defined terms).

⁸⁶ These materials are generally considered not to be biodegradable

⁸⁷ Concussive effects pose a potential hazard to the carvings and the Hall of Records because of their greater power than single break color shells. A rough rule of thumb is a 3” aerial salute with 2.5 ounces of flash powder has the same explosive power as a 5” color shell.

⁸⁸ American Pyrotechnics (APA) Standard 87-1 4.1.1 classifies such shells as FIREWORKS, UN0333, 1.1G, which is the same as for aerial shells larger than 10” and aerial salutes with more than 2.5 oz of flash powder.

⁸⁹ Inserts are plastic, paper or cardboard tubes with loose or pressed pyrotechnic compositions and a clay plug(s) that continue to function after the aerial shell bursts in the sky

- Aerial shells with any long lasting or draping effects (Crossettes, diadems, falling flowers or leaves, kamuros, parachutes⁹⁰, shells of shells, willows, crackles, etc.)
- Any aerial shells, comets or mines with strobes or magnesium-based effects
- Cakes (multiple tube aerial devices) or finale boxes⁹¹

Firing Methods & Equipment

The Author recommends any Show at MORU should be electrically fired in accordance with NFPA 1123 Chapter 9. No display fireworks or pyrotechnics should be manually fired with a fusee, portfire or other open flame.

If any theatrical performer in the Amphitheater acts as if they are firing a gun or cannon, it should be a simulation.

Inspection, Matching & Fusing of Fireworks and Articles Pyrotechnic

The Author recommends the following for the inspection, matching and fusing of fireworks and articles pyrotechnic prior to the Show:

- inspection, matching and fusing should be conducted at a Bureau of Alcohol, Tobacco, Firearms & Explosives (ATF) licensed manufacturing facility in an ATF

⁹⁰ 1123 – A.4.1.3

⁹¹ Cakes (multiple tube aerial devices) and finale boxes consist of cardboard tubes bundled together in shipping cartons with liners. Cakes and finale boxes have a tendency to burn, which can damage the ground and/or start grass fires as well as distract the spectators with flame and smoke. Cakes and finale boxes also can bounce or tip over and shoot at low angles resulting in low breaks and ground breaks if not properly secured with stakes, sandbags or other means. The cardboard tubes in cakes also can experience blowouts, which can shoot at low angles resulting in low breaks and ground breaks.

approved process building and/or area and in accordance with NFPA 1124 Chapters 4 and 5 and best practices.

- All aerial display fireworks (Aerial shells, mines and comets) should have electric matches with the shroud intact installed into the top of the lift charges in direct contact with the blackpowder (avoid placing the matchhead between layers of paper or any plastic bag that contains the blackpowder). The hole should be punched with a wooden dowel, brass punch or other non-sparking hand tool and sealed with masking or paper tape.
- The electric match leg wires should be secured with strain relief (to prevent the electric matches from being unintentionally pulled out suddenly).
- All leader fuses and any pigtail fuses with plastic T connectors should be removed and no chain fuses, with or without time delays, should be used⁹².
- Natural fiber string or twine (cotton, flax or jute, etc.) or electric match wires should be attached to the loops on the tops of all aerial shells, comets and mines for the purpose of lowering into the mortars and possibly retrieving from the mortars.
- All other display fireworks (Roman candles, single shots, illuminations, gerbs and fountains) should have electric matches installed directly into the nozzle or fuse hole to the lift charge or ignition port the leg wires secured with strain relief (to

⁹² Many leader fuses are now plastic coated and any remnants that do not completely burn when fired can remain for years (such as the piece found 10 years after the last fireworks display in 2009). Burning leader fuse paper that flies about the discharge area is also a potential ignition source of combustible vegetation and the burning fuses add to the level of smoke that can obscure the Shooter and Shooter's Assistant from observing the mortars during the fireworks display

prevent the electric matches from being unintentionally pulled out suddenly). Any leader fuses should be removed.

- All electric matches should remain shunted until ready to connect to the firing module.
- All electric match leg wires and string or twine should be neatly folded or coiled, and secured with masking tape to the fireworks.
- All fireworks with the electric matches and string should be neatly packed into the approved inner packaging and liner inside the US DOT approved shipping carton for that particular fireworks device. The fireworks should be packed in such a manner that no electric matchhead is in contact with the bottom, sides or top of the shipping carton, or an adjacent aerial shell, mine or comet.
- Under no circumstances should any fireworks with electric matches attached be packed in such a manner that impact or friction from normal handling and transportation could ignite a matchhead.
- Alternatively, electric matches with the shrouds intact could be installed into plastic bags with the requisite amount of blackpowder for the lift charge for each type and caliber of aerial shell, mine or comet. A natural fiber string or twine could be attached to the loop on top of each aerial shell, mine or comet to lower it into the mortar, with a temporary paper cap or cup protecting the time fuses on the aerial shells. The appropriate lift charge is loaded into the mortar using the leg wires of the electric match, then the paper cap or cup protecting the time fuses is removed, and then the aerial shell, mine or comet is loaded into the mortar using the natural fiber string or twine (Japanese method).

- Articles pyrotechnics typically have the electric matches installed during manufacturing. Any that do not have electric matches installed should be matched in the same manner as other display fireworks (Roman candles, single shots, illuminations, gerbs and fountains).
- All fireworks and articles pyrotechnic or the shipping cartons should be marked with their cues or locations in the Show. Alternatively, the Show plan should list the cue or location for every fireworks device and article pyrotechnic.

Preparation of the Fireworks and Articles Pyrotechnics at MORU

The Author anticipates that the preparation of the fireworks and articles pyrotechnic any Show at MORU may take a number of days prior to July 3, 2020, and recommends the following:

- Any preparation area at MORU should be secured just as if were at an ATF approved manufacturing facility and meet the requirements of NFPA 1124 Chapter 4 and best practices.
- Under no circumstances should the preparation of fireworks and articles pyrotechnic be conducted in an area open to the public or unauthorized persons, at distances to other preparation areas, magazines or temporary fireworks storage, bulk storage of hazardous materials including flammables liquids and gasses, inhabited buildings, public roads less than those prescribed in NFPA 1124 4.6.2 and 4.6.3.
- Any preparation area at MORU should be limited to containing a single carton of fireworks or articles pyrotechnic and a limited number of personnel at any one

time. Once the fireworks and articles pyrotechnic in that carton have been prepared, they should be placed back into the magazine or temporary storage or transported to the discharge site(s) for loading before another carton of fireworks and articles pyrotechnic is brought into the preparation area.

- Preparation should be limited to such activities as inspections, organizing the fireworks or articles pyrotechnic for proper loading order into mortars or holders, loading articles pyrotechnic into their respective holders and connecting the electric matches to the firing modules, making minor repairs, etc.

Protection of the Carvings and Hall of Records

The Carvings of the Presidents as well as the Hall of Records are considered antiquities and must be protected. The use of cakes by the carvings have left burn marks that are present to this day and there are concerns that concussive effects, such as those from salutes, reports or bottom shots could potentially damage the carvings or Hall of Records.

The actual Hall of Records can be protected by ¾” plywood sheets or equivalent. The other recommendations in this Report should provide reasonable and acceptable methods of protecting these national treasures.

Protection of Property & Critical Utilities

The NPS policies require protection of property and critical utilities. The NPS and the Author have identified the Guard Shack in the Hall of Records as well as the cameras and cables in the Hall of Records, Indian Camp and around the carvings in need of protection.

The Author recommends that the use of low level aerial fireworks (aerial fireworks 2" or less) such as comets and mines up to 2" (50 mm) mounted individually in aluminum holders in the immediate vicinity of the Guard Shack, and the prohibition of the use of cakes. The aluminum holders can be mounted on the risers and supports of the steps and landing.



Photo 52 A cake with crackling effects being fired. Note how many of the crackling effects function in close proximity to the cake and even on the ground. Cakes can burn, which distracts from the show and creates additional risks to any nearby combustibles or property. Cakes and finale boxes can experience blowouts and continue to shoot aerial effects in all directions until it blows itself out or is spent.

The windows may be protected with $\frac{3}{4}$ " plywood or $\frac{1}{4}$ " Lexan™ shields.

The author also recommends not using any salutes or aerial shells with reports or bottom shots to minimize the potential damage from the concussive effects of these types of aerial shells and effects.

The cameras and especially the cables are difficult to protect. Even if the cameras are enclosed in a $\frac{3}{4}$ " plywood or $\frac{1}{4}$ " Lexan™ shield, any direct hit from a fireworks shell, comet or mine stars could potentially damage or destroy a camera. Any shield would also render a camera useless or limit the usefulness of the camera.

Any ground fire, even a small one, could damage or destroy a cable, requiring an expensive and difficult repair or replacement.

Prior to the fireworks display, the NPS and the Sponsor and/or Operator should come to some agreement regarding the repair or replacement of property that is damaged or destroyed as a result of the fireworks display.

Protection of Forest and Natural Habitat

The surrounding forest and natural habitat also must be protected from unreasonable risk. The Author recommends the NPS together with other AHJs develop a comprehensive wildland fire protection plan and address everything from water flow rates of the existing water supply from the existing fire hydrants, to fuel load management and mitigation, to contingency plans based on worst case scenarios.

Fire Prevention Prior to a Show

The Author recommend placing portable firefighting water tanks at the base of MORU and other key locations prior to the display. These should be filled so they are at the ready if needed rather than after a potential wildland fire occurs.

The above ground and below ground bulk storage of propane and the above ground storage of flammable liquids (fuels) present additional hazards that must be accounted for carefully. Although these should not be within the display site⁹³, additional fire protection measures may be prudent.

⁹³ 1123 – 5.1.4.3*

One potential hazard is small bits of burning paper debris from aerial shell bursts can be carried by the wind well outside of the designated fallout area. Although the odds any will reach the ground with any active firebrand are small, in the event any lands near the bulk storage of propane or flammable liquids with leaking vapors, the consequences could be catastrophic.

The Author recommends running garden sprinklers around the bulk storage of propane or flammable liquids prior to and during the fireworks display to keep the ground wet and to disperse any flammable vapors that often are present.



Photo 53 A 4" dud shell. Note the two times fuses on the bottom that both failed to transfer fire from the lift charge to the burst charge inside the shell. Duds are difficult to find in the dark, even in an open field of short grass. They are even more difficult to find in a pine forest on steep, rock mountains.

Fire Protection During & Post Show

The Author recommends that during and after the Show, fire fighters be stationed in and around the display site. The fire fighters stationed in and around the display site should wear the appropriate personal protective equipment (PPE)⁹⁴ and instructed by the Operator on what to

⁹⁴ 1123 8.1.3.4 establishes the PPE required for personnel in the discharge site. At the least ANSI rated head protection and eye protection should be worn by any authorized personnel in the display site.

look for and how to react to hazardous debris, especially duds as well as blind stars and effects.⁹⁵
The AHJs should also instruct the Spotters on how to react to potential wildland fires.⁹⁶

Often when a show is finished, everyone smiles and breathes a sigh of relief on the false belief everything is good to go. **Burning debris is normal during a fireworks display and ALWAYS comes back down to the ground somewhere – sometimes even outside of the display site.** Most of the larger debris will be pieces of burning paper and cardboard that will land in and around the discharge site. The smaller debris will also be pieces of burning paper and cardboard that will land in and around the discharge site, but some will land in the fallout area and some may even helicopter outside of the display site.

Once on the ground, this debris will usually smolder for a short time and eventually go out; but there are times it can smolder for hours and suddenly flare up and start a fire in the middle of the night.

Along with the mandatory dud sweep after the show⁹⁷, a sweep for smoldering debris in the discharge site(s), the fallout area(s) and especially any area downwind of the fallout area should be conducted.

A fire watch should also be maintained overnight at the display site with at least one wildland fire team and apparatus at MORU on standby.

⁹⁵ Spotters are generally instructed to mentally mark where any duds may have landed and not to approach until at least 15 minutes after the display. See 1123 8.2.12.1

⁹⁶ Spotters and fire fighters will need to know what reactions and actions are expected based on a prescribes set of circumstances. Overreacting to a non-situation can result in negative consequences just as under reacting to a real dangerous situation.

⁹⁷ 1123 8.2.12*

Establish Rainwater Cisterns & Hoses Prior to Show

The Author recommends that prior to any fireworks display at any discharge site outside of the range of the existing fire hydrants and fire apparatus, rainwater collection cisterns are placed at key locations on top of and around MORU. These cisterns may be livestock watering troughs, 55-gallon plastic drums (with the top lids removed) or collapsible water troughs covered with screens to prevent pine needles and other debris from collecting in the water. Each should be fitted with a brass spigot with the standard hose $\frac{3}{4}$ " fitting. Place the appropriate length (100 feet minimum) $\frac{3}{4}$ " ID garden hoses with nozzles at each cistern.

These water cisterns can be used to wet down any dry areas prior to the display and wet down any spent fireworks, hangfires or duds after the display.

Portable pump extinguishers can also be placed by the cisterns and other key locations. The cisterns can be used to refill portable pump extinguishers as needed.

It may also be advisable to run 2 $\frac{1}{2}$ " lines up from the base of MORU to the cisterns to initially fill the cisterns. These 2 $\frac{1}{2}$ " lines can be charged prior to the display and used to wet down larger areas as needed, and to be at the ready during and after the Show.

Show Command Center

The Author recommends a Command Center for the Show be established. It should be in a location that has clear lines of site to the Shooter(s) and Shooter's Assistant(s) in the discharge site(s), or to a relay point(s) between the Command Center and the discharge site(s), as well as to and from the Spotters and fire fighters stationed in and around the display site.

The Command Center should ideally be located where the MORU closed circuit television (CCTV) system can be monitored.

Show Communications Prior to the Show

The Author recommends that prior to shipping any fireworks or equipment to MORU, the Operator and key Assistants meet with the NPS staff and other AHJs to finalize the show plan.

The Operator and/or a key Assistant should be at MORU to deliver or receive the fireworks and ensure proper temporary storage according to the Show Plan.

The Operator and key Assistant(s) should meet daily with MORU staff for a safety meeting and to discuss the daily plans and conditions.

Show Communications During the Show

The Author recommends the following for communications during the Show:

- Establish at least three 3 methods of communications between the AHJs and Operator or key Assistant in the Command Center and the Shooter(s) and Shooter's Assistant(s) in the discharge site(s), the Spotters⁹⁸ around the display site, and the personnel in any relay station(s).
- Use mobile phones with voice and text capabilities, MORU radios with a unique channel for use only by the Operator and Assistants and the Command Center, and a colored light system with relay stations.
- Recognize that mobile phone and radio communications are not always reliable at a fireworks display. Mobile phone signals can be weak or non-existent with

⁹⁸ 1123 8.1.4.3.2 requires the Spotters “be in direct communication with the Shooter during the conduct of the display”

network towers in remote areas, especially those with hills. Even with a good mobile phone signal, the large numbers of people with mobile phones can overwhelm the capacity of a network resulting in poor quality voice connections and significant delays in text reception. Radio reception can also be problematic in mountains and canyons, such as those at MORU.

- Also recognize that mobile phones limit voice communications to just two people at a time unless a conference call is initiated. If other people call the same phone at the same time, the most important communication can be missed.
- Establish a group text between the Operator, key Assistants and AHJs for communications before, during and after the Show.
- Establish another group text between the Operator, key Assistants and AHJs as well as the Spotters and fire fighters for just prior to, during and after the Show.
- Realize that both mobile and radio communications become difficult if not impossible during the firing of a Show. People may not hear a phone ring or a call on the radio due to the loud explosions of the fireworks, especially with rock walls and formations acting as a sound board to amplify the noise.
- Appreciate that hearing and being heard, and more importantly being understood with the loud explosions can be difficult because the microphones on mobile phones and radios can cut out when there is any loud noise in the background.
- Establish basic radio protocols to limit unnecessary chatter along with keywords for people, places and situations



Photo 54 Remnants of a 4" aerial shell casing (paper, cotton string and glue) on the ground after a fireworks display. This is the normal debris expected to come down to the ground in the discharge site or fallout area. The edges can have burning embers and there is likely some fireworks composition residue on the inside of the remnants

Be aware that the MORU discharge sites present additional challenges with communications because there are no clear lines of site around the display site. Spotters on the back side and sides of Mount Rushmore have no clear lines of site with the likely location of the Command Center in the Visitor Center Complex, much less some of the potential discharge site(s).

If a Spotter detects a dangerous situation, such as hazardous debris falling from the sky from the fireworks or a wildland fire, a significant amount of time could pass before that

information is relayed back to the Command Center and then up to the Shooter(s) and Shooter's Assistant(s) in the discharge site(s) to halt the show.

- A colored light signaling scheme can be utilized to communicate between the Command Center, the Operator, the Shooter(s) and Shooter's Assistant(s) in the discharge site(s), the personnel in any relay station(s) and the Spotters. It can be a simple GREEN/BLUE for GO and RED for STOP on high intensity LED flashlights. This type of LED light can be waved from one person to another to relay any STOP signal quickly around the display site.
- Establish lines of site for the Show between the Shooter(s) and Shooter's Assistant(s) to the aerial fireworks devices in the discharge site(s),
- Establish relay stations between the Shooter(s) and Shooter's Assistant(s) with an Assistant(s) to the Command Center so that they can shine a bright LED lights from one position to the next to get their attention; and likewise back from the Shooter(s) and Shooter's Assistant(s) to the Command Center.
- If it is feasible, use the existing power and network cables to the security cameras to establish a password protected wi-fi network at the discharge site(s) to provide improved voice and text capabilities around the display site.

Monitor Drone(s) with Cameras

The Author recommends the use of monitor drones outside of the display site if feasible. These monitor drones should be used to look for unauthorized access to the display site, watch for hazardous debris from the Show and any wildland fires that may arise during and afterwards, as well as a STOP signal from any Monitors.

These drones should have communication capabilities that rely on bandwidths not used by civilian mobile phone systems. The visual and audible signals should be available in the Command Center.

Crew and Fire Fighter Positions & Visibility

The Author recommends that the Operator and all Assistants, as well as all authorized personnel, wear high visibility vests or gear whenever working at MORU. At night, all personnel should also have a vest or head mounted LED flashlight that is on while in the forest and climbing up and down the mountain in the dark.

The Show Plan should also designate the locations where the Operator and all Assistants as well as all authorized personnel, including fire fighters, will be located inside and around the display site just before, during and after the fireworks display.

The purpose of these measures is to more readily differentiate every member of the fireworks crew and all authorized personnel in and around the display site for security purposes, and to make it easier to locate anyone that becomes lost or falls while climbing up and down the mountain in the dark.⁹⁹

⁹⁹ The Author was advised that during one past fireworks display some of the fire fighters in the forest who were out on the mountain in the dark putting out small fires that started from burning debris became lost for a period of time.

Show Fireworks/Pyrotechnics Recovery & Storage

The Author recommends the Operator together with the MORU AHJ develop a plan for the recovery of any unfired fireworks, misfires, duds, blind stars and effects, etc. after the display.

Storage of any unfired fireworks, misfires, duds, blind stars and effects at MORU until they can be properly and safely transported should follow the same standards as the storage of fireworks prior to the show.¹⁰⁰



Photo 55 An example of dozens of “Single shots” secured to metal holders with nylon wire ties. Single shots are a cardboard tube with a single aerial shell, mine or comet. They can either be display fireworks

¹⁰⁰ See NFPA 1124, Chapter 5 and 27 CFR, Part 555, Subpart K Storage

or articles pyrotechnic. They are typically 2” or less in diameter and come from the manufacturer with an electric match. [Photo credit: Fireworks FX, Inc]

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¹⁰² See NFPA 1123 – Annex D Extract from American Pyrotechnics Association 87-1, *Standard for Construction and Approval for Transportation of Fireworks, Novelties, and Theatrical Pyrotechnics*

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Appendix A -Definitions and Standards

NFPA Universal Definitions

To assist the reader with understanding this Report, the Author has included a number of key definitions from the applicable fire codes for a fireworks display & pyrotechnic performance (show) at MORU.

The *National Fire Codes*[®] include a number of universal definitions, including:

Approved. Acceptable to the authority having jurisdiction.

(The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with the NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.)

Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

(The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a

federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction).

Code. A standard that is an extensive compilation of provisions covering broad subject matter or that is suitable for adoption into law independently of other codes and standards.

(The decision to designate a standard a “code” is based on such factors as the size and scope of the document, its intended use and form of adoption, and whether it contains substantial enforcement and administrative provisions).

Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose. (The means for identifying listed equipment may vary for each organization

concerned with product evaluation; some organization do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product).

Shall. Indicates a mandatory requirement.

Should. Indicates a recommendation or that which is advised but not required.

Standard. An NFPA Standard, the main text of which contains only mandatory provisions using the word “shall” to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA Manuals of Style. When used in a generic sense, such as in the phrase “standards development process” or “standards development activities,” the term “standards” includes all NFPA Standards, including Codes, Standards, Recommended Practices, and Guides.

NFPA Universal Standards

The *National Fire Codes*[®] include a number of universal standards, including:

1-# **Equivalency.** Nothing in this code/standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistances, effectiveness, durability, and safety over those prescribed by this code.

1-#.1 Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

1-#.2 The system, method or device shall be approved for the intended purpose by the authority having jurisdiction.

NFPA 1123 & NFPA 1126 Key Definitions

Assistant. A person who works under supervision of the pyrotechnic Operator. (The duties of an Assistant include tasks such as setting up the equipment and fireworks, loading mortars, (Loader), spotting the bursting location of aerial shells (Spotter) tending a ready box (Ready Box Tender), igniting the fireworks (Shooter), and striking the equipment, and cleaning the discharge site). [1123 – 3.3.2]

Cake. A chain-fused firework that propels a series of aerial shell, comet or mine effects into the air from collectively attached tubes. [1123 – 3.3.6]

Fallout area: The designated area in which both normal and hazardous debris is intended to fall after a pyrotechnic device is fired. (The shells burst over the area, and unsafe, debris and malfunctioning aerial shells fall into the area. The fallout area is the location where a typical aerial shell dud falls to the ground, depending on the wind and angle of mortar placement. The term does not include the area where cardboard and nonhazardous remnants of pyrotechnic devices might fall). [1123 – 3.3.11]

Fireworks display. A presentation of fireworks for a public or private gathering. [1123 – 3.3.16]

Hazardous debris: Any debris produced or expelled by the functioning of a fireworks device that is capable of causing personal injury or unpredicted property damage. (Confetti, lightweight foam pieces, feathers, novelties, and so forth, are not to be construed as hazardous debris). [1123 – 3.3.11]

Operator: The person with overall responsibility for the operation and safety of a fireworks display. [1123 – 3.3.39] and **Pyrotechnic Operator:** The person who has overall

responsibility for the operation and safety of a pyrotechnic display (The Operator is also responsible for storing, setting up, and removing pyrotechnic materials and devices after a performance). [1126 – 3.3.42]

Performance. The enactment of a musical, dramatic, operatic, or other entertainment production. [1126 – 3.3.33]

Proximate audience. An audience closer to pyrotechnic devices than permitted in NFPA 1123. [1126 – 3.3.39]

Shooter. A member of the fireworks display crew (either the Operator or an Assistant) who performs that actual ignition of the fireworks, either by manual or electrical means. [1123 – 3.3.40]

Spotter. A member of the fireworks display crew (either the Operator or an Assistant) who observes the firing and bursting of aerial shells and other display fireworks for the purpose of detecting proper mortar angling, noting the occurrence of duds, and observing for other potentially hazardous situations. [1123 – 3.3.40]

Site: [1123 – 3.3.41]

Discharge site: The area immediately surrounding the location where fireworks and other devices are ignited for a display. [1123 – 3.3.41.1]

Display site: The immediate area where a fireworks display is conducted, including the discharge site, the fallout area, and the required separation distance from mortars to spectator viewing areas, but not spectator viewing areas or vehicle parking areas. [1123 – 3.3.41.2]

Sponsor(s) The organization (person, group, or government agency) that arranges with a duly authorized fireworks supplier for its services in presenting a fireworks display or in

providing fireworks for use in a display. [1123 – 3.3.42] **Producer:** An individual who has overall responsibility for the operation and management of the performance where the pyrotechnics are to be used. (Generally, the producer is an employee of the promotion company, entertainment company, festival, theme park, or other entertainment group). [1126 – 3.3.37].

NFPA 1123 Terms - Undefined

Monitor: A member of the Sponsor’s crew that keeps the audience in the spectator viewing area and out of the display site. [1123 – Undefined]

Spectator viewing area: An area where spectators view a fireworks display and is not within the display site. [1123 – Undefined]

Vehicle parking area: An area where spectators park their vehicles and is not within the display site. [1123 – Undefined]

Other NFPA Key Definitions

Assembly Occupancy. An occupancy (1) used for a gathering of 50 or more persons for deliberation, worship, entertainment, eating, drinking, amusement, awaiting transportation, or similar uses; or (2) used as a special amusement building, regardless of occupant load. [NFPA 101 – 3.3.196.2]

Combustible (Material). A material that, in the form in which it is used and under the conditions anticipated, will ignite and burn; a material that does not meet the definition of noncombustible or limited combustible. [NFPA 1 – 3.3.177.1]

Exit. That portion of a means of egress that is separated from all other spaces of the building or structure by construction, location, or equipment as required to provide a protected way of travel to the exit discharge. [NFPA 101 – 3.3.86]

Load. [NFPA 1 – 3.3.170]

Fuel load. The total quantity of combustible contents of a building, space, or fire area. [NFPA 1 – 3.3.170.1]

Occupant load. The total number of persons that might occupy a building or portion thereof at any one time. [NFPA 1 – 3.3.170.2]

Means of Egress. A continuous and unobstructed way of travel from any point in a building or structure to a public way consisting of three separate and distinct parts: (1) the exit access, (2) the exit, and (3) the exit discharge. [NFPA 101 – 3.3.178]

Accessible Means of Egress. A means of egress that provides an accessible route to an area of refuge, a horizontal exit, or a public way. [NFPA 101 – 3.3.178.1]

Means of Escape. A way out of a building or structure that does not conform to the strict definition of means of egress but does provide an alternate way out. [NFPA 101 – 3.3.179]

Wildland. Land in an uncultivated, more or less natural state and covered by timber, woodland, brush, and/or grass. [NFPA 1141 – 3.3.36]

Wildland Fire. An unplanned and uncontrolled fire spreading through vegetative fuels, including any structures or other improvements thereon. [NFPA 1141 – 3.3.37]

Author's Terms

In order to assist the reader better understand this report, the author will use the following specific terms:

Fireworks vs. Pyrotechnics (a/k/a Articles pyrotechnic). Fireworks are typically considered to be those used in traditional fireworks displays under NFPA 1123 and usually classified for transportation purposes as FIREWORKS UN0336 1.4G, UN0335 1.3G or UN0333 1.1.G. Pyrotechnics are typically considered to be those used in proximate pyrotechnic performances under NFPA 1126 and usually classified for transportation purposes as ARTICLES PYROTECHNIC (for technical purposes) UN0341 1.4G or UN0432 1.4S.

Note: Articles pyrotechnic generally produce significantly less smoke and debris than fireworks, even if the same size and effect.

Ground level fireworks (ground level). Illuminations (Strobes, flares, Bengal fires, etc.) Niagara Falls, line rockets, lance setpieces, etc.

Low level aerial fireworks (a/k/a aerial fireworks 2” or less). Aerial fireworks or articles pyrotechnic shells, comets and mines as well as gerbs and fountains that are 2” (50mm) or less

Medium level aerial fireworks (a/k/a aerial fireworks 2.5” to 6”). Aerial shells, comets and mines and Roman candles that are larger than 2” (50mm) and up to 6” (155 mm).

High level aerial fireworks (a/k/a aerial fireworks 8” or larger). Aerial shells 8” (180 mm) and larger.

Blind stars/effects. Any stars or other effects (Ex: small shells, whistles, hummers, serpents, tourbillions, etc.) inside an aerial shell that fail to ignite when the shell bursts in the sky. Blind stars and effects always fall back to the ground and will generally be located near the discharge site. Blind stars and effects remain “live” and may ignite from a glowing ember or some other source of heat or flame. Blind stars and

effects can remain “live” until recovered or until the weather eventually breaks down any paper casing and dissolves the “live” fireworks compositions and blackpowder.¹⁰⁵

Catastrophic aerial shell malfunction in a mortar (a/k/a blowout): An aerial shell that functions prematurely inside a mortar, but the mortar fails to maintain its integrity and the burst charge blast and burning stars are ejected, along with pieces of the failed mortar all around the discharge site.¹⁰⁶ (Contrast with Misfire a/k/a Flowerpot)

Coldfire. A fireworks device with an electric match attached that was initiated by the shooter or computer program via the firing panel, but the electric match fails to ignite, and no fire is transferred to the fireworks device.¹⁰⁷

Dud. An aerial fireworks shell or other aerial device that upon ignition, fires out of the mortar, but the shell or device fails to burst/ignite. Duds always fall back to the ground and will generally be located near the discharge site. Duds remain “live” and may ignite from a glowing ember or some other source of heat or flame. Duds also remain

¹⁰⁵ Blind stars and effects can remain “live” for weeks, months or even years. Blind stars tend to break down quickly because they are not inside a casing. Effects tend to take much longer to break down depending on whether it has a plastic or paper casing, the thickness of the paper casing, and the exposure to ultraviolet light and moisture

¹⁰⁶ A catastrophic aerial shell malfunction in a mortar will almost always heavily damage or destroy a mortar made of lightweight materials (cardboard, fiberglass or HDPE). The exploding shell, especially larger diameter aerial shells, salutes or aerial shells or mines with magnesium compositions or reports, can damage, destroy or realign any adjacent mortars, whether buried in the ground, troughs or drums, or mounted in above ground mortar racks. Above ground wood frame mortar racks are particularly susceptible to being damaged, destroyed or realigned in such an event, especially for larger or more powerful aerial shells, such as salutes or aerial shells with reports. Fire may also transfer via the fireball of the burst charge and burning stars from the catastrophic aerial shell malfunction to other aerial fireworks in the vicinity, causing them to function either in the mortar or shoot the aerial devices at whatever angle the mortar happens to be in at that moment in time, resulting in aerial shells being fired at significant distances down range.

¹⁰⁷ See 1123 8.2.10.1.2

“live” until recovered or until the weather eventually breaks down any paper casing and dissolves the “live” fireworks compositions and blackpowder.¹⁰⁸

Hangfire. A fireworks device that receives ignition, but fails to function, usually because of some damage or defect in the ignition fuse, or in an aerial device the lift charge. It remains “live” and may ignite from a glowing ember or some other source of heat or flame.¹⁰⁹

Misfire (a/k/a Flowerpot). An aerial shell that functions prematurely inside the mortar, but the mortar maintains its integrity and the burst charge blast and burning stars are ejected from the mortar into the sky similar to a mine (hence the term “flowerpot”). (Contrast with Catastrophic aerial shell malfunction in a mortar)

Low break. An aerial shell that functions anywhere other than near the normal zenith of its trajectory, either as it fires up into the sky or as it comes back to the ground. Typically, a low break is not a hazardous condition unless it occurs at an altitude where the burning stars or other effects come back down to the ground and there is combustible fuel on the ground or spectators.

Ground break. A low break on the ground.

Muzzle break. An aerial shell that functions at the muzzle of the mortar.

Errant firework. An aerial shell or device that does not follow the expected trajectory for that type of shell or device from a mortar or tube at a particular angle.

Errant fireworks can be due to a mortar, tube, mortar rack or holder that was not properly

¹⁰⁸ Dud shells and other devices can remain “live” for weeks, months or even years depending on whether it has a plastic casing or a paper casing, the thickness of the paper casing, and the exposure to ultraviolet light and moisture.

¹⁰⁹ See 1123 8.2.10.1.1

braced or secured, a mortar, tube, mortar rack or holder mortar that failed, a blowout of a mortar or tube in a multiple tube device (cake) or a catastrophic aerial shell malfunction in a mortar rack and realigning adjacent and nearby tubes or mortars, a multiple tube device (cake) or mortar rack bouncing and/or tipping over, damaged tubes or mortars, and other causes.

Normal debris. The expected debris from aerial fireworks that falls or helicopters down to the ground and poses little to no risk to life and/or property. Every inert component of an aerial fireworks device that is not consumed when the device functions in the sky will come back down to the ground. Depending on the type and style of the aerial fireworks it could be almost nothing to approximately 3-5% of the gross weight of the device (Aerial shells with inserts have more paper, cardboard, glue and string than single break color shells). Aerial mines, comets and articles pyrotechnic usually has <1% of the gross weight of the device., which also tend to weigh less than typical aerial shells.

Hazardous debris.¹¹⁰ Debris from aerial fireworks that falls or helicopters down to the ground and poses a risk to life and/or property. (What constitutes “hazardous” is dependent on the type, size, volume and frequency of the debris, where it is landing and what is nearby, and the current weather conditions. A dud landing in the discharge site or some small bits of paper that may helicopter outside of the display site may not be considered “hazardous”. Burning stars consistently landing in areas with dense, combustible vegetation or large pieces of cardboard with firebrand landing near or in the spectator viewing area should be considered “hazardous”¹¹¹).

¹¹⁰ 1123 8.1.4.3.1 Spotters primary duty is to detect and report any unsafe condition, such as hazardous debris falling into the audience.

¹¹¹ The Operator and the AHJs will need to establish what will be considered “hazardous” debris at MORU based in part on the conditions at the time. The debris an experienced pyrotechnist would

Inserts. Plastic, paper or cardboard tubes with loose or pressed pyrotechnic compositions and a clay plug(s) inside aerial shells. After the aerial shell bursts in the sky, the inserts create moving effects in the sky as the tubes fly or spin. Some hum or whistle as they move. Some end with small reports. The spent tubes or blind effects fall back down to the ground.

House left/center/right. The point of view of the audience (house) facing the stage.

Stage left/center/right. The point of view of a performer facing the audience (house).

Show. A fireworks display and/or proximate performance utilizing either or both fireworks and articles pyrotechnic according to both NFPA 1123 and/or NFPA 1126 and best practices.

Author's Note: Aerial shells, mines and comets as well as single shots and Roman candles are measured by the inside diameter (ID) of the mortar or tube use to fire the device, not the circumference of the device, which is less than the ID of the mortar or tube [1123 – 4.1.1].

Gerbs and fountains are measured either by the duration and height of the device (i.e. a 20 x 20 gerb has a duration of 20 seconds and a performance height of 20 feet a 1 x 65 gerb has a duration of 1 second and a performance height of 65 feet), or the ID of the tube (3/8", 1/2", 5/8", 3/4", 1", etc.).

Aerial shells, mines and comets as well as gerbs, fountains, strobes, flares, etc. can be either fireworks or articles pyrotechnics depending on the construction, composition, intended use and classification for transportation purposes.

consider "normal" might be considered "hazardous" by someone with less experience. Likewise, the debris an experienced pyrotechnist would consider "normal" might be considered "hazardous" at MORU because of the potential for wildland fire.



Photo 56 A rare sight at a 21st Century Independence Day fireworks displays. An entire 4" mortar rack with American manufactured canister (cylindrical) aerial shells. Note how this rack is staked individually to the ground for support and the aerial shells are chain fused.

Appendix B – Wildland Fire Conditions

The U. S. Forest Service uses the following basic system to determine Wildland Fire Conditions.

Fire Danger Rating and Color Code	Description
Low (L) (Dark Green)	Fuels do not ignite readily from small firebrands although a more intense heat source, such as lightning, may start fires in duff or punky wood. Fires in open cured grasslands may burn freely a few hours after rain, but woods fires spread slowly by creeping or smoldering, and burn in irregular fingers. There is little danger of spotting.
Moderate (M) (Light Green or Blue)	Fires can start from most accidental causes, but with the exception of lightning fires in some areas, the number of starts is generally low. Fires in open cured grasslands will burn briskly and spread rapidly on windy days. Timber fires spread slowly to moderately fast. The average fire is of moderate intensity, although heavy concentrations of fuel, especially draped fuel, may burn hot. Short-distance spotting may occur, but is not persistent. Fires are not likely to become serious and control is relatively easy.
High (H) (Yellow)	All fine dead fuels ignite readily and fires start easily from most causes. Unattended brush and campfires are likely to escape. Fires spread rapidly and short-distance spotting is common. High-intensity burning may develop on slopes or in concentrations of fine fuels. Fires may become serious and their control difficult unless they are attacked successfully while small.
Very High (VH) (Orange)	Fires start easily from all causes and, immediately after ignition, spread rapidly and increase quickly in intensity. Spot fires are a constant danger. Fires burning in light fuels may quickly develop high intensity characteristics such as long-distance spotting and fire whirlwinds when they burn into heavier fuels.
Extreme (E) (Red)	Fires start quickly, spread furiously, and burn intensely. All fires are potentially serious. Development into high intensity burning will usually be faster and occur from smaller fires than in the very high fire danger class. Direct attack is rarely possible and may be dangerous except immediately after ignition. Fires that develop headway in heavy slash or in conifer stands may be unmanageable while the extreme burning condition lasts. Under these conditions the only effective and safe control action is on the flanks until the weather changes or the fuel supply lessens.



Photo 57 A time lapse photo of the Skyrockers annual New Year's Eve fireworks show from atop 600-foot Grandad's Bluff at the eastern edge of La Crosse, WI. This display has been a tradition since 1929 and is visible to about 100,000 people in three states along the Mississippi River.

Note: These are a 3" flash salute (left) fired at a steep angle out from the north point (red fusee is visible) and the 4", 5", and 6" color shells fired from the top, center. The rising tails show how the color shells trail off at slightly different angles even though the mortars are at or near vertical.

For reference, the flagpole is 70 feet AGL on the top of the Bluff. There are 3" to 6" mortars within 25 feet of the flagpole and flag but angled slightly away. [Photo credit: Wisconsin Trails Magazine]

Appendix C - Author's Biography

The Author, Charles P Weeth, has 35 years of experience planning, designing, operating and assisting with fireworks displays and pyrotechnics performances, including testing and planned malfunctions of fireworks and pyrotechnics and equipment, and manufacturing and assembly.

He has been involved in displays and pyromusicals from California to New York, Hawaii to Florida, and Mississippi to Minnesota, and many places in between. Beaches to baseball fields, bridges to barges, racetracks to riverbanks, fields to bluffs, parks to parking lots, stages to stadium rafters, and almost everything else imaginable – including his 1953 Ford F600 fire truck and a bicycle and trailer – have been the sites of fireworks displays or proximate pyrotechnic performances he has designed, operated or assisted at over the last three plus decades.

He has also participated with fireworks displays and pyrotechnics performances of varying types and sizes in Canada, Spain, Italy, Colombia, Hong Kong, China and Japan.

The Author has been the manufacturer’s representative for a Wisconsin company that makes high density polyethylene (HDPE) mortars for the fireworks trade since 1990. The company has supplied many fireworks display companies and theme parks around the world.

He has served on the National Fire Protection Association (NFPA) Technical Committee on Pyrotechnics since 1988 and the Technical Committee on Special Effects since 2003. These committees develop NFPA 1123 and 1124, and NFPA 1126 and 160 respectively, as well as the fire codes for model and sport rocketry.



Photo 58 The Author with his 1953 Ford F600 fire truck. He uses it in parades and other events with proximate pyrotechnics and propane flame effects. [Photo credit: Bob Good]

The Author is a Certified Fireworks Display and Pyrotechnic Operator in Minnesota and was previously certified in Hawaii as well. He is an ATF Responsible Person for a number of ATF licensees/permittees. He held a Commercial Driver's License (CDL) with a hazardous materials and TSA endorsements until he retired from driving trucks with regulated explosive materials in 2018.

Mr. Weeth is a Certified Operator by the PGI and is also certified to conduct the PGI Display Operator Course. He assisted with the major revision to the PGI *Study Guide for Display Operator Training Program*.

The Author is the Special Correspondent for American Fireworks News (AFN) and Fireworks Business, the monthly fireworks trade newsletters.

He has authored numerous papers and presentations, including his investigations of the SE Fireworks facility in Enschede, The Netherlands that resulted in 22 fatalities, almost 1,000 seriously injured and over 400 homes and businesses destroyed, as well as the alleged fireworks explosions aboard the 930 foot container vessel M/V Hanjin Pennsylvania that killed two sailors and resulted in a \$235 million loss.

Mr. Weeth is frequently consulted in administrative, civil and criminal proceedings involving fireworks and pyrotechnics, He has been recognized as an expert witness in Federal and state courts.



Photo 59 The Author with his German shepherd dog Miss Dodger geared up and ready to shoot another show. His many German shepherd dogs have accompanied him to fireworks show over the last 35 years.

Appendix E – Photo Credits

All photos credited to the Author unless otherwise noted. All photos used with permission or in the public domain.

Cover photo credit: Janet Williams (www.sharetheexperience.org).



Photo 60 A 3" blowmolded HDPE mortar with the shattered remnant of a 1" x 4" sideboard from an above ground wood frame mortar rack. This large splinter is piercing the bottom of the HDPE mortar, which gives an indication of the power of 3" salutes when there is a catastrophic aerial salute malfunction in a mortar.

December 17, 2019

Additional considerations for Mount Rushmore fireworks contractor/operator

The NPS recently shared with the State a report prepared for Mount Rushmore National Memorial by Mr. Weeth. The report discusses National Fire Protection Association code compliance concerns for potential fireworks launch sites. While the report lays out what the contractor believes is technically possible under the code, the National Park Service (NPS) and its partners will need to apply additional considerations to provide a safe and responsible firework display at the park in 2020.

These considerations and constraints are based on the resource protection mission and policies of the NPS, visitor experience objectives, the purpose and significance of Mount Rushmore National Memorial, safety of staff and contractors, operational best practices, and guidance from the code compliance report.

The NPS looks forward to working with the State of South Dakota and their fireworks contractor/operator to discuss and implement these additional considerations. The NPS offers to be involved in developing or to review the State's Request for Proposals (RFP), to host potential or selected contractors, and to review early proposals for compliance with these additional considerations and the code compliance report.

Considerations for fireworks show development

1. Preference for high-quality, US-manufactured fireworks, constructed of biodegradable materials. The contractor's report states that higher quality fireworks create a better display, while also providing for better burning shells, resulting in a reduction of chemicals and debris on the ground.
2. Requirement for suitable racks for holding fireworks tubes. Racks should be able to withstand a catastrophic failure without changing launch angles, a noted failure in the past.
3. Requirement to avoid attaching fireworks and supports directly to natural materials (stone or trees) or NPS facilities, unless specifically authorized by the NPS.
4. Consideration of the use of protective gear at launch locations to protect natural surfaces and facilities from burn marks.
5. Requirement for the fireworks contractor, operator, and all operator staff to have appropriate licensure or certifications.
6. Requirement for the fireworks contractor/operator to have a comprehensive unexploded ordinance location and recovery plan, and a comprehensive cleanup plan to be in place and followed.
7. Requirement for the contractor/operator to develop a staging, setup, and teardown schedule for the event. The schedule must include chain of custody for fireworks during transport, including aerial transport if required.
8. The contractor should be aware that the NPS, State, and partners will establish an incident management team (IMT) for the event, and will require the use of a Go/No-Go

checklist to confirm fuel loads, fire risk, and severe weather risk are all appropriate to move forward with the event.

Site specific considerations

After review of the contractor report, the NPS applied resource protection objectives and safety considerations to each site. The NPS requests that this additional information be reviewed by the State and, once finalized, provided to potential fireworks contractors, so that it can be incorporated into the event design.

To speed the compliance and contracting processes, the NPS prefers that the State and potential operators focus the event design on three potential launch areas: the amphitheater area, the Hall of Records Ridge area, and the talus field. Other listed launch sites would be permitted by the NPS only if sufficient considerations for safety and resource protection are provided and approved by the NPS.

Highest potential launch sites:

- **Amphitheater:** This area could be permitted for proximate fireworks, as described in the contractor report. No direct attachment to structures would be allowed. Proposed fireworks must address flammable vegetation and structures in the area and proximity to seating areas.
- **Hall of Records Area, Ridge Area:** This area could be permitted as a launch site for shells as described in the contractor report, with the following considerations:
 - Identifying a specific location for the proposed launch site, addressing the lack of level ground and the need to protect the area from burn marks.
 - Establishing and anchoring a durable free-standing frame for fireworks, as recommended by the contractor report; no anchors to the stone will be permitted.
 - A helicopter and/or rope teams would likely be required for setup and cleanup.
- **Talus field:** This area could be permitted for mines or comets of 2" or less, as described in the contractor report. Any proposal to use this area must consider that boulders are unstable and present significant safety hazards during staging. No direct connection to the stones will be permitted, and comprehensive fire protection measures are needed.

Potentially feasible launch sites that present additional challenges:

- **Hall of Records Canyon (area directly adjacent to Hall of Records itself):** The NPS would prefer not to permit fireworks in this area due to its historic importance and the challenges presented at the site. The challenges to overcome would include:
 - NFPA code requirements of 25 feet away from vertical obstruction. There is potentially a small, narrow launch site area, for fireworks to be launched at a 90 degree angle.
 - Ensuring protection of the Hall of Records and guard shack. The contractor report recommended ¾ inch plywood or ¼ inch lexan. No direct attachments to the stone will be permitted.

- Constructing a scaffolding to create a launch platform higher than the Hall of Records. The contractor report recommended 60-70 feet in height, requiring substantial material to be hauled to the site.
- No direct attachments to the stone will be permitted. Additionally, no direct attachment of fireworks or scaffolding to park structures will be permitted (i.e. the staircase to the guard shack).
- A helicopter and/or rope teams would likely be required for setup and cleanup.
- **Middle Marker Trail and Middle Marker Road areas:** The NPS would prefer not to permit fireworks in this area. These sites were not recommended as suitable per the contractor report. Challenges to overcome include the size of shell required for good viewing, the resulting larger fallout area, and fuel loads in the launch and fallout areas.
- **Presidential Trail and forest openings:** This area could be permitted for ground level fireworks and proximate fireworks, as described in the contractor report. Any proposal to use these locations must address firework spacing in the tree canopy and minimum separation distances, the combustibility of the trail and fuel loads in proximity, and protection of any nearby structures (including handrails, stairs, etc). Per the contractor report, comprehensive fire protection measures are needed, and thorough technical performance evaluation of every device in each specific location is vital. It is unclear if these sites would present any additional benefit over the talus field.

Least feasible launch sites:

- **Amphitheater road:** This area would likely not be permitted for fireworks. This is the only vehicle egress in the vicinity and must remain free of obstructions for safety considerations.
- **Hall of Records Area, Canyon Entrance:** This site would likely not be permitted for fireworks. It was not recommended for use in contractor report due to its narrow configuration and overhead obstructions.
- **Hall of Records Area, Top of Carvings:** This site would not be permitted for fireworks due to its cultural and historical significance, complicated staging requirements, safety concerns, and potential to damage the sculpture. This is the fundamental resource of the park, and there is a history of damage caused by previous fireworks displays from this location.
- **Indian Camp:** The NPS would prefer not to permit fireworks in this area due to its cultural significance, complicated staging requirements, and existing fuel loads.
- **Profile Parking Area:** The NPS would prefer not to permit fireworks in this area given. The site was not recommended as suitable per the contractor report given the size of shell required for good viewing, fuel loads in the launch and fallout areas, and a launch angle that could impact the sculpture.
- **Sides of Carvings/Sculpture:** This site would not be permitted for fireworks due to its cultural significance, complicated staging, and potential to damage the sculpture. Additionally, there are safety concerns for contractors staging and cleaning up fireworks in this location.

Terms used:

Fireworks are typically considered to be those used in traditional aerial fireworks displays.

Pyrotechnics are typically considered to be those used in proximate pyrotechnic performances such as in stadium and theater settings. Pyrotechnic generally produce significantly less smoke and debris than fireworks.

Ground level fireworks include illuminations, "Niagara Falls", line rockets, and similar effects.

Low level aerial fireworks include pyrotechnic shells, comets, fountains, and mines that are 2" (50mm) or less.

Medium level aerial fireworks include aerial shells, comets, mines, and Roman candles that are larger than 2".

High level aerial fireworks include aerial shells 8" and larger.

EXHIBIT C

Permit Application.

Permitting of special events that include the use of fireworks or pyrotechnic displays is managed under Directors Order 53, Special Park Uses, and the associated Reference Manual. The following must be submitted for NPS AHJ review and approval along with the Special Event Permit Application

Qualification of Operator and Assistants

The person in charge of firing the fireworks is the fireworks display operator. The operator and key assistants must be at least 21 years of age, competent for the task and be licensed by the state where the display will be held:

- Proof of age, such as a current drivers license.
- Evidence of active participation in five fireworks displays, including references of fire protection authorities involved with the display. Three of the displays must have been in the prior four years.
- Bureau of Alcohol, Tobacco, Firearms and Explosives Notice of Clearance for individuals transporting, shipping, receiving, or possessing explosive materials, issued to the operator's company and listing the operator and assistants as a responsible persons or employee possessors.

Where the state does not require certification, the following must be provided before a permit is issued:

- Certification that the fireworks display operator understands the requirements of NFPA 1123, or has a current license to operate a fireworks display in another state

Proof of Insurance.

The display operator, sponsor, or both should present verifiable proof of liability insurance of a type and amount required by DO/RM-53. The NPS must be listed as an insured party.

Site Plans.

The display operator, sponsor, or both will collaborate with the NPS to prepare and submit site plans to the NPS AHJ for approval. These diagrams should be drawn to approximate scale, should illustrate compliance with NFPA-1123 requirements, and shall include all of the following information:

- The point at which the fireworks are to be discharged
- Spectator parking and viewing areas
- The approximate distances from mortars to spectator viewing areas
- The location and approximate distances of all buildings, highways, and other lines of communication
- The lines behind which the audience is to be restrained
- The controls that will be used to maintain audience separation
- The location of other possible overhead obstructions.
- Location of fireworks storage areas
- Fallout area, including dimensions
- North arrow
- Likely wind direction
- Location of significant roadways, including access and control points
- Traffic plans indicating the flow of vehicles into and out of the site before and after the display
- Location of emergency vehicle staging area and access routes
- Detailed diagram showing storage area(s), preparation area(s), equipment staging areas(s)

Discharge Site Details.

Detailed descriptions including specifications, diagrams, and photos will be submitted for NPS AHJ review and approval for the following:

- Mortars
- Mortar racks
- Holders
- Securement and stabilization methods
- Shields and materials
- Firing system
- The general arrangement and size of mortars
- The location of shell storage at the discharge site.
- The location of the electrical firing unit.

Changes.

Plans should be revised or updated as often as required to maintain their accuracy. Any changes in site conditions between the time plans are prepared and the time the display is conducted should be brought to the immediate attention of the NPS AHJ.

Event Description.

A description of the public display event should be prepared by the sponsor and submitted to the NPS AHJ for review and approval.

- Proposed Show Schedule
 - Date of show
 - Delivery of fireworks and equipment
 - Set up
 - Load in
 - Start of show
 - Duration
- Detailed descriptions of the fireworks and/or pyrotechnics to be used including:
 - Brand names
 - Sizes
 - Effects descriptions
 - Mortar and device locations with angles
 - Durations
 - Performance heights
 - Performance spread
 - US Department of Transportation (DOT) Explosive number (EX#) with the manufacturer's applications listing the chemical compositions of all fireworks and articles pyrotechnic
 - Safety Data Sheets (SDS)

Event Procedures

The operator and sponsor will work in collaboration with the NPS to prepare, and submit to the NPS AHJ for review and approval, details on staffing and procedures for the following:

- Communications
- Weather monitoring
- Site security
- Crowd control

- Wildland and Structural Fire response
- Emergency Medical Services response

Firing Procedures.

Operating procedures shall be prepared and submitted to the AHJ for review and approval. The operating procedures should illustrate compliance with NFPA-1123 Chapter 8 and contain all of the following information:

- Identification of operator and assistants
- Copies of applicable display personnel licenses, permits, or certificates of fitness
- Description of the firing method

Post Discharge Procedures.

A description of the procedures to be taken upon completion of the outdoor display shall be prepared and submitted for NPS AHJ review and approval. Post discharge procedures should contain all of the following information:

- Procedures and staffing for inspecting the discharge site and fallout area for any defective or unexploded fireworks
- Procedures and staffing for disposing of defective fireworks and fireworks materials

Emergency Procedures.

An Emergency plan shall be prepared and submitted to the NPS AHJ for review and approval. This plan should include all of the following information:

- Description of the means of alerting staff to emergencies
- Identification of the signal and means to notify the display operator, sponsor, or both to terminate the loading or firing of fireworks in the event a hazard arises during the outdoor display
- Identification of the means of notifying public emergency forces
- Emergency reporting instructions describing the information that should be provided to emergency operators

Public (Spectator) Notification

A public address system shall be provided to ensure the timely and effective notification of spectators of conditions affecting their safety. Public address announcements should be used to ensure an orderly spectator response.