APPENDIX B

SUMMARY OF COMPREHENSIVE PLANNING GOALS RELEVANT TO THE PROPOSED ACTION

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B.1 Charles County

B.1.1 Comprehensive Plan

Charles County last updated its comprehensive plan in 2006 (Charles County, 2006a). With regard to land use, the plan's goal is to "Maintain a planned land use pattern of compatible utilization of land and water guiding future growth into efficient and serviceable form." Specific objectives include (only those objectives relevant to the scope of this EIS are listed here):

- Concentrate the majority of future growth in areas of the county already served or proposed to be served with public water and sewer. Direct 75 percent of future growth to the Mattawoman sewer service area and the towns of Indian Head and La Plata.
- Designate areas of the county dominated by agricultural and forest cover for rural development densities, agricultural use, and conservation.
- Provide services for surrounding rural and agriculture areas in existing villages while protecting their unique character.
- Protect environmentally sensitive areas in using the county's abundant waterfront. Guide development away from areas vulnerable to natural hazards.
- Encourage future industrial and office uses to locate in and near existing office and industrial areas in Waldorf (including St. Charles), in White Plains, near the Pomonkey Airport, in the towns, and adjacent to the Nice Bridge.
- Concentrate future active recreation facilities in and near the county's major development centers and establish open space on sensitive environmental lands as a means of preserving them.
- Require residential development to be efficient, serviceable, and designed to protect and retain portions of open space that will assure protection of sensitive resources.

The county's land use concept plan identifies 12 districts: 1) Development Districts; 2) Development District Residential Districts; 3) Employment and Industrial Districts; 4) Commercial and Business Districts; 5) Mixed Use Districts; 6) Deferred Development District; 7) Neighborhood Conservation Districts; 8) Village Centers; 9) Agricultural Conservation District; 10) Rural Conservation District; 11) Rural Residential Districts; 12) Highway Corridor Districts.

Most of the county's Potomac shoreline falls within the Rural Conservation District, with a small Employment and Industrial District to the south of the Harry Nice Bridge (where the Morgantown power plant is located); a small Commercial and Business District just north of the same bridge; and a Mixed Used District at Swan Point. The following Village Centers are on or near the shore: Morgantown; Issue; Rock Point; and Cobb Island. A brief description of the county's approach to development in these types of districts follows.

- Rural Conservation District: The Rural Conservation District is intended to preserve rural character and open space, to foster agricultural activities and opportunities, to protect valuable resources, and to allow for diversification of income productive activities. It is further intended to prevent premature urbanization in areas where public utilities, roads, and other public facilities are planned to meet rural needs only. The Rural Conservation District provides for a full range of agricultural and farming activities and protects these established uses from encroaching development. However, it also accommodates residential densities up to one dwelling unit per three acres with cluster development practices permitted. Within the district, there are existing scattered clusters and individual non-farm residences on small parcels of land. Although this may satisfy some limited rural housing need or demand, the prime objective of this District is not to accommodate such development.

- Employment and Industrial District: These are areas designed to provide locations for additional, up-graded, and diverse job opportunities for residents of the county. They were selected based on previous similar use, proximity to highways, water, and sewer services; possibility to accommodate a wide range of land uses and occupations; and opportunities to minimize impacts on adjacent land uses.

- Commercial and Business District: These are areas where future commercial development should occur. They are centrally located to serve the most concentrated population areas of the county and are accessible by major state highways. Combined with the Mixed Use Districts and Villages, these areas will channel commercial development into nodes.

- Mixed-Use Districts: These areas encourage a mix of medium to high density residential, business, and employment uses in a compact, well-designed, pedestrian-friendly environment. The Swan Point district is defined under a unique approval granted pursuant to the 1974 Zoning Ordinance and projects in this area will continue to develop consistent with the terms of the approval.

- Village Centers: The Village concept recognizes and provides for the special needs of rural unincorporated population centers. Villages serve as rural service centers and locations for rural residential development. Characteristics common to most of the villages are post offices, country stores and, frequently, fire departments. Villages tend to be basically residential in character, but they can offer some employment through limited commercial services as well as public or institutional uses. Generally, villages should remain small in physical area and population size; continue to provide limited, highly localized commercial services (such as a gas station or general store); provide limited employment opportunities; and provide a population density consistent with the existing development pattern and other objectives of the plan.

B.1.2 Land Preservation, Parks, and Recreation Plan

Charles County's most recent approved land preservation, parks, and recreation plan (LPPRP) was adopted in June 2006 (Charles County, 2006b). At the time of this writing (June 2012), Charles County is in the process of updating its LPPRP. Because the 2012 draft plan is a working document still subject to review and potentially substantive modifications, this section references the 2006 LPPRP only.

With respect to the Recreation element, the plan identifies primary deficits for baseball/softball diamonds, indoor basketball courts, multi-purpose fields for team sports, trails, and fishing from piers. Secondary deficits are identified for boat ramps and public water access, playgrounds, picnic pavilions, and dog parks. The plan's major recommendations for recreation include (only those recommendations relevant to the scope of this EIS are listed):

- Completion of parks and recreation facilities currently in various phases of development, including Friendship Farm Park.

- Development at Mallows Bay focusing on natural resource-based recreation, development of a lodge or other form of accommodation at a site in west county to capitalize on the opportunities for ecotourism, trails, and a boat launch at Chapel Point State Park.

With respect to the agricultural land preservation element, maintaining rural character and agriculture as an industry is identified as a major goal of the county. Specific recommendations include (only those recommendations relevant to the scope of this EIS are listed):

- Adopt a target area for agricultural land preservation, tentatively identified in the Allens Fresh, Cobb Neck, and Charlotte Hall areas.

- Adopt zoning and development regulations that are protective of agricultural land resources.

With respect to the natural resource land conservation element, the plan notes that residential development in rural areas continues to make conservation of large contiguous blocks of natural resources land a significant challenge. Major recommendations include (only those recommendations relevant to the scope of this EIS are listed):

- Create a natural resource land conservation focus area. This area is tentatively identified in the western part of the county.

- Seek to protect 50 percent of the county in open space.

- Strengthen efforts, such as through clustering requirements, to reduce the impacts of rural development on natural resources in rural parts of the county.

- Increase the pace of capital projects and program development activities for eco-tourism and resource-based recreation.

B.2 St. Mary's County

B.2.1 Comprehensive Plan

St. Mary's County's comprehensive plan, titled *Quality of Life in St. Mary's County – A Strategy for the 21st Century*, was last updated in April 2010 (St. Mary's County, 2010). It expresses the county's vision for its future, which is to "Preserve and enhance the quality of life by recognizing and protecting the unique character of St. Mary's County as a Chesapeake Bay peninsula. Foster economic growth and create an atmosphere of excellence by focusing and managing growth to create vibrant, attractive communities; by protecting the rural character and economy of the countryside by nurturing the shoreline and adjacent waters; and by preserving and capitalizing on the natural resources and historical quality of the county."

With respect to growth management, the plan divides the county into growth areas and preservation areas to concentrate growth in suitable areas while preserving resources and rural character elsewhere. For each area, the plan establishes goals and policies, densities and development character, and indicates areas as either receiving (growth areas) or sending (other areas) areas for transferred development rights. Growth areas are targeted to receive a majority of residential, commercial, and industrial growth and include:

- Development Districts. These primary growth centers are Lexington Park and Leonardtown; they are urban in pattern and form, designated for intensive residential, commercial, and industrial development supported by a priority for provision of community facilities, services, and amenities. Development districts are concentrated in the north central part of the county; only Leonardtown is turned toward the Potomac River, via Breton Bay.

- Town Centers. These secondary growth centers are Charlotte Hall, New Market, Mechanicsville, Hollywood, and Piney Point; they are urban in pattern and form, designated for moderately intense residential, commercial, and industrial development supported by provision of community facilities and services. One designated town center – Piney Point – lies along the Potomac River.

- Village Centers. These third-order growth centers are Callaway, Chaptico, Clements, Loveville, Ridge, St. Inigoes, and Valley Lee. They are intended to serve as the focus for rural community facilities, services, and activities. All the village centers are located in the south of the county, with Clements, Valley Lee, St. Inigoes, and Ridge being closest to the water.

Rural areas comprise the majority of the county's land, including its southern shoreline. Like growth areas, for land use planning purposes, rural areas are divided into three types:

- Rural Preservation Areas. This includes prime farm land, timber land, mineral resource lands, agriculturally-related industries, and limited non-farm cottage industries. Low-density, non-farm residential developments characteristic of the county's rural character are to be preserved for a wide range of economic and aesthetic purposes. While the plan recognizes the continued nonconforming commercial and residential activities on existing parcels throughout the district, it aims to limits their expansion or creation.

- Rural Service Centers. This includes crossroad commercial, retail and business development at Avenue, Budds Creek, Dameron, Helen, Oraville, Park Hall, and St. James that has traditionally provided very localized services for the surrounding rural and agricultural area. These areas are designated and intended to offer limited opportunity for infill development to provide focused commercial nodes in the rural areas.

- Rural Commercial Areas. These are established areas of commercial use along county or state roadways that existed outside growth areas at time of passage of the plan. This category provides for continuation of commercial uses and for the commercial development of certain vacant properties where the use and commercial zoning classifications predate the plan and where commercial use or development would generally not alter the historic character of these areas located outside of a development district or town or village center as delineated in the plan.

Finally, protected areas fall into two categories:

- Resource Protection Areas. These are sensitive areas such as steep slopes, floodplains, wetlands, stream corridors, hydric soils, and critical natural habitats, where development is hazardous or detrimental. Also included are significant natural, cultural and historic resource areas subject to loss or harm as a result destruction, significant alteration, or inadequate protection from impacts of off-site development; and Chesapeake Bay critical areas.

- Neighborhood Conservation areas. These are established, predominately residential areas, where the existing development patterns and neighborhood character are to be maintained, including communities with concentrations of structures with historic designation. Limited infill development is allowed consistent with the existing patterns and character within the affected district.

B.2.2 Land Preservation, Parks, and Recreation Plan

St. Mary's County's LPPRP (St. Mary's County, 2005) identifies sizable deficits for a number of recreational facilities. These deficits are expected to grow out to 2020 and beyond as population increases, unless facilities are programmed and developed to keep pace with growth. The most significant deficits currently are: baseball/softball diamonds; multipurpose fields for team sports; indoor facilities for basketball, volley ball, etc.; pedestrian and bike trails; fishing areas; and boat ramps/water access. The greatest needs are expected to be in Election Districts 8 and 5, in the north and north central parts of the county.

In the light of the identified needs, the LPPRP sets out the county's parks and recreation priorities. Among the highlights of the program most relevant to the scope of this EIS are:

- A 25- to 50-acre waterfront park along the Potomac River in the 3rd Election District.
- A regional park in the central portion of the county, most likely in the 3rd Election District.
- Leonardtown Landing Waterfront Park.
- Colton's Point Park.

The plan also identifies an agricultural preservation focus area in the northwest part of the county, which includes areas bordering the Wicomico River and St. Clements Bay. It encompasses the portion of the county's Rural Preservation District that contains the largest concentration of protected lands and working farms and is relatively little compromised by residential development. This area would be the focus for an enhanced package of farmland preservation and enhancement tools.

Finally, a natural resources conservation focus area is delineated running approximately north-south through the north central part of the county. This area is anchored by the existing Huntersville Rural Legacy area in the north and the St. Mary's River Wildland in the south. Between these two areas is the Breton Bay watershed, with its valuable natural resources. The natural resources conservation focus area would become the focus for a series of conservation programs.

B.3 Northumberland County

Northumberland County's current comprehensive plan was adopted in June 2006 (Northumberland County, June 2006). The plan's preface notes that though the county has not experienced development pressures as strong as those felt in other Virginia counties, growth is inevitable and must be encouraged, but in a way that benefits the county, residents, and businesses and does not hurt the county's character and attractiveness. The county's guiding vision for the future states that "[…] Northumberland County will preserve its rural character and its maritime heritage while fostering economic growth and the well-being of its citizens. Economic growth will occur that provides jobs, supports agricultural and water-based activities and provides services to the retired community. Residential, commercial, and industrial development will be supported that enhances the social and economic life of the county and conserves its natural resources. It will become a model of planned waterfront residential and village business development that ensures the quality of life of its residents while attracting desirable new growth […]."

The county's land use plan consists of five distinct "building blocks:"

- Rural Uplands. This is the area of the county that lies landward from the topographic feature known as the Suffolk Scarp and generally is above 50 feet in elevation above sea level.

- Rural Low Shelf. This consists of the remainder of the county lying seaward from the Suffolk Scarp and generally between zero and 50 feet above sea level.

- Shoreline Conservation Area. This is an area extending from the edge of tidal waters 1,000 feet inland. It overlaps the Rural Low Shelf and the Rural Uplands in many places.

- Villages. These are areas of concentrated development that have become commercial hubs or areas of distinctive community identity.

- Overlays. This are areas of particular interest with special land use considerations, including shoreline development, transportation corridors, and reservoirs.

County land within the area under consideration here mostly lies within the Rural Low Shelf and Shoreline Conservation areas. For these areas, the plan lays out a range of policies to guide development, including the following ones (only those policies most relevant to the scope of this EIS are listed):

- Rural Low Shelf: 1) Land usage is intended to be a general mix of low-density residential and agricultural. Residential development should be dispersed or arranged in clusters to avoid excessive linear development along existing road frontage. 2) Development near streams should avoid steep slopes, avoid excessive removal of natural vegetation and maintain riparian buffers as required by the Chesapeake Bay Act. 3) Except for country stores and convenience stores, commercial and industrial sites unrelated to marine activities should not be established in this area.

- Shoreline Conservation Area: 1) Residential subdivisions should be allowed conditionally with the goals of protecting agricultural and forested lands, preserving the natural beauty, wetlands, dunes, beaches and other natural resources along the shoreline and adjacent lands, and maintaining as low a density of development as possible. 2) New subdivisions should be planned, whenever feasible, to provide public access to the Chesapeake Bay including beaches, boat ramps, fishing points and other water-oriented recreational activities. The establishment of community facilities on the water for the common use of the residents within subdivisions should be encouraged as a means to reduce the number of individual boat houses and piers. 3) In order to protect existing farmland and forests while permitting desirable development, there should be a requirement that the property owner place a significant portion of the original parcel acreage into open space or forest. This standard should apply for all parcels or collections of parcels above some minimum value of acreage. 4) New water-oriented enterprises that help the economic development of the county and support tourism, sports fishing, commercial fisheries, or other water-related activities are encouraged to be established at sites where they can be accommodated by deep water and appropriate access.

B.4 Westmoreland County

Westmoreland County's current comprehensive plan was adopted in 2012 (Westmoreland County, 2010). The land use element of the plan identifies primary and secondary growth areas, within which a majority of future development should occur. The primary growth areas are those immediately adjacent to the towns of Colonial Beach and Montross and are the preferred locations for new residential, commercial, and industrial development (e.g., moderate–density, single-family, and multi-family housing; small- to large-scale retail sales and services; offices and office parks; and light manufacturing, warehousing, and distribution). Public infrastructure, and new or expanded community facilities and services also are expected to be primarily located in those areas.

Secondary growth areas are located at the intersection of primary highways or heavily-traveled secondary roads. They include Oak Grove, Carmel Church, Coles Point, Kinsale, Nomini Grove, Hague, and Monroe Hall. Appropriate development in these areas includes low- to moderate-density housing, small-scale retail sales and services, offices and small office parks, light manufacturing, warehousing and distribution, and public and community facilities. Of the secondary growth areas, all but Carmel Church and Nomini Grove are located close to the Potomac shoreline or on one of the estuaries and bays opening into the river. Specific recommendations for these areas are as follows:

- Oak Grove and Monroe Hall: Development in these areas should reinforce community identity and a visual separation from the Colonia Beach primary growth area. In Oak Grove, commercial and office development should be limited to those businesses necessary to serve the area.

- Coles Point and Kinsale: Emphasis should be placed on preserving the area's character, tree cover, and water quality, as well as preserving and creating public access points to the Potomac River or Yeocomico River. Principal recommended uses include recreational and water-related establishments. In Coles Point, tourist-related commercial uses may be appropriate. Commercial and office development in Kinsale should be limited to those businesses necessary to serve the area. In both locations, uses that require a waterfront location and/or are oriented to the area's waterfront amenities are encouraged.

- Hague: Commercial and office development should be limited to what is necessary to serve the residents of the surrounding area.

Designated, transitional residential areas of moderate density (about four units per acre) are located at the edge of the designated growth areas and separate them from the rural lands, where such uses as farms, recreational, educational, and religious facilities as well as very low-density residential uses are recommended. Rural lands are intended to remain primarily for agricultural or forestland use, although with low-density residential, and scattered commercial, institutional, and industrial uses.

The land use plan also has a Conservation designation, which includes all Chesapeake Bay Resource Protection Areas, lands within 100 feet of intermittent streams, slopes greater than 25 percent, flood hazard areas, and critical habitats. Such lands are meant to remain in their natural state but may be encroached upon or developed provided impacts are properly mitigated. Examples of preferred land uses in those areas include hunting and fishing clubs, fish and game preserves, parks, and other passive recreational facilities.

B.5 Town of Colonial Beach

In January 2010, Colonial Beach adopted its updated Comprehensive Plan for the years 2009-2029 (Colonial Beach, 2010), which replaces the previous document dating back to 1999. This section briefly summarizes the land use element of the 2009 plan.

With respect to land use, the plan's goal is to create an "Overall pattern of development that reflects the vision of the community by preserving its historic resort small town character, improving its citizens' quality of life, and protecting the town's natural resources."

Objectives include:

- Improve the town's aesthetic quality to make a positive and lasting impression on visitors to the community and enhance the quality of life for residents.
- Appropriate mix of residential, commercial, and employment uses, which will provide adequate housing, shopping, and employment opportunities for present and future residents.
- Land use and development coordination with Westmoreland County for adjoining land within a one-mile radius of the town's corporate limits.
- Adequate open and green space.

The document's Future Land Use Plan outlines a generalized land use concept for Colonial Beach and its surroundings. The plan largely reflects existing land use patterns but allows for new and infill development in the existing developed and undeveloped portions of town and recommends that new development should be an extension and revitalization of the traditional patterns of growth.

The Future Land Use Plan and associated map define several land use designations, of which the two most important ones (in terms of area) are Neighborhood Preservation and Planned Unit Development (PUD). The purpose of the Neighborhood Preservation district is to meet the present and future housing needs of the citizens of Colonial Beach while maintaining the existing residential character of the areas within the district. The district encompasses all existing residential neighborhoods – Bluff Point, Riverside Meadows, Classic Shores, Central Area, and The Point – and most of the area between the Potomac River, Monroe Bay, and Route 205, where these neighborhoods are located. Each neighborhood is unique and it is important that it

preserve its unique identity. The plan supports the stabilization and preservation of such residential areas while promoting rehabilitation and infill development, as appropriate.

The PUD district is located on a large portion of the Potomac Crossing planning area, in the northwest corner of the town. There is an approved site plan for this area comprised of a mix of residential structures, a golf course, and limited commercial development.

Other land use designations include Commercial (General, Historic Resort, and Maritime, mostly concentrated along Colonial Avenue and Washington Avenue); Public Open Space (parks, trail corridors, and beaches); Conservation (Chesapeake Bay Resource Protection Areas, including shorelines, wetlands, water bodies, and drainage ways); Municipal (for municipal services and schools); Residential (in addition to Neighborhood Preservation and PUD, this category includes Cluster Development for currently vacant or agricultural areas and Medium-Density Multi-Family Residential, covering only existing such developments, though new multi-family developments may be allowed in the Neighborhood Preservation district if they are built consistent with the existing character of the area).

B.6 King George County

King George County's most recent approved comprehensive plan was adopted in 2006 (King George County, 2006). At the time of this writing (June 2012), King George County is in the process of updating its comprehensive plan. Because the 2012 draft comprehensive plan is a working document still subject to review and potentially substantive modifications, this section references the 2006 plan only.

The plan's overall goals include the following:

- Preserve the rural characteristics of King George County.
- Encourage land use patterns that sustain and enhance the health, safety, morals, order, convenience, prosperity and general welfare of the residents of King George County.
- Promote a healthy, diversified economy in the county.
- Encourage protection of critical environmental resources and maintain renewable natural resources for future generations.
- Encourage a balance of residential zoning classifications to meet the needs of all county residents while concentrating and guiding growth in and around service districts as designated in the plan.

To guide development in accordance with the stated goals, the plan defines two types of planning areas, each appropriate for a certain type of development:

- Primary Settlement Areas: these are areas served by public water and sewer systems. They include Courthouse, Dahlgren, Fairview Beach, Hopyard, Oakland Park, Cleydael (the area south of the intersection of Route 218 and Route 301), and Route 3 West (area around the county's industrial park, landfill, and the Birchwood power facility). In those areas, development proposals are encouraged to be in the form of traditional compact development with connected neighborhoods and pedestrian-oriented local streets.

- Rural Development Areas: these comprise the parts of the county that are largely agricultural and forested with dispersed residential and rural business uses. These areas are planned to remain rural, with only very low-density residential uses permitted in addition to agriculture and forest activities.

Of the Primary Settlement Areas, two are within proximity of Dahlgren: Dahlgren, immediately adjacent to the installation; and Cleydael, to the southwest of Dahlgren. The Potomac River/North Rural Development Area includes the remaining county land around Dahlgren.

The Dahlgren Primary Settlement Area surrounds NSF Dahlgren to the north and west; to the southwest, it includes the commercial development around the intersection of Route 218 and Route 301; to the northwest, it includes the land along Route 614. Lot sizes in this area are some of the smallest in the county, as the Dahlgren community and other major subdivisions are being developed on approximately 15,000-square-foot lots. The area is one of two locations in the county recommended for the creation of a "Village District," to be developed around the compact development corridor existing along Route 206 and the adjacent neighborhoods. The goal of the village district is to create a more efficient use of land and infrastructure and to promote a sense of community through development on a human scale, with special attention to walking distances and civic spaces such as parks and public buildings. Key Policies and implementation strategies for the Dahlgren Primary Settlement Area include, among others:

- The area is one of the primary locations for future residential development and community facilities in the county, including the possibility for potential rezoning to denser residential and mixed-use zoning districts.

- The proposed residential density ranges from one dwelling unit per one to five acres in areas without public utilities to up to eight units per acre in areas with public utilities.

- Commercial development is recommended to follow the existing prevailing development pattern along Routes 301, 206 east of Route 301, and that portion of 614 adjacent to Route 206.

The Cleydael Primary Settlement Area contains over 900 acres of mixed-use zoning and is located between Routes 218, 301 and 206. The area contains three percent of the county's population and approximately 256 dwelling units. Lot sizes average two acres in size. In this area, the county encourages moderate density residential uses. Densities should be between one unit per two to ten acres on property adjacent to Route 206 and an average of one unit per acre on property served by public utilities on property adjacent to Route 301. Commercial and industrial uses should be limited to the property adjacent to Route 301.

The surrounding Potomac River/North Rural Development Area includes all of the land in King George County located north of Route 3, with the exception of the Primary Settlement Areas. A key land use feature within this district is the number of subdivisions in which each lot is ten acres or more in size that are served exclusively by private roads. The Area contains 49 percent of the county's population and approximately 3,861 housing units. However, it has remained rural in character with a historical pattern of low-density residential development. Redevelopment issues in this district will be primarily the reestablishment of the buffer area along the Potomac River, major portions of which have been replaced with shoreline stabilization structures. Key policies and implementation strategies include, among others:

- Encourage very low-density rural residential growth and discourage higher density residential and commercial development. Residential densities should be in range of one dwelling unit per two to ten or more acres, unless clustering development techniques are employed with large blocks of open space being preserved.
- Encourage agricultural and forest preservation.
- Implement and encourage large lot and/or sliding scale zoning in the areas currently zoned agricultural to promote the preservation of agricultural land.
- Ensure that new residential development occurs only at very low densities and preferably in a clustered pattern, with large blocks of agricultural and forestlands permanently preserved in conjunction with the clustered development.
- Enhance limited public access to the Potomac; allow limited, small scale, carefully designed and accessed public boat ramps along the river.
- Work through the local wetlands board to encourage the protection of the Potomac River shoreline.
- Using Virginia Marine Resource Guidelines, seek one additional site to provide public waterfront access to the Potomac River.
- Encourage through zoning and subdivision requirements the continued creation of community access to the waterfront in subdivisions developed along the Potomac River.

B.7 References

Charles County. 2006a. *Charles County Comprehensive Plan*. Charles County, Maryland.

Charles County. 2006b. *Charles County Land Preservation, Parks, and Recreation Plan*. Charles County, Maryland.

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APPENDIX C

NSWCDD NOISE MANAGEMENT PROCESS

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DEPARTMENT OF THE NAVY
NAVAL SURFACE WARFARE CENTER
DAHLGREN DIVISION
17320 DAHLGREN ROAD
DAHLGREN, VIRGINIA 22448-5100

IN REPLY REFER TO
NSWCDDINST 5100.6
CX8-WG/CX03-VB
MAR 18 2011

NSWCDD INSTRUCTION 5100.6

From: Commander, Dahlgren Division, Naval Surface Warfare Center

Subj: OUTDOOR NOISE MANAGEMENT PROCESS

Ref: (a) OPNAVINST 5090.1 (series), "Environmental Readiness Program Manual"
(b) NSWCDLINST 5091.1, "Hazardous Waste and Environmental Management System Programs"
(c) DODI 4715.13, DOD Noise Program
(d) NSWCDL Environmental Policy
(e) Outdoor Noise Management Process Manual

Encl: (1) Live Rounds Authorization Request

1. Purpose.

a. In accordance with references (a) through (e), this instruction is to establish a noise-based management process for those outdoor Naval Surface Warfare Center, Dahlgren Site (NSWCDL) operations that could potentially impact sensitive surface areas.

b. Establish a procedure that ensures Blind Load and Plug (BL&P) rounds are used instead of live rounds whenever possible. Live rounds will only be used when the appropriate justification, in accordance with enclosure (1).

2. Cancellation. None

3. Definitions.

a. Blind Load and Plug (BL&P) Rounds: Also commonly referred to as "inert," these rounds have a core composed of sand or concrete with no energetic material (no explosive core or propellant), although they may have a fuze (a detonating device) with a small amount of explosive material, a sensor, or other items for testing.

b. Live Rounds: Composed of energetic material plus an outer casing, fragmentation material, a fuze, sensors, timers, or other items for testing.

c. Noise: Sound resulting from outdoor NSWCDL Research, Development, Test and Evaluation (RDT&E) and ordnance treatment operations.

d. Operations: Actions conducted in accordance with applicable Standard Operating Procedures (SOPs).

e. Sensitive Surface Areas:

(1) Towns, communities, and populated areas external to Naval Support Facility (NSF) Dahlgren. Examples include Cobb Island, Colonial Beach, and Swan Point.

(2) Base Operating Support (BOS) areas serving the community within NSF Dahlgren. Examples include Morale, Welfare, and Recreation (MWR) facilities; housing; medical clinic; and the school.

(3) Do not include NSWCDL occupational functions performed at NSF Dahlgren. These functions are addressed by Occupational Safety and Health (OSH) regulations and NSWCDL guidance and requirements.

4. Applicability and Scope. This instruction applies to military and civilian personnel and Government contractors supporting NSWCDL outdoor RDT&E and ordnance treatment operations.

5. Policy. Through effective outdoor noise management, NSWCDL meets the requirements and policies of references (a) through (c), and demonstrates continued commitment to reference (d).

6. Responsibilities.

a. The Naval Surface Warfare Center, Dahlgren Division (NSWCDD) Commander shall ensure outdoor noise management policies and procedures are developed and implemented as required by reference (a).

b. The Safety and Environmental (S&E) Office shall ensure:

(1) NSWCDL Outdoor Noise Management Process development, implementation, and maintenance on behalf of the NSWCDD Commander.

(2) Training is provided for personnel as required by references (a) and (b).

c. Department and Division Heads shall ensure:

(1) Operations are conducted consistent with reference (e).

(2) Personnel receive required training and understand outdoor noise management responsibilities and procedures.

(3) Reference (e) remains applicable to operations, with any necessary changes reported to the Safety and Environmental (S&E) Office as they are identified.

(4) That all contractor personnel are advised as appropriate of the requirements of this instruction.

d. The Engagement Systems Department, Test and Evaluation Division Head shall ensure that enclosure (1) is submitted to the S&E Office prior to conducting tests that use live rounds.

e. The NSWCDL Range Safety Director shall ensure reference (e) content remains current and applicable to operations.

f. Supervisors (defined as a Branch Head equivalent or higher) shall:

(1) Integrate the direction provided by reference (e) into their operations.

(2) Be accountable for responsibilities found in references (a) and (b) and standard operating procedures (SOPs) pursuant to this instruction.

g. Personnel shall follow all applicable rules, regulations, and Standard Operating Procedures pursuant to this instruction.

7. Effective Date. This instruction is effective immediately.

M. H. SMITH

NAVSEA
WARFARE CENTERS
DAHLGREN

Phone: 540-653-8686
Fax: 540-653-7965

Live Rounds Authorization Request

Name:		**Program:**	
Code:		**SOP:**	
Phone:		**Round type:**	
Date requested:		**Quantity:**	
Date needed:			

Test description:

Justification for using Live (rather than Blind Load and Plug) Rounds:

☐ Approved - Engagement Systems Department, Test and Evaluation Division Head

Approved form must be submitted to the Safety and Environmental Office prior to testing.

Enclosure (1)

Naval Surface Warfare Center Dahlgren Site

Outdoor Noise Management Process Manual

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Record of Revisions

Release Number	Date	Section	Page	Summary / History of Changes
0	Aug 2010	All	All	Initial Release

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Acronyms and Abbreviations

BL&P	Blind Load and Plug
BOS	Base Operating Support
dBP	decibel(s) peak
DOT	Department of Transportation
EHW	Explosive Hazardous Waste
lbs	pounds
mm	millimeter
MOA	Memorandum of Agreement
MWR	Morale, Welfare, and Recreation
NEW	Net Explosive Weight
NSASP	Naval Support Activity South Potomac
NSWCDD	Dahlgren Division, Naval Surface Warfare Center
NSWCDL	Naval Surface Warfare Center Dahlgren Site
NSWCDLINST	NSWCDL Instruction
NSF	Naval Support Facility
OSH	Occupational Safety and Health
PAO	Public Affairs Office
PRTR	Potomac River Test Range
RDT&E	Research, Development, Test and Evaluation
SIPS	Sound Intensity Prediction System
SOP	Standard Operating Procedure

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Definitions

Blind Load and Plug (BL&P) Rounds: Also commonly referred to as "inert," these rounds have a core composed of sand or concrete with no energetic material (no explosive core or propellant), although they may have a fuze (a detonating device) with a small amount of explosive material, a sensor, or other items for testing.

Live Rounds: Composed of energetic material, plus an outer casing, fragmentation material, a fuze, sensors, timers, or other items for testing.

Noise: Sound resulting from outdoor Naval Surface Warfare Center Dahlgren Site (NSWCDL) Research, Development, Test and Evaluation (RDT&E) and ordnance treatment operations.

Operations: Gun firing(s), detonations, Railgun projectile launches or other RDT&E actions conducted in accordance with applicable Standard Operating Procedures (SOPs).

Rapid Fire: Gun firing of multiple rounds, one after the other, delivered in a continuous stream.

Sensitive Surface Areas:

- Towns, communities, and populated areas external to Naval Support Facility (NSF) Dahlgren. Examples include Cobb Island, Colonial Beach, and Swan Point.
- Base Operating Support (BOS) areas serving the community within NSF Dahlgren. Examples include Morale, Welfare, and Recreation (MWR) facilities, housing, the medical clinic, and schools.
- Does not include NSWCDL occupational functions performed at NSF Dahlgren. These functions are addressed by Occupational Safety and Health (OSH) regulations and NSWCDL guidance and requirements.

Test Engineer: Person responsible for planning and executing an operation.

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References

(a) Memorandum of Agreement (MOA) between Commanding Officer, Naval Support Activity South Potomac (NSASP) and Commander, Dahlgren Division, Naval Surface Warfare Center (NSWCDD), 20 JUN 08.

(b) NSWCDL Instruction (NSWCDLINST) 5726.1A, Community Inquiries or Complaints Related to Test Range Operations and Ordnance-Related Noise and Damage, 20 JUN 08.

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1.0 Background

Naval Surface Warfare Center Dahlgren Site's (NSWCDL's) mission is to provide Research, Development, Test and Evaluation (RDT&E), engineering, and fleet support for surface warfare, surface ship combat systems, ordnance, and strategic systems. NSWCDL also provides system integration and certification for weapons, combat systems, and warfare systems.

NSWCDL understands that noise is a significant aspect of mission-related operations. Since 1975, in an effort to reduce noise complaints from surrounding communities, NSWCDL has used the Sound Intensity Prediction System (SIPS) to predict noise impacts to sensitive surface areas prior to gunfire RDT&E and ordnance treatment operations. These noise predictions have helped NSWCDL decide whether to go forward with an operation or wait until conditions provide more favorable predicted noise levels at sensitive surface areas.

2.0 Noise Management

In addition to using SIPS, NSWCDL also takes the following actions to reduce noise impacts:

- Scheduling – Whenever possible, RDT&E and ordnance treatment operations are conducted during normal business hours. Operations are conducted year-round, Monday through Friday, normally from 8 am to 5 pm.
- Public relations – In accordance with references (a) and (b), the Naval Support Facility (NSF) Dahlgren Public Affairs Office (PAO) along with the NSWCDL PAO closely monitors and records any complaints involving noise and vibration.[1] NSWCDL maintains a website that provides: the Range Schedule; a toll-free Range/Weapons Testing hotline for daily information on range operations and test schedules; a toll-free number for noise comments and questions; and the local number for the NSWCDL PAO. In addition, the NSF Dahlgren PAO maintains a list of citizens that have requested notification when predicted noise levels will be greater than normal. For example, advanced notice is provided prior to firing live rounds and, in some cases, Blind Load and Plug (BL&P) rounds from the 76 millimeter (mm) rapid fire gun and 5" or larger guns.
- Noise Measurements – Various noise monitoring sites are located along the Potomac River Test Range (PRTR) (See Figure 1). Noise meters have been installed at these locations to: measure noise levels during operations, provide quantitative data for improving the SIPS prediction model, and determine whether noise levels at sensitive surface areas are acceptable to continue the operation. Handheld noise meters are used to supplement previously-installed noise meters.

[1] NSWCDL is a tenant upon NSF Dahlgren.

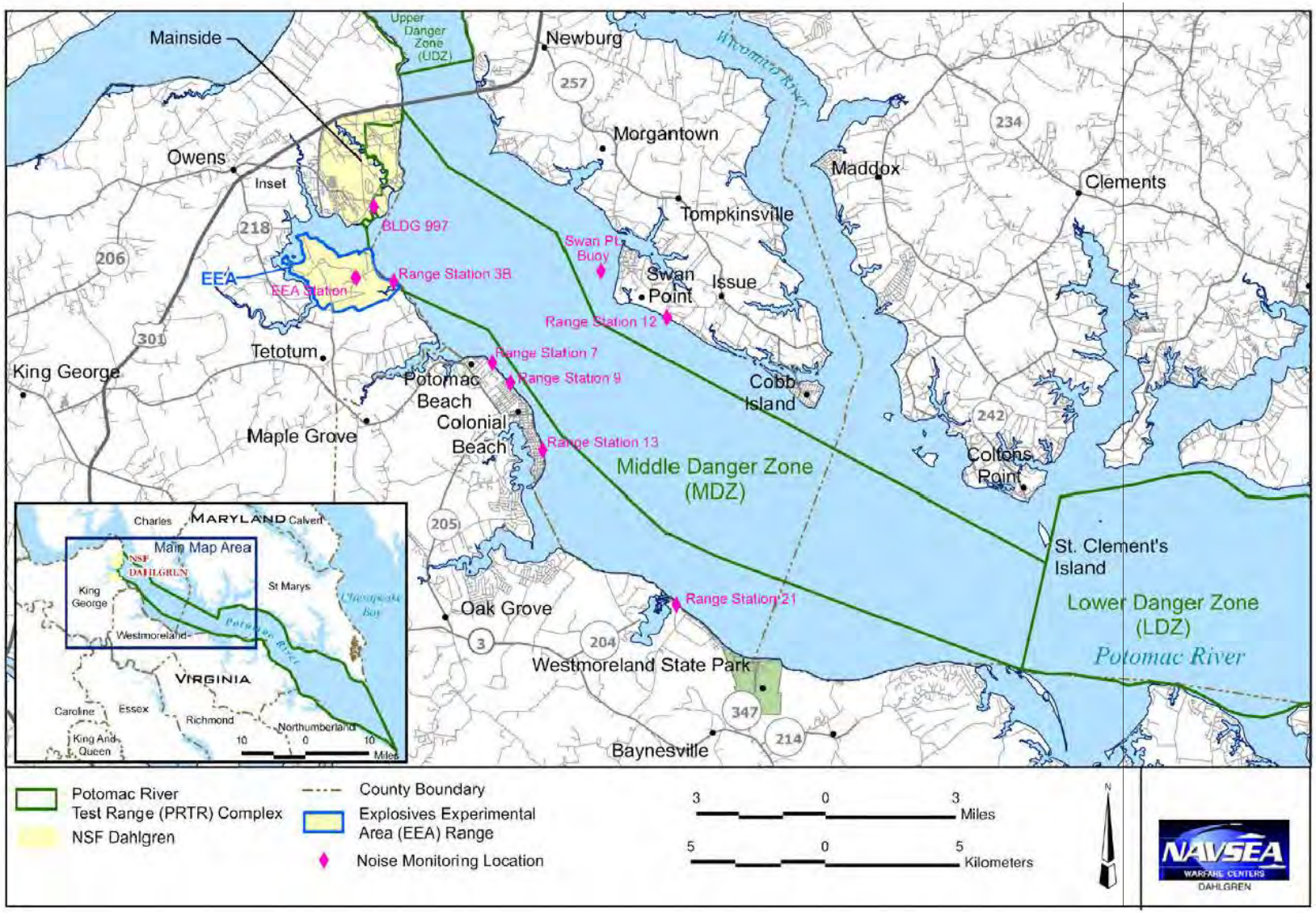


Figure 1 - Noise Monitoring[2]

[2] Figure 1 adapted from NSWCDL Draft Environmental Impact Statement, Figure 3.5-1 Peak Noise Measurement Locations.

3.0 Operation Decisions

RDT&E and ordnance treatment operations could cause significant noise impact to the surrounding sensitive surface areas. As a result, NSWCDL integrates noise consideration into these operations.[3] Deciding whether or not to proceed with an operation given the potential noise impact follows the process shown in Figures 2 through 6 and described below. If needed, modifications will be made to this Manual as described in section 4.0.

3.1 Operational Assessment

SIPS analysis is required when one or more of the following operations applies:

- Gunfire (other than Railgun operations):
  - Single shot (or single shots) from a 5-inch or larger gun
  - Live rounds with a caliber great than or equal to 57 mm
  - Rapid fire from a 76 mm or larger gun
- Open detonation:
  - Net Explosive Weight (NEW) of 30 pounds (lbs) or more.[4]
  - Fast and Slow Cook-Off tests are excluded from SIPS analysis.

Other noise-generating RDT&E will be evaluated on a case-by-case basis; for example, Railgun operations do not require SIPS analysis.

[3] Noise from open burning of Department of Transportation (DOT) class 1.3 or lower gun propellant is not addressed by this Noise Program Manual. This material does not detonate and instead burns with only negligible noise.

[4] If the NEW for an Explosive Hazardous Waste (EHW) treatment exceeds 200 lbs, the ordnance will be earth-covered prior to treatment. SIPS is not required.

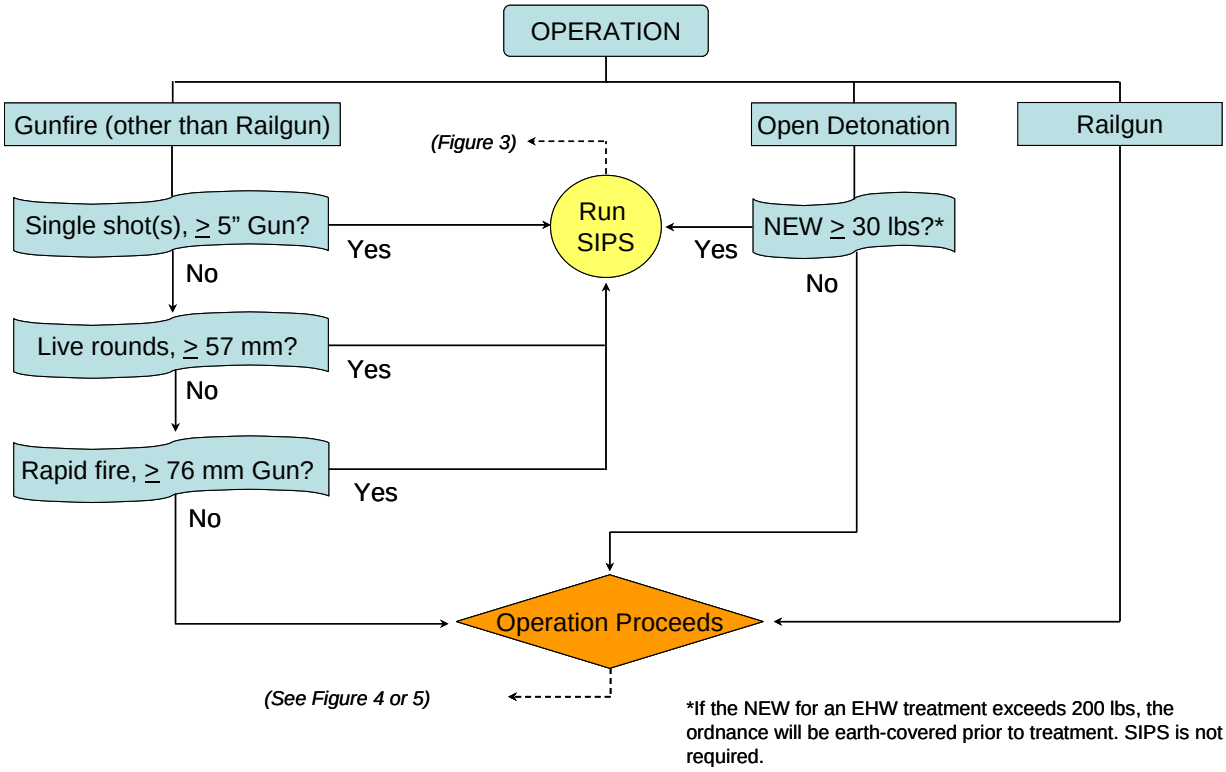


Figure 2 - Operational Assessment[5]

3.2 SIPS Decision

As shown in Figure 3, if SIPS analysis is required, the decision to proceed depends on the predicted sound intensity at sensitive surface areas:

- If the sound intensity is predicted to be less than 130 decibels peak (dBP), then the operation may proceed
- If the predicted sound intensity is greater than or equal to 130 dBP, then the operation is postponed.

[5] Noise-generating RDT&E operations not provided in Figure 2 will be evaluated on a case-by-case basis.

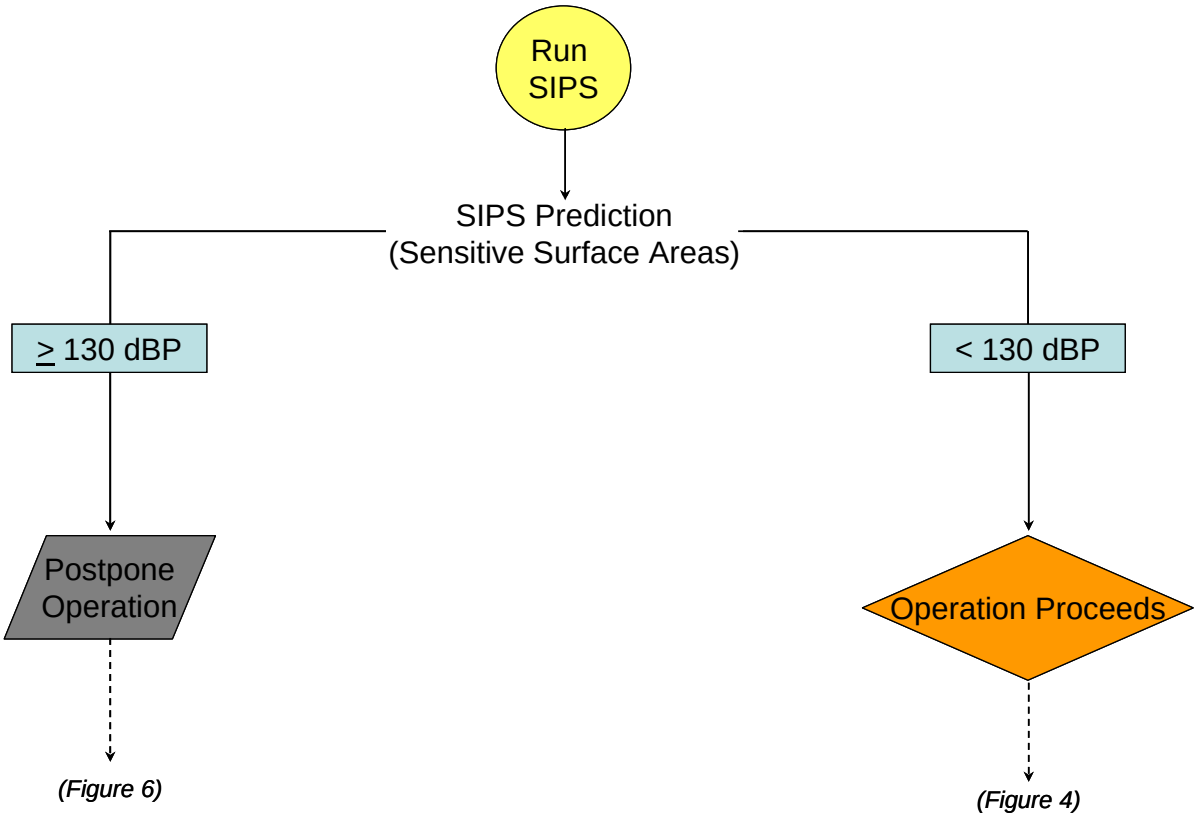


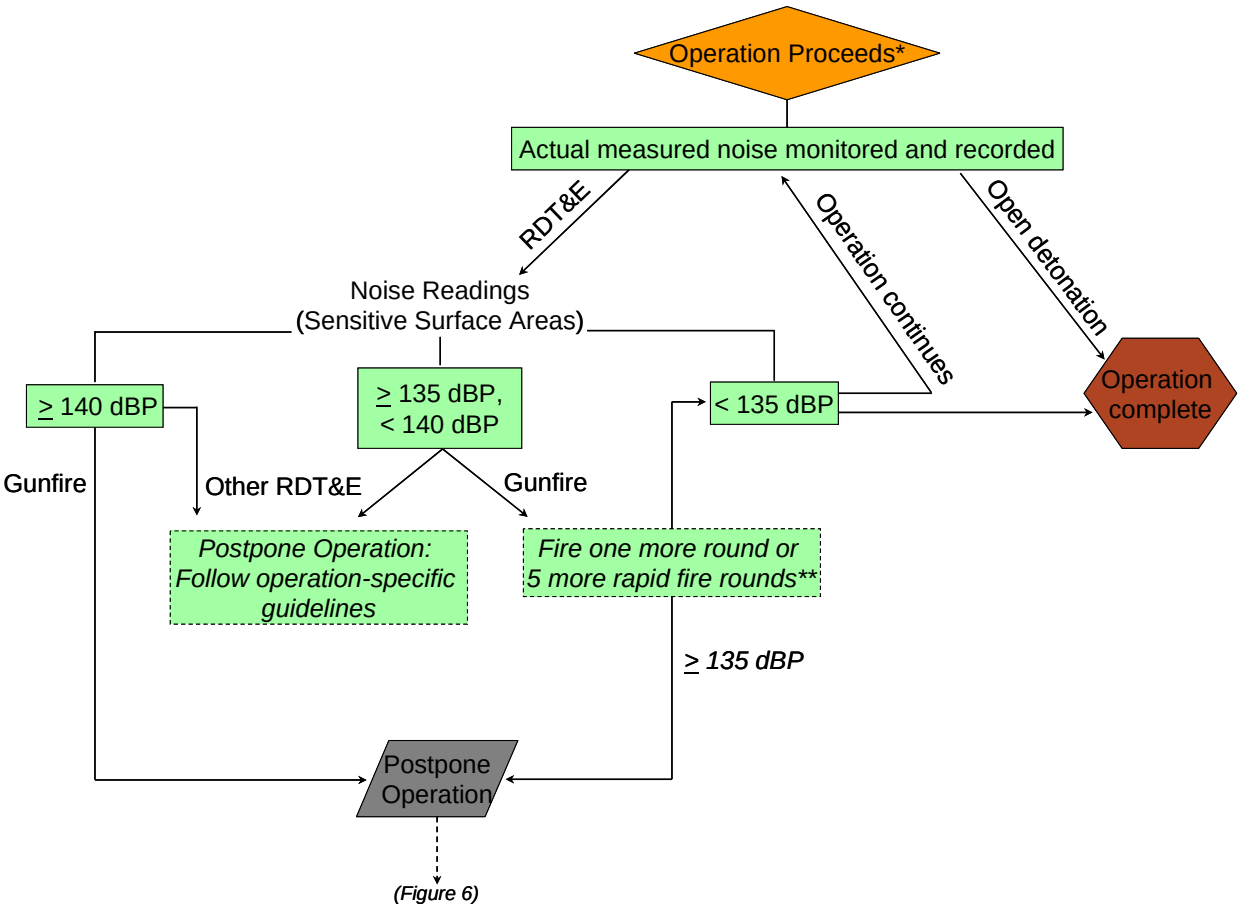
Figure 3 - SIPS Decision

3.3 Operation Proceeds

When proceeding with a noise-generating RDT&E or ordnance treatment operation, actual measured noise levels will be monitored and recorded throughout the operation.

- For safety reasons, open detonations will proceed to completion.
- Gunfire operations (other than Railgun) are dependent on actual noise meter data collected at range stations near sensitive surface areas for each shot or 5 rapid fire rounds.
    - If the actual measured noise level is less than 135 dBP, then the operation will proceed as shown in Figure 4.
    - If the actual measured noise level is greater than or equal to 135 dBP and less than 140 dBP, the gun will fire one more round or 5 more rapid fire rounds.[6] Upon firing the additional round or rounds:
        - If the resulting actual measured noise level is greater than or equal to 135 dBP, see figure 6.
        - If the resulting actual measured noise level is less than 135 dBP, see Figure 4.
    - If the actual measured noise level meets or exceeds 140 dBP, see figure 6.
- Railgun RDT&E operations will continue if the actual measured noise level at the Montana shelter is less than or equal to 140 dBP and the actual measured noise level at the Swan Point buoy is less than or equal to 135 dBP, as shown in Figure 5. Otherwise:
    - If the measured noise level at the Swan Point buoy exceeds 135 dBP, operations will be postponed for the remainder of the day.
    - If the measured noise level at the Montana shelter exceeds 140 dBP, but the level at the Swan Point buoy does not exceed 135 dBP, a waiver may be granted, allowing the operation to continue.
- Other noise-generating RDT&E operations will continue if the actual measured noise level remains below 135 dBP. Otherwise, these operations will be postponed as shown in Figure 4.

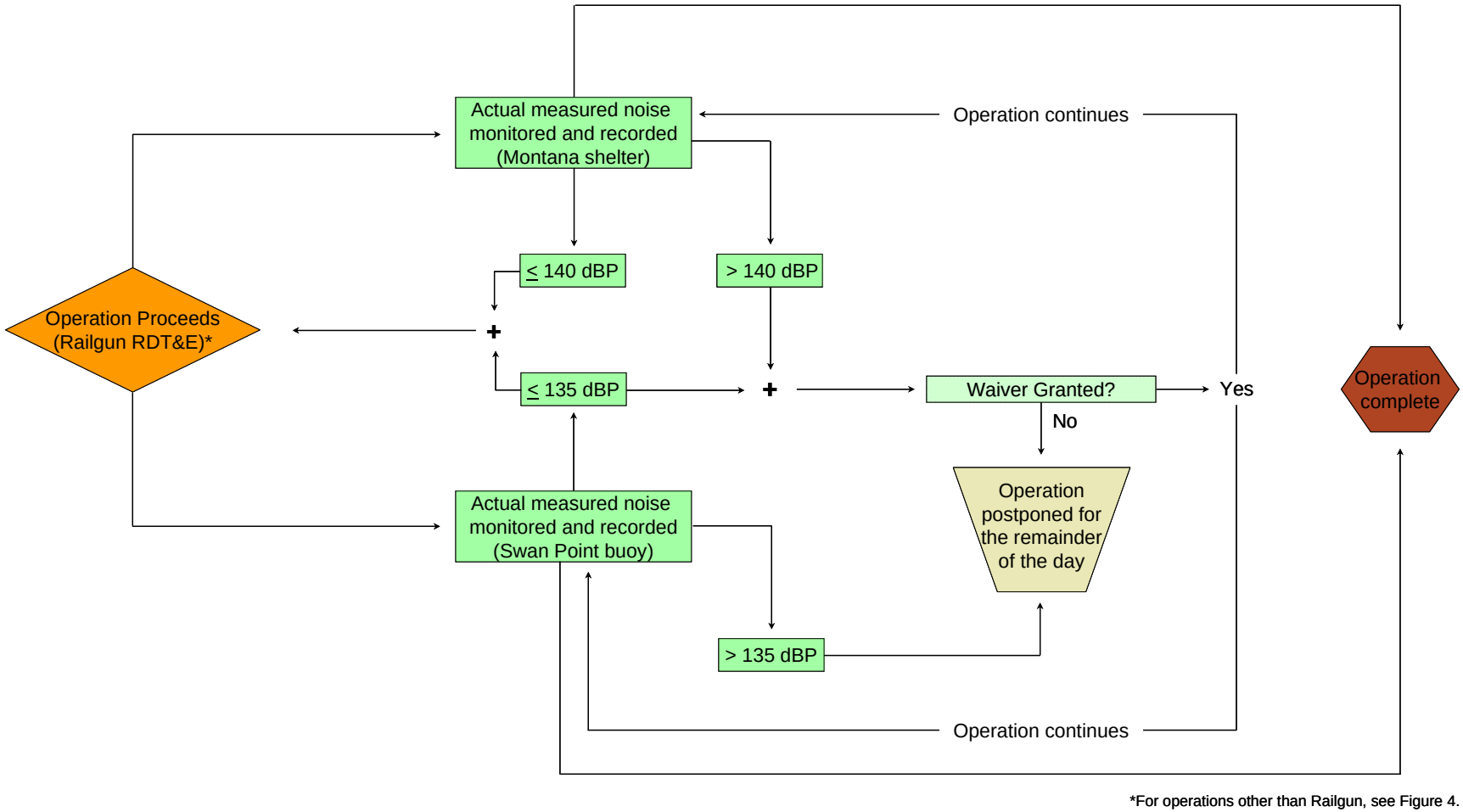
[6] If necessary (the operation may be complete at this point).



*Does not include Railgun operations (for Railgun operations, see Figure 5).

**Only necessary if operation has not been completed.

Figure 4 - Operation Proceeds



*For operations other than Railgun, see Figure 4.

Figure 5 - Railgun Operations

3.4 Operation Postponed

3.4.1 Railgun

For Railgun operations, if the actual measured noise level exceeds 140 dB at the Montana shelter but does not exceed 135 dBP at the Swan Point buoy, a waiver may be granted to continue operations. However, operations will be postponed for the remainder of the day (no waiver granted) once the measured noise at the Swan Point buoy exceeds 135 dBP (see Figure 5).

3.4.2 Gunfire and Open Detonation

As shown in Figure 6, when a gunfire operation (other than Railgun) or an open detonation operation is postponed, additional SIPS analysis may be conducted until more favorable conditions are available.[7] Otherwise, the supervising Division Head is notified. The Division Head will either concur with the decision to postpone or will grant a waiver, allowing the operation to continue. Waivers may be granted when an operation is critical; however, they cannot be applied if SIPS predictions or actual measured noise at sensitive surface areas meet or exceed 140 dBP.

In the event of a waiver, the following actions are taken:

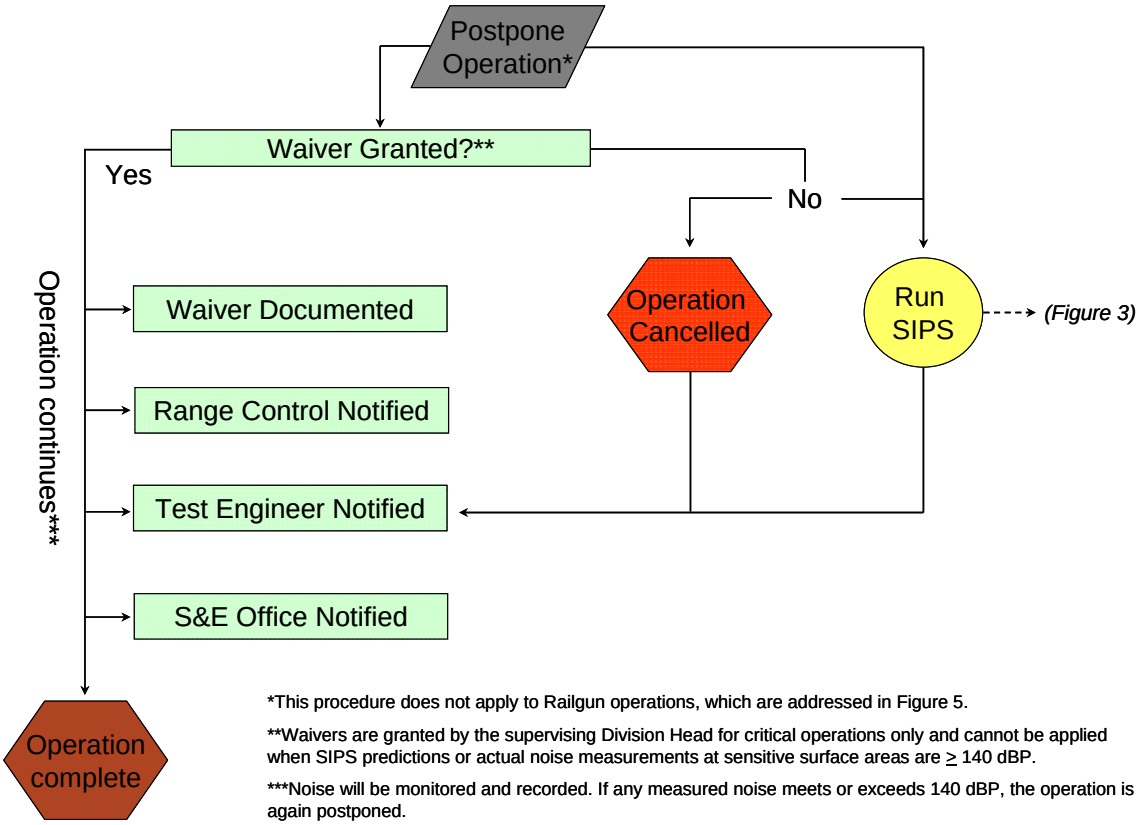
- The waiver is documented. The Division Head either drafts and signs the waiver or provides the waiver by email to:
    - Range Control
    - The Test Engineer
    - The Safety & Environmental Office
- The operation proceeds to completion—actual measured noise levels for each shot are monitored and recorded. If any measured noise meets or exceeds 140 dBP, the operation is again postponed and the procedure shown in Figure 6 starts over.

If a waiver is not granted, the operation will either be cancelled or delayed and the Test Engineer so notified. Unless cancelled, the operation will be delayed until more favorable conditions are available, as verified by running SIPS again and following the guidelines previously described.

3.4.3 Other Noise-Generating RDT&E

Postponement procedures specific to other noise-generating RDT&E operations will be determined on a case-by-case basis, as shown in Figure 4. If necessary, this manual will be updated as described in section 4.0.

[7] SIPS analysis is applicable as described in sections 3.1 and 3.2.



*This procedure does not apply to Railgun operations, which are addressed in Figure 5.

**Waivers are granted by the supervising Division Head for critical operations only and cannot be applied when SIPS predictions or actual noise measurements at sensitive surface areas are ≥ 140 dBP.

***Noise will be monitored and recorded. If any measured noise meets or exceeds 140 dBP, the operation is again postponed.

Figure 6 - Operation Postponed

4.0 Outdoor Noise Management Process Manual Changes

Due to the dynamic nature of RDT&E and ordnance treatment, periodic changes to this manual may be needed. If noise impacts fail to be addressed sufficiently (as identified by increased noise complaints or program-specific needs), the NSWCDL Safety & Environmental Office, affected Division Heads, and, where applicable, Range Safety will work together to revise the manual and implement appropriate changes.

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APPENDIX D

NOISE AND VIBRATION MEASUREMENTS AT SIX HISTORIC STRUCTURES

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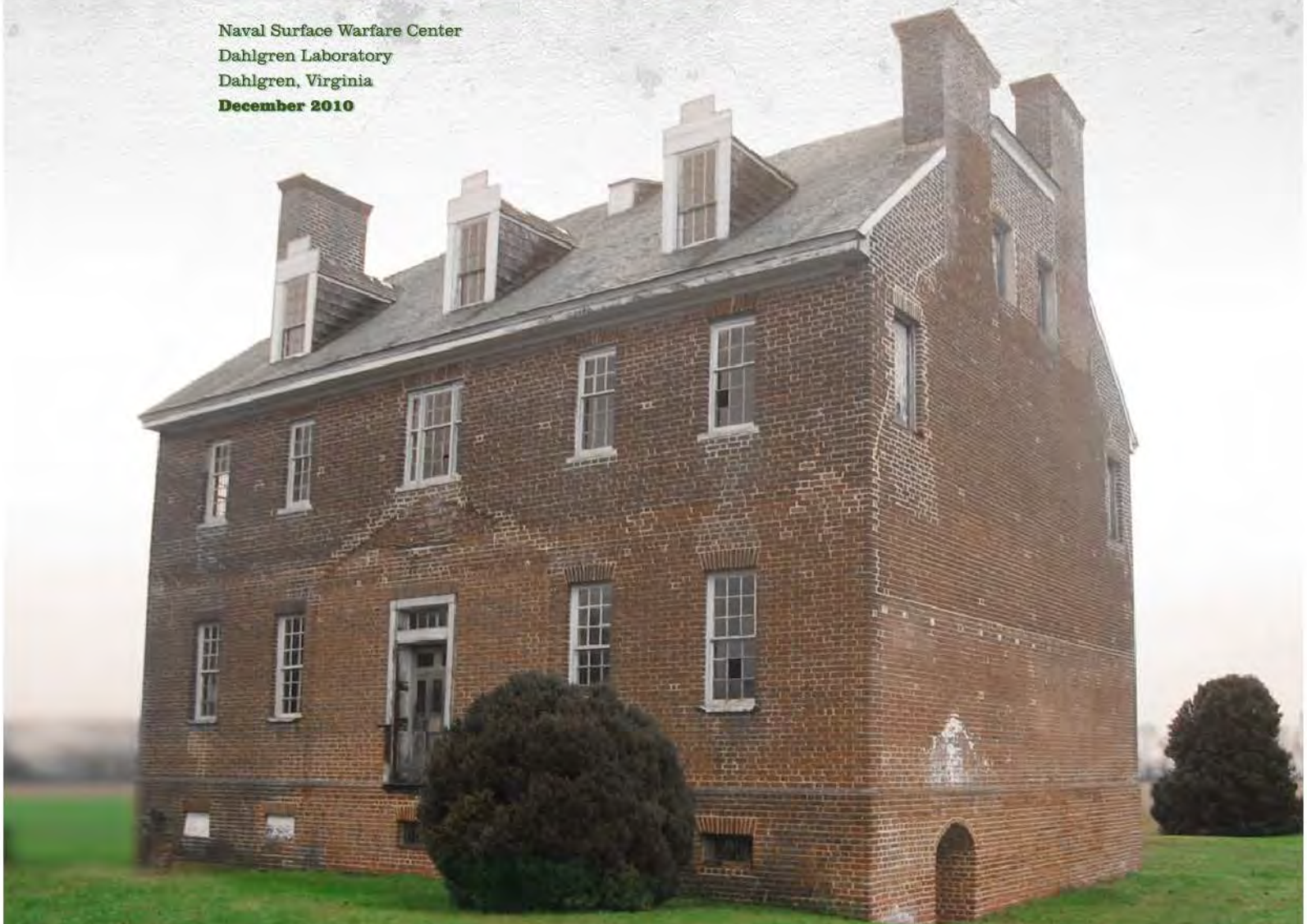
Noise & Vibration Measurements

at Six Historic Structures

Naval Surface Warfare Center
Dahlgren Laboratory
Dahlgren, Virginia
December 2010



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Noise and Vibration Measurements At Six Historic Structures

Naval Surface Warfare Center
Dahlgren Laboratory

Dahlgren, Virginia

December 2010

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ACRONYMS AND ABBREVIATIONS

APE	Area of potential effect
ARL	Air Resources Laboratory
dB	decibel(s)
dBP	peak decibel(s)
DoD	Department of Defense
EIS	environmental impact statement
in/sec	inches per second
lb(s)	pound(s)
mph	miles per hour
NDE	Non-destructive evaluation
NOAA	National Oceanic and Atmospheric Administration
NSF	Naval Support Facility
NSWCDL	Naval Surface Warfare Center, Dahlgren Laboratory
PPV	peak particle velocity
PRTR	Potomac River Test Range
SHPO	State Historic Preservation Officer
US	United States
yd	yard

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1 INTRODUCTION

Naval Surface Warfare Center, Dahlgren Laboratory (NSWCDL) conducted a noise and vibration measurement program on November 16 and 17, 2009 at six historic structures located near the Navy's Potomac River Test Range (PRTR). Section 106 of the National Historic Preservation Act requires federal agencies to take into account the effects of their undertakings on historic properties. The purpose of the measurement program was to determine noise and vibration effects on historic structures from firing a large-caliber gun with high-explosive projectiles.

NSWCDL is located on Naval Support Facility (NSF) Dahlgren in Dahlgren, Virginia. The PRTR extends along the lower 53 miles of the Potomac River (Figure 1). The historic structures were located at various distances from the gun firing point (Figure 2).

The noise and vibration measurement program took place during already-scheduled tests. Noise measurements were taken during this particular group of tests because NSWCDL was firing the largest gun routinely fired on the PRTR – the 5"/62 caliber gun – with projectiles that contained the largest amount of detonation explosives typically used – approximately 9 pounds (lbs) net explosive weight. Noise and vibration levels resulting from both the explosive charge used to propel the projectiles as a gun is fired and the explosive detonation at the target impact area on the river were expected to be the greatest experienced in 2009. There were no foreseeable tests with more projectile net explosive weight. Further, these tests used an unusually large number of target impact areas –five – at distances varying from 5,300 yards (yd) to a maximum range of 25,700 yd down the Potomac River (Figure 2), which allowed measurement of projectile detonation noise from different target areas.

Because measurements were taken during the testing of one of NSWCDL's largest guns using explosive projectiles firing at five different target areas along the river, these tests provide a rigorous basis for noise and vibration analysis at various sensitive locations along the PRTR.

2 TEST PROGRAM

The noise and vibration measurement program was carried out on the first two days of a week-long series of gun ballistics tests, the purpose of which was to test explosive replacement types for United States (US) Navy ships. Explosive projectiles were fired down the PRTR from a 5"/62 caliber gun (Figure 3) located at the AA Fuze Range on NSF Dahlgren. Accurate projectile initial velocity data, time of flight, projectile trajectory, and projectile impact coordinates were collected as part of the tests. Table 1 lists the firing angle and target distance from gun of the projectiles fired into each of the five range target areas.

Noise and vibration levels were measured at the six selected historic structures on Monday, November 16 and Tuesday, November 17, as described in Section 4.

Location of Naval Support Facility (NSF) Dahlgren

County Seat

Naval Support Facility (NSF) Dahlgren

Potomac River Test Range (PRTR)

25 0 25 Miles

40 0 40 Kilometers

N

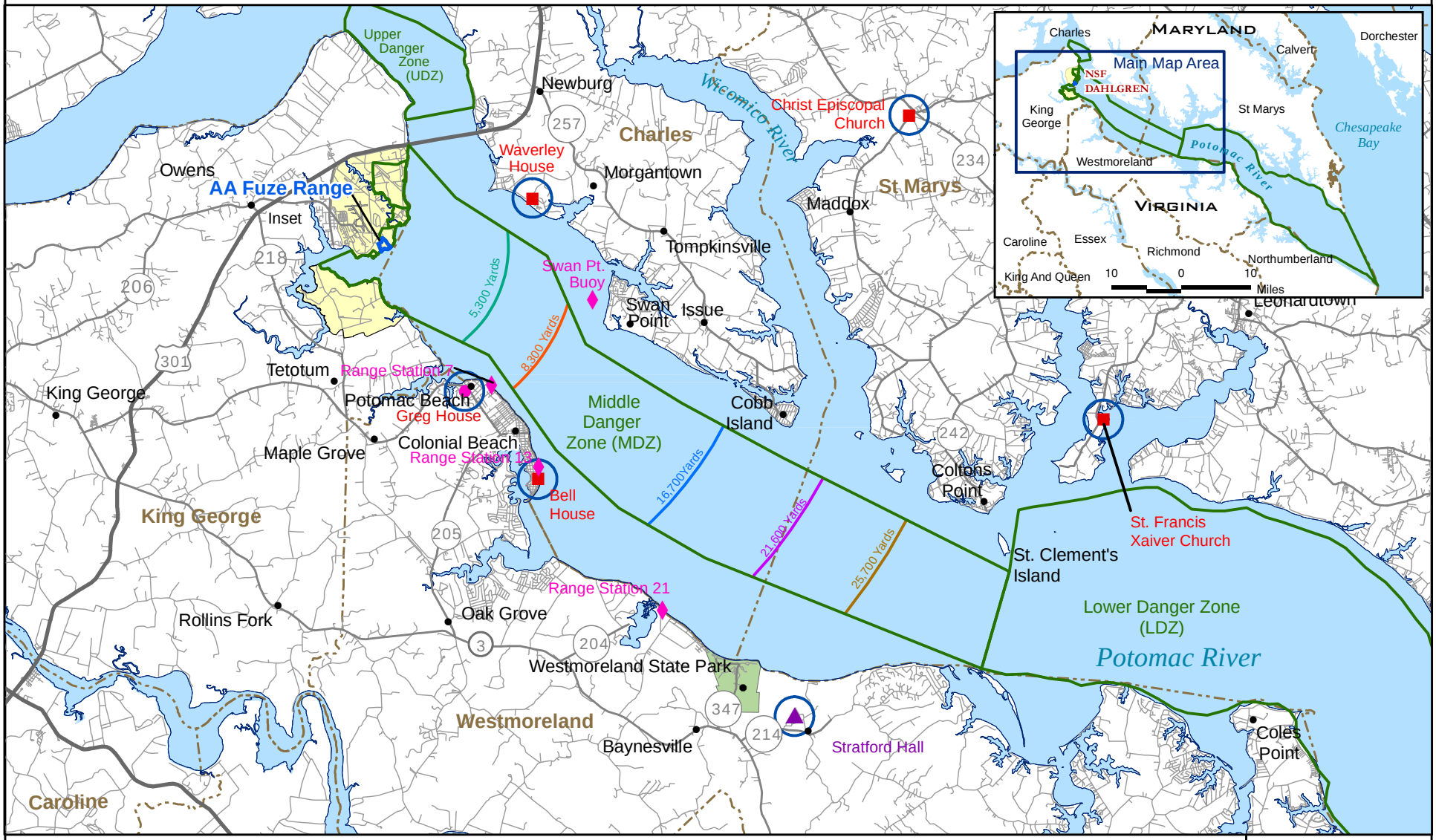
NSWCDL EIS

NAVSEA WARFARE CENTERS DAHLGREN

Source: NSWCDL GIS (2008 - 2011); Danger Zones defined in 33 CFR § 334.230.

Figure 1

Selected Historic Structures, Measurement Sites, and Target Areas



Target Areas

- 5,300 Yards
- 8,300 Yards
- 16,700 Yards
- 21,600 Yards
- 25,700 Yards

- Vibration and Noise Monitoring Site
- Selected National Historic Landmark/ National Register Listed
- Selected National Register Listed
- Selected National Register Eligible

- Potomac River Test Range (PRTR) Complex
- NSF Dahlgren
- County Boundary
- Noise Monitoring Location

Source: BNOISE2 Model & NSWCDL SIPS Model

3 0 3 Miles

5 0 5 Kilometers

N

NSWCDL

NAVSEA WARFARE CENTERS DAHLGREN

Figure 2

Table 1
Ballistic Predictions

Firing Angle (Degree)	Estimated Range Target (Yards)
2.5	5,300
4.5	8,300
15	16,700
26	21,600
43	25,700

Figure 3
5”/62 Caliber Gun Used for Testing

3 VIBRATION AND NOISE FUNDAMENTALS

The low-frequency impulse sound pressure generated by the detonation of explosive charges or large-caliber gun firing can cause structures to vibrate. Vibration is an oscillatory motion (back and forth), which can be described in terms of displacement, velocity, or acceleration. For a vibrating wall, displacement is simply the distance that a point on the wall moves away from its static position. Velocity represents the instantaneous speed of the wall movement, and acceleration is the rate of change of the speed. Because of the nature of oscillatory motion, a structure can only physically vibrate in a low-frequency range – typically below 80 hertz. Consequently, only the low-frequency component of sound pressure can cause a structure to vibrate.

The occupants of a vibrating structure often perceive vibration as the rattling of loose windows and objects on shelves, and sometimes of the structure itself. Since structural vibration is caused by low-frequency sound pressure, the evaluation of structural vibration effects caused by gun firing and projectile detonation focuses on low frequency sound pressure levels, in contrast to high frequency levels that would be heard more easily by people.

Several different methods can be used to quantify the amplitude or extent of vibrations. The method selected for this noise and vibration measurement program uses peak particle velocity (PPV), in inches per second (in/sec), to measure the maximum instantaneous positive or negative peak of the vibration signal. PPV is often used in the measurement of blasting vibration because it bears a relationship to the stresses that are experienced by structures.

There are two types of vibration, as described in the following sections:

- Vibration transmitted through the ground (ground-borne vibration).
- Vibration transmitted through the air (airborne vibration).

3.1 Ground-borne Vibration

The shaking of houses and other structures is commonly attributed to ground-borne vibration. Ground-borne vibration originates from an event – such as an earthquake or a detonation – that radiates vibration energy through the ground. When the energy reaches a structure, the face of the nearest foundation or underground structural wall responds to the ground-borne vibration and spreads waves of energy throughout the structure. The amount of structural vibration from ground-borne vibration is a function of the:

- Magnitude of the energy source.
- Distance from the source.
- Response characteristics of the transmitting media (rock and soil).
- Response characteristics of the structure itself – different kinds of construction materials react differently to vibration as can be observed after earthquakes when structures built of concrete have collapsed while structures with more flexible metal structures have survived.

Ground-borne vibration dominates structural vibration close to the source while airborne vibration dominates at greater distances (Siskind et al., 1989).

For example, The US Bureau of Mines found that for a 100-lb detonation, ground-borne vibration was the dominant cause of building vibration if the building was located less than 500 feet from the detonation point. At distances greater than 500 feet, airborne sound wave was the dominant cause of the vibration (Siskind et al., 1989).

The US Bureau of Mines recommends in its report entitled *Structure Response and Damage Produced by Ground Vibration from Surface Mine Blasting* (Siskind et al., 1989) that:

- A PPV of 0.5 in/sec is the maximum ground-borne vibration threshold to prevent damage.
- A PPV of 2.0 in/sec is the threshold level for ground-borne vibration at which minor structural damage may begin to occur in 0.01 percent of structures (or 1 structure in 10,000).

3.2 Airborne Vibration

Airborne sound volume is measured in decibels (dB). Decibels are measured on a logarithmic scale that reflects how human hearing works. In simple terms, each increase of 10 dB is perceived as being twice as loud; therefore, a vacuum cleaner at 70 dB would seem twice as loud as normal conversation at 60 dB. A nightclub at 110 dB would seem 32 times as loud as normal conversation.

Airborne vibration can cause structural shaking and window rattling, which can concern and annoy occupants. More powerful airborne vibrations can break glass panes and crack plaster. Very powerful airborne vibrations can damage a building's superstructure. A US Bureau of Mines study, *Structure Response and Damage Produced by Airblast from Surface Mining* (Siskind et al., 1980), correlated airborne vibration levels from the use of explosives with the peak sound pressure levels likely to cause potential structural damage. As described in Table 2, homeowners became concerned about structural damage at peak sound levels measured in peak decibels (dBP) of 120 dBP, which is far below levels actually capable of causing such damage. The NSWCDL Noise Management program works to manage peak airborne noise levels at sensitive surface areas from gun firing and projectile detonations on the PRTR. Before a 5" gun is fired, a model is used to predict peak noise levels at sensitive surface areas based on weather conditions. If the model-predicted noise level is less than 130 dBP at sensitive surface areas, then the firing proceeds. When and if the noise level measured at the range stations is greater than or equal to 135 dBP for two consecutive firings, then further testing is postponed.

The correlations listed in Table 2 provide a general picture of the relationship between vibration levels and peak sound level. The actual correlation is dependent on the specific structure type and condition. The worst case – a structure likely to sustain damage from vibration – is one with poorly-fitted, loose window glass and walls already cracked or stressed by structural settling and/or deterioration, for example as the result of age, prior leaks, or storm damage.

Table 2
Typical Response to Airborne Vibration Levels

Response	Vibration Level in inches per second (in/sec)	Peak Decibels (dBP)
Concern by homeowner about structural rattling and possible damage	0.1	120
Glass and plaster cracks (worst case*)	0.5	134
Gypsum wallboard (worst case*)	0.75**	141**
Structural damage to lightweight superstructure	>2.0**	175**

* Worst case = Poorly fitted, loose window glass and/or, walls already under stress through structural settling, deterioration, age, or earlier damage.

Source: Siskind et al., 1980.

** NSWCDL's noise management program aims to manage peak noise levels in order to keep them below 135 dBP.

4 SELECTION OF HISTORIC STRUCTURES FOR VIBRATION AND NOISE MEASUREMENTS

The process of selecting historic structures for measuring ground-borne and airborne noise and vibration during the November 2009 test program was as follows:

1. Historic structures within an Area of Potential Effect (APE) were candidates for vibration and noise measurement. As part of the environmental impact statement (EIS) and accompanying Section 106 process that NSWCDL is conducting for future outdoor research, development, test and evaluation activities outdoors, an APE for historic structures was defined based on noise modeling that predicts the extreme worst case condition for gun noise. This APE was agreed upon by the Maryland and Virginia State Historic Preservation Officers (SHPOs). The APE and predicted peak noise levels are illustrated on Figure 4. Historic structures close to either the gun firing or target impact detonation areas were selected (Figure 2) to maximize the potential vibration and noise impact. Three structures were selected along the Maryland shore and three along the Virginia shore to ensure representative coverage of the affected areas.

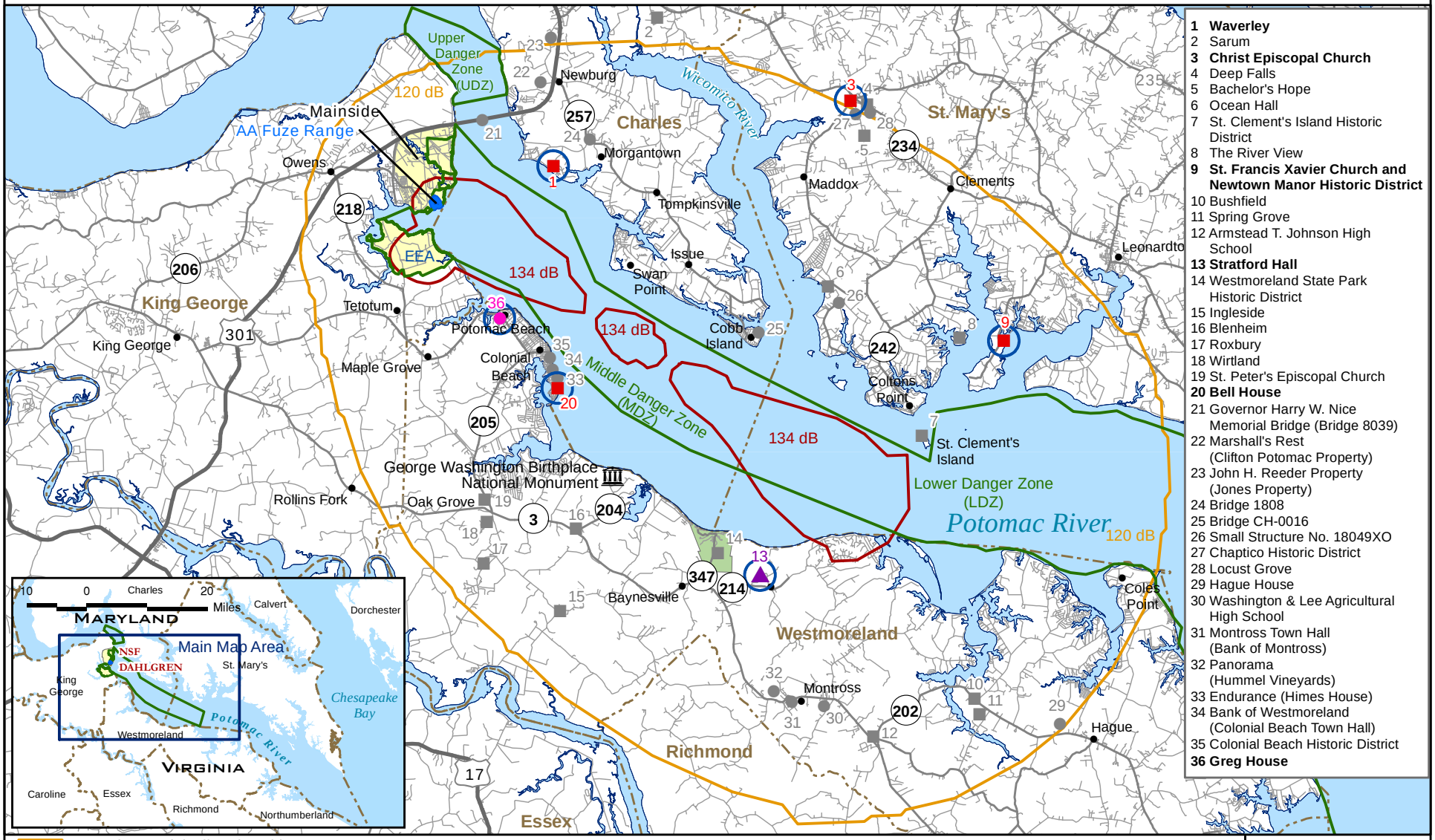
2. Only historic structures of national significance were candidates for vibration and noise measurement. Five of the six historic structures selected are listed on the National Register of Historic Places, and one structure is eligible for listing on the National Register.

3. Christ Episcopal Church in Chaptico, Maryland, which is listed on the National Register, was selected for noise and vibration measurement based on a request from members. The members expressed concerns that NSWCDL's large-caliber gun firings could be the source of cracks developing in the front of their historic church.

4. The six historical structures were selected to represent a range of construction types and ages in order to assess whether vibration and noise impacts vary with these factors. The historic structures selected date from the 17th-18th Century to the early 20th Century; building types varied from brick to wood siding.

Table 3 describes the selected structures, their National Register status, and their location relative to the Potomac River/PRTR. Figure 4 illustrates the APE, predicted peak noise levels (which formed the basis for the APE delineation), the location of the historic structures selected for measurement, and the location of other historic structures within the APE. Photographs of the historic structures are provided in Figures 5 through 10.

Area of Potential Effect, Predicted Peak Noise Levels, and Selected Historic Structures



1 **Waverley**
2 Sarum
3 **Christ Episcopal Church**
4 Deep Falls
5 Bachelor's Hope
6 Ocean Hall
7 St. Clement's Island Historic District
8 The River View
9 **St. Francis Xavier Church and Newtown Manor Historic District**
10 Bushfield
11 Spring Grove
12 Armstead T. Johnson High School
13 Stratford Hall
14 Westmoreland State Park Historic District
15 Ingleside
16 Blenheim
17 Roxbury
18 Wirtland
19 St. Peter's Episcopal Church
20 Bell House
21 Governor Harry W. Nice Memorial Bridge (Bridge 8039)
22 Marshall's Rest (Clifton Potomac Property)
23 John H. Reeder Property (Jones Property)
24 Bridge 1808
25 Bridge CH-0016
26 Small Structure No. 18049XO
27 Chaptico Historic District
28 Locust Grove
29 Hague House
30 Washington & Lee Agricultural High School
31 Montross Town Hall (Bank of Montross)
32 Panorama (Hummel Vineyards)
33 Endurance (Himes House)
34 Bank of Westmoreland (Colonial Beach Town Hall)
35 Colonial Beach Historic District
36 Greg House

Area of Potential Effect (APE)/ 120 Decibel Peak Noise Contour
134 Decibel Peak Noise Contour
Selected National Historic Landmark/ National Register Listed
Selected National Register Listed
Selected National Register Eligible
Vibration and Noise Monitoring Location
Unselected
Unselected
Unselected
County Boundary
Potomac River Test Range (PRTR) Complex
AA Fuze Range
NSF Dahlgren

Source: BNOISE2 Model & NSWCDL SIPS Model

3 0 3 Miles
6 0 6 Kilometers

N

NSWCDL
NAVSEA WARFARE CENTERS DAHLGREN

Figure 4

Table 3
Historic Structures Selected for Noise & Vibration Measurement

Number on Figure 3	Structure Name	Location	Status	Justification
1	Waverley House	Waverly Point Road Newburg Charles County, MD	National Register-listed, 1987	Example of an architecturally significant 18th-century brick residence. Structure is located along the Potomac River close to Dahlgren.
3	Christ Episcopal Church	Church: 25390 Maddox Road Chaptico St. Mary's County, MD	National Register-listed, 1994	Example of an architecturally significant 18th-century brick church. Complaints received from church occupants.
9	Newtown Manor House (St. Francis Xavier Church & Newtown Manor Historic District)	Newtown Neck Road (Maryland State Route 243) Leonardtown St. Mary's County, MD	National Register-listed, 1972	Two-story, rectangular-plan brick house capped by side-gable roof with paired chimneys at each gable end. Circa 17th-century, early 18th-century. Structure is located along the Potomac River.
13	Stratford Hall	Great House Road Stratford Westmoreland County, VA	National Historic Landmark/ National Register-listed, 1966	Excellent example of an 18th-century, Georgian-style, brick plantation house. Stratford Hall is one of Virginia's most significant historic architectural resources. Structure is located near the Potomac River; plantation house is set back from the river and screened by mature trees.
20	Bell House	821 Irving Avenue Colonial Beach Westmoreland County, VA	National Register-listed, 1987	Example of an architecturally significant, 19th-century, Stick-style frame house. Structure is located along the Potomac River.
36	Greg House	1763 McKinney Boulevard, Colonial Beach Westmoreland County, VA	National Register-eligible, 2008	Example of an architecturally significant 1920s-era frame bungalow. Structure is located along the Potomac River close to Dahlgren.

Figure 5
Waverley House (#1)

Figure 6
Christ Episcopal Church (#3)

Figure 7
Newtown Manor House at St. Francis Xavier Church (#9)

Figure 8
Stratford Hall (#13)

Figure 9
Bell House (#20)

Figure 10
Greg House (#36)

5 VIBRATION AND NOISE MEASUREMENTS

To measure the noise and vibration effects of the tests on the six historic structures, noise specialists affixed sensors to the structures and grounds. Noise and vibration levels were recorded each time the 5”/62 gun was fired and also when the projectile detonated in the target area within the PRTR.

Vibration measurements were collected from a sensor placed on a wall on each structure. These measurements assessed the potential impact caused by airborne sound pressure from both the gun firing and the projectile detonation impact areas. Peak airborne sound pressure levels were measured immediately adjacent to the structures. In addition to vibration measurements on structure walls, ground-borne vibration levels in soil and on structure foundations were measured at Waverley House, Stratford Hall, and Bell House. These three structures were selected for ground and foundation instrumentation because of their location in relation to the Potomac River and their structure type. These three structures were expected to experience the greatest vibration from the tests.

As described previously, structural vibration is caused by lower frequency sound pressure levels, hence seismic accelerometers sensitive to low frequency signals were used to measure vibration. To measure airborne vibration effects on walls, a low frequency seismic accelerometer was attached perpendicularly to a wall at each of the six monitored structures. Table 4 lists the types of measurements taken at each of the six structures. Figures 11 and 12 show the sample equipment set up at Waverley House and Stratford Hall, respectively.

Table 4
Types of Vibration and Noise Measurements at Each Structure

Number on Figure 4	Structure Name	Type of Measurement
1	Waverley House	Ground-borne soil vibration and peak sound level. Foundation and exterior wall vibration.
3	Christ Episcopal Church	Peak sound level. Interior wall vibration.
9	Newtown Manor House	Peak sound level. Exterior wall vibration.
13	Stratford Hall	Ground-borne soil vibration and peak sound level. Foundation and exterior wall vibration
20	Bell House	Ground-borne soil vibration and peak sound level. Foundation and front exterior wall vibration. Peak sound level. Side exterior wall vibration.
36	Greg House	Peak sound level. Exterior wall vibration.

Figure 11
Waverley House Measurement Setup

Figure 12
Stratford Hall Setup

6 MEASUREMENT PROGRAM RESULTS

The results of the measurement program at each of the six historic structures are summarized in the following tables:

- Table 5, Peak Airborne Noise Levels. Minimum, mean, and maximum peak noise levels expressed in peak decibels (dBP) are presented along with the number of measurements or events in three noise categories (< 115 dBP, 115 dBP – 130 dBP, > 130 dBP).
- Table 6, Wall Vibration Levels. Minimum, mean, and maximum wall vibrations in inches per second (in/sec) are presented along with the number of measurements in three vibration categories (<0.1 in/sec, 0.1 – 0.5 in/sec, > 0.5 in/sec).
- Table 7, Ground and/or Foundation Vibration Levels. Minimum, mean, and maximum wall vibrations in in/sec are presented along with the number of measurements in three vibration categories (<0.1 in/sec, 0.1 – 0.5 in/sec, > 0.5 in/sec).

6.1 Variability of Airborne Noise and Vibration Measurements

Although each projectile fired weighed the same and contained about the same amount of explosives, the airborne noise measurements recorded at each historic structure varied from shot to shot. The reasons for these variations are differences in physical and atmospheric conditions as follows:

- The location of the projectile detonation in relation to the river's surface – above, at, or below the water surface.
- Weather conditions. For example, weather conditions that can enhance peak noise at downwind sites include: steady winds of 5-10 miles per hour with gusts of greater velocities in the direction of the measuring site; a clear day with layering of smoke or fog; a cold, hazy or foggy morning; low cloud cover; a day following a day with large extremes of temperature between night and day; or high barometer readings with low temperatures.
- Type and condition of the structure subjected to noise. For example, wooden frame structures and plaster and lath walls tend to be easily rattled, as compared to solid concrete walls, which can sustain much higher airborne and ground-borne vibration levels. Different structures or parts of a structure also respond to vibration impact differently.

The major contributor to variations in airborne noise levels during the test period was changes in weather conditions. Personnel at Stratford Hall observed that the noise and vibration levels increased after noise measurement stopped at 2 pm on Tuesday, November 17, and continued to be higher on Wednesday (P. Mark, personal communication. November 19, 2009).

According to National Oceanic and Atmospheric Administration (NOAA) Air Resources Laboratory (ARL) weather measurements and modeling for the longitude and latitude of the

middle of the PRTR firing area (NOAA ARL, 2010), weather conditions on the two days of testing and the day after testing were as follows:

1. Monday, November 16: Winds early in the morning were from the west, shifting to the west-northwest through the morning, to the northwest at noon, and then by 3 pm winds were coming from the north-northeast. Winds speeds were in the 2.2-6.7 miles per hour (mph) range.

2. Tuesday, November 17: Winds were coming from the northeast early in the morning at 2.2-6.7 mph and then shifted to the east–northeast at noon. At noon, the winds picked up to the 8.9-13.4 mph range, and high cloud cover, which had varied in the morning, became complete.

3. Wednesday, November 18: Winds shifted from northeast early in the morning, to east-northeast by 9 am and east at noon. Like Tuesday, winds, which were 2.2-6.7 mph in the morning, picked up at noon Wednesday to the 8.9-13.4 mph range. Partial to complete high cloud cover on Wednesday morning gave way to complete low and high cloud cover by noon.

4. Monday through Wednesday, November 16-18: Air temperatures declined from Monday to Tuesday and increased from Tuesday to Wednesday. Atmospheric pressure rose steadily through the three-day period.

The combination of changes in wind direction, wind speeds, atmospheric pressure, and cloud cover beginning at noon on Tuesday contributed to higher airborne noise levels Tuesday afternoon and Wednesday, based on NOAA's ARL meteorological data. Cloud cover, particularly low cloud cover, reflects some of the low frequency airborne gun firing noise. This reflected sound energy at the point of receipt may have been higher than would normally have been experienced, since part of the energy normally dissipated into the atmosphere, land buffer, or surrounding vegetation could be reflected in a more direct path to the observer and structure. Atmospheric pressure was climbing steadily through the three-day period, which can also enhance peak sound levels.

Table 5
Airborne Peak Noise Levels

Site	Firing Distance (yards)	Number of Shots Measured	Noise Level[2] (dBP)			Number of Events		
			Minimum	Mean	Maximum	< 115 dBP	115 – 130 dBP	> 130 dBP
Waverley House	5,300	15	115	117	120	0	15	0
	8,300	10	118	120	122	0	10	0
	16,700[1]	-	-	-	-	-	-	-
	21,600[1]	-	-	-	-	-	-	-
	25,700	1	118	118	118	0	1	0
Christ Episcopal Church	5,300	9	73	86	96	9	0	0
	8,300	7	86	93	100	7	0	0
	16,700	7	82	86	92	7	0	0
	21,600[1]	-	-	-	-	-	-	-
	25,700	10	82	88	102	10	0	0
Newtown Manor House	5,300	15	97	102	106	15	0	0
	8,300	4	90	100	107	4	0	0
	16,700	2	103	105	108	2	0	0
	21,600[1]	-	-	-	-	-	-	-
	25,700	5	91	100	105	5	0	0
Stratford Hall	5,300	13	86	98	108	13	0	0
	8,300	8	89	100	108	8	0	0
	16,700	8	86	99	107	8	0	0
	21,600	5	110	112	114	5	0	0
	25,700	11	103	106	110	11	0	0
Bell House (Geosonics)	5,300[1]	-	-	-	-	-	-	-
	8,300[1]	-	-	-	-	-	-	-
	16,700	9	103	114	122	4	5	0
	21,600	3	105	109	112	3	0	0
	25,700	11	101	106	116	10	1	0
Bell House (B&K 2250)	5,300	14	95	111	126	11	3	0
	8,300	10	103	115	125	5	5	0
	16,700	8	105	114	122	4	4	0
	21,600	5	108	111	115	4	1	0
	25,700	11	102	110	116	10	1	0
Greg House	5,300	15	116	124	129	0	15	0
	8,300	10	116	124	128	0	10	0
	16,700[1]	-	-	-	-	-	-	-
	21,600[1]	-	-	-	-	-	-	-
	25,700	1	120	120	120	0	1	0

Notes:
1. No peak noise measurements were made.
2. Measurements were taken on November 16 and 17, 2009 at all locations except Waverley House and Newtown Manor, which were sampled only on November 16, 2009.

Table 6
Wall Vibration Measurements

Site	Firing Distance (yards)	Number of Shots Measured	Vibration Level[3] (in/sec)			Number of Events		
			Minimum	Mean	Maximum	<0.1 in/sec	0.1 – 0.5 in/sec	>0.5 in/sec
Waverley House (exterior brick wall)	5,300	14	0.039	0.139	0.298	4	10	0
	8300	10	0.059	0.113	0.180	5	5	0
	16,700[1]	-	-	-	-	-	-	-
	21,600[1]	-	-	-	-	-	-	-
	25,700	1	0.059	0.059	0.059	1	0	0
Christ Episcopal Church (interior plaster)	5,300	8	0.001	0.003	0.006	8	0	0
	8,300	7	0.001	0.002	0.005	7	0	0
	16,700	7	0.001	0.003	0.005	7	0	0
	21,600	13	0.001	0.002	0.005	13	0	0
	25,700	10	0.000	0.002	0.006	10	0	0
Newtown Manor House (exterior brick wall)	5,300[2]	-	-	-	-	-	-	-
	8,300[2]	-	-	-	-	-	-	-
	16,700	1	0.00003	0.00003	0.00003	1	0	0
	21,600[2]	-	-	-	-	-	-	-
	25,700[2]	-	-	-	-	-	-	-
Stratford Hall (exterior brick wall)	5,300	13	0.004	0.012	0.020	13	0	0
	8,300	8	0.006	0.016	0.030	8	0	0
	16,700	9	0.004	0.015	0.037	9	0	0
	21,600	5	0.008	0.039	0.056	5	0	0
	25,700	12	0.001	0.016	0.024	12	0	0
Bell House (exterior front wall)	5,300[1]	-	-	-	-	-	-	-
	8,300[1]	-	-	-	-	-	-	-
	16,700	8	0.311	0.399	0.535	0	7	1
	21,600	3	0.086	0.245	0.480	1	2	0
	25,700	12	0.071	0.142	0.354	6	6	0
Bell House (exterior side wall)	5,300	13	0.005	0.037	0.225	12	1	0
	8,300	10	0.003	0.055	0.144	7	3	0
	16,700	7	0.001	0.058	0.144	6	1	0
	21,600	5	0.025	0.039	0.069	5	0	0
	25,700	9	0.017	0.027	0.043	9	0	0
Greg House (exterior front wall)	5,300	15	0.007	0.033	0.056	15	0	0
	8,300	10	0.018	0.030	0.046	10	0	0
	16,700[1]	-	-	-	-	-	-	-
	21,600[1]	-	-	-	-	-	-	-
	25,700	1	0.021	0.021	0.021	1	0	0

Notes:
1. No vibration measurements were made.
2. Levels were too low to be detected.
3. Measurements were taken on November 16 and 17, 2009 at all locations except Waverley House and Newtown Manor House, which were only sampled on November 16, 2009.

Table 7
Ground and/or Foundation Vibration Measurements

Site	Firing Distance (yards)	Number of Shots Measured	Vibration Level[3] (in/sec)			Number of Events (Vibration Levels)		
			Minimum	Mean	Maximum	<0.1 in/sec	0.1 – 0.5 in/sec	>0.5 in/sec
Ground Vibration								
Stratford Hall	5,300	12	0.005	0.005	0.005	10	0	0
	8,300	7	0.005	0.005	0.005	7	0	0
	16,700	8	0.003	0.003	0.005	8	0	0
	21,600	5	0.003	0.005	0.008	5	0	0
	25,700	11	0.003	0.003	0.003	11	0	0
Waverley House	5,300	8	0.005	0.005	0.008	8	0	0
	8,300	8	0.005	0.005	0.008	8	0	0
	16,700[1]	-	-	-	-	-	-	-
	21,600[1]	-	-	-	-	-	-	-
	25,700	1	0.005	0.005	0.005	1	0	0
Bell House	5,300	-	-	-	-			
	8,300	-	-	-	-			
	16,700	1	0.005	0.005	0.005	1	0	0
	21,600[2]	-	-	-	-	-	-	-
	25,700[2]	-	-	-	-	-	-	-
Foundation Vibration								
Stratford Hall	5,300	12	0.0001	0.0003	0.0005	12	0	0
	8,300	8	0.0001	0.0002	0.0003	8	0	0
	16,700	9	0.0001	0.0005	0.0011	9	0	0
	21,600	5	0.0002	0.0010	0.0025	5	0	0
	25,700	12	0.0001	0.0002	0.0006	12	0	0
Waverley House	5,300	14	0.005	0.009	0.018	14	0	0
	8,300	10	0.004	0.006	0.008	10	0	0
	16,700[1]	-	-	-	-	-	-	-
	21,600[1]	-	-	-	-	-	-	-
	25,700	1	0.005	0.005	0.005	1	0	0
Bell House	5,300[1]	-	-	-	-	-	-	-
	8,300[1]	-	-	-	-	-	-	-
	16,700	8	0.003	0.006	0.012	8	0	0
	21,600[2]	-	-	-	-	-	-	-
	25,700	1	0.002	0.002	0.002	1	0	0

Notes:
1. No vibration measurements were made.
2. Levels were too low to be detected.
3. Measurements were taken on November 16 and 17, 2009 at all locations except Waverley House and Newtown Manor House, which were only sampled on November 16, 2009.

6.2 Comparison of Modeled and Actual Peak Noise Levels

One of NSWCDL's goals for the noise measurement program at historic structures was to compare the recorded airborne noise meter readings with the noise levels predicted by the Department of Defense's (DoD's) large-caliber weapon-noise model, BNOISE2. Comparing the actual noise measurements from the historic structures with model results would help to refine and validate the accuracy of the noise model.

The model-predicted noise levels were compared to the maximum airborne noise levels recorded at each historic structure, as shown in Table 8. The results indicate that the BNOISE2 model-predicted average peak airborne noise levels were equal to or above the maximum recorded peak noise levels under normal weather conditions. Therefore, the BNOISE2 model, using average weather and propagation conditions, conservatively predicted, and sometimes slightly overestimated, the peak airborne noise levels on the PRTR from 5"/62 Caliber gun firing under normal weather conditions.

Table 8
Comparison of BNOISE2-predicted Average Peak Noise Levels with Maximum Peak Noise Measurements for the 5"/62 Caliber Gun

Site	Measured Maximum Peak Noise (dBP)	BNOISE2-predicted Average Peak Noise (dBP)	Difference (BNOISE2 – Measurement)
Waverley House	122	122	0
Stratford Hall	112	118	+6
Newtown Manor House	108	114	+6
Greg House	129	129	0
Bell House	126	127	+1
Christ Episcopal Church	102	<115	N/A

7 CONCLUSIONS

The noise and vibration measurements taken at six historic structures along the PRTR in November 2009 indicate that:

- All peak airborne noise levels measured during two days of tests were below 134 dBP, the threshold for glass and plaster crack damage in stressed or deteriorated structures (Siskind et al., 1989). Therefore, the potential for structural damage impacts at historic structures – as well as at other structures along the PRTR – from the firing of NSWCDL's large guns is minimal.
- Based on the low vibration levels measured over the two-day measurement period, it is unlikely that NSWCDL's large gun firing would result in noise and associated vibration levels strong enough to cause damage to any structure, including historic structures.

  The airborne vibration levels measured on the walls of four of the six structures showed vibration levels below the 0.1 in/sec vibration concern threshold (see Table 2):

  - Christ Episcopal Church (a maximum of 0.005 in/sec for the interior plaster)
  - Newtown Manor House at St. Francis Xavier Church (non-detectable)
  - Stratford Hall (a maximum of 0.06 in/sec)
  - Greg House (a maximum of 0.06 in/sec).

  The airborne vibration levels measured on the wall of the Waverley House showed wall vibration at levels below the conservative potential vibration damage threshold of 0.5 in/sec.

  The airborne vibration levels measured at the wall of the Bell House showed one exceedance (0.54 in/sec) of the 0.5 in/sec threshold. However, since the 0.5 in/sec threshold was conservatively set as a potential effect level for glass in poorly-fitted windows with loose glass or plaster cracks on stressed walls, vibrations slightly above this level would not be expected to cause any structural damage to the house. As indicated previously, a vibration level of 2.0 in/sec is the threshold level at which minor structural damage may begin to occur in 0.01 percent of structures (one in ten thousand). The highest measured wall vibration level at Bell House is still well below this threshold.
- Comparing peak airborne noise levels predicted by the BNOISE2 model with actual measured peak noise levels indicates that BNOISE2 model-predicted average peak noise levels are equal to or above the maximum measured peak noise levels under normal weather conditions. Therefore, the BNOISE2 model conservatively predicts the peak noise levels on the PRTR from large-gun firing under normal weather conditions.
- Peak vibration and noise levels varied at each historic structure even though the projectiles being fired contained about the same amount of explosives and impacted

the same target areas. These variations were caused by changing weather conditions during the two days of measurements. For example, midday on the second day of measurement, wind direction shifted, wind speeds picked up, and partial cloud cover became complete, which enhanced noise levels that afternoon.

8 REFERENCES

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9 QUALIFICATIONS OF NOISE ANALYSTS

Coordinating with NSWCDL's test, environmental, and noise control staff, AECOM personnel planned the noise measurement process, set up and operated the measurement equipment, and analyzed the resulting data presented in this report. The qualifications and experience of the AECOM noise analysts are summarized below.

Mr. Bernhardt H. Hertlein, a Principal Scientist with a BS in Civil Engineering, Electrical and Mechanical Engineering, serves as the head of AECOM's Non-Destructive Evaluation (NDE) & Geophysics group with 39 years of experience in measuring the impact of vibration on materials and whether materials have been compromised from use. He is responsible for NDT and geophysical and vibration measurement technology used for construction quality control, structural integrity, and condition assessment, and monitoring of remedial and rehabilitation works. He specializes in developing new applications for NDE methods, designing and building required hardware, and writing appropriate software. Some of his representative projects include:

- Project Manager for evaluation of vibration conditions for new and existing magnetic resonance imaging systems at over 750 hospitals and medical centers throughout the US and Central America.
- Project Manager for quality assessment and condition evaluation on high-rise structures, including utility smokestacks and storage silos. Completed surveys on more than 25 stack and silo structures at generating plants and industrial sites in various parts of the US, using NDT test equipment, visual, and laboratory analysis techniques.
- Developed and performed NDE program for underground nuclear waste-storage tanks at the Department of Energy's Los Alamos National Laboratory.
- Project Manager for a number of vibration monitoring and evaluation projects, including continuous monitoring of vibrations at long-wall coal mines in Virginia and Kentucky and quarry blasting sites in Indiana and Illinois.
- Project Manager for cross-hole sonic log and/or gamma/gamma log testing of large-diameter drilled shafts for more than 80 large bridge and highway construction projects nationwide, including:
  - Marquette Interchange Reconstruction, Milwaukee, Wisconsin,
  - Kentucky Dam Highway and Railroad Bridges, Paducah, Kentucky,
  - Driscoll Bridge, Keasbey, New Jersey,
  - 180th Street Underpass, Kent, Washington,
  - I-85 Quarry Bridges, La Grande, Oregon.
- Peer reviewer/consultant for deep foundation testing procedures, data analysis, and interpretation on other major bridge construction projects, including:
  - Cooper River Bridge, Charleston, South Carolina,
  - Oakland Bay Bridge, San Francisco, California,
  - Richmond-San Rafael Bridge, Richmond, California,
  - Hood Canal Floating Bridge, Olympic Peninsula, Washington,
  - First Avenue Bridge, Oro Valley, Arizona.

Mr. Sean Brady is a Senior Instrumentation Specialist with a BS in Electronics Engineering in AECOM's Non-Destructive Evaluation (NDE) & Geophysics group. He has 15 years of experience with numerous geophysical exploration and NDE techniques, such as Cone Penetrometer Testing (CPT), Ground Penetrating Radar (GPR), Cross-Hole Sonic Logging (CSL), Impulse Response Spectrum (IRS), magnetometers and conductivity meters, load cells, strain gauges, Ultrasonic Pulse Velocity (UPV), and vibration monitoring. He also serves as electronics technician responsible for repair, maintenance, calibration, and fabrication of equipment used in NDE. Representative projects include:

- Emergency vibration monitoring of the Jones Waste Water Treatment plant to predict structural damage as a result of imploding a damaged section of the large Hoan Bridge in Milwaukee, Wisconsin.
- Used geophysical methods, including radio detection (RD), ground penetrating radar, conductivity, and electromagnetic survey to locate underground utilities at multiple sites for Telecom Towers at ConEd Electricity Substations, and at Exelon Nuclear Power Plants throughout Illinois.
- Monitored vibration levels at Fermi National Laboratories, Illinois, using a Sprengnether 1600 seismograph during sheet pile driving and demolition of underground tunnel for their accelerator ring expansion.
- Monitored different weighted sound level measurements during pile driving at Northwestern Medical Center, downtown Chicago.
- Performed and evaluated vibration conditions for new and existing magnetic resonance imaging (MRI) systems at over 250 hospitals and medical centers throughout the U.S. and Canada.
- Developed a vibration monitoring program for H-Pile driving at the Port Authority Tunnel in Detroit, Michigan. Reviewed data collected by AECOM field technicians.

Mr. Fang Yang, a Senior Environmental Scientist with a BS in Physics and a MS in Atmospheric Science, is the head of AECOM Environment's noise and vibration group. He has 22 years of experience conducting noise and vibration studies. He uses regulators' mathematical modeling methods plus field noise and vibration measurement programs in his work. He has developed specialized modeling methodologies to address complex and site-specific noise problems by working closely with regulatory agencies. He has extensive experience in providing noise consulting services to military installations. He has also provided expert testimony on noise studies developed by others in court cases at both federal and state levels. Representative projects include:

- US Navy, Naval Facilities Engineering Command, Mid-Atlantic. Noise Impact Study for the Army Weapons Test Facility at Fort Story, Virginia. Project manager for a field noise and vibration-monitoring program for both noise and vibration impact from various types and weights of explosive detonations.
- US Navy, EFD Pacific. Relocation of US Marines from Okinawa to Guam Environmental Impact Statement, Guam. Project manager for a task to develop aircraft noise contours around Anderson AFB for several EIS alternatives.

- US Navy, Marine Corps Base Camp Lejeune and Marine Corps Air Station at Cherry Point, North Carolina. Task manager for developing base-wide large-caliber weapon noise contours and critical range small arms noise contours under three scenarios using the BNOISE2 and SARNAM models.

- US Navy, Naval Facilities Engineering Command, Mid-Atlantic. Small Arms Testing and Evaluation Compound at Virginia Beach, Virginia. Task leader for weapon noise impact analyses for construction and operation of this explosives and small arms range complex for urban training. Predicted event peak and cumulative DNL noise contours for both small arms and large weapon components using both SARNAM and BNOISE2 models at two alternative sites. Innovatively utilized BNOISE2 model options in developing more reasonable noise contours to reflect noise propagation along the site-specific topographic conditions around the site and successfully helped the project going through the regulatory process.

- US Navy, Naval Facilities Engineering Command, Mid-Atlantic. Environmental Assessment for Proposed Range Facilities at Fort Story and Little Creek, Norfolk, Virginia. Task leader for air quality and noise impact analyses for construction and operation of this 24-acre explosives and small arms range complex including five different ranges at two potential sites. Developed a weapon noise analysis approach based on existing noise monitoring and modeling results for similar types of weapon training and performed noise impact analysis using both SARNAM and BNOISE2 models.

- US Navy, Naval Facilities Engineering Command, Mid-Atlantic. Environmental Assessment for Night-firing Range Operations at Little Creek, Norfolk, Virginia. Developed a field noise monitoring program for both pistol and rifle range night-firing exercises. Also predicted noise contours resulting from the proposed gun firing range operations using SARNAM.

Mr. Marko Stamenovic, an Acoustics and Vibration Specialist with a BS in Mechanical Engineering/Acoustics, has two years of experience in vibration monitoring for transportation projects (both tunnel and aboveground) and remediation projects in sensitive communities. Representative projects include:

- Trans Hudson Express Tunnel New Jersey Transit Vibration Monitoring. Palisades, NJ and Manhattan, NY.
- Sag Harbor Gas Ball Remediation Vibration Monitoring. Sag Harbor, NY.
- Los Angeles Metro East Bay Extension Noise and Vibration Monitoring. Los Angeles, CA.
- CSX Intermodal Freight Facility Noise Monitoring and Forecasting. Hanover, MD and Memphis, TN.

Mr. Brian Brownworth, a Noise Specialist with a BS in Mathematics and an MS in Environmental Engineering, has 7 years of experience in noise and vibration-related studies. Representative projects include:

- Weapons noise modeling at Marine Corps Base Camp Lejeune in North Carolina.
- Noise barrier design study including extensive impulsive noise monitoring and modeling at multiple CSX rail yards throughout the US.
- Noise monitoring and noise and vibration forecasting for highway, transit, and construction activities associated with the 30-mile Tappan Zee Bridge/I-287 corridor development project across the Hudson River.
- Noise impact analysis at multiple airports in the US for implementation of the F-35 Joint Strike Fighter.

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