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DEMOLITION KEY RCRA MISCELLANEOUS UNIT DRAFT PERMIT APPLICATION NAS KEY WEST FL

6/7/1996

ENSAFE/ALLEN AND HOSHALL

00174

DEMOLITION KEY
RCRA MISCELLANEOUS UNIT (OB/OD)
DRAFT PERMIT APPLICATION
CTO-0051

CONTRACT NUMBER: N62467-89-D-0318

Prepared for:

Department of the Navy
Southern Division
Naval Facilities Engineering Command
Washington, D.C.

Prepared by:

EnSafe/Allen & Hoshall
5540 Centerview Drive, Suite 205
Raleigh, North Carolina 27606

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Appendix B Modeling Results and Protocol for Open Burning/Open Detonating of Propellants, Explosives, and Pyrotechnics at Naval Air Station Key West's Demolition Key Facility
Appendix C Bangbox Test Series
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SECTION I.A

APPLICATION FOR A HAZARDOUS WASTE FACILITY PERMIT

Revision Number	0
Date	June 7, 1996
Page	1 of 12

APPLICATION FOR A HAZARDOUS WASTE FACILITY PERMIT
PART I - GENERAL
TO BE COMPLETED BY ALL APPLICANTS

Please Type or Print

A. General Information

1. Type of facility:

Disposal [ ]			
landfill	[ ]	land treatment	[ ]
surface impoundment	[ ]	miscellaneous units	[ ]
Storage [ ]			
containers	[ ]	tanks	[ ]
piles	[ ]	surface impoundment	[ ]
miscellaneous units	[ ]	containment building	[ ]
Treatment [ ]			
tanks	[ ]	piles	[ ]
incineration	[ ]	surface impoundment	[ ]
miscellaneous units	[x]	boiler/industrial furnace	[ ]
type of unit Open Burn Open Detonation		type of unit	
		containment building	[ ]

2. Type of application: [ ] TOP [ ] construction [ ] operation [x] closure [ ] RD&D
[ ] construction/operation

3. Revision Number: 0

4. Date current operation began (or is expected to begin): January 1, 1987

5. Facility name: Demolition Key

6. EPA/DEP I.D. No.: FL3170500000

7. Facility location or street address: Demolition Key

8. Facility mailing address: NAS Key West (Street or P.O. Box) Key West (City) FL (State) 33040-5000 (Zip)

9. Contact person: Patsy Watson Telephone: (305) 293-2776

Title: Environmental Manager

Mailing Address: NAS Key West, Public Works Office, P.O. Box 9001 (Street or P.O. Box) Key West (City) FL (State) 33040-9001 (Zip)

10. Operator's name: Lt. Thomas Poore Telephone: (305) 293-2839

11. Operator's address: NAS Key West, Weapons Department, P.O. Box 9001 (Street or P.O. Box) Key West (City) FL (State) 33040-9001 (Zip)

12. Facility owner's name: Commanding Officer, Capt. Linda Hutton Telephone: (305) 293-2107

13. Facility owner's address: NAS Key West, P.O. Box 9001 (Street or P.O. Box) Key West (City) FL (State) 33040-9001 (Zip)

14. Legal structure: [ ] Corporation [ ] Non-profit Corporation [ ] Partnership [ ] Individual
[ ] Local Government [ ] State Government [X] Federal Government [ ] Other

15. If an individual, partnership, or business is operating under an assumed name, specify the county and state where the name is registered.

County: N/A State: N/A

16. If the legal structure is a corporation, indicate the state of incorporation.

State of incorporation: N/A

17. If the legal structure is an individual or partnership, list the owners.

Name: N/A

Address: (Street or P.O. Box) (City) (State) (Zip)

Name: N/A

Address: (Street or P.O. Box) (City) (State) (Zip)

Name: N/A

Address: _____
Street or P.O. Box City State Zip

18 Site ownership status: [x] owned [ ] to be purchased [ ] to be leased _____ years
[ ] presently leased; the expiration date of the lease is: _____
If leased, indicate:

Land owner's name: United States Navy

Land owner's address: NAS Key West Key West FL 33040-5000
Street or P.O. Box City State Zip

19. Name of engineer: James N. Speakman Registration no.: 41460

Address: 5724 Summer Trees Drive Memphis TN 38134
Street or P.O. Box City State Zip

Associated with: Environmental and Safety Designs, Inc.

20. Facility located on Indian land: [ ] yes [X] no

21. Existing or pending environmental permits: (attach a separate sheet if necessary)

NAME OF PERMIT	AGENCY	PERMIT NUMBER	DATE ISSUED	EXPIRATION DATE
None				

B. Site Information

1. Facility location County: Monroe Nearest Community: Key West

   Latitude: 24°, 35', 48" N Longitude: 81°, 47', 45" W

   Section: N/A Township: N/A Range: N/A

   UTM #: 17/419000/2720000

2. Area of facility site (acres): 8.14

3. Attach a scale drawing and photographs of the facility showing the location of all past, present, and future treatment, storage and disposal areas. Also show the hazardous wastes traffic pattern including estimated volume and control.

4. Attach topographic map which show all the features indicated in the instruction sheet for this part

5. Is the site located in a 100-year flood plain? [x] yes [ ] no

C. Land Use Information

1. Present zoning of the site None (Military Reservation/Federal Facility)

2. If a zoning change is needed, what should the new zoning be? N/A

3. Present land use of site Military Reservation

D. Operating Information

1. Is waste generated on site? [x] yes [ ] no

   List the SIC codes (4-digit)

   9711 _____ _____ _____ _____ _____ _____

2. Attach a brief description of the facility operation, nature of the business, and activities that generate, treat, store or dispose of hazardous waste

3. Using the following table and codes provided, specify, (1) each process used for treating, storing, or disposing of hazardous waste (including design capacities) at the facility, and (2) the hazardous waste (or wastes) listed or designated in 40 CFR Part 261, including the annual quantities, to be treated, stored, or disposed by each process at the facility. (See the instructions for the list of process codes and units).

PROCESS CODE	PROCESS DESIGN CAPACITY AND UNITS OF MEASURE	HAZARDOUS WASTE CODE	ANNUAL QUANTITY OF HAZARDOUS WASTE AND UNITS OF MEASURE
T05		D003	90 G
T05		D005	90 G
T05		D006	90 G
T05		D008	90 G
T05		D009	90 G

SECTION I.B

SITE INFORMATION

SITE INFORMATION

This section provides applicable photos and drawings of Demolition Key, as required by 40 CFR 270.14(b)(11) and FAC 62-730. Included is a facility drawing (Figure I.B-1), a regional aerial photo (Figure I.B-2), and facility photos (Figure I.B-3). The facility drawing and facility photos are dated August 1995 while the aerial photo was taken during the mid-1980s.

Figure I.B-1 Facility Drawing

Figure I.B-2 Regional Aerial Photo

Figure I.B-3 Facility Photos

SECTION I.C

LAND USE INFORMATION

LAND USE INFORMATION

Information provided in this section is provided in accordance with requirements from 40 CFR 270.14(b)(19)(iv) and FAC 62-730. Unserviceable ordnance disposition operations were conducted at Demolition Key from 1960 to 1995. During this 35-year operating period, approximately 20 pounds net explosive weight (NEW) of unserviceable ordnance were open burned and detonated annually (i.e., 700 pounds NEW during operating life).

During this same period and currently, Navy SEAL and Explosive Ordnance Disposal (EOD) personnel conduct ordnance training exercises. These training exercises involve the safe destruction of military ordnance required as part of their mission statement and annual proficiency training. Ordnance destruction proficiency training is conducted one to four times annually.

While ordnance treatment has ended, ordnance and troop testing is still conducted occasionally at Demolition Key. Testing may involve ordnance destruction configuration technique modification, development testing, and reaction sequence testing.

Demolition Key will also be used to destroy unsafe military and civilian ordnance and/or munitions. These emergency destruction operations will be conducted under Florida Department of Environmental Management (FDEP) emergency treatment rules. Naval Air Station (NAS) Key West will ensure proper notification to FDEP prior to initiating emergency treatment operations.

SECTION I.D

DESCRIPTION OF FACILITY OPERATIONS

DESCRIPTION OF FACILITY OPERATIONS

The information in this section is submitted in accordance with the requirements of Florida Administrative Code (FAC) 62-730, U. S. Environmental Protection Agency (USEPA) 40 Code of Federal Regulations (CFR) Parts 270.14(b)(2) and (3) and 264.13(a), (b), and (c).

Introduction

Demolition Key is in Monroe County, Florida, north of Key West, bounded to the north, east, and west by the Florida Bay and to the south, across a narrow stretch of gulf water, by Fleming Key (Figure I.D-1). Access to Demolition Key is by boat through the Garrison Bight Channel. The facility and surrounding property are described more fully in later sections of this operating permit.

Demolition Key was used by NAS Key West for the thermal treatment (i.e., open burning and open detonation [OB/OD]) of military ordnance no longer capable of being used for their intended purpose (i.e., warfare, training, or research and development) and/or that cannot be reworked or demilitarized offsite for resuse, training, foreign sales, or disposal.

Hazardous Waste Generation Processes

The Weapons Department at NAS Key West (i.e., Boca Chica Key and Fleming Key) generates hazardous waste ordnance explosives and munitions from routine use and handling, designated as hazardous waste due to their reactive characteristics. In addition, many of the waste ordnance casings and critical parts contain metal salts of arsenic, barium, or cadmium while lead styphnate and mercury fulminate are commonly used as detonators. Thus, in addition to characterizing hazardous waste ordnance as reactive (USEPA D003), these items may fail the Toxicity Characteristic Leaching Procedure (TCLP) for leachable Resource Conservation and Recovery Act (RCRA)-regulated metals including barium (D005), cadmium (D006), lead (D008), and mercury (D009) depending on the ordnance considered. Military ordnance composition products are contained in Section II.B.7.

All hazardous waste ordnance treated at Demolition Key were defined as to their chemical composition based on knowledge of the particular items obtained through exhaustive Department of Defense (DOD) training.

Figure I.D-1 Vicinity Map

Figure I.D-2 is a flow diagram of the process by which an ordnance item is defined as hazardous waste while Figure I.D-3 describes how ordnance, once defined as a hazardous waste, was managed from generation at NAS Key West through treatment at Demolition Key.

Ordnance Classification Procedures

Serviceable to Unserviceable

Ordnance that is used for troop training and military engagements is classified as Code A (serviceable — i.e., ready for use). Code A ordnance is procured by the NAS Key West Weapons Department following individual unit submittal of NAVSEASYSCOM authorized requisitions. Navy personnel conduct ordnance training exercises to ensure troop proficiency in respective areas of responsibility based on the individual unit directives and mission descriptions.

During intended use, ordnance items and/or their shipping containers may become damaged, lose their lot numbers, or be found defective. Upon the return of such ordnance items to the Weapons Department, weapons technicians are responsible for ensuring that items no longer meeting Code A specifications are reclassified Code H (unserviceable). Reclassifying ordnance items from Codes A to H requires detailed review of military technical manuals (TM) and safety bulletins (SB) against the condition of the ordnance item returned and review of DOD Notice of Ammunition Reclassifications (NARs) issued by Ship Parts Control Center (SPCC), Mechanicsburg, Pennsylvania. TMs, SBs, and NARs are discussed in detail in the following paragraphs.

Unserviceable to RRDA

Once an ordnance item is determined to be unserviceable, it is administratively placed in the Resource Recovery and Disposition Account (RRDA) for future disposition evaluation by NAVSEASYSCOM. The ordnance item is reclassified from a Code H ordnance to Code R ordnance during this process. For an ordnance item to be placed into the RRDA, Weapons Department personnel must receive written authorization from NAVSEASYSCOM. Once authorization is obtained, the evaluation process begins.

While in the RRDA, NAVSEASYSCOM evaluates the ordnance for the following uses:

- Rework
- Resale
- EOD personnel ordnance destruction proficiency training throughout the Navy
- Demilitarization (i.e., wash out, melt out, steam out, incineration, et al.)
- Commercial offsite disposal

Figure I.D-2 Hazardous Waste Ordnance Decision Logic Flow Chart

Figure I.D-3 Hazardous Waste Ordnance Facility Flow Chart

Unserviceable and RRDA to Hazardous Waste

Ordnance items designated for demilitarization, including offsite disposal, shall be so designated by an authorized NAVSEASYSCOM representative following review of all available use options presented above. Code H ordnance items so designated shall be administratively placed in the Base Hazardous Waste (BHW) Account and physically separated from other ordnance items into a specifically designated NAS Key West Weapons Department hazardous waste accumulation area.

Weapons personnel are responsible for managing the BHW account and for accumulating hazardous waste ordnance according to the USEPA, RCRA, and FAC requirements governing hazardous waste generator and treatment facilities.

Before treating hazardous waste ordnance items in the NAS Key West BHW at Demolition Key, Weapons Department personnel must submit a request in milstrip (i.e., written order) format to NAVSEASYSCOM. Following receipt and review of this request, NAVSEASYSCOM will issue a document identifier code to denote transfer of ordnance items into or out of the BHW account. The document identifier codes include:

- A5J — Disposal release order. Issued only by NAVSEASYSCOM.
- D7J — Issue to property disposal. Used when ordnance items are transferred to Weapons Department for treatment at Demolition Key or other disposal authority (i.e., commercial facility/fellow component).
- ARJ — Disposal release confirmation. Used by the issuing command upon receipt of the disposal document, certifying the items as destroyed.
- ARK — Disposal release confirmation: greater quantity. Used when final disposal quantity is greater than original A5J amount.
- ARL — Disposal release confirmation: less than quantity. Used when final disposition is less than original A5J amount.

Notice of Ammunition Reclassification

NARs are determined by the Navy Ships SPCC in Mechanicsburg, Pennsylvania. Ordnance is reclassified unserviceable when it malfunctions and/or deficiencies are identified through use, testing, and evaluation and also when it has exceeded its allowable shelflife.

NARs are distributed by SPCC to NAS Key West and other Navy bases. Ordnance items affected by a NAR are physically and administratively segregated from serviceable (Code A) ordnance items. Once segregated, the Code H ordnance items await final disposition orders as described above. If the order was to dispose of the ordnance item through local treatment options (i.e., OB/OD), it was further segregated as a hazardous waste and accumulated along with other hazardous waste ordnance in the appropriate hazardous waste ordnance-designated magazine.

Field Returns

Field returns consist of ordnance NAS Key West and other Navy facilities cannot reissue due to physical damage, missing components, or lack of identification (mixed lots, lost identification numbers, etc.). If NAS Key West Weapons personnel cannot readily identify these items, they are reclassified as unserviceable (Code H). Reclassification of ordnance at this level is based upon general information provided in Navy-issued SBs, information from TMs for individual ordnance, and NAVSEASYSCOM ordnance publications.

Before transporting of hazardous waste ordnance to Demolition Key, Weapons Department personnel completed a Uniform Hazardous Waste Manifest to be reviewed and signed by the Weapons Officer in charge of generation, transportation, and treatment/disposal. In conjunction with completing, reviewing, and signing the Uniform Hazardous Waste Manifest, Turn-in Document 1348-1 was also completed, reviewed, and signed by the respective officers in charge.

This process ensured that all items were identified and assigned proper disposition. The process also ensured that all chemical and physical properties of the waste material could be ascertained and, therefore, actual sampling of the munitions would not be warranted.

Description of Hazardous Waste Management Units

Key West used the OB/OD treatment area on Demolition Key to treat hazardous waste ordnance generated and managed at the base. The OB/OD treatment area was operated in accordance with the Navy guidance manual titled *Ammunition and Explosives Ashore Safety Regulations for Handling, Storing, Production, Renovation, and Shipping (OP 5).* As specified per OP 5, NAS Key West designated this treatment area a Class A demolition range, with the following operational limitations:

1. The treatment area (Class A) shall be limited to a NEW per detonation of 5 pounds.

2. The treatment location shall not be closer than 670 feet (Class A) from the nearest inhabited building.

3. All vegetation -- dry grass, leaves, and other combustible materials -- shall be removed from the area of treatment so as not to interfere with treatment operations.

4. Only the exact quantity of hazardous waste ordnance to be open detonated shall be taken to the treatment area. Hazardous waste ordnance must not be stockpiled at the treatment area.

Special Procedural Requirements

Hazardous waste from NAS Key West was accepted for treatment at Demolition Key following completion of a waste profile sheet for each ordnance and only if it met the classification and weight capacities established in Part I of this operating permit. This profile sheet, along with DD Form 1348-1, accompanied the waste to Demolition Key.

SECTION I.E

INFORMATION REGARDING POTENTIAL RELEASES FROM SOLID WASTE MANAGEMENT UNITS

P. Information Regarding Potential Releases From Solid Waste Management Units

Facility name: Demolition Key

EPA I.D Number: FL3170500000

Location: City Key West

State Florida

1. Are there any of the following solid waste management units (existing or closed) at your facility? A Solid Waste Management Unit (SWMU) is a discernible unit at which solid wastes have been placed at any time, irrespective of whether the unit was intended for the management of solid or hazardous waste. Such units include all areas at a facility where solid wastes have been routinely and systematically released, as described in the July 27, 1990 Federal Register (55 FR 30798).

NOTE: DO NOT INCLUDE HAZARDOUS WASTES UNITS CURRENTLY SHOWN IN YOUR PART B APPLICATION

	YES	NO
■ Landfill	___	x
■ Surface impoundment	___	x
■ Land farm	___	x
■ Waste pile	___	x
■ Incinerator	___	x
■ Storage tank	___	x
■ Container storage area	___	x
■ Injection wells	___	x
■ Wastewater treatment units	___	x
■ Transfer stations	___	x
■ Waste recycling operations	___	x
■ Land treatment facility	___	x
■ Boiler/industrial furnace	___	x
■ Other (units not listed above)	___	x

2. If there are "Yes" answers to any of the items in 1. above please provide a description of the wastes that were stored, treated or disposed of in each unit. In particular please focus on whether or not the wastes would be considered as hazardous wastes or hazardous constituents under RCRA. Also include any available data on quantities or volumes of wastes disposed of and the dates of disposal. Please also provide a description of each unit and include capacity, dimensions, and location at facility. Provide a site plan if available

N/A

NOTE: HAZARDOUS WASTES ARE THOSE IDENTIFIED IN 40 CFR PART 261. HAZARDOUS CONSTITUENTS ARE THOSE LISTED IN APPENDIX VIII OF 40 CFR PART 261.

3. For the units noted in 1. above **and also for those hazardous waste units in your Part B application,** please describe for each unit all data available on all prior or current releases of hazardous wastes or constituents to the environment that may have occurred in the past or still be occurring.

Please provide the following information:

a. Date of release
b. Type of waste released
c. Quantity or volume of waste released
d. Describe nature of release (i.e., spill, overflow, ruptured pipe or tank, etc.)

See attached Closure Permit Application.

4. In regard to the prior releases described in 3. above, please provide (for each unit) all analytical data that may be available which would describe the nature and extent of environmental contamination that exists as a result of such releases Please focus on concentrations of hazardous wastes or constituents present in contaminated soil or ground water.

See attached Closure Permit Application.

Signature and Certification

The following certification must be included with the submittal of this information. The certification must be signed by a principal executive officer of at least the level of Vice President or by a duly authorized representative of that person.

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments. Based on my inquiry of those individuals immediately responsible for obtaining the information, the information submitted is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Signature

Name and Title (typed)

Demolition Key
Facility Name

Date:_____ Telephone (_____)_____

SECTION II.A

CLOSURE PERMIT APPLICATION CERTIFICATION

Revision Number 0
Date June 7, 1996
Page 9 of 12

APPLICATION FOR A HAZARDOUS WASTE FACILITY PERMIT
CERTIFICATION
TO BE COMPLETED BY ALL APPLICANTS

Facility Name. Demolition Key EPA ID# FL3170500000

1. Operator

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations. Further, I agree to comply with the provisions of Chapter 403, Florida Statutes, and all rules and regulations of the Department of Environmental Protection. It is understood that the permit is only transferable in accordance with Chapter 62-730, F.A.C., and, if granted a permit, the Department of Environmental Protection will be notified prior to the sale or legal transfer of the permitted facility.

_____
Signature of the Operator or Authorized Representative*

_____
Name and Title (Please type or print)

Date:_____ Telephone :(____)_____

*Attach a letter of authorization

2 Facility Owner

This is to certify that I understand this application is submitted for the purpose of obtaining a permit to construct, operate, or close a hazardous waste management facility on the property as described. As owner of the facility, I understand fully that the facility operator and I are jointly responsible for compliance with the provisions of Chapter 403, Florida Statutes, and all rules and regulations of the Department of Environmental Protection

_____

Signature of the Facility Owner or Authorized Representative*

_____

Name and Title (Please type or print)

Date:_____ Telephone:(____)_____

***Attach a letter of authorization**

3. Land Owner

This is to certify that I, as land owner, understand that this application is submitted for the purpose of obtaining a permit to construct, operate, or close a hazardous waste management facility on the property as described. For hazardous waste disposal facilities, I further understand that I am responsible for providing the notice in the deed to the property required by 40 CFR §264.119 and §265.119, as adopted by reference in Chapter 62-730, F.A.C.

_____

Signature of the Land Owner or Authorized Representative*

_____

Name and Title (Please type or print)

Date._____ Telephone:(____)_____

*Attach a letter of authorization

SECTION II.B.1

TOPOGRAPHIC MAP

TOPOGRAPHIC MAP

Figure II.B-1 Topographic Map

SECTION II.B.2

WIND ROSE

WIND ROSE

Figure II.B-2 Wind Rose

SECTION II.B.3

FACILITY TRAFFIC INFORMATION

FACILITY TRAFFIC INFORMATION

This information is provided in accordance with the requirements of 40 CFR 270.14(b)(10) and FAC 62-730.

Land

Traffic Patterns

Land traffic patterns from NAS Key West to Demolition Key are primarily along U.S. Highway 1 and around the southern part of Key West on U.S. A1A. Traffic patterns vary with seasons. Data from the Florida Department of Transportation (FDOT) permanent counters on Stock Island indicate that March is the peak month and October is the low month for traffic going to Key West. The city reports March counts of 4,000 to 4,500 Average Daily Trips (ADT) above the yearly average, and October counts about 2,800 ADT below the yearly average (Monroe County Year 2010 Comprehensive Plan).

Stock Island exhibits a classic urban commuter pattern, with almost identical peak counts on weekday mornings. March is clearly the peak month for each day of the week on Stock Island (Source: Monroe County Year 2010 Comprehensive Plan).

Estimated Traffic Volume

Average annual traffic volume for US 1 at Stock Island was 34,846 trips for 1990, the highest number between 1986 and 1990. The lowest number of trips per year was in 1986, at 29,594. The numbers have steadily increased each year, and are expected to continue along this pattern. The Stock Island counters provide the most accurate information regarding traffic flow volume onto Key West since US 1 is the only road into Key West and the counters are on the city line.

The vehicles traveling into Key West vary from personal automobiles of tourists and residents to commercial and industrial trucks transporting food and materials.

Traffic Controls

Transporting hazardous waste and materials from Demolition Key to NAS Key West involves ferrying the material by boat to Truman Annex. From Truman Annex, vehicles follow this route: Take Truman Road to a right onto Roosevelt Boulevard. Turn right onto First Street and continue to Highway A1A. Turn left onto A1A along the southern coast of Key West. The entrance/exit to Key West is the point where A1A turns into U.S. Highway 1, which is taken onto Stock Island and then NAS Key West on Boca Chica Key.

All of these roads are paved. A large portion of the journey is on US 1, a four-lane highway for the entire journey between the entrance/exit to Key West and NAS Key West. The other roads are two-lane city streets, with the exception of A1A. The load-bearing capacity of US 1 is 40 tons. For the city streets, the load-bearing capacity is 32 tons.

Traffic signals are at the major intersections, including the entrance/exit to Key West, and at First Street and Roosevelt Boulevard. A map detailing the transport route is included as Figure II.B-3.

Water

Traffic Patterns

Water traffic patterns around Demolition Key are primarily through Garrison Bight Channel, which flows between Fleming Key and Demolition Key. As with land traffic, traffic patterns vary according to season. No data were obtained regarding the peak and low traffic flow months. The number of vessels around Garrison Bight Channel can only be estimated, since counters are not employed. Data for making an estimate are the number of slips for private vessels at Garrison Bight Marina and the number of commercial vessel trips. These numbers will only account for a portion of the traffic through Garrison Bight Channel; however, generalizations can be made to account for the rest of the traffic.

Estimated Traffic Volume

Average annual traffic volume for Garrison Bight Channel is not known. However, an estimate may be made using data from the U.S. Department of Transportation (USDOT) regarding commercial vessel trips, and the number of slips in the Garrison Bight Marina, as previously stated. Commercial vessel data were obtained from a U.S. Army Corps of Engineers publication titled *Waterborne Commerce of the United States, Calendar Year 1990, Part 1 - Waterways and Harbors Atlantic Coast*, which states 4,454 trips were made from the Key West Harbor in 1990. These vessels did not necessarily travel around Demolition Key, but these data provide an idea of the commercial traffic volumes in the area. Garrison Bight Marina has 230 boat slips that are 90% occupied at any time. Thirty-six charter boats, seven pleasure boats, and 73 live-aboard boats occupy some portion of those slips.

The document defines a trip as a vessel movement. For self-propelled vessels, a trip is logged between every point of departure and every point of arrival. For loaded barges, a trip is logged from the point of loading the barge to the point of unloading (i.e., excluding fleeting areas). For empty barges, a trip is logged from the point of loading, counting the fleeting areas between (e.g., if an empty barge moved from Dock A to Dock B and the barge stopped at three fleeting areas between, four trips are logged).

Figure II.B-3 H.W. Transport Route

These numbers provide the best information regarding the flow of water traffic around Demolition Key since actual flow data are not available through the following sources:

- US Coast Guard
- Florida Marine Patrol
- Florida Department of Transportation (FDOT)
- NAS Key West Port Operations

The types of vehicles that travel through Garrison Bight Channel vary. Most of this traffic appears to be small-craft recreational and commercial.

SECTION II.B.4

FINANCIAL RESPONSIBILITY

FINANCIAL RESPONSIBILITY

Demolition Key is a part of NAS Key West, a U.S. military installation. According to 40 CFR Section 264.140(c), and FAC 62-730.170(2)(g), "states and the federal government are exempt from the requirements of this subpart." This exempts NAS Key West from providing proof of financial responsibility that is normally required under Subpart H.

Closure Cost Estimates

Under 40 CFR Section 264.140 (c) and FAC 62-730.170(2)(g), Demolition Key is exempt from the requirements of 40 CFR Section 264, Subpart H, "Financial Requirements."

Financial Assurance Mechanism for Closure

Under 40 CFR Section 264.140 (c) and FAC 62-730.170(2)(g), Demolition Key is exempt from the requirements of 40 CFR Section 264, Subpart H, "Financial Requirements."

Post-Closure Cost Estimate

Under 40 CFR Section 264.140 (c) and FAC 62-730.170(2)(g), Demolition Key is exempt from the requirements of 40 CFR Section 264, Subpart H, "Financial Requirements."

Financial Assurance Mechanism for Post-Closure Cost

Under 40 CFR Section 264.140 (c) and FAC 62-730.170(2)(g), Demolition Key is exempt from the requirements of 40 CFR Section 264, Subpart H, "Financial Requirements."

Liability Requirements

Under 40 CFR Section 264.140 (c) and FAC 62-730.170(2)(g), Demolition Key is exempt from the requirements of 40 CFR Section 264, Subpart H, "Financial Requirements."

State Financial Mechanism

Under 40 CFR Section 264.140 (c) and FAC 62-730.170(2)(g), Demolition Key is exempt from the requirements of 40 CFR Section 264, Subpart H, "Financial Requirements."

SECTION II.B.5

FLOODPLAIN

FLOODPLAIN

The following information complies with the requirements of 40 CFR 270.14(b)(9)(iii) and FAC 62-730.

Floodplain Definition

According to the Federal Emergency Management Agency (FEMA), Demolition Key lies within the 100-year floodplain due to velocity hazard causing severe wave action, Figure II.B-4. The expected flood elevation is 13 feet above mean sea level (msl), which includes the area, Zone VE.

Facility Design and Hazardous Waste Removal Activities

In the case of a 100-year flood, the facility and its practices were designed to limit or prevent the escape of contaminants and/or hazardous waste into the environment. For example, hazardous waste was never stored or accumulated at the treatment facility, except just prior to treatment operations while staging. Treatment operations were not conducted if severe weather existed or threatened.

Closure Procedures

Closure procedures are designed to remove media potentially impacted by post-treatment operations. Material removed will be transported to the NAS Key West permitted storage facility the same day, eliminating any flood impact.

Potential for Accidental Discharges

The potential for accidental discharges while removing hazardous waste from the Demolition Key hazardous waste treatment facility is remote as this material is solid and contained within drums. When operating any water craft, capsizing is a possibility. If a vessel were to capsize, the shallow depth of water would allow for swift removal of the overboard drums with remote possibility of releasing its contents.

Figure II.B-4 FEMA Floodplain Map

SECTION II.B.6

FACILITY SECURITY INFORMATION

FACILITY SECURITY INFORMATION

This information is included to comply with the requirements of 40 CFR 270.14(b)(4) and FAC 62-730. Access to Demolition Key is by water only. Visitors wishing to enter Demolition Key must obtain a pass from the NAS Key West Provost Marshal's Office (PMO) and must be accompanied by an authorized NAS Key West Weapons Department personnel.

During all hours, Demolition Key and surrounding Gulf of Mexico waters are under surveillance by the Florida Marine Patrol, the U.S. Coast Guard, and the NAS Key West Port Operations. All security personnel are equipped with two-way radios to immediately report emergencies or security problems at the Demolition Key treatment facility. All personnel in the above groups are trained in the contents of the Preparedness and Prevention Plan and Contingency Plan of this closure permit application.

CONTINGENCY PLAN

This Contingency Plan has been prepared to comply with FAC 62-730.180, 40 CFR 270.14(b)(7), and 40 CFR 264.50 relating to the closure of the Demolition Key's hazardous waste ordnance miscellaneous unit treatment facility. NAS Key West is responsible for ensuring this Contingency Plan is adequate to handle emergencies that can occur while conducting closure operations at Demolition Key.

Demolition Key is a military reservation owned and operated by the US Navy. It is under the command of the commanding officer of NAS Key West on nearby Boca Chica Key. Other missions and land masses associated with NAS Key West are Trumbo Point and Truman Annex on Key West and Fleming Key.

NAS Key West comprises several noncontiguous areas of the Florida Keys. Demolition Key consists of two uninhabited, man-made islands across Garrison Bight Channel from the northern boundary of Fleming Key. The treatment facility consists of one OB/OD unit along the southeastern border of Demolition Key NW.

Access to the Demolition Key is by boat only. Location maps of the treatment facility at Demolition Key and its relationship to NAS Key West and the State of Florida have been submitted as Figures I.B-2 and I.D-1, respectively, in Section I of this closure permit.

Due to the relationship between NAS Key West and Demolition Key, the breadth of this Contingency Plan is expanded to encompass the transport of closure debris (i.e., hazardous and remediation waste) from Demolition Key to the NAS Key West permitted hazardous waste storage facility.

Purpose

This document presents a written procedure for NAS Key West emergency response units, listed herein, to follow when responding to accidents involving the closure of Demolition Key's miscellaneous unit treatment facility. This Contingency Plan defines the roles of each key unit/individual responsible for emergency incident response. This Contingency Plan complements the *NAS Key West Facility Response Plan* (Draft February 1995).

Introduction and Scope

Introduction

While closing Demolition Key's hazardous waste ordnance treatment facility, closure personnel may identify untreated or partially treated ordnance items. Although such discoveries are unlikely, this Contingency Plan contains the necessary procedures and equipment maintained by NAS Key West to respond responsibly, including the supervision of all closure operations by trained and certified EOD personnel.

This plan will be implemented each time an accident occurs relating to the Demolition Key closure activities. All incidents related to closure will require NAS Key West to review the Preparedness and Prevention Plan and the Training Plan contained in this closure permit to assist in determining what engineering or administrative failure(s), respectively, caused the emergency.

Response to emergencies during facility closure will be supervised by the Emergency Coordinator. The Emergency Coordinator will have ultimate authority and responsibility for the following actions:

- Determining if the emergency involves a spill of a hazardous substance reportable quantity (40 CFR 117);
- Assessing the immediate threat to human health or the environment beyond the boundaries of NAS Key West or Demolition Key;
- Determining when to initiate notification procedures to local, state, and/or federal agencies;
- Establishing zones of response, evacuation requirements, and personal protective equipment (PPE) requirements;
- Ensuring the safety of all emergency personnel assisting with the response incident;
- Ensuring proper cleanup equipment and procedures are available and followed, respectively; and
- Providing assistance, personnel, and equipment for spill response.

NAS Key West units responsible for emergency response are identified in this plan. Specific methods of response to spills, fires, and explosions and available emergency and protective equipment are also described.

This Contingency Plan will be reviewed and immediately amended whenever:

- The facility closure permit or application is revised;
- The Facility Response Plan is modified in a manner that affects emergency equipment availability, incident response units, evacuation routes, etc;
- The plan fails in an emergency;
- The list of emergency coordinators changes; and/or
- The list of emergency equipment changes.

Scope

The primary mission of Demolition Key is to provide NAS Key West and surrounding DoD facilities with remote ordnance training, testing, and treatment locations. The primary mission of NAS Key West is to support military intelligence operations, maintain and service aircraft, train troops, and maintain serviceable ordnance storage for troop training and warfare. NAS Key West generated and accumulated hazardous waste ordnance that, under the supervision of NAS Key West, was eventually treated at Demolition Key through use of DOD standard operating procedures (i.e., OB/OD).

Hazardous waste from the closure activities will be transported from Demolition Key by vessel (to Truman Annex through Garrison Bight Channel and the Man of War Channel) and truck (from Truman Annex through the City of Key West to NAS Key West [Boca Chica Key]) (see Figure II.B-3). All closure operations will be performed by trained and certified Navy (NAS Mayport) EOD personnel with sole authority for conducting all such activities on Demolition Key.

This Contingency Plan shall be activated only during emergencies occurring at Demolition Key during closure activities. Although this Contingency Plan may prove helpful in responding to an emergency outside the legal confines of Demolition Key, it should only be used to supplement existing plans generated for those circumstances.

Personnel Responsibilities

The designated Emergency Coordinator for Demolition Key is the Public Works Office (PWO) Environmental Manager responsible for directing and coordinating Demolition Key's hazardous waste ordnance treatment facility closure operations. In an emergency, the Commanding Officer

delegates his/her authority as alternate Emergency Coordinator directly to the NAS Key West Weapons Department Officer.

As alternate Emergency Coordinator for closure operation emergencies, the Weapons Department Officer has available all expertise and resources of the required support personnel in determining and performing appropriate response actions. When activated, the alternate Emergency Coordinator responds immediately to the scene and works directly with the Emergency Coordinator and the Demolition Key treatment operator (EOD Officer or Technician) to assess, control, and mitigate the situation. Additional resources are provided as required from secondary support functions (i.e., Safety Department, Command Duty Officer, Security Department, Navy Medical Clinic, Civilian Authorities, etc.).

The NAS Key West Fire Department and Quarter Deck watch personnel are responsible for receiving all initial hazardous waste emergency reports through NAS Key West's emergency response telephone numbers. NAS Key West's emergency response telephone number operates 24 hours a day and initiates the internal notification procedure for emergencies at Demolition Key.

Emergency Coordinator

The Emergency Coordinator is the individual assigned primary responsibility for responding to incidents occurring within the framework of this closure permit application. At Demolition Key, this Emergency Coordinator function is assigned to the PWO Environmental Manager by authority of the NAS Key West Commanding Officer. Specific responsibilities of the Emergency Coordinator include:

- Direct and coordinate all on-scene emergency response actions.
- Activate, or authorize the activation of, all or part of NAS Key West's emergency response units as required during an incident response.
- Coordinate all required notifications to federal (outside the Navy), state, and local agencies and the news media.
- Coordinate all required assistance from federal, state, and local response organizations and private contractors.

Alternate Emergency Coordinator

At the discretion of NAS Key West's Commanding Officer, the responsibility for Alternate Emergency Coordinator has been delegated to the Weapons Department Officer.

Alternate Emergency Coordinator responsibilities include assisting the Emergency Coordinator in a manner consistent with this Contingency Plan as well as assuming the responsibilities of Emergency Coordinator in his/her absence.

Fire Chief

Responsibilities are as follows:

- Initiate action to contain and control a hazardous spill or fire and safeguard human health and the environment from further spill or fire complications.
- Coordinate with the Safety Department to ensure adequate worker protection and air monitoring. Air monitoring shall be designed to measure toxic and explosive vapor concentrations and define an area for evacuation, if necessary.
- Coordinate with Emergency Coordinator to activate other command plans, when appropriate.
- Assist in evacuating personnel from the incident site.
- Coordinate with civilian Fire Departments involved in incident response.
- Assist in the establishing site operating zones (support, decontamination, and exclusion).
- Provide personnel and equipment decontamination areas.
- Provide appropriate incident response equipment, insuring its proper working order.

Public Works Office — Environmental Protection Specialist

Responsibilities are as follows:

- Advise the Emergency Coordinator, or in his/her absence, instruct the Alternate Emergency Coordinator to assemble the response team in a designated area.
- Act as technical support coordinator for the Emergency Coordinator and furnish site-specific information relative to past operations and activities at the treatment facility, location and characteristics of waste handled, location of records, facility layout, location and capabilities of emergency equipment, etc.

- Coordinate sampling and testing of the affected lands and/or waterways to monitor the extent and/or degree of impact from the incident.

- Ensure, in concert with the Emergency Coordinator, that all reports and notifications required by state and federal regulators are filed timely and efficiently.

- Assess possible hazards to human health and/or the environment and advise the Emergency Coordinator if evacuation procedures should be initiated.

- Calculate the type and amount of hazardous waste and/or constituents released outside facility boundaries.

- Help supervise and coordinate post-emergency removal actions.

- Determine the adequacy of the ultimate cleanup effort, and advise the Emergency Coordinator of the scope of any additional cleanup required.

- Ensure proper containerization and labeling of all impacted media resulting from an incident.

- Maintain official records and photographs documenting the extent of the incident and all containment, cleanup, and recovery actions taken and procedures used.

- Ensure proper disposal of all impacted media resulting from the emergency in accordance with applicable state and federal regulations.

- Maintain a detailed log of events connected with the emergency.

Safety Department

- Provide technical assistance and advice to the Emergency Coordinator and the Navy Medical Clinic corpsmen with respect to the health and safety of personnel.

- Ensure that response personnel have the proper PPE and are trained in its care and use.

- Provide industrial hygiene air monitoring and area air monitoring at the incident release site to ensure emergency response personnel safety.

- Ensure equipment used to monitor personnel and site conditions is appropriately calibrated before and after use.

- Verify the adequacy of emergency response personnel decontamination procedures and areas.

- Provide or coordinate emergency response personnel training according to 29 CFR 1910.120(q).

Security Department

- Provide initial action to secure the emergency area, control traffic, and assist when area evacuation is required as directed by the Emergency Coordinator.

- Throughout closure operations, routinely monitor Demolition Key's treatment facility during nonduty hours, including holidays, to prevent tampering and unauthorized use or access.

- Coordinate with the NAS Key West Port Operations Office, the U.S. Coast Guard, and the Florida Marine Patrol the security and surveillance of the Demolition Key treatment facility during an emergency.

- Maintain Memorandums of Understanding with the City of Key West's Police Department and the Monroe County Sheriff's Department and provide adequate training to both regarding their roles during a closure incident.

- Ensure patrolling units are familiar with potential emergencies and report all suspect situations.

Navy Medical Clinic

- Ensure medical personnel and ambulance(s) (Medivac Unit if necessary) arrive at the incident site, upon emergency call, to assist injured personnel in a timely fashion.

- Ensure emergency treatment is rendered as necessary and injured personnel are removed to the Medical Clinic or to area hospitals for treatment.

- Ensure medical staff is familiar with the symptoms of ordnance constituent exposure and can provide or obtain the necessary treatment from qualified facilities.

- Provide assistance and oversight of personnel decontamination of injured persons requiring medical attention.

- Provide the Emergency Coordinator with current and follow-up information on injured personnel as soon as possible.

Public Affairs Officer

- Respond immediately to emergencies at the Emergency Coordinator's request and collect information necessary to keep public and local media apprised of pertinent facts relating to the emergency.

- Keep abreast of all Navy actions during a closure incident to provide prompt and accurate information to concerned parties regarding the nature of the incident and the steps being taken to correct the problem.

- Act as the central point of contact for external information requests and clear all news releases with the Commanding Officer and the Emergency Coordinator.

COMNAVBASE Legal

- Provide legal advice/assistance, at the Emergency Coordinator's request, to ensure that all necessary information, records, and samples are obtained and safeguarded for possible use in legal actions, to recover cost from or by the Navy.

- Advise the Emergency Coordinator on the legal aspects of emergency response when parties other than the Navy are responsible for the emergency.

- Assist in processing claims associated with the accident/incident.

This represents the major responsibilities by key response personnel. This section of the Contingency Plan is not all inclusive and requires the use of, by all persons, the resources available to NAS Key West and Demolition Key during a closure activity incident.

Contingency Plan Implementation Criteria

The Contingency Plan must be implemented whenever an incident results in the following:

1. Fire/Explosion
   a. Fire releases toxic fumes
   b. Fire spreads beyond area of ignition
   c. Fire threatens offsite areas
   d. Fire-fighting agents result in contaminated runoff or
   e. Threat of an uncontrolled/unplanned explosion is imminent

2. Spills/Leaks
   a. Fire hazard exists due to spilled material
   b. Toxic fume hazard exists
   c. Groundwater may be threatened
   d. Spill threatens offsite property or
   e. Spill threatens navigable water

In a hurricane, the hazardous waste facility will be secured in accordance with the NAS Disaster Response Plan. No facility closure activities will be conducted until the all-clear signal has been given.

Guidance for Fires and Spills Involving Closure Activities

Hazardous Waste Ordnance Fire/Explosion

No combustible structures are associated with the Demolition Key hazardous waste ordnance treatment facility. All transport vehicles associated with the closure operations are equipped with hand-held radios and fire extinguishers. If a fire occurrs, personnel will use fire extinguishers if the fire can be extinguished quickly and safely. If personnel deem the fire to pose too great a challenge, all personnel must evacuate Demolition Key immediately and allow the fire to burn itself out. Upon evacuating Demolition Key, the NAS Key West Fire Department shall be summoned to the northernmost point of Fleming Key to observe the fire and ensure it is confined to Demolition Key.

Because closure activities do not entail the active use of open flames or ignition sources, it is unlikely that fires will occur during closure activities. If, by chance, a fire or explosion did occur, it would likely be the cause of untreated hazardous waste ordnance items remaining as a result of former treatment operations. Because OB/OD protocols establish a system that requires the recovery and retreatment of unburned or undetonated ordnance items, the possibility of untreated ordnance items present at Demolition Key is minimal to nonexistent. Just the same, fires or explosions occurring during the closure of Demolition Key's treatment facility shall be remediated according to the response sequence outlined in this Contingency Plan.

Closure Emergencies

The most probable emergencies involving the closure of Demolition Key include:

- Spills or releases during loading or unloading remediated environmental media at the Demolition Key treatment facility or at NAS Key West's hazardous waste permitted storage facility, respectively; and

- Spills or releases as result of a vehicular accident while transporting remediated environmental media.

It is expected that the physical nature of the remediated material will be solid. (i.e., soil and military ordnance and munitions fragments) Thus, release response to these materials will consist of simply removing by hand, shovel, and broom and subsequently replacing in a proper container for direct transport to NAS Key West's permitted storage facility.

If, by chance, the release occurred into water, gross removal would be required where possible but will be limited due to the nature of the environmental media and constituent physical properties (i.e., solubility) and chemical properties (i.e., reactivity) of the released material.

If during removal unexploded ordnance items are identified, the material will be thermally treated in place. Destruction will be conducted under the emergency treatment provision following proper notification of and authorization by FDEP.

Incompatible Hazardous Waste

Weapons personnel, under the direction of EOD personnel and the Emergency Coordinator, will ensure that released material incompatible with other waste is segregated during temporary storage and that incompatible wastes are not accidentally mixed during cleanup actions following a hazardous waste ordnance incident (see Figure II.B-5 - Reactivity Matrix).

Although not seen as a potential problem, remediated spill residues and the containers in which they are placed shall be segregated according to compatibility groups at the scene of the incident to avoid further problems. The Emergency Coordinator, with assistance from the EOD Technician, will coordinate temporary container staging areas, before transport from the incident scene. Temporary container staging areas shall be a safe distance from the response scene and response/rescue personnel command areas.

Post-Emergency Equipment Maintenance

After an emergency occurs, all emergency equipment will be cleaned for reuse or replaced. Before response operations resume, all safety equipment will be inspected by those to whom it belongs. The Emergency Coordinator, or his or her designee, shall notify state authorities that post-emergency equipment maintenance has been performed and that treatment operations will resume. Notification of said responsibilities will be completed by letter and shall be filed within the Demolition Key operating record file.

Figure II.B-5 Reactivity Matrix

Contingency Plan Implementation

If an impacted environmental media release occurs during accumulation, loading, transportation, unloading, or storage, the following procedure must be initiated by personnel responsible for the ordnance at the time of the release:

1. Locate injured personnel, if any, and notify the local hospital to mobilize ambulances and medical personnel.

2. Evacuate area accordingly to ensure adequate protection of human health and removal efficiency.

3. Dispatch any necessary emergency personnel and associated response equipment to spill site.

4. Monitor response progress to determine the need of additional assistance.

5. Ensure the appropriate use and level of PPE.

6. Remove leaking container(s) to a recovery container.

This procedure is discussed in detail within the following subsections.

Initial Release Notification

Regardless of the emergency unit(s) requiring notification (see Table II.B-1), the notification content must include the following information:

- Location of the emergency response incident
- Physical and chemical nature of released material
- Estimated quantity and size (i.e., area of release)
- Type of release (spill, fire, or explosion) and
- Hazard properties of the released material (e.g. toxic, reactive)

Details shall be communicated to the Emergency Coordinator and responding unit(s) upon their arrival by those familiar with the incident and/or materials involved unless said persons require immediate medical attention. If the incident occurs off-base, personnel involved shall

immediately call 911 (or unit specific number provided in Table II.B-1) for civilian emergency response.

When releases migrate outside military property and/or may require citizen evacuation, the Emergency Coordinator (or alternate contact) or PWO authorized individual must:

1. Notify the Monroe County Emergency Management Office and the Key West fire and police departments.

2. Notify the National Response Center (1-800-424-8802) of the incident. Incident notification shall include:

   - Name and telephone number of the reporter
   - Name and address of the facility responsible for the incident
   - Time and type of incident
   - Name and quantity of material(s) involved
   - Extent of injuries, if any
   - Possible hazards to human health or the environment outside the facility

3. Notify the USEPA Regional Administrator and the appropriate state and local authorities that closure operations will not be resumed release response procedures are completed and all emergency equipment listed herein is decontaminated and reconditioned for its intended purpose before operations resume.

Table II.B-1
Emergency Organizations

Emergency	Organization	Telephone
Injury/Chemical Exposure	Station Dispensary	Ext. 2444
	Florida Keys Memorial Hospital	294-5531
	Key West Poison Control Center	294-5531
Fire/Explosion	Station Fire Department	Ext. 2776
	Explosive Ordnance Disposal Team	(904) 270-5412
	City of Key West Police (incident occurs in city)	294-2511 (911)
	City of Key West Fire Dept. (Incident occurs in city)	911
	Monroe County Emergency Management	289-6018

Table II.B-1
Emergency Organizations

Emergency	Organization	Telephone
Hazardous Material Spill	Station Fire Department	Ext. 2776
	Hazardous Waste Coordinator	Ext. 2304
	City of Key West Police (incident occurs in city)	294-2511 (911)
	City of Key West Fire Dept. (incident occurs in city)	911
	Monroe County Emergency Management	289-6018
Spill in Waterway or Spill in Quantity Exceeding Reportable Quantity (i.e., 1 pound)	National Response Center	1-800-424-8802
	EPA Region IV	(404) 881-4062
	Coast Guard Captain of the Port	294-4760
	Florida Department of Environmental Protection	(904) 488-4809
Natural Disaster	Station Security	Ext. 2515
Hurricane Threat	National Hurricane Center	661-5065

Note:
All area codes are 305 unless otherwise specified; and all extensions are for 296-3561, the main NAS Key West telephone number.

Incident Response

After being notified of an incident, NAS Key West Security Department Central Dispatch will notify the NAS Key West Fire Department or appropriate response unit. (Notifying the appropriate emergency response unit shall also serve as notification to the Emergency Coordinator.)

Upon arriving at the incident scene, NAS Key West Fire Department and/or other appropriate emergency response personnel, under the direction of the Emergency Coordinator, will establish a command post and response zones, if necessary, while trying to obtain details from those persons involved or familiar with the incident. Once the Emergency Coordinator has collected all information relevant to the incident, he/she will assess, with assistance from the NAS Key West Safety Department personnel, the possible direct and indirect human health and/or environmental hazards that may result, or may have resulted.

There is no indirect or direct exposure to constituents expected to cause health concerns requiring the construction of formal work zones. Depending on the location and size of the incident, the Emergency Coordinator may summon the NAS Key West Security Department to assist in traffic control and/or evacuation procedures.

Upon determining the nature of the incident, NAS Key West Fire Department personnel will "control and contain" the release under the guidance of the Emergency Coordinator and EOD personnel. Control and contain includes:

- Rescuing injured personnel
- Establishing "Hazard" and "Evacuation" zones
- Applying water to fires
- Establishing berms around spill material (no liquid materials or expected to be involved in the closure operations.)
- Evacuating surrounding populations (not believed to be required unless unsuspected fire or explosion occurred.)

Control and contain does not include handling or removing spill contents or residue. NAS Key West Fire Department personnel are not trained in impacted media removal techniques and will only attempt to rescue injured personnel with the assistance of an EOD Technician.

If a incident occurs off-base, authorized military personnel accompanying the waste shipment, along with City of Key West Fire Department personnel, will respond and assume incident command responsibilities until the Emergency Coordinator arrives.

All persons transporting environmental media off the legal boundaries of NAS Key West or Demolition Key will complete and have available DD Form 836 (Figure II.B-6). DD Form 836 (Emergency Instructions for Motor Vehicle Drivers and Initial Responders) includes crucial information regarding vehicle contents, emergency notification information, and personnel emergency response guidelines. Off-base transport of hazardous waste defined environmental media will also require a completed Uniform Hazardous Waste Manifest.

Figure II.B-6 DD Form 836

Site Control

The Emergency Coordinator, with assistance from all response command units, shall establish work zones around the incident site and/or area of concern. The Emergency Coordinator and/or a designated representative shall delineate work zones with fencing, rope, caution tape, or other less formal means, depending on the severity and threat of the incident.

Incidents requiring extended amounts of time to remediate or control (i.e., in excess of general chemical neutralization or absorption) shall require formal site control demarcation according to the following specifications.

- **Exclusion Zone**

  The exclusion zone (EZ) will include that location that personnel without the proper training and PPE, chemical-resistant equipment (i.e., respirator, encapsulated suit, chemical-protective gloves, boots, etc.) are prohibited from entry. Only those meeting the training and personal PPE requirement, and authorized by the Emergency Coordinator, shall enter the EZ.

- **Contamination Reduction Zone**

  The Contamination Reduction Zone (CRZ) will consist of an area upwind of the release incident capable of supporting all personnel and equipment decontamination efforts. The CRZ shall consist of adequate cleaning supplies, equipment, and personnel (equipped with the proper PPE) to ensure the complete decontamination of emergency response personnel and equipment. All contaminated equipment and PPE shall be properly contained in the CRZ to prevent the unnecessary spread of contaminants. The CRZ shall be operational before personnel are allowed to enter into the contaminated area.

  Three types of decontamination procedures may be required during removal operations:

  — Site
  — Equipment
  — Personnel

  Site and equipment decontamination procedures during and following removal operations may include removing and containerizing spilled hazardous waste from the environment and from emergency equipment and PPE.

  The final type of decontamination involves people injured during the incident or while participating in the removal operations. As required by the Naval Medical Clinic and

the City of Key West Hospital, chemically contaminated injured persons requiring medical attention must be decontaminated by trained personnel at the site before transport to the hospital. All contamination efforts shall be verified through observation and/or testing, if necessary, to prevent contamination of areas offsite.

- **Support Zone**

The Support Zone (SZ) will consist of the Incident Command Center (i.e., incident coordination and communication area), security personnel, and additional incident response equipment and supplies. The SZ should be staged upwind from the EZ and CRZ and shall be purposely separated from the CRZ to discourage and prevent the spread of contamination from those areas.

Additional site control requirements include:

— Entrance and exits from the contaminated area must be planned and emergency escape routes identified.

— Only personnel with proper PPE and an assigned activity will enter the contaminated area.

— Decontamination procedures must be established to prevent the spread of contaminants from the EZ.

— Entry team shall be thoroughly briefed and debriefed before each entry and following decontamination.

— All personnel and equipment leaving the EZ will be considered contaminated and will pass through the CRZ for proper decontamination.

— All spent wash and rinse solutions, brushes, sponges, etc., used in decontamination must be considered contaminated and shall be properly decontaminated or containerized and disposed.

Establishing site work zones requires adequate knowledge of the ordnance involved, and surrounding population, traffic, and weather patterns. Thus, it is important for the Emergency Coordinator, or his/her designated representative, to assist in the establishment of these zones. Relevant chemical information and remediation equipment knowledge shall prove helpful in determining the proper location and dimension of the incident site work zones.

Decontamination Procedures

Three types of decontamination procedures may be required during closure incident response removal operations: site, equipment, and personnel.

Site and equipment decontamination procedures during and following incident response operations may include removing and containerizing spilled environmental media from emergency equipment and PPE.

Personnel decontamination involves persons injured during the incident or participating in the removal operations. As required by NAS Key West Naval Clinic, chemically contaminated injured persons requiring medical attention must be decontaminated by trained personnel at the site before transport to the hospital. Personnel decontamination procedures may require the removal of chemically contaminated clothing and/or mechanically removing contaminated debris from clothing or skin.

Incident Investigation

At the conclusion of all incident responses, the party responsible for the impacted environmental media at the time of the incident must immediately notify the Demolition Key Emergency Coordinator. Notification shall include all information required by Central Dispatch above, and should also include all actions causing the incident.

Post-Incident Notification

In addition to the initial oral notification by the Emergency Coordinator, a written follow-up report must also be prepared. As required per FAC 62-730 and 40 CFR 264.56(j), all emergencies which require implementing the Demolition Key Contingency Plan will be reported in writing within 15 days to USEPA Region IV and the FDEP. The report will detail:

- Name, address, and telephone number of the facility
- Name, address, and telephone number of facility owner/operator
- Date, time, and type of incident
- Type and quantity of material involved
- Assessment of the impact on human health and the environment
- Quantity and disposition of material released

Evacuation Plan

General Evacuation Procedures

Although environmentally impacted media are not expected to be released during closure activities at Demolition, all personnel in the vicinity of an emergency must be evacuated when toxic fumes or gases are released (or a release is imminent), an explosion has occurred (or is imminent), and/or access for emergency responders must be provided.

If the Emergency Coordinator determines it necessary to evacuate nonessential personnel from an incident site, four methods of communicating evacuation orders/procedures exist:

- Voice or hand signals (for incidents at the Demolition Key treatment facility)
- Public announcement (PA) systems (standard equipment on all fire trucks)
- Bullhorns (standard equipment on each fire department and PMO emergency vehicle)
- Knocking on individual doors in areas of concern

In each instance, emergency personnel will alert evacuees of the reason and where to evacuate and will contact the resources in Table II.B-2 for assistance in reporting the evacuation process. Evacuation routes will depend on wind direction and the location of the incident. Maps of the evacuation routes (and alternative evacuation routes) from the treatment facility and areas along the designated transportation route between NAS Key West and Demolition Key are contained within this operating permit as Figure II.B-3. The hazardous waste treatment facility operator (Weapons Department Officer) and the facility Emergency Coordinator are responsible for determining the best evacuation route.

Table II.B-2
Evacuation Alerting

List of Potential Organizations to Be Alerted If an Evacuation Is Required		Day Phone	24-hr Phone
Naval Air Station Key West	Disaster Preparedness Officer	(305) 293-2988	(305) 293-2971
	Spill Notification Center	(305) 293-3333	(305) 293-3333
	NAS Key West Security	(305) 293-2531	(305) 293-2531
Local Authorities (law enforcement, fire, emergency planning, etc.)	Monroe County Sheriff's Office	(305) 296-2424	(305) 292-7001
	Florida Highway Patrol	(305) 289-2382	(305) 289-2382
	Florida Marine Patrol	(305) 289-2320	(305) 289-2320
	Key West Fire Department	(305) 292-8186	(305) 292-8145
	Key West Police Department	(305) 292-8143	(305) 292-8143

Table II.B-2
Evacuation Alerting

List of Potential Organizations to Be Alerted If an Evacuation Is Required		Day Phone	24-hr Phone
Nearby Institutions (schools, hospitals, etc.)	Lower Florida Keys Health System	(305) 294-5531	(305) 294-5531
	Fishermans Hospital	(305) 743-5533	(305) 743-5533
	Mariners Hospital	(305) 852-9222	(305) 852-9222
	Superintendent of Schools, Monroe County School Board	(305) 296-6523	(305) 296-6523
Radio Stations	WAVK FM 106.3	(305) 743-3434	(305) 743-3434
	WFKZ FM 103.1	(305) 852-9085	(305) 852-9085
	WKRY FM 93.5	(305) 296-2435	(305) 296-2435
Television Stations	WPLG-TV 10	(305) 325-2370 (305) 325-2418 (305) 325-2354	(305) 325-2370
	WSVN-TV 7	(305) 795-2724 (305) 795-2705	(305) 795-2724
	WTVJ-TV 4	(305) 789-4200	(305) 789-4200

The area impacted by the spill will be evacuated accordingly in all directions to ensure protection of response and other affected personnel. Navy boats used during normal operations will block the entrance to the evacuated area. Entrance is possible only by boat and only via a narrow, shallow channel. It is not probable that any spill or leak from a container will require greater evacuation.

Demolition Key Evacuation

Evacuation procedures from the treatment facility at Demolition Key will require that all persons board the vessels they traveled and return to NAS Key West. If the vessels are unable to provide adequate evacuation, a Medivac helicopter can be summoned from the hospital to evacuate personnel.

City of Key West, County of Monroe Evacuation

If the incident occurs in an area outside the Demolition Key treatment facility or NAS Key West, evacuation routes will be determined by the Emergency Coordinator upon his/her arrival with the assistance from the Monroe County Emergency Management personnel. NAS Key West

personnel will assist the Key West and Monroe County officials with equipment, personnel, and other resources to ensure a safe, timely, and efficient evacuation of civilian personnel from the area of concern.

NAS Key West Evacuation

At the time of evacuation, all personnel will be directed on where to evacuate. Evacuation assembly areas will be staffed by medical personnel (Naval Clinic corpsmen and physicians) to attend those exposed persons requiring medical attention. Evacuation assembly areas will help account for those being evacuated.

If the incident occurs or migrates off NAS Key West or Demolition Key, NAS Fire Department and/or Security personnel shall assist the appropriate Key West and Monroe County officials evacuate personnel from hazardous areas as stated above.

Interservice Support Agreement

As discussed briefly, Interservice Support Agreements (Appendix A) exists between NAS Key West and the City of Key West, Florida. These memoranda of understanding (MOUs) with both the fire and police departments outline the type of emergency services each party must provide and the means by which they are summoned and coordinated.

The MOUs provide NAS Key West and the City of Key West additional fire fighting, security, and emergency response assistance when personnel and equipment are available. This agreement does not mandate assistance, but allows for a legal, nonliable method of providing emergency response assistance to both entities when needed.

Upon approval of the closure permit application by USEPA Region IV and FDEP, approved copies of this contingency plan will be sent to and coordinated with the Station Hospital, Station Fire Department, Station Safety Officer, the Station Security Officer, and state and local emergency coordinators.

Emergency Coordinators

The Emergency Coordinator for NAS Key West has the authority to commit the necessary NAS Key West resources to implement this Contingency Plan and has been trained in relevant emergency response issues. The Emergency Coordinator is to commit resources delegated by the Commanding Officer of NAS Key West.

In an unplanned fire, explosion, and/or spill occurs during closure activities, persons responsible for or familiar with the incident shall follow the incident notification procedures above. This

notification will automatically inform the Emergency Coordinator, or his/her alternate, of the situation. The Emergency Coordinator (or Alternate Contact) will be responsible for ensuring the NAS Key West Emergency Management Department representatives and all other necessary response organizations are properly notified.

For off-base incidents, the initial Emergency Coordinator may be a civilian appointee until the NAS Key West Emergency Coordinator (or Alternate Contact) arrives on scene. The NAS Key West Emergency Coordinator will then assume the responsibility of the response activity. Assigning ultimate emergency coordination responsibilities to the NAS Key West Emergency Coordinator ensures coordination by someone familiar with the contents of this permit application, capable of rallying the necessary resources, cognizant of and having the ability to apply the appropriate regulations, and familiar with the properties of military ordnance. Table II.B-3 lists the Demolition Key Emergency and Alternate Coordinators.

Table II.B-3
Emergency Coordinators

Primary Contact	Alternate Contact
Patsy Watson Permitted Hazardous Waste Storage Facility Office (305) 293-2776 Emergency (305) 293-2583	Lt. Tom Poore Weapons Department Office (305) 293-2839 Emergency (305) 293-2653

Emergency Response Equipment

Emergency response to incidents involving closure of the Demolition Key hazardous waste ordnance treatment facility may require the skills of many different units. Each response unit has specific equipment it may use during such an incident. All NAS Key West and Demolition Key emergency response equipment shall be maintained in working condition at all times or immediately replaced with working equipment of identical function.

Tables II.B-4 and II.B-5 list emergency response equipment by equipment item and response unit, respectively, the quantity of the specific item, and phone number of the unit responsible for maintaining and replacing said equipment.

Emergency response equipment includes PPE, monitoring equipment, communication equipment, decontamination equipment, manual use equipment (shovels, rakes, brooms, etc.), absorbent/containment equipment, industrial removal/remediation equipment, and fire fighting equipment.

Table II.B-4
Emergency Response Equipment (by Item)

Equipment	Qty.	Location	Phone
Auger	1	Building A-438	305-293-2586
Backhoe	2	Building A-438	305-392-2586
Bags, Plastic (large)	6	Public Works Building A-437	305-293-2030
Base Station Radios	2	Housing Office WC 80	305-293-2258
Base Station Radios	3	Truman Pier Dispatch Office	305-293-2258
Base Station Radios	3	Main Station Building A-321	305-293-2258
Base Station Radios	1	Building A-149	305-293-2258
Boats (Misc.)	2	Port Operations Building 149	305-293-2586
Boom-Deploying Boats	2	Port Operations Building 149	305-293-2586
Bulldozers	2	Building A-438	305-293-2586
Car/Truck Radios	12	Building A-314	305-293-2258
Car/Truck Radios	4	Building A-149	305-293-2258
Car/Truck Radios	2	Building A-29	305-293-2258
Car/Truck Radios	13	Building A-132	305-293-2258
Cellular Phones	1	Truman Annex Building A-132	305-293-2258
Cellular Phones	1	Public Works	305-293-2258
Chemical-Resistant Boots/Shoes	20	Port Operations Building A-149	305-293-2030
Chemical-Resistant Clothing	380	Port Operations Building A-149	305-293-2030
Earth-Moving (Misc.)	2	Building A-438	305-294-2586
Excavator	1	Building A-438	305-294-2586
Foam-Dispensing Vehicles	6	Building A-132	305-293-2776
Full-Face Canister Respirator	60	Public Works (2)	305-293-2030
Full-Face Canister Respirator	16	Port Operations Building A-149	305-293-2030
Gloves, Rubber	70	Fire Department Building A-132	305-293-2030
Gloves, Rubber	27	Public Works Building A-437	305-293-2030

Table II.B-4
Emergency Response Equipment (by Item)

Equipment	Qty.	Location	Phone
Goggles, Plastic	25	Public Works Building A-437	305-293-2030
Hand-Held Radios	1	Building A-937	305-293-2258
Hand-Held Radios	7	Building A-149	305-293-2258
Hand-Held Radios	27	Building A-314	305-293-2258
Hand-Held Radios	113	Various personnel and Building A-29	305-293-2258
Hand-Held Radios	27	Building A-132	305-293-2258
Hard Hat	20	Port Operations Building A-149	305-293-2030
Hard Hat	4	Haz. Waste Storage Bldg. A-0478	305-293-2030
Inner Chemical-Resistant Gloves	20	Port Operations Building A-149	305-293-2030
Life Vests	40	Port Operations Building A-149	305-293-2030
Mop, Cotton	30	Public Works Haz. Collection Loc. (1)*	305-293-2030
Mop Squeezer	30	Public Works Haz. Collection Loc. (1)*	305-293-2030
Motor Grader	1	Building A-438	305-293-2586
Other (Fire Fighting)	3	Building A-132	305-293-2776
Other Fire Trucks	3	Building A-132	305-293-2776
Outer Chem.-Resistant Gloves	4	Port Operations Building A-149	305-293-2030
Outer Chem.-Resistant Gloves	360	Public Works (12)*	305-293-2030
Pail, Plastic (5-gal)	12	Public Works Haz. Collection Loc. (1)*	305-293-2030
Pail, Plastic 3-gal)	30	Public Works Haz. Collection Loc. (1)*	305-293-2030
Rags	3	Public Works Building A-437	305-293-2030
Rubber Boots	70	Fire Department Building	305-293-2030
Rubber Boots	25	Public Works Building A-437	305-293-2030
Safety Goggles	20	Port Operations Building A-149	305-293-2030
Safety Goggles	60	Public Works (2)	305-293-2030
SCBA Respirator	2	NAVOSH Building A-515	305-293-2030

Table II.B-4
Emergency Response Equipment (by Item)

Equipment	Qty.	Location	Phone
SCBA Respirator	25	Fire Department Building A-132	305-293-2030
Shovel, Sq Nose (Long)	35	Public Works Haz. Collection Loc. (1)*	305-293-2030
Shovel, Rd Nose (Long)	5	Public Works Haz. Collection Loc. (1)*	305-293-2030
Skimmers	3	Maintenance Utility Building A-437	305-293-2210
Sorbent	150	Port Operations Building A-149	305-293-5374
Sorbent Boom (White)	80	Port Operations Building A-149	305-293-5374
Sorbent Rolls	90	Port Operations Building A-149	305-293-5374
Trailers	4	Port Ops. Bldg. A-149 & Bldg. A-824	305-293-2586
Vacuum Trucks	1	Hazardous Waste Storage Bldg. A-824	305-745-6171

Notes:
* Indicates the number of stockpiled items stored at each location

Self-contained breathing apparatus (SCBA)

Table II.B-5
Emergency Response Equipment (by Location)

Location	Equipment	Qty.	Phone
Building A-29	Car/Truck Radios	2	305-293-2258
Building A-149	Base Station Radios	1	305-293-2258
Building A-149	Car/Truck Radios	4	305-293-2258
Building A-149	Hand-held Radios	7	305-293-2258
Building A-132	Foam-Dispensing Vehicles	6	305-293-2776
Building A-132	Hand-held Radios	27	305-293-2258
Building A-132	Car/Truck Radios	13	305-293-2258
Building A-132	Other (Fire Fighting)	3	305-293-2258
Building A-132	Other Fire Trucks	3	305-293-2258
Building A-314	Hand-held Radios	27	305-293-2258
Building A-314	Car/Truck Radios	12	305-293-2258
Building A-438	Bulldozers	2	305-293-2586
Building A-438	Motor Grader	1	305-293-2586
Building A-438	Earth-Moving (Misc.)	2	305-293-2586
Building A-438	Excavator	1	305-293-2586
Building A-438	Auger	1	305-293-2586
Building A-438	Backhoe	2	305-293-2586
Building A-937	Hand-held Radios	1	305-293-2258
Building A-132	SCBA Respirator	25	305-293-2030
Building A-132	Rubber Boots	70	305-293-2030
Building A-132	Gloves, Rubber	70	305-293-2030
Haz. Waste Storage Bldg. A-0478	Hard Hat	4	305-293-2030
Haz. Waste Storage Bldg. A-824	Vacuum Trucks	1	305-745-6171
Housing Office WC 80	Base Station Radios	2	305-293-2258
Main Station Building A-321	Base Station Radios	3	305-293-2258

Table II.B-5
Emergency Response Equipment (by Location)

Location	Equipment	Qty.	Phone
Maintenance Utility Building A-437	Skimmers	3	305-293-2210
NAVOSH Building A-515	SCBA Respirator	2	305-293-2030
Port Operations Building A-149	Boom-Deploying Boats	2	305-293-2586
Port Operations Building A-149	Boats (Misc.)	2	305-293-2586
Port Operations Building A-149	Sorbent	150	305-293-5374
Port Operations Building A-149	Sorbent Rolls	90	305-293-5374
Port Operations Building A-149	Sorbent Boom (White)	80	305-293-5374
Port Operations Building A-149	Outer Chem-Resistant Gloves	4	305-293-2030
Port Operations Building A-149	Safety Goggles	20	305-293-2030
Port Operations Building A-149	Hard Hat	20	305-293-2030
Port Operations Building A-149	Life Vests	40	305-293-2030
Port Operations Building A-149	Inner Chemical-Resistant Gloves	20	305-293-2030
Port Operations Building A-149	Chemical-Resistant Clothing	380	305-293-2030
Port Operations Building A-149	Full-Face Canister Respirator	16	305-293-2030
Port Operations Building A-149	Chemical-Resistant Boots/Shoes	20	305-293-2030
Port Ops. Bldg. A-149 & Bldg. A-82421	Trailers	4	305-293-2586
Public Works	Cellular Phones	1	305-293-2258
Public Works Building A-437	Bags, Plastic (large)	6	305-293-2030
Public Works Building A-437	Rubber Boots	25	305-293-2030
Public Works (2)	Safety Goggles	60	305-293-2030
Public Works (2)	Full-Face Canister Respirator	30	305-293-2030
Public Works (12)*	Outer Chem-Resistant Gloves	360	305-293-2030
Public Works Building A-437	Goggles, Plastic	25	305-293-2030
Public Works Building A-437	Gloves, Rubber	27	305-293-2030
Public Works Building A-437	Rags	3	305-293-2030

Table II.B-5
Emergency Response Equipment (by Location)

Location	Equipment	Qty.	Phone
Public Works Haz. Collection Loc. (1)*	Shovel, Rd Nose (Long)	5	305-293-2030
Public Works Haz. Collection Loc. (1)*	Shovel, Sq Nose (Long)	35	305-293-2030
Public Works Haz. Collection Loc. (1)*	Mop Squeezer	30	305-293-2030
Public Works Haz. Collection Loc. (1)*	Mop, Cotton	30	305-293-2030
Public Works Haz. Collection Loc. (1)*	Pail, Plastic (3-gal)	30	305-293-2030
Public Works Haz. Collection Loc. (1)*	Pail, Plastic (5-gal)	12	305-293-2030
Truman Annex Building A-132	Cellular Phones	1	305-293-2258
Truman Pier Dispatch Office	Base Station Radios	3	305-293-2258

Note:
* Indicates the number of stockpiled items stored at each location.

Spill control equipment consists of nonsparking shovels and a 55-gallon drum. Fire fighting equipment consists of two carbon dioxide fire extinguishers and shovels. Communications equipment consists of a minimum of two, two-way radios. Fire extinguishers, shovels, and radios will be aboard each boat and at the Demolition Key treatment facility during closure operations and at EOD Offices at Truman Annex, Key West, at other times. The first-aid kit includes:

- Burn treatment
- Antiseptic adhesive bandages
- Tape
- Compresses for treating of minor cuts and scrapes

All emergency response teams, including the hospital, will be notified each day prior to conducting closure operations. Navy band 81 is dedicated for EOD personnel and shall be used by all closure operation participants.

Table II.B-6 lists the City of Key West's Fire Department emergency response equipment available to NAS Key West during an emergency.

Training

All emergency response personnel receive training in the proper handling and storage of military ordnance as it applies to their task, according to the Training Plan included in this operating permit.

NAS Key West requires all individuals involved in operations involving hazardous constituents or waste to receive appropriate annual training. Those persons not appropriately trained according to 29 CFR 1910.120(p) are prohibited from participating in closure operations until attending and passing the requisite training requirement.

Inspection and Surveillance of Treatment Facility

As discussed later in this section, the treatment facility will be inspected daily by EOD Technicians before and during closure operations to identify hazardous conditions and prevent accidents involving untreated ordnance items from past hazardous waste ordnance treatment operations. In addition to the EOD Technician sweep of the treatment area, security personnel will survey the island to ensure unauthorized persons are not present.

Table II.B-6
City of Key West's Fire Department
Emergency Equipment List

Equipment on Ladder (75 ft. Aerial)	Equipment on Pumper
900 ft. 3.0" hose	12 ft. soft suction hose
400 ft. 1.75" hose	20 ft. hard suction hose
12 ft. soft suction	2000 ft of 3.0" fire hose
20 ft. hard suction	400 ft. 2.5" fire hose
One 10 ft. folding ladder	400 ft. of 1.75" fire hose
One 12 ft. folding ladder	One 24 ft. extension ladder
One 14 ft. roof ladder	One 14 ft. roof ladder
One 16 ft. extension ladder	One 10 ft. folding ladder
One 20 ft. extension ladder	Portable generator 3,500-watt
One 26 ft. extension ladder	Two halogen lights 500-watt
One 30 ft. extension ladder	Two free-standing lights
One 35 ft. extension ladder	One exhaust fan
Two 24" x 24" air bags	One tool box assorted
One 6" x 6" air bag	Two pike poles (8' & 10')
Hurst tool with accessories	Three 100 ft. rescue ropes
One truck radio	One high-rise pack
One mobile radio	One chain saw
Six SCBAs with 30-min. bottles	Assorted hose accessories
Four 30-min. bottles	Five SCBAs including 30-min. bottles
20 lb. ABC dry chemical extinguisher	Four 30 min. bottles
20 lb. CO_2 extinguisher	0_2 bottle with mask
0_2 bottle	One truck radio
Assorted nozzles	One mobile radio
One portable 3,500-watt generator	Two salvage covers (20 x 20)

Table II.B-6
City of Key West's Fire Department
Emergency Equipment List

Equipment on Ladder (75 ft. Aerial)	Equipment on Pumper
Exhaust fan	One 36' bolt cutters
Two lights	One 42" hooligan
Two rescue ropes (100')	One 36" pinch bar
Bolt cutters (36")	Assorted nozzles
One 36" pinch bar	200 ft. .75" hose (booster hose)
One 42" hooligan	First-aid kit
One high-rise pack	200 lb CO_2 extinguisher
One Saws-all	20 lb. ABC dry chemical extinguisher

PREVENTIVE PROCEDURES, STRUCTURES, AND EQUIPMENT

Loading/Unloading Operations

Environmentally impacted media (i.e., soil) will be loaded manually onto vessels for subsequent transport to Truman Annex. Forklifts will be used to unload and load said material from the vessels and onto trucks, respectively, for transport to the NAS Key West permitted hazardous waste storage facility.

Runoff

Runon and runoff from the treatment unit is not considered to cause additional threat to human health or the environment during closure activities above and beyond what, if any, is caused currently. As such, no runon/runoff structures will be provided during closure activities. All materials removed from the treatment facility will be immediately placed within a container to eliminate the need for engineered runon/runoff structures.

Water Supplies

Emergency water supplies are not required for closure activities.

Equipment and Power Failure

Closure activities will not require special precautions due to equipment and/or power failure.

Personal Protective Equipment

Personnel handling impacted environmental media shall be properly dressed in PPE including: latex/nitrile inner gloves, cotton or leather outer gloves, safety glasses with side shields (when required), Tyvek coveralls, Navy-issued combat boots, and full- or half-face air-purifying respirator with combination cartridges (if deemed necessary by the Safety Department).

Prevention of Reactions of Ignitable, Reactive, and Incompatible Wastes

Personnel involved in closure operations at Demolition Key's treatment facility will be properly trained according to 29 CFR 1910.120(p) at a minimum. To the greatest extent practical, personnel shall execute extreme care in removing impacted environmental media and ordnance scrap materials during facility closure operations to prevent potential reactions which may:

- Generate extreme heat, pressure, fire, explosions, or violent reactions;
- Produce uncontrolled toxic mists, fumes, dusts, or gases in sufficient quantities to threaten human health or the environment;
- Produce uncontrolled flammable fumes or gases in sufficient quantities to pose a risk of fire or explosion; or
- Through other like means, threaten human health or the environment.

All hazardous waste formerly treated at Demolition Key's treatment facility were known to be reactive due to their inherent physical characteristics. Although treatment facility maintenance operations included unit clearance of scrap and untreated waste ordnance, personnel must take appropriate measures during closure operations to prevent accidental ignition/detonation of hazardous waste ordnance and munitions if discovered. The most prominent threat arises from external ignition sources such as open flames, sparks, etc. NAVSEA OP-5, along with base-specific standard operating procedures (SOPs), dictate a number of safety guidelines which are strictly enforced to ensure that accidental ignition does not result. These guidelines include, but are not limited to:

- No-smoking signs shall be posted at the entrance(s) to the impact ranges,
- Unauthorized ignition sources shall be prohibited at the artillery impact ranges,

- Spark-producing equipment and tools shall be prohibited from use near explosive materials unless specifically authorized,

- Supervisors shall inspect all hand tools and mechanical devices to ensure they have not become unsafe for use as designated either to the item or to the operator,

PREPAREDNESS AND PREVENTION PLANS

This section discusses the procedures, equipment, and structures maintained by NAS Key West to prevent incidents related to the closure operations and processes at Demolition Key approximately one-quarter mile (1,320 feet) from the northernmost point of Fleming Key across the Garrison Bight Channel. The following information is provided in accordance with FAC 62-730.180, and 40 CFR 270.14(b)(4), (5), (6), (8), and (9) and addresses the requirements of 40 CFR 264.14, 264.15, and 264.30 to 264.37.

Waiver of Preparedness and Prevention Requirements

As owner and operator, NAS Key West does not request a waiver of the Preparedness and Prevention Plan requirements of FAC 62-730.180 and 40 CFR Subpart C as they apply to the closure operations conducted at Demolition Key. Documentation of compliance with these requirements is contained throughout this closure permit.

Inspection Schedule

General Inspection Requirements

NAS Key West regularly inspects all equipment used in the closure process of the Demolition Key hazardous waste ordnance treatment facility. Figure II.B-7 presents a comprehensive tabulation of inspection items, types of problems, and frequencies of inspection.

The NAS Key West PWO Environmental Engineer is responsible for ensuring that inspections are completed and properly documented. Logs include an inspection checklist, "typical problems" highlight list, date and time of inspection, inspector's name, and a comments column in which observations and specific recommendations may be recorded. The inspector is required to check the status of each item and indicate whether its condition is acceptable, and to follow up on unacceptable items with the date and nature of corrections or repairs. Current inspection logs are maintained at the Weapons Department office (see Section II.B.9). Completed inspection logs are maintained by the NAS Key West PWO Environmental Engineer and retained at least three years.

Figure II.B-7 Hazardous Waste Treatment Facility Checklist

Specific Inspection Requirements

Emergency equipment will be inspected prior to closure operations to ensure that all items are operational and in excellent condition. Portable fire extinguishers shall be inspected by noting the pressure of each, the condition of the hose and cylinder, placement of pull pin, and for residue in the nozzle that may prevent its operation. Extinguishers that exhibit low pressure shall be recharged either at the NAS Key West Fire Department or an offsite facility, as applicable. Extinguishers failing any of the inspection categories shall be immediately repaired or taken out of service and replaced.

The contents of all first-aid kits shall be inspected to ensure they are fully stocked or replaced. At least two fire blankets shall be taken to the treatment facility. These blankets shall be inspected for signs of deterioration, tears, and/or holes. The condition shall be noted on the inspection log sheet. Blankets in poor condition shall be replaced. All miscellaneous tools that are used at the treatment facilities shall be inspected for cracked handles or loose blades. All two-way radios shall be inspected before closure operations. They shall be in proper working order and all malfunctions shall be reported on the inspection log sheet.

Weapons personnel shall inspect all vehicles and loading/unloading equipment prior to transporting environmental media from the treatment facility to NAS Key West's permitted storage facility. Inspection items include:

- Exposed electrical wiring on all transportation and mechanical loading/unloading equipment,
- Brakes and steering fluids and condition,
- Visual inspection of fire extinguishers and first-aid kits,
- Hydraulic systems and hoses,
- Watercraft maintenance and condition,
- Pier and docking facility securing devices, and
- Communication devices in each transporting vehicle.

All malfunctions shall be repaired before to transporting to the treatment areas.

Corrective Action

NAS Key West's Public Works Department is authorized to initiate immediate corrective action for unacceptable emergency or nonemergency conditions. If an emergency actually exists, the EOD or Weapons Department inspector must immediately notify the Demolition Key Emergency Coordinator.

Required Equipment

Internal and External Communications

All vehicles (road and water) used to transport people to or remediated environmental media from Demolition Key are equipped with two-way radios for communications and emergencies. The NAS Key West Weapons Department Officer is required to notify the NAS Key West Fire Department daily prior to commencing closure operations at Demolition Key. All two-way radios used during loading/unloading, transporting, and closure operations are set to Channel 81, which is maintained as a priority frequency.

NAS Key West personnel are required to use the "buddy system" when conducting closure activities. As such, personnel will always be available to summon assistance from emergency personnel. No less than one EOD person will accompany each stage of the closure process.

Emergency Equipment

Each transport vehicle associated with the closure operations shall be equipped with fire extinguishers and first-aid kits.

Water for Fire Control

There are no structures on Demolition Key other than the treatment units themselves nor is fire expected to occur as part of closure operations. Therefore, there is no need for fire control water sources. In the unlikely event that a fire is started, personnel will retreat to a safe distance and allow the fire to burn itself out. NAS Key West has fire fighting capabilities which would respond if areas outside Demolition Key were threatened.

Interservice Support Agreement

NAS Key West and the City of Key West have interservice support agreements (Mutual Fire Fighting Assistance Agreement) which provide each entity with fire and security assistance from the other when available (Appendix A). These interservice support agreements are detailed in the facility Contingency Plan as part of this section.

PERSONNEL TRAINING

This section of the Demolition Key closure application defines the training requirements for those involved in the management and closure of Demolition Key as required by FAC 62-730.180, 40 CFR 270.14(b)(12), 40 CFR 264.16, and 29 CFR 1910.120(p).

All personnel involved in the closure operations at Demolition Key must successfully complete general and duty-specific training prior to, or within six months of assignment to said position or responsibility that complies with 40 CFR 264.16, Operational Navy Instruction (OPNAVINST) 5090.1B (or latest version) — Environmental and Natural Resources Program Manual, the NAS Key West Hazardous Waste Management Plan, and specific operational training. Additionally, these personnel must participate in annual review training as required by the above references and/or instructions.

General Personnel Training

All persons responsible for implementing the contents of this closure application at Demolition Key will be provided the following instruction as it pertains to their responsibilities, including compliance with applicable sections of RCRA and this application and familiarity with emergency procedures, emergency equipment, and emergency systems, including:

- Procedures for using, inspecting, repairing, and replacing facility emergency monitoring and control equipment.
- Communications or alarm systems.
- Safe operating procedures when responding to fires and/or explosions.
- Response to groundwater and/or surface water contamination.
- Shutdown of operations.
- Methods used to minimize the risks from health and safety hazards.
- Selection and use of appropriate PPE.
- Appropriate response to overexposure from health hazards or injury.
- Recognition of symptoms resulting from overexposure.

This training is provided to all employees within six months of assignment to a task requiring the involvement of personnel in closure remediation/removal operations as defined in this permit application and includes 24 hours of initial training and eight hours of annual refresher training. The scope of training provided within the 24- and eight-hour training courses is provided in Figures II.B-8 and II.B-9.

Personnel-Specific Training Requirements

Explosive Ordnance Disposal Personnel Training

EOD personnel are responsible for the identifying and deactivating any unexploded military ordnance and/or munitions discovered during closure operations at Demolition Key. In addition to the general training provided to all personnel managing as part of this permit application, EOD personnel receive training in the following areas as required and provided in NAVSEA OP-5:

- Ordnance identification (i.e., type of mortar, grenade, Cartridge Actuated Device [CAD], etc.)
- Ordnance classification (i.e., Code A, Code H, etc.)
- Ordnance deactivation
- Ordnance packaging, loading, and unloading
- Activity PPE and use
- Firing charge sequencing and initiator use
- Activity safe distance delineation and clearance activities

EOD personnel must attend formal schooling. The EOD course of instruction consists of 27 weeks of formal training. The EOD Basic course consists of three phases:

- Phase I — Conducted at Eglin Air Force Base, FL, consists of 12 weeks of training.
- Phase II — Conducted at Indian Head, MD, consists of six weeks of training on conventional ordnance.
- Phase III — Conducted at Indian Head, MD, consists of six weeks of training on nuclear weapons.

Figure II.B-8
24-Hour Training

DAY 1

a. Introduction: Show video — "Handling Hazardous Waste, an Introduction."

b. Regulatory Agencies/Regulations: List agencies and regulations that govern the management and treatment of hazardous waste at Demolition Key. Discuss how these regulations affect operations and the systems in place to ensure compliance. Show Aberdeen Proving Ground video. (a & b, One hour)

c. Show slides of hazardous waste operations at NAS Key West and Demolition Key. Discuss per day violations for hazardous waste violations, the lifting of sovereign immunity in relationship to paying for fines, and past practice of service in kind. (1/2 hour)

d. Defense Reutilization and Marketing Office (DRMO) hazardous waste turn-in requirements (i.e., forms, regulatory information, etc.). (1/2 hour)

e. Review 29 CFR 1910.1200 (Hazard Communication Standard) definitions and explain purpose of regulation and application to operations at Demolition Key. *Show Your Health Matters* and *MSDS* videos. Distribute two Material Safety Data Sheets (MSDS) (Hazardous Material Identification System (HMIS) and commercial source) and discuss each part of both MSDSs and the differences between them (1 hour). If time permits, show *It Can't Happen Here* video. Explain the use of MSDSs as they relate to ordnance ash handling and NAVSEAOP-5.

MEET AT NAVOSH TRAINING ROOM AT 1300

f. NAVOSH hazardous material (including hazardous waste) training and hazard communication training. Videos discussing MSDS, labeling and marking (including DOT and Resource Conservation and Recovery Act [RCRA]), training, nonroutine task descriptions, etc. (Three hours)

Figure II.B-8 (continued)
24-Hour Training

DAY 2

a. Review Day 1:

1. RCRA, OSHA, DOT - laws which govern handling of hazardous waste

2. USEPA, FDEP are regulatory agencies which oversee the laws

3. MSDS - RIGHT-TO-KNOW - OSHA

b. 49 CFR 171 & 172 definitions, hazardous materials transport (HMT), emergency response guide (ERG), reportable quantity (RQ). Provide DOT definition handout. Complete exercise (overhead), discuss manifest, and show *Packaging Hazardous Waste* video (2.25 hrs)

c. 40 CFR 260 definitions, 261 Subparts A, B, C, & D (Two hours)

d. Review Demolition Key hazardous waste Preparedness and Prevention Plan and Contingency Plan (Three hours) with emphasis on:

- Use, maintenance, and decontamination of emergency response equipment
- Establishing zones of response (i.e., exclusion, contamination reduction, and support)
- Selection of PPE and storage locations
- Response notification agencies and procedures
- Evacuation and emergency medical routes
- Response agencies and personnel responsibilities

Figure II.B-8 (continued)
24-Hour Training

DAY 3

a. Review Day 2.

1. HMT - Gives proper shipping name, hazard class, labeling information

2. DOT definition of flammable and combustible vs. ignitable and reactive

3. 40 CFR 261 listed and characteristic waste codes

4. Preparedness and prevention and contingency plans

b. Distribute the hazardous waste treatment area weekly inspection list and discuss each inspection item, documentation procedures, and corrective action procedures. (0.5 hours)

c. Do hazardous waste exercise(s), show *Hazardous Waste Management* video. (1.5 hours)

d. 40 CFR 262, 263, 265, 268 - Do hazardous waste manifest exercise (One hour)

e. NASKWINST 5090.2 and Forms, do collection point exercise (One hour) (use overhead for log example)

f. Show *Minimizations* video after lunch.

g. Site visit to Demolition Key for weekly facility inspection exercise (APPROX 1330)

h. 29 CFR 1910.120 - show *HAZWOPER Awareness and Responding to Oil Spill* videos (0.75 hours)

i. Final Exam (allow One hour)

Figure II.B-9

Hazardous Waste Handling Refresher Course (8 Hours)

INTRODUCTION

A. Environmental Regulations
B. Regulatory Agencies
C. Environmental Liability

REGULATIONS

A. 29 CFR 1910.1200
B. 29 CFR 1910.120(p)
B. 49 CFR 171-178
C. 40 CFR 261, 262, 263, 265, 273
D. 40 CFR 268

HAZARDOUS WASTE COLLECTING, HANDLING AND STORAGE PROCEDURES

A. Hazardous waste originator responsibilities
B. Collection point operations
C. MSDS and military specification information
D. Collection point exercise
E. Preparedness and prevention plan and contingency plan overview

The EOD refresher course consists of four weeks of training on both conventional and nuclear ordnance. This block of instruction is classified and requires:

- EODB students successfully complete each phase of training to acquire the MOS 2305 EOD Officer or 2336 EOD enlisted;

- EODR students attend the refresher course annually.

Due to the classification of these training courses, specific outlines cannot be included in this permit application. In addition to the formal classroom training, EOD personnel are continually instructed, through on-the-job training, to properly handle and treat military ordnance.

Due to the nature of ordnance treatment and the special training for those responsible for this treatment, responsibility-specific training will be provided by unit personnel and the US Department of the Navy. All general hazardous waste handler training will be provided by NAS Key West. Personnel-specific training outlines are provided for each personnel classification defined in the following paragraphs of this section.

Weapons Personnel

Weapons personnel are responsible for managing military ordnance (serviceable and unserviceable) at Demolition Key and assisting EOD personnel with proper management of discovered ordnance and/or munition items. In addition to the general training, Weapons personnel are trained in the following areas as required by and provided in NAVSEA OP-5:

- Navy-issued NARs, safety bulletins, and field returns
- Ordnance reclassification procedures
- Ordnance disposition request procedures
- Ordnance loading and unloading procedures
- Ordnance packaging, labeling, and manifesting procedures
- Ordnance compatibility requirements

Weapons personnel are trained in the above topics as required by the following training manuals:

- Personnel Qualification Standard for Conventional Weapons — *Explosive Handling and Stowage Afloat/Ashore*, NAVEDTRA 43202 (B) et al.

- *Explosive Handling Personnel Qualification and Certification (Qual/Cert) and Program*, COMNAVAIRLANT 8023.5G et al.

- *Conventional Ammunition Integration Maintenance System*, SPCC Instruction 8010.12D et al. Supplement NAVORDCEN Instruction 8010.2 et al.

In addition to the formal classroom training, Weapons Department personnel are continually instructed, through on-the-job training, on the contents of this permit application.

Training Certification

The safe and successful sampling and removal of impacted environmental media requires detailed and specific personnel training. As such, all personnel involved in the closure operations must receive certification by passing all examinations related to the occupation-specific training course(s) described above. The certification training program details specific procedural and behavioral requirements for working with ammunition and explosive wastes.

Relevance of Training to Job Position

Training is oriented specifically to personnel involved in handling hazardous waste ordnance and environmental remediation at Demolition Key. As such, all EOD and Weapons Department personnel receive ordnance training to ensure the handling of ordnance in the safest manner possible.

Training Frequency and Techniques

As mentioned in previous paragraphs, all personnel involved in the closure operations must successfully complete the specified classroom training and periodically receive hands-on field training (i.e., EOD and Weapons Department personnel only). The field experience ensures Demolition Key personnel have the most recent knowledge and techniques for munitions and ordnance related activities. EOD or Weapons Department personnel not receiving the required field training for a specific military ordnance will be prohibited from participating in operations until training has been received.

Formal classroom training is accomplished following appointment to an EOD or Weapons Division. Refresher courses must be attended annually. The entire training for EOD and Weapons Department personnel is a cohesive program which uses field experience with classroom instruction and refresher courses.

Implementation of Training Program

All new personnel assigned to closure operation detail will complete the initial hazardous waste handlers training course within six months of being assigned to a position that handles or directly supervises Demolition Key removal operations. Personnel not receiving the prerequisite training will be prohibited from working unsupervised.

Employee records listing the name, job title, job description, and completed training programs are maintained at the NAS Key West Weapons Department for at least three years.

SECTION II.B.7

CHEMICAL AND PHYSICAL ANALYSES

CHEMICAL AND PHYSICAL ANALYSES

Introduction

The information in this section is submitted in accordance with the requirements of FAC 62-730.181, 40 CFR 264.13(a) and (c), and 40 CFR 270.14(b)(2). This section describes the physical and chemical properties of the hazardous waste ordnance treated at Demolition Key.

The information included in Tables II.B-7 through II.B-9 of this section represents the propellant, explosive, and pyrotechnic (PEP) components in ordnance items treated at Demolition Key. The type, quantity, and concentration of a specific PEP in an ordnance item varies according to the ordnance. This section will present the physical and chemical nature of each PEP without providing information on specific classified military ordnance composition. More specific information regarding ordnance composition is presented in Section II.C.3 of this closure permit application regarding fate and transport of military ordnance treatment operations.

Table II.B-7
High Explosives

TRINITROTOLUENE (TNT)

Composition:	100% TNT
Empirical Formula:	$C_7H_5N_3O_6$
Molecular Weight (g-mole):	227.06
LeBas Molar Volume (cm^3/mol):	203.7
Coefficient for diffusion in air (m^2/sec):	5.9E-06
Coefficient for diffusion in water (m^2/sec):	5.8E-10
CAS:	118-96-7
Boiling Point:	Explodes at 240°C
Freezing/Melting Point:	80.1°C
Density:	1.65 g/ml
Vapor Pressure:	1.1E-06
Aqueous Solubility:	5.4E-04 mol/L 123 mg/L
Henry's Law Constant:	2.0E-03 (L-torr)/mol
Log octanol/water partition coefficient (K_{ow})	1.60 log K_{ow}
Derivation:	Nitration of toluene with mixed acid. Small amounts of 2,3,4- and 2,4,5- isomers are produced, which may be removed by washing with aqueous sodium sulfite solution.
Grade:	Technical

Hazard:	Flammable, dangerous fire risk, moderate explosion risk, will detonate only if vigorously shocked or heated to 450°F (232°C). Toxic by ingestion, inhalation, and skin absorption. TLV: 0.5 mg/m³ of air.
RfD_o (mg/kg/d):	5.00E-04
CPS_o (kg-d/mg):	3.00E-02
Risk-Based Concentrations:	
Tap Water (μg/L):	2.2 c
Ambient Air (μg/m³):	0.21 c
Fish (mg/kg):	0.11 c
Soil Ingestion:	
Industrial (mg/kg):	190 c
Residential (mg/kg):	21 c
Health Advisories:	
10 kg Child:	
One day (mg/L):	0.02
Ten day (mg/L):	0.02
Longer term (mg/L):	0.02
70 kg Adult:	
Longer term (mg/L):	0.02
RfD (mg/kg/d):	0.0005
DWEL (mg/L):	0.02
Lifetime (mg/L):	0.002
mg/L at 10^{-4} Cancer risk:	0.1

Co-contaminants

According to Layton et al., 1986, TNT is the most widely used military explosive, and it is present in the largest quantity in the demilitarization inventory. Also, TNT has the greatest number of co-contaminants of potential concern.

TNT co-contaminants and the sources of the contamination.

Co-contaminants	Source
1,3,5-Trinitrobenzene (TNB)	impurity in parent explosive and as a photolysis product of the explosive
1,3-Dinitrobenzene (DNB)	impurity in parent explosive
2,4-Dinitrotoluene (2,4-DNT)	impurity in parent explosive
2,6-Dinitrotoluene (2,6-DNT)	impurity in parent explosive
2-Amino-4,6-dinitrotoluene (2-amino-4,6-DNT)	degradation product of explosive
4-Amino-2,6-dinitrotoluene (4-amino-2,6-DNT)	degradation product of explosive

Partition Coefficients

Data on the movement and uptake of TNT in environmental media, including biota, are needed to understand its behavior in the environment and to estimate potential exposure pathways to humans via plants, crops, fish, etc.

Partition coefficients for use in estimating contaminant movement in environmental media and human exposures to TNT.

Partition coefficient	Value
SOC/water (K_{oc})	470 (mg/kg SOC)/(mg/kg water)
Plant/soil (K_{sp})	2 (mg/kg plant)/(mg/kg soil)
Beef-fat/diet (K_{fd})	2.6×10^{-3} (ppm in fat)/(ppm in diet)
Fish/water (K_{fw})	7 (mg/kg fish)/(mg/kg water)

Absorption

Like other nitroaromatics, TNT can be absorbed through the skin, lungs, and gastrointestinal track (Zakhari et al., 1978). Other studies (Putnam and Herman, 1919; Neal et al., 1944) have identified dermal absorption as an important pathway of TNT uptake.

In 1944, Neal et al. studied dermal absorption of TNT in pigs. A small sample of TNT was applied to the backs of the pigs. Small quantities of TNT metabolites were found in the urine for up to eight days.

Health Effects

The first long-term animal studies designed to detect carcinogenic responses in animals administered TNT in their diet were performed by Furedi et al. 1984. These researchers observed statistically significant increases in the incidence of malignant tumors in rats and mice in different tissue sites at the highest treatment levels used in the studies. There are no studies that specifically studied the association between TNT exposures and the incidence of cancer in exposed humans.

Other studies have shown that symptoms of TNT intoxication include nasal discomfort, sneezing, sore throat, epistaxis (nosebleed), coryza (common cold), erythema (reddened skin), rashes, skin eruptions, gastritis, nausea, and vomiting. Symptoms of severe toxicity include cyanosis, toxic jaundice, aplastic anemia, cataracts, menstrual disorders, and numerous neurological manifestations.

CYCLOTRIMETHYLENETRINITRAMINE (RDX)

Composition:		Not Found
Empirical Formula:		$C_3H_6N_6O_6$
Molecular Weight (g-mole):		222.09
LeBas Molar Volume (cm^3/mol):		195.0
Coefficient for diffusion in air (m^2/sec):		6.0E-06
Coefficient for diffusion in water (m^2/sec):		5.9E-10
CAS:		121-82-4
Freezing/Melting Point:		205 to 206°C
Density:		1.82 g/mL
Vapor Pressure:		1.0E-09
Aqueous Solubility:		1.9E-04 mol/L 42.2 mg/L
Henry's Law Constant:		5.0E-06 (L-torr)/mol
Diffusion coefficients:	Air: Water:	6.0×10^{-6} 5.9×10^{-10}
Log octanol/water partition		0.87 log K_{ow}
Derivation:		Reaction of hexamethylenetetramine with concentrated nitric acid.
Hazard:		High explosive, easily initiated by mercury fulminate. Toxic by inhalation and skin contact. TLV: 1.5 mg/m3 of air. RDX is 1.5 times as powerful as TNT.

Health Advisories:

10 kg Child:

One day (mg/L):	0.1
Ten day (mg/L):	0.1
Longer term (mg/L):	0.1

70 kg Adult:

Longer term (mg/L):	0.4
RfD (mg/kg/d):	0.003
DWEL (mg/L):	0.1
Lifetime (mg/L):	0.002
mg/L at 10^{-4} Cancer risk:	0.03

Co-contaminants

The major co-contaminant of RDX is HMX ($C_8H_8N_8O_8$). It is present as an impurity in the parent explosive (RDX). HMX will be discussed in a later section.

Partition Coefficients

Partition coefficients for plant/soil, beef-fat/diet, and fish/water are presented below. The only measured values for partitioning in environmental media were fish uptake studies conducted by Bentley et al. (1977). Other values were obtained by using regression equations.

Partition coefficients for use in estimating human exposure to RDX.

Partition coefficient	Value
Plant/soil (K_{sp})	2 (mg/kg plant)/(mg/kg soil)
Beef-fat/diet (K_{fd})	2.2×10^{-3} (ppm in fat)/ppm in diet)
Fish/water (K^{fw})	2 (mg/kg fish)/(mg/kg water)

Health Effects

Acute RDX toxicity in humans is primarily manifested in the central nervous system. Specific neurotoxic symptoms in humans include: hyperirritability, muscle twitching, generalized epileptiform seizures, and prolonged confusion and amnesia (Stone et al., 1969).

Other studies revealed that exposure to RDX has negative health effects on the skin, renal and urinary system, reproductive system, eyes, liver, and immune system. Toxicological data available indicate that RDX is probably noncarcinogenic, and no studies have been conducted to determine if the co-contaminant HMX poses any carcinogenic risk.

EXPLOSIVE D (AMMONIUM PICRATE)

Composition:	100% Ammonium picrate
Empirical formula:	$C_6H_6N_4O_7$
Molecular Weight (g-mole):	246.08
LeBas Molar Volume (cm^3/mol):	211.4
Coefficient for diffusion in air (m^2/sec):	5.7E-06
Coefficient for diffusion in water (m^2/sec):	5.7E-10
CAS:	131-74-8
Boiling Point:	Explodes at >300°C
Freezing/Melting Point:	Decomposes w/o melting at >265C
Density:	1.72 g/mL
Vapor Pressure:	No data available
Aqueous Solubility:	4.1×10^{-2} mol/L 10,000 mg/L
Henry's Law Constant:	Cannot be calculated without an estimated vapor pressure.
Diffusion Coefficients:	Air: 5.7×10^{-6} Water: 5.7×10^{-10}
Hazard:	Severe explosion risk when shocked or heated, especially reactive with metals or metallic salts. Toxic by skin absorption. TLV: 0.1 mg/m^3 of air.

Co-contaminants

The major co-contaminant present in Explosive D is picric acid (PiOH), present as a result of the hydrolysis process. PiOH will be discussed at a later section.

Partition Coefficients

The partition coefficients for ammonium picrate presented below were estimated from regression equations due to the limitation of data needed for the calculations.

Partition coefficients for use in estimating human exposures to ammonium picrate.

Partition coefficient	Value
Plant/soil (K_{sp})	2 (mg/kg plant)/mg/kg soil)
Beef-fat/diet (K_{fd})	—
Fish/water (K_{fw})	—
SOC/water (K_{oc})	0.2 (mg/kg SOC)/(mg/kg water)

Health Effects

Rabbits and guinea pigs exposed to ammonium picrate dust developed granular deposits in the liver and various pathological abnormalities of the kidneys (Sunderman et al., 1945). Exposure to ammonium picrate has caused dermatitis in humans and animals.

Other health effects due to exposure to Explosive D are directly related to PiOH, which will be discussed in later section.

PENTAERYTHRITOL TETRANITRATE (PETN)

Composition:		100% PETN
Empirical Formula:		$C_5H_8N_4O_{12}$
Molecular Weight (g-mol):		316.09
LeBas Molar Volume (cm^3/mole):		265.6
Coefficient for diffusion in air (m^2/sec):		5.1E-06
Coefficient for diffusion in water (m2/sec):		4.9E-10
CAS:		78-11-5
Boiling Point:		Decomposes at 210°C
Freezing/Melting Point:		140°C
Density:		1.52 g/mL
Vapor Pressure:		2×10^{-9} torr
Aqueous Solubility:		1.0×10^{-4} mol/L 32 mg/L
Henry's Law Constant:		3×10^{-4} (L-torr)/mol
Diffusion Coefficients:	Air: Water:	5.1×10^{-6} m^2/s 4.9×10^{-10} m^2/s
Log octanol/water partition coefficient (K_{ow}):		2.2 log K_{ow}
Derivation:		Esterification of pentaerythritol with nitric acid.
Hazard:		Shock-sensitive explosive. Detonates at 210°C

Co-contaminants

No data were available on this matter.

Partition Coefficients

The calculated partition coefficients for PETN are presented below. Partition coefficients were calculated based on available data instead of estimated based on regression equations.

Partition coefficients for use in estimating human exposures to PETN.

Partition coefficient	Value
Plant/soil (K_{sp})	1 (mg/kg plant)/(mg/kg soil)
Beef-fat/diet (K_{fd})	4.4×10^{-3} (ppm in fat)/(ppm diet)
Fish/water (K_{fw})	22 (mg/kg fish)/(mg/kg water)
SOC/water (K_{oc})	68 (mg/kg SOC)/(mg/kg water)

Health Effects

PETN has been used for medical purposes. It decreases the frequency of angina attacks through vasodilation and the subsequent decrease in systolic and diastolic blood pressure. However, it has been proven that it causes some secondary effects. An angina patient who had taken 0.6 mg/kg-d continuously for eight years developed an extensive red rash over most of his body. Improvement followed after the medication was stopped (Ryan, 1972).

Von Oettingen (1944) conducted extensive research on exposure of PETN in animals. He found that moderate increases in respiratory rate and volume were observed in dogs dosed with PETN at 5 mg/kg. After an hour, these effects returned to normal. He also found that the kidneys of treated rats appeared to have a greenish fluorescence in contrast to the normal coloration of the control rat kidneys.

There is no evidence of the carcinogenicity of PETN. However, Carter and Goldman (1976) proposed that highly carcinogenic nitrosamines could be formed in the gastrointestinal tract following the ingestion of PETN. No study has been conclusive regarding the carcinogenicity of PETN.

N-TETRANITRO-N-METHYLANILINE (TETRYL)

Composition:		100% Tetryl
Empirical Formula:		$C_7H_5N_5O_8$
Molecular Weight (g-mole):		287.08
LeBas Molar Volume (cm^3/mol):		251.5
Coefficient for diffusion in air (m^2/sec):		5.3E-06
Coefficient for diffusion in water (m^2/sec):		5.1E-10
CAS:		479-45-8
Boiling Point:		Explodes at 180 to 190°C
Freezing/Melting Point:		130 to 132°C
Density:		1.73 g/mL
Vapor Pressure:		4×10^{-10} torr
Aqueous Solubility:		2.6×10^{-4} mol/L 75 mg/L
Henry's Law Constant:		2×10^{-6} (L-torr)/mol
Diffusion Coefficients:	Air: Water:	5.3×10^{-6} m^2/s 5.1×10^{-10}
Log octanol/water partition coefficient (K_{ow}):		2 log K_{ow}
Hazard:		Dangerous fire and explosion risk. Skin irritant, absorbed by skin. TLV: 1.5 mg/m^3 of air.

Co-contaminants

The major co-contaminant present in tetryl is picric acid (PiOH). PiOH effects are discussed in the Explosive D section.

Partition Coefficients

The calculated partition coefficients for Tetryl are presented below. The partition coefficient for fish/water (K_{fw}) was calculated from log K_{ow}. The partition coefficient for SOC/water (K_{oc}) was estimated from solubility in water and melting point.

Partition coefficients for use in estimating human exposures to Tetryl.

Partition coefficient	Value
Plant/soil (K_{sp})	1 (mg/kg plant)/(mg/kg soil)
Beef-fat/diet (K_{fd})	3.7×10^{-3} (ppm in fat)/(ppm diet)
Fish/water (K_{fw})	15 (mg/kg fish)/(mg/kg water)
SOC/water (K_{oc})	270 (mg/kg SOC)/(mg/kg water)

Health Effects

Various occupational exposure studies have concluded that the primary effects of tetryl are dermal and respiratory irritation. According to Foulger (1953), tetryl has caused allergic dermatitis among munition plant workers. The study also concluded that contaminated clothing can transmit tetryl dust among workers who subsequently experience dermatitis.

Other studies concluded that the inhalation of tetryl dust commonly causes burning, itching, sneezing, and coryza of the nose, which frequently leads to a nosebleed. These symptoms may begin on the first day of exposure or as late as the third month.

Hardy and Maloof (1950) reported dyspepsia and epigastric pain with nausea and vomiting in tetryl workers. Bergman (1952) found that workers experienced nausea, vomiting, cramps, and diarrhea, but only on an empty stomach.

Other noted symptoms from exposure to tetryl are irritability, fatigue, general malaise, headache, lassitude, sleeplessness, asymptomatic hypotension, liver problems, and kidney damage. Carcinogenic studies have been inconclusive regarding the exposure to tetryl.

CYCLOTETRAMETHYLENE TETRANITROMINE (HMX)

Composition:		Not Found
Empirical Formula:		$C_4H_8N_8O_8$
Molecular Weight (g-mole):		296.12
LeBas Molar Volume (cm^3/mol):		265.0
Coefficient for diffusion in air (m^2/sec):		5.1E-06
Coefficient for diffusion in water (m^2/sec):		5.0E-10
CAS:		2691-41-0
Boiling Point:		Not Available
Freezing/Melting Point:		285°C (decomposes)
Density:		1.9 g/mL
Vapor Pressure:		9×10^{-16}
Aqueous Solubility:		8.8×10^{-6} 2.6 mg/L
Henry's Law Constant:		1×10^{-10} (L-torr)/mol
Diffusion Coefficients:	Air: Water:	5.1×10^{-6} 5.0×10^{-10}
Log octanol/water partition coefficient (K_{ow}):		0.13 log K_{ow}
Hazard:		Not Found

Health Advisories:

10 kg Child:	
One day (mg/L):	5
Ten day (mg/L):	5
Longer term (mg/L):	5
70 kg Adult:	
Longer term (mg/L):	20
RfD (mg/kg/d):	0.05
DWEL (mg/L):	2
Lifetime (mg/L):	0.4
mg/L at 10^{-4} Cancer risk:	—

Co-contaminants

No data were available on this matter.

Partition Coefficients

The calculated partition coefficients for HMX for use in estimating human exposure are presented below.

Partition coefficients for use in estimating human exposures to HMX.

Partition coefficient	Value
Plant/soil (K_{sp})	1 (mg/kg plant)/(mg/kg soil)
Beef-fat/diet (K_{fd})	2.9×10^{-3} (ppm in fat)/(ppm diet)
Fish/water (K_{fw})	0.5 (mg/kg fish)/(mg/kg water)
SOC/water (K_{oc})	130 (mg/kg SOC)/(mg/kg water)

Health Effects

Even though no studies have been conducted to evaluate the carcinogenic potential of HMX, other studies have concluded that HMX caused negative health effects on animals. Wilson (1985) and McNamara et al. (1974) studied health effects in rats and dogs after direct exposure to HMX. They concluded that HMX had negative consequences on organs and systems such as the hepatic, renal, dermal, cardiovascular, hematological, nervous, and immune systems.

NITROGUANIDINE

CAS:	556-88-7
Empirical Formula:	$H_2NC(NH)NHNO_2$
Exists in two forms:	Alpha and Beta
Properties:	(1) Long thin, flat, flexible, lustrous needles; (2) Small, thin elongated plates. Both melting ranges are 220-250°C. The Beta form appears to be more soluble in water.
Derivation:	(1) Results when guanidine nitrate is dissolved in concentrated sulfuric acid and the solution is poured into water. (2) Nitration of a mixture of guanidine sulfate and ammonium sulfate that results from the hydrolysis of dicyandiamide by sulfuric acid.
Hazard:	May explode when shocked or heated.
Use:	High explosives, especially flashless propellant powder (with nitrocellulose), chemical intermediate.
RfD_0 (mg/kg/d):	1.00E-01
Risk-Based concentrations:	
Tap Water (µg/L):	3,700 $_N$
Ambient Air (µg/m³):	370 $_N$
Fish (mg/kg):	140 $_N$
Soil Ingestion:	
Industrial (mg/kg):	200,000 $_N$
Residential (mg/kg):	7,800 $_N$
Health Advisories:	
10 kg Child:	
One day (mg/L):	10
Ten day (mg/L):	10
Longer term (mg/L):	10

70 kg Adult:

Longer term (mg/L):	40
RfD (mg/kg/d):	0.1
DWEL (mg/L):	4
Lifetime (mg/L):	0.7
mg/L at 10^{-4} Cancer risk:	----

PICRIC ACID

Empirical Formula:		$C_6H_3N_3O_7$
Molecular Weight (g-mole):		229.05
LeBas Molar Volume (cm^3/mol):		189.8
Coefficient for diffusion in air (m^2/sec):		6.1E-06
Coefficient for diffusion in water (m^2/sec):		6.0E-10
CAS:		88-89-1
Boiling Point:		Explodes at > 300°C
Freezing/Melting Point:		121.8°C
Density:		1.76 g/mL
Vapor Pressure:		2×10^{-8}
Aqueous Solubility:		4.8×10^{-2} 11,000 mg/L
Henry's Law Constant:		4×10^{-7} (L-torr)/mol
Diffusion Coefficients:	Air:	6.1×10^{-6}
	Water:	6.0×10^{-10}
Log octanol/water partition coefficient (K_{ow}):		2.03 log K_{ow}

Derivation: Nitration of phenolsulfonic acid, obtained by heating phenol with concentrated sulfuric acid.

Grade: Technical paste, pure paste.

Hazard: Severe explosion risk when shocked or heated, especially reactive with metals or metallic salts. Toxic by skin absorption. TLV: 0.1 mg/m^3.

Co-contaminants

No data were available on this matter.

Partition Coefficients

The partition coefficients for PiOH for use in estimating human exposure are presented below.

Partition coefficients for use in estimating human exposure to PiOH.

Partition coefficient	Value
Plant/soil (K_{sp})	2 (mg/kg plant)/(mg/kg soil)
Beef-fat/diet (K_{fd})	1.1×10^{-3} (ppm in fat/(ppm in diet)
Fish/water (K_{fw})	16 (mg/kg fish)/(mg/kg water)
SOC/water (K_{oc})	4.4 (mg/kg SOC)/(mg/kg water)
Soil/water (K_d)	3.84 (mg/kg soil)/(mg/kg water)

Health Effects

Dennie et al. (1929) discuss possible negative effects to the central nervous system after dermal application of PiOH to an individual. According to the study, the individual developed slow speech, difficulty in walking, and unequal dilation of the pupils approximately six weeks after a severe allergic response to PiOH. Kittsteiner (1902) concluded that direct contact of PiOH with the eyes produced corneal ulcers in humans. There is also evidence that exposure to picric acid has caused dermatitis in both animals and humans.

Another study conducted by Van Esch et al. (1957) showed that female rats developed mammary glands tumors after 22 months from exposure to PiOH. However, the study was conducted with a very small sample of rats, 10 males and 10 females.

AMATOL

An explosive mixture of ammonium nitrate and TNT. The 50-50 mixture can be melted and poured for filling small shells; the 80% ammonium nitrate mixture is granular.

Hazard: Highly explosive. A powerful irritant to mucous membranes and by skin absorption.

PENTOLITE

A high explosive consisting of equal parts of pentaerythritol tetranitrate and trinitrotoluene.

Hazard: Dangerous, explodes on shock or heating.

Table II.B-8
Initiating Explosives

Explosive	Empirical Formula	CAS	Properties	Derivation	Grade	Hazard	Use	Notes
Lead Azide	$Pb(N_3)_2$	13424-46-9	Colorless, very sensitive needles; an initiating explosive. Should always be handled submerged in water.	Reaction of sodium azide with a lead salt.		Severe explosion risk, detonates at 350°C. Highly toxic. TLV (as Pb): 0.15 mg/m³ of air.	Primary detonating compound for high explosives.	Explosions have occurred in cases where azide compounds have reacted with the lead in plumbing after being washed down sinks.
Lead Styphnate (lead styphnate is the legal name for lead trinitroresorcinate)	$C_6H(NO_2)_3(O_2Pb)$	63918-97-8	Monohydrate is monoclinic orange-yellow crystals, practically insoluble in water, d 3.1 (monohydrate), 2.9 (anhydrous).	Prepared by adding a solution of magnesium styphnate (from magnesium oxide and styphnic acid) to a lead salt solution.		Detonates at 260°C, dangerous explosion risk, an initiating explosive.		
Mercury Fulminate (Mercury cyanate)	$Hg(CNO)_2$		Gray, crystalline powder. Soluble in alcohol, ammonium hydroxide, and hot water; slightly soluble in cold water; d 4.42; mp explodes.	By treating mercury with strong nitric acid and alcohol.	Technical	Explodes readily when dry, keep moist until use. Highly toxic. TLV (as mercury): 0.05 mg/m³ of air.	Manufacture of caps and detonators for producing explosions of military, industrial, and sporting purposes.	

Table II.B-8
Initiating Explosives

Explosive	Empirical Formula	CAS	Properties	Derivation	Grade	Hazard	Use	Notes
Tetracene (Naphthacene)	$C_{18}H_{12}$	92-24-0	Orange solid, d 1.35, mp approximately 350°C, not easily soluble, slight green fluorescence in daylight.			Explodes when shocked, reacts with oxidizing materials.	Organic synthesis.	In commercial anthracene and coal tar.
Diazodinitrophenol (DDNP)	$(NO_2)_2C_6H_2ON_2$	87-31-0	Yellow, crystalline compound; darkens rapidly on exposure to sunlight; d 1.6; soluble in nitrobenzene, acetone, acetic acid, and nitroglycerin. Desensitized by water.	Diazotization of picramic acid in aqueous solution with sodium nitrite and hydrochloric acid.		Explodes when shocked or heated to 180°C; dangerous, an initiating explosive.	Primary charge in blasting caps.	

Table II.B-9
Other Explosives

Explosive	Narrative	Hazard	Use	CAS	Properties	Derivation	Forms
Black Powder (Blasting Powder)	A low explosive composed of potassium nitrate, charcoal, and sulfur. In some cases sodium nitrate is substituted for potassium nitrate. Typical proportions are 75%, 15%, and 10%. Gunpowder is probably the oldest variety.	Sensitive to heat, deflagrates rapidly. Does not detonate but is a dangerous fire and explosion hazard.	Time fuses for blasting and shell, in igniter and primer assemblies for propellants, pyrotechnics, mining, and blasting.				
Smokeless Powder	Nitrocellulose containing about 13.1% nitrogen, produced by blending material of somewhat lower (12.6%) and slightly higher (13.2%) nitrogen content, converting to a dough with alcohol-ether mixture, extruding, cutting, and drying to a hard, horny product. Small amounts of stabilizers (amines) and plasticizers are usually present, as well as various modifying agents (nitrotoluene, nitroglycerin salts).	A low explosive. Dangerous fire and explosion risk when exposed to flame or impact.	Sports ammunition, military purposes.				

Table II.B-9
Other Explosives

Explosive	Narrative	Hazard	Use	CAS	Properties	Derivation	Forms
Nitrocellulose (Cellulose nitrate; nitrocotton; guncotton; pyroxylin)		Flammable, dangerous fire and explosion risk. Somewhat less flammable when wet.	Fast-drying automobile lacquers, high explosives, collodion, rocket propellant, printing ink base, flashless propellant powder, coating bookbinding cloth, leather finishing, manufacture of "Celluloid."	9004-70-0	Pulpy, cotton-like, amorphous solid (dry); colorless liquid to semisolid (solution). Contains from 10% to 14% nitrogen. High nitrogen form (explosives) is soluble in acetone, insoluble in ether-alcohol mixture. Low-N form (pyroxylin) is soluble in ether-alcohol mixture and acetone (collodion and lacquers), d 1.66, flash point 12.7°C, autoignites at 170°C.	Treatment of cellulose (as cotton linters, wood pulp) with mixture of nitric and sulfuric acids. By varying strength of acids, temperature and time of reaction, and acid/cellulose ratio, widely different products are obtained.	Colloided, block; colloided, flake or granular; flakes, powder, solutions of several viscosities (from 1/4 to 1,000 sec.) May be dry or wet with alcohol or water.

Products of Combustion and Incomplete Combustion

Hazardous waste ordnance was treated by OD/OB at Demolition Key. This treatment process potentially generated products of combustion and incomplete combustion. These compounds are listed in Table II.B-10.

As discussed below, ash and debris from the treatment of hazardous waste ordnance were characterized as meeting the definition of a hazardous waste based on generator knowledge as discussed in Section II.B.8 — Waste Analyses Plan.

Table II.B.10
Products of Combustion and Incomplete Combustion

Product/ CAS	Octanol /Water Partition Coefficient	Florida DEP Class	Florida MCL	RfD_o (mg/kg/d)/ RfD_i (mg/kg/d)	Health Advisories	Risk-Based Concentrations	Soil Ingestion	Soil Screening Levels- Transfers from Soil to:	TLVs	VOC	Hazard
C_2H_2 - Acetylene/ 74-86-2						No risk based information found.					
Al - Aluminum/ 7429-90-5		Secondary Standard	200 µg/L	1.00E+00 $_E$ /none		Tap Water (µg/L) 37,000 $_N$ Ambient Air (µg/m³) 3,700 $_N$ Fish (mg/kg)1,400 $_N$	Industrial (mg/kg) 1E+06 $_N$ Residential (mg/kg) 78,000 $_N$ 10 mg/m³ of air		(Soluble salts) 2 mg/m³ of air (Alkyls) 2 mg/m³ of air (Welding fumes) 5 mg/m³		
Al_2Cl_3 - Aluminum chloride						No risk-based information found.					
$Al(Cl)_3$ - Aluminum chloride, anhydrous						No risk-based information found.					
AlOCl - Aluminum chloride oxide						No risk-based information found.					
$AlCl_2$ - Aluminum dichloride						Ionic - No risk-based information available.					
Al_2O_2 - Aluminum dioxide						Ionic - No risk-based information available.					

Table II.B.10
Products of Combustion and Incomplete Combustion

Product/ CAS	Octanol /Water Partition Coefficient	Florida DEP Class	Florida MCL	RfD_o (mg/kg/d)/ RfD_i (mg/kg/d)	Health Advisories	Risk-Based Concentrations	Soil Ingestion	Soil Screening Levels- Transfers from Soil to:	TLVs	VOC	Hazard
AlH - Aluminum hydride (as AlH_3)						No risk-based information found.					
AlCl - Aluminum monochloride						Ionic - No risk-based information available.					
Al_2O - Aluminum monoxide						Ionic - No risk-based information available.					
Al_2O_3 - Aluminum oxide/1344-28-1						No other risk-based information found.			10 mg/m³		
AlO - Aluminum oxide						Ionic - No risk-based information available.					
AlS - Aluminum sulfide						Ionic - No risk-based information available.					
NH_2 - Amide						No risk-based information found.					
NH_3 - Ammonia/ 7664-41-7		No Florida Class found.	No Florida MCL found.	2.86E-02/ none		Tap Water (µg/L) 1,000 $_N$ Ambient Air (µg/m³) 100 $_N$			25 ppm in air		

Table II.B.10
Products of Combustion and Incomplete Combustion

Product/ CAS	Octanol /Water Partition Coefficient	Florida DEP Class	Florida MCL	RfD_o (mg/kg/d)/ RfD_i (mg/kg/d)	Health Advisories	Risk-Based Concentrations	Soil Ingestion	Soil Screening Levels- Transfers from Soil to:	TLVs	VOC	Hazard
Ba - Barium/ 7440-39-3		Primary Standard	2,000 µg/L	7.00E-02/ 1.43E-04		Tap Water (µg/L) 2,600 $_N$ Ambient Air (µg/m³) 0.52 $_N$ Fish (mg/kg) 95 $_N$	Industrial (mg/kg) 140,000 $_N$ Residential (mg/kg) 5500 $_N$	Air (mg/kg)350,000 $_E$ Groundwater (mg/kg) 32 $_E$	0.5 mg/m³ (for all soluble barium compounds)		
$BaCl_2$ - Barium chloride/ 10361-37-2			No Florida MCL found.			Risk-Based concentrations are the same as those for barium (Ba).					Ingestion of 0.8 g may be fatal.
BaCl - Barium chloride						Ionic - No risk-based information available.					
Ca - Calcium/ 7440-70-2						No risk-based information found.					
$CaCl_2$ - Calcium chloride/ 10043-52-4						No risk-based information found.					
CaCl - Calcium chloride						Ionic - No risk-based information available.					
CaHO - Calcium hydroxide (as $Ca[OH]_2$)/ 1305-62-0						No other risk-based information found.			5 mg/m³ of air		
CO_2 - Carbon dioxide/ 124-38-9						No other risk-based information found.			(gas) 5,000 ppm in air		

Table II.B.10
Products of Combustion and Incomplete Combustion

Product/ CAS	Octanol /Water Partition Coefficient	Florida DEP Class	Florida MCL	RfD_o (mg/kg/d)/ RfD_i (mg/kg/d)	Health Advisories	Risk-Based Concentrations	Soil Ingestion	Soil Screening Levels- Transfers from Soil to:	TLVs	VOC	Hazard
CS_2 - Carbon disulfide/ 75-15-0		Systemic Toxicant	700 µg/L	1.00E-01/ 2.86E-03		Tap Water (µg/L) 21 $_N$ Ambient Air (µg/m³) 10 $_N$ Fish (mg/kg) 140 $_N$	Industrial (mg/kg) 200,000 $_N$ Residential (mg/kg) 7,800 $_N$	Air (mg/kg) 11 $_E$ Groundwater (mg/kg) 14 $_E$	10 ppm in air	Yes	
CO - Carbon monoxide/ 630-08-0						No other risk-based information found.			50 ppm (industrial workrooms)		
CS - Carbon monosulfide						Ionic - No risk-based information available.					
CHO - Carbonic acid						Ionic - No risk-based information available.					
CSO - Carbonyl sulfide/ 463-58-1						No risk-based information found.					
Cl - Chlorine/ 7782-50-5		No Florida Class found.	No Florida MCL found.	1.00E-01/ none		Tap Water (µg/L) 3,700 $_N$ Ambient Air (µg/m³) 370 $_N$ Fish (mg/kg) 140 $_N$	Industrial (mg/kg)200,000 $_N$ Residential (mg/kg)7,800 $_N$		0.5 ppm in air		
C_2H_6 - Ethane/ 74-84-0						No risk-based information found.					
C_2H_4 - Ethylene/ 74-85-1						No risk-based information found on ethylene by itself.					

Table II.B.10
Products of Combustion and Incomplete Combustion

Product/ CAS	Octanol /Water Partition Coefficient	Florida DEP Class	Florida MCL	RfD_o (mg/kg/d)/ RfD_i (mg/kg/d)	Health Advisories	Risk-Based Concentrations	Soil Ingestion	Soil Screening Levels- Transfers from Soil to:	TLVs	VOC	Hazard
CH_2O - Formaldehyde/ 50-00-0	log K_{ow} = 0.35 (calculated)	Organo-leptic	600 µg/L	2.00E-01/ none	10 kg Child: One day (mg/L) 10 Ten day (mg/L) 5 Longer term (mg/L) 5 70 kg Adult: Longer term (mg/L) 20 RfD (mg/kg/d) 0.15 DWEL (mg/L) 5 Lifetime (mg/L) 1 mg/L at 10^{-4} Cancer risk ----	Tap Water (µg/L) 7,300 $_N$ Ambient Air (µg/m³) 0.14 $_C$ Fish (mg/kg) 270 $_N$	Industrial (mg/kg)410,000 $_N$ Residential (mg/kg)16,000 $_N$		1 ppm in air		
CHN - Hydrocyanic acid (Hydrogen cyanide)/ 74-90-8	log K_{ow} = 1.07 (calculated)	Systemic Toxicant	10,000 µg/L	2.00E-02/ 8.57E-04		Tap Water (µg/L) 730 $_N$ Ambient Air (µg/m³) 3.1 $_N$ Fish (mg/kg) 27 $_N$	Industrial (mg/kg)41,000 $_N$ Residential (mg/kg)1,600 $_N$		10 ppm in air		
CNHO						Not found					
HCl - Hydrochloric acid (Hydrogen chloride)/ 7647-01-0		No Florida Class found.	No Florida MCL found.	none/ 2.00E-03		Tap Water (µg/L) 73 $_N$ Ambient Air ($\mu g/m_3$) 7.3 $_N$					

Table II.B.10
Products of Combustion and Incomplete Combustion

Product/ CAS	Octanol /Water Partition Coefficient	Florida DEP Class	Florida MCL	RfD_o (mg/kg/d)/ RfD_i (mg/kg/d)	Health Advisories	Risk-Based Concentrations	Soil Ingestion	Soil Screening Levels- Transfers from Soil to:	TLVs	VOC	Hazard
H - Hydrogen						No risk-based information found.					
HO_2 - Hydrogen dioxide						Ionic - No risk-based information available.					
H_2 - Hydrogen gas/ 1333-74-0		No Florida Class found.	No Florida MCL found.			No risk-based information found.					
H_2O_2 - Hydrogen peroxide						No risk-based information found.					
H_2S - Hydrogen sulfide/ 7722-84-1						No other risk-based information found.			1 ppm in air		
HS - Hydrogen sulfide						Ionic - No risk-based information available.					
HO_3 - Hydrogen trioxide						Ionic - No risk-based information available.					
HO - Hydroxyl						No risk-based information.					
CH_4 - Methane/ 74-82-8						No risk-based information found.					
CH_3 - Methyl						Ionic - No risk-based information available.					

Table II.B.10
Products of Combustion and Incomplete Combustion

Product/ CAS	Octanol /Water Partition Coefficient	Florida DEP Class	Florida MCL	RfD_o (mg/kg/d)/ RfD_i (mg/kg/d)	Health Advisories	Risk-Based Concentrations	Soil Ingestion	Soil Screening Levels- Transfers from Soil to:	TLVs	VOC	Hazard
NHO_3 - Nitric acid/7697-37-2						No other risk-based information found.			2 ppm in air		
NO - Nitric oxide/ 10102-43-9		Systemic Toxicant	10,000 µg/L	1.00E-01/ none		Tap Water (µg/L) 3,700 N Ambient Air (µg/m³) 370 N Fish (mg/kg) 140 N	Industrial (mg/kg)200,000 N Residential (mg/kg)7,800 N		25 ppm in air		
NCl - Nitrogen chloride						Ionic - No risk-based information available.					
NO_2 - Nitrogen dioxide/ 10102-44-0		Systemic Toxicant	7,000 µg/L	1.00E+00/ none		Tap Water (µg/L) 37,000 N Ambient Air (µg/m³) 3,700 N Fish (mg/kg) 1,400 N	Industrial (mg/kg)1E+06 N Residential (mg/kg)78,000 N		3 ppm in air		
N_2 - Nitrogen gas						No risk-based information found.					
NO_3 - Nitrogen trioxide (as N_2O_3)/ 10544-73-7						No risk-based information found.					
NHO_2 - Nitrous acid						No risk-based information found.					
NHO - Nitrous acid						Ionic - No risk-based information available.					

Table II.B.10
Products of Combustion and Incomplete Combustion

Product/ CAS	Octanol /Water Partition Coefficient	Florida DEP Class	Florida MCL	RfD_o (mg/kg/d)/ RfD_i (mg/kg/d)	Health Advisories	Risk-Based Concentrations	Soil Ingestion	Soil Screening Levels- Transfers from Soil to:	TLVs	VOC	Hazard
O - Oxygen/ 7782-44-7						No risk-based information found.					
O_2 - Oxygen gas						No risk-based information found.					
O_3 - Ozone/ 10028-15-6						No risk-based information found.					
P - Phosphorus (white)/ 7723-14-0		No Florida Class found.	No Florida MCL found.	2.00E-05/ none		Tap Water (µg/L) 0.73 N Ambient Air (µg/m³) 0.073 N Fish (mg/kg) 0.027 N	Industrial (mg/kg) 41 N Residential (mg/kg)1.6 N		(white): 0.1 mg/m³ of air		
P_2 - Phosphorus (II)						No risk-based information found.					
P_4 - Phosphorus (IV)						No risk-based information found.					
PO_2 - Phosphorus dioxide						Ionic - No risk-based information available.					
PN - Phosphorus nitride						Ionic - No risk-based information available.					
P_4O_6 - Phosphorus (III) oxide						No risk-based information found.					

Table II.B.10
Products of Combustion and Incomplete Combustion

Product/ CAS	Octanol /Water Partition Coefficient	Florida DEP Class	Florida MCL	RfD_o (mg/kg/d)/ RfD_i (mg/kg/d)	Health Advisories	Risk-Based Concentrations	Soil Ingestion	Soil Screening Levels- Transfers from Soil to:	TLVs	VOC	Hazard
P_3N_5 - Phosphorus (III) pentanitride						No risk-based information found.					
PO - Phosphoryl oxide						Ionic - No risk-based information available.					
K - Potassium/ 7440-09-7						No risk-based information found.					
K_2 - Potassium (II)						No risk-based information found.					
K_2CO_3 - Potassium carbonate (L)/ 584-08-7						No risk-based information found.					
K_2CO_3 - Potassium carbonate (S)/ 584-08-7						No risk-based information found.					
KCl - Potassium chloride/ 7447-40-7						No risk-based information found.					
$K_2C_2N_2$ - Potassium cyanide (as KCN)/ 151-50-8		No Florida Class found	No Florida MCL found	5.00E-02/ none		Tap Water (µg/L) 1,800 $_N$ Ambient Air (µg/m³) 180 $_N$ Fish (mg/kg) 68 $_N$	Industrial (mg/kg)100,000 $_N$ Residential (mg/kg)3,900 $_N$		(as CN): 5 mg/m³ of air		

Table II.B.10
Products of Combustion and Incomplete Combustion

Product/ CAS	Octanol /Water Partition Coefficient	Florida DEP Class	Florida MCL	RfD_o (mg/kg/d)/ RfD_i (mg/kg/d)	Health Advisories	Risk-Based Concentrations	Soil Ingestion	Soil Screening Levels- Transfers from Soil to:	TLVs	VOC	Hazard
$K_2H_2O_2$ - Potassium hydrogen peroxide						No risk-based information found.					
KHO - Potassium hydroxide/ 1310-58-3						No risk-based information found.			ceiling of 2 mg/m^3		
KO - Potassium superoxide						No risk-based information found.					
C_3H_6 - Propylene (Propene)/ 115-07-1	log K_{ow} = 1.77 (measured)					No risk-based information found.					
S - Sulfur/ 7704-34-9						No risk-based information found.					
S_2 - Sulfur (II)						No risk-based information found.					
S_8 - Sulfur (VIII)						No risk-based information found.					
SO_2 - Sulfur dioxide/ 7449-09-5						No other risk-based information found.			2 ppm in air U.S. atmospheric standard, 0.140 ppm		

Table II.B.10
Products of Combustion and Incomplete Combustion

Product/ CAS	Octanol /Water Partition Coefficient	Florida DEP Class	Florida MCL	RfD_o (mg/kg/d)/ RfD_i (mg/kg/d)	Health Advisories	Risk-Based Concentrations	Soil Ingestion	Soil Screening Levels- Transfers from Soil to:	TLVs	VOC	Hazard
SO - Sulfur monoxide						No risk-based information found.					
S_2O - Sulfur (II) oxide						Ionic - No risk-based information available.					
SO_3 - Sulfur trioxide/ 7449-11-9						No risk-based information found.					
NS - Thionitrosyl						No risk-based information found.					
H_2O - Water						No risk-based information found.					

SECTION II.B.8

WASTE ANALYSIS PLAN

WASTE ANALYSIS PLAN

The information in this section is submitted in accordance with the requirements of FAC 62-730.180 and 40 CFR 270.14(b)(2), (3) and 264.13(b). This section contains information pertaining to generator knowledge and expertise used to define unserviceable ordnance hazardous waste at Demolition Key.

This waste analysis plan has been written to comply with the State of Florida's *Hazardous Waste Facility Permit Application Instruction and Forms* requirements and the USEPA's *Waste Analysis at Facilities that Generate, Treat, Store and Dispose of Hazardous Wastes - A Guidance Manual* (April 1994) and is included in this closure permit application to provide an understanding of the techniques used to define hazardous waste ordnance at Demolition Key. The sampling and analysis protocol for closure investigation and verification is provided within Sections II.D and II.E of this closure application.

All ordnance treated at Demolition Key is, by definition, reactive hazardous waste (D003) and may also be considered toxic hazardous waste based on heavy metal composition and concentration. Ordnance were determined to meet the FDEP and USEPA definition of toxic for certain RCRA metals by NAS Key West through knowledge of said ordnance items based on DOD training.

Waste Analysis Plan Objectives

The Demolition Key, Subpart X Miscellaneous Unit Waste Analysis Plan provides guidance for the successful implementation of a solid and hazardous waste identification management program that complies with the closure permit conditions, as well as state and federal regulations.

All personnel at Demolition Key responsible for characterizing and properly managing hazardous waste shall be familiar with this waste analysis plan. Any deviation in the methods used to characterize a solid or hazardous waste, other than those presented herein, shall be reviewed and accepted by NAS Key West's Weapons Department and incorporated into this plan.

Introduction

Demolition Key is in Monroe County, Florida, north of Key West. It is bounded to the north, east, and west by the Gulf of Mexico and to the south, across a narrow stretch of gulf water, by Fleming Key (see Figure II.B-1). Access to Demolition Key is by boat through the Garrison Bight Channel. The facility and surrounding property is described in related sections of this closure permit.

NAS Key West used Demolition Key for the thermal treatment (i.e., OB/OD) of military ordnance no longer capable of being used for its intended purpose (i.e., warfare, training, or research and development [R&D]) and/or that could not be reworked or demilled offsite for resuse, training, foreign sales, or disposal.

Hazardous Waste Generation Processes History

The Weapons Department at NAS Key West (i.e., Boca Chica Key and Fleming Key) generates hazardous waste ordnance explosives and munitions from routine use and handling that are designated hazardous waste due to their reactive and toxic characteristics. Many of the waste ordnance casings and critical parts contain metal salts of arsenic, barium, or cadmium while lead styphnate and mercury fulminate are commonly used as detonation initiators. Thus, in addition to characterizing hazardous waste ordnance as reactive (EPA D003), these same ordnance items may fail the TCLP for leachable RCRA metals including arsenic [D004], barium [D005], cadmium [D006], lead [D008], and mercury [D009] depending on the ordnance considered. Military ordnance composition products are described in Section II.B.7.

All hazardous waste ordnance treated at Demolition Key were defined by their chemical composition based on knowledge of ordnance items obtained through exhaustive training provided through the DOD. Ash and debris generated from the treatment of hazardous waste ordnance were further characterized using these same principles and knowledge of the original product. Figure II.B.10 presents a flow diagram of the process by which an ordnance item is defined a hazardous waste ordnance while Figure II-B.11 describes how ordnance, once defined as a hazardous waste, was managed from generation at NAS Key West through treatment at Demolition Key.

Definitions/Terminology

For this Waste Analysis Plan, the following definitions/terminology were used are used for ordnance classification as a hazardous waste.

- *Ammunition Condition Codes*: Ordnance is classified with an ammunition condition code which identifies the material in terms of readiness for issue, reissue, and use. Codes range from Code A to W.

- *Weapons Department*: The NAS Key West unit responsible for the issue, acceptance, reissue, storage, transportation, rework, and operation of the Demolition Key hazardous waste treatment program and permit. The Weapons Department is responsible for the overall management of hazardous waste ordnance as it related to a operating permit application.

Figure II.B-10 Hazardous Waste Ordnance Decision Logic Flow Chart

Figure II.B-11 Hazardous Waste Ordnance Facility Flow Chart

- *Code A*: Ordnance classified as "ready for issue" (serviceable) for intended training of military personnel and war-time uses.

- *Code H*: Ordnance reclassified as unserviceable (not ready for use) due to its condition (missing code information, damaged or worn parts or containers, unreliability, misfires, etc.). Ordnance are classified Code H as follows.

  — NAR
  — Field Returns (per TMs and/or SBs)

  Means of ordnance reclassification and reclassification terminology are discussed below.

- *Code R*: Unserviceable ordnance administratively (electronic documentation and accounting procedures) placed in the RRDA awaiting final disposition (proficiency training, demilitarization, resale, disposal, etc.). The RRDA is maintained by the Weapons Department under direction of NAVSEASYSCOM to establish an account that ensures full utilization of military ordnance classified unserviceable.

- *Code W*: Ordnance (serviceable or unserviceable) reclassified by an authorized Department of the Navy (DON) representative as hazardous waste and subsequently placed, administratively, in the BHW and, physically, in a designated Weapons Department accumulation area at NAS Key West. This material must be disposed or treated according to USEPA RCRA and FDEP Hazardous Waste Management regulations. Ordnance placed in the BHW are considered fully regulated hazardous waste requiring appropriate treatment and/or disposal.

- *Serviceable Ordnance*: Ordnance item considered ready for issue and use for its intended capacity. Ordnance items defined as serviceable are designated Code A.

- *Unserviceable Ordnance*: Any ordnance, because of its physical condition, deemed unfit for its intended manufactured use (Code H).

Ordnance Classification Procedures

A system has been devised by the DoD and DoN to classify the readiness or status of military ordnance at each phase of its existence from manufacture to use or treatment/disposal. The following sections of this Waste Analysis Plan describe the classification process and the manner in which a military ordnance item becomes a hazardous waste under the definitions in FAC 62-730.180 and 40 CFR 261.

- **Serviceable to Unserviceable**

  Code A ordnance (serviceable or ready for use), used for troop training and military engagement purposes, is procured by the NAS Key West Weapons Department following individual unit submittal of authorized requisitions. Ordnance training exercises are conducted by Navy personnel to ensure troop proficiency in respective areas of responsibility based on the individual unit directives and mission descriptions.

  During routine troop training exercises, ordnance items and/or their shipping containers may become damaged, defective, or lose their lot numbers. Upon the return of such ordnance items to Weapons, Weapons Technicians are responsible for ensuring that items no longer meeting Code A specifications are reclassified Code H (unserviceable).

  Reclassification of ordnance items from Code A to Code H requires detailed review of TMs and SBs against the condition of the ordnance item returned and review of NARs issued by SPCC, Mechanicsburg, Pennsylvania. TMs, SBs, and NARs are discussed in more detail below.

- **Unserviceable to RRDA**

  Once an ordnance item is determined unserviceable, it is administratively placed in the RRDA (Code H inventory) for future disposition evaluation by NAVSEASYSCOM. The item is reclassified from a Code H to Code R during this evaluation. For an ordnance item to be placed into the RRDA, Weapons Department personnel must receive written authorization from NAVSEASYSCOM. Once authorization is obtained, the evaluation process begins.

  While in the RRDA, NAVSEASYSCOM evaluates the ordnance for the following uses:

  — Rework
  — Resale
  — Personnel ordnance destruction proficiency training throughout the Navy
  — Demilitarization (washout, meltout, steamout, incineration, et al.)
  — Commercial offsite disposal

- **RRDA Ordnance (Unserviceable) to Hazardous Waste**

  Ordnance items designated for demilitarization, including offsite disposal, shall be so designated by an authorized NAVSEASYSCOM representative following review of all available ordnance use options presented above. Code H ordnance items so designated shall be administratively placed in the BHW (electronic account for tracking and

managing hazardous waste ordnance) and physically separated from other ordnance items into specifically designated NAS Key West Weapon's Department hazardous waste accumulation areas.

Weapons personnel shall be responsible for managing of the BHW account and for accumulating hazardous waste ordnance according to the 40 CFR 262 and FAC 60-730.160 hazardous waste generator requirements.

Prior to formally treating hazardous waste ordnance items contained in the NAS Key West BHW at Demolition Key, Weapons Department personnel submitted a request in milstrip format (i.e., written memorandum) to NAVSEASYSCOM. Following receipt and review of this request, NAVSEASYSCOM issued a document identifier code to denote transfer of ordnance items into or out of the BHW account. The document identifier codes included:

— A5J — Disposal release order. Issued only by NAVSEASYSCOM.

— D7J — Issue to property disposal. Used when ordnance items were transferred to Weapons Department for treatment at Demolition Key or other disposal authority (i.e., commercial facility/fellow component).

— ARJ — Disposal release confirmation. Used by the issuing command upon receipt of the disposal document, certifying the items as destroyed.

— ARK — Disposal release confirmation: Greater quantity. Used when final disposal quantity is greater than original A5J amount.

— ARL — Disposal release confirmation: Less than quantity. Used when final disposition is less than original A5J amount.

Notice of Ammunition Reclassification

NARs are determined by the Navy SPCC in Mechanicsburg, Pennsylvania. Ordnance is reclassified unserviceable when malfunctions and/or deficiencies are identified through use, testing, and evaluation and also when an ordnance has exceeded its allowable shelf life.

NARs are distributed by SPCC to NAS Key West and other bases. Ordnance items affected by a NAR are physically and administratively segregated from serviceable (Code A) ordnance items and designated Code H. Once segregated, the Code H ordnance items await final disposition orders as described above. If the order was to dispose of the ordnance item through local

treatment options (i.e., OB/OD), it was further segregated as a hazardous waste and accumulated along with other such ordnance in the appropriate designated magazine and BHW account.

Field Returns

Field returns consist of ordnance NAS Key West and other Navy facilities cannot reissue due to physical damage, missing components, or lack of identification (mixed lots, lost identification numbers, etc.). If NAS Key West Weapons personnel cannot readily identify these items, they reclassify them as unserviceable (Code H). Reclassification of ordnance at this level is based upon general information provided in Navy-issued SBs, information from TMs for each ordnance, and NAVSEASYSCOM ordnance publications.

Before transporting hazardous waste ordnance to Demolition Key, Weapons Department personnel completed a Uniform Hazardous Waste Manifest that was reviewed and signed by the Weapons Officer in charge of generation, transportation, and treatment/disposal. In conjunction with completing, reviewing, and signing the Uniform Hazardous Waste Manifest, Turn-In Document DD 1348-1 Form (Figure II.B-12) was also completed, reviewed, and signed by the respective officers in charge. The DD 1348-1 Form is a turn-in/release form used to track hazardous waste ordnance from the 90-day hazardous waste accumulation area (HWAA) to the Demolition Key hazardous waste treatment facility.

The above process ensures that all items are identified and assigned proper disposition. The process also ensures that all chemical and physical properties of the waste material can be ascertained and, therefore, actual sampling of the munitions will not be warranted.

Identification and Quantities of Hazardous Wastes Managed

Several ordnance items and several ordnance item chemical constituents may have been treated at Demolition Key. Table II.B-11 describes these various ordnance item chemical constituents in greater detail and how they were classified by NAS Key West before treatment at Demolition Key.

Hazardous waste ordnance generated at NAS Key West is managed initially by the Weapons Department within specifically designated and compliant HWAA (less than 90 days). Hazardous wastes accumulated within these areas were eventually transported to Demolition Key for treatment. **Future dispositions of unserviceable ordnance generated at NAS Key West no longer includes treatment by OB/OD at Demolition Key.**

Figure II.B-12 DD 1348-1 Form

Table II.B-11
Demolition Key
Ordnance Constituent Description

Ordnance Constituent	Waste Code(s)	LDR[1] WW/ NWW	LDR Treatment Standards	Rationale for Hazardous Designation
Trinitrotoluene (TNT)	D003	NWW	DEACT	Reactive, will detonate only if vigorously shocked
Cyclotrimethylenetrinitramine (RDX)	D003	NWW	DEACT	Reactive
Explosive D (Ammonium Picrate)	D003	NWW	DEACT	Reactive with metals and metal salts, shock and heat sensitive
Pentaerythritol Tetranitrate (PETN)	D003	NWW	DEACT	Shock sensitive
N-tetrylnitro-N-methylanaline	D003	NWW	DEACT	Fire and explosion risk
Cyclotetramethylene tetranitromine (HMX)	D003	NWW	DEACT	Reactive
Amatol	D003	WW	DEACT	Highly explosive
Pentolite	D003	NWW	DEACT	Shock and heat sensitive
Nitroguanidine	D003	NWW	DEACT	Shock and heat sensitive
Picric Acid	D003	NWW	DEACT	Reactive with metals and metal salts, shock and heat sensitive

Table II.B-11
Demolition Key
Ordnance Constituent Description

Ordnance Constituent	Waste Code(s)	LDR[1] WW/ NWW	LDR Treatment Standards	Rationale for Hazardous Designation
Initiators				
Lead Azide	D003 D008	NWW	DEACT 5.0 mg/L TCLP	Severe explosion risk
Lead Styphnate	D003 D008	NWW	DEACT 5.0 mg/L TCLP	Severe explosion risk
Mercury Fulminate	D003 D009	NWW	DEACT 0.20 mg/L TCLP	Explosion
Tetracene	D003	NWW	DEACT	Reacts with oxidizers and shock
Diazodinitrophenol (DDNP)	D003	NWW	DEACT	Shock and heat sensitive
Other Explosives				
Black Powder	D003	NWW	DEACT	Fire and explosion
Smokeless Powder	D003	NWW	DEACT	Fire, explosion, and shock sensitive
Nitrocellulose	D003	NWW	DEACT	Fire and explosion

Notes:
1 = Land Disposal Restriction (LDR), Wastewater,(WW), and Non-wastewater (NWW)
mg/l = milligrams per liter

Description of Hazardous Waste Management Unit

The OB/OD treatment unit operated in accordance with the Navy guidance manual *Ammunition and Explosives Ashore Safety Regulations for Handling, Storing, Production, Renovation, and Shipping (OP 5)*. As specified per this guidance manual, NAS Key West designated the OB/OD treatment unit a Class A demolition range, with the following operational limitations:

- The unit shall be limited to a NEW per burn of 5 pounds.
- The unit shall not be closer than 670 feet from the nearest inhabited building.
- All vegetation - dry grass, leaves, and other combustible materials -- shall be removed within from the area of treatment so as not to interfere with said operations.
- Only the exact quantity of hazardous waste ordnance to be open burned shall be treated here. Stockpiling hazardous waste ordnance here is prohibited.

SECTION II.B.9

MANIFEST SYSTEM, RECORD-KEEPING, AND REPORTING

MANIFEST SYSTEM, RECORD-KEEPING AND REPORTING

The following information is included to comply with the requirtements of 40 CFR 270.14(b)(8) and FAC 62-730.

Shipping and Transportation Requirements

All shipments of hazardous waste media must be manifested before transport from Demolition Key to the NAS Key West permitted storage facility. Prior to offering hazardous waste for transportation, each container will be inspected to ensure that waste material is properly classified, packaged, marked, labeled, and in proper condition for transportation. These requirements are thoroughly delineated in the Hazardous Waste Management Plan for NAS Key West. Accompanying information must be adequate to permit ultimate disposal and compatible storage.

Hazardous Waste Manifest

General

NAS Key West must use the national Uniform Hazardous Waste Manifest when transporting hazardous waste media (i.e., soil) from Demolition Key to NAS Key West.

The regulations specify minimum information to be included on all hazardous waste manifests. The manifest must contain all of the following information:

- A manifest document number;
- The generator's name, mailing address, telephone number, and USEPA identification number;
- The name and USEPA identification number of each transporter;
- The name, address and USEPA identification number of the designated facility and alternate facility, if any;
- The description of the waste(s) required by 49 CFR 172.202 and 172.203;
- The total quantity of each hazardous waste by weight or volume, and the type and number of containers loaded into or onto the transport vehicle; and

- The following certification:

  "I hereby certify that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to the applicable international and national government regulations

  "If I am a large-quantity generator, I certify that I have a program in place to reduce the volume and toxicity of waste generated to the degree that I have determined to be economically practicable and that I have selected the practicable method of treatment, storage, or disposal currently available to me which minimizes the present and future threat to human health and the environment; OR, if I am a small-quantity generator, I have made a good faith effort to minimize my waste generation and select the best waste management method that is available to me and that I can afford."

Figure II.B-13 contains an example of the Uniform Hazardous Waste Manifest that meets the above requirements. The manifest must provide the generator, each transporter, and the owner or operator of the designated facility one copy each for their records and another copy for the permit facility to return, fully executed, to the generator.

Preparation of Manifest

Caution must be exercised in preparing the manifest to ensure that all copies are legible. Entries on the manifest must either be typewritten or printed manually. The following discussion relates to specific entries to be made on the manifest.

Manifest Document Number:

A unique five-digit number must be assigned to each manifest (i.e., 00001). Note that the manifest document number must be posted on the hazardous waste label on each container and to the Hazardous Waste Storage Record.

Identification:

Enter USEPA identification number, name, mailing address, and telephone number for the generator, each transporter, and the designated facility. An alternate designated facility should be entered even if it is NAS Key West. This ensures the transporter an alternative if the shipment cannot be delivered to the primary facility.

Figure II.B-13 Uniform Hazardous Waste Manifest

Number of Units and Container Type:

Describe the number and type of containers; e.g., seven metal drums. Enter an "X" to indicate hazardous waste.

USEPA Hazardous Waste I.D. No.:

Enter the appropriate USEPA waste number.

Description and Classification:

Enter the proper USDOT shipping name and hazardous classification for the waste. Except for Not Otherwise Specified (n.o.s.), abbreviations are not authorized.

UN NO. OR NA NO.:

Enter the applicable United Nations/North American number for the waste.

Exemption or No Labels Required:

Enter "N/A" to indicate the entry is not applicable.

Flash Point:

Enter "N/A."

Units Wt./Vol.:

Enter the quantity in each container.

Total:

Enter the total weight of the container. Note: The annual report must show quantity of waste shipped offsite by weight.

Placards Tendered:

Check "yes" to indicate when 1,000 pounds or more of a waste that is not classified as an Other Regulated Material (ORM) is being shipped. Check "no" for other shipments.

Generator's Signature:

The generator of hazardous waste at Demolition Key is NAS Key West. The Commanding Officer (CO) of NAS Key West, or a CO authorized representative, are the only individuals that can sign manifests completed for the transport of hazardous waste from Demolition Key as part of closure activities. In this case, the CO has assigned these responsibilities to the PWO Environmental Department's Director. The signature should be dated, printed, and completed in ink.

Transporter's Signature:

Obtain the handwritten signature of the designated transporter.

Manifest Copy Distribution

One copy of the manifest must be retained pending receipt of a signed copy from the owner or operator of the designated facility. A copy of the manifest containing the handwritten acceptance signature and date of acceptance by the designated facility must be retained for three years. A copy of all manifests must be submitted to FDEP within 30 days.

Routing and Out-of-State Manifests

Many individual states require additional information on the manifest. Out-of-state hazardous waste shipments should be coordinated with FDEP and its counterpart in states to be transversed to ensure compliance in each state.

Written Exception Reports:

If a signed copy of the manifest has not been received by NAS Key West from the designated facility within 45 days of the date of acceptance by the transporter, a written report must be made. The exception report must include a cover letter explaining the efforts to locate the shipment of waste and the results of those efforts; a legible copy of the manifest that does not have confirmation must also be included with the exception report. The exception report must be submitted to:

State of Florida
Department of Environmental Protection
Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, Florida 32301

Copies of all exception reports must be retained for three years.

Use of DD 1348-1 Form, Turn-In Document

All materials to be turned in to Defense Property Disposal Office (DPDO), must be accompanied by a properly prepared DD 1348-1 Form Turn-in Document. Weapons will review work-centered prepared copies of DD 1348-1 Form in relation to the preparation instructions. A copy of DD 1348-1 Form is included as Figure II.B-12 in Section II.B.8.

Use of the Land Disposal Restriction Notification Form

A Land Disposal Restriction Form must be filled out when disposing of a land banned hazardous waste. A copy of this form is included as Figure II.B-14.

Hazardous Waste Profile Sheet

A Hazardous Waste Profile Sheet must be filled out when seeking treatment, storage, and disposal (TSD) facility acceptance approval. A copy of the Hazardous Waste Profile Sheet is included as Figure II.B-15.

Truck Loading Procedures

Weapons will ensure that, in cases where an single transport container (STC) is being reused to transport hazardous waste, the container has been held for at least 24 hours after filling and that the containers are transported only by highway.

Each container of hazardous waste must be inspected for leakage, proper container, markings and labels before it is loaded onto a transport vehicle. The containers must be secured on the transport vehicle to prevent movement during transport.

Placarding

When 1,000 pounds or more of waste which is not classed as ORM is loaded onto a transport vehicle for transportation on a public highway, the vehicle must display the appropriate USDOT placard. The placards must be displayed on each end and on each side of the vehicle while the waste is carried. Public Works must affix the placards to the vehicles or offer the required placards to the transporter (unless the vehicle already displays the proper placards).

Figure II.B-14 Land Disposal Restriction Notification Form

Figure II.B-15 Hazardous Waste Profile Sheet

Record-Keeping and Reporting

The FDEP/USEPA hazardous waste management rules require NAS Key West to keep certain records. Those records and retention periods are as described below. These records must be made available upon request to the USEPA or FDEP.

Storage Records

All hazardous waste storage records become a permanent record at NAS Key West. Tenant activities will turn in their storage logs to Public Works if their operations at NAS Key West are closed.

OPNAV Hazardous Waste Annual Report

OPNAVINST 5090.1B of May 1993 requires that NAS Key West submit an annual report of all hazardous waste generated. The report must be prepared according to instructions provided with OPNAVINST 5090.1B and be submitted by February 1 each year to cover hazardous waste generated during the preceding calendar year.

Public Works will retain, for at least three years, file copies of the Hazardous Waste Annual Report required by OPNAVINST 5090.1B.

Annual Hazardous Waste Report

This report, which is submitted on USEPA Form 8700-13A must be submitted by March 1 each year and cover activities for the preceding calendar year. The report is to be prepared according to instructions on the form and submitted to FDEP.

A copy of each annual hazardous waste report (USEPA Form 8700-13) must be kept for at least three years. Public Works will maintain these records.

Incident Reports

A record of all hazardous waste incidents that require the contingency plan to be implemented must be kept as a permanent record at NAS Key West. These records must include details of the incident and will be maintained by Public Works.

Contingency Plan

A copy of the contingency plan must be kept at each hazardous waste temporary storage area. Additionally, copies of the contingency plan must be submitted to the station security officer, station fire chief, and station dispensary.

Training Records

The training records must include the following information:

- The job title for each position at the NAS related to hazardous waste management and the name of the person filling each position.
- A written job description these positions listed above.
- A written description of the type and amount of both initial and continuing training that will be given to each person filling these positions.
- Documentation that the training or job experience required has been given to, and completed by, these personnel.

Training records for current personnel must be kept as permanent records. Training records on former personnel must be kept for at least three years from the date the personnel last worked at NAS Key West. Personnel training records may accompany personnel transferred with the Navy.

Hazardous waste training records will be maintained by Public Works for all hazardous waste activity, including records of tenant commands.

Required Notices

Any changes of status relating to hazardous waste requires certain notices by Public Works to FDEP. These notices are described below.

SECTION II.B.10

OTHER FEDERAL AND STATE LAWS

OTHER FEDERAL AND STATE LAWS

This information has been provided in accordance with the requirements of 40 CFR 270.14 (b)(20), 40 CFR 270.3, and FAC 62-730. OB/OD is a multidisciplinary issue, potentially spanning a number of federal and state regulations. In addition to the hazardous waste permitting requirements set forth under RCRA regarding miscellaneous units (40 CFR 264 Subpart X), other federal and state laws must be reviewed to determine if they are relevant to the closure permitting process, including but not limited to the Clean Water Act, the Safe Drinking Water Act, the Endangered Species Act, and the National Historic Preservation Act.

Air Issues

Closure of Demolition Key's OB/OD treatment facility involves sampling soil and groundwater and removing soil. NAS Key West does not believe these operations will have any effect on air quality. As such, no air issues exist regarding closure operations.

Coastal Zone Management Act

The Coastal Zone Management Act (16 U.S. Code [USC] 1451 et seq.) and the regulations regarding its implementation (15 CFR 930) apply to Demolition Key since the facility lies in a coastal zone as defined in Section 304(1) of 16 USC 1453. Section 307(c)(2) of 16 USC 1456 states that "any federal agency that shall undertake any development project in the coastal zone of a state shall ensure that the project is, to the maximum extent practicable, consistent with the enforcement policies of approved state management programs."

The provisions set forth in 15 CFR 930 require any federal activity to comply with the management program of the state in which the facility is located. The monitoring and modeling requirements of this permit application will assist in quantifying potential adverse effects, if any, on the coastal zone, due to the closure of Demolition Key.

According to FAC 62-380.23, when an activity requires a permit subject to federal consistency review, the issuance or renewal of the permit shall automatically constitute the state's concurrence that the permitted activity, as such, is consistent with the federally approved program. This would imply that if a permit is issued and complied with, then the provisions of the Coastal Zone Management Act are being followed. The Florida Coastal Management Act is in Florida Statue (FS) 28-380. Demolition Key shall comply with the contents of this statute.

Drinking Water Issues

Drinking water for Key West is supplied via pipeline from City of Miami, Florida. Demolition Key has no drinking water supply, freshwater supply, or inhabitants. Therefore, groundwater on Demolition Key is not expected to be used as a source for drinking water. As such, closure activities are not regulated under the Safe Drinking Water Act (42 USC 300f et seq.) or the State of Florida's regulatory equivalent, in FS 403.864.

Endangered Species Issues

In situations where a federal agency will be disturbing federal land, the U.S. Fish and Wildlife Service, under the Endangered Species Act (16 USC 1531 et seq.), must survey the land for "species of concern" and endangered species. Regulations governing the provisions of this act are located in 50 CFR 402. According to Mr. Craig Johnson of the Fish and Wildlife Service, no critical habitat has been designated in the vicinity of the project site.

Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (16 USC 661 et seq.) pertains to activities that might adversely affect fish and wildlife, such as diversion, impounding, or controlling waters. No waters are to be diverted, impounded, or controlled as a part of the closure operations conducted at Demolition Key.

Hazardous Materials Transportation Act

Transportation of hazardous materials is regulated by 49 CFR 171 through 179. These regulations apply to the transport of hazardous waste ordnance to and from Demolition Key, including marking, labeling, placarding, and shipping paper completion. All applicable hazardous materials transportation regulations will be complied with during transport of hazardous waste to and from Demolition Key.

Historic Preservation Issues

The National Historic Preservation Act of 1966 (16 USC 470 et seq.) includes a federal review process pertaining to activities that may impact cultural resources. The regulations ensuring compliance with the provisions of the act are in 36 CFR 800. Fort Zachary Taylor, the only historic landmark of potential concern, is in the southwest portion of Key West. This historic landmark is not expected to be affected by hazardous waste ordnance treatment closure operations on Demolition Key.

Marine Mammals Protection Act

This act (16 USC 1361 et seq.) protects marine mammals that might be impacted by the operations at Demolition Key. According to Mr. Craig Johnson of the Fish and Wildlife Service, no critical habitat has been designated in the vicinity of the project site.

Migratory Bird Conservation Act

Migratory birds are of concern at Demolition Key, since it is in the direct migration path for several species. The Migratory Bird Conservation Act (16 U.S.C. 700-715) requires monitoring species and population trends of migratory nongame birds, identifying effects of environmental changes and human activities on all nongame migratory birds, identifying species that are likely to become candidates for listing under the Endangered Species Act, and identifying conservation efforts to ensure that nongame migratory birds do not reach the point of being listed under the Endangered Species Act. It is possible that any development in the keys may impact a migratory bird habitat. It is not likely that closure of the Demolition Key treatment facility will adversely affect the area's migratory bird habitat. Closure of Demolition Key should have a positive or neutral effect on said population.

Nondrinking Water Issues

Hazardous waste ordnance treatment facility closure activities will not produce a "wastestream" as defined in the National Pollution Discharge Elimination System (NPDES) program. An NPDES permit will not be required for closure activities as required under the provisions of the Clean Water Act (33 USC 1251 et seq.), the NPDES program, and the State of Florida's regulatory equivalents, cited in FAC Section 62-620.

Occupational Safety and Health Act

The provisions set forth in 29 CFR 1910 and 29 CFR 1926 are relevant to this application and the person(s) responsible for it. These regulations ensure compliance with the provisions of the Occupational Safety and Health Act (29 USC 651 et seq.). All personnel will be trained according to the applicable requirements of these sections according to the task they perform during closure activities.

Parks and Recreation/Wildlife Refuge/Marine Sanctuary Issues

Demolition Key is not a state park or recreation area, a wildlife refuge, or a marine sanctuary. OB/OD closure activities occurring at Demolition Key do not come under Park and Recreation

or National Marine Sanctuaries jurisdiction, and are not governed by National Wildlife Refuge regulations. National Wildlife regulations are in 50 CFR 25-37 and FAC 28-380.

Wetlands Issues

The entire Demolition Key southeast island, and an area stretching from the entire perimeter of the northern island inward 10 to 15 feet are wetlands. No closure activities will occur on these particular parts of Demolition Key. If a wetland will be impacted by the closure activities at Demolition Key, a permit will be obtained from the wetlands section of FDEP, per the FAC Sections 403 and 373. The federal laws governing the wetlands are contained at Section 404 of the Clean Water Act (33 USC 1251 et seq.)

Wild and Scenic Rivers Act

The Wild and Scenic Rivers Act (16 USC 1273 et seq.) does not apply to Demolition Key, since it has no rivers.

SECTION II.C.1

TREATMENT UNIT DESCRIPTION

TREATMENT UNIT DESCRIPTION

This section was written to comply with FAC 62-730.180; 40 CFR 264, Subpart X; and 40 CFR 270.23. This section shall describe the unit and surrounding environment in detail.

Physical Characteristics, Materials of Construction, and Dimensions of Unit

OB/OD treatment operations were conducted at one location at Demolition Key's hazardous waste treatment facility on the northwest island. Operational characteristics include OB/OD of waste propellants/pyrotechnics and high explosives, respectively, on the ground. The location of the OB/OD treatment operation is identified in Figure II.C-1.

Open Burn/Open Detonation Treatment Facility

OB/OD operations were conducted in an open earthen pit. The earthen pit is a nominal 10 feet in diameter. The deepest area of the earthen pit is 4 feet. Figure II.C-2 provides a cross-sectional view of the open detonation treatment unit at Demolition Key.

Treatment Facility-General

Water Supply

All hazardous waste ordnance items treated at the Demolition Key treatment facility were specifically manufactured to burn rapidly and completely. Thus, emergency water supplies were not required. For additional fire protection, all vegetation - dry grass, leaves, and other combustible materials - were removed from the area surrounding the unit so as not to interfere with treatment operations.

Electrical Equipment

The treatment facility operations required no electrical or other power source. Therefore, an area-wide electrical power failure would not affect this facility. Surveillance operations of Demolition Key are conducted with a boat-mounted spotlight from Garrison Bight Channel and surrounding water.

Treatment Facility Crew Shelter

A crew shelter on the southeast island of Demolition Key protected personnel conducting and supervising the hazardous waste ordnance treatment operations. The structure consists of wood

Figure II.C-1 Facility Unit

Figure II.C-2 Cross-sectional View of Open Detonation Treatment Unit

behind an earthen berm. It is equipped with a periscope to view the detonation and burns. Persons supervising the treatment operation from the crew shelter were equipped with two-way communication devices capable of summoning assistance from NAS Key West.

Unit Operations

Capacities

Open Burn Unit

The OB treatment unit operated in accordance with the Navy guidance manual *Ammunition and Explosives Ashore Safety Regulations for Handling, Storing, Production, Renovation, and Shipping (OP 5)*. As specified per this guidance manual, NAS Key West designated this OB treatment unit a Class A demolition range, with the following operational limitations:

- The unit was limited to a NEW per burn of 5 pounds.
- The unit was not closer than 670 feet from the nearest inhabited building.
- All vegetation - dry grass, leaves, and other combustible materials - was removed from the area surrounding the unit so as not to interfere with treatment operations.
- Only the exact quantity of hazardous waste ordnance to be open burned was treated at this unit. Hazardous waste ordnance was not stockpiled at the treatment location.

Open Detonation

The OD treatment unit also operated in accordance with the Navy guidance manual *Ammunition and Explosives Ashore Safety Regulations for Handling, Storing, Production, Renovation, and Shipping (OP 5)*. As specified per this guidance document, NAS Key West designated the OD treatment unit a Class A demolition range, with the following operational limitations:

- The treatment unit was limited to a NEW per detonation of 5 pounds.
- The treatment unit was not closer than 670 feet from the nearest inhabited building.
- All vegetation - dry grass, leaves, and other combustible materials - was removed from the area surrounding the unit so as not to interfere with treatment operations.

- Only the exact quantity of hazardous waste ordnance to be open detonated was taken to the treatment unit. Hazardous waste ordnance was not stockpiled at the treatment location.

Theoretically, the unit could treat more than these amounts, but hazardous waste ordnance generation rates, weather conditions, and scheduling restrictions (i.e., EOD treatment personnel scheduling, migratory bird habitat, etc.) prohibited attaining design capacity and such capacity was not required.

General Operating Information

Guidelines

This section includes a description of the minimum protective distances and a summary of the SOPs for OB/OD operations. All SOPs were written in accordance with NAVSEA OP-5 guidelines. It should be noted, however, that SOPs changed routinely as work loads changed and as safer treatment procedures were developed. The EOD Detachment at NAS Mayport, Jacksonville, Florida, maintained current treatment SOPs, and all personnel who handled and/or treated such materials were fully knowledgeable in these operational requirements as discussed in Section II.B.6 of this closure permit application.

Open Burning

Explosives from screw-top munitions, pyrotechnics, and initiators were managed in the treatment unit described above. Hazardous waste ordnance, already disassembled prior to transportation to the demolition range, was placed into the unit according to SOPs. A primer cord or electric squib was attached to the circuit wire. Operators retired to the protective shelter, unlocked the control panel, and ignited the propellants. This intense process generated sufficient heat to completely burn residual PEPs.

Open Detonation of High Explosives

Hazardous waste ordnance treated was carefully placed in the treatment unit according to NAVSEA OP-5 SOPs. Demolition material used to detonate the ammunition or components was transferred from storage to the Demolition Key treatment unit along with the hazardous waste ordnance to be treated. A primer cord was attached to the demolition material and blasting caps attached to the primer cord. The primer cord was then attached to the circuit wire. Treatment unit operators retired to the protective shelter, unlocked the control panel, and detonated the ammunition or component.

Minimum Protective Distances

The following minimum protective distances from the OB/OD operations to the property of others wa adhered to in accordance with 40 CFR 265.382:

Open Burning of PEPs: 670 feet
Open Detonation of Explosives: 670 feet

Open Detonation Standard Operating Procedures

This section summarizes the general safety requirements established in the SOPs for OD operations. Copies of the SOPs which specify detailed assignments and operating parameters have not been included because they were constantly being revised to address safety concerns and changes in the types of munitions treated. The most recent version of SOPs are on file with the NAS Key West Weapons Department.

All personnel involved with hazardous waste treatment operations at the Demolition Key treatment facility abided by the following requirements. If these requirements were not followed, severe injury to personnel may result. These requirements were as follows:

- Applicable portions of SOPs shall be conspicuously posted in or near rooms, bunkers, treatment units, or other areas involving munitions handling. Supervisory personnel shall maintain copies of all SOPs and be responsible for enforcing their provisions. There will be no deviation or changes from any SOP without prior approval of the installation Commander or his designated representative.

- Any defect or unusual condition that is not covered in SOPs will be reported immediately to supervisory personnel.

- Care will be taken to limit exposure to a minimum number of personnel, for a minimum time, to a minimum amount of hazardous material consistent with safe and efficient operations.

- Each hazardous waste vehicle/craft operator will have a valid operator's permit for the particular piece of equipment to be operated and for transporting hazardous waste (where necessary).

- Explosive-loaded ammunition, packaged ammunition, or bulk explosives shall not be handled roughly. Large ammunition items, packaged in USDOT-approved containers designed to permit dragging, rolling, or towing may be so moved when necessary. Any ammunition determined to be dangerous to handle or store will be reported immediately

to supervisory personnel. Operations will be suspended and, if warranted, personnel will be evacuated pending further instructions.

- Equipment and grounds shall be tested for electrical resistance and continuity when installed and at intervals determined locally. All exposed explosives or hazardous materials shall be removed before the test.

- Appropriate fire symbols and/or chemical hazard symbols shall be displayed on vehicles used to transport ammunition. Leather or leather-palmed gloves, steel-toed boots, and hearing protection will be worn by all personnel who handle hazardous waste ordnance.

- No hazardous waste treatment operation will be conducted during an electrical storm or when such a storm is within 5 kilometers of Demolition Key. Also, treatment operations will not be conducted during excessive wind speeds or when a low cloud ceiling exists.

- The treatment facility operator or treatment operation supervisor is responsible for reporting all injuries and accidents occurring during his/her shift to the Explosive Safety Officer. In a fire or explosion, the person(s) discovering the fire/explosion will notify the appropriate authorities in accordance with the Contingency Plan in Section II.B.6 of this application.

- All material (ash and/or debris) transferred to the NAS Key West hazardous waste storage facility will be certified free of reactive (i.e., explosive) material by the supervisor in charge.

- Components or material being transported from disassembly operation to demolition grounds or deactivation will be properly identified on the exterior pack according to USDOT and Navy shipping requirements; any misleading markings will be marked out or obliterated.

- Servicing of destruction site:

  — Vehicles transporting explosives material to the open detonation treatment unit at Demolition Key shall meet the requirements of NAVSEA OP-5. No more than two people shall ride in the cab.

  — Containers of explosives or ammunition items to be treated at the OD unit shall be spotted and opened at least 10 feet from each other and from explosive material previously staged for treatment to prevent rapid transmission of fire if premature ignition occurs.

- Materials for detonating ammunition:

  — Treatment of explosives or ammunition by detonation should, when practical, be initiated by electric blasting caps using blasting machines or permanently installed electric circuits energized by storage batteries. Improved methods for exploding electric blasting caps shall not be used unless authorized by the US Navy. The initiating explosives should be primed with detonating cord of sufficient length to extend up through the covering to a point where the blasting cap may be connected above ground level.

  — Special requirements for using electric blasting caps and electric blasting circuits include:

    (1) Electric blasting caps, other electric initiators, electric blasting circuits, and the like may be energized to dangerous levels by extraneous electricity of types and sources such as: static electricity, galvanic action, induced electric currents, high-tension wires, and radio frequency energy from radio, radar, and television transmitters. Precautions shall be taken to reduce the probability of a premature ignition of electric blasting caps and explosive charges.

    (2) The protective shunt shall not be removed from the lead wires of the blasting cap unless to connect to the blasting circuit, except when testing the electrical continuity of the blasting cap and lead wires. The individual who removes the shunt should ground himself by grasping the firing wires prior to performing the operation in order to prevent accumulation of static electricity from firing the blasting cap. **NOTE:** After electrical continuity testing of the blasting cap, lead wires must be short-circuited by twisting the bare ends together. The wires shall remain short-circuited until the time to connect them to the blasting circuit. The Blaster's Galvanometer or DuPont Blaster's Multimeter, Model 101, may be used for continuity testing of blasting caps and lead wires.

    (3) When uncoiling the lead wires of blasting caps, the explosives end of the caps should not be held directly in hand. The lead wires should be straightened out as far as necessary by hand and shall not be thrown, waved through the air, or snapped to loosen the wire coils. Avoid loops by running lead wires parallel to each other and close together. If loops are unavoidable, keep them small. Keep wires on the ground in blasting layouts.

(4) Firing wires shall be twisted pairs. Blasting circuit firing wires shall at all times be twisted together and connected to ground at the power source and the ends of the circuit wires where blasting cap wires are connected except when actually firing the charge or testing circuit continuity. The connection between blasting caps and the circuit firing wires must not be made unless the power end of the circuit lead, is shorted and grounded. The following methods should be followed when connecting electric-type blasting cap lead wires to the firing circuit wires:

(a) Check wires leading to the blasting machine for continuity and stray currents.

(b) Test electric blasting cap wires for electrical continuity, and after the test, connect to blasting machine wires.

(c) Evacuate all but two personnel from the area. Place cap into charge to be detonated.

(d) Unshort firing lead wire circuit and check for continuity.

(e) Connect firing lead wire to blasting machine and fire charge(s).

(f) After firing, remove lead wires from blasting machine and twist the ends to short them.

(g) Arrange a dummy test circuit, essentially the same as the actual blasting circuit except that a No. 47 radio pilot lamp of known good quality is inserted in place of the blasting cap without applying electric current to the circuit. Any glow is evidence of possible dangerous amounts of Radio Frequency (RF) energy, and blasting operations in such areas must be performed with nonelectric blasting caps and safety fuse.

(h) The DuPont Blaster's Multimeter, Model 101, may be substituted for the No. 47 radio pilot lamp when testing for extraneous electricity, but will not detect RF energy.

(5) Blasting or demolition shall not be conducted during an electrical storm or when a storm is approaching. All operations shall be suspended, cap wires shall be short-circuited, and all personnel must be removed to a safe location.

(6) Prior to connecting the blasting machine, the firing circuit shall be tested. The individual assigned to make the connection shall not complete it at the blasting machine or at the panel, nor shall he give the signal for detonation until he is satisfied that everyone in the vicinity is in a safe place. When used, the blasting machine or its actuating device shall be in the individual's possession at all times. When the individual uses a panel, the switch must be locked in the open position until ready and the single key plug must be in his possession.

(7) Electric blasting caps must be in closed metal boxes when being transported by vehicles equipped with two-way radios and also when in areas where extraneous electricity is known or suspected of being present.

(a) Although electrical blasting caps are the preferred method of initiation, safety fuses may be used to detonate explosives and ammunition when safety and efficiency will be enhanced. Safety fuses, when used, must be tested for burning rate at the beginning of each day's operation and whenever a new coil is used. Sufficient length of fuse shall be used to allow personnel to retire to a safe distance, but under no circumstances should a length be less than 3 feet or have less than a 120-second burning time. Fuses which are too large in diameter to enter the blasting cap without forcing shall not be used. Before igniting the safety fuse, all personnel (except the supervisor and not more than one assistant) shall retire to the personnel protective shelter on the southeast key or be evacuated from the treatment facility.

(b) When using blasting caps involving the electric or nonelectric system of destruction always point, the explosives end of the blasting cap away from the body.

- Detonation of ammunition

— This procedure should be used to destroy fragmentation grenades, high explosive (HE) projectiles, mines, photo flash munitions, mortar shells, bombs, and HE rocket heads which have been separated from motors. Rocket motors containing solid propellants should not be destroyed by detonation.

— After each treatment operation by detonation, search the surrounding area for unexploded material and items. Items or material such as lumps of explosives or unfused ammunition may be picked up and prepared for the next detonation.

Fused ammunition or items which may have internally damaged components should be detonated in place unless they can be safely handled using mechanical retrievers that protect personnel. Nonreactive debris should be removed and containerized for ultimate transport to the NAS Key West hazardous waste storage facility.

— In case of misfires, personnel shall not return to the point of treatment for at least 30 minutes, after which not more than two qualified personnel shall be permitted to examine the misfire area.

- Operation of motor vehicles

  — When loading and unloading of munitions, the brakes must be set. When on a grade at least one wheel must be chocked.

  — Vehicles containing hazardous waste ordnance or initiating devices shall not be refueled, including refueling from mobile units. A central station outside the restricted area should be used.

  — No person shall be allowed to ride in or on the truck body or van of a motor vehicle transporting ammunition or explosives except in cases involving limited quantities of small-arms ammunition with nonexplosive bullets. In the latter case, the small-arms ammunition must be in closed containers which are properly secured in the truck body and seats shall be provided for personnel, restricted in number to a minimum required.

  — No hazardous waste ordnance or initiating devices shall be loaded or unloaded from motor vehicles while their motors are running. Motors may be kept running when required to power vehicle accessories, such as mechanical handling equipment used in the loading and unloading of the vehicle, provided:

    (1) The accessory is an integral part of the vehicle.

    (2) The exhaust gases from the motor are emitted at least 6 feet from the point at which the loading operations are conducted and are directed away from this point.

    (3) The exhaust pipe is equipped with a spark arrestor.

- Inspection of vehicles

  — All vehicles used to transport ammunition and/or explosives will be inspected monthly.

  — Government-owned motor vehicles used to transport hazardous materials shall be inspected at frequent intervals by a competent person to ensure mechanical conditions and safety devices are in good working order and that oil and motor pans under engines are clean. Daily inspection shall be made by operators to determine that:

    (1) Fire extinguishers are serviceable.

    (2) Electric wiring is in good condition and properly attached.

    (3) Fuel tank and piping are secure and not leaking.

    (4) Brakes, steering, and other equipment are in good condition.

    (5) The exhaust system is not exposed to accumulation of grease, oil, gasoline, or other fuels, and has ample clearance from fuel lines and other combustible materials.

- Government motor vehicles involved only in on-post shipments shall be equipped, as a minimum, with one Class 10-BC rated portable fire extinguisher mounted outside the cab on the driver's side of the vehicle.

OB Standard Operating Procedures

This section summarizes only the maintenance of the OB treatment unit at the Demolition Key treatment facility, the general burning requirements, and the OB of out-loaded HE projectiles. Other general safety precautions for the handling of pyrotechnics and propellants were the same as those for handling explosives described in the previous section.

- Managing the OB treatment unit includes:

  — Vehicles transporting explosive materials to the treatment facility shall meet the requirements of NAVSEA OP-5. No more than two people shall ride in the cab.

  — Upon arriving at the Demolition Key treatment facility, vehicles offload explosive-containing or explosive items for subsequent thermal treatment. As

soon as all items have been removed, vehicles shall withdraw from the treatment unit to a safe location until the operation is completed. Containers of explosives shall not be opened until all vehicles have withdrawn.

— Containers of explosives or ammunition items to be destroyed shall be spotted and opened at least 10 feet from each other and from explosives material previously laid for destruction to prevent rapid transmission or fire if they prematurely ignite.

— Empty containers shall be closed and moved a sufficient distance from the treatment unit to prevent charring or damage during treatment operations. Empty containers may be returned to NAS Key West after delivery of the next quantity of hazardous waste ordnance to be treated.

- General burning requirements

— All OB treatment operations will be conducted in the treatment unit designed to treat hazardous waste ordnance at Demolition Key.

— Bulk initiating explosives and others used predominantly in detonator and photo-flash compositions shall be treated by OD. Small quantities (not exceeding 28 grams) may be decomposed chemically.

— Wet explosives may require a thick bed of readily combustible material such as excelsior underneath and beyond to ensure that all the explosives will be consumed once the materials are ignited. From the end of the layer of explosives the combustible materials should be extended in a train that serves as the ignition point. If an ignition train of combustible material leading to the explosives is used, it must be arranged so that both it and the explosive burn completely. The combustible train of explosive, if ignited directly, must be ignited by a safety fuse long enough to permit personnel to withdraw safely to the protective shelter. In some cases, it may be necessary to tie two or more squibs together to ensure ignition of the combustible train. When a misfire occurs, personnel shall not return to the point of initiation for at least 30 minutes. Not more than two qualified persons shall be permitted to examine the misfire area.

(1) Loose, dry explosive may be treated without being placed on combustible material if treatment will be complete and does not become unduly contaminated.

(2) Wet explosives shall not be burned without first preparing a bed of nonexplosive combustible material upon which the explosives are placed to ensure complete burning. RDX must be burned wet to prevent detonation.

(3) Dry grass, leaves, and other extraneous combustible material in amounts sufficient to spread fire shall be removed within a radius of 670 feet from the point of treatment.

- Treatment by burning out-loaded HE projectiles

  — TNT, Explosive D, Composition B, pentolite, and other explosives filler in open projectiles may be burned out when treatment by detonation or washing out and burning the explosive filler separately is impracticable.

  — Projectiles to be burned out should be placed on their sides and arranged in groups of not more than six, with all open ends facing the same direction.

  — Combustible material such as excelsior or scrap lumber should be used to ignite the explosive filler. Oil-soaked waste may also be used; however, it shall not be placed in the interior of the fuse activities. Use of oil or woodtreated with pentachlorophenol is prohibited.

Maintenance

The treatment units were inspected for conditions that may impede treatment operations before each burn. All communication equipment was checked before arriving onsite. The crew shelter bunker was inspected for structural integrity before each treatment operation. The Preparedness and Prevention Plan, mentioned above, details the maintenance schedule.

Inspections

The facility will be inspected during closure according to the Preparedness and Prevention Plan (Section II.B.6) in the same manner in which inspections were conducted during operation.

Monitoring

Appropriate media monitoring will be conducted according to the closure plan contained in this closure permit application. The schedules, parameters, monitoring locations, and equipment employed for monitoring purposes are also contained in the enclosed closure and sampling plans.

Closure and Post-Closure

Closure and post-closure will be conducted in accordance with the Closure and Post-closure plans submitted as Section II.D of this application.

SECTION II.C.2

ENVIRONMENTAL ASSESSMENT

ENVIRONMENTAL ASSESSMENT

This section describes in detail the geologic, hydrologic, meteorologic, and ecologic settings of the Demolition Key hazardous waste ordnance treatment facility and surrounding areas, and satisfies the requirements of 40 CFR 270.14(b)(11), 40 CFR 270.14(c) 40 CFR 270.23(b), and FAC 62-730.

Geologic and Hydrologic Setting

The low-lying limestone islands composing the Florida Keys extend 233 miles southwesterly in a gradual arc from Biscayne Bay at the southeastern tip of the Florida peninsula to the Dry Tortugas in the Gulf of Mexico. Southeast of the keys is the Florida Reef Tract, a continuous band of coral reefs bordering the Straits of Florida and lying five to seven miles offshore. The reef tract extends 220 miles from Soldiers Key to the Dry Tortugas. To the west and northwest is the Florida Bay, a shallow embayment of the Gulf of Mexico. The Florida Bay consists of an extensive network of carbonate mud shoals and seagrass beds. Demolition Key lies within the Florida Bay, and consists of two man-made, dredge spoil islands separated by a 50- to 100-foot long channel. Figure II.C-3 depicts the environmental setting.

Topography

The Florida Keys are characterized by gradually sloping keys with low elevations. Most elevations are less than 5 feet above msl. The highest point in the Florida Keys occurs at about 18 feet above msl on Windley Key. Figures II.C-4 and II.C-5 contain a regional view and a site-specific view of topography, respectively. (Figure II.B-1 also contains a color topographic map.)

Demolition Key NW

Topography on Demolition Key NW is sloping with elevations ranging from sea level to 4 feet above. The inner parts of Demolition Key NW have about 2 feet in topographic relief. Most relief occurs at the key's edges, where it rises from the Florida Bay. Most of this key is covered with thick Australian pine in the center, Brazilian pepper between the upland and the wetlands, and mangroves densely inhabiting the perimeter except for a small part facing the channel.

Demolition Key SE

Topography on Demolition Key SE is shallow and flat by virtue of excavation activities conducted during its formation. Most elevations range from sea level to 2 feet above sea level with only 1 foot of topographic relief near the center. Isolated areas of the key contain

Figure II.C-3 Regional Environmental Setting Map

Figure II.C-4 USGS Topographic Map

Figure II.C-5 Site Topographic Map

elevations of up to 4 feet while the man-made observation bunker has an elevation of 9 feet. The majority of this key is open, covered only with sporadic low-growing vegetation. The key perimeter is inhabited with dense mangroves except for the northwest portion facing the channel, which has no vegetation.

Channel

The channel was formed by ordnance detonation not associated with hazardous waste treatment, compounded by storm and sea erosion. Demolition and testing were generally conducted in the center of the key, on the seaward parts. As demolitions occurred, the Florida Bay encroached, aided by waters filling craters, storms, etc. Demolitions continued inland as the Florida Bay encroached and eventually the key was bisected.

Today, large craters can be seen throughout in the channel. These craters are 20 to 50 feet in diameter and up to 10 feet deep. It has been reported that these craters were the result of testing World War II-era sea mines towed into the area and detonated in the water, creating a cratered channel with depths ranging from 1 to 3 feet in some areas and 4 to 10 feet in others.

Surrounding Florida Bay

The bay surrounding Demolition Key consists of relatively deep waters within the Garrison Bight Channel situated to the south and east and shallow waters to the northwest. The Garrison Bight Channel trends northeast-southwest and extends from Demolition Key to Fleming Key. Depths in the channel are approximately 12 feet. Waters on the opposite side of Demolition Key (from Garrison Bight Channel) are relatively shallow, ranging from 1 to 3 feet with relatively low relief. Refer to Figures II.C-4 and II.C-5.

Regional Geology

The Florida Keys belong to the Coastal Lowlands Physiographic Province. This area lies south and southeast of Lake Okeechobee, is underlain primarily by Pleistocene limestones, and is also referred to as the Gold Coast or Florida Bay.

The Florida Keys and Florida Bay are underlain by the Floridan Plateau, which separates the Gulf of Mexico from the Atlantic Ocean and extends offshore beneath the submerged areas surrounding the Florida Keys to the edge of the continental shelf. In the gulf, the plateau slopes gently to the west and extends approximately 150 miles offshore. The south and east sides the Florida Plateau drop off sharply into the Bahamas Trench, approximately 5 to 7 miles offshore.

Geomorphologically, the keys can be divided into three areas: the Upper Keys (High and Low Coral Keys), the Lower Keys (Oolite Keys), and the Distant Atolls (Dry Totugas). Demolition Key lies within the Oolite Keys. Figure II.C-6 presents a regional geologic map of the Florida Keys.

Stratigraphy

The Miami Limestone is the uppermost deposit extending from Big Pine Key through Key West. The Miami Limestone at Key West is an offshore extension of the same formation found in southeast Florida. It is a medium to hard limestone, crystalline, white to yellowish in color, oolitic in places, rich in bryozoans in part, and may contain some quartz sand and/or oolitic sand. Oolites are circular, millimeter-sized grains of calcium carbonate. When cemented, they create an oolitic limestone. When not cemented, they form an oolitic sand. Oolitic limestone portions of this formation may be brecciated and re-cemented as a result of solution.

The Miami Limestone underlies most of the Florida Bay, where it is covered by calcareous mud derived from the disintegration of calcareous algae. The Miami Limestone has been dated to be 90,000 to 145,000 years old (Late Pleistocene), has a thickness of up to 40 feet, and averages 20 feet thick in the Lower Keys.

The Key Largo Limestone underlies the Miami Limestone in the Lower Keys. This unit occurs at land surface from Soldiers Key to Bahia Honda Key. The Key Largo Limestone, the uppermost unit in the Upper Keys, is composed mainly of corals, amorphous limestone, and reef detritus. This unit averages 60 feet thick.

Underlying the Key Largo Limestone is the Upper Pliocene Tamiami Formation consisting predominantly of sandstone and sandy limestone. The Tamiami is estimated to be 140 feet thick and forms the basal member of the Surficial Aquifer System.

The Hawthorne Group underlies the Tamiami Formation. It consists of a complex series of phosphate-bearing Miocene siliciclastic and carbonate sediments. In southern Florida, the Hawthorne group is subdivided into the Arcadia Formation, with the Tampa Member as the basal unit, overlain by the Peace River Formation. The unit is approximately 900 feet thick near the Florida Keys.

The Suwanee Limestone underlies the Hawthorne Group and consists of yellowish gray to white, fossiliferous, poor to well indurated limestone. This unit is approximately 450 feet thick.

Figure II.C-6 Regional Geologic Map

Seismology

The Florida Keys have been assigned to Zone 0 (no potential damage) of the building codes seismic ratings for potential earthquake damage. Although the Florida Keys have felt minor shocks from earthquakes in the Caribbean, no earthquakes of local origin have been recorded. No adverse impact is expected from seismic activity.

Site Geology

Stratigraphy at Demolition Key consists of 3 to 8 feet of dredge/spoils overlying the Miami Limestone. Eleven borings were installed at Demolition Key, six on Demolition Key SE and five on Demolition Key NW. Figure II.C-7 depicts these boring locations. Geologic data gathered include visual inspection of surface materials and subsurface materials to 5 feet below ground surface (bgs). These data, in combination with survey data, allow the Demolition Key subsurface to be defined and described cross-sectionally.

Lithology

Lithology encountered remained consistent for all 11 borings. In each case borings encountered a mix of white to gray gravel to cobble-sized coral/limestone rubble (60%), fine to coarse sand (10% to 30%), and brown to gray silt/mud (10% to 30%). The underlying Miami Limestone (locally referred to as "cap rock") was not encountered.

Demolition Key was created by dumping dredge/spoils on the Miami Limestone. Therefore, the Miami Limestone would be at the same elevation as found in Florida Bay immediately northwest of Demolition Key and about 3 feet below msl. Figure II.C-8 contains a cross section of Demolition Key.

Dredge/Spoils

Dredge/spoils at Demolition Key consist of a mix of white to gray gravel to cobble-sized coral/limestone rubble (60%), fine to coarse sand (10 to 30%), and brown to gray silt/mud (10 to 30%).

This dredge/spoils material was excavated from Florida Bay in an area bounded to the east by Dredgers Key, to the south by Key West, and to the west by Demolition and Fleming Keys. Dredgers, Fleming, and Demolition Keys are all dredge/spoils islands created from dredging operations. This area can be seen on the aerial photograph presented as Figure I.B-2 in Section I.B. Demolition Key is estimated to have been created in the late 1930s to early 1940s.

Figure II.C-7 Boring Locations

Figure II.C-8 Demolition Key Cross Section

Fleming Key is believed to have been created sometime in the 1910s. Dredging operations were common throughout the Florida Keys until 1973, when environmental regulations effectively halted all dredging operations there.

Regional Hydrogeology

Two aquifers are present in the Key West area: the surficial and the Floridan aquifer systems. The surficial aquifer system is also known as the Biscayne Aquifer.

The surficial aquifer system in the Lower Keys occurs in the Miami Limestone, Key Largo Limestone, and Tamiami Formation. This aquifer is considered to be under water table conditions (unconfined). Generally, the Suwannee Limestone forms the upper part of the Floridan aquifer system. However, where the basal Hawthorne sediments are permeable enough, these may form in the upper portion of the Floridan. This aquifer is considered to be under artesian conditions (confined).

The Hawthorne Group is relatively impermeable and typically acts as a confining unit between the surficial and the Floridan aquifer systems. Confining units are lithologic units that have low permeabilities and separate and/or confine aquifers with high permeabilities.

Unit Descriptions

The Miami Limestone is a porous limestone containing numerous vertical solution features most probably formed during the Pleistocene. These features are not commonly connected and, therefore, water does not move laterally as readily as in the Key Largo Limestone. The Key Largo Limestone contains cavities which make it very permeable. Fresh water readily escapes to the sea and sea water easily enters the formation.

The Tamiami Formation contains permeable sandstone and sandy limestone units. The Tamiami is estimated to be 140 feet thick and forms the basal member of the surficial aquifer system. This formation is underlain by the Hawthorne Group. The Hawthorne Group is typically recognized as a confining layer between the surficial and the Floridan aquifer systems. Where the Tampa Member of the Arcadia Formation (lower Hawthorne) is present, it may form the upper portion of the Floridan aquifer system. Abundant mollusk molds found in calcarenite sequences gives this unit high moldic porosity and permeability. Due to alternating high- and low-permeability beds, this formation is considered a minor water-bearing zone of the Floridan. The Hawthorne Group is underlain by the Suwannee Limestone, which is considered a principal artesian water-bearing zone of the Floridan system.

Groundwater Quality

Groundwater in the surficial aquifer is largely saline with relatively few freshwater lenses floating above salt water on larger keys. Freshwater lenses are known to occur on Key West, Big Pine Key, Cudjoe Key, No Name Key, Ramrod Key, and Sugarloaf Key. Although these freshwater lenses are important to the survival of wildlife and plant communities, their chloride concentrations exceed the drinking water criteria of 250 parts per million (ppm).

The surficial aquifer system yields potable water on the Florida Peninsula. This aquifer is the most important source of water supply in southeastern Florida. This water is piped via aqueduct to Florida Keys residents via Miami.

The Floridan Aquifer System does not yield potable water in the Florida Keys. Chloride concentrations exceed the drinking water criteria of 250 ppm and are reported to range from 1,600 to 20,000 ppm.

Site Hydrogeology

Fieldwork conducted for this closure permit application consisted of shallow geologic/hydrogeologic data collection and surveying work. Hydrogeologic data collection included gathering salinity and depth-to-groundwater measurements at 11 locations and a background location. These data have been used to generate salinity and groundwater elevation contour maps. These data are presented in Tables II.C-1 and II.C-2, which present the data by Demolition Key Island (i.e., Demolition Key SE or Demolition Key NW) and low/high tide.

Tidal Influence

Based on fieldwork, groundwater at Demolition Key is tidally influenced. A high-tide elevation of 1.55 feet and a low-tide elevation of -0.51 feet were measured. The groundwater level response to the rise and fall of the tide was significant (about one fifth of the rise or fall of the tide).

Some delay in groundwater rise or fall in response to tides was noted during field observations. Some areas on both islands of Demolition Key appear to be less responsive than others. For example, of six borings on Demolition Key SE, three had higher water levels at low tide than at high tide. Subsequent lowering of the groundwater level was observed but not measured and is attributed to a response delay.

Background data were collected from the channel that now runs between the NW and SE portions of Demolition Key. Background water readings were collected during low tide and are as follows: 1) Depth, 6 inches; 2) Salinity (parts per thousand), 35.5; and 3) Temperature,

31°C. Salinity was noted to be beyond uppermost salinity measurement capacity of the field instrument. Actual salinity may be significantly higher.

Tides during field observations were at their highest due to gravitational influences caused by a full moon. High tide was about 2 feet higher than low tide. Table II.C-3 provides a tide table for the times groundwater measurements were collected.

In some boreholes found on Demolition Key NW, only high tide measurements were possible due to the lowering of the groundwater table during low tide. Some boreholes that encountered groundwater during high tide were left dry at low tide. Attempts to auger further in order to encounter groundwater at low tide were not successful due to auger refusal.

Table II.C-1
Demolition Key SE Tide Levels

	High Tide			Low Tide		
Boring	Depth to Water (inches)	Salinity (Parts per Thousand)	Temp. (C°)	Depth to Water (inches)	Salinity (Parts per thousand)	Temp. (C°)
B-1	18	30	31	18.5	25.5	31
B-2	27	27	31	28.5	11	32
B-3	17.5	25	30	18.5	23	32
B-4	9	25.5	30	12	13	32.5
B-5	9	32.5	30	14.5	24	32
B-6	7	28	29	12	23.5	33

Table II.C-2
Demolition Key NW-High Tide

Boring	Date/Time Drilled	Date/Time Sampled	Depth To Water (inches)	Salinity (parts per thousand)	Temp. (C)
B-7	8/9/95 10:00	8/10/95 11:38	38.5	30	28
B-8	8/9/95 10:30	8/10/95 11:45	47.5	13	28
B-9	8/9/95 11:15	8/10/95 11:47	21	30	28
B-10	8/9/95 13:45	8/10/95 11:49	33.5	26	27
B-11	8/9/95 14:30	8/10/95 11:51	49	24.5	28

Table II.C-3
Tide Table-Key West Harbor

Date	Low	High	Low	High
8/7/95	—	6:08	13:06	19:54
8/8/95	0:12	7:13	13:57	20:40
8/9/95	1:13	8:11	14:43	21:22
8/10/95	2:10	9:04	15:25	22:01
8/11/95	3:05	9:53	16:05	22:38

Groundwater Quality

No freshwater lens exists on Demolition Key. Salinity measurements taken from 11 boreholes showed salinity to range from 11 to 32.5 ppt. Florida Bay water in the channel was found to have a salinity of at least 35.5 However, due to the meter equipment scale limitations, actual salinity may be higher.

Lower groundwater salinity, as illustrated at various sampling points and times, is attributed to dilution from percolation of precipitation. Therefore, groundwater salinity would be expected to vary greatly over time depending on precipitation.

Figures II.C-9 and II.C-10 provide salinity contours for high tide at both keys and salinity contours for low tide at Demolition Key SE. Measuring low tide at Demolition Key NW was not possible at that time. Although Florida Bay may have a higher salinity, 35.5 ppt was used to generate these figures.

Groundwater Quantity

Demolition Key NW has been estimated to be 354,000 square feet. Demolition Key SE has been estimated to be 216,000 square feet. Assuming a 30% porosity, a sea level change of 2 feet, and groundwater response of 6 inches, groundwater quantity can be estimated to be 399,000 gallons at Demolition Key NW and 244,000 gallons at Demolition Key SE.

Groundwater Flow Direction

Groundwater flow direction is expected to be influenced primarily by tidal conditions. Groundwater elevations responded to tidal conditions in all parts of Demolition Key. During high tide, surface water from the surrounding Florida Bay infiltrates both Demolition Key NW and Demolition Key SE, causing groundwater level rise. During low tide, the effect is reversed as groundwater discharges from Demolition Key NW and SE to Florida Bay. Figures II.C-11 and II.C-12 show groundwater flow direction to be roughly radial.

This rise and fall of groundwater, twice in a 24-hour period, results in a continuous saline water flushing action from the surrounding Florida Bay. Any flow attributed to the percolation of precipitation would be expected to be minor and only occur during and shortly after precipitation.

Figures II.C-11 and II.C-12 provide groundwater elevation contours for high tide at both islands of Demolition Key and groundwater elevations for low tide at Demolition Key SE. Measuring low tide at Demolition Key NW was not possible during field observation but could be expected to act similarly to Demolition Key SE.

Soil

Soil at Demolition Key consists of dredge/spoils material. The relatively young age of Demolition Key precludes the formation of natural soil. Based on observations of tidally influenced groundwater fluctuations, permeability of soil (dredge/spoils) at Demolition Key is estimated to be 2 to 6 inches per hour.

Figure II.C-9 High Tide Salinity Contour Map

Figure II.C-10 Low Tide Salinity Contour Map

Figure II.C-11 High Tide Groundwater Levels

Figure II.C-12 Low Tide Groundwater Levels

Drinking Water

Neither the surficial nor the Floridan aquifer systems contain water of sufficient quantity and quality to be considered a viable freshwater supply in the Florida Keys. Groundwater from either aquifer would require desalination for potable use. Potable water is piped via aqueduct from the Florida Peninsula to the Florida Keys. Presently, no potable water supply system is available at Demolition Key.

Florida Key Aqueduct Authority

Monroe County receives its potable water from the Florida City Wellfield in Dade County via aqueduct. Groundwater is withdrawn from the wellfield by the Florida Keys Aqueduct Authority (FKAA). The wellfield taps the surficial aquifer system in Dade County on the Florida Peninsula.

Water is piped through a 130-mile, large-diameter aqueduct and approximately 430 miles of distribution lines to residents by the FKAA. The aqueduct runs the length of U.S. Highway 1. The FKAA is the sole supplier of potable water for Florida Keys residents.

Key West Wells

Some mainland Monroe County residents maintain their own water supplies using home reverse osmosis to desalinate groundwater from the surficial aquifer system. Some residents collect rainwater in cisterns. Well water or rainwater usually supplements FKAA water, primarily for irrigation. Demolition Key has no wells.

Regulations

The protection of water table levels and regulation of aquifer withdrawals are primarily the domain of the South Florida Water Management District (SFWMD). Water quality is regulated by FDEP.

Floodplain Analysis

FEMA has categorized Demolition Key as being in Zone VE 13 of the 100-year floodplain. This designation is defined as having additional hazards of coastal floods with velocity hazard (wave action) up to a base flood elevation of 13 feet above msl. No part of Demolition Key lies above 13 feet msl. Figure II.B-4 in Section II.B.5 presents Demolition Key on the FEMA floodplain map.

Approximately 80% of the Florida Keys, including Demolition Key, are subject to storm surge impact from a Category I hurricane. The Coastal High Hazard Area (CHHA) includes areas which have historically experienced destruction or severe damage, or are predicted to, from storm surge, waves, erosion, or other features of rapidly moving or storm-driven water. A large percentage of Monroe County, including Demolition Key, lies within the CHHA.

Meteorological Assessment

The Florida Keys experience a sub-tropical savanna-type climate characterized by warm humid summers and mild dry winters. The average annual temperature ranges from 89°F in July and a low of 63°F in February. Temperatures below freezing have not been recorded in the keys. The average temperature is approximately 77°F. The proximity of the Gulf Stream, combined with the effects of the Gulf of Mexico, tend to mitigate advancing cold fronts. Easterly trade winds and sea breezes suppress the summer heat.

The average annual total precipitation in the keys is estimated at 36 inches. Approximately 65% of the rain comes in the wet season, from May to October. Winter rainfalls account for only a third of the annual precipitation. Thunderstorms are the primary source of water during the wet months. Hazardous waste ordnance is not treated during thunderstorms.

The wet season is dominated by large convective thunderstorms with an average frequency of every third day. During the winter most rainfall results from rapidly moving cold fronts which pass through the region approximately once a week.

Demolition Key is in an area susceptible to hurricanes and tropical storms. Hurricanes normally form in the warm, moist air over the tropical sea areas around the Lesser Antilles and occasionally in the Caribbean. They move westerly to northwesterly, gradually turning northward and eastward. Most hurricanes approach Key West from the south and east, with their effects felt on the south, east, and west sides of the island. However, severe hurricanes have struck Key West from all directions. It is estimated that 75% of all damage that occurs during the hurricane is from tidal flooding. The probability that a hurricane will occur in a year within a 50-mile segment of the U.S. coastline near Key West is 13%.

The prevailing wind direction is from the southeast in the spring and summer and from the northeast in the fall. These winds are relatively mild, averaging 11 to 12 knots over the course of the year. The strongest winds occur between December and March, when cold fronts move down from the north. Meteorological surface data from five previous years indicate similar annual patterns for wind direction frequency and speed, as shown by the wind rose plots from 1988 through 1992 (Figures II.C-13 through II.C-17).

Figure II.C-13 Wind Rose Map 1988

Figure II.C-14 Wind Rose Map 1989

Figure II.C-15 Wind Rose Map 1990

Figure II.C-16 Wind Rose Map 1991

Figure II.C-17 Wind Rose Map 1992

Pasquill stability class is a description of the atmosphere that can be interpreted in terms of atmospheric dispersion (Table II.C-4). Atmospheric dispersion was modeled for this facility's operations to determine the dispersion patterns of products created by the treatment of hazardous waste ordnance. Air dispersion modeling is discussed in Section II.C.3.

The stability classification scheme considers the effects of turbulence, buoyancy, and heating and cooling to gain an idea of the atmosphere's stability. From this estimation of atmospheric stability, the area of dispersion can be predicted.

There are six stability classes, A through F. The classes representing unstable conditions are A, B, and C. Class D represents neutral conditions, and classes E and F represent stable conditions. The unstable classes (A, B, and C) have the most dilution within the plume due to rapid mixing. These plumes also meander less than those under stable conditions, resulting in pollutants reaching the ground closer to the source. At the same time, meteorological conditions present with unstable plumes lead to higher plume rises. The net result is that unstable plumes rise higher, come down quicker than a stable plume would if it were at the same height (a stable plume will actually be much lower height), and at the same time have the most dilution due to the rapid mixing.

Table II.C-4
Pasquill Stability Categories

	Day (Insolation)			Night[2]	
Surface Wind Speed (m/s)	**Strong[1]**	**Moderate**	**Slight[1]**	**Thinly overcast > 4/8 cloud**	**< 3/8 cloud**
<2	A	A-B	B	—	—
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D[3]	E
5-6	C	C-D	D	D	D
>6	C	D	D	D	D

Notes:

1 = Strong insolation corresponds to sunny midday in midsummer in England; slight insolation to similar conditions in midwinter.

2 = Night refers to the period from one hour before sunset to one hour after sunrise.

3 = The neutral category D should also be used, regardless of wind speed, for overcast conditions during day or night and for any sky conditions during the hour preceding or following night as defined above.

The most frequently occurring stability class for Key West is class D. Using meteorological data from 1992, stability class D resulted most frequently, occurring 52% of the time. Classes C and E both occurred 16% of the time, and all other classes occurred less than 10% of the time. Table II.C-4 provides a key to the Pasquill Stability Categories.

ECOLOGICAL ASSESSMENT

General Site Information

Demolition Key is actually two adjacent keys separated by a channel approximately 20 feet wide at its narrowest point. The northernmost key is the largest and contains 2- to 3-foot deep pits from past training and ordnance demolition. This key is generally flat and contains mostly the invasive/exotic species of Australian pine (*Casuarina* spp.) and Brazilian pepper (*Schinus terebinthifolius*). The bay cedar (*Suriana maritima*), a plant species protected by Monroe County, was abundant. No mammalian, migratory bird, or reptile species appeared to be using the northernmost key as permanent habitat, but it is reportedly used during part of the year as nesting habitat for migratory birds. Local bird species appear to use the key for regular habitat.

The southernmost key is the smaller of the two and also appears to have been impacted by demolition activity. Also, this island has been excavated recently. The island did not have as much invasive/exotic vegetation as the northernmost key and was not as elevated topographically. Because of the reduced vegetation, this key did not appear to be used as frequently by local bird populations.

Wetlands on Demolition Key

The northernmost key was determined to contain wetlands, delineated according to Chapter 62-340 of the Florida Regulations, Delineation of the Landward Extent of Wetlands and Surface Waters, through analysis of topography and the presence of four vegetative species: white mangrove (*Laguncularia racemosa*), red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), and sea-purslane (*Sesuvium portulacastrum*). All three of the mangrove species are identified as obligate wetland plant species. The sea-purslane is a succulent herbaceous facultative wetland species. The boundary where wetland hydrology begins and ends is undefinable as rocky conditions prevent intrusive investigations at the key.

Soil is also not useful in delineating wetlands because of its homogeneous nature throughout the key and lack of any organic base to provide evidence of hydric conditions. However, the method used in delineating wetlands relied on topography and vegetation only; the fact that hydrology and soil could not be used as indicators should not impact the results of the delineation. Also, high tides flood much of the area delineated as wetland.

Thirty survey flags were placed in the northernmost key marking the wetland boundary. Boundaries were chosen based on topography, vegetation, and the presence or evidence of standing water. A copy of this map is included as Figure II.C-18. Most of the northernmost key contains dramatic topographic breaks where the boundary between wetland and upland was relatively easy to determine. Where the topographic changes were more subtle, vegetation was the determining factor in delineating the wetland boundary.

Wetland boundaries on the southernmost key were also delineated and evaluated for any and all pertinent ecological characteristics. This key is not as elevated as the northernmost key, and subsequently the entire key was considered a wetland. Sea-purslane was prevalent throughout the entire key and all three mangrove species were noted along its edges. During high tide, this key is almost completely inundated. Thus, the smaller key is considered entirely wetland.

Regional Air Quality

USEPA and the FDEP have implemented an air quality monitoring program throughout the state to measure concentrations of major pollutants in the ambient air. This program is designed to provide data regarding compliance with the legal limitations on ambient air concentrations of major pollutants established by both USEPA and FDEP. Ambient air is defined as that portion of the atmosphere near ground level and external to buildings and other structures.

The six major pollutants for which limits on air quality standards have been set are: carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide. FDEP has adopted ambient air quality standards at least as stringent as the national secondary standards.

Air quality in the Florida Keys is generally excellent. Sea breezes, coupled with the lower intensity of development and small number of point sources, result in relatively low pollutant loads which are dispersed by winds. Based on ambient air quality monitoring, FDEP has designated Monroe County as an area meeting ambient air quality criteria for all six major air contaminants.

Surface Water Characteristics

Both keys are surrounded by surface water, specifically Florida Bay. Surface water temperature measured between the two keys was 31°C. This measurement was taken on August 8, 1995.

Figure II.C-18 Demolition Key Wetland Boundary Map

Demolition Key is tidally influenced. During high tide, the smaller of the two keys was almost completely inundated. However, the larger key is higher in elevation and does not appear to be as inundated by tides.

Comprehensive long-term water quality monitoring data are not available for the Florida Keys' waters. In a recent FDEP report, the state ranked Monroe County's waters as the least studied in the state, with more than 90% still unassessed for water quality. Data were unavailable to demonstrate temporal changes in water quality because well-designed, long-term studies have not been conducted. Past water quality studies have been limited to mostly short-term (one year or less) water quality monitoring, usually comparing impacted or developed sites to undeveloped or offshore control sites. Impacted sites have typically included artificial water bodies such as canals. Since 1985, three large-scale water quality studies have been undertaken in the Florida Keys; they are summarized in the *Monroe County Comprehensive Plan.*

The water surrounding Demolition Key reportedly has abundant marine grass beds at shallow depths. These grass beds provide habitat for fish and other marine organisms and are a vital component of the benthic food chain. Healthy communities of marine grass beds are reported to be present near Demolition Key. Many commercially and recreationally important fish species are reported to live and feed in the area of Demolition Key (Monroe County Comprehensive Plan).

The nearby surface waters are used for recreation and transportation. A navigable channel, Garrison Bight Channel, runs adjacent to the key but is closed during treatment operations.

Regional Fisheries Resources

Seagrass beds are transitional habitats between the coral reef and mangrove habitats. As such, they are important to many species of both ecosystems. They provide abundant food and shelter for many species of fish, sea turtles, and invertebrates. They represent the richest nursery and feeding grounds in South Florida's coastal waterways. In addition to representing a primary resource for grazers, seagrasses provide vast amounts of energy via detritus that may cycle internally or be expected in mangrove or coral reef communities.

Many species of fish complete their life cycle within the mangrove community. Others depend on mangroves during juvenile life stages and migrate to grassbeds and/or coral reefs when mature. Others are seasonally or locally abundant. Many of the invertebrates and fishes are important to the region's recreational and commercial fisheries (Monroe County Comprehensive Plan).

Threatened and Endangered Species

Four governmental organizations (US Fish and Wildlife Service, Florida Game and Freshwater Fish Commission (FGFFC), NAS Key West Natural Resources Department, and Monroe County) with knowledge of the area were contacted to determine whether threatened or endangered species may live on Demolition Key. None of these groups had any evidence that threatened or endangered species live on the key. According to the FGFFC the Least Tern (a listed threatened/endangered species) *may* nest on Demolition Key from March to June. To protect the nesting and survival of the Least Tern, during these months no testing or training operations will be conducted at the Demolition Key hazardous waste ordnance treatment facility. Monroe County has published a map showing threatened and endangered species known to exist in the area. None of these species' habitat was noted on Demolition Key or within approximately 3 miles of it. This map is included as Figure II.C-19.

At least one plant species listed for protection by Monroe County, the bay cedar (*S. maritima*), is common on Demolition Key. Since this species is listed by Monroe County, it has no legal status in relation to Demolition Key. Other vegetative species noted on the key include the Australian pines, Brazilian peppers, and the mangroves.

Demolition Key is also between the Key West National Wildlife Refuge, approximately 2.5 miles west of Truman Annex, and the Great White Heron National Wildlife Refuge, approximately .5 miles north-northeast of Demolition Key. The locations of any possible endangered or threatened species habitat or other sensitive environments on these preserves is not known.

Migratory Bird Habitat

Impacts to migratory bird habitat during nesting season are the primary concerns relating to any plant or animal species. The red and black mangroves along the shore of the northernmost key range to about 30 feet in height and provide habitat and nesting sites for wading birds, perching birds, and other migratory species. Large migratory species such as the great white heron (*A.h. occidentalis*) and the great blue heron (*A. herodias*) are common in the area as are the smaller species such as the little blue heron (*E. carulea*) and the night heron (*Nytctanassa sp*).

According to the NAS Key West Natural Resources Management Department, September and October are the only months when any of three common migratory bird species would not be considered to possibly nest on Demolition Key. This is based on a review of species that live in the area and known characteristics about their breeding behavior. No published documentation was available to support this assumption, since the NAS Key West Natural Resources Management Plan has not yet been published. FGFCC also concurred with the Natural Resource Manager of NAS Key West concerning when migratory birds may nest on Demolition Key.

Figure II.C-19 Monroe County Threatened and Endangered Species Map

SECTION II.C.3

POTENTIAL PATHWAYS OF EXPOSURE

POTENTIAL PATHWAYS OF EXPOSURE

The following section satisfies the requirements of 40 CFR 270.14(c), 40 CFR 270.23(c), and FAC 62-730, and discusses the fate and transport of OB/OD treatment operation by-products in the environment, and the potential adverse effects on human or ecological receptors. Fate and transport assessment involves estimation of dispersion, conversion, degradation, immobilization or elimination of chemicals as they move within and between environmental media. Potential human and/or ecological effects are estimated based on identification of possible receptors, projections of potential exposure (or intake), and toxicological properties of the chemicals involved. Each element is discussed separately in the following paragraphs.

Fate and Transport Modeling

The following paragraphs discuss the results of fate and transport modeling performed to predict chemical dispersion during OB/OD treatment activities.

Air Modeling

Relative to OB/OD operations, air pathway modeling is the linchpin for evaluating chemical fate and transport in all media. During open burning or detonation, the chemical components of waste ordnance are transformed through rapid oxidative processes producing numerous reaction by-products. These by-products are subsequently dispersed in air around the treatment site through energetic propulsion from the reaction or entrainment in the heated plume emanating from the reaction. As kinetic energy is lost, the by-products may move from the air medium to other media as a function of trajectory for energetically emitted particulates or the plume drop (deposition) with distance from the source for gaseous, liquid or aerosol emissions.

In order to assess the potential emissions from OB/OD activities at Demolition Key, El Dorado Engineering Inc. (EDE) was retained to perform air dispersion modeling. EDE used the Products of Combustion/Atmospheric Dispersion (PCAD) computer model for this purpose. The PCAD model was developed by EDE specifically for quantifying and evaluating airborne emissions from OB/OD operations. The modeling protocol, model description and report are included as Appendix B.

Based on information provided by Weapons Department personnel, the following estimates were made regarding the ordnance makeup of the five pounds 'net explosive weight' (NEW) treated during each operation's cycle (i.e., eight OB and one OD event per annum). The assumed typical chemical composition of each ordnance class is provided in the modeling protocol.

- CAD (as composite propellant) 95 %
- Cartridges 1 %
- Smokes/Flares (as flare mix) 1 %
- Trinitrotoluene (TNT) 3 %

The PCAD model predicted (qualitatively and quantitatively) the products of combustion, heat release rates and dispersion characteristics of the resulting plume based on this combination of waste ordnance. Table II.C-5 summarizes the predicted reaction by-products as well as the mass of each expected to be produced during each treatment event assuming a 4:1 air to fuel (ordnance) ratio as determined by EDE based on previous ordnance treatment studies.

As shown in Table II.C-5, 11.34 kilograms of by-products were predicted to be created during each treatment event. The principle products are expected to be carbon dioxide (11.37 %), potassium chloride (0.93%), potassium hydroxide (1.07%), water (3.05%), nitrogen (64.56%), oxygen (14.55%), and potassium carbonate (4.30%). These chemicals account for 99.83 percent (11.32 kilograms) of all expected reaction by-products (by mass). Magnesium oxide (0.066%), strontium oxide (0.049%) and nitric oxide (0.043%) were the only other products for which greater than 1 gram was expected.

Previous studies on ordnance disposal (BANG BOX reference) have suggested that complex organic compounds could form during OB/OD activities. These findings were not corroborated by the model projections which were based on the documented thermodynamic properties of each reactant. The PCAD model does assume that oxygen availability to the reaction site is limitless and that complete oxidation of each reactant is achieved. In actual OB/OD operations, localized oxygen depletion and/or energetic ejection of partially reacted ordnance components could result in incomplete decomposition. These conditions would be much more likely to exist during OD making this method of treatment less desirable than the more controlled OB process in terms of creating incomplete combustion products. In either case, the mass of complex organic by-products is expected to be low relative to those by-products quantified during EDE's modeling process based on their absence in EDE's qualitative model outputs. EDE's qualitative modeling showed that thermodynamic conditions in the modeled OB/OD event were not conducive to the formation of complex organics. Air monitoring activities scheduled to be conducted during and after each (at least initially) treatment action will be used to confirm both the qualitative and quantitative modeling outputs (see Section II.C.1).

For both OB and OD treatment schemes, the highest maximum air concentrations of reaction by-products were predicted under atmospheric stability class D with a high vertical temperature gradient (VTG). This information is summarized in the modeling protocol, model description

Table II.C-5
OB/OD Combustion Products
Summary of Product Mass — Demolition Key

Product	Grams Product Per 5# Treated Material	Percent of Total Mass Produced	Principle Products
Carbon monoxide	0.000759447	0.000007%	
Carbon dioxide	1289.857	11.37%*	11.37%
Calcium hydroxide	6.554E-05	0.000001%	
Chlorine	4.061E-05	0.0000004%	
Hydrogen chloride	0.0014893	0.000013%	
Hypochlorous acid	2.97E-06	0.00000003%	
Potassium chloride	97.06228	0.856%*	0.86%
Chlorine oxide	5.8E-06	0.00000005%	
Potassium chloride	8.105365	0.071%	
Hydrogen	1.3E-07	0.000000001%	
Potassium hydroxide	121.767	1.07%*	1.07%
HNO	3.5E-07	0.000000003%	
Nitrous acid	0.00020685	0.000002%	
Nitric acid	0.00016794	0.000001%	
Hydroxide	0.06669558	0.00059%	
HO_2	0.00014448	0.000001%	
Hydrogen	1.854E-05	0.000000%	
Potassium peroxide	0.4393562	0.0039%	
Magnesium hydroxide	1.653E-05	00000001%	
Water	345.3974	3.05%*	3.05%
Hydrogen peroxide	1.851E-05	0.0000002%	
Strontium hydroxide	0.00162623	0.000014%	
Potassium	0.02558986	0.000226%	
Potassium oxide	0.00363223	0.000032%	
Nitric oxide	4.858757	0.0428%	
Nitrogen oxide	0.05397237	0.00476%	
Nitrogen	7320.916	64.56%*	64.56%
Nitrous oxide	0.00038581	0.000003%	
Oxygen	0.00081659	0.000007%	
Oxygen	1649.936	14.55%*	14.55%
Sulfur dioxide	6.54E-06	0.00000006%	
Ozone	5.4E-07	0.000000005%	
Potassium carbonate	487.257	4.30%*	4.30%
Calcium oxide	0.8399694	0.0074%	
Potassium sulfate	0.2355759	0.0021%	
Magnesium oxide	7.519726	0.066%	
Strontium oxide	5.55232	0.49%	
Sum of Product Mass	11339.90	100%	99.76%

and report of Appendix B along with predicted maximum air concentrations under other atmospheric condition scenarios. Stability class D is generally characterized by moderate to slight incoming solar radiation (overcast conditions) with surface wind speeds in excess of 5 meters per second.

Due to treatment operation restrictions associated with windy conditions, no wind speed in excess of 6.7 meters per second (15 miles per hour) was considered.

For the OB treatment scenario, air concentrations of 3 percent or more of the maximum are projected to occur at a distance greater than 4.5 kilometers from the treatment unit with stability Class D and a low VTG. This scenario represents the greatest dispersion predicted for OB operations. Maximum dispersion for OD operations was projected under stability Class C with a low VTG. Under these conditions, air concentrations of 3 percent of predicted maximum are expected to occur at a maximum distance of 5.5 kilometers from the source.

Fate and Transport in Other Media

Based on the qualitative and quantitative outputs from the PCAD model, it was determined that greater than 99.8 percent of the total reaction by-product mass would be comprised of carbon dioxide, potassium chloride, potassium hydroxide, water, nitrogen, oxygen and potassium carbonate. Carbon dioxide, oxygen, nitrogen, and water are primary components of ambient air, and do not warrant detailed evaluation of dispersion in other media. Potassium chloride, hydroxide and carbonate are innocuous at the maximum concentrations predicted (less than 1.5 mg/M^3), and would be expected to be present in a marine environment.

Of the other predicted reaction by-products, strontium oxide was identified as having the greatest potential toxicological consequence. The maximum one hour time weighted average (TWA) concentration in air was predicted to be 0.00068 mg/M^3 strontium oxide (OB stability class D, high VTG). Based on this extremely low air concentration and the projected dispersion patterns under the referenced atmospheric conditions, no measurable impacts on other environmental media (soil or surface water) through deposition of airborne by-products would be expected after repeated treatment events. This conclusion would also be expected to apply to other transport routes such as soil to groundwater and soil to surface water. Because no appreciable accumulation of reaction by-products is expected in soil, indirect impacts on groundwater or surface water are not anticipated.

These conclusions may differ substantially from those suggested by previous RFI studies conducted on Demolition Key. Soil samples collected in the vicinity of former OB/OD treatment units were found to contain elevated concentrations of arsenic, antimony and lead. These apparent OB/OD operation impacts likely resulted from unrestricted and/or indiscriminant treatment practices. Under the conditions of the RCRA Part B permit for Subpart X treatment

operations, standard practices are stipulated for restricting the waste ordnance which may be treated, planning and conducting OB/OD, and post treatment activities (i.e. cleanup of scrap metal debris). As a result, historical post treatment impacts will not occur upon implementation of permit conditions.

Risk Calculations

The purpose of this section is to predict potential human health effects associated with exposure to OB/OD treatment by-products.

Air Pathway

As discussed in the Fate and Transport section, approximately 99.8 percent of the total by-product mass consists of harmless chemicals typically found in ambient air and/or marine environments. Many of the minor treatment by-products (NO_x, O_3, SO_2 etc.) are also present in ambient air. Magnesium oxide and strontium oxide were predicted to be emitted from the treatment unit in relatively low amounts with maximum 24 hour TWA air concentrations of 0.00003849 and 0.00002842 mg/M^3, respectively (OB scenario, stability class D, high VTG).

In order to evaluate the possible human health effects associated with exposure to magnesium oxide and strontium oxide, toxicologically based exposure standards were obtained. USEPA's Integrated Risk Information System and Health Effects Summary Tables were used as the primary references. No toxicological values for magnesium oxide were available through either primary reference. As a result, the American Conference of Governmental Industrial Hygienists 1994-1995 Threshold Limit Value (TLV) for magnesium oxide (10 mg/M^3) was used to provide a point of reference. For strontium oxide (as strontium), the reference dose provided in IRIS was used to derive an ambient air risk-based concentration protective of human health.

Comparison of the maximum predicted 24 hour TWA magnesium oxide concentration to the TLV shows that modeled value is five orders of magnitude less than the TLV. Although TLV's are not considered directly applicable to protect sensitive receptors, the five order of magnitude difference suggests that the maximum magnesium oxide concentration would not pose a human health threat via the air pathway. The strontium oxide risk-based concentration in ambient air was calculated to be 2.2 mg/M^3. The maximum predicted 24 hour TWA concentration is nearly five orders of magnitude less than the risk-based value. This comparison indicates that strontium oxide emissions from OB/OD treatment operations would not pose an unacceptable human health threat via the air pathway.

Other Exposure Pathways

Due to the innocuous nature of most treatment by-products, no formal assessment of potential human health effects is supported. Of the by-products, specific toxicological information was available only for strontium oxide (as strontium). Conservative screening values for strontium in soil and water were derived using default risk assessment assumptions. The soil screening concentration protective of human health (assuming residential use of the affected parcel) was 47,000 mg/kg, and the water (as tap water) value was 22 mg/liter.

To put the soil screening value in perspective relative to treatment by-products, the total mass of strontium oxide produced in each event was analyzed (5.55 grams/event or 4,690 milligrams strontium/event). In order for strontium to reach the screening concentrations in soil, the total mass of strontium produced during 10 treatment events (one year of scheduled events plus one) would have to be concentrated in one kilogram of soil (approximately one liter of soil). Based on the dispersion modeling outputs, by-products are distributed over a wide area downwind of the treatment unit. As a result, there is no possibility that soil pathway concerns would arise from deposition of airborne strontium oxide.

Using similar logic, direct introduction of the strontium oxide output from each treatment event into 2,100 liters (2.1 cubic meters) of water (surface water or groundwater) could result in a concentration at the screening value. Two factors would influence the legitimacy and potential for this scenario. First, both groundwater and surface water on and around Demolition Key have been shown to be saline. Thus, neither water source is fit for human consumption, and a human health-based screening value is not entirely appropriate. Second, even if either water source were potentially potable, the aqueous volume into which the strontium oxide would be introduced would be far greater than 2,100 liters (Gulf of Mexico or shallow aquifer underlying Demolition Key). As a result, no adverse human health effects can be reasonably expected in relation to treatment by-product impacts on surface or groundwater.

SECTION II.C.4

DEMONSTRATION OF THE EFFECTIVENESS OF TREATMENT

DEMONSTRATION OF THE EFFECTIVENESS OF TREATMENT

This section satisfies the requirements of 270.23(d) and FAC 62-730. Hazardous waste ordnance was treated by OB/OD to eliminate the characteristic of reactivity and reduce the ordnance item to a manageable ash residue that could be further treated, if necessary, to eliminate other RCRA toxicity characteristics (i.e., arsenic, barium, lead, mercury, etc.). Very little data exist to demonstrate the effectiveness of OB/OD for treating hazardous waste ordnance.

One such document that does explain the effectiveness of treatment of military hazardous waste ordnance by OB/OD is the *Development of Methodology and Technology for Identifying and Quantifying Emission Products from Open Burning and Open Detonation Thermal Treatment Methods, Bangbox Test Series, Vol. 1, Test Summary (Final Report - January 1992)*. This report is contained in its entirety as Appendix C.

SECTION II.C.5

IGNITABLE, REACTIVE, AND INCOMPATIBLE WASTE

IGNITABLE, REACTIVE, AND INCOMPATIBLE WASTE

This section satisfies the requirements of 40 CFR 270.14(b)(9) and FAC 62-730. All personnel handling impacted environmental media shall assume it to be hazardous due to the inherent physical and chemical characteristics of its origin and shall take appropriate measures commensurate with Navy instruction and guidance and according to Section II.B.6 (Facility Security) of this operating permit application during removal, loading, transportation, and unloading to prevent reactions which:

- Generate extreme heat or pressure, fire or explosion, or violent reactions;
- Produce uncontrolled toxic mists, fumes, dusts, or gases in sufficient quantities to threaten human health or the environment;
- Produce uncontrolled flammable fumes or gases in sufficient quantities to pose a risk of fire or explosion; and
- Through other like means threaten human health or the environment.

These criteris are accomplished by implementing the following safety guidelines:

- Ignition sources shall be prohibited or adequately controlled at the former treatment facility and around other impact areas;
- Spark-producing equipment and tools shall be prohibited from use during media removal operations unless specifically authorized;
- Incompatible materials shall not be stored in the same containers and/or locations; and
- Supervisors shall inspect hand tools and mechanical devices to ensure that they have not become unsafe for use as designated.

More detailed requirements outlining the proper management and handling of ignitable, reactive, and incompatible hazardous waste are included in Section II.C.1, Treatment Unit Description.

SECTION II.D

CLOSURE PLAN

CLOSURE PLAN

Introduction

This section satisfies the requirements of 40 CFR 270.14(b)(13) and FAC 62-730. This document provides a closure plan for the former Demolition Key OB/OD hazardous waste ordnance treatment facility on the southeast portion of Demolition Key NW which covers approximately 940 square-feet with a maximum depth of 3 feet, as shown in Figure II.C-1. This facility was used for the OB/OD of waste (unserviceable) military ordnance and propellants which, upon declaration as waste products, were classified as RCRA hazardous waste. The facility was used for training, testing, and ordnance treatment operations (i.e., OB/OD) one to four times per year between approximately 1965 and 1989. The facility was not used from 1990 through 1993. Operations recommenced, at the rate of one to four times a year, from 1994 to the present. This area is designated as a Solid Waste Management Unit (SWMU), and has interim status for the treatment of hazardous waste, per the requirements of 40 CFR 265.

The OB/OD treatment unit is within an active military reservation. The closure plan only addresses the unit and its immediate vicinity. Any potential contamination resulting from the intended use of the range will be addressed when the range is rendered inactive. At that time, any potential contamination will be addressed under the DOD "Range Rule" which is being written specifically for those issues.

Other ordnance training and testing areas are on Demolition Key NW. These ordnance training and testing areas provide area Navy EOD and SEAL personnel with a remote, unconfined, and safe area to conduct proficiency training required as a function of these positions. It also provides DOD with an area to test ordnance and perform emergency response operations on unstable and/or civilian explosives. These areas shall remain active as long as the U.S. Navy continues to provide training to local and area Navy personnel, as well as response services for emergency ordnance incidents. At the conclusion of these training and testing areas' operational lives, they will be handled as part of NAS Key West's Installation Restoration (IR) program.

This closure plan was prepared in accordance with 40 CFR 264, Subpart G, and FAC 62.730-180 to ensure clean closure at Demolition Key. Although the facility is subject to the general closure requirements of 40 CFR 264, Subpart G, closure will also meet the specific requirements of Subpart X (miscellaneous unit) under 40 CFR 264.

Figure II.D-1 Location of Closure

Facility Description and Operational Parameters

The facility is open air with no protection from weather (see Figure II.D.1). The topography of the area surrounding the site is basically flat, sloping slightly in all directions toward the Gulf Coast, and topped with a variable grass cover, pines, and mangroves. Much of the area surrounding the facility is classified as wetlands. A topographic map of the area is included as Figure II.B-1. The treatment facility is provided in Section II.C.1 of this closure permit application.

NAS Key West generates waste explosives and munitions designated as hazardous waste due to their reactive and potential toxic characteristics (D004 to D011). Between approximately 1965 and the present, the Demolition Key OB/OD facility, which is owned and operated by NAS Key West, was used to train Navy personnel, test ordnance and munitions, and treat various types of munitions and propellants used by the U.S. Navy through either OB or OD. Hazardous waste is generated when these munitions are declared waste by the DON.

Following declaration as a hazardous waste, the item is relinquished to the NAS Key West Weapons Department for accumulation and subsequent treatment. The declaration of an ordnance item as hazardous waste may arise as a result of any of the following:

- The age of the item exceeds maximum shelf life.
- The item appears to have been damaged.
- The item shows evidence of deterioration.
- The item has been declared surplus or unserviceable.
- The item can no longer be identified.

The types of ammunition and explosives shown in Table II.D-1 have been authorized for treatment through OB per *Ammunition and Explosives Ashore — Safety Regulations for Handling, Storing, Production, Renovation, and Shipping* (NAVSEA OP-5), and are assumed to have been treated by OB and/or OD at the subject facility.

All OB/OD operations were performed in accordance with NAVSEA OP-5. Due to the restricted nature of this publication, it cannot be attached to this closure permit application. However, the procedures most recently in use are described in Section II.C.1 of the Demolition Key Part B closure permit application for OB/OD activities.

Waste ordnance was burned at the facility on the ground surface. Supplemental materials such as diesel fuel may have used during burning operations in the early stages of facility's life. "Starter" or initiating fluids have not been used at the facility since recommencing treatment operations in 1994. Combustion is almost always complete. Following a burn, the area is left unaltered for 24 hours to ensure the waste has completely burned (i.e., been treated).

Periodically, ash from the OB treatment process was removed and containerized for transport to the NAS Key West permitted storage facility.

Table II.D-1
Ammunition and Explosives Treated through Open Burning

Black Powder
Floating Smoke Pots (HC-filled) and Similar Ammunition
High Explosives (Bulk) [TNT]
Cartridge-Actuated Devices (CADs)
Demolition Kits
Primers
Pyrotechnics
Smokeless Powder
TNT Demolition Blocks
Tracer Mix and Other Pyrotechnic Mixtures

Table II.D-2
Ammunition and Explosives Treated through Open Detonation

Detonators
Explosive-Loaded Grenades
High-Explosive Bombs
Mortar Ammunition
Projectiles
Rocket/Missile Warheads

Although OP-5 allows miscellaneous quantities of waste to be burned based upon the type of explosive burned and the areal size of the unit, the operators have restricted this unit to a 5 pounds NEW per burn limit.

The types of ammunition and explosives shown in Table II.D-2, classified as reactive wastes, have been authorized for treatment through OD per NAVSEA OP-5, and are assumed to have been treated at the subject treatment facility during initial operation. Since 1989, these materials have not been treated at Demolition Key.

Maximum One-time Waste Inventory

The operational maximum quantity of hazardous waste treated at the subject OB/OD facility is calculated to be approximately 600 pounds NEW. This amount equates to a (single event) one-time maximum quantity of 5 pounds NEW (i.e., the operational limit per NAVSEA OP-5) as was designed for the facility. The use of the term NEW allows Navy personnel to treat a variety of ordnance items regardless of the gross weight of all items per treatment activity. As such, it is difficult to ascertain the one-time, gross weight maximum of hazardous waste ordnance treated at Demolition Key. This quantity could be estimated from 5 pounds to more than 100 pounds.

Closure Standards and Summary

Closure Performance Standard

The facility will be closed in a manner that:

- Minimizes the need for further maintenance;
- Controls, minimizes, or eliminates, to the extent necessary to prevent threats to human health or the environment, post-closure escape of hazardous waste, hazardous waste constituents, leachate, contaminated runoff, or hazardous waste decomposition products to the ground, surface waters, or the atmosphere; and
- Complies with the closure requirements of 40 CFR 264 Subparts G and X and FAC 62.730-180.

The general steps required to accomplish this closure standard are:

- Identification and removal of ordnance debris and ash;
- Collection of samples of appropriate media to determine whether the underlying or surrounding media have been contaminated with hazardous wastes or hazardous constituents;

- Performance of any corrective actions deemed necessary to restore the area to original conditions; and

- Certification closure completion.

A Professional Engineer certified in the State of Florida will certify that all closure activities are conducted in accordance with this closure permit.

Environmental Setting

Physiography

Demolition Key NW is one of two twin keys approximately a quarter mile north-northwest of Fleming Key separated by Garrison Bight Channel. The twin keys (Demolition Key NW and SE) were formerly one larger key which was separated by a shallow channel formed by past ordnance testing. Florida Bay surrounds both keys. Demolition Key NW comprises approximately 8.14 acres. The topographic features of Demolition Key NW are described in detail in Section II.C.2-Environmental Assessment. Figures II.C-7 and II.C-8 show the topographic features of the key and surrounding areas. As shown in these figures, the key is generally flat with a maximum elevation of 4 to 5 feet above msl.

Geologic and Hydrogeologic Information

Section II.C.2 describes regional and local geologic and hydrogeologic characteristics. Figures II.C-6 through II.C-8 provide depictions of regional and key-specific geologic formations. Of principal interest in developing this closure plan are the results of previous surface material and shallow groundwater characterization studies. The outcome of these studies is discussed in Section II.C.2 and elements pertinent to sampling and analysis plan development are briefly summarized below.

Surface and Vadose Materials

Surface materials across Demolition Key NW consist of dredge spoils excavated from Florida Bay during key construction in the late 1930s to early 1940s. These dredge spoils consist of a mix of white to gray gravel to cobble-sized coral/limestone rubble (60%), fine to coarse sand (10% to 30%), and brown to gray silt/mud (10% to 30%). The depth of fill ranges from 3 to 8 feet across the key. In the immediate vicinity of the facility, the fill depth was estimated to be 2.5 to 3.5 feet. The permeability of the dredge spoil material was estimated to be 2.0 to 6.0 inches per hour based on measurements of tidally influenced groundwater fluctuations. Beneath the fill material is the Miami Limestone at an approximate elevation of -3 feet msl.

Groundwater

Groundwater has been studied on Demolition Key NW relative to tidally influenced fluctuations and general water quality parameters. Tide cycle based measurements indicate direct communication between the surficial aquifer and Florida Bay. Groundwater levels fluctuated consistently with the rise and fall of the tide, although a time lag was noted. Shallow groundwater tidal response was estimated to average approximately 6 inches compared to a 2-foot response in adjacent open water. These measurements indicate that significant shallow aquifer flushing may occur with each tide cycle. Due to the proximity of the facility to the shoreline, it is reasonable to expect that the tidal flushing action would be more pronounced at this location.

Based on salinity measurements made during the groundwater study, it was determined that no identifiable freshwater lens exists on Demolition Key NW. Groundwater salinity in the vicinity of the facility (measured at boring B-7) was 30 ppt at high tide. This salinity concentration is comparable to that recorded in the channel separately Demolition Key NW from SE (35.5 ppt). Figure II.C-9 provides groundwater salinity contours at high tide for Demolition Key NW. Salinity readings for both keys at high and low tide are provided in Section II.C.2 of this closure permit application.

It was estimated from surface material characteristics and groundwater tidal fluctuations that nearly 399,000 gallons of water moves into and out of the shallow aquifer at Demolition Key NW during each tide cycle (approximately 800,000 gallons/day). The daily tidal influences were estimated to result in flushing and/or displacement of approximately 35% of the shallow aquifer volume. Groundwater flow is expected to be radial as influenced by tidal conditions. During high tide, water from surrounding Florida Bay moves into the shallow aquifer towards the center of the key, and at low tide the flow reverses with shallow groundwater moving towards Florida Bay. Figure II.C-11 shows the potentiometric surface of the shallow aquifer during high tide.

It is widely recognized that the surficial aquifer system in the Florida Keys does not contain water of sufficient quality and quantity to be considered a viable freshwater supply. Desalination would be required if water from this aquifer were to be used for potable purposes. There is currently no potable water supply (or need) on Demolition Key NW, and drinking water for the surrounding area (Key West, Fleming Key, etc.) is provided via an aqueduct system originating in Dade County, Florida.

Climatology

The general climate in the area may be characterized as tropical. Section II.C.2 summarizes average rainfall, temperature, wind patterns, atmospheric stability class, and hurricane frequency.

Investigative Strategy

The proposed investigative approach for the site was developed to assess the nature and extent of any impacts associated with previous facility operations, and to determine what action (if any) will be necessary to prevent detrimental effects to human health and the environment. Due to the remote location of the key, the sequence of events has been planned to minimize the number of sampling phases necessary to characterize the unit.

Relevant Issues

Additional pits on and around Demolition Key NW were created by activities not regulated under RCRA, as discussed earlier. Navy personnel, such as the EOD and SEALs, have used the key for training in detonation procedures. Until the 1990s, the key was also used to test fire developmental ordnance. In fact, the channel between Demolition Keys SE and NW was formed from testing developmental ordnance items (i.e., mines, etc.).

Active impact areas may have adverse effects on the environment, but are not regulated under RCRA. As a result, certain aspects of the sampling and analysis plan have been developed in an attempt to visually/physically/analytically distinguish between impacts associated with past OB/OD operations at the facility, and the training and testing operations at those pits that are to remain in operation. No effort will be made to delineate the nature or extent of environmental media impacts outside the immediate vicinity of the facility.

Facility-Specific Investigative Approach

As described in this closure permit application, the facility was formerly used to treat waste ordnance by open burning and open detonation methods approved by the U.S. Navy. Based on these former uses, the principal chemicals of potential concern consist of metals and semivolatile organic compounds as listed in Section II.B.7, Tables II.B-7, II.B-8, II.B-9, and II.B-10. Although minor quantities of volatile organic compounds could also potentially have been produced during OB/OD operations, they would not be expected to remain in environmental media. Due to the nature of surface soil on Demolition Key NW and local climate (i.e., high average temperature, consistent winds), volatile organic compounds would be expected to rapidly disperse immediately after cessation of the disposal operation. (See Air Dispersion Modeling

Section of II.C.3.) Because the pit has been used infrequently over the past five years, there is little chance that residual volatiles are present.

Previous Investigations

Previous sampling and analysis efforts focused chiefly upon metals and semivolatile compounds in environmental media. IT Corporation conducted an investigation of the facility during a comprehensive sampling effort on Demolition Key NW from March through May 1993. Additional sampling was performed as part of a remedial investigation as documented in a report dated May 23, 1995. Figure II.D.2 shows the soil, sediment and groundwater sampling locations for previous studies in relation to the facility. Findings pertinent to the facility are summarized in the following paragraphs.

Numerous inorganic elements were detected in surface material (soil) samples. Semivolatiles were not detected in samples collected near the facility, although low concentrations (less than 1 mg/kg) of semivolatiles were detected in surface material samples collected elsewhere on Demolition Key NW. Table II.D-3 summarizes soil analytical results for the facility area. As shown, arsenic and lead were the only two analytes found to exceed their applicable risk-based soil standards. In most instances, arsenic and lead exceedances were co-located. The arsenic groundwater protection based cleanup goal was exceeded at three locations in the surface interval only. As a result, lead and arsenic are the primary chemicals of concern at the facility.

The 1- to 2-foot depth interval sample from boring SB-9 was also found to contain barium, cadmium, chromium, methylene chloride and nickel above the applicable groundwater protection-based cleanup goals. Lead and arsenic concentrations generally decreased with depth. An exception was identified at location P1D, where the lead concentration at the 1- to 2-foot depth was approximately 60% higher than that reported in the surface sample. A single sample (P1D (0-1 ft.) was subjected to TCLP lead analysis. The total lead concentration in this sample was 28,900 mg/kg and the TCLP-lead result was 4.08 mg/L. It is important to note that lead slugs are present in pit bottom materials. The limited surface area (compared to fine-grained particles) and oxidized coatings of observed slugs likely limits the solubilization of the metals present in this form, and may account for the apparent disparity between reported total and leachable (TCLP) concentrations.

The maximum reported lead concentrations were associated with samples collected at the bottom of the pit. Samples collected along the pit perimeter and from the pit walls were found to have lead and arsenic concentrations at least one order of magnitude lower than the pit bottom samples. This pattern suggests isolated impacts within the topographic sink defined by the deepest portion of the pit.

Figure II.D-2 Previous Investigation Sampling Locations

Table II.D-3
Summary of Soil Analytidcal Results
NAS-Key West Demolition Key NW OB/OD Pit #1
Key West, Florida

Parameter		Cleanup Standard: Industrial Soil	Cleanup Standard: GW Protection	AS 1006/ SB-9 (2 ft)	KW02165 P1A (0-1 ft)	KW02166 P1A (1-2 ft)	KW02163 P1B (0-1 ft)	KW02164 P1B (1-2 ft.)	KW02161 P1C (0-1 ft)	KW02162 P1C (102 ft)	KW02152 P1D (0-1 ft)	KW02153 P1D (1-2 ft)	KW02154 P1E (0-1ft)	KW02155 P1E (1-2 ft)	KW02159 P1F (0-1 ft)	KW02160 P1F (1-2 ft)	KW02157 P1G (0-1 ft)	KW02158 P1G (1-2 ft)
Acetone		20000	8	0 044	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Aluminum		100000+	Not appli.	20900	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Antimony		820	Not appli.	43.5	ND	ND	ND	ND	ND	ND	287	512	ND	ND	ND	ND	ND	ND
Arsenic	1 2	10(a)	15	19.3	0.318	0.781	7.54	0.791	73.8	12.1	48.2	10	2.59	1.26	3.31	3.4	1.14	1.05
Barium	2	140000	32	52	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzene		200	0.02	0.002	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium		1.3	180	0.36	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	2	1000	6	13.9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	2	10000	19	40.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Colbalt		120000	Not appli.	10.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper		82000	Not appli.	1540	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene		82000	980	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Indeno (1,2,3-cd) pyre		7.8	35	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	1	1000(b)	Not appli.	2100	ND	ND	2250	274	2290	1570	28900	46800	1140	144	672	66.1	ND	ND
Magnesium		Not appli.	Not appli.	7660	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Manganese		10000	Not appli.	1560	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury		610	3	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene chloride	2	760	0.01	0 078	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	2	41000	21	34.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene		61000	1400	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Silver		10000	Not appli.	9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tin		1000000	Not appli.	93.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium		14000	Not appli	5.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc		610000	42000	6240	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PCLP + Lead (mg/l)		5	(TCLP Std.)	NA	NA	NA	NA	NA	NA	NA	4.08	NA	NA	NA	NA	NA	NA	NA

Notes:
ND indicates the parameters were not detected
1 indicates the concentration in at least one sample exceeded the industrial soil risk-based concentration
(a) The 10 mg/kg limit for arsenic was discussed with USEPA Region IV and FDEP on May 2, 1995
Risk-based concentrations were derived from USEPA Region III Risk-Based Concentration Table, July-December 1995

NA indicates analysis did not include the referenced parameter
2 indicates the concentration in at least one sample exceeded the groundwater protection concentration
(b) Industrial site cleanup goal per OSWER Directive

Table II.D-4 summarizes the results for a single groundwater sample collected at the facility. This sample was collected as a grab sample from boring SB-9. As shown in Table II.D-4, the groundwater standards for antimony, cadmium, copper, lead, nickel, and zinc were exceeded in this sample. Due to the manner in which this sample was collected, the analytical results are considered suspect. Subsequent studies have documented the presence of heaving sands, and the water table is reported within 1.5 feet of ground surface at the base of the pit. As a result, it is probable that surface and near-surface sediment were entrained in the grab groundwater sample.

Table II.D-4
Summary of Groundwater Analytical Results
NAS Key West Demolition Key NW OB/OD Pit #1
Key West, Florida

Parameter	Groundwater Standard (ug/L)	AS1011/SB-9
Antimony[1]	6	249
Arsenic	50	9
Beryllium	4	1.3
Cadmium[1]	5	52.2
Chromium	100	65.2
Cobalt[1]	2200 (a)	68.4
Copper[1]	1300	4070
Lead[1]	15	1610
Mercury	2	0.34
Nickel[1]	100	116
Silver	100	31.6
Zinc[1]	5000	23500

Notes:
- All units are ug/L unless otherwise noted
- (a) Tap water risk-based concentration from USEPA Region III Risk-Based Concentration Table, July-December 1995
- [1] indicates concentration exceeds the groundwater standard and/or RBC
- Groundwater samples were collected directly from soil borings rather than monitoring wells. As a result, metals-rich sediment may have been entrained in samples.
- Only detected metals are presented. Other TAL metals analyzed were not detected

The presence of these sediments likely resulted in falsely elevated metals concentrations. The aforementioned soil TCLP-lead results do not suggest excessive leaching would be anticipated. These analyses showed that the TCLP standard was not exceeded in the extract from the maximally impacted surface soil sample. Because all other soil lead results were at least an order of magnitude lower than the maximum, the average lead leaching rate across the area of concern would not be expected to result in groundwater concentrations near the level reported at SB-9. Based on these factors, previous groundwater results should not be considered representative of true groundwater quality near the facility.

It is also worthy of note that methylene chloride was not detected in the groundwater sample. This observation indicates that either the reported soil concentration is in fact protective of shallow groundwater based on site-specific characteristics or possibly that the methylene chloride reported in soil originated from an exogenous source. In either case, the suggestion is that volatile organic compounds are not a significant concern in soil or groundwater.

IT Corporation's (IT) investigation also included the collection of two sediment samples from the channel running between Demolition Key NW and SE. Table II.D-5 summarizes the results of inorganic analyses for these samples. As shown in the table, neither sediment sample had inorganic constituent concentrations in excess of the standards provided in IT's summary. The samples were collected from locations which would be most likely to receive surface water runoff from the facility area. The absence of any impact indications suggests that facility runoff has not adversely affected channel sediments.

Table II.D-5
Summary of Sediment Analytical Results
NAS Key West Demolition Key NW OB/OD Pit #1
Key West, Florida

Parameter	Sediment Standards (mg/kg)	AS1012/SS-1	AS1013/SS-2
Arsenic	8	4.7	3.6
Barium	Not Applicable	9.4	4.7
Beryllium	4	0.28	0.2
Chromium	33	5.9	3.4
Copper	28	ND	4.5
Lead	21	11.5	5
Vanadium	Not Applicabale	ND	1.7
Zinc	68	11.4	ND

Notes:
- ND indicates the parameters were not detected
- All units are mg/kg unless otherwise noted

Treatment Alternatives

Based on previous reports and field observations, it is apparent that a significant amount of debris exists in the pit. This debris consists of metal fragments and other material associated with past OB/OD treatment operations as well as general refuse deposited by site trespassers. Elevated lead and arsenic (as well as other metals) concentrations are presumed to be related to the presence of these metals in debris and shallow soil. This hypothesis is supported by the fact that lead fragments have been visually identified on the ground surface.

Based on the identified metals sources and access restriction on the key, the most feasible and easily implemented treatment alternative is anticipated to be gross removal of debris and shallow surface materials. The removal effort would be restricted to the immediate confines of the facility (pit) and adjacent areas within 5 feet of the rim. Removal efforts will not involve areas beyond 5 feet of the pit due to the presence of operational training and testing pits within 40 feet of the facility.

Removal will be accomplished through use of a combination of methods. A fine rake and/or manual removal methods (e.g., shovel, pick, etc.) will be used to collect loose metal fragments, dislodged soil and rock, and general refuse. For maximally impacted soil and intact coral/rubble, it may be necessary to employ picks or a bobcat or backhoe to dislodge the material. Shovels, other manual methods, and/or small heavy-equipment pieces may be used to containerize these materials. Excavation will be limited to the base of the pit. Due to the shallow nature of groundwater, the maximum removal depth within the pit is expected to be 18 inches. Additional details regarding the proposed removal efforts are presented in subsequent sections (Corrective Action).

Data Gaps

The principal data gaps remaining pertain to total and leachable lead and arsenic concentrations in soil. Previous efforts have generally consisted of analyzing samples for total metals or leachable metals by TCLP. In only one instance was the same sample subjected to both types of analyses. As a result, the available data do not adequately support estimation of mean leachable fraction as a function of total metal concentrations across the area of concern. In addition, existing soil data represent a combination of debris-related and residual metals concentrations. It will be important to establish a more accurate estimate of actual soil metals (total and leachable) concentrations through a post-removal sampling effort.

In order to estimate the leachable metals fraction in previous investigations, the TCLP has been used. This method was developed as a means of estimating leachate quality in a landfill setting. As such, the extraction solution was designed to approximate the acidic qualities of domestic waste leachate. The applicability of this method in projecting leachate characteristics at the

facility is questionable. A more appropriate method for this land disposal-type unit would simulate the effects of rainwater on contaminant mobility. As a result, USEPA Method 1312 - Synthetic Precipitation Leaching Procedure (SPLP) would be expected to provide results more closely representing in situ conditions.

Existing hydrogeologic and climatological data will be used to estimate annual groundwater flow beneath the pit, tidal influences, and potential leachate volumes. This information will be coupled with the SPLP results for each target analyte to estimate any shallow groundwater impacts. Because shallow groundwater is not a viable potable water source, it is not appropriate to compare these estimates with drinking water criteria. Instead, these projections will be used to predict contaminant mass flux to the adjacent channel separating the two portions of Demolition Key.

Potential Receptors

The potential human receptors at Demolition Key include NAS Key West personnel engaged in training and testing operations, and infrequent trespassers gaining access with watercraft. Current data do not suggest that the facility has adversely affected the benthic deposits in nearby water bodies (Demolition Key channel). Sediment analytical results show metals concentrations at naturally-occurring levels. These data support a conclusion that surface runoff-related sediment transport from the facility is not a significant concern. No surface water data have been collected from the channel. As a result, no definitive information exists to support conclusions relative to this medium and potential aquatic biota receptors must be considered.

Research through four governmental organizations (US Fish and Wildlife Service, FGFFC, NAS Key West Natural Resources Department, and Monroe County) found no evidence that threatened or endangered species currently live on the key. The FGFFC indicated that the Least Tern *may* nest on Demolition Key NW. The principal concern for this species would be disruption of nesting by ordnance detonations or burning. Because the OB/OD facility is no longer in operation, no habitat impacts are expected post-closure and no formal assessment is warranted.

Objectives

The primary objectives of the tasks set forth in this Closure Plan are to assess the nature and extent of surface material and potential groundwater/surface water impacts associated with former facility operations and from this determination, provide a means of closure protective of human health and the environment (i.e., clean closure). Contaminant nature and extent information will, in turn, be used to assess the threat to receptors posed by surface material contaminants. Before sampling begins, gross removal of debris and surface and shallow subsurface material will be performed. Based on field observations made during tours of the

facility, it has been concluded that a significant fraction of the metals' concentrations previously reported in surface materials may be associated with slugs and metal munitions casing fragments. These materials were deposited within the pit confines during treatment activities principally involving munitions of 0.50 caliber or less. The removal effort will focus collecting of slugs and fragments, as well as excavating surface material excavation in the former primary burn/blast point at the base of the pit. These activities are expected to substantially reduce the concentration of metals in surface and subsurface materials.

Sampling activities will be limited in scope based on adjacent training and testing facilities which are to remain in service. Analytical results will be used to estimate potential receptor exposure to residual surface material contaminants, and the migration potential with respect to leaching to groundwater and subsequent discharge to adjacent surface water bodies. Relative to exposure to surface materials, carcinogenic risk and/or noncarcinogenic hazard posed by residual surface material contamination will be predicted based on standard risk assessment protocol. The potential receptors, as discussed below, will include infrequent recreational trespassers and NAS Key West personnel participating in training and testing exercises. The exposure assessment will be limited to evaluation of direct exposure (incidental ingestion and dermal contact) to surface materials at the facility.

The human health portion of the closure risk assessment will be performed in accordance with USEPA Region IV and FDEP guidance. Due to the current and expected future site uses, the risk assessment will incorporate industrial soil screening values as provided in:

- *Risk-Based Concentration Table, January-June 1996,* USEPA Region III (Roy L. Smith); (RBC Screening Tables).

- *Cleanup Goals for the Military Sites in Florida*, FDEP, April 5, 1995 (or latest version)(CG Tables)

Maximum surface material (soil) concentrations will be compared to the lowest of the corresponding industrial screening values, and chemicals found to exceed screening values will be retained as chemicals of potential concern (COPCs) in the formal assessment. Industrial screening values were selected because the generic scenario established to develop them provides a conservative approximation of current and future uses of the subject site. Background inorganic concentrations have been established for a limited number of parameters (i.e. arsenic) as documented in previous reports. These naturally occurring concentrations will be used as secondary screening values to determine inorganic COPCs.

For those chemicals identified as COPCs, formal risk assessment will be performed to evaluate the threat to human health posed by residual concentrations. The following human health risk assessment will be prepared generally in accordance with the guidelines set forth in:

- *Risk Assessment Guidance for Superfund (RAGS), Volume I — Human Health Evaluation Manual, Part A*, USEPA/Office of Emergency and Remedial Response (OERR), EPA/540/1-89/002, December 1989 (Interim). (RAGS Part A).

- *RAGS, Volume I — Human Health Evaluation Manual, (Part B, Development of Risk-based Preliminary Remediation Goals)*, USEPA/OERR, EPA/540/R92/003, December 1991 (Interim). (RAGS Part B).

- *RAGS, Volume I — Human Health Evaluation Manual, Supplemental Guidance- Standard Default Exposure Factors — Interim Final,* USEPA/OERR, Office of Solid Waste and Emergency Response (OSWER) Directive: 9285.6-03, March 25, 1991. (RAGS Supplement).

- *RAGS, Volume I — Human Health Evaluation Manual, Supplemental Guidance-Dermal Risk Assessment — Interim Guidance,* USEPA/OERR, August 18, 1992. (Supplemental Dermal Guidance).

- *Supplemental Guidance to RAGS: Region 4 Bulletins Human Health Risk Assessment — Interim*, USEPA Region IV Waste Management Division, Office of Health Assessment, November 1995.

- Supplemental Guidance to RAGS: Region IV Bulletin, *Development of Health-Based Preliminary Remediation Goals, Remedial Goal Options (RGO) and Remediation Levels* (Supplemental RGO Guidance).

- Supplemental Guidance to RAGS: Region IV Bulletin, *Provisional Guidance of Quantitative Risk Assessment of PAHs* (USEPA Document EPA/600/R-93-089 July 1993); (PAH Guidance).

- *Exposure Factors Handbook.* USEPA, Office of Health and Environmental Assessment. (USEPA Document EPA/600/8-89/043, July 1989)

The formal human health risk assessment will include the following steps (as appropriate):

- Site characterization: evaluation of data regarding site geography, geology, hydrogeology, climate, and demographics.

- Data collection: analysis of environmental media samples, including background/reference samples.

- Data evaluation: statistical analysis of analytical data to identify the nature and extent of contamination and to establish a preliminary list of COPCs based on risk-based and background screening. This list will subsequently be refined to identify chemicals of concern (COCs).

- Exposure assessment: identification of potential receptors under current and predicted future conditions and potential exposure pathways, and calculation/quantitation of exposure point concentrations and chemical intakes.

- Toxicity assessment: qualitative evaluation of the adverse effects of the COPCs, and quantitative estimate of the relationship between exposure and severity or probability of effect.

- Risk characterization: combination of the outputs of the exposure assessment and the toxicity assessment to quantify the total noncancer and cancer risk to the hypothetical receptors.

- Uncertainty: discussion and evaluation of the areas of recognized uncertainty in human health risk assessments in addition to medium- and exposure pathway-specific influences.

- Risk/Hazard Summary: presentation and discussion of the results of the quantification of exposure (risk and hazard) for the potential receptors and their exposure pathways identified under the current and future conditions.

- Remedial Goal Options: computation of exposure concentrations corresponding to risk projections within the target risk range of 1E-6 to 1E-4 for carcinogenic COCs and hazard quotient goals of 0.1, 1, and 3 for noncarcinogenic COCs.

An exception to this approach will have to be made for lead. USEPA and FDEP do not currently sanction any specific methods/approaches for evaluating the potential effects of lead on adults. USEPA has developed the Lead Uptake/Biokinetics Model (Version 0.99d) (Lead Model) to predict mean blood lead levels in children based on exposure to impacted environmental media. It is not expected that children would gain access to the facility at a frequency justifying specific assessment of this receptor group. USEPA and FDEP have adopted the OSWER RCRA industrial facility proposed Subpart S cleanup goal of 1,000 mg/kg. This value was derived based on protection of workers engaged in generic industrial activities that may result in incidental soil contact/ingestion.

Any reasonable modification of standard risk assessment exposure assumptions based on current/reasonably anticipated future use of the facility area can be expected to cause a corresponding change in the applicable remedial goal. For example, standard industrial exposure

frequency is 250 days/year. If a recreational trespasser use scenario were applied, which is reasonable although unlawful according to current plans for Demolition Key NW and evidence suggesting civilian use of the key, the frequency would be 52 days/year (maximum) assuming that someone were to spend one day per week in the area. This frequency is a very conservative estimate, and a more realistic assumption would probably be 5 to 20 days/year although no records have been kept. Based on available information, the frequency of training and testing operations would not be expected to approach 52 days/year, and in all likelihood would be between 5 to 10 days/year. If all other assumptions are retained, the resultant lead cleanup goal would be nearly 5,000 mg/kg when considering potential trespasser exposure. Previously collected analytical data indicate that lead concentrations in excess of 1,000 mg/kg are restricted exclusively to the bottom of the OB/OD treatment unit. The probability of focused exposure in the maximally impacted portion of the pit is extremely low, and proposed debris and surface material removal efforts are expected to substantially reduce average lead concentrations throughout the proposed area of investigation.

In addition to supporting assessment of direct exposure potential, the tasks outlined in this Work Plan are also intended to supply data necessary to evaluate the potential migration of contaminants from the facility. The shallow aquifer on Demolition Key NW is naturally high in salts and other elements which render it unfit for human consumption. Therefore, FDEP CGs and USEPA Region III RBCs for soil relating to groundwater protection are not appropriate because they assume human consumption of water from the affected aquifer. As a result, fate and transport assessment will focus on projecting the potential mass flux of surface and subsurface material (soil) contaminants from the facility through rainwater percolation to groundwater with subsequent discharge to adjacent surface waters. In order to estimate the potential migration of contaminants from the facility, leachability-based analytical data will be used in conjunction with existing hydrogeologic and climatological data.

Groundwater contaminant concentrations will be estimated based on annual percolation/leaching rates, predicted contaminant removal rates and groundwater flow through the shallow aquifer immediately beneath the unit. Contaminant removal rates will be estimated through comparison of total and SPLP sample results for each sampling location. Projected groundwater concentrations will subsequently be used to estimate contaminant migration through a shoreline discharge point in the net downgradient direction from the unit. Based upon estimates of the dilutional capacity of Demolition Key channel, resultant surface water concentrations for each chemical of concern will be computed. These concentrations will be compared to FDEP and/or USEPA Region IV chronic ambient saltwater quality criteria, and/or the expected limit of detection in a saline water sample.

Sampling and Analysis Plan

The following sections outline the methods to be employed for sample collection and analysis. These methods are proposed based on available information regarding the characteristics of the subject environmental matrices and site conditions. Where deviations from standard protocol are anticipated, contingencies are discussed. In the following sections, the term *soil* is used as a generic name for all surface and subsurface dredge materials above the water table.

Soil Sampling

Soil samples will be collected in order to provide an adequate characterization of the matrix within and immediately adjacent to the facility. Figure II.D.3 shows the proposed location of soil samples. Ten soil sampling locations are proposed. Based on the shallow water table, it is proposed that samples will be collected from the 0 to 1 foot and 1 to 2 feet deep at each location.

Techniques for sample collection depend on the soil type and depth of the sample. All surface soil sampling will adhere to Section 4.11 of the USEPA Standard Operating Procedures/Quality Assurance Plan (SOP/QAM) and FDEP SOPs for soil sampling. Surface samples are defined as 0 to 1 foot bgs exclusive of rocks, twigs, leaves and vegetation. Surface soil samples will be collected manually using a hand auger. Power auger methods may be required to collect samples below 1 foot bgs due to the cementitious nature of subsurface materials (coral and rubble). If surface materials are excavated to groundwater in limited areas during the closure process, any sample location proposed within that area will be eliminated.

Each soil sampling team will have at least two members. One person will collect the sample as the other documents information in the field logbook regarding adherence to sampling procedures, difficulties encountered, and other pertinent information/observations.

Soil Description

Samples will be described on a soil boring log by a qualified geologist using the Unified Soil Classifications System (USCS). All soil colors will be described wet, therefore, it may be necessary to wet the soil. The American Society for Testing and Materials (ASTM) standards for Description and Identification of Soils (Visual-Manual Procedure) (ASTM D2488-90) will be followed (as appropriate) in describing soil.

Figure II.D-3 Proposed Sampling Locations

Hand Auger Soil Sample Collection

Before Surface Soil Sampling:

1. Don personal protective clothing and equipment as required by the site-specific health and safety plan.

2. Survey and stake the locations to be sampled. The survey will include horizontal location and elevation relative to msl or other specified reference datum. Horizontal and vertical surveying may occur before or after the sampling event, as appropriate.

3. Clear vegetation and other debris from the surface around the boring location.

4. Place clean plastic sheeting on the ground surface near the sample collection point to contain decontaminated sampling equipment.

5. Set up a decontamination area for sampling equipment, if required.

During Surface Soil Sampling:

6. Remove surface debris from the sample location.

7. With a stainless-steel device, scrape the surface of the sample collection point to obtain a previously unexposed sample surface.

8. Begin augering the depth required for sampling.

9. Make detailed notes about geologic features of the soil or sediments on a field boring log.

10. While advancing the auger, it may be necessary to insert a polyvinyl chloride (PVC) surface casing to minimize disturbance of the borehole walls.

11. Stop augering at the top of the selected sampling depth.

12. Collect sample.

    - Place the entire sample volume into a stainless-steel bowl. Mix the sample until thoroughly homogenized and place into the appropriate containers. Label the samples and preserve to 4°C.

- Record the sample identification number, sample collection depth, and analyses required in the field logbook and/or on the appropriate field forms (chain-of-custody).

13. Proceed with additional sampling, as required.

After Augering:

14. Backfill the borehole with excess cuttings.

15. Decontaminate all equipment in accordance with the procedures outlined below.

16. Place used plastic sheeting and other disposable sampling equipment in the designated receptacle for disposal by the Navy.

17. Complete the field logbook entries and soil boring log for the location.

Due to the hardened nature of soil and vadose materials on Demolition Key NW, it may be necessary to use a power-assisted auger to collect samples. If a power auger is used, sampling will be conducted in a manner consistent with the outline above.

Analytical Methods

Based on previous studies and available information regarding contaminants formed during OB/OD activities, soil analyses will be focused on inorganics (metals) and semivolatile organic compounds. FDEP has also requested that total petroleum hydrocarbon analyses be performed. Two elements to the analytical scheme have been developed for the facility. The first element involves determination of total chemical concentrations in soil. Total concentrations are of primary importance in estimating the potential exposure for site receptors. In addition, total results will be used to correlate with leachability results (discussed below) to estimate long-term migration potential. All analytical methods proposed for this project are provided in *Test Methods for Evaluation of Solid Waste: Physical/Chemical Methods*, SW-846, Third Edition, September 1986 (SW-846).

Based on the results of previous investigations, total metals analyses will be performed for arsenic, barium, cadmium, chromium, lead, and nickel. USEPA SW-846 Method 6010 - Inductively Coupled Plasma (ICP) will used for metal analysis. Polynuclear aromatic hydrocarbons were detected at low concentrations (less than 1 mg/kg) in Demolition Key NW soil during previous investigations. These compounds were not, however, detected in samples collected in the vicinity of the subject facility. In order to verify the absence of semivolatile organic compounds at the facility, USEPA Method 8270 will be employed for sample analysis.

Each soil sample collected at the facility will be analyzed using Method 6010 and 8270. USEPA Method 418.1 will be employed to determine total petroleum hydrocarbon concentrations in each soil sample.

FDEP guidance on RCRA closure plans, Section 12 discusses detection limit, health-based standards and test methods. Specific mention is made of explosive constituent analyses and special considerations for these parameters outside the typical SW-846 regime. FDEP recognizes that some cyclization may occur during the OB/OD treatment process. Potential degradation/reaction products from the detonation of TNT, HMX, RDX, tetryl and ammonium picrate are presented in *Conventional Weapons Demilitarization: A Health and Environmental Effects Data Base Assessment: Explosives and Their Co-Contaminants Final Report, Part II*, Lawrence Livermore National Laboratory, December 1987.

Although most of the compounds potentially formed are not standard target analytes for SW-846 semivolatile analysis, their chemical structures indicate that they could in fact be detected (Method 8270). To ensure that an adequately detailed reporting system is established, the list of potential reaction products will be supplied to the analytical laboratory. The laboratory will be requested to report tentatively identified compounds (TICs) in accordance with standard mass spectral library search criteria for the method. The reaction products list will be used as a supplement to assist in making informed judgments regarding qualitative determinations for TICs.

Estimated concentrations will be reported for each qualitatively identified TIC, and these values will be compared to available human health-based standards for industrial scenarios (USEPA Region III Risk concentration tables and/or FDEP CGs for Military Sites) or site-specific goals (based on an infrequent recreational trespasser user scenario). TICs identified by general category (i.e., aliphatic hydrocarbon, alcohol, etc.) will not be included in the screening process. If the estimated concentration for a TIC is equal to or greater than the corresponding screening value, one of two courses of action may follow: 1) If the concentration suggests gross impacts, additional sampling may be required to delineate the extent of contamination possibly utilizing more specialized analytical methods; or 2) a compound-specific risk evaluation may be performed using existing data taking into consideration frequency of detection and spatial distributions to establish a more accurate exposure point concentration in accordance with standard human health risk assessment protocol.

The second element of the analytical scheme involves leachability tests to determine the mobility of soil contaminants. For purposes of this investigation, USEPA SW-846 Method 1312 - SPLP will be used. The SPLP was developed to simulate the effects of precipitation on contaminant leaching. Leachate samples produced through SPLP will subsequently be analyzed for the same list of metals developed for total analyses. No semivolatile organic compound previously reported in soil on Demolition Key NW was detected at a concentration exceeding its

leachability-based cleanup goal as provided in FDEP's *Cleanup Goals for the Military Sites in Florida*, April 1995. As a result, no semivolatile analyses are proposed in conjunction with SPLP testing. Because the intent of leachability testing is to determine contaminant mobility throughout the entire soil column, the SPLP will be performed on a composite sample of surface and subsurface soil from each location.

QA/QC Samples

Consistent with USEPA and FDEP analytical requirements, numerous QA/QC samples will be collected in conjunction with the project. The number of QA/QC samples designated is based on the collection of 20 soil samples for total analysis and 10 composite soil samples for SPLP analysis. The number and frequency of QA/QC samples is outlined in the project-specific QAP.

Decontamination

Decontamination will be performed in accordance with Appendix B, Section B-8 of the USEPA SOP/QAM for sampling equipment with the following exceptions. The detergent for use on this project will be Liqui-Nox because it contains powerful chelating agents to bind and remove trace metals from sampling equipment. A stainless-steel bowl or bucket will contain the clean water wash solution. Field reagent grade water and/or distilled water will be used for all final rinses.

Decontamination Area Setup

Decontamination will generally be performed prior to arrival onsite. However, field decontamination may also be necessary. Field cleaning and decontamination will occur at a designated area generally onsite but downgradient and downwind of the clean equipment storage area. The decontamination area will be lined with heavy-duty plastic sheeting and will be designed to promote surface runoff into a catch basin or pit. Isopropyl alcohol waste will be collected separately and containerized in its designated drum. NAS Key West is responsible for disposing of all decontamination wastes.

Cross-Contamination Prevention

Follow procedures below to reduce cross-contamination risk during decontamination.

1. Don a new pair of disposable outer gloves before handling sampling equipment.

2. Use only Teflon, glass, or stainless-steel spray bottles/pressurized containers to apply decontamination solutions. Keep each solution in a separate container.

3. Transport all necessary decontamination field equipment to each designated location to minimize the need for field cleaning.

Sampling Equipment

Sampling equipment includes any downhole equipment (e.g., augers, PVC boring liners, etc.) and any sampling utensils (e.g., stainless-steel spoons, spatulas, bowls, etc.) not dedicated to the sampling location. Hollow downhole equipment or equipment with holes potentially transmitting water or drilling fluids will be cleaned on the inside and outside.

1. Don protective gloves before decontaminating the equipment.

2. Wash and scrub with a laboratory-grade detergent and clean water wash solution or decontamination with high-pressure steam.

3. Rinse with clean water.

4. Rinse with distilled water or ASTM Type III water (as available).

5. Rinse twice with pesticide-grade isopropyl alcohol.

6. Rinse with distilled water or ASTM Type III water (as available).

7. Air dry. If adverse weather prohibits air drying, repeat the isopropyl alcohol rinse twice and final water rinse.

8. Wrap in aluminum foil for storage if the sampling equipment is to be stored or transported.

Personal Decontamination

Personal decontamination procedures are outlined in the site-specific Health and Safety Plan.

Sample Management

This section describes SOPs for sample identification and chain-of-custody to be used for all field activities. These procedures will ensure that the quality of the samples is maintained during their collection, transportation, and storage through analysis. All chain-of-custody requirements comply with SOPs indicated in the USEPA sample handling protocol.

Sample identification documents must be carefully prepared so that sample tracking and disposition may be maintained and controlled. Sample identification documents include:

- Field notebooks
- Sample label
- Custody seals and
- Chain-of-custody records

Chain-of-Custody

The primary objective of the chain-of-custody procedures is to provide an accurate record that can be used to trace the possession and handling of a sample from collection to completion of all required analyses. A sample is in custody if it is:

- In someone's physical possession
- In someone's view
- Locked up or
- Kept in a secured area that is restricted to authorized personnel

Sample Designation and Labeling System

Tracking a sample and maintaining certain information about the sample from the time of collection to the final analytical data package will be achieved in the sample identification. The sample identification will include the following information:

- Site name
- Sample matrix
- QC sample type
- Well or boring location number
- Sample interval/depth (when applicable)

Soil borings and surface soil collection points will be labeled by site, media sampled, and sample depth. A unique 10 digit (or other) sample designation will be provided for each sample collected. The first three digits signify the site from which the sample was collected. For this project, the site designation will be 051. The fourth digit identifies the matrix sampled. Soil matrix identifiers will be "S" for the standard sample and "C" for duplicate soil samples. The fifth through eighth digit indicate the boring number and the ninth and tenth digits indicate the sample depth. An example is provided below.

Example Designation: 051-S-0002-02

The sample would be soil from boring 2 at depth interval 2 collected at site 051. Two additional sample identifiers (MS and MSD) will be used by the laboratory to identify those samples receiving matrix spike and matrix spike duplicate analysis. A detailed description of sample tracking, shipping and labeling procedures is provided in below.

QA samples are used to assess the precision and accuracy of the sampling and analyses. These types of samples will replace the fourth-digit (well or boring designation) when applicable. Digit 4 will represent the type of Quality Control (QC) sample, followed by the month and day it was collected as digits 5, 6, 7 and 8. Samples required to meet this data quality objective are given below with their appropriate code.

Quality Assessment Sample Codes

The following are quality assurance codes to be used during sample collection and subsequent handling during closure of the Demolition Key treatment facility.

F	—	field blank	This will be followed by a four-digit date where the first two digits indicate the month and the second two digits indicate the day, (ex: August 14 would be written as 0814).
R	—	equipment rinsate	This would be followed by a four-digit date where the first two digits indicate the month and the second two digits indicate the day.

Field Custody Procedures

- As few persons as possible should handle samples.
- Sample bottles must be obtained precleaned from an approved source. Coolers or boxes containing cleaned bottles should be sealed with a custody tape seal during transport to the field or while in storage prior to use. Sample bottles from unsealed coolers or boxes, or which appear to have been tampered with will not be used.
- The sample collector is personally responsible for the care and custody of samples collected until they are transferred to another person or dispatched properly under chain-of-custody rules.
- The sample collector will record sample data in the field notebook.

- The field project manager and/or the QA manager will determine whether proper custody procedures were followed during the fieldwork and decide if additional samples are required.

Sample Tags

Sample tags attached to or affixed around the sample container should be used to properly identify all samples collected in the field. The sample tags are to be placed on the bottles so as not to obscure any QA/QC lot numbers on the bottles; sample information must be printed in a legible manner using waterproof black ink. For chain-of-custody purposes, all QC samples are subject to exactly the same custodial procedures and documentation as "real" samples.

Chain-of-Custody Record

The chain-of-custody record must be fully completed at least in triplicate by the field technician who has been designated by the project manager as responsible for sample shipment to the appropriate laboratory for analysis. In addition, if samples are known to require rapid turnaround in the laboratory because of project time constraints or analytical concerns (e.g., extraction time or sample retention period limitations, etc.), the person completing the chain-of-custody record should note these constraints in the "Remarks" section of the chain-of-custody form. The custody record should also indicate any special preservation techniques or whether the samples need to be filtered.

Custody Seals

Custody seals are preprinted adhesive-backed seals which are designed to indicate whether seals were tampered with. A custody seal is placed across the cap of individual sample bottles by the sampling technician. Sample shipping containers (coolers, cardboard boxes, etc., as appropriate) are sealed in as many places as necessary to ensure security. Seals must be signed and dated before use. On receipt at the laboratory, the sample custodian must check and record if seals on shipping coolers and/or bottles are not intact.

Transfer of Custody and Shipment

- The shipping coolers in which the samples are packed must be sealed and accompanied by a chain-of-custody form. When transferring samples, the individuals relinquishing and receiving them must sign, date, and note the time on the chain-of-custody record. This record documents the sample custody transfer.

- Samples must be dispatched to the analytical laboratory for analysis with a separate chain-of-custody record accompanying each shipment. Shipping containers must be

sealed with custody seals for shipment to the laboratory. The method of shipment, name of courier, and other pertinent information can be entered in the "Remarks" section of the chain-of-custody form.

- All shipments must be accompanied by the chain-of-custody form identifying their contents. The original record accompanies the shipment. The other copies are distributed appropriately to the project manager and the QA manager.

- If sent by mail, the package is registered with return receipt requested. If sent by common carrier, a bill of lading is used. Freight bills, Postal Service receipts, and bills of lading are retained as part of the permanent documentation.

Laboratory Custody Procedures

A sample custodian accepts custody of the shipped samples from the carrier and enters preliminary information about the package into a receipt log, including the initials of the person delivering the package and the status of the custody seals on the coolers (i.e., broken vs. unbroken). The laboratory sample custodian is responsible for sample log-in and will open the shipping coolers, check the contents, and verify that the information on the chain-of-custody agrees with samples received. Pertinent information as shipment, pickup, and courier must be entered into the "Remarks" section of the chain-of-custody record. The custodian will also document the temperature of the cooler (by checking the temperature blank) and the general condition of the sample containers.

Sample preservation shall be verified by the analyst prior to extraction, digestion or analysis and the pH recorded. If samples are found improperly preserved, the Laboratory QA coordinator will document the improper preservation along with the sample identification and other pertinent information. All other QA/QC discrepancies are followed in a similar manner and must be documented as an out-of-control event with the corrective action taken.

Investigation-Derived Waste

All investigation-derived waste (IDW) solids and liquids are the sole responsibility of NAS Key West and are to be handled in a manner consistent with all applicable local, state, and federal waste disposal guidelines. These wastes, where appropriate, will be containerized in a USDOT-approved drum or other collection receptacle (e.g., plastic transport bag). The disposal methods will be selected by the Navy based on waste classification and knowledge. The waste will then be disposed by the Navy in accordance with applicable guidelines for the waste category. All drums will be labeled with the site number, date of generation, and waste category.

Soil Waste

Soil will be placed back in the area from which it originated. In most instances, auger cuttings will be used to backfill borings. It is not anticipated that any soil IDW will be generated over the course of sampling activities.

Aqueous Waste

All IDW water (e.g., decontamination fluids) will be drummed and labeled as described in the paragraph above. The drums may be transported to the NAS Key West Wastewater Treatment Plant or to an offsite facility for disposal.

Isopropyl Alcohol Waste

All investigation-derived isopropyl alcohol (IPA) waste will be drummed separately. Navy personnel will transport the drums to a waste storage, treatment, or disposal facility, as appropriate.

Personal Protective Equipment and Disposable Sampling Equipment Waste

Used PPE and disposable sampling equipment will be placed in drums or other collection receptacles for disposal by the Navy. Navy personnel will transport the drums to a waste storage facility until the contents can be disposed properly.

Documentation

A drum-tracking log will be kept for the convenience of the Navy separate from field logbooks. The log will detail the number of drums, site number, waste type, and date generated.

Corrective Action

Corrective action at Demolition Key will consist of ordnance debris identification and removal (i.e., scrap metal, casing, paper, etc.), and soil removal to achieve facility-specific Site Rehabilitation Levels developed using recognized risk assessment methods. The specific approach planned for the facility is outlined in preceding sections (Objectives).

The OB/OD treatment unit is within an active military reservation. The closure plan only addresses the unit and its immediate vicinity. Any potential contamination resulting from the intended use of the range will be addressed when the range is rendered inactive. At that time, any potential contamination will be addressed under the DOD "Range Rule" which is currently being written specifically for those issues.

Debris Removal

Using a metal detector and/or magnetometer to survey the treatment unit and surrounding area (excluding training and testing areas), all metal debris abandoned from past and current treatment activities will be removed and containerized for subsequent characterization, storage, and disposal. Debris will be removed using conventional hand tools (shovels, picks, rakes, etc.) and the resources and experience of trained military EOD personnel.

Soil Excavation and Disposal

The scope of soil removal will be directed by visual evidence as well as previous analytical results. Based on available information, it is anticipated that soil in the primary blast/burn point within the pit must be removed to the depth of impact. Figure II.D.3 shows the estimated areal extent of soil removal based on previously collected data and visual evidence of impacts. If impacts are indicated in the first 1-foot interval, and not at the 2-foot interval, then the top foot of soil must be removed.

All excavation will be performed manually (i.e., hand equipment [shovels, picks, etc.]). If, during the sampling and/or excavation stages of closure, it is determined that this is insufficient, heavy equipment (i.e., small backhoe) will be used. Appropriate decontamination procedures will be incorporated before to and after each stage of excavation as discussed in the sampling and analysis plan.

After excavating based on visual evidence and/or previous sample results, verification samples shall be obtained from the bottom of the excavation to ensure that contaminated soil has been removed. The soil sampling procedures used in these activities will be the same as those described above under Sampling and Analysis Plan. Should contamination be identified in any samples above acceptable concentrations, additional excavation and resampling shall continue until levels protective of human health and the environment are achieved or until it is determined to be infeasible to continue. The protectiveness (direct exposure and groundwater protection) of residual soil concentrations will be evaluated for the entire facility area, and will not involve fixed point attainment of numerical standards. The methods proposed for use in establishing protective soil remedial action objectives are discussed in preceding sections.

It may be determined that all contaminated soil cannot be removed to acceptable concentrations due to presently unknown factors, such as the excessive depth of soil contamination, subsurface obstructions, endangerment to native species and wildlife, etc. The determination that clean closure cannot be achieved will be made during the corrective measures stage of closure. If such a determination is made, FDEP and USEPA Region IV will be notified. Their concurrence will be required prior to any subsequent corrective or post-closure activities.

All excavated soil will be containerized in USDOT and DOD specification 55-gallon, open-head steel drums by manual means and transported to the NAS Key West storage disposal facility. Hazardous waste determinations for reactivity and TCLP metals will be performed on all excavated soil. Should any soil meet the definition of a hazardous waste, it shall ultimately be treated and/or disposed in the RCRA-approved/permitted hazardous waste facility. If so, all appropriate sampling, reporting, manifesting, and additional recordkeeping requirements will be met. Any excavated soil which does not meet the definition of a hazardous waste will be transported offsite to a sanitary landfill for disposal upon approval by FDEP and the landfill management.

Groundwater Remediation

Due to site hydrogeology, the absence of a freshwater source/aquifer, the potential problems encountered when trying to obtain accurate constituent concentrations, fluctuating groundwater levels at Demolition Key, and the impracticality involved with pump-and-treat technologies in this setting, no groundwater remediation activities are recommended for this site. No groundwater monitoring is currently proposed in conjunction with closure investigations. If groundwater protective soil concentrations cannot be achieved during the removal process, an addendum to this closure plan may be required to outline appropriate groundwater monitoring requirements.

Equipment Decontamination

All equipment will be inspected before being brought onsite to ensure cleanliness and to prevent the transport of contaminants onto the site. All equipment will be left onsite during field activities. Upon completion of field activities, all equipment will be decontaminated to prevent the transport of contaminants offsite according to the procedures outlined above.

Closure Schedule

Final closure activities will be completed per the schedule shown in Table II.D-6. Closure shall commence upon FDEP approval of the closure plan.

Final closure will be witnessed and certified by an independent Florida-registered professional engineer and geologist, in addition to the owner/operator.

Notification of Closure

NAS Key West shall notify the USEPA Regional Manager and the State of Florida's Regional Office Director in writing at least 45 days prior to the date on which it expects to commence final closure operations.

Table II.D-6
Proposed Closure Schedule

Phase	Closure Activity	Start Date	Duration
I	Ordnance Debris (i.e., metal) Survey and Removal	Day 0	35 Days
	Containerize Ordnance Debris for Transport to NAS Key West Permitted Storage Facility	Day 0	35 Days
II	Remove Impacted Soil in and around Treatment Facility to Risk-based Limit	Day 35	35 Days
	Containerize Impacted Soil and IDW for Transport to NAS Key West Permitted Storage Facility	Day 70	35 Days
III	Post-removal Sampling in and around Treatment Unit	Day 105	10 Days
	Review Analytical Results[1]	Day 115	5 days
	Preparation of Draft Closure Report	Day 120	60 Days
IV	Groundwater Monitoring Well Installation (If Necessary) Following Review Sampling and Analysis Plan	Day 180	30 Days
	Groundwater Sampling (If Necessary)	Day 210	10 Days
V	Final Closure Reporting and Notification	Day 220	15 Days

Note:
[1] = Based on results of post-removal unit and surrounding area sampling, additional removal and sampling may be required. If so, an additional 40 days will be required to complete both tasks.

Closure operations will commence no later than 30 days after the date on which Demolition Key receives its known final volume of hazardous waste, or if there is reasonable possibility that the Demolition Key treatment facility will receive additional hazardous waste ordnance, no later than one year after the date on which the facility received its most recent volume of hazardous waste ordnance.

Closure Time Allowed

NAS Key West will remove all hazardous waste from the Demolition Key treatment unit within 180 days of receiving and treating the final volume of hazardous waste. NAS Key West will also complete closure within 270 days of receiving and treating the final volume of hazardous waste. NAS Key West requests the additional 90 days, respectively, for each phase of closure due to government contractual and procurement requirements and obligations.

Certification of Closure

Within 60 days of completing final closure, NAS Key West will submit to the FDEP Director by registered mail the certification by NAS Key West and an independent professional engineer and geologist (registered in the State of Florida) that the hazardous waste management unit has been closed in accordance with specifications in the approved closure plan. The Certification of Closure will be submitted to the FDEP Director within 60 days of completion of final closure as required by 40 CFR 265.115.

As part of the closure certification process, NAS Key West will submit a survey plat indicating the location and dimensions of the Demolition Key treatment facility to the local zoning authority, the FDEP, and the USEPA Regional Administrator. The plat will be prepared and certified by a professional land surveyor and shall contain, prominently displayed, NAS Key West's obligation to restrict disturbance of the treatment unit.

Closure Cost Estimate

Demolition Key is owned and operated by the DOD, a federal department. As such, a cost estimate for closure is not required.

Quality Assurance Plan

Introduction

This QAP presents policies, project organization, objectives, functional activities, and QA/QC measures intended to achieve data quality goals of the soil sampling program to be conducted at Demolition Key. Monitoring programs is to evaluate potential impacts on soil and groundwater related to the treatment of hazardous waste ordnance by OB/OD.

This document is intended to fulfill requirements for ensuring that all work will be conducted in accordance with QA/QC protocols and field procedural protocols for environmental monitoring and measurement data. This will be accomplished through strict adherence to sampling and analytical methods, and applicable standard operating procedures as outlined in FDEP, QA Section, and USEPA guidance documents.

Project Description Objective

The objective of the soil sampling program is to ensure that any impacts associated with waste ordnance treatment on Demolition Key are promptly and accurately identified. The sampling plans are designed to produce data of sufficient technical quality to assess the current site

conditions and determine if corrective action is needed. Soil samples will be collected from 10 locations at 2 depth intervals to provide a baseline analysis of soil quality on Demolition Key.

Site Background

The facility at Demolition Key has historically been used to treat hazardous waste ordnance. The facility has had RCRA Part B Interim Status since 1987 to conduct these operations. The OB/OD facility is currently subject to closure. Preceding sections of the Closure Plan provide additional background information regarding Demolition Key.

Project Quality Assurance Objectives

In general, QA objectives are to assess; document; and to the extent possible ensure the precision, accuracy, representativeness, completeness, and comparability of all sampling and analysis performed. Quality criteria are outlined here to assure suitability of data obtained during projects for its intended use, and to meet goals established by FDEP. USEPA Level III QC criteria are to be applied to all laboratory analyses required for the monitoring program.

Field Measurements

QA objectives for parameters to be measured in the field are presented in Table II.D-7. Field measurements will include photoionization detector (PID) screening of soil samples.

Table II.D-7
Field Measurements

Measurements Parameter	Reference	Matrix	Precision (%)	Accuracy % Recovery	Completeness %
PID	SOP[1]	Soil Gas	+/-10 ppm	+/- 20 ppm	100

Note:
[1] = Manufacturer's SOP for operation of Photovac TIP II, Hnu or other similar instrument.

Sampling and Analysis

Project QA objectives of analytical parameters for soil (total and SPLP analyses) are as stipulated in their respective analytical methods, and as determined by the analytical laboratory's historical data quality evaluation for the methods. Anticipated general QA goals for these methods are presented below.

Precision and Accuracy

Methods of assessing precision and accuracy measurements are discussed in subsequent sections of this document. General precision and accuracy goals for laboratory analytical procedures are provided in Table II.D-8.

Table II.D-8
Laboratory Measurements

Measurement Parameter	References	Matrix	Precision[1] (%)	Accuracy[1] % Recovery	Completeness (%)
Metals - SPLP	EPA 1312 EPA 6010/7470	Water Extract	±35	±40	90
Total Petroleum Hydrocarbons	EPA418.1	Soil	±35	±40	90
Semivolatile Organic Compounds	EPA 8270	Soil	±45	±50	90
Metals	EPA 6010	Soil	±35	±40	90

Note:
[1] = Precision and accuracy goals are subject to change based upon specific method data quality history for the analytical laboratory chosen.

Representativeness

By properly collecting soil samples in accordance with USEPA Region IV Environmental Compliance Branch SOP/QAM representative of areas of concern. Specific sampling methods are described in the preceding Sampling and Analysis Plan and FDEP QA Section protocol.

Completeness

Completeness goals for field measurements reflect the ability to reanalyze each soil headspace. The completeness goals for laboratory measurements take into consideration unavoidable non-attainment of QA goals which may occur over the course of the study. Efforts will be made to maintain soil data completeness levels above the 90 % level.

Comparability

Comparability is assured through the use of established methods of sampling and analysis as specified in the corresponding methods protocol as well as other accepted methods such as the USEPA SOP/QAM and FDEP SOPs. These methods were discussed in the Sampling and Analysis Plan and in subsequent sections of this QAP.

Project Organization and Responsibilities

Overall responsibility for projects conducted will be vested in Commanding Officer, NAS Key West (his or her approved representative).

State or Local Oversight

The Florida Department of Environmental Protection, as administrators of the RCRA program, will serve in an oversight capacity for all closure and sampling activities. The Sampling and Analysis Plan has, however, been prepared in accordance with the appropriate sampling and analytical requirements and guidelines. The analytical results will be presented to NAS Key West in the form of an interim, draft and/or final closure report. This sampling and analysis program has been prepared in accordance with the requirements of the FDEP RCRA permitting program. NAS Key West will have responsibility for submitting reports generated during the closure process to the FDEP.

In addition to conforming to the guidance and methods specified, work shall be performed in a manner consistent with:

- The Resource Conservation and Recovery Act of 1976
- The Hazardous and Solid Waste Amendments of 1984 (HSWA)
- The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended
- The National Oil and Hazardous Substances Pollution Contingency Plan (NCP), as amended.
- Other appropriate federal, state, and local guidelines, rules, regulations, and criteria (where applicable).

Soil Borings and Sampling

Soil Sampling Procedures

Soil samples will be collected in accordance with the methods specified in the Sampling and Analysis Plan. Two discrete interval soil samples will be collected from each of 10 borings proposed within or adjacent to the facility (Figure II.D.3). Due to the anticipated shallow water table, discrete samples will be collected from the these depth intervals. If groundwater is deeper than two feet bgs, the sampling strategy will be amended to collect a sample from the deepest one foot interval above the water table. One composite soil sample will be collected from each boring advanced. The composite samples will be composed of equal portions of soil from each interval sampled at a particular location. All soil samples will be collected from the hand auger bucket using disposable Teflon-coated plastic and/or stainless-steel sampling implements.

From each interval sample, a subsample will be collected and placed in a resealable plastic bag. The sample will be allowed to equilibrate to ambient temperature for at least one hour. Subsequent to equilibration, headspace volatile PID readings will be taken from each.

The samples will be placed in appropriate sample containers. The selected samples will be cooled in an ice chest to 4°C ($\pm$ 2≥ C) and shipped under chain-of-custody via overnight courier to the selected laboratory for analysis.

Soil Sample Analyses

Discrete interval soil samples will be analyzed for semivolatiles organic compounds (USEPA Method 8270), total petroleum hydrocarbons (USEPA Method 418.1), and an abridged list of priority pollutant metals (EPA Methods 6010-arsenic, barium, chromium, cadmium, lead and nickel). Composite samples collected as part of the closure investigation will be subjected to the SPLP (USEPA Method 1312), and analyzed for arsenic, barium, chromium, cadmium, lead, and nickel (USEPA Method 6010).

Soil Sample Documentation

Soil samples will be documented in accordance with this QAP. Sampling personnel will use site-specific, bound logbooks to maintain field records pertaining to Demolition Key operations. These records will document visual observations, calculations, and equipment calibrations. Every entry will be dated and the time for each entry noted. The logbooks are accountable documents that will be properly maintained and retained as part of the facility operating log. In addition, soil boring logs will be produced for all soil borings advanced onsite beyond 5 feet deep. Information to be included on boring logs includes total depth of boring, lithologic

descriptions of each geologic formation encountered, sampling intervals, OVD/PID readings, field observations (e.g., staining or odor), soil moisture/initial water, and any subsurface obstructions encountered during boring advancement (with explanations, if available). Operating logs will be retained in their original condition in the Demolition Key operating file.

Soil Sampling Equipment Decontamination

All downhole equipment (e.g., hand auger buckets and rods, etc) will be decontaminated as outlined in the Sampling and Analysis Plan.

Sample Identification, Containers, Preservation, and Labeling

Samples will be identified, contained, preserved and labeled in accordance with the Sampling and Analysis Plan contained above. Precleaned sample containers will be provided by the laboratory. Sampling personnel will receive the containers from a state-approved laboratory that has followed appropriate sample container cleaning procedures (and/or other applicable protocol), and the containers will remain in the custody of sampling personnel. Where appropriate, sample containers will also be prepreserved. While in the field and during transport to the laboratory, all samples will be retained in a field cooler with ice packs to maintain sample temperature at approximately 4≥ C (± 2≥ C).

Sample Chain-of-Custody

Sampling personnel will follow chain-of-custody procedures in accordance with the Sampling and Analysis Plan. All samples will also be documented in the facility operating log. The common carrier package bill number will be recorded on the chain-of-custody form and in the operating log.

Upon transfer of custody, the chain-of-custody form will be signed by the field sampling team leader, including the date and time the samples were relinquished. Because common carriers will not sign chain-of-custody forms, the chain-of-custody records will be sealed within each shipping container. All chain-of-custody forms received by the laboratory must be signed and dated by the laboratory sample custodian and returned to NAS Key West following receipt or as part of the data reporting package.

Field Records

Sampling personnel shall use only bound facility operating logs to maintain field records. Bound logbooks such as surveyors' logbooks are acceptable, as long as pages cannot be removed without tearing them out. Waterproof paper is preferred. The field sampling team leader and all other team member names, project name and project code should be entered on the inside of

the front cover of the logbook. All entries should be dated and recorded. At the end of each day's activity, or at the end of a particular event if appropriate, a sampling team member should draw a diagonal line at the conclusion of the entry and initial indicating the conclusion of the entry or the day's activity.

All aspects of sample collection and handling as well as visual observations shall be documented in the facility operating logs. Sample collection equipment (where appropriate), field analytical equipment, and equipment utilized to make physical measurements shall be identified in the facility operating logs. Calculations, results, and calibration data for field sampling, field analytical, and field physical measurement equipment shall also be recorded in the facility operating logs. Field analyses and measurements must be traceable to the specific piece of field equipment used and to the field sampling team member(s) collecting the sample, making the measurement, or analyses. Boring abandonment procedures, where necessary, will be recorded and documented.

All entries in facility operating logs shall be dated, legible, and contain accurate and inclusive documentation of an individual's project activities. Because field records are the basis for later written reports, language should be objective, factual, and free of personal feelings or other terminology which might prove inappropriate. Once completed, these facility operating logs become accountable documents and must be maintained as part of the Demolition Key permit.

Document Control

The term *document control* refers to the maintenance of facility-specific operating logs and files. Operating files shall be maintained by the Demolition Key facility operator. Documents as outlined below shall be kept in the facility operating files.

The following documents shall be placed in the Demolition Key operating file:

- Original chain-of-custody records and bound field logbooks.
- A copy of the receipt for sample forms.
- All records obtained during sampling activities.
- A complete copy of the analytical data and memoranda transmitting analytical data.
- All official correspondence received by Demolition Key or issued relating to sampling, treatment, or monitoring activities including records of telephone calls.

Under no circumstances are any personal observations or irrelevant information to be filed in the official facility operating file. The Facility Operator shall review the file at the conclusion of each sampling activity to ensure that it is complete.

Calibration Procedures and Frequency

The analytical laboratory will calibrate analytical instruments in accordance with the appropriate analytical methods and their approved FDEP Comprehensive Quality Assurance Plan. Adherence to proper calibration procedures will be determined during the onsite laboratory inspection. Sampling team personnel will calibrate field equipment such as PIDs according to their manufacturer's SOPs. Field equipment for which SOPs are not in force will be calibrated and operated in accordance with the manufacturer's recommendations. Field instruments will be calibrated at the beginning and end of each workday.

Analytical Procedures

This investigation will follow the analytical procedures described below.

Field Analyses

PID (or similar instrument) readings will be performed on soil headspace. As discussed above, headspace analysis will be performed after sufficient time is given for the sample to equilibrate to ambient temperature. All field measurements will be recorded in facility operating log (e.g., boring log, well construction log, etc.).

Laboratory Analyses

Discrete interval soil samples will be analyzed for semivolatiles organic compounds (USEPA Method 8270), total petroleum hydrocarbons (USEPA Method 418.1), and an abridged list of priority pollutant metals (USEPA Methods 6010-arsenic, barium, chromium, cadmium, lead and nickel). Composite samples collected as part of the closure investigation will be subjected to the SPLP Method 1312), and analyzed for arsenic, barium, chromium, cadmium, lead, and nickel (USEPA Method 6010).

Data Reduction, Validation, and Reporting

Laboratory procedures for data reduction, validation, and reporting will be conducted according to SOPs of the corresponding analytical methods. The specific procedures for data reduction, validation, and reporting will be outlined as approximately equivalent to USEPA DQO Level III. Required internal QC checks and data validation procedures are described below.

Demolition Key's use of the laboratory will be accomplished by a services agreement. This contract will specify the scope of services to be performed by the laboratory, the specific analytical QA requirements to be met, and the information to be developed and reported.

Field and Laboratory Quality Control Checks

Internal laboratory control checks used by the laboratory will be conducted in the laboratory by the laboratory staff. Demolition Key may conduct internal QC checks of sampling procedures and laboratory analyses. These checks will consist of preparing and submitting sampling equipment rinsate blanks, field blanks, and field duplicates for analysis, and evaluating the laboratory analytical package. Data validation will be performed by determining whether laboratory data meets the QA/QC requirements established herein.

The types and frequency of blank and other control check samples will be dictated by the level of QC selected.

Field Data Quality

Fieldwork will be conducted and/or supervised by NAS Key West personnel (or designated representatives) at the Demolition Key treatment facility to ensure that proper procedures are followed. Field records will be kept of all activities that take place during the investigation and these records will be maintained at NAS Key West in the Demolition Key operating log. These records will include any obstacles that may be encountered during the investigation.

Field samples will be collected per the procedures outlined above. Precision will be assessed by evaluating the results of duplicate and matrix spike duplicate samples. Accuracy will be assessed by evaluating the analyses of field blanks, laboratory matrix and surrogate spikes, and laboratory reagent blanks and blank spike samples.

A **duplicate** is a sample identical to the original, collected from the same location (e.g., well) at the same time under identical conditions. Duplicate samples are analyzed along with the original sample to obtain sample procedure precision and inherent sample source variability. One duplicate soil sample will be collected per 10 standard samples collected. The same samples used for field duplicates shall be split by the laboratory and used as the laboratory duplicate, matrix spike and/or matrix spike duplicate (MS/MSD). This means that for the duplicate sample, there will be analyses of the normal sample, the field duplicate, and the laboratory MS/MSD.

Special Note: Field sampling personnel will need to coordinate with the laboratory in advance to ensure that sufficient QC sample volumes are collected and that QC samples are numbered in a manner that is compatible with the laboratory sample tracking system (to prevent misidentification of samples).

A **field blank** is a sample container filled with the source water used to decontaminate equipment in the field. It is prepared, preserved and stored in the same manner as the other field samples. The field blanks are analyzed along with the field samples for the parameters of interest to check for contamination imparted to the samples by the final rinse water, sample containers, preservatives, or other sources. One field blank per water source per sampling event will be prepared. Field blanks will consist of either potable, deionized, or distilled water, or deionized, organic-free water.

Rinsate (or equipment) blanks are collected by retaining rinsate from sampling equipment. The equipment is rinsed with distilled water after full decontamination procedures have been performed. Rinsate samples are collected in the same type of container as the other field samples and preserved in the same manner. One rinsate sample will be collected for each groundwater analytical method during the field investigation. One rinsate blank will be collected from soil sampling equipment. The rinsate blank is analyzed along with the field samples for the parameters of interest to check for contamination imparted to the samples by the sampling equipment, containers, or other sources.

Filter blanks (or Extraction Leaching Blank) are samples of laboratory grade distilled water which is passed through the filter apparatus (associated with SPLP analysis), and subsequently analyzed for the same set of parameters as the actual extraction solutions. One filter blank will be performed for every 10 samples extracted and analyzed using SPLP methods.

The collection frequencies for QC sample collection are summarized in Table II.D-9.

Table II.D-9
Quality Control Sample Collection Frequencies

Quality Control Sample	Estimated No. of Samples to Be Collected
Filter Blank (or Extraction Leaching Blank)	One per 10 samples extracted by SPLP (Estimated Total = 1)
Rinsate Blank	One each from soil sampler per week (Estimated Total = 2 Soil Sampling Equipment)
Field Blank	One per sampling event per water source (Estimated Total = 1)

Table II.D-9
Quality Control Sample Collection Frequencies

Quality Control Sample	Estimated No. of Samples to Be Collected
Duplicates	One per matrix per 10 samples collected (Estimated Total = 2 Soil/1 SPLP Extract)
Matrix Spike/Matrix Spike Duplicates	One per 20 samples per matrix (5%) (Estimated Total = 1 Soil/1 SPLP Extract)

Analytical Data Quality

Analytical data quality is assured through the use of guidelines for QA/QC as set forth in the corresponding analytical methods. The guidelines include analysis and evaluation of matrix spikes.

Matrix spike samples are prepared by the laboratory to assess the accuracy of the analytical method relative to matrix effects. Matrix effects are those sample components which interfere with the analysis of the contaminant of concern. Analysis of matrix spike duplicates will provide a basis for determining method precision specific to the matrix under investigation. Precision is measured as relative percent difference (RPD) between duplicate analyses and the matrix spike. Matrix spikes and matrix spike duplicates will be analyzed at a frequency of one per 20 samples (or one per week, whichever is greater) per matrix.

Field Data Package

The field data package will include field records and measurements obtained at the site by sampling personnel in accordance with this QAP.

The package is validated by conducting the following:

- A review of field data contained on soil sampling logs for completeness. Failure in this area may result in the data being invalidated for litigation or regulatory purposes.

- A verification that field blanks and sampling equipment rinsate blanks were properly prepared, identified, and analyzed. Failure in this area may compromise the analytical data package and result in some data being considered qualitative or invalid.

- A check on field analyses for equipment calibration and condition. Failure in this area may result in the field measurements being invalidated.

- A review of chain-of-custody forms for proper completion, signatures of field personnel and the laboratory sample custodian, and dates. Failure in this area may result in the data being invalidated for litigation or regulatory purposes.

The field data package will be reviewed by the facility operator for completeness and accuracy.

Analytical Data Package

Validation of the analytical data package will be performed by the Demolition Key operator (or designated representative) before submittal to the regulatory agency. The validation steps will be performed by applying applicable *USEPA Laboratory Data Validation Functional Guidelines* for Evaluating Organics and Inorganics Analyses (Technical Directive Document No. HQ-8410-01) and USEPA precision and accuracy statements for the analytical methods employed.

The analytical data package validation procedure includes review of the following:

- Comparison of the data package to the reporting level requirements designated for the project, to confirm completeness.

- Comparison of sampling dates, sample extraction dates, and analysis dates to check that samples were extracted and/or analyzed within the proper holding times. Failure in this area may render the data unusable.

- Review of analytical methods and required detection limits to verify that they agree with the QAP and the laboratory contract. Failure in this area may render the data unusable.

- Review of field and laboratory blanks to evaluate possible contamination sources. The preparation techniques and frequencies, and the analytical results (if appropriate) will be considered.

- Evaluation of all blanks (rinsate blanks, field blanks, reagent blanks, method blanks, and filter/extraction blanks) must confirm freedom from contamination at the specified detection limit. All blank contaminants must be explained or the data applicable to those blanks labeled suspect and sufficient only for qualitative purposes.

As with the laboratory data validation, the classification of data is based on specifically defined criteria. Samples are evaluated by matrix against the specific class criteria and judged as acceptable, provisional, or unacceptable. Data qualifiers are then affixed to indicate relative confidence in individual values. The data validation qualifier will be as follows.

J	—	Estimated Value
U	—	Nondetect at the specific detection/quantitation limit
R	—	Unusable
UJ	—	Nondetect and detection/quantitation limit is estimated.

Data with no specific qualifier will be considered valid without any limits on use. A report of the results of the data validation for both previously collected and planned data will be submitted to the FDEP along with the closure report.

Performance and System Audits

Audits will be performed before and during the work to evaluate the capability and performance of the entire system of measurement and reporting, i.e., experimental design, sampling (or data collection), analysis, and attendant QC activities.

Field System Audits

The Demolition Key facility operator is responsible for evaluating the performance of facility personnel and general facility operations and progress. The facility operator will observe the performance of the treatment operations personnel during each kind of activity such as water-level readings and sampling rounds. A formal systems audit of facility operations personnel by the facility operator will be performed on a biannual basis and a facility audit report for each sampling team member will be maintained in the Demolition Key file by NAS Key West.

Laboratory Systems Audit

A laboratory systems audit is conducted as necessary by the facility operator (or his/her designated representative). These audits test methodology and ensure that systems and operational capability is maintained. They also verify that QC measures are being followed as specified in the laboratory's written standard operating procedures and FDEP-approved QAPs.

Performance Evaluation Audits

A performance evaluation (PE) audit assesses a laboratory's ability to obtain an accurate and precise answer in the analysis of known check samples by a specific analytical method. Following the analytical data validation described above, a PE audit of the laboratory may be conducted by the facility operator. This audit may be conducted if it is determined that the QA data provided are outside acceptance criteria control limits. PE audits may include a review of all raw data developed by the laboratory and not reported (laboratory nonreportables) and the submission of blind spiked check samples for the analysis of the parameters in question. These

check samples may be submitted disguised as field samples (the laboratory will not know the purpose of the samples), or the samples may be obvious (known) check samples that are USEPA or National Bureau of Standards (NBS) traceable.

PE audits may also be conducted by reviewing the laboratory's results from round-robin certification testing (if necessary). An additional component of PE audits includes the review and evaluation of raw data generated from the analysis of PE samples and actual field samples that may be in question. The need for a PE in conjunction with closure investigation sample analysis may be based on the laboratory's historical performance as reported by other auditing agencies (i.e., Missouri River District CoE, USEPA CLP, etc.).

Specific Routine Procedures Used to Assess Data Precision, Accuracy, and Completeness

Precision is an estimate of the reproducibility of a method, and is estimated by several statistical tests: the standard deviation of the error distribution, the coefficient of variation, and the relative percent difference between replicate (duplicate) samples. The facility operator will determine the precision of a method by analyzing replicate data.

Precision is then defined by the coefficient of variation (CV), which expresses the standard deviation as a percentage of the mean. An indicator of CV, relative percent difference will serve as quality criterion for classification of data resulting from this investigation. Specific statistical comparison of duplicate samples (field and laboratory), as a measure of precision evaluating both sample collection procedures and laboratory instrument performance, may be accomplished by first comparing the obtained duplicate results with the published FDEP/USEPA criteria for method precision (relative percent difference).

The accuracy of a method is an estimate of the difference between the true value and the determined mean value. Specific statistical comparison of percent recovery values reported by the laboratory as a measure of method accuracy will be compared with the published FDEP/EPA (or other appropriate regulatory entity) criteria for the accuracy of an individual method.

Data completeness will be expressed both as the percentage of total tests conducted and required in the scope of work that are deemed valid. A completeness goal of 90 % has been set for air, soil and groundwater analyses performed in conjunction with this project. Methods for assessing data precision, accuracy, and completeness by the laboratory will be outlined in the approved laboratory QAP (if requested).

Quality Assurance and Project Reports

NAS Key West will provide a data quality assurance summary for Demolition Key (QC Data Report) within interim and/or final closure report for submittal to FDEP.

POST-CLOSURE

Post-closure activities will not be conducted as part of the closure process. Post-closure activities are not warranted for this facility based on the remoteness of the island, its security, and the likelihood that additional emergency treatment operations will continue at Demolition Key following closure activities.

SECTION II.E

GROUNDWATER PROTECTION

GROUNDWATER PROTECTION

This section contains information to satisfy the requirements of 40 CFR 270.14(c) and FAC 62-730.

Data Summary

Groundwater chemical constituent monitoring data have not been collected at or surrounding the treatment facility nor is it anticipated to be collected during or following closure operations. However, groundwater physical characteristics, including depth to groundwater, temperature, and salinity, have been collected. The physical data are contained in Section II.B of this operating permit application.

Aquifer Identification

There are two aquifers in the Key West area: the surficial and the Floridan aquifer systems. The surficial aquifer system is also known as the Biscayne Aquifer.

The surficial aquifer system at Demolition Key NW occurs in the dredge/spoils overlying the Miami Limestone, the Key Largo Limestone, and the upper parts of the Tamiami Formation. This aquifer is considered to be under water-table conditions (unconfined).

Generally, the Suwannee Limestone forms the upper part of the Floridan aquifer system. However, where the basal Hawthorne sediments are permeable enough, these may form in the upper portion of the Floridan. This aquifer system is considered to be under artesian conditions (confined).

The Hawthorne Group is relatively impermeable and acts as a confining unit between the surficial and the Floridan aquifer systems. Confining units are lithologic units that have low permeabilities and separate and/or confined aquifers with high permeabilities.

Due to the presence of the Hawthorne Group as a confining unit, only the surficial aquifer system will be considered an aquifer of concern.

Unit Descriptions

Dredge/spoils at Demolition Key consist of a mix of white to gray gravel to cobble-sized coral/limestone rubble (60%), fine to coarse sand (10% to 30%), and brown to gray silt/mud (10% to 30%).

The Miami Limestone is a porous limestone containing numerous vertical solution features, most probably formed during the Pleistocene. These features are not commonly connected and therefore, water does not move laterally as readily as in the Key Largo Limestone. The Key Largo Limestone contains cavities which make it very permeable. Fresh water readily escapes to the sea and sea water easily enters the formation.

The Tamiami Formation contains permeable sandstone and sandy limestone units. The Tamiami is estimated to be 140 feet thick and forms the basal unit of the surficial aquifer system. This formation is underlain by the Hawthorne Group. The Hawthorne Group is typically recognized as a confining layer between the surficial and the Floridan aquifer systems.

Groundwater Monitoring

If groundwater is determined to be required to ascertain background or unit concentrations, monitoring will be conducted in accordance with Section II.D of this closure permit application and additional amendments, as required.

SECTION II.F

SOLID WASTE MANAGEMENT UNITS AND POTENTIAL RELEASES

SOLID WASTE MANAGEMENT UNITS AND POTENTIAL RELEASES

The following information satisfies the requirements of 40 CFR 270.14(d) and FAC 62-730. No solid waste management units (SWMU) exist on Demolition Key. Active and inactive range units are contained on both keys combining to form Demolition Key. Because the Navy has no intention of closing these units, due to national security, they do not meet the definition of a SWMU according to the current draft U.S. EPA regulations. If remediation of these areas is necessary in the future, remediation activities will be conducted according to the provisions of these draft regulations or NAS Key West's Installation Restoration Program.

SECTION II.G

PROCESS VENTS

PROCESS VENTS

Because treatment operations were conducted in an open environment, and closure operations will not entail processing, no ancillary air pollution control equipment or process vents exist or are required. This information satisfies the requirements of 40 CFR 270.24 and FAC 62-730.

SECTION II.H

EQUIPMENT REQUIREMENTS

EQUIPMENT REQUIREMENTS

Equipment, as it is defined in Subpart BB of 40 CFR 264, does not apply to the closure operations and equipment used in said operations at Demolition Key.

Appendix A

Memorandum of Understanding Between Naval Air Station, Key West and the City of Key West, Florida Police Department

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MEMORANDUM OF UNDERSTANDING
BETWEEN NAVAL AIR STATION, KEY WEST
AND THE CITY OF KEY WEST, FLORDIA
POLICE DEPARTMENT

PURPOSE

The purpose of this Memorandum of Understanding is to establish a mutually acceptable arrangement that will lead to more effective law enforcement at Naval Air Station, Key West, Florida.

JURISDICTION

The Key West Police Department exercises, jointly with the U. S. Navy, concurrent jurisdiction on significant portions of the area under the control of the Naval Air Station, Key West including a portion of the housing areas. Concurrent jurisdiction means that the State has authority to enforce State law on those federal reservations. The Department of the Navy enforces Federal law based on the authority vested in the Commanding Officer by Naval Regulations. Additionally, the Navy Security Force enforces State law under the Assimilated Crimes Act, 18 USC 13, based on the authority vested in the Commanding Officer by Naval Regulations which are delegated to the Security Force.

STATEMENT OF UNDERSTANDING

Under this Memorandum of Understanding, the Key West Police Department will provide services to NAS Key West at the request of the Commanding Officer or Security Officer commensurate with availability of resources. Under this same Memorandum, the NAS Key West Security Department will provide services to the Key West Police Department within the limits allowed by State and Federal Law.

The NAS Key West Security Department will coordinate and cooperate with the Key West Police Department by maintaining close liaison and keeping the Key West Police Department apprised of actual and suspected criminal activity on board the installation including housing areas.

The NAS Key West Security Officer, or in his/her absence the Assistant Security Officer, the Security Department Operations Officer (Chief of Police), or the Watch Commander, will serve as liaison officer to coordinate the activities of city police officers and other Key West Police Department officials on federal property.

Except in unusual circumstances, the serving of civil process (warrants and subpoenas) will continue to be effected by the Monroe County Sheriff's Office.

It is understood that this Memorandum is not a mutual aid agreement, and does not enlarge the authority which any law enforcement officer may presently exercise nor confer any powers not presently enjoyed.

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DEPARTMENT OF THE NAVY
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COPIER

J. M. MUNNINGHOFF
Captain, U. S. Navy
Commanding Officer
Naval Air Station
Key West, Florida

28 DEC 93
Date

E. R. PETERSON
Chief of Police
City of Key West, FL

01-10-94
Date

REPRODUCED AT GOVERNMENT EXPENSE
DEPARTMENT OF THE NAVY
168
COPIER

MEMORANDUM OF UNDERSTANDING BETWEEN NAVAL AIR STATION, KEY WEST AND THE MONROE COUNTY SHERIFF'S OFFICE

PURPOSE

The purpose of this Memorandum of Understanding is to establish a mutually acceptable arrangement that will lead to more effective law enforcement at Naval Air Station, Key West, Florida.

JURISDICTION

The Monroe County Sheriff's Office exercises, jointly with the U. S. Navy, concurrent jurisdiction on significant portions of the area under the control of the Naval Air Station, Key West including a portion of the housing areas. Concurrent jurisdiction means that the State has authority to enforce State law on those federal reservations. The Department of the Navy enforces Federal law based on the authority vested in the Commanding Officer by Naval Regulations. Additionally, the Navy Security Force enforces State law under the Assimilated Crimes Act, 18 USC 13, based on the authority vested in the Commanding Officer by Naval Regulations which are delegated to the Security Force.

STATEMENT OF UNDERSTANDING

Under this Memorandum of Understanding, the Monroe County Sheriff's Office will provide services to NAS Key West at the request of the Commanding Officer or Security Officer commensurate with availability of resources. Under this same Memorandum, the NAS Key West Security Department will provide services to the Monroe County Sheriff's Office within the limits allowed by State and Federal Law.

The NAS Key West Security Department will coordinate and cooperate with the Monroe County Sheriff's Office by maintaining close liaison and keeping the Monroe County Sheriff's Office apprised of actual and suspected criminal activity on board the installation including housing areas.

The NAS Key West Security Officer, or in his/her absence the Assistant Security Officer, the Security Department Operations Officer (Chief of Police), or the Watch Commander, will serve as liaison officer to coordinate the activities of county deputies and other Sheriff's Office officials on federal property.

Except in unusual circumstances, the serving of civil process (warrants and subpoenas) will continue to be effected by the Monore County Sheriff's Office.

It is understood that this Memorandum is not a mutual aid agreement, and does not enlarge the authority which any law enforcement officer may presently exercise nor confer any powers not presently enjoyed.

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DEPARTMENT OF THE NAVY
168
COPIER

J. M. MUNNINGHOFF
Captain, U. S. Navy
Commanding Officer
Naval Air Station
Key West, Florida

28 Dec 93
Date

RICHARD D. ROTH
Sheriff
Monroe County, FL

1/28/94
Date

Appendix B

Modeling Results and Protocol for Open Burning/Open Detonating of Propellants, Explosives, and Pyrotechnics at Naval Air Station Key West's Demolition Key Facility

MODELING RESULTS AND PROTOCOL FOR OPEN BURNING/OPEN DETONATING OF PROPELLANTS, EXPLOSIVES, AND PYROTECHNICS AT NAVAL AIR STATION KEY WEST'S DEMOLITION KEY FACILITY

October 5, 1995

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MODELING PROTOCOL

MODELING PROTOCOL FOR OPEN BURNING/OPEN DETONATING OF PROPELLANTS, EXPLOSIVES, AND PYROTECHNICS AT NAVAL AIR STATION KEY WEST'S DEMOLITION KEY FACILITY

INTRODUCTION

This protocol governs the modeling of open burning and open detonating (OB/OD) of propellants, explosives, and pyrotechnics (PEP) at Naval Air Station (NAS) Key West's Demolition Key Facility. This protocol defines the technical approach and parameters that will apply to the computer simulations, and serves the dual purpose of identifying the required input and verifying the conditions and aspects of the modeling, with the ultimate objective to ensure that the computer modeling reflects as closely as possible the physical events. It also allows the development of realistic "worst-case scenarios" and favorable meteorological envelopes relative to downwind ground-level concentrations and exposed areas.

The Products of Combustion/Atmospheric Dispersion (PCAD) computer model was selected as the most appropriate computer simulation method. A description of the PCAD model is found in Appendix 1-A, and contains an example of the PCAD output. A summary of the PCAD validation efforts is included in Appendix 1-B. PCAD has the ability to calculate products of combustion, heat release rates, and dispersion characteristics of the resulting plume from the combustion of PEP material. The computer model input for the combustion simulation includes reactants and combustion conditions. The dispersion simulation is calculated using the heat release rate and the product formation from the combustion simulation, as well as the

atmospheric conditions. This protocol identifies the necessary information and selection of variables needed to complete the modeling.

The PCAD computer model was developed by El Dorado Engineering Inc. specifically for quantifying and evaluating airborne emissions from OB/OD operations. PCAD calculates products of combustion, heat release rates, and dispersion characteristics of the resulting plume from the thermal treatment of materials. PCAD has proven an invaluable tool in preparing Subpart X permit applications because it combines combustion, plume rise, and dispersion into a single model to evaluate the OB/OD process. PCAD also had an extensive validation and refinement process (see Appendix 1-B).

BACKGROUND AND PURPOSE

The purpose of this combustion and dispersion modeling is to quantify and evaluate air emissions from OB/OD operations at NAS Key West's Demolition Key Facility. The air emissions data is required as part of the Subpart X portion of the RCRA Part B Permit Application. The typical resulting air emissions must, therefore, be identified and quantified in terms of resulting ground-level concentrations.

COMBUSTION MODELING

The following sections designate the runs that will be performed, and the specific details that will be input to PCAD, for the combustion modeling. Variables necessary for the combustion modeling are also defined and evaluated.

Modeling Configuration

Table 1 shows the configuration that will be modeled. This table shows the OB/OD constituents, as well as the reactants that make up each constituent. Analyses will be performed on this configuration for both open burning and open detonating scenarios.

Model Input Parameters

More detailed information necessary to complete the combustion modeling of the configuration in Table 1 is discussed below.

1. Reactant Heat of Formation: The heat of formation for each reactant is an essential parameter for accurate heat release rate calculations, and subsequent plume heights. The heats of formation for reactants and explosives involved in the modeling, tabulated in kcal/gmole, will be used in the computer calculations.

TABLE 1: Modeling Configuration

OB/OD CONSTITUENTS	REACTANTS	% OF SPECIFIC CONSTITUENT	% OF TOTAL REACTANTS
95% CAD (use composite propellant)	Ammonium Picrate	40.7	38.7
	Potassium Nitrate	49.8	47.3
	Ethyl Cellulose	4.5	4.3
	Chlorinated Wax	4.5	4.3
	Calcium Stearate	0.5	0.4
1% Cartridges	Nitrocellulose	82.6	0.8
	Nitroglycerin	9.6	0.1
	Dibutylphthalate	5.5	0.1
	Calcium Carbonate	1.0	0.0
	Diphenylamine	0.9	0.0
	Dinitrotoluene	0.3	0.0
	Sodium Sulfate	0.1	0.0
1% Smokes/Flares (use flare mix)	Magnesium	17.5	0.2
	Strontium Nitrate	45.0	0.5
	Potassium Perchlorate	25.0	0.2
	Polyvinyl Chloride	5.0	0.0
	Gilsinite	7.5	0.1
3% TNT	TNT	100.0	3.0

2. Burn Times: The duration of the open burning occurrences are estimated to last two minutes, while detonations (including afterburning) are estimated to last 5 seconds.

3. Quantity Burned: The quantity of each explosive modeled must be determined as input into the combustion modeling. This quantity should represent the amount that may be disposed in one treatment unit in one incident. This will be modeled as five pounds net explosive weight (NEW).

4. Air-Fuel Ratio: The approximate quantity of air must be incorporated into the combustion calculations to ensure that the model accurately predicts the products at equilibrium. The open burning and open detonation scenarios involve available oxygen from the surrounding air. This fact has been substantiated during studies that involved source sample collection and analyses. Source samples collected during nine separate open burnings at the Hercules (Bacchus Works) burning grounds all demonstrated that the combustion process involved significant quantities of ambient air. The source sampling performed during a Pershing II first stage static test firing demonstrated similar results. The details of these studies are documented in a plume characterization study sponsored by the Department of the Navy and Hercules Inc, and prepared by El Dorado Engineering Inc.[1] The data from these studies showed that the combustion air consumed during open burning of propellant and explosive material configurations was at least five times the weight of the fuel (propellant). Open detonations create turbulent atmospheric conditions, which enhances afterburning. Samples of combustion products from open

detonations at Dugway Proving Grounds demonstrated carbon dioxide generation rather than carbon monoxide, and thus provide further evidence of air taking part in the reaction process.[2] The figure of five to one will provide the basis for the air-fuel ratio applicable to both the open burning and open detonating modeling.

5. Reaction Pressure: The pressure of the reactions will be modeled at the atmospheric pressure of the burn site. A figure of 14.7 psi, corresponding to sea level, will be entered into the calculation routine.

PLUME RISE AND DISPERSION MODELING

Plume rise for the modeling scenarios will utilize Briggs-based plume rise equations for heated clouds resulting from a fire or explosion.[3] The scenarios will be modeled with the use of a Gaussian dispersion equation.[4,5]

The plume rise and dispersion portions of the modeling consist of a simulation that incorporates the output from the combustion algorithm and meteorological data input. This information allows the model to calculate downwind ground-level concentrations and isopleth plots of deposition areas. The following parameters and variables will be employed to complete the modeling.

Constant Parameters

1. Burn Radius: The burn radius is defined as the radius of a circle that is equal in area to the surface of the burn area. This value is dependent upon several factors such as facility layout and material quantities, characteristics, and configuration. This parameter serves the purpose of initializing the plume dimensions.

The treatment operations will take place in a burn tray 16' x 4'. The burn materials will be placed and occupy only a portion of the burn tray's surface area,

estimated as a 4' x 4' area. An equivalent burn radius of 2.3 feet will, therefore, be used for modeling purposes.

2. Standard Gravity: The standard gravity figure of 9.8 m/s^2 shall be used in any calculations requiring this physical parameter.

3. Air Density: The ambient air density will be input as 1225 g/m^3.

4. Ambient Temperature: The ambient temperature that shall be used during the computer simulation is 298°K (25°C), the default value in the PCAD model.

5. Specific Heat of Air: The specific heat of air that shall be used in the dispersion calculations is 0.24 cal/g°C. The specific heat of air does not vary significantly from this value when considering the range of possible temperatures ang the height of the plume, and the 0.24 value corresponds to all expected temperatures. The value at ambient pressure and 0°C is 0.238 cal/g°C, and 0.237 cal/g°C at 100°C.[6]

6. Entrainment Coefficient: The value selected for the entrainment coefficient (a dimensionless factor) is 0.5 for the burning, and .64 for the detonation. The entrainment coefficient represents the amount of ambient air entrained into the plume during plume rise. The value of 0.5 was selected based on the validation studies of open burning, and studies involving the Pershing motor static test firings.[7] The entrainment coefficient used

in these studies was 0.5, and the resulting model predictions of plume heights were consistent with those actually observed. Since the actual occurrences closely matched predictions, the 0.5 value was substantiated. Additionally, Briggs[8] cites a value of 0.5 for buoyant plumes resulting from uncontrolled fires. The value of .64 was selected for detonations, as it has been recommended by models in use by both the Army[9] and the Air Force.[10]

Variable Parameters

The PCAD model will be used to determine plume characteristics under several meteorological conditions. Modeling different atmospheric characteristics determines the environmental circumstances that promote adequate dispersion, and subsequent acceptable ground-level concentrations.

Since OB/OD operations are normally curtailed during inversions, no temperature inversion scenarios will be modeled. The selection of the modeling will, however, be based on realistic, conservative scenarios that approach restrictive situations. A discussion of the parameters that will be used follows.

1. Atmospheric Stability Class: The characteristics of Pasquill-Gifford atmospheric stability classes A through F are found in Table 2, as given by Turner.[11] Classes E and F will be eliminated entirely as candidates for the PCAD modeling because these dispersion conditions occur only at night, and no disposal activities are expected during this time. Analyses will be performed on stability classes A, B, C, and D.

2. Average Wind Speed: Average wind speed is determined by the average of wind speeds through the stabilization height of the plume. An average wind speed is difficult to determine without knowledge of approximate plume height and upper-air sounding data. For modeling purposes, however, initial scenarios can be based on surface wind

speeds. Surface wind speeds are related to atmospheric stability class as shown in Table 2. Windspeeds generally increase with altitude, as shown in Figure 1.

TABLE 2: Stability Category Conditions

Key to Stability Categories					
Surface Wind Speed (@10m) m/sec	Day Incoming Solar Radiation			Night Thinly Overcast or ≥ 4/8 Low Cloud	≤ 3/8 Cloud
	Strong	Moderate	Slight		
<2	A	A-B	B		
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
>6	C	D	D	D	D
The neutral class, D, should be used for overcast conditions during day or night.					

Source: Workbook of Atmospheric Dispersion Estimates, D. Bruce Turner, 1970,pg 6

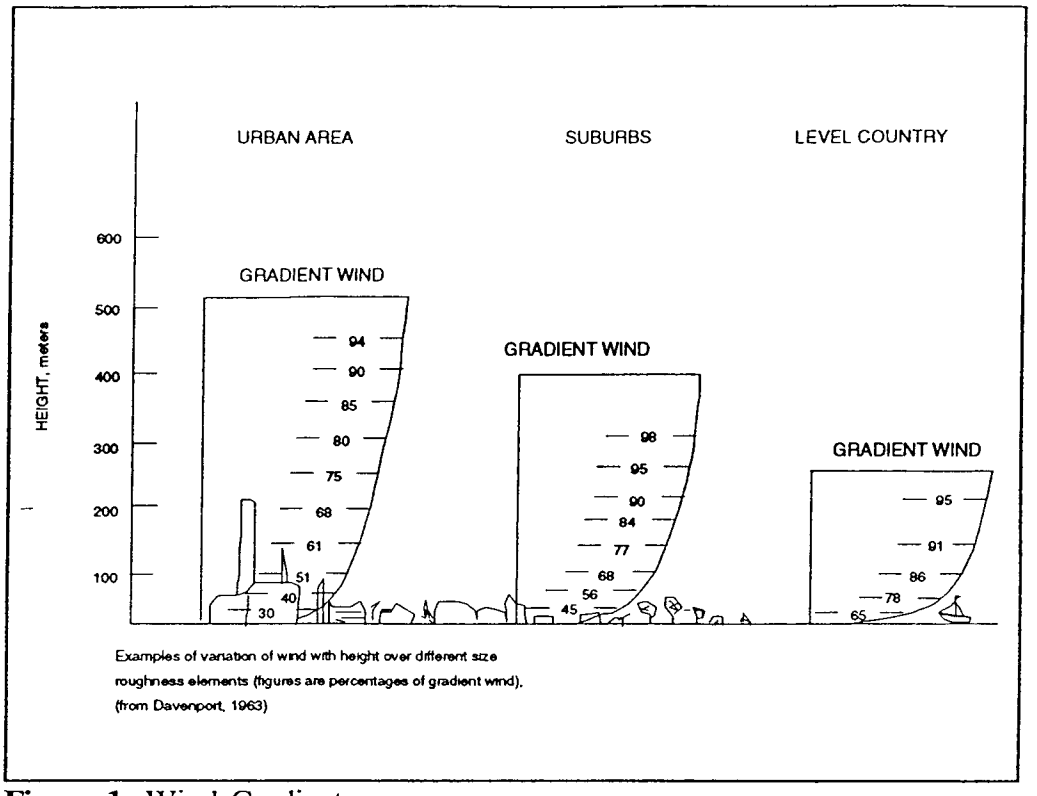


Figure 1: Wind Gradients

Surface windspeeds will be evaluated at stabilization height by the wind profile exponent:

$u = u_1 (h/z_1)^p$, where

u = adjusted wind speed

u_1 = observed wind speed

h = ½ stabilization height

z_1 = measurement height

p is based on stability class, from Table 3

No windspeeds greater that 15 mph will be modeled, as open burning operations are not initiated at windspeeds higher than this.

TABLE 3: Wind Speed Profile Exponents (p)

Stability Class	Wind Profile Exponent
A	.07
B	.07
C	.10
D	.15
E	.35
F	.55

Calculating the adjusted windspeed by ½ the stabilization height estimates an average windspeed through the height of the plume.[12] This is an iterative process in the PCAD model, as adjusted wind speed and plume stabilization height depend on each other. If ½ stabilization height is greater than 200 meters, it is set equal to 200 meters, and adjusted wind speeds are based on the 200 meter height.[13]

For this effort, wind speeds will be modeled as shown in Table 5. No high or low extremes will be modeled for Stability Class A because of the narrow wind corridor where this class may exist (see Table 2).

3. Vertical Potential Temperature Gradient: The vertical potential temperature gradient (abbreviated VTG in the PCAD program) is a measurement of the difference between dry adiabatic temperature lapse rate with altitude (defined as 1°C/100 meters), and the actual temperature lapse. The potential temperature of dry air is defined as the temperature that the air would assume if brought adiabatically from its actual pressure

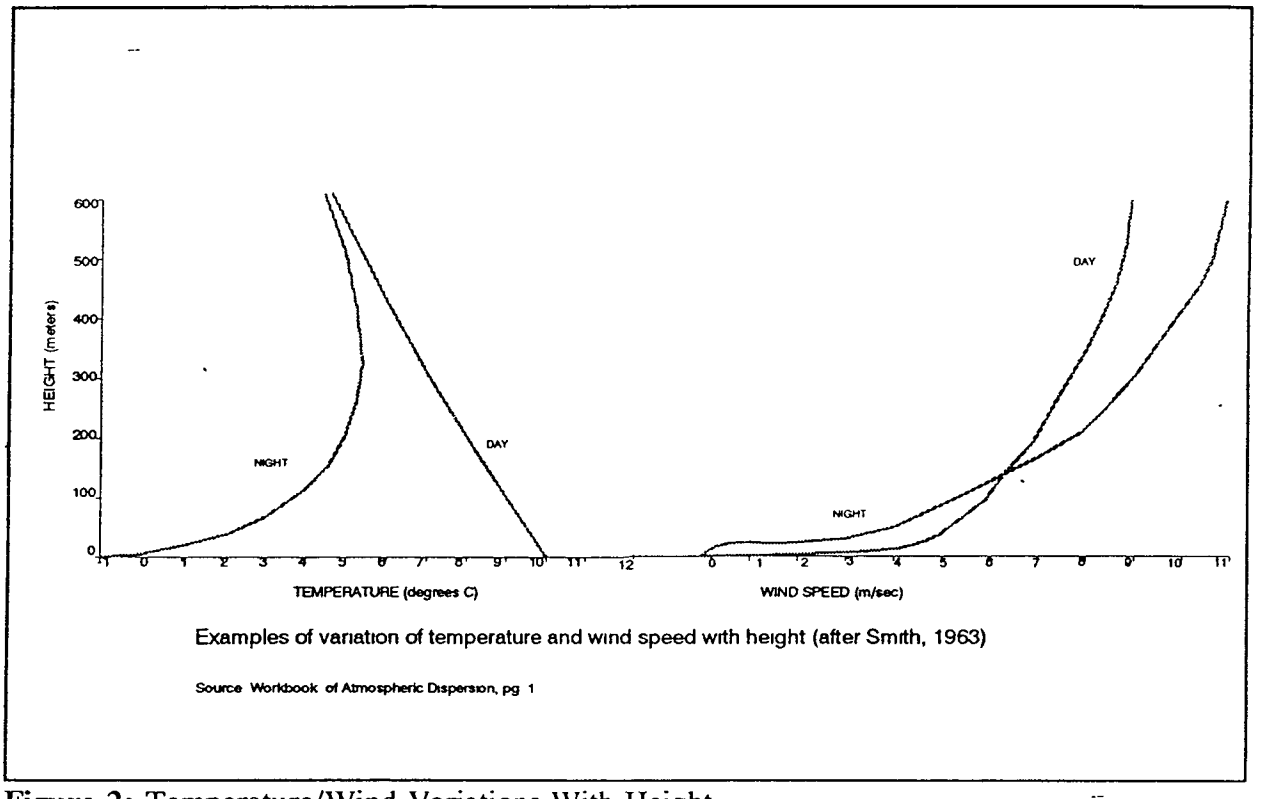


Figure 2: Temperature/Wind Variations With Height

to standard pressure.[14] When temperature decreases with height at a rate of 1°C per 100 meters, vertical motions are enhanced because the atmosphere is in an unstable equilibrium. Vertical motions, however, are damped or reduced when the temperature decreases at a lower rate or increases with height. Typical temperature variations are illustrated in Figure 2. The VTG has a significant affect on plume rise. For this effort,

VTG values will be modeled as shown in Table 5. No low extreme will be modeled for Stability Classes A and B, and the expected VTG value for these stability classes is the lowest allowable PCAD input for this parameter. Lower values must default to this value (.0003322 °C/m).

This lower limit VTG value is the same limit used in other models, such as the Air Force's REEDM computer model. "For unstable/neutral conditions, experience shows that the height at which the rate of rise determined from an adiabatic model becomes negligible for practical purposes can be predicted using a small value of [VTG] in the stable model... For this reason, the program sets [VTG] equal to 3.322E-4 when the value of [VTG] is less than 3.322E-4."[15] Because a larger vertical potential temperature gradient results in a low plume rise using the appropriate thermo-buoyant plume rise equations, PCAD incorporates vertical potential temperature gradients and ranges as determined by El Dorado Engineering's own testing on open burning operations and El Dorado Engineering's own tests as a subcontractor to NASA on the static firing of the space shuttle rocket motors. With the appropriate thermo-buoyant plume rise equations, this provides a more conservative approach to the computer modeling. These values are conservative, particularly in relation to the vertical potential temperature gradients shown in Table 4 from the ISC2 computer model.

TABLE 4: Vertical Potential Temperature Gradients—ISC2 Computer Model[16]

Atmospheric Stability Class	Vertical Potential Temperature Gradient
A	0.000
B	0.000
C	0.000
D	0.000
E	0.020
F	0.035

The results of the PCAD modeling will demonstrate plume composition, overall plume height, and ground-level concentrations of products from the disposal activities. The various scenarios modeled will be documented, and contain all the above data (see example run in Appendix 1-A).

Dispersion modeling, therefore, will be performed for the expected meteorological conditions for each stability class analyzed (A through D; see Table 5). From these expected conditions, wind speed and VTG will be varied to represent conditions that may still occur, and dispersion modeling again performed. Modeling results will include isopleth plots of concentration percentages.

TABLE 5: Modeling Cases

Stability Class	Wind Speed m/s			VTG °C/m (x 10^{-3})		
	Expected	High	Low	Expected	High	Low
Class A	2	-	-	.3322	1.83	-
Class B	3	5	2	.3322	1.83	-
Class C	4	6.7	3	1.83	3.322	.3322
Class D	4	6.7	2	3.322	10.0	1.83

END NOTES

1. El Dorado Engineering Inc, 1989, Validation of Products of Combustion Atmospheric Dispersion (PCAD) Computer Based Model, Salt Lake City, UT.

2. Johnson, M.B., et al, "Airborne Gaseous And Particulate Products From Large-Scale Bulk Explosive Detonations And Propellant Burns," U.S. Army Armament Munitions and Chemical Command.

3. Whitacre, C.G. and M.M. Myirski, 1984, Computer Program for Chemical Hazard Prediction, Chemical Systems Laboratory, Aberdeen Proving Ground, MD, Appendix A.

4. Turner, D.B., 1970, Workbook of Atmospheric Dispersion Estimates, EPA, Publication No. AP-26.

5. Bjorklund, J.R., and R.K. Dumauld, Users' Instructions For The Volume Source Diffusion Models Computer Program, TR-81-321-08, H.E. Cramer Company, 1981, p A-28.

6. Perry, R.H. and C.H. Chilton, 1973, Chemical Engineers's Handbook, Fifth Edition, McGraw-Hill, New York, NY, Page 3-134.

7. El Dorado Engineering Inc.

8. Briggs, G.A., 1971, Some Recent Analyses of Plume Rise Observation, Clean Air Congress, Academic Press.

9. Whitacre.

10. Bjorklund, J.R., User's Manual For The REEDM Version 7 (Rocket Exhaust Effluent Diffusion Model) Computer Program, H.E. Cramer Company, April, 1990.

11. Turner.

12. Turner, D. Bruce, Interview by EDE, 1993.

13. Ibid.

14. Haurwitz, B., 1941, Dynamic Meteorology, McGraw-Hill, New York, NY Pages 20-23.

15. Bjorklund, J.R., 1990, User's Manual For The REEDM Version 7 (Rocket Exhaust Effluent Diffusion Model) Computer Program, pg 20.

16. User's Guide For The Industrial Source Complex (ISC2) Dispersion Models, U.S. Environmental Protection Agency, March 1992, pg 3-5.

APPENDIX 1-A: PCAD Description

SUMMARY PROGRAM DESCRIPTION

General

The PCAD model consists of three subprograms:

The combustion products portion of the PCAD model computes the combustion products and their quantities and the amount of heat released during the combustion process. This subprogram is a specially modified version of a program written at the NASA Lewis Research Center to calculate chemical equilibrium compositions formed in rocket propellant combustion.[1]

The combustion products subprogram requires input of the combustible materials' chemical composition, heats of formation of the constituents, density (for isentropic processes), pressure, and mole ratio, weight ratio, or volume ratio of the compounds involved. Data output includes a listing of the compounds produced, product species considered, enthalpy, entropy, pressure, heat output rate, quantity of product generated, and gas mole fractions of products.

The plume rise portion of the model computes the centerline elevation of the plume at the height at which it no longer rises (stabilization height). It is from this elevation that the plume disperses downwind until it reaches the ground.

The plume rise is calculated using Briggs Plume rise equations[2] in a form developed by the US Army[3] in Chemical Hazard Prediction. The computation requires input of burn radius, average windspeed, effective heat release rate, ambient air density and temperature, and vertical potential temperature gradient (VTG). Program output is the centerline height (H) of the plume at stabilization. Initial dimensions of the plume are assumed to be spherical in nature, with the radius equal to one half of the height H.

The dispersion portion of the PCAD model uses the combustion product output rate, the heat release rate, and the plume rise value H, to compute the ground-level concentrations of the various combustion products. The only operator input required is to identify the stability category and the isopleth percentages desired. The program output provides a plot of the selected isopleth percentages which shows area plots of all areas containing a fixed percentage of the maximum centerline concentration.

Dispersion computations are based on the equations developed by Turner[4]. The PCAD program uses the Pasquill-Gifford sigma$_y$ and sigma$_z$ curves for lateral and vertical growth if the stabilization height H is less than 30 meters. For cases where H is greater than 30 meters, the program substitutes rectilinear equations to compute sigma$_z$ coefficients for the plume vertical growth.

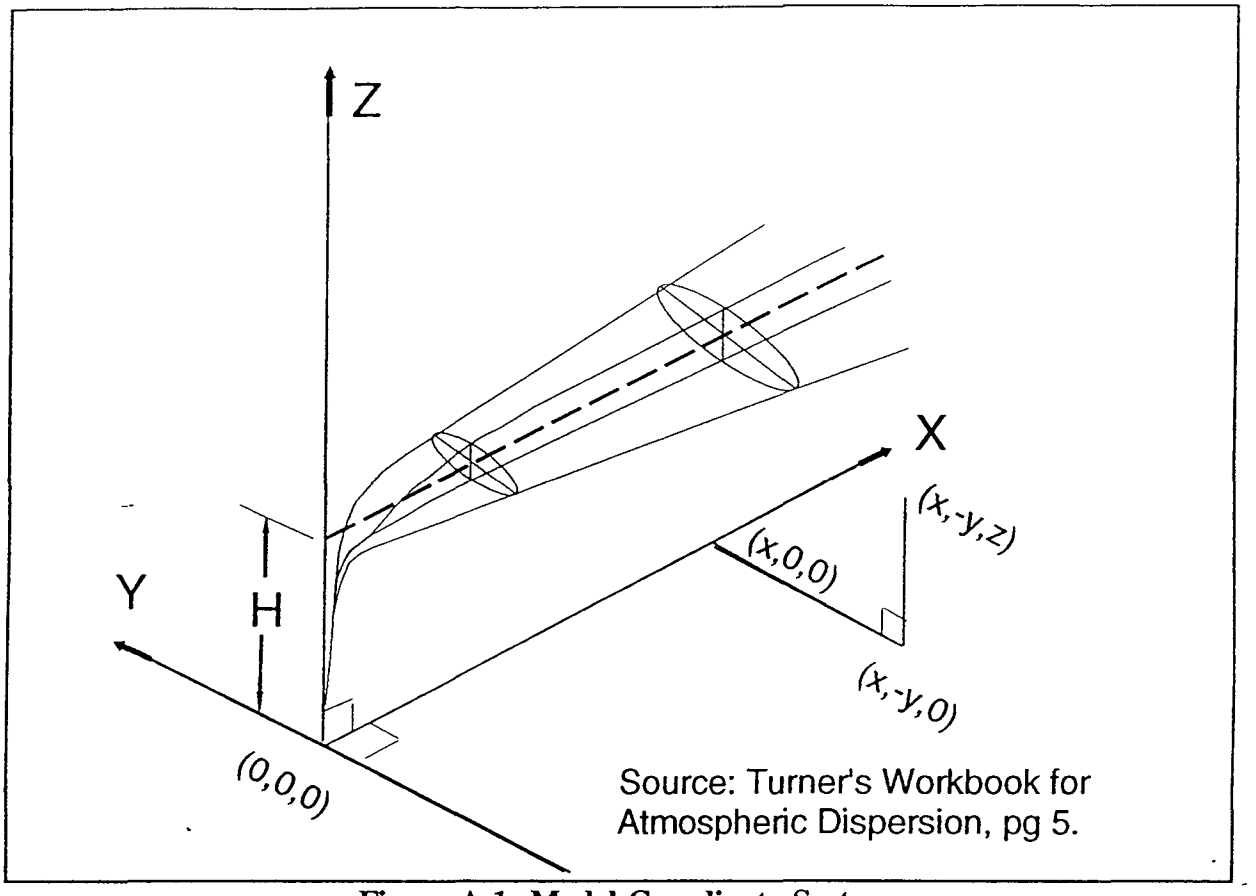


Figure A-1: Model Coordinate System

Coordinate System

The coordinate system used for the model is illustrated in Figure A-1. It is a three dimensional coordinate system where "X" is in the horizontal direction of the wind, "Y" is the crosswind, or lateral distance, and "Z" is in the vertical direction. The origin (coordinates 0,0,0) is located at the location of the burn. Coordinates "X" and "Z" are always positive while "Y" equals zero at the horizontal centerline of the plume ("X" axis)

and may be positive or negative in direction. However, since the model assumes a symmetrical spread of the plume in the lateral ("Y") direction, most calculations are based on one side and the sign of "Y" is normally ignored.

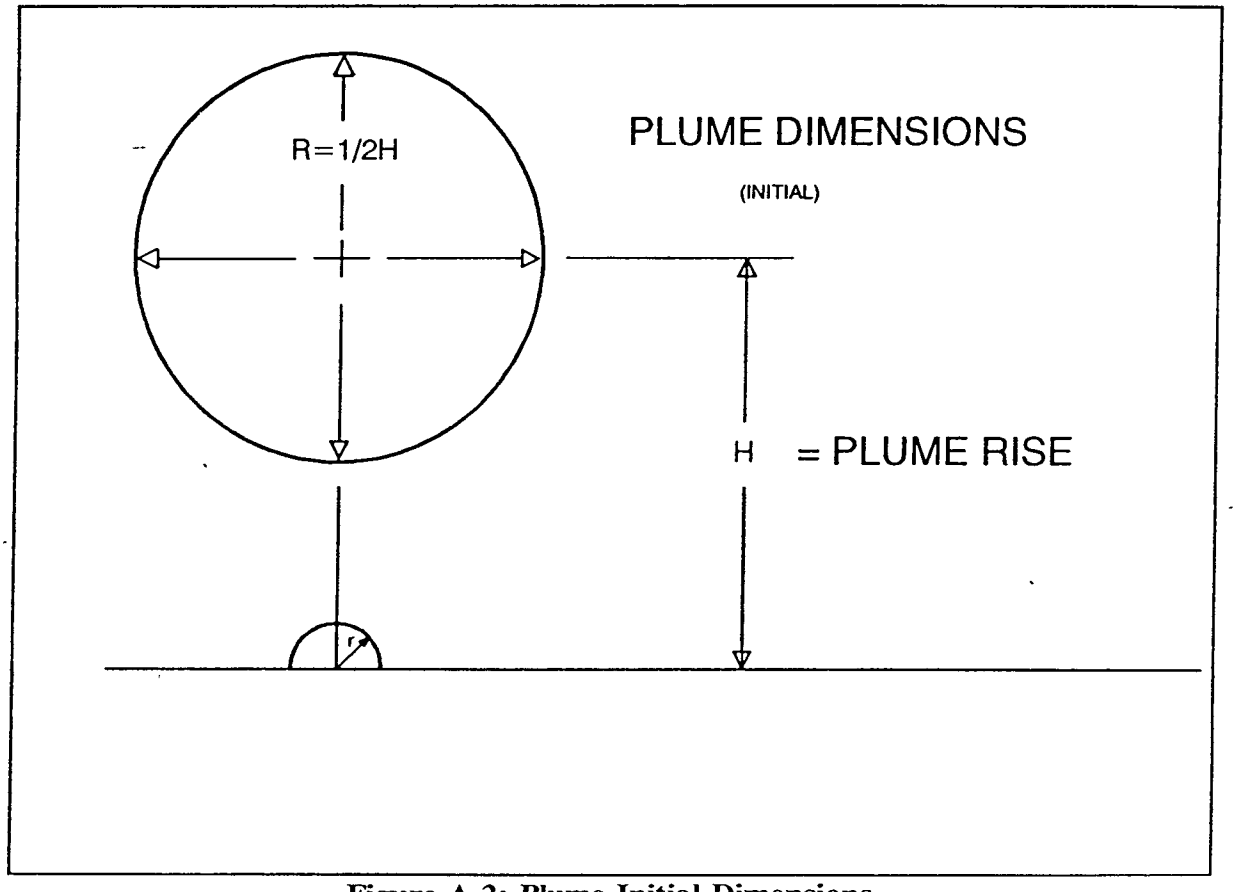


Figure A-2: Plume Initial Dimensions

Plume Dimensions

Figure A-2 illustrates the PCAD model assumptions concerning the plume dimensions. The plume initial dimensions (before rise occurs) is assumed to be hemispherical with a radius "r" equal to the burn radius. At stabilization height, the plume is assumed to be near-spherical with a radius "R" equal to ½ of the centerline height "H". (Actual plume shape is defined by σ_y and σ_z.)

As the plume moves down wind, the plume expands as a function of the vertical, lateral, and alongwind turbulent intensities at the plume stabilization height H. For values of H greater than 30 meters, the PCAD model uses vertical dispersion coefficients as defined by the rectilinear expression

$$\sigma_z = I_z \cdot X$$

where

σ_z = Vertical Dispersion Coefficient (m)

I_z = Vertical intensity of Turbulence at plume stabilization height H (dimensionless)

X = Downwind Distance (m)

When measurements of vertical intensity of turbulence are not available, the PCAD model assigns a default value for each of the Pasquill stability categories as given in the LONGZ SHORTZ models[5]. These values are listed in Table A-1.

TABLE A-1: Vertical Turbulent Intensities	
Stability Category	Vertical Turbulent Intensity (I_z)
A	0.1745
B	0.1080
C	0.0735
D	0.0435
E	0.0355
F	0.0235

If measurements of the lateral turbulent intensity are not available, the PCAD model assigns lateral dispersion coefficients (σ_y) as given by Turner (1975). The default values mentioned were assigned for the Thiokol open burning modeling.

Model Assumptions and Default Values

The PCAD model requires numerous inputs which are either requested from the operator by the program or are provided with a default value. Table A-2 below lists these variables and their default values. These default values are sample values only, and can be changed, as required, by the operator. The program will print out the value of these variables and allow changes by the operator by following the instructions displayed.

TABLE A-2: Program Default Values

Air Density	1000 g/m^3
Ambient Air Temperature	298 ^{o}K
Specific Heat of Air	0.24 cal/g-degK
Gravitational Force	9.81 meters/sec
Entrainment Coefficient	0.5 (dimensionless
Vertical Potential Temperature Gradient	0.0003322 C/meter
Burn Radius	1.0 meter
Air Stability Class	C
Minimum Concentration Prediction.	0.0050 mg/m^3
Isopleth Data Percentage Levels	50%, 20%, 10%

In addition to the above default variable, the PCAD model includes a data library listing a number of materials typically disposed of by open burning as well as some other materials that have been studied. The information in this library is available to the operator via the LIB control word selection. Once the library is accessed, the material of interest can be selected by number.

APPENDIX 1-A END NOTES

1. Computer Program for Calculation of Complex Chemical Equilibrium Compositions, Rocket Performance, Incident and Related Shocks, and Chapman-Jouguet Detonations, Gordon and McBride, 1976; NASA Lewis Research Center, NASA SP-273.

2. "Some Recent Analyses of Plume Rise Observation," Briggs, G.A., 1971; Clean Air Congress, Academic Press.

3. Computer Program For Chemical Hazard Prediction (D2), Whitacre and Myirski, 1984; US Army Armament Research and Development Command, Report # ARCSL-TR-82014.

4. Workbook of Atmospheric Dispersion Estimates, Turner, D. Bruce, 1975; Public Health Service Publication No. 999-AP-26

5. Users Instructions for the SHORTZ and LONGZ Computer Programs, EPA Report No. EPA-9039-82-004a and 004b; U.S. Environmental Protection Agency, Region III, Philadelphia, PA.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:EXAMPLE RUN

METEOROLOGICAL DATA
AIR DENSITY = 934.19 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .50
VERT. POTENTIAL TEMP. GRADIENT = .00160000 degree K/m
WIND SPEED = 6.73 METERS/sec
AIR STABILITY CLASS : C

BURN DATA
AMOUNT = 2267.57 Kg
TIME = 5.00 min
EFFECTIVE HEAT RELEASE RATE = 22255.57 Kcal/sec
RADIUS = 10.00 METERS

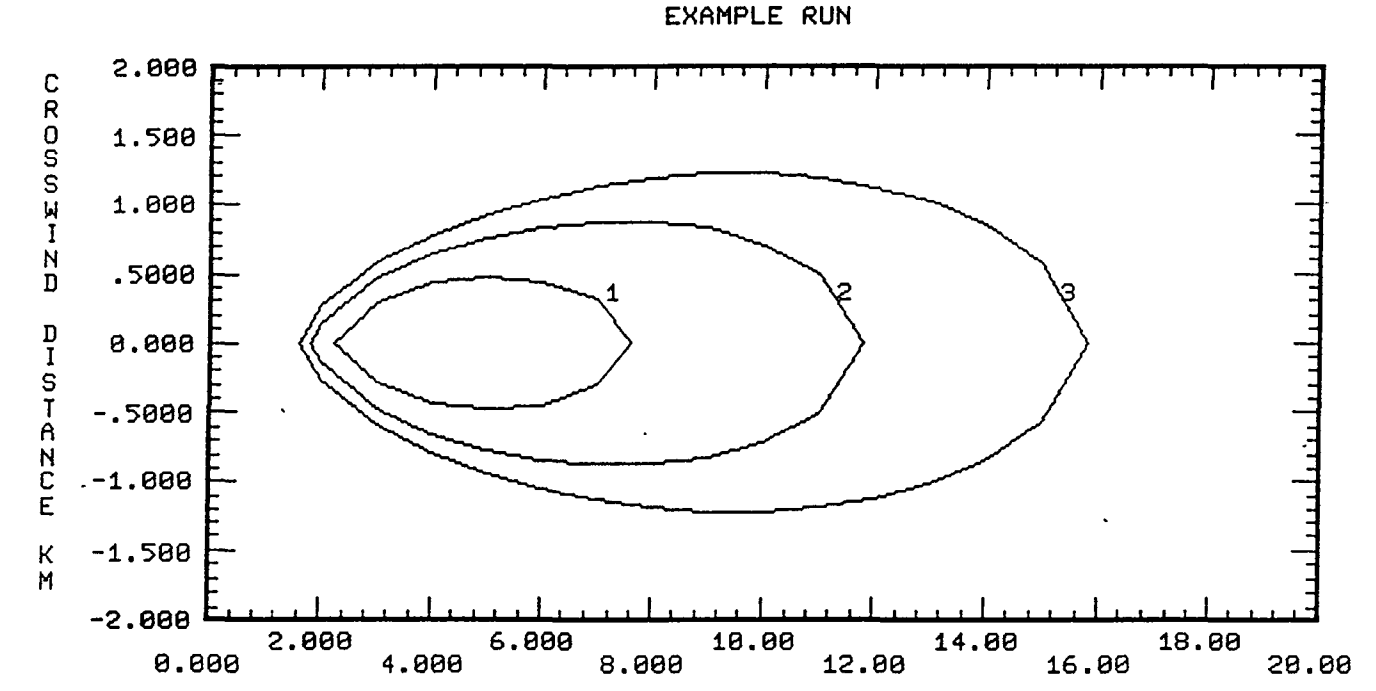
PLUME DATA
EFFECTIVE PLUME HEIGHT = 392.66 METERS
THE MAXIMUM CONCENTRATION OCCURS AT 3.8 KM
RECTILINEAR EQUATIONS USED

ISOPLETH DATA
THE 50% OF CONMAX ISOPLETH CLOSES AT 7.6 KM
THE 20% OF CONMAX ISOPLETH CLOSES AT 11.8 KM
THE 10% OF CONMAX ISOPLETH CLOSES AT 15.8 KM

PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	2265.63	679.69	.40728
CL	146.69	44.01	.02637
CLH	1461.07	438.32	.26265
H2O	1908.87	572.66	.34315
NO	185.79	55.74	.03340
N2	29554.81	8866.44	5.31289
O2	6808.07	2042.42	1.22385
AL2O3/AL	2999.69	899.91	.53924

EXAMPLE PCAD ISOPLETH PLOT



APPENDIX 1-B: PCAD Validation Summary

VALIDATION OF THE PCAD COMPUTER MODEL

The primary objective of the validation effort was to refine and substantiate the PCAD computer model. This was accomplished by applying the model to actual PEP open burning operations, and collecting actual atmospheric dispersion data. The PCAD predictions were compared to the collected dispersion data for agreement.

Pershing Testing

EDE was called upon to assist the U.S. Missile Command as a subcontractor in the environmental assessment of the air emissions from the static firing of the Pershing missile motor as a disposal procedure for the INF treaty. In rendering this support, EDE provided four mini-modeling and sampling campaigns in Huntsville, Alabama, followed by final modeling and a very extensive test program at Pueblo, Colorado. From these tests, EDE developed the technology for incorporating a tracer gas for field sampling, and developed procedures for deploying a vast mobile sampling team.

EDE's modeling results were of particular note in the Pueblo test. The State of Colorado, using existing EPA dispersion models, required that comprehensive monitoring stations be placed at approximately 2-3 miles from the firing site. The Army, having confidence in the PCAD model predictions of maximum downwind concentrations in a 3-6 mile radius elected to also place mobile samplers in a 3-6 mile radius. When the test results were analyzed, the comprehensive stations required by the State had missed the plume, while the PCAD-located mobile sampling team had sampled the plume, as validated by the tracer gas detection.

The procudure of using tracer gas use has been in existence for several years. The application of tracer gas for open burning and static firing was entirely new, and EDE developed the technology to incorporate the tracer. Many of the theoretically predicted downwind concentrations of emission products were at or below the minimum detectable limits of currently available sampling and analytical techniques. The detection level of SF_6, an inert tracer gas, is

in the parts per trillion (ppt) range, which is five or six orders of magnitude greater than the typical detection level for the identified combustion products. Consequently, SF_6 was released into the exhaust plume of the rocket motor to permit reliable tracking and more positive definition of the plume path. Detection of SF_6 at any monitoring stations at levels above the very low general background (which is on the order of one ppt), provided conclusive evidence that the station's sampling instrumentation was exposed to some portion of the plume. The presence of SF_6, therefore, supported low measurements of target species (concentrations at or below the minimum detectable level of the sampling and analytical instrumentation) as an indication of true measurements of plume concentrations at that point. For example, no reading for HCl could indicate either that the concentration of HCl in the plume was below detection limits, or that the particular instrument was not in the plume path. However, if a reading of SF_6 above the background level was obtained from that same location, it would indicate that the plume was indeed present, and that the zero reading for HCl truly reflected low HCl in the plume. As verified by the tracer gas detection, the PCAD model provided excellent agreement with the field tests.

Hercules Bacchus/Navy NIROP Testing

Hercules Bacchus/Navy NIROP testing, the main testing effort for the validation of the PCAD model, was performed as a series of open burning tests at the Navy's NIROP facilities at Hercules Bacchus Works, near Salt Lake City, Utah. EDE incorporated the previously developed technology for tracer gas and mobile sampling team use gained during the Pershing testing program for this test program as well.

The tests were highly successful. Because of budget constraints and the costs of conducting such a vast test program, it was mandatory to conduct testing on consecutive days. As EDE utilized towers for source sampling, tests could only be conducted on the days the wind blew toward the towers. EDE carefully studied weather patterns, and selected dates in July for the test program. Out of ten possible test days, nine of the days had suitable weather conditions. EDE released rawinsonde weather balloons immediately prior to open burning, analyzed the

meteorological results, ran the PCAD computer model (incorporating the meteorological results), and deployed the sampling team. In each of the test days, the plume was "caught" by the sampling campaign.

EDE was able to obtain source samples, as well as release the tracer gas, from the towers in the plume path. These source samples proved very valuable in analyzing the chemical/combustion portion of the model. Of most importance, by examining the ratios of CO_2 to CO in the plume, EDE was able to iterate the model to determine the air/fuel ratio, and subsequently the amount of ambient air that takes part in the combustion process. This was highly significant, as EDE is now able to use air/fuel ratios from testing experience for PEP material rather than assumed ratios. These results were all very consistent, yielding an air/fuel ratio of approximately 5:1 for the open burning of PEP material.

Shuttle Booster Solid Rocket Test Firing

EDE recently concluded performing numerous tests at Thiokol's Utah facilities on the Advanced Solid Rocket Motor (ASRM) test firing. This testing included taking samples on the hillside from plume impact, as well as helicopter and ground-level plume tracking. Plume height was also estimated from the helicopter tracking the plume.

Because of the amount of propellant involved (1.1 million pounds released in two minutes), the plumes from these tests rise extremely high (3,000-13,000 feet). EDE found that the best way to sample these plumes involves deploying samplers via helicopter directly in front of the plume path. EDE has been able to sample particulate from the plume as far as 16-17 miles downwind from the firing site.

Plume height and downwind concentration distances correlate well with PCAD predictions.

MODELING RESULTS

OBJECTIVE

Combustion and dispersion modeling was performed for open burning/open detonating (OB/OD) operations at Naval Air Station Key West's Demolition Key Facility by El Dorado Engineering Inc. (EDE). The objective of this modeling was to quantify and evaluated air emissions from OB/OD operation at the Demolition Key Facility. This air emission data is required as part of the RCRA Part B Subpart X Permit Application. The typical resulting air emissions must, therefore, be identified and quantified in terms of resulting ground-level concentrations.

MODELING APPROACH

As described in the accepted modeling protocol, ambient air participates in the combustion process. A 5 to 1 air/fuel ratio was selected to initially analyze the OB/OD process, as EDE has successfully used this ratio to analyze the combustion products and emissions from unconfined burns. EDE has additionally found that an air/fuel ratio of 3.5 to 1 holds well for confined releases, such as rocket motor firings. The selected modeling scenarios would not converge at a 5 to 1 air/fuel ratio, therefore an air/fuel ratio of 4 to 1 was used for all modeling. This value is well within EDE's range for acceptable air/fuel ratios, being between 3.5 to 1 and 5 to 1. All other values were input as described in the modeling protocol.

Both the OB and OD scenarios were modeled for the atmospheric conditions shown in Table 1, also described in the modeling protocol. This resulted in 16 dispersion runs for the OB scenario, and 16 dispersion runs for the OD scenario.

TABLE 1: Modeling Cases

Stability Class	Wind Speed m/s			VTG °C/m (x 10^{-3})		
	Expected	High	Low	Expected	High	Low
Class A	2	-	-	.3322	1.83	-
Class B	3	5	2	.3322	1.83	-
Class C	4	6.7	3	1.83	3.322	.3322
Class D	4	6.7	2	3.322	10.0	1.83

RESULTS SUMMARY

Modeling results for the OB scenario are summarized in Table 2, and modeling results for the OD scenario are summarized in Table 3. These tables only summarize the predicted maximum concentration values for selected emissions; complete modeling results for all emissions are found in Appendix A.[1]

[1] Potassium chloride was predicted by the modeling in both the form KCl and K_2Cl_2; the value for KCl reported in the summary tables includes the predicted values for all potassium chloride.

TABLE 2: Summary of Modeling Results for Open Burning

MODELING CASE	PLUME STABILIZATION HEIGHT (ft)	DISTANCE TO PEAK CONCENTRATION (miles)	PEAK KCl CONCENTRATION (mg/m^3)	PEAK KOH CONCENTRATION (mg/m^3)	PEAK MgO CONCENTRATION (mg/m^3)
Class A: Base Case	164.4	.12	.02619	.03286	—
Class A: High VTG	88.1	.09	.07798	.09029	.00558
Class B: Base Case	142.3	.18	.02122	.02662	—
Class B: High Wind	118.2	.15	.01833	.02300	—
Class B: Low Wind	164.4	.21	.02332	.02925	—
Class B: High VTG	75.5	.10	.07461	.08639	.00534
Class C: Base Case	67.4	.13	.07505	.08691	.00537
Class C: High Wind	54.9	.11	.06853	.07935	—
Class C: Low Wind	75.3	.15	.07937	.09190	.00568
Class C: High VTG	53.2	.10	.12295	.14235	.00879
Class C: Low VTG	127.3	.24	.02027	.02543	—
Class D: Base Case	53.3	.17	.11422	.13226	.00817
Class D: High Wind	43.3	.14	.10822	.12530	.00774
Class D: Low Wind	69.8	.24	.12505	.14479	.00894
Class D: High VTG	33.7	.10	.31125	.36038	.02226
Class D: Low VTG	67.3	.22	.06796	.07868	—

TABLE 3: Summary of Modeling Results for Open Detonating

MODELING CASE	PLUME STABILIZATION HEIGHT (ft)	DISTANCE TO PEAK CONCENTRATION (miles)	PEAK KCl CONCENTRATION (mg/m^3)	PEAK KOH CONCENTRATION (mg/m^3)	PEAK K_2CO_3 CONCENTRATION (mg/m^3)
Class A: Base Case	786.0	.51	—	—	.00675
Class A: High VTG	445.9	.29	.00657	.00824	.03296
Class B: Base Case	687.3	.72	—	—	.00797
Class B: High Wind	580.2	.61	—	—	.01279
Class B: Low Wind	786.0	.83	—	—	.00547
Class B: High VTG	389.3	.41	.00778	.00977	.03908
Class C: Base Case	347.6	.53	.01164	.01460	.05843
Class C: High Wind	292.6	.45	.01872	.02349	.09398
Class C: Low Wind	382.5	.59	.00892	.01119	.04476
Class C: High VTG	284.8	.44	.02032	.02549	.10199
Class C: Low VTG	611.1	.94	—	—	.01206
Class D: Base Case	277.9	.73	.01959	.02457	.09834
Class D: High Wind	234.3	.62	.03128	.03924	.15703
Class D: Low Wind	349.1	.91	.01038	.01302	.05211
Class D: High VTG	192.6	.50	.05456	.06844	.27387
Class D: Low VTG	338.2	.88	.01132	.01420	.05683

The Appendix A complete modeling results include combustion modeling results; dispersion modeling results for all cases showing maximum peak concentration, distance to peak concentration, and Time Weighted Average (TWA) concentrations at that distance; and isopleth plots showing concentration percentages for all dispersion cases.[2] The dispersion results list all products predicted with maximum concentration values greater than .005 mg/m^3. Other products predicted in more minute quantities may be found in the combustion modeling output.

Modeling results will be used for risk assessment evaluation for the air pathway of Subpart X permitting.

[2] Isopleth plots that are shown as only a line represent exposure areas with extremely narrow widths.

APPENDIX A: Complete Modeling Results

OPEN BURNING SCENARIO

COMPUTER RUN DATE 10/ 3/1995

PROPELLANT	HF	DENSITY	WEIGHT	MOLES	VOLUME
AMPI	-94.0000	1.0000	.387	.0016	.38700E+00
KNO3	-118.0000	1.0000	.473	.0047	.47300E+00
ECEL	-259.0600	1.0000	.043	.0002	.43000E-01
WAX	-314.1500	1.0000	.043	.0001	.43000E-01
CAST	-662.6000	1.0000	.004	.0000	.40000E-02
NC	-173.7770	1.0000	.008	.0000	.80000E-02
NG	-90.7500	1.0000	.001	.0000	.10000E-02
DIBU	-204.0300	1.0000	.001	.0000	.10000E-02
MG	.0000	1.0000	.002	.0001	.20000E-02
SRNI	-233.2500	1.0000	.005	.0000	.50000E-02
KCLO	-102.8000	1.0000	.002	.0000	.20000E-02
GILS	-4034.1700	1.0000	.001	.0000	.10000E-02
TNT	-16.0000	1.0000	.030	.0001	.30000E-01
AIR	.0000	1.0000	4.000	.0291	.40000E+01

GRAM ATOMS /100 GRAMS	C	CA	CL	H	K	MG	N	O
	.2895	.0001	.0124	.3574	.0939	.0016	4.6106	1.7116

S	SR
.0000	.0005

ENTHALPY = -15.83834 DENSITY = 1.000

	CHAMBER
PRESSURE(PSIA)	14.700
EPSILON	.000
ISP	.000
ISP (VACUUM)	.000
TEMPERATURE(K)	1342.916
MOLECULAR WGT	30.743
MOLES GAS/100G	3.219
CF	.000
PEAE/M (SEC)	.000
GAMMA	1.269
CP-PR C/100G-K	30.170
ENTROPY (")	197.743
ENTH KCAL/100G	-15.839
DENSITY (G/CC)	2.81954E-04
PROD MOL WT	30.743
GAS MOL WT	29.688
MOL PROD/100G	3.253
CP-G C/100G-K	28.584
RHO PROD(#/F3)	.018
RHO GAS (#/F3)	.017
ITERATIONS	35

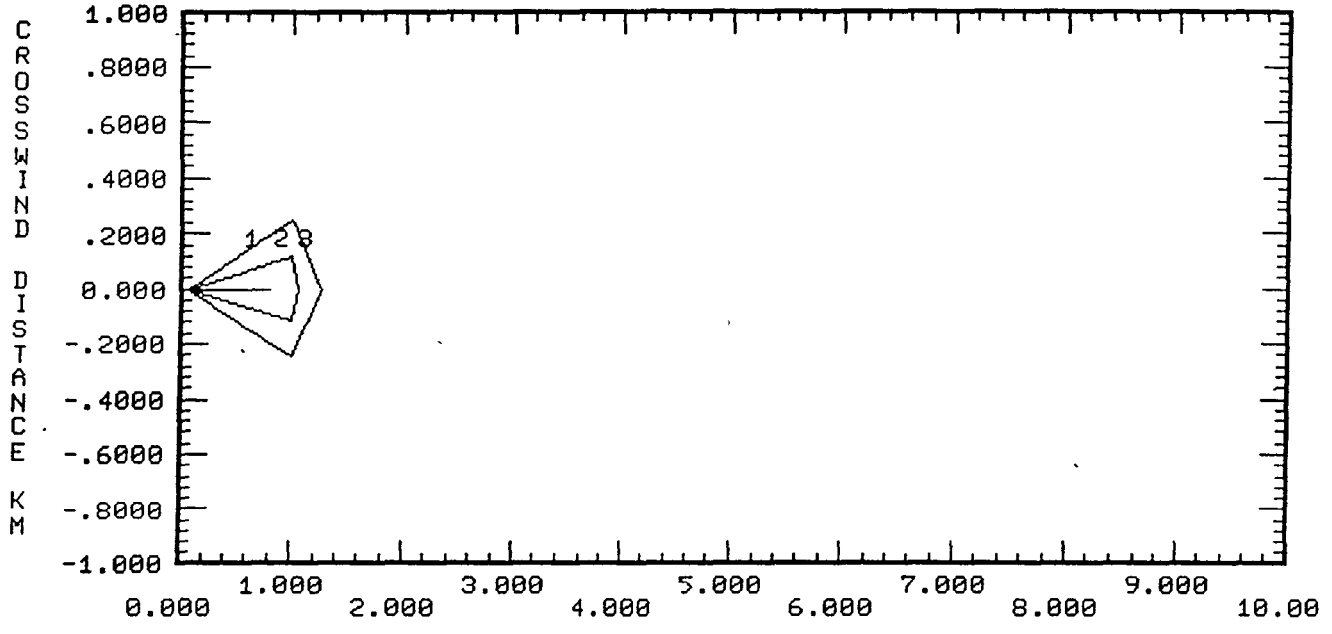
GRAMS OF PROD.
FOR 5.00 LBS OF MATERIAL BURNED

CO	.00075947
CO2	1289.85700000
CAH2O2	.00006554

CL	.00004061
CLH	.00148930
CLHO	.00000297
CLK	97.06228000
CLO	.00000058
CL2K2	8.10536500
H	.00000013
HKO	121.76700000
HNO	.00000035
HNO2	.00020685
HNO2	.00016794
HNO3	.00000071
HO	.06669558
HO2	.00014448
H2	.00001854
H2K2O2	.43935620
H2MGO2	.00001653
H2O	345.39740000
H2O2	.00001851
H2O2SR	.00162623
K	.02558986
KO	.00363223
NO	4.85875700
NO2	.05397237
N2	7320.91600000
N2O	.00038581
O	.00081659
O2	1649.93600000
O2S	.00000654
O3	.00000054
CK2O3(L)	487.25700000
CAO(C)	.83996940
K2O4S(L)	.23557590
MGO(C)	7.51972600
OSR(C)	5.55232000

BURN RATE = 29.79 KCAL/SEC

CLASS A: BASE CASE



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

DOWNWIND DISTANCE (KM)

1 = 10% OF MAX. CONC.
2 = 5% OF MAX. CONC.
3 = 3% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS A: BASE CASE

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .50
VERT. POTENTIAL TEMP. GRADIENT = .00033220 degree K/m
WIND SPEED = 2.13 METERS/sec
AIR STABILITY CLASS : A

BURN DATA
AMOUNT = 2.27 Kg
TIME = 2.00 min
EFFECTIVE HEAT RELEASE RATE = 4.47 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 50.11 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .20 KM
RECTILINEAR EQUATIONS USED

ISOPLETH DATA
THE 10% OF CONMAX ISOPLETH CLOSES AT .81 KM
THE 5% OF CONMAX ISOPLETH CLOSES AT 1.06 KM
THE 3% OF CONMAX ISOPLETH CLOSES AT 1.28 KM

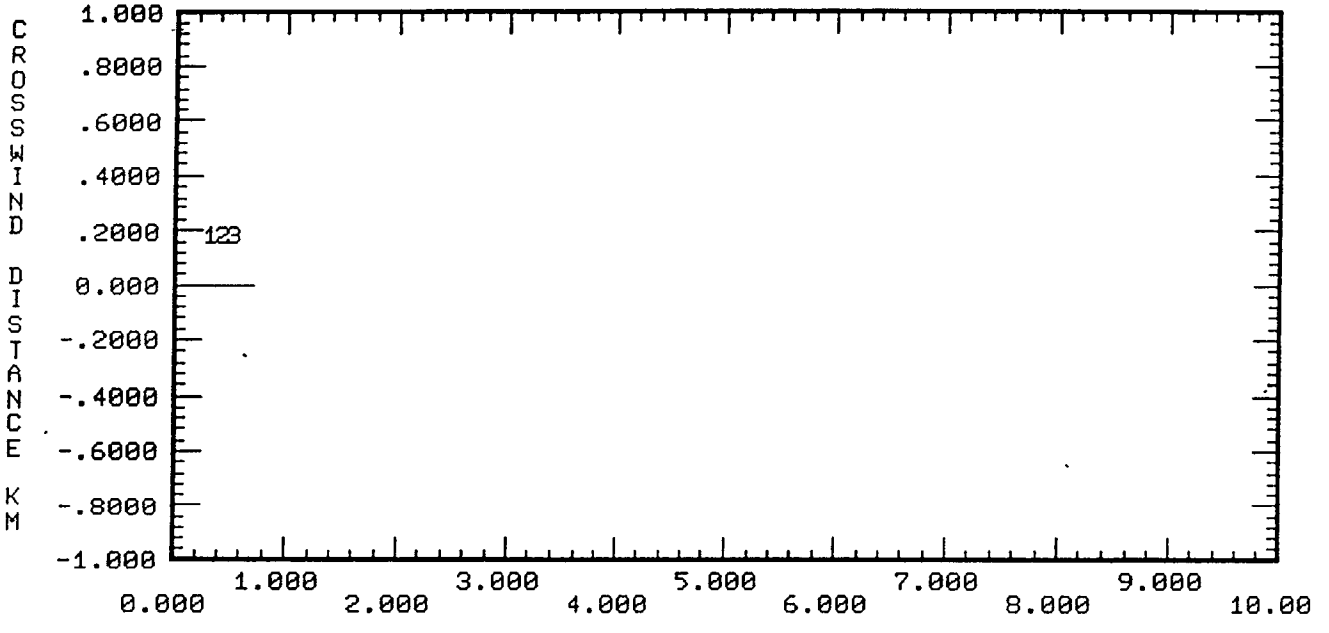
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	10.75	1.29	.34807
CLK	.81	.10	.02619
HKO	1.01	.12	.03286
H2O	2.88	.35	.09321
N2	61.01	7.32	1.97556
O2	13.75	1.65	.44524
CK2O3(L)	4.06	.49	.13149

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00373975	.00124658	.02991799
CLK	.00028142	.00009381	.00225135
HKO	.00035305	.00011768	.00282437
H2O	.00100143	.00033381	.00801143
N2	.02122610	.00707537	.16980880
O2	.00478375	.00159458	.03826999
CK2O3(L)	.00141274	.00047091	.01130194

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER-THE AVERAGING TIME

CLASS A: HIGH VTG



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

DOWNWIND DISTANCE (KM)

1 = 10% OF MAX. CONC.
2 = 5% OF MAX. CONC.
3 = 3% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS A: HIGH VTG

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .50
VERT. POTENTIAL TEMP. GRADIENT = .00183000 degree K/m
WIND SPEED = 2.04 METERS/sec
AIR STABILITY CLASS : A

BURN DATA
AMOUNT = 2.27 Kg
TIME = 2.00 min
EFFECTIVE HEAT RELEASE RATE = 4.47 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 26.86 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .14 KM
PASQUELL/GIFFORD EQUATIONS USED

ISOPLETH DATA
THE 10% OF CONMAX ISOPLETH CLOSES AT .49 KM
THE 5% OF CONMAX ISOPLETH CLOSES AT .61 KM
THE 3% OF CONMAX ISOPLETH CLOSES AT .71 KM

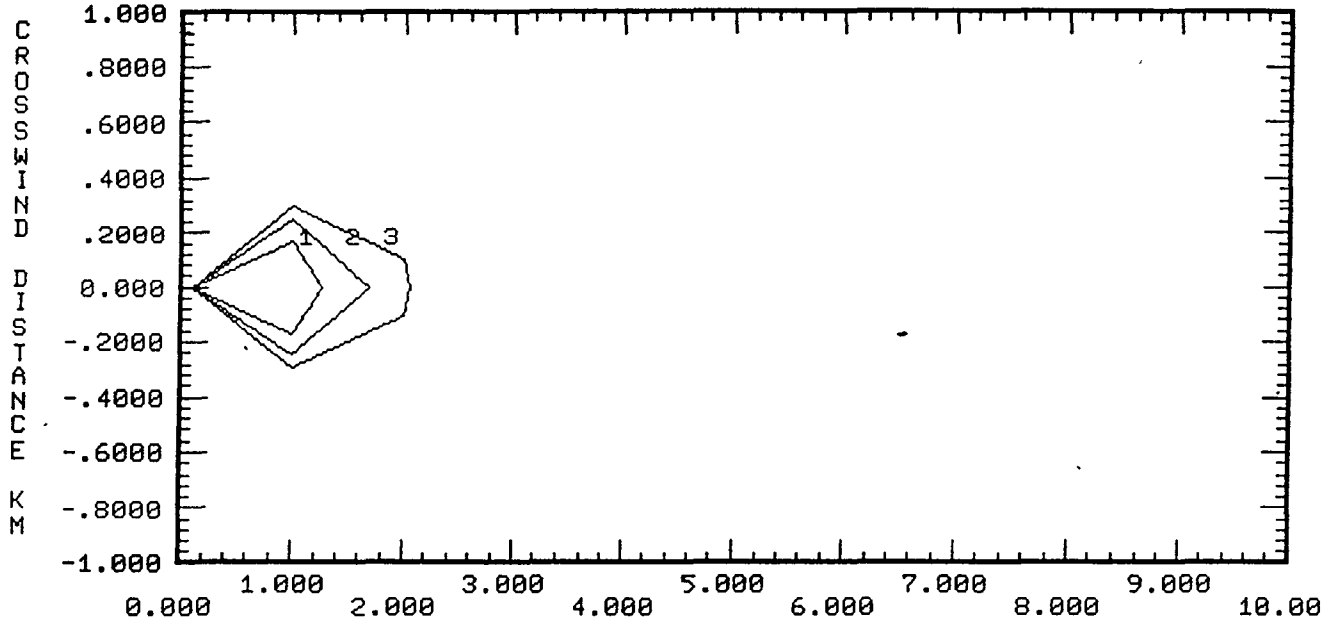
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	10.75	1.29	.95644
CLK	.81	.10	.07197
CL2K2	.07	.01	.00601
HKO	1.01	.12	.09029
H2O	2.88	.35	.25611
N2	61.01	7.32	5.42849
O2	13.75	1.65	1.22344
CK2O3(L)	4.06	.49	.36130
MGO(C)	.06	.01	.00558

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00876383	.00292128	.07011068
CLK	.00065948	.00021983	.00527588
CL2K2	.00005507	.00001836	.00044057
HKO	.00082734	.00027578	.00661870
H2O	.00234678	.00078226	.01877425
N2	.04974153	.01658051	.39793220
O2	.01121051	.00373684	.08968408
CK2O3(L)	.00331065	.00110355	.02648516
MGO(C)	.00005109	.00001703	.00040874

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

CLASS B: BASE CASE



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

DOWNWIND DISTANCE (KM)

1 = 10% OF MAX. CONC.
2 = 5% OF MAX. CONC.
3 = 3% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS B: BASE CASE

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .50
VERT. POTENTIAL TEMP. GRADIENT = .00033220 degree K/m
WIND SPEED = 3.17 METERS/sec
AIR STABILITY CLASS : B

BURN DATA
AMOUNT = 2.27 Kg
TIME = 2.00 min
EFFECTIVE HEAT RELEASE RATE = 4.47 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 43.36 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .29 KM
RECTILINEAR EQUATIONS USED

ISOPLETH DATA
THE 10% OF CONMAX ISOPLETH CLOSES AT 1.28 KM
THE 5% OF CONMAX ISOPLETH CLOSES AT 1.69 KM
THE 3% OF CONMAX ISOPLETH CLOSES AT 2.05 KM

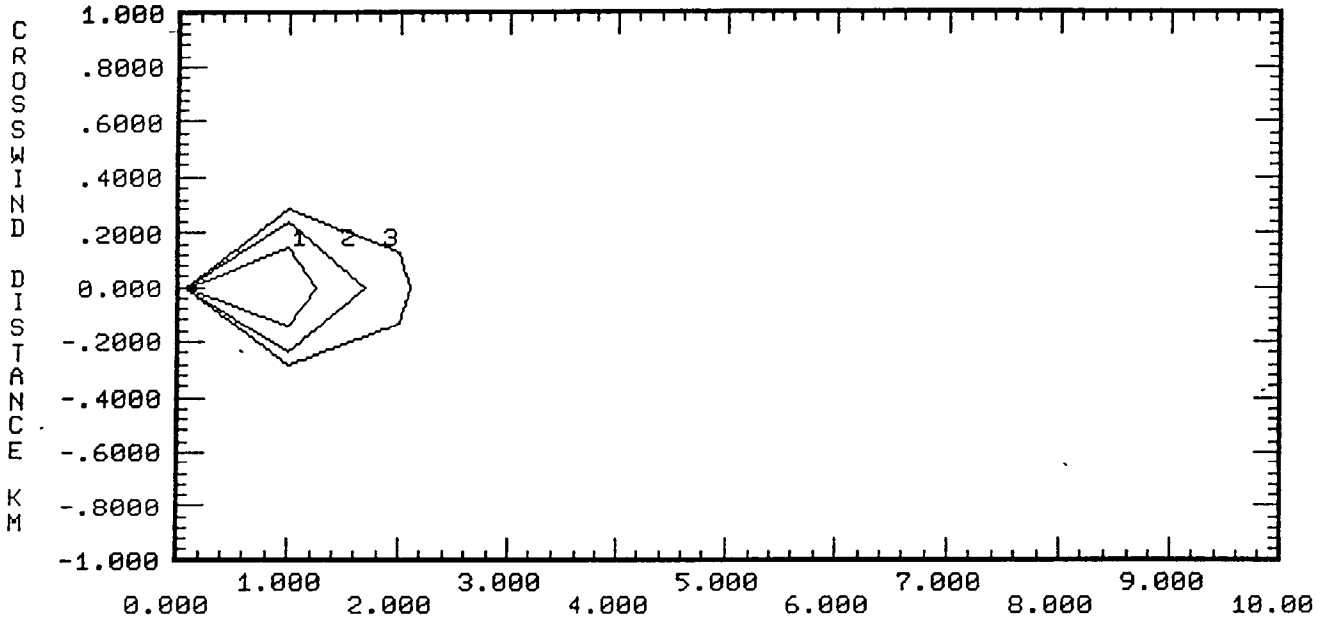
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	10.75	1.29	.28194
CLK	.81	.10	.02122
HKO	1.01	.12	.02662
H2O	2.88	.35	.07550
N2	61.01	7.32	1.60025
O2	13.75	1.65	.36065
CK2O3(L)	4.06	.49	.10651

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00243758	.00081253	.01950063
CLK	.00018343	.00006114	.00146743
HKO	.00023012	.00007671	.00184094
H2O	.00065273	.00021758	.00522187
N2	.01383519	.00461173	.11068150
O2	.00311807	.00103936	.02494460
CK2O3(L)	.00092082	.00030694	.00736654

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

CLASS B: HIGH WIND



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

DOWNWIND DISTANCE (KM)

1 = 10% OF MAX. CONC.
2 = 5% OF MAX. CONC.
3 = 3% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS B: HIGH WIND

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .50
VERT. POTENTIAL TEMP. GRADIENT = .00033220 degree K/m
WIND SPEED = 5.21 METERS/sec
AIR STABILITY CLASS : B

BURN DATA
AMOUNT = 2.27 Kg
TIME = 2.00 min
EFFECTIVE HEAT RELEASE RATE = 4.47 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 36.03 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .24 KM
RECTILINEAR EQUATIONS USED

ISOPLETH DATA
THE 10% OF CONMAX ISOPLETH CLOSES AT 1.25 KM
THE 5% OF CONMAX ISOPLETH CLOSES AT 1.70 KM
THE 3% OF CONMAX ISOPLETH CLOSES AT 2.09 KM

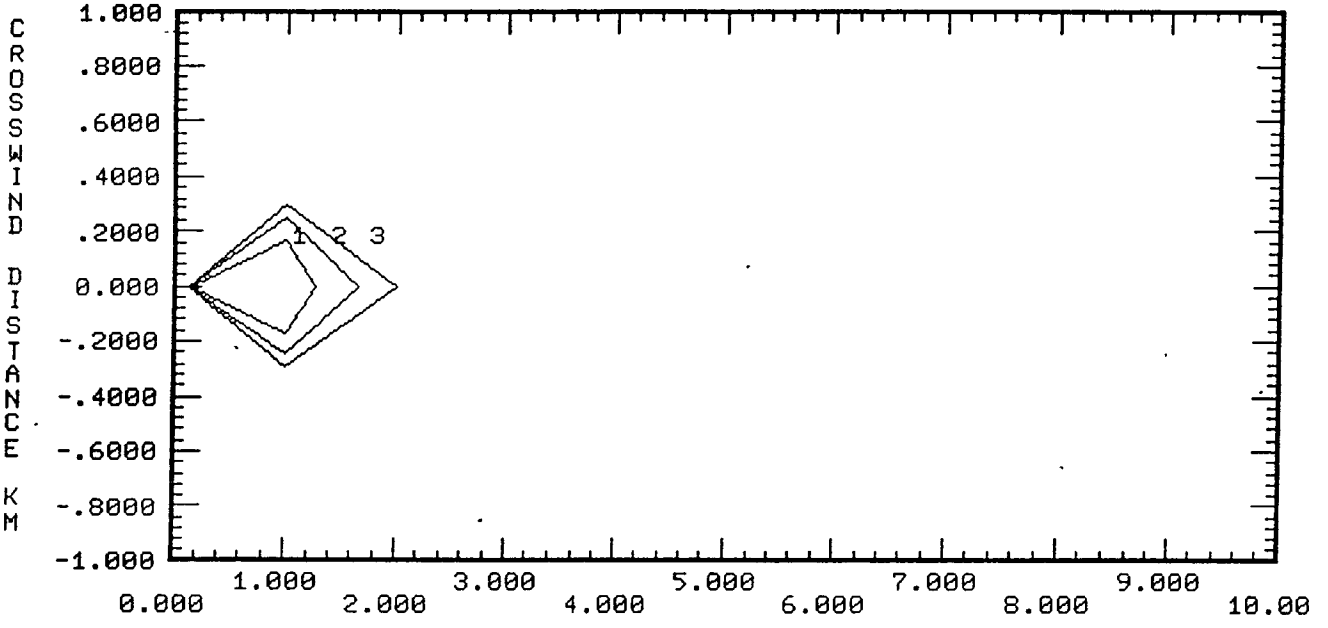
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	10.75	1.29	.24360
CLK	.81	.10	.01833
HKO	1.01	.12	.02300
H2O	2.88	.35	.06523
N2	61.01	7.32	1.38263
O2	13.75	1.65	.31161
CK2O3(L)	4.06	.49	.09202

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00157533	.00052511	.01260264
CLK	.00011854	.00003951	.00094835
HKO	.00014872	.00004957	.00118972
H2O	.00042184	.00014061	.00337470
N2	.00894112	.00298037	.07152897
O2	.00201510	.00067170	.01612077
CK2O3(L)	.00059509	.00019836	.00476073

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

CLASS B: LOW WIND



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

DOWNWIND DISTANCE (KM)

1 = 10% OF MAX. CONC.
2 = 5% OF MAX. CONC.
3 = 3% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS B: LOW WIND

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .50
VERT. POTENTIAL TEMP. GRADIENT = .00033220 degree K/m
WIND SPEED = 2.13 METERS/sec
AIR STABILITY CLASS : B

BURN DATA
AMOUNT = 2.27 Kg
TIME = 2.00 min
EFFECTIVE HEAT RELEASE RATE = 4.47 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 50.11 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .33 KM
RECTILINEAR EQUATIONS USED

ISOPLETH DATA
THE 10% OF CONMAX ISOPLETH CLOSES AT 1.27 KM
THE 5% OF CONMAX ISOPLETH CLOSES AT 1.65 KM
THE 3% OF CONMAX ISOPLETH CLOSES AT 2.00 KM

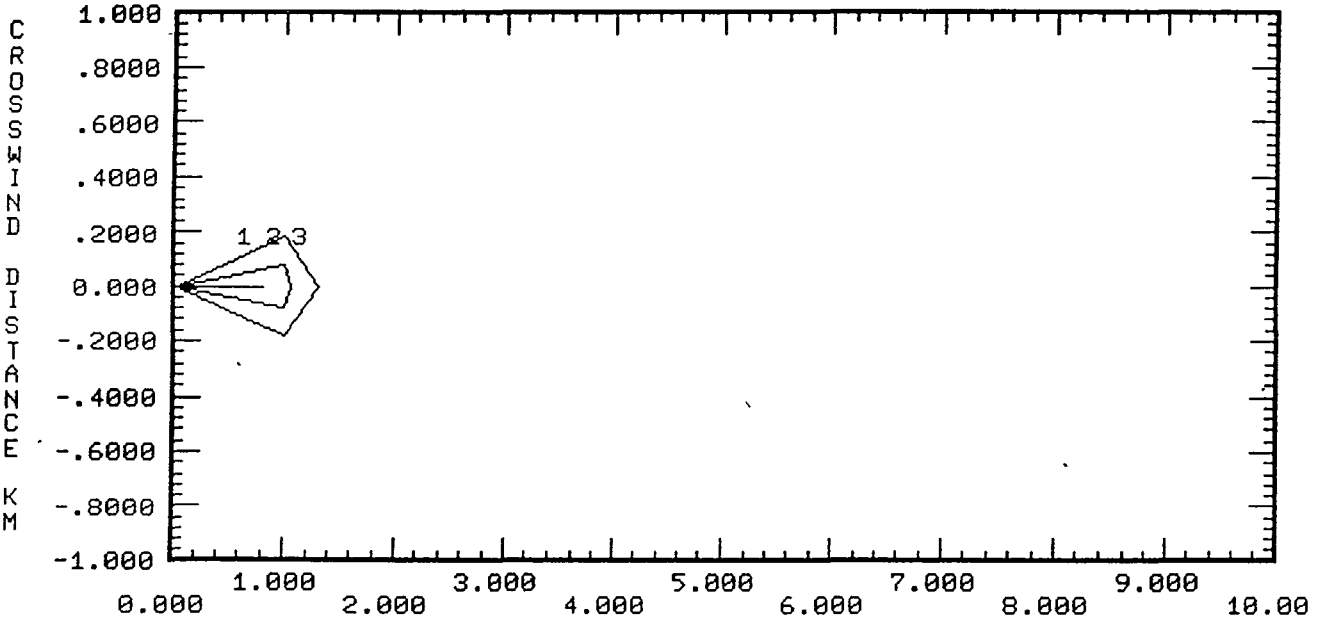
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	10.75	1.29	.30988
CLK	.81	.10	.02332
HKO	1.01	.12	.02925
H2O	2.88	.35	.08298
N2	61.01	7.32	1.75882
O2	13.75	1.65	.39639
CK2O3(L)	4.06	.49	.11706

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00360458	.00120153	.02883666
CLK	.00027125	.00009042	.00216997
HKO	.00034028	.00011343	.00272226
H2O	.00096523	.00032174	.00772188
N2	.02045877	.00681959	.16367020
O2	.00461085	.00153695	.03688676
CK2O3(L)	.00136166	.00045389	.01089330

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

CLASS B: HIGH VTG



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

DOWNWIND DISTANCE (KM)

1 = 10% OF MAX. CONC.
2 = 5% OF MAX. CONC.
3 = 3% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS B: HIGH VTG

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .50
VERT. POTENTIAL TEMP. GRADIENT = .00183000 degree K/m
WIND SPEED = 3.03 METERS/sec
AIR STABILITY CLASS : B

BURN DATA
AMOUNT = 2.27 Kg
TIME = 2.00 min
EFFECTIVE HEAT RELEASE RATE = 4.47 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 23.00 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .16 KM
PASQUELL/GIFFORD EQUATIONS USED

ISOPLETH DATA
THE 10% OF CONMAX ISOPLETH CLOSES AT .80 KM
THE 5% OF CONMAX ISOPLETH CLOSES AT 1.06 KM
THE 3% OF CONMAX ISOPLETH CLOSES AT 1.30 KM

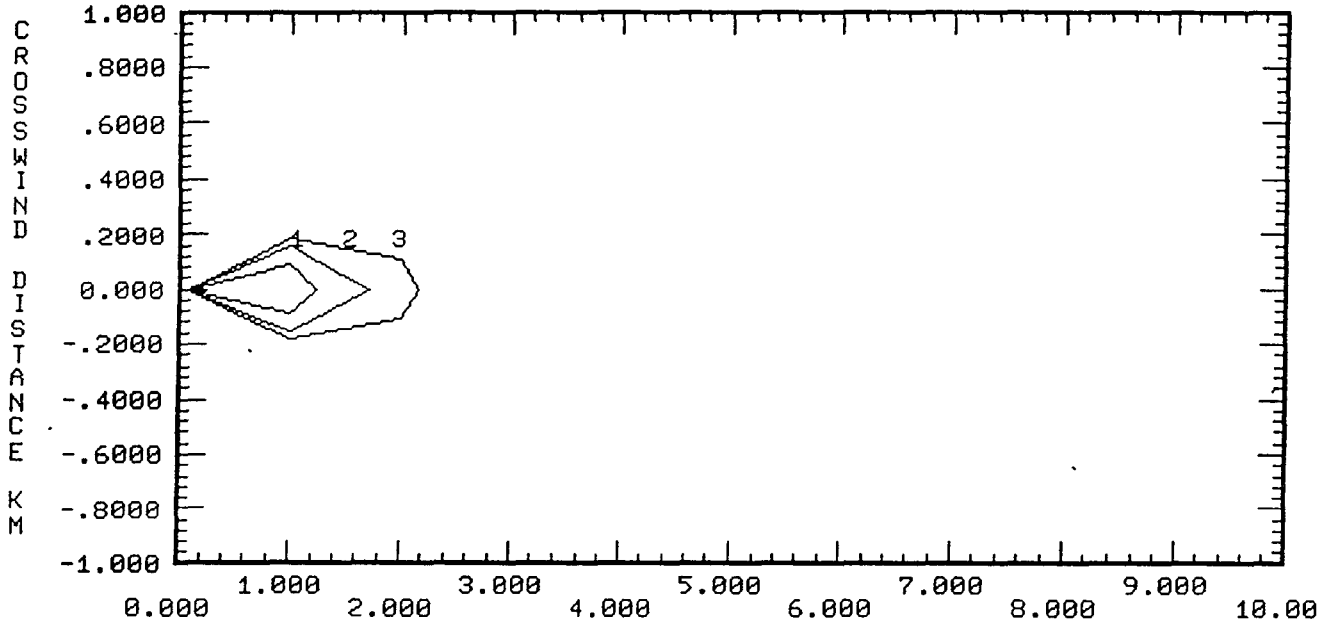
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	10.75	1.29	.91514
CLK	.81	.10	.06886
CL2K2	.07	.01	.00575
HKO	1.01	.12	.08639
H2O	2.88	.35	.24505
N2	61.01	7.32	5.19409
O2	13.75	1.65	1.17061
CK2O3(L)	4.06	.49	.34570
MGO(C)	.06	.01	.00534

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00636881	.00212294	.05095052
CLK	.00047926	.00015975	.00383407
CL2K2	.00004002	.00001334	.00032017
HKO	.00060124	.00020041	.00480991
H2O	.00170545	.00056848	.01364362
N2	.03614800	.01204933	.28918400
O2	.00814673	.00271558	.06517380
CK2O3(L)	.00240590	.00080197	.01924721
MGO(C)	.00003713	.00001238	.00029704

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

CLASS C: BASE CASE



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

DOWNWIND DISTANCE (KM)

1 = 10% OF MAX. CONC.
2 = 5% OF MAX. CONC.
3 = 3% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS C: BASE CASE

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .50
VERT. POTENTIAL TEMP. GRADIENT = .00183000 degree K/m
WIND SPEED = 4.01 METERS/sec
AIR STABILITY CLASS : C

BURN DATA
AMOUNT = 2.27 Kg
TIME = 2.00 min
EFFECTIVE HEAT RELEASE RATE = 4.47 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 20.54 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .21 KM
PASQUELL/GIFFORD EQUATIONS USED

ISOPLETH DATA
THE 10% OF CONMAX ISOPLETH CLOSES AT 1.23 KM
THE 5% OF CONMAX ISOPLETH CLOSES AT 1.71 KM
THE 3% OF CONMAX ISOPLETH CLOSES AT 2.15 KM

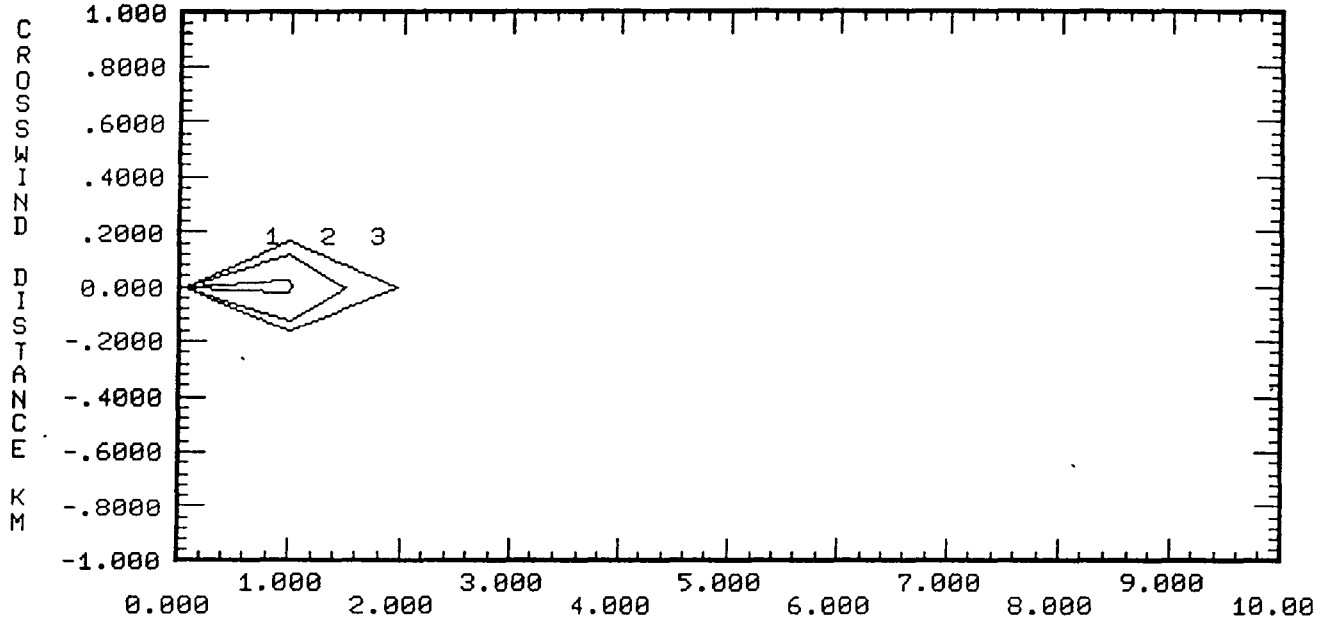
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	10.75	1.29	.92059
CLK	.81	.10	.06927
CL2K2	.07	.01	.00578
HKO	1.01	.12	.08691
H2O	2.88	.35	.24652
N2	61.01	7.32	5.22505
O2	13.75	1.65	1.17759
CK2O3(L)	4.06	.49	.34776
MGO(C)	.06	.01	.00537

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00548893	.00182964	.04391146
CLK	.00041304	.00013768	.00330435
CL2K2	.00003449	.00001150	.00027594
HKO	.00051817	.00017272	.00414537
H2O	.00146982	.00048994	.01175854
N2	.03115393	.01038464	.24923140
O2	.00702123	.00234041	.05616982
CK2O3(L)	.00207350	.00069117	.01658799
MGO(C)	.00003200	.00001067	.00025600

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

CLASS C: HIGH WIND



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

DOWNWIND DISTANCE (KM)

1 = 10% OF MAX. CONC.
2 = 5% OF MAX. CONC.
3 = 3% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS C: HIGH WIND

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .50
VERT. POTENTIAL TEMP. GRADIENT = .00183000 degree K/m
WIND SPEED = 6.59 METERS/sec
AIR STABILITY CLASS : C

BURN DATA
AMOUNT = 2.27 Kg
TIME = 2.00 min
EFFECTIVE HEAT RELEASE RATE = 4.47 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 16.74 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .17 KM
PASQUELL/GIFFORD EQUATIONS USED

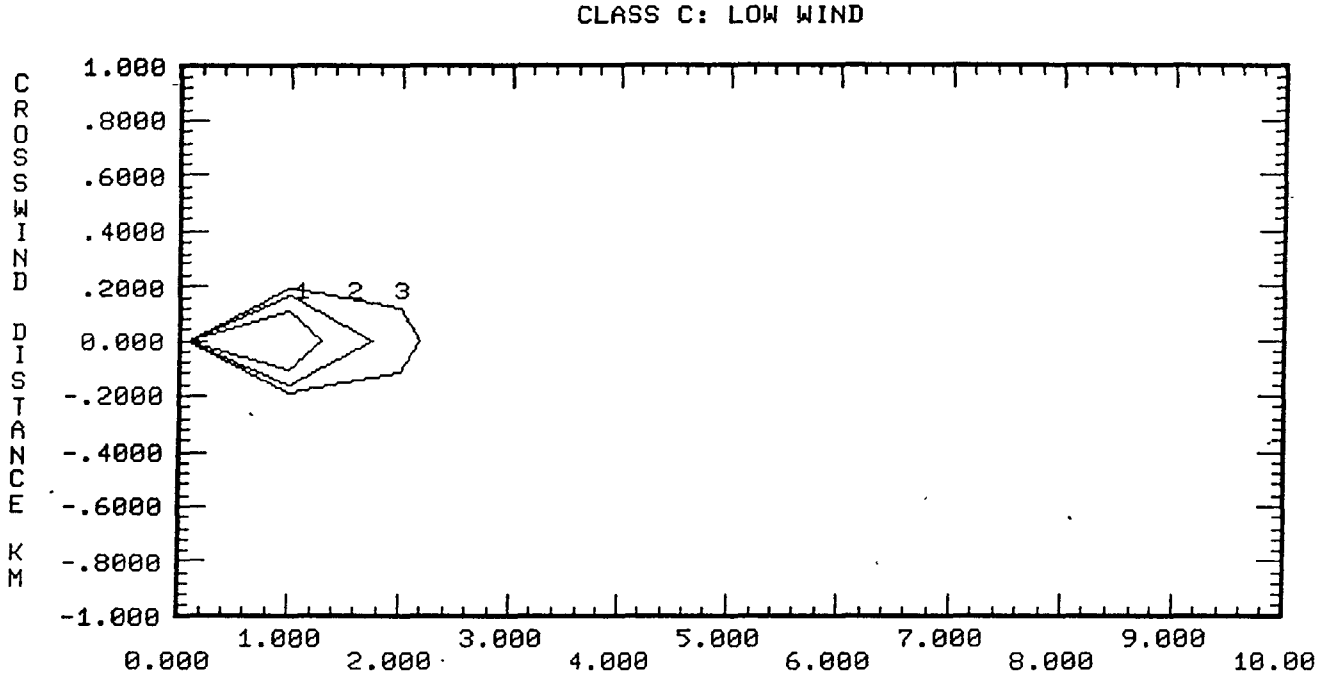
ISOPLETH DATA
THE 10% OF CONMAX ISOPLETH CLOSES AT 1.01 KM
THE 5% OF CONMAX ISOPLETH CLOSES AT 1.50 KM
THE 3% OF CONMAX ISOPLETH CLOSES AT 1.96 KM

PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	10.75	1.29	.84057
CLK	.81	.10	.06325
CL2K2	.07	.01	.00528
HKO	1.01	.12	.07935
H2O	2.88	.35	.22509
N2	61.01	7.32	4.77089
O2	13.75	1.65	1.07523
CK2O3(L)	4.06	.49	.31754

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00425874	.00141958	.03406992
CLK	.00032047	.00010682	.00256377
CL2K2	.00002676	.00000892	.00021409
HKO	.00040204	.00013401	.00321632
H2O	.00114041	.00038014	.00912325
N2	.02417154	.00805718	.19337230
O2	.00544759	.00181586	.04358076
CK2O3(L)	.00160878	.00053626	.01287023

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

1 = 10% OF MAX. CONC.
2 = 5% OF MAX. CONC.
3 = 3% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS C: LOW WIND

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .50
VERT. POTENTIAL TEMP. GRADIENT = .00183000 degree K/m
WIND SPEED = 3.04 METERS/sec
AIR STABILITY CLASS : C

BURN DATA
AMOUNT = 2.27 Kg
TIME = 2.00 min
EFFECTIVE HEAT RELEASE RATE = 4.47 Kcal/sec
RADIUS = 2.30 METERS

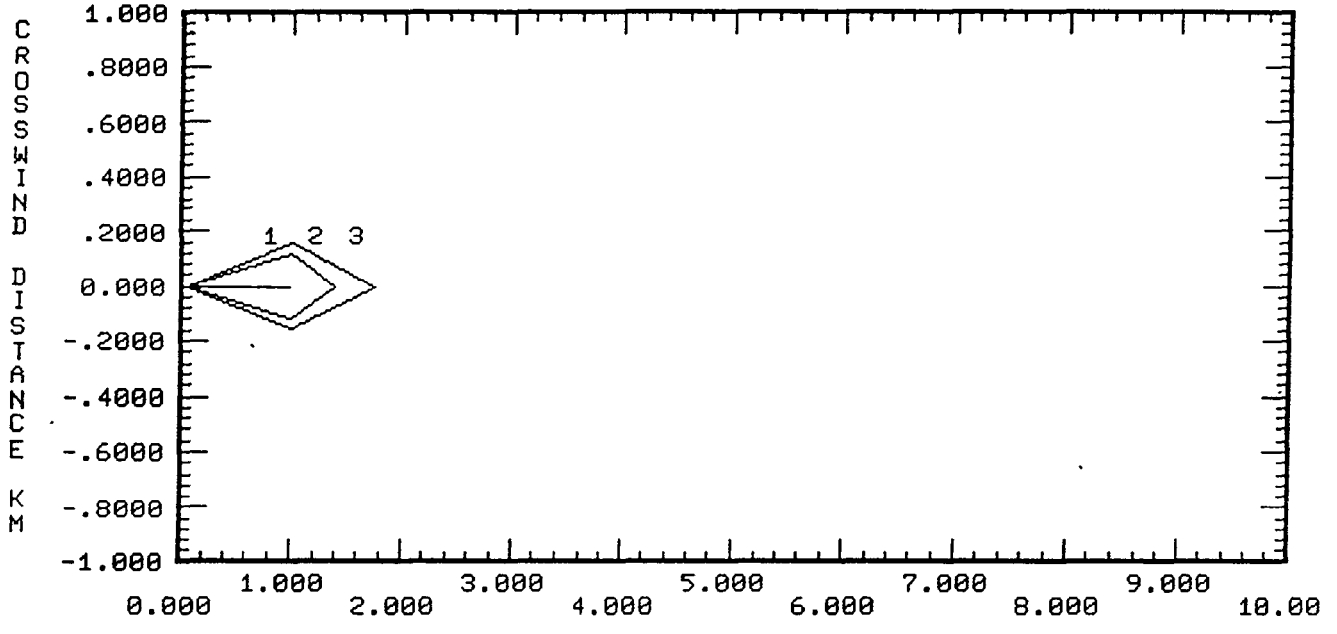
PLUME DATA
EFFECTIVE PLUME HEIGHT = 22.96 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .24 KM
PASQUELL/GIFFORD EQUATIONS USED

ISOPLETH DATA
THE 10% OF CONMAX ISOPLETH CLOSES AT 1.29 KM
THE 5% OF CONMAX ISOPLETH CLOSES AT 1.75 KM
THE 3% OF CONMAX ISOPLETH CLOSES AT 2.17 KM

PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	10.75	1.29	.97347
CLK	.81	.10	.07325
CL2K2	.07	.01	.00612
HKO	1.01	.12	.09190
H2O	2.88	.35	.26068
N2	61.01	7.32	5.52518
O2	13.75	1.65	1.24523
CK2O3(L)	4.06	.49	.36774
MGO(C)	.06	.01	.00568

CLASS C: HIGH VTG



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

1 = 10% OF MAX. CONC.
2 = 5% OF MAX. CONC.
3 = 3% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS C: HIGH VTG

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .50
VERT. POTENTIAL TEMP. GRADIENT = .00332200 degree K/m
WIND SPEED = 3.92 METERS/sec
AIR STABILITY CLASS : C

BURN DATA
AMOUNT = 2.27 Kg
TIME = 2.00 min
EFFECTIVE HEAT RELEASE RATE = 4.47 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 16.21 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .16 KM
PASQUELL/GIFFORD EQUATIONS USED

ISOPLETH DATA
THE 10% OF CONMAX ISOPLETH CLOSES AT .97 KM
THE 5% OF CONMAX ISOPLETH CLOSES AT 1.38 KM
THE 3% OF CONMAX ISOPLETH CLOSES AT 1.74 KM

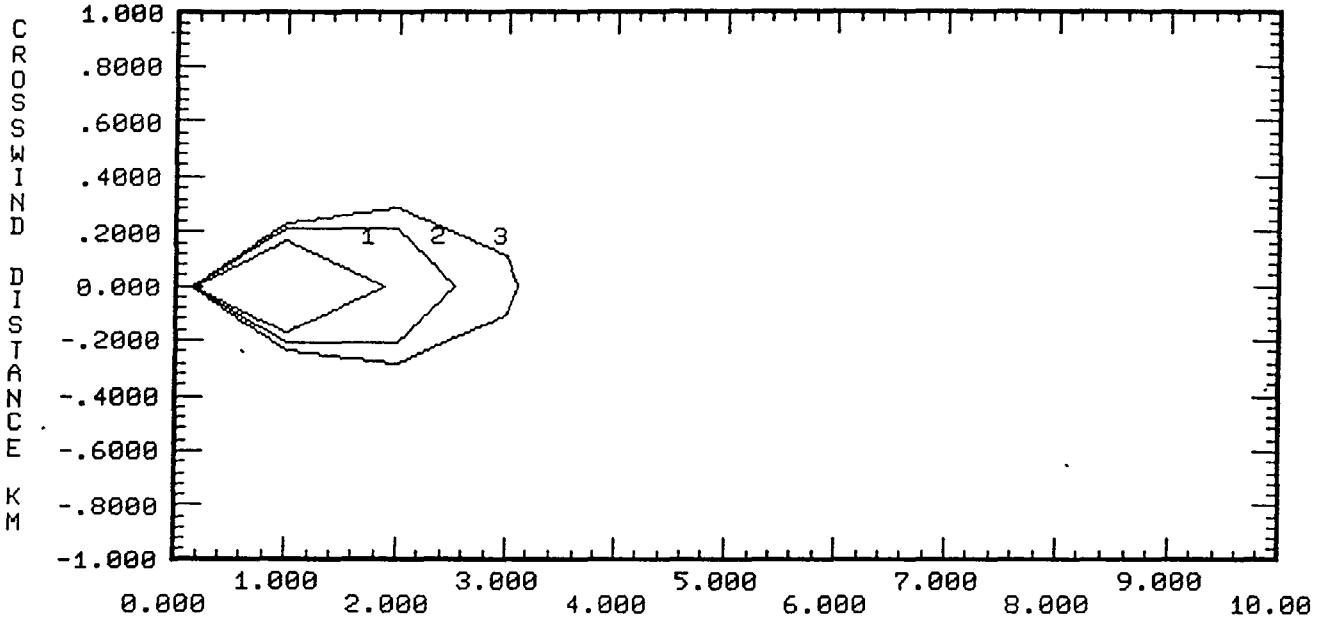
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	10.75	1.29	1.50793
CLK	.81	.10	.11347
CL2K2	.07	.01	.00948
HKO	1.01	.12	.14235
H2O	2.88	.35	.40379
NO	.04	.00	.00568
N2	61.01	7.32	8.55865
O2	13.75	1.65	1.92889
CK2O3(L)	4.06	.49	.56964
MGO(C)	.06	.01	.00879
OSR(C)	.05	.01	.00649

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00844283	.00281428	.06754264
CLK	.00063532	.00021177	.00508259
CL2K2	.00005305	.00001768	.00042443
HKO	.00079703	.00026568	.00637624
H2O	.00226081	.00075360	.01808652
NO	.00003180	.00001060	.00025443
N2	.04791914	.01597305	.38335310
O2	.01079976	.00359992	.08639805
CK2O3(L)	.00318937	.00106312	.02551498
MGO(C)	.00004922	.00001641	.00039376
OSR(C)	.00003634	.00001211	.00029074

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

CLASS C: LOW VTG



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DOWNWIND DISTANCE (KM)

1 = 10% OF MAX. CONC.
2 = 5% OF MAX. CONC.
3 = 3% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS C: LOW VTG

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .50
VERT. POTENTIAL TEMP. GRADIENT = .00033220 degree K/m
WIND SPEED = 4.28 METERS/sec
AIR STABILITY CLASS : C

BURN DATA
AMOUNT = 2.27 Kg
TIME = 2.00 min
EFFECTIVE HEAT RELEASE RATE = 4.47 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 38.80 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .38 KM
RECTILINEAR EQUATIONS USED

ISOPLETH DATA
THE 10% OF CONMAX ISOPLETH CLOSES AT 1.89 KM
THE 5% OF CONMAX ISOPLETH CLOSES AT 2.53 KM
THE 3% OF CONMAX ISOPLETH CLOSES AT 3.10 KM

PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	10.75	1.29	.26935
CLK	.81	.10	.02027
HKO	1.01	.12	.02543
H2O	2.88	.35	.07213
N2	61.01	7.32	1.52874
O2	13.75	1.65	.34454
CK2O3(L)	4.06	.49	.10175

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00189522	.00063174	.01516177
CLK	.00014262	.00004754	.00114093
HKO	.00017891	.00005964	.00143131
H2O	.00050750	.00016917	.00405998
N2	.01075681	.00358560	.08605451
O2	.00242430	.00080810	.01939436
CK2O3(L)	.00071594	.00023865	.00572751

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS D: BASE CASE

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .50
VERT. POTENTIAL TEMP. GRADIENT = .00332200 degree K/m
WIND SPEED = 3.89 METERS/sec
AIR STABILITY CLASS : D

BURN DATA
AMOUNT = 2.27 Kg
TIME = 2.00 min
EFFECTIVE HEAT RELEASE RATE = 4.47 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 16.26 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .27 KM
PASQUELL/GIFFORD EQUATIONS USED

ISOPLETH DATA
THE 10% OF CONMAX ISOPLETH CLOSES AT 1.94 KM
THE 5% OF CONMAX ISOPLETH CLOSES AT 2.83 KM
THE 3% OF CONMAX ISOPLETH CLOSES AT 3.65 KM

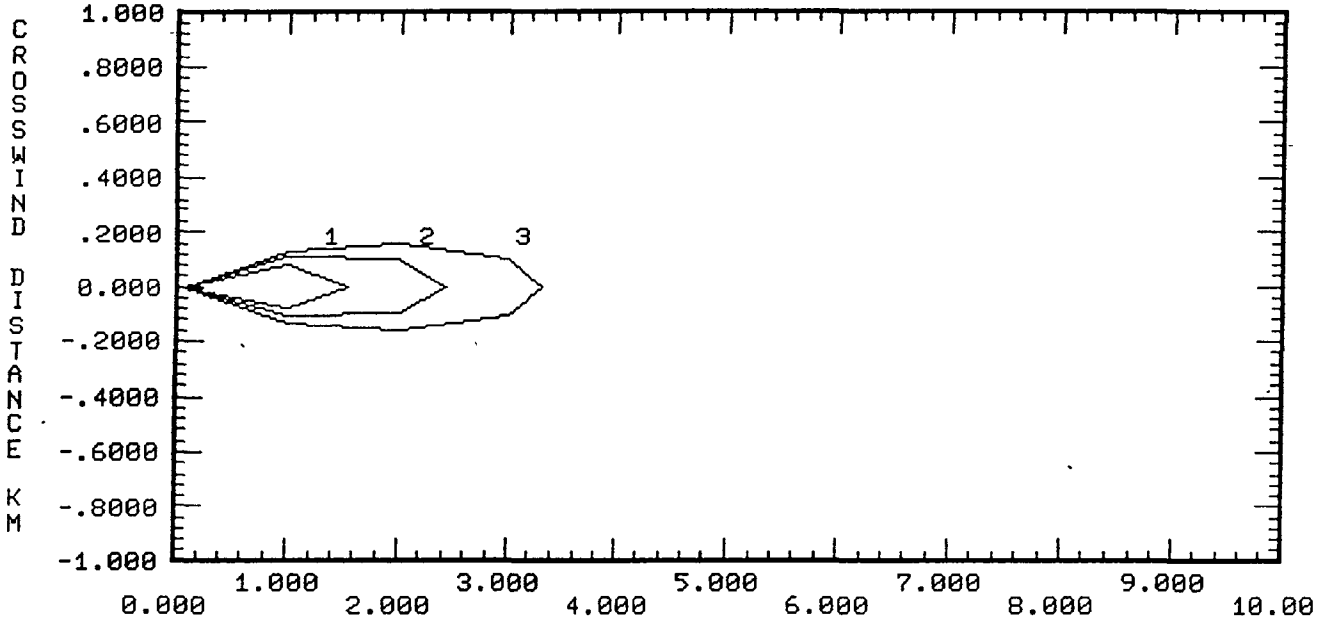
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	10.75	1.29	1.40097
CLK	.81	.10	.10542
CL2K2	.07	.01	.00880
HKO	1.01	.12	.13226
H2O	2.88	.35	.37515
NO	.04	.00	.00528
N2	61.01	7.32	7.95158
O2	13.75	1.65	1.79207
CK2O3(L)	4.06	.49	.52923
MGO(C)	.06	.01	.00817
OSR(C)	.05	.01	.00603

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00796571	.00265524	.06372568
CLK	.00059942	.00019981	.00479534
CL2K2	.00005006	.00001669	.00040044
HKO	.00075198	.00025066	.00601588
H2O	.00213305	.00071102	.01706439
NO	.00003001	.00001000	.00024005
N2	.04521140	.01507047	.36169120
O2	.01018936	.00339645	.08151489
CK2O3(L)	.00300912	.00100304	.02407298
MGO(C)	.00004644	.00001548	.00037151
OSR(C)	.00003429	.00001143	.00027431

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

CLASS D: HIGH WIND



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DOWNWIND DISTANCE (KM)

1 = 10% OF MAX. CONC.
2 = 5% OF MAX. CONC.
3 = 3% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS D: HIGH WIND

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .50
VERT. POTENTIAL TEMP. GRADIENT = .00332200 degree K/m
WIND SPEED = 6.31 METERS/sec
AIR STABILITY CLASS : D

BURN DATA
AMOUNT = 2.27 Kg
TIME = 2.00 min
EFFECTIVE HEAT RELEASE RATE = 4.47 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 13.19 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .22 KM
PASQUELL/GIFFORD EQUATIONS USED

ISOPLETH DATA
THE 10% OF CONMAX ISOPLETH CLOSES AT 1.54 KM
THE 5% OF CONMAX ISOPLETH CLOSES AT 2.42 KM
THE 3% OF CONMAX ISOPLETH CLOSES AT 3.30 KM

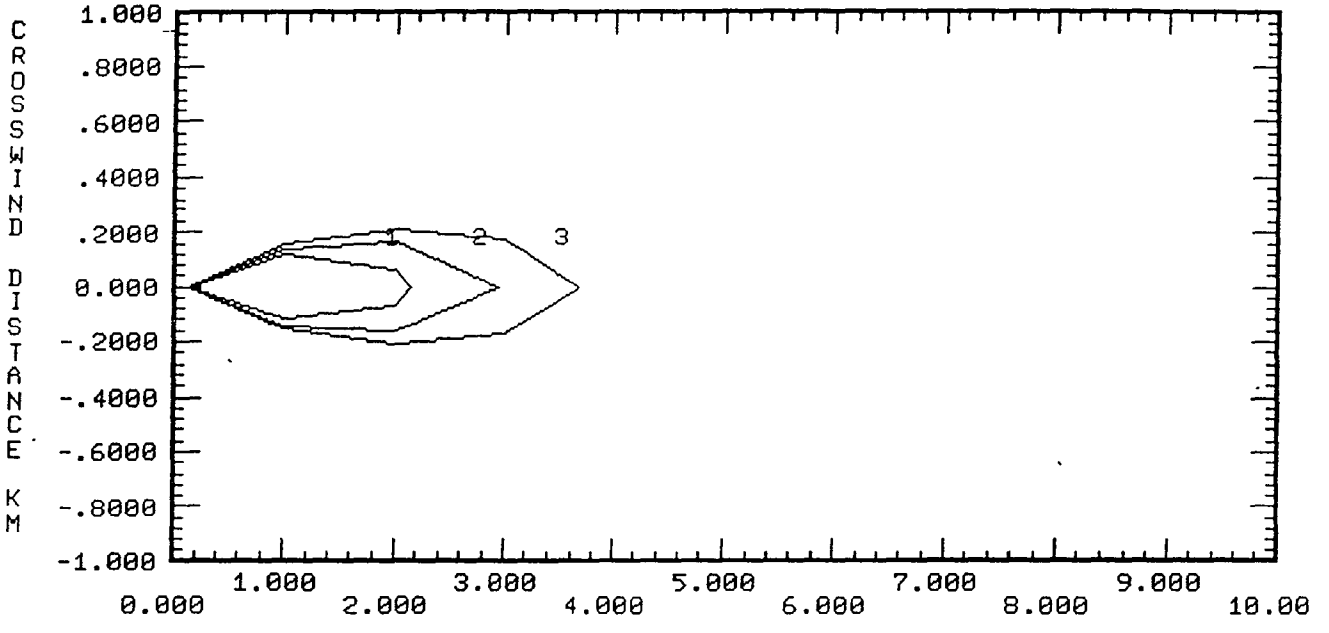
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	10.75	1.29	1.32725
CLK	.81	.10	.09988
CL2K2	.07	.01	.00834
HKO	1.01	.12	.12530
H2O	2.88	.35	.35541
N2	61.01	7.32	7.53315
O2	13.75	1.65	1.69777
CK2O3(L)	4.06	.49	.50138
MGO(C)	.06	.01	.00774
OSR(C)	.05	.01	.00571

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00656959	.00218986	.05255672
CLK	.00049436	.00016479	.00395492
CL2K2	.00004128	.00001376	.00033026
HKO	.00062019	.00020673	.00496154
H2O	.00175919	.00058640	.01407354
N2	.03728754	.01242918	.29830030
O2	.00840351	.00280117	.06722810
CK2O3(L)	.00248174	.00082725	.01985392
MGO(C)	.00003830	.00001277	.00030640
OSR(C)	.00002828	.00000943	.00022623

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

CLASS D: LOW WIND



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DOWNWIND DISTANCE (KM)

1 = 10% OF MAX. CONC.
2 = 5% OF MAX. CONC.
3 = 3% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS D: LOW WIND

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .50
VERT. POTENTIAL TEMP. GRADIENT = .00332200 degree K/m
WIND SPEED = 2.02 METERS/sec
AIR STABILITY CLASS : D

BURN DATA
AMOUNT = 2.27 Kg
TIME = 2.00 min
EFFECTIVE HEAT RELEASE RATE = 4.47 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 21.29 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .38 KM
PASQUELL/GIFFORD EQUATIONS USED

ISOPLETH DATA
THE 10% OF CONMAX ISOPLETH CLOSES AT 2.13 KM
THE 5% OF CONMAX ISOPLETH CLOSES AT 2.93 KM
THE 3% OF CONMAX ISOPLETH CLOSES AT 3.68 KM

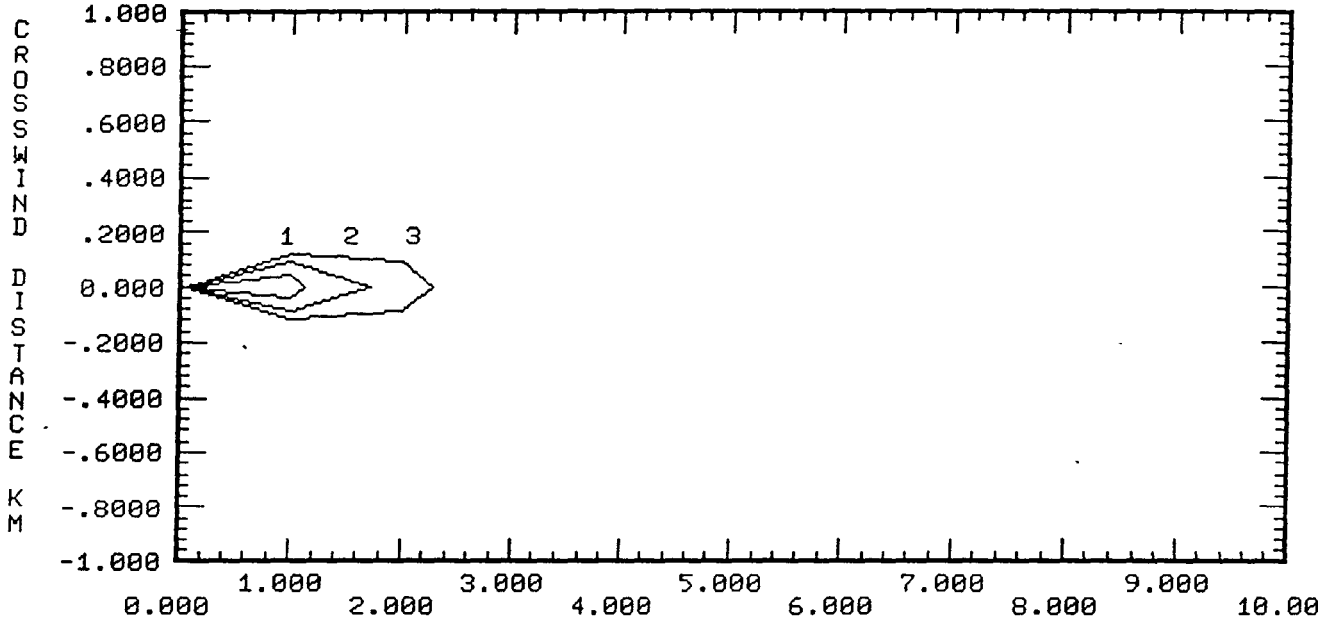
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	10.75	1.29	1.53372
CLK	.81	.10	.11541
CL2K2	.07	.01	.00964
HKO	1.01	.12	.14479
H2O	2.88	.35	.41070
NO	.04	.00	.00578
N2	61.01	7.32	8.70499
O2	13.75	1.65	1.96187
CK2O3(L)	4.06	.49	.57938
MGO(C)	.06	.01	.00894
OSR(C)	.05	.01	.00660

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.01244661	.00414887	.09957290
CLK	.00093662	.00031221	.00749294
CL2K2	.00007821	.00002607	.00062571
HKO	.00117501	.00039167	.00940005
H2O	.00333294	.00111098	.02666351
NO	.00004689	.00001563	.00037508
N2	.07064447	.02354816	.56515570
O2	.01592124	.00530708	.12736990
CK2O3(L)	.00470185	.00156728	.03761478
MGO(C)	.00007256	.00002419	.00058050
OSR(C)	.00005358	.00001786	.00042862

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

CLASS D: HIGH VTG



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PRESS <ENTER> TO CONTINUE

DOWNWIND DISTANCE (KM)

1 = 10% OF MAX. CONC.
2 = 5% OF MAX. CONC.
3 = 3% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS D: HIGH VTG

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .50
VERT. POTENTIAL TEMP. GRADIENT = .01000000 degree K/m
WIND SPEED = 3.63 METERS/sec
AIR STABILITY CLASS : D

BURN DATA
AMOUNT = 2.27 Kg
TIME = 2.00 min
EFFECTIVE HEAT RELEASE RATE = 4.47 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 10.28 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .16 KM
PASQUELL/GIFFORD EQUATIONS USED

ISOPLETH DATA
THE 10% OF CONMAX ISOPLETH CLOSES AT 1.12 KM
THE 5% OF CONMAX ISOPLETH CLOSES AT 1.71 KM
THE 3% OF CONMAX ISOPLETH CLOSES AT 2.26 KM

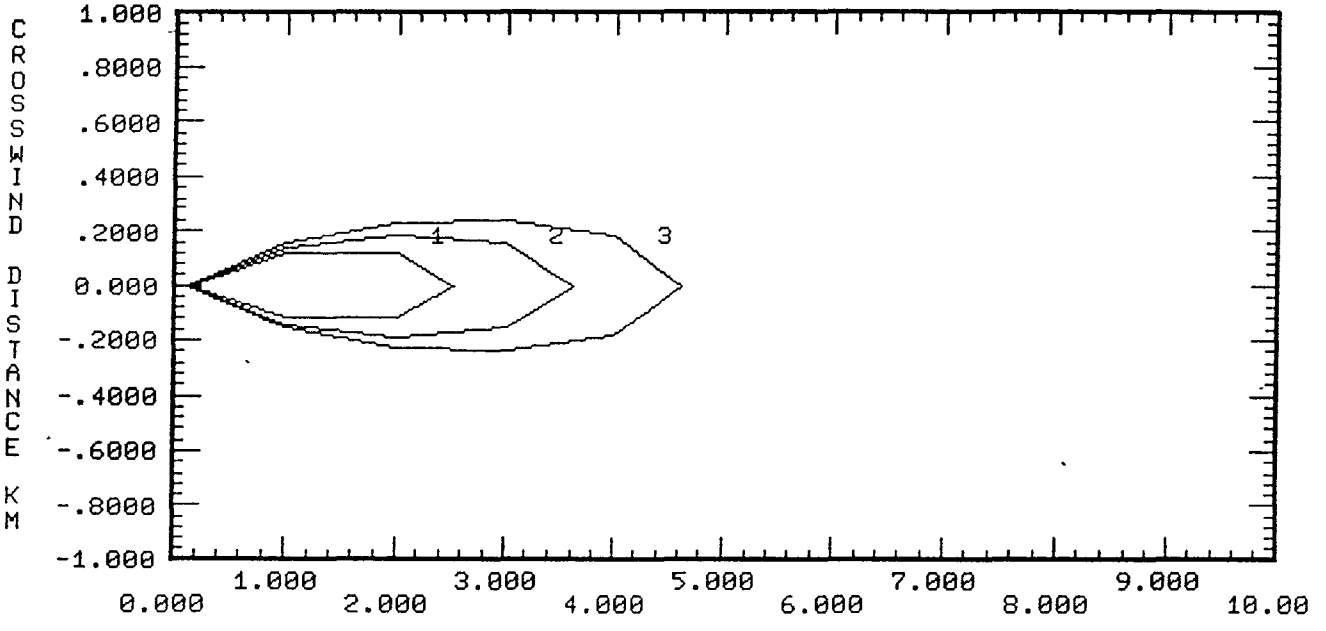
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	10.75	1.29	3.81744
CLK	.81	.10	.28726
CL2K2	.07	.01	.02399
HKO	1.01	.12	.36038
H2O	2.88	.35	1.02223
NO	.04	.00	.01438
N2	61.01	7.32	21.66686
O2	13.75	1.65	4.88312
CK2O3(L)	4.06	.49	1.44208
MGO(C)	.06	.01	.02226
OSR(C)	.05	.01	.01643

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.01980445	.00660148	.15843560
CLK	.00149029	.00049676	.01192235
CL2K2	.00012445	.00004148	.00099561
HKO	.00186963	.00062321	.01495702
H2O	.00530330	.00176777	.04242638
NO	.00007460	.00002487	.00059682
N2	.11240630	.03746876	.89925010
O2	.02533331	.00844444	.20266650
CK2O3(L)	.00748138	.00249379	.05985107
MGO(C)	.00011546	.00003849	.00092367
OSR(C)	.00008525	.00002842	.00068201

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

CLASS D: LOW VTG



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

DOWNWIND DISTANCE (KM)

1 = 10% OF MAX. CONC.
2 = 5% OF MAX. CONC.
3 = 3% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS D: LOW VTG

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .50
VERT. POTENTIAL TEMP. GRADIENT = .00183000 degree K/m
WIND SPEED = 4.02 METERS/sec
AIR STABILITY CLASS : D

BURN DATA
AMOUNT = 2.27 Kg
TIME = 2.00 min
EFFECTIVE HEAT RELEASE RATE = 4.47 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 20.52 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .36 KM
PASQUELL/GIFFORD EQUATIONS USED

ISOPLETH DATA
THE 10% OF CONMAX ISOPLETH CLOSES AT 2.53 KM
THE 5% OF CONMAX ISOPLETH CLOSES AT 3.62 KM
THE 3% OF CONMAX ISOPLETH CLOSES AT 4.62 KM

PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	10.75	1.29	.83346
CLK	.81	.10	.06272
CL2K2	.07	.01	.00524
HKO	1.01	.12	.07868
H2O	2.88	.35	.22318
N2	61.01	7.32	4.73053
O2	13.75	1.65	1.06613
CK2O3(L)	4.06	.49	.31485

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00504285	.00168095	.04034279
CLK	.00037948	.00012649	.00303582
CL2K2	.00003169	.00001056	.00025351
HKO	.00047606	.00015869	.00380850
H2O	.00135036	.00045012	.01080289
N2	.02862200	.00954067	.22897600
O2	.00645060	.00215020	.05160478
CK2O3(L)	.00190499	.00063500	.01523989

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

OPEN DETONATING SCENARIO

COMPUTER RUN DATE 10/ 3/1995

PROPELLANT	HF	DENSITY	WEIGHT	MOLES	VOLUME
AMPI	-94.0000	1.0000	.387	.0016	.38700E+00
KNO3	-118.0000	1.0000	.473	.0047	.47300E+00
ECEL	-259.0600	1.0000	.043	.0002	.43000E-01
WAX	-314.1500	1.0000	.043	.0001	.43000E-01
CAST	-662.6000	1.0000	.004	.0000	.40000E-02
NC	-173.7770	1.0000	.008	.0000	.80000E-02
NG	-90.7500	1.0000	.001	.0000	.10000E-02
DIBU	-204.0300	1.0000	.001	.0000	.10000E-02
MG	.0000	1.0000	.002	.0001	.20000E-02
SRNI	-233.2500	1.0000	.005	.0000	.50000E-02
KCLO	-102.8000	1.0000	.002	.0000	.20000E-02
GILS	-4034.1700	1.0000	.001	.0000	.10000E-02
TNT	-16.0000	1.0000	.030	.0001	.30000E-01
AIR	.0000	1.0000	4.000	.0291	.40000E+01

GRAM ATOMS /100 GRAMS	C	CA	CL	H	K	MG	N	O
	.2895	.0001	.0124	.3574	.0939	.0016	4.6106	1.7116

S	SR
.0000	.0005

ENTHALPY = -15.83834 DENSITY = 1.000

	CHAMBER
PRESSURE(PSIA)	14.700
EPSILON	.000
ISP	.000
ISP (VACUUM)	.000
TEMPERATURE(K)	1342.916
MOLECULAR WGT	30.743
MOLES GAS/100G	3.219
CF	.000
PEAE/M (SEC)	.000
GAMMA	1.269
CP-PR C/100G-K	30.170
ENTROPY (")	197.743
ENTH KCAL/100G	-15.839
DENSITY (G/CC)	2.81954E-04
PROD MOL WT	30.743
GAS MOL WT	29.688
MOL PROD/100G	3.253
CP-G C/100G-K	28.584
RHO PROD(#/F3)	.018
RHO GAS (#/F3)	.017
ITERATIONS	35

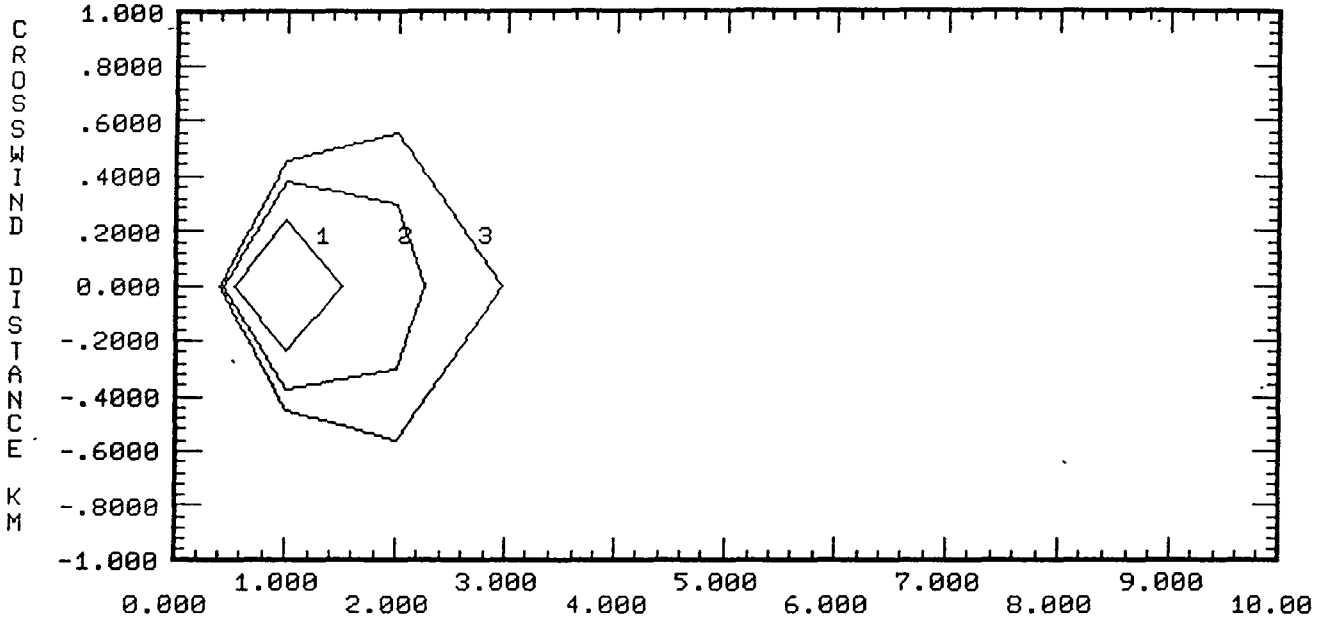
GRAMS OF PROD.
FOR 5.00 LBS OF MATERIAL BURNED

CO	.00075947
CO2	1289.85700000
CAH2O2	.00006554

CL	.00004061
CLH	.00148930
CLHO	.00000297
CLK	97.06228000
CLO	.00000058
CL2K2	8.10536500
H	.00000013
HKO	121.76700000
HNO	.00000035
HNO2	.00020685
HNO2	.00016794
HNO3	.00000071
HO	.06669558
HO2	.00014448
H2	.00001854
H2K2O2	.43935620
H2MGO2	.00001653
H2O	345.39740000
H2O2	.00001851
H2O2SR	.00162623
K	.02558986
KO	.00363223
NO	4.85875700
NO2	.05397237
N2	7320.91600000
N2O	.00038581
O	.00081659
O2	1649.93600000
O2S	.00000654
O3	.00000054
CK2O3(L)	487.25700000
CAO(C)	.83996940
K2O4S(L)	.23557590
MGO(C)	7.51972600
OSR(C)	5.55232000

BURN RATE = 717.75 KCAL/SEC

CLASS A: BASE CASE

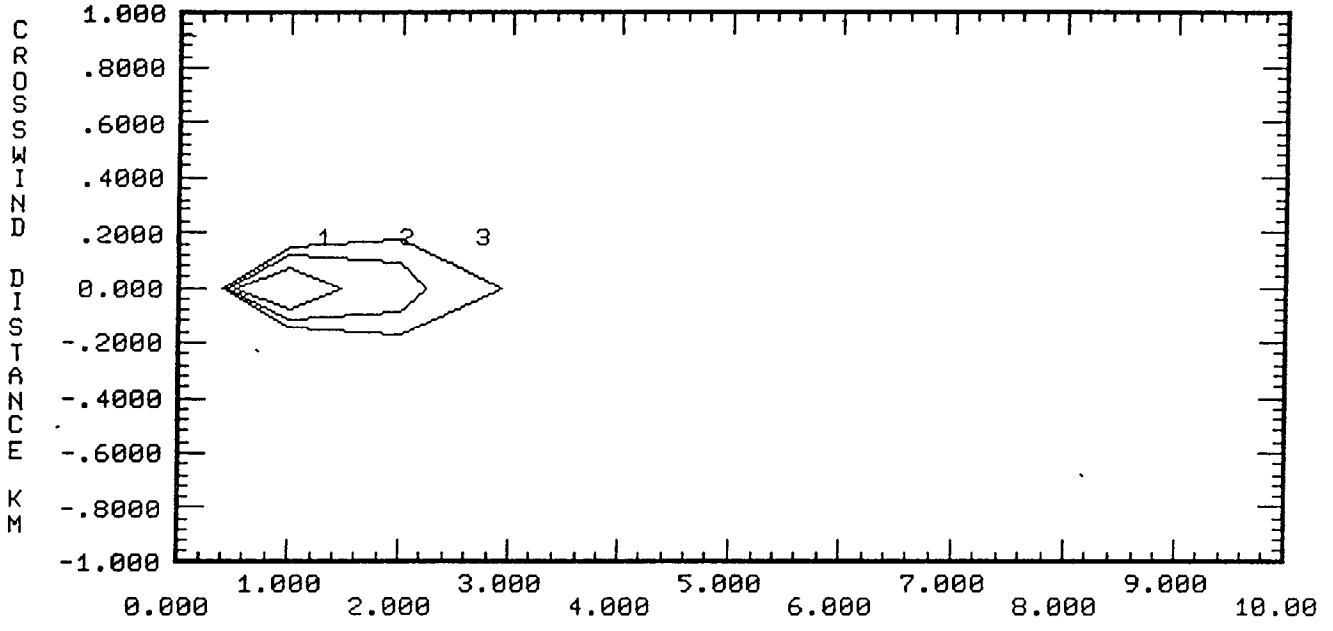


PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

DOWNWIND DISTANCE (KM)

1 = 50% OF MAX. CONC.
2 = 20% OF MAX. CONC.
3 = 10% OF MAX. CONC.

CLASS D: HIGH VTG



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

DOWNWIND DISTANCE (KM)

1 = 50% OF MAX. CONC.
2 = 20% OF MAX. CONC.
3 = 10% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS A: BASE CASE

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .64
VERT. POTENTIAL TEMP. GRADIENT = .00033220 degree K/m
WIND SPEED = 2.38 METERS/sec
AIR STABILITY CLASS : A

BURN DATA
AMOUNT = 2.27 Kg
TIME = .08 min
EFFECTIVE HEAT RELEASE RATE = 717.75 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 239.56 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .82 KM
RECTILINEAR EQUATIONS USED

ISOPLETH DATA
THE 50% OF CONMAX ISOPLETH CLOSES AT 1.49 KM
THE 20% OF CONMAX ISOPLETH CLOSES AT 2.25 KM
THE 10% OF CONMAX ISOPLETH CLOSES AT 2.97 KM

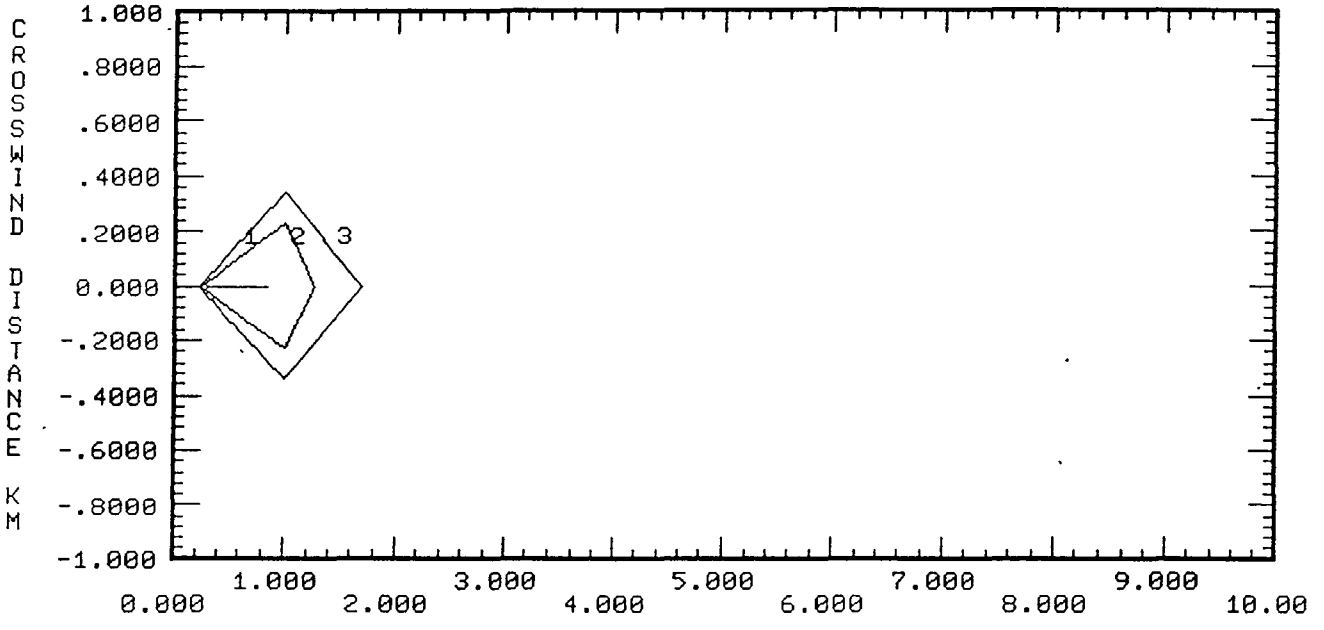
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	259.01	1.29	.01786
N2	1470.06	7.32	.10136
O2	331.31	1.65	.02284
CK2O3(L)	97.84	.49	.00675

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00037796	.00012599	.00302364
N2	.00214517	.00071506	.01716137
O2	.00048347	.00016116	.00386772
CK2O3(L)	.00014278	.00004759	.00114221

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

CLASS A: HIGH VTG



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

DOWNWIND DISTANCE (KM)

1 = 50% OF MAX. CONC.
2 = 20% OF MAX. CONC.
3 = 10% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS A: HIGH VTG

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .64
VERT. POTENTIAL TEMP. GRADIENT = .00183000 degree K/m
WIND SPEED = 2.29 METERS/sec
AIR STABILITY CLASS : A

BURN DATA
AMOUNT = 2.27 Kg
TIME = .08 min
EFFECTIVE HEAT RELEASE RATE = 717.75 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 135.92 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .47 KM
RECTILINEAR EQUATIONS USED

ISOPLETH DATA
THE 50% OF CONMAX ISOPLETH CLOSES AT .85 KM
THE 20% OF CONMAX ISOPLETH CLOSES AT 1.28 KM
THE 10% OF CONMAX ISOPLETH CLOSES AT 1.69 KM

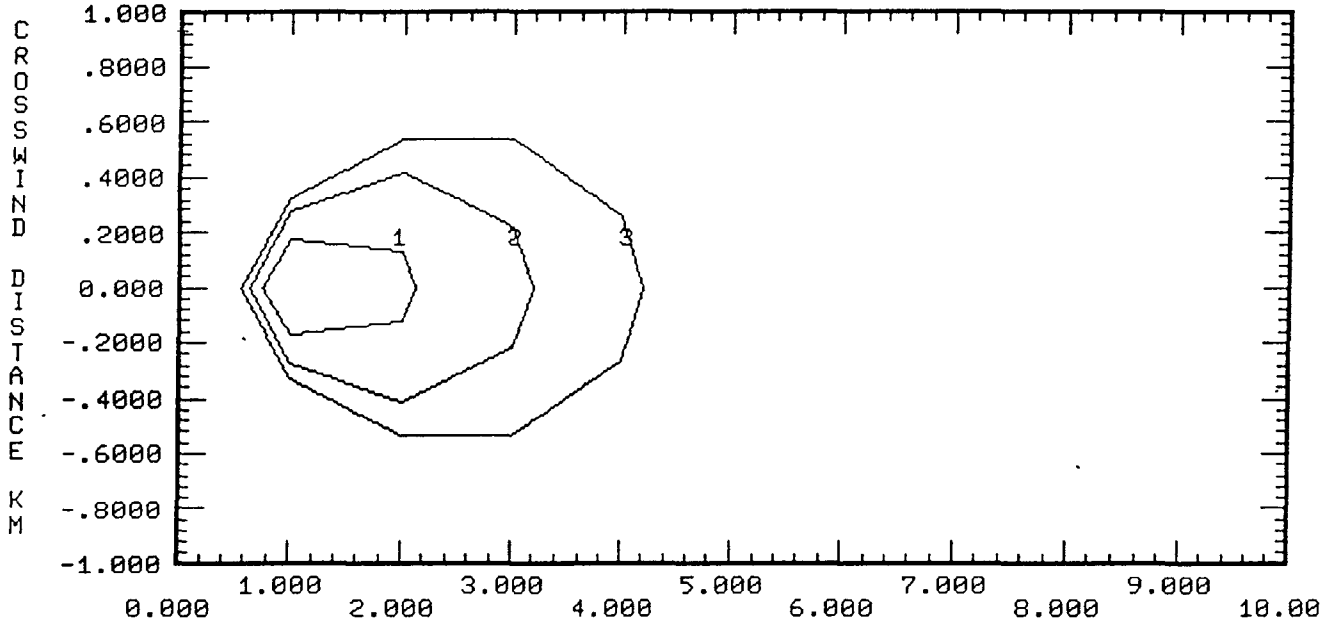
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	259.01	1.29	.08724
CLK	19.49	.10	.00657
HKO	24.45	.12	.00824
H2O	69.36	.35	.02336
N2	1470.06	7.32	.49518
O2	331.31	1.65	.11160
CK2O3(L)	97.84	.49	.03296

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00117209	.00039070	.00937669
CLK	.00008820	.00002940	.00070560
HKO	.00011065	.00003688	.00088519
H2O	.00031386	.00010462	.00251087
N2	.00665247	.00221749	.05321974
O2	.00149928	.00049976	.01199423
CK2O3(L)	.00044276	.00014759	.00354211

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER-THE AVERAGING TIME

CLASS B: BASE CASE



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

DOWNWIND DISTANCE (KM)

1 = 50% OF MAX. CONC.
2 = 20% OF MAX. CONC.
3 = 10% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS B: BASE CASE

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .64
VERT. POTENTIAL TEMP. GRADIENT = .00033220 degree K/m
WIND SPEED = 3.54 METERS/sec
AIR STABILITY CLASS : B

BURN DATA
AMOUNT = 2.27 Kg
TIME = .08 min
EFFECTIVE HEAT RELEASE RATE = 717.75 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 209.49 METERS
THE MAXIMUM CONCENTRATION OCCURS AT 1.16 KM
RECTILINEAR EQUATIONS USED

ISOPLETH DATA
THE 50% OF CONMAX ISOPLETH CLOSES AT 2.11 KM
THE 20% OF CONMAX ISOPLETH CLOSES AT 3.18 KM
THE 10% OF CONMAX ISOPLETH CLOSES AT 4.19 KM

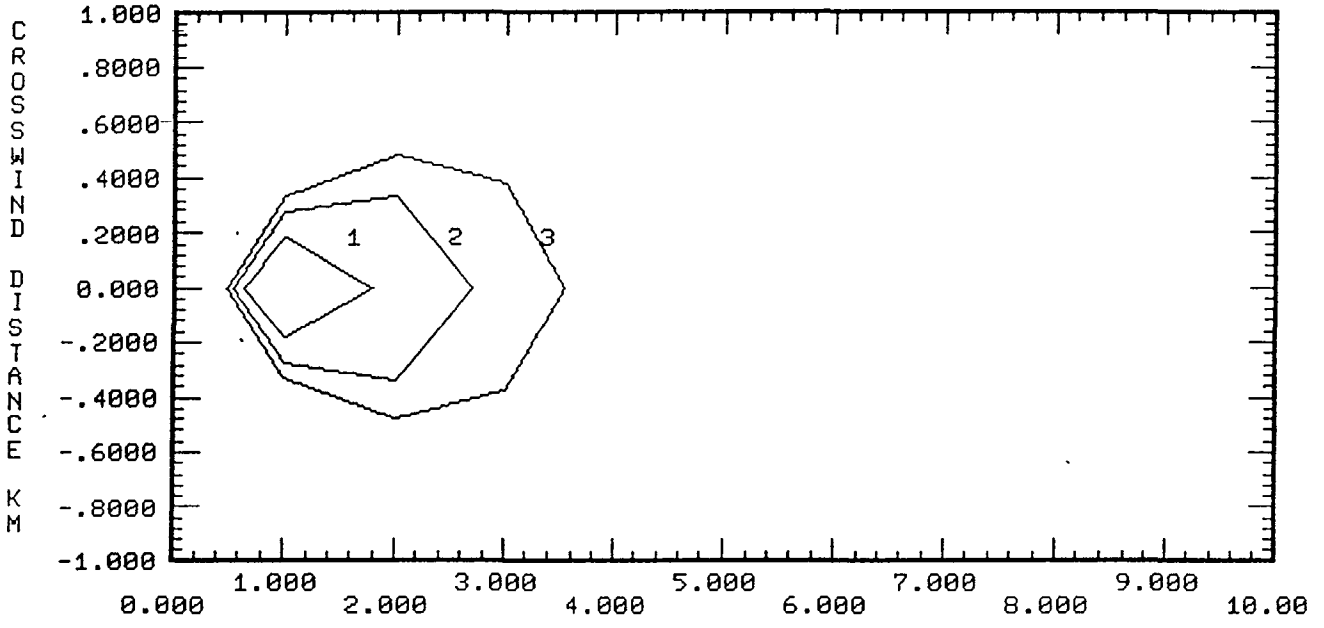
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	259.01	1.29	.02109
H2O	69.36	.35	.00565
N2	1470.06	7.32	.11968
O2	331.31	1.65	.02697
CK2O3(L)	97.84	.49	.00797

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00029707	.00009902	.00237652
H2O	.00007955	.00002652	.00063638
N2	.00168607	.00056202	.01348858
O2	.00037999	.00012666	.00303993
CK2O3(L)	.00011222	.00003741	.00089775

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

CLASS B: HIGH WIND



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

DOWNWIND DISTANCE (KM)

1 = 50% OF MAX. CONC.
2 = 20% OF MAX. CONC.
3 = 10% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS B: HIGH WIND

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .64
VERT. POTENTIAL TEMP. GRADIENT = .00033220 degree K/m
WIND SPEED = 5.82 METERS/sec
AIR STABILITY CLASS : B

BURN DATA
AMOUNT = 2.27 Kg
TIME = .08 min
EFFECTIVE HEAT RELEASE RATE = 717.75 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 176.84 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .98 KM
RECTILINEAR EQUATIONS USED

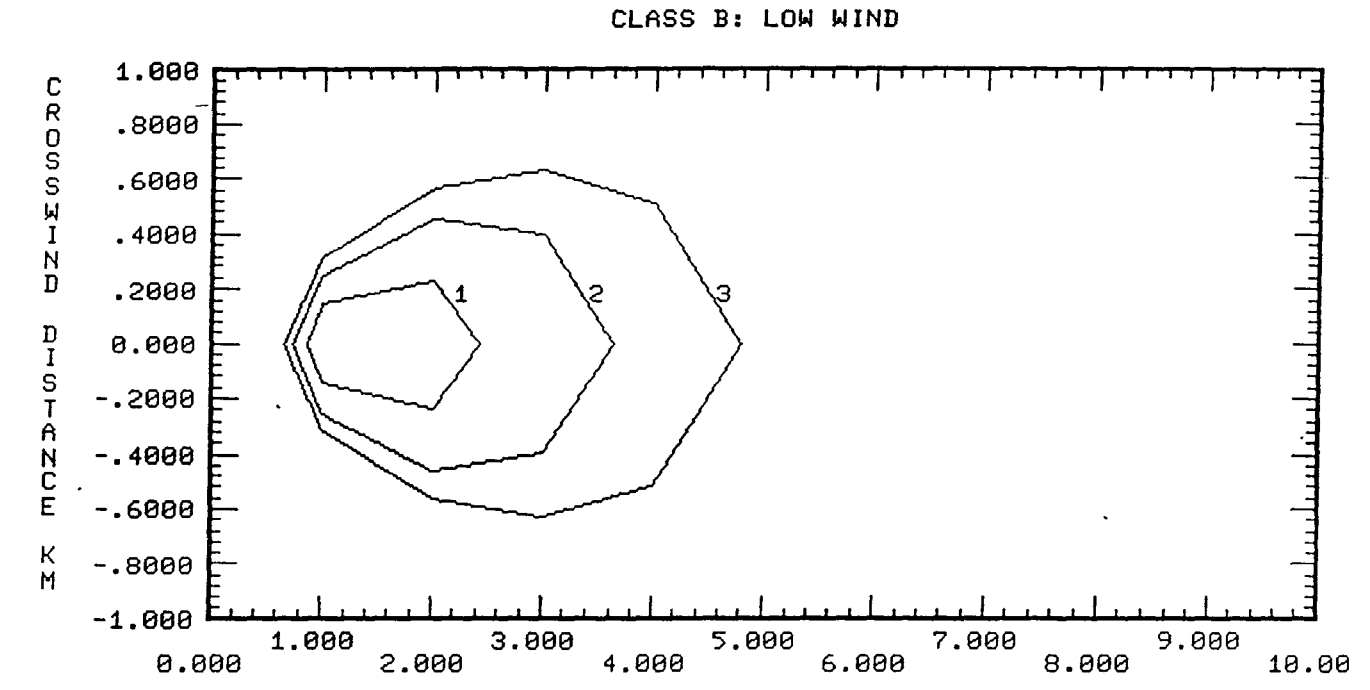
ISOPLETH DATA
THE 50% OF CONMAX ISOPLETH CLOSES AT 1.78 KM
THE 20% OF CONMAX ISOPLETH CLOSES AT 2.69 KM
THE 10% OF CONMAX ISOPLETH CLOSES AT 3.54 KM

PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	259.01	1.29	.03385
H2O	69.36	.35	.00906
N2	1470.06	7.32	.19211
O2	331.31	1.65	.04330
CK2O3(L)	97.84	.49	.01279

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00025156	.00008385	.00201245
H2O	.00006736	.00002245	.00053889
N2	.00142777	.00047592	.01142218
O2	.00032178	.00010726	.00257426
CK2O3(L)	.00009503	.00003168	.00076022

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

1 = 50% OF MAX. CONC.
2 = 20% OF MAX. CONC.
3 = 10% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS B: LOW WIND

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .64
VERT. POTENTIAL TEMP. GRADIENT = .00033220 degree K/m
WIND SPEED = 2.38 METERS/sec
AIR STABILITY CLASS : B

BURN DATA
AMOUNT = 2.27 Kg
TIME = .08 min
EFFECTIVE HEAT RELEASE RATE = 717.75 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 239.56 METERS
THE MAXIMUM CONCENTRATION OCCURS AT 1.33 KM
RECTILINEAR EQUATIONS USED

ISOPLETH DATA
THE 50% OF CONMAX ISOPLETH CLOSES AT 2.41 KM
THE 20% OF CONMAX ISOPLETH CLOSES AT 3.64 KM
THE 10% OF CONMAX ISOPLETH CLOSES AT 4.79 KM

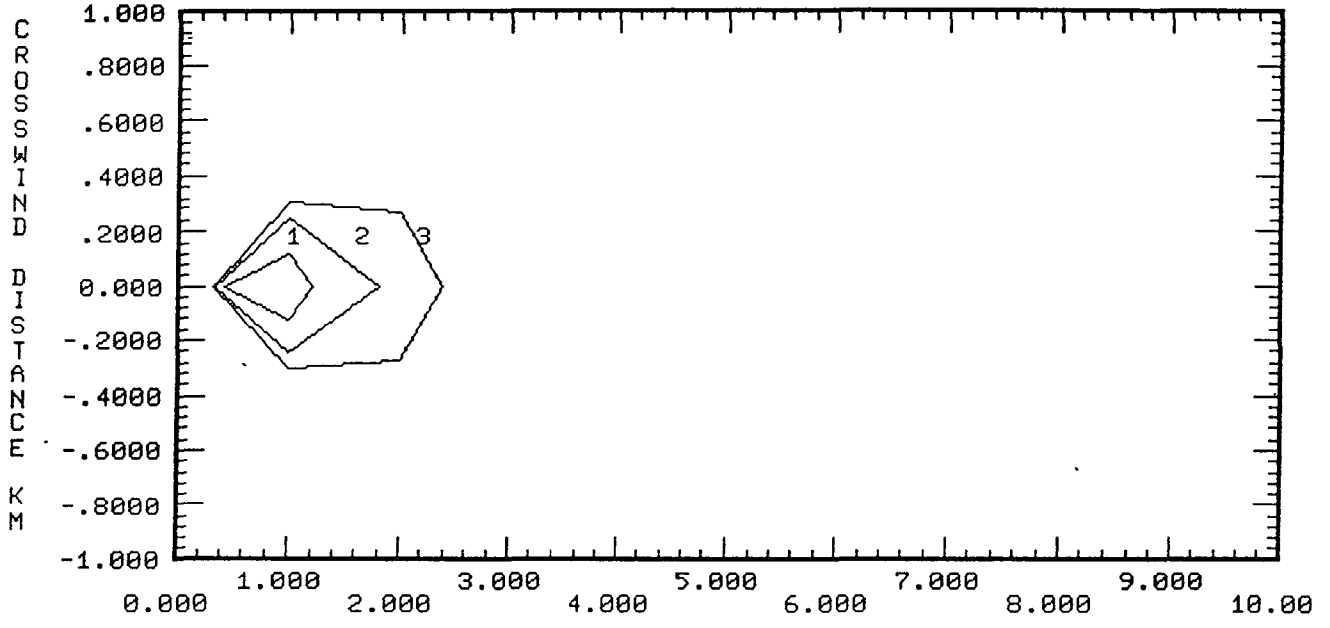
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	259.01	1.29	.01449
N2	1470.06	7.32	.08223
O2	331.31	1.65	.01853
CK2O3(L)	97.84	.49	.00547

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00034131	.00011377	.00273050
N2	.00193721	.00064574	.01549767
O2	.00043659	.00014553	.00349275
CK2O3(L)	.00012893	.00004298	.00103147

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

CLASS B: HIGH VTG



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

1 = 50% OF MAX. CONC.
2 = 20% OF MAX. CONC.
3 = 10% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS B: HIGH VTG

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .64
VERT. POTENTIAL TEMP. GRADIENT = .00183000 degree K/m
WIND SPEED = 3.40 METERS/sec
AIR STABILITY CLASS : B

BURN DATA
AMOUNT = 2.27 Kg
TIME = .08 min
EFFECTIVE HEAT RELEASE RATE = 717.75 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 118.67 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .66 KM
RECTILINEAR EQUATIONS USED

ISOPLETH DATA
THE 50% OF CONMAX ISOPLETH CLOSES AT 1.20 KM
THE 20% OF CONMAX ISOPLETH CLOSES AT 1.81 KM
THE 10% OF CONMAX ISOPLETH CLOSES AT 2.38 KM

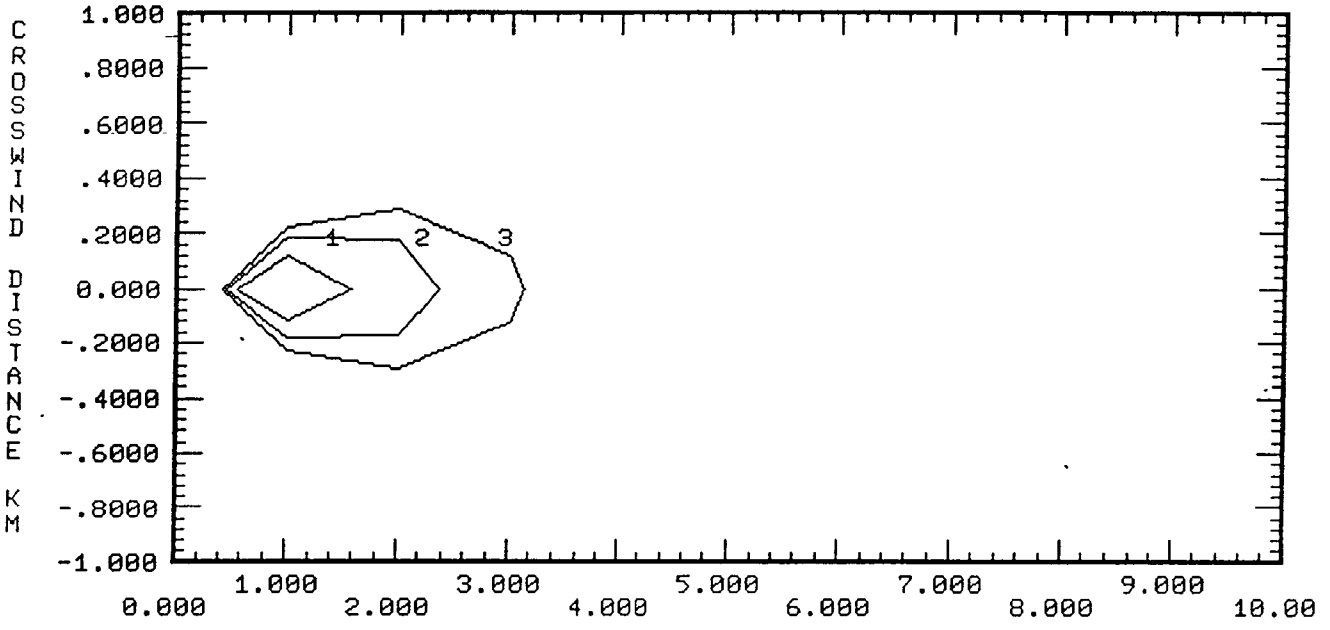
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	259.01	1.29	.10345
CLK	19.49	.10	.00778
HKO	24.45	.12	.00977
H2O	69.36	.35	.02770
N2	1470.06	7.32	.58716
O2	331.31	1.65	.13233
CK2O3(L)	97.84	.49	.03908

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00092146	.00030715	.00737166
CLK	.00006934	.00002311	.00055472
HKO	.00008699	.00002900	.00069591
H2O	.00024675	.00008225	.00197399
N2	.00522995	.00174332	.04183957
O2	.00117870	.00039290	.00942959
CK2O3(L)	.00034809	.00011603	.00278472

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

CLASS C: BASE CASE



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

DOWNWIND DISTANCE (KM)

1 = 50% OF MAX. CONC.
2 = 20% OF MAX. CONC.
3 = 10% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS C: BASE CASE

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .64
VERT. POTENTIAL TEMP. GRADIENT = .00183000 degree K/m
WIND SPEED = 4.73 METERS/sec
AIR STABILITY CLASS : C

BURN DATA
AMOUNT = 2.27 Kg
TIME = .08 min
EFFECTIVE HEAT RELEASE RATE = 717.75 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 105.94 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .86 KM
RECTILINEAR EQUATIONS USED

ISOPLETH DATA
THE 50% OF CONMAX ISOPLETH CLOSES AT 1.57 KM
THE 20% OF CONMAX ISOPLETH CLOSES AT 2.37 KM
THE 10% OF CONMAX ISOPLETH CLOSES AT 3.12 KM

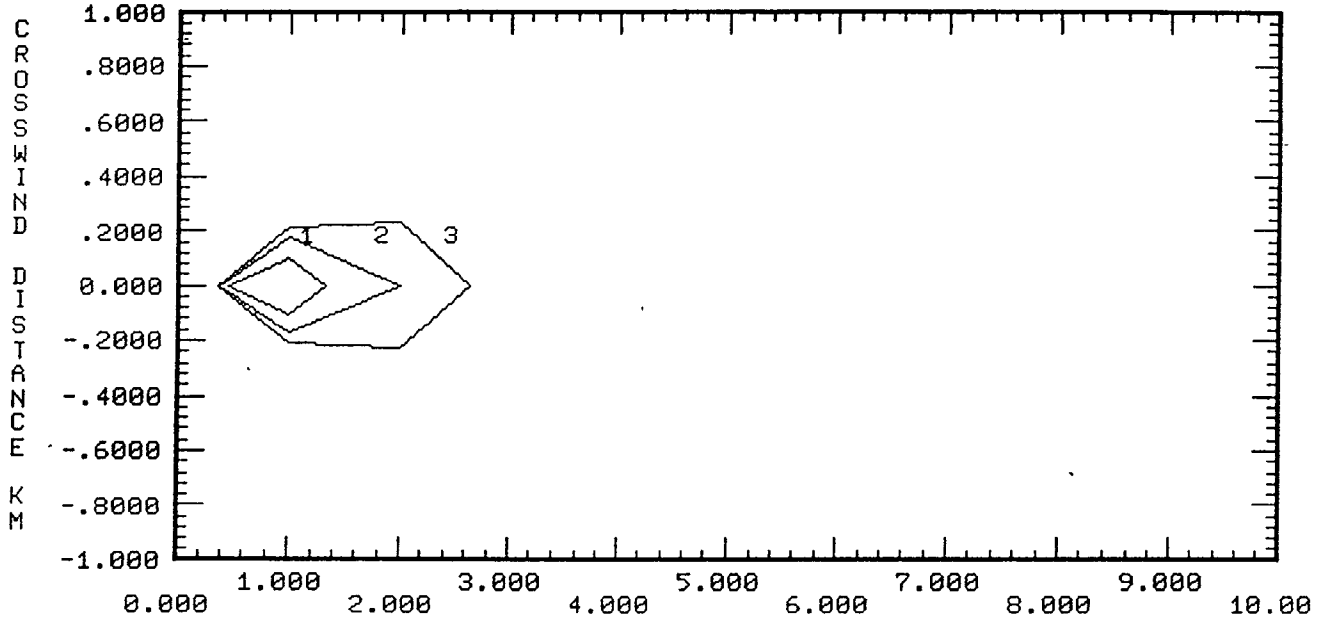
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	259.01	1.29	.15468
CLK	19.49	.10	.01164
HKO	24.45	.12	.01460
H2O	69.36	.35	.04142
N2	1470.06	7.32	.87795
O2	331.31	1.65	.19787
CK2O3(L)	97.84	.49	.05843

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00086185	.00028728	.00689479
CLK	.00006485	.00002162	.00051884
HKO	.00008136	.00002712	.00065089
H2O	.00023079	.00007693	.00184629
N2	.00489167	.00163056	.03913338
O2	.00110245	.00036748	.00881958
CK2O3(L)	.00032557	.00010852	.00260458

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER-THE AVERAGING TIME

CLASS C: HIGH WIND



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

DOWNWIND DISTANCE (KM)

1 = 50% OF MAX. CONC.
2 = 20% OF MAX. CONC.
3 = 10% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS C: HIGH WIND

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .64
VERT. POTENTIAL TEMP. GRADIENT = .00183000 degree K/m
WIND SPEED = 7.78 METERS/sec
AIR STABILITY CLASS : C

BURN DATA
AMOUNT = 2.27 Kg
TIME = .08 min
EFFECTIVE HEAT RELEASE RATE = 717.75 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 89.17 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .73 KM
RECTILINEAR EQUATIONS USED

ISOPLETH DATA
THE 50% OF CONMAX ISOPLETH CLOSES AT 1.32 KM
THE 20% OF CONMAX ISOPLETH CLOSES AT 2.00 KM
THE 10% OF CONMAX ISOPLETH CLOSES AT 2.63 KM

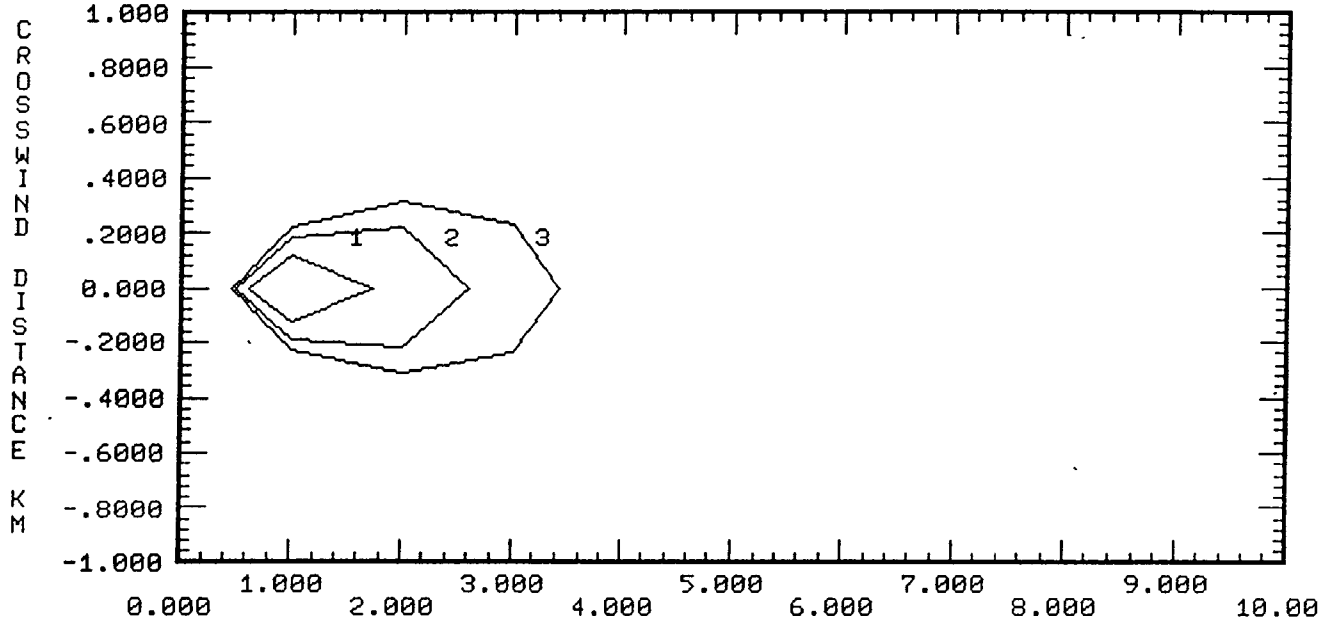
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	259.01	1.29	.24878
CLK	19.49	.10	.01872
HKO	24.45	.12	.02349
H2O	69.36	.35	.06662
N2	1470.06	7.32	1.41201
O2	331.31	1.65	.31823
CK2O3(L)	97.84	.49	.09398

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00074696	.00024899	.00597566
CLK	.00005621	.00001874	.00044967
HKO	.00007052	.00002351	.00056412
H2O	.00020002	.00006667	.00160016
N2	.00423954	.00141318	.03391628
O2	.00095548	.00031849	.00764381
CK2O3(L)	.00028217	.00009406	.00225737

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

CLASS C: LOW WIND



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

DOWNWIND DISTANCE (KM)

1 = 50% OF MAX. CONC.
2 = 20% OF MAX. CONC.
3 = 10% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS C: LOW WIND

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .64
VERT. POTENTIAL TEMP. GRADIENT = .00183000 degree K/m
WIND SPEED = 3.58 METERS/sec
AIR STABILITY CLASS : C

BURN DATA
AMOUNT = 2.27 Kg
TIME = .08 min
EFFECTIVE HEAT RELEASE RATE = 717.75 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 116.58 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .95 KM
RECTILINEAR EQUATIONS USED

ISOPLETH DATA
THE 50% OF CONMAX ISOPLETH CLOSES AT 1.73 KM
THE 20% OF CONMAX ISOPLETH CLOSES AT 2.60 KM
THE 10% OF CONMAX ISOPLETH CLOSES AT 3.43 KM

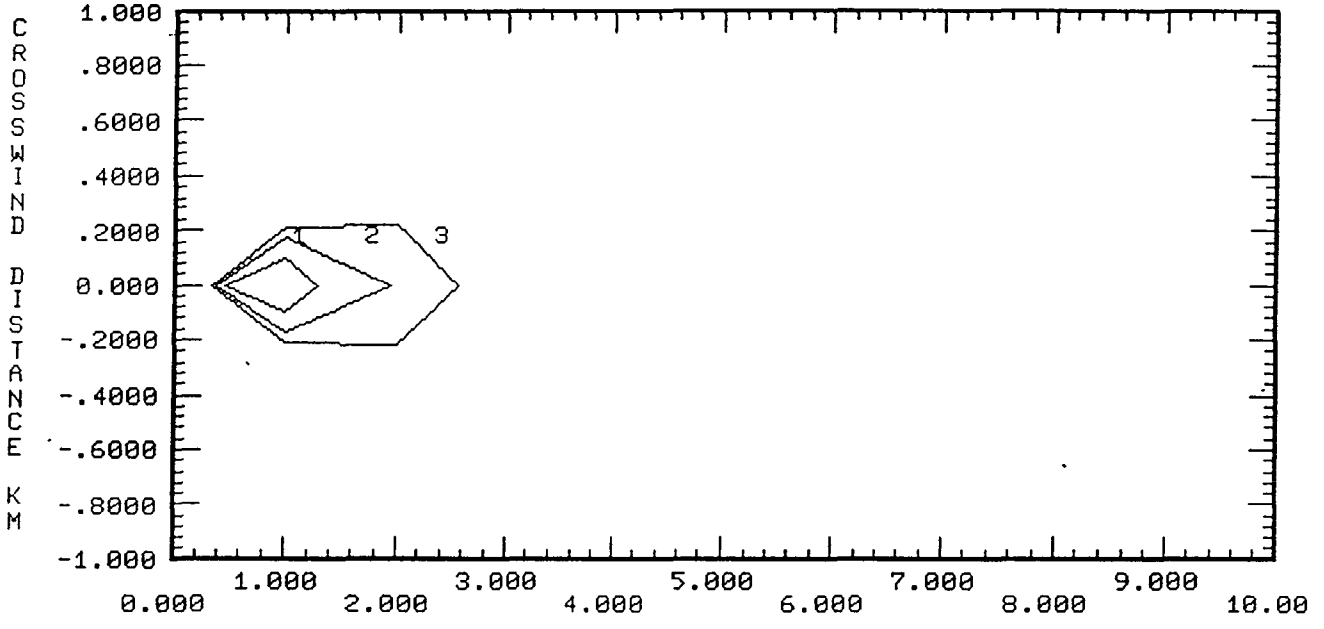
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	259.01	1.29	.11849
CLK	19.49	.10	.00892
HKO	24.45	.12	.01119
H2O	69.36	.35	.03173
N2	1470.06	7.32	.67254
O2	331.31	1.65	.15157
CK2O3(L)	97.84	.49	.04476

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00094448	.00031483	.00755588
CLK	.00007107	.00002369	.00056858
HKO	.00008916	.00002972	.00071330
H2O	.00025291	.00008430	.00202331
N2	.00536072	.00178691	.04288573
O2	.00120816	.00040272	.00966525
CK2O3(L)	.00035679	.00011893	.00285430

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

CLASS C: HIGH VTG



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

DOWNWIND DISTANCE (KM)

1 = 50% OF MAX. CONC.
2 = 20% OF MAX. CONC.
3 = 10% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS C: HIGH VTG

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .64
VERT. POTENTIAL TEMP. GRADIENT = .00332200 degree K/m
WIND SPEED = 4.63 METERS/sec
AIR STABILITY CLASS : C

BURN DATA
AMOUNT = 2.27 Kg
TIME = .08 min
EFFECTIVE HEAT RELEASE RATE = 717.75 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 86.80 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .71 KM
RECTILINEAR EQUATIONS USED

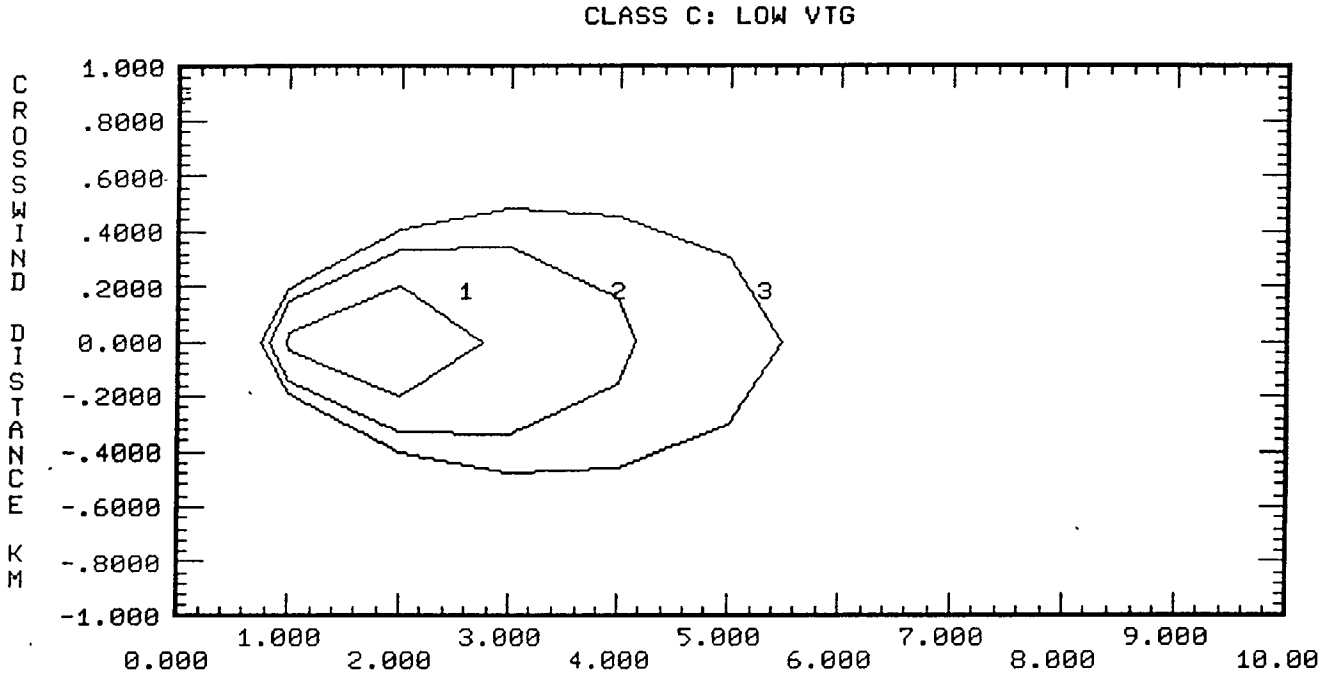
ISOPLETH DATA
THE 50% OF CONMAX ISOPLETH CLOSES AT 1.29 KM
THE 20% OF CONMAX ISOPLETH CLOSES AT 1.94 KM
THE 10% OF CONMAX ISOPLETH CLOSES AT 2.56 KM

PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	259.01	1.29	.26998
CLK	19.49	.10	.02032
HKO	24.45	.12	.02549
H2O	69.36	.35	.07229
N2	1470.06	7.32	1.53234
O2	331.31	1.65	.34535
CK2O3(L)	97.84	.49	.10199

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00129797	.00043266	.01038379
CLK	.00009767	.00003256	.00078139
HKO	.00012253	.00004084	.00098026
H2O	.00034757	.00011586	.00278056
N2	.00736701	.00245567	.05893608
O2	.00166032	.00055344	.01328255
CK2O3(L)	.00049032	.00016344	.00392256

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER-THE AVERAGING TIME



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

1 = 50% OF MAX. CONC.
2 = 20% OF MAX. CONC.
3 = 10% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS C: LOW VTG

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .64
VERT. POTENTIAL TEMP. GRADIENT = .00033220 degree K/m
WIND SPEED = 5.00 METERS/sec
AIR STABILITY CLASS : C

BURN DATA
AMOUNT = 2.27 Kg
TIME = .08 min
EFFECTIVE HEAT RELEASE RATE = 717.75 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 186.25 METERS
THE MAXIMUM CONCENTRATION OCCURS AT 1.51 KM
RECTILINEAR EQUATIONS USED

ISOPLETH DATA
THE 50% OF CONMAX ISOPLETH CLOSES AT 2.75 KM
THE 20% OF CONMAX ISOPLETH CLOSES AT 4.16 KM
THE 10% OF CONMAX ISOPLETH CLOSES AT 5.48 KM

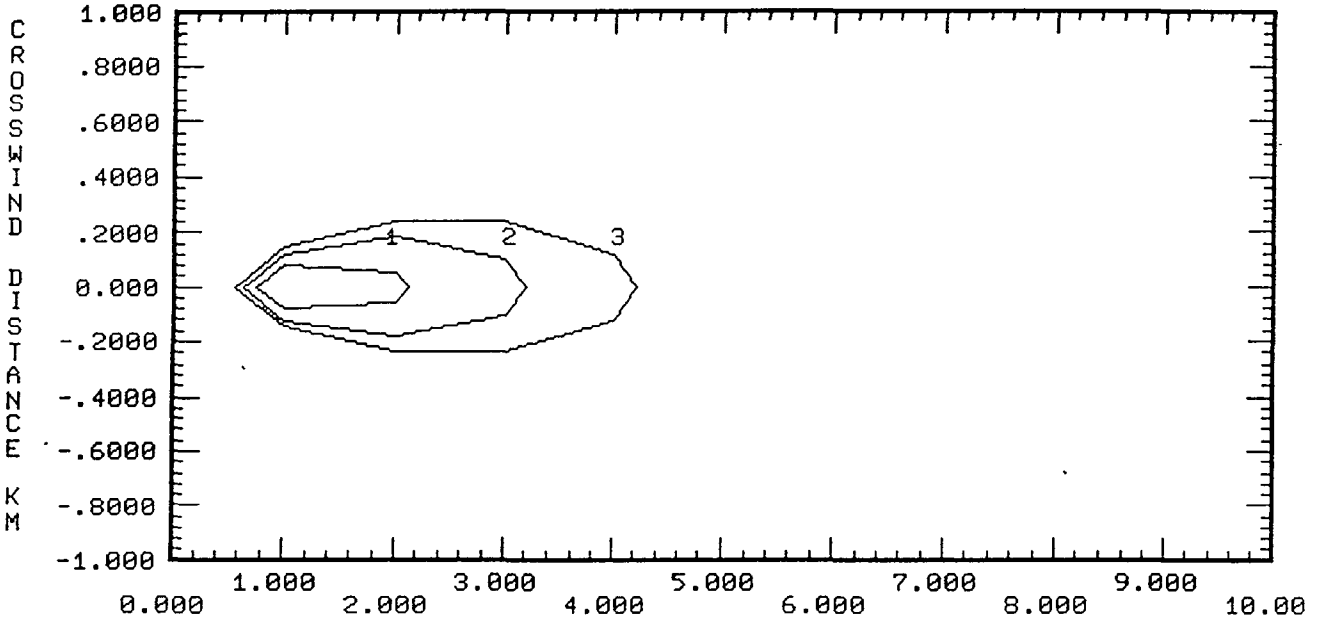
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	259.01	1.29	.03192
H2O	69.36	.35	.00855
N2	1470.06	7.32	.18118
O2	331.31	1.65	.04083
CK2O3(L)	97.84	.49	.01206

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00027587	.00009196	.00220698
H2O	.00007387	.00002462	.00059099
N2	.00156580	.00052193	.01252636
O2	.00035289	.00011763	.00282309
CK2O3(L)	.00010421	.00003474	.00083371

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

CLASS D: BASE CASE



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

1 = 50% OF MAX. CONC.
2 = 20% OF MAX. CONC.
3 = 10% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS D: BASE CASE

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .64
VERT. POTENTIAL TEMP. GRADIENT = .00332200 degree K/m
WIND SPEED = 4.97 METERS/sec
AIR STABILITY CLASS : D

BURN DATA
AMOUNT = 2.27 Kg
TIME = .08 min
EFFECTIVE HEAT RELEASE RATE = 717.75 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 84.71 METERS
THE MAXIMUM CONCENTRATION OCCURS AT 1.17 KM
RECTILINEAR EQUATIONS USED

ISOPLETH DATA
THE 50% OF CONMAX ISOPLETH CLOSES AT 2.12 KM
THE 20% OF CONMAX ISOPLETH CLOSES AT 3.20 KM
THE 10% OF CONMAX ISOPLETH CLOSES AT 4.21 KM

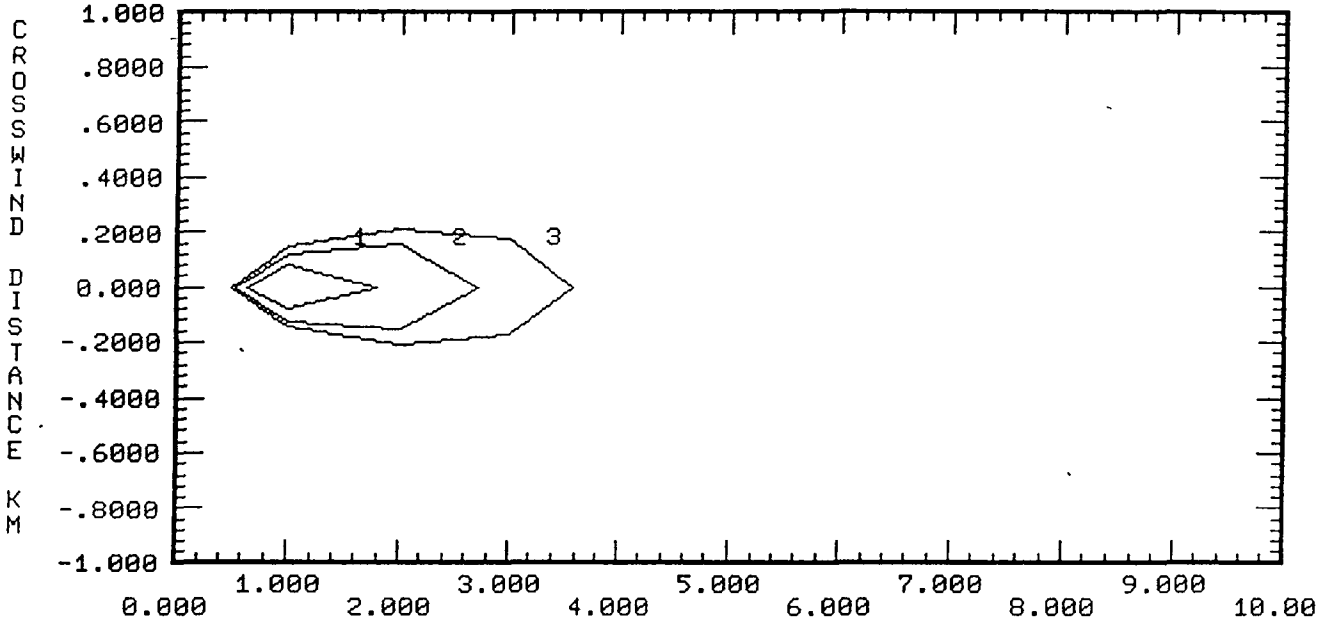
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	259.01	1.29	.26031
CLK	19.49	.10	.01959
HKO	24.45	.12	.02457
H2O	69.36	.35	.06971
N2	1470.06	7.32	1.47747
O2	331.31	1.65	.33298
CK2O3(L)	97.84	.49	.09834

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00120359	.00040120	.00962875
CLK	.00009057	.00003019	.00072456
HKO	.00011362	.00003787	.00090898
H2O	.00032230	.00010743	.00257836
N2	.00683130	.00227710	.05465037
O2	.00153958	.00051319	.01231668
CK2O3(L)	.00045467	.00015156	.00363733

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

CLASS D: HIGH WIND



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

DOWNWIND DISTANCE (KM)

1 = 50% OF MAX. CONC.
2 = 20% OF MAX. CONC.
3 = 10% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS D: HIGH WIND

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .64
VERT. POTENTIAL TEMP. GRADIENT = .00332200 degree K/m
WIND SPEED = 8.12 METERS/sec
AIR STABILITY CLASS : D

BURN DATA
AMOUNT = 2.27 Kg
TIME = .08 min
EFFECTIVE HEAT RELEASE RATE = 717.75 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 71.40 METERS
THE MAXIMUM CONCENTRATION OCCURS AT .99 KM
RECTILINEAR EQUATIONS USED

ISOPLETH DATA
THE 50% OF CONMAX ISOPLETH CLOSES AT 1.79 KM
THE 20% OF CONMAX ISOPLETH CLOSES AT 2.71 KM
THE 10% OF CONMAX ISOPLETH CLOSES AT 3.57 KM

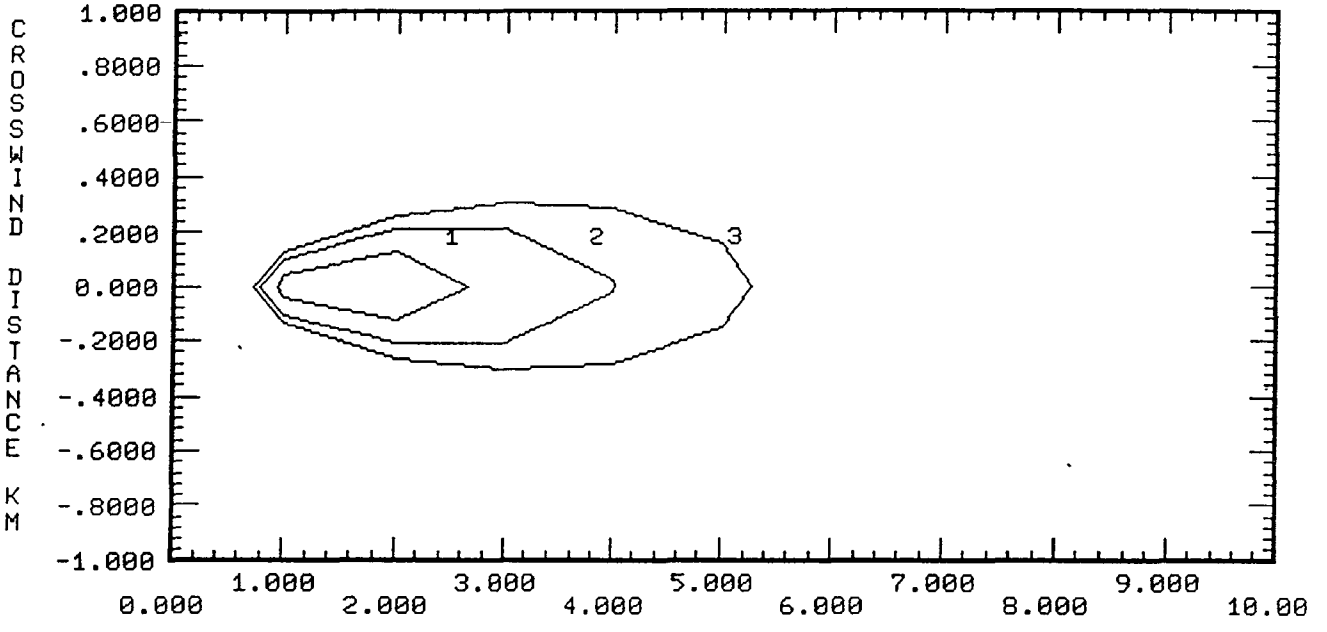
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	259.01	1.29	.41569
CLK	19.49	.10	.03128
HKO	24.45	.12	.03924
H2O	69.36	.35	.11131
N2	1470.06	7.32	2.35936
O2	331.31	1.65	.53174
CK2O3(L)	97.84	.49	.15703

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00104692	.00034897	.00837532
CLK	.00007878	.00002626	.00063024
HKO	.00009883	.00003294	.00079066
H2O	.00028034	.00009345	.00224273
N2	.00594205	.00198068	.04753643
O2	.00133918	.00044639	.01071341
CK2O3(L)	.00039548	.00013183	.00316385

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

CLASS D: LOW WIND



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

1 = 50% OF MAX. CONC.
2 = 20% OF MAX. CONC.
3 = 10% OF MAX. CONC.

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS D: LOW WIND

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .64
VERT. POTENTIAL TEMP. GRADIENT = .00332200 degree K/m
WIND SPEED = 2.57 METERS/sec
AIR STABILITY CLASS : D

BURN DATA
AMOUNT = 2.27 Kg
TIME = .08 min
EFFECTIVE HEAT RELEASE RATE = 717.75 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 106.40 METERS
THE MAXIMUM CONCENTRATION OCCURS AT 1.46 KM
RECTILINEAR EQUATIONS USED

ISOPLETH DATA
THE 50% OF CONMAX ISOPLETH CLOSES AT 2.66 KM
THE 20% OF CONMAX ISOPLETH CLOSES AT 4.01 KM
THE 10% OF CONMAX ISOPLETH CLOSES AT 5.28 KM

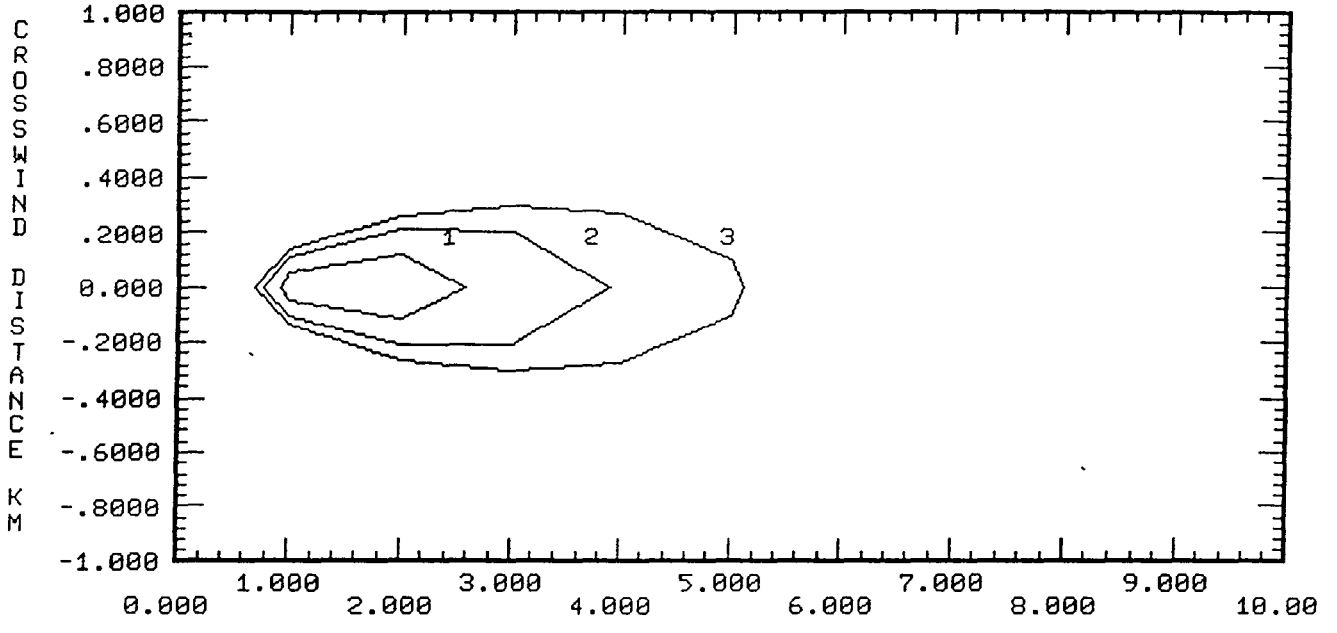
PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	259.01	1.29	.13795
CLK	19.49	.10	.01038
HKO	24.45	.12	.01302
H2O	69.36	.35	.03694
N2	1470.06	7.32	.78298
O2	331.31	1.65	.17646
CK2O3(L)	97.84	.49	.05211

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00147234	.00049078	.01177870
CLK	.00011079	.00003693	.00088635
HKO	.00013899	.00004633	.00111196
H2O	.00039426	.00013142	.00315410
N2	.00835669	.00278556	.06685353
O2	.00188335	.00062778	.01506684
CK2O3(L)	.00055619	.00018540	.00444952

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER-THE AVERAGING TIME

CLASS D: LOW VTG



PRESS "F" TO SEND TO FILE
PRESS <ENTER> TO CONTINUE

DOWNWIND DISTANCE (KM)

1 = 50% OF MAX. CONC.
2 = 20% OF MAX. CONC.
3 = 10% OF MAX. CONC.

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00079999	.00026666	.00639993
CLK	.00006020	.00002007	.00048160
HKO	.00007552	.00002517	.00060417
H2O	.00021422	.00007141	.00171377
N2	.00454057	.00151352	.03632458
O2	.00102331	.00034110	.00818648
CK2O3(L)	.00030221	.00010074	.00241764

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

PCAD COMPUTER MODEL OUTPUT SUMMARY
TITLE:CLASS D: LOW VTG

METEOROLOGICAL DATA
AIR DENSITY = 1225.00 g/m^3
AIR TEMPERATURE = 298.0 degK
SPECIFIC HEAT OF AIR = .240 cal/g-degK
GRAVITATIONAL FORCE = 9.81 m/s^2
ENTRAINMENT COEFFICIENT = .64
VERT. POTENTIAL TEMP. GRADIENT = .00183000 degree K/m
WIND SPEED = 5.12 METERS/sec
AIR STABILITY CLASS : D

BURN DATA
AMOUNT = 2.27 Kg
TIME = .08 min
EFFECTIVE HEAT RELEASE RATE = 717.75 Kcal/sec
RADIUS = 2.30 METERS

PLUME DATA
EFFECTIVE PLUME HEIGHT = 103.07 METERS
THE MAXIMUM CONCENTRATION OCCURS AT 1.42 KM
RECTILINEAR EQUATIONS USED

ISOPLETH DATA
THE 50% OF CONMAX ISOPLETH CLOSES AT 2.58 KM
THE 20% OF CONMAX ISOPLETH CLOSES AT 3.89 KM
THE 10% OF CONMAX ISOPLETH CLOSES AT 5.12 KM

PRODUCT DATA

PRODUCT	EMISSION RATE (g/sec)	TOTAL OUTPUT (Kg)	MAXIMUM CONCENTRATION (mg/m^3)
CO2	259.01	1.29	.15044
CLK	19.49	.10	.01132
HKO	24.45	.12	.01420
H2O	69.36	.35	.04028
N2	1470.06	7.32	.85384
O2	331.31	1.65	.19243
CK2O3(L)	97.84	.49	.05683

PRODUCT	MAXIMUM 8HR TWA (mg/m^3)	MAXIMUM 24HR TWA (mg/m^3)	MAXIMUM 1.00HR TWA (mg/m^3)
CO2	.00256845	.00085615	.02054760
CLK	.00019328	.00006443	.00154623
HKO	.00024247	.00008082	.00193978
H2O	.00068778	.00022926	.00550226
N2	.01457803	.00485934	.11662430
O2	.00328548	.00109516	.02628381
CK2O3(L)	.00097027	.00032342	.00776213

NOTE: THE TIME WEIGHTED AVERAGES ARE BASED ON MAXIMUM DOSAGE OVER THE AVERAGING TIME

Appendix C

Bangbox Test Series

HEADQUARTERS
U.S. ARMY ARMAMENT,
MUNITIONS AND CHEMICAL COMMAND

RECEIVED
MAR 2 - 9

FINAL REPORT

DEVELOPMENT OF METHODOLOGY AND TECHNOLOGY FOR IDENTIFYING AND QUANTIFYING EMISSION PRODUCTS FROM OPEN BURNING AND OPEN DETONATION THERMAL TREATMENT METHODS:

BANGBOX TEST SERIES

VOLUME 1
TEST SUMMARY

JANUARY 1992

Maintenance Management Division
Demilitarization and Technology Branch
Rock Island, Illinois 61299-6000
DSN: 793-3980/5534
Commercial: 309-782-3980/5534

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REPORT DOCUMENTATION PAGE

Form Approved
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1a REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b RESTRICTIVE MARKINGS None
2a SECURITY CLASSIFICATION AUTHORITY N/A	3 DISTRIBUTION / AVAILABILITY OF REPORT Unlimited
2b DECLASSIFICATION / DOWNGRADING SCHEDULE N/A	
4 PERFORMING ORGANIZATION REPORT NUMBER(S)	5 MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Andrulis Research Corporation Salt Lake City Office 6b. OFFICE SYMBOL (If applicable)	7a NAME OF MONITORING ORGANIZATION STEDP-MT-TM-A Dugway Proving Ground
6c. ADDRESS (City, State, and ZIP Code) 4600 East-West Highway, Suite 900 Bethesda, MD 20814	7b ADDRESS (City, State, and ZIP Code) Dugway, Utah 84022-5000
8a. NAME OF FUNDING / SPONSORING ORGANIZATION U.S. Army Armament, Munitions and Chemical Command 8b OFFICE SYMBOL (If applicable) AMSMC-DSM-D	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER Contract DAAD09-87-D-0008
8c. ADDRESS (City, State, and ZIP Code) Maintenance Management Division, Demilitarization and Technology Branch Rock Island, Illinois 61299-6000	10 SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO / PROJECT NO / TASK NO / WORK UNIT ACCESSION NO

11. TITLE (Include Security Classification)
Development of Methodology and Technology for Identifying and Quantifying Emission Products from Open Burning and Open Detonation Thermal Treatment Methods. BangBox Test Series - Volume 1, Test Summary

12. PERSONAL AUTHOR(S)
Mr. MacDonald Johnson

13a. TYPE OF REPORT	13b. TIME COVERED	14 DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
Final Report	FROM 12-88 TO 01-92	92 January	

16. SUPPLEMENTARY NOTATION

17 COSATI CODES			18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	open burning; open detonation; OB/OD; TNT; double base propellant; manufacturers residue propellant; air emissions; thermal treatment; carbon balance; emission factor; (Cont'd on reverse)

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The report addresses the gaseous and particulate sampling of TNT detonations and double-base and manufactures residue propellant burns. All trials were accomplished in an air supported building (BangBox). Sampling was accomplished with real time instruments for CO_2, CO, NO_x,O_3, and SO_2; canister samplers for SF_6, CO_2, CO, and volatile hydrocarbons; Quartz fiber filters with backup XAD-2™ resin cartridges for semivolatile organics, and various instruments for size and mass of particles. For each analyte measured an emission factor was calculated by the concentration times volume of the building and by the carbon balance method. The carbon balance method is based on the conservation of carbon in the detonation or burn and thus becomes the trace element used as the basis for determining emission factors. The mass balance of carbon in the TNT detonation was established in the BangBox with CO_2 contributing 97 percent of the total carbon, CO carbon (0.50 percent), semivolatile and non volatile organics carbon (0.57 percent), and soot (1.7 percent).
(Cont'd on reverse)

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT	21 ABSTRACT SECURITY CLASSIFICATION
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18. (Cont'd)

supercritical fluid chromatography; SFC; demilitarization; munition disposal; explosive disposal; environment; BB; air building

19. (Cont'd)

The tracer method (carbon balance) permits an emission factor estimate from every parcel of sampled air regardless of the homogeneity of the cloud whereas the concentrations times cloud volume method is only good when the concentration is constant throughout the entire cloud volume and the cloud volume can be measured. The test was successful in providing a method for obtaining emission factors in field testing, providing data to select samplers, and the effectiveness of the supercritical fluid chromatography assay for field detonations and burns of PEP material.

FOREWORD

A test planning directive to conduct the OB/OD test in support of U.S. Army Armament, Munitions and Chemical Command (AMCCOM) was issued by U.S. Army Test and Evaluation Command (TECOM) on 28 April 1988[1]. This test was conducted following the Technical Steering Committee Symposium which was convened in July 1988. The requirement for identifying and quantifying emissions from the open detonation of explosives and open burning of propellants was discussed in detail by authorities from throughout the military, academic, and commercial communities. Conclusions and recommendations developed during the symposium are reported in proceedings of the symposium[2].

The BangBox Test series report includes three volumes:

Volume 1. A summary which describes the planning phase, the conduct of trials, sample analyses and results, and the conclusions and recommendations. It is useful for those who need the background, synopsized results, conclusions, and recommendations without the complete details with the supporting data and information.

Volume 2. A stand-alone document which covers the detail of the complete test. It describes the test development, description of the test materiel, and the trial results as they relate to the test objectives and the explosives and propellants tested.

Volume 3. The quality assurance/quality control (QA/QC) report covers the QA/QC plan, detailed test plan, the letters of instruction (prepared for procedural instruction), the quality audits, the reports of the quality audits, and the results of the blind spikes analyzed by the laboratories.

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[1]Letter, AMSTE-TA-F, Headquarters, U.S. Army Test and Evaluation Command, Aberdeen Proving Ground, Maryland, 20 April 1988, subject: Test Planning Directive for Special Study of Open Burning/Open Detonation (OB/OD), Phase II, TECOM Project No 2-CO-210-000-017.

[2]*Proceedings of the Technical Steering Committee Symposium 6-8 July 1988*, Headquarters, United States Army Armament, Munitions and Chemical Command, Rock Island, Illinois, August 1991.

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ABSTRACT

Open burning (OB) and open detonation (OD) are currently the primary means of demilitarization employed by the Department of Defense (DoD) for the treatment of explosive residue, propellants, and munitions as they become unsafe, excess, obsolete, or unrepairable. Increasingly stringent requirements for environmental documentation of potential pollution/contamination from combustion products under such acts as the Clean Air Act, Clean Water Act, and Resource Recovery Act have resulted in a critical need for a test program to collect data to be used as a basis for informed decisions concerning the limitations/restrictions of OB/OD, the need for alternative methods where required, and maintaining an effective, economical, and environmentally safe means of accomplishing the required demilitarization/treatment.

Under the sponsorship of the Single Manager for Conventional Ammunition within the DoD, a symposium was conducted in July 1988[3] to develop planning concepts necessary to address the technical problems associated with an accurate environmental characterization of the OB/OD processes. Authorities from governmental, academic and private research organizations discussed the technical issues and concepts of testing, and the associated sampling and sample analysis technologies, data analysis processes, test organization, and preparation of reports that would be accepted by Federal and State regulatory agencies. Expertise represented included field sampling, instrumentation, field and laboratory analysis, environmental documentation, atmospheric dispersion, data processing, combustion and explosive phenomenology, and quality assurance/quality control. A technical steering committee (TSC) composed of recognized experts in their respective disciplines was formed under the leadership of the U.S. Army Armament, Munitions and Chemical Command Program Manager.

A list of volatile and semivolatile organic compounds and metals which are potential contaminants in either the soil or atmosphere from OB/OD processes was developed. A chamber (BangBox (BB)) test was conducted at Sandia National Laboratories to check out instrumentation, technology, methodology, and analytical procedures that were proposed for follow-on field tests to

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[3]*Proceedings of the Technical Steering Committee Symposium 6-8 July 1988,* Headquarters, United States Army Armament, Munitions and Chemical Command, Rock Island, Illinois, August 1991.

be sampled by the tested instrumentation placed on a fixed-wing aircraft flying through the plume. The field tests are required to obtain data to validate the technology and methodology for characterizing full scale OB/OD operations and establish correlations between the BB and full scale operations. If correlations can be established the less expensive BB type of testing may be used for emission characterization of various munitions and explosives in the demilitarization inventory. The U.S. Environmental Protection Agency (EPA) provided technical guidance and support during test planning and execution phases of test, review of data collection and analytical procedures, and assurance of instrument accuracy. Real time and near real time particulate and gaseous concentration measurements were achieved. These data were correlated with the samples collected on filters and gaseous containers and held for subsequent laboratory analysis. A methodology of using carbon balance to calculate more accurate emission factors of combustion products in diffusing clouds was verified.

The BB tests evaluated emission factors from 2,4,6-trinitrotoluene, OD and double- and composite-based propellants, OB. The tests confirmed the technologies, methodologies, and analytical procedures employed. These processes will be the basis for collecting and analyzing the data from the followon large-scale open-air tests scheduled for Phases A, B, and C to be conducted between June 1989 and September 1990. Further refinements will be made as required and approved by the TSC.

SECTION 1. INTRODUCTION

1.1. Open burning (OB) and open detonation (OD) are currently the primary means of demilitarization employed by the Department of Defense (DoD) for the treatment of explosive residue, propellants, and munitions as they become unsafe, excess, obsolete, or unrepairable.

1.2. The increasing need for data on OB/OD combustion products to support environmental documentation requirements, such as those of the Clean Air Act (CAA), Clean Water Act (CWA), and Resource Conservation and Recovery Act (RCRA) resulted in a critical need for a test program to collect data to be used as a basis for informed decisions concerning the limitations/restrictions of OB/OD, the need for alternative methods where required, and maintaining an effective, economical, and environmentally safe means of accomplishing the required demilitarization/treatment. The Single Manager for Conventional Ammunition within the DoD began to address this need in the early 1980's, and to provide scientific data to answer the question of environmental acceptability of OB/OD thermal treatment methods.

1.3. Although limited data are available from past studies on the generation of particulates and criteria pollutants from small-scale laboratory and field OB/OD operations, little field data are available on the levels of semivolatile organic emissions that result from unconstrained combustion of propellants by open-air burning or of explosives by open-air detonation. These compounds are difficult to collect and identify when produced in low concentrations. Thus, prior to the conduct of full-scale OB/OD field testing operations involving large quantities (thousands of kilograms) of explosives and propellants, a limited number of small-scale explosive detonation and burning trials were conducted within a controlled, ambient air environment. The test chamber used to provide this controlled environment was that operated by Sandia National Laboratories (SNL), Kirtland Air Force Base (AFB), New Mexico, and is locally known as the BB.

1.4. The purpose of this report is to describe the BB test technical issues, objectives, methodology development, conduct, data collection, analysis procedures, quality assurance/quality control procedures, results, and conclusions. At various places within the report or its appendices, this test is referred to as the BB, preliminary, or chamber test; these terms are considered equivalent.

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SECTION 2. TECHNICAL ISSUES

2.1. The Symposium

2.1.1. Background

OB/OD operations are conducted at a large number of DoD installations and activities. Each location has unique conditions of soil type, groundwater depth, vegetative cover, terrain, sensitivity to noise or airborne particulate levels, proximity to urban areas, and types of materials requiring demilitarization. Because of the common need of these installations and activities for high-quality data on combustion products to support permit applications and environmental documentation, the U.S. Army Armament, Munitions and Chemical Command (AMCCOM) OB/OD program manager established a technical steering committee (TSC) to provide advice and guidance on test planning, test conduct, and data analysis. In July 1988, a symposium was conducted in Salt Lake City, Utah, to develop the planning concepts necessary to address the many technical problems associated with conduct of a successful OB/OD test program. Authorities from governmental, academic, and private organizations discussed data requirements, sampling and sample analysis technologies, data analysis processes, test organization, and preparation of reports that would be accepted by Federal and State regulatory agencies. Disciplines represented at this symposium included test planning; field sampling; instrumental, field, and laboratory analysis; environmental documentation; atmospheric dispersion; data treatment; combustion and explosive phenomenology; and quality assurance/quality control (QA/QC). It was at this time that the TSC, composed of recognized experts in their respective disciplines, was formed. The results of this symposium are outlined in a separate report[4] and briefly summarized below.

2.1.2. Results.

2.1.2.1. The symposium recognized that open-air, surface detonations of explosives produce a short-term, high-temperature buoyant fireball of oxidizing gases which may entrain soil and which

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[4] *Proceedings of the Technical Steering Committee Symposium 6-8 July 1988,* Headquarters, United States Army Armament, Munitions and Chemical Command, Rock Island, Illinois, August 1991.

disperses rapidly downwind after reaching the cloud stabilization height (Figures 2.1 through 2.3). Typical propellant burns (Figures 2.4 and 2.5) produce extremely luminous, hot plumes over several seconds and with little soil involvement. They also permit more entrainment of ambient oxygen to assist in oxidation; however, they generate a less well-defined cloud, than surface detonations.

2.1.2.2. Because of the differences in explosive and propellant composition, geometry, and combustion phenomenology, it was suggested that chamber trials be conducted first using the following explosive and propellants:

2.1.2.2.1 The explosive 2,4,6-trinitrotoluene (TNT), the most oxygen-deficient (-74 percent) of the military explosives, and therefore the most likely to produce significant amounts of the products of incomplete combustion.

2.1.2.2.2 A double-base propellant containing primarily nitrocellulose and nitroglycerin with added ethyl cellulose.

2.1.2.2.3 A composite propellant containing ammonium perchlorate.

2.1.2.3. Product compositions and concentrations could then be compared with widely variable results reported in earlier computer-modeled combustion product studies and with laboratory-scale and less-controlled open-air detonation and burn studies reported in the literature.

2.1.2.4. To assess the effect that soil might have on product composition by its quenching of complete oxidation during TNT detonation, without puncturing the chamber's fabric walls, it was suggested that a surrogate fireball-mitigating material (aqueous foam) should be used to surround the TNT block on one of the detonation trials.

2.1.2.5. The air building chamber (the BB) at SNL (Figure 2.6) was chosen as the test facility because it offered several advantages over other facilities and devices designed to contain explosions. These advantages are as follows:

Figure 2.1 Typical Initial Fireball Formation, 907-kg (2000-lb) TNT OD Test.

Figure 2.2 Typical Cloud Formation With Entrained Soil, 907-kg (2000-lb) TNT Open Detonation Test.

Figure 2.3 Typical Stabilized Cloud Formation Prior to Downwind Dispersal, 907-kg (2000-lb) TNT Open Detonation Test

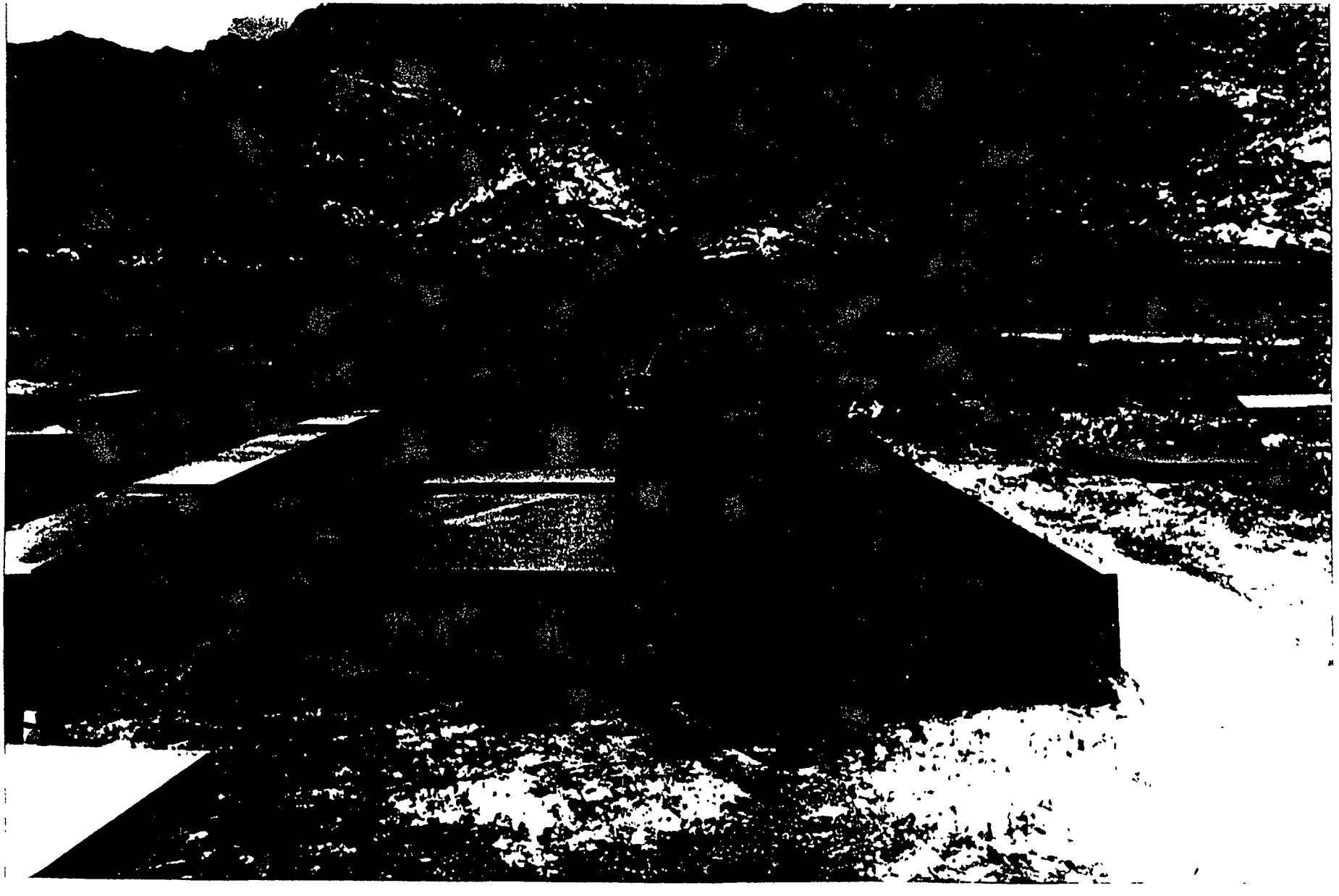

Figure 2.4 Partially-Filled Burn Pans, 3175-kg (7000-lb) Propellant Open Burn Test.

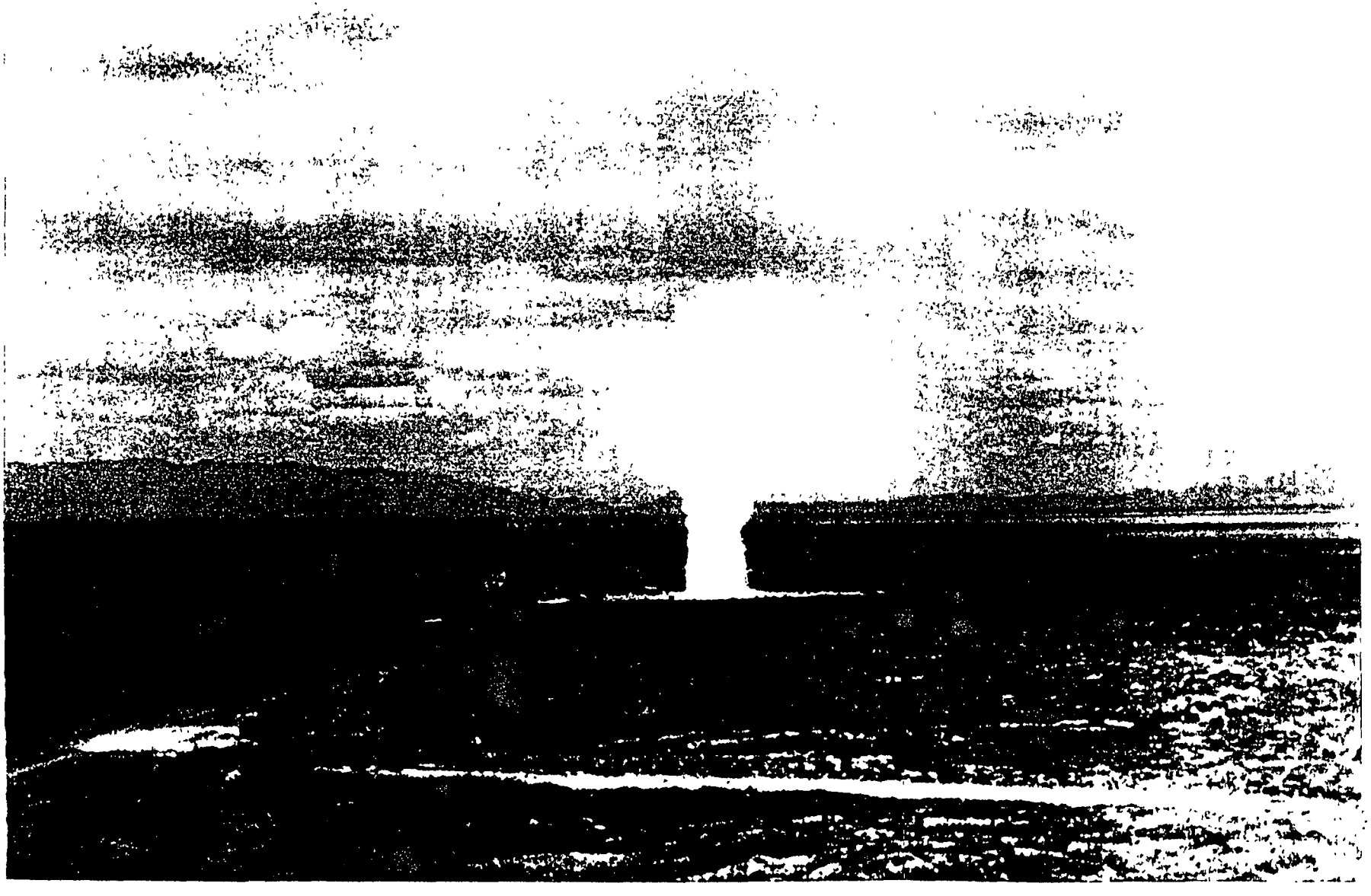

Figure 2.5 Typical Plume, 3175-kg (7000-lb) Propellant Open Burn Test.

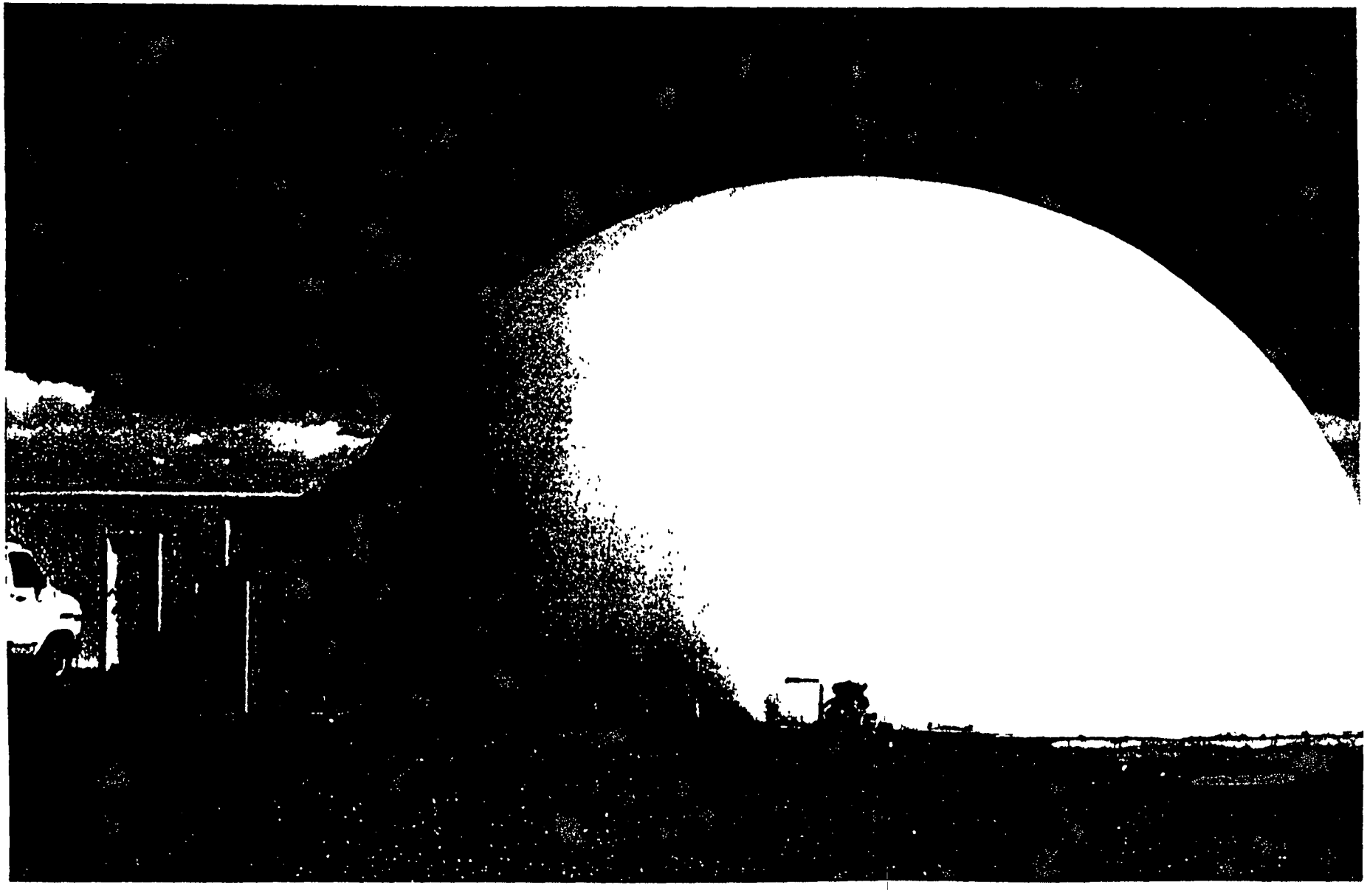

Figure 2.6 SNL BangBox Test Facility Containing Sampling and Real-Time Analysis Equipment.

2.1.2.5.1 It was large enough to permit complete combustion and containment of the product clouds from 227 grams (0.5 lb) of explosive and similar quantities of burning propellants.

2.1.2.5.2 There would be no significant spall from the aluminum-covered concrete floor to interfere with sample collection and analysis.

2.1.2.5.3 The same instruments, samplers, and data handling equipment that were proposed to be mounted in a fixed-wing aircraft (FWAC) to sample outdoor OB/OD clouds during later study phases could be completely checked under the controlled conditions of the BB trials. The FWAC planned for use is shown in Figures 2.7 and 2.8.

2.1.2.6. Characterization of the BB test facility included a determination of ventilation rate (using tracer gas) and a determination of the ability to achieve internal atmospheric homogeneity in the chamber using mixing fans. Sulfur hexafluoride (SF_6) and CO_2 would be used as tracer gases.

2.1.2.7. A list of target analytes would be developed covering gaseous criteria pollutants, volatile and semivolatile organic compounds, unreacted explosive/propellants and their manufacturing by products/contaminants, regulated metals and nonmetals, and other potentially detrimental organic compounds. The concentrations of these OB/OD products would then be determined by applying the most sensitive, reproducible, and versatile analytical methods available. Competing analytical technologies, such as gas chromatography-mass spectrometry (GC/MS) and supercritical fluid chromatography-mass spectrometry (SFC/MS), would be evaluated.

2.1.2.8. Sampling equipment and techniques would be evaluated for possible later use in the SNL FWAC during large-scale outdoor trials.

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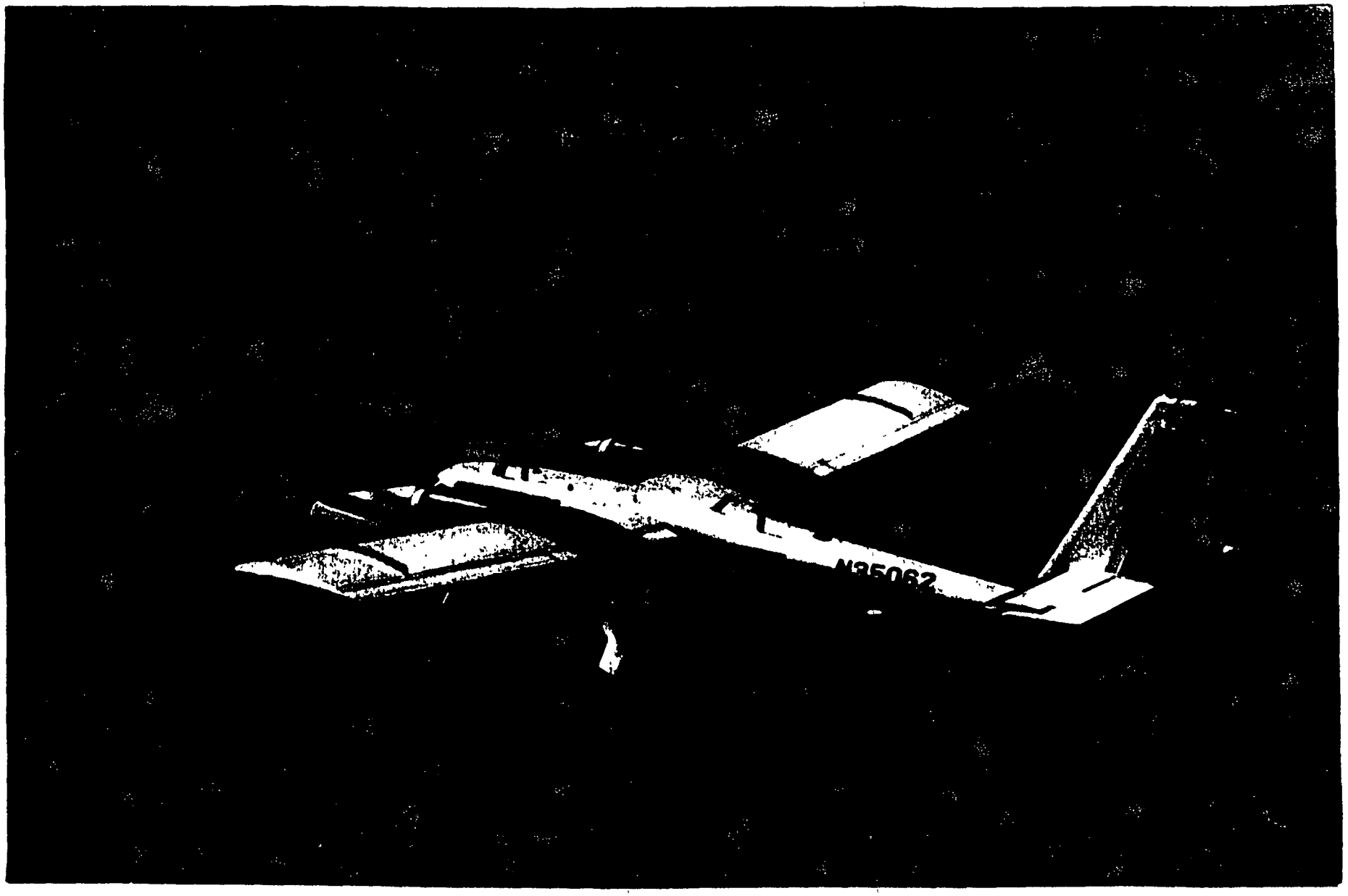

Figure 2.7 SNL Twin Otter Instrumented Fixed-Wing Aircraft for Open-Air OB/OD Sampling and Real-Time Gas Analysis

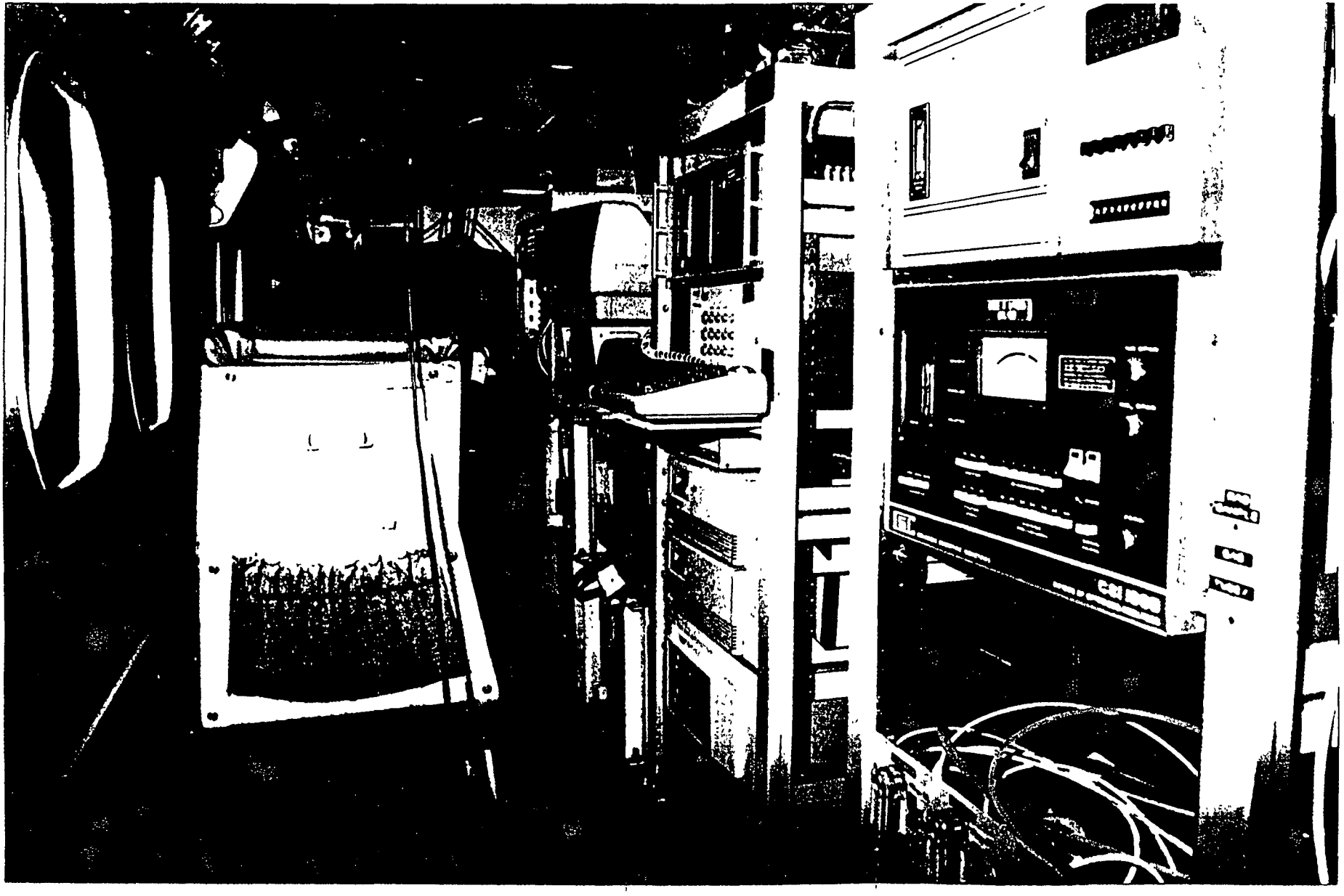

Figure 2.8 Interior View, Partial Instrument Array, SNL Fixed-Wing Aircraft.

2.1.2.9. The widely used method of estimating initial source strengths of emissions within OB/OD clouds yields extremely variable results, because the ultimate accuracy of the estimate depends not only on difficult-to-measure very low concentrations of compounds in the elevated, diffusing cloud, but also on very speculative estimates of the cloud's volume. SNL proposed an alternative method (the carbon balance method) to be evaluated during the chamber trials that did not depend on making a cloud volume estimate. This method would permit a more accurate calculation of emission factors of combustion products in diffusing clouds especially when the fuel's carbon content is well-characterized, and the concentrations of the major carbon-containing products can be accurately measured.

2.1.2.10. Adequate QA/QC procedures for use in sample collection, handling, analysis, and data treatment would need to be developed, checked, approved, and revised (where necessary) before conducting the expensive large-scale outdoor OB/OD trials.

2.2. Test Design Plan

After proposed solutions to technical issues were identified by the TSC, an AMCCOM test design plan was prepared. Formal BB testing began on 7 December 1988.

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SECTION 3. STUDY OBJECTIVES

3.1. Overall Test Program

3.1.1. Purpose

The broad overall program purpose is to supply waste characterization data for OB/OD permit applications under RCRA subpart X.

3.1.2. Objectives

3.1.2.1. Identify and/or develop sampling and analytical technology, instrumentation, and procedures needed to provide RCRA subpart X data characterization.

3.1.2.2. Identify and quantify emissions and residues produced by OB/OD thermal treatment methods.

3.1.2.3. Provide input for development and validation of an OB/OD dispersion model.

3.1.2.4. Identify specific items that can be treated by OB/OD thermal treatment methods without adverse environmental impact.

3.2. BangBox Test Series

3.2.1. Purpose

The OB/OD BB test series was designed to develop, verify and confirm the OB/OD thermal treatment method test technology/methodology.

3.2.2. Objectives

3.2.2.1. Characterize the BB chamber volume, ventilation rate, and combustion product cloud homogeneity level.

3.2.2.2. Develop and improve proposed air sampling equipment and sample analysis procedures to be used in later phases on the FWAC, for sampling product clouds from large-scale follow-on field OB/OD trials.

3.2.2.3. Refine, standardize, and compare supercritical-fluid chromatography (SFC) and gas chromatography (GC) techniques for extracting and analyzing resins, filters, and soils for trace quantities of semivolatile organic OB/OD combustion products and residues, using mass spectrometer (MS) detectors.

3.2.2.4. Verify adequacy of other standard analytical methods to be used for analyses of gases, particulates, volatile organic compounds, metals, and nonmetals.

3.2.2.5. Identify and quantify specific target analytes for TNT, a double-base propellant, and a composite propellant.

3.2.2.6. Assess polychlorinated dibenzodioxins (PCDD) and dibenzofurans (PCDF) levels generated from burning the composite propellant containing high concentration of NH_4ClO_4.

3.2.2.7. Provide information on the morphology, composition, and size distributions of airborne particulate material generated by OB/OD operations in the BB.

3.2.2.8. Examine, using data produced under controlled conditions, the validity of the proposed Carbon Balance method of calculating emission factors; compare the results with those calculated using the more-conventional cloud volume times concentration method.

3.2.2.9. Identify or develop appropriate program-specific QA/QC procedures.

3.2.2.10. Develop and establish procedures for transport and storage of sample specimens.

SECTION 4. TEST CONDUCT

4.1. Test Activities

Key test activities were conducted as outlined in Table 4.1.

Table 4.1 Key BangBox OB/OD Test Activities.

DATE	Key Test Activities
7 DEC 88	Single-charge (227-g) TNT OD: check out setup, equipment, procedures.
31 JAN 89	Single-charge (227-g) TNT OD data trial: chamber air homogeneity, volume, ventilation rate.
2 FEB 89	
6 FEB 89	
7 FEB 89	Extended (6-h) background air sampling inside and outside BB.
8 FEB 89	Multiple detonation (8 consecutive 227-g) TNT OD data trials: provided high concentrations of accumulated products.
9 FEB 89	454-g double-base propellant OB data trial.
13 FEB 89	Aqueous foam-attenuated (227-g) TNT OD data trial.
15 FEB 89	Multiple tank sampling 227-g TNT OD data trial: simultaneous air sample collection in 27 32-L tanks ("Big Gulp" trial).
16 FEB 89	454-g composite propellant OB data trial.

4.1.1. Facilities, Sampling Equipment, Materials, and Procedures.

4.1.1.1. As shown in Figure 2.6 (on page 2-13) the BB test facility is an air-supported, rubber-coated fabric hemisphere with a radius of 7.6 meters. Access to the building was through a plywood airlock, 5.5 x 2.1 x 2.5 meters in size. The building was supported by positive air pressure supplied by a blower. A damper on the outlet of the blower permitted adjustment of inflation airflow rate and positive pressure inside the building. The blower damper was manually adjusted to achieve an initial pressure differential of approximately 18 mm of water.

4.1.1.2. A number of OB/OD sampling instruments, normally installed on the FWAC, were positioned in the airlock and inside the chamber to test their performances. Gas and particulate samples were routed to airlock instruments via a 5-meter long, 8-cm diameter aluminum tube that projected 2 meters into the BB chamber. This tube is the same as that normally installed on the instrumented aircraft and serves as the sampling probe from which all particulate and gas samples

are collected during flight. A matrix of instruments and equipment used in each trial is shown in Tables 4.2a and 4.2b.

4.1.1.3. The schematic layout of sampling equipment mounted in the BB airlock and used on trials subsequent to 7 December, 1989, is shown in Figure 4.1. The airflow from the interior chamber was routed through a pneumatically driven 10-cm diameter gate valve into a 1.5-m^3 carbon-impregnated polyethylene (Velostat™) sampling bag. The bag, which was constructed of electrically conductive plastic material to minimize wall loss effects of charged particles, fills with air from the chamber interior in approximately 40 seconds.

4.1.1.3.1 Stainless steel sampling lines led to a series of filters, vapor collection systems, and gas monitors. Particulate and semivolatile compounds were collected on two semivolatile organic sampling trains (SEMI-VOSTs), which consisted of a prefired quartz-fiber filter, followed by two sections containing XAD-2™ resin. The front and backup sections contained approximately 65 and 20 grams of resin, respectively. Other filters connected to the bag outlet manifold included a Teflon™ filter, used for gravimetric analysis and X-ray fluorescence (XRF) measurements, and a Nuclepore™ polycarbonate filter used for scanning electron microscopy (SEM). A pump provided airflow through the filters at a rate of approximately 200 L/min. Mass flowmeters enabled determination of air sample volumes.

4.1.1.3.2 Real-time continuous monitors used to provide data for this report are listed in Table 4.3. In-line Teflon™ filters were provided for all these monitors to prevent particulate contamination of the instrument optics. A differential mobility particle sizer (DMPS) was used to measure particle size distributions in the 0.01- to 0.5-μm diameter range. Grab samples of air were collected in electropolished stainless steel canisters directly from the sampling duct, and indirectly from the 1.5-m^3 sampling bag, by Oregon Graduate Center (OGC) personnel. The grab samples were analyzed by OGC for H_2, CO, CO_2 and C_1 - C_{10} hydrocarbon concentrations, using (GC) with thermal conductivity detector (TCD), flame ionization detector (FID) (for SF_6), and electron capture detector (ECD). Hereafter, all samples collected and analyzed from the bag will be referred to as indirect samples.

Table 4.2a Matrix of Instrument, Sampler, and Collector Used During the OB/OD Detonation BangBox Test.

Item	Trial Number[a]									
	1	2	3	4	5	6	7	8	9	10
PARTICLE SIZERS										
DMPS[b]	X	X	X		X	X	X	X		
APS[c]	X		X	X		X	X	X	X	X
FILTERS										
Teflon™			X	X			X	X		X
Nuclepore™			X	X			X	X		X
XAD-2™			X	X	X	X	X			X
Porapak-R™			X							
Quartz-fiber			X	X	X	X	X	X		X
DETECTORS										
Nephelometer			X	X		X	X	X	X	X
FID[d]			X					X		
PID[e]	X		X	X		X	X	X	X	X
ANALYZERS										
CO_2	X	X	X	X		X	X	X	X	X
CO	X	X	X	X		X	X	X	X	X
SO_2	X	X	X	X		X	X	X	X	X
O_3	X	X	X	X		X	X	X	X	X
NO_x	X	X	X	X		X	X	X	X	X
SF_6	X	X	X	X		X	X	X	X	X
BUBBLERS										
HCN			X	X		X	X			X
NH_3			X	X		X	X			X
HCl										X
BAG										
1-m^3	X		X	X			X	X		X

NOTE: Footnotes identified on next page.

Table 4.2b Matrix of Instrument, Sampler, and Collector Used During the OB/OD Detonation BangBox Test.

	Trial Number[a]									
Item	1	2	3	4	5	6	7	8	9	10
TANKS/CANISTERS										
0.85-L	X	X	X	X			X		X	X
6-L	X		X	X			X	X	X	X
32-L	X		X	X					X	
CAMERAS										
Color Video	X	X	X	X		X	X	X		X
HS[f]							X	X		X
HS Film	X		X							
MISCELLANEOUS										
Thermometer	X	X	X	X	X	X	X	X	X	X
Barometer	X	X	X		X	X	X	X	X	X
DP[g] Gauge	X	X	X	X		X	X	X	X	

[a]Trial: 1 - Homogeneity and BB Chamber Volume (1 Dec 88).
2 - Ventilation Rate (5 Dec 88).
3 - Single-Charge TNT OD (7 Dec 88).
4 - Single-Charge TNT ODs (31 Jan 89, 2 and 6 Feb 89).
5 - Extended Background Air Sampling (7 Feb 89).
6 - Multiple Detonation (8 Feb 89).
7 - Double-Base Propellant OB (9 Feb 89).
8 - Foam-Attenuated TNT Detonation (13 Feb 89).
9 - Multiple Tank Sampling ("Big Gulp") OD Trial (15 Feb 89)
10 - Composite Propellant Burn (16 Feb 89).

[b]Differential mobility particle sizer.
[c]Aerodynamic particle sizer
[d]Flame ionization detector.
[e]Photoionization detector.
[f]High-speed.
[g]Differential pressure.

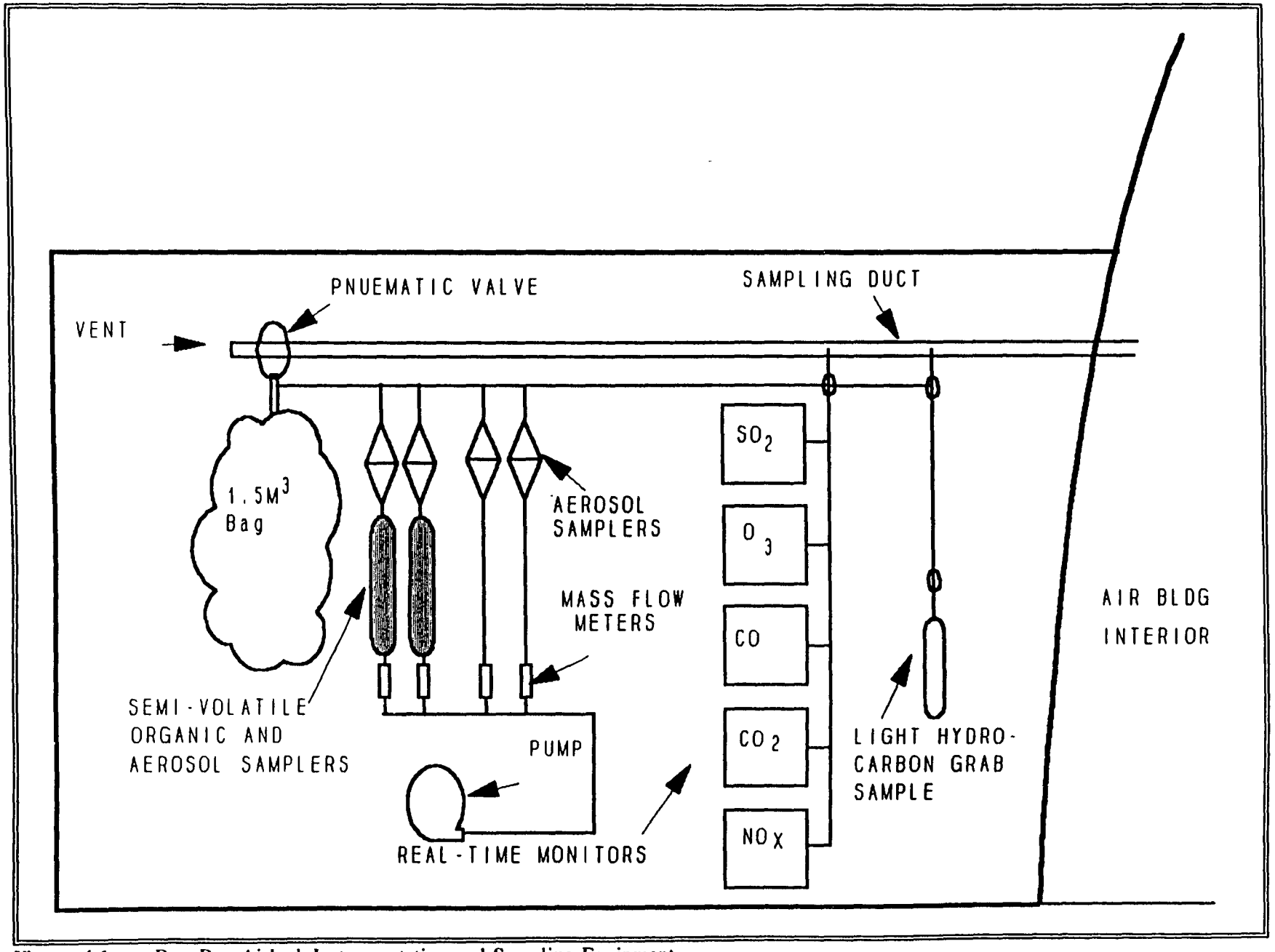

Figure 4.1 BangBox Airlock Instrumentation and Sampling Equipment.

Table 4.3 OB/OD Real-Time Continuous Monitors Positioned in the SNL BangBox Airlock.

SPECIES	INSTRUMENT	MEASUREMENT PRINCIPLE	DETECTION LEVEL[a]
CO_2	TECO Model 41H	Gas Filter Correlation	1.2 ppmv
CO	TECO Model 48	Gas Filter Correlation	0.1 ppmv
SO_2	TECO Model 43	Pulsed UV Fluorescence	2 ppbv
O_3	TECO Model 49	UV Absorption	5 ppbv
NO_x	CSI Model 1600	Chemiluminescence	6 ppbv
THC	Century OVA-128	Flame Ionization	2 ppmv
THC[b]	HNU Model PI-101	Photoionization	0.1 ppmv

[a]Detection level defined as two times the standard deviation of the instrument noise.

[b]The photoionization detector responds to other gaseous species in addition to hydrocarbons. No attempt is made in this study to correct for the non-specificity of this instrument. Hydrocarbons detected were quantitated separately by GC methods outlined elsewhere in this report.

4.1.1.3.3 In order to make direct measurements of interior chamber air following a detonation or burn, additional instruments and samplers were positioned inside the BB facility, as shown schematically in Figure 4.2. The various instruments included are listed in Table 4.4.

4.1.1.3.4 Two laser particle spectrometers that are normally installed in the SNL FWAC were used to make particulate measurements in real-time. Particles in the 0.15- to 3-μm diameter range were measured with an active scattering aerosol spectrometer probe (ASASP). Particles in the 2- to 47-μm diameter range were measured with a forward scattering spectrometer probe (FSSP). The FSSP probe is designed to incorporate true *in situ* measurement principles and, as such, requires no correction for particle transmission or sampling losses. Both the FSSP and ASASP probes provided records of total particle counts at 1-minute intervals.

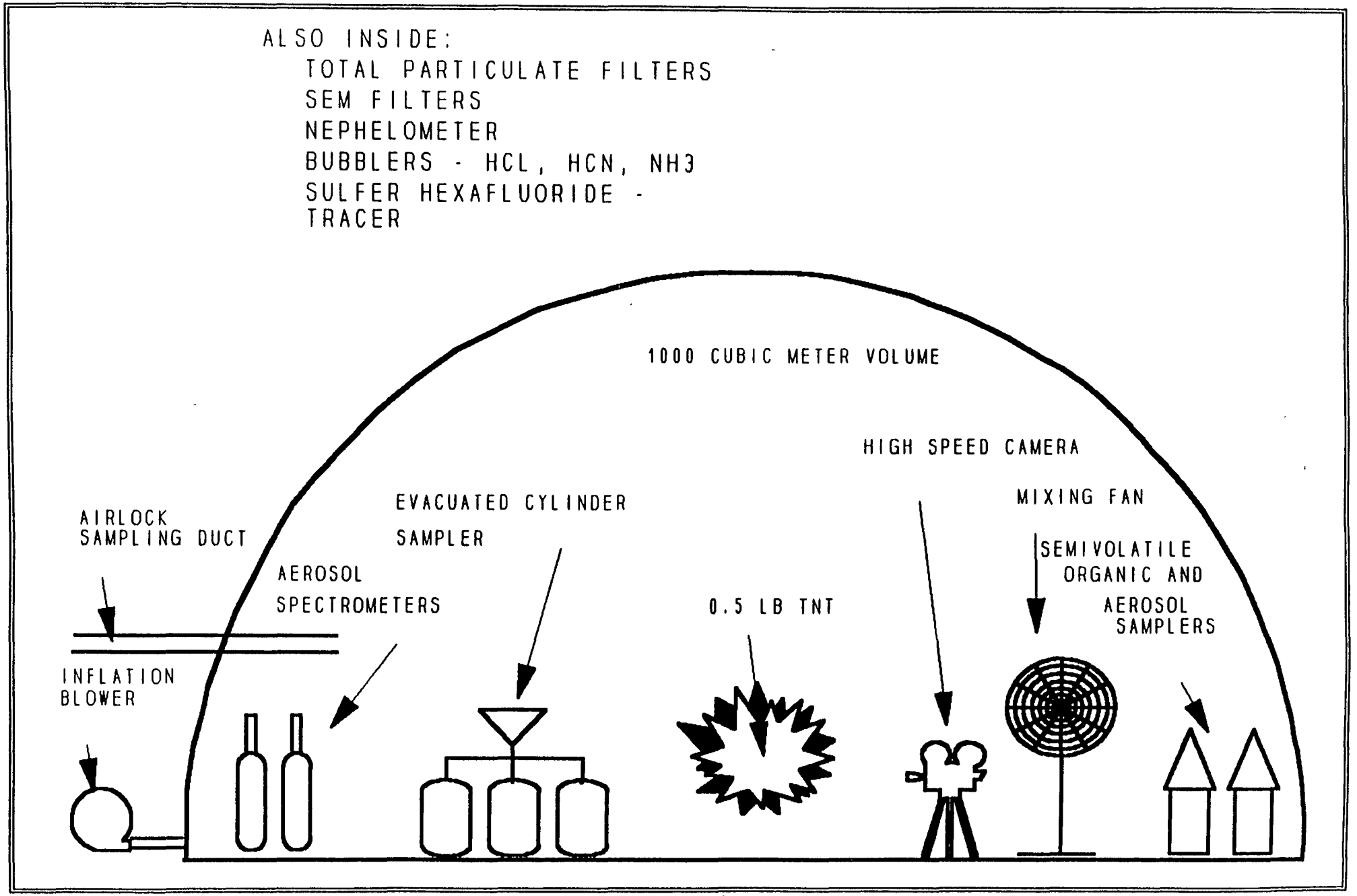

Figure 4.2 SNL BangBox Interior OB/OD Sampling Instrumentation and Equipment.

Table 4.4 Samplers Located Inside the BangBox.

Instrument - Parameter Measured	Model (Characteristics)
Aerosol spectrometer - particle size distribution	PMS ASASP-100X (0.15 - 3 μm diameter)
Aerosol spectrometer - particle size distribution	PMS FSSP-100-X (2 - 47 μm diameter)
Integrating nephelometer - particulate concentration	Belfort Ind. Model 1590 (0 - 3 μm diameter)
Nephelometer - particulate concentration	MIE Model RAM-1 (0 - 3 μm diameter)
Video camera - photometric record	NAC Model HSV-200 (200 frame/s)
Fast frame camera - photometric	NAC Model E-10 (500 - 10000 frame/s)
semi-VOST[a] (2) - trace organics	GMW Model PS-1 (≈ 100 L/min)
Teflon™ filter sampler - total particulate and metals.	GAST Model 30 (30 L/min)
Polycarbonate filter sampler - particle morphology	GAST Model 30 (3 L/min)
Bubbler sampler - Hydrogen cyanide	Gillian Model 113FS (2 L/min)
Bubbler sampler - Ammonia	Gillian Model 113FS (2 L/min)
Bubbler sampler - Hydrogen chloride[b]	Gillian Model 113FS (2 L/min)
Evacuated stainless steel canisters - volatile organics	OGC special design (6-L)
Evacuated stainless steel tanks - volatile and semivolatile organics	OGC special design (32-L)
Evacuated stainless steel canister - SF_6	OGC special design (0.85-L)

[a]semiVOST - semivolatile organic sampling train.
[b]Hydrogen chloride bubblers were used only on the composite propellant burn trial.

4.1.1.3.5 A flash-lamp integrating nephelometer and a portable forward light scattering particulate detector provided continuous measurement of particulate concentration inside the chamber during each test. Photographic coverage of detonation and burn trials was provided by video cameras and recorders and with a high-speed camera run at 5,000 frames per second. Two 1-meter diameter fans with approximate airflow rates of 250 m^3/minute were used to rapidly mix the BB chamber air prior to collection of "homogeneous" air samples. Samples collected from the chamber interior immediately after detonation or burn and before turning on the mixing fans are considered to be nonhomogeneous.

4.1.1.3.6 Semivolatile and organic particulate species were collected directly from the chamber interior by two modified semiVOSTs operating at flow rates of approximately 100 L/min. The filter and cartridge units used in these semiVOSTs were identical to those used for collection of air drawn from the 1.5-m^3 sampling Velostat bag mounted in the airlock. Standard high-volume sampler blowers were used to pull air through these direct semiVOST units.

4.1.1.3.7 As a result of these sampling arrays, data from both direct (chamber) and indirect (bag) sampling during both nonhomogeneous and homogeneous air sampling periods could be compared. Glass impingers (bubblers) filled with appropriate absorbing solutions were used to collect ammonia and hydrogen cyanide product gases.

4.1.1.3.8 An audit of criteria gas and mass flow instrument performance was conducted by personnel from the U.S. Environmental Protection Agency (EPA), Atmospheric Research and Exposure Assessment Laboratory, Quality Assurance Division, Research and Monitoring Evaluation Branch, Research Triangle Park (RTP), North Carolina. Results of the audit were excellent.

4.1.1.3.9 Teflon™ filter particulate sample weights were determined gravimetrically by precision electrobalance. The Teflon™ filters were then analyzed by XRF spectroscopy (for elements with atomic mass units in excess of 12) by Lawrence Berkeley Laboratory (LBL). Particulate carbon speciation was done by Sunset Laboratory (SSL) on 1-cm^2 punches taken from SEMI-VOST quartz-fiber filter samples. This thermo-optical analysis involves a two-step volatilization and combustion process to differentiate between organic, elemental, and inorganic carbon on the filter. Bubbler samples were analyzed by National Institute for Occupational Safety and Health (NIOSH) method 205 (colorimetric) for NH_3 and NIOSH method 116 (cyanide-specific ion electrode) for HCN. Trace-level semivolatile organic compounds from semiVOST filters, XAD-2™ resins, cartridges, swab samples, and 32-L tanks were identified, separated, and quantified by both Battelle Columbus Division (BCD) and by Alpine West Laboratories (AWL). Battelle used GC/MS and AWL used SFC/MS for analysis of solutions prepared by extraction of sample media with methylene chloride followed by concentrating by rotary evaporation.

4.1.1.3.10 During the composite propellant burn, high-volume air samplers sampling at 283 L/min were also used to take duplicate samples on quartz-fiber filters. The filters were backed up by pre-cleaned polyurethane foam-filled cartridges. Analyses were made for PCDD and for PCDF by BCD. The analyses included determination of total hepta-, hexa-, penta-, and tetra-chlorinated dibenzodioxin (CDD) and -chlorinated dibenzofuran (CDF) congeners, as well as octa- and 2,3,7,8-tetra-CDD and - CDF concentrations. Taking into account the relative toxicities of the congeners and converting the results to an equivalent quantity of the most toxic, only 2 ng of PCDD and 3.3 μg of PCDF were detected per ton of composite propellant.

4.2. Chronology

A typical chronology of events for a TNT detonation trial is shown in Table 4.5. The chamber was washed and the floor vacuumed before detonation trials began. Event chronology for the propellant burn and foam-attenuated TNT detonation trials was similar, except for fuel setup configurations and modifications of sampling procedures because of unique data requirements for those trials. A typical detonation of a suspended rectangular 227gram (0.5 lb) TNT block is shown in Figure 4.3. On completion of each trial, samples were collected, sealed, stored at ambient temperatures (usually 0 to 5°C), and subsequently transported to the various laboratories for extraction.

Table 4.5 Typical Chronology of Events for a TNT Detonation Trial.

Time[a] (min)	Event
t-75	Install background filters, SEMI-VOST cartridges, bubblers. Record initial flow rates on all samplers. Check zero and span on all continuous monitors.
t-60	Clear all personnel from chamber interior. Begin background sampling with all instruments and samplers.
t-30	Complete background sampling. Record final flow rates on all samplers. Remove background sampling media. Install all test filters, SEMI-VOST cartridges, bubblers, etc. Record initial flow rates on all samplers.
t-15	Hang 227-g (0.5-lb) TNT charge in test fixture.
t-5	Start data acquisition on all continuous instruments. Clear all personnel to safe bunker. Connect detonator cable to charge and arm.
t-0	Detonate charge.
t+3	Remotely start all filter and SEMI-VOST samplers inside chamber. Collect nonhomogeneous sample No. 1 from sampling bag. Pump bag sample through sampling media in airlock. Switch criteria gas monitors to sample directly from bag for 3 minutes. Fill 6-L evacuated cylinder from interior of chamber.Fill 6-L evacuated cylinder from bag.
t+5	Switch mixing fans on for 3 minutes.
t+10	Change sampling media on bag system.
t+15	Collect homogeneous (mixed) air sample No. 1 in sampling bag. Pump bag sample through sampling media. Switch criteria gas monitors to sample directly from bag for 3 minutes. Fill 6-L evacuated cylinder from interior of chamber. Fill 6-L evacuated cylinder from bag.
t+25	Change sampling media on bag system.
t+30	Collect homogeneous sample No. 2 from sampling bag. Pump bag sample through sampling media. Switch criteria gas monitors to sample directly from bag for 3 minutes. Fill 6-L evacuated cylinder from chamber interior. Fill 6-L evacuated cylinder from bag.
t+35	Stop direct SEMI-VOST, filter, and bubbler samplers. Reenter chamber and measure final sampler flows.
t+45	Check zero and span on all continuous monitors. Retrieve and back-up all test data. Collect and preserve all sampling media.

[a]t = time of detonation.

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Figure 4.3 Detonation Fireball from Suspended 227-g (0.5-lb) TNT Block Detonation in BangBox.

SECTION 5. SAMPLE ANALYSIS AND ANALYSIS RESULTS

5.1. Sample Handling and Analysis

Sample handling and analysis procedures are outlined in individual laboratory Letters of Instruction (LOIs) (See Volume 3).

5.2. Chemical Compounds Targeted for Analysis

5.2.1. Potentially hazardous substances for which present data was most lacking relative to OB/OD operations were the trace organic compounds, sometimes called products of incomplete combustion (PIC), formed in any combustion process that is less than ideal. The application of the term PIC to OB/OD operations is somewhat misleading, because it may imply that these organic substances occur as a part of the original mass of uncombusted material that happens to escape complete oxidation. In actuality, the OB/OD PIC are formed by pyrolysis of organic matter at flame temperatures. They occur in the combustion effluent because insufficient oxygen is present and/or thermodynamic equilibrium with the environment is not achieved because of premature quenching. Because of electron delocalization, these exotic organic compounds have large atomic bonding energies, and are thermodynamically stable at high temperatures. Furthermore, certain polycyclic aromatic hydrocarbons, along with their nitrogen or oxygen heterocyclic counterparts and their nitro and/or amino derivatives, are among the most mutagenic of known organic compounds. Consequently, such compounds received major attention when targeting certain semivolatile organic compounds for specific analysis. The PIC of greatest interest to OB/OD activities can be placed in eight main groups: (1) residual primary explosives, (2) propellants and their contaminants; (3) inorganic gases, (4) particulates, (5) volatile and semivolatile (exotic) organics, (6) other pyrolysis/combustion products, (7) metals, and (8) anions. Target compounds for detailed analysis from each of these groups were selected by the technical steering committee in July 1988; the target analyte lists were modified slightly after preliminary results were studied.

5.2.2. A consolidated list of chemical compounds targeted for analysis (target analytes), together with a notation as to whether or not they were detected above background levels by detailed sample analysis, is shown in Tables 5.1a, b, c, d, e, and f.

Table 5.1a Target Analytes Detected Above Background Levels for TNT Detonations, Double-Base Propellant Burn, and Composite Propellant Burn in the BangBox Test.

Species	TNT	Double-Base	Composite
Carbon dioxide	X[a]	X	X
Carbon monoxide	X	X	X
Nitrogen dioxide	X	X	X
Nitric oxide	X	X	X
Sulfur dioxide	X	X	X
Ozone	-[b]	X	ND[c]
Methane	X	X	X
Acetylene	X	X	X
Benzene	X	X	X
PARAFFINS			
n-Heptane	X	X	X
2,4-Dimethylhexane			
2-Methylheptane	X	X	X
2-Methylpentane	X	X	
3-Methylpentane	X	X	
Ethylcyclohexane			
n-Hexane	X	X	X
i-Butane	X	X	
Methylcyclopentane	X	X	X
n-Butane	X		
2,4-Dimethylpentane	X		
2,2-Dimethylpropane			
Cyclohexane	X	X	
n-Pentane	X	X	
2,3-Dimethylpentane	X	X	X
Cyclopentane	X	X	X
3-Methylhexane	X		X
n-Octane	X	X	X
Ethane	X	X	X
2,3-Dimethylhexane	X		
Methylcyclohexane	X	X	X
2,3,4-Trimethylpentane	X	X	
n-Nonane	X	X	X

See Table 5.1f for notes.

Table 5.1b Target Analytes Detected Above Background Levels for TNT Detonations, Double-Base Propellant Burn, and Composite Propellant Burn in the BangBox Test.

Species	TNT	Double-Base	Composite
PARAFFINS (cont'd)			
2,3-Dimethylbutane	X	X	X
2,2,3-Trimethylpentane			
i-Pentane	X	X	X
Propane	X	X	X
2,2-Dimethylbutane	X		X
3-Ethylhexane	X	X	X
OLEFINS			
Ethylene	X	X	X
2-Methyl-1-pentene			
Propene	X	X	X
1-Butene	X	X	X
trans-2-Hexene			
3-Methyl-1-butene			
Mycrene			
Isoprene			
1,3-Butadiene	X	X	X
trans-2-Pentene			
cis-2-Butene		X	X
cis-2-Hexene			X
1-Pentene	X		
2-Methyl-2-butene			
1-Hexene			
4-Methyl-1-pentene			X
trans-2-Butene		X	X
i-Butene	X	X	X
2-Methyl-2-pentene			
2-Methyl-1-butene	X	X	
cis-2-Pentene			
Cyclopentene		X	X

See Table 5.1f for notes.

Table 5.1c Target Analytes Detected Above Background Levels for TNT Detonations, Double-Base Propellant Burn, and Composite Propellant Burn in the BangBox Test.

Species	TNT	Double-Base	Composite
NONBENZENE AROMATICS			
Toluene	X	X	
3-Ethyltoluene	X	X	
1,3,5-Trimethylbenzene			
n-Propylbenzene		X	
1-Ethyltoluene			
Styrene	X	X	X
i-Propylbenzene			
2-Ethyltoluene			
Ethylbenzene	X	X	X
o-Xylene	X	X	X
p-Xylene	X	X	X
m-Xylene			
1,2,4-Trimethylbenzene & sec-Butylbenzene			
TERPENES			
β-Pinene			
α-Terpinene			
d-Limonene			
α-Pinene			
Δ^3-Carene			
γ-Terpinene			
Terpinolene			
SEMIVOLATILE ORGANICS			
2,6-Dinitrotoluene	X	X	X
4-Nitrophenol	X	X	X
2,4-Dinitrotoluene	X		X
2-Nitronaphthalene	X	X	X
2,4,6-Trinitrotoluene	X	X	
1-Nitropyrene	X		X
1,6-Dinitropyrene			
Phenol	X	X	X
Dibenzofuran	X	X	X

See Table 5.1f for notes.

Table 5.1d Target Analytes Detected Above Background Levels for TNT Detonations, Double-Base Propellant Burn, and Composite Propellant Burn in the BangBox Test.

Species	TNT	Double-Base	Composite
SEMIVOLATILE ORGANICS (cont'd)			
2-Naphthalenamine			
Diphenylamine			
Benz[c]acridine			
Benz[a]anthracene	X		
Benzo[a]pyrene	X	X	
Dibenz[a,h]anthracene	X		
N-Nitrosodiphenylamine	X	X	X
Naphthalene	X		X
1-& 2-Methylnaphthalene	X	NA[d]	NA
1,3,5-Trinitrobenzene	X	NA	NA
Biphenyl	X	NA	NA
Phenanthrene	X	NA	NA
2,5-Diphenyloxazole	X	NA	NA
1,1,3-Trimethyl-3-phenylindane	X	NA	NA
Pyrene	X	NA	NA
4-Nitrosodiphenylamine	NA		NA
2-Nitrodiphenylamine	NA		NA
4-Nitrodiphenylamine	NA		NA
Nitroglycerin	NA		NA
Resorcinol	NA		NA
Di-n-propyl adipate	NA		NA
Triacetin	NA		NA
Salicylic acid	NA		NA
2,2-Methylene bis(4-methyl)-t-butylphenol	NA	NA	
Phenyl di-isodecyl phosphite	NA	NA	
5-ethyl-1,3-diglycidyl-5-methyl hydantoin diepoxide	NA	NA	
Diethylenetriamine	NA	NA	
Dioctyl sebacate	NA	NA	
Isophorone di-isocyanate	NA	NA	

See Table 5.1f for notes.

Table 5.1e Target Analytes Detected Above Background Levels for TNT Detonations, Double-Base Propellant Burn, and Composite Propellant Burn in the BangBox Test.

Species	TNT	Double-Base	Composite
METALS			
Aluminum	X		X
Silicon	X		X
Sulfur	X		X
Chlorine	X		X
Potassium	X		X
Calcium	X		X
Titanium			
Vanadium			X
Chromium	X		X
Magnesium	X		X
Iron	X		X
Nickel	X		X
Copper	X	X	X
Zinc	X		X
Gallium	X		X
Germanium	X		
Arsenic			
Selenium	X		
Bromine	X		
Uranium	X		
Strontium	X		
Lead	X	X	X
Zirconium	X		
Molybdenum	X		
Silver	X		
Cadmium	X		
Tin	X		X
Antimony	X		X
Iodine	X		
Barium	X		X

See Table 5.1f for notes.

Table 5.1f Target Analytes Detected Above Background Levels for TNT Detonations, Double-Base Propellant Burn, and Composite Propellant Burn in the BangBox Test.

Species	TNT	Double-Base	Composite
BUBBLERS			
Ammonia	X		
Hydrogen Cyanide[e]			
Hydrogen Chloride			X

BLANK SPACE - analyzed - not detected above background levels.
[a]X-detected above background levels.
[b]Ambient ozone reduced to below background levels immediately after the detonation.
[c]ND denotes no data.
[d]NA denotes not targeted for analysis for that type of trial.
[e]Analysis of bubbler samples enabled estimation of the CN- anion (as HCN).

5.3. Emission Factor Calculations

5.3.1. Parameter Values

Before EFs for each BB OB/OD product could be calculated for the concentration times volume method and the carbon balance method, several important parameter values were needed: BB volume, BB ventilation rate, total quantity of carbon in the fuel (TNT and propellants), total (combined) carbon content of the compounds generated from the detonation or burn, and the concentrations of the compounds in the samples collected.

5.3.2. BangBox Volume and Ventilation Rates

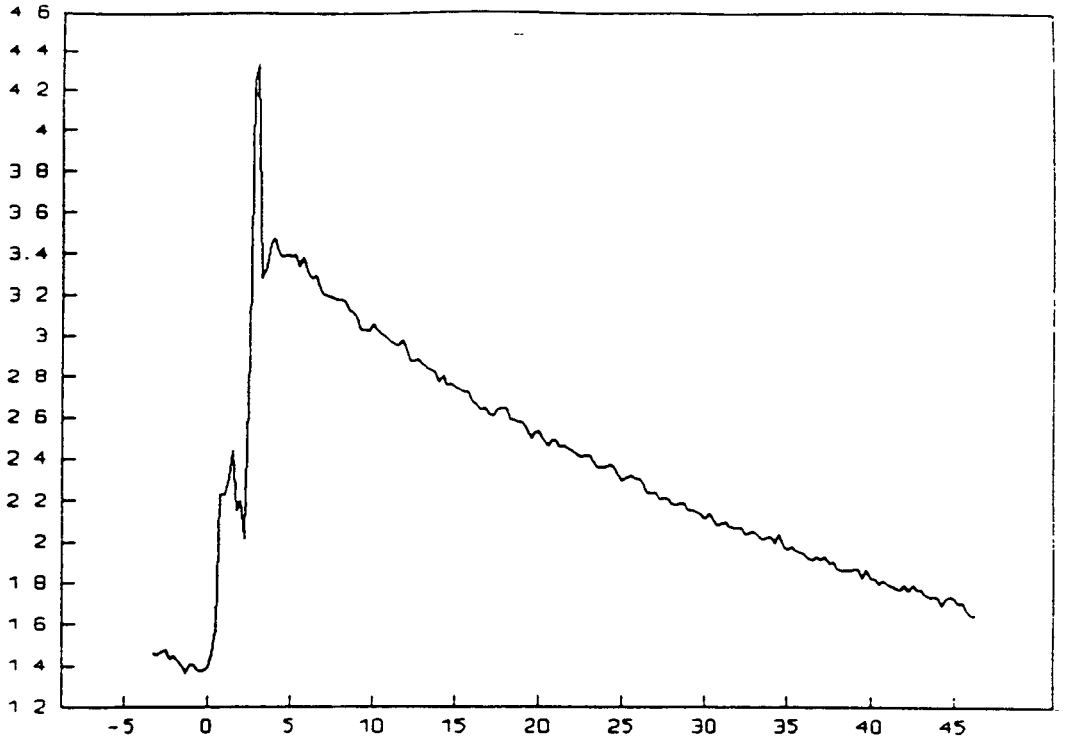
Volume of the BB for each trial was determined by analyzing data from release of known amounts of SF_6, a tracer gas whose concentration was then carefully measured. These volumes varied (from trial to trial) between 759 and 1078 m^3. The appropriate value, pertinent to the specific trial day, was used in analyzing each trial's data. Trial-specific BB ventilation rates were also determined and served as the bases for determining the "time zero" values for target analyte air concentrations; i.e., the initial postdetonation source strengths of each product. These ventilation rates were extremely well-characterized because of the high quality (accuracy and precision) of the SF_6 data collected. A typical plot of instrument voltage versus time for the CO_2 monitor (Figure 5.1) shows that

homogeneity is achieved after 3 minutes of mixing with fans (generally fans are turned on 3 to 5 minutes after detonation) and then the chamber air containing combustion products is slowly diluted (ventilation) as makeup air is brought into the chamber to keep it inflated. Typical plots of net CO_2 concentration above background levels (including 95-percent confidence limits), as measured by real-time instruments during the homogeneous period of sampling after one of the 8 February 1989 227-gram TNT detonations, are shown in Figure 5.2.

5.3.3. Concentrations of Target Analytes in Air Samples

5.3.3.1. Target analyte concentrations in the bangbox air immediately after OB or OD were determined by the variety of sensitive analytical methods listed in Table 5.2. The most unique of these methods was application of the relatively new technique of supercritical fluid chromatography (SFC) for separation of semivolatile organic compounds in extract solutions of filter- and canister-collected samples of BB air. SFC was chosen for use in the OB/OD program, because certain thermally unstable OB/OD products that are converted to other compounds *during analysis* by GC remain stable when separated by SFC. An example is N-nitrosodiphenylamine, which is specifically identifiable by SFC but converts to diphenylamine when subjected to GC. However, certain volatile compounds, such as phenol, are not easily detected by SFC when supercritical CO_2 is used; these compounds *are* easily detected by GC. Other detection methods such as HPLC, were not considered sensitive enough for the scope and detection limits needed.

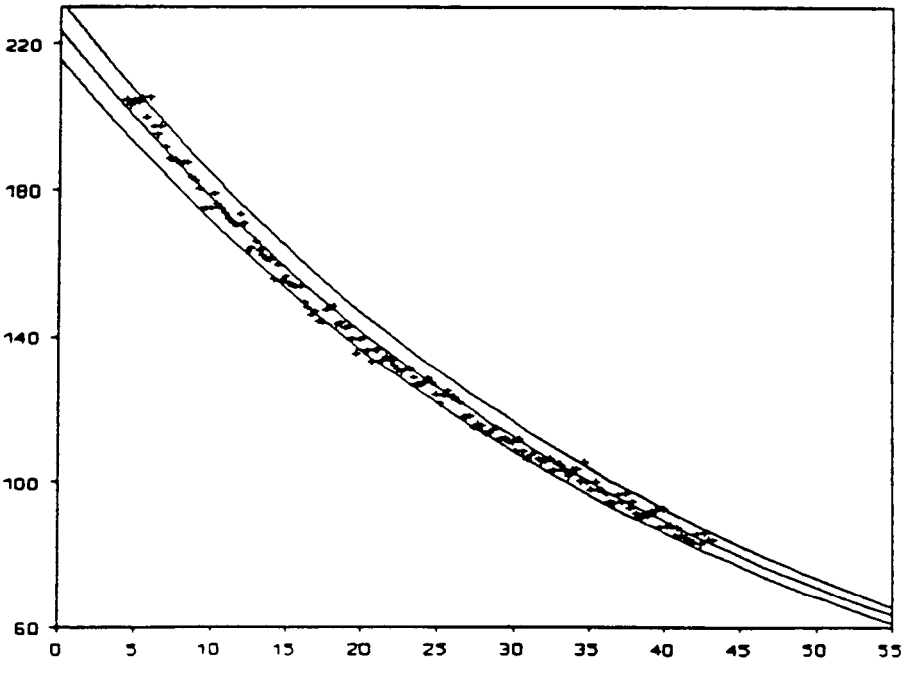
5.3.3.2. The extremely sensitive methods of chemical ionization negative and positive selective ion monitoring by mass spectrometry were used for product quantification with both SFC and GC separation techniques. Semivolatile organic compound assay results by SFC/MS and GC/MS showed that *both* separation techniques are applicable and that MS detection and quantification are extremely sensitive. For example, the laboratory responsible for the SFC/MS analyses reported typical lower detection limits (signal-to-noise >3) for compounds in methylene chloride solution of 0.03 to 2.3 ng/mL, depending on the specific analyte being assayed.



CO_2 (Volts)

Figure 5.1 CO_2 Instrument Voltage Trace, TNT Detonation Number 2, 8 February 1989.

Time (min)



CO_2 (ppmv)

Figure 5.2 CO_2 Concentration and 95 Percent Confidence Limits During the Homogeneous Period of Direct Sampling From the BangBox TNT Detonation Number 2, 8 February 1989.

Time (min after detonation)

Table 5.2 Summary of OB/OD BangBox Sample Analysis Program.

TYPE	TARGET SPECIES	ASSAY METHOD	ASSAY LAB
Exotic organics	Approx 33 compounds	SFC-MS[a]	AWL[b]
Exotic organics	Approx 15 compounds	GC-MS[c]	BCD[d]
Inorganic (metals)	7	XRF[e]	LBL[f]
Total particulate carbon	Organic, elemental, and inorganic carbon	Thermooptical	SL[g]
Volatiles	THC[h], CH_4, H_2, C_2-C_{10}, C_6H_6, CO, CO_2	GC[i]	OGC[j]
Particle characterization	NA[k]	SEM[l]	SNL[m]
Near-real-time	SF_6	GC/ECD[n]	OGC
Real-time	CO, CO_2, NO_x[o], SO_2, O_3, THC	Gas and total hydro-carbon analyzers	SNL
Bubbler	HCN, HCl, NH_3	NIOSH standard methods	SNL
Particle size/mass	Particulate	DMPS[p], APS[q], ASASP[r], FSSP[s]	SNL
Dibenzodioxin compounds Dibenzofuran compounds	Specified	GC-MS	BCD

[a]Supercritical fluid chromatography-mass spectrometry.
[b]Alpine West Laboratory.
[c]Gas chromatography-mass spectrometry.
[d]Battelle Columbus Division.
[e]X-ray fluorescence.
[f]Lawrence Berkeley Laboratory.
[g]Sunset Laboratory.
[h]Total hydrocarbons.
[i]Gas chromatography.
[j]Oregon Graduate Center.
[k]Not applicable.
[l]Scanning electron microscopy.
[m]Sandia National Laboratories.
[n]Electron capture detector.
[o]Nitrogen oxides.
[p]Differential mobility particle sizer.
[q]Aerodynamic particle sizer.
[r]Active scattering aerosol spectrometer probe.
[s]Forward scattering spectrometer probe.

5.3.4. Audit samples

Audit samples in the form of spiked canisters were provided by the EPA, RTP NC. These samples were successfully analyzed (as ascertained by EPA auditors) by laboratories involved in both volatile and semivolatile organic compound analyses (AWL, BCD, and OGC).

5.4. Carbon Mass Balance.

5.4.1. Analysis

Analysis of the aerosol and particulate samples taken during a given trial provided an estimate of carbon mass released, based on the combined carbon mass contained in generated CO_2 and CO, the organic particulate/semivolatile carbon, volatile organic compound (C_1-C_{10} hydrocarbons), elemental carbon (soot), HCN, and inorganic carbon (as carbonate). The carbon from CO_2 was estimated from the real-time continuous monitor, with extrapolation of the fitted exponential curve (fit to the data from the homogeneous period of sampling) to detonation time zero ($t = 0$) . As noted earlier, the carbon from CO and volatile C_1-C_{10} hydrocarbons was estimated from the results of 6-L canister sampling, with extrapolation of the fitted exponential curve to detonation time zero. Total particulate organic carbon, elemental carbon (soot), and inorganic carbonate were estimated from thermal analysis of 1-cm^2 samples taken from quartz-fiber filters. This latter analysis incorporates a two-step volatilization and combustion process that permits estimation of the contributions by each of these carbon sources.

5.4.2. Carbon Mass

Table 5.3 shows the carbon mass derived from each source during 11 TNT detonations, as well as ratios of total carbon detected to that predicted as available from the TNT fuel (37.01 percent). The carbon mass determined by the analysis of sampled aerosol and particulate carbon sources overaccounts for the (theoretical) mass of carbon available in bulk TNT by about 9 percent. Results showed that the total carbon amounts contributed by volatile organics (C_1-C_{10}), HCN, and inorganic carbonate are negligible (<0.01 percent), while CO_2 contributes the vast majority of carbon measured (97.2 percent). Minor amounts of CO (0.50 percent) carbon, carbon from semivolatile

principally to CO_2, upon detonation in ambient air. Table 5.3 also shows the carbon mass derived from the foam-attenuated TNT detonation, the double-base propellant burn and the composite propellant burn. The overestimate of the carbon mass (0.29) in the composite propellant burn could easily be the result of uncertainty in the carbon content of the composite propellant. Three composite propellant samples assayed for elemental carbon gave percentages of carbon ranging from 12.67 to 21.26.

5.4.2.1. These results are in sharp contrast to those predicted by certain theoretical models or determined during experiments involving limited available oxygen from surrounding air. The results

Table 5.3 Measured Carbon Mass Derived From Each Source Resulting From TNT Detonation or Propellant Burn.

DATE	SOURCE	CARBON MASS MEASURED (g)				Total Carbon (g)		RATIO[d]
		CO_2	CO	OC[a]	EC[b]	MEASURED[c]	THEORETICAL	
31 JAN 89	TNT	94.96	0.6688	0.4161	1.0331	97.08	82.90	1.17
2 FEB 89		82.18	0.4093	0.6495	1.5160	84.75	82.31	1.03
6 FEB 89		82.92	0.3384	0.4685	2.0492	85.78	83.22	1.03
8 FEB 89-2[e]		90.34	0.4578	0.5150	1.5426	92.86	82.99	1.12
8 FEB 89-3		90.26	0.4578	0.5150	1.5426	92.77	83.25	1.11
8 FEB 89-4		87.43	0.4578	0.5150	1.5426	89.95	82.62	1.09
8 FEB 89-5		87.15	0.4578	0.5150	1.5426	89.66	82.71	1.08
8 FEB 89-6		87.92	0.4578	0.5150	1.5426	90.43	82.42	1.10
8 FEB 89-7		86.74	0.4578	0.5150	1.5426	89.26	82.47	1.08
8 FEB 89-8		85.86	0.4578	0.5150	1.5426	88.37	81.87	1.08
15 FEB 89		83.78	0.3813	0.4751	1.4229	86.06	81.88	1.05
							Average	1.09
							Std. Dev.	0.04
13 FEB 89	TNT w/foam	24.13	2.7154	NS[f]	NS	26.85	82.00	0.33
9 FEB 89	Double base	131.66	0.1950	0.2725	0.0000	132.13	125.17	1.06
16 FEB 89	Composite	66.05	0.0706	0.0000	0.0065	66.12	51.16	1.29

[a]OC-Organic carbon: includes carbon from semivolatile organics.
[b]EC-Elemental carbon.
[c]Carbon in HCN, volatile HC(C_1-C_{10}) and inorganic carbonate account for less than 0.01 percent, when combined.
[d]Ratio of total carbon mass measured to carbon mass in fuel.
[e]Number following date is detonation number of multidetonation trial.
[f]NS - not sampled.

5.4.2.1. These results are in sharp contrast to those predicted by certain theoretical models or determined during experiments involving limited available oxygen from surrounding air. The results of the BB TNT detonation tests are included, with some of these literature values, in Table 5.4. Clearly, OD of even the most oxygen-deficient of the common military explosives, TNT, yields a much higher fraction of CO_2 and lower fractions of CO and other carbonaceous products than models or earlier small-scale laboratory experiments have predicted (most of these assume oxidant is available only from the molecule and not from ambient air entrainment).

Table 5.4 Comparison of Carbon-Containing TNT Detonation Product Levels as Predicted by Literature and Determined by Experiment (kg/ton).

SPECIES	OB/OD[a]	COOK[b]	HAID/SCHMIDT[c]	ORNELLAS[d]	ORNELLAS$_e$
Carbon dioxide	1.20×10^{3}	399.00	220.00	220.00	11.2
Carbon monoxide	4.07	25.40	239.00	221.00	658.00
Hydrogen cyanide	0.00	27.00	7.85	2.21	2.70
Carbon (soot)	5.77	154.70	159.00	175.40	47.9
Methane	2.45×10^{-2}	43.6	6.11	6.40	0.58
Ethane	-[f]			0.55	
Nonmethane HC	5.72×10^{-2}				
Semivolatile OC[g]	1.93				

[a]Present BB TNT OB work (density $\approx$ 1.4 g/cm^3). Values are estimates derived from mean emission factor data.
[b]Computed data for TNT (density = 1.59 g/cm^3).
[c]Experimental data from TNT detonation (density = 1.59 g/cm^3) from Haid and Schmidt (1931).
[d]Experimental data from confined TNT (density = 1.54 g/cm^3) under vacuum from Ornellas (1982).
[e]Experimental data from unconfined TNT (density = 1.54 g/cm^3) under vacuum from Ornellas (1982).
[f]C_2H_6 included in NMHC value of 5.72×10^{-2} kg/ton.
[g]Organic carbon from thermooptical analysis of aerosol/particulate collected on quartz-fiber filters.

5.5. Carbon-Balance Method

5.5.1. Calculating EF's

The carbon balance method of calculating EFs depends on two assumptions: (1) the mass of carbon available in the TNT can be accounted for in the masses of the various carbon-containing product species, and (2) the proportional distribution among carbon-containing products within individual microregions of the cloud remains relatively constant, even though the actual values for individual concentrations may be considerably different within different macroregions of the cloud.

5.5.1.1. Based on these two assumptions, the total volume of the cloud becomes irrelevant in making EF calculations, and the EF of any individual product *i* can be estimated by the equation:

Equation 5.1 Carbon Balance Emission Factor Determination.

$$EF_i = (f_c)\,\frac{[D_{ij}]}{[C_j]}$$

where, f_c = mass fraction of carbon in the fuel (0.3701 for TNT),
$[D_{ij}]$ = average concentration of product *i* over any specific volume element *j* of the cloud, and
$[C_j]$ = concentration of all forms of carbon in the sample taken from volume element *j*.

5.5.1.2. For example, the maximum EF value calculated for 2,4-dinitrotoluene from analyses of 11 OD samples was 1.05×10^{-6} weight units (e.g., kg) of product per weight unit (e.g., kg) of TNT detonated. (Values used were $f_c = 0.3701$, $[D_{ij}] = 2.2 \times 10^{-4}$ mg/m^3, and $[C_j] = 77.9$ mg/m^3.)

5.5.2. Value in Field Testing

The carbon balance method has great potential for calculating OB/OD combustion product EFs in large-scale field tests, because total volumes of clouds and total concentrations of products over that whole "volume" do not need to be known; only "grab samples" need to be taken within the cloud by aircraft sampling, and CO_2 and target analyte levels above background need to be clearly measured.

5.6. Concentration Times Cloud Volume (C • V) Method.

5.6.1. Calculating EF's

The more traditional method of calculating an EF for product *i* is the C • V method.

Equation 5.2 Cloud Volume Emission Factor Determination

$$EF_i = \frac{[D_i]V}{M}$$

where: $[D_i]$ = average concentration of product *i* over the entire cloud immediately after detonation,
V = volume of the entire cloud, and
M = mass of TNT (or propellant) consumed.

5.6.2. Use of C • V

The use of this method is extremely difficult in the field environment because concentrations of products are not homogeneous over the entire cloud; therefore, many points in the diffusing cloud must somehow be sampled in order to obtain a true average product concentration. Also, it is difficult to accurately measure the actual volume of the diffusing, nonsymmetrical, ill-defined cloud at the precise time at which concentration samples are collected. These difficulties can be readily overcome in a chamber environment in which air concentrations and chamber volumes can be accurately determined as functions of sampling time. Thus, although difficult to apply in the field, this method was successfully used in calculating EFs from BB data. For example, the maximum EF calculated for 2,4-dinitrotoluene by this method was 0.819×10^{-6} weight units (e.g. kg) of the product produced per weight unit (e.g. 1 kg) of TNT detonated. (Values used were $[D_i] = 2.2 \times 10^{-4}$ mg/m^3, V = 833.8 m^3, and M = 0.224 kg or 224 g.)

5.6.2.1. Thus, the calculated carbon balance method EF (1.05×10^{-6}) for this compound compares extremely well with the C • V method EF of 0.819×10^{-6}.

5.6.2.2. As noted earlier, conducting these tests in an enclosed chamber environment allowed comparison of a proposed method of calculating these EFs (the carbon balance method) with the more traditional method involving multiplication of air emission concentration by the cloud volume (the C • V method). Results showed clearly that the proposed-carbon balance method, which is not dependent on cloud volume and therefore can be applied to cases in which the cloud volume is extremely difficult to estimate (such as after outdoor OD), gave EFs which were not statistically different from those obtained by the C • V method. This is certainly true when the cloud is homogeneous and its volume is accurately known (as in the BB). Even when the emission concentrations are nonhomogeneous (a condition which exists in outdoor OB/OD operations) in the chamber EFs from the carbon balance method were not different from the EFs obtained during the homogeneous period of sampling. The C • V method did not provide a good estimate of EFs when the emission concentrations are nonhomogeneous in the chamber. As a result, it was concluded that the carbon-balance method should be further evaluated in large-scale outdoor OB/OD operations. This assessment will determine the degree to which the principal carbon-containing species (CO_2) are above ambient background levels when the OB/OD clouds are sampled by FWAC, and the degree to which dilute, measurable concentrations of the volatile and semivolatile combustion products can be detected by analysis of FWAC samplers mounted on FWAC. If above-background CO_2 concentrations and detectable emission concentrations can be measured by analysis of FWAC-mounted samplers, then EFs can be calculated more accurately than by using methods requiring careful cloud volume estimations.

5.7. Emission Factors.

5.7.1. Calculations

After sample analysis concentrations, BB volumes, BB ventilation rates, fuel carbon contents, and total product carbon contents became known, EFs for each combustion product were calculated. These EFs are expressed as weight (e.g., kg) of each combustion product produced per unit weight (e.g., 1 kg) of explosive or propellent consumed. The maximum EFs detected are summarized in Tables 5.5a through 5.5d.

5.7.2. Carbon Dioxide

Tables 5.3 and 5.4 indicate that CO_2 was by far the dominant product in both TNT detonations and double-base and composite propellant burns.

5.7.3. Carbon Monoxide and Other Organic Compounds

The proportion of carbon monoxide, volatile organic hydrocarbons (C_1-C_{10}), total organic carbon, and elemental carbon decreases when the two types of propellants are burned. Emission factors for the exotic semivolatile organics rarely reached levels of 10^{-4} kg of emissions per kilogram of fuel; most are generated in quantities approximating 10^{-6} to 10^{-9} kg per kg of fuel. For this latter range of values, initial source strengths of emitted compounds would be in the range of 0.05 to 50 grams (10^{-3} to 10^{-6} lb) for a 907-kg (2000-lb) OB/OD operation. These source strengths, once dispersed by atmospheric meteorological conditions, even at short downwind distances, are not expected to create measurable quantities of the analytes at downwind receptor populations/locations.

5.7.4. Metals and Nonmetals

After TNT detonations or propellant burns, metals and nonmetals were rarely detected in concentrations high enough for EFs to exceed 10^{-4}, except in cases where the element was traceable directly to the fuel mixture (Al, Cu), igniter, chamber pan, or floor material, or previous, unrelated SNL test activities conducted in the BB.

Table 5.5a Maximum Emission Factors (kg/kg) and ppmw for Species Found for TNT Detonations, Double-Base, and Composite Propellant Burns.

Species	TNT Detonation		Double-Base Burn		Composite Burn	
	EF (kg/kg)	ppmw	EF	ppmw	EF	ppmw
Carbon dioxide	1.33	$1.33 \times 10^{+6}$	9.7×10^{-1}	$9.7 \times 10^{+5}$	4.18×10^{-1}	4.18
Carbon monoxide	7.17×10^{-3}	7170	9.54×10^{-4}	954	4.28×10^{-4}	4.28
Nitrogen dioxide	2.60×10^{-3}	2600	2.81×10^{-3}	2810	1.57×10^{-3}	1570
Nitric oxide	1.46×10^{-2}	14600	2.47×10^{-2}	24700	5.37×10^{-3}	5370
Sulfur dioxide	2.23×10^{-4}	223	3.60×10^{-4}	360	1.44×10^{-4}	144
Ozone[a]						
Methane	1.31×10^{-4}	131	7.26×10^{-5}	72.6	7.99×10^{-5}	79.9
Acetylene	1.82×10^{-5}	18.2	2.18×10^{-5}	21.8	5.27×10^{-5}	52.7
Benzene	8.67×10^{-6}	8.67	1.27×10^{-5}	12.7	3.02×10^{-5}	30.2
Paraffins[b]	1.45×10^{-4}	145	6.98×10^{-5}	69.8	6.95×10^{-5}	69.5
Olefins[b]	3.03×10^{-5}	30.3	7.94×10^{-5}	79.4	$3.93 \times 10_{-5}$	39.3
Non-benzene aromatic	2.99×10^{-5}	29.9	9.8×10^{-5}	98.5	1.98×10^{-5}	19.8
SEMIVOLATILE ORGANICS						
2,6-Dinitrotoluene	4.39×10^{-7}	0.439	1.43×10^{-8}	0.0143	3.72×10^{-9}	0.00372
4-Nitrophenol	2.59×10^{-6}	2.59	6.87×10^{-7}	0.687	4.08×10^{-7}	0.408
2,4-Dinitrotoluene	1.05×10^{-6}	1.05	$< 1.75 \times 10^{-10}$	<0.000175	1.04×10^{-8}	0.0104
2-Nitronaphthalene	6.43×10^{-7}	0.643	5.43×10^{-8}	0.0543	2.03×10^{-8}	0.0203
2,4,6-Trinitrotoluene	3.38×10^{-6}	3.38	5.01×10^{-8}	0.0501	$< 1.37 \times 10^{-9}$	<0.00137
1-Nitropyrene	1.06×10^{-6}	1.06	$< 1.66 \times 10^{-8}$	<0.0166	$1.98 \times 10_{-8}$	0.0198
1,6-Dinitropyrene	ND[c]	ND	ND	ND	ND	ND
Phenol	2.52×10^{-5}	25.2	4.39×10^{-6}	4.39	3.78×10^{-6}	3.78
Dibenzofuran	1.32	1.32	2.25×10^{-7}	0.225	2.79×10^{-7}	0.279

See Table 5.5d for notes

Table 5.5b Maximum Emission Factors (kg/kg) and ppmw for Species Found for TNT Detonation, Double-Base, and Composite Propellant Burns.

Species	TNT Detonation		Double-Base Burn		Composite Burn	
	EF (kg/kg)	ppmw	EF	ppmw	EF	ppmw
SEMIVOLATILE ORGANICS (cont'd)						
2-Naphthylamine	ND	ND	ND	ND	ND	ND
Diphenylamine	ND	ND	ND	ND	ND	ND
Benz[c]acridine	ND	ND	ND	ND	ND	ND
Benz[a]anthracene	$<3.30 \times 10^{-8}$	<0.033	$<1.83 \times 10^{-9}$	<0.00183	$<1.66 \times 10^{-8}$	<0.0166
Benzo[a]pyrene	3.01×10^{-6}	3.01	8.96×10^{-7}	0.896	5.23×10^{-8}	<0.0523
Dibenz[a,h]anthracene	1.73×10^{-6}	1.73	ND	ND	ND	ND
N-Nitrosodiphenylamine	1.23×10^{-6}	1.23	1.45×10^{-6}	1.45	3.45×10^{-8}	0.0345
Naphthalene	1.50×10^{-4}	150	$<1.55 \times 10^{-9}$	<0.00155	1.44×10^{-6}	1.44
1-& 2-Methylnaphthalene	3.00×10^{-5}	30				
1,3,5-Trinitrobenzene	2.75×10^{-9}	0.00275				
Biphenyl	$<5.20 \times 10^{-8}$	<0.052				
Phenanthrene	1.85×10^{-7}	0.185				
2,5-Diphenyloxazole	7.23×10	72.3				
1,1,3-Trimethyl-3-phenylindane	5.70×10^{-7}	0.57				
Pyrene	2.02×10^{-7}	0.202				
4-Nitrosodiphenylamine	---[d]		ND	ND		
2-Nitrodiphenylamine			ND	ND		
4-Nitrodiphenylamine			ND	ND		
Nitroglycerin			ND	ND		
Resorcinol			ND	ND		
Di-n-propyl adipate			ND	ND		

See Table 5.5d for notes

Table 5.5c Maximum Emission Factors (kg/kg) and ppmw Found for TNT Detonation, Double-Base, and Composite Propellant Burns.

Species	TNT Detonation		Double-Base Burn		Composite Burn	
	EF (kg/kg)	ppmw	EF	ppmw	EF	ppmw
SEMIVOLATILE ORGANICS (cont'd)						
Triacetin			ND	ND		
Salicylic acid			ND	ND		
2,2-Methylene bis(4-methyl)-6-t-butylphenol					ND	ND
Phenyl di-isodecyl phosphite					ND	ND
5-ethyl-1,3-diglycidyl-5-methyl hydantoin diepoxide					ND	ND
Diethylenetriamine					ND	ND
Dioctyl sebacate					ND	ND
Isophorone di-isocyanate					ND	ND
METALS						
Aluminium					1.33×10^{-4}	133
Chromium	3.52×10^{-6}	3.52	BD	BD	4.77×10^{-6}	4.77
Iron					6.04×10^{-4}	604
Nickel	2.54×10^{-6}	2.54	BD	BD	1.59×10^{-6}	1.59
Copper			3.71×10^{-3}	3710		
Arsenic	BD	BD	BD	BD	BD	BD
Lead	1.97×10^{-5}	19.7	1.27×10^{-2}	12700	9.39×10^{5}	93.9
Cadmium	2.86×10^{-6}	2.86	BD	BD	BD	BD
Antimony	1.06×10^{-6}	1.06	BD	BD	4.77×10^{-6}	4.77
Barium	9.31×10^{-4}	931	BD	BD	1.59×10^{-7}	159

See Table 5.5d for notes

Table 5.5d Maximum Emission Factors (kg/kg) and ppmw for Species Found for TNT Detonation, Double-Base, and Composite Propellant Burns.

Species	TNT Detonation		Double-Base Burn		Composite Burn	
	EF (kg/kg)	ppmw	EF	ppmw	EF	ppmw
BUBBLERS						
Ammonia	2.92×10^{-4}	292	BD	BD	BD	BD
Hydrogen cyanide	BD	BD	BD	BD	BD	BD
Hydrogen chloride					9.43×10^{-2}	94300

[a]Ambient ozone was reduced to near zero at detonation by reacting with the detonation products.

[b]For a full listing of compounds included within these groupings as analyzed by Oregon Graduate Center, refer to Table 3.4.4, this report.

[c]ND - detection limit was not determined

[d]Blank Cell - not a target analyte during the cited detonation or burn.

[e]BD - target analyte not found in concentrations above detection limits. Detection limits (approximately 0.5 $\mu g/m^3$ for the elements corresponds to an EF of 2×10^{-6} for TNT and 1×10^{-6} for double-base and composite propellant). Detection limits (approximately 10 $\mu g/m^3$) for ammonia and hydrogen cyanide corresponds to an EF of 4×10^{-5} for TNT and 2×10^{-5} for double-base and composite propellant.

5.7.5. HCN, NH_3, and HCl

HCN was never detected during analysis of bubblers. NH_3 concentrations were detected slightly above background levels in only two TNT OD samples. These detections were also characterized by abnormally low values in the applicable background samples and are therefore speculative. As expected, HCl was measured in significant concentrations during air sampling from the composite fuel burn, however because of significant problems encountered with the HCL bubbler during sampling the data is considered unreliable.

5.7.6. Dioxins/Furans

A team from BCD specializing in sampling for polychlorinated dibenzodioxins (PCDD) and polychlorinated dibenzofurans (PCDF) sampled the chamber air following the burn of the composite propellant (the only propellant, explosive, and pyrotechnic (PEP) material containing chlorine tested in the BB), (Volume 2, Appendix B). The tetrachloro derivatives, particularly the symmetrically substituted 2,3,7,8-tetrachlorodibenzofuran and 2,3,7,8-tetrachlorodibenzodioxin isomers are of particular concern as toxicants. None of the most toxic 2,3,7,8-tetrachlorodibenzodioxin was detected and only one of two samples showed a barely marginal value for the less toxic 2,3,7,8-tetrachlorodibenzofuran showing that even its presence is problematical. Small amounts of some of the other, much less toxic, chlorinated derivatives were detected. The hepta-, and octa-CDD were detected in concentrations of 2.6 pg/m^3 and 15 pg/m^3 respectively. These concentrations result in EFs of 5.3×10^{-12}, and 30×10^{-12}. Using these EFs a similar mix of 10 metric tons of an AP composite propellant, when burned, would yield 53 μg of hepta-CDD, and 300 μg of octa-CDD.

5.7.7. Foam-Attenuated TNT Test

As might be expected, the foam-attenuated TNT detonation conducted 13 February 1989 produced generally lower concentrations of CO_2 and greater concentrations of CO, NO_2, NO, and volatile organics than did the various non-attenuated TNT detonations. The main effects of the foam were mitigation of the blast and noise, reduction of the total carbon mass recovery accounted for as CO_2, and the spreading of viscous, sulfonate-glycol/ether-xanthan polymer residue widely about the chamber floor.

SECTION 6. SAMPLE DISPERSION MODEL CALCULATION

6.1. The Volume Source Diffusion Model

The volume source diffusion model (VSDM) was used by the DPG Meteorology Division to estimate concentrations of emissions downwind from the detonation site. The dispersion model was applied to nominal source strengths of the combustion products as calculated from the maximum EF's determined from BB testing. Typical meteorological input parameters were chosen, based on conditions that provide a clearing index of at least 500 (a State of Utah test conduct requirement at DPG). The cloud height at stabilization for 907-kg (2000-lb) TNT detonations was calculated from the instantaneous cloud rise equations developed by National Aeronautic and Space Administration (NASA). The stabilization height is the calculated point relative to detonation at which the energy input from the detonation has been expended and the cloud growth and movement are thereafter only influenced by the ambient environment meteorological conditions.

6.2. Sample Calculations

The following sample calculations use the maximum EF for 2,4-dinitrotoluene, a TNT OD combustion product of interest. The maximum EF calculated for this compound, based on BB results, was 1.05×10^{-6}. Multiplying the EF by the weight of TNT to be detonated yields the maximum total source strength of that compound. Thus, the amount of 2,4-dinitrotoluene resulting from a 907-kg (2000-lb) TNT detonation would be approximately 1 gram (1×10^{-3} kg). Figure 6.1 shows that the maximum momentary peak ground-level 2,4-dinitrotoluene concentration (1.1×10^{-3} $\mu g/m^3$) would be detected approximately 2.5 km downwind from the detonation site and should not have persisted for more than a few minutes. The maximum ambient air concentration limits for 2,4-dinitrotoluene exposure to the general population have been set by several states. One of the most restrictive is presently 15 $\mu g/m^3$, set by North Dakota for an 8-hour exposure. Thus, for the 2,4-dinitrotoluene expected from a 907-kg (2000-lb) TNT open detonation, there would be essentially no risk to the receptor site/general population since the peak concentration at ground level (at approximately 2.5 km downwind) would be 14,000 times less than the North Dakota ambient air standard.

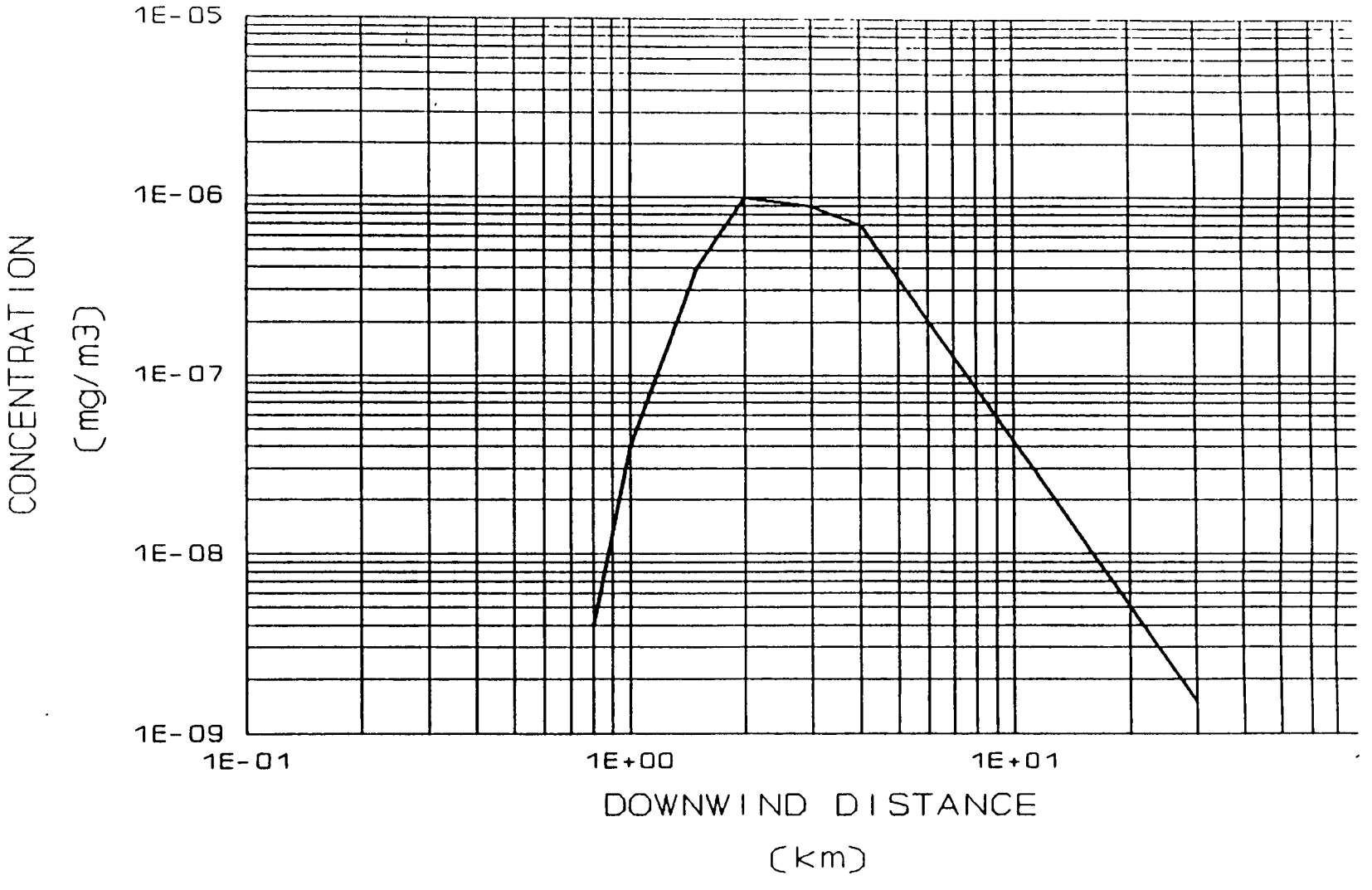


Figure 6.1 Calculated Profile of Peak Concentration at Ground Level Versus Downwind Distance for 2,4-DNT

6.2.1. Calculation Method

6.2.1.1. Criterion/Restriction: 15 $\mu g/m^3$ ambient air concentration limit for an 8-h time period for the general population, North Dakota.

6.2.1.2. Maximum EF for 2,4-dinitrotoluene: 1.05×10^{-6} kg/kg for TNT detonation.

6.2.1.3. Maximum peak 2,4-dinitrotoluene concentration calculated from application of the VSDM for a 1×10^{-3} kg source: approximately 1.1×10^{-6} mg/m^3 (1.1×10^{-3} $\mu g/m^3$).

Equation 6.1 Equation Used To Calculate Safety Factor for 2,4-DNT.

$$\frac{15\ \mu g/m^3\ (\textit{general population concentration limit, ND})}{1.1\ x\ \mu g/m^3\ (\textit{momentary peak concentration max at ground level 2.5 km det.})} = 1.4x10^4\ (\textit{about } 14{,}000 \times \textit{less than allowable ND standards})$$

6.3. Risk Assessments

No attempt has been made in this report to prepare detailed, formal risk assessments based on the source strengths of each projected product derived from the BB data. However, there appears to be sufficient data here to support such analyses by applying concepts similar to those outlined in the November 1988 EPA Report, Risk Assessment Guidelines and Information Directory, the October 1989 EPA Draft Final Report, Background Information Document for the Development of Regulations for PIC Emissions from Hazardous Waste Incinerators, and other similar documents pertinent to implementation of ambient air quality standards.

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SECTION 7. CONCLUSIONS

7.1. Conclusions (Addressed by Study Objectives)

7.1.1. Objective 1 - BangBox Characterization: Characterize the BB chamber volume, ventilation rate, and combustion product cloud homogeneity level.

The chamber volume, ventilation rate, and cloud homogeneity were successfully determined, and found satisfactory for subsequent use throughout the data evaluation/analysis processes.

7.1.2. Objective 2 - Sampling and Analyses: Develop and improve proposed air sampling equipment and sample analysis procedures to be used in later phases on the FWAC, for sampling product clouds from large-scale follow-on outdoor OB/OD trials.

7.1.2.1. Samplers and detectors used in the BB tests that were felt to have performed well enough to be used for FWAC sampling of open-air clouds of OB/OD products included 0.85-L evacuated canisters; 6-L evacuated canisters; 32-L evacuated tanks; CO_2, CO, SO_2, and NO_x real-time gas monitors; quartz-fiber particulate filters; Teflon™ particulate filters; the Belfort integrating nephelometer; the RAM nephelometer; and DMPS, ASASP, and FSSP aerosol spectrometers.

7.1.2.2. Samplers used in BB tests that were felt to have performed marginally included the resin filters (both Porapak-R™ and XAD-2™) which were an integral part of the semi-VOST system and the Velostat™ bag. The resin filters greatly constricted airflow, thus limiting their suitability for FWAC grab sampling. The bag proved inadequate for some volatile and semivolatile organic compounds, because of absorption and subsequent off-gassing.

7.1.2.3. The CO real time instrument did not perform properly. The CO data was obtained from the 6-L canister analysis.

7.1.3. Objective 3 - Comparison of SFC/MS and GC/MS: Refine, standardize, and compare SFC and GC techniques for extracting and analyzing resins, and filters, for trace quantities of semivolatile organic OB/OD combustion products and residues, using MS detectors.

Both SFC/MS and GC/MS are sufficiently sensitive analysis techniques to detect and quantify semivolatile organic (exotic) target analytes collected from chamber air by quartz-fiber filters, resin-filled canisters, and evacuated stainless steel cylinders. SFC is superior for some of the less thermally stable exotic species of interest, e.g. N-nitrosoamines, and some of the nitro compounds.

7.1.4. Objective 4 - Other Standard Analytical Methods: Verify adequacy of other standard analytical methods to be used for analyses of gases, particulates, volatile organic compounds, metals, and nonmetals.

7.1.4.1. The Velostat™ bag sampler proved inadequate for some volatile and semivolatile organic compounds because of absorption and subsequent off-gassing problems.

7.1.4.2. The liquid impingers (bubblers) used for measuring HCN, NH_3, and HCL in the cloud were adequate for the BB.

7.1.4.3. The extraction and analytical procedures (GC/FID) used for analysis of the volatile organics (VOC's) and the SF_6 (GC/ECD) proved to be highly successful.

7.1.4.4. Elemental analysis proved successful using XRF techniques.

7.1.5. Objective 5 - Identify and Quantify Specific Target Analytes: Identify and quantify specific target analytes for TNT, a double-base propellant, and a composite propellant.

7.1.5.1. TNT Detonation

7.1.5.1.1 The maximum EF values calculated from TNT detonation data are given in Table 7.1.

Table 7.1 Maximum Emission Factors From TNT Detonation by the Carbon Balance Method.

Species	Emission Factor (kg/kg)
Methane	1.3×10^{-4}
Acetylene	1.8×10^{-5}
Benzene	8.7×10^{-6}
Selected C_2-C_{10} non-methane paraffins	1.5×10^{-4}
Selected C_2-C_{10} olefins	3.0×10^{-5}
Selected non-benzene aromatics	3.0×10^{-5}
Phenol	2.5×10^{-5}
Naphthalene	1.5×10^{-4}
Other individual semivolatile (target analyte exotic) aromatics varied from	3×10^{-9} to 7×10^{-5}

7.1.5.1.2 Open detonation is an extremely efficient TNT thermal treatment method. Carbon-containing species measured from 227-gram (0.5-lb) TNT detonations were generally distributed as shown in Table 7.2.

Table 7.2 Distribution from Carbon-containing Species Measured From TNT.

Species	Percent
Carbon Dioxide	97.20
Carbon Monoxide	0.50
C_1 to C_{10} volatile hydrocarbons and other organics	0.57
Elemental carbon (soot)	1.71

7.1.5.2. Propellant Burn

7.1.5.2.1 Propellant burn maximum EFs were generally one to two orders of magnitude lower than those for the corresponding TNT detonation product.

7.1.5.2.2 Based on propellant carbon conversion to CO_2 open burning of double-base and composite propellants is an extremely efficient thermal treatment method. However, further work is needed to determine the fate of chlorine in the combustion products. Carbon-containing species measured from burning these fuels are distributed as shown in Table 7.3.

Table 7.3 Carbon-containing Species Measured from Propellant Burns.

Species	Percent	
	Double-Base	Composite
Carbon Dioxide	99.64	99.88
Carbon Monoxide	0.15	0.11
Organic Carbon	0.21	0.00
Elemental carbon (soot)	0.00	0.01

7.1.6. Objective 6 - PCDD's and PCDF's: Assess polychlorinated dibenzodioxins (PCDDs) and dibenzofurans (PCDFs) levels generated from burning the composite propellant containing high concentration of NH_4ClO_4.

None of the most toxic PCDDs were detected, and only one of two samples had a marginal value for the less toxic PCDFs indicating that their source was not derived from the composite propellant.

7.1.7. Objective 7 - Morphology, Composition and Size Distribution of Particulate: Provide information on the morphology, composition, and size distributions of airborne particulate material generated by OB/OD operations in the BB.

Particulate morphology and composition was accomplished by SEM and optical microscopy. The results showed that over 90 percent of the particulate was soot (carbon) with small amounts of calcium carbonate and non-asbestos insulating material.

7.1.8. Objective 8 - Carbon Balance Method: Examine, using data produced under controlled conditions, the validity of the proposed carbon balance method of calculating emission factors; compare the results with those calculated using the more-conventional cloud volume times concentration method.

7.1.8.1. The proposed carbon balance method of calculating emission factors of products of combustion resulting from OD of TNT and double-base and composite propellant burns has been verified under conditions which permit a careful comparison with the cloud-volume method.

7.1.8.2. EFs calculated by the carbon balance-method agreed within experimental uncertainty with those calculated by the more traditional concentration times cloud volume method. During periods of nonhomogenity of cloud concentration the carbon balance-method provided better estimates of the EF.

7.1.8.3. Sufficient CO_2 concentrations (above background ambient levels) must be measurable to be able to apply the carbon balance method of calculating EFs during followon, large-scale outdoor OB/OD tests.

7.1.9. Objective 9 - QA/QC Procedures: Identify or develop appropriate program-specific QA/QC procedures.

A QA/QC program was developed specifically to address BB testing and subsequent analyses. This program, along with its findings and conclusions, is delineated in Volume 3 of this report.

7.1.10. Objective 10 - Sample Storage/Transport Procedures: Establish procedures for transport and storage of sample specimens.

Procedures were established to ensure that, during transportation and storage, semivolatile compounds would be retained by their respective sampling media, and that sample identity and integrity would be maintained. These procedures are described in Volume 3 of this report.

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SECTION 8. RECOMMENDATIONS

8.1. Particulate Counting and Sizing Measurements and Data Handling Procedures

Further review particulate counting and sizing measurements and data handling procedures for adequacy before conducting full-scale, field OB/OD operations.

8.2. Bag Sampling for the FWAC

Find a more suitable bag for FWAC use during later phases of the OB/OD program. Absorption and off-gassing properties of this replacement bag should be well-characterized. If this is not available, replace the bag with another collection media.

8.3. Semi-VOST Resin Media Sampling

Replace the semi-VOST resin media with another collection media.

8.4. SFC/MS Analytical Methods

Expand the SFC/MS method of analysis to embrace samples derived from soil.

8.5. HCL, HCN, and NH_3

Define and authenticate a means of adequately measuring HCL, HCN, NH_3 in field OB clouds from a FWAC platform before conducting large-scale composite propellant burns.

8.6. Carbon Balance Method

Conduct large scale field tests of OB/OD PEP material to obtain EFs based on the carbon balance technique proven in the BB test.

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APPENDIX A - CONSOLIDATED ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
AEHA	U.S. Army Environmental Hygiene Agency, Aberdeen Proving Ground, Maryland
AFB	Air Force Base
AMC	U.S. Army Materiel Command, Alexandria, Virginia
AMCCOM	U.S. Army Armament, Munitions and Chemical Command, Rock Island, Illinois
amino-PAH	aminopolycyclic aromatic hydrocarbons
ANOVA	analysis of variance
AP	ammonium perchlorate
APS	aerodynamic particle sizer
ASASP	active scattering aerosol spectrometer probe
AWL	Alpine West Laboratories, Provo, Utah
BB	BangBox
BCD	Battelle Columbus Division, Columbus, Ohio
BD	target analyte not found in concentrations above detection limits
BYU	Brigham Young University, Provo, Utah
CAA	Clean Air Act
CDD	chlorinated dibenzodioxin
CDF	chlorinated dibenzofuran
CI-SIM	chemical ionization, selective-ion monitoring
CSI	Columbia Scientific Instruments
C•V	concentration times cloud volume method
CWA	Clean Water Act
DMC	Data Management Center
DMPS	differential mobility particle sizer
DoD	Department of Defense
DPG	U.S. Army Dugway Proving Ground, Dugway, Utah
EC	electron capture *or* elemental carbon
ECD	electron capture detector
EDAX	energy-dispersive X-ray analysis
EER	Energy and Environmental Research Corporation, Irvine, California

EF	emission factor(s)
EI	electron impact
EI-MS	mass spectrometer used in the electron impact ionization mode
EI/MS	electron impact ionization/ mass spectrometry
EIS	environmental impact statement
ELI	Environmental Labs, Incorporated, Provo, Utah
EOD	explosive ordnance disposal
EPA	U.S. Environmental Protection Agency
EPO	Environmental Protection Office, U.S. Army Dugway Proving Ground, Dugway, Utah
ER	expansion ratio
FID	flame ionization detector
FSSP	forward scattering spectrometer probe
FTIR	Fourier Transform Infrared Spectrometry
FWAC	fixed-wing aircraft
GC	gas chromatograph(y)
GC-ECD	gas chromatography with an electron capture detector
GC-FID	gas chromatography with a flame ionization detector
GC/MS	gas chromatography-mass spectrometry
GLP	good laboratory practices
HE	high explosive
HMX	octamethylenehexanitramine
HNBB	hexanitrobibenzyl
HRGC/HRMS	combined capillary column gas chromatography/high resolution mass spectrometry
HS	high-speed
LASD	Los Angeles Sheriff Department
LBL	Lawrence Berkeley Laboratory, Berkeley, California
LC	liquid chromatography
LOD	limit of detection
LOI	letter(s) of instruction
NO_x	nitrogen oxide (s)

MR	multiple range
MRI	Midwest Research Institute, Kansas City, Kansas
MS	mass spectrometry (or mass spectrometer)
MSA	Mine Safety and Appliance Company
NA	not targeted for analysis *or* not applicable
NASA	National Aeronautical and Space Administration
NATICH	National Air Toxics Information Clearinghouse
NBS-SRM	National Bureau of Standards (now NIST)- Standard Reference Material
ND	no data *or* detection limit not determined
NEPA	National Environmental Policy Act
NF	not found in the sample matrix *or* not determined
NIST	National Institute of Science and Technology
nitro-PAH	nitropolycyclic aromatic hydrocarbons
NIOSH	National Institute for Occupational Safety and Health
NOSIH	Naval Ordnance Station, Indian Head, Maryland
NO_x	nitrogen oxides
NS	not sampled
OB	open burning
OB/OD	open burning/open detonation
OC	organic carbon
OD	open detonation
OGC	Oregon Graduate Center, Beaverton, Oregon
OSHA	Occupational Safety and Health Administration
PAH	polycyclic aromatic hydrocarbons
PANH	polycyclic aromatic nitrogen heterocycles
PAOH	polycyclic aromatic oxygen heterocycles
PCDD	polychlorinated dibenzodioxins
PCDF	polychlorinated dibenzofurans
PETN	pentaerythritol tetranitrate
PEP	propellants, explosives, and pryotechnics
PIC	products of incomplete combustion
PICI/SIM	Positive ion chemical ionization/selective ion monitoring

PID	photoionization detector
PIP	product improvement program
PM	program manager
PMS	Particle Measuring Systems, Inc.
PUF	polyurethane foam
QA	quality assurance
QA/QC	quality assurance/quality control
QC	quality control
QAA	quality assurance agency
QAPP	quality assurance project plan
QAU	quality assurance unit
RCRA	Resource Conservation and Recovery Act
RDX	hexamethylenetrinitramine
RFD	Reno (Nevada) Fire Department
RIC	relative ion count
RSD	relative standard deviation
RTP	Research Triangle Park, North Carolina
SDPDA	Special Defense Property Disposal Account
semi-VOST	semivolatile organic sampling train
SEM	scanning electron microscope/microscopy
SFC	supercritical fluid chromatography
SFC/MS	supercritical fluid chromatography/mass spectrometry
SF_6	sulfur hexafluoride
SIM	selected-ion monitoring (or selective-ion monitoring)
SNL	Sandia National Laboratories, Albuquerque, New Mexico
SOP	standing operating procedures
SS	stainless steel
SSC	stainless steel canister
SSL	Sunset Laboratory, Forest Grove, Oregon
STEL	short-term exposure limit
STP	standard temperature and pressure (25°C and 760 torr)
TCD	thermal conductivity detector

TDP	test design plan
TEAD	U S Army Tooele Army Depot, Tooele, Utah
TECO	Thermo Electron Instruments (Company)
TECOM	U.S. Army Test and Evaluation Command, Aberdeen Proving Ground, Maryland
THC	total hydrocarbon
TLV	threshold limit values
TNT	2,4,6-trinitrotoluene
TSC	technical steering committee
TSP	total suspended particulate
TWA	time-weighted average
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, Maryland
UV	ultraviolet
VOC	volatile organic compounds
VSDM	Volume Source Diffusion Model
XRF	X-ray fluorescence *or* X-ray fluorescence spectrometer

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Appendix D

References

REFERENCES

Banerjee, S., S. H. Yalkowsky, and S. C. Valvani (1980), "Water Solubility and Octanol/Water Partition Coefficients of Organics. Limitation of the Solubility-Partition Coefficient Correlation," *Environ. Sci. Technol. 14*, 1227-1230.

Bangbox Test Series (1992), *Development of Methodology and Technology for Identifying and Quantifying Emission Products from Open Burning and Open Detonation Thermal Treatment Methods*, U.S. Armament, Munitions and Chemical Command, Rock Island, IL.

Bentley, R. E., J. W. Dean, S. J. Ells, T. A. Hollister, G.A. LeBlanc, S. Sauter, and B. H. Sleight III (1977), *Laboratory Evaluation of the Toxicity of RDX to Aquatic Organisms*. Final Report, U.S. Army Medical Research and Development Command, AD-A061730.

Bergman, B. B. (1952), "Tetryl Toxicity: A Summary of Ten Years Experience," *Arch. Ind. Hyg. Occup. Med. 5*, 10-20.

Carter, J. H., and P. Goldman (1976), "Pentaerythritol Tetranitrate Metabolism: a Non-essential Role for the Flora," *Biochim. Pharmacol. 25*, 860-862.

Dean, J. A., (1985), *Lange's Handbook of Chemistry*, Thirteenth Edition. McGraw-Hill Book Co. New York, NY.

Dennie, C. C., W. L. McBride, and P. E. Davis (1929), "Toxic Reactions Produced by the Application of Trinitrophenol (Picric Acid)," *Arch. Dermatol. Syphilol. 20*, 698-704.

Dobratz, B. M. (1981), *LLNL Explosives Handbook. Properties of Chemical Explosives and Explosive Simulants*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-52997.

Foulger, J. H. (1953), "Physiologic Effects of Certain Explosives and Chlorinated Hydrocarbon Solvents," *U.S. Armed Forces Med. Journal IV*, 1425-1433.

Freier, R. K. (1976), *Aqueous Solutions: Data for Inorganic and Organic Compounds*, Vol. I (Walter de Gruyter, New York, NY).

Furedi, E. M., B. S. Levine, D. E. Gordon, V. S. Rac, and P. M. Lish (1984a), *Determination of Chronic Mammalian Toxicological Effects of TNT (twenty-Four Month Chronic Toxicity/Carcinogenicity Study of Trinitrotoluene (TNT) in the Fischer 344 Rat)*, U.S. Army Medical Research and Development Command, Fort Detrick, Frederick, MD.

Furedi, E. M., B. S. Levine, J. W. Sagartz, V. S. Rac, and P. M. Lish (1984b), *Determination of the Chronic Mammalian Toxicological Effects of TNT (Twenty-Four Month Chronic Toxicity/Carcinogenicity Study of Trinitrotoluene (TNT) in the B6C3F1 Hybrid Mouse)*, U.S. Army Medical Research and Development Command, Fort Detrick, Frederick, MD.

Glover, D. J., and J. C. Hoffsommer (1973), "Thin-Layer Chromatographic Analysis of HMX in Water," *Bull. Environ. Contam. Toxicol. 10*, 302-304.

Godish, Thad (1991), *Air Quality*, Second Edition, Lewis Publishers, Chelser, MI.

Hansch, C., and A. Leo (1979), *Substituent Constants for Correlation Analysis in Chemistry and Biology* (John Wiley & Sons, New York, NY).

Hardy, H. L., and C. C. Maloof (1950), "Evidence of Systemic Effect of Tetryl," *Arch. Ind. Hyg. Occup. Med. 1*, 545-555.

Hayes, Ralph W and Frandsen, Rick D. (1994), *Use of the PCAD Computer Model for RCRA Subpart X Permitting*, Air and Waste Management Association, Cincinnati, OH.

Kaye, S. M., Ed. (1978), *Encyclopedia of Explosives and Related Items, Vol 8*, U.S. Army Armament Research and Development Command, Large Caliber Weapon Systems Laboratory, Dover, NJ.

Kittsteiner, C. (1902), "On Picric Acid," *Vierteljahrschr. Offentl. Gesundheitws. 34*, 320.

Layton, D. W., T. E. McKone, C. H. Hall, M. A. Nelson, and Y. E. Ricker (1986), *Demilitarization of Conventional Ordnance: Priorities for Data-Base Assessments of Environmental Contaminants*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-15902, AD-A182922.

Layton D., B. Mallon, W. Mitchell, L. Hall, R. Fish, L. Perry, G. Snyder, K. Bogen, W. Malloch, C. Ham, and P. Dowd (1987), *Conventional Weapons Demilitarization: A Health and Environmental Effects Data Base Assessment - Explosives and Their Co-Contaminants, Final Report, Phase II*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-21109

Leggett, D. C. (1977), "Vapor Pressure of 2,4,6-Trinitrotoluene by a Gas Chromatographic Headspace Technique," *J. Chromatogr. 133*, 83-90.

Lewis, R. J., (!993), *Condensed Chemical Dictionary*, Twelfth Edition. Van Nostrand Reinhold Co., New York, NY.

Lindner, V. (1980). "Explosives and Propellants," *Encyclopedia of Chemical Technology*, M. Grayson and D. Eckroth, Eds., Third ed. (John Wiley & Sons, New York, NY), vol. 9, pp. 561-671.

Liu, D. H. W., R. J. Spanggord, H. C. Bailey, H. S. Javitz, and D. C. L. Jones (1983), *Toxicity of TNT Wastewater to Aquatic Organisms Final Report, Volume I, Acute Toxicity of LAP Wastewater and 2,4,6-Trinitrotoluene*, U.S. Army Medical Research and Development Command, Fort Detrick, Frederick, MD, AD-A142144.

Livermore, Lawrence (1987), *Conventional Weapons Demilitarization: A Health and Environmental Effects Data Base Assessment — Explosives and Their Co-contaminants, Final Report, Phase II*, National Laboratory, Livermore, CA.

McNamara, B. P., H. P. Averill, E. J. Owens, J. F. Callahan, D. G. Fairchild, H. P. Ciuchta, R. H. Rengstorff, and D. K. Biskup (1974), *The Toxicology of Cyclotrimethylenetrinitramine (RDX) and Cyclotetra-methylenetetranitramine (HMX) Solutions in Dimethylsulfoxide (DMSO), Cyclohexanone, and Acetone*, Edgewood Arsenal, Aberdeen Proving Ground, MD, EB--TR-73040, AD-780010.

Meyer, R. (1981), *Explosives* (Verlag Chemie, Weinheim), 2nd ed.

Monroe County Year 2010 Comprehensive Plan (1993).

Neal, P. A., W. F. von Oettingen, and R. K. Snyder (1944a), "Absorption of TNT Through the Intact Skin of Human Subjects," *Experimental Studies and the Toxicity and Potential Dangers of TNT*, Pub. Health Bull. 285, p. 55.

Neal, P. A., W. F. von Oettingen, and T. R. Sweeney (1944b), "Absorption of TNT Through the Intact Skin of Swine," *Experimental Studies and the Toxicity and Potential Dangers of TNT*, Pub. Health Bull. 285, pp. 53-54.

Nose, K. (1983), "Factors for Predicting Movement of a Soluble Chemical, Picric Acid, Through Soil," *J. Pesticide Sci. 8*, 1-7.

Putnam, T. J., and W. Herman (1919), "A Study of Fifty Workers in Trinitrotoluene," *J. Ind. Hyg. 1*, 238-245.

Prager, J. C., (1995), *Environmental Contaminant Reference Databook*, Volume 1. Van Nostrand Reinhold, New York, NY.

Ryan, F. P. (1972), "Erythroderma Due to Peritrate and Glyceryl Trinitrate," *Br. J. Derm. 87*, 498-500.

Schulze, Richard R. (1993), *Practical Guide to Atmospheric Dispersion Modeling*, Trinity Consultants, Inc., Dallas TX.

Sikka, H. C., S. Banerjee, E. J. Pack, and H. T. Appleton (1980), *Environmental Fate of RDX and TNT.* Final Report, U.S. Army Medical Research and Development Command, Fort Detrick, Frederick, MD.

Small, M. J., and D. H. Rosenblatt (1974), *Munitions Production Products of Potential Concern as Waterborne Pollutants - Phase II*, U.S. Army Medical Bioengineering Research and Development Laboratory, TR7404, Aberdeen Proving Ground, MD, AD-919031L.

Spanggord, R. J., T. Mill, T. W. Chou, W. R. Mabey, J. H. Smith, and S. Lee (1980a), *Environmental Fate Studies on Certain Munition Wastewater Constituents: Final Report, Phase I, Literature Review*, SRI International, Menlo Park CA, LSU-7934.

Spanggord, R. J., T. Mill, T. W. Chou, W. R. Mabey, J. H. Smith, and S. Lee (1980b), *Environmental Fate Studies on Certain Munition Wastewater Constituents: Final Report, Phase II - Laboratory Studies*, SRI International, Menlo Park, CA, LSU-7934, AD-A099256.

Spanggord, R. J., W. R. Mabey, T. W. Chou, D. L. Haynes, P.L. Alferness, D. S. Tse, and T. Mill (1982c), *Environmental Fate Studies of HMX, Screening Studies, Final Report, Phase I*, SRI International, Menlo Park, CA, LSU-4412, AD-A148978.

Stone, W. J., T.L. Paletta, E. M. Heiman, J. I. Bruce, and J. H. Knepshield (1969), "Toxic Effects Following Ingestion of C-4 Plastic Explosive," *Arch. Intern. Med. 124*, 726-730.

Sunderman, F. W., F. D. Weidman, and O.V. Batson (1945), "Studies of the Effects of Ammonium Picrate on Man and Certain Experimental Animals," *J. Ind. Hyg. Toxicol. 27*, 241-248.

Taylor, C. A., and W. H. Rinkenbach (1923), "The Solubility of Trinitro-Phenylmethyl-Nitramine (Tetryl) in Organic Solvents," *J. Am. Chem. Soc. 45*, 104-107.

Tucker, W. A., E. V. Dose, G. J. Gensheimer, R. E. Hall, C. D. Pollman, and D. H. Powell (1985), *Evaluation of Critical Parameters Affecting Contaminant Migration Through Soils. Final Report*, U.S. Army Toxic and Hazardous Materials Agency (Tech. Div), Aberdeen Proving Ground, MD.

USEPA (1994), *Waste Analysis at Facilities that Generate, Treat, Store and Dispose of HW — A Guidance Document.*

Van Esch, G. J., H. H. Vink, and H. van Genderen (1957), "Influence of Hexanitrodiphenylamine on the Incidence of Neoplasms in the Mammary Tissue of Rats," *Nature 180*, 509-510.

Verschueren, K. (1983), *Handbook of Environmental Data on Organic Chemicals*, 2nd ed. (Van Nostrand Reinhold Co., New York, NY).

Von Oettingen, W. F. (1944), *Toxicity and Potential Dangers of PETN*, U.S. Public Health service, Public Health Bulletin No. 282.

Wilson, A. B. (1985), *HMX: Determination of the Acute and Subchronic Mammalian Toxicity*, Inveresk Research International Limited, Musselburgh, Scotland, IRI Report No. 3465.

Windholz, M., S. Budavari, R. F. Blumetti, and E. S. Otterbein, Eds. (1983), *The Merck Index*, 10th ed. (Merck & Co., Inc., Rahway, NJ).

Zakhari, S., J. E. Villaume, and P. N. Craig (1978), *A Literature Review Problem Definition Studies on Selected Toxic chemicals, Volume 3 of 8, Occupational Health and Safety Aspects of 2,4,6-Trinitrotoluene (TNT)*, Final Report, The Franklin Institute Research Laboratories, Philadelphia, PA, AD-A055683.

Beyer, W.N. and Gish, C.D. 1980. *Persistence in Earthworms and Potential Hazards to Birds of Soil Applied DDT, Dieldrin and Heptachlor.* Journal of Applied Ecology. 17:295-307.

Cataldo, *et al.* 1989. *An Evaluation of the Environmental Fate and Behavior of Munitions Materiel (TNT, RDX) in Soil and Plant Systems.* Pacific Northwest Laboratory.

Clarke and McFarland. 1991. *Assessing Bioaccumulation in Aquatic Organisms Exposed to Contaminated Sediments.* Environmental Laboratory, Department of the Army, Waterways Experiment Station. 77pp.

Eisler, R. 1988a. *Arsenic Hazards to Fish and Wildlife, and Invertebrates: A Synoptic Review.* U.S. Fish and Wildl. Serv. Biol. Rep. 85 (1.12). 92pp.

Eisler, R. 1988b. *Lead Hazards to Fish and Wildlife, and Invertebrates: A Synoptic Review.* U.S. Fish and Wildl. Serv. Biol. Rep. 85 (1.14). 134pp.

Neff, J.M. *et al.* 1978. *Availability of Sediment-Absorbed Heavy Metals to Benthos with Particular Emphasis on Deposit-Feeding Infauna.* Tech Rep. D-78-42, U.S. Army Waterways Exp. Sta., Vicksburg, Mississippi. 286 pp.

Nriagu, J.O. (ed.). 1978. *The Biogeochemistry of Lead in the Environment.* Part A. Ecological Cycles. Elsevier/North Holland Biomedical Press, Amsterdam. 422 pp.

Wang *et al.* 1984. *Microbial Decomposition of Plant Tissue Contaminate with Arsenic and Mercury.* Environmental Pollution. 34A:275-282.

4. **Professional Engineer Registered in Florida** [Complete when required by Chapter 471, F.S or not exempted by Rule 62-730.220(7), F A C]

This is to certify that the engineering features of this hazardous waste management facility have been designed/examined by me and found to conform to engineering principles applicable to such facilities. In my professional judgment, this facility, when properly constructed, maintained and operated, or closed, will comply with all applicable statutes of the State of Florida and rules of the Department of Environmental Protection.

Signature

James N. Speakman
Name (please type)

Florida Registration Number: 41460

Mailing Address: 5724 Summer Trees Drive
Street or P.O. Box

Memphis TN 38134
City State Zip

Date: _____ Telephone(901) 372-7962

[PLEASE AFFIX SEAL]

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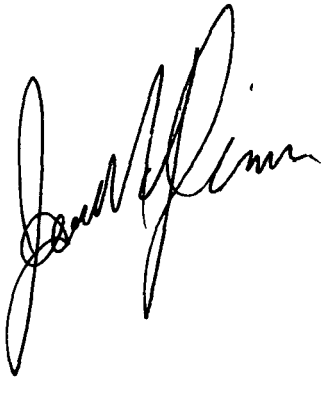

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Revision Number	0
Date	June 7, 1996
Page 11	of 12

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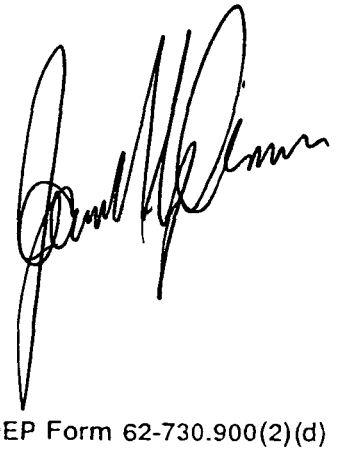

5. **Professional Geologist Registered in Florida** [Complete when required by Chapter 492, F.S. or not exempted by Rule 62-730.220(8), F.A.C.]

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Signature

Steven J. Parker
Name (please type)

Florida Registration Number: 1651

Mailing Address: 2114 Airport Boulevard
Street or P.O. Box

Pensacola FL 32504
City State Zip

Date: 5/24/96 Telephone(904) 479-4595

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[PLEASE AFFIX SEAL]

Floppy
Disc

DEMOLITION KEY NW

ORDNANCE TESTING/ TRAINING AREA

PINE TREES

FIRE PLACE

ORDNANCE TESTING/ TRAINING AREA

ORDNANCE TESTING/ TRAINING AREA

FIRE PLACE

ORDNANCE TESTING/ TRAINING AREA

GE/OSE TREATMENT UNIT

FLORIDA BAY

TESTING AND TRAINING UNIT

VEGETATION

TESTING AND TRAINING UNIT

ORDNANCE OPERATION OBSERVATION BUNKER

DEMOLITION KEY SE

LEGEND

-1- EXISTING CONTOUR (BELOW SEA LEVEL)

1 EXISTING CONTOUR

NOTE

HIGH TIDE WATER ELEVATION = 0.51'
LOW TIDE WATER ELEVATION = -1.55'
AUGUST 9, 1995

50 0 50
SCALE FEET

REVISION		
Rev Number: 000	Rev Date:00/00/00	Rev By: NAME
Rev Number: 000	Rev Date:00/00/00	Rev By: NAME
Rev Number: 000	Rev Date:00/00/00	Rev By: NAME
Rev Number: 000	Rev Date:00/00/00	Rev By: NAME
Rev Number: 000	Rev Date:00/00/00	Rev By: NAME

CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

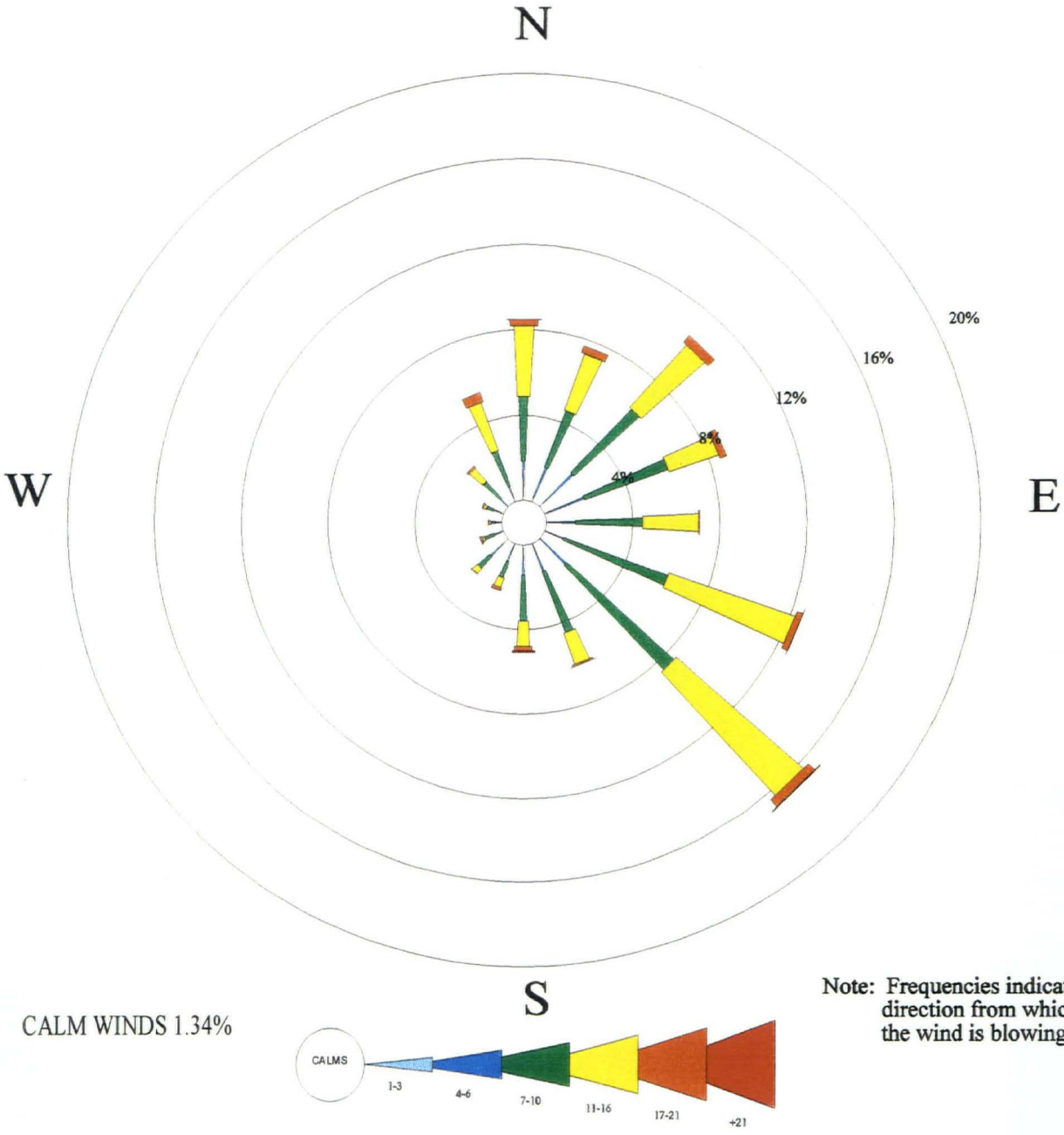
FIGURE II.B-1
TOPOGRAPHIC MAP

Dr by: JAMES A. PERRIN	Tr by:	
Ck by:	App by:	Sheet Of
Date: 06/07/96	DWG Name: 051FIB1	

Wind Rose

NAS Key West 1992

January 1 - December 31 Midnight-11 PM



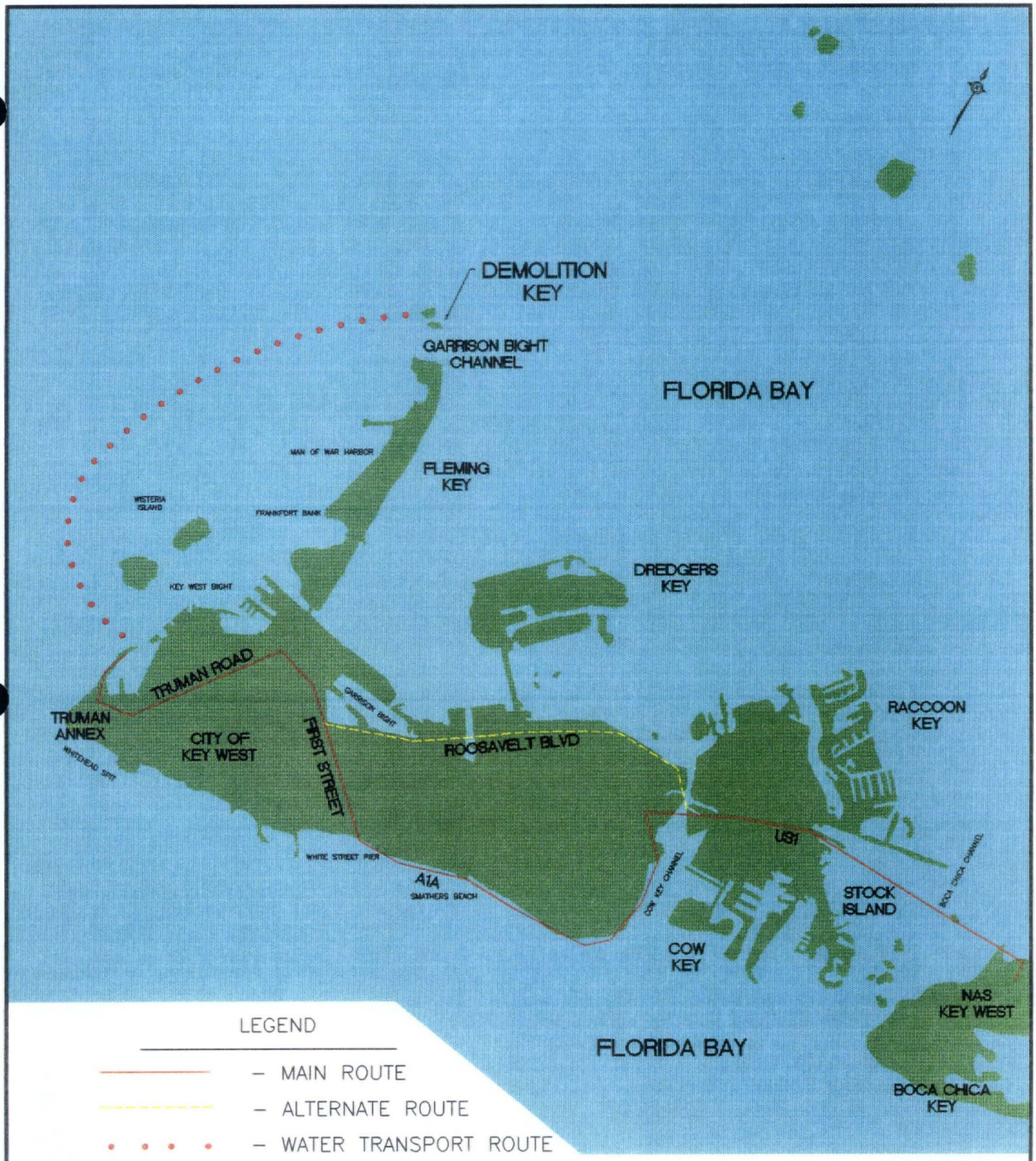
CALM WINDS 1.34%

Note: Frequencies indicate direction from which the wind is blowing.

CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

FIGURE II.B-2
WINDROSE

DWG DATE: 06/07/96 | DWG NAME: 051WR92A



NOT TO SCALE

CLOSURE PERMIT APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

FIGURE II.B–3
HAZARDOUS WASTE
TRANSPORT ROUTE

DWG DATE: 06/07/96 | DWG NAME: 051HWTR3

APPROXIMATE SCALE IN FEET

500 0 500

COASTAL BASE FLOOD ELEVATIONS APPLY ONLY LANDWARD OF THE SHORELINE SHOWN ON THIS MAP

CHANNEL

DEMOLITION KEY

BIGHT

Monroe County
Unincorporated Areas
125129

HARRISON

Fleming Key

KEY

ZONE VE (EL 13)
ZONE VE (EL 11)
ZONE AE (EL 8)
ZONE AE (EL 10)

LEGEND

SPECIAL FLOOD HAZARD AREAS INUNDATED BY 100-YEAR FLOOD

ZONE A	No base flood elevations determined.
ZONE AE	Base flood elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); base flood elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE A99	To be protected from 100-year flood by Federal flood protection system under construction; no base elevations determined.
ZONE V	Coastal flood with velocity hazard (wave action); no base flood elevations determined.
ZONE VE	Coastal flood with velocity hazard (wave action); base flood elevations determined.

CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORDIA

FIGURE II.B-4
FEMA FLOOD PLAIN MAP

DWG DATE: 06/07/96 | DWG NAME: 051BOR02

00174CC022

Storage Compatibility Mixture Chart

GROUPS	A	B	C	D	E	F	G	H	J	K	L	N	S
A	X	Z											
B	Z	X	Z	Z	Z	Z	Z						X
C	Z		X	X	X	Z	Z					Z	X
D		Z	X	X	X	Z	Z					Z	X
E		Z	X	X	X	Z	Z					Z	X
F		Z	Z	Z	Z	X	Z						X
G		Z	Z	Z	Z	Z	X						X
H								X					X
J									X				X
K										Z			
L													
N			Z	Z	Z							X	X
S		X	X	X	X	X	X	X	X			X	X

1. The marking "X" at an intersection of the above chart indicates that these groups may be combined in storage. Otherwise, mixing is either prohibited or restricted per note 2 below.

2. The marking "Z" at an intersection of the above chart indicates that when warranted by operational considerations or magazine nonavailability, and when safety is not sacrificed, logical mixed storage of limited quantities of some items of different groups may be approved by NAVSEASYSCOM. Approval is not to be considered a waiver. Combinations that violate the principles of paragraph 2.2.3 require justification by waiver or exemption. Examples of acceptable combinations of class 1 are:

a. Division 1, group A initiating explosives with division 1, group B fuzes not containing two or more independent safety features.

b. Division 3, group C bulk propellants or bagged propelling charges with division 3, group G pyrotechnics without their own means of initiation.

3. Equal numbers of separated package components of complete rounds of any single type of ammunition may be stored together. When so stored, compatibility is that of the assembled round; i.e., WP filler in group H, HE filler in groups D, E, or F, as appropriate.

4. Ammunition designated "practice" by NSN and nomenclature may be stored with the fully loaded ammunition it simulates.

5. Mixing of compatibility groups (except items in groups A, K, L and N) in limited quantities is authorized by NAVSEASYSCOM. Such mixed storage is not to exceed a total of 1,000 pounds NEW and will be considered as the highest hazard division included.

6. Group K requires not only separate storage from other groups, but also may require separate storage within the group. NAVSEASYSCOM shall determine which items in group K may be stored together and those which must be stored separately.

7. Groups A-S refer to ordnance states of readiness.

EMERGENCY INSTRUCTIONS FOR MOTOR VEHICLE DRIVERS AND INITIAL RESPONDERS

SECTION I - TO BE COMPLETED BY TRANSPORTATION OFFICE

1. THIS TRUCK IS CARRYING *(Detailed commodity description)*	2 TYPE OF PLACARD REQUIRED
3. UN ID NUMBER	4 BILL OF LADING NUMBER

SPECIFIC INSTRUCTIONS

5. IN CASE OF ACCIDENT/INCIDENT/BREAKDOWN

a. SEND FOR FIREMEN, POLICE, AMBULANCE (CALL 911)

b. SET BRAKE AND BLOCK VEHICLE TO PREVENT MOVEMENT

c. PLACE NON-FLAME PRODUCING HIGHWAY WARNING DEVICES FOR TRAFFIC APPROACHING FROM EACH DIRECTION

d DO NOT ATTEMPT TO TOW LOADED VEHICLE

e. DO NOT EXPOSE CARGO TO IMPACT, SPARKS, SMOKING, FLAMES OR HEAT OF ANY KIND.

f. DO NOT TOUCH CARGO UNTIL QUALIFIED PERSONNEL ARRIVE

6. FIRE FIGHTING METHODS

a. SEND FOR FIREMEN, POLICE, AMBULANCE (CALL 911).

b. FIRES MAY BE FOUGHT UNTIL FLAMES REACH THE CARGO, AT WHICH TIME FIREMEN AND OTHERS WOULD BE WITHDRAWN TO THE FOLLOWING DISTANCES:

PUBLIC	FIREMEN
FEET	FEET

c. FIRE EXTINGUISHING INSTRUCTION *(X one)*

☐ WATER ☐ NO WATER

d. IF FIRE IS IN TRACTOR/CAB/ENGINE, SEPARATE FROM TRAILER.

7. SPECIFIC HAZARD INSTRUCTIONS/PRECAUTIONS *(X all that apply)*

☐	BLAST	☐	EXPLOSION	☐	FIRE
☐	INTENSE HEAT	☐	FLASHBACK	☐	REIGNITION
☐	INHALATION	☐	RADIOACTIVE	☐	OTHER *(Specify)*

8. SEE ATTACHED EMERGENCY RESPONSE GUIDEBOOK, NO. PS800.4, INSTRUCTIONS:

9. SEE FURTHER INSTRUCTIONS ON THE BACK OF THIS FORM. *(X block if applicable)* ☐

10. PROMPTLY NOTIFY THE FOLLOWING:

a MUNITIONS AND EXPLOSIVES
FOR DOD EMERGENCY ASSISTANCE ONLY
CALL ARMY OPERATIONS CENTER COLLECT
ASK FOR WATCH OFFICER 202-697-0218

b INHALATION HAZARDS
TO INITIATE EMERGENCY RESPONSE ACTIONS, CALL:
_____
(To be completed by shipper based on specific commodity)

c IN ALL CASES OF ACCIDENT/INCIDENT/BREAKDOWN INVOLVING MUNITIONS AND EXPLOSIVES, INHALATION HAZARDS AND OTHER HAZARDOUS MATERIALS, PROMPT NOTIFICATION MUST BE GIVEN TO:
SHIPPER _____
CONSIGNEE _____
MTMC HOTLINES.
EASTERN US: 800-524-0331 NJ ONLY: 800-642-1361
WESTERN US: 800-331-1822 CA ONLY: 800-348-4639

d ADDITIONAL ASSISTANCE MAY BE OBTAINED FROM.
CHEMTREC: 800-424-9300
NRC: 800-424-8802

e. FOR SAFE HAVEN/REFUGE.
IMMEDIATELY CALL APPROPRIATE MTMC AREA HOTLINE.

f. IN THE EVENT OF DELAYS, NOTIFY THE SHIPPER IMMEDIATELY.

SECTION II - TO BE COMPLETED BY DRIVER

1. DRIVER PRECAUTIONS STATEMENTS *(Read before signing and X each item below)*

☐	a. I WILL COMPLY WITH ALL COMPANY RULES AND FEDERAL, STATE AND LOCAL REGULATIONS	☐	g I WILL NOT ALLOW SMOKING OR USE OF FLAME OR SPARK PRODUCING EQUIPMENT WITHIN 50 FEET OF THE VEHICLE.
☐	b. I WILL KEEP AT LEAST 600 FEET FROM TRUCKS LOADED WITH OTHER HAZARDOUS MATERIALS AND A SAFE DISTANCE FROM OTHER VEHICLES WHILE OPERATING OVER PUBLIC ROADS.	☐	h I WILL PERFORM TIRE CHECKS AND CORRECTIONS EVERY TWO HOURS/100 MILES AND AT REST STOPS.
		☐	i I WILL SELECT SAFE PARKING SPACES AT AUTHORIZED STOPPING LOCATIONS DESIGNATED BY THE STATE *(where designated)* AND/OR BY THE CARRIER.
☐	c. I WILL HAVE A COPY OF THE ROUTE PLAN AND WILL USE DESIGNATED ROUTES, AVOIDING CONGESTED RESIDENTIAL AND BUSINESS ROUTES	☐	j I WILL NOT GROUP TOGETHER WITH OTHER EXPLOSIVE VEHICLES AT STOPPING LOCATIONS
☐	d. I WILL PROTECT THE PUBLIC FROM HAZARDS OF CARGO	☐	k I WILL INSPECT VEHICLE AND MAINTAIN REQUIRED SURVEILLANCE
☐	e. I WILL NOT PERMIT UNAUTHORIZED PERSONNEL TO RIDE IN OR ON THE VEHICLE.	☐	l I UNDERSTAND THE NATURE OF THE CARGO AND ACTIONS TO TAKE IN THE EVENT OF AN ACCIDENT, INCIDENT OR FIRE
☐	f I WILL NOT EXCEED POSTED SPEED LIMITS	☐	m. I WILL ENSURE THAT DUAL AND SUBSEQUENT DRIVERS RECEIVE, READ, UNDERSTAND AND SIGN THIS FORM

SIGNATURE OF SHIPPER REPRESENTATIVE	3. SIGNATURE OF FIRST DRIVER	4. SIGNATURE OF SECOND DRIVER

DD Form 836, AUG 89 *Previous editions are obsolete* *U.S.GPO:1991—506-240 SS1-205
S/N 0102-LF-007-6300

SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND

CLOSURE PERMIT APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

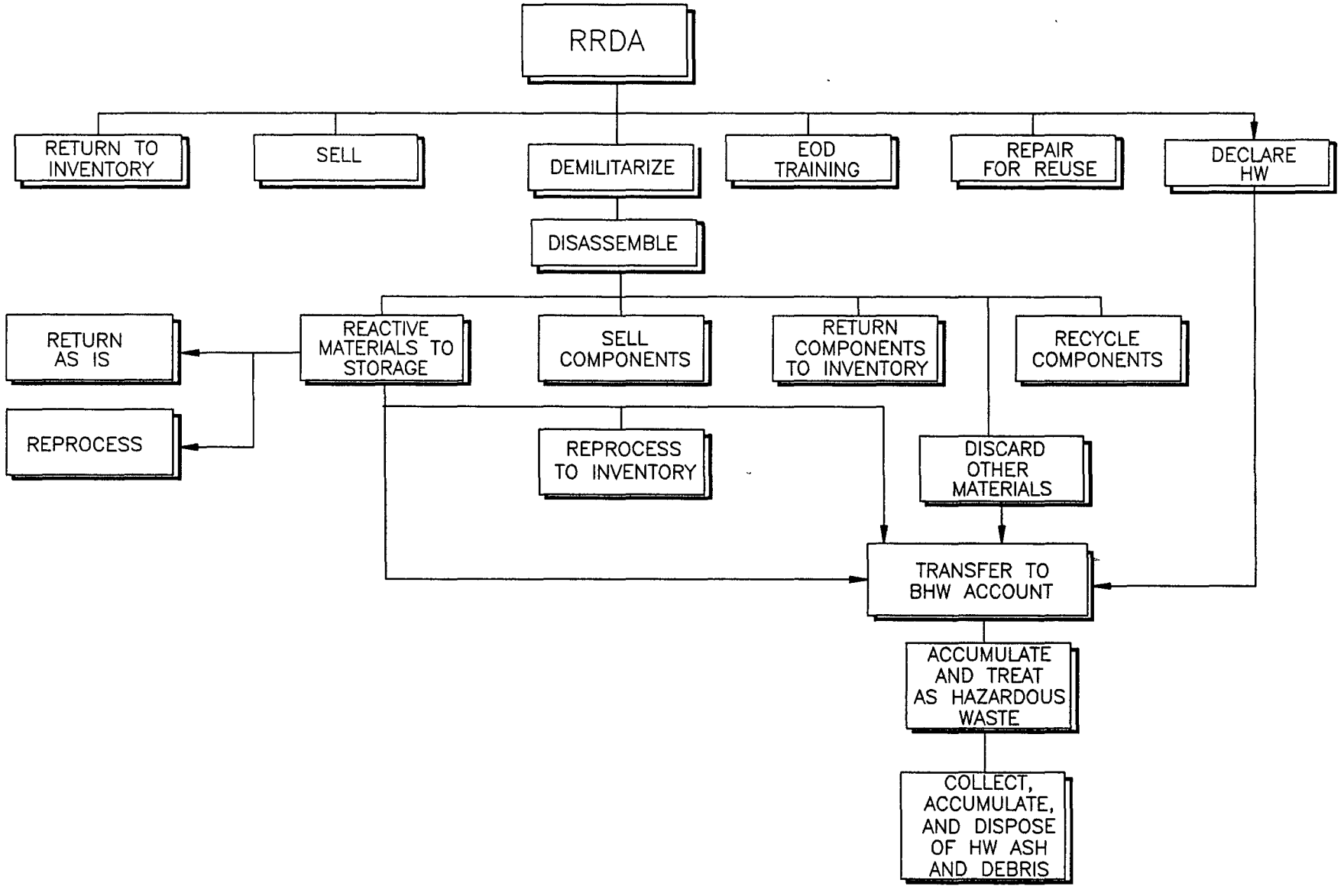
FIGURE II.B-6
DDFORM 836

DWG DATE 06/07/96 | DWG NAME 051BOR04

HAZARDOUS WASTE TREATMENT FACILITY INSPECTION CHECKLIST

TIME: DATE: INSPECTOR: POC[1]:			
	SAT[2]	UNSAT[3]	COMMENTS
FACILITY:			
Brush clearance			
Surrounding area			
TREATMENT UNITS:			
Labels, DOT/EPA and date			
SAFETY & EMERGENCY EQUIPMENT:			
Protective gloves			
Safety boots			
Eye/Face protection			
Respirators and cartridges			
Chemical protective clothing			
First aid kit			
Fire extinguishers			
Fire blanket, as used			
Two-way radios			

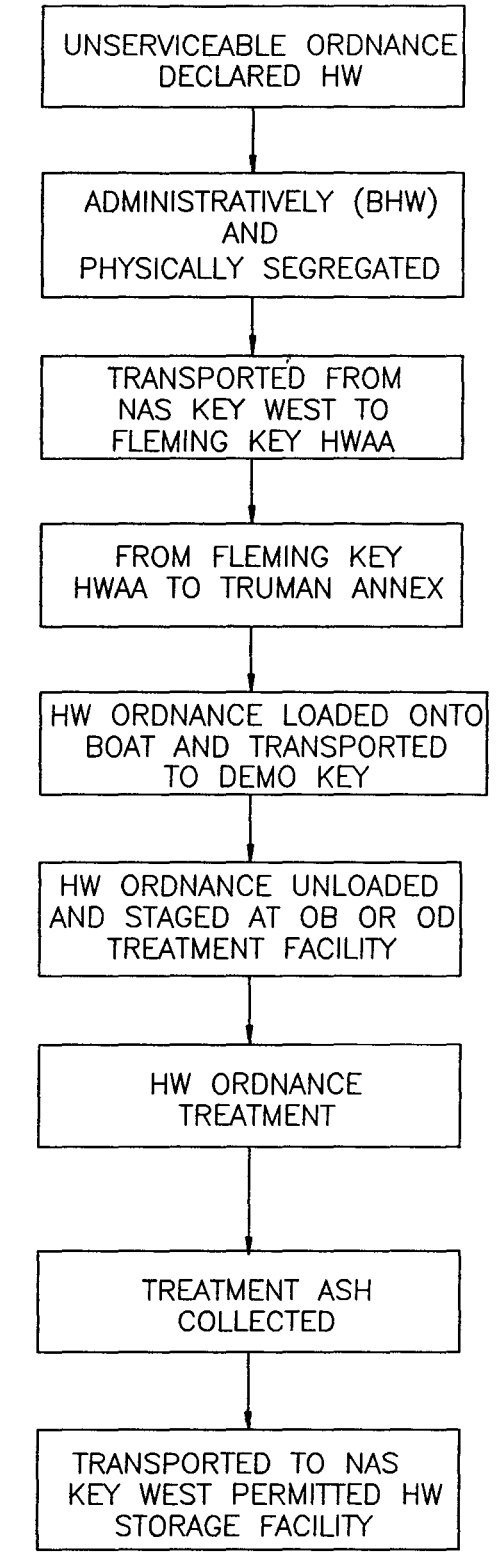
[1] Point of Contact; [2] Satisfactory; [3] Unsatisfactory



CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

FIGURE II.B-10
UNSERVICEABLE ORDNANCE
DECISION LOGIC FLOW CHART

DWG DATE: 06/07/96 | DWG NAME: 51UIIB10

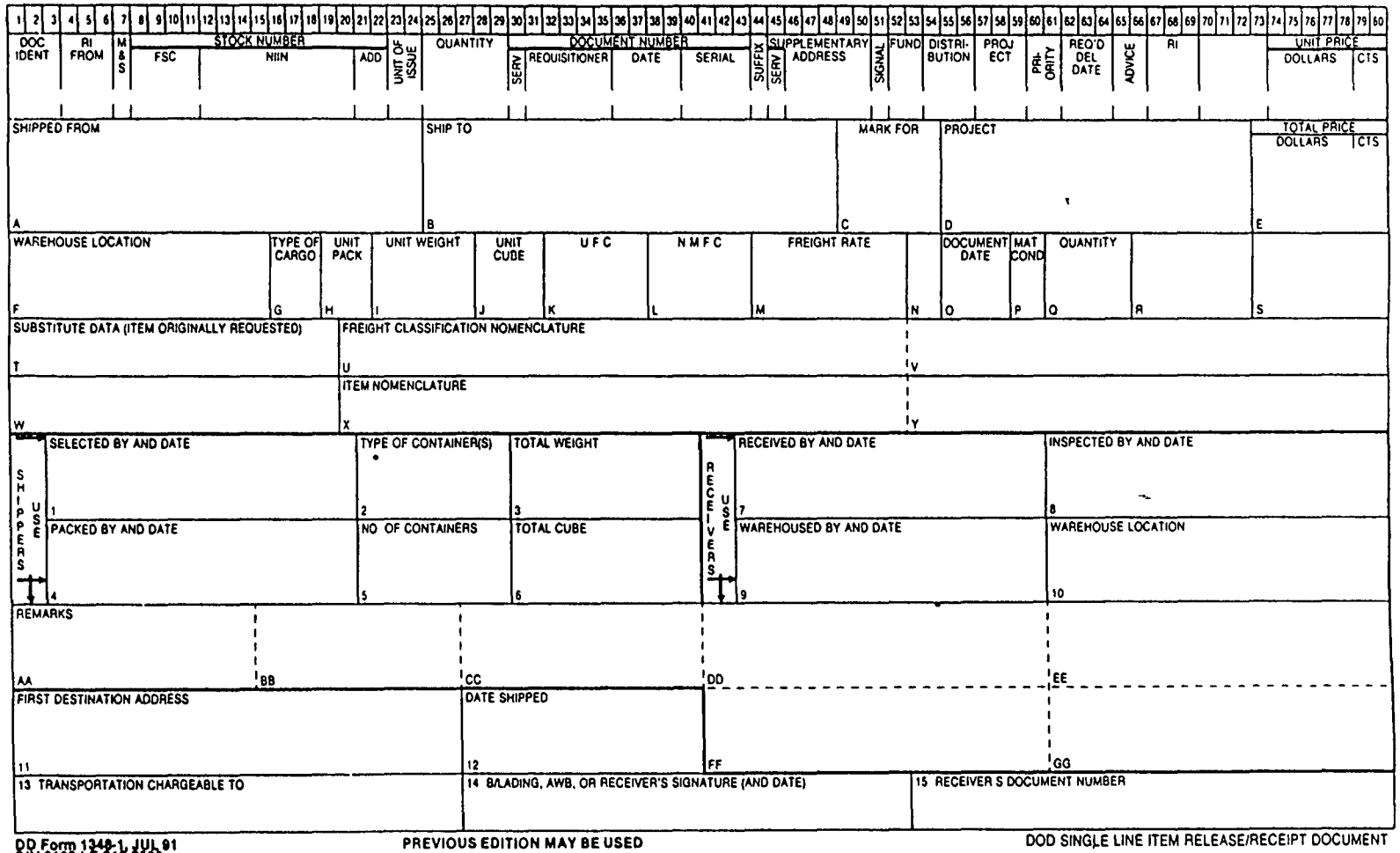


CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

FIGURE II.B-11
HAZARDOUS WASTE ORDNANCE
FACILITY FLOW CHART

DWG DATE: 06/07/96 | DWG NAME: 51HWOB11

CLOSURE PERMIT APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA



DD Form 1348-1, JUL 91
S/N 0102-LF-013-7500

PREVIOUS EDITION MAY BE USED

DOD SINGLE LINE ITEM RELEASE/RECEIPT DOCUMENT

1

FIGURE II B-12
DD 1348-1 FORM

DWG DATE 06/07/96

DWG NAME 051BOR06

Please print or type (Form designed for use on elite (12-pitch) typewriter)

Form Approved OMB NO 2050-0039 Expires 9-30-94

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator's US EPA ID No. | Manifest Document No | 2. Page 1 of | Information in the shaded areas is not required by Federal law

3. Generator's Name and Mailing Address

4. Generator's Phone ( )

A. State Manifest Document Number

B. State Generator's ID

5. Transporter 1 Company Name | 6. US EPA ID Number

C. State Transporter's ID

D. Transporter's Phone

7. Transporter 2 Company Name | 8. US EPA ID Number

E. State Transporter's ID

F. Transporter's Phone

9. Designated Facility Name and Site Address | 10. US EPA ID Number

G. State Facility's ID

H. Facility's Phone

11. US DOT Description (Including Proper Shipping Name, Hazard Class, and ID Number)	12. Containers No.	Type	13. Total Quantity	14. Unit Wt/Vol	I. Waste No.
a.					
b.					
c.					
d.					

J. Additional Descriptions for Materials Listed Above

K. Handling Codes for Wastes Listed Above

15. Special Handling Instructions and Additional Information

GENERATOR

16. GENERATOR'S CERTIFICATION: I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and national government regulations.

If I am a large quantity generator, I certify that I have a program in place to reduce the volume and toxicity of waste generated to the degree I have determined to be economically practicable and that I have selected the practicable method of treatment, storage, or disposal currently available to me which minimizes the present and future threat to human health and the environment; OR, if I am a small quantity generator, I have made a good faith effort to minimize my waste generation and select the best waste management method that is available to me and that I can afford.

Printed/Typed Name | Signature | Month Day Year

TRANSPORTER

17. Transporter 1 Acknowledgement of Receipt of Materials

Printed/Typed Name | Signature | Month Day Year

18. Transporter 2 Acknowledgement of Receipt of Materials

Printed/Typed Name | Signature | Month Day Year

FACILITY

19. Discrepancy Indication Space

20. Facility Owner or Operator: Certification of receipt of hazardous materials covered by this manifest except as noted in Item 19.

Printed/Typed Name | Signature | Month Day Year

EPA Form 8700-22 (Rev. 9-92) Previous editions are obsolete.

CLOSURE PERMIT APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

FIGURE II.B-13
UNIFORM HAZARDOUS WASTE MANIFEST

DWG DATE 06/07/96 | DWG NAME 051BOR07

Land Disposal Restriction Notification Form

Generator Name _____ US EPA ID# _____
State Manifest Number _____ Profile # _____
EPA Waste Codes _____

Treatability Group
Non-Wastewater

EPA Waste Code	Subcategory	Treatment Code	Treatment Standard
☐ D001	All descriptions based on 40 CFR 261.21, except for the §261.21(a)(1) High TOC subcategory, managed in non-CWA/non-CWA-equivalent/non-Class I SDWA systems.	DEACT and meet F039; or FSUBS, RORGS; or INCIN.	268.41 268.43
☐ D001	All descriptions based on 40 CFR 261.21, except for the §261.21(a)(1) High TOC subcategory, managed in CWA, CWA-equivalent, or Class I SDWA systems.	DEACT	
☐ D001	All descriptions based on 40 CFR 261.21 (a)(1) Low TOC Ignitable Liquids Subcategory less than or equal to 10% total organic carbon.	DEACT	268.42
☐ D002	Acid, Alkaline, and other subcategory based on 261.22 managed in non-CWA/non-CWA-equivalent/non-Class I SDWA systems.	DEACT and meet F039	268.41, 268.43
☐ D002	Acid, Alkaline, and other subcategory based on 261.22 managed in CWA, CWA-equivalent or Class I SDWA systems	DEACT	

D004-D011 Non-wastewaters with heavy metals in mg/l: 268.41

- ☐ arsenic 5.0
- ☐ barium 100
- ☐ cadmium 1.0
- ☐ chromium 5.0
- ☐ lead 5.0
- ☐ mercury 0.20 (Low mercury subcategory-less than 260 mg/kg)
- ☐ selenium 5.7
- ☐ silver 5.0

F001-F005 Spent Solvents non-waste waters; maximum constituent concentration in mg/l: 268.43

- ☐ acetone 160
- ☐ n-butyl alcohol 2.6
- ☐ carbon disulfide 4.8
- ☐ carbon tetrachloride 5.6
- ☐ chlorobenzene 5.7
- ☐ cresols (m,p) 3.2
- ☐ cyclohexane .75
- ☐ cresols (o)*5.6
- ☐ ethyl acetate 33
- ☐ 1,2 dichlorobenzene 6.2
- ☐ ethyl ether 160
- ☐ 1,2 ethyl benzene 6.0
- ☐ methanol .75
- ☐ isobutanol 170
- ☐ menthyl ethyl ketone 36
- ☐ methylene chloride 33
- ☐ nitrobenzene 14
- ☐ methyl isobutyl ketone 33
- ☐ 1,1,1 trichloroethane 5.6
- ☐ pyridine 16
- ☐ trichlorofluoromethane 33
- ☐ toluene 28
- ☐ 1,1,2 trichloroethane, 1,2,2 trifluroethane 28
- ☐ trichloroethylene 5.6
- ☐ xylene 28
- ☐ Tetrachloroethylene 5.6

F001-F005 Spent Solvents non-waste waters; maximum constituent concentration in mg/l: 268.41, 268.43

- ☐ carbon disulfide, 4.8
- ☐ 1,1,2 trichloroethane, 7.6
- ☐ cyclohexanone, 0.75
- ☐ benzene, 3.7
- ☐ methanol, 0.75

Signature _____ Date _____

*Note: Retain one copy for your files, send one copy with your shipment

Form Revised: 8/93 KMG

CLOSURE PERMIT APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

FIGURE II.B-14
LAND BAN FORM

DWG DATE 06/07/96 | DWG NAME 051BOR09

HAZARDOUS WASTE PROFILE SHEET

PART I

A. GENERAL INFORMATION

WASTE PROFILE NO. _____

1. GENERATOR NAME

2. FACILITY ADDRESS

3. GENERATOR USEPA ID

4. GENERATOR STATE ID

5. ZIP CODE

6. TECHNICAL CONTACT

7. TITLE

PHONE ( )

B. 1. NAME OF WASTE _____

2. USEPA/or/STATE WASTE CODE(S) _____

3. PROCESS GENERATING WASTE _____

4. PROJECTED ANNUAL VOLUME/UNITS _____ / _____ 5. MODE OF COLLECTION _____

6. IS THIS WASTE A DIOXIN LISTED WASTE AS DEFINED IN 40 CFR 261.31 (e.g., F020, F021, F022, F023, F026, F027, OR F028)? ☐ YES ☐ NO

7. IS THIS WASTE RESTRICTED FROM LAND DISPOSAL (40 CFR 268)? ☐ YES ☐ NO
HAS AN EXEMPTION BEEN GRANTED? ☐ YES ☐ NO
DOES THE WASTE MEET APPLICABLE TREATMENT STANDARDS? ☐ YES ☐ NO REFERENCE STANDARDS _____

PART II

1. MATERIAL CHARACTERIZATION
(OPTIONAL-NOT REQUIRED DATA)

COLOR _____
DENSITY _____ BTU/LB _____
TOTAL SOLIDS _____ ASH CONTENT _____
LAYERING: ☐ MULTILAYERED ☐ BILAYERED ☐ SINGLE PHASE

2. RCRA CHARACTERISTICS

PHYSICAL STATE: ☐ SOLID ☐ LIQUID ☐ SEMI-SOLID ☐ GAS ☐ OTHER

TREATMENT GROUP: ☐ WASTEWATER ☐ NON-WASTEWATER

☐ IGNITABLE (D001)
FLASH POINT (F) _____
☐ HIGH TOC (> 10%)
☐ LOW TOC (< 10%)

☐ REACTIVE (D003)
☐ WATER REACTIVE
☐ CYANIDE REACTIVE
☐ SULFIDE REACTIVE

☐ CORROSIVE (D002)
pH _____
☐ CORRODES STEEL

☐ TOXICITY CHARACTERISTIC
(SEE REVERSE FOR LISTING)

3. CHEMICAL COMPOSITION (ppm or mg/L)

COPPER _____ PHENOLICS _____
NICKEL _____ TOTAL HALOGENS _____
ZINC _____ VOLATILE ORGANICS _____
CHROMIUM-HEX _____ PCBs _____
(OTHER) _____

NOTE: EXPLOSIVES, SHOCK SENSITIVE, PYROPHORIC, RADIOACTIVE, AND ETIOLOGICAL WASTE NORMALLY ARE NOT ACCEPTED BY THE DRMO.

4. MATERIAL COMPOSITION

COMPONENT	CONCENTRATION	RANGE

TOTAL _____ 100%

5. SHIPPING INFORMATION

DOT HAZARDOUS MATERIAL? ☐ YES ☐ NO

PROPER SHIPPING NAME _____

HAZARD CLASS _____ U.N. or N.A. NO. _____
ADDITIONAL DESCRIPTION _____
METHOD OF SHIPMENT ☐ BULK ☐ DRUM ☐ OTHER: _____
CERCLA REPORTABLE QUANTITY (RQ) _____
EMERGENCY RESPONSE GUIDE PAGE
DOT PUBLICATION 5800.4 PAGE NO. _____ EDITION (YR) _____
SPECIAL HANDLING INFORMATION _____

6. GENERATOR CERTIFICATION

BASIS FOR INFORMATION
☐ CHEMICAL ANALYSIS *(ATTACH TEST RESULTS)*
☐ USER KNOWLEDGE *(ATTACH SUPPORTING DOCUMENTS - Explain how and why these documents comply with RCRA requirements)* _____

I, _____ *(Print or Type Name)*, HEREBY CERTIFY THAT ALL INFORMATION SUBMITTED IN THIS AND ALL ATTACHED DOCUMENTS IS TO THE BEST OF MY KNOWLEDGE AN ACCURATE REPRESENTATION OF THE WASTE TURNED IN TO THE DRMO. ALL KNOWN OR SUSPECTED HAZARDS HAVE BEEN DISCLOSED.

SIGNATURE OF GENERATOR'S REPRESENTATIVE

DATE

CLOSURE PERMIT APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

FIGURE II.B-15
HAZARDOUS WASTE PROFILE SHEET

DWG DATE 06/07/96 | DWG NAME 051BOR10

DEMOLITION KEY NW

ORDNANCE TESTING/
TRAINING AREAS

OB/OD TREATMENT
FACILITY

FLORIDA BAY

LEGEND

EDGE OF KEY

50 0 50

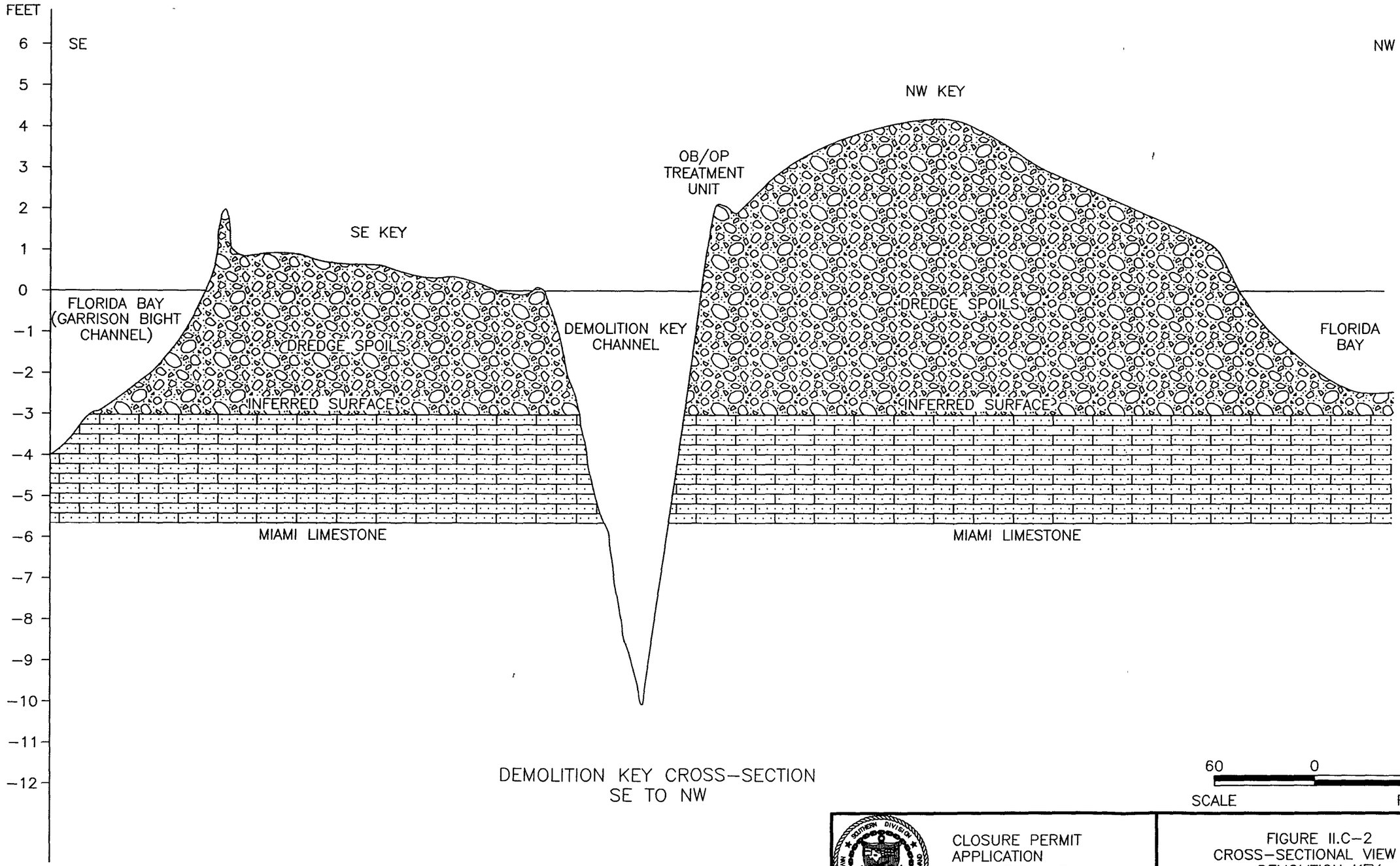
SCALE FEET

CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

FIGURE II.C-1
FACILITY/UNIT MAP

DWG DATE: 06/07/96 | DWG NAME: 051FIIC1

00174 CCB32



DEMOLITION KEY CROSS–SECTION
SE TO NW

60 0 60
SCALE FEET

CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

FIGURE II.C–2
CROSS–SECTIONAL VIEW OF
DEMOLITION KEY

DWG DATE: 06/07/96 | DWG NAME: 051DKCS3

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF FLORIDA

KEY WEST QUADRANGLE
FLORIDA—MONROE CO.
7.5 MINUTE SERIES ORTHOPHOTOMAP (TOPOGRAPHIC)

4633 II NW (SNIPE KEYS)
4633 III NE (BAY KEYS)
4633 II SW (COTTRELL KEY)
4633 II SE (BOCA CHICA KEY)

81°52'30" 24°37'30"
81°45' 24°37'30"
R. 25 E
T. 67 S.
250 000 FEET
100 000 FEET
70 000 FEET
210 000 FEET

GREAT WHITE HERON
NATIONAL WILDLIFE REFUGE
NATIONAL WILDLIFE REFUGE
KEY WEST
NORTHWEST CHANNEL
INTRACOASTAL WATERWAY
PEARL BASIN
Pearl Bank
MIDDLE GROUND
Frankfort Bank
Man of War Harbor
Calda Channel
Jack Channel
INDEFINITE BOUNDARY
Bluefish Channel
Garrison Bight Channel
Fleming Key
Salt Pond Keys
Stock Island
Wisteria Island
Mule Key
Eastcraw
Kingfish Shoals
Fort Taylor
Whitehead Spit
Smathers Beach
HAWK CHANNEL
INTRACOASTAL WATERWAY

U S NAVAL RESERVATION
U S MILITARY RESERVATION
KEY WEST INTERNATIONAL AIRPORT
Light
Radio Tower
PO
Courthouse
Mallory Dock
City Cemetery
Park
Reynolds Sch
High Sch
Fire Sta
Trumbo Pt
White Street Pier
Key West Bight
Garrison Bight
Sigsbee Sch
Poinciana Sch
BM
WT
4 LANE
BOULEVARD
ROOSEVELT BLVD
BIG PINE KEY 26 MI.
MIAMI 153 MI.

Mapped, edited, and published by the Geological Survey

Control by USGS and USC&GS

Orthophotomap prepared from aerial photograph taken April 4, 1970. Topography by planetable surveys 1971
Supersedes Army Map Service map dated 1943

Selected hydrographic data compiled from USC&GS Charts 576 (1971) and 584 (1970). This information is not intended for navigational purposes

Projection and 10,000-foot grid ticks: Florida coordinate system, east zone (transverse Mercator)
1000-meter Universal Transverse Mercator grid ticks, zone 17, shown in blue. 1927 North American datum

Where omitted, land lines have not been established or are not shown because of insufficient data

Only landmark buildings indicated in urban area

MN
GN
0°20'
6 MILS
1°
18 MILS
UTM GRID AND 1971 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000
1 MILE
1000 FEET
1 KILOMETER

CONTOUR INTERVAL 5 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS MEAN LOW WATER
THE MEAN RANGE OF TIDE IS APPROXIMATELY 1.3 FEET

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY
DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

FLORIDA
QUADRANGLE LOCATION

ROAD CLASSIFICATION
Primary highway, hard surface
Secondary highway, hard surface
Light-duty road, hard or improved surface
Unimproved road
Trails
Interstate Route
U. S. Route
State Route

KEY WEST, FLA.
N2430—W8145/7.5

1971

AMS 4633 III SE—SERIES V847

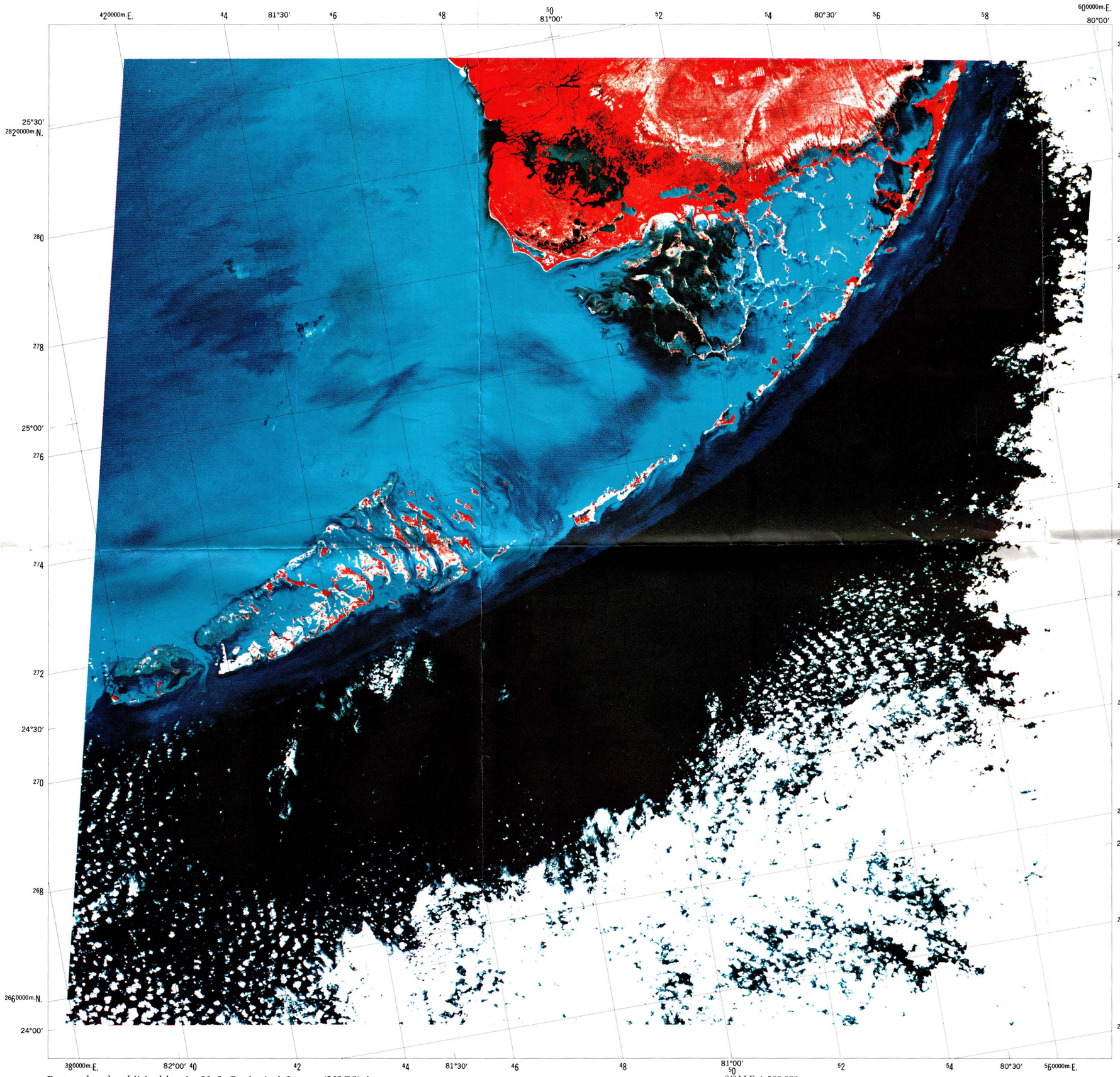
INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1977

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

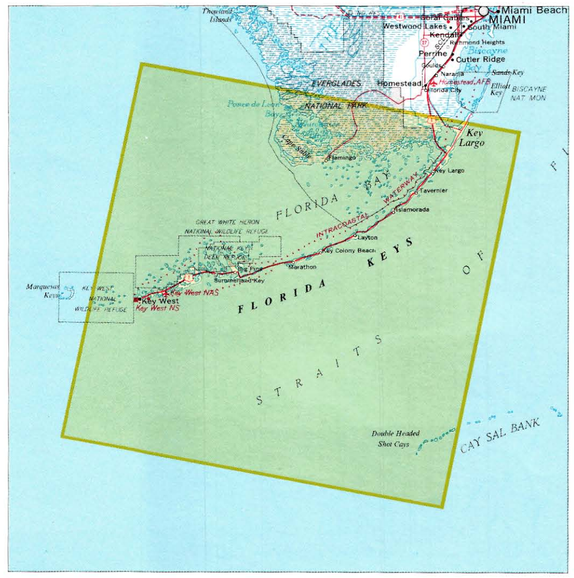
FLORIDA KEYS

FLORIDA

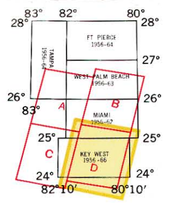
SATELLITE IMAGE MAP
NASA LANDSAT-1
1:500 000
N2430W08103



LOCATION DIAGRAM



INDEX TO 1:250 000-SCALE TOPOGRAPHIC MAPS



INDEX TO SATELLITE IMAGE MAPS

- A Sanibel Island N2557W08206
- B The Everglades N2557W08040
- C Key West N2430W08229
- D Florida Keys N2430W08103

Imagery recorded in discrete spectral bands with Multispectral Scanner (MSS) on NASA LANDSAT-1 (formerly ERTS-1) orbit 8142, 11:19 a.m. e.d.t., February 27, 1974. NASA image E-1584-15190 Orbital altitude 920 km (570 mi). Area 33 000 km² (13 000 mi²)

Generally in this false color imagery clouds appear white, cleared areas are white or light gray, vegetation is shades of red, urban areas are blue-gray, and open water is shades of blue The water shades do not directly relate to depth. Repetitive imagery obtained by LANDSAT sensors will show different conditions of vegetation, hydrography, and urban areas

Printed with magenta plate for bands 4 and 5 combined, yellow plate for band 4 and a cyan plate for band 7

Imagery controlled to photoidentified ground positions
The root-mean-square error in position of well-defined features in relation to the grid is estimated to be 250 meters

Projection based on perspective image
20 000-meter Universal Transverse Mercator grid, zone 17
1927 North American datum

Prepared and published by the U. S. Geological Survey (USGS) in cooperation with the National Aeronautics and Space Administration (NASA)

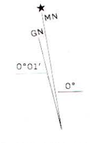
Image precision processed by Jet Propulsion Laboratory (JPL) through arrangements with NASA and USGS

Information on cost and availability of LANDSAT imagery may be obtained from U. S. Geological Survey, EROS Data Center, Sioux Falls, South Dakota 57198

SCALE 1:500 000

20 10 0 KILOMETERS 20 40
20 000 10 000 0 METERS 20 000 40 000
20 10 0 STATUTE MILES 20

FOR SALE BY U.S. GEOLOGICAL SURVEY, RESTON, VIRGINIA 22092



UTM GRID AND 1974 MAGNETIC NORTH DECLINATION AT CENTER OF IMAGE

FLORIDA KEYS
N2430W08105

1974

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1977
EXPERIMENTAL PRINTING

DEMOLITION KEY NW

ORDNANCE TESTING/ TRAINING AREA

ORDNANCE TESTING/ TRAINING AREA

ORDNANCE TESTING/ TRAINING AREA

ORDNANCE TESTING/ TRAINING AREA

ORDNANCE TESTING/ TRAINING AREA

PINE TREES

FIRE PLACE

FIRE PLACE

OB/OD TREATMENT UNIT

TESTING AND TRAINING UNIT

VEGETATION

TESTING AND TRAINING UNIT

ORDNANCE OPERATION OBSERVATION BUNKER

FLORIDA BAY

DEMOLITION KEY SE

LEGEND

-1 EXISTING CONTOUR (BELOW SEA LEVEL)

1 EXISTING CONTOUR

NOTE

HIGH TIDE WATER ELEVATION = 0.51'
LOW TIDE WATER ELEVATION = -1.55'
AUGUST 9, 1995

50 0 50
SCALE FEET

REVISION		
Rev Number: 000	Rev Date:00/00/00	Rev By: NAME
Rev Number: 000	Rev Date:00/00/00	Rev By: NAME
Rev Number: 000	Rev Date:00/00/00	Rev By: NAME
Rev Number: 000	Rev Date:00/00/00	Rev By: NAME
Rev Number: 000	Rev Date:00/00/00	Rev By: NAME

CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

FIGURE II.C-5
TOPOGRAPHIC MAP

Dr by: JAMES A. PERRIN	Tr by:	
Ck by:	App by:	Sheet
Date: 06/07/96	DWG Name:051FIIC5	Of

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
FLORIDA BUREAU OF GEOLOGY

QUATERNARY GEOLOGIC ATLAS OF THE UNITED STATES
MISCELLANEOUS INVESTIGATIONS SERIES
MAP I–1420 (NG–17)

Compiled in 1988–81
E. M. Richmond, coordinator

LIST OF MAP UNITS

HOLOCENE

- acd — ALLUVIAL CLAY AND SILT
- hs — SWAMP DEPOSIT
- hpc — FRESHWATER MARSH PEAT AND CLAY
- hp — PEAT
- hpd — DRAINED AND COMPACTED PEAT
- hcm — ALGAL MUD AND CARBONATE
- hmm — COASTAL MANGROVE SWAMP DEPOSIT
- he — SWAMP DEPOSIT AND DUNE SAND
- els — DUNE SILT AND CLAY
- be — BEACH AND DUNE SAND
- bc — BEACH SHELL-FRAGMENT AND SHELL SAND
- bd — BEACH MUD

HOLOCENE TO MIDDLE WISCONSIN

- lfm — LAKE FLIRT MARL

LATE PLEISTOCENE

- ANASTASIA FORMATION
- mol — MIAMI OOLITE

LATE PLEISTOCENE TO MIDDLE PLEISTOCENE

- bmk — BEACH SAND, WEATHERED AND OXIDIZED, UNDIFFERENTIATED
- mba — BEACH SAND AND LAGOONAL DEPOSITS, UNDIFFERENTIATED
- kls — KEY LARGO LIMESTONE
- FORT THOMPSON FORMATION

MIDDLE PLEISTOCENE TO EARLY PLEISTOCENE

- bml — BEACH SAND AND SANDY CLAY

EARLY PLEISTOCENE AND PLIOCENE

- CALOOSAHATCHEE MARL
- msa — MARINE AND ALLUVIAL SAND

LAND PEBBLE PHOSPHATE DEPOSIT

QUATERNARY AND TERTIARY

- zsc — SAND AND CLAY DECOMPOSITION RESIDUUM
- rsi — CALCAREOUS SAND SOLUTION RESIDUUM

BEACH RIDGE—Mapped along Atlantic coast and discontinuously along central carbonate ridge

NOTE 1: This map is the product of interorganizational collaboration. Following a regional meeting of state compilers with the coordinator, during which map units and related matters were established, a Quaternary map and map explanation of this quadrangle were prepared by T. M. Scott and M. S. Knapp of the Florida Bureau of Geology. Supplemental information was added by D. L. Weide, and G. M. Richmond, editors. Significant geologic problems requiring changes in the map were resolved in discussions and by correspondence. Reviewers, to whom the editors are indebted were W. A. White, University of North Carolina, and J. B. Cathcart, U.S. Geological Survey.

NOTE 2: The Pliocene-Pleistocene boundary defined by joint resolution of the International Union for Quaternary Research (INQUA) Subcommission 1–d on the Pliocene/Pleistocene Boundary (the International Commission on Stratigraphy (ICS) Working Group on the Pliocene/Pleistocene Boundary) and the Working Group on the International Geological Correlation Program (IGCP) Project No. 41 (Neogene/Quaternary Boundary) is that at the Vrica section in southern Italy. The age of that boundary currently is inferred to be 1.65 Ma (Aguirre and Pasini, 1984).

Time boundaries between the early Pleistocene and middle Pleistocene and between the middle Pleistocene and late Pleistocene are being proposed by the INQUA Working Group on Major Subdivision of the Pleistocene. The boundary between the early Pleistocene and middle Pleistocene is placed at the Matuyama-Brunhes magnetic polarity reversal. The reversal has not been dated directly by radiometric control, but it is significantly older than the Bishop Tuff (revised K-Ar age 738 ka; Izett, 1982), and the estimated K-Ar age of 730 ka assigned to the reversal by Mankinen and Dalrymple (1979) is too young. In Utah, the Bishop volcanic ash bed overlies a major paleosol developed in sediments that record the Matuyama-Brunhes reversal (Eardley and others, 1973). The terrestrial geologic record is compatible with the astronomical age of 788 ka assigned to the reversal by Johnson (1982). The boundary between the middle Pleistocene and late Pleistocene is placed arbitrarily at the beginning of marine oxygen isotope substage 5e (at Termination II or the stage 6/5 transition). That boundary also is not dated directly. It was assigned provisional ages of 127 ka by CLIMAP project members (CLIMAP Project Members, 1984) and 128 ka by SPECMAP Project members (Ruddiman and McIntyre, 1984), based on uranium-series ages of the substage 5e high eustatic sea level stand. A sidereal age of 132 ka is derived by projection of the boundary onto the astronomical time scale of Johnson (1982).

The Pleistocene-Holocene boundary is being proposed by the INQUA Subcommission on the Holocene. Currently, in the United States, it is placed arbitrarily at 10,000 B.P. (Hopkins, 1975).

Aguirre, Emiliano, and Pasini, Giancarlo, 1984, Proposal of the ICS Working Group on the Pliocene/Pleistocene boundary concerning the definition of the Pliocene/Pleistocene boundary and the stratotype: 6 p.

CLIMAP Project Members, 1984, The last interglacial ocean: Quaternary Research, v. 21, p. 123–224.

Eardley, A. J., Shuey, R. T., Gvosdetsky, V., Nash, W. P., Picard, M. D., Grey, D. C., and Kukla, G. J., 1973, Lake cycles in the Bonneville Basin, Utah: Geological Society of America Bulletin, v. 84, no. 1, p. 211–215.

Hopkins, D. M., 1975, Time stratigraphic nomenclature for the Holocene epoch: Geology, v. 3, no. 1, p. 10.

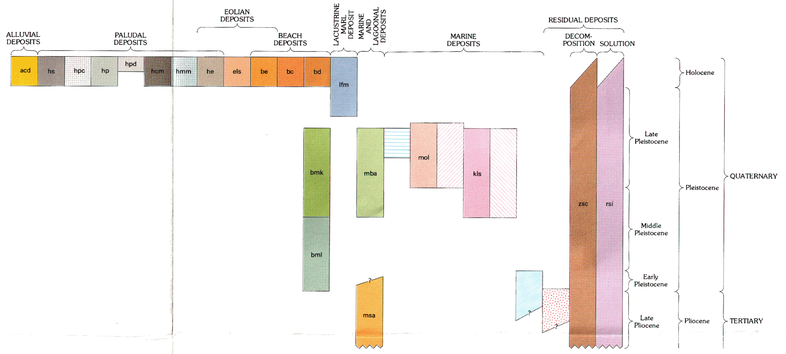
Izett, G. A., 1982, The Bishop ash bed and some older, compositionally similar, ash beds in California, Nevada, and Utah: U.S. Geological Survey Open-File Report 82–582, 47 p., 1 pl.

Johnson, R. G., 1982, Brunhes-Matuyama magnetic reversal dated at 790,000 yr B.P. by marine-astronomical correlations: Quaternary Research, v. 17, no. 2, p. 135–147.

Mankinen, E. A., and Dalrymple, G. B., 1979, Revised geomagnetic polarity time scale for the interval 0–5 m.y. B.P.: Journal of Geophysical Research, v. 84, no. B2, p. 615–626.

Ruddiman, W. F., and McIntyre, A., 1984, Ice-age thermal response and climatic role of the surface Atlantic Ocean, 40° N. to 63° N.: Geological Society of America Bulletin, v. 95, p. 381–396.

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

HOLOCENE

acd ALLUVIAL CLAY AND SILT—Light- to dark-gray, yellow to brown, poorly to well-stratified, clayey silt and silty clay alluvium. Deposit contains varying amounts of interbedded or admixed fine sand, especially in channels along upper parts of regional drainages. Locally it also includes clay balls, lenses of kaolinitic clay, and scattered phosphatic pellets and quartz sand. Mapped areas include organic muck and swamp deposits (hs) on flood plains and, locally, colluvium along margins of valley floors. Thickness generally 5–10 m

hs SWAMP DEPOSIT—Dark-brown to black muck, mucky peat, and organic residue mixed with fine to very fine quartz sand, silt, and kaolinitic clay. Commonly thinly laminated; locally includes lenses of mottled clay. Large deposits extensively bioturbated. In topographic depressions, intermittently covered by 0.5 to 1 m of standing water. Where these areas have been drained for agriculture, oxidation of the swamp deposits has resulted in subsidence as much as 3 m. Small, discontinuous areas of slightly higher ground are covered with light- to dark-brown, unconsolidated, medium to fine quartz sand. Thickness 3–10 m

hpc FRESHWATER MARSH PEAT AND CLAY—Gray to black herbaceous peat and clay, intermixed and interbedded. Color darkens as content of organic matter increases. Includes interbedded freshwater and brackish-water deposits. Mapped in part from distribution of freshwater vegetation. Thickness 1–3 m

hp PEAT—Dark-gray to black undecomposed to partially decomposed organic matter compacted into thick mats interbedded with thin layers of fine sand and silt. Mapped areas confined to deposits in which volume of organic matter exceeds that of mineral matter. Thickness 2–5 m

hpd DRAINED AND COMPACTED PEAT—Light- to dark-gray fibrous peat mixed with other organic material and interlayered with lenses of silt and fine to medium sand. Where areas are drained for agriculture and urban development, burning, oxidation, and compaction of the deposits has resulted in subsidence of as much as 4 m. Thickness 2–3 m

hcm ALGAL MUD AND CARBONATE—Blue, green, or gray, freshwater, algal matte overlying algal calcitic mud interbedded with thin layers of crystalline low-magnesian calcite. Deposit forms a rhythmite resulting from annual growth and death of calcite-secreting blue-green algae (Gleason, 1972, p. 34–38). Thickness approximately 1 m

hmm COASTAL MANGROVE SWAMP DEPOSIT—Dark-gray to black organic muck intermittently covered by as much as 1 m of sea water. Overlies wave-beveled surfaces cut on soft, porous, shelly limestone of late Pleistocene Anastasia Formation and Tertiary limestone. Mapped only in areas that support dense stands of both red and black mangrove along the Gulf of Mexico. Thickness 0.5–1 m

he SWAMP DEPOSIT AND DUNE SAND—Swamp deposit is dark-gray to orange mottled, silty, smectitic clay with abundant organic debris. Present in parallel, linear, interdune depressions along Atlantic coast. Dune sand is white, unconsolidated, and fine to medium grained. It is composed of quartz mixed with moderate amounts of shell debris. Deposit forms linear beach and dune ridges parallel to shore. Dunes are chiefly stabilized by vegetation though some are locally active. Map unit overlies the Anastasia Formation in northeast part of the quadrangle. Deposit is compacted throughout most of eastern Florida, as a result of drainage for agriculture. Thickness 5–15 m

els DUNE SILT AND CLAY—Light-gray to light-yellow, fine to medium crossbedded sand and sand-size aggregates of silt and clay particles forming a complex of large dunes. Mapped only along northeast, east, and southeast shores of Lake Okeechobee where dunes have accumulated because of intense storm activity. Thickness 5–10 m

be BEACH AND DUNE SAND—Light-tan, angular, medium to fine sand, well-sorted, crossbedded, mostly quartz with traces of heavy minerals. Upper layers locally contain crushed shell that increases gradually in proportion from north to south. Occurs along coast at and above modern beach. Also present as thin deposits, too small to map, on coastal freshwater marsh deposits (hpc). Thickness 2–7 m

bc BEACH SHELL-FRAGMENT AND SHELL SAND—White to light-gray shell fragment and shell sand including minor amounts of fine quartz sand, silt, and clay. Locally the deposit may be weakly cemented by calcium carbonate. Where exposed along the Florida Keys, the unit commonly consists of foraminiferal tests. Thickness 1–5 m

bd BEACH MUD—Gray to black silt and clay, contains shell fragments and very fine grained organic matter, color darkens as amount of organic matter increases. Underlies beaches bordering saline marsh, estuaries, and lakes from which it has been transported. Thickness 0.5–1.5 m

HOLOCENE TO MIDDLE WISCONSIN

lfm LAKE FLIRT MARL—Light- to dark-gray freshwater, calcareous fine silt and clay interbedded with soft, white, freshwater marl and thin layers of organic material, peat, or muck. Locally may be covered with swamp deposits or very thin discontinuous patches of quartz and calcareous sand. Thickness as much as 3 m

LATE PLEISTOCENE

ANASTASIA FORMATION—Present mostly in subsurface and shown by pattern on map. Light-gray to yellow, compactly interbedded, sandy marine limestone, calcareous sandstone and sand; cemented to friable coquina. Locally contains thin, discontinuous lenses of black silty muck and decayed organic matter. The Anastasia Formation is about 110,000 years old as determined by a Th^{230}/U^{234} dating method (Osmond and others, 1970). Exposures of the formation, too small to show at scale of map, occur discontinuously along the Atlantic coastal ridge of eastern Florida, but most of it unit is covered by thin swampy deposits (hs) and dune sand (he). Thickness as much as 30 m

mol MIAMI OOLITE—White to light-yellow, crystalline, oolitic limestone interbedded with thin layers of soft, unconsolidated oolitic sand. Locally this unit is perforated with numerous solution holes and channels now filled with fine to medium quartz sand. Oolitic limestone portions of the formation are commonly brecciated and re-cemented as a result of solution. Th^{230}/U^{234} ages on the Miami Oolite range from about 90,000 to about 145,000 years old (Broecker and Thurber, 1965; Osmond and others, 1965). The oolite is exposed at the surface throughout much of southeast Florida; in place it is covered by thin, discontinuous patches of eolian oolite and quartz sand (indicated by pattern). Thickness as much as 20 m

LATE PLEISTOCENE TO MIDDLE PLEISTOCENE

bmk BEACH AND MARINE SAND, WEATHERED AND OXIDIZED—Light-yellow to dark-orange quartz sand mixed with and stained by organic matter. Underlain at depths of as much as 0.5 m by fine quartz sand compacted and mixed with insoluble clay; locally, weakly to strongly cemented with calcium carbonate. Basal part of unit consists of as much as 7 m of consolidated sand containing abundant whole but rotted bivalve shells. Deposit overlies sand, clayey sand, or shelly sand of older Pleistocene beach ridges. Much shell material has been leached from upper part of the deposits, resulting in reduction of thickness by as much as 1.5 m. Locally, the dissolved shell material has been redeposited with insoluble clay to form a subsurface hardpan. Thickness 6–9 m

mba BEACH SAND AND LAGOONAL DEPOSITS, UNDIFFERENTIATED—Light-gray, yellowish-gray and brownish-gray, poorly to well-sorted sand, silt, and clay, intermixed and interbedded. Locally includes thin stringers of well-rounded quartz pebbles and shell hash in remnants of old tidal channels. In places, also contains the insoluble residues of beach sand and sandy lagoonal deposits associated with older Pleistocene shorelines. Mapped areas include numerous small swamp deposits (hs), organic muck, shell debris, and thin patches of eolian sand. Thickness 10–25 m

kls KEY LARGO LIMESTONE—Light-gray to light-yellow, coralline limestone. Highly fossiliferous with molds and casts of boring marine organisms. Locally composed of coral heads and algal mounds surrounded by amorphous limestone, coral detritus, and limestone breccia. Contains thin lenses of dense, hard, freshwater limestone in places. Upper surface brecciated and recemented. Th^{230}/U^{234} ages on coral and on oolite are mostly between about 95,000 and 145,000 years (Broecker and Thurber, 1965; Osmond and others, 1965). Maximum thickness about 20 m

FORT THOMPSON FORMATION—Present only in subsurface and shown by pattern on map. White to very light yellow, sandy limestone and calcareous sandstone, interbedded with layers and pockets of fine-grained, well-sorted quartz sand, and thin beds of dense, hard, freshwater limestone. Exposed in numerous small outcrops but is mostly covered by thin swamp deposits (hs) and deposits of weathered and oxidized beach sand (bmk). Maximum thickness about 25 m

MIDDLE PLEISTOCENE TO EARLY PLEISTOCENE

bml BEACH SAND AND SANDY CLAY—White, yellow, reddish-yellow to reddish-orange, well-sorted phosphatic sand and clayey sand. Locally contains lenses of red to orange-red, well-sorted, coarse sand stained and cemented with iron. Deposit reworked from the Pliocene Bone Valley Formation; in places overlies Tertiary limestone and fills many of the karst depressions along ridges underlain by the limestone. Locally overlain by small deposits of white, very well sorted quartz sand and thin deposits of black to blue-gray organic muck. Thickness 1–10 m

EARLY PLEISTOCENE AND PLIOCENE

CALOOSAHATCHEE MARL—Present in subsurface only and shown by pattern on map. Grayish-green or greenish-gray, silty, sandy marl with interbedded lenses of sand, silt, and clay. Locally may contain lenses of carbonaceous material that suggest former mangrove swamps. West of Lake Okeechobee, consists of a series of reefs composed of sandy shelly limestone and calcareous sandstone. Five radiometric dates on corals from the type locality range from 1.78 Ma (million years) to 1.89 Ma and average 1.84 Ma, a single date from the St. Petersburg area is 2.53 Ma (Bender, 1973). All are older than the estimated age of the Pliocene-Pleistocene boundary (1.65 Ma). A Pliocene age is indicated by the presence of *Equus (cf. E.) Leidyi* (DuBar, 1958a). Map unit is overlain by very thin, discontinuous patches of shelly sand. Maximum thickness 15 m

msa MARINE AND ALLUVIAL SAND (Facies of Citronelle Formation)—Upper part is white to light-yellow, fine to coarse, loose quartz sand, but most of unit is red, orange, yellow, or brown, crossbedded, pebbly, coarse to fine, kaolinitic quartz sand, cashedarened by iron oxide. Deposit includes red- and yellow-banded lenses of generally poorly sorted, slightly kaolinitic, pebbly, coarse to fine sand, and thin beds of white, highly kaolinitic, well sorted, fine quartz sand containing numerous shrimp burrows. Locally includes pockets of white, kaolinitic clay, and thin stringers of discoid quartz and quartzite pebbles. Locally deposited on and collapsed into karst terrain developed on limestone. Coextensive with and forms an important part of Lake Wales Ridge (Pirkle and Yoho, 1970), a major topographic feature that forms the divide of the central Florida peninsula for 250 to 300 km. Considered in part to be of marine littoral and delta origin and in part of alluvial origin. Has been correlated with the Citronelle Formation (Grogan and others, 1964; Pirkle and Yoho, 1970; White, 1970) which, in its type locality at Citronelle in Alabama, contains a vertebrate fauna assigned a Pliocene-Hemphillian age by F. C. Whitmore (Isphording and Lamb, 1971) and fossil leaves of Pliocene age (Berry, 1916; Stringfield and Lamoureaux, 1957; Doering, 1958). Thickness 12–15 m

LAND PEBBLE PHOSPHATE DEPOSIT—Present only in subsurface and shown by pattern on map. Phosphatic pellets and nodules, quartz sand, and smectitic clay; chiefly massive and structureless but locally crossbedded or with horizontal laminations in places. Locally includes pockets of clay that fill sinkholes in underlying limestone. Phosphate deposit is believed by Cathcart and others (1952) to be a residuum derived from underlying Pliocene Bone Valley Formation; by Sellards (1915) to have been deposited in a shallow marine environment following erosion of the Miocene Hawthorn Formation. Overlain by wave-reworked beach sand and sandy clay (bml) as thick as 10 m. Thickness as much as 18 m

QUATERNARY AND TERTIARY

zsc SAND AND CLAY DECOMPOSITION RESIDUUM[1]—White, light-yellow, grayish-orange or grayish-red, commonly mottled, poorly sorted, fine quartz sand and small lenses of clay, interbedded with light-gray, yellowish-gray, very pale orange, or light-brown, micaceous, medium to coarse sand; locally includes lenses of kaolinitic sandy clay that contain leached and partly decomposed oyster shell fragments. Mapped areas include some bedrock outcrops and alluvial terrace deposits too small to map separately, the latter are formed chiefly on the south side of the mouths of major rivers flowing into the Gulf of Mexico. Thickness 1–2.5 m

rsi CALCAREOUS SAND SOLUTION RESIDUUM[2]—Yellowish-gray to grayish-white quartz sand and calcareous sand residuum on soft sandy limestone and shell-hash limestone. Locally, where deposit mantles an underlying karst topography, it includes the clay-filling of sink holes. Mapped areas include some locally derived colluvium, and scattered bedrock outcrops. Thickness 1–3 m

[1]Decomposition residuum, for purpose of this map, is defined as material derived primarily by in-place chemical decay of clastic rock with no appreciable subsequent lateral transport.

[2]Solution residuum, for purposes of this map, is defined as material derived by in-place solution of carbonate rock or carbonate-cemented rock with no appreciable subsequent lateral transport.

SOURCES OF INFORMATION

Bender, M. L., 1973, Helium-uranium dating of corals: Geochemica et Cosmochimica Acta, v. 37, p. 1229–1247.

Berry, E. W., 1916, The flora of the Citronelle Formation: U.S. Geological Survey, Professional Paper 98, p. 193–202.

Broecker, W. S., and Thurber, D. L., 1965, Uranium series dating of corals and oolites from Bahaman and Florida Key limestones: Science, v. 149, p. 58–60.

Cathcart, J. B., Blade, L. V., Davidson, D. F., and Ketner, K. B., 1952, The geology of the Florida Land Pebble phosphate deposit: International Geological Congress, 19th, Algiers 1952, Section 11, p. 77–91.

Cooke, C. W., 1939, Scenery of Florida interpreted by a geologist: Florida Department of Conservation Bulletin 17, 118 p.

_____1943, Geology of the coastal plain of Georgia: U.S. Geological Survey Bulletin 941, 121 p.

Davis, J. H., 1946, The peat deposits of Florida: Florida Geological Survey Bulletin 30, 247 p.

Doering, J. A., 1958, The Citronelle age problem: American Association of Petroleum Geologists Bulletin, v. 42, p. 1816–1862.

DuBar, J. R., 1958a, Stratigraphy and paleontology of the late Neogene strata of the Caloosahatchee River area of southern Florida: Florida Geological Survey Bulletin 40, 267 p.

_____1958b, Neogene stratigraphy of southwestern Florida: Transactions, Gulf Coast Associated Geological Societies, v. 8, p. 129–155.

_____1962, Neogene biostratigraphy of the Charlotte Harbor area, Southwest Florida: Florida Geological Survey Bulletin 43, 83 p.

_____1974, Summary of the Neogene stratigraphy of southern Florida, in Oaks, R. Q., Jr., and DuBar, J. R., editors, Post-Miocene stratigraphy central and southern Atlantic coastal plain: Logan, Utah State University Press, p. 206–231.

DuBar, J. R., DuBar, S. S., Ward, L. W., and Blackwelder, B. W., with contributions by W. H. Abbott and P. F. Juddleston, 1980, Cenozoic biostratigraphy of the Carolina outer Coastal Plain, in Frey, R. W., and Neatherly, T. L., editors, Excursions in southeastern Geology, v. 1, Geological Society of America 1980 Annual Meeting, Atlanta, Georgia: American Geological Institute, p. 179–236.

Enos, Paul, and Perkins, R. D., 1977, Quaternary sedimentation in south Florida: Geological Society of America Memoir 147, 198 p.

Gleason, P. J., 1972, Holocene sedimentation in the Everglades and saline tidal lands: American Quaternary Association, Second Biennial Conference, 1972, Field trip guidebook to Everglades National Park, Dec. 2–3, 1972, Central and Southern Florida Flood Control District, 47 p.

Grogan, R. M., Few, W. G., Garnar, T. E., and Hager, C. R., 1964, Milling at Dupont's heavy mineral mines in Florida, in Arbiter, Nathaniel, editor, Milling methods in the Americas: 7th International Mineral Processing Congress, New York, Gordon and Breach Science Publishers, p. 205–229.

Harmon, R. S., Ku, T. L., Matthews, R. K., and Smark, P. L., 1979, Limits of U-series analysis—Phase 1 results of Uranium series intercomparison Project: Geology, v. 7, p. 405–409.

Hoyt, J. H., and Hails, J. R., 1967, Pleistocene shoreline sediments in coastal Georgia deposition and modification: Science, v. 155, p. 1541–1543.

_____1974, Pleistocene stratigraphy of southeastern Georgia, in Oaks, R. Q., Jr., and DuBar, J. R., editors, Post-Miocene stratigraphy, central and southern Atlantic Coastal Plain: Logan, Utah State University Press, p. 191–205.

Hoyt, J. H., Weimer, R. J., and Henry, V. J., 1965, Age of late Pleistocene coastal deposits, central Georgia Abstracts, International Association for Quaternary, Research 7th Congress, p. 228.

Isphording, W. C., and Lamb, G. M., 1971, Age and origin of the Citronelle Formation in Alabama: Geological Society of America Bulletin, v. 82, p. 375–780.

Knapp, M. S., 1980, Environmental geology series, Tampa Sheet: Florida Bureau of Geology Map Series 80, scale 1:250,000.

Lane, B. E., 1980, Environmental geology series, West Palm Beach Sheet: Florida Bureau of Geology Map Series 100, scale 1:250,000.

_____1981, Environmental geology series, Miami Sheet: Florida Bureau of Geology Map Series 101, scale 1:250,000.

Lane, B. E., Knapp, M. S., and Scott, T. M., 1980, Environmental geology series, Fort Pierce Sheet: Florida Bureau of Geology Map Series 97, scale 1:250,000.

Liddicoat, J. C., Bishop, D. F., and Wehmiller, J. F., 1982, Paleomagnetic and amino acid dating of sediment in the Atlantic Coastal Plain: Geological Society of America Abstracts with Programs, v. 14, no. 7, p. 546.

McCartan, Lucy, Owens, J. P., Blackwelder, B. W., Szabo, B. J., Belknap, D. F., Kriausakul, D. F., Mitterer, R. M., and Wehmiller, J. F., 1982, Comparison of amino acid racemization geochronometry with lithostratigraphy, biostratigraphy, uranium-series coral dating, and magnetostratigraphy in the Atlantic Coastal Plain of the southeastern United States: Quaternary Research, v. 18, p. 337–359.

McPherson, B. F., Hendrix, G. Y., Klein, Howard, and Tyus, H. M., 1976, The environment of south Florida, a summary report: U.S. Geological Survey Professional Paper 1011, 81 p.

Mitterer, R. M., 1975, Ages and diagenetic temperatures of Pleistocene deposits of Florida based on isoleucine epimerization in *Mercenaria*: Earth and Planetary Science Letters, v. 28, p. 275–282.

Oaks, R. Q., Jr., and DuBar, J. R., 1974, Tentative correlation of post-Miocene units, central and southern Atlantic Coastal Plain, in Oaks, R. Q., Jr., and DuBar, J. R., editors, Post-Miocene stratigraphy central and southern Atlantic Coastal Plain: Logan, Utah State University Press, p. 232–276.

Olsen, S. J., 1965, Vertebrate fossil localities in Florida: Florida Geological Survey Special Publication 12, 28 p.

Osmond, J. K., Carpenter, J. R., Windon, H. L., 1965, Thorium^{230}/Uranium^{234} age of Pleistocene corals and oolites of Florida: Journal of Geophysical Research, v. 70, p. 1843–1847.

Osmond, J. K., May, J. P., and Tanner, W. F., 1970, Age of the Cape Kennedy barrier and lagoon complex: Journal of Geophysical research, v. 75, p. 469–479.

Parker, G. G., Ferguson, G. E., and Love, S. K., 1955, Water resources of southeastern Florida: U.S. Geological Survey Water-Supply Paper 1255, 965 p.

Pirkle, E. C., and Yoho, W. H., 1970, the heavy mineral ore body at Trail Ridge, Florida: Economic Geology, v. 65, p. 17–30.

Pirkle, E. C., Yoho, W. H., Allen, A. T., and Edgar, A. C., 1963, Citronelle sediments of Peninsular Florida: Florida Academy of Science Quarterly Journal, v. 26, no. 2, p. 105–149.

Pirkle, F. L., and Czel, L. J., 1983, Marine fossils from region of Trail Ridge, a Georgia-Florida landform: Southeastern Geology, v. 24, p. 31–38.

Puri, H. S., and Vanstrum, W. L., 1969, Geology of the Miocene and younger sediments in south Florida, in DuBar, J. R., and DuBar, S. S., editors, Late Cenozoic stratigraphy of southwestern Florida: Gulf Coast Association of Geological Societies-Society of Economic Paleontologists and Mineralogists, Second Annual Meeting, 1969, Field Trip No. 4, p. 70–86.

Puri, H. S., and Vernon, R. O., 1964, Summary of the geology of Florida and guidebook to the classic exposures: Florida Geological Survey Special Publication 5, 312 p.

Sellards, E. H., 1915, The pebble phosphates of Florida: Florida Geological Survey Annual Report 7, p. 25–116.

Shackleton, N. J., and Opdyke, N. D., 1973, Oxygen isotope and paleomagnetic stratigraphy of equatorial Pacific core V28–238: Oxygen isotope temperatures and ice volumes on a 10^5 year and 10^6 year scale: Quaternary Research, v. 79, p. 39–55.

Stringfield, V. T., and Lamoureaux, P. E., 1957, Age of the Citronelle Formation in the Gulf Coastal Plain: American Association of Petroleum Geologists Bulletin, v. 41, p. 742–757.

van Donk, Jan, 1976, O^{18} of the Atlantic Ocean for the entire Pleistocene Epoch, in R. M. Cline and J. D. Hays, editors, Investigations of Quaternary Paleoceanography and Paleoclimatology: Geological Society of America Memoir 14, p. 147–164.

White, W. A., 1970, the geomorphology of the Florida Peninsula: Florida Bureau of Geology Bulletin 51, 164 p.

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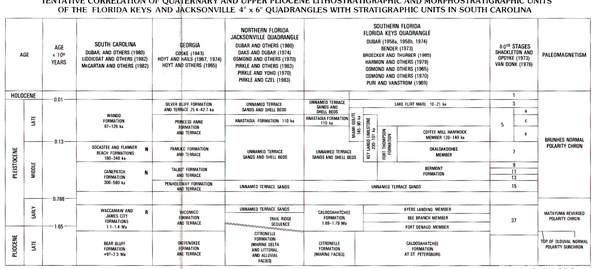
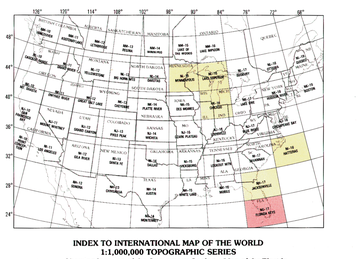
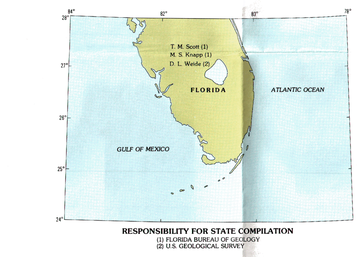




Showing location of the Quaternary Geologic Map of the Florida Keys 4° x 6° Quadrangle in red [U.S. Geological Survey, Miscellaneous Investigations Series, Map I–1420 (NG–17)] and other published maps in the Quaternary Geologic Atlas of the United States in yellow



RESPONSIBILITY FOR STATE COMPILATION
(1) FLORIDA BUREAU OF GEOLOGY
(2) U.S. GEOLOGICAL SURVEY

QUATERNARY GEOLOGIC MAP OF THE FLORIDA KEYS 4° x 6° QUADRANGLE, UNITED STATES

State compilations by
Thomas M. Scott, Michael S. Knapp, and David L. Weide
Edited and integrated by
Gerald M. Richmond, David S. Fullerton, and David L. Weide

1986

QUATERNARY GEOLOGIC ATLAS OF THE UNITED STATES

DEMOLITION KEY NW

B-10

B-9

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B-8

DEMOLITION KEY SE

B-1

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B-5

FLORIDA BAY

LEGEND

EDGE OF KEY

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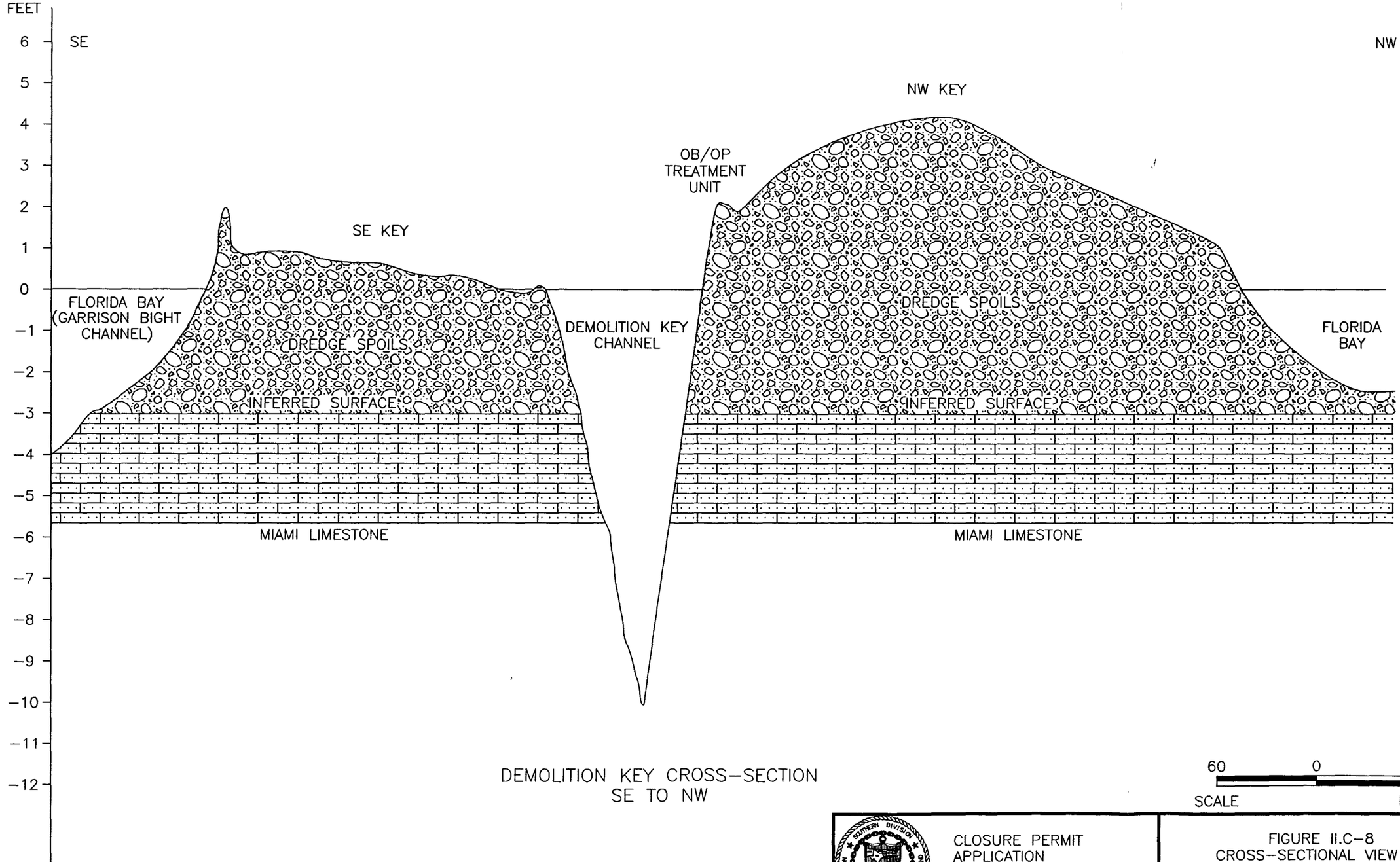
SCALE FEET

CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

FIGURE II.C-7
BORING LOCATIONS

DWG DATE: 06/07/96 | DWG NAME: 051FIIC7

00174 CCB52



DEMOLITION KEY CROSS–SECTION
SE TO NW

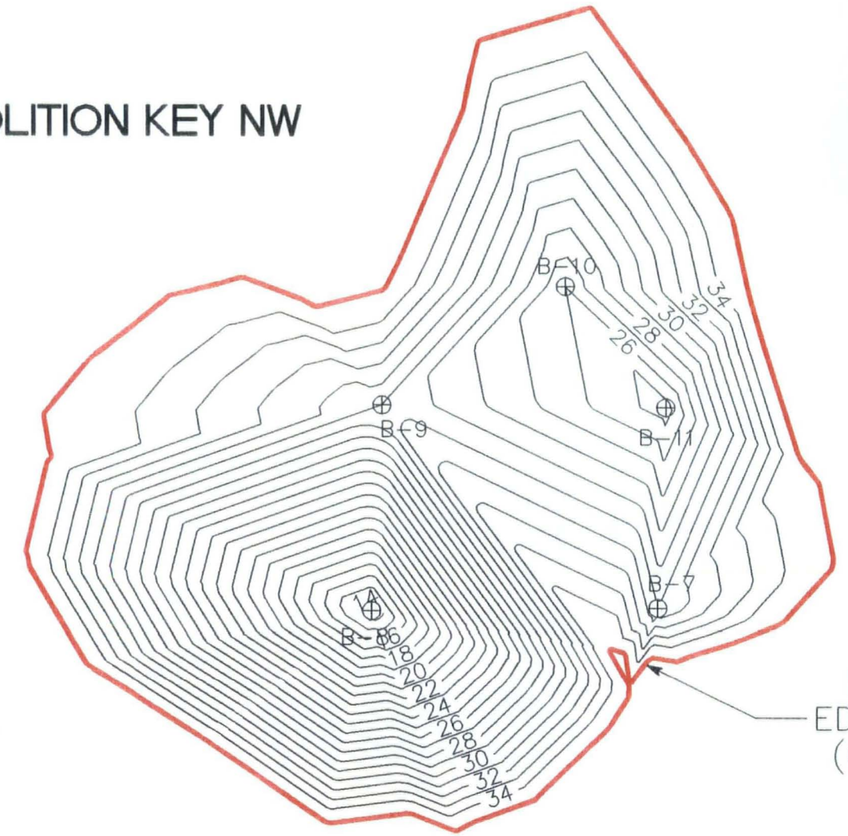
60 0 60
SCALE FEET

CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

FIGURE II.C–8
CROSS–SECTIONAL VIEW OF
DEMOLITION KEY

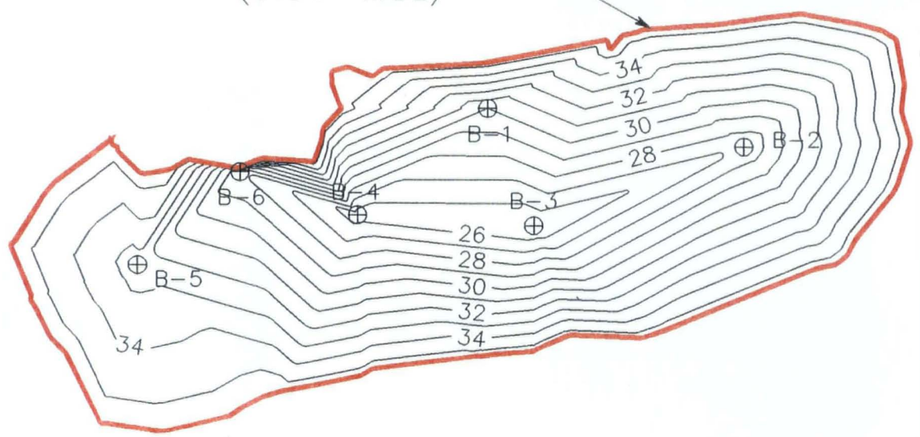
DWG DATE: 06/07/96 | DWG NAME: 051DKCS8

DEMOLITION KEY NW



HIGH TIDE
EDGE OF KEY
(0.51' MSL)

DEMOLITION KEY SE



FLORIDA BAY

LEGEND

EDGE OF KEY

24 SALINITY CONTOUR (PARTS/THOUSAND)

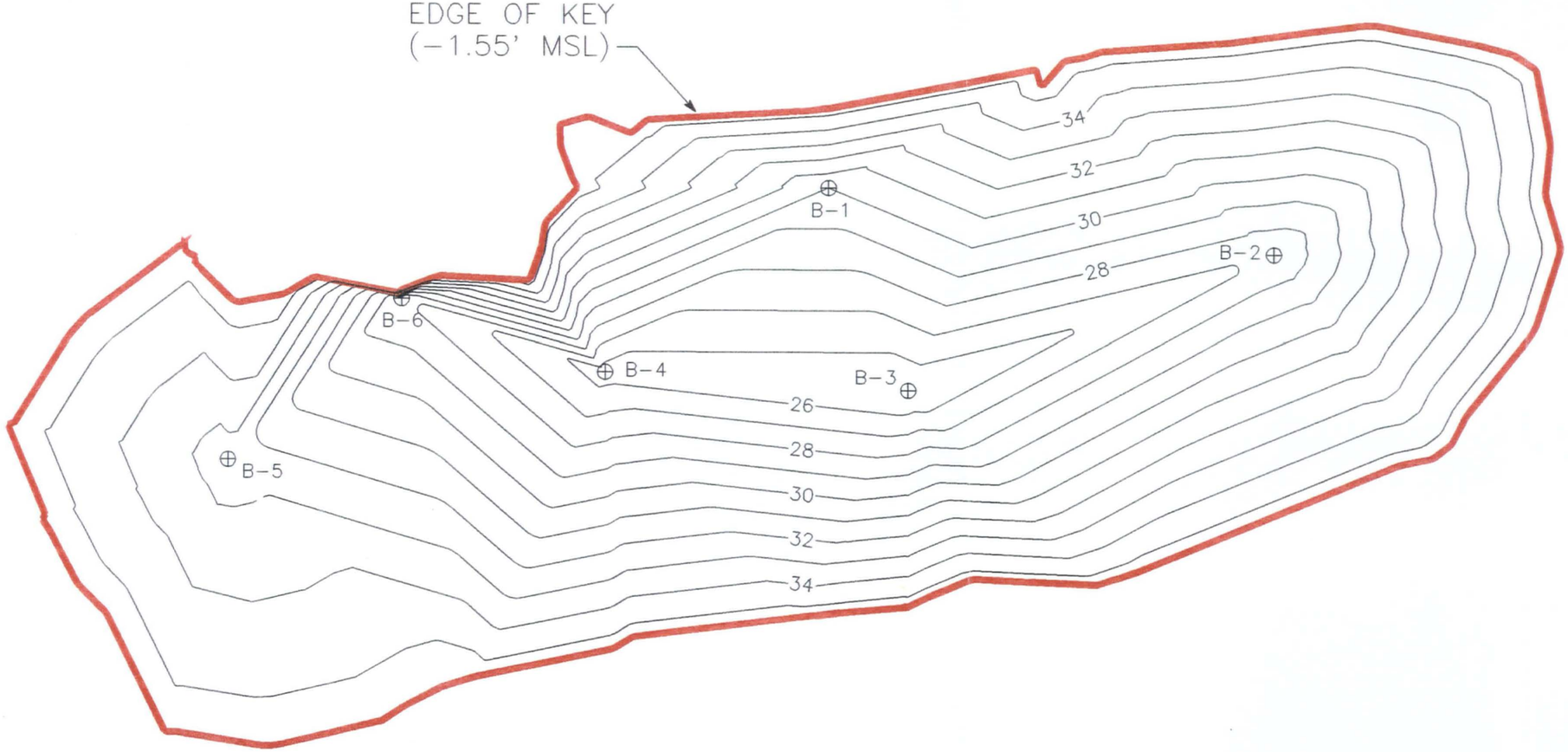
80 0 80
SCALE FEET

CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

FIGURE II.C-9
HIGH TIDE SALINITY CONTOUR MAP

DWG DATE: 06/07/96 | DWG NAME: 051FIIC9

DEMOLITION KEY SE



FLORIDA BAY

LEGEND

EDGE OF KEY

24 SALINITY CONTOUR (PARTS/THOUSAND)

40 0 40

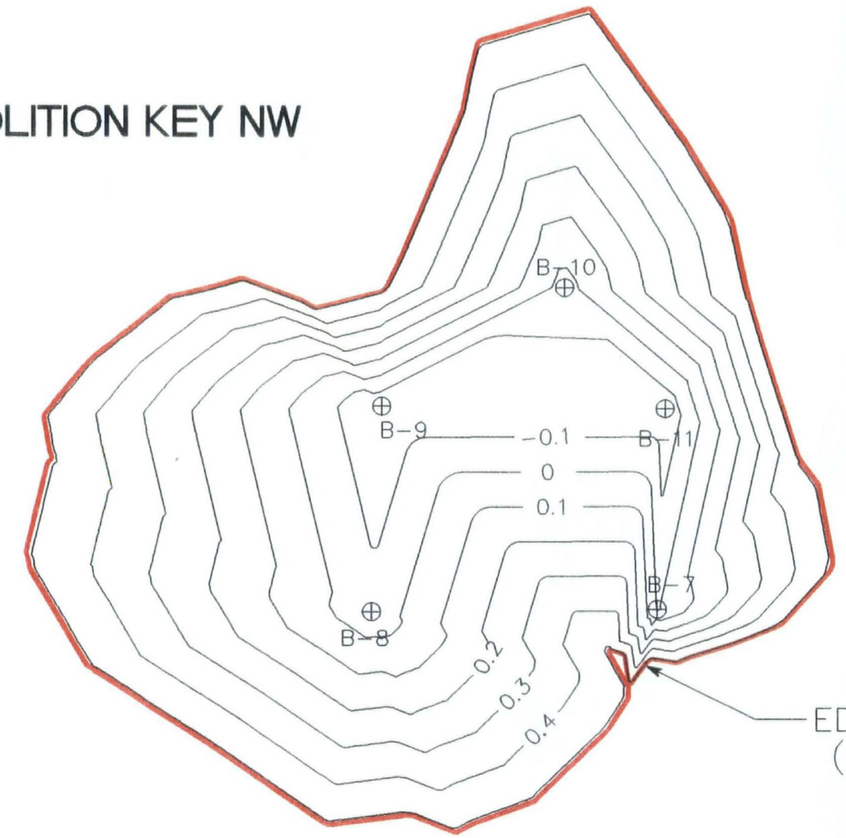
SCALE FEET

CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

FIGURE II.C−10
LOW TIDE SALINITY CONTOUR MAP

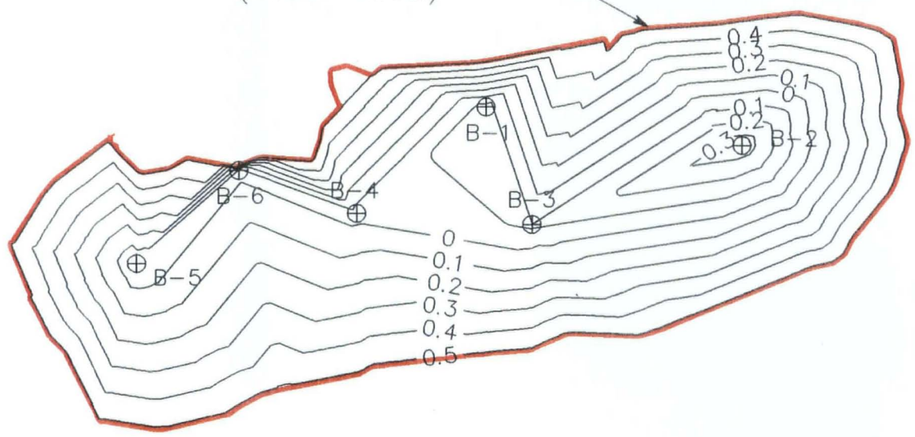
DWG DATE: 06/07/96 | DWG NAME: 51FIIC10

DEMOLITION KEY NW



HIGH TIDE
EDGE OF KEY
(0.51' MSL)

DEMOLITION KEY SE



FLORIDA BAY

LEGEND

EDGE OF KEY

0.2 GROUNDWATER CONTOUR (FT.)

80 0 80

SCALE FEET

CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

FIGURE II.C-11
HIGH TIDE GROUNDWATER LEVELS

DWG DATE: 06/07/96 | DWG NAME: 51FIIC11

DEMOLITION KEY SE

FLORIDA BAY

LEGEND

EDGE OF KEY

0.2 GROUNDWATER CONTOUR (FT.)

40 0 40

SCALE FEET

CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

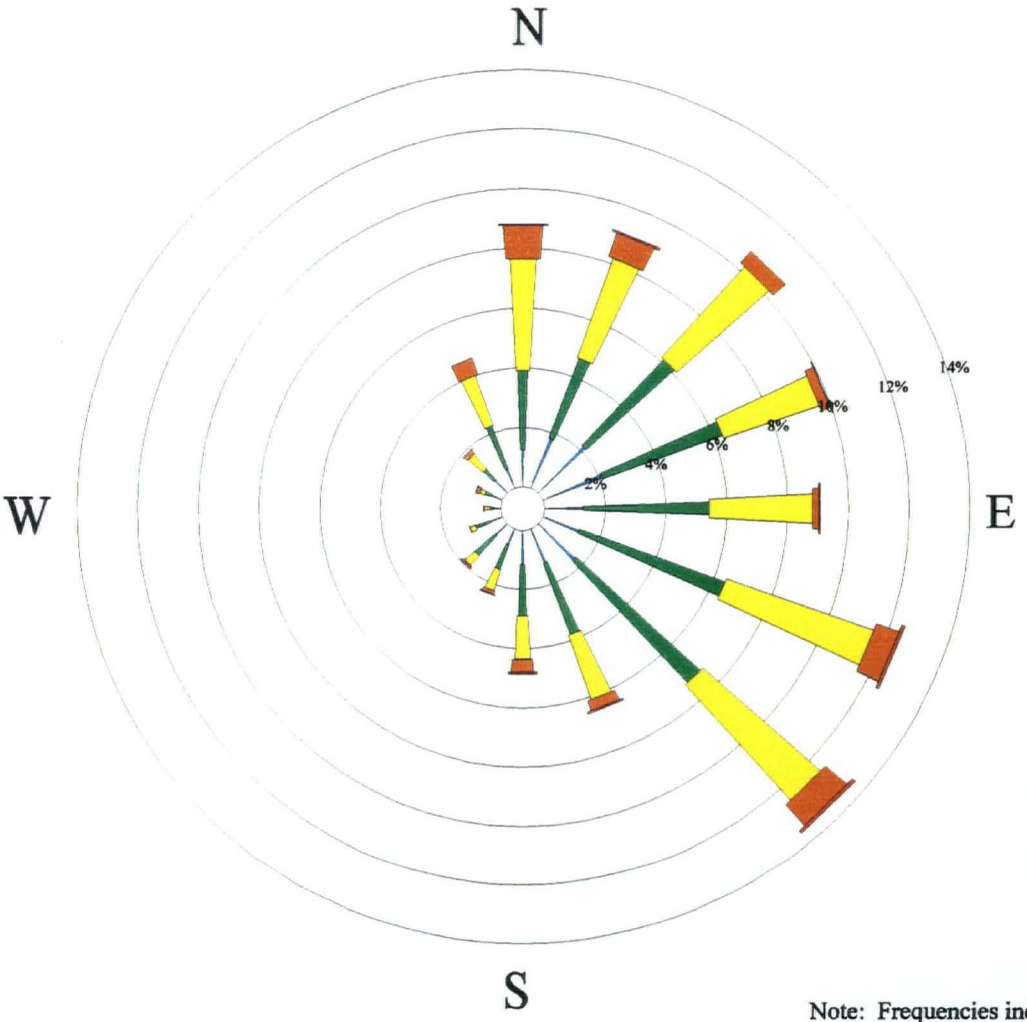
FIGURE II.C-12
LOW TIDE GROUNDWATER LEVELS

DWG DATE: 06/07/96 | DWG NAME: 51FIIC12

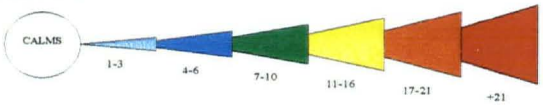
Wind Rose

NAS Key West 1988

January 1 - December 31 Midnight-11 PM



CALM WINDS 1.26%



Note: Frequencies indicate direction from which the wind is blowing.

CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

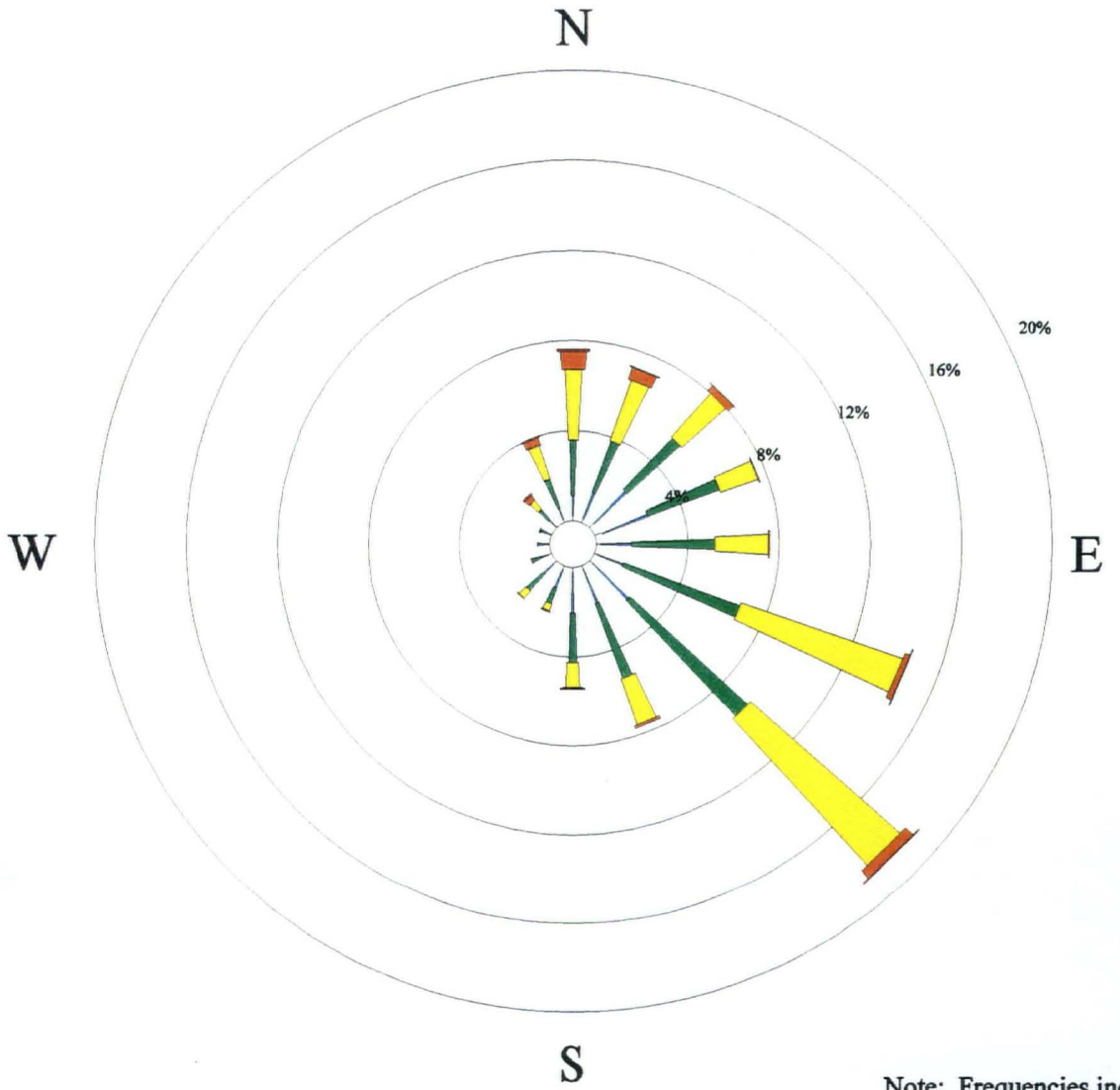
FIGURE II.C-13
1988 WINDROSE

DWG DATE: 06/07/96 DWG NAME: 051WR88

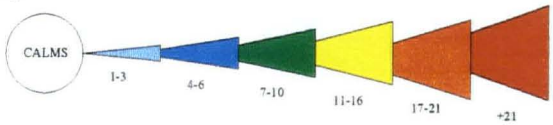
Wind Rose

NAS Key West 1989

January 1 - December 31 Midnight-11 PM



CALM WINDS 2.55%



Note: Frequencies indicate direction from which the wind is blowing.

CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

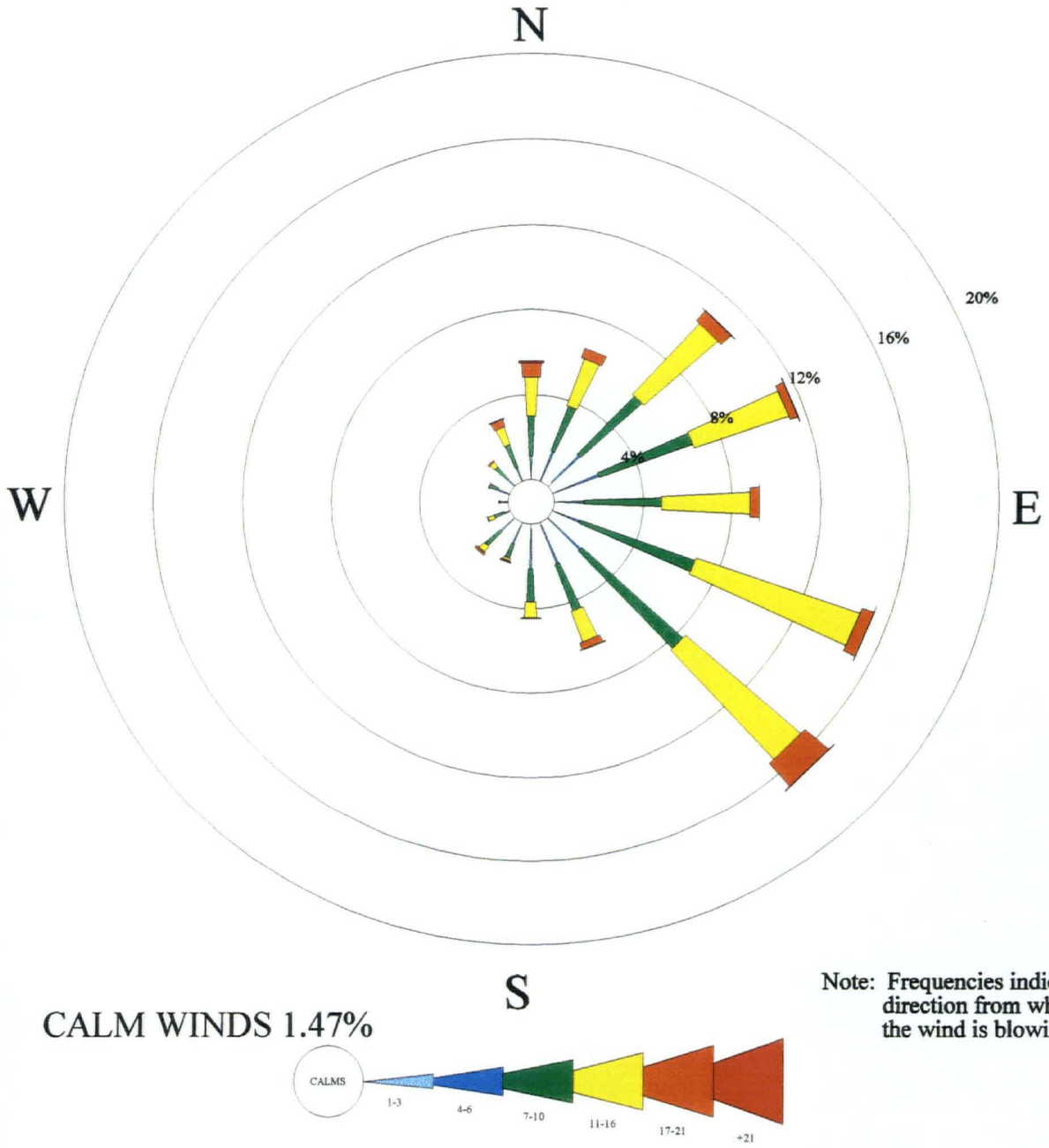
FIGURE II.C-14
1989 WINDROSE

DWG DATE: 06/07/96 | DWG NAME: 051WR89

Wind Rose

NAS Key West 1990

January 1 - December 31 Midnight-11 PM



CALM WINDS 1.47%

Note: Frequencies indicate direction from which the wind is blowing.

CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

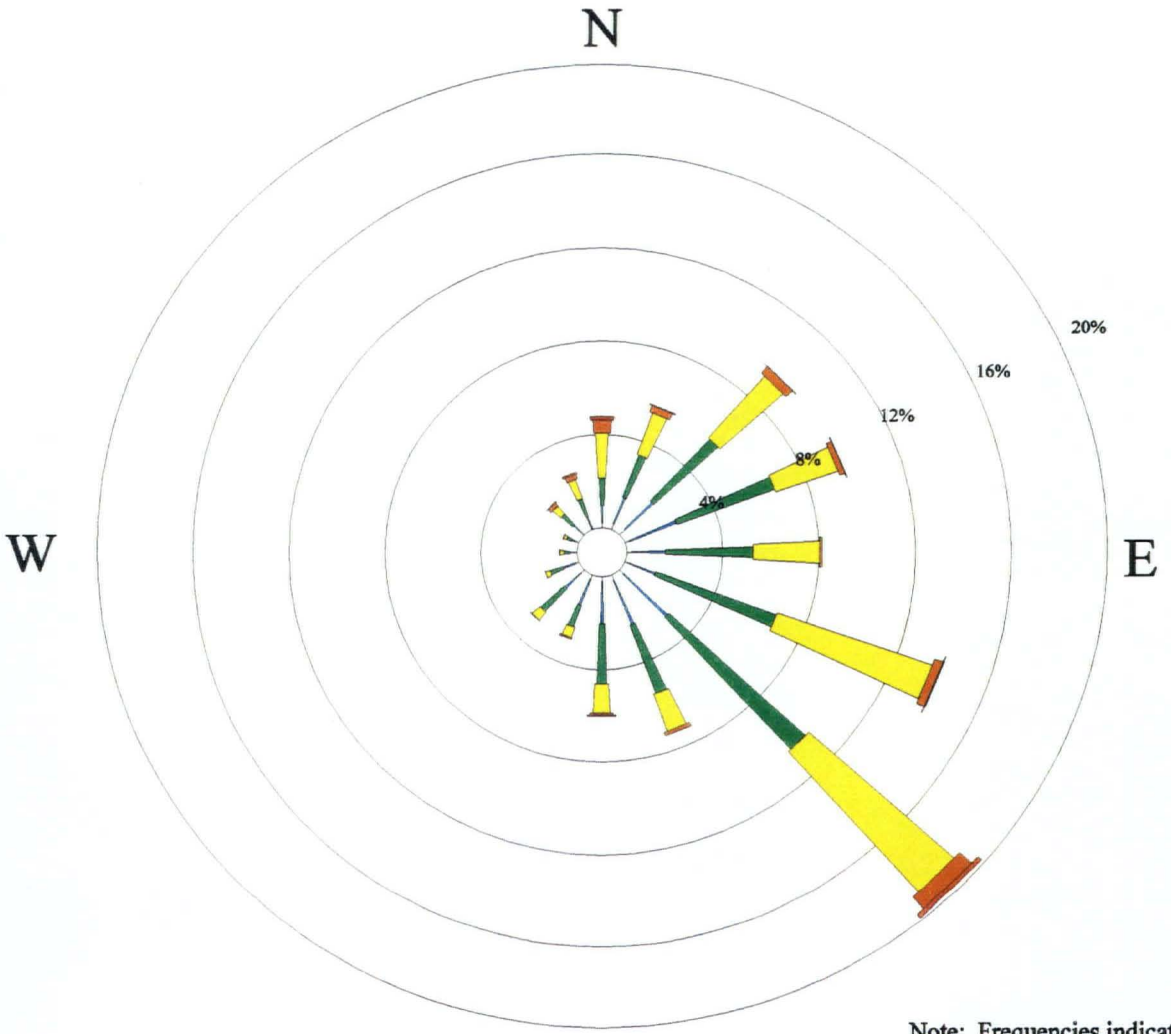
FIGURE II.C-15
1990 WINDROSE

DWG DATE: 06/07/96 | DWG NAME: 051WR90

Wind Rose

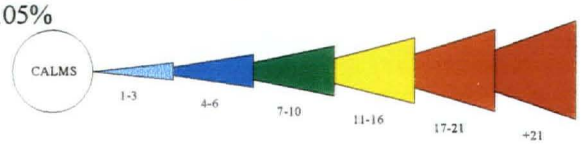
NAS Key West 1991

January 1 - December 31 Midnight-11 PM



Note: Frequencies indicate direction from which the wind is blowing.

CALM WINDS 2.05%



CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

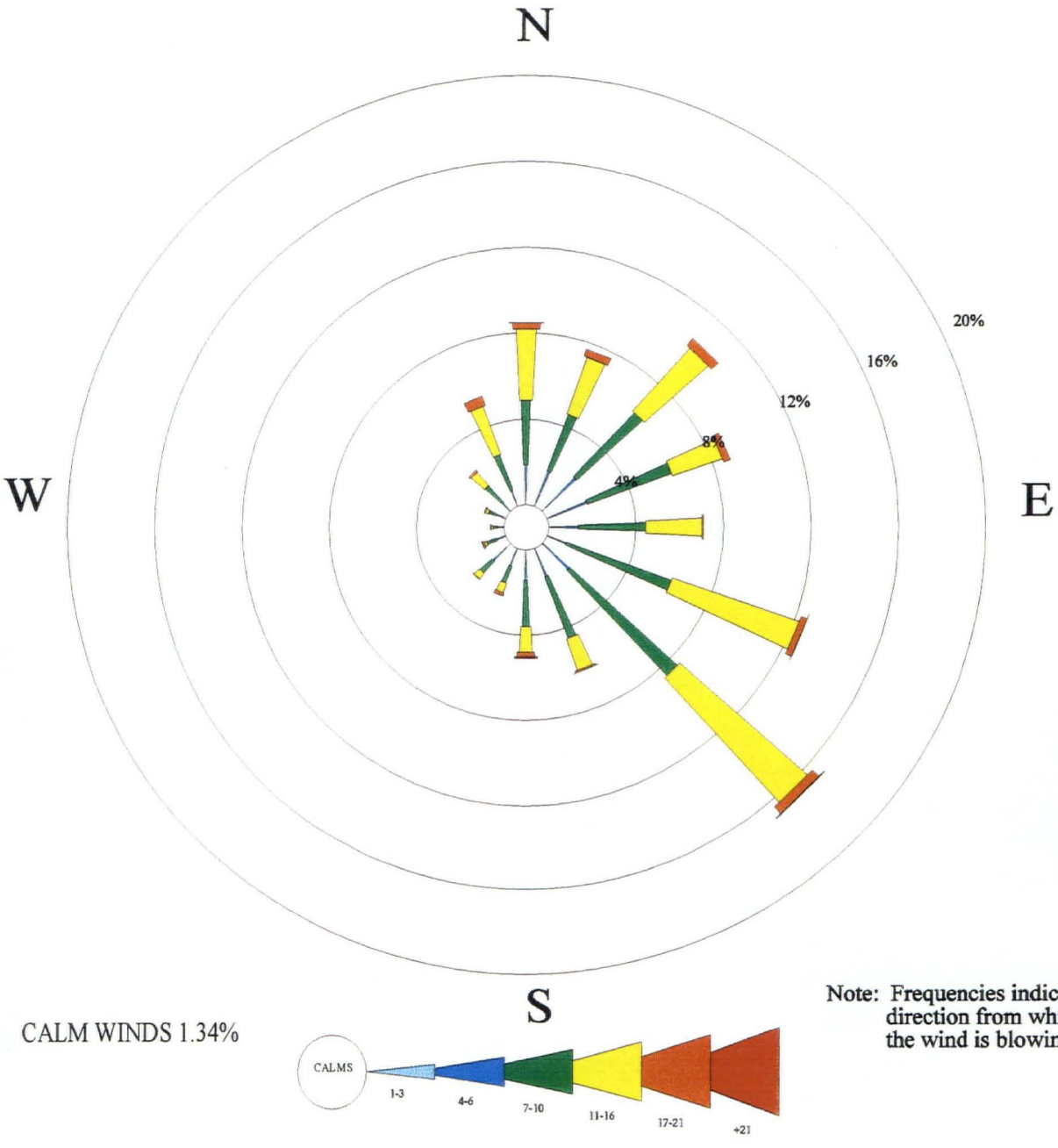
FIGURE II.C-16
1991 WINDROSE

DWG DATE: 06/07/96 | DWG NAME: 051WR91

Wind Rose

NAS Key West 1992

January 1 - December 31 Midnight-11 PM



CALM WINDS 1.34%

Note: Frequencies indicate direction from which the wind is blowing.

CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

FIGURE II.C-17
1992 WINDROSE

DWG DATE: 06/07/96 | DWG NAME: 051WR92B

DEMOLITION KEY NW
UPLAND

DEMOLITION KEY SE
(ALL WETLAND)

FLORIDA BAY

LEGEND

- SEA LEVEL
- WETLAND BOUNDARY
- MANGROVES

80 0 80
SCALE FEET

CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

FIGURE II.C-18
WETLAND BOUNDARY MAP

DWG DATE: 06/07/96 | DWG NAME: 51FIIC18

00174CC06Z

BAY KEYS

DEMOLITION KEY

MAN OF WAR HARBOR

FLEMING KEY

WISTERIA ISLAND

FRANKFORT BANK

KEY WEST BIGHT

DREDGERS KEY

UNINCORPORATED MONROE COUNTY

CITY OF KEY WEST

GARRISON BIGHT

RACCOON KEY

WHITEHEAD SPIT

A202

A501

CITY OF KEY WEST

A202

WHITE STREET PIER

A202

SMATHERS BEACH

COW KEY CHANNEL

STOCK ISLAND

BOCA CHICA CHANNEL

COW KEY

A407

FLORIDA BAY

LEGEND

A202 – ATLANTIC LOGGERHEAD TURTLE
A501 – STOCK ISLAND TREE SNAIL
A407 – KEYS RABBIT

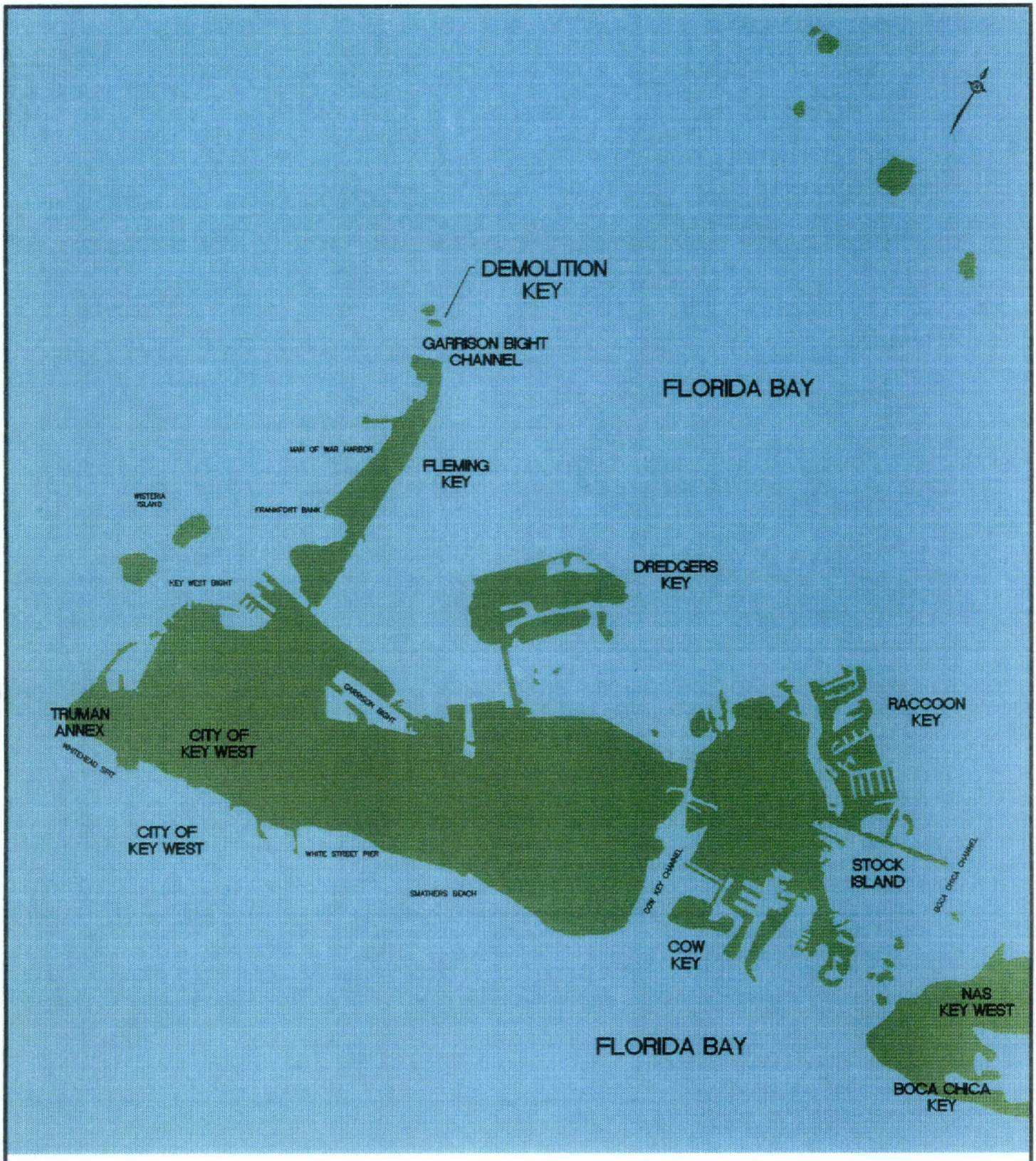
REVISION		
Rev Number: 000	Rev Date: 00/00/00	Rev By: NAME
Rev Number: 000	Rev Date: 00/00/00	Rev By: NAME
Rev Number: 000	Rev Date: 00/00/00	Rev By: NAME
Rev Number: 000	Rev Date: 00/00/00	Rev By: NAME
Rev Number: 000	Rev Date: 00/00/00	Rev By: NAME

1800 0 1800
SCALE FEET

CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

FIGURE II.C-19
MONROE COUNTY
THREATENED AND ENDANGERED SPECIES MAP

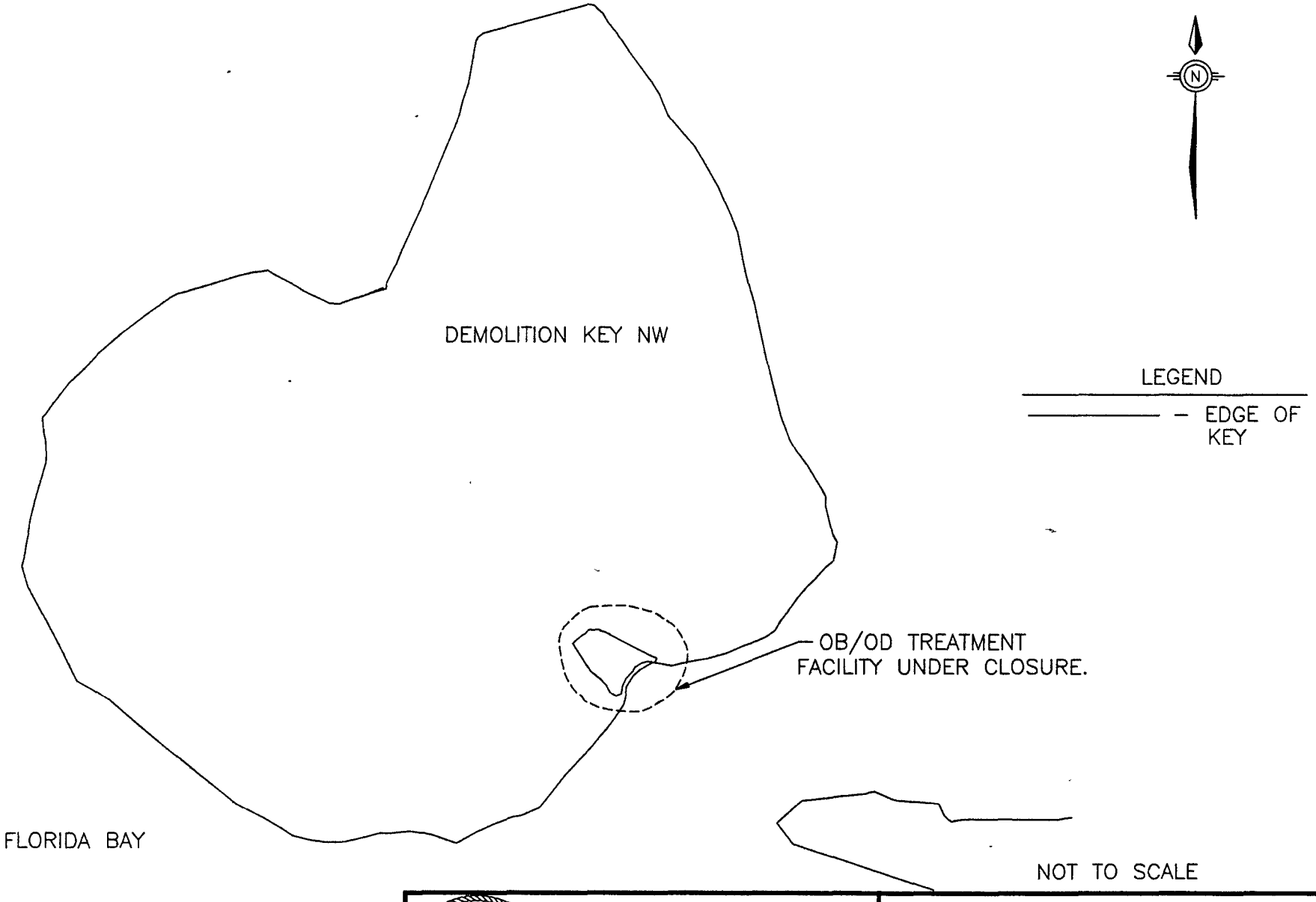
Dr by: NAME	Tr by: NAME	
Ck by: NAME	App by: NAME	Sheet 1
Date: 06/07/96	DWG Name: 051TESM9	Of 1



CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

FIGURE I.D-1
VICINITY MAP

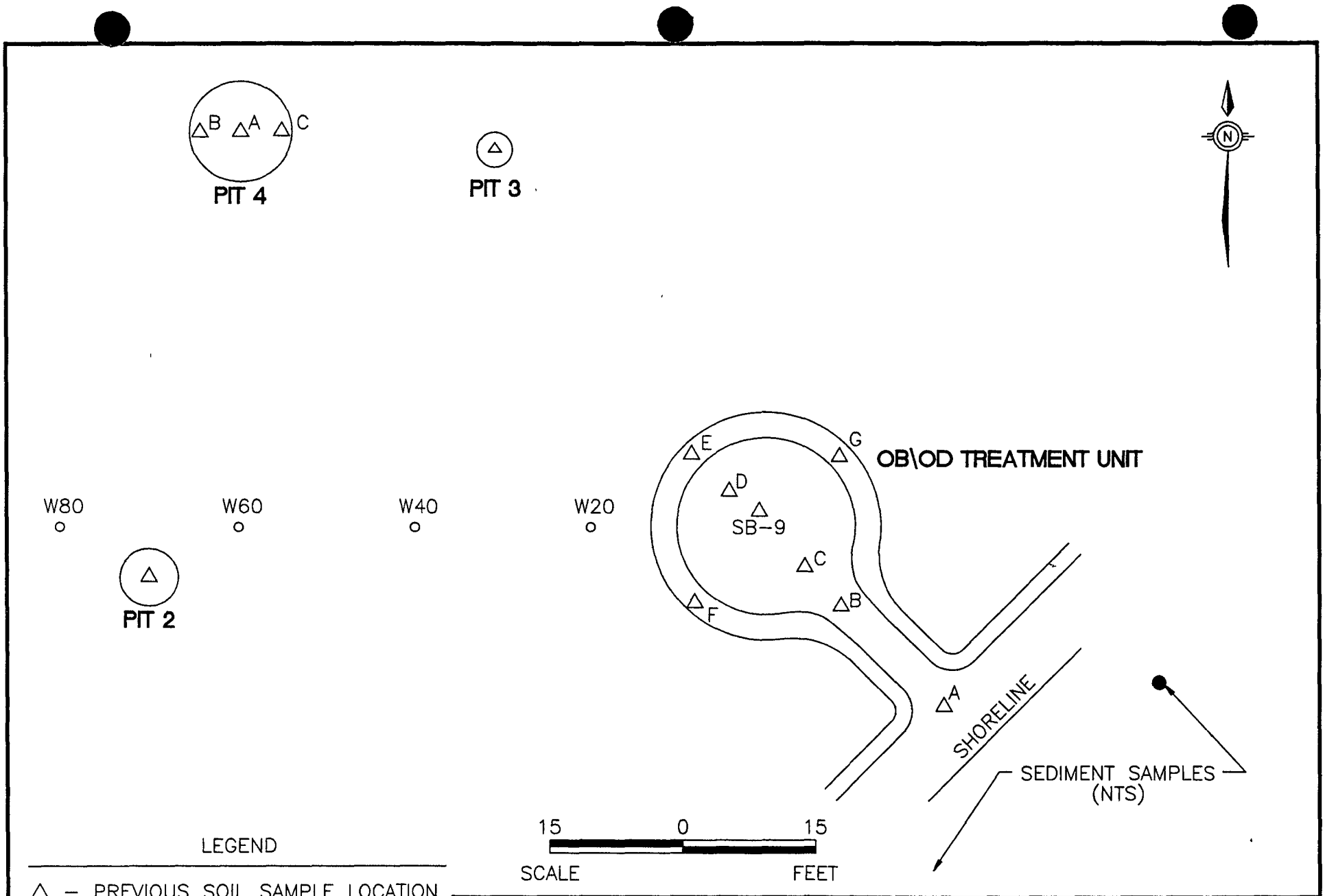
DWG DATE: 06/07/96 | DWG NAME: 051VMDK1



CLOSURE PERMIT APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

FIGURE II.D-1
FACILITY LOCATION

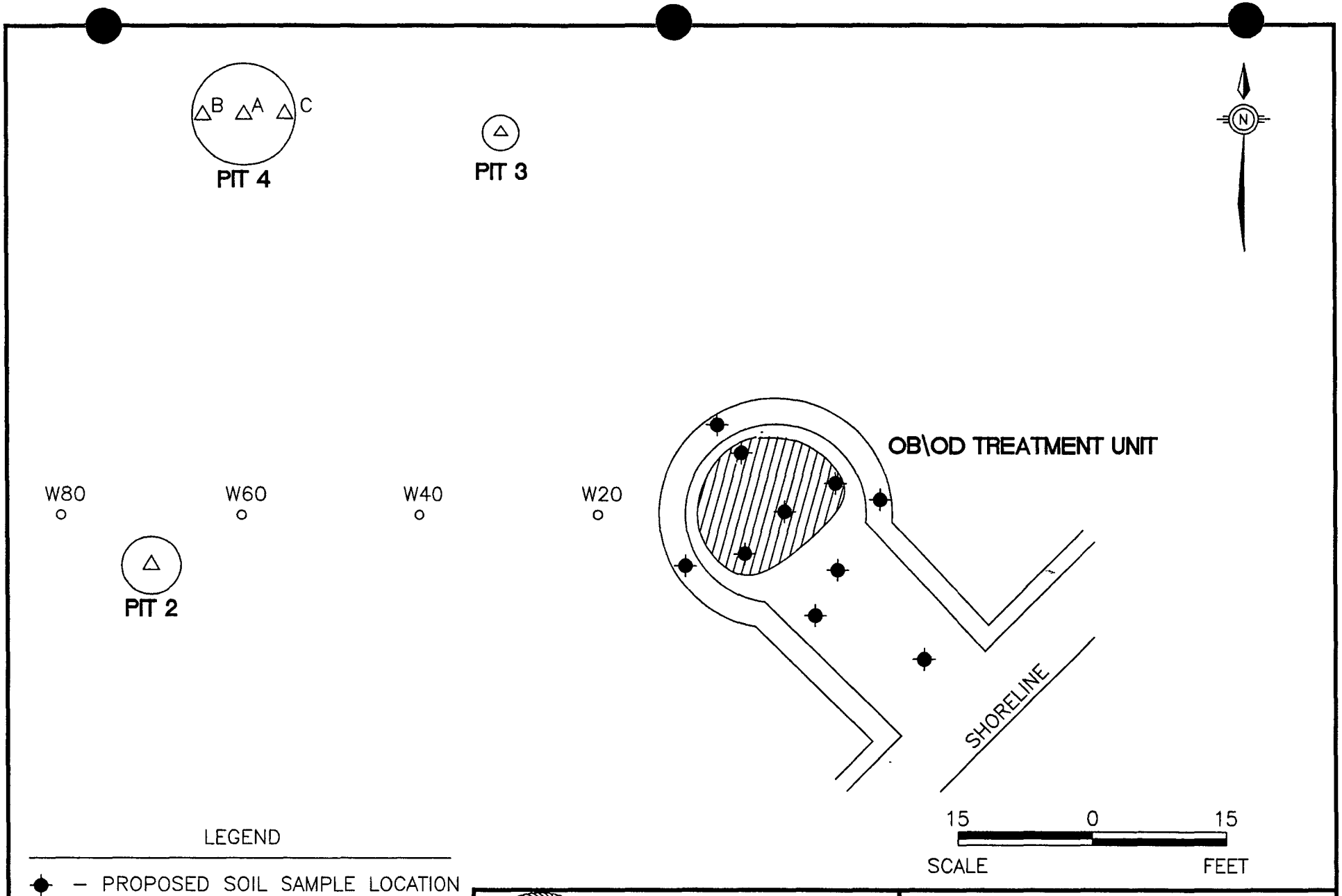
DWG DATE: 06/07/96 | DWG NAME: 51FLPBPA



CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

FIGURE II.D–2
PREVIOUS INVESTIGATION
SAMPLING LOCATIONS

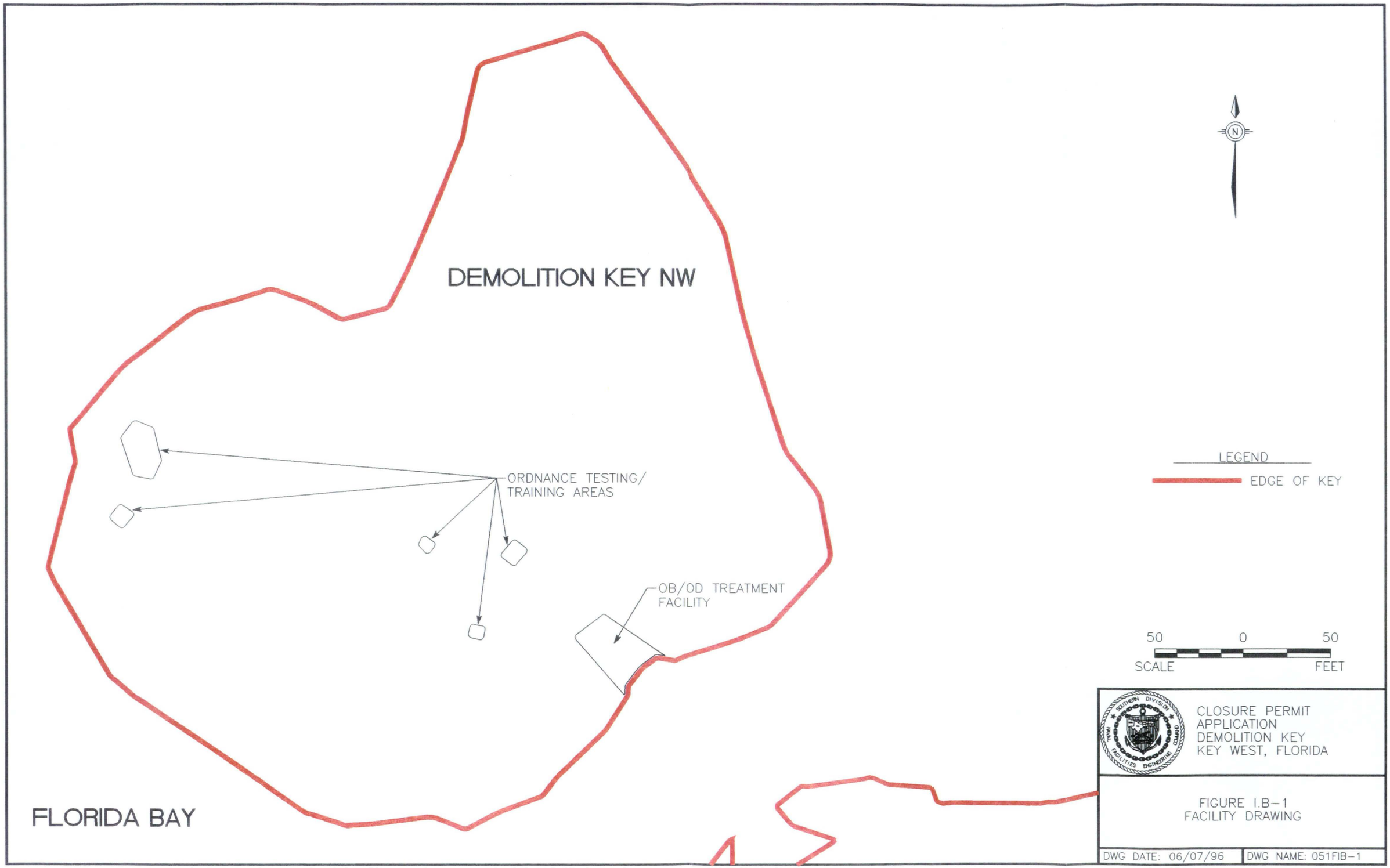
DWG DATE: 06/07/96 | DWG NAME: 051KWPIS



CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA

FIGURE II.D–3
PROPOSED SAMPLING LOCATIONS

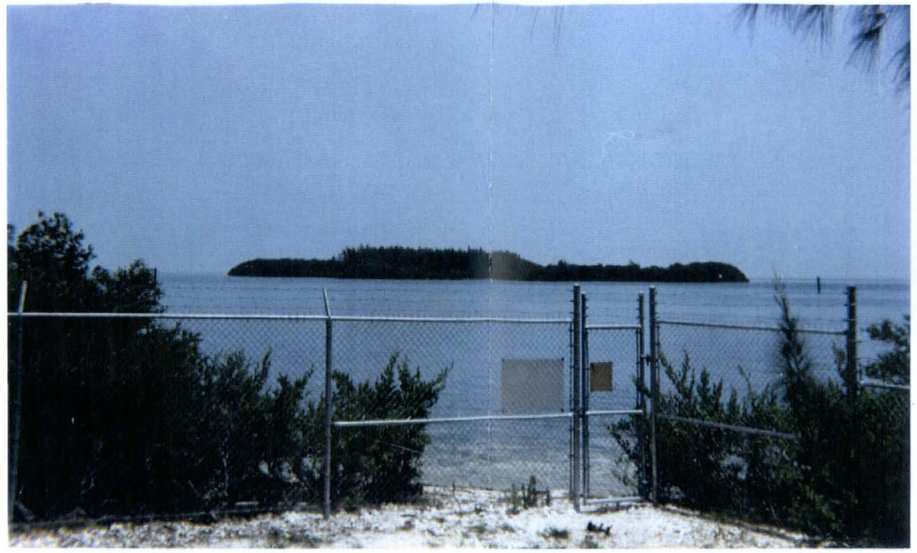
DWG DATE: 06/07/96 | DWG NAME: 051KWPSL


DEMOLITION KEY NW
ORDNANCE TESTING/
TRAINING AREAS
OB/OD TREATMENT
FACILITY
FLORIDA BAY
N
LEGEND
EDGE OF KEY
50
0
50
SCALE
FEET
SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORIDA
FIGURE I.B-1
FACILITY DRAWING
DWG DATE: 06/07/96
DWG NAME: 051FIB-1

00174 CC B8Z

A channel separates the two keys that make up Demolition Key.

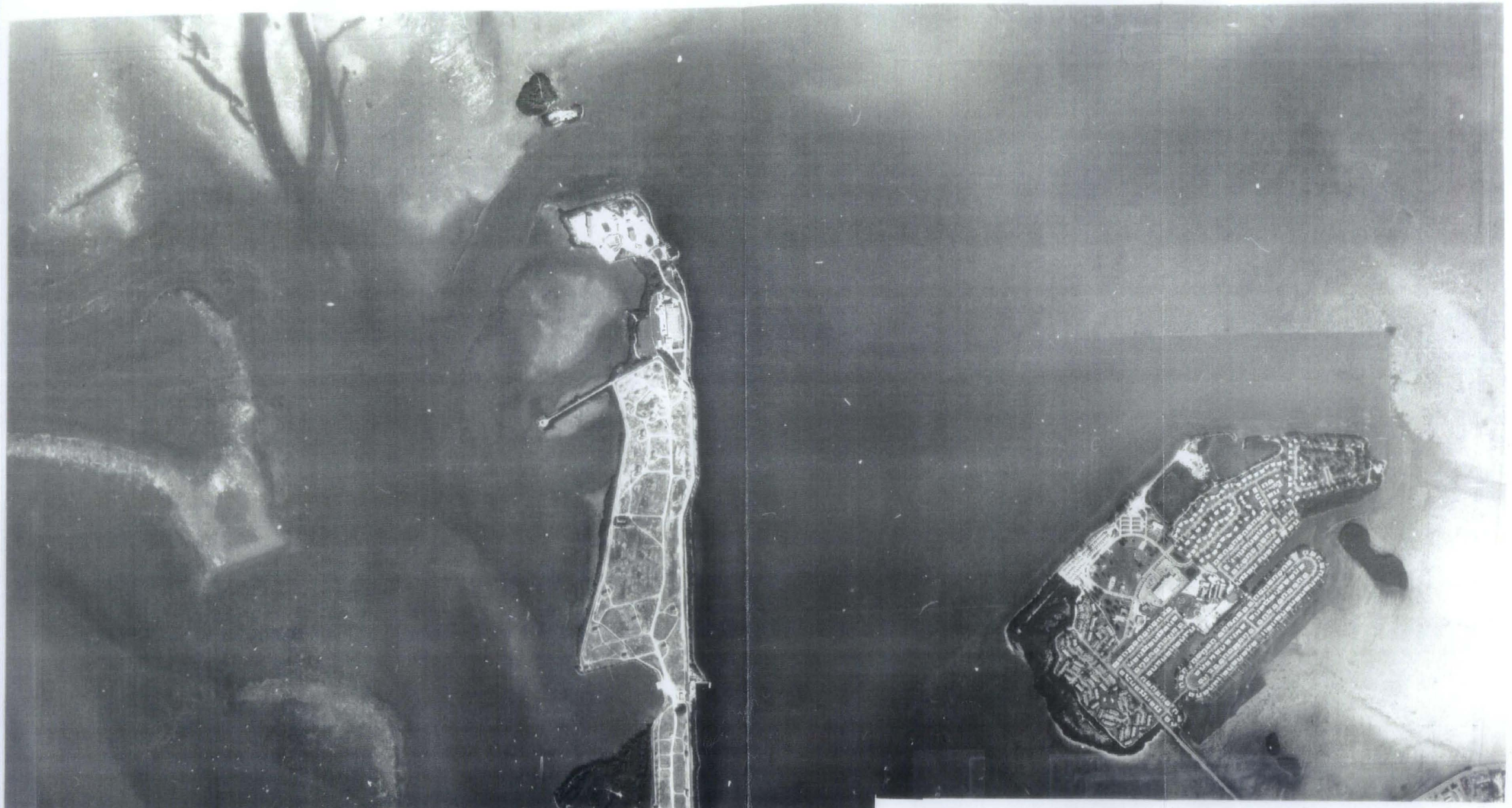
Treatment pit on Demolition Key



Demolition Key across Garrison Bight Channel,
viewing from south at northern tip of Fleming Key

Treatment pit from channel

PART B PERMIT APPLICATION NAS KEY WEST DEMOLITION KEY KEY WEST, FLORIDA	FIGURE 1.B-3 FACILITY PHOTOS	
	DWG DATE:06/03/96	DWG NAME:BOARD



CLOSURE PERMIT
APPLICATION
DEMOLITION KEY
KEY WEST, FLORDIA

FIGURE I.B-2
REGIONAL AERIAL PHOTOGRAPH

DWG DATE: 06/07/96 | DWG NAME: 051BOR01