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SUPPLEMENT TO THE STRATEGIC TARGET SYSTEMS (STARS) ENVIRONMENTAL ASSESSMENT

July 1991

U.S. Army Strategic Defense Command
STARS Program Office
P.O. Box 1500
Hunstsville, Alabama 35807-3801

FINDING OF NO SIGNIFICANT IMPACT

UNITED STATES ARMY STRATEGIC DEFENSE COMMAND

AGENCY: U. S. Army Strategic Defense Command (USASDC)

COOPERATING AGENCY: Strategic Defense Initiative Organization

ACTION: Conduct the Strategic Target System (STARS) Program

BACKGROUND: An Environmental Assessment (EA) was prepared for the STARS program in July 1990 which resulted in a finding of no significant impact (FNSI) in August 1990. In October and November 1990, lawsuits were filed against the United States Army Strategic Defense Command and the Department of Defense by the Sierra Club and the State of Hawaii challenging the adequacy of the STARS EA and the decision not to prepare an environmental impact statement (EIS). On May 9, 1991, the Federal District Court in Hawaii determined no EIS need be prepared but that the STARS EA must be supplemented on the issues of hydrogen chloride (HCl) and freon releases. Moreover, the judge indicated the STARS EA may not have adequately described the use of various computer models used to predict the dispersion or movement of air pollutants from the rocket ignition. An environmental impact statement is not planned unless information received during the 30-day public comment period reveals significant impacts on the biophysical environment.

SUMMARY: The supplement to the STARS EA discusses three areas: 1) the two predictive dispersion models; 2) the potential effects of hydrogen chloride from the rocket launches on the Kauai environment; and 3) whether the release of freon from the second stage booster of the STARS violates the Hawaii Ozone Protection Statute.

Two predictive dispersion modeling techniques (REEDM and TRPUF) were used for estimating pollutant emissions from the proposed STARS missile launches. The TRPUF model results were presented in the STARS EA because TRPUF provided a highly conservative estimate of emissions. This supplement to the STARS EA describes in more detail the assumptions and variables used in the REEDM and TRPUF models and gives a more detailed description of the findings of the two models.

A search of existing literature on environmental effects of HCl was conducted to determine if there were specific studies on HCl effects on the Hawaiian environment. No study specific to Kauai was found, but the literature did indicate experimental HCl levels and the corresponding effect on selected species of plants and animals.The studies indicate injury from HCl occurs primarily when the HCl is released in a moist or wet environment, such as when a deluge water system is used or the HCl gas comes in contact with precipitation. In moist conditions, the HCl mixes with water to form hydrochloric acid and may damage plants on contact. HCl from the STARS launches will not be released in such moist or wet environments since no deluge water is used and the missile will not be launched when it is raining.

In addition, the Launch Hazard Area (LHA) extends 10,000 feet from the launch site and the safety procedures associated with the launch require nonessential personnel to be evacuated from the LHA. The two modeling techniques produced different pollutant dispersion results. TRPUF indicated that HCl concentrations would exceed the State of Hawaii public guideline. REEDM indicated that the guideline would not be exceeded. Based on REEDM, which is believed to predict more realistic and valid field concentrations than TRPUF, it is highly unlikely that HCl releases from STARS will cause adverse human health or environmental effects on Kauai. Thus, HCl releases from STARS will not present a problem for health or the environment.

Since no site specific literature was available, field data collection was conducted on the island of Kauai. Control areas (areas not exposed to rocket exhaust but which were otherwise environmentally similar to the Kauai Test Facility (KTF) were identified and compared to areas of the KTF which have been routinely exposed to missile exhaust over a period of 28 years. No physical or chemical differences in the soil, vegetation or water were identified which could be correlated to exposure to HCl. The *Ophioglossum concinnum*, a candidate endangered species, occurs near existing launch areas and does not appear to be affected.

On January 1, 1991, the Hawaii Ozone Layer Protection statute went into effect. This law is designed to regulate the release of chlorofluorocarbon (CFC) chemicals from such sources as air conditioners or mobile air conditioners. Specifically, it regulates CFCs consisting of certain chlorine, fluorine, carbon, and hydrogen compounds. The listed compounds which are regulated are: CFC-11, CFC-12, CFC-13, CFC-112, CFC-113, CFC-114, and CFC-115. The type of freon used in the STARS second stage motor is Freon 114B2, a brominated fluorocarbon; it is not a chlorofluorocarbon. Since the Hawaii statute only regulates CFCs, bromine compounds, such as Freon 114B2, do not fall within its purview. Therefore, the STARS activities do not threaten a violation of the Hawaii statute.

FINDINGS: This supplement to the STARS EA describes in more detail the assumptions and variables used in the atmospheric dispersion models and gives a more detailed description of the findings of the models. No study specific to Kauai was found, but the literature did reveal levels of HCl, the corresponding effect on representative species of plants and animals and that the environmental injury from HCl occurs primarily when the HCl is released in a moist or wet environment, such as when a deluge water system is used or the gas comes in contact with precipitation. HCl from the STARS launches will not come in contact with such a moist or wet environment since no deluge water is used and the missile will not be launched when it is raining. Modeling methods developed from missile launch situations indicated that HCl concentrations at the boundary of the LHA would not exceed the State of Hawaii public exposure guideline. Thus, HCl releases from STARS will not present a problem for health or the environment. Since the Hawaii statute only regulates CFCs, bromine compounds, such as Freon 114B2, do not fall within its purview. Therefore, the STARS activities do not threaten a violation of the Hawaii statute.

DEADLINE FOR RECEIPT OF PUBLIC COMMENTS: AUG 16 1991

POINT OF CONTACT: A copy of the Supplement to the Strategic Target System Environmental Assessment July 1991 is available from:

U. S. Army Strategic Defense Command
Attn: D. R. Gallien, CSSD-EN
P. O. Box 1500
Huntsville, AL 35807-3801

Dated JUL 10 1991

O.E. Barfield
Commander, CEC, USN
Deputy Assistant for Planning, Shore Activities Division
Deputy Chief of Naval Operations

Dated JUL 10 1991

Robert D. Hammond
Lieutenant General, USA
Commander
U. S. Army Strategic Defense Command

FINAL

SUPPLEMENT TO THE STRATEGIC TARGET SYSTEMS (STARS) ENVIRONMENTAL ASSESSMENT

July 1991

U.S. Army Strategic Defense Command
STARS Program Office
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Hunstsville, Alabama 35807-3801

EXECUTIVE SUMMARY

An environmental assessment (EA) was prepared for the Strategic Target System (STARS) in July 1990 that resulted in a finding of no significant impact (FNSI) in August 1990. In October and November 1990, lawsuits were filed against the United States by the Sierra Club and the State of Hawaii challenging the adequacy of the STARS EA and the decision not to prepare an environmental impact statement (EIS). On May 9, 1991, the Federal District Court in Hawaii determined that no EIS needed to be prepared but that the STARS EA must be supplemented on the issues of the potential effects on the Kauai environment from HCl released during STARS launches and that a determination be made as to whether the release of freon from the second stage of the STARS would violate the Hawaii Ozone Layer Protection Statute. Moreover, the judge indicated the STARS EA may not have adequately described the various computer models used to predict the dispersion or movement of air pollutants from the rocket ignition.

The supplement to the STARS EA discusses three areas: 1) the two predictive dispersion models, 2) the potential effects of HCl and carbon monoxide (CO) from the rocket launches on the Kauai environment, and 3) whether the release of freon from the second-stage booster of the STARS violates the Hawaii Ozone Protection Statute.

Two predictive dispersion modeling techniques, the Rocket Exhaust Effluent Dispersion Model (REEDM) and Trinity Consultants modification to the EPA Puff Model (TRPUF), were used for estimating pollutant emissions from the proposed STARS missile launches. The TRPUF model results were presented in the environmental assessment because it provides a highly conservative (higher) estimate of emissions. This supplement to the STARS EA describes in more detail the assumptions and variables that were used in both REEDM and TRPUF models, and it gives a more detailed description of the findings of the two models for HCl and CO.

A detailed search of existing literature on environmental effects of HCl was conducted to determine if there were specific studies of HCl effects on the Hawaiian environment. The only study found specific to Hawaii was a study of HCl emissions at the ocean/lava interface on the island of Hawaii. The literature review identified some studies on the effects of various levels of HCl and the corresponding effects on some representative species of plants and animals. The studies indicate environmental injury from HCl occurs primarily when the HCl is released in a moist or wet environment, such as when a deluge water system is used or the gas comes in contact with precipitation (in moist conditions, the HCl mixes with water to form hydrochloric acid, which may damage plants on contact). HCl from the STARS launches will not come in contact with such a moist or wet environment since no deluge water is used, and due to operational constraints, the missile will not be launched when it is raining. In addition, the launch hazard area (LHA) extends 10,000 feet from the launch site, and the safety procedures associated with the launch require nonessential personnel to be evacuated from the LHA. The two modeling techniques produced different pollutant dispersion results. TRPUF indicated that HCl concentrations at the LHA boundary would exceed the State of Hawaii public exposure guideline. REEDM indicated that the guideline would not be exceeded. Based on REEDM, which is believed to predict more realistic and valid field concentrations than does TRPUF, it is highly unlikely that HCl releases from STARS will cause adverse human health or environmental effects on Kauai. A violation of the State of Hawaii 1-hour Ambient Air Quality Standard for carbon monoxide is highly unlikely.

Since no specific literature was available, original field research was conducted on the island of Kauai. Control areas (areas not exposed to rocket exhaust but which were otherwise environmentally similar to the Kauai Test Facility [KTF]) were identified and compared to areas of the KTF that have been routinely exposed to missile exhaust for a period of 28 years. No physical or chemical differences were identified that could be correlated to exposure to HCl. The vegetation within the KTF did not exhibit any damage due to past launches. In addition, the rare adder's tongue fern occurs near existing launch areas and does not appear to be affected.

On January 1, 1991, the Hawaii Ozone Layer Protection Statute went into effect. This law is designed to regulate the release of chlorofluorocarbon (CFC) chemicals from such sources as air conditioners or mobile air conditioners. Specifically, it regulates CFCs consisting of certain chlorine, fluorine, carbon, and hydrogen compounds. The listed regulated compounds are CFC-11, CFC-12, CFC-13, CFC-112, CFC-113, CFC-114, and CFC-115. The type of freon used in the STARS second-stage motor is Freon 114B2, a brominated fluorocarbon compound; it is not a chlorofluorocarbon. Since the Hawaii statute only regulates CFCs, bromine compounds, such as Freon 114B2, do not fall within its purview. Therefore, the STARS activities do not threaten a violation of the Hawaii statute.

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Jeyan: pls. review and brief me [initials]

DEPARTMENT OF THE ARMY
U.S. ARMY STRATEGIC DEFENSE COMMAND - HUNTSVILLE
POST OFFICE BOX 1500
HUNTSVILLE, ALABAMA 35807-3801

REPLY TO
ATTENTION OF

July 12, 1991

RECEIVED

'91 JUL 19 A11:58

OFC. OF ENVIRON.
QUALITY CON.

State of Hawaii
Office of Environmental Quality Control
465 S. King Street
Kekuanaoa Building, Rm 104
Honolulu, HI 96813

To Whom It May Concern:

A month ago, the U.S. Army Strategic Defense Command held a series of briefings for Kauai elected officials, community leaders, and interest group representatives. I found the interchange to be productive and appreciated all the questions and comments we received. As a followup to the briefings, we have prepared the enclosed list of the most typical comments and questions, along with the most up-to-date answers we can provide. These questions and answers are being sent to everyone who has expressed an interest in STARS, so that others can benefit from the exchange of information,

In addition, we are enclosing a copy of the *Supplement to the Environmental Assessment for STARS*. This document analyzes environmental issues that Judge David Ezra asked us to examine more thoroughly than we did in the original environmental assessment. Together with the release of the *Supplement*, we have decided to hold "availability sessions" during the week of July 15, 1991. These sessions will be periods of time set aside at informal locations where you may come, at your convenience, to talk with me and other STARS program representatives to ask questionsand discuss issues. The schedule for these sessions is as follows:

Date	Time	Place
July 18th	Noon - 4 pm; 6 - 8 pm	Kiluea Neighborhood Center
July 19th	9 am - Noon; 1 - 3 pm	Kauai Hilton Hotel, Midori Batik Room
July 19th	5 - 8 pm	Kekaha Neighborhood Center

I hope you will take advantage of one of these opportunities to meet with us. In the meantime, if you have any questions or need more information, please call our Public Affairs Officer, Ed Vaughn, at (205) 955-3058, collect. He will be pleased to receive or return your phone call.

Sincerely,

[signature]

LTC Gus Manguso
STARS Product Manager
U.S. Army Strategic Defense Command

Enclosure

SUMMARY: STARS BRIEFINGS

Kauai, Hawaii
20-21 June 1991

INTRODUCTION

A multi-agency team conducted a series of nine briefings with government officials, with groups and individuals who have shown interest in the Strategic Target System (STARS) program, and with the local news media on the Island of Kauai, Hawaii, June 20 and 21, 1991.

Persons attending included local staff for members of Congress from Hawaii, State legislators, officials of the Kauai County government, the media, employees of the Pacific Missile Range Facility (PMRF), and members of special interest groups.

BACKGROUND

The U.S. Army Strategic Defense Command (USASDC) is planning a series of missile launches from Kauai to support Strategic Defense Initiative (SDI) experiments. USASDC prepared an *Environmental Assessment (EA)* in 1990 to evaluate potentially negative impacts the program might have on the Kauai environment. The USASDC held a public meeting in Kekaha, Kauai in June 1990 to describe its plans and the *EA*. The *Environmental Assessment* concluded with a Finding of No Significant Impact (FNSI), which was challenged in court by the State of Hawaii and the Sierra Club. In his ruling on the case on May 9, 1991, Judge David Ezra found the *EA* to have adequately assessed the environmental impacts except in the case of air quailty, which he asked the USASDC to address in greater detail in a supplemental *EA*.

As part of the process of preparing a *Supplement to the Environmental Assessment (SEA)* to respond to the judge's orders, USASDC representatives went to Kauai to brief State and local officials and others who have expressed an interest in the program. The briefings also included a tour of the launch facility where a life-size "mock-up" of the missile was in place.

OBJECTIVES OF BRIEFINGS

a. Provide accurate information about the STARS program.

b. Address specific environmental concerns.

c. Provide information on the preparation of the *Supplement to the Environmental Assessment* and solicit additional comments and input.

All the objectives of the briefings were met.

COMMENTS AND RESPONSES

In addition to a number of general information questions, the comments and responses generally fell in the following categories:

- Physical environment
- Safety
- Social, economic, and cultural
- Public involvement
- Legal

Typical comments expressed and USASDC's most up-to-date responses to those comments are presented briefly below.

General Information questions

- What is the general plan for the launches -- how many will there be, what time of day, when are they scheduled, how big is the missile?

  Response: We have proposed up to four launches per year for ten years. The first will be launched near dawn; most other launches would occur before dawn. Before the court order, the first launch was scheduled for June 1991, but the schedule will change now. The STARS missile is 34 feet tall. A typical flight will last 18 minutes. After approximately four seconds, the missile is no longer over land.

- How are the experiments paid for, what are they, whose projects are they, are they all different, and how many are developmental?

  Response: The individual launches are funded by government agencies to deliver test objects into the vicinity of the Kwajalein Atoll. These launches support the testing of ABA components and technologies located at Kwajalein. Most test objects are intended to simulate ballistic missile re-entry systems and components. The purpose of the experiments will be to gather data that will permit an assessment of the feasibility of developing anti-ballistic missile systems.

Physical Environment

- There were 39 points in the suit and you were upheld on 37 of them. What were the other two and have you addressed those two points?

  Response: The two points the judge asked us to evaluate further were the effects of hydrogen chloride emissions and the applicability of Hawaii's new Freon law to this program. We are in the process of responding to the judge's directions.

These meetings are part of that process. We are meeting with the public to assist in identifying things we may have left out.

- What do your studies of Freon show?

Response: We studied the impacts of Freon in the original EA and found that it would not have a significant impact. Our purpose in the *SEA* was to evaluate whether Hawaii's new Freon law, the intent of which was to regulate air conditioning, applies to STARS launches. From what we can tell so far, the law does not apply to the STARS launches. Ours is a different type of Freon, and it is released at the second stage, which is 97,000 feet into the atmosphere and 12 miles out. It is actually not even in the State when it is released. The Freon is *injected into the exhaust, and a considerable amount is burned up.*

- What are the preliminary results of the air quality analysis?

Response: We are still conducting our analysis and soliciting input from the Hawaii Department of Health. There are no studies available on the effects of hydrogen chloride specific to Kauai. The Department of Health has helped us collect relevant studies on the release of hydrogen chloride at the lava flow/ocean interface on the Big Island. As it turns out, the plant that the literature indicates is most sensitive to exposure to hydrogen chloride does not grow in Kauai. We also undertook a sampling program in Kauai to collect data on plants that may have been exposed to hydrogen chloride from past Kauai Test Facility (KTF) launches and plants that have not. After evaluating the data, we found no adverse effects from hydrogen chloride. In other words, our preliminary analysis indicates no lasting adverse effects from hydrogen chloride at levels of previous exposure and quick recovery from temporary adverse effects.

- Will hydrogen chloride releases violate any air standards?

Response: Neither the Environmental Protection Agency (EPA) nor the State Hawaii has established air quality standards for hydrogen chloride in situations like this. The State of Hawaii refers to the American Conference of Governmental Industrial Hygienists (ACGIH) standard for the work place. Hawaii interprets the ACGIH standard as an average exposure not to exceed 5 ppm over an 8-hour day. Two air quality models were used to estimate hydrogen chloride emissions from a STARS launch. Predictions obtained from the two models proved to be different from one another. The more reliable model projects that hydrogen chloride levels at the LHA boundary, 10,000 feet from the launch pad, are well within the public exposure guideline used by the State. Launch safety procedures require the public and non-essential personnel to be evacuated from the LHA. Within the LHA, hydrogen chloride levels could "spike" immediately after a launch. No violation of national or Hawaii ambient air quality standards should occur.

- What was the projected concentration in the spike, what area did it cover, and how long did it last?

  Response: The spike was approximately 300 ppm at a radius of about 500 feet. Depending on the wind speed, it would disperse well within 10 minutes. We exclude people from the immediate launch area to protect against such exposures.

- Will you monitor air emissions during the launches?

  Response: We will monitor emissions on the first launch. We made that commitment to Cpt. McFeely at the public meeting last summer, and we want to confirm our projections with monitoring. That is, we will compare the modeling results with the actual emissions to refine our conclusions.

- Aren't these boosters too old to be reliable? We hear that one out of four or five blows up. If there is a failure, it could have a significant impact.

  Response: The missiles go through extensive refurbishment and are recertified. The Polaris was made to be used on a submarine in very close quarters to people, and it has a high success rate to begin with. For security reasons, we cannot give you the exact failure rate because the Polaris is still in use in the British fleet, but we can tell you that the *system* reliability of the Polaris used by the U.S. is 97 percent. That means that the individual systems within the missile functioned correctly 97 percent of the time. They are safe.

  To respond to public concerns, we have taken additional steps to assure reliability. For example, we have done static firings. We also have a system that allows us to destroy the missile in flight, meaning that we would blow a hole in the top of the booster so there is no more thrust. It is not a bomb; it does not blow up. It just falls back on the earth or into the water, depending on where it is.

- In a deposition, Robert G. Gorman stated that three of five contractors declared the Polaris unsafe to do what it would be asked to do.

  Response: Gorman was invited to the preliminary STARS design review as an outside consultant. He expressed some concerns which were addressed in the final design. The difficulty is every expert can be refuted by another expert. Gorman does not represent this program; he does not now work on the STARS project, and cannot be familiar with the current program. In addition, Mr. Gorman is neither a STARS nor Polaris expert.

- Are you saying that there will be no catastrophic failures?

  Response: No, what we are saying is that although it is highly unlikely there will be a catastrophic failure, we will have taken all prudent and necessary precautions to protect the public and the environment.

- How long after a catastrophic failure over land would the area be closed?

  Response: As long as it takes to clean it up. I would expect any cleanup effort to be completed within a week.

- Would there be any attempt to retrieve the booster or the debris from the sea?

  Response: It would be like a spent match. Even if the propellant fell into the sea, it would dissolve so slowly that it would not present hazards to sea life.

- What would happen in the event of a tsunami? PMRF is in the tsunami zone.

  Response: In the event of a tsunami, PRMF would implement their emergency plans to secure the area. Portions of the PMRF are in the tsunami zone, but much of the KTF is not. The STARS launch facilities are not within the tsunami inundation zone.

Safety

- How will the fuels be transported to the Base?

  Response: The first two launches will involve only solid fuels, which are not volatile. The solid fuels will be brought in by military aircraft directly to PMRF. The third launch will involve liquid fuel, which includes two components that burn upon mixing, hydrazine and nitrogen tetroxide. The hydrazine will be transported by military aircraft directly to PMRF and the nitrogen tetroxide by sea to Pearl Harbor or Port Allen where it will be transferred to a landing craft so it can be brought ashore at PMRF. We have also reduced the size of individual liquid fuel shipments from 200 gallons to 55 gallons. Liquid fuels will be a part of relatively few missions, however.

- How much of each liquid component will be used per flight? Will the 55 gallons be used at one time during a single flight? Will you bring it in only when needed? Is the fuel packaged in 55-gallon drums?

  Response: No more than 15 gallons of each will be used per flight; not more than 65-70 gallons will be stored at any one time, and that would be when we might have overlap from one shipment to the next. We will bring it in as needed, and these shipments will be infrequent. The nitrogen tetroxide containers actually hold about 200 gallons but will only be filled with 55 gallons; the hydrazine is packaged in 55-gallon drums.

- What are the safety zones and how will they affect use of the beaches and roads?

  Response: The explosive safety quantity distance (ESQD) zone extends 1,250 feet from the launch pad in all directions during periods when the missile is on the launch pad. The ESQD is the safety distance to protect against any possible injury resulting from combustion of explosive material. The launch hazard area, which is cleared 10 minutes before and after the launch, has a radius of 10,000 feet from the launch pad. The LHA protects against falling debris from failure during launch.

- What are the impacts when you destruct a missile? Would the pieces go all over the island? Would the hydrazine spill?

  Response: The first few seconds are the most critical time; that's when it could still fall back on land. If there is a catastrophic failure, it will include some burning pieces, but they will be within the launch hazard area, and we will clean them up. Even in the most catastrophic case, all the debris would be contained within the 10,000-foot hazard launch area, which for the 10 minutes before and after the launch will be cleared of all persons except those working on the launch. The hydrazine would mix with the nitrogen tetroxide and be burned up.

- How close will it pass by Niihau? What are the chances it will fall on Niihau?

  Response: It is about 12 miles before the turn toward Kwajalein. At that time, it will be 8 miles from Niihau. This is an example of the checks and balances that the Army and the Navy have on this project. We had planned a 270° azimuth, but to maximize the distance from Niihau, the Navy asked us to make it 280° on the first launch.

- How do you know it will go the way you intend? For example, if it malfunctions when it gets near Niihau, can you guarantee it will go where you want it?

  Response: We track it by radar, observe it by television, and track by telemetry from the missile. If the missile veers off course, it will be terminated before debris would fall outside of the launch hazard area or flight safety zones between Kauai and Kwajalein. As far as controlling the missile, we have five back-up systems to assure we have the best possible communication with it throughout the flight. Plus, it can be destroyed automatically by computer or manually.

- How long will there be a potential for land impact? Will the hydrazine burn up? What would the by-products be?

  Response: It could fall back on land for only three to four seconds. There would be some remaining wastes, but we would clean them up. After the first three to four seconds, all the impacts will be to the sea, and there will be debris only. The hypergolic propellants (that is, the hydrazine and nitrogen tetroxide) will burn up. The other by-products would be normal products of combustion: carbon dioxide and carbon monoxide in small quantities.

- The County would like to see your transportation plan when it is finished.

  Response: Absolutely. In fact, we will obtain input from local government on the plan *before* we finalize it.

Social, economic, biological, and cultural

- For the 10,000-foot launch hazard area, how long will people have to be excluded from Polihale State Park?

  Response: The access roads will be closed for 20 minutes. The beach in the area of the KTF is already closed during normal operations.

- If you delay a launch, how long is it before you can try again? What will be the overall closure time?

  Response: If there is a hold, we can let people through. We will usually know about a hold before the 20-minute closure begins.

- A history of archeology of the area should be done.

  Response: An archeological study has been completed and is a part of the EA. Further, we are preparing an ethnographic history of the dunes area with a local historian. We have also completed a biological study and are preparing a transportation study.

- How many ferns were transplanted and how many survived?

  Response: We consulted with the Fish and Wildlife Service and transplanted about 75 to 100 at Barking Sands, with another 25 to the Botanical Gardens. We have had about a 75 to 80 percent survival rate of those transplanted on PMRF.

- What was the survey area for the studies in the EA?

  Response: The archeological study focused on the area around the Nohili Dune; the cultural study encompassed the entire area.

- Which is the Nohili Dune, and how do you propose to protect the most sacred of Hawaiian burial grounds?

  Response: The Nohili Dune is directly behind the launch pad. We have five back-up systems to maintain control of the missile at all times. There is risk that it will fall on land only during the first few seconds before it goes out of range, but there would be no long-term damage, and we would clean up the debris.

- Why is the vegetation on the Dune surrounding the launch area damaged?

  Response: Vegetation has to be cleared as it encroaches on the fence to avoid damage and fire. We are required to keep the perimeter clear for security reasons.

- How long will the launches go on and will the program escalate? What does Sandia plan to do in the next five to ten years?

  Response: It is difficult to speak for other programs. For STARS, we will have no more than four launches per year for ten years. Sandia anticipates the same kind of program they have had for 30 years -- small rockets, no bigger than STARS.

- Why does it have to be done here?

  Response: Kwajalein is the destination for STARS, and there is a physical limitation on how far the STARS booster can fly. The Minuteman, which had a greater range, has been used out of Vandenberg AFB, but we are running out of the Minuteman boosters.

Public Involvement

- What are you doing about public interaction?

  Response: We invited a wide range of groups to a series of briefings in June 1991, including State and County officials, the media, local businessmen, Rotary clubs, the Kauai Guardians, the Sierra Club, Responsible Citizens for Responsible Government, and 1,000 Friends of Kauai. As a follow-up, we are sending out these questions and answers to interested citizens and will make ourselves available to the public for questions and comments on July 18 and 19. Consult the *Kauai Times* and the *Garden Island* that week for details.

- Where is the Administrative Record for the *STARS Environmental Assessment*?

  Response: The Administrative Record was placed in the Lihue Public Library after the document was finalized last year, in November 1990. The Administrative Record was what the judge used to review the case.

Legal

- Why are you resisting an EIS? Wouldn't it provide a lot more protection?

  Response: The government has absolute faith that the STARS EA has revealed all potential problems and provides steps to protect public health, safety, and the environment. An EIS would take significantly longer, and we would come to the same conclusions. An EIS will analyze no new data, draw no new conclusions. However, it could be less protective in that the mitigations proposed in the EA are enforceable, while mitigations in an EIS are not as binding.

- Will you have to do other EAs on the different payloads?

  Response: If they are significantly different, we will do additional Environmental Analysis, but in general, we know what will be involved, and we assessed the types of payloads we knew about. All payloads will be reviewed and we will assess new ones that are significantly different.

- Why do you want to launch these experiments?

  Response: The question is why do research. The Patriot missile is a good example of similar research that saved lives. The Patriots, which were developed to knock down aircraft, were modified to engage tactical ballistic missiles. The Patriots were very successful in stopping Scud missiles during the Persian Gulf War. Engaging a strategic missile is even *more* complex. This kind of research helps us solve key problems and could save even more lives.

- When do you plan to go back to the judge to talk about how you have responded to his orders?

  Response: We plan to finish the analysis, have public comment, and meet with the judge and counsel for the other side by the end of August 1991, to review with the judge and counsel for the other side what the Army has done.

- How did the launch pad and facilities get built before the EA was completed?

  Response: The Navy did an evaluation in 1986 and the facility was built in 1987. That document found no significant impacts, but the evaluation was specifically for construction in that area with the potential implementation of the STARS program.

However, an assessment was required of all program activities, including those on the mainland as well as on Kauai.

- It's illegal to do these tests here under the Anti-Ballistic Missile treaty -- the only places they can be done are at White Sands and Kwajalein.

Response: The STARS vehicle is neither an anti-ballistic system nor a component of one. It is a vehicle to launch test objects into the area of Kwajalein Atoll.

1.0 INTRODUCTION

The Strategic Target System program (STARS) uses a three-stage solid propellant guided missile under development by the U.S. Army Strategic Defense Command (USASDC). The missile integrates selected parts of the Navy retired Polaris A3 fleet ballistic missile with a substantial number of newly developed subsystems. STARS will be used for testing various developmental elements of the Strategic Defense Initiative System. STARS will fly a payload of either single or multiple reentry vehicles to the Broad Ocean Area or will be targeted for impact or for reentry near the U.S. Army Kwajalein Atoll (USAKA). The missile with its payload will be launched from the Department of Energy/Sandia National Laboratory-managed Kauai Test Facility (KTF) located on the Pacific Missile Range Facility (PMRF), Kauai, Hawaii. A detailed discussion of the proposed action for the STARS program is available in the STARS Environmental Assessment (EA) (USASDC 1990).

As part of the STARS development process, an EA was prepared by the USASDC and completed in July 1990. It concluded with a finding of no significant impact (FNSI). The Army determined that the STARS program would have no significant environmental impacts and that any potential impacts could be mitigated. However, as a result of lawsuits filed with the U.S. District Court, District of Hawaii, by the Sierra Club and the State of Hawaii, the court ordered that a supplemental study be conducted of the potential effects on the Kauai environment from HCl released during STARS launches and that a determination be made as to whether the release of freon from the second stage of the STARS would violate the Hawaii Ozone Layer Protection Statute.

A series of meetings were held on June 20 and 21 at the PMRF. This provided a variety of public officials, organizations, and individuals an opportunity for input of public concerns into this supplemental EA.

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2.0 AFFECTED ENVIRONMENT

The existing environment at the KTF is described in Section 2.6 of the STARS EA (USASDC 1990a). This section will provide a brief summary of that information and will supplement it with details of the particular environment of the KTF potentially subject to the STARS exhaust emissions.

2.1 AIR QUALITY

This section supplements Section 2.6.1 Air Quality of the STARS EA.

Air quality in the vicinity of the KTF is generally excellent. The area is in attainment for the State of Hawaii and all National Ambient Air Quality Standards (NAAQS). The practice of agricultural burning of sugar cane fields produces periods of heavy smoke and ash. During these activities, visibility can be reduced over a wide area, sometimes several miles.

2.2 BIOLOGICAL RESOURCES

The biological resources within and adjacent to the KTF are discussed in Section 2.6.2 Biological Resources in the STARS EA.

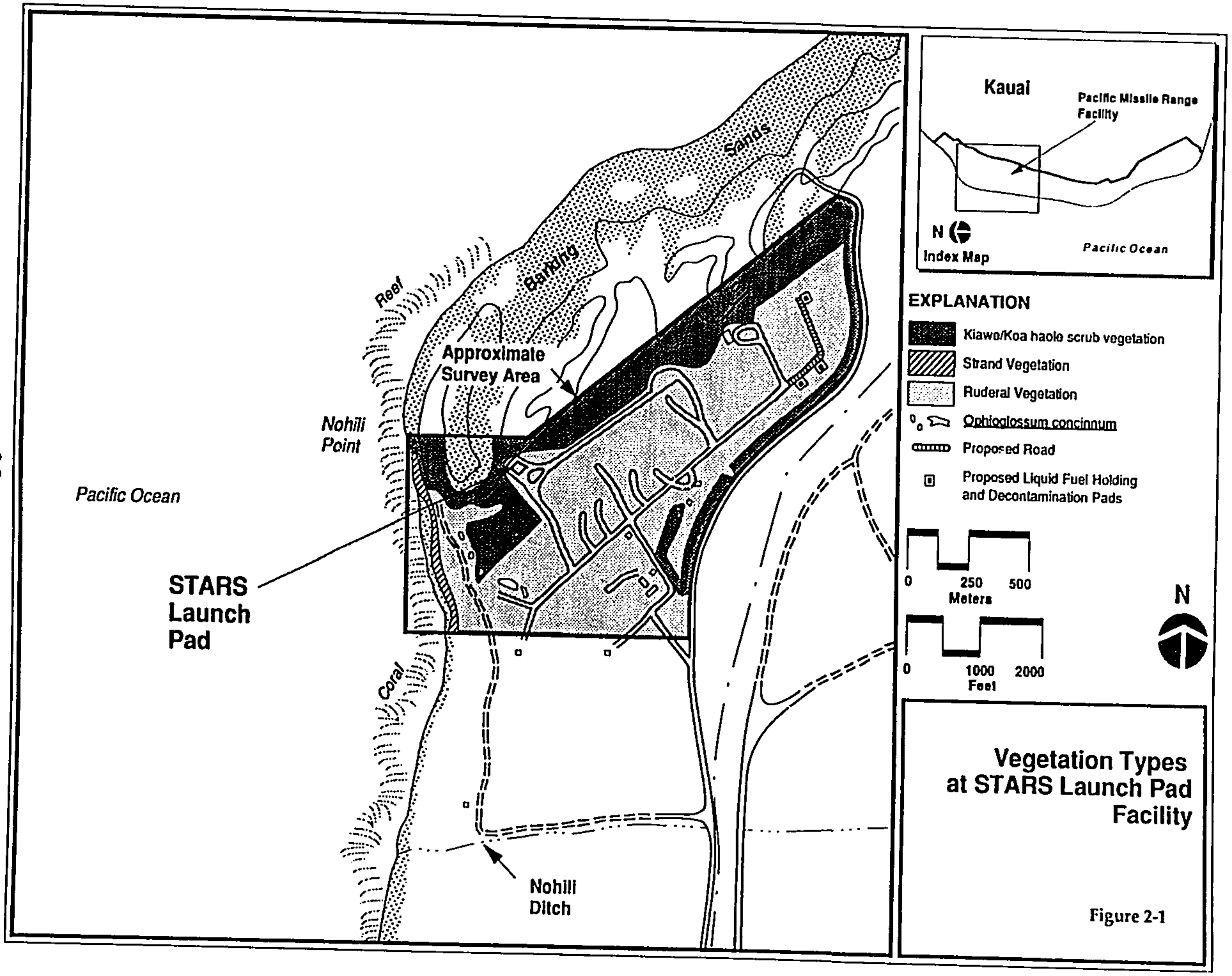
2.2.1 Vegetation

This section supplements Section 2.6.2 Vegetation of the STARS EA.

The area most likely to be affected by the exhaust cloud is within the KTF and PMRF boundaries. Vegetation types in the potential zone of influence of STARS activities can generally be described as being dominated by naturalized, exotic species. In addition to sugar cane, there are three types of vegetation on and adjacent to the KTF (Figure 2-1) kiawe/koa haole scrub, ruderal, and strand vegetation (USASDC 1990). Within KTF, the predominant vegetation is a mowed ruderal type with unmowed areas dominated by the kiawe/koa haole type. The kiawe/koa haole vegetation is characterized by kiawe (*Prosopis pallida*) and koa haole (*Leucaena leucocephala*) and has replaced native shrubland and dryland forests throughout Hawaii (Shomer and Gustafson 1987). The strand vegetation associated with the dunes (Botanical Consultants 1985) includes a common native vine *Vittex rotundifolia* as well as kiawe and koa hoale on the more stable slopes.

The small adder's tongue fern (*Ophioglossum concinnum*) is the only uncommon species of concern known to occur in the area potentially affected by the STARS exhaust cloud. This species is a category 1 candidate for being listed as a federally endangered species. A population of this species occurs in openings in the kiawe/koa haole scrub and in the mowed ruderal areas about 200 – 300 meters west and southwest of the STARS launch area near Launch Pad 1.

The KTF is bordered to the east and north primarily by sugar cane fields within the Kekaha Sugar Company lease hold. Within the sugar cane areas, a variety of agricultural ponds support



Vegetation Types at STARS Launch Pad Facility

Figure 2-1

a mix of naturalized exotic species including kiawe, koa haole, castor bean (*Ricinus communis*), monkey pod tree (*Samanea saman*), ficus (*ficus* spp.), and cherry tomato (*Lycopersicon pimpinellifolium*), among others. The vegetation associated with the ponds tends to be more diverse than the kiawe/koa haole scrub on the KTF.

O. concinnum is a diminutive, ephemeral fern. Its known range includes dry coastal habitats on the islands of Hawaii, Lanai, Maui, Molokai, Oahu, and Kauai (St. John 1957; Clausen 1954; Botanical Consultants 1985). The presence of *O. concinnum* on the island of Kauai was first recorded in 1985 (Botanical Consultants 1985) during a study of floral, faunal, and water resources present on the PMRF. Groups of *O. concinnum* were observed at the west end of the KTF in openings in the kiawe/koa haole scrub and in mowed, ruderal vegetation north and northeast of launch pad 1 (Figure 2-1).

O. concinnum is a nonseasonal, ephemeral species (Brauggman 1990). It is dormant underground until there is sufficient rainfall to send up leaves. The leaves are present for only a few weeks. The required quantity of rainfall is not known. Observations of *O. concinnum* in January and February 1990 followed 12 to 15 consecutive days of rain during which the KTF received approximately 12 inches of rain.

2.2.2 Wildlife

This section supplements Section 2.6.2 Wildlife in the STARS EA.

The wildlife resources present on the KTF, and in adjacent areas, are discussed in the EA. Of the 40 bird species known to occur in the area of the KTF, four (4) are of concern because of their endangered status, including the American (Hawaiian) coot (*Fulica americana alai*), the common moorhen (*Gallinula chloropus sandvicensis*), the black-necked (Hawaiian) stilt (*Himantopus mexicanas knudseni*), and the Hawaiian duck (*Anas wyvilliana*). All four species may occur in the drainages and ponds in the Mānā Plain area. The coot, moorhen, and the stilt were observed during field studies in 1990 and 1991. Four migratory and 8 indigenous species also may occur in the KTF region, although no rookeries or raptor nest sites were observed in 1985 (Botanical Consultants 1985) or during field studies in 1990 and 1991. The 24 exotic bird species generally are common field and urban birds.

2.2.3 Soil

This section is a supplement to Section 2.6.2 in the STARS EA.

The soils within the Mānā coastal plain are composed of alluvium washed in from uplands, calcareous clayey lagoon deposits and dunes, and beach rock.

Within the Mānā plain to the east of PMRF, the soils are dominated by a mosaic of clayey to silty clay loam soils of the kekaha-nohili association. There are areas within the Mānā plain that are fill-land. However, along the base of the Mānā cliffs, the soils are of the clayey series.

2.2.4 Water

This section is a supplement to Section 2.6.2 in the STARS EA.

Surface water in the area of the KTF and the Mānā Plain is restricted to drains, agricultural irrigation ponds, and the Mānā base pond wildlife area. The waters in the agricultural ponds along the Mānā cliffs generally do not meet drinking water standards for chlorides but are near neutral to slightly alkaline. The Mānā base pond has a high chloride level near to that of seawater. This may be due to the infiltration of brackish to saline groundwater into the pond basin or due to excessive evaporation to a low-surface level.

2.3 PUBLIC AREAS

Developed land on the KTF and PMRF contains launch complexes and support facilities. Bachelor's quarters and family housing are in the southern portion of the facility (U.S. Department of the Navy 1989) over three miles from the STARS launch facility. The next residential area is located about 12 miles away in the town of Kekaha.

Lands off the base to the north and south are designated as conservation lands in the state plan. Polihale State Park (approximately 56.7 hectares (140 acres)), north of PMRF is included in this conservation area and currently supports day-use (371,000 annual visitors in 1988) recreational activities and overnight camping (1,140 permits issued in 1988) (Niitini 1989). South of PMRF is the approximately 25-hectare (63 acre) Kekaha Sanitary Landfill (U.S. Department of the Navy 1989). The land to the east of PMRF is designated as agricultural and currently is owned by the state and leased to the Kekaha Sugar Company. Portions of the PMRF are in a tsunami flood zone, but the KTF administrative area and most of the KTF, including the STARS facilities, is not in the tsunami susceptible zone (Federal Emergency Management Agency (FEMA) 1987).

3.0 ENVIRONMENTAL CONSEQUENCES AND MITIGATIONS

This section discusses the assessment of the significance of potential environmental consequences of STARS program activities in areas that have a potential to affect Kauai's air quality. It also identifies appropriate mitigation measures. This information is supplemental to the more detailed STARS EA, Section 3.0 (USASDC, July 1990). The methodology used to predict HCl and CO contaminant levels, the field surveys conducted to assess effects of previous exposures, and the standards used to determine significance are described. In addition, an assessment to determine the applicability of the Hawaii Ozone Protection Statute to STARS activities is provided.

3.1 AIR QUALITY

This section supplements Section 3.6.1 Air Quality of the STARS EA.

Although the federal district judge's opinion did not address the adequacy of the STARS EA in the area of air pollutant dispersion modeling, this supplement to the EA describes in more detail the assumptions and variables used in the models and how the models were used to determine the potential significance of air quality impacts. This section also discusses the results of the modeling and assesses the potential for human health effects in the areas of HCl and CO in more detail and addresses the applicability of the Hawaii Ozone Protection Statute.

3.1.1 Air Quality Dispersion Modeling

Dispersion modeling techniques were used to predict concentrations of air pollutants downwind from a STARS missile launch. These calculated concentrations were compared with exposure guidance criteria (to assess potential human effects) and with published experimental and observational results (to evaluate effects on biological resources).

In order to estimate levels of pollutant emissions from STARS missile launches, two predictive air dispersion computer models, REEDM and TRPUF, were used. REEDM was selected because of its proven utility in predicting emission dispersion from rocket launches. TRPUF was chosen because of its application to emission sources that characteristically are brief in duration. Because the TRPUF model calculates potential emission levels more conservatively, the TRPUF model was selected to assess potential air quality and biological effects in the STARS EA (USASDC 1990). The results of this modeling are contained on page 72, Table 3-2 of the STARS EA and in Tables 3-1 and 3-2 of this section.

The TRPUF computer model is based on the EPA puff model, modified for easier use and extra calculations. The TRPUF model calculates downwind concentrations from a sudden release of emissions that lasts a few seconds (Trinity Consultants Inc. 1990). A missile launch acts like a puff release. The TRPUF model requires several source-specific input parameters, such as puff release altitude, quantity, and velocity. Since the exhaust from the missile is downward, a release velocity of zero is used and provides another high degree of conservatism because the dispersion due to heat for the exhaust and the resulting turbulence is ignored. Since the typical puff release (exhaust vent or smoke stack) would have an exit velocity upwards and because a missile has an exit velocity downwards, zero exit velocity was used for STARS, making the

Table 3-1. Modeled ambient hydrogen chloride concentrations from a STARS launch[1]

Downwind Distance (meters)	TRPUF					
	Peak Instantaneous Concentration (ppm)		30-Minute Average Concentration (ppm)		8-Hour Average Concentration[2] (ppm)	
	Wind Speed: 0.46 m/s	Wind Speed: 1.58 m/s	Wind Speed: 0.46 m/s	Wind Speed: 1.58 m/s	Wind Speed: 0.46 m/s	Wind Speed: 1.58 m/s
250	230	230	16.3	4.7	9.8	2.8
500	166	166	14.2	4.1	8.5	2.5
1,000	116	116	12.4	3.6	7.4	2.7
2,000	39	39	7.6	2.2	4.6	1.3
3,000 (LHA)	18	18	4.9	1.4	2.9	0.8
4,000	10	10	3.6	1.0	2.2	0.6
5,000	6	6	2.7	0.8	1.6	0.5

Downwind Distance (meters)	REEDM		
	Peak Instantaneous Concentration (ppm)	60-minute Average Concentration (ppm)	8-Hour Average Concentration[3] (ppm)
	Wind Speed: 2 m/s		
250	ND	ND	ND
500	ND	ND	ND
100	0.027	0.002	0.001
2,000	0.083	0.006	0.004
3,000 (LHA)	0.117	0.010	0.007
4,000	0.125	0.013	0.009
5,000	0.116	0.014	0.010
6,000	0.102	0.014	0.010
7,000	0.087	0.014	0.010
8,000	0.074	0.013	0.009

[1]ACGIH TLV is 5 ppm (see text pg. 3-6).
[2]Multiply 30-minute average concentration by 0.6 to obtain 8-hour average concentration.
[3]Multiply 60-minute average concentration by 0.7 to obtain 8-hour average concentration.

Table 3-2. Modeled ambient carbon monoxide concentrations from a STARS launch[1] 60-minute average concentrations (mg/m^3)

Downwind Distance (meters)	TRPUF				REEDM	
	Wind Speed: 0.46 m/s		Wind Speed: 1.58 m/s		Wind Speed: 2 m/s	
	STARS Contribution	Resulting Total[2]	STARS Contribution	Resulting Total[2]	STARS Contribution	Resulting Total[2]
1,000	38.4	38.6	11.2	11.4	0.003	0.233
3,000 (LHA)	15.4	15.6	4.4	4.6	0.022	0.252
5,000	8.5	8.7	2.5	2.7	0.031	0.261
6,000	ND	ND	ND	ND	0.031	0.261

[1]State of Hawaii one-hour ambient air quality standard is 10 mg/m^3. National Ambient Air Quality Standard is 40 mg/m^3.
[2]Total estimated 60-minute concentration is the sum of the STARS contribution and background levels of CO. Background is assumed to be 0.23 mg/m^3 (Stern et al. 1984).

model more conservative. The primary assumption used in the TRPUF model for STARS was that the entire inventory of pollutants from the motor would be released as puffs at various altitudes. Thus, the model gives a very conservative prediction for the amount of pollutants during the missile flight.

A mean wind speed of 1.69 m/s for 4,342 observations at the KTF has been reported (Range Commander Council, Meteorology Group 1983) and served as the basis for the air quality evaluations performed. The TRPUF model was used without historical wind direction data for three reasons. First, the flat-terrain assumption in the TRPUF model means that pollutant concentrations directly downwind will be the same regardless of wind direction. Second, the use of no wind direction allows the model to predict concentrations downwind in unusual wind-direction conditions. Third, because the wind direction at the time of any particular launch cannot be predicted, the modeling without a specified wind direction allows evaluation of impacts in all directions.

The REEDM computer model calculates concentrations of ground cloud constituents downwind from normal rocket launches and launch failures. REEDM has been used extensively at major launch sites to predict the direction and amount of pollutant deposition from missile launch ground clouds (Schmalzer, Hinkle, and Dreschel 1986; United States Air Force (USAF), Los Angeles Air Force Base 1991). The model can be adapted to the launch of a specific vehicle at designated weather and site conditions (USAF 1991). In order to apply the model to the A3 booster system of the STARS, specific A3 launch information was put into the REEDM model (e.g., types of pollutants, emission rate). REEDM programs were run with empirical meteorological data collected at the KTF. REEDM programs were run for both over-water and over-land conditions. The model was operated in a "no-terrain mode" for STARS since this mode assumes a flat-terrain condition that approximates the movement of pollutants over the ocean or flat agricultural land such as will be encountered at the KTF.

3.1.2 Results of Air Dispersion Modeling

Both the REEDM and TRPUF models provided ground-level pollutant estimates in terms of peak instantaneous concentrations and time-mean concentrations. REEDM provided 60-minute average concentrations, and TRPUF gave 30-minute average concentrations. Time-mean concentrations for other time periods than those produced by a computer model can be estimated by a power law equation (Turner 1970). For example, an 8-hour average concentration can be estimated from 30-minute or 1-hour average concentration by using the power law relationship, $x \propto t^{-0.20}$. Peak instantaneous concentrations and 30-minute average concentrations for HCl (Table 3-1) and 60-minute average concentrations for CO (Table 3-2) decrease with distance from the launch site. Both models predicted higher downwind concentrations at the lower wind speeds (0.46 – 2 m/s). A range of wind speeds was modeled, from 0.46 m/s to 13.9 m/s (approximating calm to high wind conditions). For HCl, model predictions were converted to 8-hour average concentrations so that comparison would be made to the public exposure guideline applied by the State of Hawaii (time weighted average $(TWA)_{8\text{-hr}}$ 0.025 ppm). Background levels were estimated and model predictions were converted to 60-minute averages for CO so that comparison could be made to the 60 minute Hawaii State Ambient Air Quality Standard (10 mg/m^3) and the NAAQS (40 mg/m^3). A screening method was applied to assess potential levels of nitrogen dioxide (NO_2) and total suspended particulates (TSP) generated by the STARS program. These NO_2 and TSP estimates were compared with applicable state and federal standards.

3.1.2.1 Hydrogen Chloride

Neither the U.S. Environmental Protection Agency (USEPA) nor the State of Hawaii has promulgated ambient air quality standards for HCl, and no federal guideline for exposure of the general public to HCl under ambient conditions has been established. In cases of HCl emissions, the Hawaii Clean Air Branch refers to the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV) for occupational workplace settings. TLVs refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect (ACGIH 1987). The TLV-Time Weighted Average ($TLV\text{-}TWA_{8\text{-}hr}$) is the time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect (ACGIH 1987). A TLV-Ceiling Limit (TLV-C) is a concentration that should not be exceeded during any part of the working exposure (ACGIH 1987). The State of Hawaii Clean Air Branch interprets the ACGIH TLV for HCl, 5 ppm (ACGIH 1987), to be a $TLV\text{-}TWA_{8\text{-}hr}$ (Hawaii Clean Air Branch 1991a). Furthermore, in order to provide health and safety protection to sensitive members of the public, the Clean Air Branch applies a safety factor of 200 to the ACGIH TLV (Hawaii Clean Air Branch 1991b). The resulting public exposure criteria used by the Clean Air Branch for HCl is a $TWA_{8\text{-}hr}$ of 0.025 ppm. This is a reference value to which concentrations for shorter (or longer) exposures can be normalized and compared. It does not mean that an individual will be exposed to a chemical for exactly 8 hours. TRPUF modeling results of estimated 8-hour equivalent average concentrations of HCl at the LHA boundary under low wind speed conditions range from 0.8 ppm to 2.9 ppm. REEDM modeling results of estimated 8-hour equivalent concentrations are 0.007 ppm at the LHA boundary under low wind speed conditions and 0.010 ppm at 5,000 – 7,000 m downwind.

It is important to understand that exposure evaluation criteria developed by ACGIH and other agencies are guidelines for occupational exposures, not regulatory standards for determining lines between safe and dangerous ambient concentrations. The ACGIH strongly discourages the use of its published exposure values for other than industrial hygiene practices (ACGIH 1987). Although the ACGIH guideline is not directly applicable to exposure of the public to STARS emissions, it is being used as an indicator of a level of significance.

Concentrations of HCl below 5 ppm show no lasting effects, and concentrations at 5 ppm or above are immediately irritating to the nose and throat. A concentration of 10 ppm is considered the maximal concentration acceptable for prolonged exposures (Sittig 1985). A concentration of 35 ppm causes irritation of the throat after brief exposures. Human male volunteers found 50 – 100 ppm barely tolerable for one hour (Sittig 1985). Indications are that recovery from brief exposures to these concentrations is expected. The Agency for Toxic Substances and Diseases Registry (ATSDR) at the Centers for Disease Control (CDC) has advised that under the maximum peak instantaneous (18 ppm) and 30-minute average (4.9 ppm) concentrations modeled by either the REEDM or TRPUF models for the LHA boundary, no adverse human health effects will result (ATSDR, CDC 1991).

The National Institute for Occupational Safety and Health (NIOSH) has published another guideline, the Immediately Dangerous to Life and Health (IDLH) level, that can be used to evaluate the potential for adverse human effects of exposure to HCl emissions. An IDLH represents a maximum concentration from which, in the event of respirator failure, one could escape within 30 minutes without experiencing any escape-impairing or irreversible health effects. The NIOSH IDLH value for HCl is 100 pm (150 mg/m^3) (U.S. Department of Health and Human Services 1987). However, this guideline also does not directly apply to a STARS launch because of the brief duration of the release (seconds). Nevertheless, the results of modeling STARS emissions indicate that the 30-minute average concentrations of HCl do not exceed the NIOSH IDLH at any distance from the launch pad at any wind speed.

HCl gas is known to dissipate rapidly from the point of origin. HCl gas concentrations in mist plumes produced by molten lava flowing into the ocean were highest (7.1 ppm) within 11 m (12 yards) of the sea and dissipated to less than 1 ppm at distances of approximately 365 m (400 yards) or greater (U.S. Department of Health and Human Services 1991). Peak instantaneous concentrations of HCl from a STARS launch could exceed 100 ppm within a distance of 1,000 m (3,280 ft) downwind at low wind speeds (Table 3-1). However, this concentration would drop to less than 15.5 ppm at a distance of 100 m within 10 minutes. Since unauthorized personnel are restricted within the 3,000 m (10,000 ft) LHA boundary, since HCl emissions dissipate quickly at typical wind speed conditions, and since HCl levels predicted by a reliable dispersion model (REEDM) are low, no adverse effects to human health and safety will result from a STARS launch. An additional consideration is the distance to populated areas, 3 miles to on-base housing and approximately 12 miles to Kekaha. In these areas as well, REEDM-modeled concentrations of HCl are far below the State of Hawaii public exposure guideline.

Four (4) discrete launch events a year will result in an annual total of 40 seconds of launch emissions that impact the ground-level environment. No long-term cumulative air quality effects will result.

3.1.2.2 Carbon Monoxide, Nitrogen Dioxide, and Particulates

As with the air dispersion modeling for HCl, potential air quality impacts of CO emissions were estimated by both REEDM and TRPUF (Table 3-2). Background levels were estimated to be 0.2 ppm (0.23 mg/m^3) (Stern et al. 1984). STARS emissions were added to background levels, and the totals were compared with the 1-hour State of Hawaii Ambient Air Quality Standard and NAAQS, 10 mg/m^3 and 40 mg/m^3, respectively. TRPUF modeling results of 60-minute average concentrations at the LHA boundary (10,000 feet) were 15.6 mg/m^3 at low wind speed conditions (0.46 m/s) (Table 3-2) and well below 8.7 mg/m^3 at the nearest populated areas. It should be noted, however, that wind speeds of 0.46 m/s are not representative of the normal meteorological environment at KTF and that most, if not all, of the launches should occur at wind speeds at or above 1.6 m/s. A wind speed of 1.6 m/s would result in a TRPUF-generated 60-minute average concentration of CO of 4.6 mg/m^3 at the LHA boundary. REEDM modeling results of 60-minute average concentration at the LHA boundary was 0.252 mg/m^3. Maximum 60-minute average concentration downwind (6,000 m) was 0.261 mg/m^3. Concentrations decreased at greater distances.

An emission above the 60-minute Hawaii Ambient Air Quality Standard for CO, 10 mg/m^3, by a STARS launch is considered unlikely, especially beyond the LHA. The impact of CO emissions due to STARS launches is not expected to be significant over the short or long term. No significant cumulative effects are expected.

An initial screening technique was exercised to assess the potential impacts of NO_2 and TSP from the STARS program on the ambient air quality of the KTF environment. The State of Hawaii and the USEPA have promulgated air quality standards for these pollutants. This screening method assumed a short-term, discrete, discontinuous source, no pollutant emissions at other times, and compete atmospheric ventilation before and after the time period averaged by the computer model. An average time-mean concentration for the source was calculated and then extrapolated by the power law to a longer term concentration (annual or 24-hour).

The maximum 30-minute average concentration of NO_2 at the LHA boundary was 5.2 ppm (TRPUF). Four discrete STARS launches a year emitted NO_2. These four 5.2 ppm 30-minute average concentration events were averaged with 17,516 30-minute average concentration intervals when the STARS contribution would be zero (there are 17,520 30-minute intervals in a year). The resulting estimate of the average 30-minute average concentration over a 1-year period was 0.00119 ppm. Using the power law, the contribution of the STARS program to the annual average of NO_2 in the KTF area was 0.000166 ppm (0.31 $\mu g/m^3$). The State of Hawaii annual NO_2 ambient air quality standard is 70 $\mu g/m^3$. The NO_2 annual NAAQS is 100 $\mu g/m^3$. The STARS program would contribute less than one percent of either annual NO_2 standard in the KTF area, where the background NO_2 value approaches zero. Therefore, the STARS activities would not violate the State standards for NO_2 emissions.

The maximum 30-minute average concentration of aluminum oxide (Al_2O_3) at the LHA boundary was 3.4 ppm (TRPUF). All Al_2O_3 was assumed to be TSP. Following the same screening technique as applied for NO_2, the estimate of the average TSP 30-minute average concentration over a 1-year period was 0.000776 ppm (approximately 3.2 $\mu g/m^3$). The contribution of the STARS program to annual TSP average in the KTF area was estimated at approximately 0.45 $\mu g/m^3$. The State of Hawaii annual TSP ambient air quality standard is 60 $\mu g/m^3$. The estimate of the average TSP 30-minute average concentration over a 24-hour period was 0.0708 ppm (294 $\mu g/m^3$). The contribution of the STARS program to the 24-hour TSP average would be 135 $\mu g/m^3$. The State of Hawaii 24-hour TSP ambient air quality standard is 150 $\mu g/m^3$. The STARS program would contribute less than one percent of the annual Hawaii TSP standard and approximately 90 percent of the 24-hour Hawaii TSP standard four times a year in the KTF area. Therefore, the STARS activities would not violate the state standards for TSP.

3.1.3 Assessment of the Applicability of the Hawaii State Ozone Protection Statute to STARS Activities

The second air quality area which the federal district judge in Hawaii addressed in his opinion was freon. The judge determined there was sufficient data in the administrative record to support the Army's original conclusion that the use of freon in the second-stage motor would not significantly impact the human environment. Nonetheless, the judge determined there was a substantial gap in the Army's original freon analysis, in that the STARS environmental assessment did not address whether the release of freon from the second stage of the STARS would violate the Hawaii Ozone Layer Protection Statute. This section of the EA supplement will address only the applicability of the Hawaii statute to the STARS program for the purpose of determining whether one of the criteria for significant impact has been triggered under the National Environmental Policy Act (NEPA).

On January 1, 1991, the Hawaii Ozone Layer Protection Statute went into effect (Hawaii Revised Statutes, Section 342C-1-5). This law is designed to regulate the release of CFC chemicals from such sources as air conditioners or mobile air conditioners. The statute specifically prohibits any person in the state from wilfully causing or allowing release of CFCs into the air from any source or process regulated under Chapter 342C, other than through the common use of the product or in the course of recovery, recycling, or safe disposal of the CFCs. The regulation of CFCs does not apply to refrigerators or freezers, and violations of the prohibitions are subject to civil penalties of $100 for each release.

Freon 114B2 is used in the second-stage STARS motor as a material in the thrust vector control system. Basically, the freon is used to guide the second stage in its flight as opposed to redirecting the rocket nozzles. The release of freon in the second stage will begin somewhere between 11 and 13 miles downrange and at an altitude of 94,000 feet, ending with second-stage burnout downrange an altitude of 555,000 feet. While most of the freon 114B2 is decomposed in the hot exhaust gases from the rockets, some of the freon 114B2 would be released without being decomposed.

The Hawaii *statute* regulates only certain types of freon. Specifically, it regulates CFCs consisting of certain chlorine, fluorine, carbon, and hydrogen compounds. The listed compounds which are regulated are CFC-11, CFC-12, CFC-13, CFC-112, CFC-113, CFC-114, and CFC-115. All of these compounds are chlorine and fluorine based; none have any bromine atoms. As indicated above, the type of freon used in the STARS second-stage motor is Freon 114B2. The "B" designator in the name indicates the compound is bromine-based and does not contain any chlorine. Freon 114B2 is a bromine compound; it is not a CFC. Since the Hawaii statute only regulates CFCs, bromine compounds, such as Freon 114B2, do not fall within its purview. Therefore, the STARS second-stage release of freon 114B2 does not threaten a violation of the Hawaii Statute.

Moreover, the Hawaii statute only applies to sources and processes that are regulated under Chapter 342C. Chapter 342C specifically lists activities that it regulates and that it does not regulate. First, it regulates the sale or offer for sale of "CFC refrigerants suitable for use in air conditioners of mobile air conditioners." Second, it regulates activities associated with CFCs such as recovery, recycling, and disposal. Third, the chapter does not regulate the use of CFCs in refrigerators or freezers. Since the use of freon in STARS does not involve CFCs, nor does it involve any of the listed sources or processes under Chapter 342C, the chapter does not apply to STARS activities. Therefore, STARS activities would not threaten to violate the chapter.

There are two additional reasons the Hawaii Ozone Layer Protection Statute does not apply to STARS. First, the release of the Freon 114B2 will occur at 94,000 feet in altitude and at least 11 miles from the launch pad on Kauai. Thus, the release will take place outside of the State of Hawaii. Second, Title II of the Clean Air Act regulates air emissions from mobile sources. Since STARS is a mobile source of air pollution, any regulation of it must flow from Title II. Title II contains several provisions for regulating mobile sources, but it only allows regulations on a national basis for air pollutants from mobile sources. The reason for limiting the regulation of mobile sources to national rules is to reduce restrictions on interstate commerce. Because STARS is a mobile source of air pollution, only national regulations can apply to its use; state and local regulations do not apply. Since the Hawaii law is a state-based regulation, the Hawaii Ozone Layer Protection Statute does not apply to STARS. Therefore, STARS activities do not threaten to violate the statute.

CORRECTION

THE PRECEDING DOCUMENT(S) HAS
BEEN REPHOTOGRAPHED TO ASSURE
LEGIBILITY
SEE FRAME(S)
IMMEDIATELY FOLLOWING

person in the state from wilfully causing or allowing release of CFCs into the air from any source or process regulated under Chapter 342C, other than through the common use of the product or in the course of recovery, recycling, or safe disposal of the CFCs. The regulation of CFCs does not apply to refrigerators or freezers, and violations of the prohibitions are subject to civil penalties of $100 for each release.

Freon 114B2 is used in the second-stage STARS motor as a material in the thrust vector control system. Basically, the freon is used to guide the second stage in its flight as opposed to redirecting the rocket nozzles. The release of freon in the second stage will begin somewhere between 11 and 13 miles downrange and at an altitude of 94,000 feet, ending with second-stage burnout downrange an altitude of 555,000 feet. While most of the freon 114B2 is decomposed in the hot exhaust gases from the rockets, some of the freon 114B2 would be released without being decomposed.

The Hawaii statute regulates only certain types of freon. Specifically, it regulates CFCs consisting of certain chlorine, fluorine, carbon, and hydrogen compounds. The listed compounds which are regulated are CFC-11, CFC-12, CFC-13, CFC-112, CFC-113, CFC-114, and CFC-115. All of these compounds are chlorine and fluorine based; none have any bromine atoms. As indicated above, the type of freon used in the STARS second-stage motor is Freon 114B2. The "B" designator in the name indicates the compound is bromine-based and does not contain any chlorine. Freon 114B2 is a bromine compound; it is not a CFC. Since the Hawaii statute only regulates CFCs, bromine compounds, such as Freon 114B2, do not fall within its purview. Therefore, the STARS second-stage release of freon 114B2 does not threaten a violation of the Hawaii Statute.

Moreover, the Hawaii statute only applies to sources and processes that are regulated under Chapter 342C. Chapter 342C specifically lists activities that it regulates and that it does not regulate. First, it regulates the sale or offer for sale of "CFC refrigerants suitable for use in air conditioners of mobile air conditioners." Second, it regulates activities associated with CFCs such as recovery, recycling, and disposal. Third, the chapter does not regulate the use of CFCs in refrigerators or freezers. Since the use of freon in STARS does not involve CFCs, nor does it involve any of the listed sources or processes under Chapter 342C, the chapter does not apply to STARS activities. Therefore, STARS activities would not threaten to violate the chapter.

There are two additional reasons the Hawaii Ozone Layer Protection Statute does not apply to STARS. First, the release of the Freon 114B2 will occur at 94,000 feet in altitude and at least 11 miles from the launch pad on Kauai. Thus, the release will take place outside of the State of Hawaii. Second, Title II of the Clean Air Act regulates air emissions from mobile sources. Since STARS is a mobile source of air pollution, any regulation of it must flow from Title II. Title II contains several provisions for regulating mobile sources, but it only allows regulations on a national basis for air pollutants from mobile sources. The reason for limiting the regulation of mobile sources to national rules is to reduce restrictions on interstate commerce. Because STARS is a mobile source of air pollution, only national regulations can apply to its use; state and local regulations do not apply. Since the Hawaii law is a state-based regulation, the Hawaii Ozone Layer Protection Statute does not apply to STARS. Therefore, STARS activities do not threaten to violate the statute.

3.2 BIOLOGICAL RESOURCES

This section will supplement Section 3.6.2 of the STARS EA by providing an assessment of the potential effects of HCl emissions from STARS launches on the particular biological environment of Kauai. Literature search results and field survey sampling results are used to clarify the evaluation criteria used for the analysis of the effects of STARS launches. Then a discussion of the evaluation of HCl emissions against these criteria with regard to the particular vegetation, wildlife, soil, and water found in the region of influence is provided.

3.2.1 Literature Search

The review of available literature on the environmental effects of HCl was conducted using the DIALOG computer search service, library search, and contacts with individuals and agencies conducting research on HCl. Most of the available HCl literature was related to areas within the continental U.S. Only one article specific to Hawaii was available; no literature was available for Kauai.

Much of the available literature on the environmental effects of HCl due to rocket launches addresses the Space Shuttle launches at the Kennedy Space Center in Florida (Schmalzer et al. 1985, 1986; Dreschel and Hall 1985, 1990; Hawkins et al. 1984; Granett 1983; Milligan and Hubbard 1983; Heck et al. 1980; NASA 1979; U.S. Department of the Air Force 1978). One monitoring study of a Titan 34-D test (Rinehart and Berlinrut 1988) and a monitoring study of Titan III launches (Pellet et al. 1983) were also reviewed.

HCl is known to cause leaf injury in plants. Laboratory and field testing have been conducted to determine the effects of solid rocket motor (SRM) exhaust products on vegetation (Schmalzer et al. 1985; Granett 1983; Heck et al. 1980; U.S. Department of the Air Force 1978). Heck et al. (1980) observed that spotted areas on both sides of leaves was the typical symptom of injury from HCl. Granett (1983) also observed spots on the leaves as well as leaf wilting when plants were sprayed with a one-percent solution (pH 0.8) of HCl.

The concentration at which damage occurs varies depending on the species. Cosmos is the most sensitive plant species for which data are available in the literature (USAF 1978). Cosmos, a commercial flower crop, exhibited traces of leaf discoloration and tip burning following a controlled 20-minute exposure to 2 ppm of HCl vapor in air (USAF 1978). Heck et al. (1980) reported that orange and grapefruit plants experienced less than 0.5 percent foliar injury after a 20-minute exposure to 80 ppm HCl, indicating these species are more tolerant of exposure to HCl.

The effects of HCl on some animal species has been documented. Controlled experiments have been conducted to determine the effects of HCl gas on animal species (USAF 1978). Domestic pigeons displayed slight unrest, irritation of eyes and nasal passages, and slightly reduced hemoglobin concentrations when exposed to 100 ppm HCl for 6 hours per day for 50 days. Laboratory mice experienced 50 percent morality when exposed to HCl gas at 14,000 ppm for 5 minutes and at 2,600 ppm for 30 minutes. HCl aerosol exposure caused 50 percent mortality of laboratory mice when exposed to 11,000 ppm for 5 minutes and 2,100 ppm for 30 minutes. The cotton mouse (*Peromyscus gossypinus*) exhibited respiratory distress when exposed to 80 ppm HCl per gram of body weight (USAF 1978). Fish kills were identified as resulting from large missile launches using water deluge systems. Deluge systems spray large quantities of cooling and sound suppression water, which interacts with the HCl gas emissions, resulting in the formation of aqueous HCl, which may run off to bodies of water and cause acid deposition in the nearfield environment (Schmalzer et al. 1980, 1986; Dreschel and Hall 1985, 1990; Hawkins et al. 1984; Granett 1983; Milligan and Hubbard 1983; U.S. Department of the Air Force 1978).

3.2.2 Field Survey and Sampling

In order to assess the potential effect of HCl on the Kauai environment, a field survey was conducted of plants, soil, and water in and around the launch site and at a control point (about 22 miles) away from the KTF. The purpose of the survey was to evaluate through field observation and field and lab analysis the historical effects of HCl on plants, soil, and water in and around the KTF.

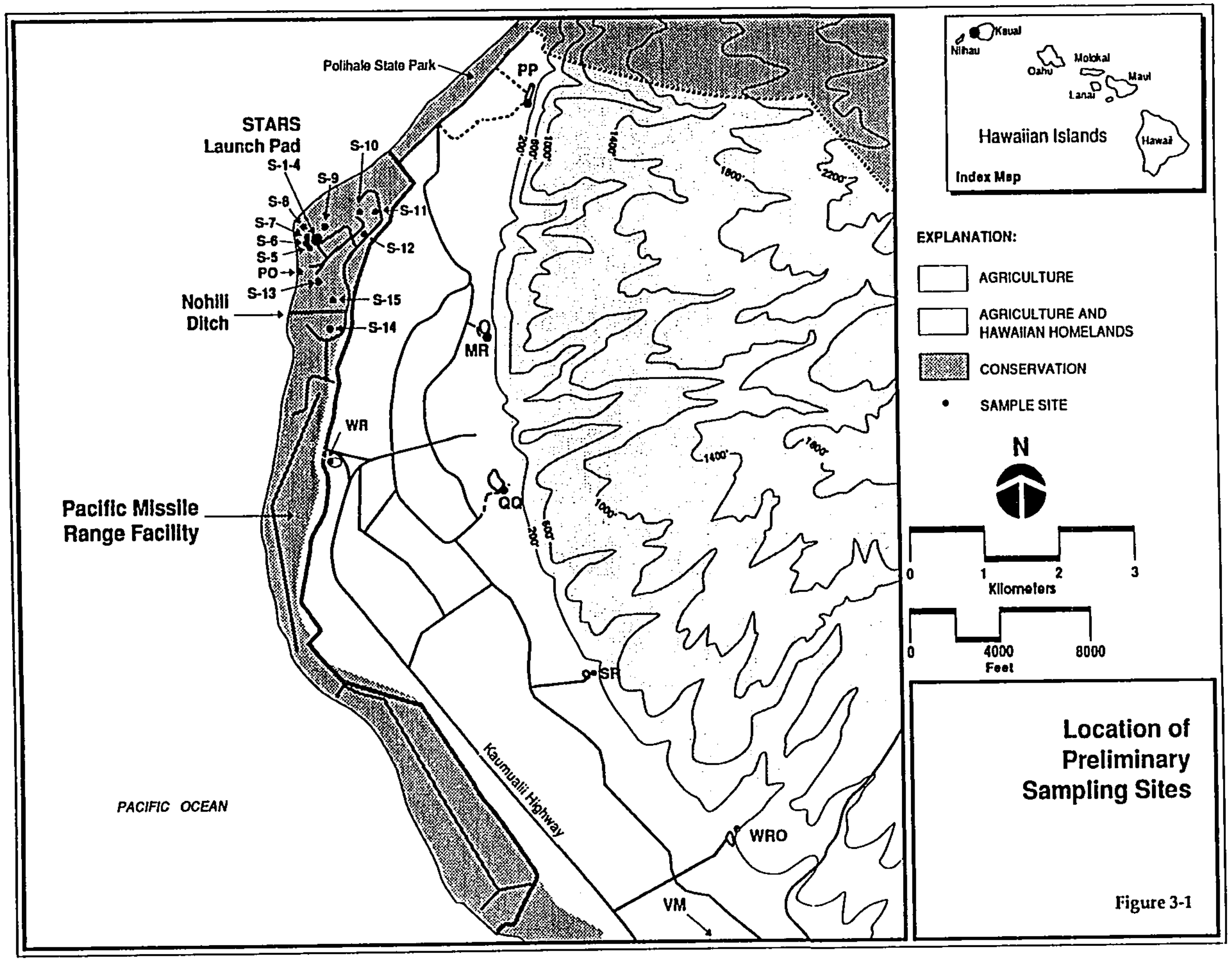
A control site was chosen near Waimea that would not have been exposed to HCl from prior KTF or Navy launches. Sampling points at various areas on and adjacent to the KTF were also established (Figures 3-1 and 3-2). These sample sites were in areas potentially exposed to HCl over the last two decades with the latest exposure in February 1991 from a launch of a STRYPI from the KTF.

Visual observation was used to identify existing plant species and to determine their general condition in order to ascertain if characteristics attributable to HCl exposure were present. Soil, water, and vegetation samples were taken, and field measurements of pH (acidity) were conducted (Tables 3-3 and 3-4).

3.2.3 Vegetation

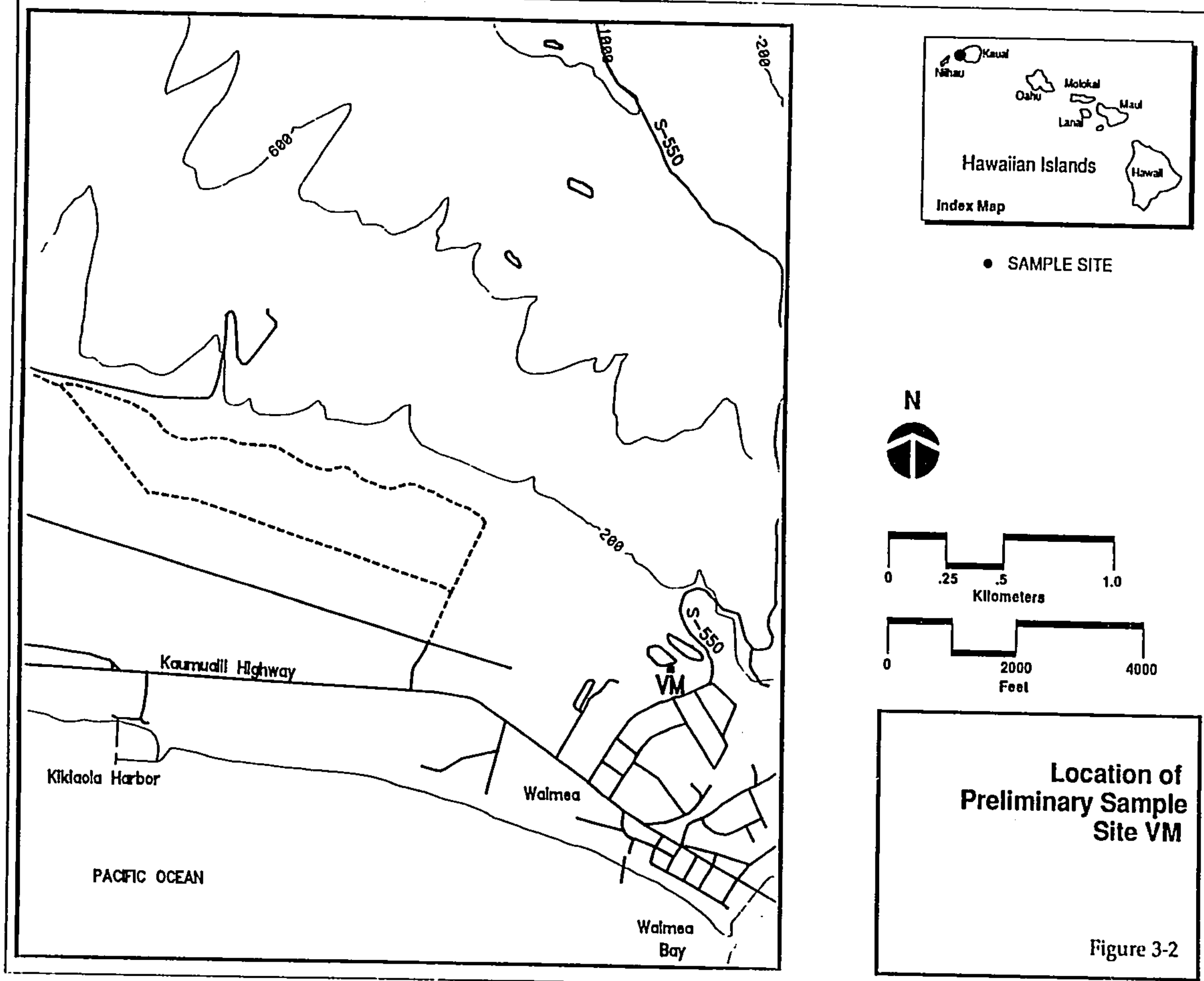
Vegetation types at all preliminary sampling sites can generally be described as being dominated by naturalized, exotic species. There are some differences in the species composition among the sites. The differences in vegetation between the KTF and other sampled locations are due to the level of disturbance, availability of water, and soil type. The KTF area was previously disturbed but appears to have been relatively undisturbed from some time, except for open mowed areas, allowing the kiawe and koa hoale to become dominant. There was no evidence of leaf damage (as characterized by spotting), and no pattern of pH and chloride values indicated any HCl effect (Tables 3-3 and 3-4). The rare adder's tongue fern occurs in this area near active launch pads, which have been used for HCl-emitting launches for over 20 years.

The time-weighted 20-minute average of HCl derived from TRPUF data for 300 to 3,000 m indicated a concentration range from 5 ppm at 300 to 1.5 ppm at 3,000 m at a nominal wind speed of 1.6 m/s (Table 3-5). When these data are compared to observed effects of various concentrations of HCl (Table 3-6) on some test plant species (Heck et al. 1980), the indication is that the predicted concentrations for a STARS launch are expected to cause little or no damage to vegetation.



Location of Preliminary Sampling Sites

Figure 3-1



Location of Preliminary Sample Site VM

Figure 3-2

Table 3-3.

Summary of field pH and miscellaneous field measurements on water, saturated soil paste, and vegetation wash water samples taken 28 and 29 May 1991 in the vicinity of the PMRF.

Sample Site[a]	Air Temp. (°C)	Water Temp. (°C)	pH (Std. units) Water	Soil	Vegetation
S-1	--	--[b]	--	7.3	7.9
S-2	--	--	--	7.9	7.5
S-3	--	--	--	7.3	5.2
S-4	--	--	--	7.7	7.3
S-5	--	--	--	7.8	5.
S-6	--	--	--	7.0	6.4
S-7	--	--	--	8.6	5.4
S-8	--	--	--	8.9	6.4
S-9	--	--	--	8.8	5.7
S-10	--	--	--	7.0	5.7
S-11	--	--	--	7.3	7.2
S-12	--	--	--	8.5	5.1
S-13	--	--	--	7.1	8.7
S-14	--	--	--	7.4	6.2
S-15	--	--	--	7.7	7.3
PO	22.8	25.6	8.1	8.2	5.5 (5.3)[c]
WR	30.6	28.9	7.8	8.2	6.4 (6.2)
PP	26.7	26.1	7.1	6.3	7.3 (6.6) (6.4)
MR	25.6	26.1	7.1	6.5	6.8
QQ	26.7	26.7	7.9	7.9	6.2
SR	26.1	25.6	7.4	6.1	6.7 (7.0) (6.3)
WRO	26.7	29.4	7.3	7.3	6.3 (6.8)
VM	24.4	25.6	7.2	6.4	6.0

[a]Locations shown on Figures 3-1 and 3-2
[b]No data available
[c]Numbers in parentheses are from duplicate samples

Table 3-4.

Chloride levels of water, saturated soil paste, and vegetation wash water samples taken 28 and 29 May 1991 in the vicinity of the PMRF.

Sample Site[a]	Water (mg/liter)	Soil (mg/kg)	Vegetation (mg/liter)
S-1	--[b]	130	3
S-2	--	50	< 0.5
S-3	--	60	0.5
S-4	--	30	1.5
S-5	--	80	< 0.5
S-6	--	360	4.5
S-7	--	30	2
S-8	--	70	9.5
S-9	--	70	7.5
S-10	--	320	< 0.5
S-11	--	50	1
S-12	--	< 10	3.5
S-13	--	320	4.5
S-14	--	60	< 0.5
S-15	--	60	< 0.5
PO	19,600 (19,900)[c]	120	< 0.5
WR	20,600 (19,400)	110 (20)	5 (0.5) (1) (0.5)
PP	305 (350)	160	1 (< 0.5) (< 0.5)
MR	388 (388)	130	< 0.5
QQ	263 (263)	90	1 (0.5) (1)
SR	150 (150)	180	2.5 (< 0.5) (1)
WRO	220 (223)	50	6.5 (< 0.5)
VM	50 (50)	190	1

[a]Locations on Figures 3-1 and 3-2
[b]No data available
[c]Numbers in parentheses are from duplicated samples

Table 3-5.

Predicted 20-minute average hydrogen chloride concentrations at a nominal wind speed of 1.6 m/s. (derived from TRPUF)

Downwind Distance (meters)	20-min Average (ppm)
300	5.0
500	4.5
1,000	3.9
2,000	2.4
3,000	1.5

Table 3-6.

Percent leaf injury from exposure to 10 ppm, 20 ppm, and 40 ppm HCL for 20 minutes.

Species	10 ppm	20 ppm	40 ppm
Radish	36	66	--
Soybean	1	70	--
Tomato	3	20	--
Corn	2	35	--
Pennywort	1	11	72
Citrus	--	--	0
Wax myrtle	< .5	3	21

The infrequency of exposure (four launches per year), field observations indicating no discernible physical or chemical effects as a result of 28 years of exposure to rocket launches of various types, and the occurrence of a rare species, such as the adder's tongue fern, near an active launch site indicate no adverse effects would be expected due to HCl emissions from STARS launches. In addition, due to the small exposure frequency and the historical lack of effect from previous launches, no adverse cumulative effects due to STARS launches are anticipated.

3.2.4 Wildlife

Studies of the effects of HCl gas on domestic pigeons (USAF 1978) indicated that there was irritation of the eyes and nasal passages and slightly reduced hemoglobin concentrations when pigeons were exposed to 100 ppm HCl for 6 hours per day for 50 days. Additional studies of laboratory mice (USAF 1978) indicated a 50-percent mortality when mice were subjected to HCl gas at 14,000 ppm for 5 minutes and to 2,600 ppm for 30 minutes. Deluge systems are used for some large missiles to quiet noise and vibrations. The deluge water interacts with the exhaust and combines with HCl gas to form aqueous HCl (Dreschel and Hall 1990; Potter 1978). The aqueous HCl may then run off into surface waters and has resulted in fish kills (Hawkins et al. 1984; Milligan and Hubbard 1983).

Wildlife species present in the KTF and adjacent areas would be exposed to no more than 5.1 ppm (for a 10-minute average) even at 250 m from the launch pad. Since no deluge systems will be used and launches will not occur during rainfall, no adverse effects to wildlife should occur due to emissions from STARS launches. Due to the small exposure frequency (four times per year), no cumulative effects are anticipated.

3.2.5 Soil

There is no chemical or physical indication that past missile launch activities at the KTF have affected the soils of the KTF and surrounding areas of Kauai (Table 3-4). The relatively small amounts of HCl released in the STARS ground cloud, the rapid dispersion of the emissions, and the facts that launches will not occur during rainfall and no deluge system will be used should minimize any deposition of HCl on the soil during the launches. No significant direct, indirect, short- or long-term impacts to soil due to HCl releases are expected. Due to the small frequency of events (four times per year) and the absence of any effect from 21 years of similar launches, no cumulative impacts are anticipated.

3.2.6 Water

There is no indication that past missile launches at the KTF have affected the urface water resources in the adjacent areas. The dispersion of the relatively small amount of HCl in the ground cloud and the near-launch plume, the absence of a deluge system, and the fact that launches will not be conducted during rainfall should minimize any deposition of HCl on surface waters. No significant direct, indirect, short- or long-term, or cumulative impacts to surface water resources due to STARS HCl releases are expected.

4. CONFLICTS WITH FEDERAL, REGIONAL, STATE, LOCAL, OR INDIAN TRIBE LAND USE PLANS, POLICIES, AND CONTROLS

This section supplements Section 3.10 of the STARS EA (July 1990) with information concerning the Hawaii Ozone Protection Statute applicability to STARS activities on Kauai. The statute applies neither to the type of material nor the activities being pursued by the STARS program (Section 3.1.3 of this supplement), and STARS activities would not threaten a violation of the State statute.

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5.0 REFERENCES

Agency for Toxic Substances and Diseases Registry, Centers for Disease Control. 1991. R. Nickle, personnel communication, June 28.

American Conference of Governmental Industrial Hygienists. 1987. *Threshold Limit Values and Biological Exposure Indices for 1987-1988*. Cincinnati OH: American Conference of Governmental Industrial Hygienists.

Botanical Consultants. 1985. Flora, Fauna, and Water Resources Report of the Pacific Missile Range Facility, Hawaii Area, Kauai, Hawaii. U.S. Navy Contract N62742-85-C-0136. Honolulu, Hawaii.

Brauggman, M. 1990. Personal communication between Brauggman, Hawaii Nature Conservancy, and S. Floyd, Advanced Sciences, Inc. concerning *Ophioglossum concinnum*, January 31.

Clausen, R.T. 1954. Ophioglossaceae of the Hawaiian Islands. American Journal of Botany 41(6):493-499.

Dreschel, T.W. and C.R. Hall. 1985. Near-Field Deposition Patterns of Chlorides and Particulates Resulting from Launches of the Space Transportation System at the John F. Kennedy Space Center. Contract NAS10-10285.

Dreschel, T.W. and C.R. Hall. 1990. Quantification of Hydrochloric Acid and Particulate Deposition Resulting from Space Shuttle Launches at John F. Kennedy Space Center, Florida, USA. Environmental Management 14 (4):501-507.

Dudley, A.L. and S.A. Sonnleitner. 1991. Dispersal of KTF STARS Combustion Products, prepared by SPECTRA Research Institute under Sandia National Laboratories, Contract Number 18-8181.

FEMA (Federal Emergency Management Agency). 1987. Flood Insurance Rate Map.

Granett, A.L. 1983. Effect of Acidic Deposition on Economic Plants in the Vandenberg Area. In *Space Shuttle Environmental Effects: the First Five Launches*. Proceedings of the NASA/USAF Space Shuttle Environment Conference, Kennedy Space Center, Florida. December 14-16, 1982. A. Potter, editor.

Hawkins, W.E., R.M. Overstreet, and M.J. Provancha. 1984. Effects of Space Shuttle Exhaust Plumes on Gills of Some. Estuarine Fishes: A Light and Electron Microscopic Study. *Gulf Research Reports* 7(4):297-309.

Hawaii Clean Air Branch. 1991a. T. Sugihara, personal communication, July 3.

Hawaii Clean Air Branch. 1991b. P. Aki, letter to Walter Odening, July 2.

Heck, W.W., W.M. Knott, E.P. Stahel, J.T. Ambrose, J.M. McCrimmon, M. Engle, L.A. Romanow, A.G. Sawyer, and J.D. Tyson. 1980. *Response of Selected Plant and Insect Species to Simulated Solid Rocket Exhaust Mixtures and to Exhaust Components from Solid Rocket Fuels.*

Milligan, J.E. and G.B. Hubbard. 1983. STS-5 Fish Kill, Kennedy Space Center, Florida. *In Space Shuttle Environmental Effects: the First Five Launches.* Proceedings of the NASA/USAF Space Shuttle Environment Conference, Kennedy Space Center, Florida. December 14-16, 1982. A. Potter, editor.

NASA. 1979. Environmental Impact Statement for the Kennedy Space Center. October. Pellet, G.L., R.J. Bendura, R.W. Storey, and W.R. Cofer. 1983. Near-Field Deposition of Acidic Droplets From Titan III and Space Shuttle Launches. In *Space Shuttle Environmental Effects: the First Five Launches.* Proceedings of the NASA/USAF Space Shuttle Environment Conference, Kennedy Space Center, Florida. December 14-16, 1982. A. Potter, editor.

Potter, A., Ed. 1983. *Space Shuttle Environmental Effects: the First Five Launches.* Proceedings of the NASA/USAF Space Shuttle Environment Conference, Kennedy Space Center, Florida. December 14-16, 1982.

Range Commanders Council, Meteorology Group. 1983. *Barking Sands, Hawaii, Range Reference Atmospheres, 0-74 km Altitude,* Document 370-83.

St. John, H. 1957. Notes on Hawaiian Terrestrial Species of Ophioglossum. *American Fern Journal* 47:74-76.

Schmalzer, P.A., C.R. Hinkle, and D. Breininger. 1985. Effects of Space Shuttle Launches STS-1 through STS-9 on Terrestrial Vegetation of John F. Kennedy Space Center, Florida. NASA Technical Memorandum 83103.

Schmalzer, P.A., C.R. Hinkle, and T.A. Dreschel. 1986. Far-Field Deposition from Space Shuttle Launches at John F. Kennedy Space Center, Florida. NASA Technical Memorandum 83104.

Sittig, M. 1985. *Handbook of Toxic and Hazardous Chemicals and Carcinogens,* 2nd ed. Park Ridge NJ: Noyes Publications.

Sohmer, S.H. and R. Gustafson. 1987. Plants and flowers of Hawaii. University of Hawaii Press, Honolulu.

Stern, A.C., R.W. Boubel, D.B. Turner, and D.W. Fox. 1984. *Fundamentals of Air Pollution,* second edition. San Diego: Academic Press, Inc.

Trinity Consultants, Inc. 1990. *User's Manual for TRPUF.* Dallas TX: Trinity Consultants, Inc.

Turner, B.D. 1970. *Workbook of Atmospheric Dispersion Estimates.* Research Triangle Park, NC: U.S. Environmental Protection Agency.

U.S. Air Force (USAF). 1991. D. Dargitz, Vandenberg Air Force Base, personal communication, June 6.

USAF. 1991. D. Berlinrut, Los Angeles Air Force Base, personal communication, May 31.

USASDC (U.S. Army Strategic Defense Command). 1990. Strategic Target System (STARS) Environmental Assessment.

U.S. Department of the Air Force. 1978. Final Environmental Impact Statement Space Shuttle Program, Vandenberg AFB, California. January.

U.S. Department of Health and Human Services. 1987. *NIOSH Pocket Guide to Chemical Hazards.* Washington DC: U.S. Government Printing Office.

U.S. Department of Health and Human Services. 1991. Health Hazard Evaluation Report RDHETA 90-200, May 1991.

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6.0 LIST OF PREPARERS

Sandy Floyd, Junior Scientist, Advanced Sciences, Inc.
B.S., 1989, Botany, Humbolt State University, Arcata, California
Area of Responsibility: Biological Resources
Years of Experience: 1

Dennis R. Gallien, Environmental Engineer, U.S. Army Strategic Defense Command
B.S., 1979, Industrial Chemistry, University of North Alabama, Florence
Area of Responsibility: STARS EA Program Management
Years of Experience: 12

George M. Mathews, Jr., Sr. Air Quality Specialist, Advanced Sciences, Inc.
M.S., 1990, Mineral Resources Ecology, Colorado School of Mines, Golden, Colorado
B.S., 1968, Zoology, Colorado School of Mines, Ft. Collins, Colorado
Area of Responsibility: Air Quality
Years of Experience: 13

Walter Odening, Assistant Vice President, Advanced Sciences, Inc.
Ph.D., 1971, Botany (Ecology), Duke University, Durham, North Carolina
M.S., 1968, Biology, San Diego State University, San Diego, California
B.S., 1963, Biology, San Diego State University, San Diego, California
Area of Responsibility: Program Director
Years of Experience: 23

Leo Rahal, Senior Scientist, Advanced Sciences, Inc.
Ph.D., 1977, Physics, University of New Mexico, Albuquerque, New Mexico
M.S., 1964, Physics, University of Detroit, Michigan
B.S., 1962, Physics, University of Detroit, Michigan
Areas of Responsibility: Nuclear Physics, Flight Profile, Air Dispersion
Years of Experience: 26

Nelson Rodriques, Director, Advanced Technology Group, Advanced Sciences, Inc.
M.S., 1968, Astronautical. Engineering, Air Force Institute of Technology, Dayton, Ohio
B.S., 1966, Nuclear Engineering, Lowell Technical Institute, Lowell, Massachusetts
Area of Responsibility: Technical Director, Launch Operations
Years of Experience: 23

George Wandler, Senior Project Manager, Advanced Sciences, Inc.
M.B.A., 1978, Business Administration, University of Tennessee, Knoxville, Tennessee
B.B.A., 1969, Business Administration, Memphis State University, Tennessee
Area of Responsibility: Project Manager, Technical Development
Years of Experience: 20

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Environment, Safety and Occupational Health
(OP-45)
Crystal Plaza, Bldg. 5, Room 644
Arlington, VA 20360

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Andrews AFB, MD 20331-5000

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HQ MAC/PA
Scott AFB, IL 62225-5000

HQ USA SDC
Technical Director CSSD-TD
CM-4 1941 Jefferson Davis Highway
Arlington, VA 22215

Chief of Public Affairs
2849 ABG
Hill AFB, UT 84056-5000

Base Civil Engineer
2849 ABG
Hill AFB, UT 84056-5000

Chief of Public Affairs
1606 ABW/PA
Kirtland AFB, NM 87117-5000

Base Civil Engineer
1606 ABW/DE
Kirtland AFB, NM 87117-5000

Commander Pacific Division
Naval Facilities Engineering Command
Pearl Harbor, Hawaii 96860-7300

Pacific Missile Range Facility
Public Works Department
Kekaha, HI 96752-0120

U.S. Army Kwajalein Atoll
CSSD-H-K/KA/KL/KS/KO/KT/KX
P.O. Box 26
APO San Francisco, CA 96555-2526

U.S. Army Strategic Defense Command
CSSD-EN
Huntsville, AL 35807-3801

1 STRAD/ET
Environmental Management Division
Vandenberg AFB, AL 35807-3801

Chief of Public Affairs
4392 ASW
Western Space and Missile Center
Vandenberg AFB, CA 93437-5000

Base Civil Engineer
4342 ASW
Western Space and Missile Center
Vandenberg AFB, CA 93437-5000

Contractors

Teledyne Brown Engineering
Cummings Research Park
300 Sparkman Drive
Huntsville, AL 35807-7007

Sandia National Laboratories
Kauai Test Facility
Waimea, Kauai, HI 96796

Sandia National Laboratories
Division 7523
Albuquerque, NM 87185-5800

Boeing Aerospace and Electronics
P.O. Box 3999
Seattle, WA 98124-2499

Nichols Research Corporation
4040 South Memorial Parkway
Huntsville, AL 35802

Utah State University
Research Park
Logan, UT 84321-9700

Federal, State, and Local Government Agencies

U.S. Department of Justice
Room 2133
10th & Pennsylvania Avenue, NW
Washington, DC 20530

Hawaii Coastal Zone Management Program
Office of State Planning
State Capitol, Room 410
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Washington, DC 20541

Office of Planning and Research
1400 10th Street
Room 121
Sacramento, CA 95814

Division of Environmental Health
288 North 1460 West
Salt Lake City, UT 84116-0690

Federal Facilities Liaison Coordinator
Environmental Protection Agency
1235 Mission Street
San Francisco, CA 94103

Federal Facilities Liaison Coordinator
Environmental Protection Agency
999 18th Street
Suite 500
Denver, CO 80202-2405

State of Hawaii
Department of Land and Natural Resources
Division of Land Management
P.O. Box 3390
Lihue, HI 92766

State of Hawaii
Office of Hawaiian Affairs
Lihue, Kauai, HI 96766

U.S. Fish and Wildlife Service
Pacific Islands Office
P.O. Box 50167
Honolulu, HI 96850

State of Hawaii
Office of Environmental Quality Control
465 S. King Street
Kekuanaoa Building, Rm 104
Honolulu, HI 96813

Clifford Ikeda, Civil Defense
4396 Rice St., #107
Lihue, HI 96766

Alejandro Lomosad, Fire Chief
Hanapepe, HI 96716

Roy C. Price, Sr.
State of Hawaii Civil Defense
3949 Diamond Head Road
Honolulu, HI 96816

Libraries

Albuquerque Public Library
501 Copper NW
Albuquerque, NM 87102

Layton Public Library
155 North Wasatch Drive
Layton, UT 84041

Ogden Public Library
2464 Jefferson Avenue
Ogden, UT 84401

Rancho Cordova Branch Library
9845 Folsom Blvd.
Sacramento, CA 95827

San Jose Public Library
180 W. San Carlos Street
San Jose, CA 95113

Office of Freely Associated States Affairs
Room 5317
Department of State
22nd & C Street, NW
Washington, DC 20520

U.S. Representative Office
P.O. Box 680
Republic of the Marshall Islands
Majuro, Marshall Islands 96960

Alele Museum/Library
c/o Ministry of the Interior and Outer Island Affairs
Republic of the Marshall Islands
Majuro, Marshall Islands 96960

Defense Technical Information Center
FDAC Division
Cameron Station
Alexandria, VA 22304-6145

Waimea Public Library
P.O. Box 397
Waimea, Kauai, HI 96796

Lihue Public Library
4344 Hardy Street
Lihue, Kauai, HI 96766

Magna Library
8339 West 3500 South
Magna, UT 84044-1853

The Lompoc Public Library
501 East North Avenue
Lompoc, CA 93436

J.F. Drake Memorial Learning Resource Center
P.O. Box 489
Alabama A&M University
Normal, AL 35762

University of Alabama in Huntsville
Attn: Library
Huntsville, AL 35899

Local Government Officials

Senator Akaka
109 Senate Hart Office Building
Washington, DC 20510-0103

Honorable Joann Yukimura
Office of the Mayor
4396 Rice Street
Lihue, Kauai, HI 96766

Honorable Ezra R. Kanoho
50th Representative District, Kauai
2755 Kepa Street
Lihue, Kauai, HI 96766

Honorable Bertha C. Kawakami
51st Representative District
P.O. Box 52
Hanapepe, Kauai, HI 96716

Kauai County Council
4396 Rice Street
Suite 206
Lihue, Kauai, HI 96766

Senator Daniel K. Inouye
722 Hart Senate Office Building
Washington, DC 20510

Honorable Patricia Saiki
1609 Longworth House Office Building
Washington, DC 20515

Earl A. Arruda
District Office of U.S. Representative Patsy Mink
P.O. Box 50124
Honolulu, HI 96850

General Alexis T. Lum
District Office of U.S. Senator Daniel Inouye
Federal Building
Honolulu, HI 96850

Private Citizens

Sandra Makuaole
P.O. Box 212
Waimea, HI 96796

Sharon Pomroy
P.O. Box 2007
Puhi, HI 96766

Diane Jager
1951 Muku Place
Koloa, HI 96756

Gary Benoit
P.O. Box 810
Hanalei, HI 96714

J. Vierkoetter
P.O. Box 3185
Princeville, HI 96722

Andrea Finch
P.O. Box 818
Kilauea, Kauai, HI 96754

Larissa Varaday
P.O. Box 1549
Hanalei, HI 96714

C.L. Sussex
P.O. Box 3568
Princeville, HI 96722

Ken Thomas
P.O. Box 1485
Hanalei, HI 96714

Sally Clark
P.O. Box 758 MSC
Kilauea, HI 96754

Jay Hanson
78-6622 Alii Drive
Kiluea Corner, HI 96740

Raymond Leach
3411 Wilcox Drive, Apt. A6
Lihue, HI 96766

Joan Hudson
P.O. Box 161
Kealia, HI 96751

Kelly Compton
P.O. Box 97
Lihue, HI 96766

Donna Buhrman
P.O. Box 1613
Kapaa, HI 96746

David O'Quinn
P.O. Box 1613
Kapaa, HI 96746

Jon Scott
6 Roundup Road
Bel Canyon, CA 91307

Elizabeth Freeman
P.O. Box 1440
Hanalei, HI 96714

Susan A. Wilson
P.O. Box 355
Hanalei, HI 96714

Lee Cataluna
P.O. Box 2116
Puhi, HI 96766

Larry Reisrr
P.O. Box 445
Hanapepe, HI 96716

Clifford P. Akana
P.O. Box 313
Waimea, HI 96796

Jacques Brown (2 copies)
P.O. Box 1398
Kapaa, HI 96746

Laura Rogers
P.O. Box 1280
Hanalei, HI 96714

Joe Munechika
4396 Rice Street
Lihue, HI 96766

James Tehada
4396 Rice Street
Lihue, HI 96766

Neal Norman
P.O. Box 1122
Hanalei, HI 96714

Uffe Madsen
P.O. Box 353
Hanapepe, HI 96716

David Leopold
P.O. Box 790
Waimea, HI 96796

Philip Freeman
P.O. 1120
Kalaheo, HI 96741

Jack Lundgren
6375 B Poo Road
Kapaa, HI 96746

Ken Jones
P.O. Box 1073
Kapaa, HI 96746

Jan TenBruggencate
P.O. Box 524
Lihue, HI 96766

Bill Dahle
P.O. Box 720
Eleele, HI 96705

Lester Chang
5888 Ohe Street
Kapaa, HI 96746

Anne E. O'Malley
4554 Lawai Road
Koloa, HI 96756

Jerry Santus
8240 Kekalea Road
Kekaha, HI 96752

G. Slater
P.O. Box 400
Kekaha, HI 96752

Suzanne Marinelli
P.O. Box 1172
Hanalei, HI 96714

Jake Welsh
P.O. Box 3317
Hanalei, HI 96714

David Nekomoto
P.O. Box 123
Lawai, HI 96765

Sabra K. McCracken
P.O. Box 700
Waimea, HI 96796

Bill Allen
P.O. Box 490
Hanalei, HI 96714

Bob Friedman
P.O. Box 316
Anahola, HI 96703

Smokey Rain
P.O. Box 753
Kapaa, HI 96746

Julia Neal
P.O. Box 3035
Lihue, HI 96766

Teri Teasdale
P.O. Box 28
Eleele, HI 96705

Janis Lyon
2829 Kanani Street
Lihue, HI 96766

Llei Beniamina
P.O. Box 330
Makaweii, HI 96769

Eduardo E. Malapit
2668 Hoonani Street
Koloa, HI 96756

Paul Lucas
P.O. Box 690
Lawai, HI 96765

Jacquie A. Bailon
P.O. Box 145
Kalalieo, HI 96741

Lei Kalamau
P.O. Box 1104
Waimea, HI 96796

Bill Asing
4113 Palaumall'i Street
Lihue, HI 96766

Sue Dixon Stong
4987 Hekili Road
Kapaa, HI 96746

Paulette Burtner
P.O. Box 865
Waimea, HI 96796

Alberto Partida
P.O. Box 1494
Hanalei, HI 96714

Wilma H. Holi
P.O. Box 368
Hanapepe, HI 96716

Jerry I. Sussman
P.O. Box 646
Hanalei, HI 96714

Joe Schlichter
P.O. Box 105
Hanalei, HI 96714

Suzannah Goodwin
P.O. Box 1431
Hanalei, HI 96714

Martin Gotie, Green Peace New Zealand
Private Bag, Wellesley Street
P.O. Auckland, New Zealand

Debra Wada
109 Senate Hart Office Bldg.
Washington, DC 20510-0103

Michael Jones
Physics Department, Univ. of Hawaii
2505 Icorrea Road
Honolulu, HI 96822

Steve Aftergood
Federation of American Scientists
307 Massachusetts Ave. Northeast
Washington, DC 20002

Lewis Hao
P.O. Box 526
Kaumakani, HI 96748

Mary Davis
P.O. Box 7
Canton, NY 13617

Ken Levine
P.O. Box 689
Calaheo, HI 96741

Brian Schaefer
P.O. Box 711
Kilauea, HI 96754

Kauai Times
P.O. Box 3272
Lihue, Kauai 96766

Kauai Cable
Attn: Dick Argus
P.O. Box 2116
Puhi, Kauai 96766

Garden Island
Attn: Rita De Silva/Claire Morris
3137 Auhio Highway
Lihue, Kauai 96766

Jeff Schomisch
1401 Wilson Blvd.
Arlington, VA 22209

Thomas Tamura
Kauai Times
4987 Hekili Road
Kapaa, HI 96746

Edward Kawamura
Kauai Veterans' Council
P.O. Box 3397
Lihue, HI 96766

Turk Tokita
Kauai Veterans' Council
2794 Pikake Street
Lihue, HI 96766

Klaus I. Kunter
Kapaa Rotary Club
P.O. Box 1148
Kapaa, HI 96746

Jack Ho
Kapaa Rotary Club
P.O. Box 844
Kapaa, HI 96746

General C.E. Beck
Kauai Rotary Club
3400 Kuhio Hwy., #A-401
Lihue, HI 96766

Larry Carlson
Kauai Rotary Club
3400 Kuhio Hwy., #A-401
Lihue, HI 96766

Raymond N. Blouin
West Kauai Rotary Club
Waihea Plantation Cottages
P.O. Box 429
Waihea, HI 96796

Clayton W. De la Cruz
International Longshore &
Warehousemen's Union
Box 1910
Lihue, HI 96766

Sue Kanoho
Kauai Economic Development Board
4370 Kukui Grove St. #211-C
Lihue, HI 96766

Lois Hamada
Pacific Missile Range Facility
P.O. Box 128
Kekaha, HI 96752-0128

Aubrey Kunishige
Pacific Missile Range Facility
P.O. Box 128
Kekaha, HI 96752-0128

John Tenuto
Pacific Missile Range Facility
P.O. Box 128
Kekaha, HI 96752-0128

Dennis Davies
Pacific Missile Range Facility
P.O. Box 128
Kekaha, HI 96752-0128

Bob Valencia
Pacific Missile Range Facility
P.O. Box 128
Kekaha, HI 96752-0128

Vince Nishina
Pacific Missile Range Facility
P.O. Box 128
Kekaha, HI 96752-0128

Sandra MaKuaole
Pacific Missile Range Facility
P.O. Box 128
Kekaha, HI 96752-0128

Jim Hager
Pacific Missile Range Facility
P.O. Box 128
Kekaha, HI 96752-0128

Lt. Dale Esperum
Pacific Missile Range Facility
P.O. Box 128
Kekaha, HI 96752-0128

Tom Cassidy
2829 Milo Ilea Loop
Koloa, HI 96756

Ken Carlson
P.O. Box 698
Kilauea, HI 96754

Fred Jager
1951 Muku Place
Koloa, HI 96756

Chaz Jetty
P.O. Box 26
Hanalei, HI 96714

Lyn Long
P.O. Box 495
Hanalei, HI 96714