Revised Draft Environmental Impact Statement

Commonwealth of the Northern Mariana Islands Joint Military Training

Appendices A through L

June 2025

EISX-007-17-XMC-1747255459

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APPENDICES A THROUGH L in Support of the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement

June 2025

The appendices of this Revised Draft EIS are compliant with Section 508 of the Rehabilitation Act. This allows assistive technology to be used to obtain the available information from the document. However, accessibility is limited to a descriptive title for some graphics, figures, tables, images, and attachments. Individuals who require assistance may submit a request through the Section 508 link on the project website at CNMIJointMilitaryTrainingEIS.com

APPENDIX A
COOPERATING AGENCY, REGULATORY AGENCY, AND ELECTED OFFICIALS CORRESPONDENCE

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UNITED STATES MARINE CORPS
COMMANDER, U.S. MARINE CORPS FORCES, PACIFIC
CAMP H. M. SMITH, HI 96861-4139

Mr. Richard Lobo
Director
International Broadcasting Bureau
330 Independence Avenue, SW, Room 4069
Washington, DC 20237

Dear Mr. Lobo:

Subj: COOPERATING AGENCY REQUEST FOR THE COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS (CNMI) JOINT MILITARY TRAINING ENVIRONMENTAL IMPACT STATEMENT/OVERSEA ENVIRONMENTAL IMPACT STATEMENT

On 25 August 2010, United States Pacific Command (PACOM) appointed Marine Forces Pacific (MARFORPAC) as the Executive Agent to conduct studies and complete appropriate environmental planning documentation in support of identifying a solution(s) for existing training deficiencies in the PACOM area of responsibility. After conduct of a Training Needs Assessment and a Requirements and Siting Study, MARFORPAC and PACOM concluded that the greatest number of training deficiencies occurred in the CNMI. The CNMI Joint Military Training Environmental Impact Statement (CJMT EIS)/Overseas EIS (OEIS) will develop and analyze range and training area alternatives to satisfy PACOM Service Components' unfilled unit-level and combined-level military training requirements in the CNMI. The proposed action is to improve existing and develop new live-fire military ranges and training areas in the CNMI; specifically the islands of Tinian and Pagan.

MARFORPAC requests International Broadcasting Bureau formal participation as a Cooperating Agency in preparation of its CJMT EIS, as prescribed in the President's Council on Environmental Quality (CEQ) National Environmental Policy Act (NEPA) Regulations, 40 CFR § 1501.6 Cooperating Agencies. Cooperating Agency responsibilities are explained in 40 CFR § 1501.6 and include, but are not limited to, the following:

a. Participating in scoping, review, and hearing processes;
b. Assuming responsibility, upon request, for developing information and preparing environmental analyses, including portions of the environmental impact statement for which the Cooperating Agency has special expertise;
c. Making available staff, at the lead agency's request, to support and enhance the latter's interdisciplinary capability; and,
d. Adherence to the overall schedule as set forth by MARFORPAC.

Please provide your response within 30 days of receipt of this letter indicating whether International Broadcasting Bureau accepts our request to serve as a Cooperating Agency and the point of contact for all EIS/OEIS matters. To avoid unnecessary delays in the NEPA process, MARFORPAC must have timely support from the cooperating agencies. In turn, MARFORPAC will ensure it provides necessary information and related materials in a timely fashion to enable International Broadcasting Bureau to complete review and respond promptly.

Ms. Sherri Eng is the Environmental Planning Program Team Lead for MARFORPAC and will contact International Broadcasting Bureau staff to address specific details of this Cooperating Agency relationship. In the meantime, should there be any questions; Ms. Eng can be reached at (808) 477-5814, or email at sherri.eng@usmc.mil.

Craig Whelden

CRAIG B. WHELDEN
Executive Director
U.S. Marine Corps Forces Pacific

Copy to:
Mr. Mark Filipek

UNITED STATES MARINE CORPS
COMMANDER, U.S. MARINE CORPS FORCES, PACIFIC
CAMP H. M. SMITH, HI 96861-4139

LTC Thomas D. Asbery
District Engineer
U.S. Army Corps of Engineers, Honolulu District
Building 230
Fort Shafter, Hawaii 96858-5440

Dear LTC Asbery:

Subj: COOPERATING AGENCY REQUEST FOR THE COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS (CNMI) JOINT MILITARY TRAINING ENVIRONMENTAL IMPACT STATEMENT/OVERSEA ENVIRONMENTAL IMPACT STATEMENT

On 25 August 2010, United States Pacific Command (PACOM) appointed Marine Forces Pacific (MARFORPAC) as the Executive Agent to conduct studies and complete appropriate environmental planning documentation in support of identifying a solution(s) for existing training deficiencies in the PACOM area of responsibility. After conduct of a Training Needs Assessment and a Requirements and Siting Study, MARFORPAC and PACOM concluded that the greatest number of training deficiencies occurred in the CNMI. The CNMI Joint Military Training Environmental Impact Statement (CJMT EIS)/Overseas EIS (OEIS) will develop and analyze range and training area alternatives to satisfy PACOM Service Components' unfilled unit-level and combined-level military training requirements in the CNMI. The proposed action is to improve existing and develop new live-fire military ranges and training areas in the CNMI; specifically the islands of Tinian and Pagan.

MARFORPAC requests U.S. Army Corps of Engineers formal participation as a Cooperating Agency in preparation of its CJMT EIS, as prescribed in the President's Council on Environmental Quality (CEQ) National Environmental Policy Act (NEPA) Regulations, 40 CFR § 1501.6 Cooperating Agencies. Cooperating Agency responsibilities are explained in 40 CFR § 1501.6 and include, but are not limited to, the following:

a. Participating in scoping, review, and hearing processes;
b. Assuming responsibility, upon request, for developing information and preparing environmental analyses, including portions of the environmental impact statement for which the Cooperating Agency has special expertise;
c. Making available staff, at the lead agency's request, to support and enhance the latter's interdisciplinary capability; and,
d. Adherence to the overall schedule as set forth by MARFORPAC.

Please provide your response within 30 days of receipt of this letter indicating whether U.S. Army Corps of Engineers accepts our request to serve as a Cooperating Agency and the point of contact for all EIS/OEIS matters. To avoid unnecessary delays in the NEPA process, MARFORPAC must have timely support from the cooperating agencies. In turn, MARFORPAC will ensure it provides necessary information and related materials in a timely fashion to enable U.S. Army Corps of Engineers to complete review and respond promptly.

Ms. Sherri Eng is the Environmental Planning Program Team Lead for MARFORPAC and will contact U.S. Army Corps of Engineers staff to address specific details of this Cooperating Agency relationship. In the meantime, should there be any questions; Ms. Eng can be reached at (808) 477-5814, or email at sherri.eng@usmc.mil.

Craig Whelden

CRAIG B. WHELDEN
Executive Director
U.S. Marine Corps Forces Pacific

Copy to:
Ms. Katherine Hammack
Mr. Ryan Wynn
Mr. George P. Young, P.E.
LTC Douglas B. Guttormsen

UNITED STATES MARINE CORPS
COMMANDER, U.S. MARINE CORPS FORCES, PACIFIC
CAMP H. M. SMITH, HI 96861-4139

Mr. Dan Ashe
Director
U.S. Fish and Wildlife Service
1849 C. Street, NW
Washington, DC 20240

Dear Mr. Ashe:

Subj: COOPERATING AGENCY REQUEST FOR THE COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS (CNMI) JOINT MILITARY TRAINING ENVIRONMENTAL IMPACT STATEMENT/OVERSEA ENVIRONMENTAL IMPACT STATEMENT

On 25 August 2010, United States Pacific Command (PACOM) appointed Marine Forces Pacific (MARFORPAC) as the Executive Agent to conduct studies and complete appropriate environmental planning documentation in support of identifying a solution(s) for existing training deficiencies in the PACOM area of responsibility. After conduct of a Training Needs Assessment and a Requirements and Siting Study, MARFORPAC and PACOM concluded that the greatest number of training deficiencies occurred in the CNMI. The CNMI Joint Military Training Environmental Impact Statement (CJMT EIS)/Overseas EIS (OEIS) will develop and analyze range and training area alternatives to satisfy PACOM Service Components' unfilled unit-level and combined-level military training requirements in the CNMI. The proposed action is to improve existing and develop new live-fire military ranges and training areas in the CNMI; specifically the islands of Tinian and Pagan.

MARFORPAC requests U.S. Fish and Wildlife Service formal participation as a Cooperating Agency in preparation of its CJMT EIS, as prescribed in the President's Council on Environmental Quality (CEQ) National Environmental Policy Act (NEPA) Regulations, 40 CFR § 1501.6 Cooperating Agencies. Cooperating Agency responsibilities are explained in 40 CFR § 1501.6 and include, but are not limited to, the following:

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c. Making available staff, at the lead agency's request, to support and enhance the latter's interdisciplinary capability; and,
d. Adherence to the overall schedule as set forth by MARFORPAC.

Please provide your response within 30 days of receipt of this letter indicating whether U.S. Fish and Wildlife Service accepts our request to serve as a Cooperating Agency and the point of contact for all EIS/OEIS matters. To avoid unnecessary delays in the NEPA process, MARFORPAC must have timely support from the cooperating agencies. In turn, MARFORPAC will ensure it provides necessary information and related materials in a timely fashion to enable U.S. Fish and Wildlife Service to complete review and respond promptly.

Ms. Sherri Eng is the Environmental Planning Program Team Lead for MARFORPAC and will contact U.S. Fish and Wildlife Service staff to address specific details of this Cooperating Agency relationship. In the meantime, should there be any questions; Ms. Eng can be reached at (808) 477-5814, or email at sherri.eng@usmc.mil.

Craig Whelden

CRAIG B. WHELDEN
Executive Director
U.S. Marine Corps Forces Pacific

Copy to:
Mr. Earl Campbell
Dr. Loyal Meyerhoff

UNITED STATES MARINE CORPS
COMMANDER, U.S. MARINE CORPS FORCES, PACIFIC
CAMP H. M. SMITH, HI 96861-4139

Mr. Michael P. Huerta
Administrator
Federal Aviation Administration
800 Independence Ave., S.W.
Washington, DC 20591

Dear Mr. Huerta:

Subj: COOPERATING AGENCY REQUEST FOR THE COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS (CNMI) JOINT MILITARY TRAINING ENVIRONMENTAL IMPACT STATEMENT/OVERSEA ENVIRONMENTAL IMPACT STATEMENT

On 25 August 2010, United States Pacific Command (PACOM) appointed Marine Forces Pacific (MARFORPAC) as the Executive Agent to conduct studies and complete appropriate environmental planning documentation in support of identifying a solution(s) for existing training deficiencies in the PACOM area of responsibility. After conduct of a Training Needs Assessment and a Requirements and Siting Study, MARFORPAC and PACOM concluded that the greatest number of training deficiencies occurred in the CNMI. The CNMI Joint Military Training Environmental Impact Statement (CJMT EIS)/Overseas EIS (OEIS) will develop and analyze range and training area alternatives to satisfy PACOM Service Components' unfilled unit-level and combined-level military training requirements in the CNMI. The proposed action is to improve existing and develop new live-fire military ranges and training areas in the CNMI; specifically the islands of Tinian and Pagan.

MARFORPAC requests Federal Aviation Administration formal participation as a Cooperating Agency in preparation of its CJMT EIS, as prescribed in the President's Council on Environmental Quality (CEQ) National Environmental Policy Act (NEPA) Regulations, 40 CFR § 1501.6 Cooperating Agencies. Cooperating Agency responsibilities are explained in 40 CFR § 1501.6 and include, but are not limited to, the following:

a. Participating in scoping, review, and hearing processes;
b. Assuming responsibility, upon request, for developing information and preparing environmental analyses, including portions of the environmental impact statement for which the Cooperating Agency has special expertise;
c. Making available staff, at the lead agency's request, to support and enhance the latter's interdisciplinary capability; and,
d. Adherence to the overall schedule as set forth by MARFORPAC.

Please provide your response within 30 days of receipt of this letter indicating whether Federal Aviation Administration accepts our request to serve as a Cooperating Agency and the point of contact for all EIS/OEIS matters. To avoid unnecessary delays in the NEPA process, MARFORPAC must have timely support from the cooperating agencies. In turn, MARFORPAC will ensure it provides necessary information and related materials in a timely fashion to enable Federal Aviation Administration to complete review and respond promptly.

Ms. Sherri Eng is the Environmental Planning Program Team Lead for MARFORPAC and will contact Federal Aviation Administration staff to address specific details of this Cooperating Agency relationship. In the meantime, should there be any questions; Ms. Eng can be reached at (808) 477-5814, or email at sherri.eng@usmc.mil.

Craig Whelden

CRAIG B. WHELDEN
Executive Director
U.S. Marine Corps Forces Pacific

Copy to:
Mr. Tim Cornelison

UNITED STATES MARINE CORPS
COMMANDER, U.S. MARINE CORPS FORCES, PACIFIC
CAMP H. M. SMITH, HI 96861-4139

Ms. Eileen Sobek
Acting, Deputy Assistant Secretary for Insular Areas
Office of Insular Affairs
1849 C Street, NW
Washington, DC 20240

Dear Ms. Sobek:

Subj: COOPERATING AGENCY REQUEST FOR THE COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS (CNMI) JOINT MILITARY TRAINING ENVIRONMENTAL IMPACT STATEMENT/OVERSEA ENVIRONMENTAL IMPACT STATEMENT

On 25 August 2010, United States Pacific Command (PACOM) appointed Marine Forces Pacific (MARFORPAC) as the Executive Agent to conduct studies and complete appropriate environmental planning documentation in support of identifying a solution(s) for existing training deficiencies in the PACOM area of responsibility. After conduct of a Training Needs Assessment and a Requirements and Siting Study, MARFORPAC and PACOM concluded that the greatest number of training deficiencies occurred in the CNMI. The CNMI Joint Military Training Environmental Impact Statement (CJMT EIS)/Overseas EIS (OEIS) will develop and analyze range and training area alternatives to satisfy PACOM Service Components' unfilled unit-level and combined-level military training requirements in the CNMI. The proposed action is to improve existing and develop new live-fire military ranges and training areas in the CNMI; specifically the islands of Tinian and Pagan.

MARFORPAC requests Office of Insular Affairs formal participation as a Cooperating Agency in preparation of its CJMT EIS, as prescribed in the President's Council on Environmental Quality (CEQ) National Environmental Policy Act (NEPA) Regulations, 40 CFR § 1501.6 Cooperating Agencies. Cooperating Agency responsibilities are explained in 40 CFR § 1501.6 and include, but are not limited to, the following:

a. Participating in scoping, review, and hearing processes;
b. Assuming responsibility, upon request, for developing information and preparing environmental analyses, including portions of the environmental impact statement for which the Cooperating Agency has special expertise;
c. Making available staff, at the lead agency's request, to support and enhance the latter's interdisciplinary capability; and,
d. Adherence to the overall schedule as set forth by MARFORPAC.

Please provide your response within 30 days of receipt of this letter indicating whether Office of Insular Affairs accepts our request to serve as a Cooperating Agency and the point of contact for all EIS/OEIS matters. To avoid unnecessary delays in the NEPA process, MARFORPAC must have timely support from the cooperating agencies. In turn, MARFORPAC will ensure it provides necessary information and related materials in a timely fashion to enable Office of Insular Affairs to complete review and respond promptly.

Ms. Sherri Eng is the Environmental Planning Program Team Lead for MARFORPAC and will contact Office of Insular Affairs staff to address specific details of this Cooperating Agency relationship. In the meantime, should there be any questions; Ms. Eng can be reached at (808) 477-5814, or email at sherri.eng@usmc.mil.

Craig Whelden

CRAIG B. WHELDEN
Executive Director
U.S. Marine Corps Forces Pacific

Copy to:
Mr. Nikolao Pula

UNITED STATES MARINE CORPS
COMMANDER, U.S. MARINE CORPS FORCES, PACIFIC
CAMP H. M. SMITH, HI 96861-4139

Mr. Samuel Rauch III
Acting, Assistant Administrator for Fisheries
National Oceanic and Atmospheric Administration, National Marine Fisheries Service
1315 East West Highway
Silver Spring, MD 20910

Dear Mr. Rauch:

Subj: COOPERATING AGENCY REQUEST FOR THE COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS (CNMI) JOINT MILITARY TRAINING ENVIRONMENTAL IMPACT STATEMENT/OVERSEA ENVIRONMENTAL IMPACT STATEMENT

On 25 August 2010, United States Pacific Command (PACOM) appointed Marine Forces Pacific (MARFORPAC) as the Executive Agent to conduct studies and complete appropriate environmental planning documentation in support of identifying a solution(s) for existing training deficiencies in the PACOM area of responsibility. After conduct of a Training Needs Assessment and a Requirements and Siting Study, MARFORPAC and PACOM concluded that the greatest number of training deficiencies occurred in the CNMI. The CNMI Joint Military Training Environmental Impact Statement (CJMT EIS)/Overseas EIS (OEIS) will develop and analyze range and training area alternatives to satisfy PACOM Service Components' unfilled unit-level and combined-level military training requirements in the CNMI. The proposed action is to improve existing and develop new live-fire military ranges and training areas in the CNMI; specifically the islands of Tinian and Pagan.

MARFORPAC requests National Marine Fisheries Service formal participation as a Cooperating Agency in preparation of its CJMT EIS, as prescribed in the President's Council on Environmental Quality (CEQ) National Environmental Policy Act (NEPA) Regulations, 40 CFR § 1501.6 Cooperating Agencies. Cooperating Agency responsibilities are explained in 40 CFR § 1501.6 and include, but are not limited to, the following:

a. Participating in scoping, review, and hearing processes;
b. Assuming responsibility, upon request, for developing information and preparing environmental analyses, including portions of the environmental impact statement for which the Cooperating Agency has special expertise;
c. Making available staff, at the lead agency's request, to support and enhance the latter's interdisciplinary capability; and,
d. Adherence to the overall schedule as set forth by MARFORPAC.

Please provide your response within 30 days of receipt of this letter indicating whether National Marine Fisheries Service accepts our request to serve as a Cooperating Agency and the point of contact for all EIS/OEIS matters. To avoid unnecessary delays in the NEPA process, MARFORPAC must have timely support from the cooperating agencies. In turn, MARFORPAC will ensure it provides necessary information and related materials in a timely fashion to enable National Marine Fisheries Service to complete review and respond promptly.

Ms. Sherri Eng is the Environmental Planning Program Team Lead for MARFORPAC and will contact National Marine Fisheries Service staff to address specific details of this Cooperating Agency relationship. In the meantime, should there be any questions; Ms. Eng can be reached at (808) 477-5814, or email at sherri.eng@usmc.mil.

CRAIG B. WHELDEN
Executive Director
U.S. Marine Corps Forces Pacific

Copy to:
Mr. Michael Tosatto
Ms. Kitty Simonds

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pacific Islands Fish and Wildlife Office
300 Ala Moana Boulevard, Room 3-122, Box 50088
Honolulu, Hawaii 96850

In Reply Refer To:
2013-TA-0153

MAR 1 3 2013

Mr. Craig B. Whelden
Executive Director
United States Marine Corps Forces, Pacific
Camp H.M. Smith, HI, 96861

Subject: Cooperating Agency Request for the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement (CJMT EIS)/ Oversea Environmental Impact Statement (OEIS)

Dear Mr. Whelden:

This is in response to your letter dated March 8, 2013, requesting the U.S. Fish and Wildlife Service (Service) to participate as a cooperating agency on the preparation of the subject EIS/OEIS. We appreciate the offer to be a cooperating agency. However, current staffing and workload constraints preclude our ability to accept this request; therefore, we respectfully decline cooperating agency status.

The Service recognizes the importance of our collaboration in the development of the EIS/OEIS and in the section 7 consultation required under the Endangered Species Act of 1973 (ESA), as amended. The Service will continue to provide technical assistance regarding aspects of draft EIS/OEIS documents as requested and will respond to Marine Corps requests for information. The Service also will continue to work collaboratively with the Marine Corps and assist you with ensuring that the best available scientific information is used in the EIS/OEIS, and the impacts to ESA-listed species and other natural resources are avoided and minimized.

If you have questions regarding this letter, please contact Leilani Takano, Fish and Wildlife Biologist (phone: 671-355-5096; email: leilani_takano@fws.gov).

Sincerely,

Loyal Mehrhoff
Field Supervisor

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
1315 East-West Highway
Silver Spring, Maryland 20910
THE DIRECTOR

MAR 1 9 2013

Commander Craig B. Whelden
Executive Director
U.S. Marine Corps Forces Pacific
Camp H.M. Smith, HI 96861-4139

Dear Commander Whelden:

Thank you for your letter requesting that NOAA's National Marine Fisheries Service (NMFS) be a cooperating agency in the preparation of the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS). NMFS supports the Marine Forces Pacific (MARFORPAC) decision to prepare this EIS/OEIS and agrees to be a cooperating agency, due, in part, to our responsibilities under section 101(a)(5)(A) of the Marine Mammal Protection Act and section 7 of the Endangered Species Act.

We will make every effort to support the Navy in the specific ways described in your letter. Therefore, NMFS, to the maximum extent practicable, will:

- Participate in scoping, review, and hearing processes, as necessary.
- Respond to MARFORPAC requests for information, in particular those related to the acoustic effects analysis and the evaluation of the effectiveness of protection and mitigation measures, in a timely manner.
- Make staff available to the maximum degree possible, at the lead agency's request, to support and enhance the latter's interdisciplinary capability.
- Adhere to the overall schedule as agreed upon by NMFS and MARFORPAC.

If you need any additional information, please contact Ms. Jolie Harrison, NMFS Office of Protected Resources, at (301) 427-8420.

Sincerely,

Samuel D. Rauch III
Deputy Assistant Administrator
for Regulatory Programs,
performing the functions and duties of the
Assistant Administrator for Fisheries

U.S. Department
of Transportation
**Federal Aviation
Administration**

MAR 2 2 2013

Mr. Craig B. Wheldon
Executive Director
Commander, U.S Marine Corps Forces, Pacific
Camp H.M. Smith. HI 96861-4139

Dear Mr. Wheldon:

Thank you for your letter requesting the Federal Aviation Administration (FAA) participate as a cooperating agency in the Environmental Impact Statement (EIS) to evaluate the potential environmental consequences for the Commonwealth of the Northern Mariana Islands (CNMI) Joint Military Training.

Since the proposal potentially involves special use airspace (SUA), the FAA will cooperate following the guidelines described in the Memorandum of Understanding (MOU) between the FAA and the Department of Defense Concerning SUA Environmental Actions, dated October 4, 2005, and in accordance with 40 CFR § 1501.6, NEPA regulations regarding cooperating agencies.

Modification of SUA resides under the jurisdiction of the Western Service Center, Operations Support Group, 1601 Lind Ave. SW, Renton, Washington. The Western Service Center will be the primary focal point for matters related to airspace and associated environmental matters. Mr. Clark Desing is the Manager of the Operations Support Group. FAA Order 7400.2, Procedures for Handling Airspace Matters, Chapter 32, indicates the airspace and environmental processes should be conducted in tandem as much as possible; however, they are separate processes. Approval of either the aeronautical process or the environmental process does not automatically indicate approval of the entire proposal. I have enclosed Appendix 2, 3, and 4 of FAA Order 7400.2 for additional details.

A copy of the incoming correspondence and this response is being forwarded to Mr. Desing of the Western Service Center, Operations Support Group. Mr. Desing can be contacted at 425-203-4500 for further processing of your proposal.

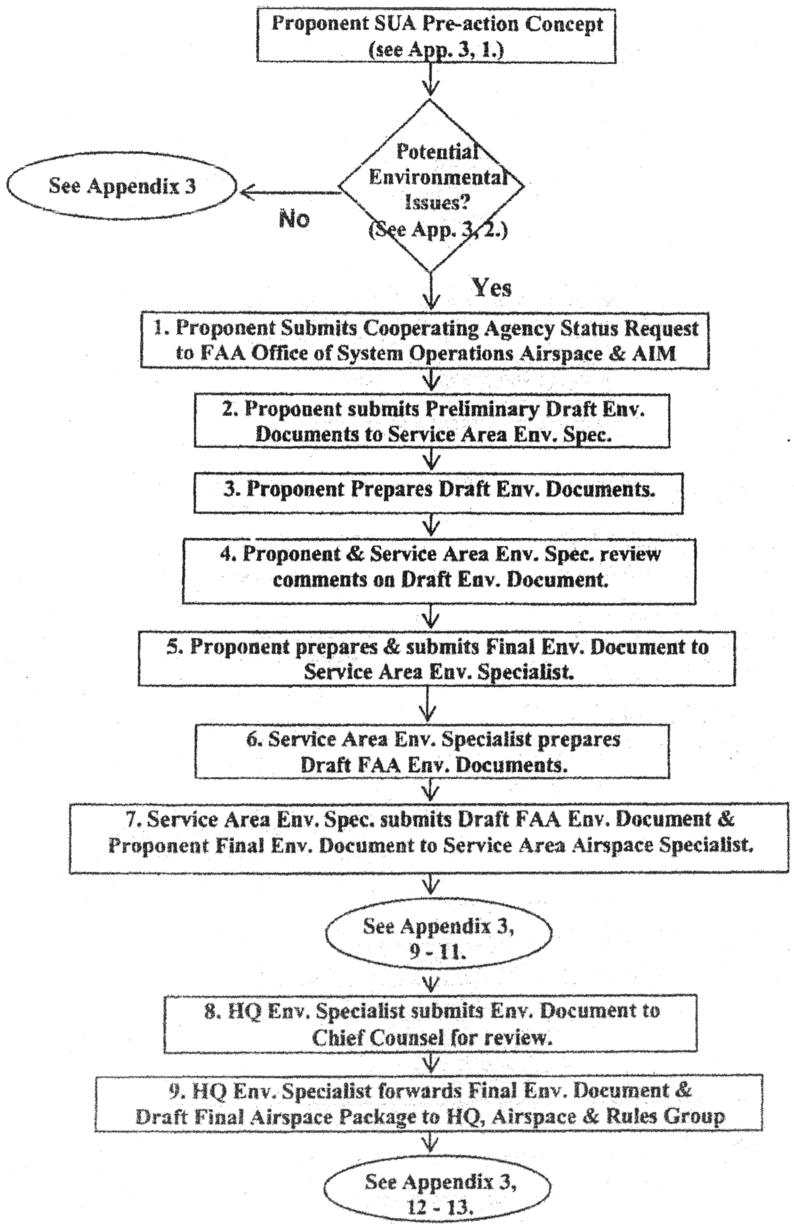
Sincerely,

Dennis E. Roberts
Director, Airspace Services
Air Traffic Organization

3 Enclosures

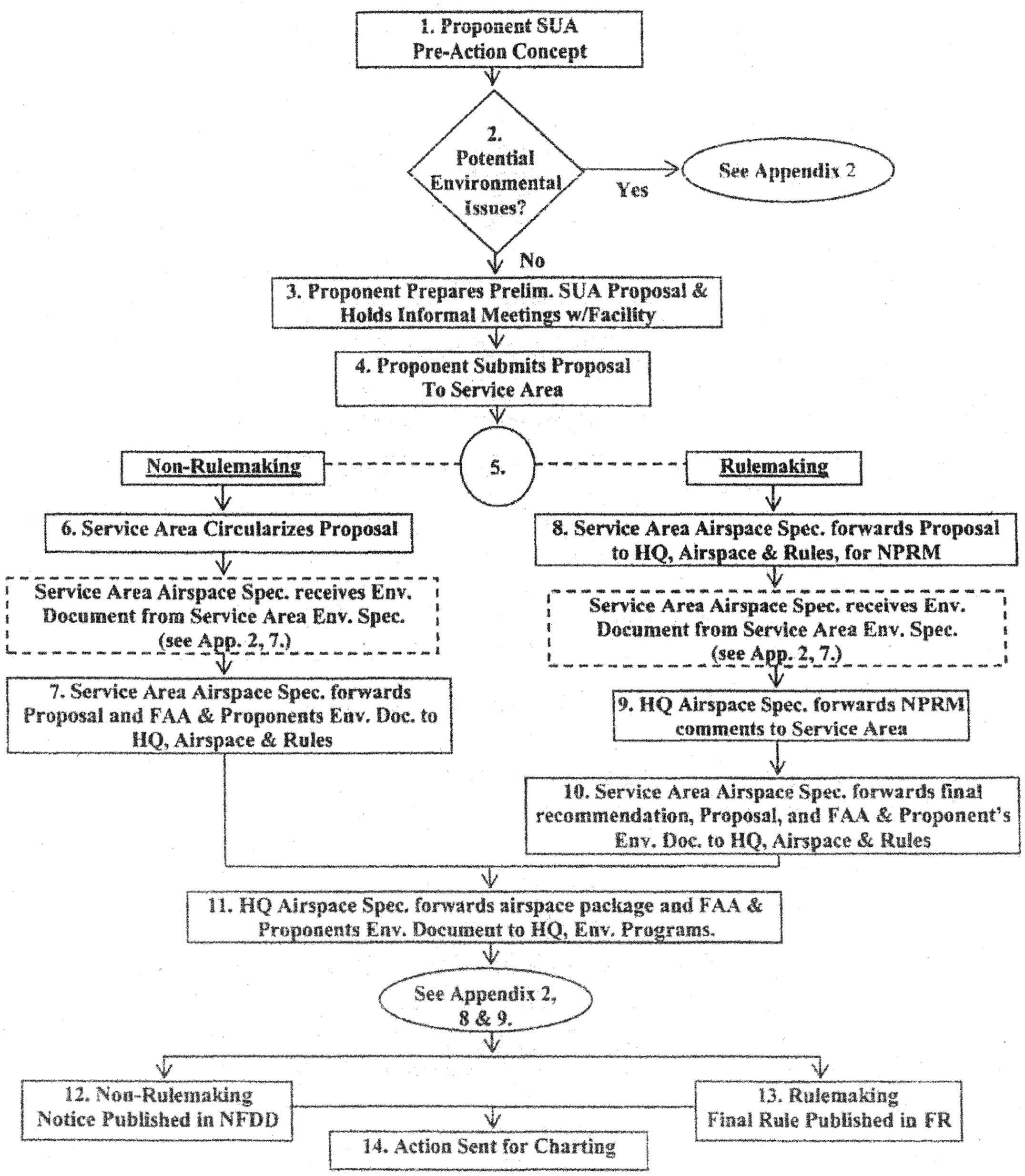
Appendix 2. Procedures For Processing SUA Actions Environmental Process Flow Chart

(This Chart is for use with Appendix 4 and the numbers correlate to the numbers in the Environmental column of that table.)



Appendix 3. Procedures For Processing SUA Actions Aeronautical Process Flow Chart

(This Appendix is for use with Appendix 4 and the numbers correlate to the numbers in the Aeronautical column of that table.)



Appendix 4. FAA Procedures for Processing SUA Actions Aeronautical and Environmental Summary Table

(The aeronautical and environmental processes may not always occur in parallel.)
(This Appendix is for use with Appendix 2 and Appendix 3, and the numbers correlate to numbers on those charts.)

(See note below.)

AERONAUTICAL	ENVIRONMENTAL
1. Proponent shall present to the Facility a Pre-draft concept (i.e., new/ revisions to SUA needed or required).	1. Proponent shall discuss with the Service Area, at the earliest time, the potential for environmental impacts associated with the proposal.
	2. If there is the potential for environmental impacts, Proponent shall make a request to the FAA for a Cooperating Agency (CA) status when Proponent decides to initiate the environmental process. Proponent shall forward the request to the Director of the System Operations Airspace and AIM. The Director will transmit the request to the Environmental Programs Group who prepares and forwards the response to Proponent. The Environmental Programs Group will send a courtesy copy of the response to the responsible Service Area. The Service Area environmental specialist works as the FAA point of contact throughout the process in development of any required environmental documentation.
	3. Proponent submits a Preliminary Draft EA or EIS to the Service Area environmental specialist. The Service Area environmental specialist shall provide comments, in consultation with the airspace specialist and the Environmental Programs Group, back to Proponent.

2. Proponent forwards the aeronautical proposal to the FAA Service Area for review and processing by the airspace specialist.	4. Proponent prepares a Draft EA or EIS with a 45-day public comment period. As the FAA CA point of contact, the Service Area environmental specialist reviews the associated draft environmental documentation to ensure that the Proponent addressed adequately all environmental concerns submitted on the Preliminary Draft. If required, the Service Area environmental specialist forwards the draft environmental documentation to the Environmental Programs Group for review and comment by the headquarters environmental specialist and the Office of Chief Counsel.
3. The Service Area airspace specialist, in accordance with this order, determines the type of airspace action(s) necessary, either Non-Rulemaking or Rulemaking. FAA Service Area and Proponent determine if informal Airspace Meetings are required.	
For Non-Rulemaking:	
4. The Service Area airspace specialist sends out a circularization with a 45-day public comment period. The Service Area airspace specialist reviews and prepares, in consultation with the Proponent, responses to the aeronautical comments from the study and circularization in accordance with Chapter 21 of this order.	5. The Proponent reviews comments received on their Draft EA/FONSI or EIS and prepares their responses to the comments, in consultation with the FAA and other cooperating agencies, if necessary, and in accordance with Chapter 32 of this order.
	6. Proponent prepares and submits their Final EA/FONSI or EIS/ROD to the Service Area environmental specialist.
	7. The Service Area environmental specialist prepares a Draft FAA FONSI/ROD or Draft FAA Adoption Document/ROD.
	8. The Service Area environmental specialist submits the Draft FAA FONSI/ROD or Draft FAA Adoption Document/ROD and the Proponent's Final EA/FONSI or EIS/ROD to the Service Area airspace specialist for inclusion with the airspace proposal package.
5. The Service Area airspace specialist then sends the completed package containing the aeronautical proposal, response to comments, Proponent's Final EA/FONSI, and the Draft FAA FONSI/ROD to the Headquarters Airspace and Rules Group with their recommendation.	

For Rulemaking:	
6. The Service Area airspace specialist sends the proposal to the Airspace and Rules Group who prepares a Notice of Proposed Rulemaking (NPRM). The Headquarters Airspace and Rules Group submits the NPRM for publication in the Federal Register with a 45-day comment period in accordance with Chapter 2 of this order.	
7. The Headquarters airspace specialist sends comments received on the NPRM to the Service Area airspace specialist for resolution.	
8. The Service Area airspace specialist then sends the completed package containing the response to comments, final service area recommendation, the proposal, Proponent's Final EA/FONSI or EIS/ROD, and the Draft FAA FONSI/ROD or Draft FAA Adoption Document/ROD to the Headquarters Airspace and Rules Group for preparation of the Final Rule.	
9. The Headquarters airspace specialist forwards the draft final rule package or draft non-rulemaking case summary (NRCS) with all supporting documentation to the Headquarters Environmental Programs Group for review (after all aeronautical comments have been resolved).	9. The Headquarters environmental specialist reviews the package for environmental technical accuracy; then submits the environmental documentation to the Office of the Chief Counsel, Airports and Environmental Law Division, for legal sufficiency review (having collaborated throughout the process).
	10. The Chief Counsel's environmental attorney's comments are incorporated into the final FAA environmental decision and signed by Headquarters Environmental Programs Group Manager. The package is then returned to the Headquarters Airspace and Rules Group.
10. For Non-rulemaking: The non-rulemaking action is published in the National Flight Data Digest. 11. For Rulemaking: The Final Rule is published in the Federal Register. The Final Rule will contain a reference to the decision rendered and location of documentation for the associated environmental process.	

Consult the following documents throughout the process for further information:

- Council on Environmental Quality Regulations for Implementing the National Environmental Policy Act (NEPA), 40 CFR Parts 1500-1508
- FAA Order 1050.1E, "Environmental Impacts: Policies and Procedures"
- FAA Order 7400.2, "Procedures for Handling Airspace Matters," Part 5
- FAA Order 7400.2, Chapter 32, "Environmental Matters" and the associated appendixes (for specific SUA environmental direction)

NOTE: The time periods below are for a non-controversial aeronautical proposal and its associated environmental process. The time periods are for FAA review/processing only. Times for proponent and/or environmental contract support processing must be added.

ENVIRONMENTAL: The estimated time of completion for EA processing is 12 to 18 months or, for EIS processing, 18 to 36 months.

AERONAUTICAL (Non-Rulemaking): A minimum 4 months is required from submission of the Formal Airspace Proposal by the Proponent to the Service Area through completion of the circularization process. Additionally, a minimum of 6 months is required from submission of the Formal Airspace Proposal by the Service Area to Headquarters through completion of the charting process.

AERONAUTICAL (Rulemaking): A minimum 6 weeks for Service Area processing, and a minimum of 9 months to complete rulemaking once the formal package is received at Headquarters.

APR 11 2013

Craig B. Whelden
Executive Director
U.S. Marine Corps Forces Pacific

Subject: Cooperating Agency Request for the Commonwealth of the Northern Mariana Islands (CNMI) Joint Military Training Environmental Impact Station/Overseas Environmental Impact Statement

Dear Mr. Wheldon:

Thank you for your letter on the above subject. I understand that in-house staff from the International Broadcasting Bureau (IBB), Office of Technology, Services and Innovation has been working closely with representatives from the U.S. Marine Corps (USMC), and the Naval Facilities Command (NAVFAC) on aspects of the planned Environmental Impact Statement (EIS) that will involve operations at the (IBB) transmitter site on the island of Tinian.

The IBB confirms that it will serve as a cooperating agency and the point of contact for EIS matters that pertain to the IBB transmitter site on Tinian. However, program commitments and budgetary constraints could limit the degree of the IBB's involvement pursuant to 40 C.F.R. Section 1501.6. The IBB is prepared to support this initiative with its in-house staff and to the extent it does not interfere with the Agency's mission. Furthermore, the IBB has not budgeted for any specialized services that might necessitate the use of contractors or consultants for the EIS matters described in your letter. Any specialized services required will need to be funded and arranged by the appropriate Department of Defense entity.

We look forward to working closely with the USMC and NAVFAC on preparation of the EIS. Mark Filipek, Director of the IBB's Operations and Stations Division, will be your primary point of contact on this initiative. Mr. Filipek can be reached at (202) 382-7359, or by email at mfilipek@bbg.gov.

Sincerely,

for Richard M. Lobo
Director

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, HONOLULU
FORT SHAFTER, HAWAII 96858-5440

REPLY TO
ATTENTION OF:

Regulatory Branch
Engineering and Construction Division

14 May 2013

Mr. Craig B. Whelden, Executive Director
U.S. Marine Corps Forces Pacific
United States Marine Corps
Camp H. M. Smith, HI 96861-4139

Dear Mr. Whelden:

This is in response to your letter, received on March 5, 2013, requesting the U.S. Army Corps of Engineers (USACE) to participate as a Cooperating Agency in the Marine Forces Pacific preparation of the Commonwealth of the Northern Mariana Islands Joint Military Training Environmental Impact Statement (CJMT EIS)/Overseas EIS (OEIS). As stated, the CJMT EIS/OEIS will develop and analyze alternatives to improve existing and develop new live-fire military ranges and training areas in the CNMI islands of Tinian and Pagan.

As a Federal agency with jurisdiction by law over elements of the proposed action, the USACE accepts your request to serve as a Cooperating Agency, in accordance with National Environmental Policy Act (NEPA) Regulations, 40 CFR § 1501.6, during the EIS/OEIS process. Based on our initial understanding of the proposed actions, our applicable statutory authorities may include Section 10 of the Rivers and Harbors Act of 1899, Section 7 of the Rivers and Harbors Act of 1917, Chapter XIX of the Army Appropriations Act of 1919, and Section 404 of the Clean Water Act.

Thank you for your request and cooperation with the DA Regulatory Program. I have designated Mr. Ryan Winn of our Guam Field Office to act as your point of contact for all EIS/OEIS matters. Mr. Winn may be reached at PSC 455, Box 188, FPO AP 96540-1088; by phone at (671) 339-2108; or by email at ryan.h.winn@usace.army.mil, should you have any questions.

Sincerely,

George P. Young, P.E.
Chief, Regulatory Branch

United States Department of the Interior

OFFICE OF INSULAR AFFAIRS
1849 C Street, NW
Washington, DC 20240

Assistant Secretary

May 23, 2013

Craig B. Whelden
Executive Director
U.S. Marine Corps Forces Pacific
Camp H.M. Smith, HI 96861 - 4139

Dear Director Whelden:

Thank you for your letter dated March 13, 2012, concerning the appointment of Marine Forces Pacific (MARFORPAC) as the Executive Agent to conduct studies and complete appropriate planning documentation in support of identifying a solution(s) for existing training deficiencies in the United States Pacific Command area of responsibility. We very much appreciate the update and information you provided regarded this recent development.

Our Office of Insular Affairs accepts your invitation to serve as a cooperating agency in the preparation of its Commonwealth of the Northern Mariana Islands Joint MilitaryTraining Environmental Impact Statement (CJMT EIS)/Overseas EIS (OEIS) that will develop and analyze range and training area alternatives. We look forward to working with your office to assist in the preparation of the CJMT EIS/OEIS.

Our staff point of contact for CNMI EIS/OEIS is Ms. Kristen Oleyte, Senior Policy Advisor to the Assistant Secretary of the Interior Office of Insular Areas and Senior Policy Advisor to US Pacific Command (PACOM). She can be reached at Kristen_H_Oleyte@ios.doi.gov or 808.477.7642.

Sincerely,

Eileen Sobeck
Acting Assistant Secretary
Insular Areas

MEMORANDUM OF UNDERSTANDING

FOR

THE CNMI JOINT MILITARY TRAINING
ENVIRONMENTAL IMPACT STATEMENT/OVERSEAS ENVIRONMENTAL IMPACT STATEMENT

BETWEEN

U.S. MARINE CORPS FORCES, PACIFIC

AND

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

MOU for the CJMT EIS/OEIS between MARFORPAC and National Oceanic and Atmospheric Administration

I. Purpose

A. This Memorandum of Understanding (MOU) sets forth the roles and responsibilities as agreed to among the U.S. Marine Corps Forces, Pacific (MARFORPAC) and National Oceanic and Atmospheric Administration (NOAA) for the purpose of preparing the CNMI Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement (CJMT EIS/OEIS).

B. This MOU encourages early and continuing coordination and collaboration of the participants to support the development of the CJMT EIS/OEIS with a target for a Record of Decision (ROD) in April 2016.

C. This MOU emphasizes the importance for MARFORPAC and NOAA to provide specific support and information to foster efficient and timely review and development of documentation that will meet National Environmental Policy Act (NEPA) and other statutory requirements.

D. CJMT EIS/OEIS Key Milestone Dates

Milestone	Anticipated Review Period
Review of pre-final version of Draft EIS/OEIS	July 2014
Notice of Availability of the Draft EIS/OEIS published	November 2014
Public Hearings/Public Meetings	December 2014
Review of pre-final version of Final EIS/OEIS	October 2015
Notice of Availability of the Final EIS/OEIS published	March 2016
Record of Decision	April 2016

E. This MOU includes the following attachments:

1. USPACOM - DOD Training in the Pacific Study Environmental Impact Statement (EIS) Executive Agent Appointment (25 Aug 10)

2. MARFORPAC – Cooperating agency request for the CNMI Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement (26 Feb 13)

3. NOAA – Cooperating agency acceptance letter

II. Applicable Laws and Regulations

- National Environmental Policy Act of 1969, 42 USC § 4321 *et seq.*
- Title 40, Code of Federal Regulations (CFR), Parts 1500-1508, Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (1978, unless otherwise noted)
- Environmental Policy and Conflict Resolution Act of 1998, P. L. 105-156
- Executive Order 11514, Protection and Enhancement of Environmental Quality, as amended by EO 11991, dated May 24, 1977
- Executive Order 12114, Environmental Effects Abroad of Major Federal Actions, dated January 4, 1979
- Executive Order 12372, as amended by EO 12416, Intergovernmental Review of Federal Programs, dated April 8, 1983)

III. Roles and Responsibilities

A. MARFORPAC: As the Executive Agent (EA) appointed by USPACOM to accomplish the CJMT EIS/OEIS, responsibilities are as follows:

1. Maintain Lead Agency responsibility for all aspects of the CJMT EIS/OEIS preparation and analysis, including preparation of the draft and final EIS, the ROD, and all supporting documents;; release of all public information and the scheduling and conduct of public meetings; coordination and scheduling for the completion of all work items; document distribution; management of the budget; and ensuring appropriate coordination among the parties to this MOU.

2. Release of NEPA documents, i.e., Draft EIS (DEIS), Final EIS (FEIS) and ROD.

3. Provide a framework for collaboration and manage that collaboration among the Cooperating Agencies to ensure timely compliance with and completion of the NEPA process.

4. Provide leadership to ensure consistent cooperation, the timely issuance of concurrence, and continuing coordination to achieve a complete and justifiable EIS/OEIS.

5. Maintain a list and ensure coordination among lead points of contact (POCs) within each Cooperating Agency.

6. After coordination with Cooperating Agencies, maintain Lead Agency responsibility for all regulatory consultations.

7. Provide regular EIS/OEIS progress updates to Cooperating Agencies and inform them of significant developments affecting the proposed action at the earliest possible opportunity.

8. Coordinate the overall design of the administrative record (AR) and organize, prepare, and maintain the AR for the CJMT EIS/OEIS.

9. Ensure Cooperating Agencies have reasonable opportunities to review and comment on EIS/OEIS versions, and provide updates on the EIS/OEIS and time estimates of document availability for review.

10. Receive all comments resulting from either agency or public review and comment periods. Coordinate with the Cooperating Agencies and request assistance, as needed, on those comments that concern their respective agencies' areas of expertise and jurisdictional responsibilities.

B. Cooperating Agency NOAA:

1. Provide a lead POC to represent NOAA in the CJMT EIS/OEIS effort.

2. Ensure timely review, to the extent practical, of all NEPA documents; provide timely comments, consistent cooperation, concurrence, and continuing coordination to achieve a complete and justifiable EIS/OEIS.

3. Participate, as available, in developing information and preparing environmental analyses, including portions of the EIS/OEIS for which the Cooperating Agency has special expertise.

4. Make staff available, to the extent practical and at the lead agency's request, to support and enhance MARFORPAC's interdisciplinary capability.

5. Adhere to the overall schedule as set forth by MARFORPAC.

6. Inform the EA for the CJMT EIS/OEIS on any projects the Cooperating Agency is conducting, has recently completed, or plans to conduct in the USPACOM AOR for purposes of cumulative effects analysis.

IV. Effective Date: This MOU is effective on the last date of signature below.

V. Effect of Agreement: Nothing in this MOU will be construed as affecting the authority of any signatory beyond the understanding contained within this MOU. This MOU in no way restricts any of the signatories from participating in similar activities with other agencies and organizations.

This MOU shall be referenced in the Draft and Final EIS for public review so that each signatory's respective roles may be understood.

VI. Review/Changes: Signatories (or their successors) will review this MOU annually. Any signatory may request modification and amendment of this MOU at any time. Both signatories will consider the proposed changes, and upon mutual agreement, adopt the modifications by amendment to this MOU. The signatory proposing the changes shall provide copies of the modified MOU to MARFORPAC or NOAA for signature approval. The effective date of an amendment is the date on which MARFORPAC and NOAA have signed the amended MOU.

VII. Term: This MOU will remain in effect for the time period beginning with the effective date of the MOU and ending with issuance of the CJMT EIS/OEIS ROD. MARFORPAC or NOAA may terminate its participation in this MOU at any time before the date of expiration, with 30 days written notice to the other parties.

VIII. Statement of No Financial Obligation: This MOU cannot be cited as the basis for any reimbursement of costs incurred by a signatory to collaborate throughout the EIS development process. Nothing in this MOU will be construed as affecting the authorities of the signatories to act as provided by statute or regulation, or as binding signatories beyond their respective authorities or to require the signatories to obligate or expend funds in excess of appropriations. All funding mechanisms related to the CJMT EIS/OEIS shall be executed separately.

IX. Dispute Resolution: A dispute shall be deemed to have arisen when MARFORPAC or NOAA notifies the other in writing of a dispute. The issues shall be clearly identified in a memorandum. The lead POCs shall work together to resolve disputes. It is the intention of the lead POCs that all disputes shall be resolved expeditiously at the lowest possible level of authority. In the event a dispute is not resolved within fifteen (15) calendar days, the dispute will be elevated for resolution as follows:

A. The lead MARFORPAC or NOAA POC shall elevate an unresolved dispute within their respective chain-of-command. A formal communication describing the issue will be provided to senior leadership. The senior leadership of the signatory making the formal complaint shall convene a meeting to resolve the dispute within 30 calendar days after issuing the formal communication to the other signatory senior leadership.

B. If signatory senior leadership is unable to resolve the dispute, the issue will be referred to the Deputy Commander, USPACOM, whose decision will be final.

X. Signatures

In witness whereof, the parties to this MOU through their duly authorized representatives for MARFORPAC and NOAA have executed this MOU, and certify that they understand and agree to support the purpose and provisions of this MOU, as set forth herein.

Craig B. Whelden
Executive Director
U.S. Marine Corps Forces, Pacific

Samuel D. Rauch III
Deputy Assistant Administrator
for Regulatory Programs performing the functions and duties of the Assistant Administrator for Fisheries,
National Oceanic and Atmospheric Administration

U.S. Department
of Transportation
**Federal Aviation
Administration**

Office of the Air Traffic Organization
Western Service Area

1601 Lind Avenue Southwest
Renton, Washington 98057

JAN 8 2014

Mr. Craig B. Whelden
Executive Director
U.S. Marine Corps Forces Pacific
Camp H. M. Smith, HI 96861-4139

RE: Request approval for the cooperating agency Memorandum of Understanding (MOU) for the Commonwealth of the Northern Mariana Islands (CNMI) Joint Military Training Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS)

Dear Mr. Whelden,

The Federal Aviation Administration (FAA) received your request to enter into a Memorandum of Understanding (MOU) for the preparation of the CNMI EIS/OEIS. The FAA understands the need to have continuity between the Marine Forces Pacific (MARFORPAC) and the FAA throughout the National Environmental Policy Act process. We believe this relationship is thoroughly described in existing orders and the signed MOU per FAA Order 7400.2J Appendix 7, "FAA/DOD Memorandum of Understanding", and Appendix 8, "FAA Special Use Airspace Environmental Processing Procedures". These documents clearly describe the relationship and formalize the cooperative relationship between MARFORPAC and the FAA.

The FAA believes existing FAA Order 7400.2J and MOU are adequate for accomplishing the EIS/OEIS process and don't believe an additional MOU is needed. The FAA appreciates your patience in this matter. If you have any questions or require further information, please contact the FAA environmental specialist, Marina Landis, at (425) 203-4561.

Sincerely,

for Clark Desing
Manager
Operations Support Group
Western Service Center

MEMORANDUM OF UNDERSTANDING

FOR

THE CNMI JOINT MILITARY TRAINING
ENVIRONMENTAL IMPACT STATEMENT/OVERSEAS ENVIRONMENTAL IMPACT STATEMENT

BETWEEN

U.S. MARINE CORPS FORCES, PACIFIC

AND

U.S. ARMY CORPS OF ENGINEERS

MOU for the CJMT EIS/OEIS between MARFORPAC and U.S. Army Corps of Engineers

I. Purpose

A. This Memorandum of Understanding (MOU) sets forth the roles and responsibilities as agreed to among the U.S. Marine Corps Forces, Pacific (MARFORPAC) and U.S. Army Corps of Engineers (USACE) for the purpose of preparing the CNMI Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement (CJMT EIS/OEIS).

B. This MOU encourages early and continuing coordination and collaboration of the participants to support the development of the CJMT EIS/OEIS with a target for a Record of Decision (ROD) in April 2016.

C. This MOU emphasizes the importance for MARFORPAC and USACE to provide specific support and information to foster efficient and timely review and development of documentation that will meet National Environmental Policy Act (NEPA) and other statutory requirements.

D. CJMT EIS/OEIS Key Milestone Dates

Milestone	Anticipated Review Period
Review of pre-final version of Draft EIS/OEIS	July 2014
Notice of Availability of the Draft EIS/OEIS published	November 2014
Public Hearings/Public Meetings	December 2014
Review of pre-final version of Final EIS/OEIS	October 2015
Notice of Availability of the Final EIS/OEIS published	March 2016
Record of Decision	April 2016

E. This MOU includes the following attachments:

1. USPACOM - DOD Training in the Pacific Study Environmental Impact Statement (EIS) Executive Agent Appointment (25 Aug 10)

2. MARFORPAC – Cooperating agency request for the CNMI Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement (26 Feb 13)

3. USACE – Cooperating agency acceptance letter

II. Applicable Laws and Regulations

- National Environmental Policy Act of 1969, 42 USC § 4321 *et seq.*
- Title 40, Code of Federal Regulations (CFR), Parts 1500-1508, Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (1978, unless otherwise noted)
- Environmental Policy and Conflict Resolution Act of 1998, P. L. 105-156
- Executive Order 11514, Protection and Enhancement of Environmental Quality, as amended by EO 11991, dated May 24, 1977
- Executive Order 12114, Environmental Effects Abroad of Major Federal Actions, dated January 4, 1979
- Executive Order 12372, as amended by EO 12416, Intergovernmental Review of Federal Programs, dated April 8, 1983)

III. Roles and Responsibilities

A. MARFORPAC: As the Executive Agent (EA) appointed by USPACOM to accomplish the CJMT EIS/OEIS, responsibilities are as follows:

1. Maintain Lead Agency responsibility for all aspects of the CJMT EIS/OEIS preparation and analysis, including preparation of the draft and final EIS, the ROD, and all supporting documents;; release of all public information and the scheduling and conduct of public meetings; coordination and scheduling for the completion of all work items; document distribution; management of the budget; and ensuring appropriate coordination among the parties to this MOU.

2. Release of NEPA documents, i.e., Draft EIS (DEIS), Final EIS (FEIS) and ROD.

3. Provide a framework for collaboration and manage that collaboration among the Cooperating Agencies to ensure timely compliance with and completion of the NEPA process.

4. Provide leadership to ensure consistent cooperation, the timely issuance of concurrence, and continuing coordination to achieve a complete and justifiable EIS/OEIS.

5. Maintain a list and ensure coordination among lead points of contact (POCs) within each Cooperating Agency.

6. After coordination with Cooperating Agencies, maintain Lead Agency responsibility for all regulatory consultations.

7. Provide regular EIS/OEIS progress updates to Cooperating Agencies and inform them of significant developments affecting the proposed action at the earliest possible opportunity.

8. Coordinate the overall design of the administrative record (AR) and organize, prepare, and maintain the AR for the CJMT EIS/OEIS.

9. Ensure Cooperating Agencies have reasonable opportunities to review and comment on EIS/OEIS versions, and provide updates on the EIS/OEIS and time estimates of document availability for review.

10. Receive all comments resulting from either agency or public review and comment periods. Coordinate with the Cooperating Agencies and request assistance, as needed, on those comments that concern their respective agencies' areas of expertise and jurisdictional responsibilities.

B. Cooperating Agency USACE:

1. Provide a lead POC authorized to expend the level of effort necessary to support the USACE role in the CJMT EIS/OEIS effort.

2. Ensure timely review of all NEPA documents; provide timely comments, consistent cooperation, concurrence, and continuing coordination to achieve a complete and justifiable EIS/OEIS.

3. Assume responsibility, upon request, for developing information and preparing environmental analyses, including portions of the EIS/OEIS for which the Cooperating Agency has special expertise.

4. Make available staff, at the lead agency's request, to support and enhance MARFORPAC's interdisciplinary capability.

5. Adhere to the overall schedule as set forth by MARFORPAC.

6. Inform the EA for the CJMT EIS/OEIS on any NEPA projects or other projects the Cooperating Agency is conducting, has recently completed, or plans to conduct in the USPACOM AOR.

IV. Effective Date: This MOU is effective on the last date of signature below.

V. Effect of Agreement: Nothing in this MOU will be construed as affecting the authority of any signatory beyond the understanding contained within this MOU. This MOU in no way restricts any of the signatories from participating in similar activities with other agencies and organizations.

This MOU shall be referenced in the Draft and Final EIS for public review so that each signatory's respective roles may be understood.

VI. Review/Changes: Signatories (or their successors) will review this MOU annually. Any signatory may request modification and amendment of this MOU at any time. Both signatories will consider the proposed changes, and upon mutual agreement, adopt the modifications by amendment to this MOU. The signatory proposing the changes shall provide copies of the modified MOU to MARFORPAC or USACE for signature approval. The effective date of an amendment is the date on which MARFORPAC and USACE have signed the amended MOU.

VII. Term: This MOU will remain in effect for the time period beginning with the effective date of the MOU and ending with issuance of the CJMT EIS/OEIS ROD. MARFORPAC or USACE may terminate its participation in this MOU at any time before the date of expiration, with 30 days written notice to the other parties.

VIII. Statement of No Financial Obligation: This MOU cannot be cited as the basis for any reimbursement of costs incurred by a signatory to collaborate throughout the EIS development process. Nothing in this MOU will be construed as affecting the authorities of the signatories to act as provided by statute or regulation, or as binding signatories beyond their respective authorities or to require the signatories to obligate or expend funds in excess of appropriations. All funding mechanisms related to the CJMT EIS/OEIS shall be executed separately.

IX. Dispute Resolution: A dispute shall be deemed to have arisen when MARFORPAC or USACE notifies the other in writing of a dispute. The issues shall be clearly identified in a memorandum. The lead POCs shall work together to resolve disputes. It is the intention of the lead POCs that all disputes shall be resolved expeditiously at the lowest possible level of authority. In the event a dispute is not resolved within fifteen (15) calendar days, the dispute will be elevated for resolution as follows:

A. The lead MARFORPAC or USACE POC shall elevate an unresolved dispute within their respective chain-of-command. A formal communication describing the issue will be provided to senior leadership. The senior leadership of the signatory making the formal complaint shall convene a meeting to resolve the dispute within 30 calendar days after issuing the formal communication to the other signatory senior leadership.

B. If signatory senior leadership is unable to resolve the dispute, the issue will be referred to the Deputy Commander, USPACOM, whose decision will be final.

X. Signatures

In witness whereof, the parties to this MOU through their duly authorized representatives for MARFORPAC and USACE have executed this MOU, and certify that they understand and agree to support the purpose and provisions of this MOU, as set forth herein.

William Febuary
Deputy Director
U.S. Marine Corps Forces, Pacific

George Young
Chief of Regulatory Branch, Honolulu
U.S. Army Corps of Engineers

X. Signatures

In witness whereof, the parties to this MOU through their duly authorized representatives for MARFORPAC and USACE have executed this MOU, and certify that they understand and agree to support the purpose and provisions of this MOU, as set forth herein.

William Febuary
Deputy Director
U.S. Marine Corps Forces, Pacific

Ryan Winn
U.S. Army Corps of Engineers

APPENDIX B
2015 DRAFT EIS/OEIS COMMENT SUMMARY

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APPENDIX B

2015 Commonwealth of the Northern Mariana Islands Joint Military Training Draft Environmental Impact Statement/Overseas Environmental Impact Statement Comment Summary

On March 14, 2013, the Department of the Navy (DON) published a Notice of Intent to prepare an Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) for the construction and operation of training ranges on Tinian and Pagan in the Federal Register (FR) (78 FR 16257). The Notice of Intent announced a 45-day public scoping period; the dates, times, and locations for public scoping meetings; and the various methods available for submitting comments on the Proposed Action. In addition, the Notice of Intent stated the public scoping process would be used to satisfy National Historic Preservation Act (NHPA) Section 106 public engagement requirements in accordance with 36 C.F.R. section 800.8(c). The public scoping period was extended an additional 14 days on April 23, 2013 (78 FR 23920) and ended on May 12, 2013. Three public scoping meetings were held in the Commonwealth of the Northern Mariana Islands (CNMI) on April 10–12, 2013.

Collectively, the scoping comment submittals from government agencies, elected officials, business and commercial entities, interest groups, and individual citizens included 1,363 comments on 24 different topics. The six topics that received the most comments were the proposed use of Tinian and Pagan for military training, socioeconomics, land use, indirect/cumulative impacts, environmental justice, and biological effects. Commenters also questioned the need for live-fire training given the availability of computer simulation and existing training ranges on Farallon de Medinilla, Guam, and Hawaii.

On April 6, 2015, the DON published a Notice of Availability for the Draft EIS/OEIS in the Federal Register (80 FR 18385). The Notice of Availability announced a 60-day public review and comment period and identified locations where the Draft EIS/OEIS could be reviewed; the dates, times, and locations for public meetings; and indicated the National Environmental Policy Act (NEPA) process, including the Draft EIS/OEIS public meetings, would also satisfy NHPA Section 106 requirements. Advertisements containing similar information concerning the availability of the Draft EIS/OEIS were also placed in local newspapers. With three announced extensions, the public comment period lasted approximately six months, from April 6 through October 1, 2015. Three public meetings were held, two on Saipan and one on Tinian.

During the Draft EIS/OEIS public comment period, 28,527 comments were received. Commenters included the CNMI and federal government agencies, elected officials, business and commercial entities, interest groups, and individual citizens. Of the total number of comments received, 2,748 comments were unique, with the remaining comments consisting of petition signatures and form letters. The Proposed Action analyzed in the 2015 Draft EIS/OEIS included 14 live-fire ranges, an airfield, amphibious landings, permanent housing, and a High Hazard Impact Area on Tinian, as well as combined arms training with aerial and ship bombardment with a High Hazard Impact Area on the island of Pagan. The comments received on the 2015 Draft EIS/OEIS were critical of the Proposed Action.

After the Draft EIS release in 2015, CNMI Governors Inos and Torres requested a Section 902 consultation with the United States (U.S.) Government, with the CNMI Joint Military Training (CJMT) EIS being one of the topics of concern. The *Covenant to Establish a Commonwealth of the Northern Mariana Islands in Political Union with the United States of America* (The Covenant) (Public Law 94-241) governs relations between the U.S. and the CNMI. Section 902 of the Covenant indicates that the Governments of the U.S. and the CNMI "will designate special representatives to meet and consider in good faith such issues affecting the relationship between the Northern Mariana Islands and the United States as may be designated by either Government and to make a report and recommendations with respect thereto." These discussions are known as 902 Consultations. The latest 902 Consultation Report was produced in 2017 (U.S. 2017) and contains the following commitments:

- Both within and apart from the NEPA process, Department of Defense (DoD) will redouble its efforts to be transparent and consult with the CNMI political leadership on all issues of concern. DoD will strive to meet that commitment with engagements through the NEPA process and through separate engagements outside the NEPA process by Joint Region Marianas and U.S. Pacific Command. In addition, DoD will work with the CNMI to establish a consultative structure shortly after conclusion of the 902 Consultations. This consultative structure would be apart from the Section 902 process and provide another avenue and regular forum to address issues of mutual interest or concern.
- DoD agrees to share the new CJMT alternatives with CNMI leaders prior to publishing the Revised Draft EIS; these revised alternatives will seek to respond to public (including the CNMI) concerns while meeting DoD's joint training requirements.

The CNMI Government agreed to continue discussions on the proposed CJMT action in 2019. Engagements included a Live-fire Demonstration in Hawaii (October 2019), a site visit to Tinian (November 2019), and a discussion of "Current Thinking" (January 2020). However, the COVID-19 pandemic interrupted subsequent discussions, as a result of required government responses and health management actions. In December 2020, U.S. Indo-Pacific Command and CNMI agreed to resume discussion in January 2021 with a "Reconnect" meeting with staff officers.

At the CNMI's request, from June to December 2016, the U.S. and CNMI governments held a series of virtual and in-person discussions pursuant to Section 902 of the 1976 Covenant (Section 902 Consultations). These discussions included, among other issues, concerns with the USMC expansive training proposal. Later, at the request of the CNMI governor, the USMC paused activity on CJMT to allow the CNMI to focus resources on the U.S. Air Force Divert proposal. During the global COVID-19 pandemic, the parties held small-group virtual meetings. The USMC re-engaged with the CNMI government on CJMT with an in-person meeting in January 2020, virtual meetings in January 2021 and June 2021, and in-person meetings in July 2021, March 2022, August 2022, March 2023, June 2023, September 2023, and December 2023 to discuss changes to the Proposed Action and the Revised Draft EIS. The USMC also held public information sharing meetings in August 2023 to share the revised training proposal with the public.

In response to the comments and input from the public, Table B-1 summarizes the 2015 comments and provides responses for how USMC made changes to the Proposed Action and environmental analysis.

Table B-1 Sumary of Representative Comments Submitted on the 2015 Draft EIS/OEIS

Issue	*Comment Summary*	*How Comments Were Addressed*
Proposed Action and Alternatives	Commenters requested that additional alternatives outside the CNMI be considered and expressed the opinion the alternatives evaluated were too similar.	USMC re-evaluated the alternatives including considering locations outside of CNMI. However, alternative locations do not meet the purpose and need. USMC made significant changes to the Proposed Action including: • Removal of all training on Pagan. • Live-fire ranges reduced from 14 to 2 (multi-purpose maneuver and explosives training). • All fixed-wing aviation delivered ordnance on Tinian was removed and replaced by simulated close air support for fixed-wing aviation only (i.e., aviators talking with ground units). • Ordnance from helicopters was removed. • Field Carrier Landing Practice was removed to reduce impacts to airport infrastructure, aviation traffic, and aircraft-generated noise on Tinian. • Proposed expeditionary aviation training would be focused around the North Field "Baker runway." • A forward arming and refueling point that would include expeditionary airfield development, sustainment, and airfield defense would be sited at Baker runway in accordance with National Park Service directives and the requirements of NHPA Section 110. • Tanks and tank trails were removed. • Additional Tactical Amphibious Landing Training was removed. • No Military Training areas were designated around wetlands and natural resources. • U.S. Agency for Global Media Communications (formerly International Broadcast Bureau) would not be relocated.
Geology and Soils	Commenters inquired about potential damage to coastal processes and beaches, potential impacts to prime farmland soils, and requested a description of how federal regulations would be applied to activities on Tinian and Pagan. Commenters also requested that baseline soil contamination data for sites on Pagan be collected for future comparison.	USMC re-evaluated the 2015 approach and eliminated additional in-water training and the beach ramp. USMC updated potential impacts to geology and soils, including farmland, related to the reduced Proposed Action footprint.
Water Resources	Commenters asked for additional details and data regarding potential impacts to groundwater, surface waters, wetlands and	USMC re-evaluated the Proposed Action to reduce impacts and site ranges away from sensitive resources. USMC eliminated

Issue	*Comment Summary*	*How Comments Were Addressed*
	watershed processes resulting from munitions constituents, potential contamination from spills of hazardous materials, impacts to limestone formation, increased potable water demand, etc. Other areas of concern included aquifer capacity, potable water sourcing options, and water rights. Additionally, commenters asked about the effectiveness of the Range Environmental Vulnerability Assessment (REVA) program and requested more baseline data generation and analysis for sites on Pagan and more detailed descriptions of Best Management Practices.	training on Pagan and reduced live-fire ranges from 14 to 2. Ranges were sited in the Exclusive Military Use Area (EMUA) and away from wetlands. The Revised Draft EIS provides a more detailed analysis and development of site-specific management practices for groundwater to ensure that groundwater is managed in accordance with CNMI regulations and coordinated with the Bureau of Environmental and Coastal Quality. In response to public concerns and to evaluate the behavior of munitions constituents in the Tinian environment, USMC utilized SEVIEW© software, which contains a combination of models (SESOIL and ATD123D) to simulate the fate of munitions constituents that are present in both soil and groundwater. The results of the modeling over a 100-year timeframe found that munitions constituents did not infiltrate to groundwater for each of the pathways modeled.
Air Quality	Commenters requested additional detail regarding significance determinations, compliance with national air quality standards, quantification of live-fire operations and airborne chemicals, monitoring plans, adaptive management, and climate change considerations.	USMC significantly reduced proposed operations and development in the revised action. The Revised Draft EIS re-evaluates the potential air quality impacts related to the reduced Proposed Action footprint and would include an assessment of mobile sources or permitted stationary sources.
Noise	Commenters were concerned with increased noise, significance thresholds, and potential impacts to daily life. They also asked whether Federal Aviation Administration's Part 150 funds would be available to soundproof affected homes and public resources.	USMC significantly reduced proposed air operations in the revised action and sited live-fire ranges in the EMUA away from the public to reduce noise impacts. The Revised Draft EIS re-evaluates the potential noise impacts related to the reduced Proposed Action footprint and would include any new aircraft.
Land Use	Commenters requested greater consistency in land use designations, inquired regarding military acquisition of lands and access to military acquired lands, and expressed concerns about the availability and application of remediation funds after the lease period.	In response to these community concerns, the USMC revised their training approach, moving from an exclusionary approach where the training areas would be gated and fenced, to a shared use model that seeks to allow the greatest possible civilian access to the Military Lease Area. USMC does not plan to acquire additional lands. USMC also created eight subdivided training areas and would establish Range Control to coordinate training with public access. Range control maintains the training schedule and would work with the community on scheduling and access planning, specifically to avoid training on days that are important to the community, such as traditional fiestas. USMC is working to prioritize public access to cultural and recreational

Issue	Comment Summary	How Comments Were Addressed
		sites, and would limit access only when required for public health and safety or to comply with DoD safety requirements. Access to agricultural uses would be available 24/7. Live-fire ranges would be for military use only.
Recreation	Commenters requested additional information regarding access to recreational resources, compatibility of training with holidays and festivals, maintenance of recreational areas, and a system for monitoring and tracking visitor data. Commenters expressed concerns about the accuracy of baseline data relating to recreational sites and the potential degradation of offsite recreational areas and requested coordination between military and tour operators to maintain existing recreational resources in acknowledgement of increased demand.	The plan for eight subdivided training areas and Range Control to coordinate training with public access would be implemented as part of the revised Proposed Action. USMC would work to prioritize public access to recreational sites and would limit access only when required for public health and safety or to comply with DoD safety requirements.
Terrestrial Biology	Commenters expressed concerns about habitat loss, effects of munitions constituents on bird species, endangered species, invasive species, biosecurity, habitat protection, International Broadcast Bureau relocation, and unexploded ordnance (UXO) removal and questioned the adequacy of proposed avoidance and mitigation measures.	The new Proposed Action greatly reduces the area of habitat and terrestrial biological impacts. USMC proposes expeditionary airfield and a Base Camp with a greatly reduced footprint. The Revised Draft EIS includes an updated terrestrial biological survey and updated analysis of potential impacts from training and construction.
Marine Biology	Commenters expressed concerns about the effects of amphibious landings, invasive species, biosecurity, sedimentation effects, and munitions constituents. They also questioned the analysis of potential impacts to coral reefs, Special Status Species, marine mammals, sea turtles, intertidal habitat, and Essential Fish Habitat; measures to avoid or mitigate impacts; and analysis of data used for impact determinations.	In response to these community concerns, the USMC revised their training approach to eliminate additional in-water training and beach landings. Only those previously approved training events would take place. The revised Proposed Action is limited to land-based training and greatly reduces the footprint from the prior proposed training approach.
Cultural Resources	Commenters requested more information regarding the preservation of cultural resources, avoidance measures, and potential impacts to the National Historic Landmark at North Field. They also expressed concern about vibration effects to cultural sites, mitigation of construction impacts, and consistency with existing programmatic agreements.	In response to these community concerns, the USMC revised their training approach, moving from a heavily developed approach to an austere approach with a greatly reduced footprint. USMC actively sited the ranges, Landing Zones, Base Camp, and communication towers to avoid impacts to cultural resources. In addition, Range Control would work with the community on scheduling and access planning, specifically to avoid training on days that are important to the community. USMC is working to prioritize public access to cultural resources and would limit access only when required for public health and safety or to comply with DoD safety requirements. USMC would also assess impacts to historic properties from training events and the Proposed Action footprint.

Issue	*Comment Summary*	*How Comments Were Addressed*
Visual Resources	Commenters requested the EIS/OEIS account for a larger definition of visual resources (e.g., 360-degree view), and consider potential impacts to vegetation at landing beaches, potential visual impacts from fences/gates, and potential wildfires from live-fire training exercises.	USMCs proposed action was changed from heavy development with many fences to an expeditionary and austere approach with less structures that are sited as far from beaches and the public as possible. USMC prepared new visual simulations from key observation points to show potential impacts on the visual environment.
Transportation	Commenters expressed concerns about the compatibility between military airspace and commercial and civilian airport use, and whether the restriction of airspace and creation of SUA would impact commercial access during inclement weather. They also requested more information about the proposed ground transportation routes, the closure of Tinian Sea space, and potential impacts to commercial and recreational watercraft, potential future ferry service, port capacity, the condition of infrastructure, and joint use of project port facilities. Commenters also requested additional information regarding the storage and disposal of hazardous materials.	Roads inside the Military Lease Area within the current Lease Back Area are proposed to be leased from CNMI. The Federal Aviation Administration would advise the USMC whether there is a need to establish a controlled firing area airspace designation over either or both proposed ranges. In addition, USMC would utilize spotters to observe when a non-participating vehicle or persons approach the surface danger zone or an aircraft in the airspace. All training operations would cease until the non-participant is safely out of the area.
Utilities	Commenters questioned solid waste compliance, demand on the Commonwealth Utilities Corporation system, potable water quality, wastewater treatment level, management of wastewater from vehicle wash-down at the port and from portable toilets, and stormwater management at the port to protect nearshore resources.	The USMC reduced Proposed Action would have much less of an impact on utilities. USMC updated utility studies taking into consideration the current demand and potential demand of the reduced Proposed Action. Studies include electrical, potable water, wastewater, stormwater, and solid and hazardous waste.
Socioeconomics	Commenters requested additional information regarding potential impacts to the economy, tourism, fishing, ranching, subsistence living, traditional cultural practices, community character, and Pagan resettlement. They expressed concern about increased use of ports and wharf facilities, and the housing for construction personnel.	USMC revised analysis of socioeconomic impacts in a collaborative manner with CNMI. Specifically, USMC has shared and collaborated with CNMI on the revised training concepts, changes to the alternatives, and the basic economic analysis and framework.
Public Health and Safety	Commenters requested more information regarding public health and safety, including transportation of hazardous materials, munitions constituents, unexploded ordnance, and site remediation and restoration.	In response to public concerns, the USMC reduced the Proposed Action eliminating many of the ranges and greatly reducing the footprint. USMC environmental management of compliance and pollution prevention measures serve to protect public health and maintain or improve the environmental quality of training areas and adjacent communities. These standard operating policies and procedures apply to all USMC training and include: • REVA. • Annual Inspections.

Issue	*Comment Summary*	*How Comments Were Addressed*
Environmental Justice	Commenters questioned the environmental justice analysis methodology and suggested that impacts be considered disproportionate, in the context of the ethnic minority population and the low-income status of residents in comparison to the U.S.	USMC re-evaluated the environmental justice population and potential impacts related to the reduced Proposed Action footprint.
Cumulative Effects	Commenters questioned the cumulative impacts methodology, analysis, and mitigation.	USMC re-evaluated cumulative impacts considering the current and future project on Tinian combined with impacts from the reduced Proposed Action footprint.

Legend: CNMI = Commonwealth of the Northern Mariana Islands; DoD = Department of Defense; EIS/OEIS = Environmental Impact Statement/Overseas Impact Statement; NHPA = National Historic Preservation Act; U.S. = United States; USMC = United States Marine Corps; UXO = Unexploded Ordnance

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APPENDIX C
TRAINING AND CONSTRUCTION ASSUMPTIONS

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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APPENDIX C

C.1 TRAINING AND WEAPONRY/EQUIPMENT DESCRIPTIONS

C.1.1 Training Structure and Tempo

This section presents general training groups and training requirements across the United States (U.S.) Armed Services for training on Tinian, which would involve ground combat and certain expeditionary aviation training.

Currently approved training on Tinian is supported and scheduled by Joint Region Marianas. The Commanding Officer of Camp Blaz provides base support functions on behalf of Joint Region Marianas.

As summarized in Chapter 2 of the Revised Draft EIS, training events are proposed to occur year-round on Tinian, as scheduled and managed by Range Control operations located within the Base Camp. For this analysis, training is divided into small, medium, and large training events. Small training events could occur throughout the year, while medium and large training events would occur less frequently, approximately 2-4 times per year as shown in Table C.1-1. The size of the units participating in an event would vary based on the type of training and events may overlap or occur simultaneously, with up to 1,000 service members participating in training at one time on Tinian under the Proposed Action.

Table C.1-1 Training Event Size Categories

Size of Training Events	*Approximate Number of Personnel*	*Approximate Training Duration[1]*	*Approximate Training Frequency[2]*
Small	Up to 100 personnel	1-2 weeks	Routinely occurring throughout the year
Medium	Up to 250 personnel	1-2 weeks	Once per quarter
Large	Up to 1,000 personnel	2-4 weeks	2-4 times per year

Notes: [1] Includes time before and after training events for logistics (e.g. setup, and turnover activities).
[2] Small, medium, and large training events could overlap but the number of personnel on island for training at one time would be up to 1,000.

Table C.1-2 provides the estimated peak population for the Proposed Action.

Table C.1-2. Estimated Peak Population Increase on Tinian from Proposed Action

	2026	*2027*	*2028*	*2029*	*2030*	*2031*	*2032*	*2033*	*2034*	*2035*	*2036*	*2037*
Direct Population[1]												
Within Military Lease Area												
Land-based Training – CJMT[2]	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Land-based Training – MITT[3]	0	0	0	0	0	0	0	0	0	0	0	0
Land-based training – Divert[4]	0	0	0	0	0	0	0	0	0	0	0	0
Outside of Military Lease Area												
Off-island workers for CJMT Range Management[5]	5-10	5-10	10-20	10-20	20	20	20	20	20	20	20	20
Off-island workers for CJMT construction[6]	40	40	40	40	40	40	40	40	40	40	40	40
Indirect and Induced Population[7]												
Outside of Military Lease Area												
Dependents: CJMT Range Management	0	0	0	0	0	0	0	0	0	0	0	0
Dependents: CJMT construction	0	0	0	0	0	0	0	0	0	0	0	0
Total Population Increase[8]												
Direct, indirect, and induced, within and outside of the Military Lease Area	**1,060**	**1,060**	**1,070**	**1,070**	**1,070**	**1,070**	**1,070**	**1,070**	**1,070**	**1,070**	**1,070**	**1,070**

Legend: CJMT = Commonwealth of the Northern Mariana Islands Joint Military Training; DoD = Department of Defense; EIS/OEIS = Environmental Impact Statement/Overseas Environmental Impact Statement; MIRC = Mariana Islands Range Complex; MITT = Mariana Islands Training and Testing; USMC = U.S. Marine Corps.

Notes: [1] Direct population includes military personnel participating in training, DoD civilian workers and contractors, and construction workers.

[2] Training population would fluctuate throughout the year, with up to 1,000 people training within the Military Lease Area at one time. Includes land-based ground and aviation training activities on Tinian that may occur as part of other training events occurring simultaneously or concurrently in the MITT Study Area, which includes the MIRC.

[3] Other approved training in-water and at on-land at locations other than Tinian (e.g., Guam, Saipan, Rota) would continue to occur as described in the 2020 MITT Supplemental EIS/OEIS and 2015 MITT EIS/OEIS. Land-based (ground and aviation) training that would occur on Tinian when scheduled as part of larger events within the MITT Study Area are reflected in the CJMT Land-based Training row.

[4] The 2016 EIS for Divert Activities and Exercises (refer to page ES-7) states that Divert-related military training activities and exercises were analyzed in the 2010 MIRC EIS/OEIS and the 2015 MITT EIS/OEIS, and are thus reflected in the CJMT Ground-based Training row.

[5] A total of approximately 30-50 government employees and contractors would be needed to support Range Control operations and management. The USMC intends to hire locally for these positions, wherever possible, based on labor availability and contracting requirements. Numbers above assume approximately 30 people formerly employed by the U.S. Agency for Global Media that ceased operations in August 2024 would provide an available local hiring pool. Hiring would be phased over the 10 to 15 year construction period as construction is completed and the training infrastructure becomes operational (i.e., expeditionary Base Camp and associated utilities, live-fire ranges, and Landing Zones). Initially, positions may be filled on a rotating basis (e.g., temporary duty assignment) from Marine Corps Base Camp Blaz Range Control staff or other federal civilians.

[6] Construction projects would be phased and individual projects may not take an entire year to construct. Thus, the number of construction workers would fluctuate throughout the year but conservatively reflects the maximum number per year, assuming at least 20 percent of workers would be able to be hired locally. The construction workforce may be supplemented or offset by using military labor, when appropriate.

[7] Population figures do not include Tinian residents who obtain employment as a result of the Proposed Action. Due to the phased nature of construction projects and the use of rotating assignments from Marine Corps Base Camp Blaz to support Range Control, the USMC does not anticipate Range Control personnel would need to relocate their families/dependents to Tinian. This is also the same assumption for construction workers (including construction managers), based on the U.S. Air Force's Divert construction workforce experiences (construction anticipated to be complete by late 2025-2026). The implementation of CJMT training and the operation of the Base Camp are not anticipated to induce additional local employment (in addition to any induced employment that may have already occurred in order to support increased activity related to Divert construction and U.S. Air Force activities to rehabilitate North Field).

[8] Population increases shown are not additive from year to year. They represent the aggregate project-related indirect and direct increases as of any given year relative to the population before project implementation, and not an annual increase.

Alternative 1 and Alternative 2 would both represent an increase in training tempo over current levels in previously approved NEPA documents (DON 2010, 2015; U.S. Air Force 2016, 2020). The training tempo in this Revised Draft EIS refers to the total amount of approved activities that could occur over an entire year. Alternative 1 would represent an approximate 15 percent increase over existing approved training (No Action Alternative) and Alternative 2 would represent an approximate 5 percent increase over existing approved training.

Table C.1-3 lists training activities that typically occur on Tinian and the proposed increases by activity. The increases to activities under Alternative 1 reflect proposed levels that provide capacity for current and planned training and testing requirements, with Alternative 2 providing a reduced tempo of training activities that still meets training requirements and strategic necessity. Each small, medium, or large training event scheduled through Range Control would be composed of one or more of the activities shown in Table C.1-3. Although the increases shown by each activity varies (some remain the same across each alternative while some increase under Alternative 1 and Alternative 2 and some only under Alternative 2), the general increase in tempo accounts for the entirety of activities in one year of training.

Table C.1-3 Comparison of Proposed Level of Training on Tinian under All Alternatives

Training Activities	*Description*	*No. of Approved Activities Per Year*		
		No Action Alternative	*Alternative 1*	*Alternative 2*
Expanded Expeditionary Airfield Operations at North Field	Expeditionary airfield operation training exercises are designed to enhance rapid deployment and air combat capability in austere environments. These operations establish and utilize an airfield to support rotary- and fixed-wing aircraft in forward-deployed locations.	12	32	16
Assault	An amphibious assault is a coordinated military operation where forces move from ships at sea to conduct an attack on a land-based objective. This type of operation is designed to secure a landing site, allowing follow-on forces to move inland and achieve strategic objectives. The land-based portion that would be covered under this Revised Draft EIS includes activities such as troop landings, vehicle deployment, maneuver operations, and securing objectives onshore. The at-sea portion of amphibious assault training falls under the MITT EIS/OEISs, and may include naval operations, ship-to-shore movements, and maritime support.	6	20	10
Raid	A raid training exercise is a military operation designed to train forces in executing rapid, small-scale, and precision attacks on a land-based objective before withdrawing to the sea. Unlike a full-scale amphibious assault, a raid focuses on speed, surprise, and minimal engagement duration to achieve objectives such as intelligence gathering, infrastructure disruption, or enemy force neutralization. Small unit forces move swiftly for a specific short-term mission. These are quick operations with raids sized to the mission requirement and no larger. This activity may employ small unit non-live-fire operations. The land-based portion that would be covered under this Revised Draft EIS includes troop insertion, target engagement, and coordinated withdrawal. The at-sea portions of raid training would fall under the MITT EIS/OEISs and may include naval operations, ship-to-shore movements, and maritime support elements.	6	16	8
Anti-Terrorism/Force Protection	An Anti-Terrorism/Force Protection training event is designed to enhance the ability of military personnel to detect, deter, and respond to potential threats, ensuring the security of personnel, facilities, and assets. This training prepares forces to handle asymmetrical threats, including terrorist attacks, unauthorized intrusions, and security breaches. The land-based portion would be covered under this Revised Draft EIS and includes perimeter defense, access control procedures, active threat response, and security patrols. Training may involve simulated attacks, surveillance detection, and defensive tactics to enhance force readiness. The at-sea portions of this training would fall under the MITT EIS/OEISs, and may include maritime security operations, vessel defense drills, and threat response scenarios at sea.	80/75[1]	100/90[1]	80/75[1]

Training Activities	*Description*	*No. of Approved Activities Per Year*		
		No Action Alternative	*Alternative 1*	*Alternative 2*
Combat Search and Rescue	A Combat Search and Rescue training event prepares military forces to locate, recover, and provide medical assistance to isolated or downed personnel in hostile environments. The land-based portion would be covered under this Revised Draft EIS and includes insertion and extraction of recovery teams, tactical evasion techniques, simulated medical treatment, and engagement with potential threats. The at-sea portions of this training would fall under the MITT EIS/OEISs and may include overwater search operations, helicopter hoist rescues, and maritime extraction procedures.	80	80	80
Direct Action (Combat Close Quarters and Breaching)	A Direct Action training event focuses on combat close quarters and breaching involves high-intensity operations designed to neutralize threats in confined spaces and penetrate fortified structures. The land-based portion would be covered under this Revised Draft EIS and includes close-quarters combat drills, breaching techniques, room-clearing operations, and small-unit coordination. The at-sea portions of this training would fall under the MITT EIS/OEISs and may include naval operations and tactical exercises such as shipboard breach scenarios or maritime infiltration.	72/72	72/72	72/72
Embassy Reinforcement	An Embassy Reinforcement training event involves military personnel practicing the procedures for securing and defending a U.S. embassy in the event of a security threat or crisis. The land-based portion would be covered under this Revised Draft EIS and includes securing embassy perimeters, defending critical infrastructure, and coordinating evacuation operations. The at-sea portions of this training would fall under the MITT EIS/OEISs and may include naval operations related to transportation and rapid deployment of security forces to the embassy location, including possible evacuation routes or maritime defense measures.	50	70	50
Field Training Exercise	A Field Training Exercise is a comprehensive, hands-on training event that simulates real-world military operations in an outdoor environment. The exercise includes ground-based tactical drills, movement exercises, logistics operations, field combat scenarios, and force protection drills. Units may engage in terrain navigation, command and control operations, and emergency medical response training.	116	160	116

Training Activities	*Description*	*No. of Approved Activities Per Year*		
		No Action Alternative	*Alternative 1*	*Alternative 2*
Humanitarian Assistance/ Disaster Relief Operations	Humanitarian Assistance/Disaster Relief operations are designed to provide immediate aid and support in the aftermath of natural or man-made disasters, focusing on the rapid delivery of essential supplies, medical care, and infrastructure repair to affected populations. These operations may include search and rescue missions, medical assistance, food and water distribution, and the restoration of critical infrastructure such as roads and utilities. The land-based portion would be covered under this Revised Draft EIS and includes establishing emergency response zones, setting up field hospitals, medical triage, and logistical hubs, and coordinating the delivery of supplies and restoration of essential services. The at-sea portions of this training would fall under the MITT EIS/OEISs and may include naval deployment and the use of amphibious assault ships, aircraft carriers, and transport ships to deliver aid and provide support.	5	10	5
Intelligence, Surveillance, and Reconnaissance	Intelligence, Surveillance, and Reconnaissance operations are designed to gather critical information to support military decision-making and operational effectiveness. These operations involve the collection of intelligence through aerial, ground, and maritime assets, enabling real-time surveillance and reconnaissance of enemy forces, terrain, and infrastructure. The land-based portion would be covered under this Revised Draft EIS and includes ground-based reconnaissance, signal interception, visual and thermal imagery, and the deployment of various platforms such as drones, manned aircraft, and sensors. The at-sea portions of this training would fall under the MITT EIS/OEISs and may include naval surveillance, maritime reconnaissance missions, and the use of unmanned aerial systems, satellite imagery, and radar systems for intelligence collection.	44	50	44
Land Demolitions (UXO, IED Discovery/Disposal)	Land demolitions training is designed to prepare military personnel for safely identifying and neutralizing explosive threats in the field, focusing on the discovery and disposal of unexploded ordnance and improvised explosive devices.	120	160	120

Training Activities	***Description***	***No. of Approved Activities Per Year***		
		No Action Alternative	***Alternative 1***	***Alternative 2***
Marine Air Ground Task Force Exercise – Battalion	A Marine Air Ground Task Force Battalion Exercise is a large-scale training event that involves integrating various elements of the Marine Corps, including ground combat units, aviation assets, and logistics support, to conduct coordinated military operations. The exercise typically lasts 10 days and simulates real-world combat scenarios where units work together to perform missions such as offensive operations, defense, and force projection. The land-based portion would be covered under this Revised Draft EIS and includes ground maneuver operations, live-fire exercises, command and control coordination, and combat support and logistics operations. The at-sea portions of this training would fall under the MITT EIS/OEISs and may include naval support for aviation and ground operations, including amphibious landings and maritime combat training.	4	12	8
Non-combatant Evacuation Operations	Non-combatant Evacuation Operations are designed to facilitate the safe evacuation of civilians—including U.S. citizens, foreign nationals, and diplomatic personnel—from areas experiencing conflict, natural disasters, or instability. The land-based portion that would be covered under this Revised Draft EIS includes security operations at evacuation points, transportation coordination, escort missions, and managing evacuation logistics to ensure the orderly movement of civilians. The at-sea portions of this training would fall under the MITT EIS/OEISs and may include maritime evacuation capabilities, such as the use of naval ships, helicopters, and landing craft to transport evacuees from shore to safe locations.	5	12	5
Parachute Insertion	Parachute operations involve training exercises designed to deploy personnel via aircraft into designated Landing Zones for tactical missions. The land-based portions, covered under this Revised Draft EIS, include drop zone preparation, parachute Landing Zone security, and ground recovery operations. The at-sea portions of parachute operations fall under the MITT EIS/OEISs, which may involve aircraft launch and retrieval for airborne personnel, and integration with naval support for logistical airlift and recovery operations.	64	64	64
Personnel Insertion/Extraction	Personnel insertion and extraction operations are training exercises focused on the rapid deployment and retrieval of personnel in challenging or hostile environments. The land-based portions, covered under this Revised Draft EIS, include ground-based insertion techniques, such as airborne drops, vehicle convoys, or helicopter landings. Extraction can also involve helicopter extractions and vehicles to retrieve personnel. The at-sea portions of these operations fall under the MITT EIS/OEISs, involving naval assets, such as landing craft, helicopters, and maritime support vessels, to insert and extract personnel in coastal or amphibious environments.	365	365	365

Training Activities	*Description*	*No. of Approved Activities Per Year*		
		No Action Alternative	*Alternative 1*	*Alternative 2*
Marine Expeditionary Unit Exercise[2]	Typically a 10-day at-sea and ashore exercise similar to the Marine Air Ground Task Force Battalion Exercise described above. A Marine Expeditionary Unit Exercise is a training event focused on enhancing the readiness and coordination of a self-contained, rapid-response Marine Corps unit capable of deploying to crisis areas worldwide. The Marine Expeditionary Unit consists of ground, air, and logistics components, and the exercise typically includes amphibious assaults, humanitarian missions, combat operations, and force protection in diverse environments. The land-based portion that would be covered under this Revised Draft EIS includes ground maneuver operations, combat training, medical response drills, and force protection exercises. The at-sea portions of this training would fall under the MITT EIS/OEISs and may include naval support and amphibious operations, such as ship-to-shore landings, helicopter insertions, and logistics supply operations. This may also involve naval reconnaissance and the use of aerial platforms to support intelligence collection.	2	6	4
Seize Airfield	A seize airfield exercise involves military personnel and assets conducting operations to capture and secure an airfield in a contested or hostile environment. The land-based portion covered under this Revised Draft EIS includes ground combat operations, including assault tactics, defensive perimeter establishment, and force protection after the airfield is secured. The at-sea portions of this training would fall under the MITT EIS/OEISs and may include naval assets to support amphibious landings and aerial operations that help establish air superiority and logistics support for the seizure operation.	12	40	26
UAS Operation (including Intelligence, Surveillance, and Reconnaissance, and Training and Certification)	UAS operations, including Intelligence, Surveillance, and Reconnaissance, and training and certification, involve the deployment of unmanned aircraft to perform surveillance, gather intelligence, and support military missions. The land-based portion that would be covered under this Revised Draft EIS includes target tracking, battlefield reconnaissance, and environmental monitoring. Training and certification exercises focus on launch, recovery, and operation of UAS platforms, and data collection, analysis, and reporting for intelligence purposes. The at-sea portions of this training would fall under the MITT EIS/OEISs and may include naval surveillance, reconnaissance, and combat support using unmanned aerial platforms such as drones or sensor-equipped aircraft.	100/951[3]	100/951[3]	100/951[3]

Training Activities	*Description*	*No. of Approved Activities Per Year*		
		No Action Alternative	*Alternative 1*	*Alternative 2*
Urban Warfare Training/Exercise	Urban warfare training/exercises are designed to prepare military forces for operations in dense, built-up environments, such as cities or towns, where they must contend with complex terrain, civilian populations, and diverse threats. This training focuses on tactics for close-quarters combat, building clearance, hostage rescue, and crowd control in urban settings. The land-based portion that would be covered under this Revised Draft EIS includes clearing of urban training sites, and simulated combat operations in buildings, streets, and other urban structures within the Military Lease Area. The at-sea portions of this training would fall under the MITT EIS/OEISs and may include amphibious landings or naval support operations to establish a foothold in urban areas near coastal zones, providing support for forces conducting urban operations.	36	80	60
Water Purification	Water purification operations are training exercises that prepare military forces to obtain and treat water in austere or combat environments where clean water is not readily available. These operations involve the use of portable or established water purification systems to convert contaminated or saline water into safe, drinkable water for military personnel and supporting operations. The land-based portion that would be covered under this Revised Draft EIS includes field water purification, where military personnel deploy mobile purification units or set up water filtration systems in training areas. The at-sea portions of this training would fall under the MITT EIS/OEISs and may include naval assets that use desalination units, reverse osmosis systems, and other technologies on ships or mobile platforms to produce potable water in maritime environments.	16	28	20
U.S. Air Force Divert Activities and Exercises				
Cargo and Tanker Exercises	Maximum of 720 operations (i.e., 360 take-offs and 360 landings). All operations take place within a maximum of 8 weeks per year of exercises at TNI.	720	720	720
Support Activities	Jet fuel is offloaded at a fuel offloading facility at the port. Fuel is transferred from the port to the airport via pipeline. Medical care is provided by military personnel on Tinian in non-life-threatening situations. Emergency medical care for military personnel occurs at Saipan Hospital under agreement.	N/A	N/A	N/A

Legend: EIS = Environmental Impact Statement; IED = Improvised Explosive Device;; N/A = Not Applicable; No. = Number; OEIS = Overseas Environmental Impact Statement; TNI = Francisco Manglona Borja / Tinian International Airport; U.S. = United States; UAS = Unmanned Aerial System; UXO = Unexploded Ordnance.

Notes: [1] Anti-Terrorism activities authorized for 80/year; Force Protection activities authorized for 75/year. Alternative 2 would authorize Anti-Terrorism activities for 100/year and Force Protection activities for 90/year.
[2] Special Purpose Marine Air Ground Task Force Exercise renamed Marine Expeditionary Unit Exercise.
[3] UAS ISR activities authorized for 100/year; UAS Aerial Training and Certification activities authorized for 951 /year.

C.1.2 Training on Tinian

Training on Tinian would be classified as either a non-live-fire or live-fire event. Non-live-fire events would include both ground and aviation training that could occur throughout the Military Lease Area. Live-fire events would only take place on either the Multi-Purpose Maneuver Range or the Explosives Training Range, in addition to the use of currently approved bullet traps in some existing structures on Tinian. Both live-fire and non-live-fire training events could be conducted continuously throughout the day and night.

In general, a degree of simultaneous use of the live-fire ranges or other training areas throughout the Military Lease Area, including aviation and ground training events at Landing Zones and North Field, could occur.

Activities and exercises performed during training events would differ in size, tempo, and complexity of training. For example, some small events could involve only a squad or platoon, last for only one to two days, and involve only a single training area and/or range. Medium events could also be limited to a single or few training areas and ranges but would typically last 1-2 weeks. Large exercises would typically encompass the entire Military Lease Area and use both live-fire ranges during the full 2-4 weeks. The following section provides a description for each size of event to illustrate what a representative day of training may include in terms of personnel, locations, and activities, including those that would result in the public being temporarily restricted from accessing certain portions of the Military Lease Area and the waterways north of the island.

C.1.3 Representative Training Descriptions

Small Event

A small exercise could consist of 30 personnel practicing various live-fire and non-live fire activities including land navigation, survival techniques, setting up communications equipment, or practicing offensive or defensive live fire drills and activities on either of the two live fire ranges. This event could last for four days and take place in a single training area (e.g., Training Area B2, refer to Figure 2.1-2 in Chapter 2 of the Revised Draft EIS). In a small non-live-fire scenario, there would be no hazards to the public based on the type and complexity of the training activities and access to the Military Lease Area would not be restricted. The public would have shared access to Training Area B2 while service members are traversing the land for training. As larger groups, up to 100 personnel, may be involved in small events, or multiple small events may be scheduled to overlap, training may occur in multiple training areas at the same time that may not be adjacent to one another. Small events could also occur at the Multi-Purpose Maneuver Range and Explosives Training Range that would require access restrictions corresponding to the surface danger zones when live-fire is occurring. An example for a medium event involving live-fire is included below.

Medium Event

A medium exercise could involve 200 personnel over two weeks practicing various live- and non-live-fire exercises with both ground and aviation elements. For example, the first week of training could involve aviation training, which could occur at North Field or at various Landing Zones throughout the Military Lease Area, using the Landing Zone(s) in Training Area B1 for helicopter training involving practicing landing/taking off and disembarking/boarding, and patrolling the airspace above the Military Lease Area. During the second week, the exercise could incorporate maneuver training on any number of ranges coupled with training on the live-fire ranges. Live-fire training could consist of daily events on the Multi-Purpose Maneuver Range located in Training Area D. A typical schedule could include:

- Rehearse in the morning from 8 a.m. to 10 a.m. (i.e., practice the movements and timing without firing weapons).
- Conduct live-fire training from 10 a.m. to 4 p.m.
- Debrief and review the day's exercise once it concludes at 4 p.m. and break to prepare for night training.
- Live-fire night training would occur from approximately 8 p.m. to 10 p.m.

Due to the types of activities that would occur in this example, the public would be restricted from accessing certain parts of the Military Lease Area while training is underway. During the first week, the public would be restricted from accessing Training Area B1. Range Control would provide advanced notice of helicopter training and would include details such as what areas are off limits to the public, what roads may be temporarily blocked with signage or sentries, etc. For the second week, in addition to range areas and roadway access limitations to Training Area D, when live-fire training is occurring on the Multi-Purpose Maneuver Range, the waterway within the surface danger zone would be closed to public access. For live-fire training, Range Control would provide advanced notice and would include a Notice to Mariners, published weekly by the U.S. Coast Guard, to identify when the surface danger zone would be active (for this example, from 10 a.m. to 4 p.m. and 8 p.m. to 10 p.m.). The size of the surface danger zone would correspond to the type of ammunition being used on the range for that training event, and multiple types of ammunition may be used during the day (refer to Figure 2.1-9 in Chapter 2 of the Revised Draft EIS). As an example, if 5.56 ammo would be used from 10 a.m. to 2 p.m., the smallest surface danger zone would be active during that time, and if 7.62 ammo would be used from 2 p.m. to 4 p.m. the middle-sized surface danger zone would be active during those hours. Range Control communications would provide this detail for each activity or exercise scheduled for the Multi-Purpose Maneuver Range.

Large Event

A large event, such as a force-on-force training exercise, could encompass all of the eight training areas and live-fire ranges for a duration of three weeks, involving 1,000 personnel distributed throughout the Military Lease Area. This type of exercise could involve two opposing forces, with one force trying to locate and capture the opposition where they are staged in different parts of the Military Lease Area, as might occur in a real life engagement, including the use of tactical vehicles and helicopters. During the exercise, Range Control at the Base Camp would monitor both forces using sensors supported by a transportable antenna system that allows for the tracking of personnel and vehicles across the Military Lease Area.

During the three weeks of training, while public access to the Military Lease Area would be more limited than for small and medium events, Range Control would schedule training to allow for public access when and where it can be safely achieved. The entire Military Lease Area would not be closed off for the duration of the exercise. As described above, Range Control would issue advance notifications to the public about areas where land and water access would be restricted based on the event's day-to-day schedule. For this example, if the first week of training included activities in six training areas (A1-A3 and B1-B3), but helicopter landings would only be occurring in Training Area A1 and A3, access restrictions would be in place to ensure the non-participants would remain a safe distance away from Landing Zone areas in Training Areas A1 and A3 but the public would have shared access to Training Areas A2, B1, B2, and B3. Service members may be visible to the public while traversing the land by foot or moving between areas on roadways or previously disturbed access paths using tactical vehicles while training is occurring.

C.1.4 Arrival of Participating Personnel, Vehicles, Supplies, and Equipment

Arrival and Departure of Personnel

Regardless of the size and type of the exercise, personnel participating in training events, along with their equipment, would arrive through one of three locations: (1) Francisco Manglona Borja / Tinian International Airport (TNI); (2) North Field; or (3) the Honorable Jose Pangelinan San Nicolas Commercial Port of Tinian (Port of Tinian). Units and assets requiring biosecurity inspection would be routed through the biosecurity station at each of these locations before transport to the Military Lease Area. All personnel would receive briefings for the exercise as part of the preparation prior to the start of training including information on the island's cultural resources, off limits or "no training" areas, and the boundaries of the training areas within the Military Lease Area.

At the conclusion of an exercise, the service members would retrograde back through Base Camp and the biosecurity facility to clean vehicles and equipment in preparation for movement off island. During this time, Tinian Range Control would inspect the Military Lease Area to ensure all trash, ordnance, and equipment has been removed from the training areas and live-fire ranges.

Use of Vehicles Within the Military Lease Area

Use of vehicles within the Military Lease Area would fall into two categories: administrative and tactical. Administrative activity would primarily occur at the beginning and end of an exercise and describes transporting personnel and equipment to set up the training (e.g. driving equipment up from Base Camp to the range to set up). Tactical activity would consist of exercise activity with military tactical vehicles as part of the exercise. During training, these tactical military vehicles (primarily Joint Light Tactical Vehicles and High Mobility Multipurpose Wheeled Vehicles, also called "humvees") would traverse established roadways throughout the Military Lease Area as part of the exercise.

C.1.5 Representative Equipment

Various types of equipment would be used during training events (Table C.1-4).

Table C.1-4 Representative Equipment

Aircraft* *(Rotary wing training at North Field and Landing Zones, Fixed-wing training at North Field, Fixed-wing cargo/personnel delivery at TNI)		***Vehicles* *(On Roads throughout the Military Lease Area)***
 Attack Helicopter (AH-1 or UH-1)	 Tilt-Rotor Aircraft (MV-22)	 Light Armored Vehicle (LAV-25)
 Fixed-Wing Aircraft (FA-18, F-35, C-130, C-17, KC-135, and similar aircraft)	 Unmanned Aircraft System (Unmanned Air Vehicle Groups 1-4)	 Wheeled Vehicles (High Mobility Multi-Purpose Wheeled Vehicles, 5- and 7-ton Trucks, Logistic Vehicle System)
 Ground/Air Task-Oriented Radar (G/ATOR)	 Navy Marine Expeditionary Ship Interdiction System (NMESIS) Mounted on a Tactical Vehicle	 Marine Air Defense Integrated System (MADIS) Mounted on a Tactical Vehicle
Live-Fire Weaponry		
 Pistols (9 mm, combat shotgun, and .45 caliber pistol)	 Rifles (5.56 mm service rifle, 7.62 mm and 50-caliber sniper weapon, and M27 infantry automatic rifle)	 Machine Guns (50-caliber machine gun, 7.62 mm machine gun, 5.56 mm squad automatic weapon)

Legend: mm = millimeter; TNI = Francisco Manglona Borja / Tinian International Airport.

C.2 RANGE MANAGEMENT

Section 2.1.8 of Chapter 2 provides information on Range Control under the Proposed Action. Additional details are provided in this appendix.

C.2.1 Public Access and No Training Areas

Training Areas

The Tinian Range Control would identify when public access during a training event would not be safe for the public and implement appropriate restrictions. Certain roads and certain areas within the Military Lease Area may be temporarily closed to the public during training periods. Public access restrictions would only be in place for the live-fire ranges during the times weapons are being fired or ordnance is used. Range Control would coordinate notifications and scheduling. One of the functions of Tinian's Range Control is to schedule training events and provide advanced notice to the public when events would occur and what portions of the Military Lease Area and/or surrounding waterways would be affected. For live-fire events, the public would be notified in advance. Non-live-fire activities that would limit access to portions of the Military Lease Area would be announced prior to the exercise. Each training event would be evaluated to minimize access disruptions to the extent as can be safely permitted. To ensure the safety of both the service members and non-participating personnel (i.e., members of the public traveling in the Military Lease Area for the purposes of tourism, foraging, recreation, etc.), access to the Military Lease Area would be coordinated directly by Range Control. The public would have access to information about training activities in the Military Lease Area through established communication channels coordinated by Range Control. In addition to proactive notifications issued prior to live-fire and non-live-fire training exercises, mechanisms for obtaining timely updates would help support public safety, awareness, and oversight of range activities. The USMC's goal is to create a structured and user-friendly process for members of the public to communicate with Range Control in order to foster a safe and well-managed environment while training is occurring within the Military Lease Area.

No Military Training Areas

There are areas within the Military Lease Area designated as no training areas, shown on Figure 2.1-3 of the Revised Draft EIS, the former Tinian Mortar range, the area reserved for a potential future landfill site, and areas to protect natural and cultural resources. Within the remainder of the Military Lease Area, training would be limited to roads and previously disturbed access paths, with the exception of limited foot maneuvering. Vegetation clearing, digging, and other ground intrusive activities would continue to be prohibited at culturally significant sites.

C.2.2 Environmental Management

All live-fire ranges on Tinian would be managed in compliance with current federal environmental laws and regulations. Department of Defense (DoD) Instruction 4715.14, *Operational Range Assessments,* establishes procedures that military services use to conduct assessments of all operational ranges within the U.S. The purposes of the assessments are to understand the potential long-term impacts of the use of military training lands and to help ensure that these resources are available for future training. Under the Environmental Compliance Evaluation Program, installations and regions complete annual inspections and Headquarters USMC inspects all aspects of an installation's environmental program every 3 years. Headquarters USMC also conducts assessments of operational ranges to ensure long-term sustainment of training areas while protecting the surrounding environment. In assuring compliance with federal laws and regulations, these actions are carried out with the goal of maintaining the safe, efficient, effective, and environmentally sustainable use of the ranges.

Hazardous Materials

All fuels, petroleum, oils, and lubricants would be stored, handled, transported, and disposed according to existing best management practices, standard operating procedures, applicable federal and CNMI regulations, and military requirements. Transportation of all hazardous materials would be conducted in compliance with the U.S. Department of Transportation regulations and Code of Federal Regulations (C.F.R.) Title 49, Subtitle B, Chapter I that regulates who may transport hazardous materials, how they are transported, the required training for handlers and transporters, the requirements for emergency spill response, and the specifications for all aspects of material and handler documentation and certification. The federal Hazardous Materials Program procedures outlined in C.F.R. Title 49 have been adopted by the CNMI.

An expeditionary Forward Arming and Refueling Point may be established for training to refuel aircraft. During training exercises, the Forward Arming and Refueling Point would be a temporary, mobile field facility, with secondary containment capabilities. It would be set up and broken down as part of a training exercise, so it would not have a designated permanent location.

Hazardous materials and fuel storage facilities on Tinian would be constructed using best management practices for construction in any unavoidable areas that are known to have seismic and tsunami hazards to minimize potential impacts from geologic hazards. Storage areas would also be located 500 feet from any surface water body and outside of inundation areas.

Training and maintenance would involve the use of hazardous materials managed according to Resource Conservation and Recovery Act regulations and other federal laws and regulations. Hazardous materials that would be routinely used on Tinian include fire extinguishers, batteries, pesticides, herbicides, paints, solvents, fluorescent light fixtures, and flameless chemical ration heaters for meals. Pesticides and herbicides would be used as part of range and facility management to control nuisance species and would be applied and managed in accordance with applicable regulations and manufacturer instructions.

Some of these hazardous materials would be stored in small quantities at the Base Camp. These include fire extinguishers that would be positioned anywhere there are flammable materials or spark sources and light bulbs that may be stored in designated areas throughout the facility where occupied buildings are located. Chemical ration heaters would be brought in with the unit supplies to support each training activity and would be stored with the unit where they are camping– either at the Base Camp or within the training areas. Best management practices would be followed regarding handling and storage.

Environmental Protection Programs

Joint Region Marianas has implemented basic environmental protection actions to ensure compliance with applicable environmental requirements across all environmental media areas. Basic environmental protection features incorporated into range management include, but are not limited to: fire condition monitoring for firefighting readiness and modification of training as appropriate, adherence to protective measures established in natural and cultural resource management plans, biological opinions, and programmatic agreements, restricting vehicular activities to designated/previously identified areas, prevention of soil erosion, and implementation of stormwater pollution prevention plans.

C.2.3 Biosecurity

The movement of munitions, military vehicles, equipment, and cargo to/from Tinian under the Proposed Action would meet the Armed Forces Pest Management Board Technical Guide 31 standards for bio-sanitation to prevent the inadvertent transport and introduction of exotic plant and animal pests resulting in damage to human health, agriculture, forestry, or the environment. Plant debris, garbage, food, soil, and even fresh water from foreign countries may contain organisms of quarantine importance. DoD policy mandates that all organizations and personnel involved in the movement of DoD-sponsored cargo, personal property, and accompanied baggage would take the steps necessary to prevent the spread of exotic pests, and plant and animal diseases from one location to another (Armed Forces Pest Management Board 2017).

Joint Region Marianas has an established comprehensive brown tree snake interdiction program to ensure that military activities, including the transport of personnel and equipment from Guam, do not contribute to the spread of brown tree snakes to the CNMI or other areas in the Pacific. Brown tree snake interdiction requirements contained in Commander, Navy Region Marianas and Joint Region instructions would be implemented for all proposed activities.

The biosecurity protocols to be set forth in the U.S. Fish and Wildlife Service (USFWS) Biological Opinion for the Proposed Action are expected to include but may not be limited to the following: (1) 100 percent inspections for brown tree snakes for all munitions, military vehicles, equipment, and cargo transported from Guam; (2) redundant brown tree snake inspections of munitions, military vehicles, equipment, and cargo within a brown tree snake barrier at the receiving jurisdiction after discussions with appropriate stakeholders; (3) bio-sanitation standard operating procedures to meet and validate the Armed Forces Pest Management Board Technical Guide 31 standards for munitions, military vehicles, equipment and cargo prior to arrival and departure on island. The USMC would strictly adhere to processes for avoiding the introduction of non-native species to Tinian. The USMC would develop Hazard Analysis and Critical Control Point plans and implement the plans for construction and operation activities. A biosecurity education program for all civilian, contractor, and military personnel (including any participating foreign ally personnel) would be provided to teach personnel how to identify native and non-native species.

Personnel or equipment arriving from Guam would undergo inspection at one of the three specified entry points.

C.3 TRAINING INFRASTRUCTURE

C.3.1 Base Camp

A Base Camp would provide basic services for up to 500 training personnel. Utilities on base camp would be sized to the surge capacity of up to 1,000 personnel training on island at one time, such as during a large event. In those situations, the additional personnel would camp in the training areas throughout the Military Lease Area.

The Base Camp would be gated with access limited to military and DoD civilian personnel only. Base Camp facilities would include:

- **Administration and Range Control building.** This building would house Range Control. This facility would provide key administrative functions: base administration, Range Control, base security, base communications, and the battalion (medical) aid station. Range Control would coordinate with TNI, Saipan International Airport, and DoD Range Control in Guam in concert with live-fire and air-based training events on Tinian. The Range Control building would be co-located with the base headquarters/administration.
- **Training Support area.** This would include a unit marshaling area, and restrooms/showers. The unit marshaling area would provide space to wash and stage vehicles, equipment, and personnel prior to their departure to the Port of Tinian or TNI. Restrooms, showers, and outdoor gear wash-down stations would be provided.
- **Warehouse.** This would provide storage for range targets and equipment and storage for units during training exercises.
- **Aircraft Shelter.** An aircraft shelter for performing minor aircraft maintenance and repairs. The proposed 105 feet wide by 154 feet long by 44 feet high shelter would be sized and constructed to provide protection for one aircraft from inclement weather including typhoon winds. The shelter could also be used for equipment staging, training unit mustering, or similar purposes.

C.3.2 Utilities

The USMC would either connect to existing utilities infrastructure or develop new utilities infrastructure on Tinian. The following subsections summarize the proposed development of utilities infrastructure that is common to both alternatives.

- **Electrical Power.** The existing Commonwealth Utilities Corporation Tinian Power Plant has sufficient generation capacity to support the anticipated power demand and no additional power generation is proposed. However, to support mission critical facilities during power blackouts, the USMC would install individual emergency power generators near mission critical facilities. The USMC would purchase electrical power from the Commonwealth Utilities Corporation and install an interconnection with the existing transmission line(s) servicing the former USAGM. Power lines would be installed to the Base Camp and each of the surface radar sites. Power lines would be placed underground to protect from weather events and to meet live-fire, aviation, and explosive safety requirements. There would be no permanent power infrastructure associated with the Landing Zones. Power to these facilities would be provided by alternative means (e.g., battery packs, photovoltaic solar panels).
- **Potable Water.** A potable water study indicated that the fresh groundwater supply from Tinian's aquifer, beneath the Military Lease Area, has ample capacity to meet the estimated average daily potable water demand (refer to Appendix M, *Utility Studies*, of the Revised Draft EIS). The Proposed Action includes construction of new water infrastructure to avoid impacts on the Commonwealth Utilities Corporation water system. This proposed new water infrastructure would supply the domestic, industrial, and fire protection demands of military training activities and the majority of water used during construction. This

proposed new water infrastructure would be operated by the USMC and would not be connected to the Commonwealth Utilities Corporation water system.

- Water infrastructure to support Base Camp would consist of up to four new groundwater wells, aboveground storage tanks, and distribution piping to meet potable water demand and fire protection demand. Wells would be connected to water supply lines and electrical power. For security purposes, fencing would be installed around each well.
- Two water wells and associated storage tanks and booster pumps for firefighting support would be developed or rehabilitated at North Field, north of the airfield.
- The specific location of wells and tanks at North Field and Base Camp would be determined during engineering design. All other training areas or other locations in the Military Lease Area would rely on water trucks to access potable water.

- **Wastewater.** Wastewater facilities would be constructed and operated at the Base Camp in the form of one or more new septic tanks and an associated leach field. Training areas and other locations may emplace temporary porta-johns to support operational activities, which would also be emptied and processed at the Base Camp septic system.
- **Solid Waste.** Solid waste generation would include municipal solid waste, construction and demolition waste, green waste, and wastewater (sewage) sludge from septic tanks. Currently, the Tinian municipality does not have solid waste infrastructure that could support the management of all solid waste generated during the construction and operational phases of the Proposed Action. During the construction phase, the USMC would manage project-related solid waste (including municipal solid waste, construction and demolition waste, and green waste) in accordance with applicable laws and regulations.

  - Solid waste on Tinian is currently transported by residents and business entities to the Tinian Puntan Diablo disposal facility located adjacent to 8th Avenue near San Jose and the southwest coast. The facility is operated by the CNMI Department of Public Works. The existing disposal facility is unlined and not presently in compliance with the design and operating requirements of the Resource Conservation and Recovery Act (RCRA) Subtitle D regulations (40 Code of Federal Regulations [CFR] Part 258) governing municipal solid waste landfills.
  - CNMI intends to convert the disposal facility to a permitted landfill by demonstrating compliance with the small community exemption available in RCRA Subtitle D regulations 40 CFR Part 258.1(f)(1) (CNMI, 2023). The anticipated timeline to complete the permitting process is 6 to 12 months.
  - CNMI is initiating permitting efforts for a new landfill at the Atgidon site, located north of 86th Street and between Riverside Drive and 10th Avenue (CNMI, 2023). The CNMI plans to permit this new site under the small community exemption. CNMI anticipates permitting would take 5 years to complete, with site development commencing shortly thereafter to ensure disposal capacity at the new Atgidon Landfill is available prior to cessation of operations at Puntan Diablo (CNMI, 2023). It is expected the on-island landfill capacity would be sufficient to manage the solid waste generated through project construction and during the ongoing training facility operational life.

    - If the planned permitting of the existing Tinian landfill and the proposed Atgidon landfill is not completed, and landfill disposal capacity is not available, the alternate management methods for solid waste that would be considered include: (1) transport solid waste generated during training to Marpi Landfill on Saipan or (2) on-site incineration, which would reduce the amount of waste landfilled.

- **Green Waste**. The USMC would generate green waste mostly during the construction period and would collect green waste at one or more locations. The USMC would potentially use a variety of methods to manage the green waste stream, including but not limited to, chipping and reuse, or chipping and decomposition.

- **Stormwater.** The USMC would manage stormwater quality and quantity to maintain existing hydrology conditions to the maximum extent feasible and control pollutant loading in accordance with the CNMI regulations and U.S. federal and military guidance/policies. The USMC would maintain existing basin and sub-basin hydrology, where feasible, to limit the required stormwater infrastructure and pond sizes. Stormwater improvements would be constructed and maintained to incorporate Low Impact Development Integrated Management Practices at the Base Camp.

    - Stormwater management facilities could include a combination of natural and engineered features such as retention/detention ponds that control the volume, direction, and rate of stormwater runoff (i.e., minimize or eliminate hydromodification), filter out pollutants, and facilitate groundwater recharge through increased infiltration. Surface conveyance and control would be via vegetated swales, pipe culverts, and retention ponds. The majority of roadways would be rural road sections (no curb and gutter), so stormwater would be managed using roadside vegetated swales.

- **Information Technology/Communications.** The USMC would use commercial Information Technology/Communications service providers to connect appropriate facilities in the Base Camp and surface radar sites. The proposed telecommunications system would consist of a combination of overhead pole-mounted cabling and underground conduits, manholes/hand holes, and pull-boxes to support government communications systems (e.g., government telephone, government data, security, and closed-circuit television), and commercial utilities services (e.g., commercial telephone, internet, and cable television).

C.4 TRAINING RANGE SUPPORT FACILITIES

C.4.1 Ammunition Holding Areas

The USMC would construct and operate two ammunition holding areas within the Military Lease Area, one at the proposed Base Camp and one at the Multi-Purpose Maneuver Range. Facilities would include concrete pads and paved roads and would be secured with temporary fencing and artificial lighting.

Both ammunition holding areas would be used on a temporary basis for storing ammunition. Ammunition would only be stored during the duration of the training exercise. Upon completion of the training all unspent ammunition would be removed by the training team. Ammunition holding areas would include an Inhabited Building Distance Explosive Safety Quantity Distance Arc and Public Traffic Route Distance Explosive Safety Quantity Distance Arc sized to the munitions (refer to Figure 2.1-10 in Chapter 2 of the Revised Draft EIS). When ammunition is stored, the facility would be guarded 24 hours a day by armed personnel.

C.4.2 Live-Fire Training Ranges: Multi-Purpose Maneuver Range and Explosives Training Range

Chapter 2, Sections 2.1.5.1 and 2.1.5.2, provide descriptions of the proposed Multi-Purpose Maneuver Range and Explosives Training Range, respectively. Range Control would manage the proposed live-fire training ranges to ensure safe operations within the established surface danger zones.

Surface danger zones would be established for the two live-fire ranges. The size and configuration is dependent on the performance characteristics of a given weapons system, training requirements, range configuration, and geographical location. A surface danger zone is defined for each range using a safety model that determines an area for which there is a one-in-a-million chance (including the ground and airspace) of a projectile landing outside the surface danger zone during training.

For the Multi-Purpose Maneuver Range, the USMC would pursue U.S. Army Corps of Engineers designation of danger zones that correlate to the type of weapon being used, in accordance with Section 7 of the Rivers and Harbors Act of 1917, 33 C.F.R. Part 209.200. The danger zones would be plotted on nautical charts and the Notice to Mariners, published weekly by the U.S. Coast Guard, would identify when the danger zones would be active.

Figure 2.1-9 in the Revised Draft EIS shows representative surface danger zones for types of ammunition typically used on the Multi-Purpose Maneuver Range and the surface danger zone for the Explosives Training Range. This surface danger zone for the Explosives Training Range does not extend over the water and would not require charting.

C.4.3 Surface Radar Sites

Two surface radar sites are required for the live-fire ranges. Each could include a metal lattice tower and observation platform, and radio transmitter and receiver equipment (Figure C.3-1). Each site would provide a surface radar, a visual color camera and thermal imager, and a diesel backup generator. The backup generator would be housed in a concrete structure providing weatherproofing and safety. The surface radar sites would include an additional camera for monitoring the danger zone to shore interface. The sites would include a security perimeter fence and gate. Information technology and communications infrastructure would be provided through aboveground and belowground transmission lines. Each site would include electrical service and single mode fiber optic communications connections linking to the communications facilities at the Base Camp.

Figure C.4-1 Representative Surface Radar Tower

C.4.4 Communication Towers

Existing communication towers at the former USAGM Tinian and Saipan sites would be repurposed to provide Range Control with consistent radio communications that provide positive control and safety of training events.

Information technology and communications infrastructure would be provided through aboveground and belowground transmission lines. Each site would include electrical service and single mode fiber optic communications connections linking to the communications facilities at the Base Camp.

C.4.5 Road Infrastructure

Existing roads in the Military Lease Area are a combination of paved roads (mostly constructed prior to or in the 1940s during World War II), unpaved (gravel) roads constructed in the last 50 years to provide access to beaches and other locations, or unimproved (grass/dirt) agricultural access roads.

Existing roads throughout the Military Lease Area would be evaluated and, as necessary, improvements made to support both military training and public access. The following road infrastructure modifications or improvements are proposed:

- **New Unpaved Roads.** The USMC would construct and maintain new unpaved roads primarily near the Explosives Training Range and some Landing Zones. Unpaved roads would be a single travel lane with no shoulder. These roads would be maintained at the level necessary to support continued USMC function and use.
- **Repairs to Existing Roads within the Military Lease Area.** The USMC proposes to repair and maintain some of the existing roads in the Military Lease Area at the level necessary to support continued USMC function and use. Broadway and 86th Street have been identified as candidates for repairs, including converting Broadway from its current

two-lane bi-directional travel back to its original World War II-era bifurcated boulevard design.

- **Repairs to Existing Roads Outside of the Military Lease Area.** The USMC would evaluate the primary and secondary access routes from the Port of Tinian to the Military Lease Area (to include West Street, 6th Avenue, 8th Avenue, 42nd Street, and Broadway) to be used for both the construction phase and during training to determine whether the roads meet U.S. Department of Transportation and American Association of State Highway and Transportation Officials roadway safety and design standards. The USMC would upgrade roads outside of the Military Lease Area to meet required roadway safety and design standards and would maintain roads to the extent USMC determines necessary to support continued USMC function and use.

C.5 CONSTRUCTION PHASING AND LOGISTICS

The Proposed Action would include the construction of support facilities, airfield improvements, and range facilities on Tinian. The following sections describe the process of obtaining necessary real estate interests on Tinian, and the phased construction schedule, public access controls during construction, and a summary of construction and ongoing vegetation maintenance on Tinian.

C.5.1 Real Estate Interests on Tinian

The USMC proposes to discuss updating real estate interests with the CNMI government to facilitate development of facilities and infrastructure within the existing leases on Tinian and the USAGM lease on Saipan. The current leases would need to be updated by mutual agreement to facilitate the implementation of either alternative.

C.5.2 Construction Schedule

The USMC would phase military construction projects over 10-15 years. The first 5 to 7 years of construction would include trimming and clearing of vegetation, fire breaks, establishment of utility connections, Range Control functions, clearing vegetation for Landing Zones, North Field improvements, development of biosecurity facilities at the Port of Tinian, and establishing the Multi-Purpose Maneuver Range, including associated surface radar towers and ammunition holding areas. The remaining years would include construction of the Base Camp, Aircraft Shelter, and Explosives Training Range. Approximately 50 construction workers are estimated to be needed each year, with a possible majority coming from off island due to the limited workforce available on Tinian. It is expected that construction contractors would utilize workforce housing recently constructed for the U.S. Air Force Divert project and other local hotels. USMC contractors would lease these facilities and utilize the adjacent mess facilities.

C.5.3 Public Access During Construction on Tinian

The USMC would require its construction contractors to prepare and implement health and safety plans. Construction contractors would be required to implement temporary controlled access to construction sites where only authorized personnel would be allowed entry. Although the phased construction period is expected to last approximately 10-15 years, construction would only result in public access controls at specific construction sites; access to most of the Military Lease Area would still be possible during activities. The USMC and its construction contractors would coordinate with the Tinian municipality and appropriate agencies regarding access controls and notify the public road closures.

C.5.4 Summary of Construction

As part of construction phase activities, the USMC would conduct munitions and explosives of concern clearance, vegetation clearance, and grubbing and grading activities. During initial site preparation for construction of the ranges, supporting facilities, and infrastructure, vegetation would be physically removed with the use of hand and heavy machinery. The USMC would also conduct varying degrees of earthwork (excavation and fill) at some of the construction sites. Excess material would be managed on island.

C.5.5 Vegetation Management

The proposed training infrastructure would require varying degrees of vegetation management to accommodate line of sight, wildland fire control, firing positions, target objective areas, Base Camp facilities, and security purposes. The USMC would identify specific vegetation removal/maintenance and earthwork techniques as part of future project-level design.

C.5.6 Summary of Construction Facilities, Vegetation Clearing, and Road Improvements

Table C.5-1 provides a summary of Construction for Buildings, Support Facilities, Utilities and Ranges. Table C.5-2 provides a summary of road improvements.

Table C.5-1 Buildings, Ranges, and Support Facilities

Description	*Building Requirement (SF)*	*New Building Construction (SF)*	*Vegetation Clearing (SF)*	*New Impervious or Semi-Impervious Surface (includes new building footprint)(SF)*
Base Camp Buildings				
Consolidated Base Camp Headquarters, including Range Control Re-use of USAGM Transmitter / Administration Building (23,000 SF)	10,200	0	0	0
Training Support (Exercise Control) Operational Trainer Building Re-use of USAGM Transmitter / Administration Building (23,000 SF)	10,000	0	0	0
Generator Building Re-use of USAGM Power Plant Building (2,600 SF)	2,600	0	0	0
Range Support Maintenance Shop Re-use of USAGM Warehouse and Maintenance Building (3,500 SF) and add 1,260 new SF to expand to required 4,760 SF	4,760	1,260	0	1,260
Fire and Non-Potable Pump Station Re-use of USAGM Water Pump House Building (400 SF)	200	0	0	0
Fuel Pump Station (supports fuel for emergency generators only) Re-use of USAGM Fuel Pump House Building (400 SF)	200	0	0	0
Guard Booth Re-use of USAGM Guard House Building (100 SF)	100	0	0	0
Communications Area Distribution Node (ADN): connects Base Camp to local Internet Service Provider to proposed communications towers and proposed Base Camp facilities.	2,700	2,700	0	2,700
General Purpose Warehouse and Hazardous materials storage and transfer Building	36,000	36,000	0	36,000
Base Camp Public Works Shop	8,700	8,700	0	8,700
Electrical Distribution Building / Switching Station	900	900	0	900

Description	*Building Requirement (SF)*	*New Building Construction (SF)*	*Vegetation Clearing (SF)*	*New Impervious or Semi-Impervious Surface (includes new building footprint)(SF)*
Electrical Controls and Fire Pump Building This building is included in the description of Base Camp Potable water wells and would go in the same area as the potable water storage tanks.			0	
Wastewater/Restrooms/Showers: Up to 2 buildings @ 1,600 SF each plus 2 outdoor gear wash stations at 1,000 SF each and space for up to 2 underground septic tanks and 2 approximately 1 acre leach fields. Note that the existing aeration tank would be removed or replaced/upgraded.	3,200	3,200	0	5,200
Aircraft Shelter: (approximately 105 feet wide by 154 feet long and 44 feet tall or 16,200 SF), Site requirements estimated at: 40,000 SF for shelter apron, parking, circulation and access road. Note: This facility is not included in the Base Camp and is same location for both Base Camp options located on the US Air Force Divert Aircraft Parking Apron.	16,200	16,200	0	56,200
Base Camp Supporting Facilities Note - other Base Camp functions such as troop marshalling area, bivouac area, and mess area could be include at Base Camp but these would not require vegetation clearing or new impervious surface				
Base Camp Ammunition Holding Area: (approximately 164 feet wide by 164 feet long or approximately 27,000 SF to support up to 4,418 lb. NEW)	N/A	N/A	0	27,000

Description	*Building Requirement (SF)*	*New Building Construction (SF)*	*Vegetation Clearing (SF)*	*New Impervious or Semi-Impervious Surface (includes new building footprint)(SF)*
Base Camp Potable Water Services: Potable Water Tanks (2 @300,000 GAL). Each tank would be approximately 33 FT in diameter and 48 FT high on a concrete pad. The tanks would be located with the Base Camp site on previously disturbed land. The tanks would require an approximately 900 SF electrical controls and fire pump building and approximately 20,000 total SF of impervious or semi-impervious surface for placement of concrete pads/tanks, pumphouse, and supporting infrastructure.	900	900	0	20,000
Potable Water Well Field: Up to four (4) wells would be installed within the well field. Each well would require an initial approximately 0.5 acre cleared area for well installation and development, 2 acres total. Each well would include a 900 SF building for equipment and an approximately 0.5 acre area fenced. The well field would also include a 3,600 SF building for electrical controls, emergency generator, and chlorination. The 3,600 SF building would require an approximately 1.5 acre fenced area. Fencing at each well head and the 3,600SF building would be double fencing: (Outer fence (8' total height – 7' fence with 1' Y top) with reinforcement cables and dead man anchors, Y top, barbed wire and razor wire. Inner fence (8' total height – 7' fence with 1' Y top) with Y top, barbed wire and razor wire.). A 20-foot wide asphalt service road would be constructed to access each well for a total of approximately 260,000 SF of roads. Entry points to wells would be gated and illuminated.	7,200	7,200	412,460	260,000
Camping Concrete Tent Pads: (10 pads, 22 feet by 46 feet)	N/A	N/A	0	10,120
Base Camp Training Unit Vehicle Parking: (87 tactical vehicles and various tactical equipment) (gravel area).	N/A	N/A	0	63,000
Base Camp Motor Pool (Base services, security, maintenance vehicles, etc.) (30 vehicles) (paved or unpaved area)	N/A	N/A	0	9,500

Description	*Building Requirement (SF)*	*New Building Construction (SF)*	*Vegetation Clearing (SF)*	*New Impervious or Semi-Impervious Surface (includes new building footprint)(SF)*
Base Camp Security Fencing The existing barbed wire fence surrounding the approximately 300 acres would be replaced with 7-foot chain link fence with double outrigger barbed wire. The existing fence has approximately 10 feet wide mowed area around the perimeter. New fencing would require 20 feet of cleared space within the fence and 10 feet of cleared space outside the fence. This would require an additional 20 feet of vegetation clearance. 15,670 linear feet x 20 feet = 313,400 SF or 7.2 Acres. The entry points to Base Camp would be illuminated.	N/A	N/A	313,400	0
Base Camp Biosecurity/Wash Rack (paved area with wash-water run-off containment)	N/A	N/A	0	5,400
Port Biosecurity/Wash Rack (paved area with BTS fencing and wash-water run-off containment). Wash rack would be connected to CUC power and water supply. Wastewater would be recycled and oil water separator and used water would be transported to Base Camp for disposal. Facility would include an estimated 5,400 SF wash rack and 20,000 SF of paved area for inspection of vehicles and equipment. The entire approximately 26,000 SF are would be surrounded with fencing and brown tree snake traps.	N/A	N/A	0	26,000
Fuel Storage and Distribution Fuel requirements are estimated at 100,000 gallons storage capacity. This would be satisfied with two 50,000 gallon fuel bladders. Total site area to include bladders, clearance and secondary containment is approximately 18,000 SF. Once facilities are constructed, fuels would be sourced from the existing Divert facilities using fuel trucks. The EIS assumes approximately 1M gallons of fuel needed per year and this would result in an average of 4 truck trips per week from Divert to the Base Camp. This could increase during peak large training events to 16 truck trips per week .	N/A	N/A	0	18,000

Description	*Building Requirement (SF)*	*New Building Construction (SF)*	*Vegetation Clearing (SF)*	*New Impervious or Semi-Impervious Surface (includes new building footprint)(SF)*
Utility alignments. Note - Electrical and communication lines would be undergrounded. Lines would be constructed to serve Base Camp, Surface Radar Towers, Well Fields and the MPMR Ammunition Holding Area. Utility trenches are expected to be located approximately 16 feet from the centerline of roads. A total of approximately 14 feet of cleared area is needed along the road to construct the trench. The trench would be approximately 3 feet in width if shored and approximately 10 feet in width if not shored. Shoring is typically required in poor soil conditions and/or if the trench is deeper than 4 feet. The trench would be up to 6 feet deep for water lines and 3 feet deep for electrical or communication lines. The EIS would assume a 10 foot wide trench for water lines and a 3 foot wide trench for electrical and telecommunications. An estimate of disturbed area is shown as follows:				
Water line from Well Field A (maximum proposed distance following 8th Avenue) 24,000 linear feet by 14 feet wide for vegetation clearing = 336,000 SF. Actual ground disturbance would be 24,000 linear feet by 10 feet wide = 240,000 SF.	N/A	N/A	336,000	0
Water line from Well Field B (maximum proposed distance following 8th Avenue) 15,540 linear feet by 14 feet wide = 217,560 SF. Actual ground disturbance would be 15,540 linear feet by 10 feet wide = 155,400 SF.	N/A	N/A	217,560	0
Proposed Combined Electrical and Communication Line in the Military Lease Area: - USAGM Site to Surface Radar Site 1 = 11,210 ft - Surface Radar Site 1 to Surface Radar Site 2 = 18,650 ft - Ushi Point Road to MPMR Wells and AHA-1 = 4,770 ft Total 34,630 ft by 14 feet wide clearing = 484,820 SF	N/A	N/A	484,820	0
Proposed Communication Line in the Military Lease Area: - TNI/Divert from Broadway to 8th Avenue = 17,040 ft - 8th Avenue to Well Field Option 1 along 86th Street = 11,600 ft - TNI/Divert 8th Avenue to Base Camp = 16,350 ft Total 44,990 linear ft by 14 feet wide clearing = 629,860 SF	N/A	N/A	629,860	0

Description	*Building Requirement (SF)*	*New Building Construction (SF)*	*Vegetation Clearing (SF)*	*New Impervious or Semi-Impervious Surface (includes new building footprint)(SF)*
Proposed Communication Line OUTSIDE the Military Lease Area: - Commercial service provider (San Jose) to Military Lease Area Via Broadway = 6,510 feet by 14 feet wide = 91,140 SF	N/A	N/A	91,140	0
Ranges, Supporting Facilities and Training Areas				
Two Surface Radar Towers Each tower is a minimum of 45 ft and a maximum of 75 feet tall. Each requires a 120 ft by 120 ft fenced area with an additional 20 feet of clearance outside the fence for a total disturbance of 160 ft by 160 ft or 25,600 SF. Each site would include an approximately 40 ft by 40 ft area for the antenna footings and approximately 30 ft by 30 ft equipment shelter. The entry gate at each Surface Radar site would be illuminated. Fencing at the Surface Radar sites would be double fencing: (Outer fence (8' total height – 7' fence with 1' Y top) with reinforcement cables and dead man anchors, Y top, barbed wire and razor wire. Inner fence (8' total height – 7' fence with 1' Y top) with Y top, barbed wire and razor wire.).	1,800	1,800	51,200	5,000
Multi-Purpose Maneuver Range Ammunition Holding Area: (approximately 164 feet wide by 164 feet long to support up to 567 lb. NEW) at Multi-Purpose Maneuver Range (MPMR). The AHA would require temporary fencing when in use. The temporary fencing typically consists of triple-strand concertina wire, a security barrier made up of three layers of razor wire arranged in a pyramid or stacked formation. The wire is secured in place using metal stakes driven into the ground. Height: 4 to 6 feet Width: 3 to 6 feet Stake Spacing: Every 5 to 6 feet Stake Depth: 18 to 24 inches	N/A	N/A	27,000	27,000

Description	*Building Requirement (SF)*	*New Building Construction (SF)*	*Vegetation Clearing (SF)*	*New Impervious or Semi-Impervious Surface (includes new building footprint)(SF)*
Multi-Purpose Maneuver Range: Perimeter Road and Firebreak (vegetation clearing and regular maintenance), 10,080 linear feet, with 50-foot vegetation clearing for fire-break, 504,000 SF	N/A	N/A	504,000	0
Multi-Purpose Maneuver Range: Interim Firebreak The interim firebreak would follow existing Boston Post road that runs east and west along the south side of the MPMR AND Ushi Point Road. Fire breaks would require 8 ft of clearance on either side of the road (vegetation clearing and regular maintenance). The estimated length for fire break along Boston Post Road is 13,690 linear feet. Ushi Point Road fire break is estimated 5,240 linear feet for a total of 18,930 linear feet. 18,930 linear feet times 16-foot vegetation clearing = 302,880 SF.	N/A	N/A	302,880	0
Multi-Purpose Maneuver Range Water Wells and Tanks: One new water well and two 100,000 gallon water tanks would be constructed at North Field near Landing Zone 13. The well would include a 900 SF building to house water pumps, and backup electrical generation. The well and tanks would NOT be fenced Each 100,000 gallon tank would be approximately 33 feet in diameter and 18 feet high and include wildland fire truck dispensing apparatus. The tanks would require approximately 7,000 total SF of impervious or semi-impervious surface for placement of concrete pads/tanks, pumphouse, and supporting infrastructure. The total disturbed area would be approximately 1.5 acres. The area would be accessed by existing roads and the well, building and tanks would be locked for security. Entry points would be illuminated.	900	900	65,340	7,000
Multi-Purpose Maneuver Range: Center Access Road/UKD Range (vegetation clearing and regular maintenance)	N/A	N/A	108,000	0

Description	*Building Requirement (SF)*	*New Building Construction (SF)*	*Vegetation Clearing (SF)*	*New Impervious or Semi-Impervious Surface (includes new building footprint)(SF)*
Multi-Purpose Maneuver Range: Target/Objective Areas (vegetation clearing and regular maintenance) The MPMR would also include thinning of vegetation between objective areas. Roads to the MPMR and Surface Danger Zone would include gates that could be closed for safety and security. Simple metal gates would also be installed along the public road to prevent access for safety reasons when the Range is in use.	N/A	N/A	531,200	0
Explosives Training Range (ETR) The Explosives Training Range would include a 2.5 acre disturbed area and a 40 feet x 8 feet Missile Proof Shelter & Operational Bunker. The road to the ETR would have a permanent steel swing gate that could be closed for safety and security. The ETR would NOT be fenced. The ETR would also include a flagpole with a redlight. The light would be illuminated and a red flag flown when the range is active.	320	320	108,900	320
Helicopter Landing Zones: (remove and maintain vegetation to allow for helicopter landings 11 small (600 feet by 600 feet) and 2 large (1200 feet by 1200 feet) = 6,840,000 SF or 157 Acres	N/A	N/A	6,840,000	0
North Field Drop Zone: (vegetation clearing for safe use of drop zone) (212 acres being cleared by USAF, 89 acres by CJMT)	N/A	N/A	3,876,840	0
TOTAL	106,880	80,080	14,900,600	589,300
		Acres	342.07	13.53
Total Building SF at USAGM site that can be reused	30,000			
Total Impervious or Semi-Impervious Surface WITHOUT new building footprints				511,020

Table C.5-2 Roadways

Road Name/Location	Road Segment Length (feet)	Road Type	Construction Type	Road Description	Road Width (feet)	Area of Disturbance (Clearing) (SF = Road Length x Road Width)
Explosives Training Range Access Road (from 86th Street, North to ETR Site/Bunker)	2,800	Gravel	New Construction	24 feet	24	67,200
72nd Street, from Pina Quarry to Pina Plateau, connects to LZ 1	6,954	Gravel	Re-established Road	2-12 foot lanes, with 3-foot shoulders	30	208,620
Road to LZ 2	300	Gravel	Re-established Road	24 feet	24	7,200
Road to LZ 3	467	Gravel	Re-established Road	24 feet	24	11,208
Road to LZ 4	1,289	Gravel	Re-established Road	24 feet	24	30,936
Road to LZ 5	226	Gravel	Re-established Road	24 feet	24	5,424
Road to LZ 6	458	Gravel	New Construction	24 feet	24	10,992
Road to LZ 7	382	Gravel	New Construction	24 feet	24	9,156
Road to LZ 8	278	Gravel	New Construction	24 feet	24	6,672
Road to LZ 9	719	Gravel	Re-established Road	24 feet	24	17,256
Road to LZ 10	606	Gravel	Re-established Road	24 feet	24	14,544
Road to LZ 11	1,398	Gravel	Re-established Road	24 feet	24	33,552
Road to LZ 12	2,588	Gravel	Re-established Road	24 feet	24	62,112
Road to LZ 13	0	Gravel	Re-established Road	24 feet	24	0
Total New Construction	3,918			Total New Construction		94,020
Total Re-establish	14,547			Total Re-establish		390,852
Grand Total	18,465			Total		484,872
				Acres New Construction		2
				Acres Re-establish		9
				Acres Grand Total		11

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APPENDIX D
BEST MANAGEMENT PRACTICES, STANDARD OPERATING PROCEDURES, AND MINIMIZATION MEASURES

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APPENDIX D

BEST MANAGEMENT PRACTICES, STANDARD OPERATING PROCEDURES, AND MINIMIZATION MEASURES

Chapter 4 of the Revised Draft Environmental Impact Statement (EIS) discusses how the Proposed Action incorporates resource management measures that avoid and/or minimize environmental impacts to resources. These resource management measures are incorporated into the design of the project in the form of avoidance and minimization measures, best management practices, and standard operating procedures. This appendix addresses best management practices and standard operating procedures, each of which is discussed below.

- Best management practices are existing policies, practices, and measures required by law, regulation, or Department of Defense (DoD) policy that reduce the environmental impacts of the Proposed Action and are common practice in the industry. Best management practices are incorporated into the Proposed Action and include standard military design, construction or operations practices or procedures, and compliance with laws and typical regulatory permit requirements that the USMC is committed to implementing. The Revised Draft EIS impact analysis assumes that best management practices are successfully implemented when assigning a level of impact.
- The USMC currently employs standard practices to provide for the safety of personnel and equipment, including vessels and aircraft, as well as the success of the training events. In many cases, there are incidental environmental, socioeconomic, and cultural benefits resulting from standard operating procedures. Standard operating procedures serve the primary purpose of providing for safety and mission success and are implemented regardless of their secondary benefits. Because standard operating procedures are crucial to safety and mission success, the USMC would not modify them as a way to further reduce impacts on environmental resources. Rather, avoidance, minimization, and mitigation measures would be used as the tool for avoiding and reducing potential environmental impacts.

The best management practices and standard operating procedures relevant to this Proposed Action are listed in Table D-1, which illustrates how avoidance and minimization measures often have a mitigating effect across multiple resource areas.

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Table D-1 Best Management Practices, Standard Operating Procedures, and Minimization Measures Included in the Proposed Action

Best Management Practice, Standard Operating Procedure, or Minimization Measure	*Description*	*Public Access*	*Land Use and Recreation*	*Socio-economics*	*Terrestrial Bio. Resources*	*Cultural Resources*	*Visual Resources*	*Transportation*	*Noise*	*Air Quality and GHGs*	*Public Health and Safety*	*Utilities*	*Topography, Geology, and Soils*	*Groundwater Hydrology*	*Surface Waters and Wetlands*
Seismic Design for Buildings	Unified Facilities Criteria 3-310-04, *Seismic Design for Buildings*, are guidelines that would be implemented to reduce geologic hazards associated with seismicity, liquefaction, and ground shaking.										X		X		
Dust Control Measures	Unified Facilities Criteria 3-260-17, *Dust Control For Roads, Airfields And Adjacent Areas, With Change 1*, are guidelines for Dust Control in construction and maintenance. Some measures include when feasible: • Minimize land disturbance. • Construct stabilized construction entrances per construction standard specifications. • Cover trucks when hauling soil, stone, and debris. • Use water trucks to minimize dust. • Stabilize or cover stockpiles. • Minimize dirt tracking by washing or cleaning trucks before leaving the construction site.		X	X						X	X		X		X
Erosion Control Measures	Erosion control measures would be implemented during construction and operations to eliminate and/or minimize nonpoint source pollution in surface waters due to sediment. *CNMI Earthmoving and Erosion Control Regulations* and *CNMI Environmental Protection Act* establish a permit process for construction activities, identify investigations and studies that are required prior to design and construction, and provide standards for grading, filling, and clearing. Erosion control measures would include Department of Environmental Quality-recommended BMPs that apply to				X						X	X	X	X	X

Best Management Practice, Standard Operating Procedure, or Minimization Measure	*Description*	*Public Access*	*Land Use and Recreation*	*Socio-economics*	*Terrestrial Bio. Resources*	*Cultural Resources*	*Visual Resources*	*Transportation*	*Noise*	*Air Quality and GHGs*	*Public Health and Safety*	*Utilities*	*Topography, Geology, and Soils*	*Groundwater Hydrology*	*Surface Waters and Wetlands*
	federal actions in CNMI. Specific BMPs may include, but are not limited to, the following: • Minimize the ground disturbance area. Contractors would be held responsible for ground disturbance/vegetation removal that occurs outside of project areas identified in contractor specifications. • Provide erosion control through the site approval process and implement control measures such as retention ponds, swales, silt fences, fiber rolls, gravel bag berms, mulch, and erosion control blankets during construction and operations to eliminate and/or minimize nonpoint source pollution in surface waters due to sediment. Topsoil removed from the site would be placed in the immediate area and reused for re-compaction purposes (if appropriate, in accordance with geotechnical recommendations). • Protect soil exposed near water as part of the project from erosion with erosion control blankets (organic or synthetic fibers held together with net to cover disturbed areas) after exposure and stabilize as soon as practicable (with vegetation matting, hydroseeding, etc.). • Contain silt using silt fences and other physical barriers that intercept runoff from drainage areas. • Cover soil piles and exposed slopes during times of inclement weather. • Stockpile excavated materials														

Best Management Practice, Standard Operating Procedure, or Minimization Measure	*Description*	*Public Access*	*Land Use and Recreation*	*Socio-economics*	*Terrestrial Bio. Resources*	*Cultural Resources*	*Visual Resources*	*Transportation*	*Noise*	*Air Quality and GHGs*	*Public Health and Safety*	*Utilities*	*Topography, Geology, and Soils*	*Groundwater Hydrology*	*Surface Waters and Wetlands*
	behind impermeable berms and away from the influence of surface waters and runoff. • Re-vegetate as soon as possible after any ground disturbance or grading and stabilize loose soils using vegetation/mulch (i.e., apply coarse plant residue to cover soil surface). The vegetation/mulch should be free of invasive species viable reproductive parts, such as rhizomes, seeds, and plants. • Utilize level spreaders (non-erosive outlets for runoff to disperse flow uniformly across slope). • Install rock outlet protection (rock protection placed at end of culverts). • Restrict vehicles in training areas to designated/previously identified areas and ensure all training areas, including transit routes necessary to reach training areas, are clearly identified or marked.														
Clean Water Act – National Pollutant Discharge Elimination System	A Stormwater Management Plan and Stormwater Pollution Prevention Plan be prepared and implemented in compliance with the CNMI Stormwater Management Manual. Elements of a Stormwater Management Plan include structural and non-structural practices such as the following: • Storm drain inlet protection (permeable barrier around inlets reducing sediment let into storm drain). • Stormwater ponds and wetlands. • Infiltration practices (capture/temporarily store water before infiltrating into the soil).				X						X	X		X	X

Best Management Practice, Standard Operating Procedure, or Minimization Measure	*Description*	*Public Access*	*Land Use and Recreation*	*Socio-economics*	*Terrestrial Bio. Resources*	*Cultural Resources*	*Visual Resources*	*Transportation*	*Noise*	*Air Quality and GHGs*	*Public Health and Safety*	*Utilities*	*Topography, Geology, and Soils*	*Groundwater Hydrology*	*Surface Waters and Wetlands*
	• Filtering practices (capture/temporarily store water and pass through filter beds of sand, organic matter, soil, or other media). • Soil stabilization (such as mulch and erosion control blankets). • Perimeter and sediment control (such as silt fences, fiber rolls, gravel bag berms, and sediment traps). • Management and covering of material, waste, and soil stockpiles when not in use. • Storage of fuels and hazardous materials with proper secondary containment, and establishment of designated vehicle and equipment maintenance and fueling areas. • Management of spills and leaks from vehicles and equipment through inspections and use of drip pans, absorbent pads, and spill kits. • Development of a contingency plan to control petroleum products accidentally spilled during the project.														

Best Management Practice, Standard Operating Procedure, or Minimization Measure	***Description***	***Public Access***	***Land Use and Recreation***	***Socio-economics***	***Terrestrial Bio. Resources***	***Cultural Resources***	***Visual Resources***	***Transportation***	***Noise***	***Air Quality and GHGs***	***Public Health and Safety***	***Utilities***	***Topography, Geology, and Soils***	***Groundwater Hydrology***	***Surface Waters and Wetlands***
Technical Guidance on Implementing Stormwater Runoff Control Measures	Section 438 of the Energy Independence and Security Act, *Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects* establishes guidance for post-development stormwater management systems that utilize a combination of natural and engineered features that reduce the volume and rate of stormwater runoff (i.e., eliminate or minimize hydromodification), filter out pollutants, and facilitate groundwater recharge through infiltration. The preservation and reestablishment of vegetation after construction would minimize the potential for erosion and sediment runoff.				X						X	X		X	X
Design Individual Projects Using LEED Certification Standards	Current USMC policy supports LEED, a voluntary point system tool that measures the degree of sustainability features incorporated into a development. LEED requirements include the following: • Reduction of electrical energy use in buildings by 10% to save power. • Construction materials: use of local sources. USMC guidance and qualification for LEED Silver points requires that 50% non-hazardous waste and demolition debris are recycled. • Increased water efficiency. • Renewable energy.			X							X	X			
Design Projects Using Low Impact Development Standards	Low Impact Development measures would be consistent with guidelines provided in Unified Facilities Criteria 3-210-10 and stormwater management techniques provided in the CNMI *Stormwater Management Manual*. Innovative methods are used to capture stormwater that would otherwise flow into nearby watersheds using a			X								X		X	X

Best Management Practice, Standard Operating Procedure, or Minimization Measure	*Description*	*Public Access*	*Land Use and Recreation*	*Socio-economics*	*Terrestrial Bio. Resources*	*Cultural Resources*	*Visual Resources*	*Transportation*	*Noise*	*Air Quality and GHGs*	*Public Health and Safety*	*Utilities*	*Topography, Geology, and Soils*	*Groundwater Hydrology*	*Surface Waters and Wetlands*
	combination of retention devices and vegetation to allow stormwater to be retained and managed at the source, rather than relying on downstream efforts to control the flow of water and contaminants. Measures may include, but are not limited to, the following: • Stormwater ponds (retention/detention) • Stormwater wetlands • Infiltration practices • Filtering practices • Open channel practices • Minimizing exposure • Watershed-based management.														
Design Projects in Compliance with the Energy Policy Act of 2005	Energy Policy Act compliance includes analysis and life-cycle cost analysis using a simulated model and the following energy conservation measures: • Ensure that buildings achieve an energy consumption level that is 30% below the level achieved by ASHRAE Standard 90.1. • Use low energy consuming products that are either "Energy Star"-qualified or Federal Energy Management Program-recommended. • Optimize building orientation to reduce cooling loads or energy loads to cool the buildings. • Optimize building insulation. • Seal building envelope for air tightness. • Incorporate "cool roof" building designs. • Use motion detectors to reduce lighting and to setback cooling in unoccupied buildings. • Use of natural lighting.			X							X	X			

Design Facilities and Implement Procedures to Minimize Hazardous Waste and Ensure Proper Management of Hazardous Substances	Hazardous Materials Management Plans describe procedures for the transportation, storage, use, and disposal of hazardous materials. Procedures also include waste minimization plans that provide protocols designed to encourage and promote the efficient use of hazardous materials, substitute products that are less toxic whenever feasible, minimize their use, and promote recycling and reuse of hazardous materials. Procedures include: • Utilize hazardous materials spill/release control (use of secondary containment and leak detection methods in operations involving liquid hazardous substances). • Ensure construction materials and all construction-related materials are free of leachable pollutants. • Ensure U.S. military personnel are trained as to proper labeling, container, storage, staging, and transportation requirements for hazardous substances. Also, ensure they are trained in accordance with spill prevention, control, and cleanup methods. • Ensure that all personnel and contractors store, handle, and dispose of all petroleum, oil, and lubricants per all applicable local and federal laws, regulations, and requirements. • Ensure contaminated topsoil removed from the site is properly disposed of in an approved landfill in accordance with applicable regulatory requirements. • Ensure that soils to be excavated are well characterized, properly handled, and disposed of to minimize dispersal of any contaminants that may be present. • Locate temporary equipment laydown or construction staging areas in previously disturbed (e.g., paved) areas when feasible. • Minimize the use of			X	X						X			X	X

Best Management Practice, Standard Operating Procedure, or Minimization Measure	*Description*	*Public Access*	*Land Use and Recreation*	*Socio-economics*	*Terrestrial Bio. Resources*	*Cultural Resources*	*Visual Resources*	*Transportation*	*Noise*	*Air Quality and GHGs*	*Public Health and Safety*	*Utilities*	*Topography, Geology, and Soils*	*Groundwater Hydrology*	*Surface Waters and Wetlands*
	contaminated sites for new construction. When new construction occurs on sites where contamination and/or munitions and explosives of concern have been identified, ensure that the risk of human/ecological risk and exposure is minimized via the use of site-specific health and safety plans, engineering and administrative controls, and personal protective equipment. These site-specific health and safety plans must specifically address how these controls would be implemented to ensure the protection of human health and the environment.														
Spill Prevention, Control, and Countermeasures Plan and Facility Response Programs	• Update and implement existing Spill Prevention, Control, and Countermeasures Plan to assess and respond to hazardous substance spills and/or releases. • Update and implement existing Facility Response Programs for responding to releases, leaks, or spills of hazardous substances. • Ensure U.S. military personnel are trained as to proper labeling, container, storage, staging, and transportation requirements for hazardous substances. Also, ensure they are trained in accordance with spill prevention, control, and cleanup methods. • Ensure petroleum, oil, and lubricants/fuel transfers are kept away from water bodies and a response/contingency plan is in place in the event of any releases, leaks, or spills. • Ensure proper labeling of all			X	X						X		X	X	X

Best Management Practice, Standard Operating Procedure, or Minimization Measure	*Description*	*Public Access*	*Land Use and Recreation*	*Socio-economics*	*Terrestrial Bio. Resources*	*Cultural Resources*	*Visual Resources*	*Transportation*	*Noise*	*Air Quality and GHGs*	*Public Health and Safety*	*Utilities*	*Topography, Geology, and Soils*	*Groundwater Hydrology*	*Surface Waters and Wetlands*
	hazardous substance containers to prevent inappropriate storage or use. • Implement contaminant migration control (e.g., reducing contaminant migration pathways by preventing releases to drains, pipelines, and sewers and the use of absorbent pads and materials to prevent and control spills and releases). • Ensure that contaminants (e.g., oils, greases, lubrication fluids for heavy equipment) are properly stored at work sites and temporary construction staging areas to avoid spills, releases, and leaks. • Ensure that emergency response plans are in place for responding to releases, leaks, or spills of hazardous substances. • Minimize the risk of uncontrolled leaks, spills, and releases through industry and USMC-accepted methods for spill prevention, containment, control, and abatement. • Minimize the risk of human exposure to contaminated media through the use of a site-specific health and safety plan, engineering and administrative controls, and appropriate personal protective equipment (e.g., indicating where eye-wash stations, fire extinguishers, etc. are located).														
Munitions and Explosives of Concern Protocol, Procedures, and Guidance	• Comply with all applicable munitions and explosives of concern protocol, procedures, and guidance including, but not limited to, the NOSSA Instruction 8020.15E,			X	X						X		X	X	X

Best Management Practice, Standard Operating Procedure, or Minimization Measure	*Description*	*Public Access*	*Land Use and Recreation*	*Socio-economics*	*Terrestrial Bio. Resources*	*Cultural Resources*	*Visual Resources*	*Transportation*	*Noise*	*Air Quality and GHGs*	*Public Health and Safety*	*Utilities*	*Topography, Geology, and Soils*	*Groundwater Hydrology*	*Surface Waters and Wetlands*
	Explosives Safety Review, Oversight, and Verification of Munitions Responses, prior to any construction/demolition or other site activities; NAVFACMAR OPSNOTE 2020-002B: MEC Integrated Project Management; Munitions Response Explosives Safety Submission (MRESS) Tinian Construction Support and any supporting Annexes or Corrections to the MRESS. • Reduce the potential exposure to UXO through surveys or other means to identify and remedy this hazard prior to building upon a site. Work would be conducted by qualified UXO specialists. • Implement routine firing range clearance operations, perform sampling and analysis as deemed necessary, and implement all applicable U.S. military munitions and explosives of concern operations guidance to minimize or eliminate potential munitions and explosives of concern explosion hazards and other adverse impacts (including depositions with potential to leach into the subsurface). • Implement land use controls, signage, periodic inspections, and other means to ensure no unauthorized access to firing ranges, munitions and explosives of concern, and/or hazardous substances. • Train construction crews on identifying and responding to														

Best Management Practice, Standard Operating Procedure, or Minimization Measure	***Description***	***Public Access***	***Land Use and Recreation***	***Socio-economics***	***Terrestrial Bio. Resources***	***Cultural Resources***	***Visual Resources***	***Transportation***	***Noise***	***Air Quality and GHGs***	***Public Health and Safety***	***Utilities***	***Topography, Geology, and Soils***	***Groundwater Hydrology***	***Surface Waters and Wetlands***
	munitions and explosives of concern encountered in the field. UXO personnel would be available to monitor earthmoving activities.														
Biosecurity (also see Brown Treesnake Interdiction)	The DoD would: 1) Implement a biosecurity education program to inform the general public, contractors, and DoD civilian and military personnel about native versus non-native species, invasive species, and impacts of non-native invasive species on native species and ecosystems. USMC would follow the Marianas Training Manual (COMNAVMAR Instruction 3500.4A). Program materials may include educational brochures and posters that differentiate native and introduced species, define invasive species, describe the known impacts of invasive species on native species and ecosystems, and explain what can be done to prevent and control invasive species. 2) Coordinate biosecurity with federal and CNMI agencies. 3) Construct biosecurity facilities.				X										
Contractor Plans and Specifications	All construction would occur within the limits of construction shown in the project figures. Contractors would be responsible for any unauthorized vegetation damage and would not move outside the designated construction zone.				X	X									
Brown Tree Snake Interdiction	Joint Region Marianas has established a comprehensive brown tree snake interdiction program to ensure that military activities, including the transport of personnel and equipment from Guam, do not contribute to the spread of brown tree snake within the CNMI or other locations. Adherence to				X										

Best Management Practice, Standard Operating Procedure, or Minimization Measure	*Description*	*Public Access*	*Land Use and Recreation*	*Socio-economics*	*Terrestrial Bio. Resources*	*Cultural Resources*	*Visual Resources*	*Transportation*	*Noise*	*Air Quality and GHGs*	*Public Health and Safety*	*Utilities*	*Topography, Geology, and Soils*	*Groundwater Hydrology*	*Surface Waters and Wetlands*
	COMNAVMAR Instruction 3500.4A, *Marianas Training Manual, Appendix A: Brown Tree Snake Control and Interdiction Requirements*; COMNAVMAR Instruction 5090.10A, *Brown Tree Snake Control and Interdiction Plan*; 36 Wing Instruction 32-7004, *Brown Tree Snake Management*; and anticipated final Joint Region Marianas Instruction 5090.4, *Brown Tree Snake Control and Interdiction*, which would replace COMNAVMAR Instruction 5090.10A and 36 Wing Instruction 32-7004, and would minimize the likelihood of brown tree snake introduction to Tinian. In addition, for CJMT construction and training events, the DoD would commit to implementing 100% inspection of all outgoing aircraft and all outgoing cargo transported via ship or aircraft from Guam to CNMI with trained quarantine officers and dog detection teams. Redundant 100% inspections would also be conducted on Guam within snake-free quarantine areas for all cargo transported from Guam to Tinian. The snake-free quarantine areas would be subject to (1) multiple day and night searches for snakes with appropriately trained interdiction canine teams, (2) snake trapping, and (3) human visual inspection for snakes. For all brown tree snake interdiction work, the skills and standards required to certify an inspection team as "qualified" would be agreed upon mutually by the DoD, U.S. Geological Survey Biological Resources Discipline, and U.S. Fish and Wildlife Service. The DoD would produce standard operating procedures for temporary brown tree snake barrier construction														

Best Management Practice, Standard Operating Procedure, or Minimization Measure	*Description*	*Public Access*	*Land Use and Recreation*	*Socio-economics*	*Terrestrial Bio. Resources*	*Cultural Resources*	*Visual Resources*	*Transportation*	*Noise*	*Air Quality and GHGs*	*Public Health and Safety*	*Utilities*	*Topography, Geology, and Soils*	*Groundwater Hydrology*	*Surface Waters and Wetlands*
	and use when permanent quarantine facilities are not available or are inadequate in size. Standard operating procedures would ensure that temporary barriers would be constructed and maintained in a manner that ensures the efficacy of the barrier, and that staff maintaining and constructing the temporary barriers are trained and qualified prior to barrier construction and maintenance. Standard operating procedures would be developed in cooperation with the U.S. Geological Survey Biological Resources Discipline and the brown tree snake interdiction program to ensure that risk is adequately minimized. Barrier specifications and the qualifications of brown tree snake barrier maintenance and management staff would be mutually agreed upon by the DoD, U.S. Geological Survey Biological Resources Discipline, and U.S. Fish and Wildlife Service. The DoD would provide brown tree snake awareness briefings for all CJMT-associated military and contractor personnel prior to all CJMT construction and training events. Brown tree snake awareness briefings would be scaled to the type of activity to take place. Awareness materials may consist of a brown tree snake educational video and distribution of brown tree snake information and personal inspection guidelines. Awareness briefs would emphasize that brown tree snake awareness must extend through the chain of command from the Commanding Officer to the individual military service member or from the contract project manager to the individual contractor.														

Best Management Practice, Standard Operating Procedure, or Minimization Measure	*Description*	*Public Access*	*Land Use and Recreation*	*Socio-economics*	*Terrestrial Bio. Resources*	*Cultural Resources*	*Visual Resources*	*Transportation*	*Noise*	*Air Quality and GHGs*	*Public Health and Safety*	*Utilities*	*Topography, Geology, and Soils*	*Groundwater Hydrology*	*Surface Waters and Wetlands*
	The DoD would also plan for and support implementation of rapid response procedures in the event of a brown tree snake sighting on Tinian that is associated with military training. The DoD is aware of the limited availability of brown tree snake inspectors, trained dogs, and quarantine facilities and equipment on Guam and in the CNMI. Accordingly, the DoD would: • Coordinate closely with the U.S. Fish and Wildlife Service, brown tree snake interdiction program, brown tree snake rapid response program, and CNMI Department of Lands and Natural Resources staff on planning for training events in the CNMI; • Identify, along with these agencies, the inspection and interdiction requirements for CJMT activities, including the number of qualified quarantine officers and dog detection teams needed to ensure that inspection and interdiction requirements are met; and • In cooperation with U.S. Fish and Wildlife Service, brown tree snake interdiction program, brown tree snake rapid response program, and CNMI Department of Lands and Natural Resources staff, plan for and support implementation of brown tree snake rapid response procedures needed in the event of a brown tree snake sighting associated with military training.														

Best Management Practice, Standard Operating Procedure, or Minimization Measure	***Description***	***Public Access***	***Land Use and Recreation***	***Socio-economics***	***Terrestrial Bio. Resources***	***Cultural Resources***	***Visual Resources***	***Transportation***	***Noise***	***Air Quality and GHGs***	***Public Health and Safety***	***Utilities***	***Topography, Geology, and Soils***	***Groundwater Hydrology***	***Surface Waters and Wetlands***
Pest Control Measures	In accordance with OPNAVINST 6250.4C, *Navy Pest Management Programs* (April 11, 2012); OPNAVINST 5090.1D, *Environmental Readiness Program* (January 10, 2014); and MCO P5090.1A Chapter 3, *Environmental Compliance and Protection Manual* (August 26, 2013), the DoD would develop and implement a comprehensive Integrated Pest Management Plan. This Plan would encompass all activities regarding the importation, handling, storage, use, and application of pesticides as well as address prevention of the introduction of potential invasive species to CNMI. U.S. military personnel and contractors would be trained in accordance with appropriate pesticide management regulations, regarding the importation, handling, use, and application of pesticides (e.g., during maintenance, pre- and post-construction activities, and general operations activities).				X						X				
Armed Forces Pest Management Board Technical Guide 31	The DoD would continue bio-sanitation standard operating procedures to meet and validate the Armed Forces Pest Management Board Technical Guide 31 standards for munitions, military vehicles, equipment, and cargo prior to arrival and departure on-island.				X										

Best Management Practice, Standard Operating Procedure, or Minimization Measure	***Description***	***Public Access***	***Land Use and Recreation***	***Socio-economics***	***Terrestrial Bio. Resources***	***Cultural Resources***	***Visual Resources***	***Transportation***	***Noise***	***Air Quality and GHGs***	***Public Health and Safety***	***Utilities***	***Topography, Geology, and Soils***	***Groundwater Hydrology***	***Surface Waters and Wetlands***
Fire Prevention and Wildland Management Plan	The DoD would implement fire prevention and management specific to proposed CJMT activities upon initiation of live-fire training. Fire prevention and wildland management would include protocols for monitoring fire conditions and adjusting training as needed; establishing and managing fire breaks; establishing firefighting roads and water infrastructure; and educating training units. To minimize fire risk, vegetation within the Multi-Purpose Maneuver Range would be maintained to within 6 inches of the ground, and firebreaks would be established along the perimeter of the Multi-Purpose Maneuver Range.										X				
Joint Region Marianas Integrated Natural Resources Management Plan	In accordance with the USMC Conservation Program, the Integrated Natural Resources Management Plan would be updated with additional management tools developed in coordination with cooperating agencies to protect native vegetation on Tinian. The construction contractor would also conduct bird and turtle nesting surveys prior to construction and would coordinate avoidance and minimization measures as appropriate with U.S. Fish and Wildlife Service.				X										

Best Management Practice, Standard Operating Procedure, or Minimization Measure	*Description*	*Public Access*	*Land Use and Recreation*	*Socio-economics*	*Terrestrial Bio. Resources*	*Cultural Resources*	*Visual Resources*	*Transportation*	*Noise*	*Air Quality and GHGs*	*Public Health and Safety*	*Utilities*	*Topography, Geology, and Soils*	*Groundwater Hydrology*	*Surface Waters and Wetlands*
Design for Exterior Lighting	Whenever feasible, exterior night lighting would include wildlife-friendly design features such as shielded lights (to reduce ambient light), use of motion detectors and/or other automatic controls, long wavelength bulbs, lowest possible lumens, and lighting design that uses shields to prevent light from shining upward into the sky. ○ Outdoor lighting would be placed as low to the ground as possible, while still maintaining efficacy, to reduce ambient lighting into the environment that may impact wildlife. The necessary amount of exterior light fixtures would be determined for safety purposes, to avoid over lighting an outdoor space. ○ Lighting would be downward-directed and would shield the bulb, lamp, or glowing lens, whenever feasible to reduce impacts to seabirds and other wildlife. This includes full cut off shields whenever possible near shorelines and downward directed lights for landward side exterior lights. ○ Outdoor lighting would utilize bulbs that produce the lowest wattage/lumen necessary for their needed purpose. ○ Bulbs would emit long-wavelength light (560 nm or higher) such as red LED, orange LED, amber LED or low-pressure sodium (LPS) bulbs.				X										

Best Management Practice, Standard Operating Procedure, or Minimization Measure	***Description***	***Public Access***	***Land Use and Recreation***	***Socio-economics***	***Terrestrial Bio. Resources***	***Cultural Resources***	***Visual Resources***	***Transportation***	***Noise***	***Air Quality and GHGs***	***Public Health and Safety***	***Utilities***	***Topography, Geology, and Soils***	***Groundwater Hydrology***	***Surface Waters and Wetlands***
Implement Bird/Animal Aircraft Strike Hazard Plan	DoD would comply with Commonwealth Ports Authority BASH program at Tinian International Airport and in accordance with OPNAVINST 3750.6S. Naval Aviation Safety Management System would implement a Bird/Animal Aircraft Strike Hazard Plan to address all aircraft operations on Tinian. This plan is prepared to minimize the occurrence of bird/animal-aircraft strikes and would provide detailed procedures to monitor and react to heightened risk of aircraft strikes of birds and other animals.				X						X				
Implement Traffic Management Plan and Work Zone Traffic Management	In coordination with CNMI Tinian Department of Public Works, in order to minimize impacts of construction on vehicular travel, bicycle and pedestrian circulation, and/or access to destinations near the construction area, a construction management plan and appropriate traffic management strategies would be implemented. The traffic management plan may include the following elements: • A set of comprehensive traffic control measures, to be implemented during each construction phase and specific to each construction site, including scheduling of major truck trips and deliveries to avoid peak traffic hours; provision of detour signs if required; development of lane closure procedures, signs, and cones for drivers, bicycles, and pedestrians; and identification of designated construction access routes. • Notification procedures for adjacent property owners (for each construction site) and public safety personnel			X				X			X				

Best Management Practice, Standard Operating Procedure, or Minimization Measure	*Description*	*Public Access*	*Land Use and Recreation*	*Socio-economics*	*Terrestrial Bio. Resources*	*Cultural Resources*	*Visual Resources*	*Transportation*	*Noise*	*Air Quality and GHGs*	*Public Health and Safety*	*Utilities*	*Topography, Geology, and Soils*	*Groundwater Hydrology*	*Surface Waters and Wetlands*
	regarding the timing of major deliveries, detours, and lane closures. • A map depicting approved locations of construction staging areas for materials, equipment, and construction personnel vehicles. • A process for tracking and responding to complaints regarding construction activity. • Provision of parking management and spaces for construction workers. In addition, the following BMPs for the maintenance of roadways and public rights-of-way may be imposed on the general contractor during the construction periods: • Any damage to the roadways caused by heavy equipment or resulting from project construction shall be repaired. All damage that is a threat to public health or safety shall be repaired immediately. The public rights-of-way shall be restored to their preconstruction condition as established by a designated inspector and/or photo documentation.														

Best Management Practice, Standard Operating Procedure, or Minimization Measure	*Description*	*Public Access*	*Land Use and Recreation*	*Socio-economics*	*Terrestrial Bio. Resources*	*Cultural Resources*	*Visual Resources*	*Transportation*	*Noise*	*Air Quality and GHGs*	*Public Health and Safety*	*Utilities*	*Topography, Geology, and Soils*	*Groundwater Hydrology*	*Surface Waters and Wetlands*
	• Any heavy equipment brought to the construction site shall be transported by truck, where feasible. • No materials or equipment shall be stored on the traveled roadway at any time. • Portable toilet facilities and debris boxes shall be installed on the site before construction and shall be maintained properly through project completion. • Before the end of each work day during construction, the general contractor or other subcontractors shall pick up and properly dispose of all litter resulting from, or related to the project, whether located on the property, within the public rights-of-way, or properties of adjacent or nearby neighbors.														
Diesel Emissions Control on Off-road Equipment	• Comply with U.S. Environmental Protection Agency Tier 2 engine emission standards. • Use ultra-low sulfur diesel fuel. • Minimize truck idling time.			X						X	X				
Noise Abatement	BMPs to abate noise from construction include the following: • Ensure that all equipment items have the manufacturers' recommended noise abatement measures, such as mufflers, engine enclosures, and engine vibration isolators, intact and operational. • Inspect all construction equipment at periodic intervals to ensure proper maintenance and presence of noise control		X	X	X				X		X				

Best Management Practice, Standard Operating Procedure, or Minimization Measure	*Description*	*Public Access*	*Land Use and Recreation*	*Socio-economics*	*Terrestrial Bio. Resources*	*Cultural Resources*	*Visual Resources*	*Transportation*	*Noise*	*Air Quality and GHGs*	*Public Health and Safety*	*Utilities*	*Topography, Geology, and Soils*	*Groundwater Hydrology*	*Surface Waters and Wetlands*
	devices (e.g., mufflers and shrouding). • Turn off idling equipment. • Implement a construction noise monitoring program to limit the impacts. • Plan noisier operations during times least sensitive to receptors. • Avoid scheduling construction during nighttime hours (10:00 p.m. to 7:00 a.m.) and on weekends. • Keep noise levels relatively uniform and avoid impulsive noises. • Maintain good public relations with the community to minimize objections to the unavoidable construction impacts. • Provide frequent activity updates of all construction activities. BMPs to abate operational noise impacts include the following: • Implement approach and departure patterns to minimize noise over populated areas.														
Notice to Mariners and Notice to Airmen	Range Control would coordinate with the U.S. Coast Guard and Federal Aviation Administration to include when the danger zones would be active in the Notice to Mariners and Notice to Airmen.		X				X				X				
Energy and Water Conservation/Energy Policy Act	Implement Energy and Water Conservation/Energy Policy Act 2005, Executive Order 13221 (2001) to reduce energy and water consumption through conservation; efficiency; use of Energy Star appliances, building orientation, and insulation to reduce			X								X			X

Best Management Practice, Standard Operating Procedure, or Minimization Measure	*Description*	*Public Access*	*Land Use and Recreation*	*Socio-economics*	*Terrestrial Bio. Resources*	*Cultural Resources*	*Visual Resources*	*Transportation*	*Noise*	*Air Quality and GHGs*	*Public Health and Safety*	*Utilities*	*Topography, Geology, and Soils*	*Groundwater Hydrology*	*Surface Waters and Wetlands*
	energy use; setback thermostats; cool roof technology; solar energy; and efficient and/or natural lighting, among others.														
Solid Waste Recycling/Executive Order 13514	Recycle material from municipal solid waste, such as glass, paper, metals, etc.											X			
Green Waste and Construction and Demolition Debris Diversion	During construction and operations, all green waste would be processed for reuse on island (e.g., chip and reuse or chip and decompose in place). Construction and demolition debris would be diverted for reuse at a minimum of 50% (including such actions as concrete crushing and reuse as base material and grinding and reuse of asphaltic concrete from roads), in accordance with Executive Order 13693, *Planning for Federal Sustainability in the Next Decade*.				X							X			
Cultural Resources	During construction and operations, Integrated Cultural Resources Management Plan standard operating procedures would be followed including procedures for stop work and post-review discovery. The Integrated Cultural Resources Management Plan would be updated with required revisions in support of this proposed action. For post-review discoveries, an assessment would be made for National Register of Historic Places eligibility in consultation with the CNMI Historic Preservation Officer.			X		X									
Implement Range Training Area Management Plan	Manage live-fire ranges in accordance with MCO 3550.10, *Policies and Procedures for Range and Training Area Management*. Update the existing training area management plans to include the new live-fire ranges. There are many management practices addressed in the plan and mentioned above, which include the following: • Remove expended rounds from		X		X						X				

Best Management Practice, Standard Operating Procedure, or Minimization Measure	*Description*	*Public Access*	*Land Use and Recreation*	*Socio-economics*	*Terrestrial Bio. Resources*	*Cultural Resources*	*Visual Resources*	*Transportation*	*Noise*	*Air Quality and GHGs*	*Public Health and Safety*	*Utilities*	*Topography, Geology, and Soils*	*Groundwater Hydrology*	*Surface Waters and Wetlands*
	the ranges and transport them to an appropriate recycling contractor or smelter in accordance with appropriate regulations. • Develop and implement a Range Safety Program to conduct or coordinate training area safety, emergency response (medical and fire), Explosive Ordnance Disposal, Training Mishap Investigations, safety training, and range inspections. • Provide advanced notice for periods of range use to airmen, mariners, and the general public, as required for safe training area operations.														
Range Environmental Vulnerability Assessment Program	The USMC would utilize the Range Environmental Vulnerability Assessment program, in compliance with DoD Instruction 4715.14, to assess the potential impacts to human health and the environment from live-fire training operations. The purpose of the program is to identify whether there is a release or a substantial threat of a release of munitions constituents from an operational range or range complex area to off-range areas and determine if the release causes an unacceptable risk to human health and/or the environment. A baseline survey would be conducted before the Multi-Purpose Maneuver Range and Explosives Training Range are approved for use. After the live-fire ranges have been in use for a minimum of 1 year, an operational assessment would be conducted. Conservative fate and transport models of the Range Environmental Vulnerability Assessment-indicator munitions constituents (i.e., trinitrotoluene,			X	X						X		X	X	X

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APPENDIX E
APPLICABLE FEDERAL AND LOCAL REGULATIONS AND LAND USE AGREEMENTS

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APPENDIX E

E.1 APPLICABLE FEDERAL AND LOCAL REGULATIONS

This appendix provides a list of federal and Commonwealth of the Northern Mariana Islands (CNMI) regulations that may be required for implementation of the Proposed Action. The Department of Defense (DoD) Proposed Action would be implemented in accordance with all applicable regulatory mandates.

Table E-1 lists Executive Orders, Table E-2 lists federal regulations, and Table E-3 lists CNMI regulations. In addition, facilities would be designed and constructed in accordance with Unified Facilities Criteria (UFC), including Seismic Design for Buildings (UFC 3-310-04).

Table E-1. Executive Orders

Regulatory Requirement	*Resource Area*
Executive Order 12788: Defense Economic Adjustment Program	Socioeconomics
Executive Order 11990: Protection of Wetlands	Surface Waters and Wetlands
Executive Order 13112: Invasive Species	Terrestrial Biological Resources
Executive Order 13186: Responsibilities of Federal Agencies to Protect Migratory Birds	Terrestrial Biological Resources
Executive Order 13751: Safeguarding the Nation from Impacts of Invasive Species	Terrestrial Biological Resources
Executive Order 10854: Extension of the Application of the Federal Aviation Act of 1958	Transportation

Table E-2. Federal Law and Regulation

Regulatory Requirement	*Resource Area*
Clean Air Act 42 U.S.C. section 7401 et seq.	Air Quality and Greenhouse Gases; Utilities
National Environmental Policy Act, 42 U.S.C. section 4321 et seq.	All
Procedures for Implementing the National Environmental Policy Act, 32 C.F.R. 775	All
Environmental Readiness Program Manual, OPNAV M-5090.1	All
DON, Marine Corps Order 5090.2, Environmental Compliance and Protection Program	All
Historic Sites Act, 16 U.S.C. section 461-467	Cultural Resources
Abandoned Shipwreck Act, 43 U.S.C. sections 2101–2106 National Historic Landmarks Program, 36 C.F.R. 65	Cultural Resources
Sunken Military Craft Act of 2004, 10 U.S.C. 113–118 Protection of Historic Properties, 36 C.F.R. 800	Cultural Resources
Determinations of Eligibility for Inclusion in the National Register of Historic Places, 36 C.F.R. 63	Cultural Resources
American Battlefield Protection Act as amended, 16 U.S.C. section 469k	Cultural Resources
Archaeological Resources Protection Act of 1979, 16 U.S.C.	Cultural Resources

Regulatory Requirement	***Resource Area***
470aa-470mm; Public Law 96-95 as amended	
Curation of Federally-Owned and Administered Archeological Collections, 36 C.F.R. Part 79	Cultural Resources
National Historic Preservation Act, 54 U.S.C. section 300101 et seq.	Cultural Resources
National Register of Historic Places, 36 C.F.R. Part 60	Cultural Resources
Department of Defense Instruction 4715.16, Cultural Resources Management	Cultural Resources
Territorial Submerged Lands Act, 48 U.S.C. sections 1701–1708	Land Use
Covenant to Establish a Commonwealth of the Northern Mariana Islands in Political Union with the United States of America, U.S. Public Law 94-241, 90 Stat. 272, Article 8 (1976)	Land Use
Proclamation No. 9077, 79 Federal Register 3479 (January 15, 2014)	Land Use
Coastal Zone Management Act Federal Consistency Regulations (15 C.F.R. Part 930)	Land Use
Air Pollution Control Act (Title IV – Noise Pollution), 42 U.S.C. section 7641	Noise
Occupational Safety and Health, 29 U.S.C. section 651 et seq.	Noise
Department of Defense Instruction 4715.13, DoD Operational Noise Program	Noise
Federal Aviation Administration Regulation 150/5370-2G, 14 C.F.R. Part 77, Operational Safety on Airports During Construction	Public Health and Safety
Federal Aviation Administration Regulation, 14 C.F.R. Part 91, General Operating and Flight Rules	Public Health and Safety
Navigable Airspace regulations, 14 C.F.R. Part 77	Public Health and Safety
MCO 5530.14A, Marine Corps Physical Security Program Manual (U.S. Marine Corps 2009)	Public Health and Safety
UFC 4-020-01, DoD Security Engineering Facilities Planning Manual (DoD 2008a)	Public Health and Safety
MCO 3570.1C, Range Safety (U.S. Marine Corps 2012)	Public Health and Safety
MCO 5100.29C, Marine Corps Safety Management System, Volume 7, Marine Corps Radiation Safety Program (U.S. Marine Corps 2021)	Public Health and Safety
Toxic Substances Control Act (40 C.F.R. 761)	Public Health and Safety, Surface Waters and Wetlands
Comprehensive Environmental Response Compensation and Liability Act, 42 U.S.C. sections 9601 to 9675	Public Health and Safety; Surface Waters and Wetlands
Emergency Planning and Community Right-to-Know Act, 42 U.S.C. sections 11001 to 11050	Public Health and Safety; Topography, Geology, and Soils; Surface Waters and Wetlands
Military Base Reuse Studies and Community Planning Assistance, 10 U.S.C. section 2391	Socioeconomics
Rivers and Harbor Act, 33 U.S.C. section 403, Section 10	Surface Waters and Wetlands
Coastal Zone Management Act, 16 U.S.C. ch.33 section 1451 et seq.	Surface Waters and Wetlands; Land Use; Topography, Geology, and

Regulatory Requirement	***Resource Area***
	Soils
Safe Drinking Water Act, 42 U.S.C. sections 300f to 300j-26	Surface Waters and Wetlands; Utilities; Groundwater Hydrology
Endangered Species Act, 16 U.S.C. sections 1531–1544	Terrestrial Biological Resources
Migratory Bird Treaty Act, 16 U.S.C. sections 703–712	Terrestrial Biological Resources
Fish and Wildlife Coordination Act	Terrestrial Biological Resources
Department of Defense Instruction 4715.03, Natural Resources Conservation Program	Terrestrial Biological Resources
Farmland Protection Policy Act, 7 U.S.C. section 4201	Topography, Geology, and Soils
Hazardous Materials Transportation Safety Act, 49 U.S.C. sections 1801–1819	Topography, Geology, and Soils
Toxic Substances Control Act, 15 U.S.C. sections 2601-2629	Topography, Geology, and Soils
Department of Defense Construction Guidelines (UFC 3-310-04) addressing seismic activity	Topography, Geology, and Soils; Public Health and Safety
Clean Water Act, 33 U.S.C. section 1251 to 1387 • Section 401, Certification and Wetlands • Section 402, National Pollutant Discharge Elimination System • Section 404, Dredge/fill navigable waters	Topography, Geology, and Soils; Public Health and Safety; Groundwater Hydrology
Security Zones; Tinian, CNMI (33 C.F.R. 165.1403)	Transportation
Shipping Safety Fairways (33 C.F.R. 166)	Transportation
Offshore Traffic Separation Themes (33 C.F.R. 167)	Transportation
Federal Highway Administration's *A Policy on Geometric Design of Highways and Streets* (American Association of State Highway and Transportation Officials 2011)	Transportation
UFC 3-250-18FA, *General Provisions and Geometric Design For Roads, Streets, Walks, and Open Storage Areas* (Department of Defense 2004)	Transportation
Aeronautics and Space, 4 C.F.R. Part 73, Special Use Airspace	Transportation
Department of Defense Directive 5030.19, Department of Defense Responsibilities on Federal Aviation	Transportation
U.S. Department of Transportation regulations and C.F.R. Title 49	Transportation
FAA Advisory Circular 70/7460-1, Obstruction Marking and Lighting	Transportation
FAA Order Job Order 7400.2, Procedures for Handling Airspace Matters	Transportation
FAA Order Job Order 7400.10, Special Use Airspace	Transportation
FAA Order Job Order 7110.65, Air Traffic Control	Transportation
FAA Order 7930.2, Notices to Airmen	Transportation
FAA Order 8260.19, Flight Procedures and Airspace	Transportation
Title 49, U.S.C. section 40101 et seq., Air Commerce and Safety	Transportation
Federal Highway Administration, Department of Transportation, 23 C.F.R. sections 1–1275	Transportation

Regulatory Requirement	*Resource Area*
Solid Waste Disposal, 42 U.S.C. section 7401 et seq.	Utilities
Resource Conservation and Recovery Act, including Military Munitions Rule 42 U.S.C. sections 6901 to 6992k	Utilities; Public Health and Safety; Surface Waters and Wetlands; Topography, Geology, and Soils

Legend: C.F.R. = Code of Federal Regulations; DoD = Department of Defense; DON = Department of the Navy; FAA = Federal Aviation Administration; MCO = Marine Corps Order; OPNAV = Office of the Chief of Naval Operations; UFC = Unified Facilities Criteria; U.S. = United States; U.S.C. = United States Code.

Table E-3. CNMI Regulations

Regulatory Requirement	*Resource Area*
CNMI Public Law 3-39, the Commonwealth Historic Preservation Act of 1982	Cultural Resources
CNMI Public Law 3-33; establishes a permit and penalty process for the excavation and removal of human remains	Cultural Resources
CNMI Public Law 10-71; amends the Commonwealth Historic Preservation Act of 1982 to increase the membership of the Review Board and to increase the monetary penalty for violations of the Act	Cultural Resources
Well Drilling and Well Operation Regulations (CNMI Administrative Code Chapter 65-140)	Groundwater Hydrology
Water Quality Standards, Northern Mariana Islands Administrative Code section 65-130	Groundwater Hydrology
Coastal Resources Management Act, (2 CMC section 1501 et seq.)	Land Use
Public Lands Act (Public Law 15-2)	Land Use
CNMI Constitution Article XI, Public Lands	Land Use
CNMI Public Law 16-50 (2010), as amended by Public Law 20-05 (2017)	Land Use
CNMI Public Law 15-10 (2018), Coastal Resources Management Rules and Regulations	Land Use
CNMI Homestead Program, CNMI Public Law 15-02 (2007)	Land Use
Constitution of the CNMI, Section 9	Noise
Harmful Substance Clean Up Regulations	Public Health and Safety
Hazardous Waste Management Regulations	Public Health and Safety
DoD Construction Guidelines addressing seismic activity, Unified Facilities Criteria 3-310-04	Public Health and Safety
Commonwealth Environmental Protection Act, Public Law 3-23	Public Health and Safety
Above Ground Storage Tank Regulations, Northern Mariana Islands Administrative Code section 65-5	Public Health and Safety
CNMI Coastal Resources Management Rules and Regulations (Administrative Code Title 15-10)	Socioeconomics
Wastewater Treatment and Disposal Rules and Regulations Wastewater Treatment and Disposal Rules and Regulations (CNMI Administrative Code Chapter 65-120)	Surface Waters and Wetlands
Drinking Water Regulations (CNMI Administrative Code Chapter 65-20)	Surface Waters and Wetlands; Groundwater Hydrology
Threatened and Endangered Species (CNMI Administrative Code section 85-30.1-101)	Terrestrial Biological Resources

Regulatory Requirement	*Resource Area*
Endangered Species Act, Public Law 2-51	Terrestrial Biological Resources
Federal Aid in Wildlife Restoration Act	Terrestrial Biological Resources
Title 2 Section 5103: Conservation Offices	Terrestrial Biological Resources
Title 85 Section 309.1 100: Threatened and Endangered Species	Terrestrial Biological Resources
Water Quality Standards, Northern Mariana Islands Administrative Code section 65-140	Topography, Geology, and Soils; Groundwater Hydrology; Utilities
Environmental Protection Act (2 CMC section 3101 et seq.)	Topography, Geology, and Soils; Public Health and Safety; Surface Waters and Wetlands
Earthmoving and Erosion Control Regulations, Regulations (CNMI Administrative Code Chapter 65-30)	Topography, Geology, and Soils; Public Health and Safety; Utilities
CPA, Seaport Division, Northern Mariana Islands Administrative Code section 40-20	Transportation
DPW, Public Rights-of-way and Related Facilities Regulations, Northern Mariana Islands Administrative Code section 155-20.1	Transportation
CPA Title 40-10, Airport Division	Transportation
Specific Regulated Navigation Areas and Limited Access Areas, Island of Tinian, CNMI (33 C.F.R. 110.239)	Transportation
Solid Waste Management Regulations (CNMI Administrative Code Chapter 65-80)	Utilities
Underground Injection Control Regulations (CNMI Administrative Code Chapter 65-90)	Utilities
CNMI and Guam Stormwater Management Manual (2006)	Utilities
Pesticide Management Regulations, Northern Mariana Islands Administrative Code section 65-70	Utilities
Air Pollution Control Regulations (CNMI Administrative Code Chapter 65-10)	Utilities; Air Quality and Greenhouse Gases

Legend: C.F.R. = Code of Federal Regulations; CMC = Commonwealth Code; CNMI = Commonwealth of the Northern Mariana Islands; CPA = Commonwealth Ports Authority; DoD = Department of Defense; DPW = Department of Public Works.

E.2 LAND AGREEMENTS WITHIN THE MILITARY LEASE AREA

The history of DoD use of the Military Lease Area has been defined by several land use agreements, beginning in 1975:

- **1975 Covenant and Technical Agreement.** Sections 802 and 803 of the *Covenant to Establish a Commonwealth of the Northern Mariana Islands in Political Union with the United States of America* (hereinafter "the Covenant") (United States of America and the Commonwealth of the Northern Mariana Islands 1975) along with the concurrently adopted *Technical Agreement Regarding Use of Land to Be Leased by the United States in the Northern Mariana Islands*, made property available to the United States (U.S.) by lease to enable it to carry out its defense responsibilities. This property included approximately 17,799 acres on Tinian. As part of the agreements, all shoreline areas in and around the northern two-thirds of Tinian would remain open to anglers at all possible times except for those limited areas that must be closed to comply with safety, security, and hazardous risk requirements from either military activities or commercial activities. In addition, the Covenant assured CNMI residents the same access to beach areas that military personnel and dependents would have, limited only by safety restrictions during times of active military training. During times of military maneuvers, operations, or related activity, the public use of certain beaches or areas of the beach would be restricted.

- **1983 Lease.** In 1983, the U.S. entered into a lease agreement with the Marianas Public Land Corporation and the CNMI for use of property to carry out DoD defense responsibilities on Tinian. The term of the lease agreement is 50 years, with an option to renew at the sole discretion of the U.S. for an additional 50 years. Under the lease provisions, the Federal government shall have the right to construct, place, erect, or install such buildings, structures, equipment, and facilities as may be necessary.
- **1988 Lease Amendment.** In 1988, the U.S. leased back approximately 709 acres for the Francisco Manglona Borja / Tinian International Airport (TNI) and expansion land north of the airport back to the Commonwealth Ports Authority for use as a public airport. The 1988 leaseback agreement allowed for future military use, future joint use, and modification or termination of the leaseback agreement as necessary to support defense operations.
- **1994 Lease Amendment.** In 1994, the U.S. declared approximately 1,245 acres of lease property south of TNI, including the area surrounding the Port of Tinian, as surplus and moved to dispose of the property. Within the 1994 disposal area, the Federal government reserved rights related to the use of San Jose Harbor (i.e., Tinian Harbor), the temporary use of surplus land for military training exercises, and the operation of fuel and utility lines between San Jose Harbor and the remaining leased areas. The 1994 lease amendment also expanded the Exclusive Military Use Area by approximately 3,312 acres through the redesignation of Lease Back Area lands north of Dankulo Beach Road. Under the 1994 Lease Amendment (Article 1, Section G), "permanent improvements may be permitted on the Premises with the prior written consent of the U.S."
- **1999 Lease Agreement.** In 1999, the U.S. terminated the 1988 lease-back agreement with the Commonwealth Ports Authority and conveyed 709 acres comprising TNI property and expansion land north of the airport to the CNMI. The 1999 lease agreement also conveyed approximately 645 acres north of TNI, known as the West Tinian Airport Expansion Land, to the CNMI. In addition, the 1999 lease agreement released leasehold interest in 10 acres at Unai Masalok and lands along public rights-of-way within the 1994 Lease Back Area and disposal area.
- **1999 Conservation Agreement.** Concurrent with the 1999 lease agreement, the U.S. and the CNMI agreed to preserve approximately 970 acres of Lease Back Area lands for wildlife conservation for the Tinian monarch. In accordance with the conservation agreement, and as stated in the U.S. Fish and Wildlife Service Biological Opinion 1-2-98-F-07, the military retains the right to use the Wildlife Conservation Area for low-impact, non-habitat-destructive military training.
- **2019 Lease Agreement.** In 2019, the U.S. and the Commonwealth Ports Authority entered into an agreement for the lease of real property at and adjacent to TNI and at the Port of Tinian. This agreement supports implementation of the Pacific Air Forces Divert project. This initial lease was for a term of 40 years, with a renewal request authorized no later than 5 years prior to the expiration of the lease term. Although this lease includes areas covered by previous lease agreements, this lease does not change, amend, or otherwise alter the

1994 or the 1999 lease agreements. It includes non-exclusive use of taxiways at TNI and easement areas for construction and utilities.

- **2023 Lease Agreement.** In 2023, the U.S. and the CNMI signed an administrative amendment to the 1983 agreement. The administrative amendment grants the U.S. “the right to the reasonable use of roadways as well as the right to improve, construct, maintain and repair roads and utilities owned by the Commonwealth including all supporting facilities and structures. All such improvements shall be made in the easement areas or in such other location authorized by the Commonwealth following coordination with the Commonwealth regarding the improvement, construction, maintenance, and repair.” Under the amendment, the CNMI government “reserves the right to construct improvements including additional roads and utility lines and pipelines and to grant additional nonexclusive easements and rights of way on, in, under, across, through and over the easement areas as it shall determine to be in the public interest, provided that the Commonwealth shall consult with the U.S. prior to granting any such easements and obtain written concurrence of the U.S. that any such additional grants are not inconsistent with the use of the affected easement area by the U.S.”

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APPENDIX F
RESERVED

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APPENDIX G
TERRESTRIAL BIOLOGY SURVEY REPORT

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Final

Survey Report for Surveys of Federally Listed Species

Revised Environmental Impact Statement for the Proposed Commonwealth of the Northern Mariana Islands Joint Military Training on the Island of Tinian

Department of the Navy

Naval Facilities Engineering Systems Command, Pacific

258 Makalapa Drive, Suite 100

Joint Base Pearl Harbor-Hickam, HI 96860-3134

Prepared under: Contract N62742-18-D-1802, Task Order N6274222F0161

August 2023

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FINAL

SURVEY REPORT FOR SURVEYS OF FEDERALLY LISTED SPECIES

REVISED ENVIRONMENTAL IMPACT STATEMENT FOR THE PROPOSED COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS JOINT MILITARY TRAINING ON THE ISLAND OF TINIAN

Prepared By:
Cardno Government Services – AECOM Pacific Joint Venture

Prepared For:
Naval Facilities Engineering Systems Command, Pacific

Purpose: Surveys of Federally Listed Species in Support of the Revised Environmental Impact Statement for the Proposed Commonwealth of the Northern Mariana Islands Joint Military Training on the Island of Tinian

Date: 25 August 2023

Recommended Citation:
Cardno Government Services – AECOM Pacific Joint Venture. 2023. Final Survey Report for Surveys of Federally Listed Species, Revised Environmental Impact Statement for the Proposed Commonwealth of the Northern Mariana Islands Joint Military Training on the Island of Tinian. Prepared for NAVFAC Pacific under Contract N62742-18-D-1802, Task Order N6274222F0161. August.

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Final Survey Report for Surveys of Federally Listed Species

Revised Environmental Impact Statement for the Proposed Commonwealth of the Northern Mariana Islands Joint Military Training on the Island of Tinian

TABLE OF CONTENTS

List of Figures

List of Tables

List of Appendices

ACRONYMS AND ABBREVIATIONS

CJMT	Commonwealth of the Northern Mariana Islands Joint Military Training
CNMI	Commonwealth of the Northern Mariana Islands
EIS	Environmental Impact Statement
GIS	geographic information system
GPS	global positioning system
JV	Joint Venture
NAVFAC	Naval Facilities Engineering Systems Command
U.S.	United States
USFWS	United States Fish and Wildlife Service

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CHAPTER 1 INTRODUCTION

1.1 BACKGROUND AND OVERVIEW

In April 2023, the Cardno GS – AECOM Pacific Joint Venture (JV) team performed surveys of federally listed species (those listed as threatened or endangered under the Endangered Species Act) in support of environmental planning and analysis for the Commonwealth of the Northern Mariana Islands (CNMI) Joint Military Training (CJMT) Revised Environmental Impact Statement (EIS) on the island of Tinian. Naval Facilities Engineering Systems Command (NAVFAC) Pacific is the administering agency for this task order. As outlined in the work plan prepared for the surveys (NAVFAC Pacific 2023), the JV conducted a presence/absence survey of the following federally listed species in the CJMT survey area:

- *Partula gibba* (humped tree snail) (federally endangered)
- *Solanum guamense* (berenghenas halomtano) (federally endangered)
- *Dendrobium guamense* (no common name) (federally threatened)
- *Heritiera longipetiolata* (ufa-halomtano) (federally endangered)

Previous surveys documented the presence of humped tree snail, *D. guamense*, and *H. longipetiolata* on Tinian (Table 1-1; Figures 1-1 and 1-2) (NAVFAC Pacific 2014, 2018, 2019). Historically, *S. guamense* likely occurred on Tinian; however, in recent decades it was only known from the island of Guam. Currently, all known populations of *S. guamense* have been extirpated, including historical populations on Tinian (United States [U.S.] Fish and Wildlife Service [USFWS] 2020).

Table 1-1 lists the three most recent surveys of federally listed species on Tinian, species surveyed for, and species detections.

Table 1-1 Recent Surveys of Federally Listed Species on Tinian

Survey Type	***Survey Year(s)***	***Federally Listed Species Surveyed for and Presence/Absence Results on Tinian***
Federally listed snail and plant species	2019	Humped tree snail (*Partula gibba*) (not detected) *Dendrobium guamense* (detected in the Mount Lasso region) *Heritiera longipetiolata* (detected in coastal karst limestone areas)
Federally listed plant species	2016-2018	*Solanum guamense* (not detected) *Dendrobium guamense* (detected in the Mount Lasso region) *Heritiera longipetiolata* (detected in coastal karst limestone areas) *Tuberolabium guamense* (not detected)
Terrestrial biological resources	2013	Micronesian megapode (*Megapodius laperouse*) (not detected) Mariana common moorhen (*Gallinula chloropus guami*) (detected at wetland locations) Humped tree snail (live individuals detected at Dump Coke region of Lamanibot Bay)

Sources: NAVFAC Pacific 2014, 2018, 2019.

Figure 1-1 CJMT Survey Area – Vegetation Communities

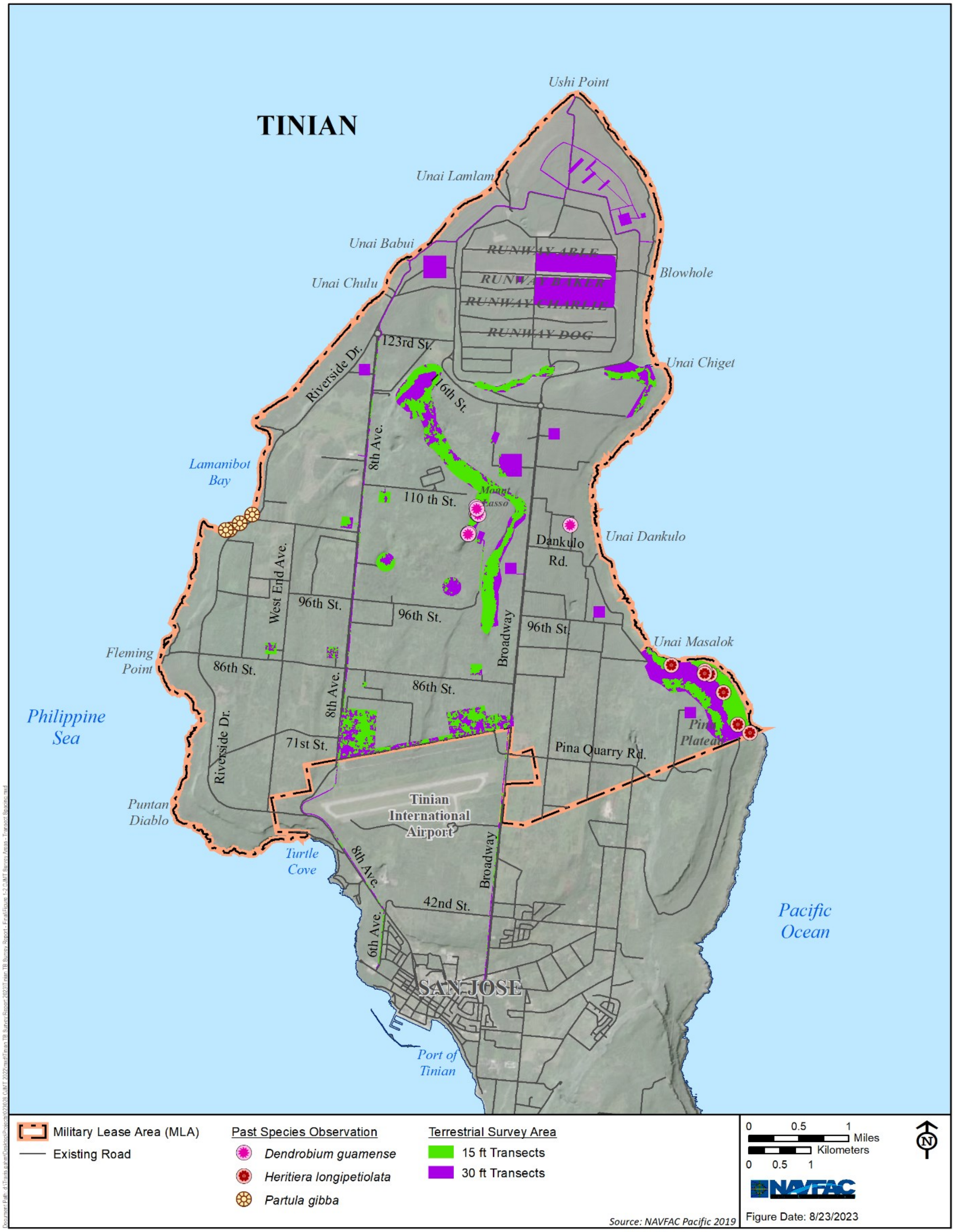

Figure 1-2 CJMT Survey Area – Transect Spacing

1.2 Purpose

The purpose of the federally listed species surveys was to document the presence and population status of the four federally listed species identified in Section 1.1. The results of the surveys summarized in this report, as well as data collected from past surveys, will be incorporated into the CJMT Revised EIS and supporting Biological Assessment to assess the potential environmental impacts of the proposed action and to develop avoidance, minimization, and conservation measures, where applicable.

1.3 Project Contacts

The Cardno GS–AECOM Pacific Joint Venture Team members involved in performing the project tasks are listed in Table 1-2 along with their project-specific roles.

Table 1-2 Personnel for Surveys of Federally Listed Species on Tinian

Role	*Name*	*Organization*
Project Management/Technical Support		
TOCOR	Lesley Matsumoto	NAVFAC Pacific
Alternate TOCOR	Garwin Eng	NAVFAC Pacific
Project Manager	Douglas Gilkey	JV
Terrestrial Project Manager	Ben Berridge	JV
Lead Health and Safety Officer	Lynne Black	JV
GIS Specialist	Travis Gahm	JV
In-Field Survey Leads		
Lead Field Biologist and Onsite Health and Safety Officer	Clint Scheuerman	JV
Terrestrial Biology TPOC	Coralie Cobb	NAVFAC Pacific
Additional Survey Personnel		
Field Biologist	Josh De Guzman	JV
Field Biologist	John Lowenthal	JV
Field Biologist	Aja Reyes	JV
Field Biologist	Todd Finlayson	JV
Field Biologist	Colleen Smith	JV
Field Biologist	Claudine Camacho	Dueñas Camacho & Associates
Field Biologist	Jessica Gross	Dueñas Camacho & Associates
Field Biologist	Joney Rengiil	Dueñas Camacho & Associates
Field Biologist	Domanique Smith	Sundance Consulting Inc.
Field Biologist	Trevor Boykin	Sundance Consulting Inc.
Field Biologist	John Hapdei	Island Eco Services
Field Biologist	Dorian Hadoar	Island Eco Services
Field Biologist	Arnold Ulith	Island Eco Services
Field Biologist	Nicholas Lenger	Island Eco Services

Notes: GIS = geographic information system; JV = Joint Venture; TOCOR = Task Order Contracting Officer Representative; TPOC = Technical Point of Contact; NAVFAC = Naval Facilities Engineering Systems Command.

1.4 Survey Area

The survey area components are located throughout the northern portion of the island, totaling approximately 1,543 acres, and the survey area components and names are reflected in Figure 1-3. For the purpose of this project, and in accordance with the final work plan, the survey area was divided into two distinct transect areas based on the required transect spacing between surveyors, either 30 feet (non-limestone habitats) or 15 feet (limestone habitats) apart. These distinct transect areas are represented in Figure 1-2 and are detailed in Table 1-3.

Figure 1-3 CJMT Survey Area Components

1.4.1 Vegetation Communities

Figure 1-1 depicts the distinct vegetation communities in the survey area. Table 1-1 provides the vegetation communities and acreages broken out by transect area within the survey area. The dominant vegetation type within the combined survey area is *Leucaena* forest, followed by limestone degraded forest, and, to a lesser degree, limestone native forest.

The vegetation communities in the survey area are described briefly below per the descriptions provided in NAVFAC Pacific (2019) that are based on Amidon (2017) with modifications from NAVFAC Pacific (2018).

Barren

This community classification applies to areas of barren, non-vegetated soil, sand, or rock, and occurs both inland and along the coastline.

Casuarina Forest

Ironwood or Australian pine (*Casuarina equisetifolia*) tolerates dry and salty or exposed conditions. It forms a sparse forest or woodland with little understory. Although it tends to function ecologically as an invasive species, ironwood is generally accepted as native to the Mariana Islands.

Coconut Forest

Coconut forest is a cover type almost exclusively dominated by coconut palm (*Cocos nucifera*). Stands of this forest type can have either minimal understory or can support a relatively diverse understory of mixed native and non-native shrubs, herbs, and/or ferns. Some of these stands may be remnants of previous coconut plantations while others may be the result of natural dispersion.

Developed

These are human-occupied or otherwise highly disturbed areas that include lawns and other anthropogenically landscaped or maintained areas (e.g., mowed fields, utility corridors), buildings, roads, parking lots, and other paved areas.

Leucaena Forest

This plant community is dominated by tangantangan (*Leucaena leucocephala*), and typically occurs on limestone where it can occur in pure stands. In areas where it is adjacent to native forest, *Leucaena* forest can be invasive, mixing with native woody species. While not considered a native vegetation community on Tinian, *Leucaena* forest does provide habitat for some native bird species.

Limestone Coastal Scrub

This native-dominated plant community is present on limestone terraces and cliff edges. The floristic composition may be either simple or complex and composed of a few or many species. Species may include some of those found in limestone native forest, such as fig species (*Ficus* spp.), but are stunted by climactic conditions. Other woody species such as bantigue (*Pemphis acidula*) and great woolly Malayan lilac (*Callicarpa candicans*) occur in this community near coastlines.

Table 1-3 Vegetation within the Survey Area Components

Survey Area Component	***Limestone Habitat (15-foot Transect Areas)***			***Non-limestone Habitats (30-foot Transect Areas)***								**TOTAL**
	Limestone Coastal Scrub	**Limestone Degraded Forest**	**Limestone Native Forest**	**Barren**	***Casuarina* Forest**	**Coconut Forest**	**Developed**	***Leucaena* Forest**	**Open Water**	**Other Scrub/ Grassland**	**Scrub/ Shrub**	
Base Camp Alternative 1[1]	-	62.74	-	-	19.73	-	1.92	0.16	-	30.87	-	**115.42**
Base Camp Alternative 2[2]	-	61.17	-	-	11.70	-	0.23	0.01	-	25.31	-	**98.42**
ETR Options	-	1.41	-	-		-	-	5.01	-	3.31	-	**9.73**
LZ Areas	-	32.25	-	-	0.68	-	-	93.94	-	23.81	6.33	**157.01**
MPMR Perimeter Road and Firebreak	-	-	-	-	-	-	0.09	11.28	-	-	-	**11.37**
MPMR	-	-	-	-	-	-	0.12	13.75	-	-	-	**13.87**
New Roads	-	3.02	-	-	0.26	-	0.02	2.08	-	0.73	0.22	**6.33**
Primary Utility Corridor	0.07	16.84	-	0.02	0.11	0.03	25.27	21.60	-	19.93	0.42	**84.29**
Surface Radar Sites	0.08	0.10	-	0.07	0.02	-	0.14	0.03	-	-	-	**0.44**
Utilities and Access Corridor (Alternatives 1 and 2)[3]	-	-	-	-	-	-	-	-	-	-	-	**0.00**
Mount Lasso Limestone Forest	-	149.64	120.29	-	7.95	-	-	54.22	-	37.39	11.59	**381.08**
Pina Plateau Limestone Forest	20.51	46.36	57.36	0.53	-	-	2.24	122.67	-	6.68	2.46	**258.81**
Bateha Wetland Buffer	-	15.49	-	1.02	-	0.06	0.01	0.01	-	19.47	-	**36.06**
Chiget Limestone Forest	0.06	19.07	37.89	0.39	0.14	-	-	43.50	0.44	0.70	0.58	**102.77**
Unai Masalok	12.39	-	-	0.53	2.53	-	0.06	1.55	0.18	0.09	4.73	**22.06**
AHAs	-	1.20	-	-	-	-	-	1.39	-	0.19	-	**2.78**
North Field Drop Zone	-		-	-	8.12	-	12.52	190.75	-	0.02	28.52	**239.93**
Aircraft Shelter (North Field Drop Zone)	-		-	-	-	-	-	2.29	-	-	-	**2.29**
TOTAL	**33.11**	**409.29**	**215.54**	**2.56**	**51.24**	**0.09**	**42.62**	**564.24**	**0.62**	**168.50**	**54.85**	***1,542.67***

Legend: AHA = Ammo Holding Area; ETR = Explosive Training Range; LZ = Landing Zone; MPMR = Multi-purpose Maneuver Range.

Notes: [1]Total acreage includes Base Camp 1 and 2 areas of overlap.
[2]Total acreage excludes Base Camp 1 and 2 areas of overlap.
[3]Occurs in the Base Camp corridor (no additional acreage, and not shown on Figure 1-3).

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Limestone Degraded Forest

This cover type consists of limestone forest plant communities that have been significantly disturbed by clearing, invasive plants, and introduced animals. This vegetation community tends to exhibit one or more of the following characteristics: (1) the dominance of a variety of non-native woody species; (2) substantial forest clearings (visible in aerial imagery); or (3) dominance of sea hibiscus (*Talipariti tiliaceum*) (NAVFAC Pacific 2018). Common non-native tree species in this type of disturbed limestone forest on Tinian include siris tree (*Albizia lebbeck*), Formosan koa (*Acacia confusa*), flame tree (*Delonix regia*), and Madras thorn (*Pithecellobium dulce*). Native tree species in these forests often include one or more of the following species: headache tree (*Premna serratifolia*), screw pine (*Pandanus tectorius*), fingersop (*Meiogyne cylindrocarpa*), and mapunyao (*Aglaia mariannensis*).

Limestone Native Forest

This native community type is a relatively undisturbed forest that occurs on shallow limestone soils dominated by native tree and shrub species. Forest clearings from ungulate or other disturbances tend to be absent or very limited. The term limestone native forest also describes areas that may have been cleared and have regrown to be dominated by native tree and shrub species. Dominant tree species in these forests usually include one or more of the following: twin-apple (*Ochrosia oppositifolia*), fig species, headache tree, screw pine, fingersop, sea hibiscus, cedar bay cherry (*Eugenia reinwardtiana*), mapunyao, and *Macaranga thompsonii* (no common name). On Tinian, the very large, canopy-emergent trees wrinkle pod mangrove (*Cynometra ramiflora*), *Mammea odorata* (no common name), *H. longipetiolata*, Marianas breadfruit (*Artocarpus mariannensis*), and yoga tree (*Elaeocarpus joga*) may be present.

Open Water

Open water includes areas covered by water with no vegetative cover, such as ocean waters, rivers, and lakes.

Other Shrub/Grassland

This largely, non-native community is characterized by the presence of shrubs and grasses. It may be present in degraded forest areas as clearings with herbaceous vegetation and scattered shrubs. Also included in this category are areas that have been recently cleared or that are actively mowed periodically to prevent forest regeneration. These areas may consist primarily of grassland with limited regrowth of woody species.

Scrub/Shrub

This plant community is characterized by the predominance of low-stature woody vegetation that can occur as a mixture of native and non-native species. The vegetation may be a secondary thicket of woody species but may also include some interspersed herbaceous species. The woody vegetation tends to be too low or sparse to be characterized as forest. This low-stature character may be the result of human disturbance or physical conditions, such as fire, soil saturation, or poor soils.

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CHAPTER 2
SURVEY METHODOLOGY

2.1 SURVEY METHODS

Field surveys were conducted by 16 survey personnel divided into teams of three and one four-person team, for a total of five in-field survey teams. All survey personnel are experienced natural resources experts with the experience and identification skills to conduct surveys in the habitats of Tinian and identify the target species. Surveys were conducted Monday through Saturday from April 3, 2023 to April 24, 2023. Prior to the start of each survey day, the Lead Field Biologist (C. Scheuerman) assigned areas to be covered by each of the five teams. Every morning, the Lead Field Biologist conducted a tailgate safety meeting to discuss potential safety concerns, safety measures, and confirm logistics for the day with each survey team.

Using geographic information system (GIS)-provided boundaries, the field survey teams traversed the entirety of their assigned areas and surveyed along transects that were spatially delineated approximately 15 feet or 30 feet apart (as depicted in Figure 1-2). All accessible areas mapped as having higher quality limestone vegetation (i.e., limestone coastal scrub, limestone degraded forest, and limestone native forest) were surveyed using approximately 15-foot transects. All other vegetation and land cover types of lower habitat quality for the target species were surveyed using approximately 30-foot transects. Each survey team walked in relative parallel fashion along the established transects while the surveyor in the middle position (for 3-person teams) or far end (for the 4-person team) carried a portable global positioning system (GPS) unit with a tracking application to continuously track the movements of the survey team. All survey track logs were stored as polyline layers and are provided on figures in Appendix A.

For 15-foot transect surveys, line-of-sight observations were recorded up to 7.5 feet on each side of the survey transects. For 30-foot transect surveys, line-of-sight observations were recorded up to 15 feet on each side of the survey transect guidelines. Deviations from 15-foot and 30-foot transects were necessary in areas where there were obstacles such as buildings, impassable vegetation, or steep slopes (greater than 40 degrees). Certain areas did not require transect surveys due to lack of habitat, such as paved roads, structures, mowed/cleared fields, and monocultures of invasive/noxious plants (e.g., patches of swordgrass [*Miscanthus floridulus*] and common lantana [*Lantana camara*]). In addition, low-statured limestone coastal scrub habitat was not traversable due to steep, unsafe terrain and dense, stunted vegetation (i.e., Chiget limestone forest, Unai Masalok, and Pina Plateau limestone forest). In such areas, surveyors were able to gain visual observations from the tops of slopes/cliff lines where safe to do so. When areas were unable to be surveyed in full or according to transect guidelines, photos were taken for documentation and notes recorded as to why the area was not surveyed in full or why there was a deviation from the 15-foot or 30-foot transect spacing. Impassable areas are noted accordingly on figures in Appendix A.

When and where federally listed species were identified, surveyors stopped to map the location(s) of species and collect baseline data (refer to Section 2.3 for the types of data collected). Locations of federally listed species were mapped using portable GPS units. When individual plants or animals of interest were observed, a single point was collected on the GPS to map the location of that individual. For

H. longipetiolata groves, the boundaries of the local populations were mapped on the GPS in the form of a polygon.

2.2 SURVEY EQUIPMENT AND STANDARDS

Each survey team was equipped with a portable/handheld Trimble TDC 650 or Geo7x GPS unit with sub-meter level mapping accuracy.

All existing GIS data was preloaded onto the GPS units prior to surveys, including the survey area boundaries, previously mapped species locations, and transect area spacing. Following daily surveys, collected data was synced from the GPS units, backed up, and checked for completeness. Following daily checks of data completeness, survey teams were assigned new areas to cover so as to avoid overlap of survey effort and ensure that all accessible areas were surveyed.

2.3 DATA COLLECTED FOR FEDERALLY LISTED SPECIES

When and where federally listed species were detected, the field survey personnel documented the following on a GPS unit:

1. Species name.
2. GPS location (sub-meter level accuracy).
    a. For individual occurrences of an organism, a single data point was collected, and relevant data noted.
    b. For multiple *D. guamense* individuals found growing on the same substrate or host plant, a single data point was collected along with the number of individuals counted on the substrate or host plant.
    c. For plant species detected that grew in clumps, groves, or stands, the locations were mapped in the form of a polygon along with the number of individuals within the polygon.
3. Host plant species (if applicable).
4. Life stage (e.g., adult, juvenile, sapling, seedling – if applicable and discernible in the field).
5. Reproductive stage (e.g., flowering, fruiting – if applicable and discernible in the field).
6. Condition (e.g., dead, poor, fair, good – if applicable and discernible in the field).

Focus was then temporarily put on habitat in the immediate vicinity, as opposed to continuing straight ahead on a transect path, to ensure that any and all other individuals were accounted for and mapped.

More specific species data types and observations are discussed in Chapter 4.

CHAPTER 3
RESULTS

Results of the 2023 surveys of federally listed species are summarized in Tables 3-1 through 3-3 and are depicted in Figures 3-1 through 3-6. Appendix B contains the complete data matrices for both point and polygon federally listed species observation data collected during the surveys. All survey GIS data collected in the field will be provided to NAVFAC Pacific with submission of the final survey report.

3.1 Federally Listed Plant Species Recorded

Individuals of both *D. guamense* and *H. longipetiolata* were observed and mapped in multiple locations in 2023. Table 3-1 details the survey point data collected for each location of *D. guamense* that was observed and mapped, and each observation point is depicted in Figures 3-1, 3-2, and 3-3. In total, 208 individual *D. guamense* plants were observed at 23 unique locations, all within the Mount Lasso limestone forest survey area component.

Table 3-1 Summary of *Dendrobium guamense* Observations

Substrate Type/Host Species	*Vegetation Community*	*Number of Living Individuals[1]*	*Overall Condition*	*Total by Substrate/Host*
Dead/downed tree/branch (unidentifiable)	Limestone Native Forest	1	Good	77
	Limestone Native Forest	1	Fair	
	Limestone Native Forest	6	Poor	
	Leucaena Forest	28	Fair	
	Leucaena Forest	10	Fair	
	Limestone Native Forest	5	Good	
	Limestone Native Forest	3	Fair	
	Limestone Native Forest	17	Good	
	Limestone Native Forest	6[2]	Fair	
Dead shrub	Other Scrub/Grassland	6	Good	6
Leaf litter	Other Scrub/Grassland	3	Fair	3
Limestone (organic matter on limestone substrate)	Other Scrub/Grassland	16	Fair	44
	Other Scrub/Grassland	8	Fair	
	Other Scrub/Grassland	9	Good	
	Limestone Native Forest	7	Good	
	Limestone Native Forest	4	Fair	
Ficus sp.	Limestone Native Forest	8	Fair	16
	Limestone Native Forest	8	Fair	
Premna serratifolia	Other Scrub/Grassland	34	Fair	34
Eugenia sp.	Other Scrub/Grassland	4	Fair	16
	Limestone Native Forest	12	Fair	
Meiogyne cylindrocarpa	Limestone Native Forest	5	Fair	5
Unknown shrub	Limestone Native Forest	7	Fair	7
			TOTAL	**208**

Notes: [1]Each row represents a single observation point.
[2]Nine individuals were located at this location; however, three were noted as dead.

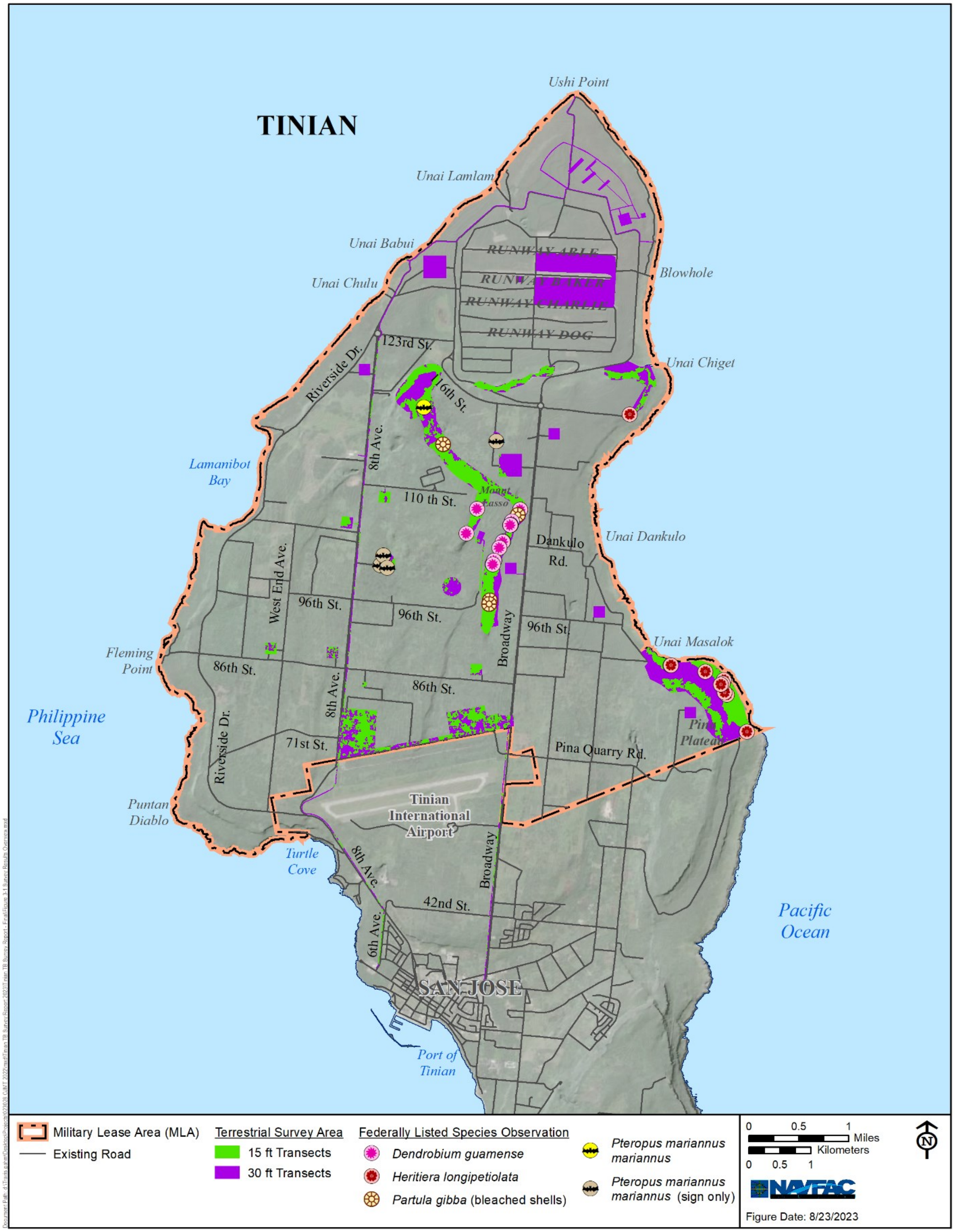

Figure 3-1 Survey Results Overview

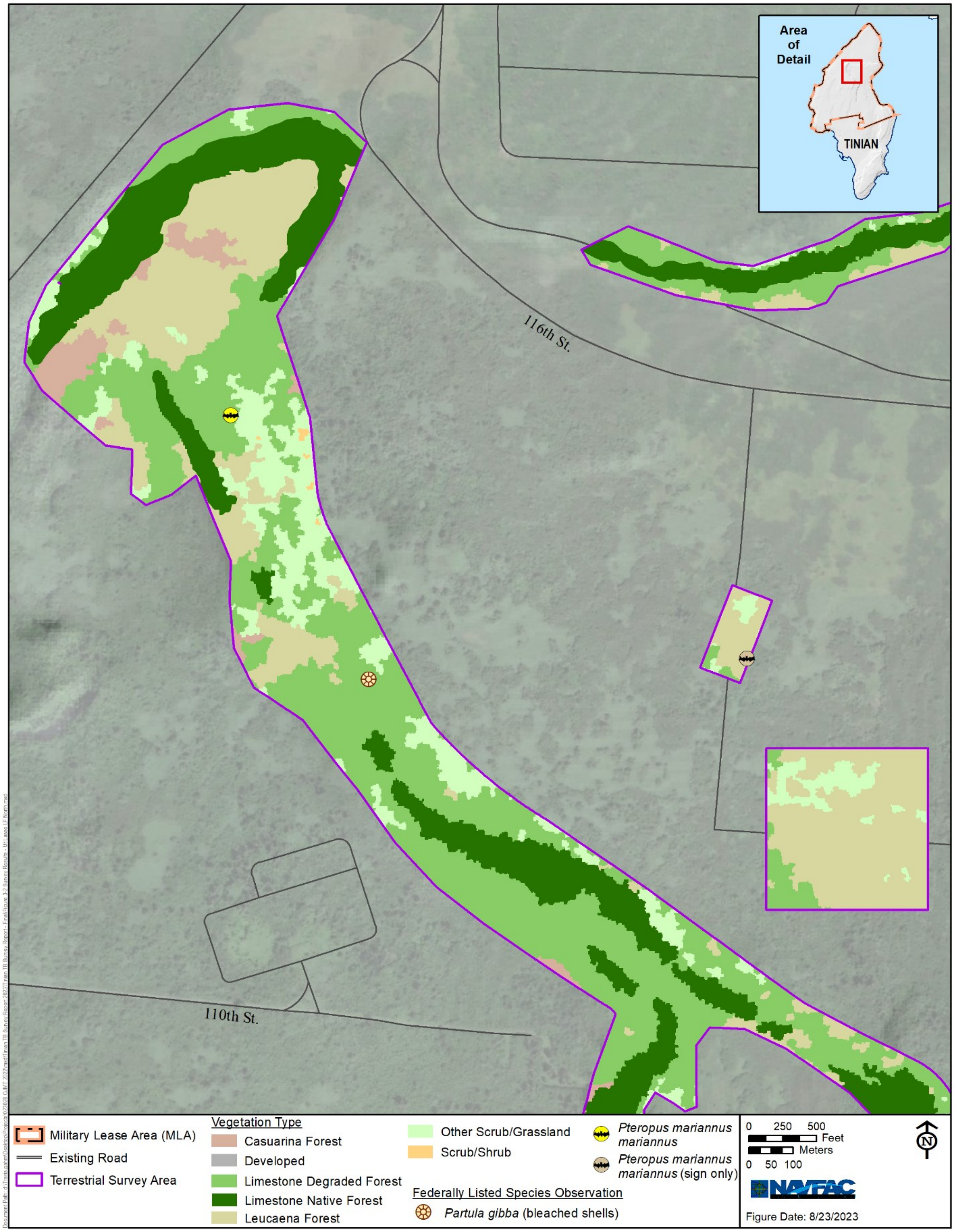

Figure 3-2 Survey Results – Mount Lasso Limestone Forest North

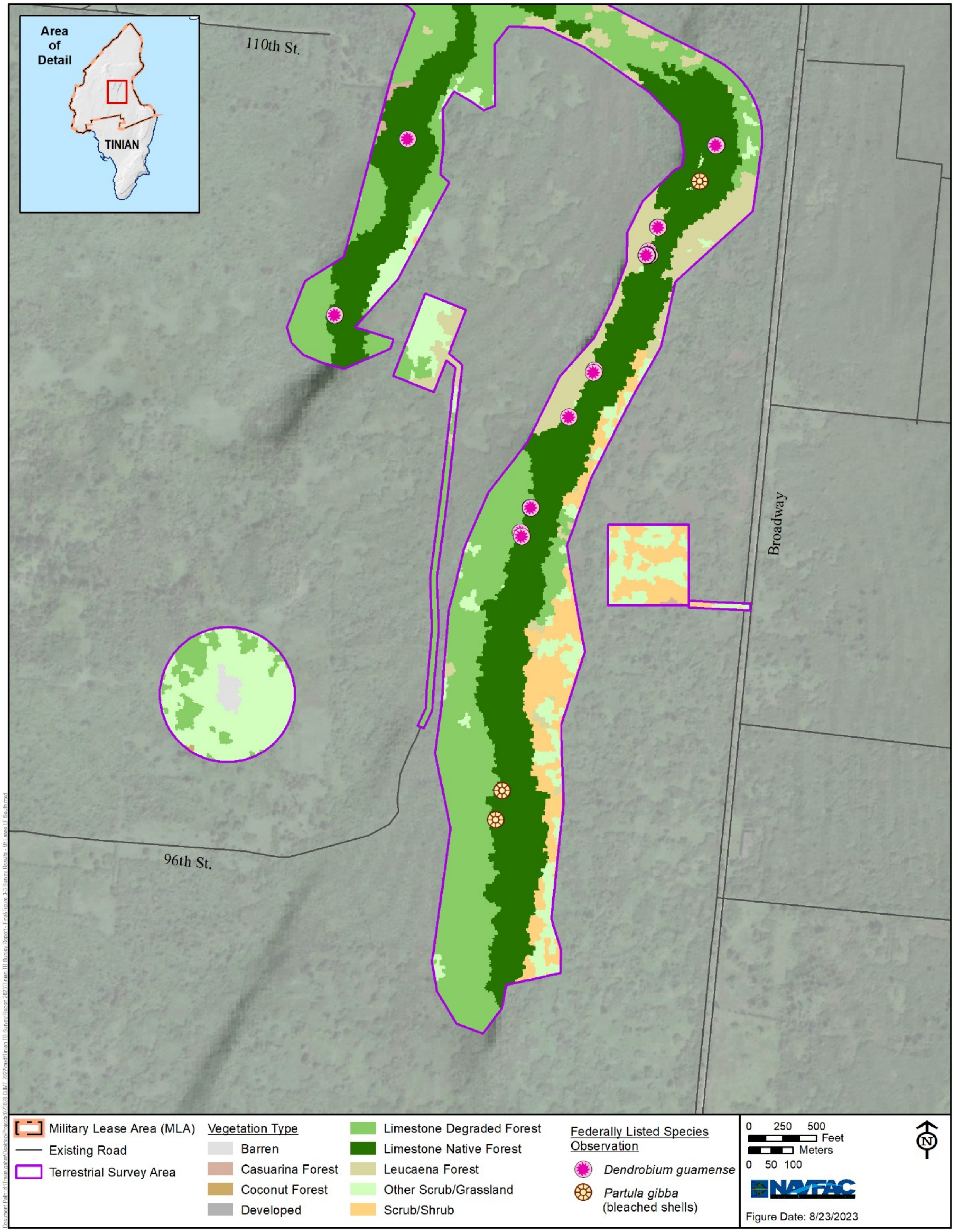

Figure 3-3 Survey Results – Mount Lasso Limestone Forest South

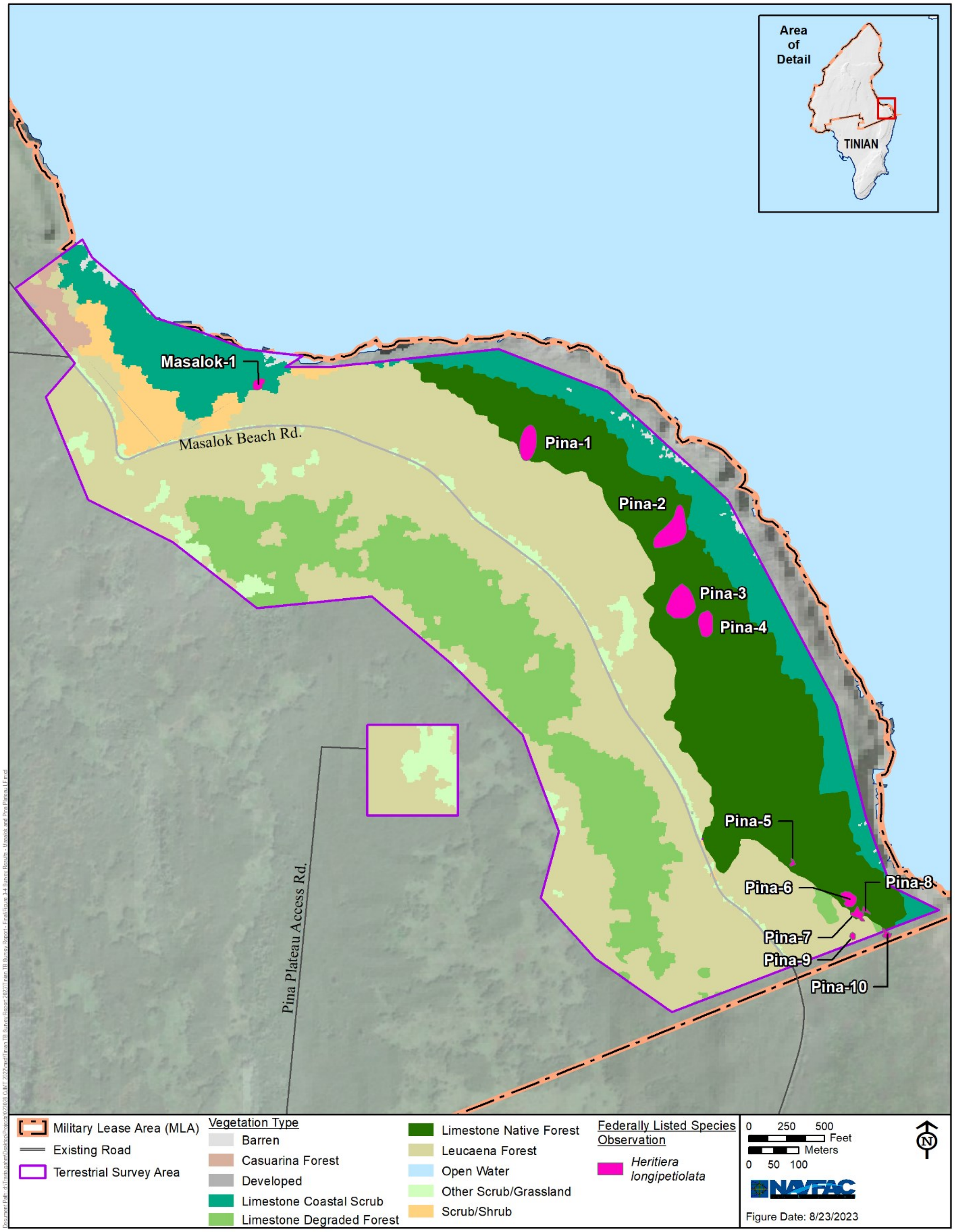

Figure 3-4 Survey Results – Unai Masalok and Pina Plateau Limestone Forest

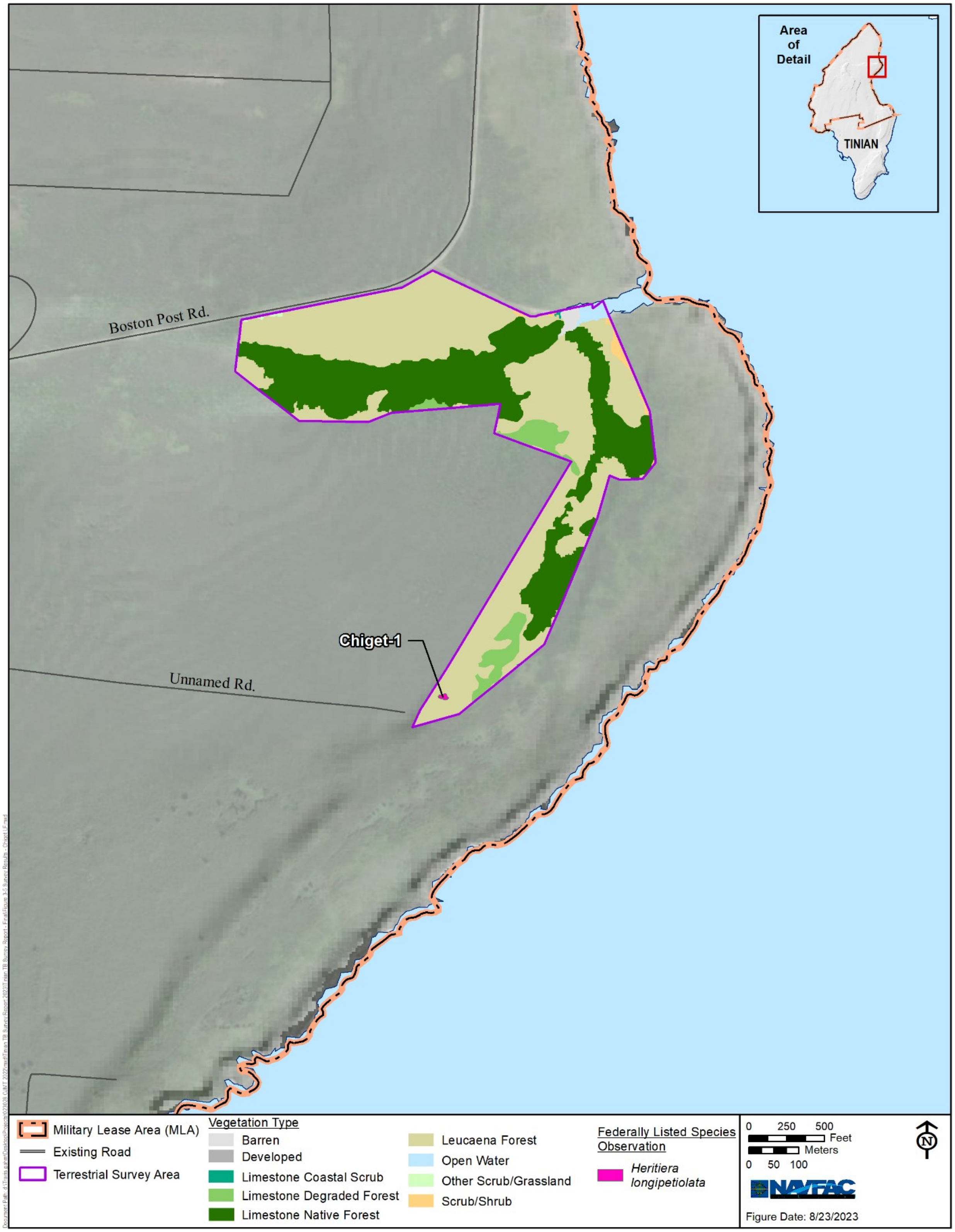

Figure 3-5 Survey Results – Chiget Limestone Forest

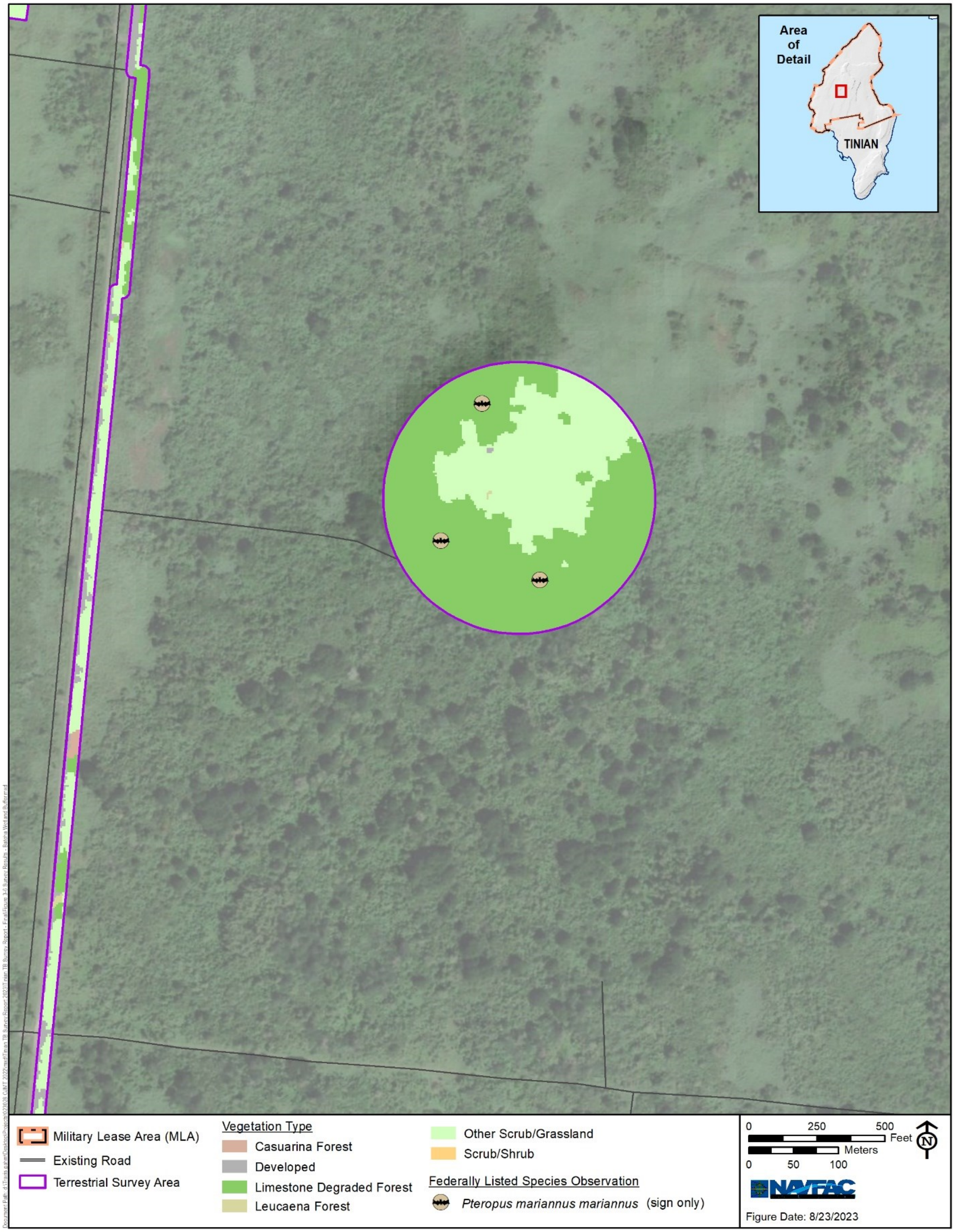

Figure 3-6 Survey Results – Bateha Wetland Buffer

Table 3-2 details the survey data collected for each grove of *H. longipetiolata* that was observed and mapped, and each grove is depicted in Figures 3-1, 3-4, and 3-5. In total, 290 living *H. longipetiolata* trees were observed within 12 unique grove locations. Ten groves occur in the Pina Plateau limestone forest survey area component, a single grove occurs in the Unai Masalok survey area component, and a single grove occurs in the Chiget limestone forest survey area component.

Table 3-2 Summary of *Heritiera longipetiolata* Observations

Grove ID	*Survey Area Component*	*Vegetation Community*	*Number of Individuals*		
			Mature	*Seedling/ Sapling*	*Dying/ Dead*
Masalok-1	Unai Masalok	*Leucaena* Forest	8	5	0
Pina-1	Pina Plateau Limestone Forest	Limestone Native Forest	45	0	0
Pina-2		Limestone Native Forest	40	0	0
Pina-3		Limestone Native Forest	21	0	0
Pina-4		Limestone Native Forest	12	0	1
Pina-5		Limestone Native Forest	6	0	0
Pina-6		Limestone Native Forest	19	5	0
Pina-7		Limestone Native Forest	11	7	1
Pina-8		Limestone Native Forest	20	0	0
Pina-9		*Leucaena* Forest	1	23	0
Pina-10		Limestone Native Forest	9	0	2
Chiget-1	Chiget Limestone Forest	Limestone Coastal Scrub	58	0	0
		TOTAL	**250**	**40**	**4**

3.2 FEDERALLY LISTED WILDLIFE SPECIES RECORDED

Table 3-3 details the survey point data collected for each federally listed wildlife species that was observed and mapped, and each observation point is depicted on Figures 3-1 through 3-6. No living humped tree snails were observed in any survey area component during this 2023 survey. Only bleached, empty shells were observed in four locations in the Mount Lasso limestone forest survey area component.

Although the Mariana fruit bat (*Pteropus mariannus mariannus*) (federally threatened) was not a target species during 2023 surveys, incidental observations were recorded. A single Mariana fruit bat was observed flying over the Mount Lasso limestone forest survey area component (see Figure 3-2). In addition, sign of fruit bat occurrence (feces and/or ejecta) was observed in four separate locations (Figures 3-1, 3-2, and 3-6, and Table 3-3).

Discussions of mapped individuals and populations of federally listed wildlife species is provided in Chapter 4.

Table 3-3 Federally Listed Wildlife Species Summary

Common Name	***Observation Type***	***Survey Area Component***	***Mapped Individuals[1]***	***Vegetation Community***	***Life Stage/Condition/Notes***
Humped tree snail	Bleached shell(s)	Mount Lasso Limestone Forest	4	Limestone Native Forest	All bleached, empty shells on ground – no living individuals observed
			1	Limestone Native Forest	
			1	Limestone Native Forest	
			1	Limestone Degraded Forest	
Mariana fruit bat	Single individual flying	Mount Lasso Limestone Forest	1	Limestone Degraded Forest	Single individual observed flying over the Mount Lasso limestone forest survey area component, appeared to be healthy
	Sign (ejecta/feces on leaves)	Bateha Wetland Buffer	1	Limestone Degraded Forest	Ejecta and/or feces of fruit bat found on various leaf types in 4 locations
			1	Limestone Degraded Forest	
			1	Limestone Degraded Forest	
		ETR Options	1	*Leucaena Forest*	

Note: [1]Each row represents a single observation point.
Legend: ETR = Explosives Training Range.

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CHAPTER 4
DISCUSSION

This chapter provides discussion and details of mapped individuals and populations of federally listed species observed and mapped during the 2023 Tinian terrestrial surveys.

4.1 *DENDROBIUM GUAMENSE*

All observations of *D. guamense* during 2023 surveys occurred in the Mount Lasso limestone forest survey area component, primarily in the southern portion of the survey area component (see Figures 3-1 and 3-3). In all, 23 occurrence data points were collected, ranging from single individuals to localized populations of up to 34 individual plants. As noted in Table 3-1, the majority of occurrence locations and individuals were observed growing on dead and/or downed trees or branches that were unidentifiable. Host plant species noted in Table 3-1 are all native species to Tinian, and the majority of *D. guamense* occurrences were in areas previously mapped as limestone native forest habitat (see Table 3-1 and Figure 3-3).

Consistent with past known locations of *D. guamense* in the Mount Lasso limestone forest survey area component (NAVFAC Pacific 2019), all recorded observations were located in the southern portion of the survey area component. However, during 2023 surveys, *D. guamense* occurrences were observed across a larger geographic area, occurring within both southern "legs" of the Mount Lasso limestone forest survey area component (see Figure 3-3), as opposed to only the westernmost of the "legs" (see Figure 1-1).

Example photographs of *D. guamense* individuals observed growing on various substrates during surveys are provided in Appendix C.

4.2 *HERITIERA LONGIPETIOLATA*

All observations of *H. longipetiolata* during 2023 surveys were in the easternmost survey area components, occurring in jagged limestone (karst) habitat along the eastern coast of Tinian. *H. longipetiolata* groves had been previously assessed and mapped during past surveys (NAVFAC Pacific 2019) in the Unai Masalok and Pina Plateau limestone forest survey area components. These groves were revisited and mapped during the 2023 surveys.

A new *H. longipetiolata* grove was discovered during 2023 surveys in the southernmost portion of the Chiget limestone forest survey area component (see Table 3-2 and Figure 3-5). This grove contained 58 individual mature trees with no seedlings or saplings observed and is located at the top of a steep escarpment dominated by low-stature limestone coastal scrub, which was largely impenetrable by surveyors due to the density of vegetation and unsafe slope and terrain.

Although groves Masalok-1 and Pina-9 are noted as occurring in *Leucaena* forest (see Table 3-2 and Figure 3-4), it should be noted that all groves mapped in 2023 occurred in very distinct patches of karst habitat. Although these two groves may have been surrounded by larger areas of *Leucaena* forest, they were in fact observed growing in distinct karst limestone topography.

Across all groves mapped during the 2023 surveys, nearly every individual *H. longipetiolata*, both mature trees and seedlings/saplings, appeared to be vigorous and healthy. No individuals were observed flowering or fruiting during surveys. There were no evident signs of stress, stunted growth, loss of vigor, or stripped vegetation on any of the individuals, except for the four individual trees noted as dying or dead in Table 3-2.

Example photographs of *H. longipetiolata* individuals/groves observed during surveys are provided in Appendix C.

4.3 HUMPED TREE SNAIL

No living humped tree snails were observed during these surveys. Although humped tree snail shells were found in four locations in the Mount Lasso limestone forest survey area component, they were weathered, bleached, and consistent with previous surveys (NAVFAC Pacific 2019), likely many decades old (Table 3-3). Example photographs of the bleached, weathered shells that were discovered during surveys are provided in Appendix C.

4.4 MARIANA FRUIT BAT

A single adult Mariana fruit bat was seen flying on one occasion above the Mount Lasso limestone forest survey area component. Harassed by a pair of adult white terns (*Gygis alba*) that were presumably defending a nest, the fruit bat circled overhead for approximately 90 seconds before disappearing into the adjacent tree line.

Mariana fruit bat sign (ejecta and/or feces) was observed in three different locations in the westernmost Bateha Wetland Buffer survey area component and in one location in the northernmost Explosives Training Range options survey area component. Pteropodid bats feed by squeezing out the juices of plant parts, which they swallow, and then spit out pellets known as "ejecta" that contain the fibers and often seeds of the plant (Aziz et al. 2021). Presence of fruit bat feces/ejecta is a sign that the species is utilizing a given area for movement and/or foraging. Ejecta can also be an indicator of fruit bat day roost locations (Aziz et al. 2021). Example photos of fruit bat ejecta/feces observed and recorded during surveys are provided in Appendix C.

CHAPTER 5 CONCLUSIONS

5.1 SURVEY SUMMARY

The CJMT survey area components were thoroughly surveyed from April 3–24, 2023, as evidenced by the survey track data in Appendix A. As discussed in Section 2.1, certain portions of the survey area were either impassable due to dense and/or noxious patches of weedy vegetation (e.g., swordgrass and common lantana patches), steep slopes and/or cliffs, and habitats that were impenetrable due to safety concerns (e.g., low-statured, dense limestone coastal scrub in jagged, steep karst habitat). Dense patches of weedy vegetation did not contain a diversity of vegetation or high habitat suitability for federally listed species and were often avoided by having survey teams momentarily pause transects, move around them, and reinitiate transects once they were able to get around the patches. Where surveyors encountered steep slopes or cliffs, every effort was made to survey the areas using all means necessary (e.g., using binoculars from the top and bottom of the slope/cliff, finding alternate routes to get up or down, and conducting transects along safe portions of such areas). In the easternmost portions of the survey area components on the east coast, low-statured, dense limestone coastal scrub was often impenetrable and unsafe due to jagged karst topography that was too steep or had deep canyons and crevices. In such areas, surveyors conducted transects up to and along the areas that were accessible and were able to gain visual observations using binoculars over the canopies that stretched down to the coastline. Impassable areas are noted accordingly on figures in Appendix A. Example photographs of impassable areas and weedy vegetation that were avoided are provided in Appendix C.

During the course of conducting survey transects, where and when federally listed species were encountered, focus was temporarily put on habitat in the immediate vicinity, as opposed to continuing straight ahead on a transect path, to ensure that any and all other individuals were accounted for and mapped. This is evidenced by survey transect data presented in Appendix A, specifically in the survey area components that contained a high amount of federally listed species observations (e.g., Mount Lasso limestone forest and Pina Plateau limestone forest).

Consistent with past surveys (NAVFAC Pacific 2014, 2018, 2019), results of the 2023 surveys show high habitat value in the remaining limestone forest areas of Tinian. *D. guamense* was only observed in the Mount Lasso limestone forest survey area component and *H. longipetiolata* was only observed in the easternmost, coastal survey area components in jagged, limestone karst habitat. Although there were observations of these species that occurred in areas mapped as other than limestone habitat (see Tables 3-1 and 3-2), such occurrences were always in areas surrounded by limestone habitat that generally defined the local conditions. No observations of federally listed species occurred in the lowland survey area components that had high amounts of weedy vegetation (e.g., those areas dominated by *Leucaena* forest, *Casuarina* forest, and other areas with high amounts of non-native vegetation and signs of past disturbance).

The lack of *S. guamense* observations during 2023 surveys was expected and is consistent with the current known status of the species – all known populations of *S. guamense* have been extirpated (USFWS 2020). In multiple locations, *S. torvum*, a similar species that was introduced to Tinian (Raulerson 2006) was observed growing in disturbed and/or ruderal habitats.

Similarly, the lack of living humped tree snail observations in any of the 2023 CJMT survey area components is consistent with recent survey results; the species is only known to occur on Tinian in the southern portion of Lamanibot Bay, well outside of the 2023 survey area (NAVFAC Pacific 2014, 2019).

Although not a target species of the 2023 surveys, one Mariana common moorhen (*Gallinula chloropus guami*) (federally endangered) was incidentally observed foraging within a water retention structure on the northern end of the historic Japanese Communications Center, well outside of the survey footprint and outside of the survey window. No further evidence of moorhens (e.g., tracks, sign, calls) was detected anywhere else on the island during the remainder of the survey window.

CHAPTER 6
REFERENCES

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APPENDIX A SURVEY TRACKS LOG

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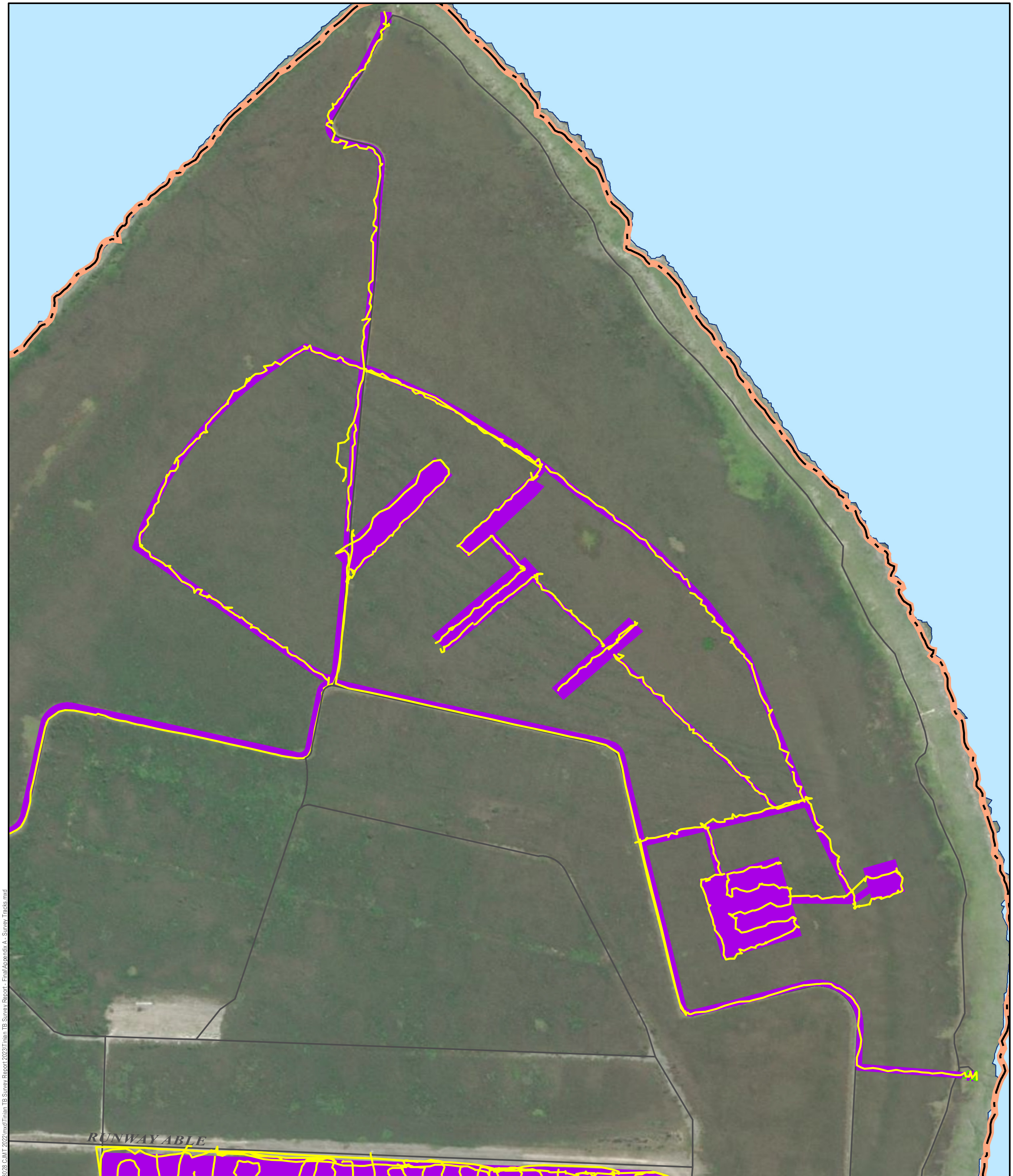


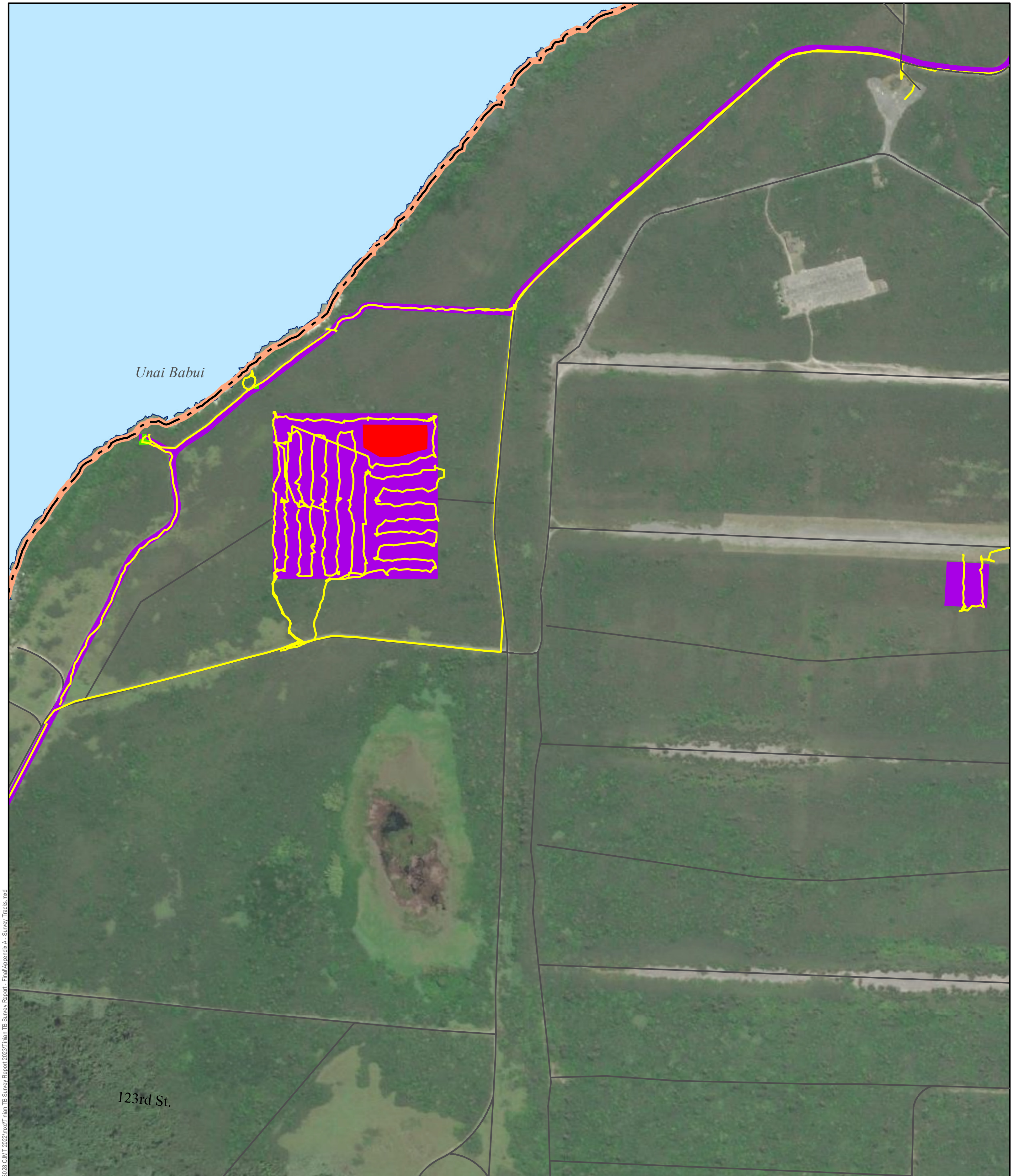
Military Lease Area (MLA)
Existing Road
Terrestrial Survey Track
Terrestrial Survey Area
15 ft Transects
30 ft Transects

Area of Detail
01

0 500 1,000 Feet
0 100 200 Meters

NAVFAC Naval Facilities Engineering Systems Command

Figure Date: 8/23/2023



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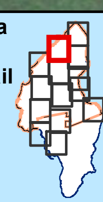
Terrestrial Survey Area
15 ft Transects
30 ft Transects
Not Surveyed - Impassable Area

Area of Detail



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0 500 1,000 Feet
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NAVFAC
Naval Facilities Engineering Systems Command

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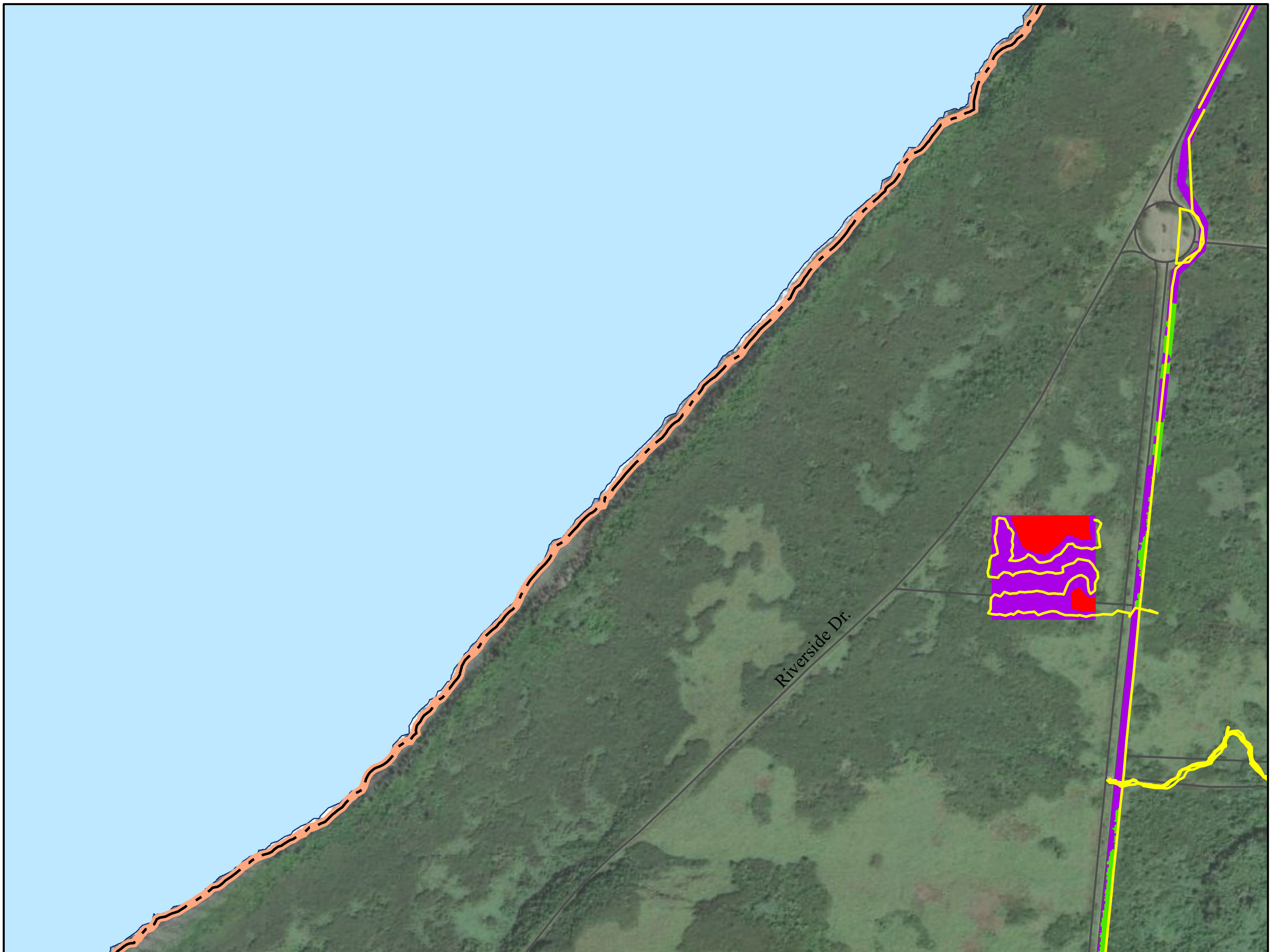

Area of Detail

03

NAVFAC
Naval Facilities Engineering Systems Command

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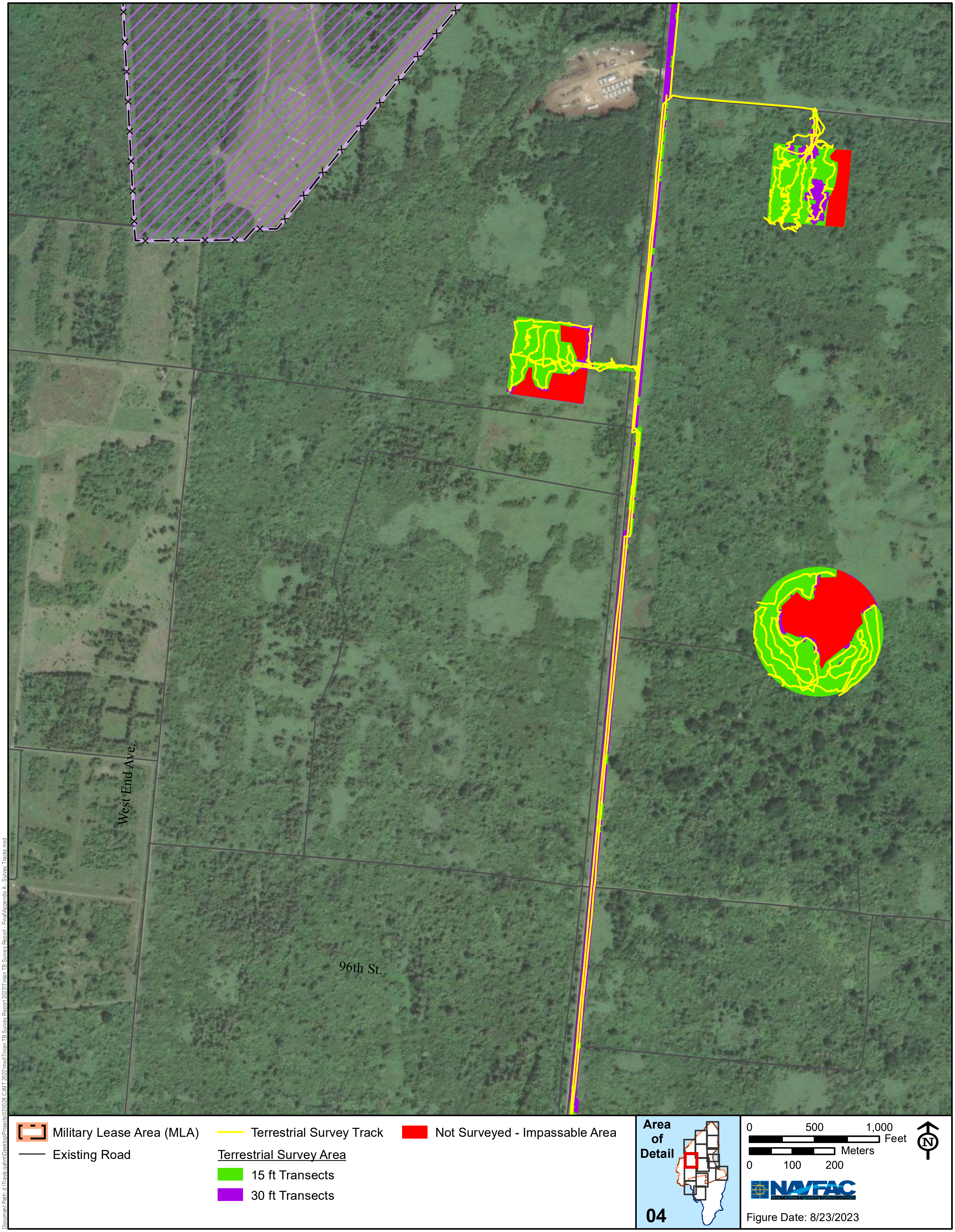

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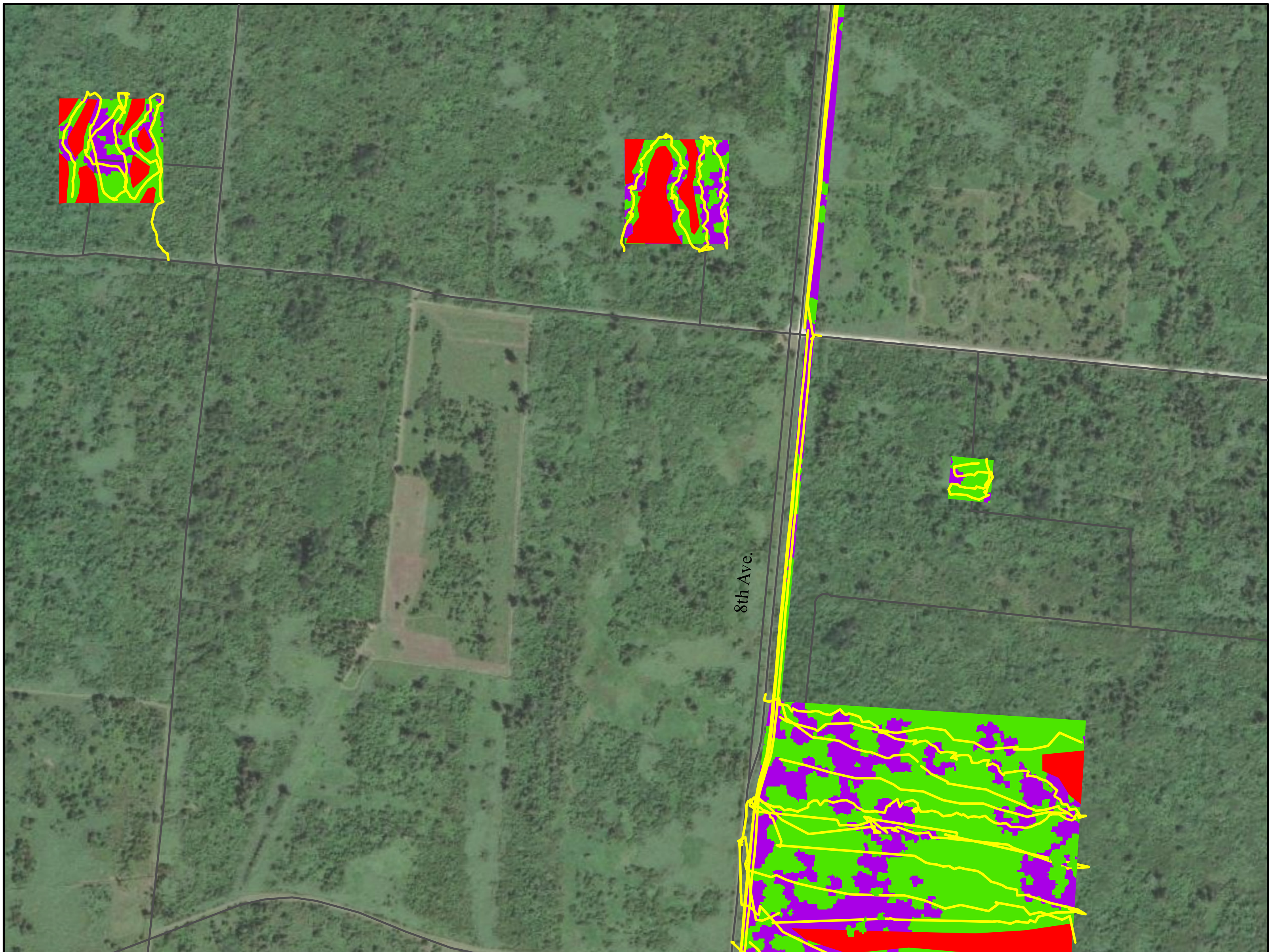

Military Lease Area (MLA)
Existing Road
Terrestrial Survey Track
Terrestrial Survey Area
15 ft Transects
30 ft Transects
Not Surveyed - Impassable Area

0 500 1,000 Feet
0 100 200 Meters

Figure Date: 8/23/2023

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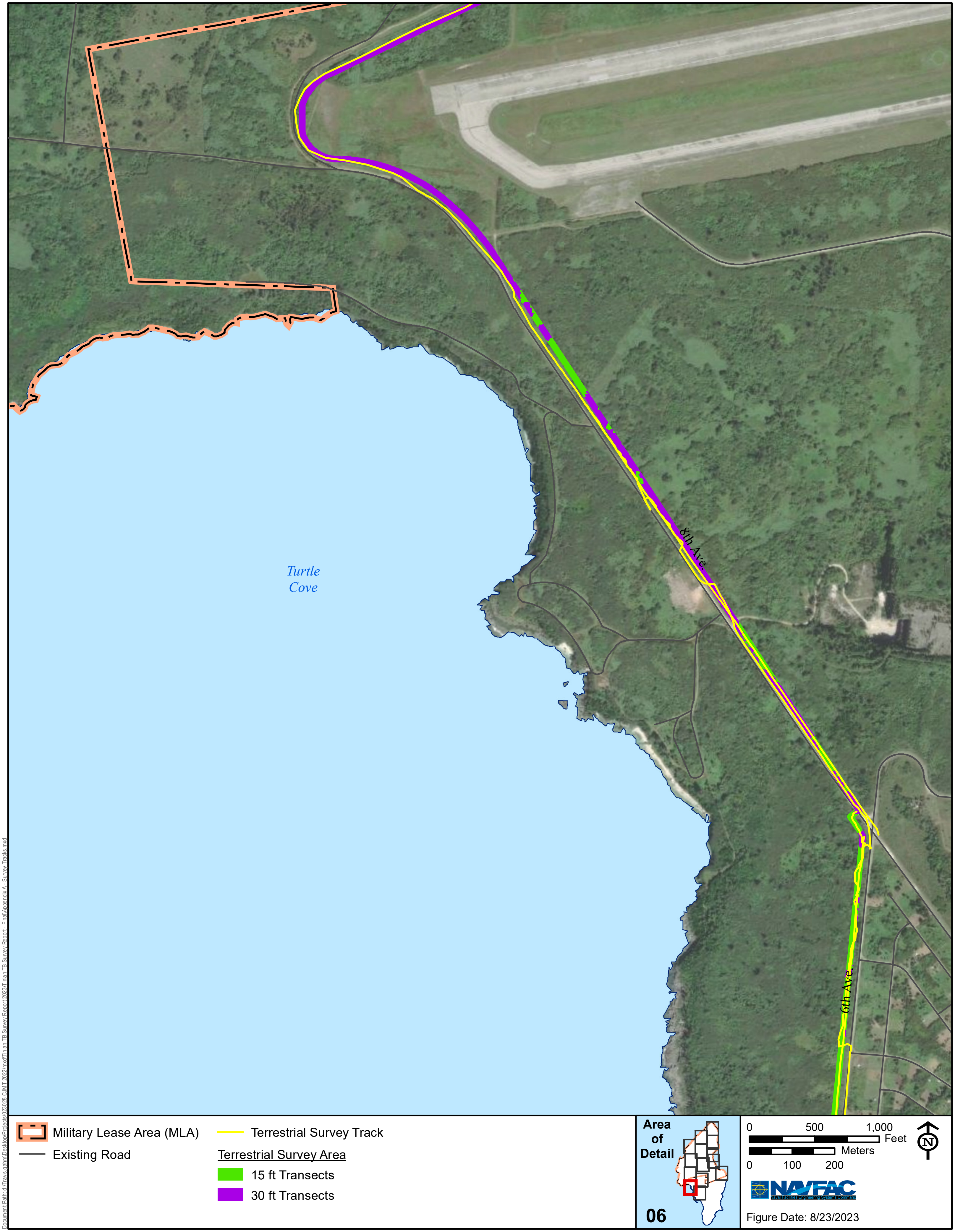

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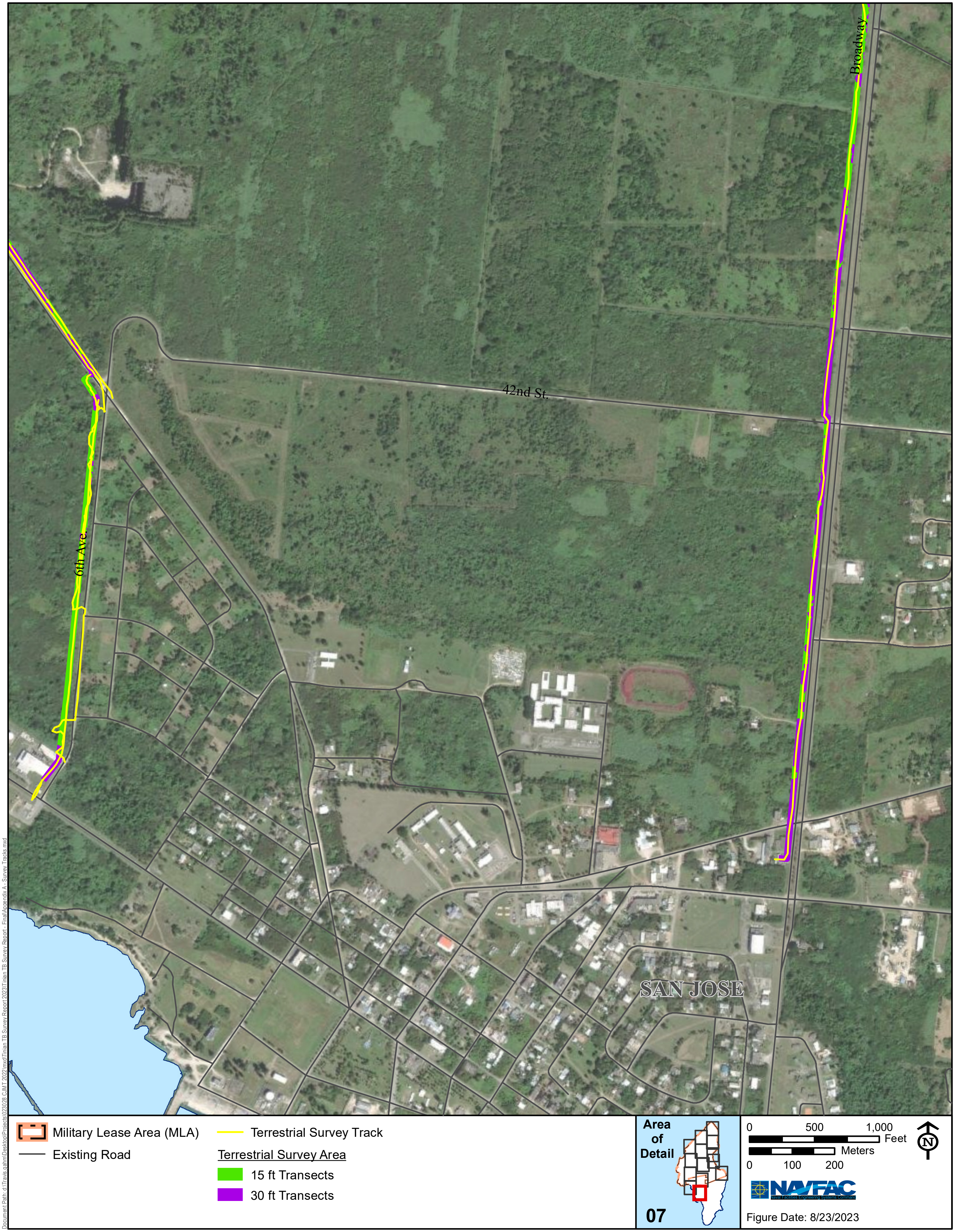
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6th Ave.
SAN JOSE
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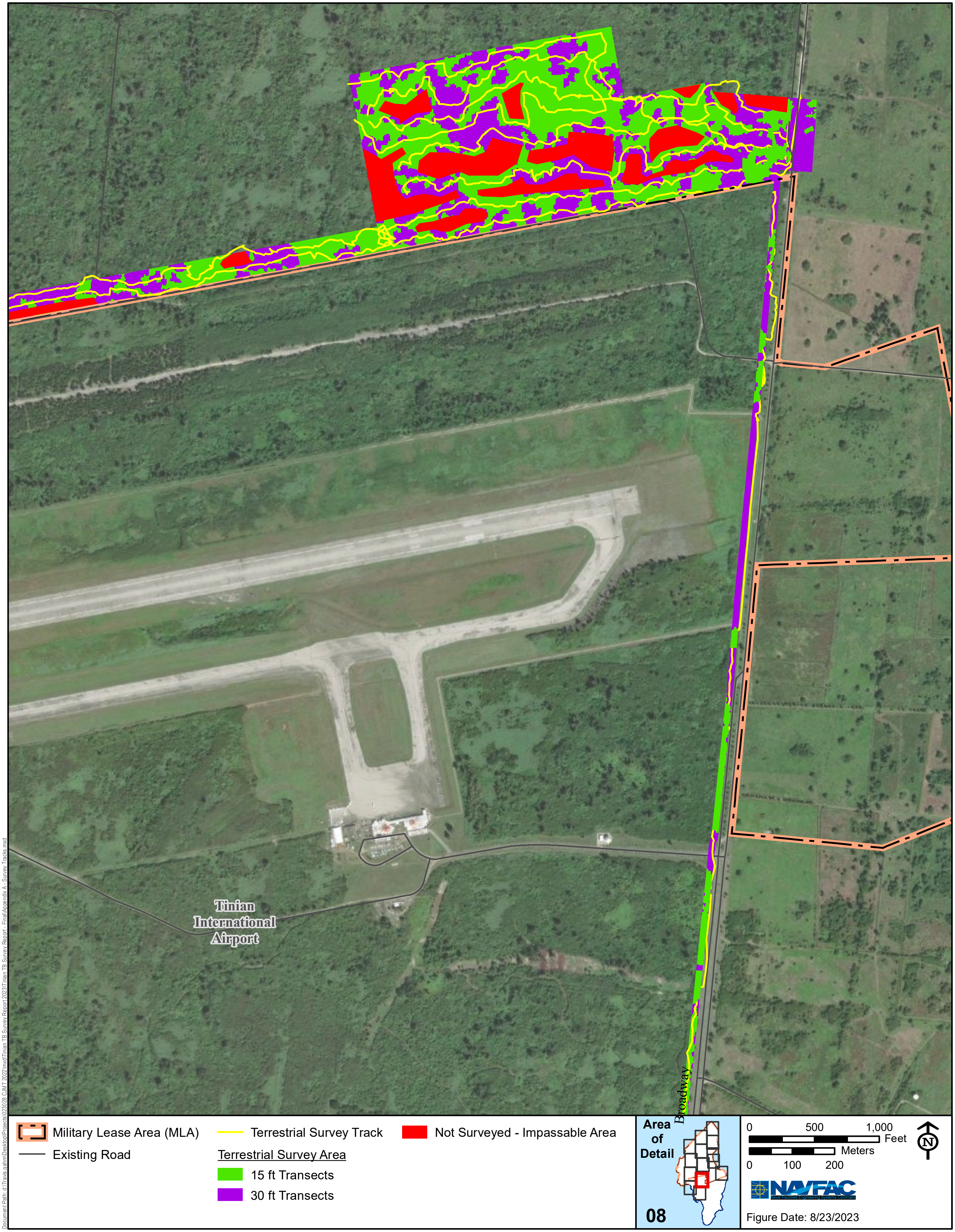
Existing Road
Terrestrial Survey Track
Terrestrial Survey Area
15 ft Transects
30 ft Transects
Area of Detail
07
0 500 1,000 Feet
0 100 200 Meters
NAVFAC
Figure Date: 8/23/2023



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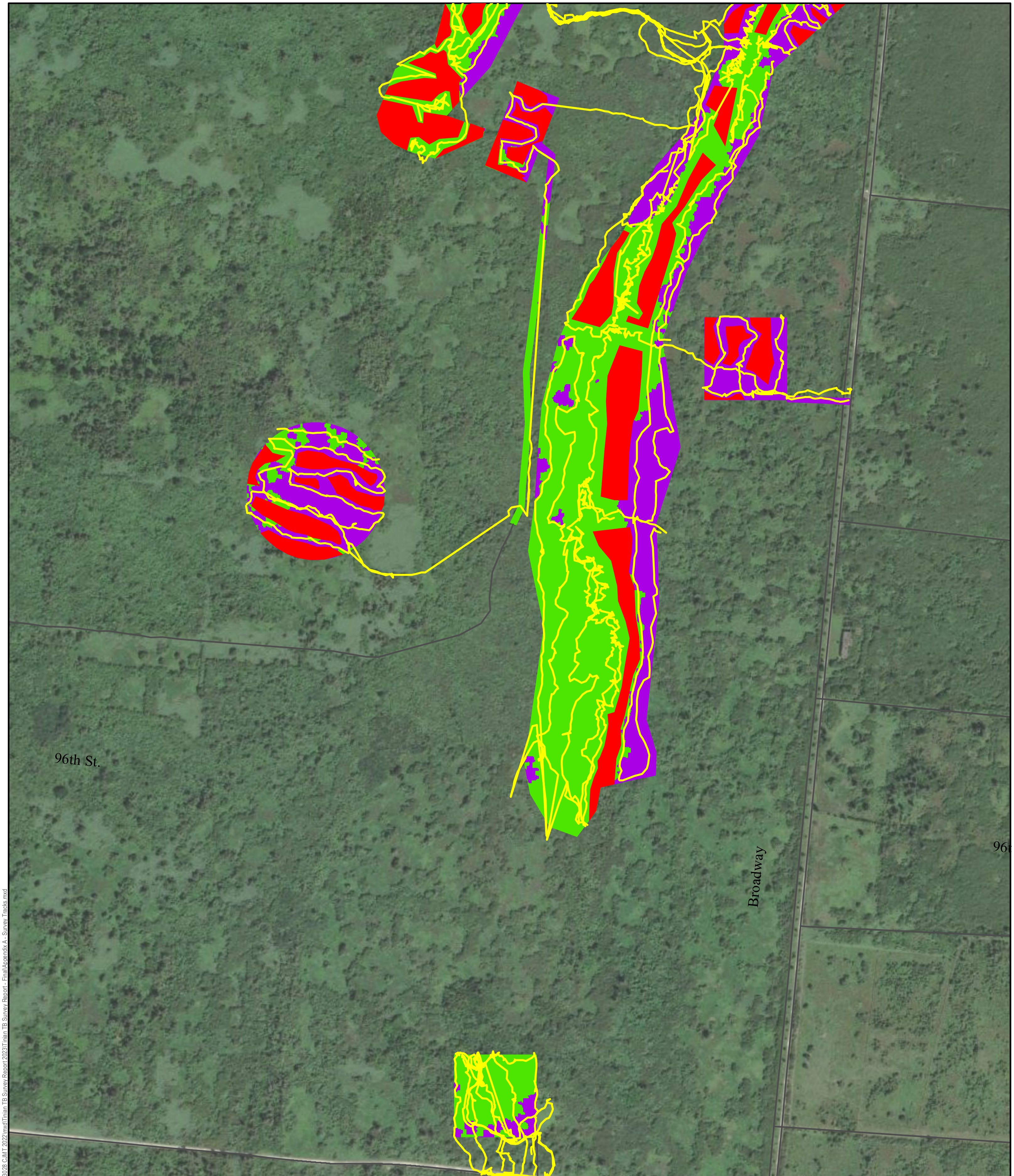


Military Lease Area (MLA)
Existing Road
Terrestrial Survey Track
Terrestrial Survey Area
15 ft Transects
30 ft Transects
Not Surveyed - Impassable Area

Area of Detail

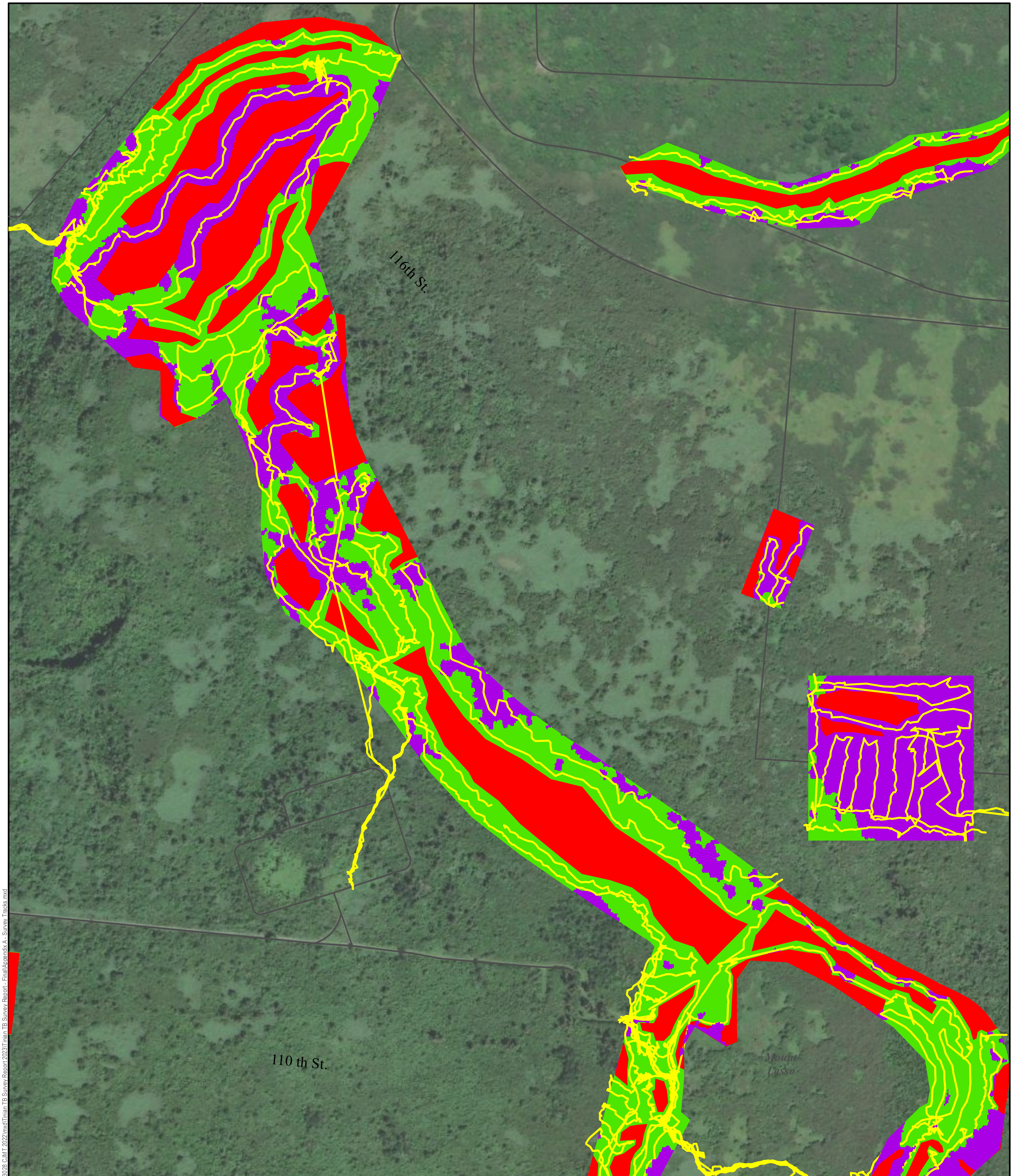
09

0 500 1,000 Feet

0 100 200 Meters

NAVFAC
Naval Facilities Engineering Systems Command

Figure Date: 8/23/2023



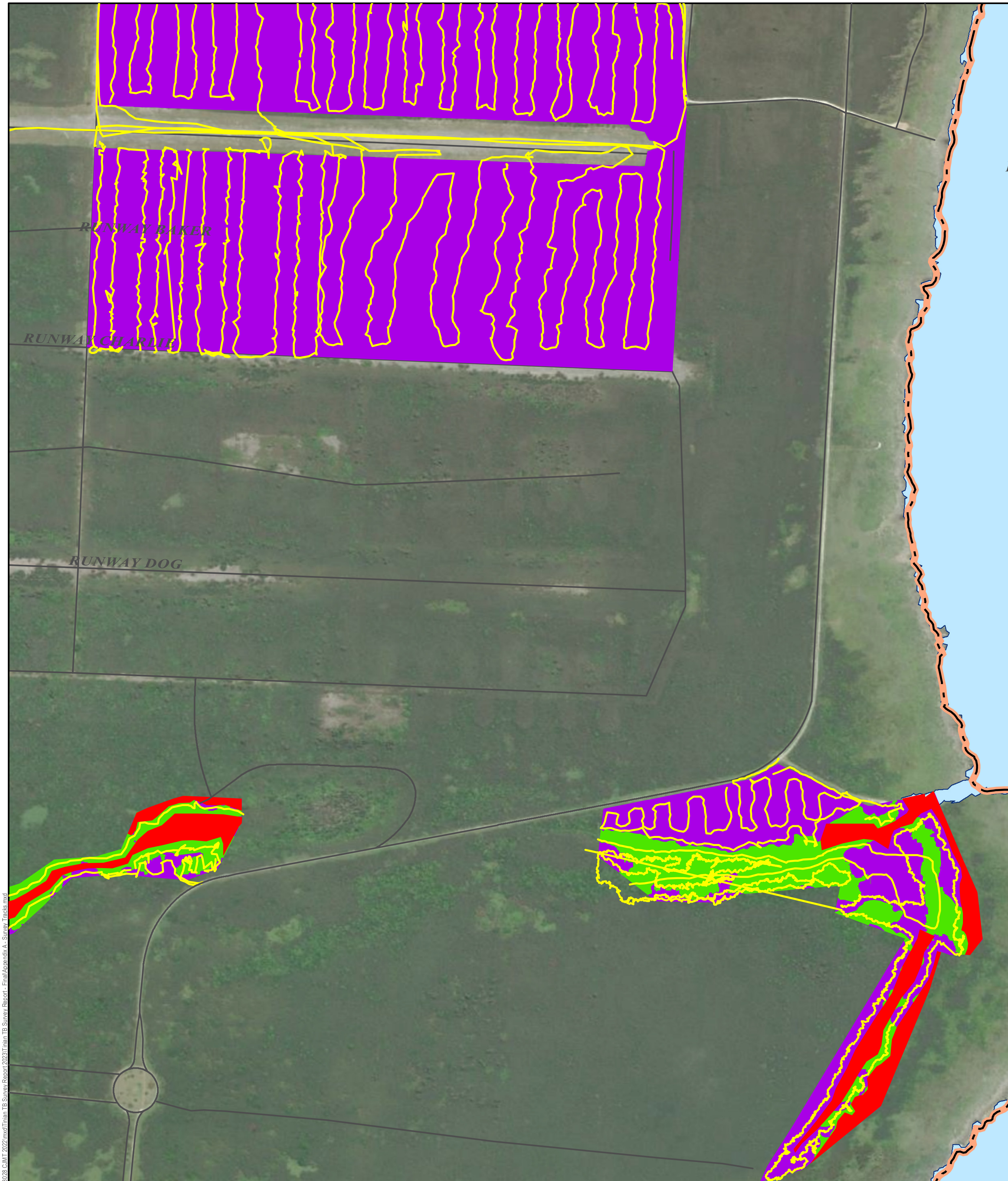
Military Lease Area (MLA)
Existing Road
Terrestrial Survey Track
Terrestrial Survey Area
15 ft Transects
30 ft Transects
Not Surveyed - Impassable Area

Area of Detail
10

0 500 1,000 Feet
0 100 200 Meters

NAVFAC
Naval Facilities Engineering Systems Command

Figure Date: 8/23/2023



Military Lease Area (MLA)
Existing Road
Terrestrial Survey Track
Terrestrial Survey Area
15 ft Transects
30 ft Transects
Not Surveyed - Impassable Area

Area of Detail

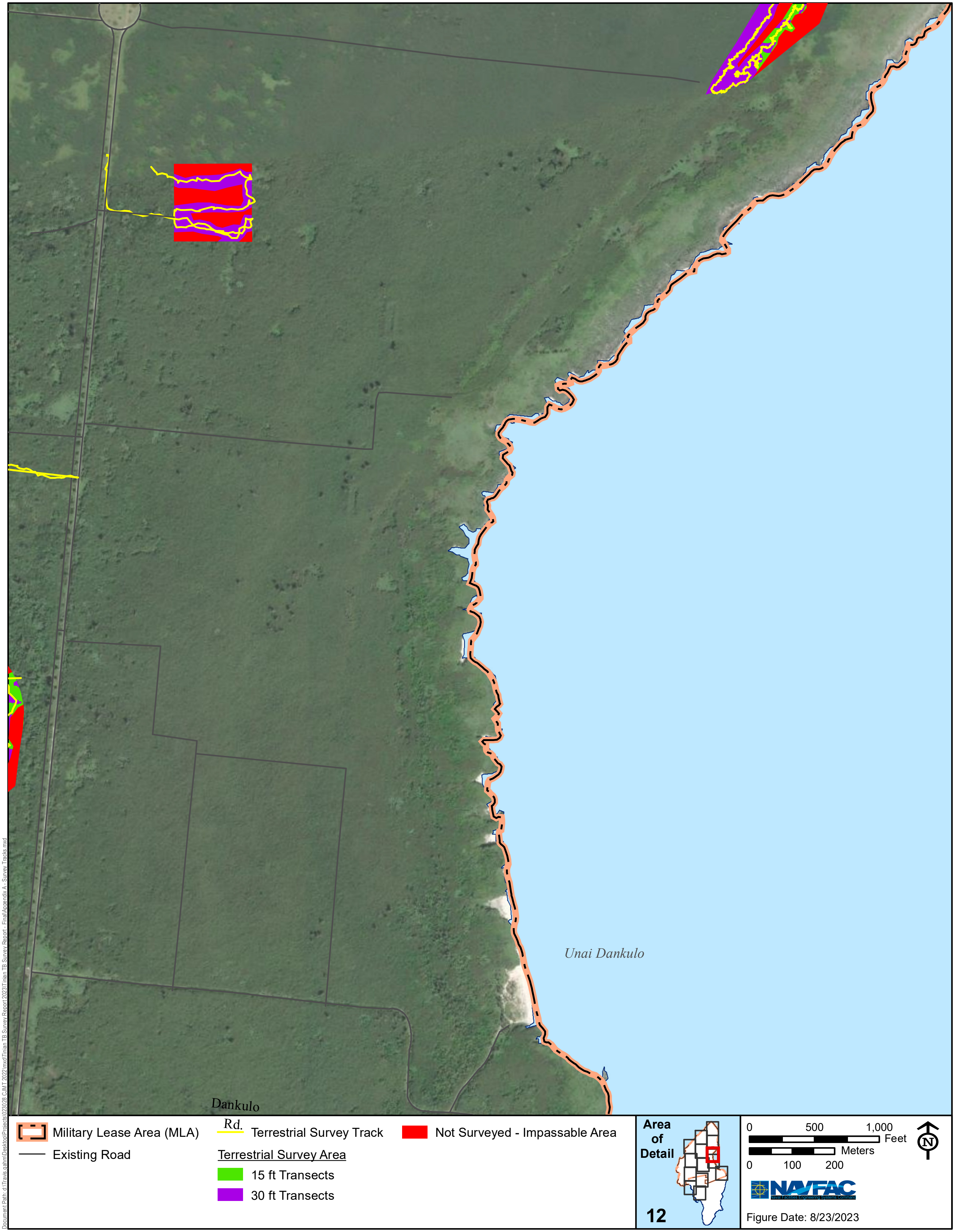
11

0 500 1,000 Feet

0 100 200 Meters

NAVFAC
Naval Facilities Engineering Systems Command

Figure Date: 8/23/2023



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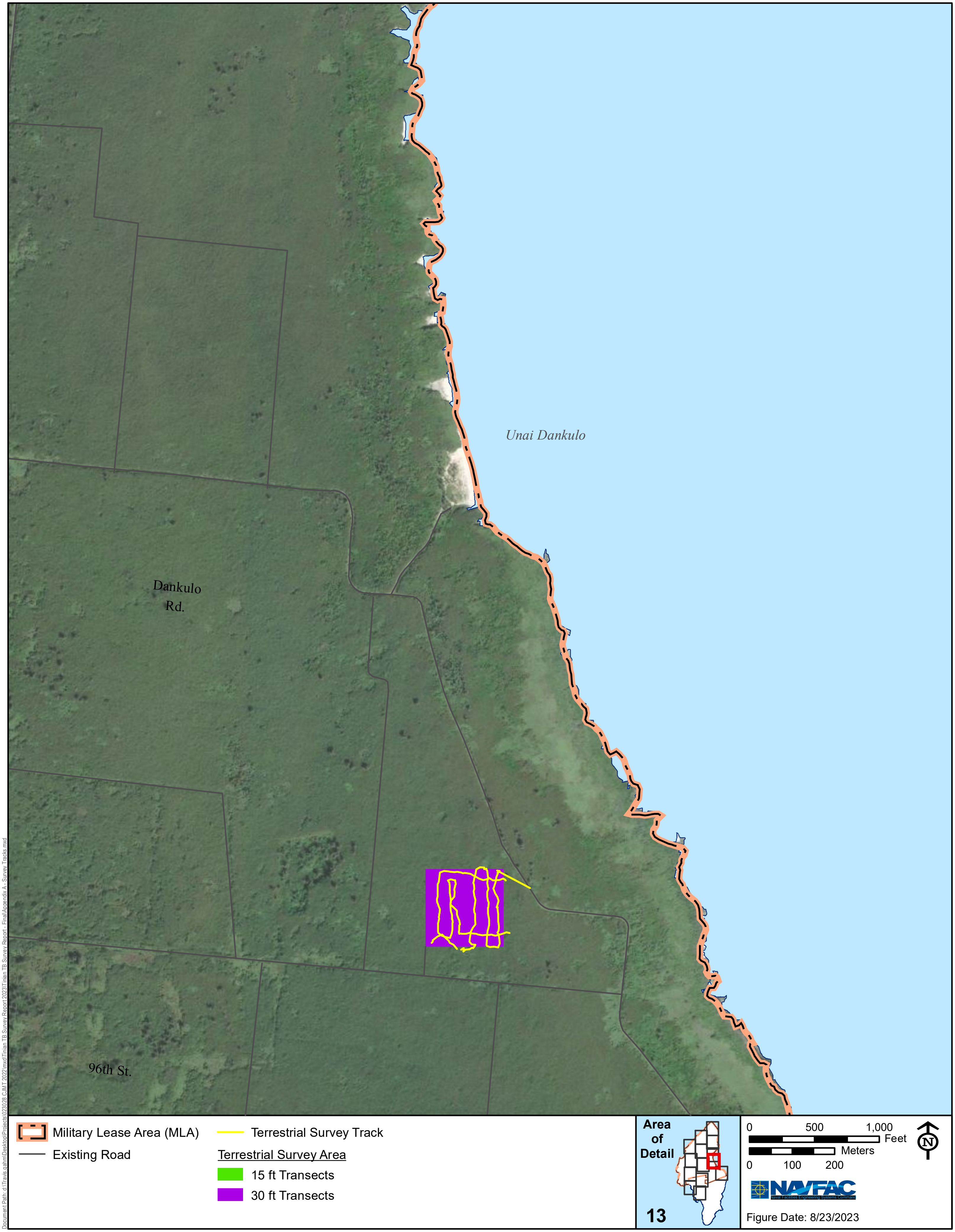
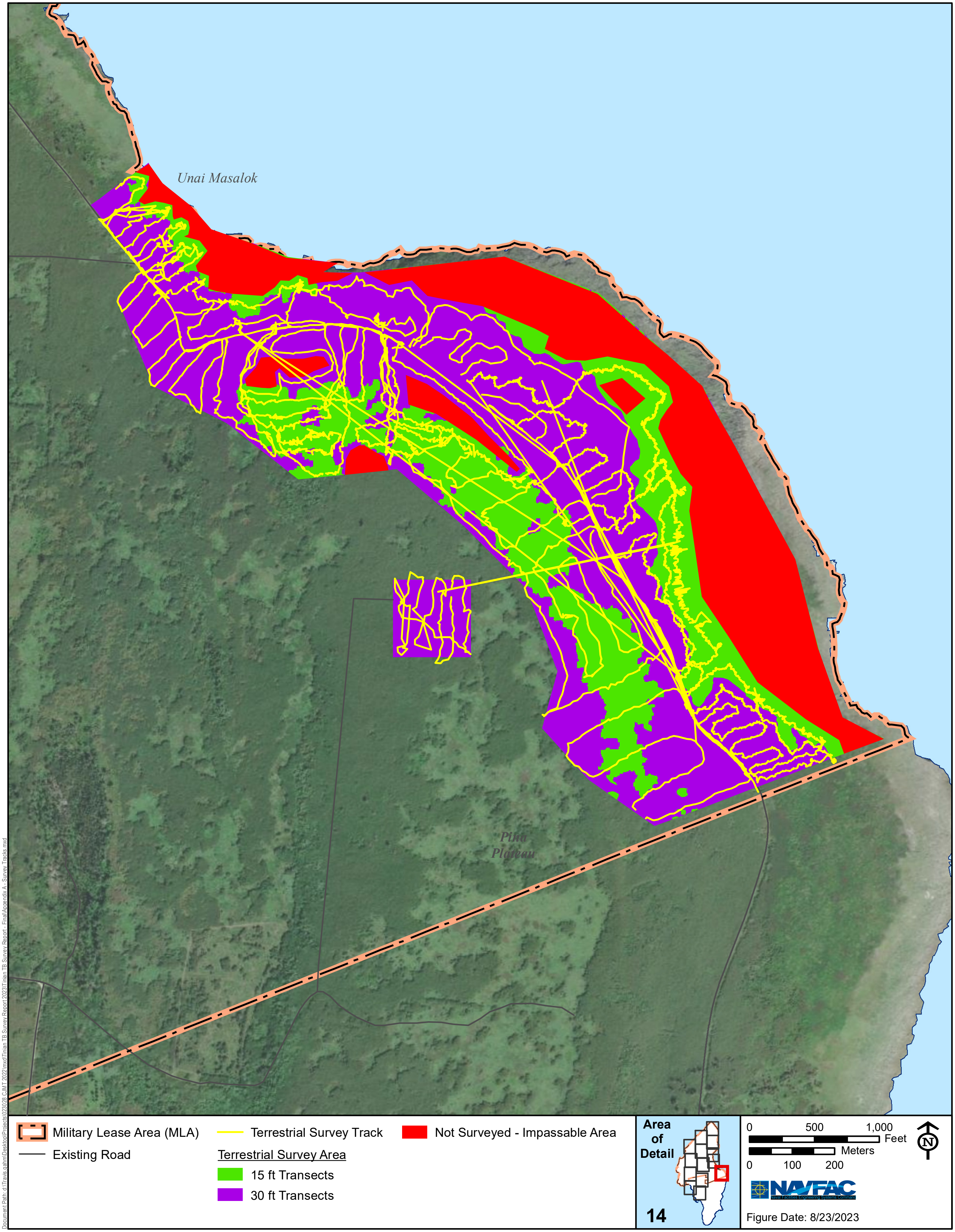

Unai Dankulo
Dankulo Rd.
96th St.
Military Lease Area (MLA)
Existing Road
Terrestrial Survey Track
Terrestrial Survey Area
15 ft Transects
30 ft Transects
Area of Detail
13
0 500 1,000 Feet
Meters
0 100 200
NAVFAC
Figure Date: 8/23/2023



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APPENDIX B SURVEY OBSERVATION DATA MATRICES

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Survey Point Data

Object ID	Species	Quantity	Life Stage	Condition	Host Species/Substrate	Vegetation Community	Date Observed	Notes	Northing (m)	Easting (m)
41	Pteropus mariannus mariannus	1	N/A	N/A	N/A	Limestone Degraded Forest	4/4/2023	fruit bat feces	1662330.9097	351164.3989
42	Pteropus mariannus mariannus	1	Adult	Good	N/A	Limestone Degraded Forest	4/21/2023	Life Stage: 1 adult	1664877.0190	351867.8158
43	Pteropus mariannus mariannus	1	N/A	N/A	N/A	Limestone Degraded Forest	4/4/2023	fruit bat feces	1662484.6955	351210.5939
44	Pteropus mariannus mariannus	1	N/A	N/A	N/A	Leucaena Forest	4/5/2023	fruit bat feces	1664326.3732	353033.8675
45	Pteropus mariannus mariannus	1	N/A	N/A	N/A	Limestone Degraded Forest	4/4/2023	fruit bat feces on leaves	1662286.8285	351275.2580
46	Dendrobium guamense	1	Adult	Good	Dead/downed tree/branch	Limestone Native Forest	4/11/2023	Life Stage: 1 adult; Host: dead tree	1663237.4255	352722.3502
47	Dendrobium guamense	1	Adult	Fair	Dead/downed tree/branch	Limestone Native Forest	4/11/2023	Life Stage: 1 adult; Host: dead tree	1662839.6571	352557.4532
48	Dendrobium guamense	8	Adult	Fair	Ficus sp.	Limestone Native Forest	4/14/2023	Life Stage: 8 adults; Host: Ficus	1663224.4897	353419.3888
49	Dendrobium guamense	8	Adult	Fair	Ficus sp.	Limestone Native Forest	4/14/2023	Life Stage: 8 adults; Host: Ficus	1663223.3444	353418.9580
50	Partula gibba	1	Dead	Dead	Leaf litter	Limestone Native Forest	4/14/2023	Life Stage: 1 dead individual; Host: leaf litter	1663141.9799	353381.8203
51	Dendrobium guamense	16	Adult	Fair	Limestone	Other Scrub/Grassland	4/17/2023	Life Stage: 16 adults; Host: limestone	1663038.5448	353287.3134
52	Dendrobium guamense	8	Adult	Fair	Limestone	Other Scrub/Grassland	4/17/2023	Life Stage: 8 adults; Host: limestone	1663037.5578	353288.0682
53	Dendrobium guamense	34	Adult	Fair	Premna serratifolia	Other Scrub/Grassland	4/17/2023	Life Stage: 34 adults, Host: Premna serratifolia	1662983.8174	353266.0825
54	Dendrobium guamense	6	Adult	Poor	Dead/downed tree/branch	Limestone Native Forest	4/17/2023	Life Stage: 6 adults; Host: dead branch	1662974.7671	353268.5723
55	Dendrobium guamense	6	Adult	Good	Dead shrub	Other Scrub/Grassland	4/17/2023	Life Stage: 6 adults; Host: dead shrub	1662976.6954	353262.4872
56	Dendrobium guamense	7	Adult	Fair	Unknown shrub	Limestone Native Forest	4/17/2023	Life Stage: 7 adults; Host: shrub sp.	1662974.4010	353263.7818
57	Dendrobium guamense	9	Adult	Good	Limestone	Other Scrub/Grassland	4/17/2023	Life Stage: 9 adults; Host: limestone	1662974.4768	353261.9592
58	Dendrobium guamense	4	Adult	Fair	Eugenia sp.	Other Scrub/Grassland	4/17/2023	Life Stage: 4 adults; Host: Eugenia sp.	1662974.3785	353262.2385
59	Dendrobium guamense	28	Adult	Fair	Dead/downed tree/branch	Leucaena Forest	4/17/2023	Life Stage: 28 adults; Host: dead branch	1662974.2153	353261.4755
60	Dendrobium guamense	3	Adult	Fair	Leaf litter	Other Scrub/Grassland	4/17/2023	Life Stage: 3 adults; Host: leaf litter	1662975.3763	353261.9788
61	Dendrobium guamense	10	Adult	Fair	Dead/downed tree/branch	Leucaena Forest	4/17/2023	Life Stage: 10 adults; Host: dead branch	1662974.5615	353261.5257
62	Dendrobium guamense	5	Adult	Good	Dead/downed tree/branch	Limestone Native Forest	4/18/2023	Life Stage: 5 adults; Host: dead branch	1662715.5203	353143.8230
63	Dendrobium guamense	5	Adult	Fair	Meiogyne cylindrocarpa	Limestone Native Forest	4/18/2023	Life Stage: 5 adults; Host: Meiogyne cylindrocarpa	1662710.0770	353142.4288
64	Dendrobium guamense	3	Adult	Fair	Dead/downed tree/branch	Limestone Native Forest	4/19/2023	Life Stage: 3 adults; Host: dead tree	1662608.8206	353086.2493
67	Dendrobium guamense	17	Adult	Good	Dead/downed tree/branch	Limestone Native Forest	4/18/2023	Life Stage: 17 adults; Host: dead log	1662348.4927	352977.6099
68	Dendrobium guamense	7	Adult	Good	Limestone	Limestone Native Forest	4/13/2023	Life Stage: 7 adults; Host: limestone	1662404.7412	352999.5980
69	Dendrobium guamense	4	Adult	Fair	Limestone	Limestone Native Forest	4/18/2023	Life Stage: 4 adults; Host: limestone	1662403.6555	352999.7485
70	Dendrobium guamense	12	Adult	Fair	Eugenia sp.	Limestone Native Forest	4/18/2023	Life Stage: 12 adults; Host: Eugenia sp.	1662403.9472	353000.6160
71	Partula gibba	1	Dead	Dead	N/A	Limestone Native Forest	4/19/2023	Life Stage: 1 dead individual	1661764.6847	352935.4532
72	Partula gibba	4	Dead	Dead	N/A	Limestone Native Forest	4/20/2023	Life Stage: 4 dead individuals, bleached shells	1661699.1614	352921.1672
73	Partula gibba	1	Dead	Dead	N/A	Limestone Degraded Forest	4/21/2023	Life Stage: 1 dead individual	1664279.9677	352179.1110
74	Dendrobium guamense	9	Adult	Fair	Dead/downed tree/branch	Limestone Native Forest	4/21/2023	Life Stage: 6 adults, 3 dead individuals; Host: dead branch	1662339.0201	352979.9433

Survey Polygon Data

Object ID	Species	Polygon ID	Quantity	Vegetation Community	Condition	Date Observed	Notes	Northing (m)	Easting (m)
13	Heritiera longipetiolata	Chiget-1	58	Limestone Coastal Scrub	Good	4/21/2023	Life Stage: 58 adults	1660722.8292	355854.7061
14	Heritiera longipetiolata	Masalok-1	13	Leucaena Forest	Good	4/14/2023	Life Stage: 8 adults, 5 saplings	1664760.2814	355188.1301
15	Heritiera longipetiolata	Pina-5	6	Limestone Native Forest	Good	4/17/2023	Life Stage: 6 adults	1659757.4559	356931.3529
16	Heritiera longipetiolata	Pina-7	19	Limestone Native Forest	Good	4/17/2023	Life Stage: 11 adults, 7 saplings, 1 dead	1659653.5412	357062.6814
17	Heritiera longipetiolata	Pina-10	11	Limestone Native Forest	Good	4/17/2023	Life Stage: 9 adults, 2 dead individuals	1659613.5268	357120.8897
18	Heritiera longipetiolata	Pina-9	24	Leucaena Forest	Good	4/17/2023	Life Stage: 1 adult, 23 saplings	1659609.1155	357052.4685
19	Heritiera longipetiolata	Pina-6	24	Limestone Native Forest	Good	4/19/2023	Life Stage: 19 adults, 5 saplings	1659684.0387	357044.4031
20	Heritiera longipetiolata	Pina-8	20	Limestone Native Forest	Good	4/19/2023	Life Stage: 20 adults	1659661.0531	357079.1356
21	Heritiera longipetiolata	Pina-1	45	Limestone Native Forest	Good	4/21/2023	Life Stage: 45 adults	1660604.2145	356398.0200
22	Heritiera longipetiolata	Pina-4	13	Limestone Native Forest	Good	4/20/2023	Life Stage: 12 adults, 1 dead individual	1660239.3082	356755.9566
23	Heritiera longipetiolata	Pina-3	21	Limestone Native Forest	Good	4/20/2023	Life Stage: 21 adults	1660282.9588	356706.0266
24	Heritiera longipetiolata	Pina-2	40	Limestone Native Forest	Good	4/21/2023	Life Stage: 40 adults	1660431.6038	356686.3722

APPENDIX C PHOTOGRAPHIC RECORD

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Photo 1. *Dendrobium guamense* on a dense understory brush.

Photo 2. *Dendrobium guamense* on a dead branch.

Photo 3. *Dendrobium guamense* in leaf litter.

Photo 4. *Dendrobium guamense* on a live branch.

Photo 5. *Dendrobium guamense* on a limestone cliff.

Photo 6. Mariana fruit bat ejecta

Photo 7. Bleached *Partula gibba* shell.

Photo 8. Bleached *Partula gibba* shell

Photo 8. Bleached *Partula gibba* shell found on forest floor.

Photo 9. Bleached *Partula gibba* shell found in limestone choss.

Photo 10. *Heritiera longipetiolata* found in limestone karst forest.

Photo 11. *Heritiera longipetiolata* found in limestone karst forest.

Photo 12. *Heritiera longipetiolata* growing out of karst crevice at edge of canyon ledge.

Photo 13. Dense *Heritiera longipetiolata* grove growing in karst limestone.

Photo 14 *Heritiera longipetiolata* found amongst limestone karst.

Photo 15. Low-stature, impassable limestone coastal scrub, showing canopy overview

Photo 16. Swordgrass-dominated patch.

Photo 17. Dense patch of mixed invasives typical of clearings on Tinian.

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APPENDIX H
CULTURAL RESOURCES SUPPORTING INFORMATION

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APPENDIX H

H.1 CULTURAL RESOURCES SUPPORTING DOCUMENTATION

H.1.1 Historical Overview

On Tinian, few archaeological and architectural resources show evidence of the area's status as a colony of Spain and Germany, while numerous structures and relics attest to the island's role in World War II. Other areas on the island are important because of their historical and traditional use, to the Chamorro as well as to former residents of American, Japanese, and Korean descent.

Pre-Contact Period in the Mariana Islands. The Pre-Latte Period dates from the time of initial settlement, approximately 3,500 years ago to 1,013 years ago. Moore et al. (2002) subdivides the Pre-Latte Period into four phases based on pottery styles: Early Unai, Middle Unai, Late Unai, and Huyong. The Latte Period is distinguished from these earlier periods by the presence of stone structures called *latte*. *Latte* are typically large limestone pillars, or more infrequently basalt, each topped by a capstone. *Latte* are most commonly found along the shorelines of all the major Mariana Islands and can consist of clusters of up to 18 individual structures forming hamlets or villages (although the Mochong site of Rota has at least 47 documented structures). The earliest *latte* structures date to approximately 1,013 years ago and are accompanied by a change in pottery technology.

Post-Contact Period. Western contact in the Mariana Islands is considered to have occurred in 1521, the year Ferdinand Magellan landed on Guam. At the time of western contact, the Mariana Islands were inhabited by a group of people that came to be known as the Chamorro. Spain colonized the Mariana Islands for over 200 years, beginning in 1668 with the arrival of Catholic missionaries. The original Chamorro population in the Mariana Islands was estimated to be between 40,000 and 73,000. On Tinian, however, that number was reduced to 600 by 1825 because of two centuries of Spanish rule that included war, famine, disease, and forced relocation to Spain and Guam (Bowers 1950). Once depopulated, Tinian was not reoccupied by the Chamorro until after World War II.

At the conclusion of the Spanish American War in 1899, Spain sold the islands currently in the CNMI to Germany. The Germans saw the islands as an opportunity to capitalize on economic and commercial endeavors already begun in the Marshall Islands and Palau. In 1914, a Japanese naval squadron seized control of Saipan and the Northern Mariana Islands along with other German possessions in Micronesia. Saipan was placed under military jurisdiction and German nationals were expelled. The League of Nations awarded German Micronesia, including Saipan and the Northern Mariana Islands, to Japan in 1921, with the stipulation it not be fortified for military use. By 1922, the Japanese had developed large-scale sugarcane production on Saipan and then on Tinian and Rota.

Japanese war preparation brought further changes to Saipan, Tinian, Pagan, and Rota. On Saipan, the sugar cane fields near Asurito were developed into an airfield, and two other airfields were quickly built at Marpi Point and on the coastal lowland between Chalan Konoa and Garapan. Two airfields were built on Tinian, and construction of a third airfield was started. The Japanese built barracks and administrative buildings around these airfields.

World War II battles devastated large areas of Saipan and Tinian. In 1944, air strikes destroyed 150 Japanese planes in the battle for Saipan. From Saipan, United States forces began a bombardment of Tinian that ended with an invasion in July 1944. Shortly thereafter, United States forces began construction of the Tinian airfields for the B-29. Tinian would eventually become a critical launching point for the bombing of Japan, culminating in the dropping of atomic bombs from planes based on Tinian that ended the war.

After World War II, the United States administered the Northern Marianas under a mandate of the United Nations. When Japanese nationals were removed in January and February of 1946, Tinian, Saipan, and Rota were all occupied by American military personnel. Intensive military construction took place on all three islands, including removal of remnants of bombings and battles. Several villages have been resettled or established in the Northern Marianas since World War II, including one on Tinian (San Jose was resettled in 1947 by Chamorro immigrants from Yap Island, who first occupied the former Chulu camp used for Japanese prisoners). Two smaller settlements attempted on Alamagan and Agrihan were unsuccessful. In 1976, the Marianas entered into an agreement with the United States, and its government reorganized as the CNMI.

H.1.2 Cultural Resources Within the Area of Potential Effect

The cultural resources surveys (Table H-1), in addition to the cultural resources that are eligible for or listed in the National Register of Historic Places (Table H-2) and separately the cultural resources that have been evaluated and determined not eligible for the National Register of Historic Places (Table H-3), as discussed in Section 3.5.2.2 are presented below. These studies occur within the Military Lease Area, Tinian International Airport, and 8th Avenue to and including Tinian Harbor, with an indirect APE that extends into the Philippine Sea along the northwest and northeast tip of Tinian.

Table H-1. Cultural Resource Surveys within the Area of Potential Effect

Authors	*Year of Publication*	*Type of Work*	*Location*	*Acres*
Marche	(1882) 1982	Excavation	House of Taga/Port of Tinian vicinity	Not Applicable
Hornbostel	1924-1925	Excavation	House of Taga/Port of Tinian vicinity	Not Applicable
Hasebe	1928	Excavation	House of Taga/Port of Tinian vicinity	Not Applicable
Spoehr	1957	Excavation	House of Taga/Port of Tinian vicinity	Not Applicable
Pellet and Spoehr	1961	Excavation	House of Taga/Port of Tinian vicinity	Not Applicable
Thomas	1980	Excavation	House of Taga/Port of Tinian vicinity	Not Applicable
Pangelinan	1982	Survey, site specific	North Field	1,436
Denfeld	1983	Survey, site specific	North Field	Not Applicable
Moore et al.	1986	Survey and testing	All beaches	1,779
Donham	1986	Survey	North end of North Field	312
Haun	1988	Survey	North end of North Field	80
Haun	1989	Site recording	North end of North Field	80
Haun and Donham	1989a	Site recording	North end of North Field	80
Haun and Donham	1989b	Site recording	North end of North Field	80
Haun et al.	1990	Survey	North end of North Field	37

Authors	*Year of Publication*	*Type of Work*	*Location*	*Acres*
Jones	1991	Historic architectural survey	Military Lease Area, Tinian Port	17,798
Welch and Bodner	1993	Known site assessments	Military Lease Area	Not Applicable
Welch	1994	Survey, site specific	Unai Chulu, Unai Dankulo	Not Applicable
Craib	1995	Survey	Unai Chiget, roadways	528
Henry and Haun	1995	Survey and testing	Unai Chulu	25
Franklin and Haun	1995a	Survey	Unai Dankulo	200
Franklin and Haun*	1995b	Data recovery excavations	Road corridor (8th Avenue)	83
Eblé et al.	1997	Survey	International Broadcasting Bureau	Small sample of 2,400 area
Putzi et al.	1997	Survey	International Broadcasting Bureau, Area A	192
Athens and Ward	1998	Sediment coring	Lake Hagoi	Not Applicable
Bouthillier	1998	Site recording (Post Contact Period sites)	Exclusive Military Use Area	Not Applicable
Craib	1998	Survey and testing	Exclusive Military Use Area	750
Welch and Tuggle	1998	Site specific assessment	Military Lease Area	Not Applicable
Moore et al.	1998	Survey and testing	Tinian Power Plant/Port of Tinian vicinity	4.94
Bouthillier	1999	Historic architectural survey	Unai Chiget, Unai Chulu, Unai Babui, Unai Dankulo, Unai Masalok	4,000
Craib	1999	Survey and testing	Unai Dankulo, Banderon Nunu, portion of Mount Lasso (also area north of House of Taga)	690
Haun et al.	1999	Survey, testing; excavation	Unai Chulu	Not Applicable
Tuggle and Welch	1999	Site protection plan, selected site mapping	Military Lease Area	Not Applicable
Henry et al.	1999	Survey and testing	Exclusive Military Use Area	4,162
Dixon et al.	2000	Survey	International Broadcasting Bureau, Areas B and C	1,590
Allen et al. Allen and Nees Allen et al. Gosser et al. Gosser et al.	2000 2001 2002 2001 2002	Survey; testing, excavation	Military Lease Back Area	7,710
Dixon and Welch	2002	Survey	Tinian International Airport	494

Authors	*Year of Publication*	*Type of Work*	*Location*	*Acres*
Denfeld	2002	Military structures survey	Central Pacific	Not Applicable
Moore et al.	2001	Survey and testing	International Broadcasting Bureau Area A	150
Swift et al.	2002a	Survey and monitoring	San Jose Waterline/Port of Tinian and supply route vicinity	1
Swift et al.	2002b	Survey and monitoring	San Jose Route 202/Port of Tinian and supply route vicinity	63
Swift et al.	2005	Survey and monitoring	San Jose Route 205/Port of Tinian and supply route vicinity	84
Dixon et al.	2003	Excavation	8th Avenue realignment/Port of Tinian and supply route vicinity	0.67
Athens	2009	Survey and testing	Military Lease Area	4,597
Griffin et al.	2010	Traditional Cultural Properties Study	Military Lease Area	Not Applicable
Burns	2010	Underwater survey	Near Unai Chulu and Unai Dankulo	60
Fowler et al.	2010	Cultural Landscape study	North Field National Historic Landmark	2,500
Thursby	2010	Architectural survey	Tinian Port	Not Applicable
Carson	2014	Excavation	House of Taga/Port of Tinian vicinity	.02
DoN	2014a	Traditional Cultural Properties Study	Military Lease Area	Not Applicable
DoN	2015c	Survey	Tinian Port/roads/site SC 5029	79
DoN	2017a	Underwater survey/remote sensing	Puntan Diablo	Not Applicable
LeClerc et al.	2018	Survey	West Field	2,906

Table H-2. Historic Properties and Other Resources of Cultural Importance within the Area of Potential Effect

*Site Number**	*Site Description*	*Time Period*	*NRHP Criteria***	*Primary Reference*
TN-4/6-0002	Chulu/Churo Village and Internment Camp	Japanese Administration/ American Administration	A, D	Allen and Nees 2001
TN-4-0004	Mount Lasso Shrine	Japanese Administration	A, C, D	Tuggle 2009
TN-4-0006	Japanese Village (Hagoi) with Railroad Line	Japanese Administration	A, D	Henry et al. 1999
TN-4-0007	Asahi (Sunrise) Shrine, Reconstruction	Japanese Administration/ American Administration	A, C, D	Tuggle 2009
TN-4-0008	NKK Shrine	Japanese Administration	A, C, D	Tuggle 2009
TN-5/6-0009	Radio Complex and Holding Area for Japanese POWs	Japanese Administration/ American Administration	A, C, D	Tuggle 2009
TN-4-0011	86th Street Shinto shrine, part of Kahi Village	Japanese Administration	A, D	Tuggle 2009
TN-1/5-0015	Defensive Caves	Pre-Contact/ Japanese Administration	A, C, D	Tuggle 2009
TN-5/6-0016	Unai Chulu Pillboxes, White Beach 2 (Chulu), Bunkers and WWII Assault Beach	Japanese Administration/ American Administration	A, C, D	Tuggle 2009
TN-5-0018	Ushi Field Drainage Ditch	Japanese Administration	A, C, D	Henry et al. 1999
TN-5-0019	Revetments	Japanese Administration	A, C, D	Tuggle 2009
TN-5-0020	Defensive Tunnels	Japanese Administration	A, C, D	Tuggle 2009
TN-5-0022	Unai Dankulo Defenses	Japanese Administration	A, D	Tuggle 2009
TN-5-0024	Peipeinigul Gun	Japanese Administration	A, C, D	Jones 1991
TN-5/6-0025	Antenna Tower Supports	Japanese Administration/ American Administration	A, C, D	Tuggle 2009
TN-6-0030	West Field	American Administration	A, D	Tuggle 2009
TN-6-0031	58th Wing Headquarters (HQ)	American Administration	A, D	Tuggle 2009

*Site Number**	*Site Description*	*Time Period*	*NRHP Criteria***	*Primary Reference*
TN-6-0032	107th Naval Construction Brigade (NCB)	American Administration	A, D	Tuggle 2009
TN-6-0034	Old Village Cemetery (Camp Churo)	American Administration	A, D	Tuggle 2009
TN-6-0036	313th Bomb Wing HQ	American Administration	A, D	Tuggle 2009
TN-6-0038	Army Hospital	American Administration	A, C, D	Tuggle 2009
TN-6-0039	509th Composite Group	American Administration	A, B, C, D	Jones 1991
TN-6-0041	A Bomb Assembly Area	American Administration	A, B, C, D	Tuggle 2009
TN-6-0042	17th Anti-Aircraft Artillery (AAA) Recreational Structure	American Administration	A, B, C, D	Tuggle 2009
TN-6-0043	Munitions Quonsets, Masalok Bomb Dump	American Administration	A	Tuggle 2009
TN-6-0045	Masalok Revetments	American Administration	A, D	Allen and Nees 2001
TN-6-0049	462nd Bomb Group	American Administration	A, D	Tuggle 2009
TN-6-0050	Army Garrison Depot	American Administration	A, D	Tuggle 2009
TN-6-0051	Guard Rail	American Administration	D	Jones 1991
TN-6-0056	504th BG Camp	American Administration	A, D	Tuggle 2009
TN-1-0071	San Hilo Pictographs	Pre-Contact	A, D	Moore et al. 1986
TN-1-0072	Sabanaten Famalaoan West Coast Latte Site	Pre-Contact	A, C, D	Henry et al. 1999
TN-1-0073	Unai Chulu Latte Complex	Pre-Contact	A, C, D	Tuggle 2009
TN-1-0074	Unai Babui Latte Set	Pre-Contact	A, D	Henry et al. 1999
TN-1-0075	Unai Lamlam Ceramics	Pre-Contact	A, D	Moore et al. 1986
TN-1-0076	Puntan Tahgong Latte Complex	Pre-Contact	A, C, D	Tuggle 2009
TN-1-0077	Unai Chiget Latte Sets	Pre-Contact	A, C, D	Tuggle 2009
TN-1-0078	Unai Dangkulo Latte Sets	Pre-Contact	A, C, D	Tuggle 2009
TN-4-0353	Cistern	Japanese Administration	D	Henry et al. 1999
TN-5-0354	Defensive Enclosure	Japanese Administration	A, D	Henry et al. 1999
TN-5/6-0355	Unai Babui Defenses	Japanese Administration/ American Administration	A, C, D	Henry et al. 1999
TN-5-0356	Gun Position	Japanese Administration	A, D	Donham 1986

*Site Number**	*Site Description*	*Time Period*	*NRHP Criteria***	*Primary Reference*
TN-6-0357	Gun Position	American Administration	A, D	Henry et al. 1999
TN-6-0358	Gun Position	American Administration	A, D	Henry et al. 1999
TN-6-0359	Landing Craft	American Administration	A, D	Henry et al. 1999
TN-1-0360	Pottery Scatter	Pre-Contact	D	Craib 1998
TN-4-0361	Trash Scatter	Japanese Administration	D	Henry et al. 1999
TN-6-0362	509th Composite Group Service Area	American Administration	A, C, D	Henry et al. 1999
TN-5-0363	Gun Emplacement	Japanese Administration	A, C, D	Henry and Haun 1995
TN-6-0364	North Field Runways and Aprons	American Administration	A, B, C, D	Thompson 1984
TN-6-0365	Atomic Bomb Loading Pits	American Administration	A, B, C, D	Denfeld 1983
TN-5-0373	Ushi Field Storage Bunker	Japanese Administration	A, C, D	Donham 1986
TN-5-0374	Ushi Field Storage Bunker	Japanese Administration	A, C, D	Donham 1986
TN-5-0375	Ushi Field Gun Positions	Japanese Administration	A, C, D	Donham 1986
TN-5/6-0378	Ushi Field Gun Position and Defensive Complex	Japanese Administration/ American Administration	A, D	Tuggle 2009
TN-6-0380	Debris and Equipment	American Administration	D	Donham 1986
TN-1-0381	Pottery Scatter	Pre-Contact	D	Donham 1986
TN-6-0382	A Battery, 17th AAA	American Administration	A, D	Tuggle 2009
TN-6-0390	Dump	American Administration	D	Henry et al. 1999
TN-5-0391	Gun Complex	Japanese Administration	A, D	Henry et al. 1999
TN-1-0392	Ceramics	Pre-Contact	A, D	Henry et al. 1999
TN-1-0396	Ceramics	Pre-Contact	D	Henry et al. 1999
TN-6-0398	U.S. Marine Corps Former Cemetery	American Administration	A	Tuggle 2009
TN-6-0399	Dump	American Administration	D	Henry et al. 1999
TN-5-0400	Gun Enclosure	Japanese Administration	D	Craib 1998
TN-6-0401	313th Wing Base Service Command	American Administration	A, D	Tuggle 2009
TN-6-0402	B-29 Service Apron	American Administration	A, B, D	Donham 1986

*Site Number**	*Site Description*	*Time Period*	*NRHP Criteria***	*Primary Reference*
TN-6-0403	Aircraft Debris	American Administration	D	Donham 1986
TN-1-0404	Pottery Scatter	Pre-Contact	D	Donham 1986
TN-5-0405	Gun Position	Japanese Administration	A, D	Donham 1986
TN-5-0407	Unai Babui Defenses	Japanese Administration	A, C, D	Craib 1998
TN-6-0408	Amtrak	American Administration	A, C, D	Henry and Haun 1995
TN-1-0421	Ceramics	Pre-Contact	D	Henry et al. 1999
TN-?-0422***	Bulldozed Debris	Historic	D	Henry et al. 1999
TN-6-0423	U.S. Enclosure, Earthen Pit, Storage	American Administration	D	Henry et al. 1999
TN-6-0424	Dump	American Administration	D	Henry et al. 1999
TN-6-0425	Dump	American Administration	D	Henry et al. 1999
TN-6-0426	121st Construction Battalion (CB) Service Area	American Administration	A, B, C, D	Henry et al. 1999
TN-1-0431	Ceramics	Pre-Contact	D	Henry et al. 1999
TN-1/5-0432	Laderan Chiget Defenses, Rock Shelters	Pre-Contact/ Japanese Administration	A, C, D	Tuggle 2009
TN-1-0433	Latte Sets Above Chiget Cliffs	Pre-Contact	A, C, D	Tuggle 2009
TN-5-0439	Laderan Gatot Defensive Caves	Japanese Administration	A, D	Tuggle 2009
TN-1-0441	Ceramics	Pre-Contact	D	Henry et al. 1999
TN-6-0442	Central Bomb Dump	American Administration	A	Tuggle 2009
TN-1/6-0453	Artifact Scatter and Temporary Encampment	Pre-Contact/ American Administration	D	Henry et al. 1999
TN-5-0458	Laderan Lasu Defenses	Japanese Administration	A, C, D	Henry et al. 1999
TN-?-0460***	Road	Historic	D	Henry et al. 1999
TN-4-0461	Fourth Farm District (VI)	Japanese Administration	D	Tuggle 2009
TN-5-0463	Mount Lasso Defenses	Japanese Administration	A, C, D	Henry et al. 1999
TN-5-0468	Laderan Gagot Defenses	Japanese Administration	A, D	Tuggle 2009
TN-6-0471	67th NCB Camp	American Administration	A, D	Tuggle 2009

*Site Number**	*Site Description*	*Time Period*	*NRHP Criteria***	*Primary Reference*
TN-5/6-0472	Dump	Japanese Administration/ American Administration	A, C, D	Henry et al. 1999
TN-6-0478	Fuel Tanks, East H-14-C, North Field	American Administration	A, D	Tuggle 2009
TN-6-0480A	121st NCB Camp	American Administration	A, D	Tuggle 2009
TN-6-0480B	9th NCB Camp	American Administration	A, D	Tuggle 2009
TN-6-0481	18th NCB, Temporary 509th Comp. Camp	American Administration	A, B, D	Tuggle 2009
TN-5-0488	Gun position, Fuel Drum, Japanese Defenses	Japanese Administration	A, D	Tuggle 2009
TN-6-0489	C Battery, 17th AAA	American Administration	A, C, D	Tuggle 2009
TN-6-0491	Mine Depot Number 4	American Administration	D	Tuggle 2009
TN-5/6-0493	Defenses	Japanese Administration/ American Administration	A, D	Henry et al. 1999
TN-6-0494	Debris in Cave	American Administration	D	Henry et al. 1999
TN-4-0502	Farmstead	Japanese Administration	A, C, D	Henry et al. 1999
TN-5-0503	San Hilo Defenses	Japanese Administration	A, D	Henry et al. 1999
TN-4-0505	Farmstead	Japanese Administration	A, C, D	Henry et al. 1999
TN-5-0506	Defensive Depression	Japanese Administration	D	Henry et al. 1999
TN-4-0507	Railroad Bed	Japanese Administration	C, D	Henry et al. 1999
TN-4-0512	Farmstead	Japanese Administration	A, C, D	Henry et al. 1999
TN-6-0513	Munitions Storage	American Administration	A, D	Henry et al. 1999
TN-1-0521	Sinkhole with Artifacts	Pre-Contact	D	Henry et al. 1999
TN-1-0522	Rock Overhang	Pre-Contact	A, D	Henry and Haun 1995
TN-6-0525	Defensive Platform	American Administration	D	Henry et al. 1999
TN-5-0526	Defensive Platform	Japanese Administration	A, D	Henry et al. 1999
TN-5-0527	Cliff line Defenses/Japanese Defensive Caves	Japanese Administration	A, C, D	Tuggle 2009
TN-5-0528	Observation Post	Japanese Administration	A, D	Henry et al. 1999

*Site Number**	*Site Description*	*Time Period*	*NRHP Criteria***	*Primary Reference*
TN-6-0529	Debris	American Administration	D	Henry et al. 1999
TN-?-0530***	Road on Maga	Historic	D	Henry et al. 1999
TN-6-0531	West H-14C Fuel Tanks	American Administration	D	Henry et al. 1999
TN-5-0532	Gun Enclosure	Japanese Administration	D	Henry et al. 1999
TN-4-0533	Cisterns	Japanese Administration	D	Henry et al. 1999
TN-1-0534	Ceramics	Pre-Contact	D	Henry et al. 1999
TN-4-0535	Farmstead	Japanese Administration	A, D	Henry et al. 1999
TN-4-0537	Farmstead	Japanese Administration	A, D	Henry et al. 1999
TN-4-0538	Farmstead	Japanese Administration	D	Henry et al. 1999
TN-5-0543	Radio Direction Finding (RDF) Tower Bases, Radio Station	Japanese Administration	A, C, D	Donham 1986
TN-6-0544	B Battery, 17th AAA and ABCD Annex	American Administration	A, C, D	Henry et al. 1999
TN-6-0545	Quonset Hut	American Administration	A, C, D	Denfeld 1983
TN-?-0546***	Airplane Wreck	Historic	D	Henry et al. 1999
TN-6-0547	Landing Craft	American Administration	A, D	Henry et al. 1999
TN-6-0549	Gun Enclosure	American Administration	D	Henry et al. 1999
TN-5-0553	Overhang with Trash	Japanese Administration	D	Henry et al. 1999
TN-6-0554	Landing Craft	American Administration	A, D	Henry et al. 1999
TN-6-0555	Water Pumping Station, 12th CB	American Administration	A, D	Henry et al. 1999
TN-6-0556	U.S. Cistern	American Administration	D	Henry et al. 1999
TN-5-0558	Gun Position	Japanese Administration	A, D	Henry et al. 1999
TN-1-0559	Pottery Scatter	Pre-Contact	D	Craib 1998
TN-4-0561	Land Boundary Marker	Japanese Administration	D	Craib 1998
TN-1-0563	Pre-Contact Petroglyphs in Cave	Pre-Contact	A, C, D	Tuggle 2009
TN-6-0567	U.S. Quarry, Camp Churo Cesspool and Drainage Ditch	American Administration	D	Tuggle 2009

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TN-5-0574	JPN Concrete Terraced Structure (Possible Water Management)	Japanese Administration	D	Tuggle 2009
TN-1/?-0588***	Rock Shelter, Latte Set, Cistern	Pre-Contact/ Historic	A, D	Dixon et al. 2000
TN-5-0589A	JPN Airfield No. 2	Japanese Administration	A, C	Tuggle 2009
TN-5/6-0589B	JPN Airfield No. 2; U.S. West Field Runway No. 4	Japanese Administration/ American Administration	A	Tuggle 2009
TN-5/6-0589C	JPN Airfield No. 2; U.S. West Field Runway No. 4	Japanese Administration/ American Administration	A	Tuggle 2009
TN-1/2-0590	Latte Sets and Pottery	Pre-Contact/ Spanish Administration	A, D	Gosser et al. 2001
TN-1/2-0591	Latte Sets	Pre-Contact/ Spanish Administration	A, D	Dixon et al. 2000
TN-1/2/4-0592	Latte Sets	Pre-Contact/ Spanish Administration/ Japanese Administration	A, D	Allen and Nees 2001
TN-1-0593	Rock Shelter, Mortar	Pre-Contact	A, D	Gosser et al. 2001
TN-1-0594	Mortar and Pottery	Pre-Contact	D	Moore et al. 1986
TN-1-0595	Surface Material	Pre-Contact	D	Moore et al. 1986
TN-1-0596	Surface Material	Pre-Contact	D	Dixon et al. 2000
TN-6-0598	Radio Transmission Station	American Administration	D	Tuggle 2009
TN-4/6-0599	Agricultural Facility and 696 Signal Aircraft Warning Company	Japanese Administration/ American Administration	A, C, D	Tuggle 2009
TN-6-0601	444th Bomb Group	American Administration	A, D	Tuggle 2009
TN-6-0602	6th Bomb Group and Church	American Administration	A, D	Tuggle 2009
TN-6-0603	9th Bomb Group	American Administration	A, D	Tuggle 2009
TN-6-0604	468th Bomb Group	American Administration	A, D	Tuggle 2009
TN-6-0605	40th Bomb Group	American Administration	A, D	Gosser et al. 2001
TN-6-0606	87th and 25th Service Corps	American Administration	A, D	Tuggle 2009

*Site Number**	*Site Description*	*Time Period*	*NRHP Criteria***	*Primary Reference*
TN-6-0609	C Battery, 18th AAA	American Administration	A, D	Dixon and Welch 2002
TN-5-0609	Anti-Aircraft Bunker	Japanese Administration/ American Administration	A, C, D	Dixon and Welch 2002
TN-6-0610	A Battery, 18th AAA	American Administration	A, D	Tuggle and Welch 1999
TN-6-0611	HQ Light Anti-Aircraft, 18th AAA	American Administration	A, D	Tuggle 2009
TN-6-0612	Extension of West Field Runway No. 4	American Administration	A	Tuggle 2009
TN-6-0613	D Battery, 18th AAA	American Administration	A, D	Tuggle 2009
TN-6-0619	U.S. Fuel Farm, East H-14-A	American Administration	A, D	Tuggle 2009
TN-6-0623	U.S. Military Butchering Facility and Corral	American Administration	A, D	Tuggle 2009
TN-4-0631	Japanese Concrete Structure	Japanese Administration	A, D	Tuggle 2009
TN-4-0648	Farmstead	Japanese Administration	A, D	Dixon et al. 2000
TN-5-0649	Defenses	Japanese Administration	A, C, D	Dixon et al. 2000
TN-1-0650	Latte Sets Disturbed	Pre-Contact	D	Dixon et al. 2000
TN-1-0651	Latte Sets Disturbed	Pre-Contact	D	Dixon et al. 2000
TN-1-0653	Rock Shelters, Latte Sets	Pre-Contact	D	Dixon et al. 2000
TN-1-0654	Latte Sets Disturbed	Pre-Contact	D	Dixon et al. 2000
TN-1/5-0655	Aguidun Area Rock Shelter	Pre-Contact/ Japanese Administration	D	Dixon et al. 2000
TN-1-0656	Latte Sets	Pre-Contact	D	Dixon et al. 2000
TN-5-0657	Rock Shelters	Japanese Administration	A, C, D	Dixon et al. 2000
TN-1-0658	Aguidun Area Rock Shelter and Latte Site	Pre-Contact	C, D	Dixon et al. 2000
TN-1/5-0659	Rock Shelters	Pre-Contact/ Japanese Administration	D	Dixon et al. 2000
TN-1/5-0660	Latte Sets and Rock Shelter Refuge Defenses	Pre-Contact/ Japanese Administration	A, D	Dixon et al. 2000
TN-6-0664	Military Machinery	American Administration	D	Dixon et al. 2000
TN-4-0681	Railroad Bed	Japanese Administration	A, C, D	Dixon and Welch 2002
TN-4-0682	Farmstead	Japanese Administration	A, D	Dixon and Welch 2002

*Site Number**	*Site Description*	*Time Period*	*NRHP Criteria***	*Primary Reference*
TN-4-0683	Farmstead	Japanese Administration	A, C, D	Gosser et al. 2001
TN-5-0690	Anti-Aircraft Defenses	Japanese Administration	A, C, D	Dixon and Welch 2002
TN-1-0691	Artifact Scatter	Pre-Contact	D	Dixon and Welch 2002
TN-1-0907	Dankulo Petroglyphs	Pre-Contact	A, C, D	Allen and Nees 2001
TN-5-0936	Battleline	American Administration	A, C, D	Allen and Nees 2001
TN-6-0971	C Battery, 17th Anti-Aircraft Gun Position	American Administration	A, D	Tuggle 2009
TN-4-1004	JPN Defenses	Japanese Administration	A, D	Tuggle 2009
TN-4-1010	NKK Administration Building and Laboratory Building	Japanese Administration	D	Dixon et al. 2015
TN-5-1013	JPN Defenses (Expanded)	Japanese Administration	A, D	Tuggle 2009
TN-5-1015	JPN Defenses	Japanese Administration	A, D	Tuggle 2009
TN-5-1025	JPN Defenses, Foxhole Complex	Japanese Administration	A, D	Tuggle 2009
TN-1/5-1033	Artifacts and Straggler Cave	Pre-Contact/ Japanese Administration	D	Allen and Nees 2001
TN-5-1034	Defensive Shelter	Japanese Administration	D	Allen and Nees 2001
TN-4-1035	Agricultural Boundary Marker	Japanese Administration	D	Allen and Nees 2001
TN-4-1036	Agricultural Field Mounds	Japanese Administration	D	Allen and Nees 2001
TN-6-1037	U.S. Dump	American Administration	D	Allen and Nees 2001
TN-4-1044	Agricultural Boundary Wall	Japanese Administration	D	Allen and Nees 2001
TN-5-1045	Bunkers	Japanese Administration	A, C, D	Allen and Nees 2001
TN-1/5-1046	Artifacts and Sinkhole Use	Pre-Contact/ Japanese Administration	D	Allen and Nees 2001
TN-5-1047	Defensive Enclosure	Japanese Administration	D	Allen and Nees 2001
TN-5-1048	Defensive Ravine	Japanese Administration	A, C, D	Allen and Nees 2001
TN-1/2/4-1049	Artifacts and Ravine Farming	Pre-Contact/ Spanish Administration/ Japanese Administration	A, C, D	Allen and Nees 2001

*Site Number**	*Site Description*	*Time Period*	*NRHP Criteria***	*Primary Reference*
TN-4-1050	Rock Shelter Use	Japanese Administration	A, D	Allen and Nees 2001
TN-4-1051	Agricultural Feature	Japanese Administration	D	Allen and Nees 2001
TN-4-1052	Cistern	Japanese Administration	D	Allen and Nees 2001
TN-4-1053	Agricultural Wall	Japanese Administration	D	Allen and Nees 2001
TN-4-1054	Farmstead	Japanese Administration	A, C, D	Allen and Nees 2001
TN-4-1055	Farmstead	Japanese Administration	A, D	Allen and Nees 2001
TN-4-1056	Road	Japanese Administration	A, D	Allen and Nees 2001
TN-4-1057	Agricultural Enclosure	Japanese Administration	D	Allen and Nees 2001
TN-5-1058	Defensive Rock Shelter	Japanese Administration	A, C, D	Allen and Nees 2001
TN-4-1059	Agricultural Enclosure	Japanese Administration	D	Allen and Nees 2001
TN-1/5-1060	Defensive Cave and Artifacts	Pre-Contact/ Japanese Administration	D	Allen and Nees 2001
TN-5-1063	Defensive Rock Shelter	Japanese Administration	A, C, D	Allen and Nees 2001
TN-5-1064	Defensive Rock Shelter	Japanese Administration	A, C, D	Allen and Nees 2001
TN-5-1065	Defensive Rock Shelter	Japanese Administration	A, C, D	Allen and Nees 2001
TN-5-1068	Defensive Rock Shelter	Japanese Administration	A, C, D	Allen and Nees 2001
TN-4-1071	Farmstead	Japanese Administration	A, D	Allen and Nees 2001
TN-4-1077	Road	Japanese Administration	A, D	Allen and Nees 2001
TN-5-1078	Defensive Pits and Walls	Japanese Administration	A, C, D	Allen and Nees 2001
TN-4-1079	Agricultural Boundary Marker	Japanese Administration	D	Allen and Nees 2001
TN-5-1080	Gun Position Enclosure	Japanese Administration	D	Allen and Nees 2001
TN-5-1081	Gun Position Trench	Japanese Administration	A, D	Allen and Nees 2001
TN-4-1082	Agricultural Structures	Japanese Administration	D	Allen and Nees 2001
TN-5-1089	JPN Defenses (Expanded)	Japanese Administration	A, C, D	Tuggle 2009

*Site Number**	*Site Description*	*Time Period*	*NRHP Criteria***	*Primary Reference*
TN-4/5-1096	Farmstead and Defenses	Japanese Administration	A, C, D	Allen and Nees 2001
TN-4-1098	Agricultural Mounds	Japanese Administration	D	Allen and Nees 2001
TN-4-1099	Railroad Berm	Japanese Administration	D	Allen and Nees 2001
TN-1-1100	Latte Set and Mortar	Pre-Contact	D	Allen and Nees 2001
TN-4-1102	Farmstead	Japanese Administration	A, C, D	Gosser et al. 2001
TN-4-1103	Farmstead	Japanese Administration	A, D	Gosser et al. 2001
TN-4-1104	Farmstead (Mortar Also in Area)	Pre-Contact/ Japanese Administration	A, C, D	Gosser et al. 2001
TN-5-1105	Rock Shelters, Defense	Japanese Administration	A, C, D	Gosser et al. 2001
TN-4-1106	Farmstead	Japanese Administration	A, C, D	Gosser et al. 2001
TN-4-1107	Farmstead	Japanese Administration	A, D	Gosser et al. 2001
TN-4-1108	Agricultural Feature (Rock Enclosure)	Japanese Administration	D	Gosser et al. 2001
TN-1-1109	Rock Shelter with Pottery, Mortar	Pre-Contact	D	Gosser et al. 2001
TN-1/2-1110	Latte Set and Tool Manufacturing	Pre-Contact/ Spanish Administration	D	Gosser et al. 2001
TN-4-1111	Farmstead Plus Mortar	Pre-Contact/ Japanese Administration	A, C, D	Gosser et al. 2001
TN-1-1112	Prehistoric, Latte Set	Pre-Contact	D	Gosser et al. 2001
TN-4-1113	Rock Shelter (Farm Shelter)	Japanese Administration	A, D	Gosser et al. 2001
TN-4-1114	Agricultural Feature (Rock Wall)	Japanese Administration	D	Gosser et al. 2001
TN-4-1115	Road	Japanese Administration	D	Gosser et al. 2001
TN-4-1116	Farmstead	Japanese Administration	A, C, D	Gosser et al. 2001
TN-1/5-1117	Rock Shelters with Ceramics, Defensive Use, Probably 75-millimeter (mm) Gun Position	Pre-Contact/ Japanese Administration	D	Gosser et al. 2001
TN-4-1118	Farmstead	Japanese Administration	A, C, D	Gosser et al. 2001
TN-4-1119	Farmstead	Japanese Administration	A, C, D	Gosser et al. 2001
TN-1-1120	Cave with Artifacts	Pre-Contact	D	Gosser et al. 2001

*Site Number**	*Site Description*	*Time Period*	*NRHP Criteria***	*Primary Reference*
TN-1/5-1121	Cave with Artifacts, Defensive Use (HQ?), and Straggler Shelter	Pre-Contact/ Japanese Administration	A, C, D	Gosser et al. 2001
TN-4-1122	Farmstead	Japanese Administration	A, D	Gosser et al. 2001
TN-1/5-1123	Cave with Pictographs, Military Shelter	Pre-Contact/ Japanese Administration	C, D	Gosser et al. 2001
TN-4-1124	Farmstead	Japanese Administration	A, D	Gosser et al. 2001
TN-1/5-1125	Cave with Ceramics, Defensive Position	Pre-Contact/ Japanese Administration	D	Gosser et al. 2001
TN-5-1126	Japanese, Defensive Position, Rock Structures	Japanese Administration	A, C, D	Gosser et al. 2001
TN-5-1127	Cave, Defense	Japanese Administration	A, C, D	Gosser et al. 2001
TN-5-1128	Gun Position, Rock Features, Pits	Japanese Administration	A, C, D	Gosser et al. 2001
TN-5-1129	Cave, Gun Position	Japanese Administration	A, C, D	Gosser et al. 2001
TN-5-1130	Rock Shelter, Defense	Japanese Administration	A, C, D	Gosser et al. 2001
TN-5-1131	Cave, Defense	Japanese Administration	A, C, D	Gosser et al. 2001
TN-5-1132	Cave, Gun Position	Japanese Administration	A, D, D	Gosser et al. 2001
TN-5-1133	Cave, 20 mm Anti-Aircraft Gun Position	Japanese Administration	A, C, D	Gosser et al. 2001
TN-5-1134	Cave, Shelter	Japanese Administration	A, D	Gosser et al. 2001
TN-6-1135	Communication Tower Foundations, West Field	American Administration	A, C, D	Gosser et al. 2001
TN-4-1136	Processing Facility, Possibly for Tofu	Japanese Administration	A, C, D	Gosser et al. 2001
TN-4-1137	Agricultural Use, Excavated Area	Japanese Administration	D	Gosser et al. 2001
TN-4-1138	Gun Position	Japanese Administration	A, C, D	Gosser et al. 2001
TN-4-1139	Farmstead	Japanese Administration	A, C, D	Gosser et al. 2001
TN-5-1140	Defensive Position, Sandbags; "Probably One of the Few Japanese Machine Gun Check Points Left"	Japanese Administration	A, C, D	Gosser et al. 2001
TN-5-1151	Quarried Area, Associated with Kahi Airfield	Japanese Administration	D	Gosser et al. 2001

*Site Number**	*Site Description*	*Time Period*	*NRHP Criteria***	*Primary Reference*
TN-5-1152	Quarried Area, Associated with Kahi Airfield	Japanese Administration	D	Gosser et al. 2001
TN-4-1153	Farmstead	Japanese Administration	A, D	Gosser et al. 2001
TN-4-1154	Farmstead	Japanese Administration	A, D	Gosser et al. 2001
TN-5-1155	Anti-Aircraft Gun Position	Japanese Administration	A, D	Gosser et al. 2001
TN-4-1156	Agriculture Feature	Japanese Administration	D	Gosser et al. 2001
TN-4-1157	Agriculture Feature	Japanese Administration	A, C, D	Gosser et al. 2001
TN-5-1165	Gun Position	Japanese Administration	A, D	Gosser et al. 2001
TN-4-1166	Farmstead	Japanese Administration	A, D	Gosser et al. 2001
TN-4-1167	Railroad Station	Japanese Administration	A, C, D	Gosser et al. 2001
TN-4-1169	Farmstead	Japanese Administration	A, D	Gosser et al. 2001
TN-4-1170	Cistern	Japanese Administration	D	Gosser et al. 2001
TN-4-1171	Cistern	Japanese Administration	D	Gosser et al. 2001
TN-4-1177	Farmstead	Japanese Administration	A, C, D	Gosser et al. 2001
TN-4-1178	Farmstead	Japanese Administration	A, C, D	Gosser et al. 2001
TN-4-1179	Farmstead and Kiln	Japanese Administration	A, C, D	Gosser et al. 2001
TN-4-1180	Farmstead	Japanese Administration	A, C, D	Gosser et al. 2001
TN-4-1181	Farmstead	Japanese Administration	A, D	Gosser et al. 2001
TN-4-1182	Japanese Railroad	Japanese Administration	A, C, D	Gosser et al. 2001
TN-4-1186	Wall	Japanese Administration	D	Gosser et al. 2001
SC-5003	East Hagoi Farm District (II) and Artifacts	Pre-Contact/ Japanese Administration	A, D	Tuggle 2009
SC-5007A	Third Farm District (I)	Japanese Administration	A, D	Tuggle 2009
SC-5007B	Third Farm District (II)	Japanese Administration	A, D	Tuggle 2009
SC-5008	Camp Churo Cemetery	Japanese Administration	A, D	Tuggle 2009

*Site Number**	*Site Description*	*Time Period*	*NRHP Criteria***	*Primary Reference*
SC-5009A	Chulu Farm District (I)	Japanese Administration	A, D	Tuggle 2009
SC-5009B	Chulu Farm District (II)	Japanese Administration	A, C, D	Tuggle 2009
SC-5010	Churo Latte (Disturbed)	Pre-Contact	D	Tuggle 2009
SC-5011	Earth Terraces	Japanese Administration	A, C, D	Tuggle 2009
SC-5012	Defensive Rock Shelters	Japanese Administration	A, D	Tuggle 2009
SC-5013	Defensive Rock Shelters	Japanese Administration	A, D	Tuggle 2009
SC-5017	Fourth Farm District (III)	Japanese Administration	A, C, D	Tuggle 2009
SC-5018	Fourth Farm District (V)	Japanese Administration	A, C, D	Tuggle 2009
SC-5019	Latte, Mount Lasso (Disturbed)	Pre-Contact	D	Tuggle 2009
SC-5020	Defensive Caves	Japanese Administration	A, D	Tuggle 2009
SC-5021	Defenses and Farms	Japanese Administration	A, D	Tuggle 2009
SC-5022	Second Farm District (I)	Japanese Administration	A, D	Tuggle 2009
SC-5023	Fourth Farm District (VII)	Japanese Administration	A, D	Tuggle 2009
SC-5024	Fourth Farm District (IX)	Japanese Administration	A, D	Tuggle 2009
SC-5027	112th NCB Camp	American Administration	Not Evaluated	Tuggle 2009
SC-5031	Fourth Farm District (I)	Japanese Administration	A, D	Tuggle 2009
SC-5034	Kahi Farm District (I)	Japanese Administration	A, D	Tuggle 2009
SC-5036	Mound of Bulldozed farmhouse Debris	Japanese Administration	D	Tuggle 2009
SC-5038	U.S. gun position and other	American Administration	A, D	Tuggle 2009
SC-5039	Kahi Farm District (II)	Japanese Administration	A, D	Tuggle 2009
SC-5040	Kahi Administrative Center (Portion)	Japanese Administration	A, D	Tuggle 2009
SC-5041	Defensive Position	Japanese Administration	A, D	Tuggle 2009
SC-5042	Third Farm District (III)	Japanese Administration	A, D	Tuggle 2009
SC-5043	Third Farm District (IV)	Japanese Administration	A, D	Tuggle 2009

*Site Number**	*Site Description*	*Time Period*	*NRHP Criteria***	*Primary Reference*
SC-5044	Kahi Farm District (III)	Japanese Administration	A, C, D	Tuggle 2009
SC-5045	Defensive Caves	Japanese Administration	A, D	Tuggle 2009
SC-5046	Kahi Farm District (IV)	Japanese Administration	A, D	Tuggle 2009
SC-5047	Dangkulo Beach Deposit (BAA-A)	Pre-Contact	A, D	Tuggle 2009
SC-5048	Shinminato Farm District (I)	Japanese Administration	A, D	Tuggle 2009
SC-5049	Shinminato Farm District (II)	Japanese Administration	A, D	Tuggle 2009
SC-5050	Shinminato Village (Portion)	Japanese Administration	A, D	Tuggle 2009
SC-5053	U.S. Quarry	American Administration	D	Tuggle 2009
SC-5054	Shinminato Farm District (III)	Japanese Administration	A, D	Tuggle 2009
SC-5055	Fourth Farm District (IV)	Japanese Administration	A, D	Tuggle 2009
SC-5056	Fourth Farm District (II)	Japanese Administration	A, D	Tuggle 2009
SC-5058	Experimental Agricultural Station	Japanese Administration	A, D	Tuggle 2009
SC-5059	Defensive Complex	Japanese Administration	A, D	Tuggle 2009
SC-5060	Fourth Farm District (VIII)	Japanese Administration	A, D	Tuggle 2009
SC-5061	Fourth Farm District (X)	Japanese Administration	A, D	Tuggle 2009
SC-5062	Fourth Farm District (XI)	Japanese Administration	A, D	Tuggle 2009
SC-5065	Second Farm District (III)	Japanese Administration	A, D	Tuggle 2009
SC-5066	Second Farm District (IV)	Japanese Administration	A, D	Tuggle 2009
SC-5067	Second Farm District (V)	Japanese Administration	A, D	Tuggle 2009
SC-5068	Second Farm District (VI), Piña section	Japanese Administration	A, D	Tuggle 2009
1537-T-60	Ceramic Scatter	Pre-Contact	D	Henry and Haun 1995
1537-T-62	Artifact Scatter	Pre-Contact	D	Henry and Haun 1995
1537-T-63	Concrete Slab Fragments	American Administration	D	Henry and Haun 1995
HDR-18-07	Japanese gun emplacement with historic and prehistoric artifact scatter	Pre-Contact/ Japanese Administration	D	LeClerc and Gilmore 2018

*Site Number**	*Site Description*	*Time Period*	*NRHP Criteria***	*Primary Reference*
3028	Tinian Harbor	American Administration	A, C	Thursby and Rudolph 2010
T-0009	Artifact Scatter	Pre-Contact/ Japanese Administration	D	Dixon et al. 2015
Unai Chulu	Traditional Cultural Place (Fishing and Recreation)	N/A	A	Griffin et al. 2015
Unai Dankulo	Traditional Cultural Place (Fishing and Recreation)	N/A	A	Griffin et al. 2015
Puntan Masalok	Traditional Cultural Place (Fishing and Recreation)	N/A	A	Griffin et al. 2015
Mount Lasso^	Shrine (TN-4-0004) and additional cultural resources	N/A	N/A	Griffin et al. 2015
Ushi Point^ Cross and Memorial	Cross and Memorial at Ushi Point on the northern tip of the island	N/A	N/A	N/A

Legend: CNMI = Commonwealth of the Northern Mariana Islands; GPS = Global Positioning System; HPO = Historic Preservation Office; HQ = headquarters; JPN = Japanese; NRHP = National Register of Historic Places; U.S. = United States; WWII = World War II.

Notes: NA – not applicable
*TN-series numbers are assigned by the CNMI HPO, all other site numbers are temporary numbers assigned at the time of documentation.
**NRHP criteria for significance contained in Federal Regulation 36 CFR 60.4.
*** ? = general historic, specific component unknown.
^Significant cultural resource under the National Environmental Policy Act.

Table H-3. NRHP In-Eligible Cultural Resources within the Area of Potential Effect

*Site Number**	*Site Description*	*Time Period*	*Primary Reference*
T-0001	GROPAC 6 Encampment	American Administration	Dixon et al. 2015
T-0002	Metal Tank Debris	Japanese Administration	Dixon et al. 2015
T-0003	Railroad Debris	Japanese Administration	Dixon et al. 2015
T-0004	Concrete and Metal	Japanese Administration	Dixon et al. 2015
T-0005	Railroad Car Debris	Japanese Administration	Dixon et al. 2015
T-0006	Metal Barrels	American Administration	Dixon et al. 2015
T-0010	Tinian Harbor WWII Structures	American Administration	Dixon and Welch 2002
TN-6-0393	B Battery, 17th AAA	American Administration	Tuggle 2009
TN-1-0394	Ceramics	Pre-Contact	Tuggle 2009
TN-6-0597	505th Bomb Group	American Administration	Tuggle 2009
TN-6-0600	Hospital	American Administration	Tuggle 2009
TN-6-0607	240th Ordnance Ammunition Company, 813, 827, 891 Chemical Companies	American Administration	Tuggle 2009
TN-1-0684	Possible *Latte* Stones and a Telephone Pole	Pre-Contact/American Administration	Dixon and Welch 2002
TN-6-0686	Telephone Pole, Rock Pile	American Administration	Dixon and Welch 2002
TN-1-0693	Ceramic Scatter	Pre-Contact	Dixon and Welch 2002
TN-6-0694	Telephone Pole	American Administration	Dixon and Welch 2002
TN-4-0695	Railroad Cart	Japanese Administration	Dixon and Welch 2002
SC-5000	East Hagoi Farm District (IV) (bulldozed)	Japanese Administration	Tuggle 2009
SC-5001	17th AAA Camp (Camp Stinsom)	American Administration	Tuggle 2009
SC-5002	17th AAA Camp (Remnant)	American Administration	Tuggle 2009
SC-5004	East Hagoi Farm District (II)	Japanese Administration	Tuggle 2009
SC-5005	U.S. Military Activity	American Administration	Tuggle 2009
SC-5006	Ordnance Area	Historic	Tuggle 2009
SC-5014	U.S. Coral Pit Number 5	American Administration	Tuggle 2009

*Site Number**	*Site Description*	*Time Period*	*Primary Reference*
SC-5015	U.S. Military (Unknown)	American Administration	Tuggle 2009
SC-5016	U.S. North Asphalt Aggregate Quarry and Tank Facility	American Administration	Tuggle 2009
SC-5025	Fourth Farm District (XII)	Japanese Administration	Tuggle 2009
SC-5026	Fourth Farm District (XII)	Japanese Administration	Tuggle 2009
SC-5028	Second Farm District (II)	Japanese Administration	Tuggle 2009
SC-5029	1st Sep. Engineer Battalion	American Administration	Tuggle 2009
SC-5030	U.S. Fuel Farm; East, 8-14-C, West Field	American Administration	Tuggle 2009
SC-5032	U.S. Military Activity	American Administration	Tuggle 2009
SC-5033	East Hagoi Farm District (I)	Japanese Administration	Tuggle 2009
SC-5037	107th NCB Park	American Administration	Tuggle 2009
SC-5051	U.S. Military Activity	American Administration	Tuggle 2009
SC-5052	U.S. Quarry and Associated Activity	American Administration	Tuggle 2009
SC-5057	U.S. Tank Farm (Water?)	American Administration	Tuggle 2009
SC-5063	West Hagoi Farm District	Japanese Administration	Tuggle 2009
SC-5064	U.S. Coral Pit Number 4	American Administration	Tuggle 2009
1537-T-61	Ceramic Scatter	Pre-Contact	Henry and Haun 1995
1537-T-64	Ceramic Scatter	Pre-Contact	Henry and Haun 1995
1537-T-65	Artifact Scatter, Concrete Slab	Japanese Administration	Henry and Haun 1995
1537-T-66	Ceramic Scatter	Japanese Administration	Henry and Haun 1995
HDR-18-01	Historic period multi-use dump	American Administration	LeClerc and Gilmore 2018
HDR-18-02	Small historic-era depression with subterranean chamber	Historic	LeClerc and Gilmore 2018
HDR-18-03	Small historic-era depression	Historic	LeClerc and Gilmore 2018
HDR-18-04	Push pile with WWII-era debris	American Administration	LeClerc and Gilmore 2018
HDR-18-05	Push pile	American Administration	LeClerc and Gilmore 2018

Site Number*	***Site Description***	***Time Period***	***Primary Reference***
HDR-18-06	Push pile with WWII-era debris	American Administration	LeClerc and Gilmore 2018
HDR-18-08	Possible road or railroad grade	Japanese Administration	LeClerc and Gilmore 2018
HDR-18-09	Large berm or push pile	American Administration	LeClerc and Gilmore 2018
HDR-18-10	Large berm or push pile	American Administration	LeClerc and Gilmore 2018
TPP Site	Tinian Power Plan	Japanese Administration	Moore et al. 1998

Legend: WWII = World War II.

DRAFT PROGRAMMATIC AGREEMENT REGARDING JOINT MILITARY TRAINING CONSTRUCTION ON THE ISLAND OF TINIAN

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DRAFT AMENDMENTS TO THE MARCH 2022 PROGRAMMATIC AGREEMENT FOR MILITARY TRAINING AND TESTING ON AND WITHIN THE SURROUNDING WATERS OF THE ISLANDS OF THE COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS

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DRAFT PROGRAMMATIC AGREEMENTS

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JRM Military
Training Location
CNMITIN2A

Tinian
Section 106

Legend

Military Training Location

- Airfield Expeditionary
- Amphibious Assault
- Amphibious Raid
- Anti-terrorism Force Protection
- Bivouac
- Combat Search and Rescue (CSR)
- Direct Action (CQB)
- Embassy Reinforcement
- Field Training Exercise
- Humanitarian Assistance
- Intelligence, Surveillance, Reconnaissance (ISR)
- Insertion/Extraction
- Maneuver (Convoy, Land Navigation)
- Marine Air-Ground Task EX (Amphibious)
- Maritime Security Operations (MSO)
- Non-Combatant Evacuation Operation
- Personnel Insertion/Extraction
- Seize Airfield
- Small Boat Operations
- Special Purpose Marine Air-Ground TF EX
- Underwater Survey Area
- Unmanned Underwater Vehicle Training
- Urban Warfare Training
- Water Purification (Desalination)
- Military Area

N

Coordinate System: UTM Zone 55 North

Projection: Transverse Mercator

Datum: D WGS 1984

Sheet Size: 22" Width x 17" Length

Scale: 1 inch = miles

0 0.25 0.5 0.75 1 Miles

0 0.5 1 1.5 2 Kilometers

PREPARED BY:

Date: 5/9/2025

Contact: XXXXX XXXXX

CNMI Tinian MLA – CNMITIN2C				
Training Activity	Location	Descriptions	Mitigations	CR Stressors
Live-Fire	On Land	The Multi-Purpose Maneuver Range (MPMR) occupies approximately 200 acres at the northern tip of Tinian for small arms live-fire and ground maneuvers. Military units use objective areas that contain objects of military value such as a simulated opposing force target to be captured or neutralized by the training unit. Training units use live-fire to engage fixed, portable, and robotic targets and explosive breaching of an obstacle. Live-fire includes small arms (.50 caliber and below). No dud-producing munitions are used on this range.	Foot traffic only except on improved or unimproved roads. No digging allowed. Access is restricted at the range and the surface danger zones when live-fire events are occurring. Access updates are communicated via Range Control. The MLA has also been subdivided into smaller training areas that allow Range Control to schedule training in discrete areas of the MLA while allowing safe public access in other areas.	Physical disturbance and strike.

JRM Military
Training Location
CNMITIN2C

Tinian
Section 106

Legend

Military Training Location

Live-Fire

Military Area

N

Coordinate System: UTM Zone 55 North

Projection: Transverse Mercator

Datum: D WGS 1984

Sheet Size: 22" Width x 17" Length

Scale: 1 inch = 500 feet

0 300 600 900 1,200 Feet

0 100 200 300 400 Meters

PREPARED BY:

NAVFAC

Date: 9/18/2024

Contact: NFM GeoRediness Center (671) 339-3420

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CNMI Tinian MLA – CNMITIN2D				
Training Activity	Location	Descriptions	Mitigations	CR Stressors
Explosive Live-Fire	On Land	The Explosive Training Range (ETR) occupies approximately 2.5 acres for the employment of demolitions and military explosives for offensive and defensive operations of both fragmentation and non-fragmentation detonations with a net explosive weight of 50 pounds. Explosive ordnance disposal and combat engineer personnel conduct training operations which include unexploded ordnance disposal, breaching operations, and mine and countermine operations.	Foot traffic only except on improved or unimproved roads. Access is restricted at the range and the surface danger zones when live-fire events are occurring. Access updates are communicated via Range Control. The MLA has also been subdivided into smaller training areas that allow Range Control to schedule training in discrete areas of the MLA while allowing safe public access in other areas.	Physical disturbance and strike.

JRM Military
Training Location
CNMITIN2D

Tinian
Section 106

Legend

Military Training Area

Explosives Training

Military Range

N

Coordinate System: UTM Zone 55 North

Projection: Transverse Mercator

Datum: D WOS 1984

Sheet Size: 22" Width x 17" Length

Scale: 1 inch = 100 feet

0 50 100 150 200 Feet

0 15 30 45 60 Meters

PREPARED BY:

NAVFAC

Date: 2/6/2025

Contact: NFM GeoRediness Center (671) 339-3420

DRAFT
PROGRAMMATIC AGREEMENT
AMONG
THE UNITED STATES MARINE CORPS,
COMMANDER, JOINT REGION MARIANAS
THE ADVISORY COUNCIL ON HISTORIC PRESERVATION, AND
THE COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS
HISTORIC PRESERVATION OFFICE
REGARDING JOINT MILITARY TRAINING CONSTRUCTION
ON THE ISLAND OF TINIAN

WHEREAS, the United States Marine Corps (USMC) proposes construction (undertaking) in support of expanded military training activities within the federally managed Military Lease Area (MLA) on the island of Tinian in the Commonwealth of the Northern Mariana Islands (CNMI) pursuant to Title 10, enabling U.S. Armed Forces to meet individual mandates to be trained and equipped to protect U.S. national security by being ready to effectively prosecute war and defend the nation [ ]; and

WHEREAS, the undertaking consists of construction of supporting infrastructure, including two live-fire ranges, safety towers, improvements to an expeditionary runway, landing zones, an expeditionary base camp, biosecurity facilities, road improvements, and utilities, among others; and

WHEREAS, the USMC is the executive agent for the undertaking, responsible for initial compliance with Section 106 and funding of mitigation measures; and

WHEREAS, Commander, Joint Region Marianas (JRM) is the land manager of the MLA and Supporting Component for Tinian according to the 2020 Memorandum of Agreement Between the United States Navy, Supporting Component and United States Air Force and United States Marine Corps, Supported Component(s), responsible for executing the terms and processes of the of this Programmatic Agreement (PA); and

WHEREAS, JRM and USMC operate a cultural resources program with a qualified staff of specialists to ensure compliance with applicable laws and regulations; and

WHEREAS, Commander, JRM and CNMI Historic Preservation Officer (HPO) executed a *Programmatic Agreement Between the Commander, Joint Region Marianas and the Commonwealth of the Northern Mariana Islands State Historic Preservation Officer, Regarding Military Training and Testing on and Within the Surrounding Waters of the Islands of the Commonwealth of the Northern Mariana Islands* (PATT) in March 2022 that was amended to include the expanded military training portion of the undertaking; and *[Note to Reviewer: PATT will be amended prior to execution of this PA.]*

WHEREAS, the USMC, in consultation with the CNMI HPO, has defined the undertaking's area of potential effect (APE) as the MLA, Tinian International Airport, and 8th Avenue to, Tinian Harbor, and the United States Agency of Global Media (USAGM) site on the southwestern tip of Saipan, with an indirect APE that extends into the Philippine Sea along the northwest and northeast tip of Tinian, in accordance with 36 CFR § 800.4(b)(1)(ii) and (iv), and as depicted in Appendix A; and

WHEREAS, JRM completed the *Integrated Cultural Resources Management Plan for the Commonwealth of the Northern Mariana Islands* in 2015 that lists and describes existing historic properties as well as Standard Operating Procedures (SOP); and

WHEREAS, the term "historic properties" includes prehistoric or historic districts, sites, buildings, structures or objects included in, or eligible for, inclusion in the National Register of Historic Places (NRHP), including properties of traditional religious and cultural importance that meet the NRHP criteria; and

WHEREAS, the US Air Force (USAF) developed a draft Historical Interpretive Plan for the Island of Tinian as stipulated in the 2016 *Programmatic Agreement Among the Pacific Air Forces, Directorate of Strategy, Plans, and Programs, the Commonwealth of the Northern Mariana Islands State Historic Preservation Office, and the Advisory Council on Historic Preservation Regarding the Proposed Construction and Operation of Divert Activities and Exercises within the Commonwealth of the Northern Mariana Islands* to resolve adverse effects from the Operation of Divert Activities and Exercises within the CNMI; and

WHEREAS, the USMC has consulted on the entirety of the undertaking and its individual components, as listed in Appendix B, through a series of consultation correspondence dated 18 July 2023, 17 November 2023, 11 April 2024, 23 July 2024, and 12 February 2025, as well as consultation meetings in August 2023, September 2023, December 2023, May 2024, August 2024, and February 2025; and

WHEREAS, in consultation, the USMC has determined that certain undertaking components, including the Ammunition Holding Area 1, Explosive Training Range, Landing Zones 9 and 13, Multi-Purpose Maneuver Range, Surface Radar Towers 1 and 2, and Public Access, will have an adverse effect to historic properties as listed in Appendix B; and

WHEREAS, not all effects on historic properties can be fully determined prior to approval of the undertaking pursuant to 36 CFR § 800.14(b)(1)(ii), and previously defined undertaking components may involve modifications requiring an alternate Section 106 review process; and

WHEREAS, in accordance with 36 CFR § 800.6(a)(1), the USMC requested the participation of the Advisory Council on Historic Preservation (ACHP) and the ACHP has chosen to participate in the consultation pursuant to 36 CFR § 800.6(a)(1)(iii); and

WHEREAS, the APE includes the *Tinian Landing Beaches, Ushi Point Field, and North Field, Tinian Island National Historic Landmark* (NHL), and as such, the USMC invited the National Park Service (NPS) to consult on this undertaking pursuant to 36 CFR § 800.10(c); and

WHEREAS, the USMC has consulted with the CNMI HPO, the ACHP, the NPS, and the Mayor of the Municipality of Tinian pursuant to 36 CFR § PART 800, the regulations implementing Section 106 of the National Historic Preservation Act (54 USC § 306108); and

WHEREAS, pursuant to 36 CFR § 800, which implement 54 USC § 306107 of the National Historic Preservation Act (NHPA), and including 36 CFR § 800.14(b), the USMC has invited the ACHP and CNMI HPO to sign this PA as Signatories, and invited NPS and the Municipality of Tinian to sign this PA as Concurring Parties**.**

NOW, THEREFORE, the USMC, JRM, the ACHP, and the CNMI HPO agree that the undertaking shall be implemented in accordance with the following stipulations in order to take into account the known and unknown effects of the undertaking on historic properties thereby fulfilling its responsibilities under Section 106 of the NHPA.

STIPULATIONS

The USMC and JRM shall ensure that the following measures are carried out:

I. APPLICABILITY

This PA resolves adverse effects related to the undertaking in support of joint military training on the island of Tinian and addresses effects that could not be fully determined at the time of consultation.

A. Undertaking components include those with effects that were assessed and agreed upon in consultation. A detailed list of known undertaking components and the effect is provided in Appendix B.

II. STANDARDS

A. All work to meet the Stipulations of this PA shall be carried out by, reviewed by, or under oversight or supervision of a person or persons meeting the applicable professional standards as described in the Secretary of the Interior's Historic Preservation Professional Qualifications Standards (finalized and adopted in 1983 in Federal Register Vol. 48, No. 190, p.44716-44740) ("Qualified Personnel").

B. Contracts utilized for work that may affect historic properties, shall follow all federal acquisition requirements, and shall include minimum qualifications for historic preservation experience and be developed with participation of qualified personnel.

C. For the purposes of this PA, the term "day" means consecutive calendar days inclusive of weekends and holidays.

III. RESOLVING ADVERSE EFFECTS

A. The following avoidance, minimization, and mitigation measures shall be implemented to resolve adverse effects to historic properties consistent with the consultation with consulting parties.

1. Cultural Resource Training

   a. All personnel associated with construction activities pursuant to this PA shall complete Cultural Resource Training prior to beginning work. The existing JRM training shall be electronically shared with personnel.

   b. The number of personnel who complete the training shall be documented in accordance with Stipulation VIII.

2. Painting of Undertaking Components

   The surface radar towers and the water tanks supporting the MPMR shall be painted in an inconspicuous color to blend in with the surrounding landscape.

B. Consulting parties shall be afforded thirty (30) days to review and provide comments on draft deliverables associated with the following mitigation. The following interpretive elements (Stipulation B.1, B.2, and B.3) will be completed within four years of the specific MILCON funding appropriation.

1. Interpretive Signage

   a. The USMC shall produce and install four weather resistant interpretive signs to be placed at the Atomic Bomb pits and Mt. Lasso.

   b. Topics and themes of the signs shall be informed by the USAF draft Historical Interpretive Plan for the Island of Tinian.

   c. Each sign shall be in both Chamorro and English with a QR code (for a virtual version) and shall be 2 x 3 feet in size.

2. Virtual Tour

   a. The USMC shall produce a virtual tour focusing on the NHL and its contributing resources. The tour shall include, but not be limited to, a historical overview and timeline, photographs, maps, and references.

   b. Topics and themes of the signs shall be informed by the USAF draft Historical Interpretive Plan for the Island of Tinian.

   c. The virtual tour shall be made available for consulting parties to host and maintain on their websites, and thereby made available to the public.

   d. The virtual tour shall utilize geospatial data.

3. Interpretive Pamphlet

   a. The USMC shall produce and print an interpretive pamphlet on Chamorro history and culture.

   b. The pamphlet would focus on historical themes and contexts as well as interpretations of Chamorro sites and practices without providing specific locational information.

   c. The brochure shall be two pages, front and back, in an 8 1/2 by 14-inch trifold format with professional color quality.

   d. The USMC shall print 1,000 copies and distributed to the Mayor of Tinian, Commonwealth Bureau of Military Affairs, NPS, and the Joeten Kiyu Public Library. An electronic copy of the document shall also be provided to the CNMI HPO for additional future printing at its expense.

4. Interpretive Center

   a. The USMC recognizes the importance of artifacts recovered from sites on Tinian and the desire to create an interpretive center on Tinian to display such artifacts. Therefore, within three years of execution of this PA, the USMC, in collaboration with other Military Services, shall work to develop a plan including milestones to fund an interpretive center on Tinian that is sized appropriately to meet the above stated needs.

   b. Should within five years of execution of this PA, the USMC finds that this mitigation measure cannot be met, the USMC shall consult with consulting parties whether to consider other measures with the intent to agree on an alternate plan for mitigation within ninety (90) days of the start of those discussions.

5. Data Recovery

   a. While the preference is to avoid and preserve in place, data recovery and recordation methods will be implemented when adverse effects to character defining features are unavoidable.

   b. Historic properties with adverse effects associated with undertaking components and identified for data recovery during consultation are listed in Appendix B and include SC-5009A (Explosive Training Range), TN-6-0401 (Multi-Purpose Maneuver Range/Landing Zone 13/Ammunition Holding Area 1), TN-6-0042 (Surface Radar Tower 2), and TN-6-0442 (Landing Zone 9).

   c. Data recovery strategies shall include collection and recordation. Collection shall focus on diagnostic samples of historic and faunal remains that are consistent with research questions.

   d. Recordation shall include, but not be limited to drawings, measurements, black-and-white photographs, stratigraphic profiles, geographic information system data, and soil samples.

e. The USMC shall develop one Data Recovery and Archaeological Monitoring Plan applicable to all construction activities and shall identify existing collections to avoid redundant collection.

f. The Data Recovery and Archaeological Monitoring Plan shall incorporate provisions consistent with the ACHP's "Recommended Approach for Consultation on Recovery of Significant Information from Archaeological Sites" (Appendix C), and consistent with confidentiality restrictions imposed by ARPA (16 U.S.C. 470hh).

g. The draft Data Recovery and Archaeological Monitoring Plan shall be submitted to consulting parties for a thirty (30) day review period, and comments incorporated or responded to in the final document. Should consulting parties not reply within this timeframe, the Data Recovery and Archaeological Monitoring Plan shall be finalized.

h. Qualified personnel shall submit reports of archaeological data recovery projects to the CNMI HPO for a forty-five (45) day review prior to being finalized. Hard copies of final documents shall be provided to the CNMI HPO.

IV. ALTERNATE SECTION 106 REVIEW PROCESS

Should the undertaking require additional Section 106 review and consultation for new or changing undertaking components and/or the review of undertaking components with unknown effects listed in Appendix B, and for post-review discoveries pursuant to 36 CFR 800.13, the alternate streamlined review process shall be followed:

A. Component Footprint

1. Area of Potential Effect (APE) has been defined pursuant to 36 CFR 800.16(d) and in consultation with Signatories and Concurring Parties. For each individual undertaking component that requires additional Section 106 review, a qualified individual shall define the components footprint and determine the geographic extent of the component's effects. This component footprint shall be delineated by the scale and nature of the component and shall not require individual consultation with the consulting parties.

2. The APE, as defined during the initial consultation, is not expected to change. If the APE does need to be changed, the USMC will consult with CNMI HPO.

B. Finding of Effect

1. No Historic Properties Affected - When qualified personnel find that an undertaking with the potential to affect historic properties will not affect listed, contributing, or eligible historic properties or no historic properties are present per 36 CFR § 800.4(d)(1), no further review under this PA is required. The review shall be documented in accordance with Stipulation VIII.

2. No Adverse Effect - When qualified personnel find that an undertaking has the potential to affect historic properties but will have no adverse effect or if a property affected by an undertaking is modified or conditions are imposed in accordance with the Secretary of the Interior's Standards for the Treatment of Historic Properties to avoid adverse effects per 36 CRF § 800.5(b), notification shall be provided to consulting parties for a fifteen (15) day review period. Any input will be considered by USMC and a written response provided. If there is no response from consulting parties after the review period, the undertaking shall commence. The review shall be documented in accordance with Stipulation VIII.

3. Adverse Effect - When qualified personnel find that an undertaking may have an adverse effect on a historic property, the USMC shall initiate a fifteen (15) day consultation with consulting parties to identify available avoidance and/or minimization measures. After consultation, if the USMC determines that adverse effect cannot be avoided, the USMC shall implement data recovery or recordation per Stipulation III.B.5. A separate Memorandum of Agreement or amendment to this PA shall not be required. The review shall be documented in accordance with Stipulation VIII.

C. Undertaking Modifications

1. If during the implementation of a previously reviewed undertaking component, there are modifications that may result in a change to the component footprint and/or the finding of effect, qualified personnel shall follow Stipulation IV.A and Stipulation IV.B.

V. EMERGENCY PROCEDURES

Should an emergency occur pursuant to 36 CFR § 800.12(a), the SOP for "Emergency Situations" as defined in the JRM ICRMP and included in Appendix D shall be followed and documented in accordance with Stipulation VIII.

VI. ARCHAEOLOGICAL MONITORING

Ground disturbing activities associated with construction, including undertaking components reviewed under Stipulation IV, shall be monitored by qualified personnel. Prior to construction, the USMC shall develop one Data Recovery and Archaeological Monitoring Plan for all ground disturbing activities. The Data Recovery and Archaeological Monitoring Plan shall use all available background research and geospatial data, including LiDAR to support in-field identification of existing historic properties and features. The draft Data Recovery and Archaeological Monitoring Plan shall be submitted to consulting parties for a thirty (30) day review and comment period. Should consulting parties not reply within this timeframe, the Data Recovery and Archaeological Monitoring Plan shall be finalized.

VII. INADVERTENT DISCOVERIES

If previously unknown human remains, and/or historic or prehistoric properties are discovered or unanticipated effects on known historic properties occur, work shall stop and USMC shall implement one or more of the following SOPs "Inadvertent Discovery of Archaeological

Remains" and/or "Inadvertent Discovery of Human Remains," which are included in Appendix E. Work may continue in another area after a 10-meter buffer has been established.

VIII. REPORTING

Qualified personnel shall provide an Annual Report to ACHP, CNMI HPO, NPS, and the Mayor of Tinian for the previous federal fiscal year by December 15 of each year that the PA is applicable. Electronic reporting shall be utilized as the preferred method to transmit the Annual Report. The Annual report shall include a summary of:

A. Finding of effect assessments conducted in accordance with Stipulation IV.B;

B. Emergencies responded to pursuant to Stipulation V;

C. Inadvertent discoveries reported pursuant to Stipulation VII;

D. The total number of personnel who completed the cultural resource training specified in Stipulation III.A.1;

E. Anticipated undertaking components to begin in the following federal fiscal year;

F. Mitigation status within Stipulation III, to also include archaeological monitoring and data recovery/recordation projects; and

G. Proposed scheduling changes, problems encountered, and any disputes and objections received in the USMC's efforts to carry out the terms of this PA.

IX. DISPUTE RESOLUTIONS

Should any Signatory to this PA object to any actions proposed or the manner in which the terms of this PA are implemented, the USMC shall consult with such party to resolve the objection. If the USMC determines that such objection cannot be resolved, the USMC shall:

A. Forward all documentation relevant to the dispute, including the USMC's proposed resolution, to the ACHP. The ACHP shall provide the USMC with its advice on the resolution of the objection within thirty (30) days of receiving adequate documentation. Prior to reaching its final decision on the dispute, the USMC shall prepare a written response that takes into account any timely advice or comments regarding the dispute from the ACHP, signatories and concurring parties, and provide them with a copy of this written response. The USMC shall then proceed according to its final decision.

B. If the ACHP does not provide its advice regarding the dispute within the thirty (30) day time period, the USMC may make a final decision on the dispute and proceed accordingly. Prior to reaching a final decision, the USMC shall prepare a written response that takes into account any timely comments regarding the dispute from the signatories to the PA and provide them and the ACHP with a copy of such written response.

X. DURATION

This PA shall expire if its terms are not carried out within twenty (20) years from the date of its execution. Prior to such time, the USMC may consult with the signatories to reconsider the terms of the PA and amend it in accordance with Stipulation XI below.

XI. AMENDMENT

This PA may be amended when such an amendment is agreed to in writing by all signatories. The amendment shall be effective on the date a copy, signed by all signatories, is filed with the ACHP.

XII. TERMINATION

A. If any Signatory to this PA determines that its terms shall not or cannot be carried out, that party shall immediately provide notice to all signatories explaining the reasons for the proposed termination. The signatories shall consult to seek mutual agreement, per Stipulation IX, or such other action as would avoid termination. This PA may be amended in accordance with Stipulation XI.

B. If this PA is not amended as provided for in this Stipulation or should any Signatory wish to continue termination of the PA after first pursuing consultation under Stipulation IX, any Signatory may continue with terminating this PA by notifying all Signatories in writing and providing a written explanation of the reasons for termination. If ACHP concurs with the justification, the PA shall be terminated when the final notice of termination is received by all signatories.

C. Once the PA is terminated, and prior to work continuing on the undertaking, USMC must either (a) execute an MOA pursuant to 36 CFR § 800.6 or (b) request, take into account, and respond to the comments of the ACHP under 36 CFR § 800.7. The USMC shall notify all signatories as to the course of action it shall pursue.

XIII. ANTI-DEFICIENCY ACT

The USMC's obligations under this PA are subject to the availability of appropriated funds, and the stipulations of this PA are subject to the provisions of the Anti-Deficiency Act. The USMC shall make reasonable and good faith efforts to secure the necessary funds to implement its obligations under this PA. If compliance with the Anti-Deficiency Act alters or impairs the USMC's ability to implement its obligations under this PA, the USMC shall consult in accordance with the amendment and/or termination procedures found in Stipulations XI and XII.

Execution of this PA by the USMC, ACHP, CNMI HPO, and Commander JRM and implementation of its terms evidence that the USMC has taken, and shall, take into account the effects of the undertaking on historic properties within the APE. Each of the undersigned certifies that they have full authority to bind the party that they represent for purposes of entering into this agreement.

SIGNATORIES

UNITED STATES MARINE CORPS

____

United States Marine Corps

JOINT REGION MARIANAS

____

Rear Admiral Brent de Vore, Commander

ADVISORY COUNCIL ON HISTORIC PRESERVATION

____

Reid Nelson, Executive Director

CNMI HISTORIC PRESERVATION OFFICE

____

Frank M. Rabauliman, Historic Preservation Officer

CONCURRING PARTIES

NATIONAL PARK SERVICE

____

Add Name Here

MUNICIPALITY OF TINIAN

____

Edwin P. Aldan, Mayor

APPENDIX I
VISUAL SIMULATIONS

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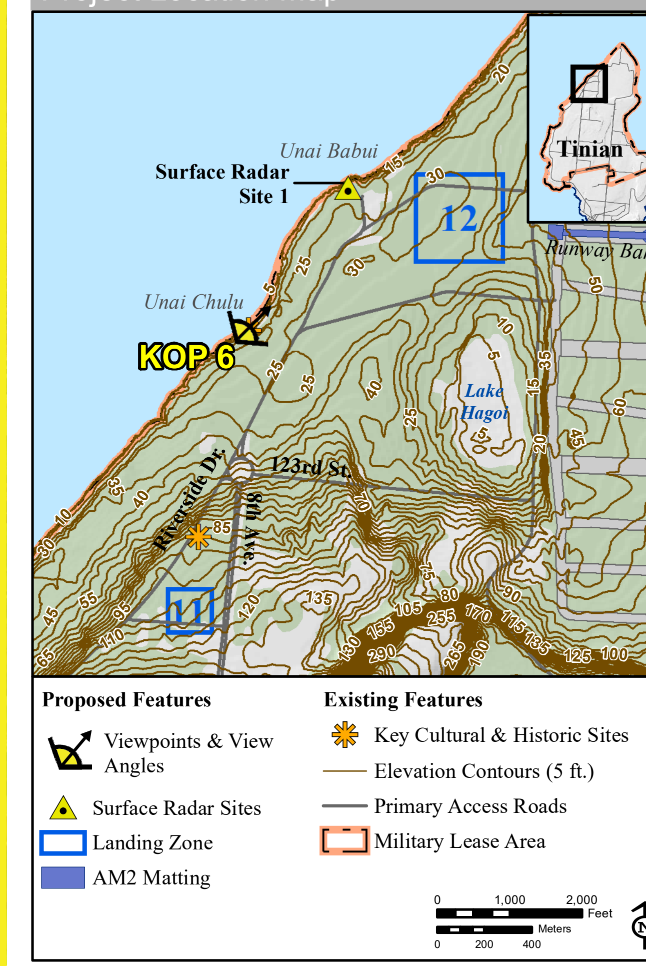
CJMT VISUAL RESOURCES

KOP 6
Existing Conditions
Unai Chulu

Project Location Map



Photograph Information

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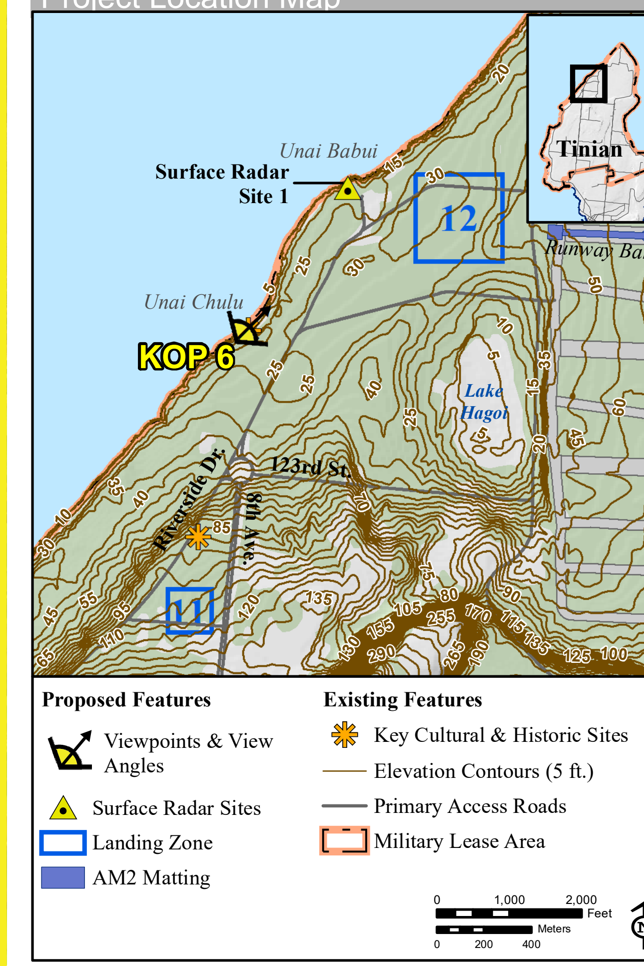
Date of photograph:	4-25-2023
Weather condition:	Partly cloudy
Viewing direction:	North
Latitude:	15° 04' 16.1571" N,
Longitude:	145° 36' 53.6578" E
Distance to project:	2,450 ft

CJMT VISUAL RESOURCES

KOP 6
Simulated Conditions
Unai Chulu
Surface Radar not Visible

Project Location Map



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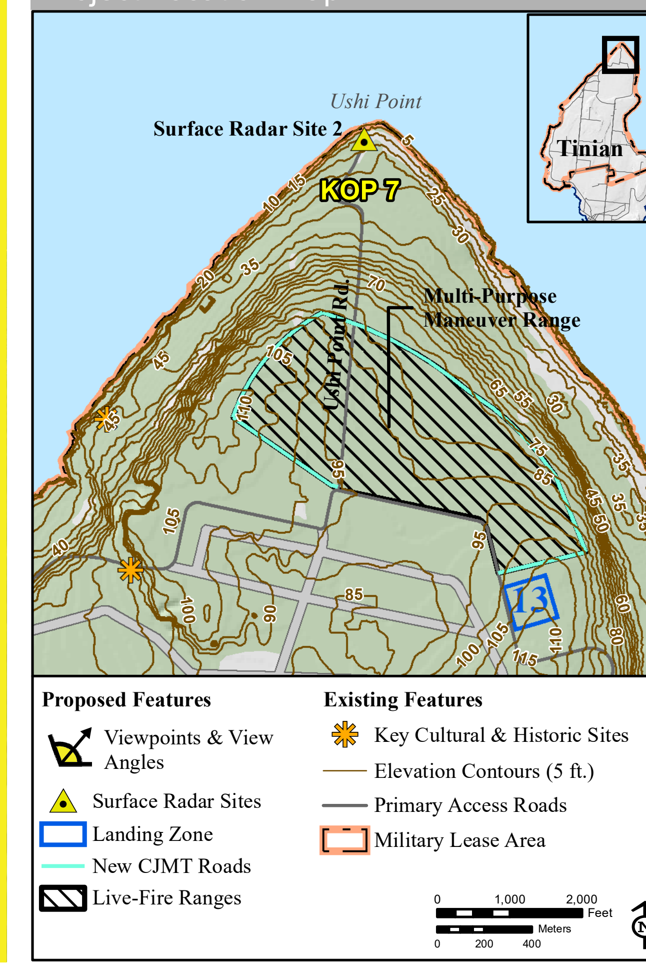
Date of photograph:	4-25-2023
Weather condition:	Partly cloudy
Viewing direction:	North
Latitude:	15° 04’ 16.1571” N,
Longitude:	145° 36’ 53.6578” E
Distance to project:	2,450 ft

May 2025

CJMT VISUAL RESOURCES

KOP 7
Existing Conditions
Ushi Point Road
Surface Radar Site 2

Project Location Map



Photograph Information

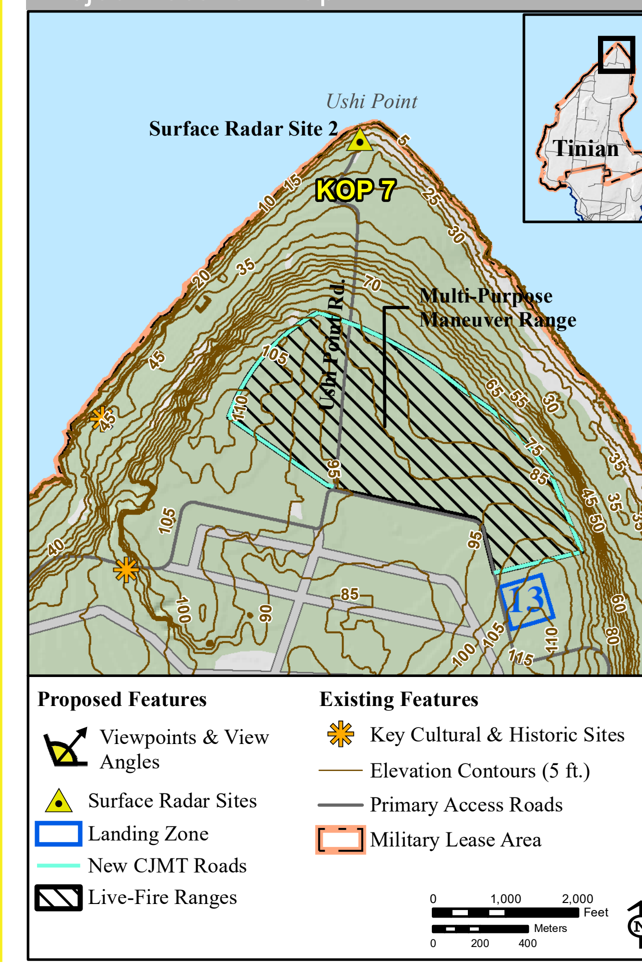
Time of photograph:	1:43 PM
Date of photograph:	4-26-2023
Weather condition:	Partly cloudy
Viewing direction:	North
Latitude:	33°30’29.79” N
Longitude:	112°25’36.44” E
Distance to surface radar:	534 ft

May 2025

CJMT VISUAL RESOURCES

KOP 7
Simulated Conditions
Ushi Point Road
Surface Radar Site 2

Project Location Map



Photograph Information

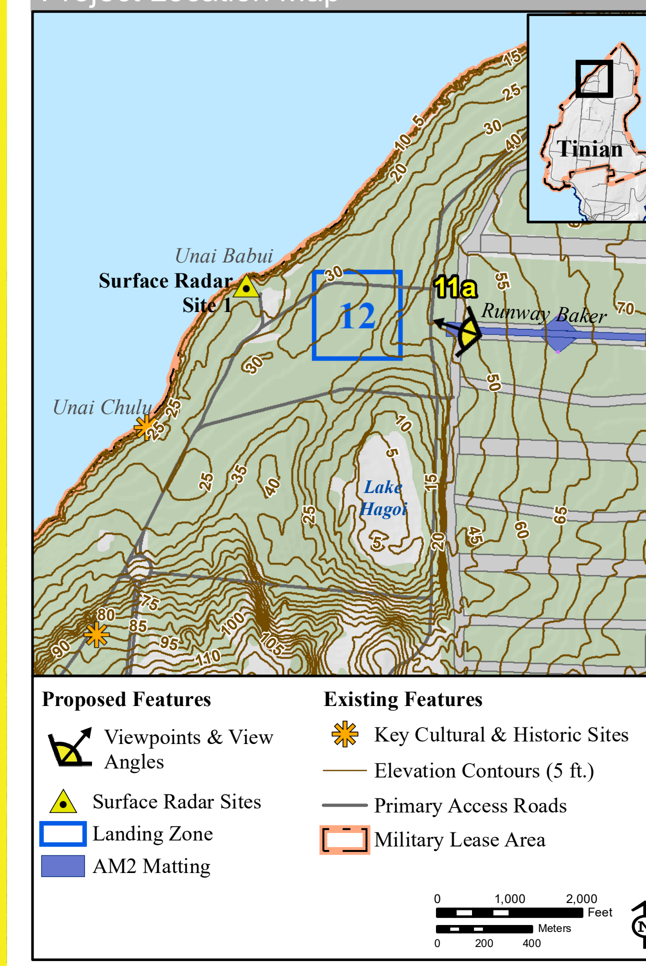
Time of photograph:	1:43 PM
Date of photograph:	4-26-2023
Weather condition:	Partly cloudy
Viewing direction:	North
Latitude:	33°30’29.79” N
Longitude:	112°25’36.44” E
Distance to surface radar:	534 ft

May 2025

CJMT VISUAL RESOURCES

KOP 11A
Existing Conditions
Runway Baker - West

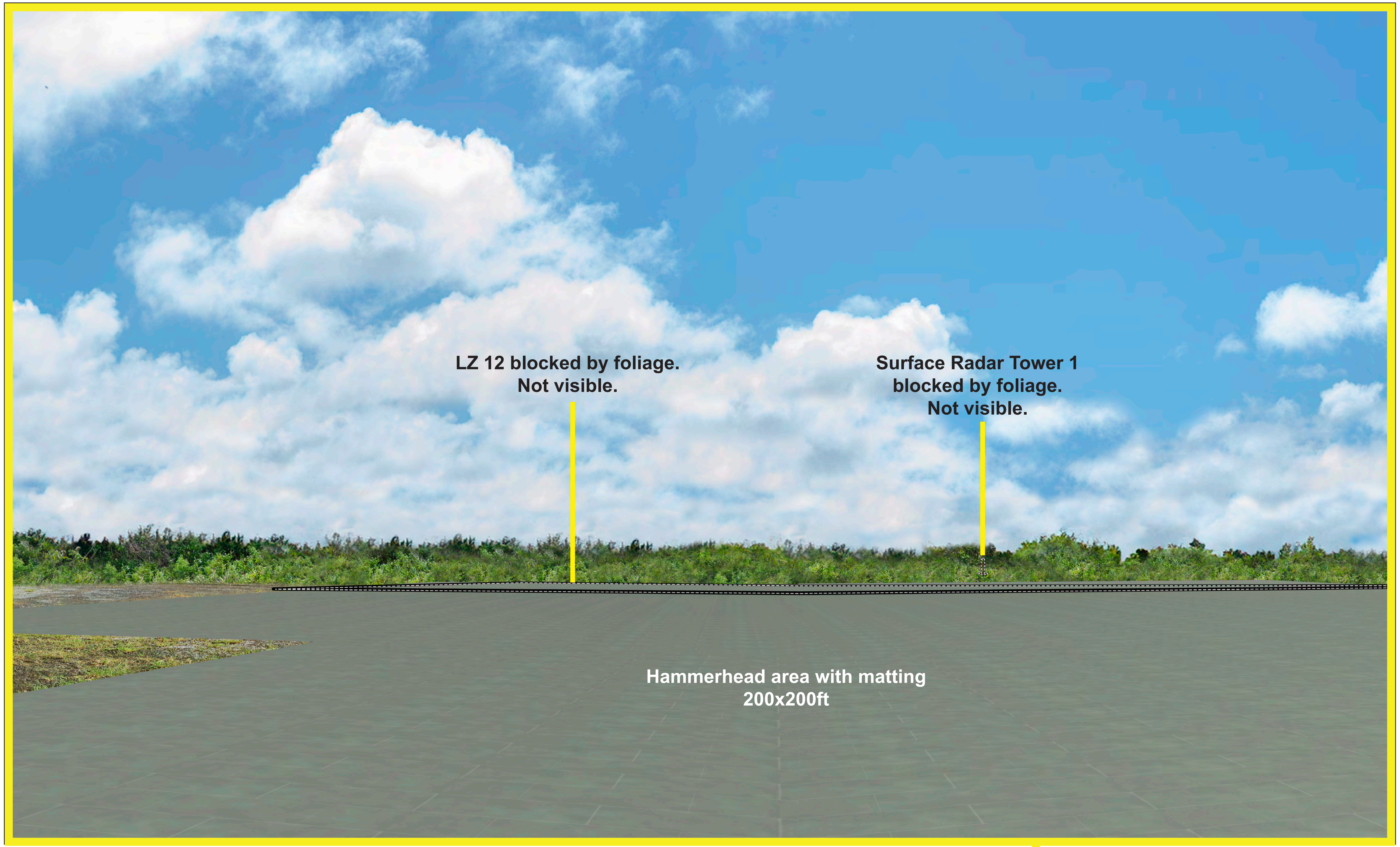
Project Location Map

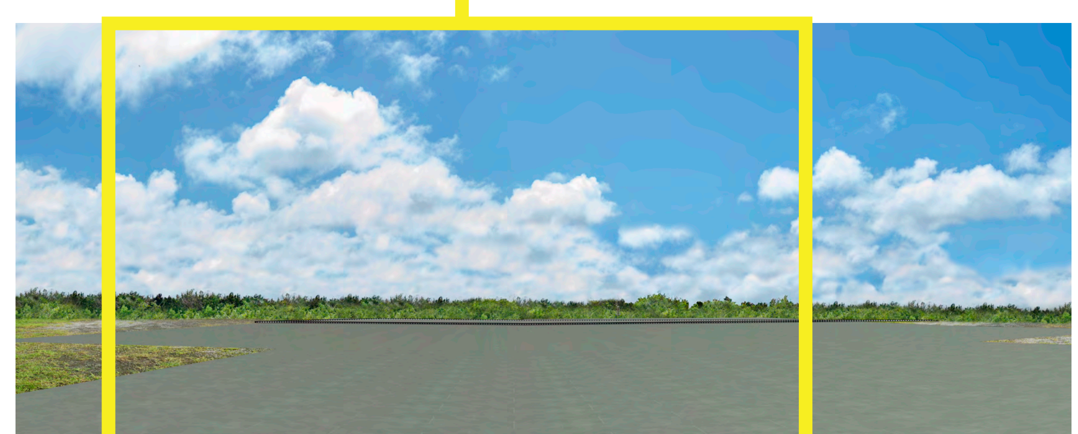


Photograph Information

Time of photograph:	2:02 PM
Date of photograph:	4-26-2023
Weather condition:	Partly cloudy
Viewing direction:	West
Latitude:	33°30'29.79" N
Longitude:	112°25'36.44" E
Distance to project:	2,800 ft

May 2025

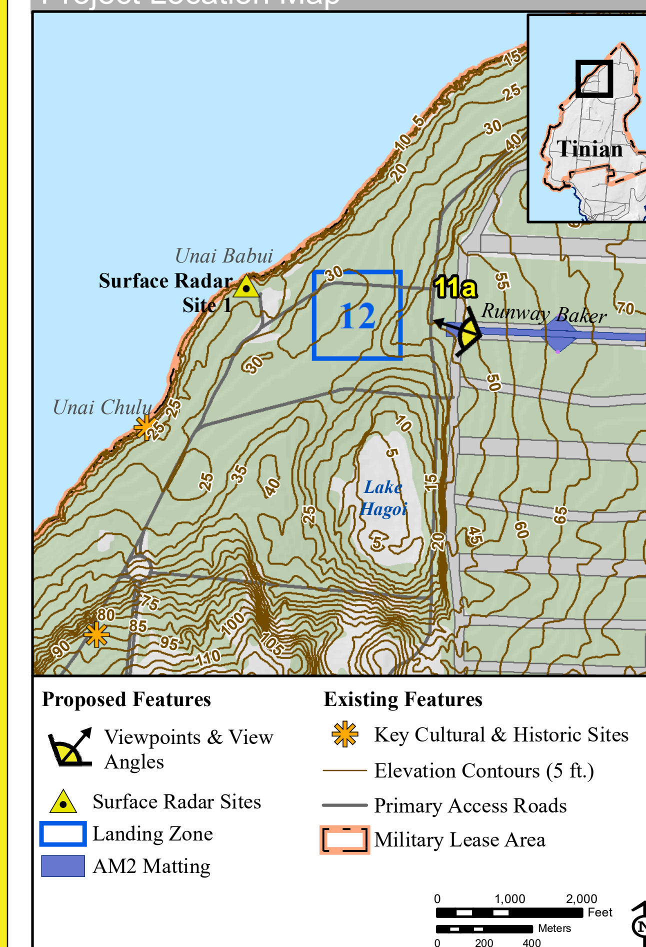




CJMT VISUAL RESOURCES

KOP 11A
Simulated Conditions
Runway Baker - West
Surface radar and above
ground electrical lines not visible

Project Location Map



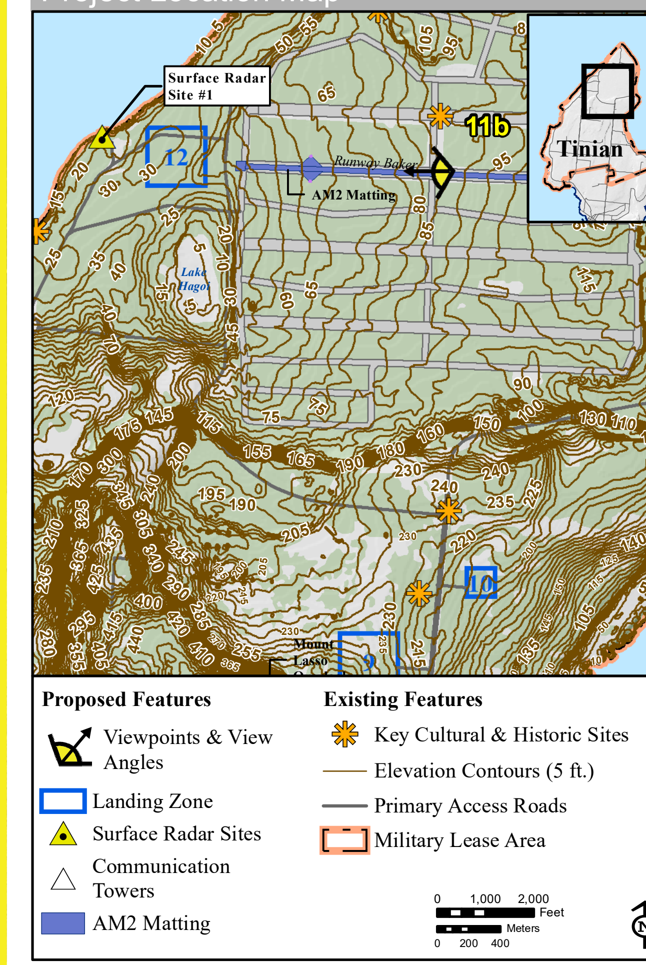
Photograph Information

Time of photograph:	2:02 PM
Date of photograph:	4-26-2023
Weather condition:	Partly cloudy
Viewing direction:	West
Latitude:	33°30'29.79" N
Longitude:	112°25'36.44"E
Distance to project:	2,800 ft

CJMT VISUAL RESOURCES

KOP 11B
Existing Conditions
Runway Baker looking West

Project Location Map



Photograph Information

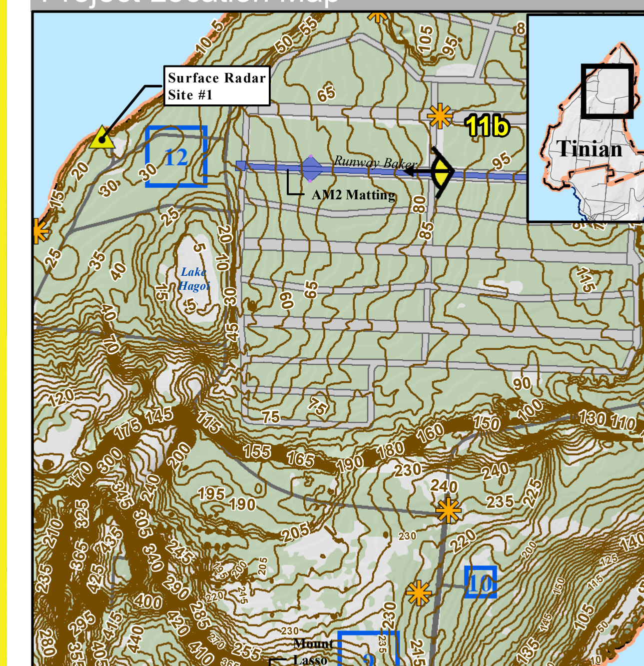
Time of photograph:	11:29 AM
Date of photograph:	5-5-2016
Weather condition:	Partly cloudy
Viewing direction:	West
Latitude:	15°4’28.40” N
Longitude:	145°38’18.43” E
Distance to project:	0 ft

May 2025

CJMT VISUAL RESOURCES

KOP 11B
Simulated Conditions
Runway Baker looking West
Vegetative clearing shown
with no matting and
surface radar is not visible

Project Location Map



Proposed Features
- Viewpoints & View Angles
- Landing Zone
- Surface Radar Sites
- Communication Towers
- AM2 Matting

Existing Features
- Key Cultural & Historic Sites
- Elevation Contours (5 ft.)
- Primary Access Roads
- Military Lease Area

0 1,000 2,000 Feet
0 200 400 Meters

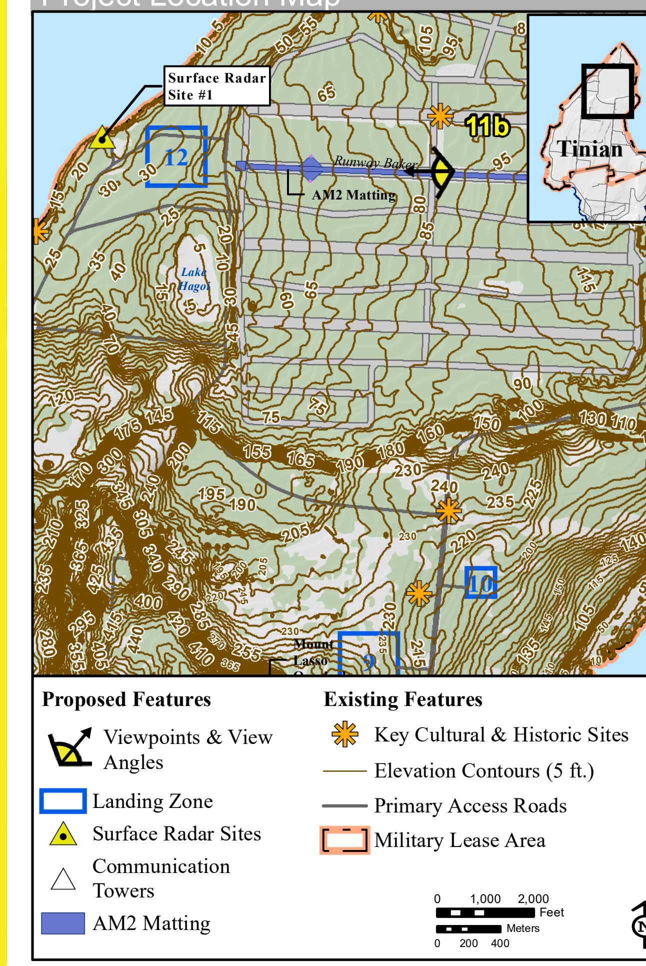
Photograph Information

Time of photograph:	11:29 AM
Date of photograph:	5-5-2016
Weather condition:	Partly cloudy
Viewing direction:	West
Latitude:	15°4'28.40" N
Longitude:	145°38'18.43" E
Distance to project:	0 ft
Distance to North Tower:	1.9 Miles

CJMT VISUAL RESOURCES

KOP 11B
Simulated Conditions
Runway Baker looking West
Vegetative clearing shown
with matting and
surface radar is not visible

Project Location Map



Photograph Information

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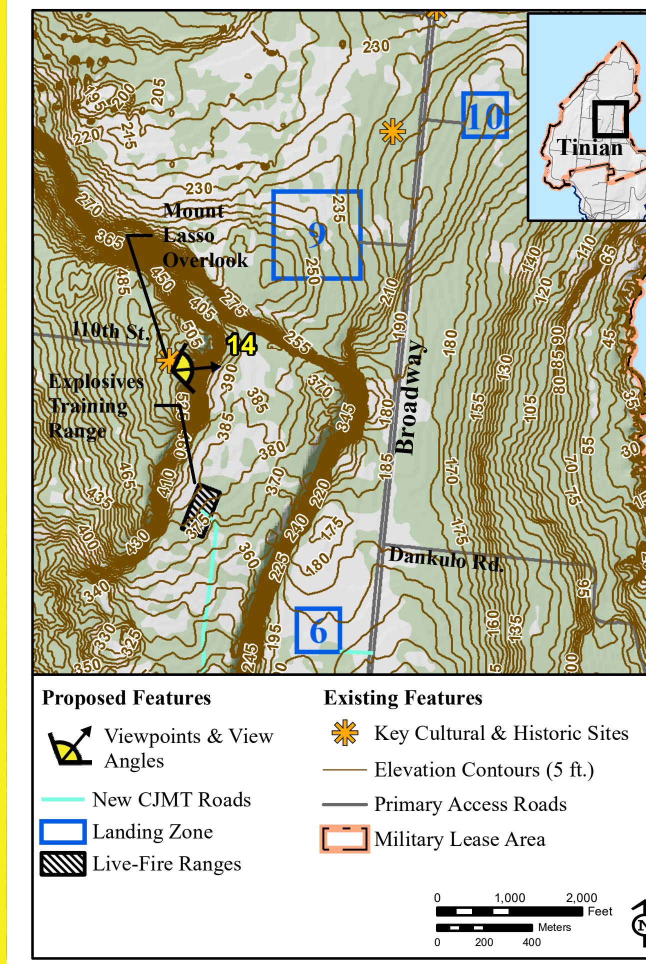
Date of photograph:	5-5-2016
Weather condition:	Partly cloudy
Viewing direction:	West
Latitude:	15°4’28.40” N
Longitude:	145°38’18.43” E
Distance to project:	0 ft
Distance to North Tower:	1.9 Miles

May 2025

CJMT VISUAL RESOURCES

KOP 14
Existing Conditions
Mount Lasso

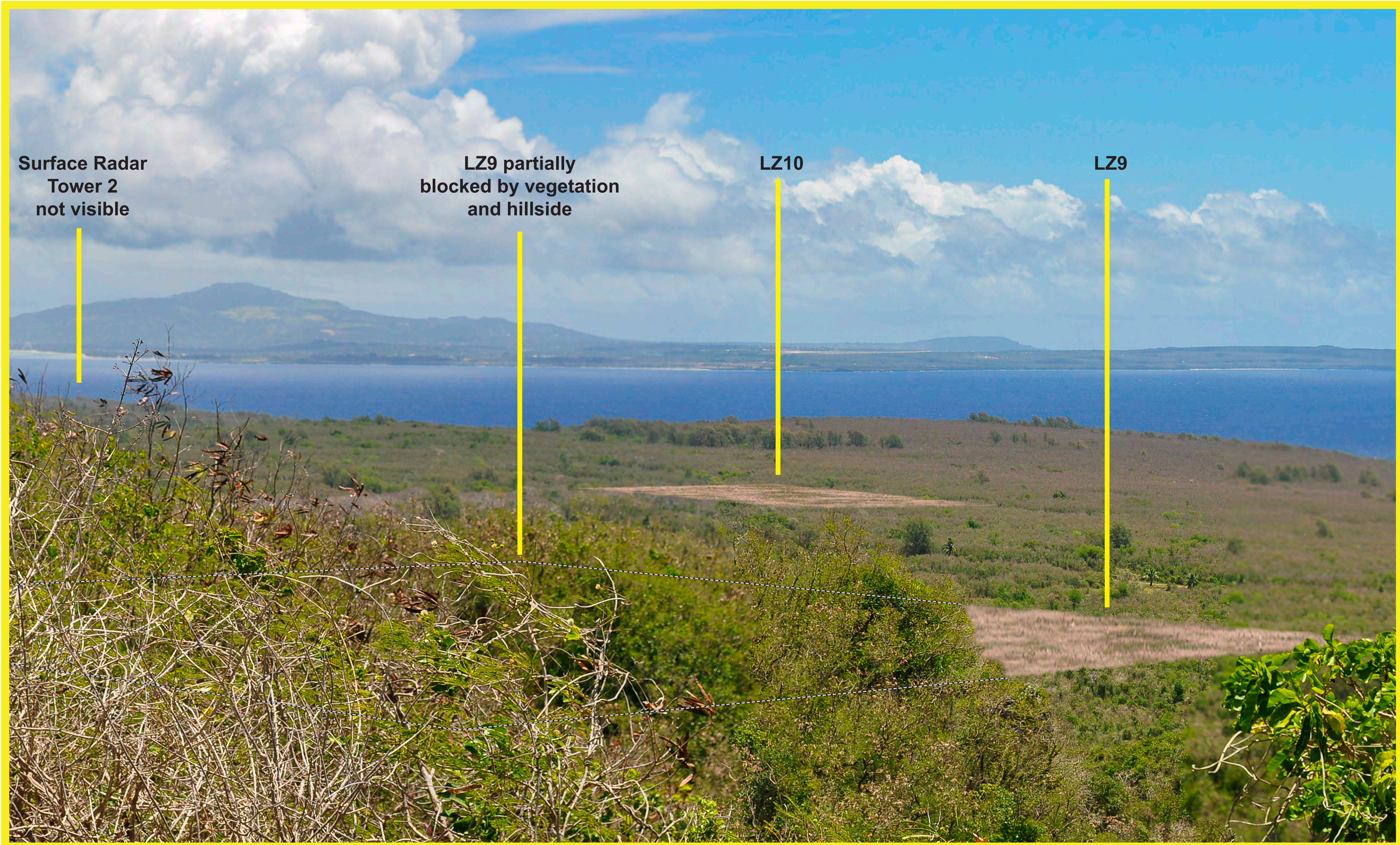
Project Location Map



Photograph Information

Time of photograph:	4:30 PM
Date of photograph:	4-25-2023
Weather condition:	Mostly cloudy
Viewing direction:	Northeast
Latitude:	33°30'29.79” N
Longitude:	112°25'36.44” E
Distance to nearest LZ:	1.684 ft

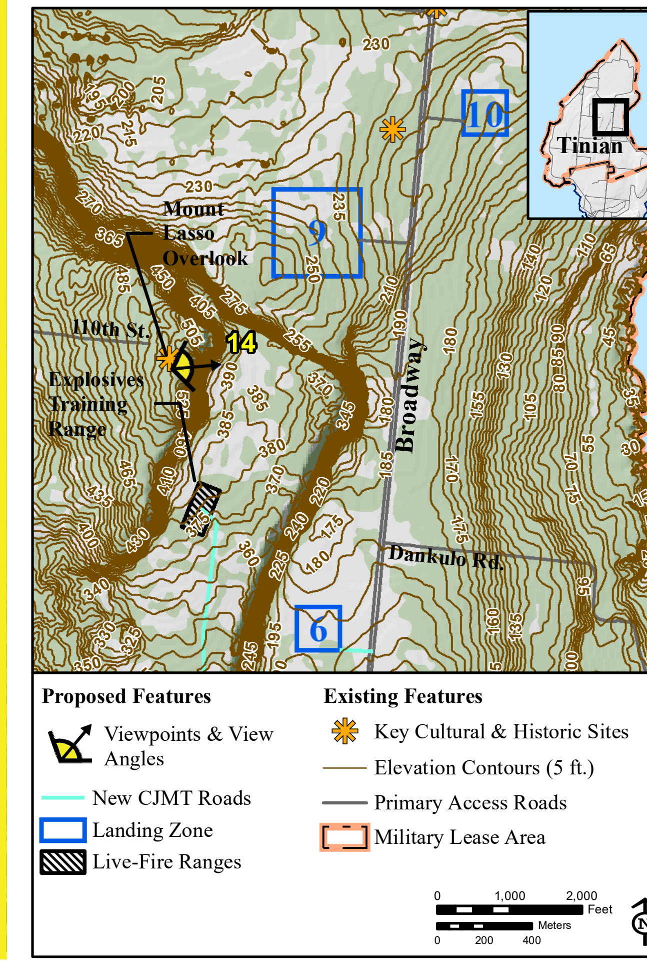
May 2025



CJMT VISUAL RESOURCES

KOP 14
Simulated Conditions
Mount Lasso
LZ Area 9 partially visible

Project Location Map



Photograph Information

Time of photograph:	4:30 PM
Date of photograph:	4-25-2023
Weather condition:	Mostly cloudy
Viewing direction:	Northeast
Latitude:	33°30'29.79" N
Longitude:	112°25'36.44" E
Distance to nearest LZ:	1,684 ft

May 2025

APPENDIX J
NOISE STUDY

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TABLE OF CONTENTS

LIST OF TABLES

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LIST OF FIGURES

LIST OF ATTACHMENTS

APPENDIX J

This appendix provides a detailed discussion on noise metrics and calculations for training activities associated with the No Action Alternative and Proposed Action.

J.1 INTRODUCTION

This section describes the methodology used in the noise analysis. Section J.2 provides the modeling data used and the noise exposure for the baseline conditions (No Action Alternative). Section J.3 provides the modeling data used and the noise exposure for the proposed Alternatives 1 and 2, Section J.4 provides additional details for the aviation modeling, and Section J.5 is the list of references.

J.1.1 Methodology

The Department of Defense (DoD) and the Federal Interagency Committee on Noise (FICON) (1978), a member of the DoD, outline the types of metrics to describe noise exposure for environmental impact assessment, while the Defense Noise Working Group (DNWG) provides guidance on military noise modeling methodology. The following subsections describe these noise metrics and noise modeling methodology. Additional detail on the basics of sound, metrics, and its effects are available in Attachment 1 to this appendix.

J.1.1.1 Noise Modeling and Metrics

The DoD prescribes use of the NOISEMAP suite of computer programs (Wyle 1998; Wasmer Consulting 2006) containing the core computational programs called “NMAP,” version 7.3, and “MRNMap,” version 3.0 for analysis of aircraft noise. The small arms (SARNAM) and large caliber weapons (BNOISE) noise models apply to range activity noise analysis. NOISEMAP suite of programs refers to BASEOPS as the input module, NOISEMAP as the noise model for predicting noise exposure in the installation environment, and MRNMap as the noise model used to predict noise exposure in the airspace. NMPLOT is the tool used to combine the noise contours produced by NOISEMAP and MRNMap into a single noise exposure map for aircraft noise. Due to differences in the noise metrics applicable to range activity, the noise grids from these must be presented separately. As indicated in Table J-1, the grid spacing used for calculating noise exposure for each model was 500 feet.

Table J-1 Noise Modeling Parameters

Software	*Analysis*	*Version*
NMAP	Airfield noise	7.3
MR_NMAP	Airspace noise	3.0
SARNAM	Range noise – small arms	2.6
BNOISE	Range noise – explosives	2003
Parameter	***Description***	
Receiver Grid Spacing	500 ft in x and y	
Aviation Noise Metrics	DNL (A-weighted for aircraft noise) SEL, L_{max} (single event noise levels comparison)	
Range Noise Metrics	CDNL (C-weighted for impulsive range noise) PK15(met) (Peak levels exceed 15% of the time accounting for varied meteorological conditions)	
Basis	Average Annual Daily Operations (Airfield/Airspace); Busiest Month (Range)	
Topography	***Description***	
Elevation Data Source	USGS 25m NED	
Elevation Grid Spacing	500 ft in x and y	
Impedance Data Source	USGS Hydrography DLG	
Impedance Grid spacing	500 ft in x and y	
Flow Resistivity of Ground (soft/hard)	225 kPa-s/m^2 / 100,000 kPa-s/m^2	
Modeled Weather[1]	***Description***	
NMAP and MR_NMAP	Temperature = 82 °F	
	Relative Humidity = 82%	
	Barometric Pressure = 29.87 in Hg	
SARNAM and BNOISE	Standardized Weather Simulation	

Legend: % = percent; °F = degrees Fahrenheit; CDNL = C-weighted Day-Night Average Sound Level; DLG = Digital Line Graph; DNL = Day-Night Average Sound Level; ft = feet; in Hg = inches Mercury; in = inches; kPa-s/m^2 = kilopascal-seconds per square meter; L_{eq} = Equivalent Sound Level; L_{max} = maximum sound level; m = meters; NED = National Elevation Dataset; PK15(met) = Single Event Peak Level Exceeded by 15 Percent of Events Level; SEL = Sound Exposure Level; USGS = United States Geological Survey.

Source: [1] Saipan International Airport. 2021, local monthly averages weather, November selected for use in NMAP and MR_NMAP modeling. The SARNAM and BNOISE software requires the use of a built-in internal simulated weather condition.

Human hearing sensitivity to differing sound pitch, measured in cycles per second or hertz (Hz), varies by frequency. To account for this effect, sound measured for environmental analysis utilizes “A-weighting,” which emphasizes sound roughly within the range of typical speech and de-emphasizes very low and very high frequency sounds. All decibels (dB) presented in this study for aircraft noise utilize A-weighted (dBA) unless otherwise noted. For community sounds that are impulsive and contain significant low frequency energy, such as large-caliber weapon firings and explosive detonations, a different weighting filter called “C-weighting” is used, which includes more low frequency noise than does the A-weighting filter and is consistent with environmental analysis prescribed for military ranges (Army 2007).

This analysis uses the day-night average sound level (DNL) as the primary metric for analyzing noise impacts. DNL is a cumulative metric that includes all noise events occurring in a 24-hour period with a nighttime noise penalty applied to events occurring after 10 p.m. and before 7 a.m. DNL is A-weighted and applicable for subsonic aircraft operations (i.e., flying at sounds below the speed of sound). The daytime period is defined as 7 a.m. to 10 p.m. An adjustment (penalty) of 10 dB is added to events occurring during the nighttime period to account for the added intrusiveness while people are most likely to be relaxing at home or sleeping. Note that "daytime" and "nighttime" in the calculation of DNL are sometimes referred to as "acoustic day" and "acoustic night" and always correspond to the times given above. This is often different than the "day" and "night" used commonly in military aviation, which are directly related to the times of sunrise and sunset and vary throughout the year, latitudinally, and with seasonal changes.

Similar to DNL, CDNL represents a cumulative metric that includes all noise events occurring in a 24-hour period with a nighttime noise penalty applied to events occurring after 10 p.m. and before 7 a.m. However, CDNL is C-weighted for impulsive sounds that contain greater low frequency noise to better reflect the level of annoyance generated by these activities, like ordnance or supersonic "booms".

The DoD Noise Program Policy (DoD Instruction 4715.13, January 28, 2020) requires the use of the DNL noise metric to describe aircraft noise exposure levels at airfields based on average annual day (AAD) averaged over 365 days for purpose of long-term compatible land use planning. Consistent with that standard, this study analyzed both military and civil operations at the airfield on an average annual basis. The range analysis considers the "busiest month" to better reflect more sporadic use of the proposed ranges, which provides a more conservative noise analysis approach.

Assessment of noise associated with a proposed action requires prediction of future conditions that cannot be easily measured until after implementation or would require excessive cost or time to measure. The solution to this includes the use of computer software to simulate the future conditions, as detailed in the following sections. A recent congressionally-mandated study compared the accuracy of noise modeling methods described in this section to real-world field measurements. The report found that DoD-approved noise models operate as intended providing accurate prediction of noise exposure levels from aircraft operations for use in impact assessments and long-term land use planning (Department of the Navy [DON] 2021). The study also determined that the largest variable in any aircraft noise-modeling effort is the expected operational flight parameter data, such as runway and flight track utilization, altitudes at various points in the flight track, engine power settings, and other parameters.

J.1.1.2 Commonwealth of the Northern Mariana Islands Joint Military Training

Modeling of noise, using the NOISEMAP software suite, was accomplished by determining and building each aircraft's flight tracks (paths over the ground at Francisco Manglona Borja/Tinian International Airport (TNI) and North Field) or area activity (in the Military Lease Area [MLA] and in the vicinity of each proposed Landing Zone [LZ]), which applies altitude, airspeed, power settings, and other flight conditions. This information is developed iteratively with a team primarily made up of representatives from the United States (U.S.) Marine Corps (USMC) and previous military studies of similar types of training. This data has been combined with the numbers of each type of operation by aircraft/flight track or flight area/profile, local climate, and terrain surrounding the airfield. Section J.4 shows details of these modeling inputs.

NOISEMAP ability to account for the effects of sound propagation includes consideration of varying terrain elevation, taken from the United States Geological Survey National Elevation Dataset, and ground impedance conditions, taken from U.S. Geological Survey Hydrography data. In this case, "soft ground" (e.g., grass-covered ground) is modeled with a flow resistivity of 225 kilopascal-seconds per square meter (kPa-s/m2) and "hard ground" (in this case, water) is modeled with a flow resistivity of 100,000 kPa-s/m2. For ambient temperature, humidity, and pressure, each month was assigned a temperature, relative humidity, and barometric pressure from data available for the Commonwealth of the Northern Mariana Islands (CNMI). NOISEMAP then determined and used the month with the weather values that produced the median results in terms of noise propagation effect, which in this case was the month of June (with the values noted in Table J-1).

Aircraft noise exposure is defined in terms of contours (i.e., lines of equal DNL value) in 5-dB increments between 65 to 85 dB to delineate where the aircraft noise environment in the vicinity of the airfield may impact noise sensitive uses.

J.1.1.3 Airspace

In the airspace environment, the Onset-Rate Adjusted Monthly Day-Night Average Sound Level (L_{dnmr}) is identical to the DNL except that an additional penalty is applied to account for the startle effect due to the quick increase in sound level created by aircraft operating at low altitudes and high rates of speed (over 400 knots). The penalty is based on how quickly the sound increases when heard by an observer on the ground, described as 'rise-time' rate, and ranges from 0 to up to 11 dB. L_{dnmr} commonly applies to military training routes or airspace allowing low altitude operation (often within a few hundred feet above the ground) where military jets operate at speeds above 400 knots. None of these conditions apply to the baseline or proposed operations for aviation training on Tinian under CJMT so airspace noise results are presented in DNL, which can be directly correlated to land use recommendations for noise sensitive uses.

J.1.1.4 Range Training

The proposed activity includes a Multi-Purpose Maneuver Range (MPMR) and an Explosives Training Range (ETR). The SARNAM software applies to the small arms activity at the MPMR, which allows operators to move throughout the MPMR while firing at fixed target locations. Therefore, various firing points were identified along the proposed border of the MPMR and at various firing angles to produce the greatest noise levels off range to conservatively determine the potential for those noise impacts. The MPMR also provides for deployment of equipment containing explosives, such as anti-personnel obstacle breaching system (APOBS) and breaching charges. Detonations of explosives at the ETR would represent the primary source of noise. The maximum length of the ETR would be 200 meters (656.2 feet), which is small relative to the predicted noise contours that would be at least an order of magnitude greater. This means the exact firing point within the ETR's boundary would have minimal influence on whether the activity would generate noise impacts. The BNOISE model provides the method of analysis for all explosives at both the MPMR and ETR.

The range noise analysis presents single event noise levels (PK 15(met)) for each category of equipment proposed for use in the MPMR and ETR to determine the single event noise complaint risk. Additionally, the analysis provides the cumulative CDNL based upon a typical three week training period during a busy month of range activity to consider the potential for impact related to land use off-range. Section J.1.2 provides details on these two noise metrics and applicable noise level thresholds.

J.1.2 Single Event Noise Metrics

DNL and CDNL are the appropriate metrics to predict the overall noise environment at airfields and airspace that does not include low altitude/high speed military jet operations when considering compatible land use and assessment of noise impacts to noise sensitive receptors. The DoD expands upon DNL/CDNL with the following supplemental metrics described in the DoD Noise Working Group (DNWG) guidelines (DNWG 2009a, 2018), Army Regulation (Army 2007), and Marine Corps Order 3550.13 (2021).

- A measure of the greatest sound level generated by single events:
  - Maximum Sound Level (L_{max}) for aircraft noise
  - Single Event Peak Level Exceeded by 15 Percent of Events (PK15[met]) for range activity (artillery, demolition, etc.)
- A combination of the sound level and duration: Sound Exposure Level (SEL) applicable to aircraft noise

J.1.2.1 Maximum Sound Level

The highest A-weighted sound level measured during a single event in which the sound changes with time is called the maximum A-weighted sound level or L_{max}. L_{max} is the maximum level that occurs over one-eighth of a second and denoted as "fast" response on a sound level meter (American National Standards Institute 1988). Although useful in determining when a noise event may interfere with conversation, TV or radio listening, or other common activities, L_{max} does not fully describe the noise because it does not account for how long the sound is heard.

J.1.2.2 Unweighted Peak Decibels

Unweighted peak decibel (dBP) levels describe the noise environment for ground training ranges involving the live fire of small caliber (.50 caliber and smaller) munitions.

J.1.2.3 Single Event Peak Level Exceeded by 15 Percent of Events

PK15(met) applies to range training activities, such as artillery, mortars, and demolition activities. This metric presents unweighted peak sound pressure levels that accounts for adverse weather conditions and statistical variation in received single event peak noise level while reporting the sound level that would be expected to be exceeded by 15 percent of all events that might occur. If there are multiple weapon types fired from one location, or multiple firing locations, the single event level reported is the loudest level that occurs at each receiver location from any of the events (USMC 2021, Army 2007).

J.1.2.4 Sound Exposure Level

Sound Exposure Level (SEL) combines both the intensity of a sound and its duration by providing the L_{eq} that would contain the same sound energy of an event if occurring over a 1 second period. This means that SEL does not represent a sound level that is heard directly at any given time. However, SEL provides a much better metric for comparison of aircraft flyovers than L_{max} because it allows normalization of disparate events to their 1 second energy average. SEL values are larger than those for L_{max} for the same event because aircraft noise events last more than a few seconds.

J.1.3 Tinian and Saipan Points of Interest

Depicted on Figure J-1, points of interest (POI) located on both the islands of Tinian and Saipan are comprised of sensitive receptors and notable locations. Sensitive receptors would include residences, schools, hospitals, places of worship, biological, and cultural resources.

ID	Name
T1	Tinian High School
T2	Lake Hagoi
T3	Mahalang Ephemeral Ponds
T4	Marpo Heights
T5	Mt Lasso/Overlook Area
T6	Bateha 1 - Isolated Wetlands
T7	Northeast of Marpo Heights
T8	Bateha 2 - Isolated Wetlands
T9	San Jose
T10	San Jose Catholic Church
T11	Tinian Elementary School
T12	Unai Chiget
T13	Unai Chulu
T14	Unai Dankulo
T15	Unai Masalok
T16	North Field National Historic Landmark
T18	Old West Field
T19	Northern Marianas College - Tinian
T20	Ushi Point
T21	Native Limestone Forest
T22	Unai Lam Lam
T23	House of Taga
T24	Kammer Beach
T25	Natural Resource Area
T26	Unai Babui
S1	Saipan Southern High School
S2	Coral Ocean Point Resort
S3	Koblerville Elementary School
S4	San Antonio Residential Area

Figure J-1 Points of Interest on Tinian and Saipan

J.2 BASELINE/NO ACTION ALTERNATIVE

The following subsections detail the modeling data and the resultant noise exposure for the baseline condition for military training on Tinian.

J.2.1 Francisco Manglona Borja/Tinian International Airport

J.2.1.1 Modeling Data

Existing reported operations at TNI comprise a combination of air taxi, general aviation, and military operations. No air carriers currently operate at TNI. According to Federal Aviation Administration (FAA) data, the annual operations at TNI are reported as the following (FAA Airport Master Record for TNI in 2023, OMB 2120-0015):

- Air Carrier: 0
- Air Taxi: 21,610
- General Aviation-Local: 2,365
- General Aviation-Itinerant: 5,154
- Military: 78
- Total: 29,207

Currently military aircraft utilize TNI for conventional operations resulting in arrivals and departures to the TNI runways and primarily comprised of C-130 and KC-135, but also include such aircraft as C-5, C-12, C-17, C-35, C-40, F-18E/F, and F-35A/B/C. Counts of annual operations at civil airfields often under report the numbers of military aircraft because military aircraft may fly as a group with multiple aircraft landing or departing in quick succession and only one of the aircraft utilize their transponder, which provides one of the primary sources for annual airfield counts. Also, in some cases, military aircraft may be captured in operations data as their civilian counterparts. The FAA data source for TNI airfield operations reported the identical 78 military operations for each of the past five years. This indicates it may be an outdated source for military operations that does not capture all activity. Therefore, this study collected baseline military operations data from operators and prior analyses. Table J-2 summarizes current estimated annual military operations at TNI that exceeds the FAA report, citing 78 annual operations and models military aircraft consistent with USMC existing estimates totaling 1,536 annual as described in Table J-2, and proportions civil operations to 27,670 in order to match the total TNI operations of 29,207 consistent with the most recent FAA report (FAA 2023).

Table J-2 Baseline/No Action Flight Operations at TNI

Category	Aircraft	Departures			Arrivals			Totals		
		Day	*Night*	*Total*	*Day*	*Night*	*Total*	*Day*	*Night*	*Total*
Civil	GA/AT	10,133	3,702	13,835	10,133	3,702	13,835	20,266	7,404	27,670
Military	C-130	98	12	110	98	12	110	196	24	220
	KC-135	240	120	360	240	120	360	480	240	720
	C-5	33	15	48	31	17	48	66	30	96
	C-12	73	7	80	73	7	80	146	14	160
	C-17	32	16	48	32	16	48	64	32	96
	C-35	24	-	24	24	-	24	48	-	48
	C-40	24	-	24	24	-	24	48	-	48
	F-18E/F	34	3	37	34	3	37	68	6	74
	F-35A/B/C	30	7	37	30	7	37	60	14	74
Military Total		*588*	*180*	*768*	*586*	*182*	*768*	*1,176*	*360*	*1,536*
Totals		**10,721**	**3,882**	**14,603**	**10,719**	**3,884**	**14,603**	**21,442**	**7,764**	**29,207**

Legend: % = percent; GA/AT = General Aviation and Air Taxi.
Note: GA/AT modeled as Single Engine Fixed Pitch (GASEPF) aircraft.

The existing civil and military operations, as described in Table J-2, are expected to continue at approximately the same tempo for the foreseeable future in the No Action condition.

Section J.4.1 provides figures of modeled civil and military flight tracks at TNI, which includes interfacility for General Aviation and Air Taxi between TNI and Francisco C. Ada/Saipan International Airport. Additionally, Section J.4.1 provides graphics of representative flight profiles for both civil and military aircraft. Each representative flight profile applies to all flight tracks of the same type. For instance, the C-130 representative departure flight profile applies to all modeled C-130 departure flight tracks.

J.2.1.2 Noise Exposure

Based upon the baseline operations detailed in Section J.2.1.1, the 65 dB contour, the threshold at which DoD guidance identifies for consideration of impacts at noise sensitive receptors, extends approximately a half mile south, 8,800 feet east, and 11,500 feet west of TNI runways. In all of these locations the area under the contours is either undeveloped or overwater.

Table J-3 lists the estimated sound levels calculated for the POIs on Tinian and Saipan, located less than 5 miles northeast of Tinian. The noise contours for aviation training under Baseline/No Action Alternative are shown in Figure J-2. Calculated with noise modeling software, existing civil and military aircraft operations at TNI results in baseline noise levels at noise sensitive points of interest that range from less than 35 dB DNL at S2: San Antonio Residential Area on Saipan up to 57 dB DNL at T18: Old West Field. Because the Baseline DNL calculations do not include other sources of noise (i.e., street traffic, wind, and recreational or domestic activities, and existing aircraft activity at the Saipan International Airport for the points on Saipan) the actual baseline level may be substantially greater once these non-military aircraft sources are included. According to the U.S. EPA, the typical outdoor ambient noise level at a field in a rural area is 44 dB and a suburban residential area is 55 dB (U.S. EPA 1974). Given that both civil and military operations at TNI would remain approximately the same under No Action, the noise exposure and lack of impacts at noise sensitive locations on Tinian would be the same as Baseline.

Figure J-2 Baseline/No Action Alternative DNL Contours at TNI

Table J-3 Baseline/No Action Alternative Noise Levels (DNL) at Noise Sensitive Receptors due to Existing TNI Operations

ID	Description	Type	DNL (dB)[1]
T1	Tinian High School	School	46
T2	Lake Hagoi	Natural Resource	44
T3	Mahalang Ephemeral Ponds	Natural Resource	40
T4	Marpo Heights	Residential	47
T5	Mount Lasso Overlook Area	Natural Resource	45
T6	Bateha 1 – Isolated Wetlands	Natural Resource	46
T7	Northeast of Marpo Heights	Residential	52
T8	Bateha 2 – Isolated Wetlands	Natural Resource	44
T9	San Jose	Residential	44
T10	San Jose Catholic Church	Church	44
T11	Tinian Elementary School	School	44
T12	Unai Chiget	Cultural Resource	38
T13	Unai Chulu	Cultural Resource	42
T14	Unai Dankulo	Cultural Resource	46
T15	Unai Masalok	Cultural Resource	51
T16	North Field National Historic Landmark	Cultural Resource	40
T18	Old West Field	Cultural Resource	57
T19	Northern Marianas College – Tinian	School	47
T20	Ushi Point	Natural Resource	36
T21	Native Limestone Forest	Natural Resource	56
T22	Unai Lam Lam	Cultural Resource	38
T23	House of Taga	Cultural Resource	44
T24	Jones (Kammer) Beach/Park	Natural Resource	44
T25	Natural Resource Area	Natural Resource	42
T26	Unai Babui	Natural Resource	38
S1	Saipan Southern High School	School	40
S2	Coral Ocean Resort	Resort	44
S3	Koblerville Elementary School	School	39
S4	San Antonio Residential Area	Residential	<35

Legend: < = less than; dB = decibels; DNL = Day-Night Noise Level; N/A = not available; U.S. = United States.
Note: Shading indicates that sensitive receptors are within the Military Lease Area.
[1] Modeled baseline DNL does not include other sources of noise (i.e., street traffic, wind, and recreational or domestic activities, and existing aircraft activity at the Saipan International Airport for the points on Saipan) the actual baseline level may be substantially greater once these non-military aircraft sources are included.

J.2.2 Airspace (Military Lease Area including North Field)

J.2.2.1 Modeling Data

Runways at North Field are unimproved World War II-era airfields currently used for military vertical and short field landings and helicopter insertion and extraction of personnel as part of existing military training. Additionally, small unit field exercises and expeditionary warfare training occurs at North Field (DON 2015, 2020). These events are sporadic and occur only a few times each year for a short period of time. Without current regular aircraft operations in the airspace over Tinian or at North Field the existing aircraft operations do not occur frequently enough to impact the Day-Night Average Sound Level (baseline) beyond the DNL reported in previously in Table J-3 due to the flights in and out of TNI. Therefore, the baseline DNL ranges from less than 35 dB to a maximum of 52 dB from all existing military and civil operations at TNI.

J.3 PROPOSED ACTION

The following section details the modeling data and the resultant noise exposure for Alternative 1 and Alternative 2, which would create 13 landing zones which may be used for tilt-rotor and helicopter training, increased training operations at North Field and in the airspace above the MLA and would increase operations related to troop lift and materials and equipment transport to support training events at TNI. Civil operations at TNI would continue at the same rates consistent with Baseline/No Action presented in Section J.2.

J.3.1 Francisco Manglona Borja/Tinian International Airport

J.3.1.1 Modeling Data

Under this Proposed Action, the existing KC-135, F-18E/F, and F-35A/B/C activity would remain the same while other aircraft operations related to cargo and troop lift at the beginning and end of training events would increase by 15 percent under Alternative 1 and 5 percent under Alternative 2. Table J-4 details the TNI operations under Alternative 1, which would total 29,308 annually, and Table J-5 details the TNI operations under Alternative 2, which would total 29,238 annually. This is an overall increase under both alternatives of less than 1 percent.

Table J-4 Proposed Alternative 1 Flight Operations at TNI

Category	*Aircraft*	*Departures*			*Arrivals*			*Totals*		
		Day	*Night*	*Total*	*Day*	*Night*	*Total*	*Day*	*Night*	*Total*
Civil	GA/AT	10,133	3,702	13,835	10,133	3,702	13,835	20,266	7,404	27,670
Military	C-130	113	14	127	113	14	127	226	28	254
	KC-135	240	120	360	240	120	360	480	240	720
	C-5	38	17	55	36	19	55	74	36	110
	C-12	84	8	92	84	8	92	168	16	184
	C-17	37	18	55	37	18	55	74	36	110
	C-35	28	-	28	28	-	28	56	-	56
	C-40	28	-	28	28	-	28	56	-	56
	F-18E/F	23	2	25	23	2	25	46	4	50
	F-35A/B/C	41	8	49	41	8	49	82	16	98
Totals		**10,765**	**3,889**	**14,654**	**10,763**	**3,891**	**14,654**	**21,528**	**7,780**	**29,308**

Legend: % = percent; GA/AT = General Aviation and Air Taxi.
Note: GA/AT modeled as Single Engine Fixed Pitch (GASEPF) aircraft.

Table J-5 Proposed Alternative 2 Flight Operations at TNI

Category	Aircraft	Departures			Arrivals			Totals		
		Day	Night	Total	Day	Night	Total	Day	Night	Total
Civil	GA/AT	10,133	3,702	13,835	10,133	3,702	13,835	20,266	7,404	27,670
Military	C-130	103	13	116	103	13	116	206	26	232
	KC-135	240	120	360	240	120	360	480	240	720
	C-5	34	16	50	32	18	50	66	34	100
	C-12	77	7	84	77	7	84	154	14	168
	C-17	34	16	50	34	16	50	68	32	100
	C-35	25	-	25	25	-	25	50	-	50
	C-40	25	-	25	25	-	25	50	-	50
	F-18E/F	23	2	25	23	2	25	46	4	50
	F-35A/B/C	41	8	49	41	8	49	82	16	98
Totals		**10,735**	**3,884**	**14,619**	**10,733**	**3,886**	**14,619**	**21,468**	**7,770**	**29,238**

Legend: % = percent; GA/AT = General Aviation and Air Taxi.
Note: GA/AT modeled as Single Engine Fixed Pitch (GASEPF) aircraft.

J.3.1.2 Noise Exposure

The 65 dB contour, the threshold at which DoD guidance identifies for consideration of impacts at noise sensitive receptors, extends approximately a half mile south (25 feet further than baseline), 9,000 feet east (200 feet further than baseline), and 11,700 feet west (200 feet further than baseline) of TNI runways. In all of these locations the area that would be newly exposed to 65 dB DNL or greater are either undeveloped or overwater. No noise sensitive receptors would be impacted by the additional operations at TNI under Alternative 1.

The contours for TNI under Alternative 1 and Alternative 2 are presented in Figures J-3 and J-4. The 65 dB contour, the threshold at which DoD guidance identifies for consideration of impacts at noise sensitive receptors, extends approximately a half mile south (50 feet further than baseline), 9,300 feet east (500 feet further than baseline), and 11,800 feet west (300 feet further than baseline) beyond the TNI runways. In all of these locations the areas that would be newly exposed to 65 dB DNL or greater are either undeveloped or overwater. No noise sensitive receptors would be impacted by the additional operations at TNI under Alternative 2.

Therefore, the calculated DNL and change to DNL at sensitive receptors is presented in Table J-7 in Section J.3.2.2 as the total DNL due to all aviation noise that accounts for both the MLA and TNI activity.

Figure J-3 Alternative 1 DNL Contours at TNI

Figure J-4 Alternative 2 DNL Contours at TNI

J.3.2 Airspace (Military Lease Area including North Field)

The following section details the modeling data and the resultant noise exposure that includes use of the newly established LZs, North Field, and activity in the airspace above the MLA that would occur under Alternatives 1 and 2.

J.3.2.1 Modeling Data

Table J-6 presents the estimated annual training hours that would occur under CJMT Alternatives 1 and 2 broken out by area of operation (LZ, North Field, MLA or offshore) determined as the location most appropriate for each type of training activity. Aircraft activity that would operate with an LZ focus would generate time both in the vicinity of LZ and transit time within the MLA.

Table J-6 Alternatives 1 and 2 Aircraft Noise Modeling Hours with Altitude Ranges by Aircraft Type

Area of Operation	*Modeled Aircraft*	*Alt 1 Annual*	*Alt 2 Annual*	*Alt 1 Monthly*	*Alt 2 Monthly*	*Altitude Range*	*Power Setting*
At/Near LZs		**6,671**	**3,481**	**556**	**290**		
MV-22	MV22B	3,336	1,740	278	145	100% <3k	N/A
CH-53	CH53E	1,668	870	139	73	100% <3k	N/A
AH-1/UH-1	AH-1W	1,668	870	139	73	100% <3k	N/A
At/Near North Field		16,791	9,008	1,399	751		
F-18	F-18E/F	960	480	80	40	50% <3k	Varies
F-35	F-35B	1920	960	160	80	50% <3k	Varies
KC-130	C-130J	600	300	50	25	50% <3k	Varies
MV-22	MV22B	6,656	3,634	555	303	100% <3k	N/A
CH-53	CH53E	3,328	1,817	277	151	100% <3k	N/A
AH-1/UH-1	AH-1W	3,328	1,817	277	151	100% <3k	N/A
MLA or <1 mi of land		**29,154**	**14,718**	**2,430**	**1,227**		
F-18	F-18E/F	240	120	20	10	5% <3k	25% MIL, 75% 86%NC
F-35	F-35B	480	240	40	20	5% <3k	25% MIL, 75% 70% ETR
KC-130	C-130J	150	75	13	6	5% <3k	10% Takeoff, 90% Inter
MV-22	MV22B	9,991	5,374	833	448	100% <3k	N/A
CH-53	CH53E	4,996	2,687	416	224	100% <3k	N/A
AH-1/UH-1	AH-1W	4,996	2,687	416	224	100% <3k	N/A
Overwater >1 mi offshore		**5,691**	**2,229**	**474**	**186**		
F-18	F-18E/F	1,423	557	119	46	5% <3k	25% MIL, 75% 86%NC
F-35	F-35B	2,846	1,115	237	93	5% <3k	25% MIL, 75% 70% ETR
KC-130	C-130J	1,423	557	119	46	5% <3k	
Grand Total Hours		**58,308**	**29,436**	**4,859**	**2,453**		

Legend: % = percent; <3k = altitude less than 3,000 feet above ground level; >1 mi = flight time occurring at a distance greater than 1 mile from shore; ETR = engine thrust request; LZ = landing zone; MLA = Military Lease Area; NC = compressor speed in revolutions per second.

Note: MV-22, CH-53, and AH-1/UH-1 modeled as volume sorties at LZ or MLA; F-18E/F, F-35B, C-130 modeled with flight tracks at North Field and volume sorties in MLA. Overwater not modeled for noise.

Approximately half of each training event would be at or near the LZs and half transiting within the MLA. For example, the monthly LZ-focused hours for Alternative 1 are calculated as 1,112 so half of that time (556 hours) are to be modeled in the vicinity of the LZs and half within the MLA. Same estimation applies to the North Field activity with 2,799 calculated monthly hours with half to be modeled in the vicinity of North Field (1,399 hours) and the other half throughout the MLA. The training activity that does not directly occur at LZs or North Field is assumed to include time when aircraft would overfly the island and offshore areas. The directional usage of the North Field runway is assumed to be primarily dictated by wind local wind patterns and is modeled at the same ratio as TNI, which amounts to 85 percent easterly and 15 percent westerly flow.

For the purposes of noise modeling, a portion of these remaining training hours (2,430 hours) under Alternative 1 are assumed to occur overland or within 1 mile of the shoreline and the remaining hours are assumed to occur over water and more than 1 mile from shore where there would be no noise impacts on land, and these hours would not be modeled.

Summary of monthly high estimated hours under Alternative 1 by areas to model are:

- LZ vicinity = 556 hours
- North Field vicinity = 1,399 hours
- MLA or within 1 mile of shore = 2,430 hours (includes transit time LZs/North Field)
- Overwater greater than 1 mile from shore = 474 hours (noted as part of overall flight time, not used in noise modeling).

Aircraft Type Utilization

The distribution of training time among likely airframes for LZ activity listed in Table J-6 is assumed to mirror typical USMC training ratios for helicopters/tilt-rotor:

- MV-22 x12 A/C = 50%
- CH-53E x6 A/C= 25%
- AH-1 / UH-1 x6 A/C = 25%

The North Field activity is split between fighter aircraft refueler and helicopter/tilt-rotor based upon the listed aircraft types in Table J-6. Fighter aircraft are assumed conservatively as two-thirds F-35A/B/C and one-third F-18E/F. The KC-130 is estimated at up to 50 landings and 1 landing per hour of North Field training time per month under Alternative 2. Helicopter and tilt-rotor are assumed split at the same ratio as applied to LZ training. These same airframe ratios are applied to the MLA and the overwater training time.

Aircraft Profiles

For LZ training, a total of 13 LZs would be created comprised of two large and eleven small LZs. These helicopter and tilt-rotor LZ events would be modeled as concentric cylindrical volumes of space centered at each LZ. The lowest cylinder would be smallest where aircraft are either landing on the ground at the LZ or at low altitude. Each subsequent cylinder would be at a higher altitude extending to a larger distance from the LZ to simulate the approach path to land from any possible approach heading. Aircraft speeds would match assumptions developed during previous data collection efforts in 2017 and 2019.

Helicopter and tilt-rotor activity at North Field is assumed to allow approaches from any heading to land on the runway so the same concentric cylinders will be modeled at North Field. Fixed-wing aircraft activity at North Field would be assumed to operate on Runway Baker with similar flight tracks and flight profiles as recorded during the 2017 and 2019 data collection process. Section J.4.3 details the modeled MLA areas and flight profiles.

LZ Usage Distribution

The possible usage rates of each LZ are currently unknown because it would vary due to many factors. Rather than simply model each LZ at an equal and average distribution, which would underpredict noise for heavily used LZs, this analysis takes a more conservative approach. The monthly hours are first spread evenly across all LZs and then modeled at double that rate at all LZs. This will provide an upper bound that would estimate a highly used LZ's noise exposure for all LZs since it is not yet known which LZs would get used more heavily. The two larger proposed LZs (LZ 9 and LZ 12) may be used more often so modeled operations doubled relative to the other nine landings zones.

J.3.2.2 Noise Exposure

Under Alternative 1 the training activity proposed at LZ would result in DNL contours of 65 dB or greater centered at each location but generally limited to the LZ boundary. This occurs because the lowest portion of each operation (less than 30 feet and down to the ground) only occurs within the LZ boundary. Aircraft operations beyond that boundary would be at slightly greater altitudes and would not produce a 65 dB DNL contour at the proposed annual number of operations. The activity that occurs at North Field would result in noise contours that would extend both west and east along the heading of Runway Baker primarily due to military jet operations (arrivals and departures). The remaining modeled operations that would be spread throughout the MLA over the northern part of Tinian and modeled within 1 mile off-shore would produce DNL that would range from 40 to 45 dB. This level is considered to be compatible with all noise-sensitive land uses. The contours for Alternative 1 and Alternative 2 are presented in Figures J-5 and J-6.

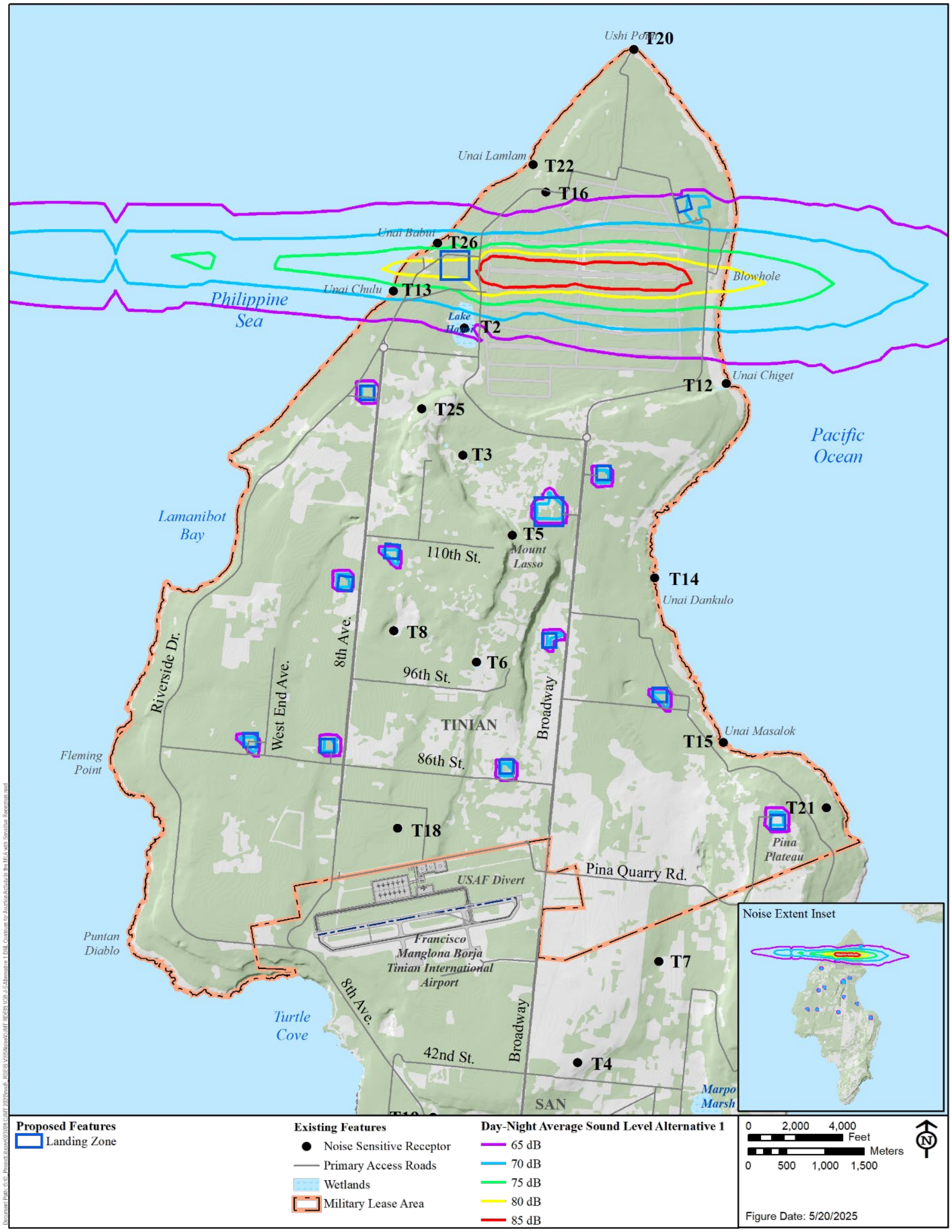


Figure J-5 Alternative 1 DNL Contours within the MLA

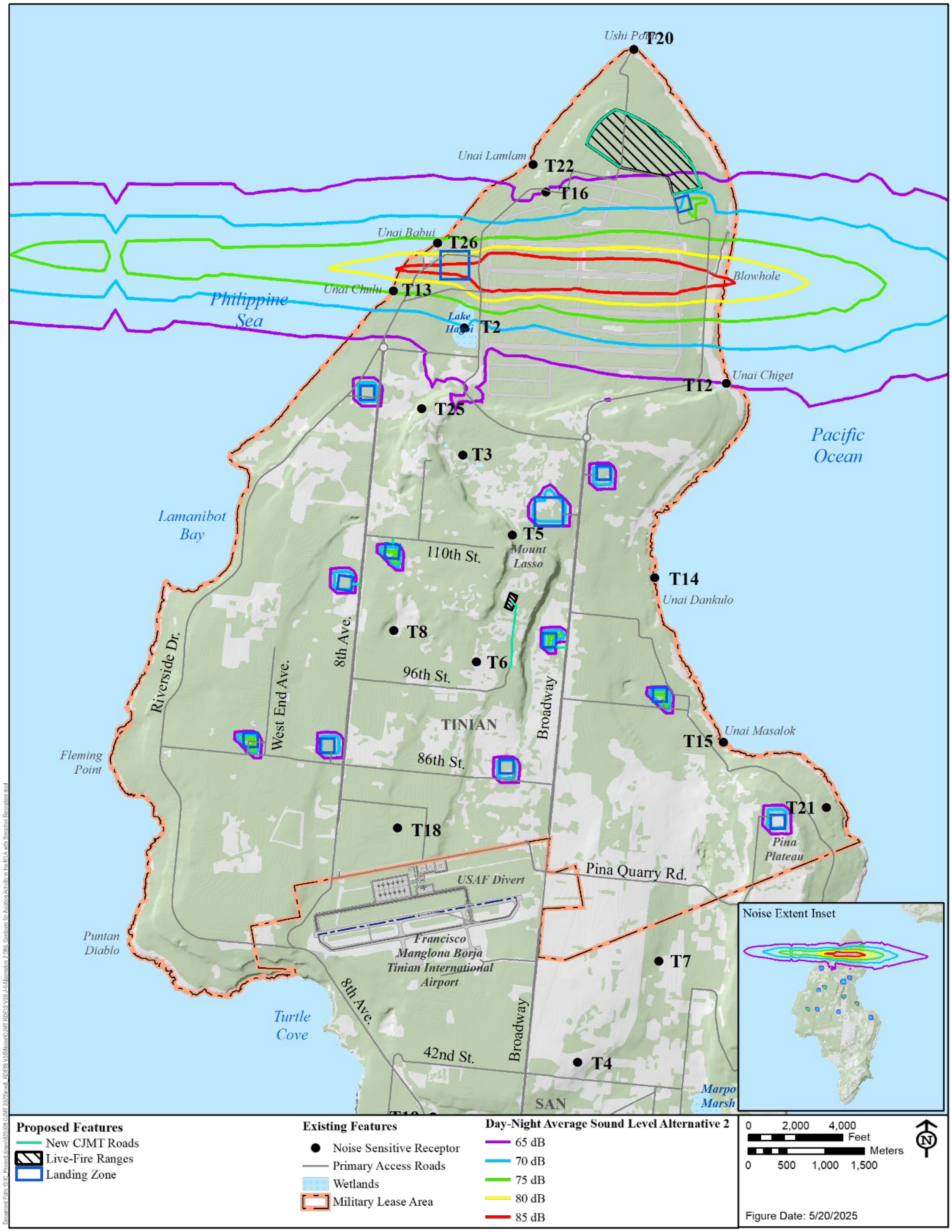


Figure J-6 Alternative 2 DNL Contours within the MLA

Table J-7 Alternative 1 and 2 Noise Levels at Sensitive Receptors on Tinian and Southern Saipan Due to All Aviation Noise (TNI and MLA Operations)

ID	*Description*	*Type*	*Alt 1 Noise Level – DNL (dB) / Change from Baseline[1]*	*Alt 2 Noise Level – DNL (dB) / Change from Baseline[1]*	*Lmax (dB) (same for Alt 1 and Alt 2)*
T1	Tinian High School	School	46 / +0	46 / +0	104
T2	Lake Hagoi	Natural Resource	70 / +26	67 / +23	102
T3	Mahalang Ephemeral Ponds	Natural Resource	60 / +20	57 / +17	95
T4	Marpo Heights	Residential	47 / +0	47 / +0	107
T5	Mount Lasso Overlook Area	Natural Resource	55 / +10	52 / +7	100
T6	Bateha 1 – Isolated Wetlands	Natural Resource	49 / +3	48 / +2	99
T7	Northeast of Marpo Heights	Residential	53 / +1	52 / +0	97
T8	Bateha 2 – Isolated Wetlands	Natural Resource	49 / +5	47 / +3	99
T9	San Jose	Residential	45 / +1	45 / +1	93
T10	San Jose Catholic Church	Church	44 / +0	44 / +0	94
T11	Tinian Elementary School	School	45 / +1	45 / +1	96
T12	Unai Chiget	Cultural Resource	65 / +27	62 / +24	95
T13	Unai Chulu	Cultural Resource	76 / +34	73 / +31	108
T14	Unai Dankulo	Cultural Resource	51 / +5	49 / +3	104
T15	Unai Masalok	Cultural Resource	52 / +1	52 / +1	99
T16	North Field National Historic Landmark	Cultural Resource	65 / +25	62 / +22	100
T18	Old West Field	Cultural Resource	57 / +0	57 / +0	102
T19	Northern Marianas College – Tinian	School	47 / +0	47 / +0	103
T20	Ushi Point	Natural Resource	53 / +17	51 / +15	91
T21	Native Limestone Forest	Natural Resource	57 / +1	56 / +0	105
T22	Unai Lam Lam	Cultural Resource	62 / +24	59 / +21	99
T23	House of Taga	Cultural Resource	45 / +1	45 / +1	97
T24	Jones (Kammer) Beach/Park	Natural Resource	45 / +1	44 / +0	98
T25	Natural Resource Area	Natural Resource	57 / +15	54 / +12	104
T26	Unai Babui	Natural Resource	76 / +38	73 / +35	108
S1	Saipan Southern High School	School	47 / +7	45 / +5	87.4
S2	Coral Ocean Point Resort / Saipan	Resort	49 / +5	47 / +3	91.6
S3	Koblerville Elementary School	School	47 / +8	45 / +6	86.3
S4	San Antonio Residential Area	Residential	43 / +9	41 / +7	74.9

Legend: < = less than; dB = decibels; DNL = Day-Night Noise Level; Lmax = A-weighted maximum noise level; N/A = not available; U.S. = United States.

Note: Shading indicates that the sensitive receptors are within the Military Lease Area.

[1] Modeled baseline DNL does not include other sources of noise (i.e., street traffic, wind, and recreational or domesticactivities, and existing aircraft activity at the Saipan International Airport for the points on Saipan) the actual baseline level may be substantially greater once these non-military aircraft sources are included.

In addition to Day-Night Average Sound Level, a different metric can be used to describe noise sources in motion, where the sound level changes over time (i.e., sound increases as the source moves closer and decreases as it moves further away). In these cases, the maximum sound level for a particular noise event, like an aircraft flying overhead, can be used. The maximum sound level provides the loudest sound level for a moment in time, but does not account for the duration of time, or how long one hears the sound. For example, the maximum sound level for a gun firing a bullet and a freight train passing nearby may be the same at any discreet moment, but you are exposed to the sound level for a longer time period standing near the train.

Table J-8 presents single event noise levels of aircraft operations that would apply to areas adjacent to North Field or for aircraft flying over the airspace in the MLA. In these areas, helicopters and tilt-rotor aircraft (MV-22, CH-53E, and AH-1/UH-1) would operate at a variety of altitudes but generally below 2,000 feet. The MV-22 and CH-53E would produce approximately the same L_{max} of 91 dB that would be experienced on the ground directly underneath the aircraft operating at 300 feet above. The AH-1/UH-1, which is smaller and lighter, would produce an L_{max} of 88 dB under the same conditions. The SEL would range from 96 to 98 dB for all three aircraft.

The fixed-wing aircraft (F-35B, F-18E/F, and KC-130J) would typically operate above 10,000 feet. However, Table J-4 includes SEL and L_{max} noise levels at 5,000 and 2,000 to account for situations where this may occasionally occur. Both F-35A/B/C and F-18E/F would produce similar noise levels ranging from an L_{max} of 80 to 82 at 10,000 feet and 102 to 104 if operating at 2,000 feet, which would mostly occur in the vicinity of North Field. SEL would range from 90 to 111 dB under these conditions for the F-35A/B/C and F-18E/F. The KC-130J would generate L_{max} ranging from 56 to 77 dB and SEL from 67 to 85 dB.

Table J-8 Single Event Noise Levels (Sound Exposure Level and Maximum Noise Level) for Common Military Aircraft Operating Conditions

Altitude (ft AGL)	*MV-22 at 80 kts*		*CH-53 at 80 kts*		*AH-1/UH-1 at 80 kts*		*F-35A/B/C at 220 kts*		*F-18E/F at 220 kts*		*KC-130 at 220 kts*	
	SEL (dB)	*L_{max} (dB)*	*SEL (dB)*	*L_{max} (dB)*	*SEL (dB)*	*L_{max} (dB)*	*SEL (dB)*	*L_{max} (dB)*	*SEL (dB)*	*L_{max} (dB)*	*SEL (dB)*	*L_{max} (dB)*
300	98	91	97	91	96	88						
500	95	86	95	87	93	84						
2,000	89	75	87	73	87	73	110	102	111	104	85	77
5,000							100	90	101	93	76	66
10,000							90	80	91	82	67	56

Legend: ft AGL = feet above ground level; kts = knots; dB = decibels; L_{max} = maximum sound level; SEL = sound exposure level.
Note: Modeled at a constant speed and altitude.

J.3.3 Live-Fire Ranges and Explosive Detonation

J.3.3.1 Modeling Data

Multi-Purpose Maneuver Range

Training activity proposed for the MPMR would involve personally moving through the area from the east while periodically firing towards the targets to the west with multiple stops along the way. Training personnel would utilize gun fire (9mm, 5.56mm, 7.63mm[1], M2, and M14), structure breaching explosives (typically C-4 with Net explosive weight [NEW] of 1.25 pounds [lbs]) to open doors, and the antipersonnel obstacle breaching (APOBS). The firing direction would be limited to range from west and north cardinal directions and darkness training would occur within the DNL daytime period between 0700 and 2200 (7 a.m. to 10 p.m.).

Table J-9 details estimated annual activity that could occur in the MPMR, which includes small arms rounds, practice grenades, training rockets, and antipersonnel obstacle breaching (APOBS). Annual 5.56mm ammunition expenditure estimated at 526,500 for 10/clip and 105,300 for single

[1]7.62mm will be used during training, but data for this type was not available in SARNAM so 7.63mm was used as a surrogate.

rounds. Usage of 7.62mm rounds estimated at 162,000 and 50 caliber at 108,000 annually. For the purposes of noise modeling similar equipment were grouped by category when producing similar noise characteristics and Section J.3.3.2 provides the single event PK15(met) noise levels for commonly used equipment that includes 9mm, 5.56mm, 7.63mm rounds and the M2 and M14 weapon systems. Additionally, the MPMR single event noise analysis considers atypical equipment, such as MAAWS 20mm, 40mm Green Star Parachute M661, MAAWS Full Range Training Rocket, Rocket 83 mm HEAA Practice MK7, etc.

Table J-9 MPMR Proposed Annual Activity

DODIC	*Nomenclature*	*Platoon Off Def Scenario*	*Iterations by Platoon (2x day; 1x night)*	*Battalion Estimate (9 Platoon)*	*Annual*
A059	Cartridge, 5.56mm Ball M855 10/Clip Sub f/AA45	3,900	11,700	105,300	526,500
A063	Cartridge, 5.56mm Tracer M856 Single Round	780	2,340	21,060	105,300
A131	Cartridge, 7.62mm 4 Ball M80/1 Tracer M62 Linked	1,200	3,600	32,400	162,000
A254	MAAWS 7.62 Tracer Trainer	9	27	243	1,215
A358	Cartridge, 9mm TP-T M939 for AT-4 Trainer	9	27	243	1,215
A576	Cartridge, Caliber .50 4 API M8/1 API-T M20 Linked	800	2,400	21,600	108,000
AA11	Cartridge, 7.62mm Long Range M118 LR	10	30	270	1,350
AC05	MAAWS 20mm Subcal Training System	9	27	243	1,215
B504	Cartridge, 40mm Green Star Parachute M661	9	27	243	1,215
B508	Cartridge, 40mm Green Smoke Ground Marker M715	9	27	243	1,215
B509	Cartridge, 40mm Yellow Smoke Ground Marker M716	9	27	243	1,215
B535	Cartridge, 40mm White Star Parachute M583/M583A1	12	12	108	540
B647	Cartridge, 60mm Illuminating M721	15	15	135	675
BA15	Cartridge, 60mm Target Practice	18	54	486	2,430
BA35	Cartridge, 40mm Practice Day Night	27	81	729	3,645
C385	MAAWS Smk	9	27	243	1,215
C386	MAAWS Full Range Training Rocket	9	27	243	1,215
C484	Cartridge, 81mm Illuminating IR XM816	12	12	108	540
C871	Cartridge, 81mm Illuminating M853A1 with MTSQ Fuze M772	12	12	108	540

DODIC	Nomenclature	Platoon Off Def Scenario	Iterations by Platoon (2x day; 1x night)	Battalion Estimate (9 Platoon)	Annual
C875	CTG, 81MM PRAC FRTR M879	18	54	486	2,430
CA36	MAAWS Illum	9	27	243	1,215
G811	Grenade, Hand Practice Body M69	12	36	324	1,620
G878	Fuze, Hand Grenade Practice M228	12	36	324	1,620
G881	Grenade, Hand Fragmentation M67	3	9	81	405
G940	Grenade, Hand Green Smoke M18	3	9	81	405
G945	Grenade, Hand Yellow Smoke M18	3	9	81	405
G982	Grenade, Hand Practice Smoke TA M83	9	27	243	1,215
HA21	Rocket, 21mm Sub-Caliber, M72AS Trainer	9	27	243	1,215
HX07	Rocket, 83mm HEAA Practice MK7 Mod 0 (SMAW)	3	9	81	405
L305	Signal, Illumination	3	9	81	405
L307	Signal, Illumination Ground White Star Cluster M159	3	9	81	405
L311	Signal, Illumination Ground Red Star Parachute M126A1	3	9	81	405
L312	Signal, Illumination Ground White Star Parachute M127A1	3	9	81	405
L314	Signal, Illumination Ground Green Star Cluster M125A1	3	9	81	405
L498	MAAWS 7.62 Primer cap	9	27	243	1,215
L594	Simulator, Projectile Ground Burst M115A2	6	18	162	810
M023	Charge, Demolition Block M112 1-1/4 pound C-4	6	18	162	810
M131	Cap, Blasting Non-Electric M7	4	12	108	540
M456	Cord, Detonating PETN Type I Class E	20	60	540	540'
M670	Fuse, Blasting Time M700	10	30	270	270'
MN08	Igniter, Time Blasting Fuse with Shock Tube Capability M81	4	12	108	540
MN79	Mine, Antipersonnel Obstacle Breaching System MK 7 Mod 1	1	3	27	135

Analysis of the CDNL applicable for land use impact consideration requires the frequency of use for each proposed type of equipment. Typical training in the MPMR could occur over a two week period and each training event would require planning and setup. The actual training would vary from day to day based upon training requirements, but a typical day with 3 separate training events in one day may comprise:

- 14,040 rounds of 5.56
- 3,800 rounds of 7.62
- 2,400 rounds of 50cal
- 9 M67 Hand Grenades
- 18 C4 shots 1.25 NEW
- 3 APOBS 125lbs NEW (Note: 125 lb NEW is the total weight of the APOBS, which is a series of individual smaller charges of ~1 lb NEW) - 3 separate training with 2 during night)

Rather than spreading the proposed activity over an entire year, which may include some months with little to no range operations, this analysis of CDNL focuses on a busy month that contains 10 days of the training activity listed above and 10 days of either preparation or clean up. CDNL only applies to the explosive activity at MPMR because small arms only relies upon the peak metric (USMC 2021).

Explosives Training Range

The proposed action includes an ETR near the middle of Tinian that would be for explosives training. The largest detonations would be cratering charges with a maximum of 40 lbs NEW that would occur up to 4 times per year. However, when practicable, cratering detonations would utilize smaller 10 lbs NEW for most cratering training to reduce resulting noise levels in the vicinity of the training area. Detonation of breaching charges represents to other types of training that would occur at the ETR, which would include up to 12 shots per day and charge weight ranging from 0.25 to 1.25 lbs NEW. Although detonation training requirements include a darkness component, all cratering charge training events and nearly all breaching charge events would occur during the DNL daytime period 7 a.m. to 10 p.m. This analysis considers up to 1 breaching charge of 1.25 lbs NEW per quarter would occur during the DNL nighttime 10 p.m. to 7 a.m.

The noise analysis calculated single event PK15(met) noise contours for the maximum cratering charge of 40 lbs NEW (modeled at 44 lbs NEW as the closest noise source available in the BNOISE software), 10 lbs NEW (modeled at 11 lbs NEW as the closest noise source available in the BNOISE software), and the maximum breaching charge of 1.25 lbs NEW.

The busy month analysis calculates the CDNL metric comprised of 15 events of the maximum breaching charge of 1.25 lbs NEW (the maximum weight), 12 events of a charge utilizing 10 lbs NEW, and one cratering charge:

- Breaching charge = x15 events at 1.25 lbs NEW per quarter (14 during DNL daytime and 1 during DNL nighttime)
- Intermediate charge= x12 events at 10 lbs NEW (modeled at 11 lbs NEW, 10 during DNL daytime and 2 DNL nighttime)
- Cratering charge = 1 event at 40 lbs NEW (modeled at 44 lbs NEW during DNL daytime)

Section J.3.3.2 presents the resulting single event PK15(met) and CDNL noise contours for the proposed ETR activity.

J.3.3.2 Noise Exposure

Multi-Purpose Maneuver Range

Figure J-7 depicts the single event peak noise levels as dBP for the various types of small arms weapons that would be used at the MPMR showing the 87 and 104 dBP contours. According to Marine Corps Order 3550.13, sensitive land uses, such as housing, schools, and medical facilities, should not be regularly exposed to unweighted peak noise levels between 87 and 104 dBP and are incompatible with exposure to greater than 104 dBP from small arms weapon fire noise. With the firing direction oriented to the west or north the largest portion of the contour would extend out over the ocean to the northwest for all types of weapons. The M2 would produce the largest 87 dBP contour while the 9mm the smallest. Overall, none of the analyzed small arms would generate peak contours of 87 dBP or greater at any noise sensitive areas.

Figure J-7 Complaint Risk due to Proposed MPMR Small Arms – Peak Unweighted dBP

Figure J-8 depicts the single event PK15(met) noise levels for the various types of categorized as explosives equipment broken out by typical and rarely used types. Figure J-8 plots the analogous 115, 130, and 140 dBP contour annoyance thresholds consistent with Marine Corp Order 3550.13. Exposure below 115 dBP corresponds to a low risk of noise complaints, between 115 and 130 dBP a medium risk, and greater than 130 dBP a high risk. The typical equipment types would produce 115 dBP that would extend approximately 1 mile south of the MPMR, on land primarily within North Field.

Figure J-9 presents the CDNL for both the small arms and large caliber/explosives activity depicting the 62 and 70 dBC contours as the thresholds for noise impacts to noise sensitive uses. Although the Marine Corps Order 3550.13 only requires CDNL for large caliber and explosive activity, because CDNL applies to impulsive events. The 62 dBC CDNL contour would extend approximately to Baker Runway to the south while the 70 dBC CDNL contour would extend approximately to the ammunitions holding area. Small arms activity would generate 62 dBC CDNL primarily to the northwest remaining north of Runway Baker while the 80 dBC CDNL would remain north of Ammunitions Holding Area.

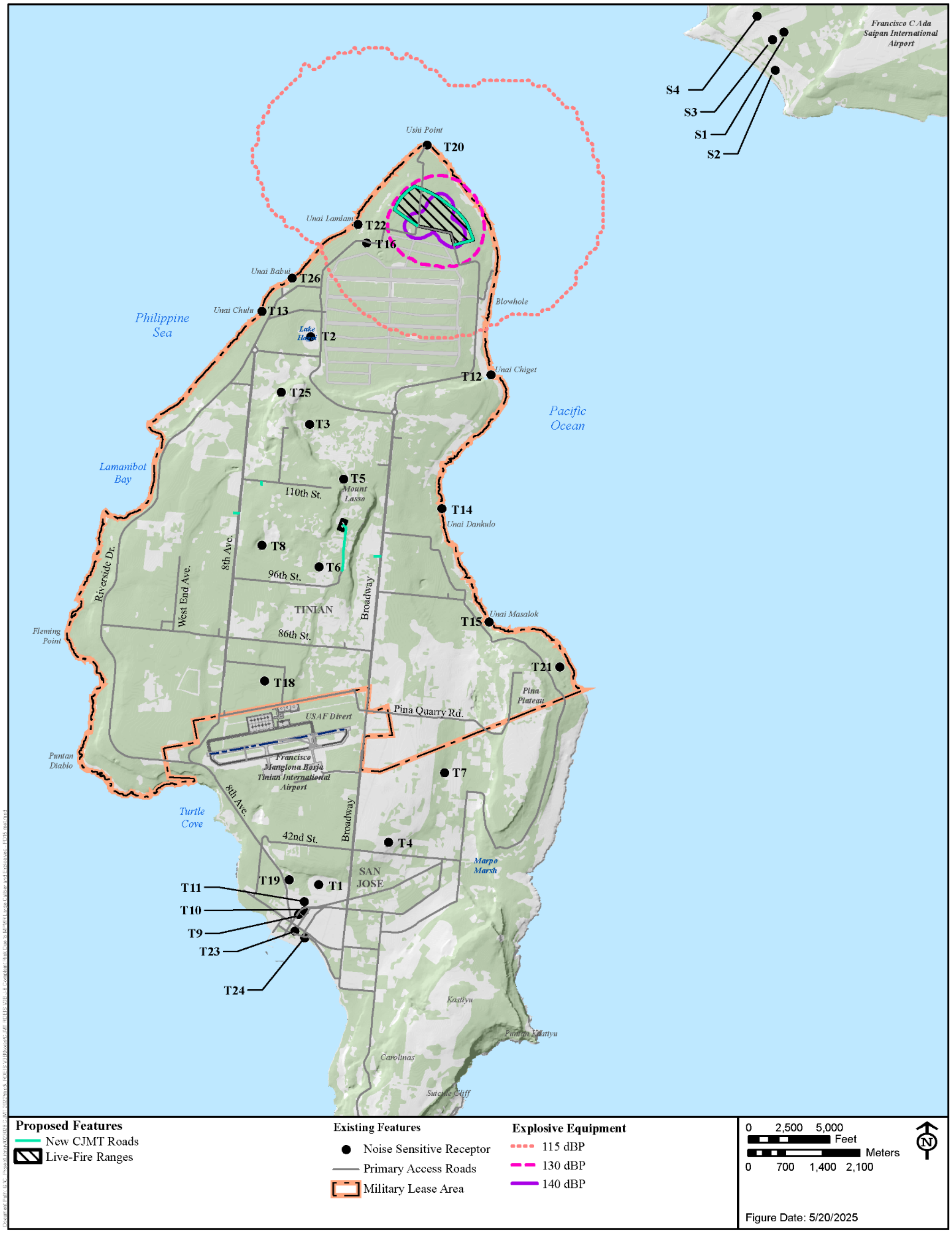


Figure J-8 Complaint Risk due to MPMR Explosives - PK15(met)

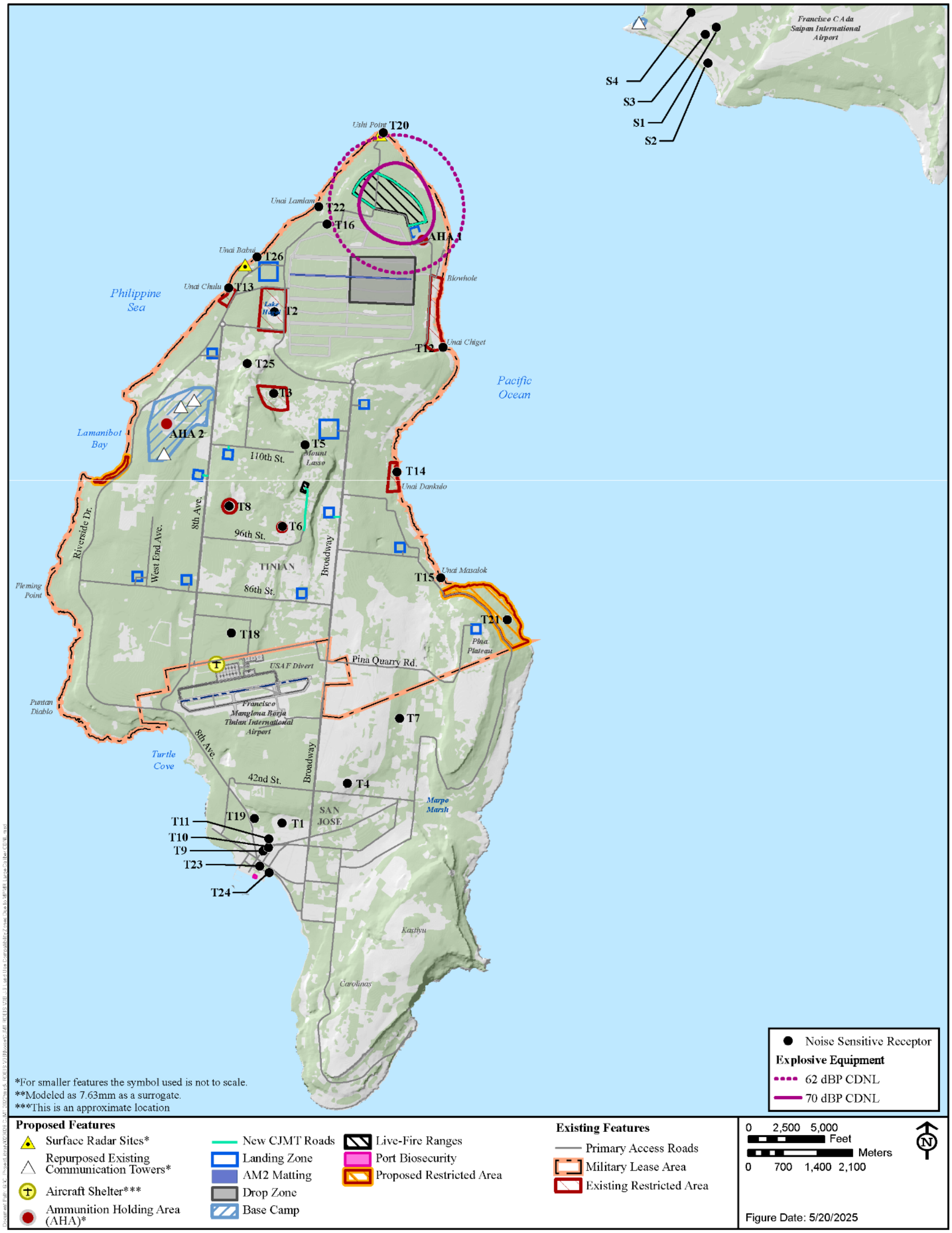


Figure J-9 Land Use Incompatibility Zones due to MPMR Explosives - CDNL

Table J-10 identifies POIs on both the islands of Tinian and Saipan and resulting CDNL and PK15 noise levels of proposed MPMR operational noise levels.

Table J-10 Proposed MPMR Operational Noise Levels at POIs

ID	Description	Type	CDNL (dB)	PK15(met)(dBP)
T1	Tinian High School	School	<35	90
T2	Lake Hagoi	Natural Resource	48	108
T3	Mahalang Ephemeral Ponds	Natural Resource	45	104
T4	Marpo Heights	Residential	<35	93
T5	Mount Lasso Overlook Area	Natural Resource	43	102
T6	Bateha 1 – Isolated Wetlands	Natural Resource	40	98
T7	Northeast of Marpo Heights	Residential	<35	94
T8	Bateha 2 – Isolated Wetlands	Natural Resource	41	99
T9	San Jose	Residential	<35	92
T10	San Jose Catholic Church	Church	<35	92
T11	Tinian Elementary School	School	<35	92
T12	Unai Chiget	Cultural Resource	49	109
T13	Unai Chulu	Cultural Resource	47	106
T14	Unai Dankulo	Cultural Resource	43	102
T15	Unai Masalok	Cultural Resource	40	98
T16	North Field National Historic Landmark	Cultural Resource	61	124
T18	Old West Field	Cultural Resource	38	96
T19	Northern Marianas College – Tinian	School	<35	92
T20	Ushi Point	Natural Resource	61	122
T21	Native Limestone Forest	Natural Resource	39	98
T22	Unai Lam Lam	Cultural Resource	60	122
T23	House of Taga	Cultural Resource	<35	92
T24	Jones (Kammer) Beach/Park	Natural Resource	<35	92
T25	Natural Resource Area	Natural Resource	45	104
T26	Unai Babui	Natural Resource	49	110
S1	Saipan Southern High School	School	45	106
S2	Coral Ocean Point Resort	Resort	47	109
S3	Koblerville Elementary School	School	47	108
S4	San Antonio Residential Area	Residential	47	108

Legend: < = less than; dB = decibels; dBP = Peak decibels; CDNL = C-weighted Day-Night Noise Level; N/A = not available; PK15(met) = Peak decibels exceeding 15% of all events; U.S. = United States.
Note: Shading indicates that the sensitive receptors are within the Military Lease Area.

Explosives Training Range

Figures J-10 through J-12 depict the single event PK15(met) noise levels for the maximum cratering charge of 40 lbs NEW (modeled at 44 lbs NEW), 10 lbs NEW (modeled at 11 lbs NEW), and maximum breaching charge of 1.25 lbs NEW resulting in 115, 130, and 140 dBP contour thresholds applicable to large caliber and detonation operations. Figure J-10 depicts the 115 dBP PK15(met) contour due to largest explosive of 40 lbs NEW and representing a low risk of noise complaints would extend approximately 4.8 miles south of the ETR reaching residential areas along the northern end of San Jose and exposing 6 sensitive receptors to the south. The 115 dBP from the 40 lbs NEW would also cover the northern end of Tinian (4 sensitive receptors) and would reach the southern shore of Saipan and not impact any sensitive receptors. The 130 dB PK15(met) contour due to 40 lbs NEW representing a medium risk of noise complaints would extend approximately 1.6 miles both north and south of the ETR and would expose 2 sensitive receptors on Tinian. The 140 dBP PK15(met) contour representing a high risk of noise complaints would extend approximately 1 mile in all directions from the proposed ETR location while exposing one sensitive receptor. Although residential areas in San Jose would be within the low risk of noise complaint area, the detonation of 40 lbs NEW would be rare occurring 2 to 4 times per year. No residential areas would experience a medium or high risk of noise complaints due to the 40 lbs NEW.

Figure J-11 depicts the PK15(met) due to the 10 lbs NEW occurring potentially 12 times per quarter or more would generate far smaller areas with noise complaint risks. The 115 dBP contour and low risk of noise complaints would extend approximately 3.4 miles from the ETR exposing no residential areas and five POI applicable to biological resources. The 130 and 140 dBP contour would extend 1.3 and 0.8 miles from the ETR, respectively.

As depicted in Figure J-12 the PK15(met) due to the 1.25 lbs NEW occurring potentially a dozen times per training day or more would generate far smaller areas with noise complaint risks. The 115 dBP contour and low risk of noise complaints would extend approximately 2 miles from the ETR exposing no residential areas and two POI applicable to biological resources. The 130 and 140 dBP contour would extend 0.9 and 0.5 miles from the ETR, respectively.

The effects of ground terrain on noise propagation can be seen in the shape and extent of the PK15(met) contours for all proposed detonations (40 lbs NEW, 10 lbs NEW, and 1.25 lbs NEW) where areas to the southwest of the ETR would experience reduced noise levels due to a ridgeline southwest of the ETR with a peak approximately 200 feet above the ETR elevation. In addition to terrain modeling, the software adjusts the noise levels to account for difference in sound propagation across water versus land. As shown in Figures J-10 through J-12, the contours extend the furthest to the east where water comprises the largest portion of the surface.

Figure J-13 presents the CDNL for a busy month of operations at the proposed ETR depicting the 62- and 70-dB thresholds. The size of the CDNL contours would extend less than 1,200 and 700 feet from the ETR for the 62 and 70 dBC, respectively. No noise sensitive areas would be affected by the busy month of proposed operations at the ETR.

Table J-11 depicts POIs on both the islands of Tinian and Saipan and resulting CDNL and PK15 noise levels of proposed ETR operational noise levels.

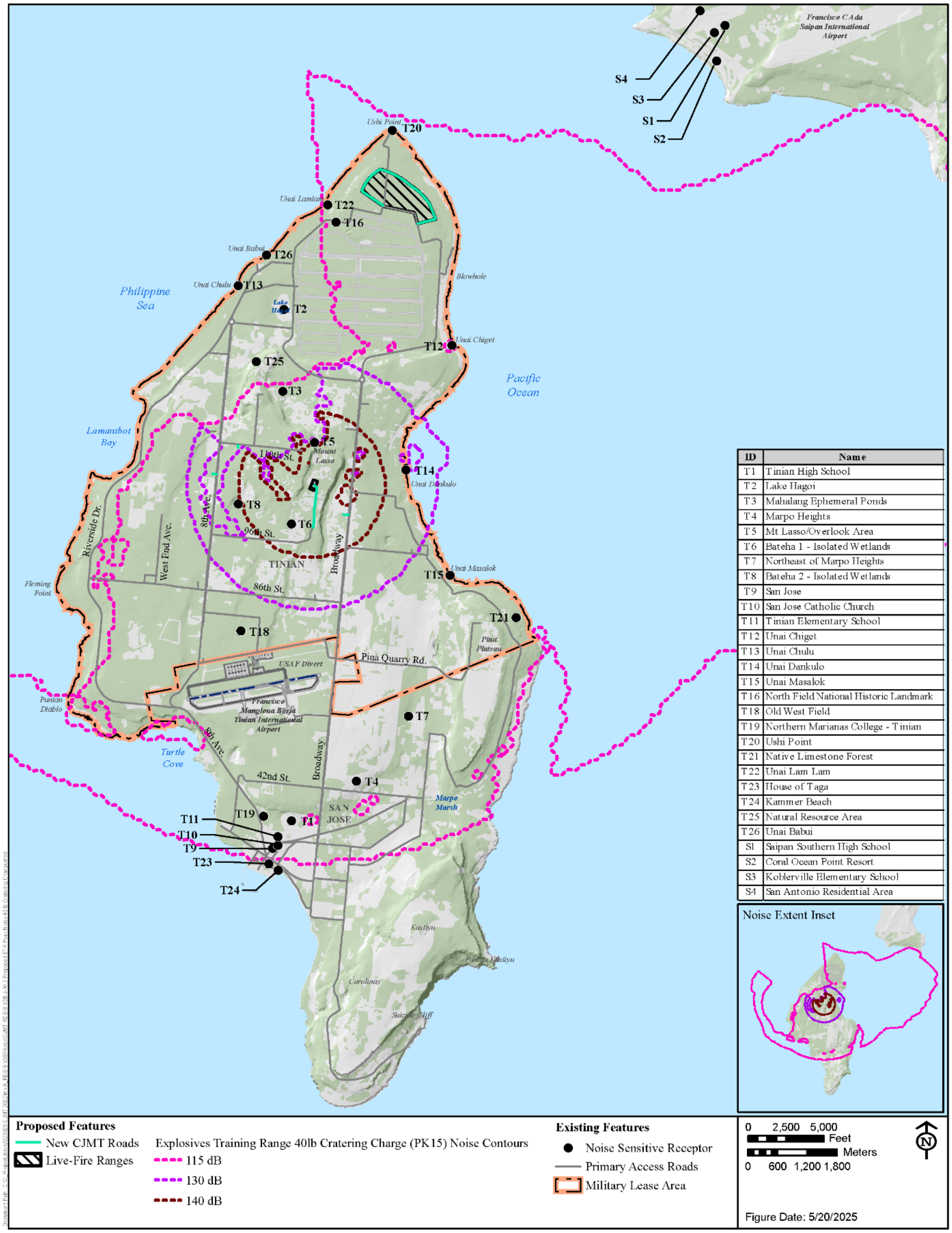
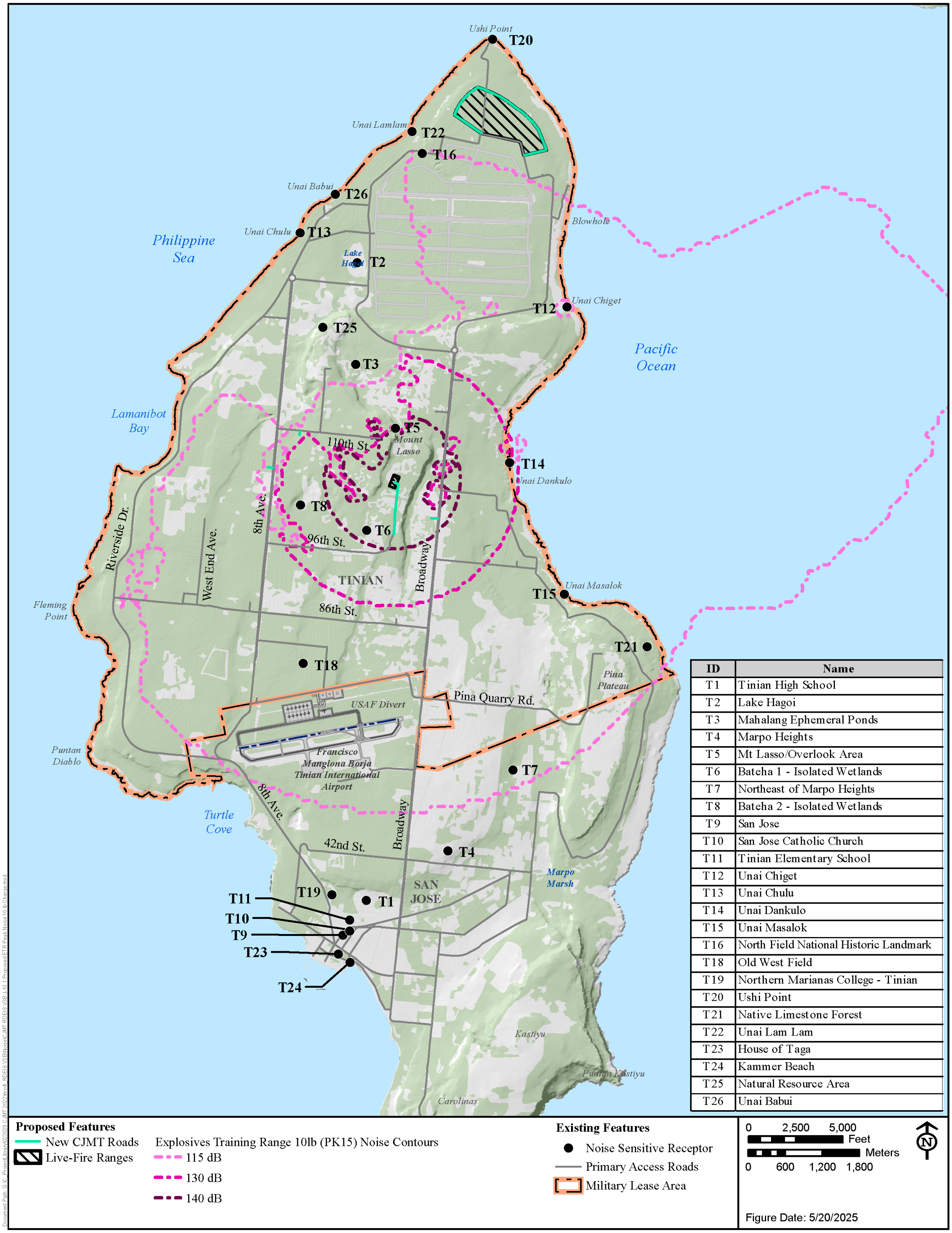
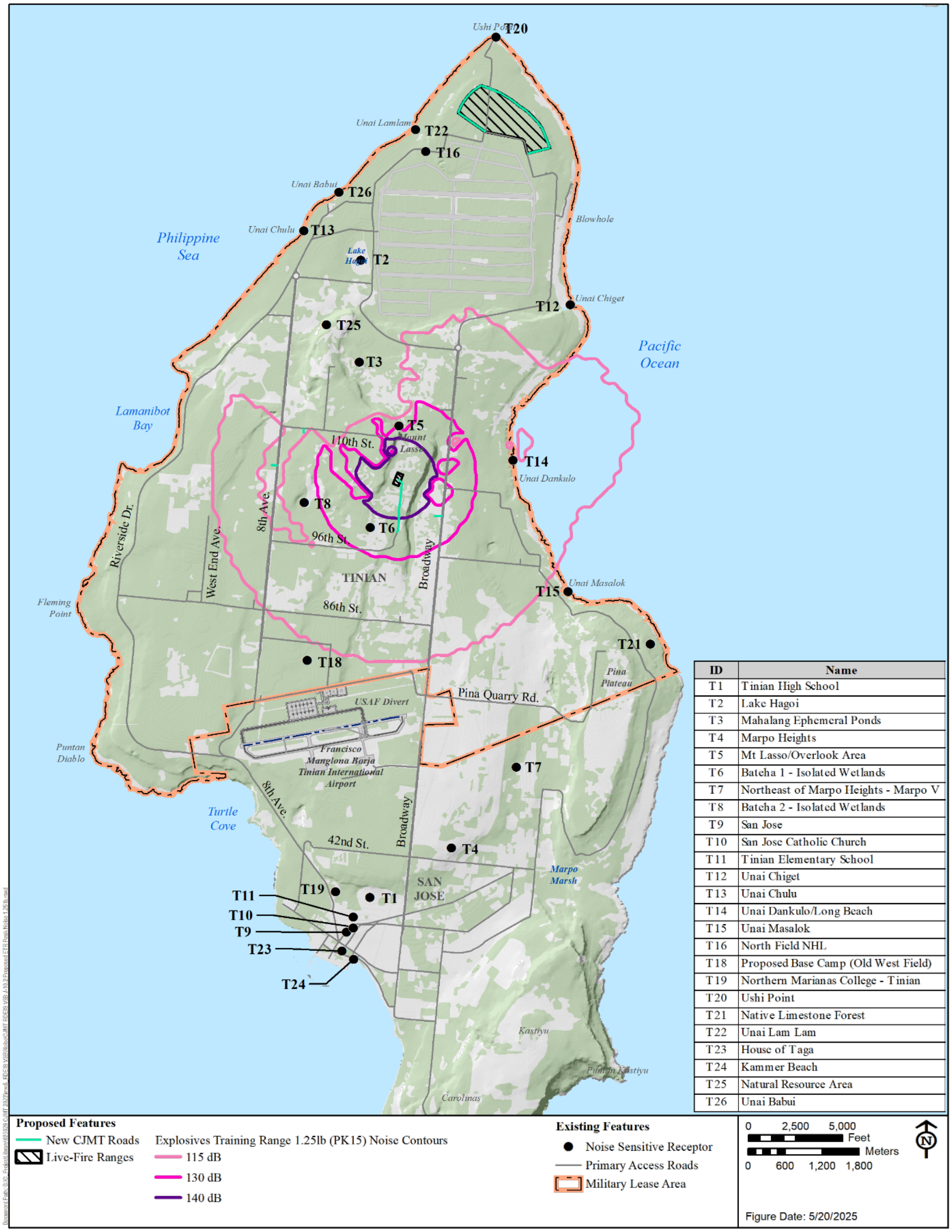


Figure J-10 Noise Complaint Risk due to Proposed Explosives Detonation of 40 lbs NEW at the ETR - PK15(met)



ID	Name
T1	Tinian High School
T2	Lake Hagoi
T3	Mahalang Ephemeral Ponds
T4	Marpo Heights
T5	Mt Lasso/Overlook Area
T6	Bateha 1 - Isolated Wetlands
T7	Northeast of Marpo Heights
T8	Bateha 2 - Isolated Wetlands
T9	San Jose
T10	San Jose Catholic Church
T11	Tinian Elementary School
T12	Unai Chiget
T13	Unai Chulu
T14	Unai Dankulo
T15	Unai Masalok
T16	North Field National Historic Landmark
T18	Old West Field
T19	Northern Marianas College - Tinian
T20	Ushi Point
T21	Native Limestone Forest
T22	Unai Lam Lam
T23	House of Taga
T24	Kammer Beach
T25	Natural Resource Area
T26	Unai Babui

Figure J-11 Noise Complaint Risk due to Proposed Explosives Detonation of 10 lbs NEW at the ETR - PK15(met)



ID	Name
T1	Tinian High School
T2	Lake Hagoi
T3	Mahalang Ephemeral Ponds
T4	Marpo Heights
T5	Mt Lasso/Overlook Area
T6	Batcha 1 - Isolated Wetlands
T7	Northeast of Marpo Heights - Marpo V
T8	Batcha 2 - Isolated Wetlands
T9	San Jose
T10	San Jose Catholic Church
T11	Tinian Elementary School
T12	Unai Chiget
T13	Unai Chulu
T14	Unai Dankulo/Long Beach
T15	Unai Masalok
T16	North Field NHL
T18	Proposed Base Camp (Old West Field)
T19	Northern Marianas College - Tinian
T20	Ushi Point
T21	Native Limestone Forest
T22	Unai Lam Lam
T23	House of Taga
T24	Kammer Beach
T25	Natural Resource Area
T26	Unai Babui

Figure J-12 Noise Complaint Risk due to Proposed Explosives Detonation of 1.25 lbs NEW at the ETR - PK15(met)

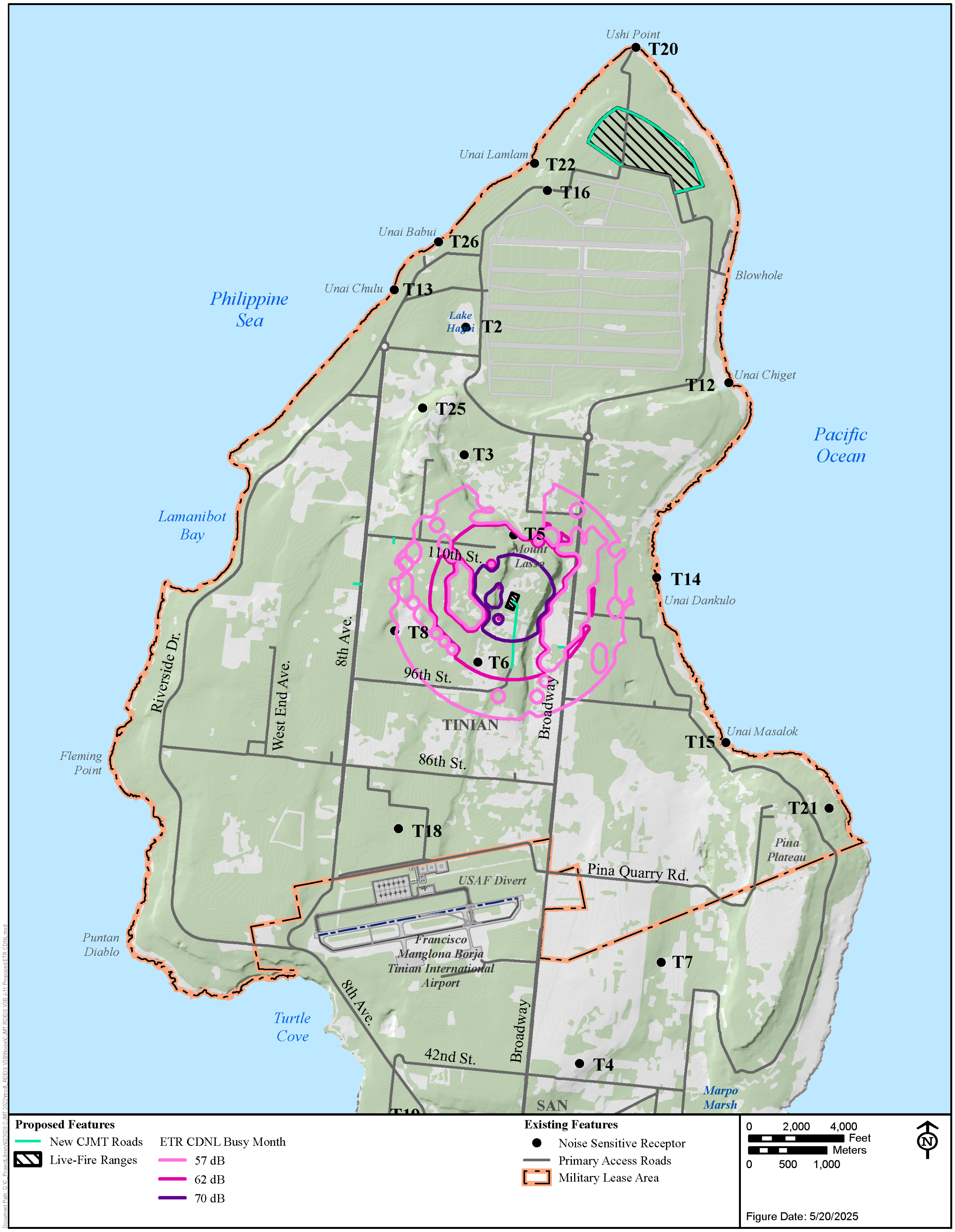


Figure J-13 Land Use Compatibility for Proposed Explosive Detonation at the ETR – CDNL

Table J-11 Proposed ETR Operational Noise Levels at POIs

ID	*Description*	*Type*	*CDNL (dB) (Busy Month All Explosives)*	*PK15(met) (2-4 events per year) (dBP): 40lb Cratering Charge*
T1	Tinian High School	School	<35	117
T2	Lake Hagoi	Natural Resource	<35	106
T3	Mahalang Ephemeral Ponds	Natural Resource	50	115
T4	Marpo Heights	Residential	39	118
T5	Mount Lasso Overlook Area	Natural Resource	61	126
T6	Bateha 1 – Isolated Wetlands	Natural Resource	64	148
T7	Northeast of Marpo Heights	Residential	48	120
T8	Bateha 2 – Isolated Wetlands	Natural Resource	43	138
T9	San Jose	Residential	36	116
T10	San Jose Catholic Church	Church	34	116
T11	Tinian Elementary School	School	<35	116
T12	Unai Chiget	Cultural Resource	36	123
T13	Unai Chulu	Cultural Resource	<35	104
T14	Unai Dankulo	Cultural Resource	40	137
T15	Unai Masalok	Cultural Resource	46	126
T16	North Field National Historic Landmark	Historic	40	119
T18	Old West Field	Historic	45	125
T19	Northern Marianas College – Tinian	School	36	117
T20	Ushi Point	Natural Resource	37	116
T21	Native Limestone Forest	Natural Resource	42	121
T22	Unai Lam Lam	Cultural Resource	40	104
T23	House of Taga	Cultural Resource	37	115
T24	Jones (Kammer) Beach/Park	Natural Resource	37	115
T25	Natural Resource Area	Natural Resource	<35	107
T26	Unai Babui	Natural Resource	<35	104
S1	Saipan Southern High School	School	<35	112
S2	Coral Ocean Point Resort	Resort	<35	113
S3	Koblerville Elementary School	School	<35	113
S4	San Antonio Residential Area	Residential	<35	112

Legend: < = less than; dB = decibels; dBP = Peak decibels; CDNL = C-weighted Day-Night Noise Level; N/A = not available; PK15(met) = Peak decibels exceeding 15% of all events; U.S. = United States.

Note: Shading indicates that the sensitive receptors are within the Military Lease Area.

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ATTACHMENT 1

Discussion of Noise and Its Effects on the Environment

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Acknowledgements

This review of noise and its effects on the environment was prepared by Wyle Laboratories, Inc., with contributions from Blue Ridge Research and Consulting LLC and Ecology and Environment, Inc.

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TABLE OF CONTENTS

List of Figures

List of Tables

Abbreviations and Acronyms

Acronym	Definition
AGL	Above Ground Level
ANSI	American National Standards Institute
CHABA	Committee on Hearing, Bioacoustics, and Biomechanics
dB	Decibel
dBA or dB(A)	A-Weighted Decibel
DLR	German Aerospace Center (*Deutsches Zentrum für Luft- und Raumfahrt e.V.*)
DNL	Day-Night Average Sound Level
DNWG	Defense Noise Working Group
DoD	Department of Defense
EU	European Union
FAA	(U.S.) Federal Aviation Administration
FICAN	Federal Interagency Committee on Aviation Noise
FICON	Federal Interagency Committee on Noise
HYENA	Hypertension and Exposure to Noise near Airports
Hz	Hertz
IHD	Ischemic heart disease
IRR	Incidence Rate Ratio
ISO	International Organization for Standardization
L	Sound Level
LAX	Los Angeles International Airport
L_{ct}	Community Tolerance Level
L_{dn}	Day-Night Average Sound Level
L_{dnmr}	Onset-Rate Adjusted Monthly Day-Night Average Sound Level
L_{eq}	Equivalent Sound Level
$L_{eq(24)}$	Equivalent Sound Level over 24 hours
$L_{eq(30min)}$	Equivalent Sound Level over 30 minutes
$L_{eq(8)}$	Equivalent Sound Level over 8 hours
$L_{eq(h)}$	Hourly Equivalent Sound Level
L_{max}	Maximum Sound Level
L_{pk}	Peak Sound Pressure Level
mmHg	millimeters of mercury
NA	Number of Events Above
NAL	Number of Events Above a Threshold Level
NDI	Noise Depreciation Index
NIPTS	Noise-induced Permanent Threshold Shift
NORAH	Noise-Related Annoyance, Cognition, and

Acronym	Definition
	Health
OSHA	United States Occupational Safety and Health Administration
PHL	Potential Hearing Loss
PTS	Permanent Threshold Shift
RANCH	Road Traffic and Aircraft Noise Exposure and Children’s Cognition and Health
SEL	Sound Exposure Level
SIL	Speech Interference Level
SUA	Special Use Airspace
TA	Time Above
TTS	Temporary Threshold Shift
U.S.	United States
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
WHO	World Health Organization

1 Discussion of Noise and its Effects on the Environment

This appendix discusses sound and noise, and the potential effects of noise, particularly aircraft noise, on the human and natural environment. Section 1.1 provides an overview of the basics of sound and noise. Section 1.2 defines and describes the various metrics used to describe noise. Section 1.3 reviews the potential effects of aircraft noise, focusing on effects on humans but also addressing effects on property values, terrain, structures, and animals.

1.1 Basics of Sound

Section 1.1 describes sound waves and decibels, and Section 1.2 describes sound levels and types of sounds.

1.1.1 Sound Waves and Decibels

Sound consists of minute vibrations that travel through the air and are sensed by the human ear. Figure 1 depicts how sound waves emanate from a tuning fork. As shown, the waves move outward as a series of crests, in which the air is compressed, and troughs, in which the air is expanded. The height of the crests and the depth of the troughs determine the *amplitude* of the wave. The sound *pressure* determines the sound wave's energy, or intensity. The number of crests or troughs that pass a given point each second is called the *frequency* of the sound wave.

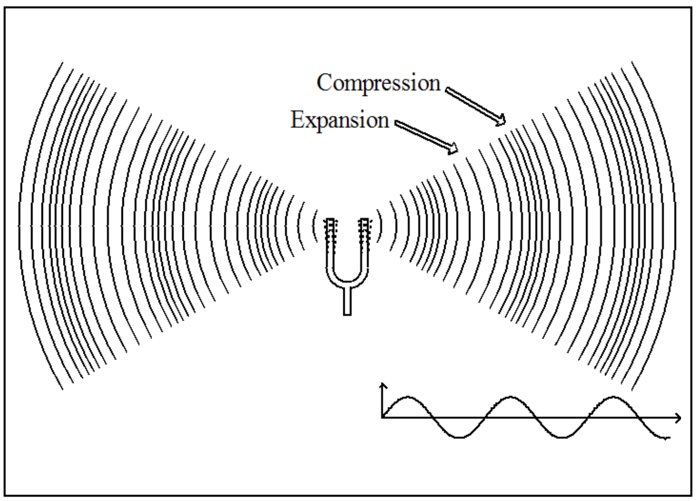


Figure 1 Sound Waves from a Vibrating Tuning Fork

The measurement and human perception of sound involves three basic physical characteristics: intensity, frequency, and duration.

- *Intensity* is a measure of the acoustic energy of a sound and is related to sound pressure. The greater the sound pressure, the more energy is carried by the sound and the louder the perception of that sound will be.
- *Frequency* determines how the pitch of a sound is perceived. Low-frequency sounds are characterized as rumbles or roars, while high-frequency sounds are often described as sounding like sirens or screeches.

- *Duration* is the length of time a sound can be detected.

The loudest sounds that can be comfortably heard by the human ear have intensities a trillion times higher than those of sounds barely heard. Because of this vast range, it is unwieldy to use a linear scale to represent the intensity of sound. As a result, a logarithmic unit known as the decibel (dB) is used to represent the intensity of a sound. Such a representation is called a sound level and is abbreviated as L. A sound level of 0 dB is approximately the threshold of human hearing and is barely audible under extremely quiet listening conditions. Normal speech has a sound level of approximately 60 dB. Sound levels above 120 dB would be uncomfortable for the average person, and levels of 130 to 140 dB would start to be felt as pain (Berglund and Lindvall, 1995). It is important to realize some people will be more sensitive to sound and some less sensitive; therefore, the level at which sound becomes uncomfortable or painful will vary across the population.

As shown in Figure 1, the sound from a tuning fork spreads out uniformly as it travels from its source. This spreading causes the sound's intensity to decrease with distance from the source. For a point source of a sound, such as an air conditioning unit, the sound level will decrease by about 6 dB for every doubling of its distance from a receptor. For a busy highway, which creates a linear distribution of noise sources, the sound level will decrease by 3 to 4.5 dB for every doubling of distance.

As sound travels from its source, it is also absorbed by the air. The amount of absorption depends on the frequency composition of the sound and the temperature and humidity of the air. Sound with high-frequency content, such as a human voice, gets absorbed by the air more readily than sound with low-frequency content, such as a military jet. More sound is absorbed in colder and drier air than in hot and wet air. Sound is also affected by wind and temperature gradients, terrain (elevation and ground cover), and structures.

Because of the logarithmic nature of the dB unit, sound levels cannot simply be added or subtracted and are somewhat cumbersome to handle mathematically. However, some simple rules are useful in understanding sound levels.

First, if a sound's intensity is doubled, the sound level increases by 3 dB, regardless of the initial sound level. For example:

$$60 \text{ dB} + 60 \text{ dB} = 63 \text{ dB, and}$$

$$80 \text{ dB} + 80 \text{ dB} = 83 \text{ dB.}$$

Second, the total sound level produced by two sounds of different levels is usually only slightly greater than the higher of the two. For example:

$$60.0 \text{ dB} + 70.0 \text{ dB} = 70.4 \text{ dB.}$$

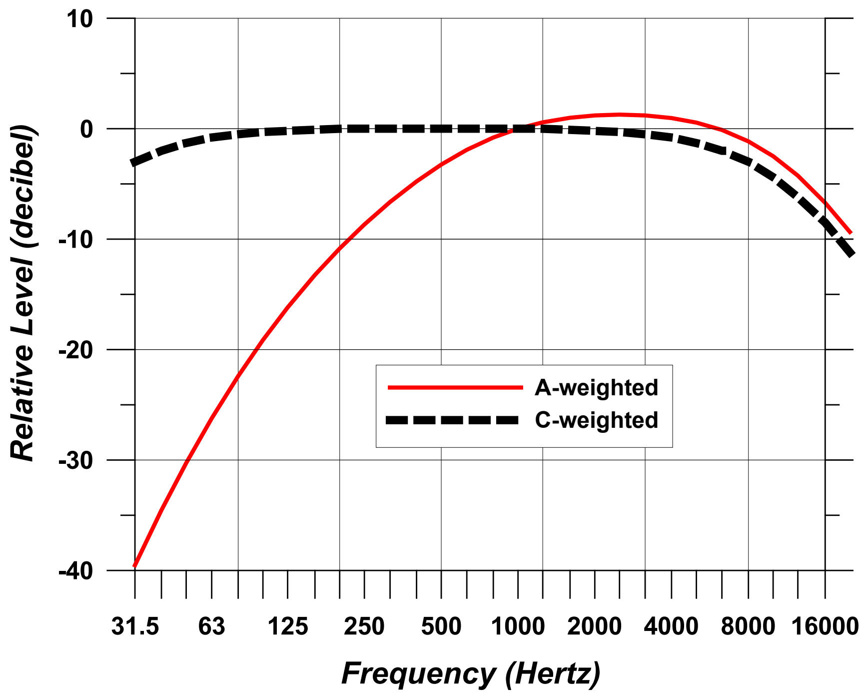
Because the addition of sounds of differing levels is different than that of simply adding numbers, this process is often referred to as "decibel addition."

The minimum change in the sound level of individual events that an average human ear can detect is about 3 dB. On average, a person perceives a change in sound level of about 10 dB as a doubling (or halving) of that sound's loudness. This relation holds true for both loud and quiet sounds. A decrease in sound level of 10 dB actually represents a 90-percent decrease in sound intensity but only a 50-percent decrease in perceived loudness because the human ear does not respond to sound linearly. Intensity of a sound is the physical measure of the stimulus, and loudness of a sound is the perceptual measure of a listener's response to it.

Sound frequency is measured in terms of cycles per second, or hertz (Hz). The normal ear of a young person can detect sounds that range in frequency from about 20 Hz to 20,000 Hz. Not all sounds in this wide range of frequencies are heard equally. Human hearing is most sensitive to frequencies in the 1,000 to 4,000 Hz range, and as we get older, we lose the ability to hear high-frequency sounds. The notes on a piano range in frequency from just over 27 Hz to 4,186 Hz, with middle C equal to 261.6 Hz. Most sounds (including a single note on a piano) are not simply pure tones like those produced by the tuning fork in Figure 1 but instead contain a mix, or spectrum, of many frequencies.

Sounds with different frequency spectra are perceived differently even if the sound levels are the same. Weighting curves have been developed to correspond to the sensitivity and perception of different frequencies of sound. A-weighting and C-weighting are the two most common frequency weightings.

These two curves, shown in Figure 2, are adequate to quantify most environmental sounds. A- weighting puts emphasis on the 1,000 to 4,000 Hz frequency range.



Source: ANSI S1.4A -1985 "Specification of Sound Level Meters".

Figure 2 Frequency Characteristics of A- and C-Weighting

Very loud or impulsive sounds, such as explosions or sonic booms, can sometimes be felt and can cause secondary effects, such as shaking of a structure or rattling of windows. These types of sounds can add to annoyance and are best measured by C-weighted sound levels, denoted dBC. C-weighting is nearly flat throughout the audible frequency range and includes low frequencies that may not be heard but cause shaking or rattling. C-weighting approximates the human ear's sensitivity to higher intensity sounds. For example, using the A-weighted curve, a 125 Hz tone at moderate sound levels (around 50 dB) is perceived to be about 17 dB lower than a 1,000 Hz tone. However, using the C-weighted curve, if the sound level is increased to 100 dB, the two tones are perceived to be the same level.

1.1.2 Sound Levels and Types of Sounds

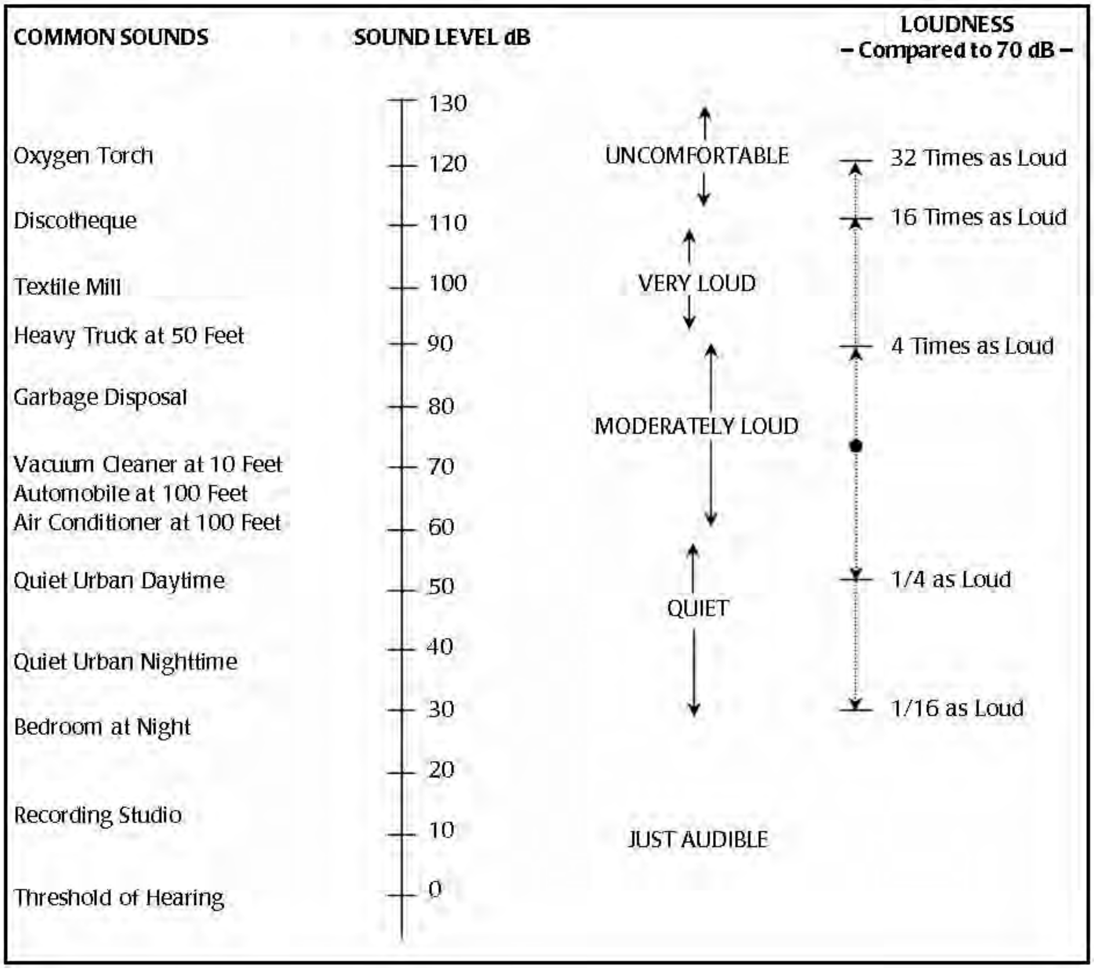
Most environmental sounds are measured and described as A-weighted sound levels, and they may be labeled as dBA or dB(A) rather than dB. When the use of A-weighting is understood, the term "A-weighted" is often omitted, and the unit dB is used. Unless otherwise stated, dB units refer to A-weighted sound levels.

Sound becomes noise when it is unwelcome and interferes with normal activities, such as sleep or conversation. Noise is unwanted sound and can become an issue when its level exceeds the ambient or background sound level. Ambient sound levels in urban areas typically vary from 60 to 70 dB but can be as high as 80 dB in the center of a large city. Quiet suburban neighborhoods experience ambient sound levels around 45 to 50 dB (U.S. Environmental Protection Agency [USEPA], 1978).

Figure 3 is a chart of dBA sound levels emitted from common sources. For some sources depicted on the figure, such as the air conditioner and vacuum cleaner, the sound levels shown are continuous sounds, and these sound levels are constant for some time. For other sources depicted on the figure, such as the automobile and heavy truck, the sound levels shown are the maximum sound level emitted during an intermittent event such as a vehicle pass-by. Some sound levels shown, for sources such as "urban daytime" and "urban nighttime," are average sound levels over extended periods. A variety of noise metrics have been developed to describe noise over different time periods. These are discussed in detail in Section 1.2.

Aircraft noise consists of two major types of sound events: flight (including takeoffs, landings, and flyovers) and stationary, such as engine maintenance run-ups. The former is intermittent and the latter primarily continuous. Noise from aircraft overflights typically occurs beneath main approach and departure paths at an airfield, in local air traffic patterns around the airfield, and in areas near aircraft parking ramps and staging areas. As aircraft climb, the noise received on the ground drops to lower levels, eventually fading into the background or ambient levels.

Impulsive noises are generally short, loud events, with a single-event duration that is usually less than 1 second. Examples of impulsive noises are small-arms gunfire, hammering, pile driving, metal impacts during rail-yard shunting operations, and riveting. Examples of high-energy impulsive sounds are explosions associated with quarrying or mining operations; sonic booms; demolition explosions; and industrial processes that use high explosives; military ordnance use (e.g., armor, artillery, and mortar fire, and bomb detonation); explosive ignition of rockets and missiles; and any other explosive source where the equivalent mass of dynamite exceeds 25 grams (ANSI [American National Standards Institute], 1996).



Source: Harris 1979.

Figure 3 Typical A-weighted Sound Levels of Common Sounds

1.1.3 Low-Frequency Noise

Normally, the components of a structure most sensitive to airborne noise are the windows and, infrequently, the plastered walls and ceilings. An evaluation of the sound pressures impinging on the structure may be used to assess the risk for damage. In general, sound pressure levels below 130 dB (unweighted) are unlikely to pose a risk to structures. While certain frequencies (such as 30 Hz for window breakage) may be of more concern than other frequencies, conservatively, only sounds lasting more than one second and at a sound pressure level above 130 dB (unweighted) are potentially damaging to structural components (CHABA [Committee on Hearing, Bioacoustics, and Biomechanics] 1977).

Noise-induced structural vibration may result from aircraft operating at low altitudes, which would occur during takeoff and landing operations. Such vibrations are likely to cause annoyance to dwelling occupants because of induced secondary vibrations or rattling of objects within the dwelling such as hanging pictures, dishes, plaques, and bric-a-brac. Windowpanes may also vibrate noticeably when exposed to high levels of airborne noise. In general, such noise-induced vibrations occur at sound pressure levels of 110 dB (unweighted) or greater.

Aside from concerns about potential structural damage from low-frequency noise, the perception of low-frequency sound may differ considerably when compared with mid- or high-frequency sound.

Laboratory measurements of annoyance from low-frequency noise each use different spectra and levels, making comparisons difficult, but the majority share the same conclusion that annoyance caused by

low-frequency sound increases rapidly with level and that dBA sound level alone can underestimate the effects of low-frequency noises (Leventhall, 2004). The most recent update to the International Organization for Standardization (ISO) standard (ISO 1996:1 [2016]) describes the main causes for these differences as:

- a weakening of pitch sensation as the frequency of the sound decreases below 60 Hz
- a perception of sounds as pulsations and fluctuations
- a much more rapid increase in loudness and annoyance with increasing sound pressure levels at low frequencies than at middle or high frequencies
- complaints about feelings of ear pressure
- an annoyance caused by secondary effects such as rattling of buildings elements, windows, and doors, or the tinkling of bric-a-brac
- less building sound-transmission loss at low frequencies than at middle or high frequencies.

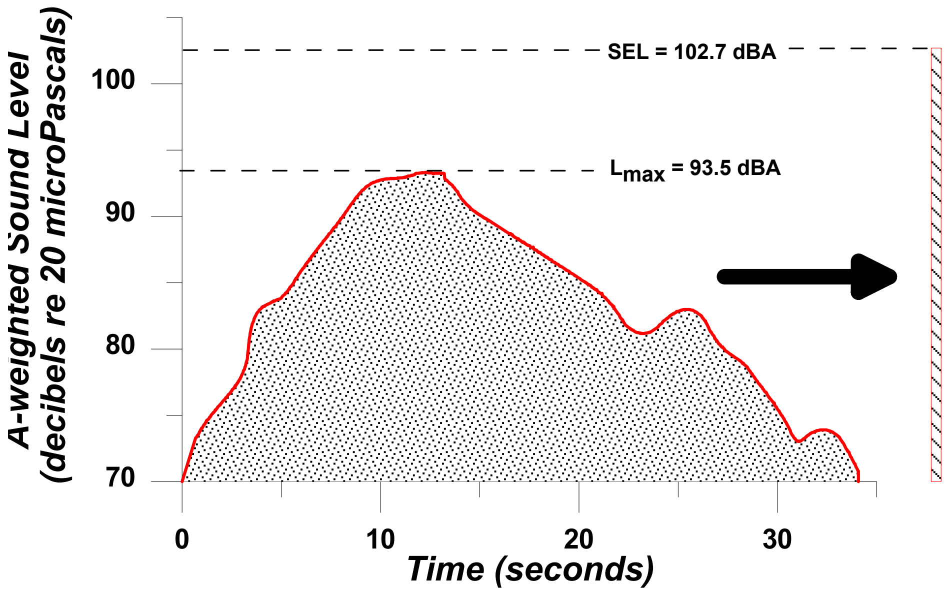
While the Federal Interagency Committee of Noise (FICON) recommends the use of the dBA Day-Night Average Sound Level (DNL) metric as the primary basis of both commercial and military aircraft noise impacts (FICON, 1992), in a recent update to a research needs statement, the Federal Interagency Committee on Aviation Noise (FICAN) stated the following for low-frequency noise concerns:

> FICAN finds that additional research needs to be conducted before a [low-frequency noise] metric and an associated dose-response relationship can be recommended. For airports with low-frequency noise concerns, supplemental noise analysis--possibly including vibration measurements--should be considered (FICAN, 2018).

1.2 Noise Metrics

Noise metrics quantify sounds so they can be compared with each other, and with their effects, in a standard way. The simplest metric is the overall dBA sound level, which is appropriate by itself for quantifying constant noise such as that generated by an air conditioner. However, unlike noise from an air conditioning unit, aircraft flyover noise varies with time. During an aircraft overflight, noise starts at the background level, rises to a maximum level as the aircraft flies close to the receptor, and then returns to the background as the aircraft recedes into the distance. An example graph of the resulting sound levels from a flyover is provided in Figure 4, which also indicates two metrics (Maximum Sound Level [L_{max}] and Sound Exposure Level [SEL]), that are described in Section 1.2.1 below.

A number of metrics can be used to describe a range of situations--from the effect of a particular individual noise event to the cumulative effect of all noise events over a long time. This section describes the metrics relevant to environmental noise analysis of aircraft operations.



Source: Wyle Laboratories

Figure 4 Example Time History of Aircraft Noise Flyover

1.2.1 Maximum Sound Level (L_{max})

The highest dBA sound level measured during a single event in which the sound changes with time, such as a flyover, is called the maximum dBA sound level, or Maximum Sound Level, and is abbreviated L_{max}. The L_{max} is depicted for a sample event in Figure 4.

L_{max} is the maximum sound level that occurs over a fraction of a second. For aircraft noise, this "fraction of a second" is one-eighth of a second, denoted as "fast" response on a sound-level measurement meter (ANSI, 1988). Slowly varying or steady sounds are generally measured over 1 second and denoted as "slow" response. L_{max} is important in determining whether a noise event will interfere with conversation, television or radio listening, or other common activities. Although L_{max} provides some measure of a given sound event, it does not fully describe the noise because it does not account for how long the sound is heard.

1.2.2 Peak Sound Pressure Level

The Peak Sound Pressure Level (L_{pk}) is the highest instantaneous level measured by a sound-level measurement meter. L_{pk} is typically measured every 20 microseconds, and it is usually based on unweighted or linear response of the meter. L_{pk} is used to describe individual impulsive events, such as blast noise. Because blast noise varies from explosion to explosion and with meteorological (weather) conditions, the United States (U.S.) Department of Defense (DoD) usually characterizes L_{pk} by the metric PK 15(met), which is the L_{pk} that is exceeded 15 percent of the time. The "met" notation refers to the metric accounting for varied meteorological or weather conditions.

1.2.3 Sound Exposure Level

SEL combines both the intensity of a sound and its duration. For an aircraft flyover, SEL includes the maximum and all lower noise levels produced as part of the overflight, together with how long each part lasts. SEL represents the total sound energy in the event. Figure 4 indicates the SEL for a sample flyover event, representing it as if all the sound energy were contained within 1 second.

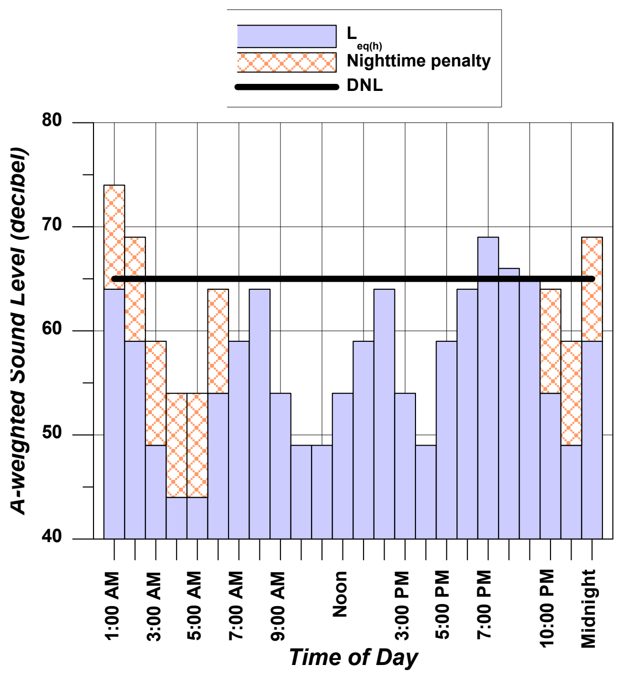
Because aircraft noise events last more than a few seconds, the SEL value is larger than L_{max}. SEL does not directly represent the sound level heard at any given time during the event but rather during the entire event. SEL provides a much better measure of aircraft flyover noise exposure than L_{max} alone.

1.2.4 Cumulative Events Equivalent Sound Level

Equivalent Sound Level (L_{eq}) is a "cumulative" metric that combines a series of noise events, such as aircraft operations, over a period of time. L_{eq} is the sound level that represents the dB average SEL of all sounds in a specific time period. Just as SEL has proven to be a good measure of a single event, L_{eq} has proven to be a good measure of a series of events during a given time period.

The time period of an L_{eq} measurement is usually related to some activity and is given along with the value. The time period is often shown in parenthesis (e.g., $L_{eq(24)}$, or the equivalent sound level for 24 hours). The L_{eq} from 7:00 A.M. to 3:00 P.M. may give exposure of noise for a school day and would be represented as $L_{eq(8)}$, or the equivalent sound level for 8 hours.

Figure 5 provides an example of $L_{eq(24)}$ using notional hourly equivalent sound levels ($L_{eq(h)}$) for each hour of the day as an example. The $L_{eq(24)}$ for this example is 61 dB.



Source: Wyle Laboratories.

Figure 5 Example of $L_{eq(24)}$, DNL and Computed from Hourly Equivalent Sound Levels

1.2.5 Day-Night Average Sound Level and Community Noise Equivalent Level

DNL, or L_{dn}, is a cumulative metric that accounts for all noise events, such as aircraft operations, in a 24-hour period. However, unlike $L_{eq(24)}$, DNL contains a nighttime noise adjustment. To account for humans' increased sensitivity to noise at night, DNL applies a 10 dB adjustment to noise events that occur during the nighttime period, defined as 10:00 P.M. to 7:00 A.M. The notations DNL and L_{dn} are both used for Day-Night Average Sound Level and are equivalent.

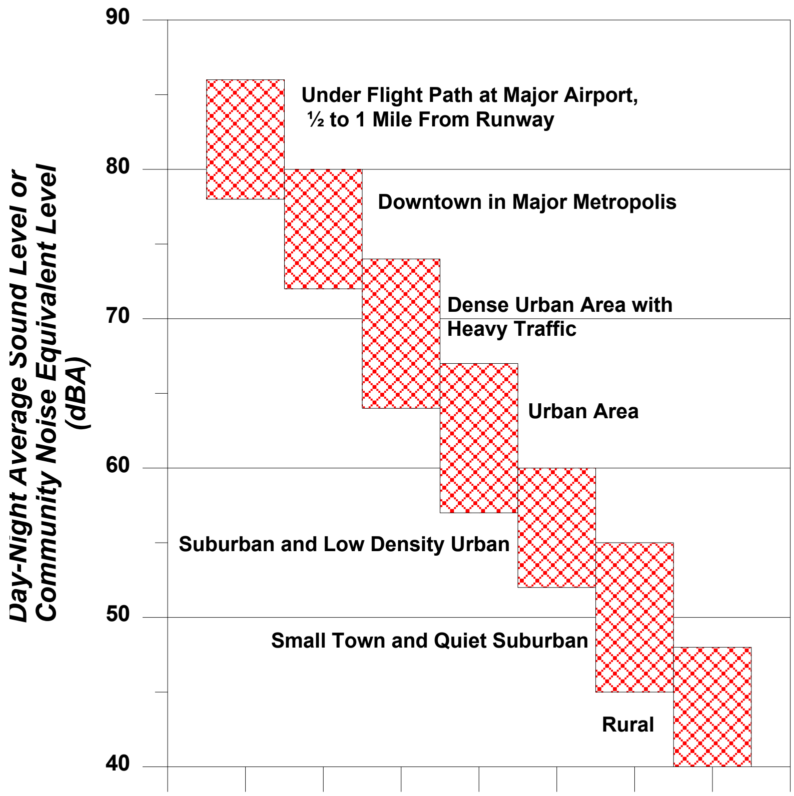
For airports and military airfields, DNL represents the average sound level for an average annual day. Figure 5 provides an example of DNL using notional $L_{eq(h)}$ for each hour of the day. Note the $L_{eq(h)}$ for the hours between 10:00 P.M. and 7:00 A.M. have a 10 dB adjustment assigned. The DNL for this example is 65 dB.

The dB summation nature of these metrics causes the noise levels of the loudest events to control the 24-hour average. As a simple example, consider a case in which only one aircraft overflight occurs during the daytime over a 24-hour period, creating a sound level of 100 dB for 30 seconds. During the remaining 23 hours, 59 minutes, and 30 seconds of that day, the ambient sound level is 50 dB. The DNL for this 24-hour period is 65.9 dB. Assume, as a second example, that 10 such 30-second overflights occur during daytime hours during the next 24-hour period and with the same ambient sound level of 50 dB during the remaining 23 hours and 55 minutes of the day. The DNL for this 24-hour period is 75.5 dB. Clearly, the averaging of noise over a 24-hour period does not ignore the louder single events and tends to emphasize both the sound levels and number of those events.

A feature of the DNL metric is that a given DNL value could result from a very few noisy events or a large number of quieter events. For example, a single overflight at 90 dB creates the same DNL as 10 overflights at 80 dB.

DNL does not represent a sound level heard at any given time, but they represent long-term sound exposure. Scientific studies have found good correlation between the percentages of groups of people highly annoyed by noise and their level of average noise exposure measured in DNL (Schultz, 1978; USEPA, 1978).

DNL can be used to measure sound levels in a variety of types of communities. Figure 6 shows the ranges of DNL that occur in various types of communities. For example, under a flight path at a major airport, the DNL may exceed 80 dB, while rural areas not near a major airport may experience DNL less than 45 dB. Sound levels in a downtown area of a major metropolis may be equivalent to the sound levels under a flight path of a major airport.



Source: DOD 1978.

Figure 6 Typical DNL Ranges in Various Types of Communities

1.2.6 Onset-Rate Adjusted Monthly Day-Night Average Sound Level (L_{dnmr}) and Onset-Rate Adjusted Monthly Community Noise Equivalent Level

Military aircraft utilizing Special Use Airspace (SUA), such as Military Training Routes, Military Operations Areas, and Restricted Areas/Ranges, generate a noise environment that is somewhat different from that generated around airfields. Rather than regularly occurring operations such as those conducted at airfields, activity in SUAs is highly sporadic. SUA activity is often seasonal, ranging from 10 operations per hour to less than one per week. Individual military overflight events also differ from typical community noise events in that noise from a low-altitude, high-airspeed flyover can have a rather sudden onset, with rates of up to 150 dB per second.

The cumulative daily noise metric devised to account for the "surprise" effect of the sudden onset of aircraft noise events on humans and the sporadic nature of SUA activity is L_{dnmr}. Onset rates between 15 and 150 dB per second require an adjustment of 0 to 11 dB to the event's SEL, while onset rates below 15 dB per second require no adjustment to the event's SEL (Stusnick et al., 1992). The term "monthly" in

L_{dnmr} refers to the noise assessment being conducted for the month with the most operations or sorties--the so-called “busiest month.”

1.2.7 Supplemental Metrics

1.2.7.1 Number of Events Above a Threshold Level

The Number of Events Above (NA) metric gives the total number of events that exceed a noise threshold level (L) during a specified period of time. Combined with the selected threshold, the metric is denoted NAL. The threshold can be either SEL or L_{max}, and it is important that this selection is shown in the nomenclature. When labeling a contour line or point of interest, NAL is followed by the number of events in parentheses. For example, where 10 events exceed an SEL of 90 dB over a given period of time, the nomenclature would be NA90SEL(10). Similarly, for L_{max} it would be NA90L_{max}(10). The period of time can be an average 24-hour day, daytime, nighttime, school day, or any other time period appropriate to the nature and application of the analysis.

NA is a supplemental metric. It is not supported by the amount of science behind DNL, but it is valuable in helping to describe the number of noise events the community may hear. A threshold level and metric are selected that best meet the need for each situation. An L_{max} threshold is normally selected to analyze speech interference, while an SEL threshold is normally selected for analysis of sleep disturbance.

The NA metric is the only supplemental metric that combines single-event noise levels with the number of aircraft operations. In essence, it answers the question of how many aircraft (or range of aircraft) flyover events will occur on average at a given location or area at or above a selected threshold noise level.

1.2.7.2 Time Above a Specified Level

The Time Above (TA) metric is the total time, in minutes, that the dBA noise level is at or above a threshold. Combined with the threshold L, it is denoted TAL. TA can be calculated over a full 24-hour average annual day, the 15-hour daytime and 9-hour nighttime periods, a school day, or any other time period of interest, provided there are operational data for that time.

TA is a supplemental metric, used to help understand noise exposure. It is useful for describing the noise environment in schools, particularly when assessing classroom or other noise-sensitive areas for various scenarios.

TA helps describe the noise exposure of an individual event or many events occurring over a given time period. When computed for a full day, the TA can be compared alongside the DNL in order to determine the sound levels and total duration of events that contribute to the DNL. TA analysis is usually conducted along with NA analysis, so the results show not only how many events occur but also the total duration of those events above the threshold.

1.3 Noise Effects

Noise is of concern because of potential adverse effects. The following subsections describe how noise can affect communities and the environment, and how those effects are quantified. The specific topics discussed are:

- annoyance

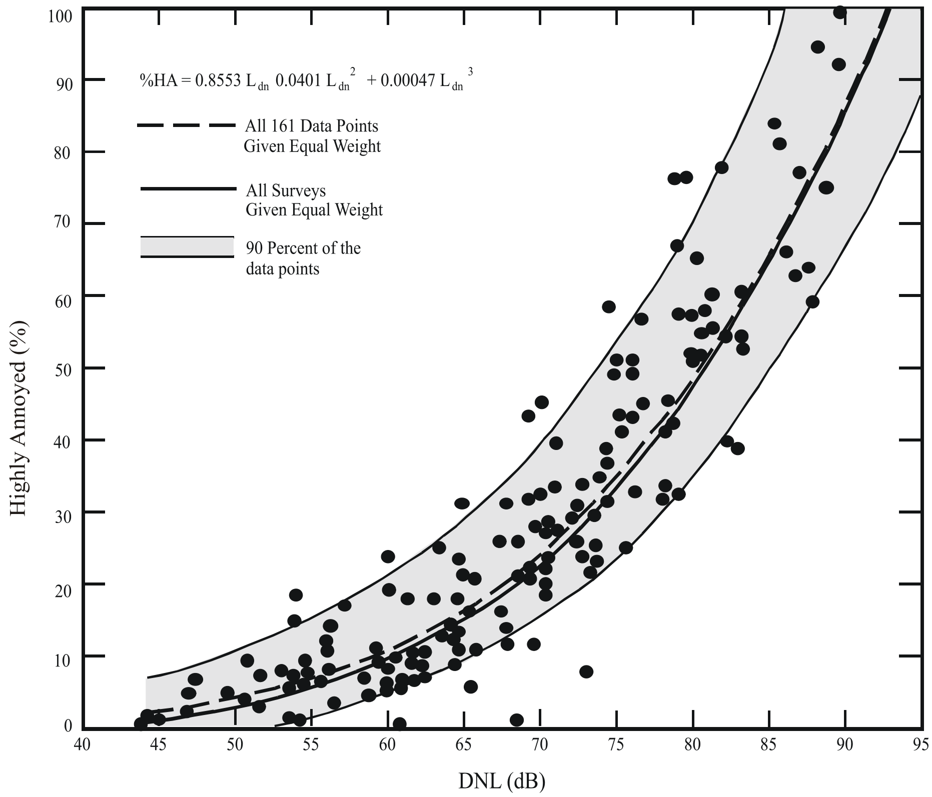
- speech interference
- sleep disturbance
- noise-induced hearing impairment
- non-auditory health effects
- performance effects
- noise effects on children
- property values
- noise-induced vibration effects on structures and humans
- noise effects on terrain
- noise effects on historical and archaeological sites
- noise effects on domestic animals and wildlife

1.3.1 Annoyance

With the introduction of jet aircraft in the 1950s, it became clear that aircraft noise annoyed people and was a significant problem around airports. Early studies, such as those of Rosenblith et al. (1953) and Stevens et al. (1953), showed that effects depended on the quality of the sound, its level, and the number of flights. Over the next 20 years, considerable research was performed refining this understanding and setting guidelines for noise exposure. In the early 1970s, the USEPA published its "Levels Document" (USEPA, 1974), which reviewed the noise factors that affected communities. DNL (or L_{dn}) was identified as an appropriate noise metric, and threshold criteria were recommended.

Threshold criteria for annoyance were identified from social surveys, in which people exposed to noise were asked how noise affected them. Surveys provide direct real-world data on how noise affects actual residents.

Surveys in the early years had a range of designs and formats, and they needed some interpretation to find common ground. In 1978, Schultz showed that the common ground was the number of people "highly annoyed," defined as the upper 28-percent range of whatever response scale a survey used (Schultz, 1978). With that definition, Schultz was able to show a remarkable consistency among the majority of the surveys for which data were available. Figure 7 shows the result of his study relating DNL to individual annoyance as measured by percent highly annoyed.



Source: Schultz 1978.

Figure 7 Schultz Curve Relating Noise Annoyance to DNL

Schultz's original synthesis included 161 data points. Figure 8 compares revised fits of the Schultz data set with an expanded set of 400 data points collected through 1989 (Finegold et al., 1994). The new form of the curve is the preferred form in the U.S., endorsed by FICAN (1997). Other forms have been proposed, such as that of Fidell and Silvati (2004), but these have not gained widespread acceptance.

When the goodness of fit of the Schultz curve is examined, the correlation between groups of people is high, in the range of 85 to 90 percent. However, the correlation between individuals is much lower, at 50 percent or less. This finding is not surprising, given the personal differences between individuals, with some people more sensitive to noise than others. The surveys underlying the Schultz curve include results that show that annoyance from noise is also affected by non-acoustical factors. The influence of non-acoustical factors is a complex interaction influencing an individual's annoyance response to noise (Brisbane Airport Corporation, 2007). Newman and Beattie (1985) divided the non-acoustic factors into the emotional and physical variables shown in Table 1.

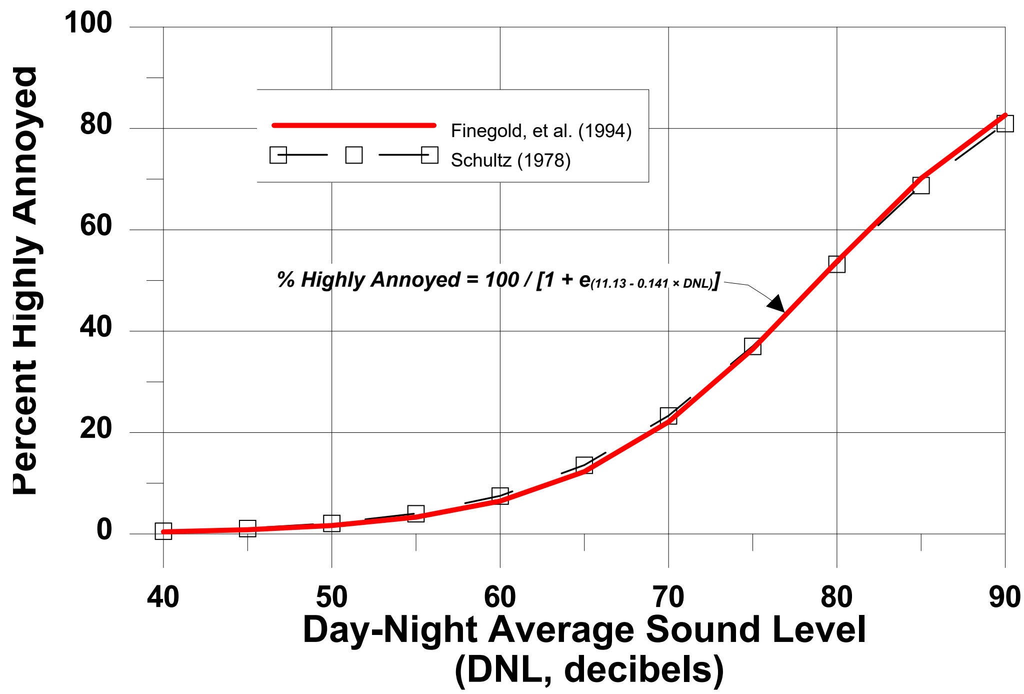


Figure 8 Response of Communities to Noise: A Comparison of Original Schultz (1978) Curve to Finegold et al (1994) Curve

Table 1 Non-Acoustic Variables Influencing Aircraft Noise Annoyance

Emotional Variables	*Physical Variables*
Feeling about the necessity or preventability of the noise	Type of neighborhood
Judgement of the importance and value of the activity that is producing the noise	Time of day
Activity at the time an individual hears the noise	Season
Attitude about the environment	Predictability of the noise
General sensitivity to noise	Control over the noise source
Belief about the effect of noise on one's health	Length of time an individual is exposed to a noise
Feeling of fear associated with the noise	

Schreckenberg and Schuemer (2010) and Laszlo et al. (2012) examined the importance of some of these factors on short-term annoyance. Attitudinal factors were identified as having an effect on annoyance. In formal regression analysis, however, L_{eq} was found to be more important than attitude. Similarly, a series of studies conducted by Marki (2013) at three European airports showed that less than 20 percent of the variance in annoyance can be explained by noise alone (Marki, 2013). Miedema and Voss (1998) found that fear and noise sensitivity have a significant influence on an individual annoyance response.

Moreover, in another study, they demonstrated that noise sensitivity is not a function of noise exposure and that noise-sensitive individuals have a steeper annoyance response to increasing noise levels compared to people who are not noise sensitive (Miedema and Vos, 2003).

A study by Plotkin et al. (2011) examined updating DNL to account for these non-acoustic variables. Plotkin et al. (2011) concluded that the data requirements for a general analysis were much greater than are available from most existing studies. It was noted that the most significant issue with DNL is that the metric is not readily understood by the public and that supplemental metrics such as TA and NA were valuable in addressing attitude when communicating noise analysis to communities (DoD, 2009a).

A factor that is partially non-acoustical is the source of the noise. Miedema and Vos (1998) presented synthesis curves for the relationship between DNL and percentage "annoyed" and percentage "highly annoyed" for three transportation-noise sources. Different curves were found for aircraft, road traffic, and railway noise. Table 2 summarizes their results. Comparing the updated Schultz curve to these results suggests that the percentage of people highly annoyed by aircraft noise may be higher than previously thought. Authors Miedema and Oudshoorn (2001) supplemented that investigation with further derivation of percentage of population highly annoyed as a function of either DNL or DENL[1], along with the corresponding 95-percent confidence intervals, and obtained similar results.

Table 2 Percent Highly Annoyed by Different Transportation-Noise Sources

DNL (dB)	***Air***	***Road***	***Rail***	***Schultz Combined***
55	12	7	4	3
60	19	12	7	6
65	28	18	11	12
70	37	29	16	22
75	48	40	22	36

Source: Miedema and Vos, 1998.

As noted by the World Health Organization (WHO), however, even though aircraft noise seems to produce a stronger annoyance response than road traffic noise, caution should be exercised when interpreting synthesized data from different studies (WHO, 1999).

Consistent with the WHO's recommendations, FICON considered the Schultz curve to be the best source of dose information to predict community response to noise but recommended further research to investigate the differences in perception of noise from different sources (FICON, 1992).

The ISO update (ISO 1996-1 [2016]) introduced the concept of Community Tolerance Level (L_{ct}) as the DNL at which 50 percent of the people in a particular community are predicted to be highly annoyed by noise exposure. L_{ct} accounts for differences between sources and/or communities when predicting the percentage highly annoyed by noise exposure. ISO also recommended a change to the adjustment range used when comparing aircraft noise to road traffic noise. The previous edition suggested a +3 dB to +6 dB adjustment range for aircraft noise relative to road traffic noise, while the latest edition recommends

[1] DENL is the Day-Evening-Night Average Sound Level, which is similar to DNL except it has a 5.0 dB adjustment to the evening period. DENL is not used in the U.S.

an adjustment range of +5 dB to +8 dB. This adjustment range allows DNL to be correlated to consistent annoyance rates when originating from different noise sources (i.e., road traffic, aircraft, or railroad).

This change to the adjustment range would increase the calculated percent highly annoyed at 65 dB DNL by approximately 2 percent to 5 percent greater than the previous ISO definition. Figure 9 depicts the estimated percentage of people highly annoyed for a given DNL using both the ISO 1996-1 and FICON 1992 estimation methods. DENL is the Day-Evening-Night Average Sound Level, which is similar to DNL except DENL has a 5.0 dB adjustment to the evening period. DENL is not used in the U.S. and the older FICON 1992 method. The results suggest that the percentage of people highly annoyed may be greater for aircraft noise than previously thought.

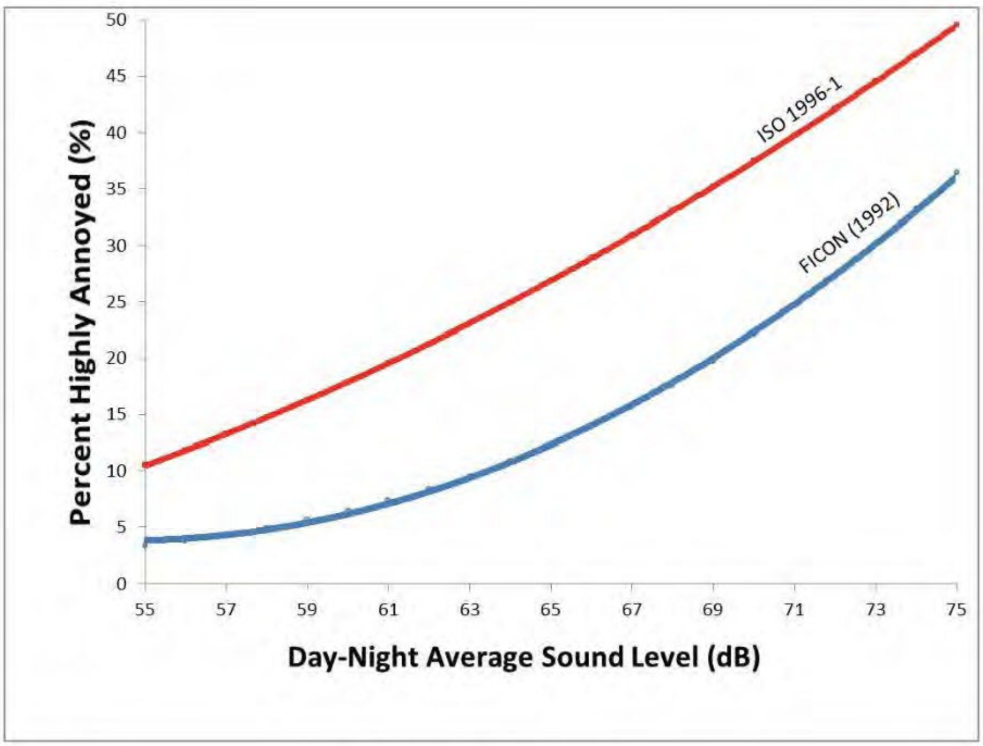


Figure 9 Percent Highly Annoyed: A Comparison of ISO 1996-1 to FICON 1992

In the 2008 Hypertension and Exposure to Noise near Airports (HYENA) study, annoyance levels due to aircraft noise and road traffic noise were assessed in subjects who lived in the vicinity of six major European airports using the 11-point International Commission on Biological Effects of Noise scale.

Exposure-response curves for road noise were congruent with the European Union (EU) standard curves used for predicting the number of highly noise-annoyed subjects, but ratings of annoyance due to aircraft noise were higher than predicted. The study supports findings that people's attitude toward aircraft noise has changed over the years and that the EU standard curve for aircraft noise should be modified (Babisch et al., 2009).

The U.S. Federal Aviation Administration (FAA) is currently conducting a major airport community noise survey at approximately 20 U.S. airports in order to update the relationship between aircraft noise and annoyance (Miller et al., 2014). Results from this study are expected to be released in late 2018.

In a study related to assessing aircraft noise exposure for people in the surrounding community, the Brisbane Airport in Queensland, Australia, assembled a Health Impact Assessment (Volume D7), which discussed, among other noise effects, annoyance and human response to changes in noise exposure versus steady-state response (Section 7.9 of the report) (Brisbane Airport Corporation, 2007). The authors suggest there is a difference between the gradual increase in noise exposure and the additive property of increasing noise levels from a particular event. The latter is called a "step change." The Brisbane Health Impact Assessment references Brown and Kamp (2005), who have reviewed the literature available on human response to such changes. They observe:

> "Most information on the relationship between transport noise exposure and subjective reaction (annoyance/dissatisfaction) comes from steady state surveys at sites where there have not been step changes in noise exposure. Environmental appraisals often need to assess the effects of such step changes in exposure and there is growing evidence that when noise exposure is changed, annoyance-ratings may change more than would be predicted from steady state relationships.
>
> "Conventional wisdom is that human response to a step change in exposure to transport noise can be predicted from exposure-response curves that have been derived from studies where human response has been assessed over a range of steady-state noise conditions. However, in situations where a step change in transport noise exposure has occurred, various surveys suggest that human response may be different, usually greater, as a result of the increase/decrease in noise, to what would be predicted from exposure-response curves derived under steady-state conditions. Further, there are suggestions that such (over)reaction may be more than a short-term effect. (Brown and Kamp, 2005)."

Guski (2004) describes this change effect in a hypothetical model and also notes that where the noise situation is permanently changed, the annoyance of residents usually changes in a way that cannot be predicted by steady-state dose/response relationships. Most studies show an "over reaction" of the residents: with increasing noise levels, people are much more annoyed than would be predicted by steady-state curves, and, with a decrease of noise levels, people are much less annoyed. Guski also notes that the annoyance may change prematurely before the change of levels, with residents expecting an increase in noise levels reacting more annoyed, and residents expecting a decrease in noise levels less annoyed than would be predicted in the steady-state condition. Brown and Kamp (2005) conclude:

> "Our review of the literature on response to changes in noise leads us to the conclusion that we cannot discount the possibility that overreaction to a step change in transport noise may occur, and that this effect may not attenuate over time. However, evidence is still inconclusive and based on limited studies that tend not to be comparable in terms of method, size, design and context. Further, our view is that most explanations given in the literature for an overreaction are only partly supported, in some cases not at all, and generally there is conflicting evidence for them. There is still also no accepted view on the mechanism by which annoyance changes in response to a change in exposure. In particular, most explanations are usually post-hoc and the noise change studies have not been designed to test them. (Brown and Kamp, 2005)."

The Brisbane Airport Corporation Health Impact Assessment suggests that the potential for "over-reaction" to stepped changes in noise exists and needs to be recognized; people subject to an increase in noise may experience more annoyance than predicted, while people subject to a decrease in noise may experience less annoyance than predicted. Further, any such over-reaction should not necessarily be assumed to be a temporary phenomenon; evidence from existing studies suggests that it could persist for years after the exposure changes (Brisbane Airport Corporation, 2007).

An individual with an increased sensitivity to sounds may have hyperacusis, which results in a lower tolerance of everyday sound (Aazh et al., 2018). A person with hyperacusis reacts differently to sounds due to reactions of increased distress and discomfort from everyday sounds. This condition arises from a problem with the auditory processes within an afflicted individual's brain. The causes and diagnosis are not well understood (Aazh et al., 2018). Physical causes of hyperacusis may range from head injury, ear damage, or viral diseases, to temporomandibular joint disorders (TMJ). Neurologic causes may range from Post-Traumatic Stress Disorder (PTSD), chronic fatigue syndrome, depression, to migraine headaches (American Academy of Otolaryngology--Head and Neck Surgery, 2018). An individual with hyperacusis will also likely have tinnitus, which may lead to further discomfort. Hyperacusis can lead to misophonia, which may cause an individual to react with abnormally strong emotions and behaviors to specific sounds, but hyperacusis does not cause this reaction. Studies of misophonia are very limited at this time.

Another condition that falls under the condition of hyperacusis is noise sensitivity (Aazh et al., 2018). A noise-sensitive individual is characteristically more prone to being annoyed by environmental noise compared to a non-noise-sensitive person regardless of the overall noise exposure (Kishikawa et al., 2006). This result indicates that the annoyance response for noise-sensitive people is not a direct function of noise exposure levels.

1.3.2 Speech Interference

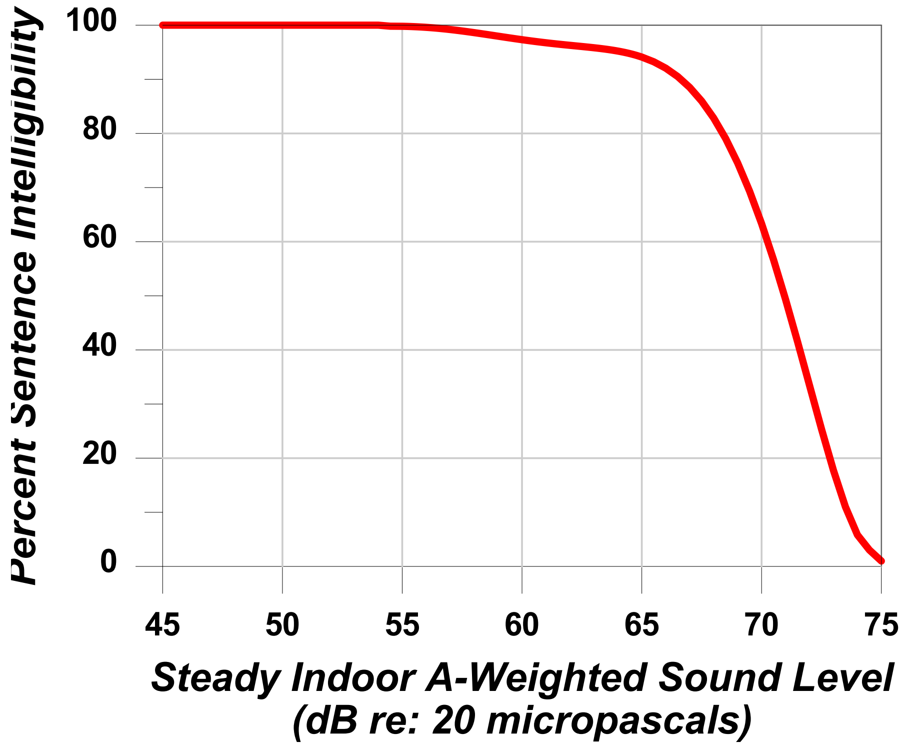
Speech interference from noise is a primary cause of annoyance for communities. Disruption of routine activities such as radio or television listening, telephone use, or conversation leads to frustration and annoyance. The quality of speech communication is also important in classrooms and offices. In the workplace, speech interference from noise can cause fatigue and vocal strain in those who attempt to talk over the noise. In schools it can impair learning.

Speech comprehension is measured in two ways:

1. *Word Intelligibility,* or the percentage of words spoken and understood. This might be especially important for students in the lower grades who are learning the English language and particularly important for students who are studying English as a Second Language.
2. *Sentence Intelligibility*, or the percentage of sentences spoken and understood. This might be especially important for high-school students and adults who are familiar with the language and who do not necessarily have to understand each word spoken in order to understand sentences.

1.3.2.1 U.S. Federal Criteria for Interior Noise

In 1974, the USEPA identified a goal of an indoor $L_{eq(24)}$ of 45 dB to minimize speech interference based on sentence intelligibility and the presence of steady noise (USEPA, 1974). Figure 10 shows the effect of steady indoor background sound levels on sentence intelligibility. For an average adult with normal hearing and fluency in the language, steady background indoor sound levels of less than 45 dB L_{eq} are expected to allow 100-percent sentence intelligibility.



Source: USEPA, 1974.

Figure 10 Speech Intelligibility Curve

The curve in Figure 10 shows 99-percent intelligibility at L_{eq} below 54 dB and less than 10 percent above 73 dB. Recalling that L_{eq} is dominated by louder noise events, the USEPA $L_{eq(24)}$ goal of 45 dB generally ensures that sentence intelligibility will be high most of the time.

1.3.2.2 Classroom Criteria

For teachers to be understood, their regular voice must be clear and uninterrupted. Background noise must be below the teacher's voice level. Intermittent noise events that momentarily drown out the teacher's voice need to be kept to a minimum. It is therefore important to evaluate the steady background noise level, the level of voice communication, and the single-event noise level from aircraft overflights that might interfere with speech.

Lazarus (1990) found that for listeners with normal hearing and fluency in the language, complete sentence intelligibility can be achieved when the signal-to-noise ratio (i.e., a comparison of the level of the sound to the level of background noise) is in the range of 15 to 18 dB. The initial American National Standards Institute (ANSI) classroom noise standard (ANSI, 2010) and American Speech-Language-Hearing Association (American Speech-Language-Hearing Association, 2005) guidelines concur, recommending at least a 15 dB signal-to-noise ratio in classrooms. If the teacher's voice level is at least 50 dB, the background noise level must not exceed an average of 35 dB. The National Research Council of Canada (Bradley, 1993) and the WHO (1999) agree with this criterion for background noise.

For eligibility for noise insulation funding, the FAA guidelines state that the design objective for a classroom environment is 45 dB L_{eq} during normal school hours (FAA, 1985).

Most aircraft noise is not continuous. Instead, it consists of individual events like the one depicted by the graph in Figure 4. Since speech interference in the presence of aircraft noise is caused by individual aircraft flyover events, a time-averaged metric alone, such as L_{eq}, is not necessarily appropriate. In addition to the background level criteria described above, single-event criteria that account for those noisy events are also needed.

A 1984 study for the Port Authority of New York and New Jersey recommended using Speech Interference Level (SIL) for classroom noise criteria (Sharp and Plotkin, 1984). SIL is based on the maximum sound levels in the frequency range that most affects speech communication (500 to 2,000 Hz). The study identified an SIL of 45 dB as the goal, a level that would provide 90-percent word intelligibility for the short time periods during aircraft overflights. While SIL is technically the best metric for measuring speech interference, it can be approximated by an L_{max} value. An SIL of 45 dB is equivalent to an L_{max} of 50 dBA for aircraft noise (Wesler, 1986).

Lind et al. (1998) also concluded that an L_{max} criterion of 50 dB would result in 90-percent word intelligibility. Bradley (1985) recommends SEL as a better indicator. His work indicates that 95-percent word intelligibility would be achieved when indoor SEL did not exceed 60 dB. For a typical single aircraft overflight, this corresponds to an L_{max} of 50 dB. While the WHO (1999) only specifies a background L_{max} criterion, the organization also notes the SIL frequencies and that interference can begin at around 50 dB.

The Airport Cooperative Research Program (ACRP) conducted a study to assess aircraft noise conditions affecting student learning by analyzing the interior and exterior sound levels while observing students and teachers at 11 schools surrounding Los Angeles International Airport (LAX). The five schools located under the LAX flight paths experienced frequent overflight events, while the six schools further south of the airport experienced minimal LAX aircraft noise exposure events. The study found a positive correlation between teacher voice-masking or voice-raising and fluctuations in interior noise events. A majority of teachers reported that they felt aircraft noise interfered with teacher-student communication and caused students to lose concentration. However, the student observations were unable to identify any aircraft-noise-related events that caused a distraction in a child. Other students caused the majority of distractions while playing with various items and daydreaming and were found to be the significant sources of distractions. The authors, as well as the teachers' opinions gathered in the teacher surveys, concluded that even moderate levels of aircraft noise exposure can impact children's learning due to the correlation between voice-masking events and measured interior sound events (National Academies of Sciences, Engineering, and Medicine, 2017).

The United Kingdom Department for Education and Skills established in its classroom acoustics guide a 30-minute time-averaged metric of $L_{eq(30min)}$ for background levels and the metric of $L_{A1,30min}$ for intermittent noises, at thresholds of 30 to 35 dB and 55 dB, respectively. $L_{A1,30min}$ represents the dBA sound level that is exceeded 1 percent of the time (in this case, during a 30-minute teaching session) and is generally equivalent to the L_{max} metric (United Kingdom Department for Education and Skills, 2003).

Table 3 summarizes the criteria discussed. Other than the FAA (1985) 45 dB L_{max} criterion, the criteria are consistent with a limit on indoor background noise of 35 to 40 dB L_{eq} and a single-event limit of 50 dB

L_{max}. It should be noted that the limits listed in Table 3 were set based on students with normal hearing capability and no special needs. At-risk students may be adversely affected at lower sound levels.

Table 3 Indoor Noise Level Criteria Based on Speech Intelligibility

Source	*Metric/Level (dB)*	*Effects and Notes*
U.S. FAA (1985)	$L_{eq(during\ school\ hours)}$ = 45 dB	Federal assistance criteria for school sound insulation; supplemental single-event criteria may be used.
Lind et al. (1998), Sharp and Plotkin (1984), Wesler (1986)	L_{max} = 50 dB / SIL 45	Single-event level permissible in the classroom.
WHO (1999)	L_{eq} = 35 dB L_{max} = 50 dB	Assumes average speech level of 50 dB and recommends signal-to-noise ratio of 15 dB.
U.S. ANSI (2010)	L_{eq} = 35 dB, based on Room Volume (e.g., cubic feet)	Acceptable background level for continuous and intermittent noise.
United Kingdom Department for Education and Skills (2003)	$L_{eq(30min)}$ = 30-35 dB L_{max} = 55 dB	Minimum acceptable in classroom and most other learning environs.

1.3.3 Sleep Disturbance

Sleep disturbance is a major concern for communities exposed to aircraft noise at night. A large amount of research developed in the laboratory during the past 30 years has produced variable results, suggesting a complex interaction of factors including the noise characteristics and individual sensitivity, rather than a clear dose-effect relationship (Muzet, 2007; Kwak et al., 2016). Sleep disorders may cause negative health effects such as cardiovascular problems, neuroendocrine abnormalities, and changes in cognition, mood, and memory. The causal relationships between noise exposure, effects on sleep, and contribution to health disturbances, both behavioral and physical, are not yet firmly established (Zaharna, 2010; Perron et al., 2012). A number of studies have attempted to quantify the effects of noise on sleep. This section provides an overview of the major noise-induced sleep disturbance studies. Emphasis is on studies that have influenced U.S. federal noise policy. The studies have been separated into two groups:

1. Initial studies, conducted in the 1960s and 1970s, in which the research was focused on sleep observations performed under laboratory conditions.
2. Later studies, conducted from the 1990s up to the present, in which the research was focused on field observations.

1.3.3.1 Initial Studies

The relationship between noise and sleep disturbance is complex and not fully understood. The disturbance depends not only on the depth of sleep and the noise level but also on the non-acoustic factors cited for annoyance. The easiest effect to measure is the number of arousals or awakenings caused by noise events. Much of the literature has therefore focused on predicting the percentage of the population that will be awakened at various noise levels.

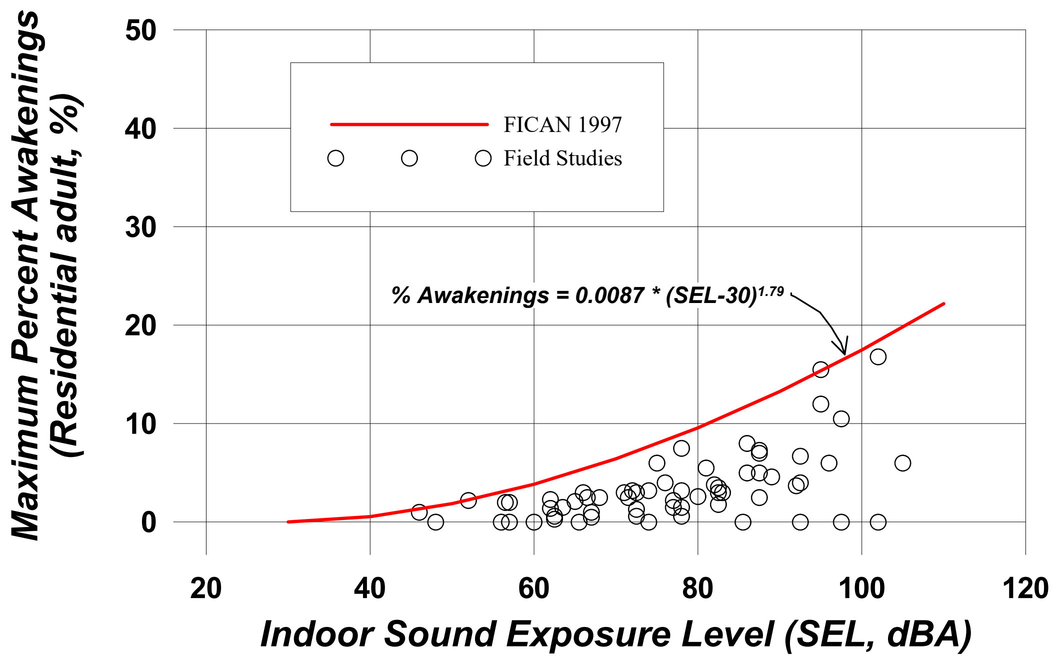
FICON's 1992 review of airport noise issues (FICON, 1992) included an overview of relevant research conducted through the 1970s. Literature reviews and analyses were conducted from 1978 through 1989 using existing data (Griefahn, 1978; Griefahn and Muzet, 1978; Lukas, 1978; Pearsons et. al., 1989).

Because of large variability in the data, FICON did not endorse the reliability of those results. FICON did, however, recommend an interim dose-response curve, awaiting future research. That curve predicted the percentage of the population expected to be awakened as a function of the exposure to SEL. This curve was based on research conducted for the U.S. Air Force (Finegold et al., 1994). The data included most of the research performed up to that point and predicted a 10-percent probability of awakening when exposed to an interior SEL of 58 dB. The data used to derive this curve were primarily from controlled laboratory studies.

1.3.3.2 Recent Sleep Disturbance Research: Field and Laboratory Studies

As noted above, early sleep laboratory studies did not account for some important factors, including habituation to the laboratory, previous exposure to noise, and awakenings from noise other than aircraft. In the early 1990s, field studies in people's homes were conducted to validate the earlier laboratory work conducted in the 1960s and 1970s. The field studies of the 1990s (e.g., Horne et al., 1994) found that 80 to 90 percent of sleep disturbances were not related to outdoor noise events but rather to indoor noises and non-noise factors. The results showed that, in real life conditions, noise had less of an effect on sleep than had been previously reported from laboratory studies. Laboratory sleep studies tend to show more sleep disturbance than field studies show because people who sleep in their own homes are accustomed to their environment and, therefore, do not wake up as easily (FICAN, 1997).

Based on this new information, FICAN in 1997 recommended a dose-response curve to use instead of the earlier 1992 FICON curve (FICAN, 1997). Figure 11 shows FICAN's curve, the red line, which is based on the results of three field studies, which are also shown in the figure (Ollerhead et al., 1992; Fidell et al., 1994; Fidell et al., 1995a; Fidell et al., 1995b) along with the data from six previous field studies.



Source: FICAN 1997

Figure 11 FICAN 1997 Recommended Sleep Disturbance Dose- Response Relationship

1.3.3.3 Number of Events and Awakenings

It is reasonable to expect that sleep disturbance is affected by the number of events. The German Aerospace Center (DLR) conducted an extensive study focused on the effects of nighttime aircraft noise on sleep and related factors (Basner et al., 2004). The DLR study was one of the largest studies to examine the link between aircraft noise and sleep disturbance, and it involved both laboratory and in-home field research phases. The DLR investigators developed a dose-response curve that predicts the number of aircraft events at various values of L_{max} expected to produce one additional awakening over the course of a night. The dose-effect curve was based on the relationships found in the field studies.

Later studies by DLR conducted in the laboratory comparing the probability of awakenings from noise generated by different modes of transportation showed that aircraft noise led to significantly lower awakening probabilities than either road traffic or rail noise (Basner et al., 2011). Furthermore, it was noted that the probability of awakening, per noise event, decreased as the number of noise events increased. The authors concluded that by far the majority of awakenings from noise events merely replaced awakenings that would have occurred spontaneously anyway.

A different approach was taken by an ANSI standards committee (ANSI, 2008), which used the average of the data on field studies shown in Figure 11 rather than the upper envelope (i.e., the red line), to predict average probability of awakening from one event. Probability theory is then used to project the awakening from multiple noise events.

Currently, there are no established criteria for evaluating sleep disturbance from aircraft noise, although recent studies have suggested a benchmark of an outdoor SEL of 90 dB as an appropriate tentative criterion when comparing the effects of different operational alternatives. The corresponding indoor SEL would be approximately 25 dB lower (at 65 dB) with doors and windows closed, and approximately 15 dB lower (at 75 dB) with doors and windows open. According to the ANSI (2008) standard, the probability of awakening from a single aircraft event at this level is between 1 and 2 percent for people habituated to the noise and sleeping in bedrooms with their windows closed, and 2 to 3 percent for those sleeping in bedrooms with their windows open. The probability of the exposed population awakening at least once from multiple aircraft events at noise levels of 90 dB SEL is shown in Table 4.

Table 4 Probability of Awakening from NA90SEL

Number of Aircraft Events at 90 dB SEL for Average 9-Hour Night	*Minimum Probability of Awakening at Least Once with Windows Closed*	*Minimum Probability of Awakening at Least Once with Windows Open*
1	1%	2%
3	4%	6%
5	7%	10%
9 (1 per hour)	12%	18%
18 (2 per hour)	22%	33%
27 (3 per hour)	32%	45%

Source: DoD, 2009b.

In December 2008, FICAN recommended the use of this standard. FICAN also recognized that more research is underway by various organizations and that work may result in changes to FICAN's position.

FICAN reaffirmed its recommendation for the use of the ANSI (2008) standard (FICAN, 2008). However, it is noted that this standard has been withdrawn, but it will be used until further recommendations are made by FICAN.

A recent study further examined the relationship between self-reported sleep insufficiency and airport noise using the U.S. Behavioral Risk Factor Surveillance System data and DNL contours generated by the FAA's Integrated Noise Model software for 95 airports (Holt et al., 2015). The survey data comprise the results of a random-digit-dialed telephone survey of non-institutionalized U.S. civilians 18 years or older covering all 50 states. Responses that included sleep insufficiency questions were included in this study totaling more than 700,000 respondents for 2008 and 2009 year datasets. The authors found that, once controlled for individual sociodemographic characteristics and ZIP Code-level socioeconomic status, there were no significant associations between airport noise exposure levels and self-reported sleep insufficiency. These results are consistent with a study that found aircraft-noise-induced awakening are more reasonably predicted from relative rather than absolute SELs (Fidell et al., 2013). However, Kim et al. (2014) found a response relationship between aircraft noise and sleep quality in a community-based cross-sectional study when controlling for a mental health condition (Kim et al., 2014).

The WHO recommends the use of the dBA long-term average sound level L_{night}, measured outside the home, for sleep disturbance and related effects, with an interim target of 55 dB $L_{night, outside}$ and a night noise guideline of 40 dB (WHO, 2009).

The choice of a noise metric for policy-making purposes depends on both the particular type of noise source and the particular effect being studied. Even for sleep disturbance caused by aircraft noise, there is no single noise exposure metric or measurement approach that is generally agreed upon (Finegold, 2010).

1.3.3.4 Summary

Sleep disturbance research still lacks the details to accurately estimate the population awakened for a given noise exposure. The procedure described in the ANSI (2008) standard and endorsed by FICAN is based on probability calculations that have not yet been scientifically validated. While this procedure certainly provides a much better method for evaluating sleep awakenings from multiple aircraft noise events, the estimated probability of awakenings can only be considered approximate.

1.3.4 Noise-Induced Hearing Impairment

Residents in communities surrounding airfields express concerns regarding the effects of aircraft noise on hearing. This section provides a brief overview of hearing loss caused by noise exposure. The goal is to provide a sense of perspective as to how aircraft noise (as experienced on the ground) compares to other activities that are often linked with hearing loss.

The *Noise-Induced Hearing Impairment* bulletin is one of a series of technical bulletins issued by the DoD Defense Noise Working Group (DNWG) under the initiative to educate and train DoD military, civilian, and contractor personnel, and the public on noise issues. "The ability to convey the effects of military aircraft noise exposure should facilitate both the public discussions and the environmental assessment process," according to DNWG (2013). In its background discussion on the topic of noise-induced hearing impairment, DNWG (2013) states:

> "Considerable data have been collected and analyzed by the scientific/medical community on the effects of noise on workers in industrial settings, and it has been well established that continuous exposure to high noise levels from any source will damage human hearing and result in noise induced hearing loss (USEPA, 1974). The scientific community has concluded that there is little likelihood of hearing damage resulting from exposure to aircraft noise at commercial airports. Until recently, the same was thought true for military airbases, but the introduction of new generation fighter aircraft with high thrust to weight ratio and correspondingly high noise levels has required a re-analysis of the risk of hearing damage for those communities close to military airbases. Residents in surrounding communities are expressing concerns regarding the effects of these new aircraft on hearing."

DNWG goes on to define the major components of hearing loss, temporary versus permanent loss, and threshold shift in hearing, and how they can be differentiated:

> "Hearing loss is generally interpreted as a decrease in the ear's sensitivity or acuity to perceive sound, i.e. a shift in the hearing threshold to a higher level. This change can either be a Temporary Threshold Shift or a Permanent Threshold Shift.
>
> "A Temporary Threshold Shift (TTS) can result from exposure to loud noise over a given amount of time, yet the hearing loss is not necessarily permanent. An example of TTS might be a person attending a loud music concert. After the concert is over, the person may experience a threshold shift that may last several hours, depending upon the level and duration of exposure. While experiencing TTS, the person becomes less sensitive to low-level sounds, particularly at certain frequencies in the speech range (typically near 2,000 and 4,000 Hertz). Normal hearing ability eventually returns, as long as the person has enough time to recover in a relatively quiet environment.

"A Permanent Threshold Shift (PTS) usually results from repeated exposure to high noise levels, where the ears are not given adequate time to recover from the strain and fatigue of exposure. A common example of PTS is the result of working in a very noisy environment such as a factory. It is important to note that TTS can eventually become PTS over time. Thus, even if the ear is given time to recover from TTS, repeated occurrence of TTS may eventually lead to permanent hearing loss. The point at which a Temporary Threshold Shift results in a Permanent Threshold Shift is difficult to identify and varies with a person's sensitivity. In general, hearing loss (be it TTS or PTS) is determined by the duration and level of the sound exposure (DNWG, 2013)."

On the topic of noise-induced hearing loss and its specific components, DNWG (2013) provides the following overview:

"The 1982 EPA Guidelines for Noise Impact Analysis presents the risk of hearing loss from exposure to noise in the workplace in terms of the Noise-Induced Permanent Threshold Shift (NIPTS), a quantity that defines the permanent change in hearing level, or threshold, caused by exposure to noise (USEPA, 1982). It represents the difference in PTS between workers exposed to noise and those who are not exposed. Numerically, the NIPTS is the change in threshold averaged over the frequencies 0.5, 1, 2, and 4 kHz that can be expected from daily exposure to noise over a normal working lifetime of 40 years, with the exposure beginning at an age of 20 years. A grand average of the NIPTS over time (40 years) and hearing sensitivity (10 to 90 percentiles of the exposed population) is termed the Average NIPTS, or Ave. NIPTS for short. The Ave. NIPTS that can be expected for noise exposure as measured by the 24-hour average noise level, Leq24, is given in Table 5 (USEPA, 1982).

"Thus, for a noise exposure of 80 Leq24, the expected lifetime average value of NIPTS is 3 dB. The Ave. NIPTS is estimated as an average over all people exposed to the noise. The actual value of NIPTS for any given person will depend on their physical sensitivity to noise – some will experience more hearing loss than others. The EPA Guidelines provide information on this variation in sensitivity in the form of the NIPTS exceeded by 10 percent of the population, which is included in Table 5 in the '10th Percentile NIPTS' column (USEPA, 1982). As in the example above, for individuals exposed to 80 Leq24, the most sensitive of the population would be expected to show a degradation to their hearing of 7 dB over time. To put these numbers in perspective, changes in hearing level of less than 5 dB are generally not considered noticeable or significant. Furthermore, there is no known evidence that a NIPTS of 5 dB is perceptible or has any practical significance for the individual. Lastly, the variability in audiometric testing is generally assumed to be ±5 dB (USEPA, 1974). (DNWG, 2013)."

Table 5 Average (Ave.) NIPTS and 10th Percentile NIPTS as a Function of $L_{eq(24)}$

$L_{eq(24)}$	*Ave. NIPTS (dB)**	*10th Percentile NIPTS (dB)**
75-76	1.0	4.0
76-77	1.0	4.5
77-78	1.6	5.0
78-79	2.0	5.5
79-80	2.5	6.0
80-81	3.0	7.0

$L_{eq(24)}$	***Ave. NIPTS (dB)****	***10th Percentile NIPTS (dB)****
81-82	3.5	8.0
82-83	4.0	9.0
83-84	4.5	10.0
84-85	5.5	11.0
85-86	6.0	12.0
86-87	7.0	13.5
87-88	7.5	15.0
88-89	8.5	16.5
89-90	9.5	18.0

Note: * rounded to the nearest 0.5 dB

Source: DoD, 2012.

According to DNWG, applying these measurement tools for NIPTS to a specific population is the next step in the process of fully understanding noise impacts on a community (DNWG, 2013):

> "In order to quantify the overall impact of noise on a community it is necessary to include the numbers of people who are exposed. This is accomplished by calculating the population average value of Ave. NIPTS, known as the Potential Hearing Loss (PHL), using the following equation:
>
> $$\text{PHL} = \frac{\sum_i NIPTS_i \times P_i}{\sum_i P_i} \quad (1)$$
>
> where NIPTSi is the Ave. NIPTS for people within the *ith* noise level band (see Table 5), and Pi is the total population living within the *ith* noise level band. The quantity PHL represents the average change in hearing threshold, or the average hearing loss, for the local community exposed to the noise.
>
> The actual noise exposure is determined by the portion of the time the population is outdoors and the outdoor noise levels to which they are exposed. The EPA Guidelines allows for calculating the exposure taking into account the length of time the population is indoors and exposed to lower levels. If the outdoor exposure exceeds 3 hours per day, the contribution of the indoor levels can usually be neglected. (DNWG, 2013)."

The criteria for measuring permanent hearing loss in the workplace are similar but more complex, according to DNWG (2013):

> "The database from which the risk of hearing loss in Table 5 was developed is based almost entirely on extensive audiometric measurements of workers in industrial settings. A considerable amount of hearing loss data have been collected and analyzed, including measurements of hearing loss in people with known histories of noise exposure. The available evidence consists of statistical distributions of hearing levels for populations at various exposure levels. Much of the analysis consists of grouping these measurements into populations of the same age with the same history of noise exposure and determining the percentile distribution of hearing loss for populations with the same noise exposure. Thus, the evidence for noise-induced permanent threshold shift can be clearly seen by comparing the distribution of a noise-exposed

population with that of a relatively non-noise-exposed population (USEPA, 1974).

"Most of these data are drawn from cross-sectional rather than longitudinal studies. That is, individuals or populations have been tested at only one point in time. Because complete noise exposure histories do not exist, many conclusions are limited by the need to make certain assumptions about the onset and progression of noise-induced hearing loss. (DNWG, 2013)."

The USEPA, National Academy of Sciences, WHO, the Occupational Safety and Health Administration (OSHA), National Institute for Occupational Safety and Health, and DoD have each established their own criteria for measuring hearing loss within the workplace, according to DNWG (2013):

"Using this database, the EPA established 75 dB for an 8-hour exposure and 70 dB for a 24-hour exposure as the average noise level standard requisite to protect the most sensitive (approximately 1 percent) of the population from greater than a 5 dB permanent threshold shift in hearing. The EPA document explains that the requirement for an adequate margin of safety necessitates a highly conservative approach which dictates the prevention of any effect on hearing, defined here as an essentially insignificant and not measurable NIPTS of less than 5 dB. (USEPA, 1974).

"The National Academy of Sciences Committee on Hearing, Bioacoustics, and Biomechanics (CHABA) identified 75 dB as the minimum level at which hearing loss may occur from continuous, long-term (40 years) exposure (CHABA, 1965).

"The World Health Organization has concluded that environmental and leisure-time noise below a Leq24 value of 70 dB 'will not cause hearing loss in the large majority of the population, even after a lifetime of exposure (WHO, 2000).'"

"The OSHA regulation of 1971 standardizes the limits on workplace noise exposure for protection from hearing loss as an average level of 90 dB over an 8-hour work period, or 85 dB over a 16-hour period (U.S. Department of Labor, 1971). The standard is based on a 5 dB decrease in allowable noise level per doubling of exposure time. Exposure at levels greater than this require a hearing conservation program to be implemented. The maximum level for workplace exposure to continuous noise is 115 dB, and exposure to this level is limited to 15 minutes. A maximum level of 140 dB is specified for impulsive noise."

"The National Institute for Occupational Safety and Health recommends a maximum exposure of 85 dB for a period of 8 hours, with a recommended exchange rate of 3 dB per doubling of exposure time (NIOSH, 1998). The maximum allowable exposure level is 140 dB for both continuous and impulsive noise."

"The Department of Defense requirements for hearing conservation specify that a hearing conservation program should be implemented if the 8-hour average noise level (Leq8) is greater than 85 decibels (DoD, 2004). The recommended exchange rate is a decrease of 3 dB per doubling of exposure time, although an alternative rate of 4 dB is allowed. (DNWG, 2013)."

The DoD has issued guidelines for hearing risk assessment in local communities, according to DNWG (2013):

"The current DoD policy for assessing hearing loss risk as part of the EIS process is stated in the June 16, 2009 memorandum "Methodology for Assessing Hearing Loss Risk and Impacts in DoD Environmental Impact Analysis" issued by the Under Secretary of Defense (DoD, 2009c). The memorandum defines the conditions under which assessments are required, references the methodology from the 1982 EPA report, and describes how the assessments are to be calculated.

> 'Current and future high performance aircraft create a noise environment in which the current impact analysis based primarily on annoyance may be insufficient to capture the full range of impacts on humans. As part of the noise analysis in all future environmental impact statements, DoD components will use the 80 Day-Night A-Weighted (DNL) noise contour to identify populations at the most risk of potential hearing loss. DoD components will use as part of the analysis, as appropriate, a calculation of the Potential Hearing Loss (PHL) of the at-risk population. The PHL (sometimes referred to as Population Hearing Loss) methodology is defined in EPA Report No. 550/9-82-105, *Guidelines for Noise Impact Analysis* (USEPA, 1982).' (DoD, 2009c).

"The 2009 DoD policy directive requires that hearing loss risk be estimated for the population most at risk, defined as the population exposed to a Day-Night Average Noise Level (DNL) greater than or equal to 80 dB, including residents of on-base housing. Limiting the analysis to the 80 DNL contour area does not necessarily imply that populations outside this contour, i.e. at lower exposure levels, are not at some degree of risk of hearing loss, but it is generally considered that this risk is small. The exposure of workers inside the base boundary area should be considered occupational and evaluated using the appropriate DoD component regulations for occupational noise exposure.

"Environmental noise assessments normally estimate the number of people exposed to noise expressed in terms of the DNL noise metric, which contains a 10 dB weighting factor for aircraft operations occurring between the hours of 2200 and 0700 to account for people's increased sensitivity to noise during the normal sleeping period. However, the mechanism by which high noise levels may cause hearing impairment is physical in nature (by damaging the hair cells in the cochlear) and has no such temporal effects – noise is noise as far as the potential for hearing loss is concerned, regardless of the time of day the exposure occurs. Thus, even though the population most at risk is identified in terms of the 80 DNL contour, it is not appropriate to estimate risk using the DNL metric. The actual assessment of hearing loss risk should be conducted using 24-hour average noise levels (Leq24). (DNWG, 2013)."

Regarding community hearing loss and aircraft noise, DNWG (2013) provides this overview:

"The preponderance of available information on hearing loss risk upon which Table 5 is based is from the workplace with continuous exposure throughout the day for many years. Community exposure to aircraft noise is not continuous but consists of individual events where the sound level exceeds the background level for a limited time period as the aircraft flies past the observer. The maximum noise levels experienced from military aircraft may be very high, and the exposure could result in a temporary threshold shift (TTS). But unless the flights are continuous, the ear may have adequate time to recover from the strain and fatigue of individual exposures, and normal hearing ability may eventually return.

> "There is very limited data on the effect of aircraft noise on hearing. From a civilian airport perspective, the scientific community has concluded that there is little likelihood that the resulting noise exposure from aircraft noise could result in either a temporary or permanent hearing loss (Newman and Beattie, 1985). The EPA criterion (Leq24 = 70 dB) can be exceeded in some areas located near airports, but that is only the case outdoors. Inside a building, where people are more likely to spend most of their time, the average noise level will be much less than 70 dB (Eldred and von Gierke, 1993). Eldred and von Gierke (1993) also report that 'several studies in the U.S., Japan, and the U.K. have confirmed the predictions that the possibility for permanent hearing loss in communities, even under the most intense commercial take-off and landing patterns, is remote.' (DNWG, 2013)."

DNWG (2013) then provides a closer look at military aircraft noise specifically:

> "Military aircraft are in general much noisier than their civilian counterparts, but the available data, while sometimes contradictory, appears to indicate a similar lack of significant effects of noise on hearing. A laboratory study (Nixon et al., 1993) measured changes in human hearing from noise representative of low-flying aircraft on Military Training Routes (MTRs). The potential effects of aircraft flying along MTRs are of particular concern as the maximum overflight noise levels can exceed 115 dB, with a rapid increase in noise level exceeding 30 dB/sec. In this study, participants were first subjected to four overflight noise exposures at A-weighted levels of 115 dB to 130 dB. One-half of the subjects showed no change in hearing levels, one-fourth had a temporary 5 dB increase in sensitivity, and one-fourth had a temporary 5 dB decrease in sensitivity. In the next phase, participants were subjected to up to eight successive overflights, separated by 90 second intervals, at a maximum level of 130 dB until a temporary shift in hearing was observed. The temporary hearing threshold shift showed a decrease in sensitivity of up to 10 dB.
>
> "In another study of 115 test subjects between 18 and 50 years old, TTSs were measured after laboratory exposure to military low-altitude flight (MLAF) noise (Ising et al., 1999). The results indicate that repeated exposure to MLAF noise with maximum noise levels greater than 114 dB, may have the potential to cause permanent noise induced hearing loss, especially if the noise level increases rapidly (Ising et al., 1999).
>
> "A report prepared by researchers at the University of Southampton (Lawton and Robinson, 1991) summarized the state of knowledge as of 1991. Their review of the literature indicated that the main body of information with which comparisons can be made of the hearing damage risk from military overflight noise is to be found in standards and regulatory documents published by various organizations. It was concluded that the risk of hearing loss due to a single event of 125 dB maximum level and equivalent duration of the order 0.5 seconds is small, even after repeated daily occurrences over several years. Supplementary experimental evidence, involving TTS, showed that a small amount of TTS might be engendered by military overflight noise at the levels in question, but that this would have no significant long-term effect even on the more susceptible ears. The literature search did uncover a small number of population

surveys of hearing loss related to noise, but the quantitative results were rare and only one investigation produced audiometric results linked to noise measurements.

"The report concluded that there is little evidence of hearing loss risk from military overflights, either for adults or children. 'Whether in the case of TTS or PTS, laboratory or field studies, adults or children, there appear to be no reports of significant hearing damage attributable to the noise of aircraft overflights (Lawton and Robinson, 1991).'

"In Japan, audiological tests were conducted on a sample of residents who had lived near Kadena Air Base for periods ranging from 19 to 43 years (Yamamoto, 1999). The sample had been exposed (not necessarily continuously) to noise levels ranging from DNL 75 to 88 dB. Examinations showed that there was a one in ten chance of a NIPTS of 20 dB at 4 kHz. However, the NIPTS at 2 kHz and lower was much less, so that the value of Ave. NIPTS was on the order of 10 dB or so. These results are consistent with the '10th Percentile NIPTS' figures in Table 5.

"Ludlow and Sixsmith (Ludlow and Sixsmith, 1999) conducted a cross-sectional pilot study to examine the hypothesis that military jet noise exposure early in life is associated with raised hearing thresholds. The authors concluded that there were no significant differences in audiometric test results between military personnel who as children had lived in or near stations where fast jet operations were based, and a similar group who had no such exposure as children. (DNWG, 2013)."

According to DNWG's (2013) conclusions, noise levels at commercial and military airfields have important distinguishing characteristics:

"Aviation noise levels near commercial airports are not comparable to the occupational or recreational noise exposures associated with hearing loss, and studies of aircraft noise levels have not definitively correlated permanent hearing impairment with aircraft activity. It is unlikely that airport neighbors will remain outside their homes 24 hours per day, so there is little likelihood of hearing loss below an average sound level of 75 dB.

"Near military airbases, average noise levels above 75 dB may occur, and while new DoD policy dictates that NIPTS should be evaluated, research results to date have not found a definitive relationship between significant permanent hearing impairment (greater than 10 dB) and prolonged exposure to aviation noise. (DNWG, 2013)."

1.3.5 Nonauditory Health Effects

The general understanding of the possible effects of aircraft noise has been hindered by the publication of overly sensational and misleading articles in the popular press and by similarly sensational statements from reputed scientists, who are calling attention to their work. These statements have proven less than useful in the research and understanding of potential health effects from aircraft noise exposures.

Moreover, the sensational statements have disturbing consequences because they provide misleading information, create unfounded worry and negative bias, distort certain facts, and add to a growing mistrust of science. These sensational statements have been firmly criticized by other researchers as lacking in rigor because they do not consider other known factors that cause health problems and because they analyze only a selection of the available data (ANR, 2010). The following discussion attempts to summarize the research into the possible nonauditory effects of aircraft noise based on a review of peer-reviewed research. The research reviewed ranges from general stress-related effects on health to specific individual studies on effects such as heart disease and stroke. In addition to these individual studies, there are summaries of meta-analyses of pooled results from individual studies addressing the same issue. The meta-analyses evaluate the studies for consistent results among the smaller individual studies, and they derive effect estimates from the different studies for a quantitative risk assessment (Babisch, 2013). Meta-analysis is an analytical technique designed to summarize the results of multiple smaller studies in order to increase the sample size and to identify patterns among the several smaller studies. The validity of meta-analysis is highly dependent on the quality of the included smaller studies because it cannot correct the poor design and/or bias of the original studies. Because of these limitations, a meta-analysis of several smaller studies cannot predict the results of a single large study and may result in misleading information for the general public.

1.3.5.1 Overview

The potential for aircraft noise to impair one's health deserves special attention and accordingly has been the subject of numerous epidemiological studies and meta-analyses of the gathered data. The basic premise is that noise can cause annoyance, annoyance can cause stress, and prolonged stress is known to be a contributor to a number of health disorders, such as hypertension, myocardial infarction (heart attack), cardiovascular disease, and stroke (Munzel et al., 2014). According to Kryter and Poza (1980), "It is more likely that noise-related general ill-health effects are due to the psychological annoyance from the noise interfering with normal everyday behavior than it is from the noise eliciting, because of its intensity, reflexive response in the autonomic or other physiological systems of the body."

The connection between annoyance and stress and health issues requires careful experimental design because of the large number of confounding issues, such as heredity, medical history, smoking, diet, lack of exercise, and air pollution. Some highly publicized reports on health effects have, in fact, been rooted in poor science. Meecham and Shaw (1979) apparently found a relation between noise levels and mortality rates in neighborhoods located under the approach path to LAX. When the same data were analyzed by others (Frerichs et al., 1980), no relationship was found. Jones and Tauscher (1978) found a high rate of birth defects for the same neighborhoods. But when the Centers for Disease Control performed a more thorough study near Atlanta's Hartsfield International Airport, no relationships were found for DNL greater than 65 dB (Edmonds et al., 1979).

To put the Odds Ratio (OR) number in context, an OR of 1.5 would be considered a weak relationship between noise and health; 3.5 would be a moderate relationship; 9.0 would be a strong relationship; and 32 a very strong relationship (Cohen, 1988).

An early study by Cantrell (1974) confirmed that noise can provoke stress, but it noted that results on its effect on cardiovascular health were contradictory. Some studies in the 1990s found a connection between aircraft noise and increased blood pressure (Michalak et al., 1990; Ising et al., 1990; Rosenlund et al., 2001), while others did not (Pulles et al., 1990). This inconsistency in results led the WHO in 2000 to conclude that there was only a weak association between long-term noise exposure and hypertension and cardiovascular effects, and that a dose-response relationship could not be established (WHO, 2000).

Later, van Kempen concluded that "Whereas noise exposure can contribute to the prevalence of cardiovascular disease, the evidence for a relation between noise exposure and ischemic heart disease is still inconclusive" (van Kempen et al., 2002).

More recently, major studies have been conducted in an attempt to identify an association between noise and health effects, develop a dose-response relationship, and identify a threshold below which the effects are minimal. The most important of these are briefly described below. In these studies, researchers usually present their results in terms of the OR, which is the ratio of the odds that health will be impaired by an increase in noise level of 10 dB to the odds that health would be impaired without any noise exposure. An OR of 1.25 means that there is a 25-percent increase in likelihood that noise will impair health. To put the OR number in context, an OR of 1.5 would be considered a weak relationship between noise and health; 3.5 would be a moderate relationship; 9.0 would be a strong relationship; and 32 a very strong relationship (Cohen, 1988). For examples, the OR for the relationship between obesity and hypertension is 3.4 (Pikilidou et al., 2013), and the OR for the relationship between smoking and coronary heart disease is 4.4 (Rosengren et al., 1992). The summary of these studies shows that the relationship between noise and impaired health is a very weak one because none of the statistically significant ORs were greater than 1.5. Most of the ORs were less than 1.2.

1.3.5.2 Blood Pressure and Hypertension

The carefully designed HYENA study was conducted around six European airports from 2002 through 2006 (Jarup et al., 2005, 2007, 2008; Babisch et al., 2008). The study covered 4,861 subjects, aged between 45 and 70. Blood pressure was measured, and questionnaires were administered for health, socioeconomic, and lifestyle factors, including diet and physical exercise. Noise from aircraft and highways was predicted from models.

HYENA study results showed an OR less than 1 for the association between daytime aircraft noise and hypertension, which was not statistically significant[2] and indicated no positive association. The OR for the relationship between nighttime aircraft noise and hypertension was 1.14--a result that was marginally significant statistically. For daytime road traffic noise, the OR was 1.1 and not significant. The measured effects were small and not necessarily distinct from other events. A close review of the data for nighttime aircraft noise raised some questions about the data and the methods employed (ACRP, 2008). Using data from the HYENA study, Haralabidis et al. (2008) reported an increase in systolic blood pressure of 6.2 millimeters of mercury (mmHg) for aircraft noise events (about 6 percent) and an increase of 7.4 mmHg (about 7 percent) for other indoor noises, such as snoring; a snoring partner and road traffic had similar impacts on blood pressure.

[2] In many of the studies reported above, the researchers use the word "significant" to describe a relationship between noise and health, conjuring up the idea that the relationship is strong and that the effect is large. But this is an inappropriate and misleading use of the word in statistical analysis. What the researchers really mean is that the relationship is "statistically significant" in that they are sure that it is real. It does not mean that the effect is large or important, or that it has any decision-making utility. A relationship can be statistically significant, i.e. real, while being weak, or small and insignificant.

Ancona et al. (2010) reported a study on a randomly selected sample of subjects aged 45 to 70 years who had lived in the study area for at least 5 years. Personal data were collected via interview, and blood pressure measurements were taken for a study population of 578 subjects. No statistically significant association was found between aircraft noise levels and hypertension for noise levels above 75 dB $L_{eq(24)}$ compared to levels below 65 dB. However, there was an increase in nocturnal systolic pressure of 5.4 mmHg (about 5 percent) for subjects in the highest exposure category (greater than or equal to 75 dB).

Eriksson et al. (2007) found that for subjects exposed to energy-averaged levels above 50 dBA, the adjusted relative risk for hypertension was 1.19 (95-percent CI = 1.03 to 1.37). Maximum aircraft noise levels presented similar results, with a relative risk of 1.20 (1.03 to 1.40) for those exposed above 70 dBA. Stronger associations were suggested among older subjects, those with a normal glucose tolerance, nonsmokers, and subjects not annoyed by noise from other sources. The study comprised a cohort of 2,754 men in four municipalities around Stockholm Arlanda airport who were followed from 1992 to 1994 and 2002 to 2004.

Matsui et al. (2008) reported higher OR for noise levels greater than L_{den} 70 dB, but not altogether statistically significant, for hypertension from the effects of military aircraft noise at Kadena Air Base in Okinawa, Japan. The study was conducted in 1995 and 1996 but used older noise data that were not necessarily appropriate for the same time period.

A study of Noise-Related Annoyance, Cognition and Health (NORAH), designed to identify transportation noise effects in communities around German airports, has reported results of self-monitoring of blood pressure of approximately 2,000 residents near Frankfurt Airport exposed to aircraft $L_{eq(24)}$ in the range of 40 to 65 dB during the period 2012 to 2014 after the opening of a new runway (Shreckenberg and Guski, 2015). The results showed small positive effects of noise on blood pressure without statistical significance. No statistically significant effect was determined between aircraft noise and hypertension as defined by the WHO.

A meta-analysis of Huang el al. (2015) examined four research studies comprising a total of 16,784 residents. The overall OR for hypertension in residents with aircraft noise exposure was 1.36 for men and statistically significant, and 1.31 and not statistically significant for women. No account was taken for any confounding factors. The meta-analysis suggests that aircraft noise could contribute to the prevalence of hypertension, but the evidence for a relationship between aircraft noise exposure and hypertension is still inconclusive because of limitations in study populations, exposure characterization, and adjustment for important confounders.

The four studies in Huang's meta-analysis include one by Black et al. (2007) that purports to show relatively high OR values for self-reported hypertension, but these results only applied to a select subset of those surveyed that reported high noise stress. When this data set is excluded, Huang's meta-analysis yields results similar to those obtained in the HYENA and NORAH studies. Furthermore, the longitudinal study included in the analysis that followed 4,721 people for 8 years (Eriksson et al., 2010) reported an OR of 1.02, which was not statistically significant.

Rhee et al. (2008) found that subjects exposed to helicopter noise had a significantly higher prevalence of hypertension than the unexposed control group. Although a source-specific difference in the risk of cardiovascular disease by environmental noise exposure is suggested, no other study has evaluated whether or not exposure to noise from helicopters differs from exposure to noise from fighter jets in their influence on the prevalence of hypertension.

Hwang et al. (2012) conducted a 20-year prospective cohort study of 1,301 aviation workers in Taiwan to follow AGT genotypes (TT, TM, and MM) across four exposure categories according to the levels of noise representing high (>80 dBA), medium (80-65 dBA), and low exposure (64-50 dBA) and the reference level (49-40 dBA). AGT (TT vs MM adjusted incidence rate ratio [IRR] 1.77, 95-percent CI 1.24 to 2.51) and noise exposure (high and medium combined) during 3 to 15 years (adjusted IRR 2.35, 95-percent CI 1.42 to 3.88) were independent determinants of hypertension. Furthermore, the risk of hypertension increased with noise exposure (adjusted IRR 3.73, 95-percent CI 1.84 to 7.56) among TT homozygotes but not among those with at least one M allele (Rothman synergy index = 1.05).

Haralabidis et al. (2011) studied the association between exposure to transportation noise and blood pressure reduction during nighttime sleep utilizing 24-hour ambulatory blood pressure measurements at 15-minute intervals carried out on 149 persons living near four major European airports. Although road traffic noise exposure was found to decrease blood pressure dipping in diastolic blood pressure, no associated decrease in dipping was found for aircraft noise exposure.

1.3.5.3 Heart Disease and Stroke

Huss et al. (2010) examined the risk of mortality from myocardial infarction (heart attack) resulting from exposure to aircraft noise using the Swiss National database of mortality records for the period 2000 to 2005. The analysis was conducted on a total of 4.6 million people, with 15,500 deaths from acute myocardial infarction. The results showed that the risk of death from all circulatory diseases combined was not associated with aircraft noise, and there was not any association between noise and the risk of death from stroke. The overall risk of death from myocardial infarction alone was 1.07 and not statistically significant, but it was higher (OR = 1.3 and not statistically significant) in people exposed to aircraft noise of 60 dB DNL or greater for 15 years or more. The risk of death from myocardial infarction was also higher (OR = 1.10), and statistically significant, for those living near a major road. Cardiovascular risk factors, such as smoking, were not directly taken into account in this study.

Floud (2013) used the HYENA data to examine the relationship between noise levels and self- reported heart disease and stroke. There was no association for daytime noise and no statistically significant association for nighttime noise. However, for those exposed to nighttime aircraft noise for more than 20 years, the OR was 1.25 per 10 dB increase in noise (L_{night}) and marginally significant.

Correia et al. (2013) evaluated the risk of hospitalization for cardiovascular diseases in older people (65 years of age and older) residing in areas exposed to a DNL of at least 45 dB around U.S. airports. Health insurance data from 2009 Medicare records were examined for approximately 6 million people living in neighborhoods around 89 airports in the U.S. The potential confounding effect of socioeconomic status was extracted from several zip-code-level variables from the 2000 U.S. Census. No controls were included for smoking or diet, both of which are strong risk factors for cardiovascular disease. Noise levels were calculated at census block centroids. Taking into account the potential effects of air pollution, they report an OR of 1.035, which was marginally significant statistically. While the overall results show a link between increased noise and increased health risk, some of the individual airport data show a decreased health risk with increased aircraft noise exposure.

Hansell et al. (2013) investigated the association of aircraft noise with risk of hospital admission for, and mortality from, stroke, coronary heart disease, and cardiovascular disease in neighborhoods around London's Heathrow airport exposed to an equivalent sound level over 16 hours of at least 50 dB. The data were adjusted for age, sex, ethnicity, deprivation, and a smoking proxy (lung cancer mortality) at the census area level but not at the individual level. It was important to consider the effect of ethnicity (in particular, South Asian ethnicity, which is itself strongly associated with risk of coronary heart disease). The reported ORs for stroke, heart disease, and cardiovascular disease were 1.24, 1.21, and 1.14, respectively. Similar results were reported for mortality. The results suggest a higher risk of mortality from coronary heart disease than cardiovascular disease, which seems counter-intuitive given that cardiovascular disease encompasses all the diseases of the heart and circulation, including coronary heart disease and stroke along with heart failure and congenital heart disease (ERCD, 2014).

Evrard et al. (2015) studied mortality rates for 1.9 million residents living in 161 communes near three major French airports (Paris-Charles de Gaulle, Lyon Saint-Exupéry, and Toulouse-Blagnac) for the period 2007 to 2010. Noise levels in the communes ranged from 42 to 64 dB L_{den}. Lung cancer mortality at the commune level was used as a proxy measure for smoking because data on individual smoking or smoking prevalence were not available. Noise exposure was expressed in terms of a population-weighted level for each commune. After adjustment for concentration of nitrogen dioxide, Risk Ratios (similar to Odds Ratios) per 10 dB increase in noise were found to be 1.18 for mortality from cardiovascular disease, 1.23 for mortality from coronary heart disease, and 1.31 for mortality from myocardial infarction. There was no association between mortality from stroke and aircraft noise. As the author notes, results at the commune level may not be applicable to the individual level.

Seidler et al. (2016) found a statistically significant linear exposure-risk relationship with heart failure or hypertensive heart disease for aircraft traffic noise (1.6-percent risk increase per 10 dB increase in the 24-hour continuous noise level; 95-percent CI 0.3 to 3.0 percent), road traffic noise (2.4 percent per 10 dB; 95-percent CI 1.6 to 3.2 percent), and railway noise (3.1 percent per 10 dB; 95-percent CI 2.2 to 4.1 percent). For individuals with 24-hour continuous aircraft noise levels less than 40 dB and nightly maximum aircraft noise levels exceeding 50 dB six or more times, a significantly increased risk was observed. In general, risks of hypertensive heart disease were considerably higher than the risks of heart failure.

The NORAH study also included an examination of the effect of aircraft noise on cardiovascular disease (heart attack and stroke) based on examination of health insurance data between 2006 and 2010 for approximately 1 million people over the age of 40 exposed to aircraft $L_{eq(24)}$ in the range of 40 to 65 dB (Shreckenberg and Guski, 2015). A questionnaire was used to obtain information on confounding factors. The results showed a non-statistically significant increase in risk for heart attack and stroke, and there was no apparent linear relationship between noise level and either effect. There was, however, a marginally significant but small increase in risk for heart failure (OR of 1.016). The risk of cardiovascular disease was found to be greater for road and rail noise than for aircraft noise.

Meta-analyses from Babisch and Kamp (2009), Babisch et al. (2013), and Babisch (2013) focused on epidemiological studies or surveys directly related to associations between aircraft noise and cardiovascular disease outcomes. Considering studies at 10 airports covering over 45,000 people, the pooled effect estimate of the relative risk for hypertension was 1.13 per 10 dBA and only marginally significant (WHO, 2011). One of the studies included in the analysis was for military aircraft noise at

Okinawa (see Matsui et al., 2008) for which the OR was 1.27 but not statistically significant. The authors conclude that "No single, generalized and empirically supported exposure-response relationship can be established yet for the association between aircraft noise and cardiovascular risk due to methodological differences between studies." The pooled results show different slopes from different studies with different noise level ranges and methods being used.

A meta-analysis of 11 studies on road and aircraft noise exposure in relation to incident cases of ischemic heart disease (IHD) was transformed into risk estimates per 10 dB increase in exposure by Vienneau et al. (2013). Pooled relative risk for IHD was 1.08 (1.03 to 1.14) per 10 dB increase in noise exposure, with the linear exposure-response starting at 50 dB.

Passchier-Vermeer and Passchier (2000) reviewed studies on noise exposure and health effects and found sufficient evidence to support observation thresholds for hearing impairment, hypertension, IHD, annoyance, performance, and sleep disturbance due to noise exposure. The intent of the article was not to quantify impacts necessarily but instead to show that noise exposure can have a major effect in industrial societies in general, and it should be up to policy- makers and regulators to address this potential public health problem. In addition, the article recommended prioritizing additional study in two topic areas: 1) cardiovascular effects, and 2) the underlying mechanisms and the study of the effects of noise on children.

Seidler et al. (2016) studied myocardial infarction risk due to aircraft, rail, and road noise by investigating patients of the Rhine-Main region of Germany who were diagnosed with myocardial infarction in the years 2006 through 2010. The linear model revealed a statistically significant risk increase due to road noise (2.8 percent per 10 dB rise, 95-percent CI [1.2; 4.5]) and railroad noise (2.3 percent per 10 dB rise [0.5; 4.2]) but not airplane noise. Airplane noise levels of 60 dB and above were associated with a higher risk of myocardial infarction (OR 1.42 [0.62; 3.25]). This higher risk is statistically significant if the analysis is restricted to patients who had died of myocardial infarction by 2014/2015 (OR 2.70 [1.08; 6.74]. In this subgroup, the risk estimators for all three types of traffic noise were of comparable magnitude (3.2 percent to 3.9 percent per 10 dB rise in noise level).

Floud et al. (2011) examined the health effects of aircraft and road traffic noise exposure and the association with medication use. The cross-sectional study measured the use of prescribed antihypertensives, antacids, anxiolytics, hypnotics, antidepressants, and antiasthmatics in 4,861 persons living near seven airports in six European countries. Differences were found between countries in the effect of aircraft noise on antihypertensive use; for nighttime aircraft noise, a 10 dB increase in exposure was associated with ORs of 1.34 (95-percent CI, 1.14 to 1.57) for the UK and 1.19 (1.02 to 1.38) for the Netherlands, but no significant associations were found for other countries. For daytime aircraft noise, excess risks were found for the UK (OR 1.35; CI: 1.13 to 1.60), but a risk deficit was found for Italy (OR 0.82; CI: 0.71 to 0.96). There was an excess risk of taking anxiolytic medication in relation to aircraft noise (OR 1.28; CI: 1.04 to 1.57 for daytime and OR 1.27; CI: 1.01 to 1.59 for nighttime) that held across countries. The authors also found an association between exposure to 24-hour road traffic noise and the use of antacids by men (OR 1.39; CI 1.11 to 1.74).

1.3.5.4 Mental Health Issues

The NORAH study found a risk for unipolar depression to increase with exposure to aircraft noise (OR of 1.09), but the relationship was not linear, with the risk decreasing at the higher noise levels, so this result was not considered reliable (Schreckenberg and Guski, 2015).

A survey study around Frankfurt Airport explored the relationship between aircraft, road traffic, and railway noise with Quality-of-Life (QoL) concerns for both health and environmental views (Schreckenberg et al., 2010). Aircraft noise affected environmental QoL and, to a lesser extent, health QoL. However, one of the study's observations concerned vulnerable groups, such as people with pre-existing illness and/or high noise sensitivities. This group may have limited resources to deal with noise, which can result in increased health problems.

A study of the effect of aircraft noise around a large international airport, Schiphol Airport, near Amsterdam, found an association between the use of non-prescribed sleep medication or sedatives with aircraft noise during the late evening (10:00 P.M. to 11:00 P.M.). However, the correlation between L_{den} and L_{eq} (10:00 P.M. to 11:00 P.M.) to sleep aids (ORs 1.25 and 1.26, respectively) was not statistically significant (Franssen et al., 2004).

Beutel et al. (2016) assessed the association of day and night noise annoyance from road traffic, aircraft, railways, industrial, and neighborhood indoor and outdoor noise to anxiety and depression in 15,000 people ages 35 to 74 living in the Rhein-Main Region of Germany. The source and magnitude of noise annoyance was measured by a self-administered questionnaire. Depression and anxiety were also assessed based on established questionnaires. In this study, aircraft noise was the most commonly reported source of annoyance, followed by road noise annoyance. Depression and anxiety increased with the degree of overall noise annoyance. Compared to no annoyance, prevalence ratios for depression and anxiety, respectively, increased from moderate (PR depression 1.20; 95-percent CI 1.00 to 1.45; PR anxiety 1.42; 95- percent CI 1.15 to 1.74) to extreme annoyance (PR depression 1.97; 95-percent CI 1.62 to 2.39; PR anxiety 2.14; 95-percent CI 1.71 to 2.67). Compared to other sources, aircraft noise annoyance was prominent, affecting almost 60 percent of the population. More simply stated, strong noise annoyance was associated with a two-fold higher prevalence of depression and anxiety in the general population. The authors admit that the identified association of annoyance, particularly with aircraft noise, to depression and anxiety is suggestive of a cause but that more study is needed to identify causal relationships. The authors recognized that pre- existing anxiety and depression could contribute to increased susceptibility to noise annoyance. Also, the focus of this paper was on subjective annoyance, which is not related to objective measures of noise exposition.

Van den Berg et al. (2015) conducted a study that explored the suggested limitation in the Beutel (2016) study: the relationship between pre-existing concern and annoyance. More specifically, they sought insight in the relation between worry about a noise source and annoyance from that source. The motivation for the study was the longstanding important public concern for noise at a political level in Amsterdam, despite implementation of several measures to reduce noise exposure, and the desire to find other variables such as reducing fear and worry that might also help the situation. Using questionnaires from 1,968 respondents and modeling flight-related noise levels in a greater cosmopolitan area around Amsterdam, the researchers found that respondents with a high risk of anxiety/depression are significantly more likely to be highly worried about living close to the airport or an air route compared to those with a low risk (all $p < 0.05$). Also, respondents who report to have bad/moderate health are significantly more likely to be highly worried about living close to the airport or an air route compared to those with good/excellent health. More generally, the results show there is a strong correlation between annoyance from aircraft or airport noise and worry about the risk for health and/or safety associated with living close to an air route or airport. Also, for aircraft noise, worry increases with both the subjective exposure (annoyance) and the objective exposure (sound level). The authors conclude “that more noise or odor is related to more worry, and this has more effect on persons that have a higher personal risk for being worried and annoyed.” When considered within the context of other studies, such as Beutel (2016), it would seem that those who are predisposed to worry are more susceptible to both annoyance and the negative health effects associated with anxiety and depression.

An individual with an increased sensitivity to sounds may have hyperacusis, which results in a lower tolerance of everyday sound (Aazh et al., 2018). A person with hyperacusis reacts differently to sounds due to reactions of increased distress and discomfort from everyday sounds. This condition arises from a problem with the auditory processes within an afflicted individual’s brain. The causes and diagnosis are not well understood (Aazh et al., 2018). Physical causes of hyperacusis may range from head injury, ear damage, or viral diseases, to TMJ. Neurologic causes may range from PTSD, chronic fatigue syndrome, depression, to migraine headaches (American Academy of Otolaryngology--Head and Neck Surgery, 2018). An individual with hyperacusis will also likely have tinnitus, which may lead to further discomfort. Hyperacusis can lead to misophonia, which may cause an individual to react with abnormally strong emotions and behaviors to specific sounds, but hyperacusis does not cause this reaction. Studies of misophonia are very limited at this time. Another condition that falls under the condition of hyperacusis is noise sensitivity (Aazh et al., 2018). A noise-sensitive individual is characteristically more prone to being annoyed by environmental noise compared to a non- noise-sensitive person regardless of the overall noise exposure (Kishikawa et al., 2006). This result indicates that the annoyance response for noise-sensitive people is not a direct function of noise exposure levels.

1.3.5.5 Hospital and Care Facilities

The ACRP (ACRP, 2008) reviewed the literature available at that time to draw the following conclusions regarding noise impacts on patients in hospitals and care facilities:

> “A careful search of recent research regarding aviation noise and hospitals and care facilities identified no studies that addressed this specific issue. It is common for airport noise/land-use compatibility guidelines to list hospitals and care facilities as noise-sensitive uses, although there are no studies that have identified health effects associated with aviation noise. There are numerous studies that identify problems with internal hospital noises such as warning alarms, pagers, gurney collisions with doors, talking, etc.; however, none that addressed aviation or roadway noise.”

The WHO (2000), in its Guidelines for Community Noise (Section 4.3.3), applies available information on noise to derive the following general guidance. However, the guidance is not informed by research on hospital and care facility effects from aircraft noise.

> “For most spaces in hospitals, the critical effects of noise are on sleep disturbance, annoyance and communication interference, including interference with warning signals. The L_{Amax} of sound events during the night should not exceed 40 dB indoors. For wardrooms in hospitals, the

guideline values indoors are 30 dB L_{Aeq}, together with 40 dB L_{Amax} during the night. During the day and evening the guideline value indoors is 30 dB L_{Aeq}. The maximum level should be measured with the instrument set at '*fast*'.

Since patients have less ability to cope with stress, the equivalent sound pressure level should not exceed 35 dB L_{Aeq} in most rooms in which patients are being treated or observed. Particular attention should be given to the sound pressure levels in intensive care units and operating theatres. Sound inside incubators may result in health problems, including sleep disturbance, and may lead to hearing impairment in neonates. Guideline values for sound pressure levels in incubators must await future research."

1.3.5.6 Summary of Nonauditory Effects

Research studies seem to indicate that aircraft noise may contribute to the risk of health disorders, along with other factors such as heredity, medical history, smoking, alcohol use, diet, lack of exercise, and air pollution, but that the measured effect is small compared to these other factors and often not statistically significant--i.e., not necessarily real. Despite some sensational articles purporting otherwise and the intuitive feeling that noise in some way must impair health, there are no studies that definitively show a causal and significant relationship between aircraft noise and health. Such studies are notoriously difficult to conduct and interpret because of the large number of confounding factors that have to be considered for their effects to be excluded from the analysis. The WHO notes that there is still considerable variation among studies (WHO, 2011). And, almost without exception, research studies conclude that additional research is needed to determine whether such a causal relationship exists. The European Network on Noise and Health (ENNAH, 2013), in its summary report of 2013, concludes that "…..while the literature on non-auditory health effects of environmental noise is extensive, the scientific evidence of the relationship between noise and non-auditory effects is still contradictory."

As a result, it is not possible to state that there is sound scientific evidence that aircraft noise is a significant contributor to health disorders.

1.3.6 Performance Effects

The effect of noise on the performance of activities or tasks has been the subject of many studies. Some of these studies have found links between continuous high noise levels and performance loss. Noise-induced performance losses are most frequently reported in studies where noise levels are above 85 dB. Moderate noise levels appear to act as a stressor for more sensitive individuals performing a difficult psychomotor task. Little change has typically been found in low-noise cases; however, cognitive learning differences were measured in subjects exposed to noise of passing aircraft with maximum amplitudes of 48 dBA, presented once per minute, while performing text learning compared to a control group exposed to 35 dBA (Trimmel et al., 2012). The findings suggest that background noise below 50 dBA results in impaired and changed structures of learning, as indicated by reproduction scores, because test persons are less able to switch between strategies

While the results of research on the general effect of periodic aircraft noise on performance have yet to yield definitive criteria, several general trends have been noted, including:

- A periodic intermittent noise is more likely to disrupt performance than a steady-state continuous noise of the same level. Flyover noise, due to its intermittent nature, might be more likely to disrupt performance than a steady-state noise of equal level.
- Noise is more inclined to affect the quality than the quantity of work.
- Noise is more likely to impair the performance of tasks that place extreme physical and/or mental demands on workers.

1.3.7 Noise Effects on Children

Recent studies on school children indicate a potential link between aircraft noise and both reading comprehension and learning motivation. The effects may be small but of particular concern for children who are already scholastically challenged.

1.3.7.1 Effects on Learning and Cognitive Abilities

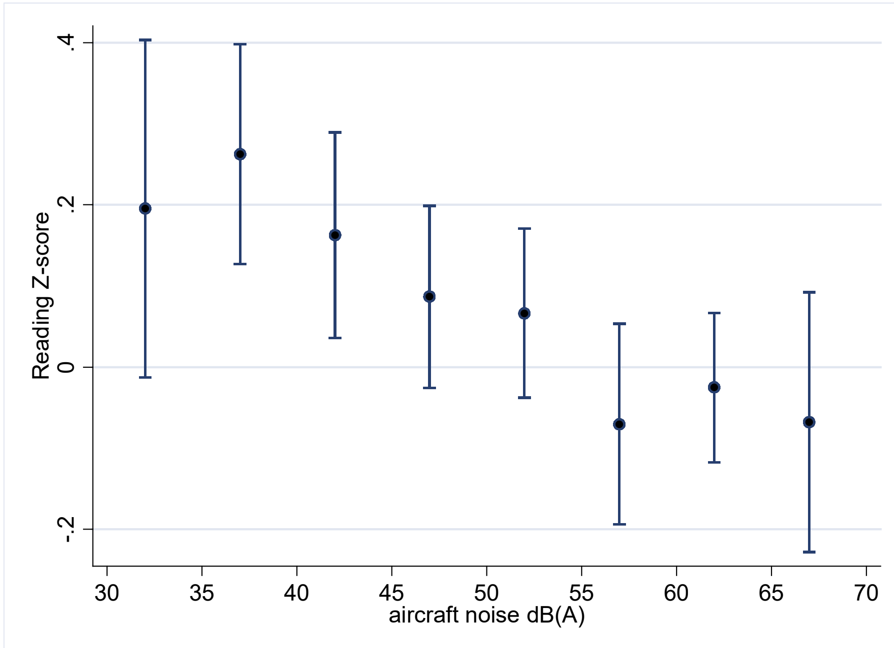
Early studies in several countries (Cohen et al., 1973, 1980, 1981; Bronzaft and McCarthy, 1975; Green et al., 1982; Evans et al., 1998; Haines et al., 2002; Lercher et al., 2003) showed lower reading scores for children living or attending school in noisy areas than for children away from those areas. In some studies, noise-exposed children were less likely to solve difficult puzzles or more likely to give up while attempting to do so.

A longitudinal study reported by Evans et al. (1998) conducted prior to relocation of the old Munich Airport in 1992, reported that high noise exposure was associated with deficits in long-term memory and reading comprehension in children with a mean age of 10.8 years. Two years after the closure of the airport, these deficits disappeared, indicating that noise effects on cognition may be reversible if exposure to the noise ceases. Most convincing was the finding that deficits in memory and reading comprehension developed over the two-year follow-up for children who became newly noise exposed near the new airport.

More recently, the Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health (RANCH) study (Stansfeld et al., 2005; Clark et al., 2005) compared the effect of aircraft and road traffic noise on over 2,000 children in three countries. This was the first study to derive exposure-effect associations for a range of cognitive and health effects and the first to compare effects across countries.

The study found a linear relation between chronic aircraft noise exposure and impaired reading comprehension and recognition memory. No associations were found between chronic road traffic noise exposure and cognition. Conceptual recall and information recall surprisingly showed better performance in high road-traffic-noise areas. Neither aircraft noise nor road traffic noise affected attention or working memory (Stansfeld et al., 2005; Clark et al., 2005).

Figure 12 shows RANCH's result relating noise to reading comprehension. It shows that reading falls below average (a z-score of 0) at L_{eq} greater than 55 dB. Because the relationship is linear, reducing exposure at any level should lead to improvements in reading comprehension.



Sources: Stansfeld et al. 2005; Clark et al. 2005.

Figure 12 RANCH Study Reading Scores Varying with L_{eq}

The RANCH study observed that children may be exposed to aircraft noise for many of their childhood years and the consequences of long-term noise exposure were unknown. A follow-up study of the children in the RANCH project is being analyzed to examine the long-term effects on children's reading comprehension (Clark et al., 2009). Preliminary analysis indicated a trend for reading comprehension to be poorer at 15 to 16 years of age for children who attended noise-exposed primary schools. An additional study utilizing the same data set (Clark et al., 2012) investigated the effects of traffic-related air pollution and found little evidence that air pollution moderated the association of noise exposure on children's cognition.

There was also a trend for reading comprehension to be poorer in aircraft-noise-exposed secondary schools. Significant differences in reading scores were found between primary school children in the two different classrooms at the same school (Bronzaft and McCarthy, 1975). One classroom was exposed to high levels of railway noise, while the other classroom was quiet. The mean reading age of the noise-exposed children was 3 to 4 months behind that of the control children. Studies suggest that the evidence of the effects of noise on children's cognition has grown stronger over recent years (Stansfeld and Clark, 2015), but further analysis adjusting for confounding factors is ongoing and is needed to confirm these initial conclusions.

Studies identified a range of linguistic and cognitive factors to be responsible for children´s unique difficulties with speech perception in noise. Children have lower stored phonological knowledge to reconstruct degraded speech, reducing the probability of successfully matching incomplete speech input when compared with adults. Additionally, young children are less able than older children and adults to make use of contextual cues to reconstruct noise-masked words presented in sentential context (Klatte et al., 2013).

FICAN funded a pilot study to assess the relationship between aircraft noise reduction and standardized test scores (Eagan et al., 2004; FICAN, 2007). The study evaluated whether abrupt aircraft noise reduction within classrooms, from either airport closure or sound insulation, was associated with improvements in test scores. Data were collected in 35 public schools near three airports in Illinois and Texas. The study used several noise metrics. These were, however, all computed indoor levels, which makes it hard to compare with the outdoor levels used in most other studies.

The FICAN study found a significant association between noise reduction and a decrease in failure rates for high school students, but not middle or elementary school students. There were some weaker associations between noise reduction and an increase in failure rates for middle and elementary schools. Overall, the study found that the associations observed were similar for children with or without learning difficulties and between verbal and math/science tests. As a pilot study, the FICAN study was not expected to obtain final answers, but it provided useful indications (FICAN, 2007).

A recent study of the effect of aircraft noise on student learning (Sharp et al., 2013) examined student test scores at a total of 6,198 U.S. elementary schools, 917 of which were exposed to aircraft noise at 46 airports and with noise exposures exceeding 55 dB DNL. The study found small but statistically significant associations between airport noise and student mathematics and reading test scores, after taking demographic and school factors into account. Associations were also observed for ambient noise and total noise on student mathematics and reading test scores, suggesting that noise levels per se, as well as from aircraft, might play a role in student achievement. Recent evidence suggests that potential negative effects on classroom performance can be due to chronic ambient noise exposure. A study of French 8- and 9-year-old children found a significant association between ambient noise levels in urban environments due primarily to road noise (Pujol et al., 2014). The study estimated noise levels at children's bedrooms (L_{den}) and found a modest effect of lower scores on French tests, and these lower scores were associated with higher L_{den} at children's homes. Once adjusted for classroom $L_{Aeq,day}$, the association between L_{den} and math test scores became borderline significant.

As part of the NORAH study conducted at Frankfurt Airport, reading tests were conducted on 1,209 school children at 29 primary schools. It was found that there was a small decrease in reading performance that corresponded to a 1-month reading delay. However, a recent study observing children at 11 schools surrounding LAX found that the majority of distractions to elementary age students were other students, followed by themselves, which includes playing with various items and daydreaming. Less than 1 percent of distractions were caused by traffic noise (National Academies of Sciences, Engineering, and Medicine, 2017).

While there are many factors that can contribute to learning deficits in school-aged children, there is increasing awareness that chronic exposure to high aircraft noise levels may impair learning. This awareness has led the WHO and a North Atlantic Treaty Organization working group to conclude that daycare centers and schools should not be located near major sources of noise, such as highways, airports, and industrial sites (North Atlantic Treaty Organization, 2000; WHO, 1999). The awareness has also led to the classroom noise standard discussed earlier (ANSI, 2010).

1.3.7.2 Health Effects on Children

A number of studies, including some of the cognitive studies discussed above, have examined the potential for effects on children's health. Health effects include annoyance, psychological health impacts, coronary risk, stress hormones, sleep disturbance, and hearing loss.

Annoyance. Chronic noise exposure causes annoyance in children (Bronzaft and McCarthy, 1975; Evans et al., 1995). Annoyance among children tends to be higher than among adults, and there is little habituation (Haines et al., 2001a). The RANCH study found annoyance may play a role in how noise affects reading comprehension (Clark et al., 2005).

Psychological Health. The available literature on psychological health impacts of noise exposure reveals inconsistent findings that are perhaps suggestive of highly situational-specific factors. Lercher et al. (2002) found an association between noise and teacher ratings of psychological health, but only for children with biological risk defined by low birth weight and/or premature birth. Haines et al. (2001b) found that children exposed to aircraft noise had higher levels of psychological distress and hyperactivity. Stansfeld et al. (2009) replicated the hyperactivity result, but not the result for distress. Crombie et al. (2011) found similar hyperactivity results but no significant associations between aircraft noise at school and later mental health issues in children at risk at birth--i.e., those with low birth weight.

Dreger et al. (2015) investigated the influence of different environmental noise sources at children's homes on the incidence of mental health problems in school-aged children. Using a survey of reported level of day and night annoyance by parents as the metric of noise level, the study identified an association between exposure to noise at home and mental health problems such as emotional symptoms, conduct problems, and hyperactivity. Road noise was the most common exposure and was significantly associated with the total difficulties score, emotional symptoms, and conduct problems. Noise by neighbors was associated with conduct problems and hyperactivity. However, aircraft noise (by day) and construction work (by day) were not associated with any of the SDQ categories at a significant level. More generally, and perhaps more importantly, the study found that children who were in the group of constant high exposure, and therefore were continuously exposed for a long time, had higher risk for mental health problems. The authors recognized the lack of quantitative noise measurements as an important study limitation but provide evidence from prior studies indicating reported annoyance as a good proxy.

Hjortebjerg et al. (2016) used noise models to determine average time-weighted road and railroad noise exposure for 46,940 children from birth to age 7 years. Airfield noise was similarly determined but only evaluated as a confounding variable, as was air pollution. A 10 dB increase in average time-weighted road traffic noise exposure from birth to 7 years of age was associated with a 7-percent increase in abnormal versus normal total difficulties scores; 5-percent increases in borderline and abnormal hyperactivity/inattention subscale scores, respectively; and 5-percent and 6-percent increases in abnormal conduct problem and peer relationship problem subscale scores, respectively. Exposure to road traffic noise during pregnancy was not associated with child behavioral problems at 7 years of age. While this study is quantitative, its application to airfield noise is limited due to the different nature of road versus airfield noise.

As with studies of adults, the available evidence suggests that chronic noise exposure is probably not associated with serious psychological illness, but there may be effects on well-being and quality of life. Further research is needed.

Coronary Risk. The HYENA study discussed earlier indicated a possible relation between noise and hypertension in older adults. Cohen et al. (1980, 1981) found some increase in blood pressure among school children, but this increase was within the normal range and not indicating hypertension. Hygge et al. (2002) found mixed effects. The RANCH study found some effect for children at home and at night but not at school (van Kempen, 2006). In the Munich study (Evans et al., 1998), chronic noise exposure was found to be associated with both baseline systolic blood pressure and lower reactivity of systolic blood pressure to a cognitive task presented under acute noise. After the new airport opened, a significant increase in systolic blood pressure was observed, providing evidence for a causal link between chronic noise exposure and raised blood pressure. No association was found between noise and diastolic blood pressure or reactivity (Stansfeld and Crombie, 2011; Stansfeld, 2015).

However, the relationship between aircraft noise and blood pressure was not fully consistent between surveys in different countries. These findings, taken together with those from previous studies, suggest that no unequivocal conclusions can be drawn about the association between aircraft noise exposure and blood pressure. Overall, the evidence for noise effects on children's blood pressure is mixed and less certain than for noise effects on older adults.

Stress Hormones. Some studies investigated hormonal levels between groups of children exposed to aircraft noise and those in a control group. Two studies analyzed cortisol and urinary catecholamine levels in school children as measurements of stress response to aircraft noise (Haines et al., 2001a, 2001b, 2001c). In both instances, there were no differences between the aircraft-noise-exposed children and the control groups.

Sleep Disturbance. A sub-study of RANCH in a Swedish sample used sleep logs and the monitoring of rest/activity cycles to compare the effect of road traffic noise on child and parent sleep (Ohrstrom et al., 2006). An exposure-response relationship was found for sleep quality and daytime sleepiness for children. While this suggests effects of noise on children's sleep disturbance, it is difficult to generalize from one study. Davies (2012) discusses how a study in France among 10-year-old schoolchildren showed that school noise exposure was associated with higher cortisol levels, indicative of a stress reaction; these findings are supported by a Swedish study that found increased prevalence of reduced diurnal cortisol variability in relation with classroom L_{eq} during school day noise levels of between 59 and 87 dBA.

1.3.8 Property Values

Noise, along with many other conditions, (i.e., location, number of rooms, crime rate, school district) can affect the value of homes. Economic studies of property values based on selling prices and noise have been conducted to find a direct relation. Studies of the effects of aviation noise on property values are highly complex due to differing community environments, market conditions, and methodological approaches, so study results generally range from some negative impacts to significant negative impacts. However, studies that considered positive aspects of airport accessibility have found net positive impacts on property values, while others found poorly informed buyers often bid higher prices in noise-impacted areas, only to potentially be disappointed after purchase (ACRP, 2008). The value-noise relation is usually presented as the Noise Depreciation Index (NDI), or Noise Sensitivity Depreciation Index, for the percent loss of value per dB (measured by the DNL metric). An early study by Nelson (1978) at three airports found an NDI of 1.8 to 2.3 percent per dB. Nelson also noted a decline in NDI over time, which he theorized could be due to either a change in population or the increase in commercial value of the property near airports. Crowley (1973) reached a similar conclusion. A larger study by Nelson (1980) studying property values near 18 airports found an NDI from 0.5 to 0.6 percent per dB.

In a review of property value studies, Newman and Beattie (1985) found a range of NDI from 0.2 to 2 percent per dB. They noted that many factors other than noise affected values. These socioeconomic factors include size of house, number of rooms per house, repair of the house, distance from amenities and business districts, and demographics.

Frankel (1991) conducted surveys of 200 realtors and 70 appraisers in 35 suburban communities near Chicago O'Hare International Airport and found that a significant segment of buyers lacked adequate information about the noise environment and often overbid, only to be disappointed after purchase. Frankel classified noise-affected property owners into two groups: one that moved to the location while the environment was quiet but later became noise-impacted and another that purchased from a previous owner while the property was already noise impacted. Frankel concluded that the former group members bore the true financial burden of airport noise.

Fidell et al. (1996) studied the influence of aircraft noise on actual sale prices of residential properties in the vicinity of a military base in Virginia and one in Arizona. They found no meaningful effect on home values. Their results may have been affected by non-noise factors, especially the wide differences in homes between the two study areas.

Tomkins (1998) conducted a study of the residential areas near Manchester Airport, England, and showed that when using the Noise and Number Index (no longer used but similar to DNL), there was no significant negative relationship between noise and property values. When L_{eq} measure was analyzed, fewer properties are included, but the most noise-blighted are identified. Ultimately, the proximity to the airport had a significant impact and was found to be a more important factor of property values than noise. This could be that potential buyers were more likely to be aware of potentially negative noise impacts when properties were closest to airports and much less aware at further distances.

Lipscomb (2003) analyzed the City of College Park, Georgia, and found that noise did not significantly affect the values of residential properties. Lipscomb concluded that local residents were more accepting of noise because many were employed in airport-related occupations, so the proximity provided offsetting benefits, such as short work commutes.

Recent studies of noise effects on property values have recognized the need to account for non-noise factors. Nelson (2004) analyzed data from 33 airports and discussed the need to account for those factors and the need for careful statistics. His analysis showed NDI from 0.3 to 1.5 percent per dB, with an average of about 0.65 percent per dB. Nelson (2007) and Andersson et al. (2013) discuss statistical modeling in more detail.

Enough data are available to conclude that aircraft noise has a real effect on property values. This effect falls in the range of 0.2 to 2.0 percent per dB, with the average on the order of 0.5 percent per dB. The actual value varies from location to location, and it is very often small compared to non-noise factors such as location, market conditions, neighborhood characteristics, and property age, size, and amenities.

1.3.9 Noise-Induced Vibration Effects on Structures and Humans

The sound from an aircraft overflight travels from the exterior to the interior of a house in one of two ways: through the solid structural elements or directly through the air. Figure 13 illustrates the sound transmission through a wall constructed with a brick exterior, stud framing, interior finished wall, and absorbent material in the cavity. The sound transmission starts with noise impinging on the wall exterior. Some of this sound energy will be reflected away, and some will make the wall vibrate. The vibrating wall radiates sound into the airspace, which in turn sets the interior finished surface vibrating, with some energy lost in the airspace. This surface then radiates sound into the dwelling interior. As the figure shows, vibrational energy also bypasses the air cavity by traveling through the studs and edge connections.

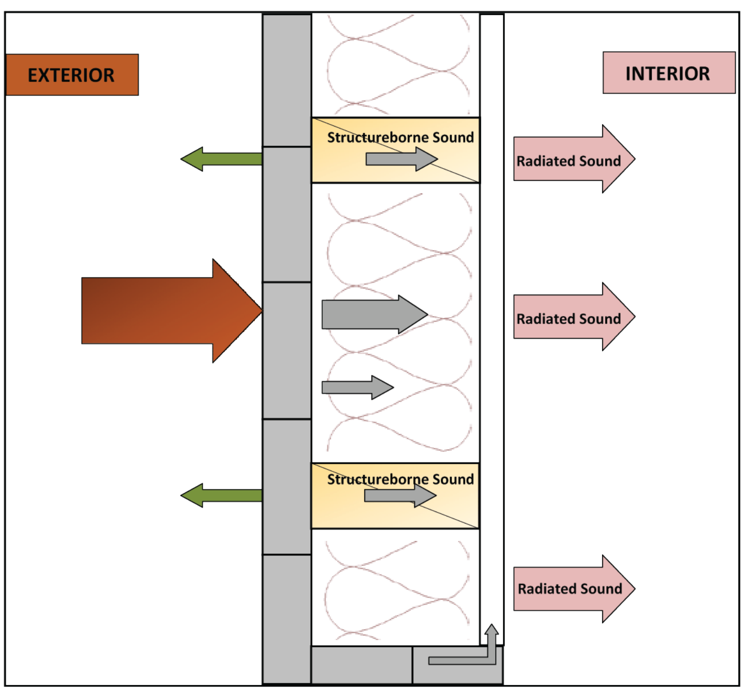


Figure 13 Depiction of Sound Transmission through Built Construction

High noise levels can cause buildings to vibrate. If noise levels are high enough, building components can be damaged. The most sensitive components of a building are the windows, followed by plaster walls and ceilings. Possibility of damage depends on the sound pressures levels and the resonances of the building. While certain frequencies (such as 30 Hz for window breakage) may be of more concern than other frequencies, in general, only sounds lasting more than one second at greater than an unweighted sound level of 130 dB in the 1 Hz to 1,000 Hz frequency range are potentially damaging to structural components (CHABA, 1977; von Gierke and Ward, 1991). Sound levels from normal aircraft operations are typically much less than 130 dB. Even sounds from low-altitude flyovers of heavy aircraft do not reach the potential for damage (Sutherland, 1990).

Noise-induced structural vibration may cause annoyance to dwelling occupants because of induced secondary vibrations, or "rattle," of objects--hanging pictures, dishes, plaques, and bric-a-brac--within the dwelling. Loose windowpanes may also vibrate noticeably when exposed to high levels of airborne noise, causing homeowners to fear breakage. In general, rattling occurs at unweighted sound levels that last for several seconds at greater than 110 dB.

A field study conducted by Schomer and Neathammer (1985, 1987) examined the role of structural vibration and rattle in human response to helicopter noise. It showed that human response is strongly and negatively influenced when the noise induces noticeable vibration and rattles in the house structure. The A-frequency weighting was adequate to assess community response to helicopter noise when no vibration or rattle was induced. When rattle or vibrations were induced by the helicopter noise, however, A-weighting alone did not assess the community response adequately, such that significant corrections from 12 dB (for little vibration or rattles) to 20 dB (high level of vibration or rattles) needed to be applied for subjects indoors. It was also found that the presence or absence of high-level noise-induced vibration and rattles was strongly dependent on the helicopter's slant distance. It was recommended that no housing or noise-sensitive land uses be located in zones where high levels of vibration or rattle are induced by helicopter noise.

Community reactions to conventional helicopter noise from low numbers of operations for two helicopter types were studied by Fields and Powell (1987). Using resident interviews in combination with controlled helicopter operations, the authors obtained relations between the annoyance score and noise exposure for short-term (9-hour daytime) periods. It was determined that annoyance increased steadily with noise exposure measured in L_{eq} from 45 to 60 dBA for that period. Annoyance response in terms of percentage annoyed was also presented on this scale for various annoyance rating values. The shape of these curves is similar to the well-known dose-response relationship (Schultz curve) for general transportation noise but relates to only the 9-hour daytime period and with no direct comparison with long-term noise exposure.

In a later review of human response to aircraft noise and induced building vibration, Powell and Shepherd (1989) also indicate that in aircraft noise surveys, the annoyance scores are on average greater when vibration is detected than with no vibration detected. Based on the results of the study by Fields and Powell (1987), they conclude, however, that no effect of increased annoyance was found for cases where the helicopter noise level and slant distance were such that appreciable rattle was expected to occur, in contrast to the results of Schomer and Neathammer (1987). Powell and Shepherd (1989) also quote a laboratory study (Cawthorn et al., 1978) in which the sound of rattling glassware added to the aircraft flyover noises but did not increase the level of annoyance.

Community annoyance in the vicinity of airports due to noise-induced vibration and rattle resulting from aircraft ground operations was studied by Fidell et al. (1999) and summarized in the Minneapolis-St. Paul International Airport Low Frequency Noise (LFN) Expert Panel Report (Sutherland et al., 2000). These field surveys of operations in the vicinity of a major international airport indicated that low-frequency aircraft noise can lead to secondary vibration and rattle in residential structures, which may significantly increase annoyance. These studies, however, have been criticized (FICAN, 2002) due to the absence of direct measurements of vibration in support of the findings on the presence of perceptible vibration and rattle. These issues were further addressed by Hodgdon et al. (2007). It was confirmed that the highest levels of noise near the runway during start-of-takeoff-roll and acceleration and during thrust reversal are at frequencies below 200 Hz. It was also found that aircraft noise exposures that contained audible rattling were not the most annoying, likely because the rattle content was audible but not loud compared to the overall noise content. This result is consistent with an earlier study of human response to aircraft noise and induced building vibration (Powell and Shepherd, 1989).

In the assessment of vibration on humans, the following factors determine whether a person will perceive and possibly react to building vibrations:

1. Type of excitation: steady state, intermittent, or impulsive vibration
2. Frequency of the excitation. ISO standard 2631-2 (ISO, 1989) recommends a frequency range of 1 to 80 Hz for the assessment of vibration on humans
3. Orientation of the body with respect to the vibration
4. The use of the occupied space (i.e., residential, workshop, hospital)
5. Time of day

Table 6 lists the whole-body vibration criteria from ISO 2631-2 for one-third octave frequency bands from 1 to 80 Hz.

Table 6 Vibration Criteria for the Evaluation of Human Exposure to Whole-Body Vibration - RMS Acceleration (m/s/s)

Frequency (Hz)	*Combined Criteria Base Curve*	*Residential Night*	*Residential Day*
1.00	0.0036	0.0050	0.0072
1.25	0.0036	0.0050	0.0072
1.60	0.0036	0.0050	0.0072
2.00	0.0036	0.0050	0.0072
2.50	0.0037	0.0052	0.0074
3.15	0.0039	0.0054	0.0077
4.00	0.0041	0.0057	0.0081
5.00	0.0043	0.0060	0.0086
6.30	0.0046	0.0064	0.0092
8.00	0.0050	0.0070	0.0100
10.00	0.0063	0.0088	0.0126
12.50	0.0078	0.0109	0.0156
16.00	0.0100	0.0140	0.0200
20.00	0.0125	0.0175	0.0250
25.00	0.0156	0.0218	0.0312
31.50	0.0197	0.0276	0.0394
40.00	0.0250	0.0350	0.0500

Frequency (Hz)	*Combined Criteria Base Curve*	*Residential Night*	*Residential Day*
50.00	0.0313	0.0438	0.0626
63.00	0.0394	0.0552	0.0788
80.00	0.0500	0.0700	0.1000

Source: ISO, 1989.

1.3.10 Noise Effects on Terrain

It has been suggested that noise levels associated with low-flying aircraft may affect the terrain under the flight path by disturbing fragile soil or snow, especially in mountainous areas, thereby causing landslides or avalanches. There are no known instances of such events. It is improbable that such effects would result from routine subsonic aircraft operations.

1.3.11 Noise Effects on Historical and Archaeological Sites

Historic buildings and sites can have elements that are more structurally fragile than conventional buildings. Aircraft noise may affect such sites more severely than newer, modern structures. In older structures, seemingly insignificant surface cracks caused by vibrations from aircraft noise may lead to greater damage from natural forces (Hanson et al., 1991). There are few scientific studies of such effects to provide guidance for their assessment.

One study involved measurements of noise and vibration in a restored plantation house, originally built in 1795. It is located 1,500 feet from the centerline at the departure end of Runway 19L at Washington Dulles International Airport. The aircraft generating the sound measured was the Concorde. There was special concern for the building's windows because roughly half of the house's 324 panes were original. No instances of structural damage were found. Interestingly, despite the high levels of noise during Concorde takeoffs, the induced structural vibration levels were actually less than those induced by touring groups and vacuum cleaning (Wesler, 1977).

As for conventional structures, noise exposure levels for normally compatible land uses should also be protective of historic and archaeological sites. Unique sites should, of course, be analyzed for specific exposure.

1.3.12 Effects on Domestic Animals and Wildlife

Hearing is critical to an animal's ability to react, compete, reproduce, hunt, forage, and survive in its environment. While the existing literature does include studies on possible effects of jet aircraft noise and sonic booms on wildlife, there appears to have been little concerted effort in developing quantitative comparisons of aircraft noise effects on normal auditory characteristics. Behavioral effects have been relatively well described, but the larger ecological context issues, and the potential for drawing conclusions regarding effects on populations, has not been well developed.

The relationships between potential auditory/physiological effects and species interactions with their environments are not well understood. Manci et al. (1988) assert that the consequences that physiological effects may have on behavioral patterns are vital to understanding the long-term effects of noise on wildlife. Questions regarding the effects (if any) on predator-prey interactions, reproductive success, and intra-inter specific behavior patterns remain.

The following discussion provides an overview of the existing literature on noise effects (particularly jet aircraft noise) on animal species. The literature reviewed here involves those studies that have focused on the observations of the behavioral effects that jet aircraft and sonic booms have on animals.

A great deal of research was conducted in the 1960s and 1970s on the effects of aircraft noise on the public and the potential for adverse ecological impacts. These studies were largely completed in response to the increase in air travel and as a result of the introduction of supersonic jet aircraft.

According to Manci et al. (1988), the foundation of information created from that focus does not necessarily correlate or provide information specific to the impacts to wildlife in areas overflown by aircraft at supersonic speed or at low altitudes.

The abilities to hear sounds and noise and to communicate assist wildlife in maintaining group cohesiveness and survivorship. Social species communicate by transmitting calls of warning, introduction, and other types that are subsequently related to an individual's or group's responsiveness.

Animal species differ greatly in their responses to noise. Noise effects on domestic animals and wildlife are classified as primary, secondary, and tertiary. Primary effects are direct, physiological changes to the auditory system, and these most likely include the masking of auditory signals. Masking is defined as the inability of an individual to hear important environmental signals that may arise from mates, predators, or prey. There is some potential that noise could disrupt a species' ability to communicate or could interfere with behavioral patterns (Manci et al., 1988). Although the effects are likely temporary, aircraft noise may cause masking of auditory signals within exposed faunal communities. Animals rely on hearing to avoid predators, obtain food, and communicate with, and attract, other members of their species. Aircraft noise may mask or interfere with these functions. Other primary effects, such as ear drum rupture or temporary and permanent hearing threshold shifts, are not as likely, given the subsonic noise levels produced by aircraft overflights.

Secondary effects may include non-auditory effects such as stress and hypertension; behavioral modifications; interference with mating or reproduction; and impaired ability to obtain adequate food, cover, or water. Tertiary effects are the direct result of primary and secondary effects, and these include population decline and habitat loss. Most of the effects of noise are mild enough that they may never be detectable as variables of change in population size or population growth against the background of normal variation (Bowles, 1995). Other environmental variables (e.g., predators, weather, changing prey base, ground-based disturbance) also influence secondary and tertiary effects, and confound the ability to identify the ultimate factor in limiting productivity of a certain nest, area, or region (Smith et al., 1988). Overall, the literature suggests that species differ in their response to various types, durations, and sources of noise (Manci et al., 1988).

Many scientific studies have investigated the effects of aircraft noise on wildlife, and some have focused on wildlife "flight" due to noise. Animal responses to aircraft are influenced by many variables, including size, speed, proximity (both height above the ground and lateral distance), engine noise, color, flight profile, and radiated noise. The type of aircraft (e.g., fixed wing versus rotor-wing [helicopter]) and type of flight mission may also produce different levels of disturbance, with varying animal responses (Smith et al., 1988). Consequently, it is difficult to generalize animal responses to noise disturbances across species, especially with respect to habituation and ability to adapt to change.

One result of the Manci et al. (1988) literature review was the conclusion that, while behavioral observation studies were relatively limited, a general behavioral reaction in animals from exposure to aircraft noise is the startle response. The intensity and duration of the startle response appears to be dependent on which species is exposed, whether a group or an individual is exposed, and whether there have been some previous exposures. Responses range from flight, trampling, stampeding, jumping, or running, to movement of the head in the apparent direction of the noise source. Manci et al. (1988) reported that the literature indicated that avian species may be more sensitive to aircraft noise than mammals.

1.3.12.1 Domestic Animals

Although some studies report that the effects of aircraft noise on domestic animals is inconclusive, a majority of the literature reviewed indicates that domestic animals exhibit some behavioral responses to military overflights but generally seem to habituate to the disturbances over a period of time. Mammals in particular appear to react to noise at sound levels higher than 90 dB, with responses including the startle response, freezing (i.e., becoming temporarily stationary), and fleeing from the sound source.

Many studies on domestic animals suggest that some species appear to acclimate to some forms of sound disturbance (Manci et al., 1988). Some studies have reported such primary and secondary effects as reduced milk production and rate of milk release, increased glucose concentrations, decreased levels of hemoglobin, increased heart rate, and a reduction in thyroid activity. These latter effects appear to represent a small percentage of the findings occurring in the existing literature.

Some reviewers have indicated that earlier studies and claims by farmers linking adverse effects of aircraft noise on livestock, did not necessarily provide clear-cut evidence of cause and effect (Cottereau, 1978). In contrast, many studies conclude that there is no evidence that aircraft overflights affect feed intake, growth, or production rates in domestic animals.

Cattle

In response to concerns about overflight effects on pregnant cattle, milk production, and cattle safety, the U.S. Air Force prepared a handbook for environmental protection that summarized the literature on the impacts of low-altitude flights on livestock (and poultry) and includes specific case studies conducted in numerous airspaces across the country. Adverse effects have been found in a few studies but have not been reproduced in other similar studies. One such study, conducted in 1983, suggested that 2 of 10 cows in late pregnancy aborted after showing rising estrogen and falling progesterone levels. These increased hormonal levels were reported as being linked to 59 aircraft overflights. The remaining eight cows showed no changes in their blood concentrations and calved normally. A similar study reported abortions occurred in three out of five pregnant cattle after exposing them to flyovers by six different aircraft. Another study suggested that feedlot cattle could stampede and injure themselves when exposed to low-level overflights (U.S. Air Force, 1994a).

A majority of the studies reviewed suggest that there is little or no effect of aircraft noise on cattle. Studies presenting adverse effects to domestic animals have been limited. A number of studies (Parker and Bayley, 1960; Casady and Lehmann, 1967; Kovalcik and Sottnik, 1971) investigated the effects of jet aircraft noise and sonic booms on the milk production of dairy cows. Through the compilation and examination of milk production data from areas exposed to jet aircraft noise and sonic boom events, it was determined that milk yields were not affected. This was particularly evident in those cows that had been previously exposed to jet aircraft noise.

A study examined the causes of 1,763 abortions in Wisconsin dairy cattle over a 1-year time period, and none were associated with aircraft disturbances (U.S. Air Force, 1993). In 1987, researchers contacted seven livestock operators for production data, and no effects of low-altitude and supersonic flights were noted. Of the 43 cattle previously exposed to low-altitude flights, three showed a startle response to an F/A-18 aircraft flying overhead at 500 feet above ground level (AGL) and 400 knots by running less than 10 meters. They resumed normal activity within 1 minute (U.S. Air Force, 1994a). Beyer (1983) found that helicopters caused more reaction than other low-aircraft overflights and that helicopters at 30 to 60 feet overhead did not affect milk production and pregnancies of 44 cows in a 1964 study (U.S. Air Force, 1994a).

Additionally, Beyer (1983) reported that five pregnant dairy cows in a pasture did not exhibit fright-flight tendencies or disturb their pregnancies after being overflown by 79 low-altitude helicopter flights and four low-altitude, subsonic jet aircraft flights. A 1956 study found that the reactions of dairy and beef cattle to noise from low-altitude, subsonic aircraft were similar to those caused by paper blowing about, unfamiliar persons, or other moving objects (U.S. Air Force, 1994a).

In a report to Congress, the U. S. Forest Service concluded that "evidence both from field studies of wild ungulates and laboratory studies of domestic stock indicate that the risks of damage are small (from aircraft approaches of 50-100 m), as animals take care not to damage themselves (U.S. Forest Service, 1992). If animals are overflown by aircraft at altitudes of 50-100 m, there is no evidence that mothers and young are separated, that animals collide with obstructions (unless confined) or that they traverse dangerous ground at too high a rate." These varied study results suggest that, although the confining of cattle could magnify animal response to aircraft overflight, there is no proven cause-and-effect link between startling cattle from aircraft overflights and abortion rates or lower milk production.

Horses

Horses have also been observed to react to overflights of jet aircraft. Several of the studies reviewed reported a varied response of horses to low-altitude aircraft overflights. Observations made in 1966 and 1968 noted that horses galloped in response to jet flyovers (U.S. Air Force, 1993). Bowles (1995) cites Kruger and Erath as observing horses exhibiting intensive flight reactions, random movements, and biting/kicking behavior. However, no injuries or abortions occurred, and there was evidence that the mares adapted somewhat to the flyovers over the course of a month (U.S. Air Force, 1994a). Although horses were observed noticing the overflights, it did not appear to affect either survivability or reproductive success. There was also some indication that habituation to these types of disturbances was occurring.

LeBlanc et al. (1991) studied the effects of F-14 jet aircraft noise on pregnant mares. They specifically focused on any changes in pregnancy success, behavior, cardiac function, hormone production, and rate of habituation. Their findings reported observations of "flight-fright" reactions, which caused increases in heart rates and serum cortisol concentrations. The mares, however, did habituate to the noise. Levels of anxiety and mass body movements were the highest after initial exposure, with intensities of responses decreasing thereafter. There were no differences in pregnancy success when compared to a control group.

Swine

Generally, the literature findings for swine appear to be similar to those reported for cows and horses. While there are some effects from aircraft noise reported in the literature, these effects are minor.

Studies of continuous noise exposure (i.e., 6 hours and 72 hours of constant exposure) reported influences on short-term hormonal production and release. Additional constant exposure studies indicated the observation of stress reactions, hypertension, and electrolyte imbalances (Dufour, 1980). A study by Bond et al. (1963) demonstrated no adverse effects on the feeding efficiency, weight gain, ear physiology, or thyroid and adrenal gland condition of pigs subjected to observed aircraft noise.

Observations of heart rate increase were recorded, noting that cessation of the noise resulted in the return to normal heart rates. Conception rates and offspring survivorship did not appear to be influenced by exposure to aircraft noise.

Similarly, simulated aircraft noise at levels of 100 to 135 dB had only minor effects on the rate of feed utilization, weight gain, food intake, or reproduction rates of boars and sows exposed, and there were no injuries or inner ear changes observed (Gladwin et al., 1988; Manci et al., 1988).

Domestic Fowl

According to a 1994 position paper by the U.S. Air Force on effects of low-altitude overflights (below 1,000 feet) on domestic fowl, overflight activity has negligible effects (U.S. Air Force, 1994b). The paper did recognize that given certain circumstances, adverse effects can be serious. Some of the effects can be panic reactions, reduced productivity, and effects on marketability (e.g., bruising of the meat caused during “pile-up” situations).

The typical reaction of domestic fowl after exposure to sudden, intense noise is a short-term startle response. The reaction ceases as soon as the stimulus is ended, and within a few minutes all activity returns to normal. More severe responses are possible depending on the number of birds, the frequency of exposure, and environmental conditions. Large flocks of birds, and birds not previously exposed, are more likely to pile up in response to a noise stimulus (U.S. Air Force, 1994b). According to studies and interviews with growers, it is typically the previously unexposed birds that incite panic crowding, and the tendency to do so is markedly reduced within five exposures to the stimulus (U.S. Air Force, 1994b). This suggests that the birds habituate relatively quickly. Egg productivity was not adversely affected by infrequent noise bursts, even at exposure levels as high as 120 to 130 dB.

Between 1956 and 1988, there were 100 recorded claims against the Navy for alleged damage to domestic fowl. The number of claims averaged three per year, with peak numbers of claims following publications of studies on the topic in the early 1960s. Many of the claims were disproved or did not have sufficient supporting evidence. The claims were filed for the following alleged damages: 55 percent for panic reactions, 31 percent for decreased production, 6 percent for reduced hatchability, 6 percent for weight loss, and less than 1 percent for reduced fertility (U.S. Air Force, 1994b).

The review of the existing literature suggests that there has not been a concerted or widespread effort to study the effects of aircraft noise on commercial turkeys. One study involving turkeys examined the differences between simulated versus actual overflight aircraft noise, turkey responses to the noise, weight gain, and evidence of habituation (Bowles et al., 1990). Findings from the study suggested that turkeys habituated to jet aircraft noise quickly, that there were no growth-rate differences between the experimental and control groups, and that there were some behavioral differences that increased the difficulty in handling individuals within the experimental group.

Low-altitude overflights were shown to cause turkey flocks that were kept inside turkey houses to occasionally pile up and experience high mortality rates due to the aircraft noise and a variety of disturbances unrelated to aircraft (U.S. Air Force, 1994b).

1.3.12.2 Wildlife

Studies on the effects of overflights and sonic booms on wildlife have been focused mostly on avian species and on ungulates such as caribou (*Rangifer tarandus*) and bighorn sheep (*Ovis canadensis*). Few studies have been conducted on marine mammals, small terrestrial mammals, reptiles, amphibians, and carnivorous mammals. Generally, species that live entirely below the surface of the water have also been ignored due to the fact they do not experience the same level of sound as terrestrial species (National Park Service, 1994). Wild ungulates appear to be much more sensitive to noise disturbance than domestic livestock. This may be due to previous exposure to disturbances. One common factor appears to be that low-altitude flyovers seem to be more disruptive in terrain where there is little cover (Manci et al., 1988).

Mammals

<u>Terrestrial Mammals</u>

Studies of terrestrial mammals have shown that noise levels of 120 dB can damage mammals' ears, and levels at 95 dB can cause temporary loss of hearing acuity. Noise from aircraft has affected other large carnivores by causing changes in home ranges, foraging patterns, and breeding behavior. One study recommended that aircraft not be allowed to fly at altitudes below 2,000 feet AGL over important grizzly bear (*Ursus arctos horribilis*) and polar bear (*Ursus maritimus*) habitat. Wolves (*Canis lupus*) have been frightened by low-altitude flights that were 25 to 1,000 feet AGL. However, wolves have been found to adapt to aircraft overflights and noise as long as they were not being hunted from aircraft (Dufour, 1980).

Wild ungulates (American bison [*Bison bison*], caribou, bighorn sheep) appear to be much more sensitive to noise disturbance than domestic livestock (Weisenberger et al., 1996). Behavioral reactions may be related to the past history of disturbances by humans and aircraft. Common reactions of reindeer kept in an enclosure exposed to aircraft noise disturbance were a slight startle response, rising of the head, pricking ears, and scenting of the air. Panic reactions and extensive changes in behavior of individual animals were not observed. Caribou in Alaska exposed to fixed-wing aircraft and helicopters exhibited running and panic reactions when overflights were at an altitude of 200 feet or less. The reactions decreased with increased altitude of overflights, and, with more than 500 feet in altitude, the panic reactions stopped. Also, smaller groups reacted less strongly than larger groups. One negative effect of the running and avoidance behavior is increased expenditure of energy. For a 90-kilogram animal, the calculated expenditure due to aircraft harassment is 64 kilocalories per minute when running and 20 kilocalories per minute when walking. When conditions are favorable, this expenditure can be counteracted with increased feeding; however, during harsh winter conditions, this may not be possible. Incidental observations of wolves and bears exposed to fixed-wing aircraft and helicopters in the northern regions suggested that wolves are less disturbed than wild ungulates, while grizzly bears showed the greatest response of any animal species observed (Weisenberger et al., 1996).

It has been proven that low-altitude overflights do induce stress in animals. Increased heart rates, an indicator of excitement or stress, have been found in pronghorn antelope (*Antilocapra Americana*), elk (*Cervus Canadensis*), and bighorn sheep. As such reactions occur naturally as a response to predation, infrequent overflights may not, in and of themselves, be detrimental. However, flights at high frequencies over a long period of time may cause harmful effects. The consequences of this disturbance, while cumulative, are not additive. It may be that aircraft disturbance may not cause obvious and serious health effects, but coupled with a harsh winter, it may have an adverse impact. Research has shown that stress induced by other types of disturbances produces long-term decreases in metabolism and hormone balances in wild ungulates.

Behavioral responses can range from mild to severe. Mild responses include head raising, body shifting, or turning to orient toward the aircraft. Moderate disturbance may be nervous behaviors, such as trotting a short distance. Escape is the typical severe response.

<u>Marine Mammals</u>

The physiological composition of the ear in aquatic and marine mammals exhibits adaptation to the aqueous environment. These differences (relative to terrestrial species) manifest themselves in the auricle and middle ear (Manci et al., 1988). Some mammals use echolocation to perceive objects in their surroundings and to determine the directions and locations of sound sources (Simmons, 1983 in Manci et al. 1988).

In 1980, the Acoustical Society of America held a workshop to assess the potential hazard of manmade noise associated with proposed Alaska arctic (North Slope-Outer Continental Shelf) petroleum operations on marine wildlife and to prepare a research plan to secure the knowledge necessary for proper assessment of noise impacts (Acoustical Society of America, 1980). Since 1980, it appears that research on responses of aquatic mammals to aircraft noise and sonic booms has been limited. Research conducted on northern fur seals (*Callorhinus ursinus*), sea lions, and ringed seals (*Pusa hispida*) indicated that there are some differences in how various animal groups receive frequencies of sound. It was observed that these species exhibited varying intensities of a startle response to airborne noise, and this response was habituated over time. The rates of habituation appeared to vary with species, populations, and demographics (age, sex). Time of day of exposure was also a factor (Myrberg, 1978 in Manci et al., 1988).

Studies were conducted near the Channel Islands near the area where the space shuttle launches occur. It was found that there were some response differences between species relative to the loudness of sonic booms. Those booms that were between 80 and 89 dB caused a greater intensity of startle reactions than lower-intensity booms at 72 to 79 dB. However, the duration of the startle responses to louder sonic booms was shorter (Jehl and Cooper, 1980).

Jehl and Cooper (1980) indicated that low-flying helicopters, loud boat noises, and humans were the most disturbing to pinnipeds. According to the research, while the space shuttle launch and associated operational activity noises have not had a measurable effect on the pinniped population, it also suggests that there was a greater “disturbance level” exhibited during launch activities. There was a recommendation to continue observations for behavioral effects and to perform long-term population monitoring (Jehl and Cooper, 1980).

The continued presence of single or multiple noise sources could cause marine mammals to leave a preferred habitat. However, it does not appear likely that overflights could cause migration from suitable habitats because aircraft noise over water is mobile and would not persist over any particular area. Aircraft noise, including supersonic noise, currently occurs in the overwater airspace of Eglin, Tyndall, and Langley Air Force bases from sorties predominantly involving jet aircraft. Survey results reported in Davis et al. (2000) indicate that cetaceans (i.e., dolphins) occur under all of the Eglin and Tyndall marine airspace. The continuing presence of dolphins (family Delphinidae) indicates that aircraft noise does not discourage use of the area and apparently does not harm the locally occurring population.

In a summary by the National Park Service (1994) on the effects of noise on marine mammals, it was determined that gray whales (*Eschrichtius robustus*) and harbor porpoises (*Phocoena phocoena*) showed no outward behavioral response to aircraft noise or overflights. Bottlenose dolphins (*Tursiops truncatus*) showed no obvious reaction in a study involving helicopter overflights at 1,200 to 1,800 feet above the water. Neither did they show any reaction to survey aircraft unless the shadow of the aircraft passed over them, at which point there was some observed tendency to dive (Richardson et al., 1995). Other anthropogenic noises in the marine environment from ships and pleasure craft may have more of an effect on marine mammals than aircraft noise (U.S. Air Force, 2000). The noise effects on cetaceans appear to be somewhat attenuated by the air/water interface. The cetacean fauna along the coast of California have been subjected to sonic booms from military aircraft for many years without apparent adverse effects (Tetra Tech, Inc., 1997).

Manatees (*Trichechus spp.*) appear relatively unresponsive to human-generated noise to the point that they are often suspected of being deaf to oncoming boats (although their hearing is actually similar to that of pinnipeds [Bullock et al., 1980]). Little is known about the importance of acoustic communication to manatees, although they are known to produce at least 10 different types of sounds and are thought to have sensitive hearing (Richardson et al., 1995). Manatees continue to occupy canals near Miami International Airport, which suggests they have become habituated to human disturbance and noise (Metro-Dade County, 1995). Since manatees spend most of their time below the surface and do not startle readily, no effect of aircraft overflights on manatees would be expected (Bowles et al., 1993).

Birds

Auditory research conducted on birds indicates that they fall between reptiles and mammals relative to hearing sensitivity. According to Dooling (1978), within the range of 1,000 to 5,000 Hz, birds show a level of hearing sensitivity similar to that of the more sensitive mammals. In contrast to mammals, bird sensitivity falls off at a greater rate with increasing and decreasing frequencies. Passive observations and studies examining aircraft bird strikes indicate that birds nest and forage near airports. Aircraft noise in the vicinity of commercial airports apparently does not inhibit bird presence and use.

High-noise events (like a low-altitude aircraft overflight) may cause birds to engage in escape or avoidance behaviors, such as flushing from perches or nests (Ellis et al., 1991). These activities impose an energy cost on the birds that, over the long term, may affect survival or growth. In addition, the birds may spend less time engaged in necessary activities like feeding, preening, or caring for their young because they spend time in noise-avoidance activity. However, the long-term significance of noise-related impacts is less clear. Several studies on nesting raptors have indicated that birds become habituated to aircraft overflights and that long-term reproductive success is not affected (Ellis et al., 1991; Grubb and King, 1991). Threshold noise levels for significant responses range from 62 dB for the Pacific black brant (*Branta bernicla nigricans*) to 85 dB for the crested tern (*Thalasseus bergii*) (Brown, 1990; Ward and Stehn, 1990).

Songbirds were observed to become silent prior to the onset of a sonic boom event (F-111 jets), followed by "raucous discordant cries." There was a return to normal singing within 10 seconds after the boom (Higgins, 1974 in Manci et al., 1988). Ravens (*Corvus corax*) responded by emitting protestation calls, flapping their wings, and soaring.

Manci et al. (1988) reported a reduction in reproductive success in some small territorial passerines (i.e., perching birds or songbirds) after exposure to low-altitude overflights. However, it has been observed that passerines are not driven any great distance from a favored food source by a nonspecific disturbance, such as aircraft overflights (U.S. Forest Service, 1992). Further study may be warranted.

A cooperative study between the DoD and the U.S. Fish and Wildlife Service (USFWS) assessed the response of the red-cockaded woodpecker (*Leuconotopicus borealis*) to a range of military training noise events, including artillery, small arms, helicopter, and maneuver noise (Pater et al., 1999). The project findings show that the red-cockaded woodpecker successfully acclimates to military noise events.

Depending on the noise level that ranged from innocuous to very loud, the birds responded by flushing from their nest cavities. When the noise source was closer and the noise level was higher, the number of flushes increased proportionately. In all cases, however, the birds returned to their nests within a relatively short period of time (usually within 12 minutes). Additionally, the noise exposure did not result in any mortality or statistically detectable changes in reproductive success (Pater et al., 1999).

Red-cockaded woodpeckers did not flush when artillery simulators were more than 122 meters away and SELs were 70 dB.

Lynch and Speake (1978) studied the effects of both real and simulated sonic booms on the nesting and brooding eastern wild turkey (*Meleagris gallopavo silvestris*) in Alabama. Hens at four nest sites were subjected to between eight and 11 combined real and simulated sonic booms. All tests elicited similar responses, including quick lifting of the head and apparent alertness for 10 to 20 seconds. No apparent nest failure occurred as a result of the sonic booms. Twenty-one brood groups were also subjected to simulated sonic booms. Reactions varied slightly between groups, but the largest percentage of groups reacted by standing motionless after the initial blast. Upon the sound of the boom, the hens and poults fled until reaching the edge of the woods (approximately 4 to 8 meters). Afterward, the poults resumed feeding activities while the hens remained alert for a short period of time (approximately 15 to 20 seconds). In no instances were poults abandoned, and they did not scatter and become lost. Every observation group returned to normal activities within a maximum of 30 seconds after a blast.

<u>Bald Eagle</u>

A study by Grubb and King (1991) on the reactions of the bald eagle (*Haliaeetus leucocephalus*) to human disturbances showed that terrestrial disturbances elicited the greatest response, followed by aquatic (i.e., boats) and aerial disturbances. The disturbance regime of the area where the study occurred was predominantly characterized by aircraft noise. The study found that pedestrians consistently caused responses that were greater in both frequency and duration. Helicopters elicited the highest level of aircraft-related responses. Aircraft disturbances, although the most common form of disturbance, resulted in the lowest levels of response. This low response level may have been due to habituation; however, flights less than 170 meters away caused reactions similar to other disturbance types. Ellis et al. (1991) showed that eagles typically respond to the proximity of a disturbance, such as a pedestrian or aircraft within 100 meters, rather than the noise level. Fleischner and Weisberg (1986) stated that reactions of bald eagles to commercial jet flights, although minor (e.g., looking), were twice as likely to occur when the jets passed at a distance of 0.5 mile or less. They also noted that helicopters were four times more likely to cause a reaction than a commercial jet and 20 times more likely to cause a reaction than a propeller plane.

The USFWS advised Cannon Air Force Base that flights at or below 2,000 feet AGL from October 1 through March 1 could result in adverse impacts to wintering bald eagles (USFWS, 1998). However, Fraser et al. (1985) suggested that raptors habituate to overflights rapidly, sometimes tolerating aircraft approaches of 65 feet or less.

Golden Eagle

In its guidelines for aerial surveys, USFWS (Pagel et al., 2010) summarized past studies by stating that most golden eagles (*Aquila chrysaetos*) respond to survey aircraft (fixed- and rotary-wing) by remaining on their nests and continuing to incubate or roost. Surveys take place generally as close as 10 to 20 meters from cliffs (including hovering less than 30 seconds if necessary, to count eggs) and no farther than 200 meters from cliffs, depending on safety considerations (Pagel et al., 2010).

Grubb et al. (2007) experimented with multiple exposure to two helicopter types and concluded that flights with a variety of approach distances (800, 400, 200, and 100 meters) had no effect on golden eagle nesting success or productivity rates within the same year or on rates of renewed nesting activity the following year when compared to the corresponding data for the larger population of non-manipulated nest sites (Grubb et al., 2007). They found no significant, detrimental, or disruptive responses in 303 helicopter passes near eagles. In 227 AH-64 Apache helicopter experimental passes (considered twice as loud as a civilian helicopter also tested) at test distances of 0 to 800 meters from nesting golden eagles, 96 percent resulted in no more response than watching the helicopter pass. No greater reactions occurred until after hatching, when individual golden eagles exhibited five flatten and three fly behaviors at three nest sites. The flight responses occurred at approach distances of 200 meters or less. No evidence was found of an effect on subsequent nesting activity or success, despite many of the helicopter flights occurring during early courtship and nest repair. None of these responding pairs failed to successfully fledge young, except for one nest that fell later in the season.

Excited, startled, or avoidance reactions were never observed. Non-attending eagles or those perched away from the nests were more likely to fly than attending eagles but also with less potential consequence to nesting success (Grubb et al., 2007). Golden eagles appeared to become less responsive with successive exposures. Much of helicopter sound energy may be at a lower frequency than golden eagles can hear, thus reducing expected impacts. Grubb et al. (2007) found no relationship between helicopter sound levels and corresponding eagle ambient behaviors or limited responses, which occurred throughout recorded test levels (76.7 to 108.8 dB, unweighted). The authors thought that the lower than expected behavioral responses may be partially due to the fact that the golden eagles in the area appear acclimated to the current high levels of outdoor recreational, including aviation, activities.

Based on the results of this study, the authors recommended reduction of existing buffers around nest sites to 100 meters (325 feet) for helicopter activity.

Richardson and Miller (1997) reviewed buffers as protection for raptors against disturbance from ground-based human activities. No consideration of aircraft activity was included. They stressed a clear line of sight as an important factor in a raptor's response to a particular disturbance, with visual screening allowing a closer approach of humans without disturbing a raptor. A Geographical Information Systems (GIS)-assisted viewshed approach combined with a designated buffer zone distance was found to be an effective tool for reducing potential disturbance to golden eagles from ground-based activities (Richardson and Miller, 1997). They summarized recommendations that included a median 0.5-mile (800-meter) buffer (range = 200 to 1,600 m, n = 3) to reduce human disturbances (from ground-based activities such as rock climbing, shooting, vehicular activity) around active golden eagle nests from February 1 to August 1 based on an extensive review of other studies (Richardson and Miller, 1997).

Physical characteristics (i.e., screening by topography or vegetation) are important variables to consider when establishing buffer zones based on raptors' visual- and auditory-detection distances (Richardson and Miller, 1997).

Osprey

A study by Trimper et al. (1998), in Goose Bay, Labrador, Canada, focused on the reactions of nesting osprey (*Pandion haliaetus*) to military overflights by CF-18 Hornets. Reactions varied from increased alertness and focused observation of planes to adjustments in incubation posture. No overt reactions (e.g., startle response, rapid nest departure) were observed as a result of an overflight. Young nestlings crouched as a result of any disturbance until 1 to 2 weeks prior to fledging. Helicopters, human presence, float planes, and other ospreys elicited the strongest reactions from nesting ospreys. These responses included flushing, agitation, and aggressive displays. Adult osprey showed high nest occupancy rates during incubation regardless of external influences. The osprey observed occasionally stared in the direction of the flight before the flight was audible to the observers. The birds may have been habituated to the noise of the flights; however, overflights were strictly controlled during the experimental period. Strong reactions to float planes and helicopters may have been due to the slower flight and therefore longer duration of visual rather than noise-related stimuli.

Red-tailed Hawk

Anderson et al. (1989) conducted a study that investigated the effects of low-level helicopter overflights on 35 red-tailed hawk (*Buteo jamaicensis*) nests. Some of the nests had not been flown over prior to the study. The hawks that were naïve (i.e., not previously exposed) to helicopter flights exhibited stronger avoidance behavior (nine of 17 birds flushed from their nests) than those that had experienced prior overflights. The overflights did not appear to affect nesting success in either study group. These findings were consistent with the belief that red-tailed hawks habituate to low-level air traffic, even during the nesting period.

Upland Game Birds

Greater Sage-grouse. The greater sage-grouse (*Centrocercus urophasianus*) was recently designated as a candidate species for protection under the Endangered Species Act after many years of scrutiny and research (USFWS, 2010). This species is a widespread and characteristic species of the sagebrush ecosystems in the Intermountain West. Greater sage-grouse, like most bird species, rely on auditory signals as part of mating. Sage-grouse are known to select their leks based on acoustic properties and depend on auditory communication for mating behavior (Braun, 2006). Although little specific research has been completed to determine what, if any, effects aircraft overflight and sonic booms would have on the breeding behavior of this species, factors that may be important include season and time of day, altitude, frequency and duration of overflights, and frequency and loudness of sonic booms.

Booth et al. (2009) found, while attempting to count sage-grouse at leks (breeding grounds) using light sport aircraft at 150 meters (492 feet) to 200 meters (650 feet) AGL, that sage-grouse flushed from leks on 12 of 14 approaches when the airplane was within 656 to 984 feet (200 to 300 meters) of the lek. In the other two instances, male grouse stopped exhibiting breeding behavior and crouched but stayed on the lek. The time to resumption of normal behavior after disturbance was not provided in this study.

Strutting ceased around the time when observers on the ground heard the aircraft. The light sport aircraft could be safely operated at very low speed (68 kilometers per hour or 37 nautical miles per hour) and was powered by either a two-stroke or a four-stroke engine. It is unclear how the response to the slow-flying light sport aircraft used in the study would compare to overflight by military jets, operating at speeds 10 to 12 times as great as the aircraft used in the study. It is possible that response of the birds was related to the slow speed of the light sport aircraft causing it to resemble an aerial predator.

Other studies have found disturbance from energy operations, and other nearby development have adversely affected breeding behavior of greater sage-grouse (Holloran, 2005; Doherty, 2008; Walker et al., 2007; Harju et al., 2010). These studies do not specifically address overflights, do not isolate noise disturbance from other types of disturbance (e.g., visual, human presence), and do not generally provide noise levels or qualification of the noise source (e.g., continuous or intermittent, frequency, duration).

Because so few studies have been done on greater sage-grouse response to overflights or sonic booms, research on related species may be applicable. Observations on other upland game bird species include those on the behavior of four wild turkey (*Meleagris gallapavo*) hens on their nests during real and simulated sonic booms (Manci et al., 1988). Simulated sonic booms were produced by firing 5-centimeter mortar shells from a location 300 to 500 feet from the nest of each hen. Recordings of pressure for both types of booms measured 0.4 to 1.0 pounds per square foot at the observer's location.

Turkey hens exhibited only a few seconds of head alert behavior at the sound of the sonic boom. No hens were flushed off the nests, and productivity estimates revealed no effect from the booms. Twenty brood groups were also subjected to simulated sonic booms. In no instance did the hens desert any poults (young birds), and the poults did not scatter or desert the rest of the brood group. In every observation, the brood group returned to normal activity within 30 seconds after a simulated sonic boom. Similarly, researchers cited in Manci et al. (1988) observed no difference in hatching success of bobwhite quail (*Colinus virginianus*) exposed to simulated sonic booms of 100 to 250 micronewtons per square meter.

Migratory Waterfowl

Fleming et al. (1996) conducted a study of caged American black ducks (*Anas rubripes*) and found that noise had negligible energetic and physiologic effects on adult waterfowl. Measurements included body weight, behavior, heart rate, and enzymatic activity. Experiments also showed that adult ducks exposed to high noise events acclimated rapidly and showed no effects.

The study also investigated the reproductive success of captive ducks and indicated that duckling growth and survival rates at Piney Island, North Carolina, were lower than those at a background location. In contrast, observations of several other reproductive indices (i.e., pair formation, nesting, egg production, and hatching success) showed no difference between Piney Island and the background location. Potential effects on wild duck populations may vary because wild ducks at Piney Island have presumably acclimated to aircraft overflights. It was not demonstrated that noise was the cause of adverse impacts. A variety of other factors, such as weather conditions, drinking water and food availability and variability, disease, and natural variability in reproduction, could explain the observed effects. Fleming noted that drinking water conditions (particularly at Piney Island) deteriorated during the study, which could have affected the growth of young ducks. Further research would be necessary to determine the cause of any reproductive effects (Fleming et al., 1996).

Another study by Conomy et al. (1998) exposed previously unexposed ducks to 71 noise events per day that equaled or exceeded 80 dB. It was determined that the proportion of time black ducks reacted to aircraft activity and noise decreased from 38 percent to 6 percent in 17 days and remained stable at 5.8 percent thereafter. In the same study, the wood duck did not appear to habituate to aircraft disturbance. This supports the notion that animal response to aircraft noise is species-specific. Because a startle response to aircraft noise can result in flushing from nests, migrants and animals living in areas with high concentrations of predators would be the most vulnerable to experiencing effects of lowered birth rates and recruitment over time. Species that are subjected to infrequent overflights do not appear to habituate to overflight disturbance as readily.

Black brant (*Branta bernicla nigricans*) studied in the Alaska Peninsula were exposed to jets and propeller aircraft, helicopters, gunshots, people, boats, and various raptors. Jets accounted for 65 percent of all the disturbances. Humans, eagles, and boats caused a greater percentage of brant to take flight. Brant demonstrated a markedly greater reaction to Bell-206-B helicopter flights than fixed wing, single-engine aircraft flights (Ward et al., 1986).

The presence of humans and low-flying helicopters in the Mackenzie Valley North Slope area did not appear to affect the population density of Lapland longspurs (*Calcarius lapponicus*), but the experimental group was shown to have reduced hatching and fledging success and higher nest abandonment. Human presence appeared to have a greater impact than fixed-wing aircraft on the incubating behavior of the black brant, common eider (*Somateria mollissima*), and Arctic tern (*Sterna paradisaea*) (Gunn and Livingston, 1974).

Gunn and Livingston (1974) found that waterfowl and seabirds in the Mackenzie Valley and North Slope of Alaska and Canada became acclimated to float plane disturbance over the course of three days.

Additionally, it was observed that potential predators (e.g., the bald eagle) caused a number of birds to leave their nests. Non-breeding birds were observed to be more reactive than breeding birds. Waterfowl were affected by helicopter flights, while snow geese (*Chen caerulescens*) were disturbed by Cessna 185 flights. The geese flushed when the planes were less than 1,000 feet AGL compared to higher flight elevations. An overall reduction in flock sizes was observed. It was recommended that aircraft flights be reduced in the vicinity of promigratory staging areas.

Manci et al. (1988) reported that waterfowl were particularly disturbed by aircraft noise. The most sensitive appeared to be snow geese. Canada geese (*Branta Canadensis*) and snow geese were thought to be more sensitive to aircraft noise than other animals such as turkey vultures (*Cathartes aura*), coyotes (*Canis latrans*), and raptors (Edwards et al., 1979).

Wading and Shorebirds

Black et al. (1984) studied the effects of low-altitude (less than 500 feet AGL) military training flights with sound levels from 55 to 100 dB on wading bird colonies (i.e., the great egret [*Ardea alba*], snowy egret [*Egretta thula*] tricolored heron [*Egretta tricolor*], and little blue heron [*Egretta caerulea*]). The training flights involved three or four aircraft and occurred once or twice per day. This study concluded that the reproductive activity--including nest success, nestling survival, and nestling chronology--was independent of F-16 overflights. Dependent variables were more strongly related to ecological factors, including location and physical characteristics of the colony and climatology.

Another study on the effects of circling fixed-wing aircraft and helicopter overflights on wading bird colonies found that at altitudes of 195 to 390 feet, there was no reaction in nearly 75 percent of the 220 observations. Approximately 90 percent displayed no reaction or merely looked toward the direction of the noise source. Another 6 percent stood up, 3 percent walked from the nest, and 2 percent flushed (but were without active nests) and returned within 5 minutes (Kushlan, 1978). Apparently, non-nesting wading birds had a slightly higher incidence of reacting to overflights than nesting birds. Seagulls observed roosting near a colony of wading birds in another study remained at their roosts when subsonic aircraft flew overhead (Burger, 1981). Colony distribution appeared to be most directly correlated to available wetland community types and was found to be distributed randomly with respect to military training routes. These results suggest that wading bird species' presence was most closely linked to habitat availability and that they were not affected by low-level military overflights (U.S. Air Force, 2000).

Burger (1986) studied the response of migrating shorebirds to human disturbance and found that shorebirds did not fly in response to aircraft overflights but did flush in response to more localized intrusions (i.e., humans and dogs on the beach). Burger (1981) studied the effects of noise from JFK Airport in New York on herring gulls (*Larus argentatus*) that nested less than 1 kilometer from the airport. Noise levels over the nesting colony were 85 to 100 dB on approach and 94 to 105 dB on takeoff. Generally, there did not appear to be any prominent adverse effects of subsonic aircraft on nesting, although some birds flushed when the Concorde flew overhead and, when they returned, engaged in aggressive behavior. Groups of gulls tended to loaf in the area of the nesting colony, and these birds remained at the roost when the Concorde flew overhead. Up to 208 of the loafing gulls flew when supersonic aircraft flew overhead. These birds would circle around and immediately land in the loafing flock (U.S. Air Force, 2000).

In 1970, sonic booms were potentially linked to a mass hatch failure of sooty terns (*Onychoprion fuscatus*) on the Dry Tortugas (Austin et al., 1970). The cause of the failure was not certain, but it was conjectured that sonic booms from military aircraft or an overgrowth of vegetation were factors. In the previous season, sooty terns were observed to have reacted to sonic booms by rising in a "panic flight," circling over the island, then usually settling down on their eggs again. Hatching that year was normal. Following the 1969 hatch failure, excess vegetation was cleared, and measures were taken to reduce supersonic activity. The 1970 hatch appeared to proceed normally. A colony of noddies (*Anous* spp.) on the same island hatched successfully in 1969, the year of the sooty tern hatch failure.

Subsequent laboratory tests of exposure of eggs to sonic booms and other impulsive noises (Cottereau, 1972; Cogger and Zegarra, 1980; Bowles et al., 1991, 1994) failed to show adverse effects on hatching of eggs. A structural analysis by Ting et al. (2002) showed that, even under extraordinary circumstances, sonic booms would not damage an avian egg.

Burger (1981) observed no effects of subsonic aircraft on herring gulls in the vicinity of JFK International Airport. The Concorde aircraft did cause more nesting gulls to leave their nests (especially in areas of higher density of nests), causing the breakage of eggs and the scavenging of eggs by intruder prey.

Clutch sizes were observed to be smaller in areas of higher-density nesting (presumably due to the greater tendency for panic flight) than in areas where there were fewer nests.

Raptors

In a literature review of raptor responses to aircraft noise, Manci et al. (1988) found that most raptors did not show a negative response to overflights. When negative responses were observed, they were predominantly associated with rotor-winged aircraft or jet aircraft that were repeatedly passing within 0.5 mile of a nest.

Ellis et al. (1991) performed a study to estimate the effects of low-level military jet aircraft and mid- to high-altitude sonic booms (both actual and simulated) on nesting peregrine falcons (*Falco peregrinus*) and seven other raptors (common black-hawk [*Buteogallus anthracinus*], Harris' hawk [*Parabuteo unicinctus*], zone-tailed hawk [*Buteo albonotatus*], red-tailed hawk, golden eagle, prairie falcon [*Falco mexicanus*], and bald eagle). They observed responses to test stimuli, determined nest success for the year of the testing, and evaluated site occupancy the following year. Both long- and short-term effects were noted in the study. The results reported the successful fledging of young in 34 of 38 nest sites (including all eight species) subjected to low-level flight and/or simulated sonic booms. Twenty-two of the test sites were revisited in the following year, and observations of pairs or lone birds were made at all but one nest. Nesting attempts were underway at 19 of 20 sites that were observed long enough to be certain of breeding activity. Reoccupancy and productivity rates were within or above expected values for self-sustaining populations.

Short-term behavior responses were also noted. Overflights at a distance of 150 meters or less produced few significant responses and no severe responses. Typical responses consisted of crouching or, very rarely, flushing from the perch site. Significant responses were most evident before egg laying and after young were "well grown." Incubating or brooding adults never burst from the nest, thus preventing egg breaking or knocking chicks out of the nest. Jet passes and sonic booms often caused noticeable alarm; however, significant negative responses were rare and did not appear to limit productivity or re-occupancy. Due to the locations of some of the nests, some birds may have been habituated to aircraft noise. There were some test sites located at distances far from zones of frequent military aircraft usage, and the test stimuli were often closer, louder, and more frequent than would be likely for a normal training situation (Ellis et al., 1991).

Manci et al. (1988) noted that a female northern harrier (*Circus hudsonius*) was observed hunting on a bombing range in Mississippi during bombing exercises. The harrier was apparently unfazed by the exercises, even when a bomb exploded within 200 feet. In a similar case of habituation/non-disturbance, a study on the Florida snail-kite (*Rostrhamus sociabilis*) stated that the greatest reaction by that species to overflights (approximately 98 dB) was “watching the aircraft fly by.” No detrimental impacts to distribution, breeding success, or behavior were noted.

Fish and Amphibians

The effects of overflight noise on fish and amphibians have not been well studied, but conclusions regarding their expected responses have involved speculation based upon known physiologies and behavioral traits of these taxa (Gladwin et al., 1988). Although fish do startle in response to noise from low-flying aircraft, and probably to the shadows of aircraft, they have been found to habituate to the sound and overflights. Amphibians that respond to low frequencies and those that respond to ground vibration, such as spadefoot toads, may be affected by noise.

Summary

Some physiological/behavioral responses such as increased hormonal production, increased heart rate, and reduction in milk production have been described in a small percentage of studies. A majority of the studies focusing on these types of effects have reported short-term or no effects.

The relationships between physiological effects and how species interact with their environments have not been thoroughly studied. Therefore, the larger ecological context issues regarding physiological effects of jet aircraft noise (if any) and resulting behavioral pattern changes are not well understood.

Animal species exhibit a wide variety of responses to noise. It is therefore difficult to generalize animal responses to noise disturbances or to draw inferences across species because reactions to jet aircraft noise appear to be species-specific. Consequently, some animal species may be more sensitive than other species and/or may exhibit different forms or intensities of behavioral responses. For instance, wood ducks appear to be more sensitive and more resistant to acclimation to jet aircraft noise than Canada geese in one study. Similarly, wild ungulates seem to be more easily disturbed than domestic animals.

The literature does suggest that common responses include the “startle” or “fright” response and, ultimately, habituation. It has been reported that the intensities and durations of the startle response decrease with the number and frequency of exposures, suggesting no long-term adverse effects. The majority of the literature suggests that domestic animal species (e.g., cows, horses, chickens) and wildlife species exhibit adaptation, acclimation, and habituation after repeated exposure to jet aircraft noise and sonic booms.

Animal responses to aircraft noise appear to be somewhat dependent on, or influenced by, the size, shape, speed, proximity (vertical and horizontal), engine noise, color, and flight profile of the aircraft. Helicopters also appear to induce greater intensities and durations of disturbance behavior as compared to fixed-wing aircraft. Some studies showed that animals that had been previously exposed to jet aircraft noise exhibited greater degrees of alarm and disturbance to other objects creating noise, such as boats, people, and objects blowing across the landscape. Other factors influencing response to jet aircraft noise may include wind direction, speed, and local air turbulence; landscape structures (i.e., amount and type of vegetative cover); and, in the case of bird species, whether the animals are in the incubation/nesting phase.

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ATTACHMENT 2
Supporting Modeling Details

TNI Modeled Flight Tracks

TNI Modeled Representative Flight Profiles

MLA Modeled Flight Areas and Flight Profiles

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Maps of TNI Flight Profiles

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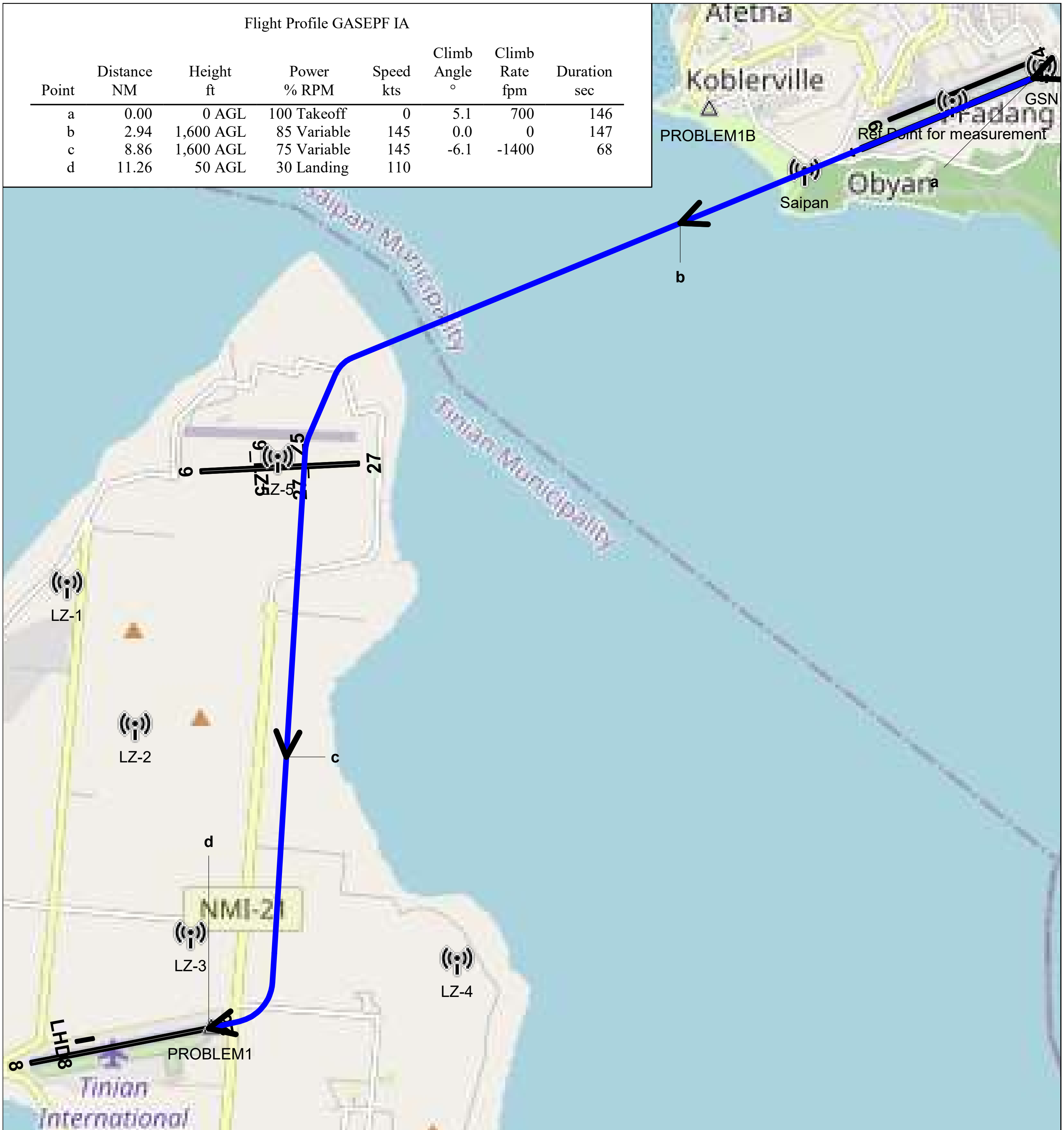
Flight Profile GASEPF IA

Point	Distance NM	Height ft	Power % RPM	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0.00	0 AGL	100 Takeoff	0	5.1	700	146
b	2.94	1,600 AGL	85 Variable	145	0.0	0	147
c	8.86	1,600 AGL	75 Variable	145	-6.1	-1400	68
d	11.26	50 AGL	30 Landing	110			



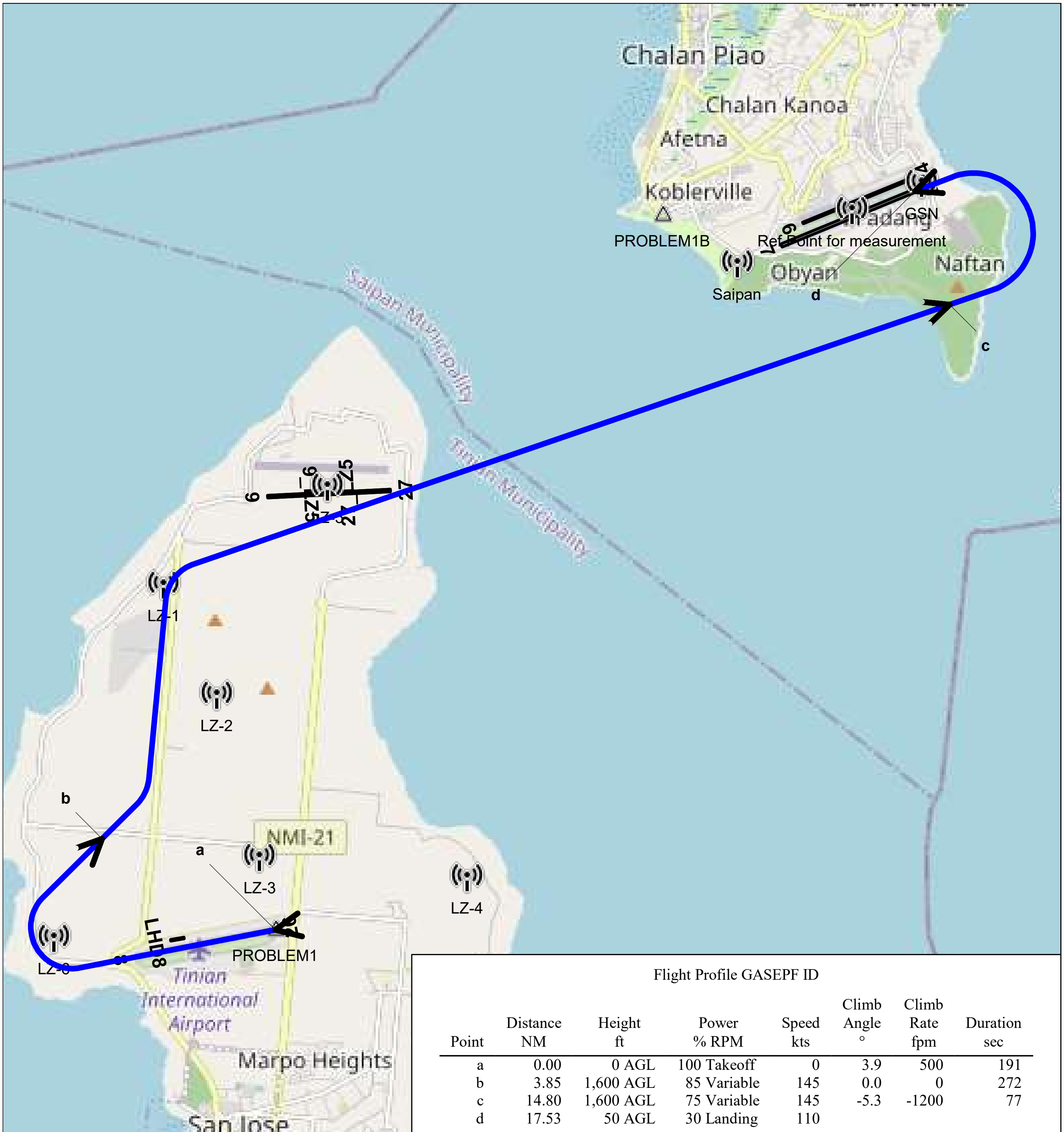
Civilian Flight Profile GASEPF IA

Flight Track 25I1 - INTERFACILITY SAIPAN TO TINIAN

0 4,000 8,000 12,000 16,000 20,000 24,000

Scale in Feet 1:82,300 (1 inch = 6,860 feet)

N



Flight Profile GASEPF ID

Point	Distance NM	Height ft	Power % RPM	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0.00	0 AGL	100 Takeoff	0	3.9	500	191
b	3.85	1,600 AGL	85 Variable	145	0.0	0	272
c	14.80	1,600 AGL	75 Variable	145	-5.3	-1200	77
d	17.53	50 AGL	30 Landing	110			

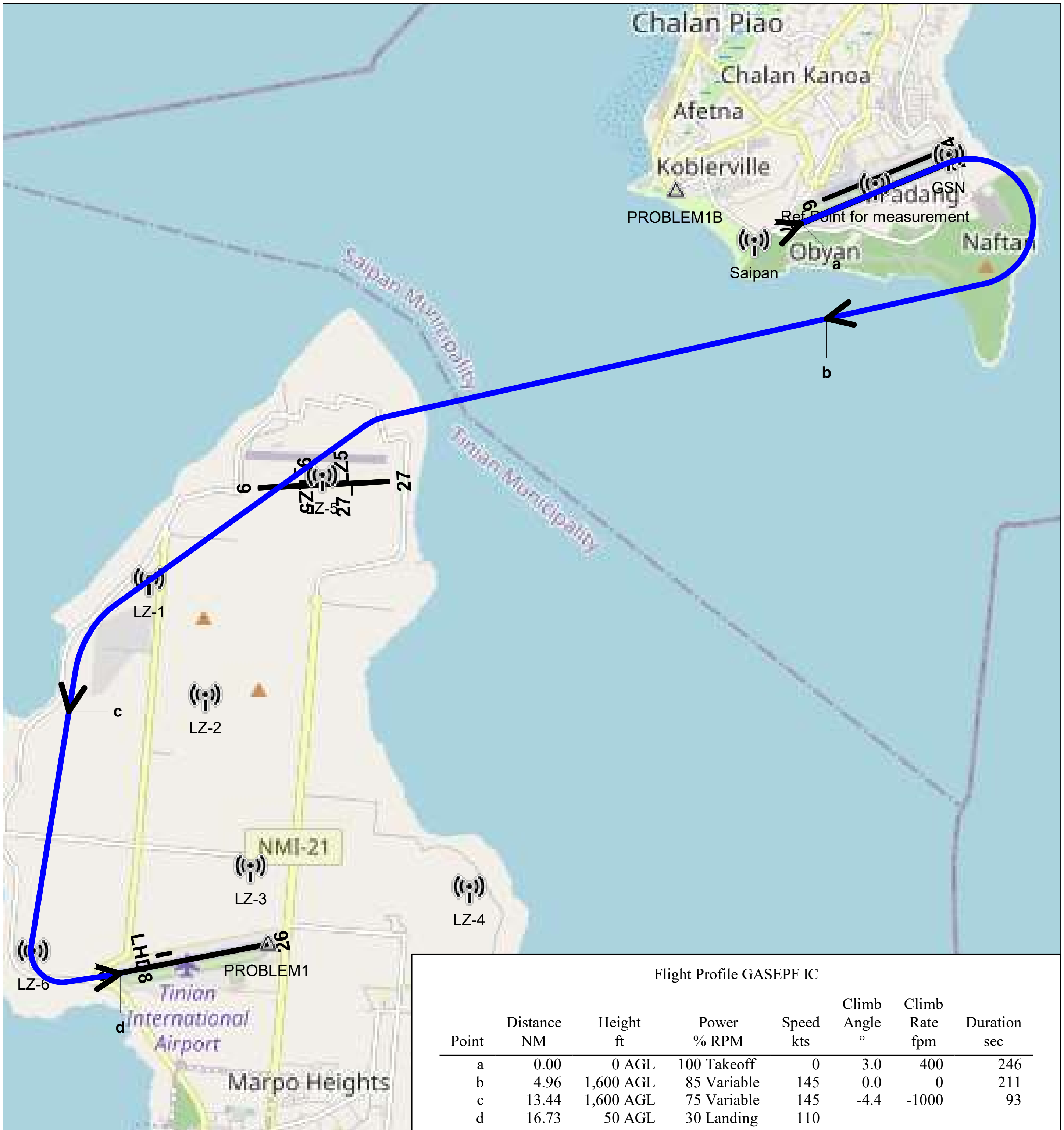
Civilian Flight Profile GASEPF ID

Flight Track 26I1 - INTERFACILITY TINIAN TO SAIPAN

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000

Scale in Feet 1:106,000 (1 inch = 8,820 feet)

N



Flight Profile GASEPF IC

Point	Distance NM	Height ft	Power % RPM	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0.00	0 AGL	100 Takeoff	0	3.0	400	246
b	4.96	1,600 AGL	85 Variable	145	0.0	0	211
c	13.44	1,600 AGL	75 Variable	145	-4.4	-1000	93
d	16.73	50 AGL	30 Landing	110			

Civilian Flight Profile GASEPF IC

Flight Track 07I1 - INTERFACILITY SAIPAN TO TINIAN

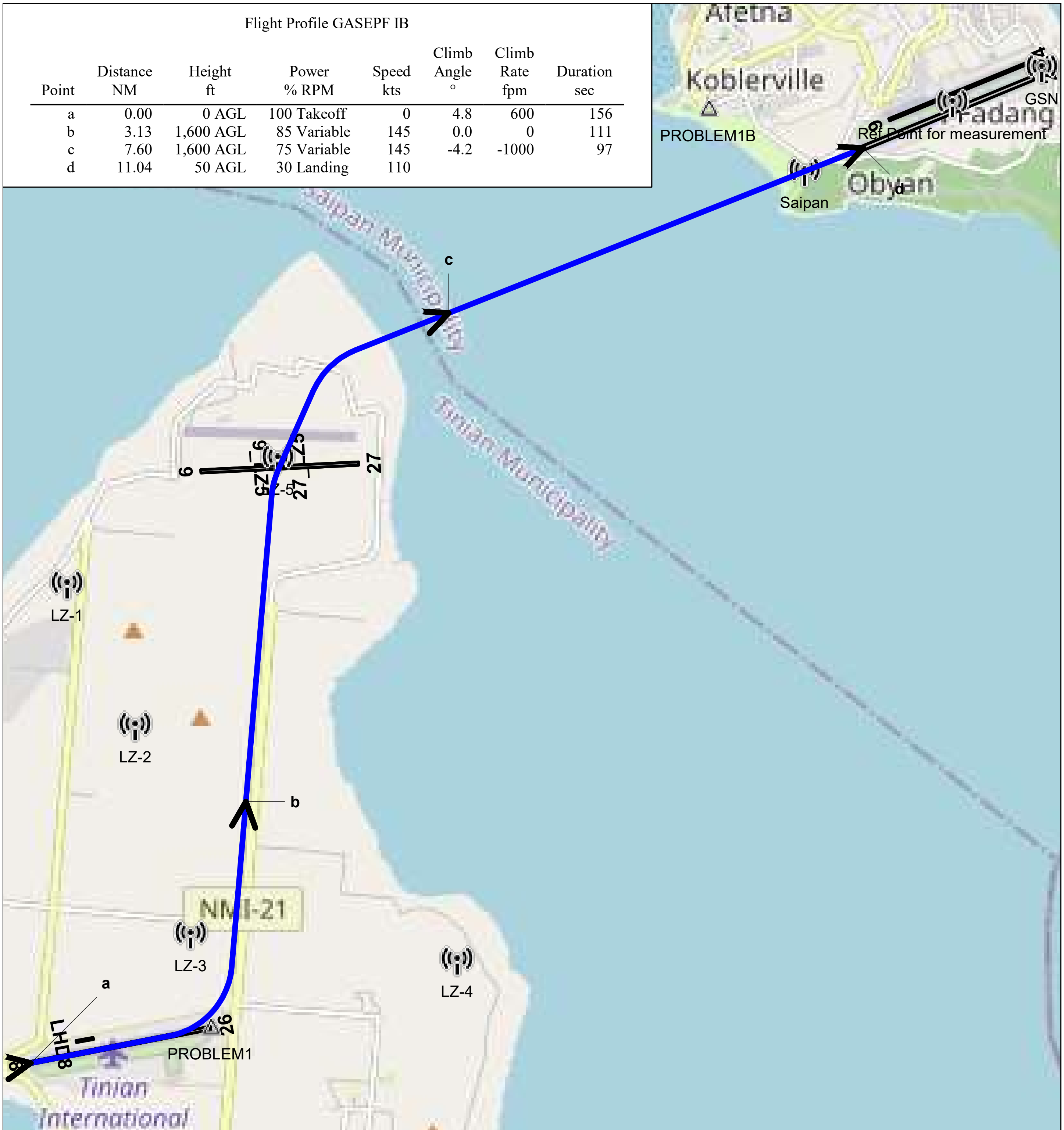
0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000

Scale in Feet 1:100,000 (1 inch = 8,370 feet)

N

Flight Profile GASEPF IB

Point	Distance NM	Height ft	Power % RPM	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0.00	0 AGL	100 Takeoff	0	4.8	600	156
b	3.13	1,600 AGL	85 Variable	145	0.0	0	111
c	7.60	1,600 AGL	75 Variable	145	-4.2	-1000	97
d	11.04	50 AGL	30 Landing	110			



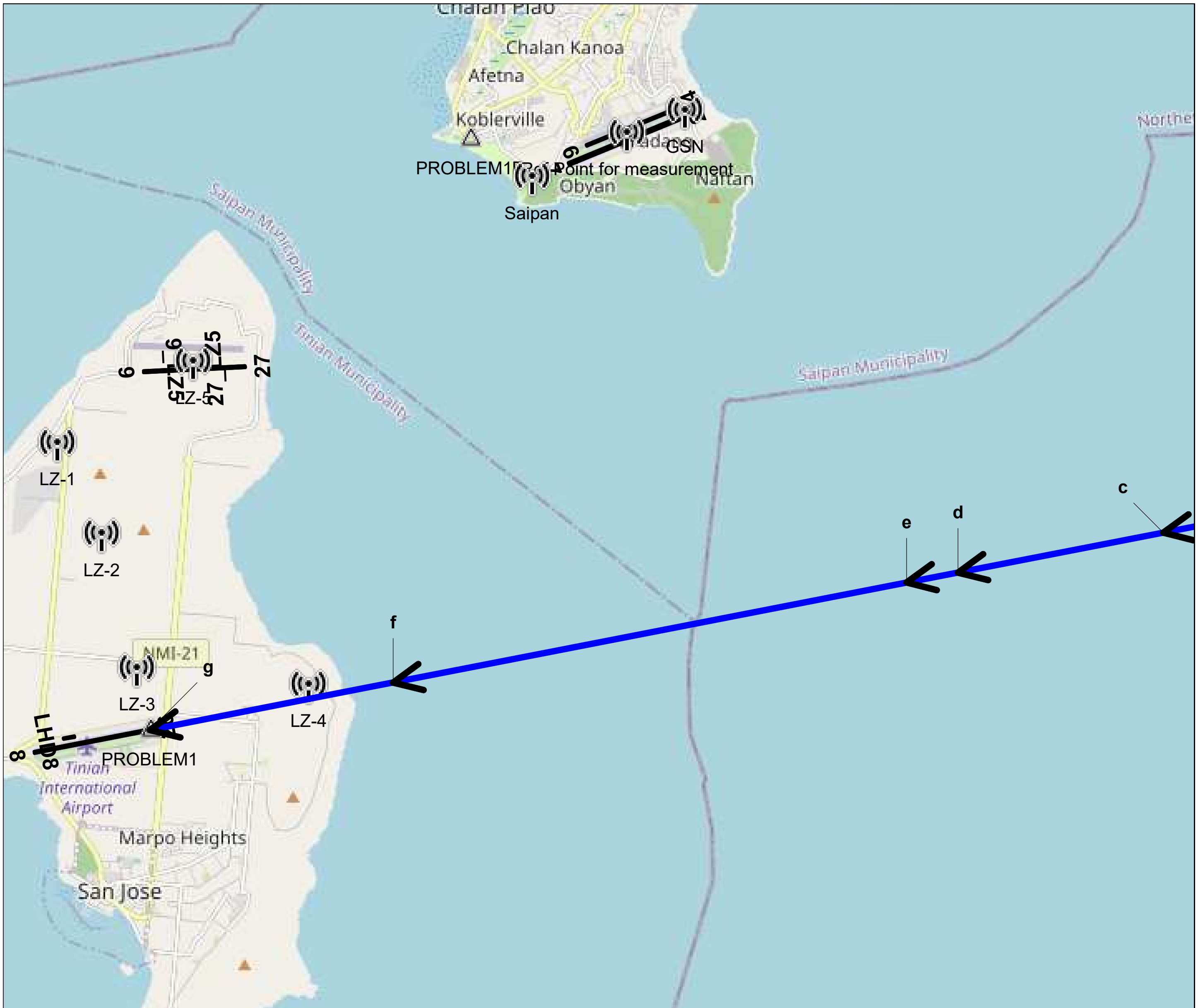
Civilian Flight Profile GASEPF IB

Flight Track 08I1 - INTERFACILITY TINIAN TO SAIPAN

0 4,000 8,000 12,000 16,000 20,000 24,000

Scale in Feet 1:82,300 (1 inch = 6,860 feet)

N



Flight Profile B-747_AE

Point	Distance NM	Height ft	Power LBS	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	10,580 AGL	8240 Variable	250	-3.0	-1300	205
b	18.67	6,000 AGL	8340 Variable	250	-3.0	-1300	90
c	12.39	4,000 AGL	8340 Variable	250	-3.0	-1100	45
d	9.88	3,200 AGL	8340 Variable	151	-3.0	-800	15
e	9.26	3,000 AGL	8340 Variable	151	-3.0	-800	150
f	2.97	1,000 AGL	8340 Variable	151	-3.0	-800	71
g	0.00	50 AGL	8340 Variable	151			

Military Flight Profile B-747_AE

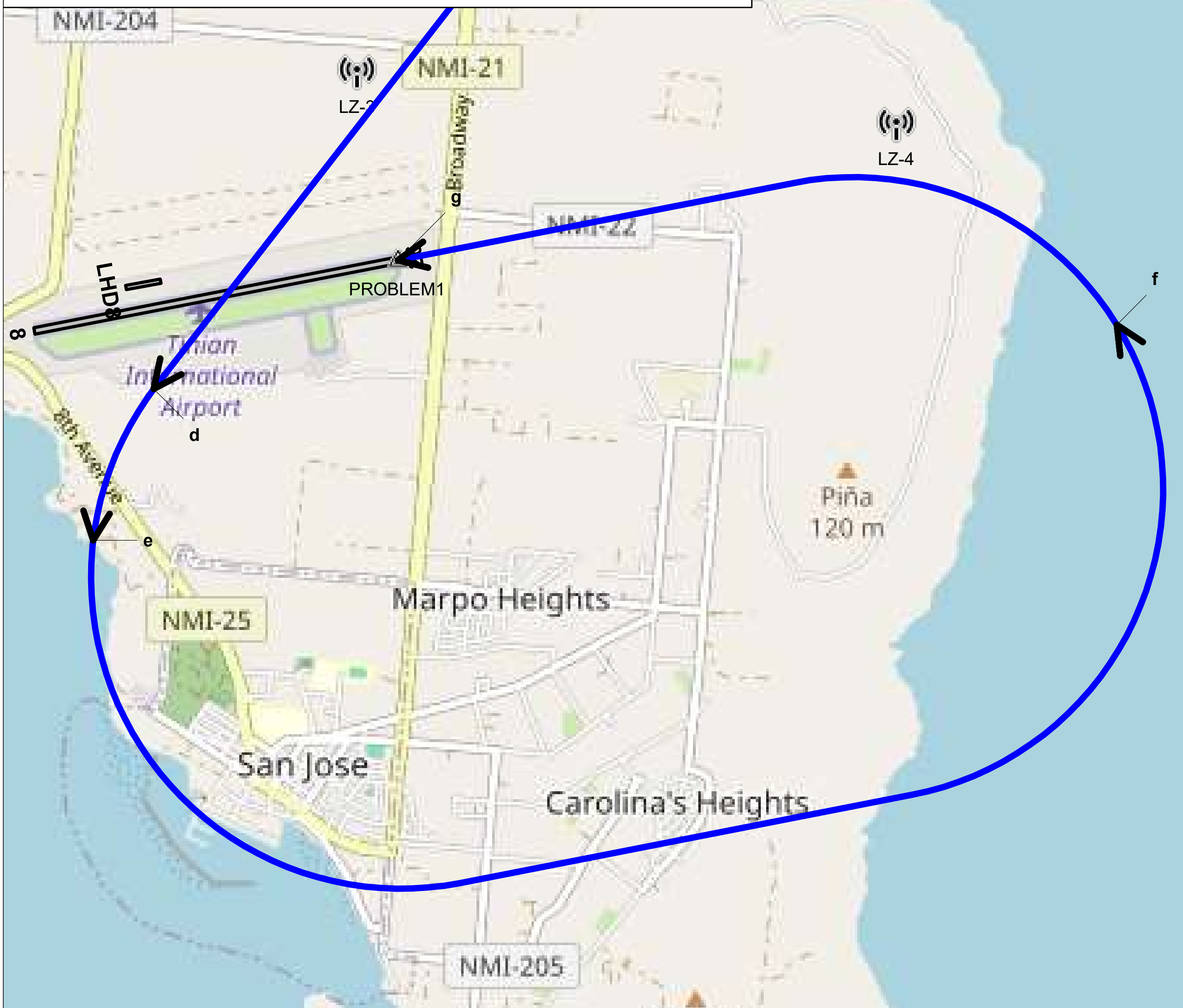
Flight Track 26A1 - RNAV ARRIVAL

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000 40,000 44,000 48,000

Scale in Feet 1:144,000 (1 inch = 12,000 feet)

Flight Profile B-747_AF

Point	Distance NM	Height ft	Power LBS	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	10,580 AGL	8240 Variable	250	-3.0	-1300	205
b	18.67	6,000 AGL	8340 Variable	250	-3.0	-1300	90
c	12.39	4,000 AGL	8340 Variable	250	-3.0	-1100	45
d	9.88	3,200 AGL	8340 Variable	151	-3.0	-800	15
e	9.26	3,000 AGL	8340 Variable	151	-3.0	-800	150
f	2.97	1,000 AGL	8340 Variable	151	-3.0	-800	71
g	0.00	50 AGL	8340 Variable	151			



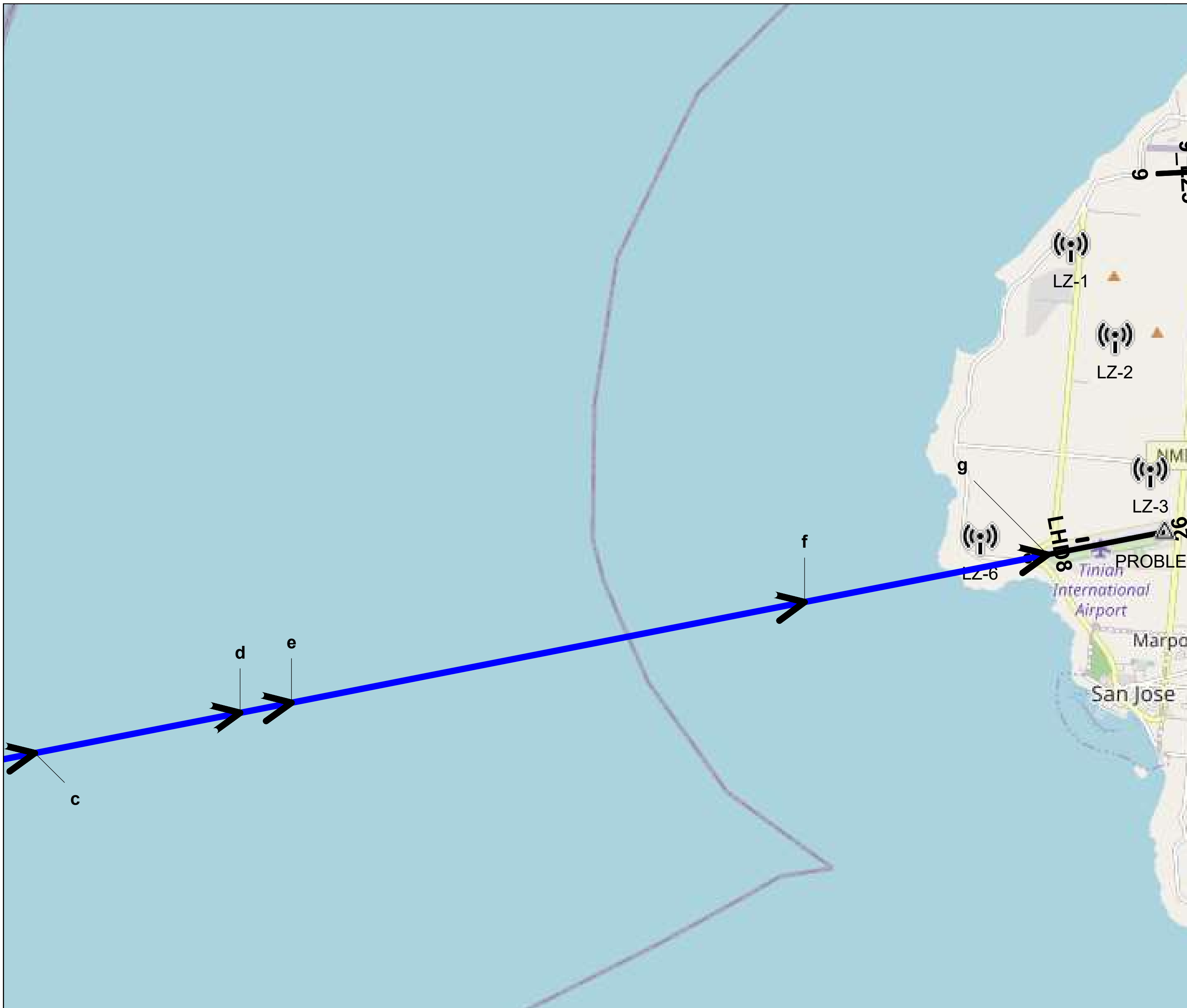
Military Flight Profile B-747_AF

Flight Track 26A2_2 - NDB ARRIVAL

0 2,000 4,000 6,000 8,000 10,000 12,000 14,000

Scale in Feet 1:45,800 (1 inch = 3,820 feet)

N



Flight Profile B-747_AA

Point	Distance NM	Height ft	Power LBS	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	10,580 AGL	8240 Variable	250	-3.0	-1300	205
b	18.67	6,000 AGL	8340 Variable	250	-3.0	-1300	90
c	12.39	4,000 AGL	8340 Variable	250	-3.0	-1100	45
d	9.88	3,200 AGL	8340 Variable	151	-3.0	-800	15
e	9.26	3,000 AGL	8340 Variable	151	-3.0	-800	150
f	2.97	1,000 AGL	8340 Variable	151	-3.0	-800	71
g	0.00	50 AGL	8340 Variable	151			

Military Flight Profile B-747_AA

Flight Track 08A1 - RNAV ARRIVAL

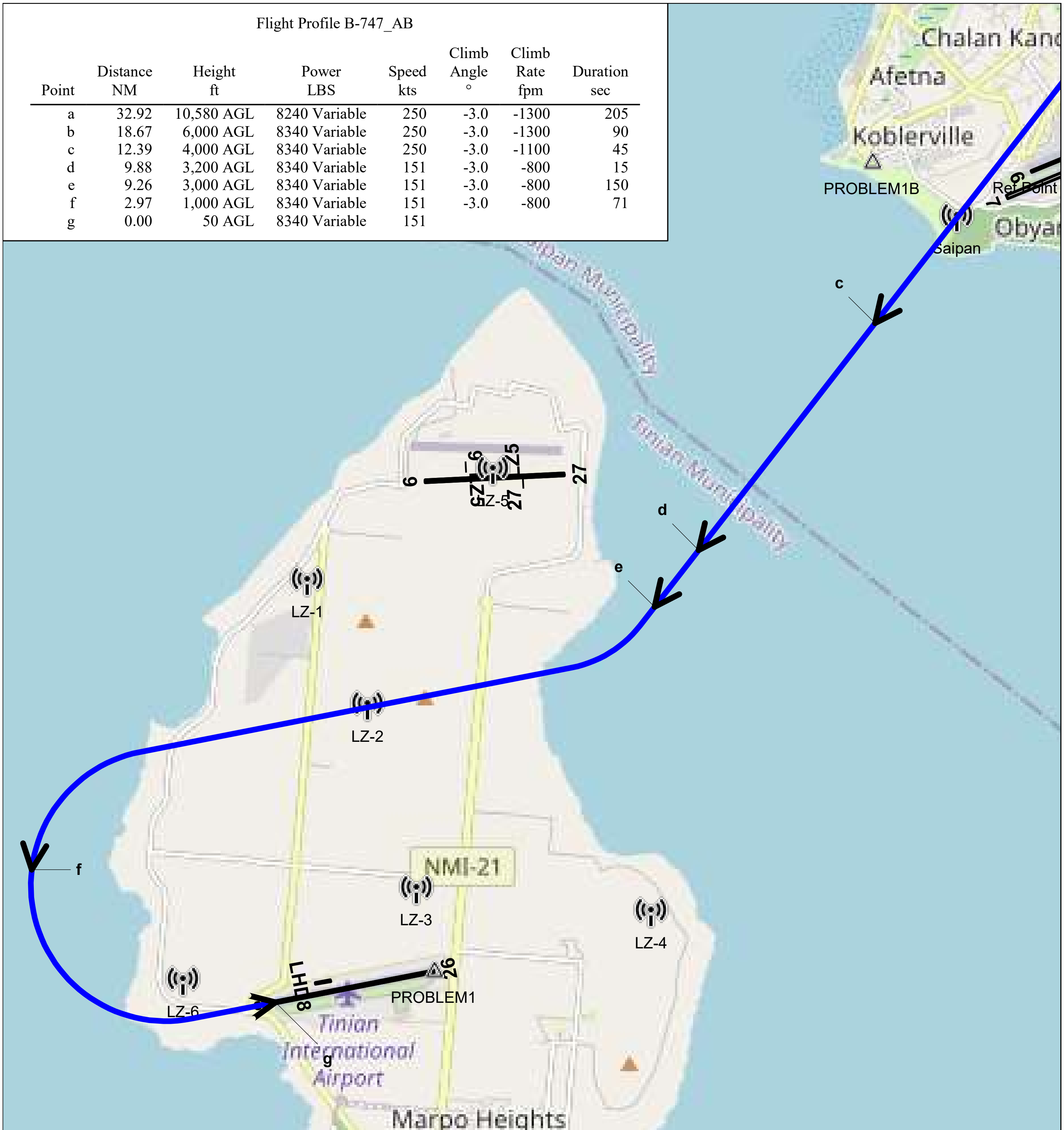
0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000 40,000 44,000 48,000

Scale in Feet 1:144,000 (1 inch = 12,000 feet)

N

Flight Profile B-747_AB

Point	Distance NM	Height ft	Power LBS	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	10,580 AGL	8240 Variable	250	-3.0	-1300	205
b	18.67	6,000 AGL	8340 Variable	250	-3.0	-1300	90
c	12.39	4,000 AGL	8340 Variable	250	-3.0	-1100	45
d	9.88	3,200 AGL	8340 Variable	151	-3.0	-800	15
e	9.26	3,000 AGL	8340 Variable	151	-3.0	-800	150
f	2.97	1,000 AGL	8340 Variable	151	-3.0	-800	71
g	0.00	50 AGL	8340 Variable	151			



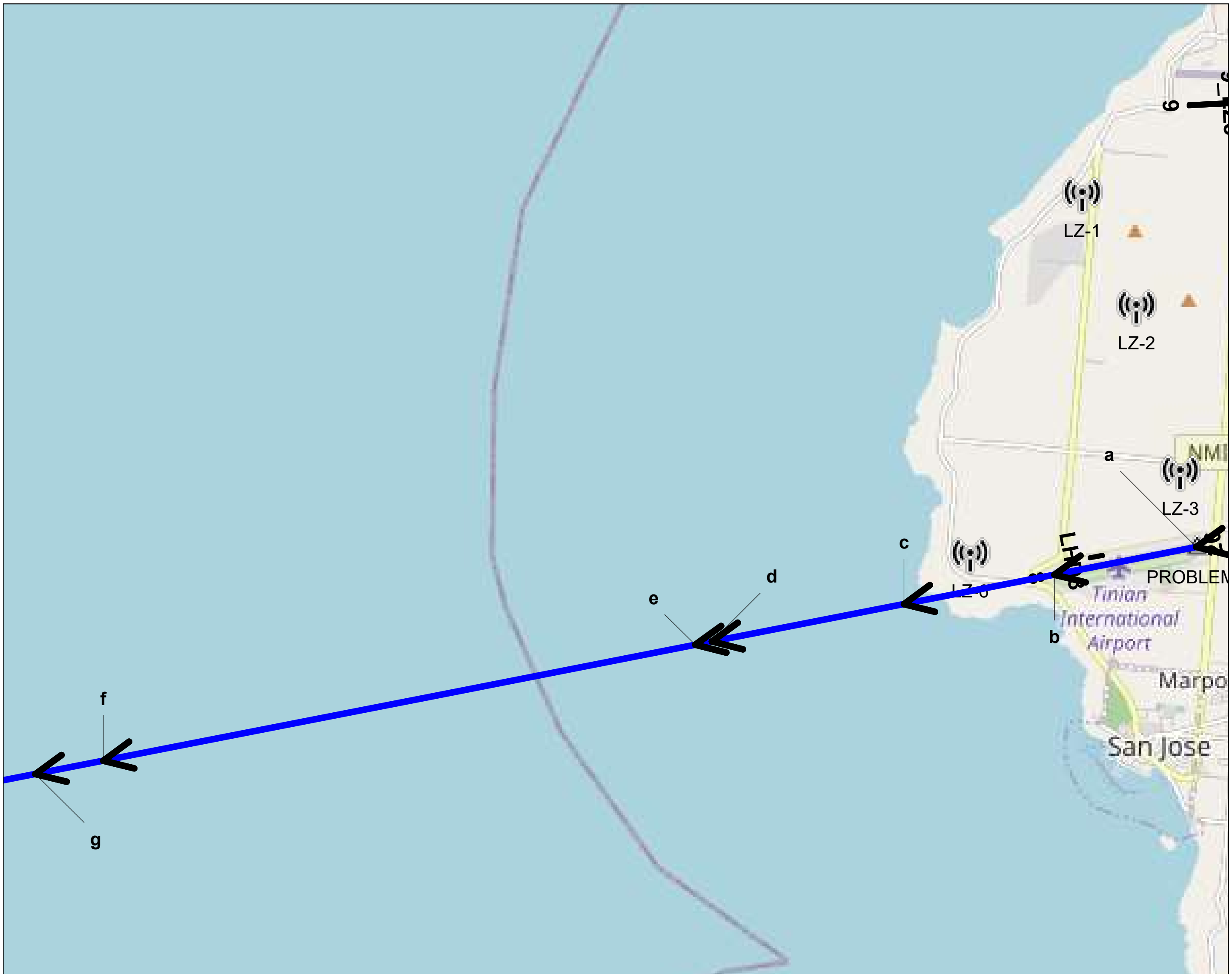
Military Flight Profile B-747_AB

Flight Track 08A2_2 - NDB ARRIVAL

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000

Scale in Feet 1:93,500 (1 inch = 7,790 feet)

N



Flight Profile B-747_DB

Point	Distance NM	Height ft	Power LBS	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0.00	0 AGL	34530 Variable	0	0.0	0	58
b	1.41	0 AGL	34530 Variable	175	6.3	2000	31
c	2.90	1,000 AGL	34530 Variable	175	3.9	1300	37
d	4.80	1,794 AGL	34530 Variable	200	1.5	500	3
e	4.97	1,820 AGL	23954 Variable	201	1.5	600	94
f	10.84	2,760 AGL	23954 Variable	250	3.4	1500	10
g	11.51	3,000 AGL	23954 Variable	250	3.0	1300	112
h	19.28	5,500 AGL	23954 Variable	250	2.5	1100	108
i	26.77	7,500 AGL	23954 Variable	250	4.5	2000	75
j	32.00	10,000 AGL	23954 Variable	250			

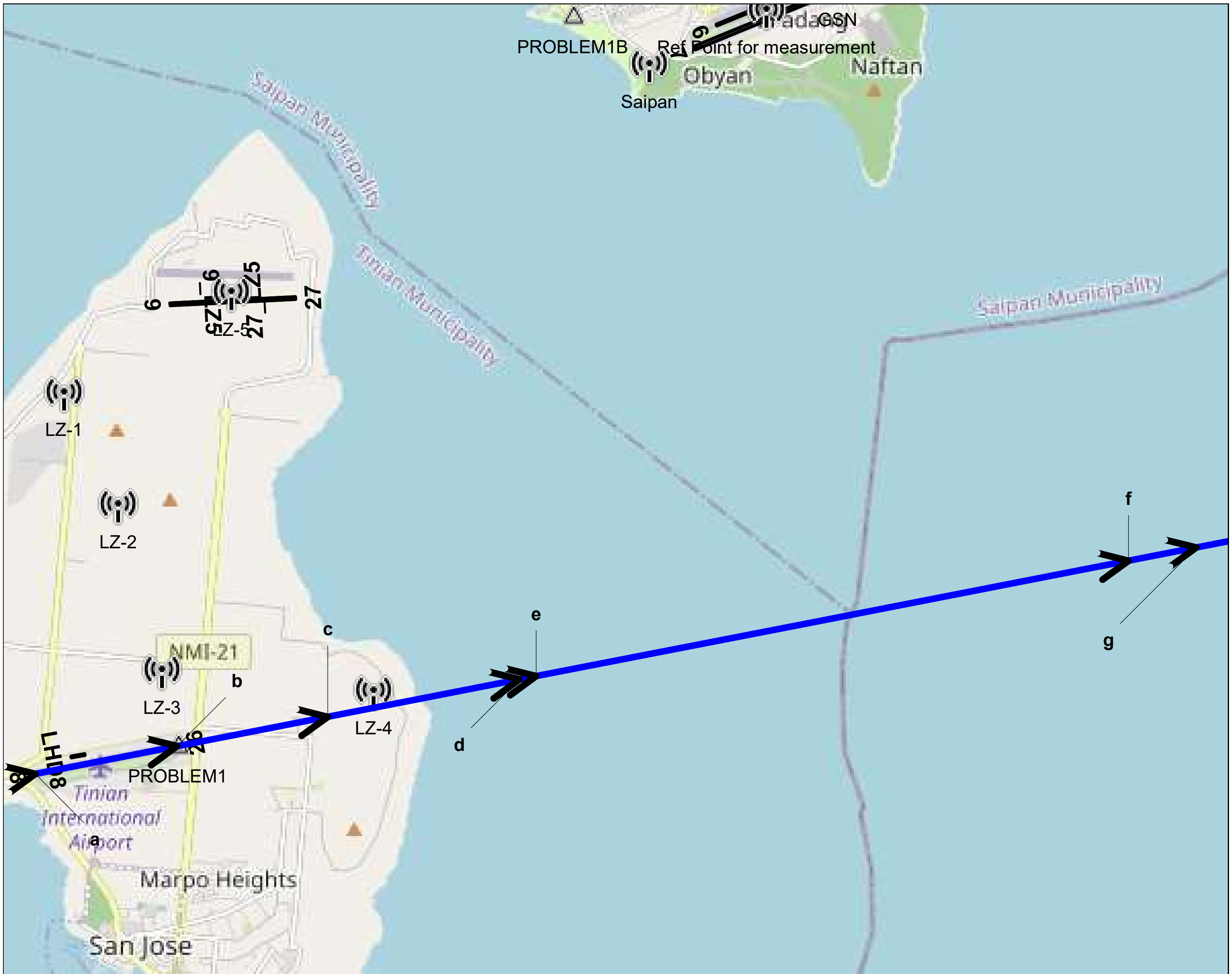
Military Flight Profile B-747_DB

Flight Track 26D1 - STANDARD DEPARTURE

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000 40,000

Scale in Feet 1:120,000 (1 inch = 10,000 feet)

N



Flight Profile B-747_DA

Point	Distance NM	Height ft	Power LBS	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0.00	0 AGL	34530 Variable	0	0.0	0	58
b	1.41	0 AGL	34530 Variable	175	6.3	2000	31
c	2.90	1,000 AGL	34530 Variable	175	3.9	1300	37
d	4.80	1,794 AGL	34530 Variable	200	1.5	500	3
e	4.97	1,820 AGL	23954 Variable	201	1.5	600	94
f	10.84	2,760 AGL	23954 Variable	250	3.4	1500	10
g	11.51	3,000 AGL	23954 Variable	250	3.0	1300	112
h	19.28	5,500 AGL	23954 Variable	250	2.5	1100	108
i	26.77	7,500 AGL	23954 Variable	250	4.5	2000	75
j	32.00	10,000 AGL	23954 Variable	250			

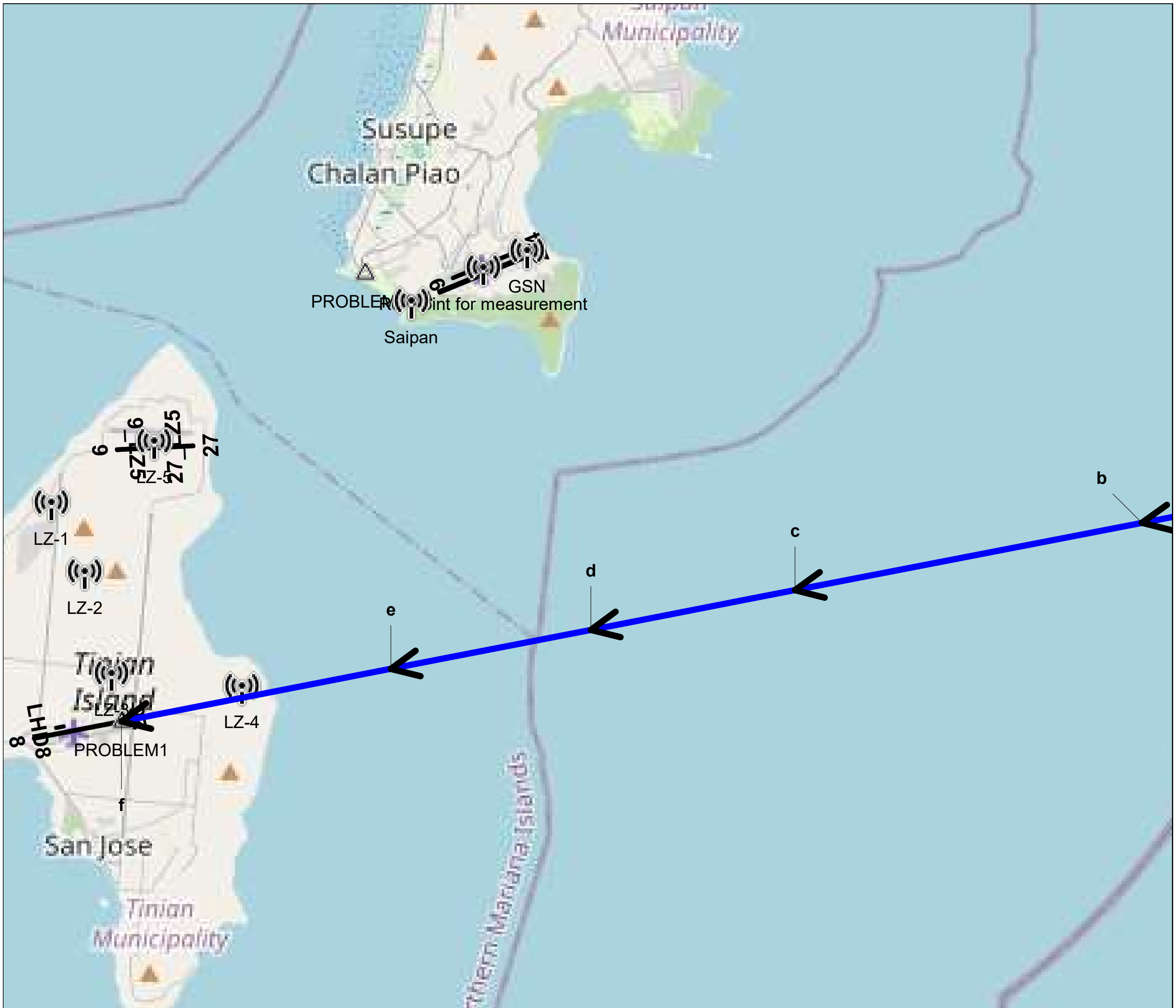
Military Flight Profile B-747_DA

Flight Track 08D1 - STANDARD DEPARTURE

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000 40,000

Scale in Feet 1:120,000 (1 inch = 10,000 feet)

N



Flight Profile C-12_AE1

Point	Distance NM	Height ft	Power % RPM	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	8,000 AGL	90 Variable	190	-2.0	-700	320
b	16.46	4,500 AGL	93 Variable	180	-1.8	-500	122
c	10.86	3,450 AGL	93 Variable	150	-3.0	-700	85
d	7.57	2,400 AGL	93 Variable	130	-2.9	-700	89
e	4.34	1,400 AGL	85 Variable	130	-2.9	-600	125
f	0.00	50 AGL	30 Variable	120			

Military Flight Profile C-12_AE1

Flight Track 26A1 - RNAV ARRIVAL

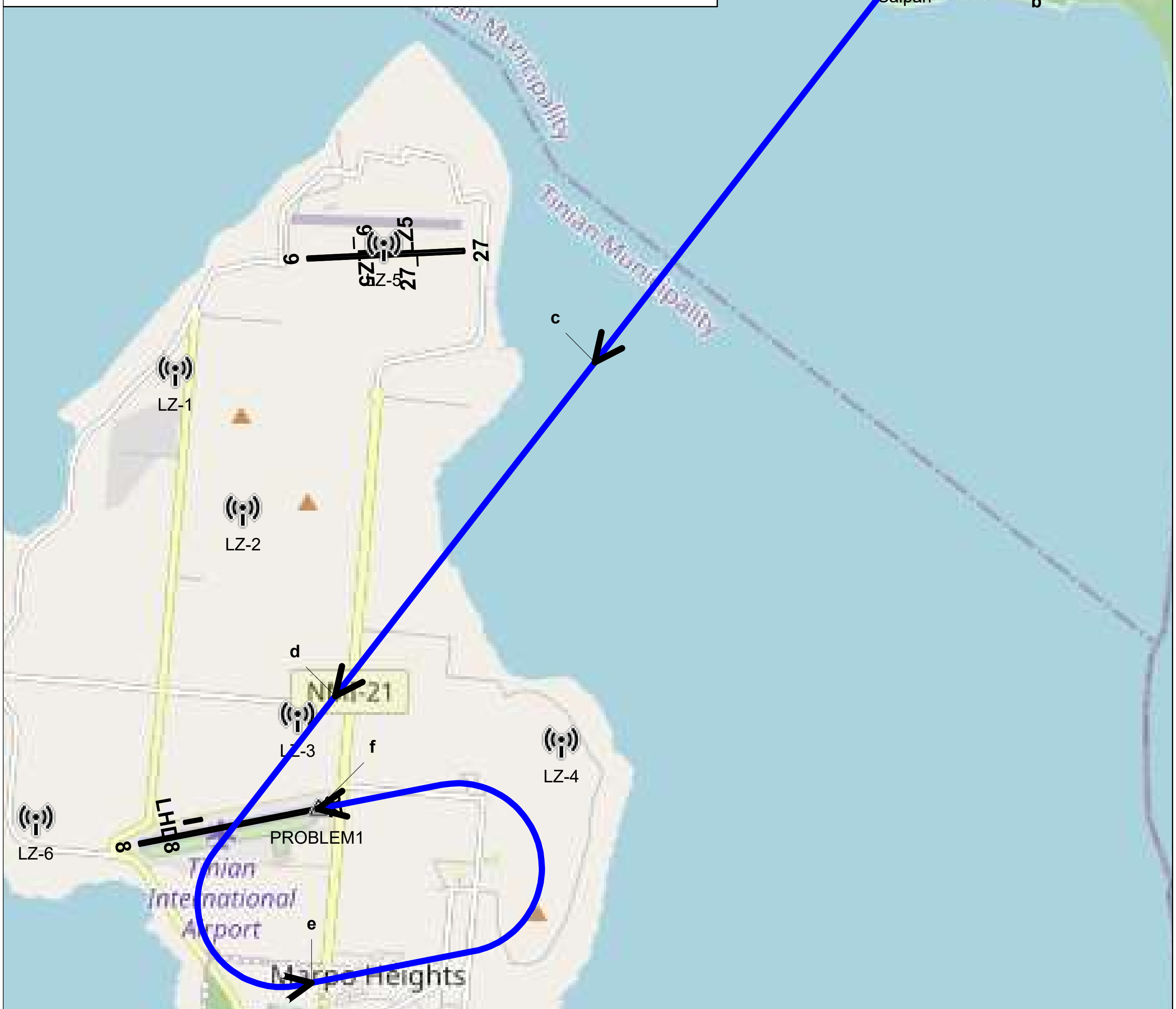
0 10,000 20,000 30,000 40,000 50,000 60,000

Scale in Feet 1:186,000 (1 inch = 15,500 feet)

N

Flight Profile C-12_AF1

Point	Distance NM	Height ft	Power % RPM	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	8,000 AGL	90 Variable	190	-2.0	-700	320
b	16.46	4,500 AGL	93 Variable	180	-1.8	-500	122
c	10.86	3,450 AGL	93 Variable	150	-3.0	-700	85
d	7.57	2,400 AGL	93 Variable	130	-2.9	-700	89
e	4.34	1,400 AGL	85 Variable	130	-2.9	-600	125
f	0.00	50 AGL	30 Variable	120			

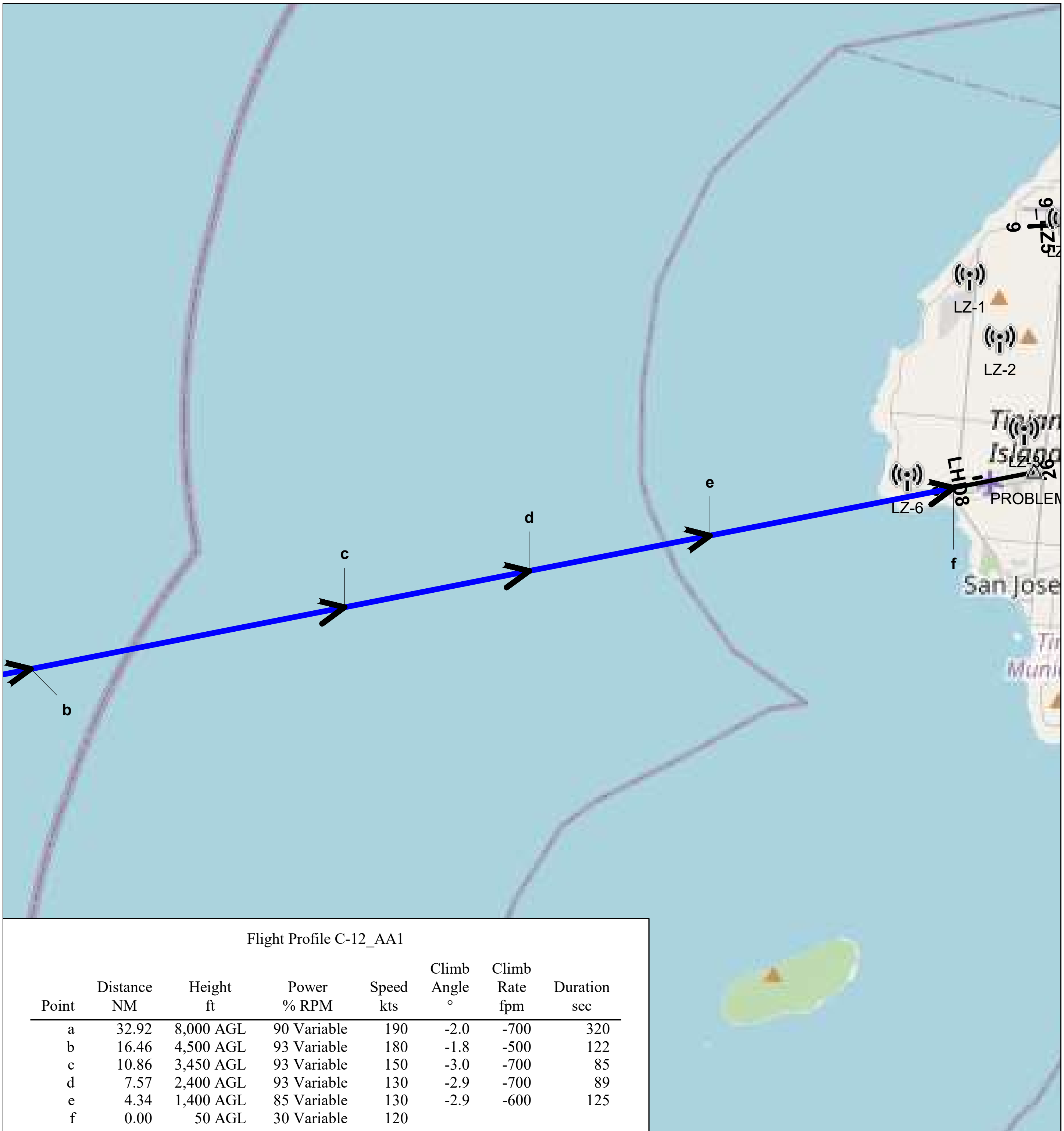


Military Flight Profile C-12_AF1
Flight Track 26A2 - NDB ARRIVAL

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000

Scale in Feet 1:92,000 (1 inch = 7,670 feet)

N



Flight Profile C-12_AA1

Point	Distance NM	Height ft	Power % RPM	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	8,000 AGL	90 Variable	190	-2.0	-700	320
b	16.46	4,500 AGL	93 Variable	180	-1.8	-500	122
c	10.86	3,450 AGL	93 Variable	150	-3.0	-700	85
d	7.57	2,400 AGL	93 Variable	130	-2.9	-700	89
e	4.34	1,400 AGL	85 Variable	130	-2.9	-600	125
f	0.00	50 AGL	30 Variable	120			

Military Flight Profile C-12_AA1

Flight Track 08A1 - RNAV ARRIVAL

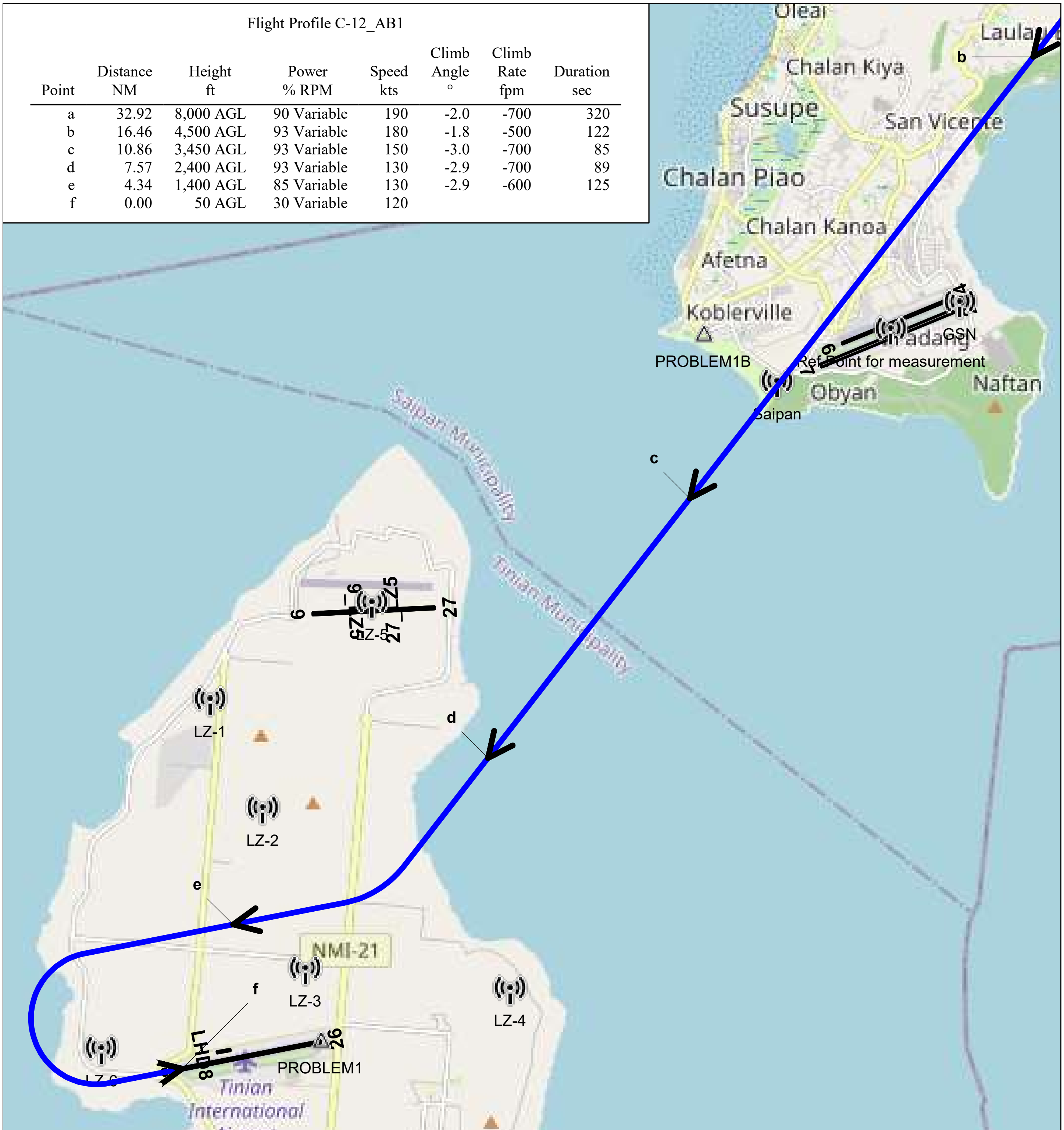
0 10,000 20,000 30,000 40,000 50,000 60,000

Scale in Feet 1:186,000 (1 inch = 15,500 feet)

N

Flight Profile C-12_AB1

Point	Distance NM	Height ft	Power % RPM	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	8,000 AGL	90 Variable	190	-2.0	-700	320
b	16.46	4,500 AGL	93 Variable	180	-1.8	-500	122
c	10.86	3,450 AGL	93 Variable	150	-3.0	-700	85
d	7.57	2,400 AGL	93 Variable	130	-2.9	-700	89
e	4.34	1,400 AGL	85 Variable	130	-2.9	-600	125
f	0.00	50 AGL	30 Variable	120			

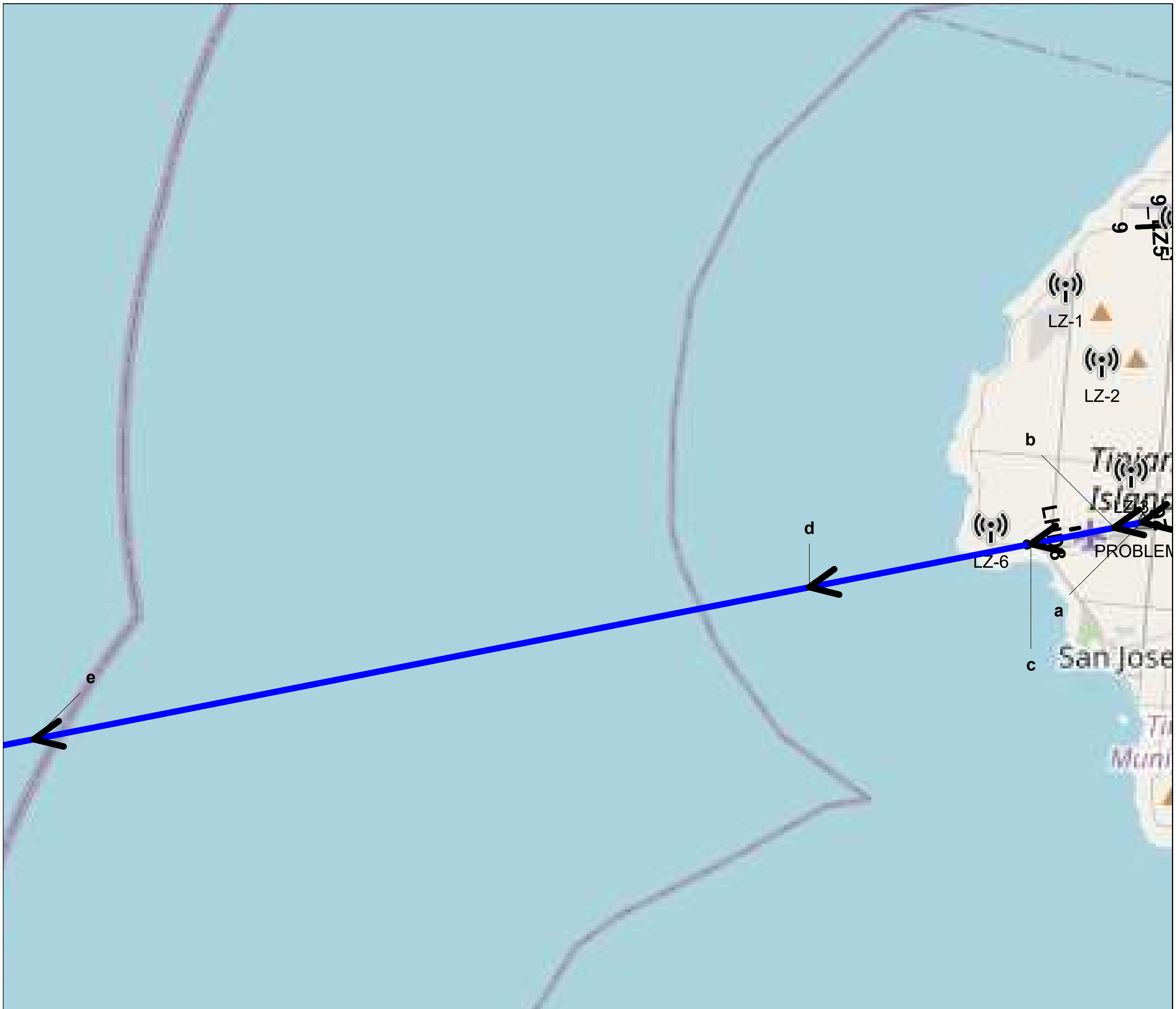


Military Flight Profile C-12_AB1
Flight Track 08A2 - NDB ARRIVAL

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000

Scale in Feet 1:107,000 (1 inch = 8,920 feet)

N



Flight Profile C-12 _DB1

Point	Distance NM	Height ft	Power % RPM	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0.00	0 AGL	98.1 Variable	0	0.0	0	23
b	0.41	0 AGL	100 Variable	130	3.8	1000	31
c	1.65	500 AGL	98 Variable	155	6.3	1700	76
d	4.94	2,700 AGL	95 Variable	155	1.6	400	268
e	16.46	4,700 AGL	95 Variable	155	3.0	800	382
f	32.92	10,000 AGL	95 Variable	155			

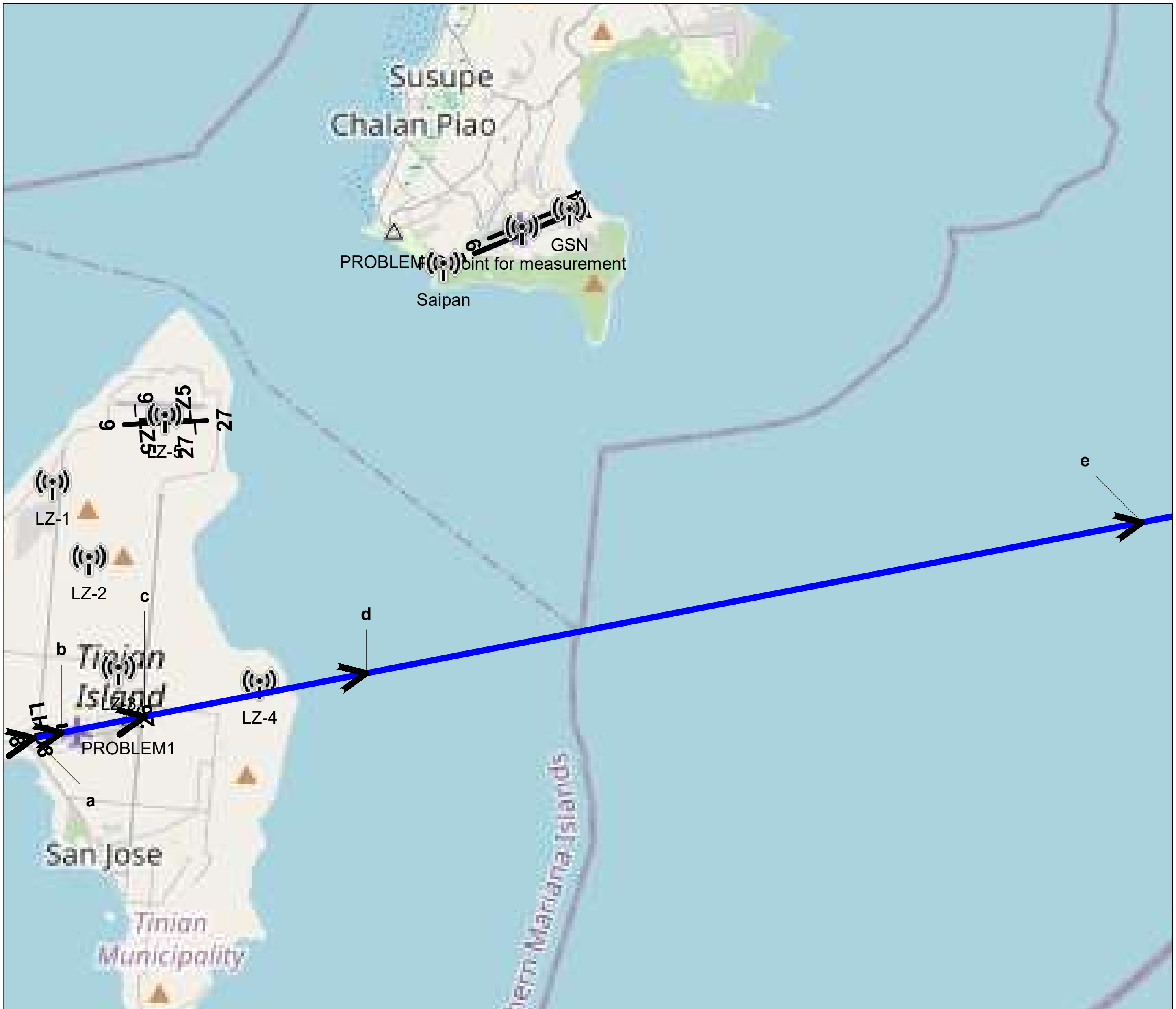
Military Flight Profile C-12 _DB1

Flight Track 26D1 - STANDARD DEPARTURE

0 10,000 20,000 30,000 40,000 50,000

Scale in Feet 1:172,000 (1 inch = 14,300 feet)

N



Flight Profile C-12 _DA1

Point	Distance NM	Height ft	Power % RPM	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0.00	0 AGL	98.1 Variable	0	0.0	0	23
b	0.41	0 AGL	100 Variable	130	3.8	1000	31
c	1.65	500 AGL	98 Variable	155	6.3	1700	76
d	4.94	2,700 AGL	95 Variable	155	1.6	400	268
e	16.46	4,700 AGL	95 Variable	155	3.0	800	382
f	32.92	10,000 AGL	95 Variable	155			

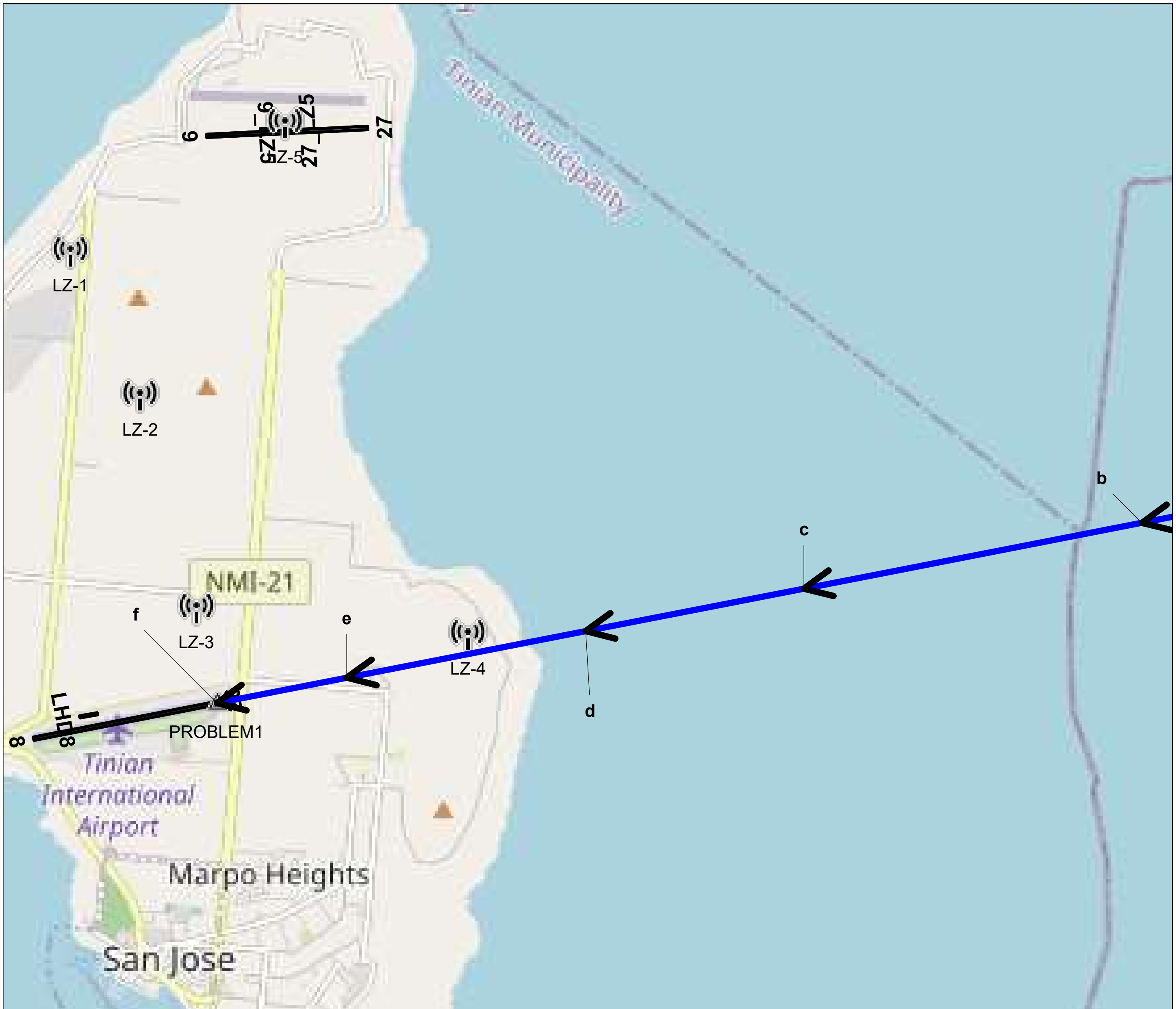
Military Flight Profile C-12 _DA1

Flight Track 08D1 - STANDARD DEPARTURE

0 10,000 20,000 30,000 40,000 50,000

Scale in Feet 1:172,000 (1 inch = 14,300 feet)

N



Flight Profile C-130_AE1

Point	Distance NM	Height ft	Power HP	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	9,000 AGL	700 Variable	200	-2.7	-1000	464
b	7.15	1,600 AGL	750 Variable	200	-1.8	-600	54
c	4.54	1,100 AGL	700 Intermediate	150	0.0	0	40
d	2.85	1,100 AGL	1400 Intermediate	150	-4.1	-1000	49
e	1.00	300 AGL	580 Intermediate	120	-2.3	-500	31
f	0.00	50 AGL	470 Parallel	110			

Military Flight Profile C-130_AE1

Flight Track 26A1 - RNAV ARRIVAL

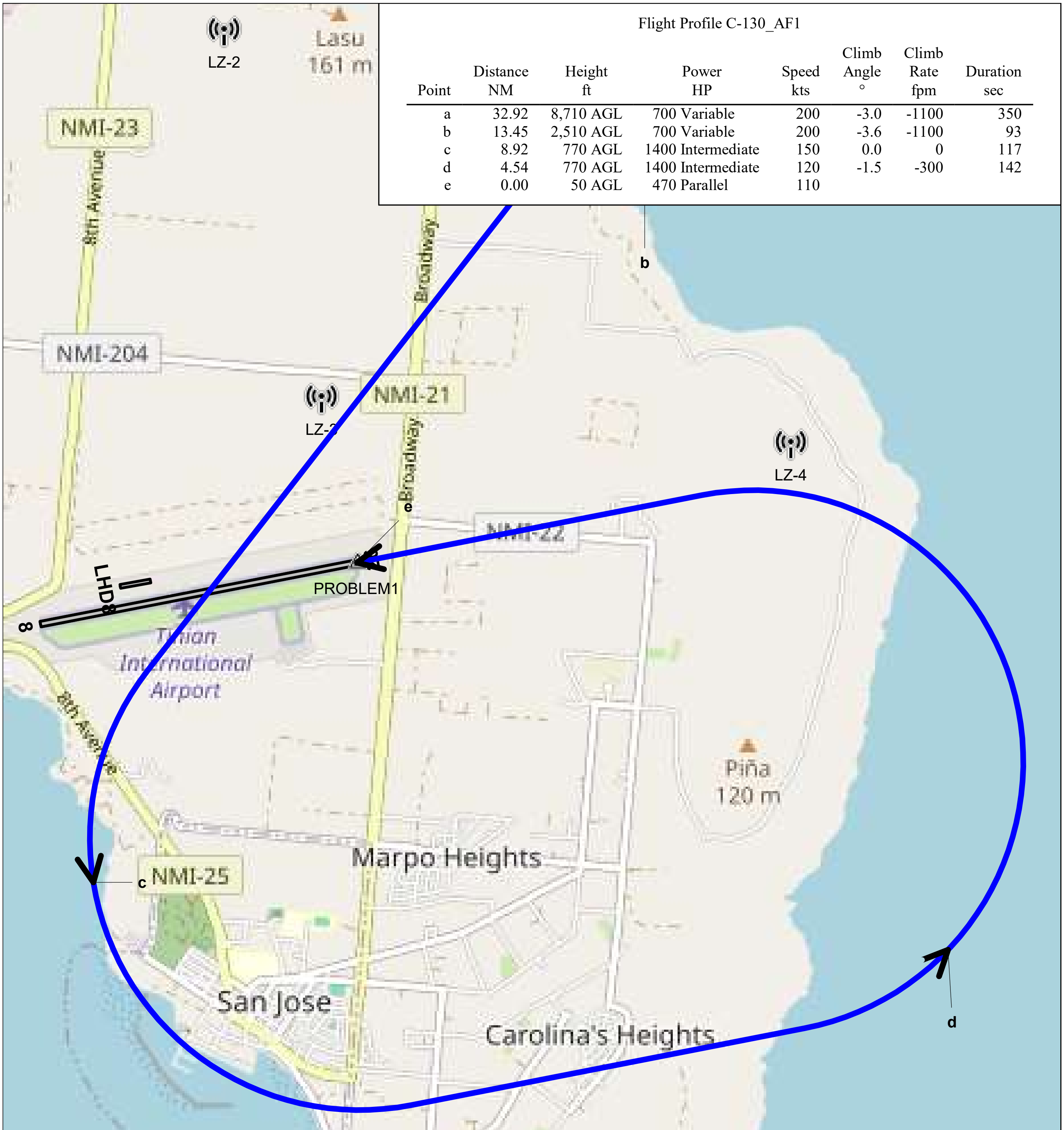
0 4,000 8,000 12,000 16,000 20,000 24,000 28,000

Scale in Feet 1:89,300 (1 inch = 7,440 feet)

N

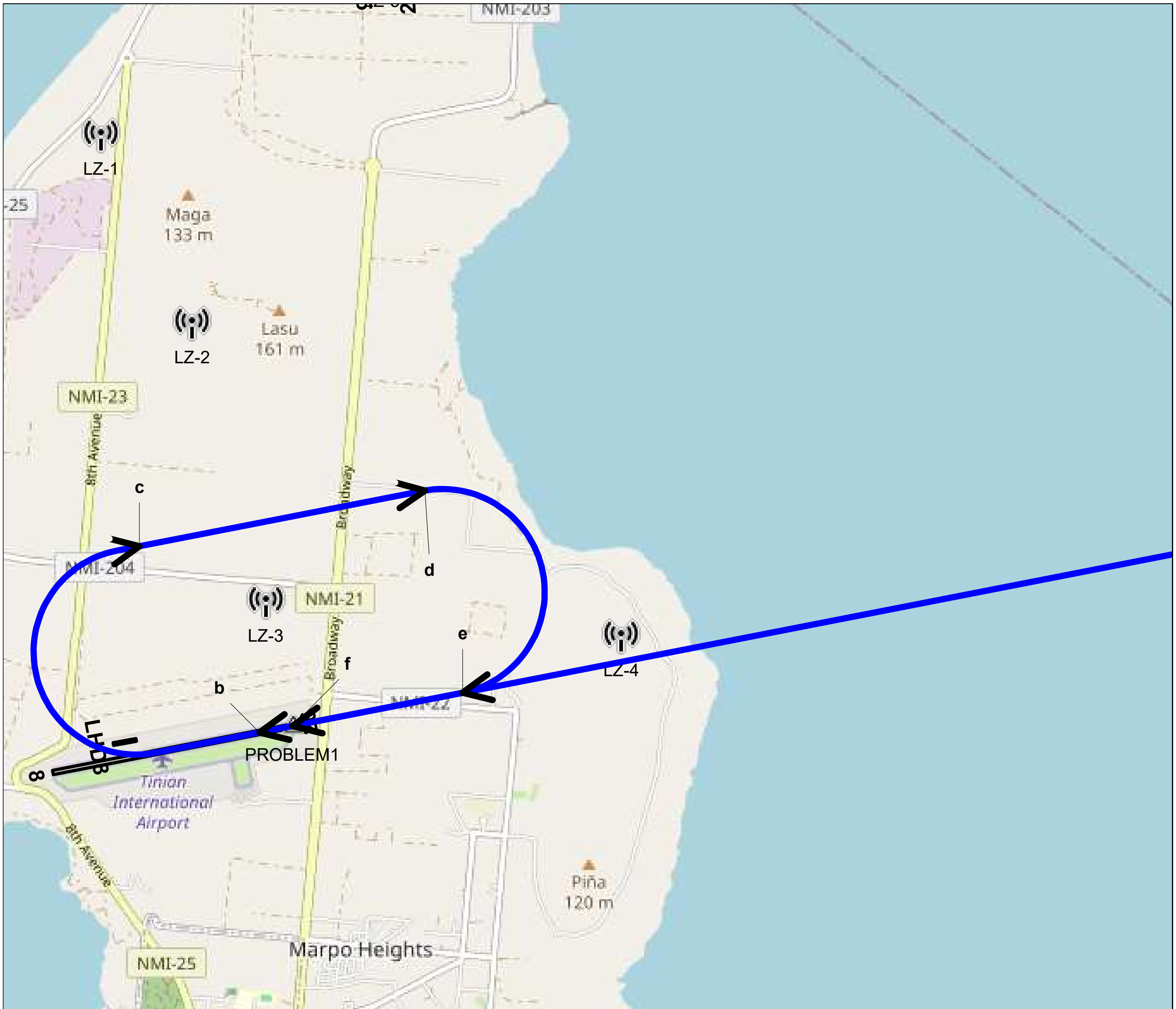
Flight Profile C-130_AF1

Point	Distance NM	Height ft	Power HP	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	8,710 AGL	700 Variable	200	-3.0	-1100	350
b	13.45	2,510 AGL	700 Variable	200	-3.6	-1100	93
c	8.92	770 AGL	1400 Intermediate	150	0.0	0	117
d	4.54	770 AGL	1400 Intermediate	120	-1.5	-300	142
e	0.00	50 AGL	470 Parallel	110			



Military Flight Profile C-130_AF1
Flight Track 26A2_2 - NDB ARRIVAL

Scale in Feet 1:46,800 (1 inch = 3,900 feet)



Flight Profile C-130_AH1

Point	Distance NM	Height ft	Power HP	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	9,000 AGL	700 Variable	200	-2.7	-1000	464
b	7.15	1,600 AGL	750 Variable	200	-1.8	-600	54
c	4.54	1,100 AGL	700 Intermediate	150	0.0	0	40
d	2.85	1,100 AGL	1400 Intermediate	150	-4.1	-1000	49
e	1.00	300 AGL	580 Intermediate	120	-2.3	-500	31
f	0.00	50 AGL	470 Parallel	110			

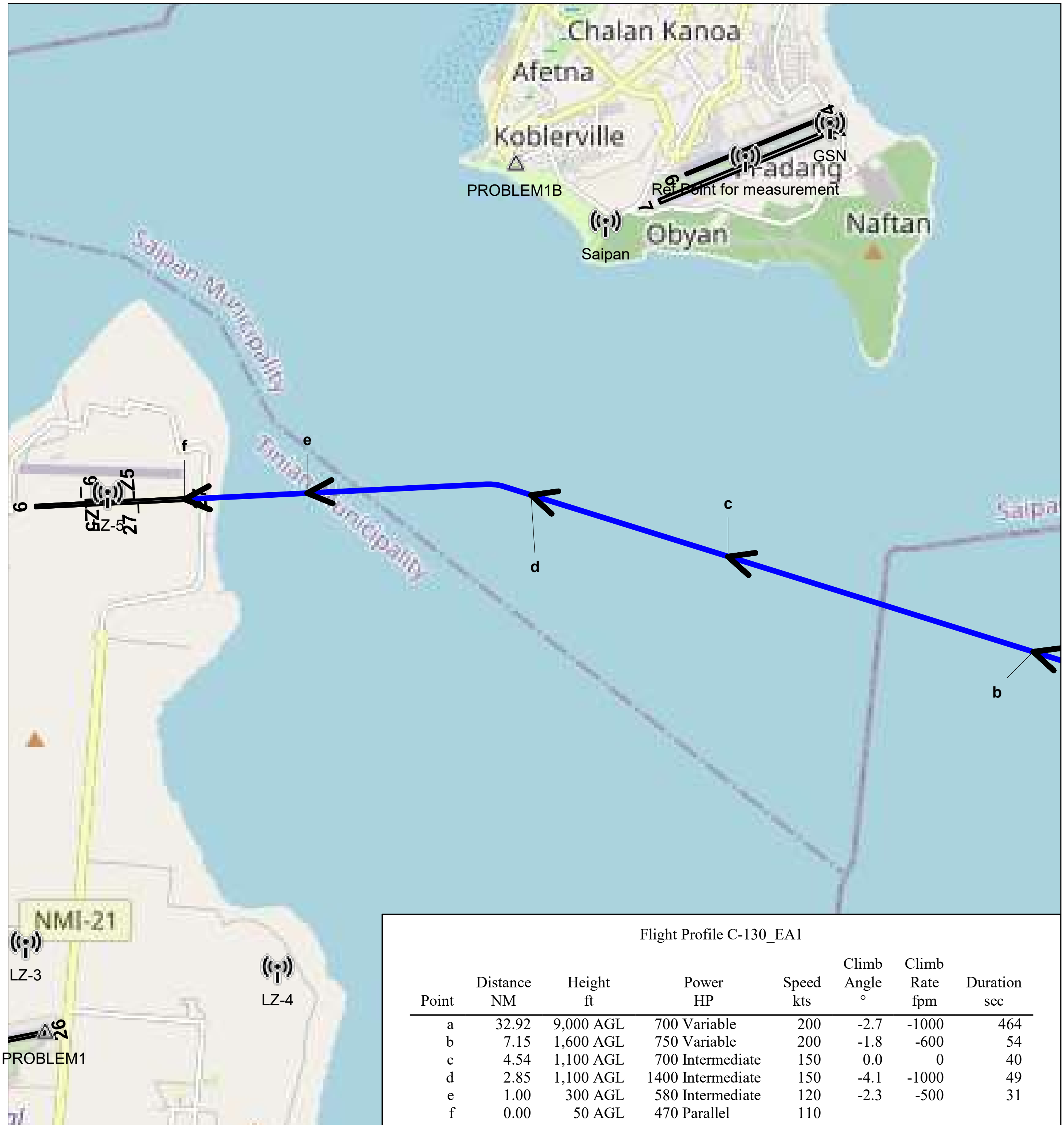
Military Flight Profile C-130_AH1

Flight Track 26A4 - OVERHEAD BREAK ARRIVAL

0 4,000 8,000 12,000 16,000 20,000

Scale in Feet 1:68,200 (1 inch = 5,690 feet)

N



Flight Profile C-130_EA1

Point	Distance NM	Height ft	Power HP	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	9,000 AGL	700 Variable	200	-2.7	-1000	464
b	7.15	1,600 AGL	750 Variable	200	-1.8	-600	54
c	4.54	1,100 AGL	700 Intermediate	150	0.0	0	40
d	2.85	1,100 AGL	1400 Intermediate	150	-4.1	-1000	49
e	1.00	300 AGL	580 Intermediate	120	-2.3	-500	31
f	0.00	50 AGL	470 Parallel	110			

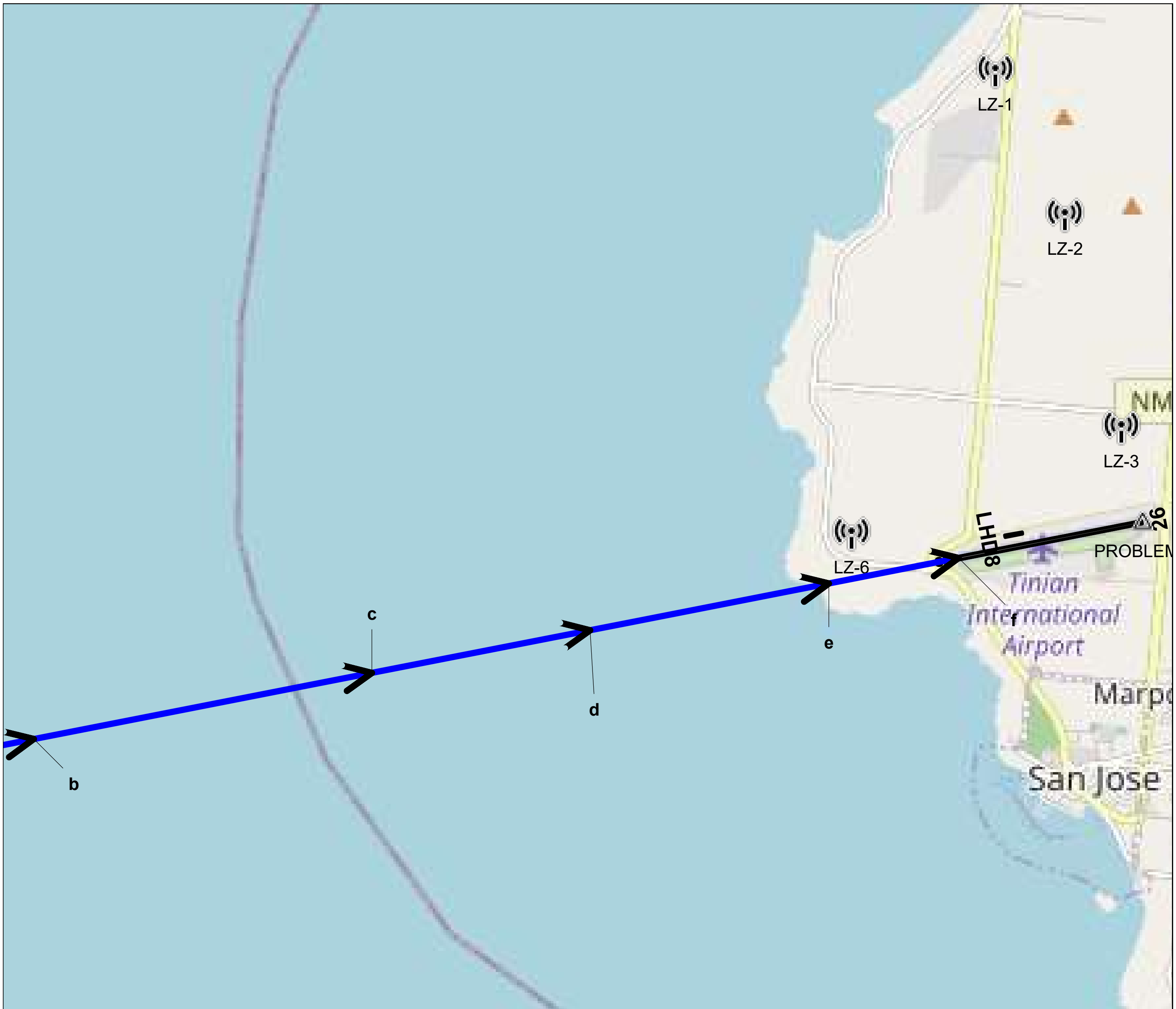
Military Flight Profile C-130_EA1

Flight Track 27A1 - STRAIGHT IN ARRIVAL

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000

Scale in Feet 1:86,700 (1 inch = 7,230 feet)

N



Flight Profile C-130_AA1

Point	Distance NM	Height ft	Power HP	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	9,000 AGL	700 Variable	200	-2.7	-1000	464
b	7.15	1,600 AGL	750 Variable	200	-1.8	-600	54
c	4.54	1,100 AGL	700 Intermediate	150	0.0	0	40
d	2.85	1,100 AGL	1400 Intermediate	150	-4.1	-1000	49
e	1.00	300 AGL	580 Intermediate	120	-2.3	-500	31
f	0.00	50 AGL	470 Parallel	110			

Military Flight Profile C-130_AA1

Flight Track 08A1 - RNAV ARRIVAL

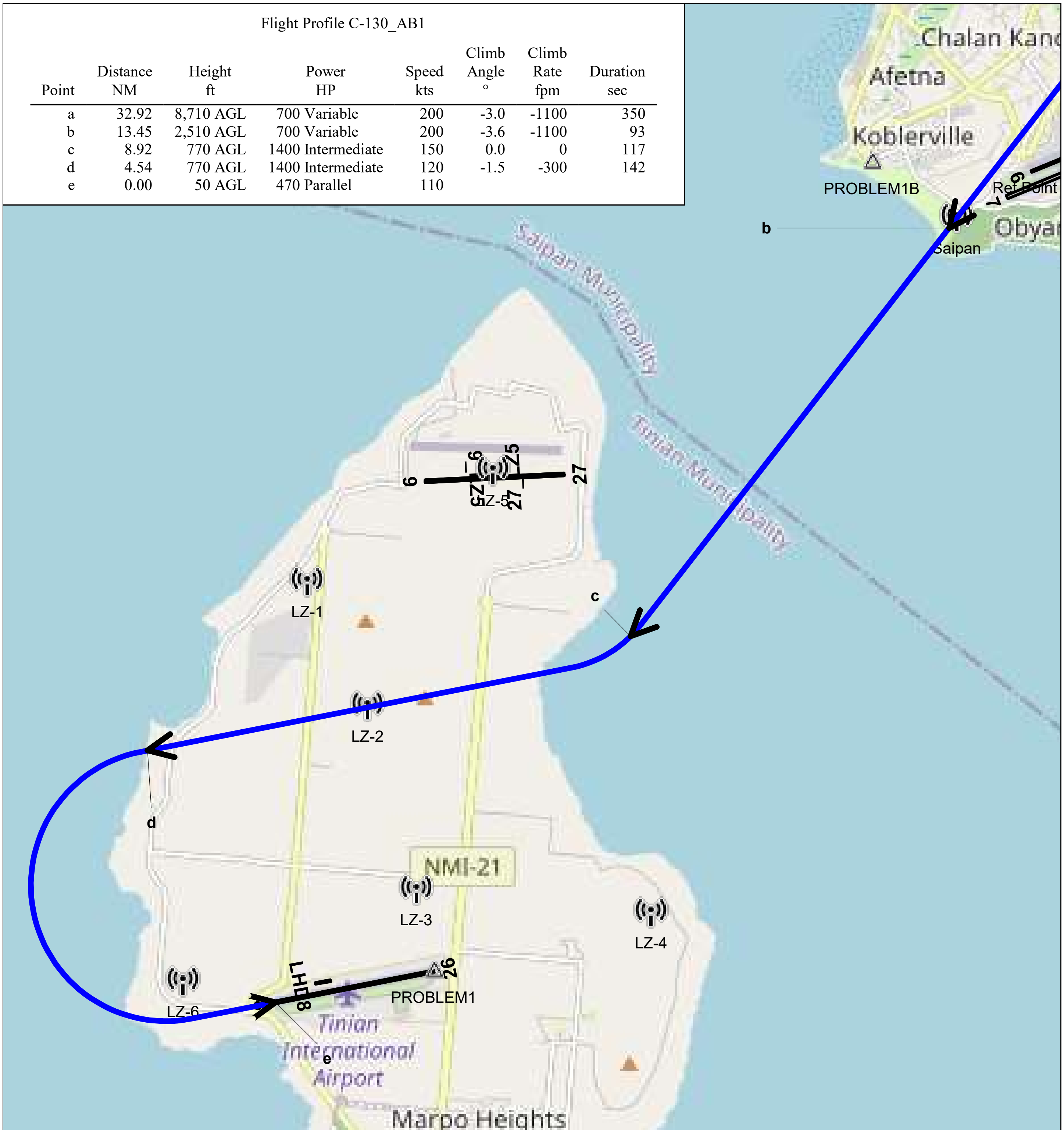
0 4,000 8,000 12,000 16,000 20,000 24,000 28,000

Scale in Feet 1:89,300 (1 inch = 7,440 feet)

N

Flight Profile C-130_AB1

Point	Distance NM	Height ft	Power HP	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	8,710 AGL	700 Variable	200	-3.0	-1100	350
b	13.45	2,510 AGL	700 Variable	200	-3.6	-1100	93
c	8.92	770 AGL	1400 Intermediate	150	0.0	0	117
d	4.54	770 AGL	1400 Intermediate	120	-1.5	-300	142
e	0.00	50 AGL	470 Parallel	110			



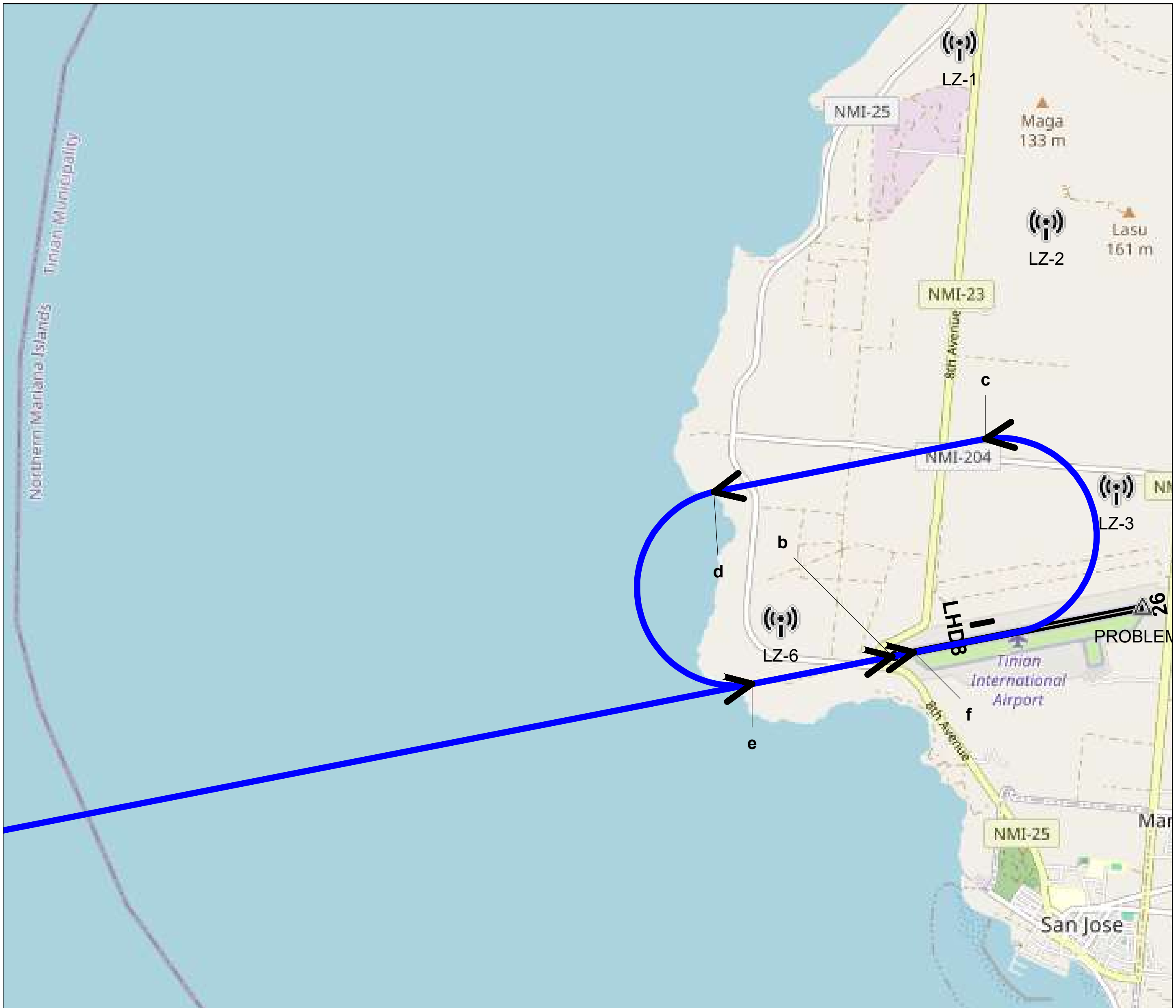
Military Flight Profile C-130_AB1

Flight Track 08A2_2 - NDB ARRIVAL

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000

Scale in Feet 1:93,500 (1 inch = 7,790 feet)

N



Flight Profile C-130_AD1

Point	Distance NM	Height ft	Power HP	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	9,000 AGL	700 Variable	200	-2.7	-1000	464
b	7.15	1,600 AGL	750 Variable	200	-1.8	-600	54
c	4.54	1,100 AGL	700 Intermediate	150	0.0	0	40
d	2.85	1,100 AGL	1400 Intermediate	150	-4.1	-1000	49
e	1.00	300 AGL	580 Intermediate	120	-2.3	-500	31
f	0.00	50 AGL	470 Parallel	110			

Military Flight Profile C-130_AD1

Flight Track 08A4 - OVERHEAD BREAK ARRIVAL - FW

0 4,000 8,000 12,000 16,000 20,000

Scale in Feet 1:71,700 (1 inch = 5,980 feet)

N

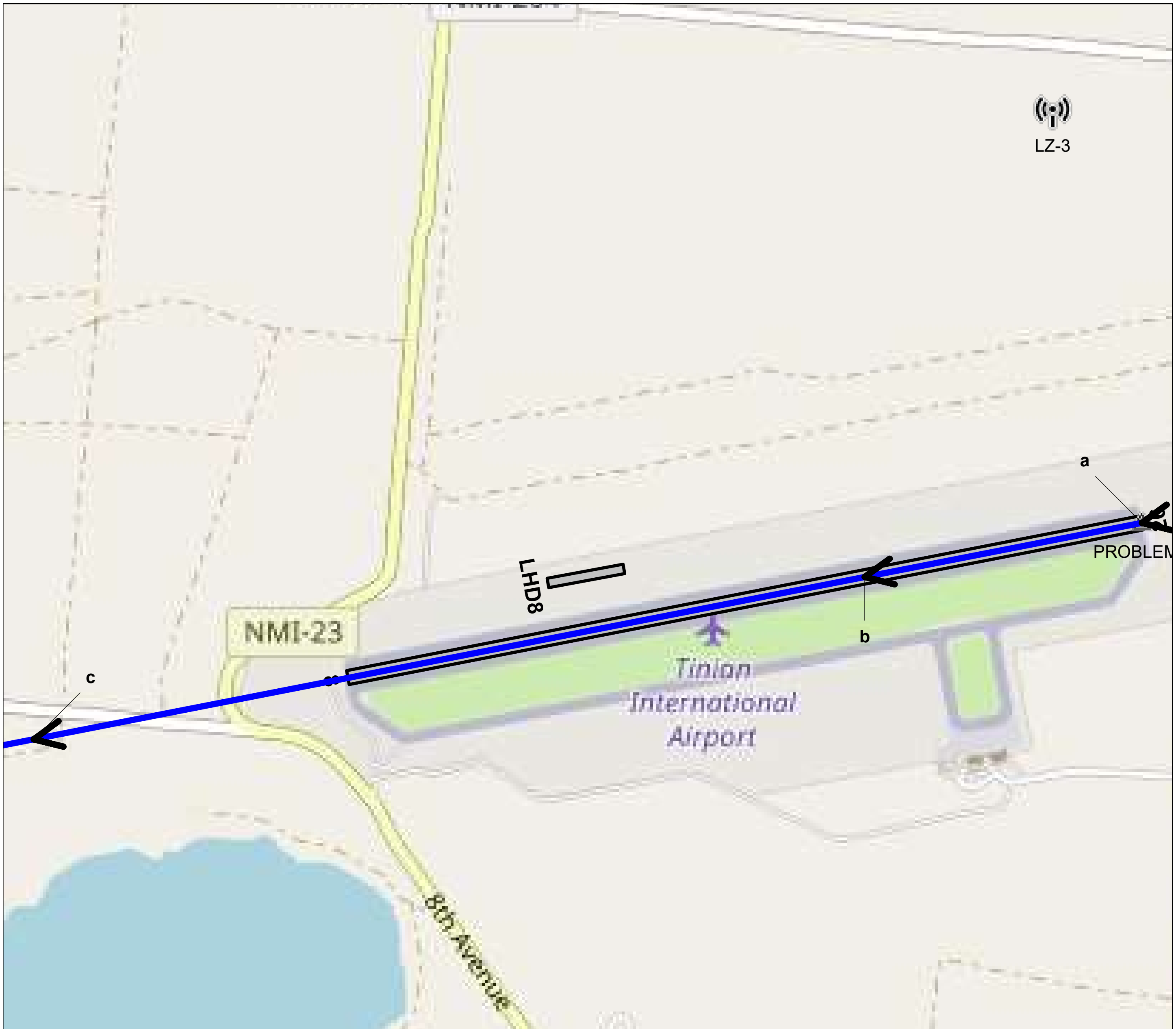
Flight Profile C-130_EB1

Point	Distance NM	Height ft	Power HP	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	9,000 AGL	700 Variable	200	-2.7	-1000	464
b	7.15	1,600 AGL	750 Variable	200	-1.8	-600	54
c	4.54	1,100 AGL	700 Intermediate	150	0.0	0	40
d	2.85	1,100 AGL	1400 Intermediate	150	-4.1	-1000	49
e	1.00	300 AGL	580 Intermediate	120	-2.3	-500	31
f	0.00	50 AGL	470 Parallel	110			

Military Flight Profile C-130_EB1

Flight Track 09A1 - STRAIGHT IN ARRIVAL

Scale in Feet 1:88,800 (1 inch = 7,400 feet)



Flight Profile C-130_DB1

Point	Distance NM	Height ft	Power HP	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0.00	0 AGL	970 Takeoff	0	0.0	0	31
b	0.49	0 AGL	970 Takeoff	115	2.5	600	39
c	1.97	400 AGL	970 Variable	155	5.5	1600	187
d	10.70	5,500 AGL	970 Takeoff	180	1.5	500	421
e	32.92	9,000 AGL	700 Variable	200			

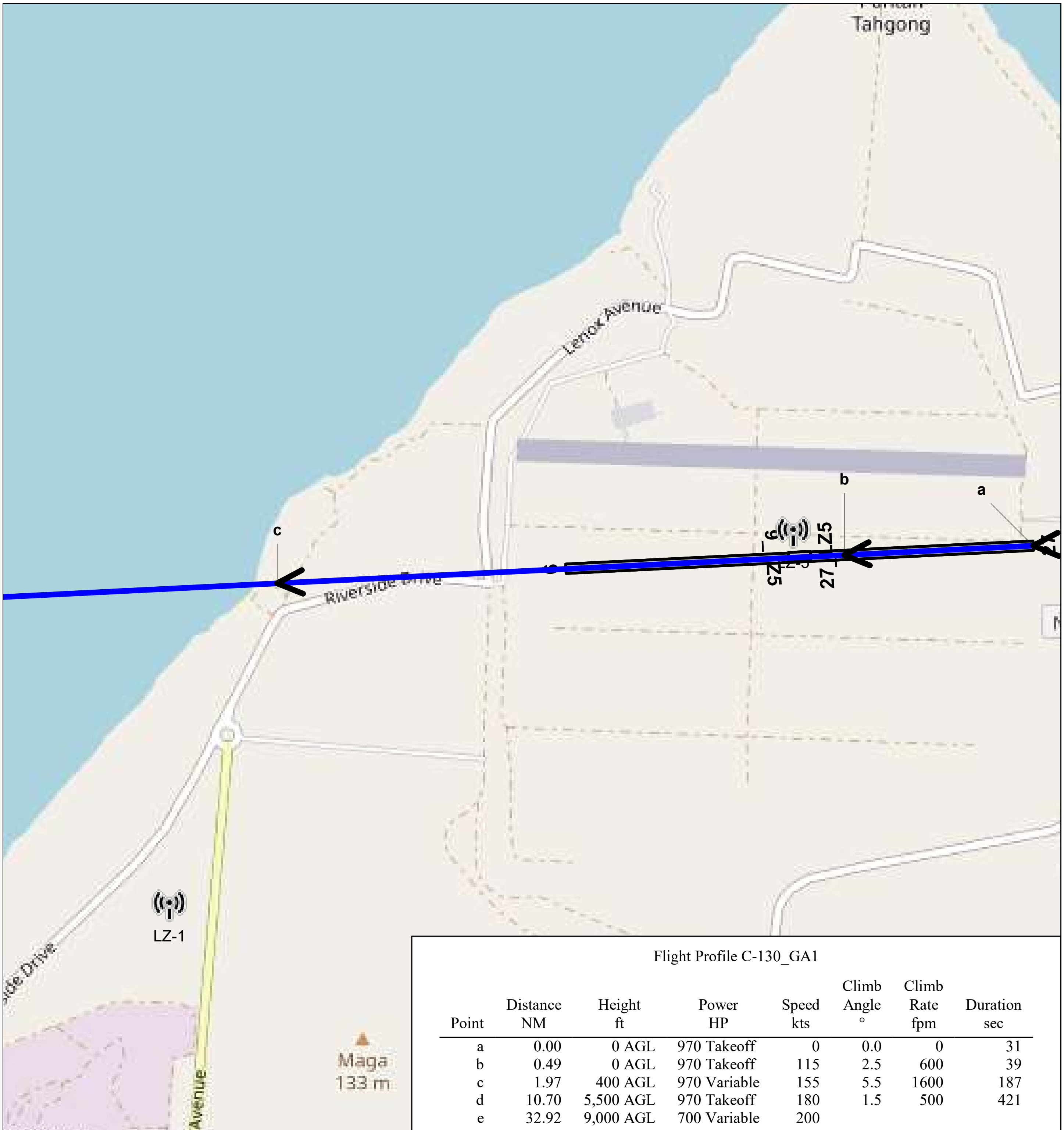
Military Flight Profile C-130_DB1

Flight Track 26D1 - STANDARD DEPARTURE

0 1,000 2,000 3,000 4,000 5,000 6,000

Scale in Feet 1:20,600 (1 inch = 1,720 feet)

N



Flight Profile C-130_GA1

Point	Distance NM	Height ft	Power HP	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0.00	0 AGL	970 Takeoff	0	0.0	0	31
b	0.49	0 AGL	970 Takeoff	115	2.5	600	39
c	1.97	400 AGL	970 Variable	155	5.5	1600	187
d	10.70	5,500 AGL	970 Takeoff	180	1.5	500	421
e	32.92	9,000 AGL	700 Variable	200			

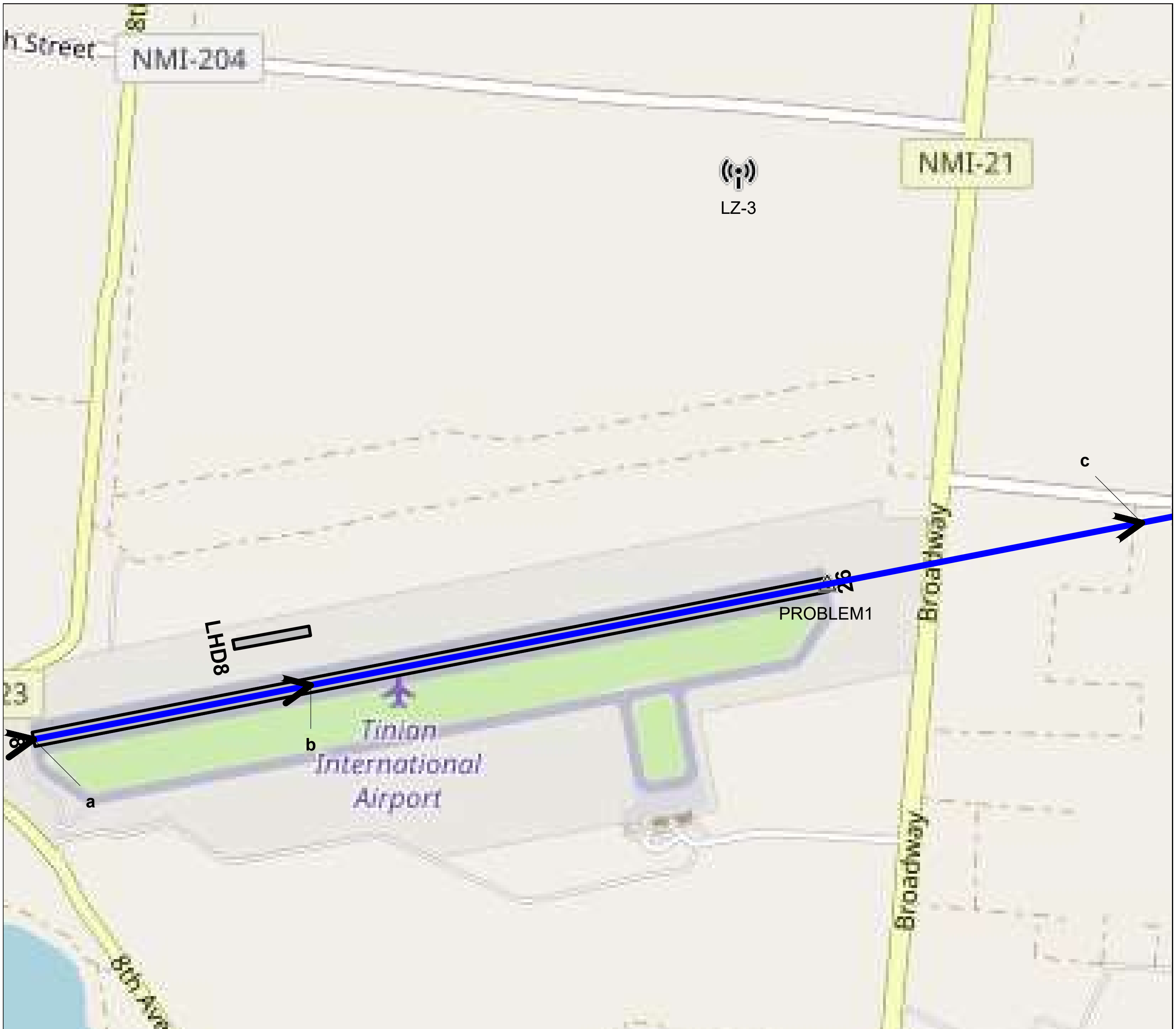
Military Flight Profile C-130_GA1

Flight Track 27D1 - STANDARD DEPARTURE

0 1,000 2,000 3,000 4,000 5,000 6,000 7,000 8,000 9,000

Scale in Feet 1:27,800 (1 inch = 2,320 feet)

N



Flight Profile C-130_DA1

Point	Distance NM	Height ft	Power HP	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0.00	0 AGL	970 Takeoff	0	0.0	0	31
b	0.49	0 AGL	970 Takeoff	115	2.5	600	39
c	1.97	400 AGL	970 Variable	155	5.5	1600	187
d	10.70	5,500 AGL	970 Takeoff	180	1.5	500	421
e	32.92	9,000 AGL	700 Variable	200			

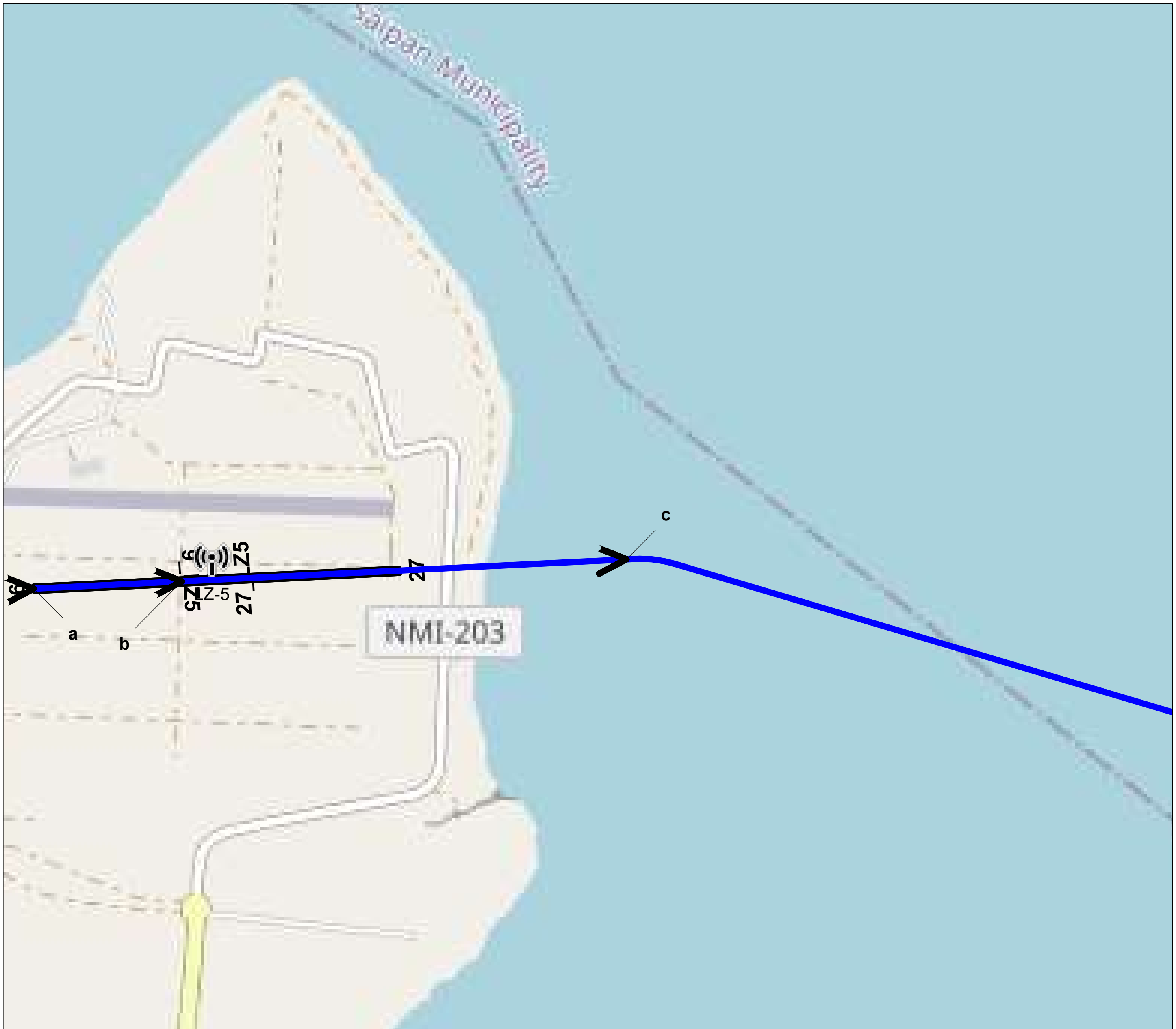
Military Flight Profile C-130_DA1

Flight Track 08D1 - STANDARD DEPARTURE

0 1,000 2,000 3,000 4,000 5,000 6,000

Scale in Feet 1:20,600 (1 inch = 1,720 feet)

N



Flight Profile C-130_GB1

Point	Distance NM	Height ft	Power HP	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0.00	0 AGL	970 Takeoff	0	0.0	0	31
b	0.49	0 AGL	970 Takeoff	115	2.5	600	39
c	1.97	400 AGL	970 Variable	155	5.5	1600	187
d	10.70	5,500 AGL	970 Takeoff	180	1.5	500	421
e	32.92	9,000 AGL	700 Variable	200			

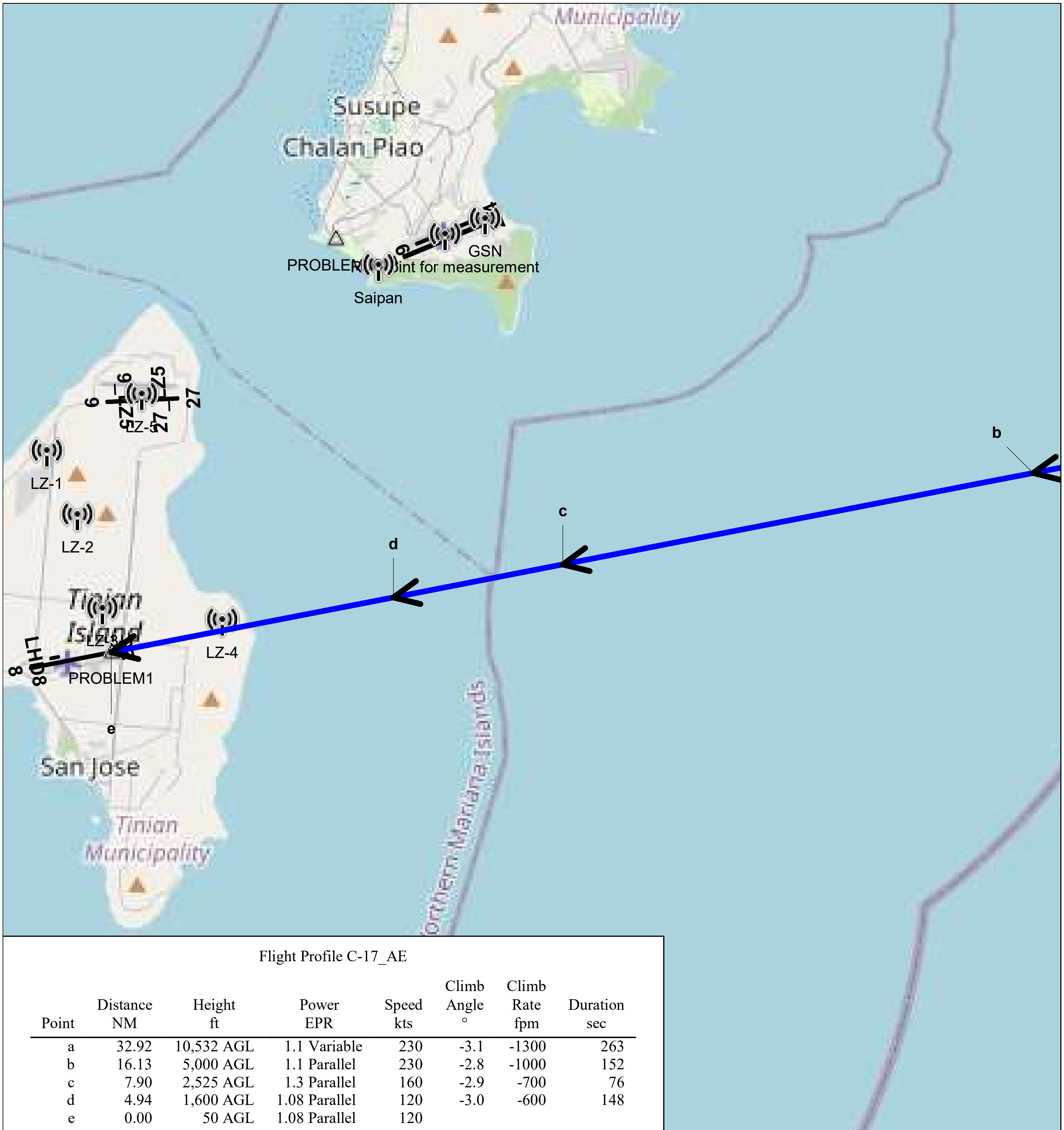
Military Flight Profile C-130_GB1

Flight Track 09D2 - SOUTH DEPARTURE

0 2,000 4,000 6,000 8,000 10,000 12,000

Scale in Feet 1:39,200 (1 inch = 3,270 feet)

N



Flight Profile C-17_AE

Point	Distance NM	Height ft	Power EPR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	10,532 AGL	1.1 Variable	230	-3.1	-1300	263
b	16.13	5,000 AGL	1.1 Parallel	230	-2.8	-1000	152
c	7.90	2,525 AGL	1.3 Parallel	160	-2.9	-700	76
d	4.94	1,600 AGL	1.08 Parallel	120	-3.0	-600	148
e	0.00	50 AGL	1.08 Parallel	120			

Military Flight Profile C-17_AE

Flight Track 26A1 - RNAV ARRIVAL

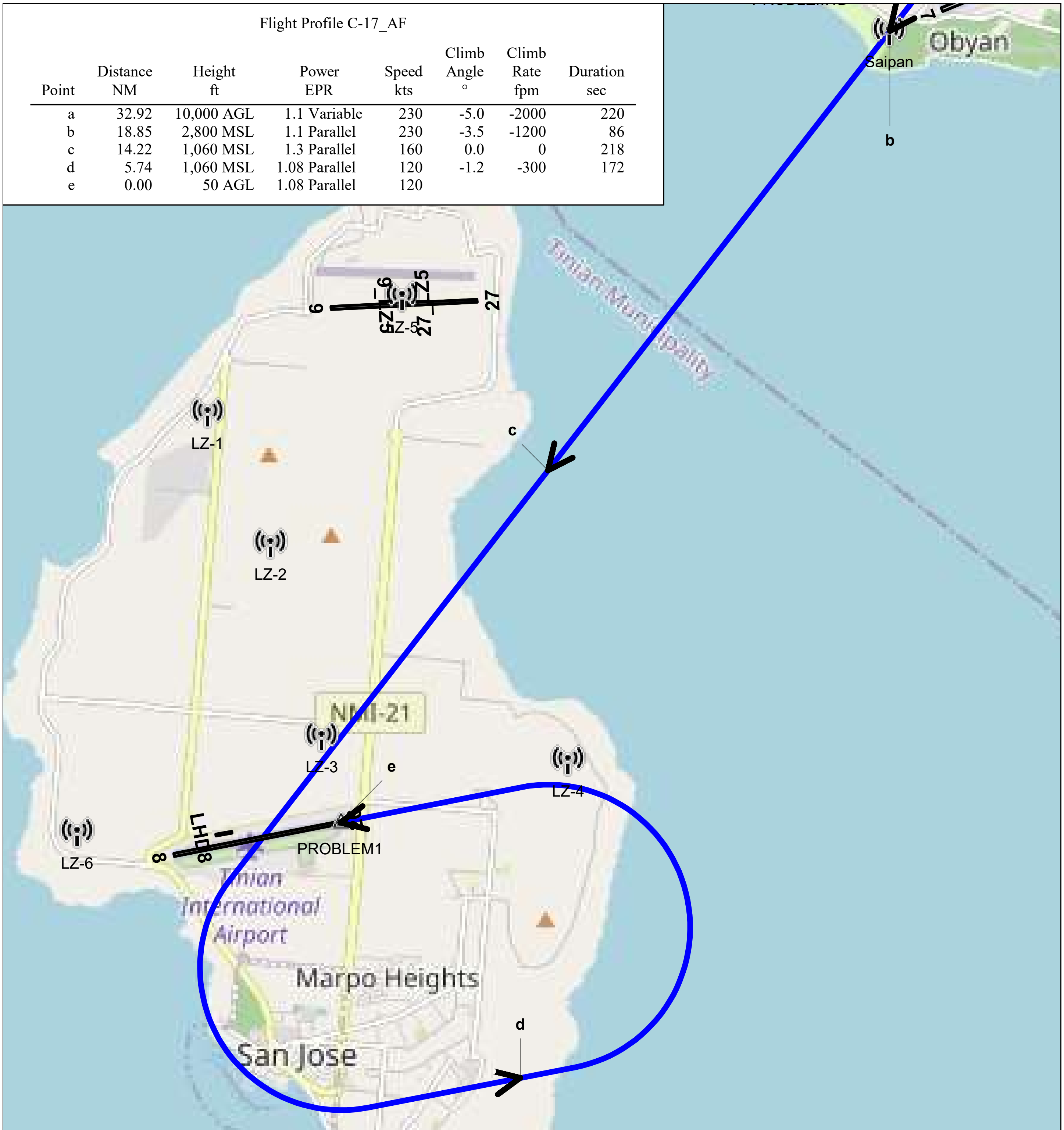
0 10,000 20,000 30,000 40,000 50,000 60,000

Scale in Feet 1:183,000 (1 inch = 15,300 feet)

N

Flight Profile C-17_AF

Point	Distance NM	Height ft	Power EPR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	10,000 AGL	1.1 Variable	230	-5.0	-2000	220
b	18.85	2,800 MSL	1.1 Parallel	230	-3.5	-1200	86
c	14.22	1,060 MSL	1.3 Parallel	160	0.0	0	218
d	5.74	1,060 MSL	1.08 Parallel	120	-1.2	-300	172
e	0.00	50 AGL	1.08 Parallel	120			



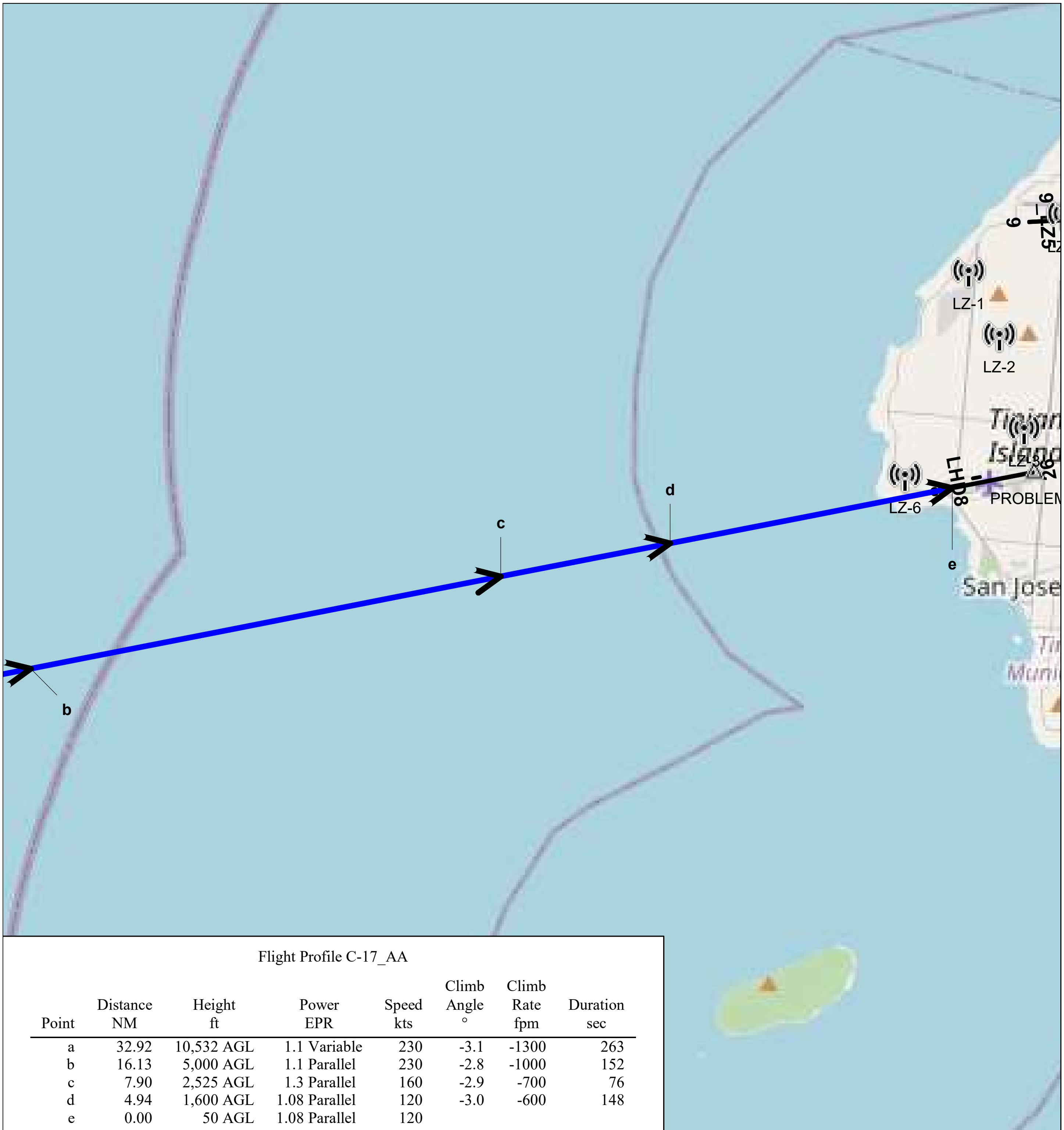
Military Flight Profile C-17_AF

Flight Track 26A2_2 - NDB ARRIVAL

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000

Scale in Feet 1:89,100 (1 inch = 7,420 feet)

N



Flight Profile C-17_AA

Point	Distance NM	Height ft	Power EPR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	10,532 AGL	1.1 Variable	230	-3.1	-1300	263
b	16.13	5,000 AGL	1.1 Parallel	230	-2.8	-1000	152
c	7.90	2,525 AGL	1.3 Parallel	160	-2.9	-700	76
d	4.94	1,600 AGL	1.08 Parallel	120	-3.0	-600	148
e	0.00	50 AGL	1.08 Parallel	120			

Military Flight Profile C-17_AA

Flight Track 08A1 - RNAV ARRIVAL

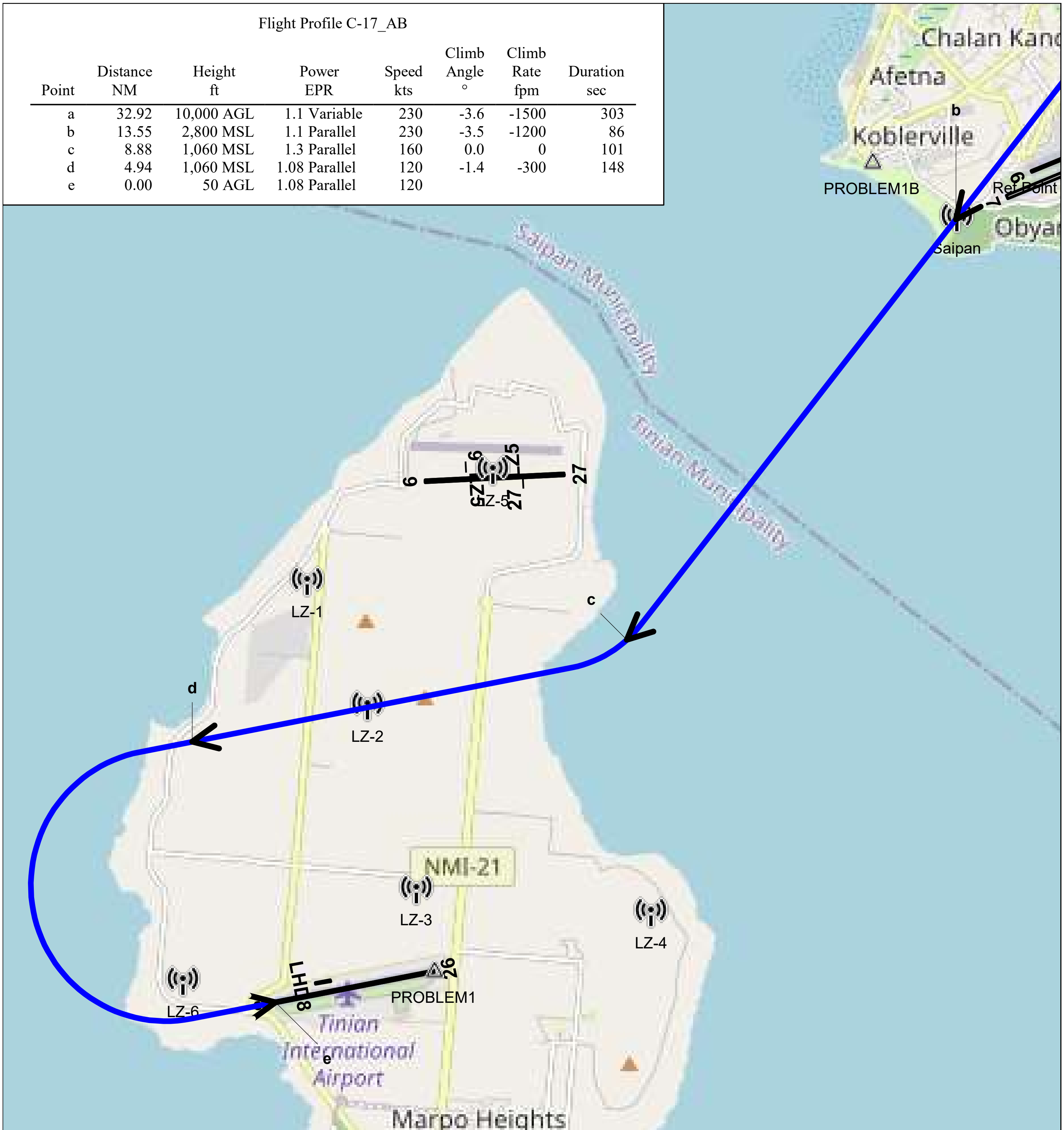
0 10,000 20,000 30,000 40,000 50,000 60,000

Scale in Feet 1:183,000 (1 inch = 15,200 feet)

N

Flight Profile C-17_AB

Point	Distance NM	Height ft	Power EPR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	10,000 AGL	1.1 Variable	230	-3.6	-1500	303
b	13.55	2,800 MSL	1.1 Parallel	230	-3.5	-1200	86
c	8.88	1,060 MSL	1.3 Parallel	160	0.0	0	101
d	4.94	1,060 MSL	1.08 Parallel	120	-1.4	-300	148
e	0.00	50 AGL	1.08 Parallel	120			



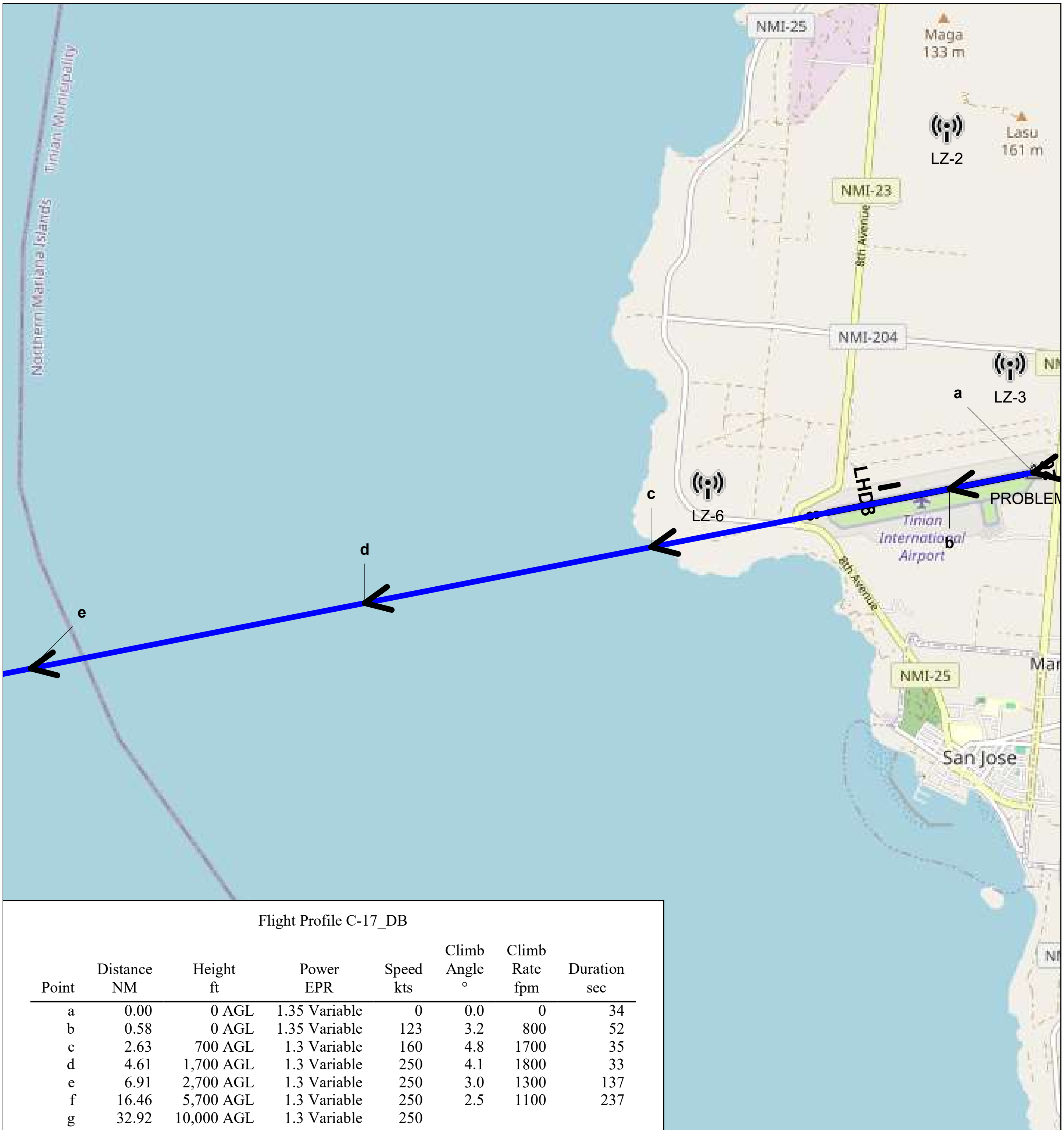
Military Flight Profile C-17_AB

Flight Track 08A2_2 - NDB ARRIVAL

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000

Scale in Feet 1:93,500 (1 inch = 7,790 feet)

N



Flight Profile C-17_DB

Point	Distance NM	Height ft	Power EPR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0.00	0 AGL	1.35 Variable	0	0.0	0	34
b	0.58	0 AGL	1.35 Variable	123	3.2	800	52
c	2.63	700 AGL	1.3 Variable	160	4.8	1700	35
d	4.61	1,700 AGL	1.3 Variable	250	4.1	1800	33
e	6.91	2,700 AGL	1.3 Variable	250	3.0	1300	137
f	16.46	5,700 AGL	1.3 Variable	250	2.5	1100	237
g	32.92	10,000 AGL	1.3 Variable	250			

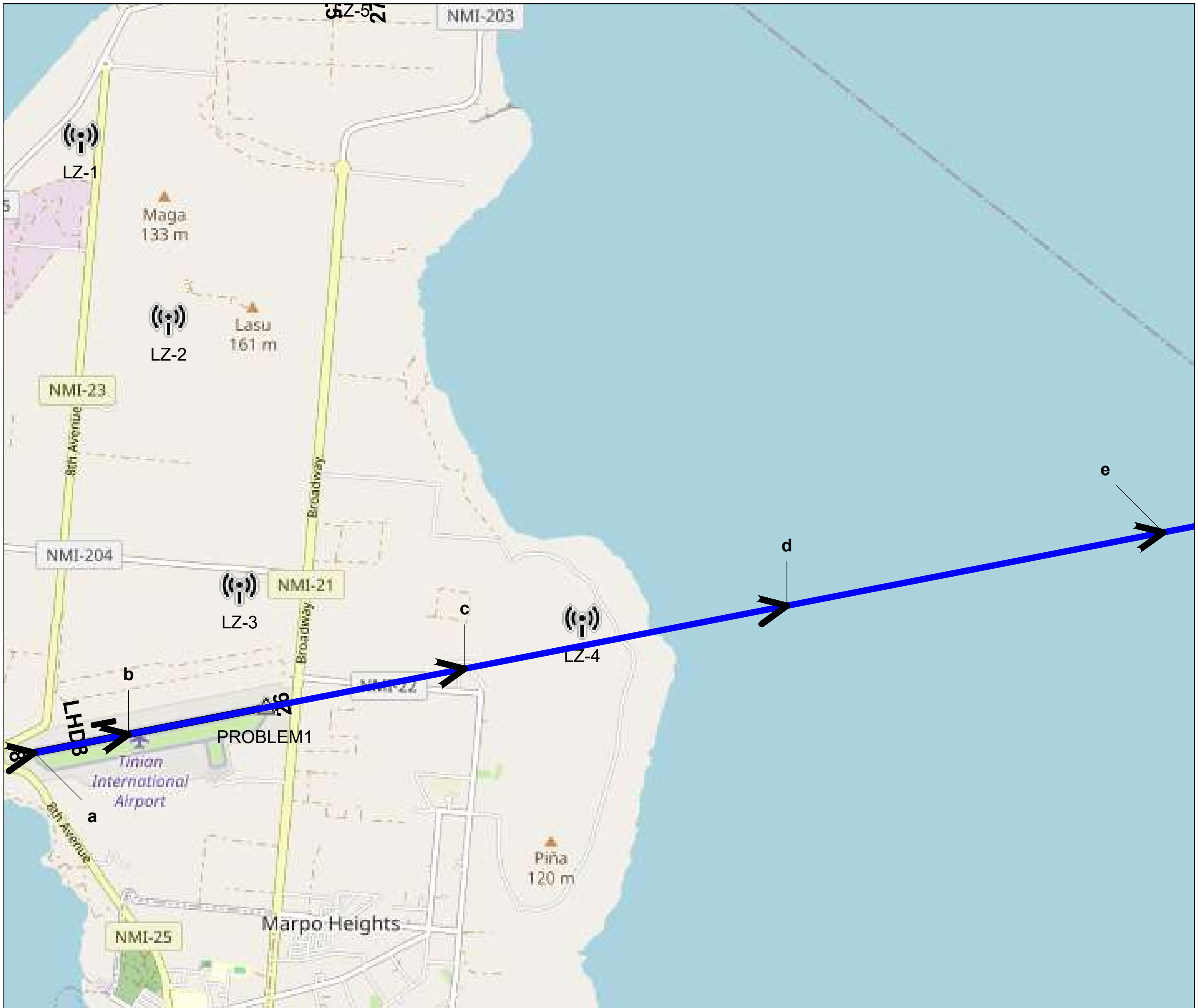
Military Flight Profile C-17_DB

Flight Track 26D1 - STANDARD DEPARTURE

0 4,000 8,000 12,000 16,000 20,000

Scale in Feet 1:72,100 (1 inch = 6,010 feet)

N



Flight Profile C-17_DA

Point	Distance NM	Height ft	Power EPR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0.00	0 AGL	1.35 Variable	0	0.0	0	34
b	0.58	0 AGL	1.35 Variable	123	3.2	800	52
c	2.63	700 AGL	1.3 Variable	160	4.8	1700	35
d	4.61	1,700 AGL	1.3 Variable	250	4.1	1800	33
e	6.91	2,700 AGL	1.3 Variable	250	3.0	1300	137
f	16.46	5,700 AGL	1.3 Variable	250	2.5	1100	237
g	32.92	10,000 AGL	1.3 Variable	250			

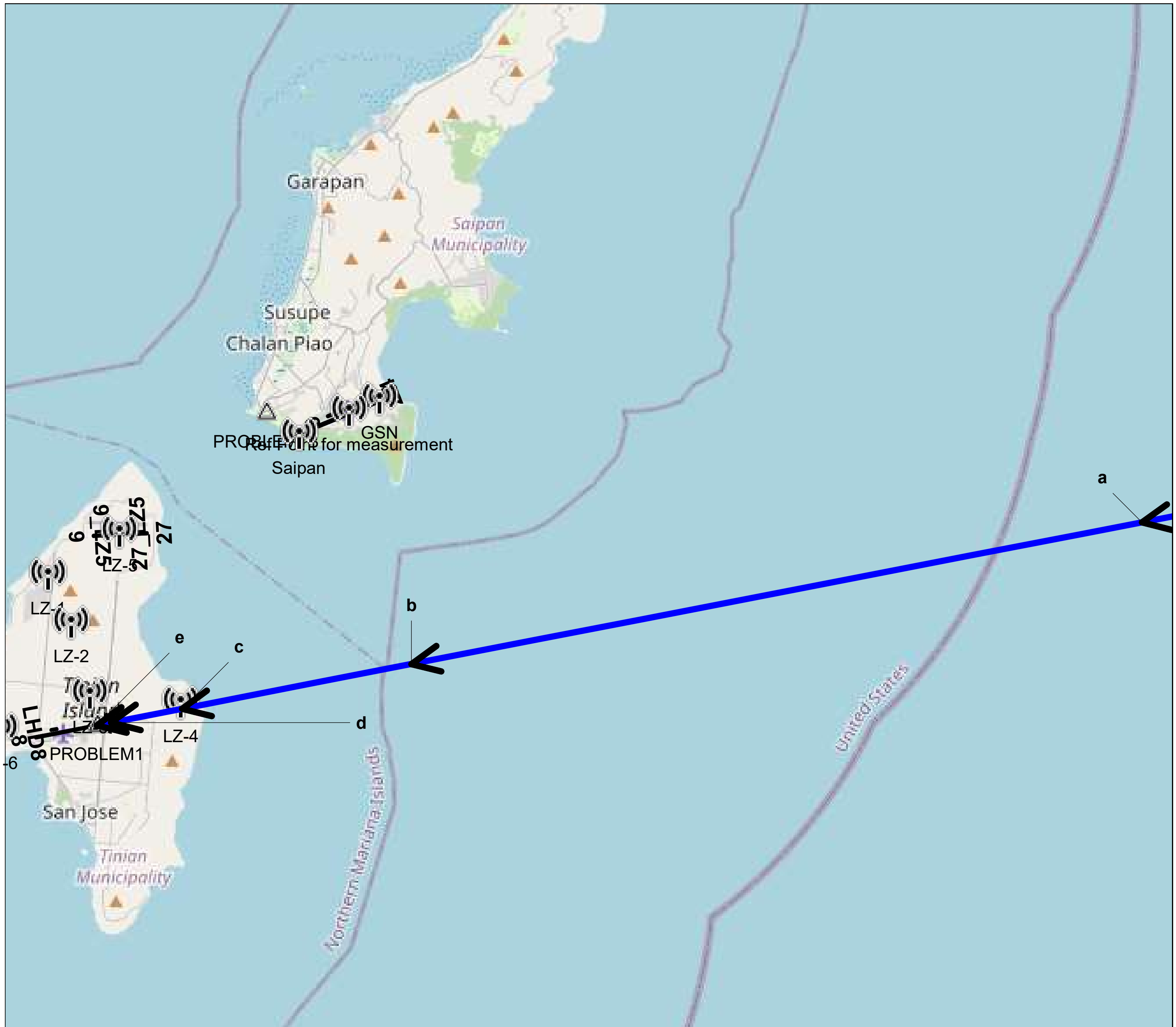
Military Flight Profile C-17_DA

Flight Track 08D1 - STANDARD DEPARTURE

0 4,000 8,000 12,000 16,000 20,000

Scale in Feet 1:72,100 (1 inch = 6,010 feet)

N



Point	Distance NM	Height ft	Power EPR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	24.18	3,500 MSL	3.07 Intermediate	200	-1.1	-400	304
b	7.28	1,600 MSL	3.07 Intermediate	200	-1.6	-500	106
c	1.97	420 AGL	5.05 Takeoff	160	-1.7	-400	41
d	0.33	120 AGL	5.05 Takeoff	130	-2.0	-500	9
e	0.00	50 AGL	5.05 Approach	145			

Flight Profile C-5A_E1

Military Flight Profile C-5A_E1

Flight Track 26A1 - RNAV ARRIVAL

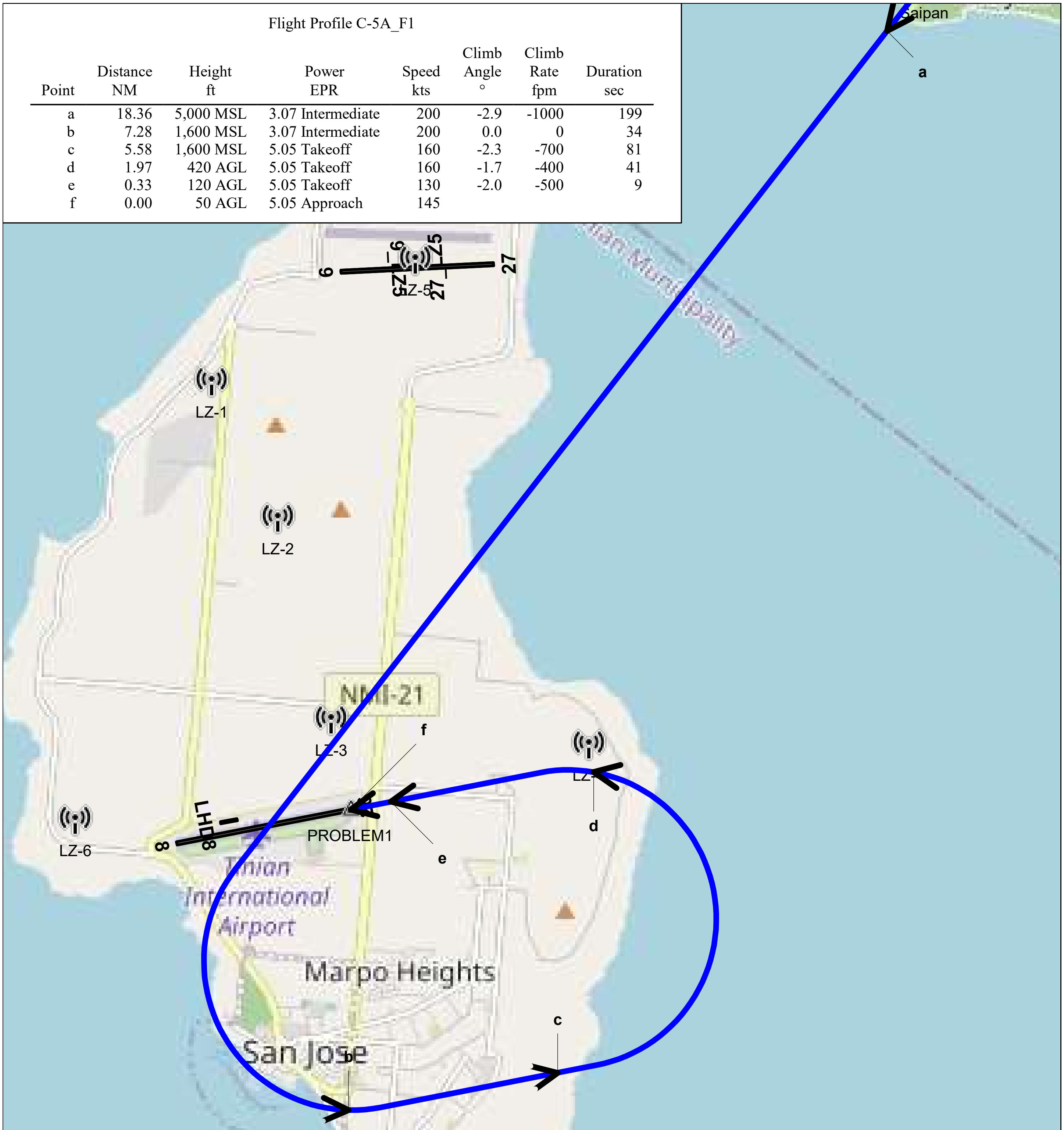
0 10,000 20,000 30,000 40,000 50,000 60,000 70,000 80,000 90,000

Scale in Feet 1:267,000 (1 inch = 22,300 feet)

N

Flight Profile C-5A_F1

Point	Distance NM	Height ft	Power EPR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	18.36	5,000 MSL	3.07 Intermediate	200	-2.9	-1000	199
b	7.28	1,600 MSL	3.07 Intermediate	200	0.0	0	34
c	5.58	1,600 MSL	5.05 Takeoff	160	-2.3	-700	81
d	1.97	420 AGL	5.05 Takeoff	160	-1.7	-400	41
e	0.33	120 AGL	5.05 Takeoff	130	-2.0	-500	9
f	0.00	50 AGL	5.05 Approach	145			



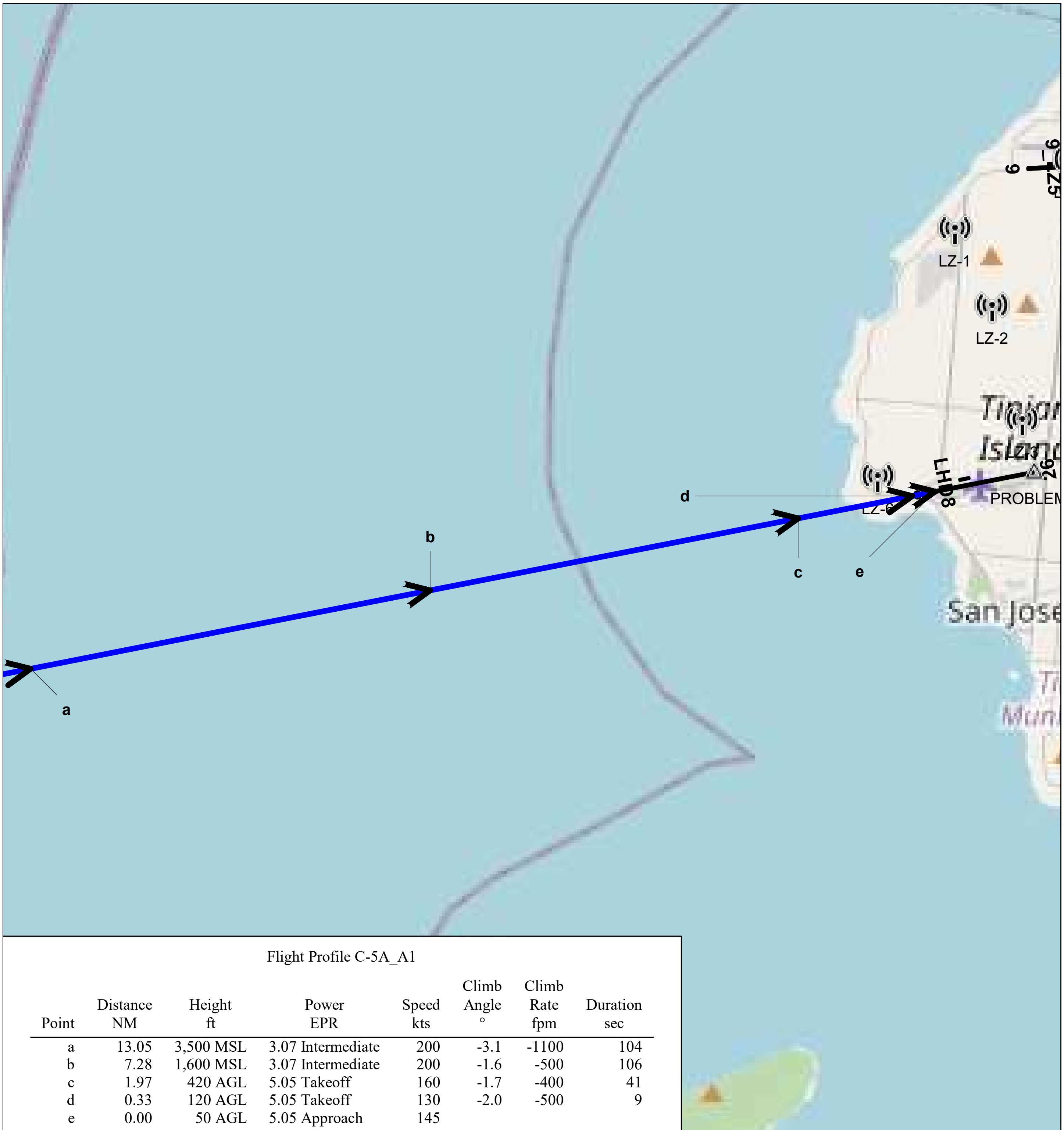
Military Flight Profile C-5A_F1

Flight Track 26A2_2 - NDB ARRIVAL

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000

Scale in Feet 1:85,200 (1 inch = 7,100 feet)

N



Flight Profile C-5A_A1

Point	Distance NM	Height ft	Power EPR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	13.05	3,500 MSL	3.07 Intermediate	200	-3.1	-1100	104
b	7.28	1,600 MSL	3.07 Intermediate	200	-1.6	-500	106
c	1.97	420 AGL	5.05 Takeoff	160	-1.7	-400	41
d	0.33	120 AGL	5.05 Takeoff	130	-2.0	-500	9
e	0.00	50 AGL	5.05 Approach	145			

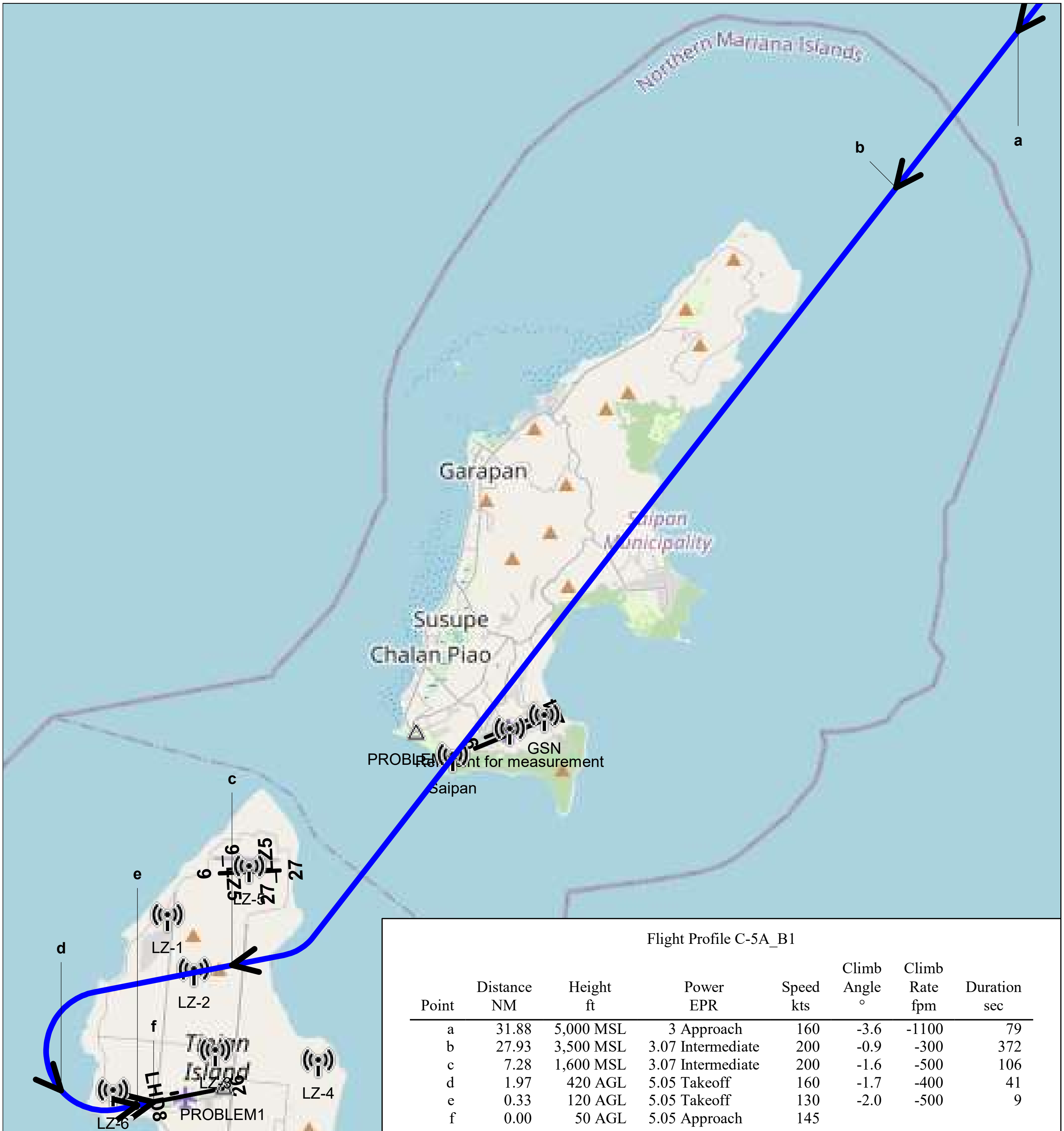
Military Flight Profile C-5A_A1

Flight Track 08A1 - RNAV ARRIVAL

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000 40,000 44,000 48,000 52,000

Scale in Feet 1:151,000 (1 inch = 12,600 feet)

N



Flight Profile C-5A_B1

Point	Distance NM	Height ft	Power EPR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	31.88	5,000 MSL	3 Approach	160	-3.6	-1100	79
b	27.93	3,500 MSL	3.07 Intermediate	200	-0.9	-300	372
c	7.28	1,600 MSL	3.07 Intermediate	200	-1.6	-500	106
d	1.97	420 AGL	5.05 Takeoff	160	-1.7	-400	41
e	0.33	120 AGL	5.05 Takeoff	130	-2.0	-500	9
f	0.00	50 AGL	5.05 Approach	145			

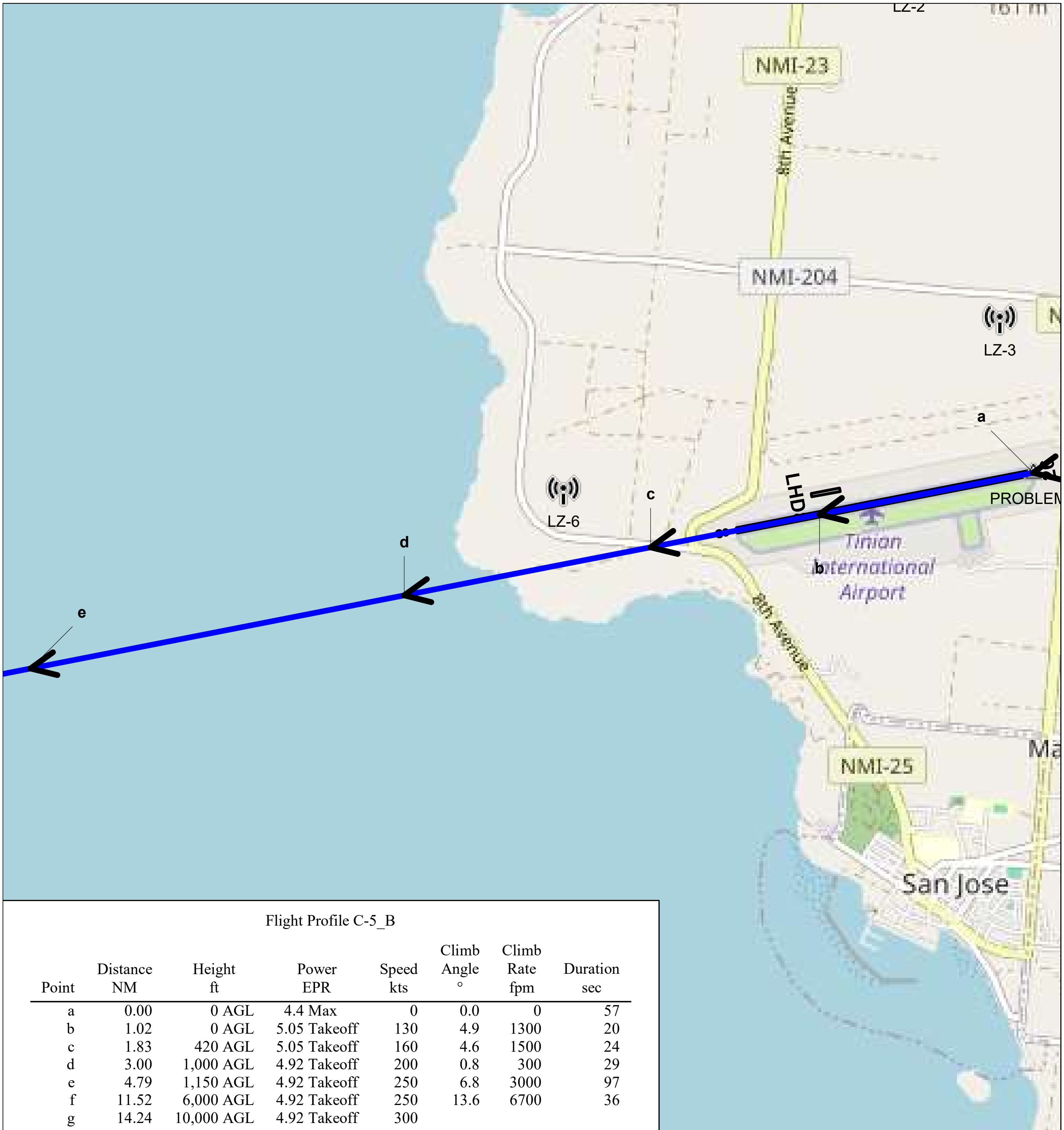
Military Flight Profile C-5A_B1

Flight Track 08A2_2 - NDB ARRIVAL

0 10,000 20,000 30,000 40,000 50,000 60,000 70,000

Scale in Feet 1:213,000 (1 inch = 17,800 feet)

N



Flight Profile C-5_B

Point	Distance NM	Height ft	Power EPR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0.00	0 AGL	4.4 Max	0	0.0	0	57
b	1.02	0 AGL	5.05 Takeoff	130	4.9	1300	20
c	1.83	420 AGL	5.05 Takeoff	160	4.6	1500	24
d	3.00	1,000 AGL	4.92 Takeoff	200	0.8	300	29
e	4.79	1,150 AGL	4.92 Takeoff	250	6.8	3000	97
f	11.52	6,000 AGL	4.92 Takeoff	250	13.6	6700	36
g	14.24	10,000 AGL	4.92 Takeoff	300			

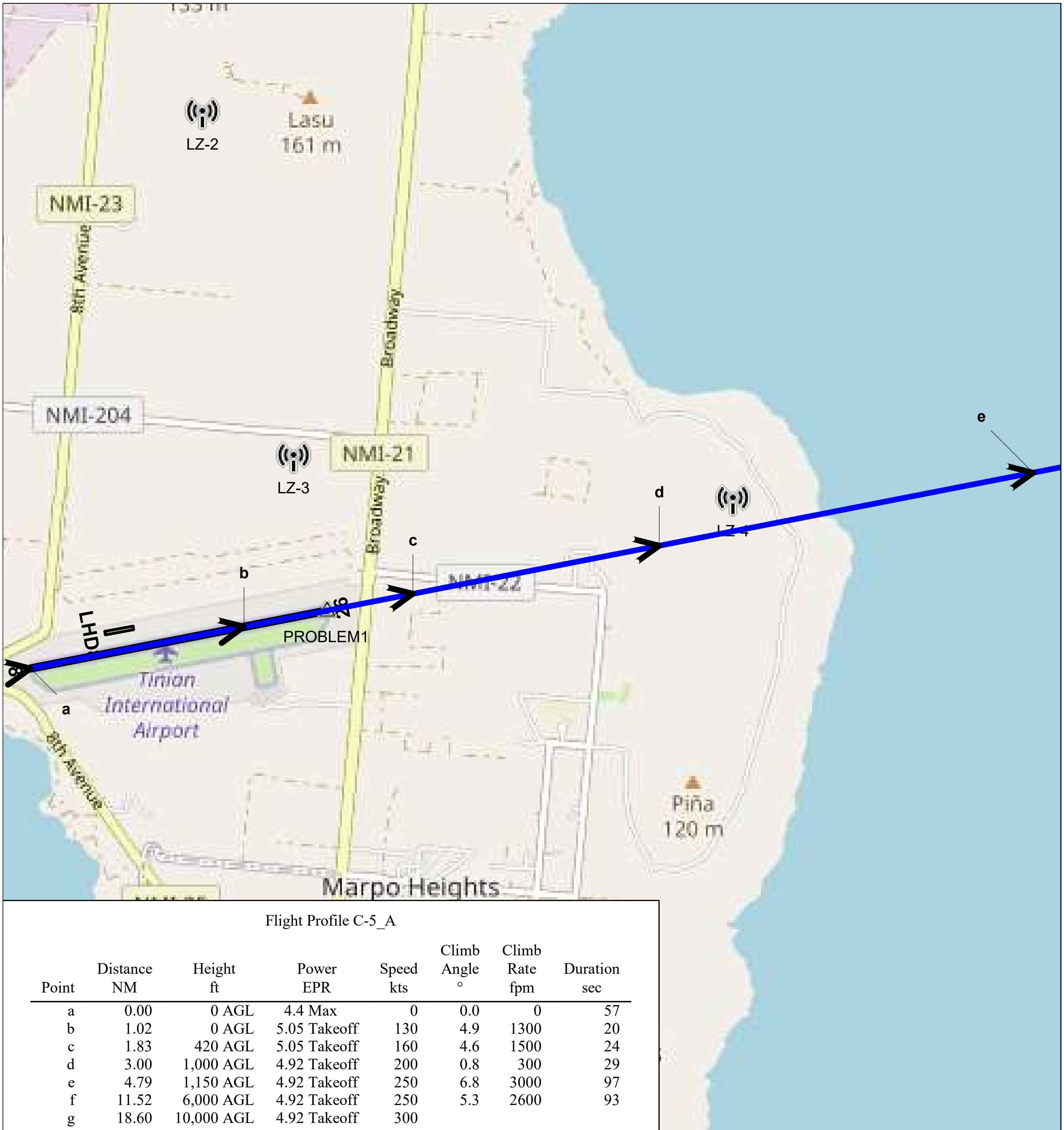
Military Flight Profile C-5_B

Flight Track 26D1 - STANDARD DEPARTURE

0 2,000 4,000 6,000 8,000 10,000 12,000 14,000 16,000

Scale in Feet 1:50,000 (1 inch = 4,160 feet)

N

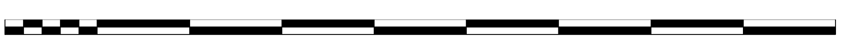


Flight Profile C-5_A

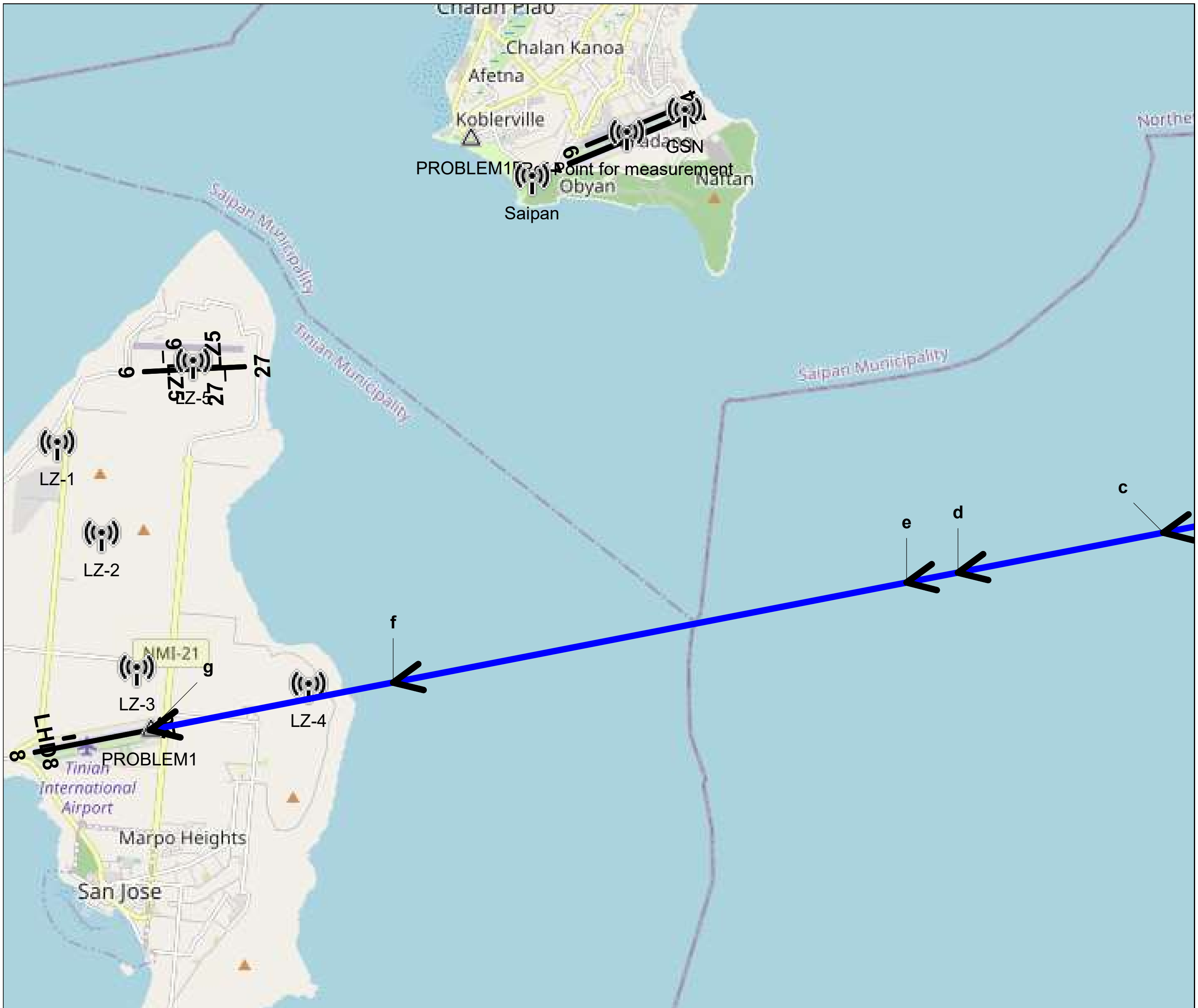
Point	Distance NM	Height ft	Power EPR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0.00	0 AGL	4.4 Max	0	0.0	0	57
b	1.02	0 AGL	5.05 Takeoff	130	4.9	1300	20
c	1.83	420 AGL	5.05 Takeoff	160	4.6	1500	24
d	3.00	1,000 AGL	4.92 Takeoff	200	0.8	300	29
e	4.79	1,150 AGL	4.92 Takeoff	250	6.8	3000	97
f	11.52	6,000 AGL	4.92 Takeoff	250	5.3	2600	93
g	18.60	10,000 AGL	4.92 Takeoff	300			

Military Flight Profile C-5_A

Flight Track 08D1 - STANDARD DEPARTURE



Scale in Feet 1:50,000 (1 inch = 4,160 feet)



Flight Profile Cit_AE

Point	Distance NM	Height ft	Power LBS	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	10,580 AGL	8240 Variable	250	-3.0	-1300	205
b	18.67	6,000 AGL	8340 Variable	250	-3.0	-1300	90
c	12.39	4,000 AGL	8340 Variable	250	-3.0	-1100	45
d	9.88	3,200 AGL	8340 Variable	151	-3.0	-800	15
e	9.26	3,000 AGL	8340 Variable	151	-3.0	-800	150
f	2.97	1,000 AGL	8340 Variable	151	-3.0	-800	71
g	0.00	50 AGL	8340 Variable	151			

Military Flight Profile Cit_AE

Flight Track 26A1 - RNAV ARRIVAL

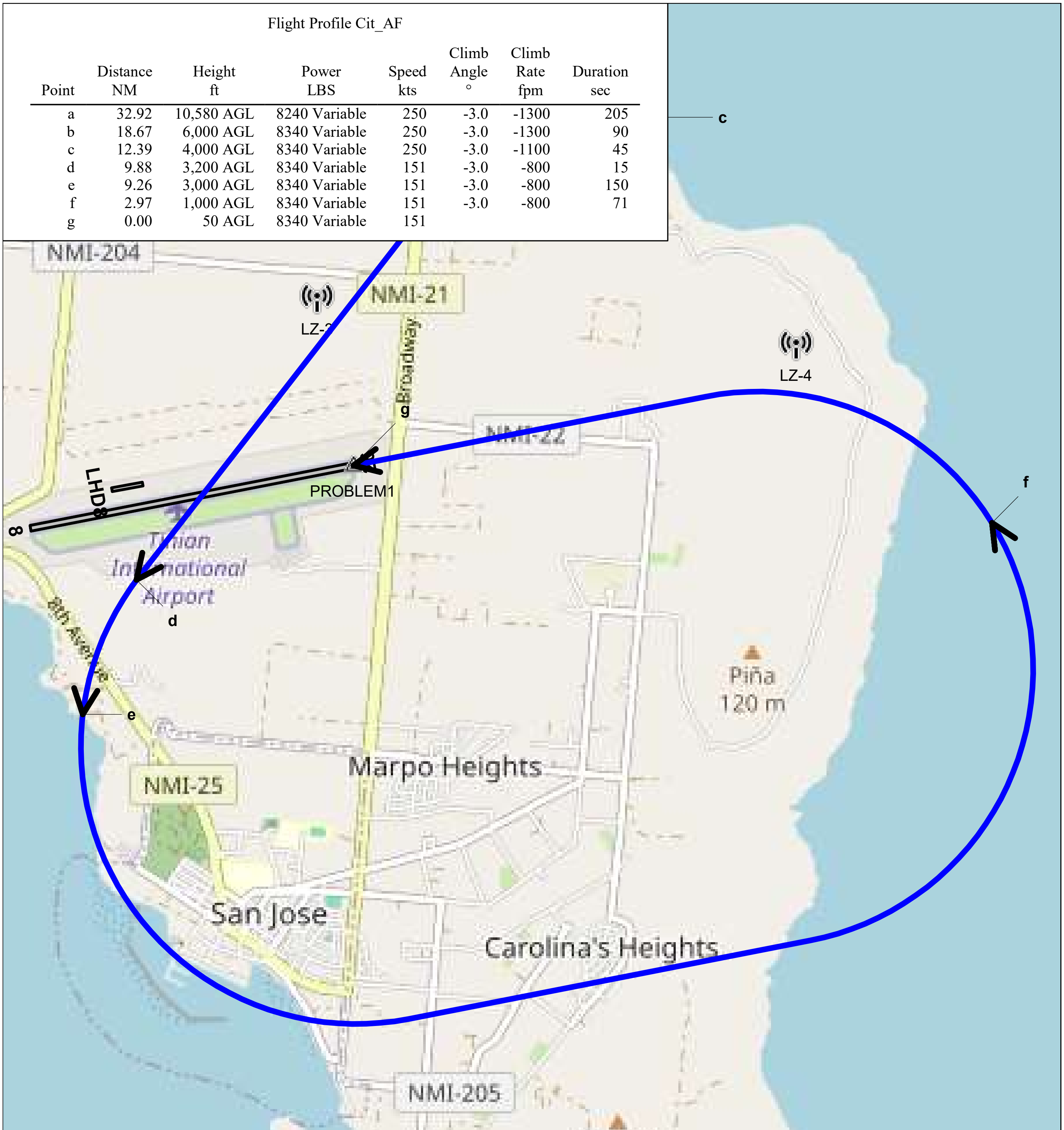
0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000 40,000 44,000 48,000

Scale in Feet 1:144,000 (1 inch = 12,000 feet)

N

Flight Profile Cit_AF

Point	Distance NM	Height ft	Power LBS	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	10,580 AGL	8240 Variable	250	-3.0	-1300	205
b	18.67	6,000 AGL	8340 Variable	250	-3.0	-1300	90
c	12.39	4,000 AGL	8340 Variable	250	-3.0	-1100	45
d	9.88	3,200 AGL	8340 Variable	151	-3.0	-800	15
e	9.26	3,000 AGL	8340 Variable	151	-3.0	-800	150
f	2.97	1,000 AGL	8340 Variable	151	-3.0	-800	71
g	0.00	50 AGL	8340 Variable	151			



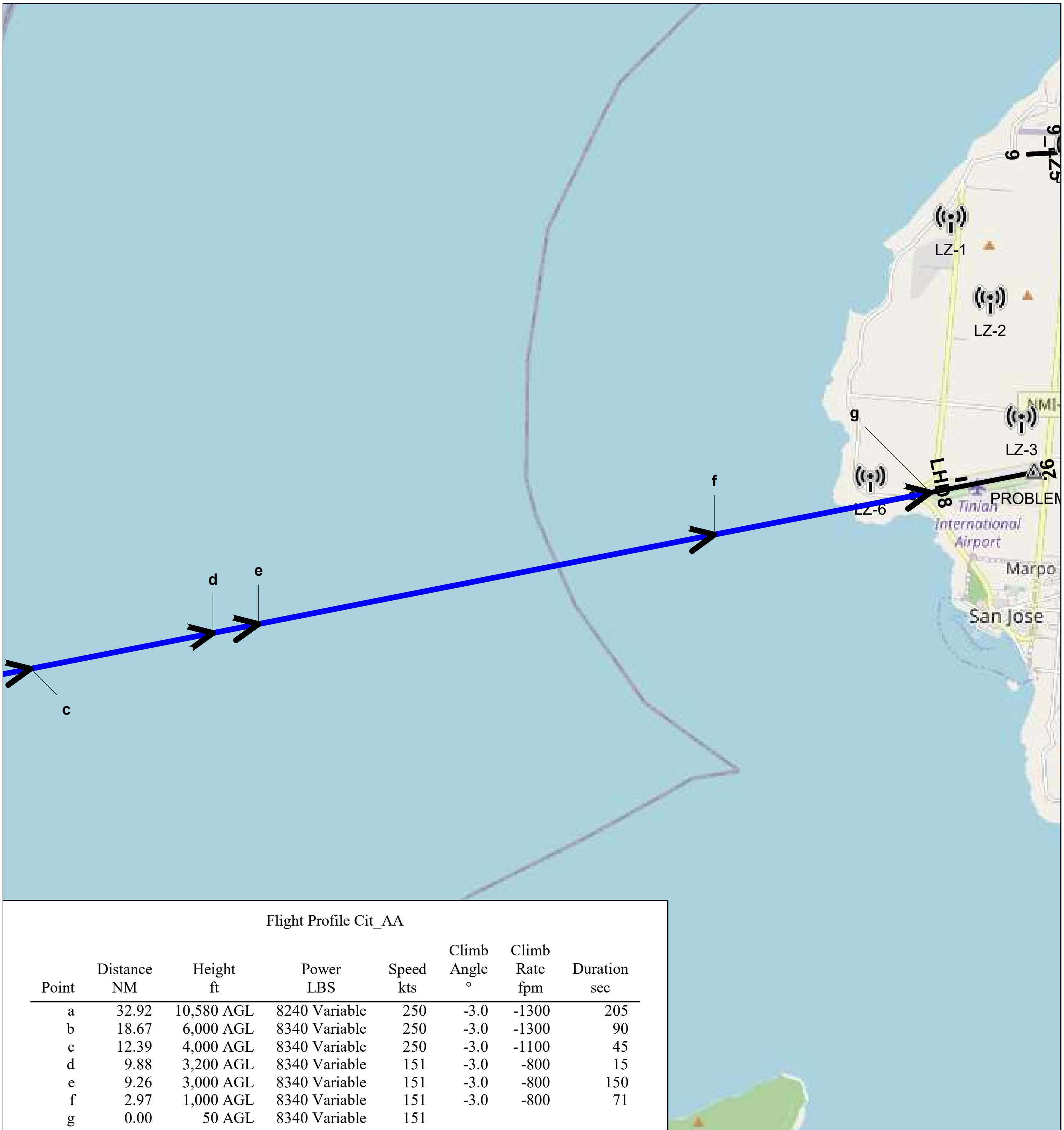
Military Flight Profile Cit_AF

Flight Track 26A2_2 - NDB ARRIVAL

0 2,000 4,000 6,000 8,000 10,000 12,000 14,000

Scale in Feet 1:45,800 (1 inch = 3,820 feet)

N



Flight Profile Cit_AA

Point	Distance NM	Height ft	Power LBS	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	10,580 AGL	8240 Variable	250	-3.0	-1300	205
b	18.67	6,000 AGL	8340 Variable	250	-3.0	-1300	90
c	12.39	4,000 AGL	8340 Variable	250	-3.0	-1100	45
d	9.88	3,200 AGL	8340 Variable	151	-3.0	-800	15
e	9.26	3,000 AGL	8340 Variable	151	-3.0	-800	150
f	2.97	1,000 AGL	8340 Variable	151	-3.0	-800	71
g	0.00	50 AGL	8340 Variable	151			

Military Flight Profile Cit_AA

Flight Track 08A1 - RNAV ARRIVAL

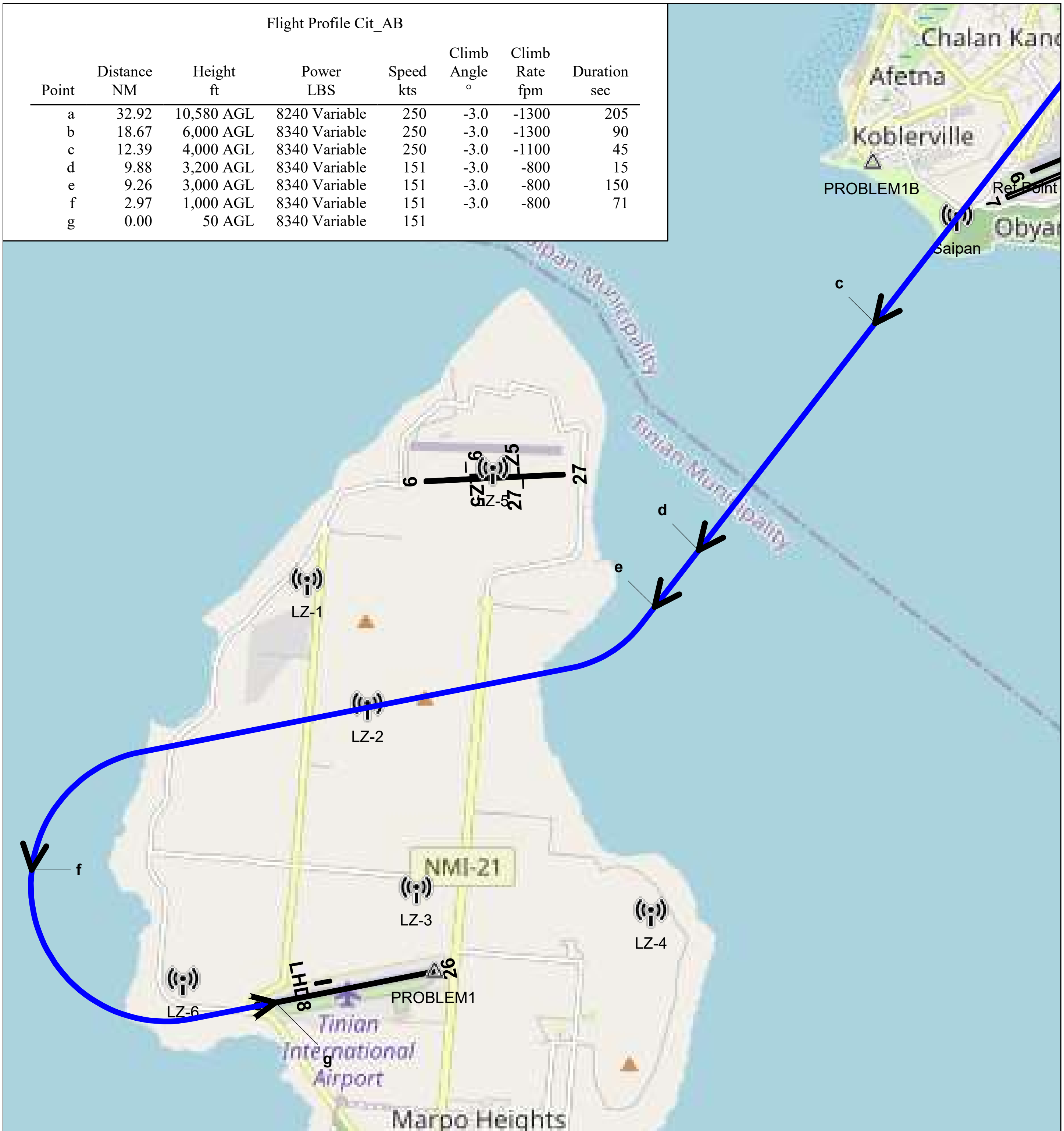
0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000 40,000 44,000 48,000

Scale in Feet 1:144,000 (1 inch = 12,000 feet)

N

Flight Profile Cit_AB

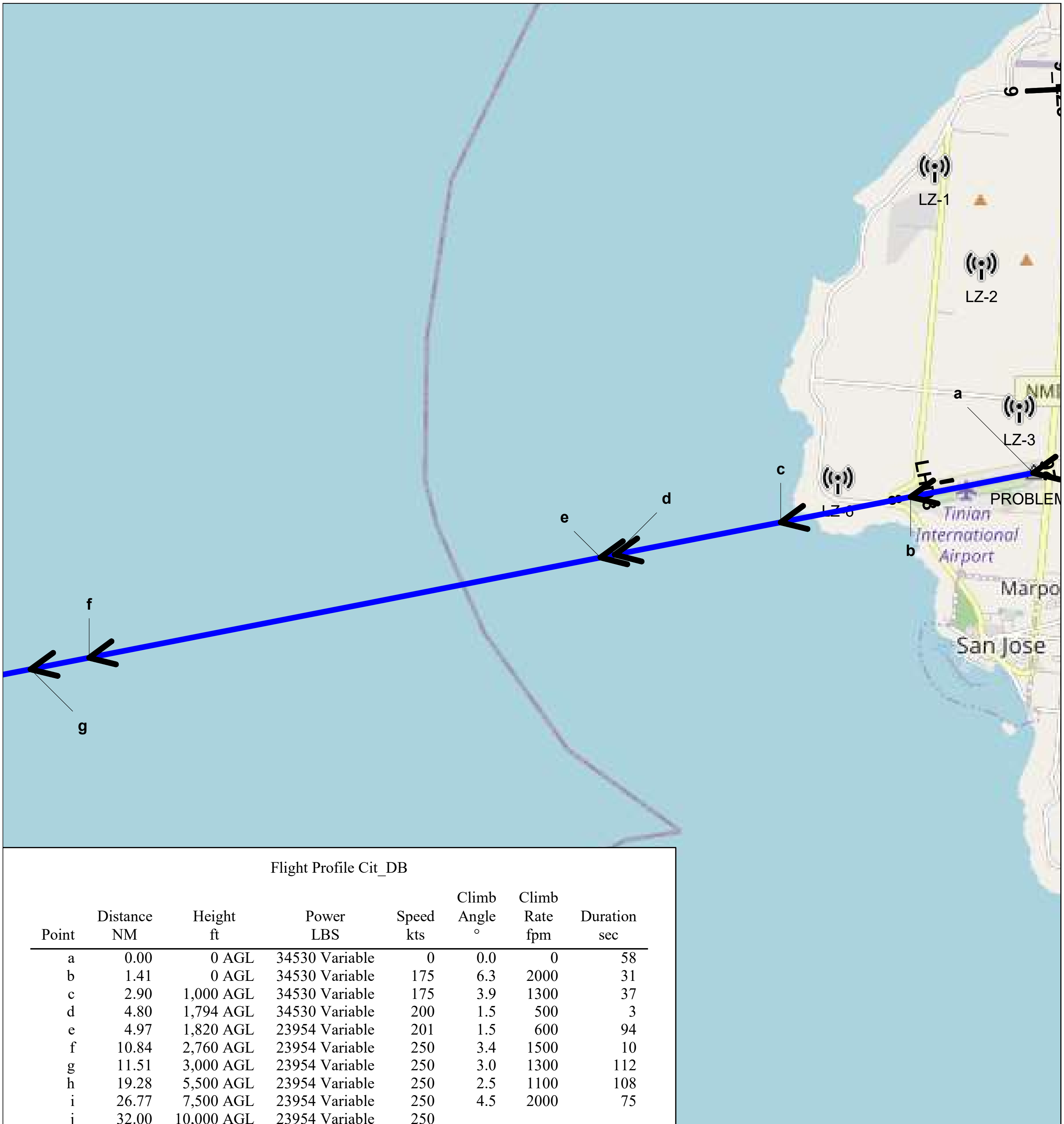
Point	Distance NM	Height ft	Power LBS	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	10,580 AGL	8240 Variable	250	-3.0	-1300	205
b	18.67	6,000 AGL	8340 Variable	250	-3.0	-1300	90
c	12.39	4,000 AGL	8340 Variable	250	-3.0	-1100	45
d	9.88	3,200 AGL	8340 Variable	151	-3.0	-800	15
e	9.26	3,000 AGL	8340 Variable	151	-3.0	-800	150
f	2.97	1,000 AGL	8340 Variable	151	-3.0	-800	71
g	0.00	50 AGL	8340 Variable	151			



Military Flight Profile Cit_AB

Flight Track 08A2_2 - NDB ARRIVAL

Scale in Feet 1:93,500 (1 inch = 7,790 feet)



Flight Profile Cit_DB

Point	Distance NM	Height ft	Power LBS	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0.00	0 AGL	34530 Variable	0	0.0	0	58
b	1.41	0 AGL	34530 Variable	175	6.3	2000	31
c	2.90	1,000 AGL	34530 Variable	175	3.9	1300	37
d	4.80	1,794 AGL	34530 Variable	200	1.5	500	3
e	4.97	1,820 AGL	23954 Variable	201	1.5	600	94
f	10.84	2,760 AGL	23954 Variable	250	3.4	1500	10
g	11.51	3,000 AGL	23954 Variable	250	3.0	1300	112
h	19.28	5,500 AGL	23954 Variable	250	2.5	1100	108
i	26.77	7,500 AGL	23954 Variable	250	4.5	2000	75
j	32.00	10,000 AGL	23954 Variable	250			

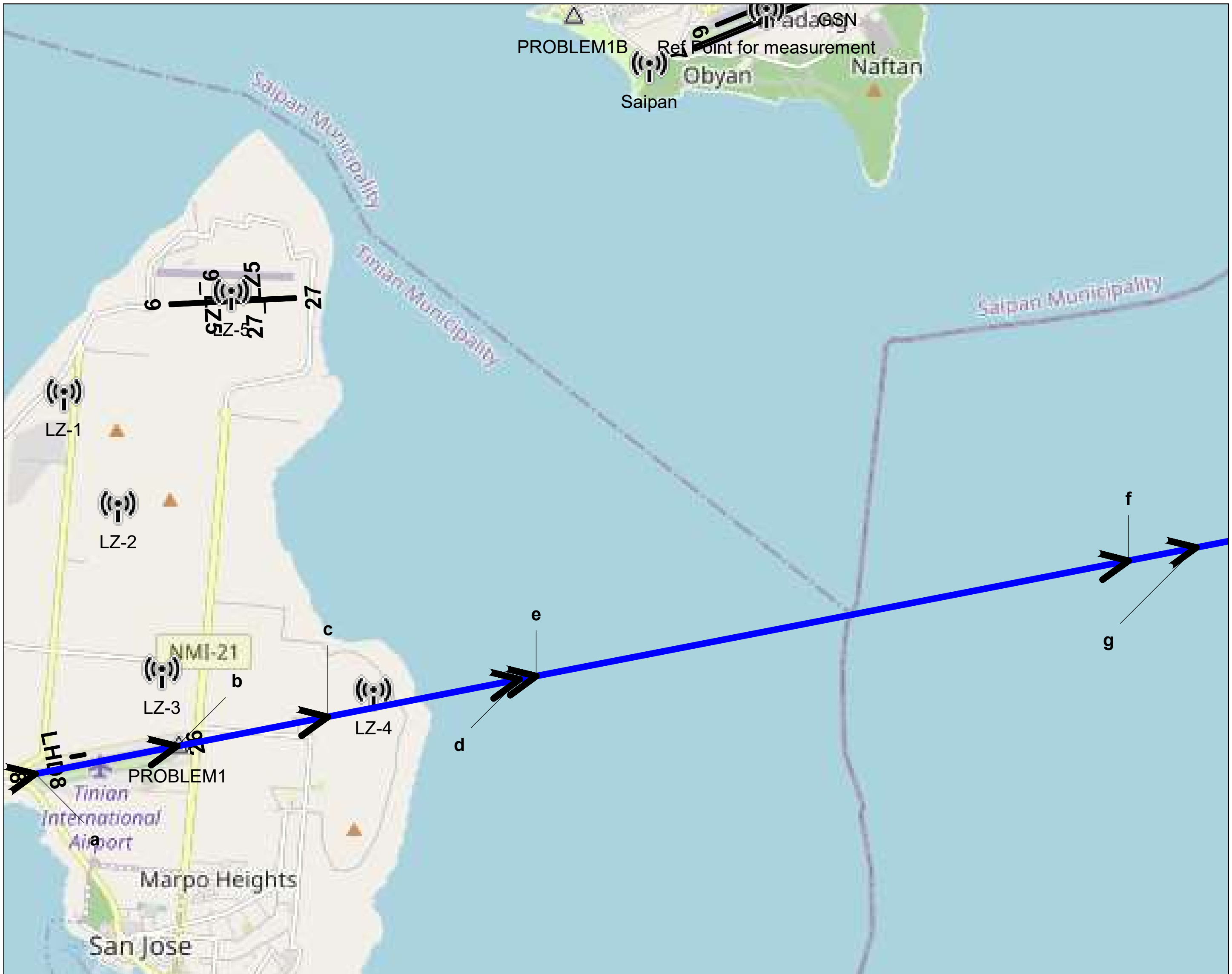
Military Flight Profile Cit_DB

Flight Track 26D1 - STANDARD DEPARTURE

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000 40,000

Scale in Feet 1:120,000 (1 inch = 10,000 feet)

N



Flight Profile Cit_DA

Point	Distance NM	Height ft	Power LBS	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0.00	0 AGL	34530 Variable	0	0.0	0	58
b	1.41	0 AGL	34530 Variable	175	6.3	2000	31
c	2.90	1,000 AGL	34530 Variable	175	3.9	1300	37
d	4.80	1,794 AGL	34530 Variable	200	1.5	500	3
e	4.97	1,820 AGL	23954 Variable	201	1.5	600	94
f	10.84	2,760 AGL	23954 Variable	250	3.4	1500	10
g	11.51	3,000 AGL	23954 Variable	250	3.0	1300	112
h	19.28	5,500 AGL	23954 Variable	250	2.5	1100	108
i	26.77	7,500 AGL	23954 Variable	250	4.5	2000	75
j	32.00	10,000 AGL	23954 Variable	250			

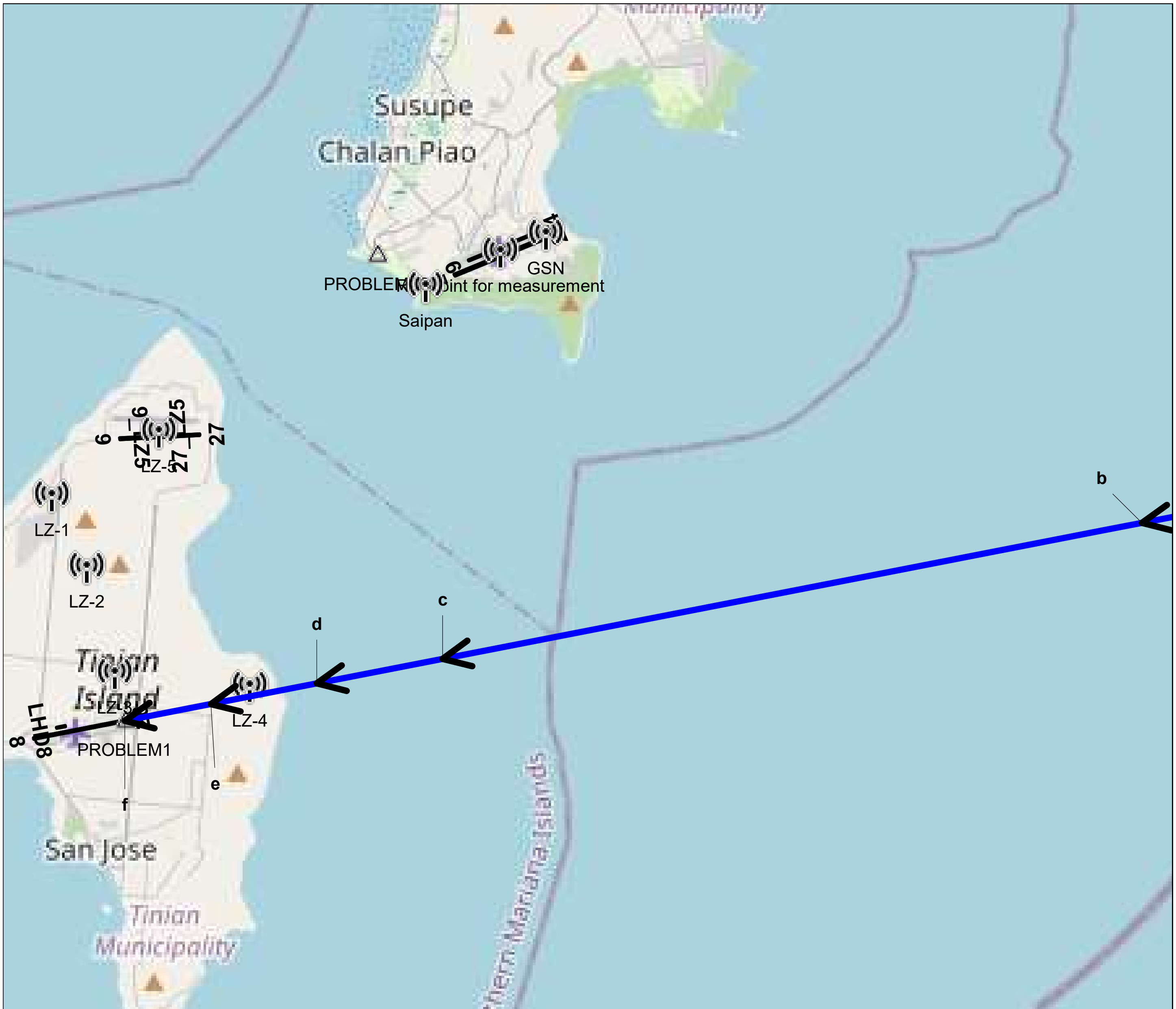
Military Flight Profile Cit_DA

Flight Track 08D1 - STANDARD DEPARTURE

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000 40,000

Scale in Feet 1:120,000 (1 inch = 10,000 feet)

N



Flight Profile F-18E_AF1

Point	Distance NM	Height ft	Power % NC	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	20,000 AGL	75 Variable	300	-8.2	-4400	205
b	15.80	5,000 AGL	80 Variable	300	-2.6	-1000	182
c	4.94	2,000 AGL	80 Approach	130	-3.9	-900	54
d	2.98	1,200 AGL	85 Approach	130	-4.0	-900	46
e	1.34	500 AGL	85 Approach	130	-3.2	-700	37
f	0.00	50 AGL	85 Approach	130			

Military Flight Profile F-18E_AF1

Flight Track 26A1 - RNAV ARRIVAL

0 10,000 20,000 30,000 40,000 50,000

Scale in Feet 1:180,000 (1 inch = 15,000 feet)

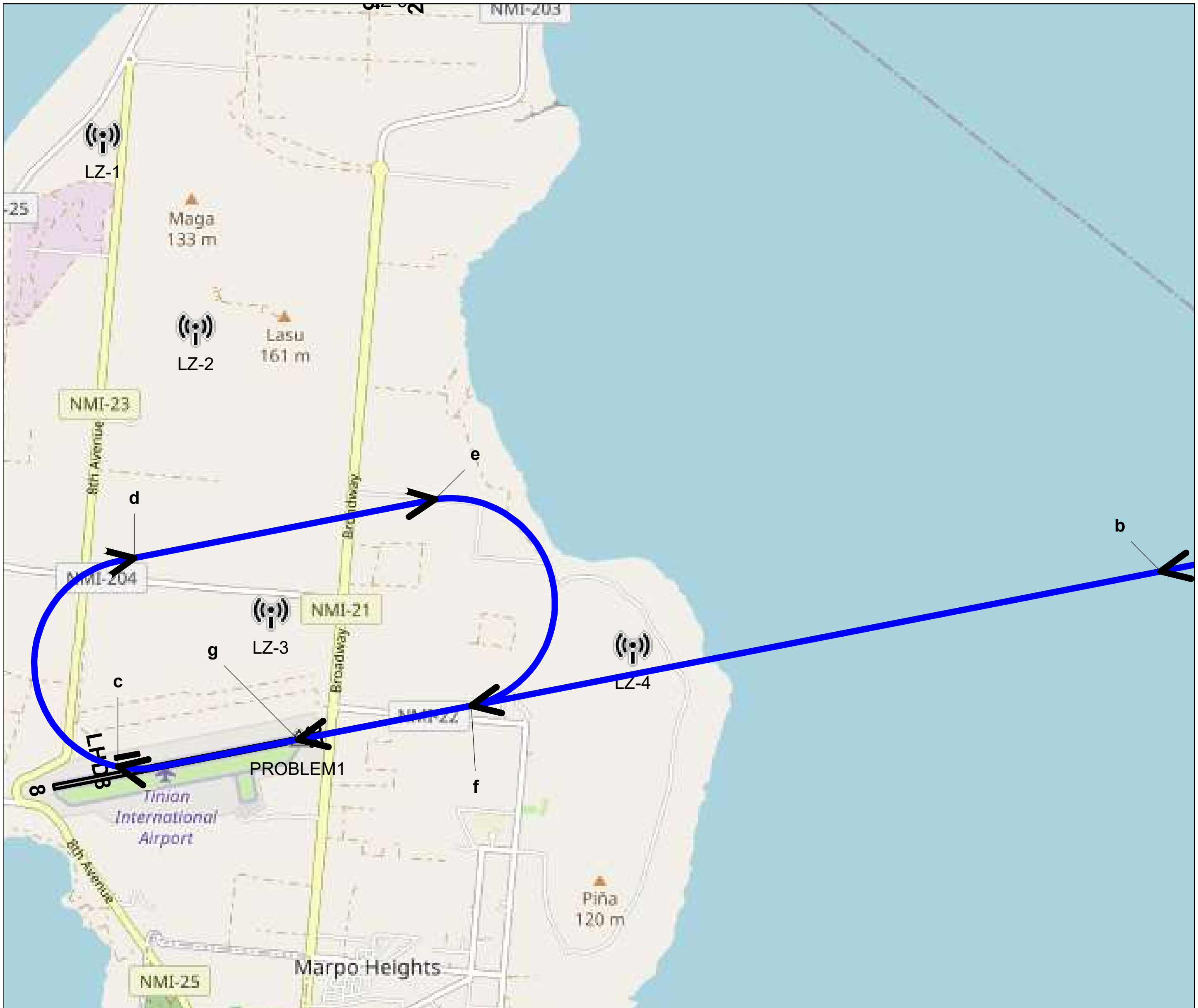
N

Flight Profile F-18E_AG1

Point	Distance NM	Height ft	Power % NC	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	18,000 AGL	80 Variable	300	-8.0	-3900	237
b	14.80	2,800 MSL	80 Approach	250	-3.5	-1200	84
c	10.14	1,060 MSL	85 Approach	150	0.0	0	180
d	3.13	1,060 MSL	66 Approach	130	-2.1	-500	59
e	0.99	300 AGL	85 Approach	130	-2.4	-500	27
f	0.00	50 AGL	85 Approach	130			

Military Flight Profile F-18E_AG1
Flight Track 26A2 - NDB ARRIVAL

Scale in Feet 1:79,000 (1 inch = 6,580 feet)

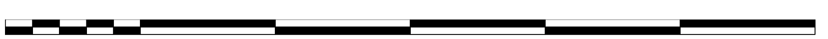


Flight Profile F-18E_AI1

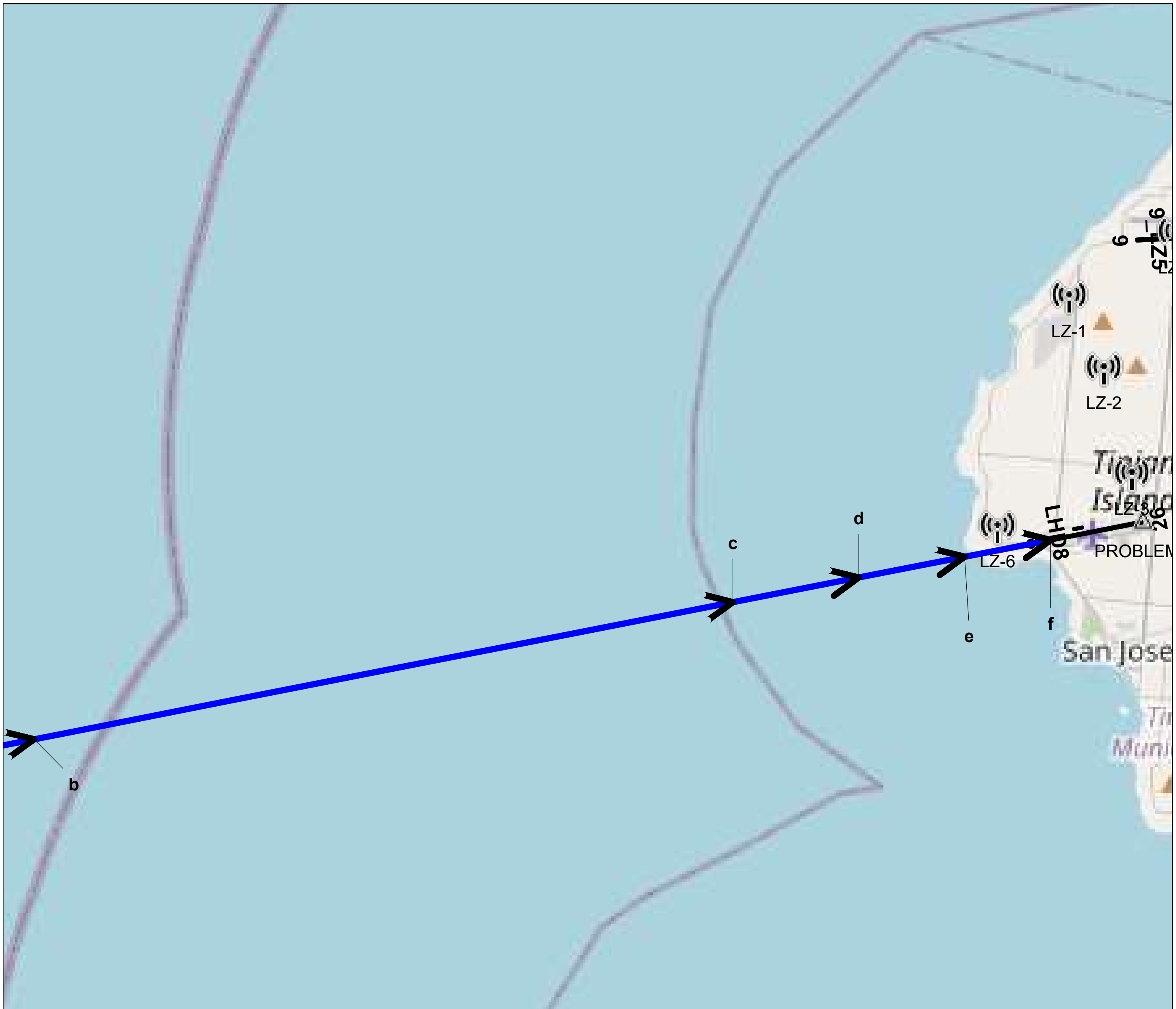
Point	Distance NM	Height ft	Power % NC	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	20,000 AGL	75 Variable	300	-7.7	-4100	247
b	12.34	3,000 AGL	80 Variable	300	-2.6	-1400	72
c	6.30	1,600 MSL	66 Variable	300	-2.7	-1000	29
d	4.58	1,100 MSL	84 Parallel	130	0.0	0	48
e	2.84	1,100 MSL	81 Approach	130	-2.6	-600	51
f	1.00	300 AGL	84 Approach	130	-2.3	-500	28
g	0.00	50 AGL	84 Approach	130			

Military Flight Profile F-18E_AI1

Flight Track 26A4 - OVERHEAD BREAK ARRIVAL



Scale in Feet 1:68,200 (1 inch = 5,690 feet)



Flight Profile F-18E_AA1

Point	Distance NM	Height ft	Power % NC	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	20,000 AGL	75 Variable	300	-8.2	-4400	205
b	15.80	5,000 AGL	80 Variable	300	-2.6	-1000	182
c	4.94	2,000 AGL	80 Approach	130	-3.9	-900	54
d	2.98	1,200 AGL	85 Approach	130	-4.0	-900	46
e	1.34	500 AGL	85 Approach	130	-3.2	-700	37
f	0.00	50 AGL	85 Approach	130			

Military Flight Profile F-18E_AA1

Flight Track 08A1 - RNAV ARRIVAL

0 10,000 20,000 30,000 40,000 50,000

Scale in Feet 1:180,000 (1 inch = 15,000 feet)

N

Flight Profile F-18E_AB1

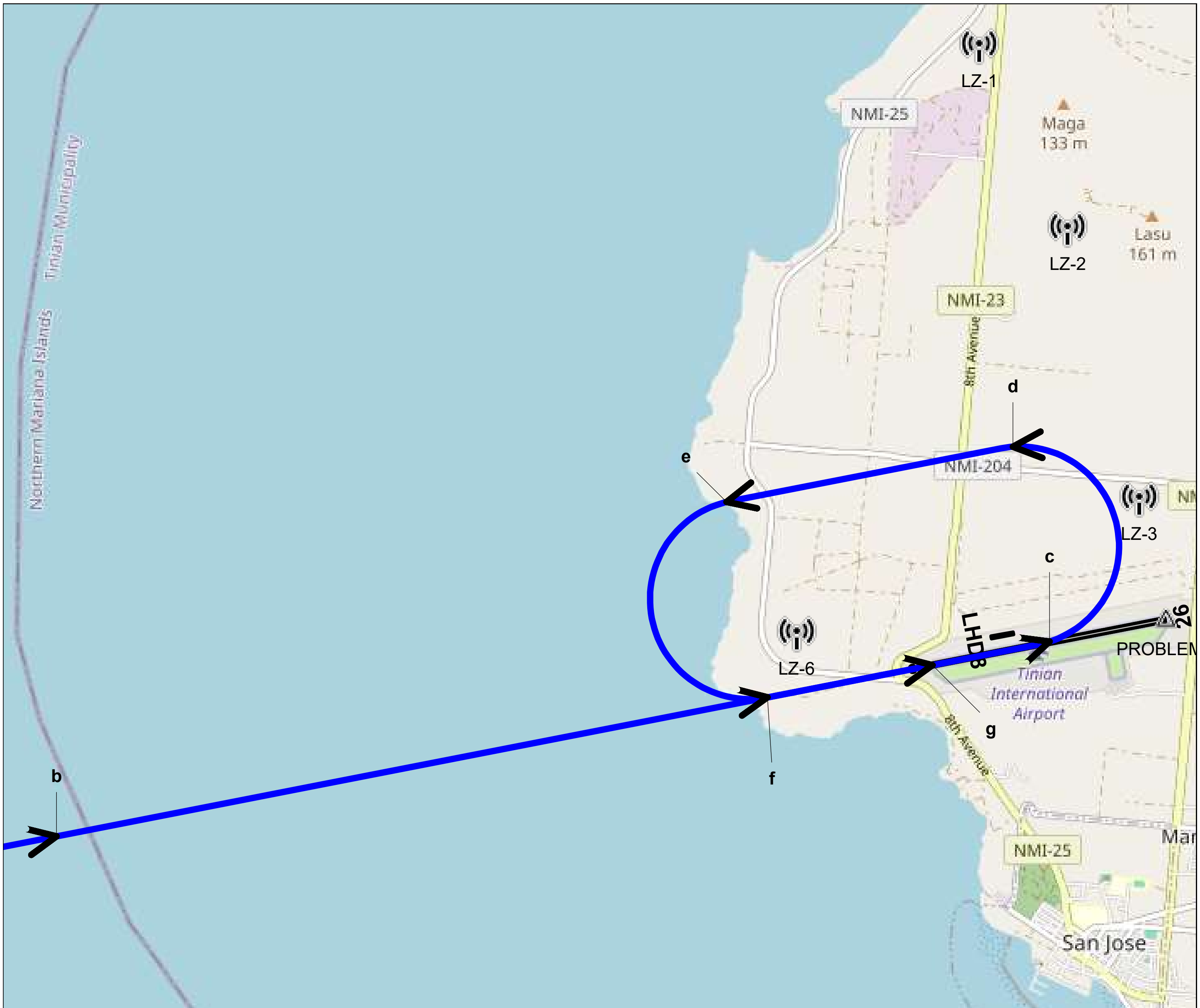
Point	Distance NM	Height ft	Power % NC	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	18,000 AGL	80 Variable	300	-7.0	-3400	270
b	12.27	2,800 MSL	80 Approach	250	-3.5	-1300	83
c	7.64	1,060 MSL	85 Approach	150	0.0	0	122
d	2.89	1,060 MSL	66 Approach	130	-2.3	-500	53
e	0.99	300 AGL	85 Approach	130	-2.4	-500	27
f	0.00	50 AGL	85 Approach	130			

Military Flight Profile F-18E_AB1
Flight Track 08A2 - NDB ARRIVAL

0 4,000 8,000 12,000 16,000 20,000 24,000

Scale in Feet 1:79,600 (1 inch = 6,630 feet)

N



Flight Profile F-18E_AD1

Point	Distance NM	Height ft	Power % NC	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	20,000 AGL	75 Variable	300	-7.7	-4100	247
b	12.34	3,000 AGL	80 Variable	300	-2.6	-1400	72
c	6.30	1,600 MSL	66 Variable	300	-2.7	-1000	29
d	4.58	1,100 MSL	84 Parallel	130	0.0	0	48
e	2.84	1,100 MSL	81 Approach	130	-2.6	-600	51
f	1.00	300 AGL	84 Approach	130	-2.3	-500	28
g	0.00	50 AGL	84 Approach	130			

Military Flight Profile F-18E_AD1

Flight Track 08A4 - OVERHEAD BREAK ARRIVAL - FW

0 4,000 8,000 12,000 16,000 20,000

Scale in Feet 1:71,700 (1 inch = 5,980 feet)

N

Flight Profile F-18E_DB1

Point	Distance NM	Height ft	Power % NC	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0.00	0 AGL	97 Min A/B	0	0.0	0	18
b	0.33	0 AGL	97 Afterburner	135	4.8	1600	18
c	1.32	500 AGL	96 Variable	250	4.1	2000	15
d	2.47	1,000 AGL	95 Variable	300	19.7	10900	94
e	10.29	18,000 AGL	84 Cruise	300	0.0	0	272
f	32.92	18,000 AGL	84 Cruise	300			

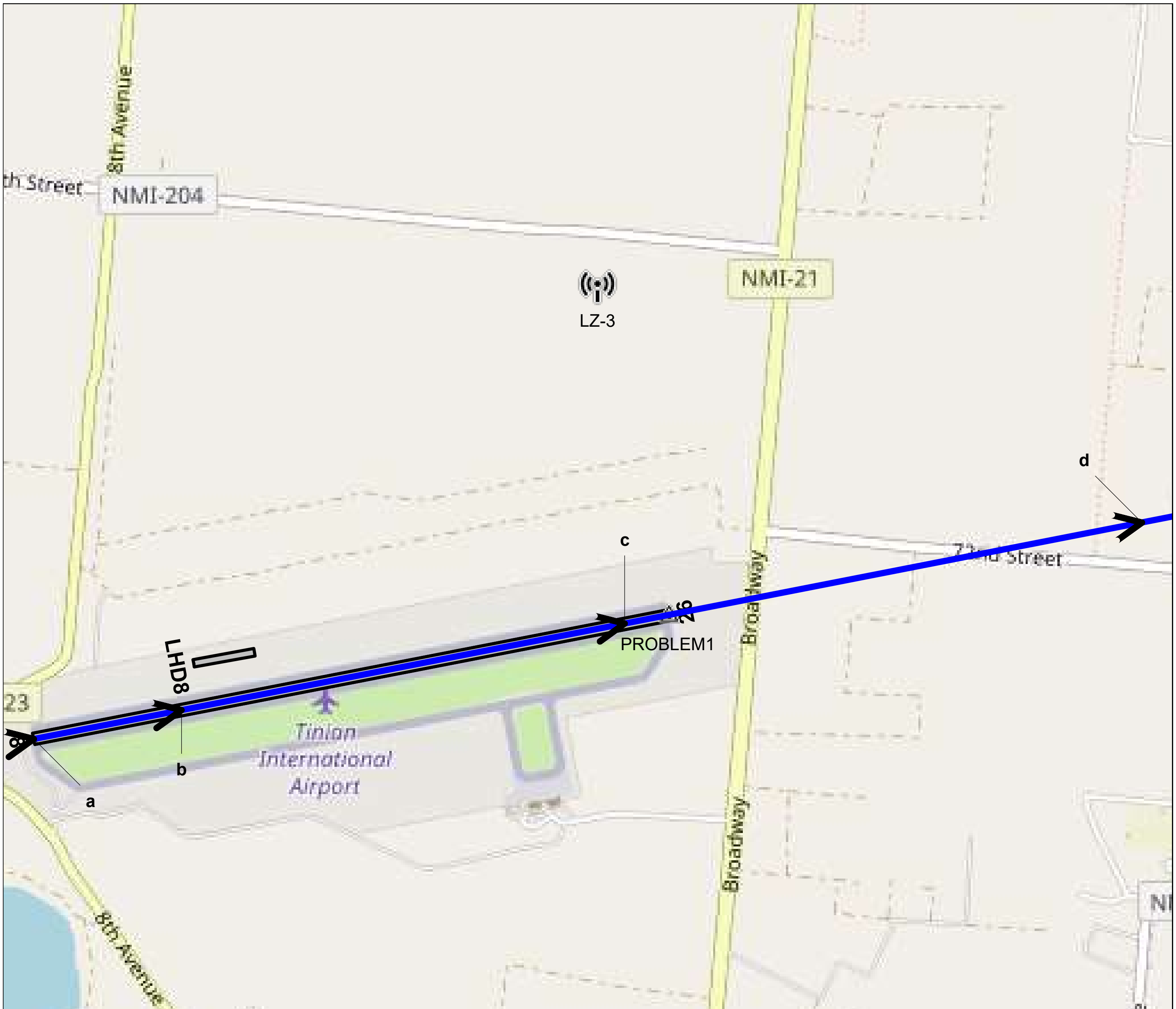
Military Flight Profile F-18E_DB1

Flight Track 26D1 - STANDARD DEPARTURE

0 1,000 2,000 3,000 4,000 5,000 6,000 7,000 8,000

Scale in Feet 1:25,700 (1 inch = 2,150 feet)

N



Flight Profile F-18E_DA1

Point	Distance NM	Height ft	Power % NC	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0.00	0 AGL	97 Min A/B	0	0.0	0	18
b	0.33	0 AGL	97 Afterburner	135	4.8	1600	18
c	1.32	500 AGL	96 Variable	250	4.1	2000	15
d	2.47	1,000 AGL	95 Variable	300	19.7	10900	94
e	10.29	18,000 AGL	84 Cruise	300	0.0	0	272
f	32.92	18,000 AGL	84 Cruise	300			

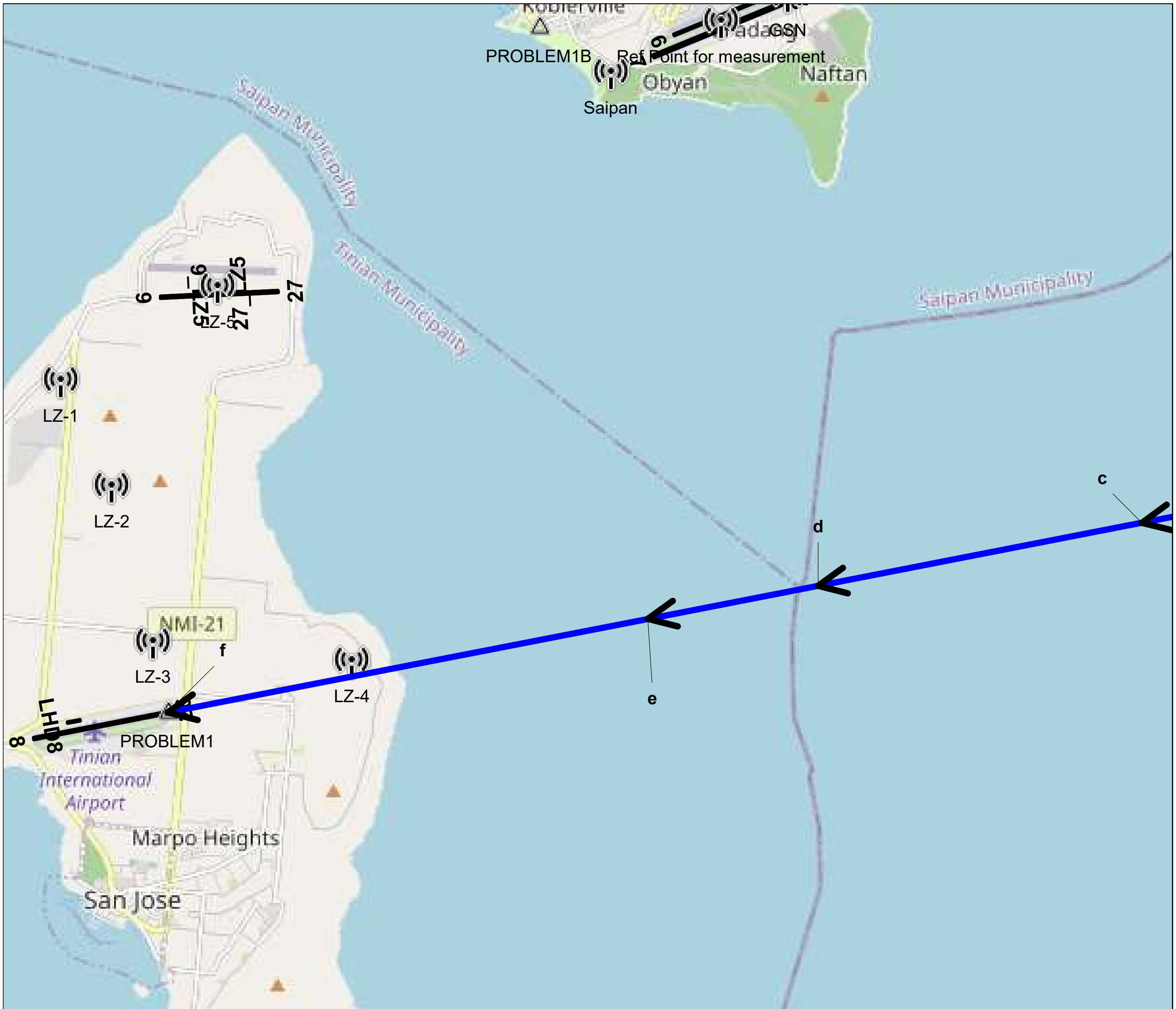
Military Flight Profile F-18E_DA1

Flight Track 08D1 - STANDARD DEPARTURE

0 1,000 2,000 3,000 4,000 5,000 6,000 7,000 8,000

Scale in Feet 1:25,700 (1 inch = 2,150 feet)

N



Flight Profile F-35B_AF

Point	Distance NM	Height ft	Power % ETR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec	Notes
a	32.92	10,000 AGL	15 Variable	350	0.0	0	133	
b	20.00	10,000 AGL	15 Variable	350	-5.5	-3100	108	
c	10.28	4,350 AGL	15 Variable	300	-5.2	-2400	47	
d	6.86	2,450 AGL	40 Approach Low	225	-3.4	-1200	32	Gear Down
e	5.07	1,800 AGL	40 Approach Low	180	-3.3	-1000	103	
f	0.00	50 AGL	40 Approach Low	175				

Military Flight Profile F-35B_AF

Flight Track 26A1 - RNAV ARRIVAL

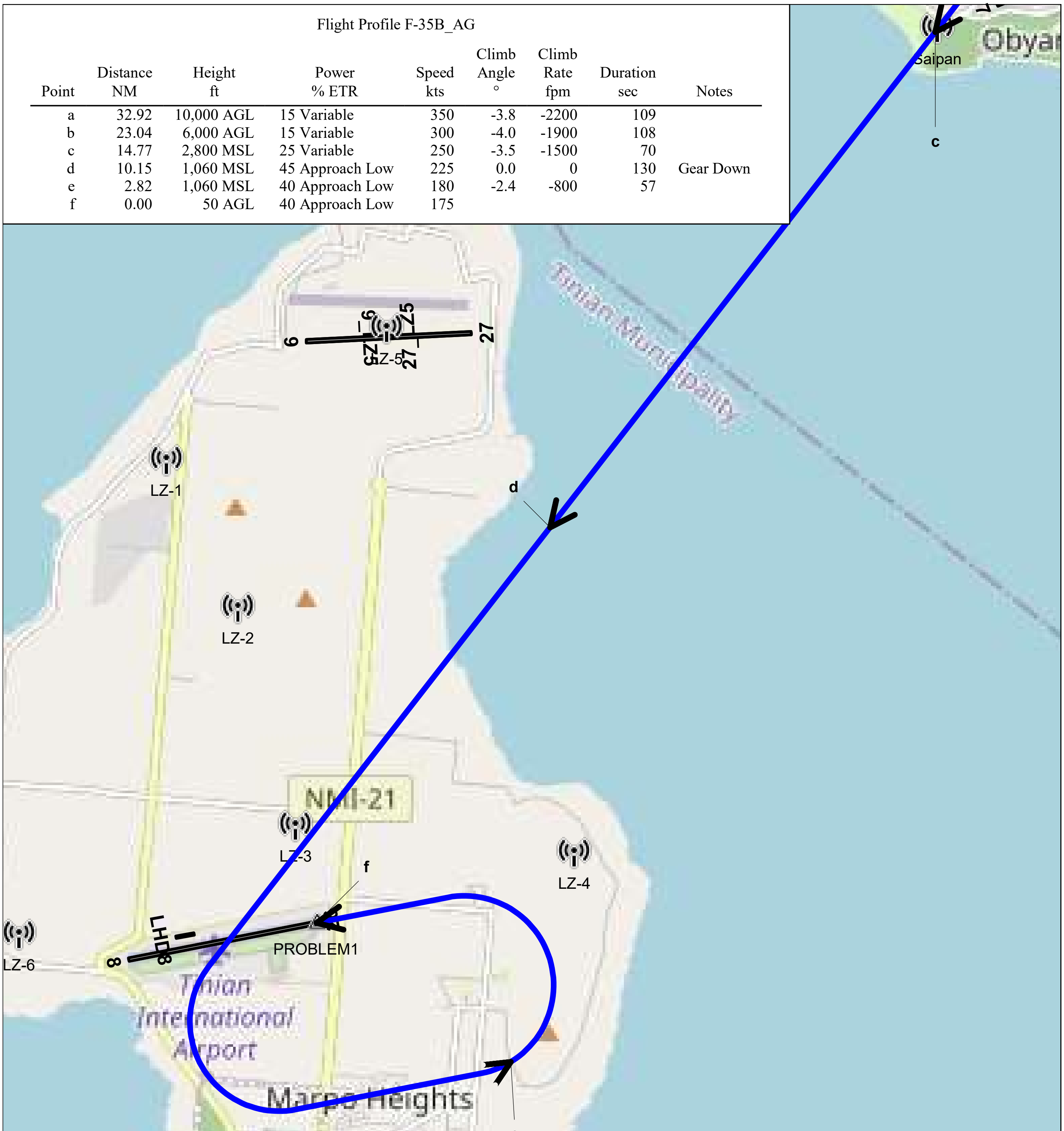
0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000 40,000

Scale in Feet 1:122,000 (1 inch = 10,200 feet)

N

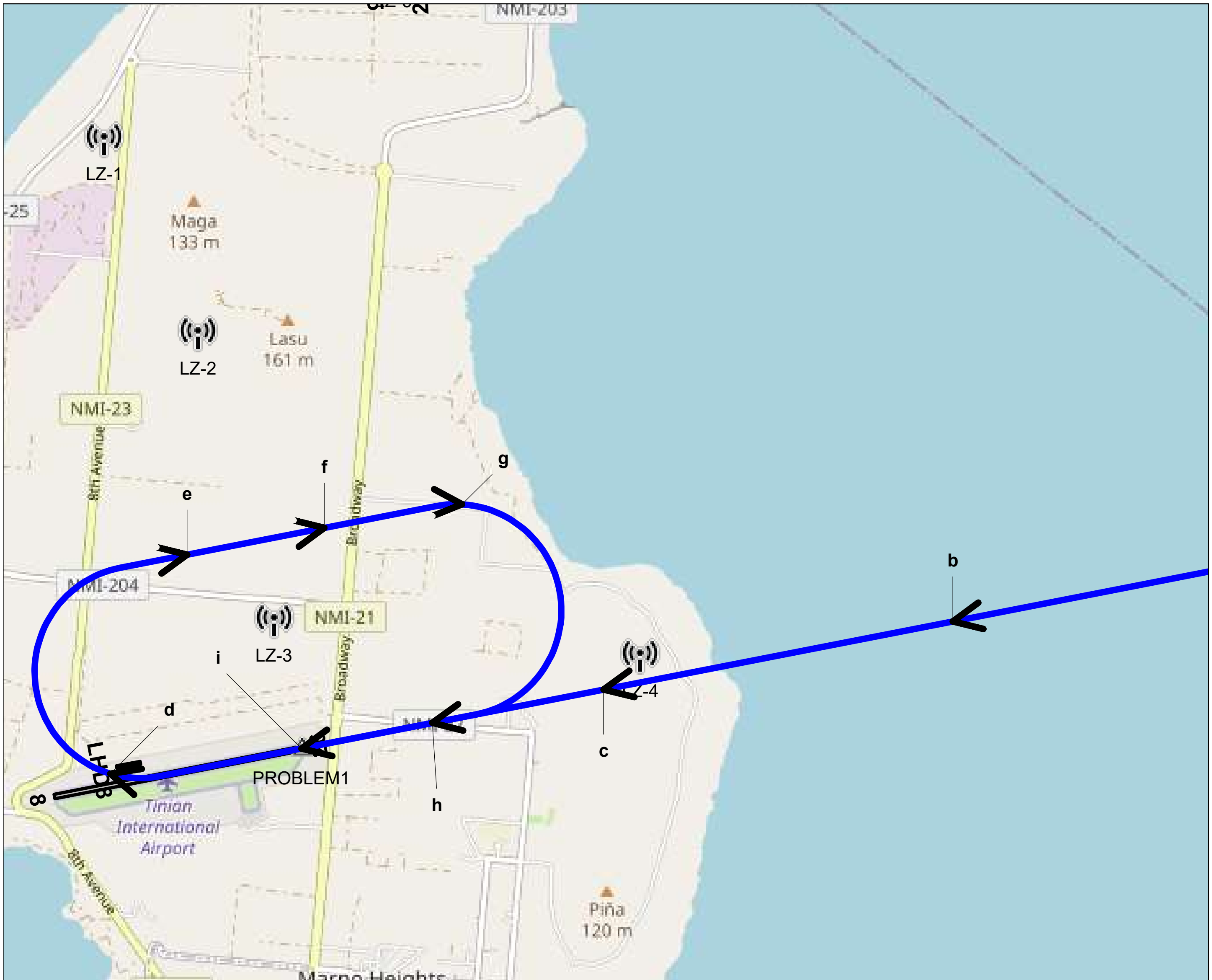
Flight Profile F-35B_AG

Point	Distance NM	Height ft	Power % ETR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec	Notes
a	32.92	10,000 AGL	15 Variable	350	-3.8	-2200	109	
b	23.04	6,000 AGL	15 Variable	300	-4.0	-1900	108	
c	14.77	2,800 MSL	25 Variable	250	-3.5	-1500	70	
d	10.15	1,060 MSL	45 Approach Low	225	0.0	0	130	Gear Down
e	2.82	1,060 MSL	40 Approach Low	180	-2.4	-800	57	
f	0.00	50 AGL	40 Approach Low	175				



Military Flight Profile F-35B_AG
Flight Track 26A2 - NDB ARRIVAL

Scale in Feet 1:78,800 (1 inch = 6,560 feet)



Flight Profile F-35B_AI

Point	Distance NM	Height ft	Power % ETR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec	Notes
a	32.92	20,000 AGL	15 Flight Idle	350	-8.0	-5000	225	
b	11.07	1,600 MSL	35 Level Flight	350	0.0	0	21	
c	9.07	1,600 MSL	35 Level Flight	350	0.0	0	29	
d	6.25	1,600 MSL	35 Level Flight	350	0.0	0	25	
e	4.29	1,600 MSL	35 Approach Low	225	-6.0	-2000	15	Gear Down
f	3.50	1,100 MSL	55 Approach Low	145	0.0	0	20	
g	2.71	1,100 MSL	55 Approach Low	145	-2.4	-600	49	
h	0.75	300 AGL	55 Approach Low	145	-3.1	-800	19	
i	0.00	50 AGL	55 Approach Low	145				

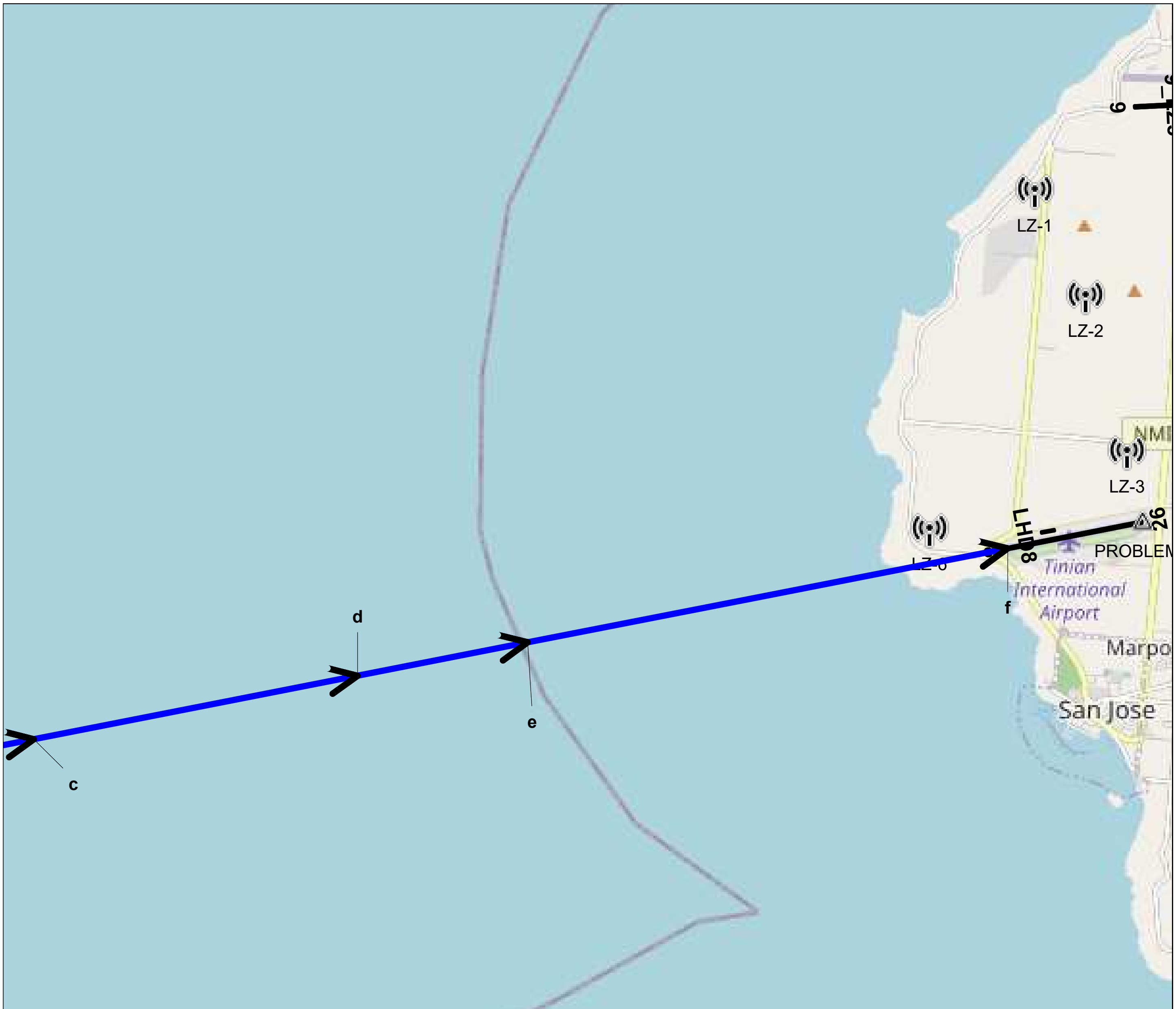
Military Flight Profile F-35B_AI

Flight Track 26A4 - OVERHEAD BREAK ARRIVAL

0 4,000 8,000 12,000 16,000 20,000

Scale in Feet 1:68,200 (1 inch = 5,690 feet)

N



Flight Profile F-35B_AA

Point	Distance NM	Height ft	Power % ETR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec	Notes
a	32.92	10,000 AGL	15 Variable	350	0.0	0	133	
b	20.00	10,000 AGL	15 Variable	350	-5.5	-3100	108	
c	10.28	4,350 AGL	15 Variable	300	-5.2	-2400	47	
d	6.86	2,450 AGL	40 Approach Low	225	-3.4	-1200	32	Gear Down
e	5.07	1,800 AGL	40 Approach Low	180	-3.3	-1000	103	
f	0.00	50 AGL	40 Approach Low	175				

Military Flight Profile F-35B_AA

Flight Track 08A1 - RNAV ARRIVAL

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000 40,000

Scale in Feet 1:122,000 (1 inch = 10,200 feet)

N

Flight Profile F-35B_AB

Point	Distance NM	Height ft	Power % ETR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec	Notes
a	32.92	10,000 AGL	15 Variable	350	-2.9	-1700	143	
b	20.00	6,000 AGL	15 Variable	300	-4.3	-2100	101	
c	12.31	2,800 MSL	25 Variable	250	-3.5	-1500	71	
d	7.60	1,060 MSL	45 Approach Low	225	0.0	0	85	Gear Down
e	2.82	1,060 MSL	40 Approach Low	180	-2.4	-800	57	
f	0.00	50 AGL	40 Approach Low	175				

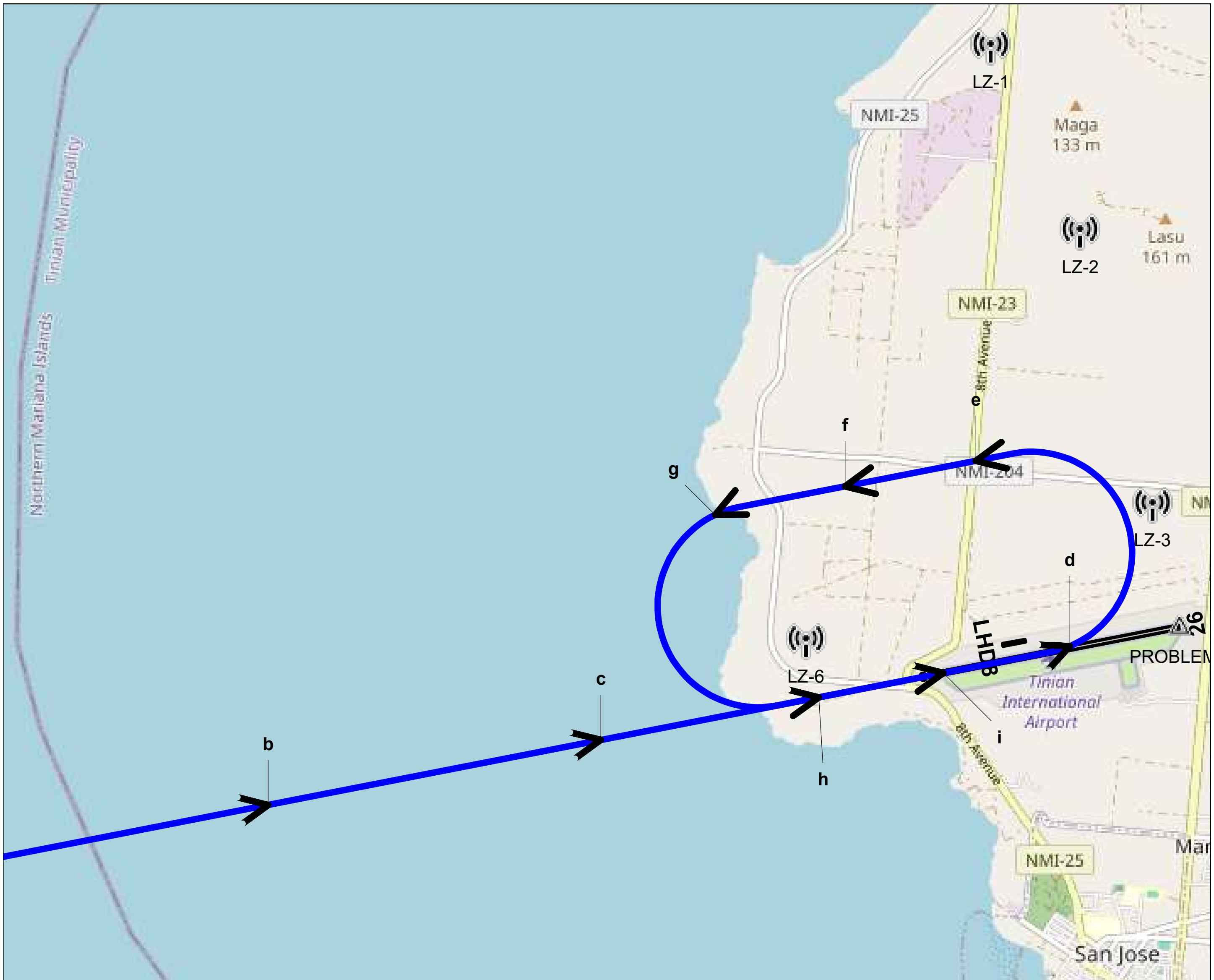
Military Flight Profile F-35B_AB

Flight Track 08A2 - NDB ARRIVAL

0 4,000 8,000 12,000 16,000 20,000 24,000

Scale in Feet 1:79,900 (1 inch = 6,660 feet)

N



Flight Profile F-35B_AD

Point	Distance NM	Height ft	Power % ETR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec	Notes
a	32.92	20,000 AGL	15 Flight Idle	350	-8.0	-5000	225	
b	11.07	1,600 MSL	35 Level Flight	350	0.0	0	21	
c	9.07	1,600 MSL	35 Level Flight	350	0.0	0	29	
d	6.25	1,600 MSL	35 Level Flight	350	0.0	0	25	
e	4.29	1,600 MSL	35 Approach Low	225	-6.0	-2000	15	Gear Down
f	3.50	1,100 MSL	55 Approach Low	145	0.0	0	20	
g	2.71	1,100 MSL	55 Approach Low	145	-2.4	-600	49	
h	0.75	300 AGL	55 Approach Low	145	-3.1	-800	19	
i	0.00	50 AGL	55 Approach Low	145				

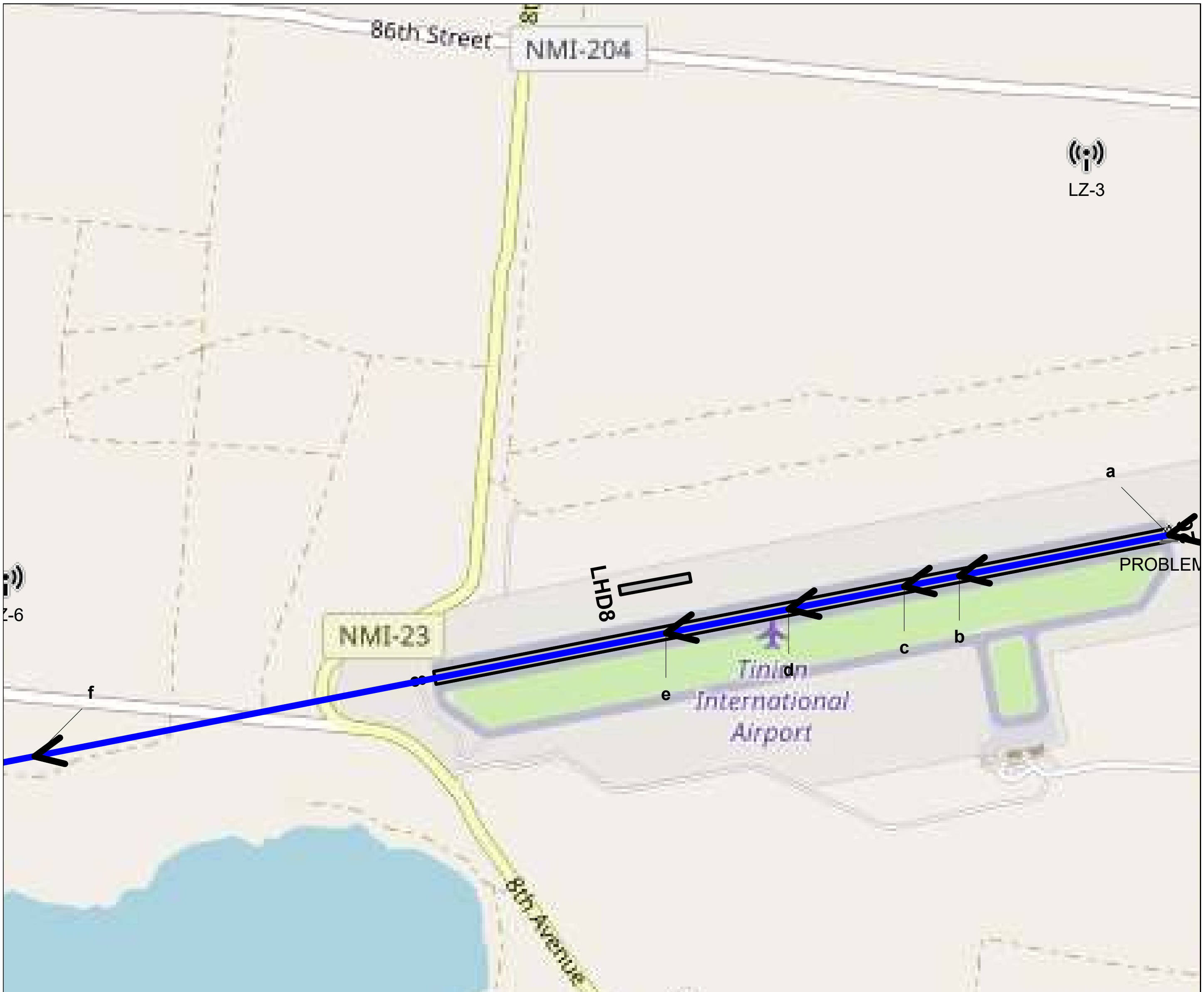
Military Flight Profile F-35B_AD

Flight Track 08A4 - OVERHEAD BREAK ARRIVAL - FW

0 4,000 8,000 12,000 16,000 20,000

Scale in Feet 1:71,700 (1 inch = 5,980 feet)

N



Flight Profile F-35B_DB

Point	Distance NM	Height ft	Power % ETR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec	Notes
a	0.00	0 AGL	50 50% ETR	0	0.0	0	16	1 sec @ 50%ETR before brake release
b	0.40	0 AGL	150 Afterburner	185	0.6	200	2	rotate
c	0.51	7 AGL	100 Mil	190	1.8	600	4	Mil
d	0.73	50 AGL	100 Mil	205	4.0	1500	4	
e	0.97	150 AGL	100 Mil	220	7.0	3200	17	Gear Up
f	2.19	1,060 AGL	100 Mil	300	15.9	8700	62	
g	7.35	10,000 AGL	40 Mil	300	0.0	0	305	
h	32.75	10,000 AGL	40 Mil	300				

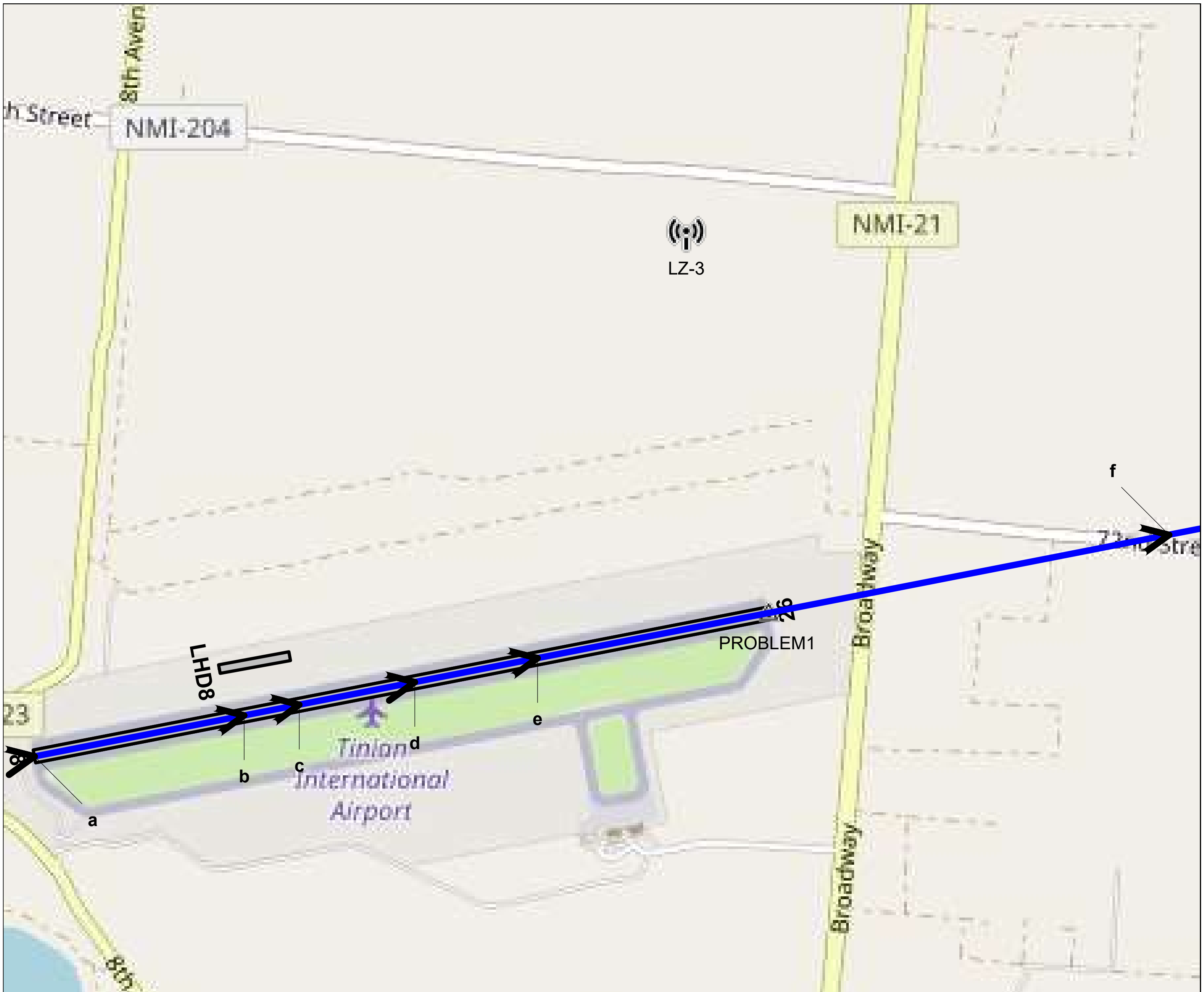
Military Flight Profile F-35B_DB

Flight Track 26D1 - STANDARD DEPARTURE

0 1,000 2,000 3,000 4,000 5,000 6,000 7,000

Scale in Feet 1:22,800 (1 inch = 1,900 feet)

N



Flight Profile F-35B_DA

Point	Distance NM	Height ft	Power % ETR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec	Notes
a	0.00	0 AGL	50 50% ETR	0	0.0	0	16	1 sec @ 50%ETR before brake release
b	0.40	0 AGL	150 Afterburner	185	0.6	200	2	rotate
c	0.51	7 AGL	100 Mil	190	1.8	600	4	Mil
d	0.73	50 AGL	100 Mil	205	4.0	1500	4	
e	0.97	150 AGL	100 Mil	220	7.0	3200	17	Gear Up
f	2.19	1,060 AGL	100 Mil	300	15.9	8700	62	
g	7.35	10,000 AGL	40 Mil	300	0.0	0	307	
h	32.92	10,000 AGL	40 Mil	300				

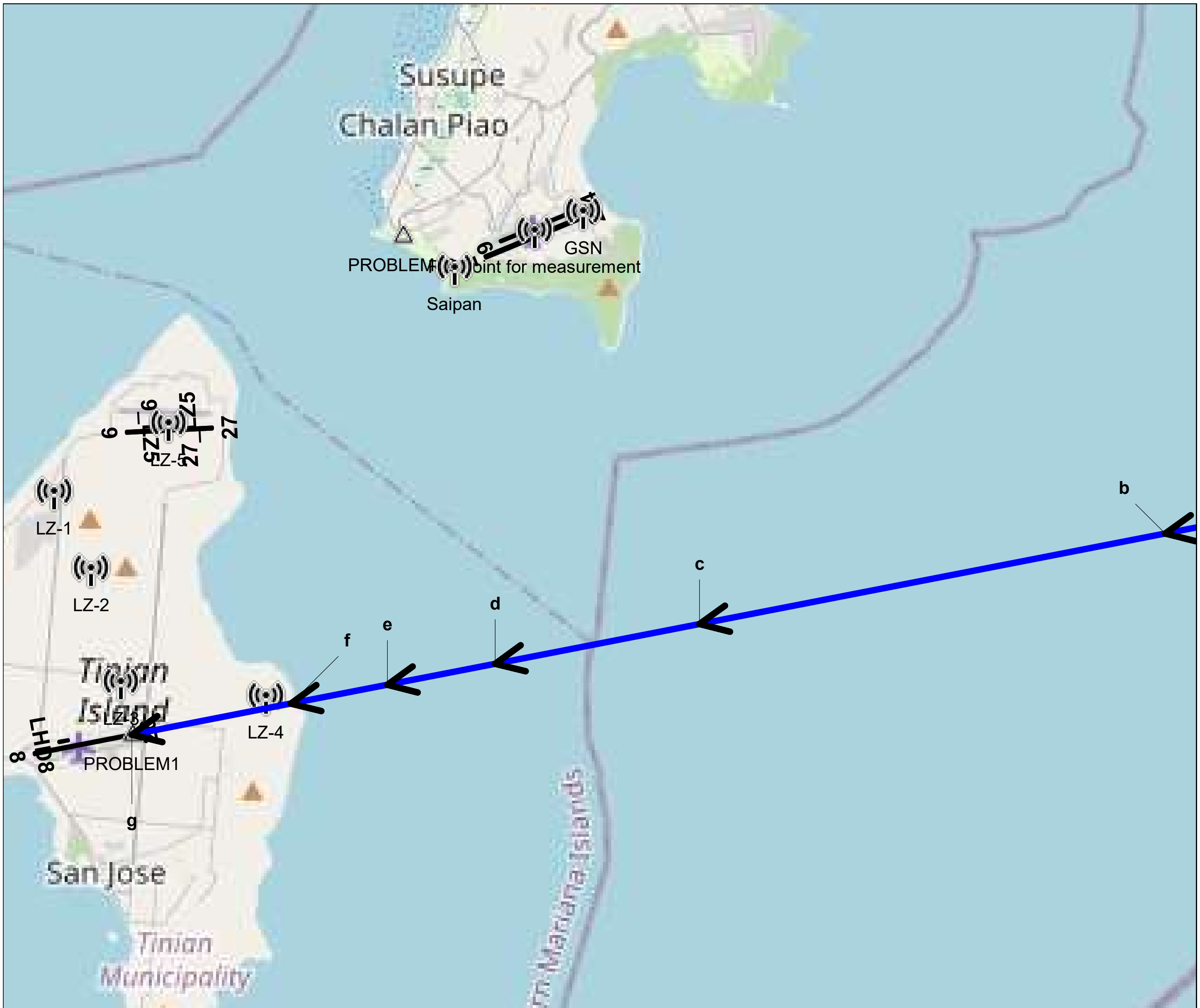
Military Flight Profile F-35B_DA

Flight Track 08D1 - STANDARD DEPARTURE

0 1,000 2,000 3,000 4,000 5,000 6,000 7,000

Scale in Feet 1:22,800 (1 inch = 1,900 feet)

N



Flight Profile KC-135_AE1

Point	Distance NM	Height ft	Power % NF	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	6,000 AGL	88 Variable	230	-1.4	-500	300
b	14.98	3,300 AGL	88 Variable	200	-1.0	-300	130
c	8.23	2,600 AGL	62 Parallel	175	-2.9	-800	66
d	5.27	1,675 AGL	61 Parallel	150	-2.9	-800	38
e	3.70	1,200 AGL	61 Parallel	150	-3.1	-800	33
f	2.30	735 AGL	61 Parallel	152	-2.8	-700	55
g	0.00	50 AGL	55 Parallel	150			

Military Flight Profile KC-135_AE1

Flight Track 26A1 - RNAV ARRIVAL

0 10,000 20,000 30,000 40,000 50,000

Scale in Feet 1:171,000 (1 inch = 14,200 feet)

N

Flight Profile KC-135_AF1

Point	Distance NM	Height ft	Power % NF	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	6,000 AGL	88 Variable	230	-2.8	-1100	152
b	23.81	3,300 AGL	88 Variable	200	-1.5	-500	96
c	18.83	2,800 MSL	62 Parallel	175	-3.5	-1000	103
d	14.17	1,060 MSL	61 Parallel	150	0.0	0	221
e	4.97	1,060 MSL	61 Parallel	150	-0.1	0	64
f	2.30	735 AGL	61 Parallel	152	-2.8	-700	55
g	0.00	50 AGL	55 Parallel	150			

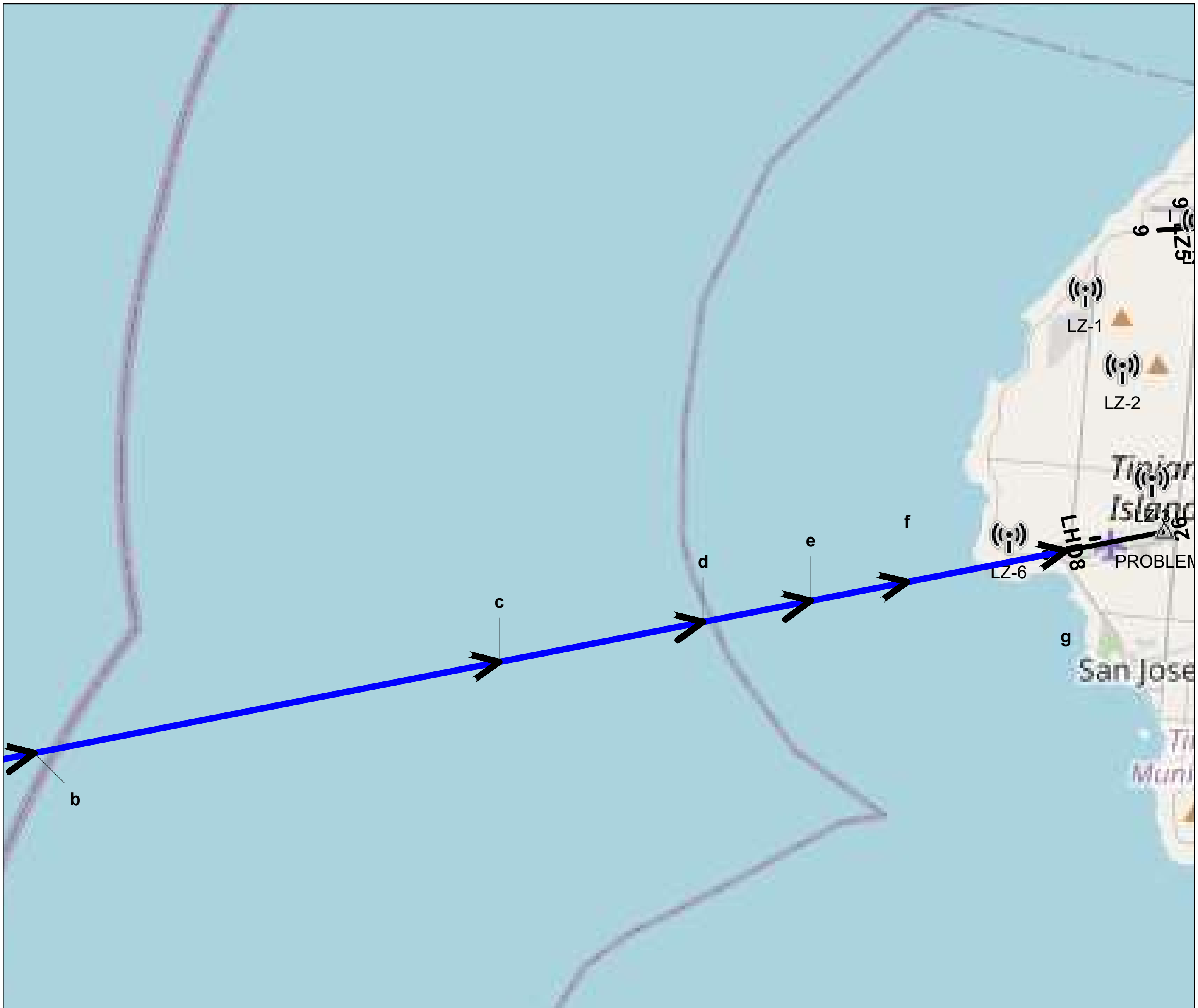
Military Flight Profile KC-135_AF1

Flight Track 26A2_2 - NDB ARRIVAL

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000 40,000 44,000

Scale in Feet 1:128,000 (1 inch = 10,700 feet)

N



Flight Profile KC-135_AA1

Point	Distance NM	Height ft	Power % NF	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	6,000 AGL	88 Variable	230	-1.4	-500	300
b	14.98	3,300 AGL	88 Variable	200	-1.0	-300	130
c	8.23	2,600 AGL	62 Parallel	175	-2.9	-800	66
d	5.27	1,675 AGL	61 Parallel	150	-2.9	-800	38
e	3.70	1,200 AGL	61 Parallel	150	-3.1	-800	33
f	2.30	735 AGL	61 Parallel	152	-2.8	-700	55
g	0.00	50 AGL	55 Parallel	150			

Military Flight Profile KC-135_AA1
Flight Track 08A1 - RNAV ARRIVAL

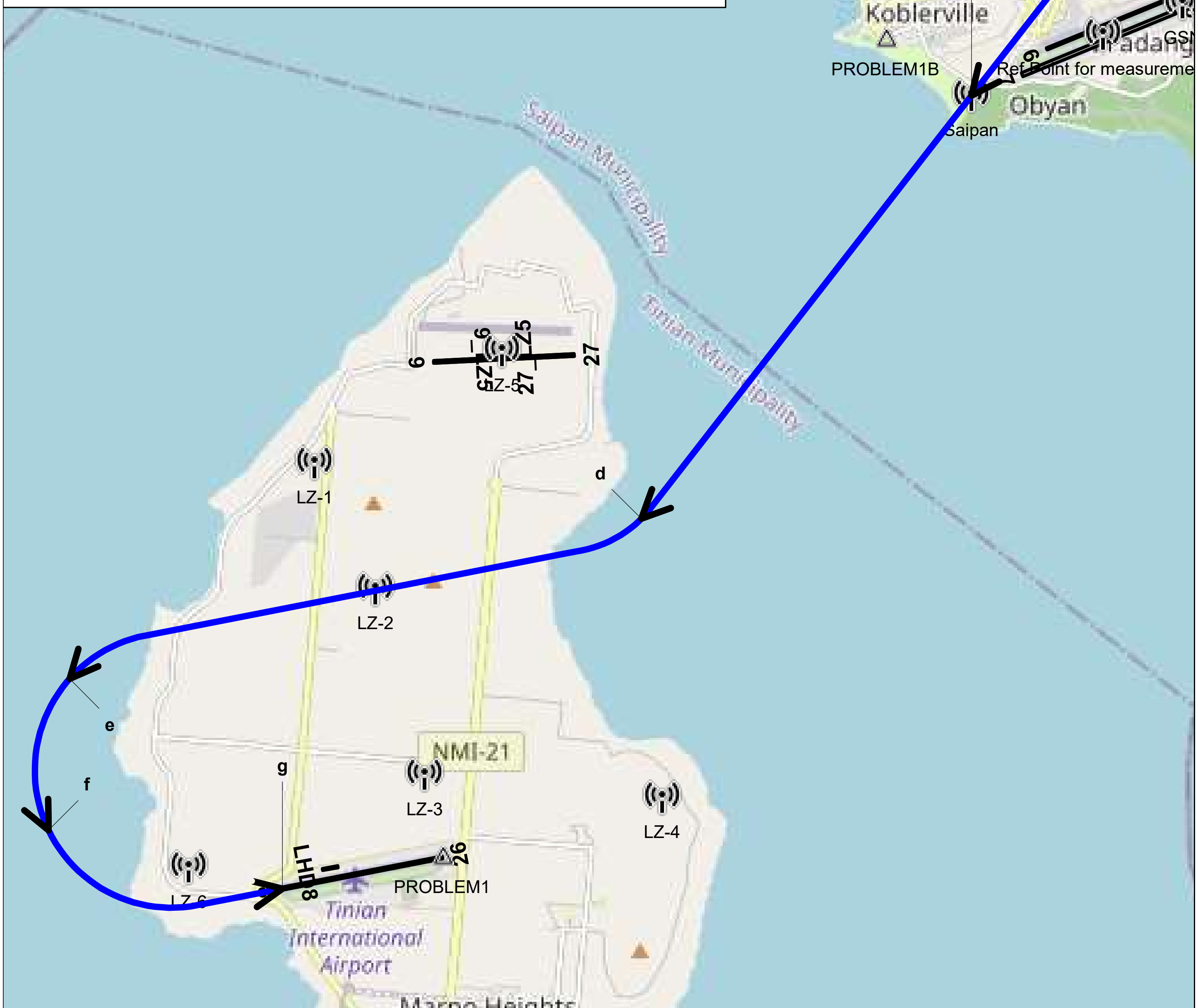
0 10,000 20,000 30,000 40,000 50,000

Scale in Feet 1:171,000 (1 inch = 14,200 feet)

N

Flight Profile KC-135_AB1

Point	Distance NM	Height ft	Power % NF	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	32.92	6,000 MSL	88 Variable	230	-1.4	-500	279
b	16.26	3,300 AGL	88 Variable	200	-2.8	-900	52
c	13.56	2,800 MSL	62 Parallel	175	-3.5	-1000	103
d	8.92	1,080 MSL	61 Parallel	150	0.0	0	125
e	3.70	1,080 MSL	61 Parallel	150	-0.4	-100	33
f	2.30	735 AGL	61 Parallel	152	-2.8	-700	55
g	0.00	50 AGL	55 Parallel	150			



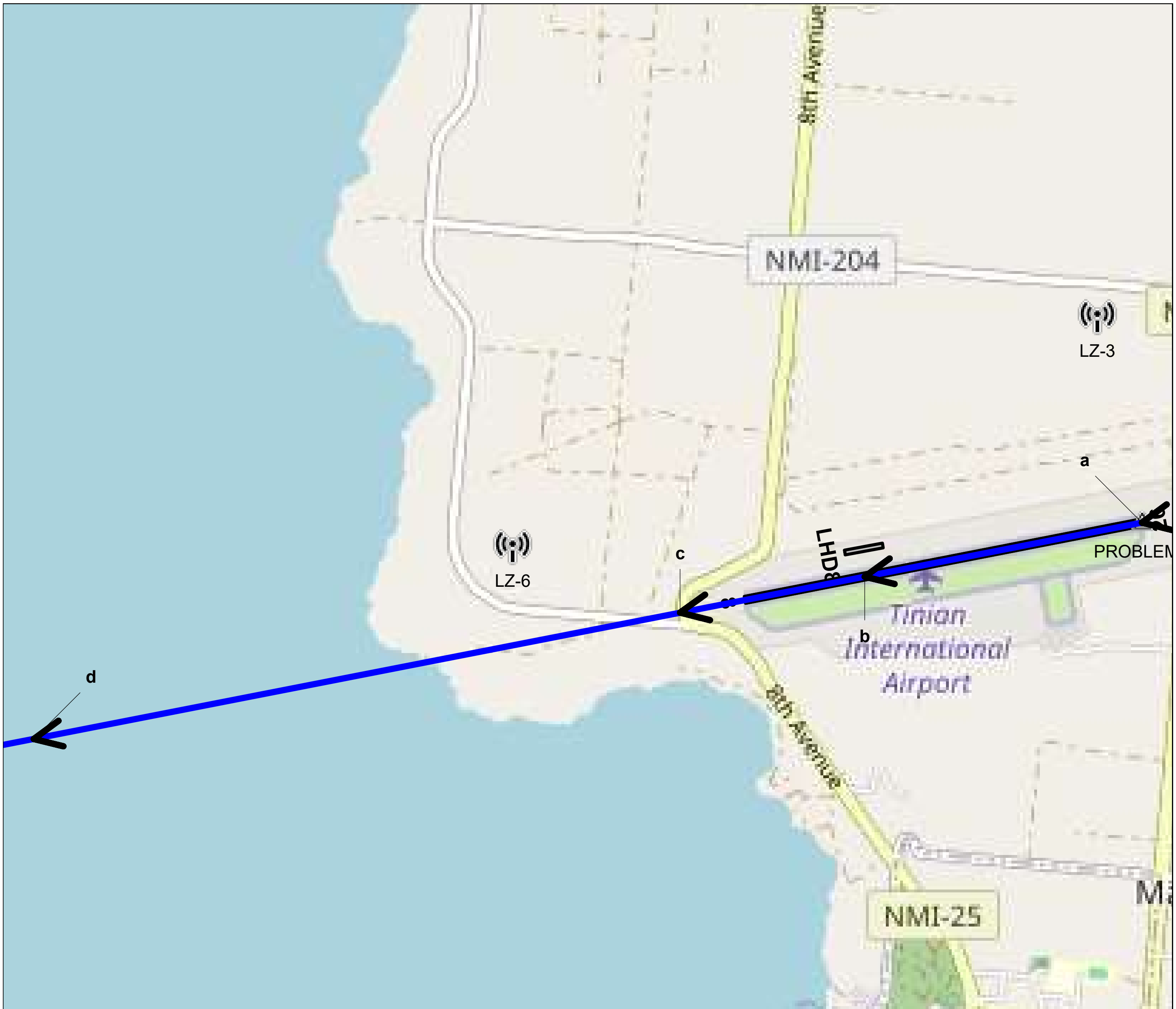
Military Flight Profile KC-135_AB1

Flight Track 08A2_2 - NDB ARRIVAL

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000

Scale in Feet 1:104,000 (1 inch = 8,670 feet)

N



Flight Profile KC-135_DB1

Point	Distance NM	Height ft	Power % NF	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0.00	0 AGL	70 70% RPM Eng Runup	0	0.0	0	41
b	0.99	0 AGL	89.6 Variable	175	2.9	900	13
c	1.65	200 AGL	89.6 Variable	185	4.1	1500	41
d	3.95	1,200 AGL	89.6 Variable	220	6.0	2500	212
e	17.77	10,000 AGL	88 Variable	250	6.2	3000	198
f	32.92	20,000 AGL	82 Variable	300			

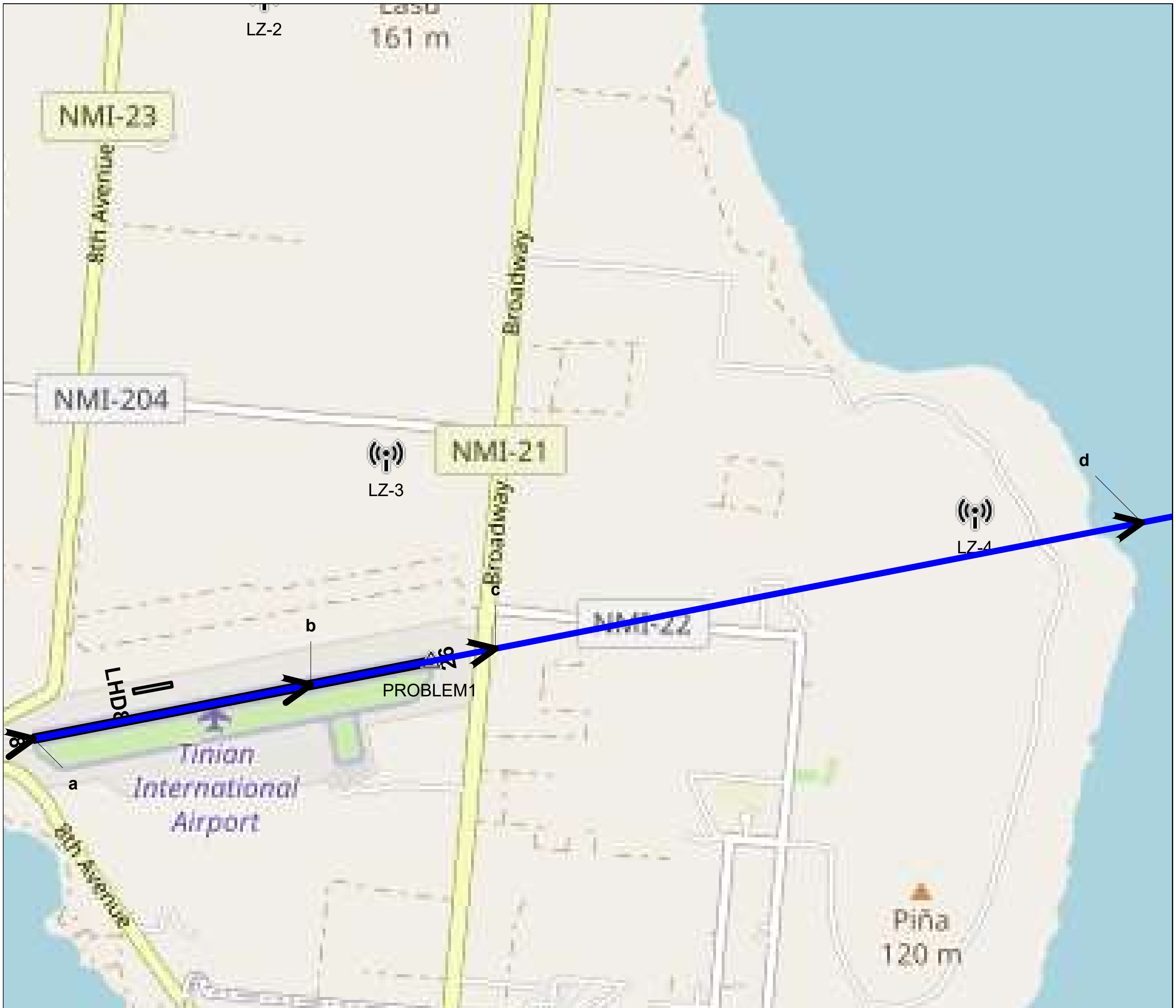
Military Flight Profile KC-135_DB1

Flight Track 26D1 - STANDARD DEPARTURE

0 2,000 4,000 6,000 8,000 10,000 12,000

Scale in Feet 1:41,200 (1 inch = 3,430 feet)

N



Flight Profile KC-135_DA1

Point	Distance NM	Height ft	Power % NF	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0.00	0 AGL	70 70% RPM Eng Runup	0	0.0	0	41
b	0.99	0 AGL	89.6 Variable	175	2.9	900	13
c	1.65	200 AGL	89.6 Variable	185	4.1	1500	41
d	3.95	1,200 AGL	89.6 Variable	220	6.0	2500	212
e	17.77	10,000 AGL	88 Variable	250	6.2	3000	198
f	32.92	20,000 AGL	82 Variable	300			

Military Flight Profile KC-135_DA1

Flight Track 08D1 - STANDARD DEPARTURE

Scale in Feet 1:41,200 (1 inch = 3,430 feet)

N

Maps of North Field Flight Profiles

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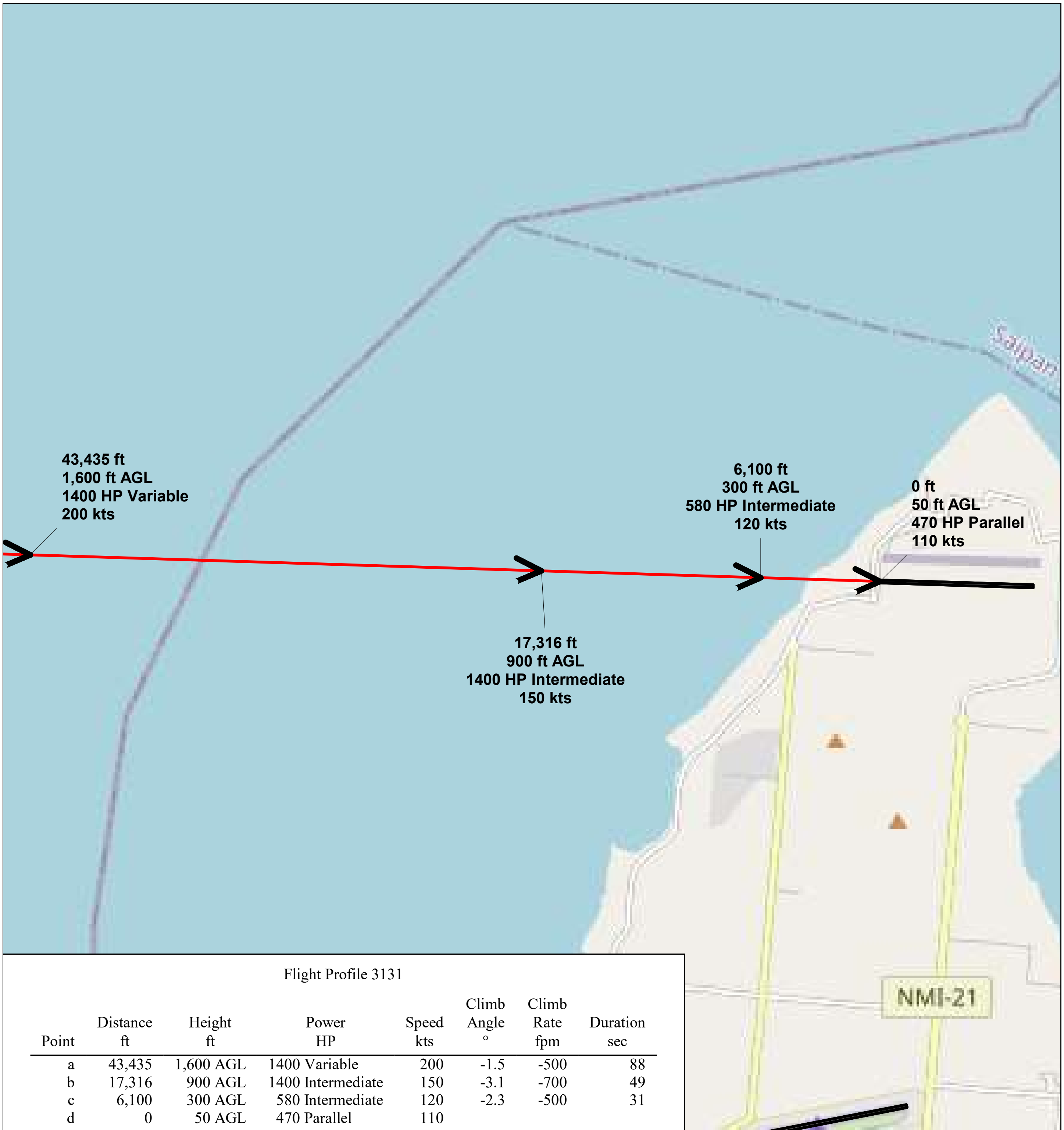


Flight Profile 3131

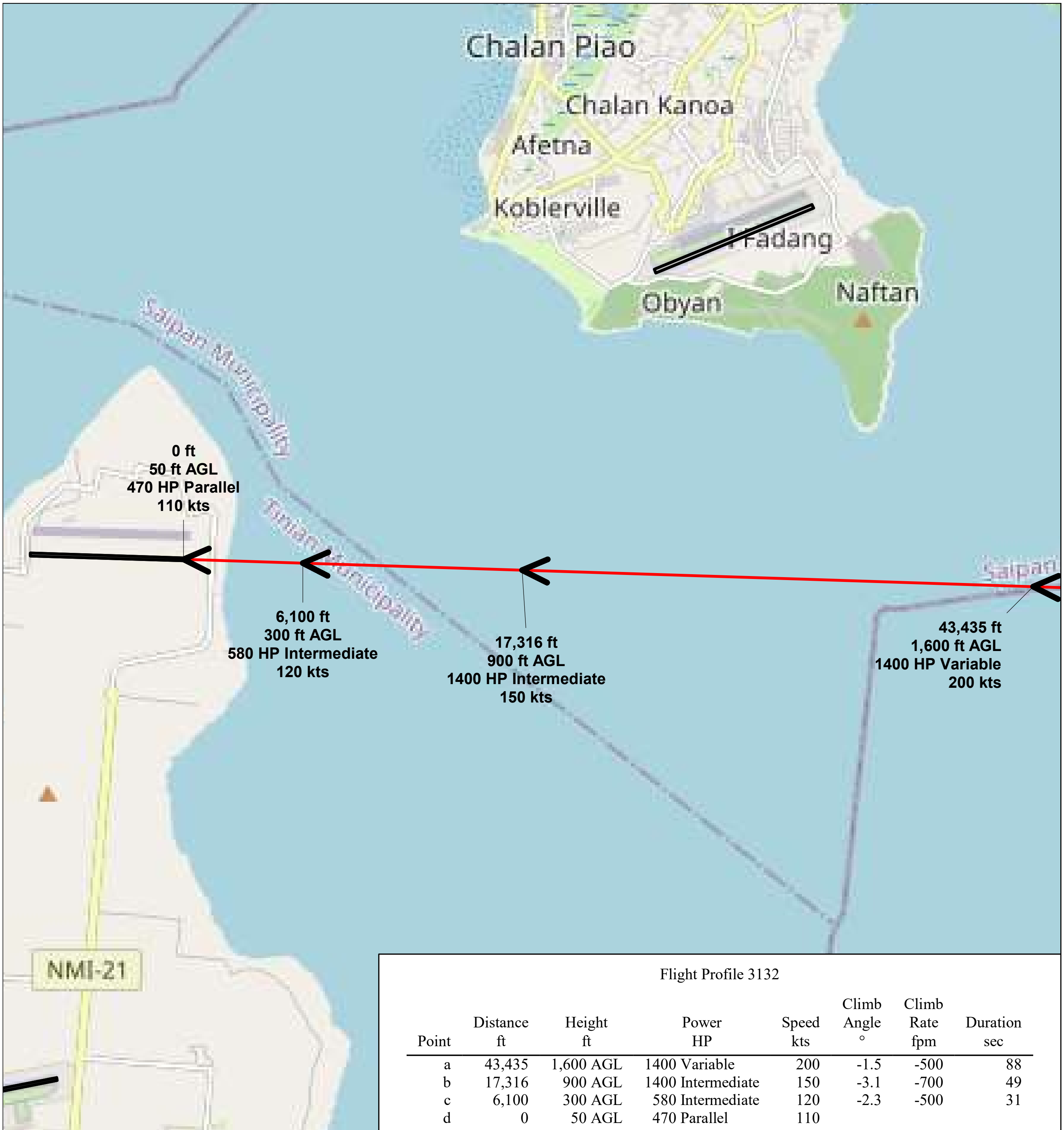
Point	Distance ft	Height ft	Power HP	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	43,435	1,600 AGL	1400 Variable	200	-1.5	-500	88
b	17,316	900 AGL	1400 Intermediate	150	-3.1	-700	49
c	6,100	300 AGL	580 Intermediate	120	-2.3	-500	31
d	0	50 AGL	470 Parallel	110			

C-130J Flight Profile 3131
SI ARRIVAL North Field

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000

Scale in Feet 1:89,600 (1 inch = 7,470 feet)

N



Flight Profile 3132

Point	Distance ft	Height ft	Power HP	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	43,435	1,600 AGL	1400 Variable	200	-1.5	-500	88
b	17,316	900 AGL	1400 Intermediate	150	-3.1	-700	49
c	6,100	300 AGL	580 Intermediate	120	-2.3	-500	31
d	0	50 AGL	470 Parallel	110			

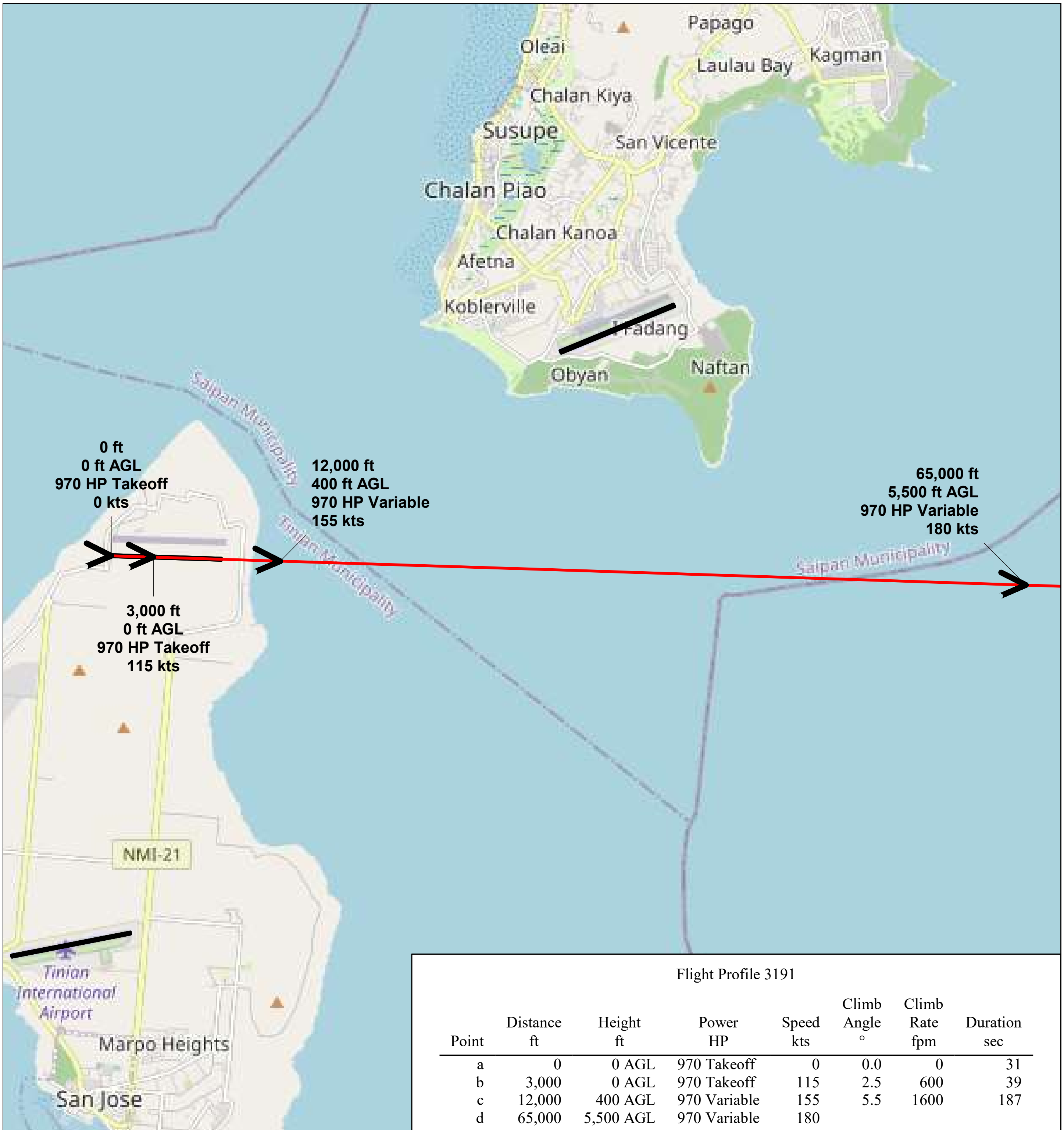
C-130J Flight Profile 3132

SI ARRIVAL

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000

Scale in Feet 1:89,600 (1 inch = 7,470 feet)

N



Flight Profile 3191

Point	Distance ft	Height ft	Power HP	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0	0 AGL	970 Takeoff	0	0.0	0	31
b	3,000	0 AGL	970 Takeoff	115	2.5	600	39
c	12,000	400 AGL	970 Variable	155	5.5	1600	187
d	65,000	5,500 AGL	970 Variable	180			

C-130J Flight Profile 3191

North Field SO Departure

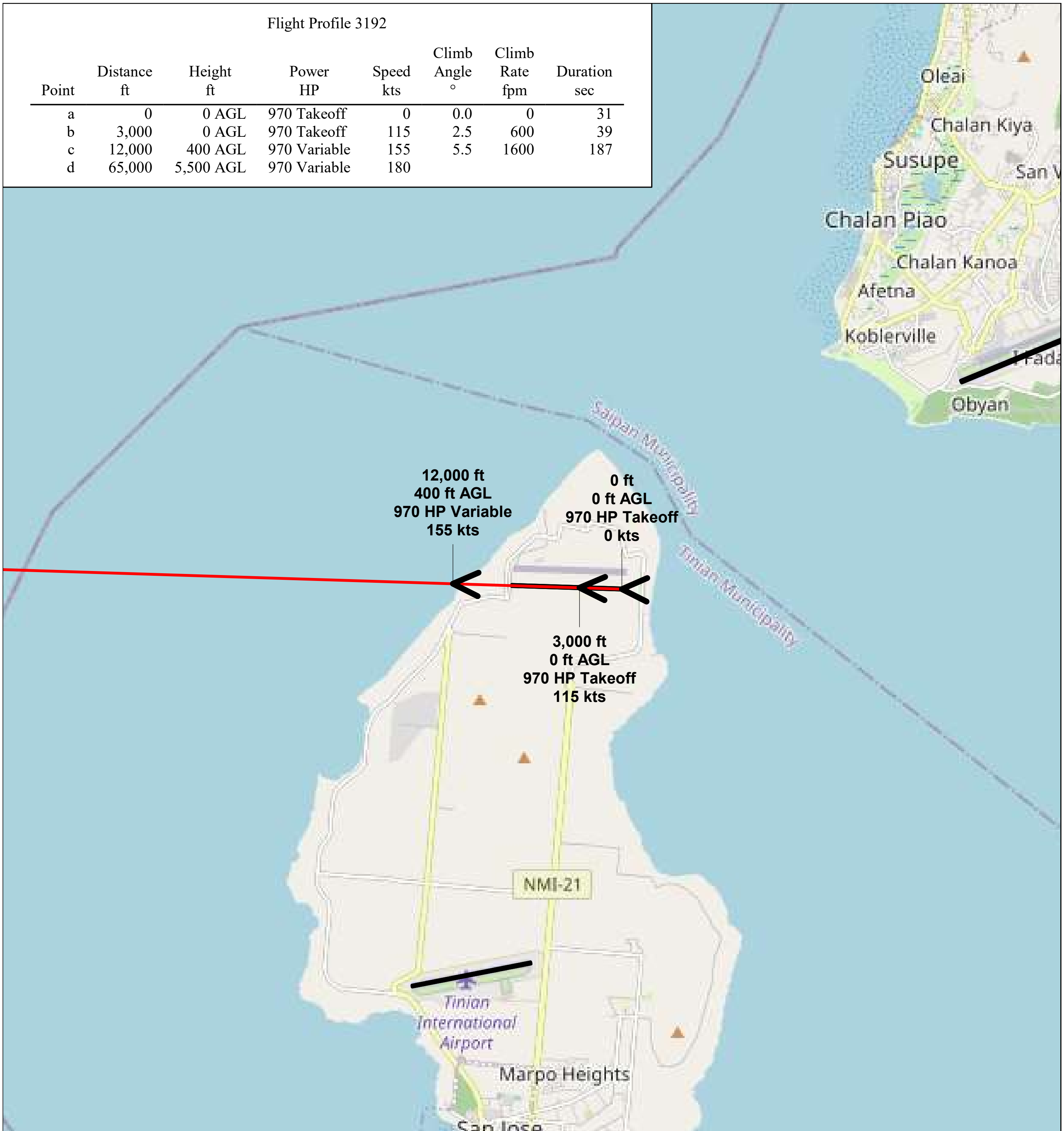
0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000 40,000

Scale in Feet 1:125,000 (1 inch = 10,400 feet)

N

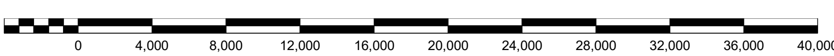
Flight Profile 3192

Point	Distance ft	Height ft	Power HP	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0	0 AGL	970 Takeoff	0	0.0	0	31
b	3,000	0 AGL	970 Takeoff	115	2.5	600	39
c	12,000	400 AGL	970 Variable	155	5.5	1600	187
d	65,000	5,500 AGL	970 Variable	180			



C-130J Flight Profile 3192

North Field SO Departure



Scale in Feet 1:125,000 (1 inch = 10,400 feet)

N

Flight Profile F18E-A01

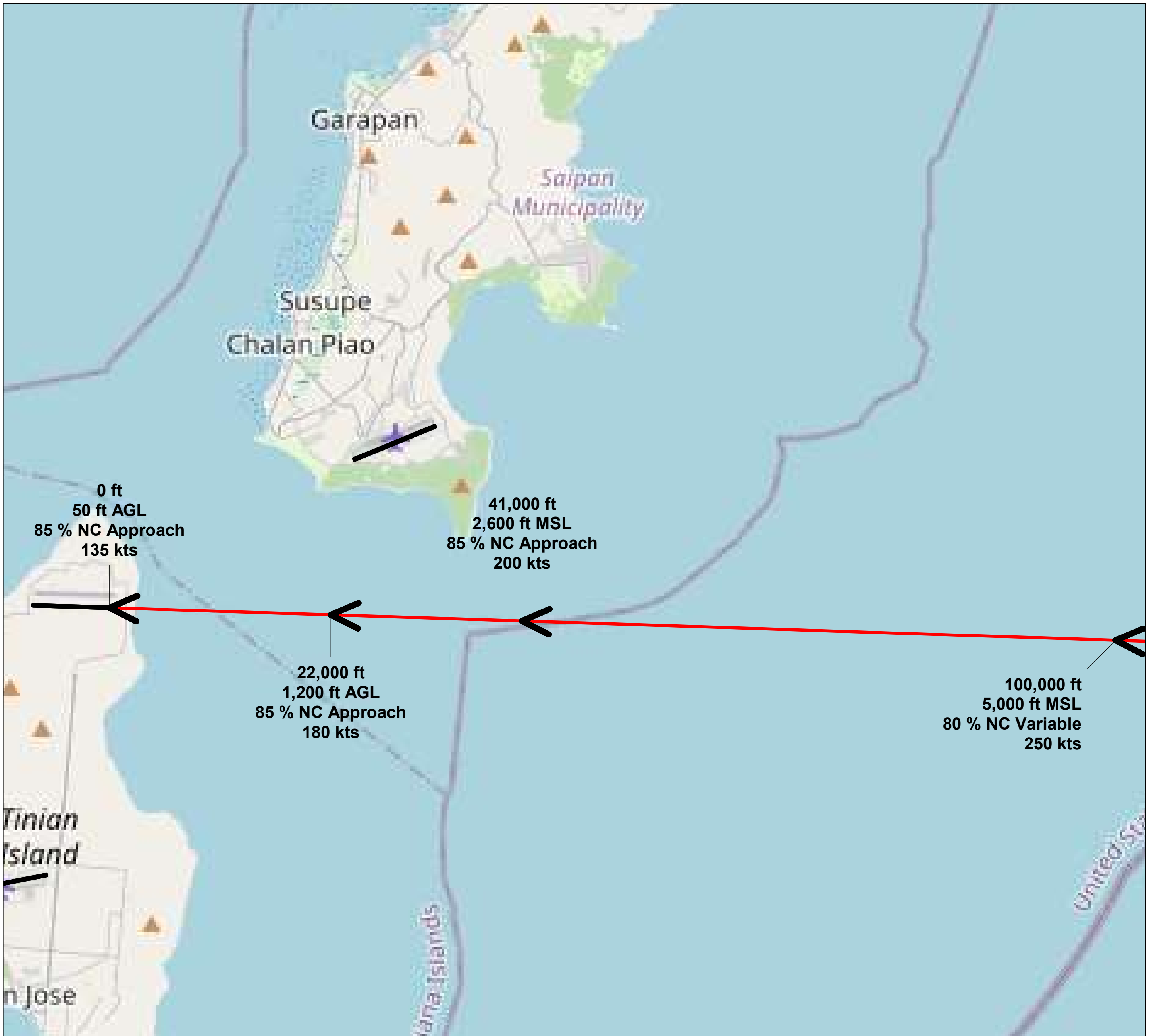
Point	Distance ft	Height ft	Power % NC	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec	Notes
a	100,000	5,000 MSL	80 Variable	250	-2.3	-900	155	
b	41,000	2,600 MSL	85 Approach	200	-4.2	-1400	59	Initial Point passing Point Charlie
c	22,000	1,200 AGL	85 Approach	180	-3.0	-800	83	
d	0	50 AGL	85 Approach	135				

F-18E/F Flight Profile F18E-A01

0 10,000 20,000 30,000 40,000 50,000 60,000

Scale in Feet 1:188,000 (1 inch = 15,700 feet)

N



Flight Profile F18E-A02

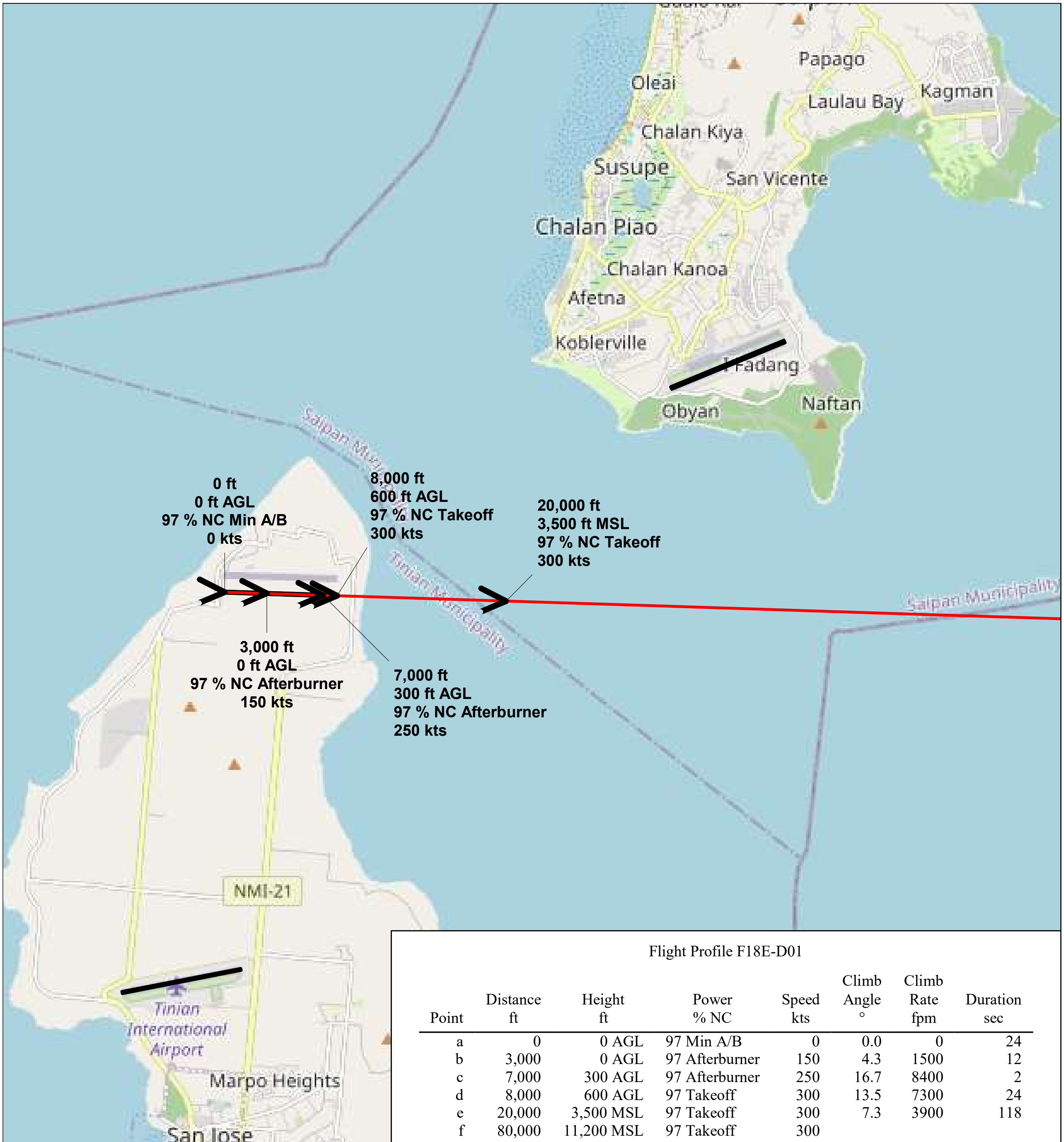
Point	Distance ft	Height ft	Power % NC	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec	Notes
a	100,000	5,000 MSL	80 Variable	250	-2.3	-900	155	
b	41,000	2,600 MSL	85 Approach	200	-4.2	-1400	59	Initial Point passing Point Charlie
c	22,000	1,200 AGL	85 Approach	180	-3.0	-800	83	
d	0	50 AGL	85 Approach	135				

F-18E/F Flight Profile F18E-A02

0 10,000 20,000 30,000 40,000 50,000 60,000

Scale in Feet 1:188,000 (1 inch = 15,700 feet)

N



Flight Profile F18E-D01

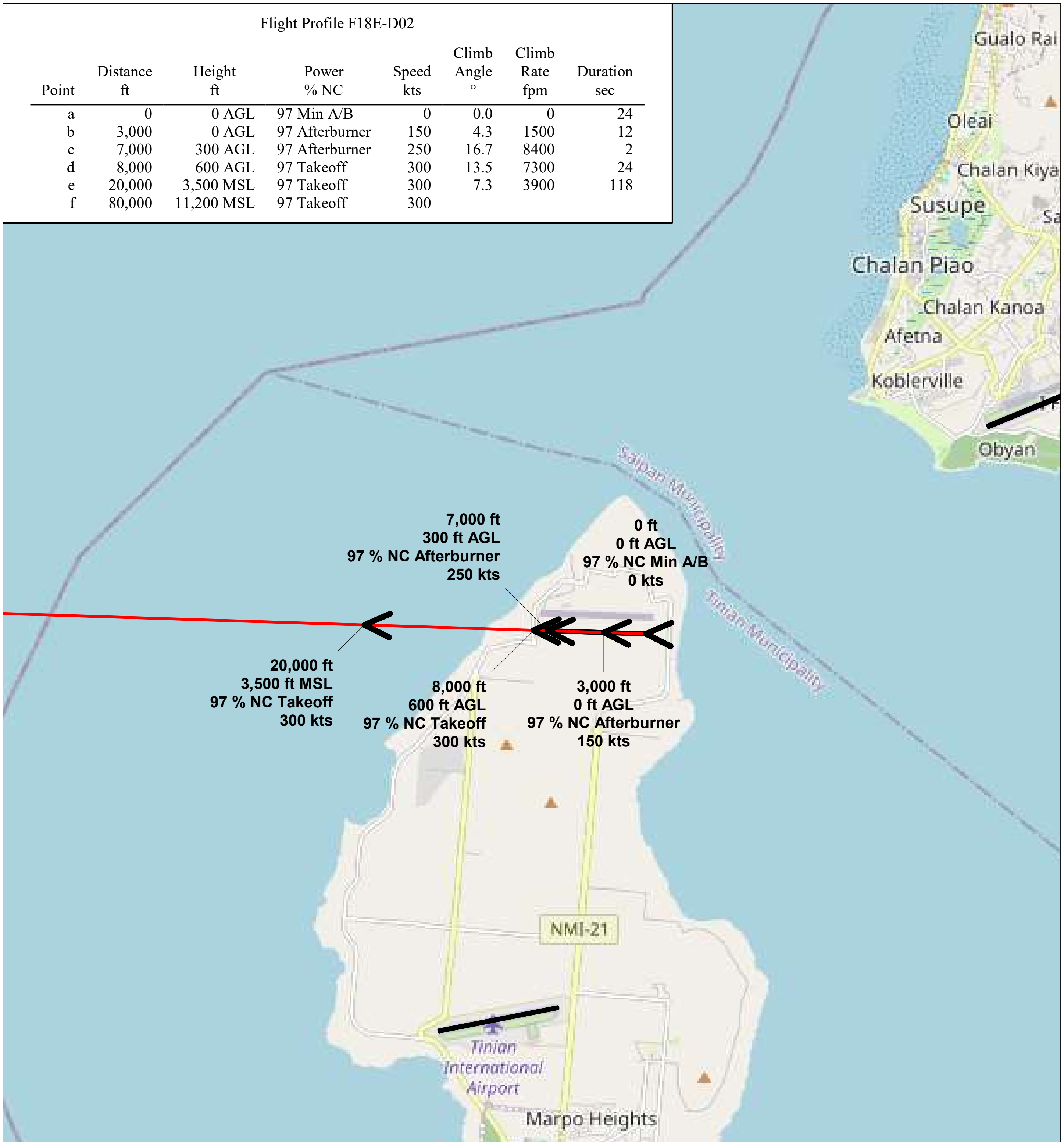
Point	Distance ft	Height ft	Power % NC	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0	0 AGL	97 Min A/B	0	0.0	0	24
b	3,000	0 AGL	97 Afterburner	150	4.3	1500	12
c	7,000	300 AGL	97 Afterburner	250	16.7	8400	2
d	8,000	600 AGL	97 Takeoff	300	13.5	7300	24
e	20,000	3,500 MSL	97 Takeoff	300	7.3	3900	118
f	80,000	11,200 MSL	97 Takeoff	300			

F-18E/F Flight Profile F18E-D01

Scale in Feet 1:125,000 (1 inch = 10,400 feet)

Flight Profile F18E-D02

Point	Distance ft	Height ft	Power % NC	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec
a	0	0 AGL	97 Min A/B	0	0.0	0	24
b	3,000	0 AGL	97 Afterburner	150	4.3	1500	12
c	7,000	300 AGL	97 Afterburner	250	16.7	8400	2
d	8,000	600 AGL	97 Takeoff	300	13.5	7300	24
e	20,000	3,500 MSL	97 Takeoff	300	7.3	3900	118
f	80,000	11,200 MSL	97 Takeoff	300			



F-18E/F Flight Profile F18E-D02

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000 40,000

Scale in Feet 1:125,000 (1 inch = 10,400 feet)

N

Flight Profile F35A1

Point	Distance ft	Height ft	Power % ETR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec	Notes
a	200,000	20,000 MSL	15 Variable	350	-6.2	-3200	350	
b	30,380	1,500 AGL	55 Parallel	225	0.0	0	27	Initial 5 nm, 1500 feet, Gear down, Start of conversion
c	20,000	1,500 AGL	55 Parallel	225	-3.5	-1400	4	begin descent
d	18,350	1,400 AGL	55 Parallel	225	-2.5	-1000	4	
e	16,850	1,335 AGL	40 Parallel	220	-4.0	-1400	15	Reduce power
f	12,000	1,000 AGL	40 Parallel	175	-4.1	-1200	13	Begin to reduce TVA
g	8,500	750 AGL	40 Parallel	150	-5.3	-1300	19	
h	4,200	350 AGL	55 Parallel	120	-4.1	-900	21	Increase power
i	0	50 AGL	55 Parallel	120				Threshold crossing, appox. 1200 feet from touchdown point

F-35B Flight Profile F35A1

0 4,000 8,000 12,000 16,000 20,000

Scale in Feet 1:66,800 (1 inch = 5,570 feet)

N

Flight Profile F35A2

Point	Distance ft	Height ft	Power % ETR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec	Notes
a	200,000	20,000 MSL	15 Variable	350	-6.2	-3200	350	
b	30,380	1,500 AGL	55 Parallel	225	0.0	0	27	Initial 5 nm, 1500 feet, Gear down, Start of conversion
c	20,000	1,500 AGL	55 Parallel	225	-3.5	-1400	4	begin descent
d	18,350	1,400 AGL	55 Parallel	225	-2.5	-1000	4	
e	16,850	1,335 AGL	40 Parallel	220	-4.0	-1400	15	Reduce power
f	12,000	1,000 AGL	40 Parallel	175	-4.1	-1200	13	Begin to reduce TVA
g	8,500	750 AGL	40 Parallel	150	-5.3	-1300	19	
h	4,200	350 AGL	55 Parallel	120	-4.1	-900	21	Increase power
i	0	50 AGL	55 Parallel	120				Threshold crossing, appox. 1200 feet from touchdown point

F-35B Flight Profile F35A2

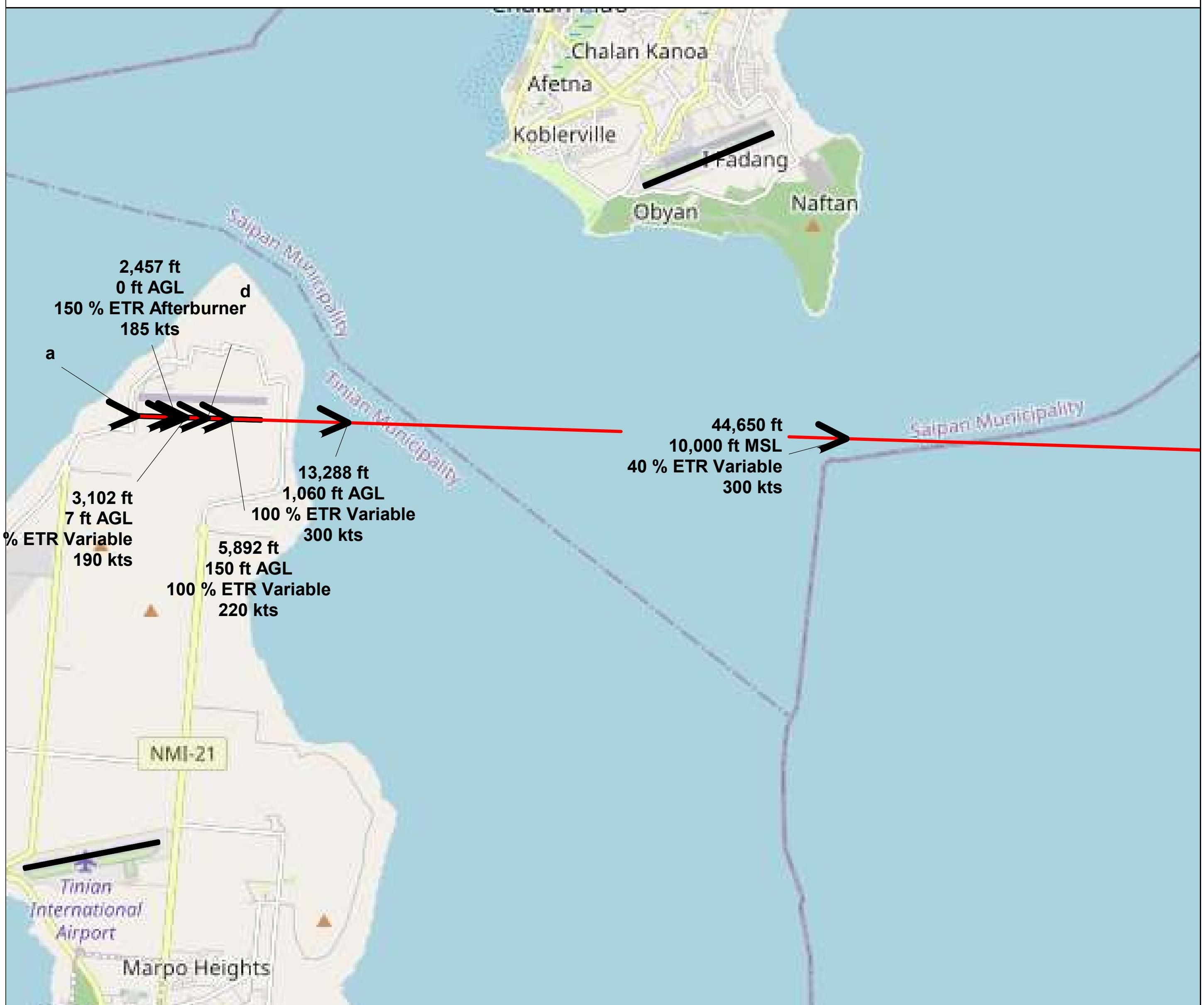
0 4,000 8,000 12,000 16,000 20,000

Scale in Feet 1:66,800 (1 inch = 5,570 feet)

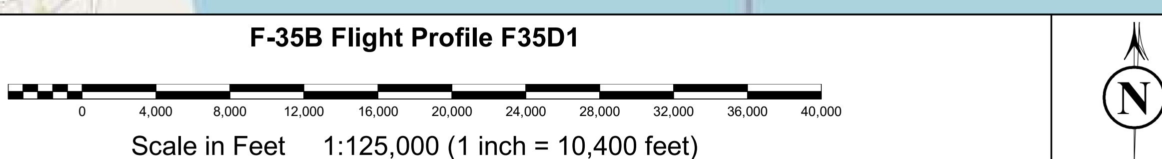
N

Flight Profile F35D1

Point	Distance ft	Height ft	Power % ETR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec	Notes
a	0	0 AGL	50 Variable	0	0.0	0	16	Assume 1 second @ 50%ETR before brake release
b	2,457	0 AGL	150 Afterburner	185	0.6	200	2	Rotate
c	3,102	7 AGL	100 Variable	190	1.8	600	4	Mil power
d	4,454	50 AGL	100 Variable	205	4.0	1500	4	
e	5,892	150 AGL	100 Variable	220	7.0	3200	17	Gear up
f	13,288	1,060 AGL	100 Variable	300	15.9	8700	62	
g	44,650	10,000 MSL	40 Variable	300	0.0	0	307	Assumes continuous climb to 10,000 ft MSL and level flight (p
h	200,000	10,000 MSL	40 Variable	300				



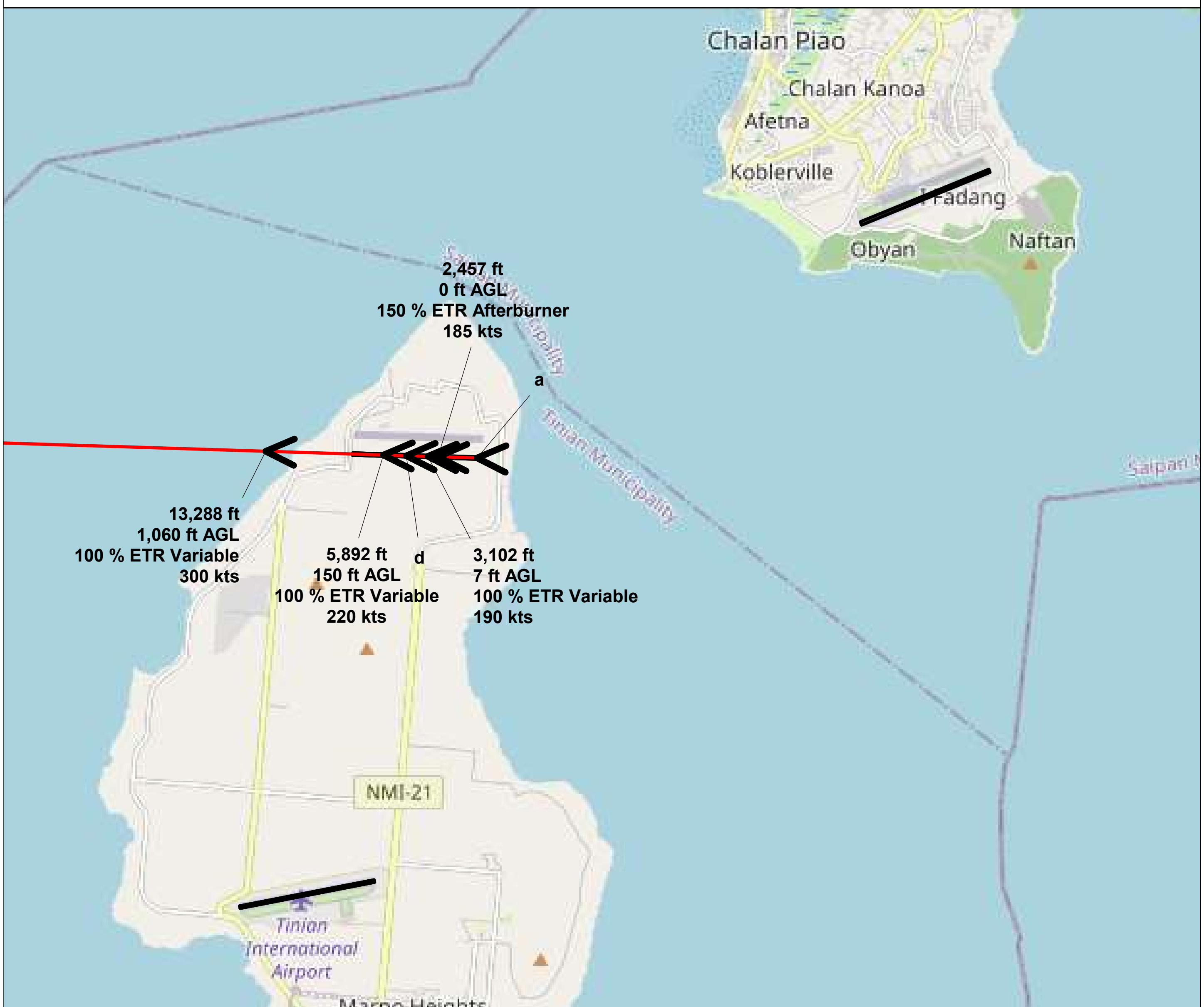
F-35B Flight Profile F35D1



Scale in Feet 1:125,000 (1 inch = 10,400 feet)

Flight Profile F35D2

Point	Distance ft	Height ft	Power % ETR	Speed kts	Climb Angle °	Climb Rate fpm	Duration sec	Notes
a	0	0 AGL	50 Variable	0	0.0	0	16	Assume 1 second @ 50%ETR before brake release
b	2,457	0 AGL	150 Afterburner	185	0.6	200	2	Rotate
c	3,102	7 AGL	100 Variable	190	1.8	600	4	Mil power
d	4,454	50 AGL	100 Variable	205	4.0	1500	4	
e	5,892	150 AGL	100 Variable	220	7.0	3200	17	Gear up
f	13,288	1,060 AGL	100 Variable	300	15.9	8700	62	
g	44,650	10,000 MSL	40 Variable	300	0.0	0	307	Assumes continuous climb to 10,000 ft MSL and level flight (p
h	200,000	10,000 MSL	40 Variable	300				

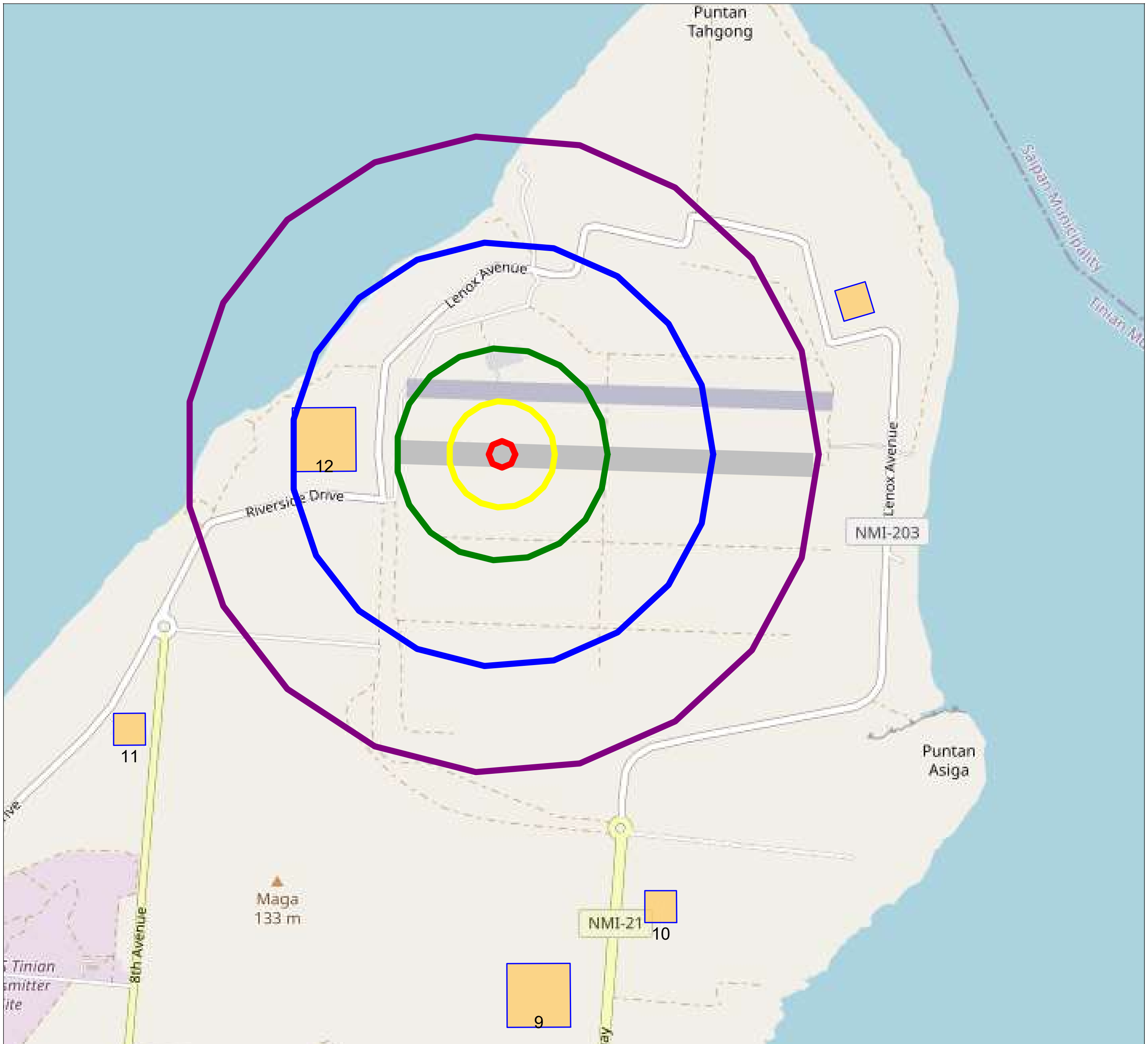


F-35B Flight Profile F35D2

0 4,000 8,000 12,000 16,000 20,000 24,000 28,000 32,000 36,000 40,000

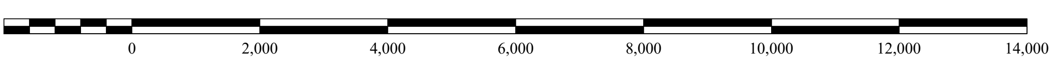
Scale in Feet 1:125,000 (1 inch = 10,400 feet)

N

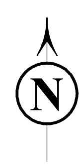


Modeled Landing Area for Helicopters and Tilt-Rotor

Red = 0 to 50 ft AGL
Yellow = 30 to 100 ft AGL
Green = 100 to 200 ft AGL
Blue = 200 to 300 ft AGL
Violet = 300 to 500 ft AGL



Scale in Feet 1:36,000 (1 inch = 3,000 feet)



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Maps of Modeled Landing Zones and Military Lease Area

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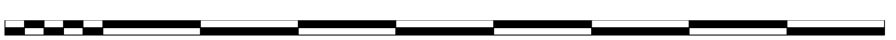
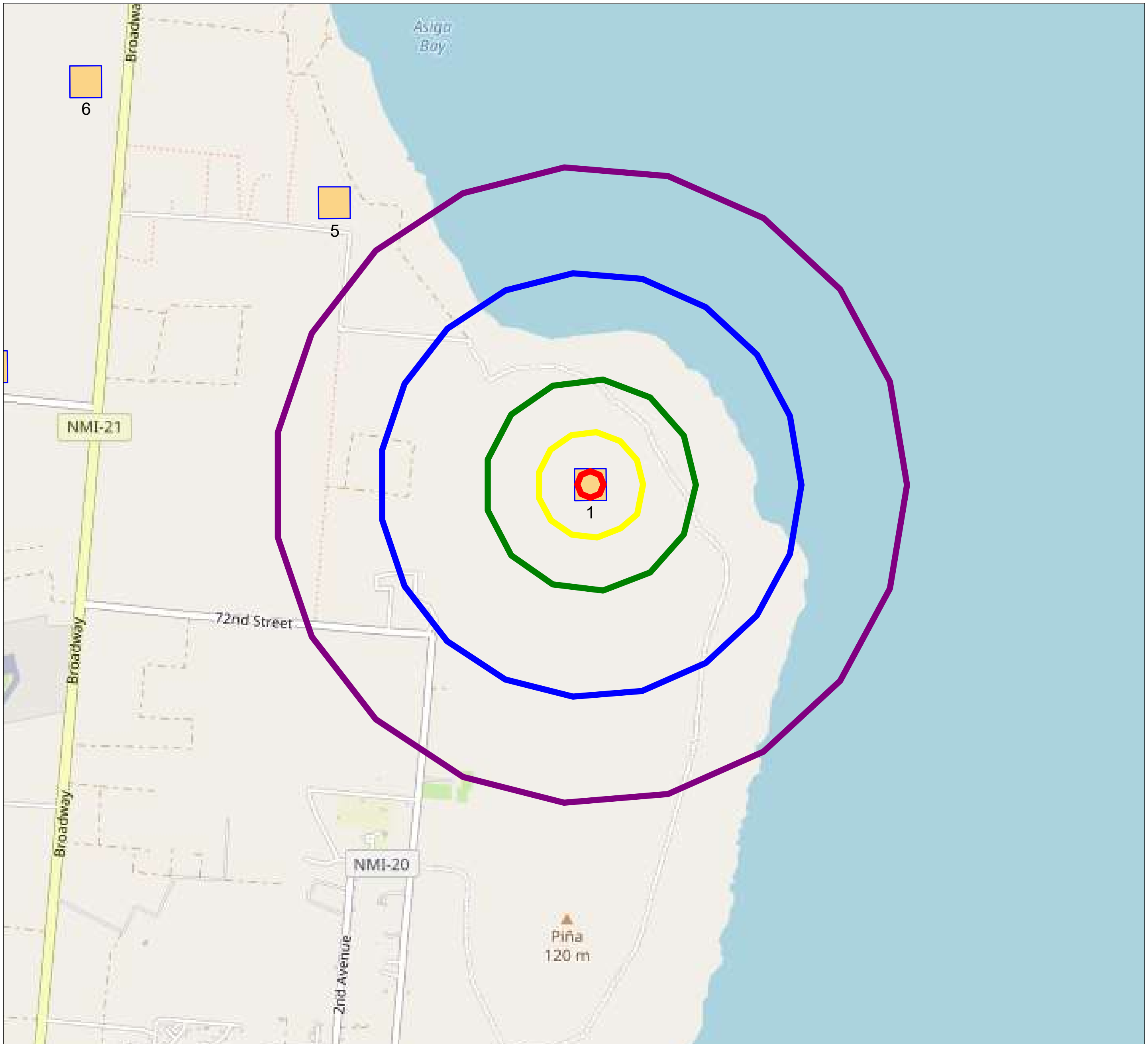
Modeled Flight Area - Within 1 mile of shoreline and in MLA



Scale in Feet 1:94,200 (1 inch = 7,850 feet)

N



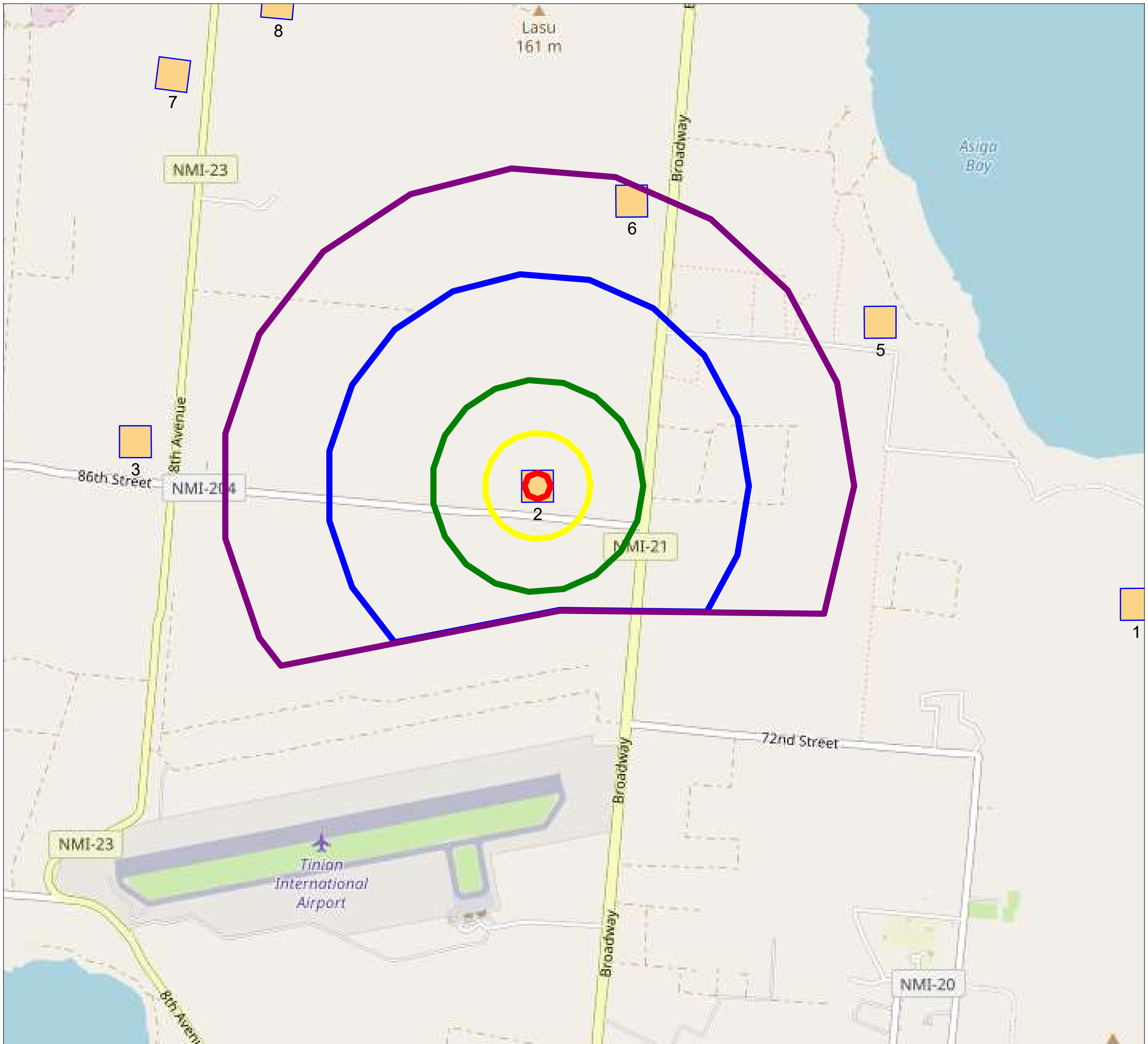
Modeled Landing Zone 1 for Helicopters and Tilt-Rotor

Red = 0 to 50 ft AGL
Yellow = 30 to 100 ft AGL
Green = 100 to 200 ft AGL
Blue = 200 to 300 ft AGL
Violet = 300 to 500 ft AGL

0 2,000 4,000 6,000 8,000 10,000 12,000 14,000

Scale in Feet 1:36,000 (1 inch = 3,000 feet)

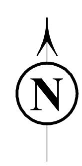
N

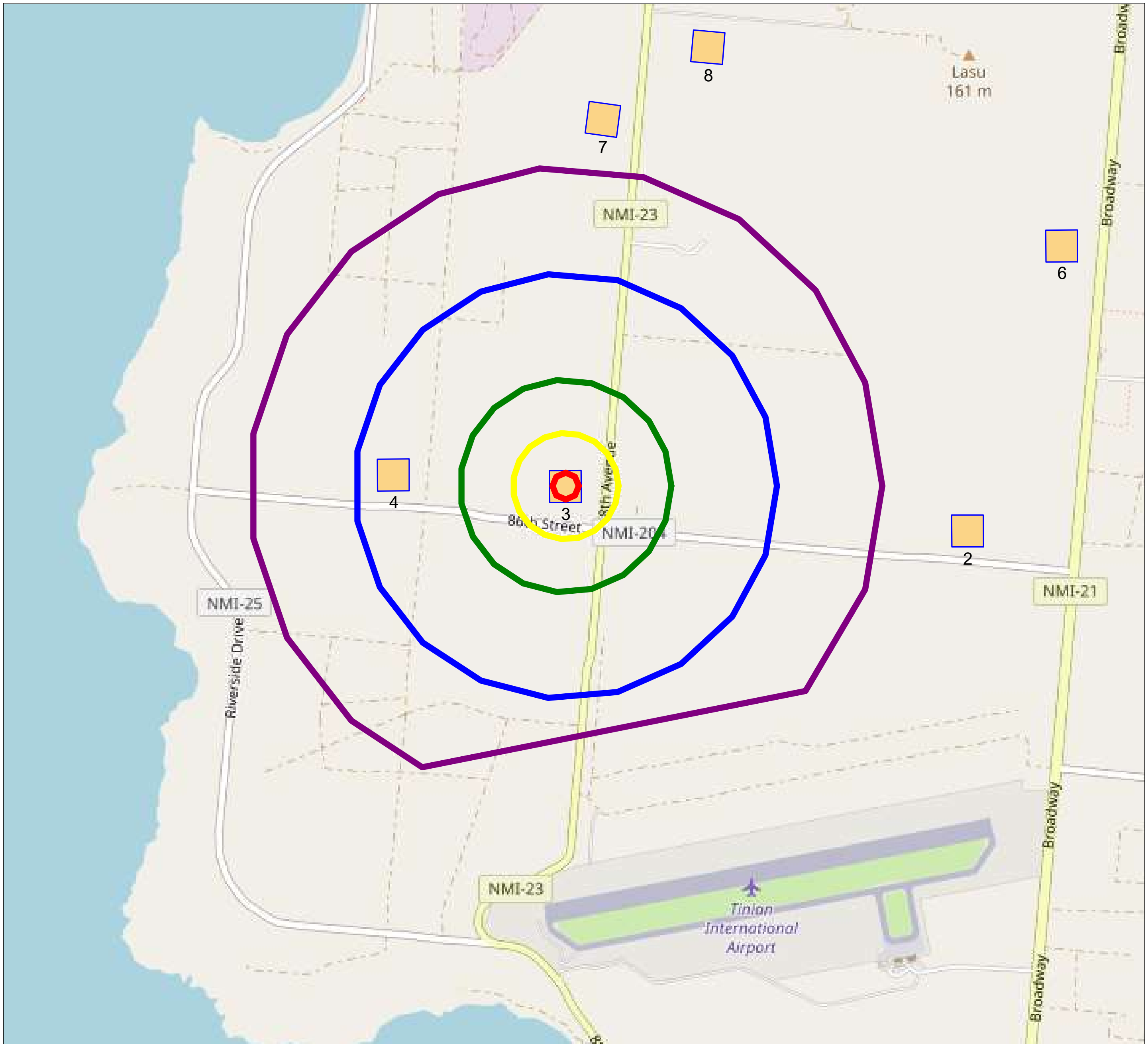


Modeled Landing Zone 2 for Helicopters and Tilt-Rotor

Red = 0 to 50 ft AGL
Yellow = 30 to 100 ft AGL
Green = 100 to 200 ft AGL
Blue = 200 to 300 ft AGL
Violet = 300 to 500 ft AGL

Scale in Feet   1:36,000 (1 inch = 3,000 feet)





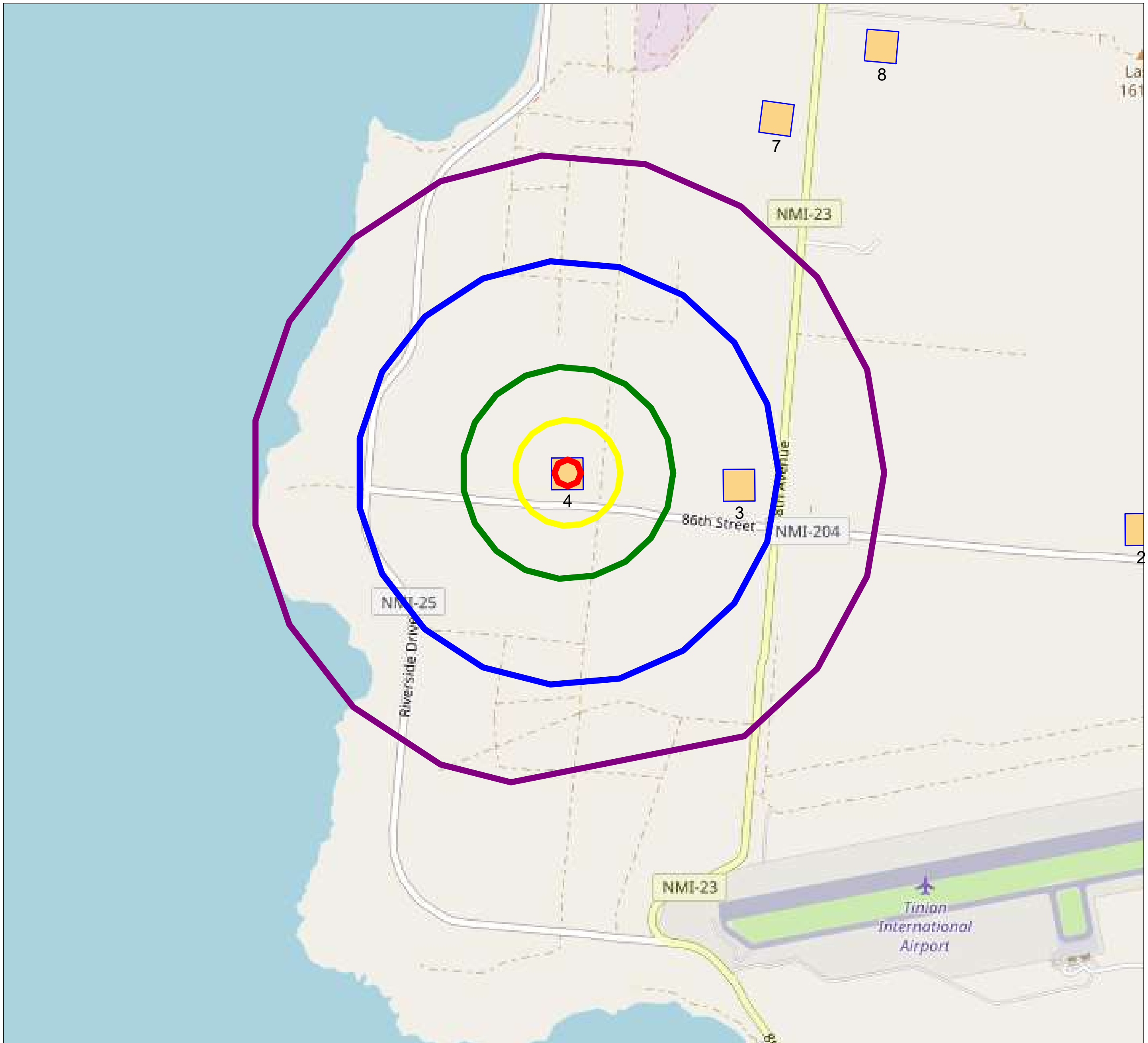
Modeled Landing Zone 3 for Helicopters and Tilt-Rotor

Red = 0 to 50 ft AGL
Yellow = 30 to 100 ft AGL
Green = 100 to 200 ft AGL
Blue = 200 to 300 ft AGL
Violet = 300 to 500 ft AGL

0 2,000 4,000 6,000 8,000 10,000 12,000 14,000

Scale in Feet 1:36,000 (1 inch = 3,000 feet)

N



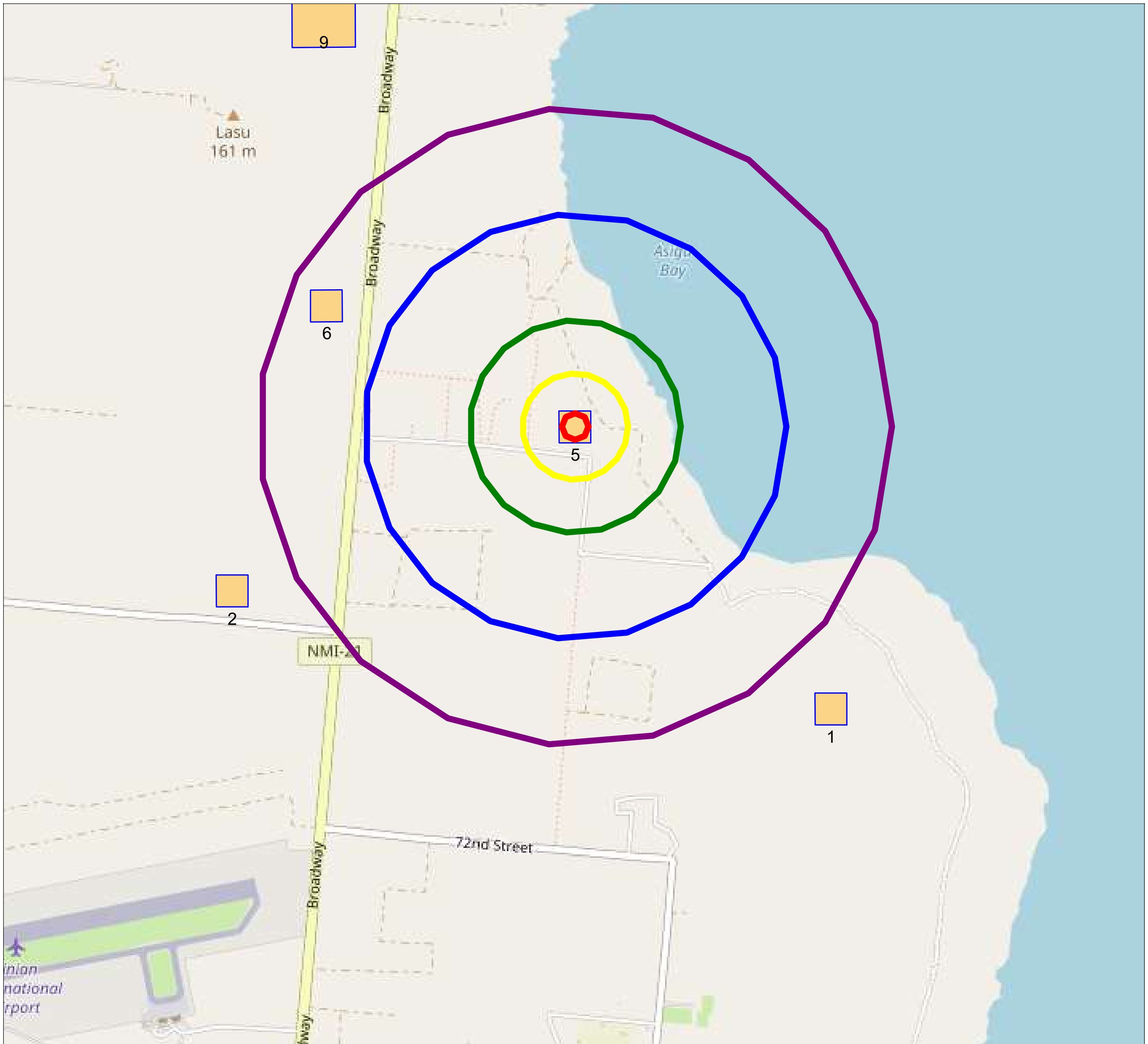
Modeled Landing Zone 4 for Helicopters and Tilt-Rotor

Red = 0 to 50 ft AGL
Yellow = 30 to 100 ft AGL
Green = 100 to 200 ft AGL
Blue = 200 to 300 ft AGL
Violet = 300 to 500 ft AGL

0 2,000 4,000 6,000 8,000 10,000 12,000 14,000

Scale in Feet 1:36,000 (1 inch = 3,000 feet)

N



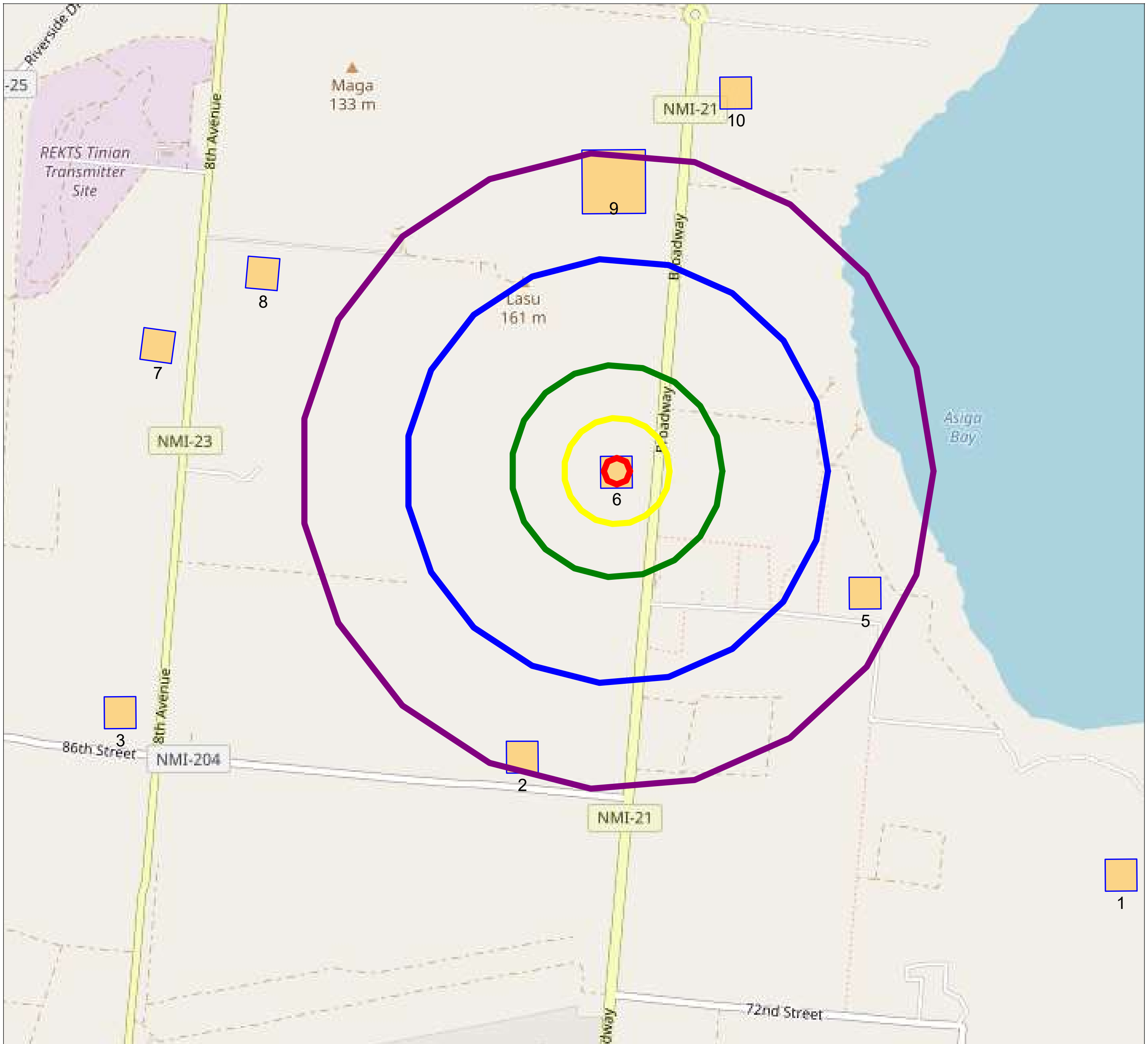
Modeled Landing Zone 5 for Helicopters and Tilt-Rotor

Red = 0 to 50 ft AGL
Yellow = 30 to 100 ft AGL
Green = 100 to 200 ft AGL
Blue = 200 to 300 ft AGL
Violet = 300 to 500 ft AGL

0 2,000 4,000 6,000 8,000 10,000 12,000 14,000

Scale in Feet 1:36,000 (1 inch = 3,000 feet)

N



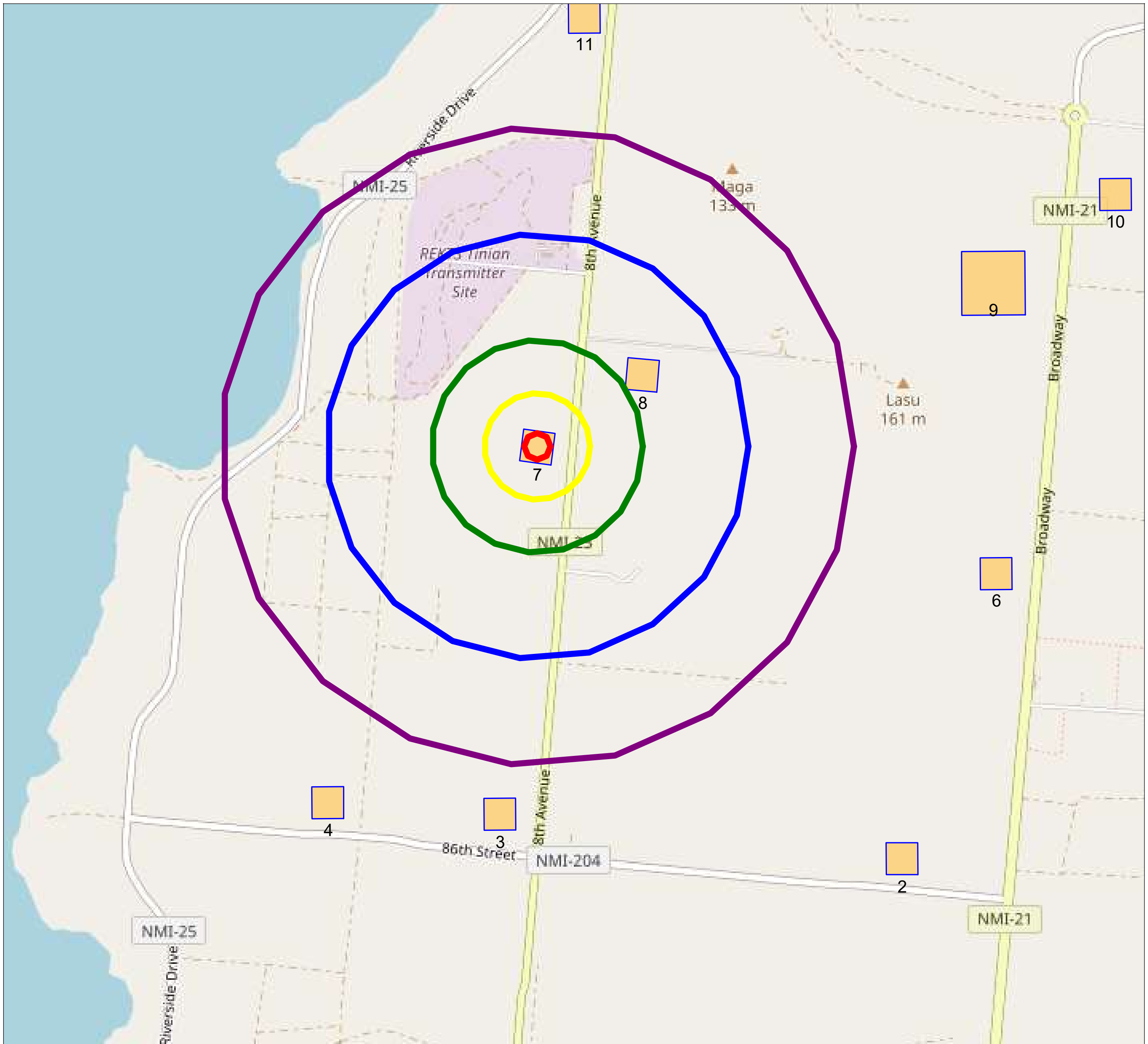
Modeled Landing Zone 6 for Helicopters and Tilt-Rotor

Red = 0 to 50 ft AGL
Yellow = 30 to 100 ft AGL
Green = 100 to 200 ft AGL
Blue = 200 to 300 ft AGL
Violet = 300 to 500 ft AGL

0 2,000 4,000 6,000 8,000 10,000 12,000 14,000

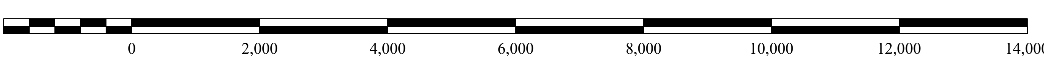
Scale in Feet 1:36,000 (1 inch = 3,000 feet)

N

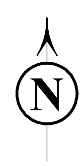


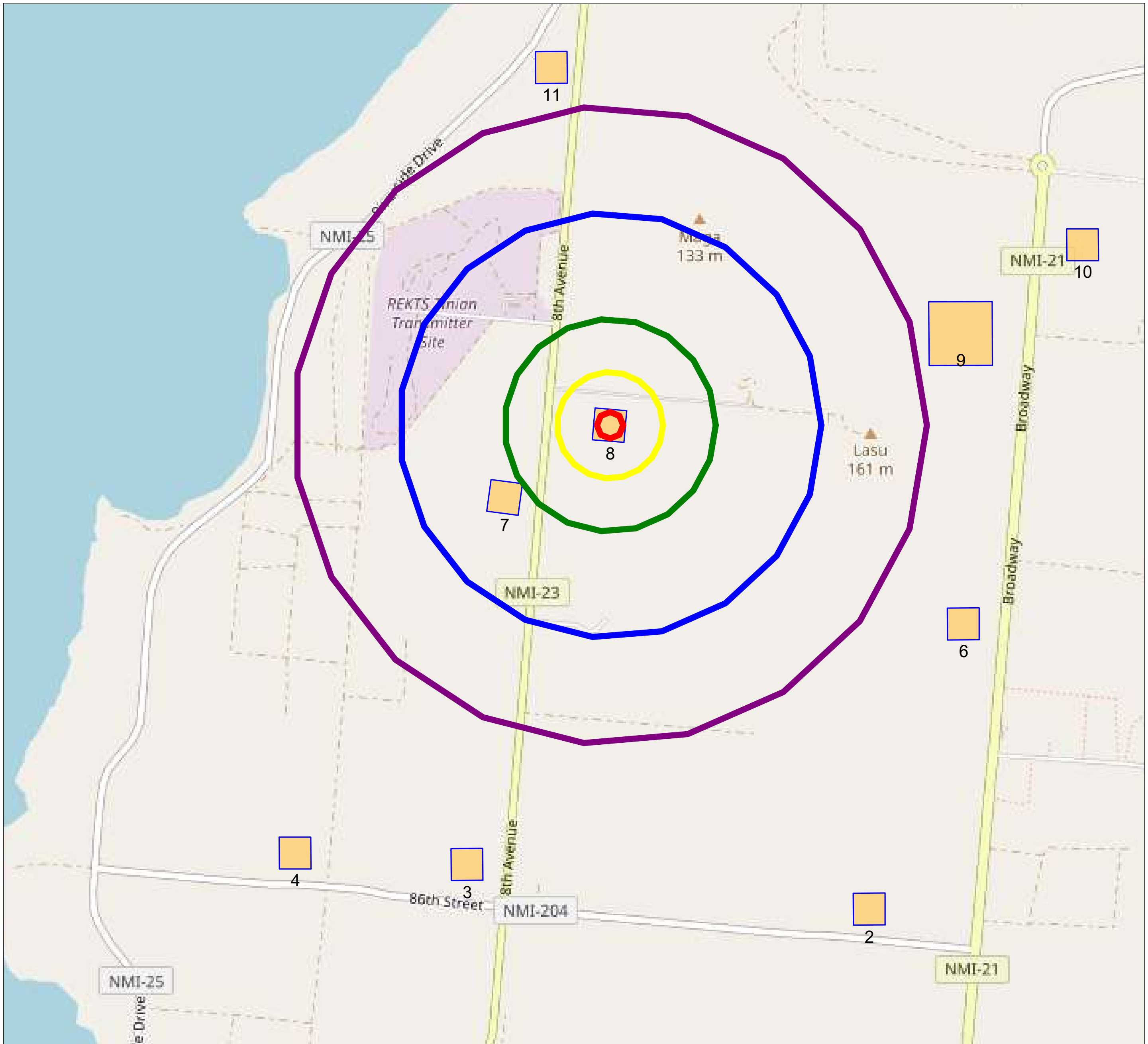
Modeled Landing Zone 7 for Helicopters and Tilt-Rotor

Red = 0 to 50 ft AGL
Yellow = 30 to 100 ft AGL
Green = 100 to 200 ft AGL
Blue = 200 to 300 ft AGL
Violet = 300 to 500 ft AGL



Scale in Feet 1:36,000 (1 inch = 3,000 feet)





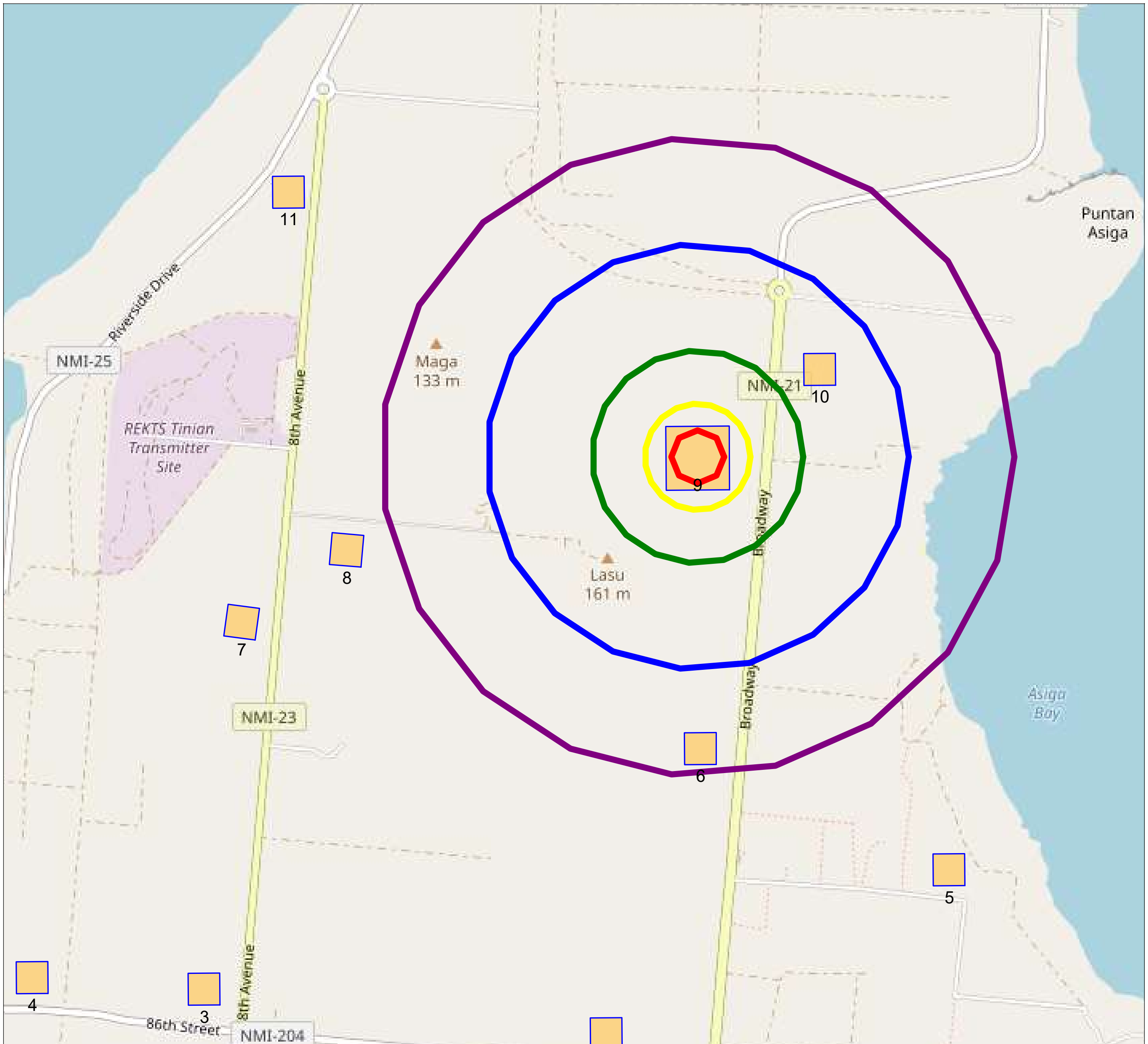
Modeled Landing Zone 8 for Helicopters and Tilt-Rotor

Red = 0 to 50 ft AGL
Yellow = 30 to 100 ft AGL
Green = 100 to 200 ft AGL
Blue = 200 to 300 ft AGL
Violet = 300 to 500 ft AGL

0 2,000 4,000 6,000 8,000 10,000 12,000 14,000

Scale in Feet 1:36,000 (1 inch = 3,000 feet)

N



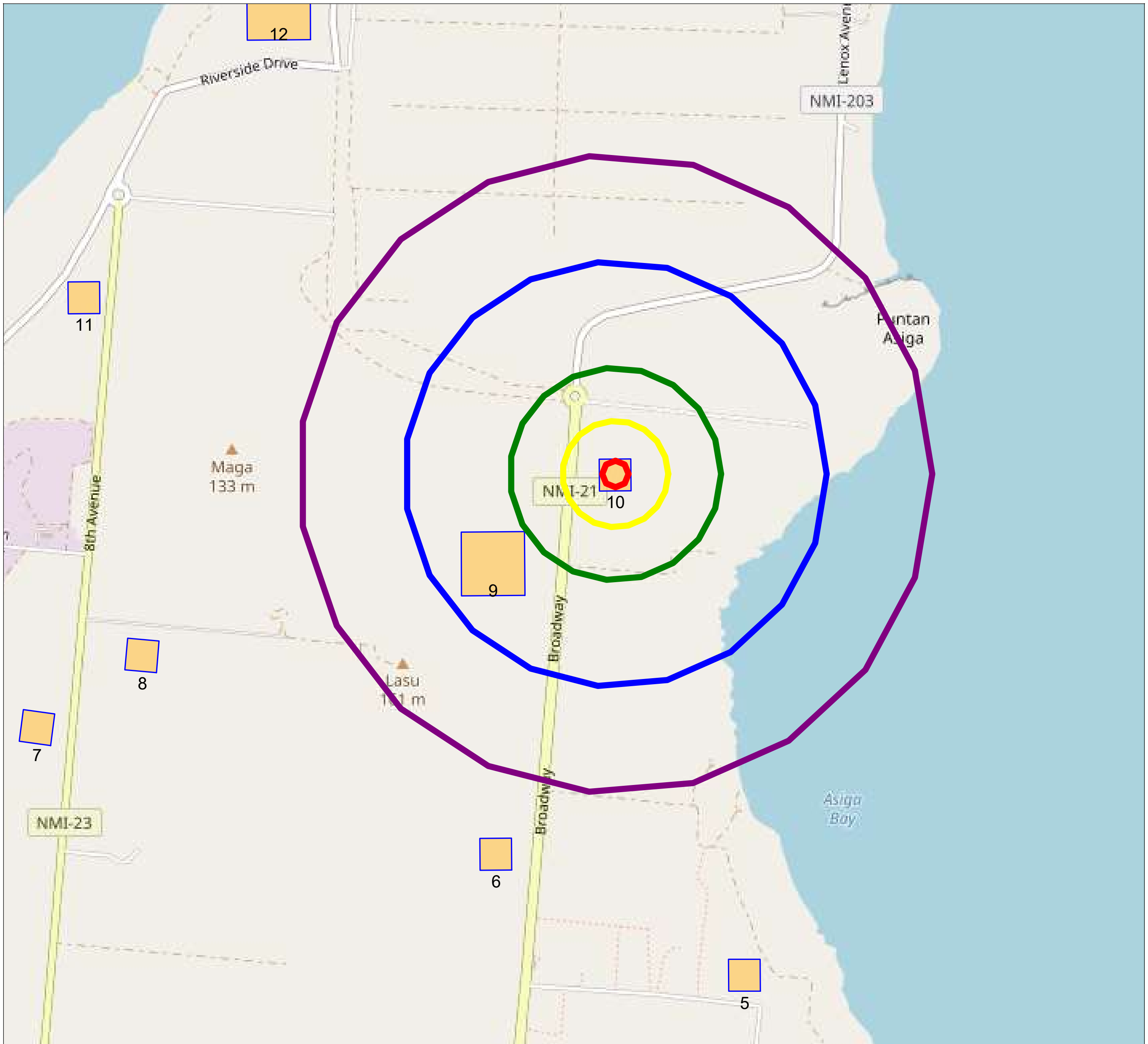
Modeled Landing Zone 9 for Helicopters and Tilt-Rotor

Red = 0 to 50 ft AGL
Yellow = 30 to 100 ft AGL
Green = 100 to 200 ft AGL
Blue = 200 to 300 ft AGL
Violet = 300 to 500 ft AGL

0 2,000 4,000 6,000 8,000 10,000 12,000 14,000

Scale in Feet 1:36,000 (1 inch = 3,000 feet)

N



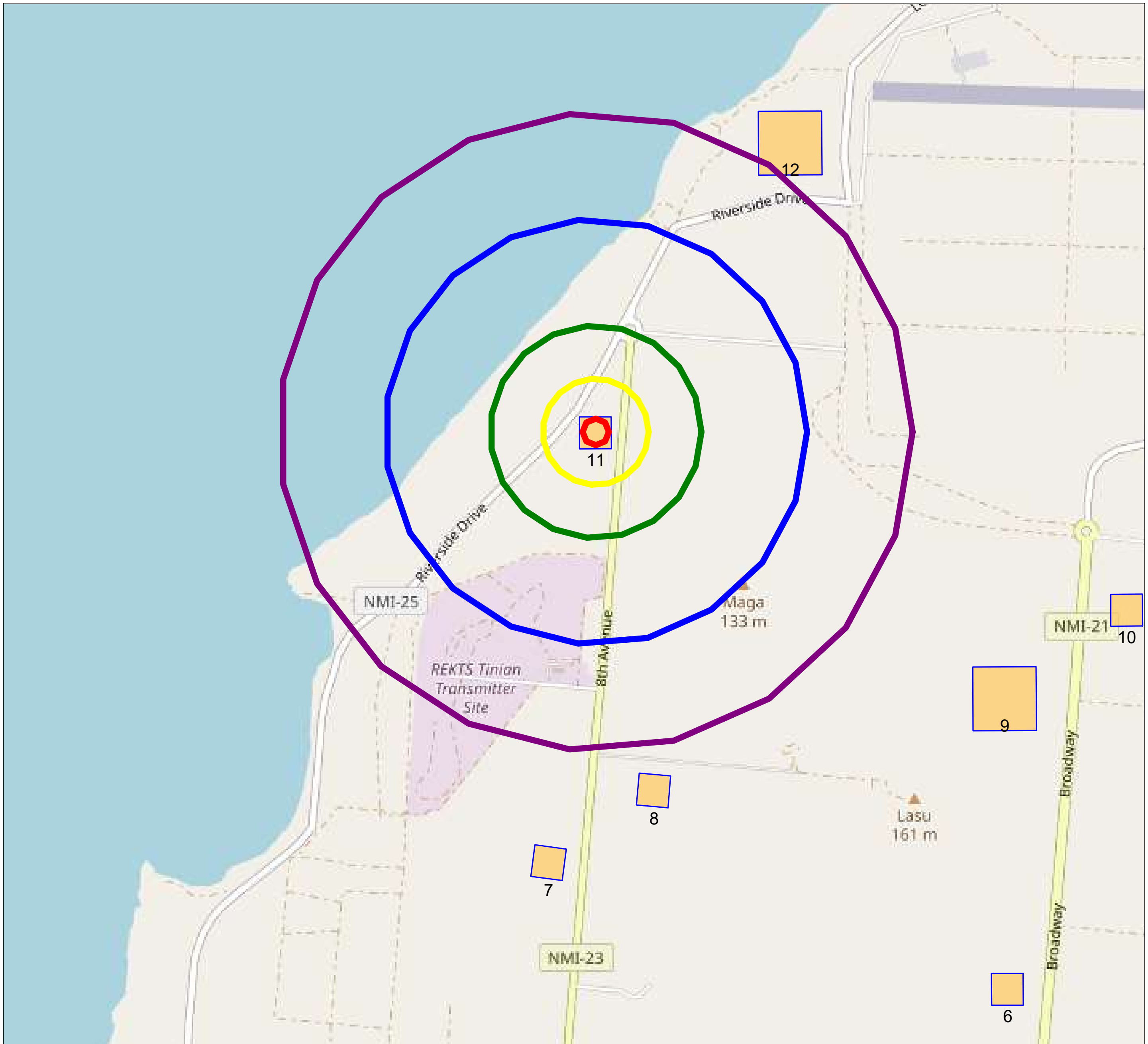
Modeled Landing Zone 10 for Helicopters and Tilt-Rotor

Red = 0 to 50 ft AGL
Yellow = 30 to 100 ft AGL
Green = 100 to 200 ft AGL
Blue = 200 to 300 ft AGL
Violet = 300 to 500 ft AGL

0 2,000 4,000 6,000 8,000 10,000 12,000 14,000

Scale in Feet 1:36,000 (1 inch = 3,000 feet)

N



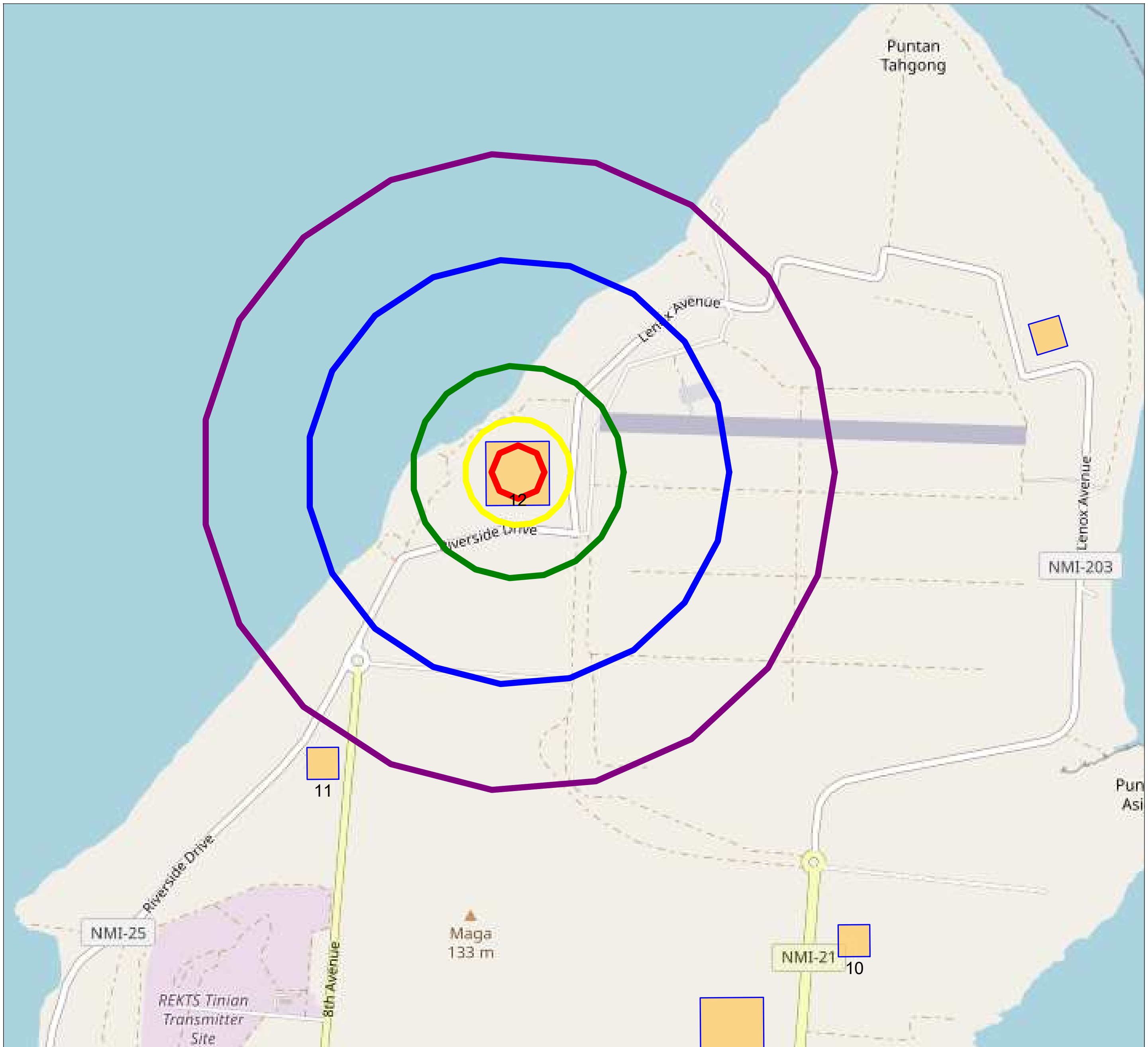
Modeled Landing Zone 11 for Helicopters and Tilt-Rotor

Red = 0 to 50 ft AGL
Yellow = 30 to 100 ft AGL
Green = 100 to 200 ft AGL
Blue = 200 to 300 ft AGL
Violet = 300 to 500 ft AGL

0 2,000 4,000 6,000 8,000 10,000 12,000 14,000

Scale in Feet 1:36,000 (1 inch = 3,000 feet)

N



Modeled Landing Zone 12 for Helicopters and Tilt-Rotor

Red = 0 to 50 ft AGL
Yellow = 30 to 100 ft AGL
Green = 100 to 200 ft AGL
Blue = 200 to 300 ft AGL
Violet = 300 to 500 ft AGL

0 2,000 4,000 6,000 8,000 10,000 12,000 14,000

Scale in Feet 1:36,000 (1 inch = 3,000 feet)

N

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APPENDIX K
AIR QUALITY EMISSIONS CALCULATIONS

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TABLE OF CONTENTS

LIST OF TABLES

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APPENDIX K

This appendix provides a detailed discussion on emission estimates calculated for construction and training activities associated with the No Action and Proposed Action.

K.1 REGULATORY SETTING

K.1.1. Criteria Pollutants

The U.S. Environmental Protection Agency (EPA) implements and enforces Clean Air Act requirements. The U.S. EPA Region 9 incorporates the Pacific Islands, including the CNMI. Locally, the CNMI Bureau of Environmental and Coastal Quality, Division of Environmental Quality is the primary agency for management of CNMI natural resources. Its Clean Air Program is tasked with limiting the release of air emissions from diesel-powered motor vehicles, air-polluting equipment, and other polluting industries through enforcement of local and federal environmental regulations.

Criteria pollutants, regulated under Clean Air Act amendments, are a set of common air pollutants that are harmful to human health and the environment and can cause property damage (U.S. EPA 2023a). They include carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), suspended particulate matter less than or equal to 10 micrometers in aerodynamic diameter (PM_{10}), suspended particulate matter less than or equal to 2.5 micrometers in aerodynamic diameter ($PM_{2.5}$), and lead (Pb). Under Clean Air Act amendments, the U.S. EPA has established National Ambient Air Quality Standards for these pollutants. National Ambient Air Quality Standards are classified as primary or secondary:

- Primary standards protect against adverse health effects.
- Secondary standards are designed to protect public welfare, such as prevention of damage to farm crops, vegetation, and buildings.

Some pollutants have long-term standards, designed to protect against chronic health effects, and short-term standards that target against acute health effects.

Table K-1 presents the National Ambient Air Quality Standards for the criteria pollutants, along with their averaging times (i.e., period over which pollutant concentrations are measured for comparison to the National Ambient Air Quality Standards). Per CNMI Administrative Code Chapter 65-10, *Bureau of Environmental and Coastal Quality, Division of Environmental Quality*, the National Ambient Air Quality Standards are adopted by CNMI.

Table K-1 National and CNMI Ambient Air Quality Standards

Air Pollutant	*Averaging Time*[1]	*Federal Primary Standard*[2]	*Federal Secondary Standard*[3]
CO	1-hour 8-hour	35 ppm 9 ppm	—
NO_2	1-hour Annual	100 ppb 53 ppb	— 53 ppb
PM_{10}	24-hour Annual	150 µg/m^3 —	150 µg/m^3 —
$PM_{2.5}$	24-hour Annual	35 µg/m^3 12 µg/m^3	35 µg/m^3 15 µg/m^3
O_3	8-hour	0.070 ppm	0.070 ppm
SO_2	1-hour 3-hour 24-hour Annual	75 ppb — — —	— 0.5 ppm — —
Pb	Rolling 3-month	0.15 µg/m^3	0.15 µg/m^3

Legend: "—" = none; µg/m^3 = microgram per cubic meter; CNMI = Commonwealth of the Northern Mariana Islands; CO = carbon monoxide; NO_2 = nitrogen dioxide; O_3 = ozone; Pb = lead; ppb = parts per billion; ppm = parts per million; PM_{10} = particulate matter less than or equal to 10 micrometers in diameter; $PM_{2.5}$ = particulate matter less than or equal to 2.5 micrometers in diameter; SO_2 = sulfur dioxide.

Notes: [1] The period over which pollutant concentrations are measured.
[2] Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly.
[3] Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

Source: U.S. EPA 2023b.

K.1.2 General Conformity

The Clean Air Act requires geographic areas to be designated according to their ability to attain the National Ambient Air Quality Standards. These areas are categorized for each criteria pollutant as:

- Attainment Area – Area where no exceedance of National Ambient Air Quality Standards for a specific criteria pollutant has occurred (i.e., meets or is cleaner than the national standard).
- Nonattainment Area – Area where exceedance of National Ambient Air Quality Standards for a specific criteria pollutant has occurred.
- Maintenance Area – Area that has been redesignated to attainment status but must demonstrate via the preparation of a maintenance plan how measures would be implemented to maintain attainment of the National Ambient Air Quality Standards for a period of 10 years. Most Clean Air Act rules for nonattainment areas are still applicable to a maintenance area until attainment has been maintained for 10 years.

The U.S. EPA General Conformity Rule applies to federal actions occurring in nonattainment or maintenance areas when the total direct and indirect emissions of nonattainment pollutants (or their precursors) exceed specified thresholds. The emissions thresholds that trigger requirements for a conformity analysis are called *de minimis* levels. *De minimis* levels (in tons per year) vary by pollutant and also depend on the severity of the nonattainment status for the air quality management area in question. However, as Tinian is classified by the U.S. EPA to be in attainment of the National Ambient Air Quality Standards per 40 Code of Federal Regulations (CFR) 81.354, the General Conformity Rule does not apply to the Proposed Action.

K.1.3 Hazardous Air Pollutants

In addition to the criteria pollutants, the Clean Air Act also lists 187 air toxics, known as hazardous air pollutants. While ambient standards do not exist, national regulations under Section 112 of the 1990 Clean Air Act Amendments exist for hazardous air pollutants for specific source categories, and these regulations require compliance with technology-based emission standards for major sources and certain area sources of hazardous air pollutants. Hazardous air pollutants are those pollutants that are known or suspected to cause cancer and other serious health impacts when exposure occurs at sufficient concentrations and durations. Populations most susceptible to exposures include children, the elderly, and those who already suffer from compromised health. "Major sources" are defined as a stationary source or group of stationary sources that emit or have the potential to emit 10 tons per year or more of a hazardous air pollutant or 25 tons per year or more of a combination of hazardous air pollutants.

K.1.4 Greenhouse Gases

Greenhouse gases are gas emissions that trap heat in the atmosphere. These emissions occur from natural processes and human activities. Scientific evidence indicates a trend of increasing global temperature over the past century due to an increase in greenhouse gas emissions from human activities.

Greenhouse gases can remain in the atmosphere for different amounts of time, ranging from a few years to thousands of years. All of these gases remain in the atmosphere long enough to become well mixed, meaning that the amount that is measured in the atmosphere is roughly the same all over the world regardless of the source of the emissions. The Global Warming Potential allows the comparison of the global warming impacts of different gases. Specifically, a Global Warming Potential is a relative measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time. CO_2 has a Global Warming Potential of 1 and serves as a baseline for other Global Warming Potential values. CO_2 remains in the atmosphere for a very long time; changes in atmospheric CO_2 concentrations persist for thousands of years. The larger the Global Warming Potential, the greater potential to trap heat as compared to CO_2 over time, which is most commonly defined as 100 years. Per 40 CFR Part 98, the 100-year Global Warming Potential for methane (CH_4) is 25, and the Global Warming Potential for nitrous oxide (N_2O) is 298. The concept of CO_2 equivalence (CO_2e) is used to account for the different Global Warming Potentials of greenhouse gases. Greenhouse gas emissions are typically measured in metric tons of CO_2e. For NEPA disclosure purposes, greenhouse gas emissions associated with the Proposed Action were estimated for both construction and operational activities.

K.2 CONSTRUCTION EMISSIONS

Increased direct emissions of criteria pollutants, hazardous air pollutants and greenhouse gases would result from the following potential construction activities:

- Use of diesel- and gas-powered construction equipment

- Movement of trucks containing construction and removal materials
- Commute of construction workers
- Earth disturbance dust emissions from equipment and truck operations

To estimate air emissions associated with construction activities, estimates of the equipment needed to complete the work, operational time for that equipment, and construction manpower (for purposes of estimating emissions related to worker transport) were performed first. Although projects only developed to planning-level schematics typically do not have engineering plans available from which conventional construction cost estimates would be developed, construction activity inputs for emissions estimates can be developed on the basis of the size and type of the structures, and/or site work and some basic assumptions of anticipated work.

Estimates of construction crew and equipment requirements and productivity are based on data presented in the following sources:

- 2003 RSMeans Facilities Construction Cost Data, R.S. Means Co., Inc., 2002
- 2011 RSMeans Facilities Construction Cost Data, R.S. Means Co., Inc., 2010

The Proposed Action would include the construction of various training ranges and support facilities throughout Tinian. The assumptions considered and calculations performed are based on the program cost estimates developed for the work that roughly quantify the major components of the work. Some portions of the work are considered incidental or not generally associated with heavy equipment use. For example, erosion control is expected to include relatively low-intensity, low-frequency work items. Additionally, it is assumed that the landform would be utilized largely in its existing condition, and no mass grading activities are required; other than excavation necessary specifically to constructing building foundation elements, grading would be employed only to prepare site areas and level localized areas, but earth would not be transported over large distances.

The items and the work necessary to construct the project are described below on a unit basis to match the format of the estimates and are scaled to total size for each individual project to establish total equipment requirements.

The primary components of the work include the following elements:

K.2.1 Multi-Purpose Maneuver Range

The total size of the Multi-Purpose Maneuver Range would be 200 acres, within which several training elements would be constructed:

- Clearing or thinning of vegetation to cover entire area.
- Access road that is 10,080 feet long with 50-foot clearing around the perimeter, creating fire breaks that would include grading, base courses, and gravel, back run, and compacted surface area.
- Interim fire break on existing road.
- Four objective areas with maximum of 15 acres each including vegetation removal, object construction and monitoring well construction.

- Two support-by-fire positions and firing lane: it is assumed that these elements would only be demarcated within the range but would require no construction beyond general clearing already identified.
- Clearing ammunition hazard area.
- Unimproved road down spine of training area.
- Two surface radar sites including clearing with fencing, radar towers, and flagpole for training alert flags.
- Portable water services and well field including water well, tanks, and one support building construction.

K.2.2 Explosives Training Range

The total size of the Explosives Training Range would be 2.5 acres. Minimal construction would be associated with this element and includes clearing vegetation, construction of a bunker and four monitoring wells.

K.2.3 North Field Improvements

The North Field improvements would include upgrades to the surface of Runway Baker, thinning of vegetation throughout, installation of unimproved roadways for access, and installation of arresting gear on Runway Baker.

K.2.4 Landing Zones

There would be 2 large (1,200 feet by 1,200 feet) Landing Zones and 11 small (600 feet by 600 feet) Landing Zones constructed. The work for Landing Zone establishment consists of site clearing only. New access roads would be constructed for Landing Zones not sited adjacent to existing infrastructure; the total length of these new roads is estimated at approximately 2,000 linear feet. These roadways are assumed to be 20 feet wide with gravel surfaces.

K.2.5 Base Camp

<u>Building Reuse and Construction</u>

Reuse of existing buildings is proposed for much of the footprint and no new construction activity is associated with reuse. However, there would be some new construction considered – one structure would be used as an aircraft shelter (16,200 square feet), and there would be new building construction for a range maintenance shop (1,260 square feet), communications node (2,700 square feet), a warehouse (36,000 square feet), a public works shop (8,700 square feet), electrical distribution building (900 square feet) and restrooms/showers (3,200 square feet). Functionally, it is assumed that the aircraft shelter would consist of a pre-engineered building erected on site, while the remaining structures are of similar nature that can be estimated as a simple prototype building and construction effort scaled to the listed size of the specific structures.

Construction would include foundation, single floor with roof enclosure, mechanical systems, heating, ventilation and air conditioning distribution, sprinkler system, interior finishes, and interior utility installation.

In addition to the building construction, some non-prototype items would be constructed including a potable water services and well field.

K.2.6 Site Work

Additional site disturbances would include various hardscape areas and other ground disturbances for construction-phase laydown areas, leach fields, etc. associated with the Base Camp, including the following:

- Utility line installations
- Communications tower and support infrastructure
- Concrete tent pads
- Camp and port biosecurity/wash rack
- Fueling pads
- Ammunition holding area
- Motor pool
- Hardscape construction
- Base Camp training parking
- Septic leach field
- Base camp fencing

Emission factors for all criteria pollutants and hazardous air pollutants from both construction equipment (non-road engines including cranes, forklifts, excavators, front end loaders, generators, and other construction equipment) and motor vehicles were derived from U.S. EPA's Motor Vehicle Emission Simulator Version 4 (MOVES 4) emission factor model (U.S. EPA 2023c), which is associated with the national default model database for both non-road equipment and on-road vehicle engines. The national default input parameters available for the Virgin Islands (the available data closest to the CNMI modeling conditions) were used in emission factor modeling, per prior U.S. EPA recommendations.

To calculate emission factors for the Proposed Action, model runs were conducted for an assumed construction start year of 2026 and project-level emission rate mode. Non-road emission factors from the MOVES 4 emission model are provided in units of grams per horsepower-hour), so emissions were estimated by multiplying the emission factor by the non-road engine's assumed horsepower rating, the total operating hours developed, and the load factor for each different type of equipment as applied in the MOVES 4 model. Emission factors for greenhouse gases, in terms of CO_2 and CH_4, were also predicted using the MOVES 4. Emissions for N_2O were prorated based on U.S. EPA emission factors for construction equipment (0.57 grams CH_4/gallon fuel and 0.26 grams N_2O/gallon fuel, respectively) (U.S. EPA 2016).

K.2.7 Nonroad Engines

An example of the calculation methodology for non-road engines using the MOVES 4 emission factors is as follows:

$$E = EF \times hp \times HR \times LF \times 1.10231E(-6)$$

Where:

E	=	non-road emissions per unit per duration (tons)
EF	=	non-road emission factor per unit type (grams per horsepower-hour)
HR	=	hours of operation per duration (hour)

LF = load factor
1.10231E(-6) = mass conversion factor (ton/gram)

For N_2O emissions, the following equation was applied:

$$E = \text{CH4}\ EF \times \frac{\text{N2O}}{\text{CH4}} conversion\ factor\ x\ PR \times HR \times LF \times 1.10231E(-6)$$

Where:

E = non-road emissions per unit per duration (tons)
EF = non-road emission factor per unit type (grams per horsepower-hour)
N_2O/CH_4 conversion factor = 0.26/0.57 = 0.45614
PR = power rating (horse power)
HR = total operating hours per duration (hour)
LF = load factor
1.10231E(-6) = mass conversion factor (ton/gram)

Typical load factors for various equipment types were based on Appendix A of the U.S. EPA's "Median Life, Annual Activity, and Load Factor Values for Non-road Engine Emissions Modeling" (U.S. EPA 2010).

K.2.8 On-Road Vehicles

On-road emission factors from the MOVES 4 are provided in grams per vehicle mile traveled for running operations, gram/hour for idling and gram/start for vehicle starts. Total emissions from on-road vehicles during construction were estimated based on running, idling, and starting operational modes.

The equation for emissions during running operations is the following:

$$E = EF \times VMT \times 1.10231E(-6)$$

Where:

E = on-road emissions per unit per duration (tons)
EF = on-road emission factor per vehicle type (gram/vehicle miles traveled)
VMT = vehicle miles traveled per duration
1.10231E(-6) = gram to ton conversion factor

Idling emissions were calculated by taking the MOVES 4–produced idle emission factor and multiplying by the number of hours (represented as a fraction) spent in idle mode. Idling time, 10 minutes per day, was estimated based on engineering judgement.

The equation for emissions during idle operations is the following:

$$E = EF \times HR \times 1.10231E(-6)$$

Where:

E = on-road emissions per unit (tons)
EF = on-road emission factor per idle time (gram/hour)
HR = total idling hours (hour)
1.10231E(-6) = mass conversion factor (ton/gram)

Emissions from starts were calculated by taking the MOVES 4 starts emission factor and multiplying by the number of starts, where two starts were assumed per day of use.

Equation for emissions during starts is the following:

$$E = EF \times ST \times 1.10231E(-6)$$

Where:

E	=	on-road emissions per unit (tons)
EF	=	on-road emission factor per starts (gram/start)
ST	=	total number of starts
1.10231E(-6)	=	mass conversion factor (ton/gram)

K.2.9 Fugitive Dust (Earth Disturbance)

In addition to engine emissions, fugitive dust emissions resulting from earth disturbance (e.g., excavation and transferring of excavated materials into dump trucks) were estimated with particulate emission factors from the Western Regional Air Partnership (WRAP) Fugitive Dust Handbook (WRAP 2006). The PM_{10} emission factor is the following:

$$PM_{10}\ emission\ factor\ (tons/acre - month) = 0.11$$

Where:

$PM_{2.5}$ = PM_{10} emission factor × ratio [0.1 for construction and demolition activity]

Emissions were calculated using the following equation:

$$E = EF \times acres\ x\ months\ of\ activity$$

Where:

E	=	fugitive dust emissions (tons)
EF	=	emission factor (ton/acre-month

The amount of earth disturbed was based on square footage of land disturbed by new or modified buildings, other impervious surfaces, and other ground disturbances.

K.3 OPERATIONAL EMISSIONS

Operational emissions were calculated for the following sources:

- Road surface re-entrainment dust emissions
- On-road and off-road training personnel vehicles
- Fixed-wing and rotary-wing aircraft
- Ground-based training activities and support vehicles
- New stationary sources: electrical power generators and solid waste management

K.3.1 Ground Training Activities and Support Vehicles

Ground training activities would include operation of training vehicles (such as Assault Amphibious Vehicles, Light Armored Vehicles, and High Mobility Multipurpose Wheeled Vehicles) and supporting mobile and portable equipment (such as water and fuel trucks, forklifts, reverse osmosis water purification units, and generators).

Exhaust emissions from vehicles and supporting mobile and portable equipment were estimated with the same method used to estimate emissions from construction vehicles and MOVES 4 non-road vehicle module–predicted emission factors for such sources as off-highway tractors.

The amount of equipment and hours operating were based on the 2015 *Mariana Islands Training and Testing Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS)* scaled based on number of events proposed versus what was assumed for the previous studies.

In addition, because the training vehicles would maneuver on a mix of paved roads, unpaved roads, and military training trails with potential to generate fugitive dust, the U.S. EPA AP-42 was used to estimate roadway fugitive dust emissions from training vehicles. Given the lack of inputs to divide the time for training vehicles running on paved and unpaved roads, it was conservatively assumed that all roadway surface fugitive dust emissions (PM_{10} and $PM_{2.5}$) would be generated from unpaved roadways. Hours operated on roadways was also conservatively assumed to be the entire range time, while in reality vehicles would not be operating the full range hours.

For unpaved roads, the following equation was used (U.S. EPA 2006):

$$E = EF\left(\frac{lb}{VMT}\right) x \text{ VMT x } \frac{1 \text{ ton}}{2000 \text{ lb}}$$

$$EF\left(\frac{lb}{VMT}\right) = k \times (s/12)^\wedge a \times (W/3)^\wedge b \times [(365 - P)/365]$$

Where:

E	=	unpaved roads emissions per duration (tons)
EF (lb/VMT)	=	emission factor in units of pound/vehicle miles traveled
VMT	=	vehicle mile traveled
k	=	particulate size multiplier (pound/vehicle miles traveled) [1.5 for PM_{10} and 0.15 for $PM_{2.5}$]
s	=	surface material silt content (percent) [for purposes of these calculations, assumed default U.S. EPA AP-42 value of 8.5 percent for a construction site]
W	=	mean vehicle weight (tons) [based on average weights per vehicles type]
P	=	number of wet days in a year with at least 0.01 inches of precipitation
a	=	constant 0.9 for PM_{10} and $PM_{2.5}$
b	=	constant 0.45 for PM_{10} and $PM_{2.5}$

K.3.2 Airport/Airfields and Aircraft

Fixed-wing aircraft and helicopter engines would emit air emissions during operation. As with the previous studies for activities in the Mariana Islands Training and Testing Study Area, training and testing aircraft flights are assumed to originate offshore from aircraft carriers or other Department of the Navy (DON) vessels outfitted with flight decks or from Andersen Air Force Base in Guam. Except for helicopters, all aircraft are assumed to travel to and from training ranges at or above 3,000 feet above ground level.

The types of aircraft activity (e.g., flight characteristics for each training activity) were assumed to be similar to those that occur in the Mariana Islands Training and Testing Study Area, and number of sorties was scaled based on number of events proposed versus what was assumed for the previous studies. Changes were made to adjust for the current types of aircraft used for training and testing (such as the FA-18E/F and the F-35 B/C). Additionally, operations were added to account for the aircraft associated with Divert support activities at Francisco Manglona Borja / Tinian International Airport (U.S. Air Force 2016, 2020) and additional aircraft associated with supply transport to reflect current or baseline activities.

Criteria pollutant emission factors are typically provided as pound per hour of activity. Emission factors were taken from the 2015 *Mariana Islands Training and Testing EIS/OEIS* or, if they had been updated, from the 2020 *Mariana Islands Training and Testing Supplemental EIS/OEIS*. For most military engines, emissions factors were originally obtained from the DON Aircraft Environmental Support Office memoranda and previous DON EIS/OEIS documentation (primarily citing the Federal Aviation Administration's Emissions and Dispersion Modeling System model). Additional emission factors were taken from other aircraft-specific Aircraft Environmental Support Office memorandums and the June 2023 *Air Emissions Guide for Air Force Mobiles Sources: Methods for Estimating Emissions of Air Pollutants for Mobile Sources at United States Air Force Installations* (Air Force Civil Engineer Center [AFCEC] 2023). These emission factors were multiplied by total hours of flight activities per year per aircraft to calculate total emissions. Total hours per aircraft per testing and training activity were based on the number of sorties and the average of time on range per sortie. Time on range (activity duration) was based on the operational limit of the aircraft and is generally unchanged from what was considered in the 2015 *Mariana Islands Training and Testing EIS/OEI*S, except for additions of the new aircraft types/activities. To speciate emissions based on locations, the calculated hours were separated based on time spent overland through 3 nautical miles offshore, between 3 and 12 nautical miles from shore, and greater than 12 nautical miles from shore.

A simplified example equation for these calculations is the following:

$$E = EF \times \text{Hours of Activity} \times 1 \text{ ton}/2000 \text{ pounds}$$

Where:

E	=	aircraft emissions per unit per duration (tons)
EF	=	pounds per hour
Hours of Activity	=	hours of activity per location (overland through 3 nautical miles offshore, between 3 and 12 nautical miles overwater, greater than 12 nautical miles from shore)

Emissions for particulate matter are provided as total particulate matter. As was assumed for 2015 *Mariana Islands Training and Testing EIS/OEIS*, total particulate matter was conservatively assumed to be equivalent to PM_{10}. $PM_{2.5}$ was estimated by assuming 90 percent of PM_{10} is composed of $PM_{2.5}$. This ratio is included as approved estimation methodology within the June 2023 *Air Emissions Guide for Air Force Mobiles Sources: Methods for Estimating Emissions of Air Pollutants for Mobile Sources at United States Air Force Installations* (AFCEC 2023).

For hazardous air pollutants, emissions are based on calculated volatile organic compounds emissions and mass fractions of hazardous air pollutants within aircraft engine exhausts. The hazardous air pollutant mass fractions and methodology was taken from the June 2023 *Air Emissions Guide for Air Force Mobiles Sources: Methods for Estimating Emissions of Air Pollutants for Mobile Sources at United States Air Force Installations* (AFCEC 2023). The hazardous air pollutant mass fractions were sourced from *Recommended Best Practice for Quantifying Speciated Organic Gas Emissions from Aircraft Equipped with Turbofan, Turbojet, and Turboprop Engines* (U.S. EPA 2009). Emissions of each speciated hazardous air pollutant are calculated by converting the separately calculated volatile organic compounds emissions to total organic gases and multiplying the total organic gases by the hazardous air pollutant mass fraction.

$$E(HAP) = \frac{E\ (VOC)}{0.99}\ x\ MF(HAP) x\ \frac{1\ ton}{2000\ lb}$$

Where:

E (HAP)	=	emissions of speciated hazardous air pollutant (tons)
E (VOC)	=	emissions of total volatile organic compounds(pounds/year)
0.99	=	factor converting volatile organic compounds to total organic gases
MF (HAP)	=	mass fraction of speciated hazardous air pollutant

Greenhouse gas emission factors, in units of pound per 1,000 pounds of fuel (pounds/1,000 pounds) were taken from the June 2023 *"Air Emissions Guide for Air Force Mobiles Sources: Methods for Estimating Emissions of Air Pollutants for Mobile Sources at United States Air Force Installations"* (AFCEC 2023) when aircraft-specific factors were not available. Fuel used in aircraft was assumed to be jet fuel, and the fuel flow rate per aircraft was taken from the *2015 Mariana Islands Training and Testing EIS/OEIS* and the *2020 Mariana Islands Training and Testing Supplemental EIS/OEIS*. The following equation was used to calculate emissions:

$$E = EF\ x\ FF\ x\ HR\ x\ \frac{1}{1000}$$

Where:

E	=	emissions (tons)
EF	=	emission factor (pounds/1,000 pounds of fuel)
FF	=	fuel flow (pounds of fuel/hour)
HR	=	hours per duration
1/1000	=	conversion to 1,000 pound units

K.3.3 On-Road Vehicles

To support the training activities, material and personnel transport, vehicles traveling on paved roadways around the island would occur. The on-road vehicle emission factors were obtained from the MOVES 4, and the methodologies that were used are the same as those used for emissions from vehicles during the construction period, as described above. The number of personnel vehicles operating per year is conservatively assumed to be equivalent to the maximum number of personnel per training event (1,000 personnel per large training event, 250 personnel per medium training event and 100 personnel per small training event) and the maximum number of training events per year and their duration (three large training events per year operating four weeks per event, four medium training events per year operating two weeks per event, and four small training events per year operating two weeks per event). Based on engineering estimates, it was assumed each vehicle traveled 15 miles per day, idled 10 minutes a day, and had two startups per day of operation.

For fugitive dust from on-road vehicular traffic, emissions were calculated based on procedures detailed in U.S. EPA AP-42 Chapter 13.2. Paved road emissions used the following equation (U.S. EPA 2011):

$$E = EF\left(\frac{lb}{VMT}\right) \text{ x VMT x } \frac{1 \text{ ton}}{2000 \text{ lb}}$$

$$E\ (lb/VMT) = [k(sL\hat{}0.91 \times (W)\hat{}1.02](1 - P/4N)$$

Where:

E	=	paved road emissions per duration (tons)
EF (lb/VMT)	=	emission factor in units of pounds/vehicle mile traveled
VMT	=	vehicle miles traveled
K	=	particulate size multiplier (pounds/vehicle mile traveled) [0.0022 for PM_{10} and 0.00054 for $PM_{2.5}$]
sL	=	Silt Loading Value (grams/meters squared) [assumed a default U.S. EPA AP-42 value of 7.4 grams/meters squared]
W	=	mean vehicle weight (tons) [based on average weights per vehicle types]
P	=	number of wet days in a year with at least 0.01 inches of precipitation
N	=	number of days in averaging period (365 for annual)

For unpaved roads, the methodology used for calculations was the same as applied for ground training activities and support vehicle operations on unpaved roads.

K.3.4 New Stationary Sources: Electrical Power Generators and Solid Waste Management

Several emergency and back-up stationary generators would be installed at the Tinian Base Camp and mission-critical facilities for support during power outages:

- Two approximately 200 kilowatt (kW) diesel-fired generators at Base Camp;
- Four approximately 200 kW diesel-fired generators associated with communication towers; and
- Three approximately 50 kW diesel-fired generators associated with the surface radar sites.

U.S. EPA AP-42 emission factors, U.S. EPA Tier 2 standards and the anticipated diesel generator parameters considering number and size will be used to estimate emissions. A maximum of 500 hours of emergency operational capacity was assumed for each stationary generator to estimate emissions.

Generator emissions used the following equation per generator for pollutants using U.S. EPA emission factors (U.S. EPA 1996):

$$E = EF \text{ x Heat Input Rate x } 500 \frac{\text{hours}}{\text{year}}\, x\, \frac{1 \text{ ton}}{2000 \text{ lb}}$$

Where:

E	=	generator emissions per year (tons)
EF (lb/MMBtu)	=	emission factor in units of lb/MMBtu (fuel input)
Heat Input Rate	=	heat input rate in units of MMBtu/hr

For pollutants that used the U.S. EPA Tier 2 standards, the following equation was used:

$$\mathrm{E} = \mathrm{EF} \text{ x } \text{power rating} \text{ x } \frac{1 \text{ lb}}{453.59 \text{ grams}} \text{ x } 500 \frac{\text{hours}}{\text{year}} x \frac{1 \text{ ton}}{2000 \text{ lb}}$$

Where:

E	=	generator emissions per year (tons)
EF	=	emission factor in units of g/kWh
Power Rating	=	kW

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APPENDIX L
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