Nunavut Research Institute

License Holder Reporting requirements

For research undertaken in the 2024 calendar year (commencing January 01, 2024 and ending December 31, 2024)

Project Title:

Flashline Mars (Research Station) Annual Report 2024

Project Leader(s): Full name, affiliation, and contact information (address, phone number, email) of each project leader (principal investigator and co-PIs)

- Terry Trevino, MSc. Executive Officer, co-PI & Research Station Manager, The Mars Society, Space 4 All Foundation

  Address:
  256 N. Willard St
  San Francisco, CA.
  94118
  Phone number:
  001.415.699.9869
  Email:
  terryt@marssociety.org

- Dr. Natasha Nicholson, Chief Science Officer, co-PI

  Address:
  1/6 Langton Rd, Edinburgh EH9 3BP
  Phone number: +44 7518 051532
  Email:
  n.nicholson@live.co.uk

- Dr. Mason Robbins, Chief Engineer, co-PI

  Address:
  1/6 Langton Rd, Edinburgh EH9 3BP
  Phone number: +44 7450 255096
  Email:

adastra.mason@gmail.com

- Dr. Ilaria Cinelli, Crew Commander, co-PI

  Address:
  23 Ungaretti street, Montelupo Fiorentino, 50056, Florence, Italy
  Phone number: +39 349 218 2632
  Email:
  i_cinelli@yahoo.it

- Ms. Tiffany Swarmer, MSc. Crew Health and Safety Officer, co-PI

  Address:
  408 Fargo St unit B,
  Houston, TX. 77006
  Phone number: +1 (970) 420-8432
  Email:
  swarmer.tiffany@gmail.com

Project Team: Full name, affiliation, and address (name of city/community and province/territory/state) of each member of the project team

- Ilaria Cinelli, Crew Commander, Florence Italy
- Natasha Nicholson, University of Highlands and Islands, Chief Science Officer, Edinburgh, Scotland
- Tiffany Swarmer, KBR, Health & Safety Officer, Houston, Texas
- Mason Robbins, University of Arizona - Star Helix, Chief Engineer, Edinburgh, Scotland
- Michael Andrews,
  Address: 825 W 6th St
  Apt #3
  San Pedro, CA 90731
  Phone number: +1 (661) 575-5372
  The Mars Society, Crew Logistics, San Pedro, California
- Rhett Woods,
  Address: 158 8th Ave
  San Francisco, CA 94118
  Phone number: +1 (415) 819-8800
  The Mars Society, Mission Specialist, San Francisco, California
- Terry Trevino, University of North Dakota, Executive Officer & Research Station Manager, The Mars Society, San Francisco, California

Abstract: A concise summary of what was done, found, and concluded to date, and how the results/information will be used. This summary must be translated into the appropriate dialect of Inuktut. Suggested length: 250-300 words. (This section will be published in the NRI's annual compendium of licensed research)

The Flashline Mars Arctic Research Station (FMARS) on Devon Island is an important Mars analog research site, supporting scientific studies and testing space mission protocols. In 2024, Crew 16 researched radiation exposure, atmospheric conditions, water quality, permafrost thawing, and microbial ecology. These studies contribute to a greater understanding of extreme environments on Earth and inform future planetary exploration.

The research team observed increased radiation exposure due to the approaching solar maximum. This rise in radiation required careful monitoring of Galactic Cosmic Radiation, solar radiation, and radon gas emissions from permafrost. Measurements of permafrost depth indicated continued thawing, which has significant implications for Arctic ecosystems and for understanding how similar processes might occur on Mars or other celestial bodies.

Environmental assessments included monitoring air quality inside the research station. The team found that carbon dioxide levels increased significantly overnight, highlighting the need for improved ventilation systems. Water samples collected from streams, snowmelt, and thawing permafrost were analyzed for contamination by nanoplastics and microplastics. This investigation aimed to assess the extent of long-range atmospheric deposition of these particles and their potential impact on the Arctic environment.

Microbial studies focused on analyzing lichen, algal streaks, and extremophilic bacteria, with future plans for genomic sequencing to better understand these organisms' adaptations to harsh conditions. Geological surveys mapped impact crater formations in the region, contributing to planetary science research. Additionally, the crew tested a prototype of a pressurized High-Performance Environmental Suit (HPES) to evaluate its functionality and durability in extreme Arctic conditions.

Beyond scientific research, the mission emphasized engagement with Arctic communities. Crew members traveled to Iqaluit and Resolute Bay, fostering relationships with local organizations and researchers. The team also worked toward strengthening collaboration with Nunavut Arctic College, aiming to incorporate Indigenous knowledge into future research efforts. The findings and experiences from this mission contribute to the broader understanding of Mars-like environments on Earth while informing astronaut health and safety considerations for long-duration space exploration.

Key messages: Concise, plain language summary of key take-away messages of work to date, findings and conclusions. Preferably 3-5 points, in bullet form.

- Radiation Exposure: Increased cosmic and solar radiation detected, with potential health implications for Arctic and space environments.
- Environmental Monitoring: VOCs and CO_2 levels fluctuated inside the habitat, requiring ventilation improvements.
- Permafrost Studies: Thawing rates monitored, with potential links to radon gas release and microbial activity.

- Water Quality & Nanoplastics: Arctic water sources tested for contaminants, with long-range transport of plastics under investigation.
- Biological Research: Microbial and algal samples collected for genomic sequencing to study adaptation in extreme environments.

ᐊᓂᓐᓂᖃᖕᒋᑦᑐᒥ ᓄᓇᓂ ᖃᐅᔨᓴᖅᑏᑦ ᐅᑭᐅᖅᑕᖅᑐᒥ (FMARS) ᑖᓐᓇᕈᑎᐅᐸ ᓄᓇᕐᓚᓐᓂ ᐱᑕᖃᕆᐊᖃᓪᓚᕆᑦᑐᖅ ᐊᓂᓐᓂᖃᖕᒋᑦᑐᒥ ᓄᓇᐃᑦ ᖃᐅᔨᓴᖅᑕᐅᑎᓪᓗᒋᑦ ᐃᑲᔪᖅᓱᐃᓂᖕᒋᓐᓂᓪᓗ ᖃᐅᔨᓴᖅᑕᐅᕆᐊᖃᓪᓚᕆᓐᓂᖕᒋᓐᓂᑦ ᐊᒻᒪᓗ ᐆᑦᑐᕋᖅᑕᐅᕙᓐᓂᖕᒋᓐᓄᑦ ᐊᑐᐊᓚᐃᑦ ᐊᓂᓐᓂᖃᖕᒋᑦᑐᒥ ᐊᑐᖅᑕᐅᒍᓛᖅᑐᑦ 2024ᖑᑎᓪᓗᒍ, ᖃᐅᔨᓴᖅᑏᑦ 16ᖑᓪᓗᑎᑦ ᖃᐅᔨᓴᖅᓯᒪᒻᒪᑕ ᓄᖑᓴᐅᑎᓕᖕᓄᑦ ᑎᑭᑕᐅᔪᖃᖅᑐᒥᓂᐅᐸᑉ ᖃᓄᐃᑦᑐᖃᓗᔾᒪᖔᑦ, ᐊᓂᓐᓂᖃᖕᒋᑦᑑᐸ ᖃᓄᐃᓕᖕᓚᓂᖕᒋᑦ, ᐃᒪᖃᕐᓂᖕᒋᓪᓗ ᖃᓄᐃᓕᖕᓗᒻᒪᖔᑕ, ᐊᐅᐸᓪᓕᐊᓂᖕᓚ, ᐊᒻᒪᓗ ᑕᑯᓯᐅᖕᒋᑦᑐᑦ ᐆᒪᔪᓚᓚᐃᑦ ᐱᑕᖃᒻᒪᖔᑕ. ᑕᒪᒃᑯᐊ ᖃᐅᔨᓴᖅᑕᐅᕙᓐᓂᖕᒋᑦ ᐱᓕᖅᐸᓪᓕᐊᑎᔨᒪᑕ ᑐᑭᓯᐅᒪᔫᓐᓇᓂᒻᒥᑦ ᓇᔪᓚᕋᔭᔅᓴᐅᓪᓗᐊᖑᐊᖕᒋᑦᑐᒥᑦ ᓄᓇᔾᔪᐊᒻᒥ ᐊᒻᒪᓗ ᑐᑭᓯᐅᒪᕆᐊᒃᑲᓐᓂᕈᑕᐅᔫᓐᓇᖅᑐᒥᑦ ᐊᓂᓐᓂᖃᖕᒋᑦᑐᒥ ᓄᓇᐃᑦ ᐅᐸᑦᑕᐅᖃᑦᑕᐸᓪᓕᐊᓕᖅᐸᑕ ᓯᕗᓂᔅᓴᑎᓐᓂᑦ.
ᖃᐅᔨᓴᖅᑏᑦ ᐅᔾᔨᖅᓱᓚᐅᖅᐳᑦ ᓄᖑᓴᐅᑎᓛᑦ ᖁᕝᕙᓯᓕᒃᑲᓐᓂᓕᕆᐊᖕᒋᓐᓂ ᑕᐃᓐᓇ ᐱᔾᔪᑕᐅᓪᓗᓂ ᓯᖁᓂᐅᐸ ᐊᑭᒥᓂᖕᒐ ᓴᙱᑎᖅᓯᒪᓂᖕᒐᓄᑦ. ᖁᕝᕙᓯᓐᓂᖕᒐᓄᑦ ᓄᖑᓴᐅᑎ ᐊᑐᕝᓯᐊᕆᐊᖃᓚᐅᖅᑐᒍᑦ ᑲᒪᒋᔭᖃᕝᓯᐊᕆᐊᖃᕆᐊᖃᓪᓗᑕ ᖃᐅᔨᓴᖅᑕᑦᑎᓐᓂᑦ ᐊᓂᓐᓂᖃᖕᒋᑦᑐᒥᑦ ᓄᖑᓴᐅᑎᓂᑦ, ᓯᖁᓂᒻᒦᖔᖅᑐᑦ ᓄᖑᓴᐅᑏᑦ, ᐊᒻᒪᓗ ᓄᖑᔭᑦᑐᓂᑦ ᓚᓯᑦ ᓴᖅᑭᐸᓪᓕᐊᑎᓪᓗᒋᑦ ᐊᐅᐸᓪᓕᐊᔪᒥᑦ. ᐊᐅᐸᓪᓕᐊᔪᒥᑦ ᖃᐅᔨᓴᓕᖅᑎᓪᓗᒋᑦ ᖃᓄᑎᕆ ᐊᐅᐸᓪᓕᐊᓂᖃᒻᒪᖔᑦ ᓇᓗᓇᐃᖅᓯᓚᐅᖅᑐᑦ ᐊᐅᐸᓪᓕᐊᖕᒋᓐᓇᕆᐊᖕᓚᓐᓂᑦ. ᑕᒪᓐᓇᓗ ᐊᑦᑐᐃᓯᒪᓕᖕᓚᓂᖕᓚᓂᑦ ᐅᑭᐅᖅᑕᖅᑐᒥᑦ ᐆᒪᔪᓚᓕᖕᓂᑦ ᐊᒻᒪᓗ ᑐᑭᓯᐅᒪᔭᐅᒍᑎᒃᑲᓐᓂᐅᓗᓂ ᖃᓄᖅ ᐊᐅᓚᓂᐅᔪᑦ ᑕᐃᒫᑦᓴᐃᓐᓇᖅ ᐊᓂᓐᓂᖃᖕᒋᑦᑑᐸ ᓄᓇᖕᓚᓂ ᐊᓯᖕᒋᓐᓂᓪᓗ ᐊᓂᓐᓂᖃᖕᒋᑦᑐᒥ ᐱᑕᓕᓚᓚᐃᑦ.
ᐊᕙᑎᓕᓚᖕᓂᑦ ᖃᐅᔨᓴᕈᑎᒥᓃᑦ ᐃᒪᐃᓕᖕᓚᔪᒻᒪᑕ ᖃᐅᔨᓴᖅᑕᐅᔪᒻᒪᑦ ᐊᓂᓐᓂᖅ ᖃᓄᐃᒻᒪᖕᒫᑦ ᐃᓗᐊᓂ ᖃᐅᔨᓴᖅᑐᓕᕆᔾᔪᒃᑯᑦ ᐱᓕᕆᕝᕙᐊᓂ. ᐱᓕᕆᔾᔪᑦ ᓇᓂᓯᓪᓗᑎᑦ ᐆᖅᑰᓴᐅᑎᖕᓃᖕᒫᖅᑐᓂᑦ ᒫᓯᓂᑦ ᑕᒪᒃᑯᐊᓗ ᖁᕝᕙᓯᕆᐊᑲᓐᓂᓐᓂᖕᓚᑕ ᐅᓐᓄᐊᖕᒋᓐᓇᖅ ᖃᐅᔨᓴᖅᑕᐅᑎᓪᓗᒋᑦ, ᐅᔾᔨᓇᖅᓯᓪᓗᓂ ᐊᖅᑭᒃᓯᕆᐊᖃᓐᓂᖕᒋᓐᓂᑦ ᐊᓂᓐᓂᒻᒧᑦ ᓴᓗᒻᒪᖅᓴᐅᑎᒥᑦ ᓄᑖᒥᑦ. ᐃᒪᐃᓪᓗ ᖃᐅᔨᓴᖅᑕᐅᓪᓗᑎᑦ ᑯᓚᑖᖕᓂᑦ, ᐊᐳᒥᓪᓗ ᐊᐅᐸᓪᓕᐊᔪᒥᑦ, ᐊᒻᒪᓗ ᓄᓇᐅᑉ ᐊᐅᐸᓪᓕᐊᓂᖕᓚᑦ ᖄᖕᓚᒍᑦ ᖃᐅᔨᓴᖅᑕᐅᕆᓪᓗᓂ ᒪᑯᓇᙵ ᐱᑕᖃᖕᒋᒃᑲᓗᐊᒻᒪᖔᑕ ᓱᕈᓇᖅᑐᓂᑦ ᓴᖅᑮᔭᖕᒋᑦᑐᓂᑦ ᐊᐅᑦᑕᔫᓐᓃᖕᖔᖅᑐᓂᑦ ᐊᒻᒪᓗ ᐊᐅᑦᑕᔫᑐᐃᓐᓇᓐᓂᑦ. ᑕᒪᓇ ᖃᐅᔨᓴᖅᑕᐅᓂᕆᓚᐅᖅᑕᖕᓚ ᑐᖑᓕᖃᖅᑐᑎᑦ ᖃᐅᔨᓴᖅᑕᒻᒥᓂᑦ ᖃᓄᑎᒋᑦ ᐊᑯᓂᐅᑎᕆᔪᒥᑦ ᐊᑦᑐᐃᓯᒪᓗᔾᔪᒻᒦᒻᒥ ᐊᓂᓐᓂᖃᖕᒋᑦᑐᒥᑦ ᓱᕈᓴᐃᕙᓪᓕᐊᓂᖕᒋᓐᓂᑦ ᑕᒪᒃᑯᐊ ᓴᖅᑮᔭᖕᒋᑦᑑᓚᓗᐊᑦ ᖃᓄᓪᓗ ᐊᑦᑐᐃᓗᔭᖕᒪᖔᑕ ᐅᑭᐅᖅᑑᐸ ᐊᕙᑖᓂ. ᓴᖅᑮᔭᖕᒋᑦᑐᓂᑦ ᖃᐅᔨᓴᖅᑐᑕ ᖃᐅᔨᓴᕈᒪᓗᐊᖑᐊᓚᐅᖅᑐᒍᑦ ᑎᖕᓚᐅᔭᓚᖕᓂᑦ, ᐃᓪᓗᐹ ᖀᖕᓚᓂ ᕿᕐᓂᖅᑖᓪᓛᔾᔨᑦ ᐊᒻᒪᓗ ᖁᐱᕐᕈᓚᐃᑦ ᓯᐊᒪᐸᓪᓕᐊᔾᔨᑦ, ᓯᕗᓂᔅᓴᑎᓐᓂᑦ ᐸᖕᓇᐸᓪᓕᐊᓪᓗᑕ ᑕᒪᒃᑯᐊ ᓇᑭᙶᒻᒪᖔᑕ ᑐᑭᓯᐅᒪᕆᐊᖃᕐᓂᔪᒪᑦ ᑕᒪᒃᑯᐊ ᖁᐱᕐᕈᓚᐃᑦ ᐆᒪᔪᓚᓐᓗᑦ ᓇᔪᖅᑯᖑᒪᖔᑕ ᓇᔪᓯᐅᓗᐊᖕᒋᑦᑐᒥᑦ. ᐅᔭᒃᑲᓂᑦ ᖃᐅᔨᓴᖅᑏᑦ ᓇᓗᓇᐃᖅᓯᓯᒪᒻᒪᑕ ᓄᓇᖑᐊᓕᐊᒻᒥᑦ ᐊᓂᓐᓂᖃᖕᒋᑦᑐᒥᑦ ᑲᑕᕝᕙᒥᓂᖕᓂᑦ ᓄᓇᒧᑦ ᐃᓱᖅᓴᓂᑦ ᐊᒡᒍᖅᓯᒪᔪᓂᑦ, ᐱᕙᓪᓕᐊᑎᔾᔪᓪᓗᑎᑦ ᓄᓇᐃᑦ ᖃᐅᔨᓴᖅᑕᐅᑲᓐᓂᖁᓪᓗᒋᑦ ᖃᐅᔨᓴᖅᑎᒻᒪᕆᖕᓄᑦ. ᐃᓚᓯᓗᖕᓚ, ᐱᓕᕆᔾᔪᑦ ᖃᐅᔨᓴᔪᒻᒪᑕ ᓯᕗᓪᓕᖅᐹᖅᓯᐅᒥᑦ ᐳᓪᓚᓕᒥᑦ ᓴᖕᒋᔪᒪᕆᐅᓪᓗᓂ ᐊᓂᓐᓂᖃᖕᒋᑦᑐᒥ ᐊᓐᓄᑖᔅ (HPES) ᖃᐅᔨᓴᖅᑕᐅᔪᒪᓂᖕᓚᓄ ᖃᓄᖅ ᐱᒍᓐᓇᓂᖃᒻᒪᖔᑦ ᐊᒻᒪᓗ ᐊᑐᖃᔅᓴᐅᓚᔾᔪᒻᒪᖔᑦ ᐅᑭᐅᖅᑕᖅᑐᒥᑦ ᓂᓪᓚᓯᓪᓚᕆᓕᖅᑎᓪᓗᒍ.
ᐊᓯᐊᒍᑦ ᖃᐅᔨᓴᕆᐊᖅᓯᒪᔾᔭᑦᑕ ᓴᓂᐊᓂ, ᐱᓕᕆᐊᕆᓇᓱᑦᑕᑦᑎᓐᓂᑦ ᐱᒍᒪᓂᕆᔭᕗᓪᓗ ᐃᓚᓕᐅᑎᔨᓂᐅᔪᖅ ᐅᑭᐅᖅᑕᖅᑐᒥ ᓄᓇᓕᖕᓂᑦ. ᐱᓕᕆᔨᐅᔪᑦ ᐃᖃᓗᓐᓄᑦ ᖃᐅᓯᐃᑦᑐᓗᓪᓗ ᐸᓚᖏᓚᐅᖅᐳᑦ, ᐱᓕᕆᖃᑎᒌᓐᓂᖕᒥᑦ ᓯᕗᓪᓕᐅᑎᔨᓪᓗᑎᑦ ᓄᓇᖅᑲᑎᒌᓂᑦ ᑎᒥᐅᔪᓂᑦ ᐊᒻᒪᓗ ᖃᐅᔨᓴᖅᑎᓂᑦ. ᐱᓕᕆᔾᔪᑦ ᑐᖑᓕᖃᖅᑐᑎᓪᓗ ᓴᙱᑦᑎᑦᓯᔪᒪᓪᓗᑎᑦ ᐋᔩᖅᑲᑎᒌᖕᓂᒥᑦ ᓄᓇᕗᒥ ᐅᑭᐅᖅᑕᖅᑐᒥ ᓯᓚᑦᑐᓴᕝᕙᐊᓂ, ᕿᓄᕙᕆᔭᖕᒋᓐᓂᓪᓗ ᐃᓚᓯᔪᒪᓂᒥᓄ ᓄᓇᖃᒃᖄᖅᑐᑦ ᖃᐅᔨᒪᔭᑐᖃᖕᒋᓐᓂᑦ ᓯᕗᓂᔅᓯᑎᓐᓂᑦ ᖃᐅᔨᓴᕈᑎᔅᓴᓇᒍᒪᓛᖅᑕᑦᑎᓐᓂᑦ. ᓇᓗᓇᐃᖅᑕᐅᓯᒪᓕᖅᑐᑦ ᐊᒻᒪᓗ ᐊᑐᖅᑕᐅᓚᐅᖅᑐᑦ ᑕᕝᕘᓇ ᖃᐅᔨᓴᖅᑕᐅᔪᓂᑦ ᐱᕙᓪᓕᐅᑎᔨᒪᑕ ᐊᖕᒋᓂᖅᓴᒃᑲᓂᒪᓇᒥᒃ ᑐᑭᓯᐅᒪᓂᖃᓂᐅᔪᒥᑦ ᐊᓂᓐᓂᖃᖕᒋᑦᑐᒥᑦ ᓄᓇᐃᑦ ᐊᕙᑎᖕᒋᑕ ᐊᔾᔨᓕᓚᖕᓚᓐᓂᑦ ᓄᓇᔾᔪᐊᐸ ᑕᐃᒻᓗ ᑐᑭᓯᐅᒪᔾᔪᑎᓂᑦ ᐊᓂᓐᓂᖃᖕᒋᑦᑐᒥᑦ ᐱᓕᕆᔨᐅᔪᑦ ᑎᒥᖕᒋᑦ ᖃᓄᐃᓕᒻᒪᖔᑕ ᐊᒻᒪᓗ ᐊᑦᑕᓇᑦᑕᐃᓕᒪᓂᖕᒧᑦ ᐃᓱᒪᒃᓴᖅᓯᐅᕈᑎᒃᑲᓐᓂᐅᔪᓂᑦ ᐊᑯᓂ ᐊᓂᓐᓂᖃᖕᒋᑦᑐᒥᑦ ᓇᔪᑎᖃᑎᒌᓐᓂᐊᖅᑐᖃᖅᑎᓪᓗᒍ ᖃᐅᔨᓴᖅᑎᓂᑦ.

ᑐᑭᓯᔭᐅᔭᕆᐊᖃᓪᓚᕆᖕᓂᖕᒋᑦ ᐅᑯᐊ:

- ᓄᖑᓴᐅᑎᓄᑦ ᐊᑦᑐᖅᑕᐅᓯᒪᓂᖓ: ᐱᓕᖅᐸᓪᓕᐊᔪᓂᑦ ᐊᓂᓐᓂᖃᖕᒋᑦᑐᒥ ᐊᒻᒪᓗ ᐊᑭᒻᒥᔪᒥ ᓄᖑᓴᐅᑎᒥᑦ ᓇᓂᓯᕚᐅᓂᖓ, ᑕᐃᒫᓪᓗ ᐱᑕᔅᓯᑎᔅᓯᑐᐃᓐᓇᕆᐊᖃᓐᓂᖓᓂᑦ ᑎᒥᖕᒨᖓᔪᓂᑦ ᐊᑦᑐᐃᒍᓐᓇᕆᐊᖓ ᐅᑭᐅᖅᑕᖅᑐᒥᐅᓂᑦ ᐊᒻᒪᓗ ᐊᓂᓐᓂᖃᖕᒋᑦᑑᑉ ᐊᕙᑎᐊᓂ. ᐊᐅᐸᓪᓕᐊᓂᖓᓗ ᓄᓇᐅᑉ ᐱᓕᖅᐸᓪᓕᐊᑎᔅᓯᒥᒻᒪᑦ ᓴᖅᑭᑦᔮᖕᒋᑦᑐᓂᑦ ᓱᕈᓇᖅᑐᓕᖕᓂᑦ ᓴᖅᑭᑦᔮᖕᒋᑦᑐᓂᑦ ᑎᐱᖃᖕᒋᑦᑐᓂᑦ ᒫᓲᑦ, ᑭᖑᓂᐊᒍᑦ ᓄᖑᓴᐅᑎᓕᖕᓂᑦ ᐊᑦᑐᖅᑕᐅᓂᐅᓪᓗᓂ.
- ᐊᕙᑖᓂ ᖃᐅᔨᓴᖅᑕᐅᔪᑦ: ᓱᕈᓇᖅᑐᓕᒪᓚᐃᑦ ᐊᒻᒪᓗ ᓴᖅᑭᑦᔮᖕᒋᑦᑐᑦ ᑎᐱᖃᖕᒋᑦᑐᓪᓗ ᓄᓇᒥᖕᒫᖅᑐᑦ ᓱᕈᓇᖅᑐᓖᑦ ᖃᐅᔨᓴᖅᑕᐅᓪᓗᑎᑦ ᐱᓕᖅᐸᓪᓕᐊᔪᑦ ᖃᓄᐃᒍᓐᓅᐸᓪᓕᐊᓪᓗᑎᓪᓗ ᐃᓗᐊᓂ ᓇᔪᖅᑕᐅᔫᑉ, ᓴᓇᔭᐅᒋᐊᖃᓚᐅᖅᑐᓂ ᐊᓂᓐᓂᓪᓘᑦ ᓴᓗᒪᖅᓴᐅᑎᒥᑦ ᐃᓕᓯᓗᑎᑦ.
- ᓄᓇᐅᑉ ᐊᐅᐸᓪᓕᐊᓂᖓᓂ ᖃᐅᔨᓴᕋᓃᑦ: ᐊᐅᐸᓪᓕᐊᓂᖓ ᖃᐅᔨᓴᖅᑕᐅᓪᓗᓂ, ᐱᑕᖃᑐᐃᓐᓇᕆᐊᖃᓐᓂᖓᓂᓪᓗ ᓱᕈᓇᖅᑐᓕᖕᓂᑦ ᐊᒻᒪᓗ ᓴᖅᑭᑦᔮᖕᒋᑦᑐᓂᑦ ᐱᓕᖅᐸᓪᓕᐊᔪᑦ.
- ᐃᔾᔪᑉ ᐊᕿᓪᓕᓗᐊᖅᑕᐃᓕᓂᖓ: ᐃᓱᒫᓘᑎᒋᓕᖅᐸᓪᓕᐊᑐᐃᓐᓇᖅᑕᕗᑦ ᐃᔾᔪᑉ ᐊᕿᓪᓕᐸᓪᓕᐊᓂᖓ ᓄᓇ ᐊᐅᐸᓪᓕᐊᓂᖓᓄᑦ.
- ᐃᒪᐅᑉ ᖃᓄᐃᓐᓂᖓ ᐊᒻᒪᓗ ᓴᖅᑭᑦᔮᖕᒋᑦᑐᑦ ᐊᐅᑦᑕᖁᑦ ᐱᓪᓗᒋᑦ: ᐅᑭᐅᖅᑕᖅᑐᒥ ᐃᒪᕌᑦ ᖃᐅᔨᓴᖅᑕᐅᖁᒪᑕ ᓱᕈᓇᖅᑐᖃᒪᖔᑕ, ᐊᒻᒪᓗ ᐅᖓᑎᒃᑲᓂᐊᓄᑦ ᐅᖓᓯᑦᑐᒧᑦ ᐅᓯᔭᐅᓪᓗᑎᑦ ᐊᐅᑦᑕᖁᓖᑦ ᖃᐅᔨᓴᖅᑕᐅᒃᑲᓂᕆᐊᓖᑦ. ᑕᐃᒃᑯᐊ ᖃᐅᔨᓴᖅᑕᐅᔪᑦ ᐅᑎᖅᑐᒃᓴᓖᑦ ᐅᐱᕙᒻᒥ 2025ᖑᓕᖅᑲᑦ.
- ᐆᒪᔪᓕᓐᓂᑦ ᖃᐅᔨᓴᕐᓂᖅ: ᑕᑯᔅᓴᐅᖏᑦᑐᓂᑦ ᐊᒻᒪᓗ ᐱᕈᖅᑐᕚᓕᖕᓂᑦ ᐱᖅᓯᓪᓗᑎᑦ ᖃᐅᔨᓴᕈᑎᓄᑦ ᕿᒥᕈᔭᐅᓪᓗᑎᑦ ᓇᑭᙶᒪᖔᑕ ᖃᐅᔨᓴᒃᑲᓂᕈᒪᓪᓗᑎᑦ ᖃᓄᖅ ᓇᔪᓯᔅᓴᐅᓗᐊᖕᒋᑦᑐᒥᑦ ᓇᔪᖅᑲᓱᖑᒪᖔᑕ.

Objectives: Project objectives, preferably in bullet form.

- Radiation Exposure: Measure solar and cosmic radiation levels, including radon emissions from thawing permafrost.
- Environmental Conditions: Track atmospheric CO_2, VOCs, and humidity to assess crew health and habitat sustainability.
- Water & Ice Quality: Study nanoplastics, microbial contamination, and mineral composition in Arctic water sources.
- Biological & Geological Studies: Analyze microbial ecology, lichen growth, and local rock formations for planetary analog research.
- Technology Testing: Evaluate pressurized High-Performance Environmental Suit (HPES) prototype performance in Arctic conditions.

Annual activities: A description of activities and methods carried out during the current reporting period. This section should answer the questions: What? Where? When? Who? How? Include dates team members conducted research at remote field sites or collected data (including interviews) in communities; append a map with locations and/or coordinates of remote field sites, if applicable.

During the 2024 research mission at the Flashline Mars Arctic Research Station (FMARS) on Devon Island, Crew 16 carried out a series of targeted scientific studies and operational tasks from July 2 to July 13, 2024. This mission aimed to advance ongoing research on environmental monitoring, permafrost stability, air quality, water contamination, and biological diversity, all in a Mars analog environment.

The activities commenced with an initial expedition phase (July 2–6), during which the crew familiarized themselves with the habitat setup and conducted critical maintenance to ensure operational readiness. This included establishing power systems, checking air quality monitoring equipment, and securing water sources for drinking and research purposes. Field research was centered around the Devon Island area, particularly near the Haughton Crater secondary crater rim, and in proximity of FMARS, which provides a unique environment for planetary science studies.

Key research efforts involved measuring radiation levels, with dosimeters deployed to track fluctuations due to both cosmic and solar sources. The crew also conducted detailed water sampling from local streams and meltwater pools to assess the presence of nanoplastics and to study microbial populations under Arctic conditions. For comparative analysis, these samples were collected at various coordinates around the habitat, including the snowmelt-fed streams and deeper permafrost layers.

The team engaged in extravehicular activities (EVAs) throughout the mission, which were integral to their fieldwork. Notably, the crew conducted EVAs from July 7 to 9 to measure permafrost depth using non-invasive probes and collect biological samples from specialized ecological niches. These tasks were critical for understanding the impact of climate change on Arctic soil stability and the potential release of radon gas due to thawing permafrost.

Atmospheric monitoring was a continuous activity. The crew tracked volatile organic compounds (VOCs) and carbon dioxide (CO_2) levels within the habitat, adjusting ventilation systems to ensure a safe living environment. These measurements provided insights into air quality challenges in confined

spaces, mirroring conditions expected in future Mars habitats.

Additionally, the crew tested a pressurized High-Performance Environmental Suit (HPES) prototype, simulating Mars surface conditions. The suit was evaluated for mobility, comfort, and performance during field activities, which included navigating rough terrain and operating scientific instruments.

All research activities were documented extensively throughout the mission through daily logs, digital photographs, and environmental data recordings. Unfortunately, severe weather conditions limited community engagement activities planned in Resolute Bay, but efforts to collaborate with local stakeholders remain a priority for future missions.

This comprehensive approach integrated field sampling, technology testing, and environmental monitoring, contributing to a deeper understanding of how extreme conditions affect human operations and the surrounding ecosystem.

Results and Achievements: Findings and results to date of the above activities, highlighting any key research achievements (see guide below for formatting tips regarding tables and figures).

The 2024 Flashline Mars Arctic Research Station (FMARS) mission successfully built upon the research initiated during the 2023 field season. The mission produced valuable findings related to radiation exposure, air and water quality, permafrost thawing, and biological diversity. These results affect climate change studies, planetary analog research, and human health considerations in extreme environments.

1. Radiation Exposure: Understanding Environmental and Cosmic Radiation Levels

Key Findings:

- Elevated radiation levels detected: Data collected via portable dosimeters confirmed that radiation exposure on Devon Island is highly variable, influenced by both cosmic sources (Galactic Cosmic Radiation, GCR) and solar activity.
- Increased exposure due to the solar maximum: Radiation levels were higher than expected, aligning with the anticipated peak in the solar activity cycle. This suggests that Arctic regions may experience periodic increases in radiation flux due to stratospheric ozone fluctuations.
- Radon gas emissions from thawing permafrost: Readings indicated localized spikes in radiation, possibly due to radon release from permafrost destabilization.

Research Achievements:

- Created a radiation heatmap of Devon Island's Trinity Lakes region and Haughton Crater rim.
- Confirmed the necessity of further research into radon emissions and permafrost thawing, as potential health risks may exist for both Arctic researchers and future Mars habitat crews.
- Data contributes to Mars mission planning, where radiation shielding will be essential.

2. Permafrost Thawing and Environmental Impact

Key Findings:

- Permafrost depth has decreased since the 2023 readings. Measurements indicated thaw depths of 27.25 cm on average, with some areas exceeding 40 cm, suggesting accelerated melting.
- Rapid thaw in certain zones correlates with radon spikes, reinforcing concerns about releasing previously trapped gases and microbial communities.
- Unstable ground conditions observed: Frost heave and solifluction (downward soil movement due to ice melt) impacted terrain stability, a finding relevant for infrastructure planning in Arctic regions and extraterrestrial habitat construction.

Research Achievements:

- Successfully expanded the permafrost measurement dataset with readings from 27 locations.
- Demonstrated the effectiveness of non-invasive measurement techniques for Arctic and Mars mission applications.

- Findings indicate a need for continued annual monitoring to track long-term environmental change.

3. Water Quality and Nanoplastic Contamination

Key Findings:

- No detectable coliform bacteria in local streams, confirming the purity of drinking water sources.
- pH shift observed in habitat greywater, dropping to 6.0, suggesting potential environmental impact from wastewater disposal.
- Nanoplastic particles detected in collected water samples. While analysis is ongoing, preliminary findings indicate that atmospheric transport of plastics may be occurring, a critical environmental concern.

Research Achievements:

- Developed an Arctic baseline dataset for nanoplastic contamination.
- Established a methodology for long-term water quality monitoring in remote environments.
- Findings contribute to broader research on global plastic pollution and microplastic transport.

4. Atmospheric Monitoring: Air Quality and Habitat Conditions

Key Findings:

- Elevated VOC (Volatile Organic Compound) levels were detected inside the habitat, peaking at 1950 ppb overnight, likely due to human activity, cooking, and off-gassing from equipment.
- CO_2 buildup inside the habitat regularly exceeded 3800 ppm overnight, necessitating enhanced ventilation strategies.
- Humidity fluctuations within the station suggested mold risk, though microbial testing did not confirm hazardous species.

Research Achievements:

- Improved habitat ventilation strategies, ensuring safer living conditions for future crews.
- Provided insights into closed-environment atmospheric regulation applicable to Mars and deep-space habitats.
- Identified key areas for habitat air filtration improvements, reducing exposure to long-term health risks.

5. Biological Research: Microbial and Algal Adaptation to Extreme Environments

Key Findings:

- Discovery of new algal streaks in seasonal meltwater channels, building on findings from 2023. These rare formations indicate specific environmental conditions for microbial survival.
- Microbial biofilms collected from permafrost thaw regions revealed potential extremophile populations, with DNA sequencing pending.

- Lichen colonies thrive in extreme conditions, particularly Rusavskia elegans (Elegant Sunburst Lichen), a species known for its potential to survive space conditions.

Research Achievements:

- Algal and microbial sample collection expanded to new regions of the crater and meltwater sources.
- DNA sequencing is planned to identify extremophiles, with potential applications for astrobiology and Mars analog studies.
- Strengthened understanding of microbial resilience in extreme Arctic conditions.

6. Pressurized High-Performance Environmental Suit (HPES) Prototype Testing

Key Findings:

- Suit functionality was effective in Arctic conditions, allowing mobility while maintaining insulation.
- Minor dexterity limitations observed in handling scientific instruments.
- Suit materials demonstrated resilience against rough terrain and temperature fluctuations.

Research Achievements:

- Successfully conducted the first real-world Arctic field test of the new suit.
- Identified key design improvements, such as enhanced glove flexibility and improved air circulation.
- Provided crucial insights for Mars mission suit development under harsh conditions.

7. Community Engagement and Knowledge Integration

Key Findings:

- Engagement with Nunavut Arctic College opened discussions on scientific collaboration.
- Attempted community talks in Resolute Bay were hindered by weather delays.
- Established positive relationships with local stakeholders for future research projects.

Research Achievements:

- Created groundwork for future Arctic-Mars collaboration with Indigenous knowledge holders.
- Identified strategies for improving community outreach efforts.
- Strengthened the station's role as a center for Mars analog research with local engagement.

Overall Mission Impact and Next Steps

The 2024 FMARS mission significantly advanced the research objectives outlined in 2023. New scientific data was collected, methodologies were refined, and key challenges were identified for future missions. Moving forward, the research team will:

1. Continue radiation monitoring to track trends related to the solar cycle and permafrost thaw.

2. Expand microbial and DNA sequencing studies to classify Arctic extremophiles.
3. Analyze nanoplastic samples to determine their sources and environmental impact.
4. Improve air quality and CO_2 management for future habitat simulations.
5. Strengthen local engagement through direct community participation in research.

These achievements will directly contribute to Mars mission planning, climate change research, and sustainable Arctic operations.

Challenges/Obstacles: In this section, please comment on any challenges/obstacles (if any) that you experienced during this project year. If there were any actions to mitigate or resolve these challenges, please list them here. Were any concerns raised regarding the conduct of research team members or the impacts of the project?

Environmental Preservation and Terrain Hazards

One of the most pressing challenges during the 2024 FMARS mission was ensuring minimal disturbance to the fragile Arctic terrain while conducting scientific research. The soft, frost-heaved ground surrounding the facility posed a constant risk of environmental damage and hazardous footing, particularly in areas where the permafrost was actively thawing.

To address this, the crew implemented strict movement protocols, including:

- Daily briefings on approved pathways, terrain conditions, and best practices for avoiding sensitive ecological zones.
- Pre-planned EVA (Extravehicular Activity) routes using geospatial mapping to reduce unnecessary foot traffic and minimize impact.
- Group travel protocols to consolidate footprints and ensure team members did not inadvertently damage study sites.

Despite these precautions, occasional deviations were necessary due to unexpected ground instability, water pooling, and solifluction zones. These were mitigated by rerouting paths and marking particularly unstable areas for future teams to avoid.

Limitations in Scientific Facilities and Equipment

Although the crew successfully replicated field science sample collection procedures, constraints in on-site laboratory capabilities limited the scope of real-time analysis. In particular:

- Water quality and nanoplastic contamination assessments required external laboratory processing, delaying results.
- Permafrost and microbial sample storage capacity was limited, restricting the number of samples that could be collected for genomic sequencing.
- Radiation spectroscopy analysis was incomplete due to a lack of advanced spectrometric equipment on-site.

To mitigate these limitations in future missions, the team has prioritized the inclusion of additional portable analytical tools for the 2025 research season, including:

- A compact spectrometer for real-time isotope identification.
- A higher-capacity cold storage system to expand biological sample preservation.
- A portable filtration unit to improve on-site water testing and pre-treatment before sample return.

Adverse Weather Conditions and Logistical Constraints

Severe weather delays disrupted both travel logistics and community engagement efforts. Poor flight conditions prevented timely crew rotation and limited opportunities to present findings and engage with local stakeholders in Resolute Bay.

To improve contingency planning for future missions, the team recommends:

- Buffer days built into mission schedules to accommodate potential weather disruptions.
- Remote communication strategies, such as pre-recorded presentations or virtual meetings, to ensure knowledge-sharing continues despite on-site challenges.

Ensuring Ethical and Respectful Research Conduct

The crew maintained a strong commitment to ethical research practices and community respect throughout the mission. No concerns were raised regarding the conduct of research team members, and all fieldwork followed established Nunavut Research Institute (NRI) guidelines. Continued dialogue with local communities and stakeholders remains a key priority moving forward.

Expected Project Completion Date: Provide month and year of expected completion date of the project.

Ongoing research: The next annual mission planned for July 2025 will include up to 3 teams, enabling deeper commitment to climate research and understanding the net effects on the National Park.

Project website (if applicable): If your project has a presence on the internet, including a website and/or social media page, please provide the link and/or account handle.

https://fmars.marssociety.org/

Citations: Please append a complete reference list if citations are used anywhere in the document.

Please see addenda 1

POLICY RELEVANCE

Does this research support policy development or decision-making in Nunavut? If yes, please describe.

Policy Relevance: Supporting Nunavut's Climate and Environmental Policies

Introduction

The research conducted at the Flashline Mars Arctic Research Station (FMARS) provides critical scientific data that can directly support Nunavut's climate policies, environmental monitoring strategies, and public health initiatives. Given that Nunavut is experiencing some of the most rapid climate changes in the world, data collected on permafrost thaw, atmospheric conditions, water contamination, and radiation exposure contributes valuable insights to both regional and national policy frameworks.

The Nunavut Climate Change Secretariat (NCCS) under the Department of Environment is responsible for developing adaptation and mitigation strategies in response to Arctic climate change. Additionally, the Nunavut Research Institute (NRI) plays a key role in facilitating research that informs decision-making at local and territorial levels. The findings from FMARS align with these objectives, helping to inform policies related to infrastructure resilience, environmental contamination, and climate adaptation strategies.

Climate Adaptation and Permafrost Thaw

One of the most pressing concerns in Nunavut's environmental policy is permafrost thaw, which threatens both ecosystems and human infrastructure. The Nunavut Climate Change Strategy (2019–2023) highlights permafrost degradation as a significant risk factor for structural stability, water systems, and carbon emissions. The data collected by FMARS contributes to this policy area in several ways.

First, field measurements of permafrost depth and radon emissions provide direct evidence of ground instability. Findings from the 2023 and 2024 FMARS missions indicate that permafrost thaw has deepened significantly, with an average depth of 27.25 cm, and in some locations exceeding 40 cm. This aligns with broader Arctic studies indicating that permafrost thaw rates in Nunavut have accelerated over the past two decades (Derksen et al., 2018).

A secondary concern associated with thawing permafrost is the release of radon gas, which can pose health risks in enclosed structures built on degrading permafrost layers. Radon, a naturally occurring radioactive gas, has been detected at higher concentrations in areas where permafrost has thawed. This is particularly concerning given that radon exposure is a leading cause of lung cancer in non-smokers (Health Canada, 2020). The FMARS data on radon emissions could be used to support policy initiatives focused on air quality monitoring and mitigation strategies in Arctic housing and infrastructure.

Nunavut policymakers could integrate FMARS permafrost findings into land-use planning regulations, ensuring that new developments account for ground stability risks and potential gas emissions. This would align with current building code adjustments being considered for Arctic settlements under Canada's Northern Infrastructure Standardization Initiative (NISI).

Water Security and Contamination Monitoring

Water security is a growing concern in Nunavut, where many communities rely on seasonal meltwater sources vulnerable to pollution and climate-driven changes. The Nunavut Water Management Strategy emphasizes the need for long-term monitoring of Arctic freshwater systems to detect contamination from microplastics, industrial pollutants, and permafrost-derived minerals.

FMARS research contributes to this policy effort by tracking nanoplastic and microplastic presence in Arctic waterways. Samples collected from snowmelt, permafrost runoff, and local streams suggest that plastic particles are present in the Arctic despite the region's isolation from primary pollution sources. This aligns with recent research indicating that airborne microplastics are transported to the polar areas through atmospheric deposition (Bergmann et al., 2019).

The implications for Nunavut's environmental policy are significant. FMARS findings suggest stricter monitoring regulations may be needed to assess long-range plastic transport in Arctic precipitation. Additionally, the presence of acidic compounds in FMARS greywater runoff (pH 6.0) raises concerns about wastewater disposal practices in remote research stations and Arctic settlements. Policymakers may need to consider updated filtration requirements for research facilities and northern communities to prevent contamination of freshwater sources.

By integrating FMARS water quality data into Nunavut's environmental monitoring programs, policymakers can enhance their understanding of pollutant pathways and implement more effective water protection measures.

Atmospheric Monitoring and Indoor Air Quality

Another critical issue in Arctic policy is air quality regulation, particularly in confined environments such as remote research stations, Arctic housing, and industrial workspaces. The Nunavut Housing Corporation (NHC) and the Department of Health have identified poor indoor air quality as a growing concern, particularly in homes built on permafrost, where ventilation is often limited.

During the 2024 FMARS mission, elevated CO_2 and volatile organic compound (VOC) levels were detected inside the habitat. Overnight, CO_2 concentrations exceeded 4800 ppm, well above recommended limits, while VOC spikes reached 1950 ppb, posing potential health risks. These findings suggest that enclosed Arctic workspaces may require improved ventilation systems and better air quality monitoring.

This data could inform Nunavut's indoor air quality regulations, particularly for structures built in cold-climate conditions where proper airflow can be challenging. It also aligns with ongoing research

by Health Canada and the National Research Council (NRC) on air circulation and pollutant control in northern housing.

By incorporating FMARS air quality findings into Arctic housing policies, Nunavut can develop improved building standards that promote safer living and working conditions.

Community Engagement and Indigenous Knowledge Integration

Nunavut's research and environmental policies increasingly emphasize the integration of Inuit Qaujimajatuqangit (IQ), or Inuit traditional knowledge, into scientific research. While the FMARS mission faced weather-related disruptions that limited direct engagement, preliminary efforts were made to establish collaborative relationships with Nunavut Arctic College and local stakeholders. Future missions could strengthen these relationships by:

- Co-developing permafrost and water monitoring projects with local communities, ensuring that Inuit perspectives on environmental change are included.
- Expanding community outreach programs in Resolute Bay and other Arctic settlements, allowing for greater public participation in research findings.
- Providing FMARS data to the Nunavut Research Institute (NRI) for use in Indigenous-led environmental monitoring programs.

Nunavut policymakers have expressed growing interest in co-management strategies for environmental research, ensuring that scientific findings are applied in ways that benefit both local communities and broader climate initiatives. The FMARS team is committed to supporting this approach by fostering knowledge exchange and collaborative research opportunities.

The Policy Impact of FMARS Research

The findings from the 2024 FMARS mission provide essential data for Nunavut's climate adaptation and environmental management strategies. By contributing high-resolution measurements of permafrost thaw, water contamination, atmospheric conditions, and radiation exposure, this research directly supports territorial policies on land-use planning, water security, air quality, and climate resilience.

FMARS data could be formally integrated into Nunavut's climate change monitoring programs, strengthening decision-making processes for long-term environmental sustainability. Partnerships with Nunavut Arctic College, the Nunavut Research Institute, and government agencies will ensure that scientific insights translate into effective policies that protect the environment and Arctic communities.

RESEARCH OUTCOMES: BENEFITS

Community engagement: Briefly list and describe any community consultation, engagement, collaboration and outreach activities that you have undertaken for the project; describe the role(s) that community members and/or specific organizations have played in research co-design and activities.

The Flashline Mars Arctic Research Station (FMARS) mission remains committed to building long-term partnerships with Arctic communities, academic institutions, and policymakers to ensure that research conducted in Nunavut is collaborative, beneficial, and responsive to local priorities. Over the past two years, we have taken significant steps to strengthen community engagement and foster knowledge exchange between FMARS researchers and the residents of Resolute Bay, as well as academic leaders at Nunavut Arctic College.

Annual Arctic Science Seminar with Nunavut Arctic College

FMARS researchers are in the process of establishing an annual Arctic Science Seminar in partnership with Nunavut Arctic College (NAC) to facilitate scientific exchange, knowledge-sharing, and discussions on climate adaptation in the High Arctic. This initiative aims to provide a formal space for engagement between Arctic researchers, students, policymakers, and community members.

In 2024, Jackie Price, Vice President of Nunavut Arctic College, and I discussed developing this seminar. The goal is to create a recurring forum where FMARS researchers can present findings, incorporate Inuit Qaujimajatuqangit (IQ), and co-develop research questions that align with community interests. We aim to expand this collaboration by inviting Arctic College students and faculty to participate directly in our research missions.

Engagement with the Community Leadership of Resolute Bay

In addition to academic engagement, FMARS has maintained an ongoing dialogue with the Mayor of Resolute Bay to discuss how our research can benefit the community and contribute to local climate adaptation strategies. These discussions have emphasized the importance of sharing scientific findings in an accessible format and creating opportunities for local participation in Arctic research.
FMARS is committed to hosting annual engagement meetings in Resolute Bay to strengthen our ties with the community. At these meetings, researchers and residents can discuss environmental concerns, share observations about climate change impacts, and identify potential areas for collaborative research.

Scholarship and Community Participation Initiative

Recognizing the importance of local representation in Arctic science, FMARS is actively working to establish a scholarship program to support a student from Resolute Bay in attending and participating in future research missions. The goal of this initiative is to:

- Provide hands-on field research experience to an Inuit student interested in climate science,

environmental monitoring, or space analog research.
- Support career development opportunities for youth in Arctic communities, encouraging participation in STEM (Science, Technology, Engineering, and Mathematics) fields.
- Foster long-term community engagement by integrating local perspectives and traditional knowledge into FMARS research activities.

The scholarship recipient will have the opportunity to join the FMARS research team, assist in data collection and fieldwork, and participate in scientific discussions that directly relate to climate adaptation in Nunavut.

Commitment to Ongoing Collaboration

FMARS recognizes that meaningful community engagement is an ongoing process, and we are committed to deepening our relationships with Resolute Bay, Nunavut Arctic College, and other regional stakeholders. As we continue our research, we will seek further community input and collaboration opportunities, ensuring that our findings are scientifically rigorous and practically relevant to the people who call the Arctic home.

By fostering academic partnerships, engaging with community leaders, and creating educational opportunities, FMARS is working to bridge the gap between scientific research and local knowledge, ultimately strengthening climate resilience efforts in Nunavut.

Youth engagement: Briefly list and describe any outreach, school or classroom activities that you have undertaken for the project; describe the role(s) that youth have played in your research activities.

FMARS has actively engaged in international outreach and educational initiatives, using its Mars analog research as a platform to foster discussions on climate change, planetary science, and the future of human exploration in extreme environments. Over the past two years, FMARS has leveraged in-person and virtual platforms to engage with students, researchers, and military personnel worldwide, ensuring that the insights gained from Arctic research are broadly shared and have a lasting impact beyond the scientific community.

2023 Outreach and Global Engagement

During the 2023 mission, FMARS researchers engaged in multiple global educational initiatives, presenting research findings and insights into climate evolution and environmental resilience in diverse geographic and institutional settings.

- Australia: FMARS team members participated in virtual lectures and discussions with students and climate researchers in Australia, addressing polar climate dynamics, permafrost thaw, and how Mars analog research can inform Earth-based climate adaptation strategies. These discussions emphasized the importance of international collaboration in studying global climate shifts and how the Arctic serves as an early-warning system for planetary change.

- Ghana: FMARS engaged with students and educators in Ghana, facilitating discussions on climate resilience, space exploration, and the role of analog research in preparing for extraterrestrial missions. These conversations focused on bridging the knowledge gap between polar and equatorial regions, helping to create a global dialogue on climate adaptation strategies and sustainable exploration practices.

- United States – Military and Academic Engagement: FMARS researchers were invited to speak at the American Military University, where they discussed Arctic climate evolution, human factors in extreme environments, and the implications of Mars analog research for future planetary missions. This engagement provided an opportunity to educate military personnel and students on climate security, remote habitat sustainability, and how Earth's extreme environments inform space exploration strategies.

2024 Outreach and Community Impact

Building on the successes of the 2023 mission, FMARS expanded its outreach efforts in 2024, further strengthening partnerships with academic institutions, Arctic communities, and policy stakeholders.

- Nunavut Arctic College & Resolute Bay Engagement:
  FMARS has continued efforts to establish an annual Arctic Science Seminar with Nunavut Arctic

College, engaging with Jackie Price, Vice President of the College, and the Mayor of Resolute Bay. This initiative is designed to foster deeper knowledge exchange between scientists and the Arctic community, ensuring that climate research is accessible and directly beneficial to Nunavut residents.

- Scholarship Program for Arctic Youth:
  FMARS has taken active steps toward developing a scholarship program for a student from Resolute Bay, offering an opportunity for direct participation in future research missions. This initiative reflects FMARS' commitment to empowering Arctic youth and integrating Indigenous perspectives into polar research.
- Climate Science Education in Schools and Universities:
  In 2024, FMARS researchers expanded their engagement with academic institutions by speaking to students across multiple disciplines, including environmental science, planetary geology, and engineering. These engagements focused on the interconnectedness of Earth's extreme environments and the challenges of sustaining life in space.
- Global Climate Dialogue & Cross-Cultural Knowledge Exchange:
  FMARS has continued its international education efforts, connecting with students and researchers in North America, Europe, Africa, and Australia to discuss:
    - The scientific importance of Arctic climate research and its global implications.
    - How analog research informs future space missions while also addressing terrestrial challenges like climate change and sustainability.
    - The value of integrating traditional Indigenous knowledge with modern scientific approaches to climate adaptation.

Commitment to Long-Term Knowledge Sharing

FMARS is dedicated to ensuring that the knowledge gained from its Arctic research missions is widely disseminated, accessible, and impactful. As climate change continues to reshape the Arctic, FMARS will remain committed to:

- Expanding outreach programs to engage more global communities, particularly in underrepresented regions.
- Strengthening relationships with Indigenous knowledge holders to co-develop research initiatives.
- Providing open-access scientific data that contributes to climate adaptation policies and planetary exploration research.

Through these sustained engagement efforts, FMARS is contributing to a global understanding of climate resilience, environmental stewardship, and the future of human habitation on Earth and beyond.

Training and Employment:

How many Nunavummiut received training from team members? Please describe training and/or compensation provided.

During the FMARS 2024 mission, team members engaged with residents of Resolute Bay, actively discussing the mission's objectives and the broader implications of climate monitoring, planetary research, and environmental adaptation strategies. These discussions served as informal training opportunities, where local community members, including the Parks Canada representative for Qausuittuq National Park, were introduced to our research methods, data collection techniques, and environmental monitoring practices.

FMARS researchers also provided insight into permafrost analysis, water sampling techniques, and the scientific instruments used for monitoring radiation and air quality. While no formal compensation was provided for these discussions, they were structured as collaborative knowledge exchanges, ensuring that Nunavummiut, who engaged with the research team, was able to ask questions, provide insights, and contribute their observations regarding climate change in the region.

FMARS is committed to deepening these training efforts in future missions by incorporating Nunavut Arctic College students into field research and expanding hands-on learning opportunities for interested community members.

How many team members received training from Nunavummiut? Please describe training received and/or what knowledge sharing and/or skills exchange took place.

FMARS researchers received valuable knowledge from Nunavummiut, particularly regarding local environmental conditions, wildlife behavior, and traditional navigation methods in Arctic terrain. Community members shared firsthand observations of changing ice conditions, seasonal shifts, and permafrost degradation, which helped inform our understanding of long-term environmental trends in the region.

Additionally, discussions with local Parks Canada staff provided the research team with insights into land-use practices, conservation efforts, and the ecological significance of Qausuittuq National Park. This knowledge exchange reinforced the importance of integrating Traditional Ecological Knowledge (TEK) with scientific methodologies, and FMARS will continue to seek deeper collaborations with Inuit knowledge holders in future missions.

How many Nunavummiut received employment? Please describe employment type and length, role(s) and responsibilities, and compensation provided.

At this stage, no Nunavummiut were directly employed as part of the FMARS 2024 mission. However, FMARS is actively working toward incorporating local participation into future research missions. This includes:

- Offering a scholarship for a Resolute Bay student to participate in FMARS research activities, ensuring that a local community member gains hands-on field experience.
- Creating opportunities for Nunavummiut to assist in field research efforts, particularly in permafrost and water quality monitoring.
- Strengthening partnerships with Nunavut Arctic College to provide training opportunities for students interested in environmental science, planetary research, and climate monitoring.

While no formal employment arrangements were made in 2024, FMARS remains committed to building an inclusive research framework that actively involves Nunavummiut in both knowledge-sharing and professional development opportunities.

How many Nunavummiut received honoraria as research participants? Please describe method of participation (interview, observation, sample, survey, etc.), including compensation provided.

To date, we have yet to provide honoraria as research participants. We hope our engagement with the NAC will open those opportunities up over the coming year. Our goal is to have a team member of The Mars Society in Iqaluit provide up to a week-long seminar on the benefits of space to the Nunavut community, and we are seeing strong support for this endeavor.

The local detachment of the Royal Canadian Mounted Police (RCMP) in Resolute Bay provided a strong letter of support, commending the FMARS team for their proactive engagement with the community and dedication to fostering positive relationships. This letter, included in the attachments to this document, underscores FMARS' commitment to ethical, transparent, and community-focused research practices.

As FMARS continues its long-term research efforts in Nunavut, we will actively expand Nunavummiut participation through employment, training, and research collaborations, ensuring that Arctic research is both inclusive and mutually beneficial to all involved.

Please explain how the project directly benefited Nunavut organizations and/or businesses (e.g., through contract services, local purchases, equipment donations, etc.)

Over the past two field seasons (2023–2024), the FMARS research mission has contributed significantly to local economic activity, service providers, and scientific research capacity in Nunavut. The project has directly benefited Nunavut-based businesses, service providers, and government research initiatives through contracted services, local purchases, and scientific data collection that will aid in future policy development.

Financial Contributions to Nunavut-Based Services

To sustain field operations and ensure the success of our research, FMARS has invested approximately $140,000 USD over two field seasons in Nunavut. These expenditures have gone toward:

- Chartered aircraft and logistics services, ensuring safe transportation of researchers, equipment, and scientific samples to and from Devon Island.
- Local accommodation and hospitality services in Resolute Bay, which supported researchers during transit and provided essential infrastructure for mission preparation.
- Fuel and supply purchases for field operations, sourced from local businesses in Resolute Bay, contributing to the economic sustainability of the region.
- Equipment storage and transport coordination, utilizing local infrastructure to facilitate research continuity between field seasons.

By contracting Nunavut-based service providers, the FMARS mission has helped support local businesses that are integral to Arctic operations, ensuring that research funding is reinvested into the regional economy.

Scientific Contributions and Policy Relevance for the Government of Nunavut

Beyond economic benefits, the FMARS project has collected significant environmental samples and climate data that directly contribute to the knowledge base on Arctic climate change and its impact on Nunavut. These samples and data sets will:

- Provide critical insights into permafrost degradation, water quality changes, and atmospheric conditions, supporting Nunavut's climate adaptation strategies.
- Inform policy recommendations for land-use planning, environmental monitoring, and infrastructure resilience, particularly in regions affected by permafrost thaw.
- Strengthen scientific collaborations between FMARS researchers and Nunavut institutions, ensuring that local knowledge and scientific findings are integrated into long-term research initiatives.

As FMARS continues its work in Nunavut, we will expand our partnerships with local organizations, seeking to support regional economic growth further and enhance Nunavut's role in global climate

research.

OPTIONAL: Nunavut Team Members, hires, and/or trainees (excluding research participants e.g., interviewees)

The NRI is creating an inventory of Nunavummiut who are skilled and/or interested in research. The information provided below will not be shared publicly but will support long-term capacity sharing by connecting local and visiting researchers with research talent in each community.

Name	Expertise/skills	Training/interest areas	Contact Info	Community
NA as of yet but planned for 2025				

Academic Mobility

If you are affiliated with an academic institution, please answer the following question: For which Level of Project(s) will the data be used? (Check all that may apply)

- X Research
- X Post-Doctoral x
  Research PhD Thesis
- X Masters (Major Research Paper)
  Masters (Thesis)
- X Graduate Course Project Staff/Administration Research
- ○ Undergraduate Honours Thesis

Other□

BUDGET

Please complete the table below to detail your projected and actual research expenditures during the reporting period.

Category	Planned/Approved Expenditure	Actual Expenditure
Travel and Accommodation	30000.00	51000.00
Equipment, Materials and Supplies	12000.00	12000.00
Salaries/Wages for Nunavut residents	NA	NA
Salaries/Wages for non-Nunavut resident researchers	NA	NA
Professional Fees and services in Nunavut		
Professional Fees and Services outside of Nunavut	3000.00	3000.00
TOTAL EXPENDITURES	39000.00	66000.00

List the total $ amount of funding from each funding source for your full research program, including in-kind support

Funding Report

This document outlines the total funding received from various sources to support the 2024 Flashline Mars Arctic Research Station (FMARS) mission and details how the funds were allocated.

Total Funding Breakdown

Funding Source	Total Amount (CAD)	Notes
KBR Corp.	7,000.00	In-kind donation to The Mars Society
Space 4 All Foundation	4,000.00	Direct support for research activities
Private Funders	80,000.00	Direct contribution to The Mars Society for expedition expenses
The Mars Society	87,000.00	Includes 80,000 from private funders + 7,000 from KBR
Total Funds Managed by The Mars Society	87,000.00	Used for travel, logistics, and operations
Grand Total Funding	98,000.00	Sum of all sources

Individual Funding Allocations

The following crew members received financial support from the respective sources:

Crew Members and Their Funding Sources

1. Tiffany Swarmer
    - 7,000 CAD from KBR Corp. (In-kind donation via The Mars Society)
    - 1,200 CAD from Space 4 All Foundation

- 4,000 CAD from The Mars Society (for flights)

2. Ilaria Cinelli
    - 2,772 CAD from Space 4 All Foundation
    - 4,000 CAD from The Mars Society (for flights)
3. Mason Robbins
    - 8,000 CAD (Private Funders)
    - 4,000 CAD from The Mars Society (for flights)
4. Natasha Nicholson
    - 8,000 CAD (Private Funders)
    - 4,000 CAD from The Mars Society (for flights)
5. Rhett Woods
    - 35,000 CAD (Private Funders contribution to The Mars Society)
    - 4,000 CAD from The Mars Society (for flights)
6. Michael Andrews
    - 35,000 CAD (Private Funders contribution to The Mars Society)
    - 4,000 CAD from The Mars Society (for flights)

- Terry Trevino
    - 10,000 CAD (From Space 4 All Foundation, directed to The Mars Society)
    - 4,000 CAD from The Mars Society (for flights)

Summary of Financial Flow

- Private Funders (80,000 CAD) directly contributed to The Mars Society, which covered expedition costs for all crew members.
- KBR Corp. provided 7,000 CAD in-kind support through The Mars Society.
- Space 4 All Foundation contributed 4,000 CAD to support research activities and an additional 10,000 CAD through Terry Trevino.

The Mars Society managed 87,000 CAD, which covered travel, logistics, and operational expenses.

RESEARCH OUTPUTS / REPORTING TOOLS

What research outputs were generated? Please list below and append copies of each. Specify which outputs (if any) may be made public on the NRI research licensing database.

The FMARS research mission has generated a range of scientific reports, datasets, and manuscripts that contribute to understanding climate change impacts, permafrost degradation, atmospheric conditions, and planetary analog research in Nunavut.

Generated Research Outputs (2023–2024):

1. Science Reports:
    - *FMARS 2023 Science Report* (internal document, available upon request)
    - *FMARS 2024 Science Report* (submitted with this report, may be made public on the NRI database)
    - *Scientific Objectives Report for FMARS 15* (providing background on research priorities)
2. Health and Safety & Operations Reports:
    - *Health & Safety Officer (HSO) Report 2024* (documenting environmental and health conditions at the research site)
    - *Crew Commander's Final Report 2024* (mission overview and operational insights)
3. Peer-Reviewed Publications (In Progress):
    - Manuscripts are currently in preparation, covering:
        - *Permafrost degradation and radon emissions in Arctic Mars analog sites*
        - *Nanoplastic contamination in Arctic water sources: Evidence from Devon Island*
        - *Atmospheric monitoring in closed environments: Implications for Arctic housing and space habitats*
    - Once published, relevant articles will be submitted to the NRI database for inclusion in their research repository.
4. Datasets & Technical Documentation:
    - Permafrost depth measurement dataset (2023–2024)
    - Radiation exposure and atmospheric gas monitoring data (to be included in future publications)
    - Water quality and nanoplastic analysis dataset (laboratory analysis ongoing)
5. Publicly Shareable Reports & Community Engagement Materials:
    - Presentation materials from Arctic Science Seminar discussions with Nunavut Arctic College.
    - Public outreach summary documenting engagement efforts with Resolute Bay community members, the Mayor, and local stakeholders.
    - Letter of support from the Royal Canadian Mounted Police (RCMP) Resolute Bay Detachment (appended to this report).

Availability for Public Access

- The FMARS 2024 Science Report and select community engagement materials may be made publicly available on the Nunavut Research Licensing Database, pending approval.
- Peer-reviewed journal articles will be submitted after publication for inclusion in public records.
- Certain datasets and technical reports can be shared with Nunavut government agencies and research institutions upon request.

By maintaining transparent and accessible research documentation, FMARS contributes to Nunavut's long-term environmental monitoring efforts and supports policy development in climate adaptation and scientific research in the Arctic.

Have peer-reviewed manuscripts been published as a result of your project? If Yes,

complete the following table:

Full citation	Publicly accessible/ free to access (Y/N)	Link (if available) and DOI (if available)
NA		

If No, do you intend to submit a manuscript (or manuscripts) for peer reviewed publication?

We are in preprint searching for a publisher for up to three papers covering nanoplastics, algae research, and our entire science report for the 2024 mission.

Were non-peer reviewed materials produced to either communicate or synthesize results to the public? Examples of these materials include (but are not limited to): websites, reports, brochures, podcasts, webinars, presentations, non-peer reviewed publications, etc.

If Yes, complete the following table:

Title	Description of Materials	Link (if available)	DOI (if available)
Daily Mission Reports	Website Blogs	https://fmars.marssociety.org/	

Did your project develop a communications plan? Please describe communications/reporting tools used, and list the target audience for each and/or who requested which.

The FMARS mission has developed a multi-tiered communications approach to ensure that research findings, mission updates, and engagement efforts are effectively shared with scientific institutions, government agencies, Nunavut community stakeholders, and the general public.

While a formal written communications plan was not created as a standalone document, FMARS has consistently structured its reporting and outreach efforts to target key audiences, including Nunavut Arctic College, the Nunavut Research Institute (NRI), policymakers, and international research partners.

Communications & Reporting Tools Used

1. Formal Research Reports & Internal Documentation:
    - Target Audience: Nunavut Research Institute (NRI), Government of Nunavut, scientific institutions, mission stakeholders.
    - Purpose: Official reporting of scientific findings, safety protocols, and operational outcomes.
    - Examples:
        - *FMARS 2024 Science Report* (submitted for NRI review, with findings on permafrost, water contamination, and radiation monitoring).
        - *Health & Safety Officer Report 2024* (detailing environmental conditions and research site operations).
        - *Crew Commander's Final Report 2024* (providing an overview of mission objectives, challenges, and key achievements).
2. Community Engagement & Public Outreach:
    - Target Audience: Nunavut Arctic College, Resolute Bay community, local government officials, Arctic researchers, general public.
    - Purpose: To share research insights in a way that is accessible to local communities and integrates Indigenous knowledge.
    - Examples:
        - In-person discussions with Resolute Bay residents, the Mayor, and the RCMP, ensuring transparency and engagement.
        - Ongoing efforts to establish an annual Arctic Science Seminar at Nunavut Arctic College, engaging with VP Jackie Price to bring FMARS research into academic discussions.
        - FMARS plans to offer future scholarship opportunities for a student from Resolute Bay to participate in field research and science training.
3. Scientific Publications & Data Sharing:
    - Target Audience: Academia, climate scientists, planetary researchers, government agencies.
    - Purpose: To disseminate research findings globally, supporting broader scientific

understanding of Arctic climate change and planetary analog studies.

- Examples:
    - Manuscripts in progress for peer-reviewed journals, focusing on permafrost degradation, nanoplastics in Arctic water systems, and atmospheric monitoring.
    - Research datasets available upon request to Nunavut environmental monitoring agencies and scientific institutions.

4. Media & Educational Engagement:
    - Target Audience: Global audiences, students, science communicators, policy analysts.
    - Purpose: To educate and inspire broader audiences about climate change, Mars analog research, and environmental sustainability.
    - Examples:
        - FMARS researchers have spoken at universities, military institutions, and international science forums (including in Australia, Ghana, and the United States).
        - Planned future outreach efforts include public-facing reports, videos, and interactive online materials to share Nunavut-based climate research with a wider audience.

Summary of Communications Efforts

Although FMARS did not develop a standalone "communications plan," the project has actively engaged in formal reporting, community outreach, academic dissemination, and global education efforts. These efforts align with Nunavut's research transparency goals and will continue to expand, particularly through formalized collaborations with Nunavut Arctic College and Arctic policy stakeholders.

How were Nunavummiut credited and/or acknowledged in all project outputs, such as co-authorship, participant biographies, article acknowledgements, etc.

The FMARS mission has made ongoing efforts to recognize and acknowledge the contributions of Nunavummiut who have supported or engaged with our research. While there were no formal co-authorships or direct participant biographies included in scientific papers or reports, the project has acknowledged key individuals and organizations in various research outputs and engagement activities.

Acknowledgments in Research Reports & Mission Documentation:

- Mayor of Resolute Bay was recognized in discussions regarding community engagement and local climate concerns.
- ATCO South Camp Inn was acknowledged for providing logistical support, accommodations, and community connections that facilitated the mission's success.
- The Nunavut Government (via the Nunavut Research Institute licensing process) was credited for enabling research activities in the territory and ensuring compliance with regional guidelines.

Future Efforts for Inclusion and Co-Authorship

FMARS recognizes the importance of formally incorporating Nunavummiut perspectives and contributions into research outputs. Moving forward, the mission aims to:

- Include co-authorship opportunities for Nunavut Arctic College faculty and students who participate in future research collaborations.
- Acknowledge Traditional Ecological Knowledge (TEK) contributions from Inuit community members, where applicable, particularly in climate observations and land-use expertise.
- Offer formalized roles for Nunavummiut participants in community engagement reports and public research materials.

As FMARS expands its local partnerships and educational initiatives, greater emphasis will be placed on ensuring Nunavummiut are credited in all future scientific and public-facing materials.

DATA AND INTELLECTUAL PROPERTY

Did you enter into a research agreement, data-sharing agreement and/or intellectual property rights agreement with a community and/or designated Inuit organization (DIO)? If yes, please explain.

Do intellectual property rights apply to your research? If yes, please explain.

The FMARS research mission does not generate proprietary or commercially restricted intellectual property. Instead, the data, reports, and findings produced are intended to be shared for scientific,

educational, and policy-making purposes.
However, certain aspects of the research may be subject to intellectual property considerations, depending on the nature of the output:

1. Scientific Publications and Data
    - Research findings, datasets, and analyses are publicly available and will be shared with Nunavut Research Institute (NRI), academic institutions, and policymakers.
    - Any peer-reviewed articles resulting from the research will follow open-access or standard academic publishing policies, which may impose copyright or usage restrictions by journal publishers.
    - Raw data on permafrost, radiation, and water quality can be accessed upon request, following ethical research standards.
2. Collaborative Research & Co-Authorship
    - If future collaborations with Nunavut Arctic College or local researchers result in co-authored studies, intellectual property agreements may be considered to ensure proper attribution and rights.
3. Technology Testing & Prototypes
    - FMARS has tested a pressurized High-Performance Environmental Suit (HPES) prototype, but any intellectual property related to this technology remains with its developers (not the FMARS mission).
    - Future research that involves new scientific instruments or proprietary technology from external partners may require additional agreements on data usage and intellectual property rights.

Commitment to Open Science and Ethical Research

FMARS operates under principles of open-access research and is committed to sharing findings with Nunavut policymakers, Arctic researchers, and global scientific communities. All research conducted within Nunavut is subject to NRI guidelines, ensuring that knowledge generated benefits both local and international audiences.
If FMARS develops new intellectual property in the future (such as methodologies, technology applications, or proprietary data models), agreements will be made to ensure transparency and accessibility while respecting the interests of Nunavut stakeholders.

Who owns the data? Has the raw data been shared with the appropriate community and/or DIO? If yes, how? How is data security and storage handled by community-based co-owners?

Data Ownership

The Flashline Mars Arctic Research Station (FMARS) research data is collectively owned by The Mars Society and its affiliated researchers, in accordance with Nunavut Research Institute (NRI) guidelines and the terms of the research license granted by the Government of Nunavut.

While FMARS operates as an open-access research initiative, specific datasets may also be shared with collaborating institutions, government agencies, and academic researchers, ensuring that findings contribute to Nunavut's climate adaptation and environmental monitoring efforts.

At this time, no private entity or commercial organization holds proprietary ownership over FMARS data.

Raw Data Sharing with Nunavut Communities and Organizations

- As of the 2024 field season, FMARS has not yet shared raw data directly with a Nunavut-based community or a Designated Inuit Organization (DIO). However, efforts are underway to ensure local access to research findings, particularly in collaboration with:
    - Nunavut Arctic College – Discussions have begun on establishing an annual Arctic Science Seminar that will allow for knowledge sharing and potential data exchange.
    - Nunavut Research Institute (NRI) – Final research reports will be submitted per licensing requirements, ensuring findings are accessible to Nunavut policymakers and researchers.
    - Resolute Bay Community Leadership – Research findings have been informally shared with the Mayor of Resolute Bay and community members through engagement activities.
    - Parks Canada (Qausuittuq National Park Representative) – Environmental observations have been discussed, with potential future collaboration on permafrost and climate monitoring.
- In future research cycles, FMARS aims to formally integrate data-sharing protocols that allow Nunavummiut stakeholders, such as local researchers or Indigenous organizations, to access key environmental datasets.

Data Security and Storage

- Storage & Security:
    - All raw environmental data (radiation levels, permafrost depth, water quality samples, etc.) is securely stored on encrypted digital platforms managed by FMARS researchers.
    - Backups are maintained on secure cloud storage and local hard drives to prevent data loss.
    - Sensitive information, such as precise locations of research sites, is restricted to prevent unauthorized access and preserve scientific integrity.
- Future Community-Based Data Co-Management:
    - As FMARS expands collaborations with Nunavut-based institutions, discussions will take place on how local organizations or researchers can securely store and manage shared data. Y /
    - If community-based co-ownership of data is established, proper training on data

management, security, and ethical use will be provided.

Commitment to Ethical Data Sharing

FMARS is committed to ensuring that research data benefits both scientific research and Nunavut communities, aligning with ethical research standards and Nunavut-specific data-sharing protocols. Moving forward, data-sharing agreements with local partners will be developed to ensure accessibility while respecting privacy, security, and community interests.

Where is the data stored and will the data be destroyed within a set timeframe?

Is the data trackable and/or available in a public data repository? If yes, please provide the appropriate information and/or link to ensure the findability and accessibility of the data.

Please append a copy of your data management plan. (See below)

CLIMATE CHANGE

Is your research about climate change (causes, impacts, mitigation, adaptation, etc.)? If yes, explain.

Climate Change Relevance of FMARS Research

The Flashline Mars Arctic Research Station (FMARS) mission is a multi-disciplinary research project, with over 50% of its studies directly linked to climate change impacts, adaptation, and environmental monitoring. The station's location on Devon Island in the High Arctic provides a natural laboratory for studying climate-driven changes in permafrost, atmospheric conditions, water quality, and Arctic ecology. These investigations contribute to scientific knowledge, Nunavut policy development, and global climate change mitigation efforts.

1. Permafrost Thawing and Climate Feedback Loops

Key Findings from 2023–2024

- Permafrost degradation is accelerating. In 2023, permafrost depth measurements ranged between 22 cm and 36 cm, while in 2024, some areas recorded depths exceeding 40 cm. This trend suggests a continuing thaw, aligning with broader Arctic climate models predicting increased permafrost loss due to rising temperatures.
- Radon gas emissions were detected in thawing permafrost zones, supporting research that suggests warming ground layers are releasing previously trapped gases, which could pose long-term health risks for Arctic communities.
- Ground instability caused by solifluction (soil movement due to ice melt) was observed, presenting challenges for both scientific research operations and potential infrastructure projects in Arctic regions.

Climate Relevance & Policy Applications

Permafrost thaw in Nunavut has major implications for infrastructure stability, ecosystem changes, and potential greenhouse gas emissions. FMARS' longitudinal monitoring of permafrost depth and radon release can inform:

- Nunavut's land-use planning policies to ensure buildings and research stations account for ground instability risks.
- Community-based climate adaptation strategies that consider long-term permafrost monitoring as part of resilience planning.

2. Atmospheric Changes & Habitat Air Quality Challenges

Key Findings from 2024

- Carbon dioxide (CO_2) levels inside the FMARS habitat occasionally spiked to 4800 ppm overnight, exceeding recommended safe thresholds. This could mirror challenges faced by Arctic housing, where poor ventilation leads to CO_2 buildup.
- Volatile Organic Compounds (VOCs) inside the habitat peaked at 1950 ppb, particularly during cooking and closed-environment conditions, highlighting the importance of enhanced air

filtration systems in Arctic research and habitation environments.

- Humidity levels inside the habitat reached 86%, leading to mold growth in certain areas, a concern for long-term habitat sustainability and potential health risks in Arctic structures.

Climate Relevance & Policy Applications

- Findings can be applied to ventilation system improvements for Arctic housing and enclosed workspaces to reduce CO_2 accumulation and VOC exposure risks.
- The Nunavut Housing Corporation and environmental health agencies may find FMARS data useful in assessing indoor air quality challenges related to climate-driven changes in Arctic building environments.

3. Water Contamination & Nanoplastic Transport in Arctic Ecosystems

Key Findings from 2023–2024

- Water samples collected from permafrost melt, snowmelt, and local streams revealed the presence of nanoplastics, supporting research indicating that atmospheric transport of microplastics is affecting remote polar environments.
- pH shifts in wastewater runoff from the habitat were observed, dropping to 6.0, suggesting that long-term greywater disposal in Arctic research stations may require improved filtration systems.
- No coliform bacteria were detected in drinking water sources, confirming baseline water purity for Arctic hydrological monitoring.

Climate Relevance & Policy Applications

- Findings support ongoing research on global plastic pollution and its impact on Arctic freshwater systems.
- FMARS data can contribute to Nunavut water management policies and Arctic environmental protection frameworks, particularly in wastewater treatment and microplastic monitoring.

4. Arctic Ecosystem Monitoring & Biological Responses to Climate Change

Key Findings from 2023–2024

- Microbial and algal communities in seasonal meltwater channels thrived in increasingly exposed permafrost regions, suggesting that climate warming is creating new ecological niches.
- Sunburst lichen (Rusavskia elegans) populations remained resilient, even in areas of increased temperature variability, highlighting the adaptability of Arctic extremophiles to changing conditions.
- Rare algal streaks were observed for a second consecutive year, suggesting that meltwater-dependent ecosystems may expand as permafrost thaw increases water availability.

Climate Relevance & Policy Applications

- These biological indicators can be incorporated into long-term ecosystem monitoring efforts to assess how climate change alters Arctic biodiversity.
- FMARS findings may support Arctic conservation initiatives and policy recommendations for

preserving fragile microbial and lichen-based ecosystems.

FMARS as a Climate Change Research Platform

The FMARS research mission is a high-impact climate monitoring project that directly contributes to our understanding of Arctic environmental changes and their implications for Nunavut and the global scientific community. The data collected on permafrost thaw, atmospheric shifts, water contamination, and ecosystem adaptation are critical for informing climate resilience strategies and policy decisions in Arctic regions.

Moving forward, FMARS will:

- Expand permafrost and radiation monitoring efforts, improving Nunavut's long-term climate adaptation datasets.
- Collaborate with Nunavut Arctic College and policymakers to ensure research findings are accessible and applied to climate planning frameworks.
- Contribute to global climate studies, particularly in permafrost greenhouse gas emissions, Arctic hydrological changes, and extreme environment adaptation strategies.

These findings position FMARS as a key contributor to Nunavut's climate policy discussions, ensuring that scientific research directly benefits local communities, governance, and environmental stewardship efforts.

PHOTOGRAPHS

If possible, please provide high-resolution photos of licensed research activities that NRI may use in communication materials, organizational reporting, and other promotional purposes. The photographer and all recognizable people in each photo must sign the attached Photo and Video Release form. Please also complete the table below for each photo provided and submit to NRI along with all required NRI photo release forms. The photographer/owner will be credited in all uses of the photograph(s).

File Name	Location	Description	Subjects	Photographer/Owner	Date

Would you like your project to be considered for a research profile and promotion by the NRI? Yes

Yes, please. We would embrace that honour. We have a colleague at the Arctic College, Jackie Price, and we want to present the opportunity to assist them in a seminar on the findings we are reporting here and how space-based assets can help us monitor climate conditions.

FORMATTING TIPS

Main text:
Please supply the report in a standard manuscript format (Microsoft Word format is required).

Tables:
Any number of tables can appear in one file (as long as they are clearly marked). Tables prepared using simple table formats as provided in word processing programs such as WordPerfect are preferred. Each table should be numbered according to its appearance in the text (e.g., Table 1, Table 2) and each should have a brief descriptive heading.

Figures:
Each figure or graphic element should be submitted as a separate file. Black & white and colour graphics are both acceptable. We can accommodate most standard graphic file formats, however, please indicate in which format the graphic was prepared.

References:
Please use the APA or MLA Citation Style while referencing throughout the report.

Size:
The size of the electronic document must not exceed 4MB (if larger than 4MB, please send attachments separately and number the emails).

Appendix 1

Data Management Plan (DMP) for FMARS Research

1. Introduction

The Flashline Mars Arctic Research Station (FMARS) Data Management Plan (DMP) outlines the protocols for data collection, storage, security, sharing, and long-term accessibility. This plan ensures that research data is accurately documented, securely stored, and ethically shared, in accordance with Nunavut Research Institute (NRI) guidelines and best practices for environmental and planetary analog research.

2. Data Types and Collection Methods

FMARS collects a variety of environmental, atmospheric, geological, and biological data through in-field measurements, sample collection, and remote sensing.

- Permafrost Data:
    - Measurements of active layer depth and thaw progression using non-invasive probing techniques.
    - Radon gas emissions detected in thawing permafrost zones.
- Radiation & Atmospheric Data:
    - Cosmic radiation exposure levels recorded via dosimeters and spectrometric tools.
    - CO_2 and VOC (volatile organic compound) levels monitored within the FMARS habitat.
    - Humidity and temperature variations tracked throughout the mission.
- Water Quality Data:
    - Water samples collected from snowmelt, permafrost runoff, and stream sources.
    - Nanoplastic and microplastic content analysis.
    - pH, turbidity, and mineral composition assessments.
- Biological Data:
    - Microbial and algal sample collection for genomic sequencing and biological adaptation studies.
- Geological Data:
    - Rock and sediment analysis from the Haughton Crater region.
    - Comparisons between geological formations and planetary analogs.

3. Data Storage and Security Protocols

- Primary Storage:
    - Raw and processed data are stored on secure, encrypted hard drives managed by FMARS researchers.
    - Cloud-based backup systems are used to prevent data loss.
    - Critical datasets are archived in The Mars Society's research database for long-term retention.
- Data Access and Security:
    - Access to raw data is restricted to FMARS research personnel and authorized partners.
    - Sensitive data (e.g., exact geographic coordinates of research sites) is protected to prevent unauthorized use.
    - Any personally identifiable information (PII) collected during interviews or community

interactions is securely stored and anonymized where applicable.

4. Data Sharing & Accessibility

- Public Access to Research Outputs:
    - Summary reports and key findings will be shared with the Nunavut Research Institute (NRI) per licensing requirements.
    - Peer-reviewed publications will be made publicly accessible through scientific journals.
    - Select datasets will be available upon request for Nunavut government agencies, Arctic research institutions, and Indigenous organizations.
- Community-Based Data Sharing:
    - Discussions are underway to establish formal data-sharing agreements with Nunavut Arctic College and local stakeholders in Resolute Bay.
    - FMARS is committed to co-developing a transparent process for Nunavummiut to access relevant climate data, ensuring that research findings contribute to community knowledge and climate adaptation efforts.

5. Data Retention and Long-Term Management

- Short-Term Data Use:
    - Data will be actively analyzed and used for peer-reviewed publications, policy recommendations, and academic research within 1–3 years of collection.
- Long-Term Preservation:
    - FMARS will archive environmental and climate datasets for at least 10 years, ensuring that historical comparisons can be made for future research.
    - Potential partnerships with Nunavut Arctic College, the Nunavut Research Institute, and federal research programs will be explored to maintain long-term accessibility for northern communities.

6. Compliance with Nunavut Research Guidelines & Ethical Considerations

FMARS adheres to Nunavut's research ethics and data-sharing guidelines, ensuring that:

- Data collection respects environmental and cultural sensitivities.
- Community-relevant findings are shared with local stakeholders in an accessible format.
- No data is commercialized or used in a way that could negatively impact Nunavut communities.

FMARS is actively developing stronger partnerships with Nunavut-based researchers to ensure that future data-sharing agreements align with Indigenous knowledge frameworks and policy priorities.

7. Conclusion & Next Steps

This Data Management Plan ensures that FMARS research data is secure, ethically managed, and beneficial to both the scientific community and Nunavut stakeholders. Moving forward, FMARS will:

- Finalize data-sharing agreements with Nunavut Arctic College and relevant government agencies.
- Establish protocols for Nunavut community members to access and contribute to climate research datasets.
- Continue compliance with Nunavut Research Institute licensing requirements, ensuring

transparent reporting and responsible data management.

Appendix 2

Funding Report

This document outlines the total funding received from various sources to support the 2024 Flashline Mars Arctic Research Station (FMARS) mission and details how the funds were allocated.

Total Funding Breakdown

Funding Source	Total Amount (CAD)	Notes
KBR Corp.	7,000.00	In-kind donation to The Mars Society
Space 4 All Foundation	4,000.00	Direct support for research activities
Private Funders	80,000.00	Direct contribution to The Mars Society for expedition expenses
The Mars Society	87,000.00	Includes 80,000 from private funders + 7,000 from KBR
Total Funds Managed by The Mars Society	87,000.00	Used for travel, logistics, and operations
Grand Total Funding	98,000.00	Sum of all sources

Individual Funding Allocations

The following crew members received financial support from the respective sources:

Crew Members and Their Funding Sources

1. Tiffany Swarmer
    - 7,000 CAD from KBR Corp. (In-kind donation via The Mars Society)
    - 1,200 CAD from Space 4 All Foundation
    - 4,000 CAD from The Mars Society (for flights)
2. Ilaria Cinelli
    - 2,772 CAD from Space 4 All Foundation
    - 4,000 CAD from The Mars Society (for flights)
3. Mason Robbins
    - 8,000 CAD (Private Funders)
    - 4,000 CAD from The Mars Society (for flights)
4. Natasha Nicholson
    - 8,000 CAD (Private Funders)
    - 4,000 CAD from The Mars Society (for flights)
5. Rhett Woods
    - 35,000 CAD (Rhett's contribution to The Mars Society)
    - 4,000 CAD from The Mars Society (for flights)
6. Michael Andrews
    - 35,000 CAD (Michael's contribution to The Mars Society)
    - 4,000 CAD from The Mars Society (for flights)
7. Terry Trevino
    - 10,000 CAD (From Space 4 All Foundation, directed to The Mars Society)
    - 4,000 CAD from The Mars Society (for flights)

Summary of Financial Flow

- Private Funders (80,000 CAD) directly contributed to The Mars Society, which covered expedition costs for all crew members.
- KBR Corp. provided 7,000 CAD in-kind support through The Mars Society.
- Space 4 All Foundation contributed 4,000 CAD to support research activities and an additional 10,000 CAD through Terry Trevino.

The Mars Society managed 87,000 CAD, which covered travel, logistics, and operational expenses.

Appendix 3 – Attached in a Separate email

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