Fuel Leak Detection and Reconciliation System (FLDRS)

Feasibility Report:

Long Range Radar (LRR) Sites & Short Range Radar (SRR) Sites

This report is submitted to the Nunavut Water Board by the North Warning System Office, Department of National Defence (the licensee), as required by the licences below.

Licensee: North Warning System Office, Department of National Defence, Government of Canada

Licences and Locations:

Licence	Location
3BC-SHE0919 - Type "B"	CAM-3 North Warning System Site, Shepherd Bay, Kitikmeot Region, Nunavut
3BC-FOD0919 - Type "B"	FOX-3 North Warning System Site, Dewar Lakes, Qikiqtani Region, Nunavut
3BC-DYE0919 - Type "B"	DYE-M North Warning System Site, Cape Dyer, Qikiqtani Region, Nunavut
3BC-BAF0919 - Type "B"	BAF-3 North Warning System Site, Brevoort Island, Qikiqtani Region, Nunavut

Report prepared by: Nasittuq Corporation

Date: March 2010

EXECUTIVE SUMMARY

Diesel engine generators are used to produce the electrical power required to operate the 47 radar sites making up the North Warning System (NWS). Access to most sites for fuel re-supply is limited to the summer shipping season, and this necessitates storage of large quantities of bulk fuel at each site. Fuel monitoring and reconciliation is currently done by manually measuring the volume of fuel in each tank and manually calculating (reconciling) the volume of fuel remaining against expected usage. Manual measurement and reconciliation is completed during each quarterly preventive maintenance visit unless weather conditions make it unsafe to climb the tanks and measure the depth of fuel remaining.

In 2001, a pilot Fuel Leak Detection and Reconciliation System (FLDRS) project was initiated in anticipation of changes to the Canadian Environmental Protection Act (CEPA) regulations concerning storage tank systems for petroleum products. However, when these regulations officially came into force in June 2008 as the Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations, there was no regulatory requirement to install leak detection systems on the NWS tanks provided that the tanks are inspected at least every ten years.

In July 2008, the first FLDRS pilot system was installed at the LAB-6 Long Range Radar (LRR) site in Cartwright, Labrador and is currently operating in “Pilot System Status.” During the testing and monitoring period, several challenges were identified that would need to be addressed prior to future installations including premature failure and/or erratic behaviour of equipment in the extreme environments, system false alarms, and configuration management of software and equipment.

In addition, an analysis of the spills at Nunavut based LRRs since 1995 (when sites were shifted to “unattended” status) shows that of the 26 JET-A1 fuel spills, approximately 65% would not have been detected with the FLDRS design. The main limitation of the existing system is that, due to a lack of power supply, it cannot address tanks located at beach sites. Furthermore, it will not detect leaks occurring due to ruptured hoses at refueling stations or on equipment not connected to the fuel system (i.e. ruptured drums or decommissioned tanks).

The implementation of a FLDRS at the remaining NWS sites would require approximately ten fiscal years and an estimated $15 million in capital costs. While the FLDRS has proven to be a technically feasible option in the Sub-Arctic zone, the implementation of a similar system on the more remote Arctic sites will require significant capital investment and adequate time and resources.

As 70% of the total number of spills at unattended Nunavut based LRR sites can be attributed to failing equipment and piping, it is recommended that these funds and resources be diverted towards upgrading and maintaining the aging NWS fuel systems.

TABLE OF CONTENTS

ACRONYMS & ABBREVIATIONS

API	American Petroleum Institute
AWR	Additional Work Requirement
CCME	Canadian Council of Ministers of the Environment
CEPA	Canadian Environmental Protection Act
CMO	Contract Management Office
DEG	Diesel Engine Generator
DND	Department of National Defense
FLDRS	Fuel Leak Detection and Reconciliation System
FMT	Facilities Maintenance Technician
GFM	Government Furnished Material
LCMM	Life Cycle Material Manager
LHCN	Long Haul Communications Network
LRR	Long Range Radar
LSS	Logistics Support Site
MOV	Motor Operated Valve
NWS	North Warning System
NWSCC	North Warning System Control Centre
NWSO	North Warning System Office
NWSSC	North Warning System Support Centre
O&M	Operations and Maintenance
PGS	Power Generation System
PLC	Programmable Logic Controller
PMI	Preventative Maintenance Inspection
PMP	Preventative Maintenance Program
POL	Petroleum, Oil & Lubricant
ROCC	Regional Operations & Control Centre
SRD	Short Range Development
SRR	Short Range Radar
TSB	Technical Services Building

Fuel Leak Detection and Reconciliation System (FLDRS) FEASIBILITY REPORT

1.0 AIM

The aim of the report is to investigate the feasibility of installing remote leak detection systems at long range radar sites (LRRs) to reduce the risk of environmental incidents at unattended (i.e. unmanned) North Warning System (NWS) sites. In 2001, Nasittuq initiated a project to investigate this possibility, and found that there were no existing fuel monitoring systems suitable to the unique requirements of the remote arctic sites. Therefore, a pilot design, known as the Fuel Leak Detection and Reconciliation System (FLDRS), was commissioned and developed specifically for the NWS line. A review of this pilot project will serve as the basis for this report.

2.0 BACKGROUND

2.1 NWS Configuration & Existing Bulk Fuel Inventory Management

The North Warning System is a chain of radar sites across Northern Canada from the Alaska/Yukon border to Labrador, linked by a satellite communications network to the military control centre in North Bay, Ontario. The NWS in Canada consists of eleven (11) unattended LRR sites and thirty-six (36) unattended Short Range Radar (SRR) sites. Sites are maintained and supported by five (5) Logistic Support Sites (LSS) situated in Inuvik, Cambridge Bay, Hall Beach, Iqaluit and Goose Bay.

Nasittuq Corporation (hereinafter Nasittuq) is the contractor to the Department of National Defense (DND) for the Operation and Maintenance (O&M) of the NWS.

Primary electrical power for all NWS radar sites is provided by diesel engine generators (DEGs) using JET A-1 fuel. This fuel is stored in bulk storage tanks and is re-supplied annually or biannually by sealift or airlift depending on the site. Bulk fuel is off-loaded from the ship or barge into beach storage tanks (Beach Site) at most locations and is then moved by pipeline, tanker truck or helicopter to the radar site summit tanks (Summit Site). Individual storage tank capacities range from 9,000 to 946,300 litres (see Figures 1.0 and 2.0).

Fuel inventories at unattended sites are measured manually from the top of each storage tank using a tape and bob or dipstick – commonly referred to as dipping. Dips are completed during each quarterly maintenance visit, weather permitting, and the temperature adjusted dip result (remaining volume) is reconciled against the expected consumption and anticipated remaining volume. Discrepancies in the expected remaining volume amount may be the result of either a fuel leak or an error in measurements or calculations, and the ability to check the system for a suspected leak may be limited due to the extent of snow cover.

The intention of the FLDRS pilot project was to investigate the effectiveness and accuracy of a remote fuel monitoring and leak detection system on the NWS line.

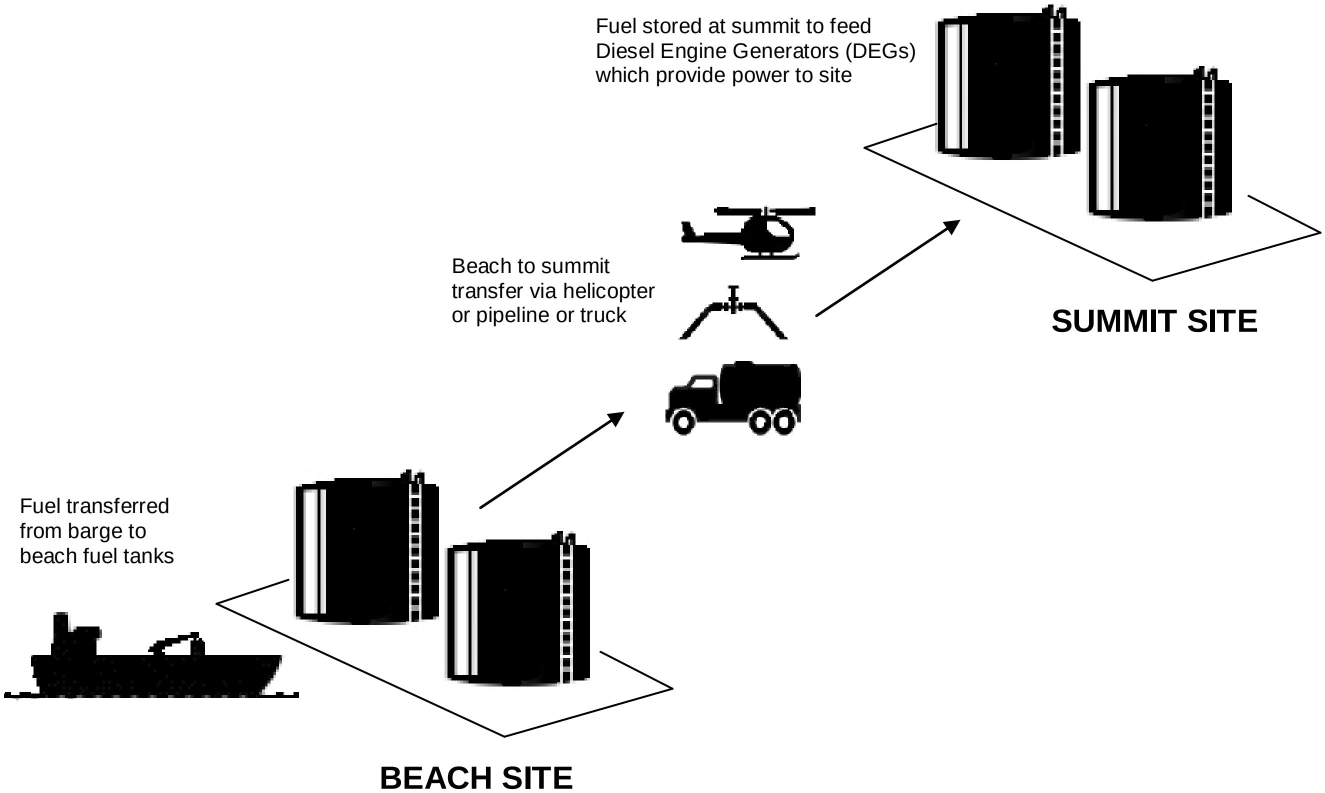

Figure 1.0 – Typical NWS Site Fuel Transfer Configuration

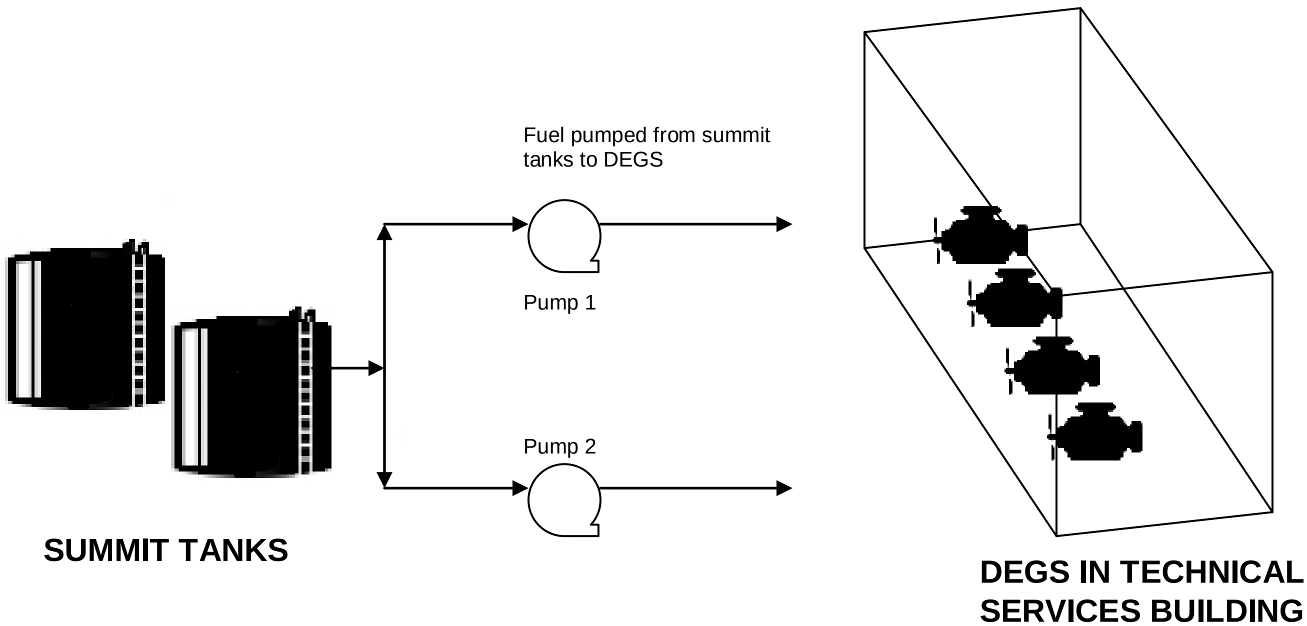

Figure 2.0 – Typical NWS Summit Site Fuel Transfer Configuration

2.2 Existing NWS Fuel System Monitoring, Maintenance & Inspection Programs

Nasittuq has implemented the following programs to ensure that the NWS fuel systems are regularly monitored, maintained and inspected to mitigate any potential environmental risks.

Tank Cleaning & API Inspection Program

In 2004, Nasittuq instituted an annual Tank Cleaning & American Petroleum Institute (API) Inspection Program to ensure that all tanks on the NWS line would be cleaned and inspected at regular intervals in accordance with CEPA and the API 653 Standard. By the end of 2011, every bulk fuel storage tank on the line will be cleaned, and inspected by certified API inspectors, therefore creating a baseline for future inspections.

Preventive Maintenance Program

All NWS fuel systems are maintained with the Nasittuq Preventative Maintenance Program (PMP). The PMP Preventative Maintenance Inspection (PMI) task cards dictate the maintenance tasks to be performed, the procedures by which they are performed and the intervals. These tasks are performed quarterly by Facilities Maintenance Technicians (FMTs) with any uncompleted tasks (due to weather, time on site, etc.) being documented via PMI Exception Reports.

Annual POL Facility Inspections

Each site requires fuel transfer to the summit from the beach, every other year, completed by the Nasittuq Petroleum, Oil & Lubricant (POL) technician team. During these transfers, the POL technicians perform a POL Facility Inspection, reviewing the fuel system piping, tanks, valves and fittings. Any required repairs are either completed at the time of inspection (within the limits of time and resources available) and documented, or are documented within the report for future action. All inspection reports are returned to the Nasittuq POL Coordinator for evaluation and review.

POL Infrastructure Inspection

During the summers of 2008 and 2009, a series of inspections were carried out along the NWS line in an effort to fully document and baseline the condition of the NWS POL infrastructure. These inspections focused on the POL pipelines and associated fixtures and fittings and were carried out by two Nasittuq Civil Technologists and contracted Plumber/Pipe Fitter. A full report of the findings was reviewed by the Facilities Engineering/Maintenance /Logistics teams to determine appropriate future actions which are then incorporated into the business plan for implementation.

2.3 Existing LRR & SRR Environmental Safeguards

LRR Environmental Safeguards

Several environmental safeguards currently exist at all summit tanks that are directly connected to the power generation system (PGS) at LRR sites. Aviation, summit bulk tanks (i.e. vertical storage tanks) and beach tanks are exempt from these safeguards as the fuel transfers involving these tanks are performed manually with technicians on-site, while the summit PGS fuel system is operated automatically with some remote controlling capabilities.

For East Coast LRRs (i.e. LAB-2 – Saglek Bay, Labrador; LAB-6 – Cartwright, Labrador and BAF-3 – Brevoort Island, Nunavut) the safeguards are as follows:

- **Overfill Prevention on Vertical Bulk Fuel Tanks (at LAB-2 and BAF-3 only)**
  - The Varec level gauges on the vertical bulk fuel tanks at East Coast sites are connected to the motor operated valves (MOVs) on the tank fill line. If the fuel exceeds a preset high level, the gauge electronics will trigger the MOVs to close therefore preventing an overfill situation.

- **Pressure Switch**
  - The fuel supply line between the summit fuel tanks and the Technical Services Building (TSB) contains a pressure switch that is interlocked with the tank pumps. When the pressure switch detects a low pressure in the supply line (due to a break or a leak in the pipe) the tank pumps are shut off and the MOVs are closed, preventing fuel from flowing into the TSB.

For the remaining LRRs, the safeguards are as follows:

- **Automatic Time-Outs**
  - **Flow-Switch**
    - The pumps that transfer fuel from the summit PGS tanks to the primary day tanks located in the TSB on site will automatically shut off if the sensor on the pump does not detect fuel flow within several seconds of pump activation. Following the primary pump failure, the secondary pump will be activated, and a primary pump failure alarm will be transmitted to the NWSCC. A similar sequence occurs if the secondary pump fails.
  - **Fuel Transfer Pump**
    - The fuel transfer pump will remain activated until a high level sensor in the primary day tank transmits a stop signal. However, a timeout feature will limit the duration of the fuel transfer cycle. If the fuel transfer cycle exceeds the preset duration, the operating pump will be shut off and a timeout alarm will be transmitted to the NWSCC.

SRR Environmental Safeguards

Similar safeguards exist at SRR sites as follows:

- **Hydrocarbon Leak Detection Cables**
  - Leak detection sensors are installed within the interstitial spaces of the summit fuel system tanks. Any leaks in a PGS fuel storage tank will trigger the sensor which a) de-activates the fill/discharge valve on the tank, and b) transmits a leak alarm message to the NWSCC.

- **Automatic Time-Outs**
  - Similar to LRR sites.

2.4 FLDRS Pilot Program

The FLDRS pilot program was implemented in a phased approach as follows:

Preparation Phase (2001) – Level Sensor Purchase
In March 2001, a total of 186 Magnetrol wave guided radar level sensors (one for each summit bulk fuel tank) were procured and staged to each NWS site. The intention of this procurement was to assist in monitoring fuel levels in anticipation of changes to CEPA regulations concerning storage tank systems for petroleum products.

PHASE I (2002) – Level Sensor Trial
In November 2002, three sensors were installed in one tank at the North Bay Short Range Development Site (SRD), FOX-M (LRR site at Hall Beach, Nunavut) and CAM-M (LRR site at Cambridge Bay, Nunavut), and were monitored for one year to determine suitability and effectiveness. These two sites were chosen for the initial installation of the level sensors because they are both fully attended sites.

PHASE II (2005-2009) – Unattended LRR Pilot Project
In 2007, a subcontractor, Sigit Automation Inc., was hired to design and install a pilot FLDRS for LAB-6 (LRR site at Cartwright, Labrador). This site was selected because of its close proximity to the communities of Goose Bay and Cartwright, making it accessible via helicopter from Goose Bay or Cartwright within 2 to 3 hours. Furthermore, LAB-6 underwent upgrades to the Programmable Logic Controller (PLC) system, and was, at the time, the most representative of future site control configurations.

The pilot FLDRS was installed at LAB-6 in June/July of 2008 and was monitored, troubleshooted and modified throughout the course of the year. As of August 2009, the system was deemed fully functional in “Pilot System Status” and operating effectively as per the design requirements. The FLDRS design is now the property of DND and can be modified and applied to other sites as required.

3.0 REGULATORY REQUIREMENTS & CCME CODE OF PRACTICE

3.1 Canadian Environmental Protection Act (CEPA), Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations

The FLRDS was originally intended to comply with anticipated changes to CEPA regulations that were introduced as the Proposed Federal Petroleum Products and Allied Petroleum Products Storage Tank System Regulations (2007). However, when these regulations officially came into force in June 2008 as the Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations, the following requirements were stated in Section 22:

- Horizontal Tanks with Secondary Containment
  - No leak detection requirements stated

- Vertical Tanks without Secondary Containment
  - Use continuous in-tank leak detection; OR
  - Use continuous external vertical aboveground tank leak monitoring for each tank; OR
  - Once every ten years, inspect those tanks or the floor of those tanks

Assuming the existing tank cleaning and inspection schedule for all NWS tanks continues, ensuring that the tanks are cleaned and inspected at least every ten years, there is no regulatory requirement to install leak detection systems on the NWS tanks.

It should be noted that tank inspections are required to maintain due diligence in accordance with API standards. Therefore, the implementation of a FLDRS would not serve as a replacement for the existing NWS tank inspection program, but rather as a complementary system.

3.2 Canadian Council of Ministers of the Environment (CCME) – Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products

Part 6 of the CCME Code of Practice, which is not adopted under the current CEPA regulations, recommends that continuous monitoring be provided for bulk fuel storage tanks with a capacity of 2,500 litres or more to reduce the amount of time required to detect leaks. The Code of Practice also provides guidelines for the parameters for the leak detection system further outlined in 4.0.

4.0 FLDRS Pilot Project Review

4.1 Functional Requirements of Pilot System

The Pilot Project at LAB-6 was designed based on the following functional requirements to provide a continuous real time bulk fuel monitoring and reconciliation system for radar site fuel storage tanks:

a) ***CCME***

The system was designed to meet the requirements for continuous monitoring as specified in the CCME Code of Practice. Therefore, the system includes the following leak detection triggers including:

- Any unexplained loss in excess of the following (whichever is greater)
  - i. 1% of the throughput in one month from the storage tank system as indicated by the recording and reconciliation of inventory records; **OR**
  - ii. 1% of the tank capacity.
- Five or more consecutive weeks of unexplained product losses; and
- An unexplained loss in one calendar month.

The probability of detection must be 95% with a 5% probability of false alarm.

b) ***Operations & Maintenance***

- The system was designed to be operable and maintainable by operations and maintenance personnel currently employed by Nasittuq, with a maximum of five days initial familiarization training on the new system operation characteristics and components;
- The component maintenance intervals were established to be compatible with the current NWS maintenance concept, i.e. quarterly preventive maintenance checks and servicing;

c) ***Service Life***

- The system was designed to have an expected service life of no less than 10 years;

d) ***Availability and Reliability***

- The system was designed to:
  - i. have an availability rate capable of collecting and retaining data during an electrical power outage of 72 hours or less;
  - ii. have a reliability rate, i.e. Mean Time Between Failure (MTBF), of not less than 8,760 hours for all locations;

e) ***Alarms***

- The system was designed to raise an audible and visual alarm condition at the NWSCC workstations when a fuel leak or overfill conditions is detected;

f) ***Automatic Shutdown***

- The system was designed to automatically shut down pumps and/or close motor operated valves (MOVs) necessary to contain a leak or overfill condition with manual override feature.

4.2 Design Constraints

The following NWS constraints impacted on the approach used for the Pilot Project at LAB-6 in providing continuous monitoring for bulk fuel storage and distribution systems.

a) **Unattended Sites & Remote Operation**

- The FLDRS had to follow the same remote operation and reporting procedures as the existing on-site systems with communications via the Long Haul Communication Network (LHCN).

b) **Lack of Electrical Power Source at Beach Tanks**

- As there is no electrical power source at any of the NWS Beach Sites, the FLDRS electronic sensors are not a viable option for providing continuous monitoring for the beach tanks.

c) **Long Haul Communications Network (LCHN) Configuration**

- The NWSCC in North Bay is the only NWS location staffed 24/7; therefore, sensor data is relayed to the NWSCC.

d) **LHCN Bandwidth Availability**

- The LHCN has a fixed bandwidth for data passage, affecting the quantity/format of new electronic sensor data that can be transmitted. Therefore, the FLDRS sensor data must be transmitted in the most efficient format possible.

4.3 System Performance & Monitoring Issues

At present, the FLDRS system is deemed to be operating effectively, accurately monitoring and reconciling fuel levels on the LAB-6 fuel system. However, the system required substantial monitoring over the course of approximately two years. The major issues identified during this monitoring period are outlined below:

False Alarms

From the initial installation of the FLDRS in July 2008 to present, there have been approximately 20 false alarms documented on the system. For roughly half of the alarms, a crew was not present on site and had to be dispatched to verify the validity of the alarm.

Equipment and Materials

The following equipment and materials issues were identified during the monitoring period:

- Due to the lengthy process required to design and implement the pilot project, the Government Furnished Material (GFM) experienced a high rate of premature failure as the sensors are beyond the manufacturer recommended life cycle.
- Equipment (i.e. level sensors) was found to be unreliable and erratic during extreme weather conditions. Performance is compromised when equipment is operating at the limits of its specified working temperature range (i.e. -40C).
- Exterior flow meters have been found to prematurely fall out of calibration, affecting the reconciliation totals accuracy and therefore triggering alarms on the system. The affected FLDRS system module has been disconnected until recalibration of the flow meters can be completed.
- Site power outages caused FLDRS interruptions triggering alarms on the system. A full reset of the system requires a crew to be dispatched to site to affect the reset.

4.4 Challenges for Future Implementation

The pilot project at LAB-6 has highlighted the following challenges for implementation at future sites:

Materials and Equipment

The existing Magnetrol level sensors staged at the NWS sites are approximately 10 years old and are no longer serviceable by the manufacturer. The equipment has been found to be beyond its shelf life and as such, during the pilot installation, there was a high rate of equipment failure out of the box. Furthermore, this older version of the sensors are not compatible with all probe lengths nor the new diagnostic software. Future systems will require procurement of new materials.

Configuration Management

Due to the timeframe required to design, implement and test a FLDRS at each site, typically 1 to 2 years, it is inevitable that the equipment and software will become obsolete before the completion of the project. Since it is unreasonable from a configuration management perspective to manage unique systems at each site, additional funds and resources will have to be allocated to upgrade and maintain equipment for each FLDRS.

Beach Tanks

Continuous monitoring for beach storage tanks was not provided in the FLDRS pilot project. The electronic sensors that are integral to the existing FLDRS design were not a viable option for the unattended beach sites due to the lack of a continuous electrical source and data communication links. The marine proximal tanks contain approximately 50% of each site's fuel volume and therefore should be considered for future FLDRS installations to ensure a more complete monitoring system.

Fuel System Modifications & Upgrades

The majority of the fuel systems on the LRR sites were constructed during the 1950s and are therefore consistently being upgraded and modified. If a leak detection system was to be installed at each LRR site, each fuel system modification would require corresponding revisions to the FLDRS.

Design Modifications & Testing/Monitoring

While the pilot FLDRS design forms a solid basis for future system designs, each site will require a unique design to accommodate its specific requirements. This design modification process would include but not be limited to on-site evaluation, mechanical & electrical design, and software modification. Furthermore, upon installation of each system, a testing and monitoring period would be required to ensure proper functionality.

Design Environment

The pilot system was designed and implemented at LAB-6 which is located in Cartwright, Labrador – a sub-Arctic environment which does not experience the same extreme weather conditions as other Arctic-based NWS sites. This site can be accessed via helicopter from Goose Bay or Cartwright within 2 to 3 hours. Implementing a similar FLDRS system at NWS sites in more remote, Arctic environments will introduce different, more extreme challenges to those encountered during the pilot project including: increased mobilization and shipping costs, more difficult accessibility to site (particularly important when addressing false alarms), and more extreme environmental conditions requiring more robust equipment and materials.

5.0 ENVIRONMENTAL RISK MITIGATION

5.1 Spills – Historical Data for Unattended Nunavut Based LRR Sites

An analysis of the historical spill data for Nunavut based LRR sites, since 1995 when the sites were converted to unattended mode, shows that there have been a total of 26 JET-A1 spills at unattended Nunavut based LRRs (i.e. CAM-3 – Shepherd Bay, NU; FOX-3 – Dewar Lakes, NU; DYE-M – Cape Dyer, NU; and BAF-3 – Brevoort Island, NU).

Of these incidents, 69% involved less than 100 liters of product, and roughly 20% (i.e. 6 spills) involved volumes greater than 500L (see Figure 3.0).

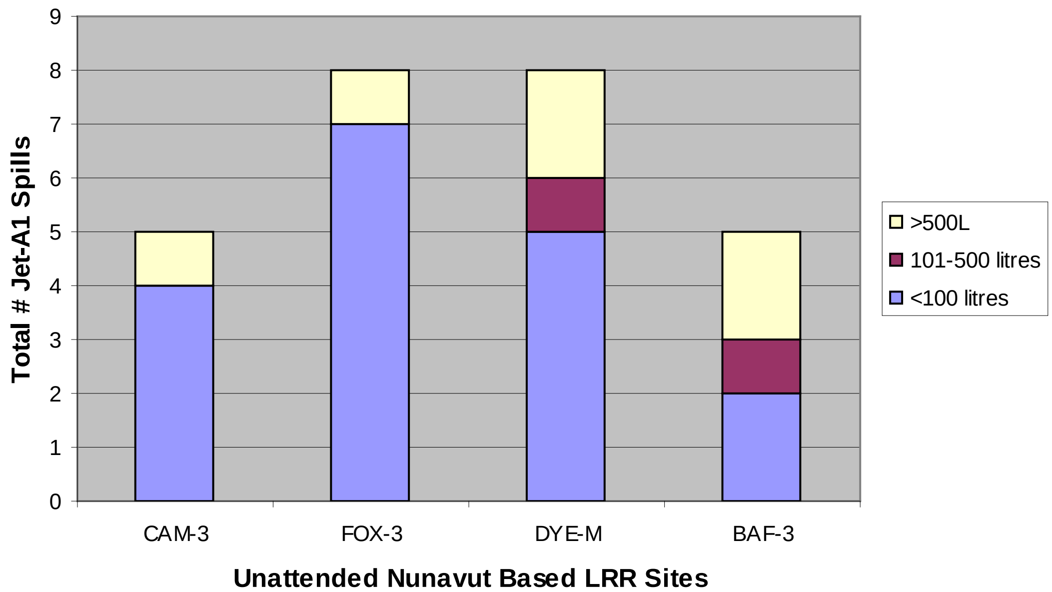

Figure 3.0 – Total number of JET-A1 spills at Unattended Nunavut Based LRR Sites since 1995

Further evaluation of the causes of the spills reveals that 23% of the spills were caused by human error with the remaining being caused by equipment or piping failure. With the existing FLDRS design, approximately 35% of the total number of JET-A1 spills would have been detected. A list of leaks/spills that would not trigger the FLDRS include, but is not limited to, the following:

- Leaks occurring at beach tanks/piping
- Leaks occurring due to ruptured hoses at refueling stations
- Leaks occurring on equipment not connected to the fuel system (i.e. decommissioned tanks, ruptured drums)

5.2 Monitoring of Beach Sites

The current FLDRS configuration does not allow for beach storage tank monitoring due to a lack of power source at the beach sites. Approximately 50% of the total volume of fuel stored at the unattended Nunavut based LRR sites is located at the beach sites. The FLDRS system would therefore be incapable of detecting any leaks or spills for half of the fuel content on the site, and would therefore not be able to fully mitigate the environmental risks on site. Developing and sourcing the appropriate technology to address the specific requirements of the beach sites will require additional funding and resources beyond the scope of this report.

6.0 COST PROJECTION BREAKDOWN

The total cost of implementing the pilot project at LAB-6 was approximately $1.2 million dollars.

Since the base design was developed during the pilot, it is estimated that approximately $500,000 per site would be required for the design modification, material procurement and implementation of the FLDRS at each additional LRR site. This is assuming that the existing site PLC upgrade project will be completed prior to the FLDRS implementation. Otherwise, additional funds associated with upgrading the site control system would be required beyond this estimate.

Extrapolating to smaller SRR sites, where some leak detection safeguards already exist, it is estimated that approximately $250,000 would be required for an adapted FLDRS system at SRR sites. The SRR estimate is based on the assumption that the implementation would take place in each zone at once therefore creating efficiencies for resources, travel and accommodation.

The following projected budget breakdown represents capital costs only - operations & maintenance costs, adjustments for taxes and increased project costs for remote Arctic locations have not been included. As such, the accuracy of this estimate is +100%/-50%.

	LRR	SRR
Materials	$75,000.00	$40,000.00
Labour	$300,000.00	$100,000.00
Travel & Living	$90,000.00	$85,000.00
R&Q	$30,000.00	$20,000.00
Courier & Freight	$5,000.00	$5,000.00
Total Per Site	**$500,000.00**	**$250,000.00**
10 LRR Sites	~ $5 million	
36 SRR Sites	~ $9 million	
Total for All Sites	**greater than $15 million**	

7.0 TIMEFRAME

Due to the remote arctic locations of the NWS sites, implementation of any outdoor equipment is restricted to the short summer season from May to August. The following estimated timeframe was compiled based on the following assumptions:

- LRR sites would be outfitted prior to SRR sites due to the comparably large amount of fuel storage

- Resources/funding would allow for 2 LRR sites to be designed and implemented each fiscal year
- Resources/funding would allow for all SRR sites in each zone to be designed and implemented each fiscal year

LRR Sites	
2 LRRs	2011/2012
2 LRRs	2012/2013
2 LRRs	2013/2014
2 LRRs	2014/2015
2 LRRs	2015/2016
Total 10 Sites	**5 Fiscal Years**

SRR Sites	
ZONE 1 - 9 SRRs	2016/2017
ZONE 2 - 10 SRRs	2017/2018
ZONE 3 - 8 SRRs	2018/2019
ZONE 4 - 5 SRRs	2019/2020
ZONE 5 - 4 SRRs	2020/2021
Total 36 Sites	**5 Fiscal Years**

8.0 CONCLUSION AND RECOMMENDATIONS

The FLDRS pilot project has demonstrated that it is technically feasible to implement a fuel leak detection and monitoring system at a NWS site located in the Sub-Arctic zone. However, the initial design and implementation of such a system requires significant capital investment (as per Section 7.0) and the subsequent testing and monitoring require adequate time and resources to produce a functional system (as per Section 4.3).

Moreover, as noted throughout this report, it has become evident that there are substantial limitations to the existing FLDRS design including, but not limited to the following:

- The existing FLDRS will not account for 50% of site fuel stored at marine proximal locations.
- Of the total number of spills documented since 1995 at unattended Nunavut-based sites, only 35% would have been detectable by the existing FLDRS.
- The existing GFM staged at the NWS sites for this project: a) experienced a high rate of premature failure; b) is no longer serviceable by the manufacturer due to its age.
- Major components of the FLDRS system, installed in exterior locations, were found to be unreliable when exposed to extreme weather conditions.
- The time required to implement the FLDRS at all sites is over 10 years, which would render the original systems obsolete before the completion of the project.

As highlighted in Section 5, approximately 70% of the total number of spills at the unattended Nunavut based LRR sites could be attributed to failing equipment and piping. It is recommended that a preventive strategy be adopted for mitigating potential environmental risks associated with bulk fuel storage, rather than the prescriptive FLDRS system. The substantial resources and funding that would be required to install FLDRS across the NWS line could alternatively be diverted towards continuing the upgrading and maintenance of the aging NWS fuel systems.