UTILITIES INFRASTRUCTURE DESIGN – PreAIMS
ISSUED FOR CONSTRUCTION
BASIS OF DESIGN

McMurdo Station, Antarctica

Submitted to:
United States Antarctic Program
Leidos Innovations - Antarctic Support Contract

Submitted by:

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TABLE OF CONTENTS - PreAIMS

SECTION 1 EXECUTIVE SUMMARY

A. General

1. This Basis of Design (BOD) addresses one element of a major effort by the National Science Foundation (NSF) to modernize McMurdo Station, its primary U.S. Antarctic Program (USAP) facility. This modernization effort is entitled Antarctic Infrastructure Modernization for Science (AIMS) and is a multi-year, multi-project effort to upgrade facilities on Station. The overarching goal of this infrastructure modernization is to ensure that McMurdo Station remains a viable platform for supporting Antarctic science for the next 35 to 50 years. The BOD presented here is for the McMurdo Utilities Infrastructure Design Project (Project) and reflects Merrick & Company's understanding of performance criteria contained in the Project Statement of Work (SOW), augmented by information collected from McMurdo Station (Station) user interviews, and Station site investigations. This Basis of Design will guide development of construction documents for the Project.

2. Work accomplished under this Project's SOW encompasses activities performed in advance of AIMS work. The construction documents have been developed as two separate and freestanding design packages. These packages are entitled "AIMS" and "PreAIMS" and are denoted as such on all construction documents. Narrative in this BOD applies to PreAIMS efforts only.

3. The goals of both this Utilities Infrastructure Design Project and the overarching AIMS program include:

   a. Redevelop McMurdo Station into a more energy and operationally efficient campus, optimized for support of local and deep field science

   b. Improve energy consumption and infrastructure support systems

   c. Reduce maintenance requirements to the greatest extent possible

   d. Provide predictable operational costs and operational efficiencies

   e. Offer a reliable, safe and healthy working environment for personnel and visitors

   f. Provide flexibility to adapt to changing needs of U.S. science in Antarctica

g. Reflect the influential presence in Antarctica in a manner consistent with U.S stature in the international research community

4. Utilities components of PreAIMS work include:

   a. Combined domestic and fire suppression water.

   b. Sanitary sewer.

   c. Heat loop (hydronic) supply and return.

   d. Fuel.

   e. Communications outside plant cabling.

   f. New modular telecommunication (Node) facilities.

   g. Node building site power.

5. Station elements impacted by PreAIMS construction include:

   a. Aboveground utilidors.

   b. Direct-bury utility mains in limited locations.

   c. Concrete culvert utility chases for below-grade utilities.

   d. Site grading.

   e. Demolition of existing utility systems as new systems become operational.

B. Project Summary

1. The Utilities Infrastructure Design Project includes the design and production of construction documents (drawings, specifications, basis of design narrative, and calculations) for improved utility distribution systems at McMurdo Station, Antarctica.

2. Information contained in this PreAIMS Basis of Design is based upon:

   a. "McMurdo Station Master Plan" prepared by OZ Architects and Merrick & Company.

   b. Project meetings, user interviews, design team deployment to McMurdo in February 2016 and February 2017, and other correspondence related to the Antarctic Infrastructure Modernization for Science program.

   c. Phasing concepts as developed by Leidos and presented to Merrick & Co.

d. Leidos meeting and presentation of delineation of work to be performed by Leidos versus work to be bid by and performed by the Contractor

3. The design documentation presented herein accommodates PreAIMS construction to include:

   a. New IT&C Primary Operations Center building (also known as Data Center, IT&C Primary, or Building 010) which is a separate project by others and not included within this Project.

   b. Water, sewer, hydronic, fuel, power, and communications nodes and exterior routing of fiber optic and copper lines in support of the new IT&C Primary building.

C. Delineation of Work

The McMurdo Utilities Infrastructure Design Project includes designs for work that will be executed by Leidos Innovations Corporation. Such designs are presented as part of the contract documents in order to facilitate coordination, cooperation and collaboration between the Contractor and Leidos, but are not part of the Contractor's scope of work. Information contained in this PreAIMS basis of design document applies to both Contractor performed work and Leidos performed work. Reference PreAIMS drawing packages for delineation of efforts information.

D. Stakeholder Interviews and Results

A major effort was coordinated to solicit input from the wide range of parties with activities associated with the Station. This effort primarily took the form of a series of charrettes, each focused on a major "community" (e.g., grantees, logistics and operational senior managers, tenant government agencies). A summary of the charrettes is contained in the report "Design Charrette Meeting Minutes" produced by the Antarctic Support Contract, led by Lockheed Martin at the time and now by Leidos Innovations Corporation. (Any previous reference to Lockheed Martin should now be considered Leidos).

E. Relevant Codes and Guiding Principles

1. The following codes are utilized in the design of the Project.

   a. International Building Code (IBC) 2015

b. International Plumbing Code (IPC) 2015

c. International Mechanical Code (IMC) 2015

d. NFPA 1 – Fire Code 2015

e. IECC - International Energy Conservation Code (IECC) 2015

f. NFPA 54 – National Fuel Gas Code

g. NFPA 70 - National Electrical Code 2014

h. NFPA 70E - Standard for Electrical Safety in the Work Place

i. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems

j. IESNA - Lighting Handbook (10th Edition)

k. IESNA RP8 – Roadway Lighting

l. IES RP-8-14 - Roadway Lighting

m. IEEE C2-2012 - National Electric Safety Code

n. IEEE Standard 142-2007 - Recommended Practice for Grounding Industrial and Commercial Power Systems (Green Book)

o. IEEE Standard 242-2001 - Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (Buff Book)

p. IEEE Standard 399 - Recommended Practices for Industrial and Commercial Power System Analysis

q. IEEE Standard 399-1997 - Recommended Practice for Power Systems Analysis (Brown Book)

r. TIA/EIA 568-B.1 - Commercial Building Telecommunications Cabling Standard, 2001

s. TIA/EIA 569-B - Commercial Building Standard for Telecommunications Spaces and Pathways, 2004

t. TIA/EIA 606-A - Administration Standard for Commercial Telecommunications Infrastructure, 2002

u. J-STD-607-A - Commercial Building Grounding and Bonding Requirements for Telecommunications, 2002

v. AHRI 1060 - Performance Rating of Air to Air Heat Exchangers for Energy Recovery Ventilation Equipment

w. AMCA 210 - Laboratory Methods of Testing Fans for Rating

x. ABMA 9 – Load Ratings and Fatigue Life for Ball Bearings

y. ABMA 11 - Load Ratings and Fatigue Life for Roller Bearings

z. ASHRAE Fundamentals - ASHRAE Handbook of Fundamentals 2013

aa. ASHRAE Guideline 0 - The Commissioning Process 2013

bb. ASHRAE Guideline 1.1 - HVAC&R Technical Requirements for the Commissioning Process, 2007

cc. ASHRAE 62.1 - Ventilation for Acceptable Indoor Air Quality 2010

dd. AABC MN-1 - National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems

ee. SMACNA 1780 – HVAC Systems Testing, Adjusting and Balancing

ff. SMACNA 1966 - HVAC Duct Construction Standards Metal and Flexible

SECTION 2 CIVIL AND SITE WORK

A. Existing Site and Utilities Description

1. McMurdo Station (Station), Antarctica is located on the southwestern tip of Ross Island. The Station site, as defined for this Project, consists of the area bounded by Winter Quarters Bay on the west, Observation Hill and the Tank Farm on the east, McMurdo Sound on the south, and Fortress Rocks on the north. The Station is approximately 140 acres, containing buildings, utilities, roadways, and other infrastructure to support the National Science Foundation's (NSF) mission of science and exploration through the United States Antarctic Program (USAP).

2. The existing exterior utility distribution systems at the Station consist primarily of individual and a collection of Arctic pipes on above ground pipe racks supported by stanchions, with the collective system known also as "utilidor". Arctic pipe represents the most obvious component of utilities within the Station. Arctic pipe is a system of interior carrier pipe(s) surrounded by heat trace elements, insulation and an outer corrugated metal pipe (CMP) jacket. Individual Arctic pipes are currently individually protected from freezing via the use of electric resistive heat tracing.

   Existing utilidors span the Station site from the Power Plant (Building 196) area north to the Vehicle Maintenance Facility (VMF, Building 143) and to the Tank Farm to the east, with systems concentrated on the south side of Scott Base Road. Existing utilidors convey a range of utilities to buildings and facilities, including potable water, fire suppression water, seawater, heat distribution loop (hydronic) supply and return, fuel, sanitary sewer, communications, and power. Conventional utility poles and overhead distribution are also present for communications and power.

3. In some areas, primarily at road crossings, the existing above ground utilidor system transitions to a belowground system to allow vehicle circulation through the Station. These belowground crossings utilize a culvert system to convey the utilities to the other side of the road or obstruction. In a few instances, Arctic pipe systems and metal conduit are directly buried beneath the soil. In other instances, such as fuel lines, outer casing pipes are placed around the interior carrier pipe and then this double-piped system is directly buried beneath the soil.

B. Concept of New Utilities System

1. With the implementation of the McMurdo Master Plan (MP), Pre-AIMS, and AIMS projects, a series of new facilities will be constructed to support the NSF's mission. The primary goal of the new construction to upgrade facilities is to increase efficiency of operations and the research mission at the Station. Several existing facilities will be demolished as new facilities are constructed and brought online. NSF's requirements for the Station's capabilities will remain the same so all activities currently supported in the existing Station will be present in the new facilities, and will be expected to be performed more efficiently. The Station's utility network will be modified to meet the new goals and facilities, including removing and replacing elements of the existing utility distribution systems.

2. The purpose of this Utilities design is to serve the new facilities as they are brought online and to continue services to existing facilities. Some existing facilities will remain in the final Station condition (i.e. after AIMS and MP completion) while other existing facilities will continue to support the NSF science mission until they are replaced by new facilities and subsequently demolished.

   This Project focuses on the exterior utility distribution systems at the Station, no work associated with this Project will occur within the existing Station production facilities (Power Plant Building 196, Water Treatment Plant Building 198, and Wastewater Treatment Plant Building 199 (WWTP)), unless otherwise noted. The current treated water production, current wastewater loading and treatment, and the current power production remain as they are today.

3. The routing of new utilities as proposed in this design is based on the current understanding of Pre-AIMS and AIMS construction and facility phasing (see Section 1, Part B).

4. Merrick & Company established high-level goals in generating this design including:

   a. Reduction of reliance on heat tracing for primary freeze protection.

   b. Design of looped water system where possible to provide redundancy and more robust infrastructure in case of emergency or maintenance.

c. Standardization of systems to reduce spare part inventory (and associated allocated space) and to reduce the training necessary to maintain systems.

d. Reduction of energy usage (e.g., heat loss from outdoor runs of the hydronic loop).

e. Efficient planning for location and utility needs associated with both existing and proposed facilities, understanding that some existing facilities will persist well into the future and others will only remain active until new facilities allow for their demolition.

f. Fully supporting new and existing facilities at the end of each constructed phase without reliance on future phases to complete a system.

g. Eliminating or mitigating potential conflicts between phased facility construction and existing facilities which need to remain operational.

h. Maximizing reliance on gravity for sanitary sewer mains. (New alignments will be placed at slopes greater than 0.5% prescribed in the IPC.)

i. Reduction of pedestrian and vehicle conflicts with the utility distribution systems.

5. To the maximum extent possible, this design will incorporate Station utility runs (utilidors) within new facilities. This approach takes advantage of the ambient building heat for the utilities for freeze protection, which lessens heat trace energy needs. This approach results in a reduction of per-foot cost of piping results, since internal utility runs will not need heat trace, insulation or CMP exterior jacketing. Further, efficiency and safety are gained through the ability to perform maintenance and repair for a larger portion of the overall utilities network in all weather conditions.

6. In locations where utilities cannot be placed within buildings, aboveground utilidors, belowground concrete utility trenches, and direct-bury utility mains (in a small area supporting the GC Staging Area), are designed in descending order of desirability.

   a. Aboveground utilidors will look much like the current systems in use at the Station currently, with Arctic piping and cable trays installed on pipe racks and stanchion supports. Some aboveground locations in this Project will install new utility lines on existing utilidors.

b. A below grade pre-cast concrete utility trench, consisting of a box culvert with a removable lid, will be a method of conveying underground utilities. The utility trench will be composed of pre-cast sections placed at prescribed grades. Depending on location and surrounding grade, the trench will be either partially-buried or fully-buried (primarily at road crossing locations).

7. For water, sewer, and heat loop systems, Arctic pipe systems with insulation and heat trace (as backup freeze protection) are designed for all culvert chase and direct-bury locations. Communications conduits in a direct-bury application will also have heat trace installed as backup freeze protection. Pipelines without insulation or heat trace will be the norm for fuel lines since there is no risk of freezing. All Arctic pipe systems are proposed to be CMP-jacketed, whether they are above ground or below. Specific information on each utility system is further defined in the paragraphs below.

C. Analysis of Pre-AIMS Utility Needs

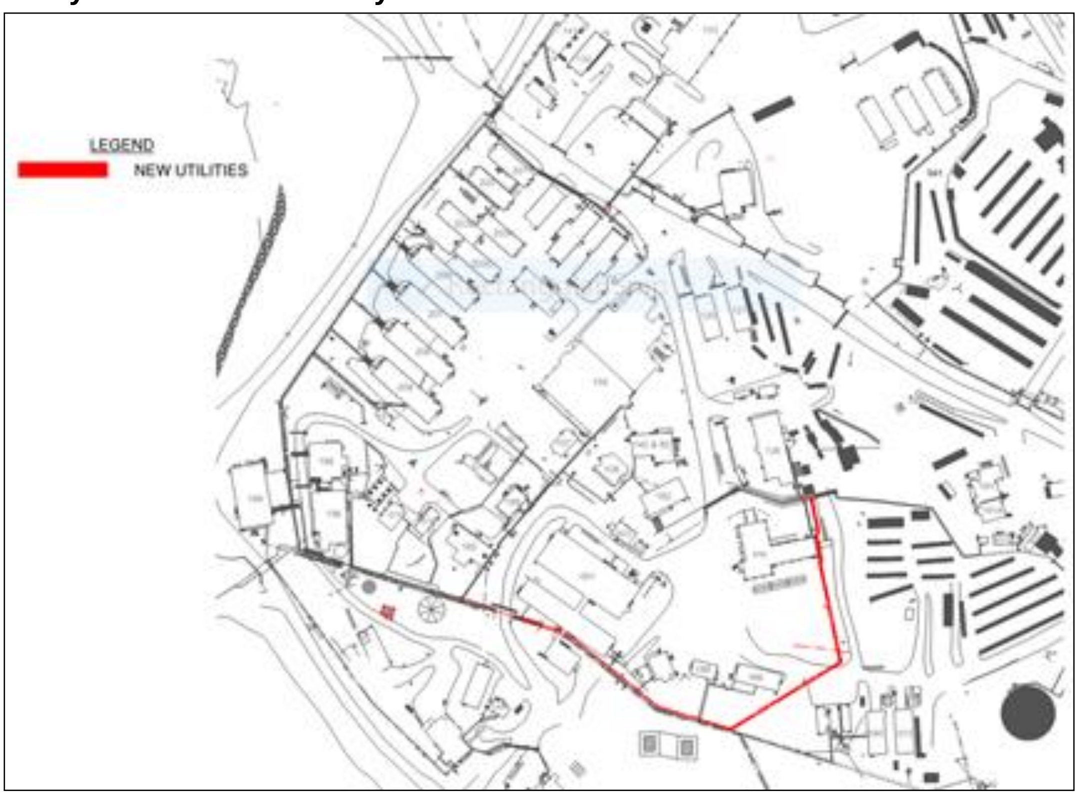

Figure 2.1 Site Plan

1. Information Technology & Communications (IT&C) improvements

   Site and civil support for IT&C consists of siting and grading new node building locations. Refer to Pre-AIMS drawings for further information on the IT&C design scope.

2. New Utilidor Configuration

   As part of the pre-AIMS work, a new utilidor will be constructed to support IT&C Primary, existing Building 136, and the existing Building 191 area. This utilidor will tie into existing utilities just northeast of existing Building 004. New utilities will then proceed aboveground to the south (east of Building 004), go beneath the existing roadway in a concrete utility trench, daylight to aboveground south of Building 166, and tie into the existing utilidor in this area. When this new utilidor is completed, the existing utilities currently between Building 004 and Building 182 will be removed. Alternatively, a portion of the existing utility piping can be cut, capped, and preserved for future tie-in potential when Core Facilities construction is complete.

3. Water Supply and Distribution

   In the new utilidor configuration, an 8-inch diameter HDPE water main carrier pipe (within an Arctic pipe system) will connect the existing 6-inch bond strand carrier pipe northeast of Building 004 to the existing 6-inch bond strand carrier pipe south of Building 166.

4. Sanitary Sewer

   In the new utilidor configuration, a 6-inch diameter HDPE sewer main carrier pipe (within an Arctic pipe system) will connect the existing 6-inch bond strand carrier pipe northeast of Building 004 to the existing 6-inch bond strand carrier pipe south of Building 166. As a part of this work, the existing sewer services for Building 136 and Building 004 will be modified to drain to the northeast through the new utilidor configuration.

5. Fuel Distribution

In the new utilidor configuration, a 4-inch diameter steel main (no Arctic pipe necessary for fuel) will connect the existing 4-inch steel fuel main northeast of Building 004 to the existing utilidor south of Building 166. For the fuel system, an extension to the west will be necessary, as there is no existing fuel distribution south of Building 166. The new fuel main will extend westbound from the Building 166 area as an addition to the existing pipe rack and utilidor. It will continue west beneath Building 001 (Crary), cross under two vehicle traffic corridors through existing culverts, and ultimately tie in to the existing fuel main south of Building 165.

6. Hydronic Distribution

In the new utilidor configuration, 4-inch diameter polypropylene random copolymer (PP-R) carrier pipes (one each for supply and return), within an Arctic pipe system will connect the existing hydronic supply and return mains northeast of Building 004 to the existing utilidor south of Building 166. For the hydronic system, an extension to the west will be necessary, as there is no existing hydronic system south of Building 166. New lines will extend westbound from the Building 166 area as an addition to the existing pipe rack and utilidor. They will continue west beneath Building 001 (Crary), cross under one vehicle traffic corridor through an existing culvert, and tie-in to the existing dead-end fittings near the Crary hydronic service lines.

D. Grading and Drainage

1. Grading

The majority of aboveground utilidors associated with this Project will require little to no grading for construction. There will be areas where existing grades will need modification to support the new utilities configuration, nodes, and appurtenances, but the amount of earthwork will not be significant.

New buried concrete utility trenches will require excavation for construction. To the extent practical, the concrete utility trenches will be installed at, or as close to, existing grades in order to limit the amount of excavation required. Backfill placed over the buried concrete utility trenches will be completed to smoothly match surrounding final grades.

Grading associated with the siting of node buildings and the new routing for electrical and comm lines along the goat path will be required as part of this Project.

2. Drainage

This PreAims portion of the Project will not address drainage issues.

E. Utilidor Concept

1. Aboveground Utilidor

Most locations in this Project will place new utilities aboveground, similar to the way they currently exist on Station. Two concepts are utilized for aboveground utilidors: attachment to or utilization of existing pipe racks and construction of new pipe racks nearly identical to the ones currently in use.

2. Belowground Utilidor

Several concepts associated with accommodating underground utilities at the Station were considered and evaluated by this Project design team. Despite potential drawbacks, underground utilities must exist on Station to allow vehicle circulation. Additionally, some Master Plan facilities and their vertical relationships to existing grade warrant sections of underground utilities, as does the high-level goal of capitalizing on gravity flow to avoid pumping stations.

Belowground utilidor options considered varied from large cross-section, fully walkable culverts to direct burial of utility lines. Evaluating the options, including discussions with Station operations and maintenance personnel, this Project design of all belowground utilidors (concrete utility trenches) will consist of buried pre-cast concrete box culvert sections of a size just adequate to transmit the necessary utility lines. They will feature a removable concrete lid to facilitate maintenance and repair activities, when necessary. This concept is currently in use on the Station at several roadway crossing locations, and, according to discussions with maintenance personnel, is a desirable way to both keep utilities underground and yet accessible when necessary. Utilization of the removable lid will require minimal excavation, where it then can be removed with integral pick hooks.

SECTION 3 STRUCTURAL

A. Design Criteria

1. The utility support structures are classified as Risk Category IV structures for wind and seismic per ASCE 7 and IBC 2015.
2. Dead Loads: Dead loads include the weight of all permanent materials and equipment supported in or on a structure, including the structure's own weight.
3. Live Loads: Minimum live loads are in accordance with IBC and ASCE 7 as follows:

AREA	LOADS
Pipe Racks	40 psf
Floor Live Loads	100 psf
Platform Live Loads	50 psf
Snow Load (Ground)	40 psf

4. Wind Loads: Wind Speed (Three-Second Ultimate Gust Speed) of 180 mph, Risk Category IV, Exposure D.
5. Seismic Loads: Minimum seismic requirements are in accordance with ASCE 7. The new support structures, classifications and applicable ground motions are determined by their use and geographical location. Within the Station, the Seismic Design criteria is based on the Golder Geotechnical Assessment Report titled Geotechnical Assessment Report, McMurdo Station, Ross Island, Antarctica – Phase II (June 2017).
   a. Seismic Accelerations: Ss = 0.454g, S1 = 0.128g
   b. Site Class = A
   c. Seismic Design Category = C for Risk Category IV Facilities
6. Deflection Criteria
   a. Lateral wind load drift requirements for the steel pipe rack structures will be limited to H/150.
   b. Lateral wind load drift requirements for the building structures will be limited to H/400.

7. Foundation Design Criteria

   a. The designs of support structure foundation systems will be based on recommendations provided by Golder Associates. The allowable bearing capacity for frozen soil is 2100 psf.

   b. Pipe rack support will use pole embedded in bedrock or fill material utilizing passive pressure for lateral resistance.

   c. Passive and active pressure used in the design of foundations are based on the Golder Geotechnical report entitled Geotechnical Assessment Report, McMurdo Station, Ross Island, Antarctica – Phase II (June 2017).

B. Basic Materials of Construction

1. Steel

   a. Structural steel will be ASTM 992 for wide flange beam members, ASTM A500 Grade B Fy= 46 ksi for HSS members, ASTM A53 Grade B for pipe, and ASTM A36 for remaining structural shapes.

   b. Anchor Bolts: ASTM F1554 grade 36.

2. Concrete

   a. 5000 psi for the precast footings.

C. Utility Structures

1. Steel pipe and channel bent support structures will be used for the support of above ground utilities and will be designed to resist lateral loading via pole embedded frames. Design of the lateral load resisting system for this structure will be controlled by wind loading.

2. Prefabricated structures will be used for the Node Buildings. These structures will be slightly elevated above grade and will be supported on wide flange beams and precast footings providing vertical and lateral support of the structures.

SECTION 4 MECHANICAL AND PLUMBING

A. Mechanical and Plumbing Design Criteria

1. Space Design Conditions

   a. Utilidor Cooling: Not Applicable

   b. Utilidor Heating: Not applicable

2. Outdoor Design Conditions

   a. Summer: 50°F DB

   b. Winter: -53°F

3. Energy Sources: The available energy sources are electricity and fuel oil.
4. Design Calculations: Not Applicable.
5. Direct Digital Control (DDC) Systems: Not Applicable.

B. Operation and Maintenance

1. Hydronic utility line water temperatures will be established based on ambient conditions to maximize efficiency.
2. All clearances associated with utilities will be determined to allow for efficient maintenance, repair and replacement of piping, sensors and controls.
3. Access doors will be provided at specific locations to facilitate maintenance within utilidors in locations where utilidor lid removal may cause major Station operations interference.

C. Testing, Adjusting, and Balancing (TAB)

Not Applicable

D. Commissioning

Not Applicable

E. Plumbing System

Not Applicable

SECTION 5 FIRE PROTECTION

A. Fire Suppression Systems

1. This Project will support allowing all Station fire suppression service in the future to be provided through the water distribution mains.
2. Freeze-proof hydrants will be provided in accordance to NFPA requirements.

SECTION 6 ELECTRICAL AND COMMUNICATIONS

A. Electrical Power Systems – Distribution

1. 15kV Electrical service will not be installed as part of Pre-AIMS. Pre-AIMS will install underground power raceways where both power and communication raceways are common within a single trench. Power cable tray support systems will be constructed in Pre-Aims where both power and communication cable tray exist on a common support system in order to minimize rework during AIMS construction. A heat trace cable will be installed in each empty conduit sealed at both ends are ready for AIMS construction. All below grade conduits will be insulated conduits with an internal installed heat trace cable (unconnected). Insulation material will improve future conduit access capability in the even ice is present within the conduit.

2. Each standalone node building power distribution system consists of a 208/120V, 3-phase, 60 amp panelboard. Each node is provided with convenience 120V receptacles, electric heating, and lighting. Electrical service will be provided from an adjacent building scheduled to remain in McMurdo's final build out.

B. Electrical Power Systems – Power Quality and Grounding

1. The grounding system employed for this Project will connect to an established Equipotential Reference Plane (ERP) connected to an existing submerged heavy steel construction tractor in Winter Quarter's Bay as well as a supplemental drill-emplaced steel "electrode" set 20-feet deep just inside the shoreline. The electro conductors are in turn connected to the Power Plant main ground bar. The existing main ground bar connects to the generator and existing grid feeder grounding conductors and will remain as- is during this Project.

2. Building service grounding electrodes will consist of a concrete-encased electrode (UFER) ground system (reference NEC 250.52 (A)(3), in addition to connection to the McMurdo ERP grounding system. Reference Figure 6.1. Where new facilities are located, concrete embedded grounding conductors within the building foundation will be provided and tied to the Station and facility grounding system. Each service transformer grounding electrode will consist of a 12-inch x 20-foot concrete cylinder with an embedded 4/0 copper cable.

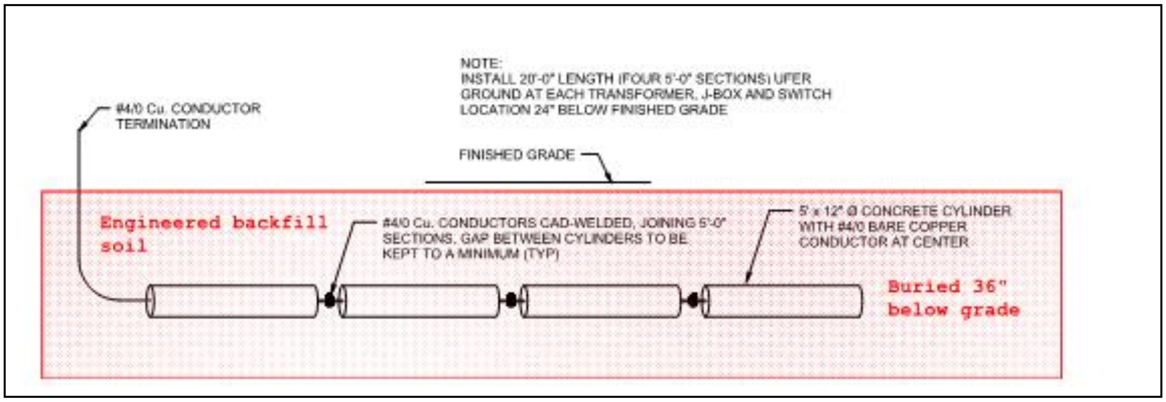

Figure 6.1

3. Each telecommunication node will include a Telecommunication Main Ground Bus (TMGB) where all telecommunication equipment within each node will be bonded to the TMGB with a telecommunication equipment-bonding conductor (TEBC). The TMGB will be bonded to the node electrical panel ground bus, node metallic structure, 20’ concrete encased electrode (UFER) ground, and other node TMGB’s. The telecommunication grounding and bonding will originate at the building service ground and extend to the building’s TMGB. TMGB’s between buildings and nodes will be interconnected with a telecommunication bonding backbone (TBB) green insulated conductor providing grounding equalization between buildings and nodes. Communication grounding standards and techniques applied for this design package are from communication grounding standard J-STD-607-A (Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications. Refer to Figure 6.2.

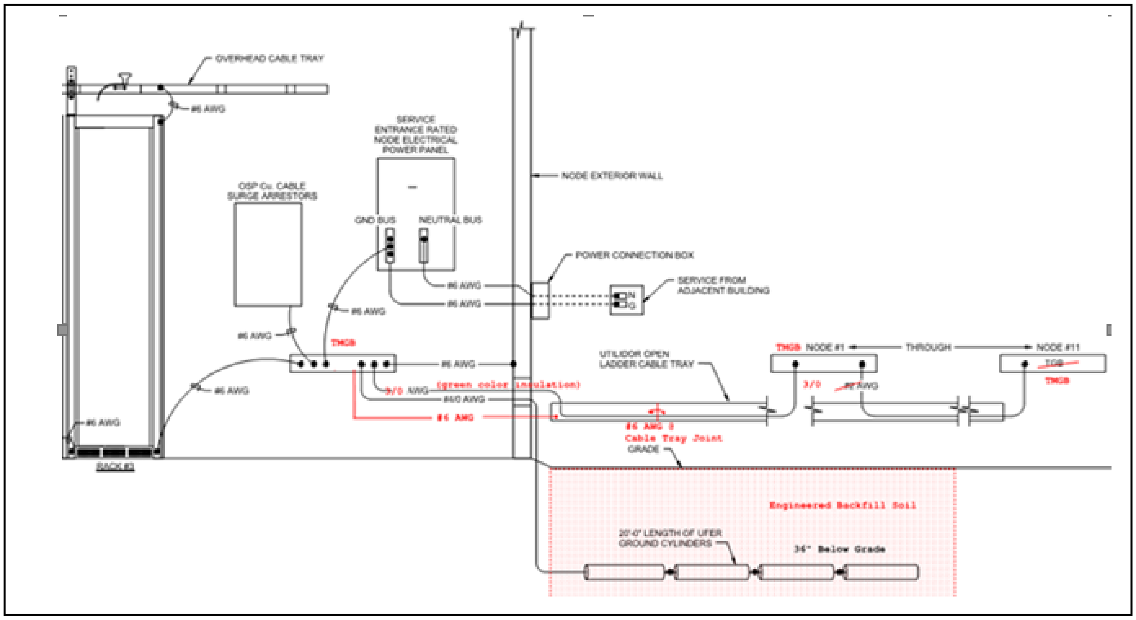

Figure 6.2

4. Earth grounding is difficult to achieve in McMurdo Station for individual buildings due to soil conditions. Single ground rods offer little benefit in high soil resistivity. Soil conditions vary greatly between summer and winter months and it is therefore difficult to achieve optimum building grounding at a local level. McMurdo Station's ERP and the supplemental drill-emplaced steel "electrode" provides a consistent earth reference throughout the year with the installation of electrodes in soil with constant low impedance soil conditions. Therefore, the McMurdo Station ground reference will be extended to all building electrical systems primarily through the 5kV distribution system. Each building will include a counterpoise grounding system interconnected with the McMurdo Station (ERP) ground reference. Communication nodes will include a TBB ground reference that provides a grounding interconnection between nodes and building services for the site. The make-up of the entire interconnecting grounding system between buildings, nodes, and ERP will provide a more suitable ground reference for McMurdo Station as one interconnected ground system. Interconnecting of metallic systems within a building, utilidor, and conductive utilities such as steel piping will reduce stray voltages and minimize touch and step potential hazards.

C. Lighting Systems

1. Exterior conduits will be RMC or LFMC, as appropriate for location and application, with a 3/4-inch minimum trade size. Interior conduits will be RMC, EMT, LFMC or FMC, as appropriate for location and application; also with a 3/4-inch minimum trade size.
2. Electrical wiring installed in raceways, either exterior or interior, will be high-conductivity copper, 600-volt, type XHHW/XHHW-2 of #12 AWG minimum conductor size.
3. An equipment-grounding conductor shall be installed with branch circuit conductors in all raceways.

D. Telecommunication System

1. The outside plant telecommunications system will be installed in two phases. In phase one, Nodes 2, 4, 8, and 10 will be constructed. Infrastructure and cabling between the power plant region, Node 8, Node 10, Node 6 (provided by IT&C Prime contractor), and Node 4 will be constructed. In phase two, Nodes 1 and 7 will be constructed. Infrastructure between power plant region, Node 7, Node 1, and Node 2 will be installed. Cabling between Node 6 (in IT&C Prime) and Node 2 will be provided. Additional cabling will be provided from Node 2 to building 71.
2. The primary outside plant cabling consists of a series of single mode fiber optic and copper cables providing several loops around the site. Primary outside plant cabling terminates in a total of 11 nodes. Four nodes are located within the shell of new facilities: three within the Core Facilities and one within IT&C Prime. Seven stand-alone nodes are provided. Connections from the nodes to individual facilities are provided utilizing a 25 pair copper and 12 pair single mode fiber optic connection. Select facilities have dual telecommunication feeds, originating from two separate nodes.
3. Outside plant cabling will follow the path of the new aboveground and direct-bury utilidors. The cabling will be installed primarily in a cable tray wire management system and connect directly into the buildings.
   a. Air core cable will be used in this Project rather than gel-filled, due to the greater ease of handling and installation. Since all cabling is to be terminated

or spliced in a node or indoor space, the possibilities for water ingress into any cable is minimal. Further, there are cost savings associated with reduced preparation time and clean up, as well as the fact that gel-filled cable needs to be converted to premises cable within a node or indoor space in order to be terminated and connected. Given that real estate is at a premium, the decision not to install splice cases for OSP cables was made for this Project.

b. Copper OSP is typically armored, and due to the potential for flying objects during storm events. In order to mitigate the potential for impact damage, armored optical fiber cable was selected as well. In Chapter 4 of the BICSI OSP Design Reference Manual, guidance is given that “the OSP designer should consider cable bend radius greater or equal to 15 times the cable diameter.”

c. Aluminum cable tray was chosen due to the performance of the material at low temperature. Steel alloys, except stainless steel which would be prohibitively expensive for this type of installation, become brittle in subzero temperatures, and are prone to impact breakage.

4. Stand-alone exterior node facilities consist of insulated pre-manufactured building structures with a single 4-foot personnel access door. The door is weatherproof to not allow any outside air into the facility. In addition, each node facility has a unit heater for those infrequent times when personnel have to occupy the area. A 12-inch ceiling-mounted cable tray with 18-inch radius fittings is installed within the node along the perimeter walls to support the bending radius of a cabling. Each service cable installed within the node structure includes a minimum of one service loop within the node structure before it is terminated in its termination demarcation point.

5. Site communication nodes (10-feet x 13-feet) will be installed at seven remote locations within the McMurdo site. Three additional building nodes located at Building 003, 005 and 006 where all site infrastructure cabling will be terminated. Exterior installed single mode fiber optic (SMFO) cabling will be installed along the site utilidor system and will be routed into communication nodes. Cabling will be terminated on floor rack-mounted 24-port optical fiber entrance patch panels with

SC/APC connectors. Nodes will provide communication services to adjacent buildings providing service with back-up capability between nodes.

6. Similar to fiber optic cables, copper cables will be installed along the site utilidor system, will be routed into communication building nodes, and terminated on wall mounted entrance protector cabinets. Nodes will provide communication services to adjacent buildings providing service with back-up capability between nodes.

7. Plywood telephone backboards are located in each node and have a dedicated Telecommunications Grounding Busbar (TGB) grounding bus with a #3/0 ground conductor tied to the Telecommunications Main Grounding Busbar (TMGB) of the adjacent node buildings. The TGB is bonded to the node power distribution panel board grounding system per J-STD 607-A. Node building service electrical grounding consists of a 12" x 20' concrete cylinder with an embedded 4/0 copper cable grounded to the TMGB ground bus. Telecommunications ground shall be bonded to the node electrical system ground, including the building service ground system, as required by NEC 250.50.

SECTION 7 ARCHITECTURE

1. Guiding Principles

1. Addressing one of this Project's high-level goals, all buildings are designed to provide efficient, durable facilities that both support and reflect the long-term U.S. commitment to responsibly advancing science in Antarctica. Facility design is a direct response to each of the functional and physical requirements of Station operation.

2. Facility design was influenced by the following conditions:

   a. The Telecommunications Node facility is designed to be a modular, prefabricated building that is capable to be efficiently stacked in shipping containers and assembled on-site. The facility, designed by a single manufacturer, is a provided as a "kit of parts" that is put together by one installer.

   b. By placing the small facility on a concrete footing, the structure is capable of being adaptable to varying site conditions.

2. Design of the Node Building

1. Massing

   The facility employs a geometry that minimizes the volume required to accommodate the functions supported by the building. The design consists of a simple box-like structure with insulated panels for the roof and walls, and fire retardant plywood laminated to the insulated floor panels.

   This facility is modular and will arrive at the Station ready to be assembled. It is easily stacked within shipping containers. The facility height is determined by operating clearances of the housed telecommunication equipment. The facility will be elevated above the ground, and with its minimal footprint will allow snow and ice to scour beneath. A detachable platform and stairs provide access, and are designed for snow and ice management using open steel grating walking surfaces.

2. Plan Organization

   For efficiency, the building layout consists of a single room which is compact, yet allows for optimal equipment use and replacement.

3. Building Enclosure

The design is functional, durable, easy to construct, and easily maintainable. Wall, floor, and roof panel systems are comprised of 4-inch thick pre-fabricated insulated metal panels. Panels are of a dimension and orientation that allows for off-site construction, maintains quality during transit, and maximizes efficiency during on-site erection. Roof and wall panels are adjoined with lock connectors. Freezer doors provide an insulation value of R-32 and ensure tight weatherproof seals.

a. Panel Details

The panels for the Node building are sized approximately 11 feet in height and up to 4 feet in width. All panels will be packaged for shipment in a compact "flat-pack." All panels will be erected vertically to achieve quick assembly and to reduce the possibility of water pooling in the seams.

b. Panel Cladding

The exterior sheathing of the wall panels plays a critical role in determining the exterior character and durability of the facilities. Durability, including resistance to abrasion and corrosion as well as snow and ice management, was considered in the selection of panels. The panel design employs a 4-inch thick extruded polystyrene foam insulation which is laminated between 26 gauge galvanized steel covers on both the interior and exterior side of the panel. The insulation value of the panel will be a minimum R-32. The edges of the panels will be CNC (Computer Numeric Control) machined tongue and groove to assure a controlled tolerance on the seam connections. The panels will be sealed at the joints with double beaded vinyl gaskets on both the interior and exterior surfaces. The vinyl gasket will overlap the edges of the metal cover to ensure a positive seal. The panels will be mechanically joined using cam-lock connectors engaged with a single hex wrench. Relatively high UV exposure at the Station resulted in the selection of a Kynar finish that better withstands fading. A limited color palette of white and grey will be used.

4. Comparison to AIMS Telecommunications Node Buildings

Both PreAIMS and AIMS node facilities will be a family of identical units located throughout the Station grounds. Each facility will be placed on a structural platform providing the required elevation above grade, and is adaptable for variable terrain at individual erection locations.

5. Interiors of the Node Building

The Node building interior follows the same guiding principles as its exterior and highlights durability, ease of maintenance, and maximum equipment utilization.

Interior walls and ceilings are the backside of the insulated metal panels and the finish will be white enamel applied by the manufacturer. Exposed interior structural framing is unfinished. Flooring fire retardant plywood laminated to the insulated wall panels and finished with a commercial grade floor tile with vinyl cove base.

The door frame is pre-finished by the building manufacturer to match the panel system. The entrance door of the buildings are weather sealed, 23 gauge insulated metal doors with a Lever lockset, latch-guard and drip caps. Associated with the door is one pre-wired, vapor proof light fixture

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SECTION 8 ENVIRONMENTAL COMPLIANCE

A. Environmental Protection Compliance

This section to be provided by Leidos ASC.

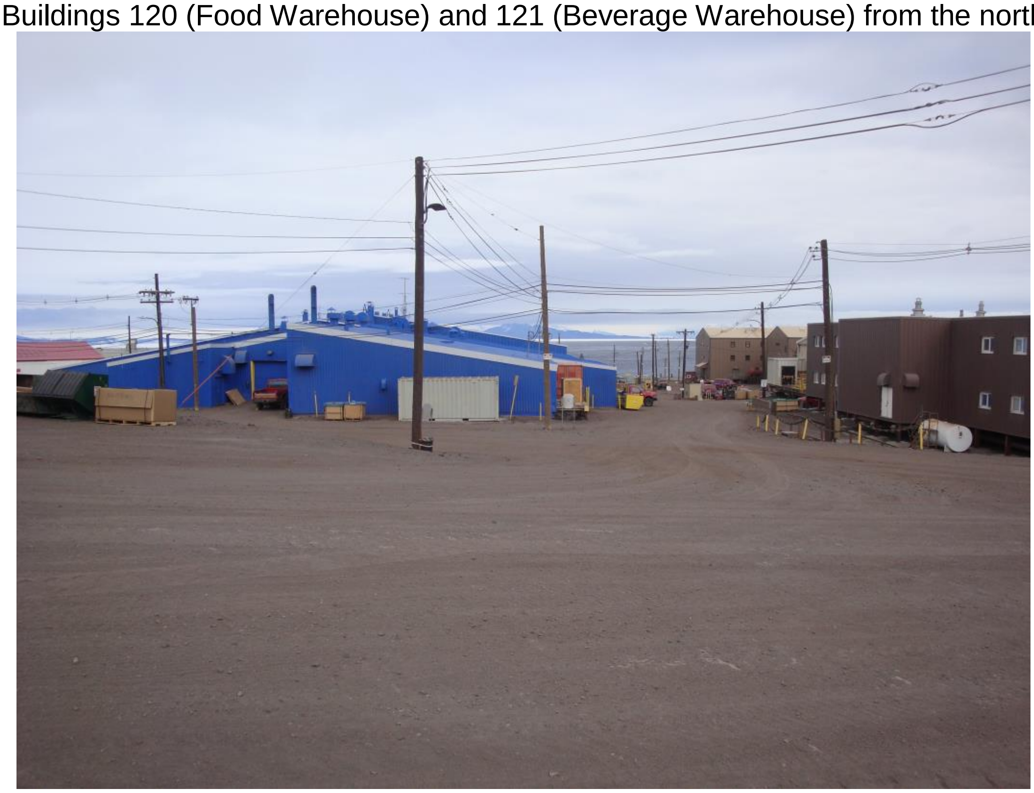
SECTION 9 APPENDICES

APPENDIX 1 SITE PHOTOGRAPHS

Observation Hill looking northwest into town

Building 155 from the northeast with Building 120 (Food Warehouse) in the foreground

Buildings 120 (Food Warehouse) and 121 (Beverage Warehouse) from the north



Building 155 from the NE with Building 211 (Lodging) on the right, looking SW along corridor to Derelict Junction

Building 155 from the NE with Building 211 (Lodging) on the right, looking SW along corridor to Derelict Junction and Building 007 (Chapel of the Snows)

NE corner of Building 155 looking SW with Building 142 (MAC Medical) on the left

Building 155 from the east

Building 155 from the east with Building 142 (MAC Medical) on the left

Building 136 (Trade Shop) from the northwest

Building 142 (MAC Medical) from the east

Building 182 (Fire House) from the northeast

North face of Building 001 (Crary Lab) from the east

Utilidor looking north with Building 107 (Southern Exposure) and Building 155 in the background

Utilidor pedestrian bridge looking NW with Building 107 (Southern Exposure), Building 155, and uppercase lodging in the background

Utilidor looking SW with Building 189 (JSOC) in the foreground and Building 165 (MAC OPS) in the background

Building 165 (MAC OPS) looking west with Building 010 (Hut Ten) and Building 007 (Chapel of the Snows) in the background

Looking NE through Derelict Junction with uppercase lodging on the left and Buildings 155, 076 (Coffee House), and 078 (Gym) on the right

Buildings 155 and 078 (Gym) from the southwest

Derelict Junction looking NE with Buildings 206 (Lodging), 203 (Lodging), 164 (Frozen Food Warehouse), and 155 in the background

Looking north at Buildings 208, 207, 206, and 203 (all Lodging) and 164 (Frozen Food Warehouse)

Derelict Junction looking east toward Observation Hill with Buildings 155, 107 (Southern Exposure), and 078 (Gym)

Derelict Junction looking NE with Building 164 (Frozen Food Warehouse) on the left and Building 155 on the right

Derelict Junction looking SW with Buildings 78 (Gym), 007 (Chapel of the Snows), and 209 (Lodging) in the background

Looking NE with Building 211 (Lodging) on the left and Building 155 on the right

Looking SW at Building 007 (Chapel of the Snows) with Building 155 on the left and Building 211 (Lodging) on the right

Utilidor east of Building 189 (JSOC) looking northeast at Building 155

Utilidor looking north at the south corner of Building 155

Looking NW at Building 155 and Building 120 (Food Warehouse)

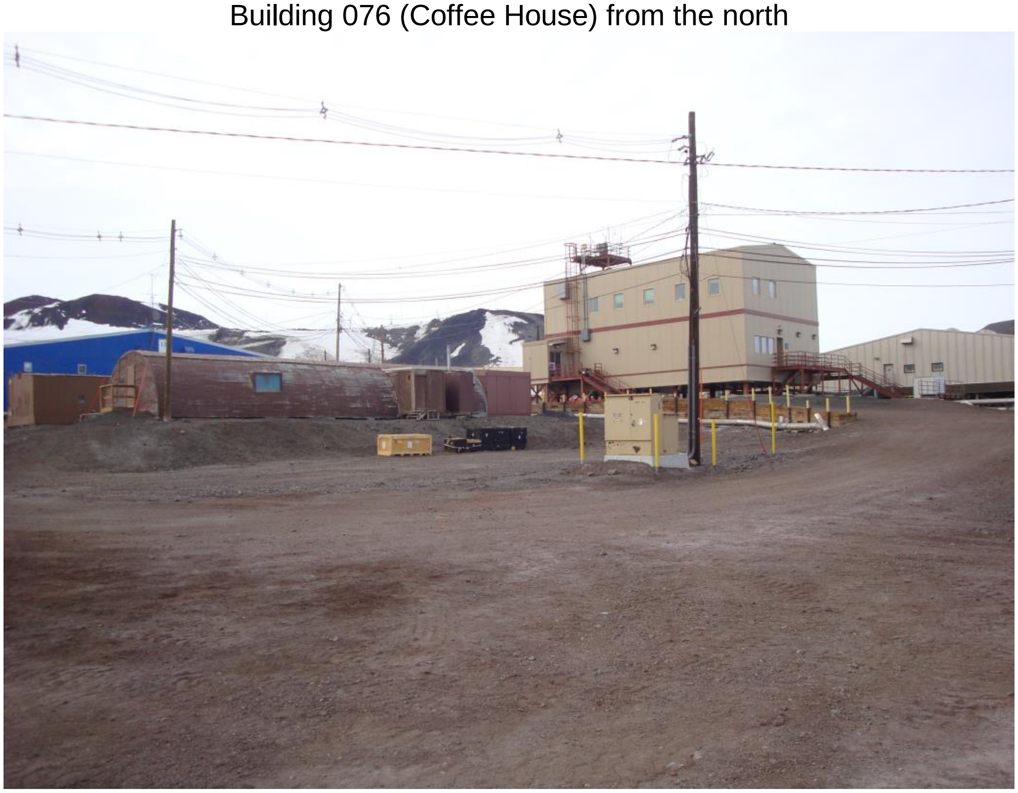
Looking SW with Buildings 142 (MAC Medical), 108 (Gallagher's), 189 (JSOC), and 155 in the background

Looking west from south platform of Building 155 with Building 107 (Southern Exposure) and uppercase lodging

Looking SE from south platform of Building 155 with Building 108 (Gallagher's) and Building 001 (Crary Lab) in the background

Looking south from south platform of Building 155 with Building 107 (Southern Exposure), Building 001 (Crary Lab), and Building 189 (JSOC) in the background

Building 076 (Coffee House) from the north



Looking east at Buildings 076 (Coffee House), 189 (JSOC), and 001 (Crary Lab)

TECHNICAL MEMORANDUM

July 29, 2016

TO: Brandon Neahusan, Antarctic Support Contract (ASC) Project Manager

FROM: Christine Lurtz, PMP, Merrick & Co. Project Manager

CC: Eric Hein, PE, Merrick Civil/Water Engineer and Kevin Breslin, PE, FPE, Merrick Fire Protection Engineer

SUBJECT: **McMurdo Utilities Infrastructure Design**
Fire Flow Criteria Determination for Water System Design

INTRODUCTION

Merrick & Company and Michael Baker International (collectively known as the Architecture/Engineering (A/E) Team) are under contract to provide 100% design documents for the McMurdo Utilities Infrastructure Design. As part of the McMurdo Utilities Infrastructure Design, an upgraded water system will provide fire protection storage and distribution to support the series of new facilities at McMurdo Station that will be constructed as part of the McMurdo Master Plan and AIMS projects. The design fire flow is an important design criteria that the A/E needs to determine in order to progress their design.

The purpose of this memorandum is to facilitate establishing the design fire flow for the project. Alternative codes for calculating fire flow are presented for comparative purposes, constraints of firefighting at McMurdo Station are reviewed, and a recommendation is made for an adequate design fire flow and associated storage to serve McMurdo Station.

ASSUMPTIONS

- Fire protection capabilities of the new system will meet or exceed the capabilities of the existing system, so that existing buildings not programmed for demolition will be provided with equal or better protection.
- All new buildings will be sprinklered in accordance with National Fire Protection Association Standard 13 (NFPA 13). Fire sprinklers provide an excellent first line of fire fighting offense and can greatly reduce the water input provided manually by fire crews.
- The largest floor area enclosed by fire-rated separation walls within a new facility is 38,600 square feet, at the Industrial Trades Shops (Trades).
- All new buildings will be of fire-resistive construction (IBC Type IIB or better).

- McMurdo Station has a fire pumper truck with an on-board pump rated at 1,250 gpm, based on information provided by Neel Pahl, McMurdo Station Fire Chief.

FIRE WATER DEMAND BASED ON CODES

The following analysis reviews fire demand requirements based on various alternative codes that may be interpreted to apply. The analysis results in different fire flow values that can be compared with each other to reach a reasonable single value that can be used for design. A reasonable value may not necessarily be the highest value.

1. NFPA 13, Standard for the Installation of Sprinkler Systems, 2016 edition:
   - The Warehouse building is the most stringent building under this code analysis. If adequate fire protection is provided for the most stringent building, adequate fire protection will therefore be available for all other buildings.
   - The applicable part of this code is Chapter 12 for General Requirements for Storage and Chapter 16.2 for Protection of Class 1 through Class IV Commodities. The following assumptions are made. These assumptions will be made design criteria for architectural design and layout of the warehouse space.
     - Storage height: 20 feet
     - Commodity Class: II
     - Encapsulated: No
     - Aisle width: 8 feet
     - In-rack sprinklers: No
     - Ceiling sprinklers: Yes
     - Sprinkler temperature (ordinary or high): Ordinary
     - Design area of sprinkler operation (2,000 to 3,000 SF allowed): 2,000 SF
   - Based on Figure 16.2.1.3.2(b) Curve F and Figure 16.2.1.3.4.1, the required ceiling sprinkler density is 0.375 gpm/SF. The design sprinkler flow is therefore 0.375 * 2,000 = 750 gpm.
   - In accordance with paragraph 12.8, an inside hose allowance of 100 gpm is required. Per table 12.8.6, an additional outside hose allowance of 500 gpm is also required.
   - The fire flow duration is 120 minutes (2 hours) in accordance with table 12.8.6.
   - The total required fire flow based on NFPA 13 is <u>1,350 gpm</u>.

2. NFPA 11, Standard for Low, Medium and High Expansion Foam, 2016 edition
   - This code pertains to foam firefighting of fires at the oil tank farm.
   - The following assumptions are made:
     - The diameter of the largest petroleum, oil, lube (POL) tank is 120 feet, based on record drawing information.

- Per Table 5.2.4.2.2, the minimum application rate for tanks containing JP-5 is 0.16 gpm/SF. This results in a total flow of 1,800 gpm.
- The fire flow duration is 50 minutes in accordance with Table 5.2.4.2.2.
- The total required fire flow based on NFPA 11 is 1,800 gpm.

3. NFPA 1142, Standard on Water Supplies for Suburban and Rural Fire Fighting
   - We believe this code does not apply for the following reasons:
     - Per paragraph 1.1.1, NFPA 1142 applies to sites where "adequate and reliable supply systems for fire-fighting purposes" do not exist.
     - Per paragraph 1.1.2, "An adequate and reliable municipal-type water supply is one that is sufficient every day of the year to control and extinguish anticipated fires in the jurisdiction, particular building, or building group served by the water supply."
     - Per paragraph 3.3.16, a Municipal-Type Water System is a system having water pipes servicing fire hydrants and designed to furnish, over and above domestic consumption, a minimum of 250 gpm residual pressure for a 2-hour duration.
     - It is our interpretation that the water system upgrades proposed under this project will meet the definition of an "adequate and reliable municipal-type water supply" that will satisfy the site's fire protection demands. Therefore, NFPA Standard 1142 does not apply.

4. International Fire Code (IFC) Appendix B, Fire Flow Requirements for Buildings, 2012 edition
   - The Trades building is the most stringent building under this code analysis. The largest floor area encompassed by rated fire walls is 38,600 SF. Building construction is Type IIB.
   - Based on IFC Appendix B, Fire Flow Requirements for Buildings, the resulting fire flow per Table B105.1 is 4,250 gpm.
   - Paragraph B105.2, Buildings other than one- and two-family dwellings, allows a fire flow reduction for buildings equipped with fire sprinklers. All new buildings at McMurdo Station will be equipped with fire sprinklers and the reduction should be taken accordingly. The resulting fire flow is therefore 1,100 gpm. However the code specifies that the fire flow after the reduction is taken cannot be less than 1,500 gpm.
   - The total required fire flow based on IFC Appendix B is 1,500 gpm.

DISCUSSION OF PRACTICAL FIRE FIGHTING APPROACHES AND CONSTRAINTS

Setting codes aside, from a practical point of view it should be recognized that McMurdo Station is a unique installation from the standpoint of weather, type of building construction, and firefighting approaches. **Direct application of codes developed for the mainland United States may not necessarily apply on all levels.** For example:

- It does not make sense to make available a fire flow rate in excess of the flow rate that can realistically be applied by fire sprinklers and firefighting crews based on actual practices and equipment in the local environment.
- Water distribution and storage systems that are oversized can result in operational, maintenance, and health and safety risks and inefficiencies that could outweigh any additional benefit to firefighting.
- Over-application of water during a fire event could be harmful to structures, due to temperature (freezing water and ice can further damage buildings or render them unoccupiable for a longer duration), and because of building construction techniques (structural floors elevated above the ground could collapse if over-loaded with pooling water).
- Higher cost of oversized systems is a significant issue when capital budget is limited.

The water system should be right-sized, not oversized, for fire protection needs.

Site-specific considerations for determination of a design fire flow should include the following:

- Fire sprinklers are highly effective at extinguishing fires on their own, or would otherwise significantly reduce the flow of water needed via manual delivery by firefighting crews operating from the fire truck and hydrants. Gallon for gallon, sprinklers provide a much higher level of water use efficiency than manual firefighting. All new and remodeled buildings will be equipped with NFPA 13-compliant fire sprinkler systems.
- The McMurdo Fire Department has the capability to deploy hoses from the pumper truck to draw directly from the ocean as a supplemental supply of water for firefighting.
- Manual firefighting approaches are most likely to involve in-building operations, which limits the flow of water that can be applied by its operational nature. Typical fire department handheld hoses deliver an estimated 150 gpm each. Assuming three hoses are brought to bear on a fire inside a building, operated by 6 fire crewmembers (two on each hose), the maximum flow associated with hose use is 450 gpm. This flow is in addition to sprinkler flow through a limited number of “popped” (activated) sprinkler heads in the vicinity of the fire. Flow is limited.

- A high-capacity fire truck supported nozzle (estimated to be 600 gpm) brought to bear on the exterior face of a building is less likely to be used in the local environment, based on assumed application challenges in low temperatures and since building shells are constructed of fire-resistive materials. Building fires are likely to be fueled by building contents (requiring interior firefighting methods) rather than the buildings themselves.

RECOMMENDATION

Based on the considerations discussed in this memo, Merrick recommends the following fire protection criteria be used in the design of the water system:

- Fire Flow = 1,500 gpm
- Flow Duration = 120 minutes
- Fire Storage Volume = 180,000 gallons

We believe that these criteria meet a reasonable and balanced code interpretation, are adequate to protect McMurdo Station from foreseeable fire events, and appropriately balance fire protection needs with other considerations of the water system design (operational and maintenance costs, health of Station personnel related to water age, and available capital funding).

Christine Lurtz

From:	Christine Lurtz
Sent:	Tuesday, July 19, 2016 11:00 PM
To:	Kevin Breslin; Eric Hein
Cc:	Aaron Seal; Brendan Ahern; Orlando Trujillo
Subject:	FW: Fire Flow Requirements

All,
Please see below and include this information in your design / calcs / recommendations / pricing going forward. Thanks. CL

Christine Lurtz, PMP, NCIDQ, LEED AP | Project Manager **|** Merrick & Company
T: 210-446-4314 **| C:** 720-317-3674 **|** www.merrick.com

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From: Neahusan, Brandon (Contractor) [mailto:Brandon.Neahusan.Contractor@usap.gov]
Sent: Tuesday, July 19, 2016 7:06 AM
To: Christine Lurtz <Christine.Lurtz@Merrick.com>; Aaron Seal <Aaron.Seal@Merrick.com>
Subject: FW: Fire Flow Requirements

From: Hilden, James (Contractor)
Sent: Monday, July 18, 2016 5:29 PM
To: Winkler, David (Contractor); Neahusan, Brandon (Contractor); Gassman, Jim (Contractor)
Cc: Epperson, Mike (Contractor)
Subject: FW: Fire Flow Requirements

Gents,
Recommendations from the Fire Chief regarding our firewater discussions this afternoon.

Regards,

James

From: Pahl, Neel (Contractor)
Sent: Monday, July 18, 2016 4:45 PM
To: Hilden, James (Contractor)
Subject: Fire Flow Requirements

Hi James,

I wrote all of this code info based on the conversation today given the available standards. I guess the bottom line is that my position is always advocating following the standards. I know that there are other opinions in the room based on practical, financial, logistical and other constraints that may well be perfectly valid. I feel that it falls to those other people to justify why we aren't going to follow the standard. I don't want the reason to be that "we think the standard is too demanding so we're just not going to".

NFPA Standards 1142 and 11 are my go to sources, and they are what I would like to see. Below are my thoughts and back of the cocktail napkin calculations, but ultimately it will be for the engineers to figure these now, and again every time the designs changes, keeping in mind that that this isn't just for the core facility. This will need to be calculated for every building and make sure that the required fire flows are available at each respective location

Thanks

Neel

- NFPA 1142 and ISO both have guides or calculating the needed fire flow for designing a water supply for structural fire protection. The ISO version is a little more involved. The NFPA version is pretty straight forward, and I could calculate an approximate number if I had the volume of the structure. A similar exercise will need to be done for the VEOC other facilities to make sure that the water supply is adequate at those locations also.

- I need to know the diameter of the largest POL tank, but if it is 60 feet then the water/foam application rate is 1421 GPM for 50 minutes (This comes from NFPA 11).

- All this being said, I know that I might get overruled on any or all of this. The AHJ has the prerogative, per the standard, to reduce the fire flow requirements were the building is protected with an NFPA 13 compliant system (which it presumably will be). It also gives them the prerogative to increase the requirements for any of these reasons (some of which are applicable and worth contemplating).

    1. Limited fire department resources
    2. Extended fire department response time or distance
    3. Potential for delayed discovery of the fire
    4. Limited access
    5. Hazardous vegetation
    6. Structural attachments, such as decks and porches
    7. Unusual terrain
    8. Special uses and unusual occupancies

- Also, I have confirmed that our fire trucks have 2x 6" water inlets (one on each side of the truck), in addition to 3x 2 ½" inlets. They definitely have pump capacity, inlets, and discharges rated to 1250 GPM under the NFPA 1901 standard pump conditions.

MERRICK & COMPANY

TECHNICAL MEMORANDUM

August 9, 2016

TO:	Brandon Neahusan, Antarctic Support Contract (ASC) Project Manager
FROM:	Christine Lurtz, PMP, Merrick & Co. Project Manager
CC:	Eric Hein, PE, Merrick & Co. Civil/Water Engineer
SUBJECT:	**McMurdo Utilities Infrastructure Design** **Water Storage Tank Capacity Recommendation**

INTRODUCTION

Merrick & Company and Michael Baker International (collectively known as the Architecture/Engineering (A/E) Team) are under contract to provide 100% design documents for the McMurdo Utilities Infrastructure Design. As part of the McMurdo Utilities Infrastructure Design, an upgraded water system will be provided to serve the station. As part of the design basis development, a determination is needed on the volume of water storage that will be provided.

The purpose of this memorandum is to provide a rational discussion for sizing the total storage for the site, present a recommendation, and facilitate decision making by the NSF to identify the storage capacity that should be carried forward for design and implementation.

Total water storage capacity at McMurdo Station needs to satisfy two purposes:

1. Provide storage volume that will be maintained for firefighting reserve. This quantity of water is referred to as "fire storage".
2. Provide storage volume that will be used to meet domestic demands of the station, or "domestic storage".

FIRE STORAGE

Fire storage volume is a function of the fire flow and duration. In a Technical Memorandum entitled "Fire Flow Criteria Determination for Water System Design" prepared by Merrick dated July 29, 2016, a fire flow of 1,500 gpm for 120 minutes was recommended as the design basis fire flow for the Station. We believe that this criteria is supported by code, is adequate to protect McMurdo Station from foreseeable fire events, and appropriately balances fire protection needs with other considerations of the water system design (operational and maintenance costs, health of Station personnel related to water age, and available capital funding).

The corresponding fire storage volume is therefore 1,500 gpm x 120 min = 180,000 gallons. This is the volume of water that will normally be maintained at all times in the water tanks, and will be readily available should an unexpected fire event occur.

DOMESTIC STORAGE

The purpose of domestic storage is twofold:

1. Manage daily diurnal demands.
2. Supply water in times of water production outage, ideally while minimizing use of the fire storage reserve.

Daily Diurnal Demands

Domestic demands fluctuate thorough the day, depending on the level of activity of station inhabitants. Typically demands are at their lowest during the night, when inhabitants are sleeping. Demands usually peak in the morning while inhabitants are showering and getting ready for the day. Demands drop off somewhat in the middle of the day, and may peak again in the evening. Also demands may fluctuate depending on day of the week, and from week to week. Since the water production equipment produces water at a constant average daily rate, the water volume in the storage tank will vary; draining during peak hours when demand exceeds production, and filling during off hours when production exceeds demand.

Accepted sizing parameters for equalizing diurnal flow is to provide a volume equal to 40% of the total daily flow. For McMurdo Station, the peak average daily flow is assumed to be 65,000 gallons. The minimum volume that should be made available for equalizing diurnal demands is therefore 25,000 gallons.

Emergency Domestic Storage

Due to the remoteness of McMurdo Station and its inaccessibility during extended periods of the year, it is prudent to provide a volume of water that can meet domestic demands should there be an emergency outage of the seawater intake or treatment equipment, which halts new water production. In an extreme case, an outage of the facilities might not be repairable without outside resources or in a reasonable short period of time, and so it is assumed an emergency evacuation of inhabitants could be necessitated. The water system must therefore supply a minimal amount of water for human needs until an evacuation can be completed. Ideally the water can be supplied while minimizing use of any fire storage water, so that fires can be fought as well. A catastrophic emergency that requires evacuation and at the same time renders water production equipment inoperable could include a large fire.

For this analysis, the following assumptions are made:

- In the event of emergency, emergency water restrictions would immediately go into effect, and remain in effect until an emergency evacuation can be completed.
- Emergency water restrictions can be stringent given the seriousness of the situation in that environment, and would include suspension of bathing, laundry, cleaning and maintenance activities, and rationing of toilet flushing.
- According to the World Health Organization (WHO), the minimum amount of water that should be provided per capita per day in emergency situations is 4 to 5 gallons. This quantity is sufficient for drinking and food preparation, but not for bathing or other non-essential activities.
- The maximum station population in the summer season is 1,000 persons.
- An emergency evacuation will take 2 weeks to substantially complete, during any time of year.

Based on these assumptions, a reasonable volume of water that can be made available for an emergency is 1,000 persons x 5 gpcpd = 5,000 gallons per day x 14 days = 70,000 gallons. Note that this volume is conservative since the population will be decreasing during the course of the evacuation, and it is likely possible to get by on fewer gallons per capita per day.

Also the Station has a portable RO unit that can be used during emergencies to produce 10 gpm, or 14,000 gpd. It is assumed the RO unit can be made operational during any time of year, can be placed in any suitable location around the Station (where unaffected by the emergency), access to raw seawater can be provided for the suction hose (even through sea ice during winter by ice coring or melting with a hotsy), and portable boilers or heaters can be employed for seawater pre-heating. The daily production of the portable RO unit (14,000 gallons) exceeds the maximum daily water demand during emergencies (5,000 gallons), so potentially the unit could supply emergency water demands indefinitely until an evacuation can be effected.

RECOMMENDATION

Based on the considerations discussed above, Merrick recommends a total of 250,000 gallons of water storage be provided for McMurdo Station. This volume is sufficient to meet the recommended fire storage of 180,000 gallons, and provides 70,000 gallons for managing domestic and emergency demands. The four existing 50,000 gallon tanks are proposed for re-use, and one new 50,000-gallon tank is proposed. For the dual water system, 100,000 gallons would be allocated to the drinking water system, and 150,000 gallons allocated to the reuse system. All tanks would be available for fire storage, though the sequence would be such that drinking water tanks are used last in a fire event. Total storage volume is the same for either a single or dual water system. The proposed location of the new tank is discussed in a separate memo.