



# User's Handbook

**Revision 2**

*26 June 2006*

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## Abstract

The purpose of this Handbook is to communicate information to users of the SNOLAB facility. It includes information on polices and procedures, organizational structure, laboratory design, laboratory infrastructure and the underground environment. It is intended as a living document and will be periodically updated. While the authors will attempt to keep this document current, it should only be considered a starting point for information collection by an experimenter and is not the definitive source. Users should consult with SNOLAB management for guidance on how to find the most current information for their needs.

## **Resources**

Additional information and links to resources can be found on the SNOLAB web site,

[www.snolab.ca](http://www.snolab.ca)

Members of the SNOLAB Users Group can find internal information at

[www.snolab.ca/usersgroup/](http://www.snolab.ca/usersgroup/)

## Revisions

Rev	Date	Notes
0	4 Nov 2005	First release of the SNOLAB User's Handbook.
1	16 Feb 2006	Added information on SNO GPS timing.
2	26 Jun 2006	Updated and expanded tabulation of the excavated and experimental spaces.

# Chapter 1

## Introduction

SNOLAB is an underground science laboratory situated two km below the surface in the INCO Ltd. Creighton Mine located near Sudbury Ontario Canada. The site is off the north shore of Lake Huron, approximately 400 km northwest of Toronto. SNOLAB is an expansion of the existing facilities constructed for the Sudbury Neutrino Observatory (SNO) solar neutrino experiment and is constructed from funds from the Canadian Federal and Ontario Provincial Governments. Including the existing SNO facilities, SNOLAB will have 53,000 sq ft of clean space underground for experiments and the supporting infrastructure. On surface there is a 34,000 sq ft building constructed on the Creighton mine site to support the underground experiments. At nearby Laurentian University there will be a facility for radio-isotope measurements and water analysis.

Excavation of the underground laboratory is being done in a phased approach. Phase I will result in two new experimental areas and 27,000 sq ft of new laboratory space. Phase II would add an additional large experimental hall and it's support space, adding an additional 7,000 sq ft of laboratory space. Phase I will be operational in 2007. As of October 2005, the option for Phase II to be completed in conjunction with Phase I is still being investigated.

### 1.1 Scientific Scope

SNOLAB follows on the important achievements in neutrino physics achieved by the SNO and the other underground physics measurements. The primary scientific emphasis at SNOLAB will be on particle astrophysics with the principal topics being:

- Low Energy Solar Neutrinos;
- Neutrinoless Double Beta Decay;
- Cosmic Dark Mater Searches and
- Supernova Neutrino Searches.

These are fields where the next generation of experiments require great depths to reduce cosmogenic backgrounds to acceptable levels. They also require extreme levels of cleanliness to reduce environmental radiological backgrounds to the levels necessary for these very sensitive measurements. SNOLAB achieves these goals by being located 2 km underground and by having the entire laboratory constructed as a single large clean room.

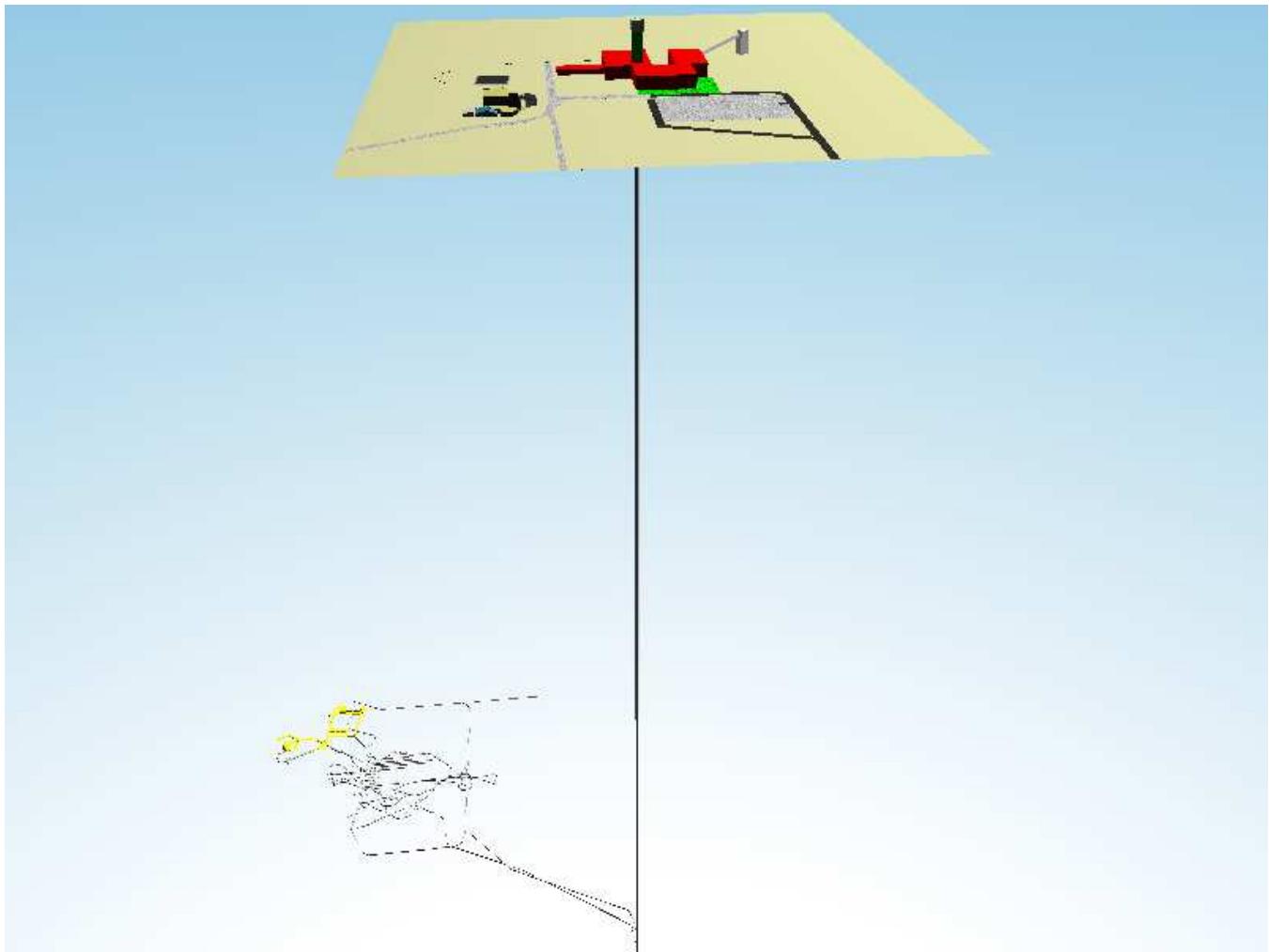


Figure 1.1: View of Creighton Mine and the SNOLAB underground and surface facilities. SNOLAB is located on the 6800 ft level of the Creighton mine and is accessed via the #9 Shaft.

While particle astrophysics is the principle focus for SNOLAB, there is a growing interest in other scientific fields to exploit deep underground laboratories and their associated infrastructure. In particular, there has been interest expressed in the fields of Seismology and Geophysics interested in precision, long term measurements at depth and in the field of Biology where there is a growing interest in deep under ground life.

## 1.2 Management Structure and Organization

Because SNOLAB is an outgrowth from the existing SNO experiment, it's management structure will go through several phases. The SNO experiment ceases data taking at the end of 2006 and decommissions during 2007. During this same period, SNOLAB is in a construction phase. Both the SNOLAB and SNO projects are administered through the *SNO Institute* under the *SNO Institute Director* but with SNOLAB organized under the *SNOLAB Director* and SNO organized under the *SNO Director* (figure 1.2). The SNOI oversees the SNO project with the input of an *Agency Review Committee* (ARC) representing the funding agencies of all three countries sponsoring the SNO experiment<sup>1</sup>. Similarly, the over-site of the SNOLAB project takes input from the *SNOLAB Scientific Sub-committee*.

The transitional management structure for SNOLAB during the construction phase is shown in figure 1.3. Construction is divided into Surface Facilities under the Supervision of UMA and Underground Facilities under the supervision of Acres. The laboratory's scientific program has been developed by the *Scientific Executive Committee* (SEC) under the supervision of the *Associate Director, SNOLAB Development*. The laboratory's scientific staff consists of Several *Site Scientists* and Research Associates. The Experimental Program is developed with input from the *Experiment Advisory Committee* (EAC).

## 1.3 Construction Schedule

As of June 2006 the surface facilities are complete and occupied. Underground the excavation of the Ladder Labs is complete and the excavation of the Rectangular Hall is underway. The excavation of the new personnel facilities is almost complete. Phase I excavation is expected to be finished in early 2007 with occupancy by the end of 2007.

## 1.4 SNOLAB Users Group

A *SNOLAB Users Group* (SUG) will be formed for persons conducting or wishing to conduct experiments at SNOLAB. The charter for this group needs to be written.

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<sup>1</sup>Canada, USA, UK

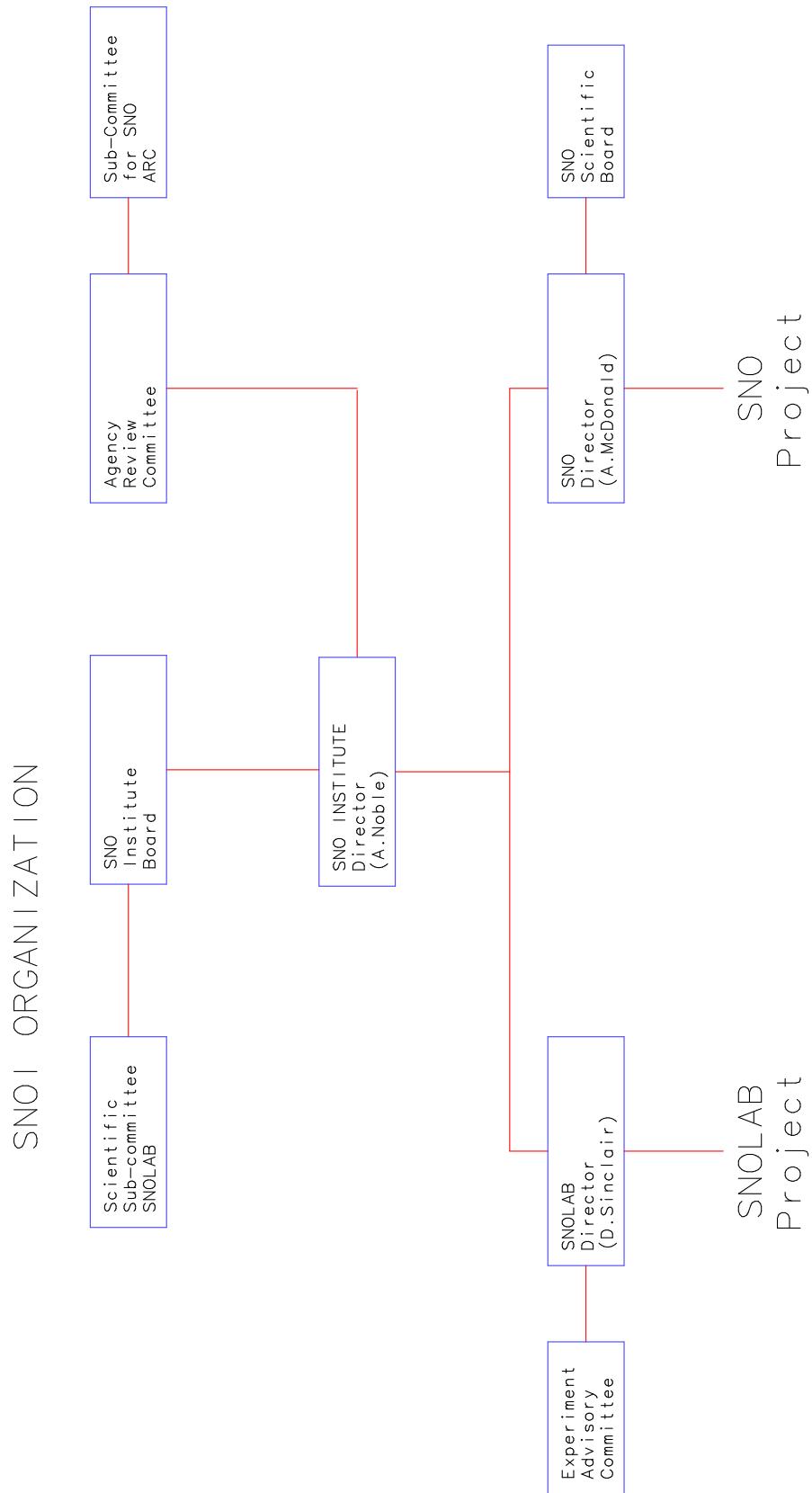


Figure 1.2: Transitional Organizational Chart for the SNO Institute.

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2005/10/02

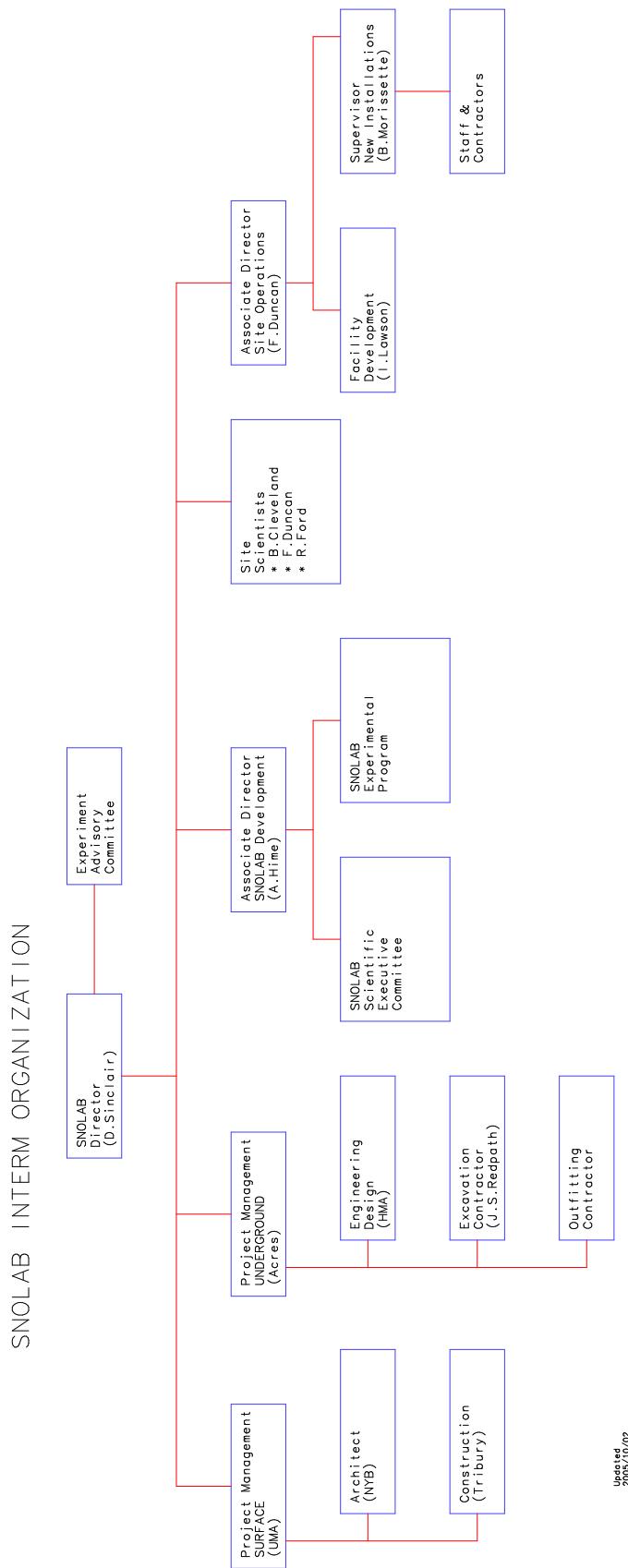


Figure 1.3: Transitional Organizational Chart for SNOLAB during the Construction Phase.

# Chapter 2

## Research Proposals

Proponents wishing to site an experiment at SNOLAB are asked to submit either a *Letter of Interest* (LOI) or a *Research Technical Proposal* (RTP) to SNOLAB to be received by the *Associate Director of SNOLAB Development*. The scientific merit of the research is evaluated by the *Experiment Advisory Committee* (EAC) which reports to the SNOLAB Director. The technical readiness of the research and its impact on laboratory operations is evaluated by a subcommittee of the *Scientific Executive Committee* which also reports to the Director.

Usually a researcher wishing to stage an experiment at SNOLAB will first submit a *Letter of Interest* (LOI) which describes the intended experiment or research program and fill out an *Experiment Infrastructure Matrix* (appendix A). An LOI justifies the science of the experiment, describes the technical readiness and how the program will be implemented. The LOI will be reviewed by the EAC which will make a recommendation to the SNOLAB director on the merits of the research program. If the research is deemed appropriate for siting at SNOLAB, the researcher will be invited to submit a *Research Technical Proposal* (RTP) which should present a specific request for SNOLAB resources (laboratory space and infrastructure) to implement an experiment or experimental program. A Research Technical Proposal does not necessarily have to cover the complete experimental program. It may only be proposing a prototype or one stage in a sequence. The Research Technical Proposal should have a mature description of the resource requirements, schedule and manpower. The process for submitting an RTP to SNOLAB is still under development. Meanwhile however, a prototype for an RTP is given in appendix B.

### 2.1 Experiment Advisory Committee

LOIs or RTPs to SNOLAB will be evaluated by the *Experiment Advisory Committee* (EAC) which is composed of experienced experimental and theoretical physicists. The Letters or Proposals will be evaluated on the basis of their scientific merit and their technical feasibility. The EAC reports to the SNOLAB Director with the Associate Director of SNOLAB Development acting as Secretary to the committee.

## 2.2 Guidelines for Drafting LOIs in Staging Experiments at SNOLAB

Below are guidelines for drafting an LOI for an experiment to be situated at SNOLAB.

### 1. Scientific Merit

Describe the scientific motivation/reach of the experiment and how it requires or benefits from the unique opportunities at SNOLAB. How is the technical approach of the experiment novel and what competition exists? Can the experiment lead to a fundamental discovery in the field? Can the experiment provide a valuable stepping-stone in the development of future experiments?

### 2. Infrastructure Needs

Provide a summary of the infrastructure needs of your experiment. Appendix A contains an infrastructure matrix that has been used effectively in interactions with the scientific community that can be used as a guide. Please take the freedom to add to, or eliminate from, the existing list as it seems appropriate.

### 3. Progress on R&D

Describe the key technical requirements/challenges of the experiment and the R&D program in place or envisioned to meet these requirements. Describe the manpower and resources in place or required to carry out this R&D. If SNOLAB facilities are required during the R&D phase, provide details and schedule.

### 4. Technical Feasibility

Describe the process in place or envisioned to move from the R&D phase to a full-scale construction project. If a full-scale construction proposal exists can it be made available to SNOLAB management? Provide information regarding the engineering plan required to bring the project into operating mode, as well as the plan to operate the experiment once full-scale construction is complete. The focus should be on the technical details to stage and carry out a full-scale construction project.

### 5. Safety

Address any safety issues relevant to the construction and operation of the experiment while recognizing the unique safety aspects of operating underground in an active mine. Indicate how safety issues will be addressed in the design, construction and operation of the experiment.

### 6. Funding and Scheduling

Describe the construction plan and schedule, including laboratory access needs for both manpower and hardware. Describe any steps taken or envisioned to secure the necessary funding for construction and operation of the experiment. Describe the decommissioning plan for the experiment.

### 7. Participation & Management

Describe the participants in the experimental program. Does a formal collaboration exist? If so, describe the institutional responsibilities of the collaboration and means by which the project will be managed.

# Chapter 3

## Mine and Laboratory Environment

### 3.1 Creighton Mine

Creighton Mine is an operational mine that has been excavating nickel and associated minerals since 1901. It originally started as an open pit mine and is presently actively mining 7600 ft below the surface. As of 2005 Creighton Mine has extracted 4.8 billion pounds of nickel. Access to the mine is through the 7130 ft deep #9 *Shaft* (figure 3.1) with the lowest level directly accessible from the shaft being the 7000 ft level. Access below 7000 L is through a network of ramps. SNOLAB is located on the 6800 ft level of the mine in the hanging wall north west of the mining region — about 1.8 km from the shaft (figure 3.2). While there is still some activity on the 6800 level, most of the mining takes place below the 7000 ft level. Personnel usually walk into the laboratory while equipment and material are trammed in on a narrow gauge railway.

### 3.2 Seismic Activity

While the Sudbury Region is in general geologically inactive the extensive mining activity in the region leads to seismic events both as blast concussions and as stress relief of the rock (referred to as *rockbursts*). Because of the ongoing mining induced seismic activity in Creighton Mine, the SNOLAB excavations are designed to withstand a 4.0 Nuttli Scale seismic event which is deemed to be the largest plausible event that could occur in the mine. The laboratory excavations are designed to withstand such an event with ground motions up to 400 mm/s *Peak Particle Velocity* (PPV). A event of this nature generates oscillations of with a frequency of order 10 Hz and would correspond to an acceleration of 2.5 g.

In addition to the design of the laboratory for large seismic events, there is an ambient environment of smaller scale ground motion due to the ongoing blasting and stress relief in the mine. Figure 3.3 shows data from a seismograph situated near the existing SNO facility in what will be the clean space of SNOLAB. It shows seismic events over a two month period during the excavation of SNOLAB and shows both seismic events from mining activities and events specifically from the excavation of SNOLAB. The PPV can be approximately converted to a maximum acceleration by the expression

$$a[g] = 0.13 \left[ \frac{g}{mm/s} \right] \times PPV[mm/s]$$

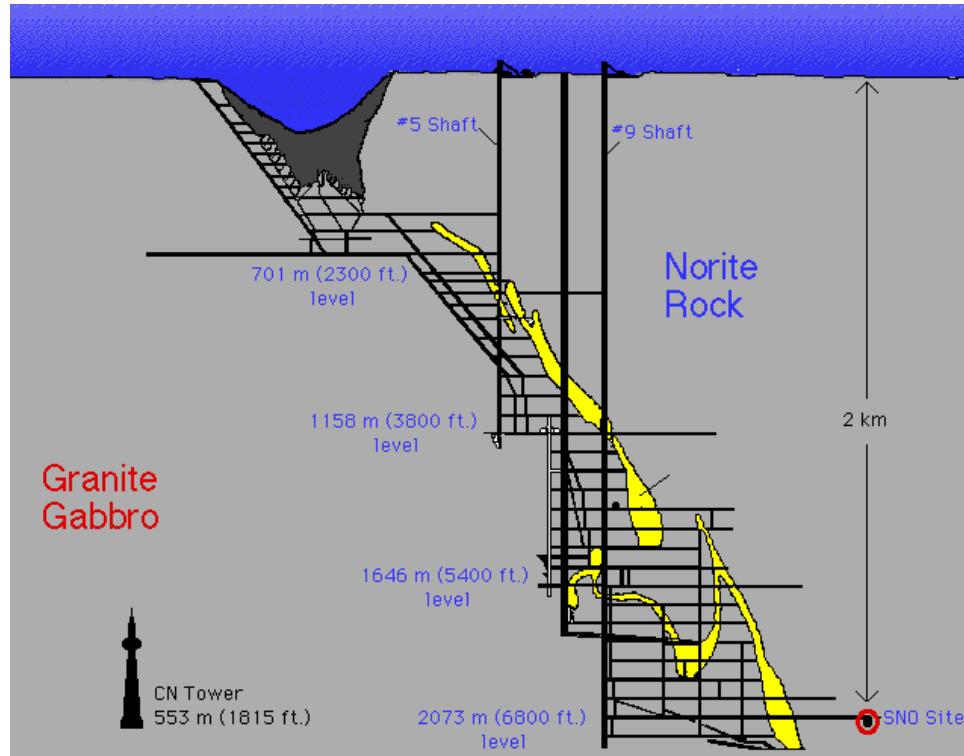


Figure 3.1: Ore body and level structure of Creighton Mine.

The maximum acceleration in a mining event observed in this period was 1.5 g while the maximum acceleration due to the SNOLAB excavation was 1 g.

### 3.3 Mining Byproducts

The most obvious byproducts of the mining activities are exhaust gasses from the explosives such as CO and NO and oxygen deficient environments resulting in potential *Oxygen Deficiency Hazards* (ODH). As a consequence, O<sub>2</sub>, CO and NO levels are constantly monitored both in SNOLAB and in the mine in general. Ventilation air flow is adjusted and personnel travel may sometimes be restricted due to blasting and the subsequent clearing of the air. In the event of high CO or NO levels outside the laboratory, the main air intake to the lab is shut off. This can typically happen two or three times per week due to blasting and may last from 30 to 60 minutes.

There is a mining byproduct gas that is a more subtle concern for experiments in SNOLAB. During the running of the SNO experiment the presence of hydrogen sulphide (H<sub>2</sub>S) was identified in the laboratory at the few Parts Per Billion (PPB) level. This is well below the level of concern for personnel (10 PPM OSHA TWA) but has caused corrosion of exposed copper and silver components such as in electronics. In the SNO experiment, this problem was partially mitigated by installing NaOH impregnated charcoal filters to remove the H<sub>2</sub>S. The filtration was in a recirculating air handler located near the detector electronics and while not fully effective, it did reduce the H<sub>2</sub>S by about a factor of three. For SNOLAB, all fresh air to the laboratory will be filtered by the installation of appropriate filters in the main air intake. The filter material to be used is still under

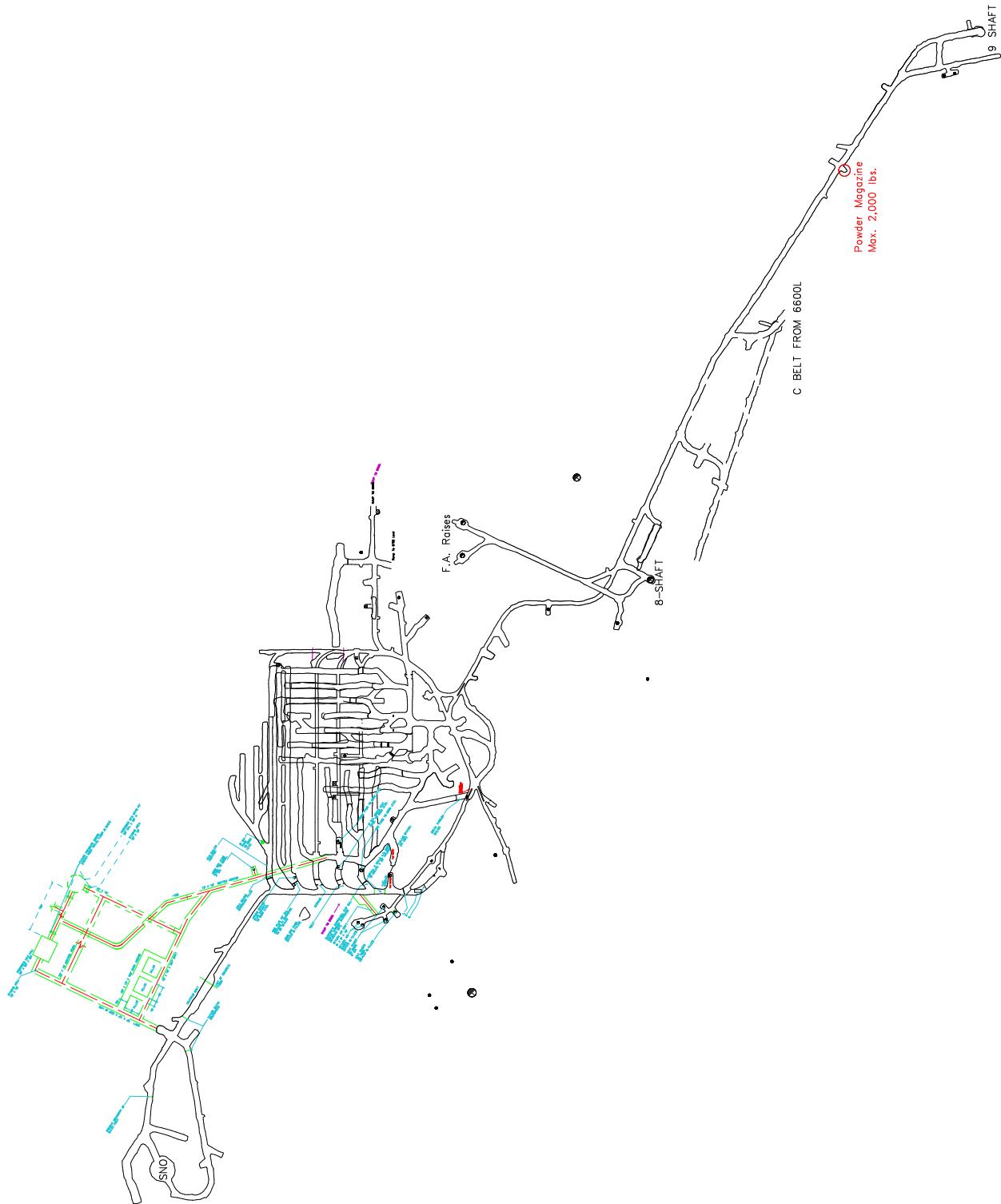


Figure 3.2: 6800 Level of Creighton Mine.

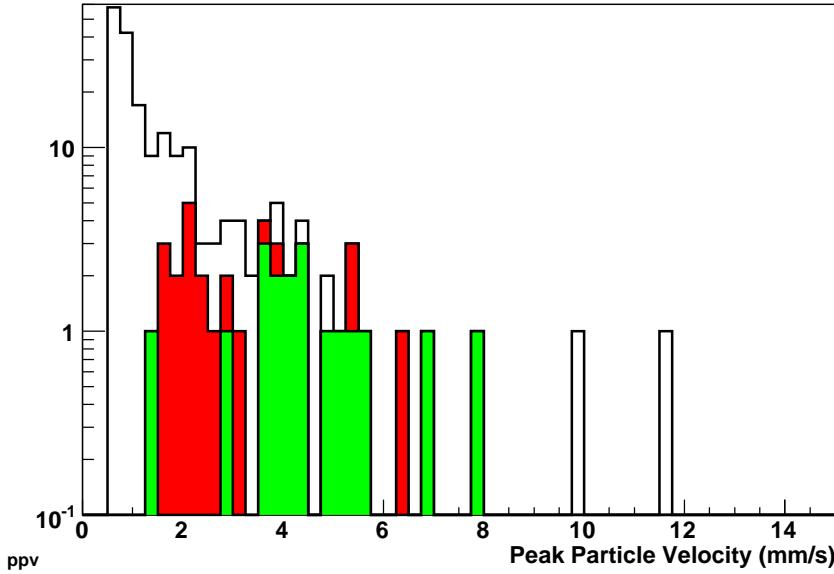


Figure 3.3: Seismic activity near SNOLAB in terms of Peak Particle Velocity. The red and green points are blasts due to SNOLAB excavation. the Red points blasts in the bottom access drift the the main halls. The green points are blasts in the region of the Ladder Labs. The data are taken between 22 April and 20 June 2005.

consideration with the choices being either an NaOH based or an KMnO<sub>4</sub> based product.

### 3.4 Temperature and Humidity

The ambient rock temperature at the depth of SNOLAB in Creighton Mine is 42C. As a consequence, geothermal heat removal is a significant issue. As much as 20% of the heat to be removed from SNOLAB may be geothermal in origin. The nominal ventilation on the 6800 L of Creighton provides air at approximately 29C and 50% relative humidity. Inside the SNO facility the temperature is typically 20C and 46% humidity. The SNOLAB facility will be maintained at levels similar to SNO.

### 3.5 Magnetic Field

Measurements were made of the local magnetic field on the 6800 ft level of the Creighton mine during the excavation for the SNO laboratory [8]. Results are listed in table 3.1. The field measurements were consistent with a vertical field value of  $55 \pm 5$  kgamma ( $0.55 \pm 0.05$  G) and a horizontal field value of approximately 15 kgamma (0.15 G) in a direction generally towards magnetic north. Anomalies of up to 10 kgamma were observed. Field variations near steel objects of from 0 to 100 kgamma (vertical) were observed.

Location	Inst	Field kgamma	Orient	Notes
Creighton Parking Lot	PM	57.5	T	
6800 ft Creighton Mine	PM	55 ± 5	V	2 m above gnd
# 9 shaft - 10 m in	FM FM FM	57.5 10 95	T V V	1 m above gnd 20 cm from scoop of tram 20 cm from flat car (1.5 x 3 m)
6800 - site 1 (drift next to SNO)	FM FM PM	60 ± 3 100 56 ± 2	V V T	1.5 m above gnd 5 cm from rail 1-3 m above gnd
6800 - site 2 (Junc. SNO Drift)	FM FM PM FM	52 ± 3 20 ± 5 54 ± 2 63 ± 3	V H T V	1 m above gnd see Fig 2 dir. 2 m see fig 2 dir. 10 cm from wall (steel mesh)
6800 - site 3 (Chiller MPC)	FM FM FM FM	57 ± 3 20 ± 10 100 ± 20 55	V V V V	1 m from 4 ore cars (side) 1 m from car end 5 m from car end
6800 - site 4 (wash station)	PM FM FM FM FM	53 ± 2 55 ± 1 15 ± 5 65 25	T V H V V	2 m height across drift see fig 2 for direction at cross sec J (anomaly) 20 cm from scissor lift

Table 3.1: Magnetic field measurements made during the construction of SNO. Abridged table taken from [8]. Notes: FM - Fluxgate magnetometer (Scintrex Model FM-2-100); PM - Proton Magnetometer (E.G.& G. Model G 816); T = Total Field; V = Vertical Field; H = Horizontal Field. Measurements made 12 July 1990. 1 gamma =  $10^{-9} \text{T} = 10^{-5} \text{ G}$ .

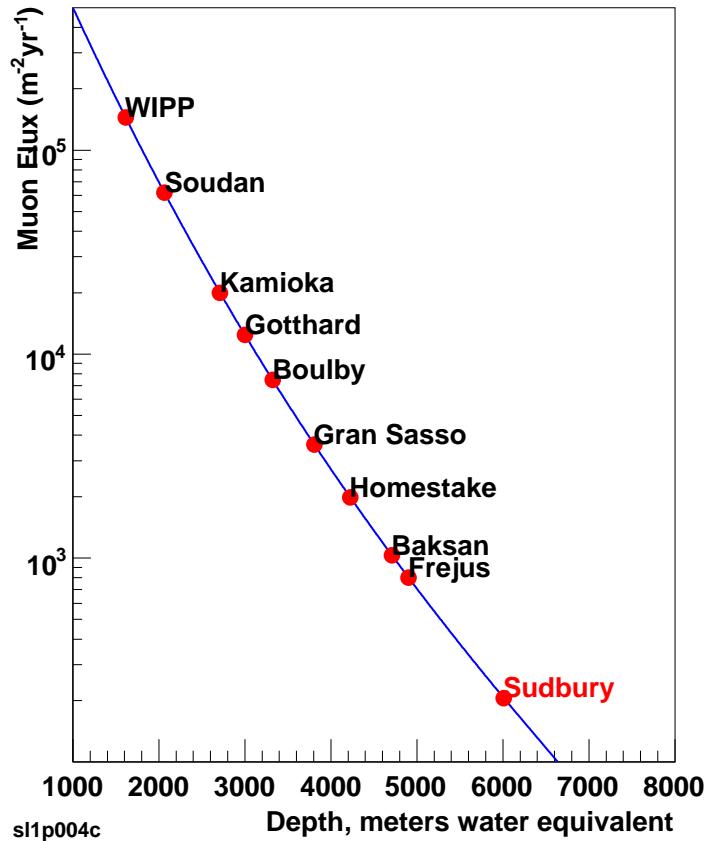
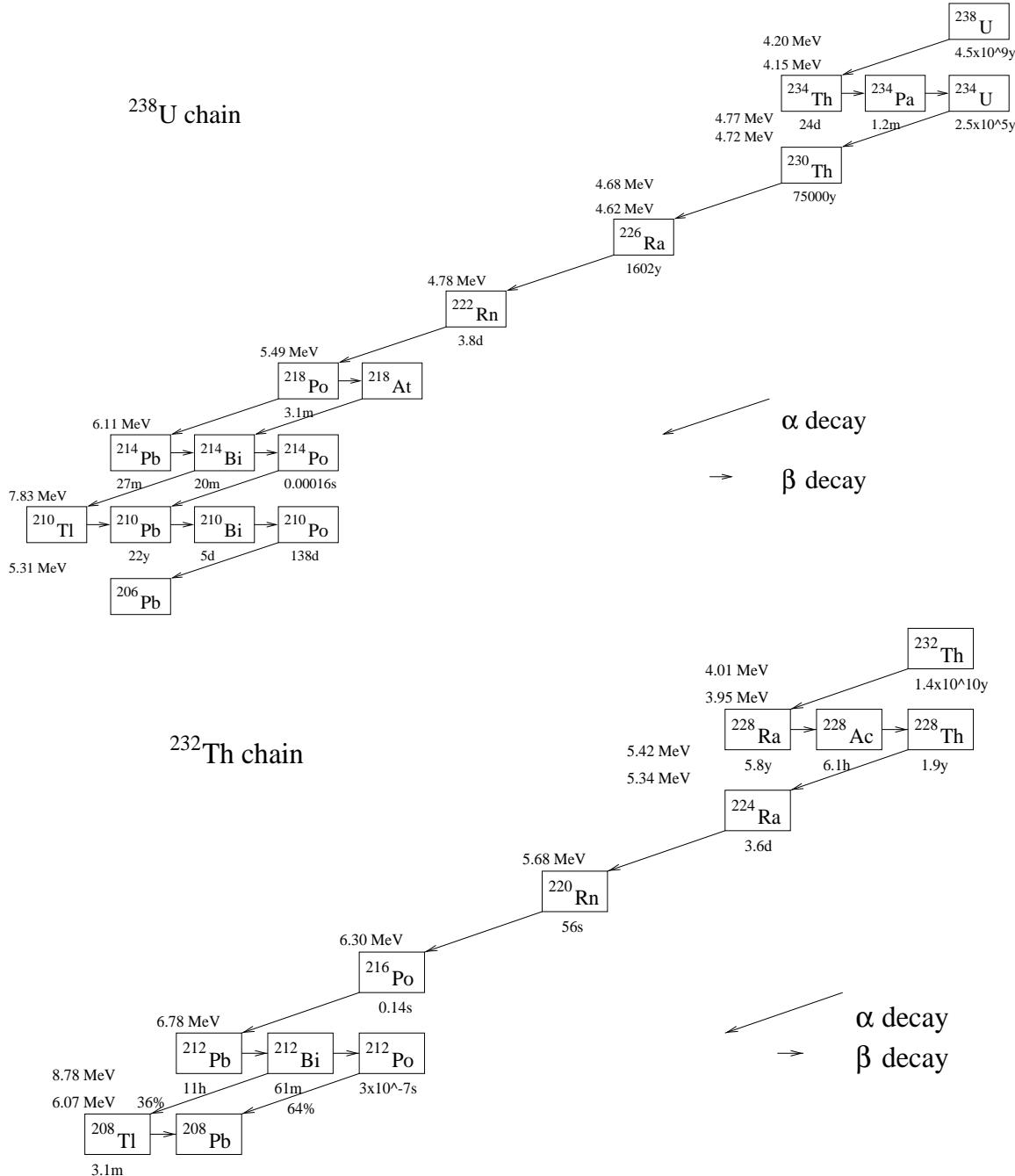


Figure 3.4: Muon Flux as a function of Depth.

### 3.6 Geological and Cosmological Radiation Backgrounds

The muon flux as a function of depth is shown in figure 3.4. At the 6800 Level of Creighton Mine, SNOLAB has an overburden of 6010 m water equivalent. At this depth the muon flux is less than  $0.27 \mu/\text{m}^2/\text{day}$  [1]. SNOLAB is sited in a norite rock formation which — apart from the materials used to fabricate the lab — is the principle source of dust and thus radiological backgrounds. Table 3.2 gives the elemental composition of the norite rock which contains 1.2% potassium, 1.2 ppm  $^{238}\text{U}$  and 3.3 ppm  $^{232}\text{Th}$ . The gamma ray flux from norite was measured during the installation of the SNO experiment and is tabulated in table 3.3. The thermal neutron flux from the rock is  $4144.9 \pm 49.8 \pm 105.3 \text{ neutrons}/\text{m}^2/\text{day}$  [2]. The fast neutron flux is estimated to be 4000 neutrons/ $\text{m}^2/\text{day}$  [1].

Figure 3.5:  $^{238}\text{U}$  and  $^{232}\text{Th}$  Decay Chains

Element	% Composition by weight
H	0.15
C	0.04
O	46.0
Na	2.2
Mg	3.3
Al	9.0
Si	26.2
K	1.2
Ca	5.2
Mn	0.1
Fe	6.2
Ti	0.5
$^{232}\text{Th}$	$3.3 \times 10^{-6} \text{ g/g}$
$^{238}\text{U}$	$1.2 \times 10^{-6} \text{ g/g}$

Table 3.2: Elemental composition of norite [3].

$E_\gamma$ (MeV)	Measured Flux $\gamma m^{-2}d^{-1}$	Calculated Flux $\gamma m^{-2}d^{-1}$
4.5-5	$510 \pm 200$	
5-7	$360 \pm 220$	320
>7	$180 \pm 90$	250
>8	<20	15

Table 3.3: High-energy  $\gamma$ -ray fluxes from norite. The flux was measured using a 10 cm x 12.5 cm NaI(Tl) detector with various thicknesses of Pb shielding. The calculations are based on neutron capture in the elements of norite with a neutron flux predicted from the measured Th and U concentrations in the rock [3].

## 3.7 Radon Levels in the Underground SNO Laboratory

A Durridge RAD7[9] radon monitor was recently acquired by SNOLAB to monitor the radon levels in the SNO laboratory underground on a continuous basis. The RAD7 is a solid state alpha detector that is designed to detect the Polonium daughters of Radon 220 and 222. Four isotopes of Po are detectable,  $^{212}\text{Po}$  and  $^{216}\text{Po}$  which are from the  $^{220}\text{Rn}$  decay chain, and  $^{214}\text{Po}$  and  $^{218}\text{Po}$  which are from the  $^{222}\text{Rn}$  decay chain. Note that  $^{220}\text{Rn}$  is often referred to as Thoron in the literature while  $^{222}\text{Rn}$  is referred to as Radon. The four radon daughters each have distinctive energies from one another, although some overlap between the energy bins is possible. The RAD7 uses the distinct energies of the four Polonium daughters to estimate the amount of Radon and/or Thoron detected. The energy peaks of the Polonium isotopes are:

- $^{212}\text{Po}$ : 8.78 MeV
- $^{214}\text{Po}$ : 7.69 MeV
- $^{216}\text{Po}$ : 6.78 MeV
- $^{218}\text{Po}$ : 6.00 MeV

The decay chain of Radon and Thoron is shown in figure 3.5. The figures show the half-lives of the various isotopes until the stable lead isotope is reached and the energy of any alpha particles emitted in the decay process.

The radon levels were measured in the old SNO surface building to ensure the correct operation of the RAD7 and to achieve a base line measurement of the surface radon levels. The measurement after six days gave a radon concentration of  $0.15 \pm 0.12 \text{ pCi/L}$  ( $5.55 \pm 4.44 \text{ Bq/m}^3$ ). The measurement is statistically limited due to the low counting rate, a measurement over a much longer period of time will be done in the future to improve the statistical accuracy of this measurement.

On August 26, 2005 the RAD7 was taken underground to the SNO laboratory and placed in the detector control room. The data have been continuously recorded since that time and are shown in figure 3.6 up to September 30, 2005. The average radon level during this period is  $3.33 \pm 0.35 \text{ pCi/L}$  ( $123.2 \pm 13.0 \text{ Bq/m}^3$ ). The radon counts are accumulated for two hour periods and the radon concentration is calculated for this period correcting for detector live time.

## 3.8 Absolute Air Pressure and Pressure Swing Model

The absolute air pressure in the mine at the 6800 foot level is approximately 20% higher than the air pressure on the surface. The SNOLAB laboratory is designed to be at a slightly higher pressure than the mine itself to keep mine dust out. This pressure difference is between 0.25 and 0.60 inches of water depending on the cleanliness level of the filters in the air handling system. To keep this pressure differential constant, the laboratory air handling system is designed to track the mine pressure and adjust as necessary. The mine pressure can vary due to mine ventilation changes and seasonal effects. The pressure changes due to ventilation changes can sometimes be very rapid with changes up to 0.5 psi possible within a 10 minute period.

Figure 3.7 shows the absolute pressure with respect to time for the period between January 14, 2004 and September 16, 2005. It is observed that the absolute pressure is maintained between

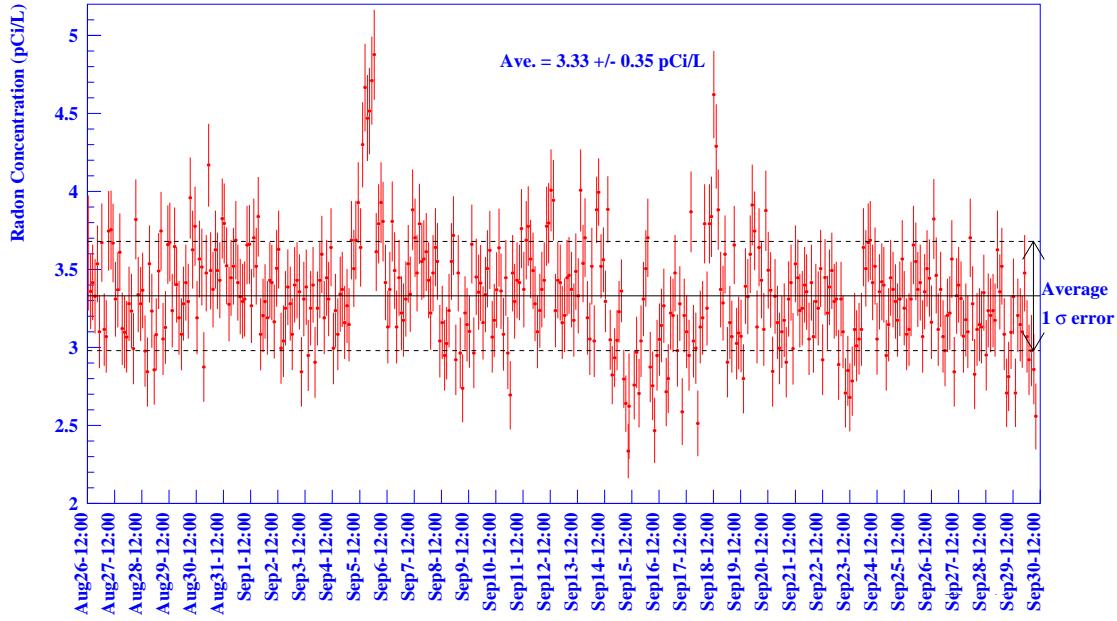


Figure 3.6: The radon concentration levels in the SNO underground control room.

approximately 17.5 and 18.5 psia. The average pressure over this period was 17.91 psia. Most of the pressure changes take place over several hours, but there are several in which the pressure changes suddenly over a period of just 5–10 minutes or less.

The general model to describe abrupt pressure changes over time is

$$P = P_0 \pm \Delta P(1 - e^{-\lambda t}), \quad (3.1)$$

where  $P$  is the final pressure,  $P_0$  is the initial pressure before the abrupt change took place,  $\Delta P$  is the difference between the initial and final pressure,  $\lambda$  is the decay or rise constant,  $t$  is the time during which the pressure change took place and for pressure rises the ‘+’ sign is used while for pressure drops the ‘−’ sign is used.

A search through the data was done to find sudden pressure changes on the order of 15 minutes or less, in which the pressure changed by at least 0.2 psi. The data was then fit to equation 3.1 to determine  $\Delta P$  and  $\lambda$ . Combining the fit results for  $\Delta P$  and  $\lambda$  gives the following pressure change model:

$$P = P_0 \pm 0.41(1 - e^{-0.30t}), \quad (3.2)$$

where pressure rises use the ‘+’ sign while for pressure drops the ‘−’ sign is used. The value of  $P_0$  can be estimated to be the average of all absolute pressure values, which is 17.91 psia. A typical pressure rise is shown in figure 3.8 with the fit results shown for  $\Delta P$  and  $-\lambda$  on the plot. A typical pressure drop is shown in figure 3.9 with the fit results also shown.

Although an average pressure change equation is needed for adjusting the pressure by the air handling system, the largest pressure change is of note if one wants to determine if the laboratory can still remain above the outside drift pressure, noting that the current laboratory is maintained at a differential pressure between 0.25 and 0.60 inches of water. The maximum pressure rise was

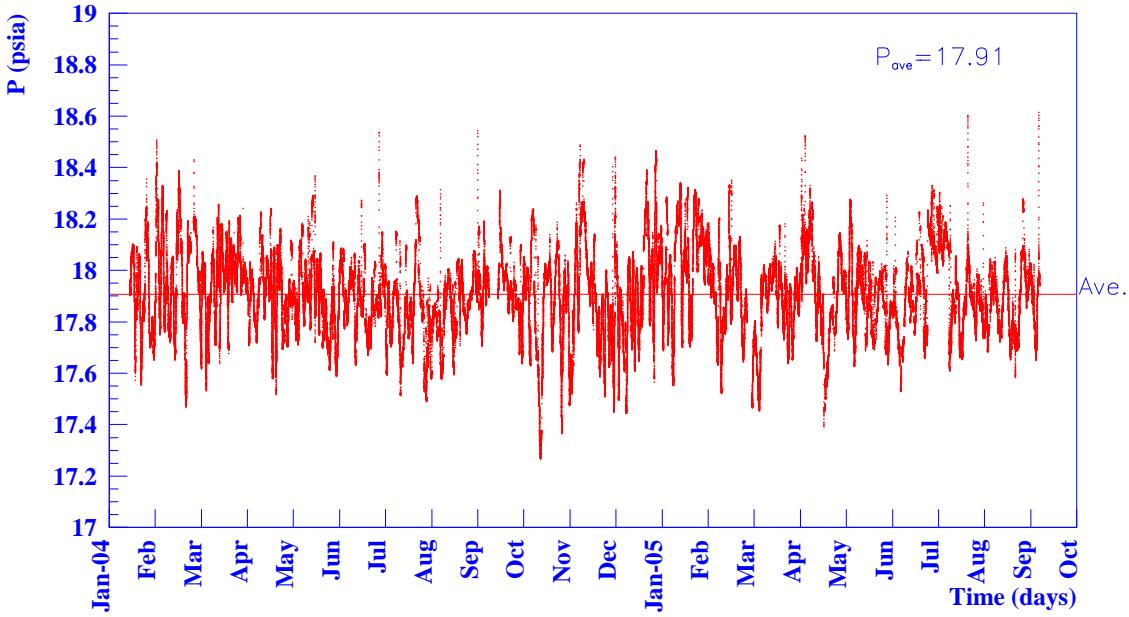


Figure 3.7: The change in absolute pressure versus time for the time period between January 14, 2004 and September 16, 2005.

found for the data set to be

$$P = P_0 + 0.64(1 - e^{-0.20t}), \quad (3.3)$$

while the maximum pressure drop was found to be

$$P = P_0 + 0.63(1 - e^{-0.11t}). \quad (3.4)$$

For both equations,  $\Delta P$  is larger by approximately 0.22 psia than the average value shown in equation 3.2.

### 3.9 Lab Pressure Response Design

The amount of air that must be added to or removed from the laboratory to maintain the differential pressure between the laboratory and the drift needs to be determined to ensure that the air handling system can handle the increased air flow required during any pressure rises. Table 3.4 shows the various areas of the existing SNO laboratory and their respective volumes and air flows. The current laboratory has a volume of approximately 333,360 ft<sup>3</sup> ( $\approx 9440\text{m}^3$ ) (excluding the water filled SNO cavity) and has an air circulation of 41,100 cubic feet per minute (cfm). Air handling unit (AHU) 5 adds 6,700 cfm of fresh make up air into the lab, while the 3 exhaust fans remove 4,200 cfm of air into the drift outside the laboratory. This implies that the air flow around and to the outside of the existing SNO laboratory entrance is 2,500 cfm. Table 3.5 shows the volumes of

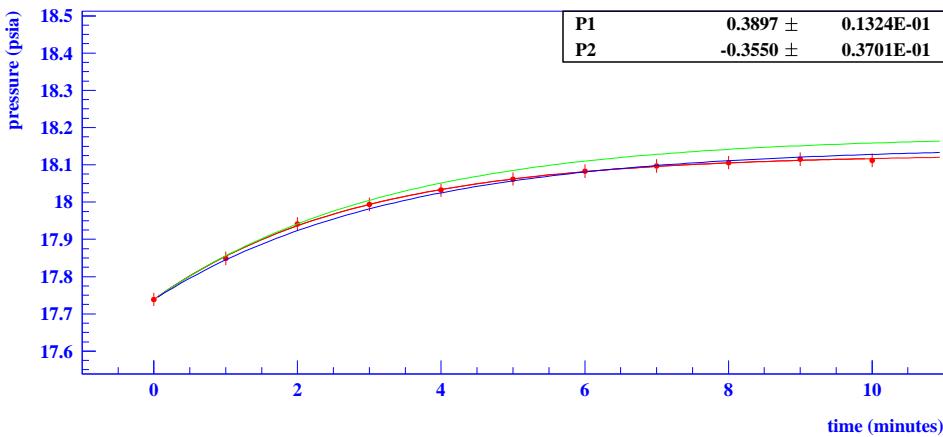


Figure 3.8: A typical sudden pressure rise plot. The red line is the fit to the points (the results are in the upper right corner), the green curve is the average pressure rise fit and the blue curve is the combined pressure change equation.

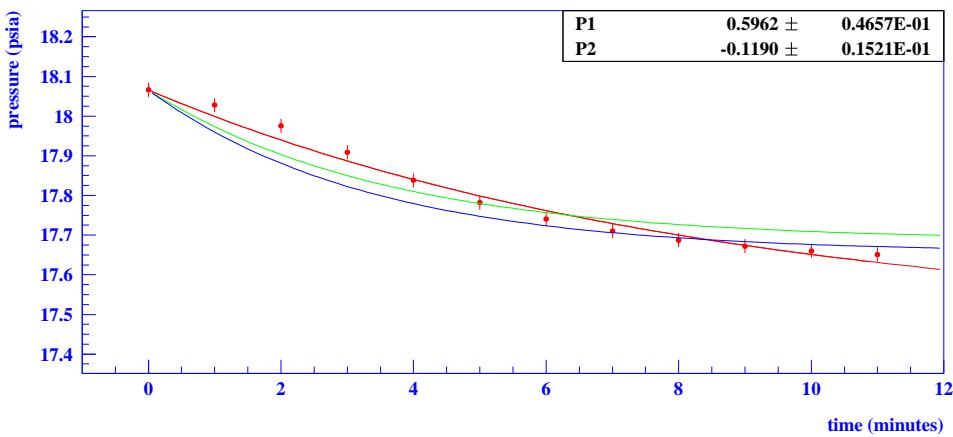


Figure 3.9: A typical pressure drop plot. The red line is the fit to the points (the results are in the upper right corner), the green curve is the average pressure drop fit and the blue curve is the combined pressure change equation.

Air Handling Units (Recirculating)			
Equipment	Area	Volume	Air Flow
AHU1	Utility Room	63,000 ft <sup>3</sup>	13,300 cfm
AHU2	SNO Cavity (excluding cavern filled with water)	221,180 ft <sup>3</sup>	16,000 cfm
AHU3	Car Wash and Junction	34,330 ft <sup>3</sup>	7,200 cfm
AHU4	Personnel Facilities	14,800 ft <sup>3</sup>	4,600 cfm
Total	Existing SNO Facilities	333,360 ft <sup>3</sup>	41,100 cfm

Air Handling Unit (Recirculating, including SNO cavern)			
Equipment	Area	Volume	Air Flow
AHU2	SNO Cavern currently filled with water	330,000 ft <sup>3</sup>	–
Total	Existing SNO and SNO Cavern	666,360 ft <sup>3</sup>	–

Air Handling Unit (Make up)		
Equipment	Area	Air Flow
AHUS	Fresh Air Unit	6,700 cfm

Exhaust Fans		
Equipment	Area	Air Flow
EF1	Service area of AHU4	1,500 cfm
EF4	Service area of AHU1 and 3	1,200 cfm
EF5	Service area of AHU1 and 3	1,500 cfm
Total	Existing SNO Facilities	4,200 cfm

Table 3.4: The existing SNO laboratory volume and air flow details.

Air Handling Units (Recirculating)		
Equipment	Area	Volume
AHU6	Cryogen Area (Stage 2)	184,000 ft <sup>3</sup>
AHU7	Rectangular Area	235,000 ft <sup>3</sup>
AHU8	Drift H (Stage 2)	52,000 ft <sup>3</sup>
AHU9	Ladder/Chemistry Area	147,000 ft <sup>3</sup>
AHU10	Drift F	137,000 ft <sup>3</sup>
AHU11	Personnel Facilities/Car Wash	33,000 ft <sup>3</sup>
Total	SNOLAB (Stage 1)	552,000 ft <sup>3</sup>
Total	SNOLAB (Stage 1 and 2)	788,100 ft <sup>3</sup>
Total	SNOLAB (Stage 1) + SNO	885,360 ft <sup>3</sup>
Total	SNOLAB (Stage 1 and 2) +SNO	1,121,460 ft <sup>3</sup>
Total	SNOLAB (Stage 1) + SNO + SNO Cavern	1,218,360 ft <sup>3</sup>
Total	SNOLAB (Stage 1 and 2) +SNO + SNO Cavern	1,454,460 ft <sup>3</sup>

Table 3.5: The SNOLAB laboratory volumes for the expanded laboratory. In addition, the total volumes are shown for the expanded laboratory and the existing SNO laboratory. AHU12 will control the fresh make-up air in the new laboratory at approximately 7,500 cfm and there are up to 6 exhaust fans for the various areas.

the expanded laboratory and gives the total volumes of the existing and expanded areas with and without the phase II of the expansion included.

Currently the pressure inside the SNO laboratory is maintained at a differential pressure of between 0.25 and 0.6 inches of water as compared to the mine. The pressure range is due to the filter conditions of the air handlers, as the filters become dirty, the differential pressure decreases. Nevertheless, the pressure inside the laboratory remains higher than outside. Recalling equation 3.1, one can calculate the final pressure after a sudden pressure increase or decrease occurs, if one knows the duration and rate of the pressure change. Using Boyle's Law and substituting it into equation 3.1, the volume of air required to maintain the pressure differential can be calculated. This calculation gives the final volume,  $V_f$  after time  $t$  of

$$V_f = \frac{V_i}{1 \pm \Delta P/P_i(1 - e^{-\lambda t})}, \quad (3.5)$$

where  $V_i$  and  $P_i$  are the initial volume and pressure, respectively,  $\lambda$  is the pressure rise or fall constant, and  $\Delta P$  is the pressure change.

For example, if one assumes the current laboratory volume of 333,360 ft<sup>3</sup> an initial pressure of 18.0 psi,  $\lambda = 0.30$  and a pressure increase of 0.5 psi in 5 minutes the volume of the laboratory after the pressure increase is calculated to be 326757 ft<sup>3</sup>, which implies that  $\Delta V = 6603$  ft<sup>3</sup>. Since the volume of the laboratory does not physically decrease, the volume of air sent into the laboratory must be increased and or the volume exhausted decreased to allow for the higher pressure and to maintain the physical volume of the laboratory.

To maintain the pressure difference, the rate at which the fresh air should be added or old air exhausted can be calculated. The existing SNO laboratory currently has an air change rate of approximately 7.4 air changes per hour (ACH) and a make up air change rate of approximately 1.2 ACH. Thus to maintain the pressure differential for the physical volume of the laboratory these air change rates should remain constant. To maintain the laboratory at the new pressure of 18.5 psi, AHU5 must add 133 cfm to its existing air flow of 6,700 cfm and the recirculation fans should increase their air flow by 814 cfm. These results assume that the exhaust air fans continue to remove air at the same rate.

Table 3.6 shows several calculations of the differential volumes for the existing SNO laboratory, the existing laboratory and the empty SNO cavern and these combinations with phase 1 of the expansion. Pressure decreases give similar volume changes, where air would need to be removed from the laboratory. In addition, the first part of the table gives details concerning the amount of make up and recirculating air that is required to maintain the physical volume for the existing laboratory at the higher pressures.

The amount of recirculating and make up air has not been calculated for the expanded laboratory, since this depends on the air flow rate for the recirculating air handling units and AHU 12. However it is expected that AHU 12 will have a make up air flow rate of approximately 7,500 cfm; this flow would give 0.5 ACH for an empty expanded laboratory (phase 1 only and including the existing SNO laboratory). For example, if the mine pressure increased from 18.0 psi to 18.5 psi in 5 minutes, then the fresh make up air rate would have to be increased by 149 cfm to maintain the physical volume at the higher pressure and an air flow rate of 0.5 ACH.

Pressure Increase (Existing SNO)					
Initial Pressure (psi)	Final Pressure (psi)	Time Period (min)	Volume Change (ft <sup>3</sup> )	Make-Up Air (cfm)	Recirculating Air (cfm)
18.0	18.1	5	1342	27	165
18.0	18.2	5	2673	54	330
18.0	18.3	5	3993	80	492
18.0	18.4	5	5303	107	654
18.0	18.5	5	6603	133	814

Pressure Increase (Existing SNO + SNO Cavern)

Initial Pressure (psi)	Final Pressure (psi)	Time Period (min)	Volume Change (ft <sup>3</sup> )
18.0	18.1	5	2682
18.0	18.2	5	5343
18.0	18.3	5	7982
18.0	18.4	5	10601
18.0	18.5	5	13199

Pressure Increase (Existing SNO + SNOLAB Expansion (Phase 1))

Initial Pressure (psi)	Final Pressure (psi)	Time Period (min)	Volume Change (ft <sup>3</sup> )
18.0	18.1	5	3564
18.0	18.2	5	7099
18.0	18.3	5	10606
18.0	18.4	5	14085
18.0	18.5	5	17536

Pressure Increase (Existing SNO + SNOLAB Expansion (Phase 1) + SNO Cavern)

Initial Pressure (psi)	Final Pressure (psi)	Time Period (min)	Volume Change (ft <sup>3</sup> )
18.0	18.1	5	4904
18.0	18.2	5	9769
18.0	18.3	5	14595
18.0	18.4	5	19382
18.0	18.5	5	24132

Pressure Increase (Existing SNO + SNOLAB Expansion (Phase 1 &amp; 2) + SNO Cavern)

Initial Pressure (psi)	Final Pressure (psi)	Time Period (min)	Volume Change (ft <sup>3</sup> )
18.0	18.1	5	5655
18.0	18.2	5	11662
18.0	18.3	5	17423
18.0	18.4	5	23139
18.0	18.5	5	28809

Table 3.6: The volume changes required by the air handlers to be maintained when the laboratory pressures increase. If the pressure decreases, the results are similar but in the reverse direction. The initial volumes are taken from tables 1 and 2. The first table calculates the additional make up and recirculating air using the existing values for AHU 5 and AHUs 1-4.

# Chapter 4

## Underground Facilities

### 4.1 Overview

The existing SNO underground laboratory consists of a large experimental cavern 22 m in diameter and 30 m high (72'2" dia x 98'5" height), ancillary spaces in mining *drifts* (tunnels) for the experiment and personnel infrastructure. The SNO Detector is located [4] at 46°28'30" N, 81°12'04" W. The main level of the laboratory is located on the 6800 ft level of the mine with 2070 m of granitic rock overburden consisting mainly of norite (figure 3.1). The ambient rock temperature at this depth is 42C. The 2km of norite overburden corresponds to 6010m water equivalent. Surface elevation at the site is 309 m (1014 ft) above mean sea level. The surface topology is approximately flat. Access to the 6800 Level and SNOLAB is via #9 Shaft located 1.8 km from the laboratory entrance.

A key feature of the existing laboratory is that all the experimental spaces and personnel spaces are maintained as one large clean room. Personnel entering the laboratory pass through showers and change into clean room clothing. Equipment entering the laboratory is either cleaned in a “carwash” before entering the laboratory or is brought underground in sealed containers that are opened after being washed and brought into the clean space.

A conceptual view of SNOLAB is shown in figure 4.1. To control the uncertainties in the cost of excavation, the SNOLAB expansion will take place in two phases (shown in figure 4.2) which are summarized in table 4.1. Phase I will consist of: the relocation of the clean/dirty boundary; new expanded personnel facilities; a service facilities area (chiller, generator, sewage treatment); a network of drifts (“Ladder Labs”) for small and medium sized experiments; and a large experimental hall (the “Rectangular Hall”) and ancillary spaces for a larger experiment. Phase II will consist of the addition of another large hall (dubbed the “Cryopit”) and ancillary spaces. The design of the Cryopit envisions it’s use for an experiment using a large volume of cryogenic liquid. In addition to the new laboratory space created by SNOLAB, there is also the existing SNO detector cavern and it’s associated Utility Drift and control room. As well, the relocation of the personnel facilities in Phase I will make the existing South Drift used for the SNO personnel facilities available. The South Drift will be refurbished as experimental space. The experimental spaces that will be created for SNOLAB are listed in table 4.2. Future expansion of the laboratory beyond Phase II will be possible through “Stub Drifts” located near the Rectangular Hall and at off the bottom access ramp at the base of the Rectangular Hall and Cryopit.

The SNOLAB expansion of the SNO facility will excavate an additional 991,000 cubic feet

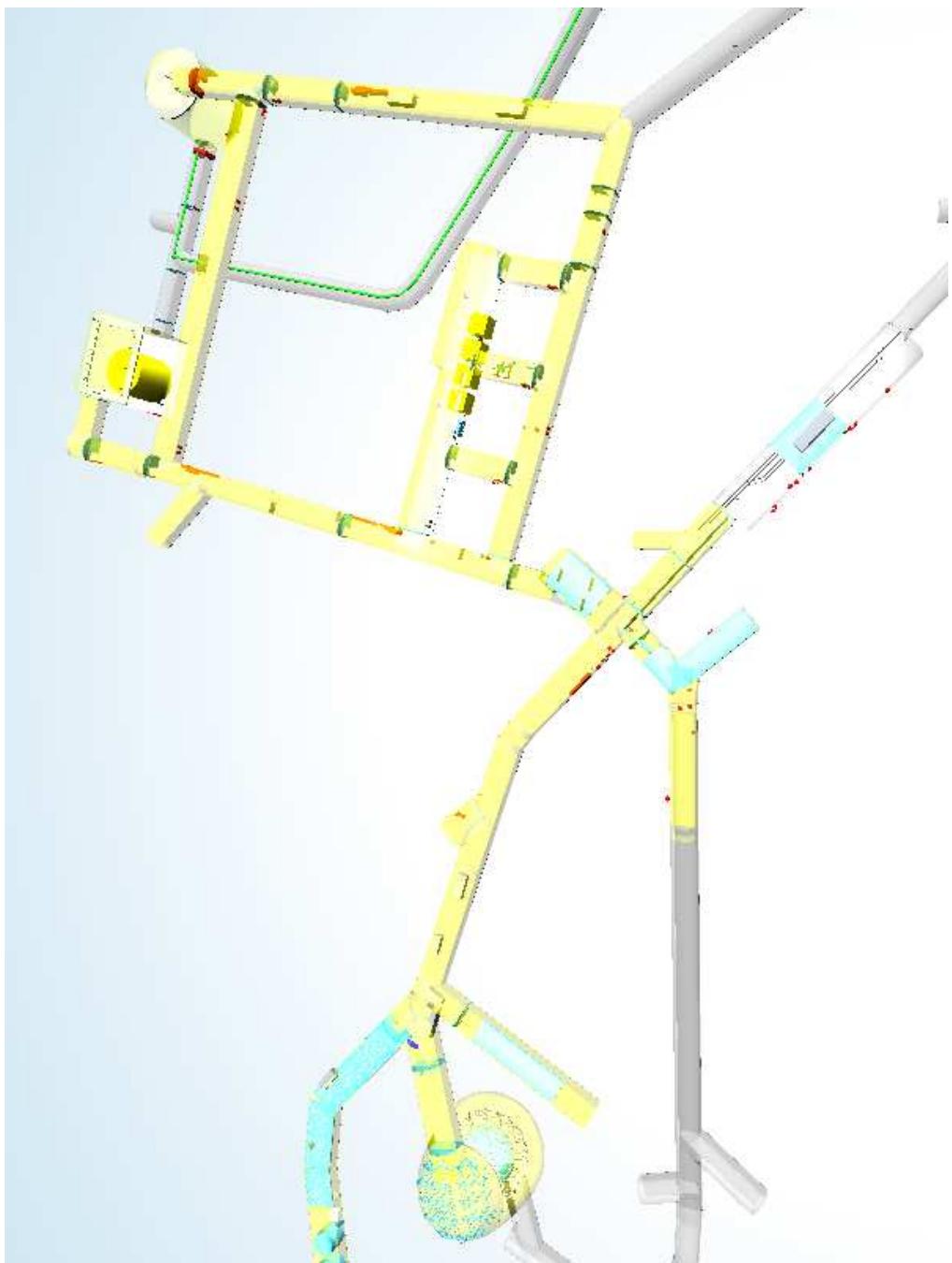


Figure 4.1: View of SNOLAB showing the existing and new laboratory spaces.

Space Type		Existing	Existing + Phase I	Existing + Phase I & II
Clean	Area	12,196 ft <sup>2</sup> 1,133 m <sup>2</sup>	41,955 ft <sup>2</sup> 3,899 m <sup>2</sup>	53,180 ft <sup>2</sup> 4,942 m <sup>2</sup>
	Volume	470,360 ft <sup>3</sup> 13,321 m <sup>3</sup>	1,049,393 ft <sup>3</sup> 29,719 m <sup>3</sup>	1,314,973 ft <sup>3</sup> 37,241 m <sup>3</sup>
Expt Space	Area	8,095 ft <sup>2</sup> 752 m <sup>2</sup>	26,117 ft <sup>2</sup> 2,427 m <sup>2</sup>	32,877 ft <sup>2</sup> 3,055 m <sup>2</sup>
	Volume	412,390 ft <sup>3</sup> 11,679 m <sup>3</sup>	837,604 ft <sup>3</sup> 23,721 m <sup>3</sup>	1,043,579 ft <sup>3</sup> 29,555 m <sup>3</sup>
Dirty	Area	7,853 ft <sup>2</sup> 730 m <sup>2</sup>	23,385 ft <sup>2</sup> 2,173 m <sup>2</sup>	24,456 ft <sup>2</sup> 2,273 m <sup>2</sup>
	Volume	112,633 ft <sup>3</sup> 3,190 m <sup>3</sup>	318,095 ft <sup>3</sup> 9,009 m <sup>3</sup>	332,161 ft <sup>3</sup> 9,407 m <sup>3</sup>
Total	Area	20,049 ft <sup>2</sup> 1,863 m <sup>2</sup>	65,340 ft <sup>2</sup> 6,072 m <sup>2</sup>	77,636 ft <sup>2</sup> 7,215 m <sup>2</sup>
	Volume	582,993 ft <sup>3</sup> 16,511 m <sup>3</sup>	1,367,488 ft <sup>3</sup> 38,728 m <sup>3</sup>	1,647,134 ft <sup>3</sup> 46,648 m <sup>3</sup>

Table 4.1: Summary of the excavated spaces in the different phases of SNOLAB construction. For the existing excavations, some

of rock adding 51,000 sq ft of space to the existing SNO excavations. In addition, existing space outside the current SNO facility will be incorporated into the new SNOLAB facility. The resulting laboratory will have 53,000 sq ft of clean room space of which 33,000 sq ft will be usable for experiments. An additional 24,000 sq ft of excavation outside the clean room will be used by SNOLAB for service infrastructure and material transportation and storage. The Phase I addition will triple the area (double the volume) of the space available for experiments. With the addition of Phase II the resulting laboratory will have four times the area and almost three times the volume of the existing experimental space in the SNO facility.

The nominal finishes inside the clean spaces of the laboratory will be shotcreted and painted walls and painted concrete floors. Nominal shotcrete thickness will be 3 in and nominal concrete floor thickness is 4 in. Outside the lab most areas will be bolted and screened but not shotcreted or painted. Material handling areas such as immediately outside the laboratory entrance will have concrete pads. Other areas will have bare gravel on the drift (tunnel) floors. In most instances services (ventilation, water, wiring) will be exposed in pipe and cable trays at the back (top) of the drifts.

#### 4.1.1 Geotechnical Considerations

SNOLAB is situated in Norite rock in the *Hanging Wall* of the mine approximately 1000 ft (300 m) from the ore body. The location of both the original SNO facility and the SNOLAB expansion was determined by geotechnical considerations. The spread out nature of the laboratory is due to the local nature of the rock that the laboratory is situated in. The large excavations (Rectangular Hall

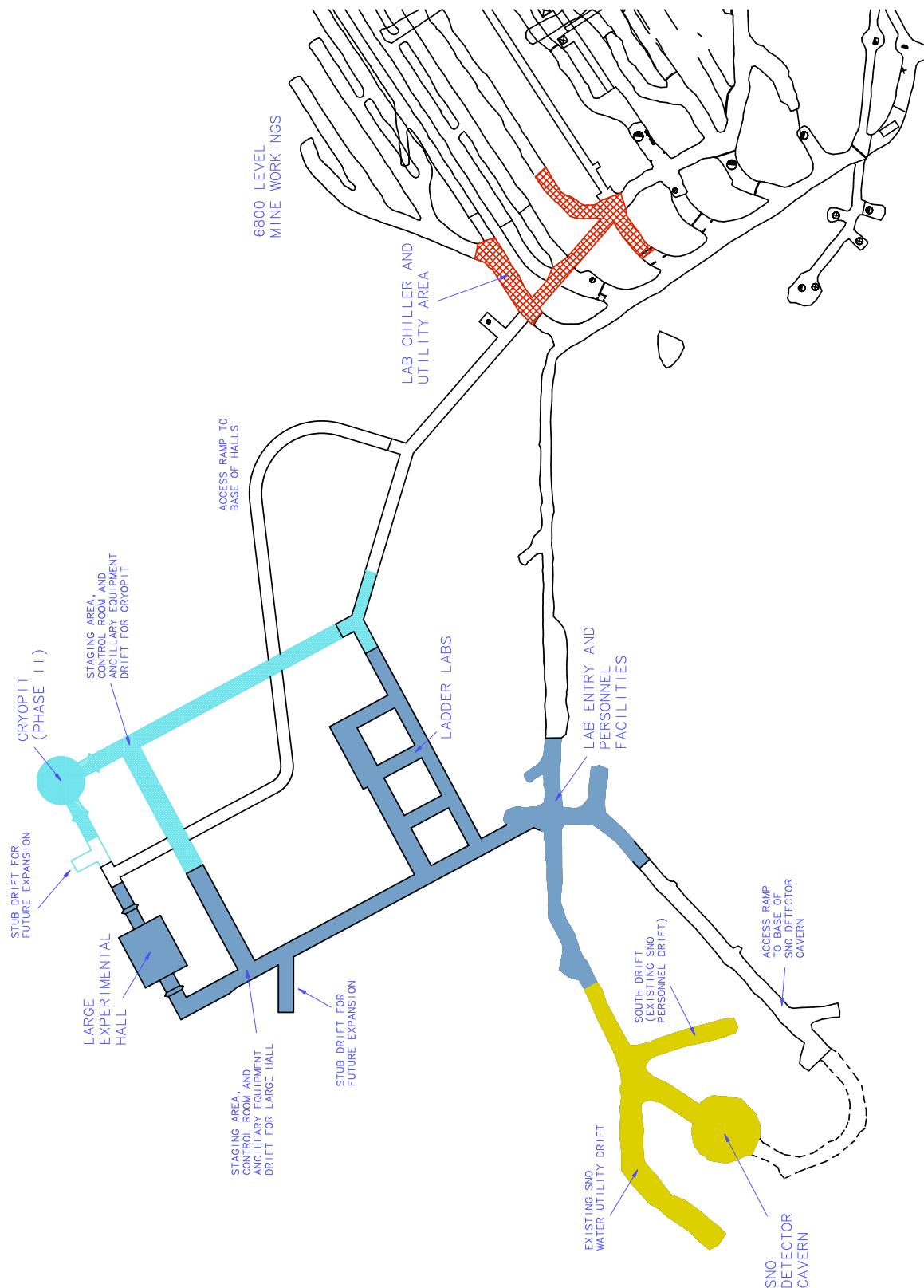


Figure 4.2: The SNOLAB layout showing the existing SNO facility (yellow), the new SNOLAB clean excavations Phase I (dark blue) and Phase II (light blue).

Laboratory Space	Style	Length	Width	Height Shoulder/Back	Area	Volume
SNO Cavern (Existing)	Cavern	58.73 (dia) <sup>a</sup> ft (17.90 m)		79.45/98.45 ft (24.21/30.01 m)	2,686 ft <sup>2</sup> (249.62 m <sup>2</sup> )	330,976 ft <sup>3</sup> (9,373.4 m <sup>3</sup> )
	Utility Drift	191 ft (58.22 m)	22.5 ft (6.86 m)	9.67/17.33 ft <sup>b</sup> (2.95/5.28 m)	4,297.5 ft <sup>2</sup> (399.4 m <sup>2</sup> )	65,220.8 ft <sup>3</sup> (1,847.1 m <sup>3</sup> )
	Control Rm	57 ft (17.37 m)	19.5 ft (5.94 m)	9.67/16.33 ft <sup>b</sup> (2.95/4.98 m)	1,111.5 ft <sup>2</sup> (103.3 m <sup>2</sup> )	16,192.96 ft <sup>3</sup> (458.6 m <sup>3</sup> )
					8,094.9 ft <sup>2</sup> (752.3 m <sup>2</sup> )	412,389.7 ft <sup>3</sup> (11,679.1 m <sup>3</sup> )
South Drift <sup>c</sup> (Existing)	Drift	95 ft (29 m)	16 ft (4.9 m)	9.67/15.16 ft <sup>b</sup> (2.95/4.62 m)	1,520 ft <sup>2</sup> (141.3 m <sup>2</sup> )	21,175.2 ft <sup>3</sup> (599.7 m <sup>3</sup> )
Ladder Labs (Phase I)	Drift C1	105 ft (32 m)	19.5 ft (5.94 m)	11.67/18.33 ft (3.56/5.59 m)	2,047.5 ft <sup>2</sup> (190.3 m <sup>2</sup> )	33,914 ft <sup>3</sup> (960.5 m <sup>3</sup> )
	Drift C2	75 ft (22.9 m)	24.5 ft (7.47 m)	16.67/25 ft (5.08/7.62 m)	1,837.5 ft <sup>2</sup> (170.8 m <sup>2</sup> )	40,819.3 ft <sup>3</sup> (1,156 m <sup>3</sup> )
	Drift B&D	397.6 ft (121.2 m)	14.5 ft (4.42 m)	9.67/14.67 ft (2.95/4.47 m)	5,765.2 ft <sup>2</sup> (535.8 m <sup>2</sup> )	75,419.2 ft <sup>3</sup> (2,135.9 m <sup>3</sup> )
					9,650.2 ft <sup>2</sup> (896.9 m <sup>2</sup> )	150,152.4 ft <sup>3</sup> (4,252.4 m <sup>3</sup> )
Rectangular Hall (Phase I)	Hall	60 ft (18.3 m)	49.5 ft (15.1 m)	49.67/64.67 ft (15.1/19.7 m)	2970 ft <sup>2</sup> (276 m <sup>2</sup> )	198,921.6 ft <sup>3</sup> (5,633.6 m <sup>3</sup> )
	Utility Drift	115 ft (35.1 m)	19.5 ft (5.94 m)	9.67/16.33 ft (2.95/4.98 m)	2,242.5 ft <sup>2</sup> (208.4 m <sup>2</sup> )	32,670 ft <sup>3</sup> (925.2 m <sup>3</sup> )
	Staging Area	29 ft (8.84 m)	15.5 ft (4.72 m)	9.67/15 ft (2.95/4.57 m)	449.5 ft <sup>2</sup> (41.8 m <sup>2</sup> )	5,865.5 ft <sup>3</sup> (166.1 m <sup>3</sup> )
	Control Rm/Office	68 ft (20.7 m)	17.5 ft (5.33 m)	9.67/15.66 ft (2.95/4.77 m)	1,190 ft <sup>2</sup> (110.6 m <sup>2</sup> )	16,429.4 ft <sup>3</sup> (465.3 m <sup>3</sup> )
					6,852 ft <sup>2</sup> (636.8 m <sup>2</sup> )	253,886.5 ft <sup>3</sup> (7,190.2 m <sup>3</sup> )
Cryopit (Phase II)	Cavern	49.5 (dia) <sup>a</sup> ft (15.1 m)		49.67/64.67 ft (15.1/19.7 m)	1,943.9 ft <sup>2</sup> (180.7 m <sup>2</sup> )	138,958 ft <sup>3</sup> (3,935.4 m <sup>3</sup> )
	Utility Drift	141 ft (43 m)	19.5 ft (5.94 m)	9.67/16.33 ft (2.95/4.98 m)	2,749.5 ft <sup>2</sup> (255.5 m <sup>2</sup> )	40,056.3 ft <sup>3</sup> (1,134.4 m <sup>3</sup> )
	Staging Area	46.3 ft (14.1 m)	15.5 ft (4.72 m)	9.67/15 ft (2.95/4.57 m)	717.7 ft <sup>2</sup> (66.7 m <sup>2</sup> )	9,364.6 ft <sup>3</sup> (265.2 m <sup>3</sup> )
	Control Rm/Office	87 ft (26.5 m)	15.5 ft (4.72 m)	9.67/15.0 ft (2.95/4.57 m)	1,348.5 ft <sup>2</sup> (125.3 m <sup>2</sup> )	17,596.5 ft <sup>3</sup> (498.3 m <sup>3</sup> )
					6,759.6 ft <sup>2</sup> (628.2 m <sup>2</sup> )	205,975.4 ft <sup>3</sup> (5,833.3 m <sup>3</sup> )
Existing					8,094.9 ft <sup>2</sup> (752.3 m <sup>2</sup> )	412,389.7 ft <sup>3</sup> (11,679.1 m <sup>3</sup> )
Existing + Phase I					26,117.1 ft <sup>2</sup> (2,427.2 m <sup>2</sup> )	837,603.9 ft <sup>3</sup> (23,721.4 m <sup>3</sup> )
Existing + Phase I & II					32,876.7 ft <sup>2</sup> (3,055.5 m <sup>2</sup> )	1,043,579.2 ft <sup>3</sup> (29,554.8 m <sup>3</sup> )

a)Diameter of Deck.

b)Estimated

c)Converted from personnel area to experimental space in Phase I.

Table 4.2: Summary of new and existing spaces available for experiments in SNOLAB. Dimensions are of clear spaces after application of shotcrete coatings and concrete floors.

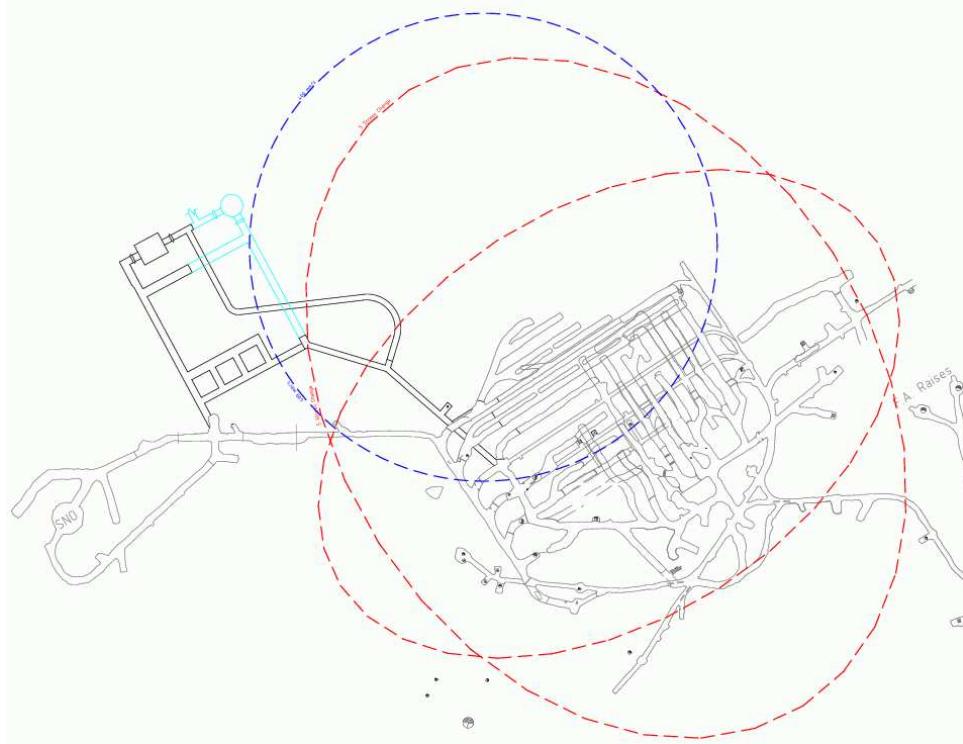


Figure 4.3: The new laboratory excavations are located outside the 5% stress zones (red) and beyond the zone of 400 mm/s Peak Particle Velocity (ppv) in the event of a 4.0 seismic event (blue line).

and Cryopit) are placed nominally three times their maximum dimension from each other to avoid rock stress. The large halls are located 200 ft north of the Ladder Labs to avoid a fracture zone. The longitudinal direction of the large excavations runs east/west in the direction of the principal rock stress. The experimental spaces are located outside the zone where mining has changed the ambient stress in the rock by more than 5% (figure 4.3). As well, geotechnical analysis of the mining considers that at the extreme a 4.0 event on the Nuttli scale is possible in the mine. SNOLAB's experimental spaces are located such that if such a large event occurred, it would induce at most 400 mm/s Peak Particle Velocity (ppv) [6]. The *Ground Support* (reinforcement of the rock) is designed to withstand such an event.

#### 4.1.2 About Excavations

SNOLAB consists of a number of large caverns connected by smaller tunnels. Most of the SNOLAB excavations are constructed following conventional mining techniques. The horizontal tunnels are referred to as *Drifts*. The roof of a drift is referred to as the *Back* of the drift. Figure 4.4 shows a typical drift cross section. The nominal shape of the drift has a flat floor, vertical walls and an arched back. The shape of the arch is usually a section of a circle. The maximum height of the drift is the height of the walls plus one third the width of the drift. The point where the vertical wall meets the arched back is called the *Shoulder* or *Spring Line*. Drift dimensions are typically quoted as width and shoulder height.

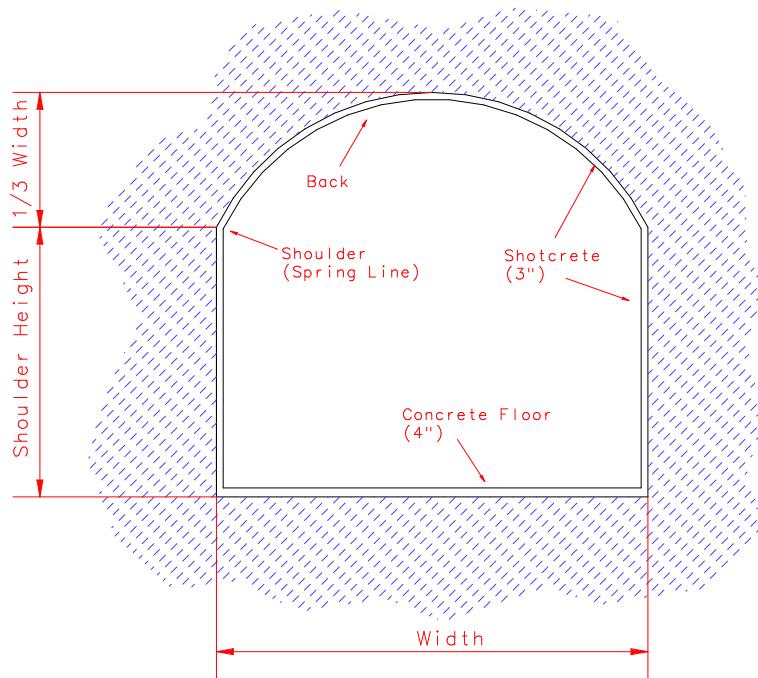


Figure 4.4: Typical Drift Cross Section in SNOLAB.

The process of strengthening the rock around excavations is called *Ground Support* or *Ground Control*. All excavations in SNOLAB and on the 6800 Level of Creighton Mine have ground support. Areas outside SNOLAB usually have 6 ft or 8 ft *Rock Bolts* and 4 or 6 inch mesh *Screen* for ground support. Large expanses will have additional ground support consisting of *Cable Bolts* which can be anchored 20 ft or more back from the opening. Inside the Lab additional ground support consists of a concrete material called *Shotcrete* which is sprayed onto the walls and backs of the drifts. The nominal thickness of the shotcrete liner for SNOLAB will be 3 inches. The floors of the drifts usually have a layer of gravel on them to provide a level surface. Inside the lab there will be a concrete floor with nominal thickness 4 inches.

The experimental halls or caverns are larger excavations which are modeled on simple geometric solids such as rectangular boxes and cylinders. However the backs are again arched (with the 1/3 of the width rule) and the walls of the caverns bulge outwards following the stress contours in the rock. Ground support consists of rock bolts, cable bolts, screen and shotcrete. The corners of rectangular halls are rounded to reduce rock stress. Similarly, the corners at the ends and the intersections of drifts are rounded.

The shapes of drifts and caverns described above are the *design shapes*. Of course the actual shape that the excavations take depends on how the rock fractures. The excavated spaces will have irregularly shaped walls. In general, the excavations will tend to be slightly larger than what is specified.

*It is important to note that unless otherwise specified, the excavated dimensions for drifts and caverns will be reported. The finished spaces with shotcrete walls and backs and concrete floors are in general 6 inches narrower ( $2 \times 3"$  shotcrete) and 7 inches shorter ( $4"$  concrete floor +  $3"$  shotcrete back).*

## 4.2 Laboratory Entry

The entry to the SNOLAB underground facility will be closely modeled after the existing SNO facility entrance. Immediately outside the laboratory entrance is the *Double Track Area* which is a 120 ft long by 22 ft wide area intended for “dirty” material handling outside the lab. The 6800 Level railway double tracks in this area to allow manipulation of rail cars. The laboratory’s main air intake is brought through an air handler situated on a mezzanine above the rail lines.

Personnel enter the laboratory through a *manway* off the Double Track Area after first washing their boots at a *Boot Wash Station*. The manway leads to a *Boot Room* where mine boots and cap lamps are removed (figure 4.6). Personnel then proceed to the *Drys* (change rooms and showers). The Men’s Dry is located on the main level, the Women’s Dry located on a mezzanine level. Personnel pass through showers, and change into clean room clothing before entering the laboratory. The Drys are situated in the *Personnel Drift* which also contains the laboratory’s *Lunch Room*, *Laundry*, and *Washrooms*. Clean room clothing is washed underground in a small *Laundry* located on the upper level of the personnel drift. A small meeting area is located on the mezzanine adjacent to the Laundry. An area at the end of the Lunch Room is allocated as a storage area but may be converted into a conference room. At the end of the Lunch Room is an airlock that will allow access to the SNO Cavern Ramp. The Personnel Drift also acts as the *Refuge Station* for the laboratory where personnel would assemble in the event of a fire either in the laboratory or elsewhere in the mine. The personnel facilities for SNOLAB are designed for nominal occupancy of 50 personnel with a peak occupancy of 70.

Materials entering the laboratory pass through the *Carwash* which is a two bay facility for cleaning and processing materials. The rail line enters *Bay 1* of the Carwash where transport containers can be cleaned prior to opening. A hatchway connects Bay 1 to Bay 2. The transport containers can be connected to the hatchway and opened from Bay 2, allowing the clean contents to be brought into the laboratory without further cleaning. Bay 1 will have a 2 Tonne bridge crane and Bay 2 a 2 Tonne monorail crane for material handling. There is a stub drift off the side of Bay 1 that can be used for “semi clean” material storage.

The area just north of the Personnel Drift is referred to as the *Junction* and is an intersection between the Personnel Drift, the Carwash/Lab Entry Drift, The SNO Access Drift and the Rectangular Hall and Ladder Labs access drift. There is a large room at the Junction which for historic reasons is referred to as the *Bladder Room*<sup>1</sup>. Two air handlers are located on a mezzanine in the Bladder Room.

## 4.3 Ladder Labs

The *Ladder Labs* consist of a network of drifts located north of the Laboratory entry (figure 4.7). The experimental space consists of the two “rails” of the ladder running east/west with three “rungs” running north south (figure 4.8) for a total of 9375 ft<sup>2</sup> of laboratory space. Access to the Ladder Labs is from a drift running north from the laboratory entry to the Rectangular Hall. The Ladder Labs are isolated from the access drift by walls at the west end of Drifts C and D. Drift D extends beyond Drift B3 and a small *Chemistry Lab* will be situated in this extension. In the

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<sup>1</sup>This room originally contained a 26,000 gal fire water bladder intended as an emergency deluge during the SNO detector excavation.

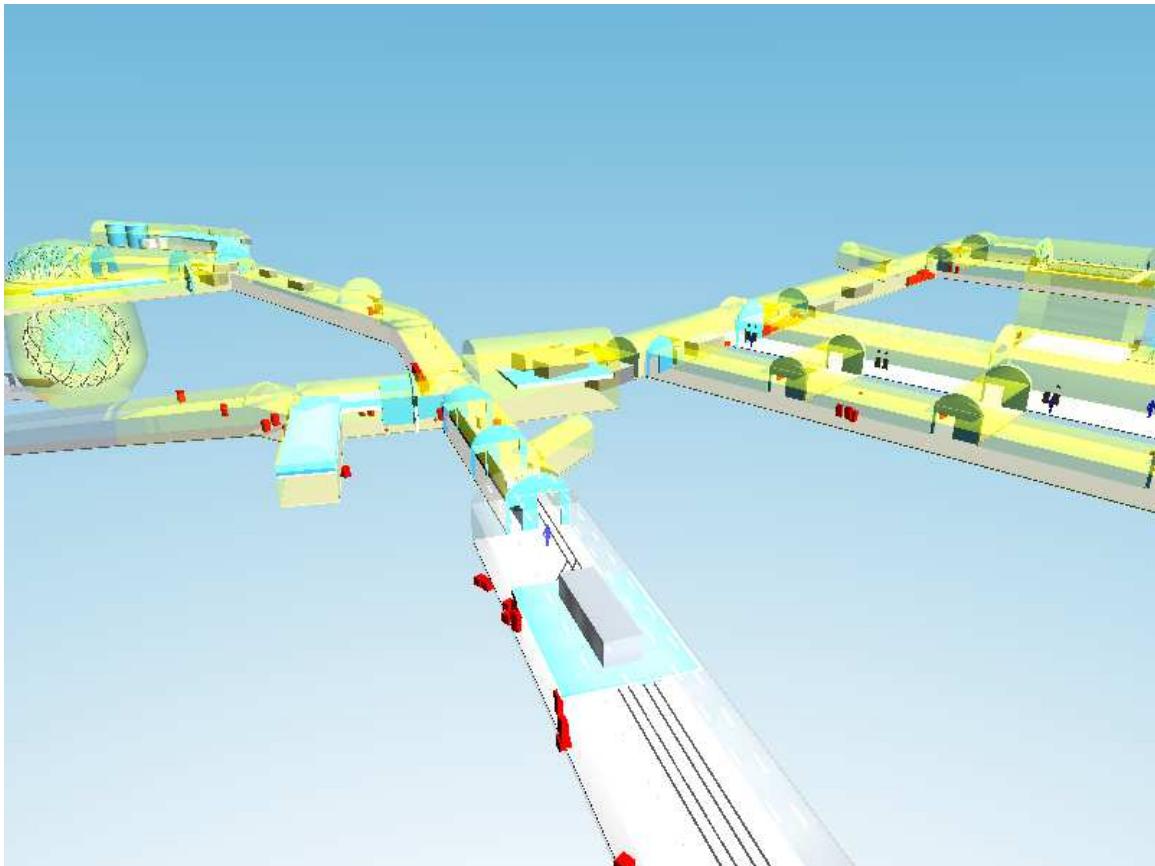


Figure 4.5: Laboratory Entry conceptual view.

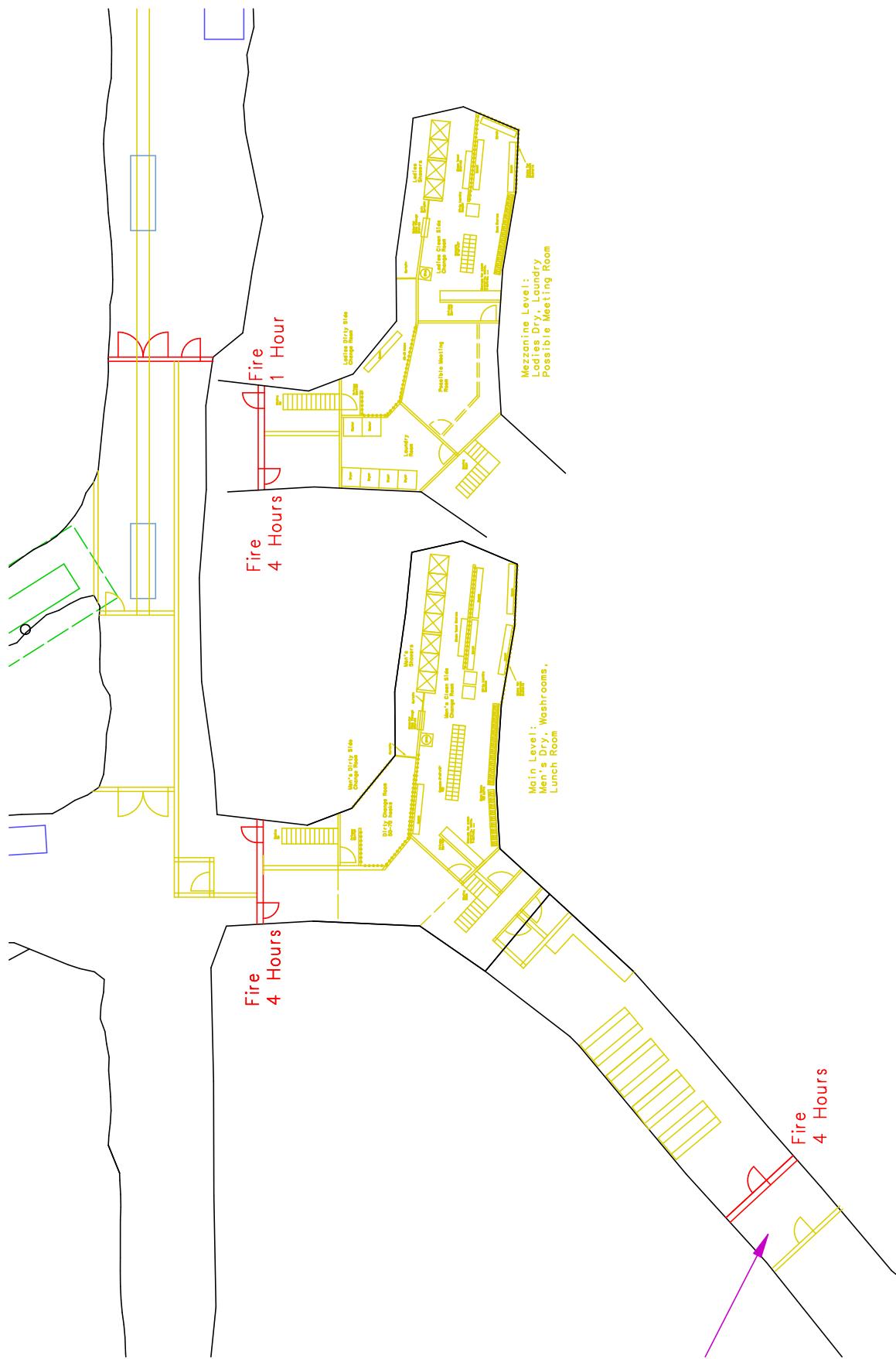


Figure 4.6: Layout of the Underground Lab Personnel Facilities

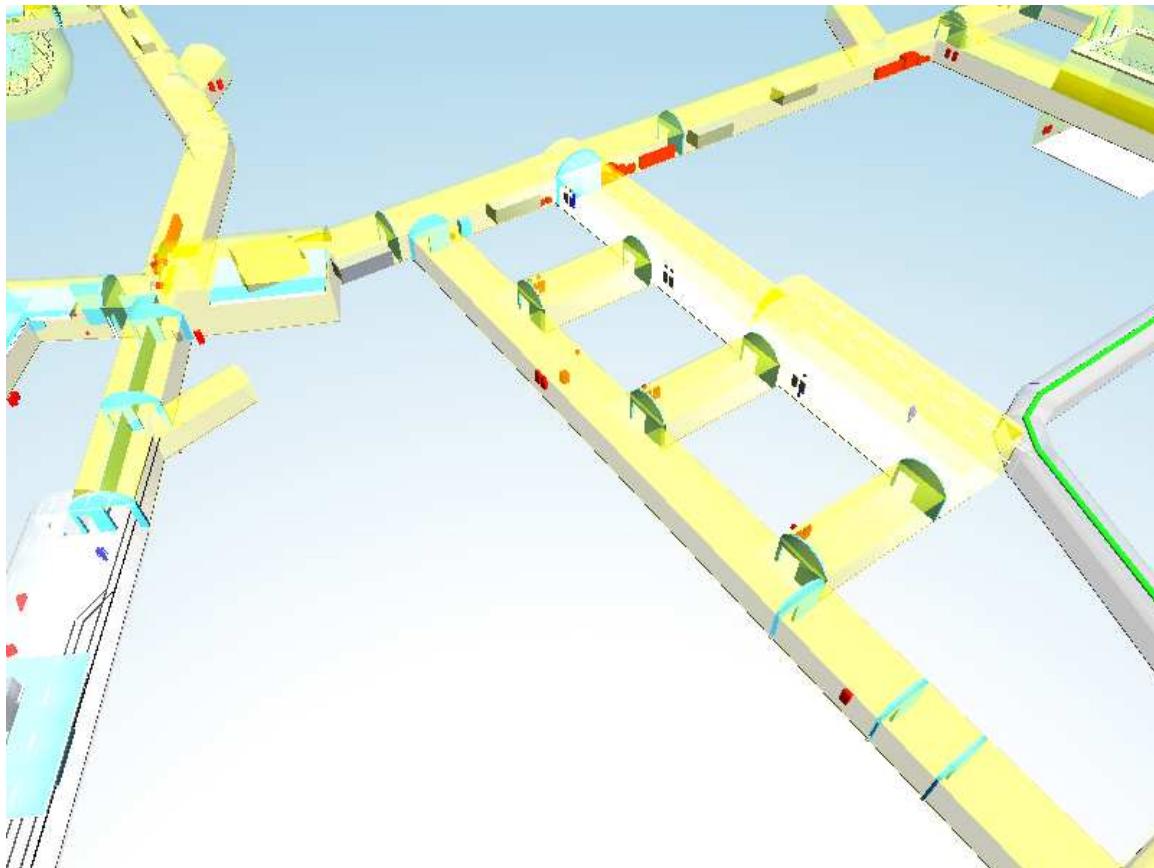


Figure 4.7: Ladder Labs conceptual view.

Phase I construction of SNOLAB, the east end of the Chemistry Lab will have an airlock to Drift E which is a mine side drift which was used for the excavation of the lab. While the air lock will make it possible to bring appropriately cleaned large equipment directly into the Ladder Labs, its primary purpose is for emergency egress. With the Phase II addition of the Cryopit, the air lock to the mine side will be moved further down Drift E and access to the Cryopit support areas will be possible through the Chemistry Lab.

The *Ladder Lab Services Area* is the access drift running north/south between the Lab entrance and the Rectangular Hall at the west end of the Ladder Labs. The Service Area contains the electrical services (Motor Control Centre, future UPSs, future power conditioners), communications hub (network and telephone) and Air Handling Units. The domestic water, chilled water, UPW, and fire water will be distributed into the Ladder Labs from this area.

The north rail of the Ladder Labs (Drift C) is the principle experimental space. The total length of this rails is 180 feet and consists of a 105 ft long section (Drift C1) that is 20 ft wide and 12 ft to the shoulder (back height 18' 8") and a 75 ft long section (Drift C2) that is 25 ft wide and 17 ft to the shoulder (back height 25' 4")<sup>2</sup> The south rail of the Ladder Labs (Drift D) is 15 ft wide, 10 ft to the shoulder and 15 ft to the back. The connecting rungs of the ladder (Drifts B1, B2, B3) are 15 ft wide, 10 ft to the shoulder and 15 ft to the back. The dimensions of the Ladder Lab drifts

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<sup>2</sup>These are excavated dimensions, see section 4.1.2.

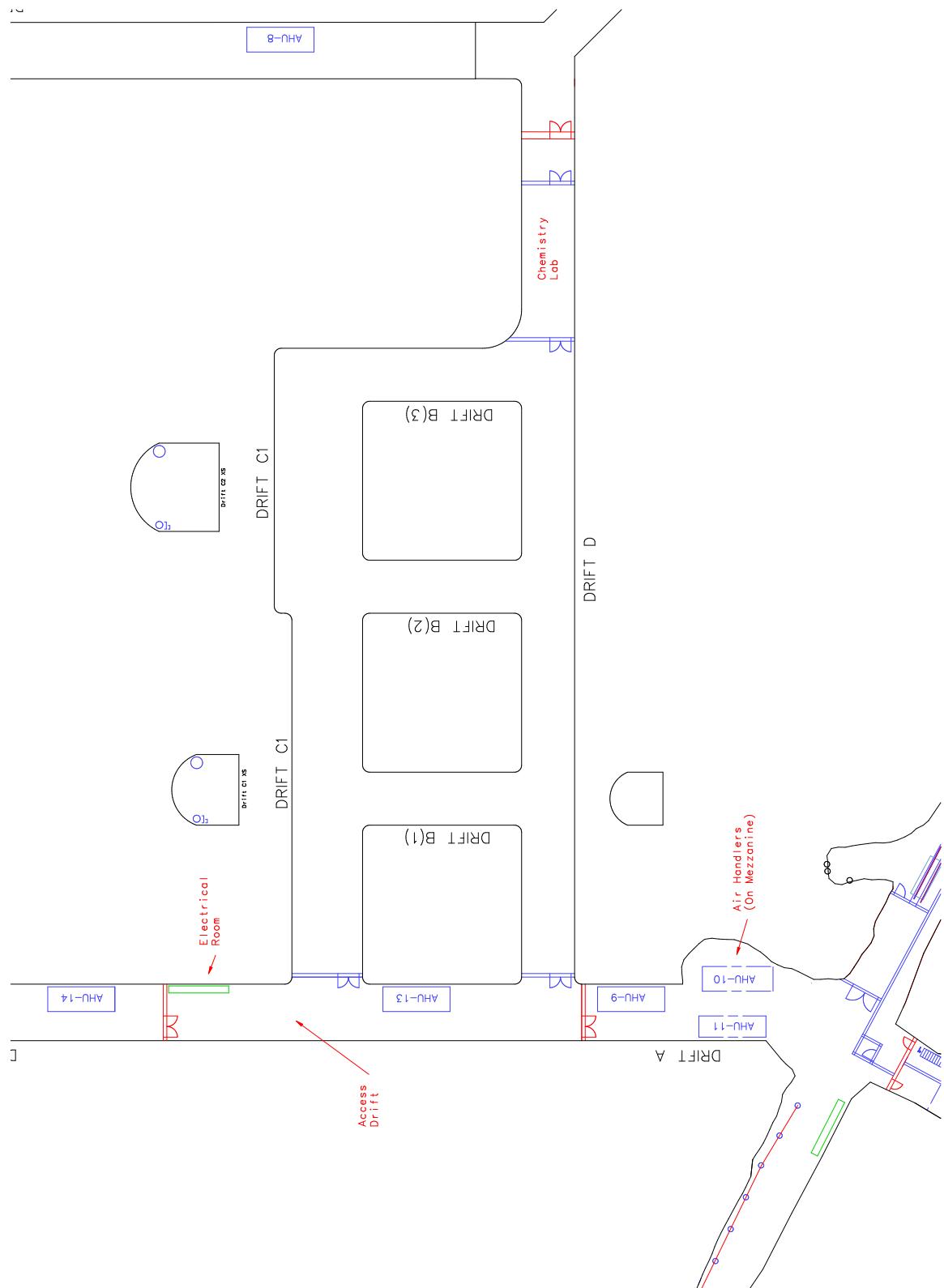


Figure 4.8: Possible configuration of the Ladder Lab area.

Rm	Name	Length	Width	H(shoulder)	H(Back)
	C1	105'	19'6"	11'7.5"	18'8"
	C2	75'	24'6"	16'7"	24'5"
	B1	45'	14'6"	9'7"	14'5"
	B2	45'	14'6"	9'7"	14'5"
	B3	45'	14'6"	9'7"	14'5"
	D	180'	14'6"	9'7"	14'5"
	Chem Lab	43'	14'6"	9'7"	14'5"
	Air Lock	12'	14'6"	9'6"	14'5"

Table 4.3: Ladder Lab Rooms. The dimensions are the finished dimensions after shotcrete is applied to the walls and back and concrete on the floor.

are tabulated in table 4.3 and cross sections are shown in figure 4.9. Initially, no interior walls are specified in the Ladder Labs. It is expected that placement of the internal walls will be determined as the experimental needs are specified.

## 4.4 Rectangular Hall

The largest new experimental space being excavated for SNOLAB is the *Rectangular Hall*. Located north of the Ladder Labs, the Rectangular Hall will have floor space 60 ft long (east/west) and 50 ft wide (north/south) with the base of the hall 50 ft below the main level of the laboratory (figure 4.10). The back of the cavern extends an additional 15 ft above the main laboratory level making the total height of the cavern 65 ft. The walls of the Rectangular Hall are bulged to follow the stress contours in the rock (see figure 4.11). In the north/south direction the walls bulge 10 ft giving a maximum width of 60 ft. In the east/west direction the walls bulge 5 ft giving a maximum width of 65 ft.

Immediately adjacent to the Rectangular Hall is the *Rectangular Hall Staging Area* which opens to the hall at the shoulder (50 ft above base). A stair well gives access to the base of the hall from the Staging Area and serves as a fire escape. A second access point to the Rectangular Hall will be through an airlock at it's base that opens to a dirty ramp (figures 4.11 and 4.12). This access drift will allow access to the hall for civil construction activities without the risk of compromising the cleanliness elsewhere in SNOLAB. In the event that a cryogenic liquid experiment is installed in the Rectangular Hall, there are cut outs in both the Staging Area and bottom access drift. These cut outs allow the installation of high pressure bulkheads to contain a catastrophic boil off of cryogen. A similar arrangement will be part of the Phase II Cryopit.

The Staging Area is accessed through the *Rectangular Hall Control Room* (figure 4.13). Adjacent to the control room is the *Rectangular Hall Utility Drift* which is intended to house the ancillary services required to operate the experiment in the Hall. The Staging Area is 16 ft wide, 10 ft to the shoulder and 45 ft long. The Control Room is a drift with width varying from 16 to 18 ft and length 58 ft. The Utility Drift is 20 ft wide, 10 ft high at the shoulder (17 ft to the back) and 115 ft long. Drift dimensions are listed in table 4.4 and cross sections are shown in figure 4.14.

The HVAC and electrical services for the Rectangular Hall are located in the access drift

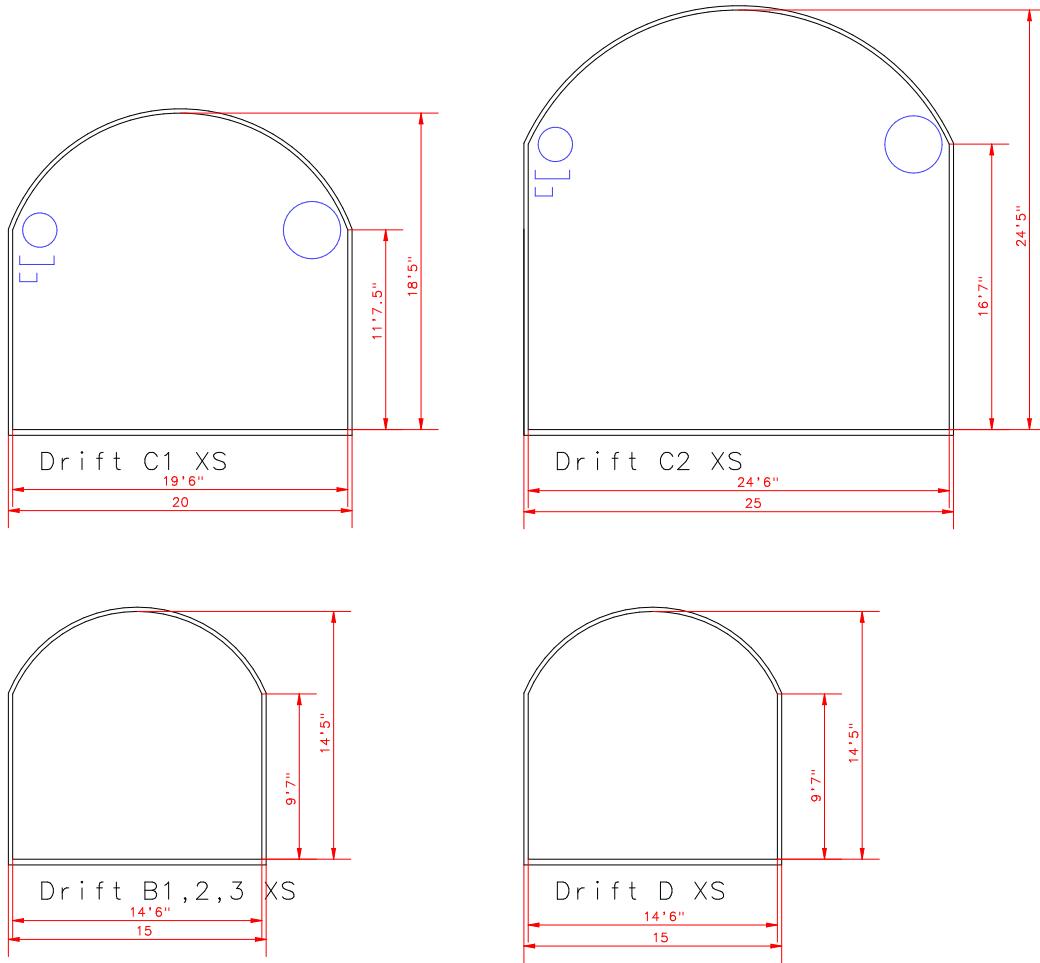


Figure 4.9: Ladder Lab drift cross sections. Nominal concrete floor thickness is 4". Nominal shotcrete wall thickness is 3". Ducts, piping and cable trays are only partially shown in the cross sections.

Rm	Name	Length	Width	H(shoulder)	H(Back)
	Rectangular Hall	59'6"	49'6"	49'8"	64'5"
	Staging Area	45'	19'6"	9'8"	18'8"
	Control Room	58'	15'6"/17'6"	9'8"	24'5"
	Utility Drift	115'	19'6"	9'7"	16'1"

Table 4.4: Rectangular Hall and Ancillary Spaces. The dimensions are the finished dimensions after shotcrete is applied to the walls and back and concrete on the floor.

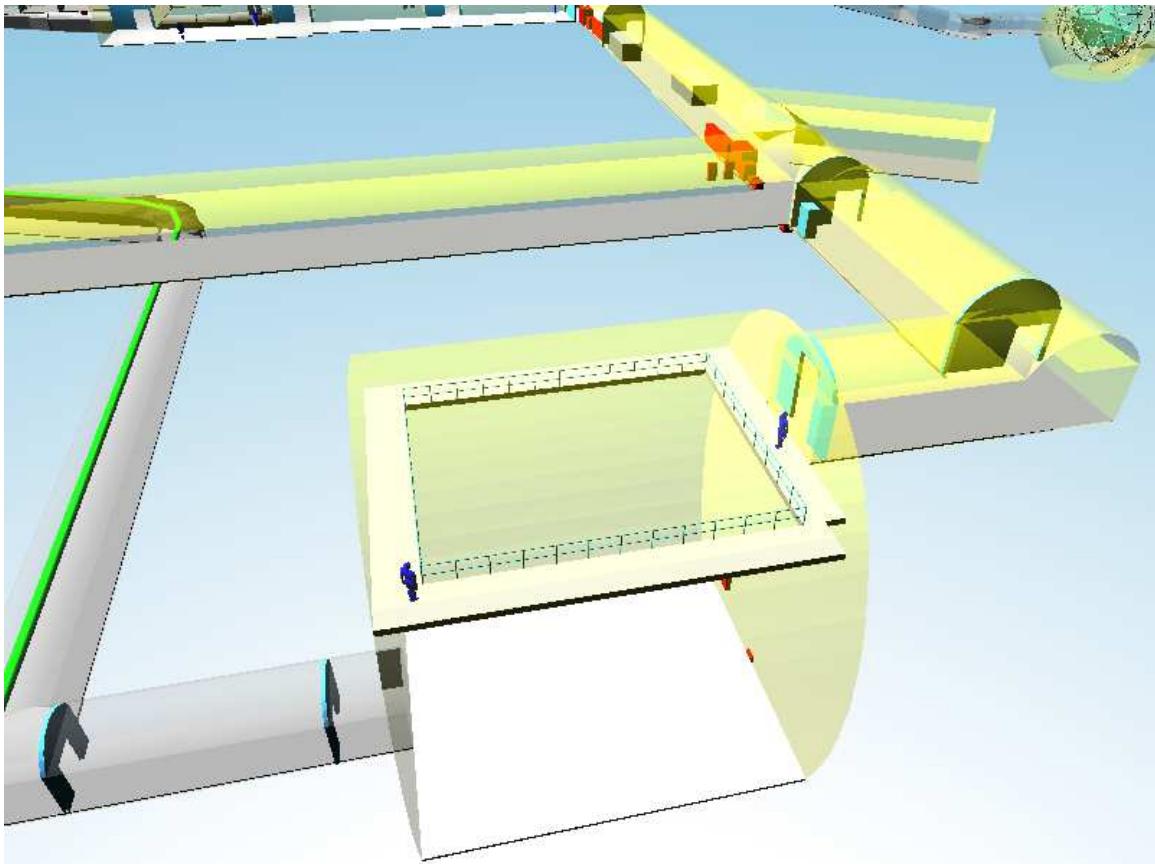


Figure 4.10: Conceptual view of the Rectangular Hall, Staging Area, Control Room and Utility Drift.

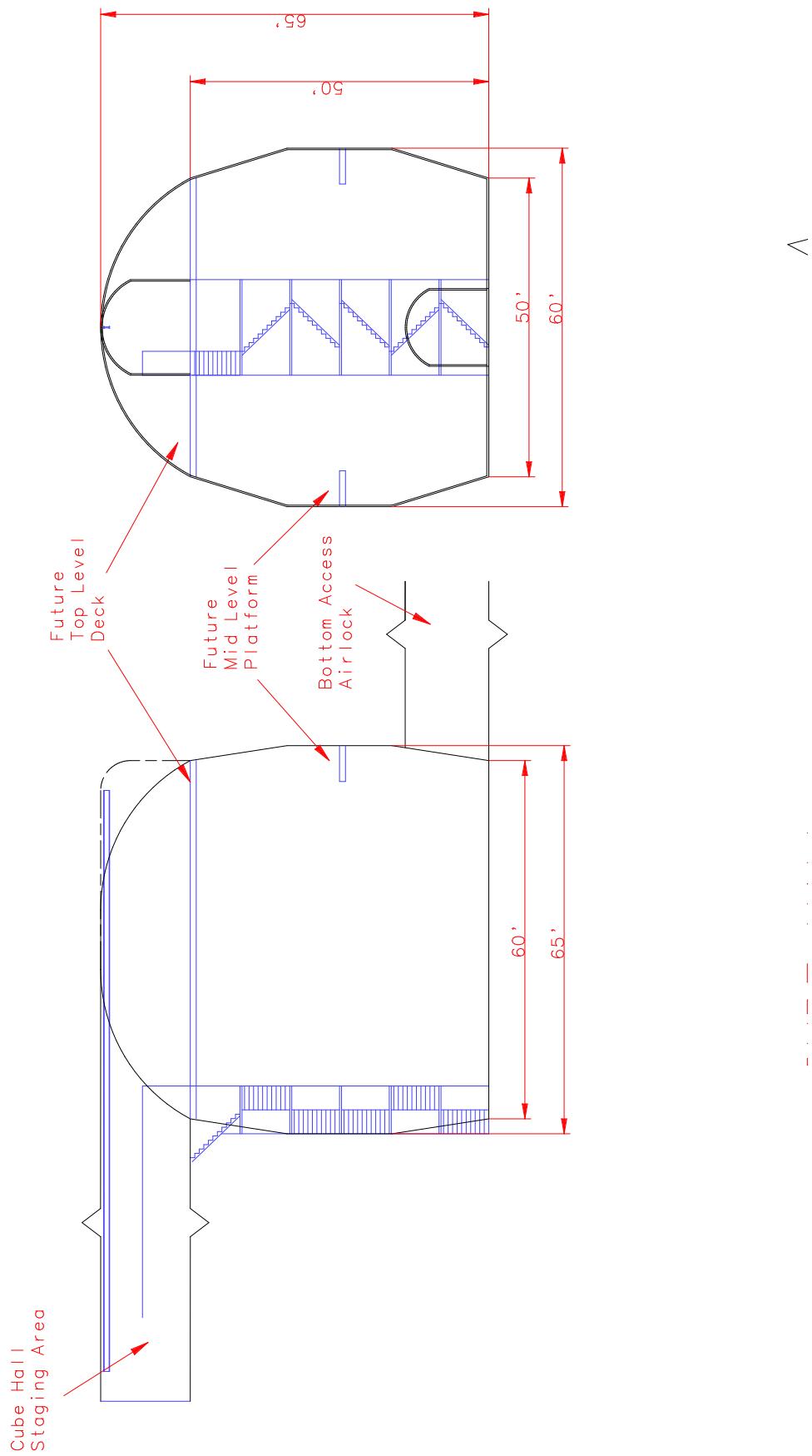


Figure 4.11: Rectangular Hall cross section.

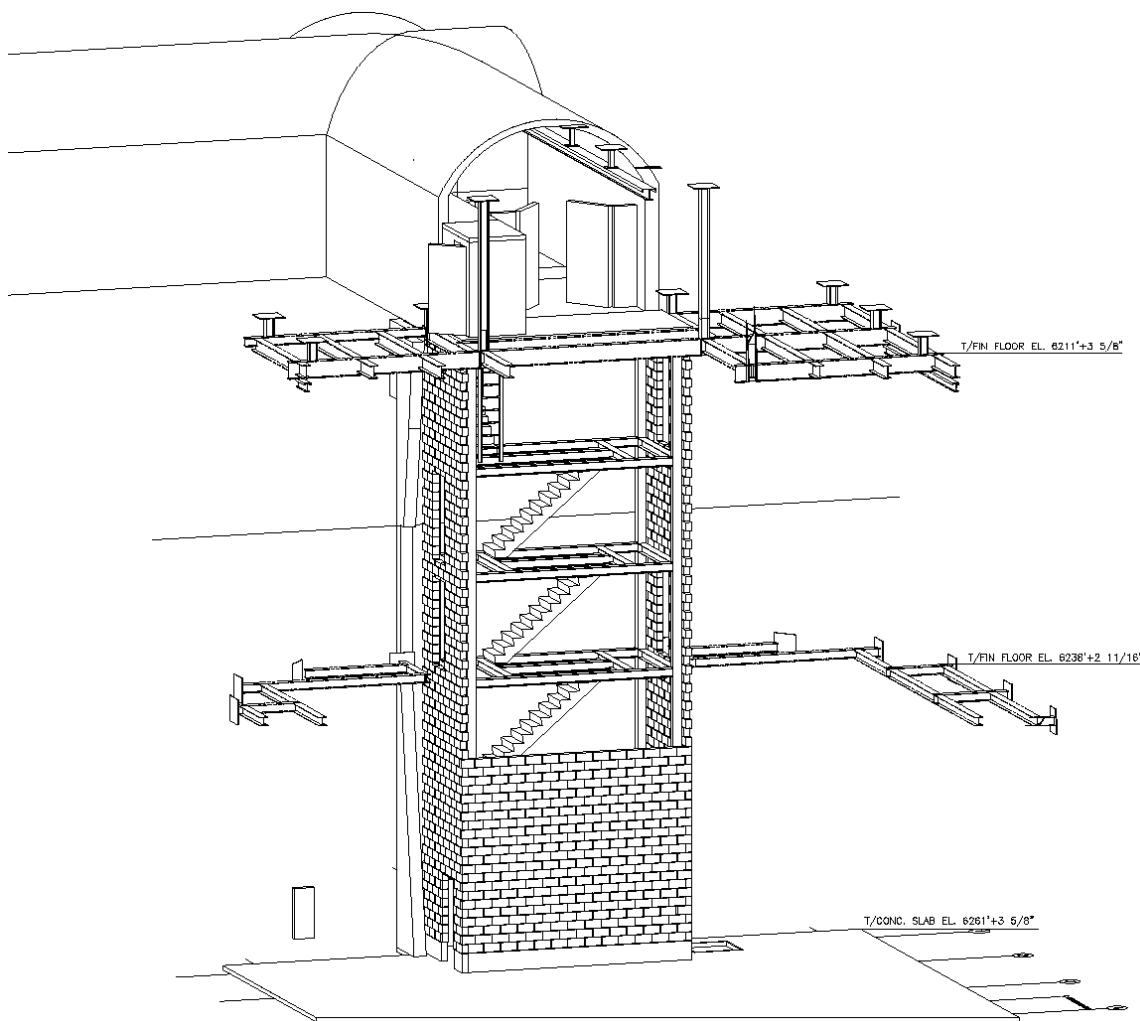


Figure 4.12: Rectangular Hall stairwell

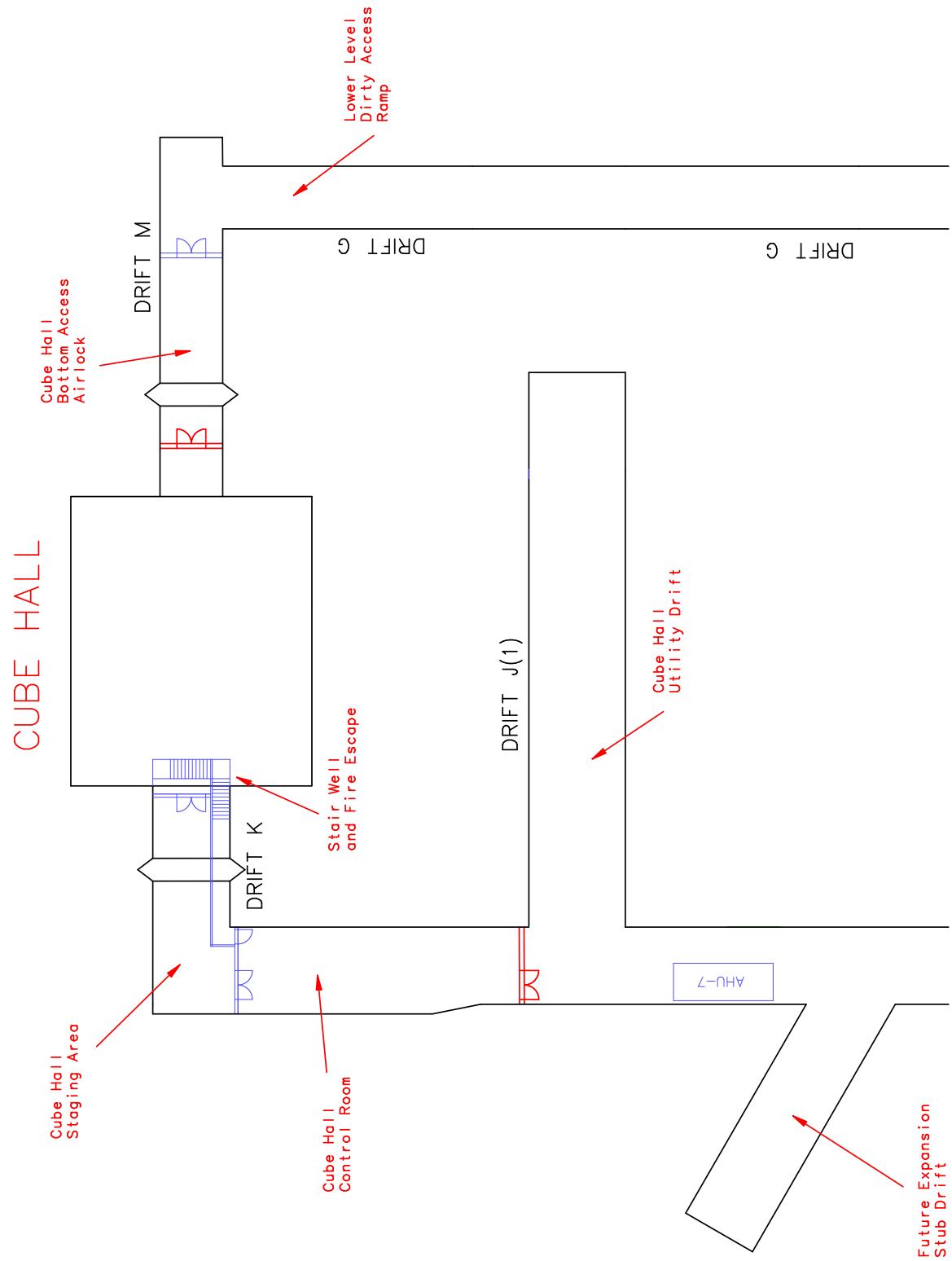
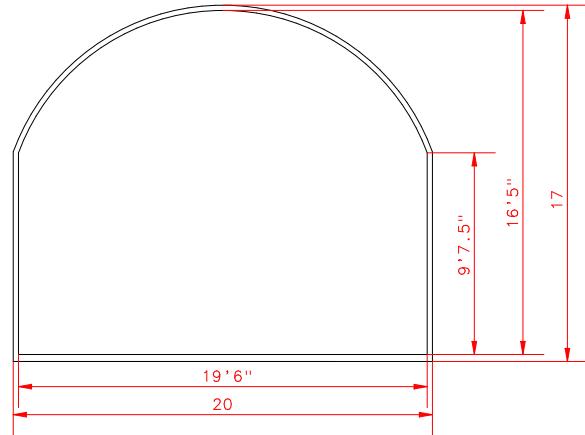
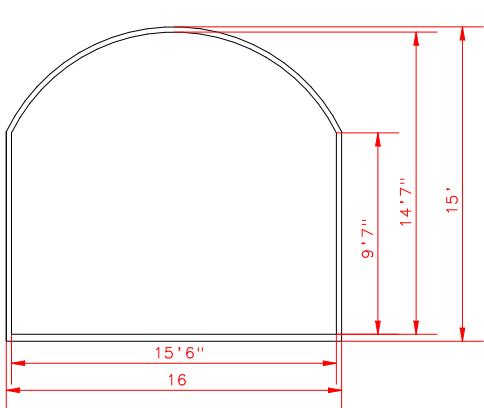


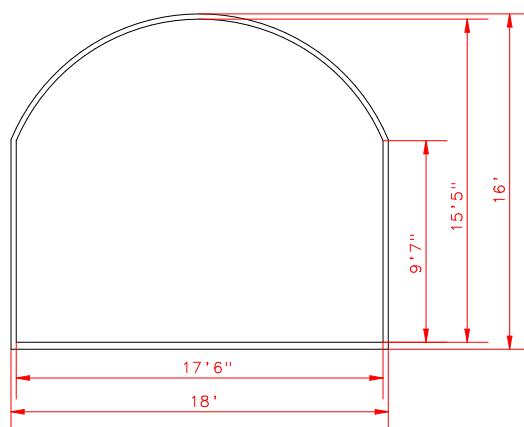
Figure 4.13: Schematic design of the Large Experimental Hall.



Cube Hall  
Utility Drift



Cube Hall  
Staging Area



Cube Hall  
Control Room

Figure 4.14: Cross Sections of the Ancillary Drifts for the Rectangular Hall. Duct work, piping and cable trays are not shown.

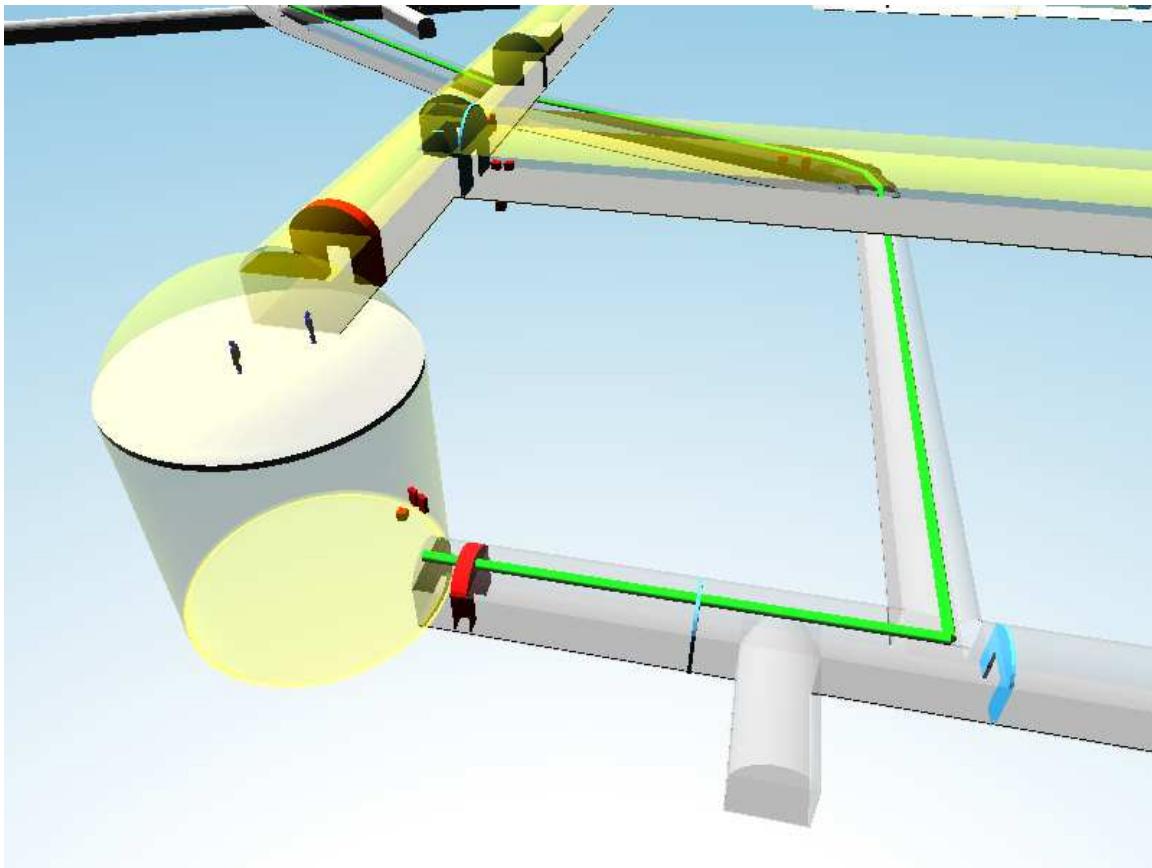


Figure 4.15: Conceptual view of the Cryopit, Staging Area, Control Room and Utility Drift. The bottom access ramp and a possible “pressure relief” ventilation pipe is shown in green.

connecting the Rectangular Hall area to the laboratory entrance south of the Hall. The initial outfitting of the Rectangular Hall will include a monorail crane running down the back of the Staging Area and across the Hall. Anchor points will be installed on the back of the hall to allow the installation of a deck structure in future (see figure 4.11). The design of the deck is modular allowing flexibility in the portion of the hall area covered by the deck. As well, it will be possible to install a bridge crane below the deck. At the waist of the hall will be anchor points to permit the installation of a mid level platform. Each of the anchor points on the back and on the sides of the hall are rated at 20 Tonnes and can be used for slinging or support other than for the deck or platform structures.

## 4.5 Cryopit (Phase II)

Phase II of the SNOLAB excavation will consist of the addition of a second large experimental cavern and its support spaces (figure 4.15). Dubbed the “Cryopit”, this cavern will consist of a barrel shaped pit 50 ft in diameter at the base and 50 ft high at the shoulder. The waist of the barrel is 60 ft in diameter and the cavern will be 65 ft high to the back (figure 4.17). Clean access to the cavern is through a Staging Area which opens into the Cryopit at the shoulder (50 ft above base).

In addition there is access to the base of the Cryopit through an airlock that opens to the dirty ramp shared by the Rectangular Hall. Adjacent to the Staging Area is the Control Room and the Utility Drift (figure 4.16). The Staging Area and Control Room will be located in 16 ft wide drifts, 10 ft to the shoulder. The Utility Drift will be a 20 ft wide drift that is 141 ft long and 10 ft to the shoulder (figure 4.18). Access to the Cryopit area will be through either the Rectangular Hall Utility Drift or through the Ladder Labs. The air handlers and electrical equipment for the Cryopit will be located south of the Control Room in Drift H.

Because the Cryopit may contain large volumes of cryogenic liquids, there is the possibility of the evolution of large volumes of gas if the cryogenic containment fails. Cut outs in the Staging Area and in the dirty access drift at the base of the hall allows the installation of pressure bulkheads to contain a catastrophic boil off. It is envisioned that a vent pipe could be installed in the dirty access ramp to the base of the pit which would exhaust the boil off gasses to the mine return air raise. The specific engineering required for an emergency exhaust of the Cryopit will be done by the experiment requiring it.

## 4.6 SNO Cavern

The *SNO Cavern* is a large barrel shaped cavern 22 m (72 ft) in diameter at it's waist, 34 m (112 ft) high. A deck supported from corbels is located approximately 20 ft below the top of cavern with the SNO neutrino detector suspended below this deck. Nominal deck loading is 100 lb/sqft. The entire cavern below the deck is flooded with ultra pure light water which acts as radiation shield for the detector and helps support the weight of the 1000 Tonnes of heavy water contained in the detector. The cavity walls are lined with urylon to make a water proof and radon proof barrier. Fourteen *Magnetic Compensation Coils* are embedded in the walls of the cavern to cancel the vertical component of the Earth's magnetic field<sup>3</sup>. The deck is accessed through the *SNO Control Room* (figure 4.20) which is 20 ft wide by 57 ft long. While there was access to the base of the Cavern via a ramp during construction, the *SNO Cavern Ramp* was partially sand filled after the construction and is no longer usable.

Adjacent to the SNO Control Room is the *SNO Utility Drift* which contains the SNO H<sub>2</sub>O and D<sub>2</sub>O water purification systems, the MCC (Motor Control Center) for the existing SNO facility and the UPS system for SNO. Situated at the back of the Utility Drift are two 60 Tonne Storage tanks for the D<sub>2</sub>O systems. A mezzanine extends most of the length of the Utility Drift (figure 4.20). While the D<sub>2</sub>O systems are expected to be decommissioned with the completion of the SNO experiment, the H<sub>2</sub>O purification system is expected to be maintained to provide ultra pure water for future experiments in SNOLAB.

## 4.7 South Drift

With the relocation of the laboratory entrance, the area currently used for personnel in the *South Drift* will be reclaimed for experimental space. This drift is approximately 17' wide by 95' long.

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<sup>3</sup>This increased the light collection efficiency of the SNO detector's PMTs by 10% and made the detector response more isotropic.

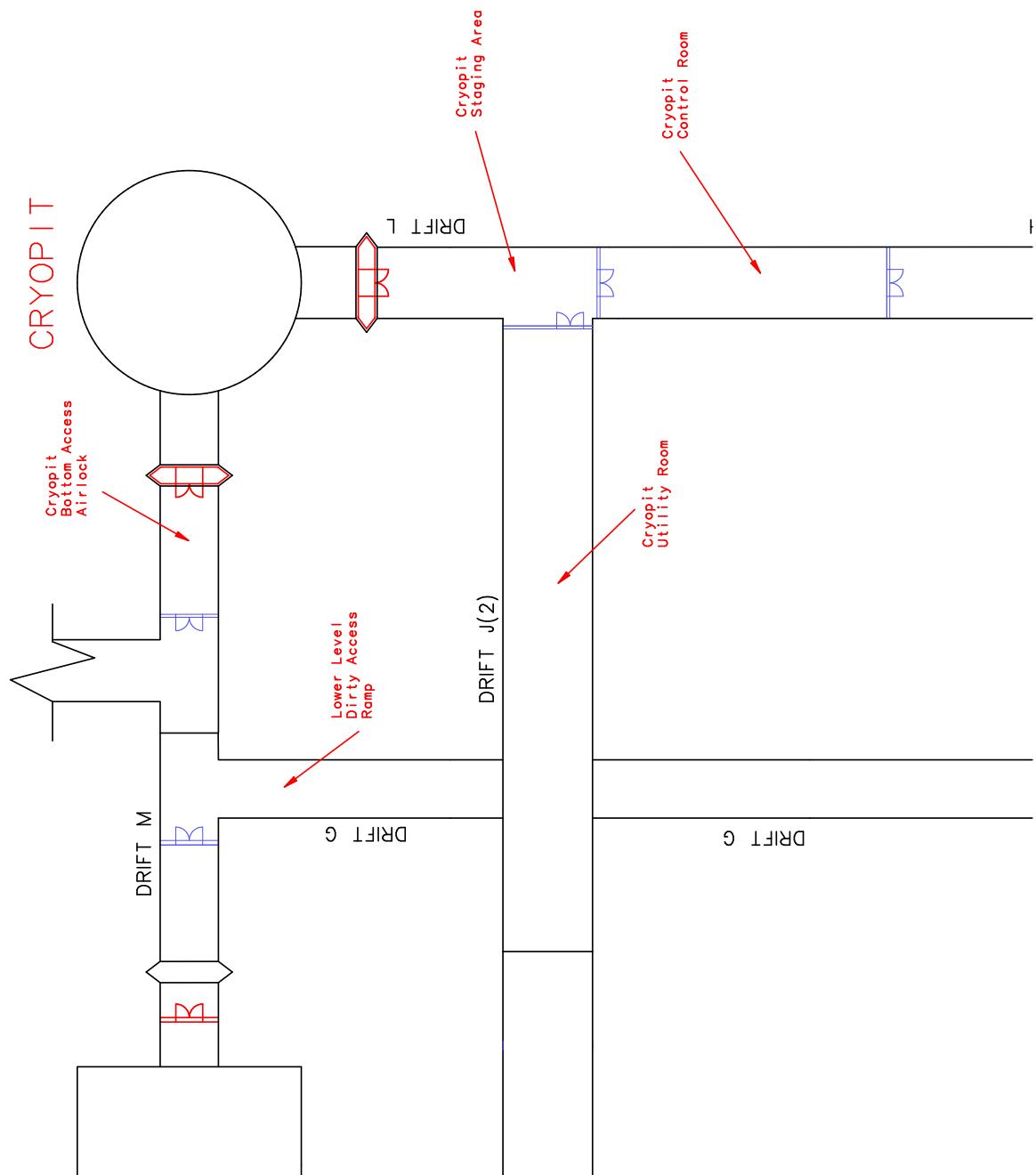


Figure 4.16: Schematic design of the Cryopit.

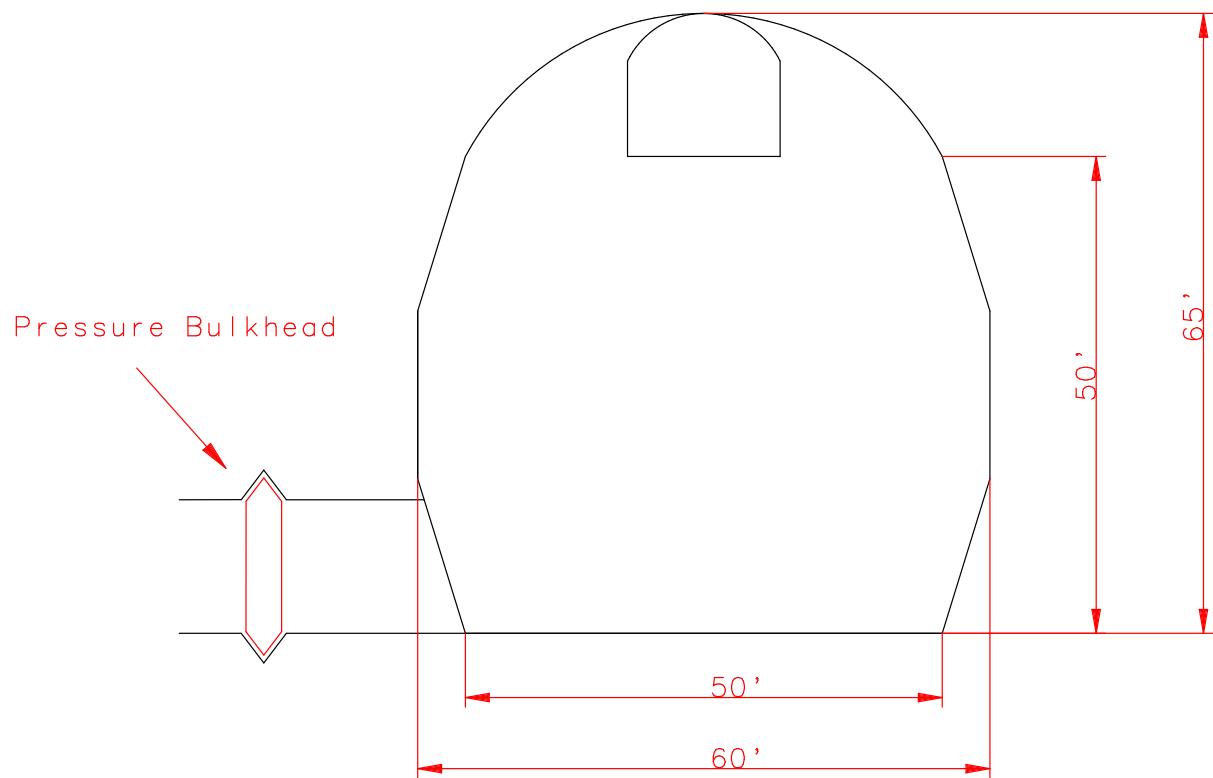


Figure 4.17: Cryopit cross section

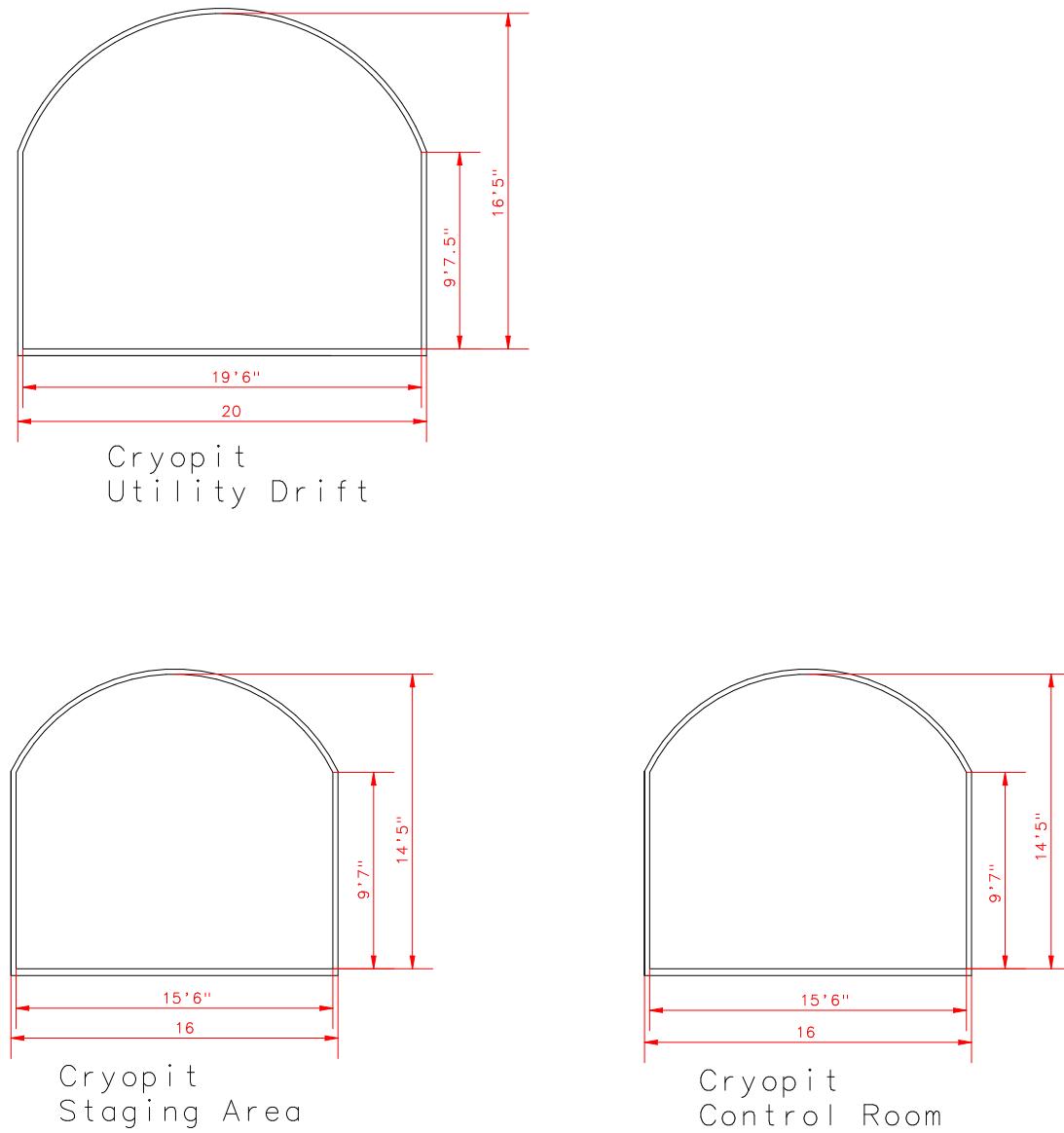


Figure 4.18: Cryopit support space cross sections. Duct work, piping and cable trays not shown.

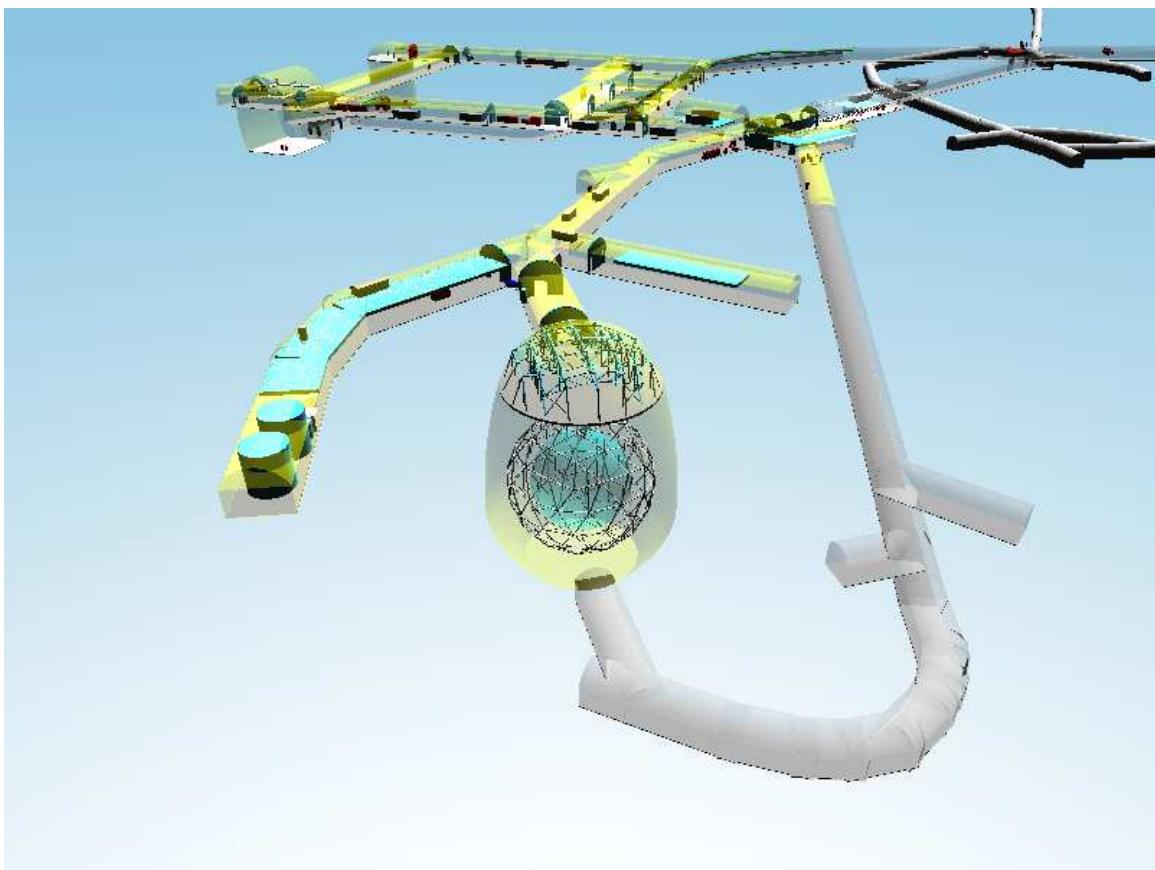


Figure 4.19: The existing SNO Cavern

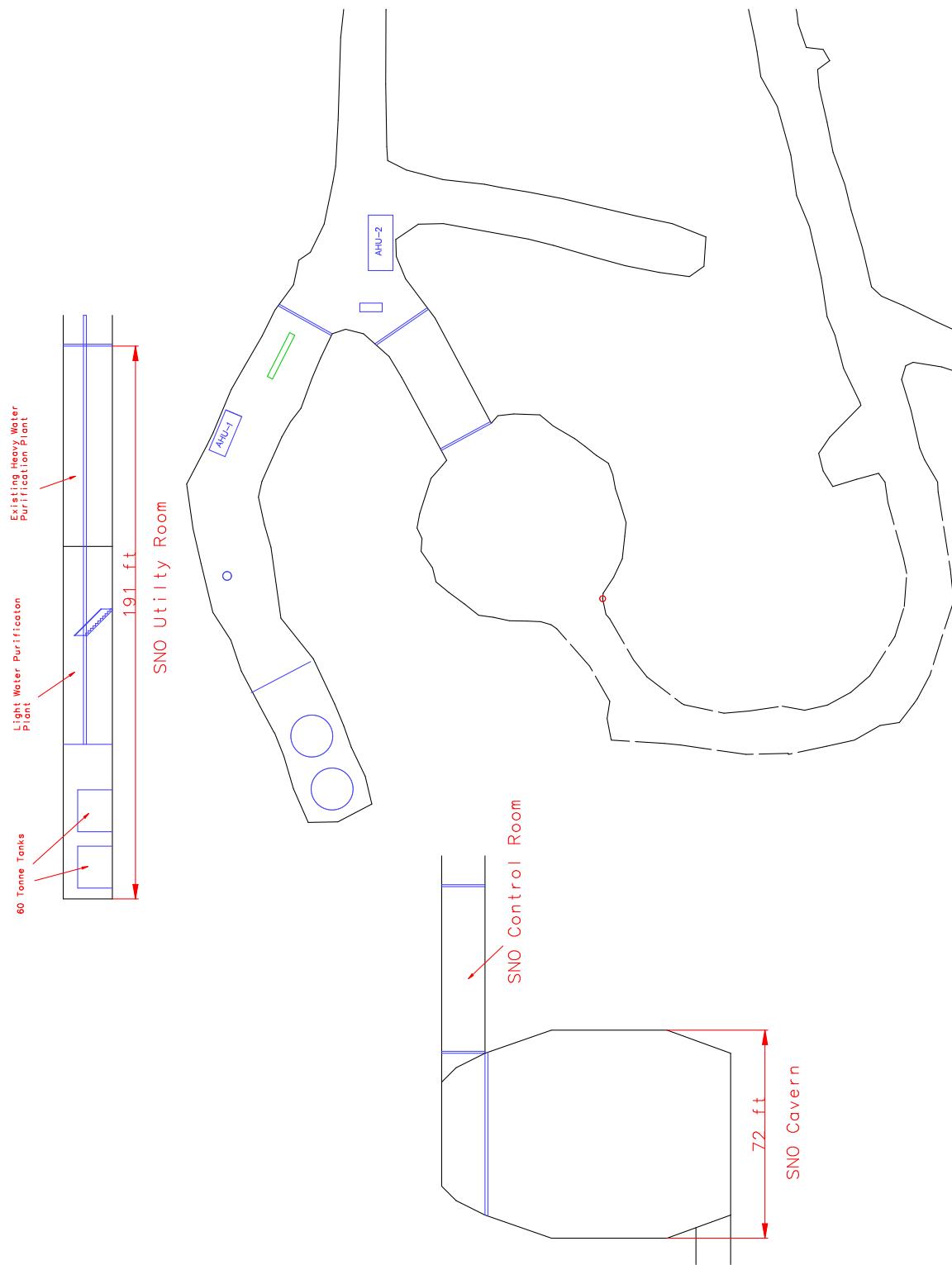


Figure 4.20: Layout of the SNO Cavern

A mezzanine occupies part of the length of this drift with a full height room at south end. This drift will be suitable for small scale experiments and prototyping.

## 4.8 Lab Utility Area

The *Lab Utility Area* (figure 4.22) is an area of the old 6800L mine workings that has been converted to house the services for SNOLAB. The Utility Drift can be accessed through a ventilation door from the *SNO Track Drift* and is situated adjacent to Drift E which provides the dirty side access to the Ladder Labs and the ramp to the base of the Rectangular Hall and the Cryopit. Located in this area is the laboratory *Chiller* (refrigeration system), the *Emergency Generator* and the *Sewage Treatment Plant* (figure 4.23). A *Mine Power Centre* (MPC) is located in the SNO Track Drift to provide power to the Utility Drift.

The chiller is an air cooled system that provides 320 Tons of cooling to a chilled water loop to the laboratory. The heat is transferred to 100,000 CFM of ventilation air which enters the mine return air system through a nine foot diameter air raise located at the back of the Chiller Drift. This return air raise is also used to exhaust the diesel generator located just south of the Chiller Drift. The return air raise is a sealed system designed to prevent exposure to personnel. The emergency ventilation from a large cryogenic experiment is intended to be ducted into this raise. As well, the fume hood from the chemistry lab is directly ducted into this raise.

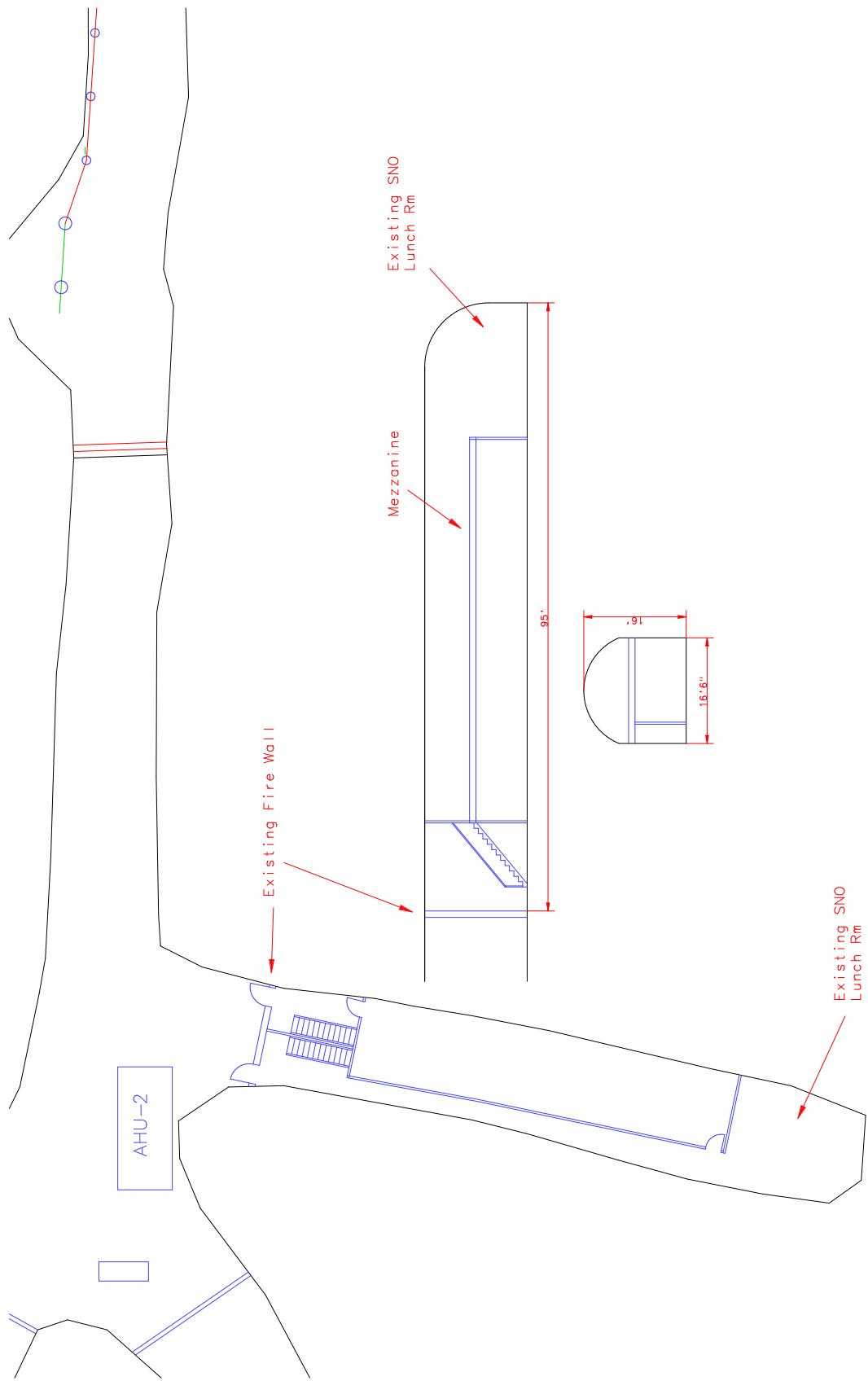


Figure 4.21: Layout of the South Drift.

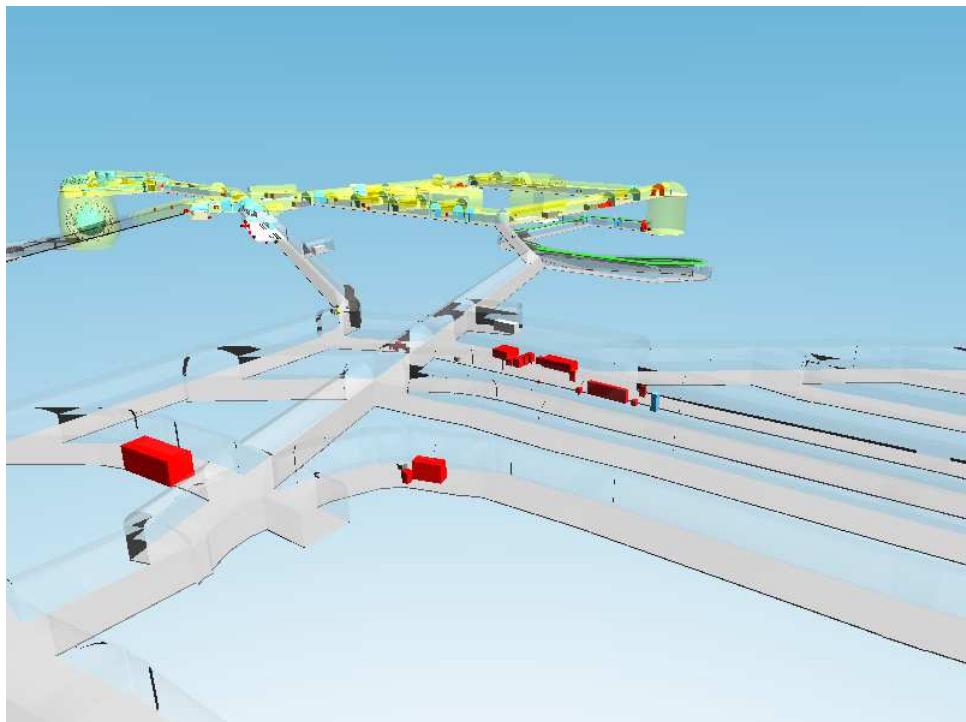


Figure 4.22: Chiller and emergency generator

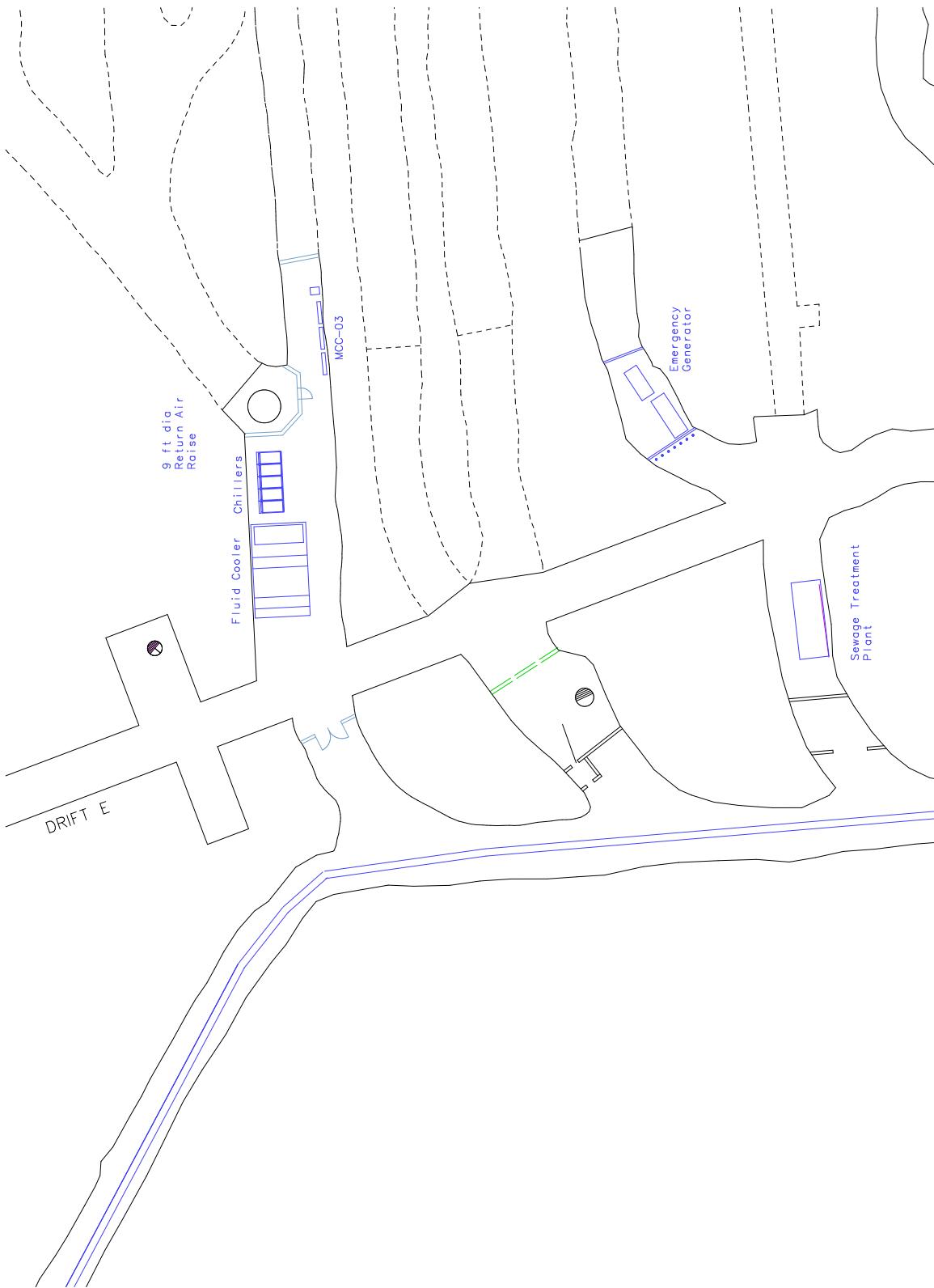


Figure 4.23: Chillers and Generator Layout

# Chapter 5

## Underground Infrastructure

### 5.1 Nomenclature

Table 5.1 lists prefixes and their meanings used in the numbering of equipment in the underground laboratory.

### 5.2 Power

A simplified single line diagram for the electrical distribution for SNOLAB is shown in figure 5.1. The main electrical power for SNOLAB comes from the INCO 13kV system and is distributed through two *Mine Power Centres* (MPCs) and six *Motor Control Centres* (MCCs) listed in table 5.2. The MPCs are substations that reduce the 13.8kV 3 phase 60 Hz electricity to 600V 3 phase 60 Hz. The MCCs are the 600V distribution centres located near the loads. MPC-01 will be located in a stub drift east of the Double Track Area and will power MCCs inside the laboratory. There will be a dedicated MCC for each experimental area (SNO Cavern, Ladder Labs, Rectangular Hall and Cryopit) as well as an MCC near the laboratory entrance to power the main HVAC, personnel area etc. The Air Handlers, large pumps, hot water heaters and other large loads are powered directly from the MCCs. The MCCs also feed the secondary transformers to supply 120/208V power to power panels located throughout the lab. MPC-02 will be located near the Utility Drift and will power the SNOLAB Chiller and Sewage Treatment Plant through an MCC located in the Chiller Drift. The locations of the MPCs and MCCs are shown in figure 5.2.

In addition to normal power, there will be a 150 kW diesel generator to provide emergency power with a 48 hour run time. The emergency generator will be located in the Utility Drift along with an *Automatic Transfer Switch* (ATS). The emergency power bus will normally be energized from normal power supplied from MPC-02. The emergency power is distributed through two emergency Distribution Power Panels (DPPs) located inside the lab (one near the entrance, the other in the Ladder Lab Services Area). Emergency power panels are located throughout the experimental areas. Some laboratory infrastructure such as communications, environmental monitoring and fire detection will be supported on the generator with a bridging UPS. This load is expected to be small and the bulk of the generator power is available for experiments. However an issue not addressed by SNOLAB is the removal of heat from equipment run on the generator. The generator is not large enough to power the laboratory chiller (500 kW) and air handlers (100 kW). Experiments

Prefix	
261	was used previously for 'construction equipment' and included cranes and monorails, etc.
311	H2O PURIFICATION AND RECIRCULATION
330	LN2/ COVER GAS
413	UG PRIMARY POWER DISTRIBUTION (Normal Power; see also 418)
414	UG UNINTERRUPTIBLE POWER SUPPLY
415	UG CLEAN POWER SUPPLY (All those future automatic voltage regulator, 'AVR', units)
418	UG Normal Power in the Dirty Drift, maybe Construction Power - small amount; see 413)
419	UG EMERGENCY GENERATOR POWER SUPPLY
421	UG / SURFACE COMMUNICATIONS (Including such as: phones, fibre optics)
422	UG ELECTRICAL SERVICES (Including such as: lighting control, emergency lighting packs, some miscellaneous, e.g., Chubb security)
433	UG INERT GAS SYSTEM CONTROLS
452	UG FIRE ALARM
460	GEOTECHNICAL INSTRUMENTATION
470	CONTROL MONITORS AND ALARMS
473	INCO ALARMS
525	DATA COMMUNICATIONS
560	UG ELECTRONICS SYSTEMS MONITORING (not currently used)
622	AIR DISTRIBUTION (Includes ventilation, exhaust, etc.)
623	UG SERVICE WATER (Includes potable water, hot water, sumps, sewage, etc.)
624	UG FIRE PROTECTION (Includes fire water, hose cabinets, etc.)
625	UG/SURFACE COMPRESSED AIR
626	CHILLED WATER
627	UG LAB/CLEANLINESS EQUIPMENT (Includes air showers, vacuums, etc., mostly 'appliances' not infrastructure)

Table 5.1: Equipment Numbering Convention.

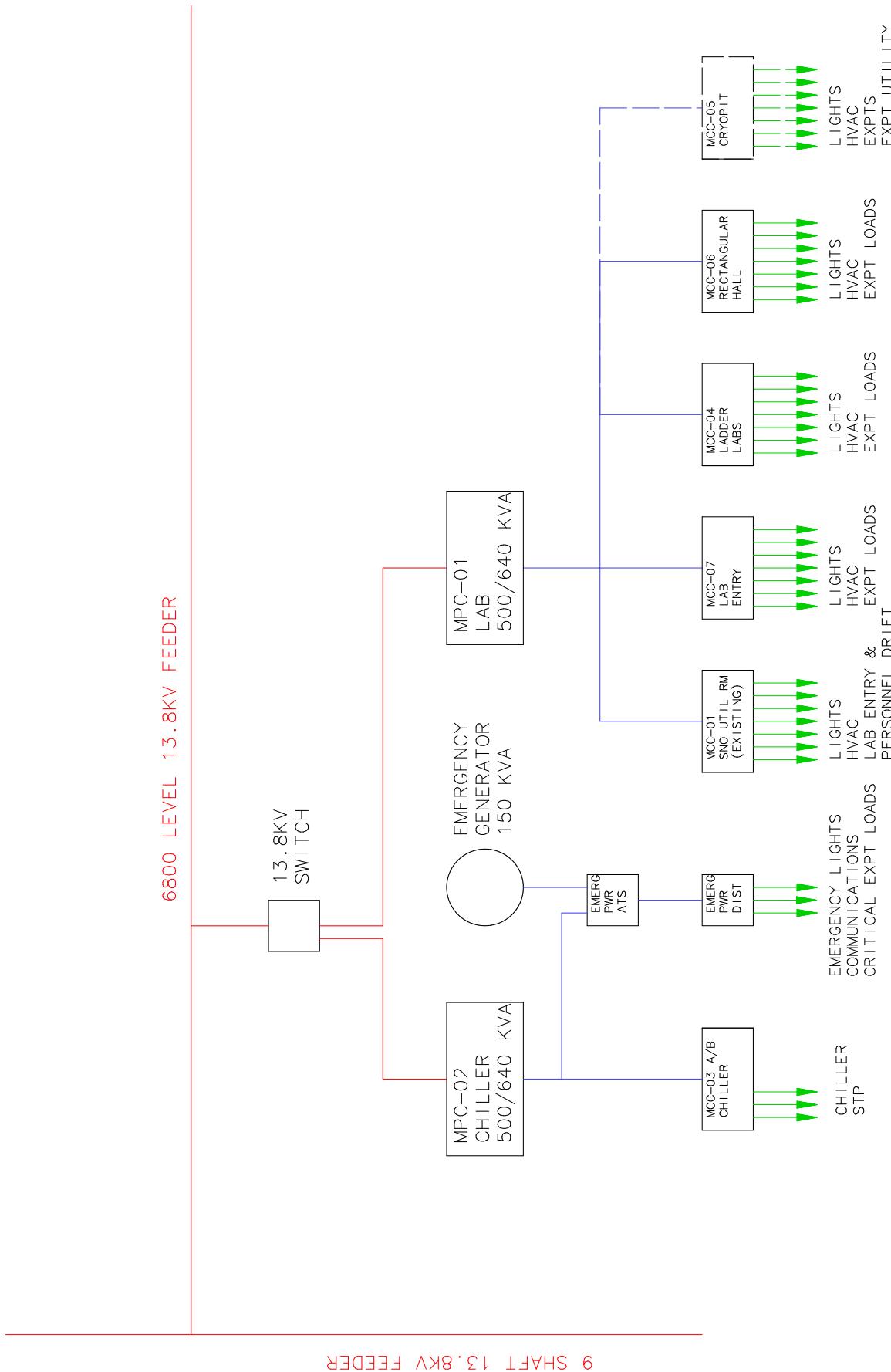


Figure 5.1: SNOLAB Power Distribution

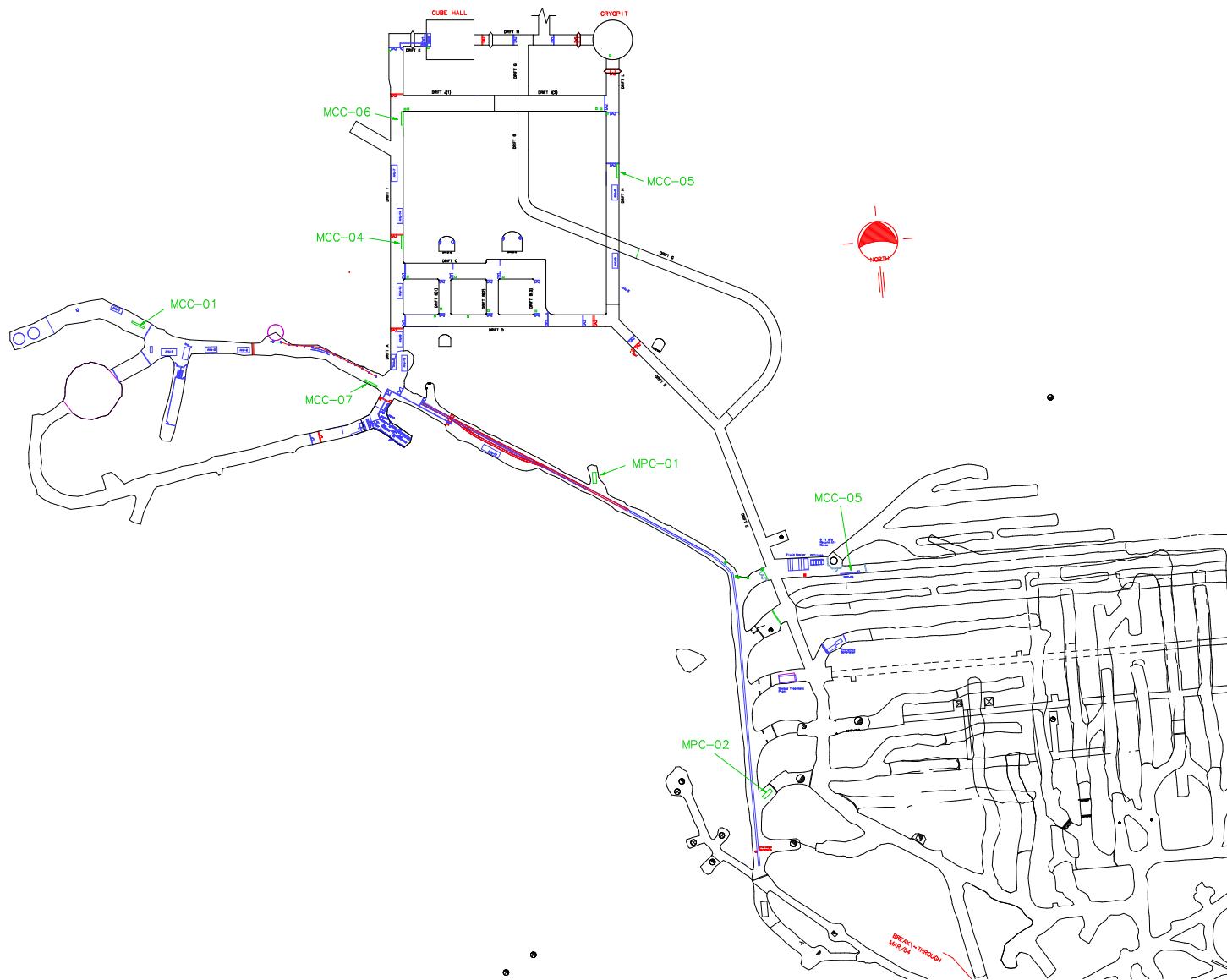


Figure 5.2: Layout of Mine Power Centres (MPCs) and Motor Control Centres (MCCs) in SNO-LAB.

	Description	Location
MPC-001	Lab Mine Power Centre 500/640 kVA	Rm 100
MPC-002	Chiller Mine Power Centre 500/640 kVA	Track Drift
MCC-001	SNO MCC	
MCC-002	SNO Chiller MCC (to be decommissioned)	
MCC-003A	Chiller MCC A	
MCC-003B	Chiller MCC B	
MCC-004	Ladder Lab MCC	
MCC-005	Cryopit MCC (Future)	
MCC-006	Cube Hall MCC	
MCC-007	Entry MCC	

Table 5.2: SNOLAB Mine Power Centres (MPCs) and Motor Control Centers (MCCs).

Prefix	Power Type	Receptacle Colour
413-	Normal Power, Clean Areas	White or Ivory
418-	Normal Power, Dirty Areas	White or Ivory
419-	Emergency Power	Red
421-	UPS Power	Grey

Table 5.3: SNOLAB Power Nomenclature. The 120/208V receptacles for different power types are uniquely coloured.

will have to address their specific heat removal requirements when on emergency power.

Uninterruptible Power Supplies (UPSs) need to be specified for the specific application. SNOLAB will put certain critical services (communications, fire detection and some environmental monitoring) on UPS which will act as a backup to the emergency generator. However, it will be the responsibility of the individual experiments to provide their own uninterruptible power supplies. Table 5.3 lists the different types of power available in SNOLAB.

MPC-01 and MPC-02 are existing 640kVA units presently being used by the SNO experiment and the SNOLAB excavation. The Day 1 power loads are for SNOLAB are expected to load these MPCs to capacity with an allowance of approximately 200 to 300 kW for Day One experimental loads (including the running SNO experiment). However the design of the power distribution system allows up sizing the MPCs with the goal of reaching the full capacity of the laboratory's cooling budget of 1 MW of cooling inside the laboratory. The electrical infrastructure will be scaled up to match the incoming experimental loads.

## 5.3 Lighting

For the most part, lighting in the laboratory will be fluorescent. Areas such as the Personnel Drift and laboratory entrance will be illuminated at conventional levels appropriate for the tasks in these areas. The access drifts will be illuminated at “hallway” levels. The experimental spaces will only be minimally illuminated on Day 1 with the intent that appropriate lighting will be set once the specific needs of each space are identified. Work areas outside the clean room space (Double Track Area, Utility Drift) will have appropriate lighting for the task. The SNO Track Drift and the access to Nine Shaft will have some minimal lighting. Three types of lighting will be used in SNOLAB:

**Normal Lighting** will be conventional fixtures powered off the normal power bus.

**Emergency Lighting** will be conventional fixtures powered off the emergency power bus. The emergency lighting fixtures will be interspersed with the normal lighting fixtures and form part of the nominal lighting for an area. In the event of a power failure the emergency lighting will fail as will the normal lighting but will be restored on successful startup of the emergency generator.

**Battery Lighting** will be conventional battery light packs located throughout the laboratory. These battery packs will be powered off the emergency bus so in the event of a power failure, the battery lighting will come on until generator power (and emergency lighting) is established. In the event that the emergency generator fails to start, the battery lighting will provide illumination for personnel to safely exit work areas and make their way to the Refuge Station.

## 5.4 Chiller and Cooling

Cooling inside the clean laboratory will be provided by a chilled water loop cooled by a chiller system located in the Lab Utility Area (section 4.8). The chilled water will run through a recirculating 6” loop approximately 800 ft to the laboratory where it will branch out to different areas of the lab from the Junction. Chilled water temperature will be 40°F supply, 50°F return. All the air handlers inside the laboratory have chilled water cooling coils. As well there are terminal cooling units in many legs of the laboratory’s HVAC system. The SNO water purification system also uses the chilled water for cooling. Provision is made to allow experimental processes to tap directly into the chilled water loop.

The chilled water is cooled by an air cooled chiller system provided by Trane (figure 5.3). The chiller has 5 parallel compressors and two parallel condensers with a secondary water loop between the compressors and condensers. The condensers are air cooled by 100,000 ACFM of air supplied from the mine ventilation system and will provide a total of 320 Tons (1.1 MW) of cooling. The estimated day 1 heat loads of the laboratory are listed in table 5.4 and it is expected that as much as 400 kW of heat will be produced by minimal laboratory operation (lighting, air handling, geothermal, personnel, etc.). This leaves approximately 700 kW of cooling power to remove heat from experiments (electronics, pumps, motors, process heat, ...).

A useful feature of the chiller system is its modularity. It is possible to operate the chiller with only some of the compressors and/or only one condenser on. Provided the system is not being fully loaded, this provides redundancy and permits maintenance without disruption to laboratory

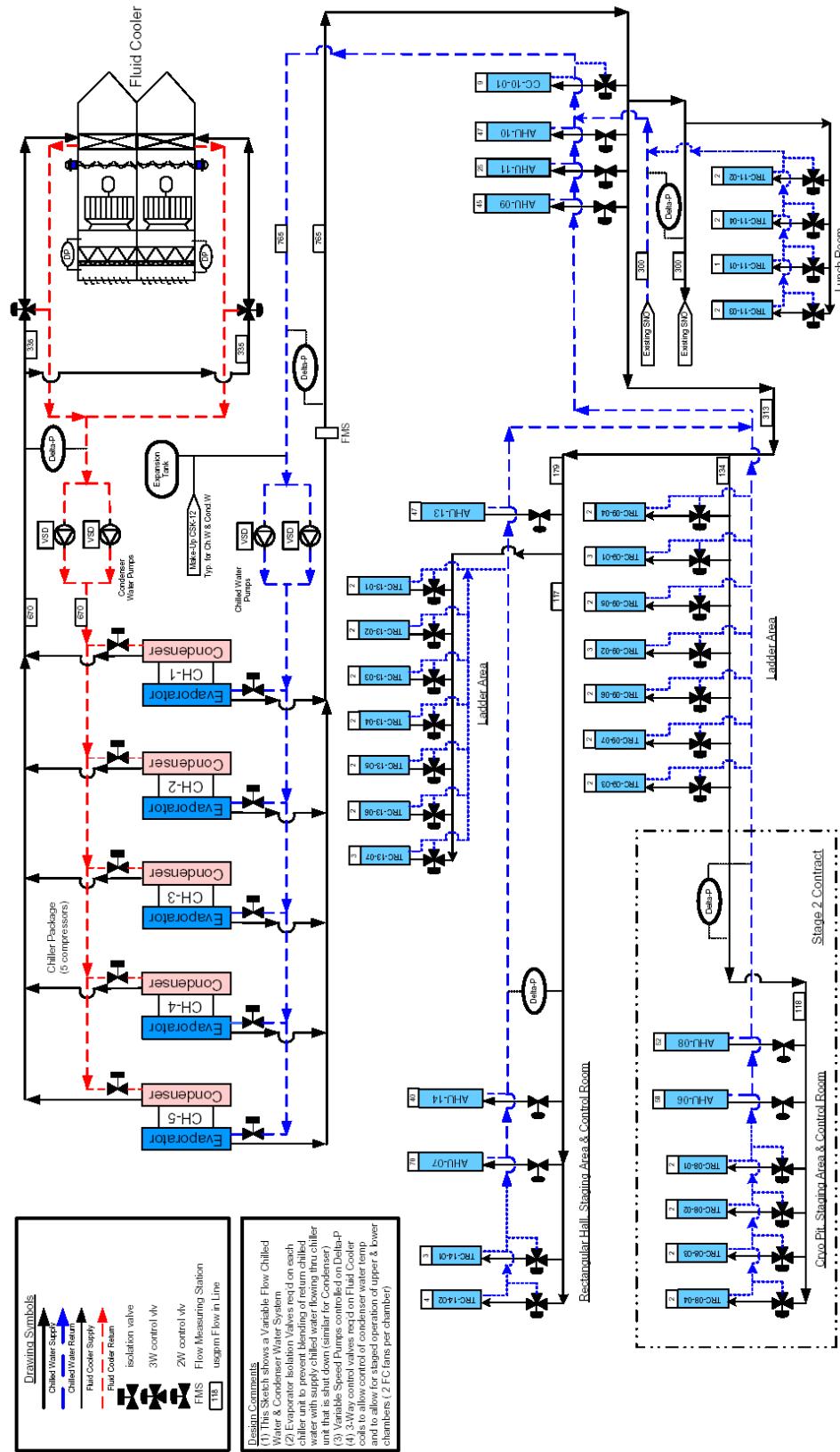


Figure 5.3: The SNOLAB Chilled Water system.

Heat Load	Power (kW)
Geothermal	260
Motors (HVAC, pumps, ...)	110
Lighting	80
Fresh Air	40
People	10
SNO Experiment	92
Total	592

Table 5.4: Estimated Heat Loads for SNOLAB on Day 1.

operations. Also for redundancy, both the primary and secondary chilled water loops have backup pumps.

The Chiller is powered off MPC-02 and when fully loaded will draw 900kVA. This presents two problems. First, the existing MPC-02 does not have capacity to run the Chiller at full load. This would necessitate running the Chiller at partial capacity which would be sufficient for the initial loads expected in SNOLAB. To power future loads, MPC-02 will have to be up sized. However, SNOLAB is considering up sizing MPC-02 for Day 1. The second problem is that in the event of a power failure, there is insufficient capacity to operate the chiller from the emergency generator (a 150 kW or 200 kVA unit). This means that there will not be cooling available in the laboratory in the event of a power outage.

## 5.5 Laboratory Ventilation

In addition to providing a comfortable working environment, the SNOLAB ventilation system removes much of the waste heat and is the primary means of keeping the laboratory clean. The ventilation system keeps the laboratory clean by extensive filtration and by maintaining a positive pressure relative to the mine. In addition, there are pressure zones within the laboratory with the experimental spaces being kept at the highest pressure (figure 5.4). Nominally the pressure drop between zones will be 0.05" water gauge (wg).

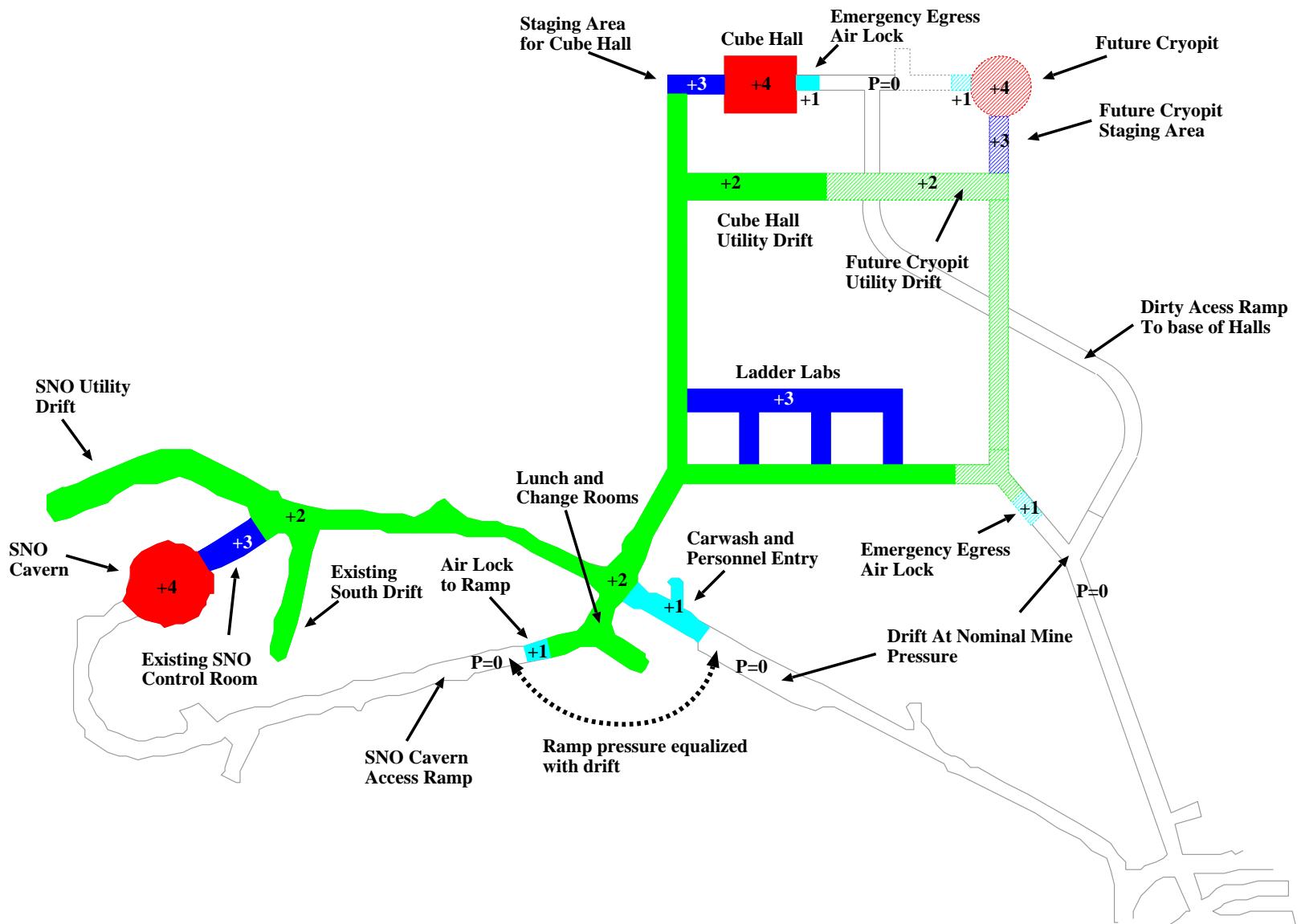
SNOLAB will have a total of fourteen *Air Handler Units* (AHUs) to provide clean air and remove waste heat from the laboratory. These consist of the original five AHUs for the original SNO facilities and an additional nine units for the new spaces (table 5.5). All of the new AHUs have *High Efficiency Particulate Air* (HEPA) filters to produce a CLASS 2000 clean room environment. This is an enhancement over the existing SNO facility which had HEPA filtration on the lab intake system and on the AHU for the SNO detector cavern (AHU-2). In addition to the AHUs, the SNOLAB ventilation system will have seven *Exhaust Fans* (EFs) in the laboratory (table 5.6). Cleanliness in the laboratory will be maintained by 10 air changes per hour in all areas except the Rectangular Hall and Cryopit which will have 5 air changes per hour when empty<sup>1</sup> Most of the air will be recirculated with 10% makeup air from outside the lab.

Fresh air to the lab is brought in through AHU-12 located on a mezzanine in the Double

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<sup>1</sup>It is assumed that these halls will have approximately 50% of their volumes filled with equipment.

Figure 5.4: The pressure zones in SNOLAB are designed to have the flow of air from the cleanest spaces to the dirtiest.



AHU	Description	Location	Filters
AHU-1	SNO Utility Drift		
AHU-2	SNO Cavern/Control Room		HEPA, Ch
AHU-3	SNO Junction		
AHU-4	South Drift		
AHU-5	SNO Makeup AHU		HEPA
AHU-6	Cryopit		HEPA
AHU-7	Cube Hall		HEPA
AHU-8	Cryopit Ctrl Rm, Utility Drift, Drift H		HEPA
AHU-9	Ladder Labs (1)		HEPA
AHU-10	Junction and Entry		HEPA
AHU-11	Personnel Drift/Refuge Station		HEPA
AHU-12	Lab Makeup Air		HEPA, Ch
AHU-13	Ladder Labs (2)		HEPA
AHU-14	Cube Hall Ctrl Rm, Utility Drift, Drift F		HEPA

Table 5.5: Air Handler Units.

Fan	Description	Location	Vents To
EF-6	Fume Hood		Return Air Raise
EF-7	Personnel Drift		Double Track Area
EF-8	SNO Utility Drift		Double Track Area
EF-9	Junction		Carwash
EF-10	Carwash		Double Track Area
EF-11	Washrooms		Return Air Raise
EF-12	Junction		Personnel Drift

Table 5.6: Laboratory Exhaust Fans.

Track Area. The inlet for AHU-12 is located near the Lab Utility Area approximately 500 ft to the east of AHU-12 and is drawn into AHU-12 through a hard duct. If noxious gas monitors near the inlet to AHU-12 detect high CO or NO, the inlet to AHU-12 is switched to a local inlet in the Double Track Area. If CO or NO are also detected in the double track area, AHU-12 will shut down to prevent noxious gases from being drawn into the laboratory. Nominally AHU-12 will bring 7,000 *Actual Cubic Feet per Minute*<sup>2</sup> (ACFM) into the lab. The fresh air passes through a sequence of successively finer filters culminating in HEPA filters. As well, AHU-12 will have a bank of activated media filters to scrub H<sub>2</sub>S present in the mine air at the few PPB level(see section 3.3). Each experimental area will have one or more AHU. In addition to HEPA filters, these AHUs will have cooling coils to remove waste heat. Many areas will have additional cooling coil units to enhance local heat removal. The cooling coils in the AHUs and terminal units transfer heat to the laboratory chilled water system (section 5.4). Note that because the ambient rock temperature is 42C, the HVAC system for SNOLAB is only designed to *remove* heat. Thus there are no heating elements in any of the SNOLAB HVAC systems.

There are seven exhaust fans in the laboratory. Their purpose range from the removal of the high humidity air in the personnel change rooms and laundry to controlling the over pressure of the laboratory entrance relative to the mine. EF-6 is an exhaust fan from the fume hood in the chemistry lab and vents directly to the return air raise at the Chiller. As well the fumes from the washrooms are vented directly to the return air raise. The ventilation scheme for the laboratory is shown in schematic form in figure 5.5.

AHU-12 nominally draws in 7000 ACFM of make up air to the laboratory. In the event that the mine air pressure undergoes a sudden increase, it is necessary to maintain overpressure of the lab. AHU-12 can increase it's draw up to 12,590 ACFM. At the same time, most exhaust fans in the lab can be shut down (except the fume hood exhaust fan, EF-6). As well, the individual AHUs in the experimental areas can adjust their air flow to maintain the pressure differentials between the various areas inside the laboratory. All AHUs are equipped with Variable Frequency Drives (VFDs) to allow them to adjust their air flow.

### 5.5.1 Off Gas Header

It is intended that the laboratory have an *Off Gas Header* system to remove the discharge from vacuum pumps, cover gas flush systems, etc. However the design for this system has not yet been implemented.

## 5.6 Mine Ventilation

Ventilation related fans located outside the clean laboratory are listed in table 5.7. To provide 1.1 MW of cooling, the SNOLAB chiller system requires 100,000 ACFM of cooling air which is delivered to the chiller through the SNOLAB access drift and the mining drifts. To remove the 100,000 ACFM exhaust air from the chiller, a 9 ft diameter air raise will be bored from the Chiller

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<sup>2</sup>Because the air pressure in the lab is 25% higher than on surface, it is important to distinguish between *Actual Cubic Feet per Minute* (ACFM) which is the true volume of air transferred and *Standard Cubic Feet per Minute* (SCFM) which is the equivalent volume of air transferred if on surface. Reference to CFM (*Cubic Feet per Minute*) usually (but not always) means ACFM.

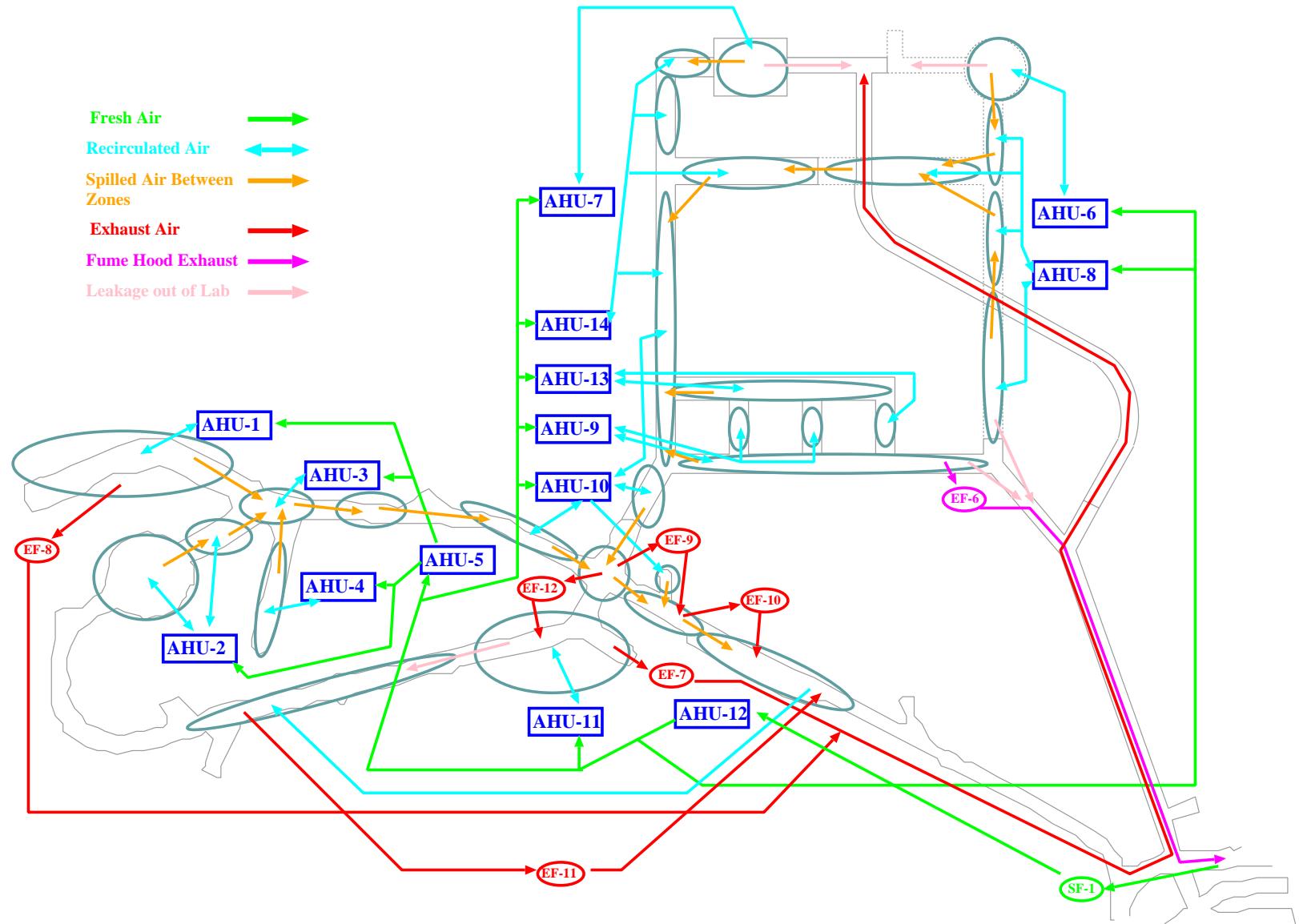


Figure 5.5: The ventilation system for SNOLAB.

FAN	Description	Location	Size
VDF-1	Primary Chiller Source	Chiller Drift Vent Wall	40 HP
VDF-2	Secondary Chiller Source	Mining access drift	40 HP
VF-XXX	6600 RAR Fan 1	6600 L	75 HP
VF-XXX	6600 RAR Fan 2	6600 L	75 HP
EF-13	Generator Room Exhaust	Generator Room	?
EF-14	STP Room Exhaust	STP Room	?
EF-15	Chiller Room Exhaust	Chiller Room	?

Table 5.7: Ventilation Fans outside the clean laboratory.

Drift on 6800 to an abandoned mining drift on the 6700 level. A second air raise will then transfer the exhaust air to the 6600 level where it will be directed into the mine exhaust system (figure 5.6). A small amount of the air supply (7000 ACFM) is ducted to the laboratory to provide fresh air and make up air to compensate for changes in the mine air pressure. The exhaust air from the laboratory is allowed to spill back through the SNOLAB access drift where it provides fresh air for the operation of diesel equipment (such as the locomotive). The laboratory air ultimately exhausts through the chiller and out the return air raise. Air is transferred from the SNO Track Drift to the Chiller Drift by a 40 HP ventilation fan. The exhaust air is drawn through the chiller air raise by two 75 HP fans located on the 6600L. Ventilation of the bottom access ramp to the base of the Rectangular Hall will be achieved by leakage air from the Rectangular Hall air lock. However a large ventilation fan and ducting will be left in place from the excavation process to permit the operation of diesel equipment in this drift when necessary.

If a large cryogenic liquid experiment is constructed in the Cryopit a dedicated exhaust duct can be installed in the bottom access ramp to vent boil off gases directly into the chiller's return air raise. Because a cryogenic boil off would evolve a large volume of inert gas, the SNOLAB exhaust air raise is a sealed system that isolates it from both SNOLAB and mine personnel.

## 5.7 Water

The nominal water usage allotted to SNOLAB by Creighton Mine is 50 gpm. This is actually a limit on discharge to the mine's sumps rather than on the supply and can be varied on agreement with INCO. Water will be brought the 1.8 km distance from the Shaft Station by 3" plastic line (nominal pressure 80 PSIG). It is passed through a pretreatment system which will be located in a stub drift off the SNOLAB access drift prior to the Double Track Area. The purified water will enter the laboratory and be available for process water in experiments and for general laboratory use. It will also go to the Ultra Pure Water (UPW) system in the SNO utility drift to provide UPW for experiments (figure 5.7). Domestic hot water for showers, sinks etc, is provided by one 500 USG and one 120 USG hot water heaters. Provision is made for a chlorination system to be located adjacent to the Pretreatment system for potable water in case the chlorination levels of the INCO supplied water are not sufficient.

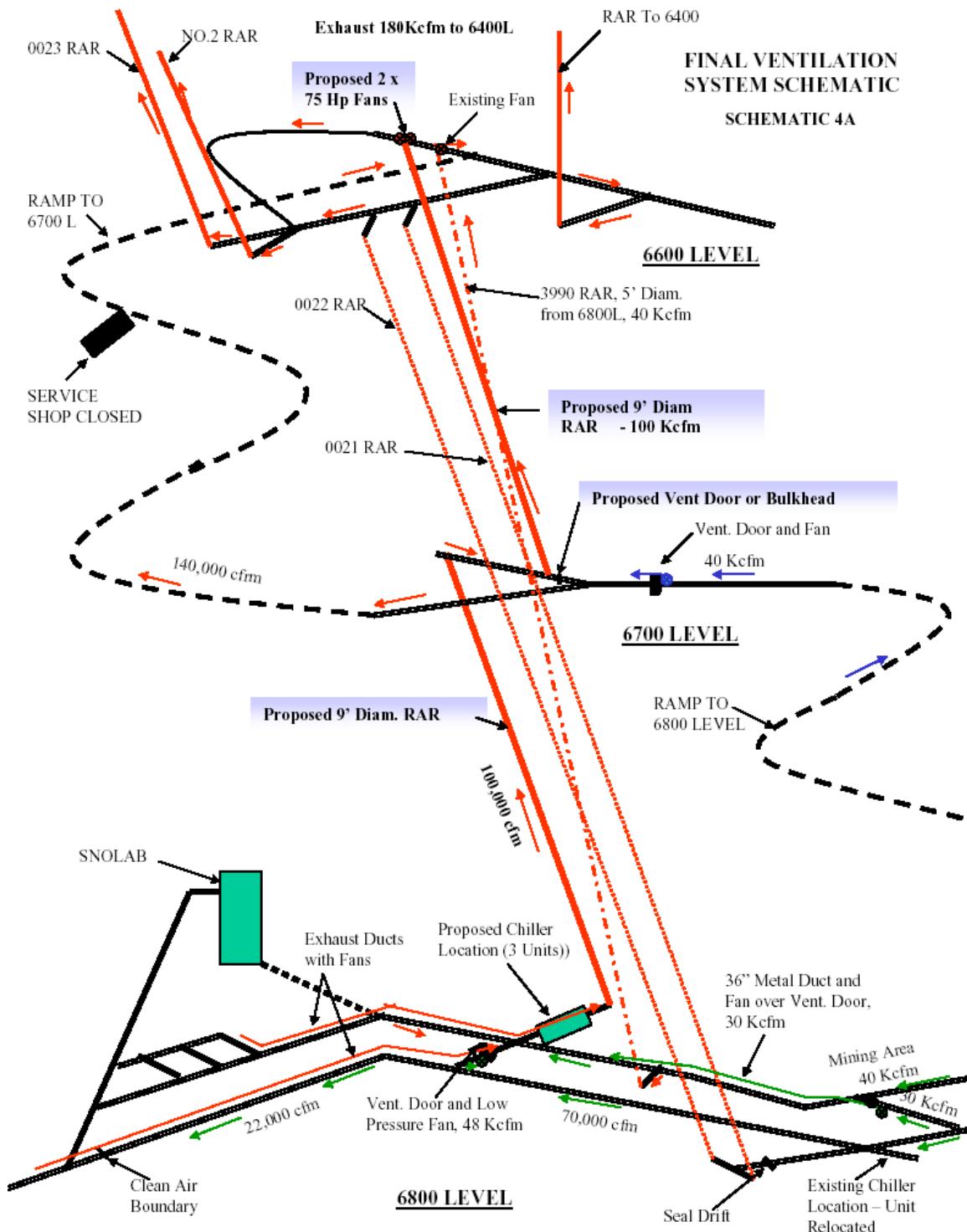


Figure 5.6: The mine side ventilation for SNOLAB

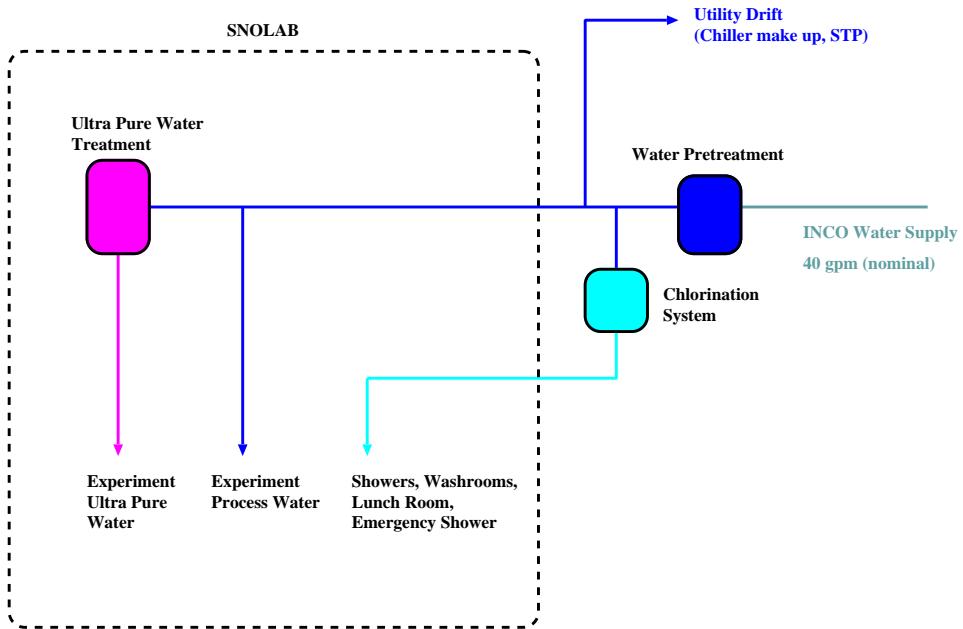


Figure 5.7: SNOLAB Water Supply

## 5.8 Dewatering

Because Creighton mine is a very dry site, the water that must be removed from SNOLAB is only the water brought into the facility for processes and personnel. Dewatering of SNOLAB will consist of local floor drains and forced drains reporting to sumps in each of the experimental areas of the laboratory. The local sumps will report to a main sump which reports to a bore hole leading to the mine's dewatering system (figure 5.8). This system is essentially the same as that used in the existing SNO underground facility with the exception that open trench drains were used extensively in the SNO facility. These have been found to be unsatisfactory and so the move to in floor or forced drains where possible. SNOLAB's average dewatering budget is 50 GPM which in turn sets the average water intake to the laboratory.

## 5.9 Sewage Handling

The existing SNO facility deals with sewage with a septic holding system and transports sewage to surface for disposal. Over the years, this system has proven to be problematic. SNOLAB will use a *Membrane Bio Reactor* Sewage Treatment Plant (STP) to process both the black water from the toilets and the grey water from the showers and sinks in the laboratory. The discharge from the STP is suitable for release into the mine water disposal system. The STP will be located in the Utility Drift by the diesel generator. Black and grey water will be piped separately to the STP where they are mixed in an intermediate holding tank. In the event that the STP malfunctions, the grey water will be discharged directly to the bore hole (thus allowing the personnel showers to continue operation). The purified discharge from the STP meets the environmental standards for discharge to the environment and will report the mine dewatering system. The STP is expected to

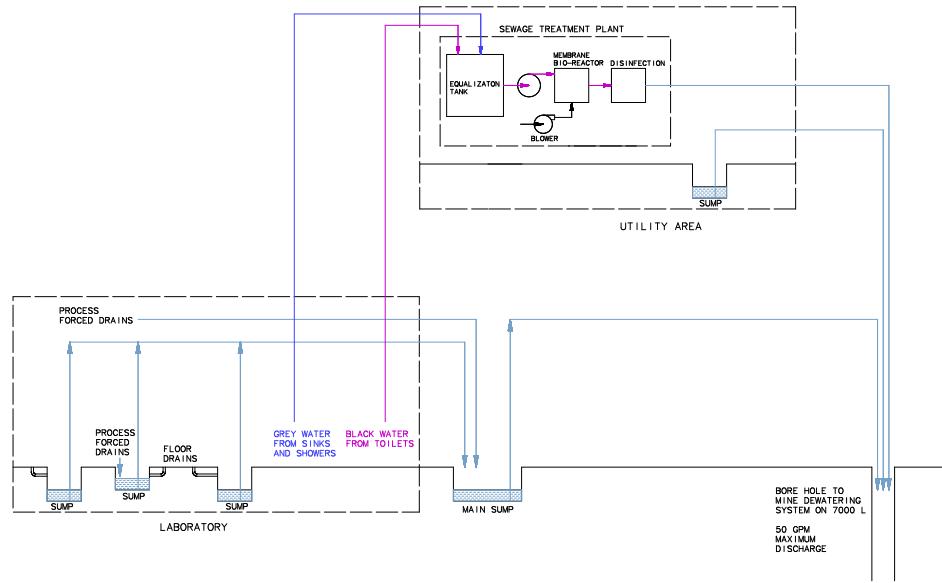


Figure 5.8: SNOLAB Dewatering System.

require clean out on approximately a yearly basis.

## 5.10 Ultrapure Water

Presently the existing SNO experiment owns and operates state-of-the-art water purification plants for both heavy water and regular light water (referred to as UPW for ultra-pure water). The UPW plant will be available after the SNO experiment, either as an integral part of a new experiment in the SNO cavity, and/or as a resource for piped UPW to other experimental areas. Depending on the applicability, even parts of the heavy water plant may be available after SNO.

The UPW plant (shown in figure 5.9) consists of a water production plant which provides medium purity makeup water from INCO's potable water, and a plant for recirculated water from the SNO cavity which acts as a UPW polishing loop. The plant also includes a sampling assay system for monitoring of the radioactivity levels.

The makeup water plant takes incoming potable water from INCO, which is deaerated and filtered at the SNO domestic water pretreatment area (section 5.7). First, a charcoal filter removes organic and free chlorine, then the water passes into softeners to exchange divalent ions (Ca and Mg) to prevent scaling of down-stream equipment. The water is then injected with a solution of EDTA to complex remaining ions and capture O and Cl ions. After more filtration the water is then fed into a 3-loop reverse-osmosis unit (RO) which produces the high purity water at a rate of 130 LPM and quality  $<5\mu\text{S}/\text{cm}$  ( $0.2 \text{ M}\Omega\text{-cm}$ ). This water is stored in a 10-tonne buffering tank, and the make-up plant is run as required to maintain makeup water.

The makeup water is then fed into the SNO cavity water recirculation loop which recirculates, purifies, cools, and returns the water to the SNO cavity at the rate of 250 LPM. The flow is split, with about half returned to the cavity after ultra-filtration and cooling, and the other half ( $\sim 150 \text{ LPM}$ ) passing through the UPW purification loop before being returned to the SNO PSUP

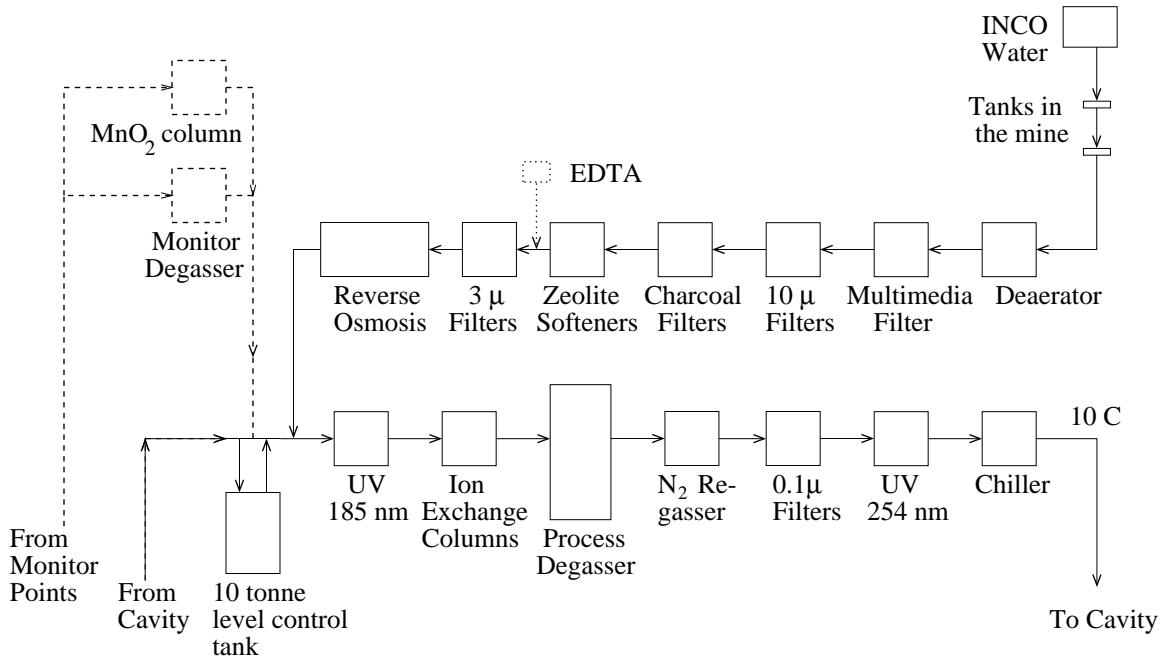


Figure 5.9: The SNO Ultra Pure Water System.

volume.

The UPW purification water loop consists of UV lamps, ion-exchange columns, a custom designed radon degasser/regassser, cooling heat exchangers and ultra-filtration. The first stage UV unit is a 185-nm mercury lamp with quartz sleeves where any remaining organic compounds are broken into ionic form. The water next goes to an ion-exchange unit comprising two banks of 6 bottles of  $0.1\text{m}^3$  cation and anion mixed bed resins that removes any dissolved ionized impurities. The exiting water has a resistivity of  $18.2\text{ M}\Omega\text{-cm}$ .

A custom-designed Process Degasser (PD) is used to reduce the  $\text{O}_2$  and  $\text{Rn}$  levels by factors of about 1000 and 50 respectively. It consists of a tower 6-m high and 81-cm diameter containing shower heads and packing and pumped with a vacuum pump to 20 Torr. The water is then regassed with pure boil-off nitrogen using gas permeable membrane cells to prevent degassing of the PMT electrical connectors in the water. This unit is followed by  $0.1\text{-}\mu\text{m}$  filters to remove particulates. Then a 254-nm UV unit is used to kill bacteria. Finally the water is passed through a heat exchanger cooled by the glycol chiller loops to cool the water to  $10^\circ\text{C}$ . The recirculated water is checked regularly for pH, conductivity, turbidity, anions, cations, suspended solids, dissolved gasses, and radioactivity.

## 5.11 Fire Protection

Fire detection in SNOLAB will consist of smoke and heat detectors located throughout clean laboratory and in high risk or high value areas outside the lab (such as the chiller and generator drifts). In the event of a fire in SNOLAB, alarms will sound and personnel will retreat to the *Refuge Station* which is also the personnel drift. The Refuge Station is capable of housing 70 personnel

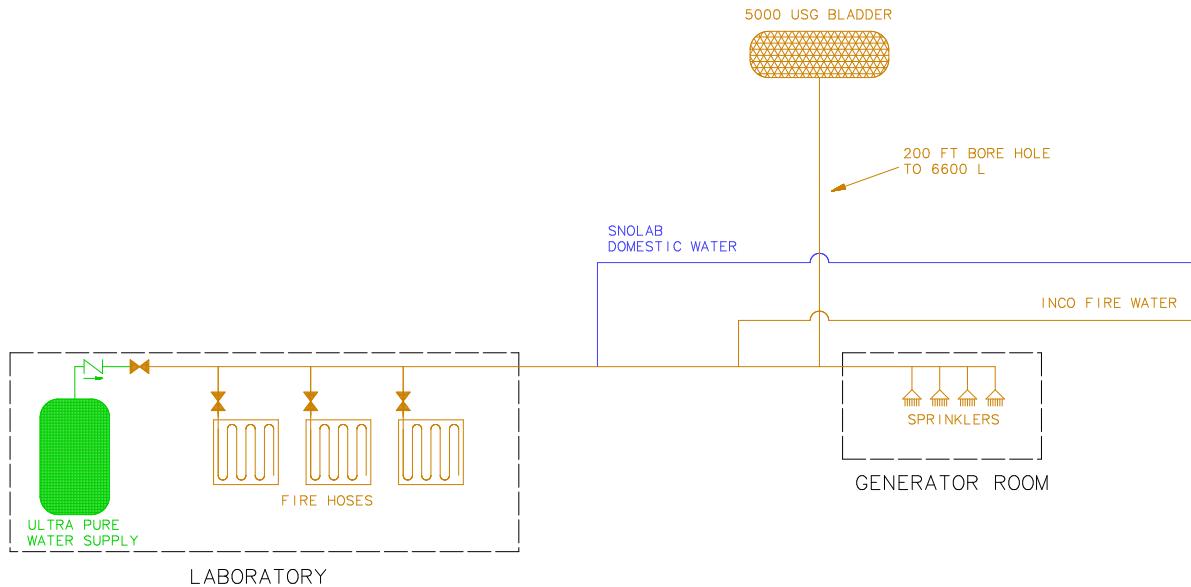


Figure 5.10: SNOLAB Fire water System

for several days if necessary. A fire in the SNO facility will alarm in the Creighton Mine Control Room, alerting the mine personnel of the fire. In the event of a fire elsewhere in the mine, an alarm will sound in SNOLAB and again personnel will retreat to the refuge station. Most areas in SNOLAB have multiple means of egress. In the case of the Rectangular Hall and some parts of the Ladder Labs, the egress is through an airlock into the dirty drifts outside the lab. If possible personnel would then make their way back to the SNOLAB Refuge Station. If that path is blocked, then personnel would make their way to the 6800L refuge station located approximately 1 km towards the 6800 shaft station. In the event of a fire alarm either in the laboratory or elsewhere in the mine, the laboratory's ventilation system shuts down.

Fire suppression in SNOLAB consists of one hour fire walls compartmentalizing key areas and four hour fire walls isolating the Refuge Station. Because of the large size of the Rectangular Hall, the stair well to the base of the hall is fire rated and can act as one of the two means of escape from the hall. Fire hoses are located in all compartments of the laboratory. A sprinkler system is located in the Diesel Generator Drift in the event of a fuel fire. The principle water source for the sprinkler and fire hose system is from the mine fire water system (figure 5.10). There are two backups to the mine fire water system: the SNOLAB 3" water line; and a 5000 USG bladder. The bladder is located on the 6600 L and feeds down into the SNOLAB fire water system through a bore hole located in the Utility Drift. Because the bladder system is a gravity feed, it offers fail safe operation in the event of a power failure.

## 5.12 Monitoring and Slow Controls

Operation of the SNO facility has demonstrated the importance of having both extensive monitoring of the underground laboratory and the ability to control the major systems remotely. Because the laboratory will not be manned 24 hours per day, the laboratory's *Slow Control System* must act

as the eyes, ears and hands of the operators on surface. SNOLAB will use the BACnet<sup>3</sup> distributed control system [10] more commonly seen in surface buildings. This is the same system used in the SNOLAB surface facility. Stand alone controllers are located throughout the laboratory with instruments connected locally by RS-485. The controllers are accessed by the Laboratory's Local Area Network (LAN). The Slow Controls System will be isolated on a VLAN (Virtual Local Area Network) within the LAN. Monitoring/control will be with dedicated Windows based computers. Additional monitoring will be via internet web server. The Slow Controls local controllers and monitoring workstations will be on UPS powered from the emergency power bus.

The system will allow monitoring of the laboratory environment from workstations within the lab and on surface. The system will permit remote control of the laboratory's systems including the chiller, air handlers, some pumps, STP, etc<sup>4</sup>. Monitoring will include power, chiller performance, laboratory environment (temperature, pressure, humidity, O<sub>2</sub>, CO, NO).

While environmental information from the slow control system will be made available to experimenters, the use of the laboratory's control system for the experiments will be discouraged. The intent being to keep prevent interference between experiment and laboratory operations. However, the laboratory's slow controls expertise *is* available to the experimenters if they wish.

## 5.13 Liquid Nitrogen

The SNO experiment uses liquid nitrogen underground as a pure nitrogen source for cover gas for the detector and water systems, and as a coolant for detectors (Ge gamma counter and XRF system) and cold traps. The cover gas system has the largest demand for LN<sub>2</sub> consuming approximately 500 l per week. SNO acquires purchases LN<sub>2</sub> which is stored on surface in a large dewar. Approximately 2000 l per week of LN<sub>2</sub> is shipped underground in 230 l transport dewars where it is transferred to two 1000l storage dewars in the laboratory. The advantage of using commercial liquid nitrogen is that it is high purity with low O<sub>2</sub> and Radon content<sup>5</sup>. However transporting LN<sub>2</sub> in small transport dewars results in significant losses and is labour intensive. Furthermore, it is not clear how effectively the supply can be scaled up with increased need for future experiments. SNOLAB is presently considering alternatives for LN<sub>2</sub> underground including

- Improving the efficiency of LN<sub>2</sub> transport underground
- LN<sub>2</sub> production underground.

Issues with liquefying nitrogen underground include

- Purity  
Ensuring the resulting LN<sub>2</sub> has an acceptable radon and oxygen content.
- Waste heat  
The laboratory's heat budget is fixed. A liquefier may have a significant heat load.
- Maintenance  
The cost of operating and maintaining the plant.

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<sup>3</sup>Building Automation and Control networks

<sup>4</sup>Provision will be made to allow remote control of the normal lighting in future.

<sup>5</sup>Because the LN<sub>2</sub> is several weeks old, any radon present in it has had a chance to decay.

SNOLAB intends to consider these issues in discussions with the experiments coming to site.

## 5.14 Cryogens

The existing SNO facility has two 1000 l dewars of LN<sub>2</sub> (2 m<sup>3</sup>) and often has another one or two m<sup>3</sup> in portable dewars. This quantity of cryogen has not posed a significant problem. A number of experiments propose using similar small volumes of cryogens. The cryogens from these experiments should not present a significant increase in hazard within SNOLAB.

However, some experiments propose using from 200 m<sup>3</sup> to more than 1000 m<sup>3</sup> of liquefied gasses. These experiments will present several significant challenges in SNOLAB:

1. The transportation of the material underground.  
Obviously to minimize the volume of the material transported, it is desirable to transport the material as a liquid. However there may be issues of containing the boil off if the material is expensive (such as an isotopically enriched material).
2. The liquefaction of the cryogen if transported as gas.
3. Storage of the material in it's gaseous form.
4. Evacuation of the material from the mine in the event of a catastrophic boil off.

While most of these issues need to be addressed by individual experiments, SNOLAB will work with the experimenters to find the optimal solutions.

## 5.15 Cranes and Lifting Devices

Installation of a suitable lifting device needs to be integrated with the experiment design. Lifting devices tend to be a source of contaminates to the experiment. Typical sources are lubricants, metal flakes, rust, paint chips, and brake dust. Clean lifting devices are available, however, there are still questions that need to be resolved that can only be done in conjunction with the experiment. Some of these questions are:

- Cleanliness level for the lifting device.
- Capacity.
- Lifting height.
- Travel range.

Typically there is a trade off between these features. As an example, increasing the lifting height may restrict the travel range. The current plan is to install lifting points in the back of the experimental ladder area, and at the top of the rectangular cavity and Cryopit. In addition, three monorails will be provided. The first monorail will be installed at the carwash to load/offload materials. The second and third monorails will be installed in the back of the rectangular cavity and Cryopit. These will extend into the access drifts and may be used to transfer material from the staging area

to the large experimental areas. Cranes, if required, may be installed by the experiments using the monorails and lifting points in the back of the Rectangular Hall and Cryopit. The experiment could then choose the appropriate crane for the application, considering capacity, travel, lift height, cleanliness, radon free materials or whatever.

## 5.16 Chemistry Laboratory

There will be a small facility for chemistry located at the east end of the Ladder Labs (figure 4.8). The Chemistry Lab will be equipped with a fume hood which is vented directly to the return air raise at the Chiller and a safety shower. The Chemistry Lab sump will be isolated from the rest of the laboratory's dewatering system to contain spills.

# Chapter 6

## Surface Facilities and Infrastructure

### 6.1 Site Surface Facility

An important aspect of SNOLAB is to have adequate facilities on the surface to support the underground experiments. A three storey, 34,000 sq ft facility has been constructed for this purpose (figure 6.1). It is located on the INCO Creighton Mine site approximately 100 m from the 9 Shaft Headframe. The new surface building replaces the existing SNO trailer complex and provides clean laboratory and assembly space for staging experiments going underground. It provides office and meeting room space; locker and shower facilities for personnel going underground; control rooms; electronics and machine shops and environmentally controlled space for IT. As well there will be an 4,200 sq ft unfinished area on the third floor of the building that will be available for future expansion. As of October 2005, the building is mostly complete with occupancy of the office and meeting room space. Full occupancy is expected in November 2005.

The central feature of the new surface facilities is a 4,700 sq ft block of clean room laboratories and the associated material handling facilities to transport materials and apparatus for experiments underground in a clean fashion. The laboratories will provide space for prototyping, staging the assembly of experiments underground and maintenance. There is a warehouse and a cleaning facility (Carwash) adjacent to the laboratories for material handling. A narrow gauge railway goes from the surface facility to the 9 Shaft Headframe and materials sent underground are loaded onto rail cars.

The new surface building is connected to the existing SNO *Operations Control Building* or OCB (referred to as the Blue Building) which contains a small warehouse, and rooms which were used for control and monitoring of the SNO experiment. These functions are being moved to the new facility and the spaces in the existing structure refitted for other uses including a small assembly space and a laundry facility. There is also the existing SNO “Water Building” which was used for D<sub>2</sub>O storage and water chemistry. The chemistry work is being moved to the new facility and the water building will be refitted as a machine shop.

### 6.2 Laboratories

The heart of the SNOLAB surface facility is the *Laboratory Block* (figure 6.2) which consists of six clean room laboratories. The Laboratory Block is situated on the ground floor of the surface

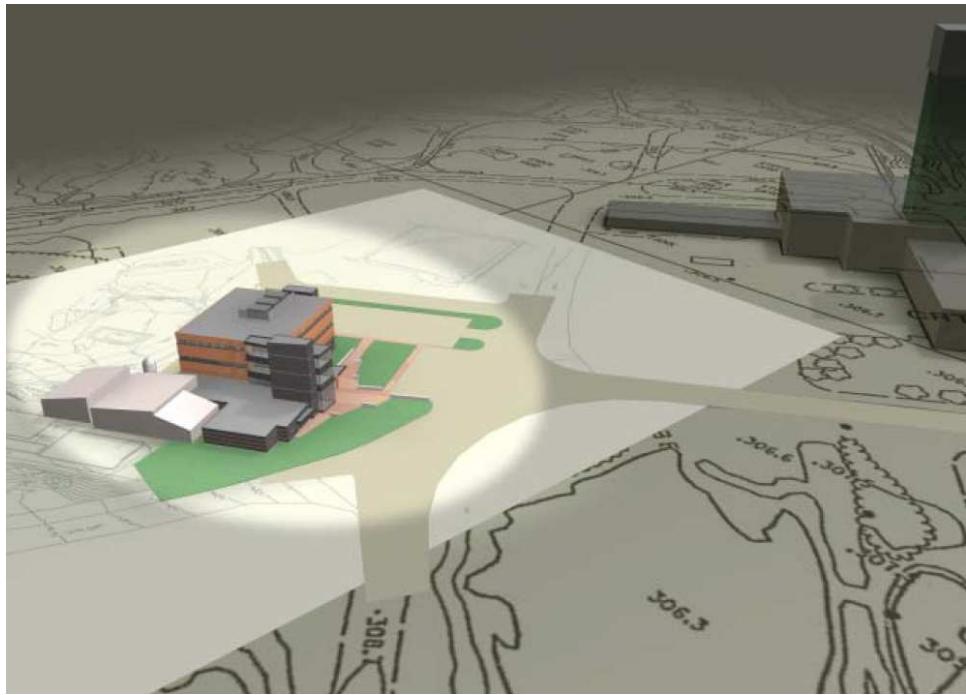


Figure 6.1: Views of the new SNOLAB Surface Facility

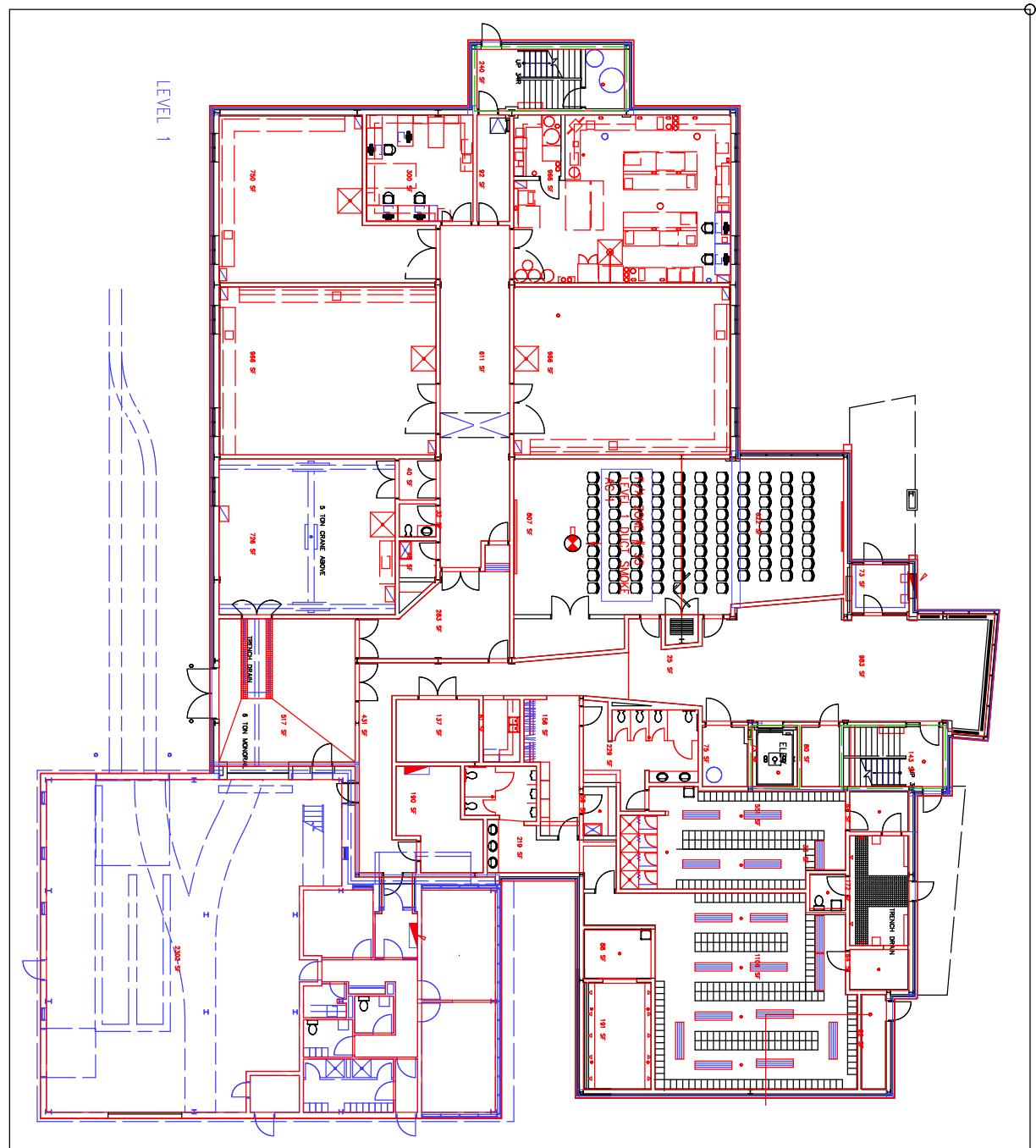


Figure 6.2: SNOLAB Surface Facility, Ground Floor

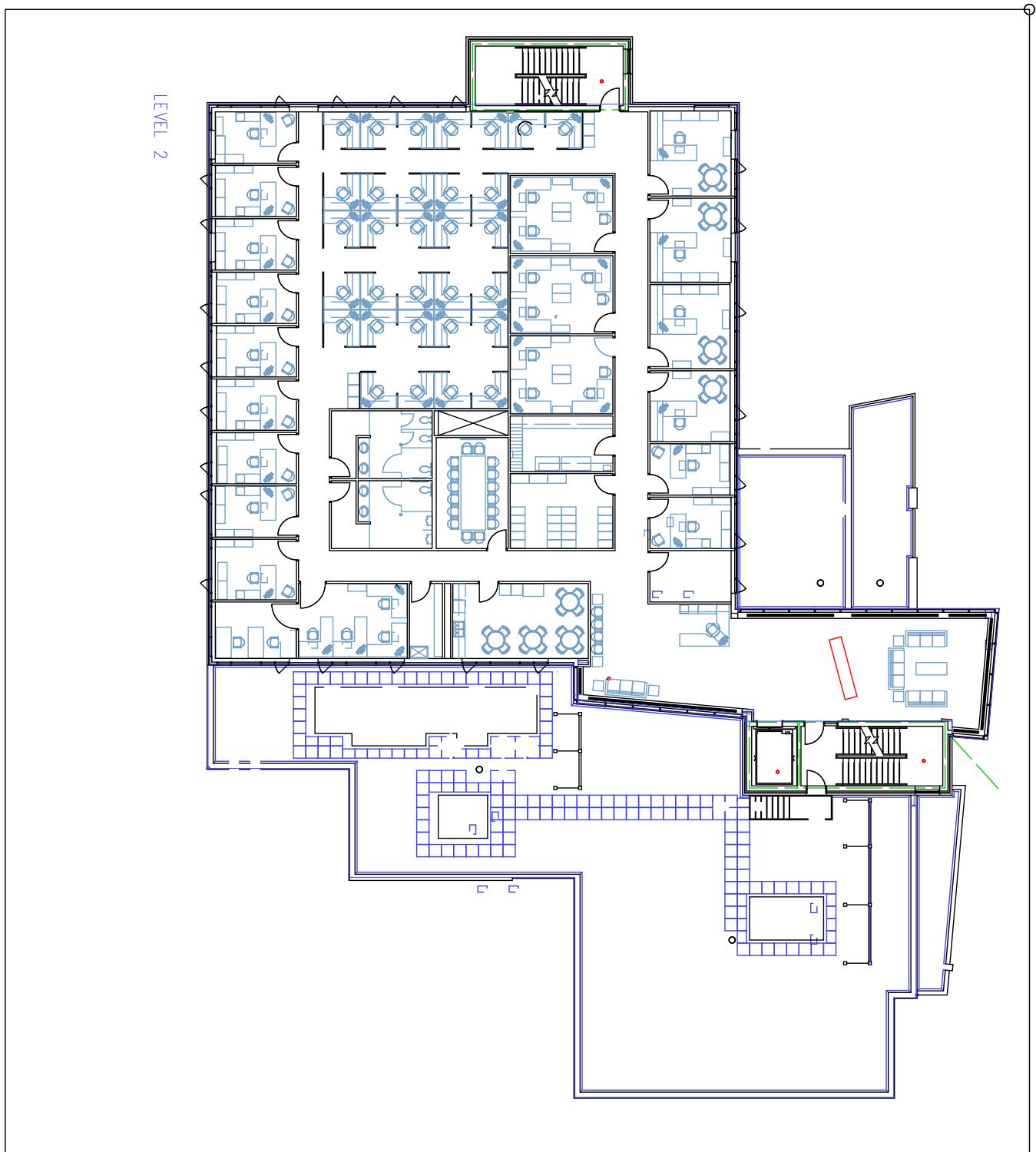


Figure 6.3: SNOLAB Surface Facility, Second Floor

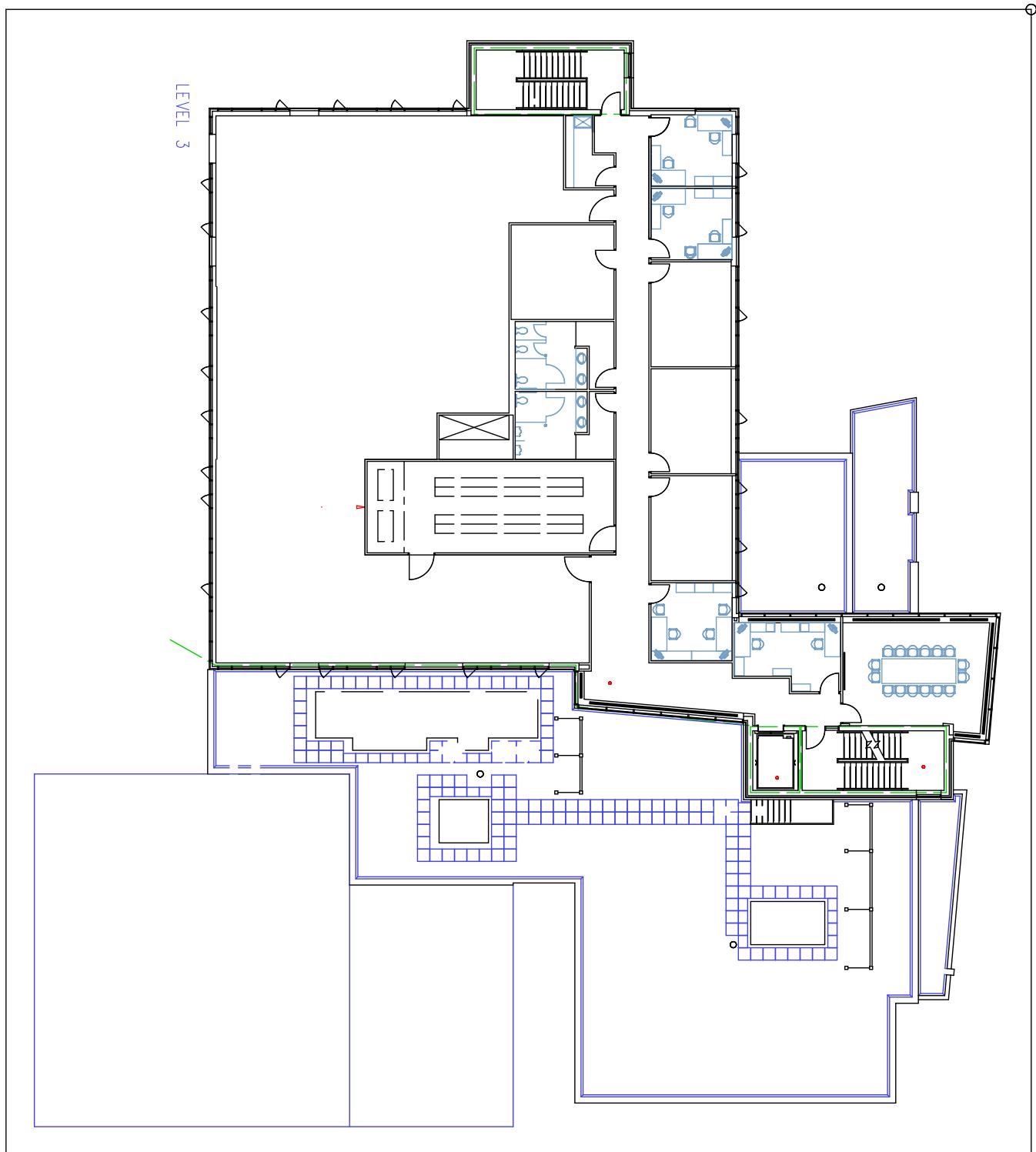


Figure 6.4: SNOLAB Surface Facility, Third Floor.

Rm	Nam	Dimensions (LxWxH)	Area (sq ft)
109	Clean Assembly	25'4" x 28'8"x 15'	724
113	Research Laboratory A	27'4" x 35'4" x 15'	966
114	Research Laboratory B	27'4" x 23'4" x 15' +9'4" x 12' x 15'	750
115	Low Background Counting	17'4" x 17'4" x 8'	300
118	Chemistry	27'4" x 35'4" x 15'	966
120	Research Laboratory C	27'4" x 35'4" x 15'	966

Table 6.1: Dimensions of the Surface Laboratories

facility. The floors are designed for 1000 lb/sq ft loading to permit heavy objects such as water tanks or lead shielding. There are three general purpose laboratories (two with 966 sq ft floor space, one with 750 sq ft.), a *Chemistry Laboratory* (966 sq ft), a *Low Background Counting Room* (300 sq ft), and a *Clean Assembly Room* (724 sq ft) (Table 6.1). All the laboratories are accessed through a common corridor. Research Labs A, B, C, Chemistry and Low Background Counting and the connecting corridor are expected to be operated as Class 10,000 or better clean rooms. Clean Assembly has more filtration and is expected to be operated at Class 2000 or better. It is entered from the lab corridor through a vestibule. It should be noted that because the clean rooms are not being used as conventional clean rooms (pharmaceuticals, semiconductor etc) they are not designed to ASHRAE<sup>1</sup> clean room standards. The expected cleanliness levels are based on experience with the SNO experiment. The performance of the clean rooms will be carefully monitored once they are commissioned.

Access to the Laboratory Block is through a vestibule where personnel transition to clean room clothing. Because Clean Assembly is at a higher level of cleanliness than the rest of the Lab Block, it is entered through a second vestibule off the Lab Corridor. The vestibule, lab corridor and door ways are designed to accept materials with dimensions of 12'x4'x7' (the dimensions of the SNOLAB shipping containers used to transport materials underground).

Each laboratory space is equipped with both normal and emergency generator 120/208V power. 600V power is also available. UPS is *not provided* and is expected to be installed by experimenters as necessary. All labs have domestic water and R/O water from a reverse osmosis plant located in the Chemistry Lab. All labs except Low Background Counting are equipped with a safety shower. All labs have compressed air and 40 PSI boil off nitrogen from a dewar located outside the warehouse. The Boil off N<sub>2</sub> in high purity with very low Radon Levels. The Chemistry Laboratory is equipped with two fume hoods. Research Labs A, B, C and Clean Assembly have rough ins to permit the installation of fume hoods in future. All labs except Clean Assembly have an off gas header system to vent waste gases or exhaust from vacuum pumps etc. The Clean Assembly Room has a 2 Tonne clean bridge crane. The steel work in the other laboratories could in future allow the installation of similar cranes.

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<sup>1</sup>American Society of Heating Refrigerating and Air-Conditioning Engineers, Inc.

## 6.3 Material Handling

Material handling is an important part of the design of the SNOLAB surface facility. The material handling areas of the surface facility are the *Warehouse* (2000 sq ft) and the *Carwash* (517 sq ft). Material being transported underground is usually shipped in sealed shipping containers called *Blue Boxes* (see section 7.4). Blue boxes are moved on rail cars on the Creighton Mine narrow gauge rail system. Rail lines from the mine Head Frame come into the SNOLAB warehouse. A switch system allows rail cars to be brought into a room called the Carwash which is located adjacent to the Lab Block. The Carwash is a room intended for the cleaning of equipment either going into surface laboratories or underground. The Carwash also has a 2 tonne monorail crane for material handling.

Materials in Clean Assembly will be of sufficient cleanliness to be brought into the underground lab. A hatch connects the Carwash to the Clean Assembly Room. A Blue Box can be mated to this hatch and then opened from within Clean Assembly. Materials in Clean Assembly can then be loaded directly into the Blue Box without exposing it to unfiltered air. On arrival underground, the process is reversed in the underground Carwash where the exterior of the Blue Box is washed and the materials removed into the clean laboratory.

## 6.4 Personnel Facilities

To go underground, personnel are required to dress in mine gear. The SNOLAB surface facility will have change rooms and showers (referred to as *Drys*<sup>2</sup>) for the personnel working underground. The Drys consist of locker rooms and shower facilities. The locker rooms are divided into clean and dirty sides. Each worker has two lockers assigned (a clean locker for street clothes and a dirty locker for mine gear). The lockers are ventilated to facilitate drying of the mine gear. The Men's Dry has capacity for 100 and the Women's Dry has capacity for 50. The dirty side of both the male and female drys connect to a common vestibule or *Mud Room* where returning personnel clean their boots before proceeding into the locker rooms. The clean side of the drys open into the common area on the main floor of the surface facility (figure 6.2).

## 6.5 Office and Control Room Space

The SNOLAB surface facility provides seating for 68 personnel, 37 in offices seating between one and three people and 31 in cubicles. Most of the seating is located on the second floor with some space available on the third floor (figures 6.3 and 6.4). There is a lunchroom on the second floor and a coffee station on the first floor.

On the third floor are three control rooms allocated for remote monitoring of experiments underground. The control rooms are equipped with normal and emergency power and can be configured for UPS. Analog phone lines will be located in each control room for emergency communications in the event of network (and thus VOIP phone) failure.

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<sup>2</sup>The term *Dry* is refers to the feature of these rooms in mines where they are kept at elevated temperatures to dry out the clothing between the worker's shifts.

## 6.6 Meeting Rooms

SNOLAB has three meeting rooms in the surface facility. An auditorium on the first floor adjacent to the lobby seats up to 100 in a common room but has a folding wall to make two smaller meeting spaces (60 seats and 40 seats). There is a small coffee station near the auditorium. There is a small conference room on the 2nd floor with 12 person seating capacity and a larger meeting room on the 3rd floor with 16 person capacity. All meeting rooms will be equipped with computer projectors and wireless network.

## 6.7 Future Expansion

Approximately half of the third floor of the surface facility is unfinished. This 4,188 sq ft area is intended for future expansion and may be used for either office or laboratory space as necessary.

## 6.8 IT and Communications

The surface building has a 590 sq ft IT server room located on the third floor. This is a climate controlled room which contains the network switches for the building and is intended to house the computers and disks for site computing. The room has residue-less fire suppression and self contained HVAC. UPSs fed off emergency power are located in the room for the computer equipment.

CAT-6 network is installed into most areas of the surface facility. Wireless network will be available in all meeting rooms. Telephony is primarily VOIP but some analog telephones will be available for emergency communications.

## 6.9 Shops and Laundry

There will be a small laundry facility located in the warehouse building to be used for washing mine gear and clean room clothing for the surface laboratories. An electronics assembly room will be situated in the warehouse building as well. A small, 1000 sq ft Machine Shop will be situated in the former SNO water chemistry building located west of the Warehouse.

## 6.10 Building Monitoring

Building monitoring and control is by Delta Control Systems and is BACnet based [10]. This is the same system as will be used in the underground laboratory.

## 6.11 Fire Alarming and Suppression

The surface fire alarm is mostly an Edwards system. The exception is the IT server room which uses a Simplex system. Fire suppression is sprinkler in all spaces except the IT server room which uses an FM-200 residue-less fire suppression system. Fire alarms in the surface facility are monitored by the Creighton Mine Control Room.

## 6.12 Emergency Power

The laboratories and control rooms will have access to emergency generator power from a 150 kW unit with a 48 hour nominal run time. While all equipment going into the IT Server room will be required to have UPS, experimenters will be required to provide for their own UPS needs in the labs and control rooms. However, the laboratories and control rooms are configured to facilitate the installation of UPSs.

## 6.13 Facilities at Laurentian University

Radio-tracer techniques are common to the characterization and monitoring of many liquids and to the evaluation of materials, and it is expected that the need for such a testing facility will be expanded as the new experiments are built and operated. A 2,500 sq ft facility is being implemented on campus at Laurentian University to support work with radioactive spikes in isolation from facilities at the SNOLAB site.

Included in this facility is a radioisotope counting room, two 500 sq ft. laboratories for liquid processing and a 1,000 sq ft laboratory for counter development work as shown in figure 6.5. The two 500 sq ft laboratories will house a wet-chemistry radioisotope analysis facility (with clean-room provisions) and a general water/liquid research unit. Equipment will include clean-room filters, fume hoods, a reverse-osmosis ultra-pure water plant, and two water recirculation systems comprising three 1 m<sup>3</sup> tanks each. The second system is equipped with a cover gas system.

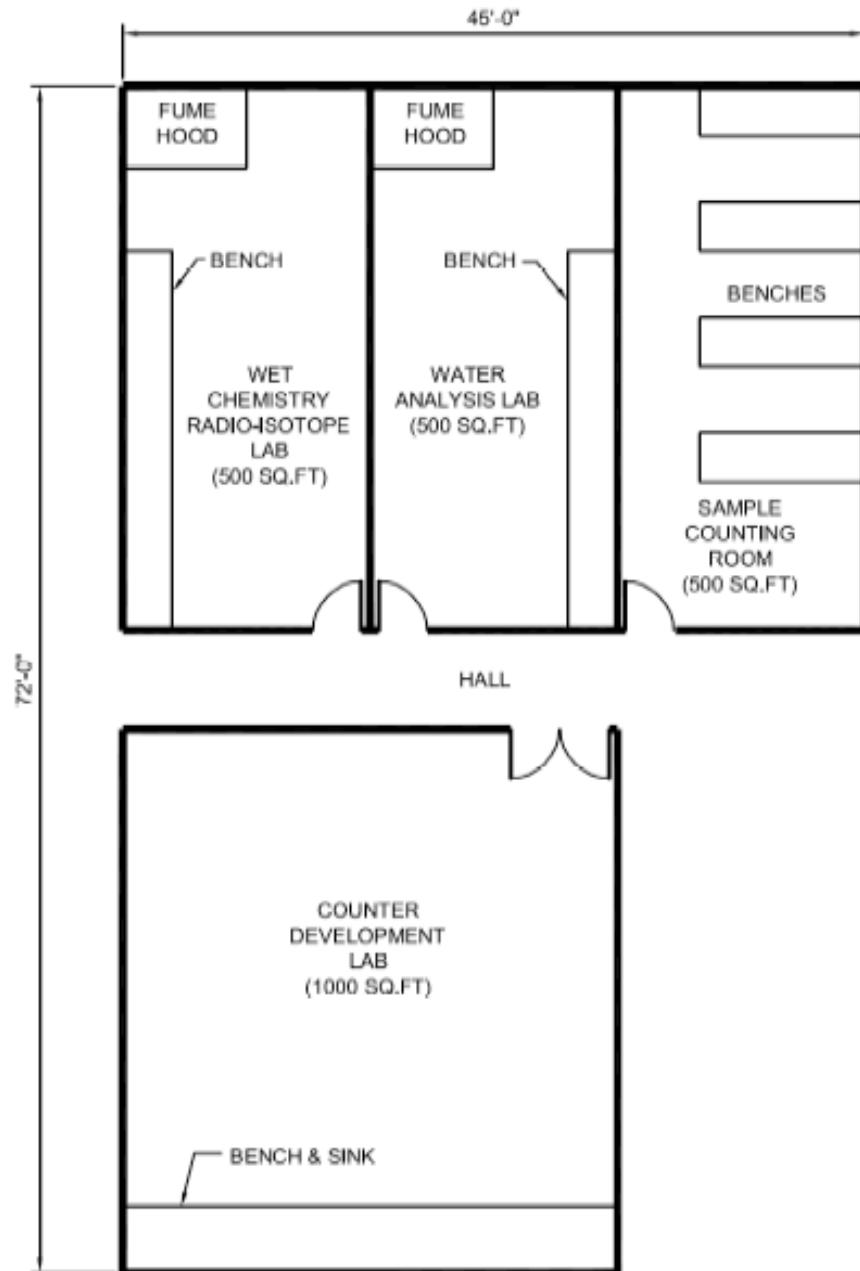


Figure 6.5: Radioisotope Lab to be sited at Laurentian University.

# Chapter 7

## Site Infrastructure

### 7.1 Network and Communications

#### 7.1.1 Underground

The back bone of the SNOLAB communications system is a high speed fibre optic link between the underground and surface laboratory which will consist of 24 multimode fibres and six single mode fibres. These fibres terminate in the IT Server Room in the Surface Facility and in the Personnel Drift in the Underground Laboratory (figure 7.1). The total span of the fibre link is just over 4 km and will run by underground conduit from the surface building to the Creighton Mine Control Room where they are connected by a patch panel to the fibres running down 9 Shaft and along the main access drift on the 6800 Level into the laboratory. The system partially exists today and in its full implementation for SNOLAB, the fibres will be run in two bundles down the shaft and along the 6800 L drift. One bundle will contain 12 multimode fibres, the other bundle is shared with INCO and contains 12 multimode and 6 single mode fibres dedicated to SNOLAB. At the 6800 L Shaft station the fibres are patched and then run as two separate bundles along the level to the lab. A recognized problem is the close proximity of the fibre bundles in the shaft (only separated by 1.5 m) which makes both bundles vulnerable to damage from a common source.

Inside the lab, the fibres to surface terminate in a communications rack in the Personnel Drift (CRU1A). There will be four other communications racks located in the laboratory in the experimental areas (Ladder Labs, Rectangular Hall, Cryopit, SNO Cavern) with fibre bundles connecting these racks back to CRU1A (see table 7.1). As well there will be a communications rack in the Utility Drift (CRU4A) which is again connected back to CRU1A by fibre bundle. Network equipment will be connected to the local communications racks by CAT-6 LAN with RJ-45 connections being the standard. Each communications rack will have UPS connected to the emergency power bus. There will be redundant fibre links to surface such that a loss of one fibre link may reduce the overall bandwidth but will not break the link to surface. As well, there will be redundant switches fed from multiple power sources (normal power and emergency via UPS) that should give the network link between underground and surface a high degree of reliability.

Telephony on the SNOLAB site both underground and on surface is primarily VOIP connected through the Site LAN and providing access both on and off site. However, there will be an independent analog phone system run on copper lines between the underground laboratory and the Creighton Control Room to act as a backup system in the event that there is a failure in the LAN.

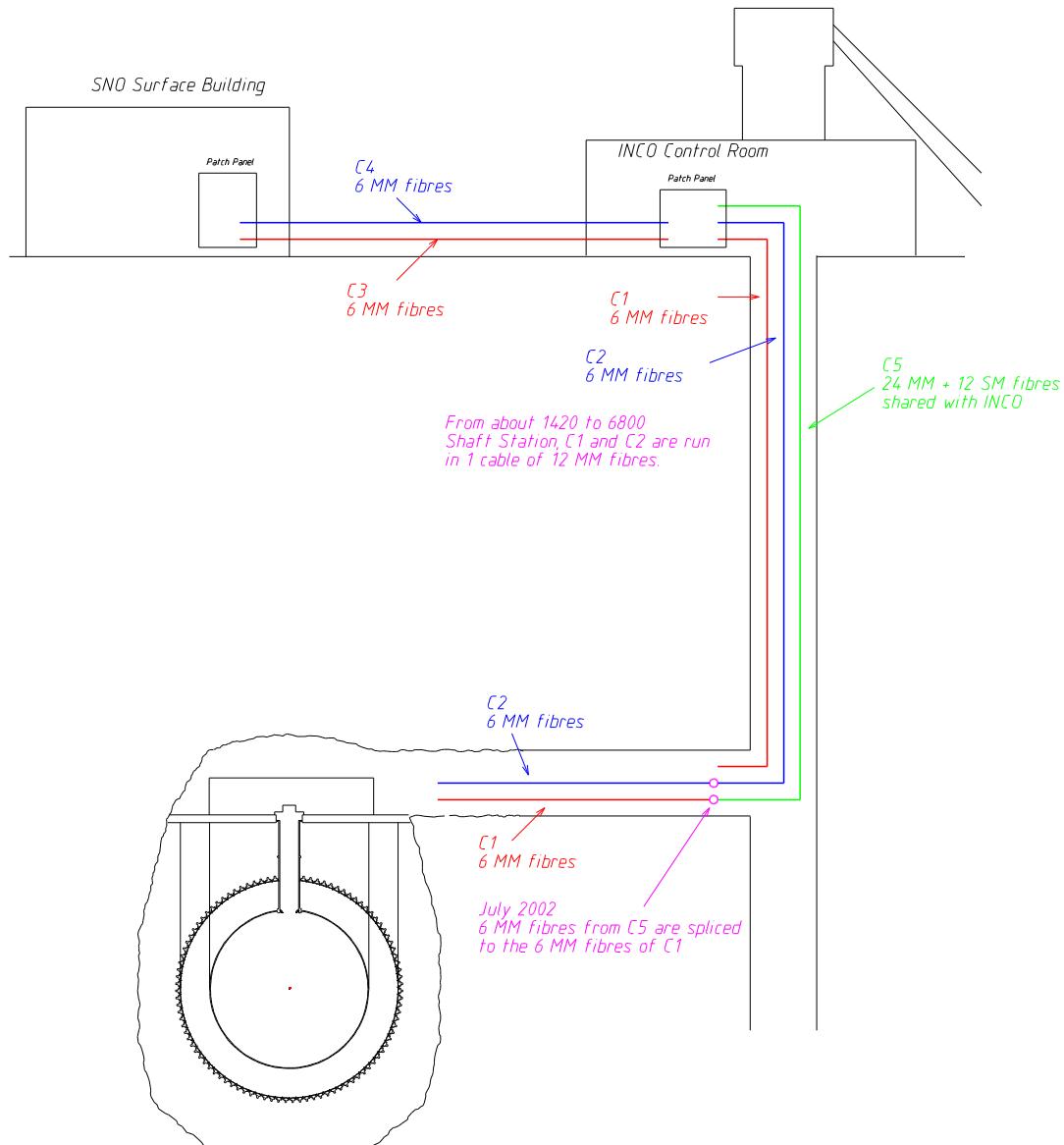


Figure 7.1: SNOLAB fibre optic communications system.

Rack	Name	Location
421-CRU1A	Refuge Communications Rack A	Personnel Drift
421-CRU1B	Refuge Communications Rack B (future)	Personnel Drift
421-CRU2A	Ladder Communications Rack A	Ladder Labs
421-CRU2B	Ladder Communications Rack A (future)	Ladder Labs
421-CRU3A	Rectangular Hall Communications Rack A	Rect Hall CR Rm
421-CRU3B	Rectangular Hall Communications Rack B (future)	Rect Hall CR Rm
421-CRU4A	Utility Area Communications Rack A	Chiller Drift Elect Rm
421-CRU5A	Cryopit Communications Rack A	Cryopit CR Rm
421-CRU5B	Cryopit Communications Rack B (future)	Cryopit CR Rm
421-CRU6A	SNO Communications Rack A	SNO Cavern Control Rm
421-CRU6B	SNO Communications Rack B (future)	SNO Cavern Control Rm

Table 7.1: SNOLAB Communications Racks

Similarly there will be several independent analog lines off site from surface.

Because of the redundancy built into the Site Local Area Network where possible, communications needs are to be met using the LAN. This includes telephony, computer data traffic, video and possibly fire alarm communications to surface. The use of dedicated fibre links will be kept to a minimum<sup>1</sup>.

### 7.1.2 Surface

Between the SNOLAB surface building and the Creighton Mine Surface Facility are 12 multimode fibres, 6 single mode fibres and 24 pair copper wires running via telephone poles. Between the IT Server room on the third floor of the surface facility and the warehouse mezzanine are 24 multimode fibres and 6 single mode fibres.

## 7.2 GPS Timing

The SNO experiment utilizes a GPS clock system to maintain accurate timing. Details are described in appendix C. While presently this system is not available as a general time standard for the laboratory, such a system is being considered.

## 7.3 Site Computing

Computing is an important part of the SNOLAB site infrastructure. IT support will be provided in the form of basic computing infrastructure and IT support staff. SNOLAB will maintain a central infrastructure consisting of mail, web and disk servers. Security including a site fire wall will be provided. Users will be provided with email accounts, personal disk space and access to printers. Private areas for experiments will be allocated on the site disk server. Provided appropriate security

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<sup>1</sup>For example with the existing SNO experiment, there are three fibres dedicated to a GPS time system. SNOLAB will investigate whether the required timing precision can be met using a LAN based system.

precautions are taken, experiments will be permitted to connect computers to the site LAN. Virtual Local Area Networks (VLANs) can be provided to experiments requiring either additional privacy or ensured bandwidth. The surface IT Server room has capacity for 24 racks in an environmentally controlled room which is available for computing support for experiments. While SNOLAB does not at this time intend to provide large scale disk or computer farms, the site is willing provide assistance for experiments wishing to set up such facilities on site.

## 7.4 Material Transport

There are a number of important issues associated with the transportation of equipment and materials to the underground laboratory. There are significant restrictions on the size of object determined by the 9 Shaft Cage (elevator car) and the size of the drifts. There are weight restrictions for the cage. And there are requirements for the cleanliness of materials entering the laboratory. Another consideration is that there are only a finite number of cage trips available for material transport per day. Nominally SNOLAB has four cargo trips per day.

Material transported to the lab is usually loaded on rail cars pulled by a diesel locomotive or “motor”. The rail cars will be loaded in the surface facility carwash and are either pulled by locomotive to the head frame or carried by forklift. Materials transported to the lab on open rail cars become contaminated with mine dust and must be cleaned in the carwash prior to entry into the lab. This is a labour intensive process which is relatively inefficient underground. It is also not practical for delicate equipment. The preferred method for transporting materials that are to enter the lab is in a *Blue Box*. Blue Boxes are sealed rail cars that are designed to transport material between the surface and underground clean rooms without exposure to the mine environment. This makes the clean room in the SNOLAB surface facility an extension of the underground clean space. A complication with a sealed shipping container is the 25% increase in air pressure on the 6800 level of the mine. Blue Boxes equalize pressure through HEPA filters to prevent dust contamination.

The following sections give specifications for the cage, Blue Boxes and rail cars currently in use for the SNO experiment. Experimenters should note that there will be a redesign of the Blue Boxes to improve their compatibility with the new SNOLAB facilities and their dimensions will probably change (i.e possibly get smaller). Experimenters should consult with SNOLAB when designing a material shipping program. Similarly, the cage specifications are subject to change.

### 7.4.1 Cage Dimensions and Specifications

The cage in the Creighton No. 9 shaft consists of two levels, so that two rail cars can be transported underground simultaneously. Some items that are too long to fit into the cage can be slung on the bottom of the cage as long as they do not exceed the specified maximum weight. Other criteria such as the maximum length of materials slung under the cage have not been taken into account. The movement of these types of materials depend on the size of the drift at the shaft station and the drift layout itself as the drifts have some sharp bends and the longer items would have to be able to traverse these.

Table 7.2 gives the maximum height, length and widths of each cage level, as well as the maximum weight each level can carry and the maximum weight that the entire cage can carry.

	Max. Height	Max. Length	Max. Width	Remarks	Maximum Weight lbs	Maximum Weight kg
Upper deck (normal)	92"	12'4"	59.5"	Full width for 12'4"	21,000 lbs.	9,545 kg
Upper Deck (Lower bumper removed)	92"	12'6"	59.5"	Width decreases to 51" for last 2" of length	21,000 lbs.	9,545 kg
Upper Deck (Lower & upper bumper removed)	92"	12'10"	59.5"	Width decreases to 51" for last 6" of length	21,000 lbs.	9,545 kg
Lower deck (normal)	103"	12'4"	58.5"	Full width for 12'4"	21,000 lbs.	9,545 kg
Lower Deck (Lower bumper removed)	103"	12'6"	58.5"	Width decreases to 51" for last 2" of length	21,000 lbs.	9,545 kg
Lower Deck (Lower & upper bumper removed)	103"	12'10"	58.5"	Width decreases to 51" for last 6" of length	21,000 lbs.	9,545 kg
Max. weight of loads on both decks					24,000 lbs	10,909 kg
Max. weight for an under slung load to 6800 level with nothing loaded on either deck					26,270 lbs	11,940 kg

Table 7.2: Creighton mine cage dimensions and specifications. Note that at the back end of each deck, there are bumper bars that go across to protect the rear wall of the cage from damage when trucks are rolled onto the cage. The length listed as normal, is with these bumper bars in place. There are a set of lower bumper bars and a set of upper bumper bars. By removing the lower bumper bars, the length increases by 2", but because these bars sit in channels attached to the wall, the width for that extra length decreases. If more inside length is required, the upper bars can also be removed, but again the width is restricted by the channels.

Figure 7.2 shows a view of both decks of the cage looking into the cage from the front and figure 7.3 shows a side view of both decks of the cage.

#### 7.4.2 Sling Box Cage

If very long objects are to be taken underground, they can be placed in a special container system that has been engineered and built for slinging long loads underground. It is essentially a long narrow cage in which objectss are placed and “bear trapped”. The whole container is then picked up and slung underneath the cage. It has some restrictions. It is not very large inside (approximately 2.5' × 2.5'), but it can hold objectss up to approximately 32' long. The maximum tare weight is 3200 pounds. Exact dimensions can be requested if it is decided that long pieces should be taken underground without being cut up into smaller pieces.

#### 7.4.3 Rail Car Specifications

SNO currently uses two main types of flatbed rail cars, which are referred to as regular and low-rider. The cars are used to transport goods underground directly on the car if cleanliness is not a concern or in blue boxes which are placed on top of the cars. If large bulky items are placed directly onto the cars and the item is to enter the lab then it must be vigorously cleaned before entering the laboratory. There is also a special rail car that is only 6" from the ground in the center, this car is designed to carry tall items. However, extra care must be taken using this car because it can derail very easily if there is excessive dirt or gravel between the tracks which can lift the rail

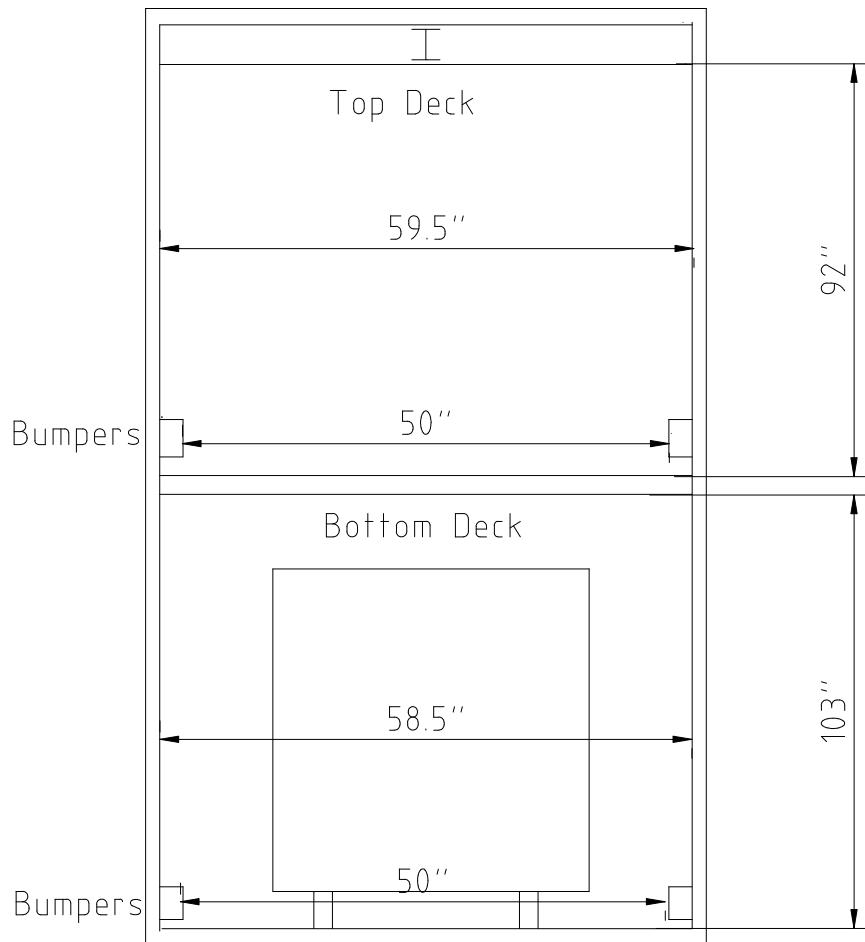


Figure 7.2: Creighton mine cage front elevation.

car clear of the tracks.

Figure 7.4 shows a schematic of the regular (or standard) flatbed car that is commonly used by INCO and SNO. Figure 7.5 shows the specially designed low-rider flatbed car, it is essentially the same as the regular flatbed car except that the distance between the wheel (truck) assembly and the car deck is reduced. The rail car decks are 11'(L)  $\times$  4'(W) and objects placed upon the cars should remain within these dimensions. If longer objects are to be placed on the cars, special care must be taken when the car is being pulled into the lab and the item must still fit within the cage (the normal length is 12'4").

#### 7.4.4 Transport Box Specifications

There are several transport boxes, commonly called “Blue Boxes”, because of their colour, in use at SNO and this section will detail the dimensions of several of the boxes. There are several smaller boxes available and a schematic of one of these is shown in figure 7.6. The average size of these boxes is 61"(L)  $\times$  44"(W)  $\times$  43"(H). Two of these small boxes can be placed on one regular flatbed car.

The standard sized large blue boxes used by SNO sit on top of the regular flatbed car and

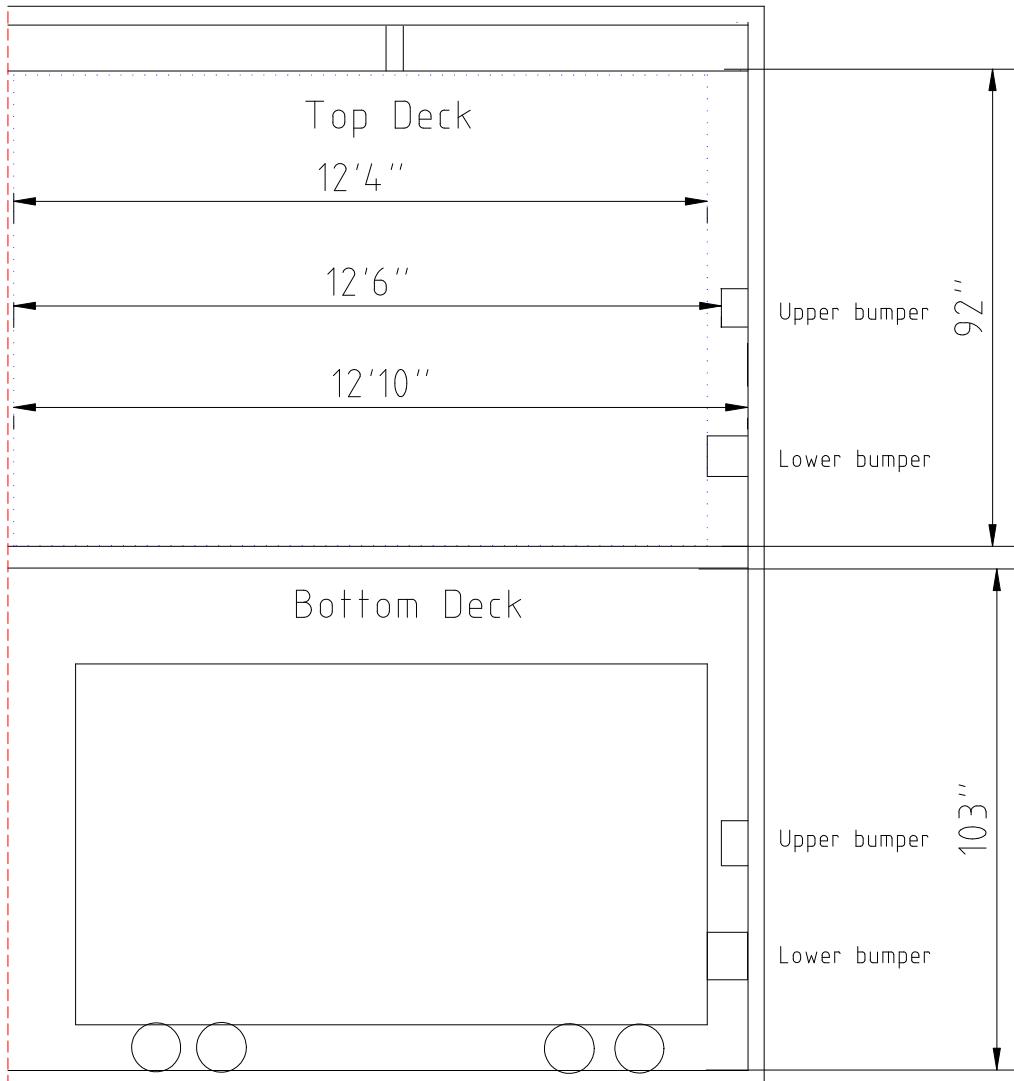


Figure 7.3: Creighton mine cage side view.

have outside dimensions of 144.5"(W)  $\times$  48"(W)  $\times$  61.5"(H). The usable interior volume of these boxes are 140.5"(W)  $\times$  44"(W)  $\times$  55.5"(H). A schematic of one of these blue boxes is shown in figure 7.7.

The largest blue box currently used by SNO is shown in figure 7.8, this blue box is usually placed upon one of the low-rider flatbed cars due to its height which is 13" taller than the box previously described. The usable interior space for this box is 140.5"(W)  $\times$  44"(W)  $\times$  68.5"(H).

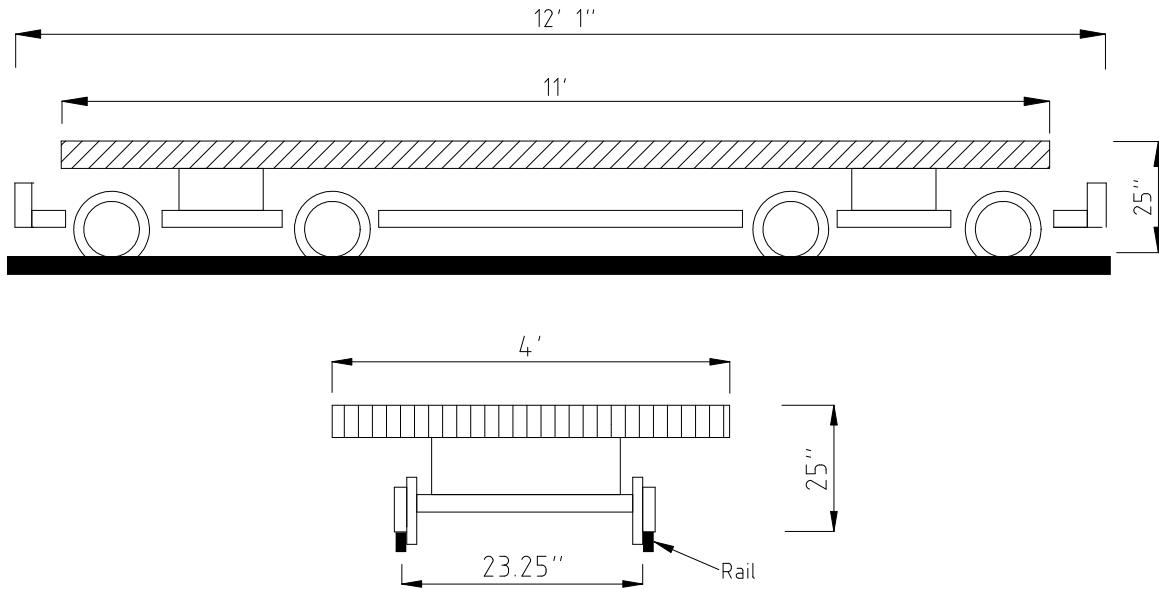


Figure 7.4: Schematic of a standard or regular flatbed car. The top figure shows a length wise view of the car and the bottom figure shows a cross wise view of the car. The car's deck is 11'(L)×4'(W) and is 25" from the tracks. Note that figures are not to scale.

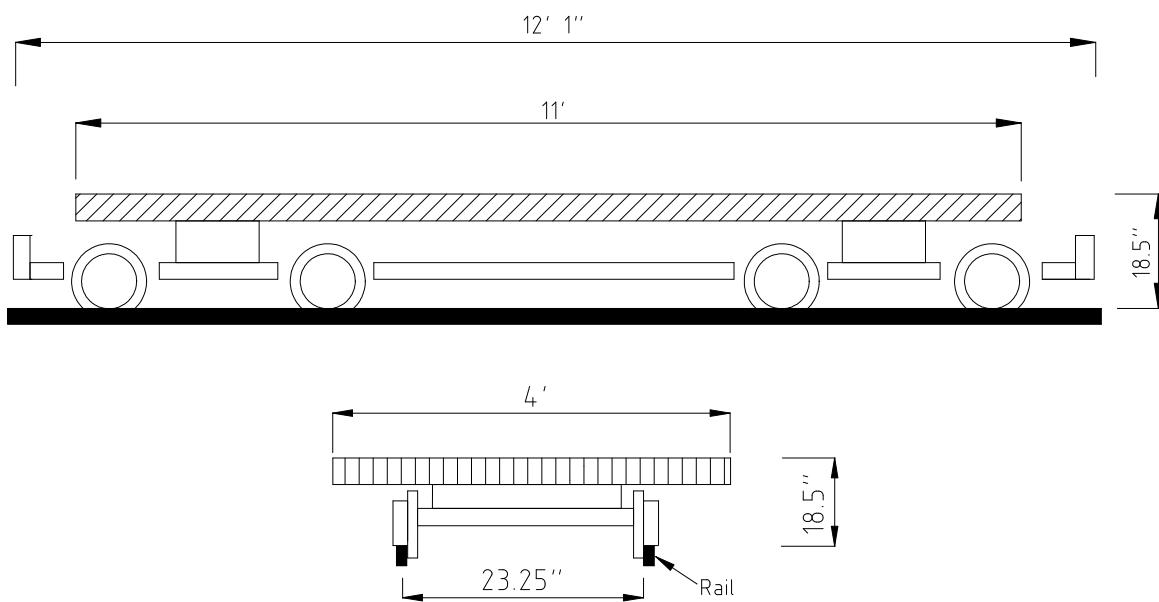


Figure 7.5: Schematic of a low-rider flatbed car. The top figure shows a length wise view of the car and the bottom figure shows a cross wise view of the car. The car's deck is 11'(L)×4'(W) and is 18.5" from the tracks. Note that figures are not to scale.

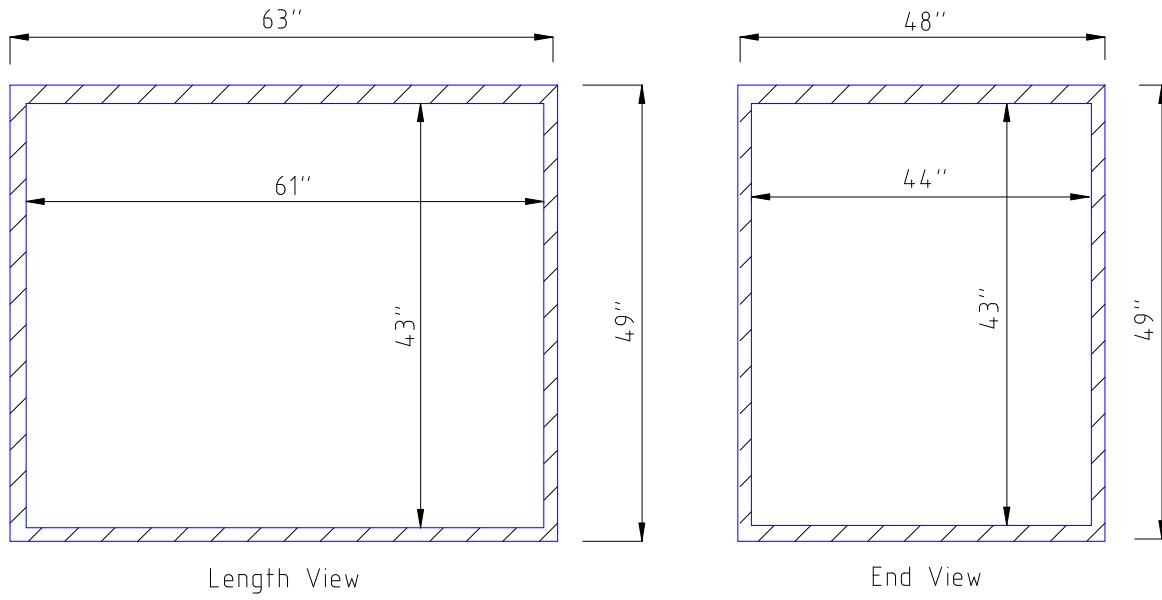


Figure 7.6: Schematic of a small blue box. The length view is shown on the right while the end view is shown on the left. The interior dimensions of the blue boxes are 61"(L)  $\times$  44"(W)  $\times$  43"(H). Note that figures are not to scale.

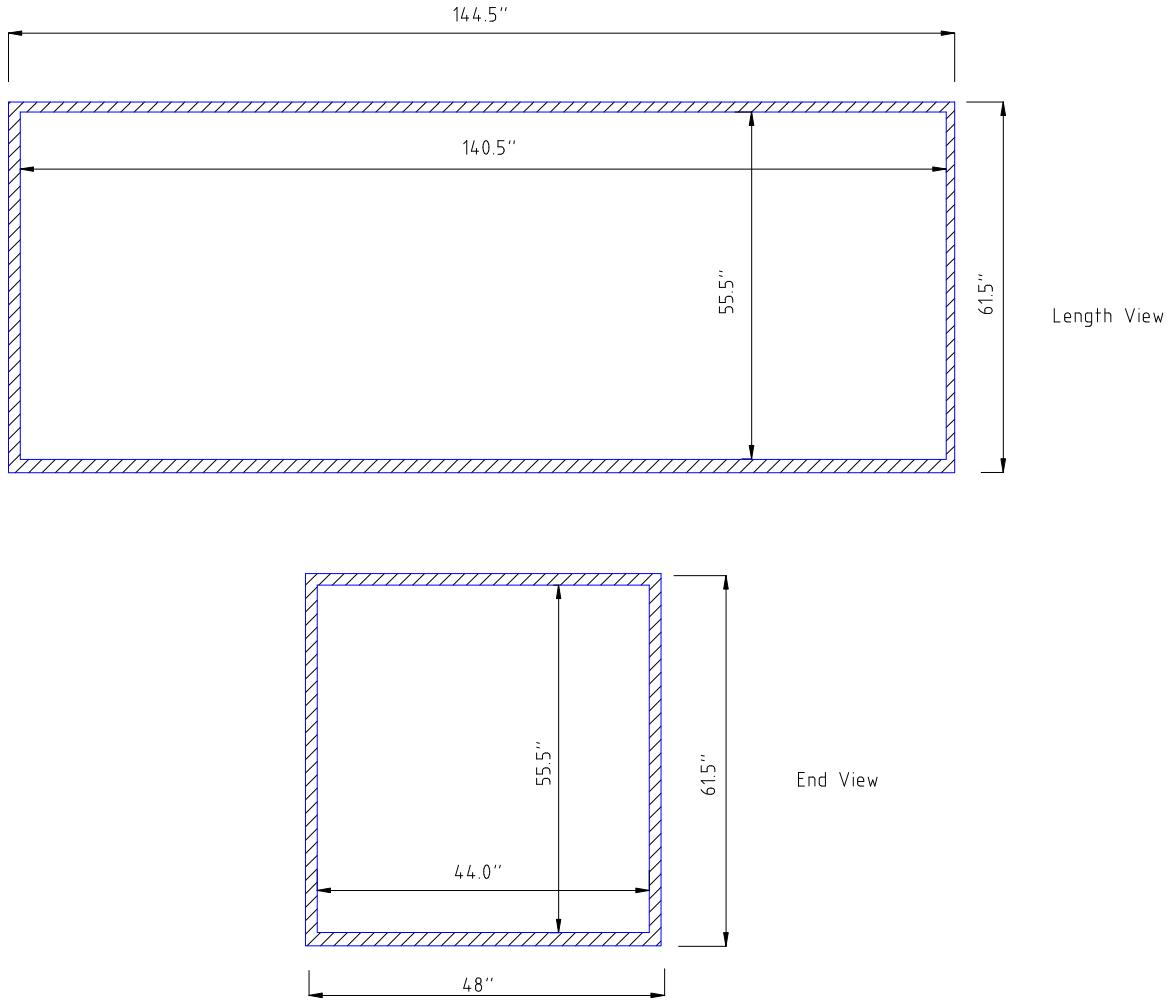


Figure 7.7: Schematic of a standard sized blue box. The length view is shown on the top while the end view is shown on the bottom. The interior dimensions of this blue box is 140.5"(W)  $\times$  44"(W)  $\times$  55.5"(H). Note that figures are not to scale.

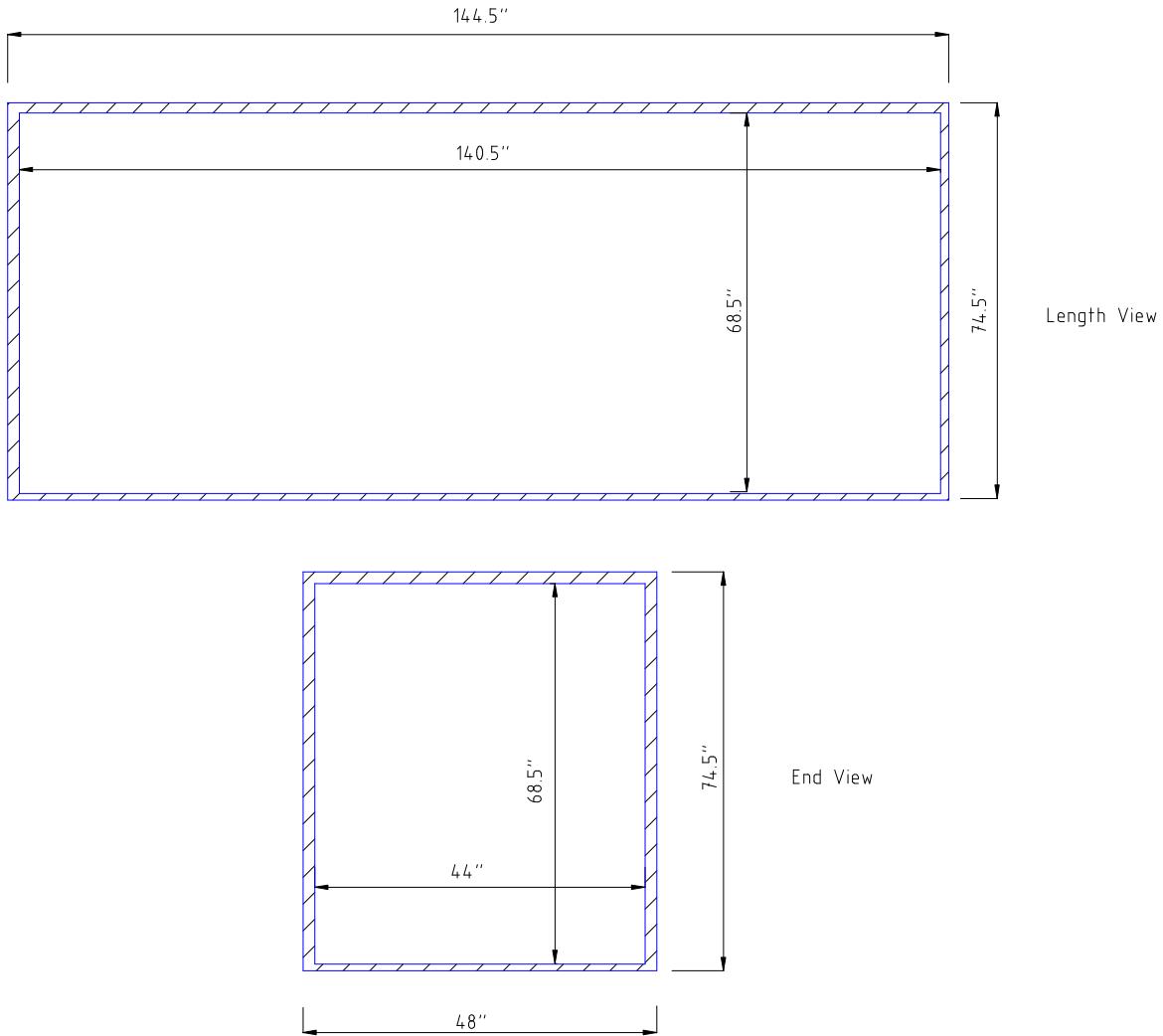


Figure 7.8: Schematic of the large extra tall blue box. The length view is shown on the top while the end view is shown on the bottom. The interior dimensions of this blue box is 140.5"(W)  $\times$  44"(W)  $\times$  68.5"(H). Note that figures are not to scale.

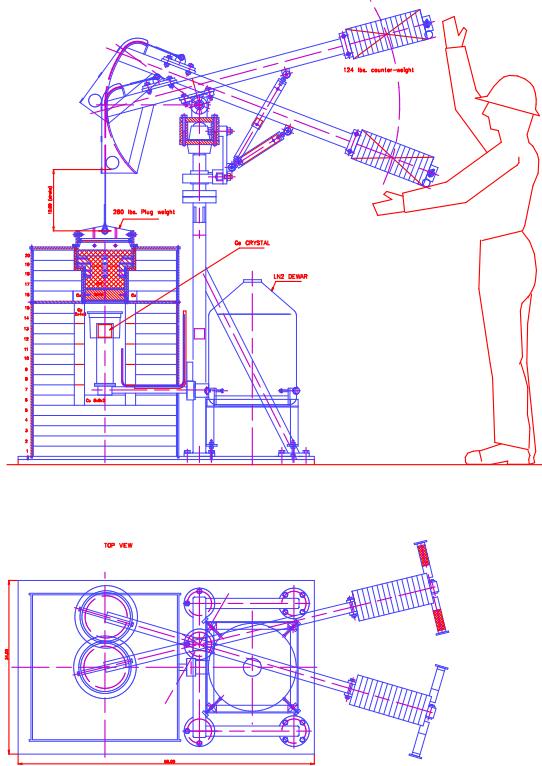


Figure 7.9: SNOLAB Ge Gamma Counter

## 7.5 Low Background Counting

### 7.5.1 Underground Facilities

SNOLAB is in the process of commissioning a hyper-pure germanium detector that will be available for experiments to use in materials selection. The detector was made by Princeton Gamma-Tech and its characteristics are given in Table 7.3. It is located in the SNO junction area and is shielded from background radiation by 5 cm of OFHC copper and 20 cm of lead. Both of these absorbers have been underground for approximately ten years and thus have low backgrounds. The detector configuration is shown in Figure 7.9.

Samples to be measured are put in a Marinelli beaker of approximately 1 liter volume which is placed on top of the Ge detector, as shown in Figure 7.10. The detection efficiency in this configuration has been measured with a mixed radionuclide source whose component activities are known with an uncertainty of 3%. The resultant efficiency curve is shown in Figure 7.11.

Preliminary values for the minimum detectable impurity concentrations of common naturally occurring radioactive contaminants are given in Table 7.4. These were obtained from a 6.7-day counting interval and will be improved upon in the future.

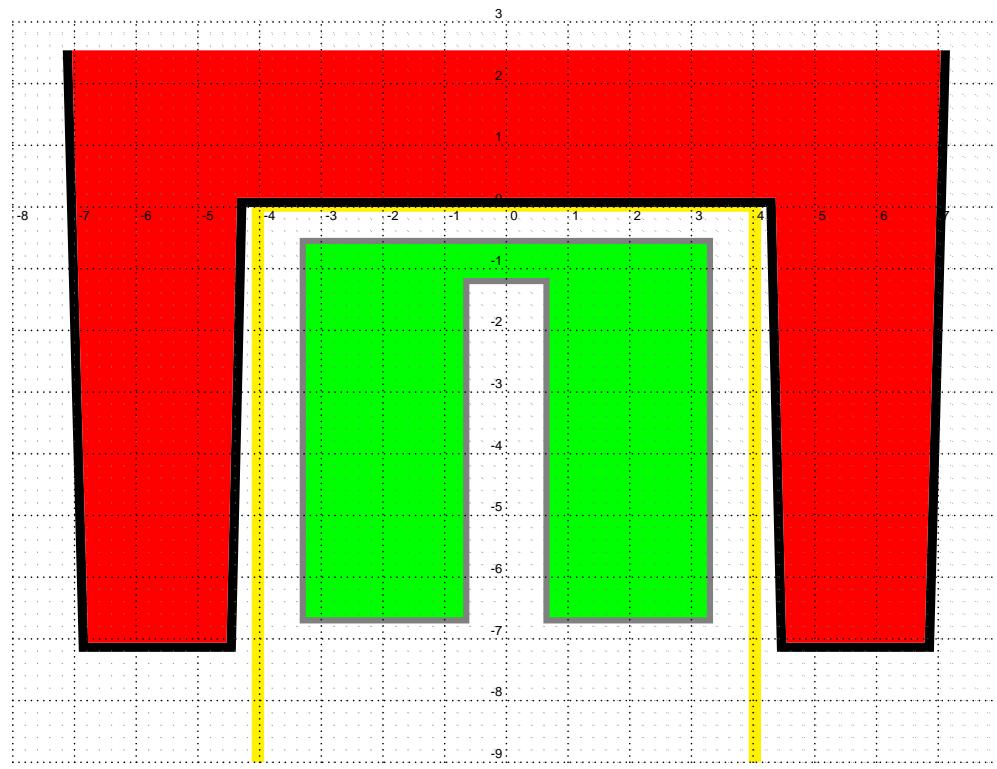


Figure 7.10: Configuration for sample counting with the Ge detector. The detector is in green, the Marinelli beaker in black, the sample being counted in red, the copper crystal housing in yellow, and an upper limit on the thickness of the crystal dead layer in gray. Dimensions are in cm.

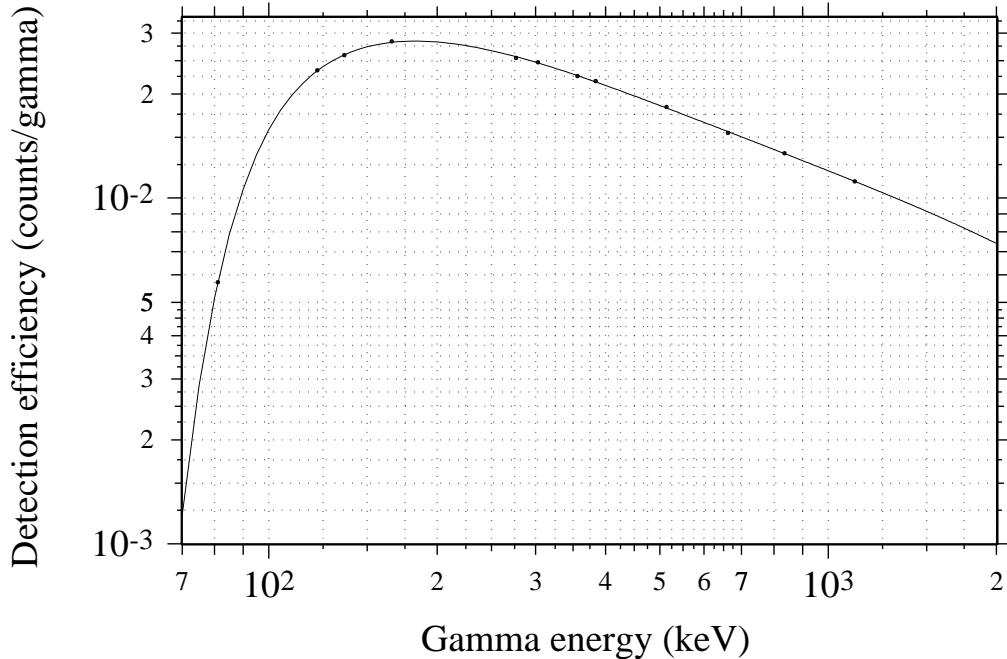


Figure 7.11: Ge detector efficiency for elements homogeneously incorporated into an epoxy matrix of density  $1.5 \text{ g/cm}^3$ . The points are measured values using a source of mixed radionuclides in a Marinelli beaker; the curve is a polynomial fit. The uncertainty in efficiency is  $\sim 5\%$ .

Table 7.3: Data on SNOLAB high-purity Ge detector.

Crystal diameter	67 mm
Crystal length	62.5 mm
Core diameter	12 mm
Core length	55 mm
Dead-layer thickness	< 1 mm
Active volume	206 cm <sup>3</sup>
Active mass	1096 g
Window material	copper
Endcap thickness	0.76 mm
Window to crystal distance	5 mm
FWHM at 122 keV	0.908 keV
FWHM at 1332 keV	1.88 keV
Efficiency at 1332 keV relative to NaI	46.7%

Table 7.4: Minimum detectable sample concentration (MDC) with the SNOLAB high-purity Ge detector.

Element	MDC (g element/g sample)
K	$(0.59 \pm 0.05) \times 10^{-6}$
Th	$(1.4 \pm 0.3) \times 10^{-9}$
U	$(0.28 \pm 0.06) \times 10^{-9}$

### 7.5.2 Surface Facilities

In addition to the gamma counting facility underground, there will be some low background counting capability on surface. The exact nature of the surface facilities still has to be determined.

## 7.6 Liquid Nitrogen

For the existing SNO experiment, liquid nitrogen ( $\text{LN}_2$ ) is supplied to site commercially. It is stored on surface in a large storage dewar located outside the warehouse.  $\text{LN}_2$  is transported underground in 230l or 160l transport dewars in rail cars and is stored underground in two cascaded 1000l dewars. Present consumption is approximately 1500l of  $\text{LN}_2$  per week. The advantages of this system of  $\text{LN}_2$  supply is that the commercially available  $\text{LN}_2$  is of very high grade (low  $\text{O}_2$  and low Rn content). The disadvantages of this system are:

- Labour intensive and wasteful of  $\text{LN}_2$  to transfer to and from small transport dewars.
- Access underground is restricted during mine shutdowns and the supply can be exhausted.
- Limit to expandability of this system.

It is estimated that the existing system can be expanded to approximately 4000l or 5000l per week. Options presently being considered for future  $\text{LN}_2$  supply for SNOLAB are:

- Larger commercial or custom built transport dewars using the commercially supplied LN<sub>2</sub>.

**Pros** Continued supply of high grade LN<sub>2</sub>. Minimal impact on the underground power and cooling infrastructure.

**Cons** Expensive to fabricate large transport dewars. Continues to be labour intensive.

- Installation of a liquefaction plant underground

**Pros** Minimizes handling of LN<sub>2</sub> underground. Continued supply available during mine shutdowns.

**Cons** Cost of installation and maintenance of the plant. Limited production. Possibly limited quality. Power consumption and cooling load.

## 7.7 Clean Rooms

The central feature of SNOLAB's underground laboratory is that it is operated as one large clean room. The model is based on the existing SNO facility which operates as a clean room and successfully met its cleanliness goals. The motivation for dust control in SNOLAB is the norite rock that the laboratory is excavated from. Norite contains 1.2 ppm <sup>238</sup>U and 3.3 ppm <sup>232</sup>Th (see section 3.6). During the construction of the SNO detector, dust deposition rates of 1-2  $\mu\text{g}/\text{cm}^2/\text{month}$  were observed with air particulate levels up to CLASS 10,000 (measured by laser particle counter). During the post construction phase, the SNO facility routinely achieves CLASS 2000 air particulate concentration corresponding to a dust deposition rate of less than 0.1  $\mu\text{g}/\text{cm}^2/\text{month}$ [7]. Dust deposition is monitored in the SNO facility using a variety of techniques. In addition to direct observation of airborne dust using laser particle counters, deposition on surfaces is monitored by witness plates on which dust is allowed to settle. The dust concentration on witness plates is measured by using X-Ray Fluorescence (XRF) to measure iron which is present in mine dust at approximately 6% by weight. This method has a sensitivity of 0.015  $\mu\text{g}/\text{cm}^2$ . For less critical surfaces in the laboratory, a simple *swipe test* allowed detection of dust at the 0.5  $\mu\text{g}/\text{cm}^2$  level.

SNOLAB is expected to achieve similar cleanliness levels as the existing SNO facility. Like the SNO facility, SNOLAB will control the cleanliness of personnel and all materials entering the laboratory. Personnel will remove their mine clothing, shower and put on clean room clothing before entering the laboratory. Equipment entering the lab will either be cleaned on surface and brought underground in dust tight shipping containers or will be cleaned before entering the laboratory in the Carwash facility. Entering the laboratory, the air pressure will increase across different zones with the experimental spaces at the highest pressure. The intent is to have the laboratory be progressively cleaner towards the experiments. It is expected that the resulting laboratory will achieve a similar cleanliness level as the existing SNO facility (CLASS 2000).

Personal objects entering the underground laboratory will be inspected by their owners. When materials are carried underground by hand, a double bagging system is used where the outer bag is discarded on entry to the boot area and the inner bag discarded when passing through the clean side change rooms. The cleanliness of large objects or large volumes of objects will be monitored with a combination of swipe tests and tape lifts with a base level of acceptability for materials entering the laboratory being 0.5  $\mu\text{g}/\text{cm}^2$  of surface dust. Of course experiments may require tighter tolerances than this.

The surface facility also contains clean room laboratories. All of the laboratories have HEPA filtration. Most are designed for 10 air changes per hour with a Clean Assembly room designed for 30 air changes per hour. Like the underground facilities, they are not built to the ASHRAE standards but based on experience with the existing SNO facilities, it is expected that the Clean Assembly will achieve at least CLASS 2000 and the other labs at least CLASS 10,000. Entry to the surface laboratories will be through a vestibule. Initially personnel will be required to wear clean room lab coats, hair nets and change their foot wear. Entry into the Clean Assembly room will be through a second vestibule separating it from the rest of the laboratories and foot wear will be changed again. Personnel will be asked to inspect and clean small equipment entering the laboratories. Large equipment will be swipe tested and are required to have less than  $0.5 \mu\text{g}/\text{cm}^2$  surface dust.

# **Chapter 8**

## **Operations and Technical Support**

### **8.1 Site Procedures and Policies**

SNOLAB is committed to providing a safe work environment that meets or exceeds Canadian Federal and Ontario provincial regulations. The goals of SNOLAB procedures, policies and guidelines in order of importance are to:

1. Provide a safe working environment.
2. Maintain SNOLAB's high standards of cleanliness and control of radiological contaminants.
3. Minimize the interference between experiments with conflicting needs.
4. Provide guidelines to assist the successful implementation, operation and completion of experiments.

Rules for conduct and operations at SNOLAB will be communicated in the form of:

#### **Site Policies and Procedures**

A living document that will cover procedures and policies for many aspects of the operation of the laboratory and rules of conduct for experiments.

#### **SNOLAB Users Handbook**

This document

In the case of Site Procedures, SNOLAB is only now beginning to develop them. However, there is an extensive body of procedures developed for the SNO experiment. If an appropriate SNOLAB Site Procedure does not exist, the SNO procedure is to be applied. If both a SNOLAB and SNO procedure exists, the SNOLAB procedure takes precedent.

### **8.2 Training**

To work in the underground laboratory at SNOLAB requires current training mandated both by the Province of Ontario and by SNOLAB:

- Workplace Hazardous Materials Safety (WHMS)

- NORCAT Basic
- NORCAT UG Mines
- NORCAT Underground
- Creighton Site Specific
- SNOLAB Site Orientation

The WHMS training must be renewed yearly. NORCAT, Creighton Site Specific and the SNOLAB Site Orientation must be renewed every two years. the NORCAT Underground training is valid for life. For a new worker to complete the training requires four days but they do not have to be taken in one block. To renew the biannual training requires one and a half days. This training does not qualify a worker to enter and leave the underground laboratory without further consideration. All personnel going underground require permission from a SNOLAB on site manager. New personnel require an escort entering and leaving the laboratory for a minimum of ten trips. If working only in the surface laboratories, WHMS, NORCAT Basic, Creighton Surface and SNOLAB Surface Orientation are required. A visiting scientist can work in the offices in the surface building without special training.

The above training imparts the basic knowledge required to work safely in SNOLAB. Additional training and authorization may be required for specific tasks (such as handling of radioactive sources, rigging and hoisting or working in specific areas of the lab).

## 8.3 Supervision

All workers in either the surface laboratories or underground facilities require supervision. This is usually by an on-site supervisor or manager. All workers should know who their supervisor is. All personnel require permission of on-site management or supervisors to go underground. When working underground, it is possible that a worker's supervisor is on surface.

In addition to work supervision, every underground shift will have a *Laboratory Coordinator*. The Lab Coordinator is responsible for the basic operation laboratory services and is responsible for coordinating the response to an emergency situation (such as a fire alarm).

## 8.4 Regulatory Issues

SNOLAB is committed to providing a safe work environment that meets or exceeds Canadian Federal and Ontario provincial regulations. Guidance will be given on the applicable regulations.

### 8.4.1 Electrical Regulations

Electrical safety in Ontario is regulated by the Electrical Safety Authority (ESA). ESA is the sole body authorized by the Ontario Electricity Act to regulate this domain.

There is a complete Ontario Electrical Safety Code (OESC), which consists of the Canadian Electrical Code (CEC Part 2), with Ontario amendments. The CEC and OESC are similar to the National Electrical Code (NEC) in the USA, but there are substantial differences.

SNOLAB's objective is to meet the requirements of the OESC. In some cases, for certain electrical systems in the mine, it will also be necessary to meet CSA-M421, which covers use of electricity in mines, and is referenced in the Occupational Health and Safety Act (OHSA) regulations for mines.

As required in the OESC, SNOLAB needs to ensure that all equipment included or connected to its electrical system is approved for use. This is 'Product Approval'. In Ontario there are many certifying bodies that are recognized for this purpose, including CSA, UL (when they certify to Canadian standards products are marked 'cUL'), ESA, and numerous others. In the science experiment field one has to be on watch for equipment that has no recognized standards of design and construction, uncertified components, and no recognized product approvals overall. Most of the time, with use of approved components, good design practices, and good workmanship, one can have special equipment receive product approval through ESA at the site. However, it is not practical to receive final approval for such equipment off site. In a large complicated experiment there is value-added to have CSA, ESA or any of the recognized bodies do partial evaluations off site, correct deficiencies off site, and finish up successfully with ESA on site.

The wiring installations for the power system require ESA inspection, and of course need to be corrected until they are free from deficiencies. The principle reference for the inspections is the OESC and CEC Part 1 & 2 (for Product Approvals) and various ESA/CSA safety bulletins and interpretations that affect the Code use. Inspections are obtained after a permit application. Permits are needed before construction begins on contemplated electrical work. SNO has had, and possibly SNOLAB will have, a *Continuous Safety Service* agreement (CSS) with ESA. This provides a virtually continuous permit for any electrical work, with periodic inspections to catch up on whatever is newly done, as well as a recurring review of facilities in general.

The OESC can be purchased in hard copy form, or in electronic version with a subscription to current bulletins. The cost is not high. Contact SNOLAB if interested in the subscription information. Additional information can be found at the ESA's web site:

<http://www.esainspection.net/business/cod-001a.php>

The Code can be purchased by following the Orderline link:

<http://www.orderline.com/default.asp?category=9>.

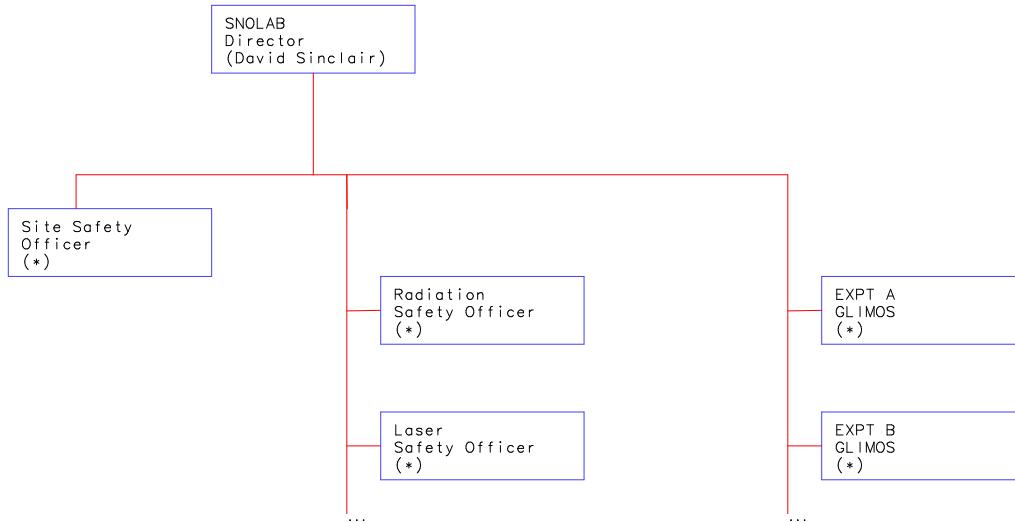
## 8.5 Safety

SNOLAB is committed to providing a safe working environment. To this end, SNOLAB will meet or exceed all applicable Canadian Federal and Ontario Provincial regulations. SNOLAB has a *Site Safety Officer* to facilitate matters of safety. As required by Provincial Law, there is a *Joint Health and Safety Committee* (JHSC) composed of SNOLAB workers and management which audits safety issues on site. There are designated officers for specific safety issues:

**Radiation Safety Officer** or RSO, is responsible for training, monitoring and auditing of radiological substances above exemption quantity as defined by the *Canadian Nuclear Safety Commission*.

**Laser Safety Officer** or LSO is responsible for training, and auditing of laser systems.

## SNOLAB SAFETY ORGANIZATION



Updated  
2005/10/02

Figure 8.1: SNOLAB Safety Organization

New experiments and process systems coming to SNOLAB will undergo a *Process Hazard Review* (PHR). To facilitate safety with experiments, SNOLAB is adopting the CERN GLIMOS (*Group Leader In Matters Of Safety*) model for experiments. Each experiment will be assigned a GLIMOS by the SNOLAB Director.

## 8.6 Radiological Materials Control

In addition to a Radiation Safety Officer, SNOLAB will have a *Radiological Materials Control Officer* (RMCO). The distinction is that the Radiation Safety Officer is responsible for human safety around radiological substances. The Radiological Materials Control Officer is responsible for ensuring that radiological substances coming onto the SNOLAB site (either surface or underground)

- Will not compromise the low background nature of the laboratory.
- Will not compromise the low background needs for any of the experiments being conducted at SNOLAB.

Before being brought to site, any radiological substance must be reviewed by the Radiation Control Officer. Usually radiological substances being brought onto site are required to be multiply contained.

Cage	Time	Type
Down	7:00	Normal Day Shift
	8:15	Normal Day Shift
	11:45	Special
	14:15	Normal Afternoon Shift
	23:00	Normal Graveyard Shift
Up	12:00	Special
	15:00	Special
	17:00	Normal Day Shift
	18:20	Normal Day Shift
	2:00	Normal Afternoon Shift
	7:00	Normal Graveyard Shift

Table 8.1: Cage Schedule (October 2005). Times are when the cage either leaves surface or returns to surface.

## 8.7 Personnel Access

To access the underground laboratory personnel require their training to be current (section 8.2) and permission of the appropriate on-site manager. Inexperienced personnel require an escort in and out of the underground laboratory. Access to the underground laboratory is not unlimited. Travel times are structured around the Creighton Mine hoist schedule. There is a fixed schedule of cages down and up that SNOLAB personnel are allowed to travel on and the times of these cages change over time. Table 8.1 lists the current cage times. Personnel coming to site should check with SNOLAB management for the current cage schedule. A minimum of two personnel are required to enter the underground laboratory and one of these personnel must be a *Laboratory Coordinator* who is a person trained in SNOLAB and Creighton Mine's emergency procedures.

Creighton Mine operates with personnel underground approximately 22 hrs per day and six and a half days per week (usually there are no personnel underground on the Saturday graveyard shift). However, SNOLAB will nominally only be occupied five days per week, 11 to 12 hours per day. Under some circumstances, operations are extended to weekend shifts and even 24 hour per day operation. Individuals are permitted to work up to 12 hours per day, with a maximum of 48 hours per week underground. In special circumstances and with management approval, this can be extended to 60 hours in a given week but must not exceed 96 hours in an two week period. 12 hours on surface is required between shifts. If an emergency arises, unscheduled accesses can usually be arranged provided a Laboratory Coordinator is available.

There are times when no access underground is possible. Scheduled times include:

- When the hoist is down for major maintenance. Typically only a few shifts per year and usually scheduled during the annual shutdown (see below).
- During the annual Creighton Mine shutdown which lasts between two and six weeks each year (average is four weeks) access can be limited to as little as one shift per week. This shutdown and the access during the shutdown is usually scheduled several months in advance.

- November 11th each year. For approximately 12 hours during the day shift of November 11th, the mine power (both underground and surface) is shut down for major electrical work.

Access underground may not be possible for unscheduled reasons as well. The most probable would be a large seismic event in the mine. Often, access is restricted following a large seismic event and may prevent access for one or two days while the ground conditions stabilize.

Because Creighton is a working mine, tours of the underground laboratory are not strongly encouraged. Another reason tours are restricted is to minimize the burden on the laboratory infrastructure to accommodate the extra people (outfitting them with mine gear, preparing clean room clothes inside the lab, etc). On average there are tours of approximately a dozen visitors once a month.

Access to SNOLAB's surface facilities are less restrictive than underground. Personnel working for extended periods on site are required to complete the appropriate training (section 8.2) but visitors for short stays do not require special training. The surface facility is accessible 24 hours per day 7 days per week. To bring a personal vehicle on site requires a permit from Creighton Mine which can be obtained with current mine training.

## 8.8 Transportation of Materials

As discussed in section 7.4, the size and weight of objects that can be taken underground is fixed by the dimensions and capacity of the Nine Shaft Hoist and the size of the 6800 L drifts. There are also restrictions on the *quantity* of material going underground. SNOLAB nominally is allocated four cage trips (equivalent of eight rail cars) per day of materials. Additional cage trips can usually be negotiated with appropriate lead time. In addition to scheduling the hoist access to move rail cars underground, it is necessary to coordinate the tramping of materials from the shaft station to the laboratory. SNOLAB employs a locomotive operator (trammer) to facilitate this, but coordination is still required.

In general, it will be SNOLAB's responsibility to handle the shipping of materials between surface and underground. This will include the loading and unloading of transport containers. Experiments will be expected to participate if there are special needs (particular care with equipment, special cleaning techniques, etc) and if there are large volumes of material to be shipped. SNOLAB will be required to know the contents of any shipment and all materials must conform to the site rules for shipping hazardous materials. It is the experiment's responsibility to ensure that their materials meet the expectation of SNOLAB's site procedures and policies. In addition to the movement of materials between surface and underground, materials being shipped on and off site through SNOLAB's surface facilities must be coordinated with the on site management.

## 8.9 Space and Resource Allocation

Since space and resources at SNOLAB are limited, they will be allocated on an as needed basis. Space at SNOLAB includes:

- laboratory space underground and on surface;
- Office and meeting room space;

- storage space underground and on surface.

Resources include:

- Normal and emergency power;
- Cooling capacity from the chiller system; ultra pure water;
- LN<sub>2</sub>
- Radon Free Air (if available);

etc. Space and resources at SNOLAB will be allocated by the SNOLAB Director or by the Director's designated official.

## 8.10 Operations Support

Underground, SNOLAB will provide the staff to maintain the basic operations of the laboratory including Lab Coordinators, maintenance personnel, cleaners and trammers. SNOLAB will provide personnel for material handling. On surface there will be shipping/receiving, purchasing, and user liaison to coordinate training and space allocation for the users.

## 8.11 Site Engineering Design Support

Some level of engineering design support is anticipated for SNOLAB. However, the exact extent of this support is still to be determined. At some level, SNOLAB Site Engineering will participate in the technical review of experiments.

## 8.12 Site Technical Support

SNOLAB will need basic technical support for the maintenance of the laboratory including and electrician, stationary engineer (for the Chiller systems), pipe fitter, mechanic, mill wright, chemist, instrumentation technician, IT experts. Depending on the experimental program, SNOLAB may consider specialized technical support such as a microelectronics technician, vacuum and cryogen technician.

# **Chapter 9**

## **Design Considerations for Experiments**

There are a number of considerations when designing an experiment that is to be operated two km underground in an active mine.

### **9.1 Layout**

It is important to work with the SNOLAB Site Design Group when laying out an experiment. Considerations include:

- Emergency egress: corridor width and number of exits.
- Clearances for electrical equipment
- Clearances for maintenance

### **9.2 Power**

Interruptions to power to an experiment can occur for a number of reasons. Power outages due to mishaps in the mine; outages, brown outs and power blinks from thunder storms. Low voltage or poor harmonic content. To facilitate experiments, SNOLAB provides a limited amount of emergency power. However it is the experiment's responsibility to provide bridging UPS if required or voltage regulation. Expensive equipment should be protected against power irregularities such as the loss of a phase in three phase power systems. Because the emergency generator is limited in capacity, loads on it will be carefully budgeted on an as needed basis.

### **9.3 Heat Removal**

An important aspect of experimental design is heat removal. An underground laboratory can be thought of as a bottle in an oven. In addition to the geothermal heat entering the laboratory, the experiment brings heat in the form of electrical loads and process heat which must be removed from the laboratory. SNOLAB anticipates that much of the heat from an experiment will be removed by the lab Air Handlers using ventilation air. However there will be some capacity for heat removal with the lab's chilled water loop.

Another issue is that the nominal heat removal processes for the laboratory requires normal power to operate the chiller and air handlers. The 150kW emergency generator is not able to operate either of these loads. An unsolved problem for experiments is heat removal when operating on emergency power.

## 9.4 Remote Operation and Monitoring

Because access to the underground laboratory is not unlimited, experiments should be able to be monitored and if possible controlled remotely. The ability to shut down apparatus and restart it remotely can save valuable time if immediate access underground is not possible. If a process requires human monitoring, it should fail to a safe state in the event of a communications failure. In particular:

- All experiments *must* be able to be safely powered down remotely.
- If an experiment cannot operate safely without remote monitoring or control, it *must* fail to a safe state in a communications failure.
- It is recommended that experiments be able to start up remotely.

## 9.5 Autonomy

The other extreme from remote operation is *Autonomy*. Access to the underground facility is *not* 24/7 nor 365 days per year. Where possible, the experiment should be designed to operate without human intervention. Similarly if not necessary, apparatus should not rely on the communications link to surface. This allows continued operation with personnel underground in the event of a communications failure.

## 9.6 Absolute Air Pressure

It is important to recognize that the air pressure in the mine is 25% higher than on surface. This has to be considered when bringing equipment underground. The SNOLAB transport containers (Blue Boxes) have HEPA filters to allow pressure equalization. Pressure vessels (such as cryostat dewars) must be designed to withstand the higher air pressure. Some environmental sensors do not function properly at high pressure<sup>1</sup>. Liquids generally boil at a higher temperature. Etc.

## 9.7 Pressure Changes

As described in section 3.8 the air pressure in the mine can undergo large, rapid pressure swings. Sealed volumes in an apparatus must be able to withstand such pressure swings. It may be impractical for large volumes to withstand forces that could amount to tonnes. Such volumes must be designed to “breathe”. If a volume contains a radon free atmosphere, it must be designed to adjust

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<sup>1</sup>It was discovered that fire sensors in the SNO facility would not work properly at 1.25 Atm

pressure without the ingress of radon laden laboratory air. In the case of the SNO experiment, the gas space above the detector contains a radon free nitrogen cover gas. This cover gas system compensates for air pressure swings by having a series of buffer volumes that allow the cover gas to equalize pressure without lab air reaching the sensitive volumes.

## 9.8 Seismic Activity

As described in section 3.2 SNOLAB is situated in an active mine. Experiments must be designed to consider the effects of seismicity. For example, in some large seismic events (magnitude 3.5 and above) the SNO experiment has observed PMT failures (a few out of 10,000).

## 9.9 Material Transport Restrictions

As noted in section 7.4 there are size and weight restrictions on materials being brought underground. Experiments must be designed accordingly. The ability to process material is finite as well. Creighton Mine can only transfer a fixed number of shipments underground per day. Equally important is the fact that both the surface and underground facilities have a finite capacity. Often, the rate of transfer of materials is limited by the ability to process them into the underground laboratory, not the number of cage cycles available from INCO.

## 9.10 Preparation on Surface vs Underground

It is difficult to work underground as effectively as on surface. Typically 1.5 hours each day is spent on travel and changing into/out of clean room clothing. A general rule of thumb is that it takes twice as long to do a job underground as on surface. When planning an experiment, careful consideration should be given when deciding what activities must be done underground as opposed to on surface. Provided sufficient cleanliness can be maintained, it is best to pre-assemble components on surface.

# Bibliography

- [1] SNO Private Communication.
- [2] *Preparation for Deployment of the Neutral Current Detectors (NCDs) for the Sudbury Neutrino Observatory*, PhD Thesis, North Carolina State University (1999)
- [3] *Sudbury Neutrino Observatory Proposal, SNO-87-12* (1987)
- [4] *The Sudbury Neutrino Observatory Nuclear Instruments and Methods in Physics Research A449* pp. 172-207 (2000)
- [5] *SNOLAB Underground Facility Project Concept Definition Report*, Rev 1.0, 22 Dec 2003
- [6] *Geomechanical Analyses of the Proposed Sudbury Neutrino Observatory Underground Facilities Expansion*, R.K.Brummer, et al, ITASCA Consulting Canada Inc, (2004)
- [7] *Clean Fabrication and Cleanliness Monitoring in SNO*, Ontario, Canada E.D.Hallman, Topical Workshop on Low Radioactivity Techniques, Sudbury Ontario, Canada, AIP Conference Proceedings, Vol 785, Melville, New York (2005)
- [8] *Magnetic Field Measurements at the Creighton Mine*, E.D. Hallman and D.L.Cluff SNO-STR-90-101 (1990)
- [9] Durridge Company Inc.: <http://www.durridge.com/>.
- [10] *BACnet A Data Communications Protocol for Building Automation and Control Networks*, ANSI/ASHRAE Standard 135-2001

# Appendix A

## Experiment Infrastructure Matrix

### Specific Infrastructure Requirements Underground — SNOLAB

Item	Comments/Details
<b>Basic Requirements</b>	
Depth	
Space	
Power	
Heating & Cooling	
<b>Other?</b>	
<b>Background Tolerances</b>	
Muons	
Gamma Rays	
Neutrons (< 10 MeV)	
Neutrons (> 10 MeV)	
Radon	
Shielding Requirements	
<b>Other?</b>	
<b>Special Facilities</b>	
Water Purification	
Laser & Optics	
Vibration Control	
Cryogenics	
Radioactive Sources	
<b>Other?</b>	
<b>Fabrication Processes</b>	
Machine Shop	
Cleanroom	
Electroforming	
Materials Storage	
Chemical Etching	
<b>Other?</b>	

## Specific Infrastructure Requirements Aboveground — SNOLAB

## Appendix B

### Research Technical Proposal

*This form is a prototype for the document required for a Research Technical Proposal (RTP) to bring an experiment or other apparatus to SNOLAB. The sections and the questions within the sections of this form are intended to guide the proponents of a Research Technical Proposal to provide the information that SNOLAB requires to make a proper assessment of the proposal. Technical proposals are assessed for:*

- *Scientific merit,*
- *Appropriateness for SNOLAB,*
- *Readiness,*
- *Safety,*
- *Interferences with other activities,*
- *Resources required from SNOLAB.*

*The scientific merit and appropriateness of the proposal is evaluated by the EAC. The readiness, safety and interactions of the proposed research with SNOLAB is evaluated by a subcommittee of the SEC.*

MINING FOR KNOWLEDGE  
CREUSER POUR TROUVER... L'EXCELLENCE**Research Technical Proposal**

TITLE	<b>My Experiment</b>
DATE	
CONTACT	Dr. X No University No Where Email: Phone:
REQUESTED LOCATION	Ladder Labs
START DATE	1 Jan 1900
EXPECTED DURATION	1 year

## 1.0 Scope and Objectives of the Proposal

*What are the scope and objectives of the technical proposal? I.e.*

1. *What measurement or activity is being attempted?*
2. *What is the scientific case for the proposal?*
3. *Is the proposal of finite duration or could it be expanded at a future date?*
4. *What is coming to site?*
5. *How long will site resources be required?*
6. *What manpower is required for the measurement? (How many people will come to site? What site personnel are required?)*
7. *What are the known and/or anticipated interferences between the proposal and existing activities in the laboratory (both underground and on surface)?*

## 2.0 Schedule

*What is the development plan for the proposal?*

1. *What is coming to site?*
2. *When will it arrive?*
3. *What and when does equipment go underground?*
4. *Sequence of events (installation, operation, decommissioning)*

## 3.0 Underground Space Requirements

*What space is required underground? Indicate if a particular location is being requested. Indicate what the requirements and constraints are including floor space; head room; necessary adjacencies; necessary non-adjacencies; clean storage; dirty storage. What are the cleanliness issues? Does the proposal require greater cleanliness than the base level of the laboratory? Does the proposal meet the base level of cleanliness for the laboratory?*

### 3.1 Space for Apparatus

*What space is required for the apparatus used in the proposal? What floor space? What height?*

### 3.2 Staging Area

*Is a staging area required for the apparatus?*

### 3.3 Control Room and/or Office Space

*Is control room and office space required? How much?*

### **3.4 Clean Storage**

*Will clean side storage (storage space inside the underground lab) be required? How much?*

### **3.5 Dirty Storage**

*Will storage space outside the lab (dirty side storage) be required? How much?*

## **4.0 Surface Space Requirements**

*Indicate what surface space is required to install, operate and decommission the proposal.*

### **4.1 Clean Laboratory Space**

*What clean laboratory space is required on surface for the proposal?*

### **4.2 Warehouse Space**

*What are the anticipated warehouse needs? Will short or long term storage of materials be required? If so will the storage need to be heated?*

### **4.3 IT Server Room Space**

*Do the proponents of the proposal wish to install equipment in the IT server room? If so, what and why?*

### **4.4 Control Room and Monitoring Space**

*Does the proposal require control room space or space for monitoring the apparatus from surface?*

### **4.5 Office Space**

*What office space is required for the experimenters?*

## **5.0 Civil/Mechanical**

- *What is the civil/mechanical layout? Where is the equipment to be located in the lab? Include drawings if possible. Specify necessary clearances (for access etc) if possible.*
- *What fabrication is required in the lab (drilling, cutting, welding etc.)? Is there significant civil work to be done in the space (e.g. assemble steel work or build clean rooms).*
- *Lifting devices?*

## **6.0 Water/Air/Gases/Drains**

*What plumbing is required for the proposal? This includes water, air, nitrogen and special gasses. Both source and disposal.*

1. *Domestic Water*
2. *Ultra Pure Water*
3. *Compressed Air*

4. *Instrument Air*
5. *Boil off Nitrogen*
6. *Drain to Lab dewatering system*
7. *Vent to Off Gas Header*
8. *Chilled Water*

## 7.0 Electrical

### 7.1 Electrical Layout and Loads

*What are the electrical loads and what is the electrical layout? Show single line diagrams. Where possible, include schematics.*

### 7.2 Electrical Service Requirements

*What electrical services are required? I.e. what electrical circuits (120VAC, 208 VAC etc). How many receptacles? What power loads are anticipated?*

### 7.3 Emergency Power Requirements

- *Does the proposal require generator power? If so, how much?*
- *Will the experiment install a UPS?*

### 7.4 Heat Dissipation

*How will electrical heat be dissipated (Ventilation, chilled water)? If running on UPS, how will heat be dissipated during a power outage?*

## 8.0

*What IT services are required for the proposal?*

### 8.1 Experiment Computer Systems

*What is the approximate number and types of computers that will be used? Where will they be located?*

### 8.2 Use of Site Computing Facilities

*Does the proposal require SNOLAB IT support such as management of disks, computer farms, tape systems, backups etc? User accounts? Email?*

### 8.3 Network Requirements

- *Network access on/off site? Special protocols required through firewalls?*
- *Bandwidth?*
- *VLAN Required?*

## 8.4 Monitoring and Control

- *Will the apparatus be monitored and/or controlled remotely?*
- *Does the apparatus fail to a safe state in the event of a power failure or communications failure?*
- *Can the apparatus be deactivated remotely?*
- *Can the apparatus be activated remotely?*

## 9.0 Consumables

*Does the activity have consumables that must be supplied on an ongoing basis? Examples of consumables are:*

- *Cryogens*
- *Bottled gas*
- *Chemicals*

## 10.0 Access

*What access is required underground? One shift per day? 24/7? 24/7/365?*

- *If the apparatus cannot be activated remotely, how long is it permissible to be without access?*
- *What access is required during annual shutdowns?*

## 11.0 Procedures

*Procedures for safe and successful operation of the apparatus. Emergency shutdown procedures. Training of Laboratory Staff to respond to an emergency.*

## 12.0 Material Transport

*What material transportation is required?*

1. *Blue boxes?*
2. *Open Rail Cars?*

3. *Special Precautions?*
4. *Estimated number of trips?*

## 13.0 Hazard Assessment

*What hazards are associated with the proposal? If hazards are identified, what has been done to mitigate them?*

### 13.1 Flammables and Combustibles

*What flammable or combustible materials are part of the experimental apparatus? E.g. electrical insulation, heat insulation. Plastics (including piping, neutron moderators etc.) If the proposal presents a significant fire risk, appropriate fire detection and fire suppression must be implemented.*

### 13.2 Ignition Sources

*Are there ignition sources for a fire such as: electrical, heat, chemical?*

### 13.3 Mechanical/Lifting

*What are the mechanical or civil hazards associated with the proposal?*

1. *Lifting devices*
2. *Mechanical support structures*
3. *Pressure vessels*

### 13.4 Chemicals

- *What chemicals are part of the proposal (both underground and surface)*
- *MSDSs for the chemicals?*
- *Site approval for the chemicals?*
- *Special procedures for the use of the chemicals.*
- *Special training for the use of the chemicals.*
- *Shipping procedures on/off site.*
- *Shipping procedures surface/underground.*
- *Disposal procedures.*
- *Inventory and plan to remove chemicals at end of activity.*
- *Spill kits and cleanup procedures*

- Antidotes for poisons.

## 13.5 Radiological

*What radiological materials will be brought underground or used on surface? The issues with radiological materials are two fold:*

- *Radiation Safety*

*Safety of personnel working around the radiological materials. This is primarily an issue of exposure to personnel.*

- *Radiation Control*

*The control of radiological materials that may effect other experiments in either the underground lab or on surface. This includes the use of calibration sources and spikes.*

## 13.6 Oxygen Deficiency Hazards (ODH)

*Does the apparatus have or can it generate gas volumes deficient in oxygen? Are there confined spaces? What procedures and engineering controls are in place to mitigate these risks?*

## 14.0 Regulatory Approval

*It is the responsibility of the experimenter to meet or exceed all Federal and Provincial (Province of Ontario) regulatory requirements. SNOLAB will provide what expertise it can to assist the experimenters.*

## 14.1 Personnel

*Personnel must have current training for working in Creighton Mine and in SNOLAB.*

## 14.2 Fire Detection and Suppression

*The proposal must meet or exceed all appropriate fire detection and fire suppression regulations.*

## 14.3 WHMS

*WHMS approval of hazardous materials being brought site.*

## 14.4 Transport of Hazardous Materials

*Regulations for the transport of hazardous materials.*

## 14.5 ESA

*Electrical Safety Authority approval or equivalent of electrical devices used in the proposal.*

## 14.6 TSSA

*TSSA approval of pressure vessels and piping if necessary.*

## 14.7 Civil/Mechanical?

*Engineer approved drawings?*

## 14.8 Radiological

*Approval to transport and store radioactive materials at SNOLAB. Non-exempt radioactive materials must be listed on the SNOLAB site license. Transportation of radioactive materials requires appropriate approvals.*

## **15.0 Decommissioning**

*It is expected that at the end of the activity, the SNOLAB spaces will be returned to their original condition and all apparatus, chemicals, radiological materials etc will be removed unless otherwise agreed to by SNOLAB. What is the decommissioning plan?*

## Appendix C

# SNO Detector GPS Clock Synchronization

The timing of events in the SNO detector relative to other experiments in the world is determined by a 10 MHz clock generated by a GPS receiver located on surface and sent underground. There are four components to the GPS timing system.

**GPS Receiver** is the unit that receives signals from the GPS satellites. It is located in the operations control building in the mezzanine in the *Fibre Communications Rack*.

**ENET GPIB Interface** is a National instruments unit that is connected to the network and allows SHaRC to send commands to the GPS receiver via a GPIB interface.

**Surf Board** is a custom device constructed by the SNO Electronics Group to send the GPS 10MHz clock and synchronization signals to the companion **UG Board** in the underground control room via three dedicated fibres. It is located in the rack next to the Fibre Rack in the Communications Room on the mezzanine of the old SNO Operations Control Building.

**UG Board** is the companion board to the Surf Board and is located in the Fibre Rack in the underground control room.

To function, the system requires an ethernet connection to the ENET GPIB interface, three fibres between surface and underground and functioning equipment. The 10 MHz clock signal is continuously sent to MTCD to act as the absolute event time (there is also an onboard 50MHz clock which is used for relative event timing on the MTCD). A task run in SHaRC(the SNO DAQ system running on a Mac computer) periodically (usually once an hour) asks the GPS to generate a sync signal which is used to check the 10 MHz counter on the MTCD against the GPS. If there is a discrepancy, the task resets the MTCD counter and automatically starts a new run.

A simplified schematic of the Mark I GPS system is shown in figure C.1. In October 2002, this system was replaced with the Mark II GPS system (new Surf and UG boards) that have enhanced diagnostics and adjustments. The Mark II system also has a backup 10MHz clock on the UG Board which is used in the event that the 10 MHz clock signal from surface is interrupted (fibre loss, failure of the Surf Board etc).

## GPS Receiver

The GPS receiver is made by *Datum Inc.* and is a

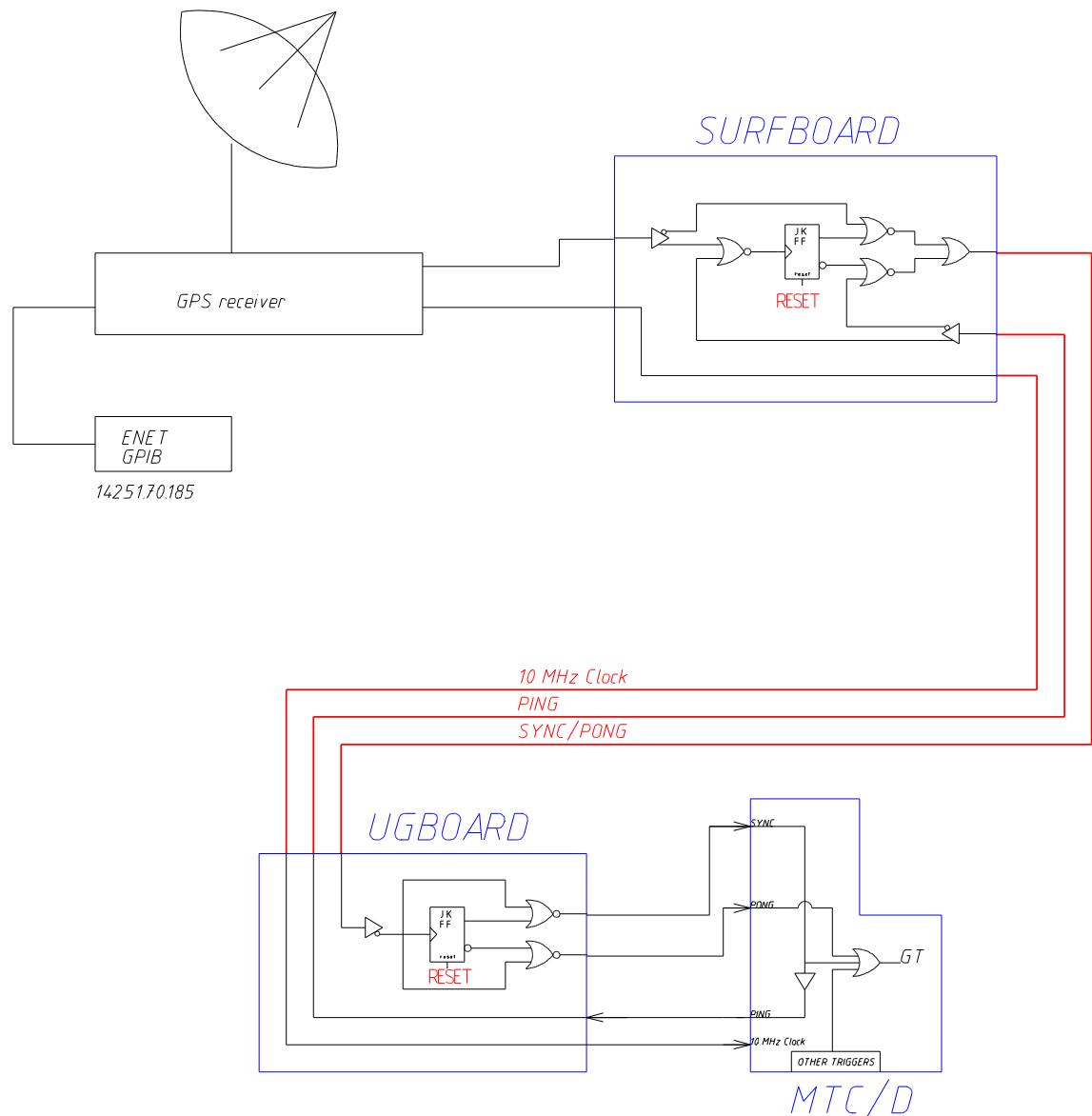


Figure C.1: Detector GPS Clock Synchronization. Mark I system.

Model 9390-52304  
 GPS Time Code &  
 Frequency Generator

Datum Inc. is located at

Datum Inc.  
 1363 S. State College Blvd.  
 Anaheim California, 92806  
 714-533-6333

## GPIB to Network Converter

National Instruments  
 Model: GPIB-ENET/100  
 Part No.: 181950K-01

## Surfboard

The Surfboard is a part of the GPS system for SNO electronics. It currently sits in the mezzanine on the fiber rack. Its functionality is twofold:

- Relay the 10MHz clock from the GPS box to the UGBOARD. We include here the continuous monitoring of the 10 Mhz clock and possibility to “spy” on it with a scope. For a description see below.
- Send the SYNC signal to the UGBOARD and then to MTCD and reflect back the PING from the MTCD (as PONG). Multiple possibilities of monitoring and control are included here. For a description see below.

### The backpanel

Provides connectors for power supplies (+5V, -5V). The currently used power supplies are commercials .... Two LEDs monitor those powers continuously.

### The front-panel

There are 5 sections on the front panel described below starting from right to left on the physical board.

#### Test points

This provides the operator the possibility to measure with a DVM the current values for the 3 voltages used (+5V, -5.2V, -2V). A test-point for GND is also provided. These should be kept covered at all times.

## BNC connectors

There is a total of 6 BNC connectors on SURFBOARD's front panel mounted on two rows of 3 each. They should be labeled. The following description goes from right to left, row by row.

- CLOCK: Input for the sin wave 10MHz clock from GPS box.
- EXTERNAL SYNC: This provides the extra capability of sending an external pulse through the SYNC line. This pulse should be TTL logic.
- PING SPY: This allows the operator to look directly at the PING line with a scope. The pulse is TTL.
- SYNC: The actual SYNC from the GPS box. The pulse should be TTL.
- CLOCK SPY: Allows the operator continuous monitoring of the CLOCK line with a scope. Pulse should be TTL.
- SYNC SPY: Same as above for SYNC.

## Switch buttons

There are 3 switch buttons on the board. From right to left they are as follows:

- FORCED SYNC: Allows manual sending of a SYNC pulse. This will take exactly the same path as the regular SYNC so all the following logic will work accordingly.
- CLOCK RESET: Allows resetting only the TEST CLOCK circuitry. This will turn off the MISS EDGE LED, described below. Should be used only when a global reset is not intended. The only effect is resetting that LED.
- MASTER RESET: Should be used any time after a power off of the detector, fiber problem, etc. This will globally reset the board. Unless in normal running, the use of this button is highly recommended.

## LED indicators

There are 7 LED indicators. From right to left they are as follows:

- SYNC WAIT: In normal mode this should be almost all of the time on. Indicates that the board waits for a SYNC pulse and since we send this pulse once an hour, most of the time the board sits in this mode.
- PONG WAIT: For a short time between the SYNC being sent and the PING coming back ( $\approx 40\mu s$ ) the will be on. If it stays on for long this indicates a problem with the PING pulse coming back.
- MISS PONG: After a SYNC pulse, the board gets set for a PONG. However, if a SYNC comes again, before a PONG has been sent, this LED will lit. It usually indicates a problem with PING coming back.

- MISS SYNC: After a PONG pulse, the board gets set for a SYNC. However, if a PONG is sent again, before a SYNC has been sent, this LED will lit.
- CLK: This LED continuously monitor the CLOCK lines. It will stay on as long as the clock is running. If it turns off, there is a clock problem.
- MISS CLOCK: If one or multiple clock edges are being missed, this LED will turn on. It will stay on until the operator will perform a CLOCK RESET or a MASTER RESET.
- TEST RX: It will turn on if there is any activity on the receiver lines. If any pulse is sent from UG and it gets on surface, this LED will lit.

## **TXs and RXs**

There are 2 TX and 1 RX on SURFBOARD. The fibers should be plugged here. From right to left they are:

- CLOCK
- SYNC
- PING

## **UG Board**

The UGBOARD provides signal relay and control to the MTCD (CLOCK, SYNC, PONG), clock monitoring and control, and relay of PING from the MTCD to the SURFBOARD.

### **The back-panel**

See SURFBOARD

### **The front-panel**

There are 5 sections on the front-panel as described below:

#### **Test-points**

See SURFBOARD

#### **BNC connectors**

There are 9 BNC connectors on the front-panel

- CLOCK: 10MHz clock signal to MTCD. ECL logic.
- NOCLOCK: Signals to the MTCD that the 10MHz clock has been lost and the UGBOARD is currently using the onboard clock (see section C).

- SYNC SPY: Allows the operator to monitor SYNC with a scope. TTL.
- PING: PING signal from MTCD. ECL logic.
- SYNC: SYNC signal to MTCD. ECL.
- EXTERNAL SYNC: Allows the operator to plug in an external pulse generator to act as SYNC generation. This might turn out to be useful when the fiber connection is lost and we can generate SYNC in close loop without the surface connection.
- PONG: PONG signal to MTCD. ECL.
- CLOCK SPY: Allows operator to monitor the CLOCK. TTL.
- PING SPY: same as above for PING

## Switch buttons

There are 4 switch buttons: FORCED PING, FORCED SYNC, CLOCK RESET, MASTER RESET. They perform the same tasks as the ones on SURFBOARD.

## LED indicators

- MISS CLOCK: Indicates a missing edge of the 10MHz clock
- TEST RX: allows the operator to test the receiver circuitry
- CLOCK: Stays on as long as the clock is running
- PING: allows monitoring of PING line

## Receivers and Transmitters

From right to left there are 2 receivers and one transmitter:

- CLOCK
- SYNC
- PING

## The on-board clock

The UGBOARD is provided with a TTL 20MHz clock (brought down to 10MHz). A 24 bit counter records how many surface clock edges have been missed since last SYNC. If this number turns out to be more than a preset number and the surface clock is still missing at this point, the on-board clock will switch in and the NOCLOCK line is being asserted which indicates the MTCD through EXT? that the on-board clock is being used. The NOCLOCK and the counters are being cleared on the first SYNC, **IF** the surface clock is running. In the case that the surface clock comes back

but no SYNC has been issued UGBOARD will continue to use the on-board clock until the first SYNC arrives, or the operator clears with CLOCK RESET or MASTER RESET.

The waiting time before the on-board clock switches in is preset using a jumper field which sets one of the last 12 bits of the 24 counter.

## Gains and thresholds

The receiver circuitry is provided with an op-amp that can set a certain gain. This could in principle be changed by the knowledgeable operator (see schematics). The current gain is set to 6.

The thresholds on the receivers are set with pots. Easy access through the front panel is provided.

# Appendix D

## Glossary

**9 Shaft** The active mine shaft for bringing material and personnel in and out of the mine is #9 *Shaft*. 9 Shaft is 7130 ft deep. The lowest level that can be reached is 7000L. The shaft has five compartments: The cage compartment; a compartment for the counter weight for the cage; a compartment for the skip ore buckets; a pipe compartment; and a man way which consists of a series of ladders from the lowest level to surface (platforms every 15 ft).

**ACFM** Actual Cubic Feet per Minute. The true volume of air moved through an air handler or fan.

**AHU** Air Handler Unit.

**ASHRAE** American Society of Heating Refrigerating and Air-Conditioning Engineers, Inc.

**Back** The roof of a mining drift (tunnel) or excavation.

**Cage** The elevator car for the mine shaft. The Creighton Mine, #9 Shaft Cage has two decks. Each deck can take either a rail car or 44 persons.

**Cap Lamp** The light that a miner wears on his or her helmet.

**Carwash** The rooms at the entrance to the underground laboratory used to wash large equipment and clean it for entry into the laboratory.

**CFM** Cubic Feet per Minute. The volume of air moved through a fan. While the term is ambiguous if the pressure is not specified, it usually means ACFM (Actual Cubic Feet per Minute).

**Drift** A mining term for a horizontal tunnel. In SNOLAB the drifts have flat floors, flat, vertical walls and an arched roof or *Back*. The height at the highest point of the Back is the height of the wall plus one third the width of the drift.

**Dry** A mining term for change rooms. The term “Dry” comes from the fact that these rooms are usually kept at an elevated temperature to facilitate the drying of clothing between work shifts. SNOLAB has surface Drys for personnel to change into mine gear and underground Drys at the laboratory for personnel to change from mine gear into clean room clothing.

**EAC** Experiment Advisory Committee.

**EF** Exhaust Fan.

**Ground Control** The process of securing the walls and roof of an excavation. Ground Control can include bolts into the rock, screen and *shotcrete*.

**Headframe** The tower like structure situated over a mine shaft.

**HEPA Filter** High Efficiency Particulate Air Filter. 99.97% efficient.

**LOI** Letter of Interest.

**Motor Control Centre** or MCC. The distribution centre for 600V power. Contains starters for large motors.

**Mine Power Centre** or MPC is a transformer to provide local power in the mine. SNOLAB uses MPCs to step the 13.8kV supply voltage down to 600 V.

**ODH** Oxygen Deficiency Hazard. The danger of air depleted of oxygen. In SNOLAB this can be caused by displacement of air by the boil off of cryogenic gases. Elsewhere in the mine, the evolution of large volumes of blasting gases can cause an ODH.

**PHR** Process Hazard Review

**Refuge Station** A room or pocket that can be sealed off from the rest of the mine as a refuge during a fire event in the mine. Refuge stations have water and compressed air supplied from surface. The SNOLAB Refuge Station is also the lab's Personnel Drift (lunch room, washrooms, changes rooms).

**Rockburst** A sudden uncontrolled stress relief in rock. Usually associated with mining activity.

**SCFM** Standard Cubic Feet per Minute. The equivalent volume of air moving through an air handler or fan at one atmosphere.

**Shaft Station** The area adjacent to the mine shaft on each level of the mine where personnel and equipment get on and off the cage.

**Shoulder** The highest point on the wall of a *Drift* where it meets the arched *Back*.

**Shotcrete** A spray on concrete used to as a form of *Ground Control*.

**Skip** The large bucket run in 9 Shaft to bring ore and rock out of the mine. There are two skip buckets run in a “teeter totter” arrangement. While waiting at the shaft station on 6800, one can often hear a great crashing sound as the skip is being loaded from the 6680 loading pocket.

**SNO** Sudbury Neutrino Observatory.

**SNOI** Sudbury Neutrino Observatory Institute.

**Spring Line** Another name for a *Shoulder*. The highest point on the wall of a *Drift* where it meets the arched *Back*.

**Tram** The process of bringing equipment and material into the laboratory by train on the narrow gauge railway which connects the underground laboratory to the 6800 shaft station.

**TRC** Terminal Re-Cool - air metering valve is a cooling unit located at the outlet of air from an AHU (Air Hanlder Unit). It provides local cooling of air to a room.

**WHMS** Workplace Hazardous Materials Safety.