9 Ash River Site and Far Detector Hall

9.1 Introduction

This chapter describes the Ash River site and the Far Detector Building at the Ash River site. The access road to the Ash River site is described at an advanced technical design level.

9.2 Details of the Ash River Site

9.2.1 Technical Design Criteria

The project site must provide adequate space and infrastructure for the construction of the Far Detector Building, assembly of the Far Detector and normal operations for the life of the project.

The Ash River Site is located approximately 3.5 miles from the Ash River Trail (St. Louis County Road 129) by way of an existing logging road. This existing access will be improved to provide all weather access to the project site.

Construction of a facility the size of the Far Detector Building requires significant contractor staging and segregated stockpiling areas. The stockpiled material will be segregated into topsoil, suitable fill material and rock areas. Each stockpile will require sediment and erosion control devices as well as adequate access. The size of the contractor staging area must accommodate not only the normal construction materials, but given the remote location, also those materials and supplies not readily available in the vicinity of the project site. The size of the Ash River Site will provide space for the anticipated stockpiles and staging areas.

The Ash River Site is within the watershed of the Ash River, a designated trout stream. The project site has been sized to allow the Far Detector Building to be located over 1,160 feet away from the river to minimize the impact of construction, assembly and operation of the facility. In addition, the preliminary Storm Water Pollution Prevention Plan (SWPPP) includes site features to minimize the transmission of sediment and storm water in the areas adjacent to the river.

A water well capable of providing 50 gallons per minute at the Ash River Site will provide potable water for both domestic uses and fire protection functions.

Electrical infrastructure with a capacity of approximately 2 megawatts is needed to support the building construction, detector assembly and normal operations of the facility is located along the Ash River Trail.

A fiber optic data network capable of DS-3 access level is required for normal operations of the detector.

Telephone communication for normal business service is required for construction of the building, detector assembly and normal operations of the facility.

9.2.2 Overview of the Ash River Site

The Ash River site is 810 km from Fermilab and offers the longest possible baseline along the NuMI beam within the United States. Figure 9.1 is a relief map of the general area around the selected site with an inset map showing how this area is located in the State of Minnesota. Voyageurs National Park dominates the northern half of Figure 9.1. U.S. 53 runs north-south on the western edge and the city of International Falls is off the map towards the northwest. The red line from the Ash River Trail to the Project Site is an existing logging road which must be upgraded for truck traffic as part of the project.

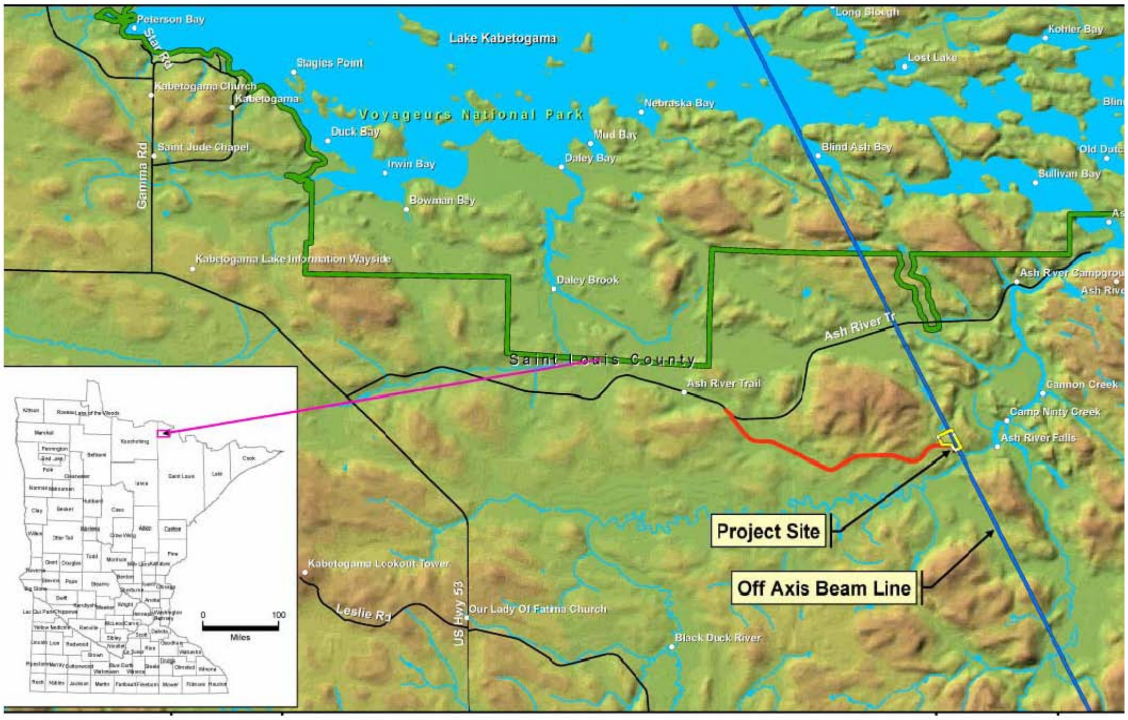


Fig 9.1: Shaded relief map of the Ash River site. The inset black and white figure indicates the site position within the State of Minnesota. North is to the top of the page in this figure.

Fig.9.2: Photo Looking East along existing access road taken in November 2006.

The project will require approximately 89 acres for the Far Detector Building and another 19 acres for the upgraded access road tentatively called "Bright Star Road".

Access to the project site will be provided through improvement of an existing logging road from the Ash River Trail (St. Louis County Road 129). The existing unpaved logging road is approximately 15 feet wide and approximately three and one half miles in length to the site of the detector. The road will be improved to a two-lane, paved roadway to provide access for construction traffic that will carry materials for construction of the facility and as well as trucks deliveries required for the assembly of the detector. The entrance will be improved to allow trucks entering the site to slow and turn onto the Brightstar Road while minimizing the impact on other traffic along Ash River Trail (St. Louis County Road 129).

The proposed site work includes extension of existing electric and communication utilities and installation of domestic water well and septic as related work. Electric utilities and fiberoptic will be extended from Ash River Trail along the improved access road. Improvements to the existing transmission system serving the site will also be required. These improvements will include only upgrades to existing transmission lines to increase capacity. No new lines will be constructed.

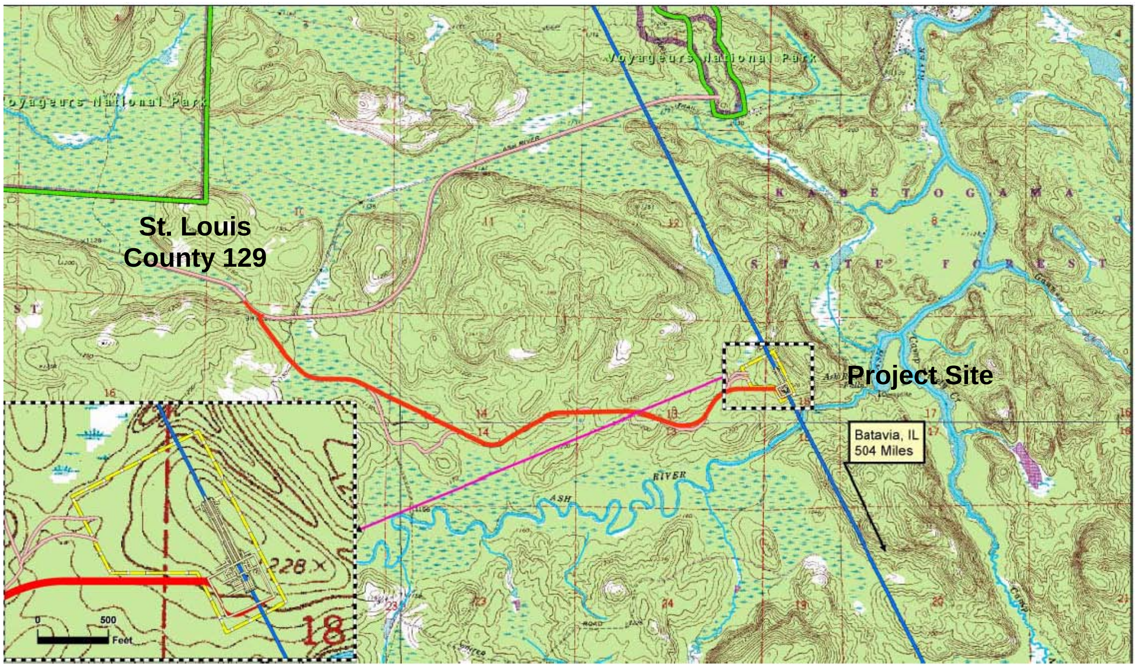


Fig. 9.3: Site Plan showing soil borings and topographic information along the Bright Star access road and at the Far Detector Building site.

Figure 9.3 is a US Geological Survey 7.5 minute, 1:24,000 scale map showing the topology of the Ash River area. The inset figure shows that the selected site is on a hilltop, roughly 70 feet above the level of the Ash River. The red line on Figure 9.3 is the access road to the site with details showing how it deviates from the logging road to provide for anticipated truck traffic to the site. The blue diagonal line indicates the 11.8 kilometer distance to the center of the existing NuMI beamline.

Figure 9.4 is an aerial photograph of the area with map details overlaid. In particular, the type of vegetation is identified, and the 100 year floodplain of the Ash River is marked. The inset figure shows the required setback from the 100 year floodplain just touches the Project Site in the southeast corner. This figure also shows how the access road crosses through an area of wetlands (bog) that will require mitigation through purchase of the required compensatory area in a wetlands bank. The road will require permits from the US Army Corps of Engineers under Section 404 of the Clean Water Act and from St. Louis County under the requirements of the Wetland Conservation Act of Minnesota. None of the impacted area is designated as a Protected Water or Wetland by the Minnesota Department of Natural Resources.

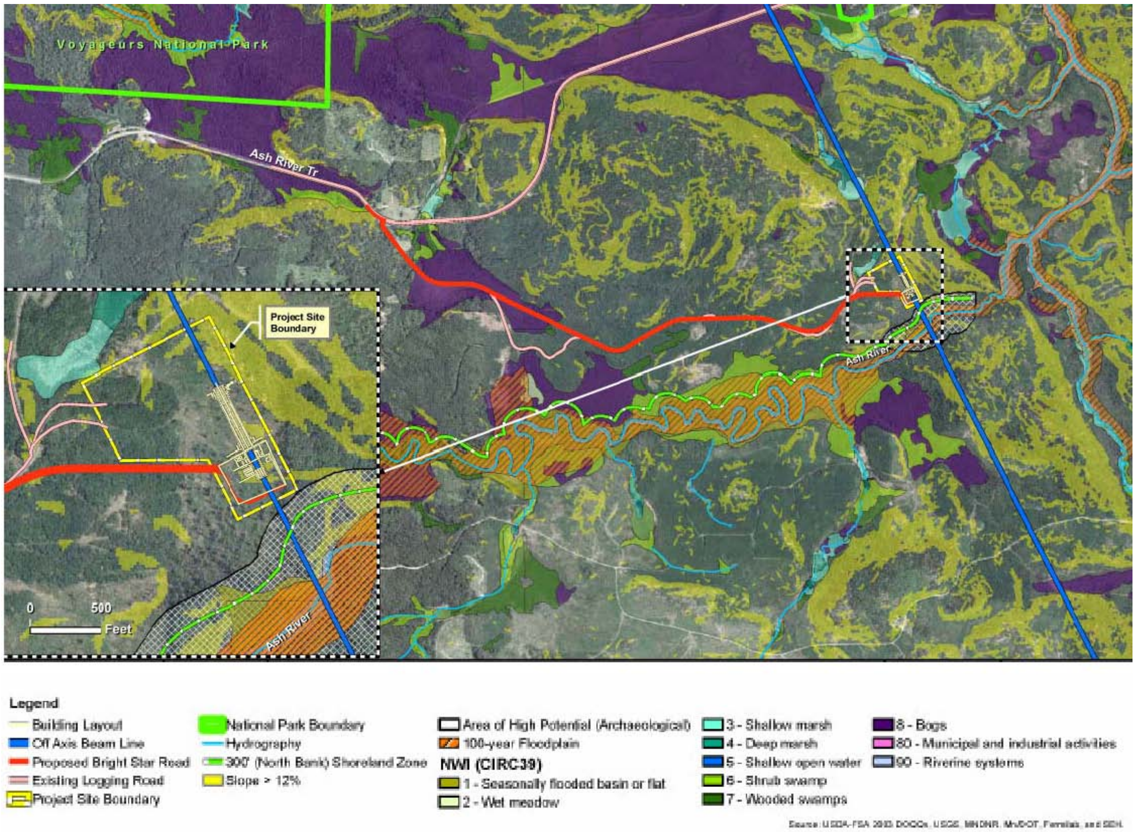


Fig. 9.4: A detailed map of the Ash River site shows wetlands, required wetlands setback lines, and other land characteristics in the area. The yellow shading in the forested areas indicates places with a > 12% slope.

Figure 9.5 is an aerial photograph that depicts the proposed project site boundaries along with the topsoil, clay and rock stockpiles as well as the subcontractor staging area. Also indicated on the figure are the one foot topographic contours showing the existing ground features. The proposed building site is approximately 70 feet above the elevation of the Ash River.

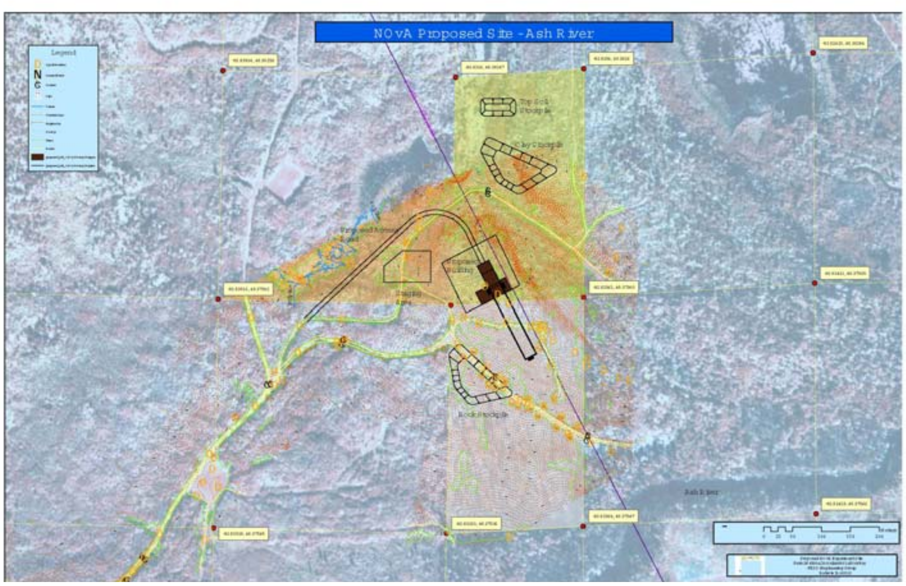


Fig. 9.5: Aerial Photo of the Far Detector Building Site.

Figure 9.6 shows the core samples from a typical core drillings done on the project site in the fall of 2006. In general, the surface deposits are approximately 7 feet deep and include soil over a layer of clay. Below the surface soils is a layer (at least 65 feet thick) of hard granite bedrock down to the proposed bottom of the NOνA excavation for the Far Detector. A packer test, used to determine hydraulic conductivity in the material, was done at several of the borings at a depth of 36 – 41 feet below the surface. No pressure loss was observed, indicating that the granite is not very fractured within the tested zone.

Fig. 9.6: Photos of typical core samples taken in fall of 2006.

9.2.3 Nearby Roads, Power, Data Communications

Highway US 53 does not have road restrictions in any season. The normal limits are 10 tons per axle (see Figure 9.7 below). The Ash River Trail (St. Louis County Road 129) between US 53 and the NOνA site access road does have road restrictions during the spring thaw, limiting trucks to 9 tons per axle for a 60 day period, March 15 – May 15 each year. Recent discussions with St. Louis County personnel indicate that the County is in the process of re-classifying the Ash River Trail as a 10 ton per axle highway. In northern Minnesota it is common to use trucks with an extra axle during restricted seasons. For example, the chassis trailers discussed in Chapter 10 for scintillator transport come in 2 and 3 axle versions, so the delivery of liquid scintillator to the site should not be interrupted except during actual severe storm conditions.

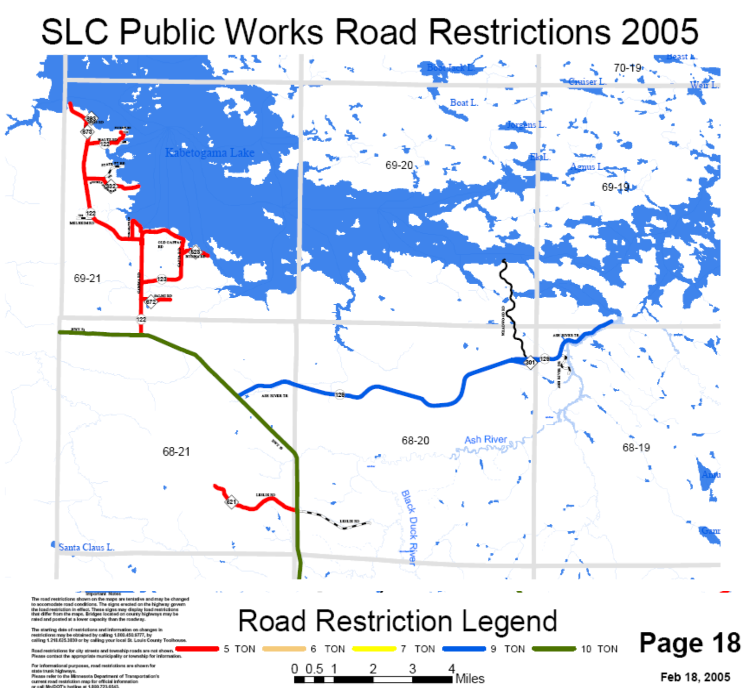


Fig. 9.7: St. Louis County Public Works Road Restrictions published for 2005.

There is limited power available along the Ash River Trail. Currently only 300 kVa is available versus the estimated need of 1,500 – 2,000 kVa. The area is served by North Star Electric, a part of the MinnKota Power, with about 6,000 customers in this part of Minnesota. North Star Electric Cooperative has provided an estimate [1] to upgrade the electrical service to the site from the Kabetogoma Substation some 35 miles from the Bright Star access road turn-off from St.Louis County 129. Figure 9.8, below, indicates the existing sources of power in the vicinity of the project site.

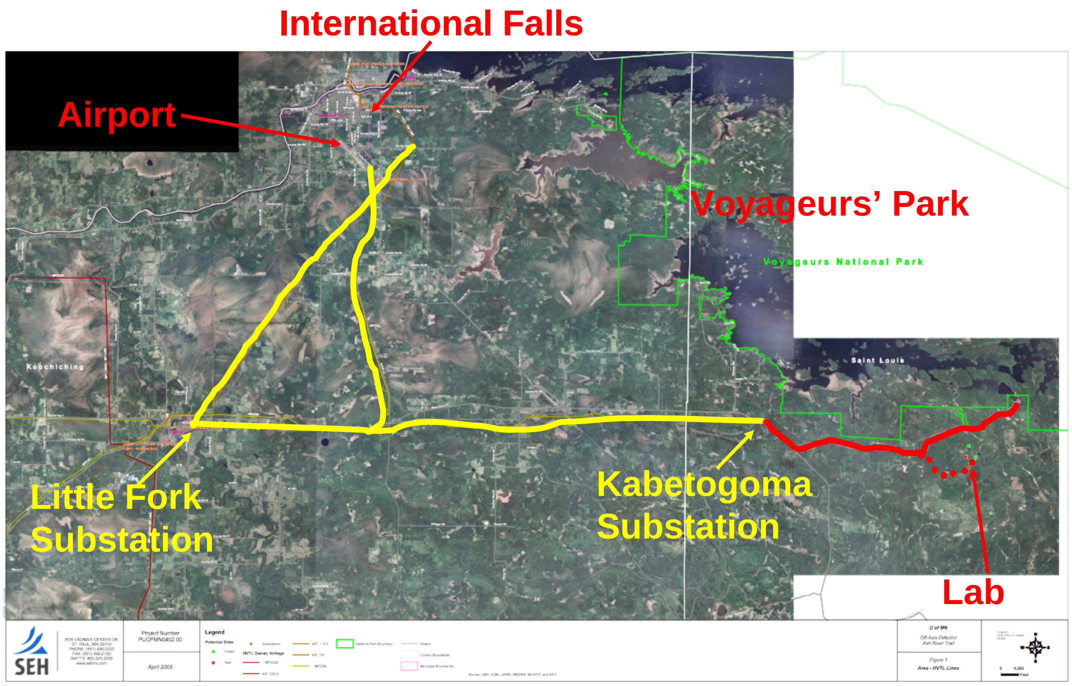


Fig. 9.8: Power distribution lines in the Ash River area.

The power in the project area is fed from the Kabetogoma substation via overhead pole lines. This area is served from a single direction with no secondary source in the event of a disruption. The NOνA site will include on-site capability for emergency power for critical systems from a backup generator powered by propane.

The project will connect to the existing electrical pole line along the Ash River Trail (St. Louis 129) at the intersection of the new Bright Star Road. The new electrical infrastructure will be routed parallel to the new access road in a designated underground utility corridor to the Far Detector Site.

Telephone and data communications in the Ash River area are provided by the Blackduck Telephone company, a small company with two (2) telephone exchanges and less than ten (10) employees. An existing underground fiber optic line and telephone line is located along the Ash River Trail (St. Louis 129) and serves the town of Ash River, Minnesota. The project will connect to the telephone and data lines at the intersection of the new Bright Star Road and Ash River Trail. Blackduck Telephone has provided an estimate for this work. [2].The new infrastructure will be routed parallel to the new access road in a designated underground utility corridor to the Far Detector Site.

9.2.4 Proximity to Voyageurs National Park

The Far Detector site is located approximately 2 miles southeast of the entry to the Ash River Trail entry to Voyageurs National Park. The design of the NOvA project incorporates features and considerations to minimize the impact on the adjacent properties in order to provide good environmental stewardship and become a respected, long term member of the Ash River community.

As part of this approach, the design includes consideration of the concerns of interested stakeholders gathered during community outreach meetings including representatives of Voyageurs National Park [3]. These concerns include project siting, noise and light pollution.

Several strategies were employed to minimize the visual impact of the facility. The first of these involved utilizing the existing logging road corridor for access to the site. This route, while approximately three times longer than a direct access from the Ash River Trail, respects the existing entry to Voyageurs National Park and provides an uninterrupted buffer between the project site and the road.

In April 2005 [4] the road alignment was discussed during a meeting included representatives from the Minnesota Department of Natural Resources (DNR) , Voyageurs National Park, Forest Capital Partners as well a the University of Minnesota. Of importance to the road alignment are notes indicating that the DNR did not prefer a route that created additional corridors that could restrict wildlife crossing. A list of attendees is included with the meeting notes is attached.

In April 2006 [5] another meeting concerning the road alignment was held. This meeting was held to discuss possible alternate road alignments for the access road. Attendees included representatives from the Minnesota Department of Natural Resources (DNR) , Voyageurs National Park, Forest Capital Partners (FCP) as well a the University of Minnesota. The FCP representative and the DNR representative recommended utilizing the existing road alignment to minimize the overall impact on the area.

Based on input from the significant stakeholders, the project team opted to accept the recommendation to follow the existing road alignment as closely as possible. During the subsequent design phases, each deviation from the existing alignment was reviewed in order to minimize the overall impact on adjacent properties while developing a design that met the criteria for road construction in St. Louis County. The variations from the existing alignment were generally based on traffic safety concerns.

In February 2007 [6] the road alignment was presented during a meeting of local stakeholders. Attendees included representatives from the Minnesota Department of Natural Resources (DNR) , St. Louis County, Forest Capital Partners (FCP) as well a the University of Minnesota. The stakeholders recommended, and the design team concurred, that the right of way access should be limited to sixty six (66) feet in lieu of the preferred one hundred (100) foot corridor in order to minimize the impact on the adjacent properties and land features.

Subsequent design refinement included investigating three modifications to further minimize impacts.

1. Refinement #1 included reducing the width of the side slopes from 4:1 to 3:1 along much of the length of the access road. This refined was incorporated into the design.
2. Refinement #2 investigated a 2:1 slope for those portions of the road through the identified wetlands. This option was rejected for safety reasons. The 2:1 slope would have required a guardrail along the shoulders of the road. It was felt that the snow plowing during winter conditions would have resulted in a narrower lane width due to the potential for the guardrail to restrict the movement of snow. This condition, especially through the wetland, was deemed to create an unacceptable condition.

3. Refinement #3 investigated a reduce road width. The conceptual design included a 31 foot wide road width (24 feet of pavement with 3 foot paved shoulders over 31 foot wide gravel base). After review, the width of the access road was reduced to 28 feet (22 feet of pavement over 28 feet of gravel base). This refinement was incorporated into the design.

Another strategy to minimize the visual impact was accomplished at the project site. Instead of constructing the Far Detector Building on top of a hill, the design will incorporate a scheme where the majority of the detector will be located below grade with approximately 40 feet of the building above grade.

The siting also includes selection of a building location in the center of the site with significant grade changes to the north. These hills, when restored, will provide a visual buffer between the building and the property to the north. By acquiring the additional land, the project can ensure that this buffer remains in place.

Fig. 9.9: Photo Looking North from Project Site taken in November 2006.

Consideration of the Ash River, a Minnesota designated trout stream, to the south was included in the design of the building orientation. This resulted in locating the truck traffic to the north end of the building, away from the Ash River.

Fig. 9.10: Photo Looking South from Project Site taken in November 2006.

The design also included noise considerations. The majority of the noise is expected to occur during construction of the new Bright Star Road and Far Detector Building over a period of approximately two years. Of this time, the rock excavation is expected to last 3-4 months. In order to help mitigate the noise concerns, the noisiest construction activities will be restricted to between 0700 and 1900 hours.

The current traffic level on the Ash River Trail has been measured at 310 vehicles per day and the NOνA plan would add about approximately 90 trips to that total, a 33% increase.

Light pollution was discussed as another concern. The NOνA project intends to balance the safety and security concerns with the light impact on the surrounding areas. The lighting will be designed to not exceed 80% of the lighting power densities for exterior areas as defined in ASHRAE/IESNA Standard 90.1-2004, Exterior Lighting Section. The project site will be defined as LZ-1 –Dark (Park and Rural Settings) per IESNA RP-33. This standard specifies that all site and building mounted luminaries produce a maximum initial illuminance value no greater than 0.01 horizontal and vertical footcandles at the site boundary.

9.2.5 *Site Design Changes since the Conceptual Design Report*

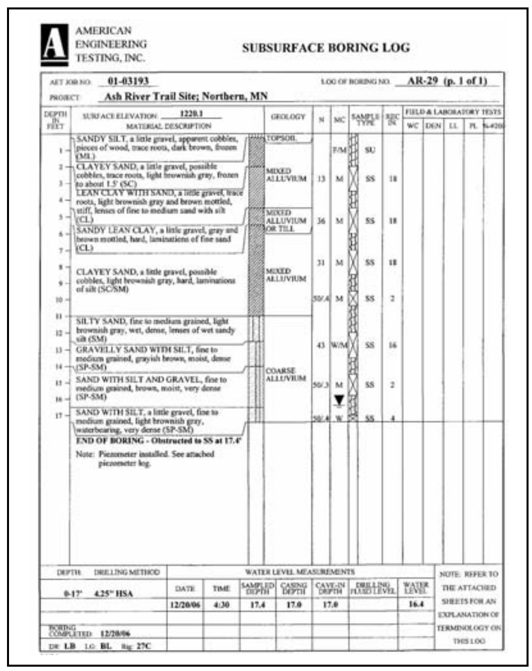
The site design changes since the Conceptual Design Report include increasing the amount of land required for the project. This increase is due to the better understanding of the site conditions, stockpile areas, contractor staging areas as well as physics driven adjustments.

The increase in the land area required an updating of the Environmental Assessment Worksheet (EAW) for the project site and access road. The field work for this updating was completed in the summer of 2006 and the updated EAW was completed by Short Elliot Hendrickson in May 2007. This work was accomplished to mitigate an identified risk associated with schedule delays [7].

In support of the EAW updating and to prepare a U.S. Army Corps of Engineers Wetland permit, a detailed delineation of the wetlands was accomplished by Short Elliot Hendrickson in the summer of 2006. The development of the permit application was prepared and submitted for review in April 2007 [8].

In December 2006, a Storm Water Pollution Prevention Plan (SWPPP) was prepared by Burns and McDonnell as part of the development of the Site Preparation package. This living document contains the information needed to comply with applicable ordinances, codes and regulations concerning storm water management. This work was accomplished to address environmental safety and health concerns during construction [9].

A detailed topographic survey of the access road and project site was completed by Hanson Professional Services in the spring of 2006. This survey documented the ground features to produce a one foot contours. This work was accomplished to mitigate an identified risk associated with unknown topographic conditions [10]



AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET JOB NO: 01-03193 LOG OF BORING NO. AR-29 (p. 1 of 1)

PROJECT: Ash River Trail Site; Northern, MN

SURFACE ELEVATION: 1220.1

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.
1	SANDY SILT, a little gravel, apparent cobbles, pieces of wood, trace roots, dark brown, frozen (ML)	TOPSOIL		F/M	SU	
2–3	CLAYEY SAND, a little gravel, possible cobbles, trace roots, light brownish gray, frozen to about 1.5' (SC)	MIXED ALLUVIUM	13	M	SS	18
4–5	LEAN CLAY WITH SAND, a little gravel, trace roots, light brownish gray and brown mottled, stiff, lenses of fine to medium sand with silt (CL)	MIXED ALLUVIUM OR TILL	36	M	SS	18
6–7	SANDY LEAN CLAY, a little gravel, gray and brown mottled, hard, laminations of fine sand (CL)					
8–10	CLAYEY SAND, a little gravel, possible cobbles, light brownish gray, hard, laminations of silt (SC/SM)	MIXED ALLUVIUM	31	M	SS	18
			50/.4	M	SS	2
11–12	SILTY SAND, fine to medium grained, light brownish gray, wet, dense, lenses of wet sandy silt (SM)	COARSE ALLUVIUM				
13–14	GRAVELLY SAND WITH SILT, fine to medium grained, grayish brown, moist, dense (SP-SM)		43	W/M	SS	16
15–16	SAND WITH SILT AND GRAVEL, fine to medium grained, brown, moist, very dense (SP-SM)		50/.3	M	SS	2
17	SAND WITH SILT, a little gravel, fine to medium grained, light brownish gray, waterbearing, very dense (SP-SM)		50/.4	W	SS	4

FIELD & LABORATORY TESTS: WC DEN LL PL %-#200

END OF BORING - Obstructed to SS at 17.4'

Note: Piezometer installed. See attached piezometer log.

DEPTH	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-17'	4.25" HSA	12/20/06	4:30	17.4	17.0	17.0		16.4

WATER LEVEL MEASUREMENTS

BORING COMPLETED: 12/20/06

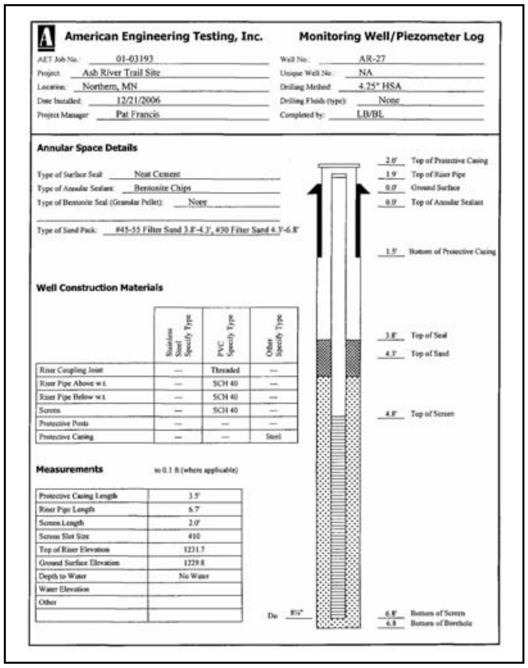
DR: LB LG: BL Rig: 27C

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

Fig. 9.11: Typical Boring Log

The project team has identified cost and schedule risks associated with unknown subsurface conditions [11]. As mitigation, a comprehensive subsurface investigation program of the access road route and project site was completed by Short Elliot Hendrickson in the fall of 2006 to better characterize the site conditions. The goal of the subsurface exploration program was to further define soils, bedrock, and groundwater conditions for the project for the purpose of developing preliminary plans for the access road and building site. In addition to the subsurface exploration program included the development of recommendations related to road, utility and building construction. The subsurface exploration program consisted of several components, all designed to obtain information necessary for the design and construction of project facilities. The components consist of a drilling and testing program, geophysical investigation, and groundwater study.

The drilling and testing component included twenty one (21) soil borings along the access road and six (6) borings at the building site. The drilling and testing field work component included the packer tests at two (2) borings. A packer test isolates specific regions of the bedrock borehole with inflatable bladders (or packers) so that water levels can be determined. This test is



American Engineering Testing, Inc. — **Monitoring Well/Piezometer Log**

AET Job No.: 01-03193
Project: Ash River Trail Site
Location: Northern, MN
Date Installed: 12/21/2006
Project Manager: Pat Francis
Well No.: AR-27
Unique Well No.: NA
Drilling Method: 4.25" HSA
Drilling Fluids (type): None
Completed by: LB/BL

Annular Space Details

Type of Surface Seal: Neat Cement
Type of Annular Sealant: Bentonite Chips
Type of Bentonite Seal (Granular Pellet): None
Type of Sand Pack: #45-55 Filter Sand 3.8'-4.3', #30 Filter Sand 4.3'-6.8'

2.0' Top of Protective Casing
1.9' Top of Riser Pipe
0.0' Ground Surface
0.0' Top of Annular Sealant
1.5' Bottom of Protective Casing
3.8' Top of Seal
4.3' Top of Sand
4.8' Top of Screen
6.8' Bottom of Screen
6.8 Bottom of Borehole
Do 8¼"

Well Construction Materials

	Stainless Steel Specify Type	PVC Specify Type	Other Specify Type
Riser Coupling Joint	—	Threaded	—
Riser Pipe Above w.t.	—	SCH 40	—
Riser Pipe Below w.t.	—	SCH 40	—
Screen	—	SCH 40	—
Protective Posts	—	—	—
Protective Casing	—	—	Steel

Measurements to 0.1 ft (where applicable)

Protective Casing Length	3.5'
Riser Pipe Length	6.7
Screen Length	2.0'
Screen Slot Size	#10
Top of Riser Elevation	1231.7
Ground Surface Elevation	1229.8
Depth to Water	No Water
Water Elevation	
Other	

Fig. 9.12: Typical Piezometer Log

useful in characterizing the amount of water inflow. A further description of the testing methods and results can be found in the completed report [12].
The drilling and testing component also included the installation of piezometer in the boreholes in the vicinity of the building. Piezometers are used to measure the level of water in the boreholes. In addition to single piezometers, three (3) boreholes received nested piezometers to better characterize the water levels. A further description of the testing methods and results can be found in the final report [12].

Laboratory testing of the boring samples included Sieve analysis, hydrometer, moisture content, Atterberg Limits, R-value, Standard Proctor and consolidation tests were performed on soil samples selected by SEH. The results of the tests are included in the boring logs and data sheets.

The geophysical component of the investigation included two (2) major components. The first was a 3D Earth Resistivity Survey. This survey at the building site was undertaken to document the depth and characteristics of the solid overburden and underlying rock. This type of survey uses the electrical properties of the subsurface materials to characterize the resistivity and thus the structure.

The survey collected subsurface data from a 68,750 square foot area in the vicinity of the building site to determine the depth and condition of the overburden and bedrock. The survey included six (6) resistivity profiles collected at the site within a rectangular-shaped survey area. The 3D earth resistivity survey consisted of six (6), 550 ft lines with a 25 ft line separation.

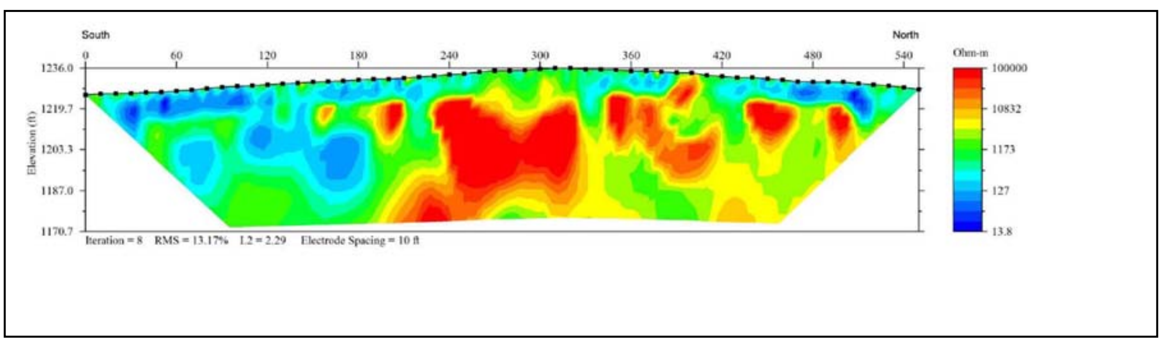


Fig. 9.13: Data collected from earth resistivity survey

In addition to the 3D Earth Resistivity Survey, shear wave seismic refraction survey was also performed. Seismic refraction surveys are used to identify the depths to various layer boundaries or to the bedrock surface. At this site, the survey consisted of two (2) crossing lines, each 220 ft in length. The lines were located in the southeast portion of the site between earth resistivity lines. Each line was comprised of twelve (12) seismic sensors (geophones) separated by 20 ft.

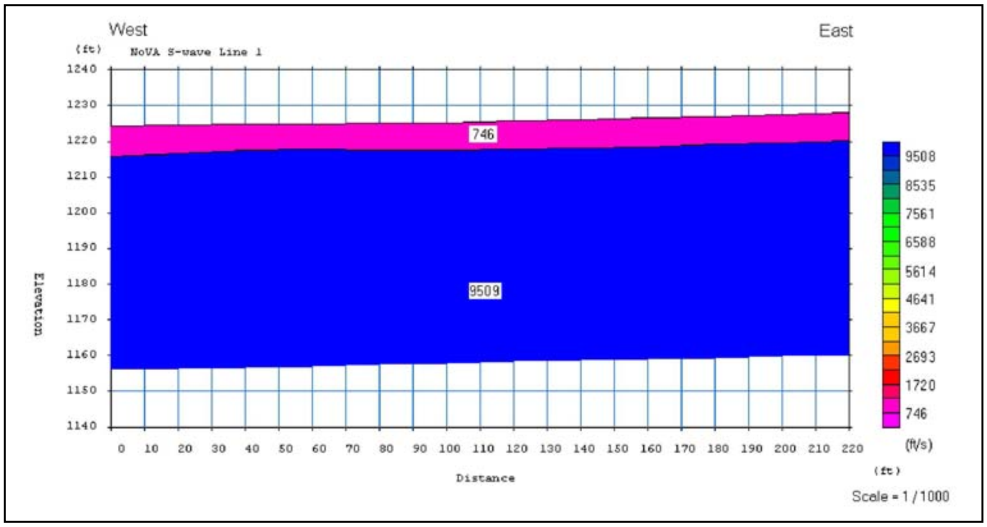


Fig. 9.14: Data collected from seismic refraction survey

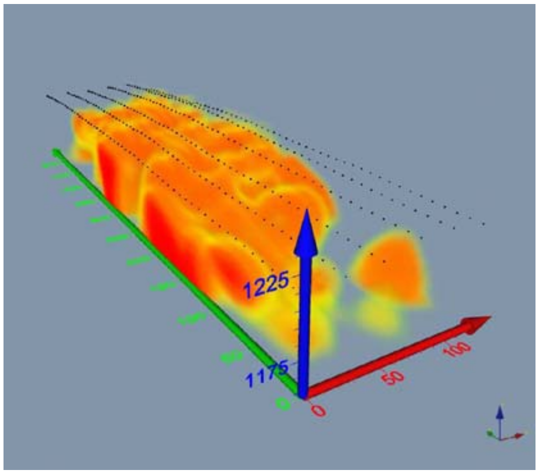


Figure 9.15: Seismic Refraction Visualization

The information collected from the earth resistivity survey and the seismic refraction survey was combined to provide a visualization of the subsurface features. Figure 9.15 at the left is one view of the visualization

The subsurface characterization program provided additional information of the subsurface conditions and reduced the unknowns. In addition, the subsurface investigation provided the basis for the design of the access road pavement, embankment, utility installation as well as foundation design, frost protection criteria and allowable bearing capacity [13].

No issues were noted during the site investigation activities since the Conceptual Design Report that would impact the EAW from being accepted by the Minnesota Environmental Quality Board as sufficient documentation for a determination that a full Minnesota Environmental Impact Statement will not be required. The Ash River EAW is available [14]. In July 2007, the University of Minnesota Board of Regents agreed to serve as the Responsible Government Unit submitting the EAW. The EAW will be published in the Minnesota Environmental Quality Board's Monitor in September 2007 which will start the thirty (30) day public comment period.

Following the example of the MINOS project done by DOE / Fermilab in the Soudan Mine, the State of Minnesota EAW will be accepted by the DOE as part of the federal Environmental Assessment for the Minnesota portion of the project.

No issues were noted during the delineation of the wetland or preparation of the Wetland Permit Application that would prevent the project from proceeding. It is expected that the University of Minnesota would serve as the submitting entity.

9.3 Advanced Technical Design of the Site Preparation Package.

9.3.1 Technical Design Criteria

The Site Preparation bid package consists of the work required to construct the access road and prepare the site for subsequent construction work including clearing and grubbing, rock excavation, establishing topsoil, clay and rock stockpile areas and creating a contractors staging area.

The Bright Star access road has been designed to serve as the primary means of access to the Ash River Site for construction, detector assembly and operations. The type and traffic volume dictate that the roadway be designed as an all weather road similar in construction to the Ash River Trail (St. Louis County Road 129). Listed below is the design criteria used in developing the roadway plan and profile

Design Criteria	AASHTO , Geometric Design of Highways and Streets, 2004	MnDOT Road Design Manual	Proposed Criteria
Functional Class	Local Rural	Collector Rural	Local Rural
Terrain	Rolling	Rolling	Rolling
Projected ADT	400-1500 veh/day	400-1500 veh/day	400-1500 veh/day
Design Speed	45 mph	45 mph	45 mph
Design Vehicle			
Stopping Sight Distance	360 ft	ft	360 ft
Stopping Sight Distance - eye height	3.5 ft		3.5 ft
Stopping Sight Distance - object height	2.0 ft		2.0 ft
Passing Sight Distance - eye height	3.5 ft		3.5 ft
Passing Sight Distance - object height	3.5 ft		3.5 ft
Stopping Sight Rate of Vertical Curvature (Crest)	61 ft	ft	61 ft
Stopping Sight Rate of Vertical Curvature (Sag)	79 ft	ft	79 ft
Passing Sight Distance	1625 ft		1625 ft
Passing Sight Rate of Vertical Curvature (Crest)	943 ft		943 ft
Minimum Longitudinal Grade		0.5%	0.5%
Maximum Longitudinal Grade	10%	8%-10%	10%
Cross Slope	2.00%	2.00%	2.00%
Maximum Superelevation	8%	6%	6%
Minimum Superelevation Runoff	192 ft		
Minimum Length of Tangent Runout	48 ft		
Minimum Radii - Horizontal Curve	587 ft		643 ft
Lane Width	10 ft	10 ft - 12 ft	12 ft
Shoulder Width	5 ft	5 ft	6 ft
Shoulder Cross Slope			4%
Foreslopes	1V:2H	1V:3H or 4H	1V:4H
Backslopes	Max. for slope stability	1V:3H	1V:3H
Clear Zone	7-10ft		7ft
Max. Longitudinal Grade Change			6%
Roadway Lighting			N/A
Pavement Marking			
Culverts			CMP w/PCC headwalls or CMP FES
Design Storm			25 yr.
		Minnesota Stormwater Manual	
Recharge		infiltration of up to 2-year, 24 hour storm	infiltration of up to 2-year, 24 hour storm
Water Quality		Rule 2 for Special Waters: 1.0""IC*1/12	Rule 2 for Special Waters: 1.0""IC*1/12
Channel Protection		12-hour ext. det. of 1-year 24 hour storm	12-hour ext. det. of 1-year 24 hour storm
Overbank Flood Protection		10-year post to pre-development runoff	10-year post to pre-development runoff
Extreme Storm Protection		100-year post to pre-development runoff	100-year post to pre-development runoff

Design Criteria Table 12/2/2006

Figure 9.16: Design Criteria for Access Road

9.3.2 Site Preparation Overview

The Site Preparation bid package consists of the work required to construct the access road and prepare the site for subsequent construction work including clearing and grubbing, rock excavation, establishing topsoil, clay and rock stockpile areas and creating a contractors staging area.

The access road portion of the work consists of a new road from St. Louis County 129 to the Ash River Site. The road generally follows the route of the existing logging trail but has been re-aligned to accommodate the anticipated 53-foot trailer truck traffic.

The road right of way will include an underground utility corridor to bring power and communication lines to the site. The Ash River site requires a power upgrade and the local electrical cooperative will upgrade the electric service to the site by replacing an existing transformer at the Kabetogama substation, replacing existing insulators and step down transformers along the route as well as installing a new transformer and related accessories at the project site. The project bears the cost for this electrical work.

9.3.3 Site Preparation Details

The Bright Star access road portion of the site preparation work is based on design criteria obtained from Association of State Highway and Transportation Officials (AASHTO) and the Minnesota Department of Transportation (MDOT). In addition, the existing site features and intended use of the road were incorporated into the design. Shown below in figure 9.17 is a representative sample of the completed documents. The complete set of the drawings and specs is available [15].

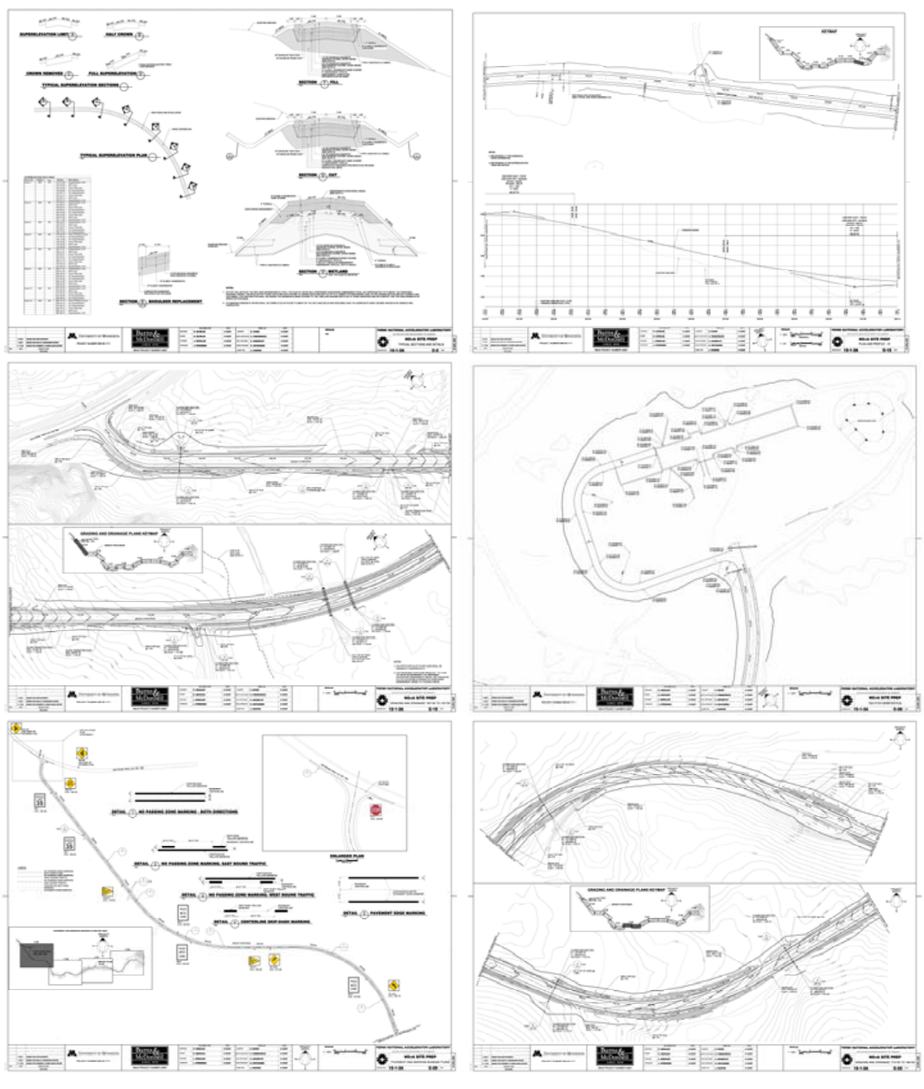


Figure 9.17: Representative Sample of Site Prep Documents

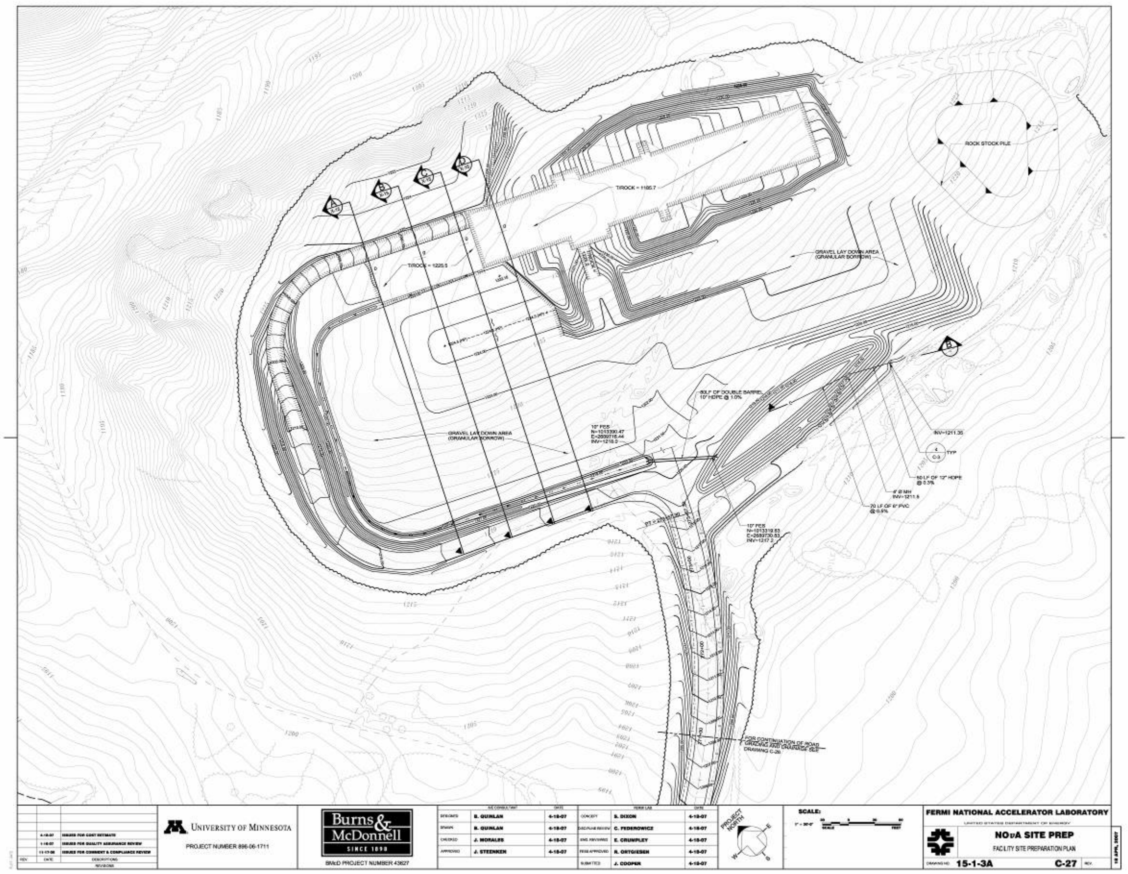


Figure 9.18: Far Detector Building site excavation

In addition to the construction of the Bright Star access road, the Site Preparation package contains the work required to prepare the project site for the construction of the Far Detector Building. This includes general clearing and grubbing of the facility site, stockpile areas and subcontractor staging areas as well as rock excavation at the Far Detector Building site. Figure 9.18 below depicts the rock excavation plan at the Far Detector Building site.

9.3.3 Design changes in the Site Preparation Package since the Conceptual Design Report

The design of the Site Preparation Package has been revised to incorporate information obtained from the site investigation work accomplished in the summer and fall of 2006. This has resulted in an increase in the project site to accommodate anticipated stockpile and staging areas. In addition, the access road alignment has been optimized to accommodate the required truck traffic and site features.

Representatives of the University of Minnesota were involved in the advanced technical design of the Site Preparation package. This coordination included telephone conversations and presentations in the offices of the Building Code Division of the University of Minnesota [16]. The input from the University of Minnesota is considered vital to the continuity of the design throughout the subsequent phases of the project since the university will coordinate the work as part of their Cooperative Agreement responsibilities.

In April 2006, members of the project team met with representatives of the Forest Capital Partners, Minnesota Department of Natural Resources and Voyageurs National Park to discuss alternate access road routes that would lessen the impact on surrounding stakeholders [17]. The consensus was that the new access road should follow the existing road as close as possible to avoid unduly impacting the adjacent land.

In the spring of 2006, the firm of Burns and McDonnell was retained to complete an independent cost and schedule review of the CDR design. This study indicated that the estimated cost of the site and building were greater than the in-house estimate completed for the CDR. The project team reconciled the two estimates and undertook a value management exercise to manage the estimated costs. The schedule component of the review indicated that a two year construction period was reasonable.

A detailed topographic survey of the access road and project site was completed by Hanson Professional Services in the spring of 2006. This survey documented the ground features to produce one foot contours.

Changes in the access road routing and building location required an updating of the Environmental Assessment Worksheet (EAW) for the project site and access road. The field work for this updating was completed in the summer of 2006 and the updated EAW was completed by Short Elliot Hendrickson in May 2007.

In the summer of 2006, the firm of Short Elliot and Hendrickson was retained to delineate and document the wetlands along the access road and project site. This was used as input for road routing and building siting in addition for use in developing the required mitigation in support of the EAW updating and to prepare a U.S. Army Corps of Engineers Wetland permit.

In order to provide a better understanding of the subsurface conditions along the access road and project site, the firm of Short Elliot and Hendrickson was retained in the summer of 2006 to perform a subsurface investigation. This investigation included a comprehensive program of field work of soil borings, rock borings, pump test and packer tests as well as lab work required to analysis and document the conditions. In addition, a 3D resistivity survey was completed of the area around the Far Detector Building site for the purpose of mapping bedrock fracture zones.

As part of the internal quality assurance procedure, the Site Preparation Package underwent two (2) formal reviews. These reviews focused on the appropriateness of the proposed systems, impacts on existing systems and operations, specific technical requirements to be incorporated into the design and compliance with best and required practices of authority having jurisdiction. The first of these reviews was completed in November 2006 was titled “Comment and Compliance Review” and included representatives of the various project WBS groups as well as the University of Minnesota code officials as was based on a design that was 40% complete. The second review, in January 2007, was a “Quality Assurance Review” and was sent to the same review team as the earlier review [18].

9.3.4 Work Remaining to Complete the Site Preparation Package.

The design of the Site Preparation Package is approximately 95% complete. Final adjustments to road alignment based on feedback from the EAW and wetland permitting process could impact the current design. In addition, slight adjustments to the building location based on bedrock topography may require modifications.

Prior to beginning construction, the road permitting process with the Corps of Engineers will need to be completed. In addition, EAW will need to be submitted to the Minnesota Environmental Quality Board and proceed through the public comments phase in parallel with the federal EA. Finally, the project will need DOE approval and a FONSI for the Minnesota work.

9.4 Design of the Far Detector Building at Ash River

9.4.1 Technical Design Criteria

The technical design criteria for the Far Detector Building (FDB) have been developed based on physics-driven requirements for the detector assembly and operation.

Listed below are the requirements for key components of the building. Where available, a reference to a NOvA note is included

- Support Functions Requirements - NOvA-doc-1192
- Loading Dock Requirements – NOvA-doc-1159
- Assembly Area Requirements – NOvA-doc-1159
- Moveable Access Platform Requirements – NOvA-doc-1155
- Detector Electronic Requirements – NOvA-doc-919
- Computer Requirements – NOvA –doc-1141
- Scintillator Transfer Station – Space for four (4) trucks under canopy and parking for an additional (2) trailers.
- Parking for 8-10 vehicles during normal operations – NOvA-doc-1192
- Scintillator Containment – 100% containment.
- Backup Electrical Power – Critical systems only.
- Structural Systems
  Design Loads shall be as listed below and in accordance with the Fermilab Engineering Standards Manual:
  - Floors shall be designed to support a concentrated load of 2000 lbs. applied to an area 2'-6" x 2'-6".
  - 150 psf or weight of actual equipment.
  - Live Load Reduction: No live load reductions are permitted for roof or mechanical equipment areas.
  - Handrails and Guardrails: Top rail = 50 plf or 200 lb. concentrated load (applied any direction – not simultaneous) infill area = 50 lbs. on an area 1'-0" x 1'-0" (the above loads are not superimposed)
- Mechanical Systems: The HVAC systems will conform to ASHRAE 90.1, ASHRAE 62 and applicable NFPA requirements and applicable sections of the Fermilab Engineering Standards Manual Mechanical systems and controls will be further investigated during subsequent phases in accordance with ASHRAE 90.1 and Federal Life Cycle costing analysis.
- Plumbing: All plumbing work to be installed in accordance with State of Minnesota and St. Louis County Plumbing Codes, ordinances and regulations.
- Electrical Systems: Electrical system design will comply with applicable sections of National Electric Code and applicable sections of the Fermilab Engineering Standards Manual.
  - Primary Supply 480/277 V, 3 phase, 4 wire
  - Secondary Supply Power Distribution: 120/208 V, 3 phase, 4 wire
  - Lighting: 277 V
  - Illumination Levels:
    Mechanical Spaces: 30 fc.
    Computer Room and Office Areas: 50 fc.
    Loading Dock: 30 fc general lighting supplemented by task lighting
    Assembly Area: 30 fc general lighting supplemented by task lighting
    Detector Enclosure: 30 fc general lighting .
    Interior Emergency Lighting: 5 fc.

- Fire Protection Systems: Fire Alarm/Fire Suppression systems shall be designed in accordance with the applicable sections of the Fermilab Engineering Standards Manual.
  - Fire alarm systems shall be designed with a minimum standby power (battery) capacity. These batteries shall be capable of maintaining the entire system in a non-alarm condition for 24 hours, in addition to 15 minutes in full load alarm condition. The most commonly used NFPA standards relative to fire alarm systems are: 70, 72, 90A, and 318.
  - Water mist fire suppression systems will be installed throughout the Detector Enclosure, Assembly Area, Loading Dock and other areas that will contain scintillator. These systems will be designed in accordance with NFPA 11, NFPA 13 and NFPA 16.
  - Areas of the facility that will not contain scintillator will include automatic sprinkler systems designed and installed in accordance with NFPA 13.
  - Exit stairways will contain a dry standpipe system in accordance with NFPA 14.
- Sustainable Building Design: Sustainability is broadly defined as the design and implementation of projects to simultaneously minimize their adverse environmental impacts, maximize occupants' health and well-being, and improve bottom line economic performance. The concept of sustainability is a desirable approach to development that recognizes that resources are limited, and that there is a responsibility of the present generation to preserve resources for future ones. The United States Green Building Council (USGBC) has developed the Leadership in Energy and Environmental Design (LEED) standard to provide guidance for builders who wish to incorporate sustainable elements into their projects. LEED for new construction is a set of specific and quantifiable measures, each of which confers a credit towards certification of a project as a "LEED-certified" building. While this project is not intended to become a certified building, the project processes and each project element will be evaluated during design to reduce their impact on natural resources without sacrificing program objectives. The project design will incorporate maintainability, aesthetics, environmental justice and program requirements to deliver a well-balanced project [19].
- A project of this scale has the potential to include an overlap of systems and construction. In order to delineate the specific area of a responsibility for each WBS section, a responsibility matrix has been developed that describes the system and the area of responsibility for each WBS [20].

9.4.2 Overburden Design

The overriding design requirement for the Far Detector Building is the cosmic overburden [21]. The overburden is defined as the ability of the material to shield the detector components from cosmic rays. Several methods of achieving the overburden have been investigated and the current design has been optimized to balance the amount of material with the shielding capacity. A shield of about 14 radiation lengths is realized in this design [21].

The overburden design is based on a system maximizing standard construction methods while minimizing exotic materials or techniques. To this end, the design is based on a combination of precast concrete, cast-in-place concrete and a small amount of loose barite material. Barite, in the form of barium sulfate, has been selected since it provides an increased shielding benefit over concrete or granite shot rock. The combination concrete/barite roof system described below has been designed to provide an equivalent of 9.86 feet of earth shielding.

From a constructability point of view, the critical shielding location is the roof of the Detector Enclosure. The long span and the weight of the overburden material have driven the structural solution for this area. The roof is designed as a composite structural member consisting of a 2.5 feet precast concrete plank that spans the width of the Detector Enclosure capped with a 1.5 feet depth of cast-in-place concrete. Once cured, this composite structural member will be topped with insulation, roof membrane and 0.5 feet of loose barite roof ballast. The precast plank will serve as the finished ceiling of the Detector Enclosure as well as the formwork for the cast-in-place concrete. Figure 9.19 below depicts the typical roof construction detail.

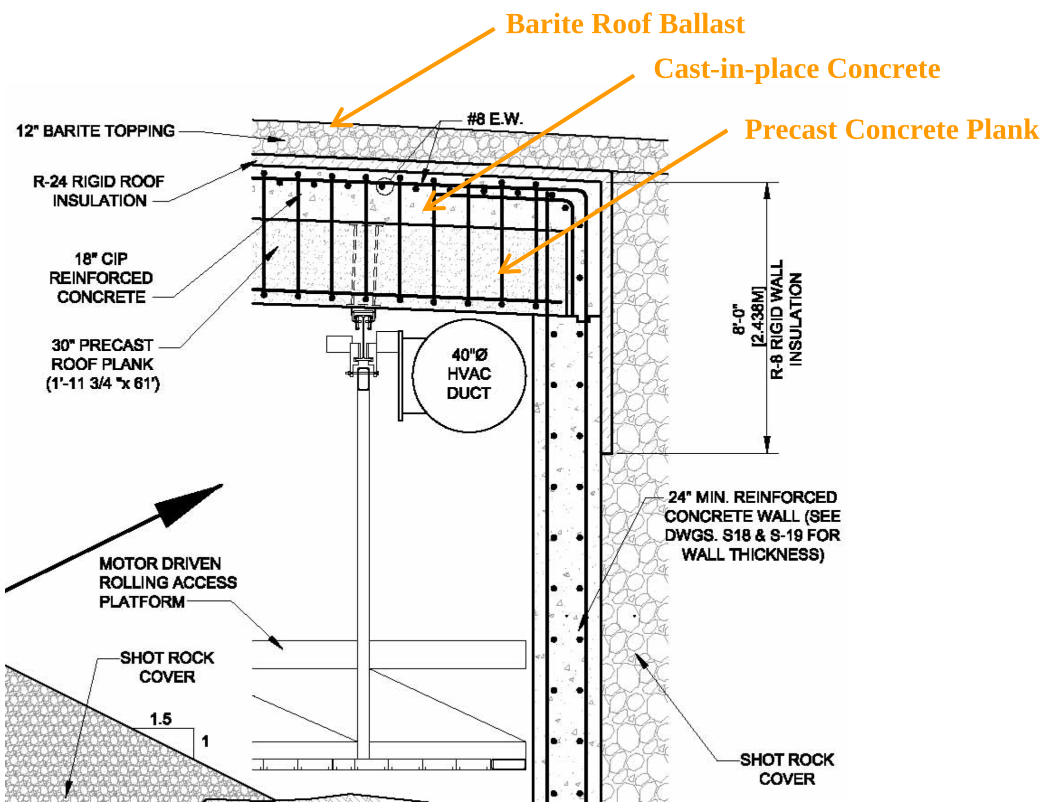


Fig. 9.19: Detail at Detector Enclosure Wall/Roof Interface showing roof construction

Those portions of the Detector Enclosure walls that extend above grade will be constructed of normal weight cast-in-place concrete and backfilled with loose granite shot rock as depicted in figure 9.20 at right. This approach utilizes conventional construction techniques and incorporates excavated material. The granite shot rock will be installed at a slope to minimize the amount of material used while providing a maintainable slope. The loose barite ballast will extend from the roof to cover the upper level of the berm.

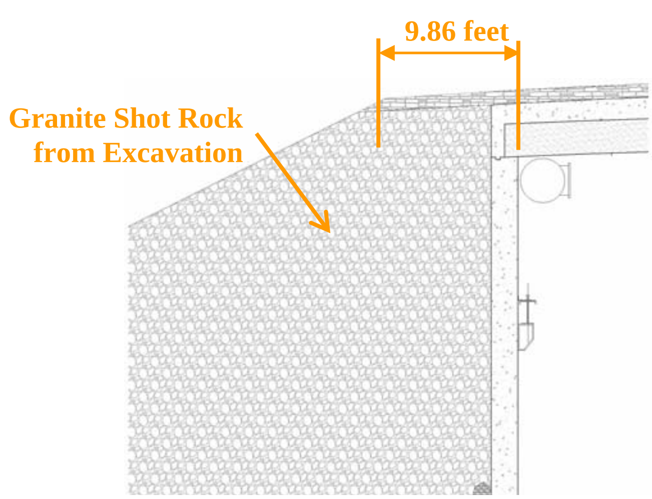


Fig. 9.20: Detail at Detector Enclosure Wall showing shielding thickness

9.4.3 Below Grade Areas

The below grade areas of the Far Detector Building consist of the Detector Enclosure and adjacent Assembly Area. The two areas combined are a single cast-in-place concrete enclosure 113.8 meters long, 20.4 meters wide and 21.4 meters high (373.25 feet long, 63 feet wide and 71 feet high) shown in Figures 9.21 and 9.22.

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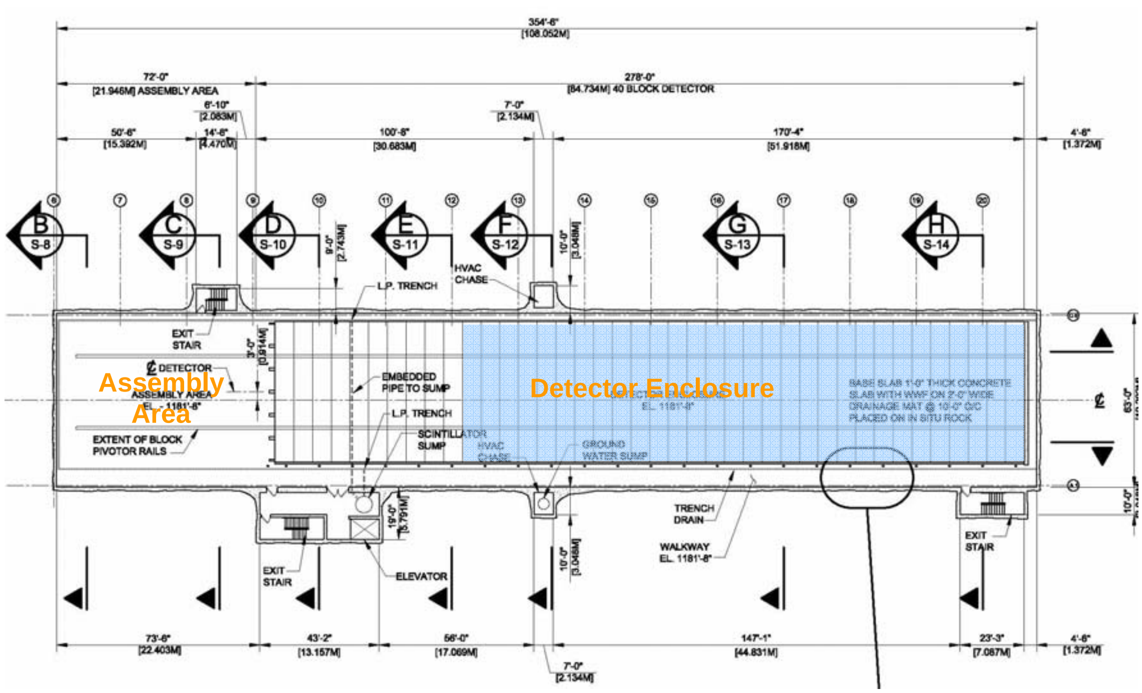

Fig. 9.21: Plan view showing relationship of the Assembly Area (at left) and the Detector Enclosure (at right) with the Far Detector indicated in blue.

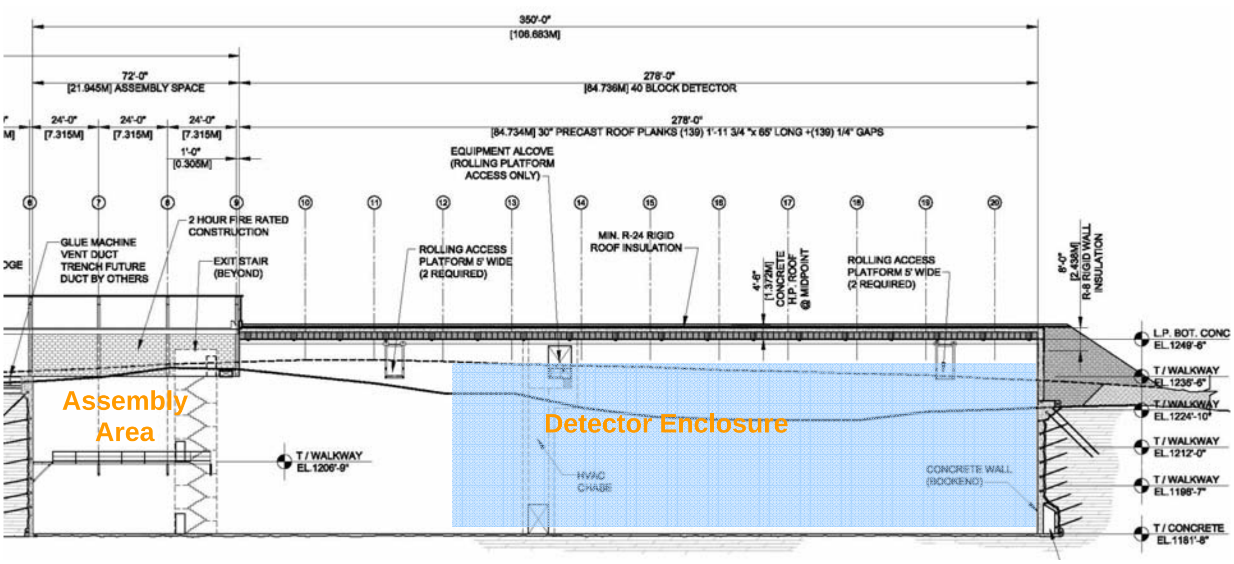

Fig. 9.22: Longitudinal section showing relationship of the Assembly Area (at left) and the Detector Enclosure (at right) with the Far Detector indicated in blue.

The Detector Enclosure (90 meters long, 20.4 meters wide and 21.6 meters high) will house the completed Far Detector, provide access to the top and sides and support installation and operation of the detector components. The Detector Enclosure is sized to accommodate up to a 20 kiloton detector.

The Assembly Area (20.1 meters long, 20.4 meters wide and 21.6 meters high) will provide space for the equipment and devices required to assemble the detector. This includes the block assembly device and associated access equipment.

One goal of the project is to provide for 100% secondary containment of the scintillator in the event of a catastrophic loss of the detector. In order to accomplish this project goal, the firm of Burns and McDonnell was retained to investigate possible alternates to providing secondary containment for the detector [22]. The concepts contained in the report were incorporated into the design.

The primary containment for the scintillator is the PVC cells of the detector. The walls and floor of the Detector Enclosure and Assembly Area will provided the secondary containment. These surfaces have been designed to contain 100% of the liquid scintillator as well as the fire protection foam that would be used in the event that a full release of water occurred during a complete release of the scintillator. The surfaces will be coated with a sealant to provide a non-porous surface. The walls and portions of the floors will be left exposed to view for inspection purposes. The bottom of the detector will be separated from the concrete floor by the steel "pallet" so that the detector will not be in direct contact with the floor. This separation will prevent scintillator from being forced into the concrete surface. Any scintillator that escapes the primary containment of the detector will be atmospheric pressure and will not be forced into the concrete surface. A trench drain will be embedded in the floor of the Detector Enclosure that will allow for the collection of spilled scintillator. These drains will be sloped to allow any spilled scintillator to be routed to a scintillator collection basin.. The scintillator collection basin will be isolated from the groundwater sumps and will be monitored for fluid levels. No automatic discharge from the scintillator collection basin will be provided in order to prevent unintended release of scintillator to the environment.

The floor of the Assembly Area and Detector Enclosure will accommodate the steel "pallet" used as the base of the detector. These pallets will separate the block from the concrete floor and serve as the "witness zone" for the space beneath the detector as a component of the secondary containment system.

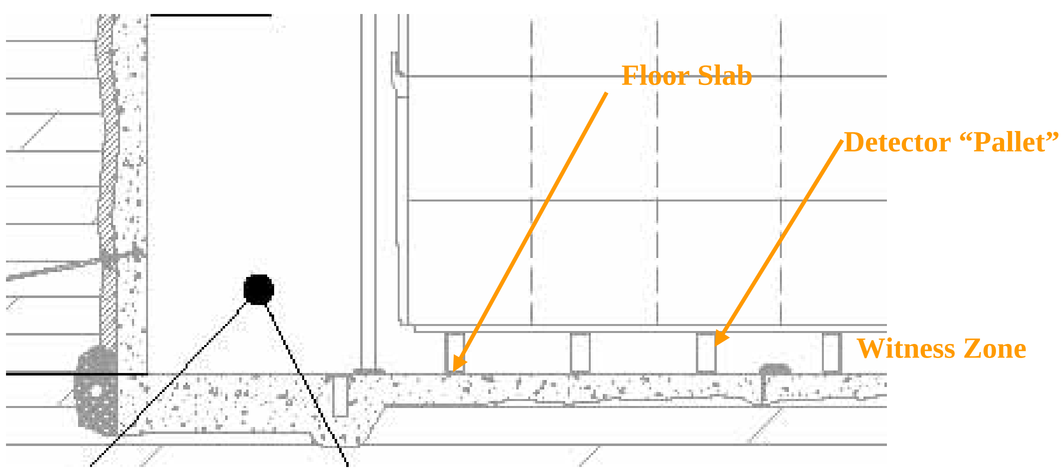

Fig. 9.23: Detail at Detector Enclosure floor slab

The Detector Enclosure and Assembly Area are serviced by three (3) code compliant exit stairs that provide two (2) means egress for each level of the below grade enclosures. These stairs also serve the Detector Enclosure access walkway system. One (1) standard sized elevator, located on the west side of the building will provide vertical access to all levels of the walkways.

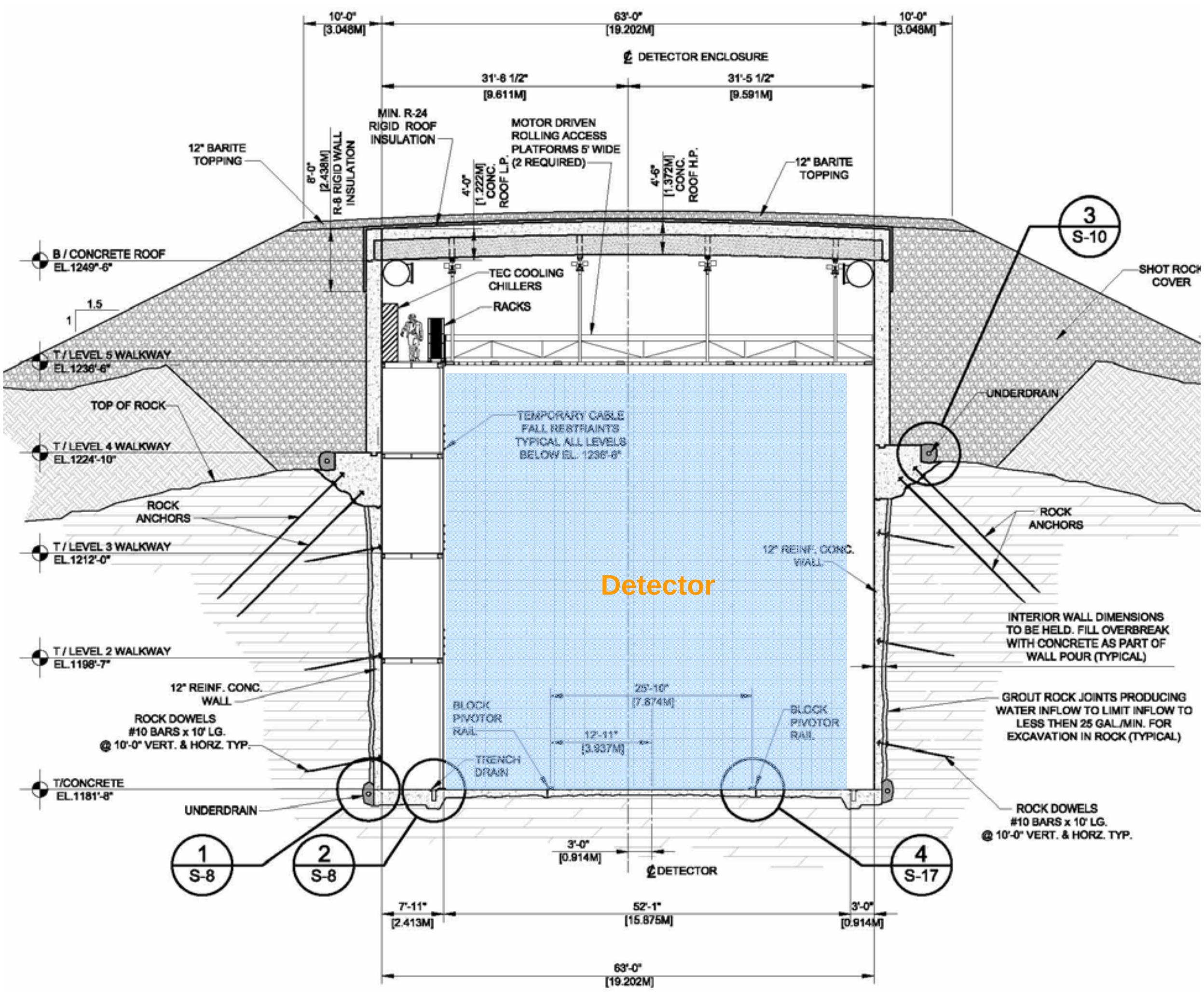

Fig. 9.24: Typical Cross Section of the Detector Enclosure

Figure 9.24 shows a typical cross section view of the Detector Enclosure. The below grade areas will be excavated to approximately 12 meters (40 feet) below grade to accommodate existing terrain as well as provide a below grade containment volume sized to contain the 100% of the liquid scintillator and a full discharge of the fire suppression system. The material removed during excavation activities will be stockpiled on site and used, as appropriate, as backfill and for site improvements

The Assembly Area is sized to support the block assembly device and related components for the assembly of the detector. The Assembly Area is adjacent to the at-grade Service Building and is served by a 10 ton capacity overhead bridge crane. The NOνA detector is assembled from right to left in Figures 9.21 and 9.22, and the Assembly Area is sized to accommodate the apparatus required to assemble the detector. This equipment includes a block assembly device, adhesive dispenser and related support devices described in Chapter 17. This assembly apparatus requires approximately 66 feet (20 meters) of floor space north of the detector face being assembled.

A subsurface investigation [1] has indicated that the top of that the site has 5 – 15 feet of soil overburden on top of granite to a depth of at least 60 feet. Based on these conditions, the walls of the Detector Enclosure and Assembly Area have been designed to be cast-in-place concrete tied to the rock below. This system provides a uniform surface suitable for treatment and use as a secondary containment for the liquid scintillator.

The roof of the Detector Enclosure is designed as a composite structural member consisting of a 2.5 feet precast concrete plank that spans the width of the Detector Enclosure capped with a 1.5 feet depth of cast-in-place concrete. Once cured, this composite structural member will be topped with insulation, roof membrane and 0.5 feet of loose barite roof ballast. The precast plank will serve as the finished ceiling of the Detector Enclosure as well as the formwork for the cast-in-place concrete.

The above grade portion of the Assembly Area is designed as a pre-engineered portion of the adjacent at-grade Service Building.

The Assembly Area requires strict environmental control. The requirements are a range of temperature that is +/- 5 degrees Fahrenheit for a 20% delta relative humidity range or no variance in space temperature at 35% delta relative humidity range. The design assumes a summer temperature set point of 70 degrees +/- 5 degrees Fahrenheit at 50% relative humidity and a winter temperature set point of 70 degrees +/- 5 degrees Fahrenheit at 15% relative humidity. In addition, the adhesive used to assemble the detector requires a unit capable of providing conditioned 100% outside air.

The Detector Enclosure requires a stable environment for the normal operation of the detector. The design assumes a summer temperature set point of 72 degrees +/- 5 degrees Fahrenheit at a relative humidity compatible with a 50 degree Fahrenheit dewpoint and a winter temperature set point of 72 degrees +/- 5 degrees Fahrenheit at 15% minimum relative humidity.

The heating, ventilation and air conditioning (HVAC) systems in the Assembly Area and Detector Enclosure will conform to ASHRAE 90.1, ASHRAE 62 and applicable NFPA requirements and applicable sections of the local codes and ordinances.

Since a portion of the detector will be operational while the remaining detector is being assembled, a temporary wall will be installed to isolate the two conditioned spaces. This wall will be removed during the final stages of detector assembly and reinstalled during gluing operations.

The mechanical systems in the Detector Enclosure and Assembly Area have been designed to support the installation and operation of the detector. The HVAC systems will conform to ASHRAE 90.1, ASHRAE 62 and applicable NFPA requirements and applicable sections of the local codes and ordinances.

The Detector Enclosure will be provided with an automatic water mist fire suppression system installed in accordance with NFPA 11, NFPA 13 and NFPA 16 Fire Alarm systems will be installed in accordance with NFPA 72 To prevent accidental discharge, the activation of the suppression system will occur in a two step process. The first step includes an air sampling system that upon signal of smoke detection will signal an alarm and notify emergency personnel. The second step includes a line type heat detection system that upon heat will signal an alarm, notify emergency personnel, shunt trip the HVAC equipment serving the spaces and activate the fire suppression system. The system has been designed to provide an application rate of per minute per square feet over the detector for a discharge time of 15 minutes. The depth of the below grade areas provide a containment volume sized to hold 100% of the NOνA detector liquid scintillator plus a full discharge of the fire suppression system.

Electrical service to the Detector Enclosure and Assembly Area will provide general house power and lighting for the installation and operation of the detector as well as power for the detector components.

Code required emergency lighting and exit lighting will be provided in the enclosure.

9.4.4 *Access to the Detector*

Access to the sides of the detector is provided by means of a steel framed access system that runs the length of west side of the detector. The design includes four (4) levels of access walkways along the side of the detector. Each level of the system will be accessible from the exit stairs as well as the elevator located on the west side of the Detector Enclosure Figure 9.25 indicates a typical column bay at the catwalk level with the service platform adjacent to detector.

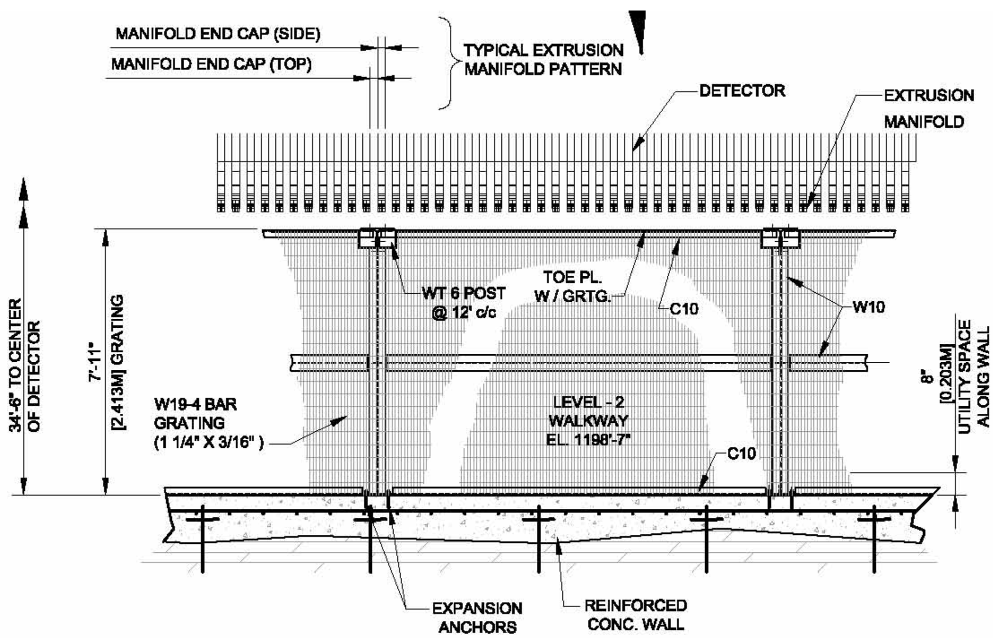

Fig. 9.25: Typical Catwalk bay

Access to the top of the detector is provided by means of two (2) moveable access platforms (MAP) that will span the width of the detector. Access to the MAPs will be from the upper access walkway level. These platforms will serve for the installation of the detector components as well as normal operation of the detector. These platforms, similar in construction to window washing scaffolds will be designed to support up to 1,000 pounds of personnel and equipment [23]. Access to the moveable access platforms will be by way of gated openings in the handrail along the inner edges of the upper catwalks. These openings will be spaced at approximately 50 feet (15.25 meters).

The uppermost access walkway (elevation 1236'-6") will provide space for the majority of equipment used to support detector operations. This equipment includes electronic racks, chillers, data connections as well as associated piping and cable trays.

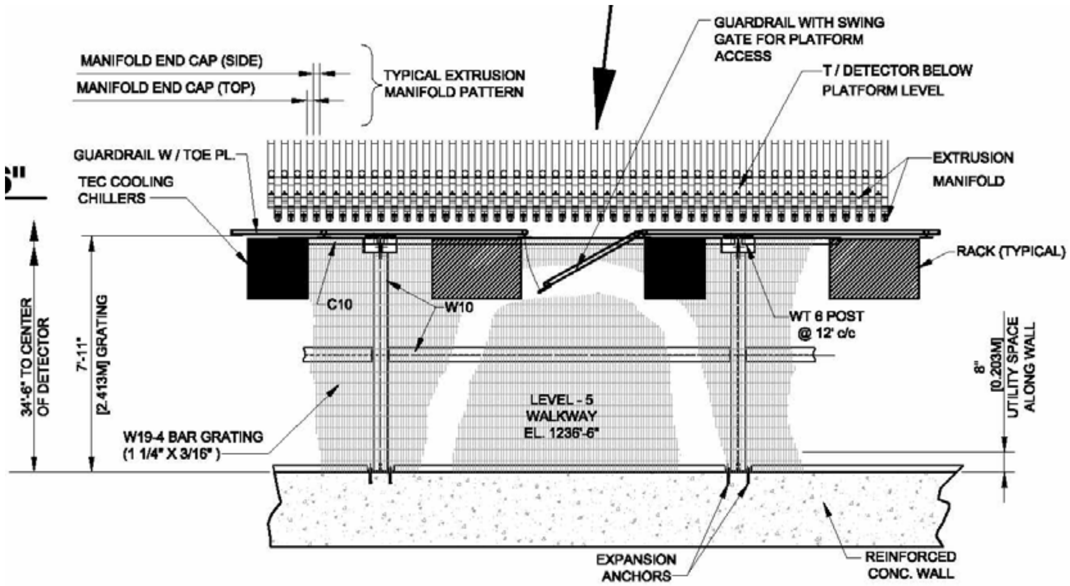

Fig. 9.26: Typical Upper Level Access Walkway Bay

9.4.5 Detector Enclosure Support Spaces

Adjacent to the Detector Enclosure are the support spaces requiring close proximity to the detector components. These spaces include the Control Room, Computer Room and Electrical Equipment Room. These spaces are constructed of cast-in-place concrete and contained within the shielding overburden.

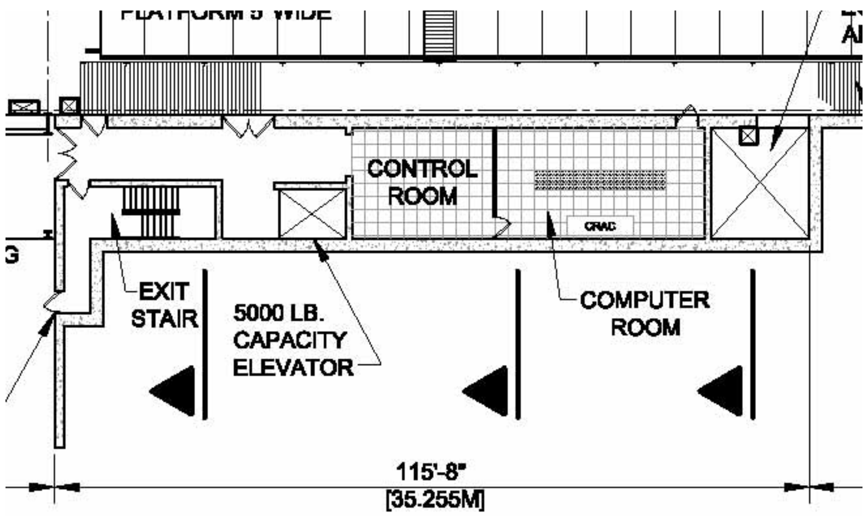

Figure 9.27: Floor Plan of Computer Room and Control Room

The Computer Room (32' long by 15' wide) will provide space for six (6) computer racks of up to 8 kW each and related equipment. For the purposes of this TDR the following computing node criteria was used for developing the space:

- A computing node has an electrical draw of 2.4 amps per node at 120 volts;
- A typical rack will hold up to 40 nodes, but will not exceed 8 kW/Rack;
- A typical rack requires five (5) 30 amp electrical circuits;
- One (1) 120v convenience outlet is required for each rack;
- A typical rack requires a floor area of 2'x3'-0";
- The operating temperature of the computing rooms is 70 degrees Fahrenheit (+/- 5 degrees);
- 40%-45% relative humidity is required;
- Standard filtration is acceptable
- Uninterruptible Power Supplies (UPS) for a total 10 kW will be needed in the Computer Room;

The above requirement describes the current computing technology used in recent computing facilities at Fermilab. As the technology continues to evolve different computer configurations and power factors will likely be employed to respond to the physic requirements. While the Computer Room will be provided with the power and cooling infrastructure to serve the known requirements, it will be possible to reconfigure the space to meet the future needs as long as the upper limits of electrical power and cooling capacity are not exceeded.

The anticipated computing Uninterruptible Power Supply (UPS) load for the Computer Room is 10 kW. A 15 kVA/12 kW system will provide approximately 10 minutes of battery backup for the computing equipment. This will allow an orderly shutdown of the computer equipment in the event of an unscheduled power disruption. The UPS system including batteries will be located in the Electrical Equipment Room.

The cooling for the Computer Room will be accomplished through a Computer Room Air Conditioning (CRAC) Unit discharging into a common below-floor plenum. The system will utilize high volume airflow tiles to create a "cold aisle" on one side of the computer racks. A corresponding "hot aisle" on the opposite side of the computer racks will collect the hot air and route it to the ceiling for return to the CRAC units. This arrangement will allow for reconfiguration of the computers if needed. The volume of air moved in this scenario requires a 2'-0 high raised access floor. Computer Site Engineering notes this system as a best practice for providing reliable cooling for server farms [24].

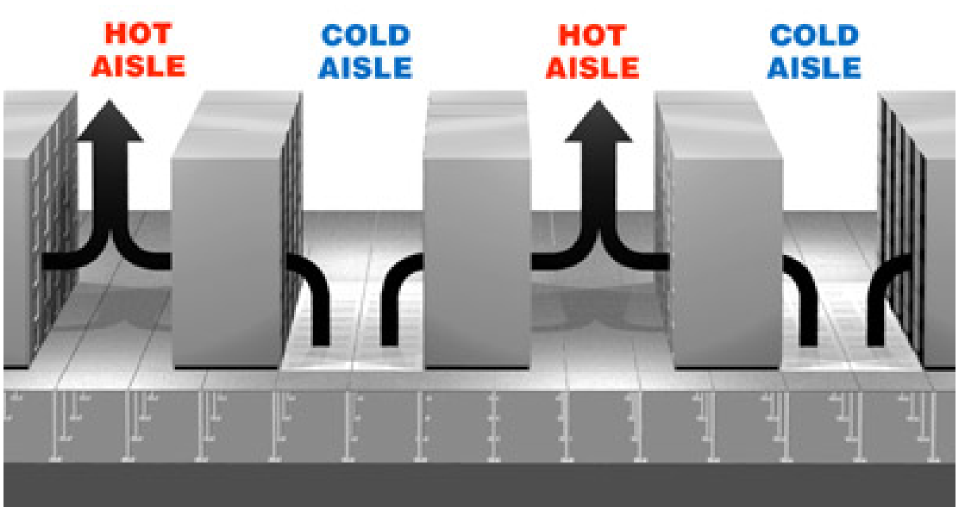

Figure 9.28 : Computer Room Cooling Strategy

One (1) 30 Ton CRAC unit will be installed in the Computer Room. The unit will be air-cooled, downflow, compressorized systems. This will provide cooling for approximately 78 kW of heat load. The unit will discharge the cooled air beneath the raised access floor for distribution throughout the room. Return heated air will be taken from the ceiling space. The matching remote air-cooled condenser unit will be located west of the building on a cast-in-place concrete slab to facilitate maintenance. The CRAC unit will be monitored by a Liebert SiteLink system.

The Computer Room will have a raised access floor system with a 2'-0" clear height to provide plenum space. This floor system will be at the same elevation as the adjacent floor areas to eliminate ramping for access to the space. The roof structure will remain exposed. This will provide a 12'-8" floor-to-ceiling height.

The raised access floor in the Computer Room will have under floor fire detection system. Sprinklers will be installed beneath the roof structure to protect the room.

Adjacent to the Computer Room will be the Control Room. The Control Room (27' long by 15' wide) will provide space for monitoring and operation of the detector. Space for four workstations and a conference table have been provided. The Control Room will be similar in construction type to the Computer Room and has been designed to allow for expansion of the Computer Room should the need arise.

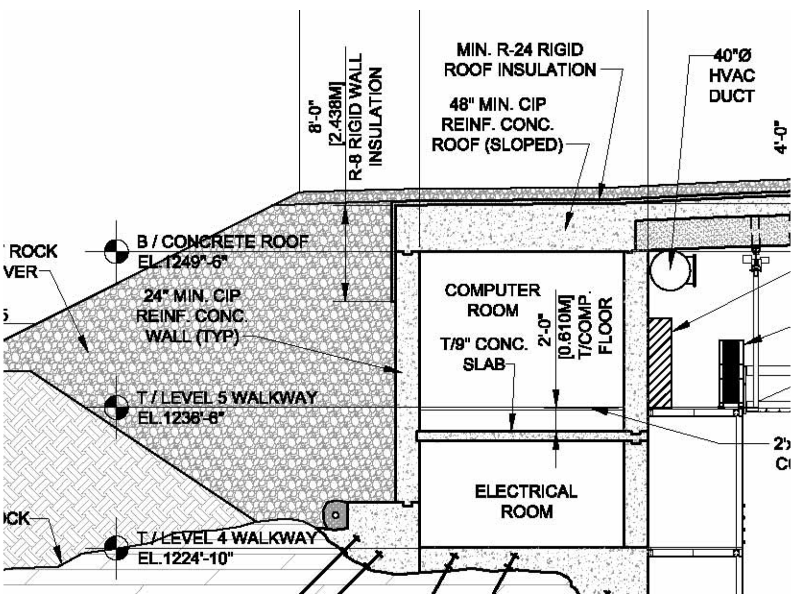

Figure 9.29: Section showing relation of Computer Room and Electrical Equipment Room to Detector Enclosure

The Computer Room and Control Room are located off the 1236'-6"Level access walkway with access to the exit stair and elevator. This will allow ease of access to the detector components located on the 1236'-6" walkway and reduce cable lengths for the experimental equipment.

Beneath the Computer Room/Control Room is the Electrical Equipment Room. The Electrical Equipment Room (72' long by 16' wide) will house the switchgear required for incoming electrical service, transfer switches, and related equipment. The Electrical Equipment Room will incorporate space for incoming telephone/data communication service equipment. This equipment will consist of space adequate for two (2) computer racks and associated equipment and has been sized based on input from the local telecommunication company [25].

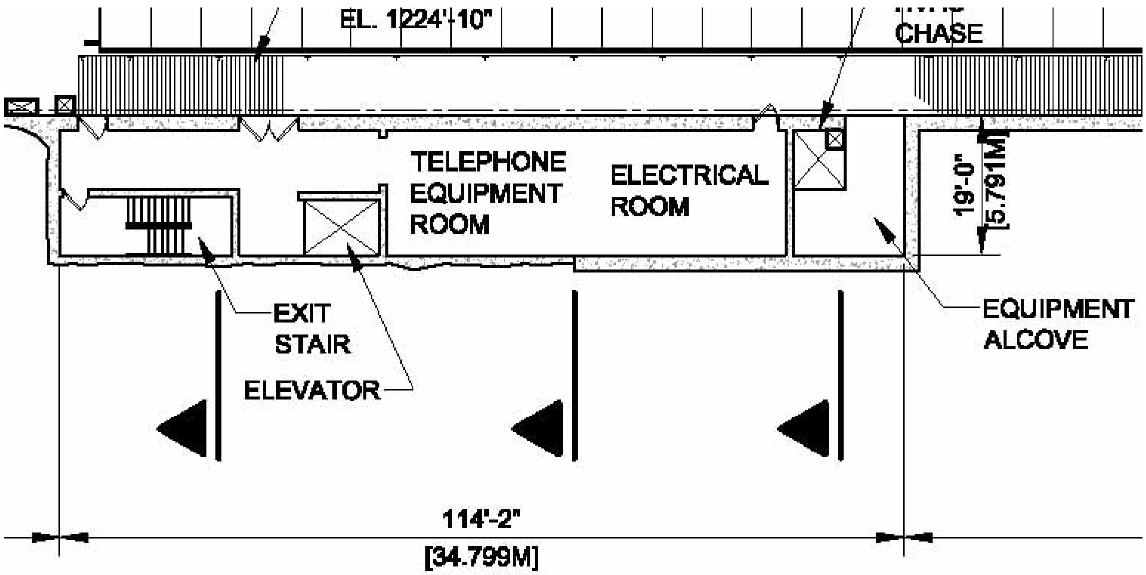

Figure 9.30: Floor Plan of Electrical Equipment Room at Grade

The design includes the provision for standby and emergency generators for the critical systems in the building. The design includes two (2) 125 kvA emergency generators. One generator will provide emergency power for life safety systems while the other will power elevators, sump pumps and building heating. These generators will be housed in Generator Rooms adjacent to the at-grade entry to the Detector Enclosure. These generators will use propane as a fuel source. The power will be brought into the Electrical Equipment Room via a new concrete encased power duct bank. The duct bank will be routed to reduce the future impact on utilities.

9.4.6 At Grade Areas

The at grade portion of the facility consists of a Service Building (121’-6”long by 71’-0” wide) that houses support spaces required to deliver, assemble and operate the Far Detector. Figure 9.31 below indicates the floor plan of the Service Building.

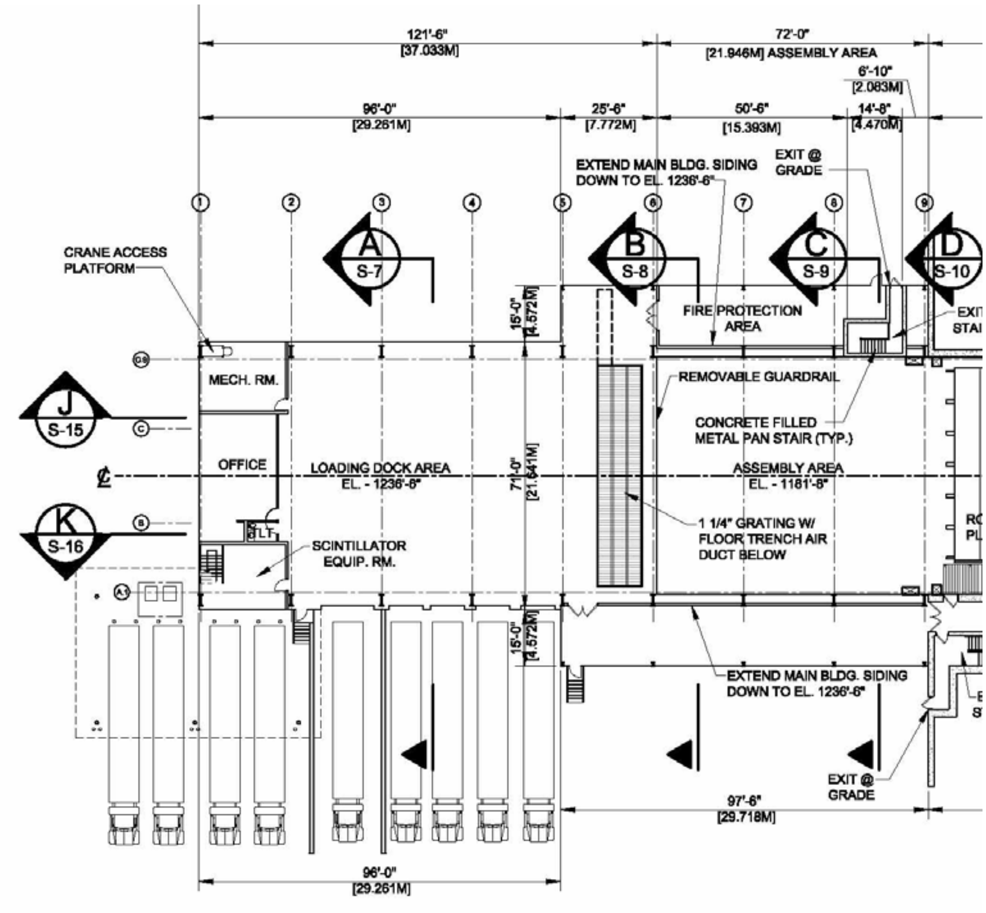

Figure 9.31: Service Building Floor Plan

The Service Building spaces can be broken down into five (5) main areas as described below.

The Loading Dock Area has been designed to accommodate deliveries of detector components, liquid scintillator and related materials. The Loading Dock Area will have four (4) dock locations for recessed loading dock along the west side and one (1) dock at-grade to allow trailers to be located inside the building and underneath the coverage of the overhead cranes. The requirements for the Loading Dock Area have been taken from technical requirements provided by the WBS 2.9 group [26]. The design solution includes a floor level of the Service Building that is four (4) feet above grade to accommodate trailer beds without a recessed dock system. These overhead door locations will be equipped with dock levelers and weather seals. The one (1) loading dock station that requires that the trailer be located inside the building will be equipped with a ramp so that a trailer can be backed into the Loading Dock and underneath crane coverage.

Adjacent to the Loading Dock Area is the Scintillator Equipment Room. This room is based on the requirements from the WBS 2.9 group [27] and includes space for pumps, inspection testing equipment, piping and related scintillator distribution equipment. Located exterior and adjacent to the Scintillator Equipment Room is a concrete pad designed for heating and cooling equipment for the scintillator. West of the Scintillator Equipment Room is a Scintillator Unloading Area sized to handle four (4) tanker trailers. The trailers will be located within a concrete containment area similar in construction to those found at gasoline fueling stations. Spills will be routed to a collection basin for removal. A canopy will cover the rear half of the trailers. A walkway system on top of the canopy will allow for access to the vent piping that will be connected to the trailers.

An Office area will provide space for support of detector assembly as well as normal facility operations. This space is sized for two (2) semi-private offices and five (5) visitor offices will be provided along with a small lunchroom and adjacent toilet facility. It is recognized that the initial arrangement will likely be configured for use during detector assembly (lunch tables, lockers, etc.) and be reconfigured for normal operations at some later date.

A Mechanical Room will house water service equipment including pumps, pressure tanks, conditioning equipment and related pumps and piping. This room will include space for building automation functions. A Janitor's Closet will also be located in the Mechanical Room.

At the east side of the Service Building, adjacent to the Assembly Area will be the Fire Protection Area. The Fire Protection Area will house the diesel fire pump, valving, water storage tanks and related equipment for the fire suppression system for the building. This space will be located in a one-store wing of the Service Building to take advantage of the central location in the building as well as the at-grade elevation.

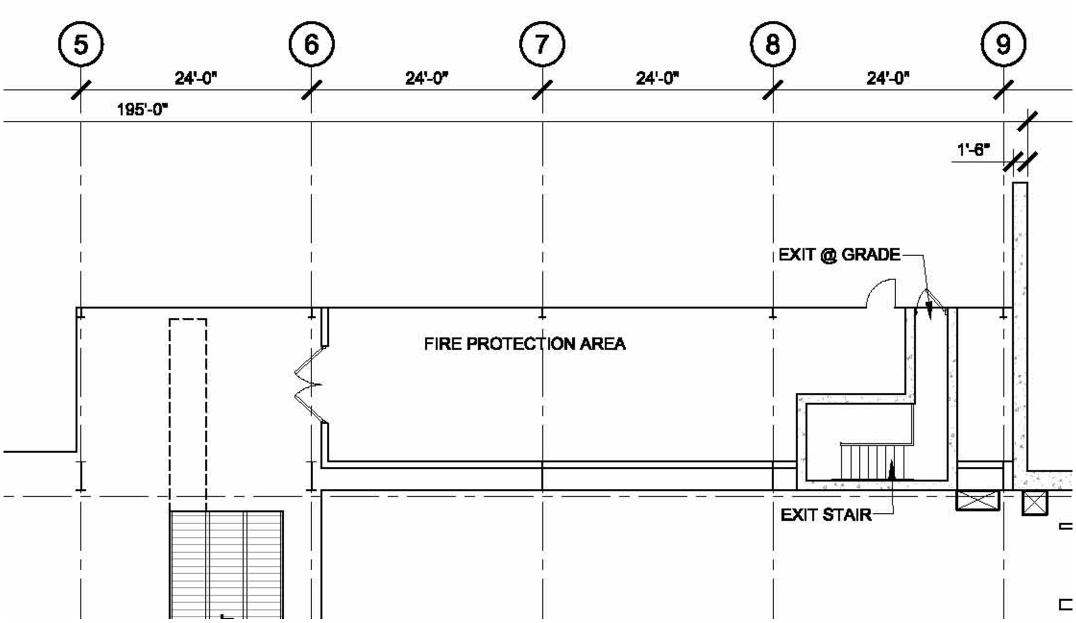

Figure 9.32: Plan at Service Building indicating location of the Fire Protection Area.

The Service Building will contain two (2) overhead bridge cranes. One bridge crane will be sized at 10 tons and will be used primarily for module handling. The second bridge crane will be sized at 10 tons and will be used for transport of the block assembly device components in addition to the module handling. Both cranes will be supported by the Service Building structure.

The Service Building shell will consist of a pre-engineered steel building based on manufacturer's standard components. This includes prefinished metal siding and roofing materials, vinyl faced batt insulation, doors and windows. Figure 9.33 below depicts the west elevation of the Service Building.

Figure 9.33: West Service Building Elevation

The Loading Dock Area of the Service Building requires strict environmental control. The requirements are a range of temperature that is +/- 5 degrees Fahrenheit for a 20% delta relative humidity range or no variance in space temperature at 35% delta relative humidity range. The design assumes a summer temperature set point of 70 degrees +/- 5 degrees Fahrenheit at 50% relative humidity and a winter temperature set point of 70 degrees +/- 5 degrees Fahrenheit at 15% relative humidity. In addition, the adhesive used to assemble the detector requires a unit capable of providing conditioned 100% outside air.

The HVAC systems in the Service Building will conform to ASHRAE 90.1, ASHRAE 62 and applicable NFPA requirements and applicable sections of the local codes and ordinances.

The Office area of the Service Building will be conditioned to provide a 75 degrees +/- 5 degrees Fahrenheit at 55% relative humidity and a winter temperature set point of 68 degrees +/- 5 degrees Fahrenheit with no relative humidity requirement. The outdoor air requirements are based on a normal operational occupancy of 10 people and are based on ASHRAE 62.

The Service Building will be provided with an automatic sprinkler system installed in accordance with NFPA 13. Fire Alarm systems will be installed in accordance with NFPA 72.

Electrical service to the Service Building and adjacent support spaces will provide general house power and lighting for the installation and operation of the detector as well as power for the overhead cranes.

Code required emergency lighting and exit lighting will be provided in the Service Building.

Parking will be provided for 10 vehicles during assembly of the detector. During normal operations 8 parking spaces are required. These parking spaces will be located along the west side of the building.

9.4.7 Other Design Features

Since the Detector Enclosure and Assembly Area will be located below grade, ground water control has been included in the design. The retaining wall will include provisions for damp proofing to be applied to the exterior face of the walls. Drainage strips ("dimple mats") will be located along the excavated rock face prior to placement of concrete for those walls in rock. These strips will divert accumulations of ground water to an underdrain system that encircles the Assembly Area and Detector Enclosure. Water from these underdrains in the rock will be routed to a sealed ground water sump basin where it will be discharged to the surface away from the enclosure. For those underdrains located at the rock/soil interface it is anticipated that the drains will be extended to daylight in order to provide a drainage system that does not rely on mechanical means to remove the groundwater.

The Detector Enclosure and Assembly Area will serve as secondary containment in the event of an unintended spill of scintillator. The volume has been sized to contain a 100% spill of the scintillator and a full discharge of the fire suppression system. The interior walls and floor of these spaces will be sealed. A separate collection basin will be installed for the interior portion of the Detector Enclosure and Assembly Area. This basin along with a perimeter trench drain will serve as the collection system for unexpected scintillator leaks from the detector. In addition, the space beneath the detector will be used as a collection system, in effect making the space a "witness zone" for the area beneath the detector. The collection basin will be outfitted with alarms that signal the presence of scintillator. No automated means of emptying the basins will be installed in order to prevent an unintended discharge of scintillator into the environment.

9.4.8 Design Changes in the Far Detector Building since the Conceptual Design Report

The design of the Far Detector Building has been revised significantly since the CDR was completed. These changes reflect the state of the knowledge of the site and physics driven requirements. In general, each component was investigated for possible reduction in size, scope and cost.

The most significant change in the design since the CDR stage was the decision to reduce the maximum size of the detector to 18 kilotons. This resulted in a shorter Detector Enclosure. In addition, the support functions previously housed in a Loading Dock building and Service Building were consolidated into one simple Service Building design.

In support of the EAW updating and to prepare a U.S. Army Corps of Engineers Wetland permit, a detailed delineation of the wetlands was accomplished by Short Elliot Hendrickson in the summer of 2006. The development of the permit application was prepared and submitted for review in April 2007.

In December 2006, a Storm Water Pollution Prevention Plan (SWPPP) was prepared by Burns and McDonnell as part of the development of the Site Preparation package. This living document contains the information needed to comply with applicable ordinances, codes and regulations concerning storm water management. This work was accomplished to address environmental safety and health concerns during construction.

A detailed topographic survey of the access road and project site was completed by Hanson Professional Services in the spring of 2006. This survey documented the ground features to produce one foot contours. This work was accomplished to mitigate an identified risk associated with unknown topographic conditions as documented in NOVA-doc-1457.

In the spring of 2006, the firm of Burns and McDonnell was retained to complete an independent cost and schedule review of the CDR design. This study indicated that the estimated cost of the site and building were greater than the in-house estimate completed for the CDR. The project team reconciled the two estimates and undertook a value management exercise to control the costs. The schedule component of the review indicated that a two year construction period was reasonable.

In order to provide a better understanding of the subsurface conditions along the access road and project site, the firm of Short Elliot and Hendrickson was retained in the summer of 2006 to perform a subsurface investigation. This investigation included a comprehensive program of field work of soil borings, rock borings, pump test and packer tests as well as lab work required analysis and document the conditions. In addition, a 3D resistivity survey was completed of the area around the Far Detector Building site for the purpose of mapping bedrock fracture zones.

The orientation and location of the building was changed to accommodate site conditions. The CDR design incorporated the Loading Dock and Service Building functions at the south end of the building. The current design has placed these functions at the north end of the building in response to recommendations in the Environmental Assessment Worksheet to provide at least a 1,000 foot buffer between the development footprint and the Ash River to the south.

The cosmic ray shielding strategy is the most significant change to the Detector Enclosure Design. The use of conventional precast concrete planks and cast-in-place concrete resulted in a minimization of the use of barite material.

As a result of the Burns and McDonnell Secondary Containment study and input from the design of the block raiser, the floor of the Assembly Area and Detector Enclosure has been designed as a "witness zone" to verify the viability of the secondary containment method.

Additional research on fire suppression systems indicated that a water mist fire suppression system would allow for a reduction in the quantity of water required for the system. Selection of an alternate method allowed the on-site water storage to be reduced from 500,000 gallons to 2,000 gallons.

9.4.9 Work Remaining to Complete the Far Detector Building Design

The overall design of the Far Detector Building is approximately 45% complete with the concrete design work approaching 55% complete. The work remaining generally includes completing the construction documents to a point where they are ready for competitive bidding. This effort will include continued optimization of the building components in order to achieve the best value solution.

As the design is developed, all aspects of the project will be periodically reviewed with regard to Quality Assurance issues from Conceptual Design through Title III completion. This review process will be completed in accordance with the applicable portions of the Fermilab policies. The following elements will be included in the design and construction effort:

- An identification of staff assigned to this project with clear definition of responsibility levels and limit of authority as well as delineated lines of communication for exchange of information;
- Requirements for control of design criteria and criteria changes and recording of standards and codes used in the development of the criteria;
- Periodic review of design process, drawings and specification to insure compliance with accepted design criteria;
- Identification of underground utilities and facility interface points prior to the commencement of any construction in affected areas;
- Conformance to procedures regarding project updating and compliance with the approved construction schedule;
- Conformance to procedures regarding the review and approval of shop drawings, samples test results and other required submittals;
- Conformance to procedures for site inspection by project personnel to record construction progress and adherence to the approved contract documents;
- Verification of project completion, satisfactory system start-up and final project acceptance.

While the design of the conventional facilities has progressed to a point where a cost and schedule range can be estimated, the design requires iteration with the other Level 2 tasks to respond to an evolving detector design. This process will continue throughout the Title 2 design phase.

The conventional facilities are seen as a significant cost and schedule driver for the project. Increased costs and/or schedule slippage has the potential to negatively impact the overall project. Prior to commencing the design portion of the Title 1 effort, the design firm completed a cost and schedule review of the revised design. This cost estimate/schedule served as the touchstone throughout the Title 1 phase. Changes and modifications to the design that impact the cost and/or schedule were tracked and evaluated prior to being incorporated into the design. The goal of this effort was to raise the awareness of the importance of the cost and schedule. As part of the Title 2 Design Process this tracking will continue.

The project team will continue to evaluate the site and building for incorporation of appropriate safeguard and securities measures. The assembled detector will be located within the concrete encased Detector Enclosure and be relatively secure, but the Loading Dock and truck dock areas are a point of vulnerability. Security measures like berms, fencing, gates, and card readers on doors are being considered.

While several value management design changes have been incorporated into the design since the CDR, the project team is committed to investigating additional value analysis possibilities. These include a “cut and fill” study to balance the amount of excavated material with the volume of the overburden, and a detector enclosure length study that will examine the implications of the depth of the detector enclosure. In addition, the mechanical systems are being investigated to determine a cost effective solution that provides the best life-cycle solution.

9.5 Chapter 9 References

[1] See NOVA-doc-1881 for the Basis of Estimate for the Northstar Electric electrical service upgrade

[2] See NOVA-doc-1914 for the Basis of Estimate for the data and communication service upgrade to the project site from Blackduck Telephone Company.

[3] Bill Miller and Marvin Marshak, NOVA-doc-384, May 2005

[4] NOVA-doc-168 contains the minutes from an informal meeting with the Minnesota Department of Natural Resources in April 2005.

[5] NOVA-doc-830 contains the minutes from a meeting to discuss road alignment issues in April 2006.

[6] NOVA-doc-1424 contains meeting minutes of a presentation to stakeholders in Orr, Minnesota in February 2007.

[7] For a complete Environmental Assessment Worksheet see NOVA-doc-205. The Cultural Resources Assessment done in conjunction with the Environmental Assessment Worksheet can be found in NOVA-doc-1834.

[8] The wetland delineation and permit application can be found in NOVA-doc1892.

[9] The Stormwater Pollution Prevention Plan can be found in NOVA-doc-1324.

[10] The topographic survey information from Hanson Professional Services can be found in NOVA-doc-1450.

[11] NOVA-doc-1458 contains the risk assessment and mitigation methods for the subsurface conditions at the Ash River Site.

[12] The Short Elliot Hendrickson Geotechnical Engineering Report is located in NOVA-doc-1225.

[13] The Geophysical Investigation Report is located in NOVA-doc-1225.

[14] For a complete Environmental Assessment Worksheet see NOVA-doc-205.

[15] The Site Preparation documents prepared by Burns and McDonnell can be found in NOVA-doc1207.

[16] The trip report from the April 2006 meeting can be found in NOVA-doc-830.

[17] The preliminary Leadership in Environmental Engineering Design (LEED) checklist was completed by the project team in December 2006 and can be found in NOVA-doc-1318.

[18] The WBS Responsibility Matrix that delineates the interfaces and responsibilities for the WBS groups can be found in NOVA-doc-1170.

[19] The presentation for the University of Minnesota in December 2005 can be found in NOVA-doc-390. The presentation held in December 2006 can be found in NOVA-doc-1289.

[20] The review information for the Comment and Compliance Review held in November 2006 can be found in NOVA-doc-1207-v4. The review information for the Quality Assurance Review held in January 2007 can be found in NOVA-doc-1207-v7.

[21] NOVA-doc-1094 contains the risk description and cosmic ray overburden requirements that were used as the basis of design. NOVA-doc-1409 contains additional information.

[22] Two documents concerning secondary containment are available in the document database. NOVA-doc-1460 contains the risk assessment form for the secondary containment. NOVA-doc-1021 contains the report of secondary containment methods produced by Burns and McDonnell in September 2006.

[23] The requirements for the moveable access platforms are taken from NOVA-doc-1155 produced by WBS 2.9.

[24] NOVA-doc-1974 contains the Best Practices paper by ComputerSite Engineering titled "Alternating Cold and Hot Aisles Provides More Reliable Cooling for Server Farms".

[25] The trip report for the February 2007 meeting in Orr, Minnesota can be found in NOVA-doc-1424.

[26] The Loading Dock requirements developed by WBS 2.9 can be found in NOVA-doc-1433.
[27] The requirements for the Scintillator Transfer Facility can be found in NOVA-doc-1921.