Long-Baseline Neutrino Experiment (LBNE) Project Conceptual Design Report

Volume 5: Conventional Facilities at the Near Site

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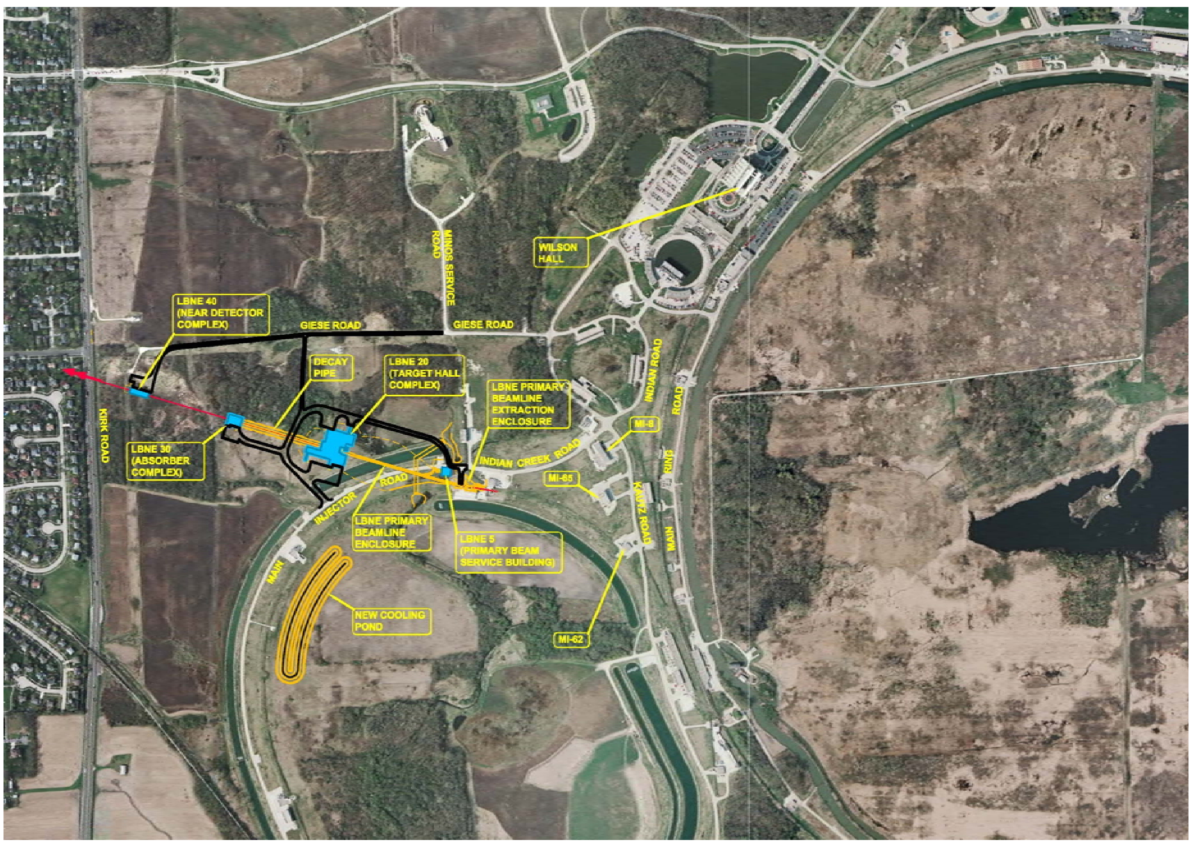

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Acronyms and Abbreviations

A	amps
AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
ADAAG	Americans with Disabilities Act Accessibility Guidelines
AHJ	Authority Having Jurisdiction
AHR	Air Handling Room
AHU	Air Handling Unit
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning
CAMs	Control Account Managers
CD	Critical Decision (CD-0, CD-1, etc)
CDR	Conceptual Design Report
CF	Conventional Facilities (Civil design and construction)
cfm	cubic feet per minute
CHW	Chilled Water
DocDB	Document Data Base (LBNE-doc-####)
DOE	Department of Energy
DUSEL	Deep Underground Science and Engineering Laboratory
DWS	Domestic Water Service
EA	Environmental Assessment
EDIA	Engineering, Design, Inspection, Administration
ED&I	Engineering, Design, and Inspection
EENF	Environmental Evaluation Notification Form
ES&H	Environment, Safety, and Health
ft	feet
ft^2	square feet
FEMA	Federal Emergency Management Agency
Fermilab	Fermi National Accelerator Laboratory
FESS	Facilities Engineering Services Section (at Fermilab)
FIRUS	Facilities Information Reporting Utility System
FLS	Fire Life Safety
FNAL	Fermi National Accelerator Laboratory
FONSI	Finding of No Significant Impact
GCL	Geosynthetic clay liner
gpm	gallons per minute
gsf	gross square feet
HEPA	High Efficiency Particle Arrestor
hp	Horse Power
HVAC	heating ventilating and air conditioning
HW	Hot Water
ICW	Industrial Cooling Water
kV	kilo (1000) volts

kVA	kilo volt amps (or kilowatt, electrical power)
kw	kilowatt
KRS	Kautz Road Substation
LEED	Leadership for Energy Efficient Design
LANL	Los Alamos National Laboratory
LAr	Liquid Argon
LBNE	Long-Baseline Neutrino Experiment
lf	lineal feet
LCW	Low Conductivity Water
m	meter
MEP	Mechanical, Electrical, and Plumbing
MI	Main Injector
MSL	mean sea level
MSS	Master Substation
MVA	Mega Volt Amps
n+1	The required number of units (n) plus one additional unit
ND	Neutrino Detector
NEC	National Electric Code
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
NSSF	Near Surface Storage Facility
NuMI	Neutrinos at Main Injector (Experiment at Fermilab)
ODH	Oxygen Depletion Hazard
ORNL	Oak Ridge National Laboratory
P5	Particle Physics Project Prioritization Panel
PDR	Preliminary Design Report (DUSEL)
plf	Pounds per Linear Foot
psf	Pounds per Square Foot
RAW	Radioactive Water
RH	Relative Humidity
sf	square feet
SMACNA	Sheet Metal and Air Conditioning Contractors Association
SR3	survey riser 3
STA (Sta.)	Station (100’) (e.g. STA 20+52 = 2052’ from start (STA 0+00))
T	tons
UFAS	Uniform Federal Accessibility Standards
UPS	Uninterruptable Power Supply
WBS	Work Breakdowns Structure
WCD	water Cherenkov detector
Wg	Water Gage

Definitions

STA or Station is a Civil Engineering/ Land Surveying term used to describe a distance of 100 foot increments, or portions thereof from STA 0+00 or the starting point along a line or alignment. It is used as an address or location for design and construction layout.

Some examples:

STA 1+00, which means 100 feet, from Station 0+00 which is typically used as the starting point,

STA 1+50 means 150 feet from Station 0+00

STA -2+38.8 is a distance of 238.8 feet before or upstream of Station 0+00

STA 12+47, 35’ LT is a distance along the line and an offset from the line, i.e.,1247’ from Station 0+00 and 35’ left (LT) of the line or alignment while facing down station.

Beam-Off: This refers to access to a facility, room, tunnel, etc., (area). If the area is called out as beam-off, it means that access to that area is restricted by an interlock system and one can only access when the proton beam is off. In an emergency situation, if access is required into/thru a beam-off area then the interlock door is opened, the beam shuts off and emergency access is allowed/available.

Beam-On: This means access to an area that is called out as beam-on is allowed when the proton beam is on.

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1 Introduction

1.1 Introduction to LBNE

The Long-Baseline Neutrino Experiment (LBNE) Project team has prepared this Conceptual Design Report (CDR) which describes a world-class facility to enable a compelling research program in neutrino physics. The ultimate goal in the operation of the facility and experimental program is to measure fundamental physical parameters, explore physics beyond the Standard Model and better elucidate the nature of matter and antimatter.

Although the Standard Model of particle physics presents a remarkably accurate description of the elementary particles and their interactions, scientists know that the current model is incomplete and that a more fundamental underlying theory must exist. Results from the last decade, revealing that the three known types of neutrinos have nonzero mass, mix with one another and oscillate between generations, point to physics beyond the Standard Model. Measuring the mass and other properties of neutrinos is fundamental to understanding the deeper, underlying theory and will profoundly shape our understanding of the evolution of the universe.

1.1.1 About this Conceptual Design Report

The LBNE Conceptual Design Report (CDR) is intended to describe, at a conceptual level, the scope and design of the experimental and conventional facilities that the LBNE Project plans to build to address a defined set of neutrino-physics measurement objectives. At this Conceptual Design stage The LBNE project presents a Reference Design for all of the planned components and facilities, and alternative designs that are still under consideration for particular elements. The scope includes:

- an intense neutrino beam aimed at a far site
- a near detector complex located at the near site just downstream of the neutrino source
- a massive neutrino detector located at the far site
- construction of facilities at both the near and far sites

The selected Near and Far Sites are the Fermi National Accelerator Laboratory (Fermilab) in Batavia, IL and the Sanford Underground Laboratory at Homestake (Sanford Laboratory), respectively. The latter is the site of the formerly proposed Deep Underground Science and Engineering Laboratory (DUSEL) in Lead, SD.

This CDR is organized into six stand-alone volumes, one to describe the overall LBNE Project and one for each of its component subprojects:

Volume 1: The LBNE Project

Volume 2: The Beamline at the Near Site

Volume 3: Detectors at the Near Site

Volume 4: The Liquid Argon Detector at the Far Site

Volume 5: Conventional Facilities at the Near Site

Volume 6: Conventional Facilities at the Far Site

Volume 1 is intended to provide readers of varying backgrounds an introduction to LBNE and to the following volumes of this CDR. It contains high-level information and refers the reader to topic-specific volumes and supporting documents, listed in Section 1.1.5. Each of the other volumes contains a common, brief introduction to the overall LBNE Project, an introduction to the individual subproject, and a detailed description of its conceptual design.

1.1.2 LBNE and the U.S. Neutrino-Physics Program

In its 2008 report, the Particle Physics Project Prioritization Panel (P5) recommended a world-class neutrino-physics program as a core component of the U.S. particle physics program [1]. Included in the report is the long-term vision of a large detector at the Sanford Laboratory and a high-intensity neutrino source at Fermilab.

On January 8, 2010, the Department of Energy (DOE) approved the Mission Need for a new long-baseline neutrino experiment that would enable this world-class program and firmly establish the U.S. as the leader in neutrino science. The LBNE Project is designed to meet this Mission Need.

With the facilities provided by the LBNE Project, the LBNE Science Collaboration proposes to mount a broad attack on the science of neutrinos with sensitivity to all known parameters in a single experiment. The focus of the program will be the explicit demonstration of leptonic CP violation, if it exists, by precisely measuring the asymmetric oscillations of muon-type neutrinos and antineutrinos into electron-type neutrinos and antineutrinos.

The experiment will result in the most precise measurements of the three-flavor neutrino-oscillation parameters over a very long baseline and a wide range of neutrino energies, in particular, the CP-violating phase in the three-flavor framework. The unique features of the experiment – the long baseline, the broad-band beam, and the high resolution of the detector – will enable the search for new physics that manifests itself as deviations from the expected three-flavor neutrino-oscillation model.

The configuration of the LBNE facility, in which a large neutrino detector is located deep underground, could also provide opportunities for research in other areas of physics, such as nucleon decay and neutrino astrophysics, including studies of neutrino bursts from supernovae occurring in our galaxy. The scientific goals and capabilities of LBNE are outlined in Volume 1 of this CDR and described fully in the LBNE Case Study Report (Liquid Argon TPC Far Detector) [2], and the 2010 Interim report of the Long-Baseline Neutrino Experiment Collaboration Physics Working Groups [3].

1.1.3 LBNE Project Organization

The LBNE Project Office at Fermilab is headed by the Project Manager and assisted by the Project Engineer, Project Systems Engineer, and Project Scientist. Project Office support staff include a Project Controls Manager and supporting staff, a Financial Manager, an Environment, Safety and Health (ES&H) Manager, a Computing Coordinator, Quality Assurance and Risk Managers, a documentation team and administrative support.

The Beamline, Liquid Argon Far Detector and Conventional Facilities subprojects are managed by the Project Office at Fermilab, while the Near Detector Complex subproject is managed by a Project Office at Los Alamos National Laboratory.

More information on Project Organization can be found in Volume 1 of this CDR. A full description of LBNE Project management is contained in the LBNE Project Management Plan [4].

1.1.4 Principal Parameters of the LBNE Project

The principal parameters of the major Project elements are given in Table 1-1.

Table 1-1: LBNE Principal Parameters.

Project Element Parameter	**Value**
Near- to Far-Site Baseline	1,300 km
Primary Beam Power	708 kW, upgradable to 2.3 MW
Protons on Target per Year	6.5×10^{20}
Primary Beam Energy	60–120 GeV (tunable)
Primary Beam Type	Horn-focused with decay volume
Neutrino Beam Energy Range	0.5–5 GeV
Neutrino Beam Decay Pipe Diameter x Length	4 m × 200 m
Near Site Neutrino Detector Type	Liquid Argon Time Projection Chamber (LArTPC) Tracker
Near Site Neutrino Detector Active Mass	18 ton
Far Detector Type	LArTPC
Far Detector Active (Fiducial Mass)	40 (33) kton
Far Detector Depth	1,480 m

1.1.5 Supporting Documents

A host of information related to the CDR is available in a set of supporting documents. Detailed information on risk analysis and mitigation, value engineering, ES&H, costing, project management and other topics not directly in the design scope can be found in these documents, listed in Table 1-2. Each document is numbered and stored in LBNE's document database, accessible via a username/password combination provided by the Project. Project documents stored in this database are also made available to internal and external review committees through Web sites developed to support individual reviews.

Table 1-2: LBNE CD-1 Documents.

Title	LBNE doc Number(s)
Acquisition Plan	5329
Alternatives Analysis	4382
Case Study Report; Liquid Argon TPC Detector	3600
Configuration Management Plan	5452
DOE Acquisition Strategy for LBNE	5442
Integrated Environment, Safety & Health Management Plan	4514
LAr-FD Preliminary ODH Analysis	2478
Global Science Objectives & Science Requirements, and Traceback Reports	4772
Preliminary Hazard Analysis Report	4513
Preliminary Project Execution Plan	5443
Preliminary Security Vulnerability Assessment Report	4826
Project Management Plan	2453
Project Organization Chart	2248
Quality Assurance Plan	2449
Report on the Depth Requirements for a Massive Detector at Homestake	0034
Requirements, Beamline	4835
Requirements (Parameter Tables), Far Detector	3747 (2843)
Requirements, Far Site Conventional Facilities	4408
Requirements, Near Detectors	5579
Requirements, Near Site Conventional Facilities	5437
Risk Management Plan	5749
Value Engineering Report	3082
Work Breakdown Structure	4219

1.2 Introduction to LBNE Conventional Facilities at the Near Site

The objective of this volume of the Conceptual Design Report (CDR) is to document the Conventional Facilities required to house the Long Baseline Neutrino Experiment (LBNE) on the Fermilab site, which is also referred to as the Near Site. Facilities in this scope of work include the Beamline and Near Detector facilities. The scope discussed in this volume represents the full scope, at a Conceptual Design level, for all Conventional Facilities required to support the Project, but particularly the Beamline and Near Detector designs that are detailed in Volume 2, *The Beamline at the Near Site*, and Volume 3, *Detectors at the Near Site*. A complete discussion on alternative design configurations and options considered during the Concept Design phase is available the *LBNE Alternatives Analysis* [5]. This Conceptual Design effort has been completed in support of obtaining DOE approval for CD-1 and as such, the programmatic requirements described in this volume are developed to a level to support the Conceptual Design milestone of this Project. Further detailed development of all aspects of the design and requirements will be required to support future phases of the project.

The Main Injector (MI) Accelerator is part of the existing Fermilab infrastructure and as discussed in Volume 2, and numerical addresses are used to indicate the points of extraction from the Main Injector. The baseline design for the LBNE Project extracts a proton beam from the MI-10 point of the Main Injector, which then determines the location of the Near Site Neutrino Detector (ND) and supporting Near Site Conventional Facilities. The Near Site Conventional Facilities not only provides the support buildings for the underground facilities, but also provides the infrastructure to house the Beamline and Near Detector technical systems from the extraction point, through the target and absorber to the Near Detector. The required infrastructure is summarized below and detailed in this volume in Chapter 3, *The Facility Layout*, Chapter 4, *New Surface Buildings*, and Chapter 5, *New Underground Structures*.

After the proton beam is extracted at MI-10, about 30 ft below grade, the Beamline will continue along the Primary Beam Enclosure at an incline into and through an embankment constructed of engineered fill which reaches a maximum height of about 70 ft above existing grade. After reaching the apex of the embankment the Beamline declines back toward existing grade and through the Target Hall, a 200–m long Decay Pipe, and the Absorber Hall. Downstream of the Absorber Hall, the Beamline is directed through 690 ft (210 m) of bedrock, allowing muons to range out before the beam enters the Near Detector Hall. Note that alternative lengths of the Decay Pipe up to 250 m long are also under consideration. Figure 1-1 shows a schematic longitudinal section of the entire Near Site, with an exaggerated vertical scale of 3 to 1 to show the entire Project alignment in one illustration. As the beam extraction point from the Main Injector (MI) is near MI-10 Service Building, and the target is above existing grade or shallow, the Project reference design is referred to as LBNE MI-10 Shallow. Other options that were considered are discussed in the *LBNE Alternatives Analysis* [5].

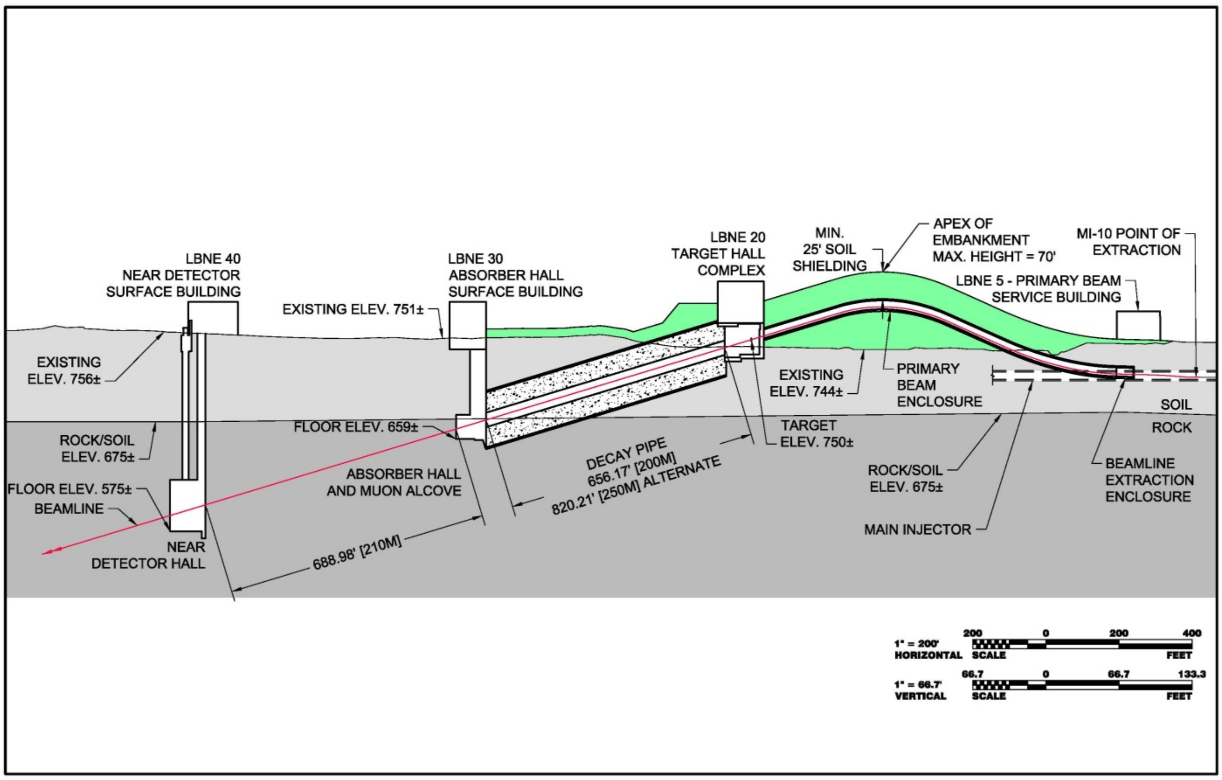

Figure 1-1: LBNE MI-10 Shallow Overall Project schematic longitudinal section view.

Specifically, the beam will travel approximately 1,227 ft (374 m) through the proposed Primary Beam Enclosure to the Target Hall where it interacts with a target and a focusing horn system to create an intense neutrino beam that will be directed through a 656 ft (200 m) long decay pipe through a hadron absorber where the beam will then leave the Absorber Hall and travel 689 ft (210 m) through bedrock to the Near Detector, to range out muons. The beam will then pass through the Near Detector and continue through the earth's mantle directed toward a detector located more than 1,300 km (~808 miles) away at the Sanford Underground Laboratory at Homestake located in Lead, South Dakota. The Sanford Laboratory at Lead is referred to as the Far Site.

The Near Site Conventional Facilities LBNE Project layout at Fermilab, the Near Site, is shown in Figure 1-2. Following the beam from southeast to northwest, or from right to left in Figure 1-2, is the underground Beamline Extraction Enclosure, the underground Primary Beam Enclosure/Pre-target Tunnel and its accompanying surface-based Service Building (LBNE 5), Target Complex (LBNE 20) located in the engineered fill embankment, the Decay Pipe, the underground Absorber Hall and its surface-based Service Building (LBNE 30), and the underground Near Detector Hall and its surface-based Service Building (LBNE 40).

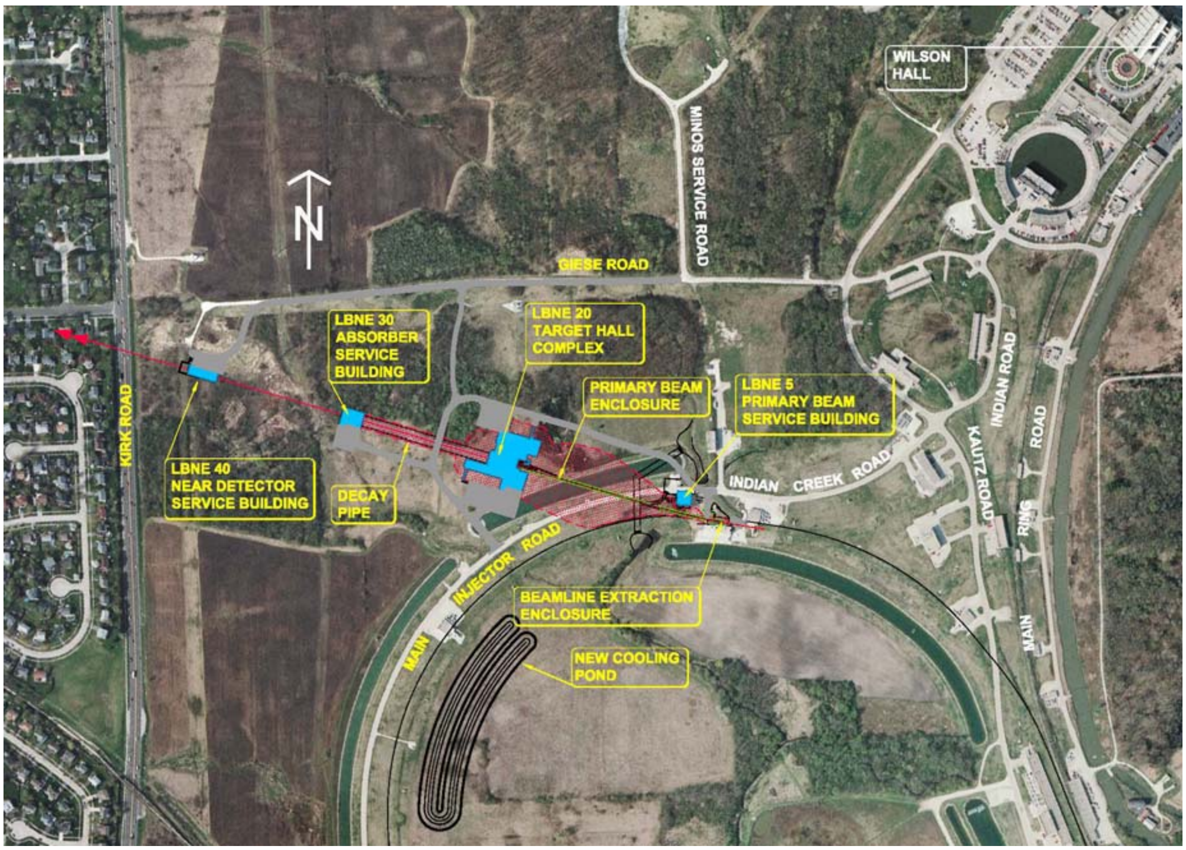

Figure 1-2: LBNE Overall Project Layout at Fermilab. Note figure orientation is shown with North at the top of the image.

1.3 Project Participants

The LBNE Beamline and Near Detector are planned to be located on the Fermilab site, which is managed by the Fermi Research Alliance, LLC. The design and construction of LBNE Near Site Conventional Facilities will be executed in conjunction with the Facility Engineering Services Section (FESS) staff.

The LBNE Project Conventional Facilities is managed by the Work Breakdown Structure (WBS) Level 2 Conventional Facilities Manager. The supporting team includes a WBS Level 3 Manager for Conventional Facilities at Near Site, who is a part of, and works directly with, the FESS engineering staff. The Level 3 Near Site Manager is also the LBNE Project liaison with the Beamline and Near Detector subprojects to ensure the beamline and detector requirements are met and is responsible for all LBNE scope at the Near Site.

The WBS Level 3 Manager for Conventional Facilities at Near Site has, and will continue to oversee multiple engineering design and construction consultants. Design consultants have specific areas of expertise in excavation, rock support, geotechnical engineering, deep foundation, geosynthetic barrier systems, fire/life safety, electrical power distribution, cyberinfrastructure, cooling with chilled water, and heating/ventilation systems. Design consultants for LBNE’s Conceptual Design were: M+W Group Inc. for surface facilities and infrastructure, and W.D. Wightman & Company for rock excavation and ground support.

Interaction between FESS engineers, LBNE Near Site design teams, and design consultants was completed with weekly conferences, periodic design interface workshops, and electronic mail. The WBS Level 3 Manager for Conventional Facilities at Near Site coordinates all information between design consultants to assure that design efforts remain on track.

1.4 Codes and Standards

Conventional Facilities to be constructed at the Near Site shall be design and constructed in conformance with the Fermilab ES&H Manual (FESHM) Chapter 1070, Work Smart Set, revision 8, dated August 2011 (http://esh.fnal.gov/xms/FESHM), but particularly the latest edition of the following codes and standards:

- Applicable Federal Code of Federal Regulations (CFR), Executive Orders, and DOE Requirements
- 2009 International Building Code (IBC)
- “Fire Protection/Life Safety Assessment for the Conceptual Design of the Near Site of the Long Baseline Neutrino Experiment (LBNE)”, a preliminary assessment dated September 9, 2011, by Aon/Schirmer Engineering
- The Occupational Health and Safety Act of 1970 (OSHA)
- NFPA 101, Life Safety Code
- NFPA 520, Standard on Subterranean Spaces, 2005 Edition
- NFPA 72, National Fire Alarm Code
- American Concrete Institute (ACI) 318
- American Institute of Steel Construction Manual, 14th Edition
- ASHRAE 90.1-2007, Energy Standard for Buildings
- ASHRAE 62, Indoor Air Quality

- 2009 National Electrical Code (NEC)
- American Society of Mechanical Engineers (ASME)
- American Society for Testing and Material (ASTM)
- American National Standards Institute (ANSI)
- National Institute of Standards & Technology (NIST)
- Insulated Cable Engineers Association (ICEA)
- Institute of Electrical and Electronics Engineers (IEEE)
- National Electrical Manufacturers Association (NEMA)
- American Society of Plumbing Engineers (ASPE)
- American Water Works Association (AWWA)
- American Society of Sanitary Engineering (ASSE)
- American Gas Association (AGA)
- National Sanitation Foundation (NSF)
- Illinois Plumbing Code
- Standard Specifications for Water and Sewer Main Construction in Illinois, Sixth Addition 2009, issued by the Illinois Society of Professional Engineers
- Federal American's with Disabilities Act (ADA) along with State of Illinois ADA amendments. These requirements shall only be applied to those facilities which are located at the ground surface and accessible to the public.

2 Existing Site Conditions

The LBNE Project area is located in the western portion of the Fermilab site in Batavia, Illinois. The sections below describe the known and anticipated surface conditions at the site and also include site geology, groundwater conditions, and natural gasses.

2.1 Surface Development, Topographic and Environmental Conditions

The site is partially developed with existing surface and underground structures for the support of ongoing research at the laboratory. Existing underground structures include building foundations, buried utilities, shallow tunnels, enclosures constructed by cut-and-cover methods, the associated remnants from previously constructed braced excavation structures, and the existing Neutrinos at Main Injector (NuMI) tunnel which was excavated in the same rock units that LBNE underground enclosures will encounter.

Existing facilities on or adjacent to the Fermilab property that will interface with or constrain the development of the Project are the Main Injector, Kautz Road, Indian Creek Road (also known as the Main Injector Road), the Main Injector Cooling Pond F, and Kirk Road.

The site surface topography is predominantly flat with areas of prairie grass, heavy brush, woodlands, wetlands and developed sites. Surface elevations within the Project area range from about 740 ft to 760 ft above mean sea level (MSL). The topography in the Project area will not be an impediment to the development of the construction sites or the use of standard heavy equipment for underground construction.

2.2 Overview of Site Geology

Subsurface conditions at the Near Site are comprised of glacial, glaciofluvial and glaciolacustrine deposits, along with flat lying bedrock strata of the middle to lower Silurian and upper Ordovician periods. In descending order, the Silurian rock formations include the Markgraf and Brandon Bridge Members of the Joliet Formation, the Kankakee Formation and the Elwood Formation. The upper Ordovician rock formations that will be encountered are the Brainard, Ft. Atkinson and Scales Formations, which collectively make up the Maquoketa Group. The Maquoketa Group is underlain by dolomites of the Galena-Platteville Groups, the uppermost component of which is the Wise Lake Formation. Most or all of these rock units may be encountered in LBNE excavations.

Glacial processes during the Wisconsin glaciation resulted in the deposition of a thick blanket of glacial tills, lacustrine silts and clays, and outwash sands and gravels across the Project area. The total thickness of these overburden sediments in the Project area ranges from about 50 ft to 85 ft. The majority of the sediments are over consolidated glacial till deposits consisting of silt, sand, gravel, cobbles and boulders in a predominantly clay matrix.

The Project area is situated on the eastern flank of a broad structural arch known as the Kankakee Arch, separating the Michigan and Illinois bedrock basins. The rock stratigraphy is composed of a sequence of sedimentary rocks consisting of dolomitic limestone, dolomite, siltstone and shale, ranging in age from Silurian to Ordovician. The tunnels and underground structures for this Project will be excavated in formations of these rock types. The bedrock surface is an erosional unconformity where overlying rocks of the Upper Paleozoic Era have been removed by glaciation. The overall dip of the bedrock strata in this region is around 10 ft to 15 ft per mile to the southeast. Bedrock outcrop exposures are rare, except in quarries (North Aurora and Elmhurst) and river bluffs, as the rock strata are overlain by thick glacial deposits.

The Fermilab site is located in a zone of the central mid-continent that is tectonically stable and a region of very low seismic risk. The closest known earthquake source zones capable of producing ground motions of any significance are located several hundred miles to the south. Active faults are not known to exist in the Project area.

Additional descriptions of subsurface materials, geologic profiles and boring logs along the Near Site Project alignment are provided in the *LBNE Site Investigation Geotechnical Engineering Services Report* [6] prepared by Groff Testing Corporation, dated February 26, 2010, and a second independent evaluation is documented in the *Geotechnical Investigation, Heuer Review* [7].

2.3 Overview of Site Groundwater Conditions

The groundwater regime within the Project area is controlled by the glacial drift aquifer, bedrock aquifers and aquitards. The glacial drift aquifer can be categorized as buried and basal drift aquifers. The buried aquifers occur as isolated lenses or layers of permeable silt, sand and gravel outwash, separated by relatively impermeable clayey and silty tills. The basal aquifers are associated with localized lenses or layers of permeable silt, sand and gravel.

The upper bedrock aquifer consists of the upper weathered and jointed bedrock regardless of stratigraphy or lithology but dominantly the Silurian dolomite formations. The upper bedrock aquifer includes the Silurian dolomites and the Brainard and Fort Atkinson Formations of the Maquoketa Group. The aquifer has a low primary permeability and a much higher secondary permeability consisting of local flow systems mostly associated with discontinuities in the rock mass. The upper bedrock aquifer is a groundwater source for many private and public wells in the Batavia area, including the main water supply for Fermilab. The potentiometric surface of the upper bedrock aquifer is approximately 10 ft below the bedrock surface; however, groundwater elevations may vary.

The upper Ordovician aquitard is a low permeability unit in the Maquoketa Group (Scales Formation). This unit overlies the Galena and Platteville Formations and acts as a base to the overlying upper bedrock aquifer and a confining unit to the underlying deep bedrock aquifer. The deep bedrock aquifer is a relatively high permeability aquifer underlying the Galena and Platteville Formations. The regional potentiometric surface for the deep bedrock aquifer system is located at depth in the Galena-Platteville.

Underground enclosures of the LBNE Project will be primarily constructed in the drift aquifer, the upper bedrock aquifer and the Ordovician aquitard. The deep bedrock aquifer will not be encountered in any of the Project features; however, the Galena-Platteville Formation may be encountered in the Near Detector Hall excavation.

2.4 Occurrence of Natural Gasses

Throughout northern Illinois isolated pockets and production quantities of methane occur in organic silts and sands associated with interglacial periods, especially the Sangamon soil unit which represents a long time interval between the Illinois and Wisconsin stages of glaciation. Methane and hydrogen sulfide gasses in bedrock formations are uncommon and are usually a result of contaminated groundwater where present.

During geotechnical investigations for the nearby NuMI Project, boreholes and representative soil and rock samples were monitored with flammable gas detection meters in the field for the presence of methane. Methane gas was not detected and is not anticipated to be encountered in the Project excavations as further described in the *LBNE Site Investigation Geotechnical Engineering Services Report* [6].

3 The Facility Layout

The LBNE Conventional Facilities on the Fermilab property (the Near Site) are envisioned to consist of eight functional areas –three surface buildings and a near surface shallow buried structure located in an embankment constructed of engineered fill at the Target Complex, and four underground facility enclosures. The three surface buildings and single shallow buried structure are shown in blue in Figure 1-2. Construction will be executed and packaged in a logical sequence based on programmatic and funding driven limitations.

Figure 1-2 shows the Project site aerial view with LBNE facilities highlighted. The Project limits are bounded by Giese Road to the north, Kautz Road to the east, Main Injector Road to the south, and Kirk Road to the west. The Beamline is shown in red in Figure 1-2. The four surface buildings consist of:

- Primary Beam Service Building (LBNE 5)
- Target Hall Complex (LBNE 20)
- Absorber Hall Service Building (LBNE 30)
- Near Detector Service Building (LBNE 40).

The four underground facilities consist of:

- Beamline Extraction Enclosure and Primary Beam Enclosure
- Decay Pipe
- Absorber Hall, Muon Alcove and support rooms
- Near Detector Hall and support rooms.

Each underground facility has a surface/above ground service building that functions as a conveyance conduit for conventional and programmatic (for the technical systems) utilities as well as a location for equipment conveyance and personnel access and egress from the underground enclosures. Note that the shallow below grade Target Hall is included in the surface based Target Hall Complex at LBNE-20. Figure 1-1 shows the Project longitudinal section view with eight LBNE Facilities, and how the surface facilities relate to their corresponding underground facilities.

Based on the Conceptual Design, there will be 510,100 yd^3 of earth excavation, 23,900 yd^3 of rock excavation, 180,850 yd^3 of cast-in-place concrete, 1,200 linear ft of cut-and-cover excavation, four shafts (equipment handling, components handling and access/egress), and four new surface buildings with a combined floor space area of 67,600 ft^2.

The conceptual drawings, consisting of an 82 page set of drawing sheets called *LBNE Conventional Facilities at Fermilab,* depict the general Project layout, transverse and longitudinal cross sections of surface and underground facilities, overall Project and individual surface and underground facilities plan views, single line diagrams of mechanical, electrical, architectural, and fire protection routing and layout, as well as details and general conceptual specifications of the Conventional Facilities as required by the technical system groups.

The LBNE Conventional Facilities CDR Drawings [8] are the source of most of the figures in this volume. These drawings may be referenced for greater design detail of the Conventional Facilities planned at the Near Site.

3.1 Project-Wide Considerations

There are several design considerations that apply to many of the facilities that will be constructed for LBNE and are not necessarily specific to any single structure or system. These considerations include the structural and architectural treatment of surface structures, structural and excavation approaches to underground or shallow buried structures, environmental protection, fire protection and life safety systems, safeguards and security, emergency shelter provisions, energy conservation, and DOE space allocation. These project-wide considerations are addressed in this section.

3.1.1 Structural and Architectural for Surface Structures

The structural building and construction systems for the Near Site Conventional Facilities will be constructed utilizing conventional methods similar to systems established at Fermilab for the near surface structures. The architectural features of the Near Site Conventional Facilities will include four surface or near surface buildings:

- Primary Beam Service Building (LBNE 5)
- Target Hall Complex (LBNE 20)
- Absorber Service Building (LBNE 30)
- Near Detector Service Building (LBNE 40).

The Primary Beam Service Building and the Absorber Service Building will be constructed as a braced-frame, steel construction with prefinished metal siding. The construction type and style will be consistent with similar adjacent facilities on the Fermilab campus. The Target Complex support service rooms will be constructed of pre-cast and cast-in-place concrete and braced-frame, steel construction with prefinished metal siding as well as natural concrete finish. A Project-specific style of architecture will be developed to unify and mitigate the presence of new buildings upon the surrounding environment.

The Near Detector Service Building at LBNE 40 is architecturally significant because of its proximity to Kirk Road and visible to Fermilab’s residential neighbors to the west. Therefore the architectural style of the Near Detector building needs to be complimentary to the surroundings. A landscape/screening embankment is planned between the construction/building site and Kirk Road to shield the neighbors from construction noise and to minimize the visual impact of the building.

The applicable requirements of the Uniform Federal Accessibility Standards (UFAS), Americans with Disabilities Act (ADA) and the Americans with Disabilities Act Accessibility Guidelines (ADAAG) will be incorporated into the design of this project. Compliance with the ADA will be based upon an evaluation of the job descriptions and required tasks for the personnel assigned to work in these surface buildings and underground facilities. Those areas of the buildings and underground facilities that will require accessibility as well as the established routes to those areas will be designed in full compliance with the existing statutes.

3.1.2 Structural and Excavation for Underground Structures

The construction systems for the LBNE Conventional Facilities underground portion of the LBNE Conventional Facilities will be constructed utilizing conventional underground excavation methods.

Most of the below grade facilities to be built will be constructed using standard open cut methods. This includes much of the Beamline Extraction Enclosure and Primary Beam Enclosure, the Target Complex, the Decay Pipe and the Absorber Hall. However, some of the Primary Beam Enclosure and all of the Target Complex will be constructed in an embankment constructed of engineered fill that reaches a maximum height of about 70 ft above existing grade. The toe of the embankment is shown as a red dashed line in Figure 3-1. The extent and height of the embankment will cause consolidation (settlement) of native in situ soils resulting in potential adverse impacts to existing facilities including the Main Injector. Figure 3-1 also shows the locations, limits, and types of braced excavation and retaining wall systems that are planned to provide protection of the Main Injector. Because of the consolidation of in situ soils caused by the embankment most of the Primary Beam Enclosure and the Target Hall Complex will be supported using drilled shaft foundations which are described in greater detail in Chapter 4.

The Decay Pipe and the Absorber Hall will be constructed using open cut methods requiring excavation down to, and into, the bedrock underlying the project site. Open cuts will be as deep and about 70 feet in soil and another 25 feet or so in rock. Rock will be excavated using quarry type drill and blast techniques. All structures will be covered with the required minimum 25 ft of earth shielding above and around all beamline enclosures.

The Near Detector Hall will be the only facility that will be constructed using conventional underground rock excavation or tunneling methods. Shaft excavations will employ an earth retention system in the soils. The rock portion of shaft excavations will be excavated using drill-and-blast methods, as will the underground cavities and halls. For underground rock support, rock bolts or rock dowels will likely provide the required ground support. Shotcrete will be applied to the exposed rock face of all excavations including the Near Detector Hall and the portion of the Absorber Hall excavated in rock.

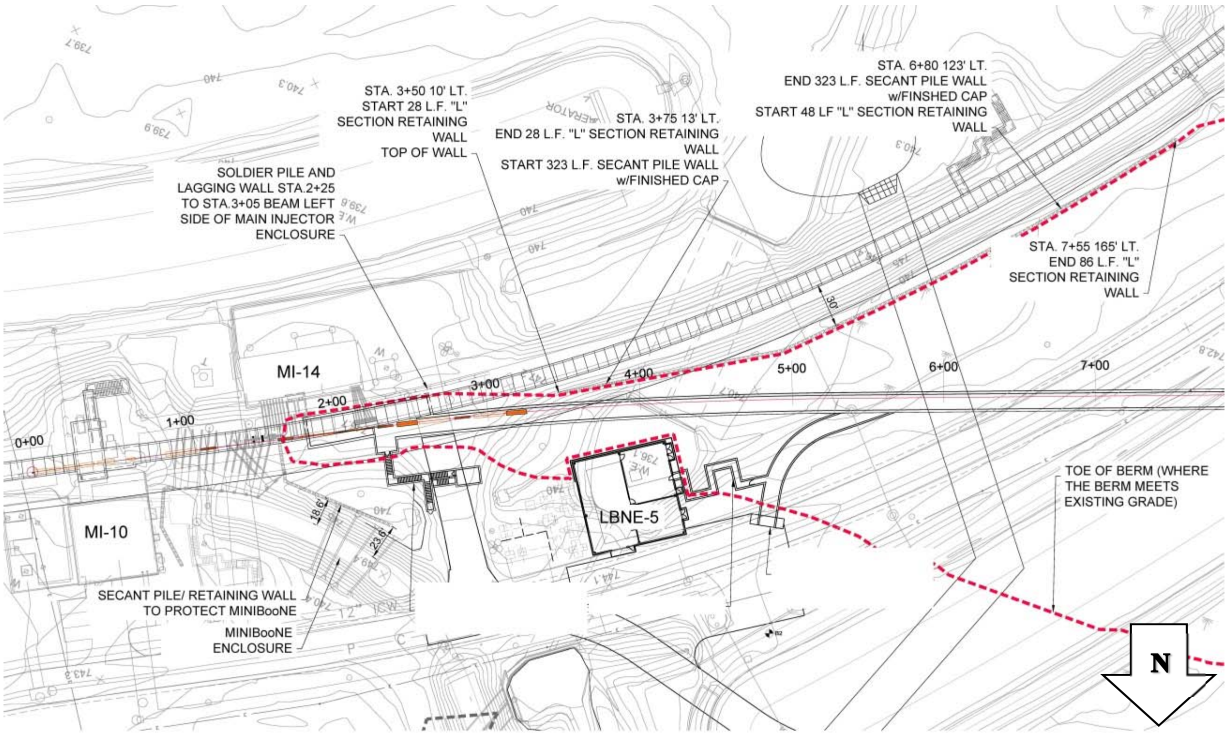

Figure 3-1: Braced Excavation and Retaining Wall Systems.

3.1.3 Environmental Protection

The overall environmental impact of this project will be evaluated and reviewed as required to conform to applicable portions of the National Environmental Policy Act (NEPA). To initiate this evaluation, an Environmental Evaluation Notification Form (EENF) will be drafted by the Fermilab NEPA Coordinator. All required permits will be obtained prior to the start of construction.

During the upcoming Preliminary Design phase of the project, environmental consultants will locate and define the limits of all areas impacted by the project including wetland areas, floodplain and storm water management areas, sites of archaeological concern, and any other ecological resource areas. They will then assist the Fermilab Environment, Safety and Health (ES&H) Section in the preparation of, a Floodplain/Wetland Assessment Report and an Environmental Assessment Report. It is anticipated that the Project will help the DOE develop an Environmental Assessment (EA) and pursue a "Finding of No Significant Impact" (FONSI).

A wetland delineation and wetland study has been conducted in areas that were anticipated to be disturbed by LBNE construction activities. The *Wetland Report* was prepared by Patrick Engineering, Inc., in August 2010 [9]. The wetland delineation and floodplain limits (see Figure 3-2) show that limited wetlands will be encountered in the area of LBNE 20, LBNE 30, and LBNE 40, and possibly other areas.

In compliance with U.S. Army Corp of Engineers requirements, LBNE must mitigate the disturbance of wetland areas caused by construction activities. To mitigate impacts, LBNE intends to purchase wetland credits from a wetland bank. The number of credits to be purchased will be based on the area and quality of wetland acres disturbed.

Any volume of the floodplain along the Project alignment that may require filling, notably at and near the LBNE 20 site and along the shielding embankment over the Primary Beam Enclosure, will be delineated and the required compensatory floodplain storage volume will be designed and constructed according to FEMA regulations.

Figure 3-2: Wetland Delineation Map.

Every effort will be made to pursue pollution prevention opportunities. Pollution prevention (source reduction) is recognized as a good business practice that also enhances site operations. Pursuing pollution prevention enables Fermilab to accomplish its mission of achieving environmental compliance, reducing risks to health and the environment, and preventing/minimizing future DOE legacy environmental issues.

3.1.4 Fire Protection / Life Safety Systems

A Fire Protection-Life Safety (FLS) Assessment/Report has been completed by Aon Fire Protection Engineering Corp. for the LBNE Project [10].

Consistent with the FLS report, facility access and egress will be designed and provided in accordance with all applicable National Fire Protection Association (NFPA) Life Safety Codes and Standards including NFPA 520: *Standard on Subterranean Spaces*, which requires adequate egress in the event of an emergency. Egress paths for surface (service buildings) and underground facilities (tunnels and halls) have been conceptually designed to limit the travel paths to egress shafts, stairways, and safe/fire rated corridors to the exterior and surface to a safe gathering location. The specific egress routes will be defined in Chapter 5.

Facility fire detection and suppression systems, as well as personnel occupancy requirements, will be defined in accordance with NFPA 101: Life Safety Code. Fire alarm systems will be designed with a minimum standby power (battery) capacity. These batteries will be capable of maintaining the entire system in a non-alarm condition for 24 hours, and to 15 minutes in full-load alarm condition. Fire alarm/fire suppression systems for the LBNE Conventional Facilities will be designed in accordance with the applicable sections of the Fermilab Engineering Standards Manual which requires that facilities be equipped with a hard-wired, zoned, general evacuation fire alarm system that also includes:

- Manual fire alarm stations at the building exits
- Sprinkler system water flow and valve supervisory devices
- Combination fire alarm horn/strobe located throughout the building
- A 24-V hard-wire extension from the existing control panel
- Connection to the site-wide Facilities Information Reporting Utility System (FIRUS) monitoring system
- Smoke detection and line type heat detection as required.

Automatic sprinkler systems will be designed to a minimum of an Ordinary Hazard Group 1 classification, in accordance with NFPA's latest edition. The NFPA design and construction standards to be used relative to fire alarm systems are referenced in the LBNE Requirements Document [11].

3.1.5 Safeguards and Securities

Direction for security issues related to the design of this project is taken from the current operating procedures for the Fermilab site.

Service buildings and facilities will be accessible to required Fermilab personnel and contractors during normal work hours. Access to the controlled areas during normal working hours will be controlled internally by the appropriate technical division occupants of each respective building or underground enclosure.

During non-working hours, when the buildings and facilities are unoccupied, all exterior roll-up and personnel access doors into the buildings and facilities will be locked. Security card access will be installed in buildings to allow access during non-working hours.

3.1.6 Emergency Shelter Provisions

Required provision for occupant protection in the event of tornadoes or other extreme weather conditions will be incorporated into the design of the service buildings. Guidelines established by the Federal Emergency Management Agency (FEMA) in publications TR-83A and TR-83B and referenced in Section 0111-2.5, DOE 6430.1A, will be used to assess the design of the buildings to insure safe areas within the buildings for the protection of the occupants. These protected areas will also serve as dual-purpose spaces with regard to protection during a national emergency in accordance with the direction given in Section 0110-10, DOE 6430.1A.

FEMA guidelines indicate that protected areas are:

- on the lowest floor of a surface building
- in an interior space, avoiding spaces with glass partitions
- areas with short spans of the floor or roof structure are best; small rooms are usually safe, large rooms are to be avoided.

3.1.7 Energy Conservation

The DOE directive, *Guiding Principles of High-Performance Building Design*, will be incorporated into the design of the LBNE Conventional Facilities. However, discussions are ongoing regarding the applicability of the guiding principles based on the type and use of the facilities. LBNE 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 as required to deliver a well-balanced project.

All elements of this project will be reviewed for energy conservation features that can be effectively incorporated into the overall building design. Energy conservation techniques and high efficiency equipment will be utilized wherever appropriate to minimize the total energy consumption.

See DOE Guiding Principles for Sustainable Design and Construction [12].

3.1.8 DOE Space Allocation

The elimination of excess facility capacity is an ongoing effort at all DOE programs. Eliminating excess facilities (buildings) to offset new building construction (on a building square foot basis) frees up future budget resources for maintaining and recapitalizing DOE’s remaining facilities.

The LBNE Near Site project has obtained a DOE Space Allocation/Space Bank waiver, that assigns elimination of excess facilities capacity elsewhere in DOE labs to offset the new LBNE building square footage. The LBNE Project waiver covers up to 142,000 gross square feet (gsf). The Near Site portion of the Project, as defined by the Conceptual Design, includes a total of 90,076 gsf including underground and surface facilities.

See the LBNE Space Bank Waiver Correspondence [13] and related DOE policies and procedures.

3.2 Project Site Infrastructure (WBS 130.06.02.05.02)

The locations of the eight Near Site Conventional Facility components define the LBNE Project Fermilab site. Facility locations were selected based on the programmatic requirement for extracting beam from the existing Main Injector near MI-10, the proximity of the Fermilab’s west boundary and the planned location of the Far Detector. A significant portion of the Project site infrastructure is provided for the benefit of the entire Project and is not provided in response to a requirement of a specific site address, such as LBNE 20. This section describes Project site infrastructure systems that apply Project-wide.

The scope of the LBNE Conventional Facilities will include the work required to provide Project site road access and the creation of hardstands, parking areas and site restoration. Also included is the extension of the utilities to the Project site.

3.2.1 Roads and Infrastructure

The existing Giese Road will be improved and extended to provide access to the Near Detector facility at LBNE 40. The road will be constructed according to the standards for all Fermilab roads and will be suitable for all-weather and emergency access during construction and Project beamline operations. AASHTO HS20-44 highway standard loading will be incorporated into the design.

Parking and staging areas will be incorporated into the design of each surface building. Designs will provide for the operation phase, with parking and hardstand requirements for construction and installation designed to be temporary. It is anticipated that most of the scientific components will be manufactured elsewhere and delivered on a just-in-time delivery basis.

As part of the civil work, the existing Main Injector Cooling Pond F and associated infrastructure will be entirely removed/filled-in to create space required for the embankment and the Target Complex (LBNE 20). Any compensatory flood plain storage volume that is required due to filling, for site grading and drainage, will be mitigated (reconstructed) in the infield of the Main Injector or near LBNE 30.

3.2.2 Electrical

Fermilab is supplied electrical power through the northern Illinois bulk power transmission system that is operated by a local investor-owned utility. The site interconnects with the bulk transmission system at two locations. Service connections, at 345 kV voltage, are made to one of two transmission lines at each location. At the interconnection sites, Fermilab takes power and delivers it along Fermilab owned and operated transmission lines to two separate electrical substations where it is transformed to 13.8 kV for site-wide distribution.

Fermilab maintains two separate types of power systems, pulsed power and conventional power. The technical systems pulsed power loads are large and can cause power quality issues for the conventional facilities if interconnected. Therefore two separate systems are maintained. The electrical systems located throughout the LBNE Project will conform to the National Electric Code (NEC) and applicable sections of the Fermilab Engineering Standards Manual.

The electrical power requirements for the LBNE Project are significant and will require the extension and expansion of the existing 13.8-kV electric distribution facilities. The improvements include electrical substation modifications, the extension of existing 13.8-kV distribution feeders from a nearby feeder for pulsed power and the expansion of Kautz Road Substation for the conventional power. The LBNE Project will also require the relocation of the existing electrical power ductbank system around the proposed facilities. Existing ductbanks will be rerouted along the proposed roadways to the LBNE facilities and continue to reconnect to the existing ductbanks to maintain the existing infrastructure.

Figure 3-3 shows the proposed project electrical power routing plan for both pulsed and conventional power. Figure 3-4 shows the location of MI power systems duct bank and feeders, both pulsed and conventional, that will need to be removed and rerouted around the proposed facilities and embankment due to the embankment fill as well as other LBNE facilities interferences and conflicts.

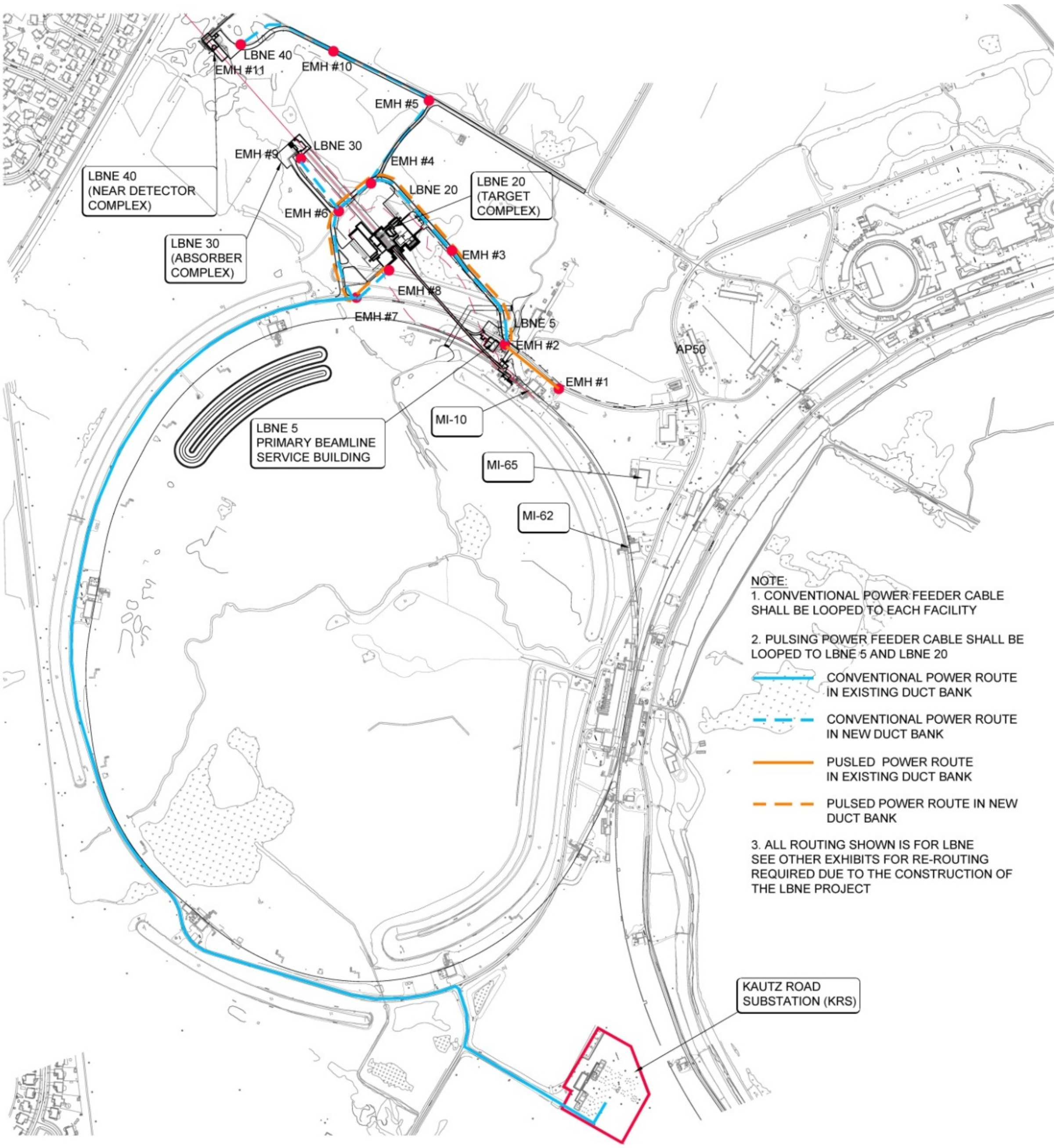

Figure 3-3: Electrical Power Routing Plan.

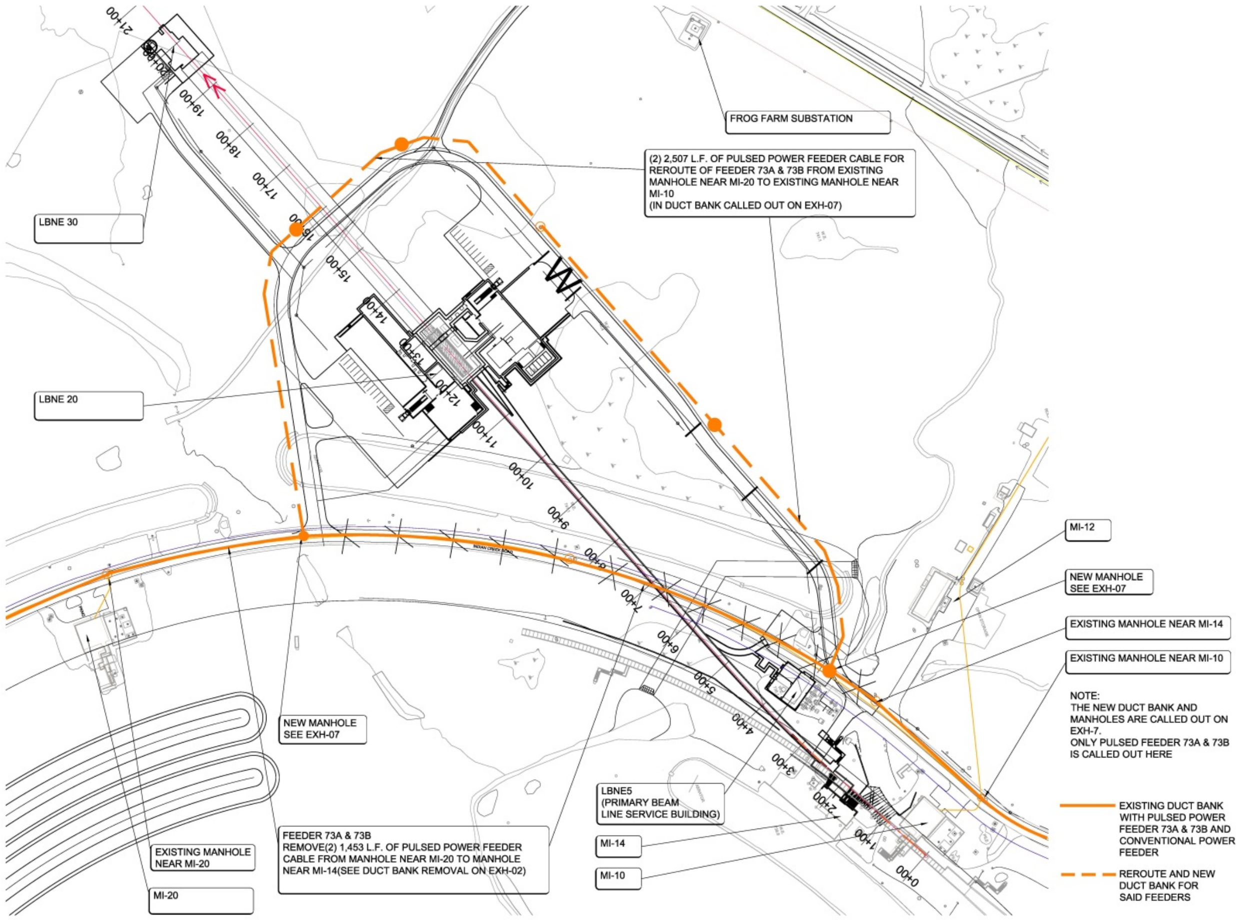

Figure 3-4: Rerouting of Existing Power System Ductbank.

3.2.2.1 Pulsed Power System

The pulsed power system for LBNE will be served from the existing Kautz Road Substation, feeder 96/97 at 13.8 kV. The pulsed power system requires a harmonic filter to maintain power quality. The existing feeder 96/97 has an interconnection to a harmonic filter at the Kautz Road Substation.

The feeder system from the substation to the LBNE Project will be provided by connecting to an existing pulsed power feeder that is currently serving the Main Injector. The feeder is configured as a loop for operational flexibility. The LBNE pulsed power services to LBNE 5 and LBNE 20 will be inserted into the loop, maintaining the configuration.

Sectionalizing switches, 13.8 kV, 600 A, will be installed at various locations along the feeder route. A switch will be installed at each location where pulsed power is required. The switches will serve to provide operational flexibility in load and fault isolation.

Pulsed power service at LBNE 5 and LBNE 20 will be routed to a 13.8-kV site switch. Each site will have an interconnection for transformers to the 13.8-kV pulsed power system. The remainder of the electrical equipment for service from the substation into the buildings will be provided by the Beamline subproject. The Conventional Facility scope of work will prepare each site by installing concrete pads and conduits for the equipment installation by the Beamline subproject.

3.2.2.2 Conventional Power System

The conventional power system for LBNE will be served from Kautz Road Substation at 13.8 kV where two new feeders will be constructed. The feeder equipment will include the cable and two new 13.8-kV Kautz Road Substation circuit breakers. The feeder system from the Kautz Road Substation to the LBNE Project will be provided by installing the new underground feeder cables in existing spare ductbank. The feeder will be constructed in a looped configuration to enable cable segment isolation, fault clearing and service restoration without cable repair or replacement and extended service outage.

Sectionalizing switches, 13.8 kV, 600 A, will be installed at various locations along the feeder route. A switch will be installed at each location that conventional power is required. The switches will serve to provide operational flexibility in load and fault isolation.

Conventional power service is required at the four sites, LBNE 5, LBNE 20, LBNE 30 and LBNE 40. The 13.8-kV feeder will be routed to each site sectionalizing switch. The switches will serve primary electrical power to the site conventional service transformer. Each site will be provided with fully constructed electrical service to the buildings. Secondary conductors from the transformer will be constructed at each building and will terminate at the main service electrical panelboard.

3.2.3 Mechanical and HVAC

The heating, ventilation and air conditioning (HVAC) systems located throughout the LBNE Project will conform to ASHRAE 90.1, ASHRAE 62, applicable NFPA requirements and applicable sections of the Fermilab Engineering Standards Manual. The design parameters for the general HVAC are summarized below:

- Air conditioned facilities will be maintained between 68° to 78°F.
- The relative humidity in air conditioned spaces will be maintained below 50%. There is no minimum requirement.
- Ventilated spaces will be maintained at maximum approximately 10ºF above ambient.
- HVAC for the Target Chase, Target Hall, Decay Pipe and Absorber Hall are specially designed systems that are detailed in other sections of this document.

All HVAC systems shall be design and installed with Metasys automated building controls capable of local and remote monitoring, control and operation optimization. Direct Digital Controls will be further investigated during subsequent phases in accordance with the applicable codes and Federal life cycle costing analysis.

3.2.4 Plumbing and Cooling Systems

The industrial cooling water (ICW), domestic water service (DWS) and sanitary sewer and other related utility services for the Project will be extended from existing services found along the Main Injector Road utility corridor to LBNE 5, the Target Complex and the Absorber Hall at LBNE 30. The residential subdivision directly west of Kirk Road has domestic water and sanitary sewer capacity to accommodate the Near Detector facility (LBNE 40) needs. All domestic plumbing work will be installed in accordance with the Illinois Plumbing Code and Standard Specifications for Water and Sewer Main Construction in Illinois, and applicable sections of the Fermilab Engineering Standards Manual.

Details of the anticipated utility work are listed below:

- ICW will be used for fire protection in the sprinkler system except at LBNE 40 where DWS from the city of Batavia will be used.
- An adequate supply of drinking water is available through an existing DWS supply line in the MI area for LBNE 20 and LBNE 30. DWS for LBNE 40 will be provided by the city of Batavia.
- The connection to the Sanitary Sewer service will be extended from existing Fermilab system for buildings LBNE 20 and LBNE 30. Sanitary sewer for LBNE 40 will be provided by connecting to the city of Batavia sanitary sewer system west of Kirk Road.
- Adequate cooling capacity for the LCW system required for the beamline magnets and power supplies will be provided at LBNE 5 through heat rejection to the Cooling Pond Water (CPW) system. The design, procurement and installation of the LCW system itself is included in the Beamline subproject.

3.2.5 Data and Communications

The existing Fermilab data, telephone communications and controls network will be extended from existing sources at the MI-8 service building to the LBNE 5, Target Complex (LBNE 20), Absorber Hall (LBNE 30), and Near Detector facility (LBNE 40) to provide normal telecommunication and controls communication support to the new LBNE facilities. Connections will be included in the form of new stub-ups for future expansion of the existing fiber network. The existing duct bank network and proposed extensions are shown as green in Figure 3-5. The required communications ductwork and manholes will be designed, estimated and constructed as part of the conventional facility portion of the project. The Conventional Facilities work will also include supplying and installing (pulling and connecting) the required fiber-optic lines.

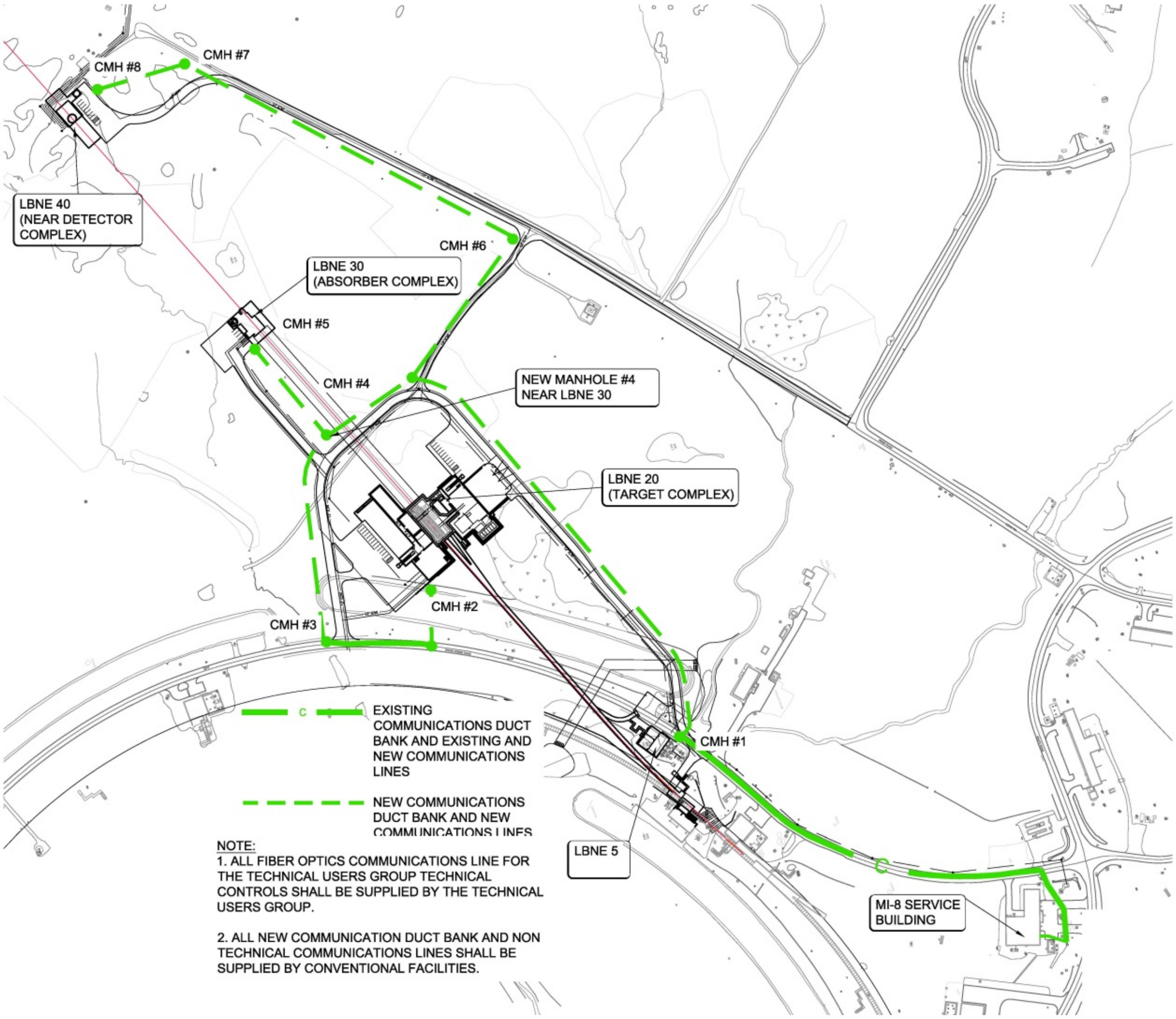

Figure 3-5: LBNE Communications Routing Plan.

4 New Surface Buildings

The LBNE Conventional Facilities on the Near Site will include surface buildings at LBNE 5, LBNE 30, and LBNE 40. A near surface, shallow, buried structure will be located in an embankment constructed of engineered fill at LBNE 20. This section provides additional details regarding these surface based structures.

4.1 Primary Beam Service Building (LBNE 5) (WBS 130.06.02.05.03.01)

One of three at grade service buildings is the Primary Beam Service Building (LBNE 5). The overall facility layout and floor plan is shown in Figure 4-1. The function of LBNE 5 is to provide housing for primary beam support equipment and utilities, and access for personnel and light equipment to the Primary Beam Enclosure below. This single-story, steel-framed, metal-sided service building will have approximately 3,600 ft^2 of floor space (60 ft by 60 ft), with a minimum 12-ft interior clear height. The building will be positioned off center and right of the beamline and will have a corridor (conduits, Gerardi Coffin, and penetrations) for technical and conventional utilities routing to the Primary Beam Enclosure. Utilities conveyed to the Primary Beam Enclosure will consist of Low Conductivity water (LCW), Cooling Pond Water (CPW), technical (pulsed) and conventional power, and communication/control lines. Access to and egress from the Primary Beam Enclosure will be provided thru the Egress Labyrinth and Magnet Installation Tunnel as described later in this section.

Space is provided in the power supply room for installation of dipole and quadrupole power supplies within the building as well as water-cooling lines and related equipment. A pump room is provided for CPW/ LCW heat exchangers, and LCW pumps; and a control room is provided for technical system controls. Electrical switchgear and power transformers will be installed on the open-equipment transformer pad adjacent to the building.

Figure 4-2 shows a detailed view of the building floor plan, the power supply room, control room, and pump room. Figure 4-3 shows the connection to the egress labyrinth and magnet installation tunnel to the Primary Beam Enclosure at the pump room. Figure 4-4 shows the location of the corridor for utilities conduits routing to/thru the Gerardi Coffin and into the Primary Beam Enclosure, as also shown in Figure 4-5 in section view.

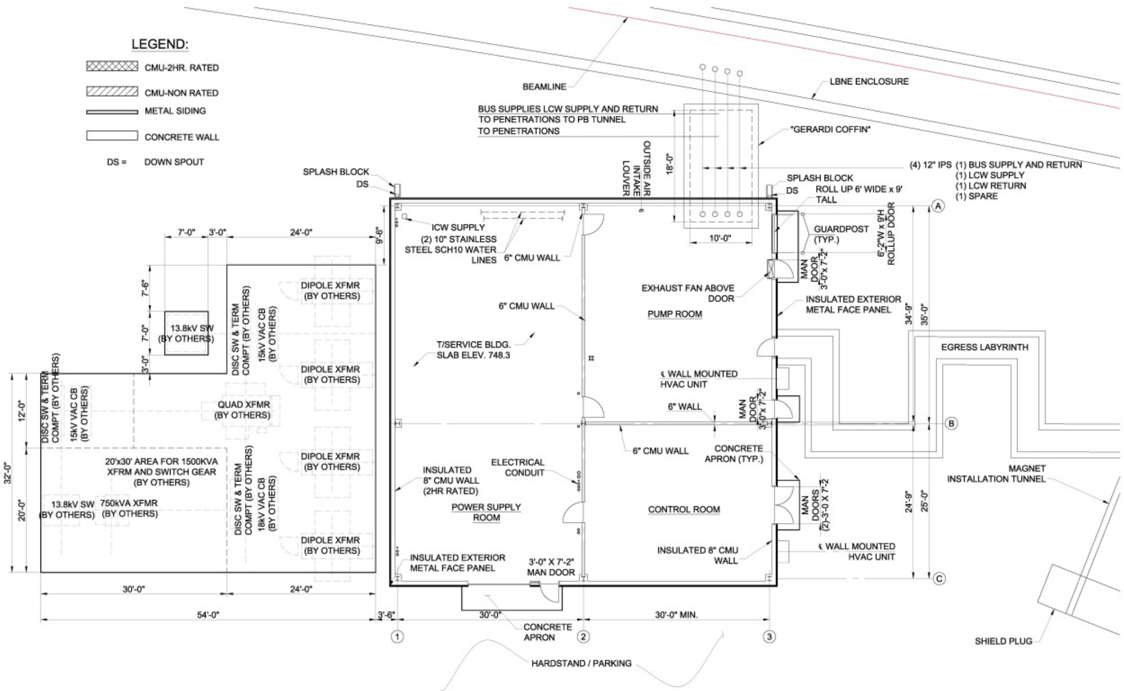

Figure 4-1: Primary Beam Service Building (LBNE 5).

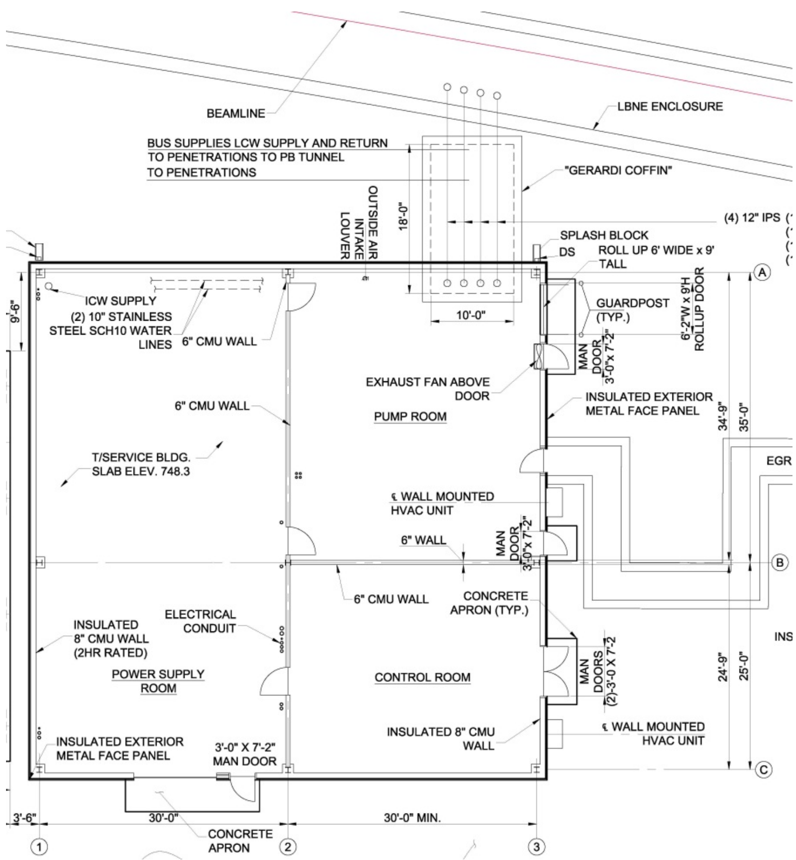

Figure 4-2: Primary Beam Service Building (LBNE 5) Floor Plan.

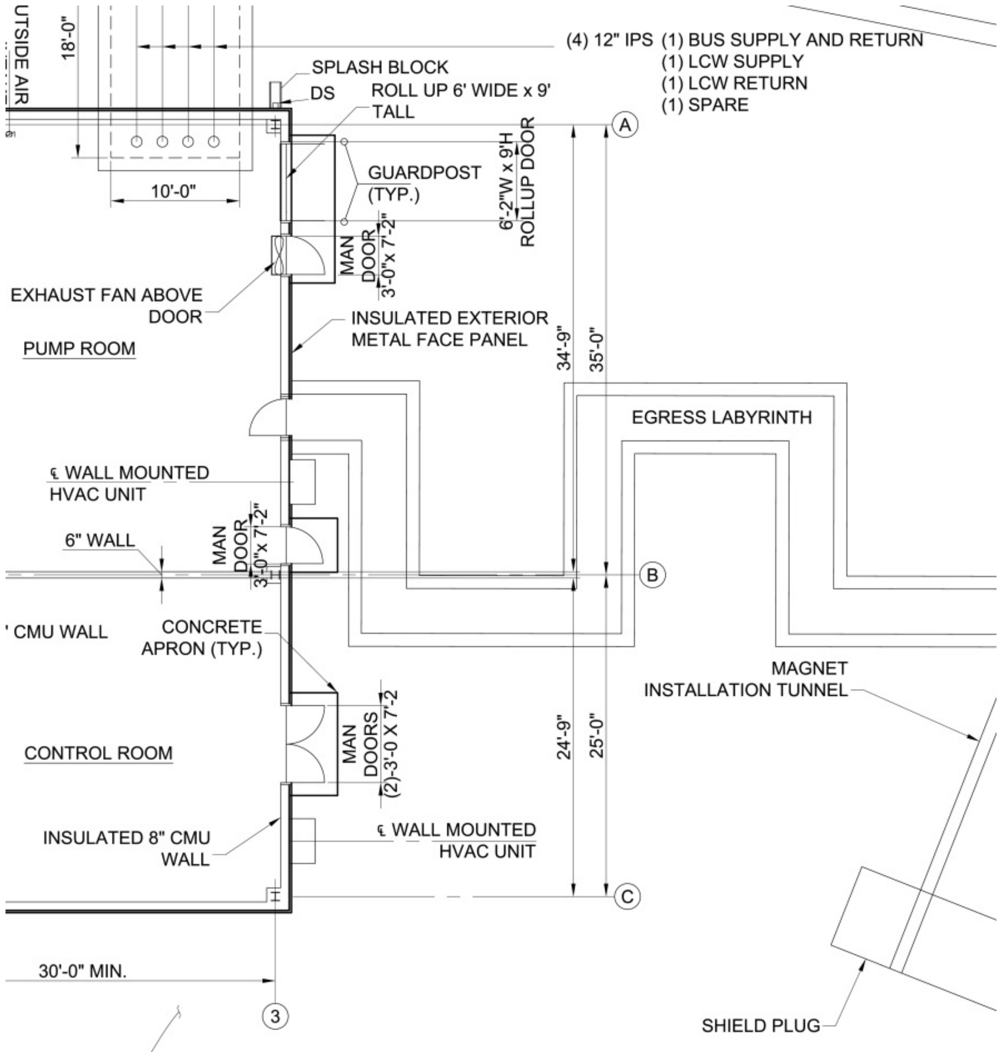

Figure 4-3: Primary Beam Service Building (LBNE 5) Egress Labyrinth.

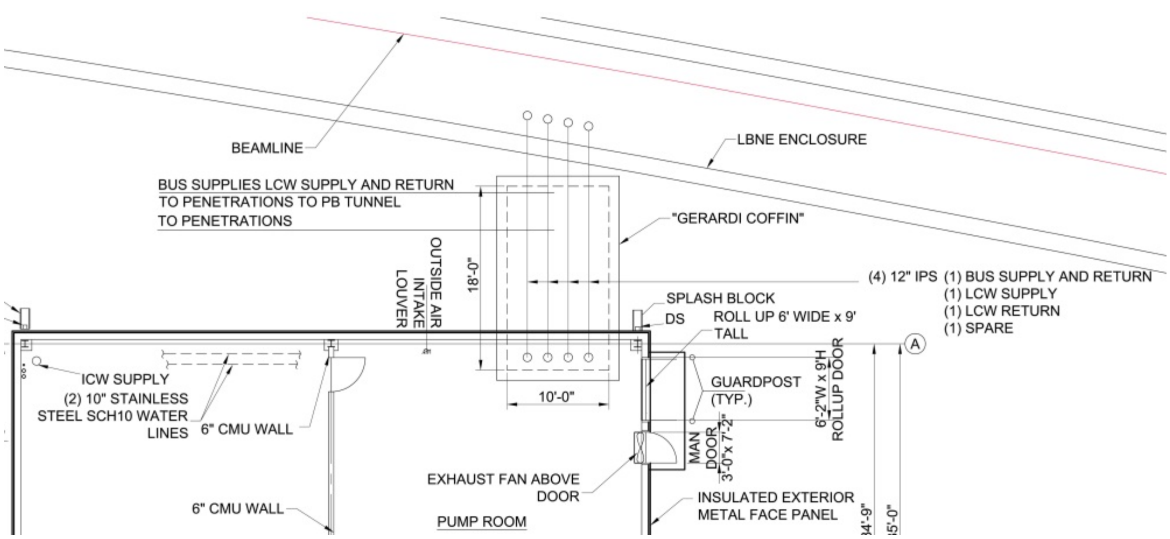

Figure 4-4: Primary Beam Service Building (LBNE 5) Corridor for Utility Penetrations.

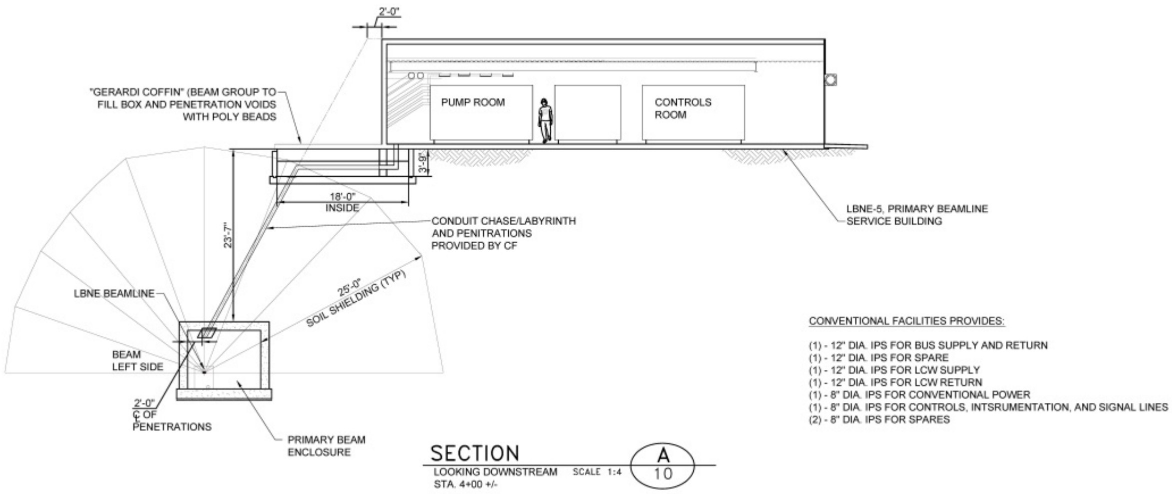

Figure 4-5: LBNE 5 to Primary Beam Enclosure Utilities Route and Penetrations.

4.1.1 Mechanical

Heat rejection for the LCW system will utilize CPW from the modified Main Injector Cooling Pond network. The building will be heated with electric unit heaters to maintain a minimum winter temperature of 68ºF. The power supply room and the pump room will be ventilated using outside air fans to maintain summer maximum temperatures of about 10ºF above ambient outdoor temperature. The electronics/control room will be cooled by wall mounted cooling units to maintain summer maximum temperatures of 78ºF. There will be no natural gas or sanitary sewer service, and restroom facilities will be available in the existing MI-65 Service Building that is located about 100 ft to the north. One of the building's roof support beams will be sized and configured to serve as a maintenance monorail for equipment removal and replacement.

4.1.2 Electrical

The electrical facilities provided at LBNE 5 will support the requirements of the Beamline in accordance with the Fermilab standards, NEC, and other applicable codes. The building site will have two separate electrical services. A conventional power system will be provided for electrical service to the building systems, lighting, HVAC, crane, miscellaneous loads, and low power technical system components such as racks and computers. A technical system power system space will be provided for electrical service to large technical systems such as beam power supplies. Conventional Facilities will provide 13.8-kV primary electrical power to an outdoor switchgear and prepare a space at LBNE 5 for the technical systems transformers and components to be installed by the technical systems. An emergency/standby power system with generator will be installed to serve critical loads for life safety and technical system components.

The building will be outfitted with panelboards, lighting, power receptacles, emergency/standby power systems and HVAC components to support the requirements of the beamline. A main switchboard/panelboard will be installed to distribute power to large dedicated loads and sub-panelboards in local building and tunnel areas. Emergency/standby power will be provided at a dedicated emergency power panelboard.

The lighting system and the level of lighting provided shall be installed according to the lighting level required by the use of the space. All lighting installed in areas that are exposed to radiation must be protected from the radiation or be resistant to the degrading and contaminating effects of radiation on electronic components. All emergency lighting in the Primary Beam Enclosure shall be powered from a separate remote battery powered uninterruptable power supply (UPS) system that is completely isolated from sources of radiation. This system will remain operable until the standby generator is available to provide power or power is restored.

Power receptacles will be provided in the building and tunnel for use as needed during outfitting and operation. The receptacles will be configured based on site equipment standards. All loads that require emergency/standby power will be served from the dedicated panelboard. The HVAC equipment will be served from the nearest conventional power panelboard as needed.

The LBNE 5 exterior transformer cast in place concrete pad will be sized for four 2,700-kVA dipole transformers, one 1,700-kVA quadrupole supply transformer, one 1,500-kVA transformer, and a 750-kVA house power transformer with two 15-kV switchgears.

The pad and the programmatic pulsed power duct banks to the pad and from the pad into the building (below the floor) are designed and will be constructed under the Conventional Facilities scope. The technical systems transformers and power supplies are designed and constructed by the Beamline subproject scope of work.

Table 4-1 shows the PBE Service Building (LBNE 5) electrical power loads, both Normal Power and the Standby Power generators.

Table 4-1: Primary Beam Service Building (LBNE 5) Electrical Power Loads.

Equipment Description	**Normal Power (kw)**	**Standby Power Generators (kw)**
Packaged AHU	73	
Electric Heater (2 heaters/room; 3 rooms = 6 total)	210	210
Lighting & Receptacle	42	11
Pump Room Ventilating Fan (3 hp; 5,000 cfm)	3	3
Power Supply Room Ventilating Fan (5 hp; 10,000 cfm)	5	5
Total Connected Load	**229**	**124**

4.1.3 Plumbing

The Primary Beam Service Building (LBNE 5) will be equipped with a wet pipe sprinkler system served from the site-wide industrial cooling water (ICW) network that is extended to the building from the existing nearby system. There are no domestic water, sanitary sewer or natural gas services provided to this building.

4.1.4 Fire Protection/Life Safety Systems

Egress paths for surface (service buildings) and underground facilities (tunnels and halls) have been conceptually designed to limit the travel path distances to egress shafts, stairways, and safe/fire rated corridors to the exterior and surface to a safe gathering location. See Section 3.1.4 of this volume for a general overview of fire protection and fire life/safety requirements.

Conventional Facilities is responsible for the design and construction of fire/life safety systems including the mechanical (emergency ventilation), electrical (emergency generator for lighting, ventilation, sump pumping, fire alarms, and communication), and plumbing (fire suppression/sprinkler piping and fixtures, and emergency sump pumping) systems.

Emergency egress routes for the Primary Beam Service Building (LBNE 5) will allow exiting thru a choice of four single exterior doors, one exterior double door, or an overhead roll-up door. Section 5.1.4 describes the egress paths from the Primary Beam Enclosure through LBNE 5 and the Target Complex and Egress Stair 1. One of the three egress route for the Primary Beam Enclosure will be to and thru the Egress Labyrinth and Primary Beam Service Building (LBNE 5).

4.2 Target Hall Complex (LBNE 20) (WBS 130.06.02.05.03.02)

The Target Complex (LBNE 20) will be a 46,700 ft^2 near-surface facility constructed in the engineered fill embankment, that combines the Target Hall, corresponding beam-on and beam-off support rooms (power supply, remote crane controls, piped system carrying radioactive water (RAW), and air handling rooms), and the Target Hall service rooms (two truck bays with lay down/staging areas, morgue area, maintenance cell, mechanical/utilities rooms, and rest room). Beam-on spaces are accessible by personnel while the beam is energized, and beam-off spaces are only accessible when the beam is not energized. These support and service rooms accommodate the support equipment and utilities and provide access needed to assemble and operate the equipment and conventional and programmatic/technical components for the Target Hall.

The Target Hall, shown in Figure 4-6, is located in the center of the Target Hall Complex, with beam-on and beam-off service and support rooms adjacent on the beam left side (as one faces downstream), which is also the south side of the Target Hall. Beam-on service and support rooms are adjacent to the beam right/north side.

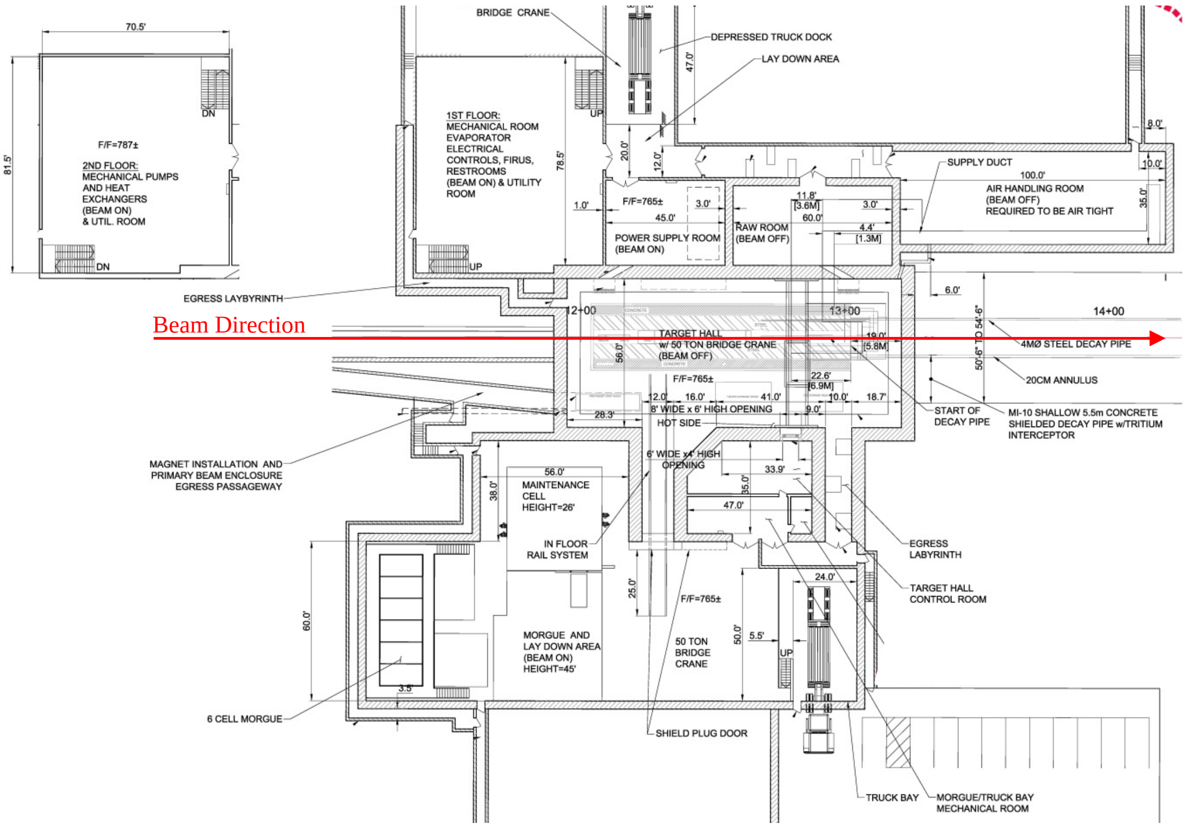

Figure 4-6: Target Complex Floor Plan.

The Target Hall will house the target and focusing horns in a shielded target chase below the floor. The required concrete and steel shielding will be provided around these beamline target components. The target chase (section views shown in Figure 4-7) consists of steel shielding blocks, and the target and horns, along with the associated power feeds, cooling water channels, and gaps/spaces for air cooling. Some steel shielding blocks will be permanently cast into concrete and will be provided by Conventional Facilities. Other shielding blocks will be moveable, and those will be provided by the Beamline subproject.

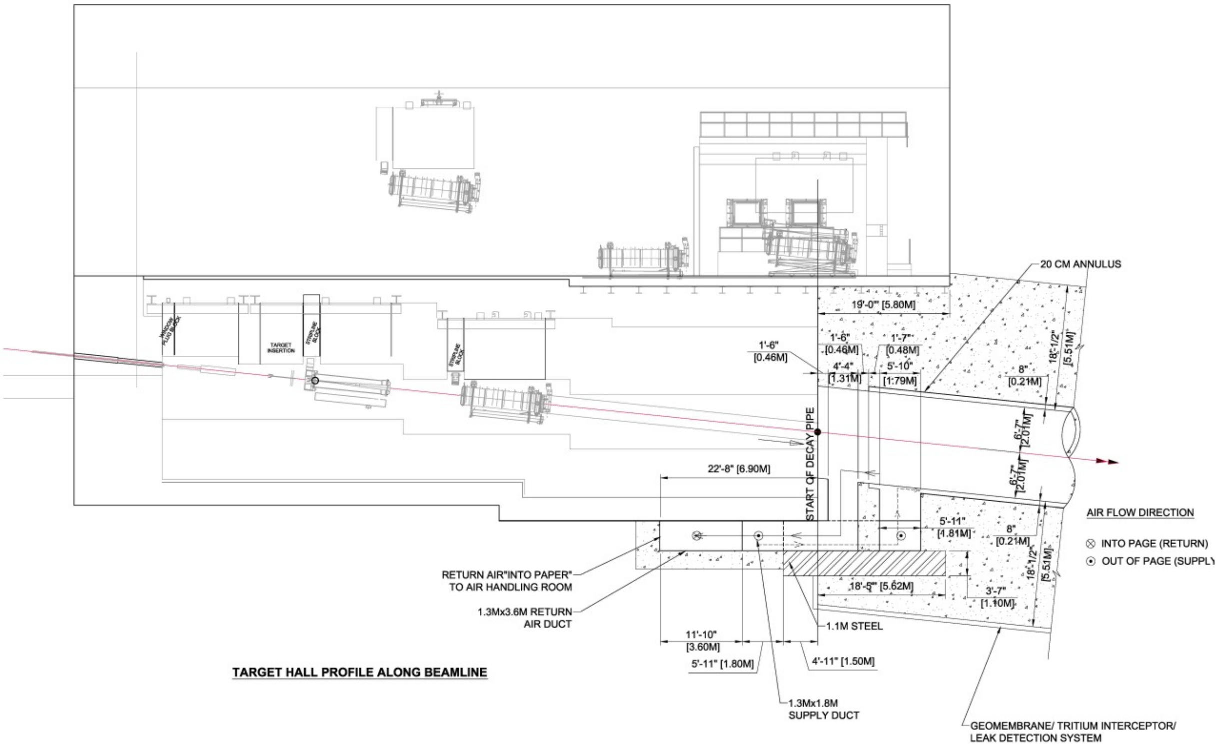

Figure 4-7: Target Chase Long Section; Decay Pipe Cooling Ducts.

The Target Hall will have a 50-ton overhead bridge crane running the length of the hall that will be used for installing and removing target modules and horn components in the chase, as well as transporting these components to the work cell. The crane will be equipped with redundant drive systems and remote electronics to ensure reliance during remote handling operations. This bridge crane will also be used to install, remove and reset shielding blocks, hatch covers, as well as other equipment and components.

The stand-alone cast-in-place concrete hot handling work cell (see Figure 4-8) is shielded from the rest of the Target Hall for personnel protection and, with the use of telemanipulators, will be used for both prepping new or refurbished target components.

This civil/conventional fit-out work will also include internal concrete masonry unit (CMU) walls, poured/cast-in-place structural concrete walls and abutments (with the required thickness for shielding), the cast-in-place work cell, doors, internal stairways, a 50-ton bridge crane in the Target Hall.

The wall and ceiling thicknesses in LBNE 20 are designed for the required beam shielding. The Target Hall, including the egress labyrinth and rail transport passageway walls will be 5-ft thick cast-in-place (CIP) structural concrete walls with a 7-ft thick CIP structural roof. The beam-left air handing room, RAW room, and beam-right truck bay, morgue, and maintenance cell will have 3-ft thick CIP structural concrete walls except that any portions of all rooms adjacent to the Target Hall will have 5-ft thick CIP structural concrete walls. All other rooms will have 1-ft thick CIP structural concrete walls. The Target Hall and air handling room, and Decay Pipe/target chase air ducts will be lined, on the exterior, with an air seal geomembrane, as these facilities are required to be air tight.

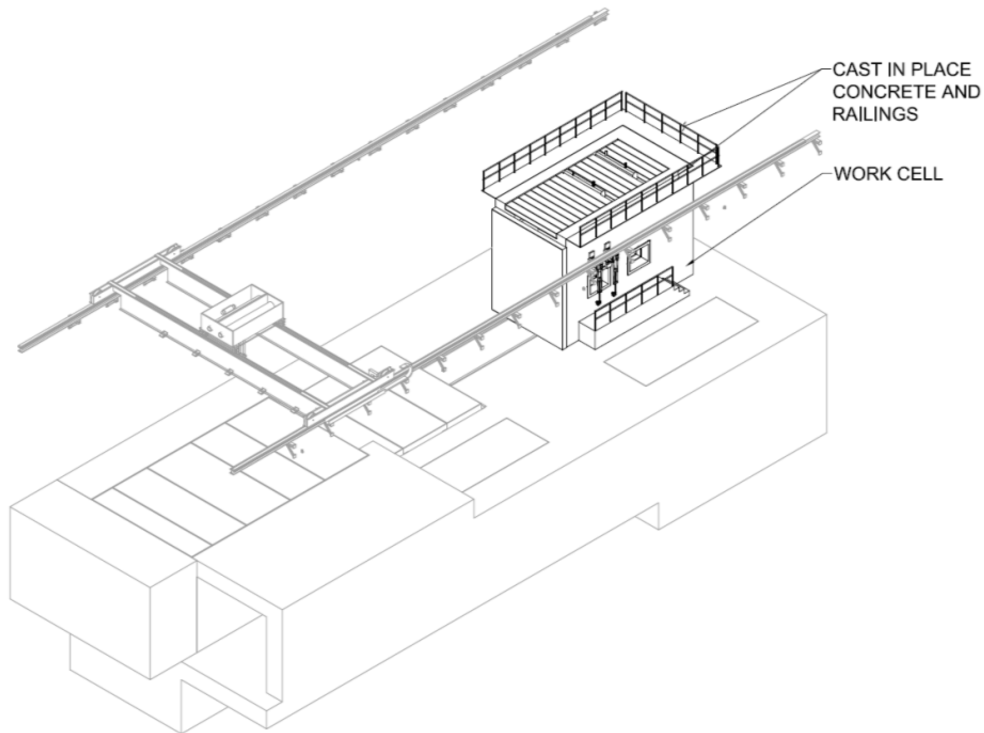

Figure 4-8: Target Hall view showing the hot handling Work Cell.

Adjacent to the Target Hall on beam-left side, which is also the south side of the Target Hall (shown in the top of Figure 4-6 (and a detailed view shown in Figure 4-9), will be an open truck bay for mechanical, electrical, and plumbing components and equipment to be unloaded and staged, using the 20-ton bridge crane. This staged equipment will be moved in/out of the mechanical, power supply, RAW, or air handling rooms for installation/replacement. Moving this equipment in/out can be accomplished through the 12-ft wide passageway and through double doors into the mechanical rooms or power supply room. An alternate path is through the air seal double doors and into an extension of the same corridor.

Adjacent to the Target Hall, on beam-right side, which is also the north side of the Target Hall (shown in the bottom of Figure 4-8 and a detailed view in Figure 4-10) is the second of the two truck bays, and will be used for unloading Target Hall and target components, shielding blocks and equipment using the 50-ton bridge crane. These target components will be staged in the laydown area for eventual transport into the Target Hall using an in-the-floor rail/track system thru a shield plug door (provided by the Beamline subproject) opening during beam-off. This 50-ton bridge crane will also be used to pick and load Target Hall spent or damaged components (target modules, horns, etc.) to the maintenance cell or to the 6-cell side-load morgue. Devices removed from the Target Hall will be transported during beam-off.

Target Hall remote crane controls will be housed in the beam-right Target Hall crane control room. This room will have a 4 ft high by 6 ft wide by 30 in thick lead glass window facing the Target Hall. The window will be supplied and installed as a part of the Beamline subproject scope of work. Adjacent to this room will be the morgue/truck bay mechanical room housing the beam-right HVAC and fire protection control systems, and a conventional electrical power panel. Adjacent will be a restroom. Interior partitions will be painted concrete masonry units (CMU).

The beam-right support room area, as shown in Figure 4-10, will contain the abovementioned 60-ft wide by 25-ft long by 13-ft high, concrete shielded, 6-cell side-loaded morgue for temporary storage of hot/spent/damaged targets, horns and other components during a cool-down period and before transporting these components to a final storage facility which is not part of the LBNE Project scope.

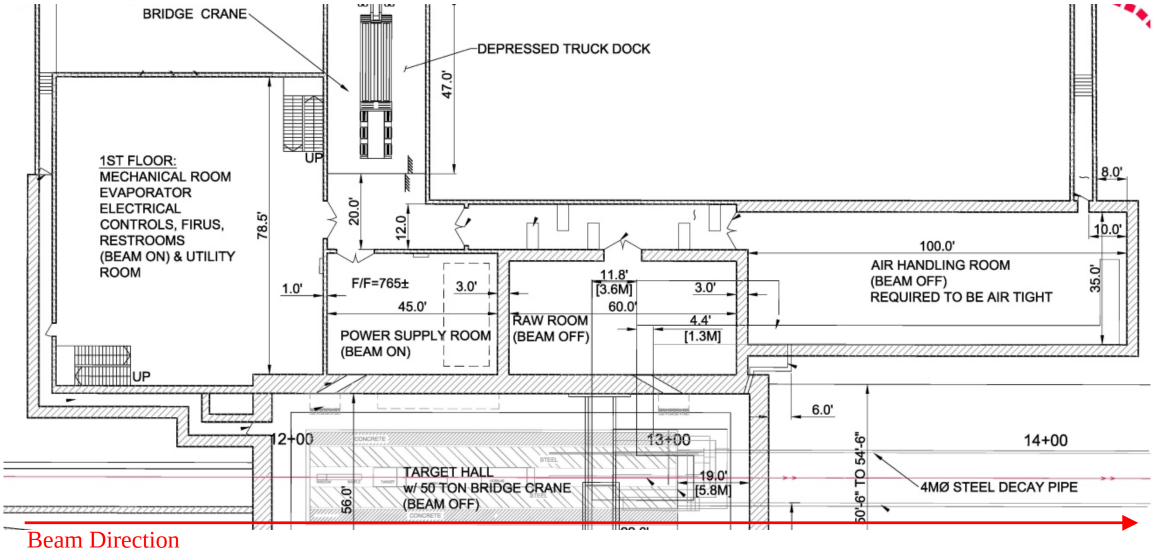

Figure 4-9: Target Complex; Beam Left.

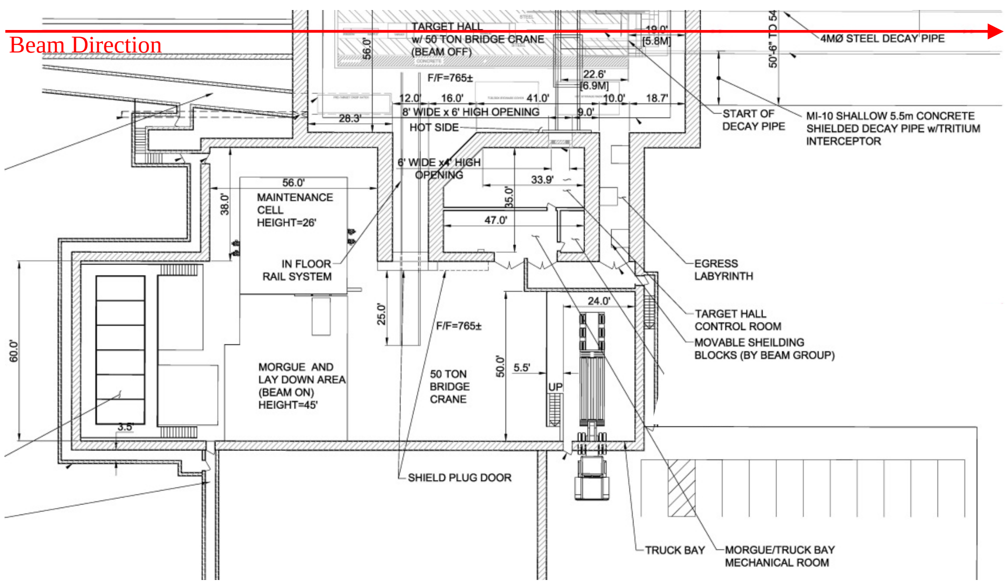

Figure 4-10: Target Complex; Beam Right.

The laydown area will also be used to store temporary shielding blocks and related components, and will be used for maintenance cell staging, fixtures and tooling storage, a shielded frisking area, and for a target insert mock-up area. Connected to this beam-right Target Hall support area will be the 38-ft by 56-ft hot handling maintenance cell for repairing and decommissioning target and horn components using telemanipulators. This area will be equipped with proper ventilation, fire protection, lighting and life safety.

To mitigate the impacts of settlement on the Primary Beam Enclosure and the Target Complex, 4-ft diameter drilled shafts will be constructed to support these structures. Drilled shafts will extend down to, and will bear on, the top of rock. An overall plan view of the extent of the embankment is shown in Figure 4-11. Note that the toe of the slope of the embankment is shown as a dashed line. Figure 4-11 also shows the plan view location of drilled shafts that will be constructed. Greater detail of the drilled shaft locations are provided in Figure 4-12 and Figure 4-13.

Analysis of the loading of a larger embankment than is currently planned as part of the MI-10 Beamline configuration indicated that the drilled shafts to rock that would be used to support the Primary Beam Enclosure would settle as much as 11mm in response to elastic shortening of the concrete drilled shaft caused by the settling soil transmitting friction to the drilled shafts as the embankment settles [14]. Analysis of the larger embankment estimated that 50% of the settlement will occur within one month of placing the embankment. Estimates include 90% of the settlement occurring within one year and 100% within two years. For these reasons, the Conventional Facilities plan is to include placement of the embankment as an early item to be constructed so that the area is preloaded to induce most settlement of underlying soils before the Beamline is constructed. Because some settlement may continue after construction of these structures, a grouting program will be established to fill the potential gap between the bottom of the structure and the embankment.

The settlement analysis work also included estimates of the impact of settlement on the Main Injector. Calculations show that about 2 mm of settlement are expected with about 1 mm of horizontal movement. For these reasons, braced excavation and retaining wall systems shown in Figure 3-1 are being provided for protection of the Main Injector. During Preliminary and Final Design the settlement analysis must be re-visited as additional project-specific geotechnical information is developed.

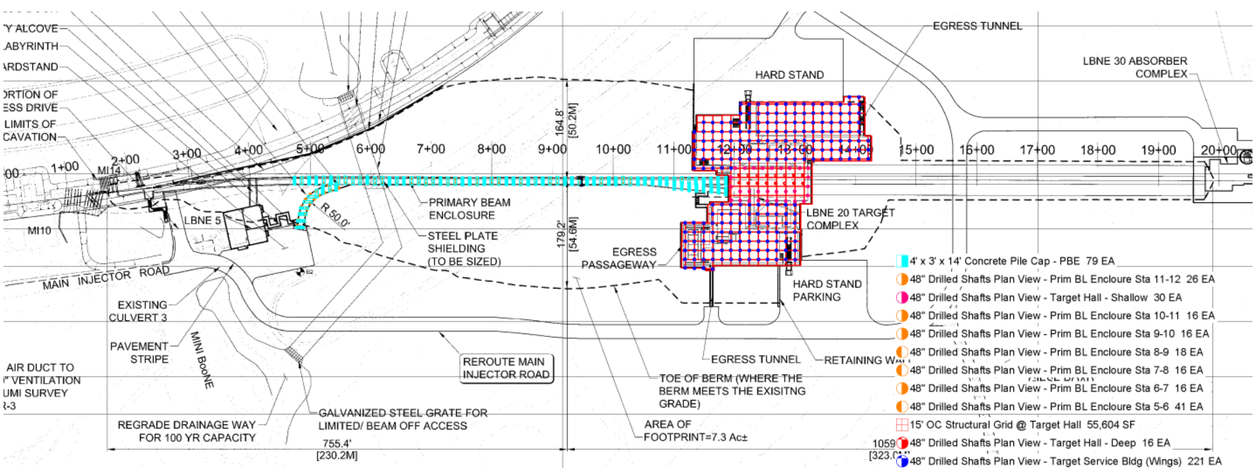

Figure 4-11: Plan view of toe of the embankment and drilled shaft locations.

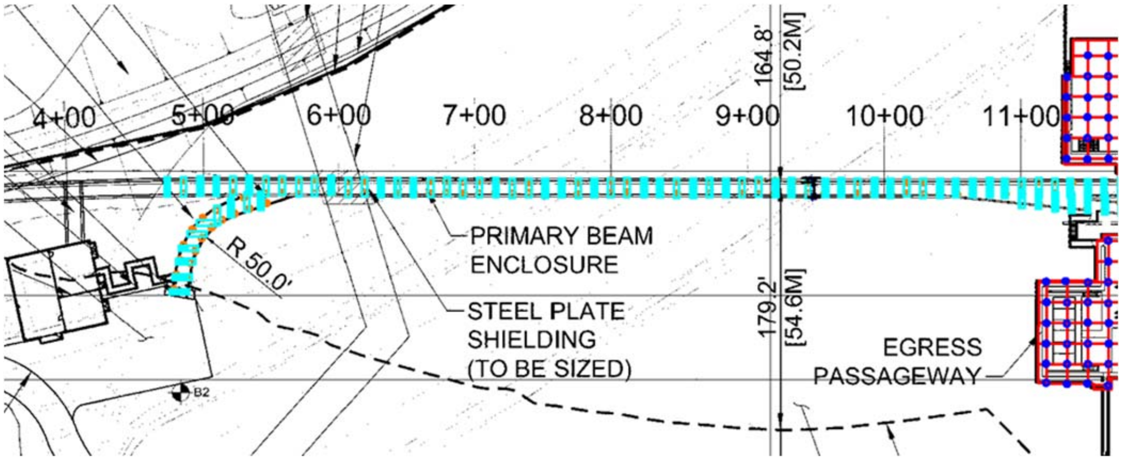

Figure 4-12: Drilled shaft pier cap locations for the Primary Beam Enclosure.

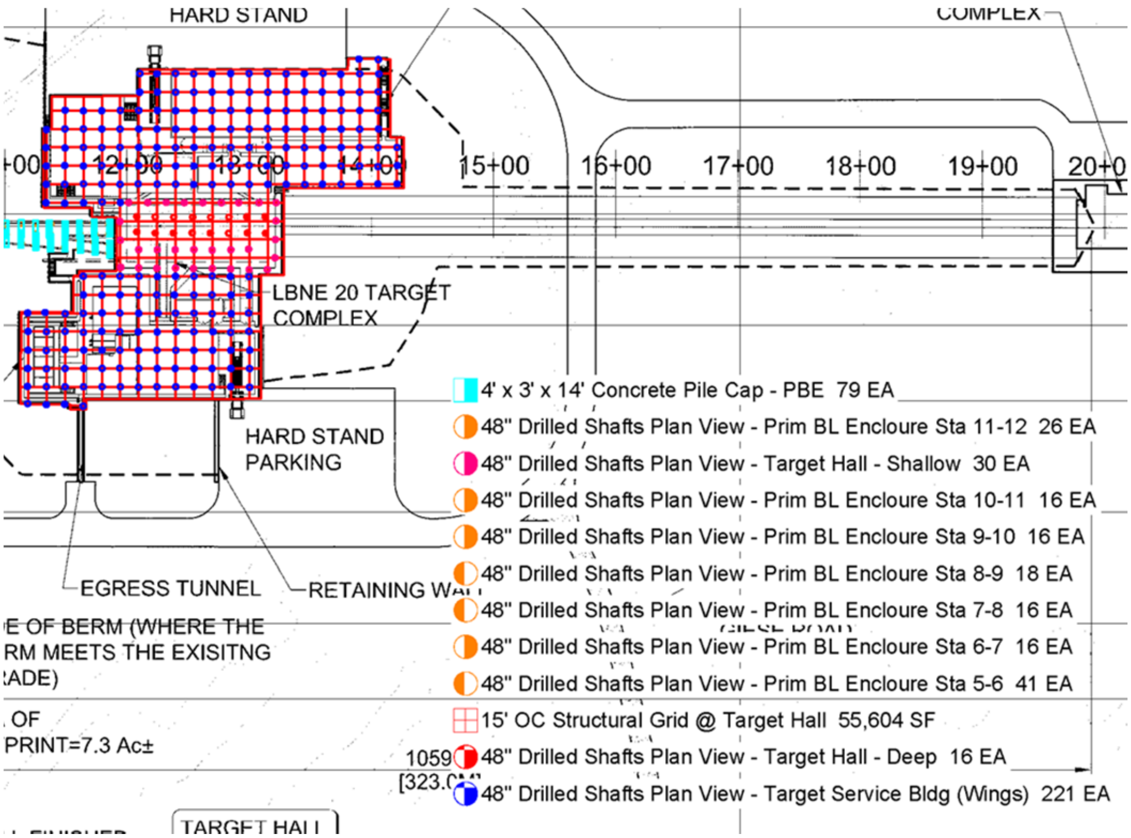

Figure 4-13: Drilled shaft locations for the Target Complex.

4.2.1 Mechanical

The entire Target Hall Complex (LBNE 20) shown in Figure 4-6 will be conditioned to 68°F (winter) or 78°F (summer) using chilled water/hot water (CHW/HW) air handling units (AHUs). Additional HW unit heaters will be strategically located as necessary to insure winter time minimum temperatures. CHW will be provided by packaged air-cooled chillers located on the LBNE 20 hardstand. The chilled water system will contain an appropriate level of propylene glycol to prevent freezing damage to all associated components. HW will be provided by natural gas hot water heaters.

The Target Hall chase/Decay Pipe AHU shall be provided with a 125,000-CFM (cubic feet per minute) custom built air conditioning unit capable of removing heat and moisture from the target chase and decay pipe. The supply air shall be divided to supply 75,000 CFM to the chase and 50,000 CFM to the Decay Pipe at a temperature of 59°F+/-2°F and 18% relative humidity (RH) maximum. The return air condition will be in the range of 90°-100°F and 35% RH. The unit will utilize CHW, HW desiccant wheels for dehumidification, and bag-in/bag-out High Efficiency Particle Arrestor (HEPA) air filter systems. All materials of the unit that come in contact with the airstream or condensate shall be resistant to corrosion from the radio-chemically induced nitric acid that is present in the air. The AHU shall be constructed minimizing single points of failure. Ductwork to and from the target chase and Decay Pipe shall be routed through excavated passageways between the Target Hall and the AHU room. Duct materials shall be welded steel constructed to Sheet Metal and Air Conditioning Contractors Association (SMACNA) 10 in water gage (wg) pressure class.

Condensate from the target chase/decay pipe AHU will contain tritium and some nitric acid. The condensate shall be captured and routed to a holding tank in the AHU room. The holding tank shall have secondary containment and multiple pumps (n+1) for pumping the condensate to the evaporation system in the LBNE 20 Service Building. A secondary pump (manually controlled) shall be provided to pump condensate to a convenient location in the accessible common underground area for barreling condensate (barreling provides back-up in case of evaporator system or other failure). All piping shall be stainless steel or Sch80 PVC and any piping outside the AHU room shall have secondary containment (double walled).

The Target Hall air conditioning unit shall be a small similarly designed unit to the target chase/Decay Pipe AHU providing one air change per hour, approximately 4,000 CFM, to the Target Hall. The two units will be located in the same room. The air supply and return shall be ducted through the pressure equalization duct that connects the hall to the AHU room. The condensate from this unit shall be routed to the condensate holding system.

Target Hall negative pressure during beam-on shall be provided by an exhaust duct near the upstream end of the Target Hall. This duct exits the hall at the upstream end above the Primary Beam Enclosure. Outside of the building but within an ES&H secured area, a fan will be provided to exhaust 6,000 CFM discharging air vertically at a height of 14 feet during beam-off for Target Hall purge. During beam-on operation the Target Hall will be maintained at a negative pressure relative to the outside air by taking an airflow of 1,250 CFM directed to the NuMI survey riser 3 (SR3) through a below-grade duct. A fan will be provided within an ES&H secured areaway at the NuMI SR3 location to direct the airflow down into the NuMI Target Hall.

The 11,465 ft^2 two-story mechanical wing will house the conventional and programmatic mechanical equipment including: chilled water pumps, hot water pumps, heat exchangers, evaporators, exterior air cooled chillers, natural gas boilers, hot water pumps, CHW/HW air handlers, and ventilation/exhaust fans. Target Hall controls are housed here as well as fire protection systems and plumbing for occupants. The wet pipe sprinkler system for this complex is served from the sitewide ICW network that is extended to the building from the existing nearby system. Any space where the application of water could constitute a radiation-related risk as determined by LBNE and the AHJ will not have sprinkler systems.

Also located in the mechanical wing are systems dedicated to serve the Target Hall Complex. These include the CHW/HW dedicated outside air system (DOAS) AHU that provides conditioned ventilation air to the Target Hall support areas; and the condensate evaporation system. Condensate from the target chase/Decay Pipe AHU system is pumped to an elevated holding tank in the second floor room. The holding tank shall have a nitric acid neutralization system to pH balance the condensate before it is evaporated. From this tank the condensate is gravity fed into evaporators. The evaporated discharge is drawn to roof mounted exhaust fans and discharged vertically at high velocity.

The 3,500 ft^2 air handing room will house the 125,000-CFM AHU and desiccant dryers to supply air cooling, dehumidification, and bag-in/bag-out HEPA air filter systems for the Target Hall, target chase, and Decay Pipe. The power supply room will house the power supply cabinet and relays, and a penetration supported by a 30 in diameter steel pipe cast into the 5 ft thick concrete Target Hall wall for the power strip line.

Target Hall support areas containing the power supply, RAW skid and utility rooms shall be conditioned by a locally placed small chilled water/hot water AHU. Ventilation for these areas shall be provided by a dedicated outside air system (DOAS) located in the service building mechanical area. The DOAS shall provide adequate personnel ventilation and dehumidified neutral air to the space for humidity control and positive pressurization with respect to the Target Hall. Maximum final space condition shall be 73°F +/- 5°F and 50% RH.

4.2.2 Electrical

The electrical facilities provided at LBNE 20 Target Hall Complex, will support the requirements of the technical systems in accordance with the Fermilab standards, NEC, and other applicable codes. The building site will have two separate electrical services: one serving the conventional system and the other serving the technical systems (pulsed power). A conventional 13.8-kV power system will be provided for electricity service to the building systems, lighting, HVAC, crane, misc. loads, and low power technical system components such as racks and computers. A technical system, (pulsed power), 13.8 kV power system will be provided for electricity service to large technical systems such as beam power supplies. The conventional systems group will provide the 13.8-kV primary electrical power to an outdoor switchgear, one for each power system. Conventional Facilities will provide a prepared space at LBNE 20 for the technical system transformers and components to be installed by the Beamline subproject. Two transformers for Conventional Facilities will be installed at LBNE 20, one to serve the building loads and the other to serve the 4.16-kV chillers. An emergency/standby power system with generator will be installed to serve critical loads for life safety and technical system components as well as the four crane systems.

The building will be outfitted with panelboards, lighting, power receptacles, emergency/standby power systems and HVAC components to support the requirements of the technical systems. A main switchboard/panelboard will be installed to distribute power to large dedicated loads and sub-panelboards in local building and tunnel areas. Emergency/standby power will be provided at a dedicated emergency power panelboard.

The lighting system shall be installed according to the lighting level required by the use of the space. All lighting installed in areas that are exposed to radiation must be protected from the radiation or be resistant to the degrading and contaminating effects of radiation on electronic components. All emergency lighting in the Target Complex shall be powered from a separate remote battery powered UPS system that is completely isolated from sources of radiation. This system will remain operable until the standby generator is available to provide power or power is restored.

Power receptacles will be provided in the LBNE 20 area for use as needed during outfitting and operation. The receptacles will be configured based on site equipment standards. All loads that require emergency/standby power will be served from the dedicated panelboard. The HVAC equipment will be served from the nearest conventional power panelboard as needed.

Table 4-3 shows the Target Hall Complex (LBNE 20) electrical power loads, for both Normal Power and the Standby Power Generators.

Table 4-2: Target Hall Complex Electrical Power Loads

Equipment Description	**Normal Power (kw)**	**Standby Power Generators (kw)**
Chiller (400 ton) (3 ea.)	1123	
Chilled water pumps [total] (2200 gpm, 100 hp) (2 ea., 1 full time)	70	
Condensate pumps (3 total)	3	
Sump pump (3 total)	3	3
Hot water pump	19	
MAU (makeup air): Support, morgue, truck dock/control rooms (3 total)	15	
MAU Desiccant	12	
RCU Desiccant (Target Hall)	203	
RCU Desiccant (other)	24	
RCU: Utility Room, Power Supply Room (2 total)	16	
AHU: service, MEP, Target Hall (3 total)	43	
Dehumidifier	5	
Exhaust fans: morgue, truck dock, Target Hall, Target Chase (4 total)	22	
Lighting & Receptacle & Experimental	233	58
50 ton bridge crane -Target Hall, morgue/laydown (2 total)	98	98
15 ton bridge crane - Maintenance Cell	25	25
20 ton bridge crane - truck bay	25	25
Total Connected Load	**1947**	**259**

4.2.3 Plumbing

Fire protection systems and plumbing systems, including restrooms on both sides of the complex are included. The wet pipe sprinkler system for this complex is served from the sitewide ICW network that is extended to the building from the existing system. Target Pile and Decay Pipe AHU cooling water is supplied from the air cooled chiller in the LBNE 20 mechanical room which is a closed-loop glycol system. Natural gas is routed to this building from the site-wide network to be used for hot water heating for domestic water and building heat.

A duplex ground water sump system is located in the target support area. The system receives drainage from the Target Hall under drainage network. This system discharges directly to the site wide ICW system.

4.2.4 Fire Protection/Life Safety Systems

Egress paths for surface (service buildings) and underground facilities (tunnels and halls) have been conceptually designed to limit the travel path distances to egress shafts, stairways, and safe/fire rated corridors to the exterior and surface to a safe gathering location. See Section 3.1.4 of this volume for a general overview of fire protection and fire life/safety requirements.

Conventional Facilities is responsible for the design, cost/scheduling and construction of these systems including the mechanical (emergency ventilation), electrical (emergency generator for lighting, ventilation, sump pumping, fire alarms, and communication), and plumbing (fire suppression/sprinkler piping and fixtures, and emergency sump pumping). Any space where the application of water could constitute a radiation-related risk as determined by LBNE and the Authority Having Jurisdiction (AHJ) will not have sprinkler systems.

The Target Complex has several egress routes which are described below and shown in Figure 4-14. Beam-Left Support Rooms Egress Routes: From the air handling room (AHR) there are two egress routes to two separate safe corridors that provide direct access to the exterior of the building. From each of the power supply room and RAW room there is a single egress route to a safe/fire rated corridor to the truck bay and to the exterior. From the two-story mechanical electrical plumbing (MEP) rooms there are two separate egress routes: one to the truck bay and to the exterior, and one to the safe/fire rated egress corridor and to the exterior.

Target Hall Egress Routes: There are two separate egress routes. One route is through the beam-right egress labyrinth at the downstream end of the hall thru the egress corridor adjacent to the beam right truck bay and to the exterior, to a safe gathering area. The other Target Hall egress is at the upstream beam-left side of the Target Hall to a safe/fire rated egress corridor adjacent to the MEP rooms and to the beam-left exterior of the Target Complex.

Beam Right Support Rooms Egress Routes: There are two separate egress routes, one is along the upstream side of the complex thru a safe/fire rated corridor to the exterior and the other is at the downstream end of the beam right portion of the truck bay and to the exterior.

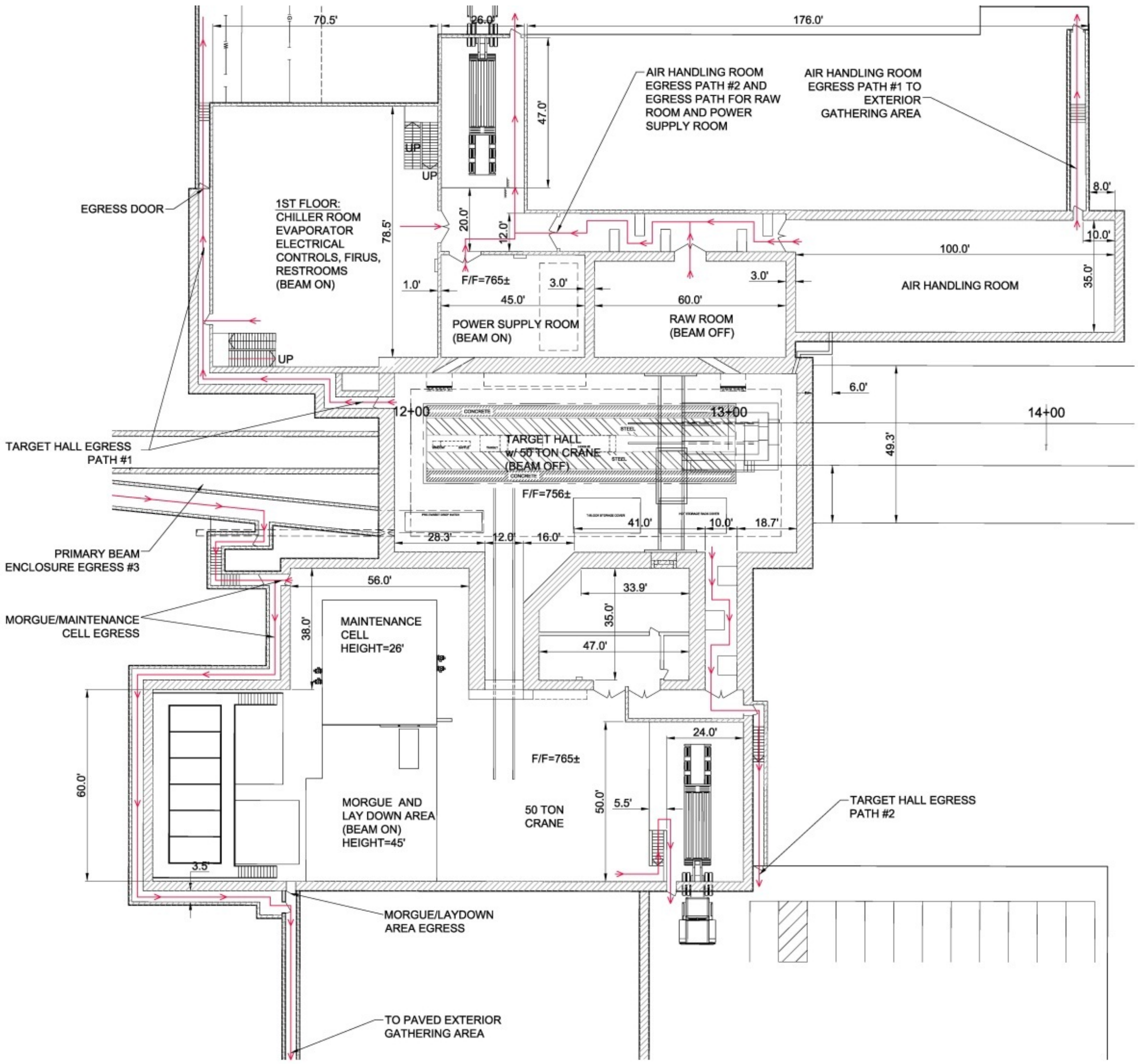

Figure 4-14: Target Complex Egress Routing.

4.3 Absorber Service Building (LBNE 30) (WBS 130.06.02.05.03.03)

The Absorber Service Building (LBNE 30), shown in Figure 4-15, consists of the 65-ft wide by 109-ft long above-grade building to accommodate the support equipment and access needed for the assembly and operation of the equipment and technical components of the Absorber Hall, Muon Alcove, and support rooms which are 83 ft below the service building floor. LBNE 30 will be located over a 22-ft diameter access/egress shaft and over the 22-ft wide by 57-ft long equipment shaft to the below-grade Absorber Hall, Muon Alcove, and support rooms (see Figure 4-15).

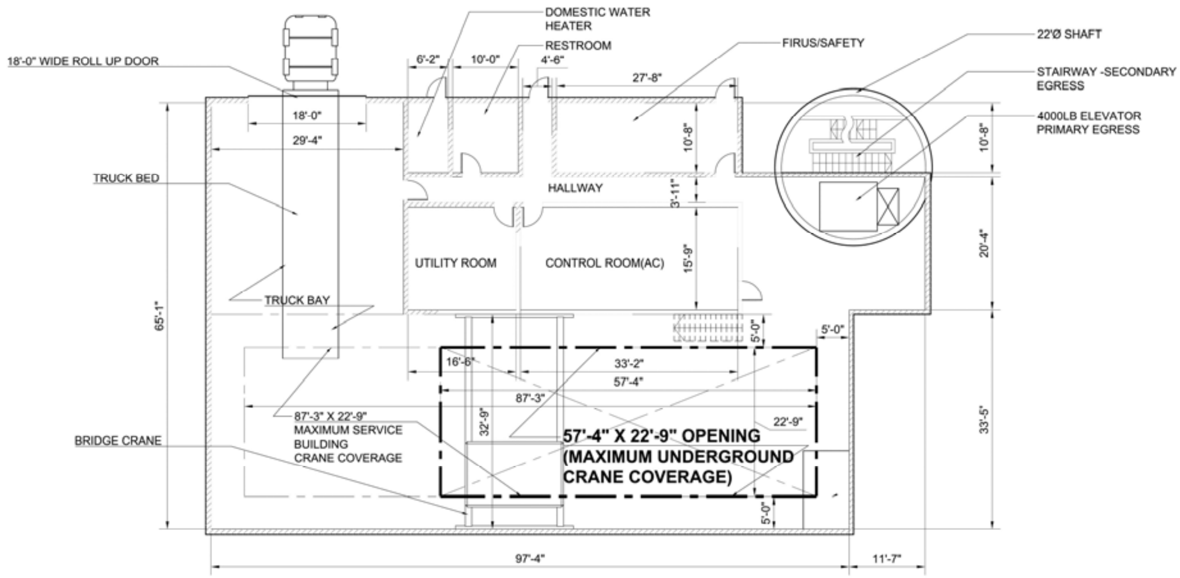

Figure 4-15: Absorber Service Building (LBNE 30) Floor Plan.

The 8,250-ft^2 near surface building will have steel framing and metal siding with a cast-in-place concrete foundation. The floor of this building will be 14 ft below grade to reduce the bridge crane hook height/vertical travel distance to the Absorber Hall and Muon Alcove floor (83 ft below as described in Section 5.3). This building has a 35-ft clear crane height and will house an open truck bay, laydown area with a 22-ft wide by 57-ft long floor opening to the Absorber Hall and Muon Alcove below, an air seal/shielded hatch cover system for the floor opening, a 30-ton bridge crane, control room, fire/life safety room, and a mechanical equipment and utility room, including: chilled water (CHW) pumps, hot water (HW) pumps, heat exchangers, exterior air cooled chillers, natural gas boilers, hot water pumps, CHW/HW air handlers, ventilation/exhaust fans for the surface building and desiccant dryers (dehumidifiers for the Absorber Hall, Muon Alcove, and support rooms). The truck bay with a ramp up to finished grade is provided for equipment to be unloaded using the overhead crane and lowered down shaft to the Absorber Hall and Muon Alcove.

4.3.1 Mechanical

The air in the Absorber Service Building (LBNE 30) will be conditioned to 68ºF (winter) and 78ºF (summer) using CHW/HW AHUs. Additional HW unit heaters will be strategically located, as necessary to insure winter time minimum temperatures. CHW will be provided by packaged air cooled chillers located on the LBNE 30 hardstand. The chilled water system shall contain an appropriate level of propylene glycol to prevent freeze damage to all associated components. HW will be provided by natural gas hot water heaters. Also located in the mechanical area are CHW/HW dedicated outdoor air AHUs with desiccant dehumidification that provide dry neutral temperature ventilation air to the below grade general areas and exit passageways.

4.3.2 Electrical

The electrical facilities provided at LBNE 30 Absorber Service Building will support the requirements of the Beamline technical systems in accordance with the Fermilab standards, NEC, and other applicable codes. The building site will have one electrical service. A conventional 13.8-kV electrical power service will be provided to the building systems, lighting, HVAC, crane, miscellaneous loads, and low power technical system components such as racks and computers. A beamline technical system (pulsed power), 13.8-kV power system is not required and will not be provided. The Conventional Facilities scope of work will provide the 13.8-kV primary electrical power to an outdoor 600 A switchgear. Two transformers for Conventional Facilities will be installed at LBNE 30, one to serve the building loads and the other to serve the 4.16-kV chillers. An emergency/standby power system with generator will be installed to serve critical loads for life safety and technical system components. A dedicated separate emergency/standby power system will be provided for the three Absorber Hall sump pump systems.

The building will be outfitted with panelboards, lighting, power receptacles, emergency/standby power systems and HVAC components to support the requirements of the technical systems. A main switchboard/panelboard will be installed to distribute power to large dedicated loads and sub-panelboards in local building and tunnel areas. Emergency/standby power will be provided at a dedicated emergency power panelboard.

The lighting system will be installed according to the lighting level required by the use of the space. All lighting installed in areas that are exposed to radiation must be protected from the radiation or be resistant to the degrading and contaminating effects of radiation on electronic components. All emergency lighting in the Absorber Service Building will be powered from a separate remote battery powered UPS system that is completely isolated from sources of radiation. This system will remain operable until the standby generator is available to provide power or power is restored.

Power receptacles will be provided in the building and tunnel for use as needed during outfitting and operation. Receptacles will be configured based on site equipment standards. All loads that require emergency/standby power will be served from the dedicated panelboard. The HVAC equipment will be served from the nearest conventional power panelboard as needed.

Table 4-3 shows the Absorber Service Building (LBNE 30) electrical power loads, both Normal Power and Standby Power Generators.

Table 4-3: Absorber Hall and Absorber Service Building (LBNE 30) Electrical Power Loads.

Equipment Description	**Normal Power (kw)**	**Standby Power Generators (kw)**
Chiller (300 tons) (2 ea.)	562	
Chilled water pump (1,400 gpm, 50 hp) (2 ea., 1 full time)	37	
Condensate pump (3 total)	3	
Hot water pump	5	
Refrigerated Dehumidifier	12	
Sump pump (6 total, 4 running full time)	163	25
Manual Pumps – Decay pipe water (2 total)	31	31
Holding tank pump (2 total, 1 running full)	38	
Fan coil	1	

Equipment Description	Normal Power (kw)	Standby Power Generators (kw)
Elevator	37	37
AHU Surface Building	27	
AHU desiccant	6	
Dehumidifier	5	
Exhaust fan	2	2
Lighting & receptacle & Experimental	85	21
30 ton bridge crane	49	49
Total Connected Load	**1060**	**302**

4.3.3 Plumbing

Fire protection systems and plumbing systems, including restrooms, are included. The wet pipe sprinkler system for this complex is served from the site wide ICW network that is extended to the building from the existing system. Natural gas is routed to this building from the site-wide network to be used for hot water heating for domestic water and building heat.

4.3.4 Fire Protection/Life Safety Systems

Egress paths for surface (service buildings) and underground facilities (tunnels and halls) have been conceptually designed to limit the travel path distances to egress shafts, stairways, and safe/fire rated corridors to the exterior and surface to a safe gathering location. See Section 3.1.4 of this volume for a general overview of fire protection and fire life/safety requirements.

Conventional Facilities (CF) is responsible for the design and construction of these systems including the mechanical (emergency ventilation), electrical (emergency generator for lighting, ventilation, sump pumping, fire alarms, and communication), and plumbing (fire suppression/sprinkler piping and fixtures, and emergency sump pumping). Any space where the application of water could constitute a radiation-related risk as determined by LBNE and the AHJ will not have sprinkler systems.

4.4 Near Detector Service Building (LBNE 40) (WBS 130.06.02.05.03.04)

The Near Detector Service Building (LBNE 40), as shown in Figure 4-16, is a 45-ft wide by 136-ft long by 42-ft high grade-level building. It will be used to house the support equipment and truck bay/lay down area needed for the assembly and operation of the equipment and technical components for the Near Detector Hall and support rooms. The truck bay/staging area portion of the building has a 35-ft interior clear ceiling height.

Also included in this building are the mechanical/electrical rooms, fire/life safety room, domestic water/meter room, and restroom. The mechanical room will house the shaft mechanicals, chilled water pumps, heat exchangers, exterior air cooled chillers, natural gas boilers, hot water pumps, CHW/HW air handlers, ventilation/exhaust fans for the surface building and desiccant dryers (dehumidifiers) for the Near Detector Hall and support rooms.

The truck bay will be provided for equipment to be unloaded using the 15-ton overhead bridge crane. Equipment and detector components will be lowered down the 22-ft diameter shaft to the Near Detector Hall approximately 185 ft below grade. This equipment can then be moved, using carts or portable hoists, where required. Because the initial detector installation and possible future removal are isolated events, the building crane capacity is not designed for these infrequent loads. Instead, a removable service building roof hatch cover over the 22-ft diameter shaft will be required for initial installation and future removal or replacement of Near Detector Hall components by use of a rented 200-ton crawler crane.

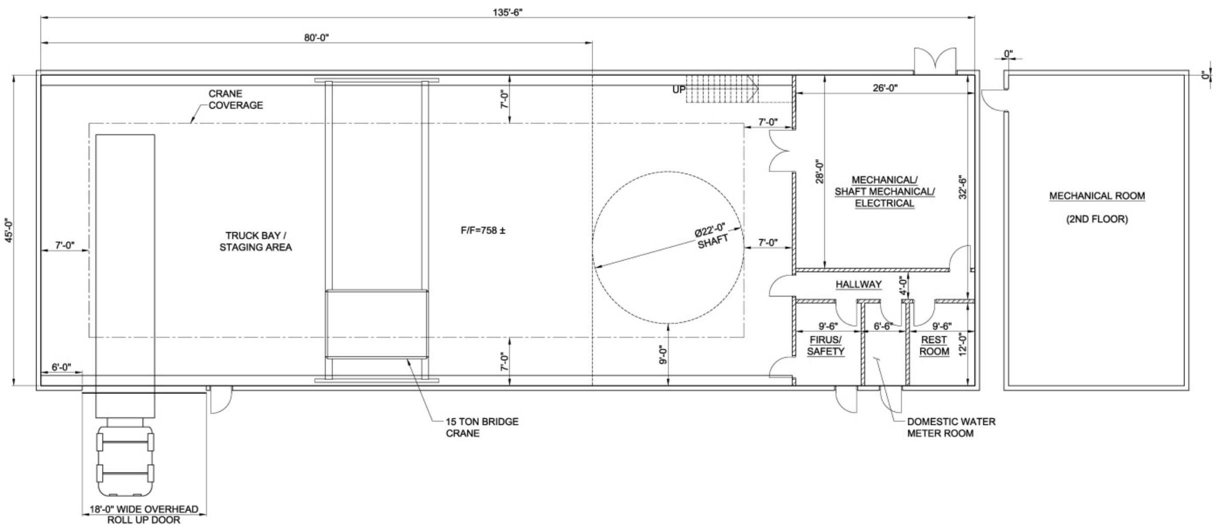

Figure 4-16: Near Detector Service Building (LBNE 40).

Due to its proximity to Kirk Road and the adjacent residential area west of Kirk Road, the LBNE Near Detector Service Building will be visible and will be architecturally-appropriate for the surroundings. The building façade is planned to consist of a steel frame with brick and metal siding on a cast-in-place concrete foundation. An earthen landscape screening berm is planned for the construction phase as well as final grading and landscaping to minimize the visual and noise effects of the construction activities and to mitigate the visual impact of the approximately 42-ft high permanent building.

4.4.1 Mechanical

The entire Near Detector Service Building (LBNE 40) will be conditioned to 68ºF (winter) and 78ºF (summer) using CHW/HW AHUs. Additional HW unit heaters will be strategically located, as necessary to insure winter time minimum temperatures. CHW will be provided by packaged air cooled chillers located on the LBNE 40 hardstand. The chilled water system shall contain an appropriate level of propylene glycol to prevent freeze damage to all associated components. HW will be provided by natural gas hot water heaters. Also located in the mechanical area are CHW/HW dedicated outdoor air AHUs with desiccant dehumidification that provide dry neutral temperature ventilation air to the below grade general areas and exit passageways.

4.4.2 Electrical

The electrical facilities provided at LBNE 40 Near Detector Service Building will support the requirements of the technical systems in accordance with the Fermilab standards, NEC, and other applicable codes. The building site will have one electrical service. A conventional 13.8-kV power system will be provided for electricity service to the building systems, lighting, HVAC, crane, miscellaneous loads, and low power technical system components such as racks and computers. A technical system (pulsed power), 13.8-kV power system is not required and will not be provided. The Conventional Facilities scope of work will provide the 13.8-kV primary electrical power to an outdoor 600-A switchgear. Two transformers for Conventional Facilities will be installed at LBNE 40, one to serve the building loads and the other to serve the 4.16-kV chillers. An emergency/standby power system with generator will be installed to serve critical loads for life safety and detector technical system components.

The building will be outfitted with panelboards, lighting, power receptacles, emergency/standby power systems and HVAC components to support the requirements of the technical systems. A main switchboard/panelboard will be installed to distribute power to large dedicated loads and sub-panelboards in the building and tunnel areas. Emergency/standby power will be provided at a dedicated emergency power panelboard.

The lighting system will be installed according to the lighting level required by the users of the space. All emergency lighting in the underground detector enclosure will be powered from a separate remote battery powered UPS system that is completely isolated from sources of radiation. This system will remain operable until the standby generator is available to provide power or power is restored.

Power receptacles will be provided in the building and tunnel for use as needed during outfitting and operation. The receptacles will be configured based on site equipment standards. All loads that require emergency/standby power will be served from the dedicated panelboard. The HVAC equipment will be served from the nearest conventional power panelboard as needed.

Table 4-4 shows the Near Detector Service Building (LBNE 40) and Near Detector Hall electrical power loads for both Normal Power and the Standby Power Generators.

Table 4-4: Near Detector Hall and Near Detector Service Building (LBNE 40) Electrical Power Loads.

Equipment Description	**Normal Power (kw)**	**Standby Power Generators (kw)**
Chiller (300 tons) (2 ea.)	243	
Chilled water pump (700 gpm, 25 hp) (2 ea., 1 full time)	19	
Hot water pump	5	
Fan coil (2 total)	4	
AHU desiccants (2 total)	11	
AHU (2 total)	27	
Elevator	37	37
Exhaust fan (2 total)	17	17
Sump pump (2 total)	38	38
Lighting & Receptacle & Experimental	85	21
15-ton bridge crane – Near Detector Hall, LBNE 40 (2 total)	310	310
Total Connected Load	**795**	**423**

The significant electrical loads in the Near Detector Hall will be served directly from 480-volt panelboards located in the underground facility. The significant 480-volt loads include the sump pumping system, HVAC systems, 15-ton crane, and the 120/208 panelboards for controls and instrumentation.

4.4.3 Plumbing

Fire protection systems, plumbing, and a restroom for occupants are included. The wet pipe sprinkler system for this complex is served from the LBNE 40 domestic water system. The domestic water and sanitary sewer services will be supplied from the city of Batavia water and SS mains located on the west side of Kirk Road. Natural gas is routed to this building from the site-wide network to be used for hot water heating for domestic water and building heat.

4.4.4 Fire Protection/Life Safety Systems

Egress paths for surface (service buildings) and underground facilities (tunnels and halls) have been conceptually designed to limit the travel path distances to egress shafts, stairways, and safe/fire rated corridors to the exterior and surface to a safe gathering location.

See Section 3.1.4 of this volume for a general overview of fire protection and fire life/safety requirements.

Conventional Facilities is responsible for the design and construction of these systems including the mechanical (emergency ventilation), electrical (emergency generator for lighting, ventilation, sump pumping, fire alarms, and communication), and plumbing (fire suppression/sprinkler piping and fixtures, and emergency sump pumping).

Emergency egress routes for the Near Detector Service Building (LBNE 40) will be provided to allow exiting through a choice of two single exterior doors or an exterior double door.

5 New Underground Structures

The LBNE Conventional Facilities on the Near Site will include new underground structures including the Beamline Extraction Enclosure and Primary Beam Enclosure, the Decay Pipe, the Absorber Hall and Support Rooms, and the Near Detector Hall and Support Rooms. This section provides additional details regarding these facilities.

5.1 Beamline Extraction Enclosure and Primary Beam Enclosure (WBS 130.02.05.04.01 and 130.06.02.05.04.02)

The first underground functional area is the Beamline Extraction Enclosure and Primary Beam Enclosure. This area, consisting of the upstream Beamline Extraction Enclosure and the downstream Primary Beam Enclosure are required to allow the beam to be extracted from the Main Injector and transported 374 m (1,227 ft) to the LBNE Target Complex. The construction of the upstream portion of this area will consist of a cut-and-cover below-grade section. The downstream portion of this area includes a transition from the below-grade section to an above-grade section located within an embankment. Some of these areas will be constructed using cast-in-place concrete sections and other areas will be pre-cast concrete enclosure sections. The Beamline Extraction Enclosure and Primary Beam Enclosure are shown in Figure 5-1.

Due to the construction of this facility over the existing Main Injector (MI) Road, Cooling Pond F, and associate existing underground and overhead utilities, rerouting of the road and utilities, plus construction of a new cooling pond will be required.

The Beamline Extraction Enclosure portion, shown in plan view in Figure 5-2 and Figure 5-3, will start from the existing Main Injector near MI-10, and extend approximately 43 ft to the start of the Primary Beam Enclosure.

Figure 5-4 shows a section view of the Beamline Extraction Enclosure at the existing MI-14 Service Building. An open cut braced excavation will be performed at MI-14 that will expose the MI Enclosure. As shown in Figure 5-5, a cast in place (CIP) structural concrete cocoon will be constructed around the MI Enclosure to protect it from the loading of the additional soil shielding fill required for LBNE and to add structural integrity to the MI Enclosure before the side wall of the MI Enclosure is removed. This opening will allow construction of a 12-in diameter steel beamline transport pipe to divert beam to the Primary Beam Enclosure, and will also allow beamline water cooling lines, power, and utility routing from the MI to the Primary Beam Enclosure.

The excavated area (as shown in Figure 5-4) will be backfilled with light weight flowable concrete fill. Secant pile braced excavation walls will be constructed to protect the existing MiniBooNE beamline enclosure. An extensive system of secant pile walls and H-pile and lagging braced excavation walls will be constructed to protect the Main Injector Enclosure from lateral loading from the 70-foot high embankment.

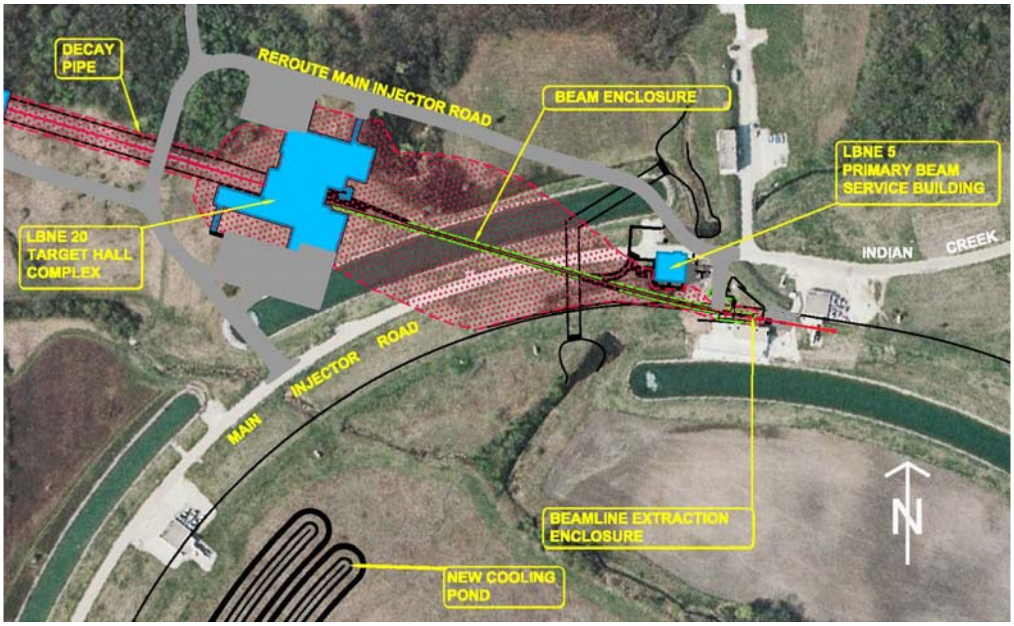

Figure 5-1: Beamline Extraction Enclosure and Primary Beam Enclosure – Aerial View.

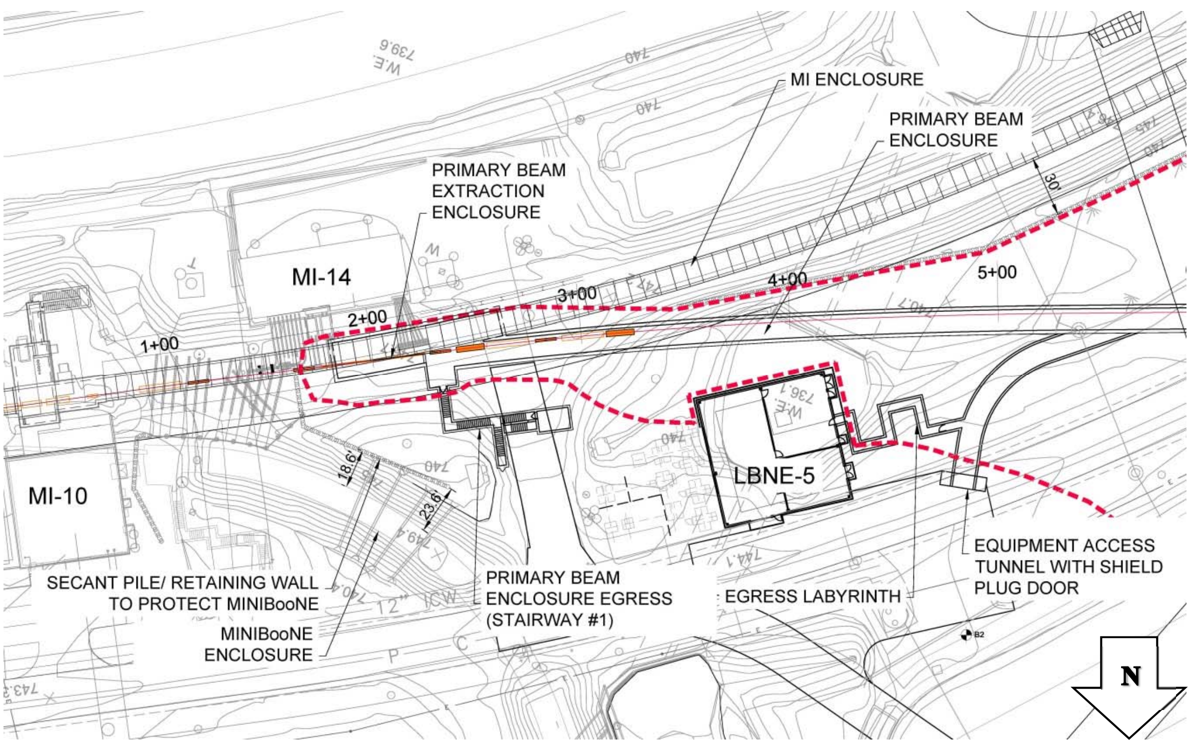

Figure 5-2: Beamline Extraction Enclosure and Primary Beam Enclosure.

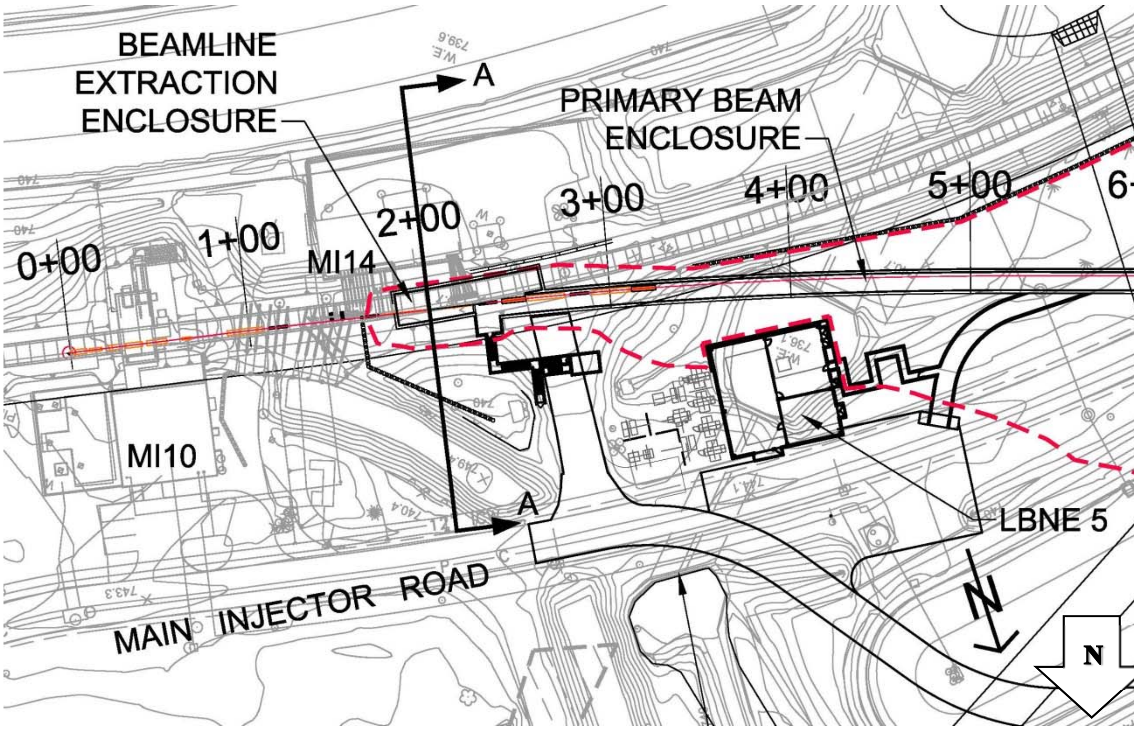

Figure 5-3: Beamline Extraction Enclosure and Primary Beam Enclosure with Section A-A cut shown to show location of section shown in Figure 5-4.

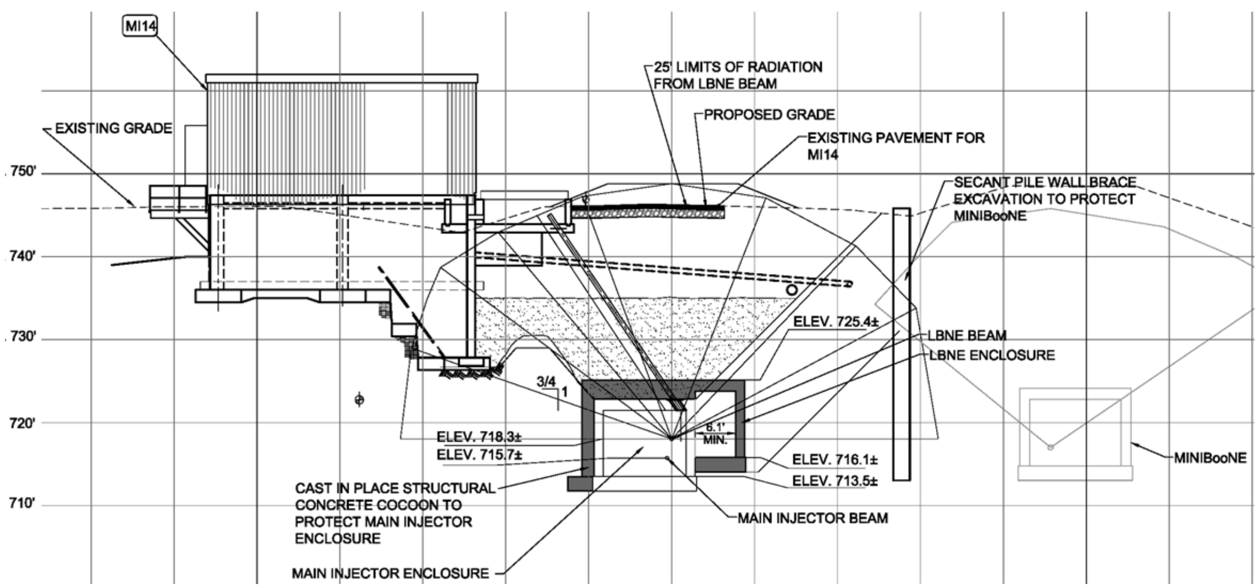

Figure 5-4: Beamline Extraction Enclosure section view at MI-14 showing the structural concrete cocoon around the MI enclosure (Section A-A as noted in Figure 5-3).

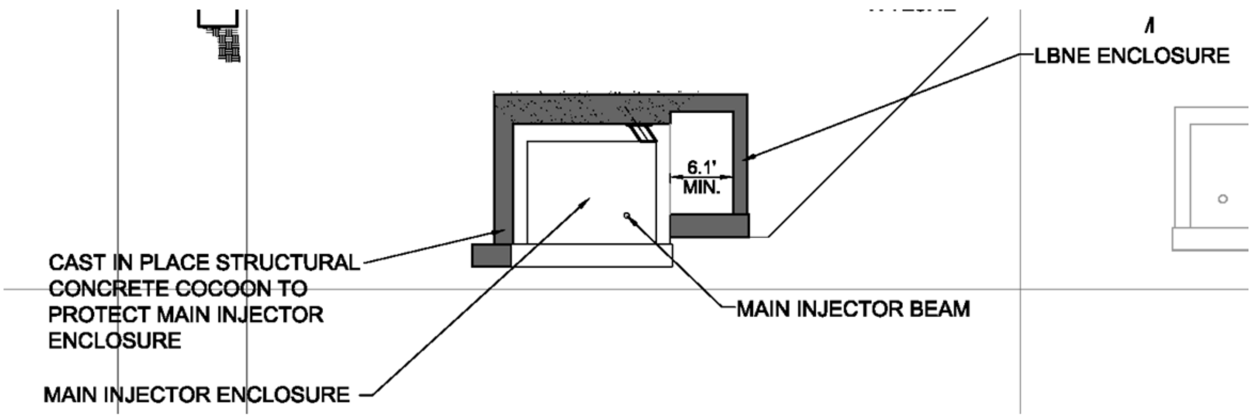

Figure 5-5: Beamline Extraction Enclosure at the connection to the MI enclosure showing the structural concrete cocoon around the MI enclosure.

The 1,200-ft long Primary Beam Enclosure will start at the end of the extraction enclosure and continue along a 15% incline into and through the above-grade embankment, and then at a 10% decline to and through the Target Hall. The depth of the enclosure will be 32.5 ft from the top of the soil shielding fill to the invert/floor. This will provide a minimum of 25 ft of soil and concrete shielding (measured from the center of the beamline) for both the 700-kW and 2.3-MW beam power levels. The apex of the embankment over the Primary Beam Enclosure will be approximately 70 ft above existing grade. With the required minimum 25 ft of soil and concrete shielding, the apex of the beamline will be 45 ft above existing grade as shown in Figure 1-1.

Figure 5-6 shows a cross section in the soil overburden which will be constructed in a cut-and-cover excavation from STA 2+68 to STA 5+60. There will be areas along the beamline where the Primary Beam Enclosure will be constructed on the first lift of embankment fill and later backfilled with the required 25 ft of soil shielding, as occurs from STA 5+60 to STA 11+90. The enclosure will be a combination of cast-in-place concrete where construction constraints require, as well as precast concrete inverted U-shaped sections constructed on a cast-in-place concrete slab. Figure 5-6 also depicts the graphical measurement of the required minimum 25 ft of soil and concrete shielding.

The Primary Beam Enclosure has interior dimensions measuring 10 ft wide and 8 ft high. These dimensions match that of the existing Main Injector enclosure. Figure 5-7 shows a typical cross section of the Primary Beam Enclosure that shows the locations of the technical components and technical and conventional utilities.

The Beamline Extraction Enclosure portion, shown in plan view in Figure 5-2 and Figure 5-3, will start from the existing Main Injector near MI-10, and extend approximately 43 ft to the start of the Primary Beam Enclosure.

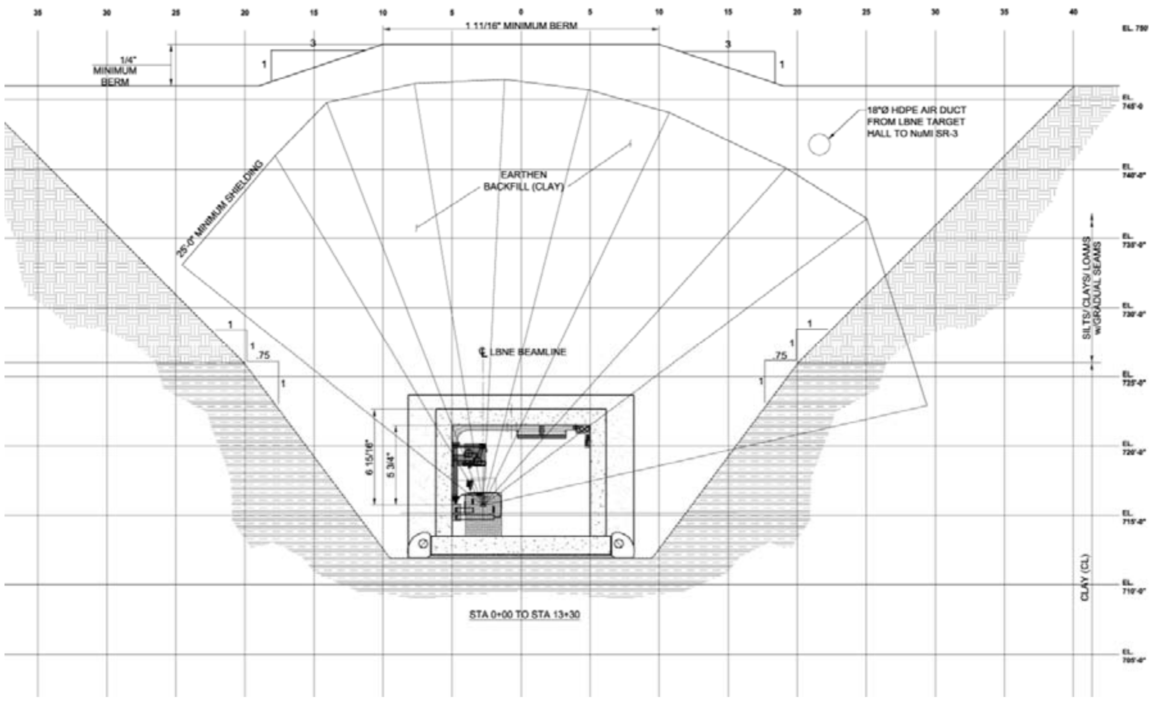

Figure 5-6: Primary Beam Enclosure section view.

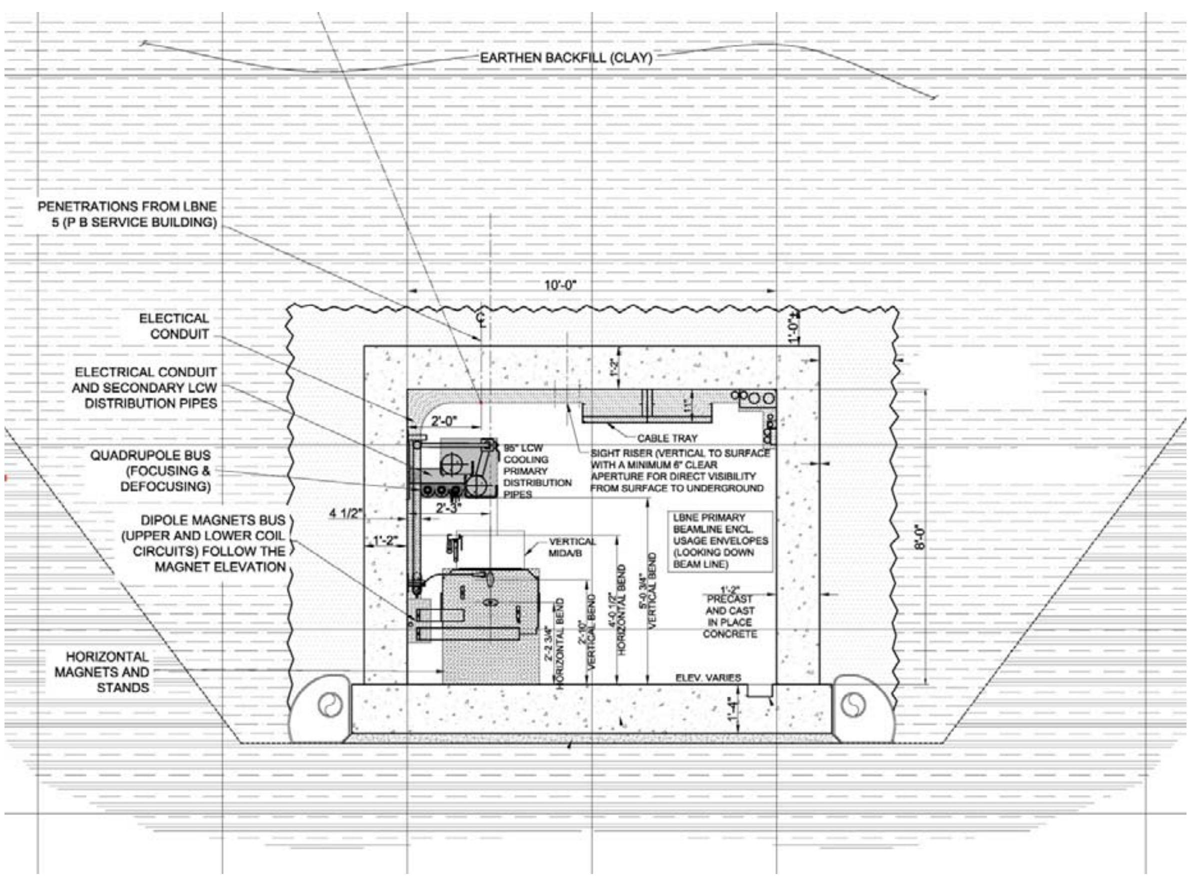

Figure 5-7: Primary Beam Enclosure showing technical components. Typical enclosure section.

Site work for the construction of the engineered embankment, the Primary Beam Enclosure, and the Target Complex (LBNE 20) includes the re-routing of Main Injector Road which is shown in Figure 5-8. Existing underground utilities, including electrical power and communications duct banks have been identified in this area and must also be re-routed around the embankment. The portion of underground work from the extraction enclosure at STA 0+00 to STA 4+00 will be completed during a scheduled Main Injector shutdown. The toe of the embankment is shown as a red dashed line in Figure 5-8.

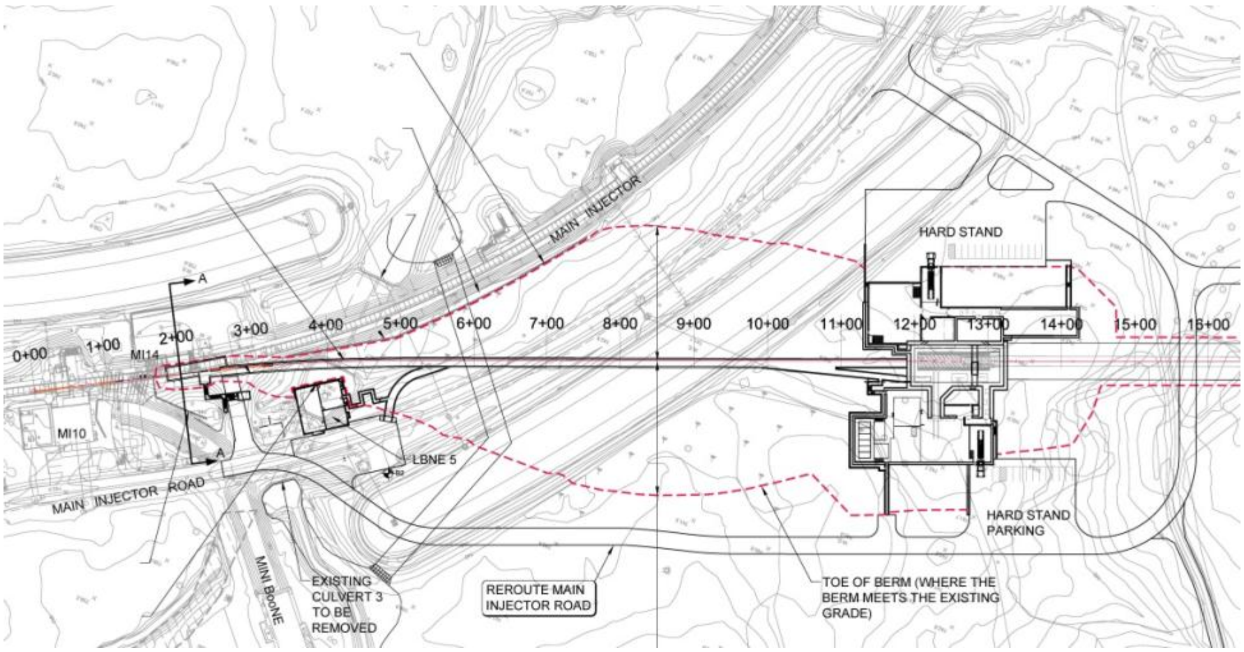

Figure 5-8: Plan View Re-route of MI Road.

5.1.1 Mechanical

Ventilation air is provided from the Target Hall support area and the Main Injector tunnel connection then exhausted through a vent shaft at the high mid-point of the enclosure.

5.1.2 Electrical

The Primary Beam Enclosure will be outfitted with electrical facilities to support the small programmatic equipment and periodic maintenance tasks. Conventional Facilities will provide lighting and electrical facilities to support all mechanical systems, small programmatic loads, and power receptacles needed for maintenance. The power will be delivered from the nearest surface building to 480-V panels in the enclosure. Dry type transformers with 208/120-V panelboards will be provided in the enclosure for small power devices and receptacles.

Lighting and emergency signage will be provided with remote or isolated ballast and alternate power sources. Batteries and electronic ballasts will not be allowed in areas that are subject to radiation due to the degradation of electronics and the possible creation of mixed waste with the batteries.

5.1.3 Plumbing

The entire Primary Beam Enclosure is equipped with a floor trench drain and exterior underdrains, a fire department stand pipe and hose connection fire suppression system, as well as LCW cooling lines, and power and control lines for the equipment. Site risers to the surface, will be constructed at the required spacing along the Primary Beam Enclosure, and will provide a minimum 6-in clear aperture for magnet/beam alignment. Enclosure underdrain water collection is provided at both low ends of the enclosure. These duplex sump pumps discharge to grade where they will flow into existing ditches or cooling ponds.

5.1.4 Fire Protection/Life Safety Systems

Conventional Facilities is responsible for the design, cost/scheduling, and construction of the fire protection and life safety systems including the mechanical (emergency ventilation), electrical (emergency generator for lighting, ventilation, and sump pumping, fire alarms, and communication), and plumbing (fire suppression/sprinkler piping and fixtures, and emergency sump pumping). Any space where the application of water could constitute a radiation-related risk as determined by LBNE and the AHJ will not have sprinkler systems.

Egress paths from underground facilities (tunnels and halls) have been conceptually designed to limit the travel path distances to egress shafts, stairways, and safe/fire rated corridors to the surface. See Section 3.1.4 of this volume for a general overview of fire protection and fire life/safety requirements. The Primary Beam Enclosure is designed to have three egress routes which are shown in Figure 5-9. From the approximate midpoint of the tunnel, the egress route requires traveling approximately 400-ft downstream to the safe rated corridor adjacent to the beam-right maintenance cell and morgue which then exits to the exterior and surface to a safe gathering location.

From the same midpoint of the Primary Beam Enclosure, the egress route requires traveling approximately 250 feet upstream to either the magnet installation tunnel and egress labyrinth to and through the Primary Beam Enclosure Service Building (LBNE 5) to the exterior. Upstream of the magnet installation tunnel, the safe/fire rated egress stair is approximately 370 feet away near the extraction enclosure, allowing access to the surface and the designated safe gathering area.

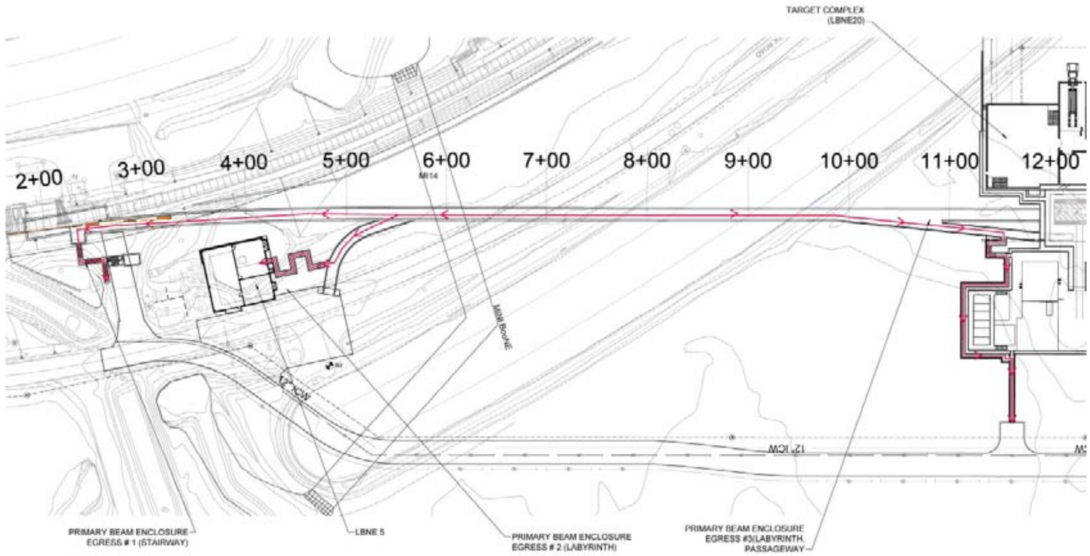

Figure 5-9: Primary Beam Enclosure Egress Routes.

5.2 Decay Pipe (WBS 130.06.02.05.04.03)

The LBNE Decay Pipe (cross section shown in Figure 5-10 begins at the downstream end of the target chase in the Target Hall and continues 656 ft (200 m) at a decline of approximately 10% to the Absorber Hall, which is approximately 94 ft below grade.

The Decay Pipe consists of two concentric pipes; the inner pipe is a 13-ft 2-in (4-m) diameter pipe and the outer pipe is a 14-ft 5-in (4.4-m) diameter pipe. Both pipes are ½-inch thick steel pipes surrounded by the required 18-ft 0.5-in (5.5m) cast-in-place concrete shielding. The direction of supply airflow for Decay Pipe cooling is down through the 20-cm annulus between the two concentric decay pipes and returns through the inner decay pipe for the air-cooling of the beam heat load deposited in the steel and concrete shielding surrounding the decay pipe (see Figure 5-11). While not shown in Figure 5-10 or Figure 5-11, an air duct connection from the interior of the Absorber to the Target Hall area will be provided. This will allow a negative air pressure to be maintained in the Absorber Hall.

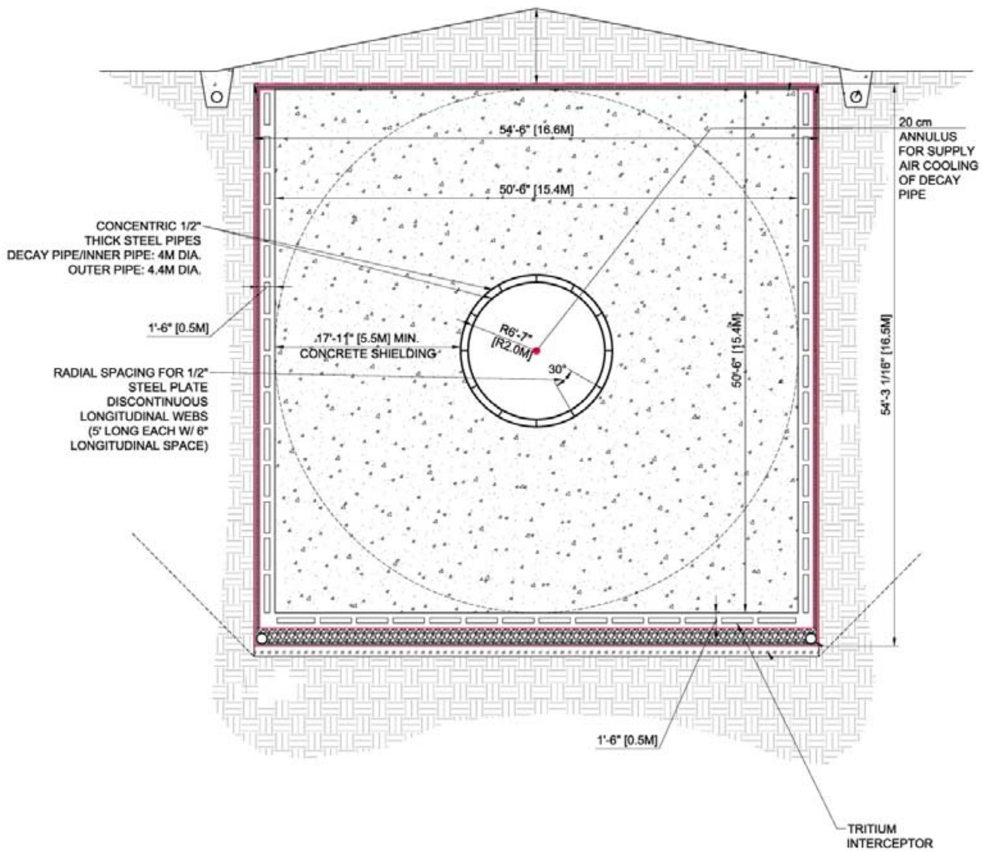

Figure 5-10: Decay Pipe Cross Section.

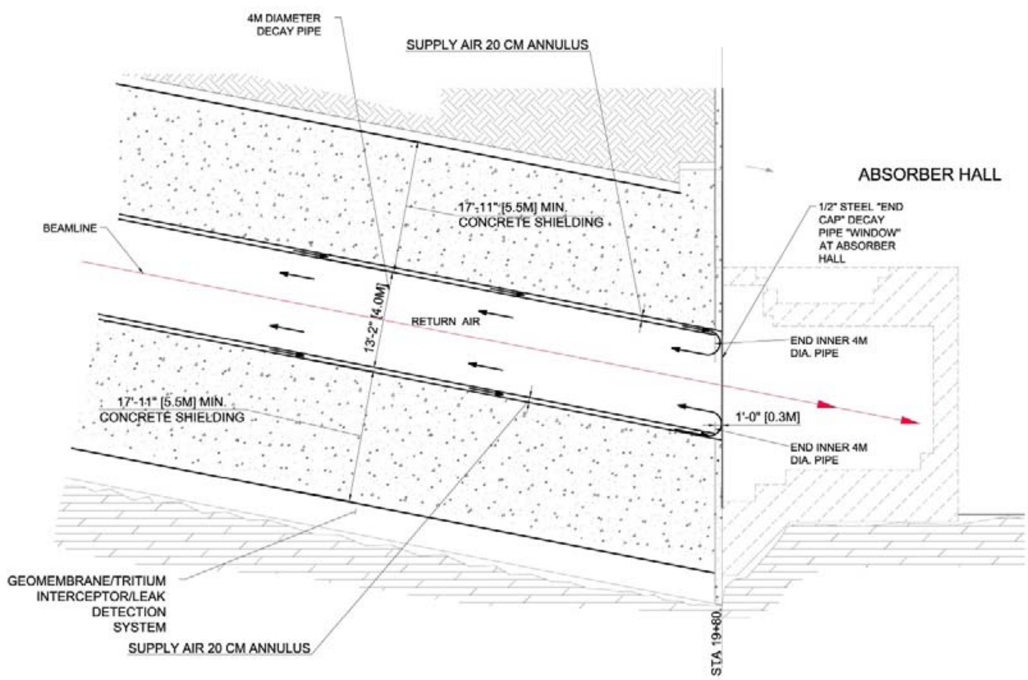

Figure 5-11: Longitudinal section of the Decay Pipe at Absorber Hall.

5.2.1 Decay Region Geosynthetic Barrier System

A geosynthetic barrier system, as shown in Figure 5-12 and Figure 5-13, along with the tritium interceptor system is designed and will be constructed to protect the decay region from potential groundwater infiltration and also to protect the surrounding groundwater from any possible tritiated water being created and escaping from the decay region. The use of the geosynthetic system in the decay region is a unique application of standard and common practices and materials used for decades in the landfill industry. This system will create a three-dimensional barrier system between the decay region and the environment.

The proposed liner system design includes two geomembrane barrier layers, an outer composite geosynthetic clay liner (GCL) barrier, and a geonet leak detection layer placed between the GCL and the inner geomembrane layer as shown in Figure 5-12.

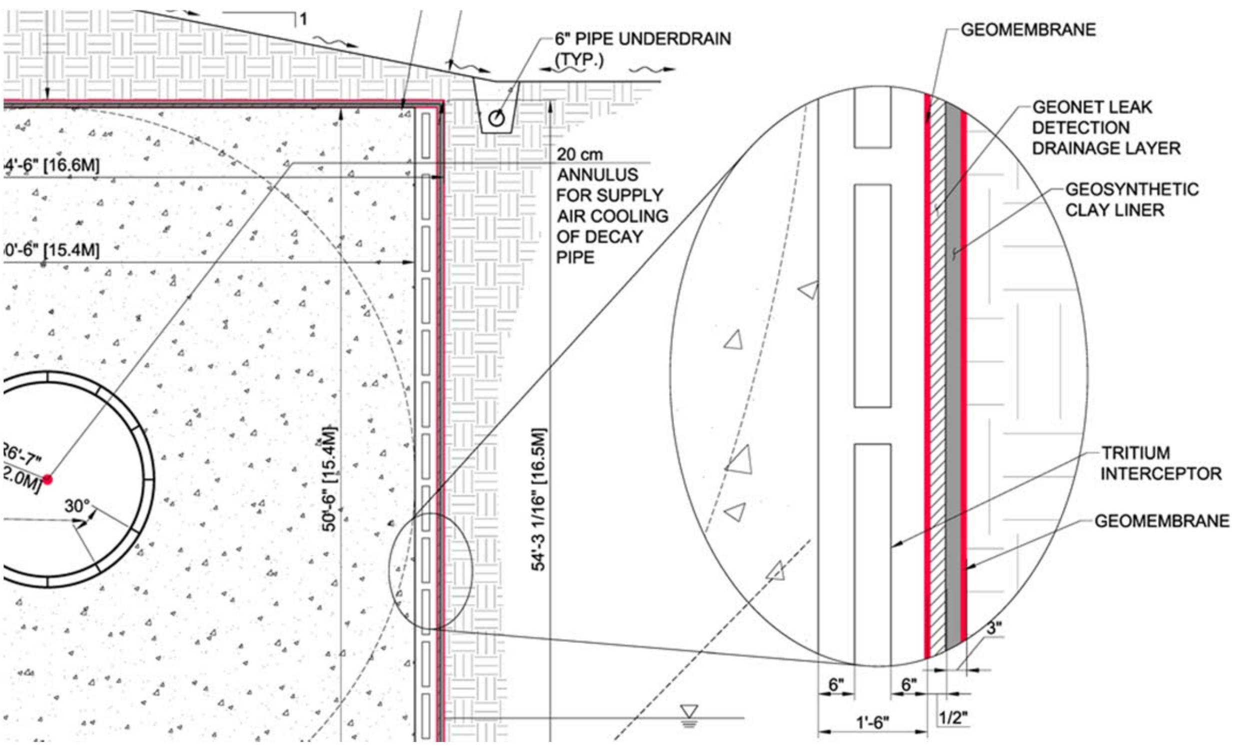

Figure 5-12: Geomembrane system section view
(from outside [right] to inside [left] in the exploded view).

At the base of the decay region cross section the geonet leak detection layer is replaced with 18 inches of open graded (no fines) aggregate/gravel with 12-inch (300-mm) diameter perforated drainage pipes as shown in Figure 5-13. This pipe underdrain system would drain down a 10% slope the length of the Decay Pipe to a collection system at the upstream face of the Absorber Hall and into the decay pipe tritium monitoring sump system.

Surface water drainage and infiltration over the top of the concrete box is managed by crowning the ground surface above the top of the box to shed surface water off to the side to drainage swales and a drain tile system, as shown in Figure 5-10.

An independent study and review was conducted by a leading expert in the geosynthetic industry who generally concurred with the application and details of the geomembrane barrier system. The review did provide some comments which will be considered during Preliminary Design [15] [16] [17].

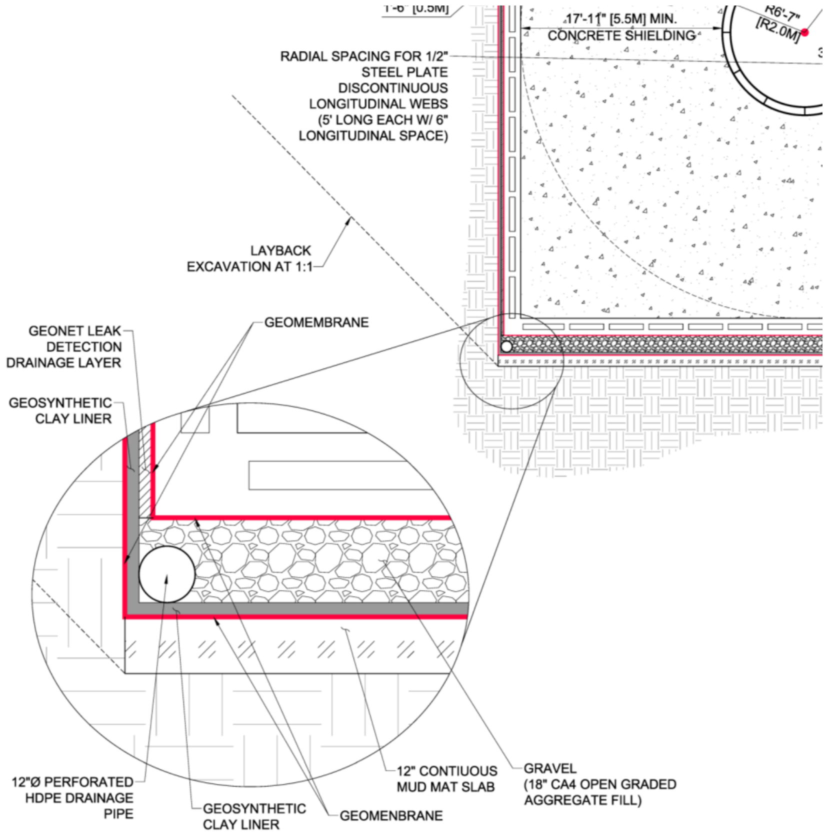

Figure 5-13: Decay Pipe cross section showing the base of the Decay Pipe barrier system.

5.3 Absorber Hall and Support Rooms (WBS 130.06.02.05.04.04)

The Absorber Hall will be approximately 94 ft below existing grade as shown in plan view in Figure 5-14 and Figure 5-15, and in longitudinal cross section in Figure 5-16. The Absorber Hall will house the concrete shielded hadron absorber and monitor, the Muon Alcove, and the absorber support rooms, all constructed in an open cut soil excavation to bedrock and then a drill-and-blast rock excavation to the base of the underground facility. A water barrier system will be included between the rock excavation and the internal concrete structure to seal the facility from groundwater infiltration. This underground facility will be a two-level cast in place concrete structure. The lower level of the Absorber Hall will house the Muon Alcove, sump and pump systems, and will provide the base of the egress shaft. The upper level of this underground facility will house the top of the absorber, the RAW room, and the instrumentation room.

The roof/ceiling of the underground portion of the facility will serve as the floor of the above ground Absorber Service Building (LBNE 30). A portion of the concrete foundation walls for the above ground service building serves as the shaft walls to the underground facilities' equipment and utilities access corridor, which is accessed via a 22 ft -9 in wide by 57 ft-4 in high opening in the truck bay floor of the above ground service building which has 30-ton bridge crane coverage.

A separate 22-ft diameter cast in place concrete shaft is designed for personnel access and will provide both primary and secondary egress routes by elevator and stairway to the surface. The corridor from the Absorber Hall/Muon Alcove (lower level) to the egress shaft will have a shielding labyrinth constructed of portable shielding blocks. An interlock and air seal door system will separate the Absorber Hall/Muon Alcove from the rest of the underground rooms. The CF outfitting of this 5,343-ft^2 facility includes conventional and technical/programmatic utilities (to the base of the shaft); air handling equipment, emergency systems, a 4,000-lb capacity personnel elevator, and the sump and pump room systems.

The scope of the Conventional Facilities Absorber Hall and support rooms includes the design and construction of the underground facility. This includes the absorber pile cast-in-place concrete shielding tub that will house the hadron monitor. Slots/voids will be cast into the beam-right side of the absorber concrete shielding pit to create a morgue for storing spent absorber components. The scope also includes the associated Conventional Facilities outfitting with required utilities.

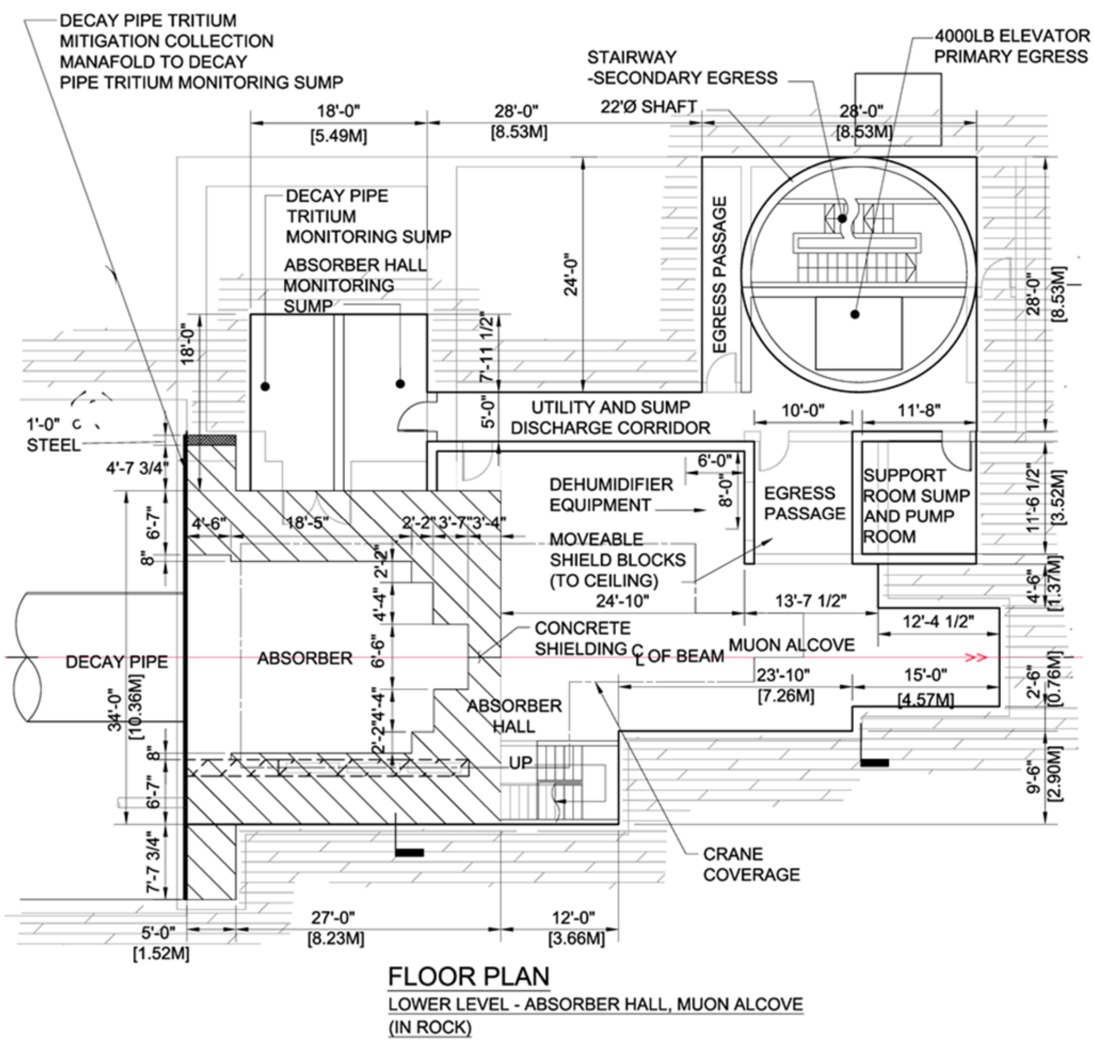

Figure 5-14: Absorber Hall. Lower level plan view in bedrock.

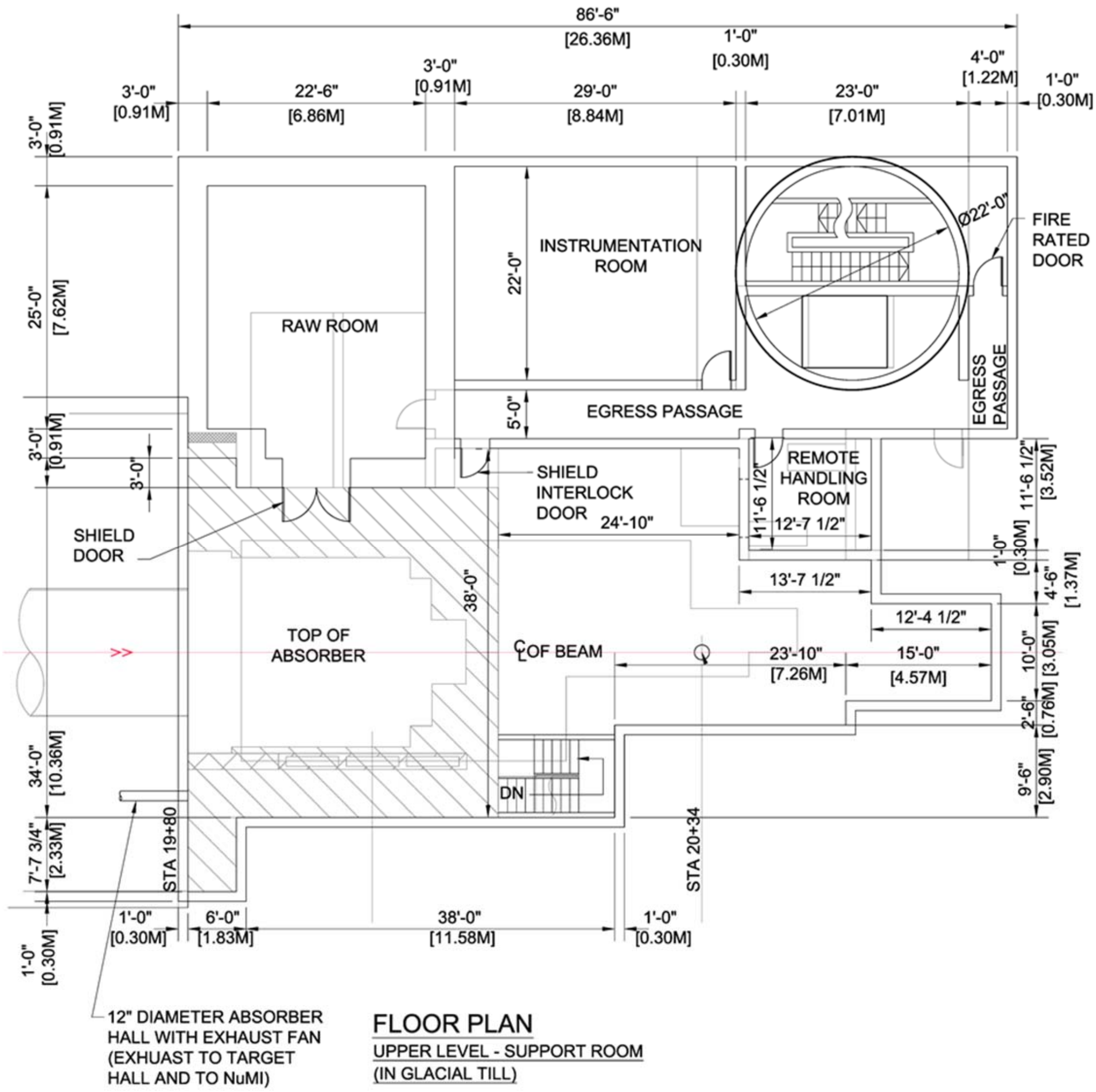

Figure 5-15: Absorber Hall. Upper Level plan view in soil.

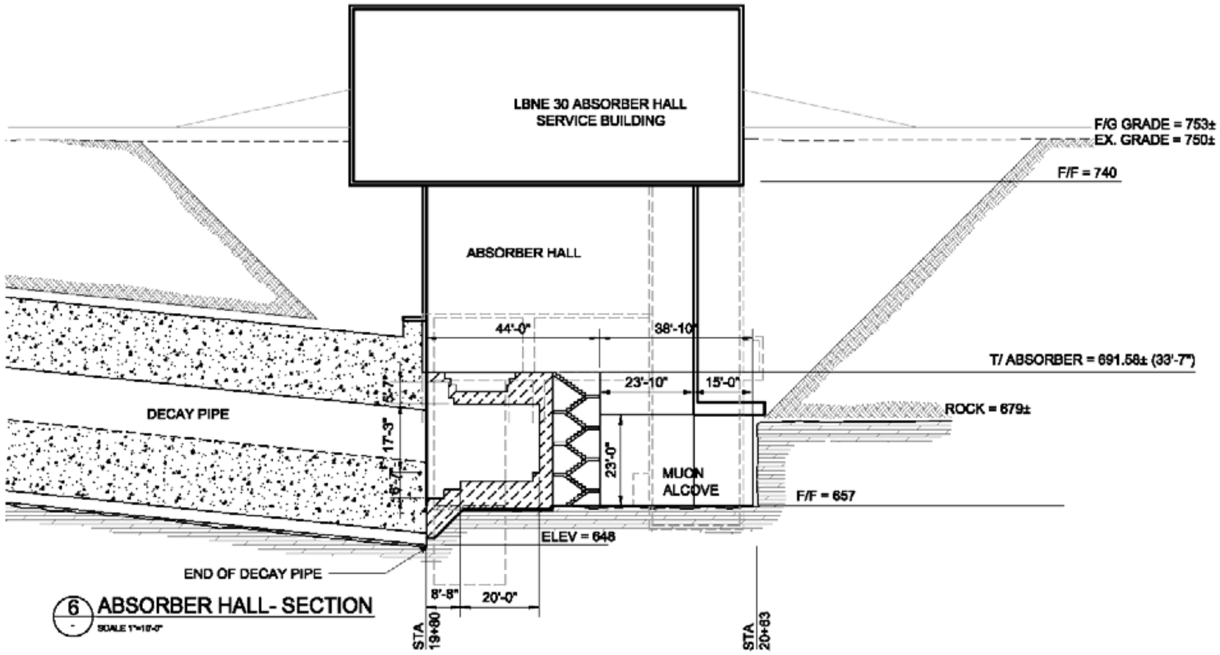

Figure 5-16: Absorber Hall longitudinal cross section cut along the decay pipe centerline.

5.3.1 Grouting of the Rock Mass in the Decay/Absorber Region

The downstream end of the Decay Region and the base of the Absorber Hall will penetrate the top of rock for a depth of up to about 25 ft. The soil/rock interface and the upper portion of the rock mass is regionally known as a water bearing zone or aquifer. Due to the importance of providing as dry a Decay Region and Absorber Hall as possible, a systematic program to grout the rock mass to seal off fractures and bedding planes is included in the conceptual design. This grouting program will be executed prior to any excavation and will augment the groundwater barrier system installed between the rock face and the internal concrete structure.

As shown in Figure 5-17 for the Absorber Hall area, a grouting program has been developed that includes a 10-foot by 10-foot grid of primary grout holes that will be drilled and grouted to create an impermeable grouted zone about 20-feet thick around the entire perimeter of the Decay Region and Absorber Hall rock excavations [18]. Secondary and tertiary grout holes will be drilled and grouted on split spacing between the primary grout holes as needed, as dictated by grout takes within holes that are drilled.

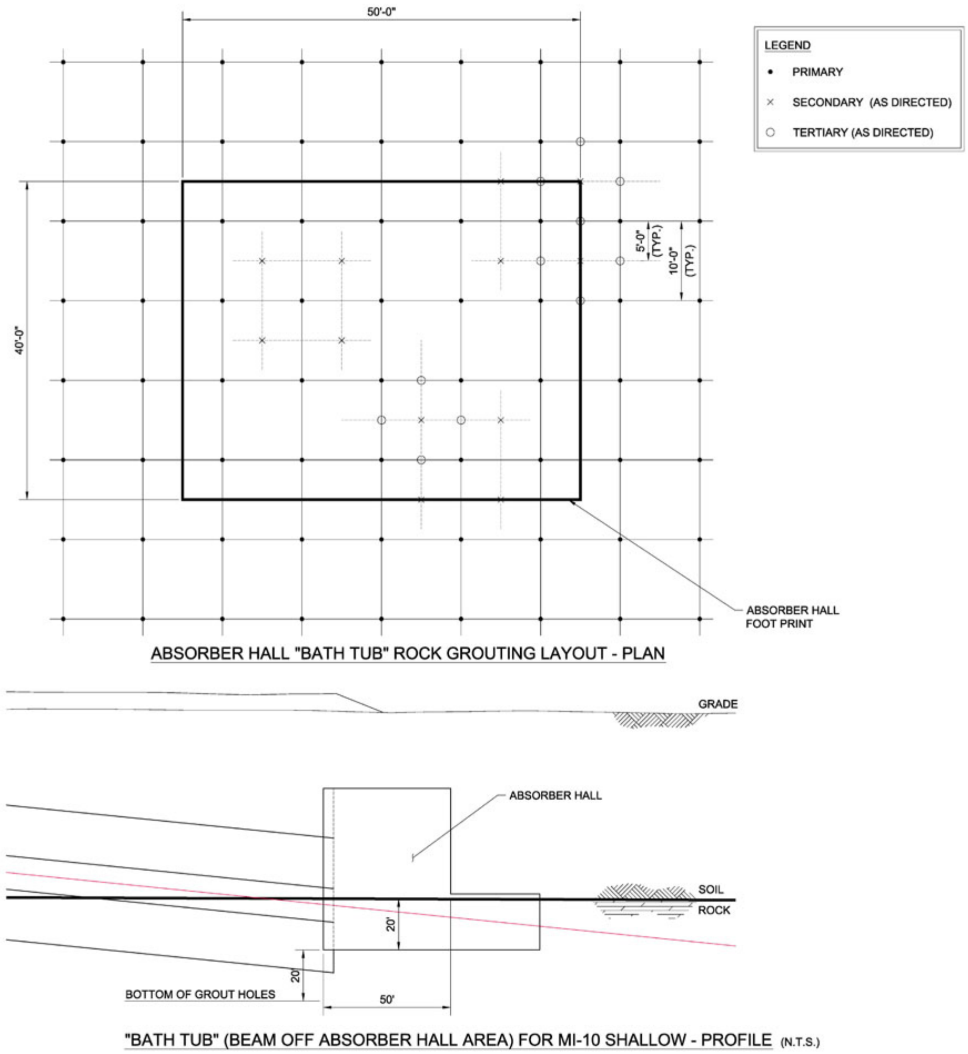

Figure 5-17: Grouting Plan and Section.

5.3.2 Mechanical

Ventilation for this area is to be provided by a dedicated outside air system (DOAS) located in the LBNE 30 service building mechanical area. The DOAS shall provide adequate personnel ventilation and dehumidified neutral air to the underground space for humidity control and positive pressurization with respect to the Absorber Hall. Maximum final space humidity shall be 50% RH.

A 2,400-CFM custom built combined refrigeration/desiccant air conditioning unit will be provided that is capable of removing of heat and moisture from the Absorber Hall. The space condition of the Absorber Hall shall be kept at 80ºF +/- 5ºF. All materials of the unit that come in contact with the airstream or condensate will be resistant to corrosion from the slight level nitric acid that is present. The AHU shall be constructed minimizing single points of failure.

Condensate from this system will contain tritium and have a slight level of nitric acid. The condensate will be captured and routed to a holding tank in the Absorber Hall. The holding tank shall have secondary containment and multiple pumps (n+1) for pumping the condensate to the Target Hall condensate holding tank. A secondary pump (manually controlled) shall be provided to pump condensate to a convenient valved location for barreling during beam-on operations. All piping will be stainless steel or high pressure radiation resistant plastic pipe. All ground water intrusion will be contained and routed outside of this room to the main ground water drainage system.

5.3.3 Electrical

The Absorber Hall will be outfitted with electrical facilities to support the small programmatic equipment and periodic maintenance tasks. Conventional Facilities will provide lighting and electrical facilities to support all mechanical systems, small programmatic loads and power receptacles needed for maintenance. The power will be delivered from the Absorber Hall Service Building main panelboard to 480 V panels in the lower Detector Hall. Dry type transformers with 208/120 V panelboards will be provided in the hall for small power devices and receptacles.

Lighting and emergency signage will be provided with remote or isolated ballast and alternate power sources. Batteries and electronic ballasts will not be allowed in areas that are subject to radiation due to the degradation of electronics and the possible creation of a mixed waste disposal problem with the batteries.

5.3.4 Plumbing

The underground absorber area sump pump system will consist of three duplex pump systems. The first will receive any drainage from the Decay Pipe enclosure system. This system will be provided a dedicated monitoring sump with switchable automatic/manual controls and a holding tank so that contaminating drainage can be held and monitored. The second system receives drainage from the decay enclosure under drainage and is discharged to the third and main sump pump system. This system will be sized to serve the entire upstream underground facilities with redundant back up pumps and emergency back-up power. The system shall be designed to a 0.9999 reliability level. This system shall discharge to a surface holding tank near LBNE30. Duplex pumps within the holding tank shall discharge to the site-wide ICW system.

5.3.5 Fire Protection/Life Safety Systems

Conventional Facilities is responsible for the design and construction of these systems including the mechanical (emergency ventilation), electrical (emergency generator for lighting, ventilation, sump pumping, fire alarms, and communication), and plumbing (fire suppression/sprinkler piping and fixtures, and emergency sump pumping). Any space where the application of water could constitute a radiation-related risk as determined by LBNE and the AHJ will not have sprinkler systems.

Each of the two levels of the underground Absorber Hall, Muon Alcove and support rooms has a safe/fire rated egress corridor leading to the 22-ft diameter egress shaft that houses a separate primary egress elevator to the service building (LBNE 30) at the surface and also a secondary egress stairway to the surface.

Egress paths for underground facilities (tunnels and halls) have been conceptually designed to limit the travel path distances to egress shafts, stairways, and safe/fire rated corridors to the surface. See Section 3.1.4 of this volume for a general overview of fire protection and fire life/safety requirements.

Figure 5-18 shows the egress paths in red from the Absorber Hall to the LBNE 30 Service Building at the surface and to the exterior to a safe gathering area. Two routes to the surface are provided, one using the Primary Egress elevator, the other using the Secondary Egress Stair.

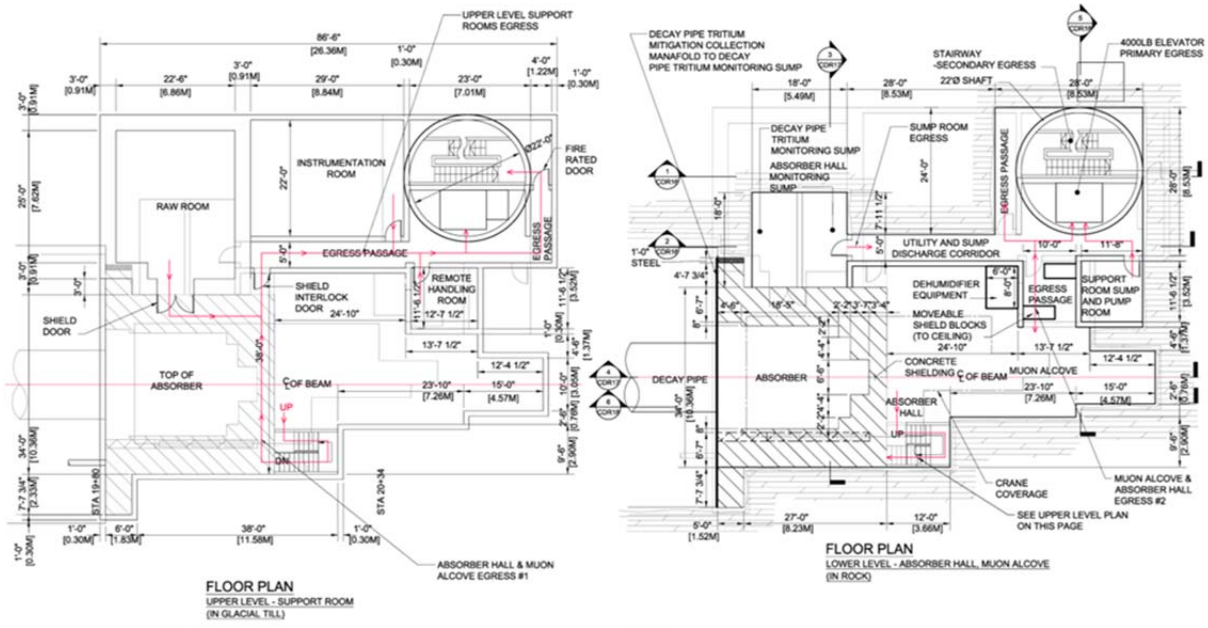

Figure 5-18: Absorber Hall, Muon Alcove, and support rooms egress routing.

5.4 Near Detector Hall and Support Rooms (WBS 130.06.02.05.04.05)

The Near Detector Hall and support rooms (see Figure 5-19 and Figure 5-20) will house the LBNE Near Detector and related components, and is located approximately 689-ft (210-m) downstream of the Absorber Hall approximately 185 ft below grade. The Near Detector Hall has been sized to accommodate either of two detector technologies that were considered during Conceptual Design; the reference design is similar to the MicroBoone liquid argon (LAr) detector and alternative design is a Straw Tube Tracker. At Conceptual Design, the Conventional Facilities design as presented is generic enough to accommodate either detector technology. The LAr detector will require special Oxygen Depletion Hazard (ODH) emergency ventilation, and egress design criteria, which has been included in the reference design.

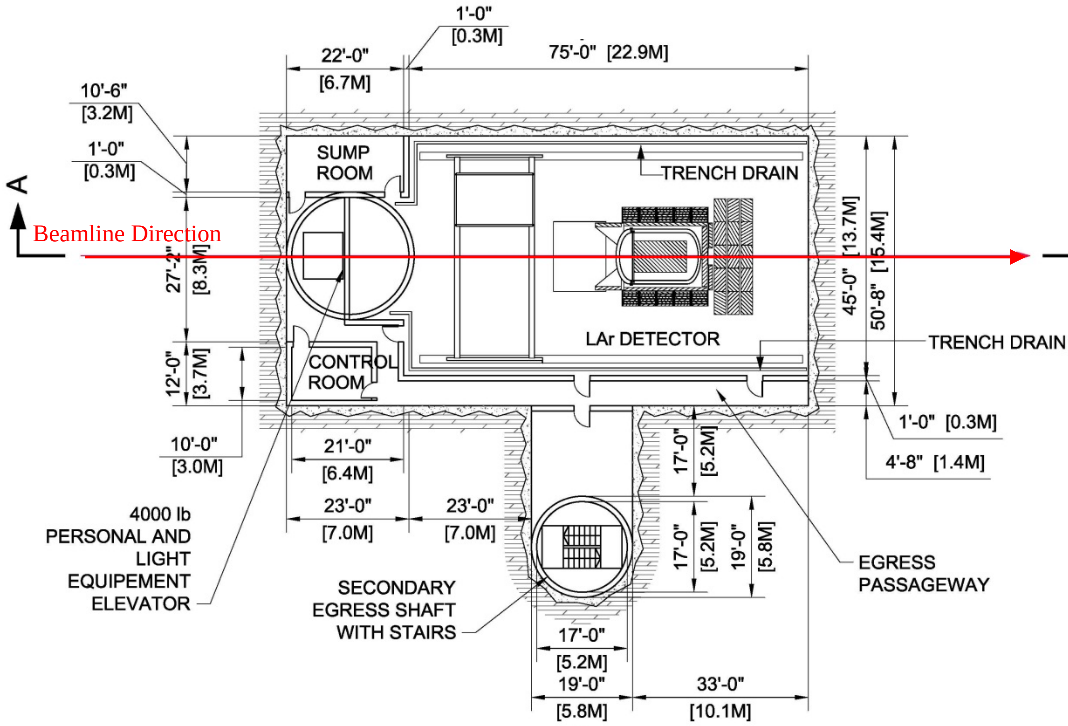

Figure 5-19: Near Detector Plan View.

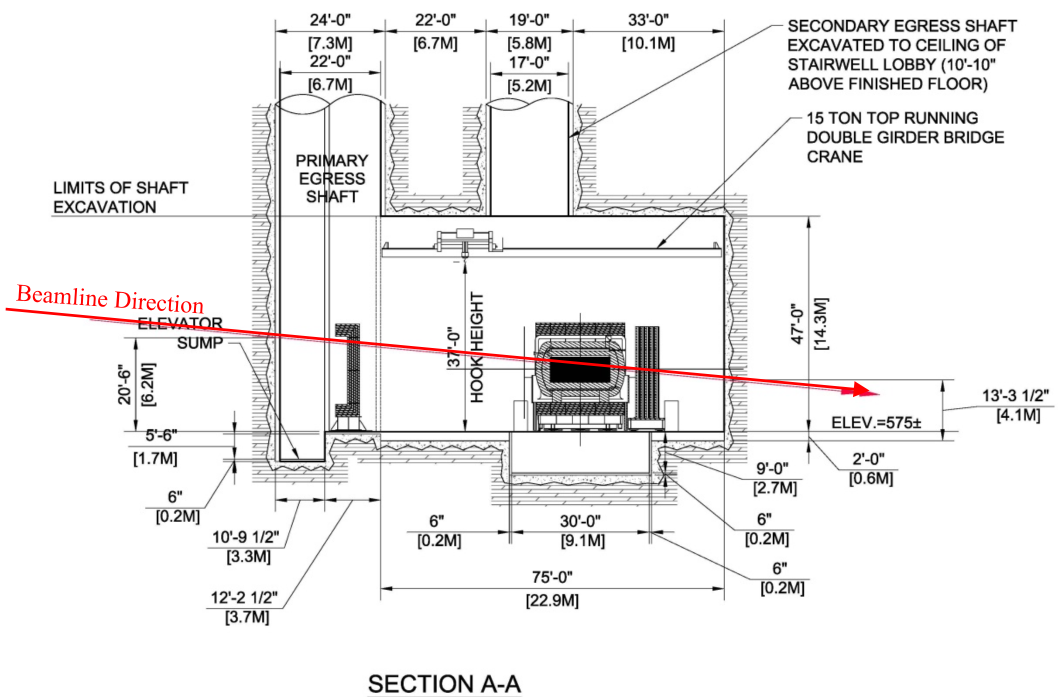

Figure 5-20: Near Detector Hall Longitudinal Section.

The 5,510-ft^2 Near Detector Hall and support rooms will include access to a 22-ft diameter shaft which will be used for equipment handling and primary egress that includes utilities and has a 4,000-lb capacity elevator. This shaft serves as the major equipment access corridor from LBNE 40 above to the Near Detector Hall and support rooms below grade. The Near Detector Hall will have a 15-ton bridge crane running the length of the hall that will be used for installing detector components and related equipment lowered down from the surface building to the Near Detector Hall. A secondary egress shaft which is 17 feet in diameter will allow for personnel to egress the hall via a stairway to the surface.

The Near Detector Hall and support rooms will also be outfitted with air handling equipment, power/control systems, and emergency systems. The 12-ft wide by 21-ft long (252 ft^2) control room is beam-right of the shaft and the Sump and Pump Room is beam-left of the shaft.

To accommodate the LAr detector, a recessed sump design below the floor of the hall is included to capture any leak or spill of LAr from the detector above as shown in Figure 5-20. A ventilation system is designed to ventilate the boil-off of the LAr gas.

Rock bolts or rock dowels will be used to provide both short- and long-term rock stability. The rock surface will be treated with shotcrete. The roof/ceiling of the Near Detector Hall and support rooms will be lined with an internal metal roof drip ceiling system (drip pans) to collect and route groundwater infiltration to protect the hall and support room contents from water and loose material. The groundwater will be channeled to the main sump via trench floor drains.

The Conventional Facilities fit-out work includes the bridge crane and its supports, internal CMU walls, fire walls, miscellaneous poured concrete walls and abutments, doors, fire protection, the sump pump system, fire detection, and mechanical, electrical and plumbing (MEP) systems.

5.4.1 Mechanical

Ventilation for the underground enclosure area is to be provided by a CHW/HW/Desiccant dedicated outside air system (DOAS) located in the Near Detector Service Building (LBNE 40) mechanical area. The DOAS shall provide adequate personnel ventilation and dehumidified neutral air to the underground space for humidity control and positive pressurization with respect to the Near Detector Hall. Maximum final space humidity shall be 50% RH. The two ventilation systems serving the Near Detector Hall/Support Rooms and the emergency egress corridor (including stairway and elevator areas also) are provided by a 2000-CFM and a 1000-CFM AHU respectively that are located in the surface service building. Additional local cooling in the Near Detector Hall/Support Rooms will be provided by a 6,000-CFM CHW AHU that will be located below grade in the near detector hall. Local cooling for the Near Detector Hall control room will be provided by small fan coil units. A separate ODH emergency ventilation exhaust system will be required for the LAr detector. This system will draw air from the LAr spill containment and exhaust directly to the outside through a separate dedicated 36-inch exhaust duct.

5.4.2 Electrical

The Near Detector Hall will be outfitted with electrical facilities to support the small programmatic equipment and periodic maintenance tasks. Conventional Facilities will provide lighting and electrical facilities to support all mechanical systems, small programmatic loads and power receptacles needed for maintenance. The power will be delivered from the main panelboard in the Near Detector Service Building to 480 V panels in the below grade Detector Hall. Dry type transformers with 208/120 V panelboards will be provided for small power devices and receptacles. Lighting and emergency signage will be provided with remote or isolated ballast and alternate power sources.

5.4.3 Plumbing

The Near Detector area sump pump system shall have redundant back up pumps and emergency back-up power. The system shall be designed to a 0.9999 reliability level. This system shall discharge to a surface holding tank near LBNE40. Pumps within the holding tank discharge to the site wide ICW system. This underground complex is provided with a wet pipe sprinkler system served from the LBNE 40 domestic water system.

5.4.4 Fire Protection/Life Safety Systems

Conventional Facilities is responsible for the design and construction of these systems including the mechanical (emergency ventilation), electrical (emergency generator for lighting, ventilation, sump pumping, fire alarms, and communication), and plumbing (fire suppression/sprinkler piping and fixtures, and emergency sump pumping).

Egress paths for underground facilities (tunnels and halls) have been conceptually designed to limit the travel path distances to egress shafts, stairways, and safe/fire rated corridors to the exterior and surface to a safe gathering location. See Section 3.1.4 of this volume for a general overview of fire protection and fire life/safety requirements. The Near Detector Hall has three egress routes; two are along the beam-right side of the Hall to a safe/fire rated egress corridor and from there to either the primary egress elevator or to the secondary egress stairway. Both the elevator and the stairway lead to the surface and then to an exterior safe gathering area. Figure 5-21 shows the egress paths in red from the Near Detector Hall.

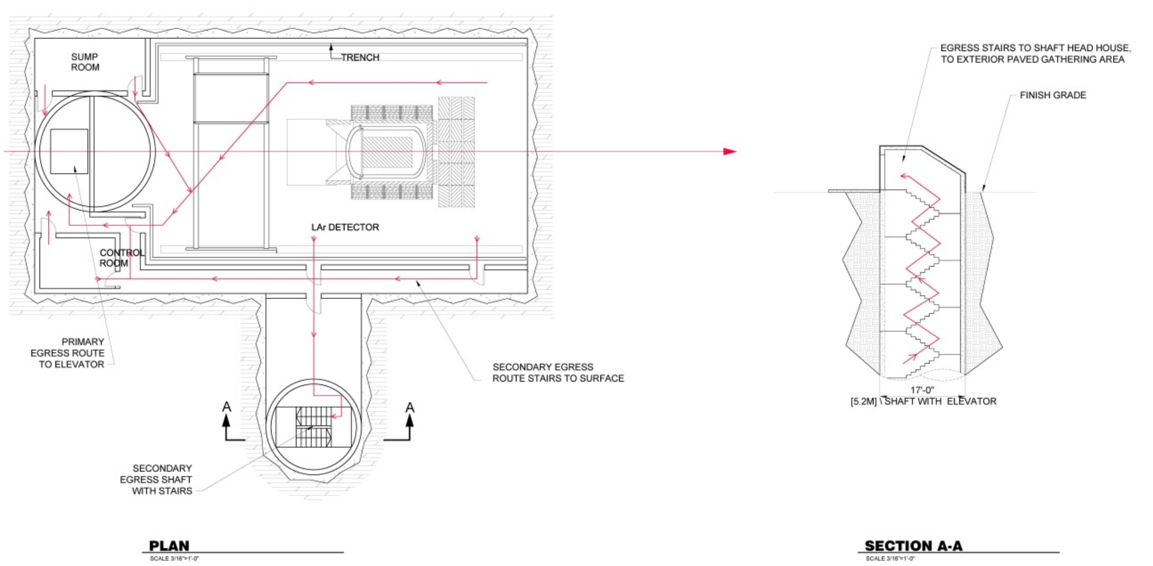

Figure 5-21: Near Detector Hall Egress Routes.

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