Off-Axis-GEN-9

Off-Axis Detector Enclosure

Design Study Report

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This Design Study Report (DSR) is intended to document engineering investigations and facilitate project planning decisions. It is not a Project Definition Report (PDR), Conceptual Design Report (CDR) or Title 1 report and has not answered every technical design question. The current level of contingency is believed to be consistent with the degree of technical confidence in the design at this stage. It is recognized that some basic construction concerns will be reviewed and optimized during the remaining stages of the project.

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This report defines the Civil Construction that is needed to accommodate the construction of a 50-kiloton detector based on the concept that the detector would be constructed in modular form at remote locations, transported to the site and finally placed in position in a structure that protects the detector modules from the extremes of the weather. The report assumes that the detector components will be housed in commercially available cargo shipping containers, but the design could provide an enclosure for any similar sized detector.

The objective of this study was to identify cost effective methods of providing an enclosure for the off-axis detector to be used as guidance during subsequent project phases. Several tasks were identified in order to achieve this objective:

- Understand the cost of a typical "Fermilab" building sized to house the detector;
- Investigate and compare alternate methods for providing the detector enclosure;
- Identify the "cost driver" elements of the base design to provide guidance for potential enclosures of varying sizes;
- Compare the base design with the design developed by The University Of Minnesota (UofM). The UofM design focused on a detector enclosure with a 10 meter shielding overburden. This study investigated an enclosure with no shielding overburden.

The detector design used as the basis of this report is comprised of 2000 - 20 foot cargo shipping containers arranged to form a detector stack 407 feet long by 80 feet wide by 85 feet high. Each detector module will require connections for electrical power, communications and detector gas. Detector module handing will be accomplished by a rubber tire gantry crane in a "1 over 4" configuration.

This study assumed a project location within 10 kilometers (6.2 miles) of the Soudan Iron Mine in Minnesota. General site conditions were assumed to be similar to that location.

Initially, a conventional steel-framed building was thought to be the most cost effective means of providing the enclosure. The base design envelope consists of 79 foot high steel-framed, metal-sided building on grade spanning a detector pit that extends 51 feet below grade. The staging area and support bay combine with the detector stack to produce a building that is 550 feet long by 110 feet wide. The base design includes a detector pit that extends 51 feet

below grade to take advantage of local rock self-supporting features. In addition, the rubber tired gantry crane in a “1 over 4” configuration is ideally suited to handle the detector modules in this configuration. It is this “1 over 4” configuration that dictates the 79 foot height of the building.

The Total Project Cost (TPC) for the civil construction portion of this project is estimated to be $21,776,000. 69% of this total ($14,967,000) is subcontracted construction cost while the remaining amount ($6,809,000) is Engineering, Design, Inspection and Administration (EDIA), Management Reserve and Indirect Costs. This is a cost of $247/SF for the subcontracted cost and $360/SF for a total project cost.

The estimated schedule for the civil portion of this project is 34 months, with Title 2 (design) completed within 12 months after start of the project.

A conventional steel framed building was initially considered the most cost effective construction type for this building scope. Appendix C investigated three alternate enclosure methods, including an Automatic Building Machine (ABM), pre-engineered building systems and tension fabric structures. While a building of this size is beyond the current capacity of an ABM, manufacturers for the other building types indicate the potential for savings in the above grade building. The base design estimated that the above grade building cost at $47/SF. Pre-engineered building systems range from $26/SF to $35/SF while the tension fabric structures range from $45/SF to $63/SF. It is recommended that the pre-engineered alternate be developed during the subsequent phases of the project.

The base design assumed that a rubber tire gantry (RTG) crane will be used for detector module handling. The “1 over 4” configuration of the RTG set the height of the building above grade. Appendix D investigated the possibility of strengthening the building structure to handle a top riding bridge crane. The cost of this alternate is estimated at $1,358,000 compared to the $1,500,000 cost of a RTG. (The RTG may have some cost savings benefits during construction in the facilitation of mucking) This alternate would be most effective in a conventional steel frame building or pre-engineered building system. Utilizing a bridge crane in a tension fabric structure would require a separate structural system for the crane and is not practical in such an application.

Appendix E identified the “cost driver” elements and investigated the cost impact of changing the building size. Although the comparison cost data presented in Appendix E can be useful determining cost drivers the accuracy of extrapolating construction costs, especially beyond the ranges provided,

can be misleading and inaccurate. The comparison studies did produce some generalized conclusions that appear reasonable.

- Width scaling - The building width impacts the total project cost close to linear between the overall structure widths of 90 ‘ and 130’. For the base building (51 foot deep pit), the cost per foot of width is approximate $135K. In general the cost scale well with width because the quantities used in the estimate scale proportionally with respect to above and below grade work items;
- Height scaling - The building height relationship with the ground surface does not scale linear; costs reduce as the volume of the structure is raised in relation to the grade;
    - The above grade quantities are either fixed, such as doors and partitions or are quantities that are in square foot units, varying with the delta of the building’s perimeter;
    - The below grade quantities vary in volume, with the largest single item being the excavation materials, a relatively expensive work item. In other words, raising the base building 1’ increases the building siding 2 square feet per foot of building length, but reduces the excavation of the 70-foot wide pit by 70 cubic feet;
    - Due to the structural requirements of the structure’s foundation, raising the structure above the rock or structurally suitable materials would not necessarily reduce the overall costs.
- Length Scaling - Although scaling cost estimates for length have not been accomplished it is reasonable that the costs should roughly scale with length as long as the grade level and pit areas are scaled proportionally to the base design;
- Scaling conclusions - Increasing the above grade portion of the structure and reducing the depth of excavation clearly reduces costs. It is not fully understood the cost effects of raising the above grade structure will have on the building alternatives, such as the pre-engineered building. Further value engineering is warranted to optimize the height of the building with the less expensive building alternatives. The width and length variables, which are directly related to the detector volume, should not be used as design drivers but rather follow the physics requirements.

Appendix E also investigated the impact of the cost of rock excavation on the overall project costs. The below grade portion of the work is 38% of the overall project costs. The significant cost driver for the underground portion of the work is the rock excavation. This report used $38 per cubic yard for the costs for rock excavation. These figures were obtained from CostWorks program by RS Means. Recent conversations with E. Peterson indicate that recent excavation work in northern Minnesota has produced rock excavation

costs averaging $10 per cubic yard. For comparison, the base design estimate was recalculated after lowering the rock excavation costs to $10 per cubic yard. This produced a Total Project Cost (TPC) for the civil construction portion of this project estimated to be $18,477,000. This is a cost of $210/SF for the subcontracted cost and $305/SF for a total project cost.

Appendix F provides a comparison between the University of Minnesota (UofM) design with a surface building housing a similar sized detector. The UofM report estimates a surface building with no shielding at $16.8 million dollars. For comparison, a similar sized building utilizing the design concepts developed for the base design estimate project cost of $11.4 million dollars. The significant differences in the two costs estimates appear to be result of access location (at-grade compared vs. below-grade) and the selection of the building envelope (precast vs. metal siding).

BACKGROUND

Neutrino physics has experienced a renewed interest in the physics community in recent years with much of the Fermilab interest centered on the physics potential of the Neutrinos at Main Injector (NuMI) beamline. The NuMI/MINOS project, currently under construction and expected to go “on-line” in 2004, will examine the physics of neutrino oscillations utilizing a neutrino beam produced at Fermilab in Batavia, Illinois directed at an iron mine in Soudan, Minnesota.

The NuMI/MINOS project currently under construction will examine the physics of neutrino oscillations utilizing a neutrino beam produced at Fermilab in Batavia, Illinois. The neutrino beam will be analyzed as it passes through the “near detector” located on the Fermilab site and again as it passes through the “far detector” located in an iron mine in Soudan, Minnesota. This traditional beamline-detector configuration is referred to as the “on-axis” detector.

Because of the physics characteristics of the NuMI beamline, a neutrino detector on or near the surface of the earth and “off” the axis of the NuMI beamline could compliment the MINOS experiment and explore the next important phase of neutrino oscillation physics. A detector located near the Soudan detector would be located on the earth’s surface 10 kilometers (6.2 miles) off the “axis” of the beamline. Other locations along the beamline would intercept the beam fringe on the surface directly over the beam in central Wisconsin. Downstream of Soudan the detector would be located, in Canada, on the surface roughly 10 kilometers below the centerline of the NuMI beam.

It is the high flux delivered by the Main Injector beam that will allow for the unique physics potential of the study of the neutrino at this time.

This study is based on utilizing commercially available cargo containers to provide an acceptable environment for physics apparatus. These readily available containers dictate the spatial requirements for the civil construction. For this study, a standard 20' container was used as the basis of the design. These containers are 8'-0" wide, 8'-6" high and 19'-10 ½" long. Appendix A of this report contains description, sizes and related cargo container information.

20' Steel Dry Cargo Container

Exterior

length	width	height
19'10 1/2"	8'0"	8'6"
6.06 m	2.44 m	2.59 m

Interior

length	width	height
19'4 1/5"	7'8 1/2"	7'9 7/8"
5.90 m	2.35 m	2.39 m

Weight

MGW	TARE	NET
52,910 lb	5,140 lb	47,770 lb
24,000 kg	2,330 kg	21,670 kg

Door Opening

width	height
7'-8 1/8"	7'-5 3/4"
2.343 m	2.280 m

Purpose:

Used for all kinds of general cargo.

Figure 1 - 20' Cargo Container Information

This modular approach to detector construction will allow the components to be assembled at locations remote to the installation site and shipped via conventional transportation methods to the detector site. Methods of installation of shipping containers on land is explored in Off-Axis Note DET-8, dated May 29, 2003

Each cargo container will house physics detector components and require electrical power, communication and detector gas. The requirements for these support services have not been finalized at this stage of the design.

Routing for these support services will be located in the spaces between the container cell guides installed as part of the experiment construction.

For the purposes of this study the detector is comprised of 2,000 modules (cargo container) configured in ten (10) layers of two hundred (200) modules. This results in a detector "stack" 407' long by 80' wide by 85' tall. Figure 2 (below) is a typical plan view of a layer of modules.

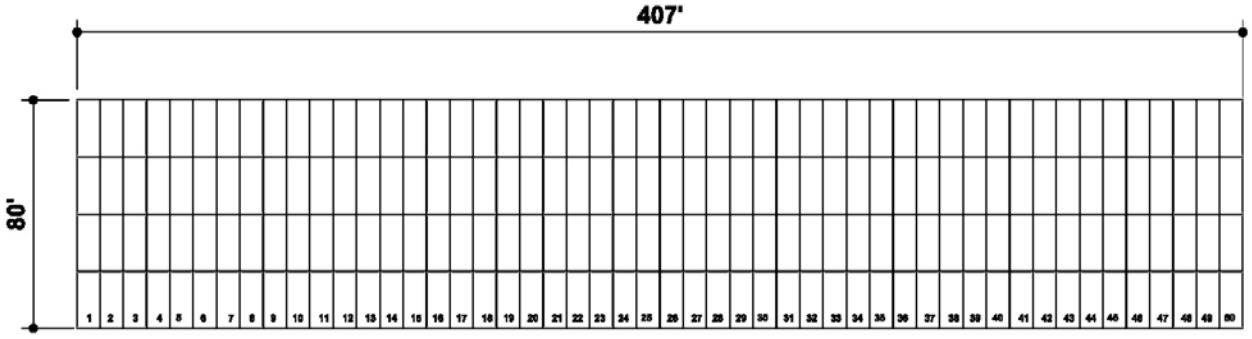

Figure 2 – Detector Stacking Plan

Figure 3 (below) is a longitudinal section through the detector stack that indicates the arrangement of the cargo containers.

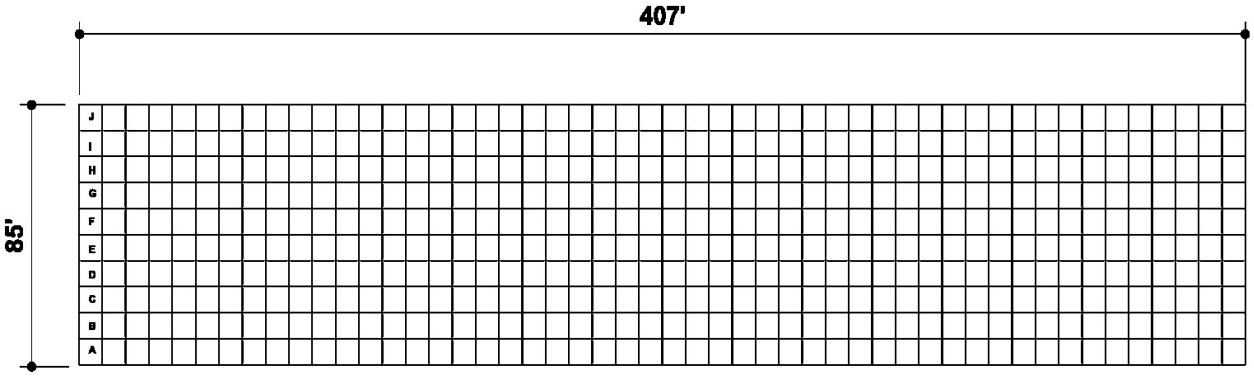

Figure 3 – Detector Section

In addition to the detector stack, the building envelope is required to house detector support functions include the following:

- Detector gas mixing and storage area;
- Staging area with unloading area with spare module storage for twenty (20) modules;
- Access space for support services utilities;

In order to achieve cost effective access to each container, the experiment will include a utility corridor along one long edge of the detector stack. This utility corridor will be fabricated from 40' cargo containers with the doors and portions of the end walls removed. This will allow for a continuous walkway and route for the support services utilities, including electronics racks, power and detector gas piping.

Utilizing cargo containers for the utility corridor will allow a uniformity of installation methods and the modularity of the 40' and 20' cargo containers is well suited to provide this type of support space.

Figure 4 below is a partial plan of the detector stack and the adjacent utility corridor.

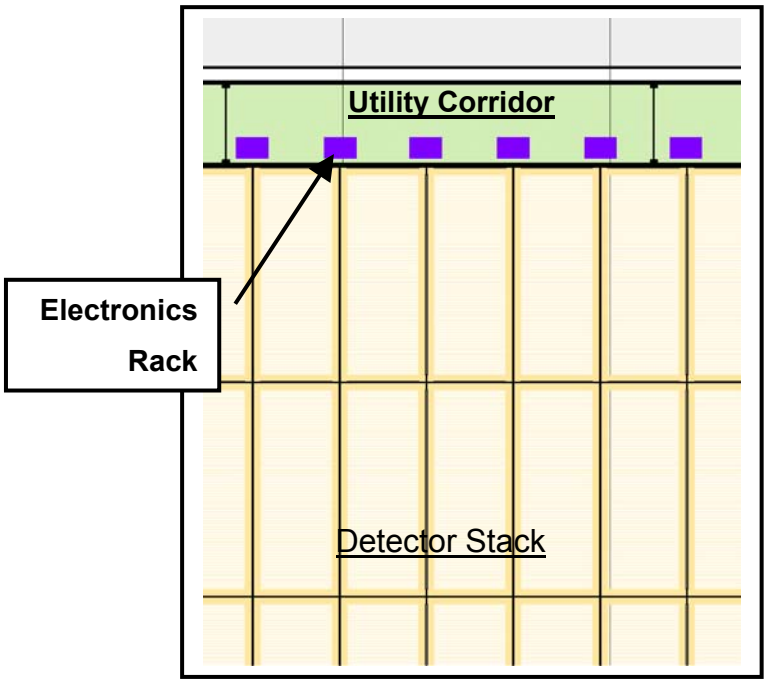

Figure 4 – Plan

Figure 5 is a typical section depicting the arrangement of the utility corridor containers and the detector stack.

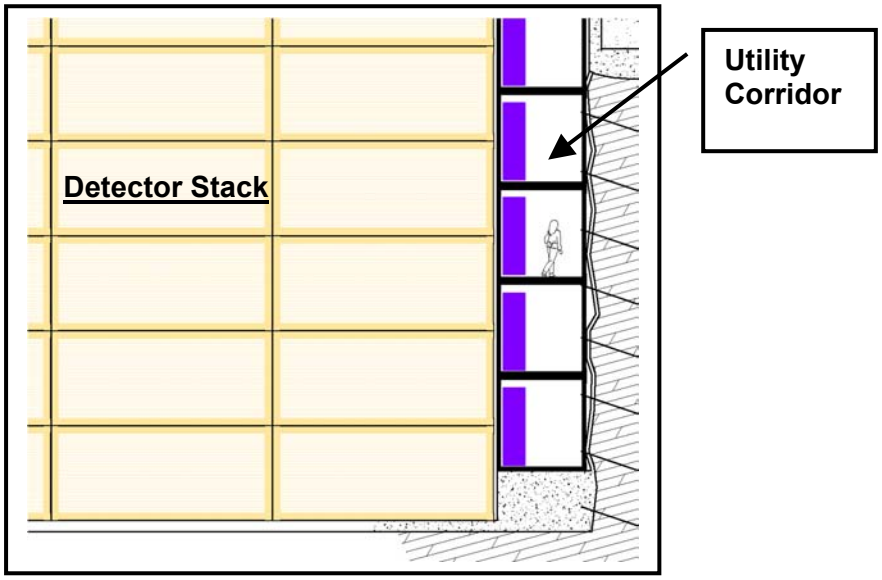

Figure 5 – Section

Several methods are available for the unloading, stacking and moving of the detector modules. For the purposes of this study, commercially available propane fueled, rubber tired gantry (RTG) crane designed for handling cargo containers will be used. The RTG will be obtained in a “4 over 1” configuration which will allow one cargo container to be moved over a stack of four. Figure 6 below is a photograph of a RTG of the general type used in the development of this project.

Figure 6 – Rubber Tire Gantry Crane

The RTG information is included for reference purposes only. The cost of the RTG is not included in the estimated costs and is assumed to procured separately.

PROJECT LOCATION **Off-Axis Detector Enclosure**

This study assumed a project location within 10 kilometers (6.2 miles) of the Soudan Iron Mine in Minnesota. General site conditions were assumed to be similar to that location including the following:

- All weather access road is available within one (1) mile of the project site and suitable for equipment and delivery of building components;
- Electrical power is available within one (1) mile of the project site;
- Adjacent area is available for staging and laydown area;
- Bedrock capable of supporting the detector and building loads is located within fifteen (15) feet of the ground surface;

This study assumed that project location does not contain any environmental concerns that would require substantial mitigation.

This study examined several possible methods to provide a building envelope to house the detector stack, support functions and material handling spatial requirements. The base design solution consists of 79 foot high steel-framed, metal-sided building on grade spanning a detector pit that extends 51 feet below grade to accommodate the rubber tire gantry in a “1 over 4” configuration. The staging area and support bay combine with the detector stack to produce a building that is 550 feet long. Figure 7 below is a plan view of the building:

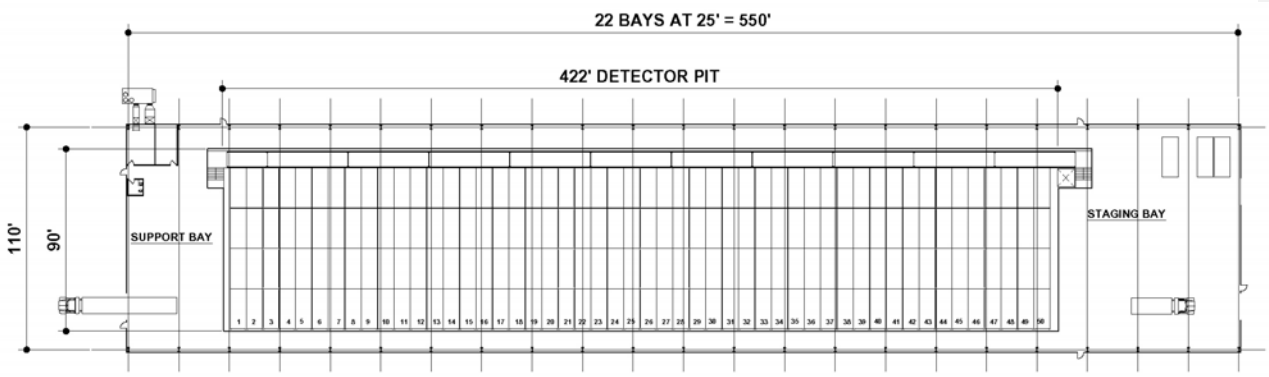

Figure 7 – Building Plan

This configuration allows 55’ long truck access to both ends of the building while separating the Staging and Support functions. The rubber tire gantry crane will travel along both sides of the detector stack and extend into both the Staging and Support bays to facilitate detector module handling.

While the detector stack is assumed to be unoccupied space, the utility corridor will house electronics racks and detector gas piping which will require periodic maintenance and adjustment. The design includes two exit stairs from the detector pit. These stairs will allow access to the ends of the cargo containers used that make up the utility corridor.

The base design is based on the detector pit extending 51 feet below grade to take advantage of local rock self supporting features thus reducing the cost of the above ground structure. In addition, the rubber tired gantry crane in a “1 over 4” configuration is ideally suited to handle the detector modules in this configuration. Figure 8 is a building cross section that depicts the arrangement of detector stack, the rubber tired gantry crane and the building components.

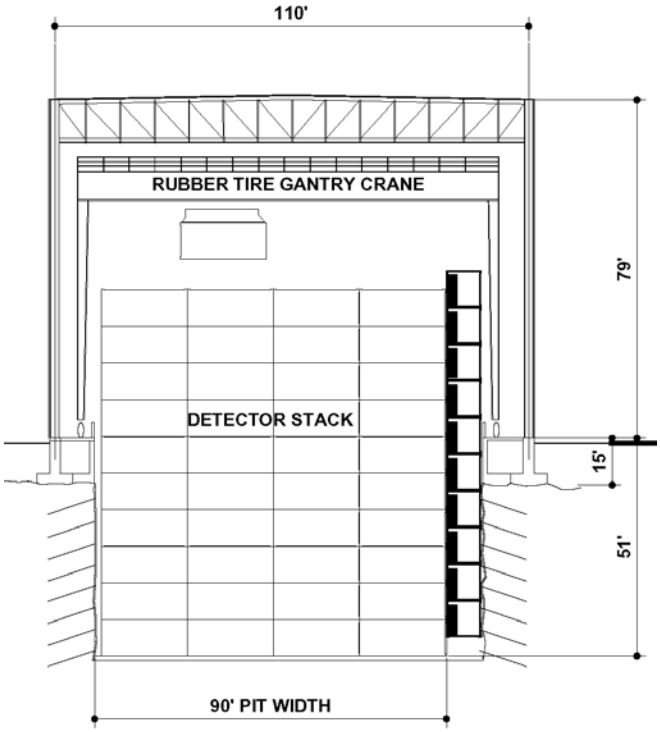

Figure 8 – Building Cross Section

The Support Bay is sized to house the support functions related to the operation of the building and detector modules. These activities include:

- Detector Gas Storage – this area will house the storage and distribution piping for the detector gas, including bottle storage. Mixing of the detector gas will occur outside the building;
- Mechanical Room – this area will house the air distribution and control equipment;
- Electrical Room – this area will provide space for electrical distribution panels for both the building and detector modules including step down transformers. Also housed in this space will be the data and communication equipment for the building.
- Toilet Room – one toilet room is provided, based on an assumed operating occupant load of four (4) people.

At this point in the design process, the support bay is provided in an open configuration allowing for flexible space utilization. Figure 9 below is a partial plan of the support bay.

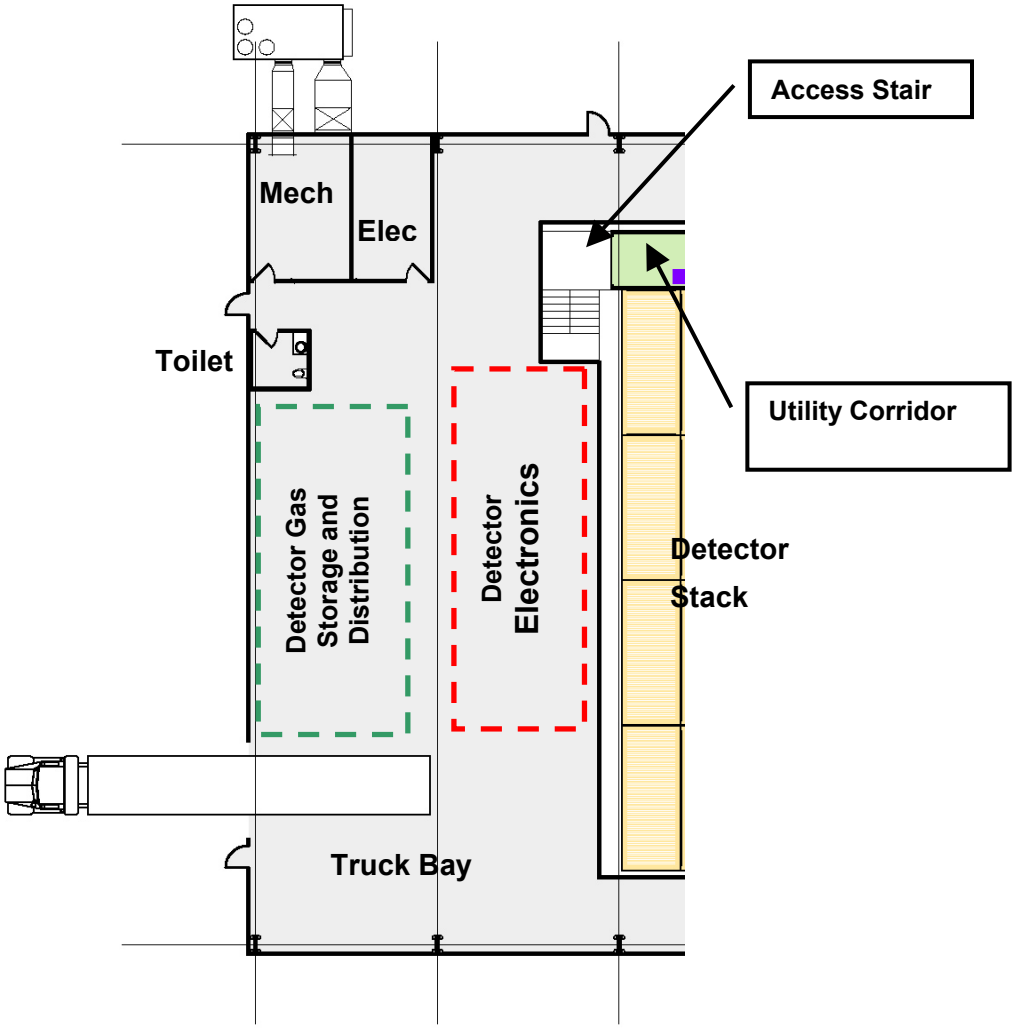

Figure 9 – Support Bay Plan

The configuration of the Support Bay is thought to be adequate for the functions to be housed within. The arrangement will be verified and modified as required in subsequent phases of the design process.

The Staging Bay will house the unloading and staging area for the detector modules. Testing and final commissioning of the detector modules will occur in this bay. Two 12' wide x 14' high overhead doors will allow for efficient handling of detector modules. The design assumes that the rubber tired gantry crane will run the length of the bay for module handling. This bay includes an equipment hoist space for vertical transport of detector support equipment including electronics racks and detector gas piping components. This hoist space is located adjacent to the detector pit and access stair. Figure 10 is a plan view of the Staging Bay.

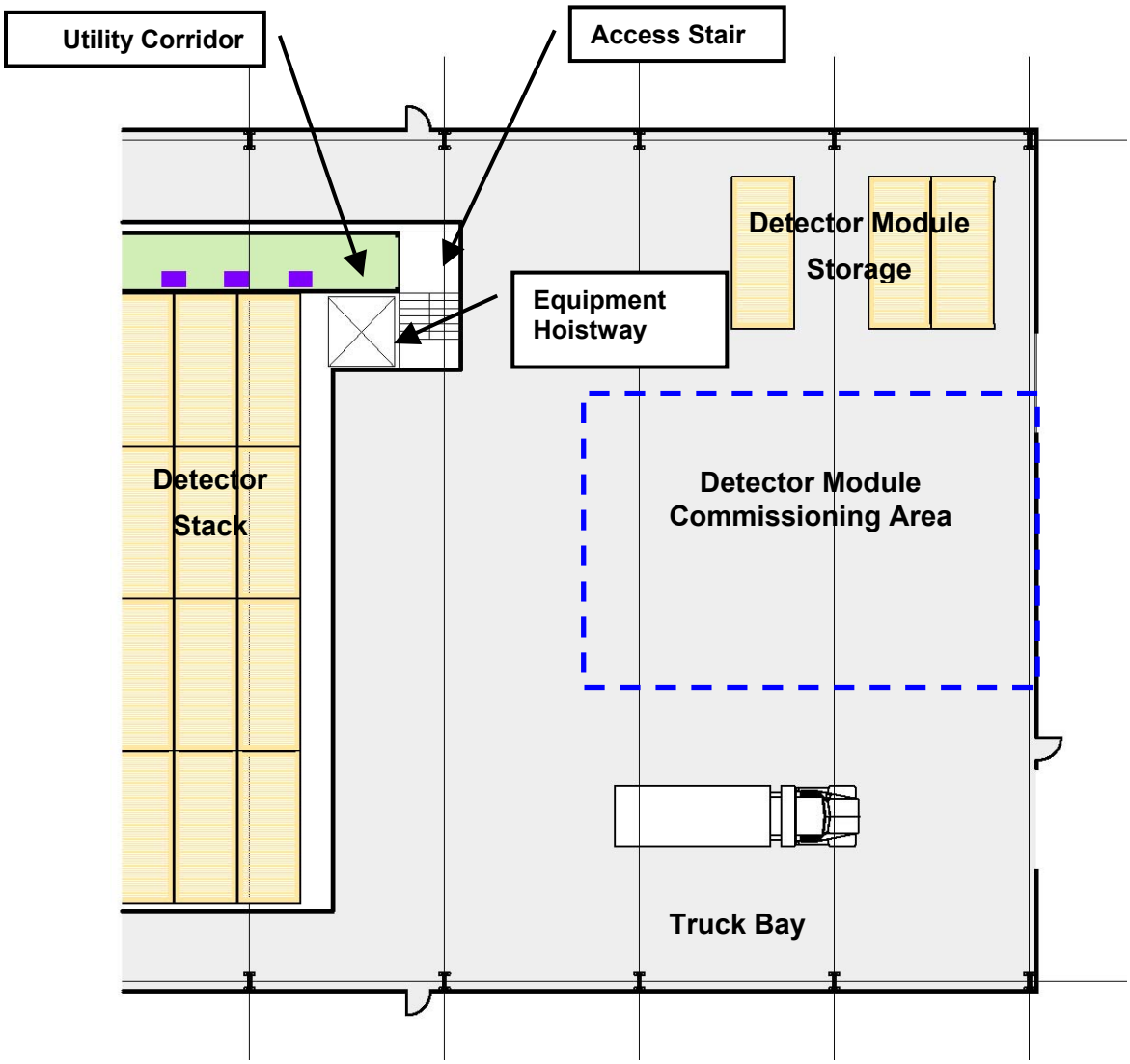

Figure 10 – Staging Bay Plan

The estimated project costs for the detector enclosure is $21,776,000. The estimated project costs are based on the detector enclosure described in Section V. The basic cost estimate format described in the "Off-Axis NuMI Neutrino Detector" report, dated January 2003 was used to organize the estimate. In order to facilitate alternate comparison, the following general categories were used:

Land Acquisition	$0
General Conditions	$2,474,000
Site Work	$1,501,000
Below Grade	$5,739,000
Above Grade	$5,129,000
Environmental	$124,000
Construction Subtotal	**$14,967,000**
EDIA	$2,499,000
Management Reserve	$3,748,000
Indirect Costs	$562,000
PROJECT TOTAL	**$21,776,000**

The construction costs listed above assumes a conventional steel framed above grade building utilizing standard steel sections, pre-finished metal siding and a 4-ply built up roof.

The below grade construction assumes removal of 15' of soil overburden. The remaining depth for the detector pit is assumed to be conventional "drill and blast" rock excavation with rock bolt support. The detector pit is faced with a drainage mat and shotcrete applied liner. The building foundation is a cast-in-place concrete foundation sized to support the building loads.

The costs associated with procurement, outfitting and installation of the cargo containers will be included in the cost of the experimental apparatus are not in the estimated project costs. The cost associated with procurement and installation of the rubber tire gantry crane and cargo container rail guides are not included in the estimated project costs.

The Engineering, Design, Inspection and Administration (EDIA) costs and the Management Reserve costs are consistent with current Fermilab criteria and DOE guidelines and recommendations for a project at this phase of planning.

The Indirect Costs included in the above estimate is based on a limited number of subcontracts and assumes the current Fermilab Indirect Cost multiplier rate.

Appendix B contains a detailed cost estimate including the descriptions of the assumptions used in developing the cost estimate. In addition, the Appendix contains further details of the basis for the EDIA, Management Reserve and Indirect Costs multipliers.

While the basis for the cost estimate in this study assumes a convention steel building, alternate methods for achieving the enclosure were investigated. Appendix C contains the results of the alternate methods of providing the detector enclosure including pre-engineered building systems and tension fabric structures.

The project schedule for the work described in this report is estimated to have duration of 34 months.

Listed below are the assumptions used to develop this schedule:

- Title 2 (Construction Document) phase to begin within one month of project start;
- Title 2 duration of nine (9) months;
- Two (2) month bid/evaluation period;
- All work in one bid package;
- 22 month Title 3 (Construction) phase;
- Beneficial Occupancy for experiment installation occurs at Month 30

Figure 12 below is the project schedule:

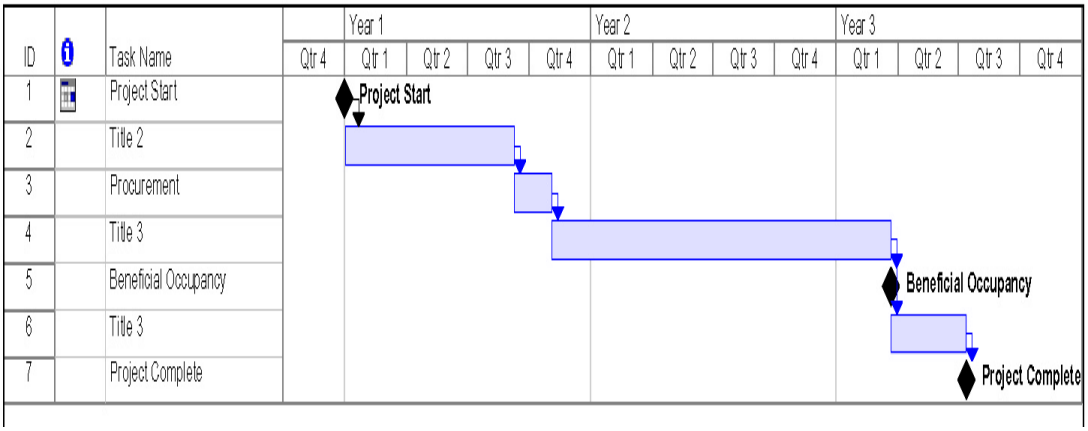

Figure 12 – Project Schedule

The conceptual nature of the schedule reflects the current state of the project design. As the design is refined, the schedule will be updated to incorporate the additional information.

This appendix contains web links to the information describing cargo containers used as the basis for the detector design. This information was obtained from shipping company web sites.

Listed below are the shipping companies used as a resource for the cargo container information:

- APL (www.apl.com)
- CMA CGM Group (www.cma-cgm.com)
- Columbus Line (www.columbusline.com)
- Evergreen Marine Corporation (www.evergreen-marine.com)
- Lloyd Triestino (www.lloydtriestino.it)
- "K" Line (www.kline.com)
- Maersk Sealand (www.maersksealand.com)
- Zim (www.zim.co.il)

This appendix contains a detailed cost estimate for the design described in Section V (Project Description) as well as a description of the assumptions used to develop the costs.

Listed below is the table of contents for this Appendix

- Cost Estimate Basis
- Detailed Cost Estimate
- Cost Item Assumptions
- DOE Directive 430.1-1
  - Chapter 6 – Project Functions
  - Chapter 10 – Escalation
  - Escalation Rate Assumptions – January 2003
  - Chapter 11 – Contingency
  - Chapter 25 – Guidelines for ED and I Costs
- Fermilab Indirect Rates for FY03

For comparison purposes, the cost estimate format described in the "Off-Axis NuMI Neutrino Detector" report, dated January 2003 was used. In order to facilitate alternate comparison, the following general categories were used:

Land Acquisition	$0
General Conditions	$2,474,000
Site Work	$1,501,000
Below Grade	$5,739,000
Above Grade	$5,129,000
Environmental	$124,000
Construction Subtotal	**$14,967,000**
EDIA	$2,499,000
Management Reserve	$3,748,000
Indirect Costs	$562,000
PROJECT TOTAL	**$21,776,000**

Cost Estimate Basis:
The costs associated with procurement, outfitting and installation of the cargo containers will be included in the cost of the experimental apparatus and not in the estimated project costs. The cost associated with procurement and installation of the rubber tire gantry crane and cargo container rail guides are not included in the estimated project costs.

The costs contained in this Design Study Report are based on FY2003 dollars. Appropriate escalation will need to be applied once a funding source is identified.

The budgetary cost estimate is based on cost data taken from Means Cost Estimating Guides, historical data and recent construction history at Fermilab. While the budgetary cost estimate can provide input for the feasibility of the project, further design refinement will affect the final cost of the project.

Where possible, the cost estimate format is based on the format of the "Off-Axis NuMI Neutrino Detector" report, dated January 2003. While the building design concept is quite different, similar factors were equalized for comparison purposes. This included utilizing similar factors for Land Acquisition Costs, General Conditions, EDIA, Management Reserve (Contingency) and Indirect Costs. Listed below is a comparison of this PDR and the University of Minnesota Detector Design.

	DSR	UofM Detector
Land Acquisition Costs	$0	$0
General Conditions	20%	20%
EDIA	20%	17%
Management Reserve	25%	25%
Indirect Costs	3%	1.25%

Detailed Cost Estimate:
Listed below is the detailed cost estimate

FERMILAB: FESS COST ESTIMATE

Project Title:		Project No.	Status:	Date:	Revision Date:	
	OFF AXIS DETECTOR	6-2-22	PDR	4/25/03		
ITEM NO.	DESCRIPTION OF WORK:	QUANTITY	UNITS	UNIT COST	AMOUNT	
01	LAND ACQUISITION $0					
01	Surface Land Costs				$0	
02	Undeground Rights Costs				$0	
03	Road Easements				$0	
04	Utility Easements				$0	
05	Public/Private Road Fees				$0	
02	GENERAL CONDITIONS $2,474,000					
01	Percentage of Construction Costs	20%	%	$12,369,000	$2,473,800	
03	SITE WORK/INFRASTRUCTURE $1,501,000					
	Includes Sub-tier contractor OH&P 15% $196,000					
01	Clear and Grub Entrance Road	0	Acres	$5,000.00	$0	1
02	Strip 1' of soil	0	CY	$5.00	$0	1
03	Entrance Road Base 1 mile x 30' x 18"	0	CY	$40.00	$0	1
04	Entrance Road Paving 1mile x 24' x 4"	0	SY	$7.50	$0	1
05	Access Road	1	LS	$4,500.00	$4,500	2
06	Site Power Pole Line	0	Mile	$181,500.00	$0	1
07	Communication Lines	1	Mile	$19,000.00	$19,000	2
08	Strip and grub	4	Acres	$5,000.00	$20,000	
09	Site Grading	1	Acres	$15,000.00	$15,000	
10	Gates and Fencing	1	LS	$18,805.00	$18,805	2
11	Sidewalks	1	LS	$6,938.00	$6,938	2
12	Construction Hardstands	0	SF	$3.10	$0	1
13	Electrical Substation (2000 kVA Transformer)	2	Each	$55,400.00	$110,800	
14	Four Way Air Switch	1	Each	$26,000.00	$26,000	
15	750 KW Diesel Generator	1	Each	$146,820.00	$146,820	
16	Oil Containment	1	Lot	$20,000.00	$20,000	
17	(2)-5" Electrical Ductbank in Concrete	150	LF	$80.00	$12,000	
18	3-1/C 750 MCM Conductors	200	LF	$230.00	$46,000	
19	Water Well (200' deep)	1	Lot	$25,800.00	$25,800	
20	Water Storage (& Fire) Tank	1	Lot	$650,000.00	$650,000	
21	Fire Protection Panel (in Building Estimate)					
22	Sanitary Sewage Holding Tank	1	Lot	$12,000.00		
23	Fire Underground Main	0	LF	$16.00	$0	1
24	Envir. Protection - silt fence	0	LF	$4.00	$0	1
25	Mine Water Treatment w chemicals	0	Lot	$500,000.00	$0	1
26	Settling basin 1/2 acre	0	Lot	$90,000.00	$0	1
27	Hydrant + PIV's	0	Lot	$3,000.00	$0	1
28	DWS 3"	0	LF	$8.00	$0	1
29	Storm Sewer	1	LS	$152,416.00	$152,416	2
30	Exterior Lighting	1	LS	$31,000.00	$31,000	2

FERMILAB: FESS COST ESTIMATE

Project Title: OFF AXIS DETECTOR		Project No. 6-2-22	Status: PDR	Date: 4/25/03	Revision Date:	
ITEM NO.	DESCRIPTION OF WORK:	QUANTITY	UNITS	UNIT COST	AMOUNT	
04	**BELOW GRADE $5,739,000**					
	Includes Sub-tier contractor OH&P 15% $749,000					
01	Excavate Overburden	36500	CY	$12.00	$438,000	
02	Haul Overburden	36500	CY	$3.00	$109,500	
03	Excavate Rock	58175	CY	$38.00	$2,210,650	
04	Haul Muck	87260	CY	$3.00	$261,780	
05	Rock Bolts 5'x5' pattern 10'LG	17000	LF	$6.75	$114,750	
06	Drainage Strips	5600	LF	$8.00	$44,800	
07	Shotcrete Liner W/ WWF 4"	41984	SF	$8.00	$335,872	
08	CIP Slab on Grade	397	CY	$250.00	$99,250	
09	CIP Retaining Wall	1250	CY	$450.00	$562,500	
10	CIP Grade Beam	155	CY	$450.00	$69,750	
11	CIP Piers and Footings	135	CY	$500.00	$67,500	
12	CIP Container Base Slab	1418	CY	$350.00	$496,300	
13	Sump and Discharge Piping	4	EA	$22,000.00	$88,000	
14	Drain Tile	1500	LF	$12.00	$18,000	
15	Dimple Mat	36900	SF	$2.00	$73,800	
05	**ABOVE GRADE $5,129,000**					
	Includes Sub-tier contractor OH&P 15% $669,000					
01	Metal Deck 18 Ga	60500	SF	$1.60	$96,800	
02	Purlins	144	Tons	$2,200.00	$316,800	
03	Trusses	155	Tons	$2,200.00	$341,000	
04	Truss Bracing	3.7	Tons	$2,200.00	$8,140	
05	High Bay Columns	105	Tons	$2,200.00	$231,000	
06	Girts	56	Tons	$2,200.00	$123,200	
07	Stairs	2	Ea	$49,000.00	$98,000	
08	Wind Bracing	4	Tons	$2,200.00	$8,800	
09	Misc Steel	5	Tons	$2,200.00	$11,000	
10	4 Ply Built-up Roofing	60500	SF	$2.10	$127,050	
11	Insulation 3"	60500	SF	$0.75	$45,375	
12	Prefinished Metal Siding	99200	SF	$12.00	$1,190,400	
13	Overhead Door 12' wide x 14' high	2	EA	$14,000.00	$28,000	
14	Overhead Door 12' wide x 12' high	1	EA	$8,000.00	$8,000	
15	Personnel Doors	6	EA	$800.00	$4,800	
16	Interior Partitions and finishes	1	Lot	$80,000.00	$80,000	
17	Extinguisher agent (200lb container)	2	EA	$7,250.00	$14,500	
18	Dispersion Nozzle and Piping	8	EA	$3,500.00	$28,000	
19	Control Release Panel	1	EA	$3,250.00	$3,250	
20	Detection Wiring	8	EA	$650.00	$5,200	
21	Emergency Release / Abort Button	4	EA	$250.00	$1,000	
22	Ventilation (Roof Exhaust)	1	Lot	$110,000.00	$110,000	
23	Heat Exchangers	2	EA	$35,000.00	$70,000	
24	HX Installation	1	Lot	$27,000.00	$27,000	
25	Tower Pumps	2	EA	$12,000.00	$24,000	

FERMILAB: FESS COST ESTIMATE

Project Title:		Project No.	Status:	Date:	Revision Date:	
OFF AXIS DETECTOR		6-2-22	PDR	4/25/03		
ITEM NO.	DESCRIPTION OF WORK:	QUANTITY	UNITS	UNIT COST	AMOUNT	
26	Piping Installation (minimal)	1	Lot	$130,000.00	$130,000	
27	Structural pipe hangers	1	Lot	$24,000.00	$24,000	
28	Starter or VFD	4	EA	$20,000.00	$80,000	
29	Electrical to Pumps	1	Lot	$12,000.00	$12,000	
30	Allowance for controls	1	Lot	$17,000.00	$17,000	
31	Flushing, Testing, and Balancing	1	Lot	$8,000.00	$8,000	
32	Cooling Tower	1	Ea	$80,000.00	$80,000	
33	Toilet Room Fixtures	1	Lot	$4,000.00	$4,000	
34	HW Heater	1	Ea	$800.00	$800	
35	Fire Pump 100psi @ 1,500 GPM	1	Lot	$75,000.00	$75,000	
36	2-Risers	1	Lot	$15,000.00	$15,000	
37	In-Rack (Detector Sprinklers)	23000	SF	$6.25	$143,750	
38	Sprinklers	60500	SF	$3.00	$181,500	
39	50 KVA transformers	4	EA	$2,400.00	$9,600	
40	2000 A switchboard	2	EA	$15,400.00	$30,800	
41	1200 Amp Panels	4	EA	$3,800.00	$15,200	
42	800 Amp Panes	4	EA	$3,200.00	$12,800	
43	400 Amp Panels	4	EA	$2,900.00	$11,600	
44	225 Amp Panels	4	EA	$2,100.00	$8,400	
45	750 MCM THWN Copper 4/c	200	LF	$23.00	$4,600	
46	Welding outlets	8	EA	$420.00	$3,360	
47	Power Distribution	60500	SF	$5.00	$302,500	
48	Unit Heaters	36	EA	$2,000.00	$72,000	
49	Lighting	60500	SF	$1.33	$80,465	
50	Fire Detection	60500	SF	$2.25	$136,125	
06	**PERMITS, FEES, PS** **$6,933,000**					
	Bare Construction Costs $12,369,000					
01	Environmental Impact Studies & Mitigation	$12,369,000	%	1%	$124,000	2
02	Engineering Design, Inspection and Administration	$12,493,000	%	20%	$2,499,000	
03	Management Reserve	$14,992,000	%	25%	$3,748,000	2
04	Indirect Costs	$18,740,000	%	3%	$562,000	

1 Cost Items noted thus indicate an item identified in the FESS/E cost estimate which has been reduced to zero to allow a comparison to the "Off-Axis NuMI Neutrino Detector" report, dated January 2003.

2 Cost Items noted thus indicate an item cost matched to the costs included in the "Off-Axis NuMI Neutrino Detector" report, dated January 2003.

Cost Item Assumptions:
Listed below is the assumptions used to developed the detailed cost estimate.

01 – Land Acquisition
Since no site has been selected, the costs associated with land acquisition, access and utility easements have not been included in the estimate.

02 – General Conditions
General Conditions include the prime subcontractor's (also know as the General Contractor) costs associated with mobilization, transportation of materials and equipment as well as project management services, including bonding, insurance and office support functions.

03 – Site Work/Infrastructure

03.05 – Access Road. The access road is assumed to be a all-weather permanent paved road from the existing road to the project site. The road will be twenty four feet wide with three foot shoulders and will be constructed with a 3" base course and a 1.5" wear course, conforming with Minnesota Department of Transportation requirements.

03.07 – Communication Lines. One (1) mile of data/telecom lines along existing power poles is included in the project costs.

03.08 – Strip and Grub. Four (4) Acres of site clearing of minor vegetation and trees in included

03.09 – Site Grading. One (1) acre of fine site grading is included to restore the site after the completion of construction.

03.10 – Gates and Fences. This item includes general site fencing. Material will include an eight (8) foot high galvanized chain link fence with sliding gates at the site entry.

03.11 – Sidewalks. This item includes cast-in-place concrete (2000 psi) sidewalks connecting the parking lots and the building. The sidewalks will be four (4) feet wide and four (4) inches thick.

03.12 – Construction Hardstands. This item includes a 1670 gravel hardstand to be used for construction staging and storage. At the completion of the project, this hardstand will become the parking lot for the building.

03.13 – Electrical Substation. Two (2) oil filled 2000 kVA transformers are included in the substation costs. The transformer cost is based on recent vendor proposals from MGM Transformer Company. The electrical service will be 480/277V and 208/120V

03.14 – Four Way Air Switch. One (1) four way air switch is included. The cost is based on recent vendor proposals provided by the S&G Company.

03.15 – 750 KW Emergency Generator. The generator fuel tank shall be sized to provide a minimum of two (2) hours of operation and provide emergency power for emergency lights, exit signs, smoke mangement systems and fire systems. The generator will be located adjacent to the electrical substation and be enclosed in a weathertight housing with intergral diesel fuel tank.

03.16 – Oil Containment. The oil containment will consist of a cast-in-place concrete containment walls with stone backfill sized to contain any oil leak from the substation equipment.

03.17 – Electrical Ductbank. This item consists of two 5” PVC conduits connecting the electrical substation to the building electrical room. The conduits will be encased in concerte.

03.18 – 750 MCM Conductors. These conductors transmit the electrical power from the electrical substation to the building electrical room.

03.19 – Water Well. The water well is the source of potable water for the facility. Uses will include domestic uses for drinking and toliets as well as a source of water for the sprinkler system. The well is assumed to be located on the project site and constructed using conventional well drilling methods. The well will be cased, developed and testing in accordance with the Minnesota Department of Health and Environment standards and regulations. The water will be pumped from the well to the mechanical room for distribution within the building and to the on-site water storage tank.

03.20 – Water Storage Tank. This item is a field fabricated above ground vertical steel insulated tank sized to provide two (2) hours of fire protection water for the sprinkler system. The tank will include an electric immersion heater connected to the emergency generator. Also included is a fire pump test manifold and siamese pumper connection

located at grade.

03.21 – Sanitary Sewage Holding Tank. A below ground holding tank for the sanitary sewage is included. The tanks will be sized to provide a one month capacity.

03.22 – Storm Sewer. The storm sewer system consists of the piping, catch basins and outfall devices to remove storm water from the project site. The system will be sized to include adequate capacity for the the below grade detector pit.

03.23 – Exterior Lighting. This item includes light fixtures, poles, foundations and electrical connections as required to provide one (1) footcandle of lighting in the parking lots and access drives.

<u>04 – Below Grade</u>

04.01 – Excavate Overburden. The soil overburden will be excvated utilzing conventional methods.

04.02 – Haul Overburden. The hauling of the soil overburden is assumed to be done by conventional methods to a location off the project site.

04.03 – Excavate Rock. The rock will be excavated in a traditional "drill and blast" method.

The below grade portion of the work is 38% of the overall project costs. Special attention was given to the unit costs for Item 04.03. These costs were taken from Cost Works program by RS Means, copyright 2003 (1st Quarter 2003 update). Listed below is a summary of the development of the costs for these activities.

Drill and Blast only, Deep hole method over 1500 cy = $29.50 / cy
Excavate and load blasted rock into muck bucket =$1.33 / cy
Clamshell at 20 cy/hr (plus 15% if loading into trucks) = $7.13 / cy
Total = $37.83 cy
use $38.00 / cy

The excavation section of CostWorks did not contain a listing for a crane and a muck bucket, so it was reasoned that a clamshell would approximate the cost for a crane and muck bucket.

04.04 – Haul Muck. The rock muck will be excavated by conventional methods to a location off the project site. Further design refinement may allow the rubber tire gantry crane to assist in the mucking portion

of the project thereby lowering the cost of this item. Scheduling and availablity will determine the final impact.

04.05 – Rock Bolts. 10' long rocks bolts on a 5'x5' pattern will be used for rock support.

04.06 – Drainage Strips. This item is a geocomposite feature driven drain strips consisting of a system of geocomposite fabric strip drains installed over water bearing joints, fractures, bedding planes, contacts and other features of the rock mass. In certain areas the geocomposite fabric drain strips may be installed on a defined grid spacing and pattern or as directed. Geocomposite drainage strips shall consist of a nylon core of fused, entangled filaments with a polyester/nylon non-woven filter thermally bonded to one side of the core, Enkadrain 9010

04.07 – Shotcrete Liner. A four (4) inch thick spray-applied concrete liner will be installed over the face of the rock surface. A 4x4 welded wire fabric mesh will be installed.

04.08 through 04.11. These items combine to form the reinfored cast-in-place foundation for the building. The foundations extend down to the top of rock approximately fifteen (15) feet below the ground surface.

04.12 – CIP Container Base Slab. This reinforced, cast-in-place concrete slab will form the base for the detector modules. The slab includes the necessary provisions and inserts as required to support the cargo containers at the corners per the manufacter's recommendations.

04.13 – Sump Pump and Drain Piping. The subsurface drainage system will consist of two systems. An upper system near the surface will direct water from the upper foundation drainage system to a duplex sump pump located near the surface. A lower level duplex sump pump system will be used to remove water collected from the drainage mat in the lower portions of the structure. A duplex sump pump located in a pit below the base of the detector pit will pump the groundwater to the stormwater sewer system. The sump pit will be sized to allow for storage of a two hour supply of water in the event of a pump failure. The pumps will be supplied with emergency generator power.

04.14 – Drain Tile. 6" perforated plastic drain tile will be located at the base of the detector pit and around the building perimeter to collect ground water and convey the water to the sump pump.

04.15 – Dimple Mat. This item is a deformed/dimpled plastic drainage mat placed between the finished concrete or concrete shielding and the rock to intercept, collect and divert seepage water coming from the rock to perimeter gutter drains or under drains. Drainage mats for use in inverts shall be Delta MS-20 (20 mm stud height) high density polyethylene as manufactured by Cosella Dörken Products, Inc. Beamsville, Ontario, Canada or Fermilab approved equivalent attached with fasteners and plastic plugs as recommended and supplied by the sheet manufacturer.

05 – Above Grade

05.01 – Metal Deck. 18 gage galvanized metal roof deck spans between the roof purlins.

05.02 through 05.04. These items combine to form the roof structure of the building. The framing system consists of a long-span steel truss system with steel purlins and horizontal truss bracing. These items are assumed to be fabricated off site, transported and erected in place.

05.05 – High Bay Columns. The structural columns are conventional steel members sized to support the building loads.

05.06 – Girts. The steel girts span between the columns and provide support and anchorage for the metal siding.

05.07 – Stairs. The steel access stairs are located at both ends of the detector pit and allow access to the ends of the cargo containers used that make up the utility corridor. These stairs will serve as a means of egress. The stairs will be switchback type and have 4’-0” wide metal grating treads, 4’-0” x 9’-0” landings and metal pipe handrails

05.08 – Wind Bracing. The wind bracing consists of structural steel members designed to withstand lateral forces transmitted to the building frame.

05.09 – Misc. Steel. This items includes miscellaneous steel angles, frames and connections required for the building structure.

05.10 through 05.11. These items comprise the roof system including 3” of rigid insulation and a 4-ply built up roof with gravel topcoat. The roof will be pitched to provide sheet drainage over the longitudinal edge

of the building.

05.12 – Prefinished Metal Siding. The sidewalls of the building will be covered with a prefinished metal siding panel system. The standing rib panel will be provided with a polyester finish of a color selected from the manufacturer's standard color palette.

05.13 through 05.14. These items are the overhead doors for truck access. Electric operators are included in the cost of these items.

05.15 – Personnel Doors. 3' wide by 7' high doors for personnel access will be provided at location around the building perimeter. This item includes door hardware.

05.16 – Interior Partitions and Finishes. This item is a lump sum allowance for interior gypsum and metal stud partitions. Also included are doors and painting.

05.17 through 05.21. These items combine to provide a fire suppression system for the detector gas storage area.

05.22 – Ventilation. A number of roof exhausters and louvers will be provided in the high bay for ventilation only, to handle the air heat load and propane crane exhaust in accordance with applicable codes. The toilet room will be conditioned using a packaged DX cooling and heating unit.

05.23 through 05.32. These items combine to provide heat rejection for the building. A complete low conductivity water (LCW) system, with stainless steel piping, stainless steel pumps, heat exchangers, expansion tanks, polishing, system and minimal controls will be provided, with heat rejection to wet or dry cooling towers. It is assumed that the LCW supply is 90 F and the load to water and air is 1500kw.

05.33 – Toilet Room Fixtures. The toilet room will be provided with a water closet and sink.

05.34 – HW Heater. An electric hot water heater will provide domestic hot water for the toilet room.

05.35 through 05.38. These items combine to provide sprinkler coverage for the building including the detector electronics racks in the

utility corridor.

05.39 through 05.47. These items combine to provide the 480/277 3 phase electrical power for the building and detector modules. The electrical components will be located in the Electrical Equipment Room in the Support Bay on the ground floor of the building.

05.48 – Unit Heaters. Electric unit heaters will sized and located to keep the building at 40 degrees F throughout the heating season.

05.49 – Lighting. Metal Halide light fixtures located in the high bay will provide general illumination of 50 foot-candles. Fluorescent light fixtures in the utility corridor and other support spaces will be located to provide 50 foot-candles of illumination. Provision for night lighting and emergency lighting will be incorporated into the design.

05.50 – Fire Detection. This item consists of an addressable fire detection system designed to meet applicable building codes. Included are pull stations, heat detectors, smoke detectors, horn/strobe units, and related devices.

06 – Permits, Fees and Professional Services

06.01 – Environmental Impact Studies and Mitigation. This study assumed that project location does not contain any environmental concerns that would require substantial mitigation. Included in this item is the development of a Storm Water Pollution Prevention Plan (SWPPP) specific to the project site.

06.02 – Engineering Design Inspection and Administration. Engineering Design Inspection and Administration (EDIA) costs are included in the budget cost estimates. ED&I activities include the Engineering and Design activities in Titles 1 and II, the Inspection activities associated with Title III. The descriptions of these activities are based on DOE Directive G430.1-1, Chapter 6. Administration activities include those defined by DOE Directive G430.1-1, Chapter 6 as Project Management (PM) and Construction Management (CM). Past historical data and DOE Directive G430.1-1, Chapter 25 indicate that 18%-25% of the construction costs is an appropriate range. This study assumed an EDIA multiplier of 20%.

06.03 – Management Reserve. Management Reserve costs are included in the budget cost estimates. Based on DOE Directive

G430.1-1, Chapter 11 DOE guidelines and the pre-conceptual nature of the design at this stage a Management Reserve of 25% of the construction.

06.04 – Indirect Costs. The project costs include Indirect Cost multipliers. Indirect Costs rates are defined by DOE Order 4700.1 that states indirect costs are "...costs incurred by an organization for common or joint objectives and which cannot be identified specifically with a particular activity or project. If this work should become an AIP, Line Item or GPP project, Indirect Costs will have to be applied, but the amount will be affected by the rates in effect at the time this project is initiated. Currently, the Fermilab Indirect Cost multiplier is ~19% of the project costs, but will be applied to only the first $500k of each subcontract. Given the magnitude of this project, Indirect Cost savings will be realized by bundling of the construction projects. For this reason, an Indirect Costs multiplier is assumed to be 3%.

CHAPTER 6

PROJECT FUNCTIONS AND ACTIVITIES DEFINITIONS FOR TOTAL PROJECT COST

1. INTRODUCTION

Because of an obvious disparity of opinions and practices with regard to what exactly is included in total estimated cost (TEC) and total project cost (TPC), guidelines were developed and are included in this chapter. The development of guidelines is important because it provides consistency in estimating and reporting of project costs and it provides uniformity of information used for cost data bases. It should be noted that TEC does not apply to most of the EM projects; only TPC applies.

2. DEFINITIONS

Total project cost is defined as all costs specific to a project incurred through startup of a facility, but prior to the operation of the facility. Thus, TPC includes TEC and other project costs (OPC), or

$$TEC + OPC = TPC.$$

A. Total Estimated Cost

TEC is defined as all engineering design costs (after conceptual design), facility construction costs, and other costs specifically related to those construction efforts. These are typically capitalized. TEC will include, but not be limited to: project and construction management during Titles I, II, and III; design and construction management and reporting during design construction; contingency and economic escalation for TEC-applied elements; ED&I during Titles I, II, and III; contractor support directly related to design and construction; and equipment and refurbishing equipment.

B. Other Project Costs

OPCs are defined as all other costs related to a project that are not included in the TEC, such as supporting research and development, pre-authorization costs prior to start of Title I design, plant support costs during construction, activation, and startup. OPCs will include, but not be limited to: research and development; NEPA documentation; project data sheets (PDSs); CDR; short form project data sheets; surveying for siting; conceptual design plan; and evaluation of RCRA/EPA/State permit requirements.

C. Total Project Cost

TPC is defined as all costs specific to a project incurred through the startup of a facility but prior to the operation of a facility. It is comprised of TEC and OPC. TPC will include, but not be limited to, activities such as: design and construction; contingency; economic escalation; Pre-Title I activities; feasibility study reports (FSRs); maintenance procedures (to support facility startup); one-time start-up costs, initial operator training, and commissioning costs; and operating procedures (to support facility start-up).

3. DISCUSSION OF CHARTS

Table 6-1 is a matrix that summarizes the different individual project activities and indicates their designation with respect to TPC and TEC. The project activities identified are divided into different phases of project development. The activities are charged to the different functions that comprise TEC and OPC and are shown in the sequence they would most likely occur.

A. Different Phases of Project Development

The different individual project activities identified are divided into different stages of project development. The first section of the matrix identifies activities encountered during pre-authorization or Pre-Title I design. The second section of the matrix identifies activities encountered during Titles I and II of design. The matrix progresses in that manner to include Title III design and start-up.

B. Different Functions of Total Estimated Cost and Other Project Cost

The different project activities are allocated to different project functions with respect to TEC and OPC. The activities are designated as based on the project phase under which the activity occurs.

1. Total Estimated Cost

TEC is divided into costs associated with ED&I, project management (PM), construction management (CM), and construction contractors (CC).

a. ED&I: ED&I activities include the engineering and design activities in Titles I & II, the inspection activities associated with Title III, and activities defined in the Brooks Bill (e.g., the 6 percent allowed for design, drawings, and specifications).

b. PM: Project management covers those services provided to the DOE on a specific project, beginning at the start of design and continuing through the completion of construction, for planning, organizing, directing, controlling, and reporting on the status of the project.

c. CM: Construction management covers those services provided by the organization responsible for management of the construction effort during Title I and Title II design, and continuing through the completion of construction. CM services are further defined in DOE Order 4700.1, PROJECT MANAGEMENT SYSTEM.

d. CC: Construction contractors cover salaries, travel, and other expenses of engineers, engineering assistants, and their secretarial support responsible for engineering and design performed by the construction contractor. When work normally performed by an architect/engineer (A/E) is performed by a CC, the associated costs are charged to the applicable ED&I accounts.

2. Other Project Cost

Any activities that are not representative of TEC functions are allocated to OPC. They are typically Pre-Title I activities, startup costs, and some support functions.

4. COST ALLOCATIONS

The definitive document within DOE for allocations of cost is DOE Order 2200.6, FINANCIAL ACCOUNTING, but a general discussion of cost allocations follows.

A. Plant and Capital Equipment (PACE) Fund

The Plant and Capital Equipment (PACE) Fund provides funding for the plant and its basic equipment/furnishings. This fund is for conventional construction projects only.

B. Operating Expense Fund

The Operating Expense Fund provides funding for ongoing activities, such as laundry, cleaning, etc. These items are typically captured in site overhead accounts and then allocated to projects as site overhead. Operating expense funded items more directly related to projects are items such as Pre-Title I and start-up activities, etc.

C. Usage

Once standard definitions are developed and the different project activities are identified, it is then possible to uniformly allocate costs to the different project development activities. Table 6-2 is a matrix that summarizes recommended cost allocations for operating expense and PACE (ED&I and construction). It is important to note that the estimator should refer to these tables throughout the entire life of a project.

TABLE 6-1

TPC AND TEC GUIDANCE AND CLARIFICATION
INCLUSION OF DETAILED ACTIVITIES IN TPC AND/OR TEC

ACTIVITY	TPC				
	OPC	TEC			
		ED&I	PM	CM	CC
1. PRE-KEY DECISION - 0 (Prior to Determination of Mission Need)					
A. Engineering Study	X				
B. Alternatives Assessment/Site Selection Studies	X				
C. Surveying for Siting	X				
D. Capital Review Board	X				
E. Candidate Projects (support sheet and presentation to DOE)	X				
F. Conceptual Design Plan	X				
G. Work Orders - CDR Preparation, etc.	X				
H. Integrated Programmatic/Project Schedule (R&D, Safety, Environmental, Operations, etc.)	X				
I. Requirements for Safety Analysis Determination	X				
J. Functional Design Criteria	X				
K. Evaluation of RCRA/EPA/State Permit Requirements	X				
L. Cultural Resources Review	X				
2. Key Decision - 0 and Key Decision - 1 (Determination of Mission Need and Approval of New Start)					
A. Conceptual Design Report	X				
B. Design Reviews	X				
C. NEPA Documentation	X				
D. Conceptual Project Schedule	X				
E. Plant Forces Work Review	X				
F. Energy Conservation Report	X				

TABLE 6-1

TPC AND TEC GUIDANCE AND CLARIFICATION
INCLUSION OF DETAILED ACTIVITIES IN TPC AND/OR TEC

ACTIVITY	TPC				
	OPC	TEC			
		ED&I	PM	CM	CC
G. Economic/Life Cycle Cost Analysis	X				
H. Alternative Engineering (before Title I)	X				
I. Physically Handicapped Review	X				
J. Energy System Acquisition Advisory Board and Acquisition Executive Review Board Support	X				
K. Preliminary Safety Analysis Report (PSAR)	X				
L. Facility/Project Security Review and Plan	X				
M. Facility Security Vulnerability Assessments	X				
N. Master Safeguards & Secure Analysis	X				
O. Construction Project Data Sheet (CPDS)	X				
P. ES&H Requirements Assessment	X				
Q. Strategic Facility Assessment	X				
R. Budget/Conceptual Estimates, as required (Parametric Assessments)	X				
S. Project/Validations Support	X				
T. Monthly Conceptual Status Report	X				
U. Architect/Engineer (A/E) Selection and Statement of Work Development	X				
V. Identification of Project Record Requirements	X				
W. Project Management Plan (PMP)	X				
X. Project Quality Assurance (QA) Plan	X				
Y. Configuration Management Plan (CMP)	X				

TABLE 6-1

TPC AND TEC GUIDANCE AND CLARIFICATION
INCLUSION OF DETAILED ACTIVITIES IN TPC AND/OR TEC

ACTIVITY	TPC				
	OPC	TEC			
		ED&I	PM	CM	CC
Z. Pilot Plants	X				
AA. Research and Development (Project Specific)	X				
AB. Facility As-Built/Existing Condition Drawings (Prior to Design Start)	X				
AC. Obtain Permits Required Prior to Start of Construction (before Title I)	X				
3. Key Decision - 1 and Key Decision - 2 (Approval of New Start and Start of Detailed Design: Title I and II Activities)					
A. PMP Revisions			X		
B. CPDS Revisions			X		
C. Integrated Detailed Project Schedules/Critical Path Analysis			X		
D. Project Revalidations			X		
E. Project Authorization Modification Support			X		
F. A/E Internal Design Coordination		X			
G. Identification of Long Lead Procurements		X			
H. Design Studies		X			
I. Design Calculations & Analysis		X			
J. CADD and other Computer Services		X			
K. Cost Estimates			X		
L. Procurement & Construction Specification Development		X			
M. Design Reviews by Project Team		X	X		
N. Design Review Support	X	X			

TABLE 6-1

TPC AND TEC GUIDANCE AND CLARIFICATION
INCLUSION OF DETAILED ACTIVITIES IN TPC AND/OR TEC

ACTIVITY	TPC				
	OPC	TEC			
		ED&I	PM	CM	CC
O. Drawings		X			
P. Project Schedules			X	X	
Q. Acceptance Test Procedures & Plans		X		X	
R. Certified Engineering Reports		X			
S. Research & Development (required to complete project as defined by KD-0)	X				
T. Performance Evaluations of A/E			X		
U. Inspection Planning			X	X	
V. Surveys - Support Design			X		
W. Design Cost & Scheduling Analysis & Control		X			
X. Decision Progress Reporting		X	X	X	
Y. Design QA Plan and Overview		X	X		
Z. Constructibility Reviews			X	X	
AA. Safety Reviews by A/E		X			
AB. Regulatory Overview by A/E		X			
AC. Reproduction - for Design		X			
AD. Travel - Support Design		X			
AE. Obtain Permits Required Prior to Start of Construction (after Title I)	X				
AF. Change Control - for Design		X	X		
AG. Value Engineering (after Title I)			X		

TABLE 6-1

TPC AND TEC GUIDANCE AND CLARIFICATION
INCLUSION OF DETAILED ACTIVITIES IN TPC AND/OR TEC

ACTIVITY	TPC				
	OPC	TEC			
		ED&I	PM	CM	CC
4. Key Decision - 3 Approval to Start Construction or Full Scale Development to Key Decision - 4: Approval to Commence Operations or Pre-Production (Title III Activities)					
A. Bid Package Preparation			X	X	
B. Bid Evaluations, Opening and Award			X	X	
C. Construction Coordination and Planning			X	X	
D. Contract Administration			X	X	
E. Engineering Support (A/E)			X		
F. Design Changes/Control		X	X	X	
G. Non-Conformance Reports (NCRs)			X	X	
H. Control Systems for Construction Activities			X	X	
I. Project Assessment & Reporting		X	X	X	
J. Construction Status Reports and Meetings			X	X	
K. Davis-Bacon Administration			X	X	
L. Vendor Submittals		X	X	X	X
M. Field Support of Construction			X	X	
N. Field or Lab Tests				X	
O. Radiation Control Timekeepers					X
P. Radiation Protection by Contractor			X		
Q. Safety and Safeguard/Security Operations				X	X
R. M&O Contractor/M&O Project Support During Construction	X				
S. Project Estimates (Purpose Dependent)		X	X	X	

TABLE 6-1

TPC AND TEC GUIDANCE AND CLARIFICATION
INCLUSION OF DETAILED ACTIVITIES IN TPC AND/OR TEC

ACTIVITY	TPC				
	OPC	TEC			
		ED&I	PM	CM	CC
T. Quality Control (QC) Inspection			X	X	X
U. Inspection and Acceptance		X		X	
V. Negotiations of Fixed Price Contract Changes			X	X	
W. Trips to Vendor/Fabricators		X	X	X	X
X. Procurement Coordination			X	X	X
Y. Equipment/Hardware Cost				X	X
Z. Material Procurement Rate				X	X
AA. Initial Office Furniture and Fixtures					X
AB. Spare Parts Inventory	X				
AC. Installation/Alterations					X
AD. Disposal of Mixed Waste					X
AE. Cost Plus Award Fee/Fixed Price Construction		X			X
AF. Plant Forces Work					X
AG. Initial Spares					X
AH. Safety Plan & Overview				X	X
AI. Decontamination (exceeds normal operating levels)	X				
AJ. Decontamination (as removal cost)					X
AK. Surveying to Support Construction			X	X	X
AL. Interest Penalties		X	X	X	X

TABLE 6-1

TPC AND TEC GUIDANCE AND CLARIFICATION
INCLUSION OF DETAILED ACTIVITIES IN TPC AND/OR TEC

ACTIVITY	TPC				
	OPC	TEC			
		ED&I	PM	CM	CC
5. Key Decision - 4: Planning and Preparation for Acceptance/Operational Startup and Pre-production for Commencement of Operations					
A. Perform Acceptance Testing			X		X
B. Perform Operation Acceptance Testing	X				
C. Final Safety Analysis Report (FSAR)			X		
D. Operational Readiness Review (ORR)	X				
E. Start-up Costs	X				
F. Training of Operators	X				
G. As-Builts		X	X		X
H. Project Closeout			X		
I. A/E & Construction Performance Appraisals			X		
J. User Move-In	X				
K. Develop Operating Procedures, Manuals, and Documentation	X				
L. Operations Planning	X				
M. Safety and System Integration	X				
N. Safety Evaluation Report (SER)	X				
O. Post-Acceptance Testing	X				
P. Start Up Coordination, Materials, and Supplies	X				
Q. Correction of Design/Construction Deficiencies					X
R. Transition Planning			X	X	X

TABLE 6-2

RECOMMENDED GENERAL COST ALLOCATION MATRIX

PROJECT DEVELOPMENT ACTIVITY	PROJECTS [1]		
	OPERATING EXPENSE	P&CE	
		ED&I	CONSTR.
Pre Title I	X		
Title I		X	
Title II		X	
Title III		X	
Construction	X[2]		X
Construction Management			X
Project Management		X[3]	X[3]
Project Support	X		
Startup	X		

[1] Applies to Line Item Projects, Major Projects, and Major Systems Acquisitions.

[2] Capital funding for betterments, conversions, and replacements. Alterations are generally funded by operating expense.

[3] Project management during the design phase of Line Item Projects, Major Projects, or Major Systems Acquisitions authorized for design only is funded by P&CE-ED&I.

Reference: DOE Order 2200.6, FINANCIAL ACCOUNTING.

CHAPTER 10

ESCALATION

1. INTRODUCTION

Escalation is the provision in a cost estimate for increases in the cost of equipment, material, labor, etc., due to continuing price changes over time. Escalation is used to estimate the future cost of a project or to bring historical costs to the present. Most cost estimating is done in "current" dollars and then escalated to the time when the project will be accomplished. This chapter discusses how escalation is calculated and how escalation indices are applied. Additional information can be found in DOE Order 5700.2, COST ESTIMATING, ANALYSIS AND STANDARDIZATION.

2. EXAMPLE OF USE OF ESCALATION

Since the duration of larger projects extends over several years, it is necessary to have a method of forecasting or predicting the funds that must be made available in the future to pay for the work. This is where predictive or forecast escalation indices are used. The current year cost estimate is, if necessary, divided into components grouped to match the available predictive escalation indices. Then each group of components is multiplied by the appropriate predictive escalation index to produce an estimate of the future cost of the project. The future costs of these components are then summed to give the total cost of the project. Escalation accuracy for the total project increases with the number of schedule activities used in summation.

To properly apply escalation indices for a particular project, the following data is required:

- escalation index (including issue date & index) used to prepare the estimate;
- current performance schedule, with start and completion dates of scheduled activities; and
- reference date the estimate was prepared.

Following is an example of a 5-year project that requires escalation calculations to determine the total project costs in the base year's dollars.

TABLE 10-1

EXAMPLE OF 5-YEAR PROJECT REQUIRING ESCALATION CALCULATIONS ESTIMATE REFERENCE DATE: JULY 1, 1992

Step 1 Determine midpoint of scheduled activity.

Scheduled Activity	WBS	Start	Duration Complete	(Months)	Midpoint
1. ED&I Title I	A1A	02/01/94	10/01/94	8	06/01/94
2. ED&I Title II	A1B	11/01/94	04/01/95	6	01/15/95
3. ED&I Title III	A1C	04/01/95	01/01/99	45	02/15/97
4. Equipment Procurement (General Services)	B2A	10/01/94	10/01/97	36	04/01/96
5. Equipment Procurement (Long-Lead, GFE)	B2B	04/01/95	12/01/95	8	08/01/95
6. Facility Construction	B2C	07/01/95	08/01/98	37	01/15/97
7. Demolition Work	D1A	01/01/98	09/01/98	8	05/01/98
8. Project Management	E1A	02/01/94	01/01/99	59	07/15/96

Step 2 Select appropriate escalation rates (assume escalation rates are for 1992 base year).

FY-1992 = 1.0	FY-1995 = 3.5
FY-1993 = 2.4	FY-1996 = 3.7
FY-1994 = 3.1	FY-1997 = 3.8

TABLE 10-1 (continued)

EXAMPLE OF 5-YEAR PROJECT REQUIRING ESCALATION CALCULATIONS ESTIMATE REFERENCE DATE: JULY 1, 1992

Step 3 **Calculate appropriate escalation rates for each scheduled activity using estimate preparation date as starting point and apply escalation rates selected in Step 2 to midpoint dates determined in Step 1.**

For Example: ED&I - Title III (midpoint = 02/15/97)

FY-Period	Years x Escalation Index = Escalation Factor		
07/01/92 to 01/01/93	6/12	.010	.005
01/01/93 to 01/01/94	1.0	.024	.024
01/01/94 to 01/01/95	1.0	.031	.031
01/01/95 to 01/01/96	1.0	.035	.035
01/01/96 to 01/01/97	1.0	.037	.037
01/01/97 to 02/15/97	1.5/12	.038	.005

Compound Escalation

Factor = 1.005 x 1.024 x 1.031 x 1.035 x 1.037 x 1.005 = 1.144 OR 14.4%

Step 4 **The compound escalation factors derived in Step 3 are then applied to the total costs (direct cost + mark ups) for each scheduled activity. Total project escalation is the summation of escalation for all project activities**

Assume costs for Title III design are $100,000 for the base year. The escalated value would be:

$100,000 x 1.144 = $114,400.

Thus, the cost used for Title III designs in the total project cost is $114,400.

Note: Repetition of calculations is obvious; thus, application to a computerized escalation rate analysis forecast program would prove beneficial. Escalation rates applied to scheduled activities are practically tied to the project WBS. Unless a better determination can be made and supported, the midpoint of cash flow for a particular category is set equal to the midpoint of the scheduled activity for that category.

3. ESCALATION RELATIONSHIPS

To compare the costs of projects with differing durations, inflation/escalation costs must be considered. Escalation in cost estimating has two main uses: to convert historical costs to current costs (historical escalation index) and to escalate current costs into the future (predictive escalation index) for planning and budgeting. Historical costs are frequently used to estimate the cost of future projects. The historical escalation index is used to bring the historical cost to the present and then a predictive escalation index is used to move the cost to the future.

Associated with escalation are concepts of present and future worth. These represent methods of evaluating investment strategies like life cycle cost analyses. For example, a typical life cycle cost evaluation would be determining whether to use a higher R factor building insulation at a higher initial cost compared to higher heating and cooling costs over the life of the building resulting from a lower R factor insulation. Present and future worth are discussed in Chapter 23.

A. Historical Escalation

Historical escalation is generally easily evaluated. For example, the cost of concrete differed in 1981 versus 1992. The ratio of the two costs expressed as a percentage is the escalation and expressed as a decimal number is the index. Generally, escalation indices are grouped. For example, all types of chemical process piping may be grouped together and a historical escalation index determined for the group.

B. Predictive Escalation

Predictive escalation indices are obtained from commercial forecasting services, such as DRI/McGraw Hill, which supplies its most current predictions using an econometric model of the United States economy. They are the ratio of the future value to the current value expressed as a decimal. Predictive escalation indices are typically prepared for various groups and may be different for different groups. For example, the escalation index for concrete may be different than the one for environmental restoration.

C. Escalation Application

Economic escalation shall be applied to all estimates to account for the impact of broad economic forces on prices of labor, material, and equipment in accordance with the following requirements.

- Escalation shall be applied for the period from the date the estimate was prepared to the midpoint of the performance schedule.

- Since economic escalation rates are revised at least annually, all estimates shall include the issue date of the escalation rates used to prepare the estimate.

- Costs used for design concept shall be fully escalated and referenced as required.

4. ESCALATION INDICES

Costs continuously change due to three factors: changing technology, changing availability of materials and labor, and changing value of the monetary unit (i.e., inflation). Cost or escalation indices have been developed to keep up with these changing costs. The use of escalation indices is recommended by DOE to forecast future project costs. The use of an established index is a quick way to calculate these costs. To ensure proper usage of an index, one must understand how it is developed and its basis.

A. Developing Escalation Indices

An escalation index can be developed for a particular group of projects. The projects are divided into their elements, which can be related to current industry indices. The elements are then weighted and a composite index is developed. Complete details on developing escalation indices can be found in the DOE Cost Guide, Volume 5, on How to Construct and Use Economic Escalation Indices.

B. Escalation Indices Published by DOE

DOE has developed construction escalation indices for various types of projects. These are published every February and August. A copy of the latest indices can be requested from Office of Infrastructure Acquisition (FM-50).

5. USE OF DOE ESCALATION INDICES

A. How to Select an Index

An index for a project or program is selected based on the type of project (i.e., the scope of work). DOE publishes several indices to cover the range of projects for DOE. If a project or program does not appear to fall into any of the categories, adjustments can be made and must be submitted to FM-50 prior to their use.

More specifically, they must be selected based on the type of cost being escalated since escalation indices represent groups of items. For example, a predictive escalation index for chemical process piping would be inappropriate for use with a cost estimate for a building construction project.

B. How to Apply an Index

The indices are developed with a base year whose index number is 1.0. Generally, the base year is the current year. Once the index is selected, it can be used to either project a current cost based on historical costs, or it can be used to project future costs based on today's dollars.

C. Limitations

Cost indices have limitations since they are based on average data. Thus, judgement is required to decide if an index applies to a specific cost being updated. If using an index for a long-term project, it must be remembered that the long-term accuracy for indices are limited. However, their usefulness to DOE is that the different groups within DOE can use a common index to produce comparable costs.

Escalation Rate Assumptions
For DOE Projects
(January 2003)

	Project Categories *									
FY	**Construction**		**EM**		**IT**		**O&M**		**R&D**	
2002	1.000	N/A	1.000	N/A	1.000	N/A	1.000	N/A	1.000	N/A
2003	1.021	2.1	1.020	2.0	1.008	0.8	1.018	1.8	1.023	2.3
2004	1.046	2.5	1.047	2.7	1.017	0.9	1.045	2.6	1.051	2.8
2005	1.076	2.9	1.075	2.7	1.022	0.5	1.073	2.7	1.080	2.7
2006	1.106	2.8	1.103	2.6	1.032	1.0	1.101	2.6	1.108	2.6
2007	1.135	2.6	1.130	2.4	1.041	0.8	1.127	2.4	1.136	2.5
2008	1.164	2.6	1.157	2.4	1.049	0.8	1.154	2.4	1.164	2.5

These Rates are based on Material and Labor data contained in the Energy Supply Model, provided by DRI-WEFA (now Global Insight), in January 2002. Locally obtained rates, different from those above, may be used. Additional advice and assistance can be obtained from OECM. Points of Contact: T. Ross Hallman, National Energy Technology Laboratory (NETL), 304-285-4837 or Terry Brennan, NETL, 412-386-5989.

* Note that Project Categories are aligned with those Project Categories in the Project Assessment and Reporting System (PARS), which are included as follows:

Construction: (formerly Defense Programs and General Construction Category)

Vertical: Examples: General Building Construction, Administration Buildings, Lab Facilities.

Horizontal: Railroads, Road Work, Bridges, Tunneling, Site Improvements, Site Utilities, Dams / Waterways

Facilities / Infrastructure: Chemical Plants, Vitrification Plants, Process Plants, Incinerators, Accelerators, One-of-a-Kind Facilities, and Modifications.

Environmental Management: (formerly Environmental Management category)

Restoration: Groundwater Remediation, Soils Remediation

D&D/d&d: Reactors, Process Facilities, Administration Facilities, Medical Facilities, Laboratory Facilities, Security Facilities

Information Technology: (***NOT*** formerly a Category or Project Type)

Information Technology and Systems: Hardware, Software, Modeling / Simulation

CHAPTER 11

CONTINGENCY

1. INTRODUCTION

The application of contingency for various types of cost estimates covers the entire life cycle of a project from feasibility studies through execution to closeout. The purpose of the contingency guidelines presented in this chapter is to provide for a standard approach to determining project contingency and improve the understanding of contingency in the project management process. These guidelines have been adopted by the DOE estimating community and should be incorporated into the operating procedures of DOE and operating contractor project team members.

2. CONTINGENCY DEFINITIONS

A. General Contingency

Contingency is an integral part of the total estimated costs of a project. It has been defined as—

> [a] specific provision for unforeseeable elements of cost within the defined project scope. [Contingency is] particularly important where previous experience relating estimates and actual costs has shown that unforeseeable events which will increase costs are likely to occur.

This definition has been adopted by the American Association of Cost Engineers. DOE has elected to narrow the scope of this definition and defines contingency as follows.

> Covers costs that may result from incomplete design, unforeseen and unpredictable conditions, or uncertainties within the defined project scope. The amount of the contingency will depend on the status of design, procurement, and construction; and the complexity and uncertainties of the component parts of the project. Contingency is not to be used to avoid making an accurate assessment of expected cost.

It is not DOE practice to set aside contingency for major schedule changes or unknown design factors, unanticipated regulatory standards or changes, incomplete or additions to project scope definition, force majeure situations, or congressional budget cuts. Project and operations estimates will always contain contingency. Estimators should be aware that contingency is an integral part of the estimate.

B. Buried Contingencies

Some estimators have sought to hide contingency estimates in order to protect the project so that the final project does not go over budget because the contingency has been removed by outside sources. This is affectionately known as buried contingency. All internal and external estimators should refrain from burying extra contingency allowances within the estimate. A culture of honesty should be promoted so that it is not necessary to bury contingency. In addition, estimators should be aware that estimate reviews will identify buried contingency. The estimate reviewer is obligated to remove buried contingency.

3. SPECIFICATIONS FOR CONTINGENCY ANALYSIS

Considerable latitude has been reserved for estimators and managers in the following contingency analysis specifications. These guidelines are to be followed by both the operating contractor and the DOE field office cost estimators to ensure a consistent and standard approach by the project team. Each contractor and field office should incorporate these guidelines into their operating procedures.

A written contingency analysis and estimate will be performed on all cost estimates and maintained in the estimate documentation file. This analysis is mandatory.

Estimators may use the ranges provided in this chapter of the cost guide for estimating small projects; however, larger projects require a more detailed analysis, including a cost estimate basis and a written description for each contingency allowance assigned to the various parts of the estimate.

Justification must be documented in writing when guide ranges for contingency are not followed. If extraordinary conditions exist that call for higher contingencies, the rationale and basis will be documented in the estimate. Computer programs, such as Independent Cost Estimating Contingency Analyzer (ICECAN), a Monte Carlo analysis program, are available to estimators and should be used to develop contingency factors. Risk analysis may also be necessary.

A. Construction Projects

Table 11-1 presents the contingency allowances by type of construction estimate for the seven standard DOE estimate types, and Table 11-2 presents the guidelines for the major components of a construction project.

Estimate types “a” through “e” in Table 11-1 are primarily an indication of the degree of completeness of the design. Type “f,” current working estimates, found in Table 11-2, depends upon the completeness of design, procurement, and construction. Contingency is calculated on the basis of remaining costs not incurred. Type “g,” the Independent Estimate, may occur at any time, and the corresponding contingency would be used (i.e., “a,” “b,” etc.).

Table 11-1. Contingency Allowance Guide By Type of Estimate

Type of Estimate	Overall Contingency Allowances % of Remaining Costs Not Incurred
PLANNING (Prior to CDR) Standard Experimental/Special Conditions	20% to 30% Up to 50%
BUDGET (Based upon CDR) Standard Experimental/Special Conditions	15% to 25% Up to 40%
TITLE I	10% to 20%
TITLE II DESIGN	5% to 15%
GOVERNMENT (BID CHECK)	5% to 15% adjusted to suit market conditions
CURRENT WORKING ESTIMATES	See Table 11-2
INDEPENDENT ESTIMATE	To suit status of project and estimator's judgment

The following factors need to be considered to select the contingency for specific items in the estimate while staying within the guideline ranges for each type of estimate.

1. Project Complexity

Unforeseen, uncertain, and unpredictable conditions will exist. Therefore, using the DOE cost code of accounts for construction, the following percents are provided for planning and budget estimates. They are listed in order of increasing complexity:

- Land and Land Rights 5% to 10%
- Improvements to Land/Standard Equipment 10% to 15%

• New Buildings and Additions, Utilities, Other Structures	15% to 20%
• Engineering	15% to 25%
• Building Modifications	15% to 25%
• Special Facilities (Standard)	20% to 30%
• Experimental/Special Conditions	Up to 50%

Considerations that affect the selection in the ranges are: state-of-the-art design, required reliability, equipment complexity, construction restraints due to continuity of operation, security, contamination, environmental (weather, terrain, location), scheduling, and other items unique to the project, such as nuclear and waste management permits and reviews.

2. Design Completeness or Status

Regardless of the complexity factors listed above, the degree of detailed design to support the estimate is the more important factor. This factor is the major reason that the ranges in Table 11-1 vary from the high of 20 to 30 percent in the planning estimate to 5 to 15 percent at the completion of Title II design. Again, parts of the estimate may have different degrees of design completion, and the appropriate contingency percent must be used. As can be seen from Figure 11-1, as a project progresses, the contingency range and amount of contingency decreases.

3. Market Conditions

Market condition considerations are an addition or a subtraction from the project cost that can be accounted for in contingency. Obviously, the certainty of the estimate prices will have a major impact. The closer to a firm quoted price for equipment or a position of construction work, the less the contingency can be until reaching 1 to 5 percent for the current working type estimate for fixed-price procurement contracts, 3 to 8 percent for fixed-price construction contracts, and 15 to 17.5 percent contingency for cost-plus contracts that have been awarded.

4. Special Conditions

When the technology has not been selected for a project, an optimistic-pessimistic analysis can be completed. For each competing technology, an estimate is made. The difference in these estimates of the optimistic and pessimistic alternative can be used as the contingency.

Table 11-2. Contingency Allowances for Current Working Estimates

	Item Contingency On Remaining Cost Not Incurred
a. ENGINEERING	
Before Detailed Estimates:	15% to 25%
After Detailed Estimates:	10%
b. EQUIPMENT PROCUREMENT	
Before Bid:	
Budget	15% to 25%
Title I	10% to 20%
Title II	5% to 15%
After Award:	
Cost Plus Award Fee (CPAF) Contract	15%
Fixed-Price Contract	1% to 5%
After Delivery to Site (if no rework)	0%
c. CONSTRUCTION	
Prior to Award:	
Budget	15% to 25%
Title I	10% to 20%
Title II	5% to 15%
After Award:	
CPAF Contract	15% to 17-1/2%
Fixed-Price Contract	3% to 8%
d. TOTAL CONTINGENCY (CALCULATED)	Total of above item contingencies

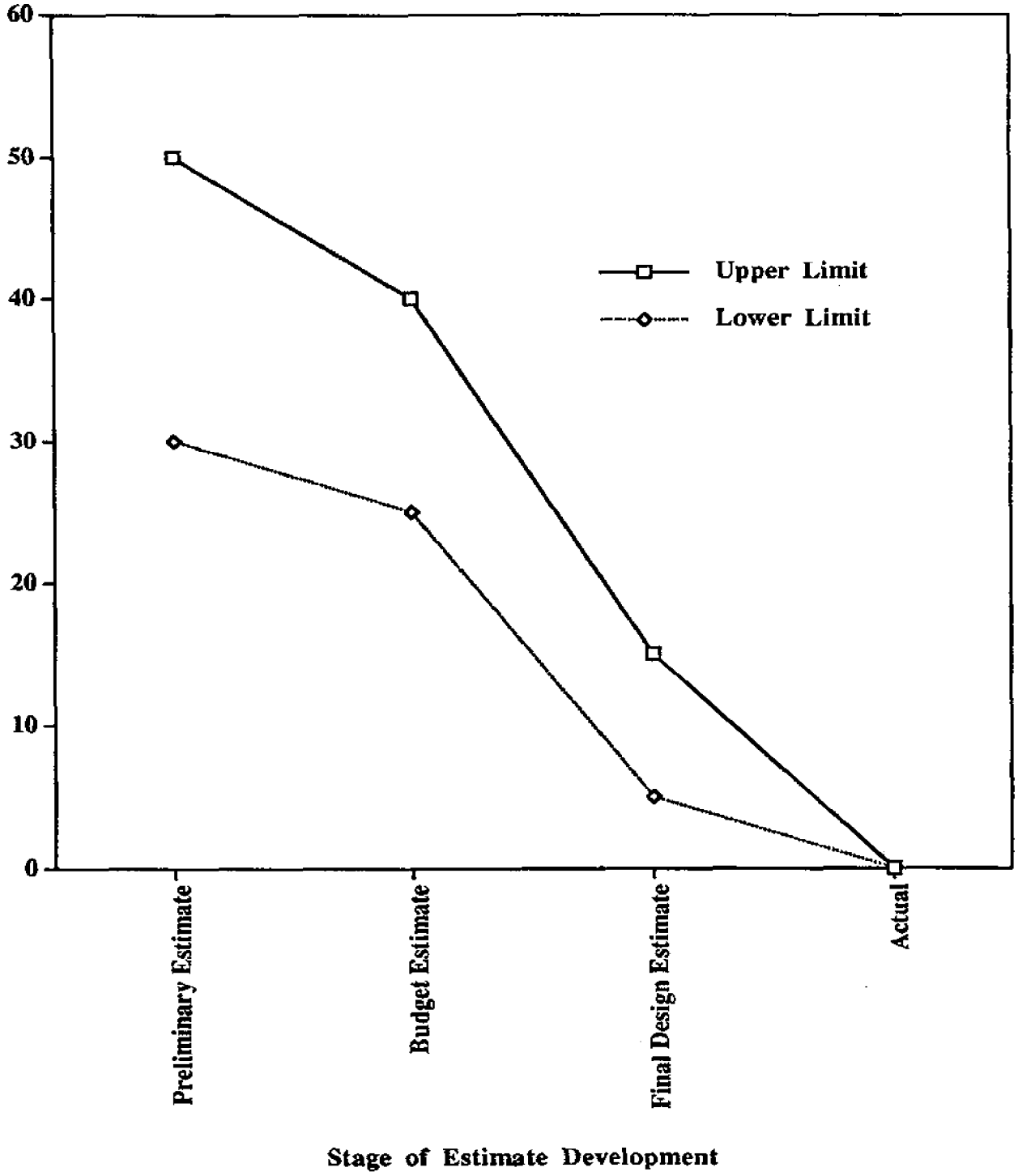

Figure 11-1. Contingency As a Function of Project Life

B. Environmental Restoration Projects

Environmental restoration projects usually consist of an assessment phase and a remediation/cleanup phase. Contingency plays a major role in the cost estimates for both phases. Recommended contingency guidelines for each phase will be discussed below. Table 11-3 lists contingency guidelines for assessment and remediation/cleanup project phases.

1. Assessment Phase

Unlike the remediation phase, the assessment phase does not include the physical construction of a remedy. An assessment determines and evaluates the threat presented by the release and evaluates proposed remedies. As a result, the assessment encompasses such items as field investigations, data analysis, screening and evaluation studies, and the production of reports.

The degree of project definition will depend on how well the scope of the assessment is defined. Higher levels of project definition will correspond to increasing levels of work completed on the assessment. Since the assessment is one of the initial stages of the environmental restoration process, there is a high degree of uncertainty regarding the technical characteristics, legal circumstances, and level of community concern. As a result, the scope of the assessment often evolves into additional operable units, and more than one assessment may be required.

Other considerations that affect the section of contingency ranges are—

- number of alternatives screened and evaluated;
- level and extent of sampling analysis and data evaluation;
- technical and physical characteristics of a site; and
- level of planning required.

Table 11-3 shows the estimate types for the assessment phase of an environmental restoration project and their corresponding expected contingency ranges. No contingency ranges for planning estimates have been provided. The contingencies become smaller as the project progresses and becomes better defined. However, it should be noted that these are only general guidelines based on the level of project definition. A higher or lower contingency may be appropriate depending on the level of project complexity, technical innovation, market innovation, and public acceptance.

Table 11-3. Contingency Guidelines for Environmental Restoration Projects

Activity and Estimate Type	Expected Contingency Range
Preliminary Assessment/Site Investigation Planning Estimate for All Assessment Activities	Up to 100%
Preliminary Estimate for All Assessment Activities	30% to 70%
Remedial Investigation/Feasibility Study Detailed Estimate for All Assessment Activities	15% to 55%
Planning Estimate for All Cleanup Phase Activities	20 to 100%
Contingency Guidelines for Remediation/Cleanup Phase	
Pre-Design Preliminary Estimate for All Remediation/Cleanup Phase Activities	Up to 50%
Remedial Design and Action Detailed Estimate for All Remediation/Cleanup Phase Activities	0% to 25%

2. Remediation/Cleanup Phase

For the remediation/cleanup phase, contingency factors are applied to the remaining design work. Remaining design work will use the same contingency factor as established in the ROD, permit, or current baseline for the project. This contingency percentage will depend upon the degree of uncertainty associated with the project, particularly the degree of uncertainty in the scheduled completion dates.

Table 11-3 shows the estimate types for the remediation/cleanup phase and their corresponding contingency ranges. While the ranges are relatively broad, they reflect the amount of contingency that would have been needed for a set of completed projects. The wide variance accounts for differences in project definition when the estimate was generated, project complexity, technical innovation, and other factors.

Other considerations that affect the section of contingency ranges are:

- innovative technology;
- required reliability;
- equipment complexity;
- construction restraints due to continuity of operation security and contamination;
- environmental conditions (weather, terrain, location, etc.);
- scheduling; and
- other unique items to the project such as waste management permits and reviews.

Prior to the completion of a remedial/corrective measure design estimate, the contingency applied to remaining cleanup work will be no more than that established in the ROD, permit, or current baseline for that project. The percent contingency will depend upon the complexity of the work and the degree of uncertainties involved.

When the construction work is defined by definitive design but the cleanup contract has not yet been awarded, a 15 to 20 percent contingency will be provided on the estimated cost. Usually, the cost estimate is based on detailed drawings and bills of material. When the cleanup work is to be performed by a Cost Plus Award Fee contractor, and the contractor has prepared a detailed estimate of the cleanup cost, and it has been reviewed and approved, a contingency of 15 to 18 percent is applied to only that portion of the cost and commitments remaining to be accrued. On fixed-price cleanup contracts where no significant change orders, modifications, or potential claims are outstanding, a contingency of 3 to 8 percent of the uncompleted portion of the work is provided depending upon the type of work involved and the general status of the contract.

C. Contingency Tools - Monte Carlo Analyses Methodology

Many tools are available to assist estimators with contingency. There is no required tool or program, but Monte Carlo analyses may be performed for all major system acquisitions. Monte Carlo or risk analysis is used when establishing a baseline or baseline change during budget formulation. The contingency developed from the Monte Carlo analyses should fall within the contingency allowance ranges in Table 11-1.

Monte Carlo analyses and other risk assessment techniques use similar methodology to obtain contingency estimates; however, for illustrative purposes, the ICECAN program developed for DOE will be discussed in this section.

The estimator must subdivide the estimate into separate phases or tasks and assess the accuracy of the cost estimate data in each phase. After the project data have been input and checked, the computer program will calculate various contingencies for the overall project based on the probability project underrun. The random number generator accounts for the known estimate accuracy. Once the program has completed its iterations (usually 1000), it produces an overall contingency for the project with a certain accuracy.

The following information is an example project estimate that was input into the ICECAN program.

Base Cost	$1,000,000	Fixed Price
Land Rights	40% $100,000 to $250,000 40% $250,000 to $500,000 20% $500,000 to $600,000	Step-Rectangular Distribution
Labor	50% Less than $100,000 20% $100,000 to $200,000 30% $200,000 to $220,000	Discrete Distribution
Profit	Mean = $235,000 Standard Deviation = $25,000	Normal Distribution

The distribution of the ranges is based on the estimator's judgment. For example, the base cost is a fixed price of $1,000,000 with no anticipated change orders. For landrights, there is a 40 percent chance the cost will be between $100,000 and $250,000, a 40 percent chance the cost will be between $250,000 and $500,000, and a 20 percent chance it will be between $500,000 and $600,000. A step-rectangular distribution was chosen.

The ICECAN program uses the mean cost calculated by the iterations as the base estimate. With the base estimate, there is a 50 percent probability that the project will be underrun. The results in Figure 11-2 show the contingency that should be used to achieve various probabilities overrun. For example, a contingency of 11.1 percent should be used to achieve an 85 percent probability of project underrun. Therefore, the total cost estimate would be $1,901,842. If the worst case cost of each variable had been used, the total estimate would be $2,080,000 or 21.5 percent contingency.

ICECAN

STIMATE FILE: EXAMPLE — Contingency Report

Cost Estimate: ***$1,711,863

Probability of Underrun	Contingency Required	Contingency + Estimate
0.50	**********$0 (0.0%)	***$1,711,863
0.55	*********$228 (0.0%)	***$1,712,091
0.60	******$33,137 (1.9%)	***$1,745,000
0.65	******$76,269 (4.5%)	***$1,788,132
0.70	*****$111,558 (6.5%)	***$1,823,421
0.75	*****$140,282 (8.2%)	***$1,852,145
0.80	*****$163,372 (9.5%)	***$1,875,235
0.85	*****$189,979 (11.1%)	***$1,901,842
0.90	*****$224,928 (13.1%)	***$1,936,791
0.91	*****$235,725 (13.8%)	***$1,947,588
0.92	*****$248,795 (14.5%)	***$1,960,658
0.93	*****$257,706 (15.1%)	***$1,969,569
0.94	*****$266,618 (15.6%)	***$1,978,481
0.95	*****$278,856 (16.3%)	***$1,990,719
0.96	*****$292,907 (17.1%)	***$2,004,770
0.97	*****$308,836 (18.0%)	***$2,020,699
0.98	*****$321,089 (18.8%)	***$2,032,952
0.99	*****$343,554 (20.1%)	***$2,055,417
1.00	*****$366,427 (21.4%)	***$2,078,290

Figure 11-2. Contingency Data Results

Operations and Maintenance: (formerly Operating Expense or Waste Management category)

Laboratory Operation and Maintenance: Equipment Replacement, System Maintenance, HEPA Maintenance, Equipment Maintenance

Production Operation and Maintenance: Chemical Processing, Vitrification Operations, Waste Management, Manufacturing

Other Operation and Maintenance: Maintenance Work, Roof Replacement, Building Systems, Landlord Activities, Hotel Load Maintenance.

Research and Development: (Formerly Energy Research and Nuclear, Fossil, Conservation and Solar Categories)

Research and Development: Fossil Energy, Energy Research, Solar Energy, Alternative Energy Sources

Applied Science: Medical, Basic Science

Nuclear Research: Weapons Production, Security Infrastructure, Weapons Simulation, Nuclear Energy

CHAPTER 25

GUIDELINES FOR ENGINEERING, DESIGN, AND INSPECTION COSTS

1. INTRODUCTION

Engineering, design, and inspection (ED&I) activities begin with the preliminary design (Title I). Pre-Title I activities are not considered part of ED&I activities. ED&I activities include the engineering and design activities in Title I & II and the inspection activities associated with Title III. A more detailed description of the Title I, II, and III activities can be found in Chapter 3 of this volume.

Architectural/Engineering (A/E) activities are part of the ED&I activities. A/E activities are services that are an integral part of the production and delivery of the design plans, specifications, and drawings. Federal statutes limit the A/E costs to a percent of total construction cost, and these statutes have specific definitions of what activities are included in A/E costs. Activities that are not an integral part of the production of the design plans, specifications, or drawings may still be ED&I activities but are not A/E activities.

This chapter defines ED&I and A/E activities and discusses how to estimate and track them.

2. ED&I ACTIVITIES

To estimate ED&I costs, the estimator must understand what activities are included in ED&I.

Following is a list of ED&I activities:

- Preliminary and final design calculations and analyses
- Preliminary and definitive plans and drawings
- Outline specifications
- Construction cost estimates
- Computer-aided Drafting (CAD) and computer services
- A/E internal design coordination
- Design cost and schedule analyses and control
- Design progress reporting

- Regulatory/code overview by A/E
- Procurement and construction specifications
- Surveys (surveying), topographic services, core borings, soil analyses, etc., to support design
- Travel to support design
- Reproduction during design
- Design kickoff meeting
- Constructability reviews
- Safety reviews by A/E
- Value engineering
- Identification of long lead procurements
- Design studies not included in Pre-Title I
- Preliminary safety analysis report if not included in the Conceptual Design Report
- Design change control
- Modification of existing safety analysis report
- Design reviews (not third party)
- Acceptance procedures
- Certified engineering reports
- Bid package preparation
- Bid evaluation/opening/award
- Inspection planning
- Inspection services
- Review shop drawings
- Preparation of as-built drawings

3. WAYS TO ESTIMATE ENGINEERING, DESIGN, AND INSPECTION COSTS

Different methods may be used to estimate ED&I costs. Some common methods are: count drawings and specifications, full time equivalents (FTEs), and percentage.

A. Count Drawings and Specifications Method

When using this method, the estimator calculates the number of drawings and specifications representing a specific project. The more complex a project is, the more drawings and specifications it will require, and, therefore, more ED&I Costs will be associated with it.

B. Full Time Equivalent Method

The FTE method utilizes the number of individuals that are anticipated to perform the ED&I functions of a project. The manhour quantity is calculated and multiplied by the cost per labor hour and the duration of the project to arrive at the cost.

C. Percentage Method

When using this method, the estimator simply calculates a certain percentage of the direct costs and assigns this amount to ED&I. Federal statutes limit the A/E portions of ED&I costs to 6 percent of construction costs. Total ED&I percentages are usually from 15 to 25 percent.

D. Documenting Engineering, Design, and Inspection Costs

DOE Headquarters developed the A/E Cost Standard Form as a tool to be used for estimating and compiling actual costs on all conventional construction projects and the conventional portions of nonconventional projects. The DOE ad hoc working group refined a U. S. Navy form to develop this standard for estimating A/E services. The form, definitions, and instructions for the A/E Cost Standard Form have been published and distributed and are included as Attachment 25-1 to this chapter. The following conditions apply to the use of the cost standard or form.

1. All conventional line-item construction projects will use the standard. General plant projects are excluded.

2. Conventional construction projects include such things as warehouses, laboratories, office buildings, non-process related utilities, sewage and water treatment facilities, parking lots, roof repair, roads, etc. Conventional construction does not mean the projects are necessarily simple, nonsophisticated, or standard, but that simply from a design point of view, prior industry experience exists. Nonconventional projects include projects that are first of a kind and the level of effort is not easily predictable.

3. In calculating the design/construction cost percentage ratio, equipment, equipment installation, and other nonconstruction costs will be excluded from the construction cost estimate. Therefore, construction costs included in the calculation will be limited to those construction items for which the A/E contractor has design responsibility. This method is used for determining <u>contract</u> performance. Additional costs for other design, drawings, and specifications (either in-house or outside source) will be documented and included in the total design/construction cost ratio, thereby measuring <u>project</u> performance.

4. The cost standard will be used in the construction of budget estimates and all subsequent estimates and in the management of the cost baselines.

5. A/E contracts will be structured in accordance with the cost standard to segregate design, drawings, and specification costs from the other A/E costs, so that tracking and analyzing actual costs can be accomplished by categories.

6. Any site overhead allocated to construction projects will be identified and documented separately from all other components of project costs so that DOE cost analyses will be comparable to those of other Federal agencies and commercial organizations.

7. The cost standard should be used on all new projects. Project managers will not be required to restructure already completed projects into the format. However, they are encouraged to restructure cost data on completed projects whose cost components are organized in a manner similar to the cost standard format.

8. The A/E Cost Standard Form was designed to provide a standard format for developing cost estimates, structuring contractor proposals, and tracking the cost performance of A/E contracts and other A/E activities. Federal statutes limit A/E cost to 6 percent of construction costs. The A/E services provided under this statute are design, drawings, and specifications. While it is our intention to minimize all A/E costs, it is our goal to keep these specific costs within the 6 percent limit. By collecting costs in this format, the Department can compare its cost performance to other agencies on a comparable basis. Therefore, field offices should ensure that all cost estimates, actual cost data collected during design and construction, and all A/E contracts are segregated to show both total ED&I costs and the subcomponents of design, drawings, and specifications. Also, each site should maintain adequate documentation on actual design and construction costs to facilitate local analysis on the site's overall performance.

   Field Office managers and individual project managers are responsible for ensuring that cost estimates, contracts, and cost management of A/E services are structured according to the above standard. Subsequent historical cost data will be used for project analysis and to support local cost databases. These data should help assess contractor performance, improve future cost estimates, and generate recommendations for reducing the A/E costs, on a site-wide basis.

   With A/E costs or activities being defined, data can be gathered on a more comparable basis. This will allow for easier evaluation, as well as support for the development of local cost databases for A/E costs.

E. Considerations When Estimating

ED&I costs are directly related to the magnitude and complexity of the project. The following items should be considered.

1. Comprehensiveness of the Functional/Operational Requirements

Project understanding is improved when comprehensive functional/operational (F/O) requirements are provided. For the F/O requirements to be well done, each item must be thought through by those who review the design and will use, operate, and maintain the facility or system.

2. Quality Level

Quality level, as defined below, is significant particularly as it affects the analysis, documentation, and inspection required. Design costs are increased by the additional work that may be required by the following levels.

a. Quality Level I

Applied to nuclear system, structure, subsystem, item, component, or design characteristics that prevent or mitigate the consequences of postulated accidents that could cause undue risks to the health and safety of the public.

b. Quality Level II

Any other system, structure, subsystem, item, or component that as a result of failure could cause degradation of required performance, such as plant operation, test results, and performance data.

c. Quality Level III

Items designated for minimal impact applications.

3. Design Planning Tabulation

Design Planning Tabulation (DPT) sets forth a number of important items that affect ED&I costs. The DPT sets the code requirements the design will meet, reviews to be held, quality levels, and documents to be issued.

4. Design Layout

Design layout costs are affected by the availability of existing documents and the accuracy of these documents. The need for an engineer to make detailed layouts rather than having it done by draftsmen/designers also affects cost.

5. Engineering Calculations

The amount and detail of calculations required is an important engineering cost factor. The need for review of these calculations by others and their documentation and storage can affect ED&I cost significantly.

6. Drafting

The drawing format and the method of accomplishment of the work depicted (i.e., by maintenance, lump sum construction contract, or cost plus construction contract) will affect the detail and time required to prepare drawing(s). The type of drawing and the discipline of work are also big factors in time required. The number of drawings involved is a direct indication of drafting time and cost. The availability of standard details, etc., can reduce costs appreciably. Quality Level I or II requirements can also add to drafting requirements and thus time.

7. Specification Preparation

The availability of draft specifications for the items of work involved or the need to develop new specifications must be considered. Projects requiring preliminary proposals require both an outline specification, which is normally prepared with Title I, and a detailed technical specification. Performance specifications for both the design and installation by a subcontractor of facilities and systems, such as fire protection, will reduce engineering costs. Design costs incurred by the subcontractor are classified as subcontract construction costs.

8. Checking

The need for field investigation can be a significant engineering cost. If drafting must be checked by checkers within that section, the time must be considered and costs added. Projects requiring inter-discipline checks must have time/cost provisions. Checks made by engineers must also be considered.

9. Cost Estimating

Time required for estimating is affected by the detail of the project, particularly the number of items involved and the areas in which good information from historical data or test hooks on cost are available. Specialty items usually require additional effort and cost.

10. Design Reviews

The number of design reviews and action taken will affect costs. If the design is so formal that a committee is established for the review and the designers

must present their designs step by step, the additional costs required for review must be included.

11. Safety Analysis Report

When a Safety Analysis Report (SAR) is required, the engineering costs are contingent upon similar documents having been prepared previously or the requirements to develop new ones.

12. Reports

Engineering costs for preparing reports such as preliminary proposals, design status reports, etc., must be included in the ED&I funds.

13. Government Furnished Equipment

Engineering costs for providing documents required for procuring Government Furnished Equipment (GFE) items must be included. These costs include specifications. Time required for engineering is more than if the item had been included with the other technical documents due to document control and the need to include in the technical documents information on the item being furnished.

14. Off-Site A/E

If an off-site A/E is to be used for the design, travel costs for field investigation, design reviews, and management of the design should be considered. Cost is a percentage of construction cost. If changes are required, onsite A/E may have to make the changes, which could lead to problems in interpreting or understanding the basis of the original design.

15. Inspection

Included as part of Title III, all construction work, including procurement and installation of associated equipment, shall be conducted in all cases prior to acceptance. Inspection should be made at such times and places as may be necessary to provide the degree of assurance required to determine that the materials or services comply with contract and specification requirements, including quality level requirements. The type and extent of inspection needed will depend on the nature, value, and functional importance of the project and its component parts, as determined by project requester/proposer. Specifically, the following should be considered.

16. Duration

Duration is the number of actual construction days anticipated for the project. Unforeseen conditions, such as delays in start-up and waiting for materials, are not included in this duration.

17. Labor Density

Labor density is the ratio of estimated costs of materials to costs of labor. In general, construction with a high labor density will require more inspection.

18. Complexity

A project having a high degree of instrumentation of a large amount of "code equivalent" welding will require more inspection per dollar of labor than will earth work or ordinary concrete work.

19. Overtime

The time schedule of utility outages, reactor windows, and the overall project schedule may require overtime.

20. Adequacy of Plans and Specifications

If the technical package is clear, with a minimum of ambiguities, and will require few field changes, the inspection cost will be lower.

21. Offsite Fabrications

Inspection costs will increase if source inspections are required. Supplies and services shall be inspected at the source where:

a. inspection at any other point would require uneconomical disassembly or nondestructive testing;

b. considerable loss would result from the manufacture and shipment of unacceptable supplies or from the delay in making necessary corrections;

c. special instruments, gauges, or facilities required for inspection are available only at source;

d. inspection at any other point would destroy or require the replacement of costly special packing and packaging;

e. a quality control system is required by the contract, or inspection during performance of the contract is essential;

f. it is otherwise determined to be in the best interest of the Government.

22. Location of the Job

Travel time to and from the job must be taken into consideration.

23. Guideline

ED&I costs have been between 15 percent and 26 percent of the total construction cost for detailed design.

24. Performance Specification

This type of specification requires the subcontractor to supply the amount of detail required to complete the project. The amount of ED&I required for a performance specification is appreciably less than that required for the detailed design.

F. Engineering

Although these services may seem similar to conventional engineering, design, and inspection, there are several important differences that distinguish cleanup design from engineering design on other projects. These differences need to be underscored when estimating cost and schedule requirements. Major factors to be considered by the estimator include the following.

1. The regulatory process requires rigorous examination of design alternatives prior to the start of cleanup design. This occurs during remedial investigation/feasibility studies under CERCLA to support a record of decision (ROD) or during corrective measure studies under RCRA to support issuance of a permit. Cleanup design executes a design based on the method identified in the ROD or permit. This often narrows the scope of preliminary design and reduces the cost and schedule requirements. The estimator needs to assess the extent to which design development is required or allowed in cleanup design. In some cases, the ROD or permit will be very specific as in the case of a disposal facility where all features, such as liner systems, as well as configuration, are fixed. In other cases, such as when treatment options like incineration are recommended, considerable design effort may be required.

2. Requirements for engineering during construction including, construction observation, design of temporary facilities, quality control, testing, and documentation, will often be higher than for conventional construction. This results from the need to conduct construction activities for environmental projects in compliance with rigid regulations governing health and safety, quality assurance, and other project requirements.

CHAPTER 25

ATTACHMENT 25-1

A/E COST STANDARD FORM USAGE GUIDANCE

The Architect/Engineer (A/E) Cost Standard Form was designed to provide a standard format for the collection of A/E costs. Federal statutes limit the A/E costs to a percent of total construction cost, and these statutes have specific definitions of what is included in A/E costs. By collecting costs in the format of this form, the Department will be consistent with the definition of A/E costs used by other Federal agencies and will be able to determine what is being spent on A/E costs on a uniform basis throughout the Department.

The form, attached, is divided into three sections:

- Section A - Design
- Section B - Title III Services
- Section C - Engineering Services

Some departments may use different names for some of the functions described in the form. If this is the case, a crosswalk sheet can be developed and used to aid in converting the terms used locally to fit those in this form. If necessary, items can be added to each section. Sheets should be attached to completely define any items added. Minimal additions or changes are anticipated in Sections A and B, while Section C will more commonly have additions.

This form is used to collect Engineering, design, and inspection (ED&I) costs according to DOE Order 2200.6. Pre-Title I activities are not a part of ED&I. Pre-Title I activities include surveys, topographical services, core borings, soil analysis, etc., that are necessary to support design. These activities are charged to operating costs. Other costs that, according to DOE Order 2200.6, are not part of operating costs, include project management, the maintenance and operation of scheduling, estimating, and project control systems during design and construction, and the preparation, revision, and related activity involved in producing the final safety analysis report.

The attached “A/E Cost Standard Form - Engineering and Design Activities” table lists the Title I, Title II, and Title III activities and groups them in Sections A, B, or C as they appear on the A/E Cost Standard Form

The following will discuss each section individually.

Section A - Design

Section A includes the Title I and Title II costs directly related to developing the design drawings and specifications necessary for the project. Note that Section A includes only the cost of labor hours that are necessary to perform this design work. If, because of project requirements, other disciplines are required, they can be added. Note that other Title I and Title II costs can be covered in Section C.

Section B - Title III Services

Section B includes the costs for reviewing shop drawing submittals, inspection services, and the preparation of as-built drawings.

Section C - Engineering Services

Section C includes the support services required during the Title I, Title II, and Title III project work. This includes such activities as the energy conservation study, cost engineering, value engineering services, travel, computer equipment costs, etc. Note that the Computer Aided Drafting (CAD) operator's time is included in Section A. Note also that some of the activities in Section C, such as travel and per diem, can occur in Title I, Title II, and Title III work.

Design Schedule

The design schedule should be filled out in the bottom left-hand portion of the form under Section C. The cost summary is filled out to the right of the design schedule and includes the costs of Sections A, B, and C, which are added together to generate a total ED&I cost.

A/E COST STANDARD

DOE Architect-Engineer
Cost Standard Form

A/E Firm Name:	Consultant's Name(s):	A/E Contract No:
Project Title:		DE No: / Field Office:
Location:		Est.Const.Cost:

		Engineering Discipline	Est. No. Dwgs.	Hourly Rate	Title I Est. Hrs.	Title I Estimated Cost A/E	Title I Estimated Cost Consul-tant	Title II Est. Hrs.	Title II Estimated Cost A/E	Title II Estimated Cost Consul-tant	Total Design Est. Hrs.	Total Design Estima-ted Cost
SECTION A DESIGN	DRAWINGS	Project Engineer										
		Architect										
		Stru Engineer										
		Mech Engineer										
		Elec Engineer										
		Civil Engineer										
		Fire Engineer										
		Coordination QC										
		Arch Draftsman										
		Stru Draftsman										
		Mech Draftsman										
		Elec Draftsman										
		Civil Draftsman										
		Fire Draftsman										
		Total Drawings										
	SPECS	Spec Writer										
		Typist										
		Total Specifications										
	Total Est. Cost A/E & Consultant											
	Overhead A/E _____ Consult. _____%											
	Subtotal											
	Profit _____%											
	Subtotal											
	Total cost of section A (Design)					$ _____ sheet		% of ECC _____%			

COMPUTE COST PER SHEET AND DESIGN PERCENTAGE OF ESTIMATED CONSTRUCTION COST

ENGINEERING SERVICES SUMMARY SHEET (PROVIDE BACK-UP FOR EACH ITEM)		TITLE I	TITLE II	TITLE III	TOTAL
Section B Title III Services	Review of Shop Drawing Submittals				
	Inspection Services				
	Prepare As-Built Drawings				
	Total Cost of Section B				
SECTION C ENGINEERING SERVICES	Inspection Planning				
	Design QA Plan				
	Reproduction During Design				
	Constructability Reviews				
	Certified Engineering Reports				
	Design Studies Not Included in Pre-Title I				
	Project Schedules				
	Cost Engineering				
	Value Engineering Services				
	Travel to Support Design				
	Other (Specify)				
	Total Cost of Section C				

DESIGN SCHEDULE	30% Submit/Rev = ____ wks 60% Submit/Rev = ____ wks 90% Submit/Rev = ____ wks Final Submit /Rev = ____ wks TOTAL = _____ wks	COST SUMMARY	Total Section A (Design)				
			Total Section B (Title III)				
			Total Section C (Engr Serv)				
			GRAND TOTAL - Fee Proposal				
SIGNATURE			APPROVAL			DATE	

A/E COST STANDARD FORM
ENGINEERING AND DESIGN ACTIVITIES

	TITLE I ACTIVITIES	TITLE II ACTIVITIES	TITLE III ACTIVITIES
S	Preliminary Design Calculations and Analyses	Final Design Calculations and Analyses	
E	Preliminary Drawings	Definitive Drawings	
C	Preliminary Plans	Definitive Plans	
T	Outline Specifications	Procurement and Construction Specs	
I	CAD and Computer Services (operators)	CAD and Computer Services (operators)	
O	A/E Internal Design Coordination	A/E Internal Design Coordination	
N	Design Cost and Schedule Analysis and Control	Design Cost and Schedule Analysis and Control	
	Design Progress Reporting	Design Progress Reporting	
A	Regulatory/Code Overview by A/E		
S	Design QA Plan and Overview	Travel to Support Design	Inspection Services
E	Travel to Support Design	Reproduction During Design	Review Shop Drawings
C	Reproduction During Design	Designs Reviews, QA, and Overview (not Third Party)	Prepare As-Built Drawings
T	CAD and Computer Services (support)	CAD and computer Services (support)	
I	Project Schedules	Project Schedules	
O	Construction Cost Estimates	Constructability Reviews	
N	Constructability Reviews	Safety Reviews by A/E	
S	Safety Reviews by A/E	Construction Cost Estimates	
	Value Engineering	Acceptance Procedures	
B	Identify Long Lead Procurements	Certified Engineering Reports	
	Design Studies Not Included in Pre-Title I	Bid Package Preparation	
and	Preliminary Safety Analysis Report if Not Included in the CDR		
	Design Change Control	Design Change Control	
C		Inspection Planning	

Note: This representative list of functions was developed from FAR and DOE definitions.
All functions meet FAR criteria, and the categories are segregated according to the FAR.

FY 2003 RATE SHEET

Indirect | Fringe | OPTO | Vacation | Chargeback

INDIRECT RATES

	ACTUAL	EFFECTIVE
MSA	5.5%	16.1%
CSS	18.5%	30.4%
G&A	10.0%	10.0%
PASS THROUGH	1.5%	1.5%

FRINGE RATES

FRINGE	30.0%	30.0%
SUMMER STUDENT FRINGE	8.0%	8.0%

VACATION/OPTO RATES

	WEEKLY	MONTHLY
VACATION ACCRUAL	11.0%	11.0%

OTHER PAID TIME OFF (OPTO)	**9.0%**	**6.5%**

CHARGEBACK RATES

MACHINE SHOP CHARGE BACK RATE	**$55.00**
FESS ENGINEERING CHARGE BACK RATE	**$71.00**

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Fermilab Notice to Users

APPENDIX C — Off-Axis Detector Enclosure

While the basis for the cost estimate in this study assumes a conventional steel-framed building, alternate methods for achieving the enclosure were investigated. This appendix contains the results of the alternate methods of providing the detector enclosure.

Listed below is the table of contents for this Appendix

- Automatic Building Systems
- Pre-engineered Building Systems
- Tension Fabric Systems

Automatic Building Systems:

Fermilab has constructed numerous buildings on site utilizing a automatic building machine. This device accepts steel coils and forms it into a variety of configuations which are self supporting when anchored to floor slab or supporting structure. This “quonset hut” technology has been used along the Meson Experimental line and recently was used to erect the Shield Block Storage Building. Discussions with a recent vendor indicate that the current available technology is not able to provide the clear span required for the detector configuration described in the base design.

Pre-engineered Building Systems:

Several manufacturers of pre-engineered building systems were contacted in order to develop comparison costs to the base design of the building. Listed below is the building criteria provided to the vendors:

- Construction Site -Northeastern Minnesota –closest town is Aurora, MN
- Clear space envelope of 110’ wide x 70’ high x 550’ long;
- (2)- 12’ wide x 14’ high overhead doors;
- (6)-3’ wide x 7’ high personnel doors;
- 1:12 roof pitch (or as recommended);
- Standard roof panel (flat panel) with a AZ50 aluminum-galvanized coating (galvalume);
- Standing rib wall panel with a standard polyester finish of a color selected from standard colors;
- No insulation in walls or roof;
- No gutters or downspouts;
- Foundation engineering and installation by others;

Two vendors responded to the request. The vendor quotes included only the fabrication and delivery of the material. Based on discussions with the vendors and recent Fermilab experience, erection costs are assumed to be 100% of the material costs. For consistency with the base estimate as described in Section V of this report, the comparison used the same 15% for

sub-tier subcontractor Overhead and Profit;

Listed below is a table which compares the base design and the two pre-engineered vendor quotes:

	BASE DESIGN	PBS #1	PBS #2
Material	$2,494,990	$696,798	$931,700
Labor	$0	$696,798	$931,700
Subtier OH&P	$374,000	$209,000	$280,000
Construction Subtotal	**$2,869,000**	**$1,603,000**	**$2,143,000**

Tension Fabric Systems:
Tension fabric structures are clear-span, metal framed structures clad with high-quality architectural fabric weathershell. The metal frame consists of regulary spaced parallel structural arches, with the fabric weathershell tensioned between the arches of the structure. These structures are able to accommodate vechicle openings and can be designed for most regions and climates. Some systems utilize a straight sidewall reducing the overall footprint of the enclosure.

Three vendors were contacted for proposals. For consistency with the pre-engineered building alternates, the following project criteria was supplied to the vendors:

- Construction Site -Northeastern Minnesota–closest town is Aurora, MN;
- Standard fabric membrane, Galvanized steel members;
- Clear envelope of 110’ w x 70’ h x 550’ long
- (2) 12’w x 14’h overhead doors;
- (6) 3’w x 7’h personnel doors;
- Please don’t include any costs for heating systems or lighting systems
- Foundation engineering and foundation installation by others;

Two vendors responded with proposals for this alternate. Listed below is a table that provides a cost comparison of the steel-frame, metal siding building contained in the base design with the vendor proposals.

	BASE DESIGN	TFS #1	TFS #2
Material	$2,494,990	$2,200,000	$1,591,911
Labor	$0	$1,100,000	$796,000
Subtier OH&P	$374,000	$495,000	$358,000
Construction Subtotal	**$2,869,000**	**$3,795,000**	**$2,746,000**

For the purposes of this study, labor costs were assumed to be 50% of the material cost. The subtier Overhead and Profit (OH&P) multipliers are based on the 15% assumption used to develop the cost estimate for the base design.

Summary:
Several alternatives were examined to provide an alternate means of enclosing the detector modules. Listed below is a summary comparison of the various methods:

	BASE DESIGN	PRE-ENGINEERED BUILDING		TENSION FABRIC STRUCTURE	
		PBS #1	PBS #2	TFS #1	TFS #2
Material	$2,494,990	$696,798	$931,700	$2,200,000	$1,591,911
Labor	$0	$696,798	$931,700	$1,100,000	$796,000
Subtier OH&P	$374,000	$209,000	$280,000	$495,000	$358,000
Construction Subtotal	**$2,869,000**	**$1,603,000**	**$2,143,000**	**$3,795,000**	**$2,746,000**

This exercise indicates that a pre-engineered building system has the potenial to provide cost savings for the building shell. It is recommended that this alternate be developed during the subsequent phases of the project.

The basis for the cost estimate in this study assumes that the detector module handling will be accomplished utilizing a commercially available rubber tire gantry crane at a cost of $1,800,000. Given that the building structure could be designed to accommodate anticipated crane loads a conventional top-riding bridge crane was investigated.

A vendor proposal indicates that a 30 ton bridge crane is $428,575.00. This is a double box girder, top running crane with four hook top running cab operated trolley. This configuration is similar to that of the rubber tire gantry crane. Not included in the vendor proposal is a lifting device required for the cargo containers used as detector modules.

Listed below is a cost estimate detailing the cost impact of providing a bridge crane.

FERMILAB: FESS COST ESTIMATE

Project Title:					Project No.	Status:	Date:	Revision Date:
OFF AXIS DETECTOR BUILDING CRANE					6-2-22	PDR	4/25/03	
Construction Total				$732,000				
Overhead and Profit @ 0 %				$0				
Bare Construction Total				$731,790				
ITEM NO.		DESCRIPTION OF WORK:			QUANTITY	UNITS	UNIT COST	AMOUNT
01		CONVEYING SYSTEMS		$732,000				
	01	Purchase Crane*			1	Lot	$428,575.00	$428,575.00
		Shipping			1	Lot	$4,000.00	$4,000.00
		Below Hook Lifting Device	Not Included					
		Install and Test Crane			1	Lot	$30,000.00	$30,000.00
		Crane Runway (includes subtier OH&P)			69	Tons	$2,200.00	$174,570.00
		Upgrade Columns (inlcudes subtier OH&P)			34	Tons	$2,200.00	$86,020.00
		Power to Crane (includes subtier OH&P)			1	Lot	$7,500.00	$8,625.00
		*See attached quote						

The addition of the crane also impacts the structural and electrical systems. These include strengthening the steel frame, providing a crane girder and runway as well as providing electrical power to the crane. The building upgrades add 10% to the cost of the building structure described in the base design. For comparison, a pre-engineered building vendor provided a proposal that increased the building material cost by 18%.

The rubber tire gantry could be used for mucking operations during rock excavation, while the bridge crane would not be installed and operational until after the building structure is complete.

A bridge crane would not be practical for tension fabric structure since it would require a separate crane support structure.

In order to provide a comparison of a bridge crane to the rubber tire gantry crane, listed below is the escalated cost of the crane and related work utilizing the same multipliers as the base estimate:

Construction/Equipment Costs		$732,000
General Conditions (20%)		$146,000
	Subtotal	$878,000
EDIA (20%)		$176,000
	Subtotal	$1,054,000
Management Reserve (25%)		$264,000
	Subtotal	$1,318,000
Indirect Costs (3%)		$40,000
	TOTAL	**$1,358,000**

Summary:
It may be cost effective to strengthen the building structure to support a bridge crane. This alternate would be most effective in a conventional steel frame building or pre-engineered building system. Utilizing a bridge crane in a tension fabric structure would require a separate structural system for the crane and is not practical in such an application.

The basis for the design contained in this report assumes a detector stack 407' long by 80' wide by 85' tall. Different configurations may allow the exploration of other physics opportunities. This appendix includes the results of the investigations into enclosures of varying widths and heights.

Listed below is the table of contents for this Appendix

- Methodology
- Width Variations
- Depth/Height Variations
- Excavation Cost Variations
- Estimates

Methodology

The estimates used to develop the charts are based on the cost estimate for the base design. The estimate was reviewed and "cost driver" items were identified. For the purposes of this study, other multiplying factors (Environmental, General Conditions, EDIA, Management Reserve and Indirect Costs) remained the same as the base estimate.

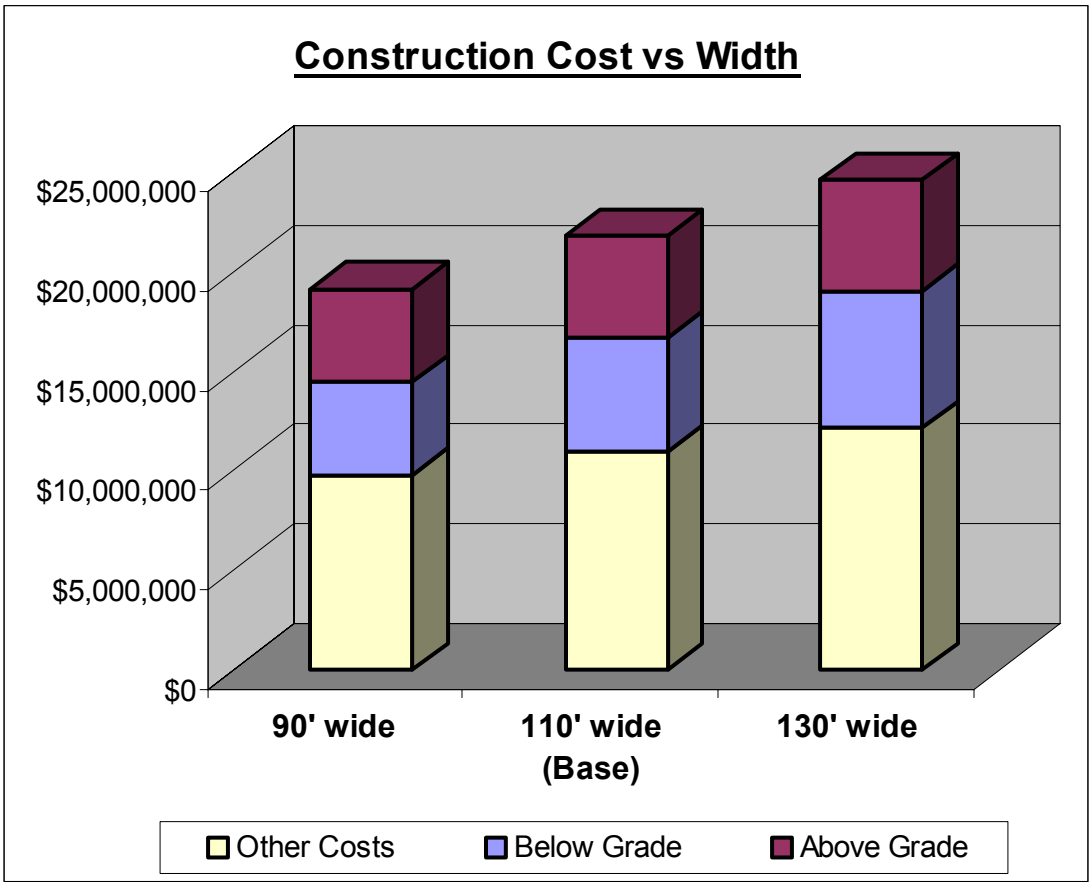
The nature of scaling variations produces results valid with a range of variables. These ranges, identified in the subsequent sections, are based on engineering principals. Outside of these ranges, the estimates become unreliable predictors. While these scaling estimates can provide general guidance for the selection of a design approach, no optimization of the design was done at this stage of the process and future design refinements will affect the overall project costs.

Width Variations

The base design assumed a building width of 110'. Two alternate building widths were scaled. The first was a narrower version 90' wide building and the second was a wider 130' wide building. Listed below is a summary of the project costs for each of the widths.

	90' Wide	110' Wide	130' Wide
Construction	$10,870,000	$12,369,000	$13,962,000
Environmental	$109,000	$124,000	$140,000
General Conditions	$2,174,000	$2,474,000	$2,792,400
Subtotal	$13,153,000	$14,967,000	$16,894,400
EDIA	$2,196,000	$2,499,000	$2,820,000
Management Reserve	$3,294,000	$3,748,000	$4,231,000
Indirect Costs	$494,000	$562,000	$635,000
TOTAL	**$19,137,000**	**$21,776,000**	**$24,580,400**

The two significant cost drivers were the above grade costs and the below grade costs. The chart below compares the three schemes based on the two cost drivers. The above grade costs include the architectural, structural, mechanical and electrical components. The below grade costs include the excavation and lining of the detector pit including the sump pumps and discharge piping. The other costs include Site Work, General Conditions, Environmental Work, EDIA, Management Reserve and Indirect Costs.



The detailed cost estimate for these variations are included at the end of this Appendix. Items noted in red indicate cost items changed and/or scaled from the base estimate.

Depth/Height Variations

The base design assumed a detector pit depth of 51'. In order to understand the general cost implications of the depth of the detector pit, three alternate detector pits depths were scaled ranging from the entire detector pit below grade (85' deep) to the detector pit on bedrock (17' deep). The 62' deep design and the 51' base design are cost variations of the two extremes.

The building designs for the 85' deep, 62' deep and 51' deep base design assume a building envelope in which the height also changes to accommodate the detector stack. In order to allow clearance for the associated support equipment and rubber tire gantry crane, the minimum height of the building is 45' above grade in the 85' deep design. The 17' deep design includes a building that is 113' above grade. Listed below is a summary of the building heights and below grade depths:

	85' Deep	62' Deep	51' Deep	17' Deep
Above Grade Building Height	45'	68'	79'	113'
Below Grade Depth	85'	62'	51'	17'

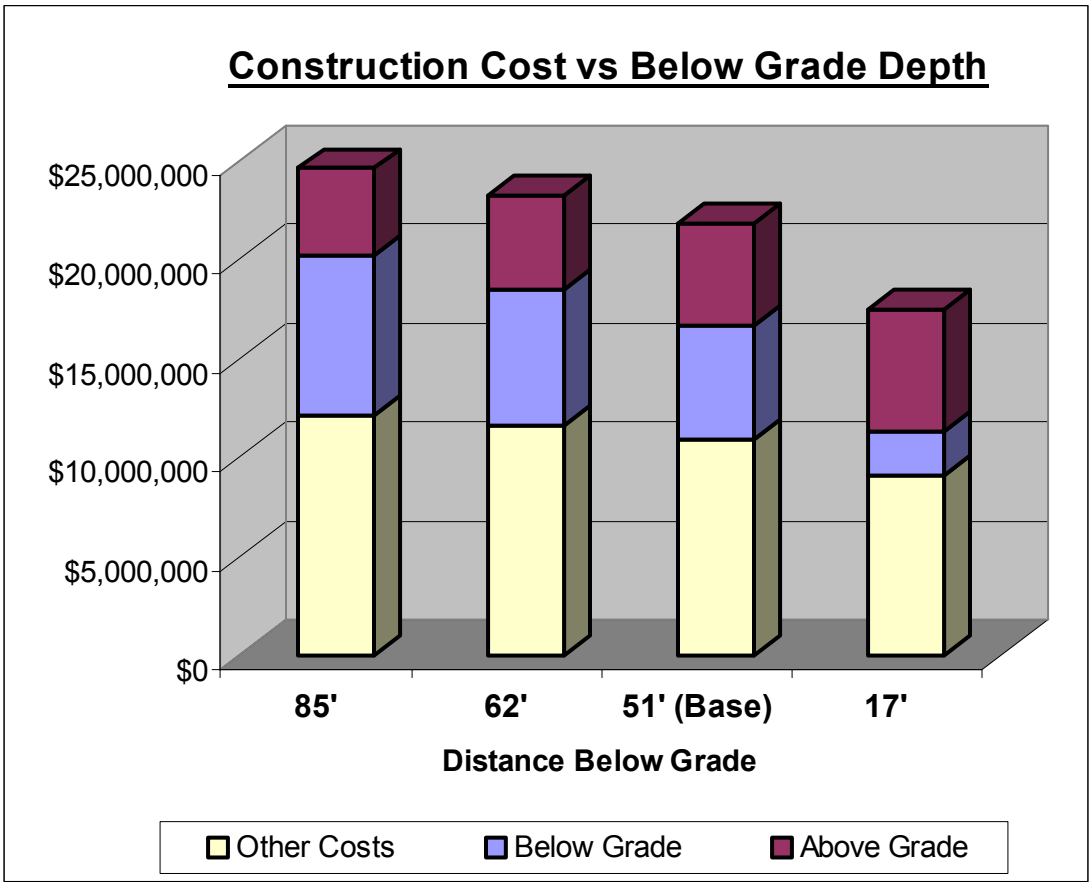
Listed below is a summary of the project costs for each of the depth alternatives:

	85' Deep	62' Deep	51' Deep	17' Deep
Construction	$13,960,000	$13,188,000	$12,369,000	$9,932,000
Environmental	$140,000	$132,000	$124,000	$99,000
General Conditions	$2,792,000	$2,637,600	$2,474,000	$1,986,400
Subtotal	$16,892,000	$15,957,600	$14,967,000	$12,017,400
EDIA	$2,820,000	$2,664,000	$2,499,000	$2,006,000
Management Reserve	$4,230,000	$3,996,000	$3,748,000	$3,009,000
Indirect Costs	$635,000	$599,000	$562,000	$451,000
TOTAL	**$24,577,000**	**$23,216,600**	**$21,776,000**	**$17,483,400**

The base design does not include the costs associated with procuring the rubber tire gantry crane to be used for module handling. As such the costs for each of the alternatives listed above do not include any changes required to the rubber tire gantry crane. The "one over four" design of the rubber tire gantry crane will be affected differently by each of the deeper alternates. These changes include additional cabling and possible reconfiguration of the "one over four" design. The 17' deep design does not appear to be configured to reasonably support a rubber tire gantry crane since the

detector stack would require a “one over eight” configuration. For the 17’ deep design, a conventional top riding bridge crane as described in Appendix D is viable alternative. Consideration of these costs should be included in the final project design.

The significant cost drivers were the above grade costs and the below grade costs. The chart below compares the four schemes based on these two cost drivers. The above grade costs include the architectural, structural, mechanical and electrical components. The below grade costs include the excavation and lining of the detector pit including the sump pumps and discharge piping. The other costs include Site Work, General Conditions, Environmental Work, EDIA, Management Reserve and Indirect Costs.



The detailed cost estimates for these variations are included at the end of this Appendix. Items noted in red indicate cost items changed and/or scaled from the base estimate.

Excavation Cost Variations

The below grade portion of the work is 38% of the overall project costs. The significant cost driver for the underground portion of the work is the rock excavation. The costs for rock excavation were taken from CostWorks program by RS Means, copyright 2003 (1st Quarter 2003 update). Listed below is a summary of the development of the costs for these activities.

Drill and Blast only, Deep hole method over 1500 cy = $29.50 / cy
Excavate and load blasted rock into muck bucket =$ 1.33 / cy
Clamshell at 20 cy/hr (plus 15% if loading into trucks) = $7.13 / cy
Total = $37.83 cy
use $38.00 / cy

The excavation section of CostWorks did not contain a listing for a crane and a muck bucket, so it was reasoned that a clamshell would approximate the cost for a crane and muck bucket.

Recent conversations with E. Peterson indicate that recent excavation work in northern Minnesota has produced rock excavation costs are averaging $10 per cubic yard.

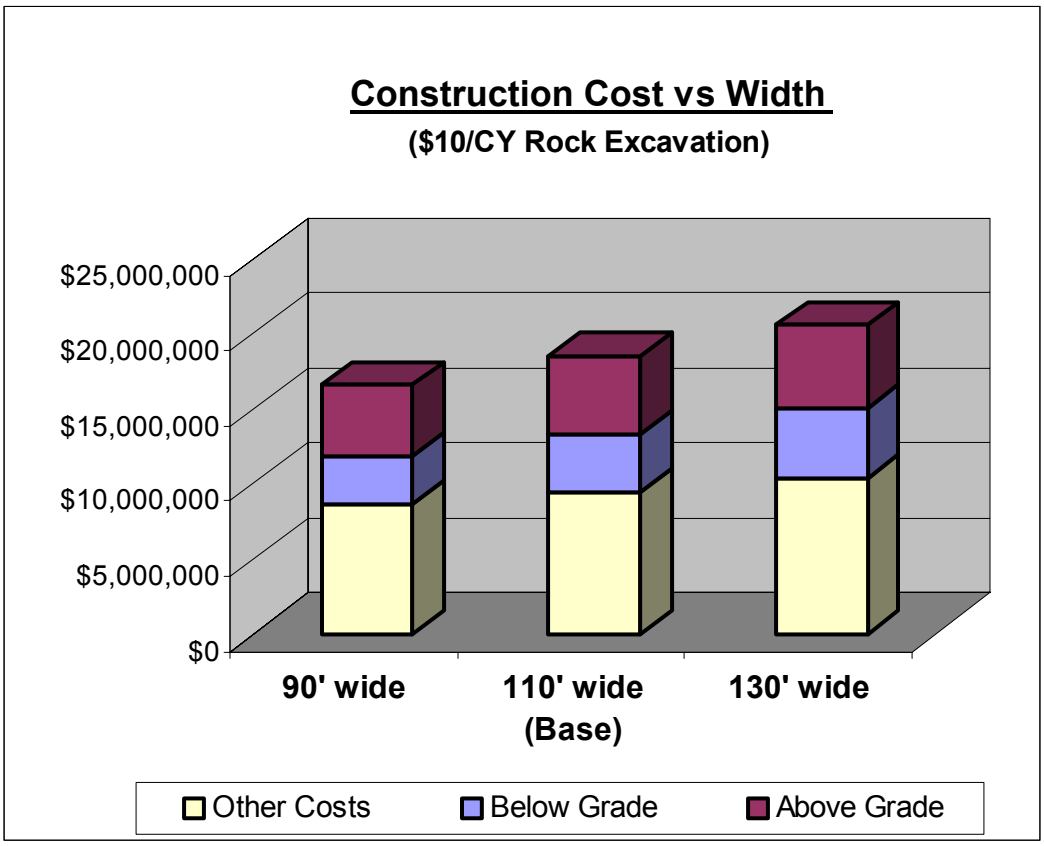
Since the driving cost of the below grade work is the rock excavation any reduction in excavation costs will impact the overall project costs and influence planning decisions. The cost estimates developed for this report were recalculated based on a $10/CY rock excavation cost in order to provide planning guidance. Listed below is a comparison of project costs for excavation costs of $38/CY and $10/CY.

	$38 PER CY	$10 PER CY
Land Acquisition	$0	$0
General Conditions	$2,474,000	$2,099,000
Site Work	$1,501,000	$1,501,000
Below Grade	$5,739,000	$3,866,000
Above Grade	$5,129,000	$5,129,000
Environmental	$124,000	$105,000
Construction Subtotal	**$14,967,000**	**$12,700,000**
EDIA	$2,499,000	$2,120,000
Management Reserve	$3,748,000	$3,180,000
Indirect Costs	$562,000	$477,000
PROJECT TOTAL	**$21,776,000**	**$18,477,000**

The lower excavation costs also impact the scaling studies down for the width variations. Listed below are the cost summaries recalculated for a rock excavation cost of $10/CY.

	90' Wide	110' Wide	130' Wide
Construction	$9,413,000	$10,496,000	$11,673,000
Environmental	$94,000	$105,000	$117,000
General Conditions	$1,882,600	$2,099,000	$2,334,600
Subtotal	$11,389,600	$12,700,000	$14,124,600
EDIA	$1,901,000	$2,120,000	$2,358,000
Management Reserve	$2,852,000	$3,180,000	$3,537,000
Indirect Costs	$428,000	$477,000	$531,000
TOTAL	**$16,570,600**	**$18,477,000**	**$20,550,600**

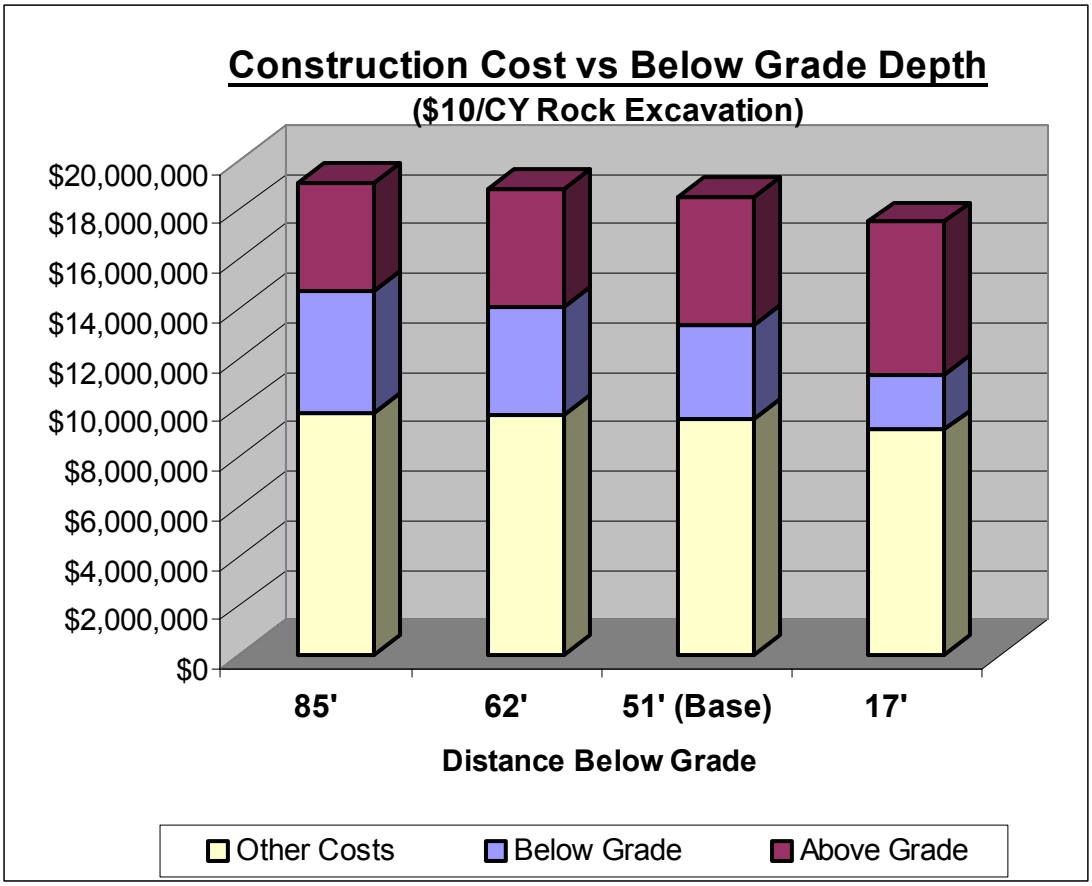
Shown below is a chart comparing the three width variations broken out by the above grade, below grade and other costs.



The lower excavation costs also impact the scaling studies down for the depth/height variations. Listed below are the cost summaries recalculated for a rock excavation cost of $10/CY.

	85' Deep	62' Deep	51' Deep	17' Deep
Construction	$10,837,000	$10,690,000	$10,496,000	$9,932,000
Environmental	$108,000	$107,000	$105,000	$99,000
General Conditions	$2,167,400	$2,138,000	$2,099,000	$1,986,400
Subtotal	$13,112,400	$12,935,000	$12,700,000	$12,017,400
EDIA	$2,189,000	$2,159,000	$2,120,000	$2,006,000
Management Reserve	$3,284,000	$3,239,000	$3,180,000	$3,009,000
Indirect Costs	$493,000	$486,000	$477,000	$451,000
TOTAL	**$19,078,400**	**$18,819,000**	**$18,477,000**	**$17,483,400**

Shown below is a chart comparing the four depth/height variations broken out by the above grade, below grade and other costs.



While the variations in width, depth/height and rock excavation costs can provide input for project planning, the actual cost of the project will be influenced by many factors including project locations, subsurface conditions, excavation methods, design complexity and economic conditions at the time of bidding. The cost scaling studies are not developed designs and significant refinement is required to verify the scaled costs. The results of these cost variations studies should not replace sound engineering judgement and common sense.

Width Variation 1 – 90' wide building:

FERMILAB: FESS COST ESTIMATE

Project Title:		Project No.	Status:	Date:	Revision Date:
	Variation 1 - 90' Wide	6-2-22	PDR	4/25/03	
ITEM NO.	DESCRIPTION OF WORK:	QUANTITY	UNITS	UNIT COST	AMOUNT
01	LAND ACQUISITION $0				
01	Surface Land Costs				$0
02	Undeground Rights Costs				$0
03	Road Easements				$0
04	Utility Easements				$0
05	Public/Private Road Fees				$0
02	GENERAL CONDITIONS $2,174,000				
01	Percentage of Construction Costs	20%	%	$10,870,000	$2,174,000
03	SITE WORK/INFRASTRUCTURE $1,515,000				
	Includes Sub-tier contractor OH&P 15% $198,000				
01	Clear and Grub Entrance Road	0	Acres	$5,000.00	$0
02	Strip 1' of soil	0	CY	$5.00	$0
03	Entrance Road Base 1 mile x 30' x 18"	0	CY	$40.00	$0
04	Entrance Road Paving 1mile x 24' x 4"	0	SY	$7.50	$0
05	Access Road	1	LS	$4,500.00	$4,500
06	Site Power Pole Line	0	Mile	$181,500.00	$0
07	Communication Lines	1	Mile	$19,000.00	$19,000
08	Strip and grub	4	Acres	$5,000.00	$20,000
09	Site Grading	1	Acres	$15,000.00	$15,000
10	Gates and Fencing	1	LS	$18,805.00	$18,805
11	Sidewalks	1	LS	$6,938.00	$6,938
12	Construction Hardstands	0	SF	$3.10	$0
13	Electrical Substation (2000 kVA Transformer)	2	Each	$55,400.00	$110,800
14	Four Way Air Switch	1	Each	$26,000.00	$26,000
15	750 KW Diesel Generator	1	Each	$146,820.00	$146,820
16	Oil Containment	1	Lot	$20,000.00	$20,000
17	(2)-5" Electrical Ductbank in Concrete	150	LF	$80.00	$12,000
18	3-1/C 750 MCM Conductors	200	LF	$230.00	$46,000
19	Water Well (200' deep)	1	Lot	$25,800.00	$25,800
20	Water Storage (& Fire) Tank	1	Lot	$650,000.00	$650,000
21	Fire Protection Panel (in Building Estimate)				
22	Sanitary Sewage Holding Tank	1	Lot	$12,000.00	$12,000
23	Fire Underground Main	0	LF	$16.00	$0
24	Envir. Protection - silt fence	0	LF	$4.00	$0
25	Mine Water Treatment w chemicals	0	Lot	$500,000.00	$0
26	Settling basin 1/2 acre	0	Lot	$90,000.00	$0
27	Hydrant + PIV's	0	Lot	$3,000.00	$0
28	DWS 3"	0	LF	$8.00	$0
29	Storm Sewer	1	LS	$152,416.00	$152,416
30	Exterior Lighting	1	LS	$31,000.00	$31,000

FERMILAB: FESS COST ESTIMATE

Project Title:		Project No.	Status:	Date:	Revision Date:
	Variation 1 - 90' Wide	**6-2-22**	**PDR**	4/25/03	
ITEM NO.	DESCRIPTION OF WORK:	QUANTITY	UNITS	UNIT COST	AMOUNT
04	**BELOW GRADE $4,645,000**				
	Includes Sub-tier contractor OH&P 15% $606,000				
01	Excavate Overburden	29863.63636	CY	$12.00	$358,364
02	Haul Overburden Spoils	29863.63636	CY	$3.00	$89,591
03	Excavate Rock	45247.22222	CY	$38.00	$1,719,394
04	Haul Muck	67868.88889	CY	$3.00	$203,607
05	Rock Bolts 5'x5' pattern 10'LG	15007.8125	LF	$6.75	$101,303
06	Drainage Strips	4943.75	LF	$8.00	$39,550
07	Shot Crete W/ WWF 4"	37064	SF	$8.00	$296,512
08	CIP Slab on Grade	360.9090909	CY	$250.00	$90,227
09	CIP Retaining Wall	1022.727273	CY	$450.00	$460,227
10	CIP Grade Beam	150.3030303	CY	$450.00	$67,636
11	CIP Piers and Footings	127.0588235	CY	$500.00	$63,529
12	CIP Container Base Slab	1102.888889	CY	$350.00	$386,011
13	Sump and Discharge Piping	4	EA	$22,000.00	$88,000
14	Drain Tile	1227.272727	LF	$12.00	$14,727
15	Dimple Mat	30190.90909	SF	$2.00	$60,382
05	**ABOVE GRADE $4,710,000**				
	Includes Sub-tier contractor OH&P 15% $614,000				
01	Metal Deck 18 Ga	49500	SF	$1.60	$79,200
02	Purlins	117.8181818	Tons	$2,200.00	$259,200
03	Trusses	114.1363636	Tons	$2,200.00	$251,100
04	Truss Bracing	3.7	Tons	$2,200.00	$8,140
05	High Bay Columns	105	Tons	$2,200.00	$231,000
06	Girts	54.3030303	Tons	$2,200.00	$119,467
07	Stairs	2	Ea	$49,000.00	$98,000
08	Wind Bracing	4	Tons	$2,200.00	$8,800
09	Misc Steel	5	Tons	$2,200.00	$11,000
10	4 Ply Built-up Roofing	49500	SF	$2.10	$103,950
11	Insulation 3"	49500	SF	$0.75	$37,125
12	Prefinished Metal Siding	96193.93939	SF	$12.00	$1,154,327
13	Overhead Door 12' wide x 14' high	2	EA	$14,000.00	$28,000
14	Overhead Door 12' wide x 12' high	1	EA	$8,000.00	$8,000
15	Personnel Doors	6	EA	$800.00	$4,800
16	Interior Partitions and finishes	1	Lot	$80,000.00	$80,000
17	Extinguisher agent (200lb container)	2	EA	$7,250.00	$14,500
18	Dispersion Nozzle and Piping	8	EA	$3,500.00	$28,000
19	Control Release Panel	1	EA	$3,250.00	$3,250
20	Detection Wiring	8	EA	$650.00	$5,200
21	Emergency Release / Abort Button	4	EA	$250.00	$1,000
22	Ventilation (Roof Exhaust)	1	Lot	$110,000.00	$110,000
23	Heat Exchangers	2	EA	$35,000.00	$70,000
24	HX Installation	1	Lot	$27,000.00	$27,000
25	Tower Pumps	2	EA	$12,000.00	$24,000
26	Piping Installation (minimal)	1	Lot	$130,000.00	$130,000
27	Structural pipe hangers	1	Lot	$24,000.00	$24,000

FERMILAB: FESS COST ESTIMATE

Project Title:		Project No.	Status:	Date:	Revision Date:
	Variation 1 - 90' Wide	**6-2-22**	**PDR**	4/25/03	
ITEM NO.	DESCRIPTION OF WORK:	QUANTITY	UNITS	UNIT COST	AMOUNT
28	Starter or VFD	4	EA	$20,000.00	$80,000
29	Electrical to Pumps	1	Lot	$12,000.00	$12,000
30	Allowance for controls	1	Lot	$17,000.00	$17,000
31	Flushing, Testing, and Balancing	1	Lot	$8,000.00	$8,000
32	Cooling Tower	1	Ea	$80,000.00	$80,000
33	Toilet Room Fixtures	1	Lot	$4,000.00	$4,000
34	HW Heater	1	Ea	$800.00	$800
35	Fire Pump 100psi @ 1,500 GPM	1	Lot	$75,000.00	$75,000
36	2-Risers	1	Lot	$15,000.00	$15,000
37	In-Rack (Detector Sprinklers)	23000	SF	$6.25	$143,750
38	Sprinklers	49500	SF	$3.00	$148,500
39	50 KVA transformers	4	EA	$2,400.00	$9,600
40	2000 A switchboard	2	EA	$15,400.00	$30,800
41	1200 Amp Panels	4	EA	$3,800.00	$15,200
42	800 Amp Panes	4	EA	$3,200.00	$12,800
43	400 Amp Panels	4	EA	$2,900.00	$11,600
44	225 Amp Panels	4	EA	$2,100.00	$8,400
45	750 MCM THWN Copper 4/c	200	LF	$23.00	$4,600
46	Welding outlets	8	EA	$420.00	$3,360
38	Power Distribution	49500	SF	$5.00	$247,500
48	Unit Heaters	36	EA	$2,000.00	$72,000
49	Lighting	49500	SF	$1.33	$65,835
50	Fire Detection	49500	SF	$2.25	$111,375
06	**PERMITS, FEES, PS** **$6,093,000**				
	Bare Construction Costs $10,870,000				
01	Environmental Impact Studies & Mitigation	$10,870,000	%	1%	$109,000
02	Engineering Design, Inspection and Administration	$10,979,000	%	20%	$2,196,000
03	Management Reserve	$13,175,000	%	25%	$3,294,000
04	Indirect Costs	$16,469,000	%	3%	$494,000

Width Variation 2 – 130' wide building:

FERMILAB: FESS COST ESTIMATE

Project Title:		Project No.	Status:	Date:	Revision Date:
Variation 2 - 130' wide		6-2-22	PDR	4/25/03	
ITEM NO.	DESCRIPTION OF WORK:	QUANTITY	UNITS	UNIT COST	AMOUNT
01	LAND ACQUISITION $0				
01	Surface Land Costs				$0
02	Undeground Rights Costs				$0
03	Road Easements				$0
04	Utility Easements				$0
05	Public/Private Road Fees				$0
02	GENERAL CONDITIONS $2,792,400				
01	Percentage of Construction Costs	20%	%	$13,962,000	$2,792,400
03	SITE WORK/INFRASTRUCTURE $1,515,000				
Includes Sub-tier contractor OH&P 15%	$198,000				
01	Clear and Grub Entrance Road	0	Acres	$5,000.00	$0
02	Strip 1' of soil	0	CY	$5.00	$0
03	Entrance Road Base 1 mile x 30' x 18"	0	CY	$40.00	$0
04	Entrance Road Paving 1mile x 24' x 4"	0	SY	$7.50	$0
05	Access Road	1	LS	$4,500.00	$4,500
06	Site Power Pole Line	0	Mile	$181,500.00	$0
07	Communication Lines	1	Mile	$19,000.00	$19,000
08	Strip and grub	4	Acres	$5,000.00	$20,000
09	Site Grading	1	Acres	$15,000.00	$15,000
10	Gates and Fencing	1	LS	$18,805.00	$18,805
11	Sidewalks	1	LS	$6,938.00	$6,938
12	Construction Hardstands	0	SF	$3.10	$0
13	Electrical Substation (2000 kVA Transformer)	2	Each	$55,400.00	$110,800
14	Four Way Air Switch	1	Each	$26,000.00	$26,000
15	750 KW Diesel Generator	1	Each	$146,820.00	$146,820
16	Oil Containment	1	Lot	$20,000.00	$20,000
17	(2)-5" Electrical Ductbank in Concrete	150	LF	$80.00	$12,000
18	3-1/C 750 MCM Conductors	200	LF	$230.00	$46,000
19	Water Well (200' deep)	1	Lot	$25,800.00	$25,800
20	Water Storage (& Fire) Tank	1	Lot	$650,000.00	$650,000
21	Fire Protection Panel (in Building Estimate)				
22	Sanitary Sewage Holding Tank	1	Lot	$12,000.00	$12,000
23	Fire Underground Main	0	LF	$16.00	$0
24	Envir. Protection - silt fence	0	LF	$4.00	$0
25	Mine Water Treatment w chemicals	0	Lot	$500,000.00	$0
26	Settling basin 1/2 acre	0	Lot	$90,000.00	$0
27	Hydrant + PIV's	0	Lot	$3,000.00	$0
28	DWS 3"	0	LF	$8.00	$0
29	Storm Sewer	1	LS	$152,416.00	$152,416
30	Exterior Lighting	1	LS	$31,000.00	$31,000

FERMILAB: FESS COST ESTIMATE

Project Title:		Project No.	Status:	Date:	Revision Date:
Variation 2 - 130' wide		6-2-22	PDR	4/25/03	
ITEM NO.	DESCRIPTION OF WORK:	QUANTITY	UNITS	UNIT COST	AMOUNT
04	BELOW GRADE $6,886,000				
Includes Sub-tier contractor OH&P 15%	$898,000				
01	Excavate Overburden	43136.36364	CY	$12.00	$517,636
02	Haul Overburden Spoils	43136.36364	CY	$3.00	$129,409
03	Excavate Rock	71102.77778	CY	$38.00	$2,701,906
04	Haul Muck	87260	CY	$3.00	$261,780
05	Rock Bolts 5'x5' pattern 10'LG	17664.0625	LF	$6.75	$119,232
06	Drainage Strips	5818.75	LF	$8.00	$46,550
07	Shot Crete W/ WWF 4"	43624	SF	$8.00	$348,992
08	CIP Slab on Grade	397	CY	$250.00	$99,250
09	CIP Retaining Wall	1477.272727	CY	$450.00	$664,773
10	CIP Grade Beam	155	CY	$450.00	$69,750
11	CIP Piers and Footings	139.0909091	CY	$500.00	$69,545
12	CIP Container Base Slab	2048.222222	CY	$350.00	$716,878
13	Sump and Discharge Piping	5	EA	$22,000.00	$110,000
14	Drain Tile	2166.666667	LF	$12.00	$26,000
15	Dimple Mat	53300	SF	$2.00	$106,600
05	ABOVE GRADE $5,561,000				
Includes Sub-tier contractor OH&P 15%	$725,000				
01	Metal Deck 18 Ga	71500	SF	$1.60	$114,400
02	Purlins	170.1818182	Tons	$2,200.00	$374,400
03	Trusses	201.5	Tons	$2,200.00	$443,300
04	Truss Bracing	3.7	Tons	$2,200.00	$8,140
05	High Bay Columns	105	Tons	$2,200.00	$231,000
06	Girts	57.6969697	Tons	$2,200.00	$126,933
07	Stairs	2	Ea	$49,000.00	$98,000
08	Wind Bracing	4	Tons	$2,200.00	$8,800
09	Misc Steel	5	Tons	$2,200.00	$11,000
10	4 Ply Built-up Roofing	71500	SF	$2.10	$150,150
11	Insulation 3"	71500	SF	$0.75	$53,625
12	Prefinished Metal Siding	102206.0606	SF	$12.00	$1,226,473
13	Overhead Door 12' wide x 14' high	2	EA	$14,000.00	$28,000
14	Overhead Door 12' wide x 12' high	1	EA	$8,000.00	$8,000
15	Personnel Doors	6	EA	$800.00	$4,800
16	Interior Partitions and finishes	1	Lot	$80,000.00	$80,000
17	Extinguisher agent (200lb container)	2	EA	$7,250.00	$14,500
18	Dispersion Nozzle and Piping	8	EA	$3,500.00	$28,000
19	Control Release Panel	1	EA	$3,250.00	$3,250
20	Detection Wiring	8	EA	$650.00	$5,200
21	Emergency Release / Abort Button	4	EA	$250.00	$1,000

FERMILAB: FESS COST ESTIMATE

Project Title:		Project No.	Status:	Date:	Revision Date:
	Variation 2 - 130' wide	6-2-22	PDR	4/25/03	
ITEM NO.	DESCRIPTION OF WORK:	QUANTITY	UNITS	UNIT COST	AMOUNT
22	Ventilation (Roof Exhaust)	1	Lot	$110,000.00	$110,000
23	Heat Exchangers	2	EA	$35,000.00	$70,000
24	HX Installation	1	Lot	$27,000.00	$27,000
25	Tower Pumps	2	EA	$12,000.00	$24,000
26	Piping Installation (minimal)	1	Lot	$130,000.00	$130,000
27	Structural pipe hangers	1	Lot	$24,000.00	$24,000
28	Starter or VFD	4	EA	$20,000.00	$80,000
29	Electrical to Pumps	1	Lot	$12,000.00	$12,000
30	Allowance for controls	1	Lot	$17,000.00	$17,000
31	Flushing, Testing, and Balancing	1	Lot	$8,000.00	$8,000
32	Cooling Tower	1	Ea	$80,000.00	$80,000
33	Toilet Room Fixtures	1	Lot	$4,000.00	$4,000
34	HW Heater	1	Ea	$800.00	$800
35	Fire Pump 100psi @ 1,500 GPM	1	Lot	$75,000.00	$75,000
36	2-Risers	1	Lot	$15,000.00	$15,000
37	In-Rack (Detector Sprinklers)	23000	SF	$6.25	$143,750
38	Sprinklers	71500	SF	$3.00	$214,500
39	50 KVA transformers	4	EA	$2,400.00	$9,600
40	2000 A switchboard	2	EA	$15,400.00	$30,800
41	1200 Amp Panels	4	EA	$3,800.00	$15,200
42	800 Amp Panes	4	EA	$3,200.00	$12,800
43	400 Amp Panels	4	EA	$2,900.00	$11,600
44	225 Amp Panels	4	EA	$2,100.00	$8,400
45	750 MCM THWN Copper 4/c	200	LF	$23.00	$4,600
46	Welding outlets	8	EA	$420.00	$3,360
47	Power Distribution	71500	SF	$5.00	$357,500
48	Unit Heaters	36	EA	$2,000.00	$72,000
49	Lighting	71500	SF	$1.33	$95,095
50	Fire Detection	71500	SF	$2.25	$160,875
06	PERMITS, FEES, PS $7,826,000				
	Bare Construction Costs $13,962,000				
01	Environmental Impact Studies & Mitigation	$13,962,000	%	1%	$140,000
02	Engineering Design, Inspection and Administration	$14,102,000	%	20%	$2,820,000
03	Management Reserve	$16,922,000	%	25%	$4,231,000
04	Indirect Costs	$21,153,000	%	3%	$635,000

Depth/Height Variation 1 – 85' Deep Detector Pit:

FERMILAB: FESS COST ESTIMATE

Project Title:		Project No.	Status:	Date:	Revision Date:
	Variation 1 - 45' above grade, 85' foot below grade	**6-2-22**	**PDR**	4/25/03	
ITEM NO.	DESCRIPTION OF WORK:	QUANTITY	UNITS	UNIT COST	AMOUNT
01	**LAND ACQUISITION $0**				
01	Surface Land Costs				$0
02	Undeground Rights Costs				$0
03	Road Easements				$0
04	Utility Easements				$0
05	Public/Private Road Fees				$0
02	**GENERAL CONDITIONS $2,792,000**				
01	Percentage of Construction Costs	20%	%	$13,960,000	$2,792,000
03	**SITE WORK/INFRASTRUCTURE $1,515,000**				
	Includes Sub-tier contractor OH&P 15% $198,000				
01	Clear and Grub Entrance Road	0	Acres	$5,000.00	$0
02	Strip 1' of soil	0	CY	$5.00	$0
03	Entrance Road Base 1 mile x 30' x 18"	0	CY	$40.00	$0
04	Entrance Road Paving 1mile x 24' x 4"	0	SY	$7.50	$0
05	Access Road	1	LS	$4,500.00	$4,500
06	Site Power Pole Line	0	Mile	$181,500.00	$0
07	Communication Lines	1	Mile	$19,000.00	$19,000
08	Strip and grub	4	Acres	$5,000.00	$20,000
09	Site Grading	1	Acres	$15,000.00	$15,000
10	Gates and Fencing	1	LS	$18,805.00	$18,805
11	Sidewalks	1	LS	$6,938.00	$6,938
12	Construction Hardstands	0	SF	$3.10	$0
13	Electrical Substation (2000 kVA Transformer)	2	Each	$55,400.00	$110,800
14	Four Way Air Switch	1	Each	$26,000.00	$26,000
15	750 KW Diesel Generator	1	Each	$146,820.00	$146,820
16	Oil Containment	1	Lot	$20,000.00	$20,000
17	(2)-5" Electrical Ductbank in Concrete	150	LF	$80.00	$12,000
18	3-1/C 750 MCM Conductors	200	LF	$230.00	$46,000
19	Water Well (200' deep)	1	Lot	$25,800.00	$25,800
20	Water Storage (& Fire) Tank	1	Lot	$650,000.00	$650,000
21	Fire Protection Panel (in Building Estimate)				
22	Sanitary Sewage Holding Tank	1	Lot	$12,000.00	$12,000
23	Fire Underground Main	0	LF	$16.00	$0
24	Envir. Protection - silt fence	0	LF	$4.00	$0
25	Mine Water Treatment w chemicals	0	Lot	$500,000.00	$0
26	Settling basin 1/2 acre	0	Lot	$90,000.00	$0
27	Hydrant + PIV's	0	Lot	$3,000.00	$0
28	DWS 3"	0	LF	$8.00	$0
29	Storm Sewer	1	LS	$152,416.00	$152,416
30	Exterior Lighting	1	LS	$31,000.00	$31,000

FERMILAB: FESS COST ESTIMATE

Project Title:		Project No.	Status:	Date:	Revision Date:
Variation 1 - 45' above grade, 85' foot below grade		6-2-22	PDR	4/25/03	
ITEM NO.	DESCRIPTION OF WORK:	QUANTITY	UNITS	UNIT COST	AMOUNT
04	BELOW GRADE $8,085,000				
	Includes Sub-tier contractor OH&P 15% $1,055,000				
01	Excavate Overburden	36500	CY	$12.00	$438,000
02	Haul Overburden Spoils	36500	CY	$3.00	$109,500
03	Excavate Rock	96958.33333	CY	$38.00	$3,684,417
04	Haul Muck	145433.3333	CY	$3.00	$436,300
05	Rock Bolts 5'x5' pattern 10'LG	28333.33333	LF	$6.75	$191,250
06	Drainage Strips	9333.333333	LF	$8.00	$74,667
07	Shot Crete W/ WWF 4"	69973.33333	SF	$8.00	$559,787
08	CIP Slab on Grade	397	CY	$250.00	$99,250
09	CIP Retaining Wall	1250	CY	$450.00	$562,500
10	CIP Grade Beam	155	CY	$450.00	$69,750
11	CIP Piers and Footings	135	CY	$500.00	$67,500
12	CIP Container Base Slab	1418	CY	$350.00	$496,300
13	Sump and Discharge Piping	4	EA	$22,000.00	$88,000
14	Drain Tile	2500	LF	$12.00	$30,000
15	Dimple Mat	61500	SF	$2.00	$123,000
05	ABOVE GRADE $4,360,000				
	Includes Sub-tier contractor OH&P 15% $569,000				
01	Metal Deck 18 Ga	60500	SF	$1.60	$96,800
02	Purlins	144	Tons	$2,200.00	$316,800
03	Trusses	155	Tons	$2,200.00	$341,000
04	Truss Bracing	3.7	Tons	$2,200.00	$8,140
05	High Bay Columns	59.81012658	Tons	$2,200.00	$131,582
06	Girts	31.89873418	Tons	$2,200.00	$70,177
07	Stairs	2	Ea	$49,000.00	$98,000
08	Wind Bracing	2.278481013	Tons	$2,200.00	$5,013
09	Misc Steel	5	Tons	$2,200.00	$11,000
10	4 Ply Built-up Roofing	60500	SF	$2.10	$127,050
11	Insulation 3"	60500	SF	$0.75	$45,375
12	Prefinished Metal Siding	56506.32911	SF	$12.00	$678,076
13	Overhead Door 12' wide x 14' high	2	EA	$14,000.00	$28,000
14	Overhead Door 12' wide x 12' high	1	EA	$8,000.00	$8,000
15	Personnel Door	6	EA	$800.00	$4,800
16	Interior Partitions and finishes	1	Lot	$80,000.00	$80,000
17	Extinguisher agent (200lb container)	2	EA	$7,250.00	$14,500
18	Dispersion Nozzle and Piping	8	EA	$3,500.00	$28,000
19	Control Release Panel	1	EA	$3,250.00	$3,250
20	Detection Wiring	8	EA	$650.00	$5,200
21	Emergency Release / Abort Button	4	EA	$250.00	$1,000
22	Ventilation (Roof Exhaust)	1	Lot	$110,000.00	$110,000
23	Heat Exchangers	2	EA	$35,000.00	$70,000
24	HX Installation	1	Lot	$27,000.00	$27,000
25	Tower Pumps	2	EA	$12,000.00	$24,000

FERMILAB: FESS COST ESTIMATE

Project Title:		Project No.	Status:	Date:	Revision Date:
Variation 1 - 45' above grade, 85' foot below grade		**6-2-22**	**PDR**	4/25/03	
ITEM NO.	DESCRIPTION OF WORK:	QUANTITY	UNITS	UNIT COST	AMOUNT
26	Piping Installation (minimal)	1	Lot	$130,000.00	$130,000
27	Structural pipe hangers	1	Lot	$24,000.00	$24,000
28	Starter or VFD	4	EA	$20,000.00	$80,000
29	Electrical to Pumps	1	Lot	$12,000.00	$12,000
30	Allowance for controls	1	Lot	$17,000.00	$17,000
31	Flushing, Testing, and Balancing	1	Lot	$8,000.00	$8,000
32	Cooling Tower	1	Ea	$80,000.00	$80,000
33	Toilet Room Fixtures	1	Lot	$4,000.00	$4,000
34	HW Heater	1	Ea	$800.00	$800
35	Fire Pump 100psi @ 1,500 GPM	1	Lot	$75,000.00	$75,000
36	2-Risers	1	Lot	$15,000.00	$15,000
37	In-Rack (Detector Sprinklers)	23000	SF	$6.25	$143,750
38	Sprinklers	60500	SF	$3.00	$181,500
39	50 KVA transformers	4	EA	$2,400.00	$9,600
40	2000 A switchboard	2	EA	$15,400.00	$30,800
41	1200 Amp Panels	4	EA	$3,800.00	$15,200
42	800 Amp Panes	4	EA	$3,200.00	$12,800
43	400 Amp Panels	4	EA	$2,900.00	$11,600
44	225 Amp Panels	4	EA	$2,100.00	$8,400
45	750 MCM THWN Copper 4/c	200	LF	$23.00	$4,600
46	Welding outlets	8	EA	$420.00	$3,360
47	Power Distribution	60500	SF	$5.00	$302,500
48	Unit Heaters	36	EA	$2,000.00	$72,000
49	Lighting	60500	SF	$1.33	$80,465
50	Fire Detection	60500	SF	$2.25	$136,125
06	**PERMITS, FEES, PS** **$7,825,000**				
	Bare Construction Costs $13,960,000				
01	Environmental Impact Studies & Mitigation	$13,960,000	%	1%	$140,000
02	Engineering Design, Inspection and Administration	$14,100,000	%	20%	$2,820,000
03	Management Reserve	$16,920,000	%	25%	$4,230,000
04	Indirect Costs	$21,150,000	%	3%	$635,000

Depth/Height Variation 2 – 62' Deep Detector Pit:

FERMILAB: FESS COST ESTIMATE

Project Title:		Project No.	Status:	Date:	Revision Date:
Variation 2 - 68' above grade, 62' foot below grade		6-2-22	PDR	4/25/03	
ITEM NO.	DESCRIPTION OF WORK:	QUANTITY	UNITS	UNIT COST	AMOUNT
01	LAND ACQUISITION $0				
01	Surface Land Costs				$0
02	Undeground Rights Costs				$0
03	Road Easements				$0
04	Utility Easements				$0
05	Public/Private Road Fees				$0
02	GENERAL CONDITIONS $2,637,600				
01	Percentage of Construction Costs	20%	%	$13,188,000	$2,637,600
03	SITE WORK/INFRASTRUCTURE $1,531,000				
Includes Sub-tier contractor OH&P 15%	$200,000				
01	Clear and Grub Entrance Road	0	Acres	$5,000.00	$0
02	Strip 1' of soil	0	CY	$5.00	$0
03	Entrance Road Base 1 mile x 30' x 18"	0	CY	$40.00	$0
04	Entrance Road Paving 1mile x 24' x 4"	0	SY	$7.50	$0
05	Access Road	1	LS	$4,500.00	$4,500
06	Site Power Pole Line	0	Mile	$181,500.00	$0
07	Communication Lines	1	Mile	$15,000.00	$15,000
08	Strip and grub	4	Acres	$5,000.00	$20,000
09	Site Grading	1	Acres	$15,000.00	$15,000
10	Gates and Fencing	1	LS	$36,772.00	$36,772
11	Sidewalks	1	LS	$6,938.00	$6,938
12	Construction Hardstands	0	SF	$3.10	$0
13	Electrical Substation (2000 kVA Transformer)	2	Each	$55,400.00	$110,800
14	Four Way Air Switch	1	Each	$26,000.00	$26,000
15	750 KW Diesel Generator	1	Each	$146,820.00	$146,820
16	Oil Containment	1	Lot	$20,000.00	$20,000
17	(2)-5" Electrical Ductbank in Concrete	150	LF	$80.00	$12,000
18	3-1/C 750 MCM Conductors	200	LF	$230.00	$46,000
19	Water Well (200' deep)	1	Lot	$25,800.00	$25,800
20	Water Storage (& Fire) Tank	1	Lot	$650,000.00	$650,000
21	Fire Protection Panel (in Building Estimate)				
22	Sanitary Sewage Holding Tank	1	Lot	$12,000.00	$12,000
23	Fire Underground Main	0	LF	$16.00	$0
24	Envir. Protection - silt fence	0	LF	$4.00	$0
25	Mine Water Treatment w chemicals	0	Lot	$500,000.00	$0
26	Settling basin 1/2 acre	0	Lot	$90,000.00	$0
27	Hydrant + PIV's	0	Lot	$3,000.00	$0
28	DWS 3"	0	LF	$8.00	$0
29	Storm Sewer	1	LS	$152,416.00	$152,416
30	Exterior Lighting	1	LS	$31,000.00	$31,000

FERMILAB: FESS COST ESTIMATE

Project Title:		Project No.	Status:	Date:	Revision Date:
Variation 2 - 68' above grade, 62' foot below grade		6-2-22	PDR	4/25/03	
ITEM NO.	DESCRIPTION OF WORK:	QUANTITY	UNITS	UNIT COST	AMOUNT
04	BELOW GRADE $6,912,000				
Includes Sub-tier contractor OH&P 15%	$902,000				
01	Excavate Overburden	36500	CY	$12.00	$438,000
02	Haul Overburden Spoils	36500	CY	$3.00	$109,500
03	Excavate Rock	77566.66667	CY	$38.00	$2,947,533
04	Haul Muck	116346.6667	CY	$3.00	$349,040
05	Rock Bolts 5'x5' pattern 10'LG	22666.66667	LF	$6.75	$153,000
06	Drainage Strips	7466.666667	LF	$8.00	$59,733
07	Shot Crete W/ WWF 4"	55978.66667	SF	$8.00	$447,829
08	CIP Slab on Grade	397	CY	$250.00	$99,250
09	CIP Retaining Wall	1250	CY	$450.00	$562,500
10	CIP Grade Beam	155	CY	$450.00	$69,750
11	CIP Piers and Footings	135	CY	$500.00	$67,500
12	CIP Container Base Slab	1418	CY	$350.00	$496,300
13	Sump and Discharge Piping	4	EA	$22,000.00	$88,000
14	Drain Tile	2000	LF	$12.00	$24,000
15	Dimple Mat	49200	SF	$2.00	$98,400
05	ABOVE GRADE $4,745,000				
Includes Sub-tier contractor OH&P 15%	$619,000				
01	Metal Deck 18 Ga	60500	SF	$1.60	$96,800
02	Purlins	144	Tons	$2,200.00	$316,800
03	Trusses	155	Tons	$2,200.00	$341,000
04	Truss Bracing	3.7	Tons	$2,200.00	$8,140
05	High Bay Columns	82.40506329	Tons	$2,200.00	$181,291
06	Grits	43.94936709	Tons	$2,200.00	$96,689
07	Stairs	2	Ea	$49,000.00	$98,000
08	Wind Bracing	3.139240506	Tons	$2,200.00	$6,906
09	Misc Steel	5	Tons	$2,200.00	$11,000
10	4 Ply Built-up Roofing	60500	SF	$2.10	$127,050
11	Insulation 3"	60500	SF	$0.75	$45,375
12	Prefinished Metal Siding	77853.16456	SF	$12.00	$934,238
13	Overhead Door 12' wide x 14' high	2	EA	$14,000.00	$28,000
14	Overhead Door 12' wide x 12' high	1	EA	$8,000.00	$8,000
15	Personnel Door	6	EA	$800.00	$4,800
16	Interior Partitions and finishes	1	Lot	$80,000.00	$80,000
17	Extinguisher agent (200lb container)	2	EA	$7,250.00	$14,500
18	Dispersion Nozzle and Piping	8	EA	$3,500.00	$28,000
19	Control Release Panel	1	EA	$3,250.00	$3,250
20	Detection Wiring	8	EA	$650.00	$5,200
21	Emergency Release / Abort Button	4	EA	$250.00	$1,000

FERMILAB: FESS COST ESTIMATE

Project Title:		Project No.	Status:	Date:	Revision Date:
Variation 2 - 68' above grade, 62' foot below grade		6-2-22	PDR	4/25/03	
ITEM NO.	DESCRIPTION OF WORK:	QUANTITY	UNITS	UNIT COST	AMOUNT
22	Ventilation (Roof Exhaust)	1	Lot	$110,000.00	$110,000
23	Heat Exchangers	2	EA	$35,000.00	$70,000
24	HX Installation	1	Lot	$27,000.00	$27,000
25	Tower Pumps	2	EA	$12,000.00	$24,000
26	Piping Installation (minimal)	1	Lot	$130,000.00	$130,000
27	Structural pipe hangers	1	Lot	$24,000.00	$24,000
28	Starter or VFD	4	EA	$20,000.00	$80,000
29	Electrical to Pumps	1	Lot	$12,000.00	$12,000
30	Allowance for controls	1	Lot	$17,000.00	$17,000
31	Flushing, Testing, and Balancing	1	Lot	$8,000.00	$8,000
32	Cooling Tower	1	Ea	$80,000.00	$80,000
33	Toilet Room Fixtures	1	Lot	$4,000.00	$4,000
34	HW Heater	1	Ea	$800.00	$800
35	Fire Pump 100psi @ 1,500 GPM	1	Lot	$75,000.00	$75,000
36	2-Risers	1	Lot	$15,000.00	$15,000
37	In-Rack (Detector Sprinklers)	23000	SF	$6.25	$143,750
38	Sprinklers	60500	SF	$3.00	$181,500
39	50 KVA transformers	4	EA	$2,400.00	$9,600
40	2000 A switchboard	2	EA	$15,400.00	$30,800
41	1200 Amp Panels	4	EA	$3,800.00	$15,200
42	800 Amp Panes	4	EA	$3,200.00	$12,800
43	400 Amp Panels	4	EA	$2,900.00	$11,600
44	225 Amp Panels	4	EA	$2,100.00	$8,400
45	750 MCM THWN Copper 4/c	200	LF	$23.00	$4,600
46	Welding outlets	8	EA	$420.00	$3,360
47	Power Distribution	60500	SF	$5.00	$302,500
48	Unit Heaters	36	EA	$2,000.00	$72,000
49	Lighting	60500	SF	$1.33	$80,465
50	Fire Detection	60500	SF	$2.25	$136,125
06	PERMITS, FEES, PS $7,391,000				
	Bare Construction Costs $13,188,000				
01	Environmental Impact Studies & Mitigation	$13,188,000	%	1%	$132,000
02	Engineering Design, Inspection and Administration	$13,320,000	%	20%	$2,664,000
03	Management Reserve	$15,984,000	%	25%	$3,996,000
04	Indirect Costs	$19,980,000	%	3%	$599,000

Depth/Height Variation 3 – 17' Deep Detector Pit:

FERMILAB: FESS COST ESTIMATE

Project Title:		Project No.	Status:	Date:	Revision Date:
Variation 3 - 113' above grade, 17' foot below grade		**6-2-22**	**PDR**	4/25/03	
ITEM NO.	DESCRIPTION OF WORK:	QUANTITY	UNITS	UNIT COST	AMOUNT
01	**LAND ACQUISITION $0**				
01	Surface Land Costs				$0
02	Undeground Rights Costs				$0
03	Road Easements				$0
04	Utility Easements				$0
05	Public/Private Road Fees				$0
02	**GENERAL CONDITIONS $1,986,400**				
01	Percentage of Construction Costs	20%	%	$9,932,000	$1,986,400
03	**SITE WORK/INFRASTRUCTURE $1,515,000**				
	Includes Sub-tier contractor OH&P 15% $198,000				
01	Clear and Grub Entrance Road	0	Acres	$5,000.00	$0
02	Strip 1' of soil	0	CY	$5.00	$0
03	Entrance Road Base 1 mile x 30' x 18"	0	CY	$40.00	$0
04	Entrance Road Paving 1mile x 24' x 4"	0	SY	$7.50	$0
05	Access Road	1	LS	$4,500.00	$4,500
06	Site Power Pole Line	0	Mile	$181,500.00	$0
07	Communication Lines	1	Mile	$19,000.00	$19,000
08	Strip and grub	4	Acres	$5,000.00	$20,000
09	Site Grading	1	Acres	$15,000.00	$15,000
10	Gates and Fencing	1	LS	$18,805.00	$18,805
11	Sidewalks	1	LS	$6,938.00	$6,938
12	Construction Hardstands	0	SF	$3.10	$0
13	Electrical Substation (2000 kVA Transformer)	2	Each	$55,400.00	$110,800
14	Four Way Air Switch	1	Each	$26,000.00	$26,000
15	750 KW Diesel Generator	1	Each	$146,820.00	$146,820
16	Oil Containment	1	Lot	$20,000.00	$20,000
17	(2)-5" Electrical Ductbank in Concrete	150	LF	$80.00	$12,000
18	3-1/C 750 MCM Conductors	200	LF	$230.00	$46,000
19	Water Well (200' deep)	1	Lot	$25,800.00	$25,800
20	Water Storage (& Fire) Tank	1	Lot	$650,000.00	$650,000
21	Fire Protection Panel (in Building Estimate)				
22	Sanitary Sewage Holding Tank	1	Lot	$12,000.00	$12,000
23	Fire Underground Main	0	LF	$16.00	$0
24	Envir. Protection - silt fence	0	LF	$4.00	$0
25	Mine Water Treatment w chemicals	0	Lot	$500,000.00	$0
26	Settling basin 1/2 acre	0	Lot	$90,000.00	$0
27	Hydrant + PIV's	0	Lot	$3,000.00	$0
28	DWS 3"	0	LF	$8.00	$0
29	Storm Sewer	1	LS	$152,416.00	$152,416
30	Exterior Lighting	1	LS	$31,000.00	$31,000

FERMILAB: FESS COST ESTIMATE

Project Title:		Project No.	Status:	Date:	Revision Date:
Variation 3 - 113' above grade, 17' foot below grade		6-2-22	PDR	4/25/03	
ITEM NO.	DESCRIPTION OF WORK:	QUANTITY	UNITS	UNIT COST	AMOUNT
04	BELOW GRADE $2,221,000				
	Includes Sub-tier contractor OH&P 15% $290,000				
01	Excavate Overburden	36500	CY	$12.00	$438,000
02	Haul Overburden Spoils	36500	CY	$3.00	$109,500
03	Excavate Rock	0	CY	$38.00	$0
04	Haul Muck	0	CY	$3.00	$0
05	Rock Bolts 5'x5' pattern 10'LG	0	LF	$6.75	$0
06	Drainage Strips	0	LF	$8.00	$0
07	Shot Crete W/ WWF 4"	0	SF	$8.00	$0
08	CIP Slab on Grade	397	CY	$250.00	$99,250
09	CIP Retaining Wall	1250	CY	$450.00	$562,500
10	CIP Grade Beam	155	CY	$450.00	$69,750
11	CIP Piers and Footings	135	CY	$500.00	$67,500
12	CIP Container Base Slab	1418	CY	$350.00	$496,300
13	Sump and Discharge Piping	4	EA	$22,000.00	$88,000
14	Drain Tile	0	LF	$12.00	$0
15	Dimple Mat	0	SF	$2.00	$0
05	ABOVE GRADE $6,196,000				
	Includes Sub-tier contractor OH&P 15% $808,000				
01	Metal Deck 18 Ga	60500	SF	$1.60	$96,800
02	Purlins	144	Tons	$2,200.00	$316,800
03	Trusses	155	Tons	$2,200.00	$341,000
04	Truss Bracing	3.7	Tons	$2,200.00	$8,140
05	High Bay Columns	225.2848101	Tons	$2,200.00	$495,627
06	Grits	120.1518987	Tons	$2,200.00	$264,334
07	Stairs	2	Ea	$49,000.00	$98,000
08	Wind Bracing	8.582278481	Tons	$2,200.00	$18,881
09	Misc Steel	5	Tons	$2,200.00	$11,000
10	4 Ply Built-up Roofing	60500	SF	$2.10	$127,050
11	Insul 3"	60500	SF	$0.75	$45,375
12	Prefinished Metal Siding	141893.6709	SF	$12.00	$1,702,724
13	Overhead Door 12' wide x 14' high	2	EA	$14,000.00	$28,000
14	Overhead Door 12' wide x 12' high	1	EA	$8,000.00	$8,000
15	Personnel Door	6	EA	$800.00	$4,800
16	Interior Partitions and finishes	1	Lot	$80,000.00	$80,000
17	Extinguisher agent (200lb container)	2	EA	$7,250.00	$14,500
18	Dispersion Nozzle and Piping	8	EA	$3,500.00	$28,000
19	Control Release Panel	1	EA	$3,250.00	$3,250
20	Detection Wiring	8	EA	$650.00	$5,200
21	Emergency Release / Abort Button	4	EA	$250.00	$1,000
22	Ventilation (Roof Exhaust)	1	Lot	$110,000.00	$110,000
23	Heat Exchangers	2	EA	$35,000.00	$70,000
24	HX Installation	1	Lot	$27,000.00	$27,000
25	Tower Pumps	2	EA	$12,000.00	$24,000

FERMILAB: FESS COST ESTIMATE

Project Title:		Project No.	Status:	Date:	Revision Date:
Variation 3 - 113' above grade, 17' foot below grade		**6-2-22**	**PDR**	4/25/03	
ITEM NO.	DESCRIPTION OF WORK:	QUANTITY	UNITS	UNIT COST	AMOUNT
26	Piping Installation (minimal)	1	Lot	$130,000.00	$130,000
27	Structural pipe hangers	1	Lot	$24,000.00	$24,000
28	Starter or VFD	4	EA	$20,000.00	$80,000
29	Electrical to Pumps	1	Lot	$12,000.00	$12,000
30	Allowance for controls	1	Lot	$17,000.00	$17,000
31	Flushing, Testing, and Balancing	1	Lot	$8,000.00	$8,000
32	Cooling Tower	1	Ea	$80,000.00	$80,000
33	Toilet Room Fixtures	1	Lot	$4,000.00	$4,000
34	HW Heater	1	Ea	$800.00	$800
35	Fire Pump 100psi @ 1,500 GPM	1	Lot	$75,000.00	$75,000
36	2-Risers	1	Lot	$15,000.00	$15,000
37	In-Rack (Detector Sprinklers)	23000	SF	$6.25	$143,750
38	Sprinklers	60500	SF	$3.00	$181,500
39	50 KVA transformers	4	EA	$2,400.00	$9,600
40	2000 A switchboard	2	EA	$15,400.00	$30,800
41	1200 Amp Panels	4	EA	$3,800.00	$15,200
42	800 Amp Panes	4	EA	$3,200.00	$12,800
43	400 Amp Panels	4	EA	$2,900.00	$11,600
44	225 Amp Panels	4	EA	$2,100.00	$8,400
45	750 MCM THWN Copper 4/c	200	LF	$23.00	$4,600
46	Welding outlets	8	EA	$420.00	$3,360
47	Power Distribution	60500	SF	$5.00	$302,500
48	Unit Heaters	36	EA	$2,000.00	$72,000
49	Lighting	60500	SF	$1.33	$80,465
50	Fire Detection	60500	SF	$2.25	$136,125
06	**PERMITS, FEES, PS** **$5,565,000**				
	Bare Construction Costs $9,932,000				
01	Environmental Impact Studies & Mitigation	$9,932,000	%	1%	$99,000
02	Engineering Design, Inspection and Administration	$10,031,000	%	20%	$2,006,000
03	Management Reserve	$12,037,000	%	25%	$3,009,000
04	Indirect Costs	$15,046,000	%	3%	$451,000

APPENDIX F — Off-Axis Detector Enclosure

This appendix provides a comparison between the University of Minnesota (UofM) design with a surface building housing a similar sized detector and focuses only on the building enclosure costs.

The UofM developed a cost estimate for an off-axis detector enclosure based on the following criteria:

- Detector Pit is 328' long x 66' wide x 72' below grade;
- Internal detector preparation area;
- Above grade building with 0' of earth shielding;
- Loading dock with adjacent ramp;
- Bridge Crane;
- Office/receiving space;

Figure 6 on the "Off-Axis NuMI Neutrino Detector" report, dated January 2003 estimates the cost of such a building at $16.8 million dollars.

Listed below are the assumptions for this comparison study:

- Detector pit is 328' long x 66' wide x 17' below grade;
- No shielding is provided;
- Steel-framed, metal sided building;
- Rubber tire gantry crane (cost of crane not included);
- Staging and Support Bays similar to base design.

The estimated cost for a surface building housing a similar sized detector to the UofM building is shown below:

	SIMILAR SIZE
Land Acquisition	$0
General Conditions	$1,296,000
Site Work	$998,000
Below Grade	$1,835,000
Above Grade	$3,648,000
Environmental	$65,000
Construction Subtotal	$7,842,000
EDIA	$1,309,000
Management Reserve	$1,964,000
Indirect Costs	$295,000
PROJECT TOTAL	**$11,410,000**

While no Work Breakdown Structure (WBS) was provided with the surface building, a review of the WBS Comparison contained in Figure 6 of the UofM report indicate that the UofM design includes an access ramp to some point below grade. The comparison estimate assumes an at grade access.

The UofM cost estimate assumed a building envelope of “masonry/precast concrete wall system” while the comparison estimate assumed an envelope of prefinished metal siding.

The significant differences in the two costs estimates appears to be result of access location (at-grade compared to below-grade) and the selection of the building envelope.

While this comparison can provide input for project planning, the actual cost of the project will be influenced by many factors including project locations, subsurface conditions, excavation methods, design complexity and economic conditions at the time of bidding. The cost comparison studies are not developed designs and significant refinement is required to verify the costs. The results of these cost variations studies should not replace sound engineering judgment and common sense.

The following pages contain the detailed cost estimate for the design described above:

FERMILAB: FESS COST ESTIMATE

Project Title:		Project No.	Status:	Date:	Revision Date:
	Off Axis Detector - Comparison to UofM Design	**6-2-22**	**PDR**	4/25/03	5/16/03
ITEM NO	DESCRIPTION OF WORK:	QUANTITY	UNITS	UNIT COST	AMOUNT
01	**LAND ACQUISITION $0**				
01	Surface Land Costs				$0
02	Undeground Rights Costs				$0
03	Road Easements				$0
04	Utility Easements				$0
05	Public/Private Road Fees				$0
02	**GENERAL CONDITIONS $1,296,200**				
01	Percentage of Construction Costs	20%	%	$6,481,000	$1,296,200
03	**SITE WORK/INFRASTRUCTURE $998,000**				
	Includes Sub-tier contractor OH&P 15% $130,000				
01	Clear and Grub Entrance Road	0	Acres	$5,000.00	$0
02	Strip 1' of soil	0	CY	$5.00	$0
03	Entrance Road Base 1 mile x 30' x 18"	0	CY	$40.00	$0
04	Entrance Road Paving 1mile x 24' x 4"	0	SY	$7.50	$0
05	Access Road	1	LS	$4,500.00	$4,500
06	Site Power Pole Line	0	Mile	$181,500.00	$0
07	Communication Lines	1	Mile	$19,000.00	$19,000
08	Strip and grub	4	Acres	$5,000.00	$20,000
09	Site Grading	1	Acres	$15,000.00	$15,000
10	Gates and Fencing	1	LS	$18,805.00	$18,805
11	Sidewalks	1	LS	$6,938.00	$6,938
12	Construction Hardstands	0	SF	$3.10	$0
13	Electrical Substation (2000 kVA Transformer)	1	Each	$55,400.00	$55,400
14	Four Way Air Switch	1	Each	$26,000.00	$26,000
15	500 KW Diesel Generator	1	Each	$96,000.00	$96,000
16	Oil Containment	1	Lot	$20,000.00	$20,000
17	(2)-5" Electrical Ductbank in Concrete	150	LF	$80.00	$12,000
18	3-1/C 750 MCM Conductors	100	LF	$230.00	$23,000
19	Water Well (200' deep)	1	Lot	$25,800.00	$25,800
20	Water Storage (& Fire) Tank	1	Lot	$330,000.00	$330,000
21	Fire Protection Panel (in Building Estimate)				
22	Sanitary Sewage Holding Tank	1	Lot	$12,000.00	$12,000
23	Fire Underground Main	0	LF	$16.00	$0
24	Envir. Protection - silt fence	0	LF	$4.00	$0
25	Mine Water Treatment w chemicals	0	Lot	$500,000.00	$0
26	Settling basin 1/2 acre	0	Lot	$90,000.00	$0
27	Hydrant + PIV's	0	Lot	$3,000.00	$0
28	DWS 3"	0	LF	$8.00	$0
29	Storm Sewer	1	LS	$152,416.00	$152,416
30	Exterior Lighting	1	LS	$31,000.00	$31,000

FERMILAB: FESS COST ESTIMATE

Project Title:		Project No.	Status:	Date:	Revision Date:
Off Axis Detector - Comparison to UofM Design		6-2-22	PDR	4/25/03	5/16/03
ITEM NO.	DESCRIPTION OF WORK:	QUANTITY	UNITS	UNIT COST	AMOUNT
04	**BELOW GRADE $1,835,000**				
	Includes Sub-tier contractor OH&P 15% $239,000				
01	Excavate Overburden	30800	CY	$12.00	$369,600
02	Haul Overburden Spoils	30800	CY	$3.00	$92,400
03	Excavate Rock	0	CY	$38.00	$0
04	Haul Muck	0	CY	$3.00	$0
05	Rock Bolts 5'x5' pattern 10'LG	0	LF	$6.75	$0
06	Drainage Strips	0	LF	$8.00	$0
07	Shot Crete W/ WWF 4"	0	SF	$8.00	$0
08	CIP Slab on Grade	192	CY	$250.00	$48,000
09	CIP Retaining Wall	1048	CY	$450.00	$471,600
10	CIP Grade Beam	128	CY	$450.00	$57,600
11	CIP Piers and Footings	135	CY	$500.00	$67,500
12	CIP Lower Base Slab	991	CY	$350.00	$346,850
13	Sump and Discharge Piping	4	EA	$22,000.00	$88,000
14	Drain Tile	1000	LF	$12.00	$12,000
15	Dimple Mat	21300	SF	$2.00	$42,600
05	**ABOVE GRADE $3,648,000**				
	Includes Sub-tier contractor OH&P 15% $476,000				
01	Metal Deck 18 Ga	35020	SF	$1.60	$56,032
02	Purlins	84	Tons	$2,200.00	$184,800
03	Trusses	90	Tons	$2,200.00	$198,000
04	Truss Bracing	2.1	Tons	$2,200.00	$4,620
05	High Bay Columns	87	Tons	$2,200.00	$191,400
06	Girts	45	Tons	$2,200.00	$99,000
07	Stairs	2	Ea	$41,000.00	$82,000
08	Wind Bracing	3	Tons	$2,200.00	$6,600
09	Misc Steel	4	Tons	$2,200.00	$8,800
10	4 Ply Built-up Roofing	35020	SF	$2.10	$73,542
11	Insulation 3"	35020	SF	$0.75	$26,265
12	Prefinished Metal Siding	77500	SF	$12.00	$930,000
13	Overhead Door 12' wide x 14' high	2	EA	$14,000.00	$28,000
14	Overhead Door 12' wide x 12' high	1	EA	$8,000.00	$8,000
15	Personnel Doors	6	EA	$800.00	$4,800
16	Interior Partitions and finishes	1	Lot	$65,000.00	$65,000
17	Extinguisher agent (200lb container)	2	EA	$7,250.00	$14,500
18	Dispersion Nozzle and Piping	8	EA	$3,500.00	$28,000
19	Control Release Panel	1	EA	$3,250.00	$3,250
20	Detection Wiring	8	EA	$650.00	$5,200
21	Emergency Release / Abort Button	4	EA	$250.00	$1,000
22	Ventilation (Roof Exhaust)	1	Lot	$75,000.00	$75,000
23	Heat Exchangers	1	EA	$35,000.00	$35,000
24	HX Installation	1	Lot	$13,000.00	$13,000
25	Tower Pumps	2	EA	$12,000.00	$24,000

FERMILAB: FESS COST ESTIMATE

Project Title:		Project No.	Status:	Date:	Revision Date:
Off Axis Detector - Comparison to UofM Design		**6-2-22**	**PDR**	4/25/03	5/16/03
ITEM NO.	DESCRIPTION OF WORK:	QUANTITY	UNITS	UNIT COST	AMOUNT
26	Piping Installation (minimal)	1	Lot	$110,000.00	$110,000
27	Structural pipe hangers	1	Lot	$18,000.00	$18,000
28	Starter or VFD	2	EA	$20,000.00	$40,000
29	Electrical to Pumps	1	Lot	$8,000.00	$8,000
30	Allowance for controls	1	Lot	$17,000.00	$17,000
31	Flushing, Testing, and Balancing	1	Lot	$6,000.00	$6,000
32	Cooling Tower	1	Ea	$60,000.00	$60,000
33	Toilet Room Fixtures	1	Lot	$4,000.00	$4,000
34	HW Heater	1	Ea	$800.00	$800
35	Fire Pump 100psi @ 1,500 GPM	1	Lot	$75,000.00	$75,000
36	2-Risers	1	Lot	$12,000.00	$12,000
37	In-Rack (Detector Sprinklers)	23000	SF	$6.25	$143,750
38	Sprinklers	35020	SF	$3.00	$105,060
39	50 KVA transformers	2	EA	$2,400.00	$4,800
40	2000 A switchboard	1	EA	$15,400.00	$15,400
41	1200 Amp Panels	2	EA	$3,800.00	$7,600
42	800 Amp Panes	2	EA	$3,200.00	$6,400
43	400 Amp Panels	2	EA	$2,900.00	$5,800
44	225 Amp Panels	2	EA	$2,100.00	$4,200
45	750 MCM THWN Copper 4/c	150	LF	$23.00	$3,450
46	Welding outlets	6	EA	$420.00	$2,520
47	Power Distribution	35020	SF	$5.00	$175,100
48	Unit Heaters	28	EA	$2,000.00	$56,000
49	Lighting	35020	SF	$1.33	$46,577
50	Fire Detection	35020	SF	$2.25	$78,795
06	**PERMITS, FEES, PS** **$3,633,000**				
	Bare Construction Costs $6,481,000				
01	Environmental Impact Studies & Mitigation	$6,481,000	%	1%	$65,000
02	Engineering Design, Inspection and Administration	$6,546,000	%	20%	$1,309,000
03	Management Reserve	$7,855,000	%	25%	$1,964,000
04	Indirect Costs	$9,819,000	%	3%	$295,000