50% Conceptual Design Review

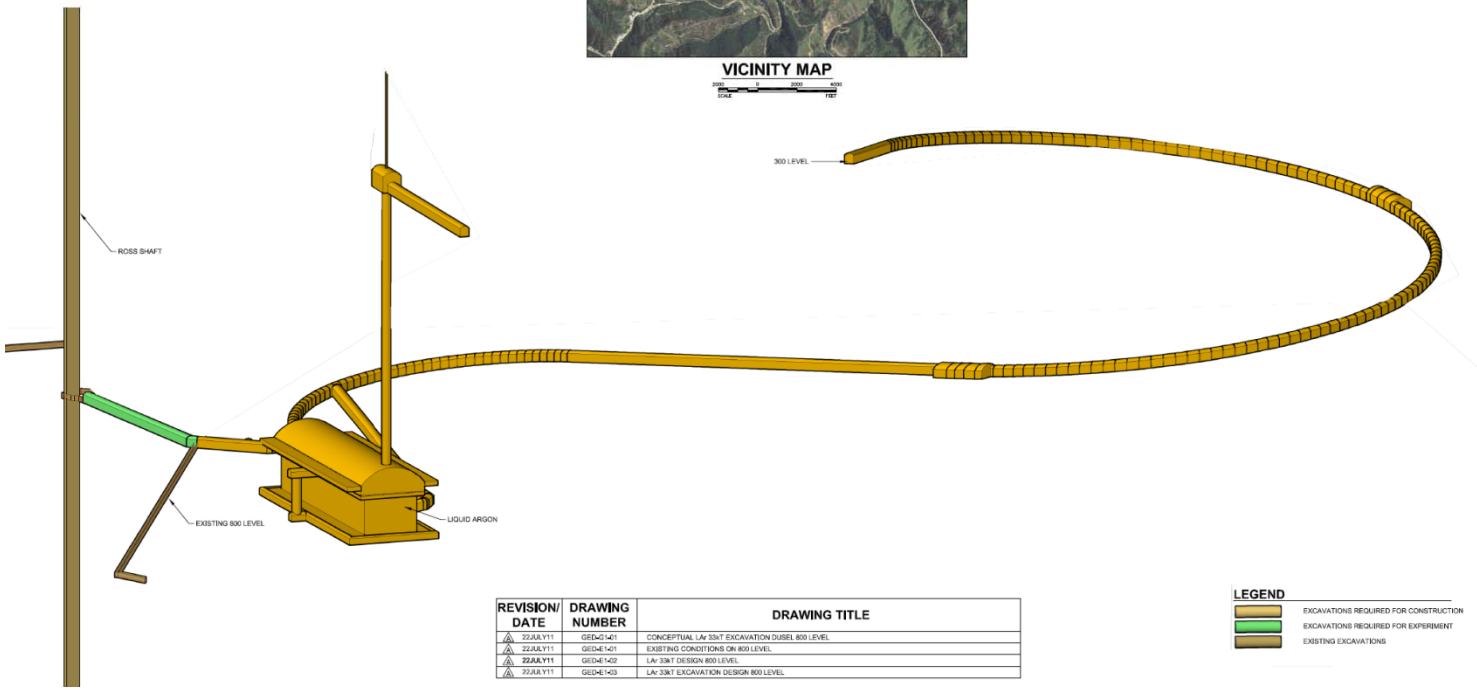
33 kT Liquid Argon Detector Excavation

Outline

- Overview of 33 kT LAr Layout
- Generalized Development Sequence
- 33 kT LAr Excavation Sequence
- Ground Support & Stability Modeling
- Veto Tube Excavation Method
- Changes for 90%
  - Shift cavern west for 690 feet rock cover
  - Relocate portals
  - 20 meter wide septum
  - Veto tube access
  - Other

33 kT LAr Layout

VICINITY MAP

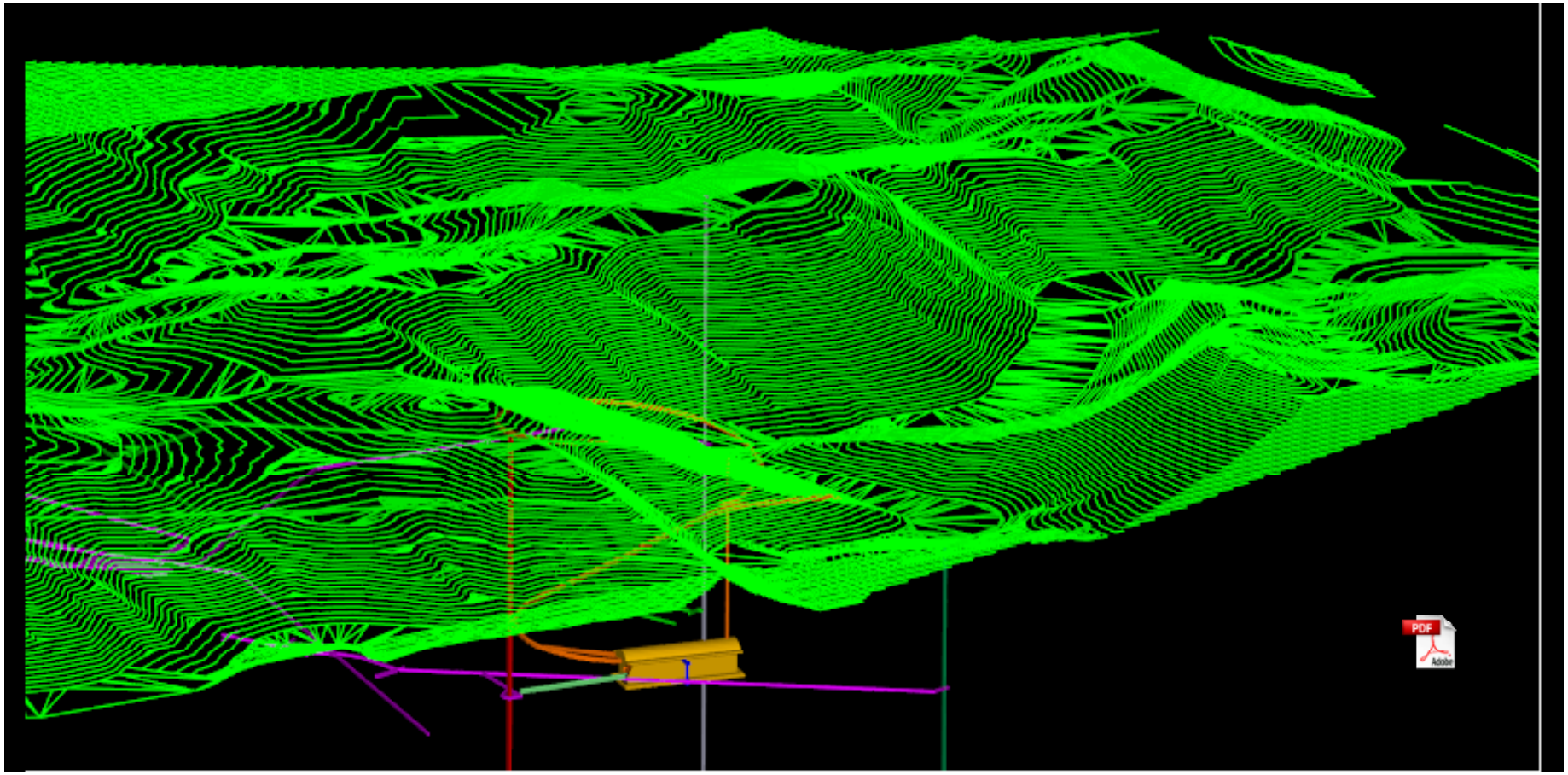


REVISION/ DATE	DRAWING NUMBER	DRAWING TITLE
22JULY11	GED-D1-01	CONCEPTUAL LAr 33kT EXCAVATION DUSEL 800 LEVEL
22JULY11	GED-E1-01	EXISTING CONDITIONS ON 800 LEVEL
22JULY11	GED-E1-02	LAr 33kT DESIGN 800 LEVEL
22JULY11	GED-E1-03	LAr 33kT EXCAVATION DESIGN 800 LEVEL

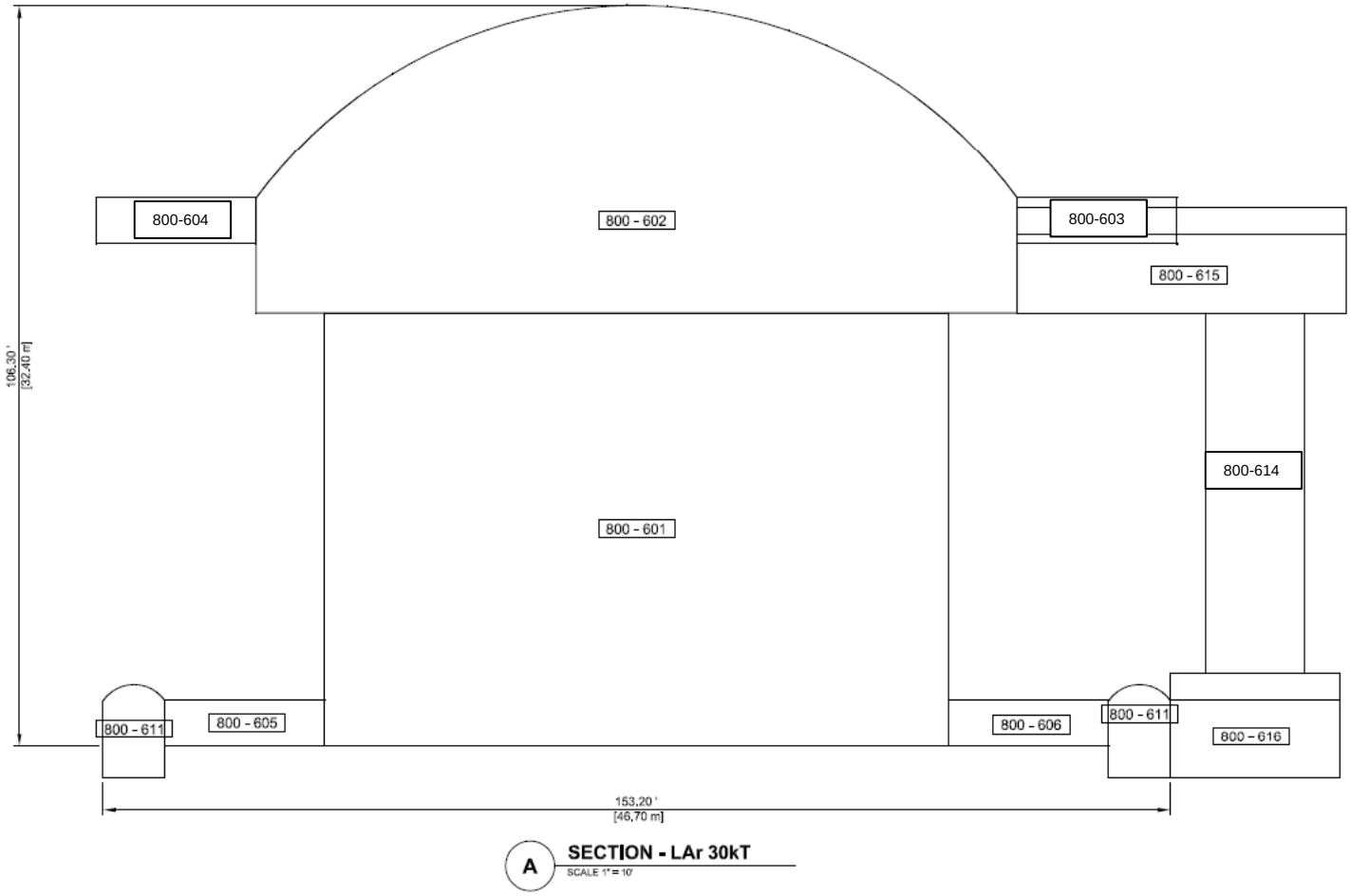
LEGEND

- EXCAVATIONS REQUIRED FOR CONSTRUCTION
- EXCAVATIONS REQUIRED FOR EXPERIMENT
- EXISTING EXCAVATIONS

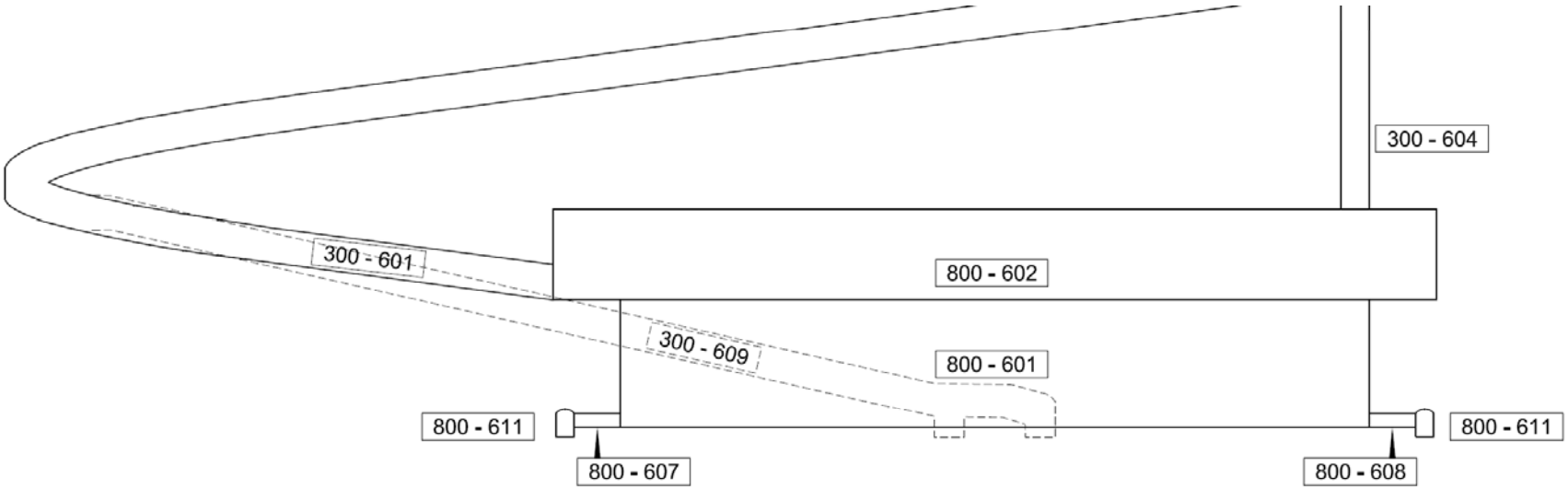
33 kT LAr Layout – 3D pdf demo



33 kT LAr Layout



33 kT LAr Layout



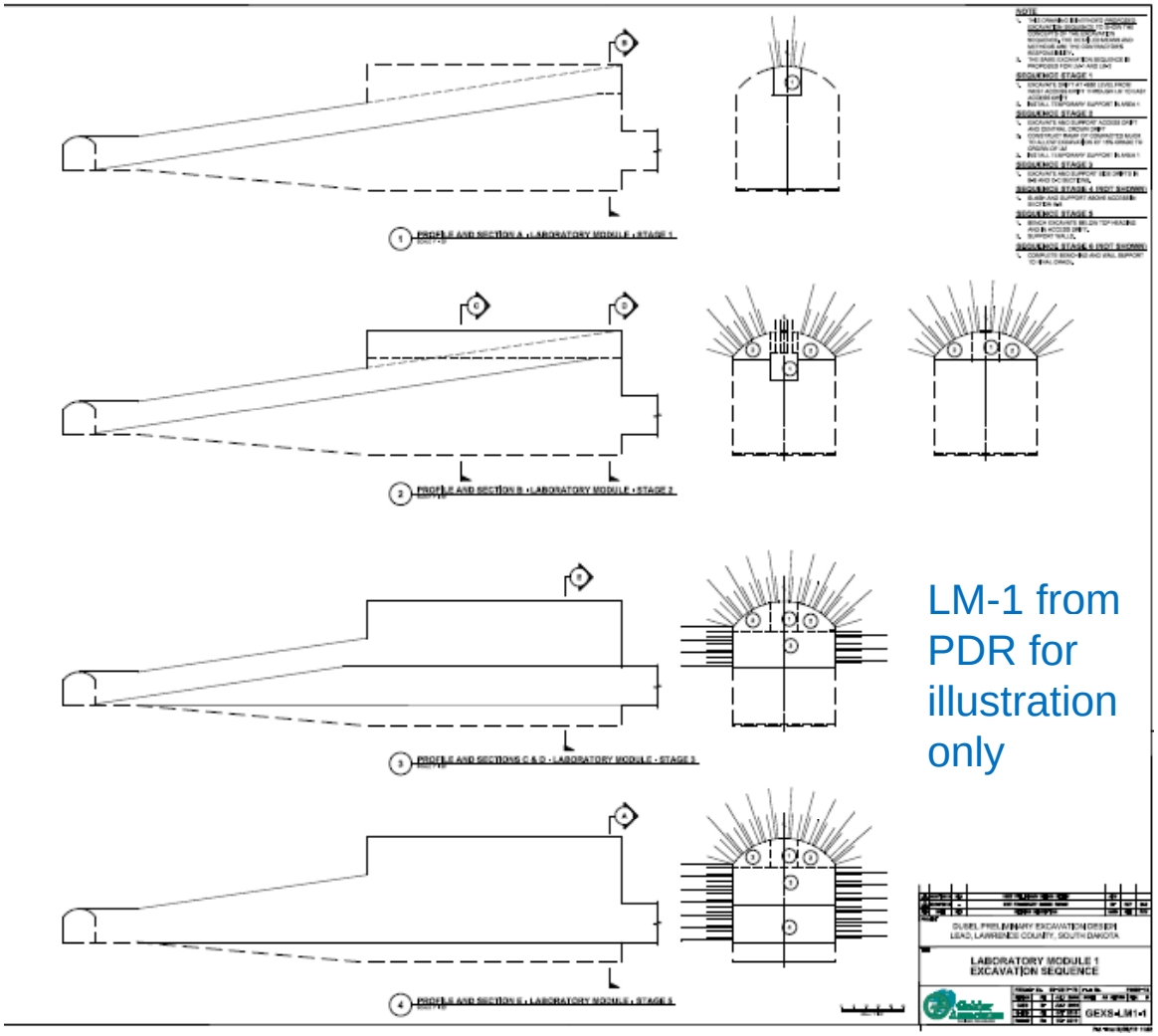
General Excavation Sequence

- Ross Shaft access
- Access ramp from portal
- 300 Level access drift and raise bore chamber
- Upper cavern crown excavate/support
- Raise bore
- Upper veto tubes
- Excavate tank
  - 5 meter benches
  - Work in sections
- Lower veto tubes

33 kT LAr Excavation Sequence

Sequence similar to PDR Lab Modules:

- Excavate center of crown
- Slash crown to full width
- Bench down into tank
- Excavate for veto tubes from bench



LM-1 from PDR for illustration only

Veto Tube Excavation option

- Water jet technology available

Veto Tube Excavation option

- Water jet technology available

Veto Tube Excavation option

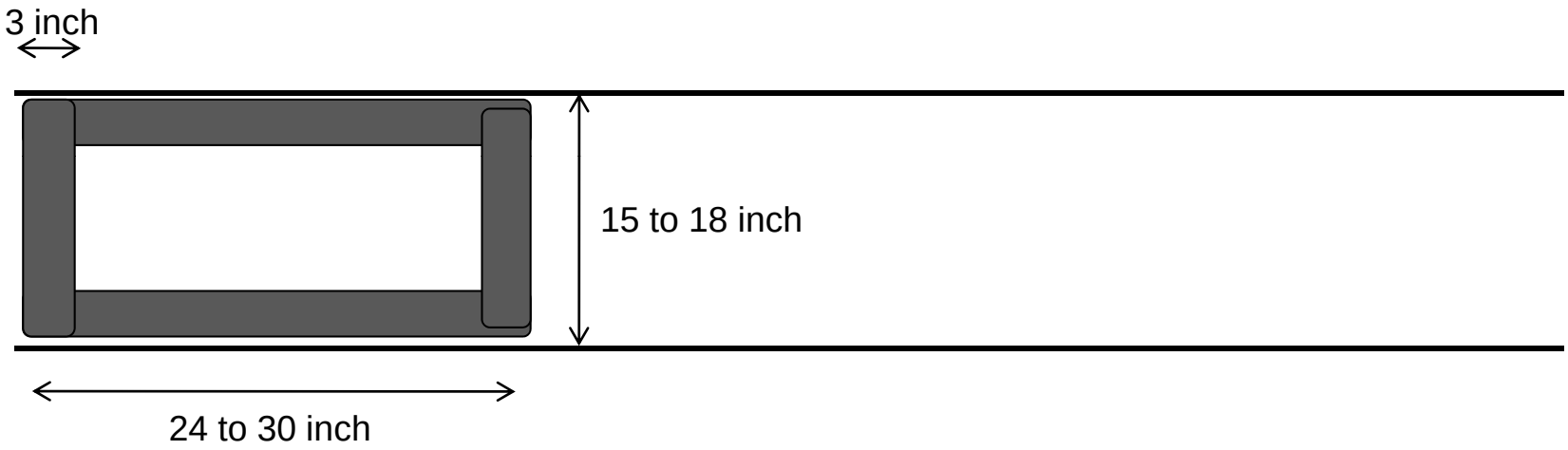
- Water jet technology available

Veto Tube Excavation option

- Water jet technology available

Veto Tube Excavation option

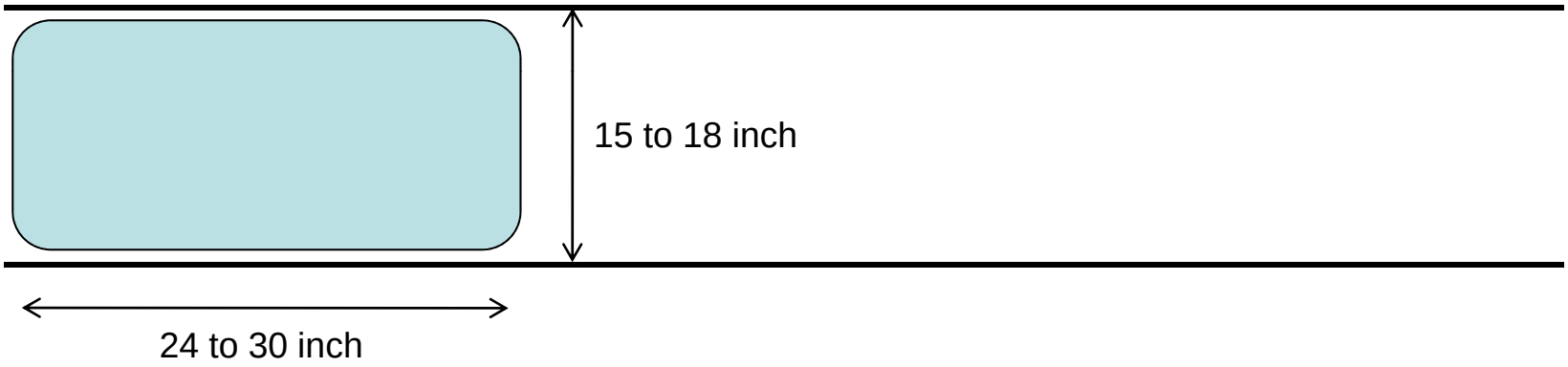
- Veto tube excavation sequence
  - Cut slots around block with water jet



Veto Tube Excavation option

Veto Tube Excavation option

- Veto tube excavation sequence
  - Remove block

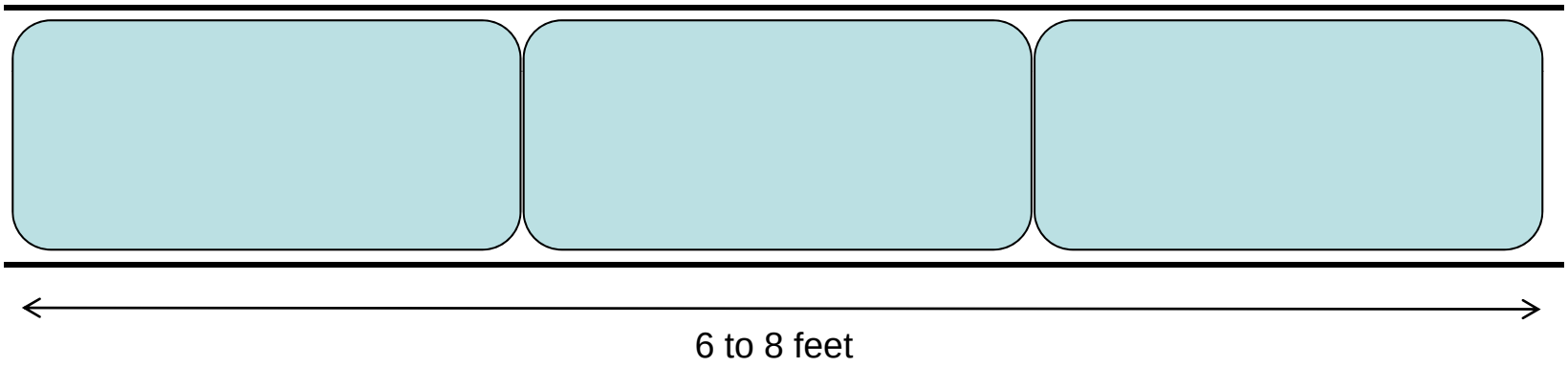


Veto Tube Excavation option

- Veto tube excavation sequence
  - Cut slots and remove next block

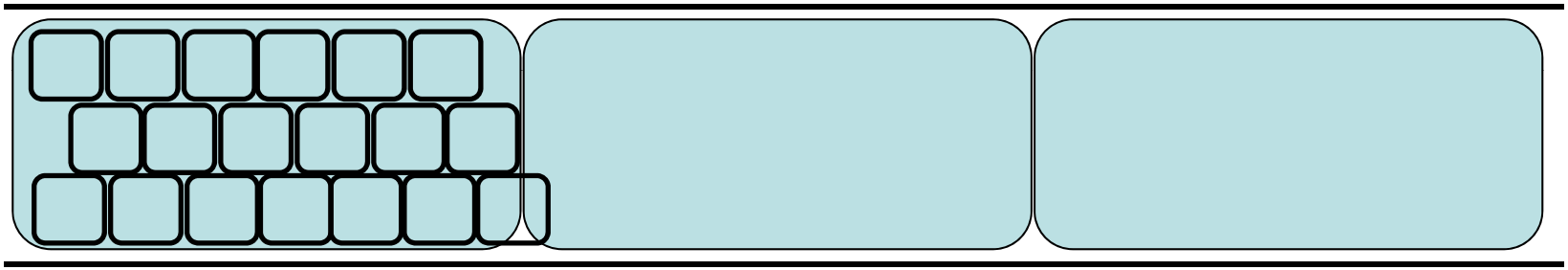
Veto Tube Excavation option

- Veto tube excavation sequence
  - Remove third block



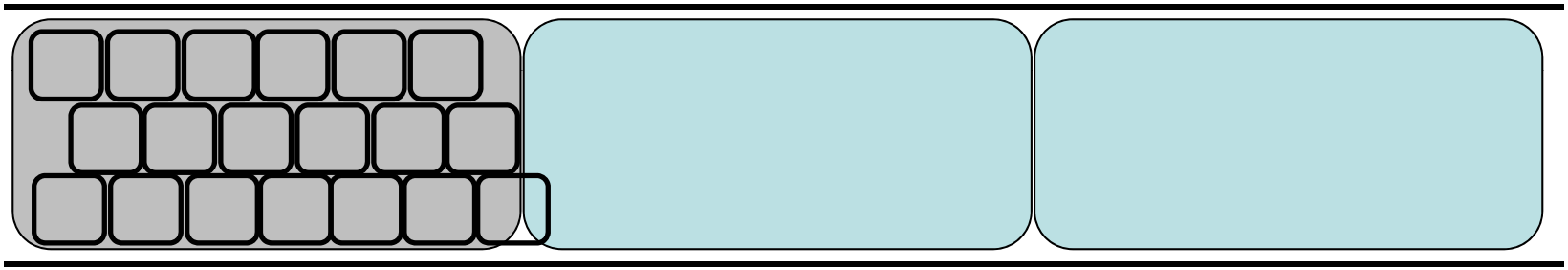
Veto Tube Excavation option

- Veto tube excavation sequence
  - Install steel tubes



Veto Tube Excavation option

- Veto tube excavation sequence
  - Grout tubes in place



Ground Support

- LAr Excavation
  - 7m, 50T cable bolts, 2.5m centers
  - 3m, 20T resin bolts, 1.25m centers
  - 100mm mesh
  - 100mm shotcrete
- Access Ramp and Drifts
  - 3m resin bolts, 1.5m centers
  - 75mm shotcrete
- Utility shaft
  - 100 mm fiber reinforced shotcrete

Existing Conditions on 800 Level

Existing Conditions on 800 Level

EMPIRICAL DESIGN OF LAr CAVERN ROOF SUPPORT – NGI-Q NORTH-WESTERN FORMATION

FIGURE 6.1

	Excavation Category	*ESR*
A	Temporary mine openings	3–5
B	Permanent mine openings, water tunnels for hydro power (excluding high pressure penstocks), pilot tunnels, drifts and headings for large excavations.	1.6
C	Storage rooms, water treatment plants, minor road and railway tunnels, surge chambers, access tunnels.	1.3
D	Power stations, major road and railway tunnels, civil defense chambers, portal intersections.	1.0
E	Underground nuclear power stations, railway stations, sports and public facilities, factories.	0.8

$$D_e = \frac{\text{Excavation span, diameter or height (m)}}{\text{Excavation Support Ratio } (ESR)}$$

Bolt Length :

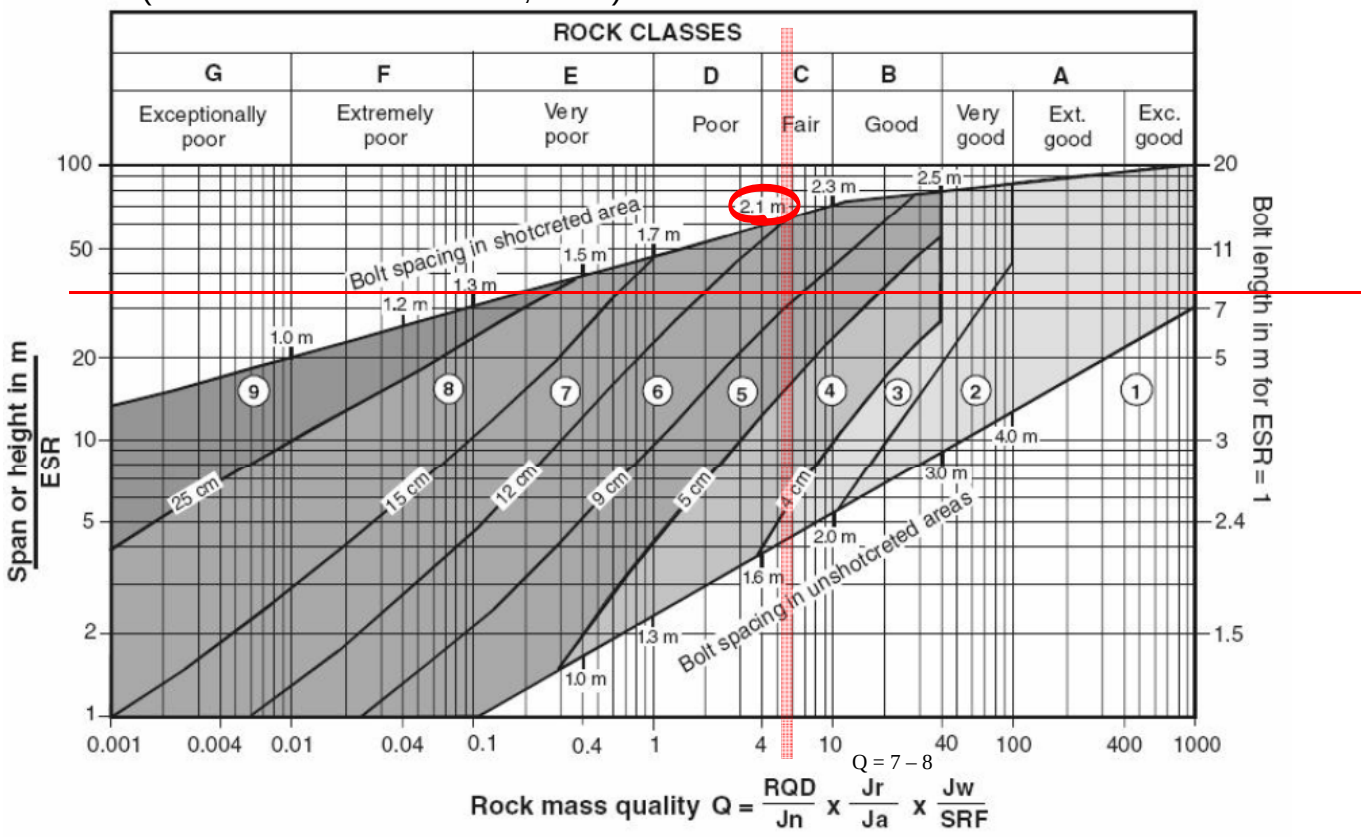
Grimstead and Barton (1993) :

$L = \frac{2 + 0.15B}{ESR}$, where B = excavation width

E. Hoek (Practical Rock Engineering)

$L = 0.4 \times \text{span}$

(After Grimstad and Barton, 1993)



REINFORCEMENT CATEGORIES:

1) Unsupported
2) Spot bolting
3) Systematic bolting
4) Systematic bolting, (and unreinforced shotcrete, 4 - 10 cm)
5) Fibre reinforced shotcrete and bolting, 5 - 9 cm
6) Fibre reinforced shotcrete and bolting, 9 - 12 cm
7) Fibre reinforced shotcrete and bolting, 12 - 15 cm
8) Fibre reinforced shotcrete, > 15 cm, reinforced ribs of shotcrete and bolting
9) Cast concrete lining

NGI-Q:

Q = 6.0 (RMR = 60)

Room Dimensions and Excavation Category:

Span : 33 m
ESR = 1.0 – D_e = 33 m
L_b = 7 m (Barton); L_b = 13 m (Hoek)

Room Support:

Bolts : 3 m long bolts @ 1.25 m c/c.
Cables: 7 m long cables @ 2.5 m c/c.
100 mm fibre reinforced shotcrete

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CHK: M.F. APD: R.P.

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EMPIRICAL DESIGN OF LAr CAVERN WALL SUPPORT – NGI-Q NORTH-WESTERN FORMATION

FIGURE 6.2

Excavation Category		*ESR*
A	Temporary mine openings	3–5
B	Permanent mine openings, water tunnels for hydro power (excluding high pressure penstocks), pilot tunnels, drifts and headings for large excavations.	1.6
C	Storage rooms, water treatment plants, minor road and railway tunnels, surge chambers, access tunnels.	1.3
D	Power stations, major road and railway tunnels, civil defense chambers, portal intersections.	1.0
E	Underground nuclear power stations, railway stations, sports and public facilities, factories.	0.8

$$D_e = \frac{\text{Excavation span, diameter or height (m)}}{\text{Excavation Support Ratio } (ESR)}$$

Bolt Length :

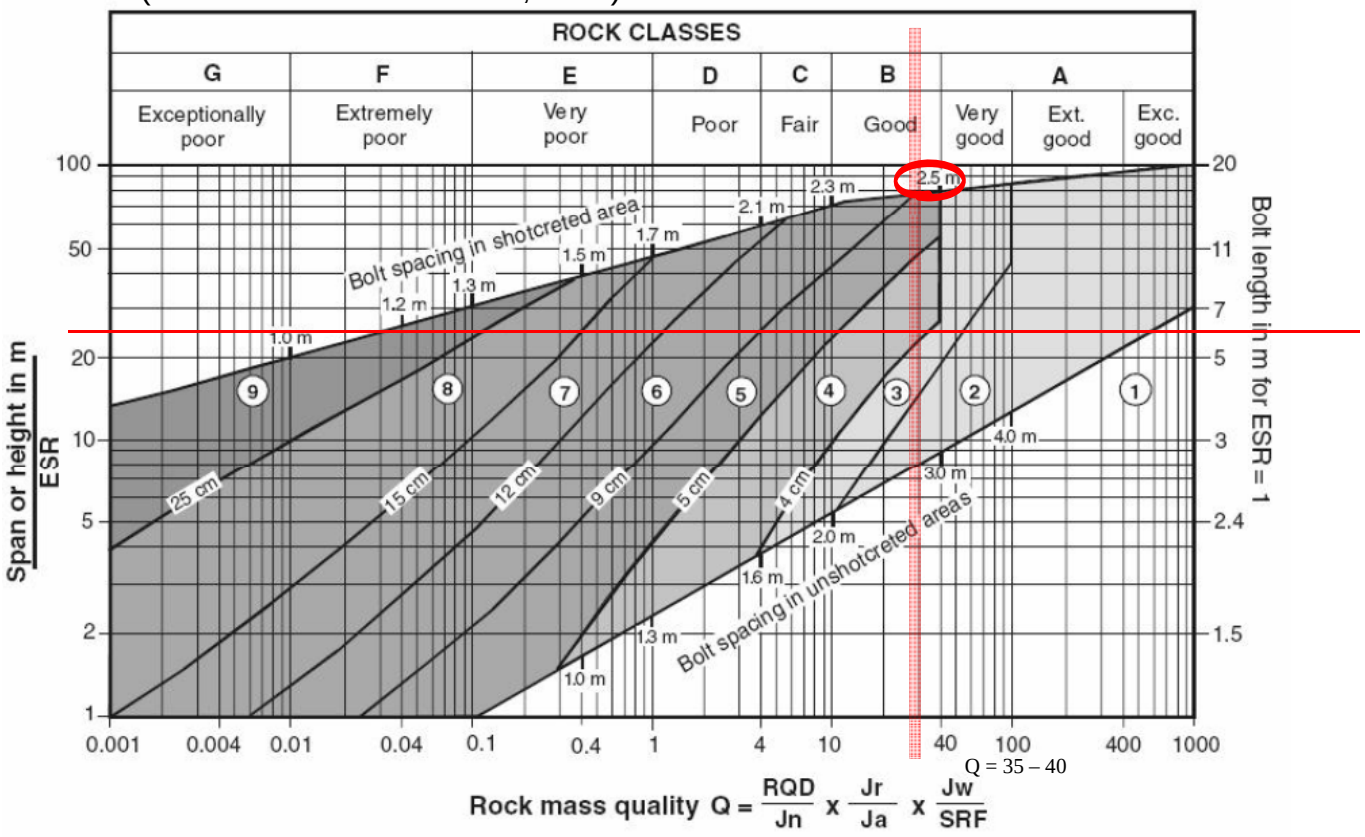
Grimstead and Barton (1993) :

$L = \frac{2 + 0.15B}{ESR}$, where B = excavation width

E. Hoek (Practical Rock Engineering)

$L = 0.4 \times \text{span}$

(After Grimstad and Barton, 1993)



REINFORCEMENT CATEGORIES:

1) Unsupported
2) Spot bolting
3) Systematic bolting
4) Systematic bolting, (and unreinforced shotcrete, 4 - 10 cm)
5) Fibre reinforced shotcrete and bolting, 5 - 9 cm
6) Fibre reinforced shotcrete and bolting, 9 - 12 cm
7) Fibre reinforced shotcrete and bolting, 12 - 15 cm
8) Fibre reinforced shotcrete, > 15 cm, reinforced ribs of shotcrete and bolting
9) Cast concrete lining

NGI-Q:

Q = 6.0 (RMR = 60)
Q_w = 5Q = 30

Room Dimensions and Excavation Category:

Wall Height : 24.5 m
ESR = 1.0 – D_e = 24.5 m
L_b = 5.7 m (Barton); L_b = 10 m (Hoek)

Room Support:

Bolts : 3 m long bolts @ 1.25 m c/c.
Cables: 7 m long cables @ 2.5 m c/c.
100 mm fibre reinforced shotcrete

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EMPIRICAL DESIGN 11.5 m DRIFT ENLARGEMENT
ROOF – NGI-Q
NORTH-WESTERN FORMATION

FIGURE 6.3

Excavation Category		*ESR*
A	Temporary mine openings	3–5
B	Permanent mine openings, water tunnels for hydro power (excluding high pressure penstocks), pilot tunnels, drifts and headings for large excavations.	1.6
C	Storage rooms, water treatment plants, minor road and railway tunnels, surge chambers, access tunnels.	1.3
D	Power stations, major road and railway tunnels, civil defense chambers, portal intersections.	1.0
E	Underground nuclear power stations, railway stations, sports and public facilities, factories.	0.8

$$D_e = \frac{\text{Excavation span, diameter or height (m)}}{\text{Excavation Support Ratio } (ESR)}$$

Bolt Length :

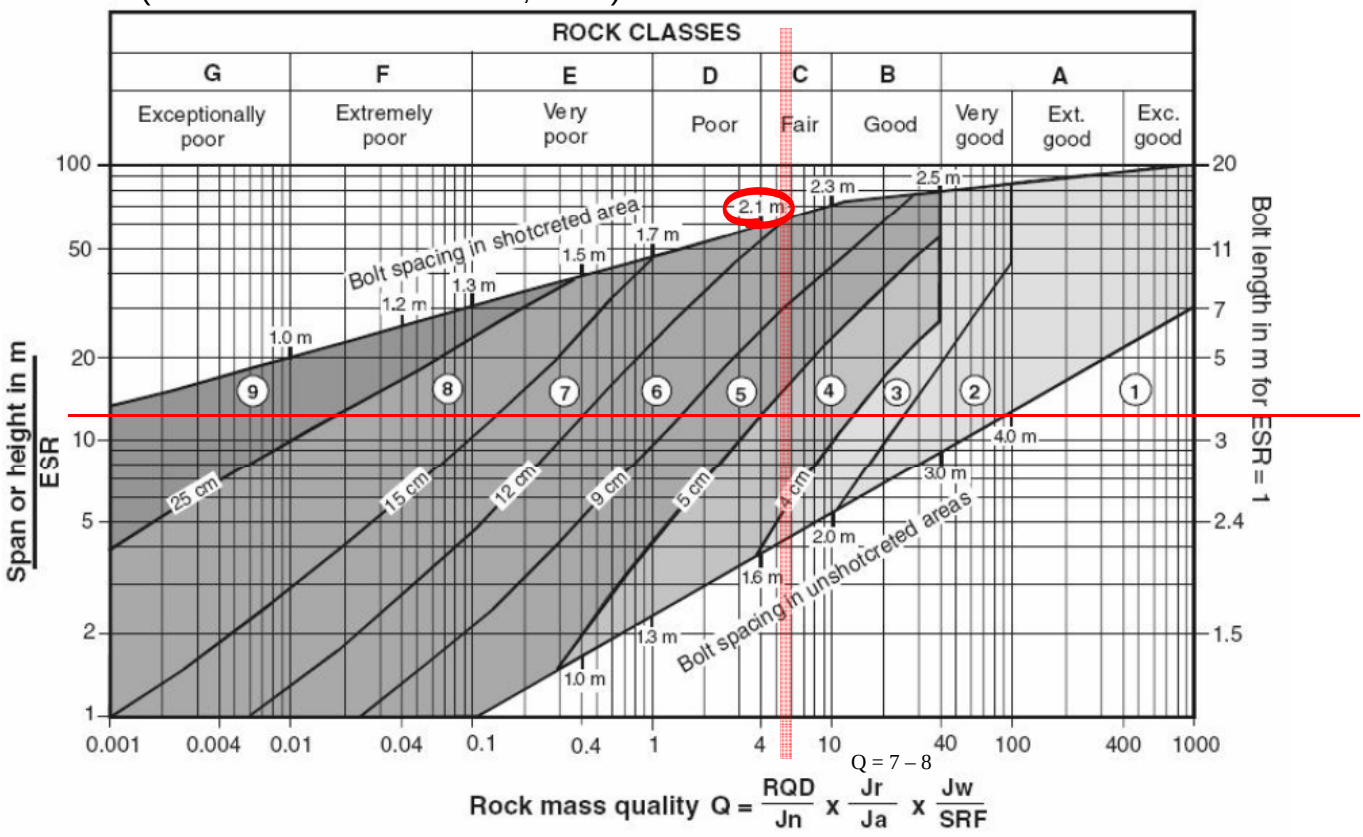
Grimstead and Barton (1993) :

$L = \frac{2 + 0.15B}{ESR}$, where B = excavation width

E. Hoek (Practical Rock Engineering)

$L = 0.4 \times \text{span}$

(After Grimstad and Barton, 1993)



REINFORCEMENT CATEGORIES:

1) Unsupported
2) Spot bolting
3) Systematic bolting
4) Systematic bolting, (and unreinforced shotcrete, 4 - 10 cm)
5) Fibre reinforced shotcrete and bolting, 5 - 9 cm
6) Fibre reinforced shotcrete and bolting, 9 - 12 cm
7) Fibre reinforced shotcrete and bolting, 12 - 15 cm
8) Fibre reinforced shotcrete, > 15 cm, reinforced ribs of shotcrete and bolting
9) Cast concrete lining

NGI-Q:

Q = 6.0 (RMR = 60)

Room Dimensions and Excavation Category:

Span : 11.5 m
ESR = 1.0 – D_e = 11.5 m
L_b = 3.7 m (Barton); L_b = 4.5 m (Hoek)

Room Support:

Bolts : 3.5 m long bolts @ 2.0 m c/c.
Shotcrete: 5 cm - unreinforced

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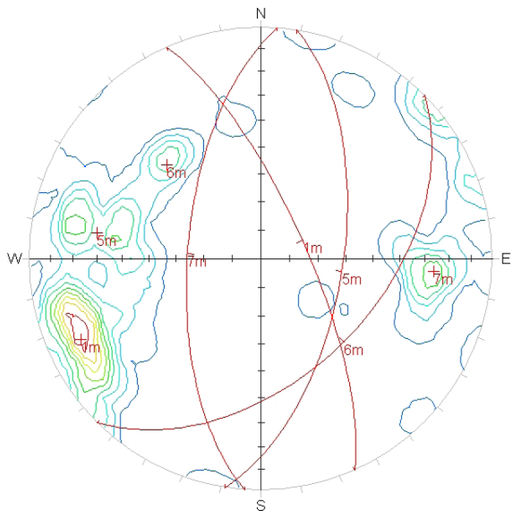
UNWEDGE ANALYSIS
LAr CAVERN

FIGURE 6.4

LAr Joint Orientations

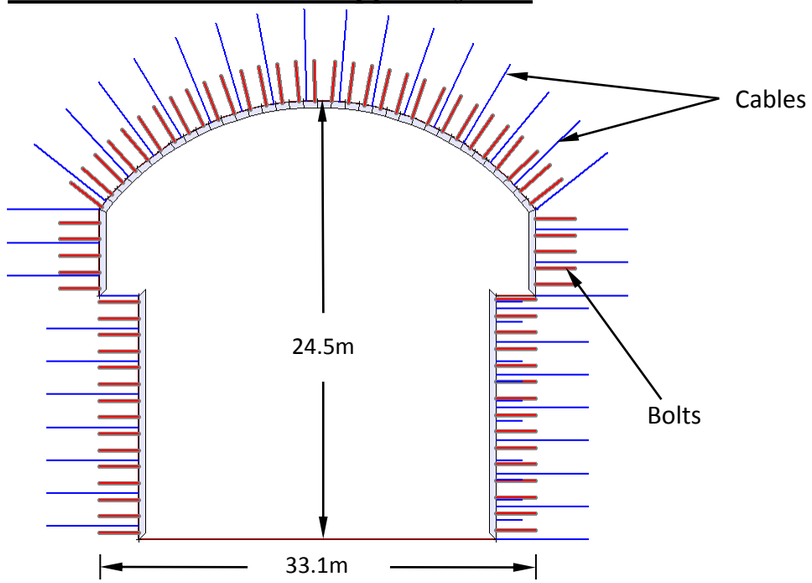


Orientations

ID		Dip / Direction
1	m	74 / 066
5	m	61 / 099
6	m	48 / 135
7	m	64 / 274

Equal Area
Lower Hemisphere
111 Poles
111 Entries

LAr Cross Section and Support System

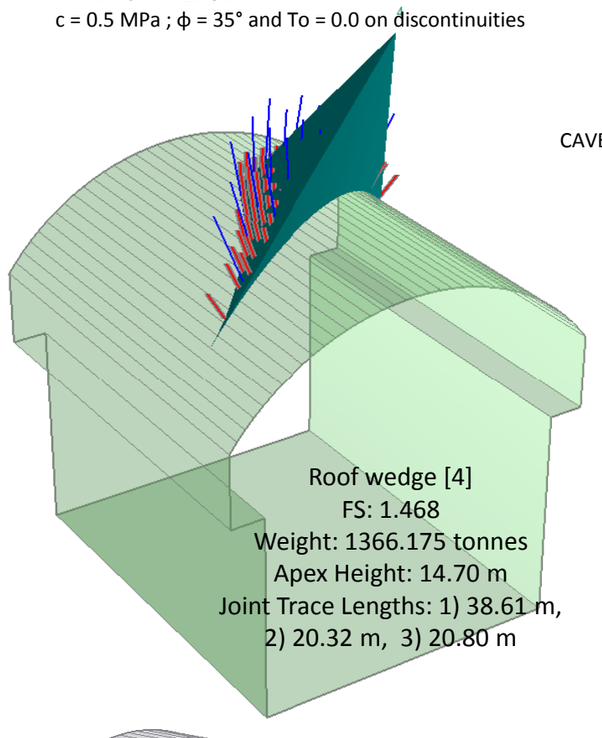


LAr Support System Properties

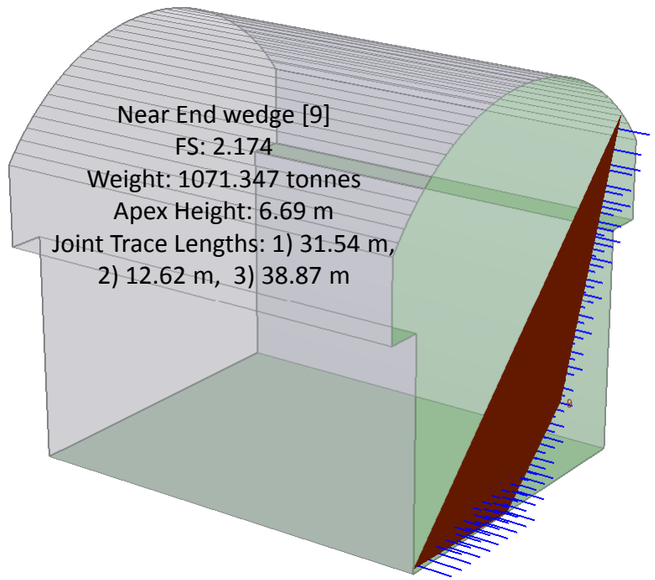
Support Type	Length (m)	Spacing (m)	Tensile Strength (tonnes)	Bond Strength (tonnes/m)
Bolts (red)	3	1.25	16	35
Cables (blue)	7	2.5	50	35

LAr Wedge Summary

MAXIMUM WEDGE
c = 0.5 MPa ; ϕ = 35° and To = 0.0 on discontinuities



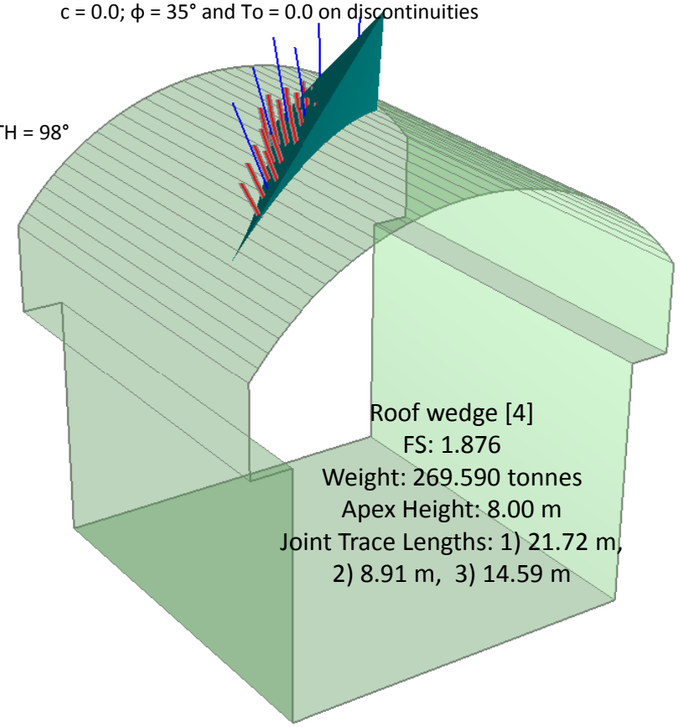
Roof wedge [4]
FS: 1.468
Weight: 1366.175 tonnes
Apex Height: 14.70 m
Joint Trace Lengths: 1) 38.61 m,
2) 20.32 m, 3) 20.80 m



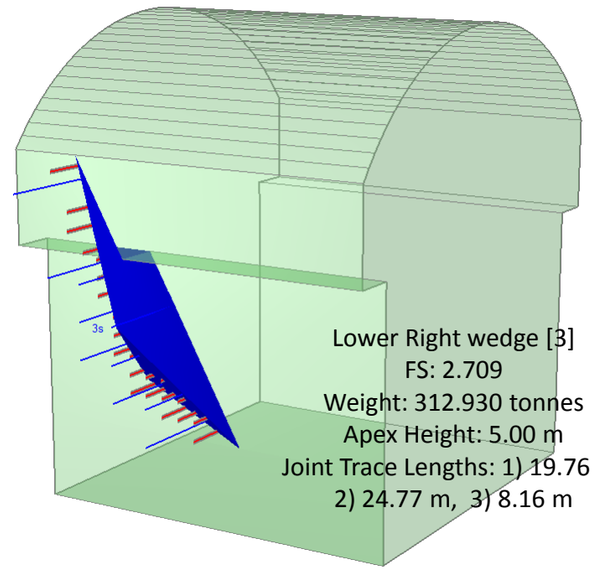
Near End wedge [9]
FS: 2.174
Weight: 1071.347 tonnes
Apex Height: 6.69 m
Joint Trace Lengths: 1) 31.54 m,
2) 12.62 m, 3) 38.87 m

SCALED WEDGE
c = 0.0; ϕ = 35° and To = 0.0 on discontinuities

CAVERN AZIMUTH = 98°



Roof wedge [4]
FS: 1.876
Weight: 269.590 tonnes
Apex Height: 8.00 m
Joint Trace Lengths: 1) 21.72 m,
2) 8.91 m, 3) 14.59 m



Lower Right wedge [3]
FS: 2.709
Weight: 312.930 tonnes
Apex Height: 5.00 m
Joint Trace Lengths: 1) 19.76 m,
2) 24.77 m, 3) 8.16 m

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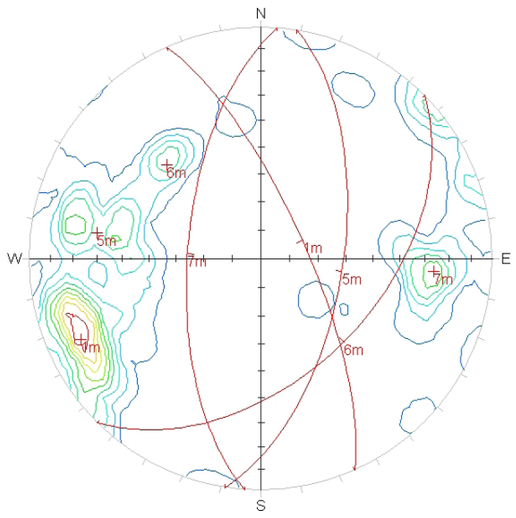
UNWEDGE ANALYSIS
RAMP AND RAMP ENLARGEMENT

FIGURE 6.5

Ramp Joint Orientations



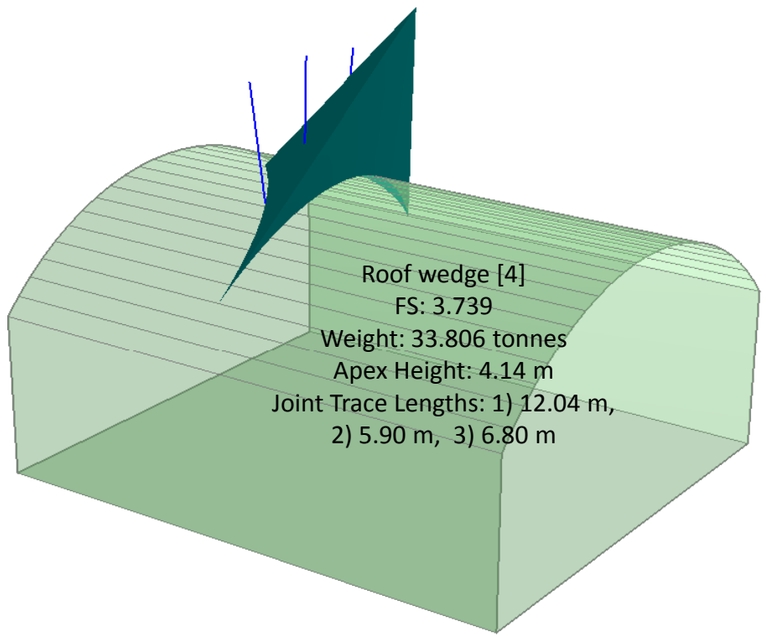
Orientations

ID		Dip / Direction
1	m	74 / 066
5	m	61 / 099
6	m	48 / 135
7	m	64 / 274

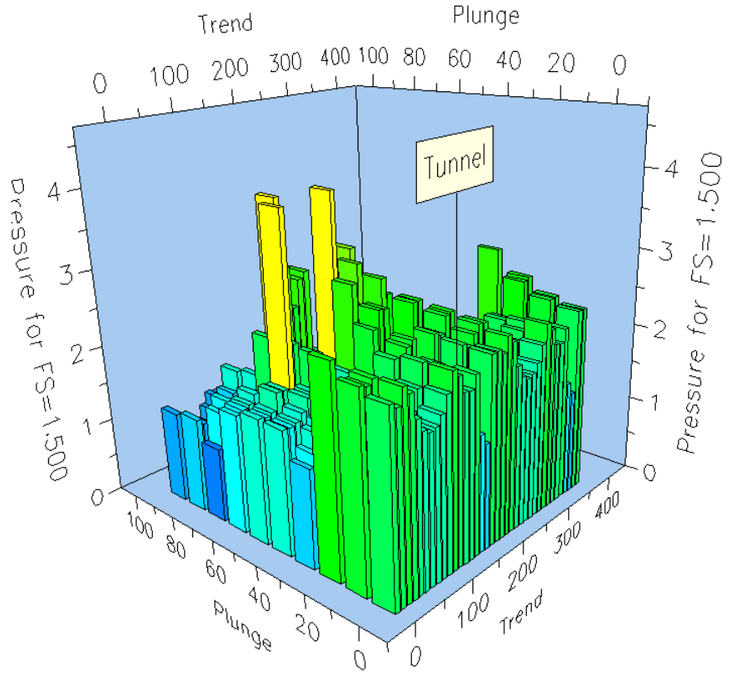
Equal Area
Lower Hemisphere
111 Poles
111 Entries

Ramp Roof Wedge Summary

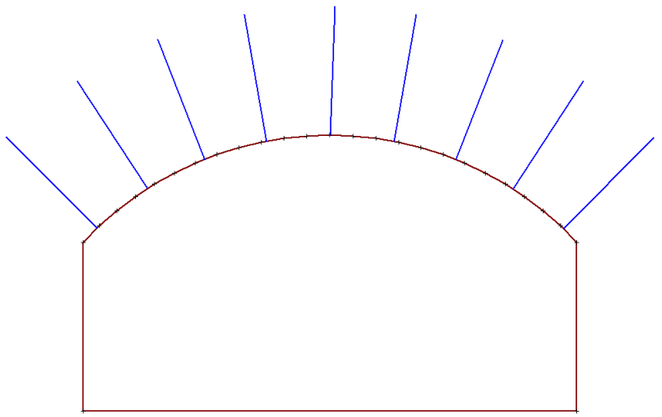
MAXIMUM WEDGE – RAMP ENLARGEMENT
c = 0,0 ; ϕ = 35° and To = 0.0 on discontinuities



RAMP AZIMUTH = VARIED
RAMP PLUNGE = 7°
c = 0.0; ϕ = 35° and To = 0.0 on discontinuities



Ramp Enlargement Cross Section and Support System



Ramp Support System Properties

Support Type	Length (m)	Spacing (m)	Tensile Strength (tonnes)	Bond Strength (tonnes/m)
Bolts (red)	3	1.25	16	35
Cables (blue)	-	-	-	-

MAXIMUM REQUIRED SUPPORT PRESSURE FOR RAMP = 2.5 tonnes/m²
Maximum spacing for 16 tonne bolts = 2.5 m x 2.5 m.
Use 1.5 m x 1.5 m spacing in ramp

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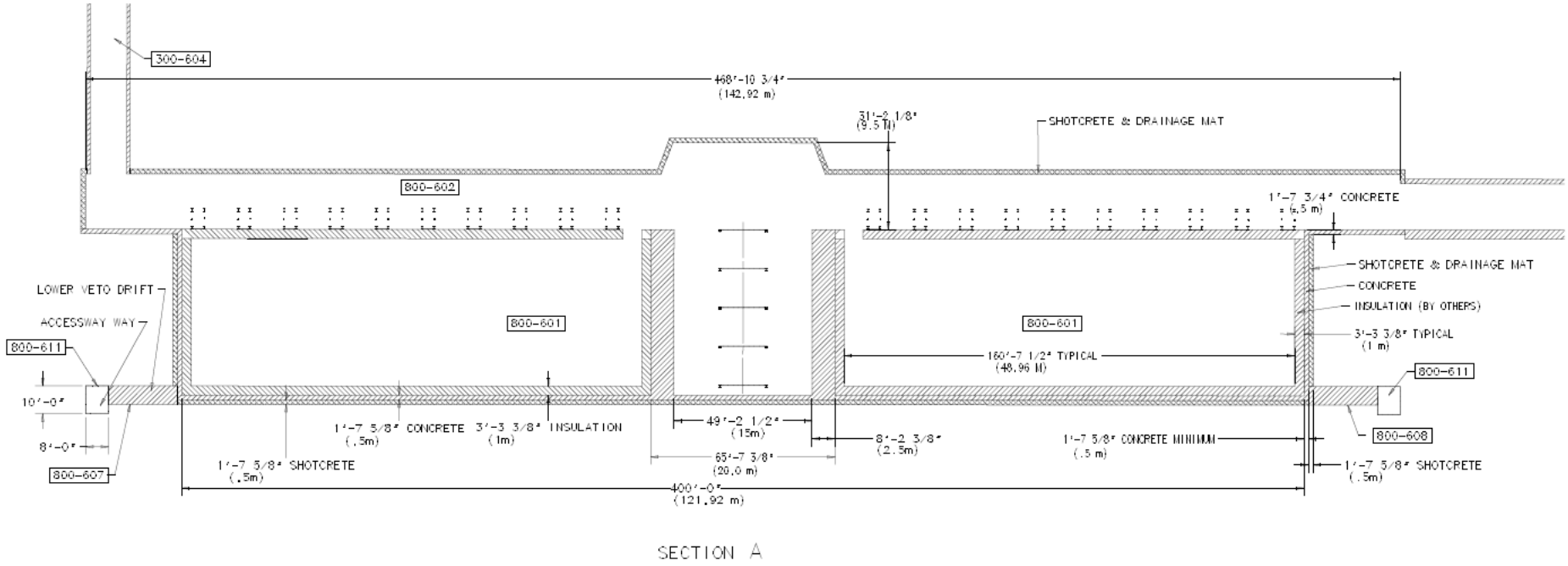
33 kT LAr Changes for 90%

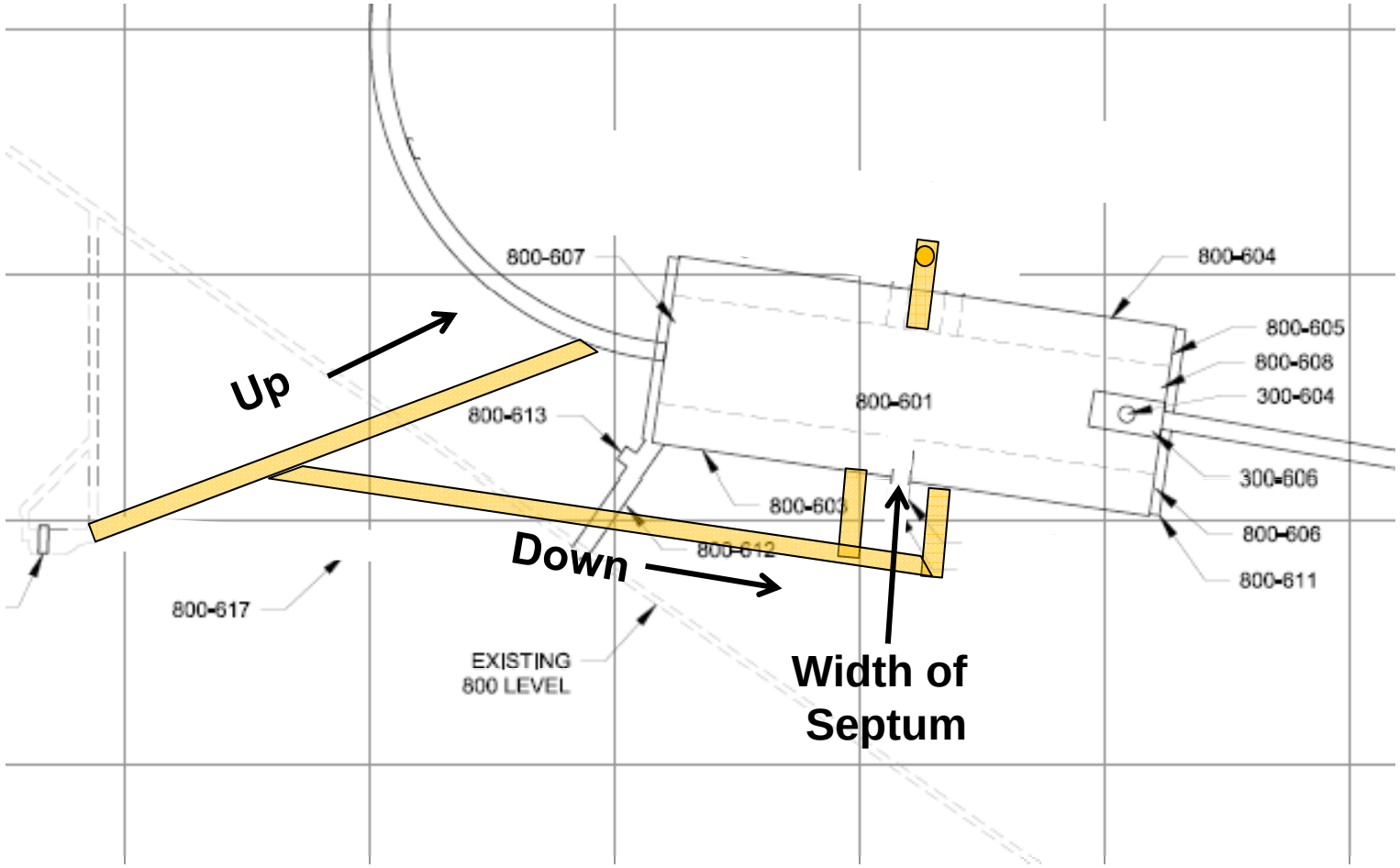
- Extend length of cavern to accommodate 20 meter septum



SECTION A

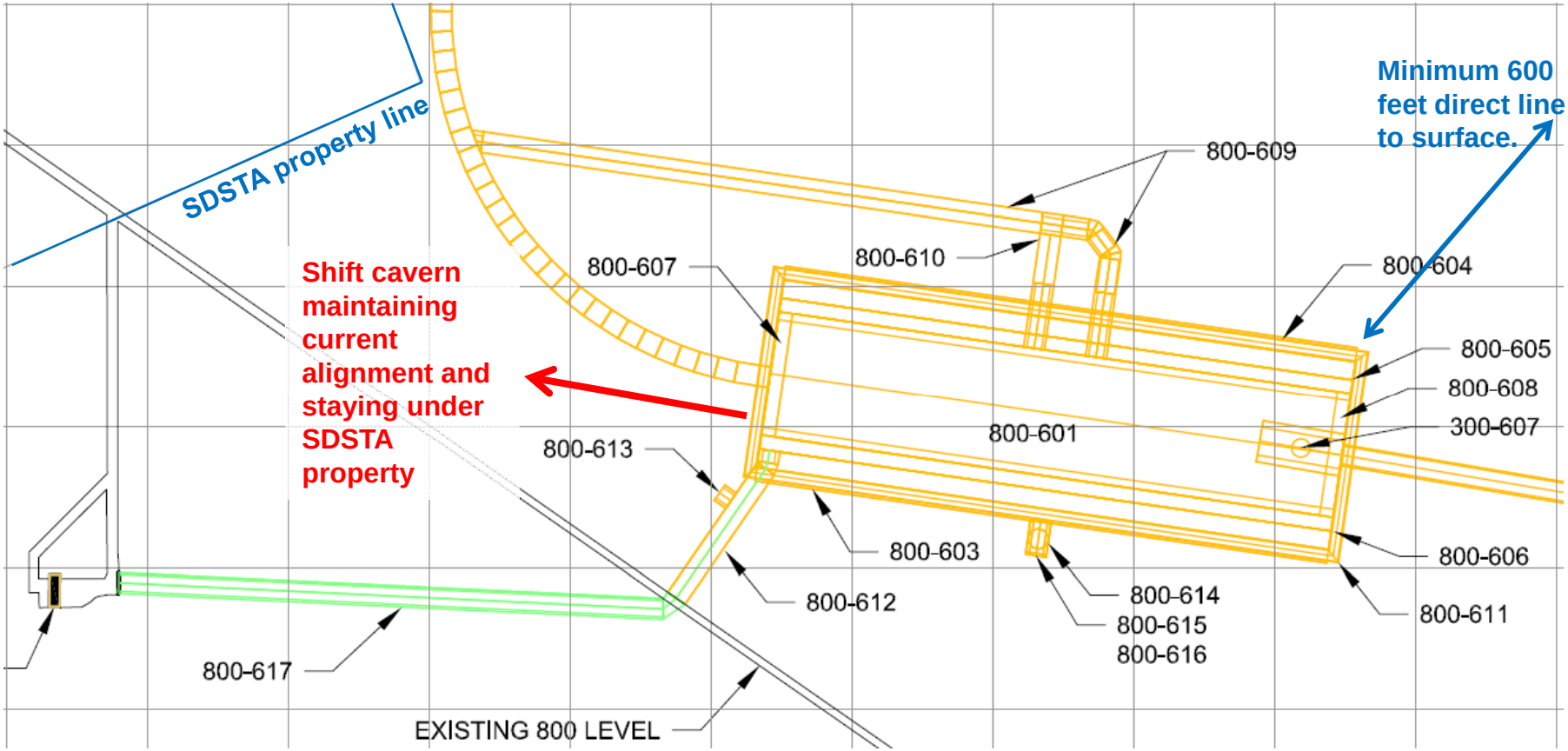
33 kT LAr Changes for 90%

- Realign Ross Access and reduce grade on lower ramp to 15%



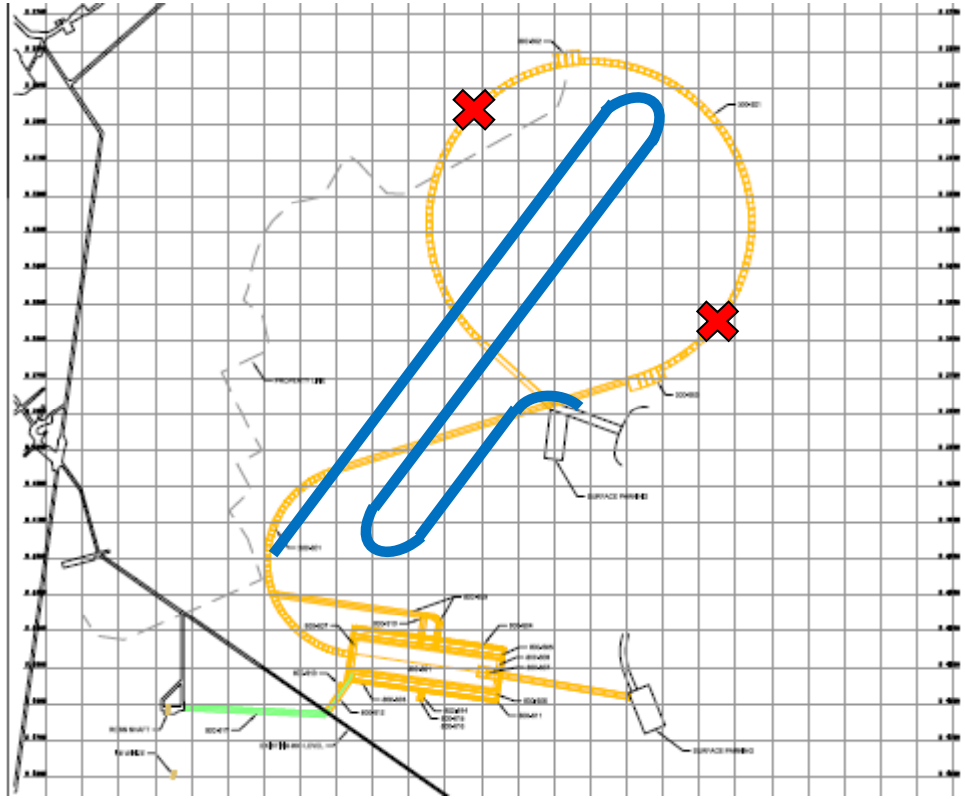
33 kT LAr Changes for 90%

- Confirm 600 feet minimum (690 ft average vertical) rock cover with new surface topo and move cavern west (deeper) if needed.



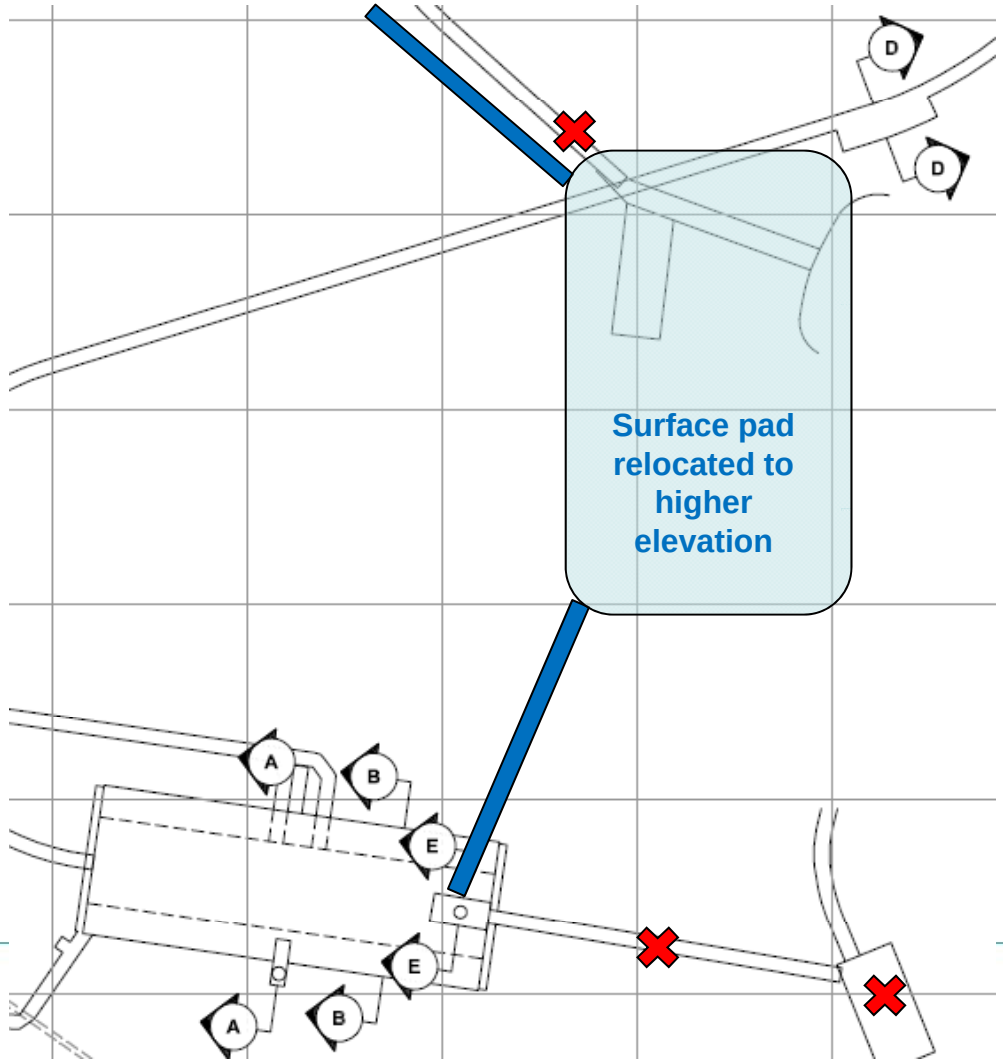
Changes for 90%

- Consider realignment of ramp with longer straight sections maintaining 12% slope and AoR / turning cutouts



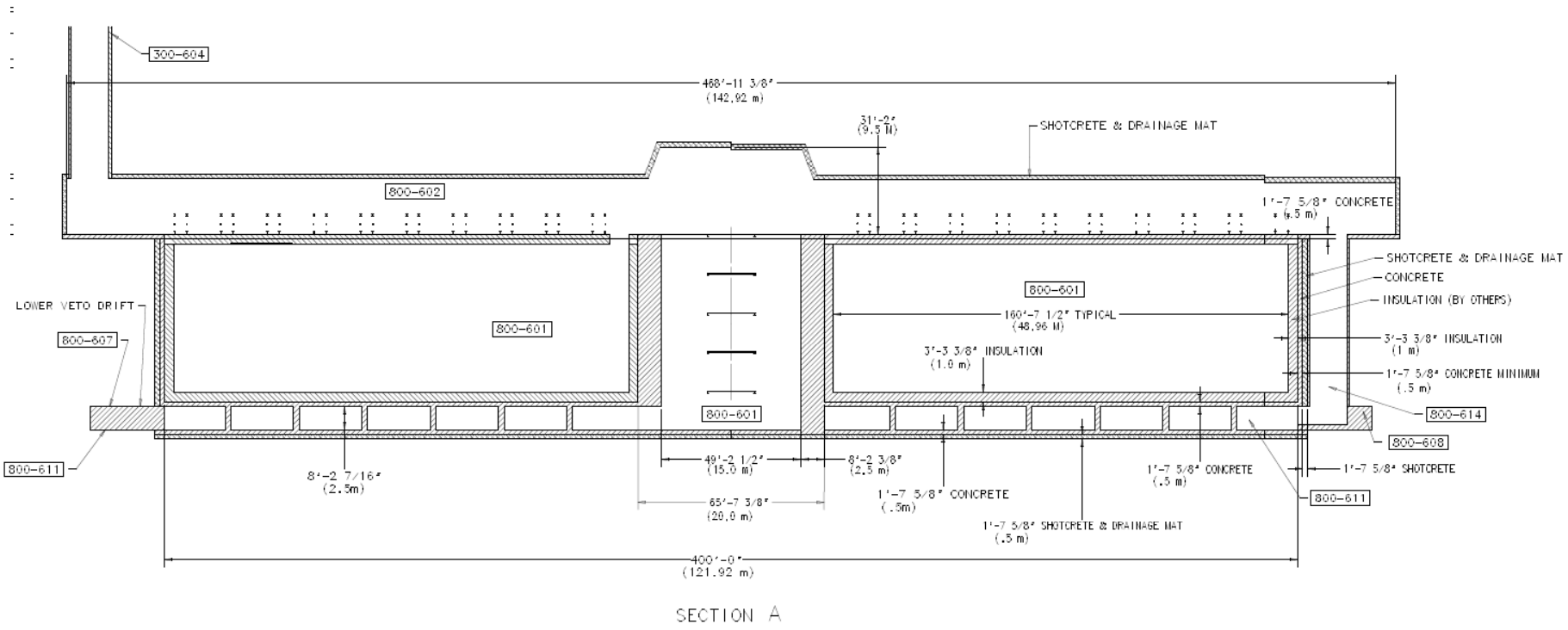
Changes for 90%

- Relocate portals to match relocation of surface facilities



33 kT LAr Changes for 90%

- No change to design for veto tube access but add qualitative discussion of "basement" alternative.



SECTION A