

PRELIMINARY LAYOUTS AND DESIGNS FOR TWO OF THE FCC SURFACE SITES

Damian DOCKERY (Fermilab)
Andrew FEDEROWICZ (Fermilab)
Brian RUBIK (Fermilab)

Overview

CERN x FNAL Collaboration

- Background on Collaboration
 - FNAL Team, CERN Visit
- Scope of work
- SITE PA (Experiment Site)
- SITE PB (Technical Site)



Aerial view of Fermilab campus. Fermilab is America's particle physics and accelerator laboratory. We bring the world together to solve the mysteries of matter, energy, space and time.

Background on Collaboration

The route to FCC Week 2023



U.S. DEPARTMENT OF
ENERGY

Office of Science



**APR
2022**
*Draft
agreement
CERN & DOE*

**JUNE
2022**
*FNAL
project
team on
board*

**NOV
2022**
*FNAL Visit
CERN*

**JAN
2023**
*Start of Conceptual
Design Development*



TODAY!

Background on Collaboration



The FNAL Team

ISD Infrastructure Services Division Engineering Group

Fermilab's in-house Architectural/Engineering (A/E) firm. The Engineering Department provides expertise for conventional facility design and construction activities and directs outside A/E services.

Tracy Lundin
Senior Strategic Planner

Damian Dockery
ISD/Deputy Director

Andrew Federowicz
Senior Architect

Brian Rubik
Senior Structural Engineer

Jacquelyn Dragovich
BIM Manager / Architect

LBNF Long Baseline Neutrino Facility Near Site Conventional Facilities

Thomas Hamernik
LBNF-NSCF Project Manager

Kennedy Hartsfield
LBNF-NSCF Deputy Project Manager

Fermilab Campus located 65km outside Chicago. Above: Aerial view of new buildings recently completed in the central campus surrounding Wilson Hall. Bottom Left: Integrated Engineering Research Building (IERC). Top Left: PIP-II Complex

Background on Collaboration



SCE
Site and Civil Engineering

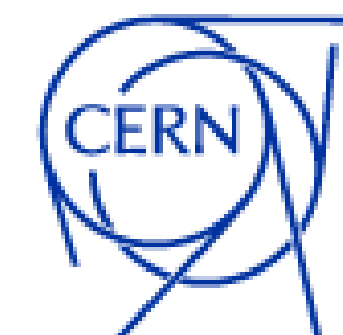
CERN Trip: November 14-19th

- Total of 3 FNAL staff spent one week at CERN visiting LHC locations and proposed FCC sites with SCE team **Tim Watson** and **Antoine Mayoux**.
- The trip's intent and itinerary at a glance:
 - Meeting with CERN staff and FCC stakeholders to tour existing LHC facilities.
 - Gain better understanding of the CERN building types, construction methods, and unique challenges at LHC surface sites.

Locations visited and meetings with FCC stakeholders

Background on Collaboration

CERN Trip: November 14-19th



SCE
Site and Civil Engineering

<p> LHC Point 1 - ATLAS</p> <p> <i>Experiment and Cryo requirements</i></p>	<p> LHC Point 2 ALICE</p> <p> <i>Requirements for Energy Management</i></p>	<p> LHC Point 5 – CMS</p> <p> <i>Site and Civil Engineering Requirements</i></p>	<p> LHC Point 8</p> <p> <i>Cooling, Ventilation, Cryo Requirements</i></p>
<p> Building 30</p> <p> <i>Technical Infrastructure Coordination</i></p>	<p> Building 54</p> <p> <i>SCE overview of drafting and Revit Standards</i></p>	<p> Medical & Fire Station</p> <p> <i>Safety Requirements</i></p>	

Locations visited and meetings with FCC stakeholders

Scope of Work

Site Visit: November 2022

New construction at LHC Point 5. Knauf acoustic panels lining the interior walls is one strategy used to control sound levels

Scope of Work

Site Visit: November 2022

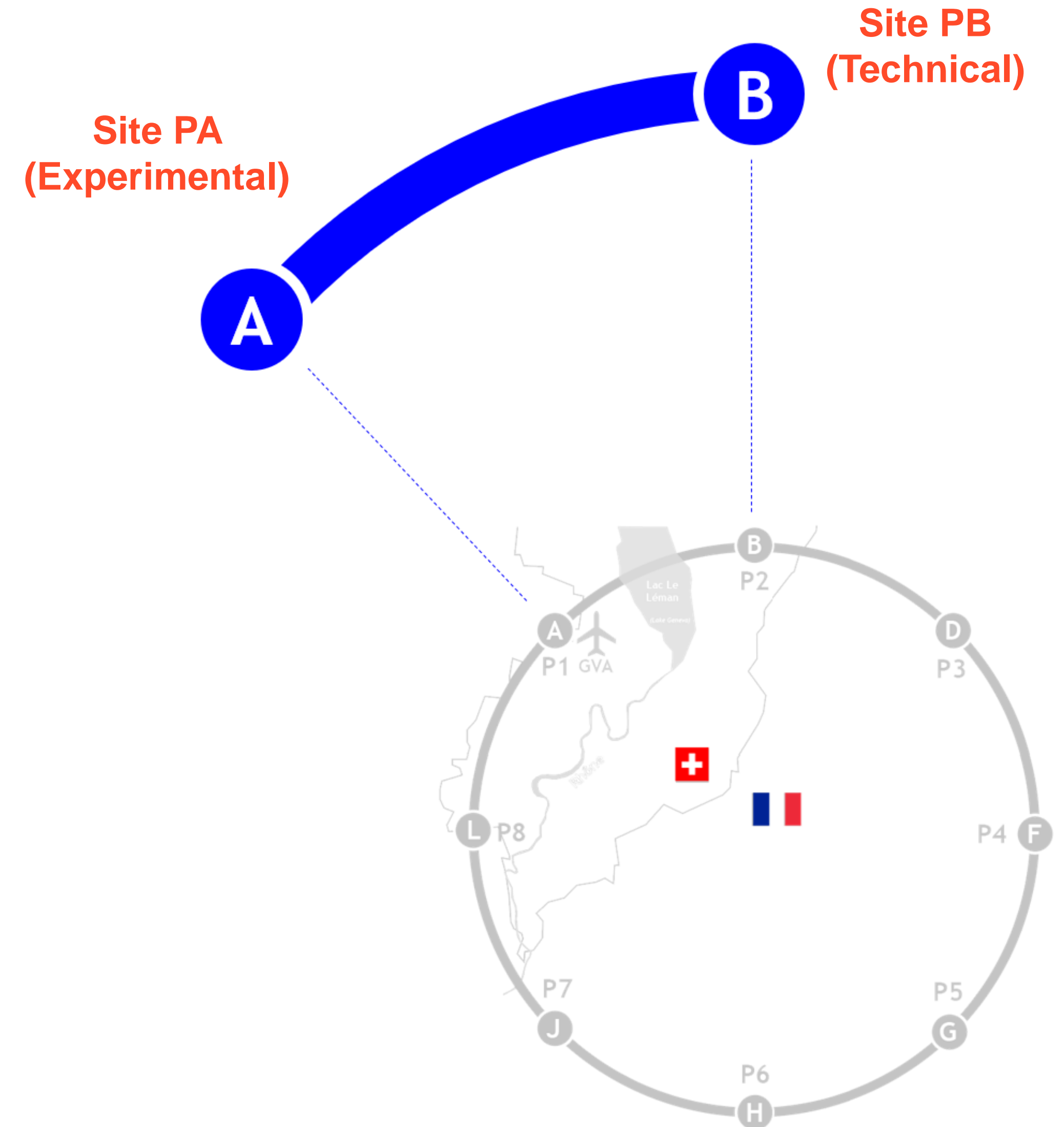


New construction at LHC Point 5. Installation of exterior building envelop

Scope of Work

Deliverables: General Requirements

- Develop building design and site layout for **2 surface sites**.
- These sites would be used a basis for estimating all 8 sites.
- **Final Deliverable includes:**
 - Preliminary Drawings w/specifications
 - Bill of Quantities
 - Architectural Visualizations
- FNAL deliverables are a collaboration with CERN that coordinates with SCE department strategy document describing industry standard contracting practices for large scale civil engineering projects.
- All renderings are conceptual and will be developed further as the study evolves

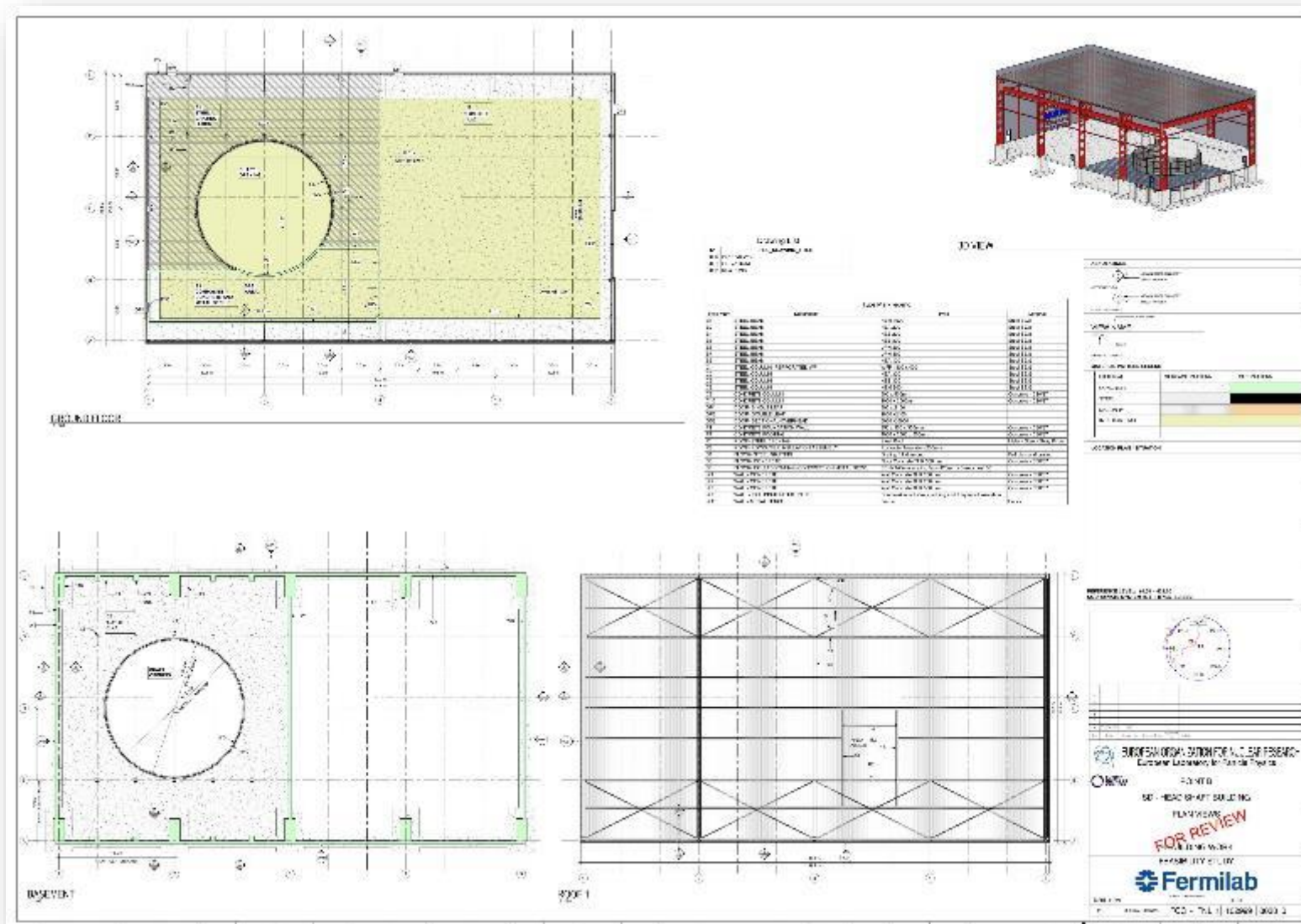


Surface sites PA and PB (FNAL deliverables)

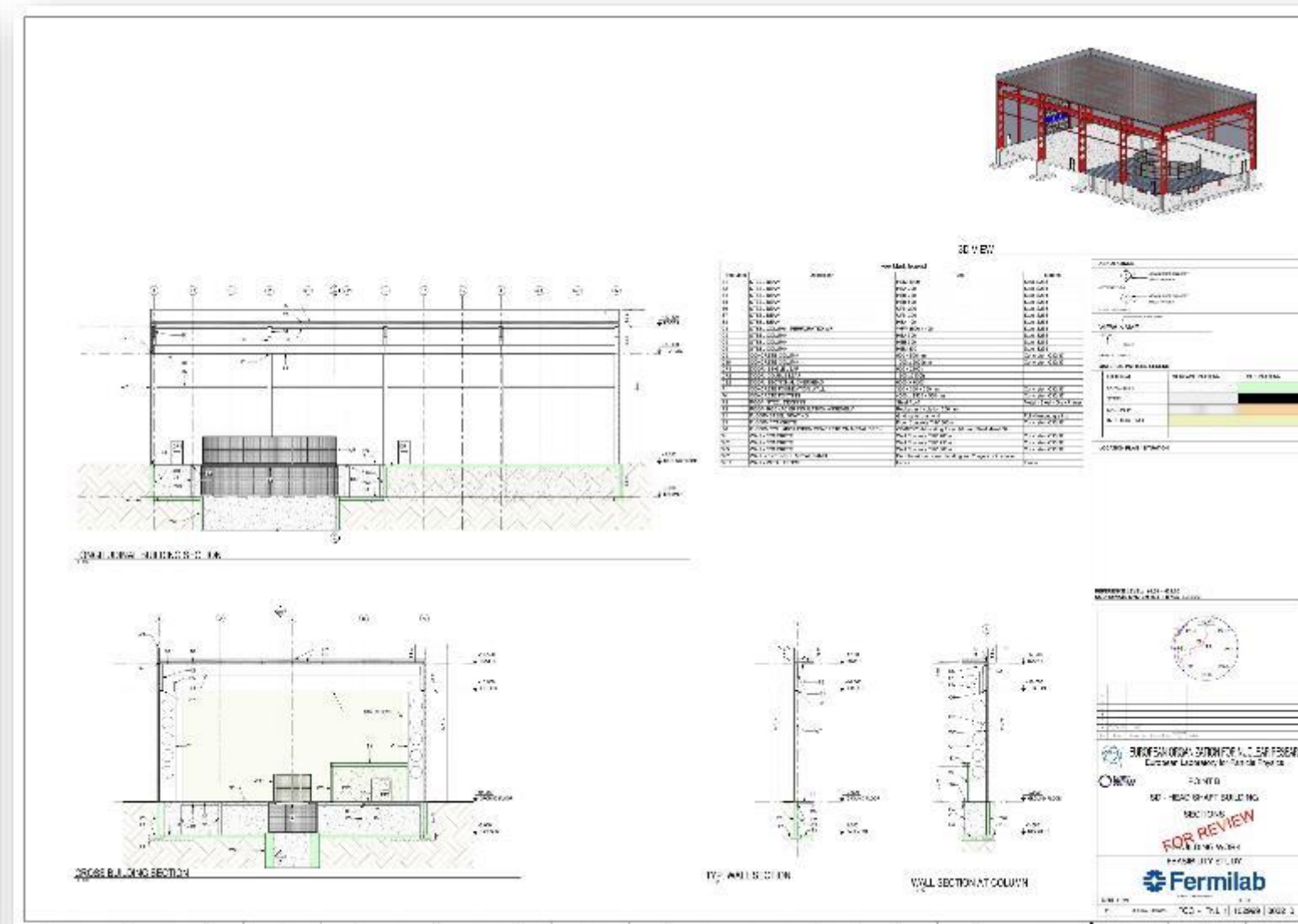
Scope of Work

Deliverables: Preliminary Drawings

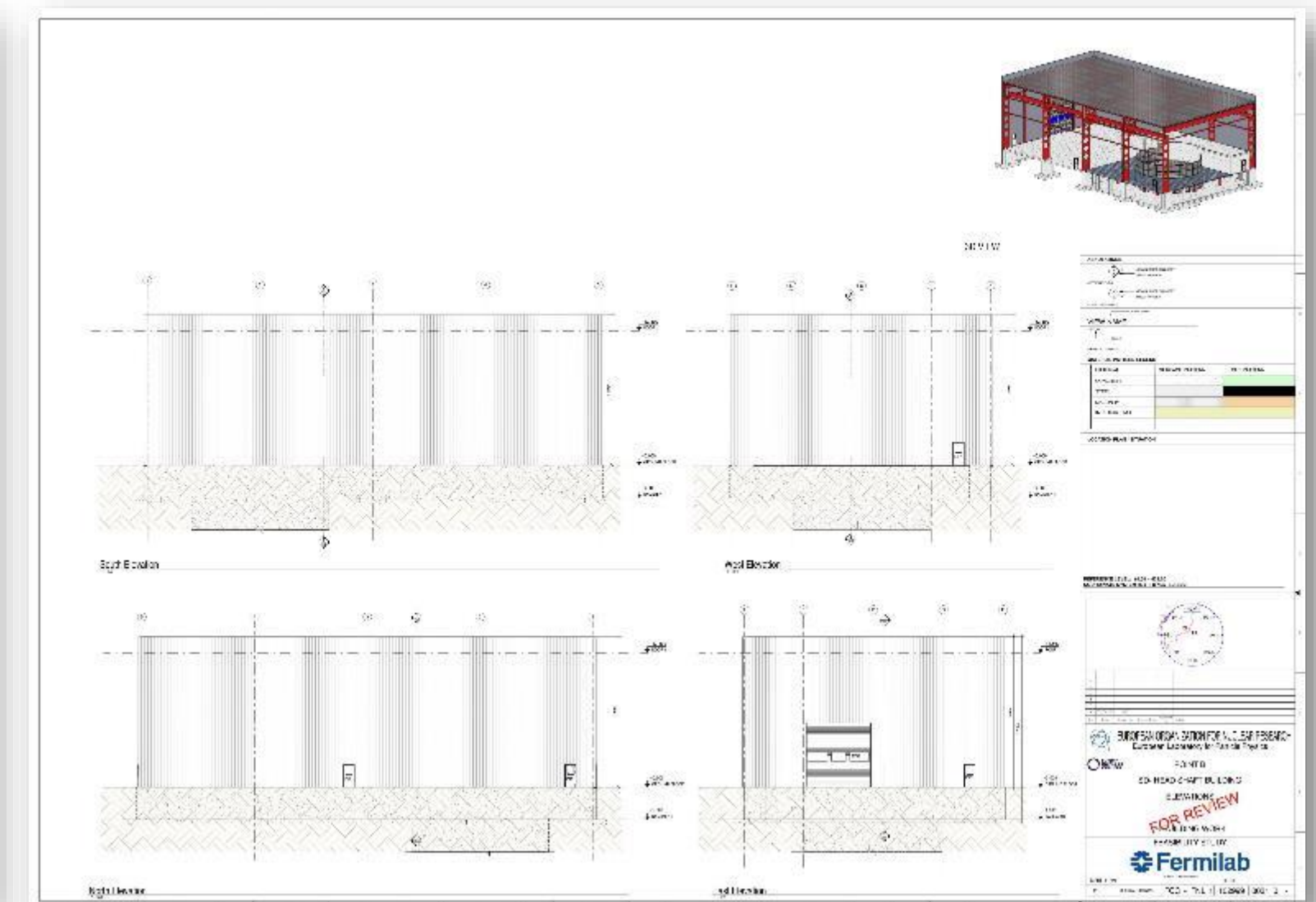
- Technical drawings for buildings developed using BIM software Autodesk Revit in accordance with SCE drafting standards



Plans: Grounds/Foundation/Basement/Roof



Sections: Building, Typical Wall



Elevations: North/South/East/West

Scope of Work



Deliverables: Bill of Quantities / Technical Report

- Based on Revit model output + some manual entry for quantities not able to be modeled
- Quantities of each material for all buildings (steel, concrete, insulation, paving, excavation, etc)
- Combined with Technical Report will allow for a cost estimate to be generated for each site (and extrapolated to other sites)
- Uses standards established by the *Civil Engineering Standard Method of Measurement (CESMM4)* by the Institution of Civil Engineers

Bill of Quantities: SD - Head Shaft Building					
Type Mark	Description	Type	Material	Quantity	Unit
C1	STEEL COLUMN- PERFORATED WF	WFP 1500 x 400	Steel S235	31.0	t
C2	STEEL COLUMN	HEA 300	Steel S235	3.3	t
C5	STEEL COLUMN	HEB 300	Steel S235	4.1	t
C6	STEEL COLUMN	HEM 300	Steel S235	6.0	t
C9	CONCRETE COLUMN	500 x 500mm	Concrete - C30/37	6.4	m ³
C10	CONCRETE COLUMN	1000 x 2000mm	Concrete - C30/37	50.9	m ³
B1	STEEL BEAM	HEM 1000	Steel S235	40.7	t
B2	STEEL BEAM	HEA 200	Steel S235	20.7	t
B4	STEEL BEAM	HEB 220	Steel S235	3.1	t
B5	STEEL BEAM	HEB 800	Steel S235	22.1	t
B6	STEEL BEAM	UPN 200	Steel S235	4.6	t
B7	STEEL BEAM	UPN 300	Steel S235	9.6	t
B8	STEEL BEAM	HEA 100	Steel S235	4.6	t
S1	FLOOR- STEEL GRATING	Grating full diamond	Full diamond grating	247.0	m ²
S3	FLOOR- CONCRETE	Floor Concrete THK 300mm	Concrete - C30/37	994.0	m ²
S6	FLOOR- COLLABORATING- CONCRETE ON METAL DECK	CE-INT-Collaborating floor-120mm - Steel sheet 60	Concrete - C30/37	148.0	m ²
R1	ROOF- STEEL DECKING	Steel Roof	Steel Deck	1024.0	m ²
R2	ROOF- ROCKACIER INSULATION ASSEMBLY	Rockacier Insulation 200mm	Rockacier Insulation 200mm	1024.0	m ²
DP1	DOOR- SINGLE LEAF	900 x 2100h	Steel Door	4	nr
DP2	DOOR- DOUBLE LEAF	1800 x 2100h	Steel Door	1	nr
DS2	DOOR- SECTIONAL-OVERHEAD	Sectional Door	Steel Door	2	nr
DS3	DOOR-OPENING AT SAS	INT-2000x2700h	Steel Door	1	nr
W7	WALL - EXT. INSUL METAL PANEL	Double-skinned steel cladding and 2 layers of insulation	Metal building envelope and insulation	1825.0	m ²
W1	WALL- CONCRETE	Wall Concrete THK 200mm	Concrete - C30/37	35.6	m ³
W2	WALL- CONCRETE	Wall Concrete THK 250mm	Concrete - C30/37	31.1	m ³
W3	WALL- CONCRETE	Wall Concrete THK 300mm	Concrete - C30/37	136.0	m ³
W5	WALL- WIRE MESH FENCE	Wire-mesh fence	Wire-mesh fence	185.0	m ²
F1	CONCRETE FOUNDATION WALL	350 x 350 x 350mm	Concrete - C30/37	35.0	m ³
F4	CONCRETE FOOTING	4000 x 2500 x 500mm	Concrete - C30/37	50.0	m ³
N/A	EXCAVATION	Excavation of soil	N/A	4501.7	m ³

SITE PA

Experimental Site (Ferney-Voltaire, France)

SITE PA

Existing Site: Local Area

- ~5.5 ha site located in France near semi-urban development
- 5km northeast of CERN campus
- 2km west of Geneva Airport
- Neighbors existing LHC surface site (Point 8)



Localized Plan of surrounding area at Site PA.

SITE PA

Existing Site: Local Area

- ~5.5 ha site located in France near semi-urban development
- 5km northeast of CERN campus
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LHC
Point 8

Localized Plan of surrounding area at Site PA.

SITE PA

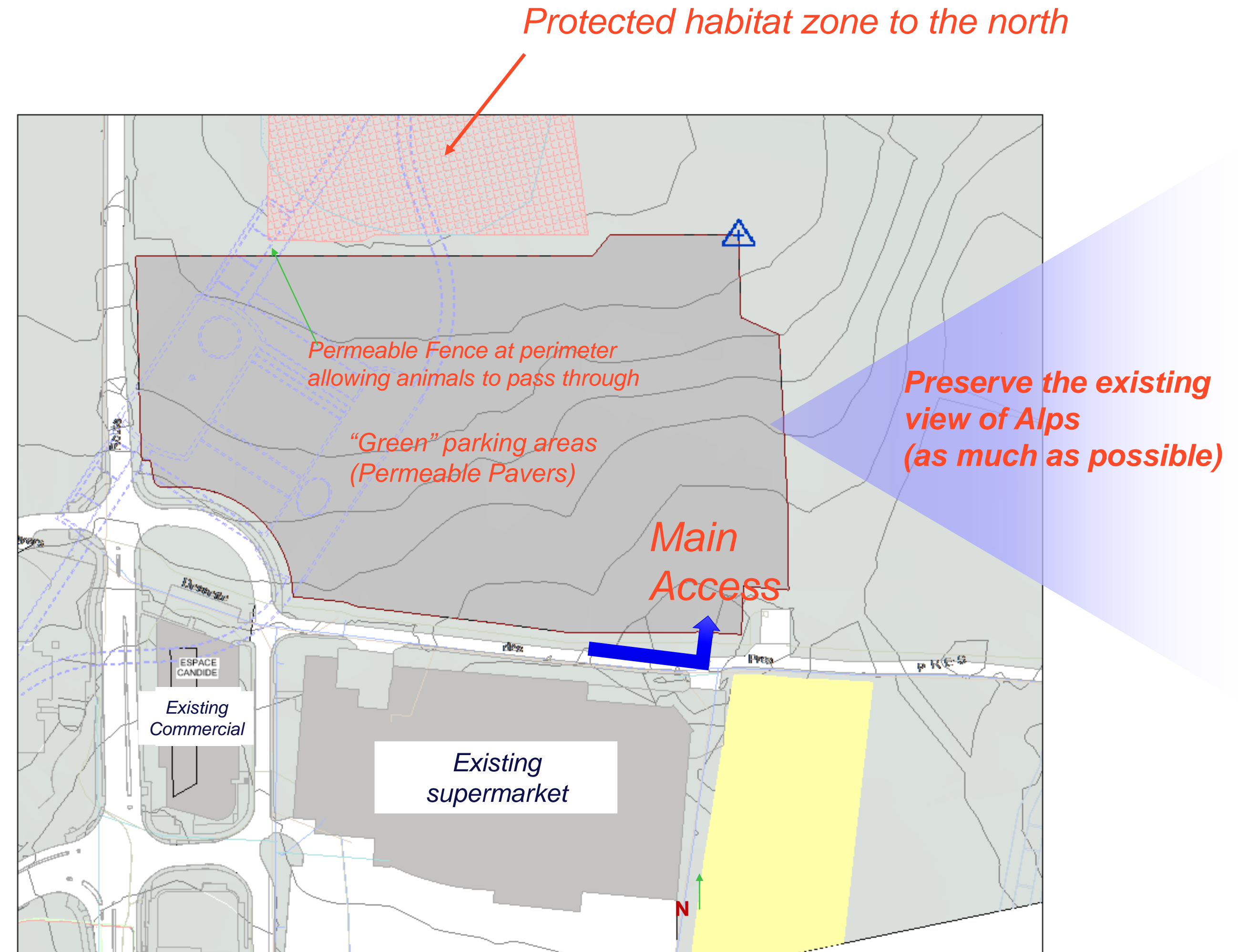
Existing Site: Constraints & Considerations

Constraints identified by CERN SCE :

- Located in semi urban area
- Ongoing construction projects
- Protected “Zone Humide” and compensation zone north of parcel
- Gas Pipeline south of parcel
- Required site access along east side of parcel

Considerations identified by CERN SCE:

- Maintain visibility from the adjacent road toward the Alps.
- Proposed building heights should be similar to existing structures in area





Existing viewshed of the Alps from Site PA



Existing semi urban development located south of proposed Site PA

SITE PA

Proposed Site: Buildings

FCC-ee Buildings

SX	ASSEMBLY HALL Dim. Interior: 25m x 100m Hmax: 23m	SHE	PRESSURIZED HELIUM STORAGE 2 stacks of 3 bottles Each skid: 27m x 15m Hmax: 9m
SD	HEAD SHAFT BUILDING Dim. Interior: 20m x 40m Hmax: 15m	SR	POWER CONVERTERS BUILDING Dim. Interior: 40m x 25m Hmax: 8m
SUX	EXPERIMENT VENTILATION Dim. Interior: 20m x 15m Hmax: 15m	SE	ELECTRICAL BUILDING Dim. Interior: 40m x 10m Hmax: 6m
SF	COOLING PLANT EVAPORATOR TOWER REJECT WATER TREATMENT Dim. Interior: 60m x 11m Hmax: 12m BASEMENT BUILDING Dim. Interior: 60m x 11m Hmax: 12m	ELECTRICAL SUBSTATION -ENERGY STORAGE -POWER TRANSFORMERS -SVC HARMONIS FILTERS -ELECTRICAL PARC Surface Dim: 3715 SQ M	
SH	COMPRESSION STATION AND CONTROL ROOM Dim. Interior: 25m x 17m Hmax: 10m	SO	STORAGE FOR RADIOACTIVE OBJECTS Dim. Interior: 20m x 10m Hmax: 6.0m
SU	TUNNEL AND SERVICES AREA VENTILATION Dim. Interior: 40 x 15m Hmax: 15m	SY	ACCESS CONTROL BUILDING Dim. Interior: 26m x 29m

FCC-hh Buildings

SX (FCC-hh) ASSEMBLY HALL Dim. Interior: 40m x 230m Hmax: 23m	SH (FCC-hh) COMPRESSION STATION AND CONTROL ROOM WARM COMPRESSOR 1 SKID (MACHINE) Dim. Interior: 40m x 30m Hmax: 7m
SD (FCC-hh) HEAD SHAFT BUILDING EXPANSION Dim. Interior: 20m x 20m Hmax: 15m	WARM COMPRESSOR 2 SKID (EXPERIMENT) Dim. Interior: 24m x 10m Hmax: 10m
SF (FCC-hh) COOLING PLANT EVAPORATOR TOWER REJECT WATER TREATMENT Dim. Interior: 60m x 11m Hmax: 12m BASEMENT BUILDING Dim. Interior: 60m x 11m Hmax: 12m	SU (FCC-hh) TUNNEL AND SERVICES AREA VENTILATION Dim. Interior: 15m x 15m Hmax: 15m
	SHE (FCC-hh) LIQUID AND PRESSURIZED HELIUM STORAGE 7 stacks of 6 bottles Each skid: 27m x 15m Hmax: 9m 6 QSDH EACH QSDH DIM: 30m x 6m Hmax: 6m
	SLN (FCC-hh) LIQUID AND PRESSURIZED NITROGEN STORAGE Surface Dim: 12.1m x 4.2m Hmax: 15m

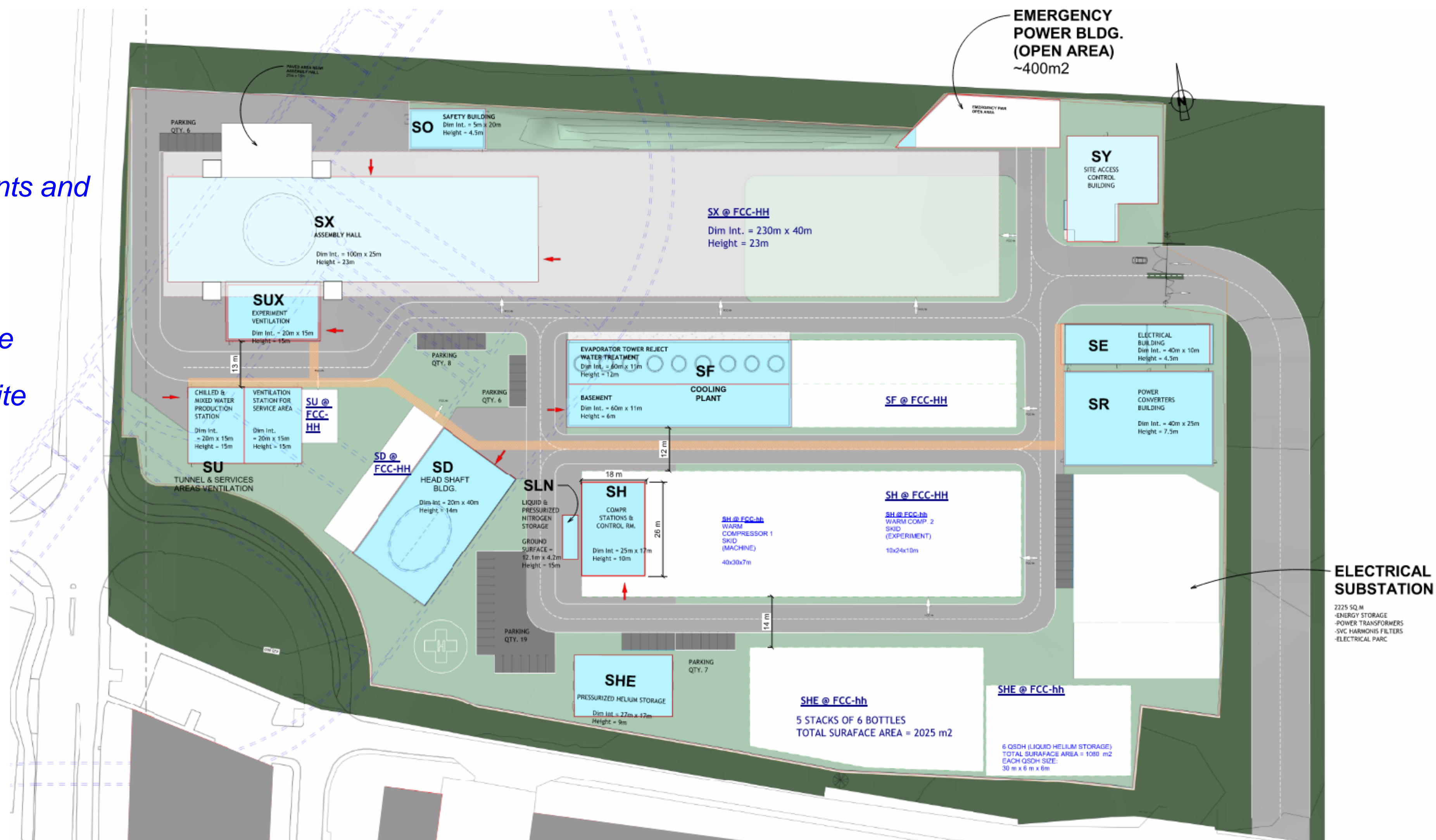
SITE PA

Proposed Site: Layout

Responding to existing constraints and general considerations

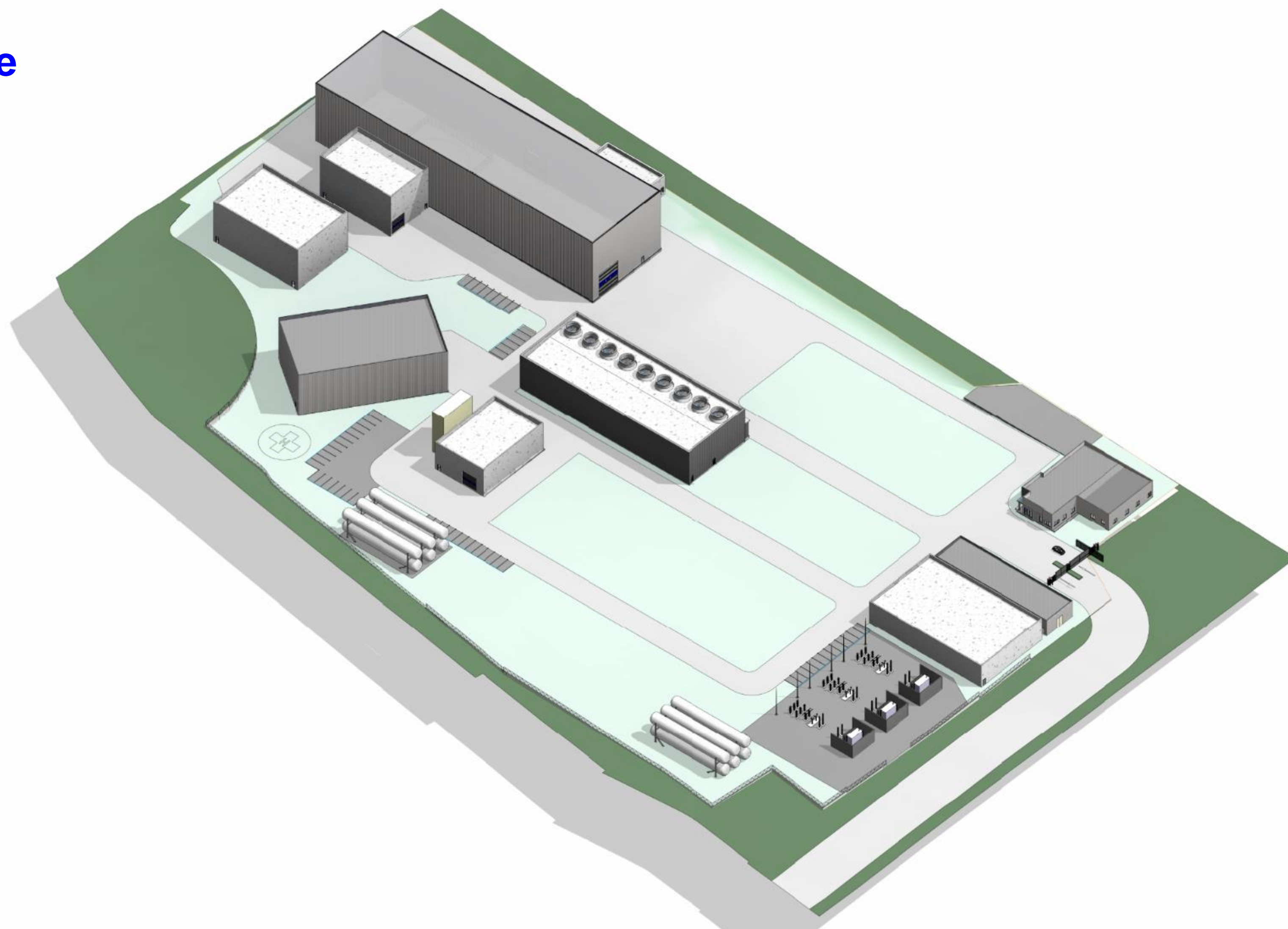
FCC-ee structures shown in blue

FCC-hh structures shown in white



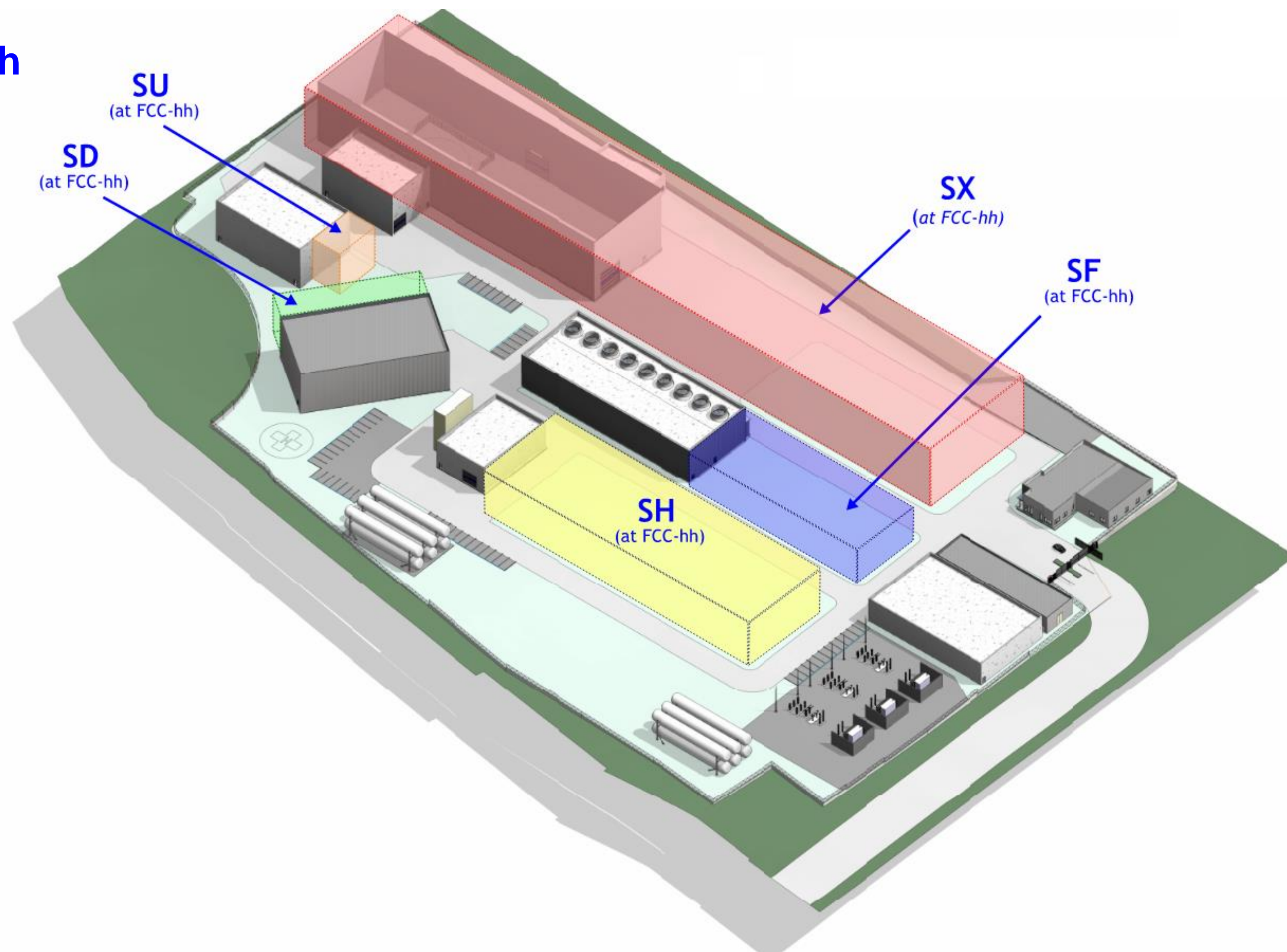
SITE PA

Proposed Site: Layout at FCC-ee



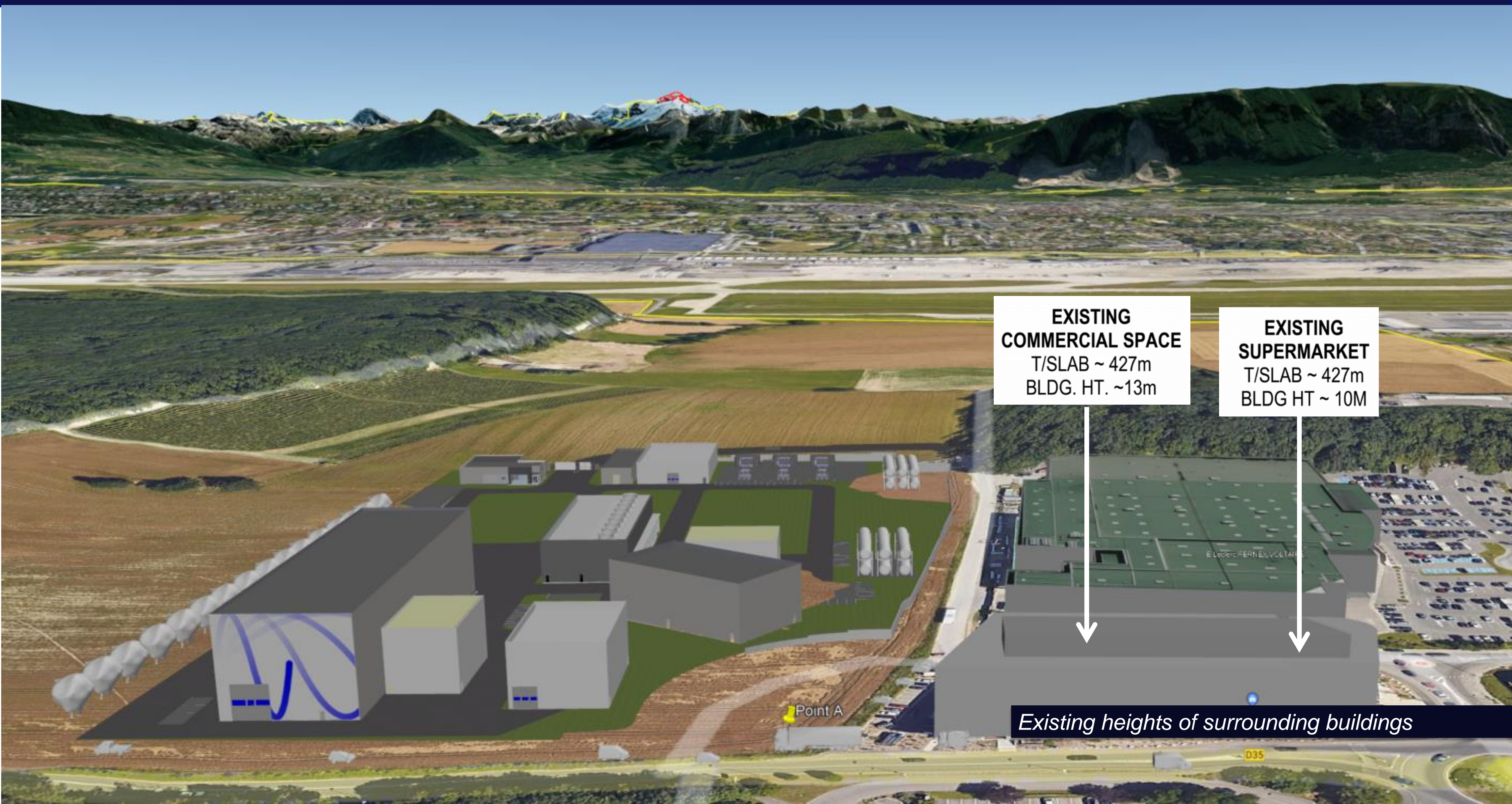
SITE PA

Proposed Site: Layout at FCC-hh





Aerial view of proposed Site PA



**EXISTING
COMMERCIAL SPACE**
T/SLAB ~ 427m
BLDG. HT. ~13m

**EXISTING
SUPERMARKET**
T/SLAB ~ 427m
BLDG HT ~ 10M

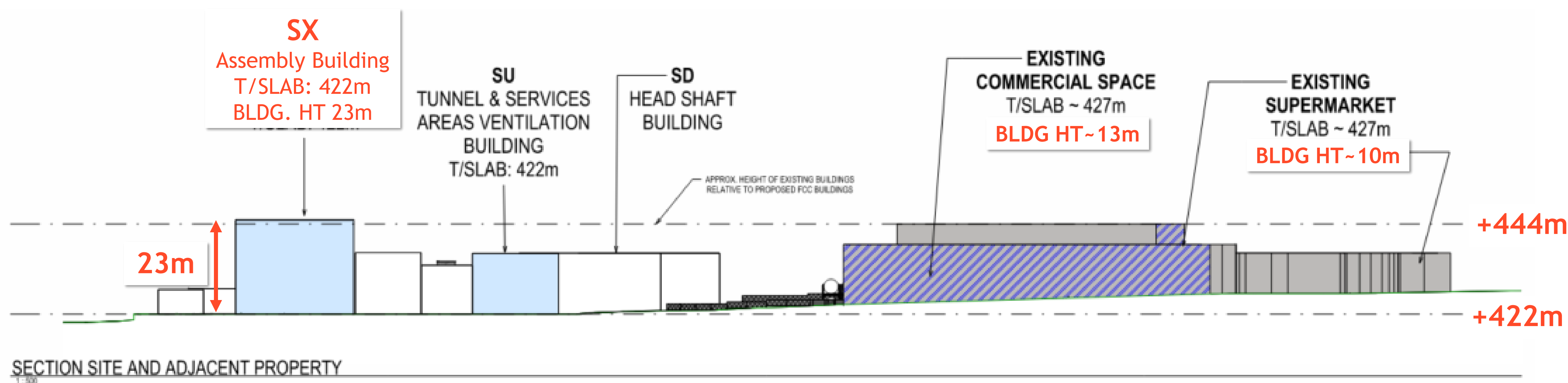
Point A

Existing heights of surrounding buildings

035

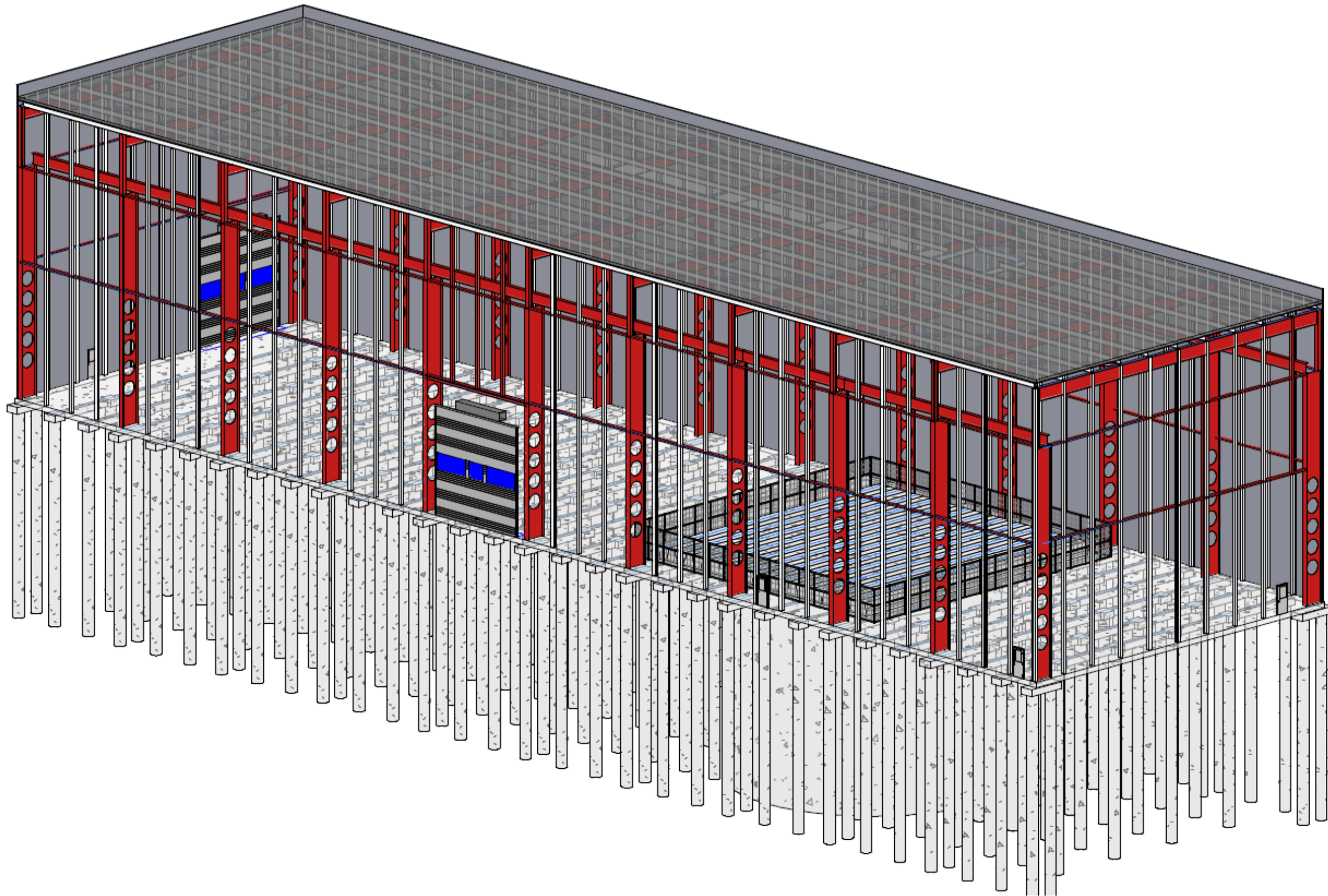
SITE PA

Proposed Site: Building Heights



SITE PA

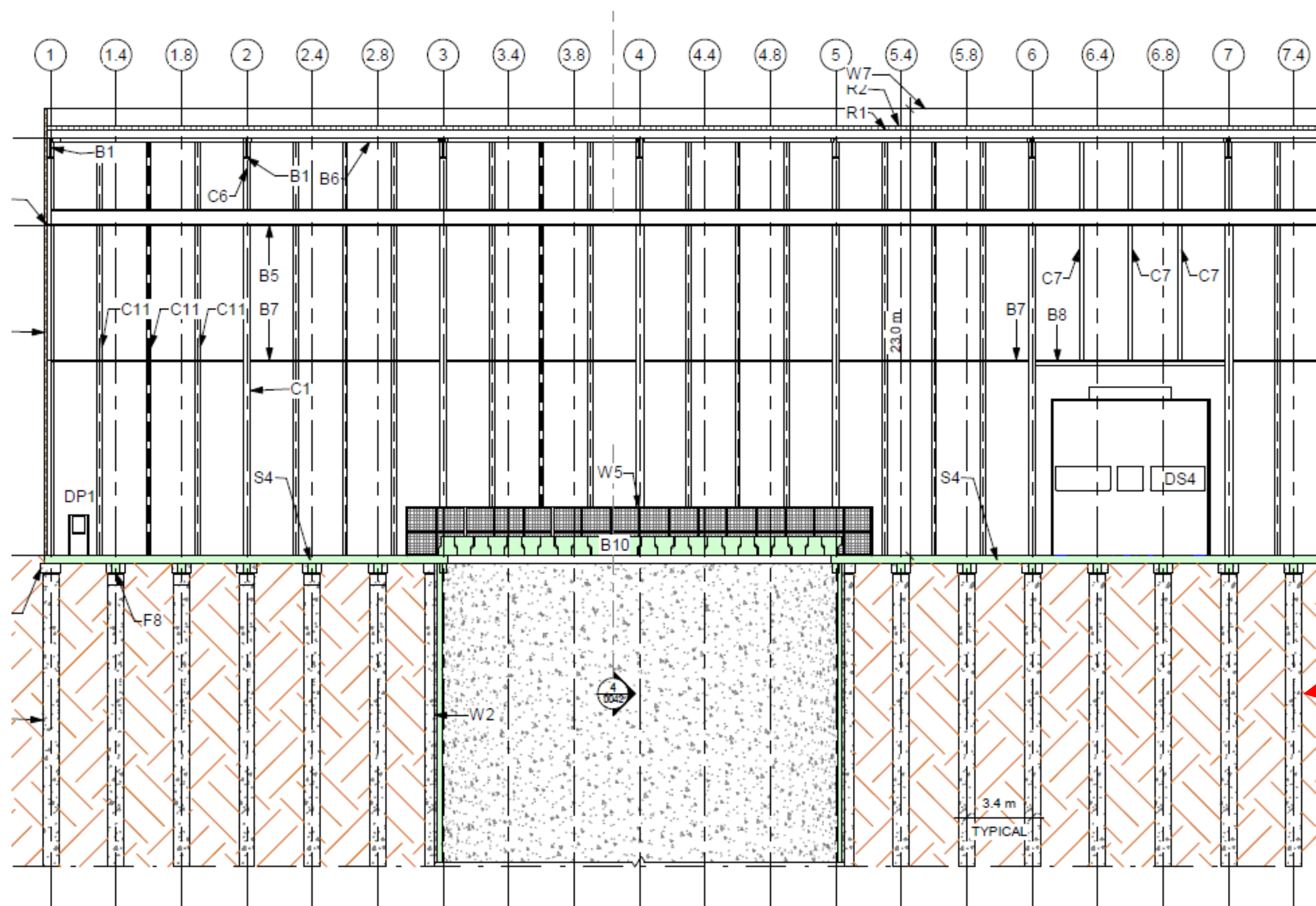
SX Assembly Building: Structural System



- Reinforced concrete foundation: piles, grade beams, slab
- Steel superstructure and roof decking
- Perforated steel columns to allow for mechanical / electrical services to pass through
- Steel panel cladding with insulation
- Precast concrete shielding blocks over shaft opening
- Steel columns support a 120 tonne overhead crane

SITE PA

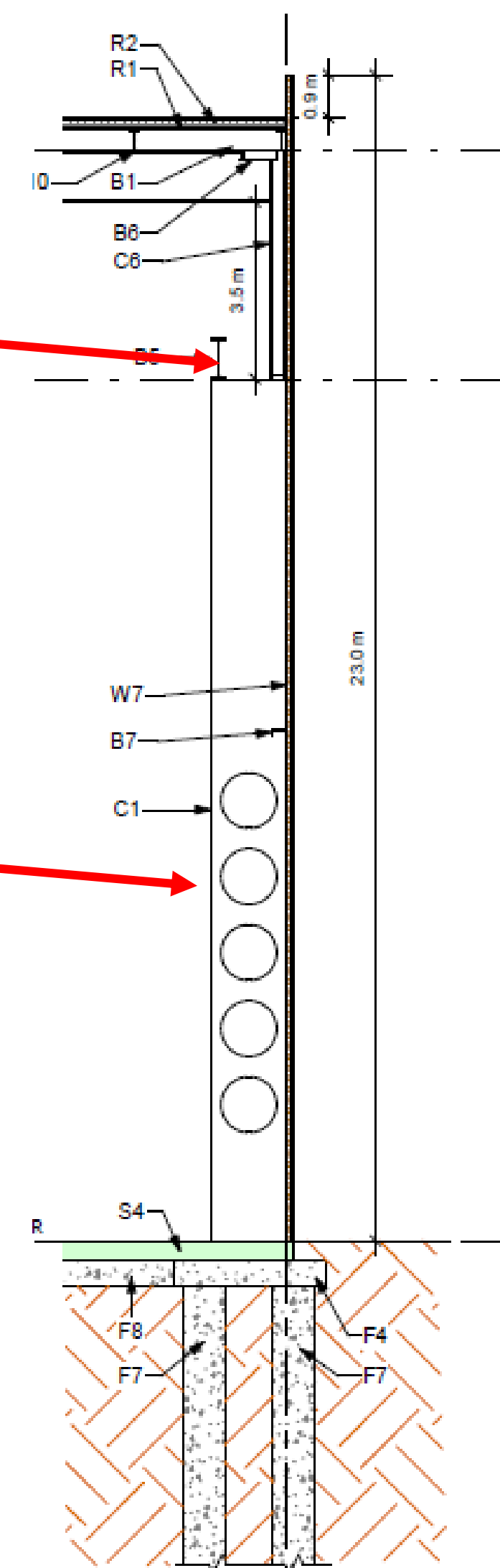
SX Assembly Building: Structural System



Crane support beam

Perforated column

Concrete pile foundation



SITE PA

Thoughts/Considerations/Recommendations

Challenges:

- FCC-hh footprint expansion
 - Further study needed on site layout to verify **ee** and **hh** layouts will fit on parcel.
 - Need to further study synergies with **LHC Point 8**
 - Limited opportunity to increase building heights. Stacking building programs on multiple levels below grade could be an option.

West limitations:
Roadway

North limitations:
Protected habitat area

South limitations:
shopping center

East:
Open land

LHC
Point
8

Expansion options surrounding Site PA.

SITE PB

Technical Site (Switzerland)

Existing Site: Overview

- 
- An aerial photograph of a rural landscape, likely in Switzerland, showing green fields, a road, and some buildings. The image is used as a background for the text.
- **~4ha** site located on Swiss rural land approximately **15km** east of the CERN campus
 - Local opposition to new industrial buildings by is anticipated.



SITE PB

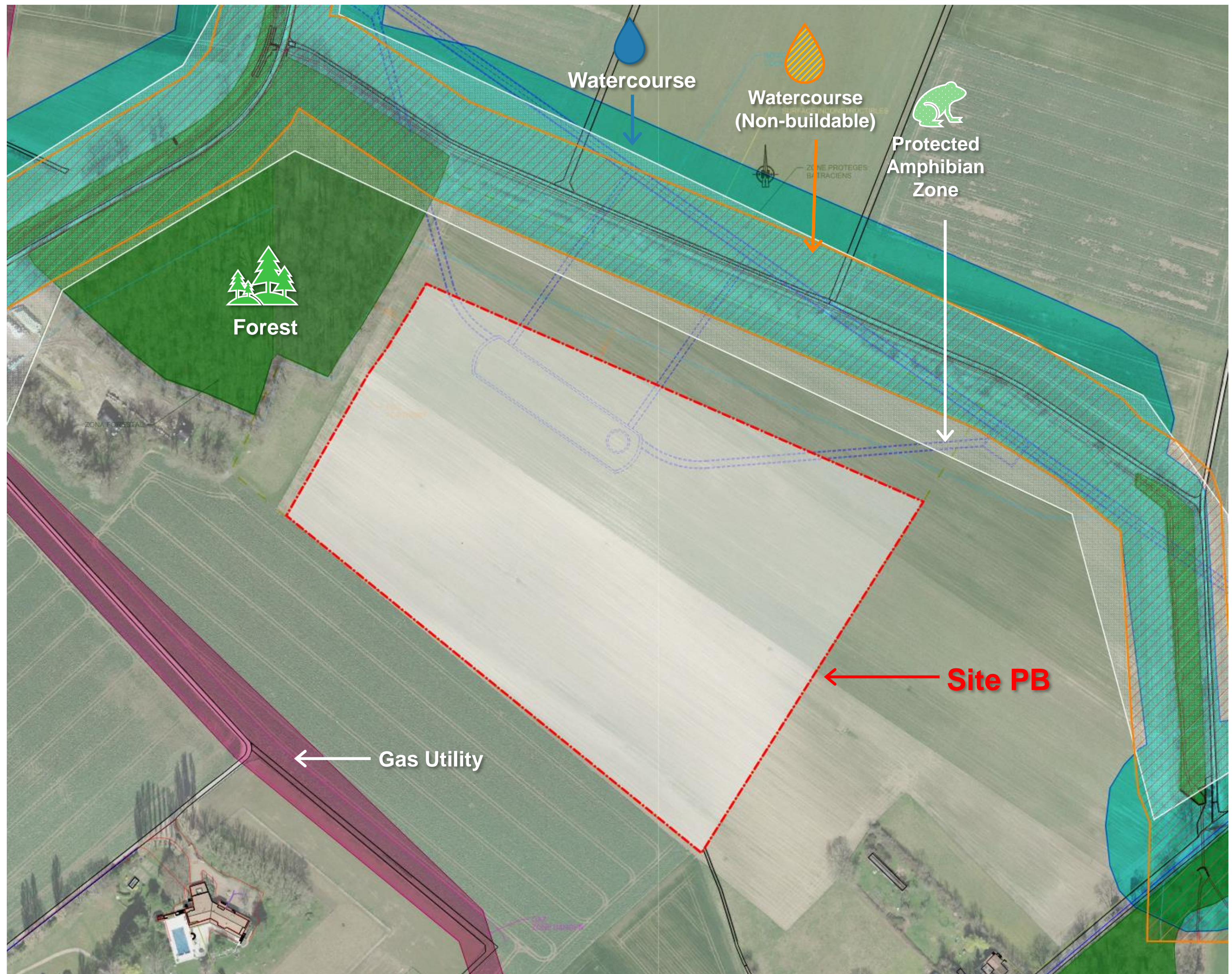
Existing Site: Overview

Constraints identified by CERN SCE :

- Located on Swiss rural land with expensive properties in surrounding area opposed new “industrial buildings”
- Protected forest (west), Protected stream (north), Buried gas pipeline (south)

Considerations identified by CERN SCE:

- Entrance to site located on the NW side of site. Road external to site will follow path of existing track.





Existing view at Site PB

SITE PB

Proposed Site: Buildings

FCC-ee Buildings

SY ACCESS CONTROL BUILDING Dim. Interior: 21m x 11m Hmax: 4m	SR POWER CONVERTERS BUILDING Dim. Interior: 40m x 25m Hmax: 8m
SD HEAD SHAFT BUILDING Dim. Interior: 24m x 43m Hmax: 14m	SE ELECTRICAL BUILDING Dim. Interior: 40m x 10m Hmax: 6m
SU TUNNEL AND SERVICES AREA VENTILATION Dim. Interior: 21m x 30m Hmax: 15m	SES ELECTRICAL POWER BUILDING Dim. Interior: 40m x 10m Hmax: 6m
SF COOLING PLANT Dim. Interior: 22m x 12m Hmax: 10m	ELECTRICAL SUBSTATION -ENERGY STORAGE -POWER TRANSFORMERS -SVC HARMONIS FILTERS -ELECTRICAL PARC Surface Dim: 3715 SQ M
	SO STORAGE FOR RADIOACTIVE OBJECTS Dim. Interior: 20m x 10m Hmax: 6.2m

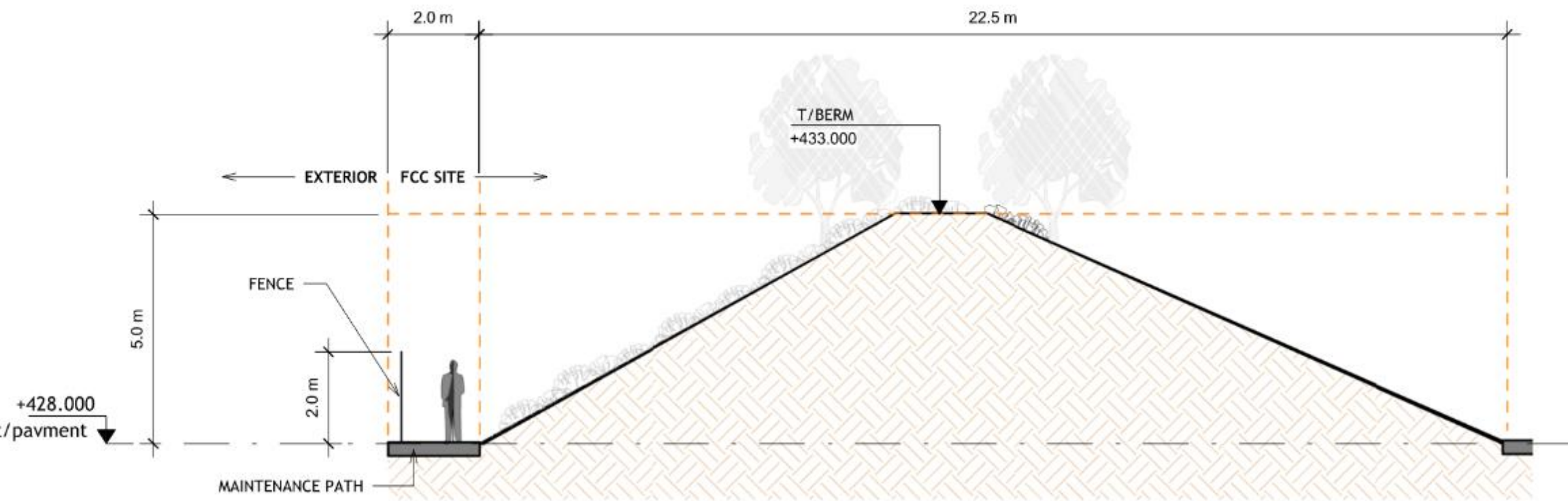
FCC-hh Buildings

SD (FCC-hh) HEAD SHAFT BUILDING EXPANSION Dim. Interior: 24m x 43m Hmax: 14m	SH (FCC-hh) COMPRESSION STATION AND CONTROL ROOM Dim. Interior: 20m x 30m Hmax: 10m
SU (FCC-hh) TUNNEL AND SERVICES AREA VENTILATION Dim. Interior: 21m x 30m Hmax: 15m	SHE (FCC-hh) LIQUID AND PRESSURIZED HELIUM STORAGE 7 stacks of 6 bottles 12 QSDH Each skid: 27m x 15m EACH QSDH DIM: 30m x 6m Hmax: 9m Hmax: 6m
SF (FCC-hh) COOLING PLANT Dim. Interior: 22m x 12m Hmax: 10m	SLN (FCC-hh) LIQUID AND PRESSURIZED HELIUM STORAGE Surface Dim: 12.1m x 4.2m Hmax: 15m

SITE PB

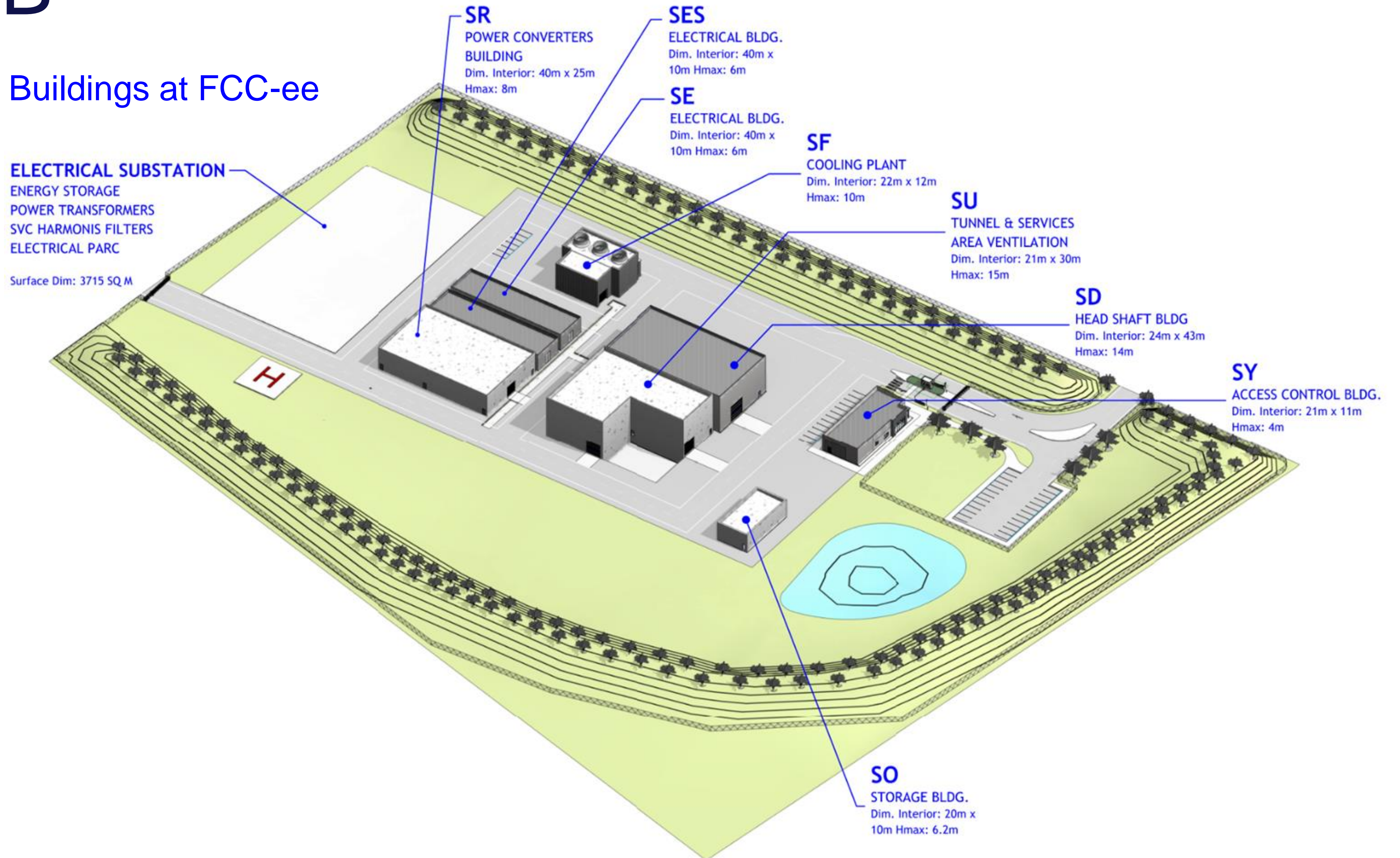
Proposed Site: Layout

Responding to existing constraints and general considerations



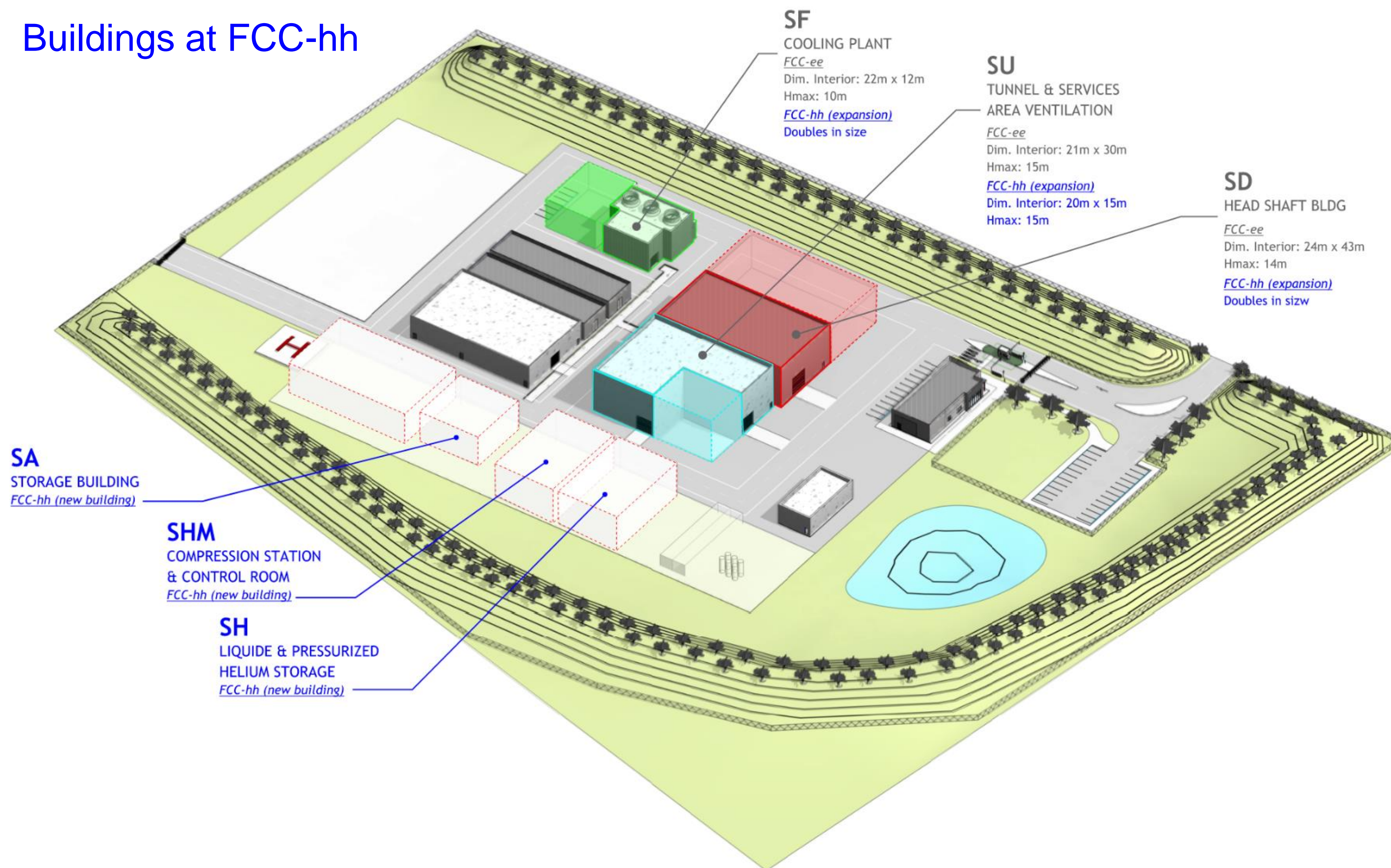
SITE PB

Proposed Site: Buildings at FCC-ee



SITE PB

Proposed Site: Buildings at FCC-hh





Aerial View of Proposed Site PB





View overlooking Site PB entrance

SY Access Building

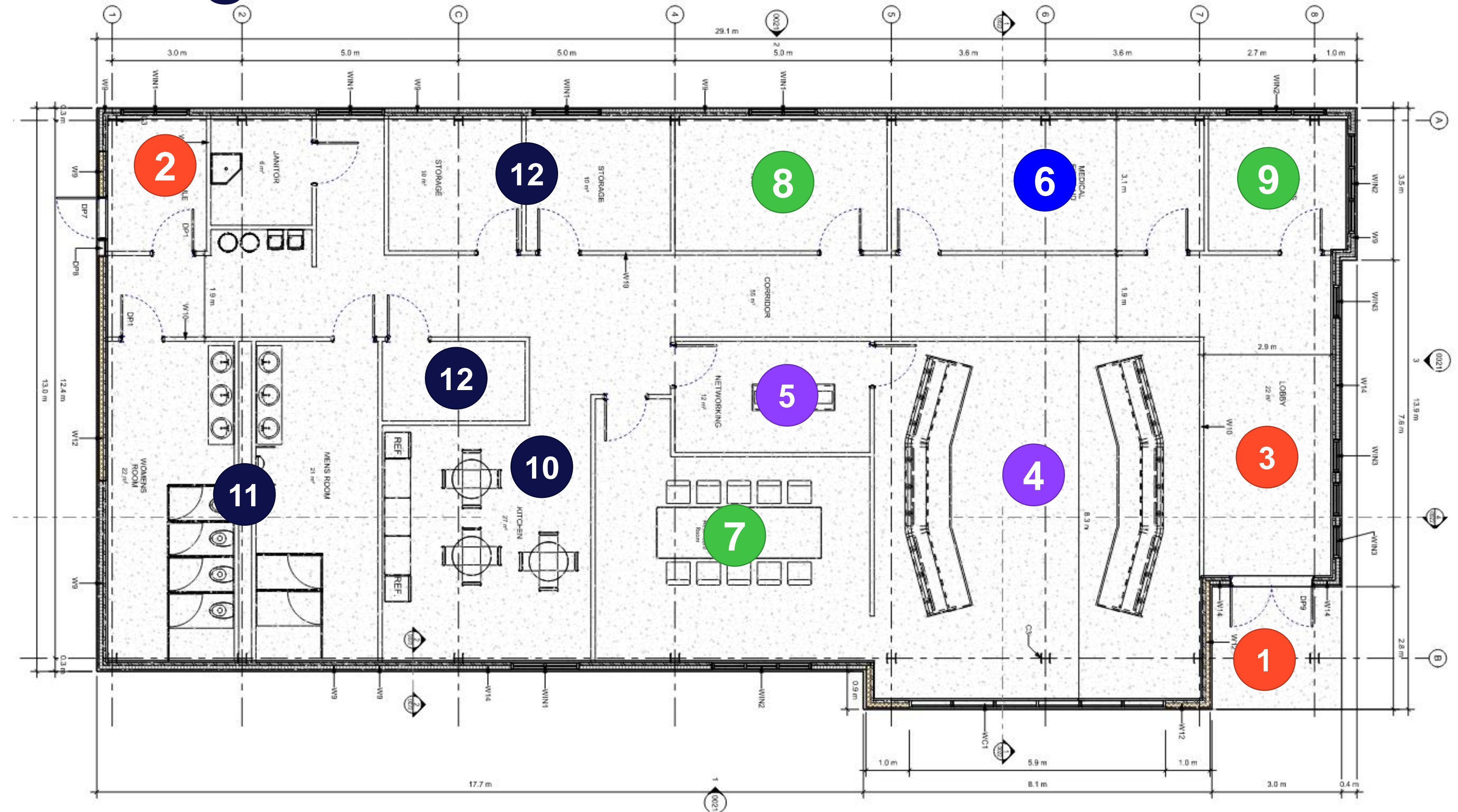


SY Access Control Building shown adjacent to the main site entrance

SY Access Building

Building Program

- 1 Main Entrance
- 2 Secondary Entrance
- 3 Lobby/Display Area
- 4 Control Room
- 5 Networking/Data Room
- 6 Medical First-aid Room
- 7 Conference Room (10 People)
- 8 Private Offices
- 9 Security Guard Office
- 10 Kitchenette/Break Room
- 11 Restrooms
- 12 Storage



SY Access Control Building Plan

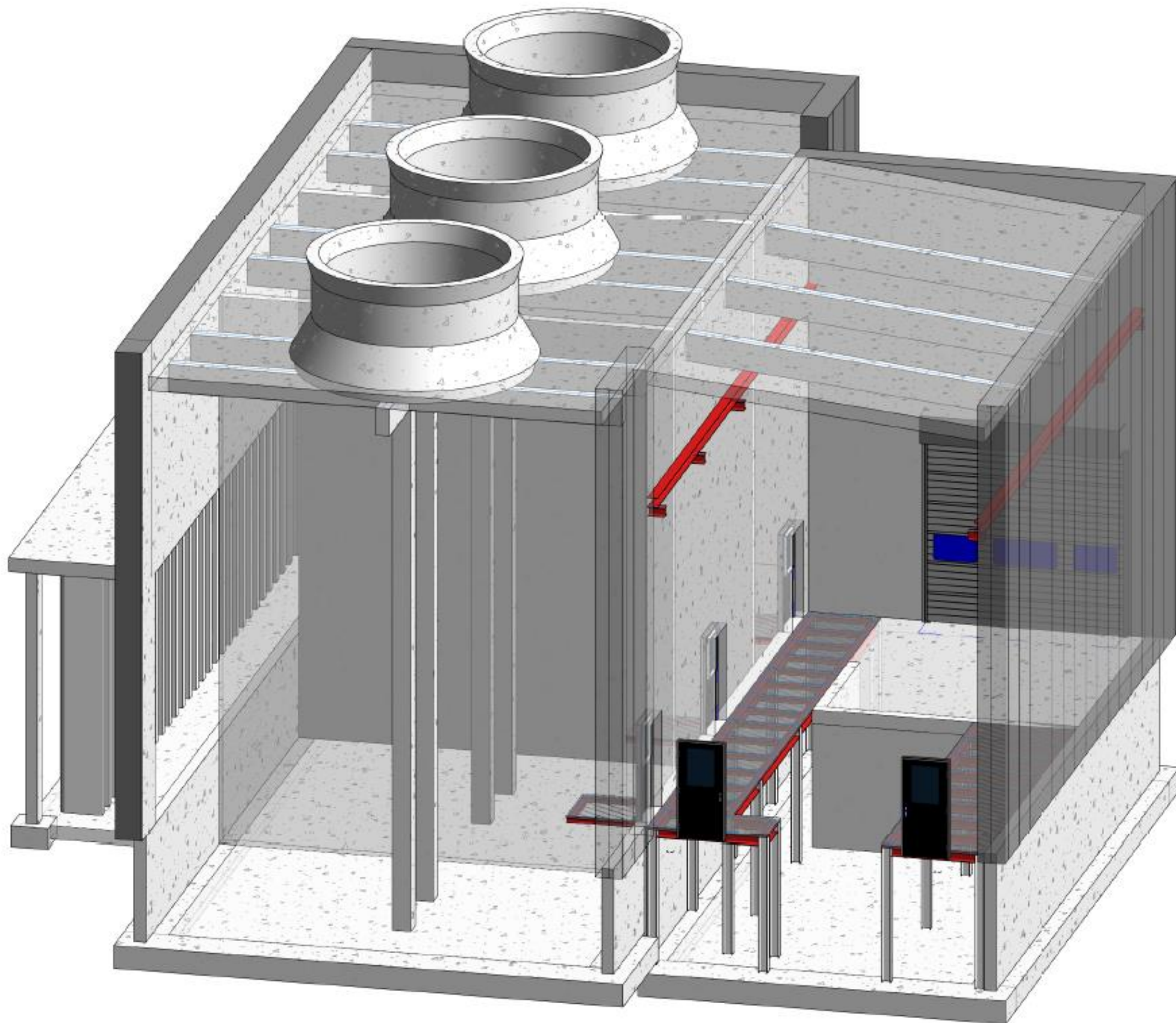
Site PB / SF Cooling Plant



The SF building host the cooling tower structures that are required to extract the heat loads from the machines for the underground.

Site PB / SF Cooling Plant

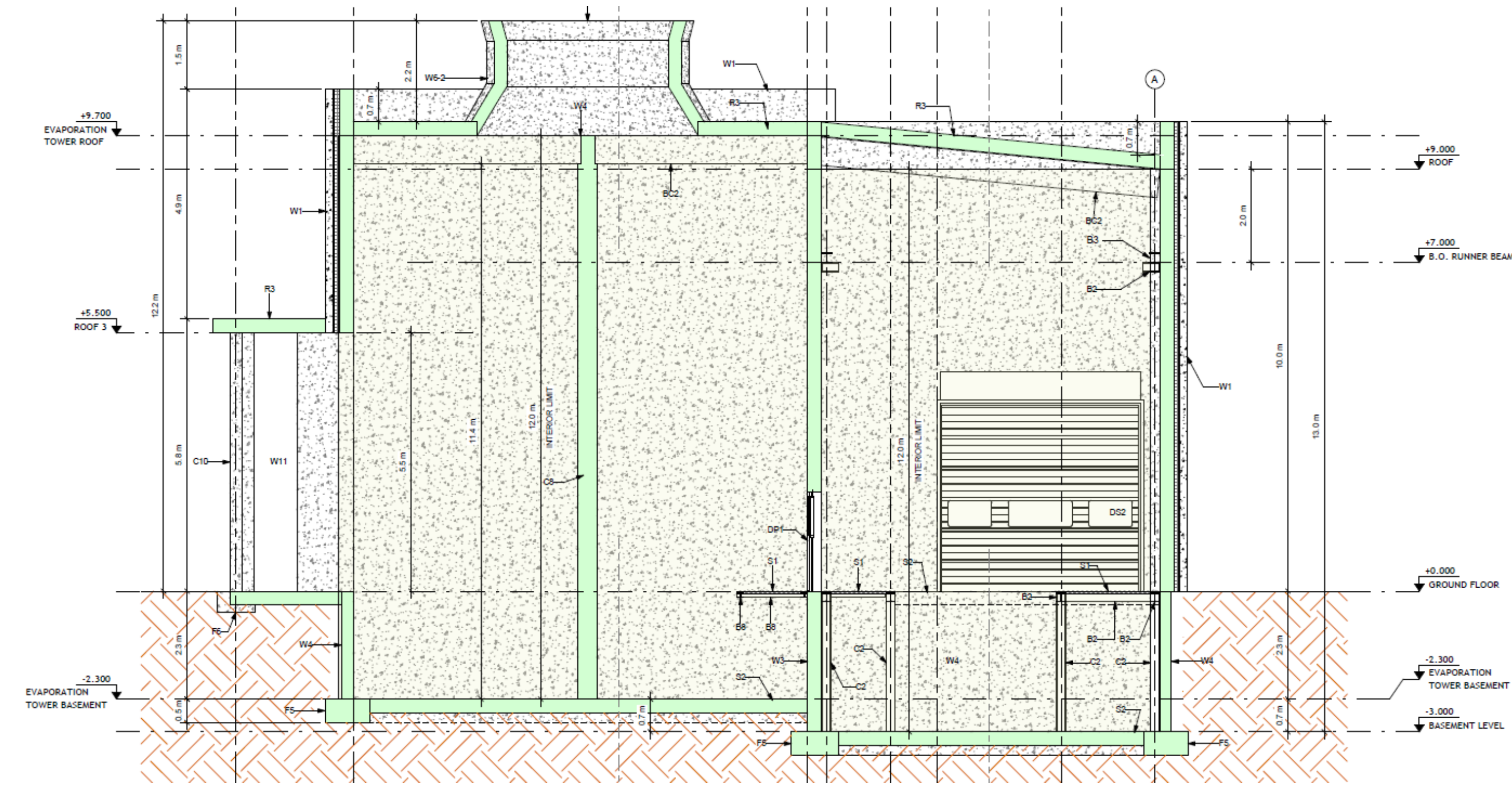
Proposed Structural System



- Reinforced concrete foundation: spread footings, slab on ground
- Reinforced concrete superstructure to help with sound attenuation
- Acoustic insulation panels on the interior walls to further reduce noise transmission to exterior
- Prefabricated concrete exterior wall panels with insulation
- Crane support beams for 3.5 tonne overhead crane
- Steel grating “false floor” to allow easy access to basement equipment level

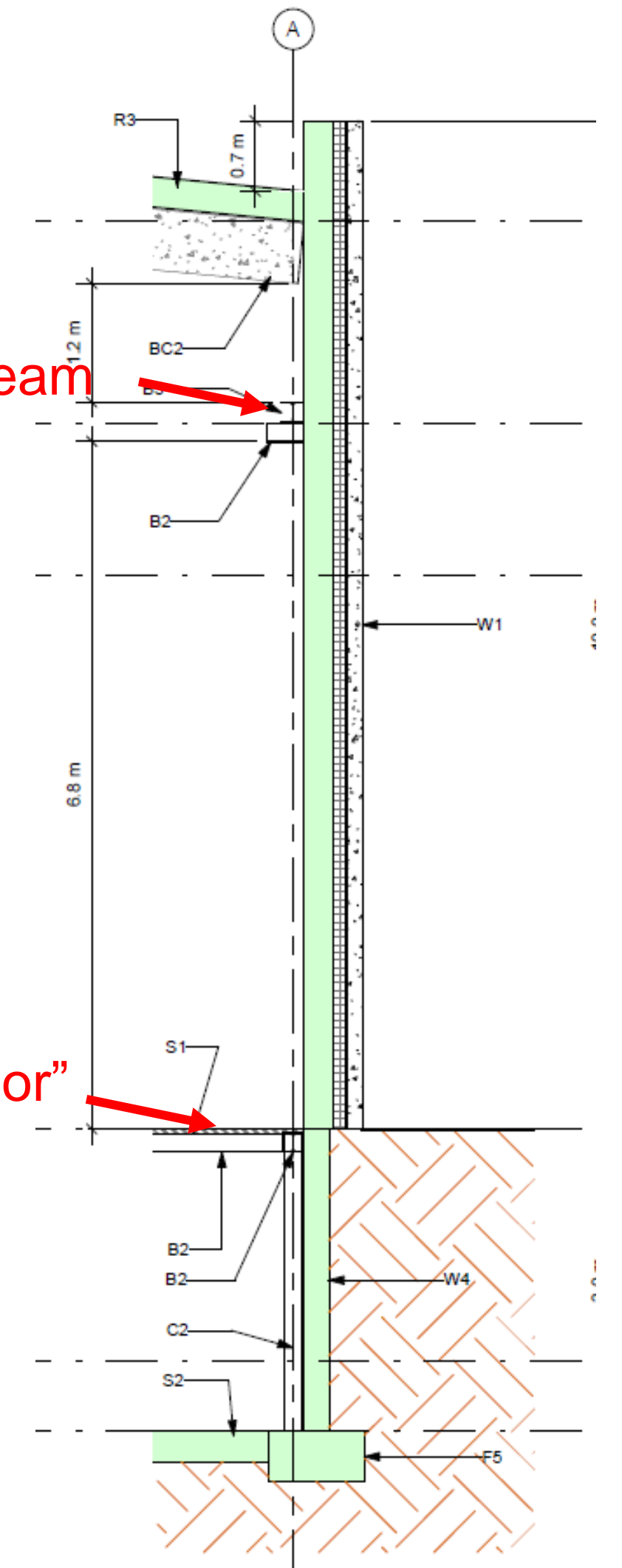
Site PB / SF Cooling Plant

Proposed Structural System



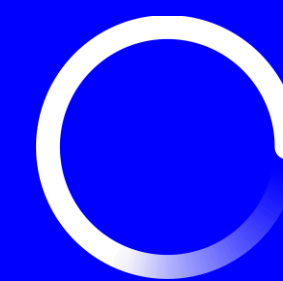
Crane support beam

Steel grating "false floor"
with basement below

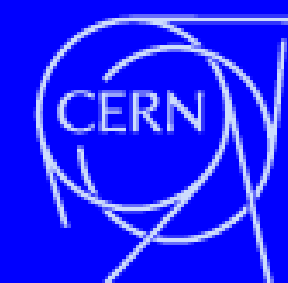


Conclusion

- All deliverables (Revit models, preliminary drawings, bill of quantities, technical report) have been transferred to CERN
- CERN has contracted a cost estimating firm to take this information and generate cost and schedule estimates that will be incorporated into the overall FCC feasibility study
- We've thoroughly enjoyed this opportunity for continued collaboration with our CERN colleagues and hope to remain a part of this effort in the future
- Special thanks to our CERN colleagues: [Tim Watson](#), [Antoine Mayoux](#), [Ludovic Barthelemy](#), [Angel Navascues Cornago](#).



FUTURE
CIRCULAR
COLLIDER



SCE

Site and Civil Engineering



Fermilab

ISD Infrastructure Services Division