

FCC Subsurface Site Investigations FCC Week 2025 Vienna

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Overview

- 1.Recap of subsurface studies and geology of FCC study area
- 2.Areas of geological uncertainty
- 3.Scope and results of site investigations works tender 2023
- 4.Overview of works and challenges
- 5.Provisional results of site investigations
- 6.Future site investigations campaigns

Recap of Subsurface Studies

ILF/GADZ 2020/21

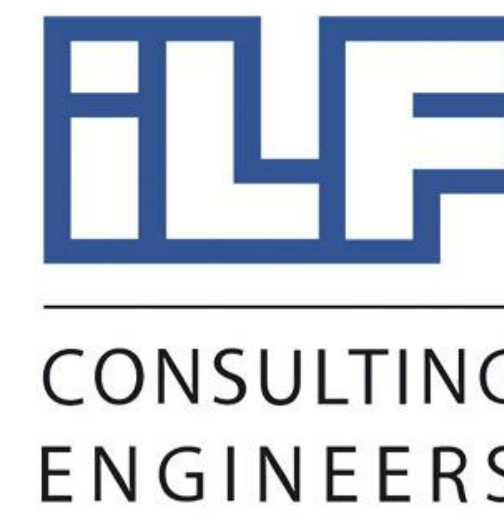
- Definition of 'Areas of Geological Uncertainty' for the preferred alignment scenario

Université de Genève 2021-2025

- Geological data gathering and creation of geological model

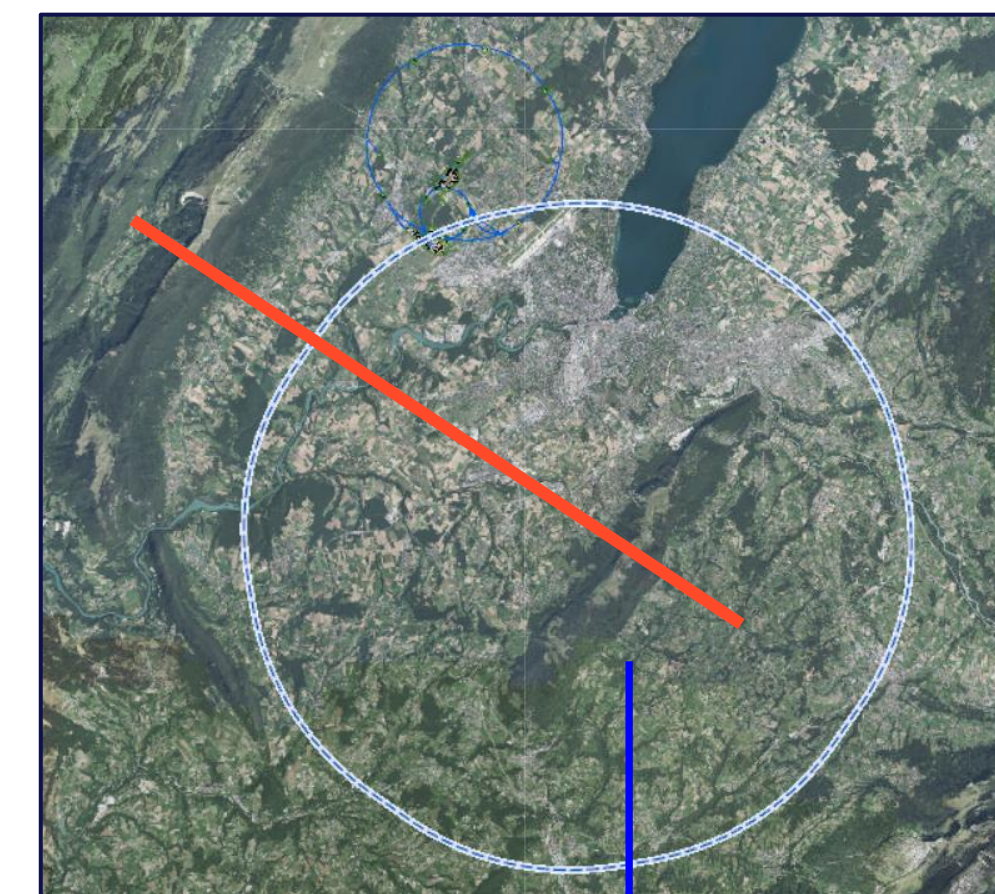
Quantum (Egis/WSP) 2022-2025

- Detailed analysis of 'Areas of Geological Uncertainty' for the amended alignment and updated geological models
- Optimization of the proposed site investigations (SSI) campaign scope of works
- Preparation of Technical Specifications for SSI Contractor MS, IT and analysis of bids
- Supervision of site works and role of Engineer under works contract

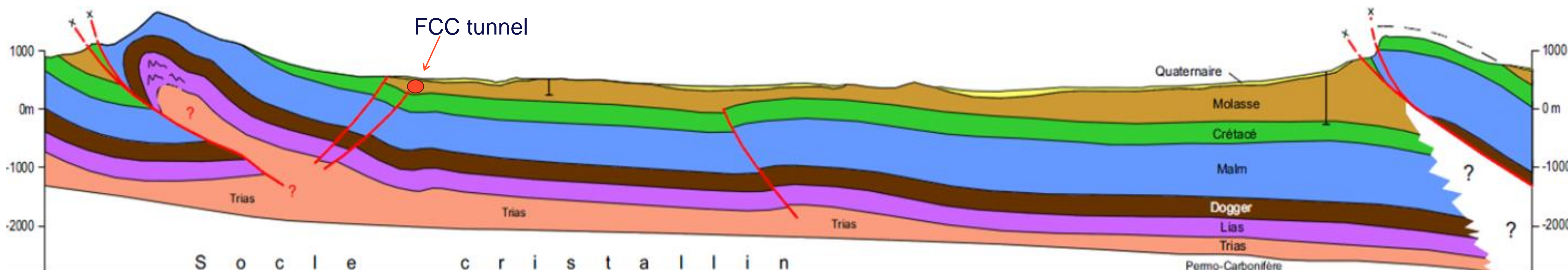


Geology in the FCC Region

- Moraines vary in depth from a few metres up to > 100m
- The molasse rock is the target horizon for the FCC.
- Karstic limestone is present in the southern and western extents of the alignment



Salève outcrop



West-East geological section of the Geneva region

Areas of Geological Uncertainty

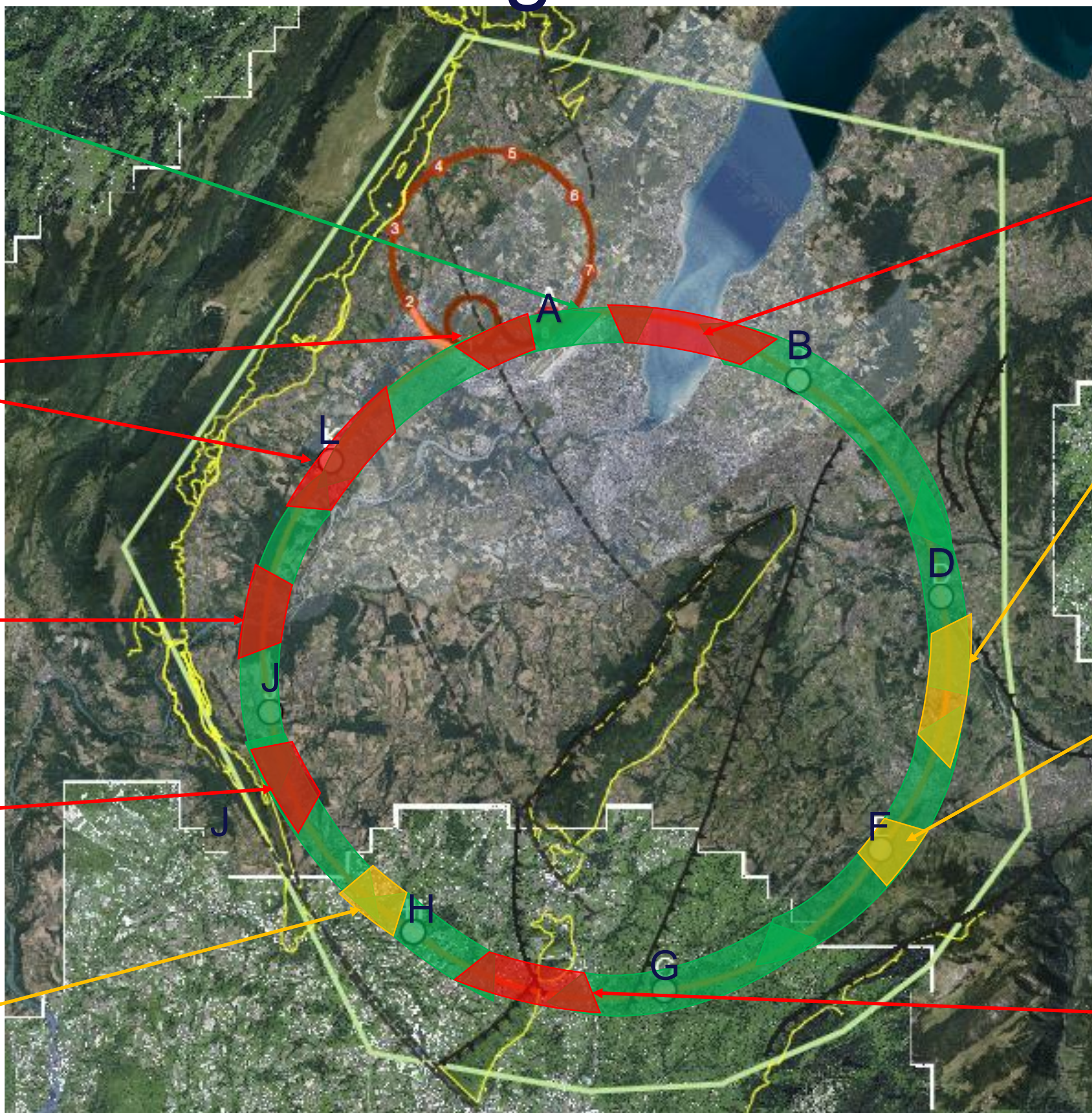
- Good knowledge of the ground (e.g. information near to CERN from LEP/LHC projects)

- Jura**
- Limestone/molasse interface uncertain.
 - Risk of karsts and high-water pressures

- Rhône**
- Moraine/molasse interface uncertain.

- Vuache**
- Limestone/molasse interface not certain.
 - Proximity to active fault

- Les Usses**
- Moraine/molasse interface uncertain.
 - Low tunnel rock cover

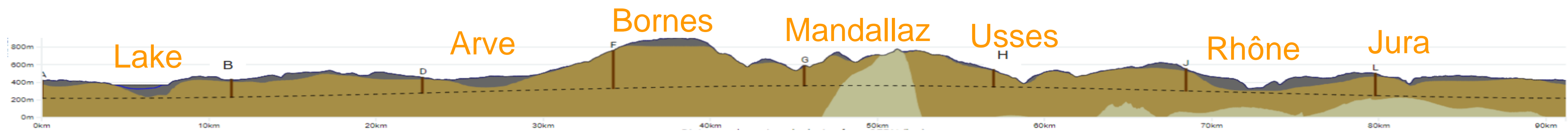


- Lac Léman**
- Moraine/molasse interface uncertain
 - Soils and rock properties uncertain
 - High uncertainty in the hydrogeological conditions

- Vallée de l'Arve**
- Moraine/molasse interface uncertain.
 - Lack of reliable borehole information

- Bornes**
- Insufficient deep borehole information
 - Complex faulted region
 - Quality of molasse is uncertain.

- Mandallaz**
- Fractured limestone formations, characteristics and locations of karsts unknown.
 - Potentially high-water pressures

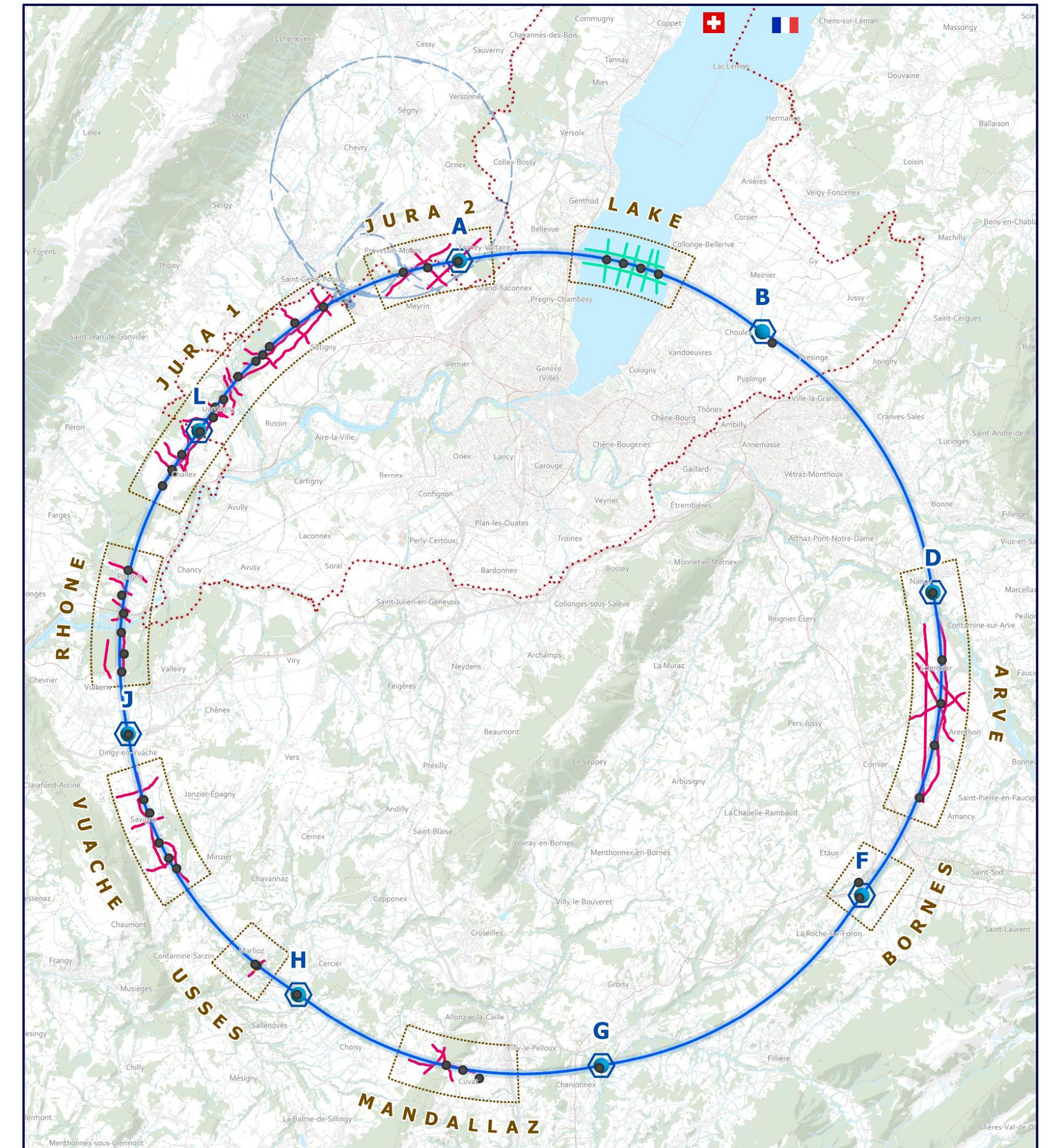
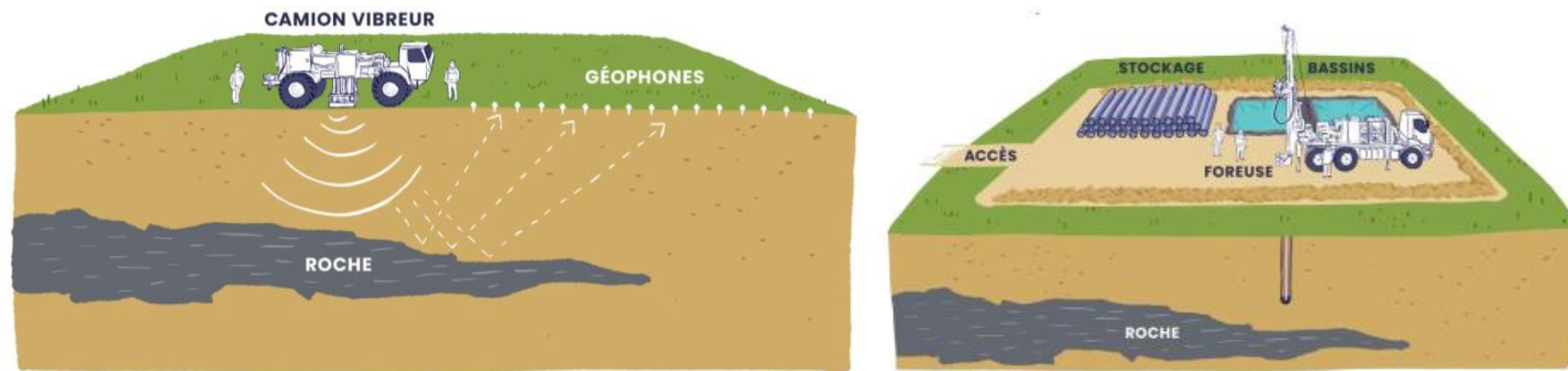


Original Scope of Site Investigations Put Out to Tender in 2023

The scope put out to tender in October 2023 was envisaged as a single contract for the entirety of the works, with investigations both in France and in Switzerland

This was made up of:

- Over 80km of 2D seismic geophysics
- 47 boreholes both fully and partially cored



Layout of scope put out to tender Oct 23

Results of Tender Oct 2023

- Three international consortia were admitted to the tender stage
- CERN received bids from two consortia were technically compliant and close in value

French/Swiss group

GEOTEC-IOI



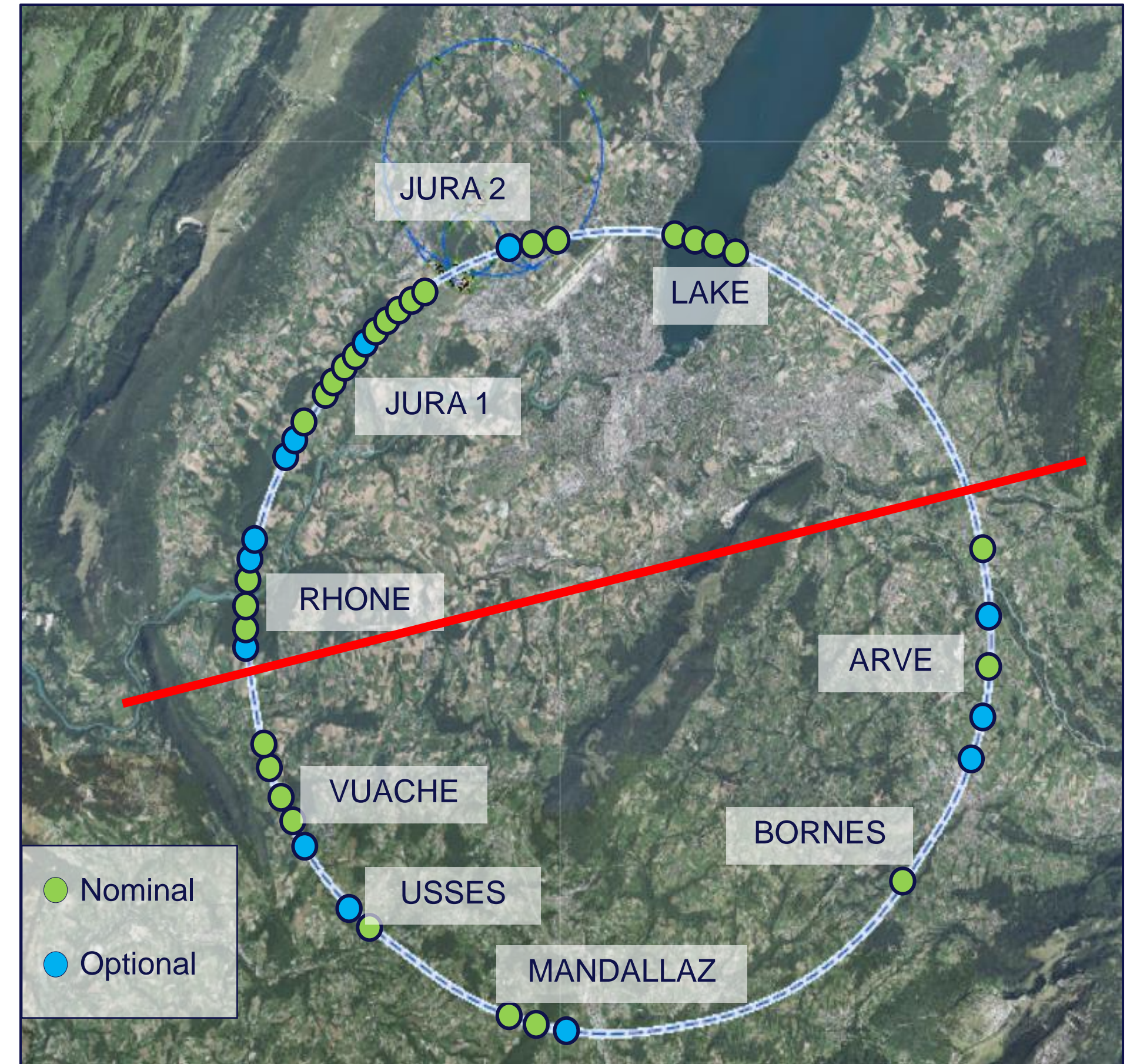
UK/Italian group

SGS3



Strategy Amendments

- With the bids being close in value, the decision was made to split the work into two contracts:
 - ✓ Contracts to 4 member states (FR/CH/UK/IT)
 - ✓ Gives CERN more flexibility to allocate works
 - ✓ Engages more industrial partners ahead of larger future SSI campaigns
- The following technical scope amendments were made:
 - ✓ 28 boreholes (nominal scope)
 - ✓ 15 boreholes optional pending geophysics results
 - ✓ 4 Shaft boreholes not located in target areas were postponed to the future campaign
- The full geophysics scope was maintained



Division of SSI scope

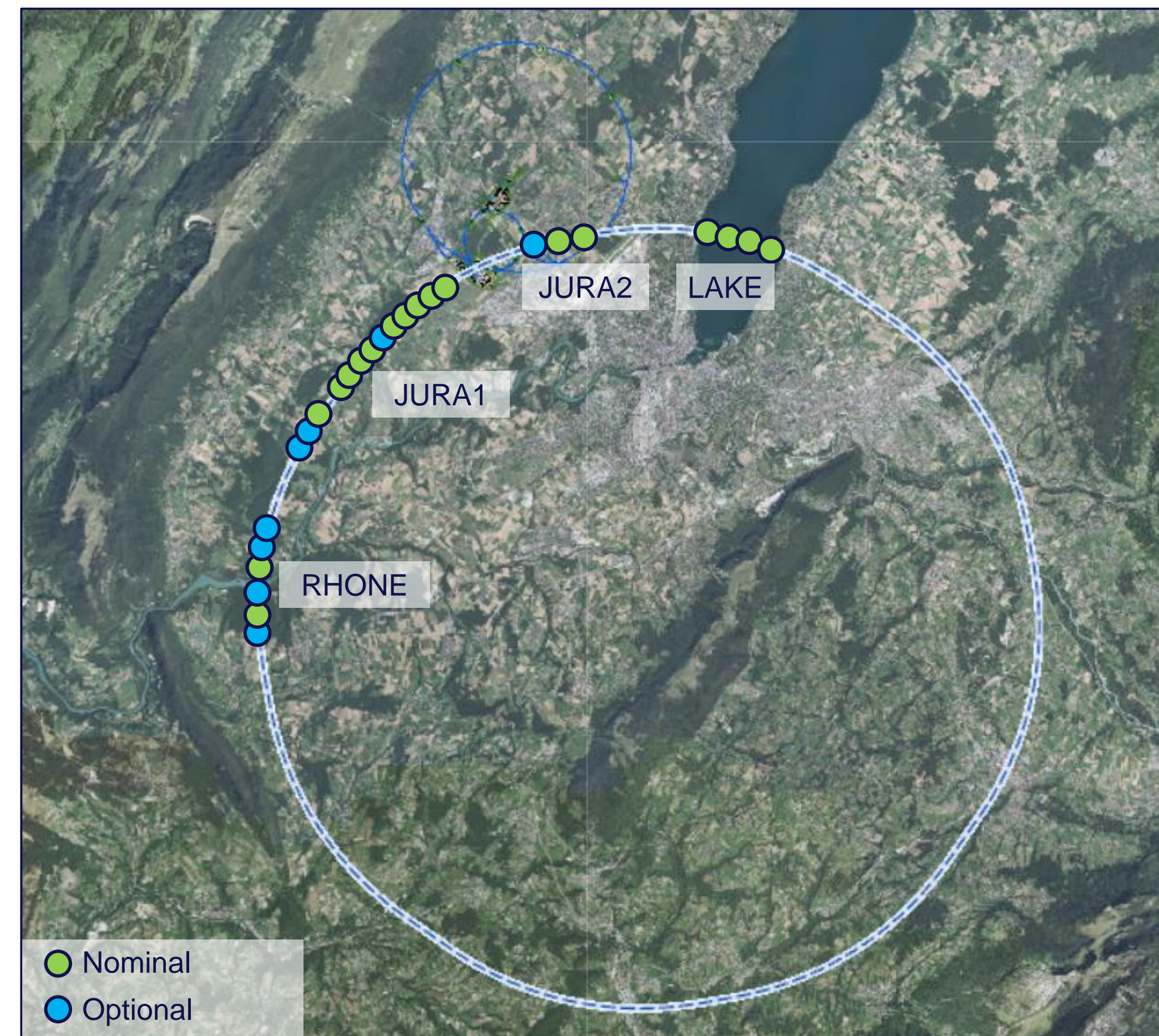
Strategy Amendments



GEOTEC-IOI were allotted northern-eastern works package

This includes 18 nominal boreholes and 50km of geophysics in sections:

- Rhone
- Jura 1
- Jura 2
- Lake



GEOTEC-ERG-ISR scope

Strategy Amendments



SGS3 were allotted south-western package

This includes 10 boreholes and 30km of geophysics in sections:

- Vuache
- Usses
- Mandallaz
- Bornes
- Arve



SGS3 scope

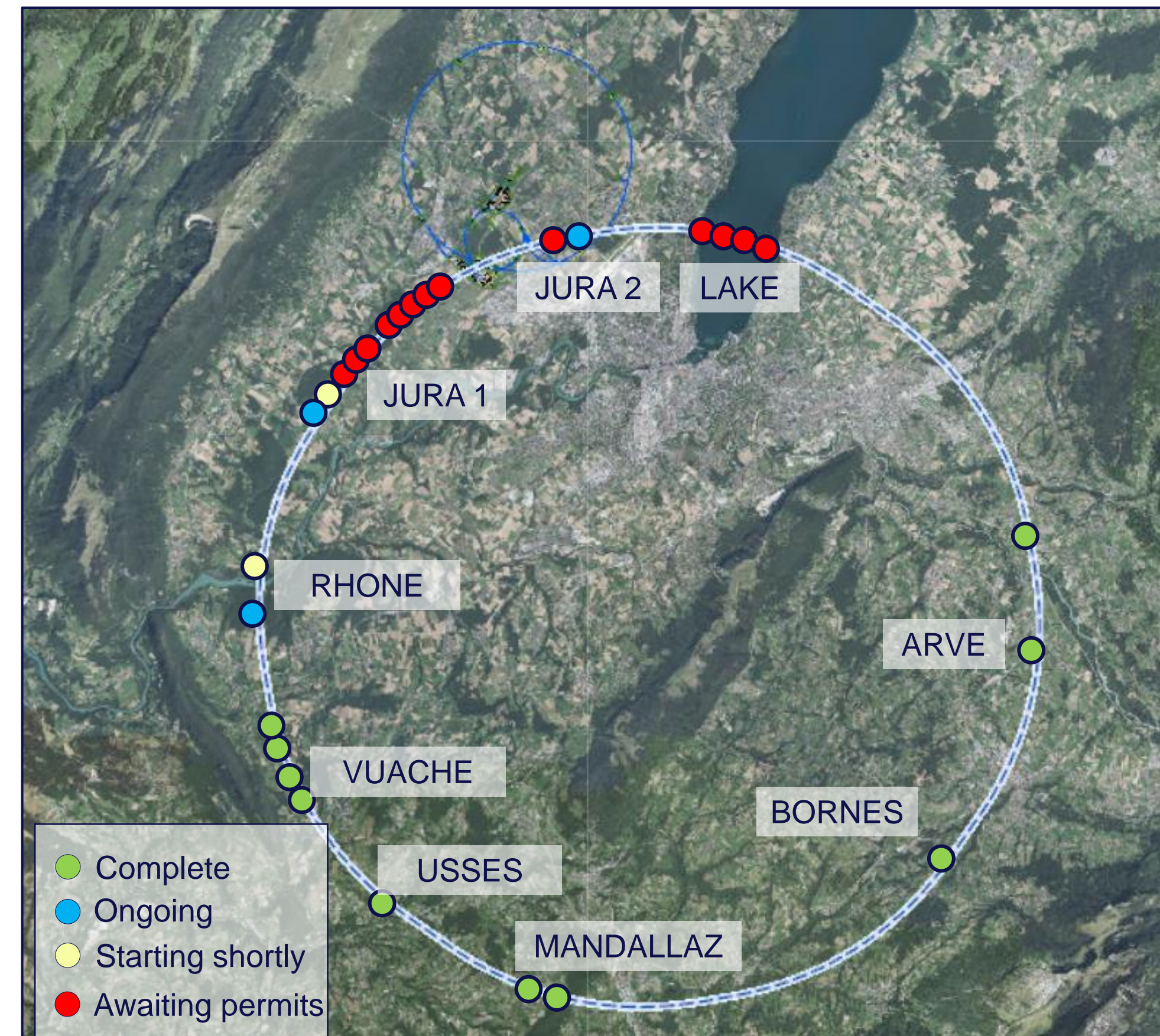
Overview of Works

South-western work package **SGS3**

- Works began in October 2024
- Geophysics acquisition complete and interpretation ongoing
- Drilling activities complete on all boreholes
- Testing and reporting currently ongoing

North-eastern work package **GEOTEC-IOI**

- Works began in France in April 2025
- Drilling activities ongoing on 3 boreholes
- Geophysics in Sept 2025 due to environmental constraints
- Still awaiting permits for drilling and geophysics in Switzerland



Challenges

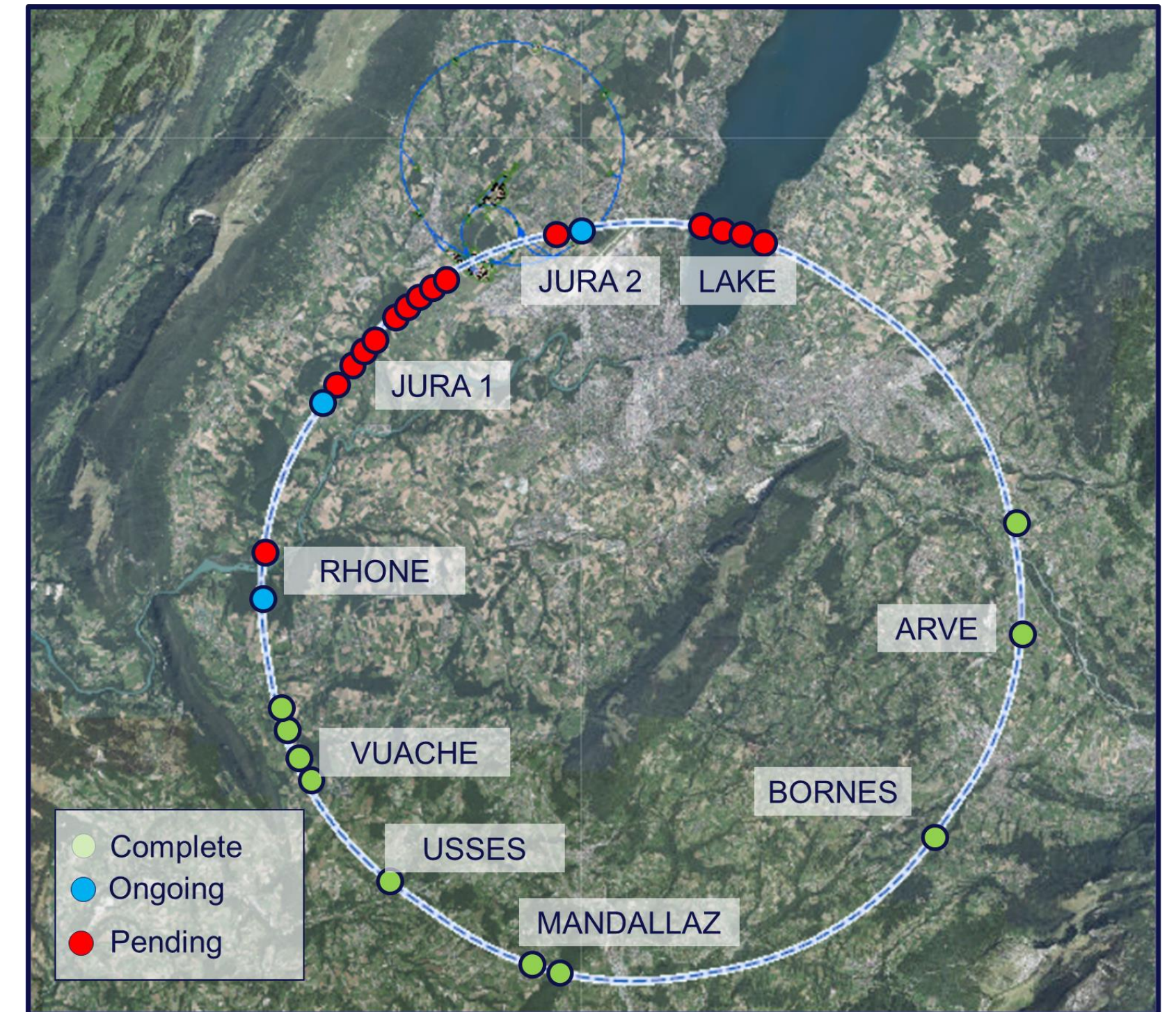
The original scope of the campaign has been reduced mainly due to environmental restrictions and permitting delays. The optional boreholes will be done in the future phase.

France

- Cumulative environmental footprint of the full scope was reduced for a project in feasibility stage
- Several boreholes were removed in Jura, Rhone, Arve and Vuache sectors before permits were granted in Oct 2024

Switzerland

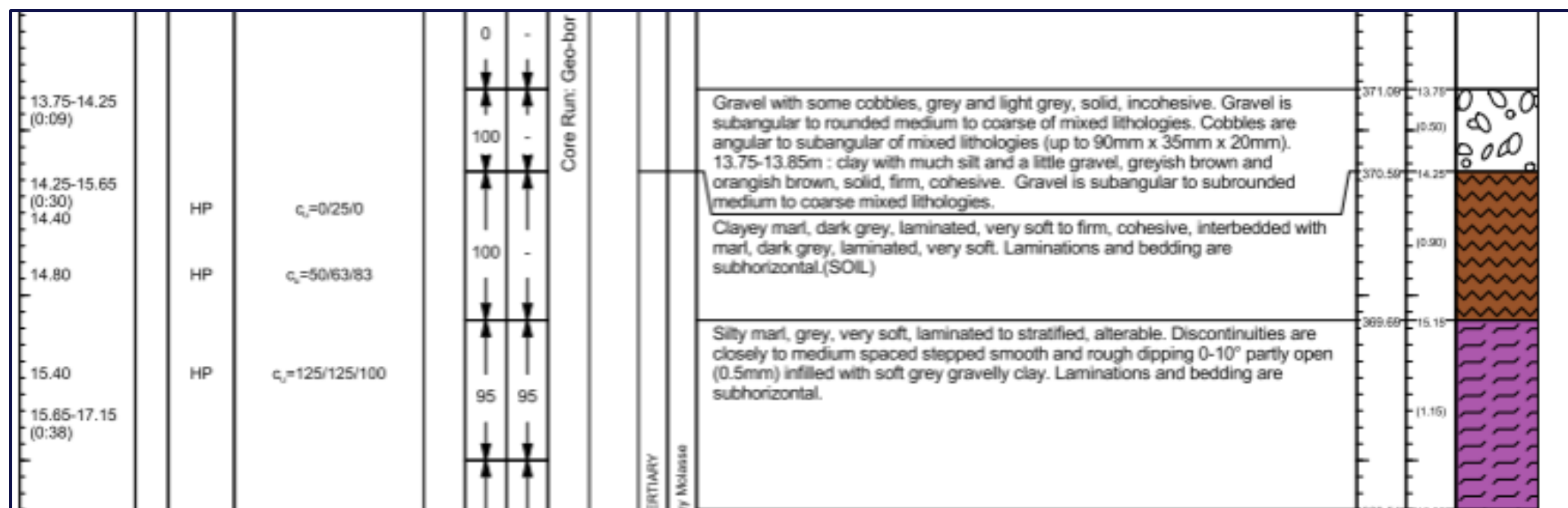
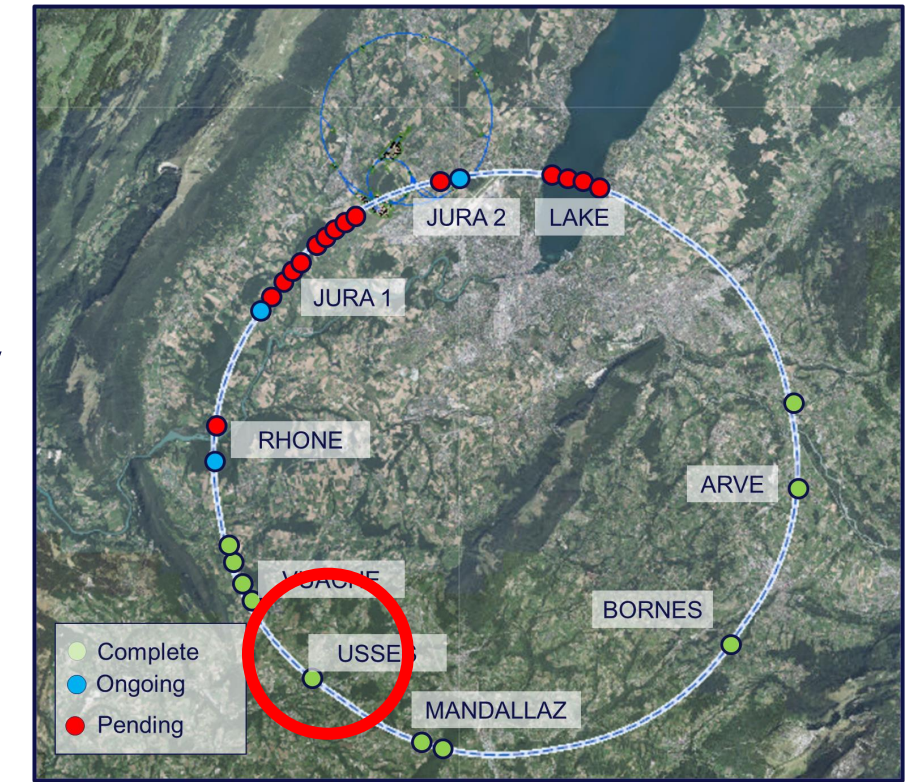
- Permitting process taking longer than originally foreseen
- Building permit (OAC) is not considered well suited to borehole works
- No firm date for permits to be granted



Results from SSI: Usse Valley

Objective: Identification of the moraine-molasse interface at the bottom of the valley

- Tunnel is located close to the surface at 60m depth
- A fully cored borehole encountered the molasse interface at 14m depth
- Baseline model had this interface closer to tunnel at 40m depth
- Geophysics results are currently being processed, but it appears this interface extends at similar depth across the entire Usse valley
- Positive as it assures the tunnel will remain well in the molasse



Extract of Usse_2 geological log

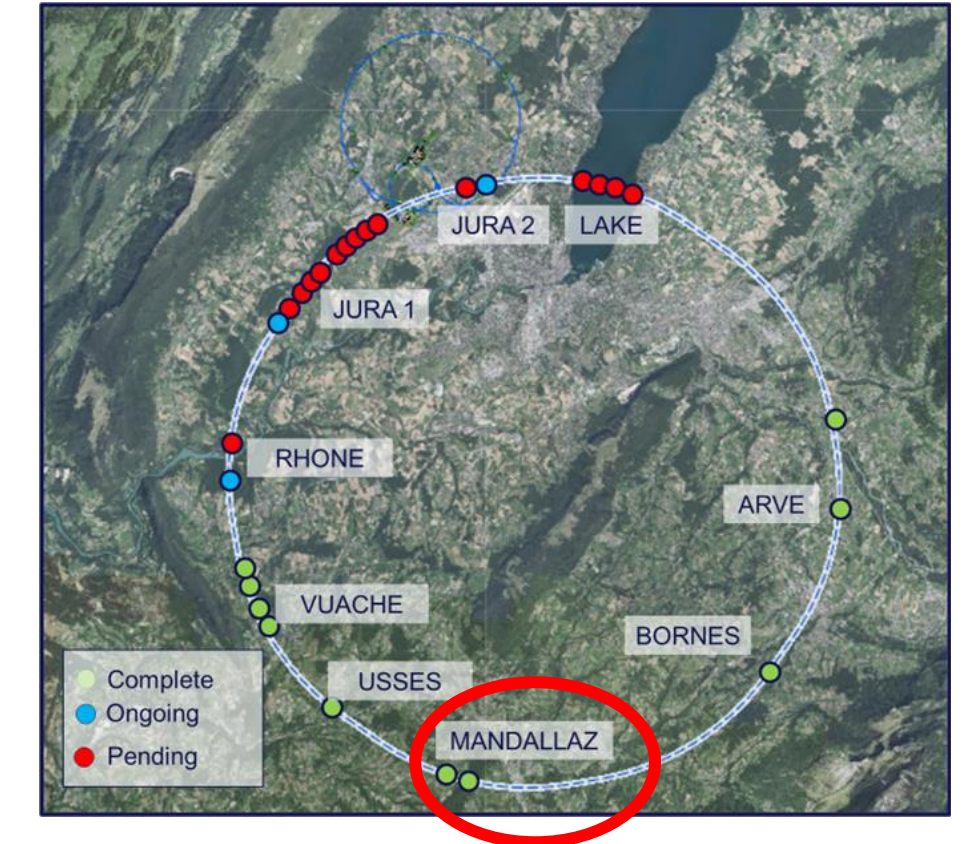


Drilling rig at Usse_2 site

Results from SSI: Mandallaz

Objective: Understand the characteristics and width of the limestone outcrop

- Tunnel cannot avoid crossing Mandallaz limestone outcrop
- One cored vertical and one cored inclined borehole and three 2d seismic lines were carried out



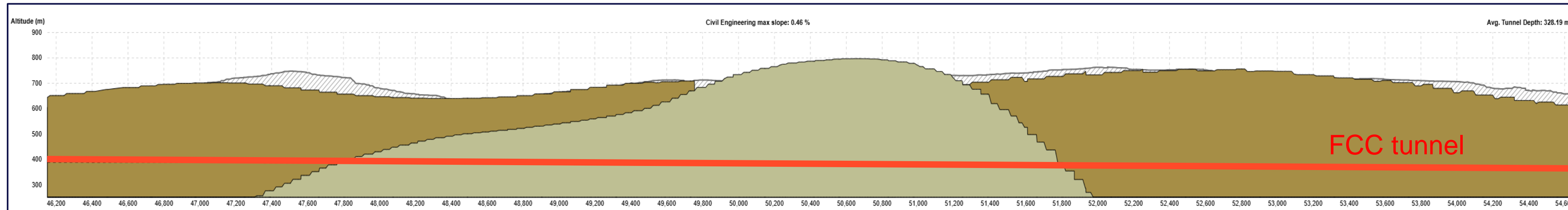
Mandallaz work sites



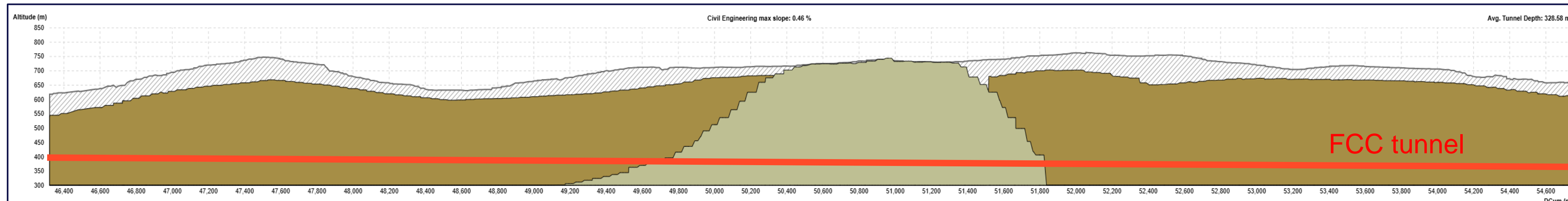
Mandallaz seismic works

Results from SSI: Mandallaz

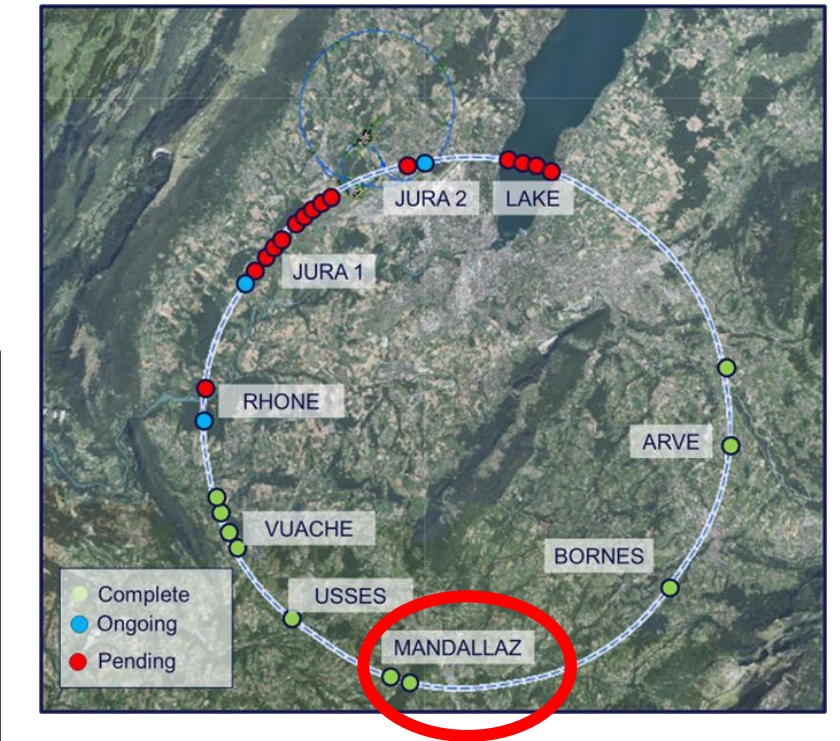
Objective: Understand the characteristics and width of the limestone outcrop



Mandallaz profile based on baseline ILF/GADZ model



Mandallaz profile based on UNIGE v5. model

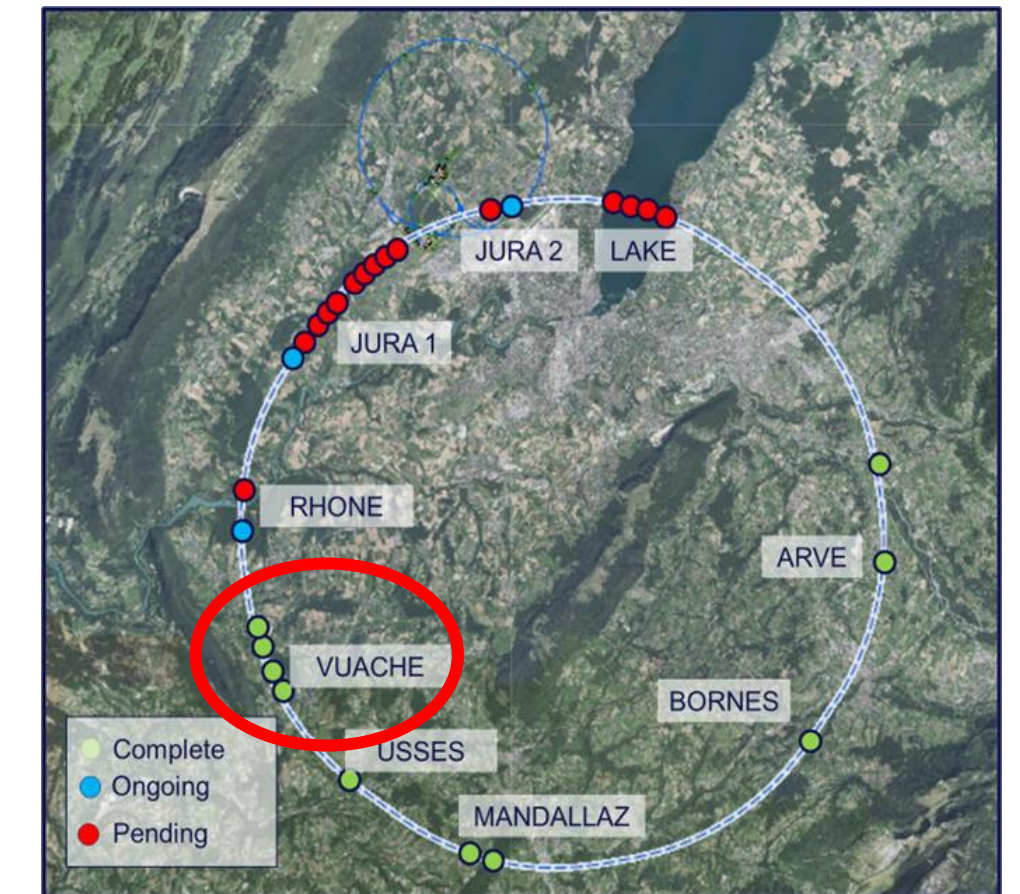


- Results positive suggesting the limestone is approx. 1.6km narrower than originally modelled at tunnel depth
- Geophysics show the presence of an inclined fault which boreholes did not reach at executed depths
- Karsts were encountered but were not filled with water
- Further targeted seismic and additional boreholes will be required to fully understand the nature of the faulting

Results from SSI: Vuache

Objective: Confirm the absence of limestone and characterize molasse

- Baseline model showed the possibility of limestone from the Vuache foothills being located close to tunnel alignment
- 4 partially cored boreholes and 5 seismic lines were undertaken



Vuache_5 worksite

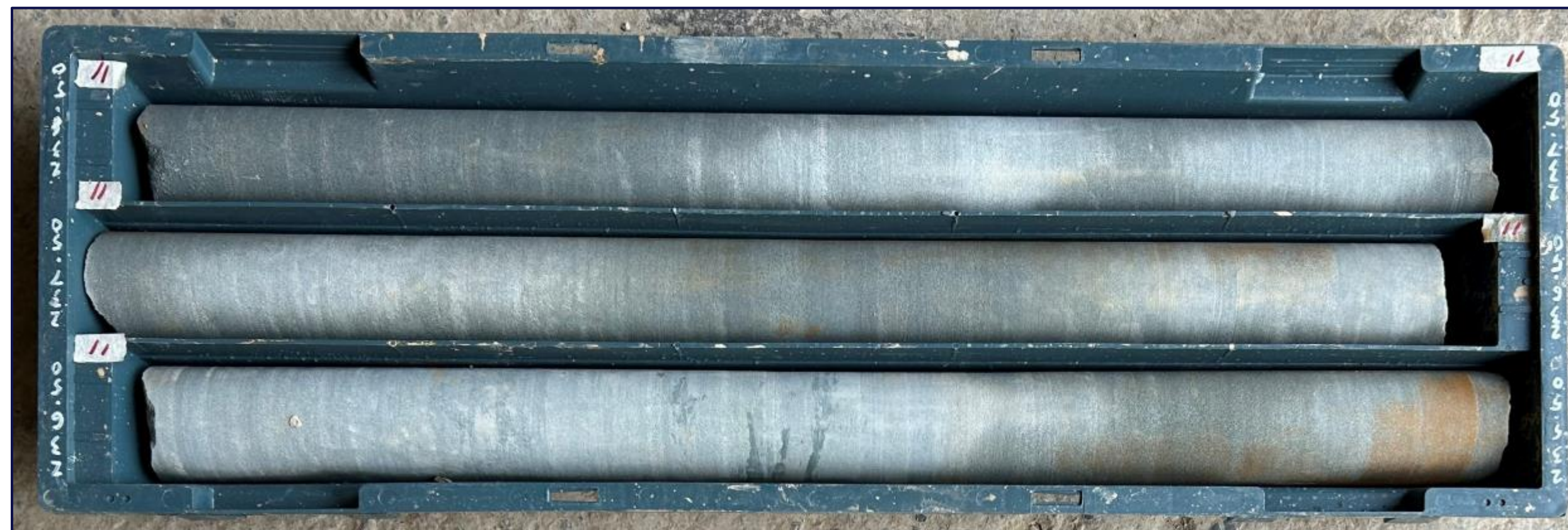
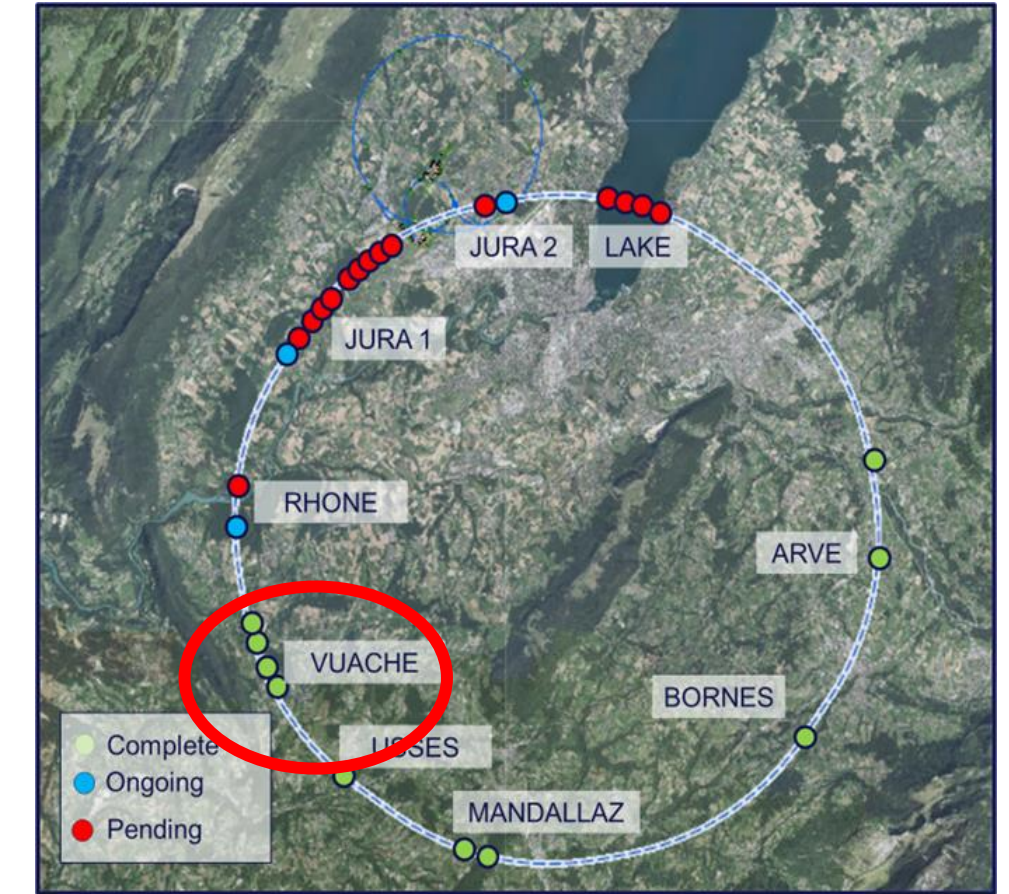


Vuache_3 worksite

Results from SSI: Vuache

Objective: Confirm the absence of limestone and characterize molasse

- All four boreholes confirmed the molasse at the tunnel alignment
- Samples taken from cores at tunnel depth show non-fractured and impermeable molasse
- Overall results are positive showing that the tunnel should remain in good molasse



Molasse cores from Vuache_2 site

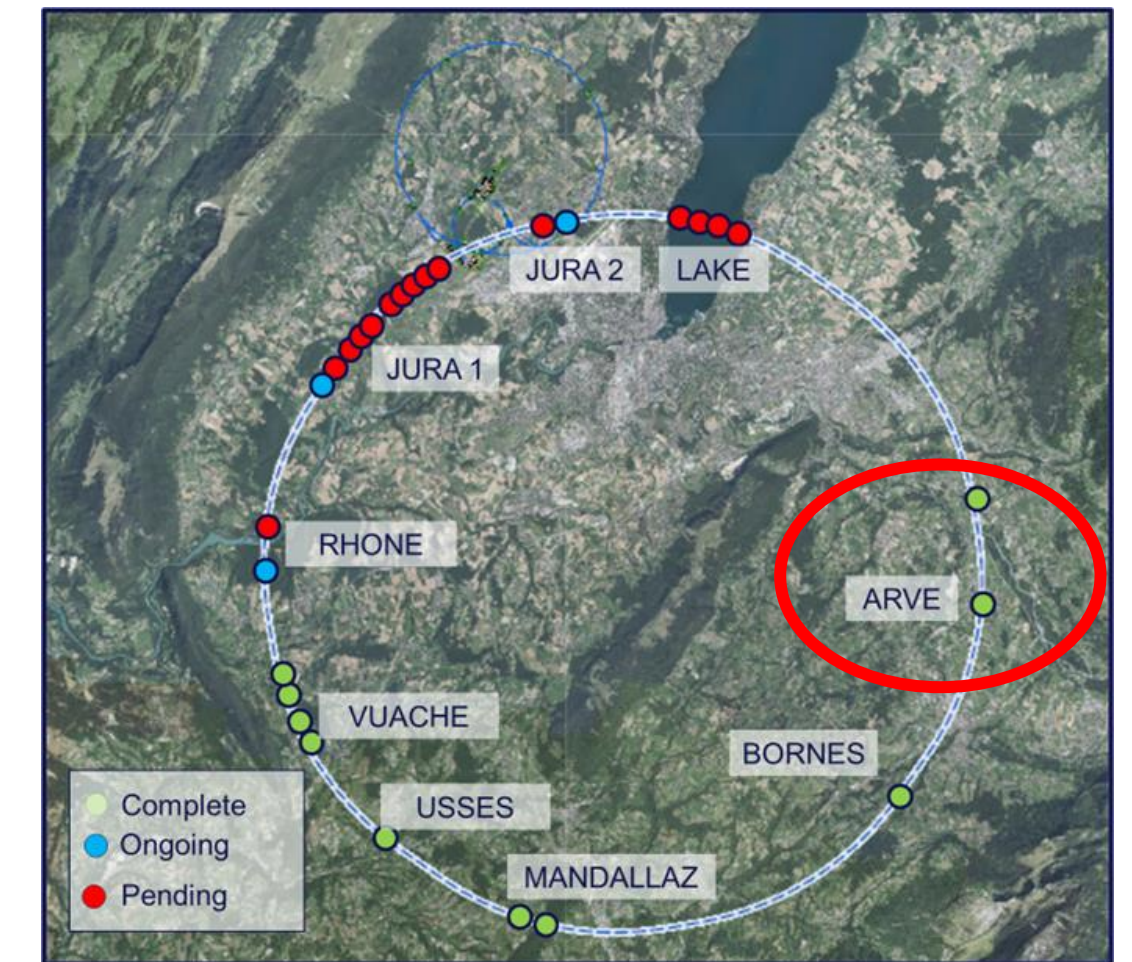


Molasse cores from Vuache_4 site

Results from SSI: Arve

Objective: Confirm the depth of molasse/moraine interface

- Works are recently complete at both Arve drilling sites
- Baseline moraine/molasse was predicted at 30m depth. Investigations encountered the interface at 15m depth, but molasse at lower depths has variable quality
- Investigations were positive as they confirmed shaft PD will mostly be excavated in molasse and the tunnel alignment remains in the molasse



Variety of core samples taken from Arve_3



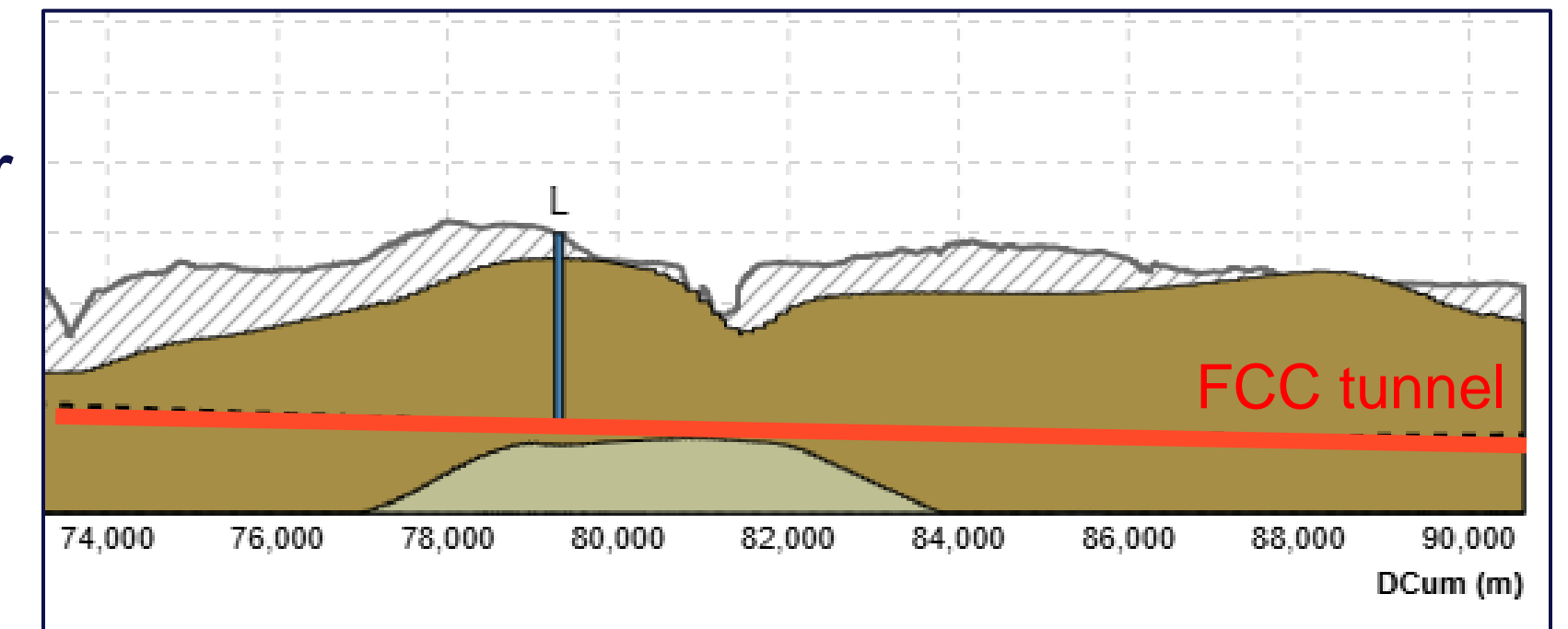
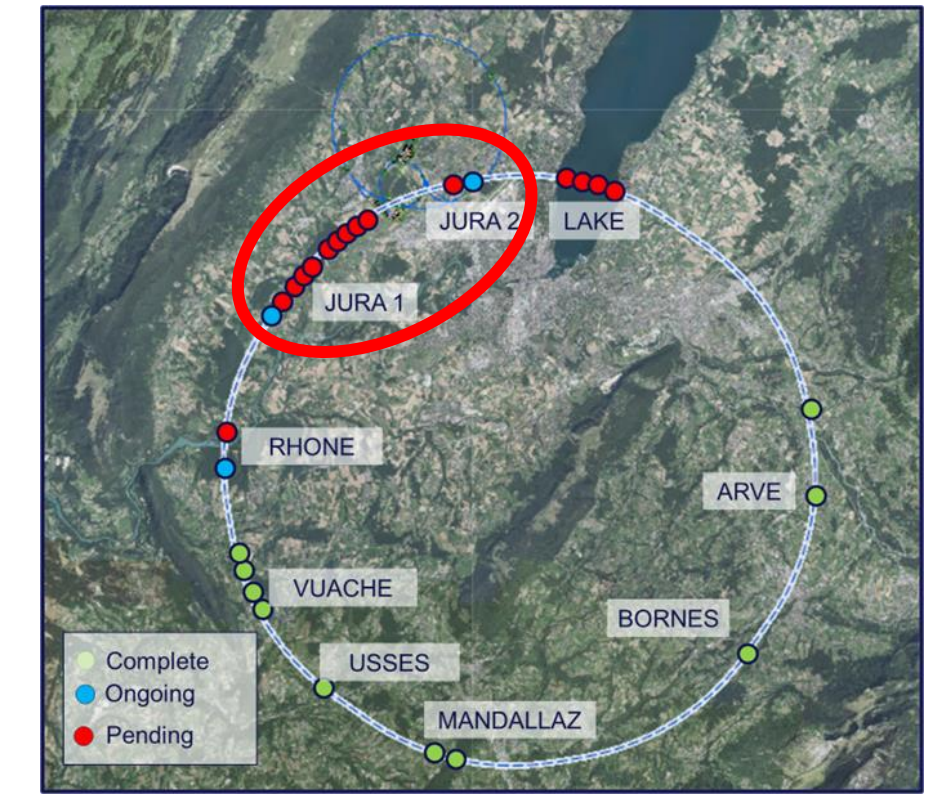
Core samples at Arve_1 at 70m depth

Results from SIG 3D Seismic Campaign: Jura

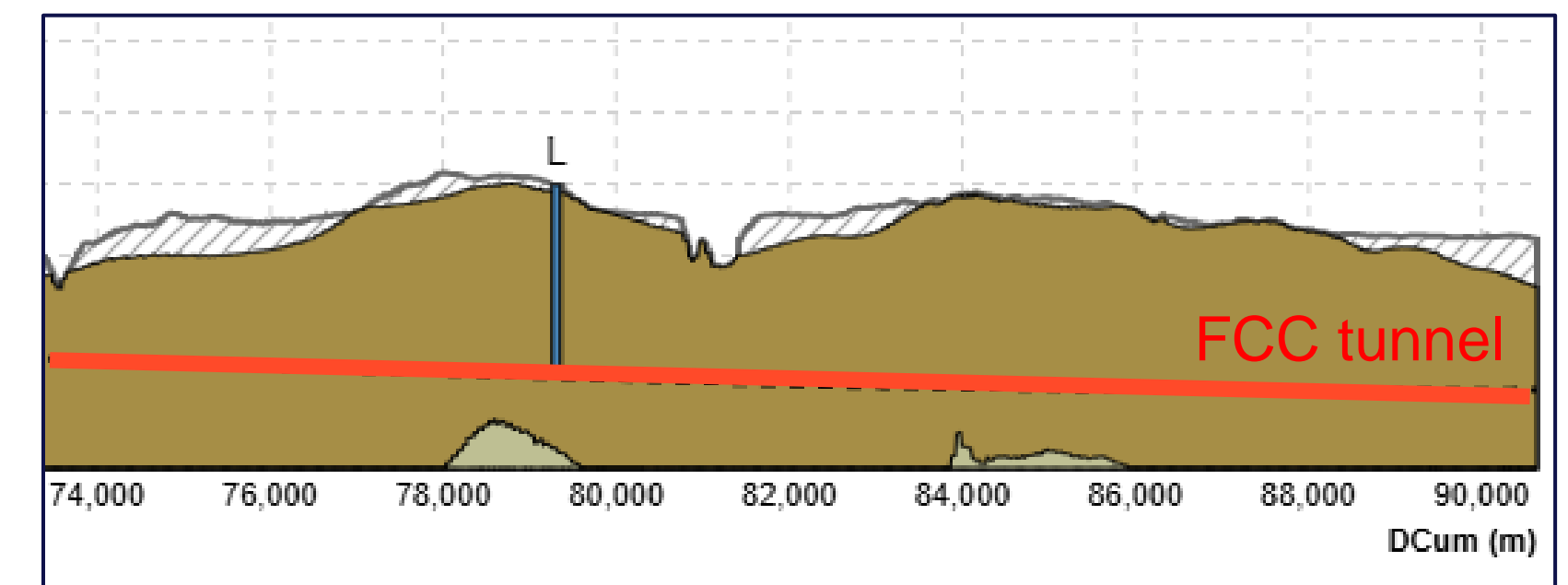
Objective: Identification of the molasse-limestone interface

Data from a deep borehole in Satigny and a 3d seismic campaign as part of the Geothermies project carried out by SIG and Canton de Geneve was recently made available. UNIGE integrated this into their 3d model suggesting in the following:

- The tunnel will remain above the limestone and entirely within the molasse
- Limestone is located approximately 50m deeper than originally modelled
- This information is more reliable in the north of the section and will hopefully be confirmed after SSI campaign is finished



Jura profile in baseline ILF/GADZ model

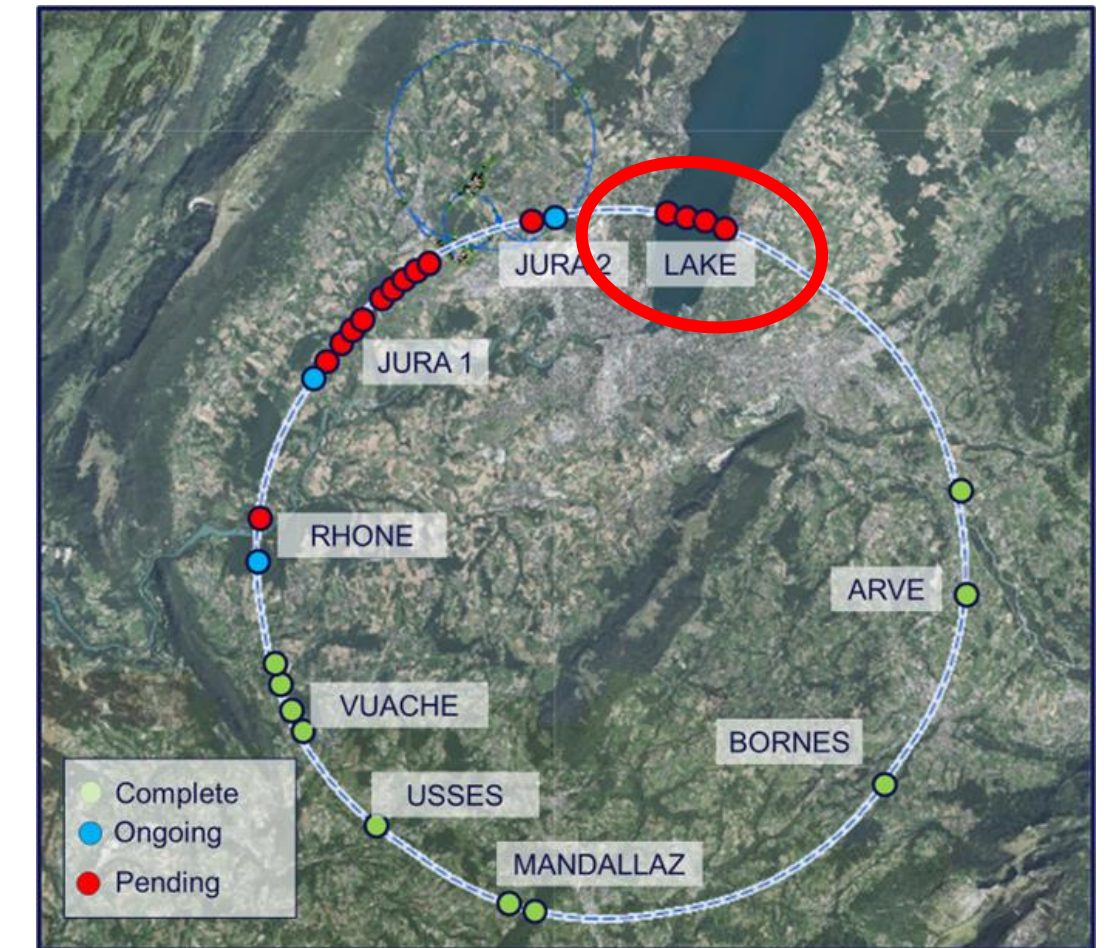


Jura profile in UNIGE v5. model

Updates from SIG 3D seismic campaign: Lake

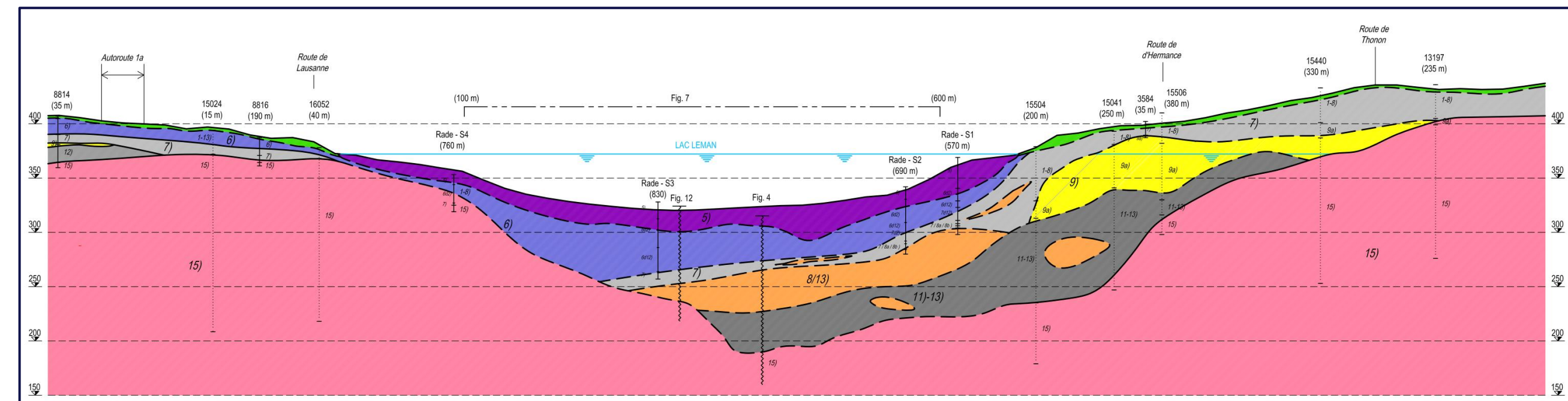
Objective: Identification of the moraine-molasse interface

- In all scenarios, the lake critically influences the depth of overall tunnel alignment
- The baseline alignment is close to the “worst case” predicted interface



UNIGE has integrated data from the SIG 3d seismic campaign into their 3d model. Although the seismic campaign was undertaken to the south of the FCC alignment, extrapolating the model suggests:

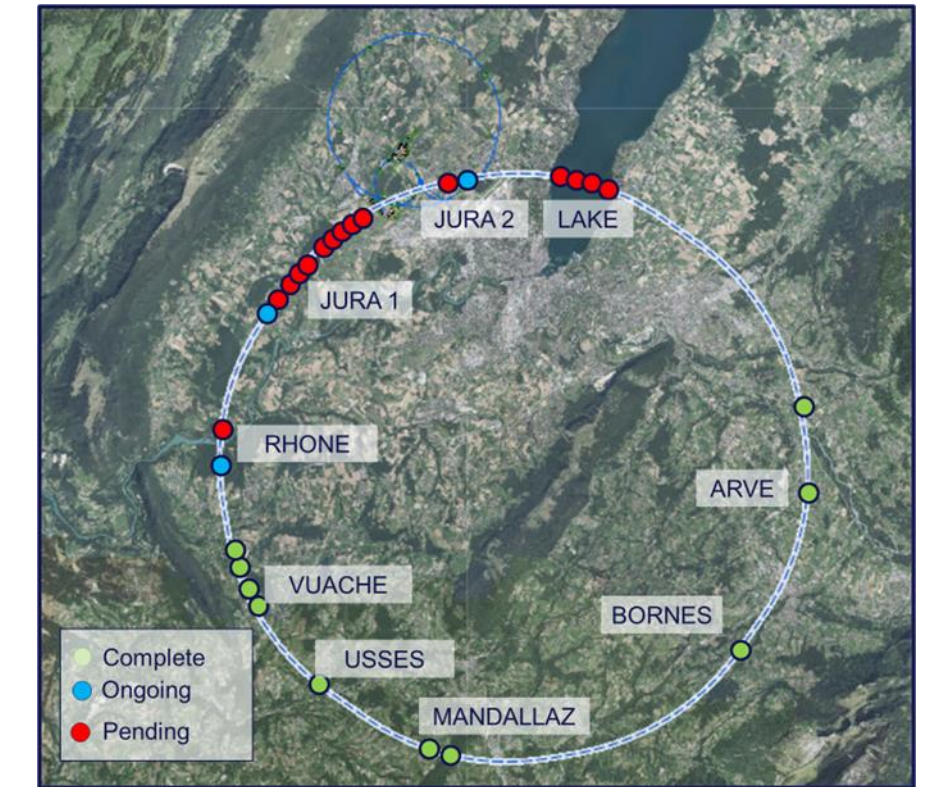
- Moraines are slightly shallower than foreseen in ILF/GADZ model
- The tunnel will remain entirely within the molasse
- This will be confirmed after SSI on the lake is undertaken.



Geological profile below Lake Geneva from ILF/GADZ model

Conclusions from SSI

- Preliminary results in Arve, Bornes, Mandallaz, Usses and Vuache are positive:
 - ✓ Tunnel alignment within molasse rock
 - ✓ Mandallaz limestone outcrop not as wide as originally considered
- In the Rhone area only the first borehole has started. This indicates the top of the molasse is close to the tunnel alignment. However, until the second borehole is completed it is too early to tell if the tunnel alignment needs adjustment in this area under the Rhone river.
- In the Jura and Lake areas where SSI has not yet commenced there is some new data obtained from SIG 3D campaign which indicates that the current alignment in these areas will be in the molasse. But the planned SSI campaign needs to confirm this.



Future Site Investigation Campaigns

Following SSI works phase 1 further site investigation works are foreseen

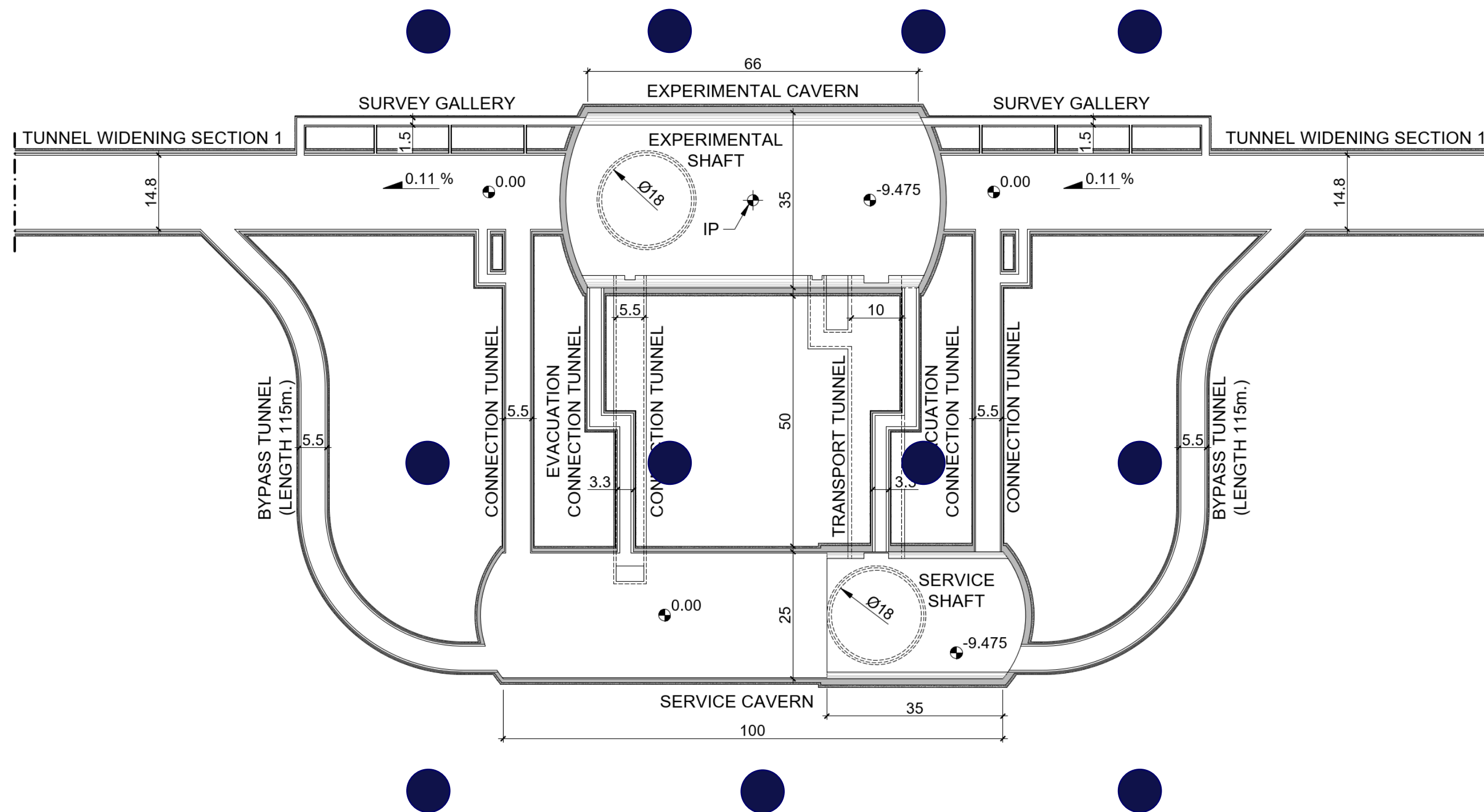
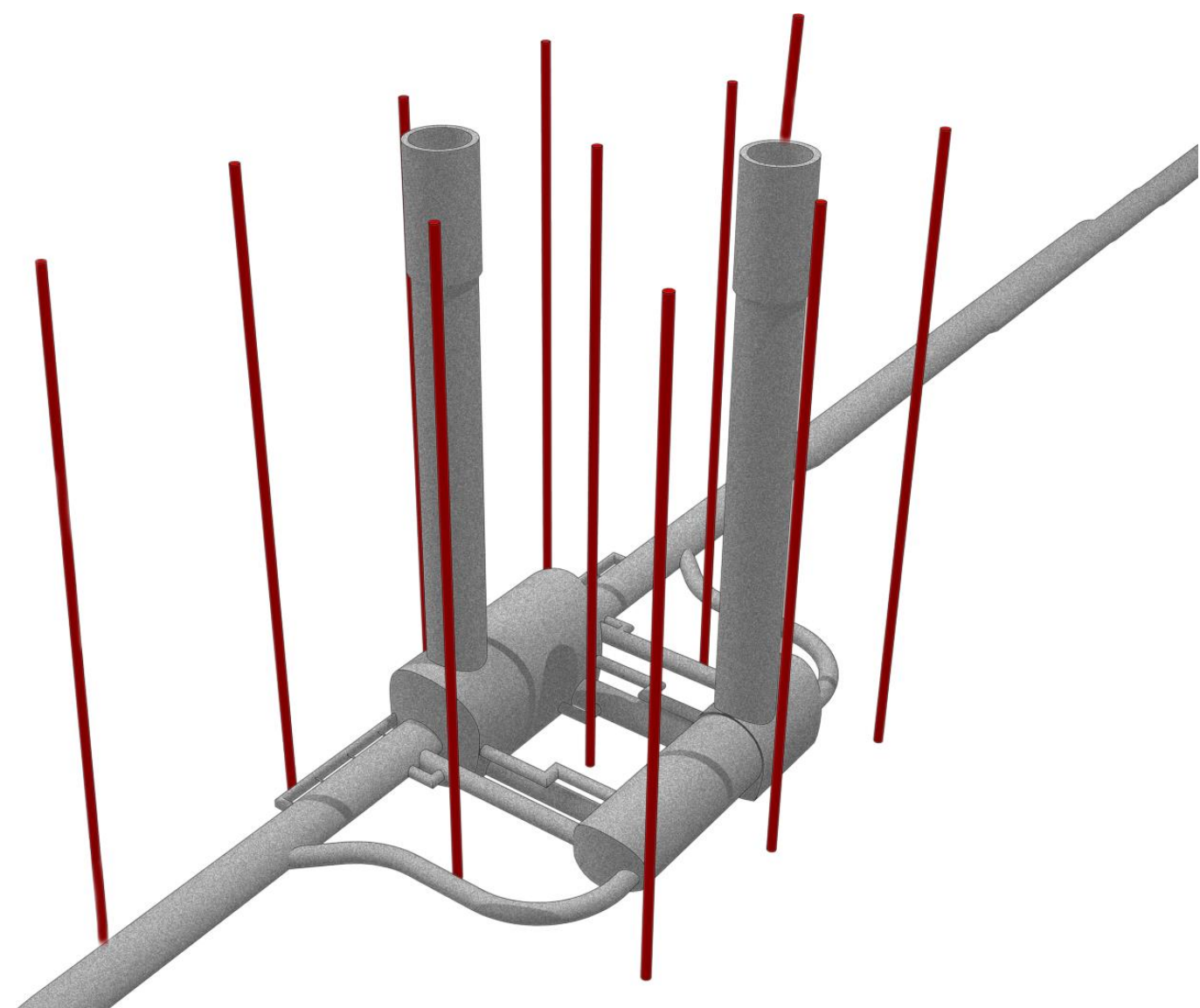
The procurement process for the consultancy firm who will assist CERN on these future investigations has commenced and it is expected to sign a contract by March 2026

Site investigation works phase 2

- Targeted additional investigations around key underground infrastructure such as caverns and shafts
- Additional boreholes along the tunnel alignment approximately every 1.5 to 2km
- This campaign will provide sufficient detail to allow for the tender of design works and construction works packages.
- Planned to be carried out largely in 2028/2029

Example of Targeted Boreholes

Targeted boreholes will allow a detailed 3d model of the cavern complexes to be created. Around 11 boreholes are foreseen at IP locations and 4 at technical sites



Schematic of FCC IP cavern complex with indicative borehole locations

Plan view of borehole locations

Summary

Preliminary results from site investigations are positive

- In Vuache, Arve, Usses and Bornes the tunnel will remain entirely in molasse
- In Mandallaz the section of tunnel located in limestone is less than originally modelled
- No unforeseen geological features encountered so far

Challenges and uncertainties still to be resolved

- Works permits in Switzerland are still to be issued
- In Jura section the interface between limestone and molasse still to be defined
- In critical Lake section interface between moraines and molasse still to be defined

Future site investigations campaign being prepared

- Larger, targeted campaign envisaged to allow civil design works and construction tenders to be launched
- Market survey for consultants is out and invitation to tender foreseen over summer 2025
- Consultants contract to begin around March 2026 and site works if project given approval in 2028

Thanks to all collaborators

SCE-PPM
SCE-SAM-TG
QUANTUM
ILF
UNIGE
GADZ