

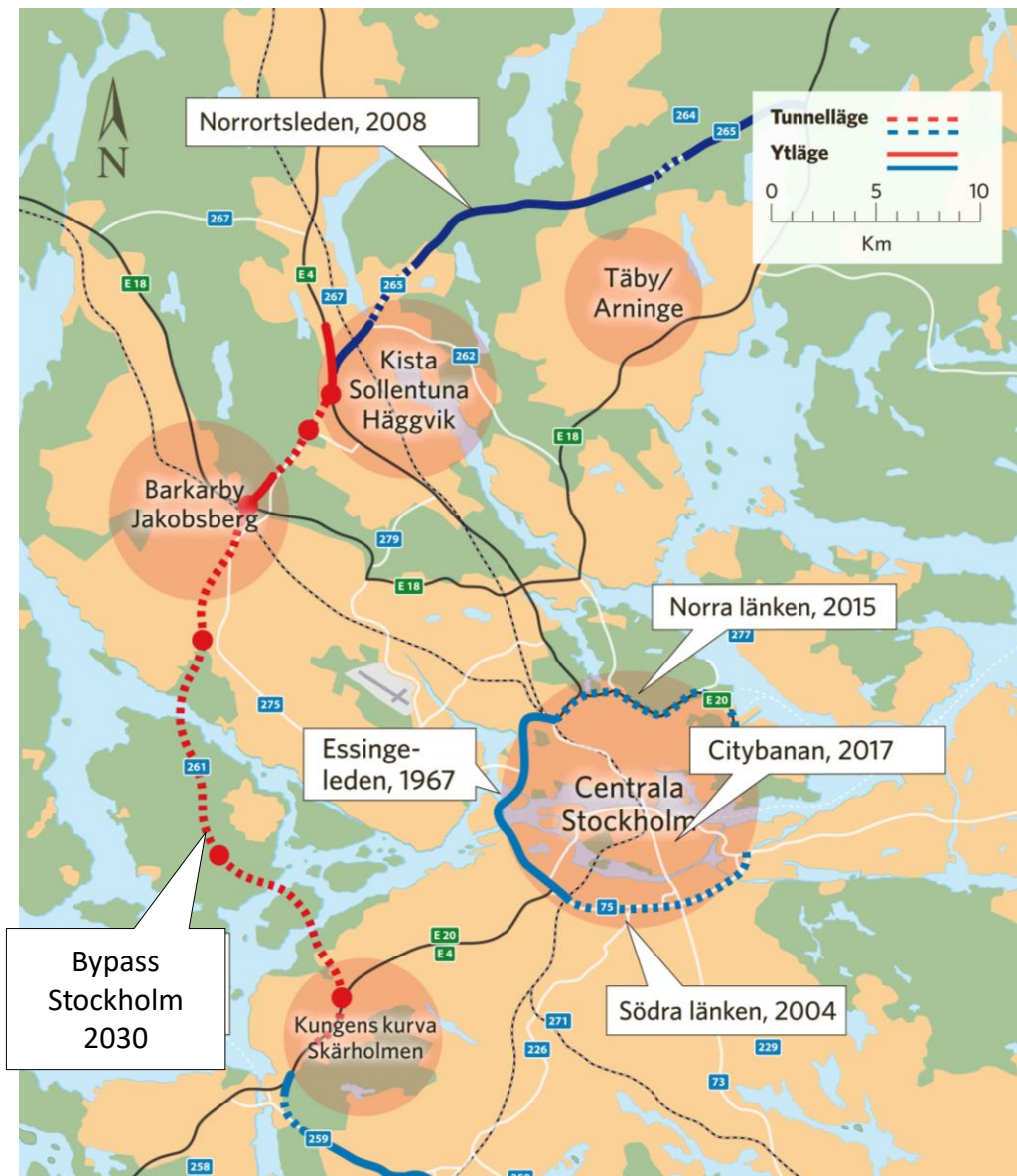
Safety concept in Swedish road tunnels

Ulf Lundström
Tunnel Safety officer
Swedish Transport
Administration

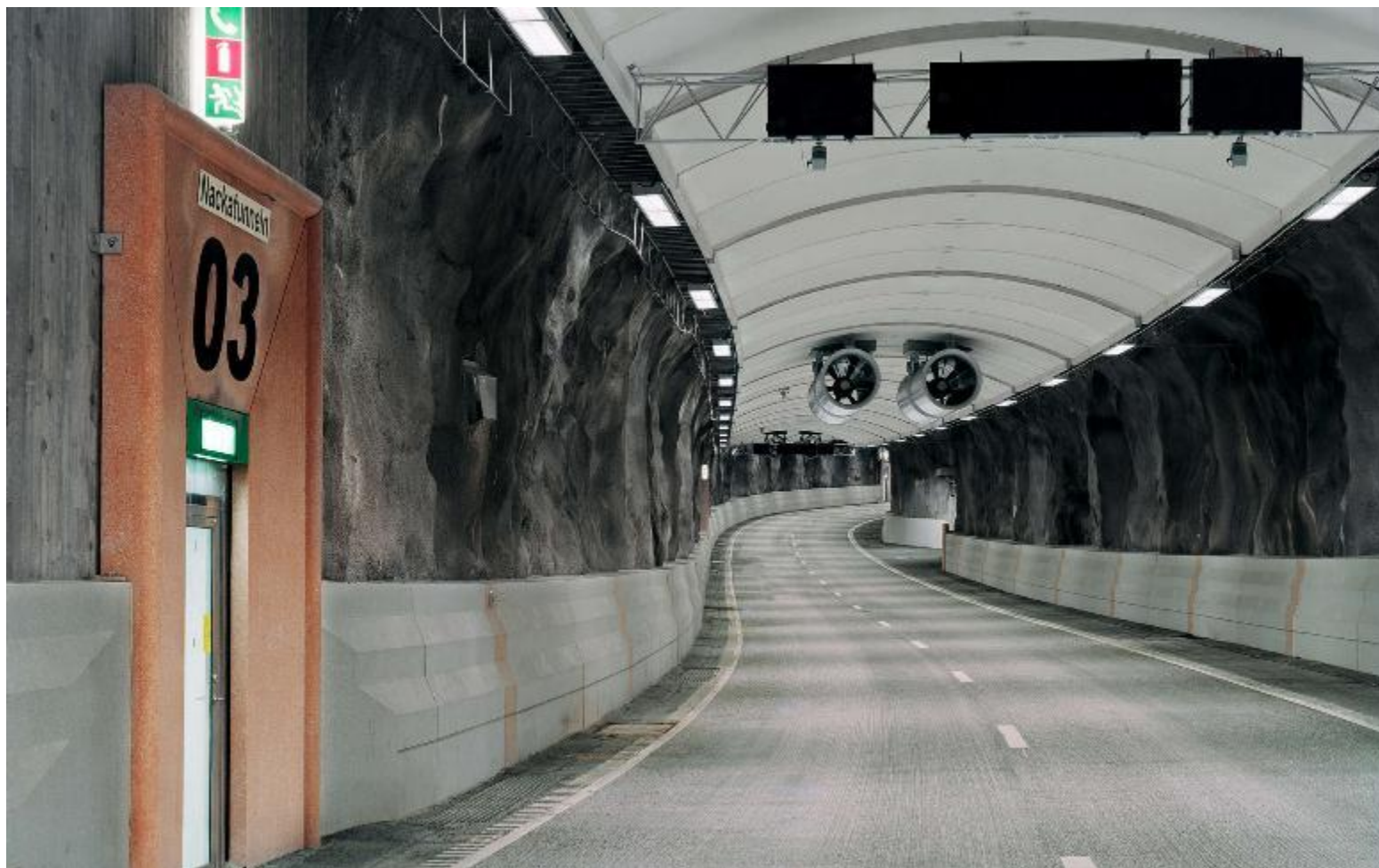


TRAFIKVERKET
SWEDISH TRANSPORT ADMINISTRATION

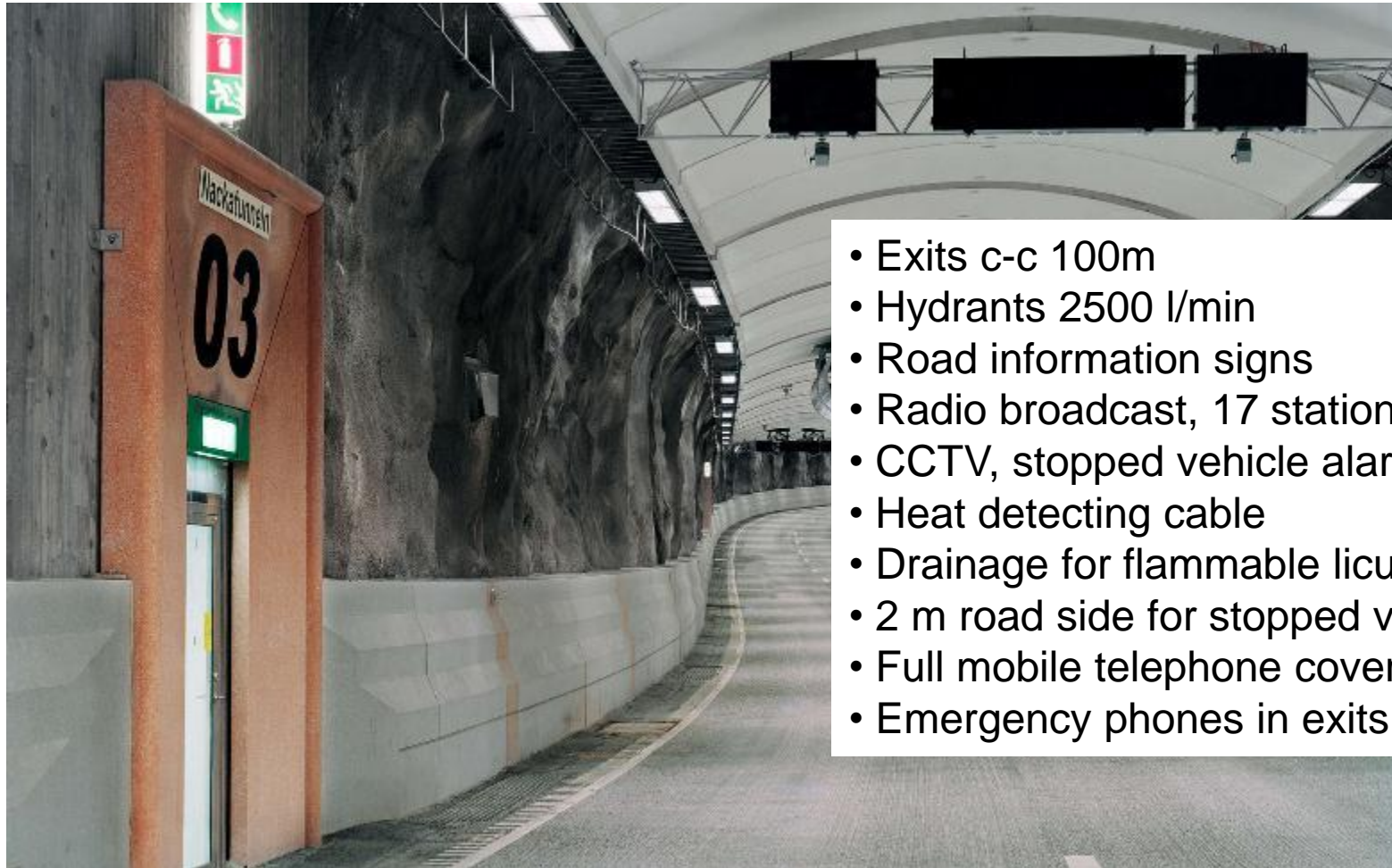




Southern Link 2004



Southern Link 2004



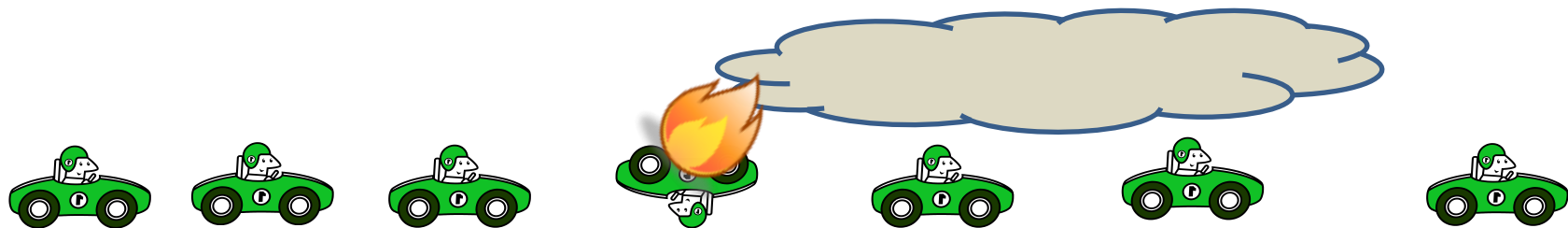
- Exits c-c 100m
- Hydrants 2500 l/min
- Road information signs
- Radio broadcast, 17 stations
- CCTV, stopped vehicle alarm
- Heat detecting cable
- Drainage for flammable liquids
- 2 m road side for stopped vehicles
- Full mobile telephone coverage
- Emergency phones in exits

Southern Link 2004

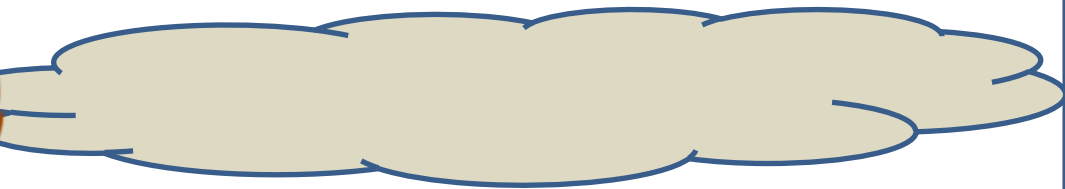


Basic fire safety concept: Free flow traffic





Fresh air

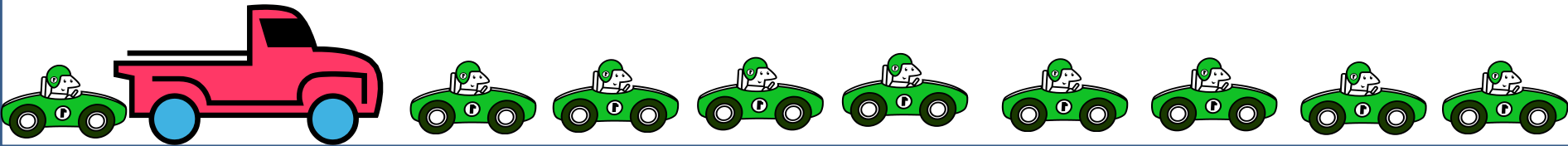


2004:

Southern Link opens for traffic:

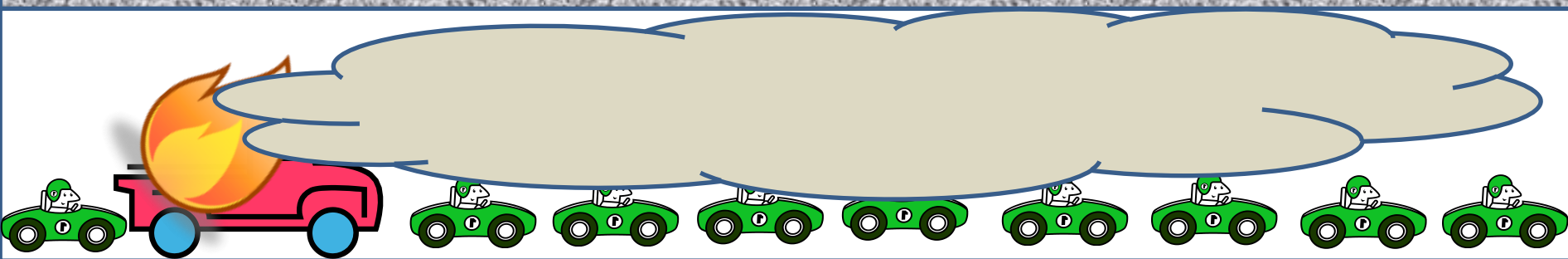
100 000 vehicles /day, estimated 60 000.

= Slow traffic



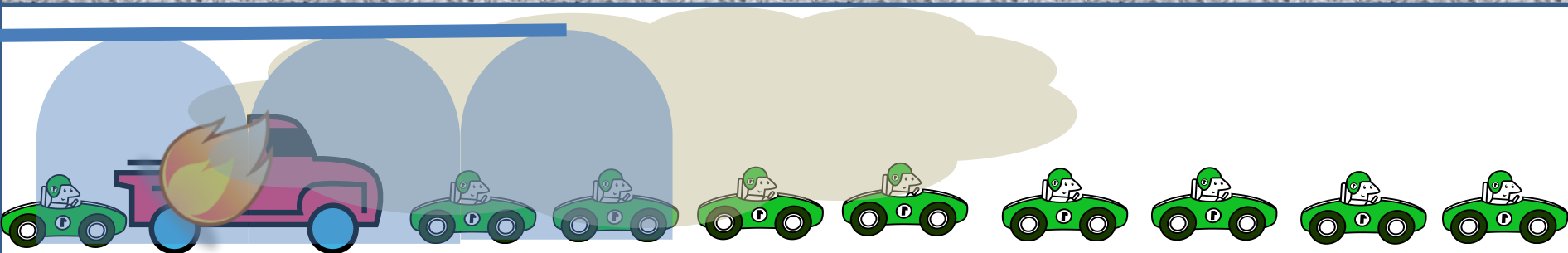
2004-2022:

The tunnel closing when
congestion occurs.



2010: Northern link

New safety concept, FFFS



Fire size MW

Evacuation

Property

**Disturbed
Traffic**

1

Untroubled

None

Hours

5

Uncomfortable

10

Disturbed

Minor

15

Critical

Days

20

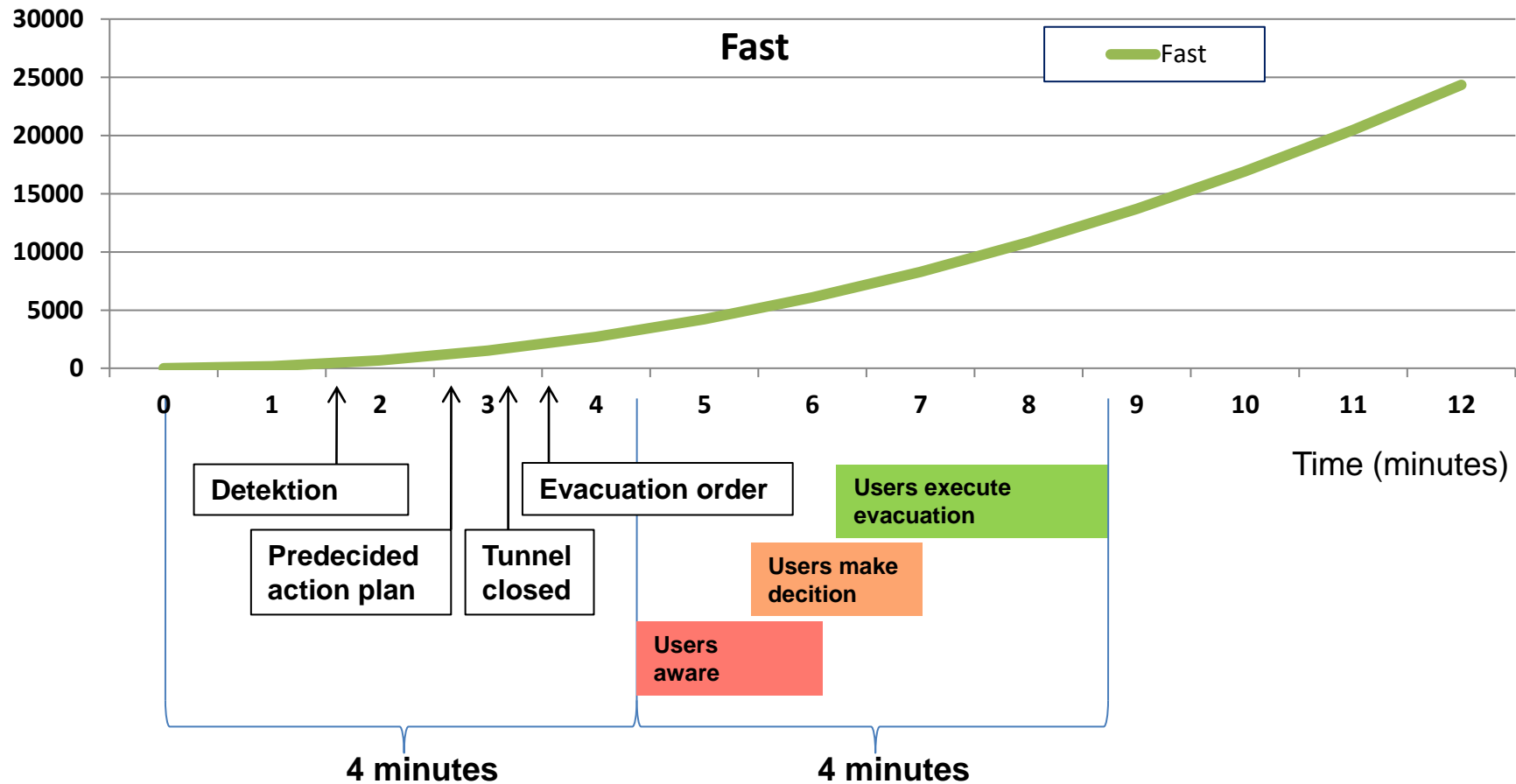
Unacceptable

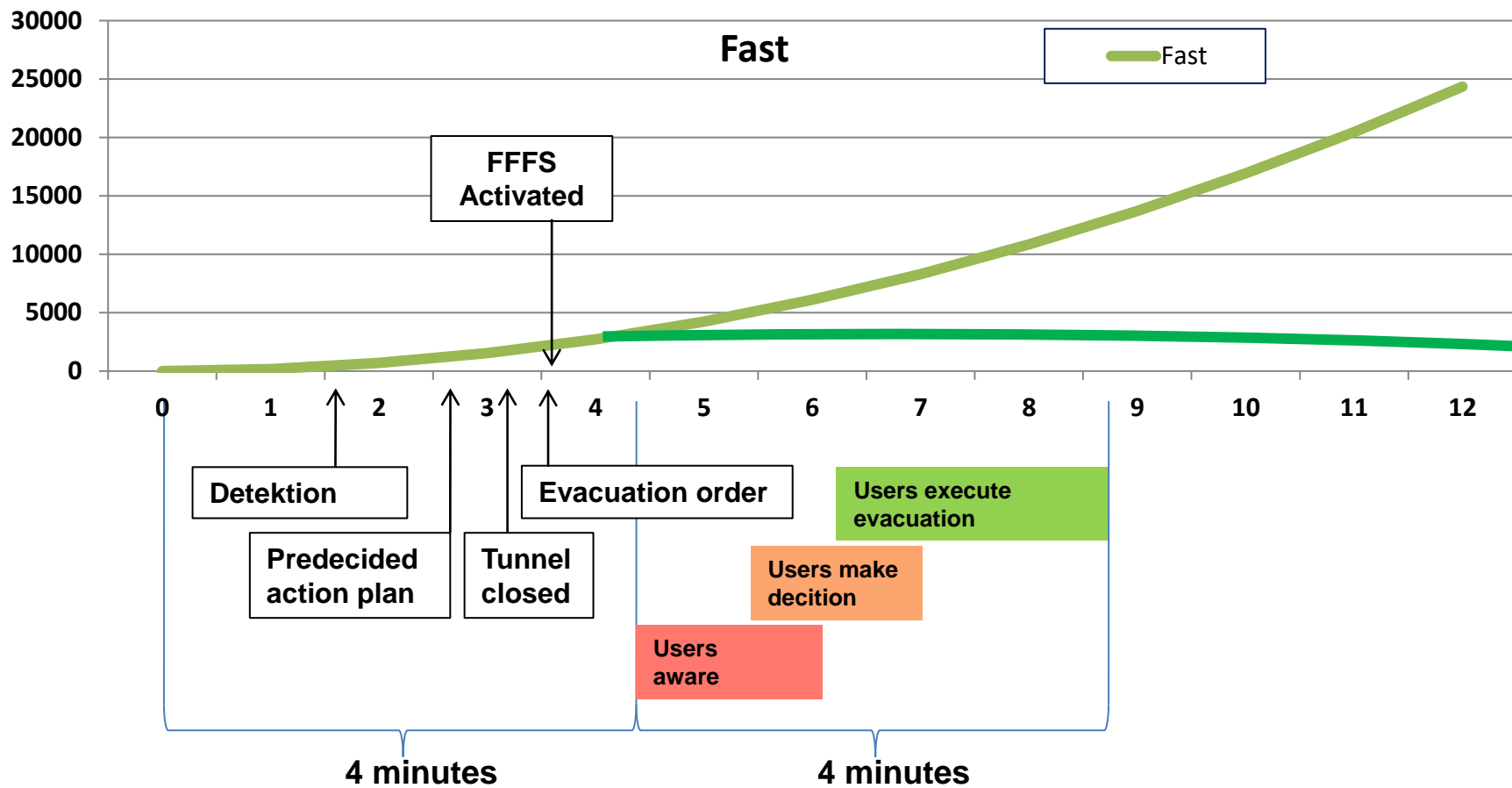
Noticeable

Weeks

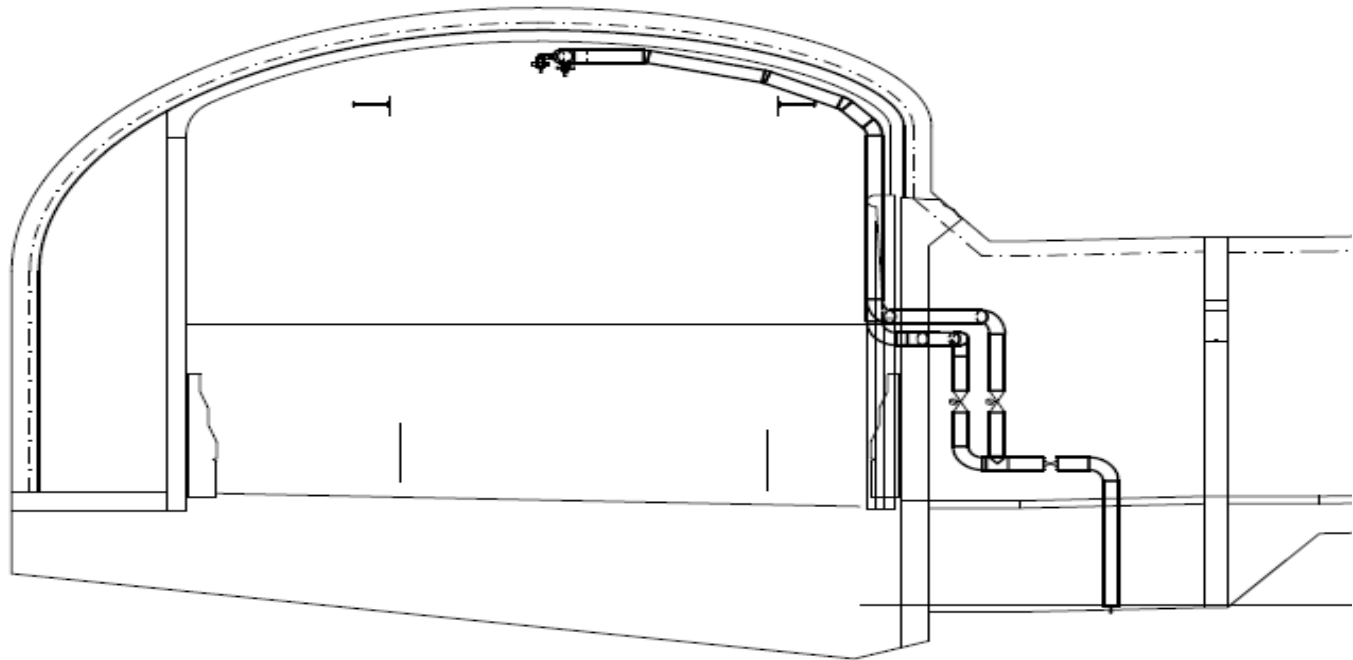
25

Fire size (kW)



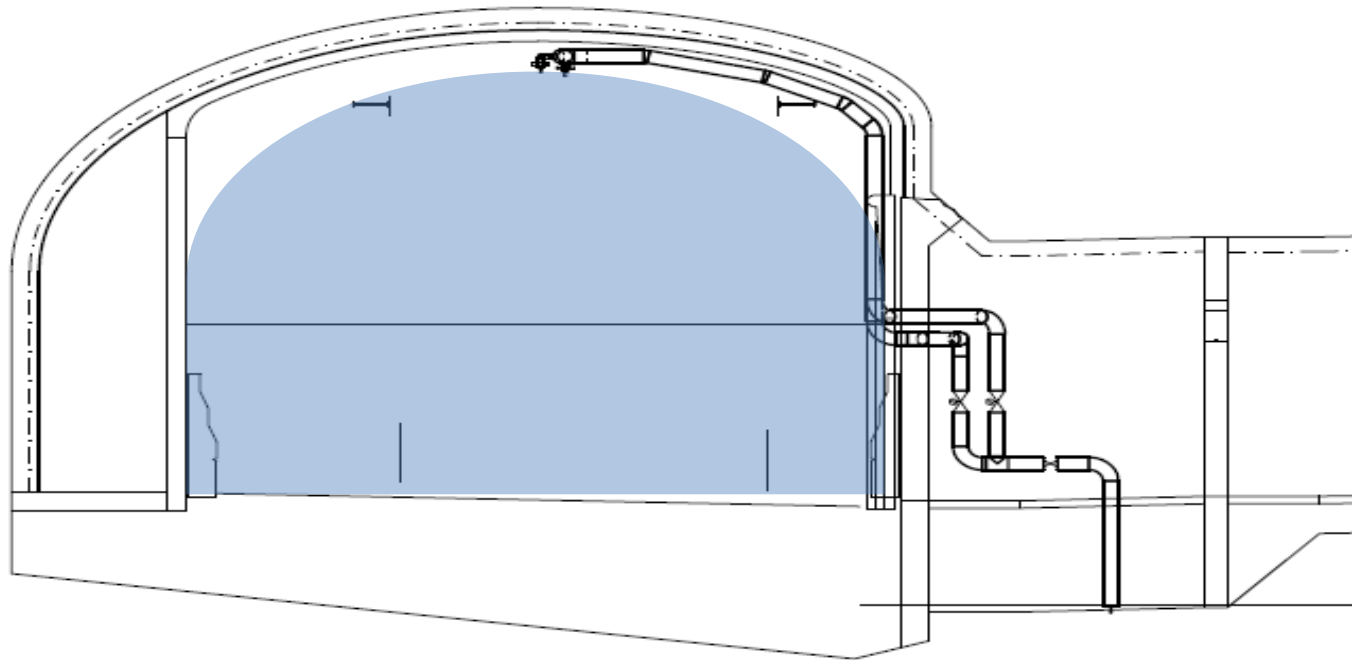


FFFS in the project Northern link

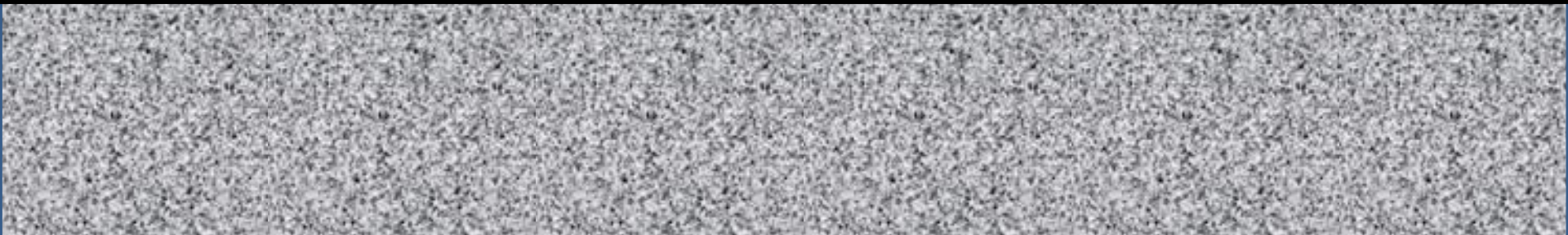
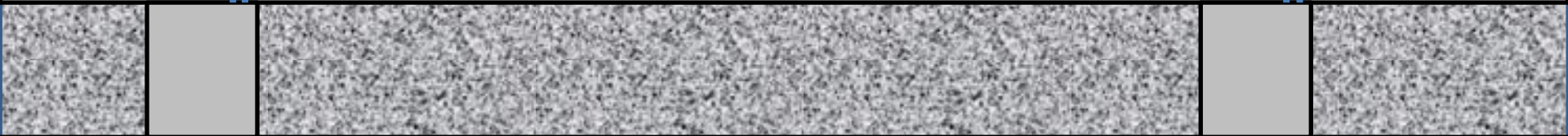
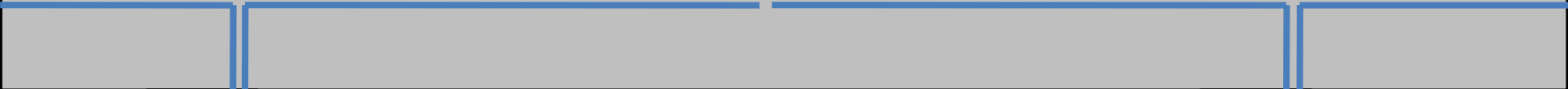
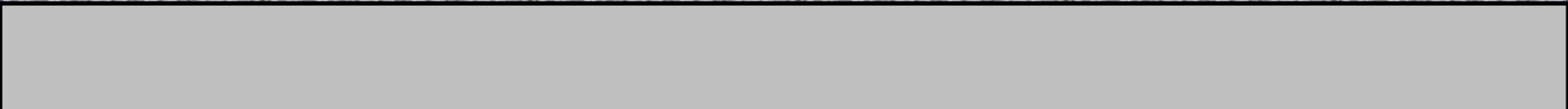
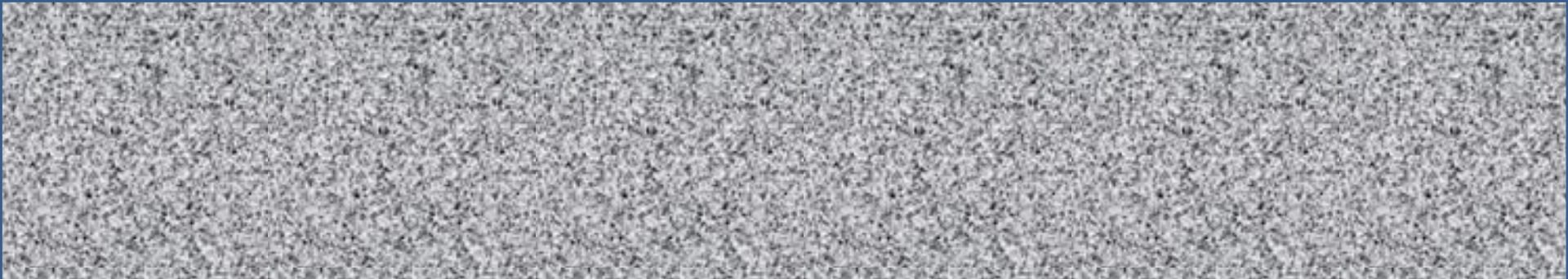


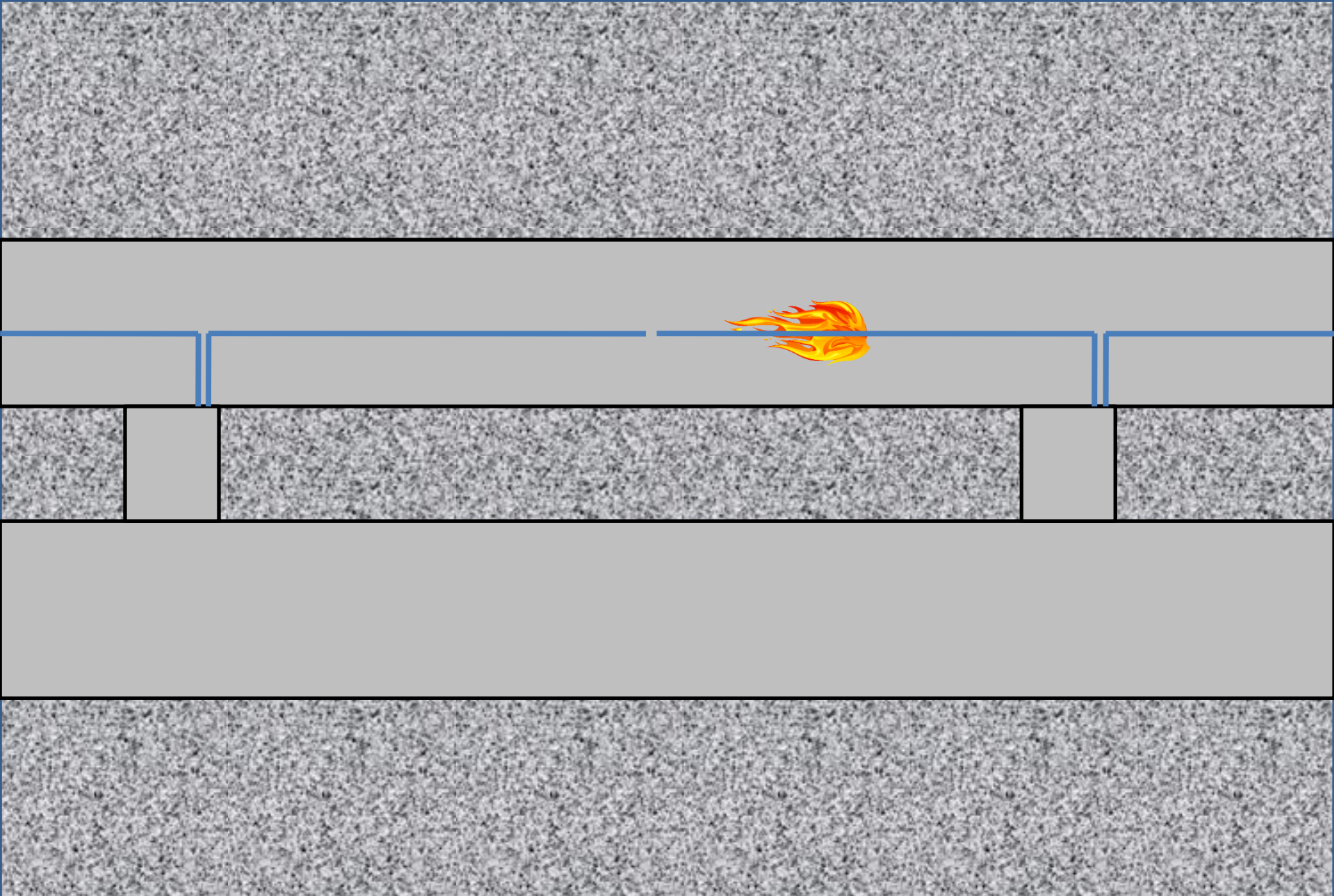


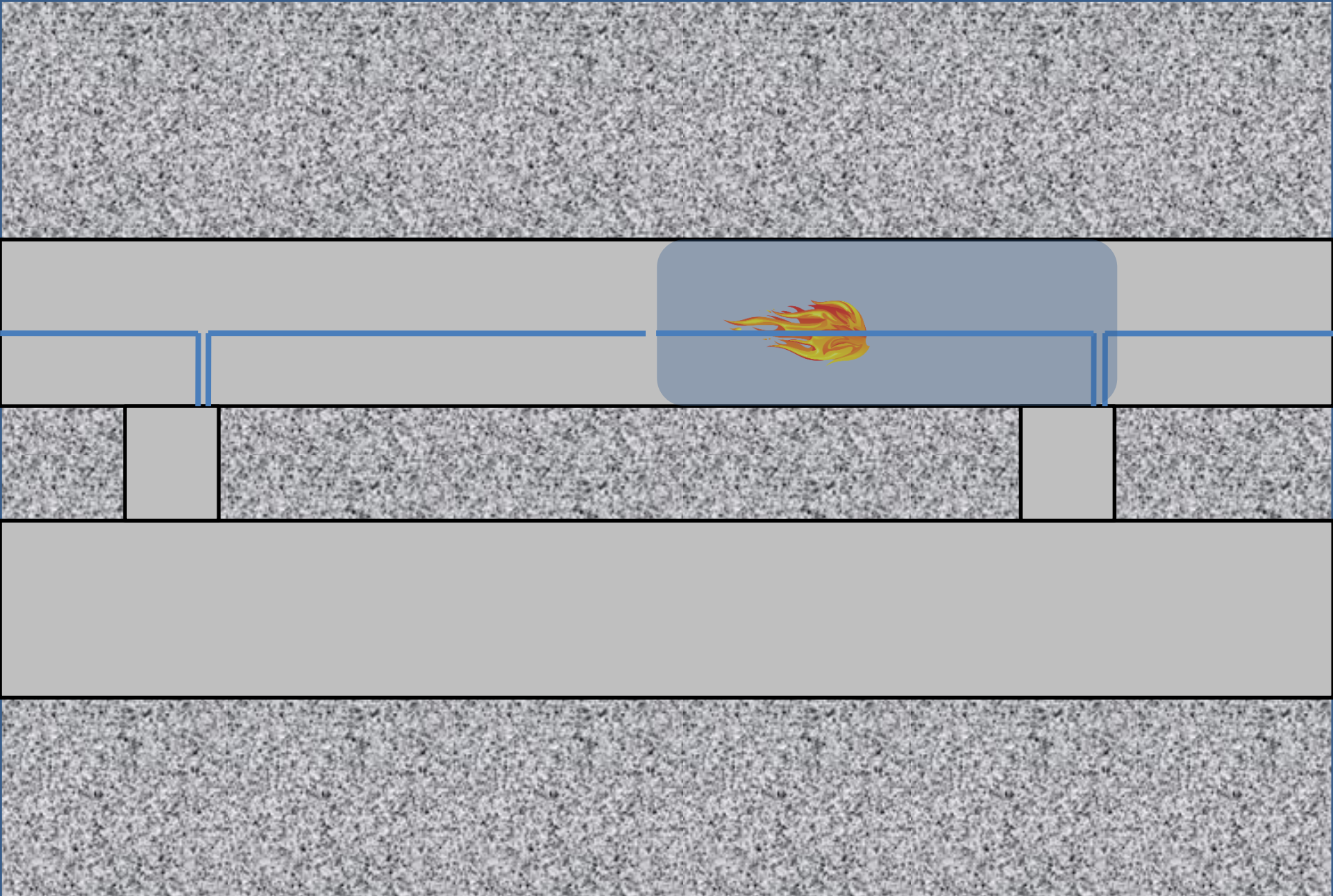
FFFS in the project Northern link

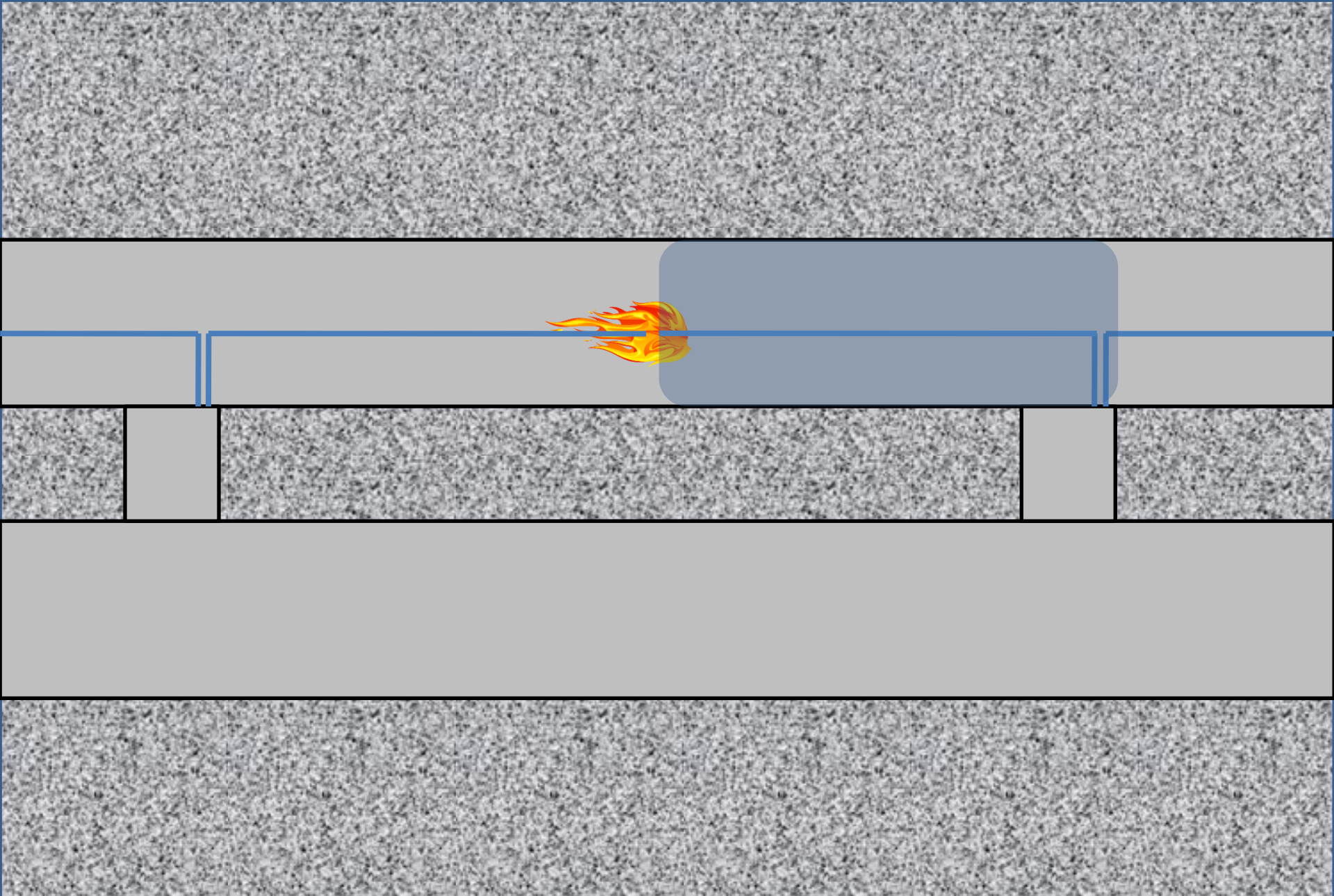


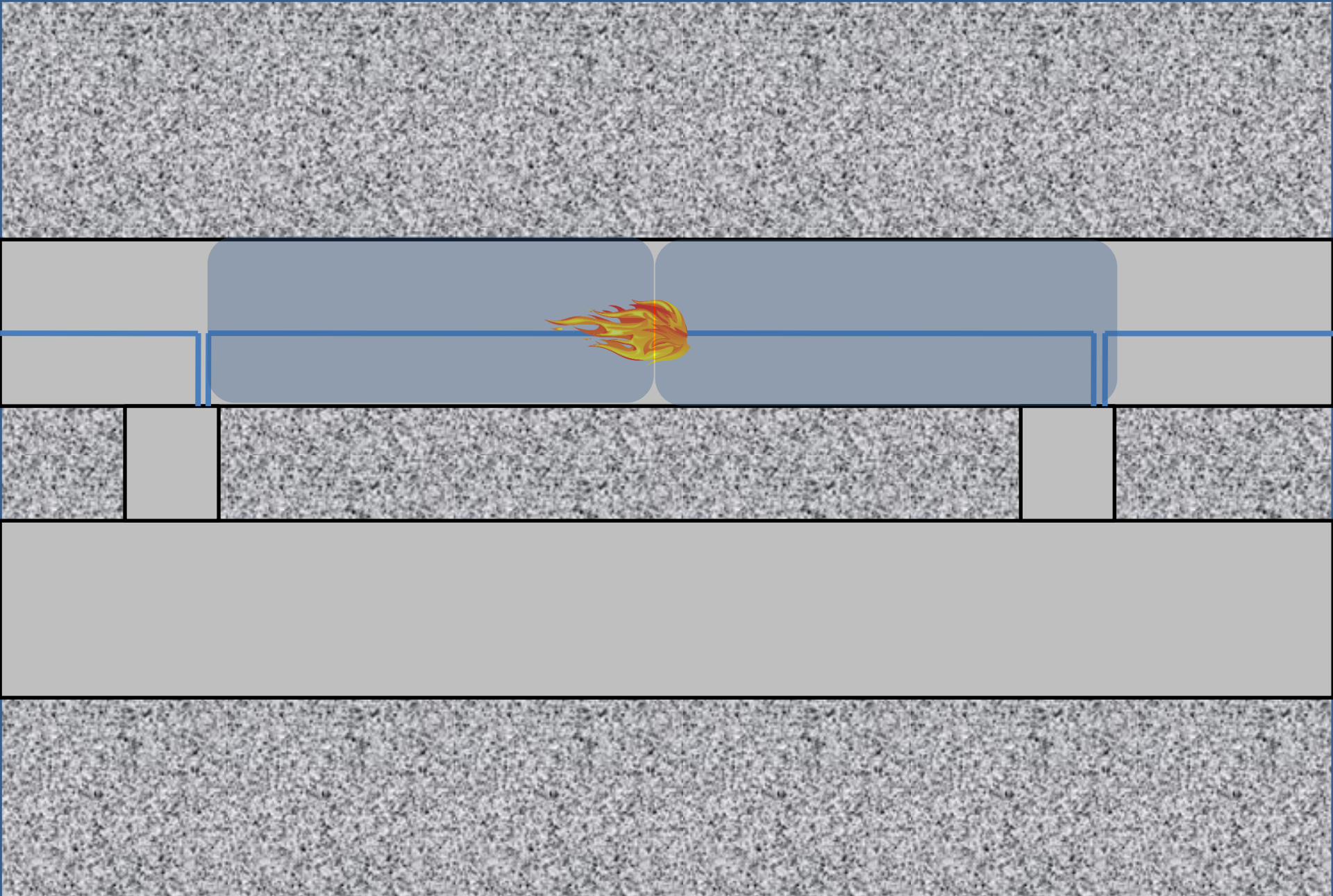












Design solutions for FFFS in Northen link:

- **Long sections (75 m)**
- **Low pressure, large droplets**
- **Extended coverage nozzles**
- **City water supply, no pumps**
- **Remtotely operated membrane valves**
- **Starts automatically at 90 C in heatdetection cable**
- **Protected against corrosion and freezing**









Tests in Törnskogstunneln, Stockholm

- Water distribution tests at different air speeds
- Visibility in an activated section
- Visibility from a moving car in a activated section
- Test of evacuation by foot through a activated section
- Fire tests: risk of fire spread between vehicles, 6 MW propan flame
- Activation in winter conditions (- 6 grader C)



Corrosion tests at SWEREA-KIMAB

Test of different sprinkler components corrosion resistance at SWEREA-KIMAB, laboratorium test and two reports.



Research at SP Brandteknik, Borås

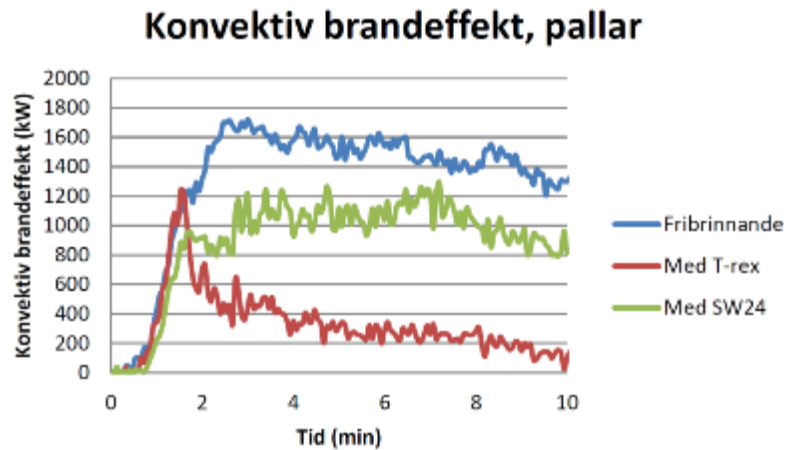
Water distribution tests for different nozzels





Example of test results:

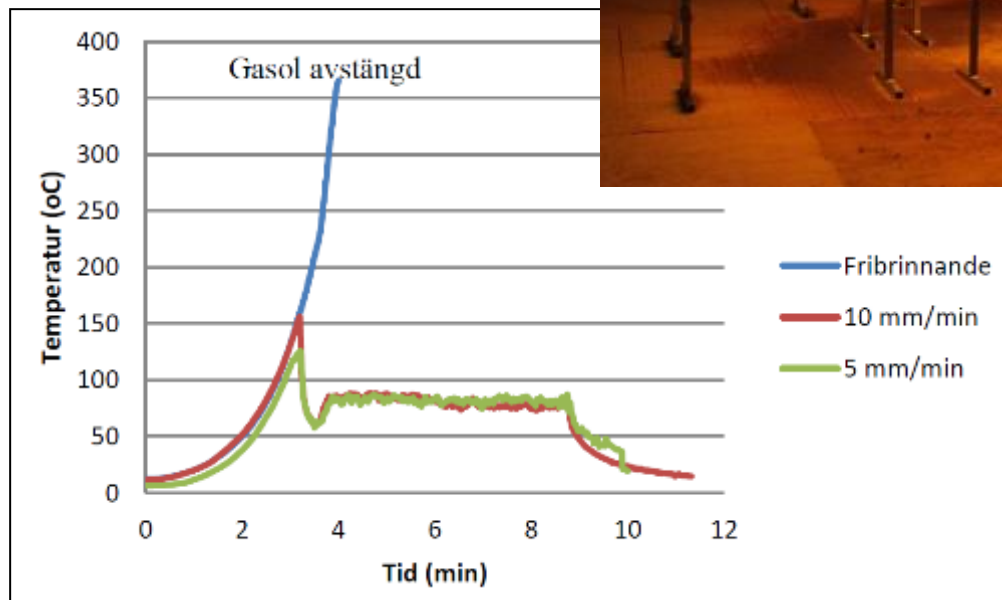
Different nozzles effect of fires in wooden pallets



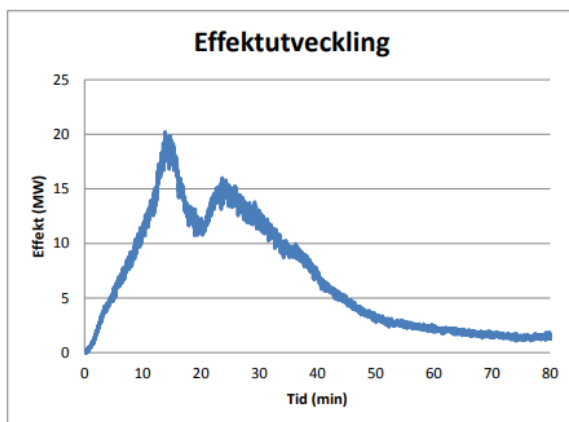
Figur 17 Skillnad mellan T-Rex och SW24 vid liknande påföringstid.

Example of test results:

Fire spread in longitudinal ventilated tunnels with FFFS

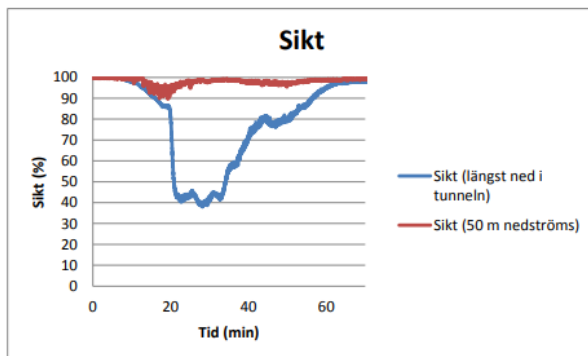






Figur 18 Effektutvecklingen under test 3

Sikten längst ned i tunneln var nere på ca 40% under ca 10 minuter, 50 m nedströms från branden var sikten fortsatt bra under hela försöket.



Figur 19 Siktförhållandena under försök 3.

Skador

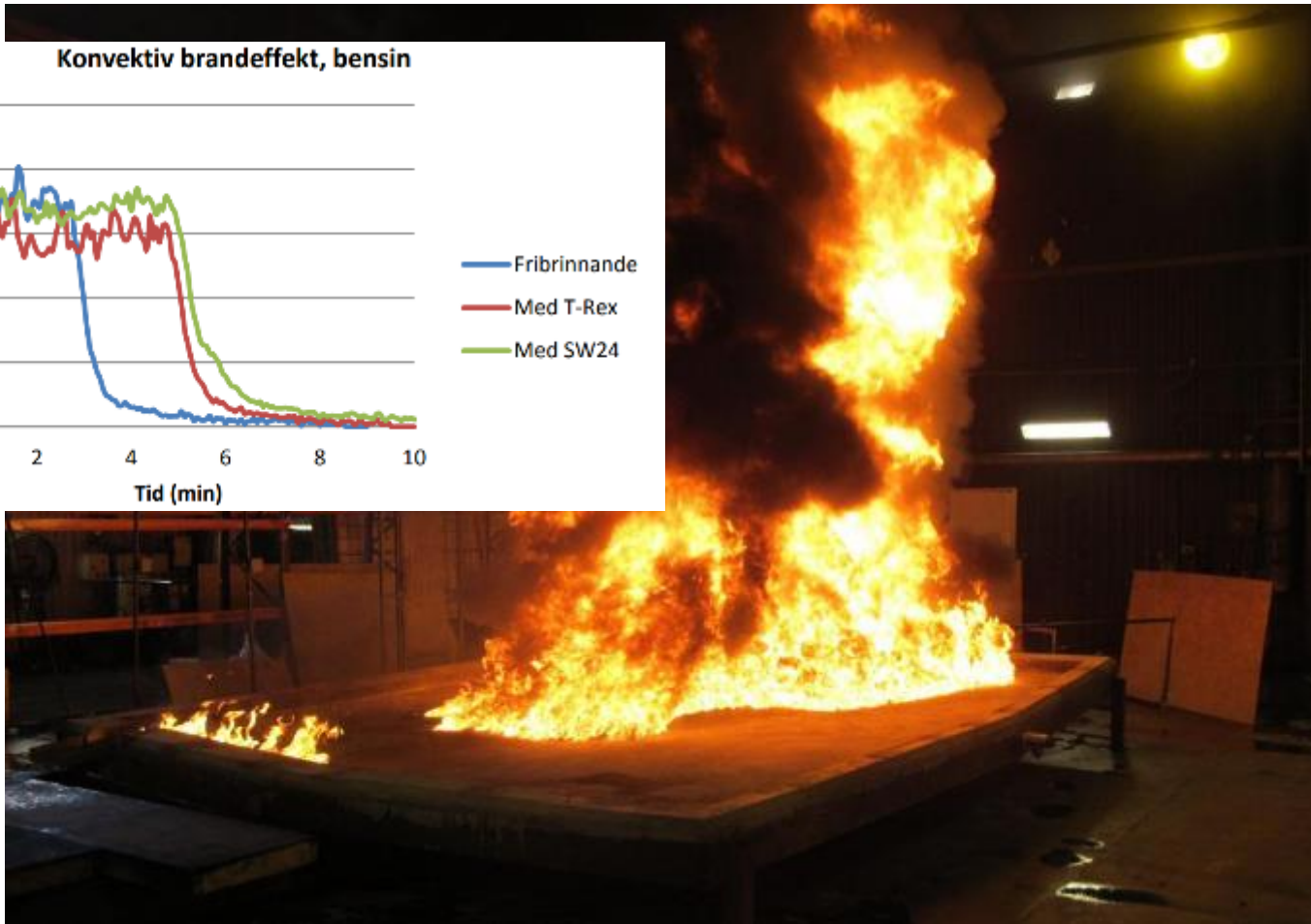
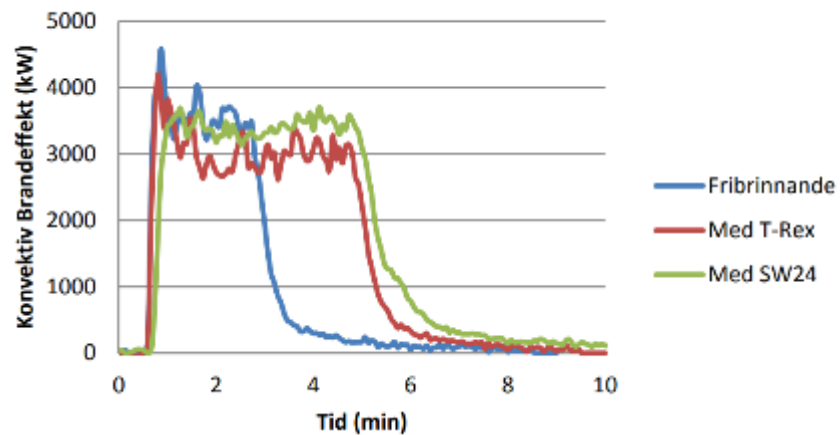
Efter provet gjordes en okulär besiktning av kvarvarande pallar för att fastställa hur mycket som hade brunnit. Systemet klarade av att i stort sett släcka branden, dock togs räddningstjänsten in för att hjälpa till med eftersläckning på plats. Lämpning med hjälp av hjullastare skedde för att undvika återantändning.



Research at SP Brandteknik, Borås

Sprinklertests at burning fuel spillages

Konvektiv brandeffekt, bensin

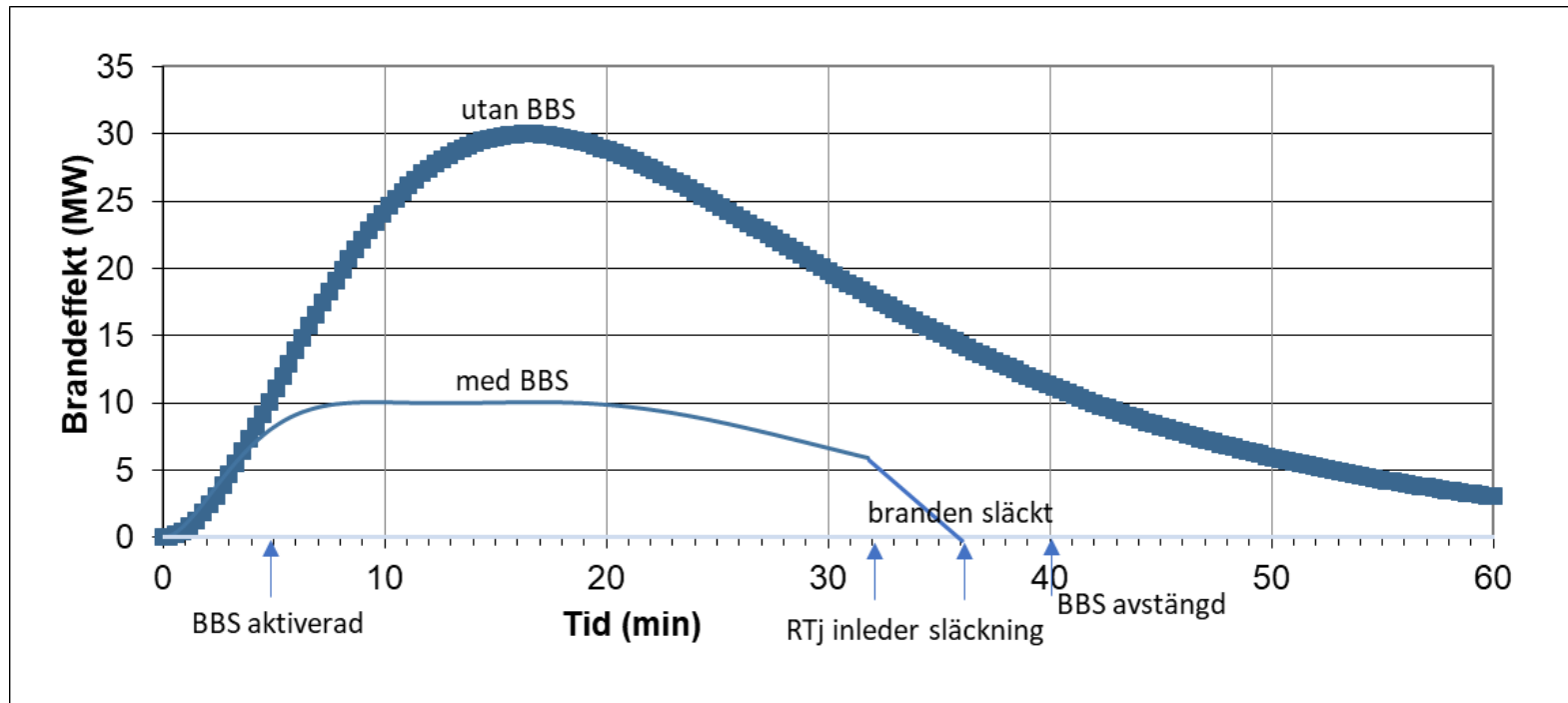


The FFFS research rewarded the "Impact delivered" –prize by European Association of Research and Technology Organisations (EARTO) in Brussels in 2019



Campervan fire, Northern Link 2022-03-17

Prof Haukur Ingassons estimations of fire sizes, with and without FFFS



“Anything may happen; everything is possible and probable”
August Strindberg, “The dream play” 1901

*“Anything may happen; everything is possible and probable”
August Strindberg, “The dream play” 1901*



Airplane in the Southern link tunnel 2007

*“Anything may happen; everything is possible and probable”
August Strindberg, “The dream play” 1901*



*Buss hit by ground drill coming through the ceiling in the Southern link tunnel
2012*

*“Anything may happen; everything is possible and probable”
August Strindberg, “The dream play” 1901*

Conclusion:

What happens in the tunnel will not always be what we expect. The safety concept should therefore be simple and robust, and be designed to handle the unexpected.