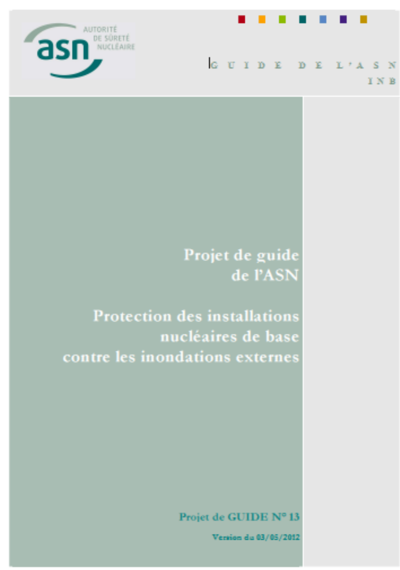
Vincent Rebour, Frédéric Ménage
IRSN: PRP-DGE/SCAN, PSN-EXP

Assessing flooding hazards: new guidelines


GUIDE DE L'ASN
INB

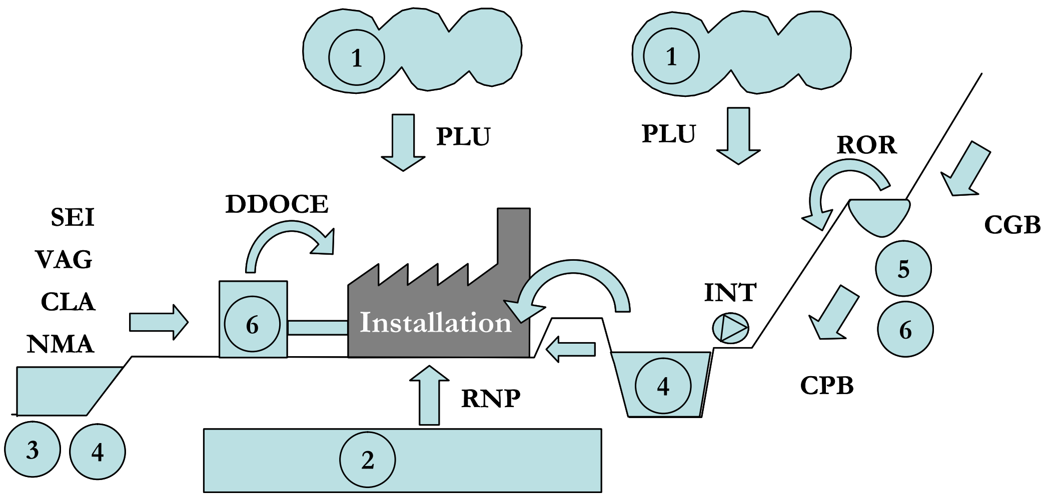
Projet de guide
de l'ASN

Protection des installations
nucléaires de base
contre les inondations externes

Projet de GUIDE N° 13
Version du 03/05/2012

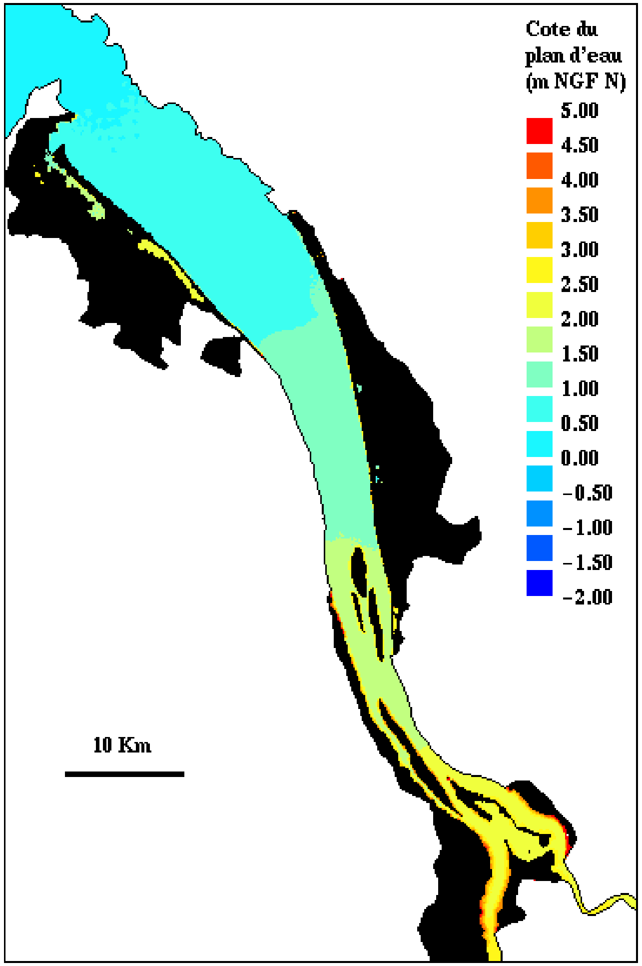
Content

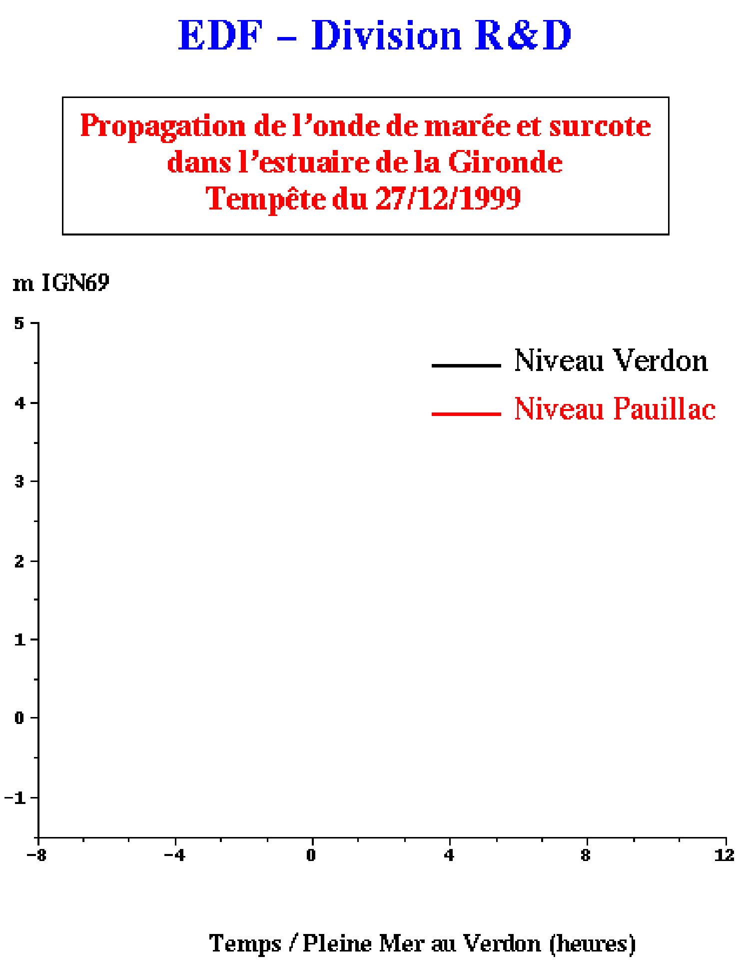
1. Experience feedback from “Le Blayais”
2. New guidelines for NPPs and other NIs
3. Conclusion



Gironde estuary and Le Blayais NPP location

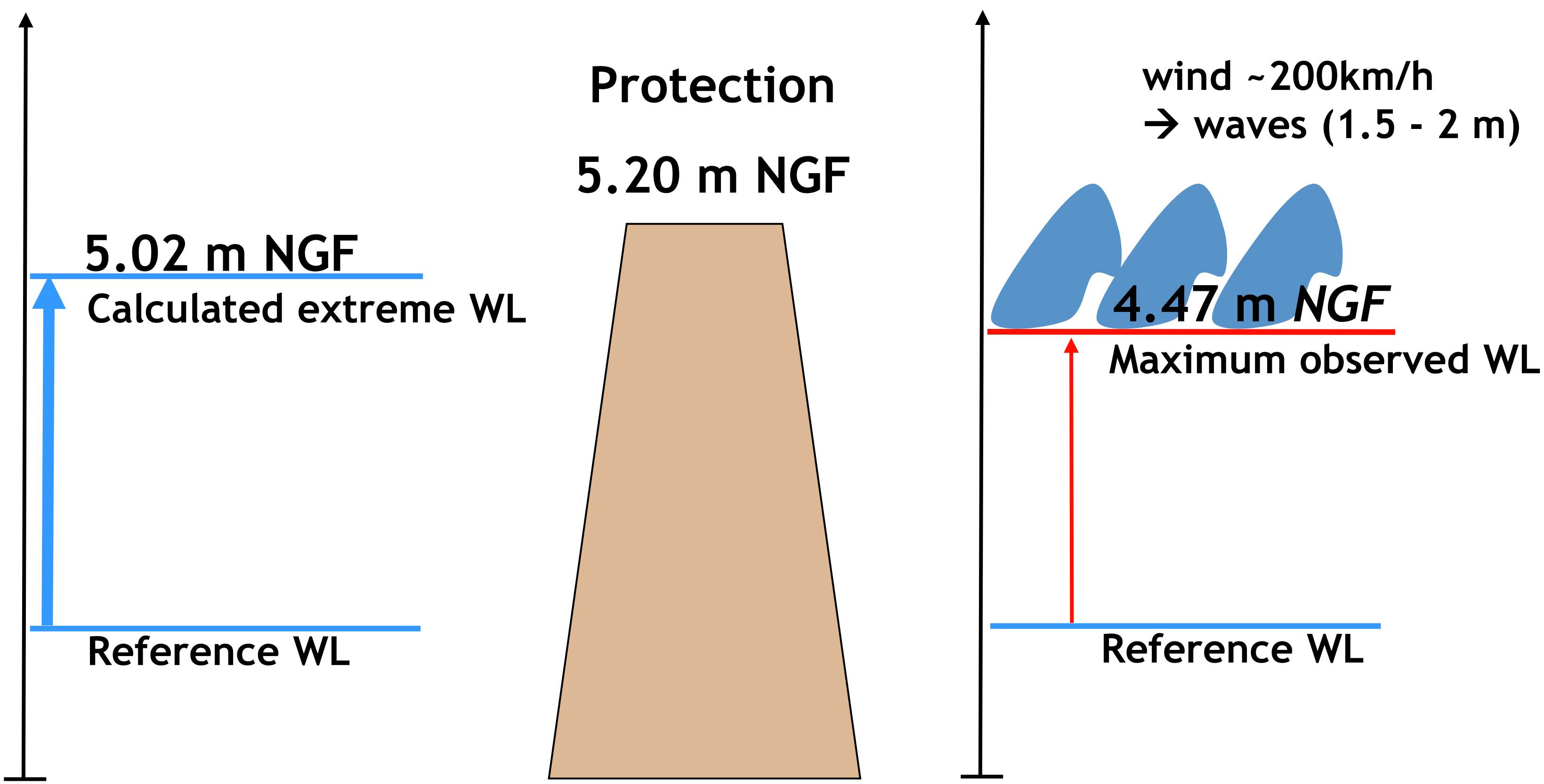
- Water progression in the Gironde estuary during the evening of the 27th of december 1999



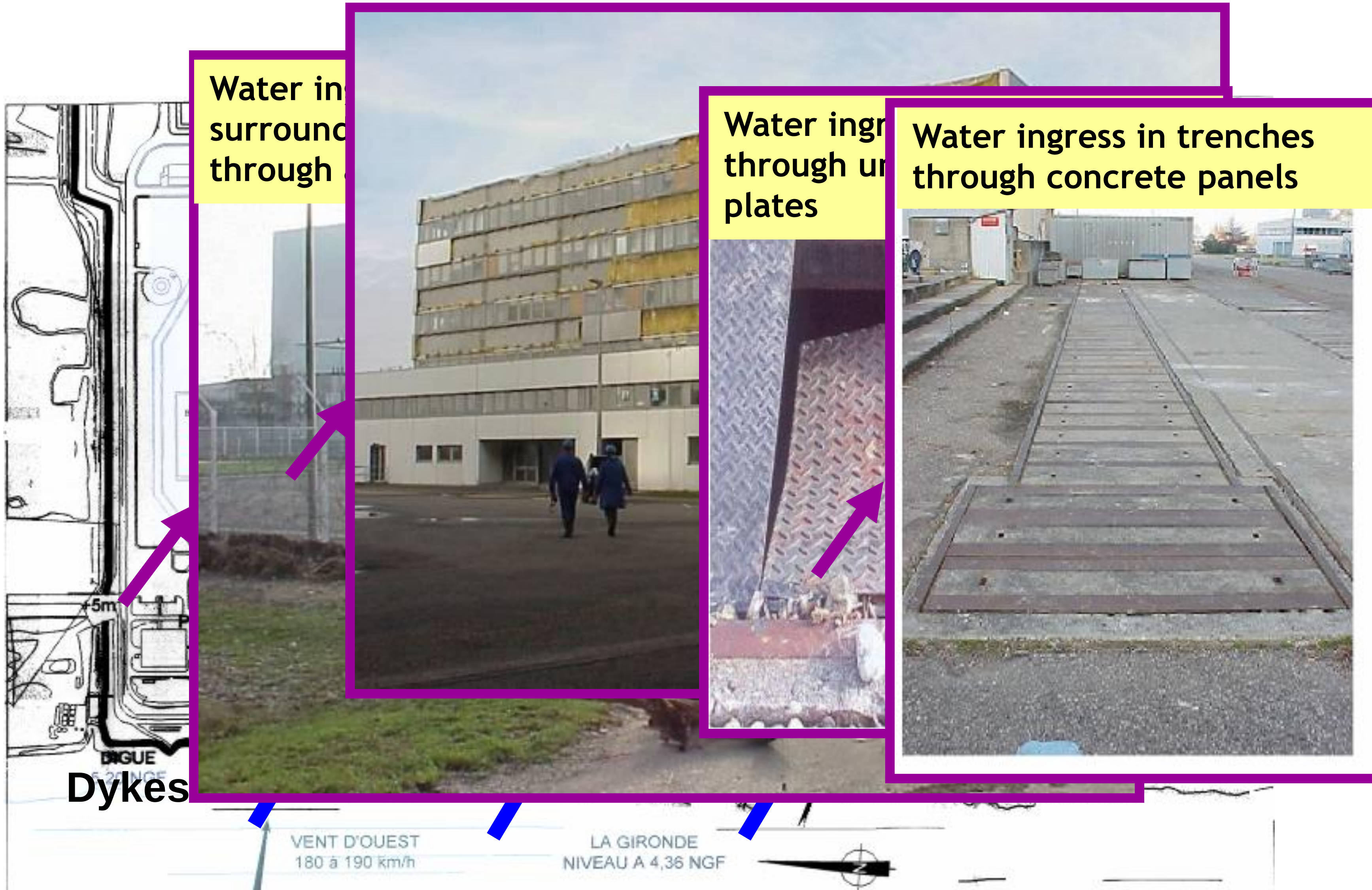


Design Basis Flood
(BSR 1.2.e)

Dec. 1999 event

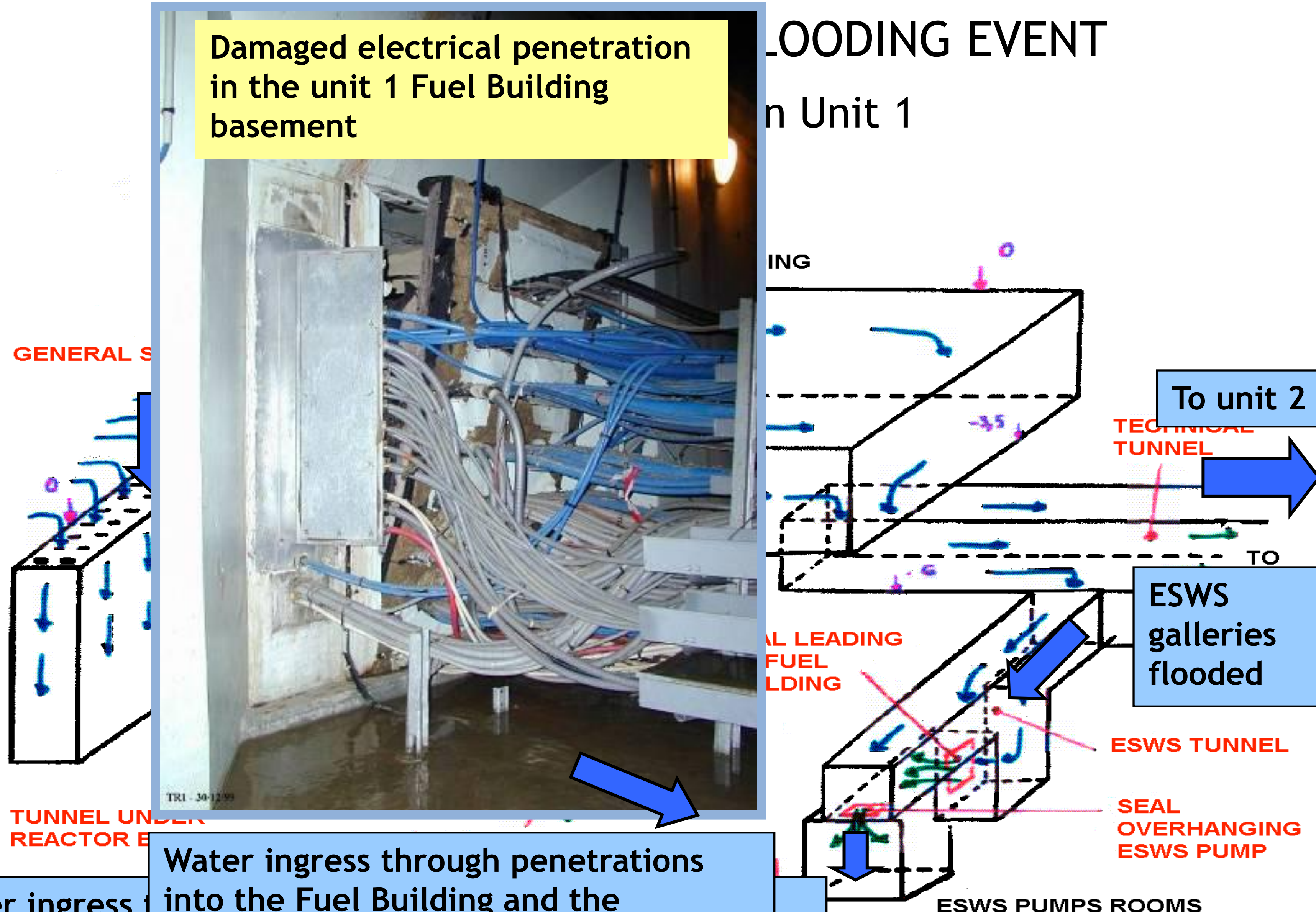


DESCRIPTION OF THE FLOODING



…LOODING EVENT

…n Unit 1

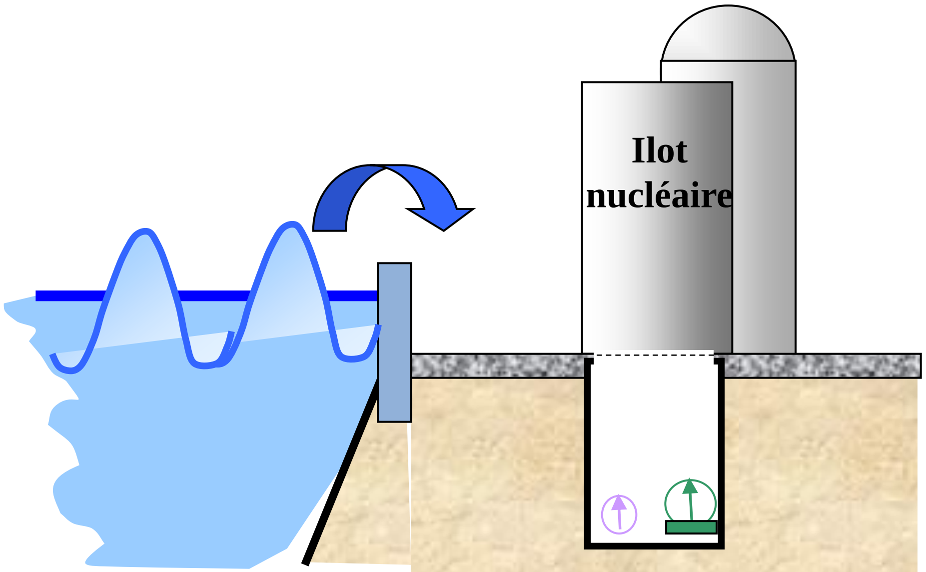


Water ingress t… penetrations i… LHSI and CSS p…

Water ingress through penetrations into the Fuel Building and the compartments housing ESWS pumps train A

Towards Convergence of Technical Nuclear Safety Practices in Europe

Lessons learnt from « LE BLAYAIS » FLOODING



High water level in la Gironde:
high tide + storm surge

and wind waves generated by the wind blowing on the estuary

➔Waves went over the dike and caused site and buildings flooding

➔Reassessment of the protection of the French Nuclear Power Plants against external flooding

Lessons learnt for the characterization of flooding hazards:

➔the necessity to identify <u>all</u> the phenomena which may cause <u>or take part</u> in the flood of the sites.

Lessons learnt from « LE BLAYAIS » FLOODING

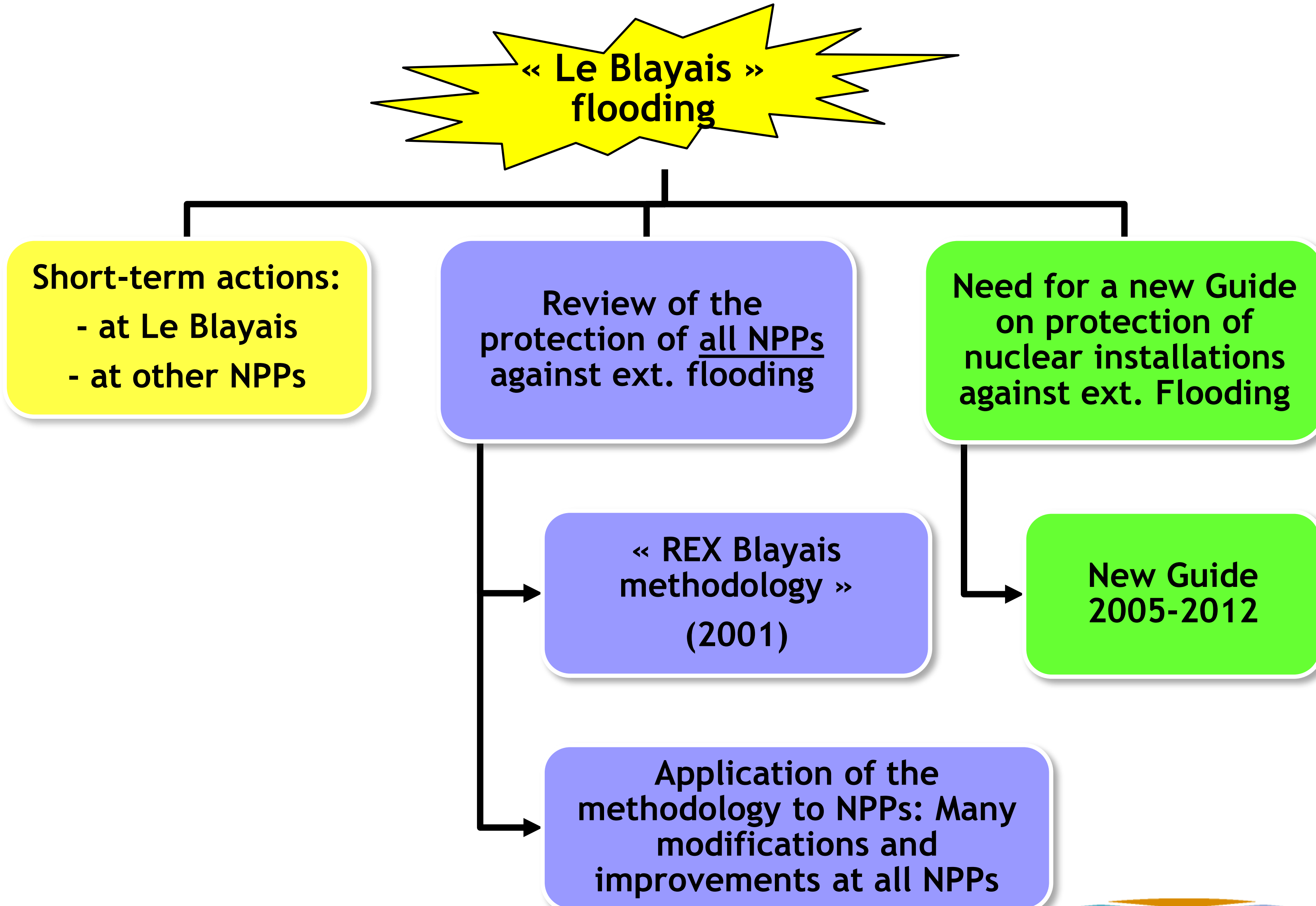
Protection means

- Site protection
- Safety equipment protection
- Warning systems and detection of water in affected rooms
- All units affected, on-site organization

Support functions and surroundings

- Risks of site inaccessibility, loss of offsite power supplies / heat sink / communications
  (Various effects of flood initiator)
- Provisions defined to avoid them or to cope with them

OVERVIEW OF « LE BLAYAIS » FLOODING FOLLOWS-UP



« Le Blayais » flooding has called into question the design bases for the protection against external flooding (Basic Safety Rule I.2.e)

↓

Update of BSR I.2.e required by the Safety Authority: replacement of the BSR by a **Guide**

2006-2009:	**Working Group to prepare a draft Guide**
2010:	**Public consultation**
2011:	**Draft modification**
Mid 2012:	**Approval by advisory committees**
End 2012:	**Edition …**

GUIDE APPLICABLE TO:

- Nuclear power plants
- All other surface nuclear installations
  - No BSR related to their protection against external flooding
  - Need for more consistency with the approach for NPPs

GUIDE DEALS WITH:

- Definition of “Reference Flooding Situations (RFS)” based on the phenomena and their possible combinations
- Methods for the characterization of the RFSs
- Principles for protection of the installations including “good practices”

Nuclear Sites in France

19 NPPs

14 river NPPs
4 sea side NPPs
1 estuary NPP

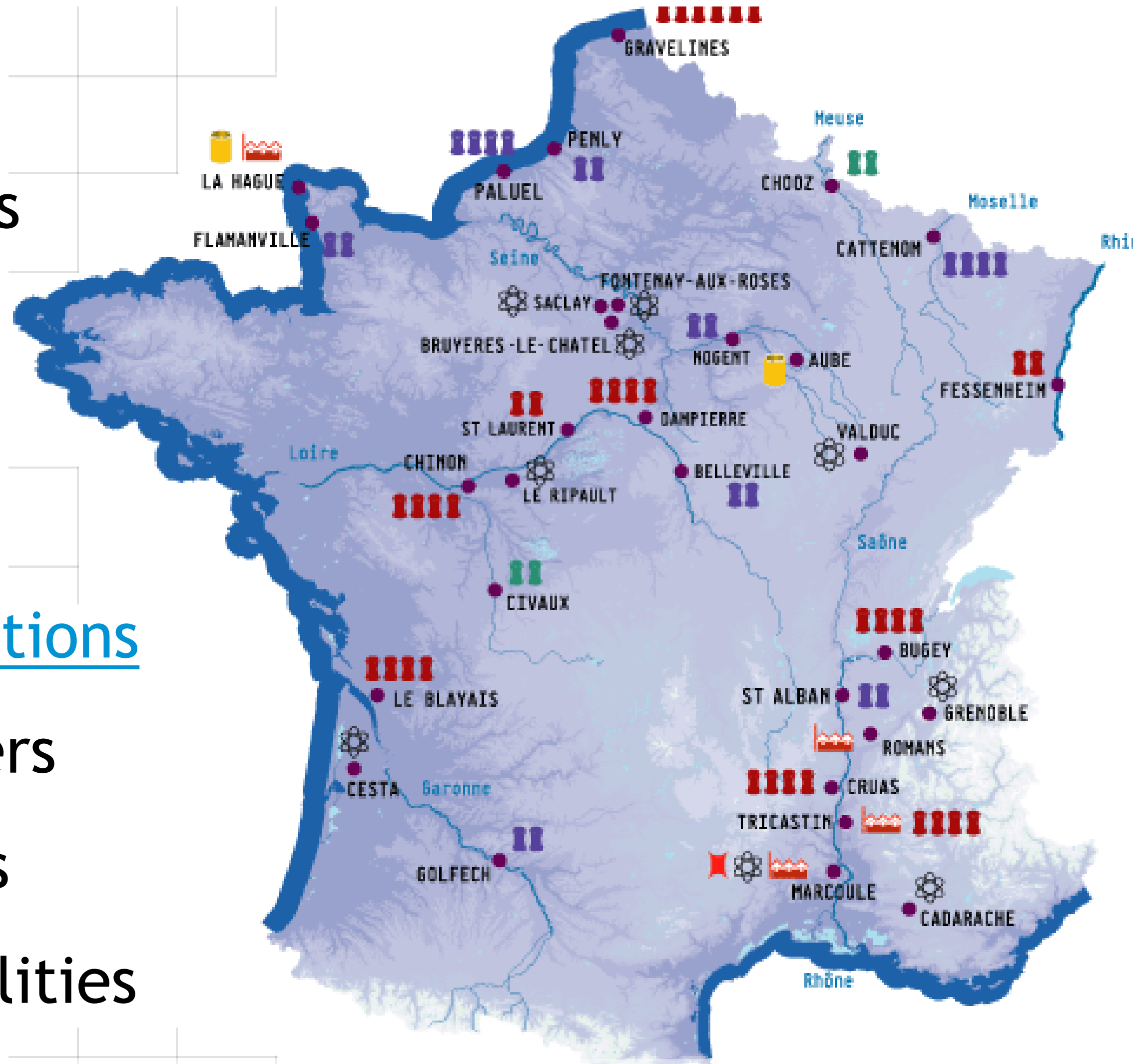
REP			RNR
900 MWe	1300 MWe	1400 MWe	

Other Nuclear Installations

Research Centers

Waste Disposals

Fuel Cycle Facilities



Variability of site conditions ⇨ Diversity of phenomena

Existing guides related to flood risk prevention

BSR

Methodology Blayais

WG Experience

Identification of Phenomena

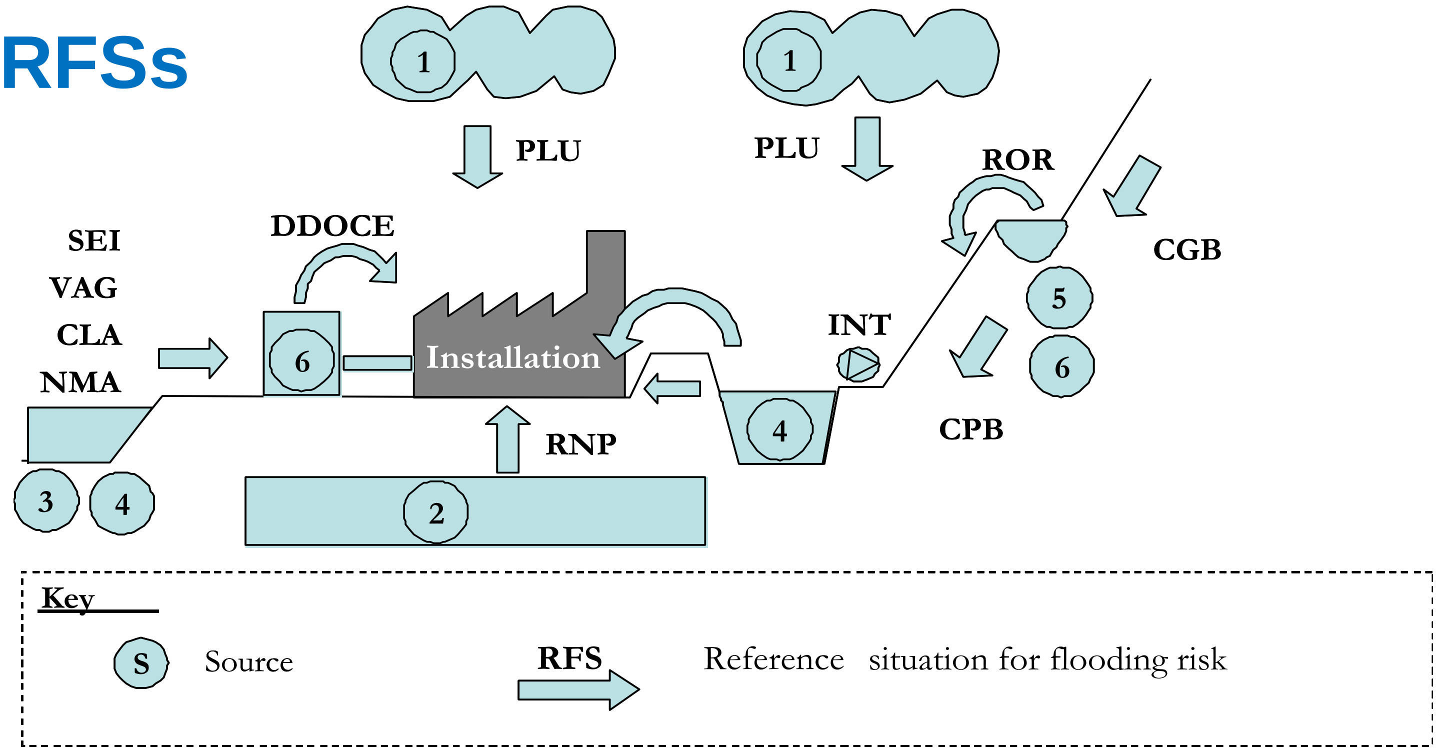
State of art

- available data
- typical parameters to be quantified (intensity, water level, duration, volume…)
- well-tried methods to estimate phenomena (deterministic or probabilistic)
- limits of these methods, reachable return period for probabilistic methods
- uncertainties and way to cover them
- influence of climate change

Reference Flooding Situation

- definition
- characterization

11 RFSs

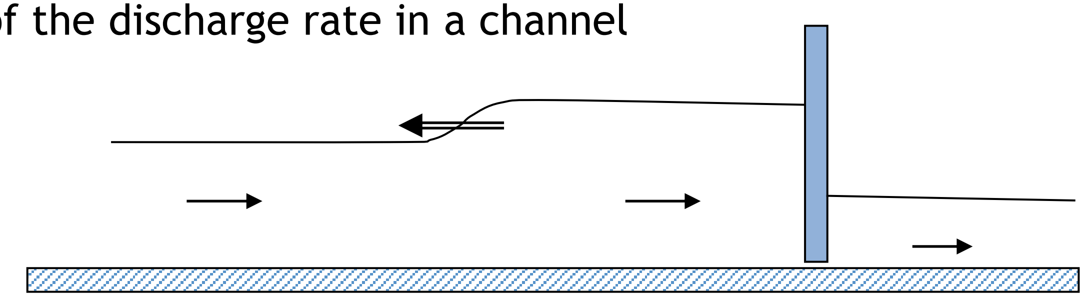


- PLU Local rainfall
- CPB Flood on a small watershed
- CGB Flood on a large watershed
- DDOCE Deterioration or malfunction of structures, circuits or equipment
- INT Intumescence – Malfunction of hydraulic structures
- RNP Rise in groundwater levels
- ROR Failure of a water-retaining structure
- CLA Chop
- NMA Sea level
- VAG Waves
- SEI Seiche

Intumescence – Malfunction of hydraulic structures

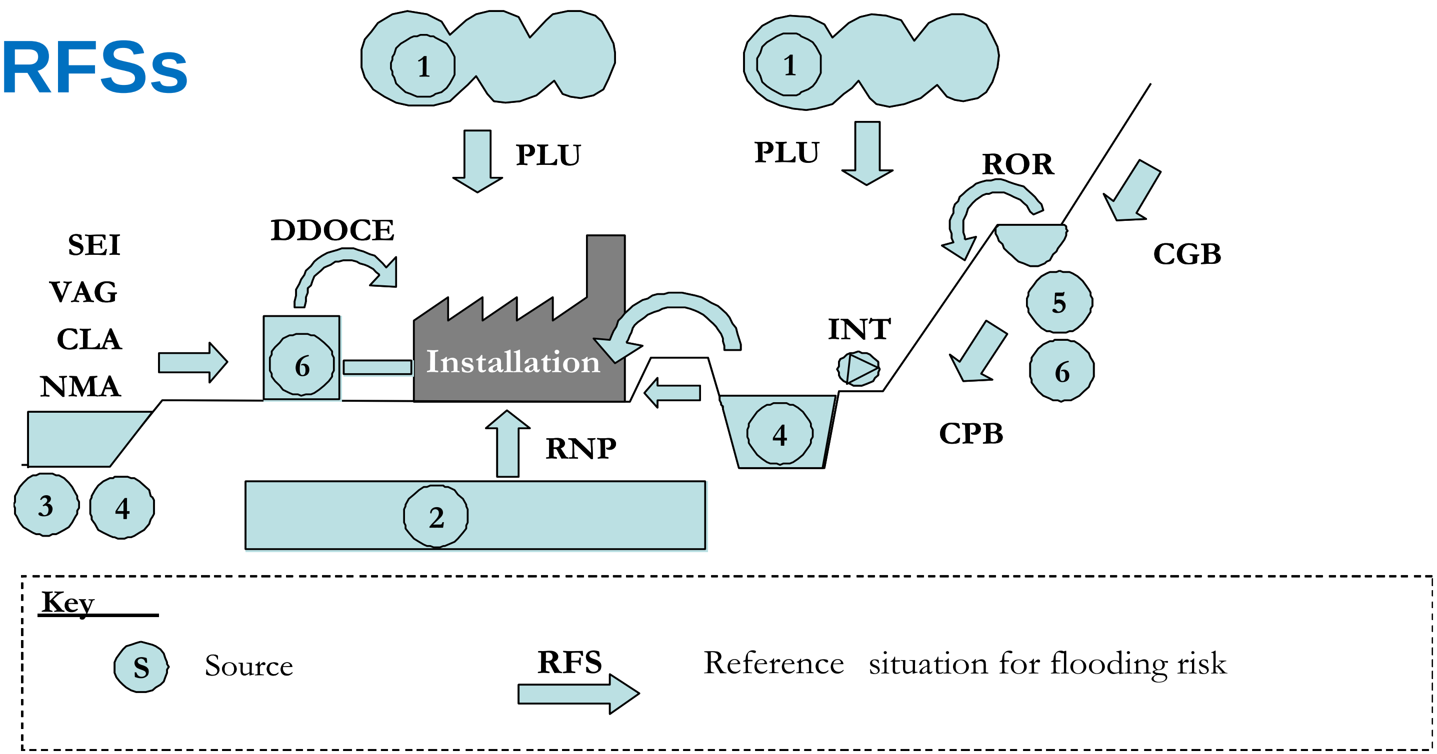
- Causes
  - Sudden charge in of the discharge rate in a channel

Positive wave moves upstream



Hydro-electrical plant
(sudden closing of the driving force channel)

11 RFSs



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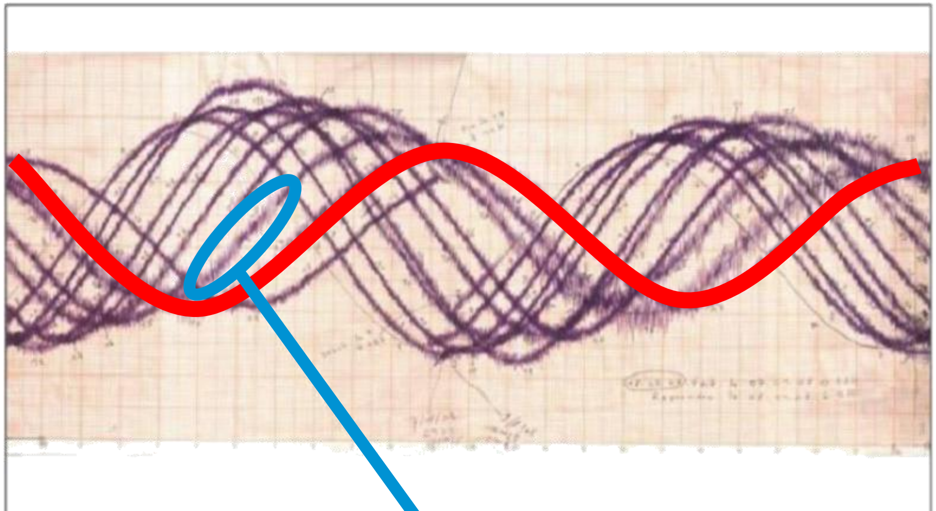
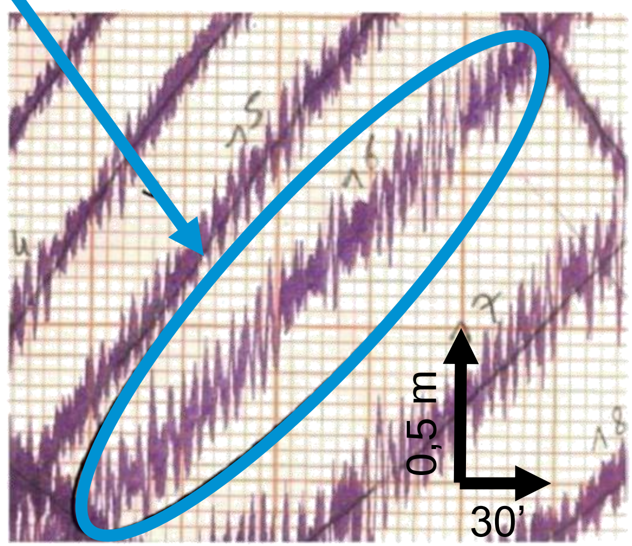
SEICHE



Tidal signal
~2 m

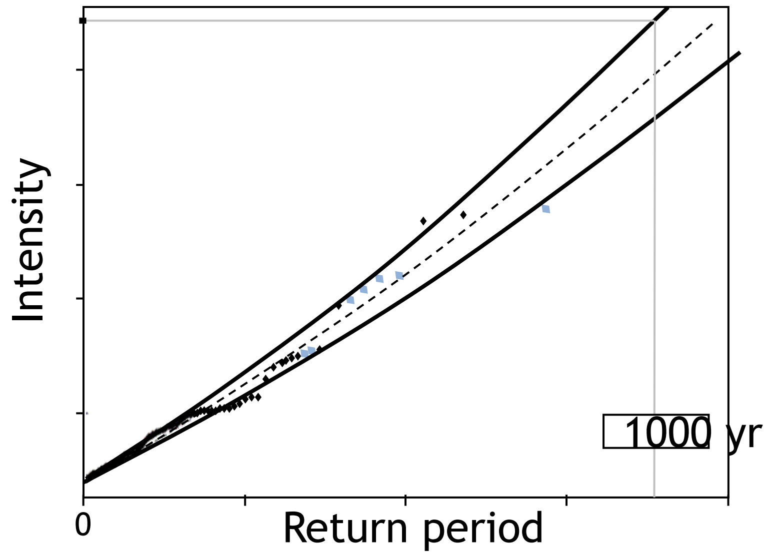


Seiche (oscillation)
~0,30 m

- RFSs definition: engineering judgment with a probabilistic target
  - statistical and deterministic methods
  - probability of exceedance of 10^{-4} per year
  - cover associated uncertainties
- Different approaches
  - direct calculations
  - additional margins
  - conventional conjunctions of events
  - definition of complementary scenarios
- Shall as a minimum encompass all situations likely to be encountered on the basis of relevant past experience

- Evolution of the hazard with time
  - climate change
  - “influence factors“ to be monitored “ (i.e. dyke modification upstream the site)

REFEFENCE FLOOD SITUATIONS - Examples
River flood from large watershed



Flow rate

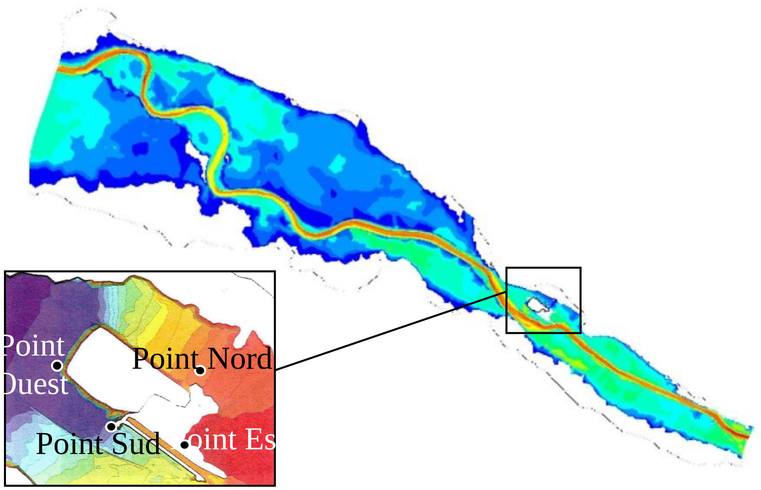
- statistical extrapolation

calculated for a return period of 1000 years, taking the upper bound of the 70 % confidence interval,

- increased of 15% of this value (additional margins)

Water Level

- a model (generally numerical) representing a reach of the river in which the flood is routed.
- sensitivity analysis to cover uncertainties related to flood routing



REFEFENCE FLOOD SITUATIONS – Examples
High sea water level RFS

- Calculated for the sites near the sea (Atlantic Ocean – Channel), the high sea water level results of the sum of:

  - the maximum water level related to astronomic tide,
  - the storm surge (set-up) calculated for a 1000 years return period (upper bound of the 70% confidence interval) and increased in order to cover frequently observed outlier,

  Combination of phenomena

  - the evolution of the average sea level extrapolated at least up to the next review of safety for existing facilities and possible life duration for new installations.

  Climate Change

REFEFENCE FLOOD SITUATIONS – Examples
Local Rainfall RFS

- **Scenario 1:** For the design of the drainage system
  - the reference rainfalls are defined by the 95 % confidence upper bound interval of the extreme intensity, with a return period of 100 years
  - various durations of rainfalls should be considered to get the most challenging conditions for the design

AND

- **Scenario 2:** For the design of the platform, runoff scenario
  - considering that all inlets of the drainage system are blocked
  - hourly rainfalls defined by the 95 % confidence upper bound interval of the extreme intensity, with a return period of 100 years

- Need of a set of 11 RFSs to define Design Basis Flood (for France)
- Various methods to characterize RFSs (deterministic or statistical)
- Different ways to reach the target "10,000 years return period / covering uncertainties " based on engineering judgment
- Influence of climate change
  - Available extrapolations for mean sea level
  - ➔ this influence is included in the definition of the high sea water level RFS
  - extreme wind, rainfalls, river flood: no obvious tendency
  - ➔ surveillance of factors whose modification may impact significantly RFS characteristics + periodical reassessment

Thank you very much for your attention

Tsunami hazard for French NPP

- Possible tsunami sources in the region (Atlantic + Channel)
  - Earthquake (M = 7,6 is the threshold for regional warning in Pacific)
  - Sea-floor instability / land slide (some km^3)
  - Volcano

  No geological sources that can generate major tsunami at this coast have been identified.

- Records and historical data
  - Sismisc and sea level records (last 50 years): no confirmed evidence of tsunami generated in the Atlantic
  - Historical data (last 300 years): description of abnormal sea level rises (tsunami ?) – flooding of flat regions

Tsunami hazard for French NPP

- Design Basis : Sea level RFS
  - the maximum water level related to astronomic tide,
  - the storm surge (set–up) calculated for a 1000 years return period (upper bound of the 70% confidence interval) and increased in order to cover frequently observed outlier,
  - the evolution of the average sea level extrapolated at least up to the next review of safety for existing facilities and possible life duration for new installations.

- Design basis : Wind waves RFS
  - Sea level (RFS)
  - 100-years wind wave

- Tsunami effects are covered by these two RFS