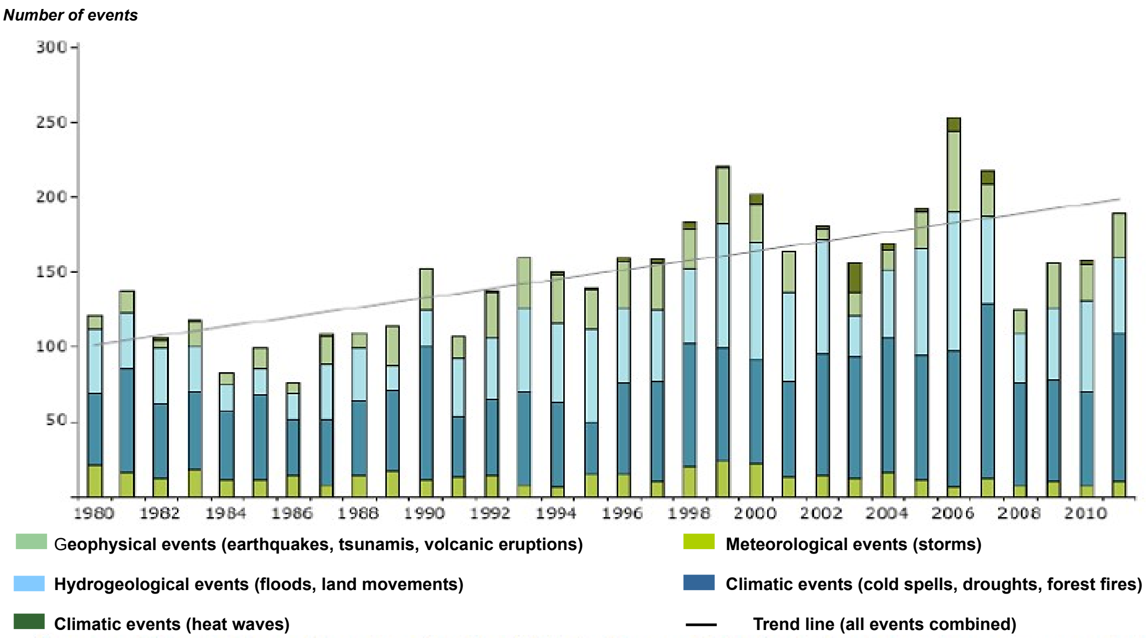
Technological incidents triggered by flooding

Many scientific studies undertaken by public or private-sector entities corroborate the observation of an increasing number of natural disasters over the past few decades. The rise in average temperature, as demonstrated by the Intergovernmental Panel of experts on Climate Change (IPCC), is modifying hydraulic systems at the global scale. This warming is also heightening the intensity of rainfall events, which are often very localised and contribute to extreme flooding. Flood events already make up the greatest share of Europe's most widespread natural disasters, accounting for 30% to 40% depending on the source. Anthropic factors, including land use, layout of water courses and the confinement of overflow zones, all heavily contribute to the occurrence of these sudden phenomena.

Graph No. 1: Natural disasters occurring in countries within the European Economic Area (1980-2011)



Source: «Climate change, impacts and vulnerability in Europe 2012, An indicator-based report», rapport de l'Agence européenne pour l'environnement, n° 12/2012.

1. Typologies inventoried in the ARIA database

ARIA database entries on technological accidents clearly distinguish several types of floods that serve to trigger technological incidents:

- overflows,
- breaks along hydraulic structures (dykes or dams),
- slow spills (rising river water) or fast spills (torrential flows),
- a rising water table,
- agricultural or urban run-off,
- tidal surges.

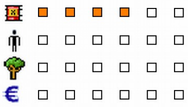
On 31 December 2014, the ARIA database contained 244 accidents occurring subsequent to an external incident tied to overflowing water courses, tidal surges or other flood events.

The phenomena known to occur at the time of these technological accidents are as follows:

Known phenomena	*No. of accidents involved*	*Proportion (%)*
Discharges of hazardous substances	*53*	*21*
Fires	*9*	*4*
Explosions	*5*	*2*

Among the phenomena encountered most often during industrial accidents, the discharge of hazardous substances remains the most significant whenever industrial installations are flooded.
The rise in water level during natural events often:

- causes the failure of vessels containing hazardous substances;
- leads to overflowing liquid waste storage facilities, especially in aqueous effluent treatment plants;
- washes soils laden with all kinds of pollutants.



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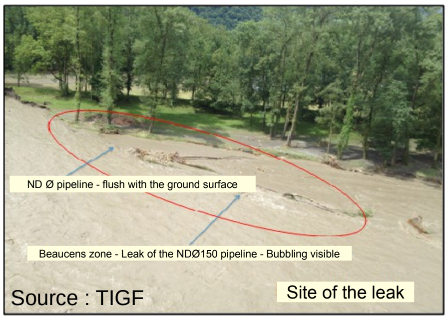
When the GAVE DE PAU water course flooded at around 3 am, the operator of a gas pipeline (nominal diameter: 150; year of initial service start-up: 1962; underground depth: > 1 m), located roughly 100 metres from a water course, detected several anomalies (pressure variations) at the Pierrefitte-Nestalas station. Fire-fighters were notified at approx. 3:20 am. At 4 that morning, on-call technicians recorded a number of facility access difficulties: roads were cut, etc. Pressure continued to drop, and the leak flow rate was estimated at 9,000 Nm³/h at 8:30 am. A strong gas odour could be smelled in the vicinity. Implementation of the Monitoring and Response Plan commenced at 9 am.



A discharge point was identified around 10 am upstream of the Beaucens switching station. The current flowing in this water course had caused a total break of the pipeline and was responsible for destroying the bank where the line had run. The pipe had been unearthed, carried, bent and broken, all due to the strength of this current. Helicopter flyovers of the flood zones were performed from 10 am to noon in order to detect other high-risk situations between the towns of Tarbes and Lacq.
Once the waters had receded and after creating a secure zone (through excavation), works to isolate the leaking pipe section began around 7:30 pm and were completed by 1:30 am on 20 June. A curved bottom was installed over the decompressed section.
To ensure customers' gas needs were being met, notably for winter 2013-14, the distribution network grid was activated. Given the degraded operating conditions, the gas pipeline was rebuilt just a few hundred metres from the previous alignment. It was expected to be operational by the end of 2014.
The facility operator estimated the volume of natural gas released during the event at 233,000 Nm³ for the 17-hour leak duration.
The GAVE DE PAU flood was notable for the extent of its damage throughout the region, which was a function of not only the height of water generated but also the deviation in water course bed and hence in its preferential flow paths.

Other specific mechanical phenomena have resulted from floods. For example, Archimedes thrust is capable of lifting and dragging containers / vessels poorly fastened to the ground. Also, missile effects have been caused by the collision of floating objects during flood events.

2. Consequences

The majority of floods entering industrial facilities engender, first and foremost, property damage (motors and electrical grid, computer equipment, production tools, etc.), but also intangible losses (e.g. Data banks, customised software, computerised archives).

A breakdown of the primary consequences from the ARIA sampled events is shown below:

Consequences	***Number of accidents involved***	***Proportion (%)***
Operating losses	*133*	*55*
Redundancy of personnel	*58*	*24*
Surface water pollution	*41*	*17*
Soil pollution	*11*	*5*

In over half the cases, installation shutdown is required. Service restart is only partial at first and then staggered over several days or even a few weeks.

Emergency plan = Mitigated consequences

A study of 118 flood-related losses by the insurer FM GLOBAL, published in issue no. 457 of the specialised review *FACE AU RISQUE*, revealed the benefits of instituting emergency plans.
Out of the 72 cases where an emergency plan had been implemented efficiently, the average damage amount stood at €1.2 million.
In the other 46 cases, the average cost rose to €4.6 million. Moreover, an effective application of emergency plans enables restarting production activities much more quickly.

3. Disturbances and causes

Floods should be considered as intense natural events that contribute to triggering technological incidents. Nonetheless, this disruptive element does not, in the majority of cases, constitute the sole origin of accidents. More specifically, the failure to incorporate flood risks often proves to be a very strong indicator of organisational shortcomings.

From the time of site design:
- inadequate attention to risk analysis;
- insufficient sizing of distribution systems and evacuation facilities for tidal surges;
- failure to install and monitor protective structures.

While operating installations:
- lack of weather tracking;
- inconsistent management of hazardous substance stockpiles;
- no preliminary inspections of emergency response resources;
- poorly trained technicians.

4. Measures adopted

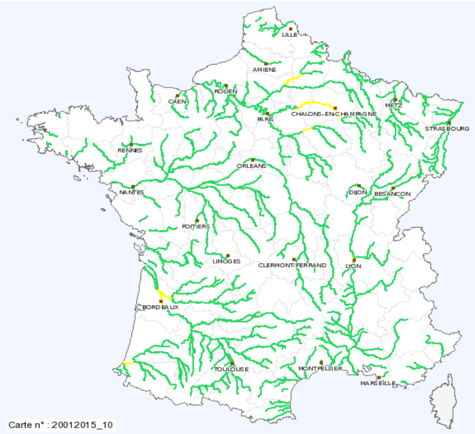
According to the ARIA sample, the first measures enacted following flood events are technical in nature:
- electrical equipment moved to higher ground;
- the piping network assembled onto racks;
- transfer of external storage or fencing to avoid being swept away by floodwaters;
- construction of protective dykes.

These technical measures are accompanied by organisational actions:
- revision of the installation safety report to account for the flood risk;
- drafting and dissemination of guidelines for securing installations ahead of time;
- adoption of an emergency evacuation plan for personnel.

5. LESSONS LEARNT

Despite the speed and intensity of flood events, regardless of origin, their anticipation appears to be of utmost importance. Along these lines, a number of best practices are worth recalling:

- remain vigilant of weather conditions by using an alert system as required,
- on a regular basis, inspect all existing protective structures,
- place all computer servers and hardware on an upper floor,
- isolate all sensitive documents (drawings, patents, essential archives, etc.) in sealed containers,
- turn off energy supplies (gas, electricity) before the water level begins to rise,
- raise all important electrical devices off the ground.



Flood alert system:
Ministry of Ecology: http://www.vigicrues.gouv.fr/
Météo France weather service: http://france.meteofrance.com/vigilance/Accueil

Red : Major flood risk. Direct and widespread threat to personal safety and property security

Orange: Risk of a flood event generating heavy overflows capable of causing a significant impact on local communities and on personal safety and property security

Yellow: Risk of flooding or a rapid rise in water level without the threat of extensive property damage, yet still requiring extra vigilance in the case of seasonal and/or vulnerable activities.

Green: No extra vigilance required.

Conclusion

The extent of physical consequences caused by floods can lead to definitively halting certain activities or even an entire industrial site. As such, incorporating this risk as of the design stage, but also at the time of each modification, serves to significantly reduce financial losses, which when uncontrolled could ruin a company. Prevention must therefore be practised:

- It seems essential from the outset to identify and then analyse this flood risk;
- The second step consists to get prepared to face this risk, with priority on avoiding any construction in flood zones, insofar as possible;
- Next, protective measures must be implemented. Technical actions, like dyke building, at the site or industrial zone scale must undergo periodic verifications;
- Lastly, an emergency plan needs to be developed in order to: organise alert procedures, notify response teams, quickly provide all useful instructions and equipment, and easily identify the individual or individuals empowered to make operational decisions.

For more information:

Consult our website http://www.aria.developpement-durable.gouv.fr/ for many *NaTech* accident analyses.

Heavy rains and flooding:

- Summary: "Atmospheric precipitation and floods: Key elements from industrial accident studies",
- Press article: "Industry and flooding: Input for experience feedback",
- Detailed fact sheet: "The impact of floods on Seveso-rated facilities: A series of events from 1993 to 2003 in both the PACA and Languedoc-Roussillon Regions (France)".