LIBER QUARTERLY, ISSN 1435-5205

Flood Prevention and Protection at the Bibliothèque Nationale de France

by CHRISTIANE BARYLA

INTRODUCTION

To begin with, let me introduce myself: my name is Christiane Baryla and I am the Director of the IFLA Core activity on Preservation and Conservation or PAC. This programme is hosted by the Bibliothèque nationale de France (BnF) in Paris and this is the reason why I am authorised to speak about flood prevention and protection in the National Library.

This paper is the last one in a morning dedicated to terrorism attacks and climate changes. When you listen to criminal experts and to flood specialists in Paris, they both say the same thing: we don't know where or when, but we do know that a terrorist attack is possible and has to be planned for. We do know that a major flood in Paris may occur, but current weather forecasting knowledge is unable to give us any probability for the year or the month of that eventuality.

Invalides Station in January 1910

Regarding flooding in Paris, the reference point is the famous flood in January 1910, when the Seine waters rose six metres above the critical flood level in Paris. The origin of that flood was that, after a very wet end to the year 1909, rains were very heavy during the first 20 days of January 1910. The river Seine was very high for about ten days but the flood lasted about two months until the water returned to its normal level. After this period, considerable damage was observed in Paris and its suburbs: many families ruined, many workshops and factories destroyed and damage to urban infrastructures.

The probability of such a phenomenon recurring is estimated at once in 100 years. That means that it may occur, on average, once in a century but not necessarily every century. Arrangements to be made in anticipation of this type of one hundred-year flood pose a crucial planning problem which is still inadequately managed even today. Until recently, it was considered that the storage basins built up around Paris, would protect the capital against a major overflowing of the Seine, but the rate of flow has increased so much over the last hundred years that the concept of 'same flood' is meaningless and these storage basins would not be able to lower the water level by more than about 20

centimetres in Paris. Consequently, the dams have not radically changed the situation, particularly since it is commonly accepted that a much higher flood than the one in 1910 is likely to occur.

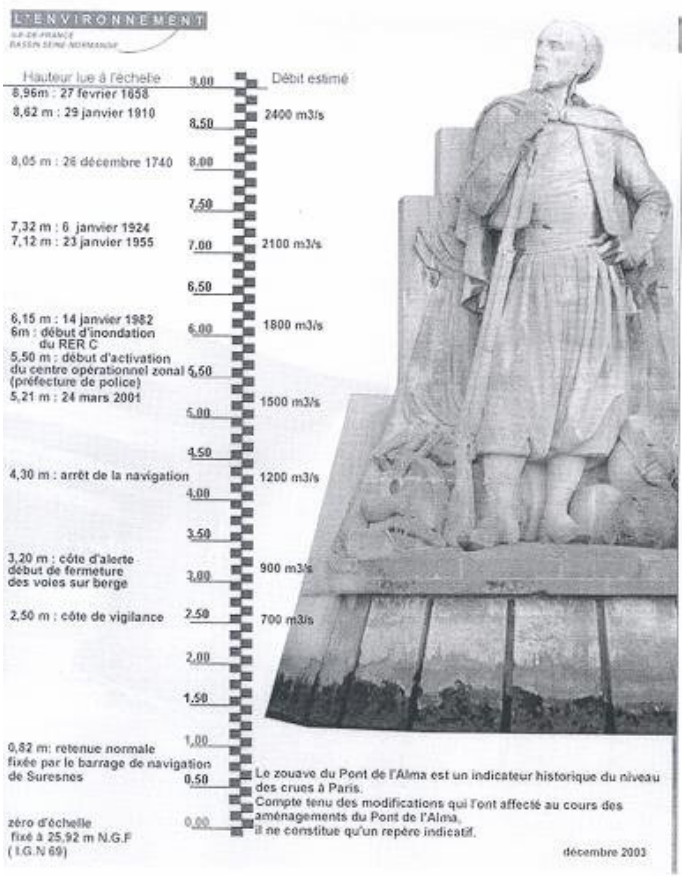
Four years ago, in 2002, the Paris Police Headquarters alerted the major cultural institutions built along the Seine to an increased risk of a major flood occurring in the capital. A number of museums and libraries are located near the river (Musée d'Orsay, Musée du Louvre, Musée des Arts décoratifs, Musée du Quai Branly, National Assembly Library), so the problem is not ours alone.

We suppose that the reason for this alert may have been the new millennium, or the approach of the year 2010, or perhaps a result of all the discussions and studies about climatic changes. However, we should say that on this occasion, several serious studies were made in the BnF to assess the different risks and try to see how to counter them.

Before studying prevention and protection for such a flood in the different sites of the BnF, we have to distinguish two possible scenarios: The first case is the arrival of a flood less than or equal to the one of 1910, and the second case is the arrival of flood higher than the reference flood of 1910.

PREVENTION & PROTECTION IN THE CASE OF A ONE-HUNDRED YEAR FLOOD (1910 LEVEL)

The one hundred-year flood was characterized by a water height of 8.62 metres, measured at the Alma bridge. Under this bridge is the statue of a Zouave. This very famous statue is used by Parisians as a reference to estimate the water level in Paris; in 1910 the river reached the Zouave's neck. Had it reached his beard it would have meant a terrible disaster. The Seine is a peaceful river, so it is accepted that it takes two weeks from the critical flood level (3.20m at the Zouave) to reach the high point. This therefore gives us some time to react and to plan**.**



Zouave, Alma Bridge

Which are the sites concerned?

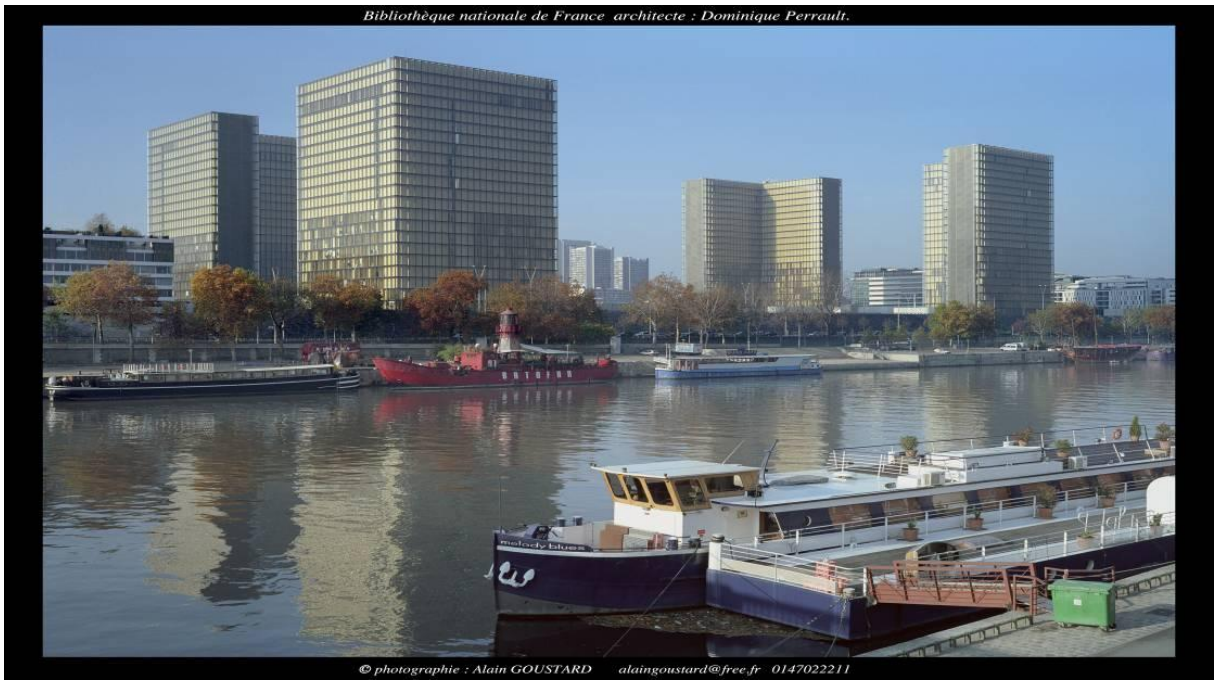
The BnF is divided into seven geographical sites that have their own specialisations, missions and collections. Three of them are not concerned by this topic: the Maison Jean Vilar in Avignon, which is a decentralised branch of the Performing Arts Department; the Joël Le Theule Centre, housed in the castle of Sablé-sur-Sarthe, which is a plant for safeguarding printed documents, and the Bussy-Saint-Georges Technical Centre (30 km from Paris) which is dedicated to storage, conservation and preservation. Four sites are concerned by our problem: the Richelieu site, the François-Mitterrand site, the Bibliothèque de l'Arsenal and, in a minor way, the Bibliothèque-Musée de l'Opéra.

RICHELIEU site

Opera Garnier site

The Richelieu site, in rue de Richelieu, between the Louvre and the Opera Garnier, was the site of the original National Library, which was rebuilt in the 19th century, and now houses collections of manuscripts, maps and plans, prints and photographs, coins, medals antiquities and music. La Bibliothèque-Musée de l'Opera, located in the Opera Garnier, houses collections of music scores, set and costume designs, posters, prints, photographs, paintings and sculptures relating to the activities of the Opera and Opéra–Comique.

Arsenal Library



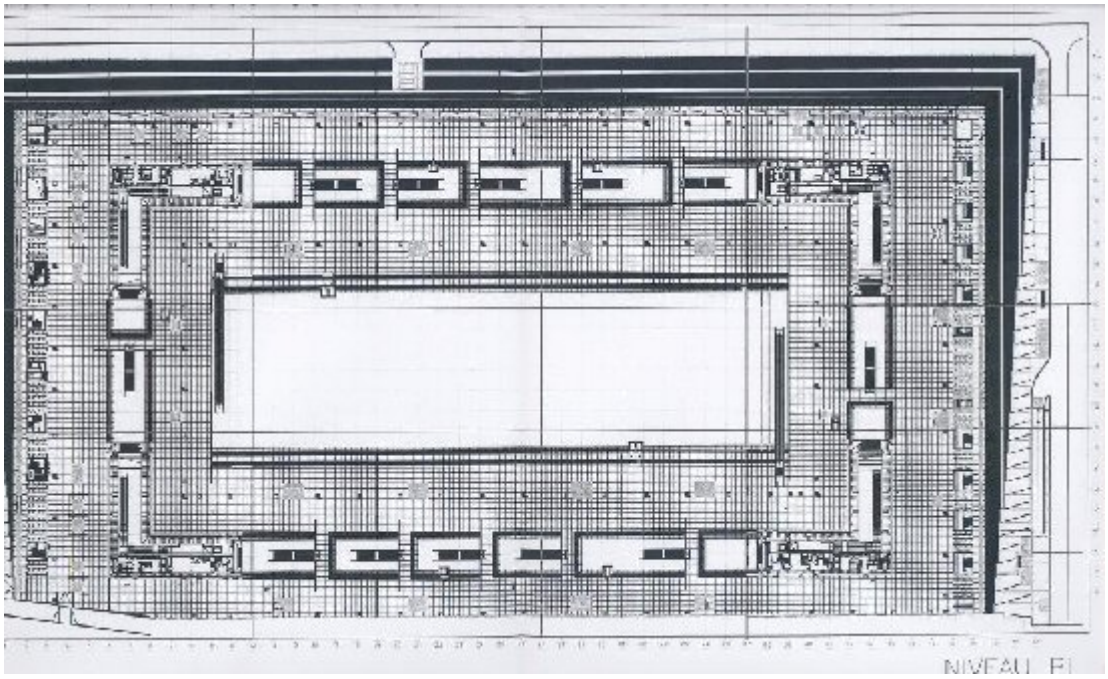
Tolbiac site

The Arsenal Library, located in rue de Sully very near the river, besides housing particularly noteworthy collections, also houses a major part of the Department of Performing Arts. Finally, of course, the Tolbiac site, la Bibliothèque François-Mitterrand is the most recent building and is also located by the river.

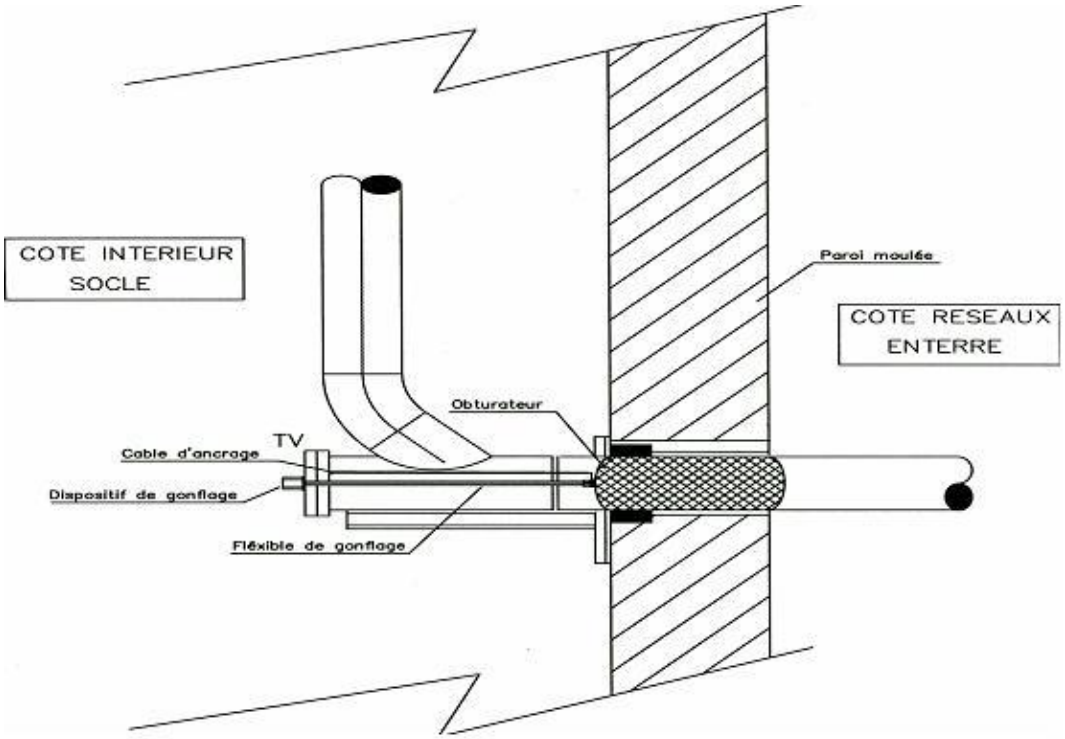
1. Risk preparedness and planning in the Bibliothèque François-Mitterrand (Tolbiac site)
As soon as the site on which the "Bibliothèque de France" was to be built was decided on, the owner (the EPBF: Etablissement Public de la Bibliothèque de France) was quick to realize the major risk created by the proximity of the Seine and set out to investigate every possible means of integrating technical elements for protection and prevention into the construction process, taking as the reference for risk assessment the level of the one hundred-year flood of 1910.

This flood, which occurred on January 28, 1910, measured at the Austerlitz bridge, reached an elevation of 34.60 NGF (Nivellement général de la France = sea level). The flood of January 23, 1955 (fifty year flood) reached an elevation of 33.02 NGF. The flood of January 14, 1982 (ten year flood) reached an elevation of 32.05 NGF.

Construction of the building
The elevation of the exceptional 1910 flood, increased by several centimetres, was taken as the reference by the EPBF, which included in its building works programme an elevation of 35.00 NGF as the design water level to "protect" the building and its patrimony.



Map of the BnF including the layout of the slurry wall



Design of the slurry wall

Technical elements: slurry wall and wells:
Protection is provided by slurry wall techniques. The walls are 0.65 metres thick and are present along the whole periphery of the basement. Several utilities were installed through the walls. The water tightness of these openings is achieved by using seals of the 'link seal' type. In case of ground water level rise, two ways of access for the flood flow to the inside of the basement remain possible at an elevation of less than 35.0 NGF through the doors of the staff car park. Therefore, these two doors are watertight and scheduled to be shut in case of ground water level rise, in such a way that the car park is out of operation during the flood period.

Although the slurry wall is deeply embedded in the geological layer, called 'false clay' at an elevation of 5.0 or 6.0 NGF, water table rises (discharge waters) are always possible and arrangements of deep wells equipped with lifting turbine pumps were made. Twenty-one wells, made up of three lines of seven wells, have been installed in the basement, under L1 level, or in the garden. These wells, all but seven of which are equipped with pumps, are all linked together in order to enable the lifting system to operate effectively, in case of malfunction of one of the pumps. The procedure for starting the pumps is to set them off when the immersed floats reach an elevation of 16.00 NGF, the sanitary space being at elevation of 18.00 NGF.

Means of monitoring and observation:
A number of alarms are located on the pump system, in case of malfunction, with their information directed to the GTC in real time, allowing for monitoring the operation and output of the pumps. At L2 level, five pressure gauges have been installed, allowing for continuous monitoring of the water table level behind the slurry walls (elevations are between 27.05 NGF and 29.45 NGF in summer, and between 27.70 NGF and 29.75 NGF in winter).

At L1 level, in the circulation gallery, six observation wells have been installed, allowing for measurement and visual monitoring of the water table level in the building, within the enclosure made by the slurry walls.

In case of flood, the slurry wall remains the sole and fundamental protection for this new building. Even under normal circumstances, one part of the library substructure is under the normal Seine level. Then, up to a water level of 35 NGF, the slurry wall performs the same role**.**

2. Risk preparedness and planning in the Richelieu site
With regard to this site, I wish to point out that I am speaking under the supervision of Suzanne Jouguelet, Deputy Director in charge of the Richelieu project, and member of *LIBER* Board.

Concerning Richelieu, the only risk to manage is the ground water inflow as the site is situated far enough away from the Seine. Maps of the 1910 flooded Ile de France areas (*Atlas des Plus Hautes Eaux Connues*), show that the site was not affected by flooding, neither by surface water nor by ground water inflow. However, it should be pointed out that in 1910 all the basements and underground storage had not yet been dug or fitted out. Later, in 1932, Michel Roux-Spitz, the architect in charge of the Library, maintained that a one hundred-year flood could generate a rise of the water table to 32 NGF. The time allowed between the time of start of the flood and the inflow of ground water could be one or two months, but collections are stored in the 3rd and 2nd basement (26.8 and 29.3 NGF). Between 1932 and 1959 the problem was solved by waterproofing part of these basements with a 'shaft-lining' (more than 50% of the basements).

Three years ago three studies were launched to figure out the risks of ground water upwelling and to assess the possible consequences for the building:

- The hydrologic survey estimated the higher water level in the case of a one hundred-year or a ten-year flood.
- The geotechnic study considered how effectively the building substructure would be able to resist the upward thrust generated by the ground water.T
- The third survey identified the weak points in the waterproof walls.

So, our conclusion is that it is not necessary to consider moving the collections

3. Risk preparedness and planning in the Bibliothèque de l'Arsenal
The Bibliothèque de l'Arsenal is the most sensitive site. As the library is located near the Seine, the ground water up welling would be very fast and there is also a risk of flooding from surface water. The old cellars are at the level of

32.89 NGF whereas the more recent ones, protected as in Richelieu with a 'shaft-lining', are located at the level of 33.40 NGF.

The three surveys were carried out. The waterproofed basement was tested. The collections stored in the ancient cellars have been removed. As was the case for Richelieu, lift pumps and generating units were bought and considered effective. At the same time, removing the collections stored in the waterproofed basements was considered and planned as a sort of 'Plan B', but this option was rejected as being unnecessary following the studies.

4. Risk preparedness and planning in the Bibliothèque –Musee de l'Opera

According to the information reported by the Opera Administration, the Palais Garnier basements were damaged in 1910. Therefore it was decided to transfer the maps designed by Garnier (10 m^3) to the first floor and store them in a room at a level of 30.80 NGF. A study was launched with the Opera managers and Suzanne Jouguelet to specify terms and conditions for dusting and transferring these documents to Richelieu.

PREVENTION & PROTECTION IN THE CASE OF A MAJOR FLOOD ABOVE 1910 LEVEL

We have seen that, in theory, prevention and protection of the Bibliothèque nationale de France against flooding is ensured up to a level of 35 NGF and does not normally entail moving the collections at the last moment. However, the library is not the only public building at risk in Paris and when we study the crisis management plans of the Paris Police Headquarters we could imagine that problems might begin not at 35 NGF, but at level 32.

Paris Police Headquarters regularly update their emergency plan for a major flood (risk assessment, optimizing distribution, clear documentation, limiting the consequences of the flood, organizing crisis management and ensuring that economic and social work is able to function in a reduced mode, organizing the return to normal conditions).

The description of the projected crisis in Paris is very interesting because, in the event of a level 35 NGF event:

- two million people would be affected;
- there would be considerable difficulties in transportation (no subway, half of the bridges inaccessible, buses requisitioned);
- hospitals would need to be reorganized (20% of the beds available are in a flood risk area);
- 335,000 people in Paris could be without electricity or gas;
- 100,000 houses would be without urban heating;
- no phone connections (landline or mobile);
- infiltration from the Seine waters to the sewers could occur;
- 1800 tonnes per day of rubbish, without incinerators, would have to be treated;
- reduced production of drinking water;
- 107 km of railways potentially flooded,
- and so on ...

Therefore we could imagine that, in the event of disaster, people would be so busy with their own problems that it would be very difficult for them to go to work.

The projected crisis in Bibliothèque nationale de France:

Above a level of 32.22 NGF there would be no more electricity in Paris and traffic would be very difficult, perhaps even impossible. But there would be 100 people (technicians, librarians and firemen) working in Tolbiac, 50 in Richelieu, 25 in Arsenal, 6 in Opera for maintenance and security.

There is an ongoing study to specify the 'life conditions' in the event of a one hundred-year flood. Orders have been placed for folding beds, working clothes, maintenance food, drinkable water. Security guards with food rations will be provided on each of the four sites. There are six generating units in Tolbiac. A satellite phone will be bought for every site. The list of the agents who will have to be present has been established.

CONCLUSION

In fact, the paradox is that the BnF, entrenched in its 'slurry wall', would be nevertheless, at the mercy of the City of Paris. (We do know that since the 13th century the coat of arms of Paris shows a vessel inscribed with the famous motto: *Fluctuat nec mergitur, meaning "tossed by the waves, she does not sink").*

Beyond the organization that has been described, the institution has to finalize the disaster plans already implemented on the different sites. At the same time, the BnF, through its technical departments has to work closely with all the different actors in the Ile de France.

Acknowledgements

With thanks to Helen Shenton for giving me the opportunity to make this presentation, which is the result of a co-operation with Gérard Bailly, the former Director of the Technical Department at the Bibliothèque nationale de France, Oreste Friscira who is in charge, more particularly, of the Richelieu site and Daniel Durritçague in charge of the flood studies.