Submitted on: 12.07.2019

Flood risk analysis and assessment: the case of the General State Archives of Greece

Maria Giannikou
Department of Conservation and Preservation, General State Archives of Greece, Athens, Greece.
E-mail address: margian72@yahoo.gr

Ourania Kanakari
Department of Conservation and Preservation, General State Archives of Greece, Athens, Greece.
E-mail address: raniakanakari@hotmail.com

Abstract:

Although the new building where the Central Service of the General State Archives of Greece moved in 2003 was constructed to operate as a model repository of the national archival asset, the economic recession has undermined the regular maintenance of the infrastructure, making the building envelope weak and prone to potential flood risk. On the other hand the preservation facilities, the fire safety and security equipment as well as the earthquake resistant construction are among the building strengths against other natural disasters and threats.
The history of incidents described in the text and consisted of all the written reports so far, yielded benefits in terms of perceiving and managing risks; a basic practice of technical checks was endorsed and an integrated approach was finally adopted to enhance protection against flood.
In this framework in 2017, a pilot project on flood risk analysis and assessment was applied to collections rare and unique, classified and well documented.
The flood risk analysis process pointed out the causes and revealed visible as well as out of view sources within the infrastructure. For risk assessment, risk mapping was selected as a methodology which visualizes the value and vulnerability of the collections distributed in storage areas and their exposure to specific flood risks. The methodology is presented step by step and constitutes a proposal for Archives and Libraries since it addresses the problems specific to the materials of their collections.
The paper discusses the extent of the risk zones in relation to the risk magnitude, the distribution of vulnerable value and the actions that could be taken to eliminate risk. It argues on options for both preparedness and response, from optimal to feasible solutions, stressing the importance of staff engagement in unfavorable circumstances.

Keywords: risk analysis and assessment, exposure to risk, collection value, material vulnerability, risk mapping.

Introduction

The General State Archives of Greece (G.S.A.) was established, in 1914. The organization consists of the Central Service in Athens and 64 Regional Services and belongs to the Ministry of Education and Religious Affairs.

The Central Service premises are situated on the top of a small hill in 6 km distance from the centre of the capital city (image 1). Gardens and pavements surround the construction which covers an area of 6,500 square meters. The architectural design of the building with marble and glass façade won the first prize in the national contest of 1978. For a number of reasons, the construction was completed after 23 years, in 2003.

Image 1: Southwest view of the Central Service premises

The main entrance is located on the ground floor. On the two upper levels there are administration offices, the Reading room and the Library.

All repositories are located on three underground floors. In the 1st basement there are four storage rooms that cover an area of 745 square meters, while archival processing facilities, conservation studios and control room are housed too. In the 2nd basement six storage rooms of 1202 square meters cover the total area. In the 3rd basement, one large storage room and building machinery are situated.

The project was the first purpose-built among museum, archive and library buildings in Greece, since the early 19th century. Its infrastructure, at the time it was built, had been a pioneer in archival facilities and equipment around the Balkans aiming to play a leading role for the Regional Services as well as all other archival organizations in Greece. The optimal performance of the building allowed high standards of archival management and preservation. Short time after moving in the new premises, the Central Service increased its staff with new experts, archivists, librarians and paper conservators, outsourcing services such as the building, electrical and mechanical installation maintenance.

The last 10 years, the public sector has been in the eye of the storm of an unprecedented economic crisis. General State Archives' operating costs depend on the national funding. Thus decline of funding resulted in inability to run regular maintenance and cover the costly repairs of the increasing building failures. The administrative efforts to find resources should have to overcome the obstacles of bureaucracy. The problems are building up neutralizing the advantages offered by the exemplary construction.
In this unfavorable environment, the educational background and expertise on archive infrastructures, as well as the long experience in civil emergency planning motivated authors to help with monitoring facilities.
The gained experience raised risk awareness and lead to the development of proactive initiatives. In 2014 a start was made in risk analysis that sought to identify different causes of risk. In this context, the proper environment, the fire safety and security facility proved to be among the major strengths. On the other hand, the past had shown that flood was the greatest threat. Although a lot of work has been done, since then, on disaster response and recovery, a risk assessment for preparedness appeared to be a big step.
Eventually, the decision for the assessment was inevitably taken in 2017, after the last flood event that took place in a storage room.

History of flood events
In 2008, after five years of operation, the heavy construction has gradually failed to perform as a barrier to the external environment. The building envelope was prone to wear and tear, which eventually caused small scale floods. Consequently, in 2010, an outburst of heavy rain resulted in extensive water infiltration into the inner western wall of the 1st basement where records of high importance are stored (image 2).

Image 2: Flood incident in the storage room in 2010

The routine checks for water leaks after a rainstorm, prevented significant loss. Proper actions were then set in place according to the envisaged response to emergency i.e. salvage

procedures for water damaged material, moving of intact material away from the hazardous area etc (image 3). Shortly after, a large scale insulation work was carried out to address the leak from the inside.

Image 3: During air drying of the water damaged material after a flood incident in 2010

Considering that the original failure on the exterior of the building continued to be a potential risk of infiltration in adjacent areas of the inner wall, precautions were taken including the removal of the archival material nearby the wall and the protection of certain storage units with polyethylene film. In 2017, seven years after the building repair, water reappeared on the same wall but further southwards, confirming thereby the initial assumption (image 4).

Image 4: Water infiltration in the storage room in 2017

Risk analysis and assessment methodology

Risk analysis precedes the assessment and includes identification of the specific risks that could range from a small water leakage to a large flood. Causes can have different origin from indoor housing to outdoor natural disasters.

As a first step information was extracted from tools for monitoring facilities as the maintenance sheet to plan and control inspections as well as the incident and damage report sheet.

At that point, we distinguished between visible sources of risk, either they have generated flood incidents or not, and those out of view within the infrastructure, e.g. inside building materials, ceiling etc.

The risk assessment project was pilot, applied in priority to collections rare and unique, classified and well documented. Different models were taken into consideration before we select mapping as a methodology that visualizes information on collections distributed in storage areas and their exposure to specific flood risks.

Besides, the risk mapping is a well-known practice in the field of civil protection. In a similar manner, maps can describe the three parameters on which the magnitude of a risk depends: 1) exposure to risk, 2) collection value and 3) vulnerability.

The methodology owes much to *The QuiskScan* [Brokerhof, Bülow, 2016], for the rationale behind mapping and benefits also from the concepts and practices used by risk assessment models in the field of cultural heritage such as *ABC method* [Michalski, 2016] etc.

Previous experience on mapping the condition of monumental art with drafting software was particularly helpful.

The compilation of the mapped information offered a comparative overview facilitating planning of action in areas of high magnitude of risk and high vulnerable value without requiring numerical calculations.

Exposure to risk

The exposure to risk depends on two parameters; probability which reflects the frequency of risk and severity on a 5 level scale (image 5). In this context, water infiltration due to failure of the building envelope is the most serious flood risk.

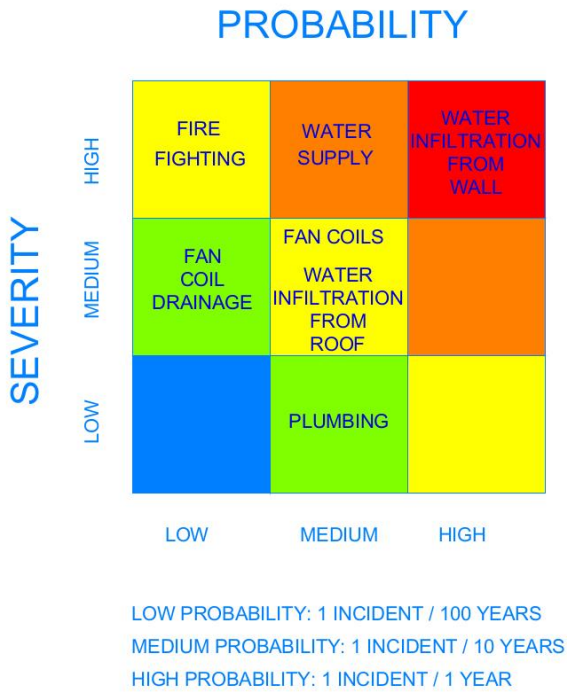

Image 5: Exposure to risk matrix

The as-built drawings, submitted by the contractor upon completion of the construction project, should be the primary tool to detect all factors associated with the underlying risk.
In the absence of the as-built and on the basis only of the design drawings of the building, the authors with a basic technical knowledge and with the professional advice of engineers working for the Ministry of Education, undertook a systematic work to understand the problems of the building.
The drawings were thoroughly examined to investigate how the storage areas are exposed to the external environment, either at ground or underground level (image 6).

Image 6: Southwest view of the Central Service. In the foreground the top of the 1st basement is shown.

In addition, a survey provided a considerable feedback on the construction characteristics and weaknesses. Apart from the particularly pronounced problem in the western wall, a risk dynamic in other parts of the building was marked out (image 7). Small deviations recorded on the drainage system and gutters could not be accused of water infiltration into the building. Though it is questionable whether the design of these systems is capable to control 100% of the runoff generated during heavy rain-falls, in recent years.

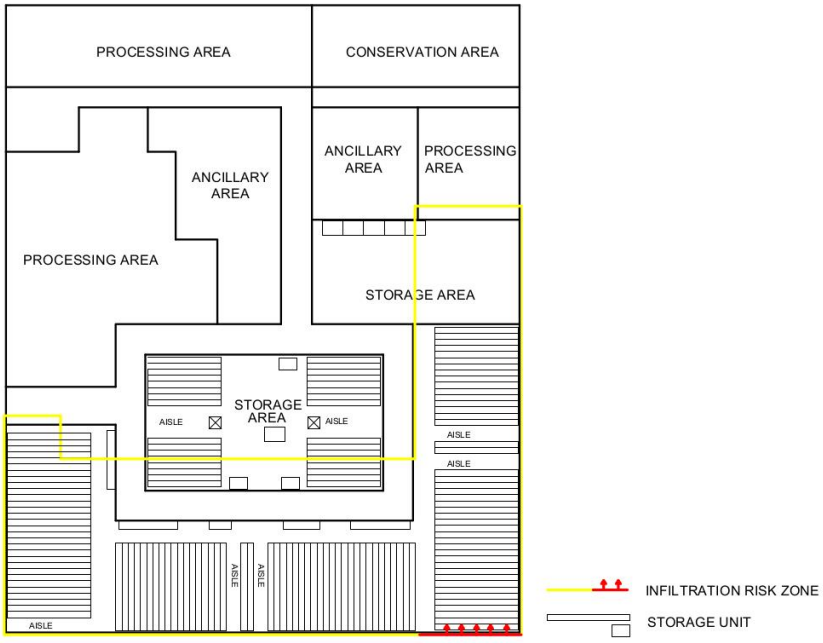

Image 7: Mapping of the water infiltration risk zone

The survey was continued to confirm the location of plumbing, drainage, Heating Ventilation Air Conditioning (HVAC) and fire protection installations. The central shaft and the open ceiling suitable for archive buildings, allow easier access to mechanical systems and faster detection of ceiling leaks. A central HVAC system as well as fan coil units operate in the building and storage areas. Each unit includes a compressor that moves the refrigerant through the pipe circuit surrounded by aluminum fins. The survey resulted in a review of the situation with significant deviations compared to original reflecting drawings. The fan coil units, their associated pipe networks and drainage connections above storage shelving are a potential threat (image 8).

Image 8: Fan coil unit in the roof ceiling

Since a regular maintenance cannot be performed an advice was sought to assess the severity of this threat. The accumulation of dust and dirt in the condensation water containers may hinder drainage and result in leakage, thus a medium probability was assigned to this risk (image 9).

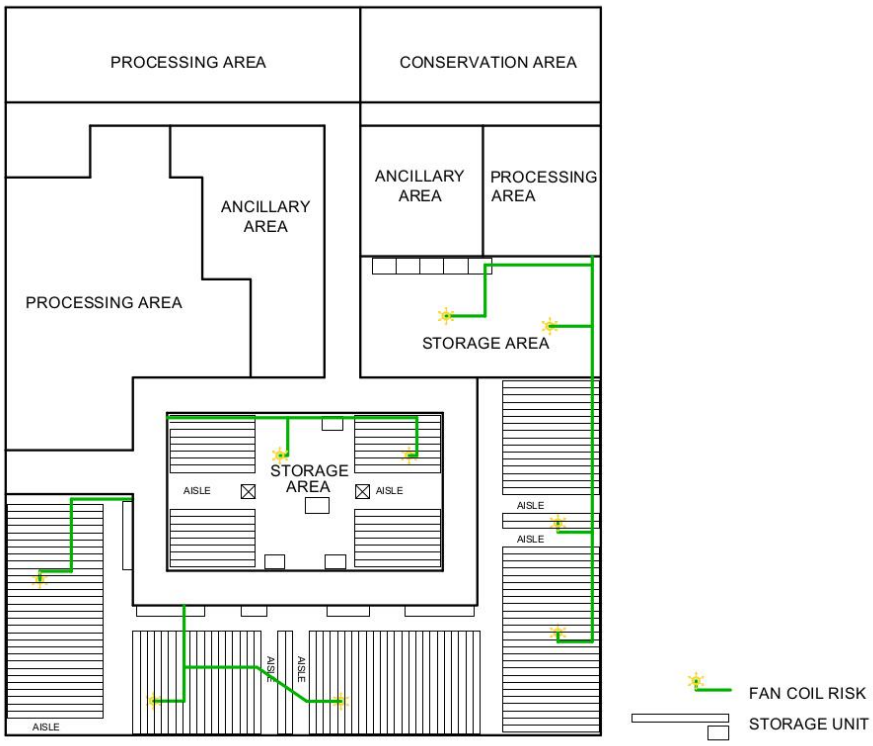

Image 9: Mapping of fan coils in the storage room ceiling

Where exposure is expected further analysis requires a scenario based approach.
The fact that plumbing equipment and water supply systems, water closets, kitchens and conservation laboratory are located in a safe distance from the storage rooms was reasonable for a purpose built construction (image 10).

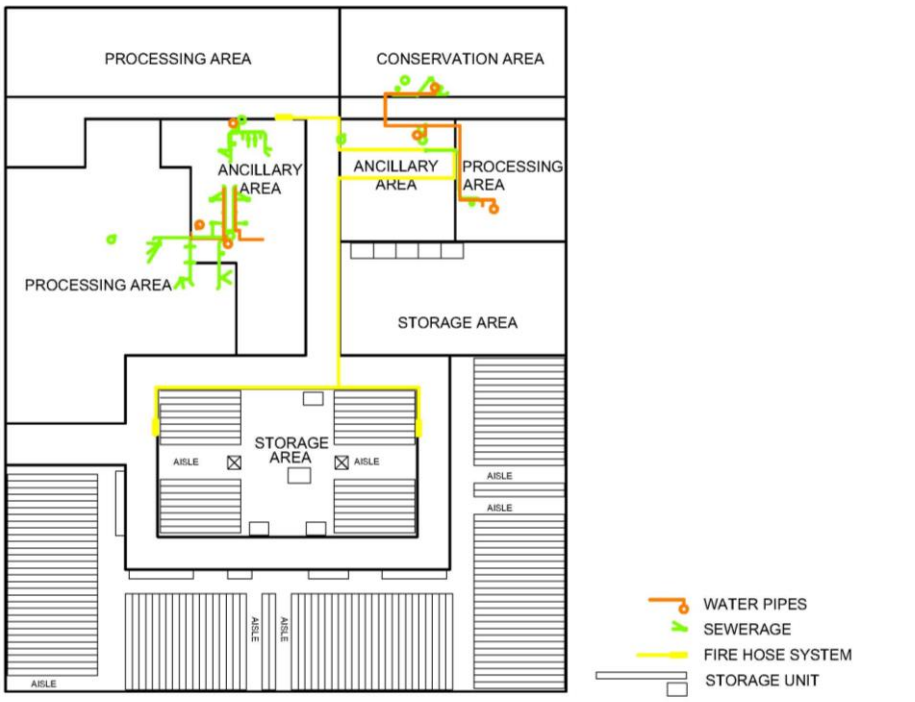

Image 10: Mapping of risks outside storage rooms

For the same reason, fire extinguishing system running inside repositories doesn't use water but the inert gas FM200 (image 11). The fire-hoses' pipe network carrying water is installed outside. Existing Condition Survey showed no changes from the original drawings leaving a serious risk and action requirement as well, behind.

Image 11: Fire extinguishing system in storage room

Vulnerability

Vulnerability is rated on a 5-level scale as a function of the type of the archival material and the degree of exposure to the storage environment. Information concerning the type of both the archival material and the protective enclosures was found in the inventory report, updated annually by the Reading Room and Library Department. At the same time, on-site surveys were also necessary.

The material was broken down into types by substrate, form and structure as these involve different physical and chemical characteristics whereas the writing and color media, etc. may remain common.

Since water can cause significant and often irreversible alterations it was reasonable to distinguish between the following types of material according to an increasing degree of vulnerability from paper documents through books to audiovisual material, parchment, transparent paper, technical drawings and historic reproductions (image 12).

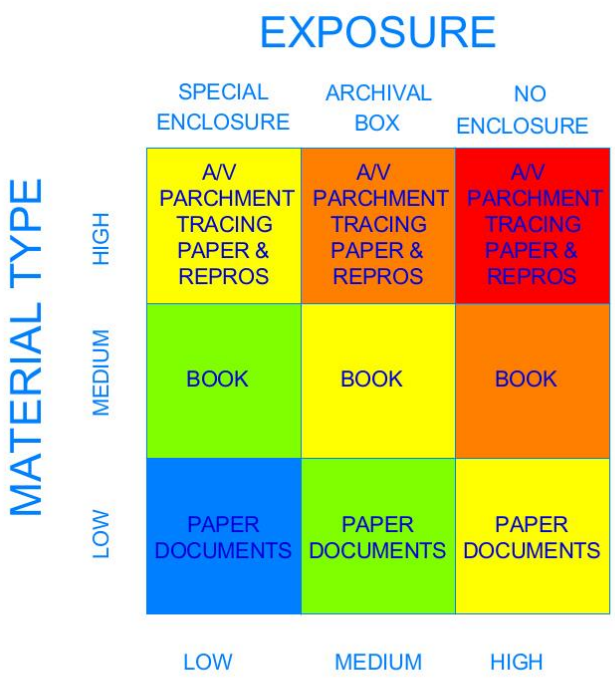

Image 12: Vulnerability matrix

Given that all material is stored in stable environment, in appropriate mobile shelving units, elevated from the floor and distant from the walls, with a closed top and doors at the end units, the degree of exposure depends only on the storage enclosures (image 13). Oversized material, such as drawings, maps and parchments, as well as microfilms are kept separately in plan drawers and cabinets that provide higher protection of the material against the flood. Exposure to the environment is analyzed on the basis of the protection offered by 1) the special enclosure that keeps the vulnerability low, 2) the simple archival box that functions as a temporary wetting barrier and 3) plain storage with improper or without enclosure that makes the material the most vulnerable (image 14).

Image 13: End units with doors

Image 14: Material with no enclosure next to material in archival boxes

Collections constituted the assessment units since they cannot be separated intellectually and physically unless this is necessary for preservation purposes. The same applies when more than one collection are shelved in the same unit (image 15).

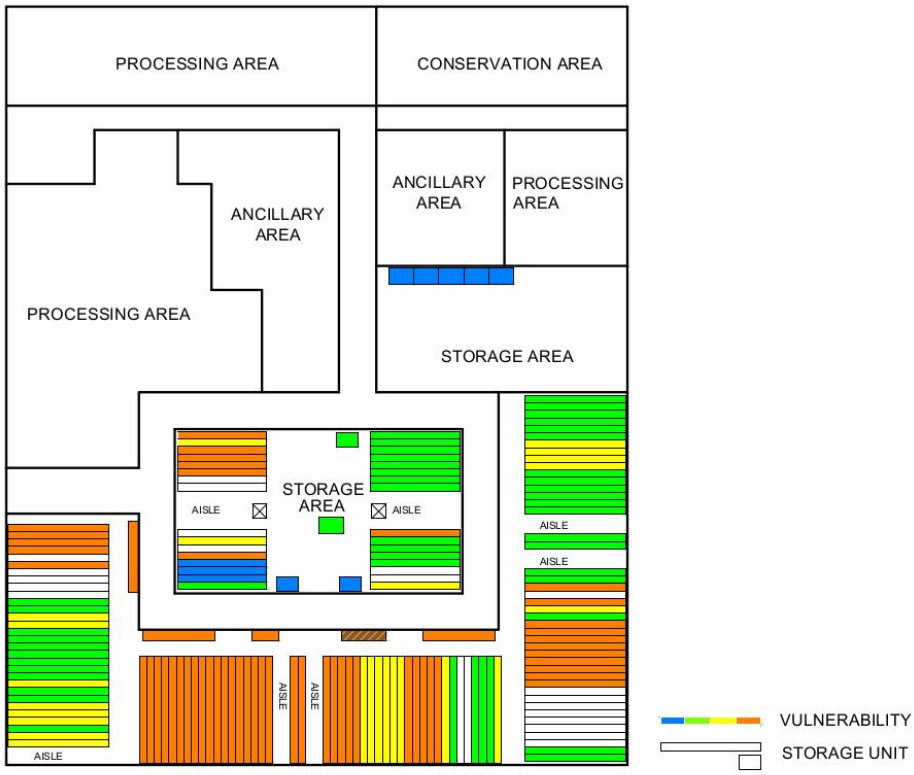

Image 15: Mapping of vulnerability

In the case of mixed collections, the percentage distribution of the types of material and protective enclosures was taken into account and an average vulnerability has been assigned. 43.7%, which represents nearly half of the material is characterized by low and 16.7% by medium vulnerability whereas 39.6% with higher vulnerability mainly concerns large size leather bound books of 19th century, placed directly on the shelf (image 16 & 17). But it is nonetheless of importance that the material of the highest sensitivity to water is found boxed and not exposed.

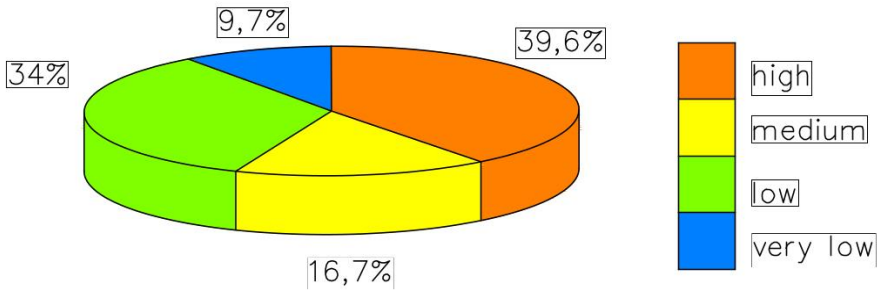

Image 16: Percentage distribution of vulnerability

Image 17: Leather bound books with no enclosures

Value

Looking for variations in the archival material, a structured and well reasoned comparative assessment of the value of records was executed.

The assessment drew on the knowledge and experience gathered and recorded in the archival tools used in all the operations carried out in the archival body, starting from the appraisal during acquisitions.

However, most of the material stored in the building level examined relates to the earliest evidence of the history of the Greek state and has been brought in as rescued, i.e. without selection because of its exceptional age and relation to specific historical events and persons. Newer archival material stored in the same area has been transferred from the creator agency after the clearance of files, according to the criteria defined by both Greek legislation and the acquisition policy of the archival body. But these criteria if explicitly expressed may change through years considering the trends of the archival thinking. And certainly they were only used to distinguish the material between what to acquire and what to dispose.

Value assessment, was in any case a new process for the purposes of our work that had to be supplemented with condition assessment, material technology and use of records.

However, in order to ensure an as far as well-defined, clear and interdisciplinary procedure, a tool was developed in collaboration with the head of the Reading Room and Library Department and responsible for the archival material in the areas of study, archivist Mrs. Amalia Pappa. This was a questionnaire of closed-ended questions that allows qualitative assessment through criteria, investigating how, why, for who is a collection important and incorporates opinions from different angles (image 18).

ARCHIVAL COLLECTION:	Assessor:	Date:

VALUE	ARCHIVAL							USE	PHYSICAL MATERIAL	
Criteria	Evidential	Informational	Integrity	Rarity	Historical	Social	Artistic	Direct/ Indirect	Condition	Technological characteristics
Comments										
Criteria score	L M H	L M H	L M H	L M H	L M H	L M H	L M H	L M H	L M H	L M H
Value score										
Total score										

Image 18: Questionnaire for collections value assessment

Examples of questionnaires in the context of collections assessment are found in studies intended for museums. The difficulty in this case lies in the particular nature of archival material; on the one hand, as evidence of the interaction of the citizen with the state following the institutional and social values, the tendencies and practices of the time and, on the other, as a tool for the protection and claiming of personal and collective rights.
Three areas of value were identified; the most significant being the archival value followed by the value associated with the use of collections and finally that associated with the physical material.
In order to examine how these values are determined, each of them is broken down into criteria of differing weight. For example archival value is defined by evidential, informational and archival integrity criteria pertinent to archival material, along with historical, social and rarity criteria. The most significant is considered to be the evidential criterion.
Use value includes both direct and indirect use of the collections as documented in the data collected by the Reading Room and Library Department as well as in the various collaborations with public, private, educational and scientific bodies. It is rated of lower importance in comparison to the archival value because of the inherent dimension of the latter, irrespective of the engagement of users.
The physical material is considered as a carrier of archival value and not much a value by itself as in museums. Similarly, condition is not a value but rather a value regulator.
For every archival collection these criteria were rated, accordingly, as low, medium or high, defining in this way, a total score for the archival, use and physical material values.
This 3-level scale corresponds to the degree of damage caused to the archival body by loss of value.
Difficulties were created by the many criteria of differing weight that resulted in a large number of possible combinations. In addition, value concepts seemed at times to overlap each other (for example, informational with historical or social value), creating a fluid situation. This complexity prompted often the assessors to instinctive judgments.
Collections constituted the assessment units.
Contrary to vulnerability, for value fluctuations within the same collection, the highest and not an average score was recorded, since any measures to be taken aim at protecting the most valuable material in priority.
Results showed that, more than half of the archival collections (57.6%) was rated high, the rest almost (41%) medium, while a very small (1.3%) low (image 19). This is explained by the fact that the most important material of the Central Service is being stored in the area under study.

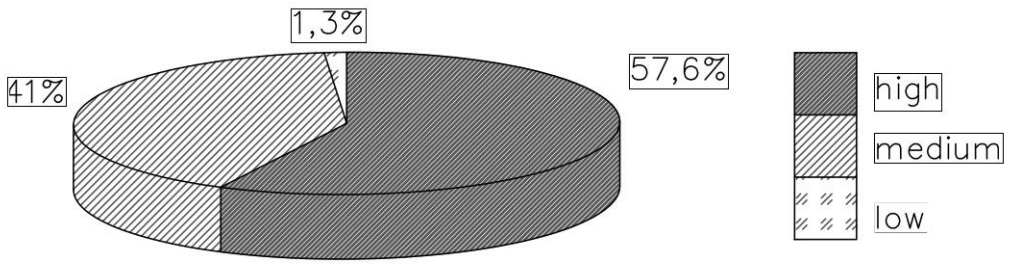

Image 19: Percentage distribution of collections value

In the value map the representation unit is the storage unit (image 20). If this contains more than one collection, the total value assigned is the highest recorded even for one small collection. Value scores were represented with line patterns to differentiate from the color scale used for vulnerability (image 21).

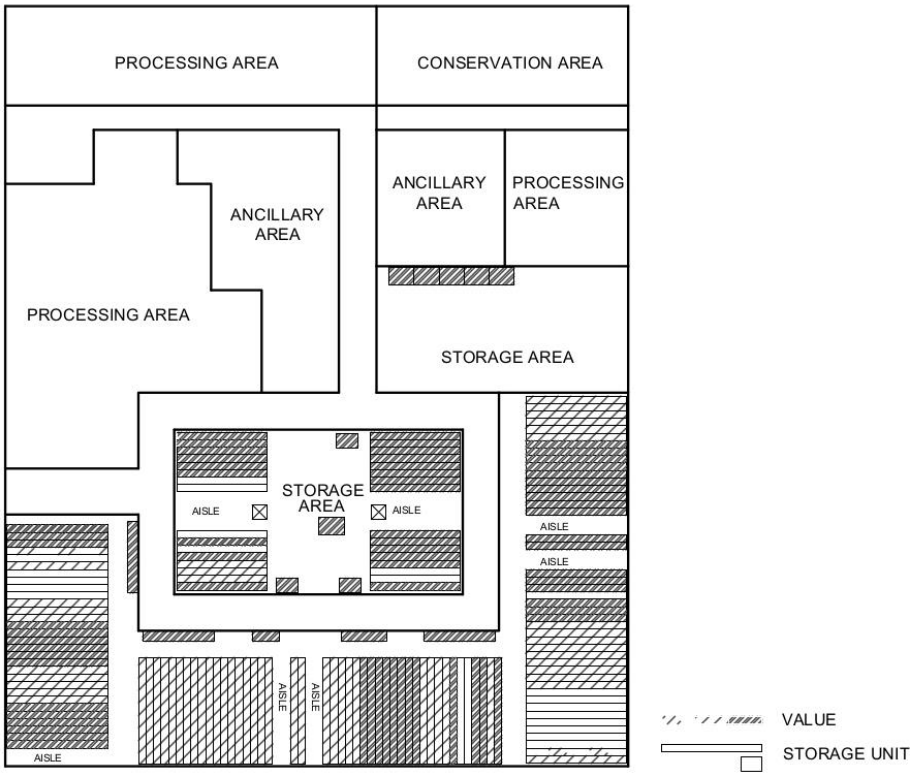

Image 20: Mapping of collections value

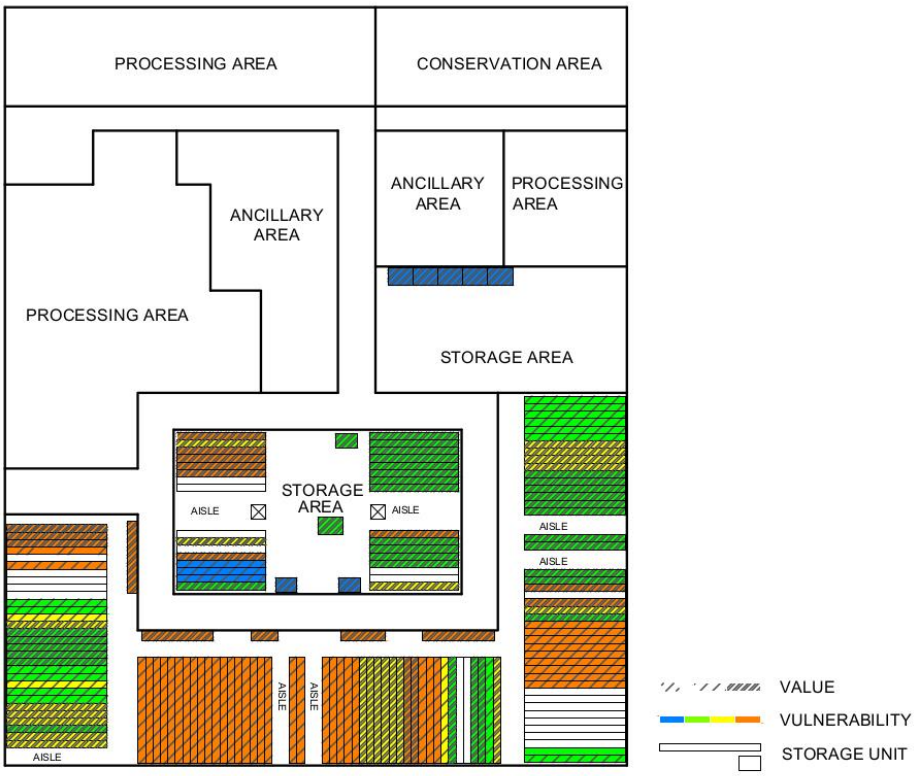

Image 21: Mapping of vulnerable value

Value was preferably not multiplied chromatically by vulnerability as in QuiskScan, because of the increased number of possible situations of the latter.

Discussion

The question is how maps could help us to delimit the zones of potential flood risks. And how could they help to design targeted measures to mitigate loss. The maps, in fact, can indicate the wider only zones where different and difficult to predict risk scenarios can take place (image 22).

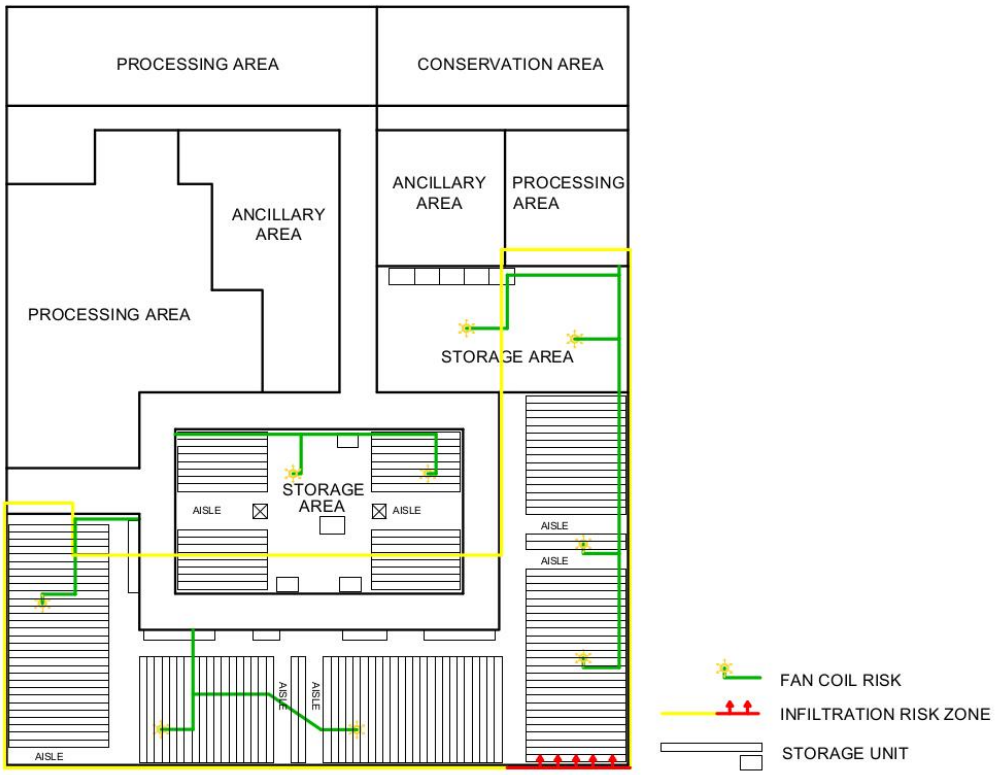

Image 22: Mapping of risk exposure in the storage rooms

In the case of water infiltration in the storage rooms, the water shows up on the inside western wall but the inflow mechanism remains unknown. Water may penetrate under the failed insulation of the roof terrace at any point exposed directly to the environment, following the inclination to the side walls. During heavier storms, as the climate changes, gutters may fail to drain water properly and generate new inflow mechanisms resulting progressively in leakage from the roof.

More than half of the total area of the storage rooms is located under the terrace but the exposure to risk is considered to diminish from the western wall inwards. The appropriate solution to addressing the problem would be the radical building reconstruction of the envelope in the areas affected.

If this is not the case, disaster planning comes to the fore.

Considering the medium risk exposure, the large extent of the risk zone, the size of the collections (over 50%) having the same medium vulnerable value[1] and the lack of vacant

[1] Either of high vulnerability and medium value or medium vulnerability and high value

space it would be rather out of place to discuss a major preventive reorganization of the collections on the shelves. However, it should be avoided that highly valued and vulnerable material is stored near the wall where water infiltration occurs.
Planning should focus rather on the response to a concrete flood event.
In accordance with the risk management principle ‘we cannot save it all’, we should try to save first the most valuable and/or sensitive material away from the affected areas. In the case of medium vulnerable value priority should be given to value.
With separate and distinctive labeling of priorities we ensure that these collections are easily identified within the entire risk zone (image 23). Because compact mobile shelving doesn’t allow direct view and access to the material, it is necessary that this information is displayed on the front side of the unit, which is visible from the main aisle (image 24). In a second step, labeling along the shelves is the best practice to mark collections assessed differently between each other, allowing salvage in priority.

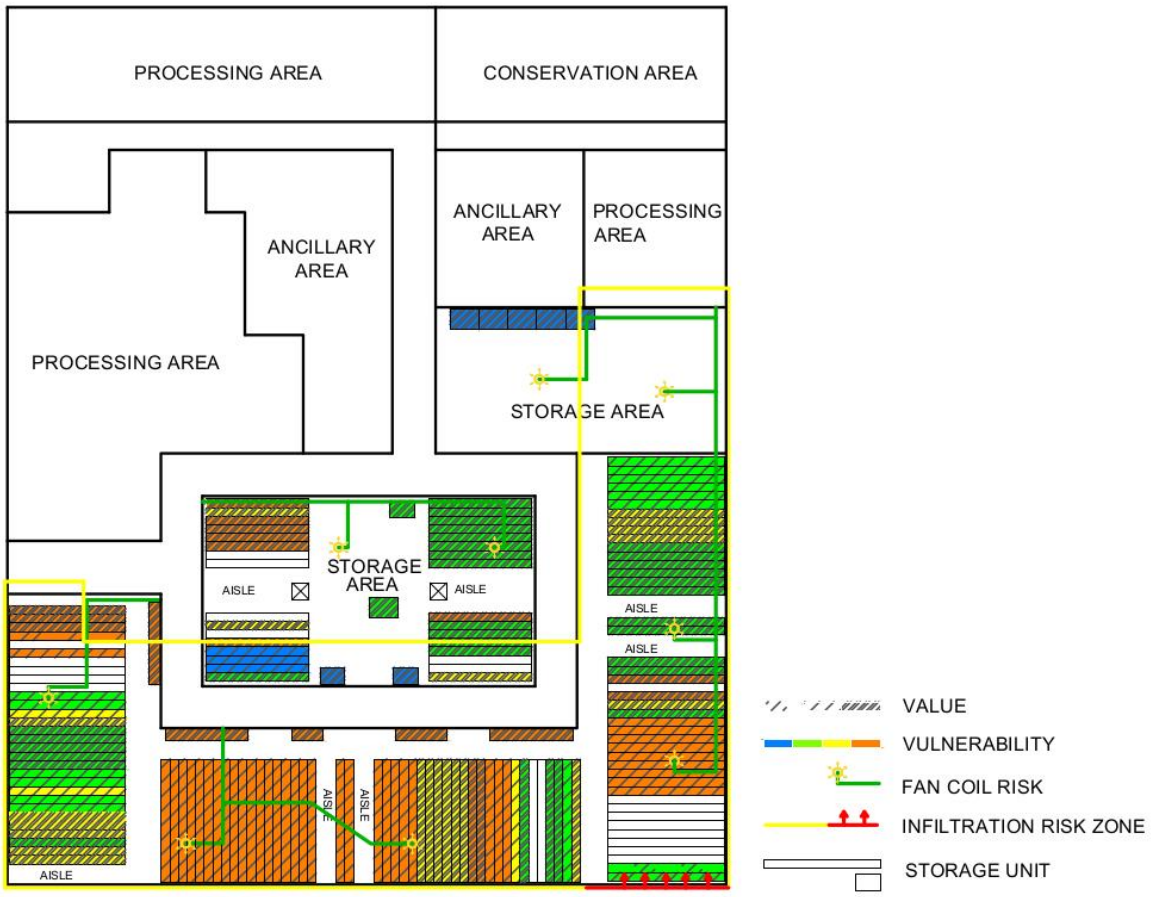

Image 23: Superimposing of the maps of risk exposure, collections value and vulnerability

Image 24: Labeling of units with vulnerable value

The risk from the fan coils (HVAC) units is assessed of secondary importance. In case of leakage it is difficult to predict the water flow pattern through the ceiling tiles to the storage units. In theory technical characteristics such as absorption and slight inclinations of the tiles may musk water leaks until they become significant and result in a delayed and not uniform flow of water.

In addition, the mobile shelving in contrast to a static one increases the range of possible affected units. The simplest scenario of a one-off leakage of two liters of water, for example, as it was the case in the past, wetting the ceiling over one square meter area, could roughly affect two out of six units that can be found under a unit, with a small amount of water. As long as this risk has been assessed as medium and considering the number of units, the reorganization of the collections on the shelves cannot be a first-line measure.

An alternative measure could be the scheduled monitoring of the ceiling by the personnel in charge of the material in the storage rooms. Marking of the fan coil unit locations on the ceiling is essential to facilitate inspections, since they are out of view (image 25). Mobile shelving offers the advantage to keep the aisle open where possible under the units, as a regular practice to avoid damage in an emergency (image 26). Well-trained employees can spot events ideally at the time they occur and take action so as they do not become problems for the archival material, thus minimizing if not eliminating risk.

Image 25: Marking the fan coil unit locations on the ceiling

Image 26: Marking the fan coil unit locations on the ceiling

Engagement of the staff is particularly important for the 64 Regional Services of GSA, struggling to cope with the operational and financial difficulties in aged buildings of no archival standards. In this direction, a start was made with a facility report questionnaire

addressed to the Regional Services to identify and monitor facilities. A training program should be established too, to deliver theoretical and practical content to encourage action in a common direction.

A variety of water detection systems compatible to machinery and equipment that are prone to leak is available on the market, but professional advice is needed. We must be careful because they are not recommended to be placed on the floor where the water would have first affected the archival material.
To improve the assessment procedure with more accurate descriptions, work must be done with collections of mixed material, for which average scores have been assigned. Where the composition remains unknown within the protective enclosures, a systematic survey of the content should be carried out and appropriate action designed. This has been already taking place for very important 17thand 19th century records, where vulnerable parchment or tracing paper and historic reproductions have been documented and physically detached from the collections for separate storage. Forthcoming projects concern photographic material often found among paper documents.
Risk analysis and assessment is being currently carried out for other building floor levels where not classified or newer material is stored, with an increased degree of uncertainty.
As a last remark, value assessment results are relevant for managing other risks as well as setting preservation and conservation priorities.

Conclusion

This project follows a period of financial distress and extreme difficulty to ensure a functional and secure building construction through an adequate degree of maintenance. Preparedness planning and action is meant to mitigate the effects of a flood risk while a complete restoration program cannot be yet commissioned.
The risk assessment methodology is an adaptation of the risk management models used in the field of cultural heritage considering the particular nature of the archival environment.
For collection assessment, definition of units followed the archival classification and was not based on material or chronological order, as it may be practiced in museums.
The project applied to rare and unique collections, which value ranges mainly between medium and high scores with few exceptions. The questionnaire provided a concrete framework for teamwork, rationalized in order for a complicated decision – making process to be performed.
Analyzing vulnerability based on the types of material and storage enclosure was deemed appropriate, especially when value assessment provided moderate fluctuations.
Because over the half of the collections found to be of the same vulnerable value, the exposure to risk plays a critical role for targeting areas of actions.
The actions proposed relate both to preparation and response against potential risks.
A range of options is argued, from the preventive reorganization to the labeling of the collections. Professional advice was indispensable; however this project would not be possible without the commitment and insistence of the staff.

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