

# FLOOD RESILIENCE

INTEGRATION IN THE LOCAL CONTEXT



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# INTRODUCTION



## Left

Figure 02:  
*North Sea  
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*How can elements of flood resilience strategies be integrated into the redesign of the former shipyard in Sliedrecht, focusing on compatibility with the local context?*

Flooding is a natural phenomenon that has always been a part of the natural hydrologic cycle, shaping landscapes and human settlements throughout history (Watson & Adams, 2010). In Dutch outer dike areas, where the proximity to the river creates a balance between economic development and safety, flooding is a significant challenge. Historically, these areas act as vital buffer spaces, to absorb excess water during periods of extreme water levels, reducing the risk of flooding in protected zones behind dikes. Despite the risk of flooding, outer dike areas are becoming increasingly attractive for human development. The proximity to water offers aesthetic and recreational benefits, while the need for urban expansion drives interest in these spaces for residential and commercial purposes, necessitating innovative and resilient architectural solutions for buildings in these areas.

The city of Sliedrecht, historically a significant place for shipbuilding along the Merwede River, is facing these challenges. This research will focus on the former Delta Shipyard, a representation of the city's industrial and maritime heritage.

The transformation of this building into a hotel presents a unique opportunity to explore how flood resilient design can coexist with cultural preservation and the local context.

Existing research, for example by Barsley (2020) or Proverbs and Lamond (2017), offers a lot of knowledge on these flood-resilient strategies, providing descriptions of the principles and technologies for each approach. However, while existing literature provides theoretical models of flood resilience strategies, there is a lack of research on how these strategies interact with the specific historical, functional and environmental characteristics of a site. For a project like the former shipyard in Sliedrecht, these considerations are crucial, as the site's unique conditions demand solutions that go beyond generic flood-resilient principles.

## Bottom

Figure 03:  
*The former  
Delta  
Shipyard.*  
(By author,  
2024)



Flood resilient strategies can be evaluated using a variety of criteria, such as cost-effectiveness, technical feasibility or long-term sustainability. However, this research narrows its focus to a single criterion: compatibility with the local context. This includes the shipyard's unique environmental conditions, its cultural and historical significance and its intended function as a public space. This localized approach ensures that the recommendations are both flood resilient and contextually appropriate for Sliedrecht.

First, an overview of flood resilient design strategies will be provided, delving into the different elements of flood resilient design. This will be followed by an analysis of the

local context of the former shipyard, considering its historical, environmental and functional characteristics. A comparative analysis of the flood resilient strategies for different opportunities and challenges following from the local context, offer insights into creating specific flood resilient designs. This will be followed by a conclusion and discussion to interpret the research findings and acknowledge any limitations encountered during this study, as well as their broader implications for flood resilience in similar redevelopment projects.

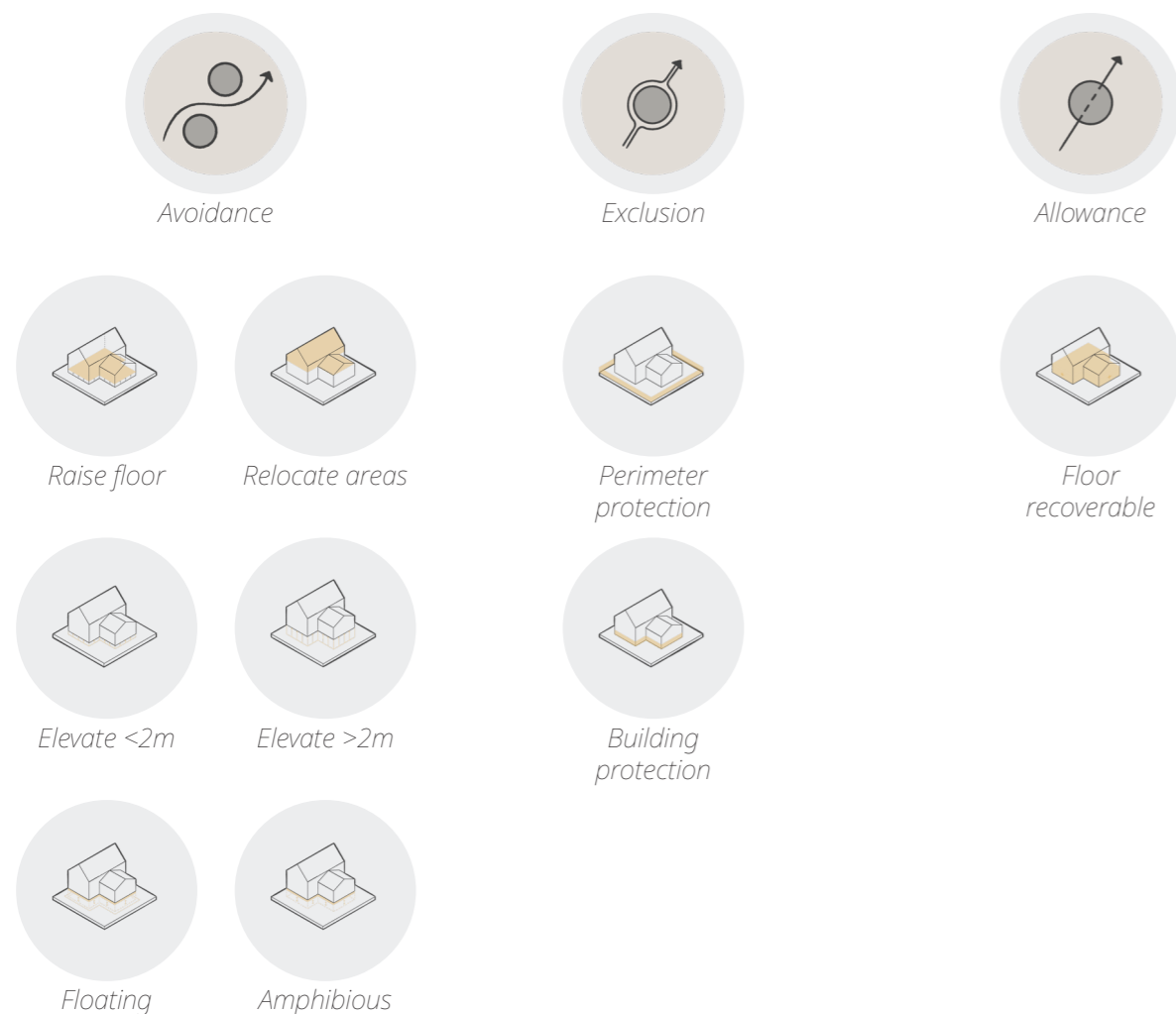
# FLOOD RESILIENCE STRATEGIES

Flood resilient design strategies aim to mitigate the risks and impacts of flooding on buildings, ensuring safety, functionality and sustainability in vulnerable areas. These strategies generally fall into three main categories:

1. Avoidance;
2. Exclusion;
3. Allowance.

(Barsley, 2020; see also Proverbs & Lamond, 2017; STOWA, 2014).

Each offers a distinct method for addressing flood risks, and elements of all three can be combined to create solutions for specific contexts.



**Left**  
Figure 04  
Flood  
resilience  
strategies.  
(By author,  
2025)

## 1

### AVOIDANCE

The avoidance strategy focuses on preventing water from reaching a building by either selecting locations less prone to flooding or physically elevating the structure (see figure 2). It is widely regarded as the most effective method for flood resilience, as it eliminates or minimizes direct contact with floodwater (Proverbs & Lamond, 2017). For existing buildings, avoidance strategies often involve retrofitting measures such as raising the ground floor or relocating essential functions to higher levels. The lower floors can be repurposed for non-essential functions, such as storage or parking, to minimize the risk of damage (Barsley, 2020).

## 2

### EXCLUSION

The exclusion strategy, also referred to as dry-proofing, aims to prevent floodwaters from entering a building. It relies on a combination of barriers and water-resistant materials to maintain a dry interior (see figure 2). For individual structures, exclusion measures focus on waterproofing the building envelope. This includes sealing walls and foundations with impermeable materials, as well as installing flood-resistant doors, windows and vents. Temporary solutions, such as flood panels or sandbags can also be used to reinforce vulnerable openings during flood events. A key consideration in the exclusion strategy is a comprehensive and holistic design. Even small vulnerabilities, such as unsealed air bricks or ventilation openings, can compromise the system's effectiveness (Barsley, 2020).

## 3

### ALLOWANCE

The allowance strategy, or wet-proofing, accepts that water may enter a building during extreme floods and focuses on minimizing the resulting damage and disruption. This approach prioritizes resilience and recoverability, enabling buildings to return to normal functionality as quickly and economically as possible after a flood (Proverbs & Lamond, 2017). This strategy involves careful planning of the building's layout, materiality and mechanical systems. Vulnerable items, such as electrical systems and valuable possessions, are positioned above potential flood levels. Water-resistant or sacrificial materials are used for walls, floors and furnishings to limit the extent of damage (Barsley, 2020). Historically, wet-proofing was a common practice in flood-prone regions, where simpler buildings could withstand occasional flooding with minimal disruption. However, in modern times the increased complexity and value of buildings have made this approach less common (Proverbs & Lamond, 2017). Nevertheless, the allowance strategy is still a viable option, particularly for structures that cannot be completely sealed or elevated. By combining traditional principles with modern innovations, wet-proofing can provide a practical and cost-effective solution for flood resilience.

# LOCAL CONTEXT

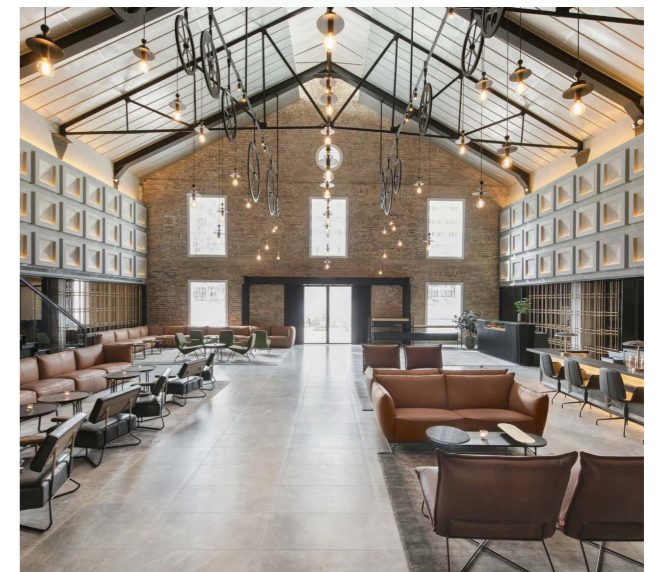
Understanding the local context of the former shipyard in Sliedrecht is essential to ensure that flood resilience strategies align with the site's historical and cultural, functional and environmental characteristics. The transformation of this industrial site into a hotel presents an opportunity to balance preservation, functionality and flood protection. This chapter examines the historical and cultural significance, the functional requirements and the environmental conditions of the site to establish a foundation for integrating appropriate flood resilience strategies.



## FUNCTIONAL CONTEXT

The former Delta Shipyard historically served as a shipbuilding site. Established around 1936, it gradually expanded into a complex of manufacturing halls, cranes and storage areas. Today, only remnants of this industrial site remain, including a covered slipway and two adjacent manufacturing halls, which bear witness to its industrial and maritime heritage. The site's transformation into a business hotel with a conference center represents a significant functional shift, requiring an adaptive reuse of the former industrial structures. The hotel will serve primarily to business travelers and professional events, making efficient space utilization, accessibility and modern amenities important considerations in the design. The conference center will serve as the core of the hotel's business oriented function, providing meeting rooms, an event space and networking areas. The hotel's restaurant will complement this function by offering high-quality dining experiences for both hotel guests and external visitors. The guest rooms must provide private, comfortable environments that remain dry at all times, requiring careful placement within the

site. Public areas, such as a lobby, restaurant and event spaces, can take advantage of the shipyard's expansive interiors, allowing for open, flexible layouts that embrace the site's industrial character. High ceilings, exposed structural elements and large windows could highlight the building's original character, while creating a unique guest experience. The riverfront setting offers opportunities for outdoor seating, recreational activities and scenic views. These features must be integrated with the flood resilience strategies, ensuring that key areas remain accessible and protected.



**Left**  
Figure 05:  
*Aerial view  
of the Delta  
Shipyard.*  
(Google Earth,  
2024)

**Top**  
Figure 06:  
*The  
Warehouse  
Hotel.*  
(Zarch, 2016)



**Left**

Figure 07:  
*Scheepwerf van Bienenkum. Historische Vereniging Slierecht, n.d.*

**From top to bottom**

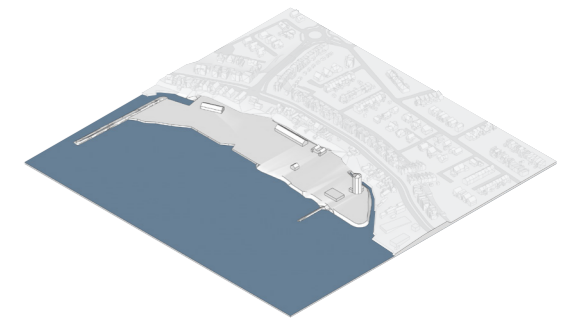
Figure 08:  
*History of the Delta Shipyard (By author, 2024)*

**HISTORICAL AND CULTURAL CONTEXT**

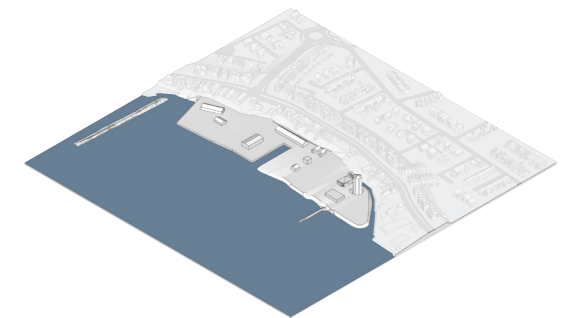
Historic shipyard buildings are important to the maritime heritage, reflecting the evolution of shipbuilding techniques over the centuries. This typology often consists of large assembly halls, dry docks and workshops. In the Netherlands, shipbuilding was important for the country's dominance in global trade and naval power. The Delta Shipyard is part of this tradition, reflecting the region's shipbuilding heritage. The shipyard contributed in the construction of tugboats for the Royal Dutch Navy, commissioned between 1987 and 1997 (Karremann, 2016).

The architectural typology of shipyard buildings has evolved significantly over time. Early shipyards featured open slipways and simple wooden structures, but the industrial revolution introduced iron and steel frameworks, enabling the construction of larger covered assembly halls and slipways. This shift allowed for year-round ship production and provided better protection for materials and workers. A notable characteristic of shipyard evolution is their increasing scale, due to the growing size of ships (Hetteema & Egberts, 2019). The Delta Shipyard's covered slipway and manufacturing halls are examples of this industrial typology, with their large, open spaces designed to accommodate the assembly of ships.

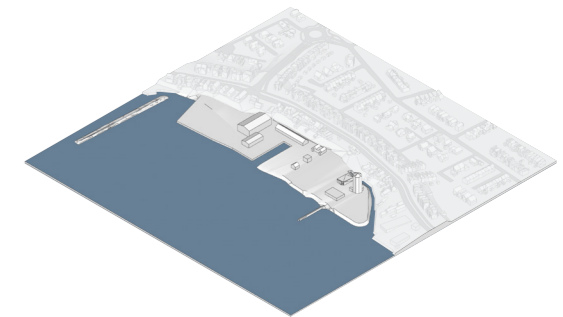
The preservation and repurposing of historic shipyards are increasingly recognized as crucial for maintaining maritime heritage. Adaptive reuse projects, such as the Kromhout Shipyard in Amsterdam, which was transformed into a museum, demonstrate how these industrial sites can be revitalized while honoring their history (Hetteema & Egberts, 2019). By integrating flood resilience measures in a way that respects the shipyard's industrial character, the hotel can maintain its historical identity, while ensuring long-term viability.



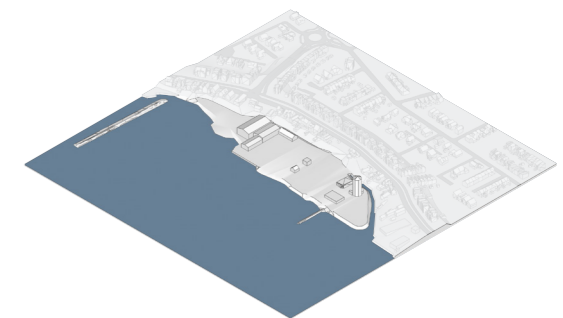
1950



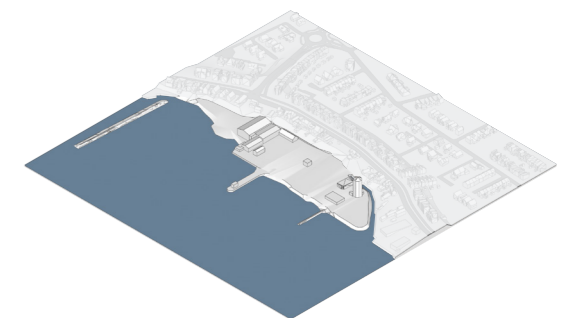
1960



1970



1980

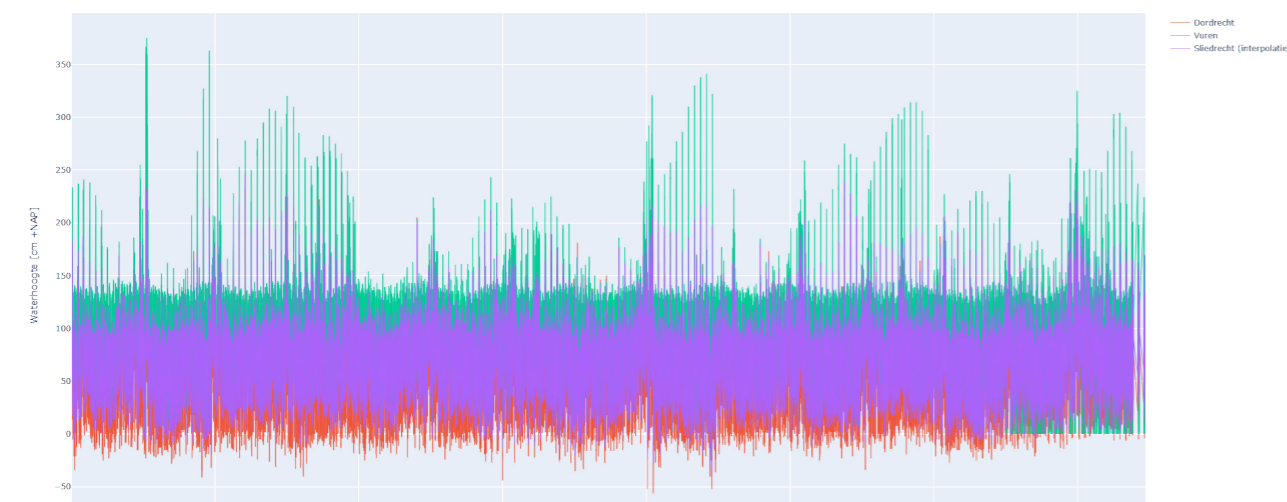


1990

## ENVIRONMENTAL CONTEXT

The environmental context of the former Delta Shipyard plays a crucial role in determining appropriate flood resilience measures. Unlike areas protected by primary dikes, outer dike locations, such as the site of the Delta Shipyard, experience a direct connection to the river, making them more exposed to fluctuation in water levels and potential flooding. Monitoring data from nearby stations in Dordrecht and Vuren, indicate that over the past 15 years, the average water level at the site has been approximately +0.66 meters above NAP, with a recorded maximum of +2.47 meters NAP (Rijkswaterstaat, 2024). The site's current elevation is +2.70 meters NAP, providing some natural protection. There have not been recorded instances flooding during this period.

Future predictions indicate that water levels could rise. For design purposes, a potential maximum water level of +3.10 meters NAP, with a potential further rise of +0.55 meters over the coming decades, leading to a worst-case scenario of +3.65 meters above NAP are estimated (AA-planadvies, 2023). This would



**Right**  
Figure 09:  
Flood risk 2050.  
(Stichting Climate  
Adaptation  
Services, n.d.)

result in 95 cm of flooding above the current ground level. However, probability assessments categorize the risk of such a significant flood as very low:

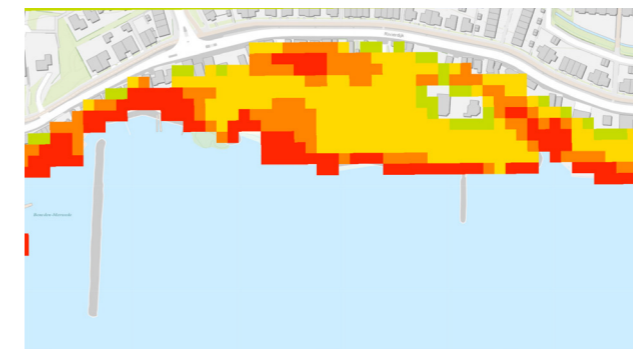
- 20 cm flood depth: The flood risk ranges from moderate (1/30 to 1/300 years) in areas closest to the river to very small (1/3.000 to 1/30.000 years) near the back of the site.

- 50 cm flood depth: The flood risk ranges from a very small risk to no risk.

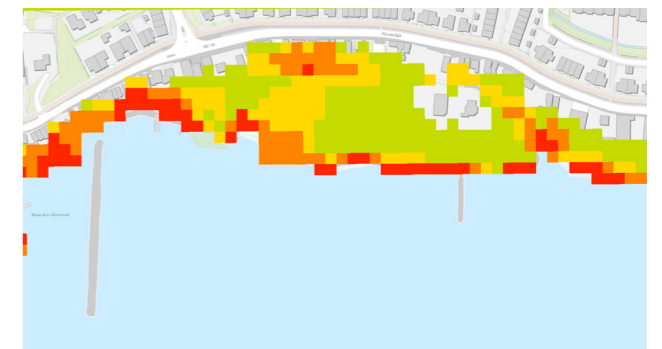
- 200 cm flood depth: There is no flood risk for this depth.  
(Stichting Climate Adapatation Services, n.d.)

These classifications indicate that while shallow flooding is possible, a major flood exceeding 1 meter is virtually non-existent and even smaller flood depths have a low probability. Given this risk profile, the redevelopment does not need extreme flood defenses, but rather practical, small-scale adaptive measures.

**Bottom**  
Figure 10:  
Water levels Merwede.  
(Rijkswaterstaat, 2024)



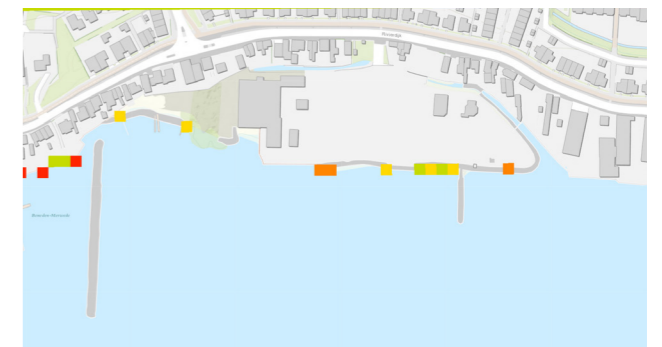
Flood risk 1cm



Flood risk 20cm



Flood risk 50cm



Flood risk 200cm



Based on this analysis, the following challenges and opportunities have been found:

I. The hotel's key spaces such as guest rooms and technical areas must remain dry at all times. Any flooding that affects these areas could cause significant damage to both guest belongings and crucial equipment.

II. Given the low likelihood of flooding, it's not essential for the hotel to remain fully operational during a flood event. Non-essential areas, such as the lobby, meeting rooms and event spaces can tolerate some water exposure without major consequences.

III. As the redevelopment involves a historic

building, it is vital to preserve important heritage elements during a flood. This includes the original steel structure, the large sliding door, the overhead crane and the slipway.

IV. The historic steel structure may not have been designed to endure flooding, raising concerns about its durability under such conditions.

V. The challenge lies in balancing the preservation of the shipyard's historic character with the need for flood adaptation measures, ensuring that flood resilience strategies do not compromise the site's industrial aesthetic.

# COMPARATIVE ANALYSIS

In this section, the key challenges and opportunities identified in the local context of the former Delta Shipyard are analyzed in relation to the three main flood resilience strategies: avoidance, exclusion and allowance. Each strategy offers its own distinct approach to mitigating flood risks, but their applicability varies depending on the specific needs and constraints of the site. This analysis will examine the compatibility of these strategies with the unique functional, historical and environmental characteristics of the shipyard, highlighting which strategies are most suitable, which may be excessive and where compromises might be necessary to maintain both flood resilience and preserve the buildings character.

## I

### GUEST ROOMS AND TECHNICAL SPACES MUST REMAIN DRY

**Avoidance:** This strategy can be very effective for guest rooms and technical spaces. Elevating these areas above predicted flood levels or relocating critical functions to higher floors could prevent water exposure. This approach is ideal for ensuring the rooms and technical spaces remain dry, especially considering their importance to the hotel's functionality.

**Exclusion:** Using exclusion techniques like waterproofing the floors and walls of these spaces could also be effective. In a historic building, this could pose some challenges, however, as the former shipyard consists of large halls, the key spaces will be newly constructed, giving the opportunity to waterproof them. However, this could be a disruptive and expensive approach.

**Allowance:** This strategy is not appropriate here, since these spaces must remain dry for both operational and safety reasons. Water intrusion into guest rooms or technical areas could lead to significant damage.

## II

### NON-ESSENTIAL SPACES CAN TOLERATE SOME WATER EXPOSURE

**Avoidance:** Although it is possible to elevate these spaces, it may not be feasible as it could

disrupt the design and aesthetics of the space, or necessary, as it does not pose a large problem if water enters these spaces. This approach therefore is not ideal for these non-essential spaces.

**Exclusion:** Flood proofing these areas by waterproofing the walls and the use of barriers in these spaces could be an option. However, the temporary nature of the flood risk (only shallow flooding) makes this approach excessive for these spaces, where the flood depth and resulting damage would be minimal.

**Allowance:** This could be the most appropriate strategy for non-essential areas. Allowing water to enter these spaces and using flood-resistant materials like sacrificial or flood proof walls and floors would minimize the damage and facilitate easy recovery. Since the flood risk here is low, this approach is a good fit.

## III

### HISTORIC ELEMENTS MUST BE PRESERVED DURING A FLOOD

**Avoidance:** Elevating or relocating historical elements, like the large sliding door, the overhead crane or the slipway, is impractical, as it would significantly impact the building's authenticity.

**Exclusion:** Protective measures like waterproof coatings or barriers around key heritage features could work well to protect the historic elements. This would ensure that the elements stay dry without altering the building's character. However, the use of barriers may impact the building's aesthetic.

**Allowance:** Allowing water to enter specific non-critical historic elements could be viable, but this could lead to the deterioration of the materials over time. It is not an ideal solution for preserving valuable historic features in the long term. A consideration is the type of historic element. For example, the concrete slipway can really well withstand an occasional flood without compromising its historic value.

historic aesthetic.

**Exclusion:** The use of exclusion techniques, such as flood barriers or waterproofing, could potentially be integrated into the redesign of the building, in a way that maintains its industrial aesthetic. The implementation of such measures would require careful planning to avoid disruptive, overly visible interventions that clash with the building's character.

**Allowance:** Allowing water to enter certain areas can be done in a way that supports the aesthetic by using materials and design that are compatible with the industrial look. For example, the use of steel or concrete materials that can tolerate flooding would align with the building's original character, while providing functional flood resilience.

## IV

### THE HISTORIC STEEL STRUCTURE MAY NOT WITHSTAND A FLOOD EVENT

**Avoidance:** Elevating or reinforcing the steel structure could be an option, but it would require a significant intervention in the historic building and may not be practical without compromising the architectural heritage.

**Exclusion:** The steel structure could potentially be protected from corrosion through exclusion measures such as applying corrosion resistant coatings or using flood barriers around vulnerable parts of the structure. This would help mitigate any long term damage from flooding.

**Allowance:** Allowance measures may be suitable here, if the structure is already protected against corrosion. Another important consideration is the depth and longevity of the flood. In this case, flood events are not likely to happen and do not have a significant depth or time. Therefore, it can be possible to allow the water to reach the structure.

## V

### BALANCING FLOOD RESILIENCE WITH PRESERVATION

**Avoidance:** Elevation of flood-prone areas may clash with the original industrial aesthetic, especially if it results in visible structural changes. This strategy, when applied in a large manner, might not be compatible with maintaining the original appearance and industrial character of the site. It can be done incidentally with some functions, without compromising the original



## FLOOD RESILIENCE APPLIED

Based on the comparative analysis of flood resilience strategies for the key challenges and opportunities within the local context of the former Delta Shipyard, an application of the best strategies has been chosen. Given the site's low probability of severe flooding, the selected measures focus on practicality and minimal intervention, while respecting the buildings historic character.

Guest rooms and technical spaces require the highest level of protection, as damage to these areas would lead to significant disruptions and personal or financial losses. To ensure these spaces remain dry, they will be placed at an elevated level where possible. When elevation is not possible, exclusion measures will be implemented. This includes the use of water-resistant materials such as concrete for the lower sections of walls, a sealed flooring and waterproof doors or the possibility to add flood barriers at openings. Non-essential spaces, such as the lobby, meeting rooms and event areas will be using the allowance strategy. These spaces will be designed to withstand occasional shallow flooding with minimal

damage. Materials that resist water exposure, such as concrete, corrosion resistant metals and water resistant finishes will be used. The steel structure of the former shipyard is an essential historic feature. Given the expected flood conditions, a shallow and temporary event, the structure is unlikely to suffer major damage. However, protective coatings can be applied in the lower sections to prevent corrosion.

All interventions will be designed with sensitivity to the shipyard's industrial aesthetic. Many historic elements, such as the overhead crane or the large sliding door are already positioned above the water level and are therefore using the avoidance strategy. The slipway was designed for water exposure and is inherently flood-resilient and requires no intervention. By applying these strategies, the redevelopment of the former Delta Shipyard will achieve a balance between flood resilience, functionality and heritage preservation, with a careful consideration of the local context.

## CONCLUSION

In addressing the challenge of integrating flood resilient strategies into the redevelopment of the former Delta Shipyard in Sliedrecht, this research has focused on achieving compatibility with the local context. It has explored the historical, functional and environmental context of the site to propose a balanced approach that ensures flood resilience while preserving the shipyard's industrial heritage.

The research identified three primary flood resilience strategies: avoidance, exclusion and allowance. It demonstrated that a combination of the three strategies could lead to a holistic approach that could effectively address the unique challenges posed by the site's location in an outer dike area. Elevating critical spaces, such as guest rooms and technical spaces, waterproofing key historical elements and incorporating water resistant materials for non-essential areas allow for a comprehensive and context-aware flood resilience plan. This approach not only protects the hotel from potential flood damage, but also respects the site's maritime, industrial heritage. The findings contribute to the redesign of the former shipyard, as well as to the broader understanding of adaptive reuse in flood-prone areas and offer valuable insights for similar heritage sites worldwide.

### Left

Figure 11:  
*Property flood resilience.*  
(CIWEM,  
2024)

## DISCUSSION

This research highlights several strengths and limitations that ask for further exploration. One of the strengths is the holistic approach that integrates multiple flood resilience strategies. The focus on the local context allowed for applicable solutions, that address the specific environmental, functional and historical conditions of this site.

However, the research also faced limitations. The analysis relied on historical data and flood projections, which inherently carry some degree of uncertainty. Additionally, the balance between flood resilience and heritage preservation required careful design decisions that may not be universally applicable to other sites. Future research could benefit from real world testing of the proposed strategies and the incorporation of more advanced flood modeling techniques to enhance the accuracy. Opportunities for further research includes the exploration of other criteria, for example the economic implication of flood resilient adaptations in industrial heritage sites and the long term maintenance requirements of different approaches. Moreover, the strategies developed for the Delta Shipyard could serve as a case study for other industrial heritage sites facing similar flood risk challenges. By refining these strategies and adapting them to different contexts, with different flood risks and implications of a flood, architects can create more resilient and sustainable built environments that preserve industrial heritage while mitigating flood risks.

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