

**Project review: Floating Homes 'De Gouden Kust'**  
Maasbommel, the Netherlands, 1998-2005



February 2011  
Boiten raadgevende ingenieurs bv  
Factor Architecten bv

**Contents**

- Introduction 3
- 1. Building experiments adapted to flood risks (EMAB) 4
- 2. The Maasbommel project 6
  - 2.1 Initial project brief 6
  - 2.2 The foundation: floating concrete hulls 7
  - 2.3 The amphibious home concept 8
  - 2.4 Orderly rise and descent 8
  - 2.5 Architecture and engineering 9
  - 2.6 Water, sewage, electricity and gas 10
  - 2.7 Infrastructure 10
  - 2.8 Further safety measures 10
- 3. Evaluation 12
  - 3.1 Normal floating conditions 12
  - 3.2 Flood conditions 12
  - 3.3 Future projects 14



Aerial view of the project, 2005. (image: maps.google.com)



## Introduction

Through the ages the Dutch have learned to cope with flood risks. Two thirds of the country would regularly be flooded if there were no dykes. For centuries they fought the water, building higher dykes and closing off rivers from the sea. After a huge storm surge in 1916 the Zuiderzee was closed off from the North Sea, and after the disastrous flood of 1953 the closure of the Schelde, Maas and Waal delta started.

In 1993 and 1995 the Dutch were once again confronted with the risks of living in a low country with big rivers. This time the water did not come from the sea. Rainfall and melting snow throughout Europe caused the water levels of the rivers Maas, Waal and Rhine to rise. The flood led to the evacuation of 200.000 people. The reinforcement of dykes started right after the flood, but a new measure was instated as well: from that moment on the government program 'Ruimte voor de rivier' (Space for the river) would focus on widening river beds, removing obstacles and instating flood areas where water could be temporarily stored.

This new way of dealing with the rivers has had huge consequences for the spatial planning of the country. These spatial planning matters, combined with the increasing awareness of a future where sea levels could rise, more rain could fall and a sustainable development is necessary, lead to many interesting studies and experiments. In 1998 Dura Vermeer, Boiten raadgevende ingenieurs and Factor Architecten started with the design of 14 floating and 32 amphibious houses near the river Maas in Maasbommel. On 12 January 2011 the houses could prove their special abilities for the first time: as the river flooded all 46 of them were afloat. The amphibious houses returned safely on the ground a few days later.



In blue the part of the Netherlands at risk of flooding. (image: KNMI)



The river Maas when flooded in 1995. (image: heemkunderavenstein.nl)

## 1. Building experiments adapted to flood risks

In 2005, just after the floating and amphibious houses in Maasbommel were built, the Dutch ministries of Traffic and Water Management and Housing, Spatial development and Environment introduced 15 locations for experiments with building adapted to flood risks, the so called EMAB-locations. Maasbommel, set as an example, was one of these locations.

There were a number of reasons for instating this possibility for project development experiments:

- Because the 'Ruimte voor de rivier' (Space for the river) program blocked desirable spatial development in certain areas.
- The experiments could ensure an improvement of quality in locations like derelict brick factories, obsolete recreation areas or urban redevelopment zones.
- Because of the requirement to increase the amount of water storage near the locations (in such way that net flood levels would fall due to the project) the safety of surrounding areas is increased.
- It is easier to create extra space for water, if this space could be used for other causes (like building houses) at the same time: double land use.

The preconditions which from then on allow to build in the riverbed are rather clear:

- Only 15 designated locations, throughout the country, can be used. These locations have been nominated by regional and local governments.
- Each project should result in a net fall in flood levels in the area.
- The buildings must be flood-resilient: they must be safe to use at all times.

One of the ways to ensure the safety is by developing buildings that will adapt to any flood in simplest way possible: making them float. It's a principle as old as Noah's Ark, but still not commonly used for buildings. The possibility to build floating or amphibious homes in the 15 experimental locations could change this.

The outcome of the experiments will set an example for the future. They will illustrate how we can adapt our buildings to rising sea levels and increasing rainfall caused by climate change and a lack of land to build on, while still respecting the space our rivers need.



Map showing water storage locations on the rivers Rhine, Waal and IJssel. (image: 'Ruimte voor de rivier', ministry of VROM)



The 15 EMAB building locations. (image: '15 experimenten met bouwen in het rivierbed', ministry of VROM / ministry of VWS)

## 2. The Maasbommel project

### 2.1 Initial project brief

Because of dyke reinforcements in 1998, a camping site in Maasbommel had to be removed. To limit the amount of economic loss (and thereby the cost of financial compensation of the owner), Rijkswaterstaat (the Dutch government organization for Public Works and Water Management) asked Boiten engineers to investigate possible uses of the location after the reinforcements. Though little land was left, Boiten found that there would still be space for houses, as long as they could be safe in case of floods. To optimize the use of the land left, a plan was created for amphibious houses with gardens and parking places for the strip of land left and floating homes further north. Because floating and amphibious houses adapt to the water level in case of floods, they will never hinder the capacity for water storage in the area. This was the main reason for Rijkswaterstaat to agree with this concept.

The architecture and engineering of the houses was provided by Factor Architecten and contractor and project developer Dura Vermeer built the project. In December 2005, when the project was finished, it would feature as one of the prime examples in the new government campaign on building experiments adapted to flood risks (EMAB).



Trailer at Maasbommel camping site, 1993.  
(image: goudenkust.nl)



Government campaign on building experiments adapted to flood risks, 2005.  
(image: '15 experimenten met bouwen in het rivierbed', ministry of VROM / ministry of VWS)



## 2.2 The foundation: floating concrete hulls

The basis for all floating objects is Archimedes' law: any floating object displaces its own weight of fluid. So a floating home weighting 100 tons displaces 100 cubic meters of water, or easier said: the part of the floating home below water level will be 100 cubic meters.

The most common way to achieve this is making a hull and building a light weight house on top of it. This is the principle used in most houseboats: a steel or concrete hull is used as the basis to build a house on. In this case most of the mass is in the hull, which gives the houseboat or floating home it's necessary stability.

Of course for a series of houses a ship-like steel hull is not that easy to build. A concrete hull, like a basement shaped to support a wooden house, would be more suitable. This concrete would be watertight as long as it is more than 20 centimeters thick. In the Maasbommel project 23 centimeter thick concrete hulls, weighting over 70 tons, were prefabricated on site, then hoisted into the water, moved to their location, put in place, and after that the wooden houses could be build on top.



Prefabrication of concrete hulls on site.



A concrete hull is hoisted from the water into the dock of a amphibious home.

### 2.3 The amphibious home concept

As said, the Maasbommel project features two different types of houses. Fourteen houses are floating in water permanently. The other 32, under normal circumstances, rest on a concrete foundation in a dock dug out of the talus of the dyke. They are so called 'amphibious', they will adapt to the situation, and start floating as soon as the water level rises.

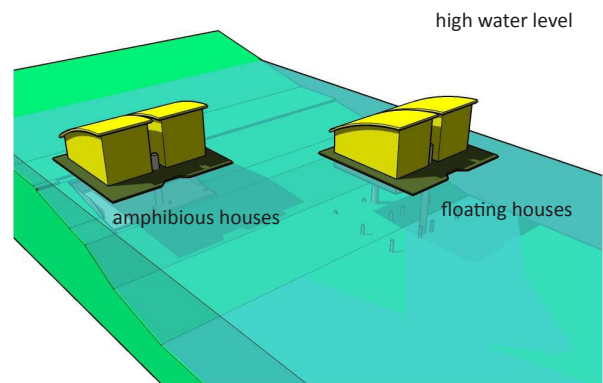
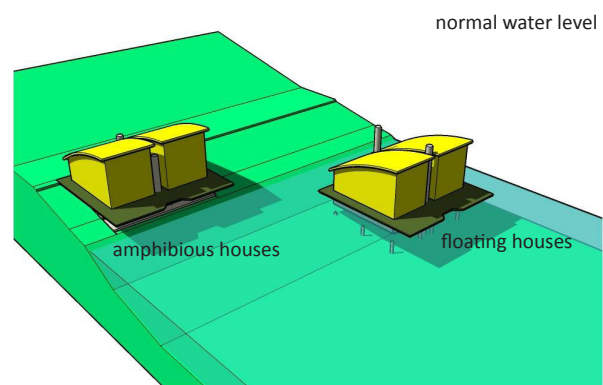
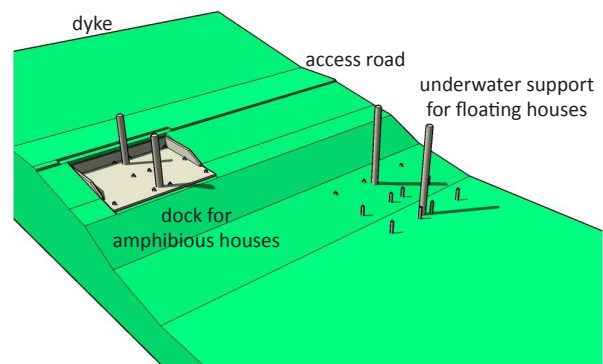
An advantage of these amphibious houses is that they are more or less the ordinary home, including a garden, access from the road and a parking place. Also the inhabitants will only feel that their house is floating when the area floods. In Maasbommel these floods, with water levels above 7 meters + NAP, occur on average once every twelve years.

### 2.4 Orderly rise and descent

Each pair of two houses is kept in place by two mooring pylons. These steel columns have been driven deep into the ground and extend up to twelve meters above NAP level. Even in case of extreme floods flowing over the dyke, the houses will be kept in place and will be able to withstand currents you would find on open seas. To keep both houses that share the set of mooring pylons stable they are connected by a steel framework. The fact that the houses are connected also limits the influence of waves on the structure, as the two houses together weight over 200 tons.

The concrete hull of an amphibious house rests on six concrete foundation piles. The same six piles are used to give a level basis for the floating homes at extremely low water levels. As water rises the houses will slide up along the mooring pylons. The amphibious houses will be lifted out of their docks, that will fill up with water.

To ensure an orderly descent after a flood, the docks and their surroundings need to be kept free of any obstacles at all time. If anything got stuck underneath a house as the water withdraws, this could hinder a level touchdown. The maintenance instructions provided with the project should ensure the attention of the owners and the estate manager for this matter.





## 2.5 Architecture and engineering

The basis of the architecture and building engineering of the houses was to build a light weight structure on top of the concrete boxes. In this way the centre of gravity is kept as low as possible, ensuring maximum stability of the house while afloat. The basic timber frame structure, identical for all the houses, was prefabricated in the Czech Republic, and then transported to Maasbommel to be assembled on site. The roof, made out of steel and wood and covered with PVC-roofing, was build on site and then hoisted on top of the houses.

The houses are designed based on the view of the water and the landscape: the arched roofs are low on the side of the dyke, rising towards the east, where the living room and master bedroom look out over the lakes north of the river Maas. To emphasize the individual expression of the houses different colours are used, while a variety of materials (wood, Trespa HPL panelling and stucco) forms a composition in each façade.

The distribution of weight over the concrete hull was calculated, to ensure a level position in the water. Because about 70% of the entire weight is in the concrete itself and another 25% in fixed parts of the construction, balancing the house proved not to be necessary. While the house weights 97 tons, the average interior, including inhabitants, is only 4 tons.



## 2.6 Water, sewage, electricity and gas

The basic facilities of the house hardly differ from those in ordinary houses in the Netherlands. The house is heated by a central heating system on natural gas, equipped with radiators. It has connections to the water, sewage, electricity and gas networks like any other house would have. The difference is in the connection of those facilities between the house and the pipelines on land. Boiten engineered an ingenious connection system, as illustrated below, that connects the amphibious houses. Between each pair of houses there is connection from the bottom of the dock to the side of the house. The length of this connection is oversized for ordinary conditions, but long enough to remain connected when the water rises. The floating houses are connected with the same type of flexible pipelines, but for these houses a main line is situated underneath the floating pier that leads to the houses.

## 2.7 Infrastructure

The amphibious houses are accessed by a road, running along the dyke at 7,4m above NAP level. A floating pier connects the floating homes to the same road. Though all facilities (electricity connections, sewage pumps, etc.) have been placed above flood level, the road itself is no longer accessible in case of a flood. When the amphibious houses start to float, once every twelve years on average, the road will flood and inhabitants will have to use a boat to get to the houses. In case of emergencies, fire fighters and ambulance personnel will not be hindered by a small flood. In case of higher water they will use boats as well.

## 2.8 Further safety measures

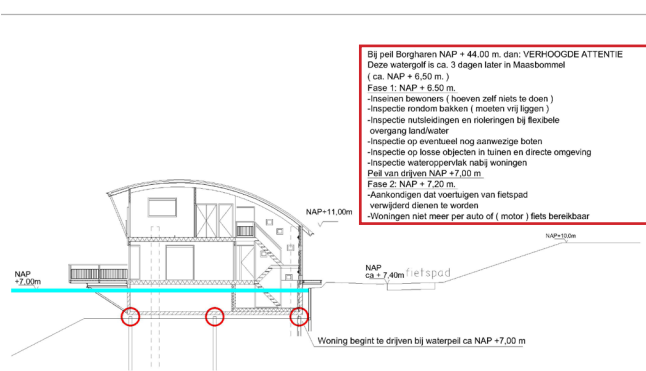
The final and most crucial measure to ensure the safety of the inhabitants is a good maintenance plan combined with a 'user manual' for the houses. The estate manager and the owners will have to check the systems around the floating piers and most importantly the facility connections and the docks of the floating homes. When a flood is announced, the user manual states when to inform inhabitants and run an extra check on all crucial points.



Floating and amphibious houses with access road and floating pier. (image: studio van hesse)



Flexible facility connections between two houses, before connection to the house.



Amfibische woning, peil NAP + 7,00

translation:

If level at Borgharen NAP+44m, then:

**INCREASED ATTENTION.**

This flood will reach Maasbommel ca. 3 days later (NAP+6,50m).

Phase 1: NAP+6,50m

- Alert inhabitants (no action by them necessary)
- Check hulls (must be free to move)
- Check facility connections
- Check boats if present
- Check gardens and surroundings for loose objects
- Check surrounding water

Floating starts at NAP+7,00m

Phase 2: NAP+7,20m

- Announce that vehicles should be removed from the road
- Houses no longer accessible by car or (motor)bike

Information about precautions after flood warning in the user manual.



### 3. Evaluation

#### 3.1 Normal floating conditions

Of course the concept of floating homes had already proven itself through the years in various small scale tests. The Maasbommel design, of which 14 houses have been permanently afloat since 2004, proved to meet all requirements. Of course both houses and infrastructure did need regular maintenance work, but there have been no alterations to the design once the project was completed.

The owners of the houses expressed their delight in the beautiful location and the spectacular view in various interviews with the press. There have been no reports of uncomfortable heaving of the houses due to waves on the water. The houses are located in a rather sheltered location. The Maasbommel project provides an extraordinary way of living near and on the water.

#### 3.2 Flood conditions

From 12 to 14 January 2011 the amphibious homes had their final test. As the water rose above 7 meters + NAP for the first time since 1995, the area flooded. There had been warnings the days before. Most cars were removed from their parking places and the owners knew what was coming. When they woke up that Wednesday morning they found that there was no longer a dry connection to the land.

The problems that occurred were no more than the expected. The inhabitants used waders or boats to get to the land, the occasional car still had to be moved away through the maximum twenty centimetres of water on the road, and there was the odd complaint about limited accessibility of the houses. As this flood happened for the first time in sixteen years, and on average happens only once every twelve years, these seem minor (and partly preventable) discomforts.

When the amphibious houses descended to their original position a few days later everything went well. Nothing got stuck in the docks and the houses landed safely, and completely level, on their foundations.



Floating and amphibious homes at normal water level, September 2005.



Floating homes seen from the dyke, January 2011.



Floating homes seen from access road, July 2005.



Amphibious house afloat, January 2011.



Amphibious house with garden and parking place, July 2005.



Amphibious house afloat, January 2011.



### 3.3 Future projects

'De Gouden Kust' in Maasbommel may have been the first larger scale floating and amphibious housing project, it surely will not be the last. In September 2010 the project won the national 'Water, Wonen & Ruimte Award' (Water, Housing & Space Award) for its iconic value as an innovative way of building.

Though floating and amphibious living may be a niche market for a very specific group of home owners, there are still plenty of chances for other developments. Dura Vermeer, Factor Architecten and Boiten are currently developing a similar project of both floating and amphibious villa's in Ohé en Laak, further upstream on the river Maas. Many other projects in the Netherlands and abroad have been designed, but mostly not yet built. Though some experts argue that building on the water will always be a minor addition to the total number of houses built, it seems to provide chances for both high quality living in wonderful locations and sustainable project development. The 'De Gouden Kust' project in Maasbommel has proven that for sure there are no technological objections against such projects.

As said in the government campaign entitled 'The Netherlands live with the water': It may sound strange, but living on the water can keep our feet dry.



'The Netherlands live with the water.' (image: ministry of VROM)



Artists impression of the floating and amphibious villas 'Maasterp', Ohé en Laak.







**Factor Architecten bv**

Geograaf 40, 6921 EW, Duiven

Postbus 223, 6920 AE, Duiven

t 026 3844460

f 026 3844479

e [info@factorarchitecten.nl](mailto:info@factorarchitecten.nl)

w [www.factorarchitecten.nl](http://www.factorarchitecten.nl)



**Boiten raadgevende ingenieurs bv**

Velperweg 14, 6824 BC, Arnhem

Postbus 257, 6800 AG, Arnhem

t 026 3537720

f 026 3537727

e [info@boiten.net](mailto:info@boiten.net)

w [www.boiten.net](http://www.boiten.net)