



MODELS „About the Material and the Machine

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# MODELS



# MODELS



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# ABOUT THE MATERIAL AND THE MACHINE

*The culture of Modelmaking in Fluid Dynamics Research as method for understanding movement.*

## Models as Scientific Devices

In hydraulic engineering and fluid dynamics, models still function as scientific experimental set-ups. Here, the model is not a purely representational object, as it is in architecture, but a device of scientific knowledge. Surprisingly, particle and fluid dynamics are still too complex or too costly to simulate digitally in their entirety. Reproducing a spatial disposition, the physical geometries, and landscapes, is thus still the fastest way to gain knowledge and necessary to verify computer-based digital simulations with control values.

In the course of my research, I visited such experimental facilities in Delft, Aachen, Hanover, Bremen.

Their models must rather be described as machines specially made for research questions, created in an enormously precise way of working. The models are hybrids between sculpture, machine, diorama, and architectural space. Next to each masonry wave channel or riverbed is a workstation with a desk and monitor for direct control of the simulations.

## Material Understanding

Although they are often visited as illustrative objects for political decisions, they are produced very pragmatically and thus speak strongly through their materiality about how artificial and resilient the materials are that are used in these engineering structures.

On request, the VAW (Versuchsanstalt für Wasserbau) of the ETH provided me with a workplace in their experimental hall, where I constructed the sedimentation model for this project. During this process, I gained insights that would have remained hidden from me if I had worked digitally: I developed a feeling for matter, its weight, its movement, dirt, wear, effort - I learned how the immense weight of the material of a landscape is difficult to manoeuvre even in 1:100. With model families that examine a project in several scales, the greatest proximity to real physical conditions is sought at immense expense. This is because each model only generates data about the section under investigation.

## Time

Jörg Backsen is a farmer on the island of Pellworm. About the way the climate around us is changing, he told me how his grandfather and then his father used to walk around the island once every spring to see what „happened outside the dyke in the winter. Things are slowly shifting here; you can feel it in trends. Sandbanks are shifting, tideways are digging themselves anew, material is eroding. To generate such knowledge and act accordingly, a long-term attachment to a place is necessary. You have to stay to understand and adapt.“ His section is larger, the time frame in which he observes it longer, his observations less measurable.

But even though this method does not use technical aids, it is still based on the same principles: close observation, repetition, comparison.

I see the moving model as neither bound to an experimental hall nor as a 100% reliable machine for gaining knowledge, but as an expression of human curiosity; our desire to understand something that is bigger than us.

And as an object of illustration through which a common understanding of these processes is made possible.







# ÜBER DAS MATERIAL UND DIE MASCHINE

*Die Kultur des Modellbaus in der Wissenschaft des Wasserbaus und der Fluidodynamik als Methode, Bewegungen zu verstehen*

## Modelle als Wissenschaftliche Apparate

Im Wasserbau und der Fluidodynamik fungieren Modelle noch immer als wissenschaftliche Versuchsaufbauten. Das Modell ist hier nicht wie in der Architektur reines Repräsentationsobjekt, sondern ein Gerät wissenschaftlicher Erkenntnis. Erstaunlicherweise sind Partikel- und Strömungsdynamiken noch immer zu komplex bzw. zu aufwändig, um sie im Ganzen digital zu simulieren. Das Nachbilden einer räumlichen Disposition, der physischen Geometrien und Landschaften, ist also noch immer der schnellste Weg zum Erkenntnisgewinn und notwendig, um computer-gestützte digitale Simulationen mit Kontrollwerten zu verifizieren.

Im Laufe meiner Recherche besuchte ich Versuchshallen in Delft, Aachen, Hannover, Bremen. Ihre Modelle muss man eher als speziell für Forschungsfragen gefertigte Maschinen beschreiben, die in einer enorm präzisen Arbeitsweise erstellt werden. Die Modelle sind Hybriden zwischen Skulptur, Maschine, Diorama und architektonischem Raum. Neben jedem gemauerten Wellenkanal oder Flussbett befindet sich ein Arbeitsplatz mit Schreibtisch und Monitor für das direkte Kontrollieren der Simulationen.

## Materialverständnis

Obwohl sie auch oft als Anschauungsobjekte für politische Entscheidungen besichtigt werden sind sie sehr pragmatisch hergestellt und sprechen so durch ihre Materialität darüber, wie artifiziell und resilient Wasserbau aufgeführt wird.

Die VAW (Versuchsanstalt für Wasserbau) der ETH stellte mir auf Nachfrage einen Arbeitsplatz in ihrer Versuchshalle zur Verfügung, wo ich das Sedimentationsmodell für dieses Projekt konstruierte. Während dieses Prozesses erlangte ich Erkenntnisse, die mir bei der digitalen Arbeitsweise verborgen geblieben wären. Ich entwickelte ein Gefühl für Materie, ihr Gewicht, ihre Bewegung, Schmutz, Abnutzung, Aufwand – ich lernte wie das immense Gewicht des Materials einer Landschaft bereits im 1:100 schwierig zu manövrieren ist.

Mit Modellfamilien, die ein Projekt in mehreren Maßstäben untersuchen wird unter immensem Aufwand die größte Nähe zu realen physischen Bedingungen gesucht. Denn jedes Modell erzeugt lediglich Daten über den untersuchten Ausschnitt.

## Zeit

Jörg Backsen ist Landwirt auf der Insel Pellworm. Über die Art, wie sich das Klima um uns verändert erzählte er mir, wie sein Großvater und dann sein Vater jedes Frühjahr einmal um die Insel liefen, um zu sehen, was „im Winter vor dem Deich draußen alles so passiert ist. Die Dinge verschieben sich langsam hier; man spürt es in Tendenzen, Sandbänke wandern, Priele graben sich neu, Material erodiert. Um solch ein Wissen zu generieren und dementsprechend zu handeln ist eine langfristige Bindung zu einem Ort nötig. Man muss bleiben, um zu verstehen und sich anzupassen.“

Sein Ausschnitt ist grösser, der Zeitrahmen, in der er ihn betrachtet länger, seine Beobachtungen weniger messbar. Doch auch wenn diese Methode sich durch keine technischen Hilfsmittel verifiziert, fußt sie dennoch auf denselben Prinzipien: Genaue Beobachtung, Repetition, Vergleich.

Ich sehe das bewegte Modell weder gebunden an eine Versuchshalle noch als 100% verlässliche Maschine des Erkenntnisgewinns, sondern als Ausdruck einer menschlichen Neugier; unseres Verlangens, etwas zu begreifen, dass grösser ist als wir. Und als Veranschaulichungsobjekt, das ein gemeinsames Verständnis dieser Prozesse ermöglicht.









**DELTARES, Technical University Delft, NL**

*Worlds longest Wave Flume, 8,5 hours test*  
*Wave Flume, Dikepiece\_*For 1:1 tests, pieces of existing dykes are cut out and transported to the flume to test cohesiveness of grassroots in actual soils: at times, a model cannot replace the actual matter.

>>> *page*  
**MARUM, Center for Marine Environmental Sciences,University of Bremen**

*Deep-sea drill core storage, ashes of the meteorite that killed all dinosaurs\_*Sediment cores in coolingracks,  
*World's largest deep-sea drill core repository, cold storage. The dark layer consists of ash from the meteorite impact that caused the extinction of the dinosaurs. (The composition of the untouched layers of earth under the oceans allow geological research on the history of the earth. Inter alia, they provide data on future questions such as the speed of the predicted global warming).*











# Ludwig Franzius Institut, Leibnitz University Hanover

Container with water from the Dead Sea used for experiments in 2012.

**Float for performing the streaking technique** Before digital recording, flow experiments were recorded using small floats. The experimental halls were completely darkened for this purpose - many of the buildings still have no windows today for this reason. The rings floating in the flow channel were recorded on photographs using long-term imaging, where the water movement became visible through the streaks of the bright markers. Subsequently superimposed, the flow became visible in this way.

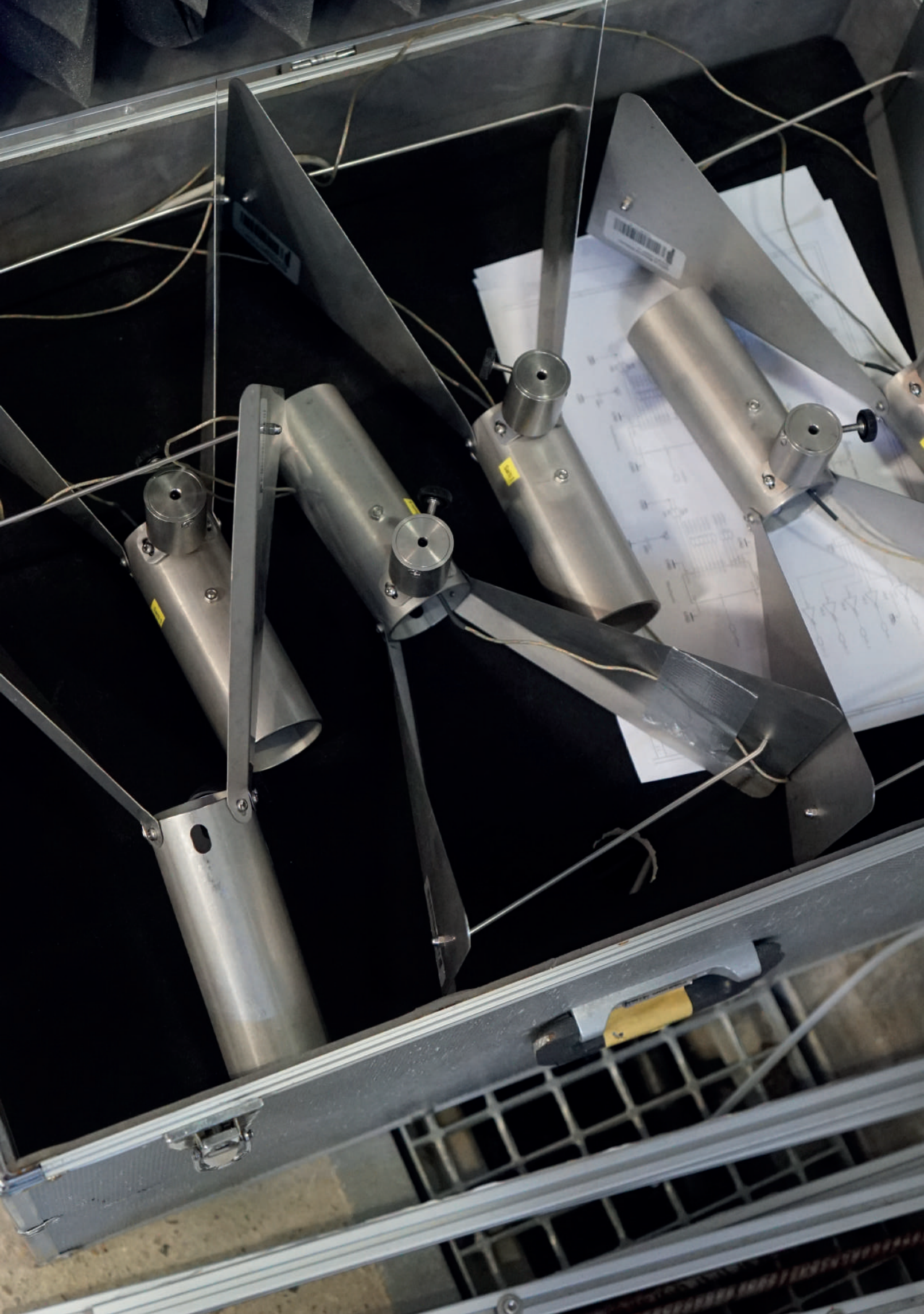
p.> **Model Families** Due to scale distortions, experiments are carried out with so-called model families. In different sizes, they provide a more diverse spectrum of measured values, which subsequently provide a more reliable result when compared with each other. Common scales in hydraulic engineering are 1:1, 1:20, 1:50, 1:70.











**Institute of Hydraulic Engineering and Water Resources Management, RWTH Aachen University**

***Saltifon, Acoustic sensor, measures aeolian sand transport through the air.***

*The wings direct the device in the wind. Flying grains of sand penetrate the front of the tube and hit a membrane, which records the impact as an acoustic signal and thus counts the amount of sand grains.*

*Unfortunately, it does not work in the rain; therefore, according to the technical manager of the test hall, it is unusable for field tests at the North Sea.*

***Resistance simulation, flow channel***

*Simulation of the resistance of vegetation in the event of a flood for possible planting in front of dikes and along river courses. Metal sticks represent tree trunks on a scale of 1:50.*

**>>> Work Station** Computers for monitoring and directing data







*reservoir: steel barrel*

*technical parts: PondPump Forever, Long Island GmbH, 40w, 5200l/h,*

*FESTO hose, FESTO coupling elements, digital timer*

*flume: steel frame, steel wires, screen printing plates, plexiglass, silicone*

*insert: mortar, pond pump, pneumatic pvc hoses, joints FESTO, sand (grain), black pigment, sediment fine-clastic,*

*roundwood beech, sealing wax, XPS, SikaBlock PUR model rigid foam*

**The model shows the section of the coast directly behind the newly inserted dike opening, as well as the terrain changing due to the flooding. As an experimental device is used to test the sediment distribution in the introduced geometries. The displayed sedimentation status is the expected topography in 2053 (30 years from now with regular floodings in winter).**

**With a flood season of 5 months (5x30days) 150-300 floodings per year are to be expected. The simulation has been run with 3000 simulated tides, which equal the expected amount of floodings within 30 years. In the scale 1:100 due to adhesive qualities of sand and water, these components cannot be downscaled precisely. The model has also an illustrative character: The movement of the water is not so much a flowing as a rather slow vertical rise. The tide regularly rises to 2.4 m above sea level. At spring tide, these values can be higher. The platform on the 1st floor of the building is located at 5.5 m above sea level and is thus outside the storm surge zone ever reached.**

**The model was planned and constructed by me with the kind support of the VAW (Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie) in the associated hydraulic engineering hall. The metalwork was carried out in the workshop of the Jugendkulturhaus Dynamo.**

**Mean high water (MHW) = +171cm above sea level**

**Mean low water (MNW) = -181cm below sea level**

**Highest measured storm surge = 546cm above sea level**

Das Modell zeigt den Küstenabschnitt direkt hinter der neu eingebrachten Deichöffnung, sowie das sich durch die Überflutung verändernde Gelände.

Der dargestellte Sedimentationszustand entspricht der zu erwartenden Topographie im Jahr 2053 (in 30 Jahren mit regelmäßigen Überflutungen im Winter). Bei einer Hochwassersaison von 5 Monaten (5x30Tage) sind 150-300 Überflutungen pro Jahr zu erwarten. Die Simulation wurde mit 3000 simulierten Tiden durchgeführt, was der erwarteten Anzahl von Überschwemmungen innerhalb von 30 Jahren entspricht. Im Maßstab 1:100 können diese Komponenten aufgrund der Adhäsionseigenschaften von Sand und Wasser nicht genau heruntergerechnet werden. Das Modell hat ebenfalls einen illustrativen Charakter: Die Wasserbewegung ist weniger ein Fließen als vielmehr ein langsames Hineinstehen. Die Tide steigt regulär auf 2,4 m über NN, kann jedoch bei Springtide höher ausfallen. Die Plattform im 1. OG des Gebäudes befindet sich auf der Kote 5,5m ü NN und liegt so außerhalb der jemals erreichten Sturmflutzone.

Das Modell wurde von mir mit freundlicher Unterstützung der VAW (Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie) in der zugehörigen Wasserbauhalle geplant und konstruiert. Die Metallarbeiten wurden im Werkbereich des Jugendkulturhaus Dynamo realisiert.

Mittleres Hochwasser (MHW) = +171cm über NN

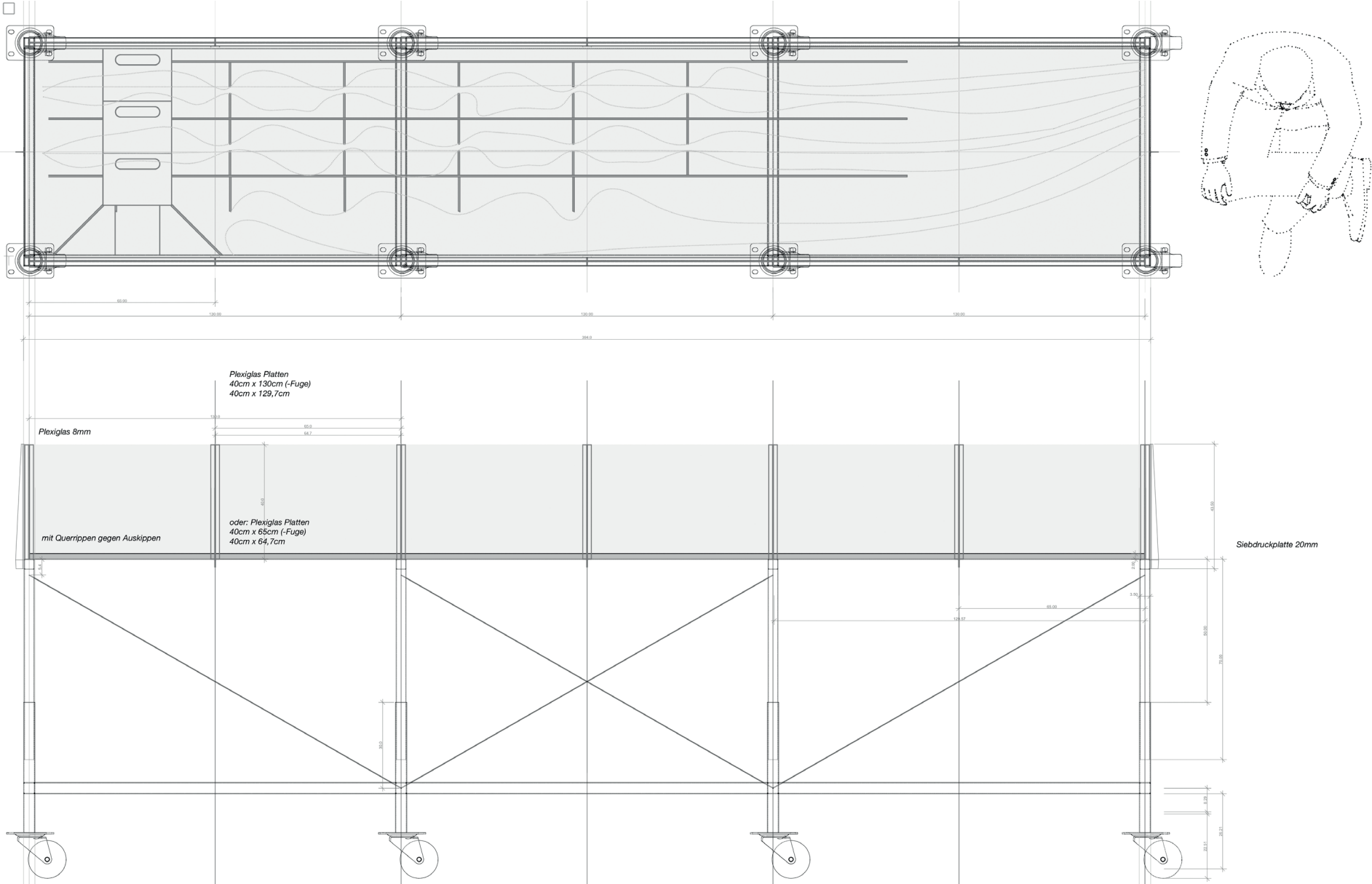
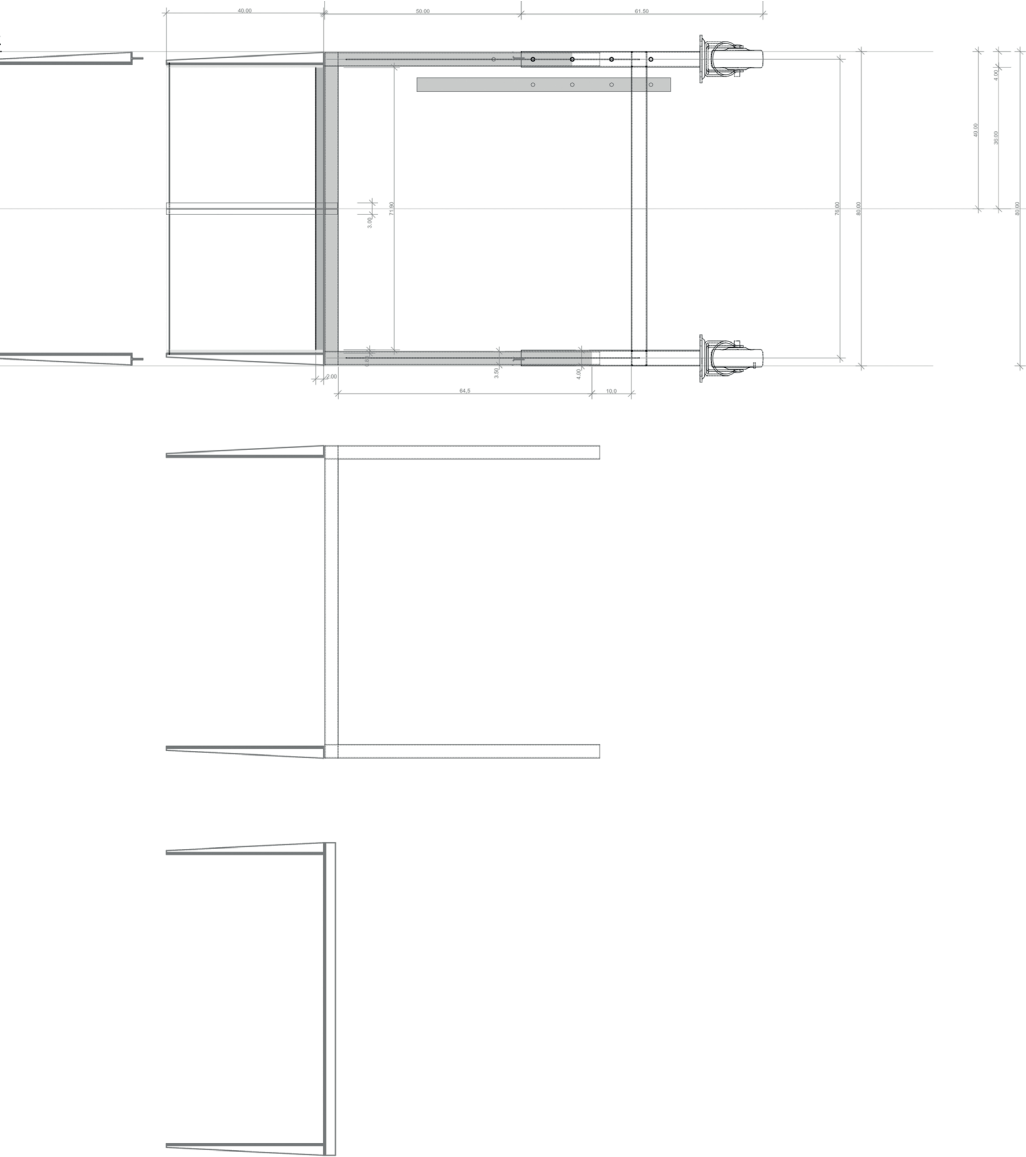
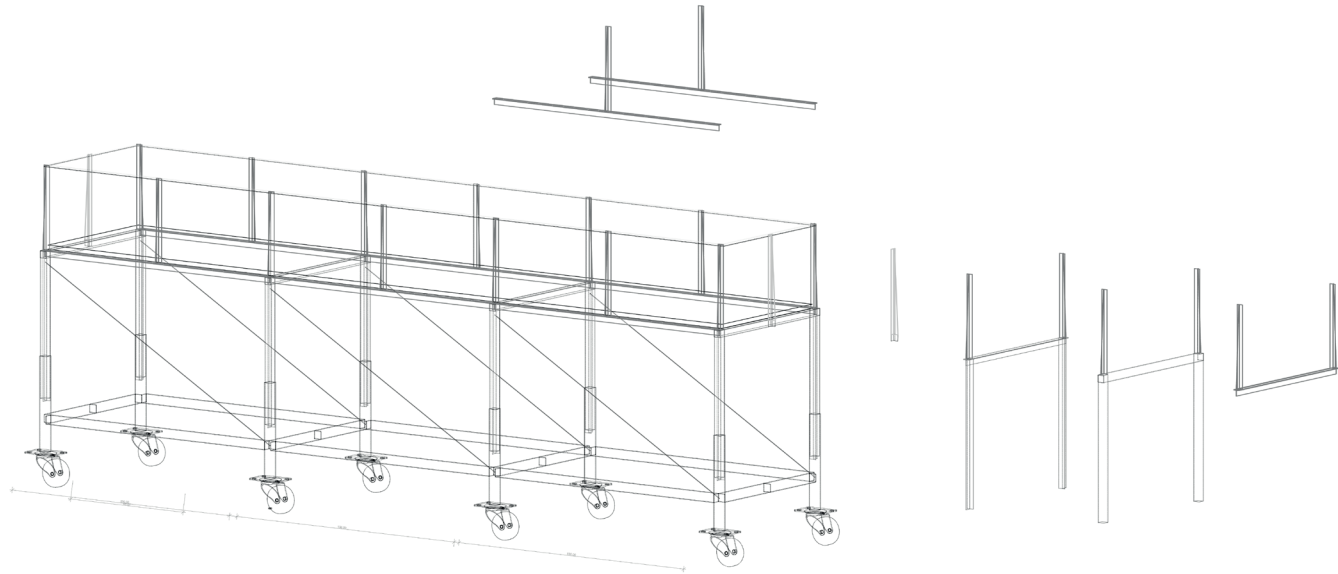
Mittleres Niedrigwasser (MNW) = -181cm unter NN

Höchste gemessene Sturmflut = 546cm über NN, 1976

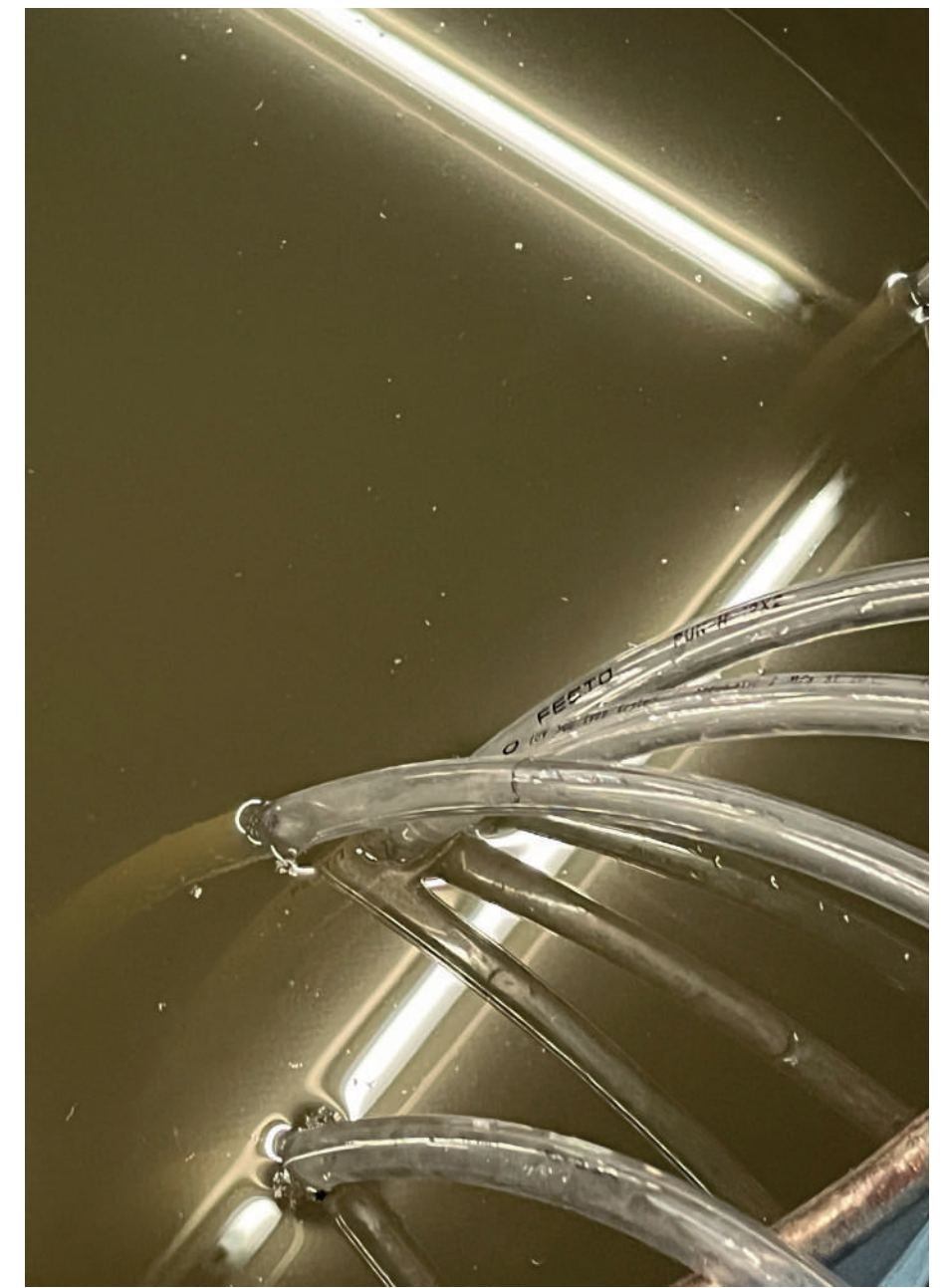


Weight Calculation 1:100

|                                   |               | Reality | Height | Width | Length | Volume           | Weight |    |
|-----------------------------------|---------------|---------|--------|-------|--------|------------------|--------|----|
|                                   |               | [m]     | [cm]   | [cm]  | [cm]   | [l]              | [kg]   |    |
| Plexibox Volume                   |               |         | 35     | 77,5  | 390    | 1058             | 1058   |    |
| if completely filled with water   |               |         |        |       |        |                  |        |    |
| House 1:100                       | 3 Stories     | 15      | 15     |       |        |                  |        |    |
| Water 1:100                       | Mean Tide     | 3       | 3      | 77,5  | 390    | 91               | 91     | kg |
|                                   | Simulation I  | 6       | 6      | 77,5  | 390    | 181              | 181    | kg |
|                                   | Simulation II | 12      | 12     | 77,5  | 390    | 363              | 363    | kg |
| Sand 1:100                        |               |         | 22     | 77,5  | 390    | 665              | 665    | kg |
| Dyke 1:100                        |               |         | 30     | 77,5  | 390    | 907              | 907    | kg |
| Steefframe                        | 40mm          |         | 50,4   |       | 2,4    |                  | 121    | kg |
| formwork panel                    | 24mm          |         | 3,003  | [qm]  | 17     |                  | 51     | kg |
| Plexigass                         | 10mm          |         | 3,269  | [qm]  | 12     |                  | 39     | kg |
| Glue,Screws, Ropes                |               |         |        |       |        |                  | 10     | kg |
|                                   |               |         |        |       |        |                  | 221    |    |
| Lift of Pump ca. 1m               |               |         |        |       |        |                  |        |    |
| Height difference [Tank Plex] 1 m |               |         |        |       |        |                  |        |    |
|                                   |               |         |        |       |        | TOTAL WEIGHT DRY | 1128   | kg |
|                                   |               |         |        |       |        | TOTAL WEIGHT MAX | 1491   | kg |



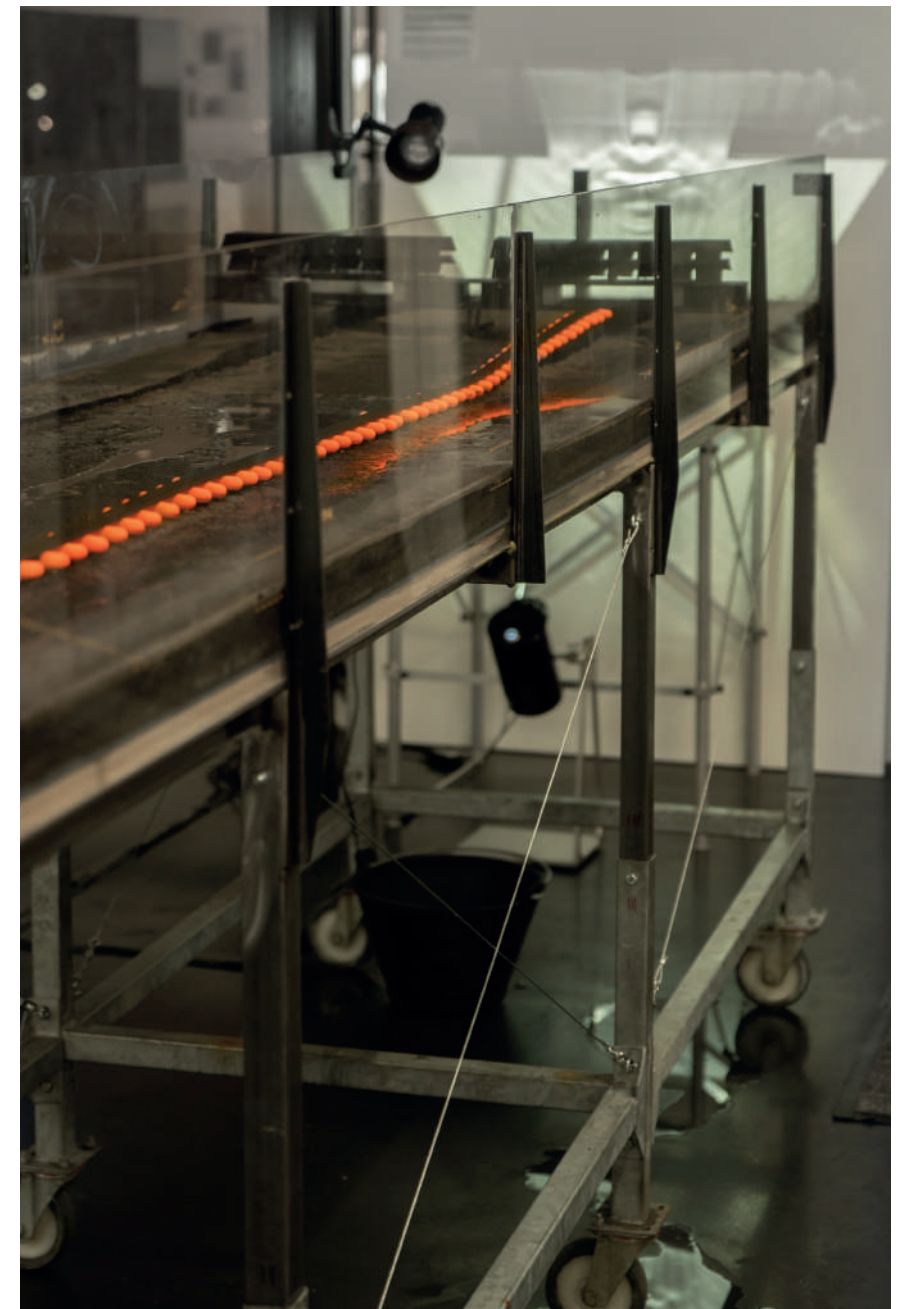
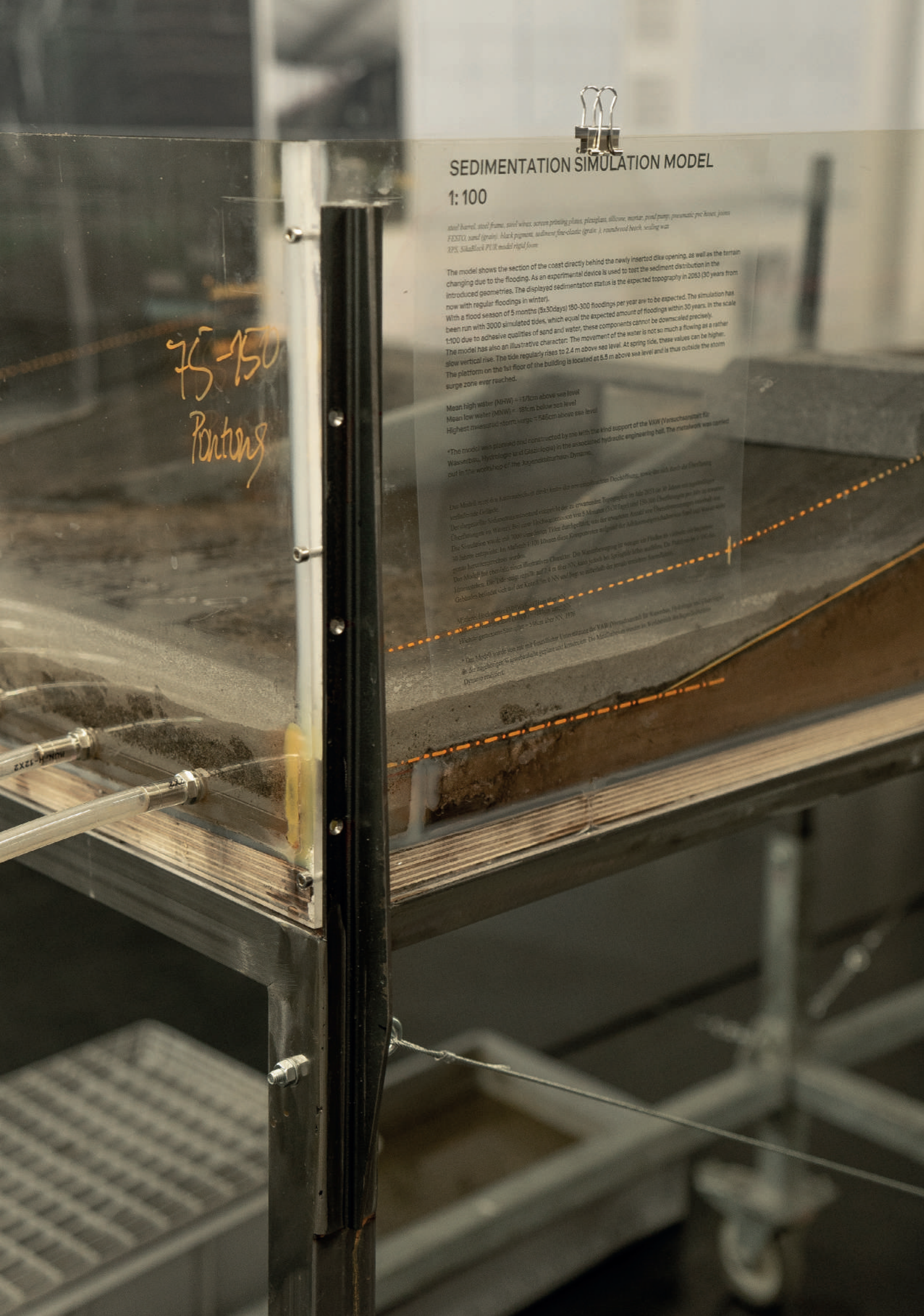












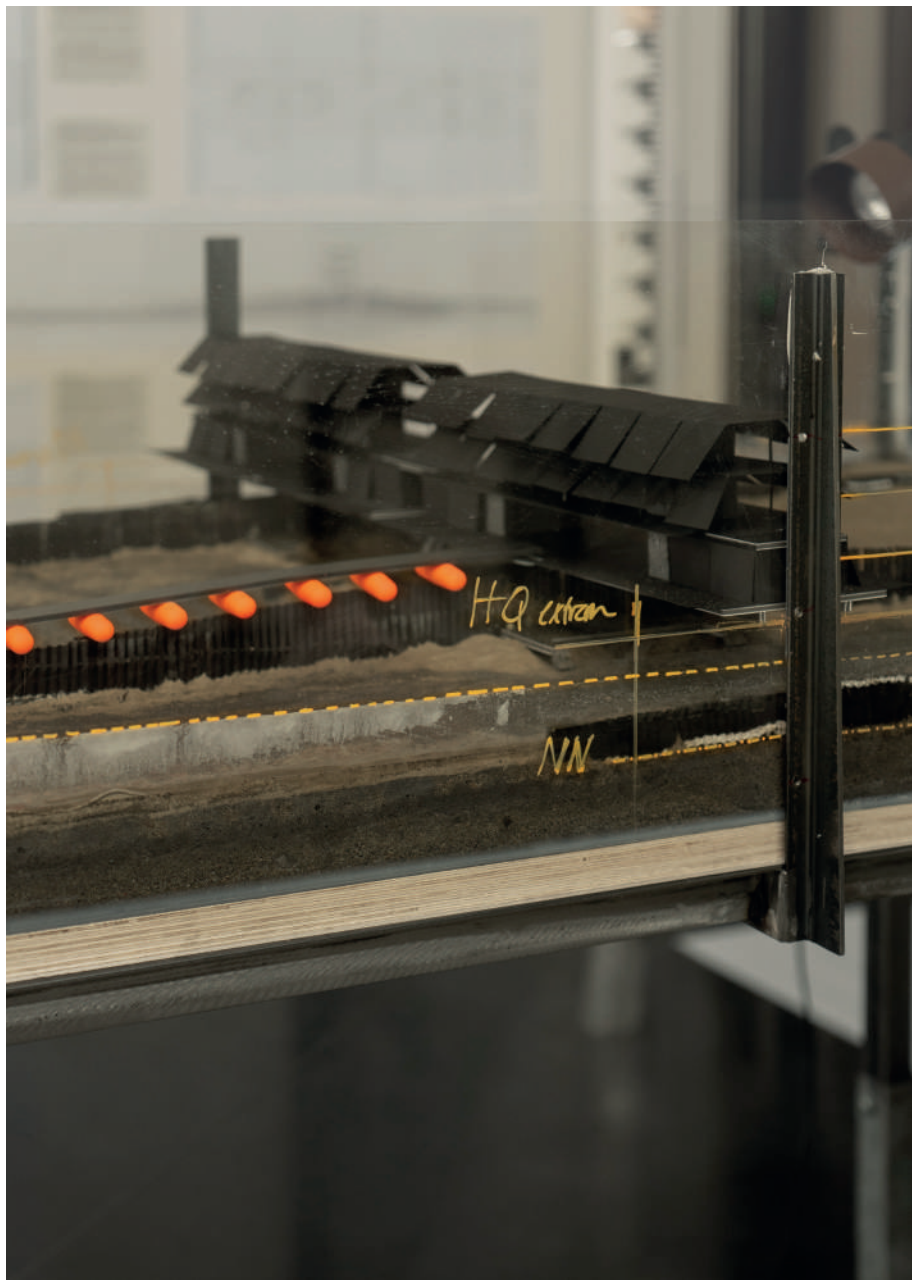




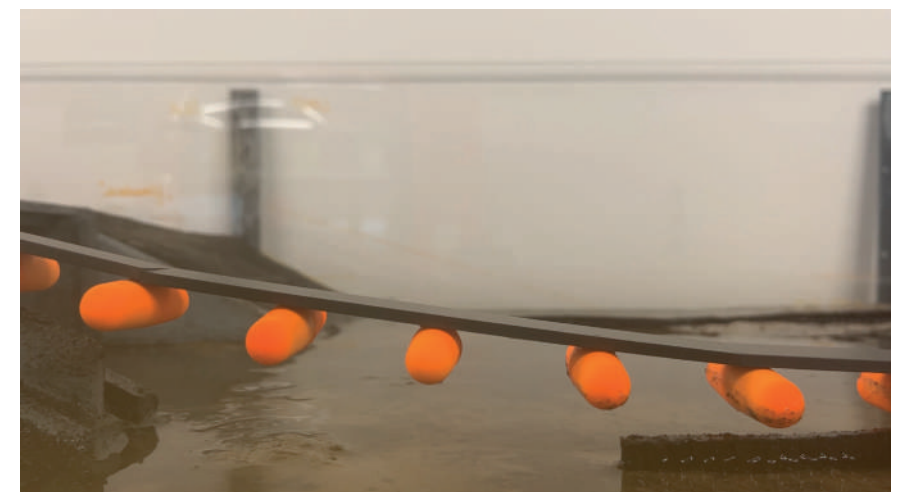
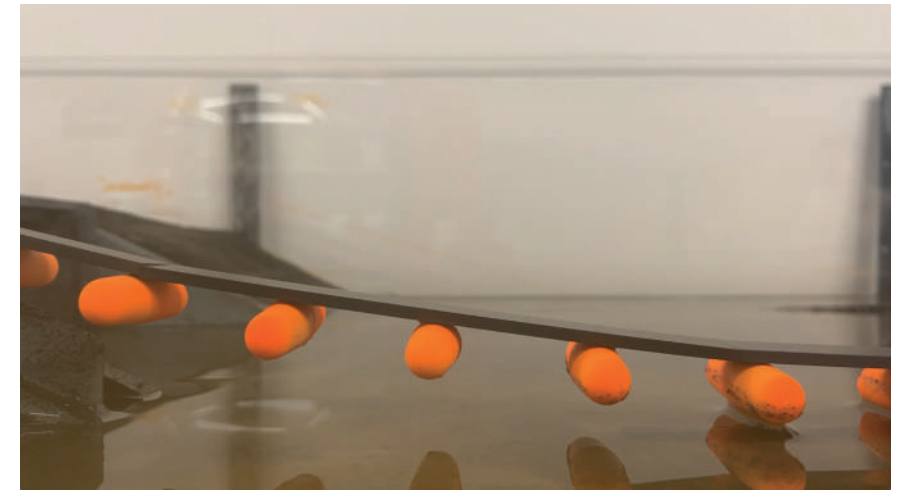
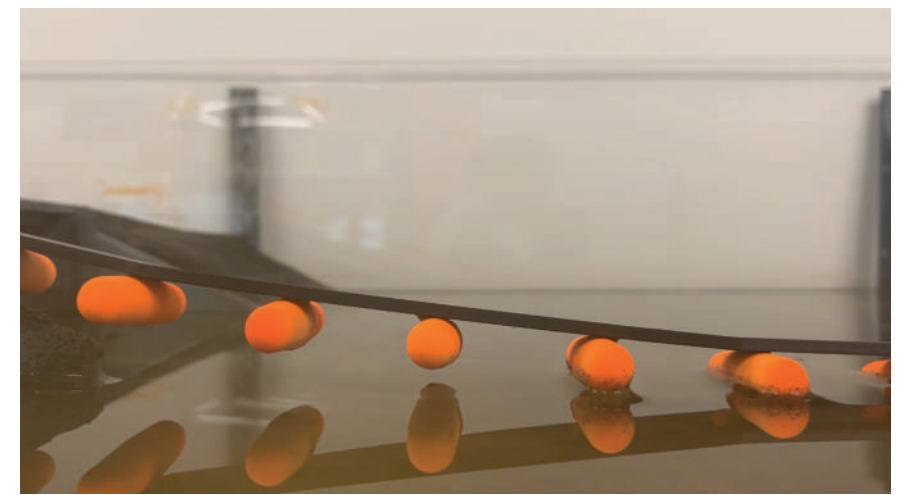








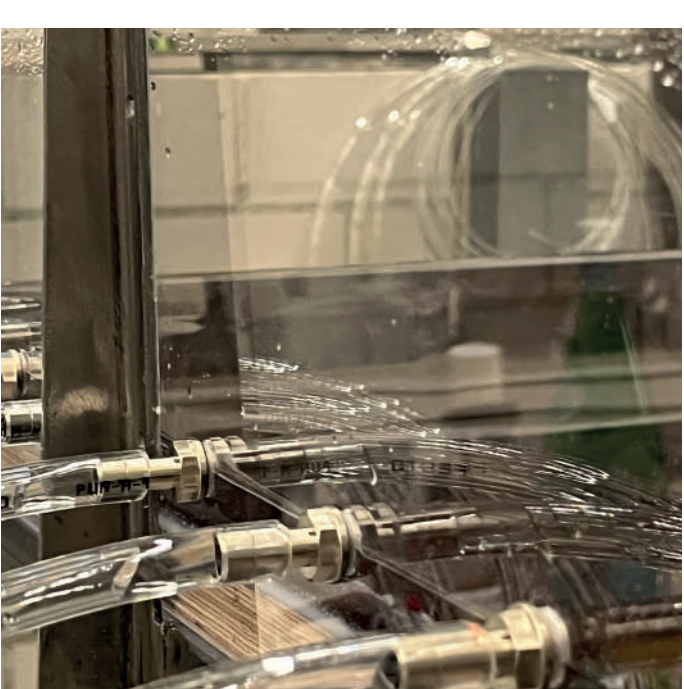
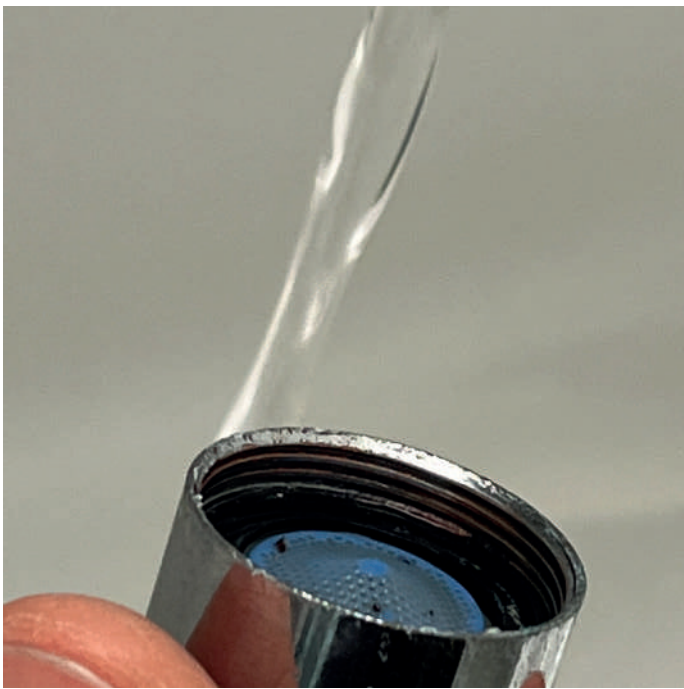
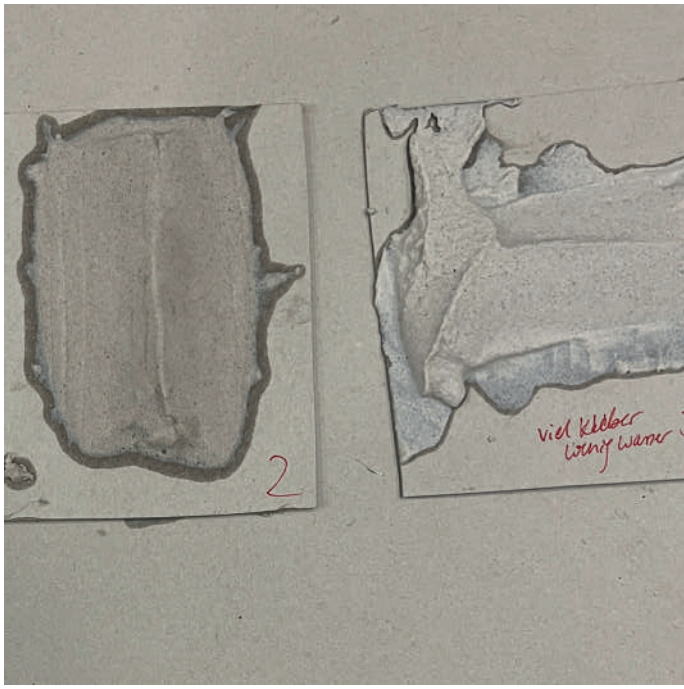
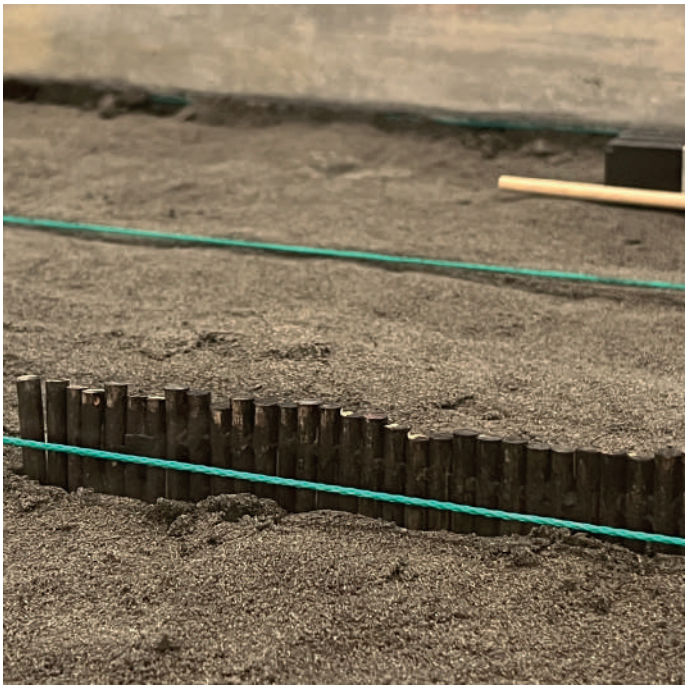
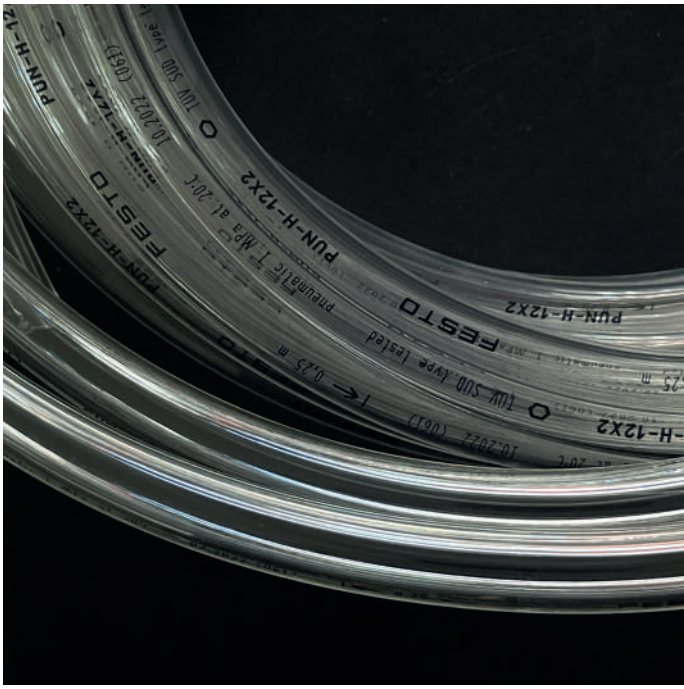
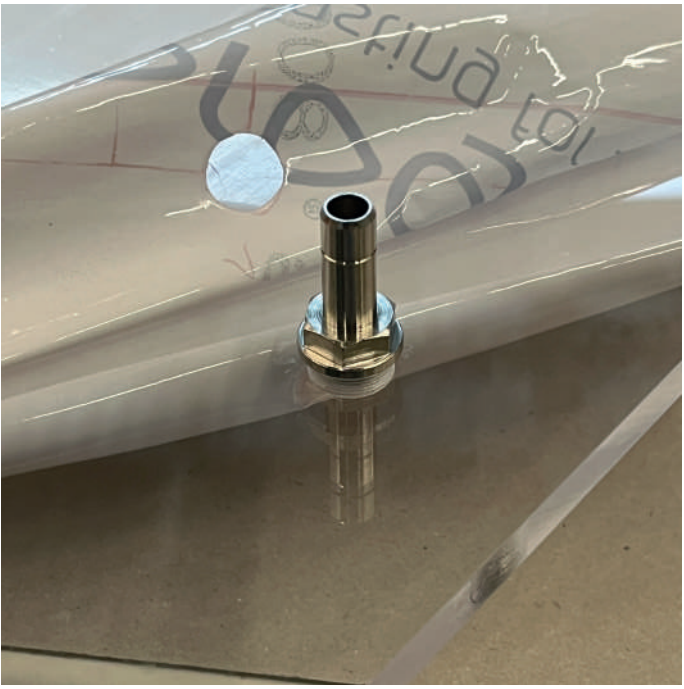
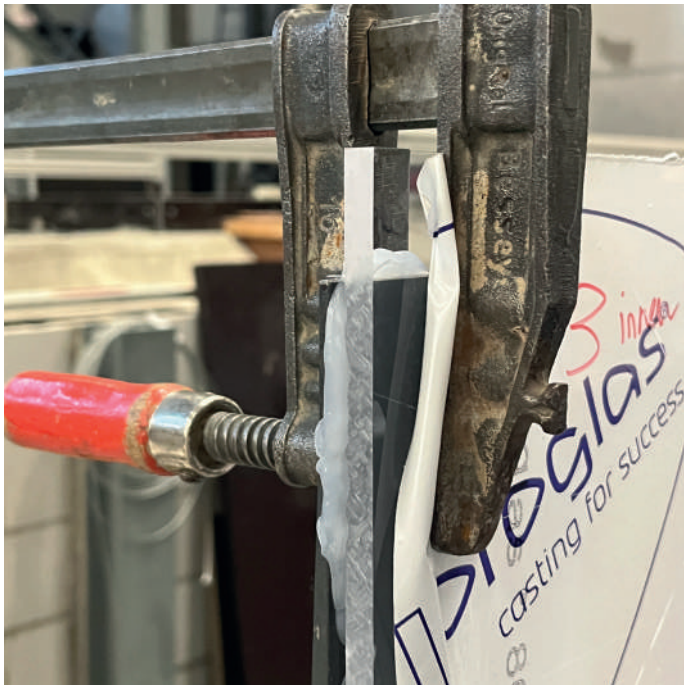
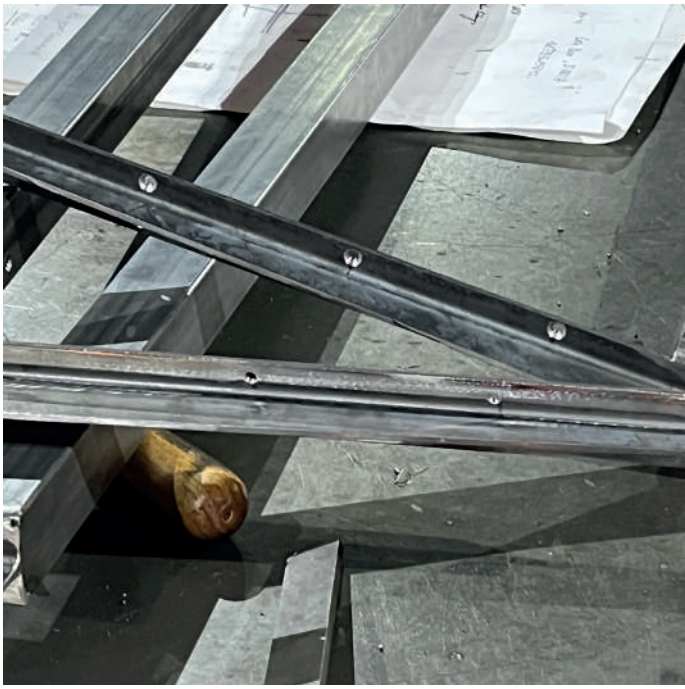














*process images from top left to bottom right*  
*p.43*  
*\_ladder I mostly worked from as arm were too short or model was too high*  
*\_frame on weldig table*  
*\_FESTO hose, most beautiful hose I've ever seen*  
*\_getting pegs straight, just to notice they are expanding*  
*\_massively in water and moving again*  
*\_testing how to attach a hose in the mens toilet in HIL to fill the barrel, eventually filled it with the firehose*  
*\_welding detail*

*p.44*  
*\_silicone while drying*  
*\_making threads in plexiglass*  
*\_dike-tests with sand and glue*  
*\_barrel on its way from the disposal of the chemistry department to the VAW*  
*\_pigmenting 500 kg of sand*  
*\_first water test*

# WAVE SIMULATION DEVICE

## 1: 20 000

*motor for even parallel wave generation*  
*point light source glass table*  
*distilled water*  
*soap*  
*aluminum frame*  
*insert of building 1:20 000*

**The wave simulator is a representation model of the environment of the building. It acts as an authoritative environment model for settlement and shows how accurately water penetrates the flood plain over the period of the flood. A small motor creates parallel waves through rhythmic movements. These break (similar to light waves on a lens) at the dike opening (sieve gate) and spread radially inland from there. The higher the wave energy, the more sediment is transported in the water. As soon as the speed of the water decreases, the sediment falls out. The distribution/drainage of the waves is decisive for how and at what distance the sediment settles on the land surfaces. The position of the building results from the optimal distance in relation to the sediment precipitation: The groins (washed in whole tree trunks) refract the waves without providing too large an attack surface. In thus calmed water areas behind the building (see drawing) it is to be expected that a small island will slowly accumulate. Thus, the position of the building influences the landscape’s future topography, it accumulates its own ground. \***

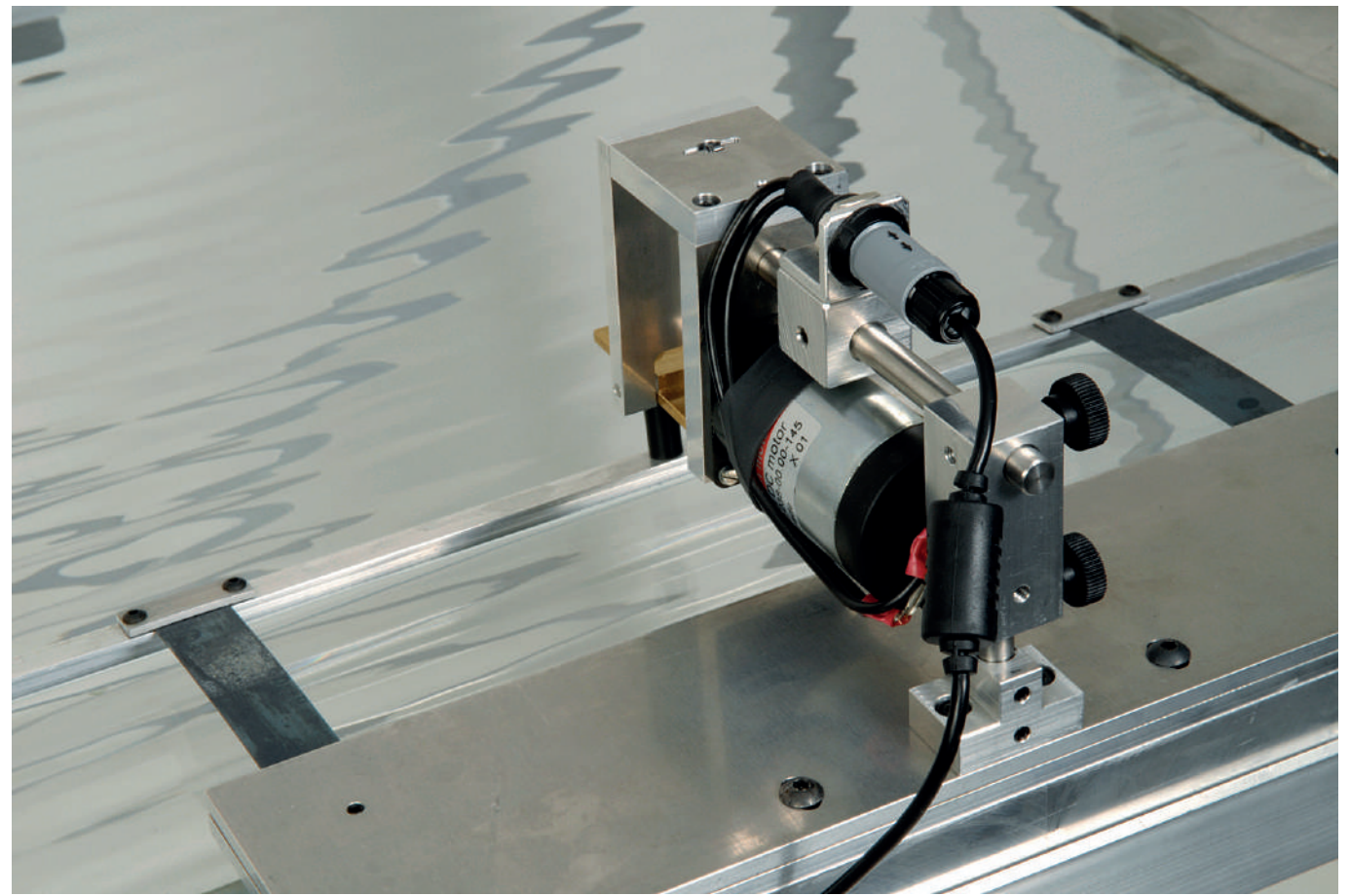
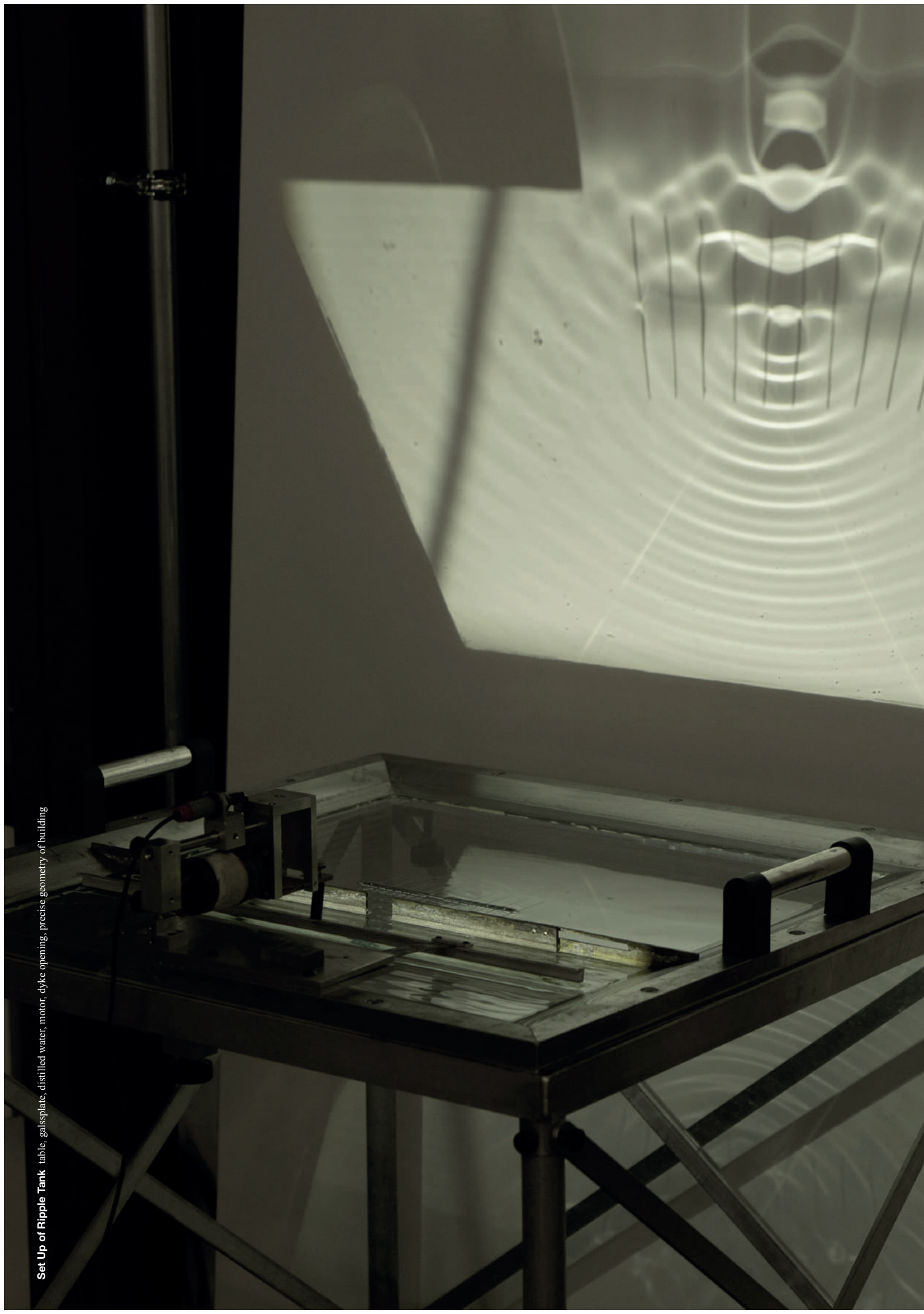
Der Wellensimulator ist ein Repräsentationsmodell der Umgebung des Gebäudes. Er fungiert für die Setzung als maßgebliches Umgebungsmodell, und zeigt, wie genau Wasser über den Zeitraum der Flut in die Flutfläche eindringt. Ein kleiner Motor erzeugt durch rhythmische Bewegungen parallele Wellen. Diese brechen sich, (ähnlich wie Lichtwellen an einer Linse) an der Deichöffnung und verteilen sich von dort aus radial im Inland. Je höher die Wellenenergie ist, desto mehr Sediment wird im Wasser transportiert. Sobald sich die Geschwindigkeit des Wassers verringert, fällt das Sediment aus.

Das Auslaufen der Wellen ist maßgeblich dafür, wie und in welchem Abstand das Sediment auf den Landflächen abregnet. Die Setzung des Hauses resultiert daher aus der optimalen Distanz in Bezug auf den Sedimentausfall. Die Buhnen (ganze Baustämme als eingespülte Fundamente) brechen die Wellen erneut, ohne eine zu große Angriffsfläche zu bieten. Ihre Geometrien erzeugen beruhigte Stellen hinter dem Gebäude (s. drawing). Hier ist zu erwarten, dass sich innerhalb von 20-50 Jahren eine kleine Insel angesammelt haben wird. So beeinflusst die Lage des Gebäudes die künftige Topografie der Landschaft, es akkumuliert seinen eigenen Boden. \*

\* Self Assembly Lab at MIT have been doing similar research in their project: Building with Waves: Growing Islands and Coastlines Through Wave Energy 2020- ongoing. By dropping a large-scale biodegradable textile bag filles with sand into the sea as initial geometry, they were able to form a new island behind it: The way the bags geometry influenced the current, it caused sediment deposition in a calculable place behind the bag. They have exhibited their research at the 2021 Venice Biennale and are currently research a possibility for upscaling to rebuild beaches and protect coastal communities from sea level rise.



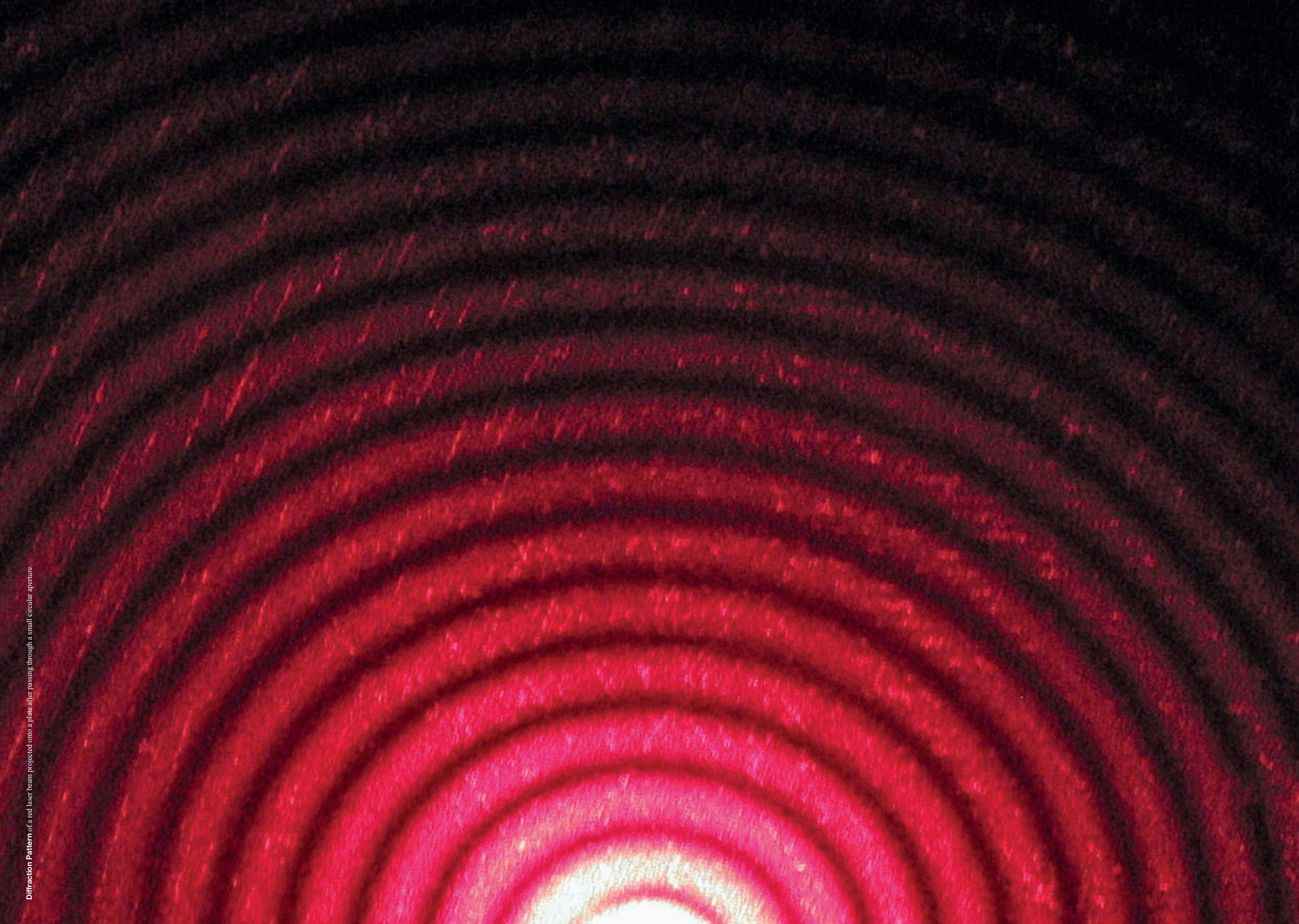
Set Up of Ripple Tank table, glassplate, distilled water, motor, dyke opening, precise geometry of building



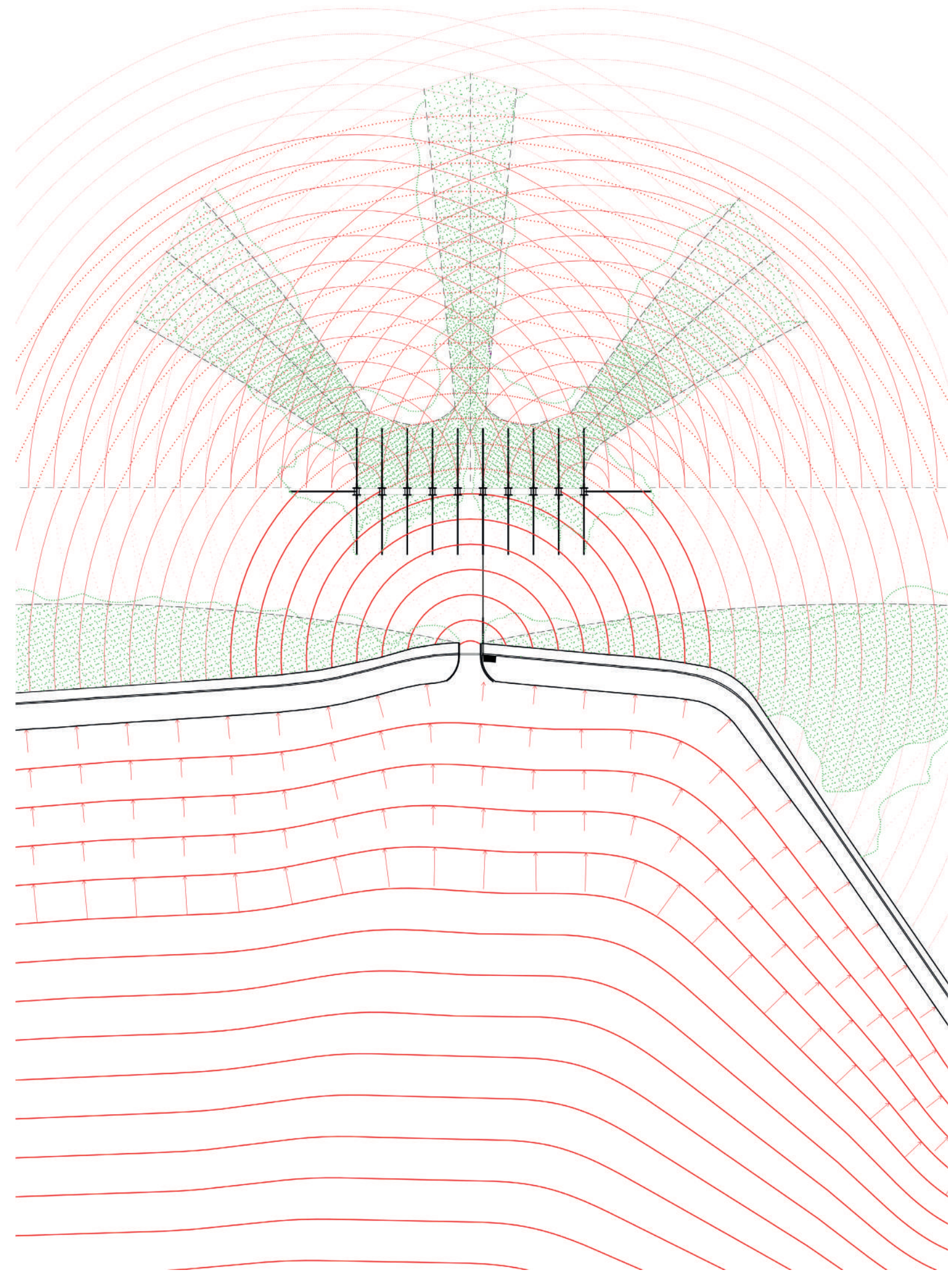
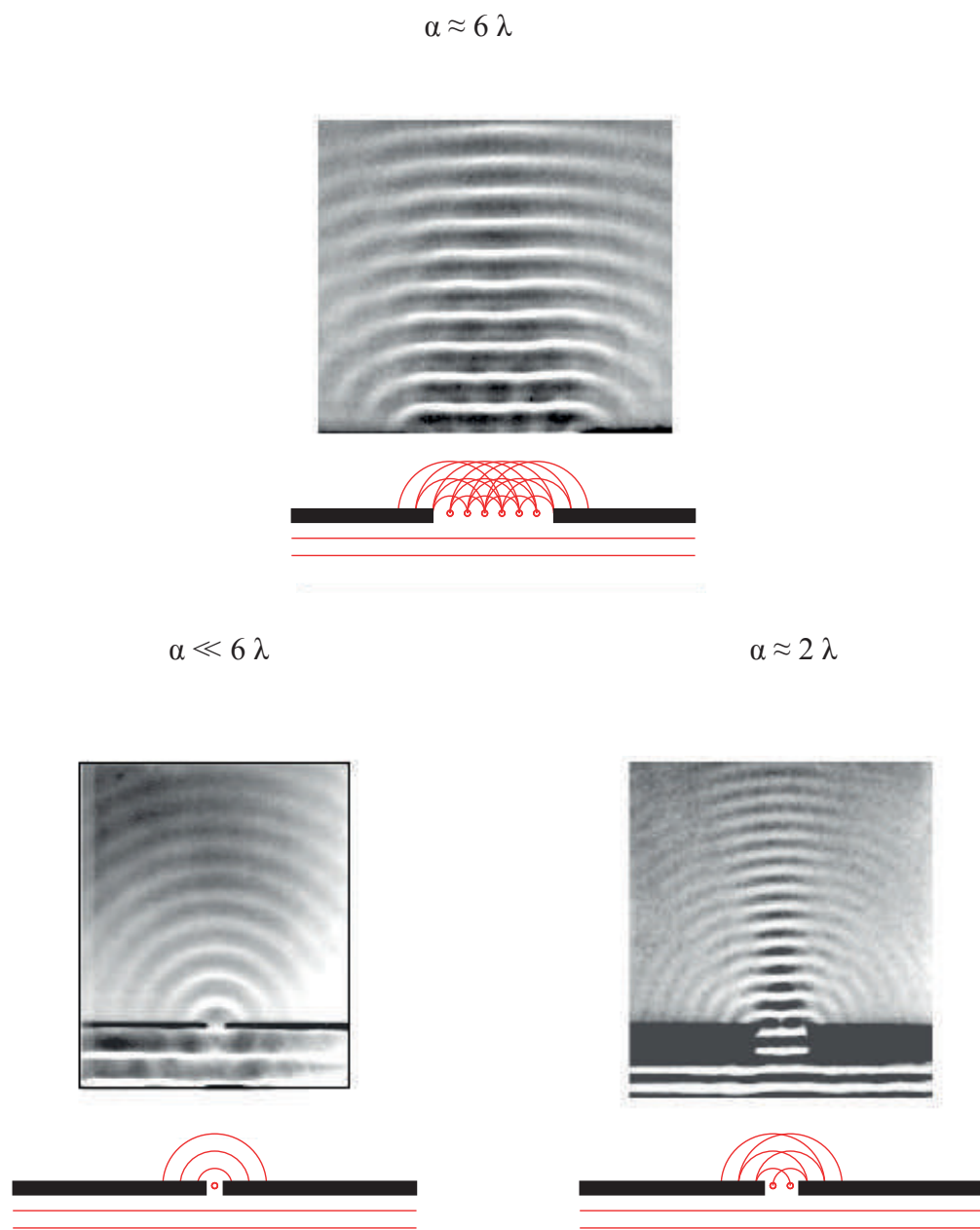
Motor simulating a regular parallel wave front



Diffraction Pattern of a red laser beam projected onto a plate after passing through a small circular aperture







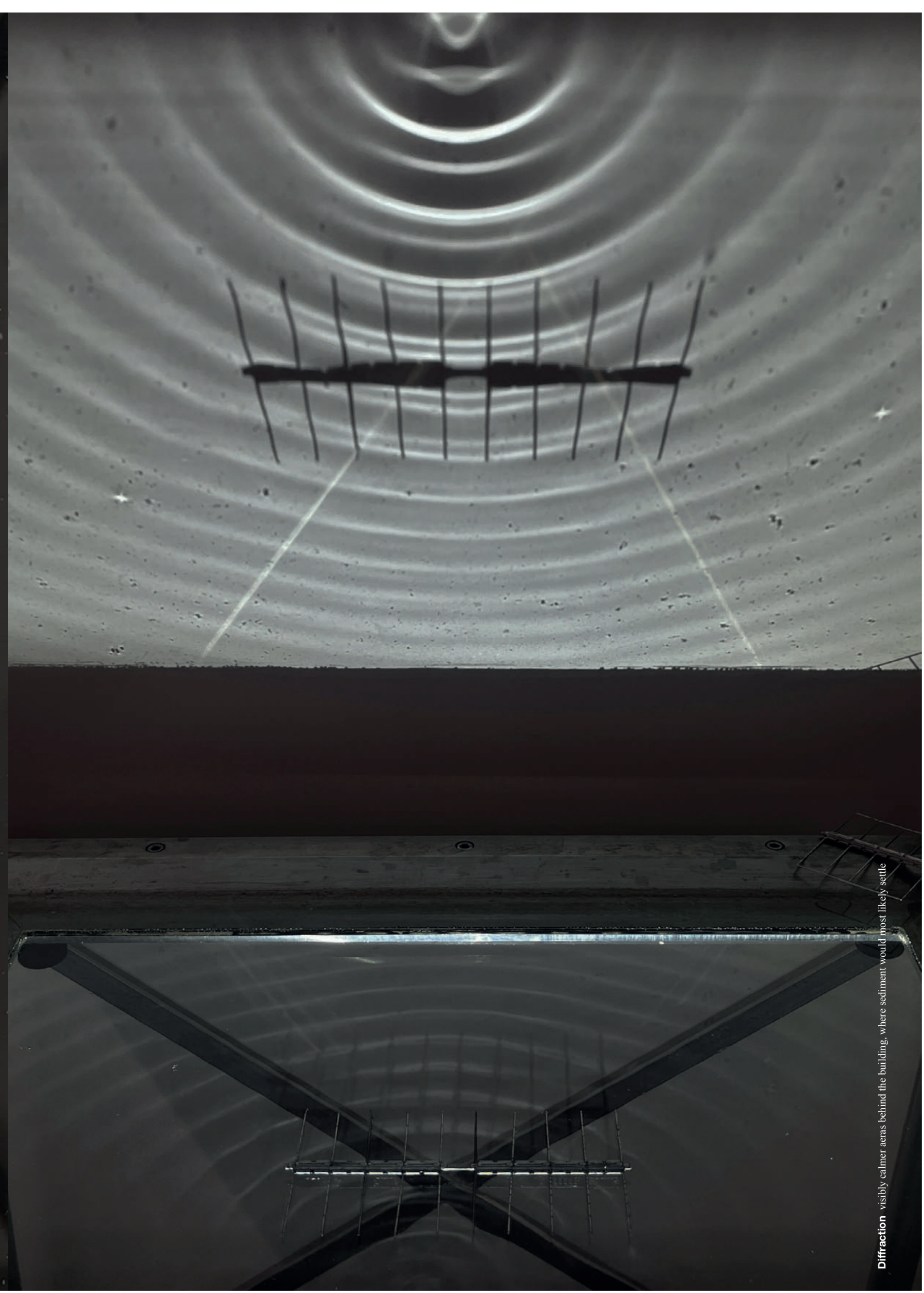
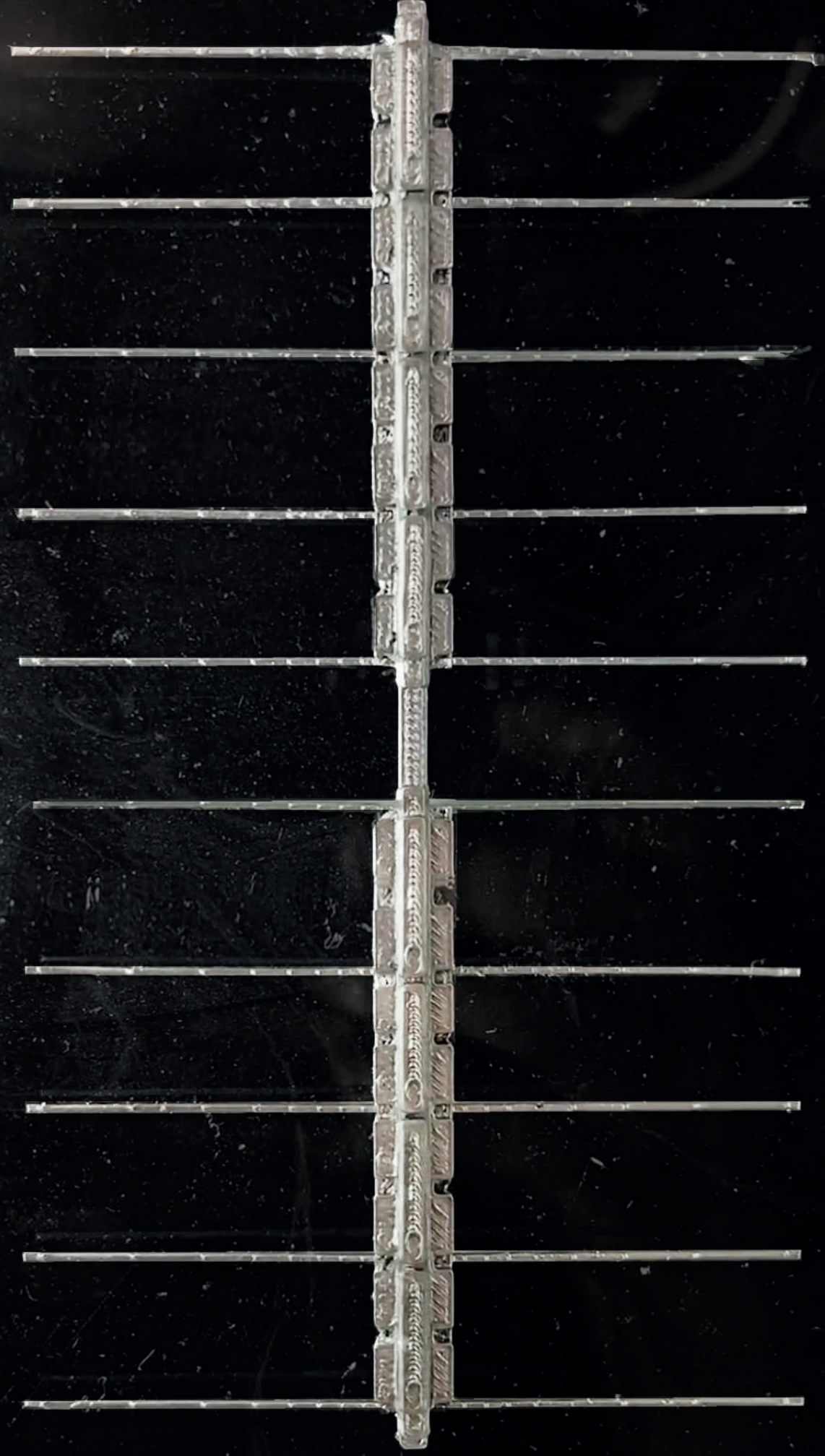
### Wave Diffraction Plan

Wave diffraction is the process by which wave energy spreads perpendicularly to the dominant direction of wave propagation. Diffraction can occur with any kind of wave. Ocean waves diffract around jetties and other obstacles. Sound waves can diffract around objects, which is why one can still hear someone calling even when hiding behind a tree.

expected sediment deposition in calmer areas (green)  
wave penetration (red)

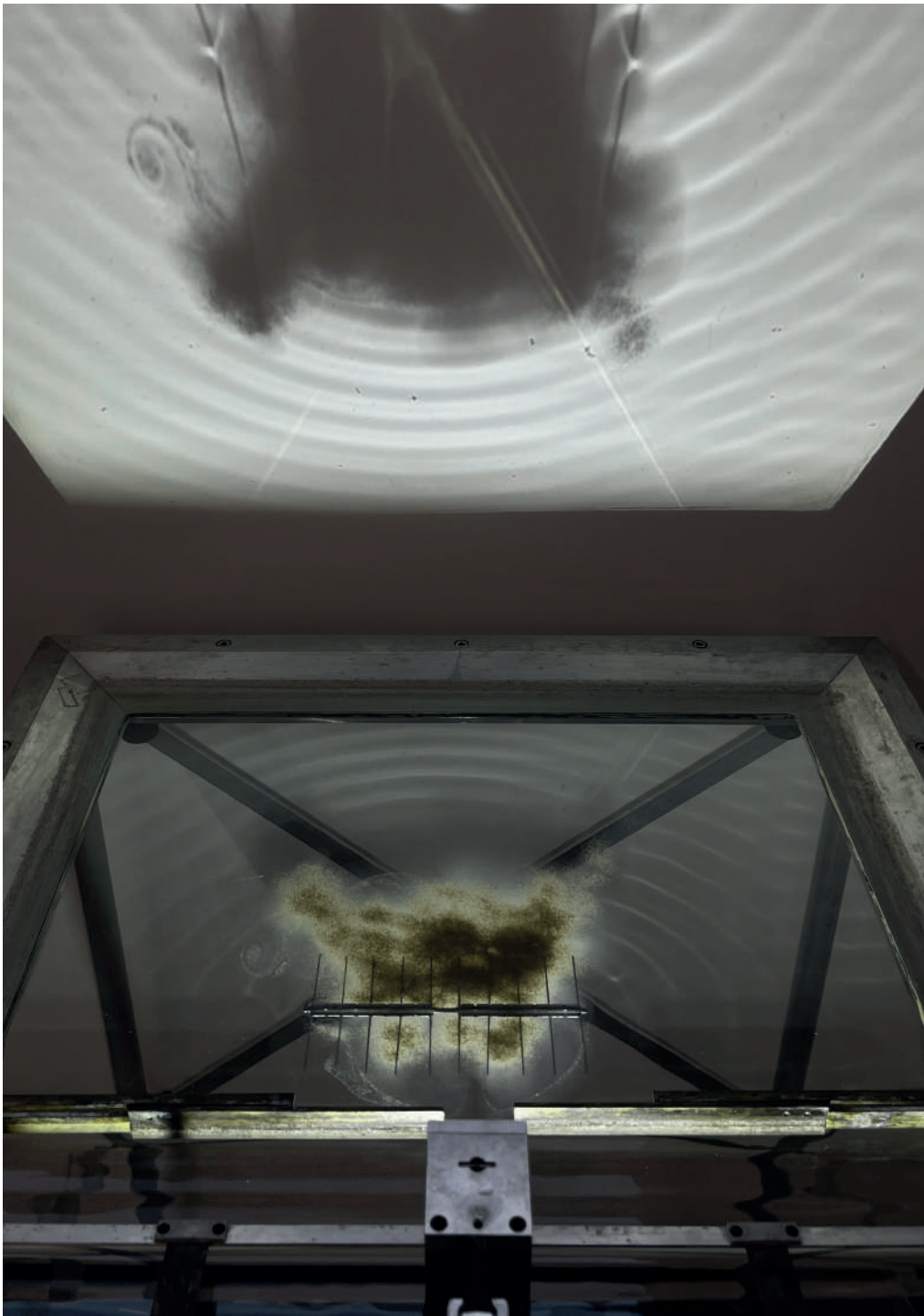


Insert Model 1: 2000 geometry of sediment catching groyne, and overall building volume

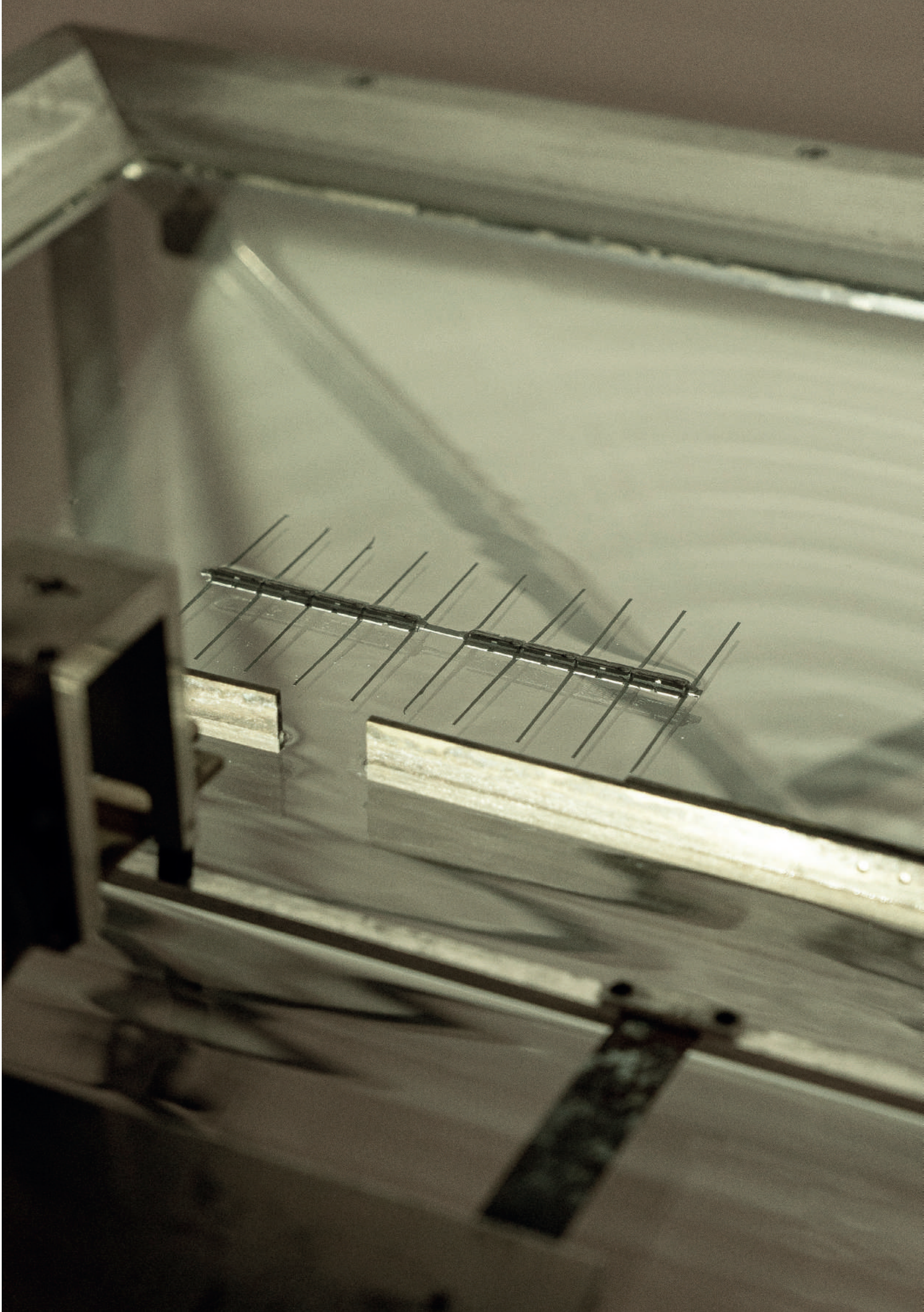


Diffraction visibly calmer areas behind the building, where sediment would most likely settle





Test with Sediment small island forming behind the building









# WADDEN GROUND

1:1

*Schlickwatt (Silt Mudflat Soil)*

*extraction site: Porrenkoog, Husum, Germany*

*date of extraction: 22.09.2022*

*amount: 60cm x 80 cm = 0,48m<sup>2</sup> soil*

*grain size 0,063 – 0,125 mm*

*high clay and silt fractions > 50 %*

*100.000 Individuals/m<sup>2</sup>, 500.000 Individuals in this box*

**The landscape of the wadden sea is a large system of sedimental flows, of mud, mud that is mostly alive. Sedimentary mudflats are washed over twice a day by the tide and fall dry between these cycles. The soils are formed by deposits of suspended organic matter that have been transported by rivers into the sea and settle in the intertidal zone. It consists mainly of broken cells, small, grated algae remains and plankton and is thus very rich in nutrients. As substrate it is very easily decomposable.**

**Up to 2,000 species live in the Wadden Sea with a total of sometimes more than 100,000 individuals per m<sup>2</sup>. The main species are mussels, snails, worms, and crabs. However, they are a food source for 1,500 species of fish, seals, whales, and crustaceans. Annually, the tidal flats are a food source and resting place for 12 million migratory birds.**

Sedimentwatten werden zweimal am Tag von den Gezeiten überspült und fallen zwischen diesen Zyklen trocken. Die Böden entstehen durch Ablagerungen von organischen Schwebstoffen, die von den Flüssen ins Meer transportiert wurden und sich in der Gezeitenzone absetzen. Sie bestehen hauptsächlich aus zerbrochenen Zellen, kleinen, zerkleinerten Algenresten und Plankton und sind daher sehr nährstoffreich.

Im Wattenmeer leben bis zu 2.000 Arten mit einer Gesamtzahl von manchmal mehr als 100.000 Individuen pro m<sup>2</sup>. Die wichtigsten Arten sind Muscheln, Schnecken, Würmer und Krebse. Sie sind aber auch eine Nahrungsquelle für 1.500 Fisch-, Robben-, Wal- und Krebstierarten, sowie jährlich ein Rastplatz für 12 Millionen Zugvögel.

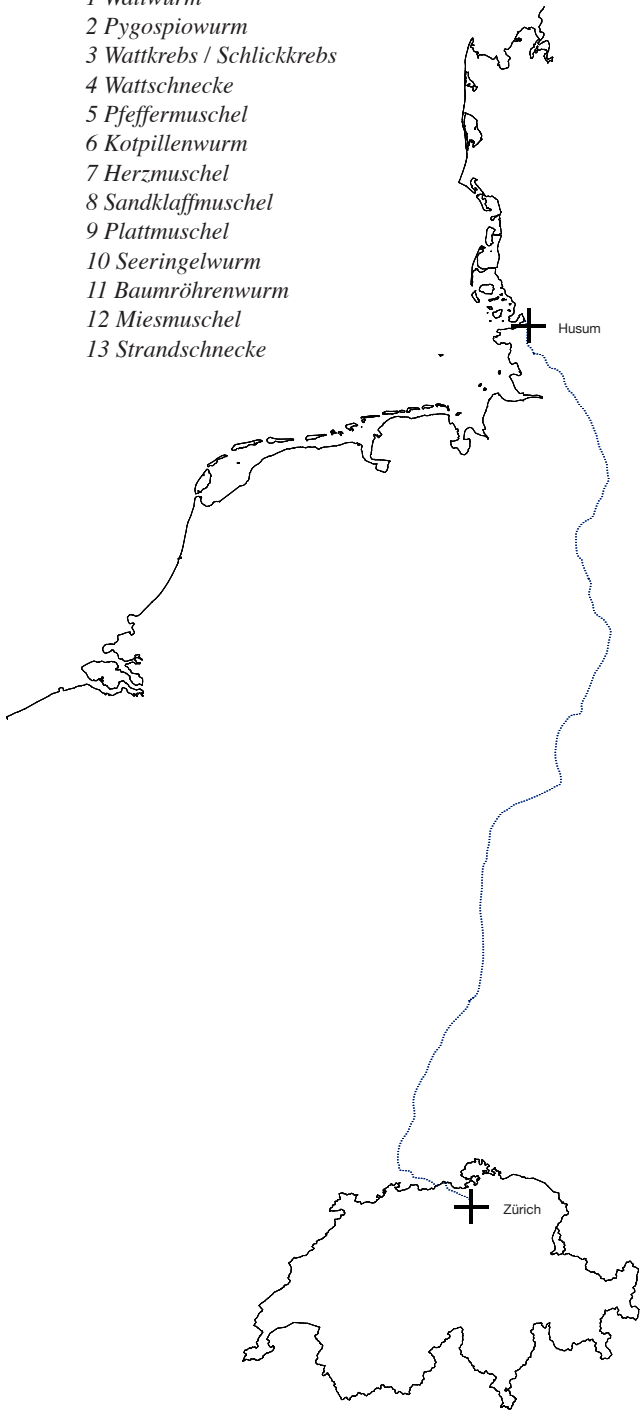




Box of Silt Mudflat Soil extracted at Porenkog Husum

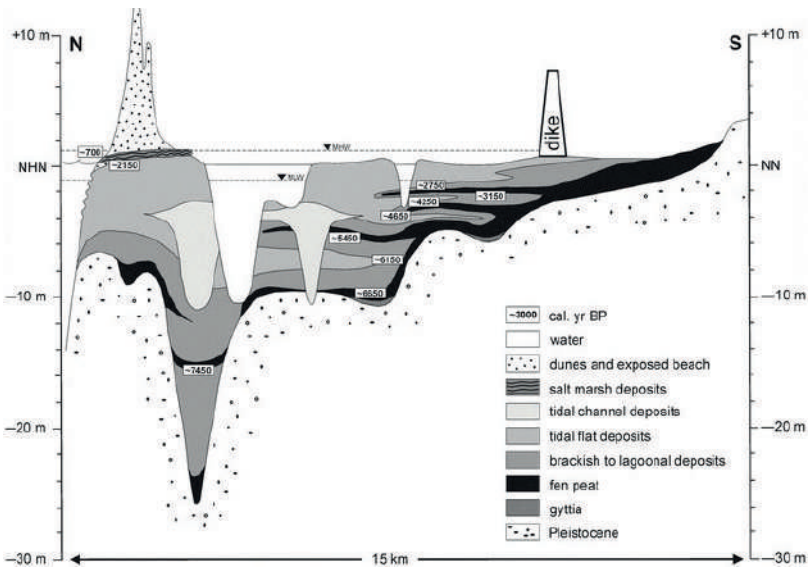
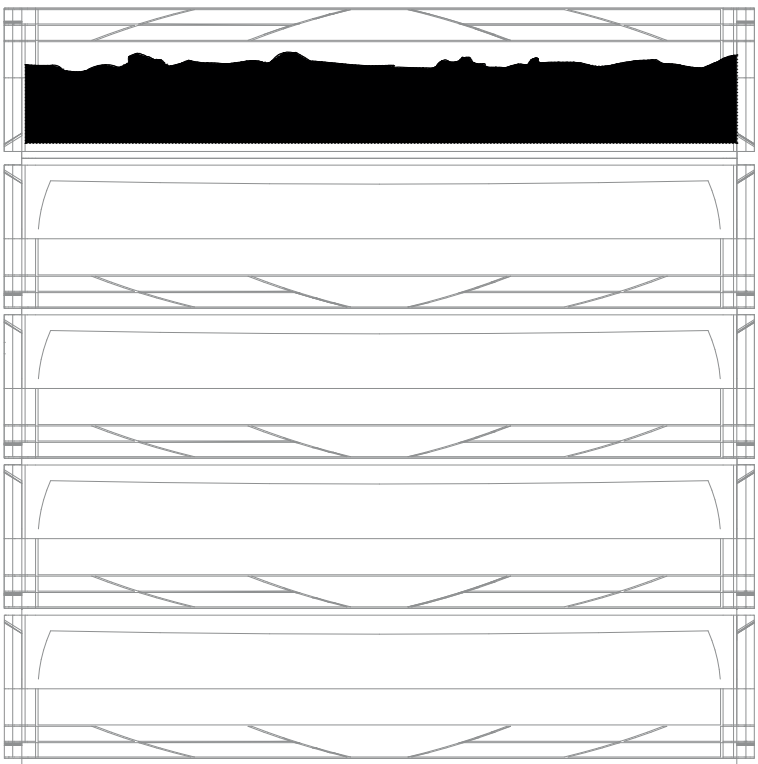
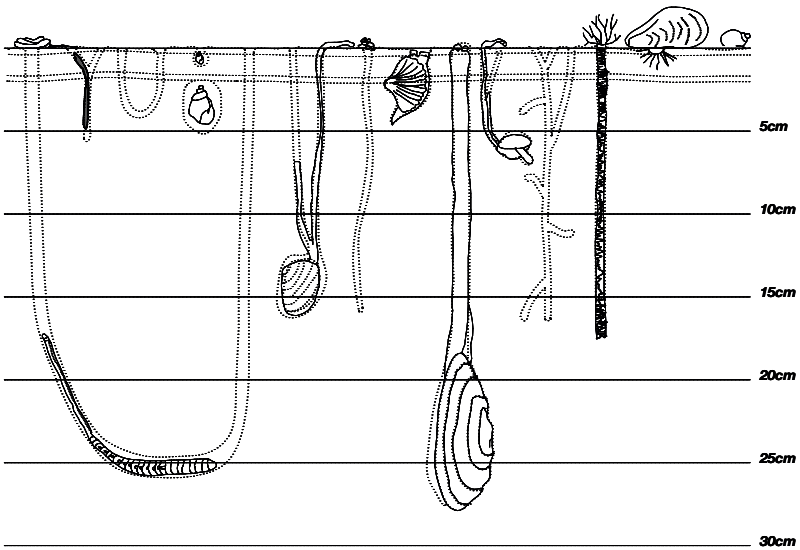
species in the box

- 1 Wattwurm
- 2 Pygospio
- 3 Wattkrebs / Schlickkrebs
- 4 Wattschnecke
- 5 Pfeffermuschel
- 6 Kotpillenwurm
- 7 Herzmuschel
- 8 Sandklaffmuschel
- 9 Plattmuschel
- 10 Seeringelwurm
- 11 Baumröhrenwurm
- 12 Miesmuschel
- 13 Strandschnecke



Husum - Zürich, 21.09.2022

Formation of soil layers in the coastal zone due to recurrent sediment deposition after flooding .















22.09.2022 site of extraction, Hussin



Transportation of northern soil to Switzerland









15.12.2022 Model Move

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**Model Process and Research**

**Free Masterthesis Architecture**  
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