Project 1: Off Grid, Surface to Air / Dungeness
Salt Garden

Design Practice 1

Studio 1

Hanaa Yakoub

The 'Salt Garden' project proposes an aparatus that harnesses and exposes Dungeness' unique conditions to manifest them in a salt- accumulation site where the structural, visual, physical and artistic qualities of salt in the landscape are spotlighted.

In response to the brief to design an aparatus to investigate an environmental parameter which can be simulated from the site, this project focuses on salinity at Dungeness (in the air, water and soil), and how this parameter is intrinsically linked to, influences, and is driven by the surroundings and environmental conditions.

The project investigates the impact of future increased salinisation of seawater at Dungeness, as well as the implications of rising sea levels.
In exploring this phenomenon and future sceneario, implications on site are explored, from flooding of the land, salt impacts on plants, changes in density and buoyancy of objects in saltier water, the changing water table after flooding, and reduced light refractivity causing alterations to the perception of the visual landscape. Structural and environmental considerations stemming from the properties of saltier water arise, and include accounting for reduced colour rendering of objects submerged in water, and the transfer of salt mass from sea to land during the formation of new salt structures.

The aparatus mediates between positions of salt from water to surface and air , and shifting states between liquid seawater, to solid salt deposition, crystalisation and buildup. Furthermore, the aparatus navigates between the physical and conceptual: from Derek Jarman's garden at Prospect Cottage to a new and evolving salt 'garden' entwined with yet new to the local landscape.

Site Plan Map of Dugneness
Aerial view of map and contour of sea

Objectives: investigating water bodies in relation to salinity
Observations and conclusions: intertidal zone identified for aparatus, aparatus connection to prospect cottage established, water bodies located and identified (inland freshwater/ saltwater)= sources of salt inland.

1km

Dungeness road
area between high and low tide
shingle
prospect cottage
my site
topography
inalnd water:
shallow water with dispersed sediment appears green
inalnd water:
clear water due to dispersed shingle, appears blue
inalnd water:
suspended mud, marshland and shingle colours the water brown
shoreline water,
salty

-14 m
-13 m
-12 m
-11 m
-10 m
-9 m
-8 m
-7 m
-6 m
-5 m
-4 m
-3 m
-2 m
-1 m
0 m
1 m

min: -26 m
max: 10 m
1m intervals between contours

Experiment on colour rendering of shingle at 5 different salinity levels in water:
Sheet 1

freshwater, current salinity levels of English channel at Dungeness, future 2070 simulating Red sea, extreme future conditions simulating Dead sea, 100% salt saturation.

Observations: High salinity = darker shingle, more mirky/ turbid water. Shingle colours changing, generally brighter to generally dimmer and darker.
Middle column showing colour tone of shingle, with average rgb composition

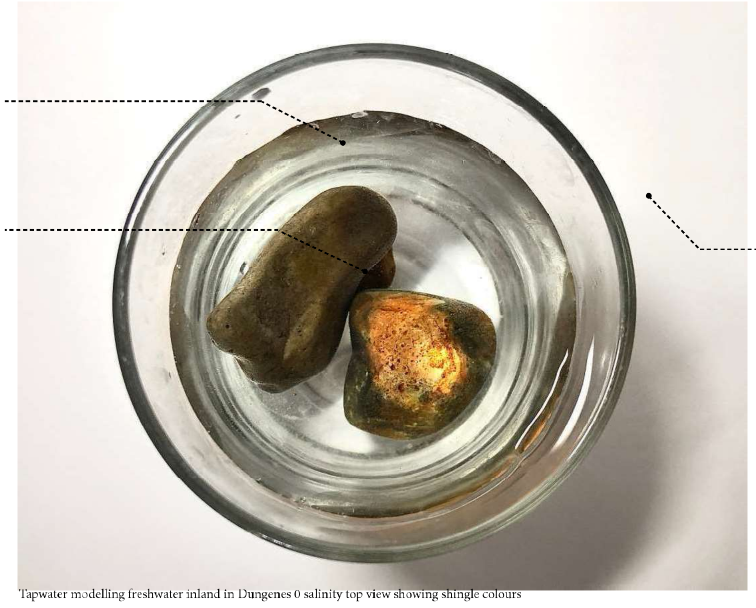
Conclusions: future saltier water will make shingle and water seem darker/ duller= a different visual landscape at Dungeness

Conditions:
Freshwater, modelling 0 salinity

Tapwater modelling freshwater inland in Dungenes 0 salinity

going down the arrow, increasing salinity in each experiment: wavelength increases, speed of light increases refractive index decreases

average colour rgb 119,99,68



Tapwater modelling freshwater inland in Dungenes 0 salinity top view showing shingle colours

Conditions:
Freshwater, modelling 0 salinity

brightest and most clear colours
good colour rendering
yellow and gold tones

Conditions:
Seawater, modelling current salinity at Dungeness

Seawater modelling current salinity of sea at Dungeness at 35ppt salt concentration modelled 5.25g salt/150ml showing shingle colours

average colour rgb 88, 70, 42

Seawater modelling current salinity of sea at Dungeness at 35ppt salt concentration modelled 5.25g salt/150ml water top view showing shingle colours

Conditions:
Seawater, modelling current salinity at Dungeness

maintaining good colour rendering, however reduced vibrancy as seen in average colour getting dimmer and darker

Conditions:
Seawater, modelling future Dungeness based on current salinity of the Red Sea

Seawater modelling salinity of sea at Dungeness for 2070 40ppt salt concentration modelled 6g salt/150ml water showing shingle colours, simulating current Red sea salt concentration due to high temperature, low precipitation and high evaporation

average colour rgb 84, 68, 43

Seawater modelling salinity of sea at Dungeness for 2070 40ppt salt concentration modelled 6g salt/150ml water top view showing shingle colours, simulating current Red sea salt concentration due to high temperature, low precipitation and high evaporation

Conditions:
Seawater, modelling future Dungeness based on current salinity of the Red Sea

steep rise in salt content corresponds to darkening colours observed in experiment

Experiment on colour rendering of shingle at 5 different salinity levels in water:
Sheet 2

freshwater, current salinity levels of English channel at Dungeness, future 2070 simulating Red sea, extreme future conditions simulating Dead sea, 100% salt saturation.

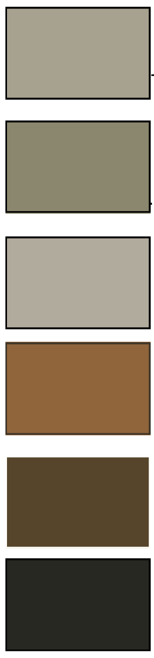
Observations: High salinity = darker shingle, more mirky/ turbid water. Shingle colours changing, generally brighter to generally dimmer and darker.
Middle column showing colour tone of shingle and water

Conclusions: future saltier water will make shingle and water seem darker/ duller= a different visual landscape at Dungeness

Conditions:
Seawater, modelling far- future atDungenes, or extreme scenario, based on current salinity at Dead sea,
observing shingle and water

Seawater modelling salinity of sea at Dungeness under extreme climate change model and extreme salt concentration increase 280ppt modelled at 42g salt/150ml water showing shingle colours, simulating current Dead sea salt concentration due to high temperature, low precipitation, high evaporation, low-lying arid desert
Snapshot modelling when salt is still unsettled, observing mirky water

observing mirkiness of water and change in colour as salinity level increases, this is due to erosive effect of salt on rocks causing them to deposit sediment in water, as well as lower refractive index of water with high salt content, causing less vibrant colour rendering



Seawater modelling salinity of sea at Dungeness under extreme climate change model and extreme salt concentration increase, 280ppt modelled at 42g salt/150ml water showing shingle colours, simulating current Dead sea salt concentration due to high temperature, low precipitation, high evaporation, low-lying arid desert, top view
Snapshot modelling when salt is still unsettled, observing mirky water and salt patterns and movement

Conditions:
Seawater, modelling far- future atDungenes, or extreme scenario, based on current salinity at Dead sea,
observing shingle and water

before settling, turbid water and salt patterns observed
high turbidity and low visibility

Conditions:
Seawater, modelling far- future at-Dungenes, or extreme scenario, based on current salinity at Dead sea
Water focus

Seawater modelling salinity of sea at Dungeness under extreme climate change model and extreme salt concentration increase 280ppt modelled at 42g salt/150ml water showing shingle colours, simulating current Dead sea salt concentration due to high temperature, low precipitation, high evaporation, low-lying arid desert
Photograph when salt is still settled, observing clearer water

Seawater modelling salinity of sea at Dungeness under extreme climate change model and extreme salt concentration increase, 280ppt modelled at 42g salt/150ml water showing shingle colours, simulating current Dead sea salt concentration due to high temperature, low precipitation, high evaporation, low-lying arid desert, top view
Photograph when salt is still settled, observing clearer water and salt depostition patterns

Conditions:
Seawater, modelling far- future at-Dungenes, or extreme scenario, based on current salinity at Dead sea
Water focus

settled water gives rise to higher clarity, yet still dark shades of pebbles

Conditions:
Seawater, modelling far- future at-Dungenes, or extreme scenario, based on current salinity at Dead sea
Water focus

Conditions:
Seawater, modelling far- future at-Dungenes, or extreme scenario, based on current salinity at Dead sea
Water focus

Seawater modelling maximum salinity of sea at Dungeness under 100% salt concentration conditions at 380ppt modelled at 57g salt/150ml water showing shingle colours, simulating salt-saturated water body, e.g. in salt manufacturing equatorial locations experiencing high evaporation and 0 precipitation
Observing visual impact of max. salt

Seawater modelling maximum salinity of sea at Dungeness under 100% salt concentration conditions at 380ppt modelled at 57g salt/150ml water showing shingle colours, simulating salt-saturated water body, e.g. in salt manufacturing equatorial locations experiencing high evaporation and 0 precipitation, top view
Observing visual impact of max. salt

Final experiment of maximum salinity and saturated solution.
Non realistic scenario, however interesting observations
high water turbidity
erosion of shingle, release of

Experiment on shingle in salty water

Setup: shingle in saturated solution of salt and water, 57g salt/ 150 ml water, flipping on unexposed side and drying.
Objectives: investigate impact of shingle shape and form on salt deposition and accumulation patterns. This is to anticipate future scenarios at Dungeness with saltier sea/ inland water due to climate change and the impact on shingle.
Observations and Conclusions: intereseting patterns on side rested on surface.
Conclusions: It's important to consider appratus form design to maximise accumulation, e.g. design for large contact area between two surfaces to generate interesting accumulation patterns.

Shingle rotated on second seide ad dried, salt deposition visible dried at surface, new patterns emerging due to impressions from salt resting on desk surface before drying

Observing coffee ring effect: a result of different rates of evaporation on the top and at the edge of droplets, leading to a flow inside the droplet that drives an accumulation of solid particles at the edge, and the droplet edge retracts, leaving a deposited ring.
The differential evaporation rates across the drop mean that liquid evaporating from the edge is replenished by liquid from the interior, with an edgeward flow carrying most material to the edge, causing acceleration of the edgeward flow during the drying process.

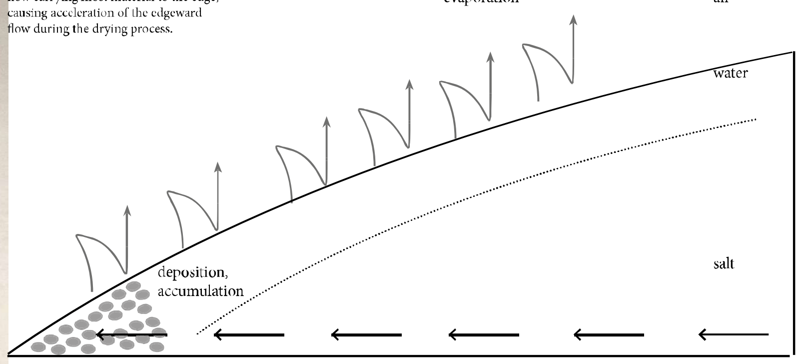


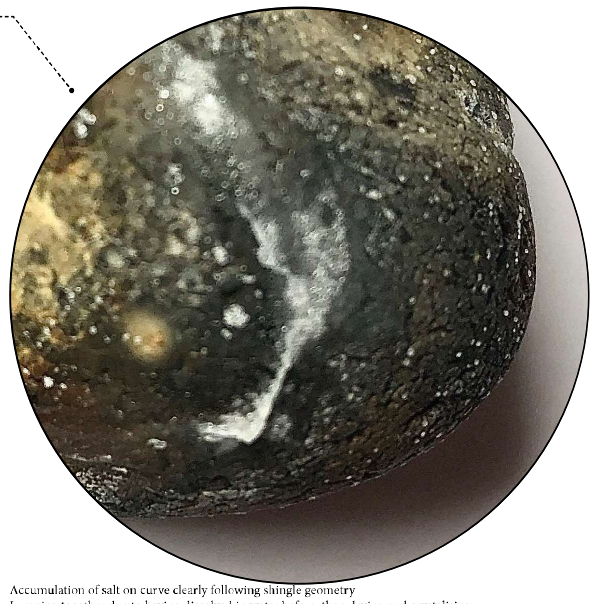
Diagram of Coffee ring effect

Shingle 1- light gray, larger surface area, flatter and smoother surface, second side flipped and dried

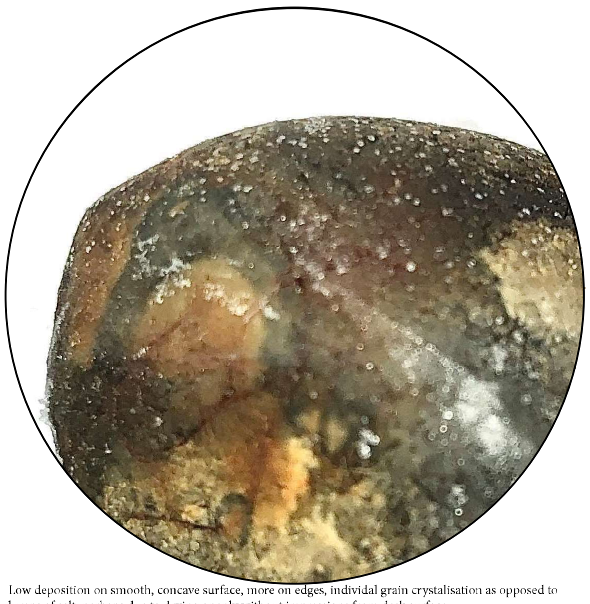
High deposition on protruding corner in contact with surface before flipping, curve pattern forming

Similar high deposition and crystalisation on edge

Shingle 2- rounder, brown/red colour, more textured, second side flipped and dried



Accumulation of salt on curve clearly following shingle geometry
Lumping together due to having dissolved in water before, then drying and crystalising



Low deposition on smooth, concave surface, more on edges, individal grain crystalisation as opposed to lumps of salt, perhaps due to drying openly without impressions from desk surface

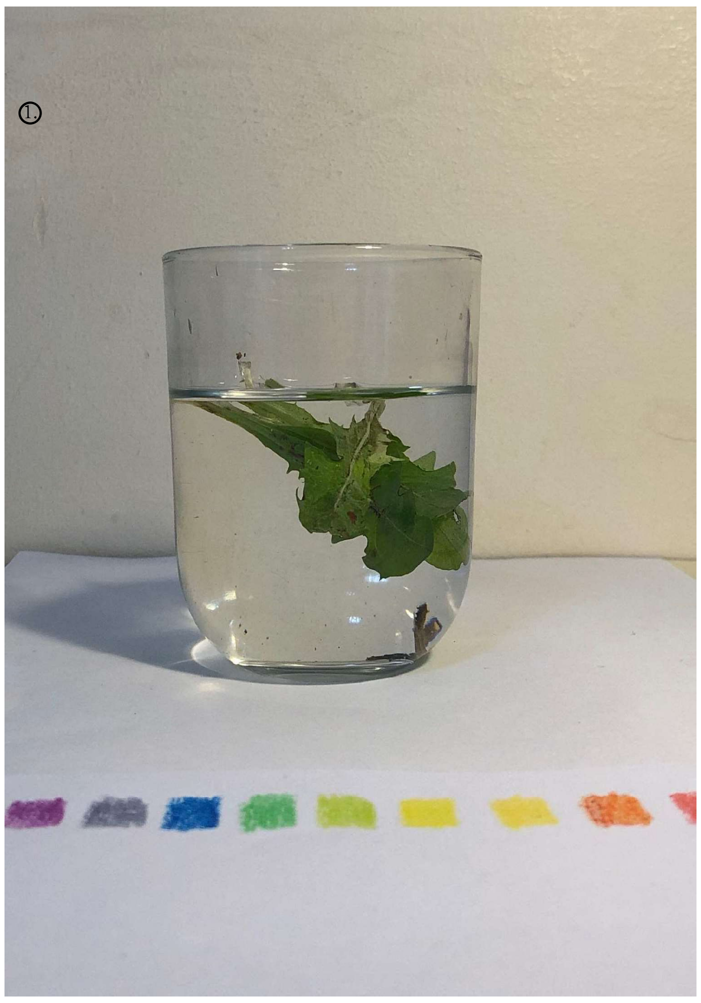
Shingle 3- smaller, smoother curves, second side flipped and dried

Low deposition on flat surface with no curves

Swirl pattern of salt deposition

Experiments on Leaves under 3 salinity conditions: freshwater, current sea-water at Dungeness and saturated saltwater

Objectives: investigate colour, shape and buoyancy properties of leaves based on waterbath salinity variations. This is to investigate properties of modelled future scenarios at Dungeness with saltier sea/ inland water due to climate change.
Observations and Conclusions: as salinity increases: leaf colours are dimmer/ rendered less vibrantly, leaves float higher/ are more buoyant, leaf shape changes and curls up more
Aparatus that harnesses saltwater will have denser and saltier water than current seawater, and foilage/ plants at Dungeness flooded with water (e.g. Derek Jarman's garden) will apper dimmer, will float at surface, and will have varied/distorted shapes/ shrivelling up.

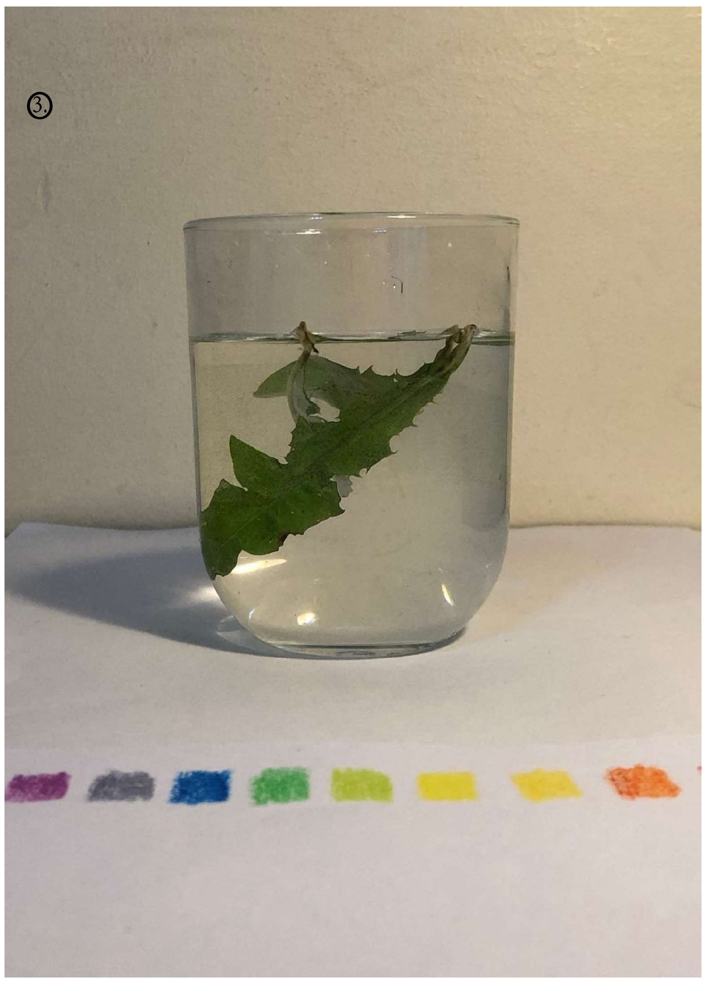


Tapwater, no added salt

freshwater simulation

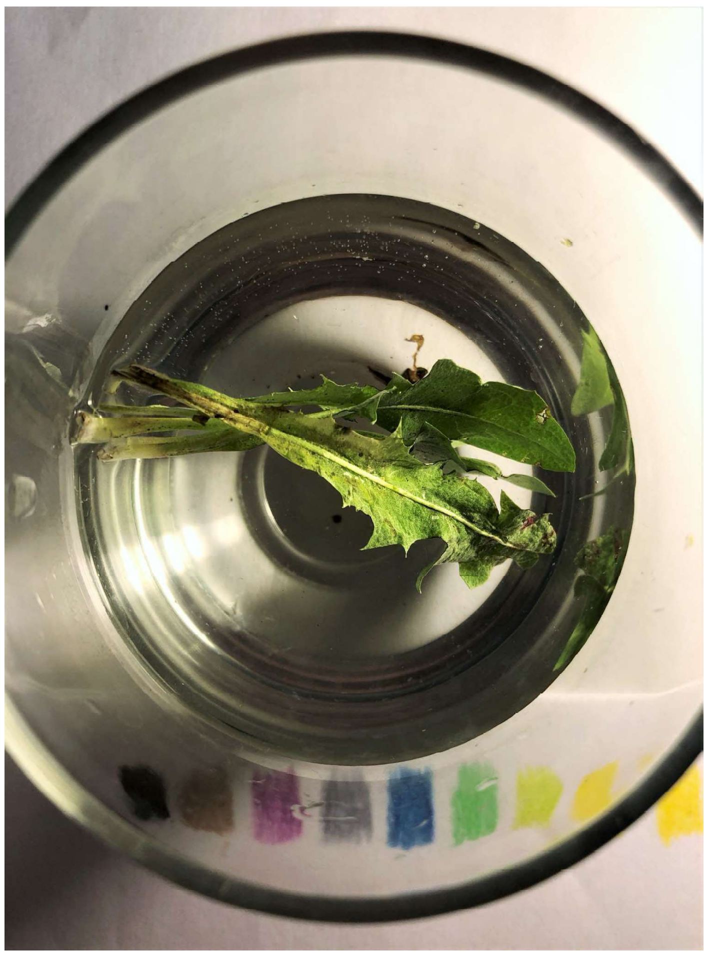
Seawater 35ppt salt

current seawater saliity level simulation



Saturated water, 357ppt salt

maximum salt saturation of sea



Top view

Salinity impact on plants experiment

Objectives: investigate salt impact on leaves (modelling greenery at Dungeness and Jarman's garden) after submerging in saltwater and letting dry.

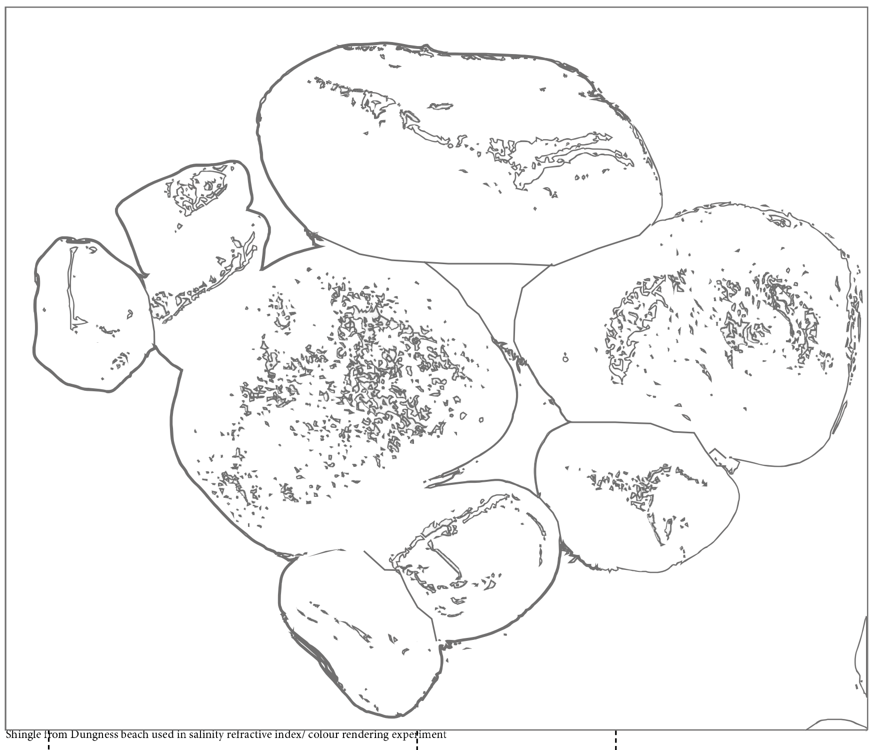
Observations : salt crystalisation on leaves causes a change in texture, colour, drying out, shrinking, decay, flaking off, weakening of structure, higher fragility.

Conclusions: Derek Jarman's garden/ surrounding greenery at Dungeness will be severely impacted in future climate scenarios due to rising sea levels and flooding, as well as increased salinity of water. Plants also a site for interesting salt crystals and structures to accumulate; a salt garden within a garden.

Observation of shape change, curling and shrinking of leaves due to high salinity and water loss

Observation of salt accumulation and crystallisation patterns on leaves

Experiment setup for experiment on colour rendering of shingle at 5 different salinity levels in water: freshwater, current salinity levels of English channel at Dungeness, future 2070 simulating Red sea, extreme future conditions simulating Dead sea, 100% salt saturation.



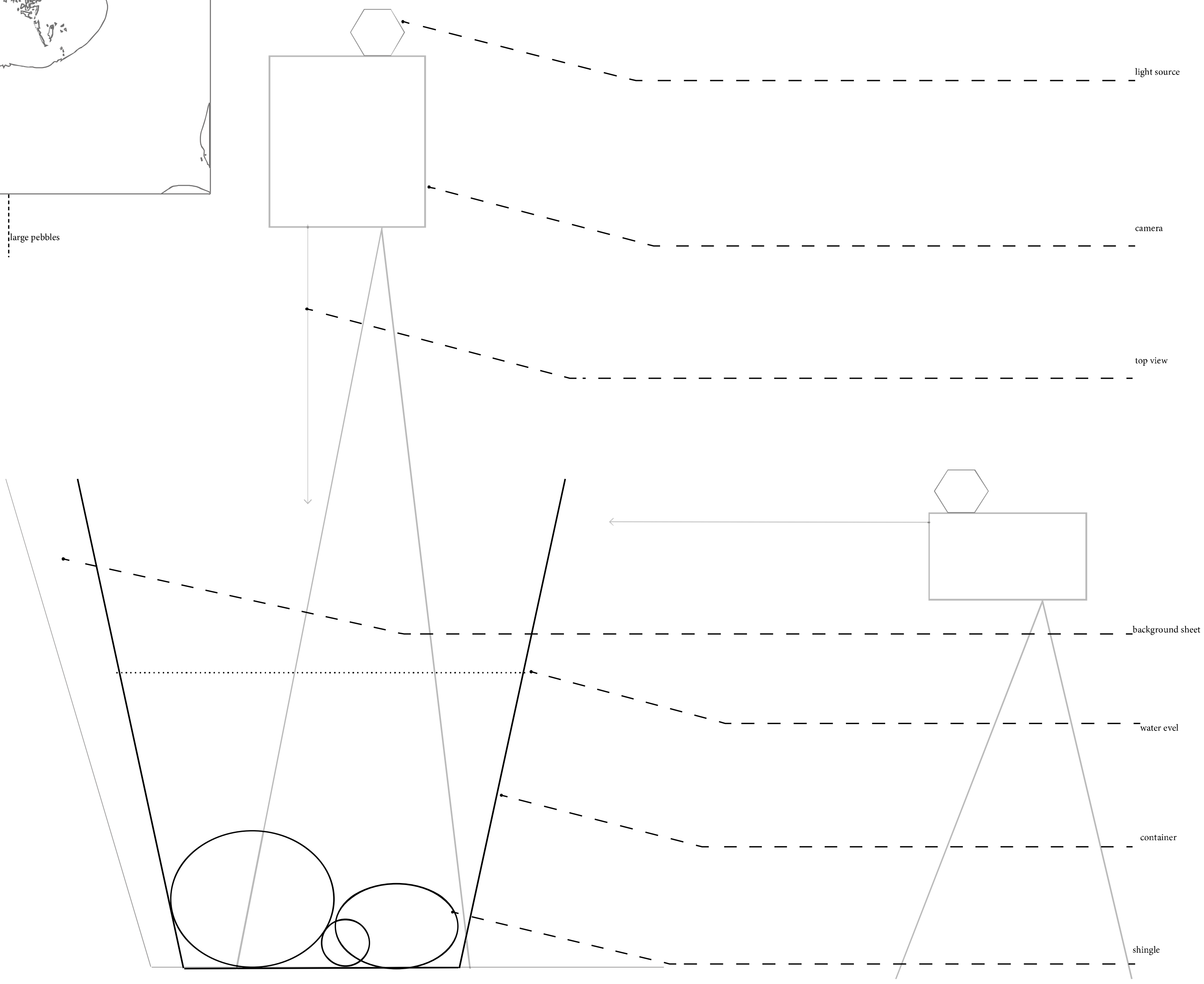
Shingle from Dungness beach used in salinity refractive index/ colour rendering experiment

small pebbles

medium pebbles

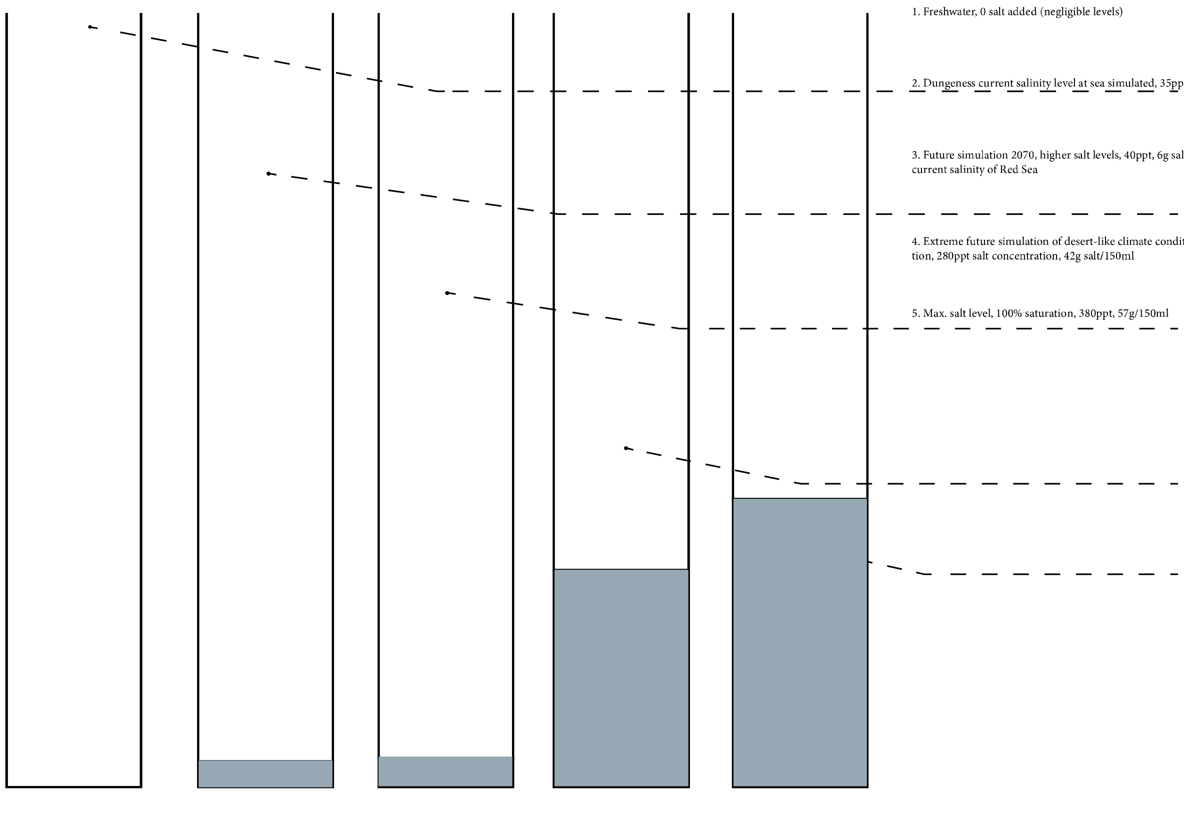
large pebbles

Control variables guaranteeing true results observed
150ml fixed volume of water,
tapwater 7C temperature, same
container, same shingle, fixed
camera exposure and lighting settings



Experiment setup including beaker, shingle of 3 sizes, tripod and camera setups for plan and elevation views, background sheet, lighting, water level

150ml fixed water volume
and same container



Salt conditions setup:
Gradual addition of salt starting with scenario 1 and ending with scenario 5, documentation, photography and observation at each stage

1. Freshwater, 0 salt added (negligible levels)

2. Dungeness current salinity level at sea simulated, 35ppt, 5.25g/150ml water

3. Future simulation 2070, higher salt levels, 40ppt, 6g salt/150ml water, simulatig current salinity of Red Sea

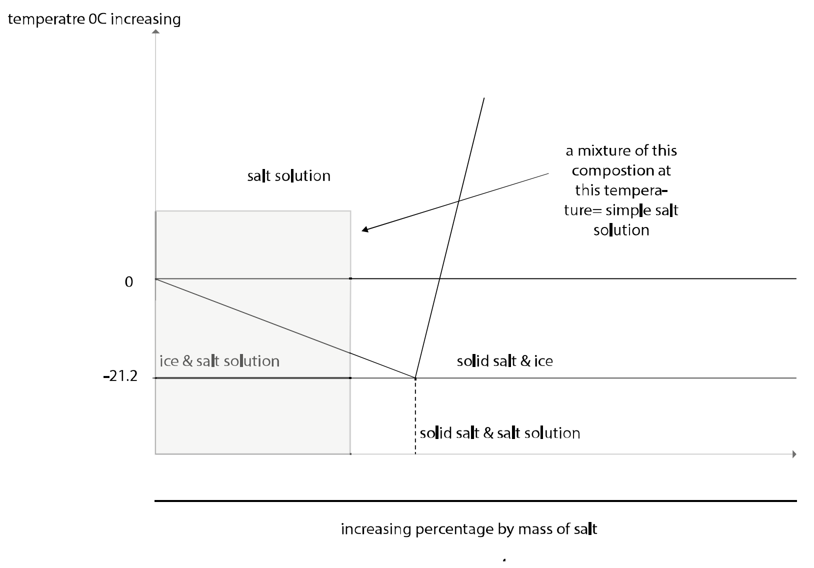
4. Extreme future simulation of desert-like climate conditions, Dead sea salnity simulation, 280ppt salt concentration, 42g salt/150ml

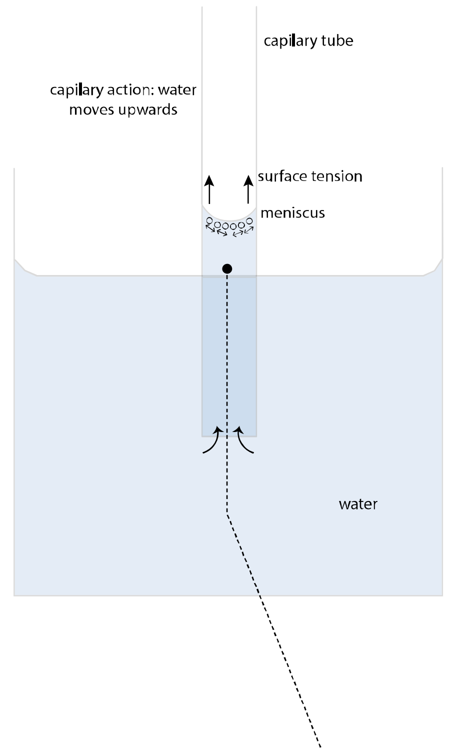
5. Max. salt level, 100% saturation, 380ppt, 57g/150ml

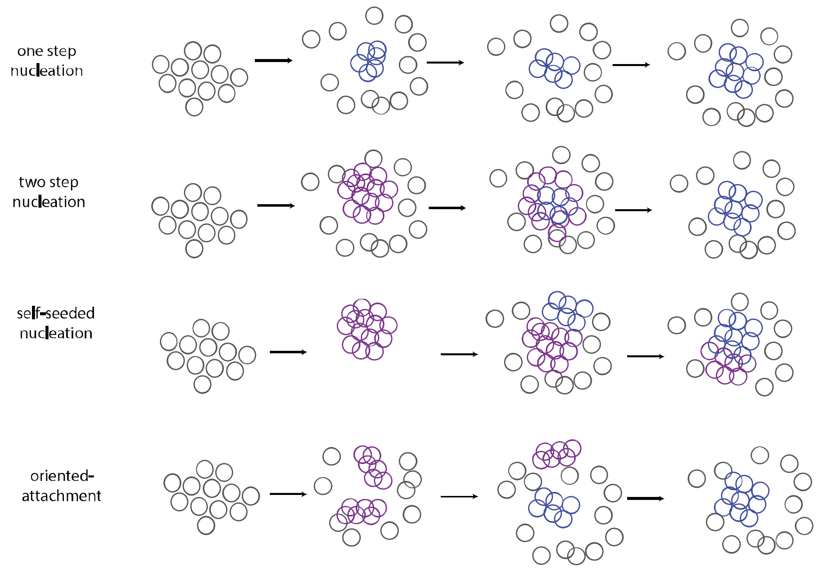
Research Salt Crystal Growth and Capilary Action

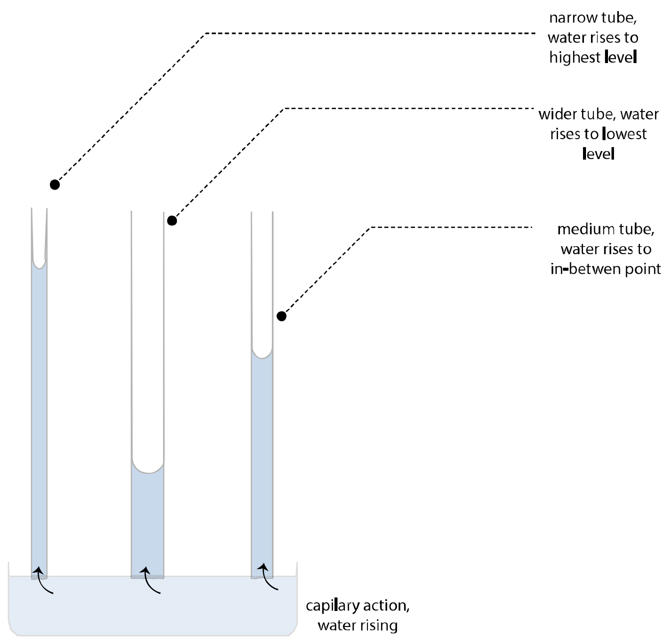
Objectives: investigate structural and practical solutions for apparatus: different uses and setups of capilary action method to draw up water, research into salt saturation and impacts, salt crystal growth understanding

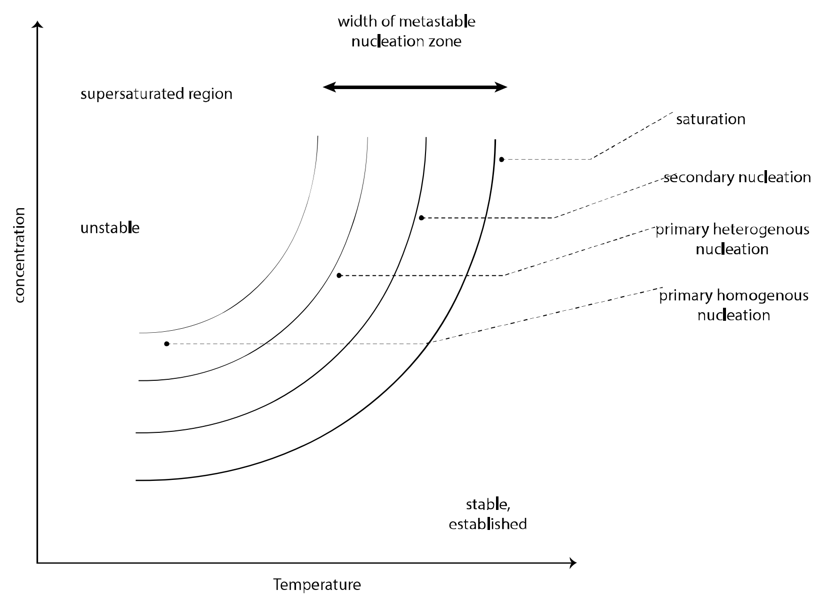
Conclusions: understanding salt crystalisation process, planning max. water suction through capilary action by having small tube diameters and high RH (predicted in future climate scenario at Dungeness)

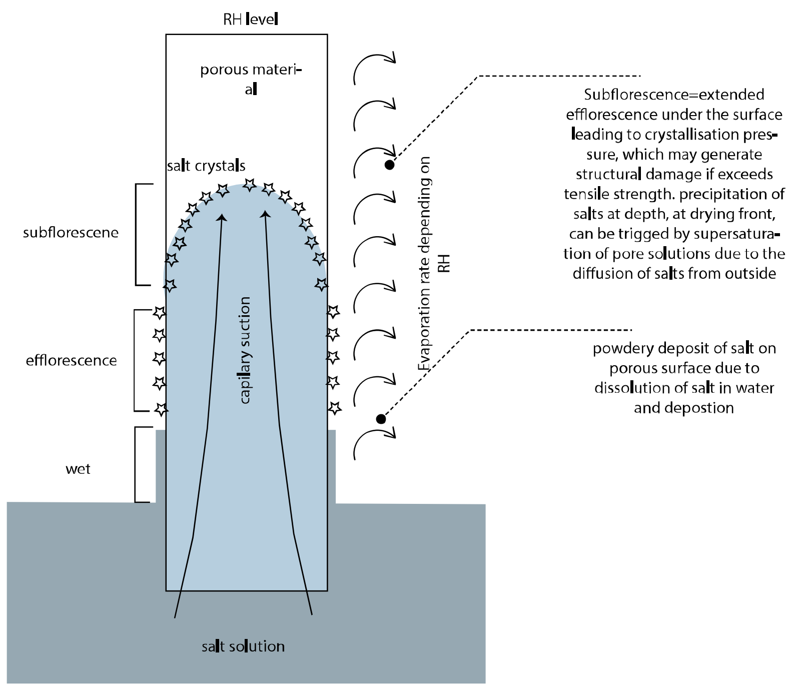










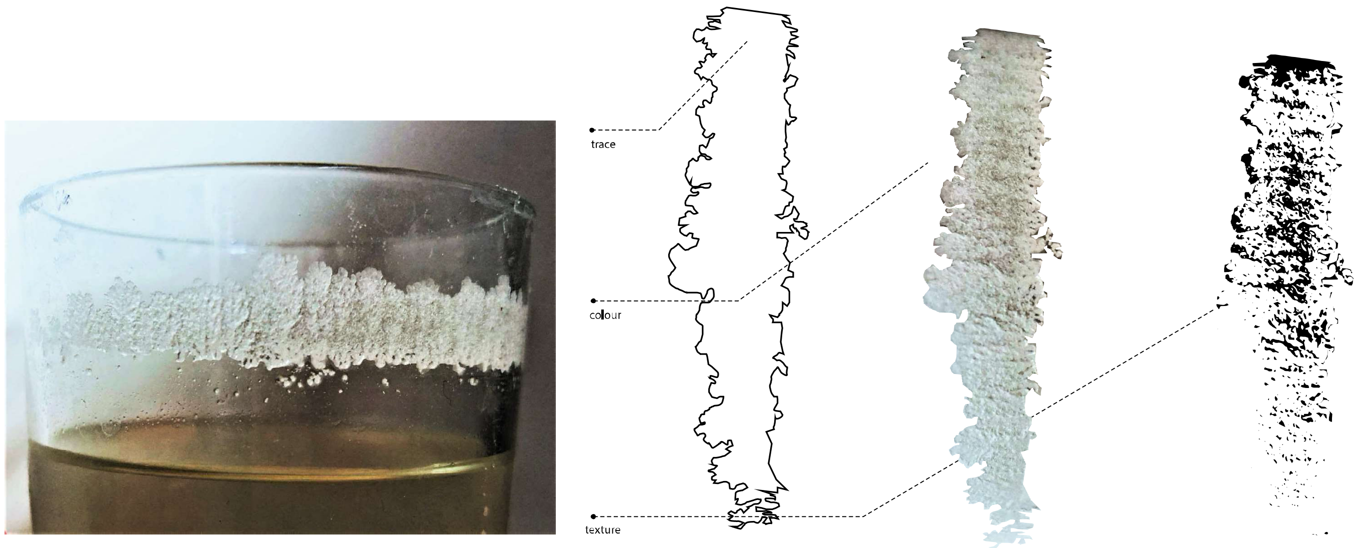


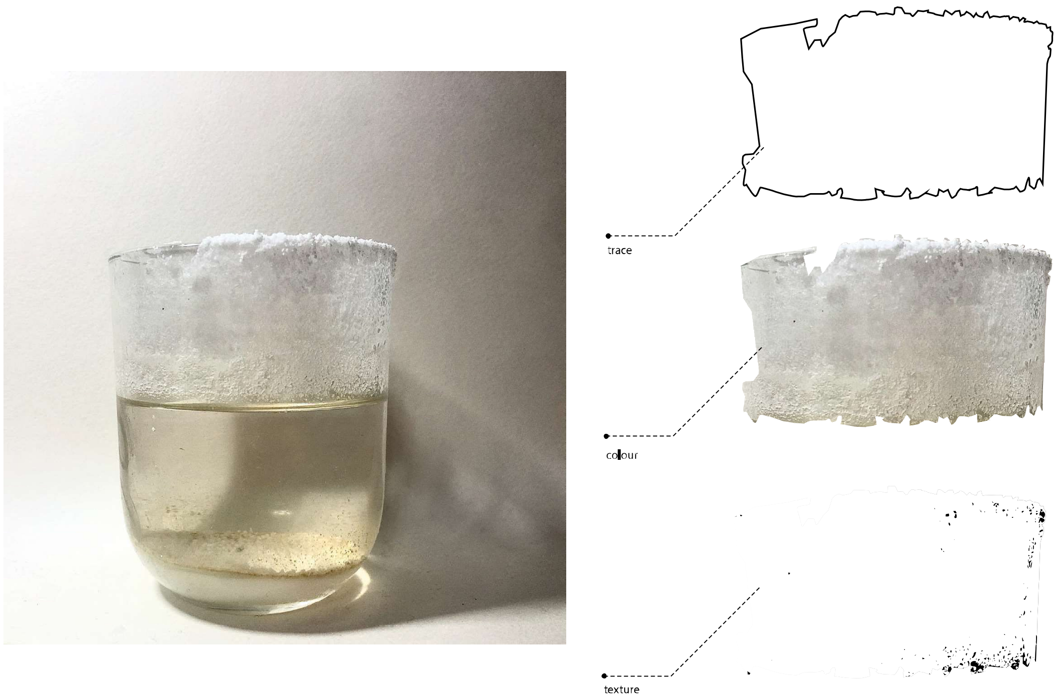
Apparatus form-finding

Method: using deposited salt structures observed in salt experiments and finding and tracing patterns/ silhouettes/ interesting shapes.

Observations: variety of textures, shapes and patterns found due to using salt crystals from various stages in deposition process, e.g. thin layer from little evaporation and thick patterns from weeks of drying.

Conclusions: using shapes with most interesting forms to make 3D preliminary models.

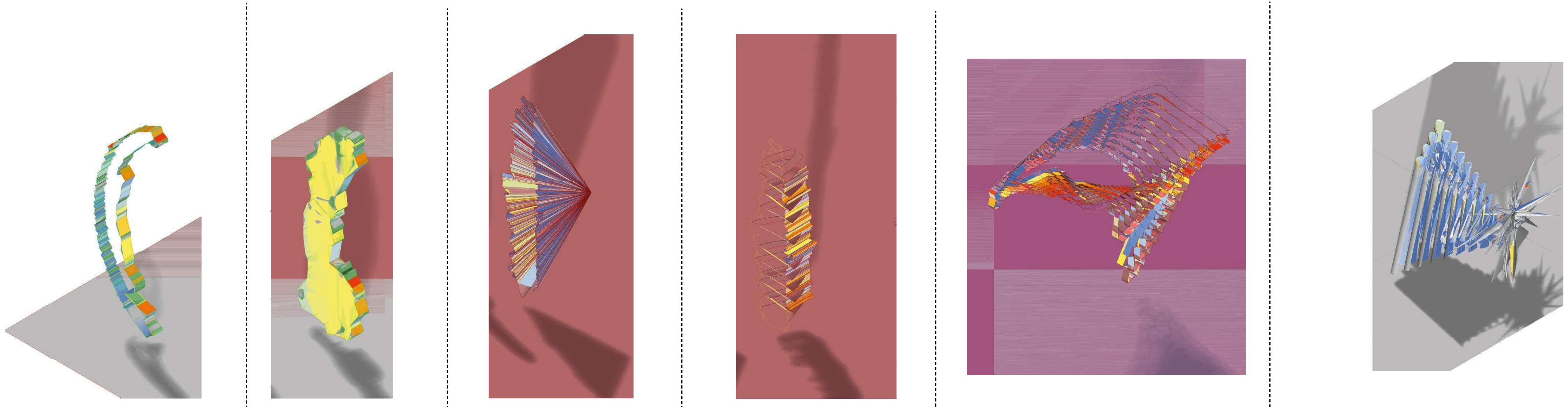




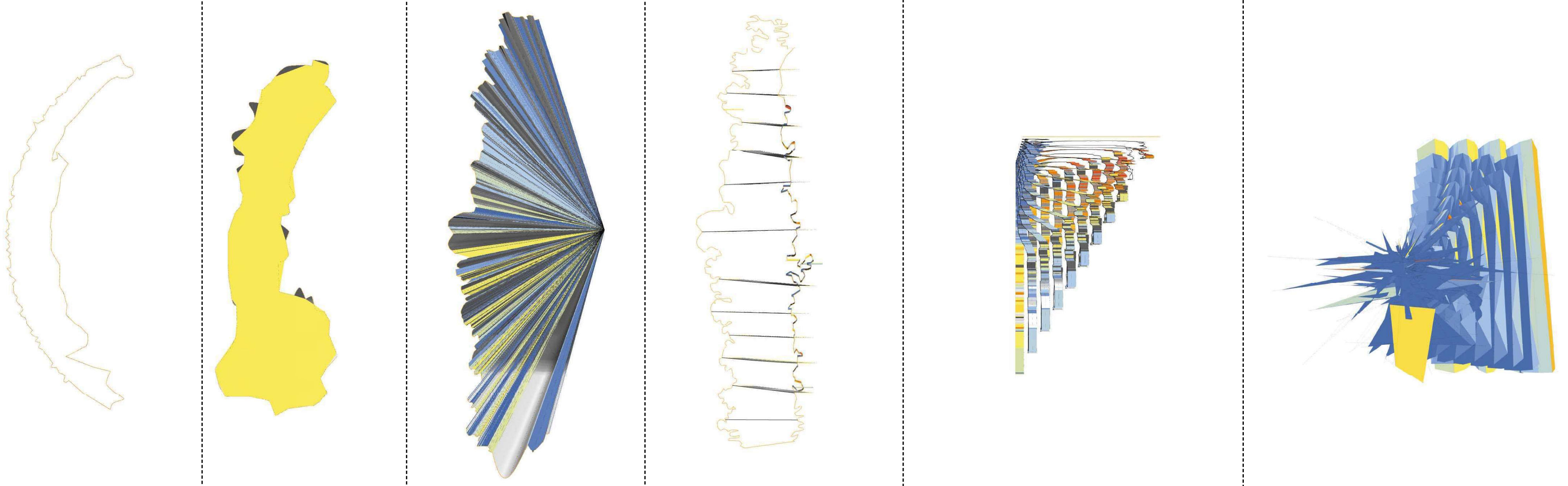
Irradiance comparisons on different structures

Through the month of June- (as concluded to be optimal in environmental analysis)

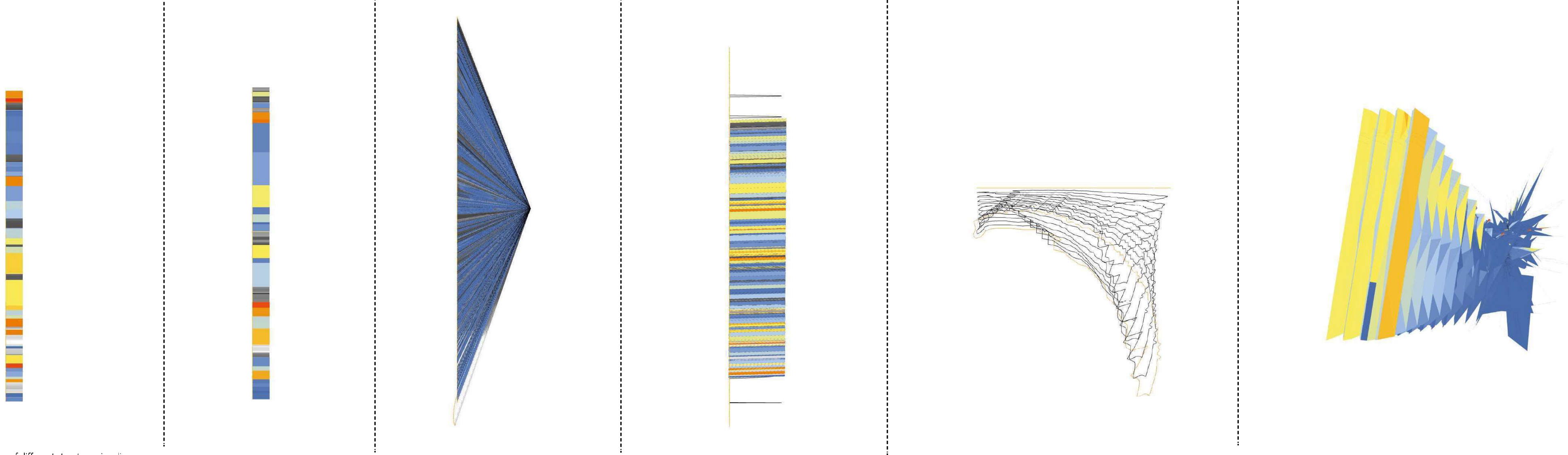
Asessing different types of structures, in terms of densities, textures, and surface areas to find optimal solution with high irradiance, which promotes evaporation and salt accumulation
variety of structure types include wireframe, extrucsions, layered extrusions and layered solid structures



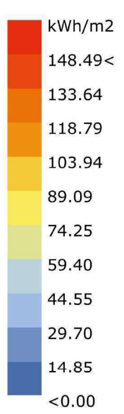
isometric vew of different structures, irradiance analysis.
Observations: highest irradiance on top surfaces and around crevices and contours in the structure as seen in image 3



Right elevation vew of different structures, irradiance analysis.
Observations: highest irradiance on solid- extruded structures as opposed to wireframe as seen in model numbers 5,6



Front elevation vew of different structures, irradiance analysis.
Observations: highest irradiance on highly textured structures as seen in models 1,2,4



Irradiance levels (kWh/m2) at Dungeness
1 Jun- 30 June

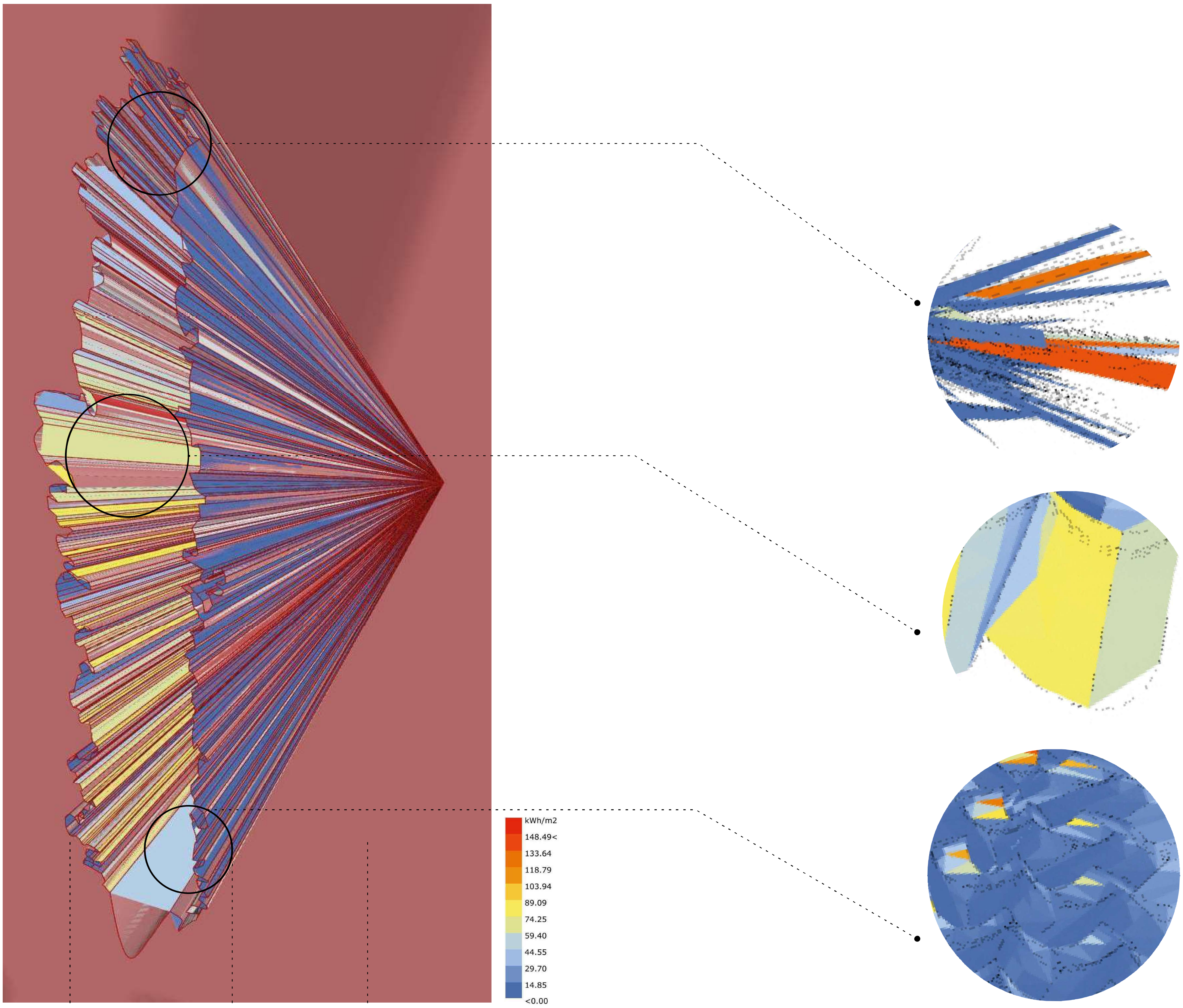
Overall observations:
highest irradiance on around crevices and contours, on solid extrusions as opposed to wireframe, on highly textured structures

Irradiance on one structure

Through the month of June- (as concluded to be optimal in environmental analysis)

Close up view and analysis of high irradiance structure to use for apparatus

Used to inform further iterations



Focus on one structure, close up on irradiance at different points
observations: large S.A. to volume ratio in high irradiance areas,
lower in larger, less textured surfaces

Structural Considerations

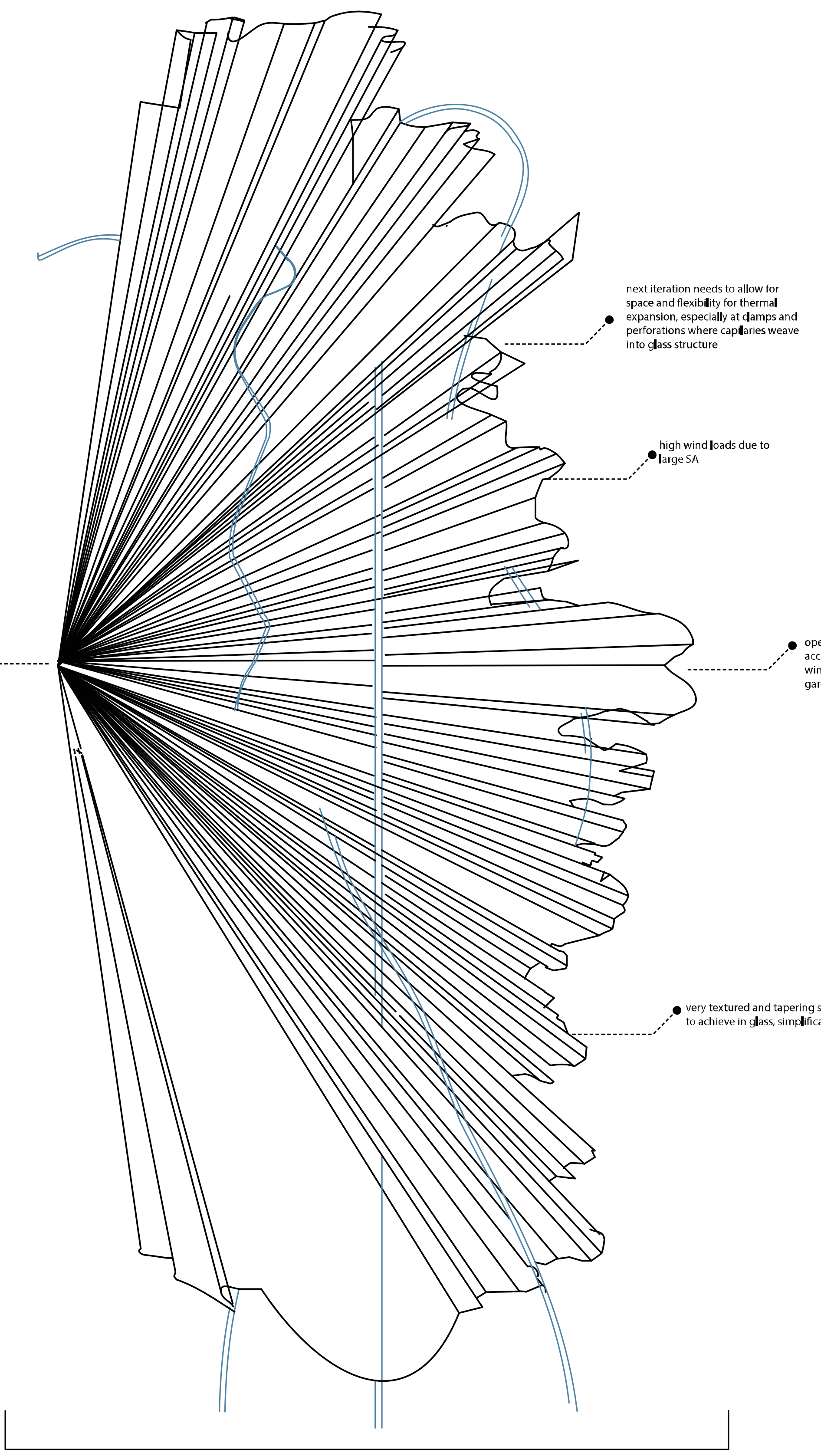
	high texture	high density	high surface area
✓	large potential for clamping, bracing, weaving in capilary tubes	generally higher strength	lower contact stress
✗	material and manufacturing limitations	higher self weight, potentially problematic; higher pressure on soil and larger contact stress	susceptible to higher wind loads and uplift force

Development of Glasas structure

first iteration

vol=0.03m^3
mass=375kg

strength=1000N/mm2
=1GPa
larger SA: volume ratio

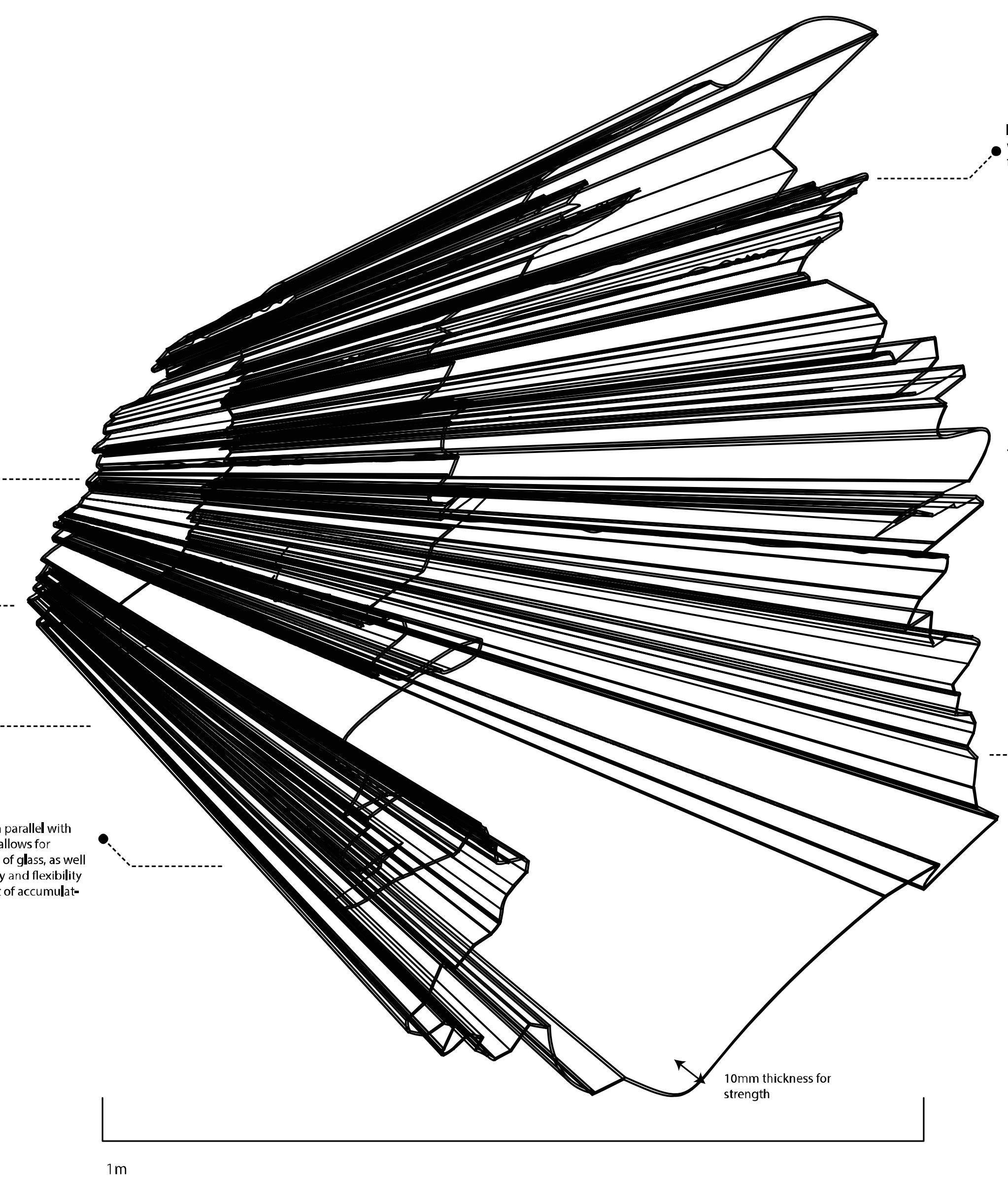


Second iteration

S.A. 35.766m^2
Volume 0.35766m^3
Thickness 10mm
Mass 894.14325kg

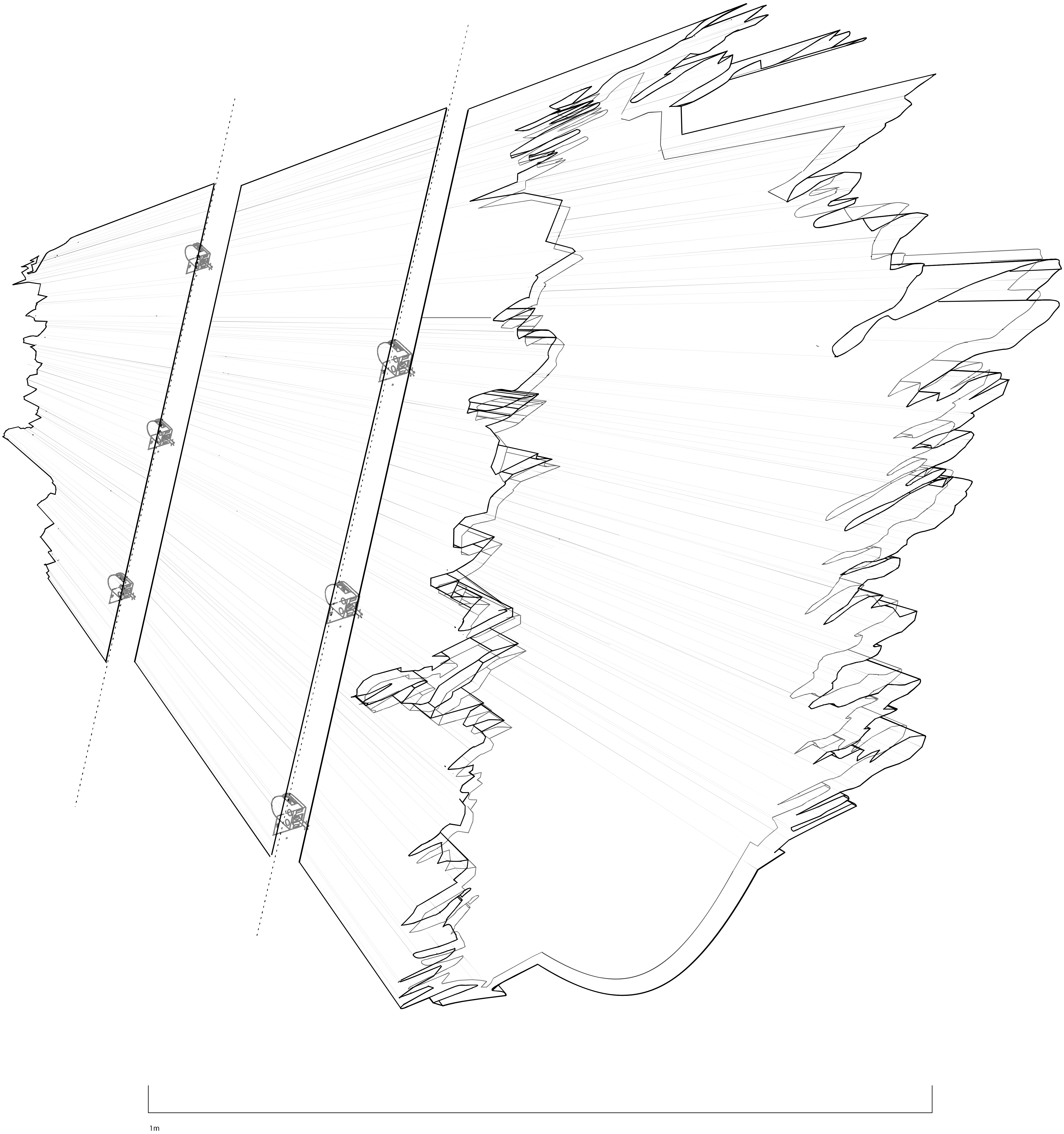
smaller surface area to volume ratio

lower wind loads



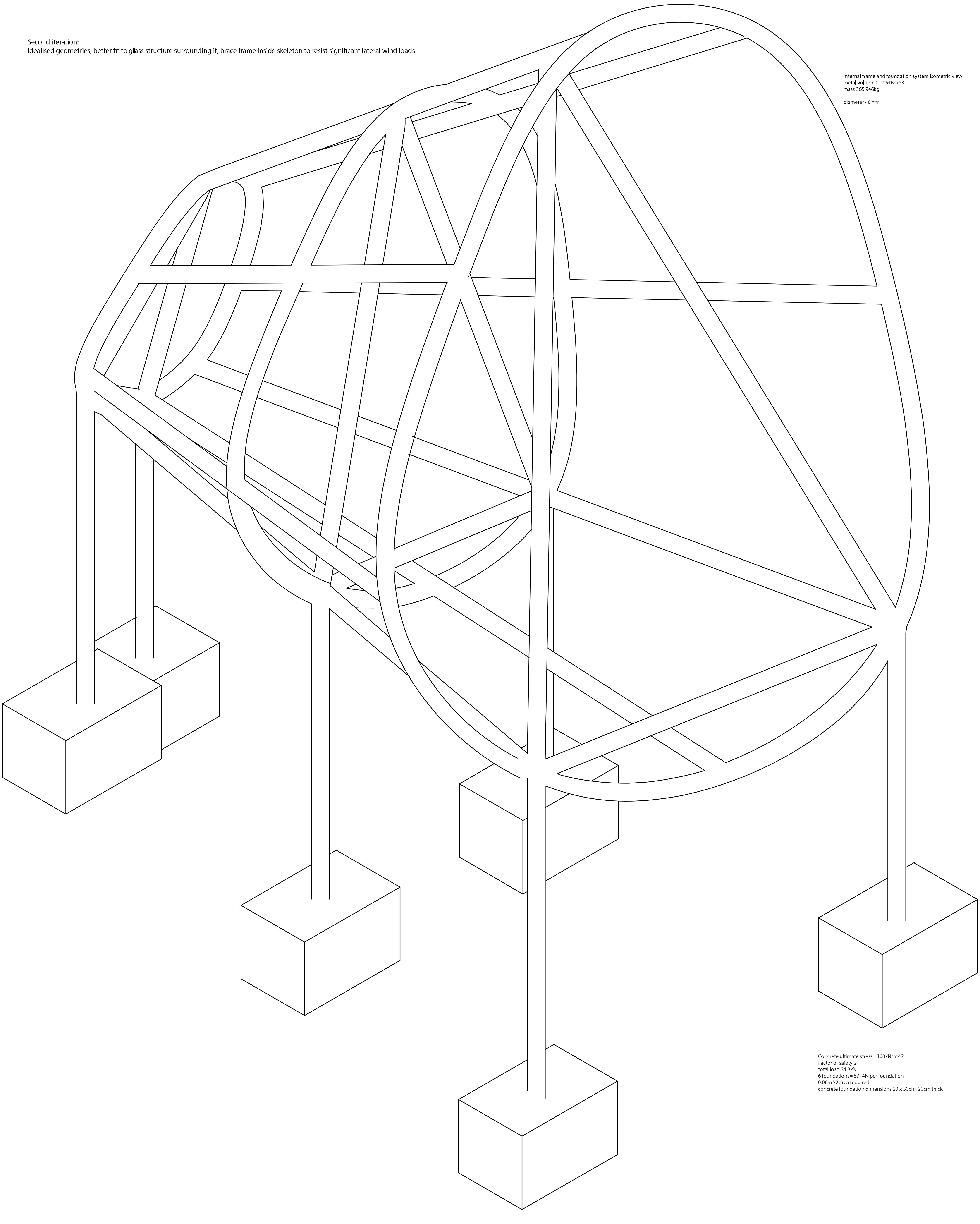
Development of Glasas structure

Third iteration
3 panels to support self weight
expanding clamps to allow for heat expansion and increasing self weight and volume from deposited salt



Internal skeleton frame and foundation system

Second iteration:
Idealised geometries, better fit to glass structure surrounding it, brace frame inside skeleton to resist significant lateral wind loads



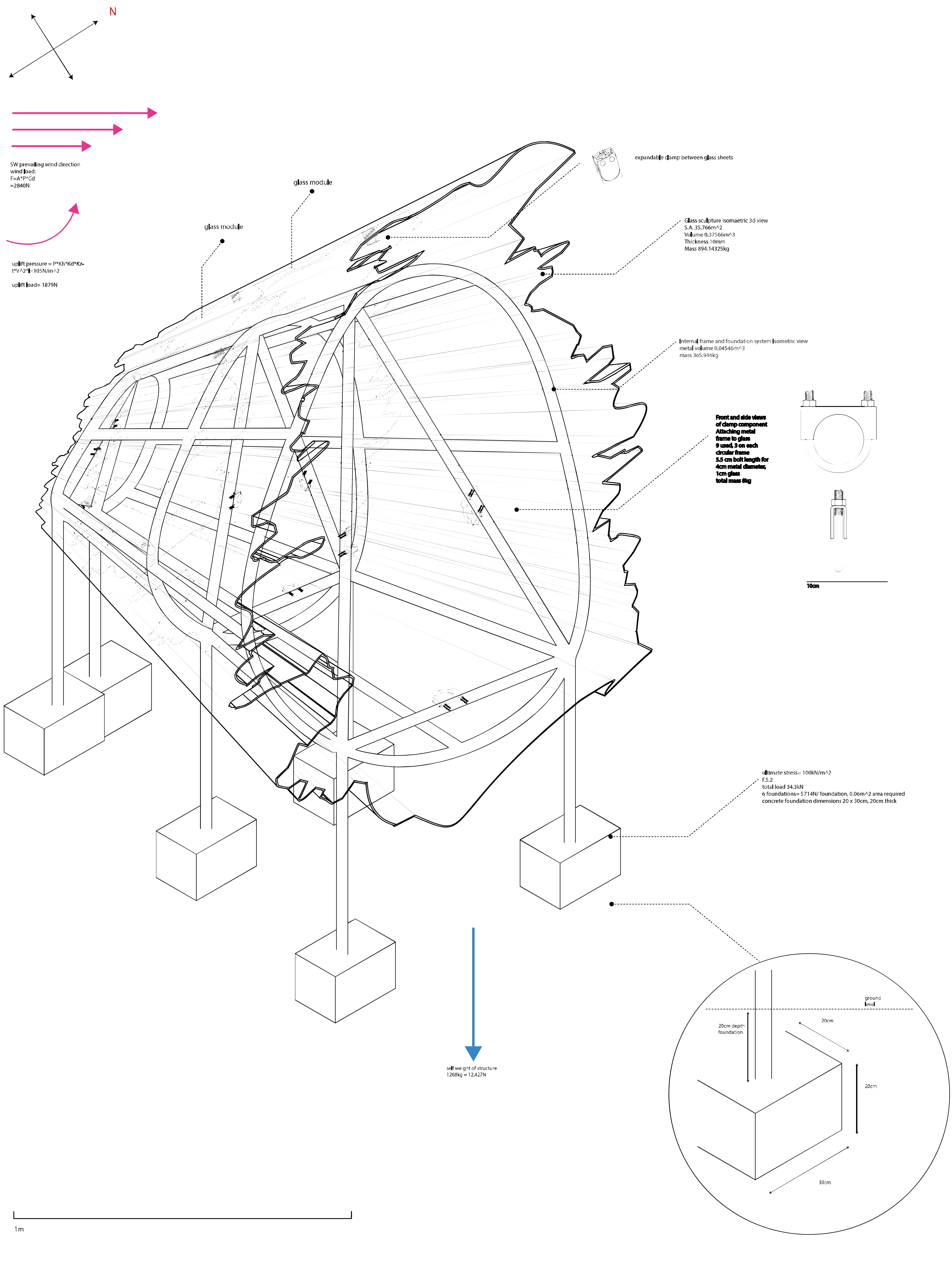
Internal frame and foundation system Isometric view
metal volume 0.04546m^3
mass 365.946kg

diameter 40mm

Concrete ultimate stress= 100kN/m^2
Factor of safety 2
total load 34.3kN
6 foundations= 5714N per foundation
0.06m^2 area required
concrete foundation dimensions 20 x 30cm, 20cm thick

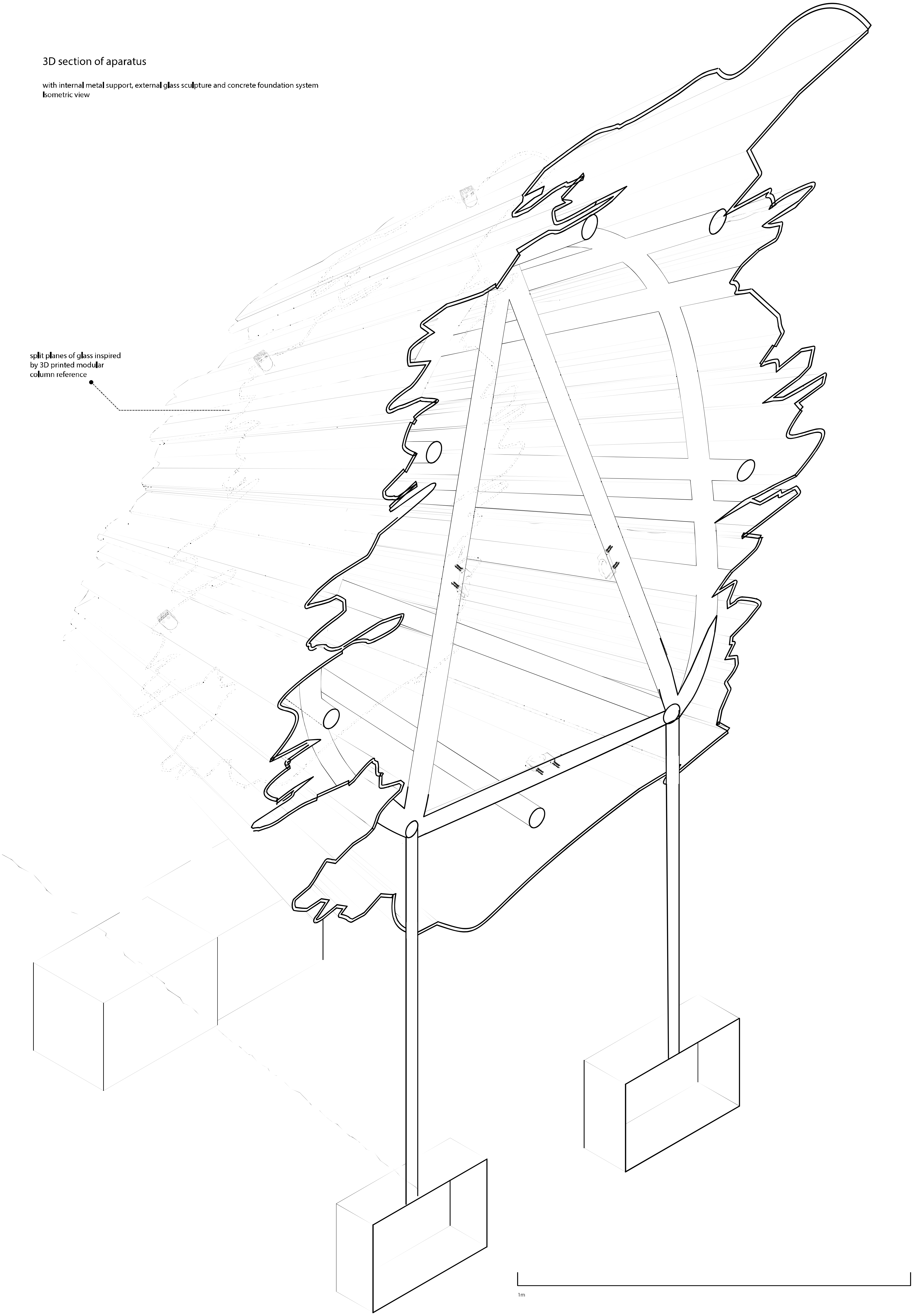
1m

Structural analysis of apparatus, load, connections and foundation considerations



3D section of aparatus

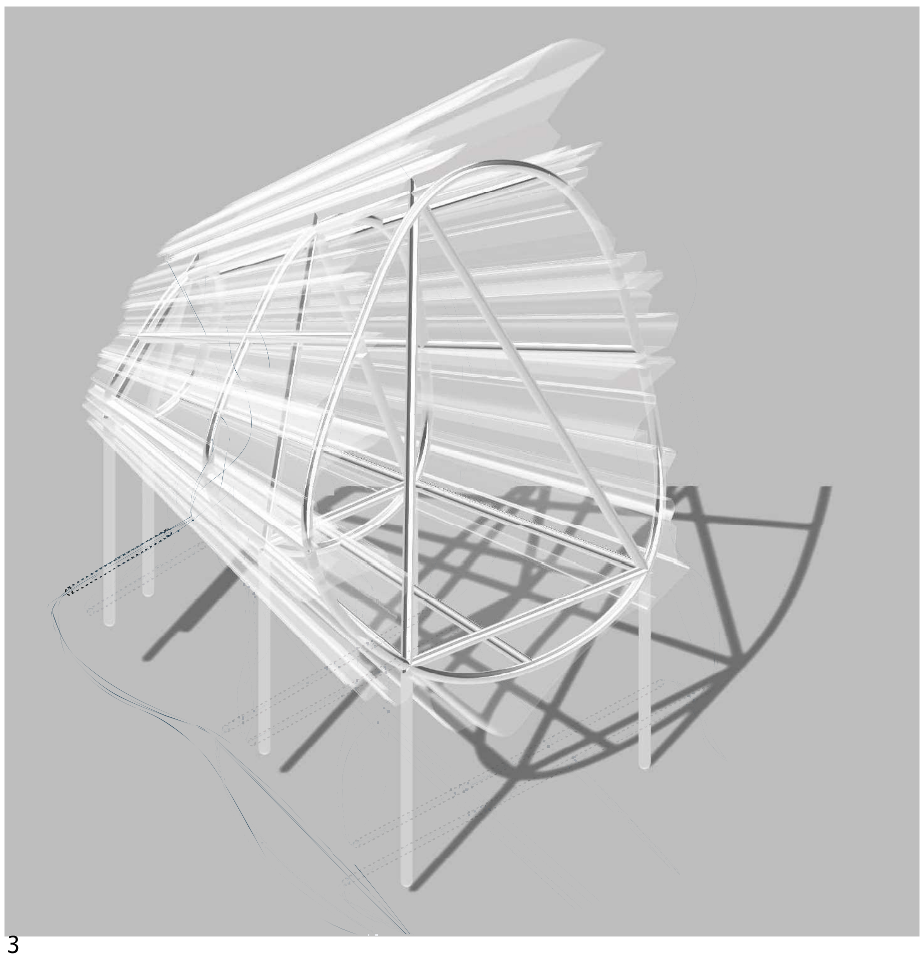
with internal metal support, external glass sculpture and concrete foundation system
Isometric view



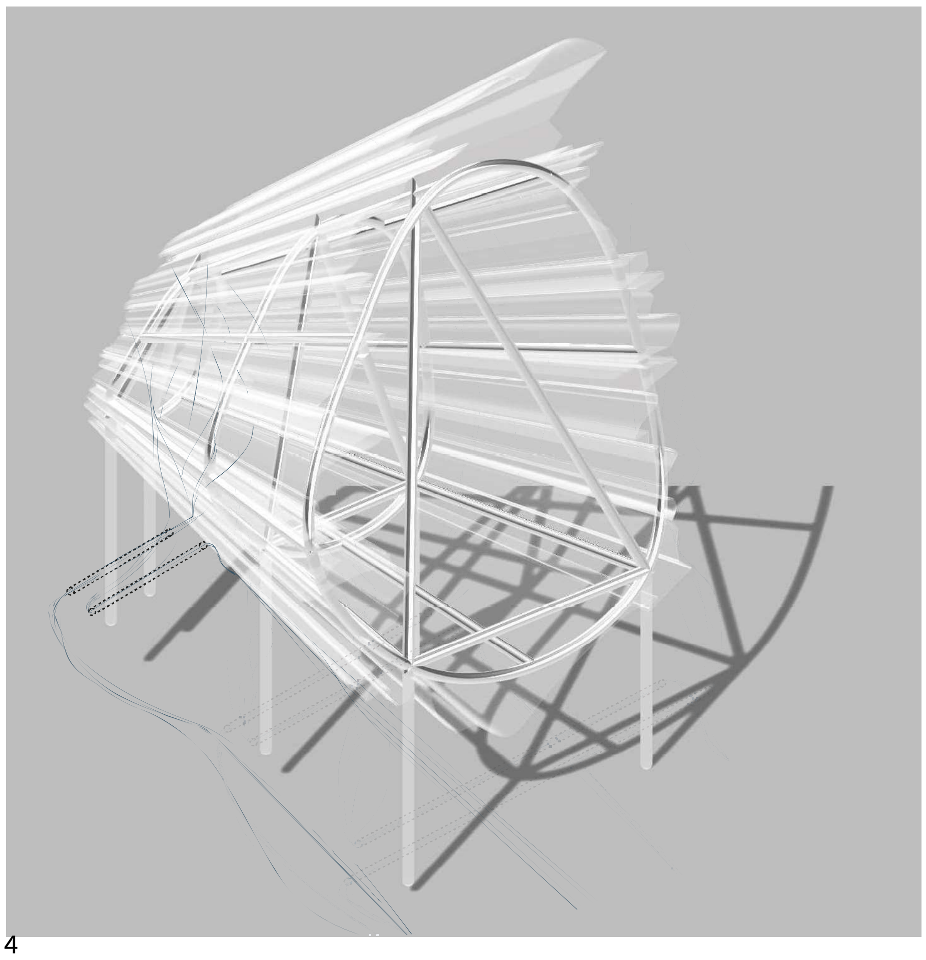
Render of structure
Capilary System

Isometric view of aparatus with metallic frame, glass structure, capilary system and tubes

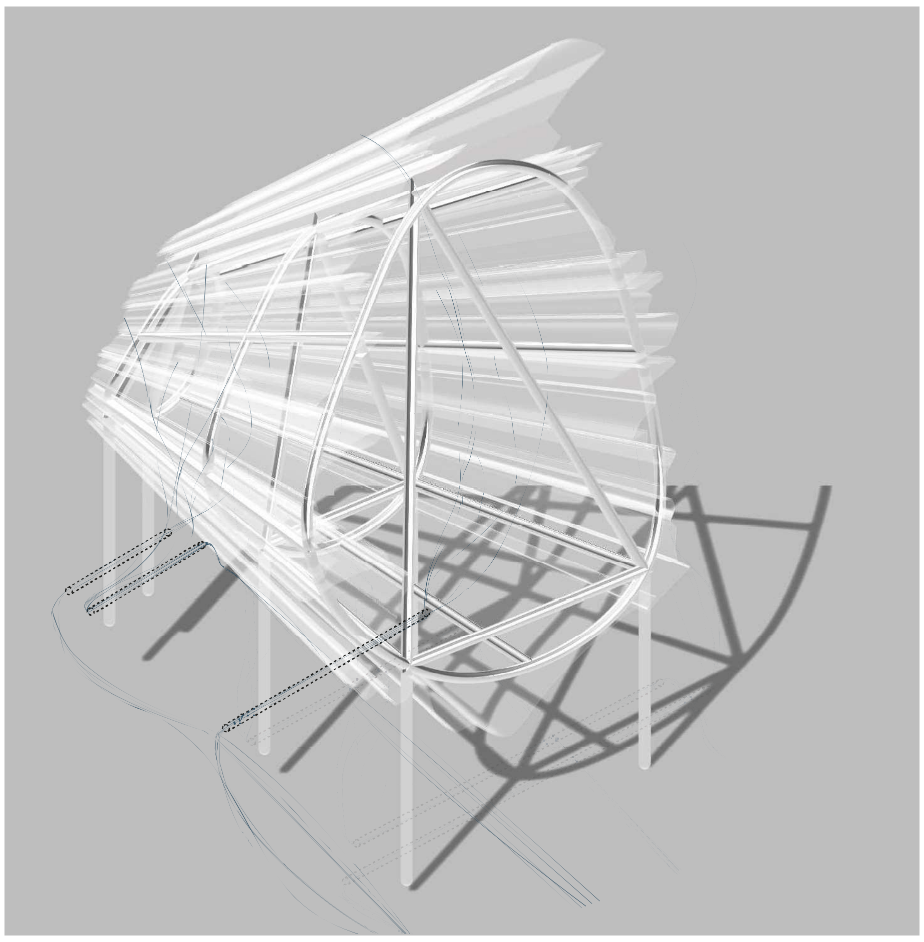
1



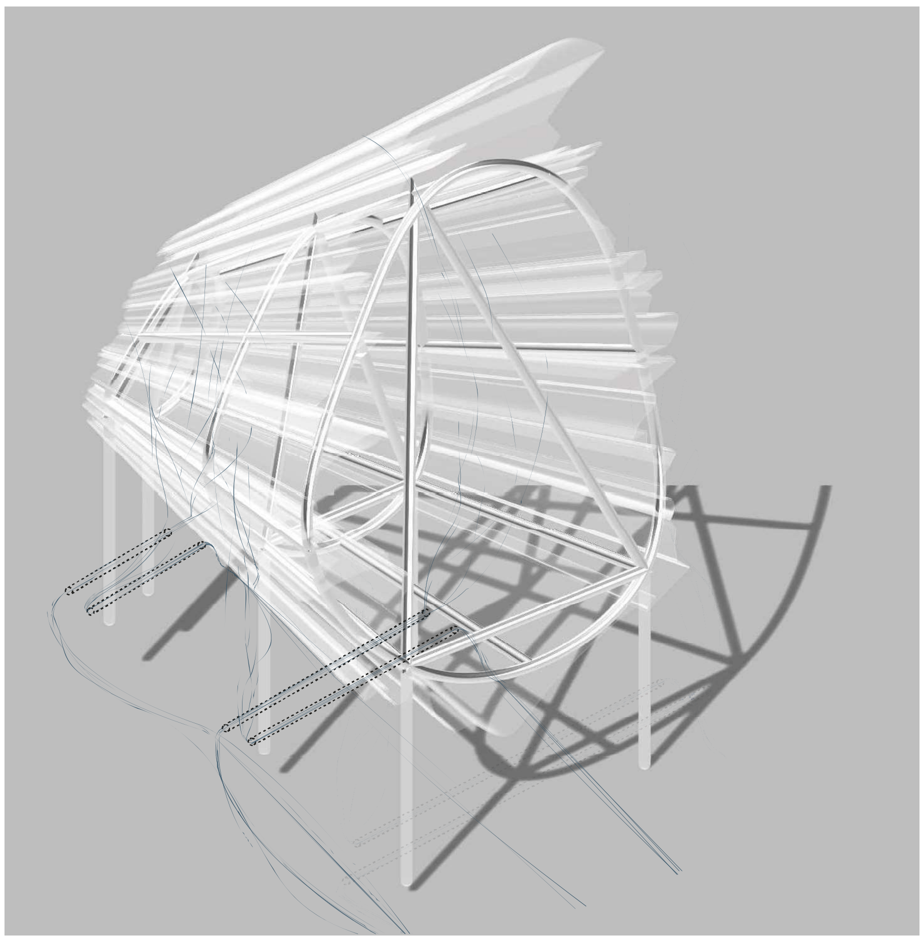
2



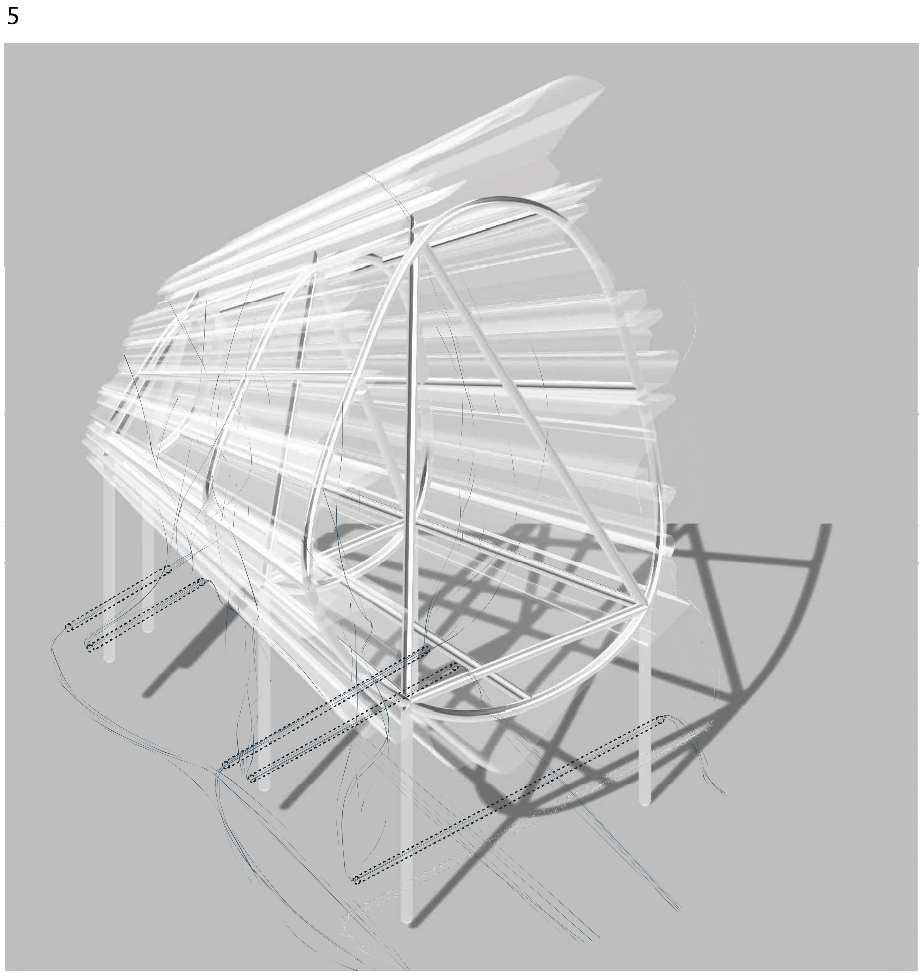
3



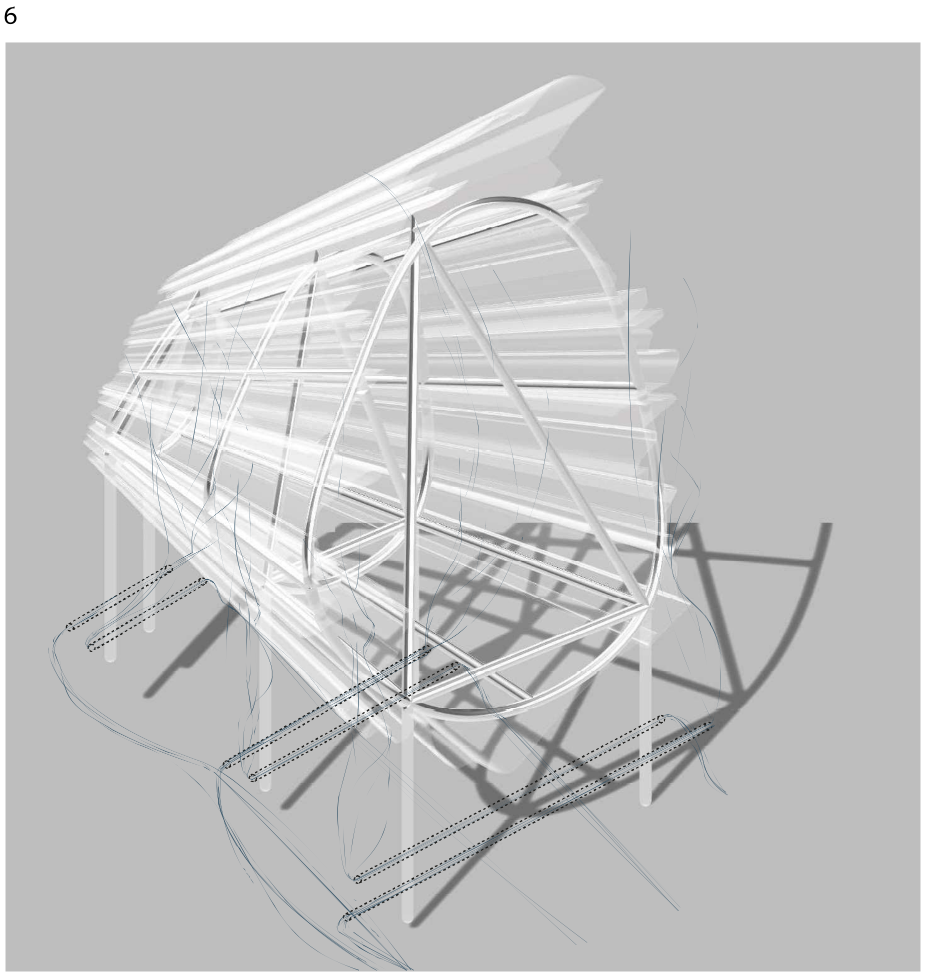
4



5



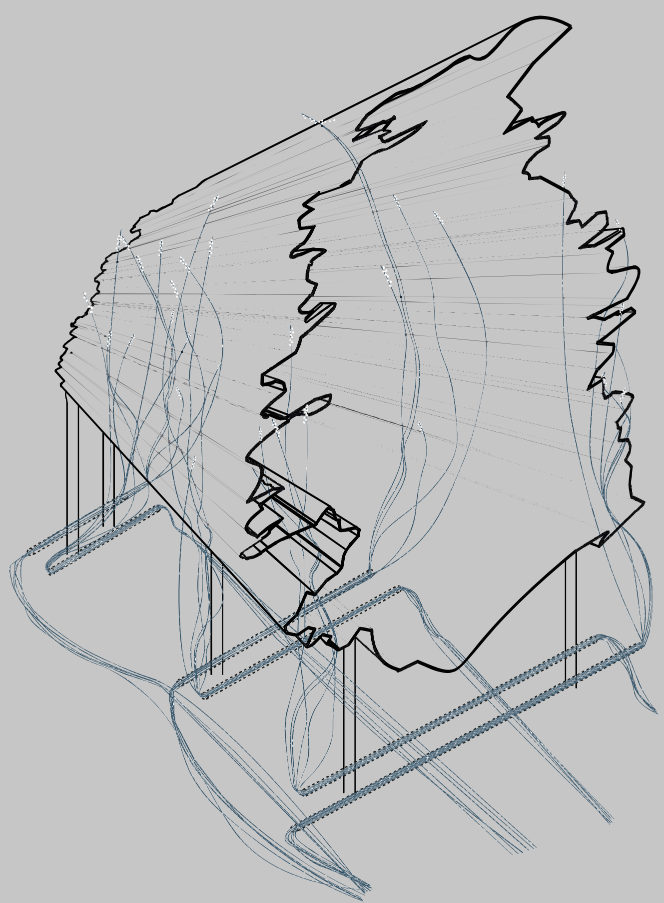
6



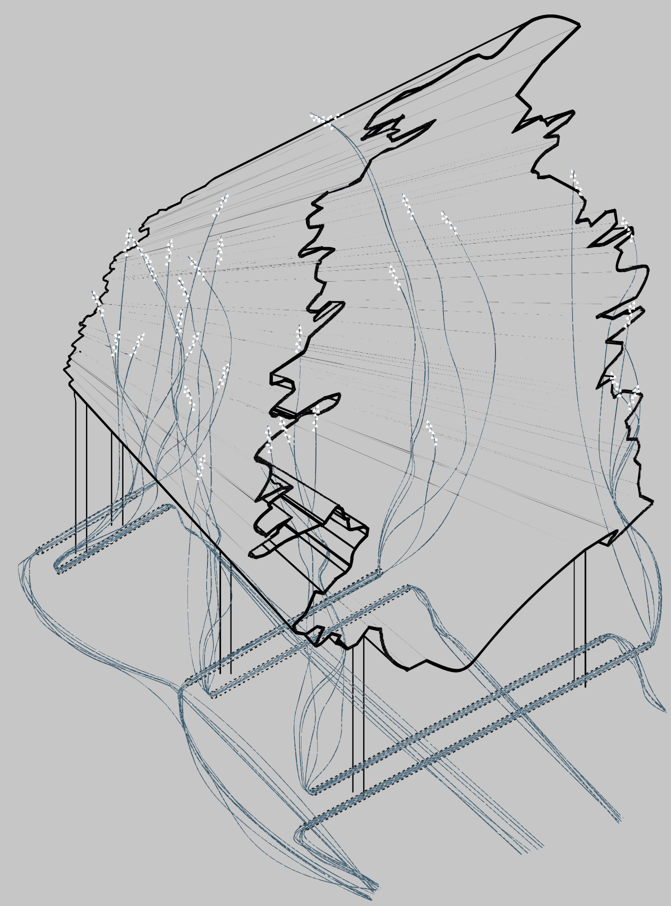
Salt buildup on aparatus over time

around capilary tubes

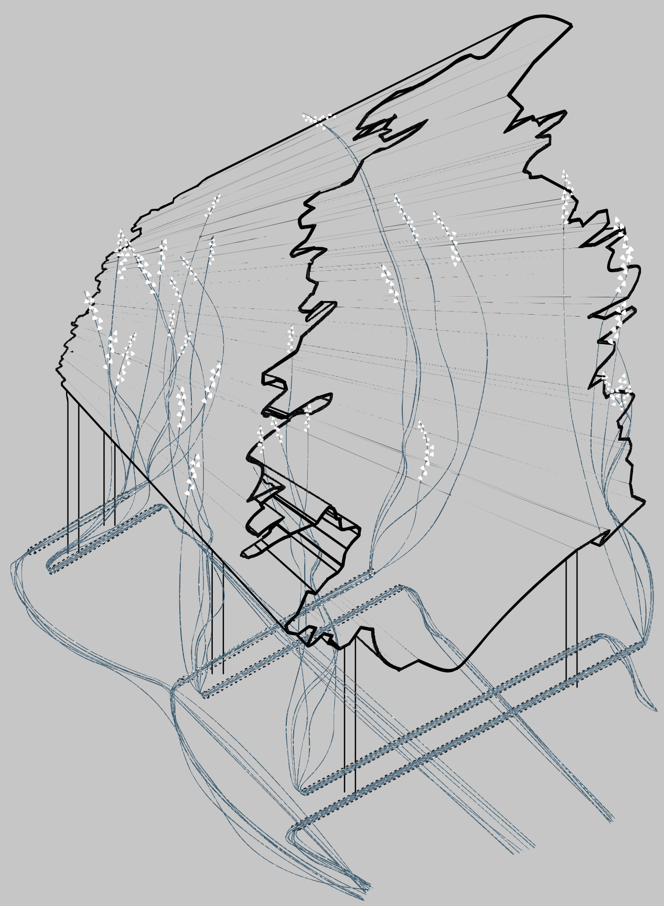
Isometric view of aparatus



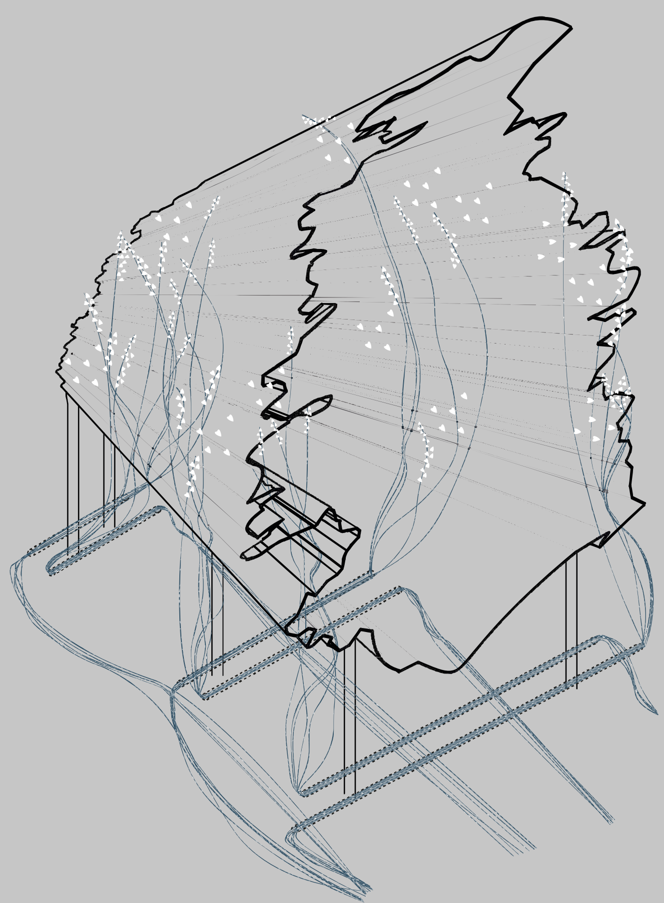
initial build up on tips of capilary tubes
1 month
accumulation style: localised clumps



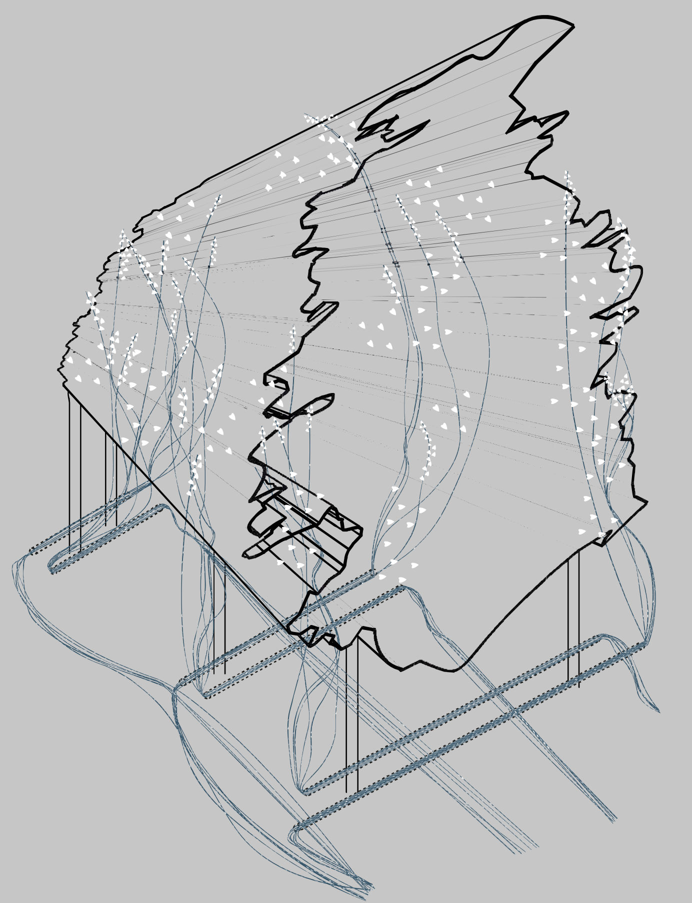
slow build up rate in winter



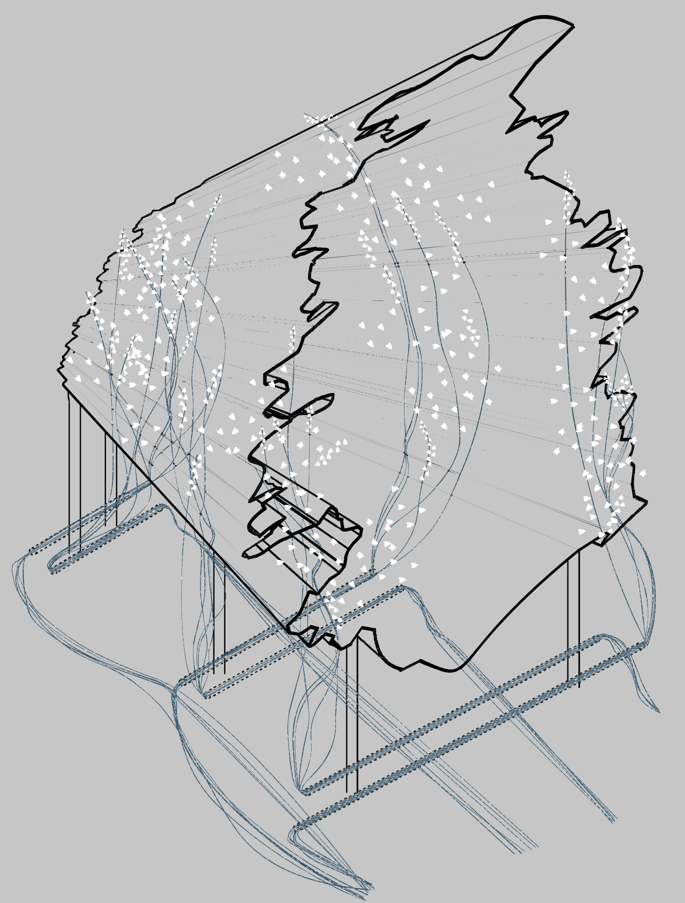
salt accumulation over one quarter



faster build up rate in summer, higher accumulation due to faster evaporation rate
accumulation style: more lateral, covering larger S.A., looser salt due to winds, movement, no longer localised in small area

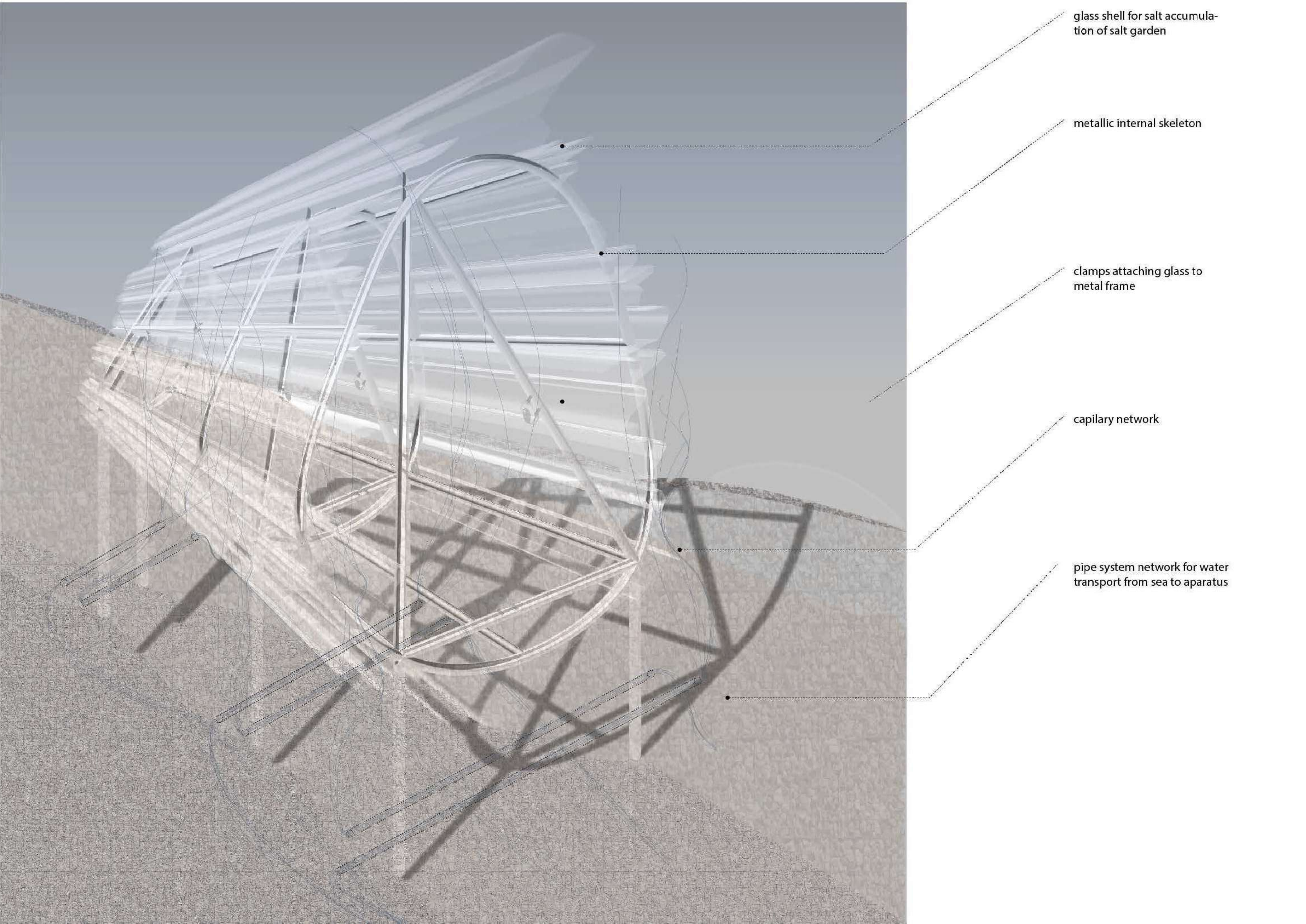


complete year cycle, ending in summer

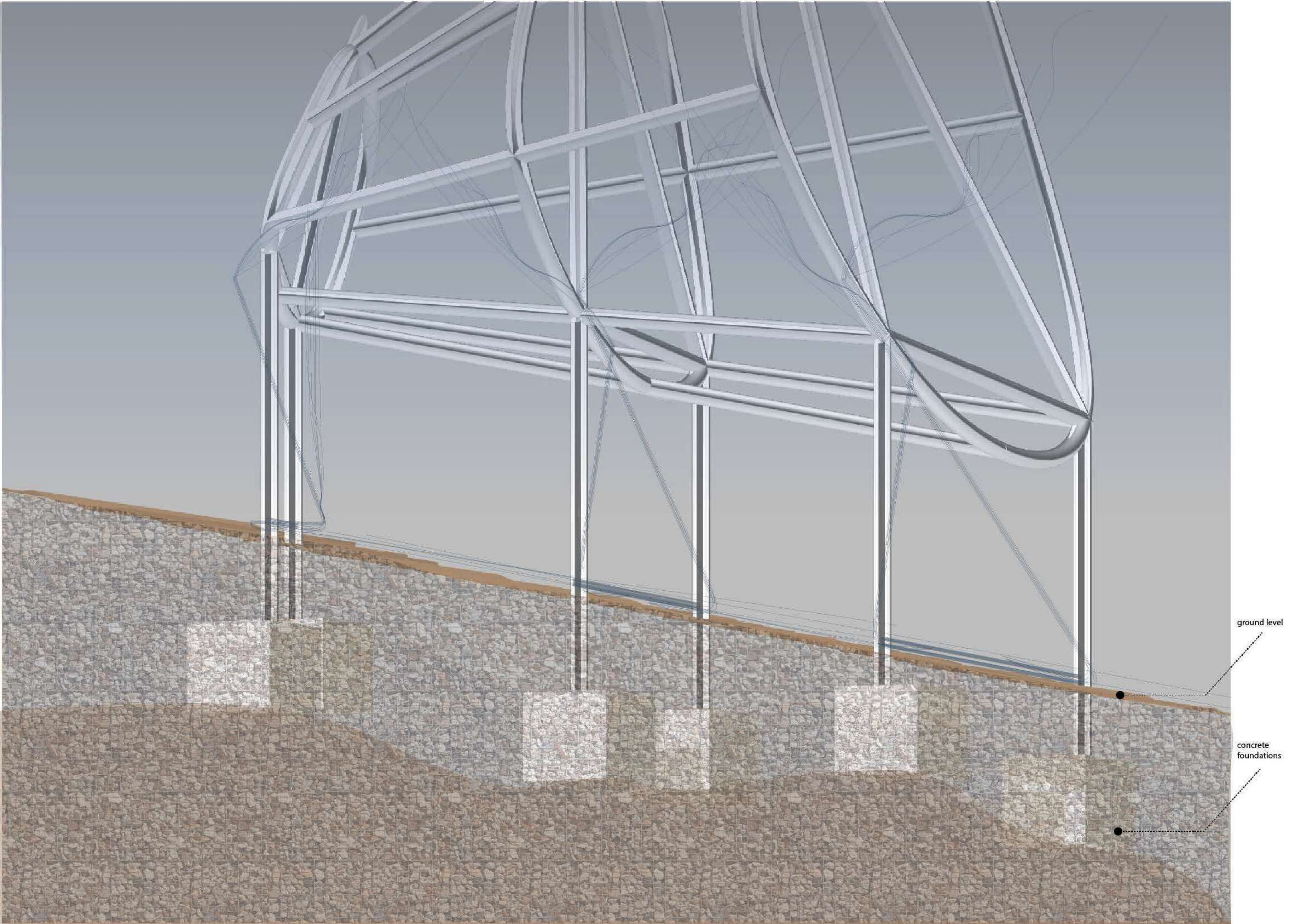


several complete year cycle ending in summer, long term accumulation

1m



glass shell for salt accumula-
tion of salt garden
metallic internal skeleton
clamps attaching glass to
metal frame
capilary network
pipe system network for water
transport from sea to aparatus


ground level
concrete
foundations