Architecture of the Machine

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16 October 2013

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abstract

A dissertation born out of the fascination of large-scaled infrastructural engineered/architectural projects, where the individual human is absent from its initial architectural and programmatic goals, rendering built form/architecture that is free to explore scale and form. A project where the architecture is formally governed by a process that is mechanical and systematic.

This dissertation that has been entitled *Architecture of the Machine* as I have chosen to explore the machine of our future water supply, that of a desalination plant. 2013 marks the year that we, South Africa, are no longer water 'secure', in other words, the population of the country is going to exceed the amount of water available to us.

A desalination plant in Hout Bay, able to produce 30 000M ℓ /day, situated on the edge of the industrial sector, harbour, the informal settlement of Hangberg and the beginning the mountainous terrain of The Sentinel. This dissertation proposes that the brine water be used for salt harvesting, via shallow pans, where naturally, the water will be evaporated from these pans, leaving salt crystals behind to be used in industry, as well as the implementation of sustainable energy devices to help supplement this extensive energy consuming process.

With great infrastructure comes great responsibility, therefore the design of this infrastructure must be coupled with public activities. Building something that helps our future livelihood must be something that people can also interact with, and identify with, thereby creating a physical and emotive landmark.

content.

figures.

Appendix A

Appendix B

preface.

Before the narrative of my personal account of this year-long master's dissertation begins, I would like to start this design report with a piece of a subject matter that is very dear to me and extremely significant to this dissertation's process and outcomes.

Beauty in infrastructure & engineering

Infrastructure is the term typically used to refer to the large structures that support societies and economies. These engineered structures consist of roads, bridges, water supply (dams, reservoirs), sewers, power plants, telecommunications, and etcetera.

All these kind of structures are typically highly engineered and pay little attention to aesthetics, they are designed by engineers, whose occupation is primarily based on rational design with limits according to governmental budgets. These engineered structures that have not strived to have any aesthetic value, have value in that their form follows function, a very practical and systematic infrastructure.

Many people might not think this kind of engineering beautiful, but I definitely do. Whenever driving over De Waal Drive I always catch myself staring so intently at the CBD and the harbour, watching the cranes at work, oil rigs and container ships in the bay, sometimes only half visible by the cold front rolling in.

But why are engineered structures and machinery so enticing? Personally, they speak of the challenges society have faced over the centuries, proving that no structure is too small or large to create, considering physical limitations of the human physical body, the birth of invention, creativity and intelligence of mankind, and the excitement of problem solving. Engineered structures, recall the above and the admiration for the legacy of 19th century engineers, and speaks of the architectural theories that set a priority on 'rationalizing' and 'expressing' the raw necessity of structure.

It also speaks of structures that have raw beauty in their form that is derived from function, at all scales, from solitary structures to industrial landscape, they are inherently provocative and sculptural, their geometries are clear and honest, displaying how the structural forces and loads are transferred.

That being said, what about examples where engineering meets architecture and they have great conversation.

Infrastructure, by nature, are structures that have certain functions that help keep societies alive and working, and therefore do not seek out to be something other than its function. Infrastructure today is not typically associated with architects, unlike during the time of the masterbuilder, these professionals would work on all projects, architectural or engineered, as long as they were skilled, they could build it.

And because of this multidisciplinary skill, infrastructure from those times were both, highly engineering, but beautifully so, with the eye for aesthetics and deep understanding of tectonic nature that all masterbuilders possessed.

For example, among many aqueducts, the Aqueduct of Vanvitelli, Italy, commissioned by Charles of Bourbon and designed by Luigi Vanvitelli (architect and engineer) constructed in the 1750's and completed, May 1762, as well as, the Valens Aqueduct in Istanbul, Turkey, completed by Roman Emperor Valens in the late 4th century AD, one of the most important landmarks of the city today.

Infrastructure today in generally designed and built solely by engineers. Civil engineers, water engineers, structural engineers etc., with more than likely no input by the architect whatsoever, that being said, there are a few Engineers and Architects like Ove Arup and Norman Foster who incorporate masterbuilder relations into their firms and designs, the result being, colossal elegance and brilliance

fig. 1 *Valens Aqueduct, Istanbul, Turkey, late 4th century AD.*

Another example, the Millau Viaduct (le Viaduc de Millau) a cable-stayed bridge that spans the valley of the river Tarn near Millau in southern France, designed by both the French structural engineer Michel Virlogeux (bridge specialist) and British architect, Norman Foster. It is the tallest bridge in the world with one mast's summit at 343.0 metres.

It has been described as

> Delicate butterfly of concrete and steel, the Viaduct of Millau soars across the sky as if eager to proclaim that no bridge on earth is taller. Yet its arrogant daring can surely be forgiven. It took a feat of engineering and a leap of the imagination to span the rough, rugged Tarn Valley in the Midi-Pyrénées region of southern France. The result is breath-taking. (Sciolino, 2005)

Jacques Chirac, President of France, expressed his awe when speaking at the reception to celebrate the viaduct's opening, 15 December, 2004

> The Millau Viaduct is a magnificent example, in the long and great French tradition, of audacious works of art, a tradition begun at the turn of the nineteenth and twentieth centuries by the great Gustave Eiffel. (Chirac, 2004)

Norman Foster explains and consolidates my thoughts in this extract from his essay, 'Architecture and Structure'

> I see no conflict in embracing tradition and new technologies because for me they are both part of a single tradition. The most enduring structures, from any point in time, have always pushed the technology of the day to the limits whether they are man-made hills from pre-history, the Gothic stone cathedrals of Europe, the magnificent timber temples of Japan, the mosques of Islam, humble barns or structures from ancient Rome. The list of my personal favourites would be a very long one but in every case the structure is synonymous with the appearance, both inside and out, as well as the feel, the spirit and the emotional poetry of the buildings. It is also significant that in each of these examples one can also rationally analyse the structure with intellectual rigour. That is real integration of architecture and structure - truly the art of necessity. (Foster, 1994)

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fig. 2 *le Viaduc de Millau, Michel Virlogeux and Norman Foster, 2004.*

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This subject is very important to me as, unlike the few masterbuilders of today, namely, Norman Foster (21st C) and Ove Arup (20th C) who believe that this collaboration is the only true way of design-build construction (and I would have to agree with their ideologies), the majority of architectural firms of today, design first and then only, almost as an afterthought, consider the input of the engineer after consulting with them, where the engineer has no real concern with aesthetics, they deal with rational design, and subsequently, the architect's design integrity is hindered, and I have witnessed many a frustration with this kind of working relationship between the two professions, going back and forth, and nowhere slowly.

I believe it is imperative that institutions produce architects and engineers, that can see eye to eye, who get excited together when they start a project and there is input from both professions right from the birth of a project. The lack of extensive knowledge of materials and construction in architects today is very much one of the reasons we would consult an engineer, as their knowledge of materials is extensive, in the form of mathematical equations, where as our knowledge is limited to the extent of their properties, but not size and span, for example.

The earlier and more often, 'we' the architects work with engineers and take an interest and learn from their knowledge and vice versa, they will, in turn develop an appreciation for the value that we place on aesthetics and place making, and the collaborations of this shared vision, is a force to be reckoned with, infinite creativity and possibilities.

fig. 3 *Oil Rig emerging from the mist in the Cape Town Harbour.*

fig. 4 *View of NYC Harbour from Staten Island Ferry, 2011, Taken by Author.*

introduction.

This dissertation was born out of the fascination of **large-scaled** infrastructural engineered/ architectural projects, where the individual human is absent from its initial architectural and programmatic goal. A notion whereby architecture is formally governed by a process that is mechanical and systematic. As well as the belief in a functionalist architecture that will inherently be true to its materials and construction, thus making visible the processes of its mechanics as a whole. An exploration of this kind of approach to architecture will also allow for pure tectonic explorations, materialistically & atmospherically.

At the beginning of the year we were asked to produce an artefact that embodies our architectural interests and investigations for our master's dissertation for the year. Please see Figure 1, Original Artefact. In this drawing I tried to depict the above mentioned fascinations.

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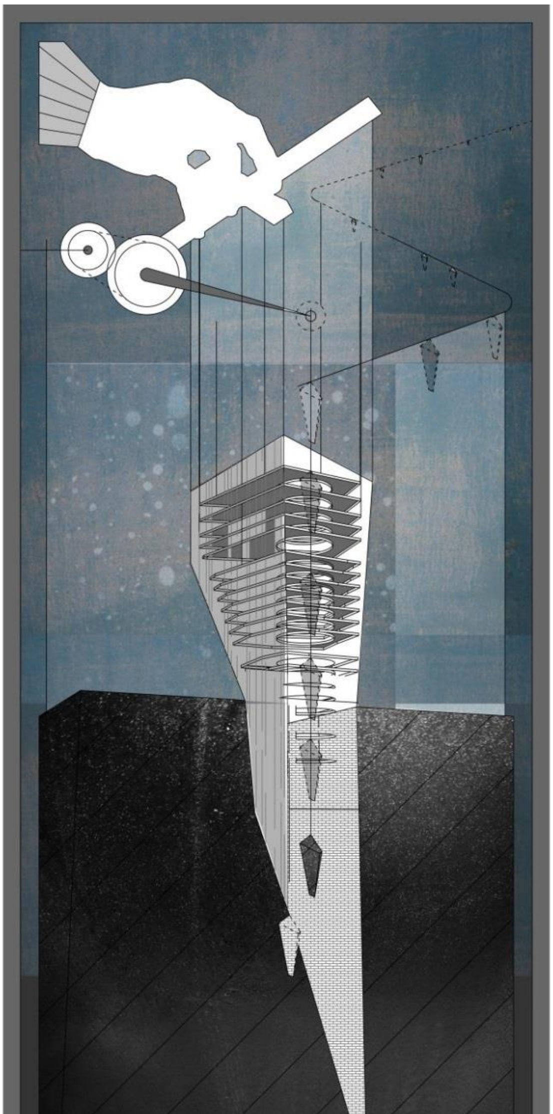

fig. 5 *Original Artefact 21.02.13*

For this dissertation that has been entitled "Architecture of the Machine", I have chosen to explore the machine of our future water supply, that of a desalination plant. The main programme for this dissertation came out of the answers to the question of what exactly is the process of desalination and why is it necessary to investigate it in the context of Cape Town.

2013 marks the year that we, South Africa, are no longer water 'secure', in other words, the population of the country is going to exceed the amount of water available to us.

The immediate future lies in water conservation and the re-use of water in the City of Cape Town, however water conservation can only help for the current population of almost 6 million people living in the Western Cape. The problems lies in the fact that, the population is forever growing, so when we reach numbers of around 8 or 10 million, water conservation alone will not be enough. If something is not done about this issue, one does not even want to try and comprehend what the water situation will be in 30 years' time, therefore action must be taken.

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This report will begin with ideas that have come out from my theory paper from the first semester that are relevant to this project, such as design born out of necessity, architecture that functions as a machine, design for process / productivity and architecture and the machine, the factory typology. As well as the notion of 'form follows function' and architectural merit and beauty found in large-scaled infrastructure.

This project came out of an initial framework for desalination plants for Cape Town, where I have chosen one site out of many to explore for my dissertation. It is important to note that desalination is an extremely energy intensive process, therefore it will need to be accompanied with a suitable sustainable energy, natural energies, to help supplement it. (For example, wind energy, wave energy, excess nuclear energy, etc.)

Hout Bay is the chosen site for the location of this desalination plant, and this paper will address the many reasons as to why I have chosen this location and specifically the site, that rests just on the outskirts of Hout Bay harbour and Hangberg, an informal settlement that will hopefully benefit greatly by this new infrastructural intervention.

design concepts.

Architecture *of* the Machine.

It is very important to discuss the early design process of this dissertation as this project has been faced with many factors that has rendered many different versions of the main fundamental ideas, the backbones, that has driven this project.

Towards the end of the first semester I knew what these fundamental ideas were, which stemmed from the Original Artefact that is spoken of in the introduction of this report. (fig. 5).

At the beginning of the second semester we were asked to do an Enloge. In this Enloge, I tried to render these ideas visually.

The Enloge (fig. 6) depicts an entity of enormous scale, this entity is a productive one, and that of a machine that works for the people. Even though its true function is to perform mechanical processes and in turn provide humankind with some kind of power source, like most machines do, it doesn't mean that it has to look like a conventional machine.

There are many ways to skin a cat, and therefore the architecture that houses the machine can be one that intuitively follows its form and be housed like the machines in previous times. This Enloge aims to show that just because something is highly engineered and mechanical, that doesn't mean that the architecture that houses it has to be something sterile, it can be something quite elegant / sculptural.

This means that the architecture can be more than just a protective skin, but can become a part of the process, the actual architecture itself can 'be' the machine and its different parts, and inherently the design of these parts allow for individual expression, design value and integrity.

Architecture that is designed for a process and not for the dwelling of people creates the freedom of scale and form.

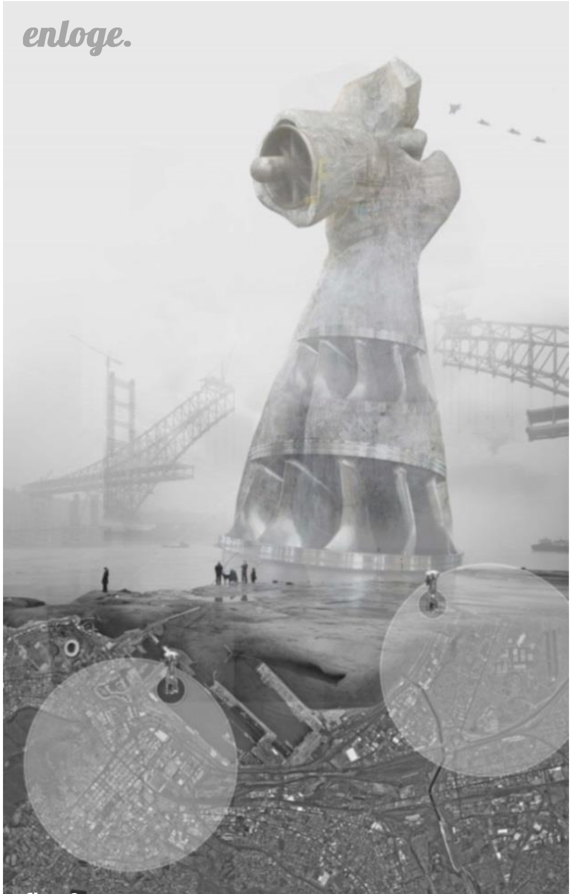

fig. 6 *Studio En Loge 20.03.2013 Depicts Desalination Plant framework & sub-stations.*

Architecture *and* the Machine: Breaking the Factory Typology of the 19th century.

Factories are one of the outcome of the industrial Revolution, they arose with the introduction of mechanized machinery that replace human efforts in the production line of goods. Because of the scale of these new machines, they needed greater space requirements, and so the manufacturing plants/factories/industrial sites were born.

From the time of the birth of factories, and still to today, most factories are large warehouse type structures that contain heavy industrial equipment, arranged in an economical assembly line of production. This seems the easiest and most economically way of housing such machinery, however, I believe that its time the ‘factory’ typology steps out of its comfort zone, and accommodates other factors that influence the productive environment. Factories can be more than just boxes dotted around in our environment, exhaling smoke like Grandpa Bernie, trooper chain smoker, aware of the risk involved, but too old and tired to care to change his ways. I read an article the other day on the PopularMechanics website that says

> Factories don't have to be huge, ominous grey buildings pouring smoke into the sky—this is an image of a late 19th-century factory, and it's hardly the norm in modern-day design. (Gottlieb, 2013)

The article also quote Diane Lewis, a practicing architect and professor in Cooper Union's architecture school.

> Companies around the world are focused on integrating "concerns for the inhabitants, surroundings, sustainability, and the overall corporeal imagery" into their buildings, says Diane Lewis. (Gottlieb, 2013)

She continues to say, and she greatly reiterates my focus for this project,

> Cutting-edge industrial buildings no longer stick to one idea or design strategy, Lewis says. (Gottlieb, 2013)

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Design for Process / Productivity, working landscapes, horizontally & vertically.

At the beginning of the design process for this dissertation, I knew that I wanted to have a project that took advantage of vertical production lines. When it comes to water or most things for that matter, vertically means taking advantage of gravitational pull, which in turns means that energy can be manifested purely from the fact that there is a differential in height. For example, hydro-electricity from dams and reservoirs etc. Even though my project turned out to being using both vertical and horizontal arrangements to its benefit, I thought it would interesting for the reader to read some excerpts from a project called the “The Urban Factory”.

Precedent:
“The Urban Factory”

> […]...this project focuses on the impact of global economies on the physical space of industries and aims to stimulate ideas for reintegrating the vertical factory and places of production into the urban fabric both programmatically and economically.
>
> […] staple industries, in fact, could serve to revive both communities and their factory infrastructures. If industrialists and urban planners reconsider the potential for building vertically in cities, this, in turn, would reinforce and reinvest in the cycles of making, consuming, and recycling as part of a natural

> feedback loop in a new sustainable urban spatial paradigm. (mgmtdesign & studiotractor, 2012)

And what I found even most relevant to my own project are the questions posed by The Urban Factory, such as:

> Can the factory as a place of work programmatically reassert its relevance in the urban fabric with the advent of free trade, globalization, and gentrification, making production more local?
>
> Can urban factories make cities more self-sufficient?
>
> What would this new urban landscape with vertical manufacturing look like urbanistically and architecturally?
>
> How can people live with industry without incurring negative health effects?
>
> How can we integrate sustainable industries into urban neighbourhoods with potential for energy production -- not just consumption -- in a symbiotic relationship? (mgmtdesign & studiotractor, 2012)

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Architecture that functions as a machine: Functionalism in 20th century Architecture

In Architecture, Functionalism is the principle that architects should design a building based on the purpose of that building and based on necessity both in purpose and construction.

This section will briefly explore the origins of the phrase “form follows function” as well as those architects who have strived to embody ‘engineering’ into their architecture. It will be also looking at architecture / form that celebrates engineering / mechanical processes, in the form of a case study, one of the few projects by the admirable architect who goes under the branch of, ironically, organic architecture.

Because my dissertation for this year is concerned with an architecture that it governed/informed by an engineered process, it is relevant that this notion be discussed, as inherently engineered structures and devices adhere to this rational and efficient notion.

From his article, *The Tall Office Building Artistically Considered*, originally published in Lippincott's Magazine #57 in 1896, Louis Sullivan states

> It is the pervading law of all things organic and inorganic,
> Of all things physical and metaphysical,
> Of all things human and all things super-human,
> Of all true manifestations of the head,
> Of the heart, of the soul,
> That the life is recognizable in its expression,
> That form ever follows function. This is the law
> (Sullivan, 1869)

Through this quote from his article, Louis Sullivan set the discourse for the founding members of the Modernists. Sullivan was an American architect, and has been called the "father of skyscrapers" and "father of modernism".

When one thinks of the Modern Movement, architects such as Le Corbusier and Mies Van Der Rohe, come to mind. Le Corbusier was one of the founding members of the Modern Movement; he was extremely active in the CIAM (International Congresses of Modern Architecture).

Le Corbusier's (and many other CIAM members) architecture exemplifies the common themes of the International Style. His architecture strictly applies to the notion of "form follows function", meaning that the outcome of design should derive directly from its purpose, as the simplicity and clarity of forms eliminates the "unnecessary detail". Also, he visually expresses structure, which related to the concept of "truth to materials", and adopted the machine aesthetic, particular to the International Style modernism.

Precedent:
20th century Architect who have strived to embody the functionalist notion of "Form there follows function"

hugo häring

However, there was another founding member of the CIAM that has gone somewhat unrecognised when one thinks of the Modern Movement; he is an architect by the name of Hugo Häring, a German architect and architectural writer.

Even though, Häring is considered more of an organic modernist, there is great merit in his work, regarding the notion of "form follows function". I have chosen to talk about his work as I think it exemplifies an architecture that is purely governed by the processes that happen with in, so pure in form that expresses function, and in turn becomes an entity that is beautifully sculptural.

In 1925, Häring completed his essay, "Wege zur Form"; in this piece of writing he outlined his beliefs in architecture. He believed architectural form should grow from the environment (its context) and the function of the building, which was individual to the project.

This laid an important emphasis on process rather than product, and on the expression of the task as opposed to the personal expression of the architect. Modernism's emphasis was on an abstract, universal and 'classical' architecture, while Häring had advocated local, site-specific and functionalist architecture. He believed in fitting spaces to functions like a glove to a hand.

Häring's inspiration was to be found in the functional programming in all his designs and therefore he has been entitled 'the most extreme of functionalists', but his attitude towards architecture is anything but utilitarian. He desired an architecture that responded to its immediate conditions and contexts and therefore reflected them: an architecture of the utmost appropriateness.

Häring believed fully that the greatest obstacle to a building becoming what it needed to become was the obligation to 'geometry' in the eyes of the Modernist. Häring saw imposed geometry as a straitjacket cramping a building's natural development. His geometry came out of the buildings natural surrounds as well as its context and function. In essence, Häring was a critical regionalist, with his approach to architecture that strives to counter placelessness and lack of identity in Modern Architecture by using the building's geographical context.

Häring's design philosophy can be seen in the Gut Garkau complex he built. It is perhaps the most demonstrative of his works. It consists of a barn and cowshed, grouped quaintly around a courtyard. These buildings illustrate Häring's belief that architecture should appear to arrive naturally and spontaneously from its surroundings.

Tectonically, Häring used primarily concrete, brick, and wood to build the horseshoe-shaped cowshed. The curving façade of the Barn is a multifarious arrangement of all three components, with bands of structural concrete articulated on the brick lower stories, and the upper levels are cladded in painted wood. The floor plans were fashioned by considerations such as animal welfare, with the concrete construction allowing for a tall, illuminated interior. Blundell-Jones (British architect, historian, academic and critic) explains how the function of the barn generated the building.

> A simple rectangle in plan, the barn was planned so that unloading carts could pass through between the asymmetrically placed doors. The cowshed lies beneath the hayloft so that the cattle can be fed directly via a trapdoor. The intermediate floor slopes inward, both to facilitate spreading the hay and to guide rising breath of cattle to vents at the sides, reducing spread of infection. The framed structure allows a continuous window band at clerestory level to maximise skylight, ventilation being achieved separately by flaps above. The pear-shaped plan gathers the cows around a food-floor which tapers with the quantity of food distributed, and the circulation space around the edge allows smooth flow. The guiding idea, though, was clearly to reflect the relationship between the 42 cows and the single bull, father of the herd and its genetic identity. (Blundell, 1999)

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These buildings are designed simply and elegantly. The Gut Garkau farm is one of the most extraordinary and beautifully modest buildings I know that came of out the Modernist period and was designed to show the world the future of free, functional architecture. Since these buildings, he was consigned to the group of architects that the Modernist put under the heading of Expressionism.

I believe, with his architecture and writings he started out with one of the masterpieces of that alternative tradition in Modernism, one that truly embodied form that follows function without sacrificing any architectural integrity, and has been of great inspiration to me.

Hugo Haring's Gut-Garkau Farm, resonates with me as, even though it's a project that's primary concern is that of the cow, and not that of the human, it is still considered architecture, and not an engineered structure, and because of its nature it can forever be used as what it was intended to be, its form is directly derived from its function, yet it is designed with integrity.

His architectural intentions born out of the discourse that came from the Modern Movement, searches for an architecture that sought out to expose all elements of its structure and process in the most honest and modest way, which, personally, I have much appreciation for, and speaks of the architectural theories and my own intentions for this dissertation, that sets a priority on rationalizing and expressing the raw necessity of structure.

fig. 10 *Barn interior, Gut-Garkau Farm, Germany, Hugo Häring 1924.*

fig. 9 *Left: Elevation of Barn interior, Gut-Garkau Farm, Germany, Hugo Häring 1924.*

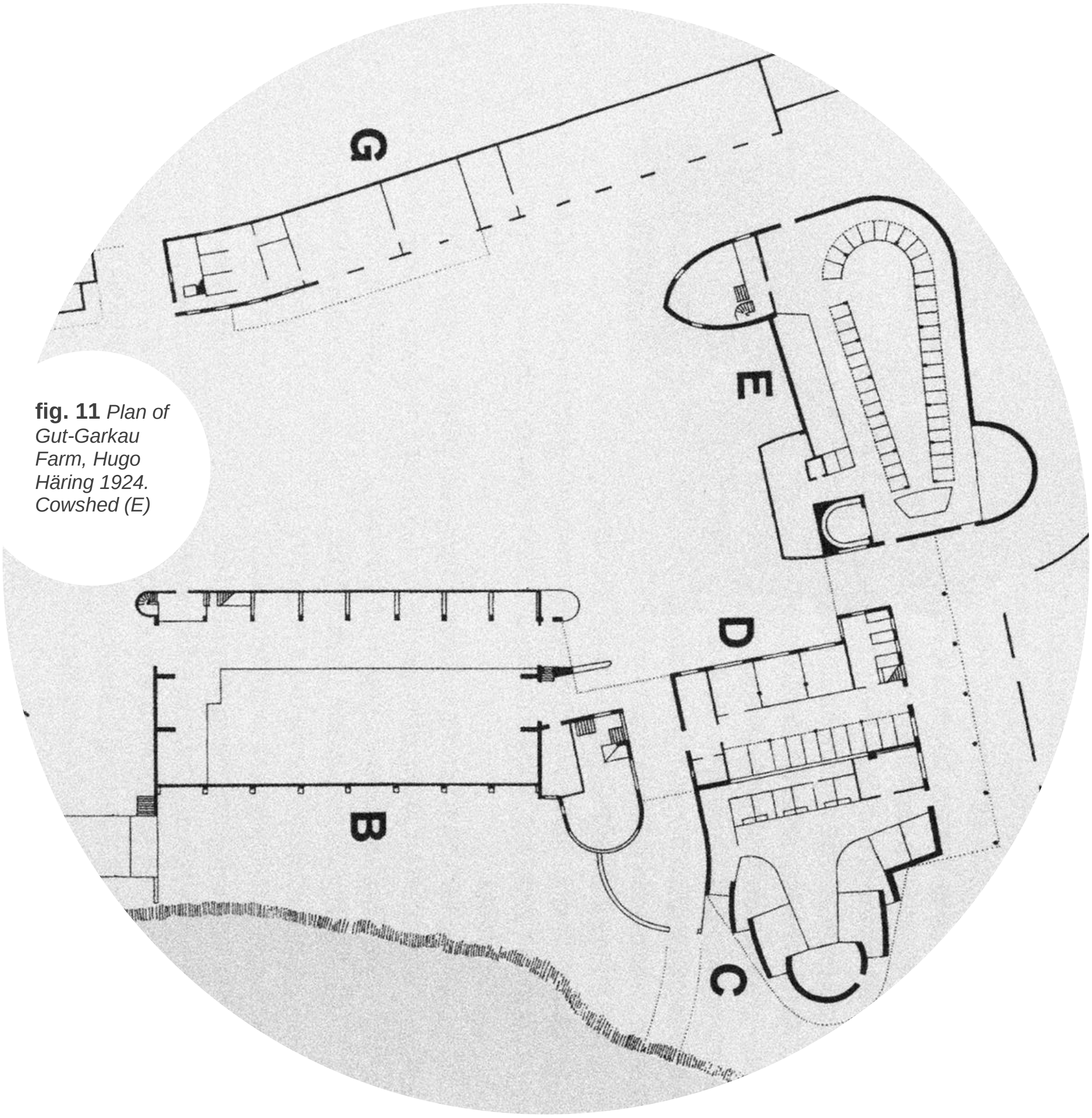

fig. 11 *Plan of Gut-Garkau Farm, Hugo Häring 1924. Cowshed (E)*

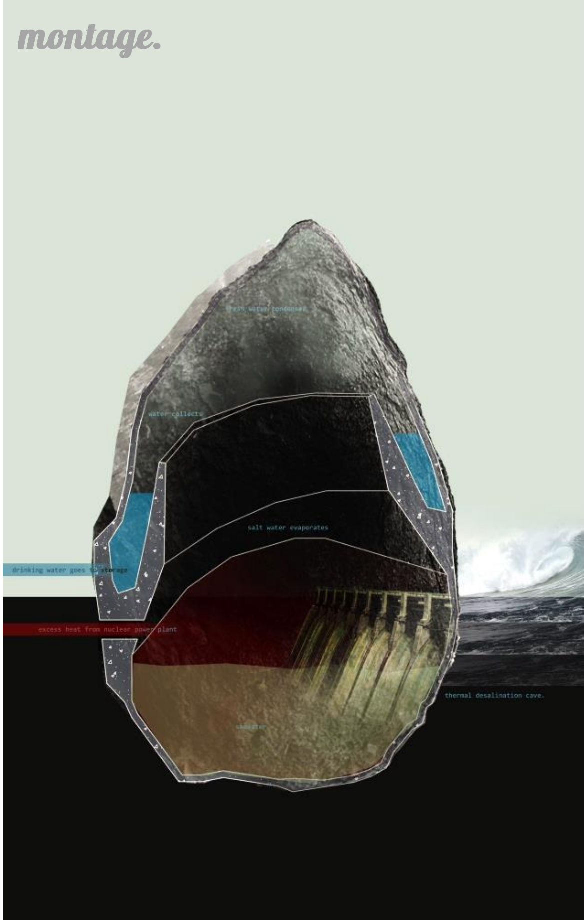

fig. 12 *Design Conceptual ideas*

Conceptual idea, based on using the excess heat from a Nuclear Power plant = collection of condensation in a giant man-made desalination cave. Another example of how a 'machine' can be so much more than just standardized machinery, it can be something organic in nature, yet still function in an extremely rational manner.

Iconography.

Referring back to fig.6, in the enloge the machine is represented as an icon, of enormous monolithic proportions, as a reminder to the City of Cape Town that we are facing a huge water crisis. Not only is it an icon for public awareness but it has huge symbolic potential, as a landmark for its location, as it would be a visual representation of place, identity for those communities that live in proximity and it's a visual manifestation of embodied ideas, economically, socially and architecturally.

The form of an icon can also suggest its meaning, and can purely be a shorter way of communicating ideas, where the form has traditional symbolic meaning or contrastly, it can have ambiguous meaning of form, where its meaning is individual to its viewer and user.

Machine vs. Nature.

I would also like to mention briefly the visual impacts that resonate with me of man-made infrastructure that sits in our natural landscapes. What is so enticing about this contrast of mad-man entities against a nature? As I have mentioned before, engineered structures, on their own, speak of the challenges society have faced over the centuries, proving that no structure is too small or large to create, considering physical limitations of the human physical body, the birth of invention, creativity and intelligence of mankind, and the excitement of problem solving. Man-made structures, like nature, knows no bounds.

But what of this, set in the context of the natural environment? There is a beautiful conversation that happens when, engineered structures that have raw beauty in their form that is derived from function, at all scales, are placed against the organic formations of natural landscapes.

There is an emphasis placed on infrastructure that expresses its inherently provocative and sculptural form generated from its geometries that are clear honest and rational. As well as the emphasis on nature's formation of its environment, that has been formed so ingeniously by complex natural design systems. These contrasts highlight the two different systems. Although, they are not actually so different in essence, this will be explained below.

Geometry:
The 'architecture' of the built and natural environment.

From the macro scales of our universe, down to the micro atomic scale of entities in our immediate environment, geometry governs form.

Fig. 13 are images taken off Google Earth, and with these images, this report brings to light that regardless of size or shape, geometry is what governs our world. I will inform the reader that these are images of quite substantially large infrastructures from around the globe, however, they can appear to be, at the same time too, images that one could see while looking through a microscope, geometries and patterns at the smallest scales.

Inherently, that is the beauty of geometry, that at any scale, patterns can be seen, formal and informal, like those of the built and natural environment. These shapes, seen from close or far, have an aesthetic quality and value, regardless of what these patterns are made of, man-made or organic.

fig. 13 *Instagrammed Google Earth Images of Infrastructure. @_art_vandelay_*

Geometry, undeniably has its roots in the study of nature, where many mathematical principles have been derived from, which, from the beginning of civilization has been used to govern the principles of planning and construction of architecture of religious iconic buildings. This geometry is known as 'Sacred' geometry.

These forms that occur in nature can be observed in, for example, logarithmic spirals that can be seen in shells, as well as the hexagonal construction of honeybees wax cells to hold their honey.

One of the things that I see when infrastructure is placed in contrast with nature, is in fact, that the man-made structure is in essence, an area of the natural environment zoomed in, to reveal its inner geometries and structural principles.

In regards to the focus of my dissertation and the relationship between architecture, engineering and form, I believe that geometry is one of the driving forces and links, between my architectural intentions and investigations thereof, as I have mentioned in the previous section that for me, expression of geometry can be provocative, sculptural, honest and evoke a certain kind of atmosphere, whether it be architectural or not.

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Geometry also gives rise to reason. Certain entities possess certain geometries that are best suited for its efficiency, function and survival. Which brings this paper back to the notion that form (geometries) follows functions, whether it be something architectural, engineered or both.

Another idea I would like to bring to light about geometry is that geometry brings to mind how our aesthetic value is placed on the geometrical principles of proportion.

This significance is especially found in architecture and the way architects design, where it comes to the spatial form and the way, us humans, the users, relate to size and proportion of our built environment.

This dissertation is challenging the notion of an architecture for the human, but rather for the machine. However, its architectural pursuit is of the same spatial nature, yet the human is replace with a different types processional activities, that of the machine and productivity.

scale.

Justifying scale of the built environment.

To bring this report back to the infrastructural scale planned for the desalination plant and its context, it is important to know that, at the moment, in Cape Town, 1 Thibault Square, built in 1972, stands as the tallest building to date, at 127 m tall with, 31 floors. However, soon it will be triumphed by a new skyscraper, a 139m tall skyscraper called Portside that should be finished construction by the end of this year. For Cape Town, this is quite the achievement, but not so far away in Johannesburg, the tallest building, the Carlton Centre, built in 1973, stands at 223 m with 50 floors

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As it is now known, the vision for this project is that the desalination plant is of an infrastructural scale, but it's necessary to determine what scale is appropriate in its context. In Cape Town, as I have been mentioned, currently the tallest building is 127m tall, and to build a desalination plant that has an element that is 150m, say for example, or as a whole, is 150m tall, seems quite extreme, but what scale determines whether a built entity is of a landmark / icon scale? And how much does the symbolism behind an object/entity determine its iconic nature.

Its environment also plays a huge role as to whether the scaled is read as iconic or simply just in proportion to its surroundings. I believe physical context and symbolic context is crucial.

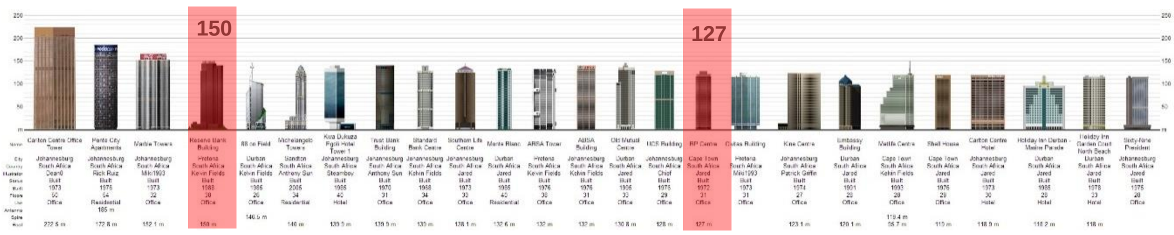

fig. 14 *Diagram of the tallest buildings in South Africa, ranging from the 223m t0 118m.*

project framework.

Why Desalination?

For this dissertation “Architecture for the Machine” I have chosen to explore the machine of our future water supply, that of a desalination plant. What is desalination and why is it necessary to investigate it in the context of Cape Town? The following section ‘water affairs’ will give a complete understanding of the current dire water situation of Cape Town. I would like to first explain the project’s original framework, as imagined before most of the designing of the plant was set to course.

Framework for Desalination Plants for Cape Town

The main idea for this framework is a series of Desalination plants on the coastline of the Western Cape, however, bigger is not always better, as portrayed in my Enloge assignment. (fig. 6)

Sites will be chosen according to the need for water in the area, as well as its ability to help supplement the desalination plant with natural energy sources. Locations with optimal natural energies are key, such as access to heat waste, solar, wind, wave and hydro power.

For example:

Wind farms in Darling and proposed developments along the Garden Route.
Solar farms.
Wave energy – identify coastal areas that are extremely active.
Excess thermal energy. E.g. Koeberg Nuclear Power Station.
Hydro power.

These sustainable energy sources will play a huge part in locating Desalination Plants. Therefore each Desalination plant with be configured and supplemented according to its context.

Architectural Investigations and opportunities.

Desalination Plants, depending on which process is used, typically Thermal Technology & Membrane Technology have a systematic layout and sequence of process. However there are architectural design opportunities in the configuration and design of some of these processes. For example

Intake of seawater
The pre-treatment pools where the salt water is left and sediment from the water sinks to the bottom of pools
Concentrated salty water disposal system and solar Salt extraction
Stabilization tanks
Storage of drinking water

As well as the great design freedom there comes with creating new feasible natural energy devices, all of which will maintain the integrity of 'form follows function' / rational design.

water affairs.

Current Water situation in Cape Town, and talk of Desalination.

The current water situation in Cape Town is quite grim, action needs to be taken, and soon. Even the Water Affairs Minister, Edma Molewa said, last year February, that we are "near crisis situation" with our water supply within the next 10 years if urgent steps are not taken to prevent such a crisis. (News24, 2012) She expressed her extreme distress while speaking at a media briefing in Cape Town that elaborated on the Government's plans to spend billions on infrastructure, including water infrastructure, across the country in the next couple of years.

Experts on the water supply and demands, warn that growing demand for water is set to place severe pressure on the country's ability to supply this limited resource, and this is just one of many reasons why I believe that desalination can be one answer to these problems. Edma Molewa is definitely not the only Water minister to be concerned, 2 years prior to her statement, the then Minister of Water Affairs Buyelwa Sonjica, in her budget speech for 2010, announced

> that in light of South Africa's present water supply constraints that it will be necessary to use desalinated sea water to service "our water-scarce country" (Service Publication, 2010).

These true, yet shocking statements have been supported by intense studies of the country's water supply shortage, as well as the effects of climate change in our region (and of course worldwide) and studies that have looked at the variation in rainfall that will have an effect on the availability of water in South Africa.

To support these studies further and the investigations into desalination of the this paper, an article from Engineering News Online explains that

> The National Water Resource Strategy, the official blueprint on which government has based its water management approach, has identified a number of regions that could be in significant water deficit by 2025 if measures are not implemented to prevent this. In some of these instances, desalination is seen as a possible solution, with the Department of Water Affairs (DWA) indicating that desalination plants could account for between 7% and 10% of the country's overall urban water supply by 2030. (Desalination currently contributes less than 1% of national supply) (Holman, 2010)

At the end of this article, Holman concludes with a quote by Water resource management specialist Anthony Turton,

> As a nation, we are flying blind if we do not include desalination in our overall national strategy (Holman, 2010)

As so many reports and articles have stressed, the process of desalination has not been, for many years, cost or energy sufficient for countries that cannot afford such a high energy water solution, however there has been great evolution of desalination technology recently, worldwide, and these advancements have allowed the process to become more energy efficient and affordably accessible, and a viable solution to all our freshwater shortage crisis.

That being said, I believe desalination must work hand in hand with other sustainable energy supplies and future plans to capture water naturally that Cape Town has yet to tap into. Desalination is the answer to the supply-side strategy to alleviate the country's water stress, but as I have mentioned, it is crucial to consider

the energy implications of this decision to go forward with desalination.

> Desalination technologies are renowned for being expensive and for requiring large amounts of energy to power the respective plants, which is a concern considering the country's current situation of being energy stressed and the constant threat of load shedding, in addition to its aim of shifting its energy mix away from being fossil fuel dependent, towards contribution by renewable energies. (Kitley, 2011)

*The most suitable sustainable energy chosen, the Stellenbosch Wave Energy Converters (SWEC) will be briefly discussed later on in the report.

Having done all the research necessary to establish which sustainable energy is the most suited to this desalination plant, I have an even higher standpoint that it is imperative that the future for desalination lies in the advances thereof and the coupling of desalination plant with sustainable energies. This will create substantial energy and cost savings, as well as creating a more efficient way of desalinating sea water, and making it more accessible to countries that cannot afford to build massive desalination plants purely run by the current membrane technology and fuelled by limited fossil fuels.

Please refer to the Appendix B, section *(3) Key natural sustainable energies: Wave,* for a detailed explanation of wave energy in the context of South Africa and the SWEC project.

desalination.

Before I could start designing for a desalination plant, I first needed to have a complete understanding of desalination. Desalination is a process, whereby either filtration or distillation, that turns (salty) sea water into potable drinking water for human consumption. After extensive research, which can be referred to in the appendix, what better way to get first-hand experience of desalination, than by going to a local plant, which is situated in the small coastal town of Mossel bay?

The Mossel Bay desalination plant is currently the biggest plant in South Africa. This desalination plant, (cost R210 million to build) was built as an emergency project when the Southern Cape experienced its worst drought in 132 years.

Working at full capacity it can produce 15 000m^3 / day (15 million ℓ /day) and it supplies 10 000m^3 / day of potable water to the Mossel Bay Municipality which is directly pumped to the Langeberg reservoir, and 5 000m^3 / day of processed water to PetroSA. The plant was designed and built by Veolia Water Solutions and Technologies.

During the semester I contacted the Mossel Bay Municipality and Mnr Dupreez was very willing to help organise myself and another classmate the opportunity to visit and tour their desalination plant. Pierre Hayward, the Mossel Bay Seawater Desalination Plant Supervisor was very helpful too, and it was extremely enlightening to see how a reverse osmosis desalination plant works, and how complex a desalination plant really is to construct, run and maintain. The plant can be run and monitored by ingenious software that is specifically designed to run the plant.

Please see Appendix B for a more in depth review of the Mossel Bay plant, as well as, photographs of the plant, architectural plans and technical drawings, for a full comprehensive overview and clarity of how the plant's processes fully function.

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Visiting the Mossel Bay desalination plant was extremely important to the beginning of this project. It helped me figure out spatial requirement for all the necessary machinery as well as an accommodation schedule for the plant. I have been in contact with Pierre Hayward throughout the year to ensure that the design of this plant is complete and has all the necessary equipment and water infrastructure to run correctly and economically.

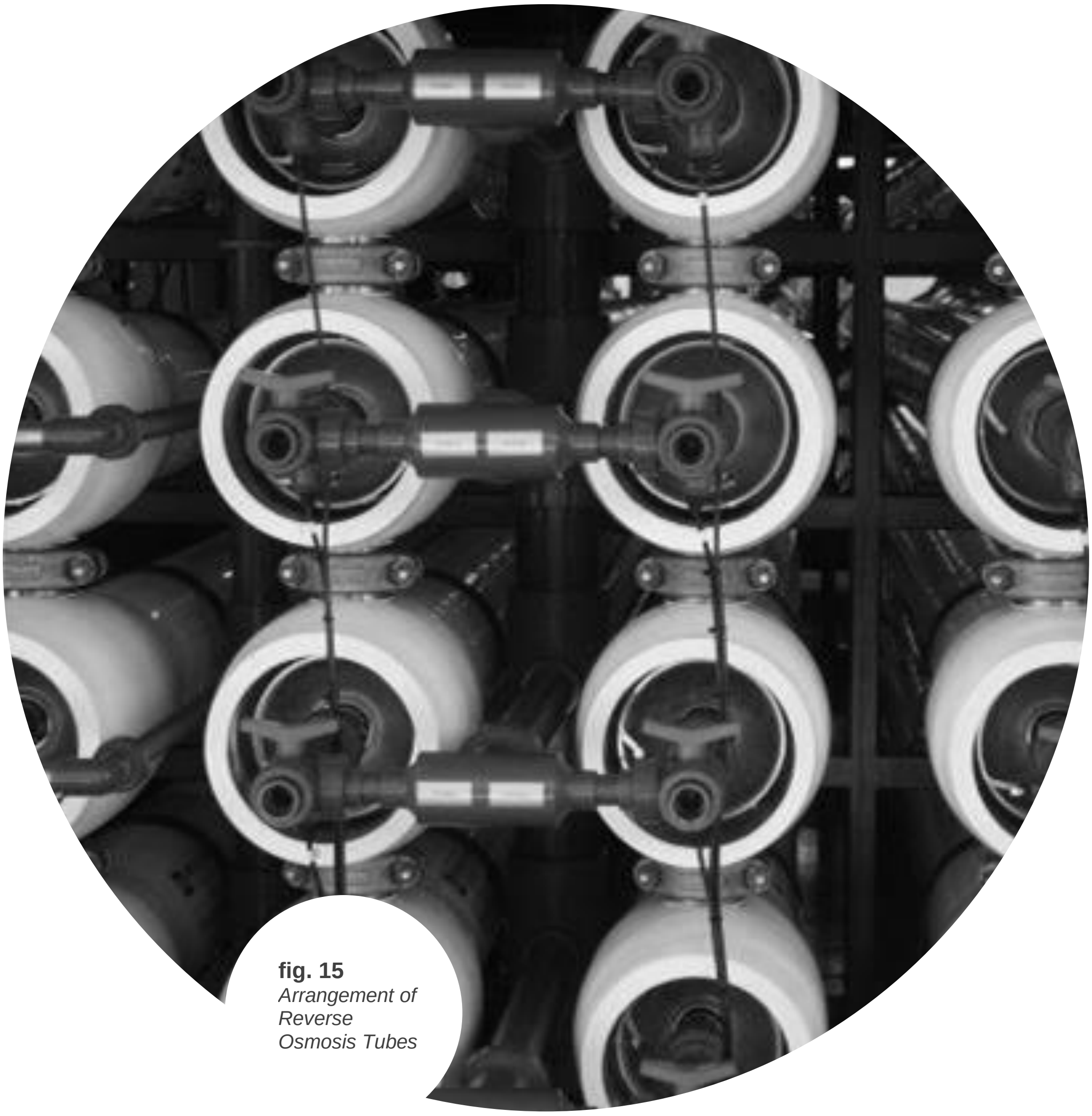

fig. 15
Arrangement of Reverse Osmosis Tubes

location location.

Hout Bay is a coastal suburb of Cape Town that has a well-mixed variety of neighbourhoods from the very affluent to the very poor.

It lies in a valley on the Atlantic seaboard of the Cape Peninsula and is 20km south of the CBD of Cape Town. Hout Bay has one of the busiest harbours in the Western Cape with an established tuna, snoek and crayfish industry.

Why Hout Bay? What brought me to this site?

(a) In Hout bay there is a need for water infrastructure as there is an increasing population growth due to the informal settlements, namely Hangberg and Imizamo Yethu.

(b) Disa River: A dying Eco-system.

Historically, water was stolen from Hout Bay's Disa River. In 1887 work started on the 700 metre Woodhead Tunnel to divert the waters of Disa Gorge through to Slangolie Ravine and via a pipe to Oranjezicht. But even before it was completed it was realised that the summer flow would not be adequate without a dam to support it. So in 1890 work began on the Woodhead reservoir. Ultimately five dams were constructed to collect water which previously flowed through Hout Bay's valley, three of which supplied water to Wynberg via Constantia Nek. This has left the Disa River without its original source of water and therefore this area's water issue needs to be addressed, if not more economical issues, but environmental ones.

(c) Chosen site has a Link to Industrial Sector of Hout Bay harbour.

(d) Need for a defined urban edge which will have a positive impact for informal settlements.

(e) The desalination plant will be a reminder of the fact that Cape Town has not implemented water saving strategies over the years, as well as, that the City of Cape Town stole water from Hout Bay and now we need to pay the price by supplementing this with an infrastructure that brings water back into this region.

(g) Wave energy is extremely high in this area, feasible to have wave energy converted SWEC, as the future of desalination, must be coupled with a sustainable energy to make it feasible.

(h) There is also talk of plans to build desalination plant in Hout bay, says Raul Rhode, Head of Resource & Infrastructure Planning, Bulk Water Branch, Water and Sanitation Department, which confirms that Hout Bay is undeniably a good choice of location.

fig. 16 *The Docks, Hout Bay Harbour.*

hangberg.

Informal settlement, Hout Bay.

The desalination plant is located at the edge of the industrial sector of Hout bay, an area which has never really been built up like the rest of The Republic of Hout bay. In this area there are only council flats that were built in the 1950s, during apartheid, to house workers from Hout Bay's fish processing factories. Within 20 years the flats have become completely overcrowded. This had led to the residents of Hangberg to spill out into backyard dwellings and info informal dwellings that spread haphazardly across the slopes of The Sentinel.

Three years ago, in September 2010 the City of Cape Town attempted to forcibly remove the informal settlers, the residents of Hangberg, from a firebreak high above the settlement. A riot arose, tyres were burned and a few residents, fighting for their homes and livelihood, lost eyes to rubber bullets.

From the top of Hangberg, one can see 1950's council flats, the harbour and Hout Bay's expensive mountainside suburbs rising on the far side of the valley. Despite these incredible views, the residents of Hangberg are living in less than ideal conditions.

When it rains, as a community they all work together to dig channels to drain the storm water, to prevent their homes from flooding and collapsing down the mountain side. Not only do they have to provide such water management themselves, without the help of the local government, they also have taken the initiative to install their own basic services such as toilets, taps, and electricity. This is a result of South Africa's backlog of over 2.1 million housing units according to the 2001 census. (Statistics South Africa, 2003)

The consequences of this housing backlog has resulted in growing land occupations in urban areas resulting in overcrowding in squatter settlements and therefore, informal settlements like Hangberg, lack sufficient access to basic services such as electricity, clean water and sanitation.

fig. 17 *View of the Sentinel Mountain from a playground in Hangberg*

design proposal.

A desalination plant in Hout Bay, able to produce 30 000M ℓ /day, situated on the edge of the industrial sector, harbour, the informal settlement of Hangberg and the beginning the mountainous terrain of The Sentinel.

With the aid of sustainable energies to help power this intensive desalination process (SWEC, solar and potentially wind), each day the production of fresh water will be piped to the proposed two reservoirs, which are situated above the informal settlement of Hangberg.

These reservoirs sit high enough to be able to supply most of Hout Bay with fresh water, and because of this height, the water can be reticulated via gravity and there is not much need for extensive pumping of water to households.

The desalination plant has another, much smaller reservoir, dedicated to Hangberg. The height of this water tank allows for the water to have a natural pressure to be reticulated through Hangberg. This small 'reservoir' creates the landmark for the desalination plant of Hout Bay.

To produce a total of 30 000M ℓ /day of potable water, the plant is required to in take a total of 75 000M ℓ /day of sea water. The process of reverse osmosis produces 40-50% potable water, and 50-60% brine water. Brine water is the extremely salty water that is left behind after the salt is extracted from the sea water. Most desalination plants, including Mossel Bay's plant, usually just pipe the brine water back into the ocean; however, I can't imagine this is too healthy for the local marine ecology.

This dissertation proposes that the brine water be used for salt harvesting, via shallow pans, where naturally, the water will be evaporated from these pans, leaving salt crystals behind to be used in industry. As well as the storage of brine waste that can be used to make saltcrete, which is put into an asphalt mixture for making roads.

With great infrastructure comes great responsibility. One must design infrastructure that is coupled with public activities. Building something that helps our future livelihood should be something that one can also interact with. Therefore there is a significant public element to the desalination plant. There will be brine pools that the public can swim in, a café overlooking the bay area, viewing decks, trails that weave through the plant, enabling visitors to continue walking around the coastline of the sentinel.

Along the path of the pipe lines from Desalination plant to reservoirs, there is a start of tranquil public hiking trail along this contour line, as well as an opportunity for locals and foreigners to view Hout bay from a great height. From this public viewing point they can also witness the production of sea salt harvesting and can visually interact with the desalination plant via a route down towards the plant that lands on the coast line.

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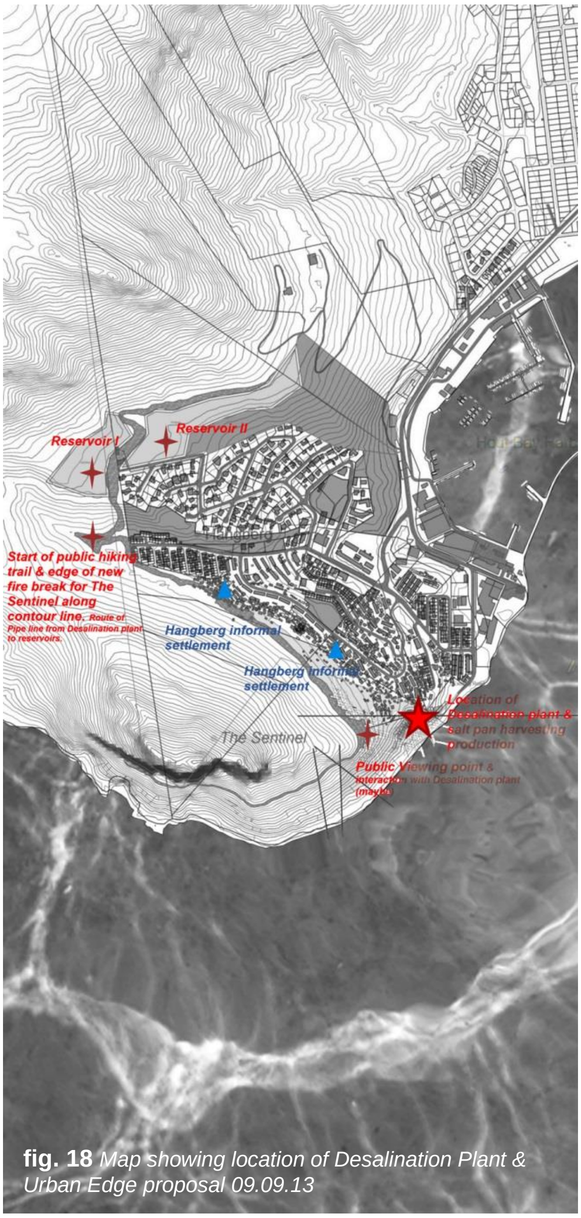

fig. 18 *Map showing location of Desalination Plant & Urban Edge proposal 09.09.13*

Urban edge proposal.

How does a desalination plant in the south west part of Hout bay help create a new urban edge for Hout bay and more specifically, spatially, for the informal settlement of Hangberg and why is it so important?

The addition of a desalination plant to Hout bay, alone, fights the water issues locally, as well as provincially as the dissertation desalination framework for Cape Town proposes.

Having Hout bay's main source of future water located at the edge of Hangberg, will propel the upgrade for Hangberg's water, rainfall, sewage and sanitation issues.

Creating a physical link from the desalination plant, along the mountain side to the reservoirs, generates a fixed urban edge. Above this physical link, a new fire break will be made, securing the infrastructure of the desalination plant and the residents of the settlement below.

Not only will the configuration of the salt pans also create an arresting feature to the Southern coast line of Hout bay, but it will also add to the definition of a new urban edge.

The sea salt harvesting production will furthermore create job opportunities for the local residents of Hangberg informal settlement.

accommodation schedule.

Storage (volumes)

02 x Reservoirs (Total 400 000m^3) *Able to hold 2 weeks' worth of water for Hout Bay.*
01 x Treated Water Tank (3 000m^3)
02 x Salt Silos (Total 2 850 m^3) = 1 185 m^3 + 1 665 m^3 = [(37m^2 (*l.b*) x 32m(*h*)) +(37m^2 (*l.b*) x 45m(*h*))]
09 x Brine Tanks for commercial distribution (Total 45 000m^3)

Production (volumes & areas)

05 x Main Pump stations (170m^2 each)
01 x Rough Sea water filtering Tank (1 475 m^3) = 170m^2 (*l.b*) x 8.675m(*h*)
07 x Rapid Gravity fed Filters beds (Total 475m^2)
07 x 5M ℓ /day Reverse Osmosis Skids + pumps (1 000m^2)
01 x Water Treatment Facility
01 x Brine Distribution Tank (2 170 m^3) = 170m^2 (*l.b*) x 12, 760m(*h*)
01 x Backwash Tank (550 m^3) = 110m^2 (*l.b*) x 5m(*h*)

Saltpans (5 800m^2)

Public Activities

01 x Restaurant (284m^2)
07 x Brine Pools (300m^2)
01 x Water Bar in Tower (320m^2)
01 x Salt outlet (145m^2)

Public open space (7 070m^2) *Including Desalination Plant Walkthrough & access to tower*
Walking Trails, above & below Desalination Plant

Total Area of Hout Bay Plant only:
Total Area of Mossel Bay Plant only: **5 335m^2** *(only 1 level)*

*Please refer to the Appendix A (fig. 63) and Appendix B *(5) Calculations & Info relevant to Desalination Plant process, production & storage,* for relevant calculations and brief explanations of the above schedule's components.

fig. 19
Conceptual Section in process 20.08.13

“1 step forward, 2 steps back.”

This project, to say the least, has not been easy, but I am going to try and recount its process as concisely as I can. *(Please refer to all process drawings in part 1 of Appendix A)*

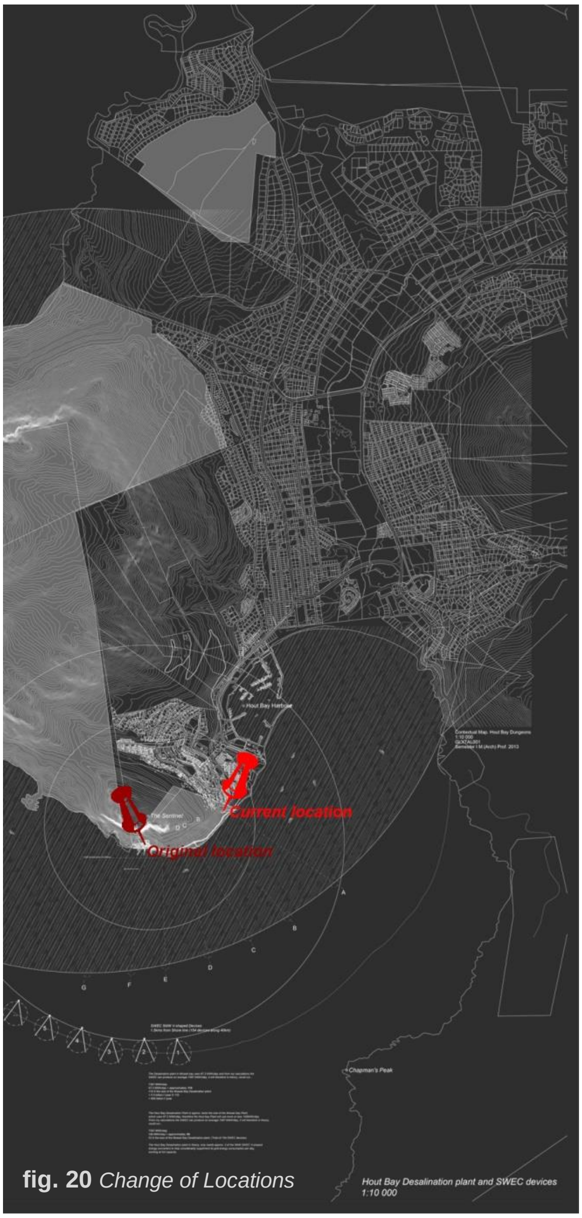

fig. 20 *Change of Locations*

Location_

Originally, the site of the project was in a more isolated area, still on The Sentinel, but much further south, therefore only visible from Chapman’s Peak side of the Mountain. One of the rationales behind this location, was driven by the idea of the romantic and symbolic contrast between the man-made and nature. For the majority of the first half of the semester’s work, the project’s location remained, but due to many difficulties faced, had to be moved, subsequently to a much more appropriate site.

The former site faced issues of environmental concerns, as this area is part of the Table Mountain National park, and would be faced with similar protest to that of the new Toll Booth on Chapman’s Peak, built not so long ago, but the fraction of the size

(Also see Appendix A: Process Work)

Vertical Production_

From the beginning of the year I knew I wanted to create an infrastructure that had vertical production, therefore the first location seemed extremely appropriate as it was almost a cliff face, with ideas of fixing the desalination plant to the mountain face, taking advantage of its height and gravitational pull.

However, this idea soon was unravelled due to many reasons, as the machinery needed for the plant to run, as well as the water storage, was extremely heavy and not well suited for vertical production. Although, in the final design, the use of gravity is fundamental to the design, where the sea water intake is distributed from a height, allowing the sea water through the production to reticulate via gravity, and relieves some of the energy used to pump the water through the system.

(Also see Appendix A: Process Work)

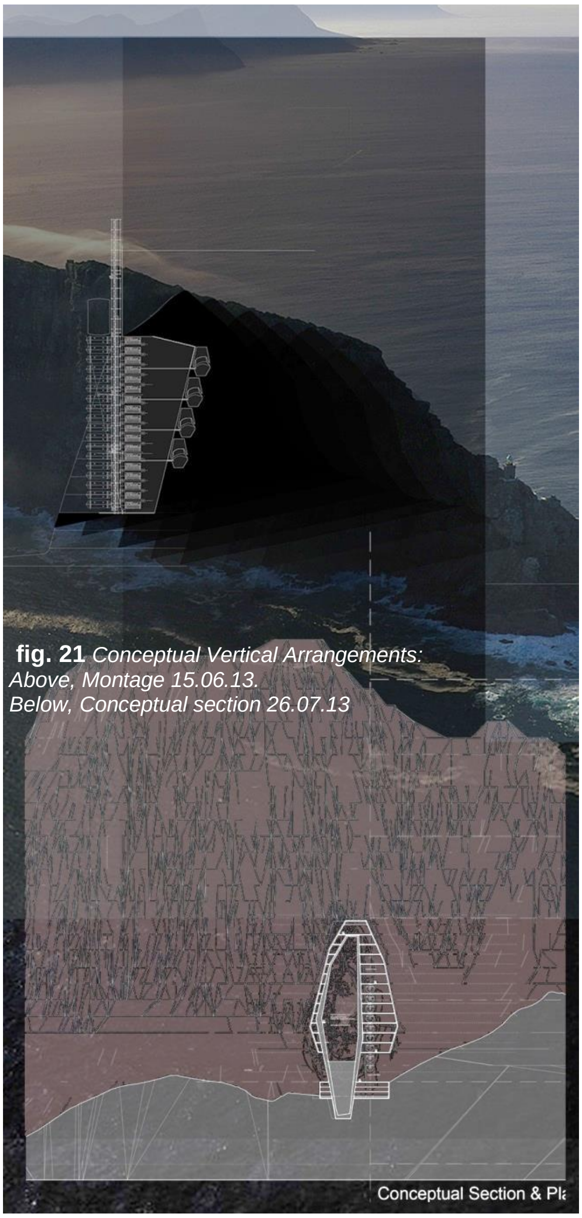

fig. 21 *Conceptual Vertical Arrangements:*
Above, Montage 15.06.13.
Below, Conceptual section 26.07.13

Water Storage_

Originally, the storage of the desalinated water was a part of the vertical arrangement, as I have mentioned before, with its tank being at the highest point of the tower, where it would be high enough to create enough water pressure needed for the water to be sent through Hout Bay.

However, water is extremely heavy, and the amount of water that was needed to be stored, was just too mammoth an amount to be fixed to the top of towering landmark of a desalination plant. The idea behind this stemmed from the water towers in the United States of America, but these towers do not hold more than 2 000M ℓ of water, where this tank needed to hold + 30 000M ℓ of water. It just did not make structural sense to have an elevated reservoir.

A more logical solution was to create two reservoirs, which are situated above the informal settlement of Hangberg. These reservoirs sit high enough to be able to supply most of Hout Bay with fresh water, and because of this height, the water can be reticulated via gravity and there is not much need for extensive pumping of water to households.

(Also see Appendix A: Process Work)

In the design proposal I stated that the desalination plant has another, much smaller reservoir, dedicated to Hangberg. However, this idea has had to be revised, after a recent meeting with a consultant engineer, as the height of this water tank does not in fact allow for the water to have a natural pressure to be reticulated through Hangberg, as the height does not create the required pressure. Again, it does not make structural sense.

The tower will have a similar programme still, however it will be in reverse, with the water tank in the core, functioning as temporary location for the final stage of desalination (treatment of water) before it is sent off to the main reservoirs.

The detailed adapted programme and design for this tower will be revealed at the final review.

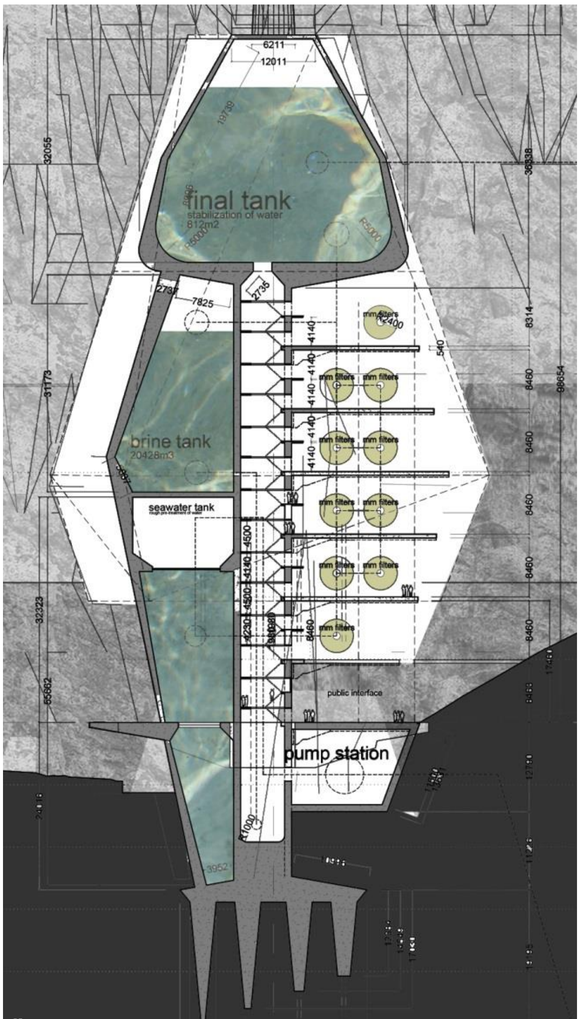

fig. 22 *One of the many early water storage arrangements, this design was one the first, dating back to 14.08.13*

Development of the landmark, The Tower_

At the beginning of the project, as I have mentioned, the whole production process of the desalination plant was to be inside a structure that created a tower due to its vertical arrangement. However this could not be realised.

The notion of a tower was still a valuable one, as it has more significance to it than the fact that it's just a tower, as I have mentioned in the design concepts section of this report. It has symbolic meaning embodying many ideas architecturally, economically and socially within its context.

Throughout this project, the form of this tower has changed and morphed according to its programme.

The skin of this tower is extremely important. I will reiterate that desalination is a highly energy intensive process and requires some form of sustainable energy to help supplement its energy usage. This skin of the tower is an element to this project that can be used to its advantage, creating a façade that can create its own energy. Even though this project proposes to acquire the majority of its energy from an external sustainable energy, the Stellenbosch Wave Energy Converters (SWEC) that has been proposed to be built along the coast of Saldanha Bay (this energy will be fed into the city grid and be used to power the desalination plant, as the plant requires a constant source of energy, not one that fluctuates), it is important that the plant has considered sustainable energies within its design, thereby creating an infrastructure that helps creates its own energy.

However, the first location of the project was constantly shaded by The Sentinel, and the idea of harnessing energy from the sun with solar panels was deemed useless as it would not be exposed to the right amount of full strength day light.

The current location changed all this, as the tower is now completely exposed to the sun at peak hours and renders the tower, once again a very important feature of the project.

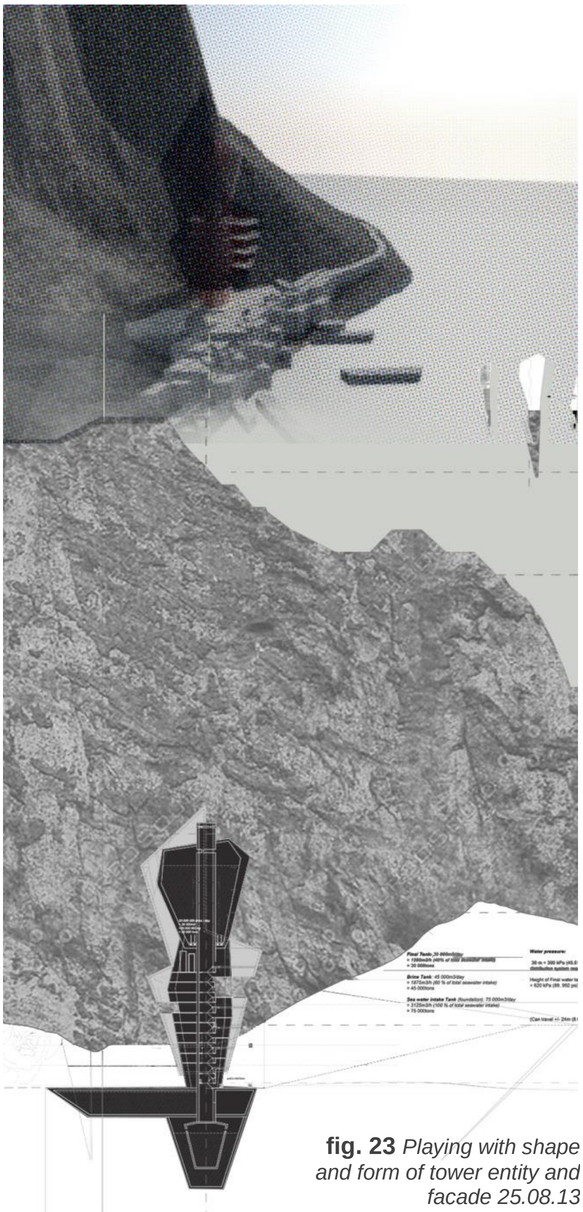

fig. 23 *Playing with shape and form of tower entity and facade 25.08.13*

The skin will be implemented with solar panels, on the sides that are most exposed to the sun. The different facets of the façade will have different functions, not only sustainable, but architectural as well, at certain moments revealing and concealing the inner workings of the tower.

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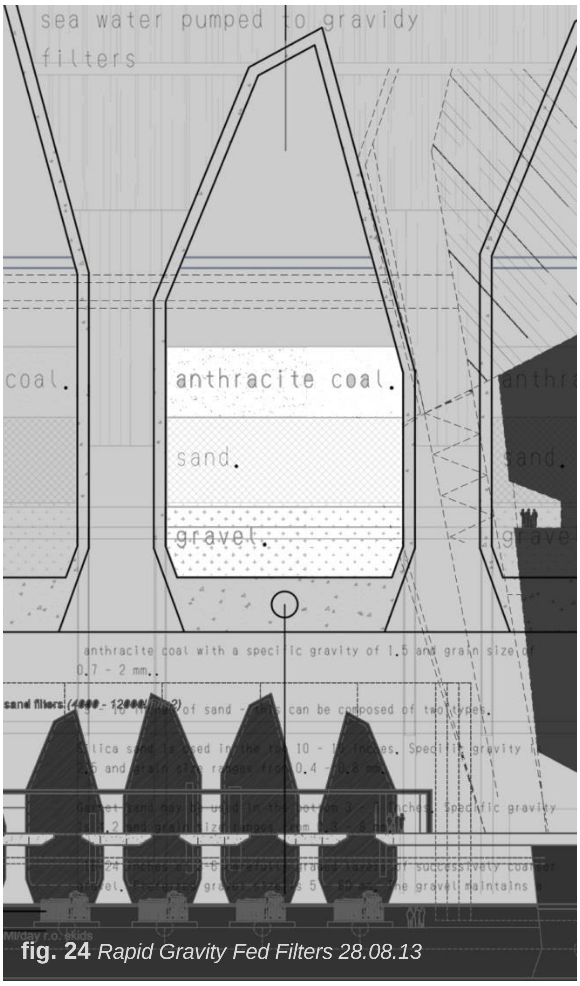

fig. 24 *Rapid Gravity Fed Filters 28.08.13*

Productive Architecture_

The project framework section of this report talks about the architectural opportunities that this project allows. Besides for the reverse osmosis skids, that cannot be replaced, there have been many architectural design opportunities in the configuration and design of some of the other processes in the plant, which have been mentioned and implemented in the design of the plant. Namely, rough filtering sea water intake tank, gravity fed filters (to be explained below), the disposal of the concentrated salty waste via salt pans and solar salt extraction, the stabilization tank and the treatment and storage of the final product, drinking water.

As well as the great design freedom there comes with creating new feasible natural energy devices, that is integral to function and form of the plant's tower.

The majority of the machinery used in this plant is based on the machinery that is used in Mossel Bay Desalination plant. The reverse osmosis skids are manufactured by Veolia Water Solutions & Technologies South Africa (Pty) Ltd. The Mossel Bay plant uses high pressurized sand filters for the second process of desalination, (before the water goes through the reverse osmosis skids).

However, these multi-media horizontal filters (MM filters) are extremely heavy, cumbersome and costly, and require more heavy machinery to perform maintenance when it is due, therefore these filters were ruled out as an option at the beginning of the project as they could not be used in a vertical arrangement when the project still was trying to maintain a vertical production line.

I chose to use rapid gravity feed filters, these filters are much cheaper to build, and can be built with local materials. This process is quite simple, as the water flows through 3 layers, first, anthracite coal, secondly, sand and lastly gravel. The most important part of these filters for production is the size of their beds; therefore their design can be of almost any shape, as long as the bed size is correct. These gravity filters do require regular maintenance to clean the top surface of the bed, which in turn can provide even more jobs for the locals at the desalination plant.

Public Interface_

As I stated in the design proposal, is it very important that this project be coupled with public activities and interaction. The public element to the desalination plant has had a steady progression throughout the project. These public spaces will allow visitors to witness the production of desalination without hindering their safety. As well as maintaining the existing coastal path around the Sentinel, which weaves through the plant, enabling visitors to continue walking around the coastline.

The establishment of new paths that originate within the informal settlement of Hangberg, hugging the edge of the desalination plant, creates public access points to the tower as well as the plant's public space.

(Also see Appendix A: Process Work)

Atmosphere: Spatially, programmatically and tectonically _

As I mentioned in the introduction that an architecture that's primary function is for production, a "functionalist" architecture, it will inherently be true to its materials and construction. This truth will make visible the processes of its mechanics as a whole and will allow for pure tectonic explorations, materialistically & atmospherically.

Because of the complexity of programme in this project, the design process proceeded in a rational sequence of primary concerns in its context: spatial ordering and layering of programme, technical and rational performance of production, integration of design within its context and tectonics; material articulation of productive architecture.

The layout of the desalination plant has been designed in such a way that the production of drinking water is visible to the public eye, yet maintaining public safety. The spatial layout of the plant, itself creates an atmosphere that indulges the public with this process of production as well as a programme that lets the public delve into an atmosphere of exploration; spatially, horizontally and vertically.

Due to the extensive scope of this project, I have to focus on a select few key moments in the project that expresses all the ideas above.

Tectonically, the main focus of this project is the iconic water tower, as it is the most prominent feature of the design and due to the function of its skin, will inherently be technically and tectonically articulated.

The plant itself has been realised in a very modest way, simple materials, and simple construction, as its architectural value lies in the articulation of form and its spatial layout, creating a dynamic atmospheric experience.

To be continued, as a result of material and tectonic explorations still in progress.

final words*

These final words are not completely conclusive, as there is still a lot of work and design to be completed before the final review. Please note that the drawings in Appendix A are not the final drawings, but those up until the day of the due date of this report.

Dear reader,

As I expressed in the introduction of this report, the reason I chose to investigate the process of desalination is due to the looming water crisis, as 2013 marks the year that we, South Africa, are no longer water secure, and because of this, the desalination plant is one of the most significant 'machines' of our future, here in Cape Town.

Architecturally, my affinity towards the Industrial age, machinery, functionalism and geometry of form, has from the get go informed the way I have conceived of this project and the rationalization thereof. As a designer who pays attention to detail on macro and micro scales, integrity of materials and process has played a huge role in the way I chose to design this project, whether it falls under architectural engineering or engineered architecture or both.

All prior investigations and research required for this project in the first semester as well as the visit to the Mossel Bay Desalination plant, enlightened me and hence awarded me with a deep understanding of how complex desalinating water is, and I thought I was substantially well-informed.

However, this project has been extremely challenging, as, at almost every moment in the project where I had to make a production, structural or architectural design decision to progress, I was faced with new and real predicaments, where I had to go back and do even more research, while each time new knowledge and countless solutions were illuminated.

This dissertation has explored, to the best of my ability in a very short time frame, my own architectural interests and hopefully this report, has given you, the reader, an insight to the inner most parts of this project, as well as the inner workings of my mind and how it brings life and flesh to a set of ideas.

Even though this architectural intervention's function was born primarily out of necessity for water, and its architecture is not intimately concerned with people, it is a machine that serves people, communities and our livelihoods.

This project also tries to show that something can be so more than its individual parts, but rather, has a whole to whole relationship, where the sum of its parts are much greater than the whole, much greater than one would expect.

This dissertation is not just a desalination plant, not just a salt harvesting plant, not just another urban edge, nor is it just a new tourist spot. It is something much greater, something that has a complex hierarchy of programme that functions simultaneously, as an intervention that is social, economic, environmental, progressive, architectural and symbolic, and therefore cannot be reduced to its singular parts.

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Finally to conclude, I will end this report with a quote that this project and myself identifies with, words by Thom Mayne, from Morphosis Architects.

I'm often called an old-fashioned modernist. But the modernists had the absurd idea that architecture could heal the world. That's impossible. And today nobody expects architects to have these grand visions any more.
(Architectuul.com, 2013)

appendices.

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Appendix B

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(3) Key natural sustainable energies: Solar, Hydro, Wave & Wind
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Appendix B

Desalination of water on a large scale (relevant to Hout bay)

Chosen processes of Desalination for large scaled plants: Membrane Technology. Reverse Osmosis. (RO)

Membrane Technology is a system that uses a pressure gradient to force the water through membranes.

Reverse Osmosis. (RO)
……………………………………………………………

The process of Reverse Osmosis (RO) was first commercialised in the 1970s and is currently the most extensively used method for desalination, especially in the United States of America (USA). Essentially, the RO process uses pressure as the driving force to push saline water through a semi-permeable filter type membrane into a product water stream and a concentrated salty water stream. RO processes are used for desalinating both brackish water (water that has more salinity than fresh water, but not as much as seawater) and seawater.

The process is explained below:

To define reverse osmosis, it is important to first explain what exactly the osmosis phenomenon is regarding desalination. The osmosis process occurs when two liquids of different concentration are separated by a semi-permeable membrane. These fluids have a tendency to move from low to high solute concentrations for chemical potential equilibrium, and therefore this movement generates osmotic pressure due to the higher concentration solvent trying to equalise solute concentrations on each side of a membrane.

Therefore, the Reverse Osmosis process occurs when an added external pressure is applied to the solution with the higher salt concentration solution, where this concentrated salt water is pressurised against one surface of the membrane, resulting in, the water flowing in a reverse direction through the semi-permeable membrane, leaving the salt behind. RO not only removes salt from the sea water, but also other substances from the water.

The RO membranes have such small pores, it is therefore very important that the water passing through the membrane be pre-treated adequately before being passed through it. It is therefore best that the water be pre-treated chemically (to prevent biological growth and scaling) and physically, to remove any suspended solids.

An RO desalination plant essentially consists of four major systems:

Order of RO process:

Saline/sea water intake
Pre-treatment System (removal of sediment in sea water)
Reverse Osmosis Process
Concentrated Salty Water Disposal
Stabilisation (Add minerals and stabilise PH levels)
Fresh water Storage

RO is the most commonly used desalination process, although there are a number of other Membrane Technologies used, which include:

- Electro dialysis. (ED)
- Electro dialysis Reversal. (EDR)
- Membrane Distillation. (MD)
- Nano Filtration. (NF)

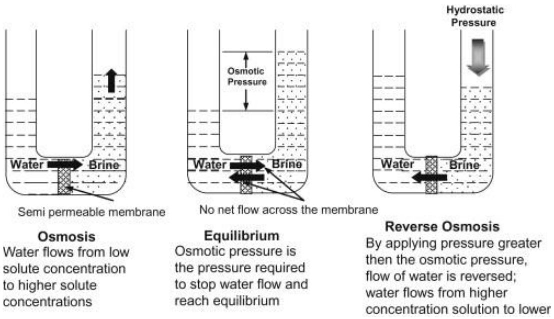

fig. 70 *Osmosis and Reverse Osmosis Diagram (NTS)*

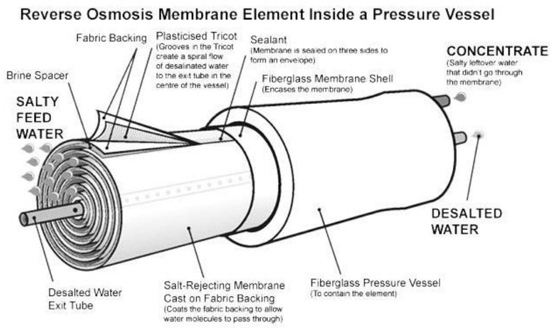

fig. 71 *Diagram of Reverse Osmosis Membrane Element Inside a Pressure Vessel (NTS)*

Local Precedent: Mossel Bay Desalination Plant

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The Mossel Bay desalination plant is currently the biggest plant in South Africa. This desalination plant, (cost R210 million to build) was built as an emergency project when the Southern Cape experienced its worst drought in 132 years.

The project was financed jointly by the National Treasury, PetroSA and the Municipality. Therefore a third of the plant's daily production is intended for PetroSA's fuel plant at Mossel Bay.

Working at full capacity it can produce 15 000m^3 / day (15 million ℓ /day) and it supplies 10 000m^3 / day of potable water to the Mossel Bay Municipality which is directly pumped to the Langeberg reservoir, and 5 000m^3 / day of processed water to PetroSA. The plant was designed and built by Veolia Water Solutions and Technologies.

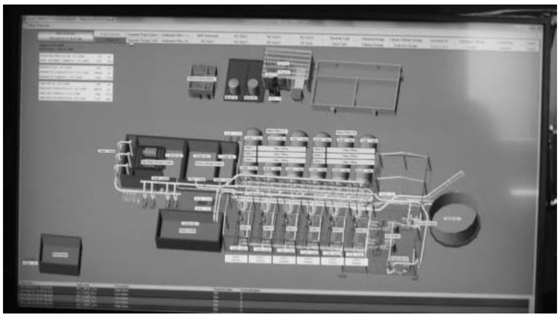
During the semester I contacted the Mossel Bay Municipality and Mnr Dupreez was very willing to help organise myself and another classmate the opportunity to visit and tour their desalination plant. Pierre Hayward, the Mossel Bay Seawater Desalination Plant Supervisor was very helpful too, and it was extremely enlightening to see how a reverse osmosis desalination plant works, and how complex a desalination plant really is to construct, run and maintain. The plant can be run and monitored by ingenious software that is specifically designed to run the plant.

The Mossel Bay desalination plant seawater supply intake is pumped directly by an open sea pipe that is 900m from the shoreline. (Brine outlet pipe sits at 600m from shoreline) This salty water is the pumped into the pumping station which is housed separately from the desalination plant, and is pumped into holding takes via 4 smaller pipes. These pre-treatment holding tanks screen incoming water via 500 microns (0, 5 mm) grid screens to rid the water of kelp, sea shells and other larger impurities that the intake pump from the sea has pumped in with the seawater.

After the seawater has been screened of larger unwanted debris, the water then passes through six filters before going to the reverse osmosis units for purification. After purifications, the stripped and treated water is then fed from the plant into split tanks, one for the Municipality and the other for the supply of PetroSA.

The 10 000m^3 of water for the Mossel Bay Municipality is treated chemically to kill any bacteria and stabilise the pH balance for human consumption, before joining up with the municipal water line through to the Langeberg reservoir.

fig. 72 *Mossel Bay Desalination Plant*



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Key natural sustainable energies to help supplement desalination plants.

……………………………………………………………

This chapter will be discussing such energies, and key locations in the Western Cape where these energies can be harnessed and any new developments thereof. This information is important for my dissertation as it will help define which sustainable energies are most suited to be coupled with desalination, and help locate optimal settings for such desalination systems, preferably in the Western Cape. I will also be using the Mossel Bay plant as precedent to illustrate how powerful sustainable energies can be in terms of their power output.

Description of Solar Energy:

Solar energy, involves the harnessing of radiant light and heat from the sun. The technologies that harness the sun's energy include, just to name a few, solar heating, solar photo-voltaics (PV), solar thermal electricity, artificial photosynthesis and many other systems. Like all sustainable energy sources, solar energy is safe and environmentally sound, as there are no emissions as the source of energy is the sun, unlike coal-powered stations, that use finite fossil fuels.

There are two types of solar energy, mainly passive and active, depending on the method of capturing, converting and distributing solar energy. The use of photovoltaic panels and solar thermal collectors to harness the energy, are considered active techniques, where passive techniques include using the orientation of the sun to harness the most energy as well as the selection of materials that have thermal mass or light dispersing properties. Sun light can be converted directly into electricity via PVs or indirectly via concentrated solar power, a system that use lenses to focus large amounts of sunlight into a small beam.

Locations of Solar Energy in Western Cape and / or South Africa.

Robben Island. (Western Cape)
Upington, Solar Farm (Northern Cape)
Aquila Private Game Reserve, Solar Farm (Western Cape)

In context of Western Cape:

The Solar Thermal Energy Research Group (STERG) at the University of Stellenbosch have stated that if the country is committed to providing for, and investing in renewable energy projects, solar energy could offer more than adequate power to South Africa. Paul Gauché, STERG senior researcher and director, has said that solar energy in South Africa is decidedly feasible if the sector was sufficiently funded and supported.

He continues to say

The potential for [photovoltaic solar energy] is immense: If we put PV farms up everywhere we could easily get more than enough power generated in the country. (SoliareDirect, 2010)

Even though main focus is on the solar farm in Upington, Solairedirect South Africa is still continuing to effectively generate energy at its solar power plant in Cape Town. This plant was built in 2009 and it has made noteworthy contributions to solar energy in South Africa.

At present Robben Island is also undergoing a project that is being supported by the South African Energy Research Institute where solar CPVs are the main method of power generated on the Island, along with the use of hybrid renewable energy technologies including wind, hydro and biomass energy. The idea behind the project is to demonstrate that South Africa can successfully reduce its dependency of finite fossil fuels.

***

The intended solar field array at Point Paterson will cover two square kilometres.

Solar-powered desalination plant leads the way

A Victorian company recently announced plans for the staged development of Australia's first solar-powered desalination plant near Port Augusta in South Australia. Combining solar energy–based power generation, desalination and commercial salt production, all integrated into a single $370 million industrial complex, the project will significantly reduce the usual greenhouse impacts associated with grid electricity demand for desalination.

Melbourne-based Acquasol Pty Ltd has identified a 50 000-hectare site at Point Paterson, seven kilometres south of Port Augusta.

The solar field will be laid out over a two-square-kilometre area with each solar mirror standing three metres tall. The captured heat will be used to create steam for electricity and desalination, with any excess heat going into thermal storage.

Initially, the desalinated seawater from the Point Paterson plant will be produced mainly for the town of Port Augusta. Eventually, however, it will be capable of supplying water to an area bounded by Port Augusta, Whyalla and Port Pirie – an area known as the 'Iron Triangle'.

This will minimise the area's reliance on the above-ground Whyalla pipeline from Morgan, which brings water from the River Murray 360 kilometres to the east.

The facility's design will also allow it to be expanded to supply power and water to South Australia's mining communities to the north, easing infrastructure concerns about the state's booming resources sector.

When the first stage is complete, the Point Paterson facility will produce 200 megawatts (MW) of electricity – 50 MW solar thermal and 150 MW combined cycle gas turbine (CCGT). It will also produce 5.5 gigalitres of water per year – enough for 34 000 people – 2 gigalitres of which will be supplied free to Port Augusta during the first two years of trialling the design.

'Point Paterson will be a world-first in combining large solar power station technologies and water desalination in a stand-alone, near-zero greenhouse gas emission facility,' says Acquasol's Managing Director, Michael Fielden.

'Unlike conventional desalination processes, Point Paterson will reduce or eliminate the need to dispose of by-product waste brine back into the sea.

'The technology is off-the-shelf, but the combination of the technologies in a high-demand commercial environment for power, water and salt is unique.

'The plant will be configured to enable ready expansion to produce more than 45 gigalitres of water – enough for more than 250 000 people for a year.

'At the end of the day, Point Paterson presents the first Australian environmental and cost-competitive alternative to climate change issues confronting the driest state and its reliance on fossil fuel-based power and stressed natural water resources.'

The Acquasol project announcement coincides with the South Australia Government decision this week to legislate for tougher, world leading greenhouse gas emission standards.

'The power needed to pump water hundreds of kilometres along the Morgan–Whyalla pipeline creates significant greenhouse emissions, yet this project provides environmental relief to the Murray River,' says Mr Fielden.

'The boom in mining projects, which are energy-hungry operations, is a negative against the state's greenhouse challenges, but Point Paterson can balance the ledger by reducing the country's reliance on burning coal for 80 per cent of its electricity needs and easing our 90 per cent reliance as a nation on natural waterways of finite resource.'

The project has attracted the interest of internationally renowned climatologist Professor Stephen Schneider, who has joined the Board of Acquasol as a non-executive director.

'Point Paterson will be a world-first in combining large solar power station technologies and water desalination in a stand-alone, near-zero greenhouse gas emission facility.'

Other companies that have registered their interest in the project include Origin Energy (which is interested in the excess power that will be produced); engineering and design contractor, Abigroup Limited; and Australia's largest domestic salt producer, Cheetham.

More information:
Acquasol: www.acquasol.biz/index2.htm

fig. 81 *Point Paterson, Australia - Solar-powered desalination plant*

Solar Precedent:

Point Paterson, Australia - Solar-powered desalination plant.

……………………………………………………………

If solely solar power were to be coupled with desalination, see figure 15, as example, the Point Paterson Desalination plant will have, in its first phase of construction, a solar field that will be laid out over a two-square-kilometre area. Each solar mirror standing three metres tall.

Acquasol Infrastructure Ltd, the company who has designed this desalination plant, believes in combining technologies, therefore, the captured heat will be used to create steam for electricity for the plant and solar desalination of the brine outlet, and any excess heat will go into thermal storage.

Acquasol Infrastructure Ltd has identified a 50 000-hectare site at Point Paterson.

The solar power and desalination's facility's design will also allow for it to be expanded, supplying power and water to South Australia's mining communities to the north. The plant will be configured to enable ready expansion to produce more than 45 billion ℓ /year.

(This is 8.2 times more than the amount of water that will be produced in the first phase of construction)

The first stage of this project, with solar panels over a two-square-kilometre area, is set out to produce 5.5 billion ℓ /year = ±15 million ℓ/day, which, to put in perspective, is in fact is the same output as the Mossel Bay Desalination plant working at full capacity.

Acquasol's Managing Director, Michael Fielden says

> Point Paterson will be a world-first in combining large solar power station technologies and water desalination in a standalone, near-zero greenhouse gas emission facility,
>
> Unlike conventional desalination processes, Point Paterson will reduce or eliminate the need to dispose of by-product waste brine back into the sea.
>
> The technology is off-the-shelf, but the combination of the technologies in a high demand commercial environment for power, water and salt is unique. (Fielden, 2007)

However, that being said, the first stage solar capacity will be 50 MW which is sufficient to power the Mossel Bay 2.8 MW RO plant. But what will happen at night or during a cloudy day?


fig. 82

hydro.

Description of Hydro Energy:

Hydro power is power derived from the energy that water can create from falling at great distances or just by running down a stream, its energy in other words, relies on the gravitation pull that the earth has on this natural element. Energy from moving water can be harnessed in many ways, historical it was used to operate various mechanical devices, such as watermills, sawmills, textile mills, dock cranes, domestic lifts and power houses.

Today, hydropower usually refers to hydroelectricity, the production of electrical power through the use of the gravitational force of falling or flowing water. Hydro power is the most widely used form of renewable energy, as it dates back to ancient times. It accounts for 16% of global electricity production.

South Africa's largest hydropower plants are only a 1/10th the size of global hydro plants around the world. The largest one being, the Drakensberg Pumped Storage Scheme in the Free State, which has the capacity of 1 GW of power.

The running cost of hydroelectricity are relatively low, making it an economical source of renewable electricity, and once a hydroelectric plant/dam is constructed, it produces no harmful waste, and has a lower output level of carbon dioxide (CO_2) than fossil fuel powered energy plants.

Locations of Hydro Energy in Western Cape and / or South Africa:

Larger scale Hydro plants: (Mega Watts)

Ingula Pumped Storage Scheme
(Still under construction) - (1332 MW)

Drakensberg Pumped Storage (1000 MW)
Palmiet (400 MW) (Western Cape)
Gariep (360 MW) (Eastern Cape & Free State)
Vanderkloof (240 MW) (Northern Cape)

In context of Western Cape:

There are no notable large hydroelectricity plants in the immediate area if Cape Town, however, the Drakensberg 1000 megawatt Pumped-Storage Facility is South Africa's major source of hydroelectricity. The country's second-largest plant is situated on the Palmiet River outside Cape Town.

The 3rd and 4th largest are the Gariep and Vanderkloof Dams, owned and operated by the Department of Water and Environmental Affairs (DW&EA). The hydro power from just the Gariep and Vanderkloof dams alone, supplement portions of Eskom's fossil stations and state that

> approximately 700 GWh generated annually by the hydros results in about 200 000 fewer kilograms of particulate matter being emitted into the air. (Eskom, n.d.)

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**To put this in perspective, just these two dams alone in theory could power approximately 30 Desalination plants the size of Mossel Bay's, 30 X 5.5 billion ℓ /year
= 165 billion ℓ /year.**

However, the setback for this energy source is that the construction of dams can disturb the natural flow of rivers and can harm local ecosystems, as well as displacing local people and wildlife.

*On the subject of harnessing water and its power, as mentioned before, it is vital for Cape Town to couple desalination with natural sustainable energies as well as tap in to fresh water that we don't have the infrastructure to do so yet, as well as the treatment and re-use of water that the desalination plants produce. This paper will not be discussing the below bulleted ideas, but they will be addressed as a later stage of this dissertations, as they are imperative to saving the water crisis in Cape Town, and South Africa at large.

- Catchment of Storm water
- Access to Deep Level Aquifer
- Water treatment stations to conserve fresh water from desalination plants.
- As well as, the staggering 30% plus of drinking water loss, that is currently unaccounted for. (Nicholas & News24, 2013)

Description of Wave energy:

Oceanic waves are created by wind as it blows across the sea surface. The energy from the wind is transferred directly from the motion of the air to the waves. These waves travel at great speeds, along immense distances across the ocean. Depending for how long the wind blows and at what strength it blows over the surface of the sea, the higher, longer, faster and more powerful the ocean waves are. The energy within a wave is proportional to the wave's height squared, so therefore a 2 meter high wave has 4 times the power of a 1 meter wave height.

Wave energy is the conversion of energy by ocean surface waves, harnessed by certain systems to be used as other sources of energy, e.g. electricity generation and sea water desalination. Machinery able to harness wave power is commonly known as a wave energy converter (WEC). This technology involves two basic components; a collector to capture the waves' energy and a turbo generator to convert the wave power into electricity. One of the main advantages of wave power over solar and wind energy is that waves keep moving along the ocean 24 hours a day, 7 days a week, and although they vary in intensity depending on climate and season, wave conditions are much more predictable than most sustainable elemental energies.

Locations Potential of Wave Energy in Western Cape:

- Saldanha (Western Cape)
- Mossel Bay (Western Cape)

In context of Western Cape:

The Engineering News Online article *Big wave energy project under investigation in the Western Cape,* in 2009, describes the on-going investigations that are under way to determine the feasibility of the construction of a R15 Billion 770-MegaWatt wave energy project in the Western Cape.

Hermann Oelsner of Wave Energy Generation, is one of the key figures heading this operation. From his publication *Pre-feasibility study of wave energy in Saldanha and Western Cape,* published July 2012, he explains that South Africa is one of the few countries in the world that have extremely high wave energy potential. SA's coastal mean annual power level is at roughly 40 to 50kW/m wave crest, especially offshore the Western Coast. Jane Davenport from Engineering News Online explains

> The south-western coast of the African continent is exposed to an energetic wave regime generated by eastwards-moving, low-pressure systems created in the south Indian and south Atlantic oceans. The passage of these depressions with their associated cold fronts and wind fields is the main cause of ocean wave energy reaching the south-western African coastline. A secondary source of wave energy generation on the south-eastern African coast is the presence of tropical cyclones in the western Indian Ocean. (Davenport, 2009)

Hermann Oelsner continues to elaborate that this project is in conjunction with The SWEC project (Stellenbosch Wave Energy Converter) who have over the past couple decades been working on the development of a wave power conversion system. This project, planned to be located in Saldanha Bay will consist of five different phases, starting from the feasibility study and finishing with the construction and installation of 154 SWEC devices.

Oelsner explains further that

> This will be achieved by building a number of submerged V-shaped collector arms along 40 km of the Western Cape coast….Each V-shape will have the capability of generating 5 MW. (Davenport, 2009)

The placement of these SWEC V shaped collectors at 1½km from the shore line, results in 30% capture of the wave's energy, which in turn means that the ecology of the shoreline will not at all be affected. The design for these wave energy converters have been completed and the project is currently in the process of appealing to investors to help secure funding for the first 5-MW demonstration phase.

However, Davenport claims the 5 MW V-device can generate 2MW with a peak of 2.9 MW. One would then expect that the minimum MW generated would be in the order of 1 MW. This is the crucial parameter to consider when you want consistent power from it. Therefore, the total power that will be generated by the project (154 units) is 2700 GWh/year or 7397 MWh/day.

The average generating capacity will be 308 MW (2 MW/unit), and not the initial 770 MW proposed power in the feasibility study. Therefore once again, one must be aware of the minimum generating envelope.

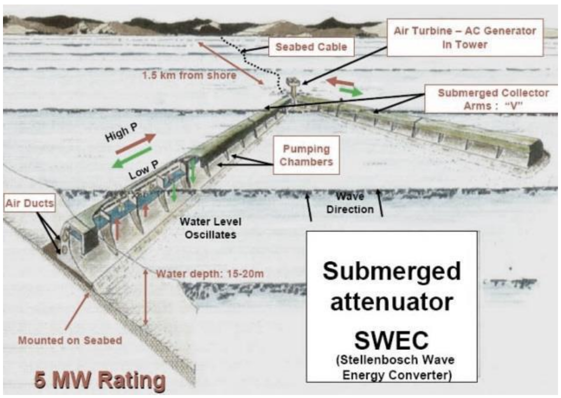
However to put this energy produced in perspective again, the Desalination plant in Mossel bay uses 67.2 MWh/day and from my calculations the SWEC can produce on average 7397 MWH/day, it will therefore in theory, could run

7397 MWh/day
67.2 MWh/day = approximately **110**

110 X the size of the Mossel Bay Desalination plant.
= 5.5 billion ℓ /year X 110

= 605 billion ℓ /year

fig. 84 *Perspective drawing of SWEC V shaped collectors*



I will be using the Mossel Bay Desalination plant as precedent for the spatial implications of a desalination plant coupled with the sustainable energy of Wind Energy. Due to the word limitations of this paper, I have chosen this particular sustainable energy to investigate the above mentioned, as I believe it has the most scope of investigation and is the most developed currently in SA regards to the rest of the sustainable energies mentioned in the former sections of the paper.

fig. 85

Description of Wind Energy:

Wind power is the translation of wind energy into other forms of energies. Today, wind power is generally associated with wind turbines, converting the wind into electricity. Historically, wind power was associated with sailboats and sailing ships for thousands of years (and still today), and masterbuilders have used wind to naturally ventilate buildings since similarly ancient times. Wind energy is also associated with wind mills translating wind into mechanical power, and wind pumps for pumping water.

Wind can be used in its natural state, translated into mechanical energy, and / or electrical energy thereafter.

There is a lot of talk of installing large wind turbine farms across South Africa. At the moment there are 4 active small scaled wind farms is South Africa:

Klipheuwel Wind Farm	(Western Cape)
Darling National Demonstration Wind Farm	(WC)
Sere Wind Farm, Vredendal	(Western Cape)
Coega Wind Farm	(Eastern Cape)

. The South African Wind Energy Association, SAWEA, have played a huge role in the research of large wind farms in SA and have put together a comprehensive proposed Integrated Resource Plan for wind energy in South Africa. Some of the key findings are listed below, for the amount of **10 000** 3MW wind turbines (30 000MW), from his Article *Industry report finds that Wind Farming is a viable Electricity generation option for South Africa*, Dr Garth Cambray explains

> Wind energy can, by 2025, provide 20% of South Africa's projected electricity demand. This can be achieved through the establishment of a **distributed** portfolio of wind farms with an installed capacity of 30 000MW **spread over the country** that would, as a result of the countries variable climate, result in a **reliable base load** of guaranteed power of about 6000MW.

Wind power consumes **no water**.

Installing 30 000MW of wind power would **save** the amount of **water** used by a city of 300 000 people.

Wind power has considerable job creation potential in South Africa, with the potential that a 30 000MW industry would create upwards of **40 000 quality jobs**.

Wind power also **saves money** by **displacing** more **expensive electricity** sources from the grid.

Wind power will save money in terms of carbon penalties we would have to pay as a nation. From 2012, there will be an array of penalties and taxes that will come into play with regards a nation's carbon output. If South Africa installs 30 000MW of wind power by 2025, this will **save** us from **emitting 70 million tons per annum of carbon dioxide.**

Wind power is a distributed power source – in other words it tends to be most effective if you have wind farms dotted all over a very wide area – **the wider the better**. (Cambray, 2010)

These points are the most important findings that I extracted from his article.

In context of Western Cape:

There are even more immediate plans for Wind Farms along the Garden Route of the Western Cape. The Council for Scientific and Industrial Research has completed an environmental- impact assessment, which evaluated the impact of putting up 70 wind turbines along the Garden Route.

InnoWind is proposing to install four commercial wind energy facilities near the towns of Swellendam, Heidelberg, Albertinia and Mossel Bay.

The project would consist of about 70 x 3MW turbines. The plan is to spread them out, ten turbines near Swellendam, another ten near Heidelberg, six near Albertinia and 44 near Mossel Bay. The combined generation capacity would be about 210 MW. These turbines have a hub height of about 60 m to 100 m and a blade diameter of between 70 m and 112 m. The distance from the ground to the top of the blade will be between 95 m and 156 m.

fig. 86 *Typical size of large commercial Wind Turbines 1: 2000*

Spatial implications of the Mossel Bay Desalination Plant and Wind Turbine Farms, using the Darling Demonstration Farm as precedent.

……………………………………………………………

The Desalination plant in Mossel bay uses:

67200 kWh/day (= 67.2 MWh/day) it will therefore use (67.2 x 365)
= 24528 MWh/year.

According to the Darling Wind farm website, they have 4 x 1.3 MW turbines that produce on **average = 8.6 GWh/year** (8600MW)

If turbines run at full Capacity 24hours/day
4 x1.3 x 24
= 124.8 MWh/day

Per year
= 124.8MWh x 365
= 45 552 kWh/year
= 45.6 GWh/year.

This is the true potential of the wind turbines if there was enough wind to keep it running at full capacity 24 hours a day, all year long.

Therefore one could say that the average overall loading efficiency of the wind turbines at Darling is 8.6/45.6 x 100
= 18.8%

This means that sometimes this efficiency drops below 18.8% at any time. Say for arguments sake it is 10% (which means that the wind turbines never produce less than 10% of their installed capacity).

To keep the Mossel Bay plant running you would need 2800kW (= 2.8MW which is the 10% minimum of their stalled capacity) to be generated at any time.

Using the above numbers it means a required installed capacity of
28 MW or 28/1.3 = 21.5, say **22 wind turbines** to guarantee electricity supply.

It is vital that one establishes the period of absolute minimum production for the Darling wind farm, for this is the determining factor to calculate the installed generating capacity that will be required, for this I have used 10% as minimum.

In theory, almost all sustainable energies that produce electricity cannot be stored. Wind powered electricity for example depends on a very variable driving force, the wind. The successful operation of the seawater desalination plant depends almost entirely on an assured constant source of electricity, from my calculations the 22 wind turbines are therefore enough turbines to guarantee a minimum reliable **base load** of guaranteed power for the Mossel Bay Desalination plant to run at full capacity annually.

If in fact the Darling Wind Farm does produce a guaranteed 8, 6 GWh/year, the spatial implications, area of Mossel Bay Desalination Plant and area needed for *22 turbines, can be seen in Figure 20

*Darling Wind Turbine specifications: (Anon., n.d.)

Rotor Diameter of 62 meter,
Hub height of 50m
Tower Average Diameter of 3meter,
Tower Length of 50 meter

The area of the grounds of the desalination plant, including the pump station is ± **5335m²** and this plant at full capacity, produces **15 000m³ water/day**, and runs at 4.48 kWh/m³ or 15000 x 4.48 = **67200 kWh/day**, which equates to 50% of plant production cost.

Wind turbines are typically spaced 2 to 3XD apart if behind each other and 5 to 7XD if they are running parallel to each other. (Eskom, 2007)

D = diameter of rotor blade.

fig. 87 *Theoretical Spatial implications of 22 Wind Turbines that could power the Mossel Bay Desalination plant*
Scale 1: 10 000

So therefore if an desalination plant of Mossel Bay with the area of **5335m²** can at full capacity, produces (**15 000m³ water/day** X 365) = 5475000m³ per year with only 22 X 1.3 MW *wind turbines per year, imagine how much power 10 000 turbines can produce and help supplement other desalination plants around South Africa.

As I mention earlier in this paper the Department of Water Affairs (DWA) indicated that desalination plants could account for between 7% and 10% of the country's overall urban water supply by 2030, and with the constructions of 10 000 Wind Turbines, this sustainable energy will definitely be able to contribute to powering desalination plants that are envisioned to account for the 7-10% of South Africa's future water supply.

Calculations & Info relevant to Desalination Plant process, production & storage.

Sea water intake requirements

Sea water intake Tank 75 000m^3/day
= 3125m^3/h (100 % of total seawater intake)
= 75 000tons

Brine vs. potable water outcome ratios

Final Amount of fresh water needed: 30 000m^3/day
= 1250m^3/h (40% of total seawater intake)
= 30 000tons

Brine Tank: 45 000m^3/day
= 1875m^3/h (60 % of total seawater intake)
= 45 000tons

Sea water intake Tank 75 000m^3/day
= 3125m^3/h (100 % of total seawater intake)
= 75 000tons

Gravity fed sand filters

> The rapid sand filter or rapid gravity filter is a type of filter used in water purification and is commonly used in municipal drinking water facilities as part of a multiple-stage treatment system. Rapid sand filters use relatively coarse sand and other granular media to remove particles and impurities that have been trapped in a floc through the use of flocculation chemicals--typically salts of aluminium or iron. Water and flocs flows through the filter medium under gravity or under pumped pressure. The flocculated material is trapped in the sand matrix. Mixing, flocculation and sedimentation processes are typical treatment stages that precede filtration. Chemical additives, such as coagulants, are often used in conjunction with the filtration system.
>
> A disinfection system (typically using chlorine or ozone) is commonly used following filtration. Rapid sand filtration has very little effect on taste and smell and dissolved impurities of drinking water, unless activated carbon is included in the filter medium. Rapid sand filters must be cleaned frequently, often several times a day, by backwashing, which involves reversing the direction of the water and adding compressed air. During backwashing, the bed is fluidized and care must be taken not to wash away the media. (Aquamarinewater.com, 2007)

Rate of filtration min 4000 (max 12000) ℓ / h / m^2 of bed.

Therefore min area of total filters = 260m^2
Max area = 781m^2

30 000m^3 potable water/day = 1250m^3/h (+/- 40% of total seawater intake)

In drawing area = 488m^2 (+/- 6504 ℓ /h/m^2)
= +/- 21 tonnes or 21m^3

Backwash requirements

When rapid sand filters are used you need to make the additional provisions for backwashing and the discard of the backwash water. For the RO plants you will require about 67000 m^3 of filtered water plus an additional 20% to allow for backwashing of the filters giving you a total requirement of about 84000 m^3 of filtered water.

Sea salt pans & harvesting

Salt is harvested through solar evaporation from seawater. Wind and the sun evaporate the water from shallow pools, leaving the salt behind. It is usually harvested once a year when the salt reaches a specific thickness. After harvest, the salt is washed, drained, cleaned and refined. This is the purest way to harvest salt, often resulting in nearly 100 percent sodium chloride.

This sea salt harvesting method of the desalination plant of Hout bay is of a low-fi nature sea salt production, and un-mechanized. The brine water is evaporated naturally by the sun and wind. The brine water is transferred from salt pan to pan almost entirely by the force of gravity, with only a few mechanical pumps at key locations. Nothing is added to the water to make the process faster or change the nature of the sea salt. At the time of harvesting, the salt is already nearly a pure product.

Because Hout Bay is situated along the coast which has extremely active ocean currents, the rest of the brine outlet that is releases into the sea, will be thoroughly mixed and diluted by the currents, preventing the salty waste from creating a brine plume on the ocean floor and the resulting salinity increase will be so slight that it will have an insignificant effect on the marine eco-system.

Water tower (N/A)

No. of Residents in Hangberg: +/- 28 000

Mean per household = 4.12 people (min 1, max 11)
Therefore = +/- 7000 households
Mean water used per household = 40 ℓ (min 2, max 250)

Most amount of water needed per day for Drawn by Author
28 000 people

= 250 x 7000
= 1 750 000 ℓ /day
= 1 750 m^3/day

Pressure of water due to height of final reservoirs

Water pressure:

30 m = 300 kPa (43.511 psi), which is enough pressure to operate and provide for most domestic water pressure and distribution system requirements.

Height of Final water reservoirs = 150m
= 1500 kPa (217.555 psi) from sea level

Stellenbosch Wave Energy Converters (SWEC)

The Hout Bay Desalination Plant is approx. twice the size of the Mossel bay Plant, which uses 67.2 MWh/day; therefore the Hout bay Plant will use more or less 140MWh/day. From my calculations the SWEC can produce on average 7397MWH/day, it will therefore in theory, could run...

7397 MWh/day
140 MWh/day = approximately 53
53 X the size of the Mossel Bay Desalination plant.

(Total of 154 SWEC devices)

The Hout Bay Desalination plant in theory only needs approx. **3 of the 5MW SWEC V-shaped** energy converters to help considerably supplement its grid energy consumption per day, working at full capacity.

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figure reference.

Appendix A *(All drawn by Author)*

Appendix B

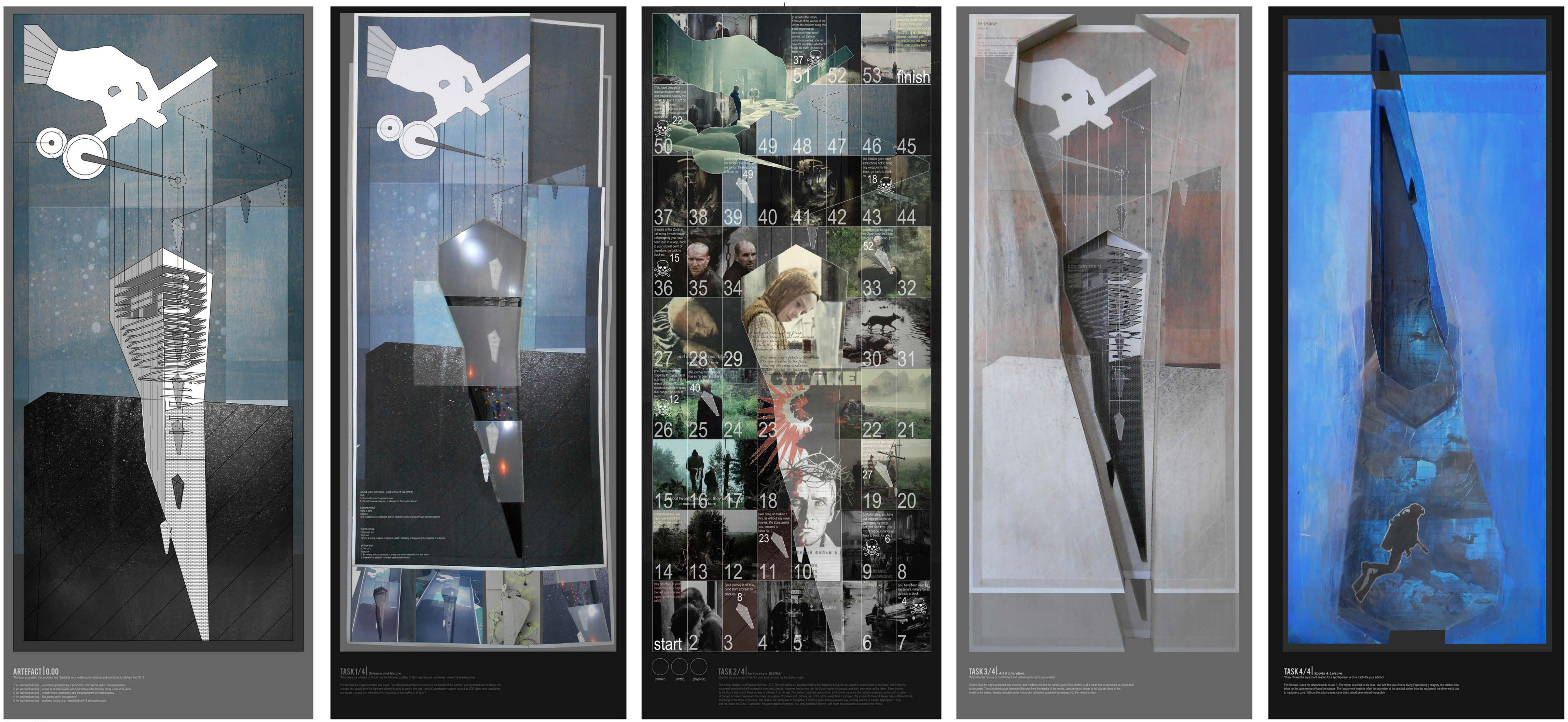


fig. 27 *Original Artefect and tasks from 1st Semester (End of 1st Semester Review Panels)*

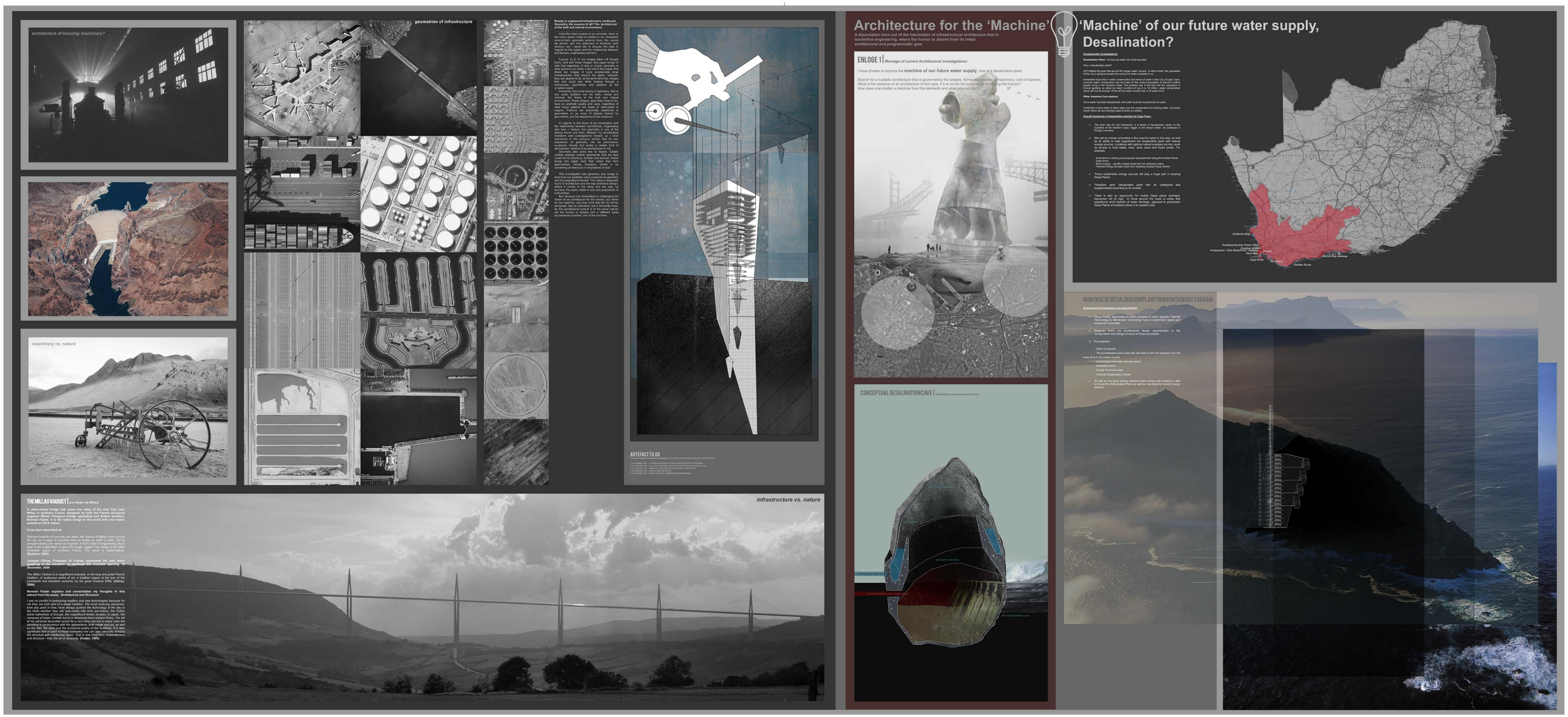


fig. 28 *End of 1st Semester Review Panels: Conceptual Panel*

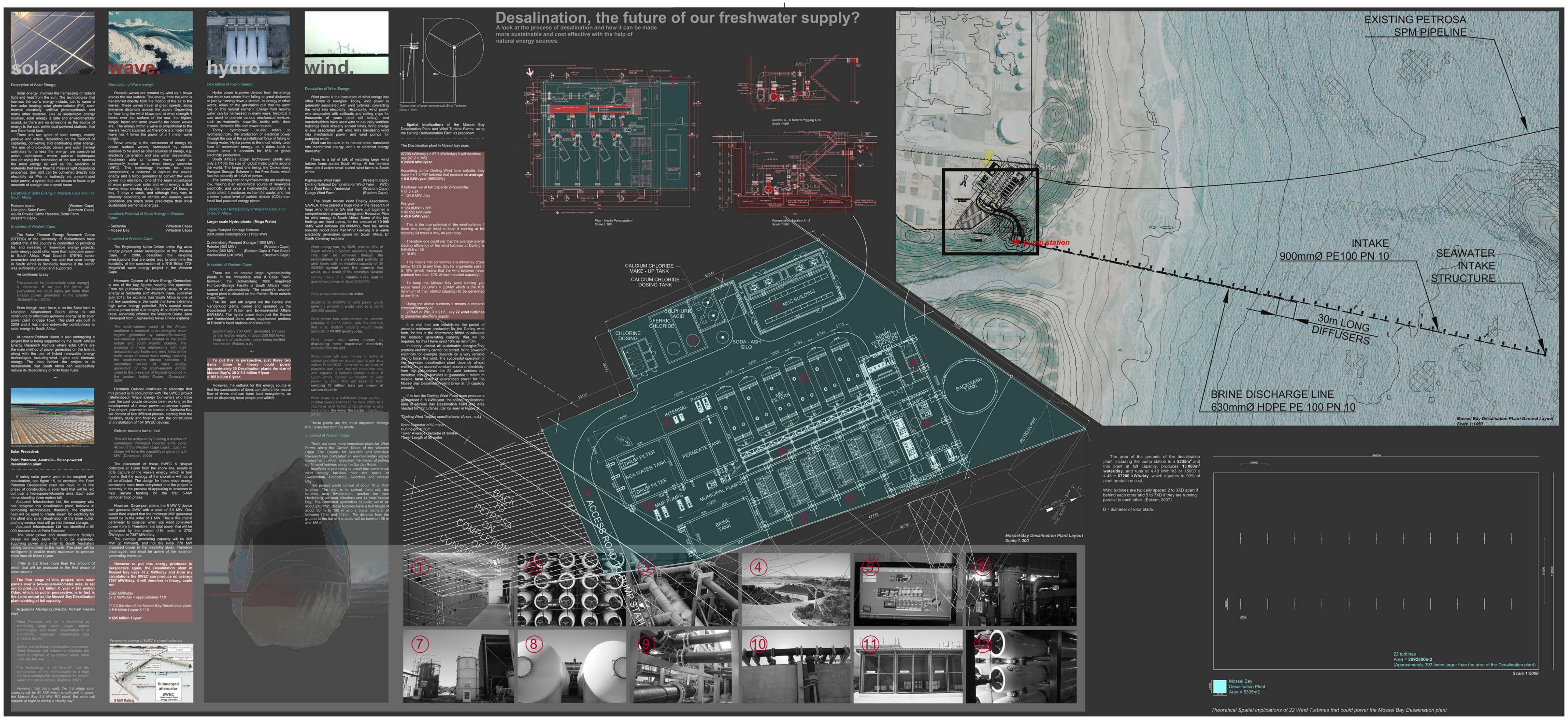


fig. 29 *End of 1st Semester Review Panels: Desalination and Sustainable Energies*

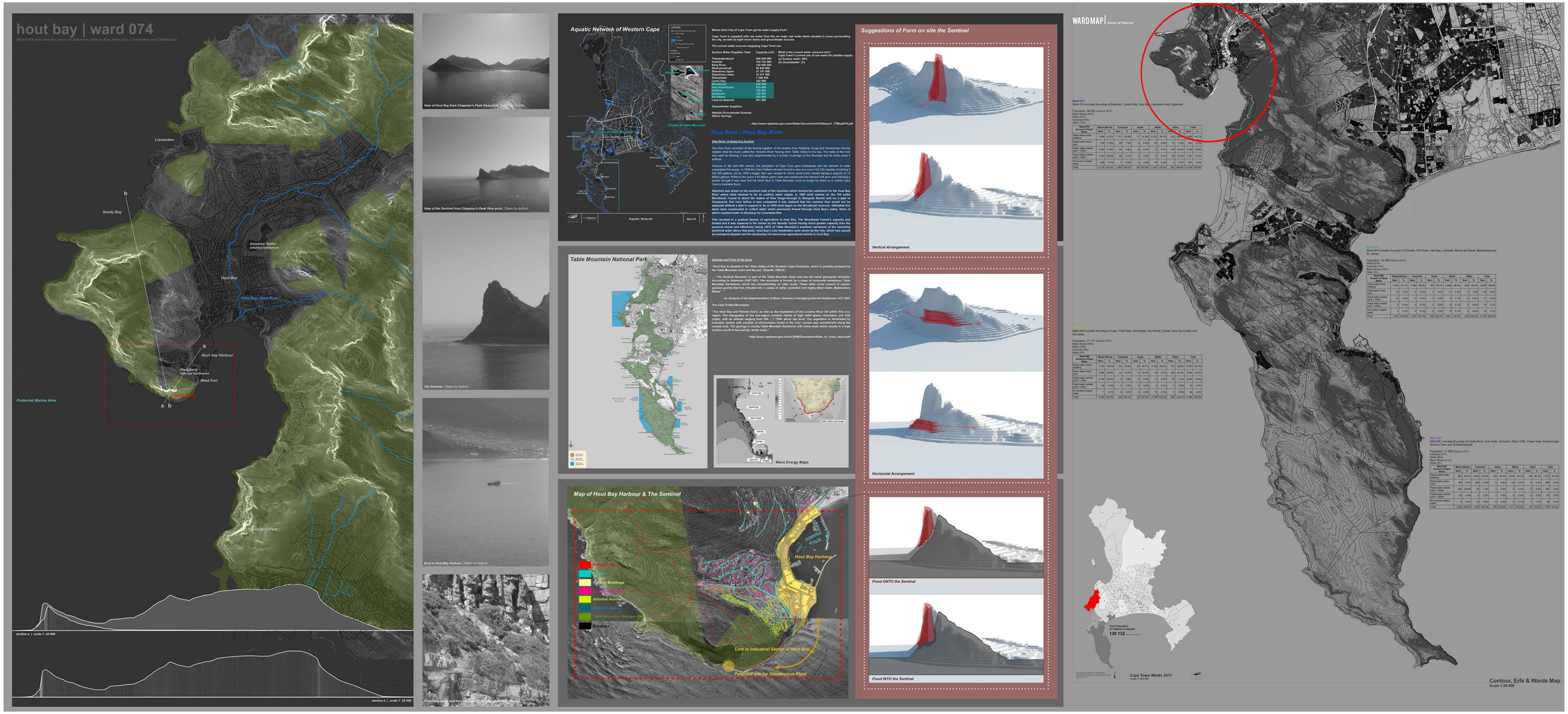


fig. 30 *End of 1st Semester Review Panels: Location_Hout Bay*

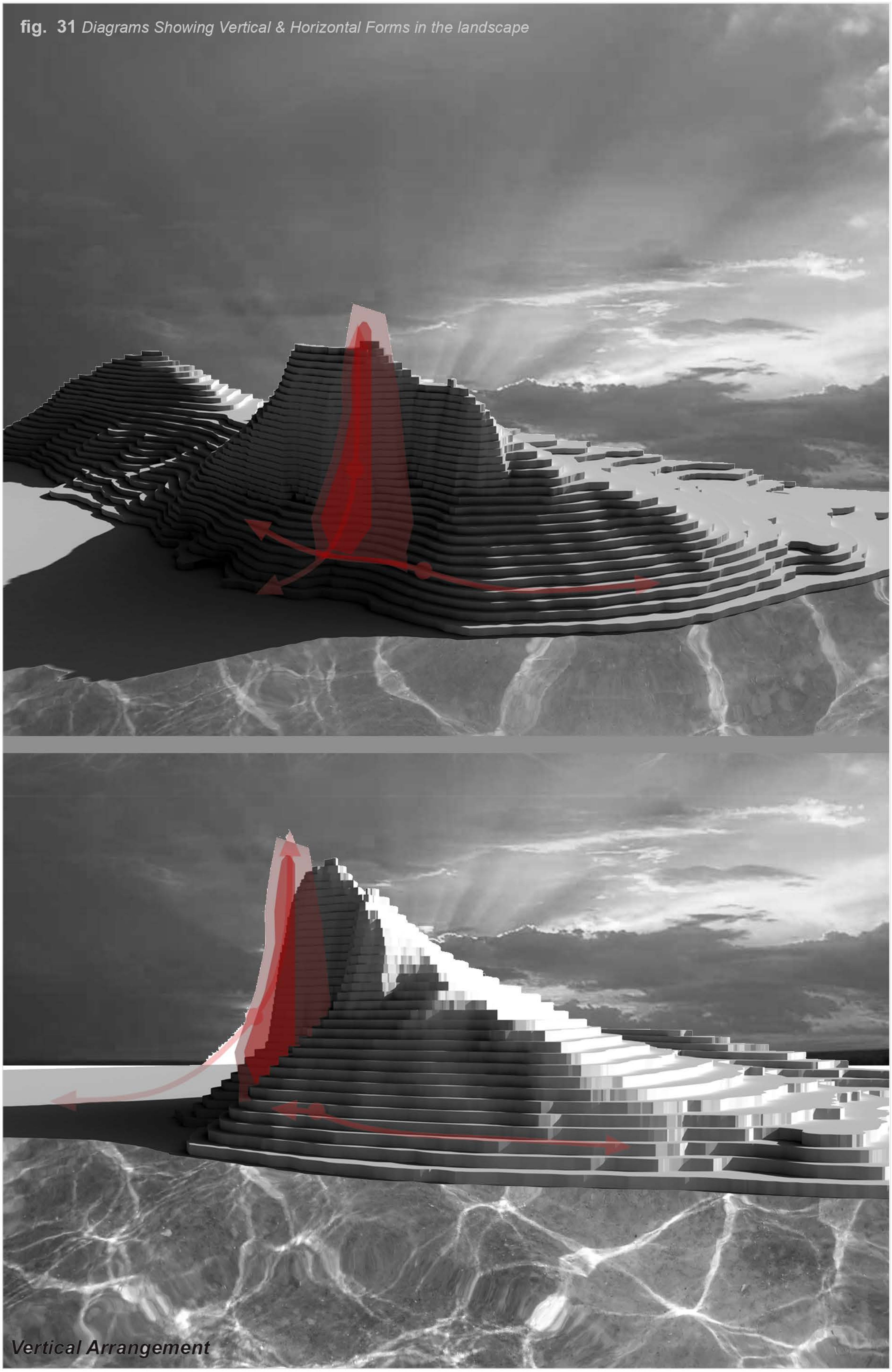


fig. 31 *Diagrams Showing Vertical & Horizontal Forms in the landscape*

fig. 32 *Early inspiration from the form and articulation of the barnacle*

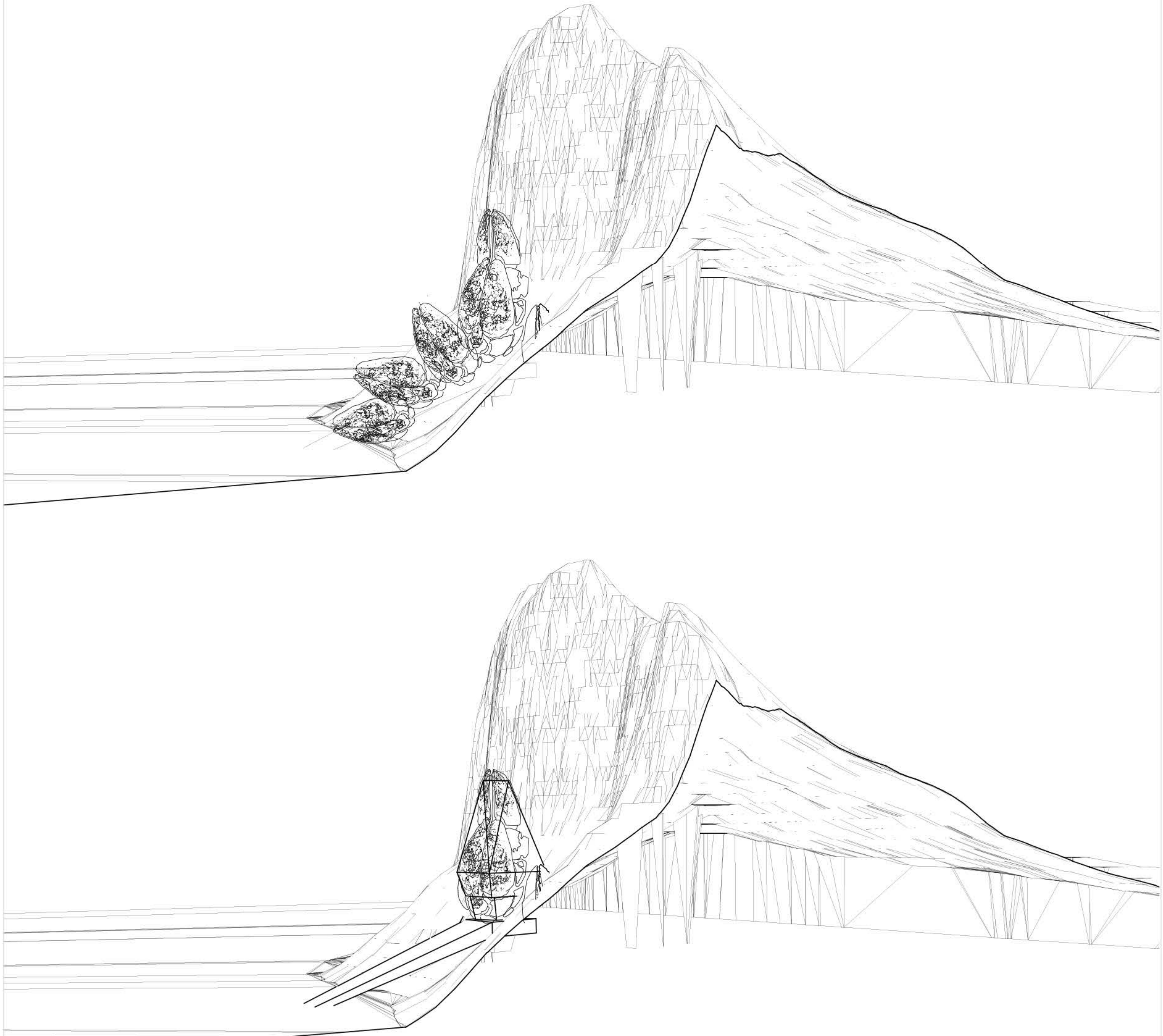


fig. 33 *Early inspiration from the form and articulation of the barnacle, in context.*

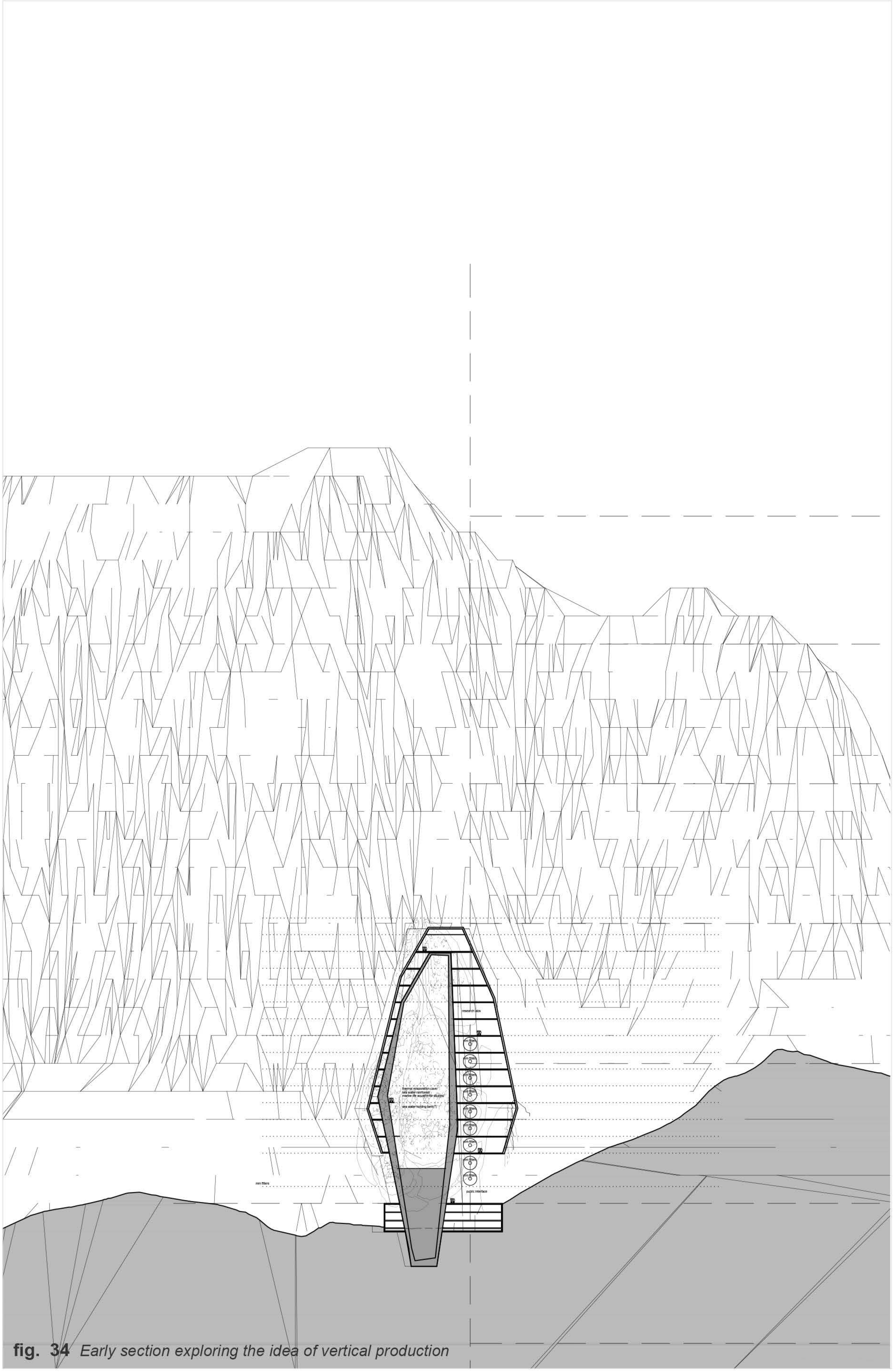
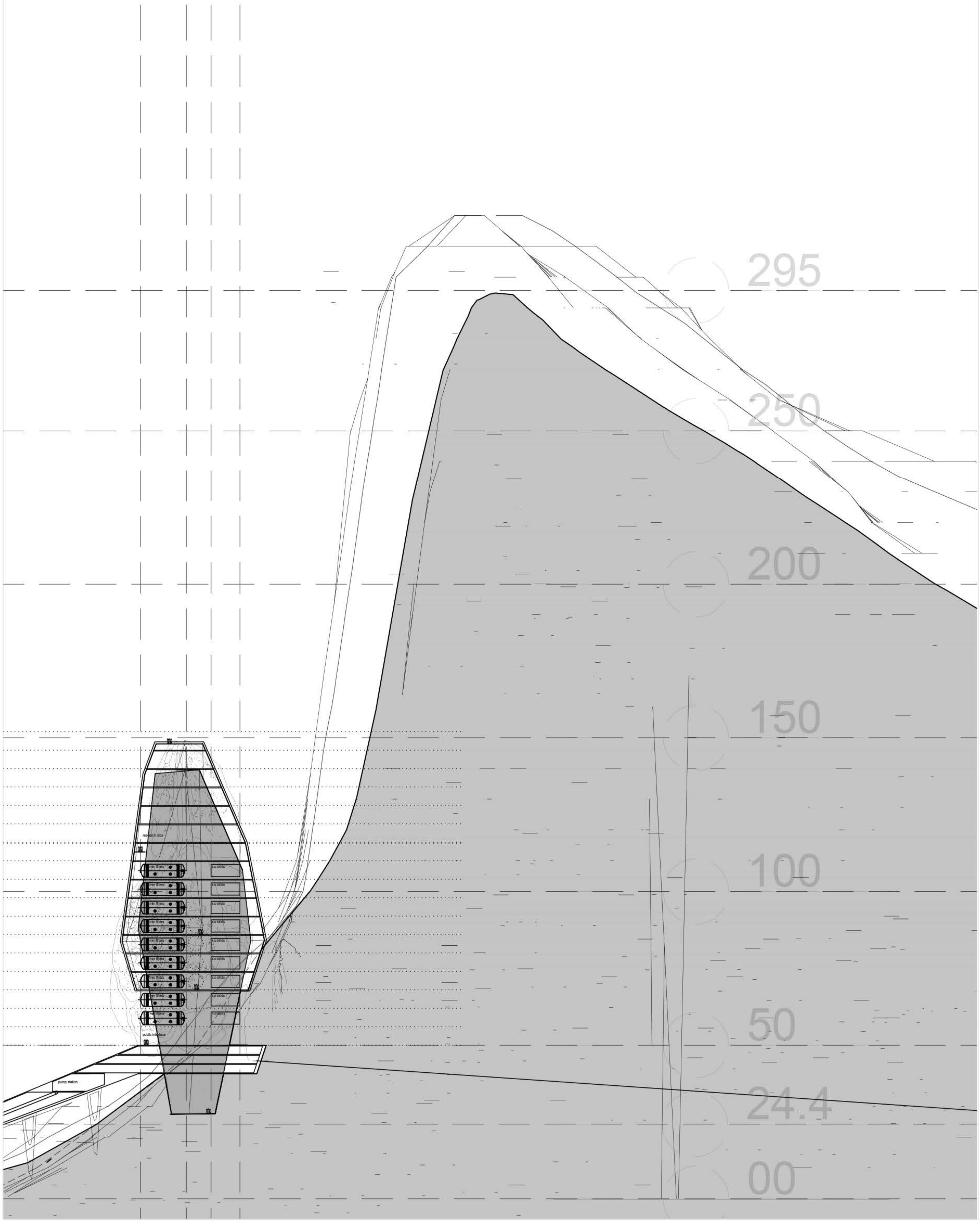


fig. 34 *Early section exploring the idea of vertical production*

fig. 35 *West facing section exploring the idea of vertical production*



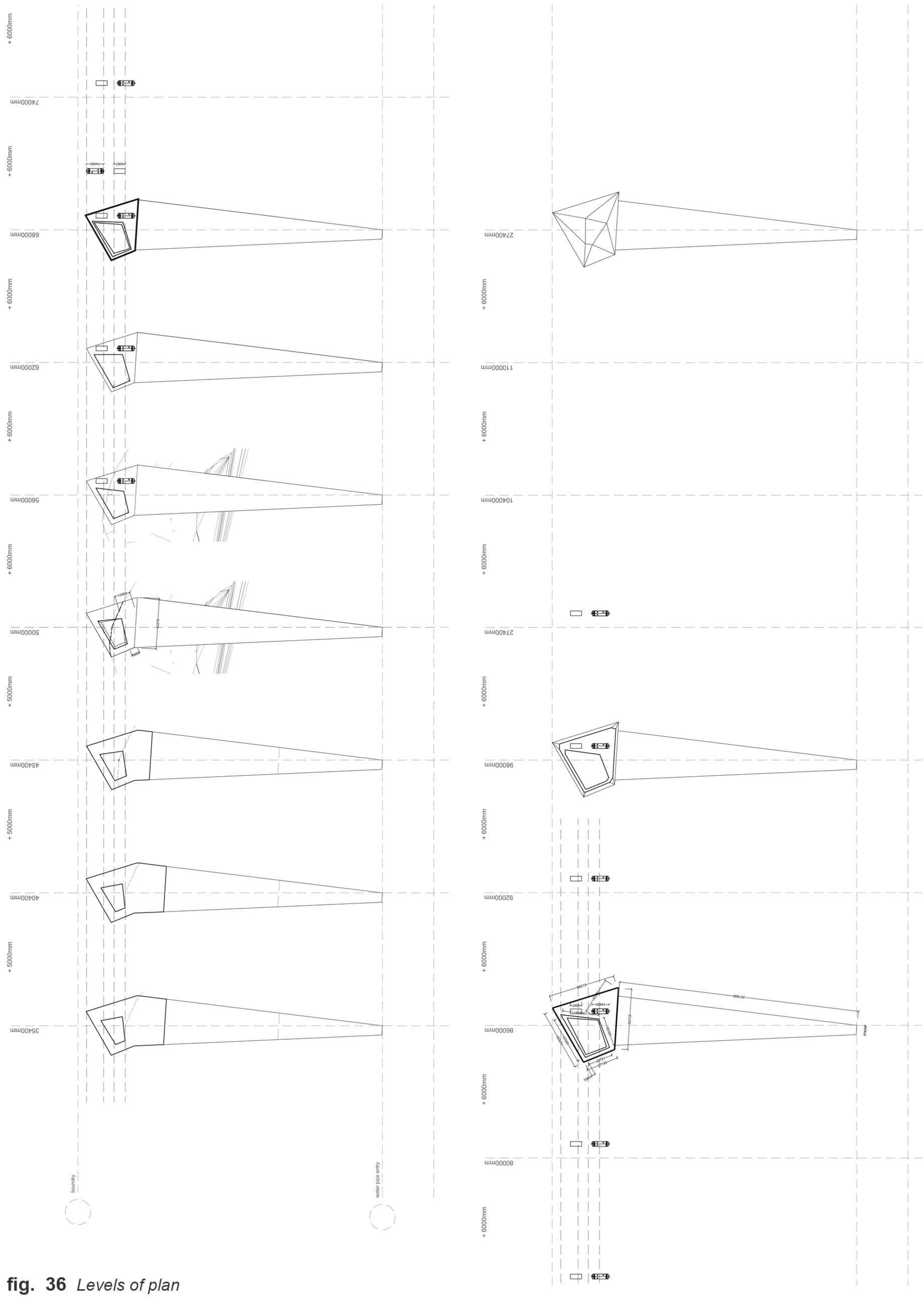


fig. 36 *Levels of plan*

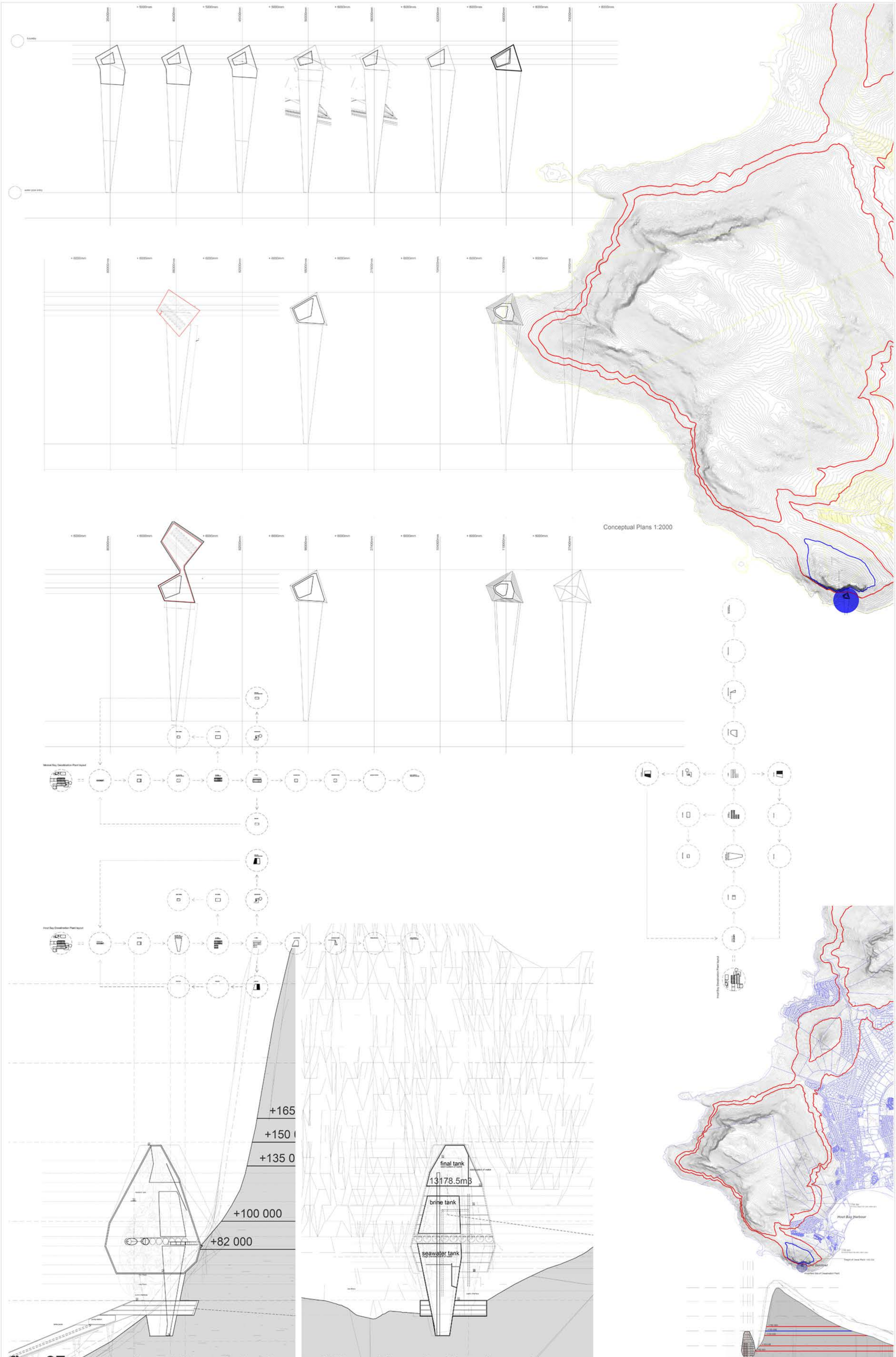


fig. 37 *Exploration of Plans & Sections, addition of Desalination elements*

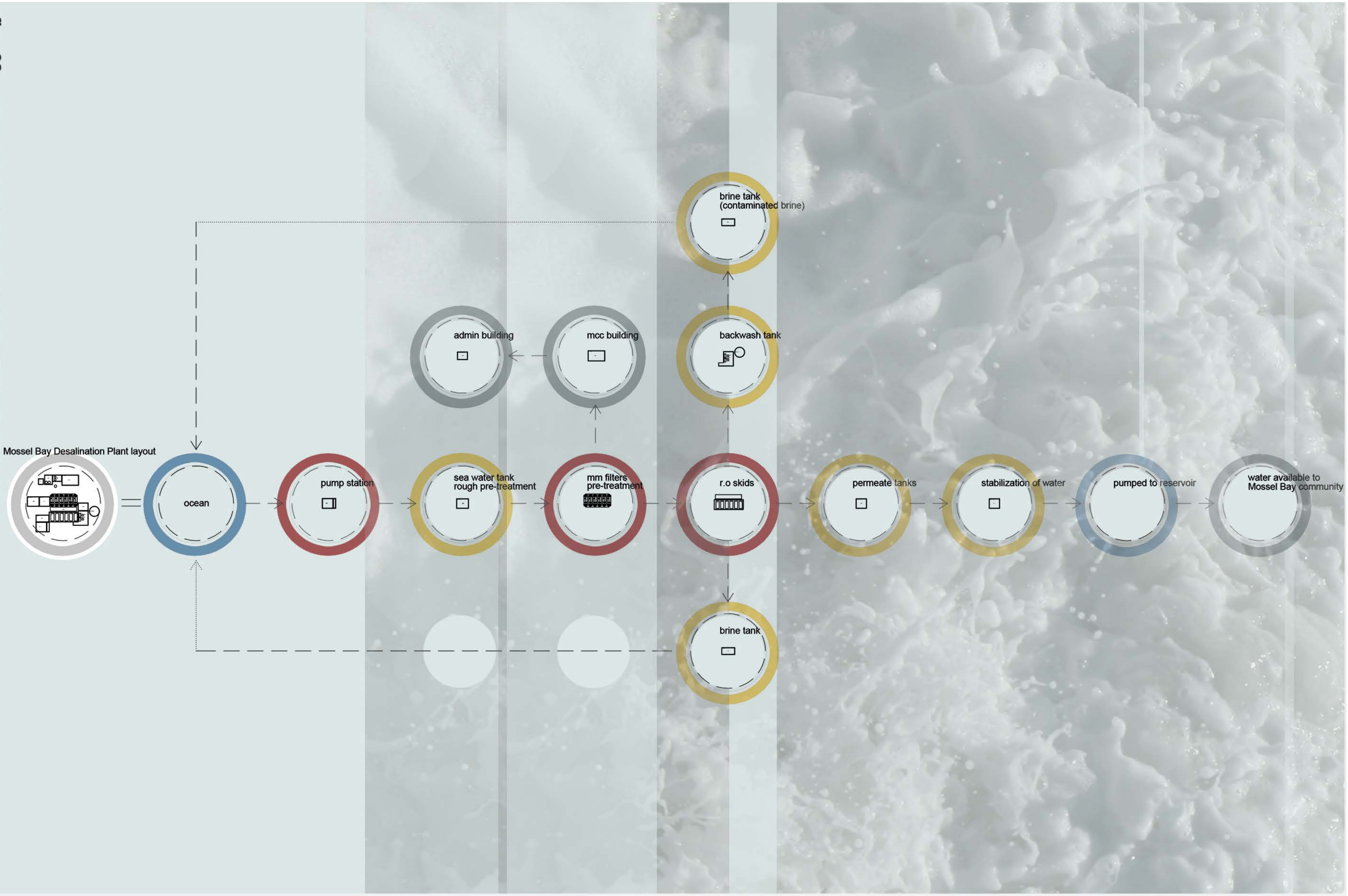


fig. 38 *Process and production line of Mossel Bay desalination plant*

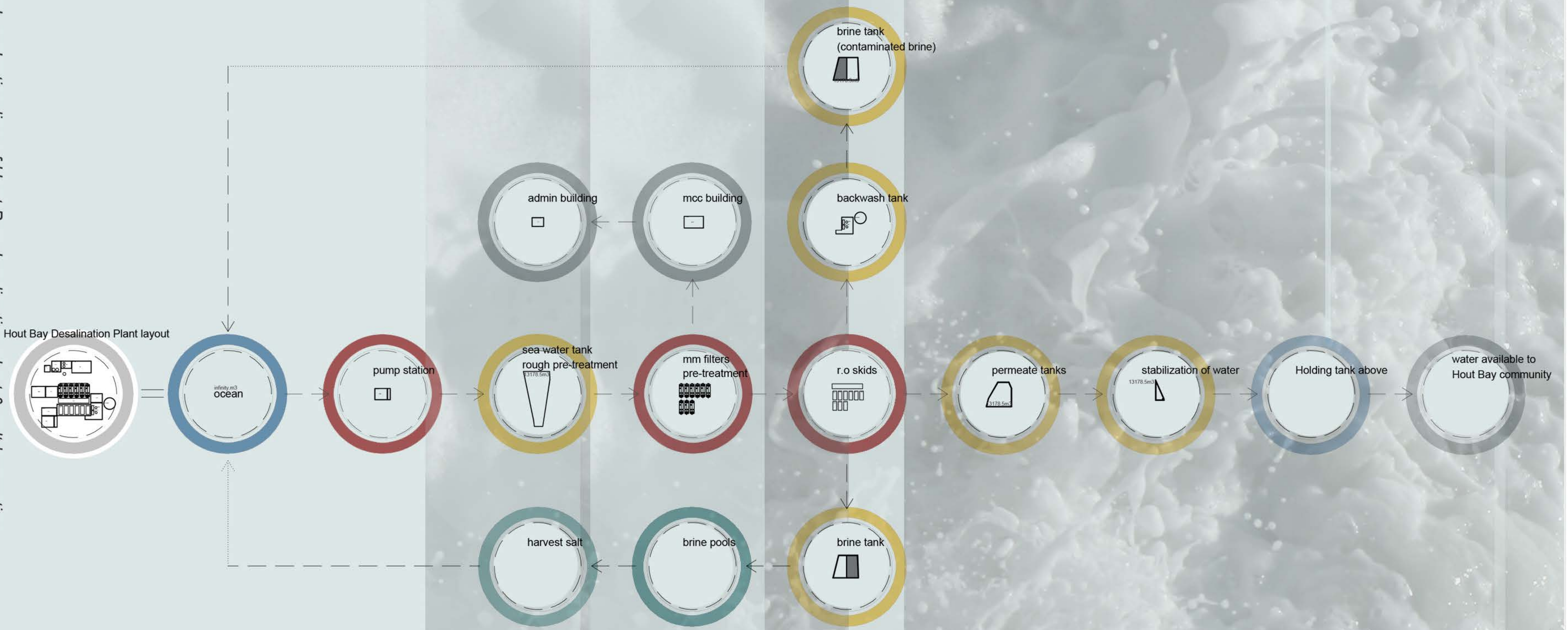


fig. 39 *Process and production line of Hout Bay desalination plant & salt harvesting*

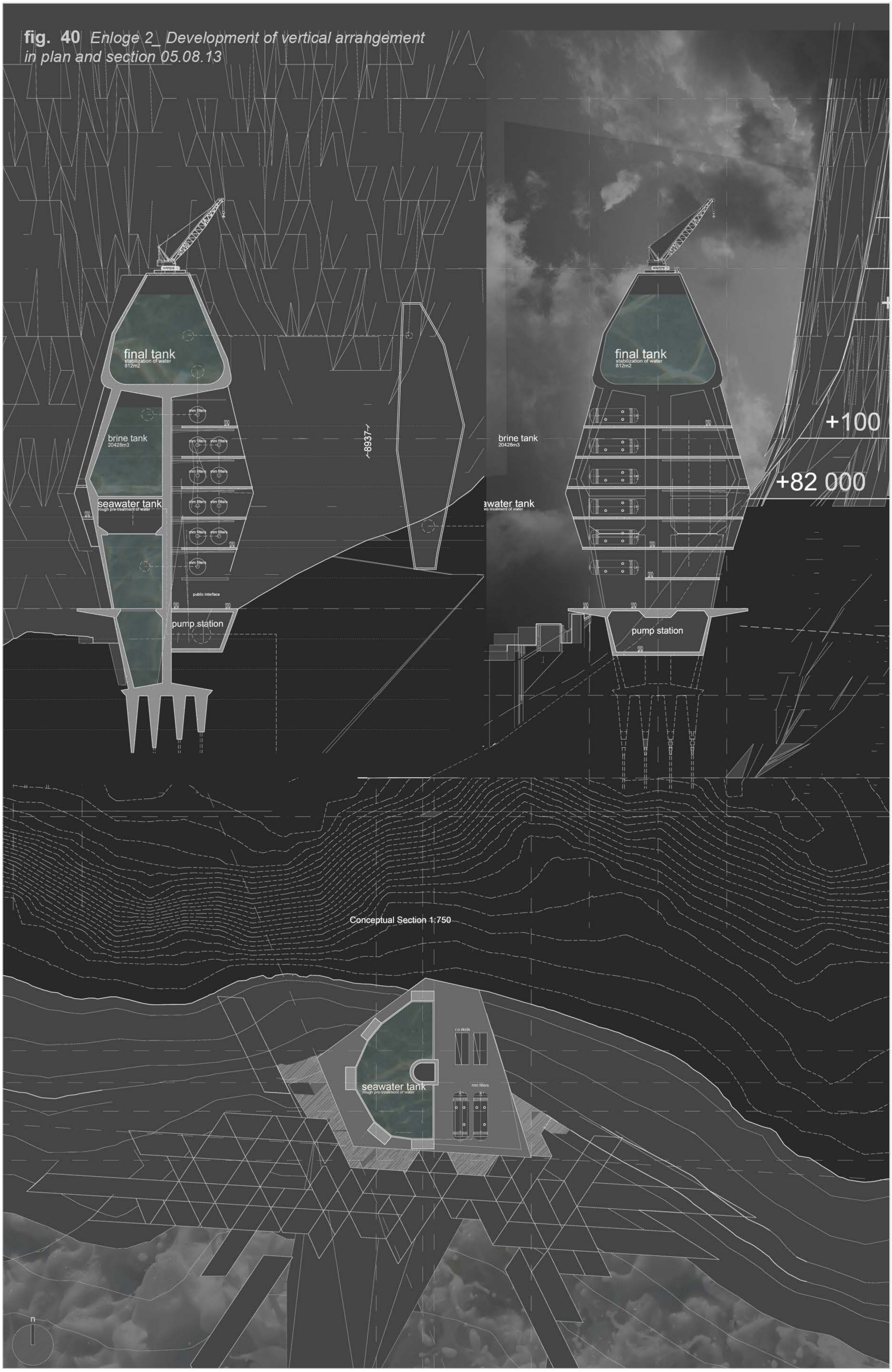


fig. 40 *Enloge 2_ Development of vertical arrangement in plan and section 05.08.13*

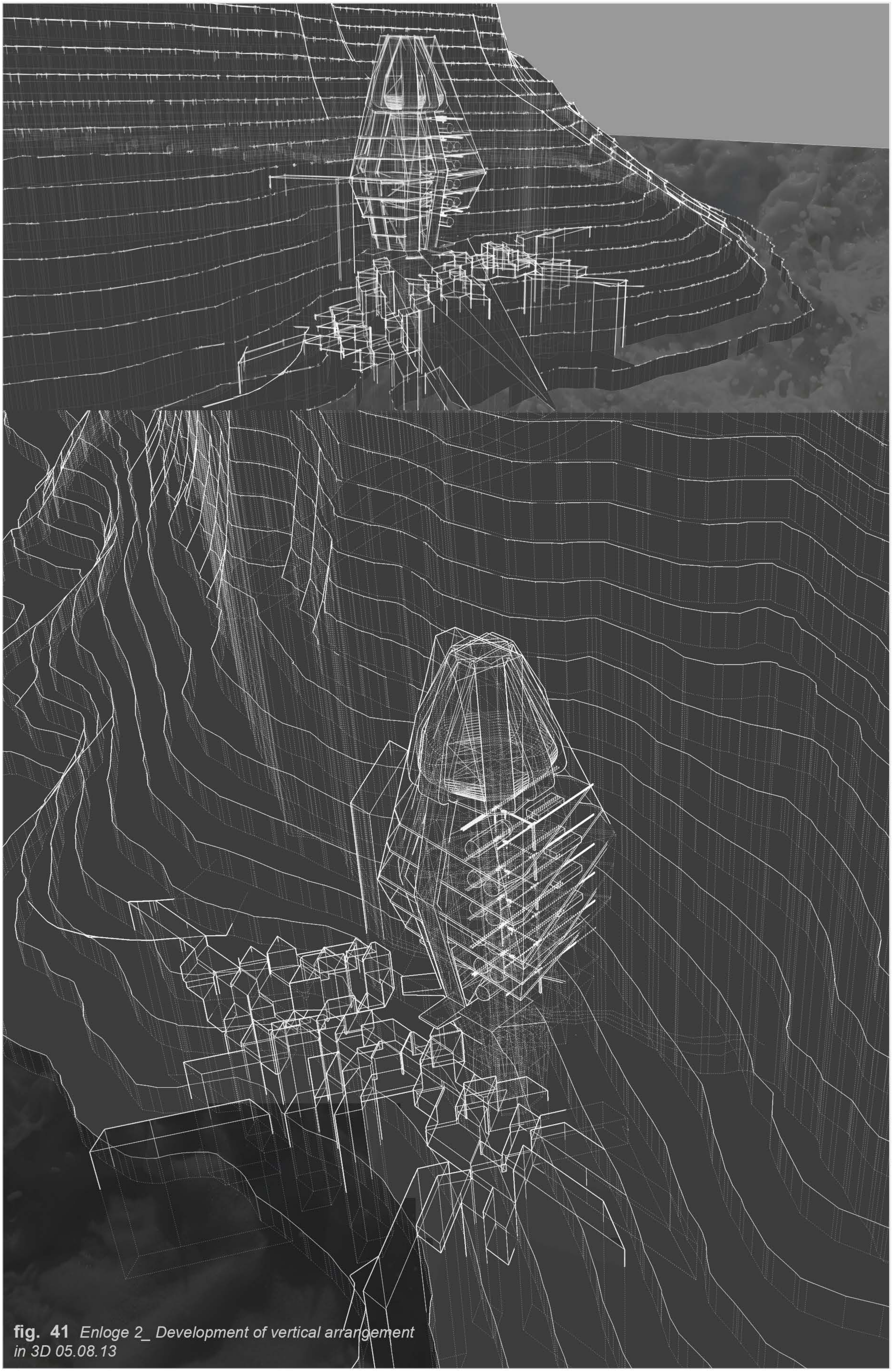


fig. 41 *Enloge 2_ Development of vertical arrangement in 3D 05.08.13*

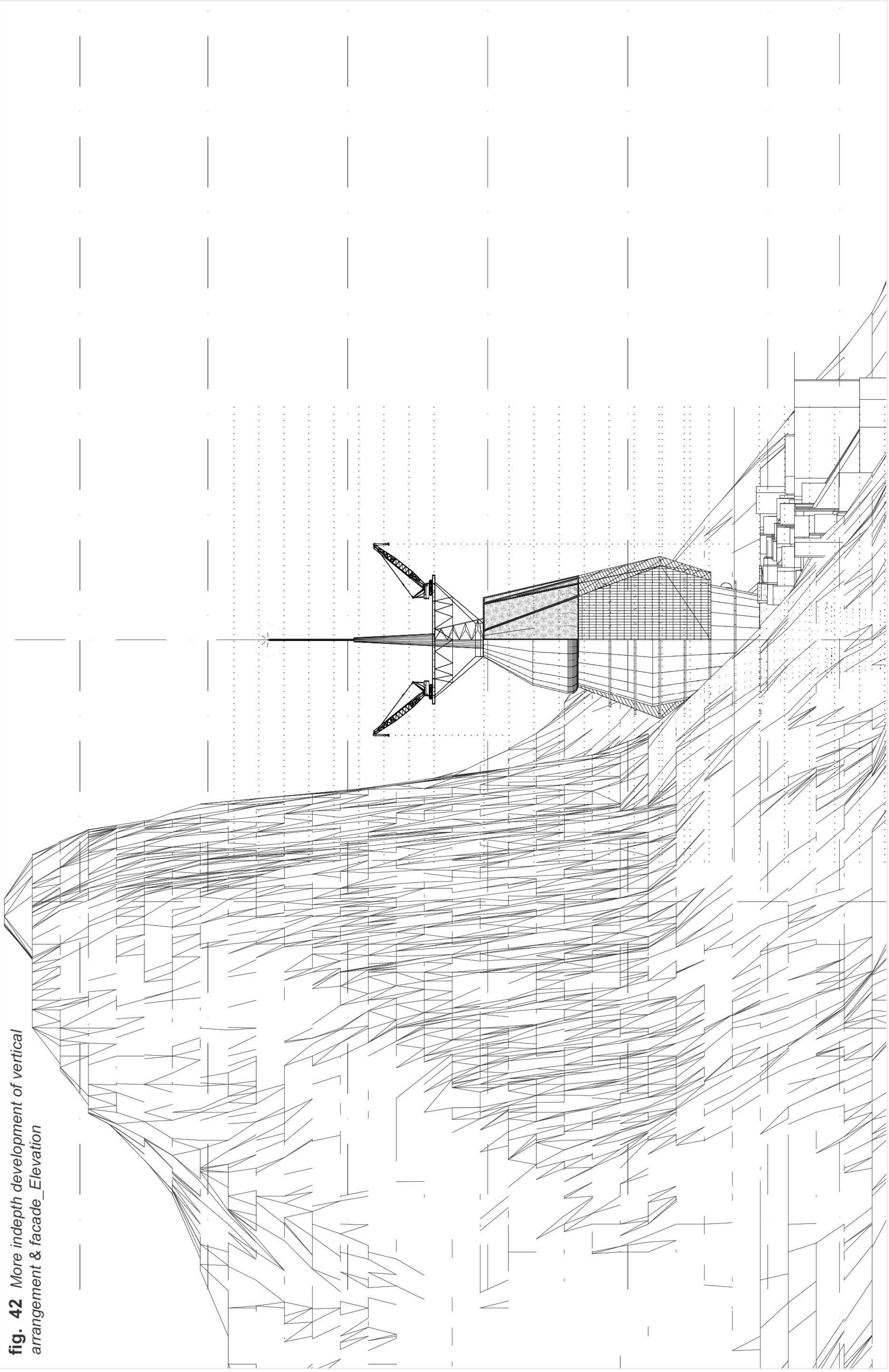


fig. 42 *More indepth development of vertical arrangement & facade_Elevation*

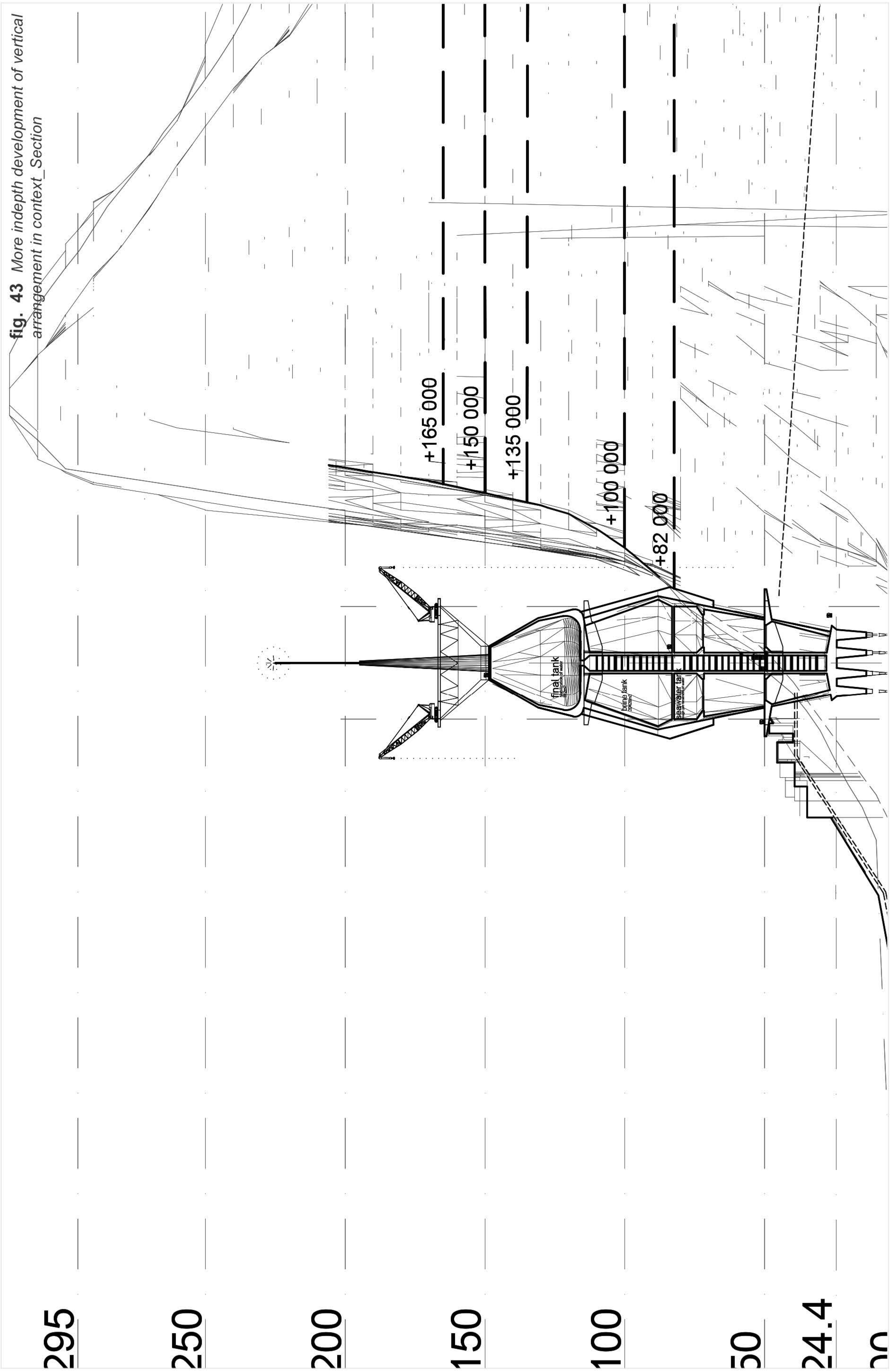


fig. 43 *More indepth development of vertical arrangement in context_Section*

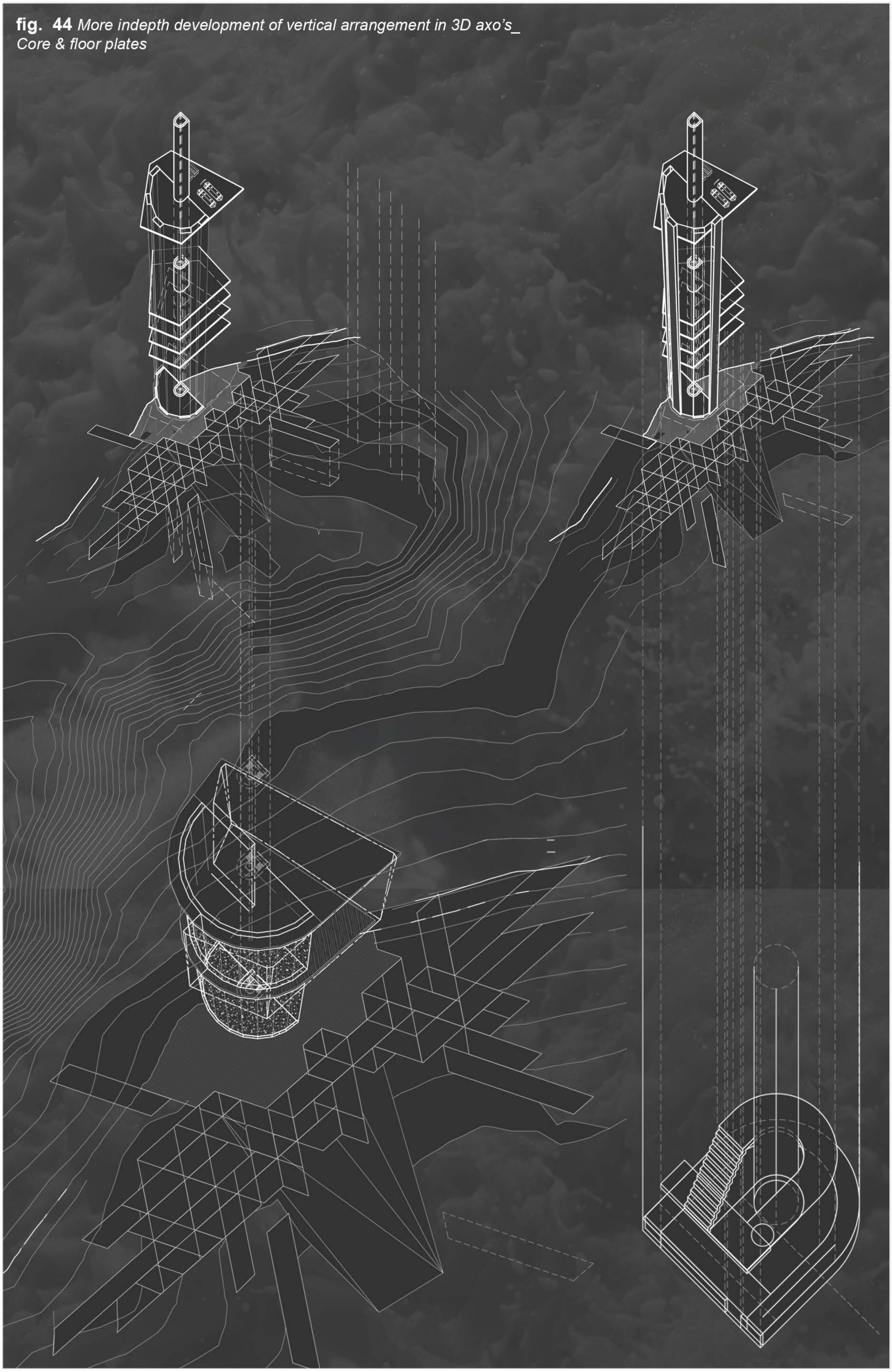


fig. 44 *More indepth development of vertical arrangement in 3D axo's_ Core & floor plates*

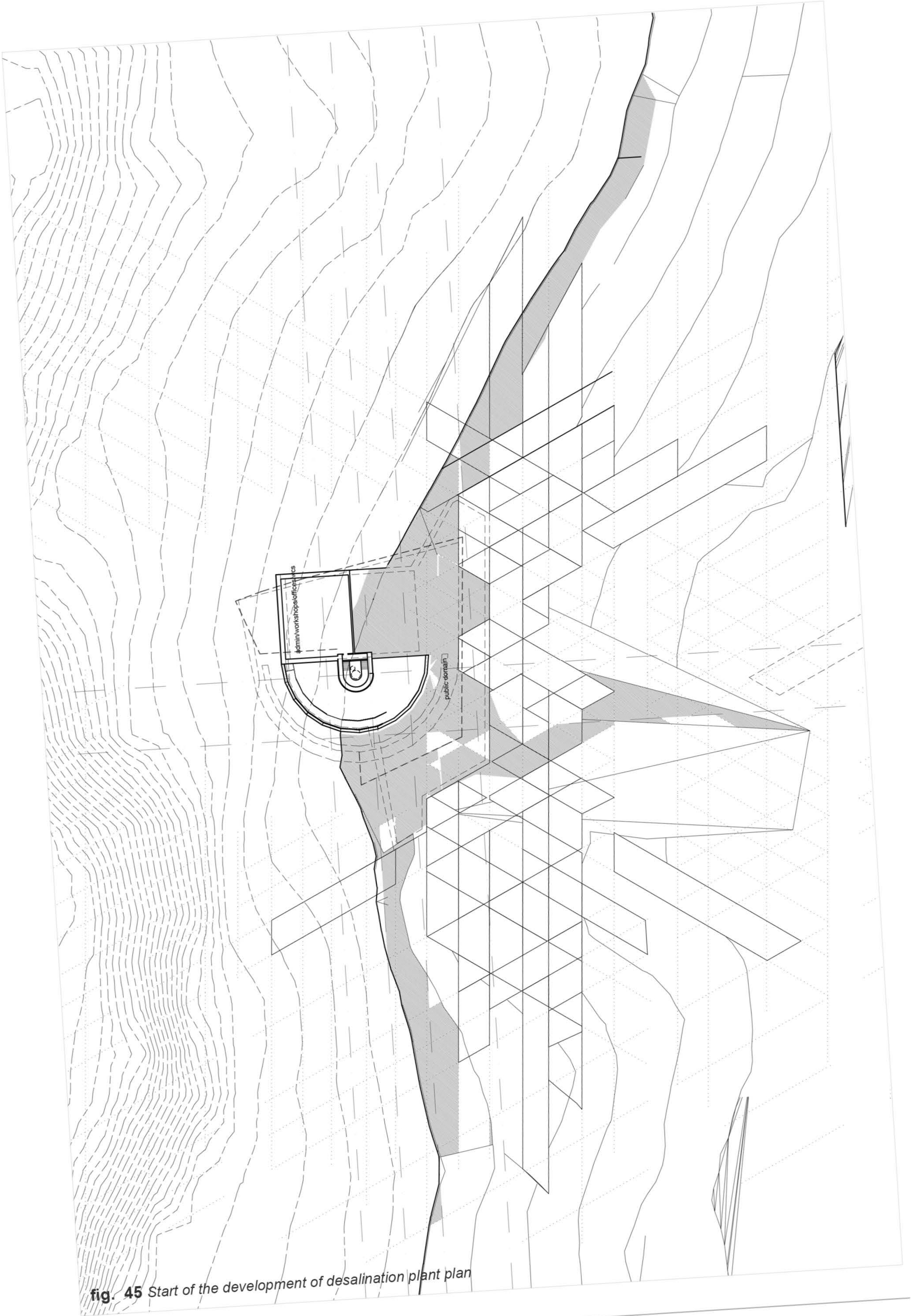


fig. 45 *Start of the development of desalination plant plan*

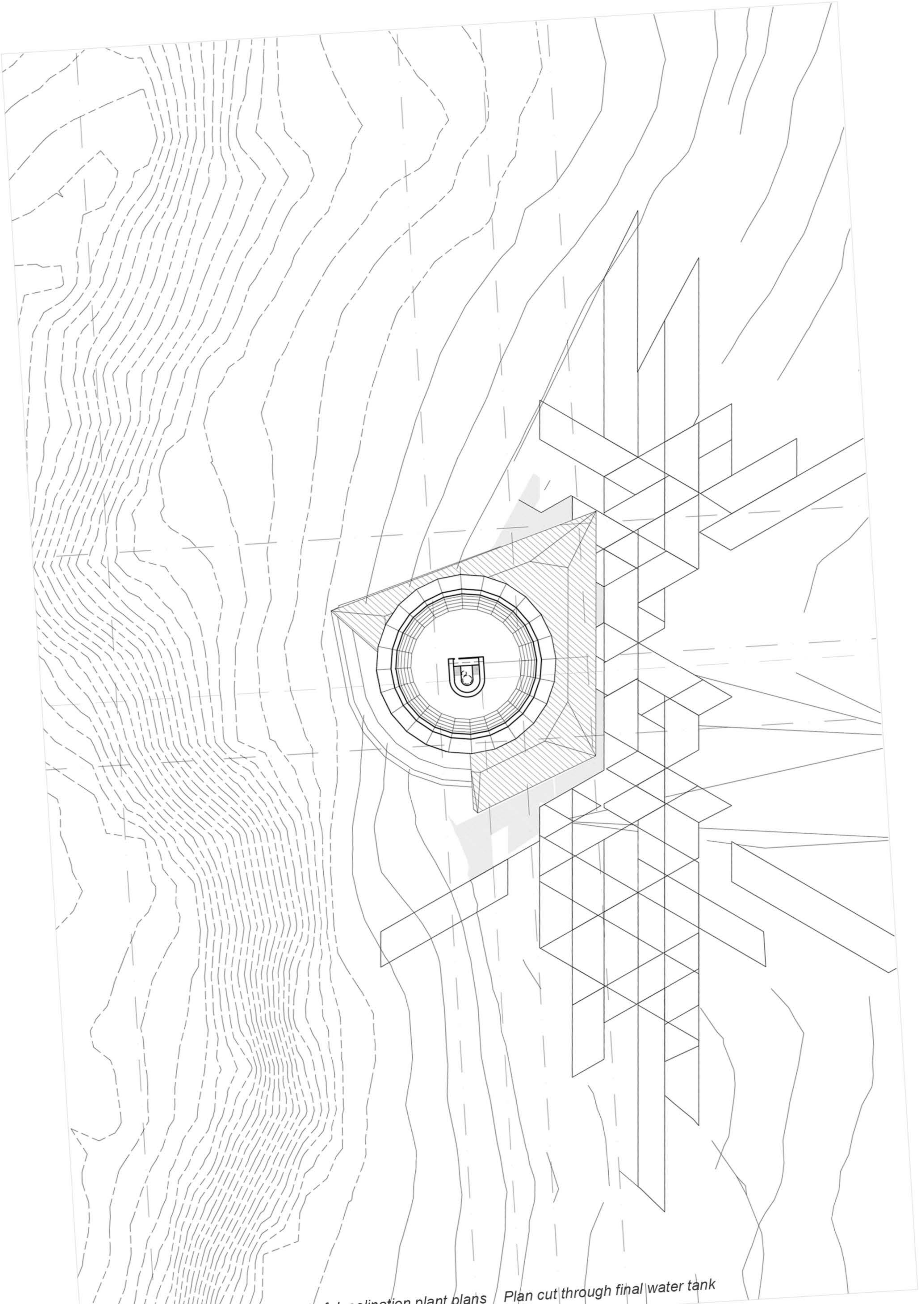


fig. 46 Start of the development of desalination plant plans _ Plan cut through final water tank

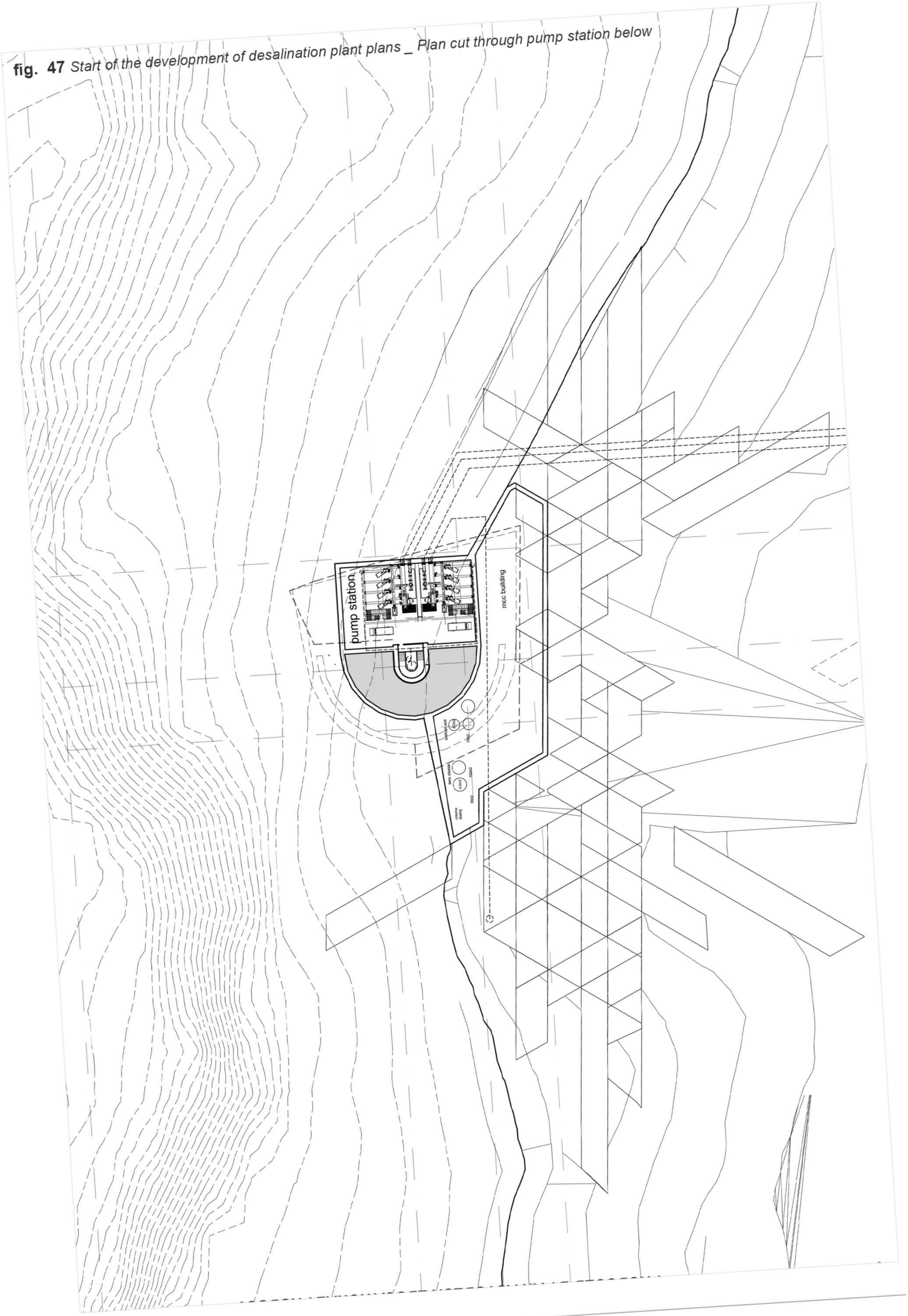


fig. 47 *Start of the development of desalination plant plans _ Plan cut through pump station below*

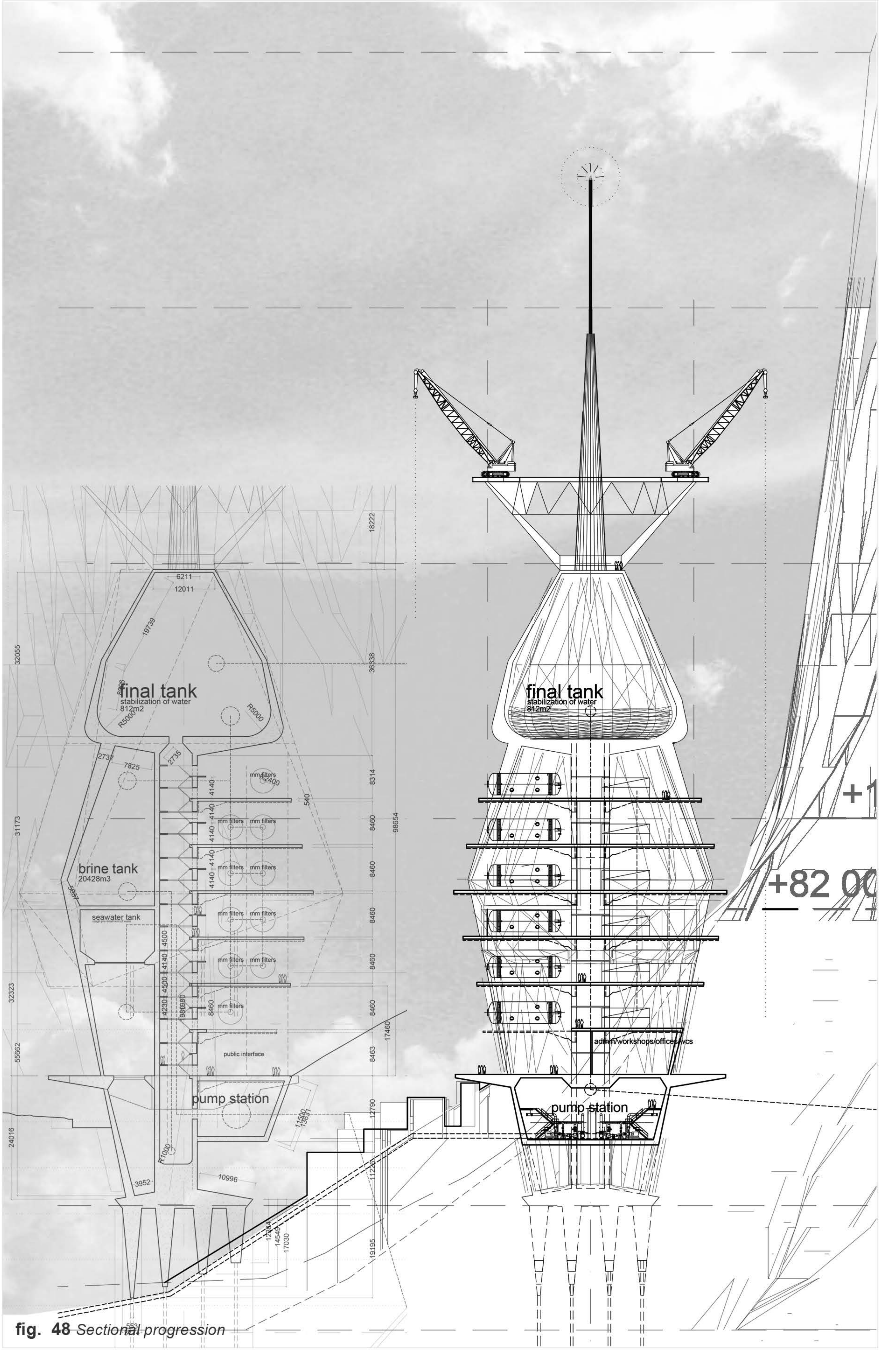


fig. 48 Sectional progression

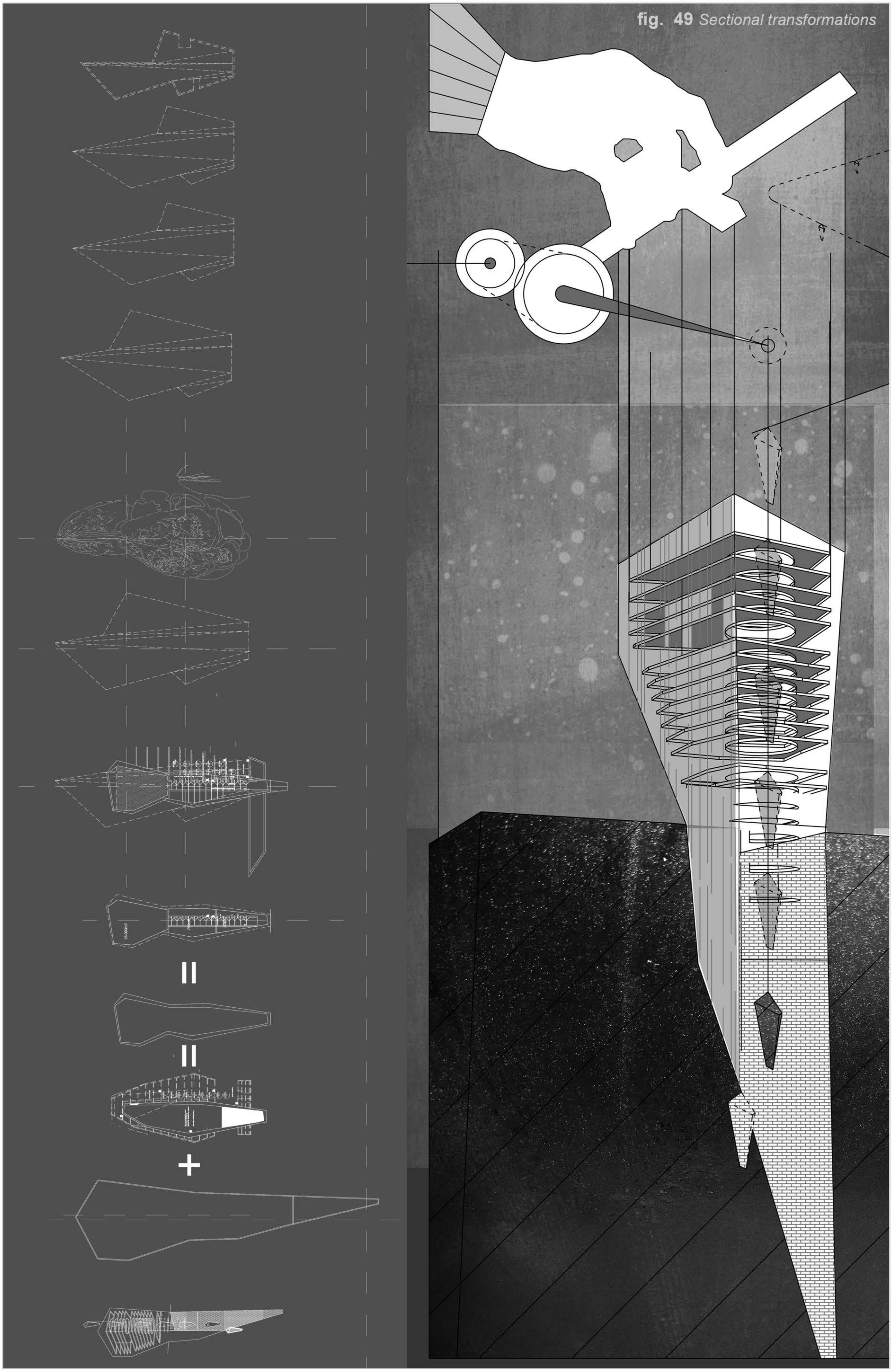


fig. 49 *Sectional transformations*

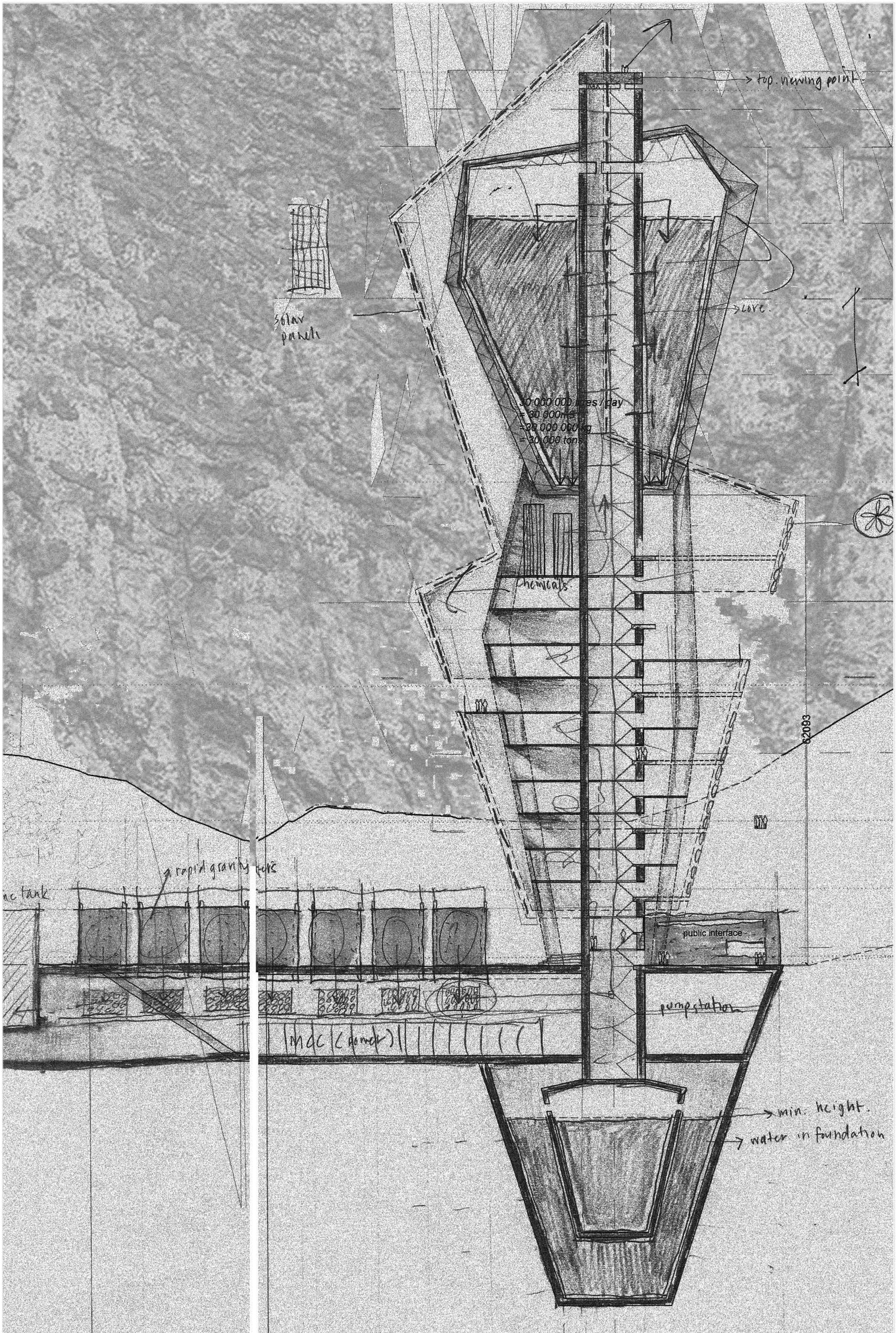


fig. 50 *Sectional transformation 26.08.13*

fig. 51 *Sectional transformation 3D 26.08.13*

fig. 52 *Development of public level 26.08.13*

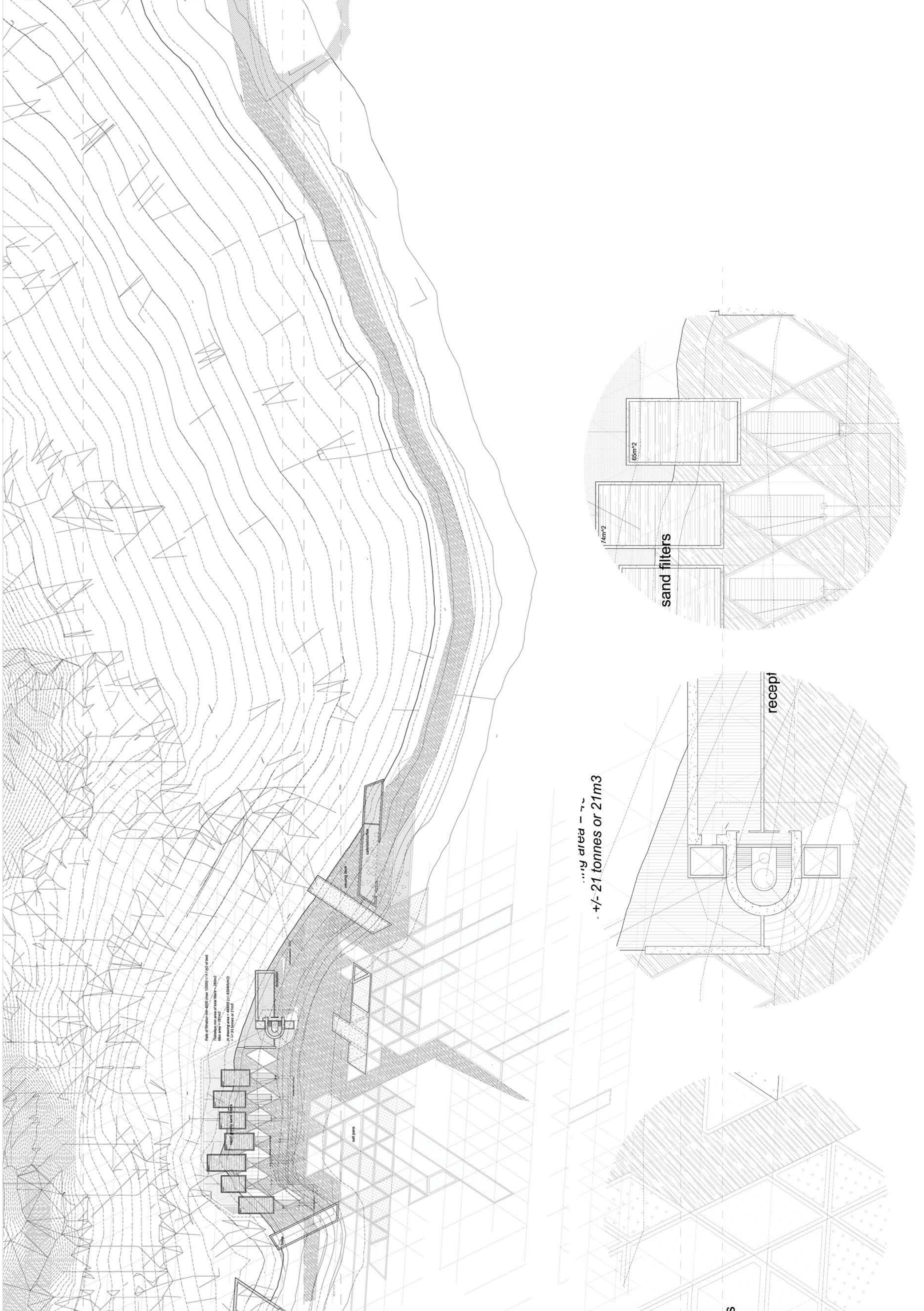
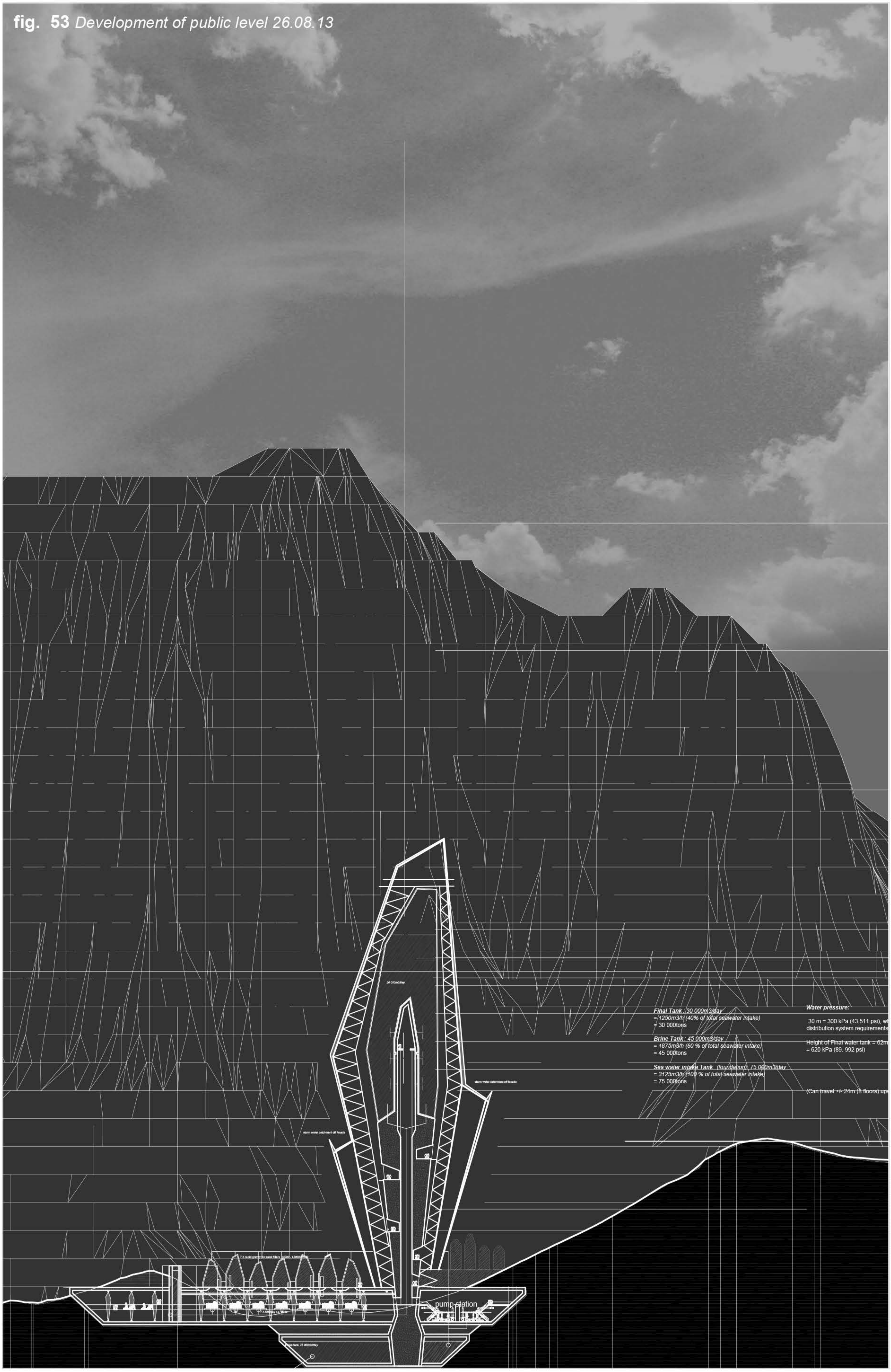


fig. 53 *Development of public level 26.08.13*



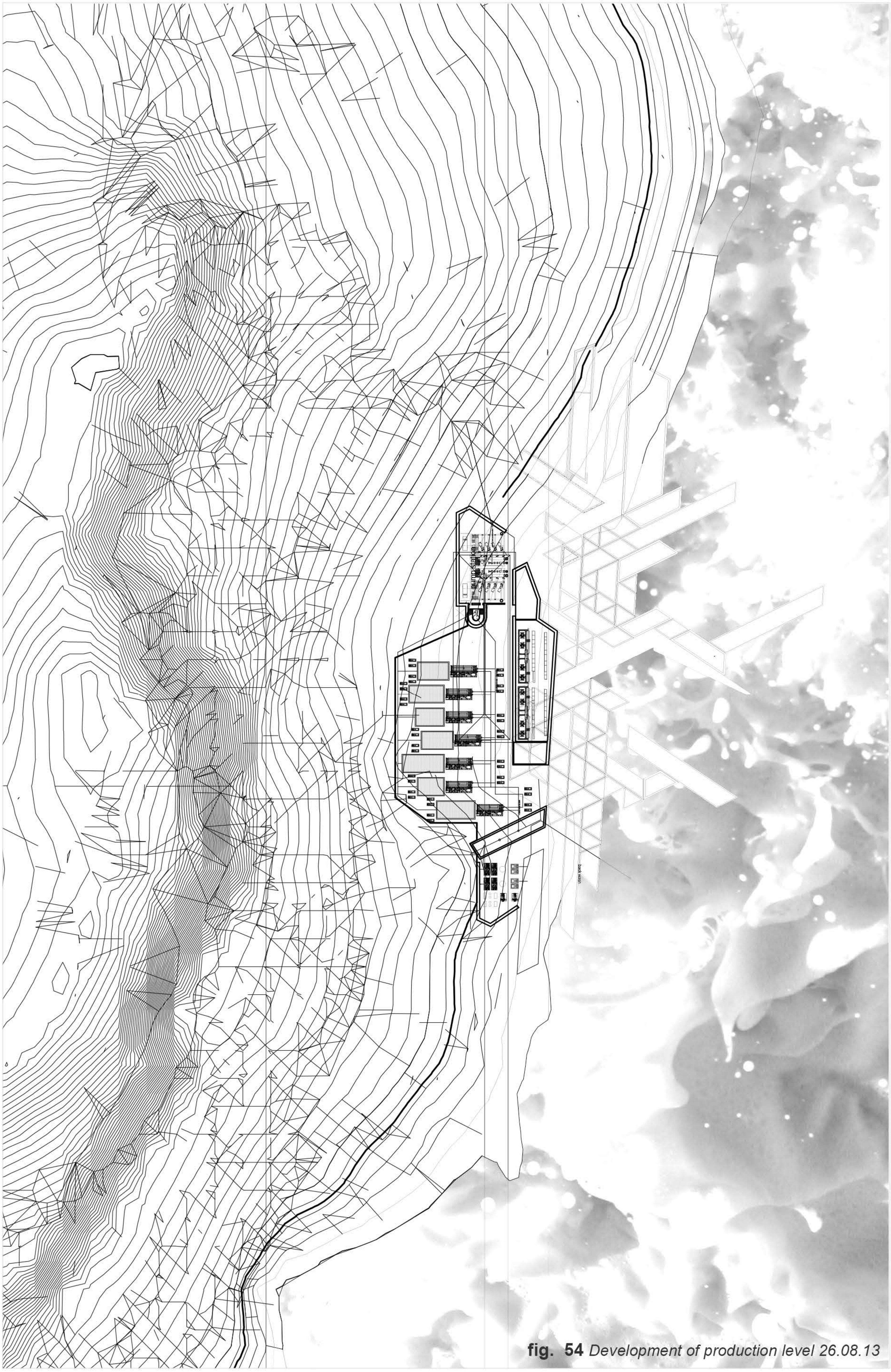


fig. 54 Development of production level 26.08.13

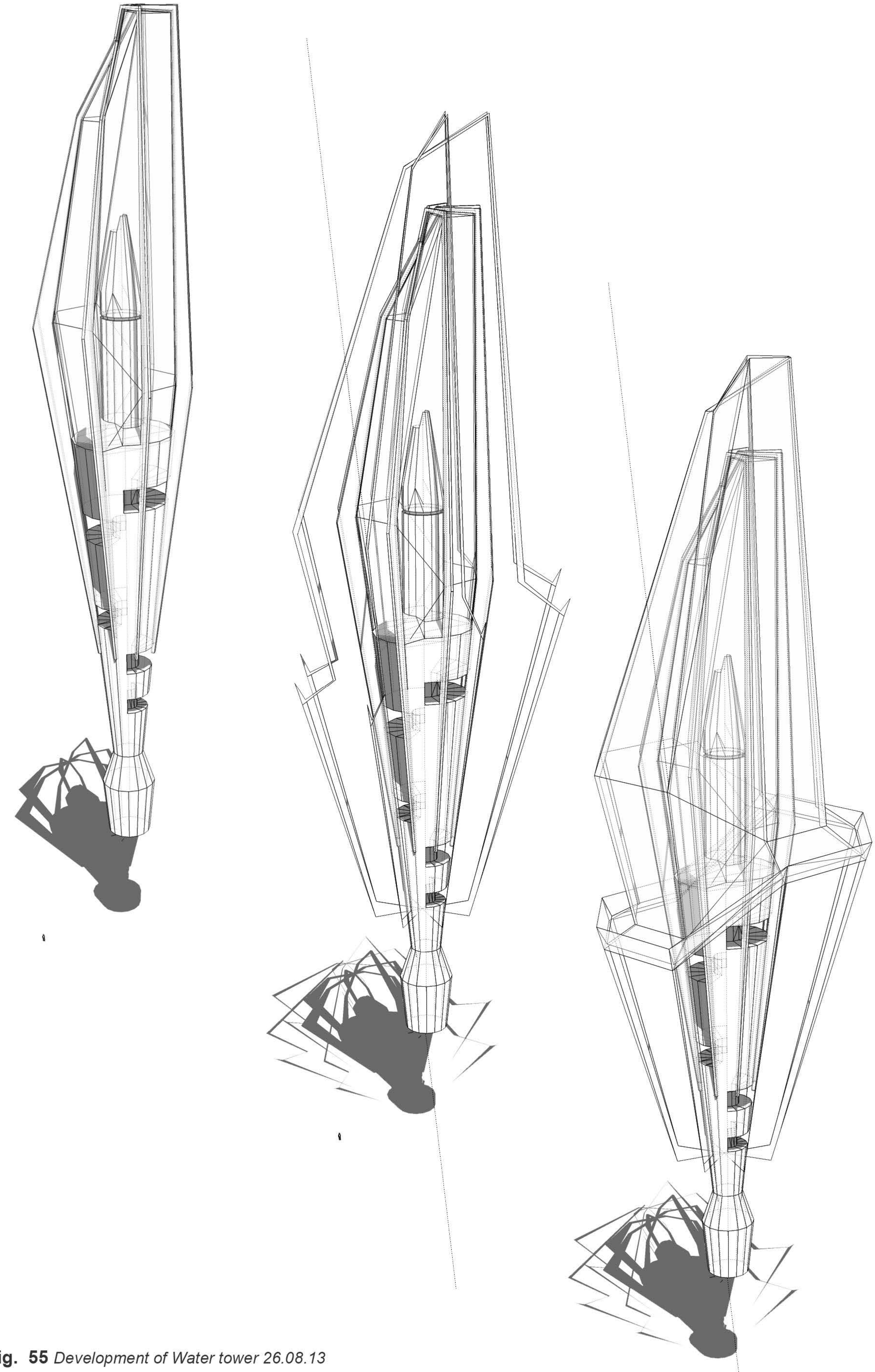


fig. 55 *Development of Water tower 26.08.13*

fig. 56 *New location and Urban Edge proposal in context*

fig. 57 *Development of Desalination plant & Tower sections in new location*

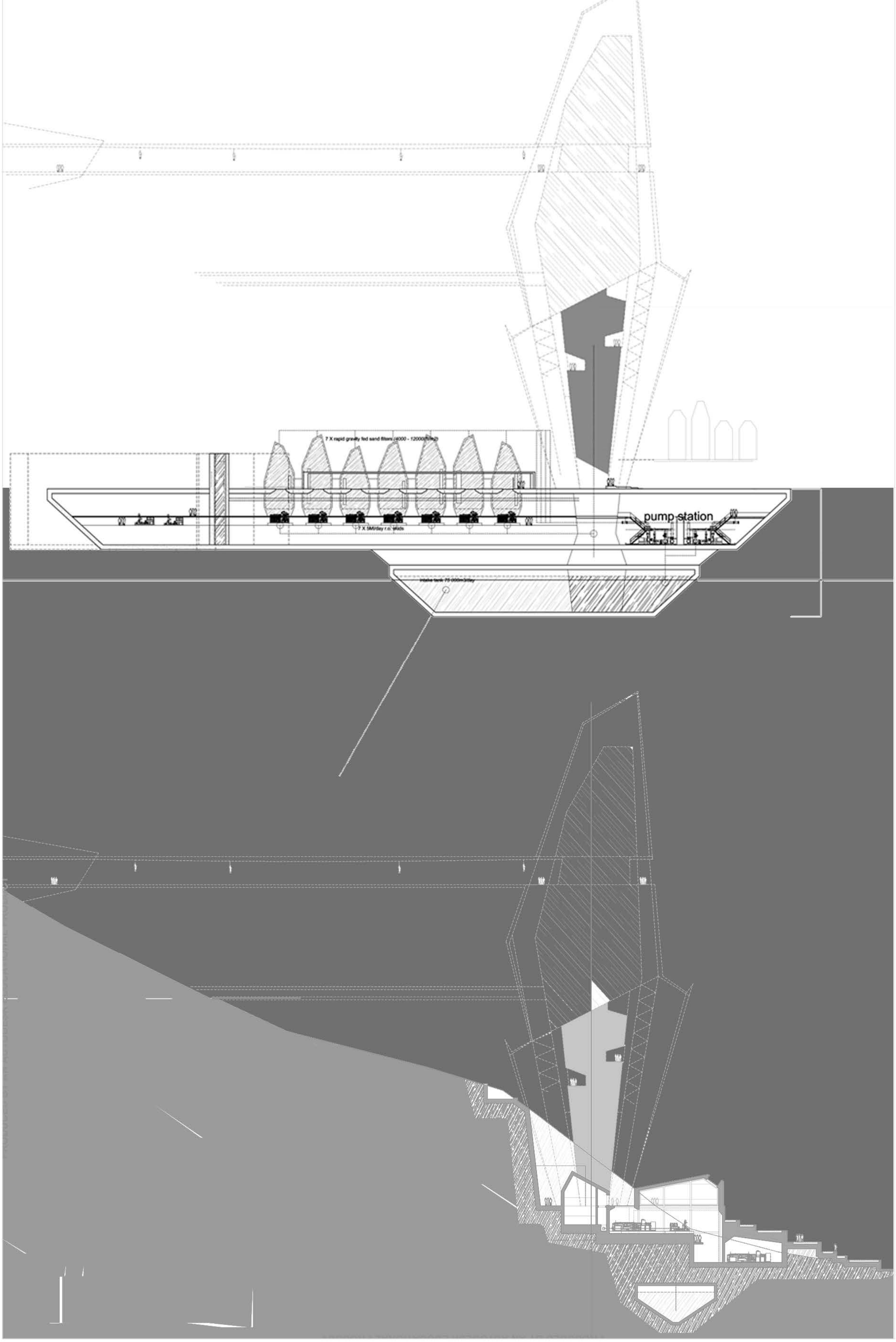


fig. 58 Development of plans_Roof, production & public level

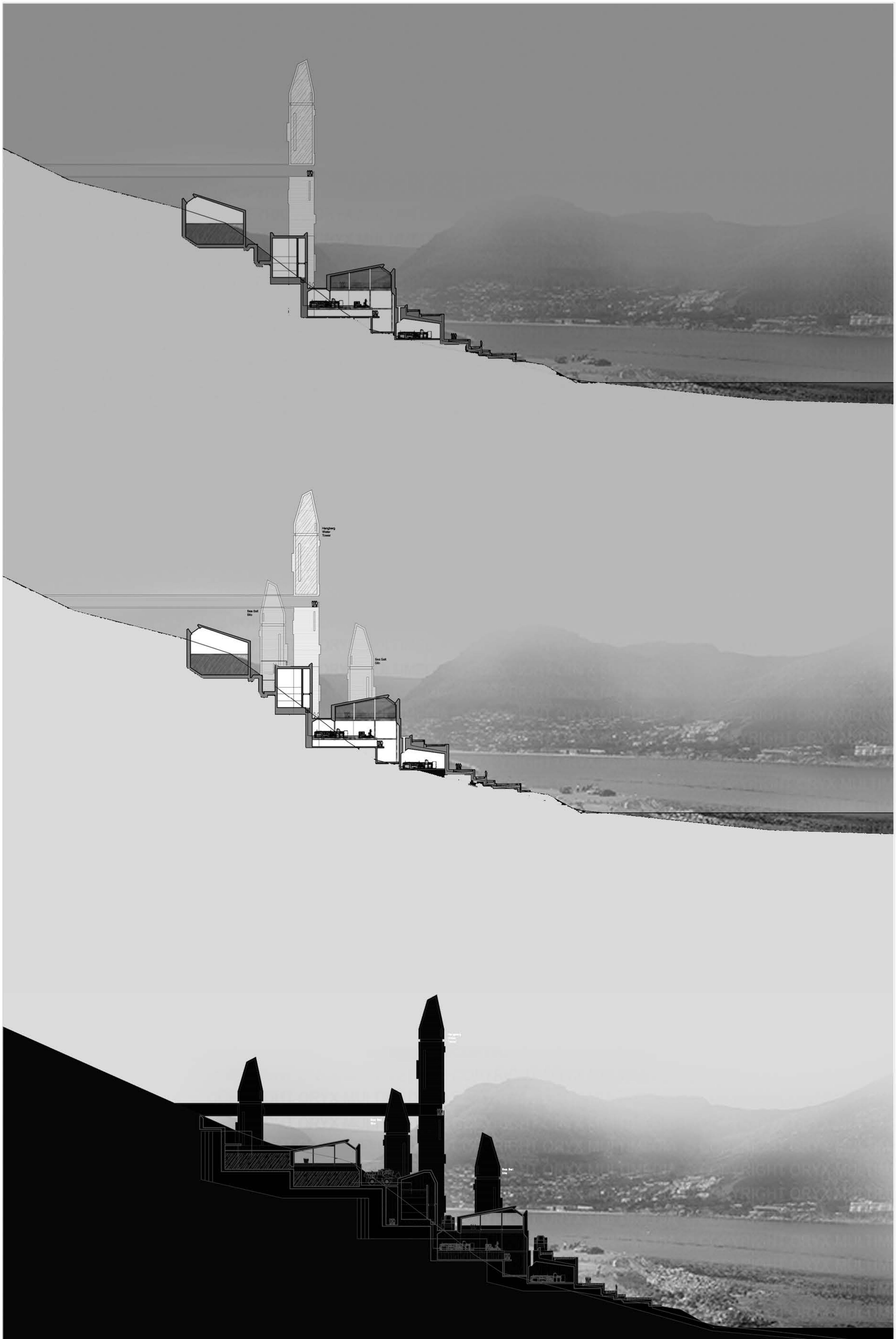


fig. 59 *Sectional Montages_Salt Silos & Tower*

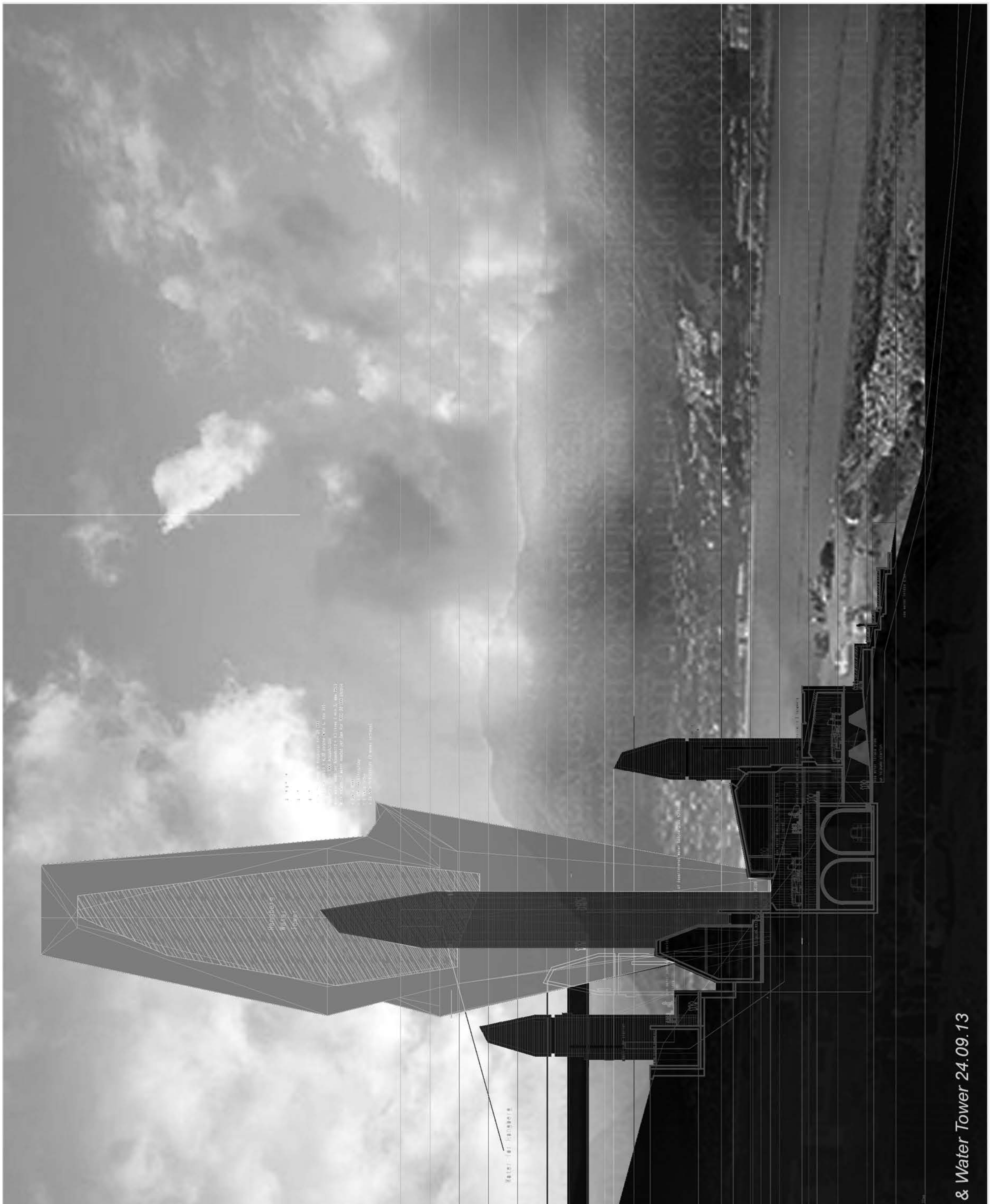
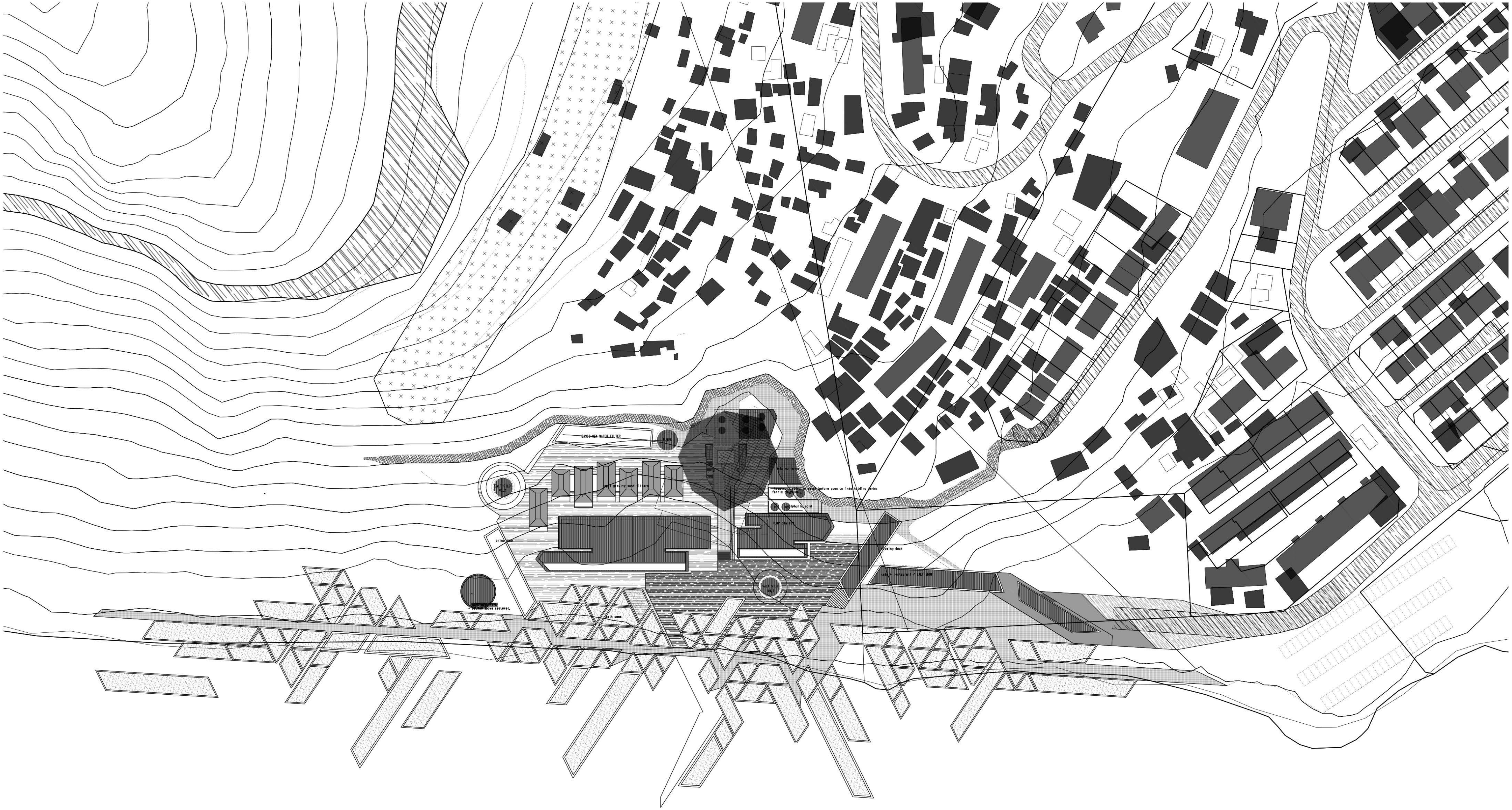


fig. 60 Sectional Montages_ Salt Silos & Water Tower 24.09.13

fig. 61 *Bird's eye View of Desalination & Salt Harvesting Plant_1:1500*


BASIC SEA WATER FILTER
PUMPS
mixing tanks
SALT SILO NO.2
treatment added to water before goes up into holding tanks
ferric chloride
sulphuric acid
PUMP STATION
brine tank
viewing deck
cafe + restaurant / SALT SHOP
SALT SILO NO.1
salt pans

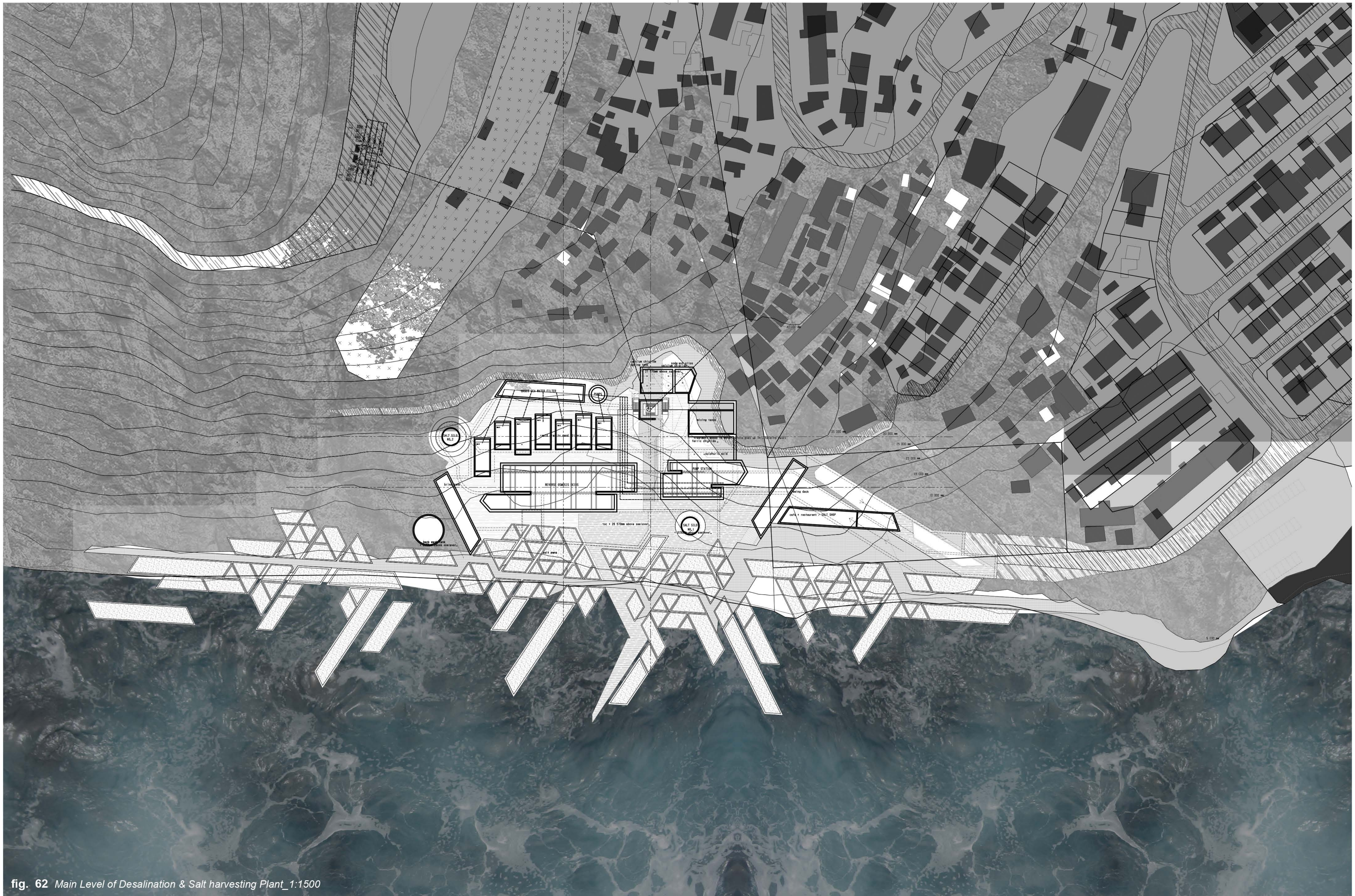
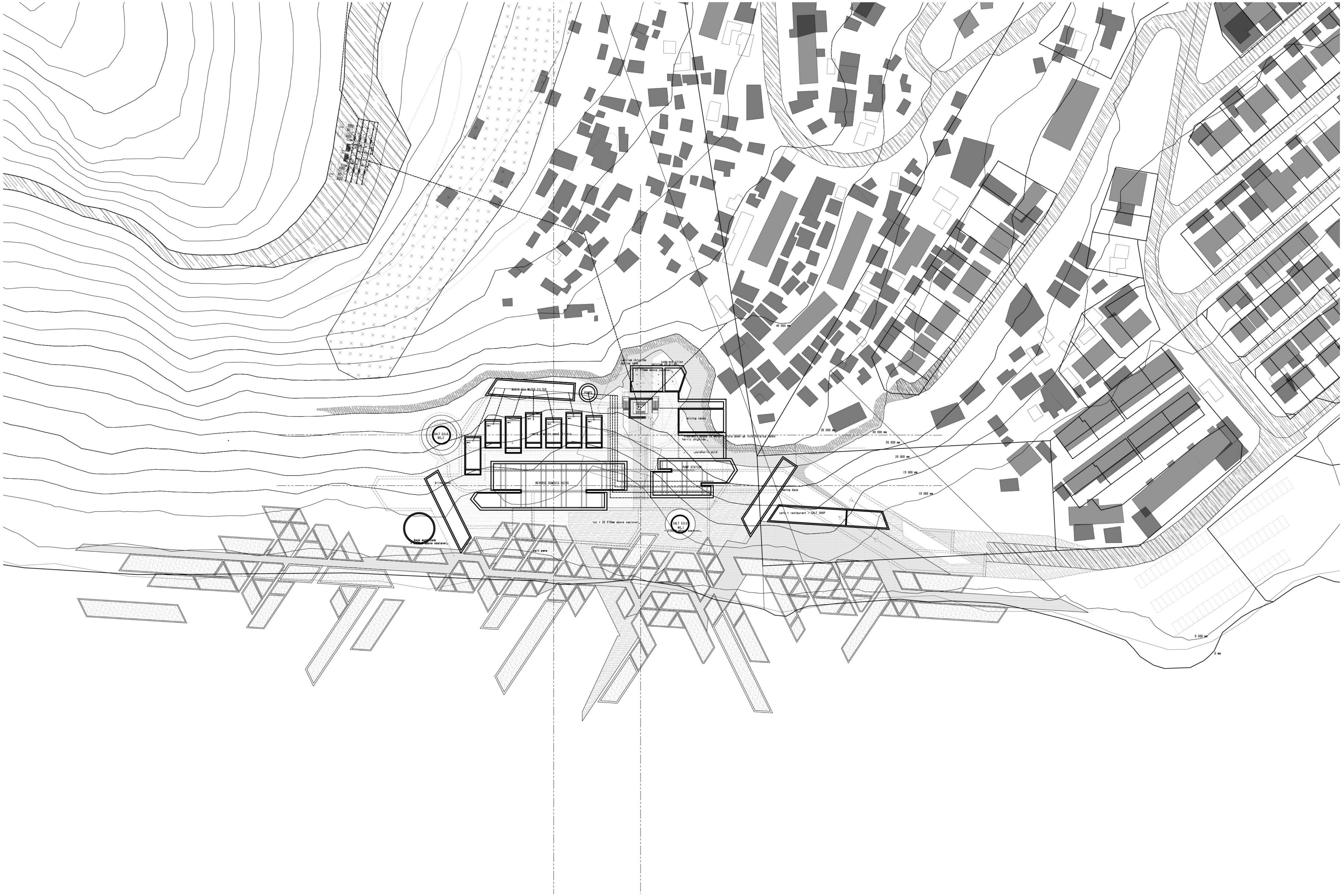


fig. 62 *Main Level of Desalination & Salt harvesting Plant_1:1500*


calcium chloride dosing tank
soda-ash silos
calcium chloride
27 570mm above sealevel.
BASIC SEA WATER FILTER
PUMPS
SALT SILO NO.2
rapid gravity sand filters
mixing tanks
treatment added to water before goes up into holding tanks
ferric chloride
sulphuric acid
PUMP STATION
brine tank
REVERSE OSMOSIS SKIDS
viewing deck
cafe + restaurant / SALT SHOP
toc + 26 570mm above sealevel.
SALT SILO NO.1
back wash tank
salt pans
40 000 mm
35 000 mm
30 000 mm
25 000 mm
20 000 mm
15 000 mm
10 000 mm
5 000 mm
0 mm

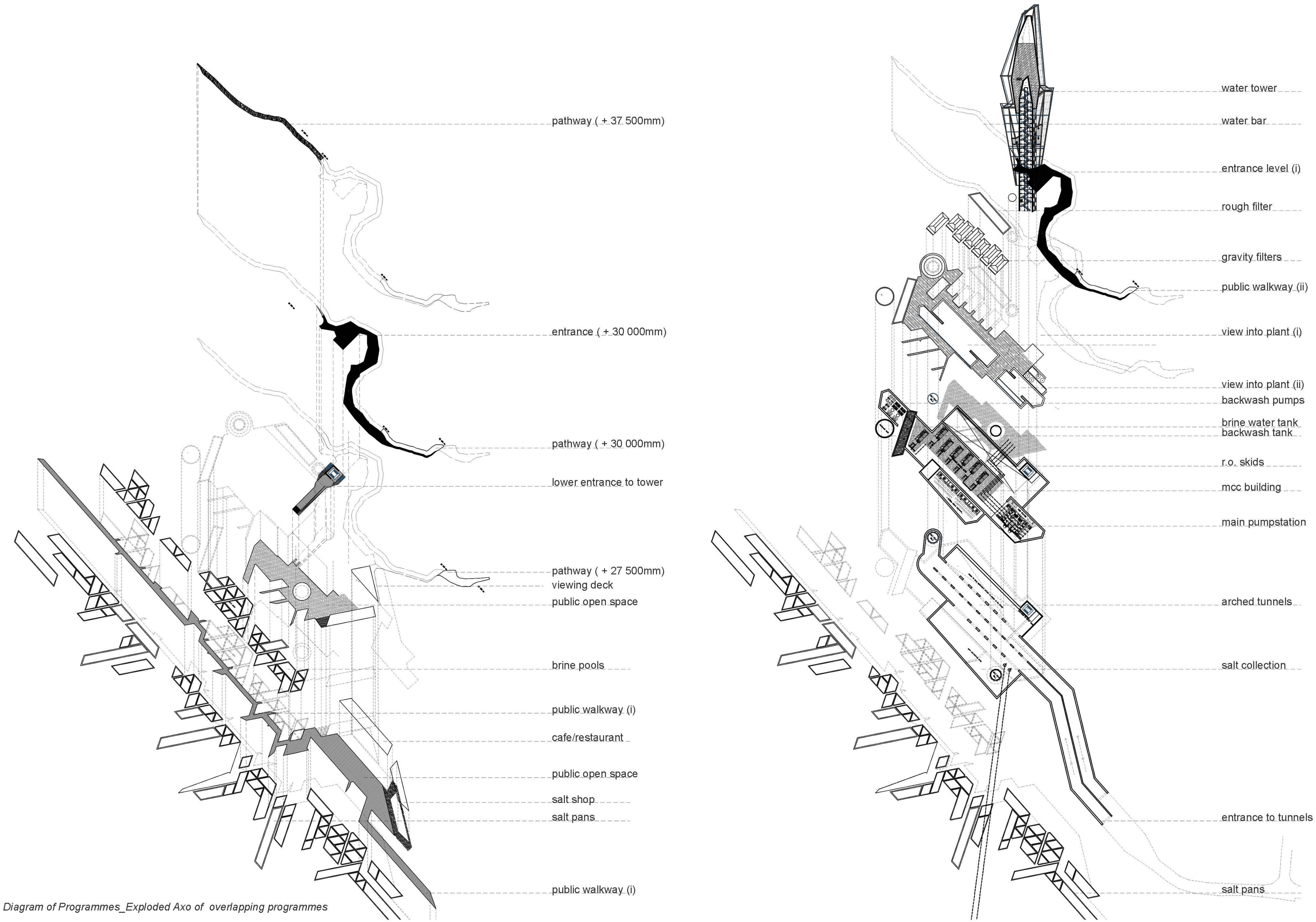
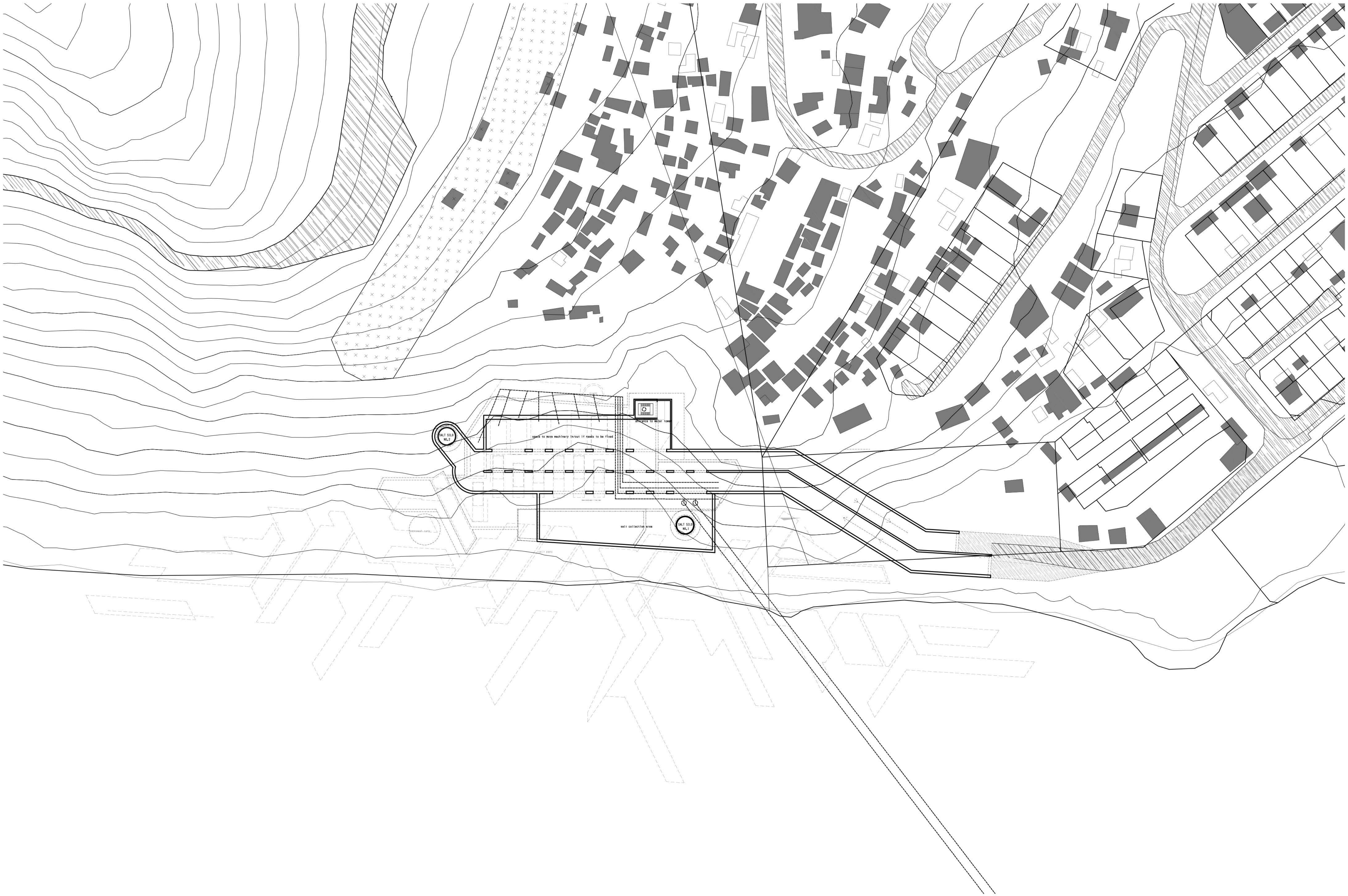


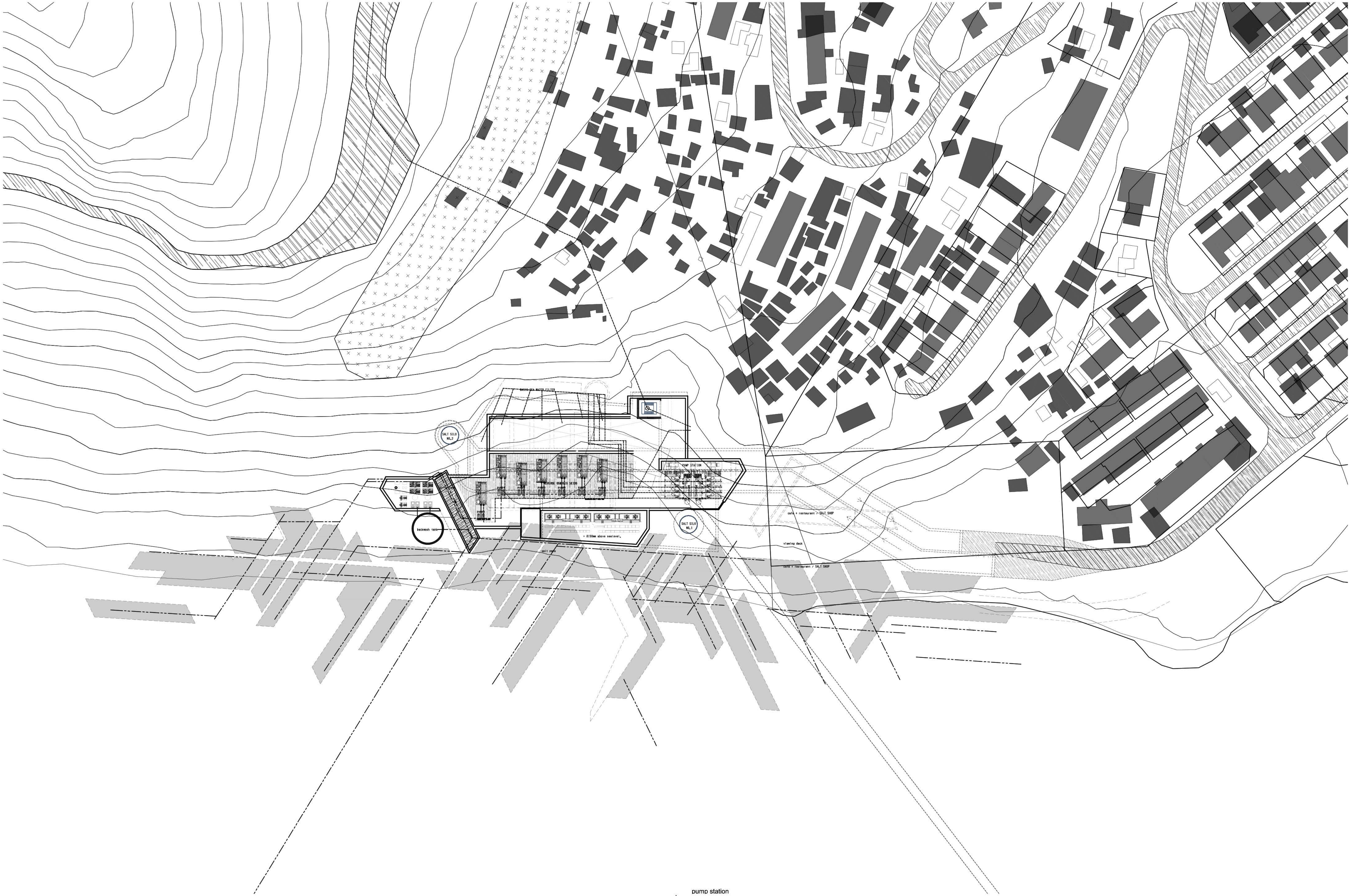
fig. 63 *Diagram of Programmes_Exploded Axo of overlapping programmes*

fig. 64 *Underground Tunnels and access to machinery_1:1500*



SALT SILO NO.2
space to move machinery in/out if needs to be fixed
entrance to water tower
salt collection area
SALT SILO NO.1

fig. 65 Production Level, RO Skids and Pump station_1:1500



pump station

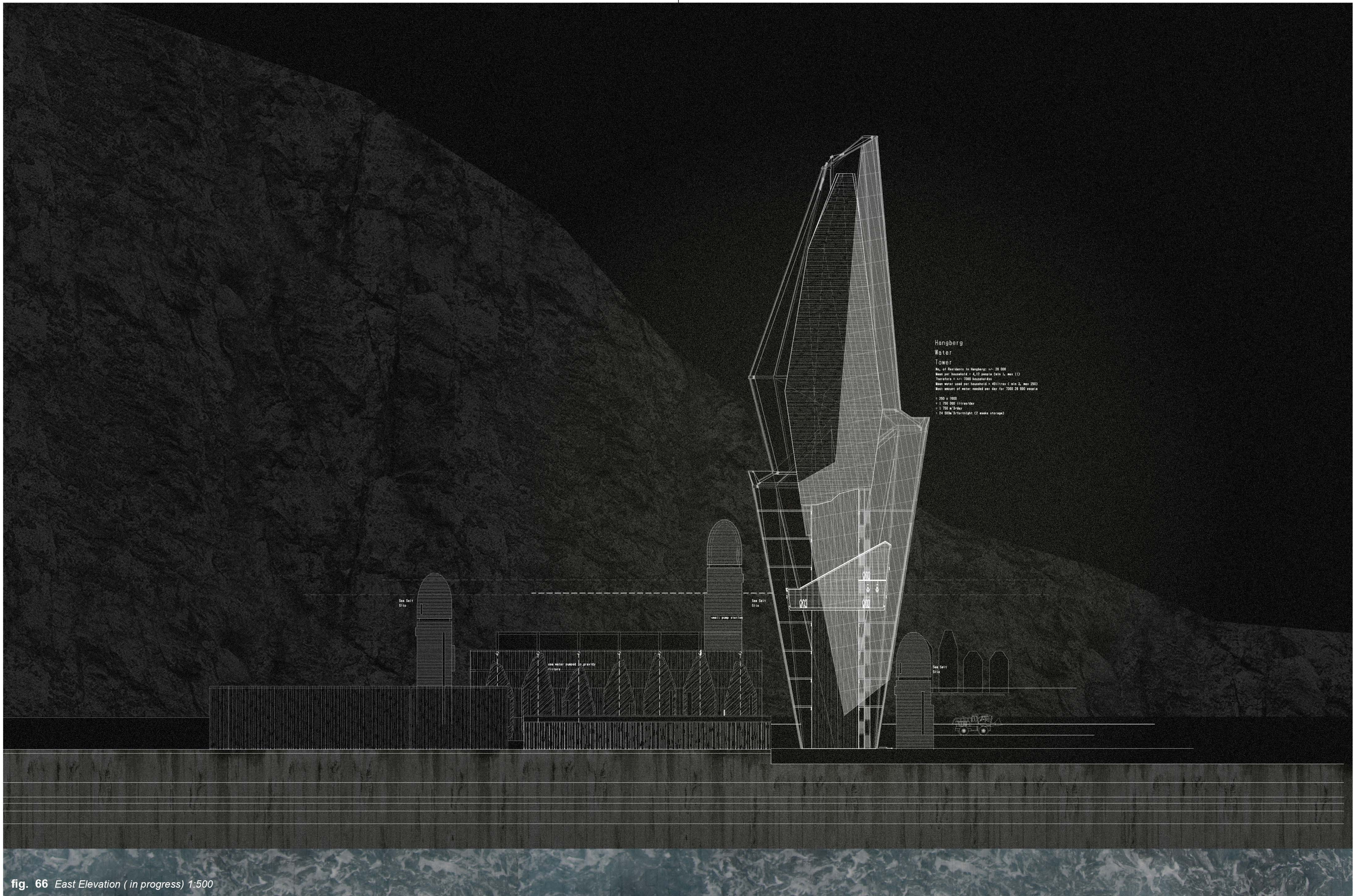
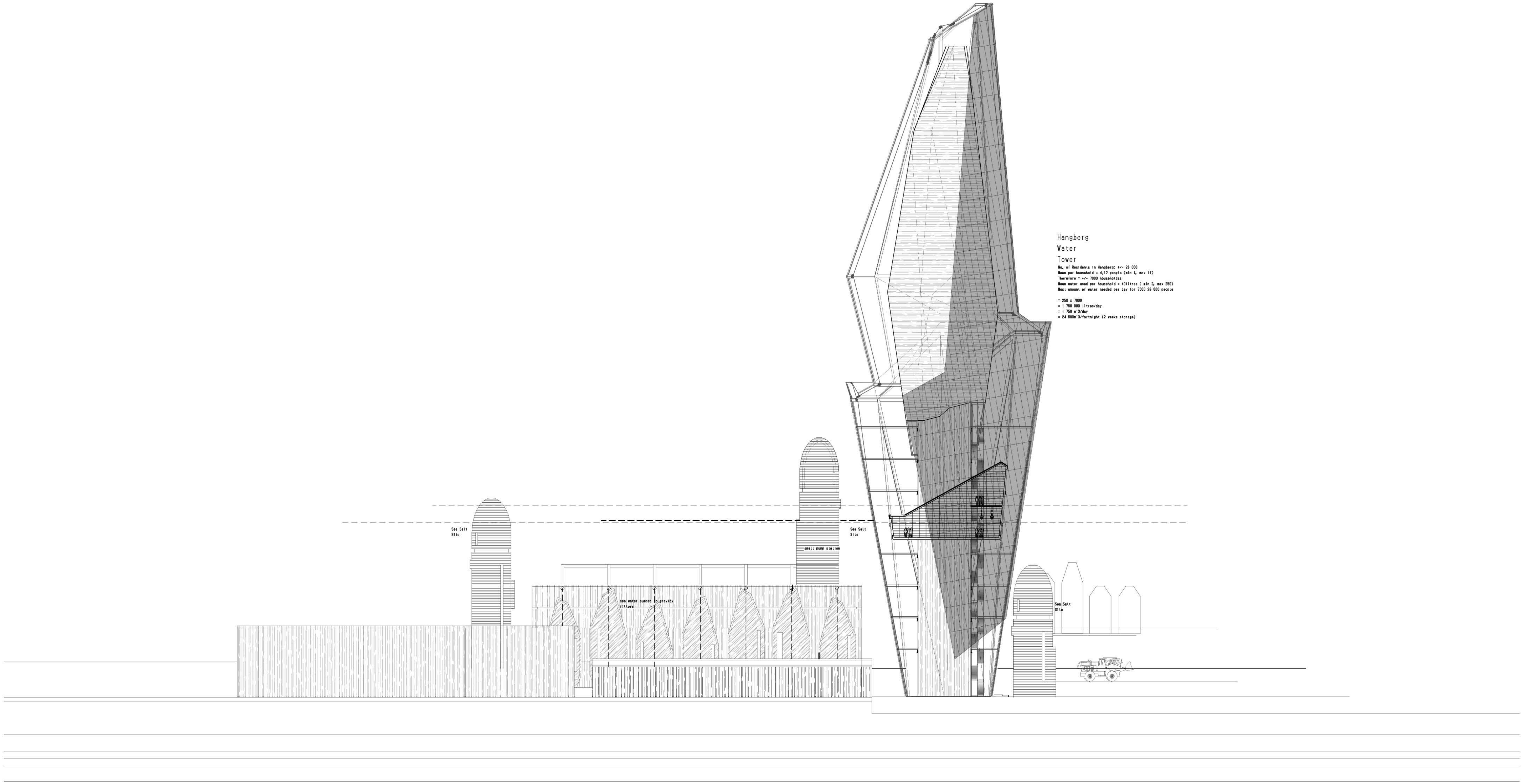


fig. 66 *East Elevation (in progress) 1:500*


Hangberg
Water
Tower
No. of Residents in Hangberg: +/- 28 000
Mean per household = 4.12 people (min 1, max 11)
Therefore = +/- 7000 householdss
Mean water used per household = 40litres (min 2, max 250)
Most amount of water needed per day for 7000 28 000 people
= 250 x 7000
= 1 750 000 litres/day
= 1 750 m^3/day
= 24 500m^3/fortnight (2 weeks storage)
Sea Salt
Silo
small pump station
Sea Salt
Silo
sea water pumped to gravidy
filters
Sea Salt
Silo

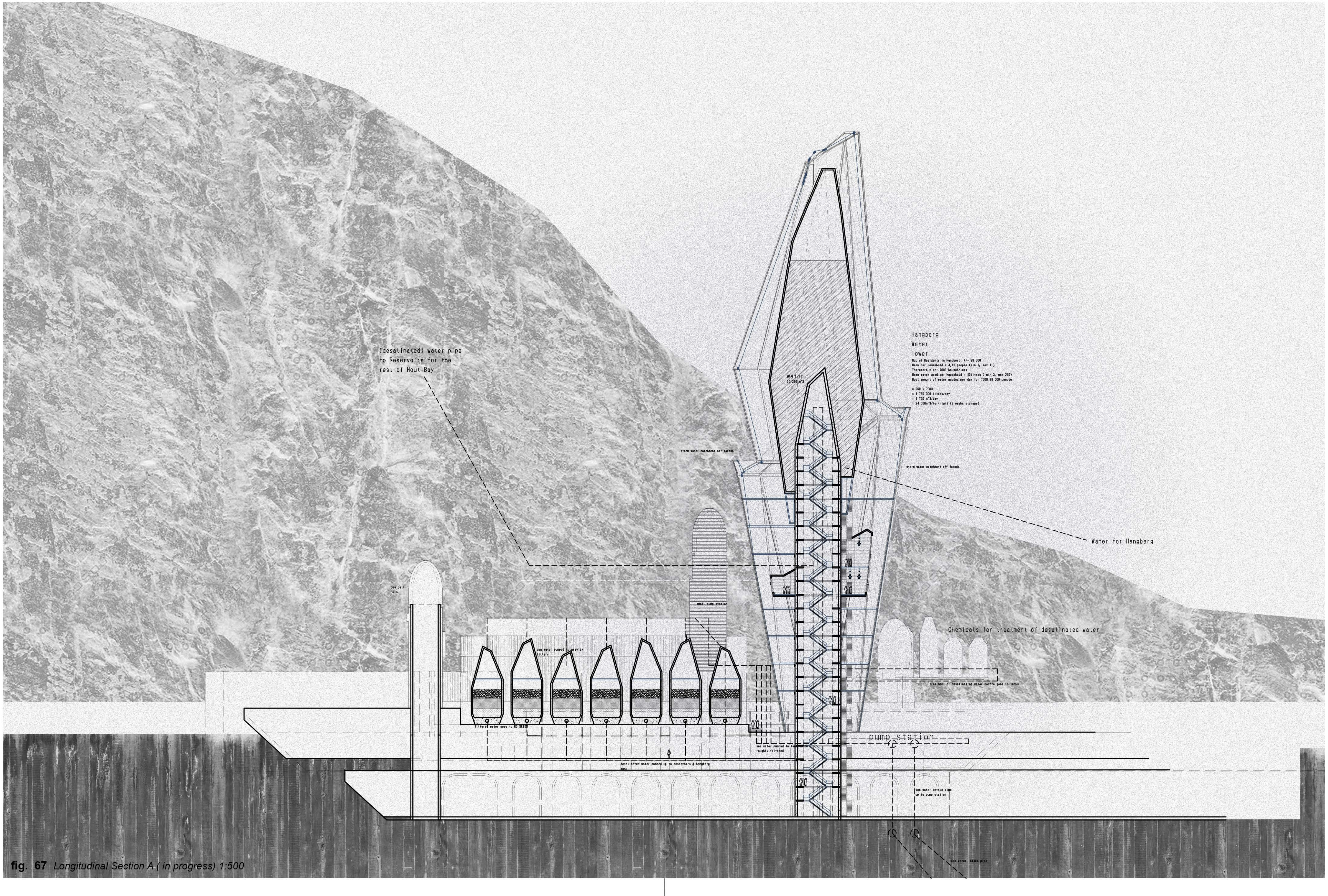
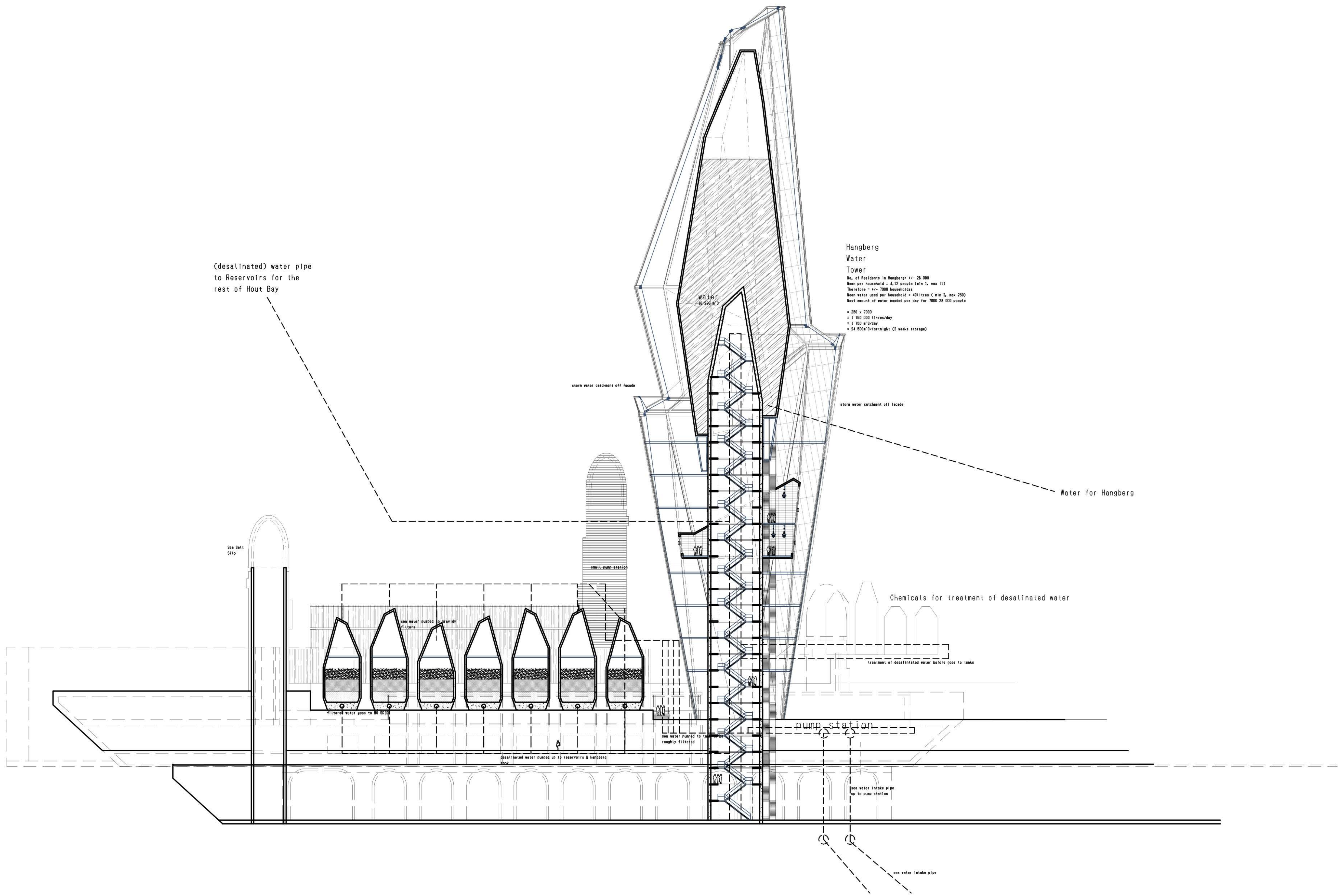


fig. 67 *Longitudinal Section A (in progress) 1:500*



(desalinated) water pipe
to Reservoirs for the
rest of Hout Bay
Hangberg
Water
Tower
No. of Residents in Hangberg: +/- 28 000
Mean per household = 4.12 people (min 1, max 11)
Therefore = +/- 7000 householdss
Mean water used per household = 40litres (min 2, max 250)
Most amount of water needed per day for 7000 28 000 people
= 250 x 7000
= 1 750 000 litres/day
= 1 750 m^3/day
= 24 500m^3/fortnight (2 weeks storage)
storm water catchment off facade
storm water catchment off facade
Water for Hangberg
Sea Salt
Silo
small pump station
Chemicals for treatment of desalinated water
sea water pumped to gravidy
filters
treatment of desalintated water before goes to tanks
filtered water goes to RO SKIDS
pump station
sea water pumped to tank to be
roughly filtered
desalinated water pumped up to reservoirs & hangberg
tank
sea water intake pipe
up to pump station
sea water intake pipe

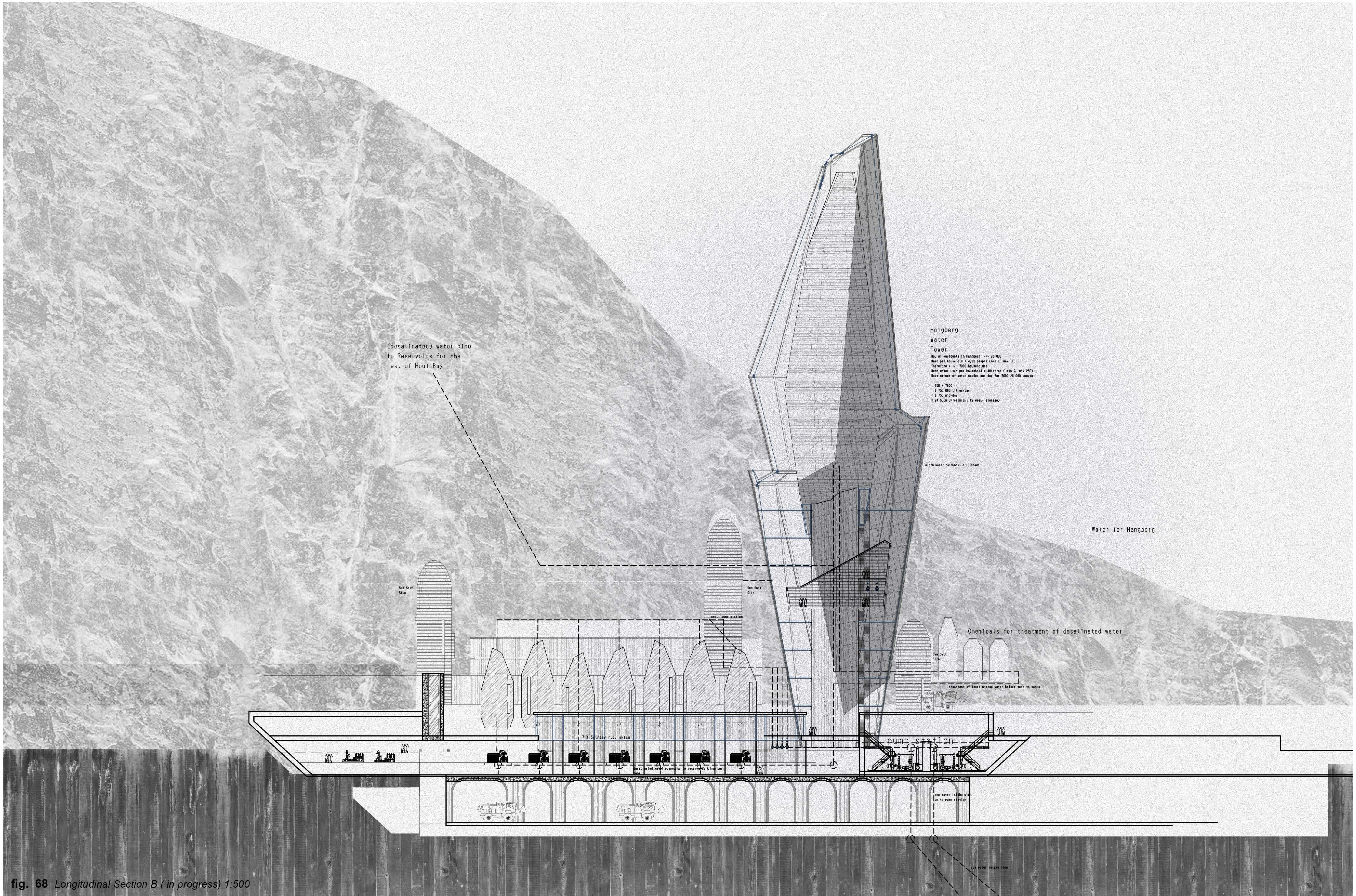
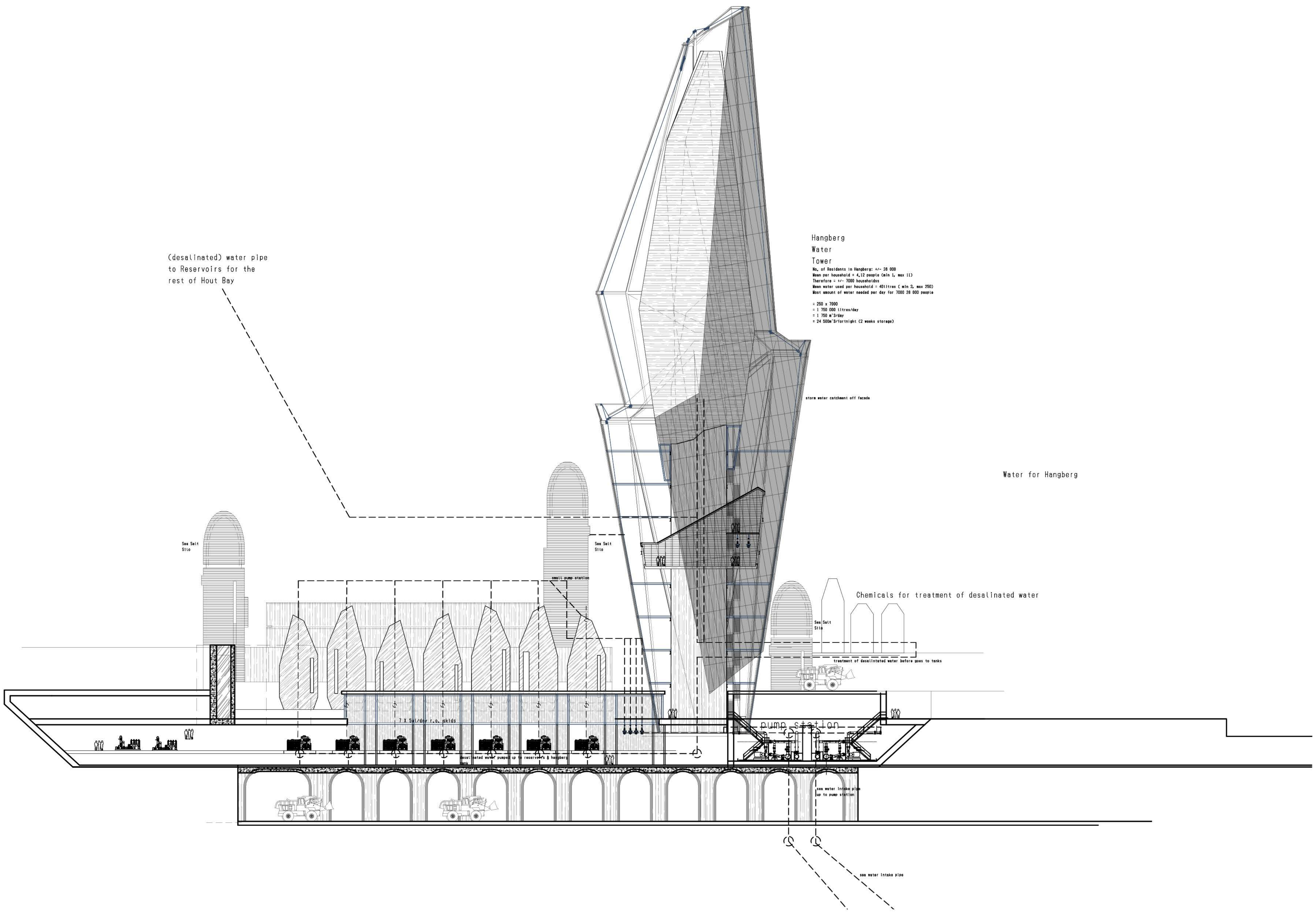


fig. 68 *Longitudinal Section B (in progress) 1:500*


(desalinated) water pipe
to Reservoirs for the
rest of Hout Bay
Hangberg
Water
Tower
No. of Residents in Hangberg: +/- 28 000
Mean per household = 4.12 people (min 1, max 11)
Therefore = +/- 7000 householdss
Mean water used per household = 40litres (min 2, max 250)
Most amount of water needed per day for 7000 28 000 people
= 250 x 7000
= 1 750 000 litres/day
= 1 750 m^3/day
= 24 500m^3/fortnight (2 weeks storage)
storm water catchment off facade
Water for Hangberg
Sea Salt
Silo
Sea Salt
Silo
small pump station
Chemicals for treatment of desalinated water
Sea Salt
Silo
treatment of desalintated water before goes to tanks
7 X 5Ml/day r.o. skids
pump station
desalinated water pumped up to reservoirs & hangberg
tank
sea water intake pipe
up to pump station
sea water intake pipe

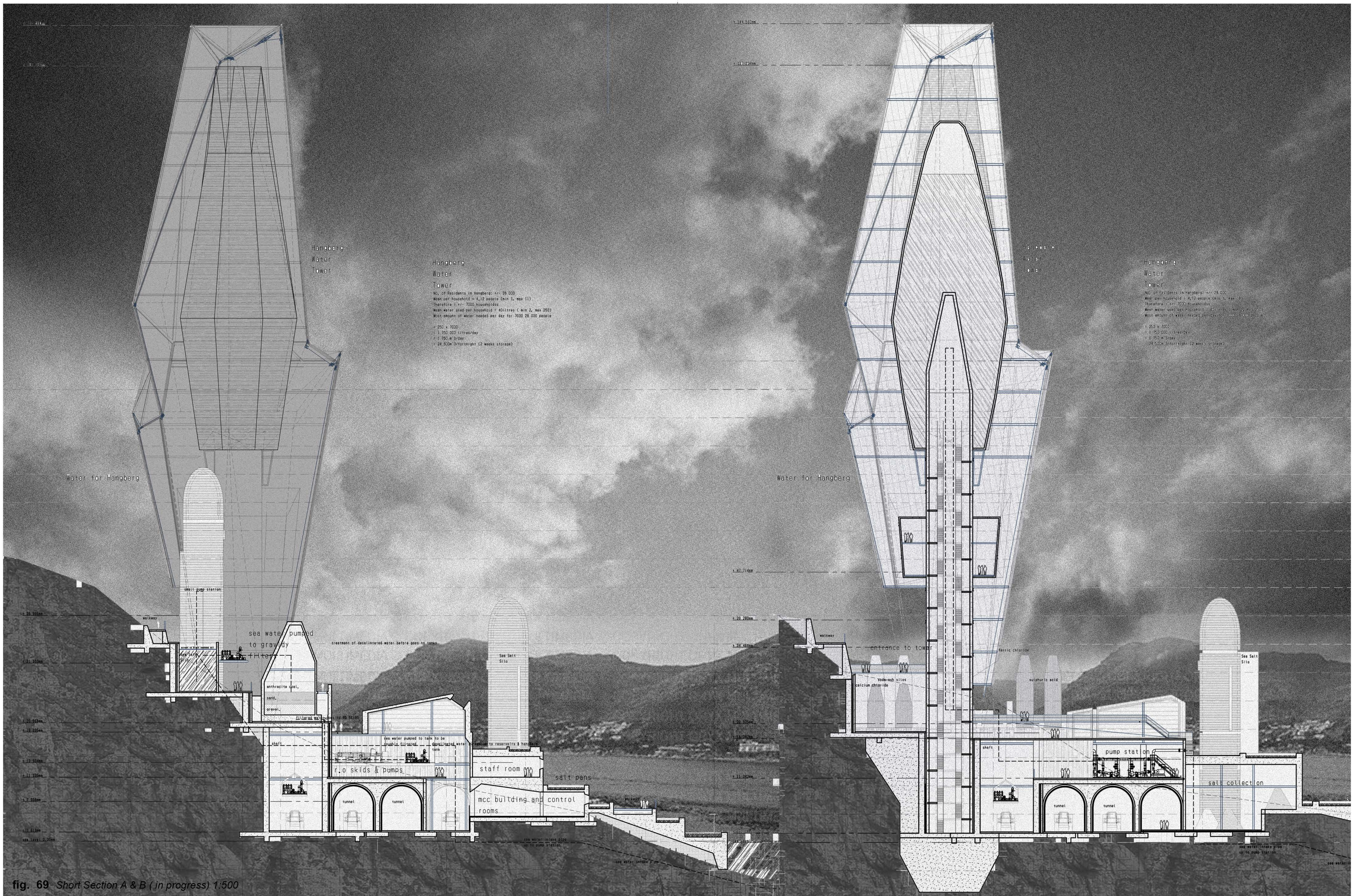
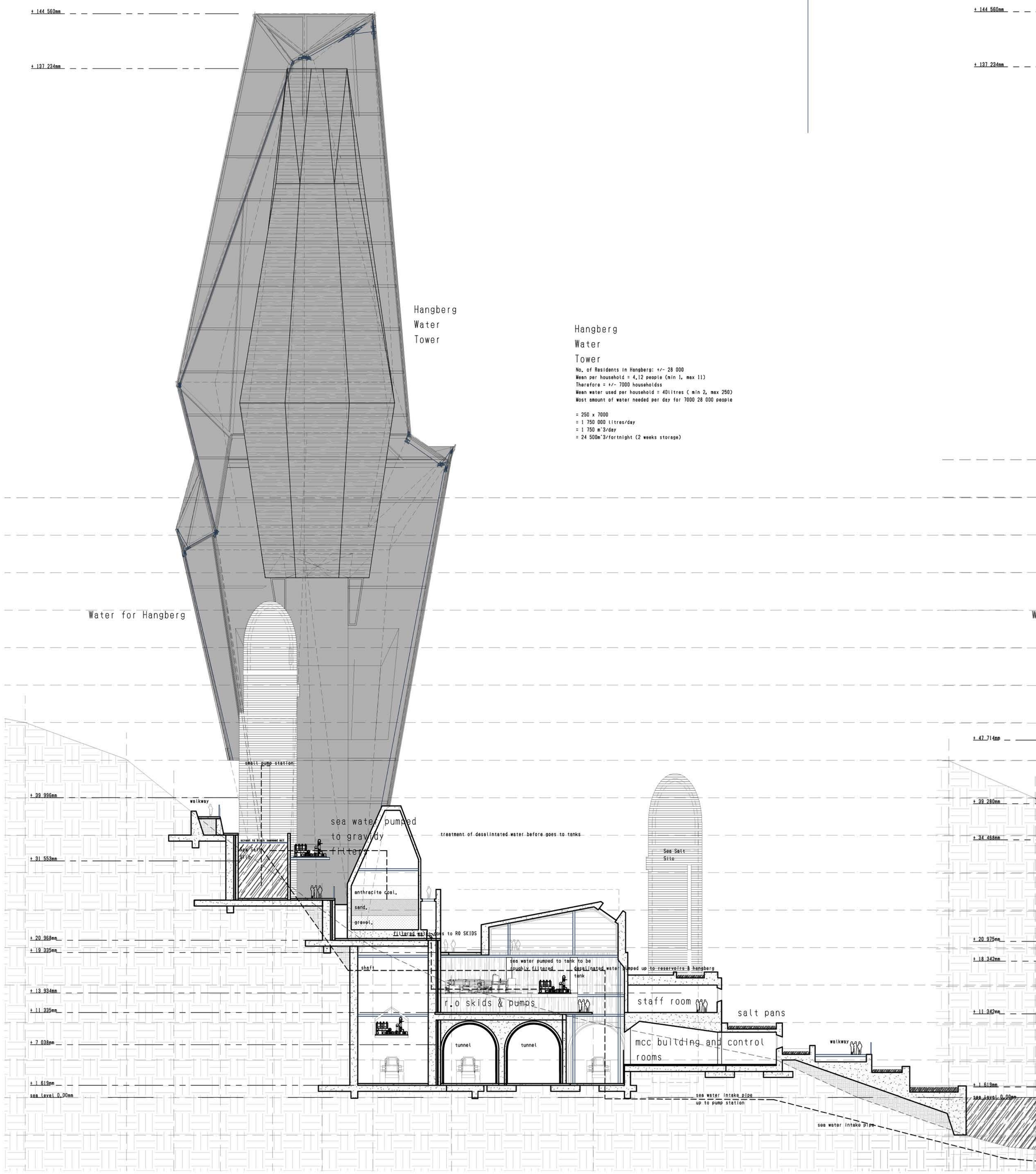


fig. 69 *Short Section A & B (in progress) 1:500*


Hangberg
Water
Tower
Hangberg
Water
Tower
No. of Residents in Hangberg: +/- 28 000
Mean per household = 4.12 people (min 1, max 11)
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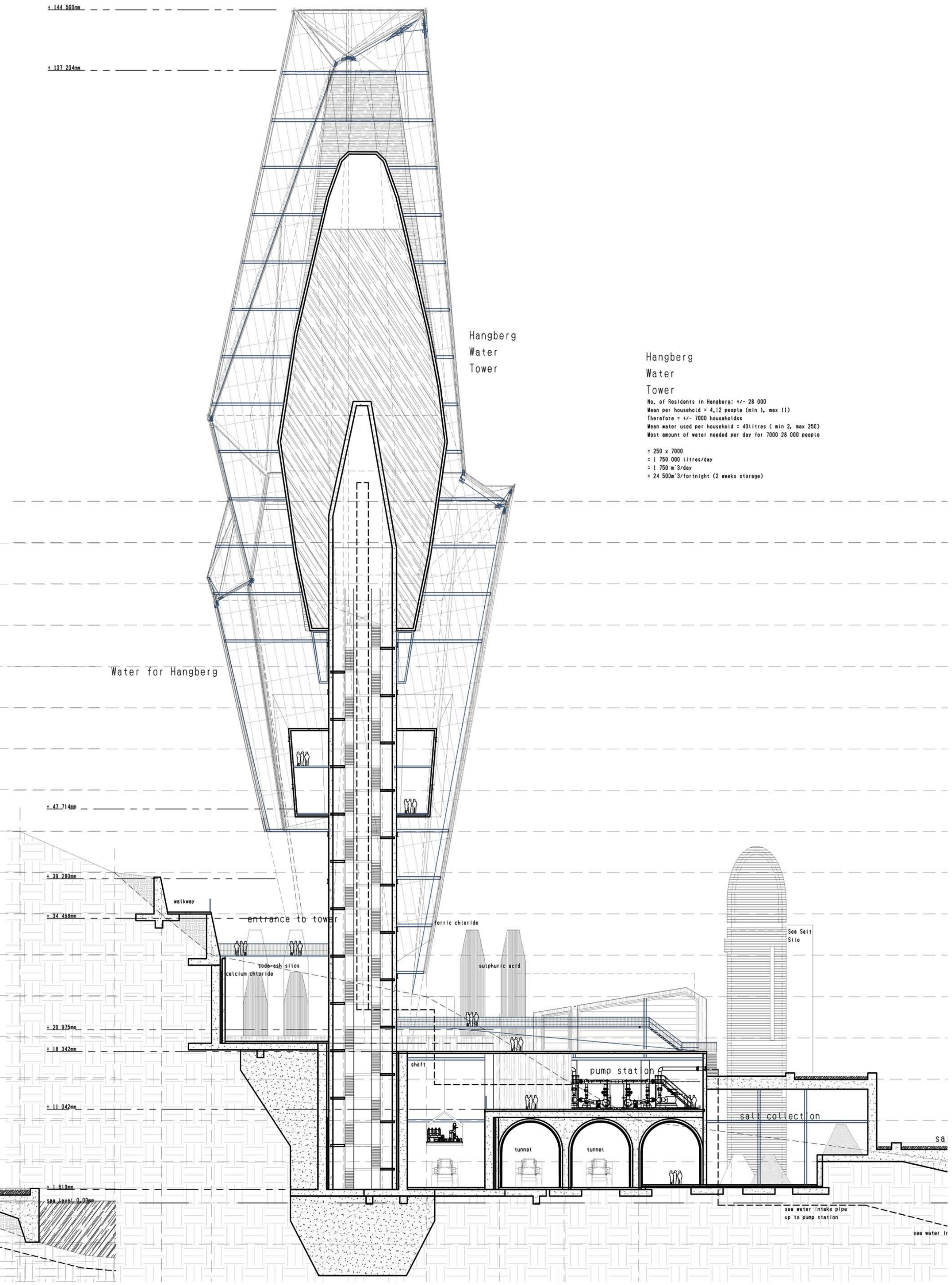
Most amount of water needed per day for 7000 28 000 people
= 250 x 7000
= 1 750 000 litres/day
= 1 750 m^3/day
= 24 500m^3/fortnight (2 weeks storage)
Water for Hangberg
sea water pumped
to gravity
filters
treatment of desalinated water before goes to tanks
anthracite coal,
sand,
gravel,
Sea Salt
Silo
r.o skids & pumps
staff room
salt pans
tunnel
tunnel
mcc building and control
rooms
walkway


Hangberg
Water
Tower
Hangberg
Water
Tower
No. of Residents in Hangberg: +/- 28 000
Mean per household = 4.12 people (min 1, max 11)
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Most amount of water needed per day for 7000 28 000 people
= 250 x 7000
= 1 750 000 litres/day
= 1 750 m^3/day
= 24 500m^3/fortnight (2 weeks storage)
Water for Hangberg
entrance to tower
ferric chloride
sulphuric acid
calcium chloride
Sea Salt
Silo
pump station
salt collection
tunnel
tunnel
tunnel

fig. 76 *Mossel Bay Desalination plant in context*
Plan 1:1500

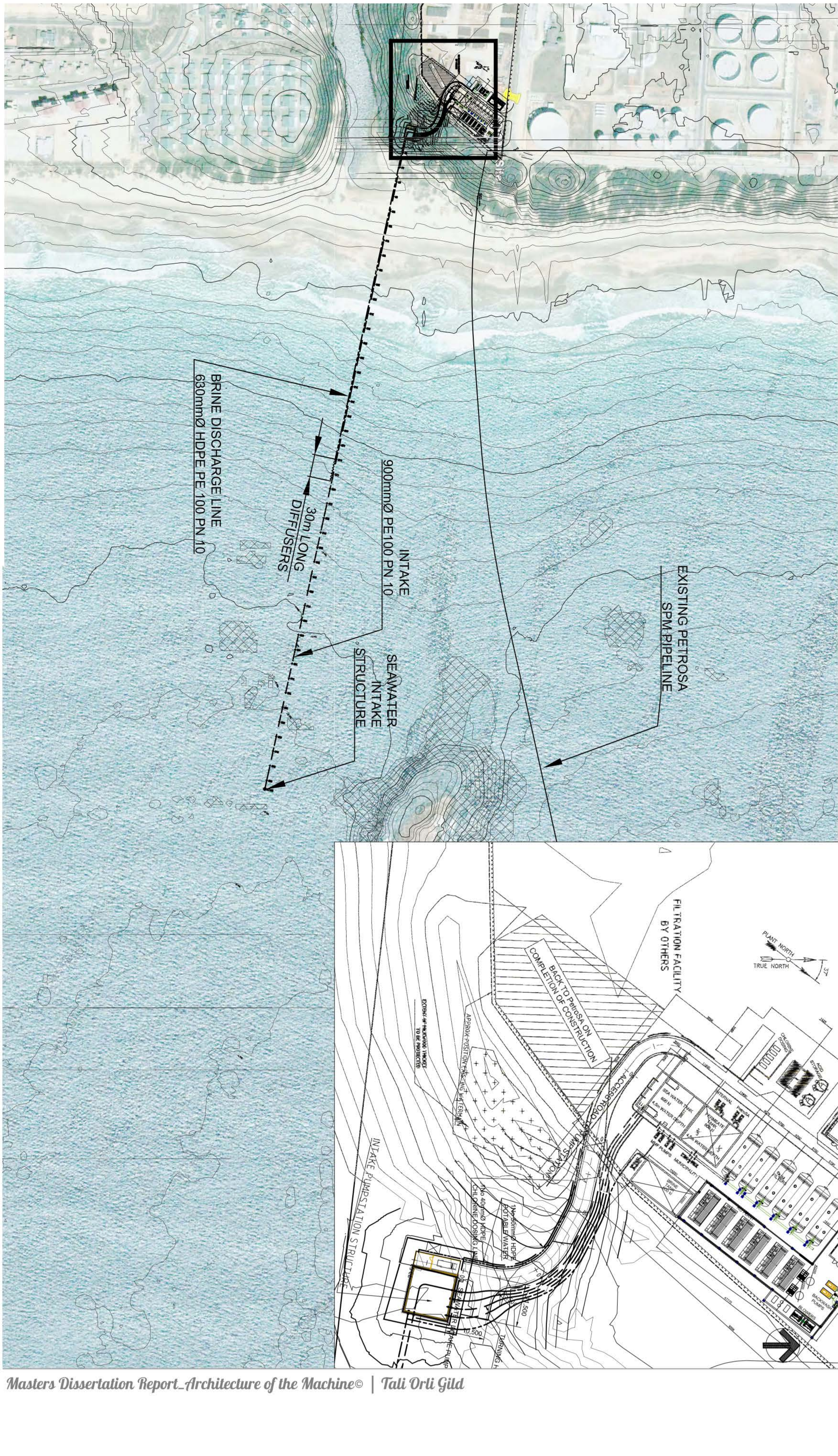


fig. 77 *Mossel Bay Desalination plant general layout*
Plan 1:750

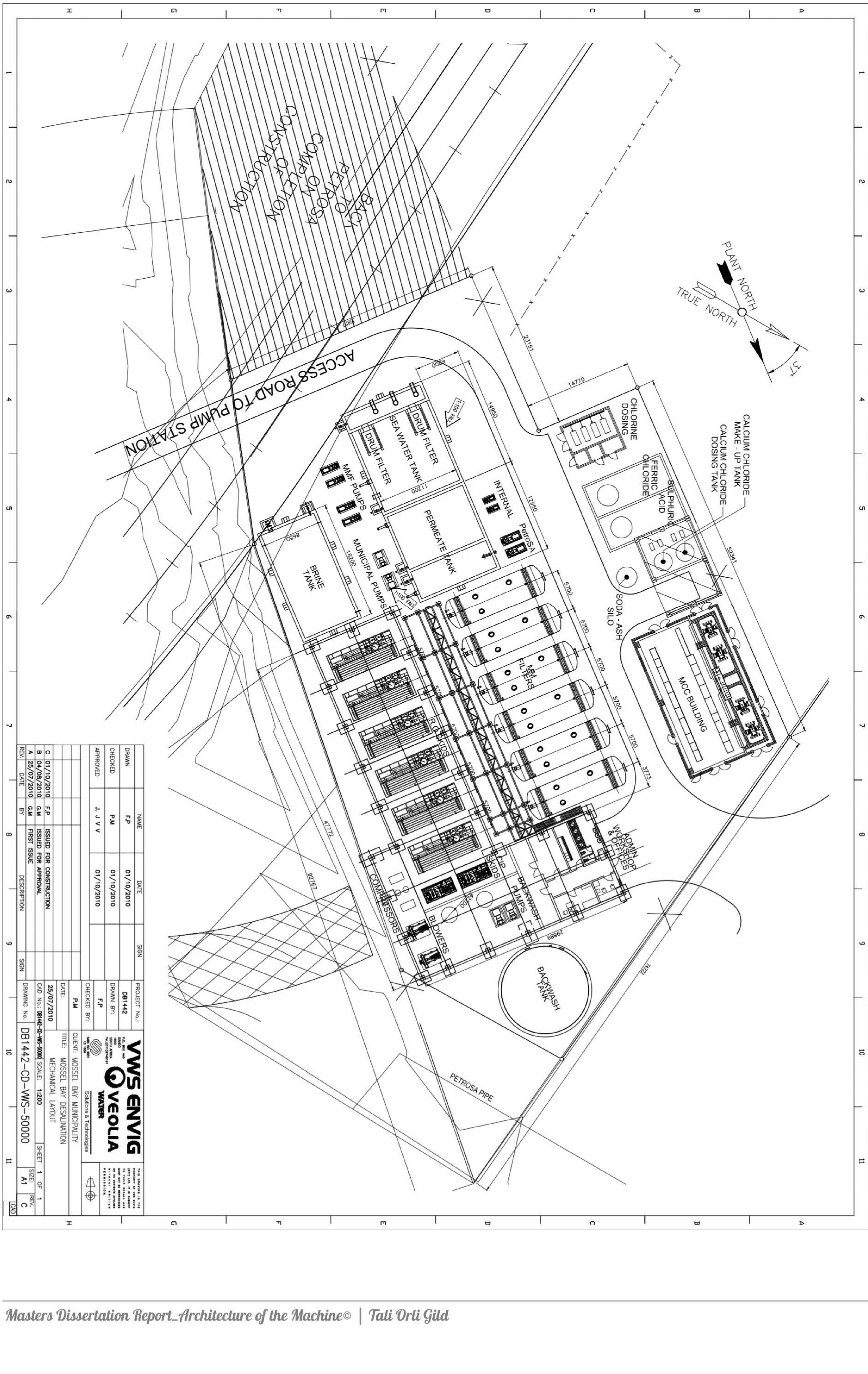


fig. 78 *Pump Station. Plan and Sections 1:250*

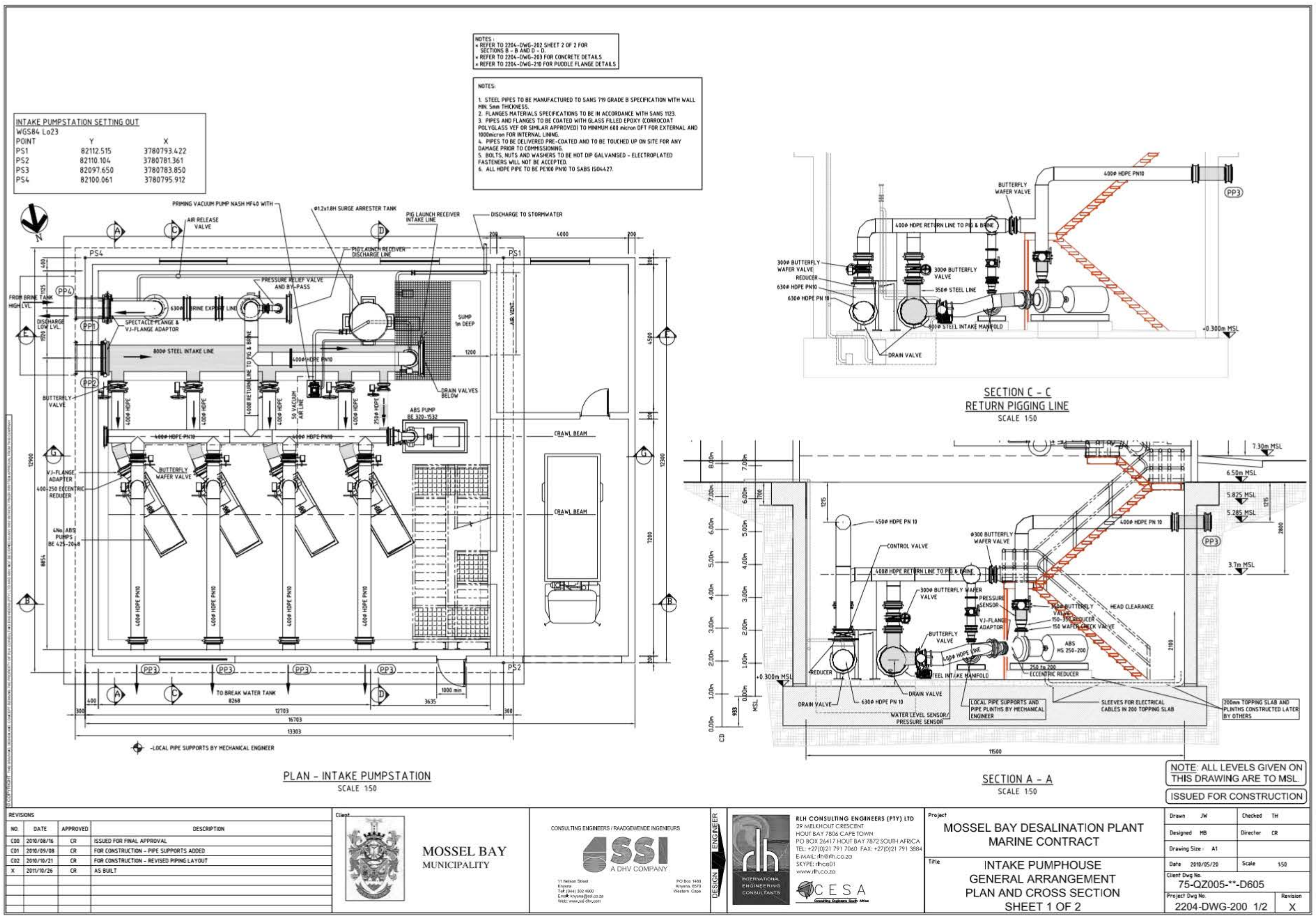
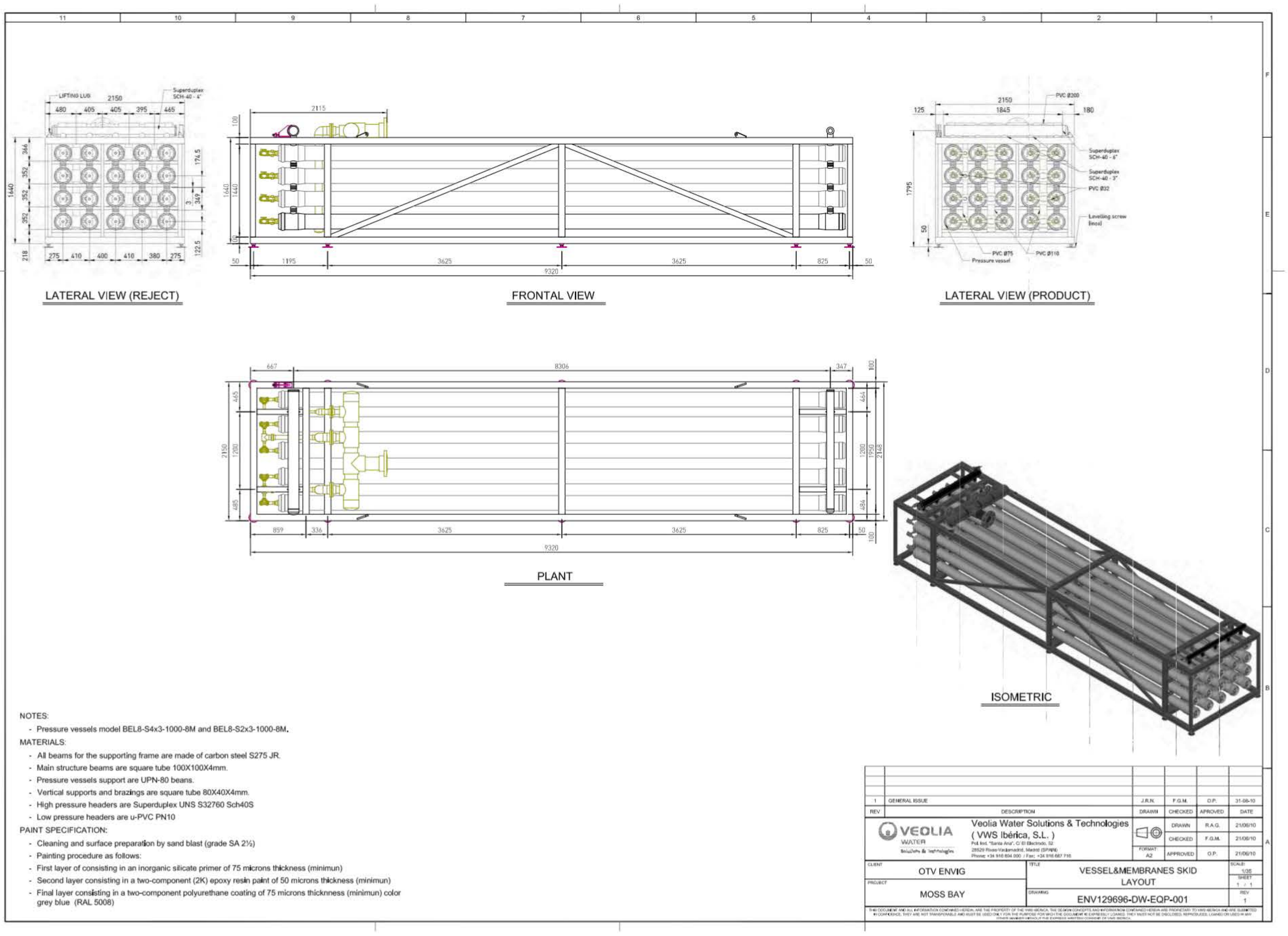


fig. 79 *Veolia Reverse Osmosis Membrane Tube Arrangement. Elevations and Isometric View 1:175*



Wind power consumes **no water**.

Installing 30 000MW of wind power would **save** the amount of **water** used by a city of 300 000 people.

Wind power has considerable job creation potential in South Africa, with the potential that a 30 000MW industry would create upwards of **40 000 quality jobs**.

Wind power also **saves money** by **displacing** more **expensive electricity** sources from the grid.

Wind power will save money in terms of carbon penalties we would have to pay as a nation. From 2012, there will be an array of penalties and taxes that will come into play with regards a nation's carbon output. If South Africa installs 30 000MW of wind power by 2025, this will **save** us from **emitting 70 million tons per annum of carbon dioxide.**

Wind power is a distributed power source – in other words it tends to be most effective if you have wind farms dotted all over a very wide area – **the wider the better**. (Cambray, 2010)

These points are the most important findings that I extracted from his article.

In context of Western Cape:

There are even more immediate plans for Wind Farms along the Garden Route of the Western Cape. The Council for Scientific and Industrial Research has completed an environmental- impact assessment, which evaluated the impact of putting up 70 wind turbines along the Garden Route.

InnoWind is proposing to install four commercial wind energy facilities near the towns of Swellendam, Heidelberg, Albertinia and Mossel Bay.

The project would consist of about 70 x 3MW turbines. The plan is to spread them out, ten turbines near Swellendam, another ten near Heidelberg, six near Albertinia and 44 near Mossel Bay. The combined generation capacity would be about 210 MW. These turbines have a hub height of about 60 m to 100 m and a blade diameter of between 70 m and 112 m. The distance from the ground to the top of the blade will be between 95 m and 156 m.

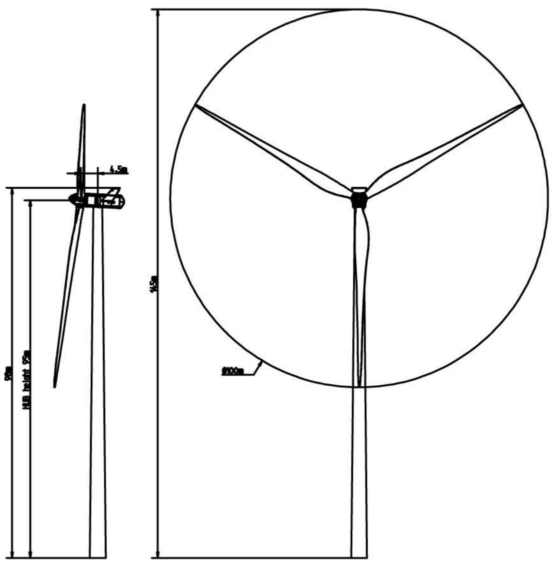


fig. 86 *Typical size of large commercial Wind Turbines 1: 2000*

The area of the grounds of the desalination plant, including the pump station is ± **5335m²** and this plant at full capacity, produces **15 000m³ water/day**, and runs at 4.48 kWh/m³ or 15000 x 4.48 = **67200 kWh/day**, which equates to 50% of plant production cost.

Wind turbines are typically spaced 2 to 3XD apart if behind each other and 5 to 7XD if they are running parallel to each other. (Eskom, 2007)

D = diameter of rotor blade.

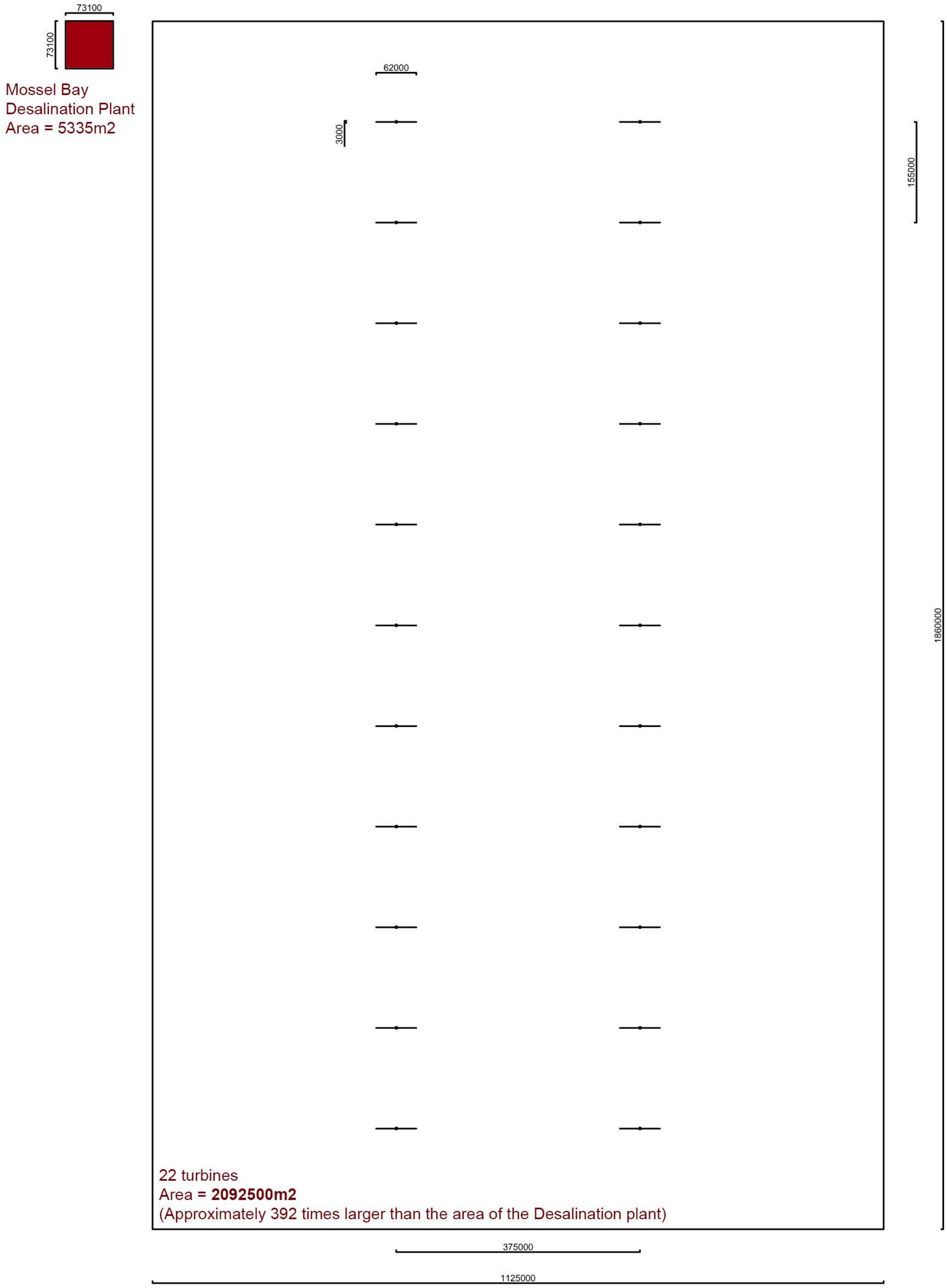


fig. 87 *Theoretical Spatial implications of 22 Wind Turbines that could power the Mossel Bay Desalination plant Scale 1: 10 000*