Fukushima Exclusion Zone Survival Handbook

by

Mengqiao Zhao

MSE Nuclear Engineering and Radiological Sciences
University of Michigan, 2016

SUBMITTED TO THE DEPARTMENT OF ARCHITECTURE
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARCHITECTURE
AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

FEBRUARY 2022

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ABSTRACT

Ten years have passed since the 2011 Fukushima nuclear accident in Japan, but its devastating impact has not subsided and may never end, given the radioactivity from the long-term decay period. As one of the most serious nuclear accidents in human history, this is a disaster not only for Japan but for the whole world. Radioactivity has no boundaries, whether for countries or species: both humans and nonhumans are impacted.

Challenging traditional problem-solving methods that focus on overcoming, solving, remediating and isolating, this thesis proposes an unconventional method of coexisting with radiation in a survival handbook. “The Survival Handbook of the Fukushima Exclusion Zone” is a fiction and an imaginative guide that describes how to coexist in a future radioactive world. It is designed for humans -- residents and visitors returning to the site--and nonhumans--flora and fauna and nuclear waste itself. Based on an investigation of both traditional and promising new materials, this book offers schemes for imagining the future in this radioactive world. Organized around future daily life in the Fukushima Exclusion Zone, this project investigates whether different forms of life can live in a radioactive world and how we might do so. At the scale of atoms, bodies, buildings, and landscapes, the timeframe of the design proposed in this thesis ranges from an almost negligible nuclear reaction time to the whole nuclear waste decay period, lasting more than 10,000 years.

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Fukushima Exclusion Zone Survival Handbook

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Mengqiao Zhao

Advisor: Ana Miljački
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THANK YOU

My Thesis Advisor:
Ana Miljački

My Thesis Readers:
Gediminas Urbonas
Rania Ghosn

My Specialists in Nuclear Engineering:
Hua Zhao
Yang Li

My Technical Instructors:
Christopher Dewart
Graham Yeager

My Family:
Mom, Dad and my Husband

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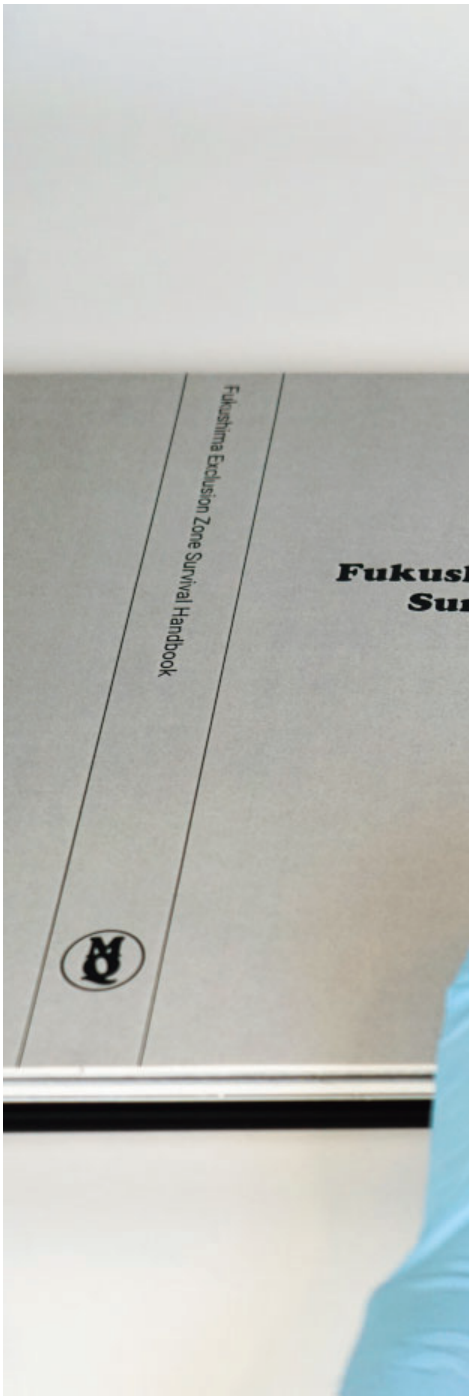


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Mengqiao Zhao
Building Rubble
Wood
Water
Tyvek
Ceramics
Lead
Fungi
Concrete

Chapter One Introduction

1.1 History
1.2 Fukushima Exclusion Zone
1.3 Nuclear Waste
1.4 Land Animals
1.5 Marine Life
1.6 Humans and Global

History

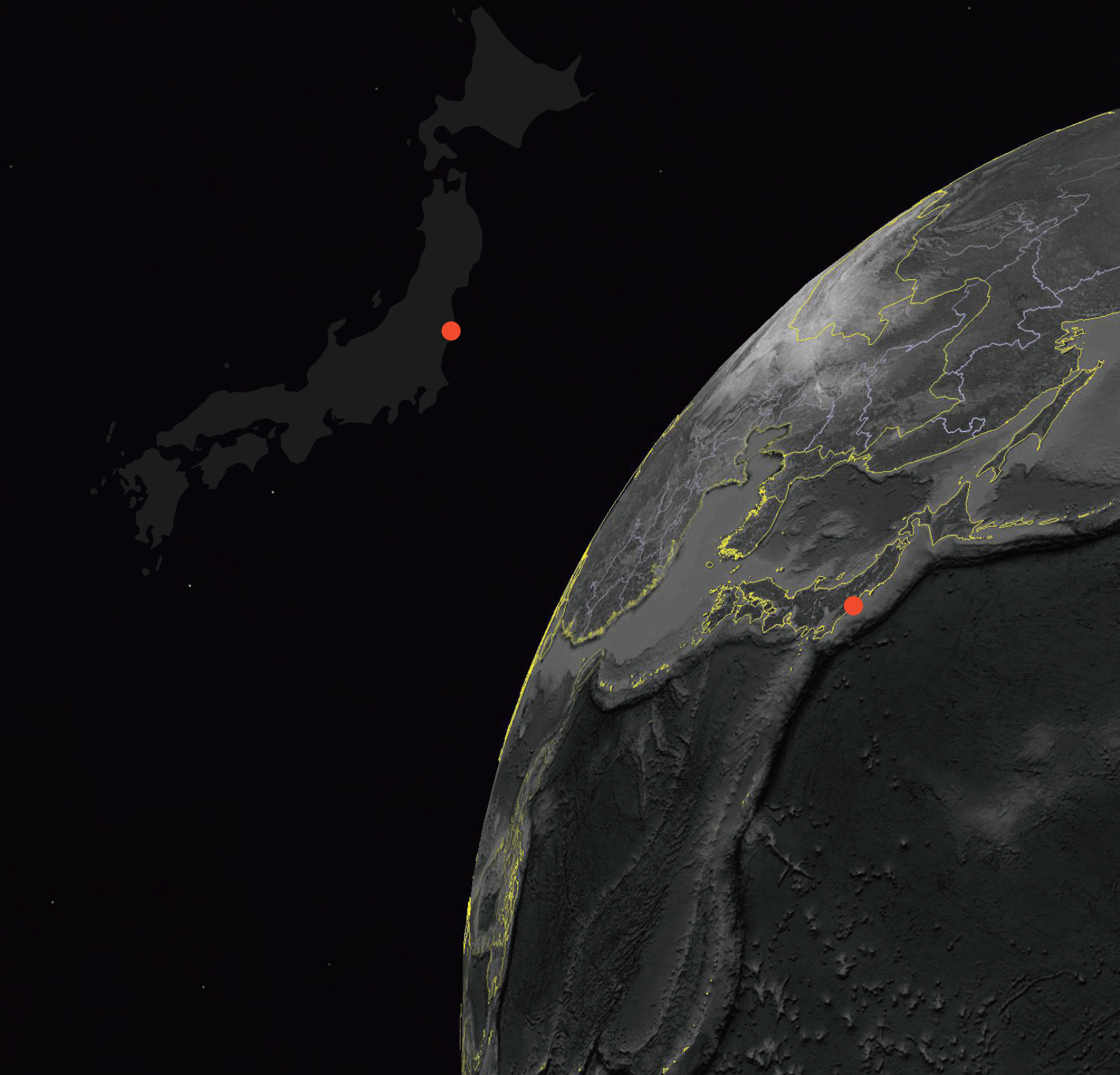
Nuclear energy has not only opened the door to new energy sources and ended wars, but has also introduced a by-product, radioactivity. This term, which was coined by Marie Curie, represents the research direction of her whole life, and the cause of her death. Thus nuclear energy must be understood as both powerful and destructive.

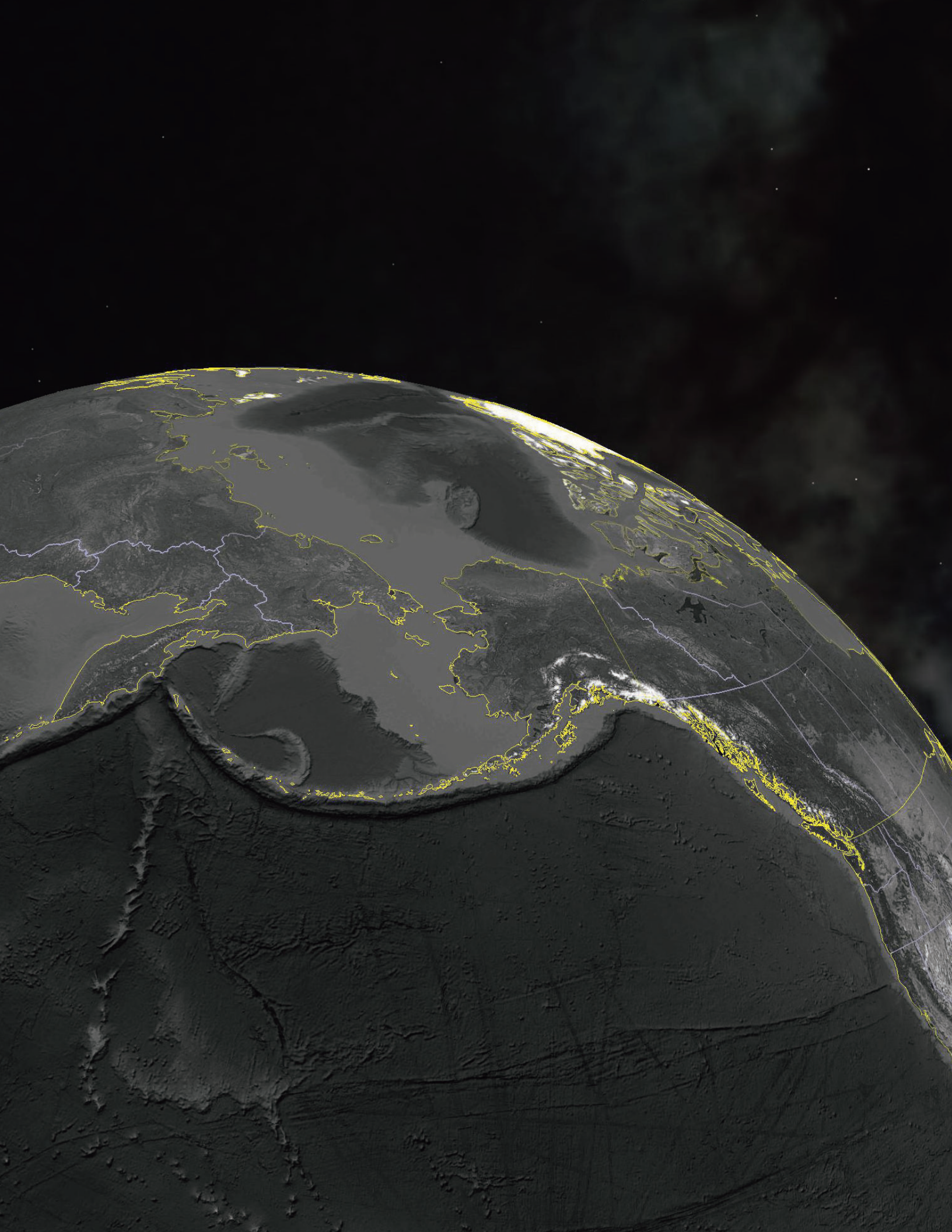
Nuclear reactors have produced both controllable and uncontrollable nuclear reactions. Initiated in 1942, the first nuclear reactor in human history, Chicago Pile-1, was designed to be controllable on the basis of its technology. The first successful test explosion of a nuclear bomb, Trinity, produced uncontrollable nuclear reactions, launching the Atomic Age in 1945. Three years earlier, two atomic bombs, were designed by what's known as the Manhattan Project. The first use of nuclear technology in warfare, the Little Boy and Fat Man bombs were dropped on Hiroshima and Nagasaki in 1945, leading to Japan's surrender and the end of World War II. Yet, these nuclear weapons also caused the deaths of more than 100,000 people, the destruction of cities, and long-term radiation impacts on the environment.

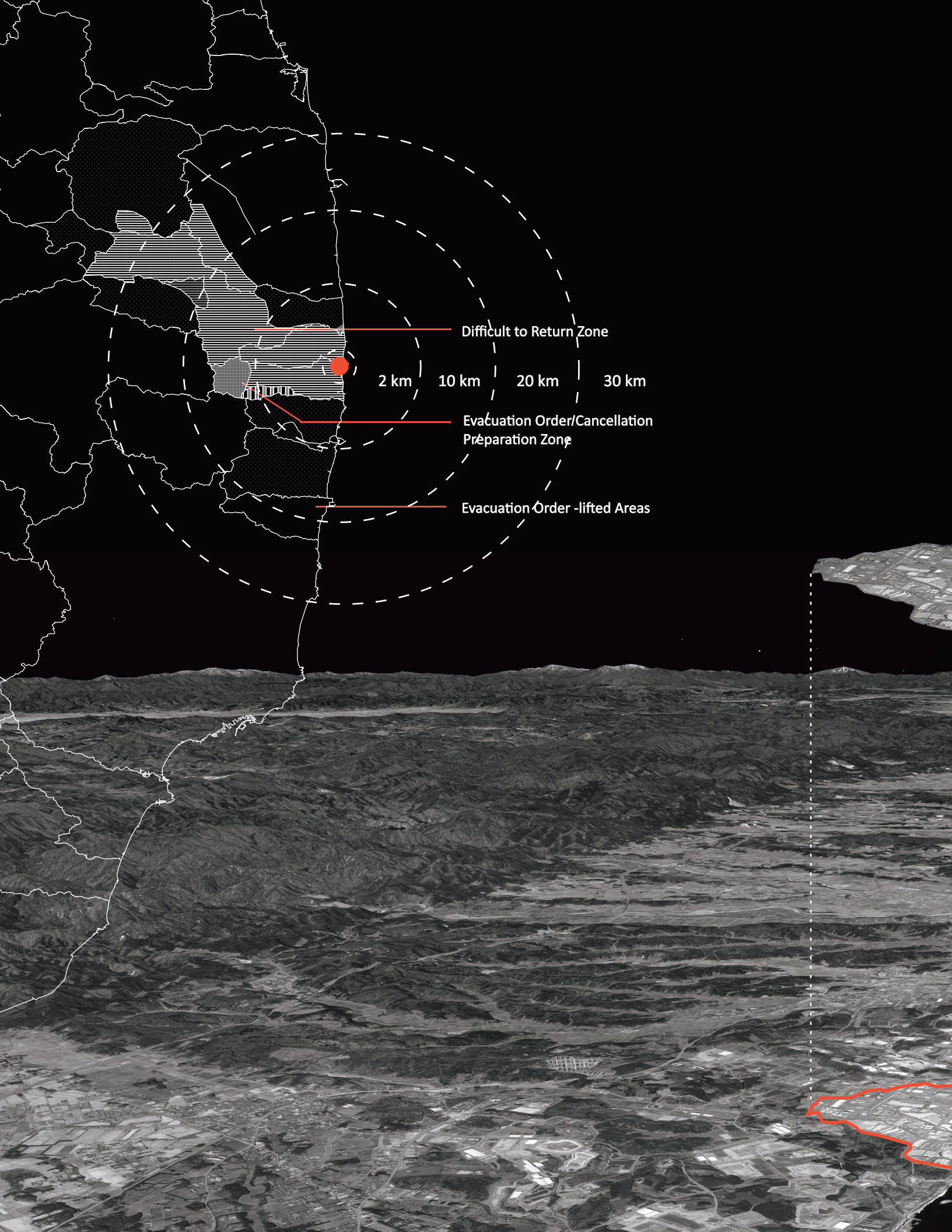
As a metaphor for nuclear destruction, the film "Godzilla" was produced in Japan in 1954, featuring a fictional monster that expressed people's terror and panic during that post-war period. Decades later, Godzilla was reborn in 2011 in response to the bombing of the Fukushima Daiichi Nuclear Power Plant, where the peaceful use of nuclear energy caused an even greater impact than atomic weapons. This was one of the worst nuclear accidents in human history, for this radiation, which has no boundaries, impacted both the land and sea, its species -- both human and nonhuman -- and its environments, lasting more than ten thousand years due to its long decay time.

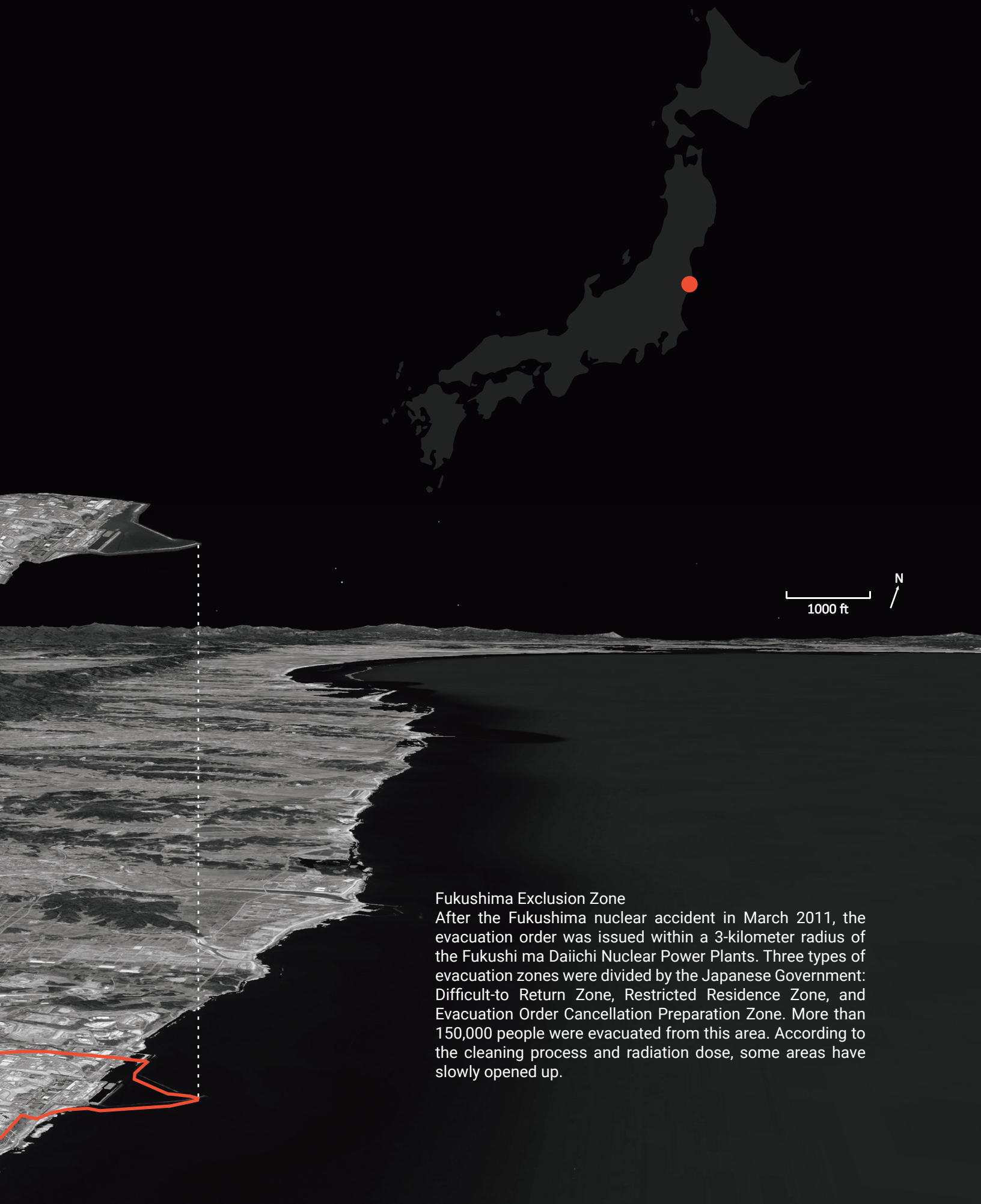
This survival handbook of the Fukushima Exclusion Zone is a guide for how to coexist with the reborn Godzilla: the radiation created by ourselves in Fukushima. It is a book for humans (residents and visitors) returning to the site and for nonhumans (flora and fauna, and nuclear waste).

Peaceful use of nuclear energy may also cause a greater impact than weapon use. The Fukushima nuclear accident is like the rebirth of Godzilla. This accident is not a problem within a country, but a problem for the whole world. Radioactivity has no boundaries, whether for countries or species. Both humans and nonhumans will be affected. Because the decay period of radioactive elements is more than ten thousand years, this impact is long-term.





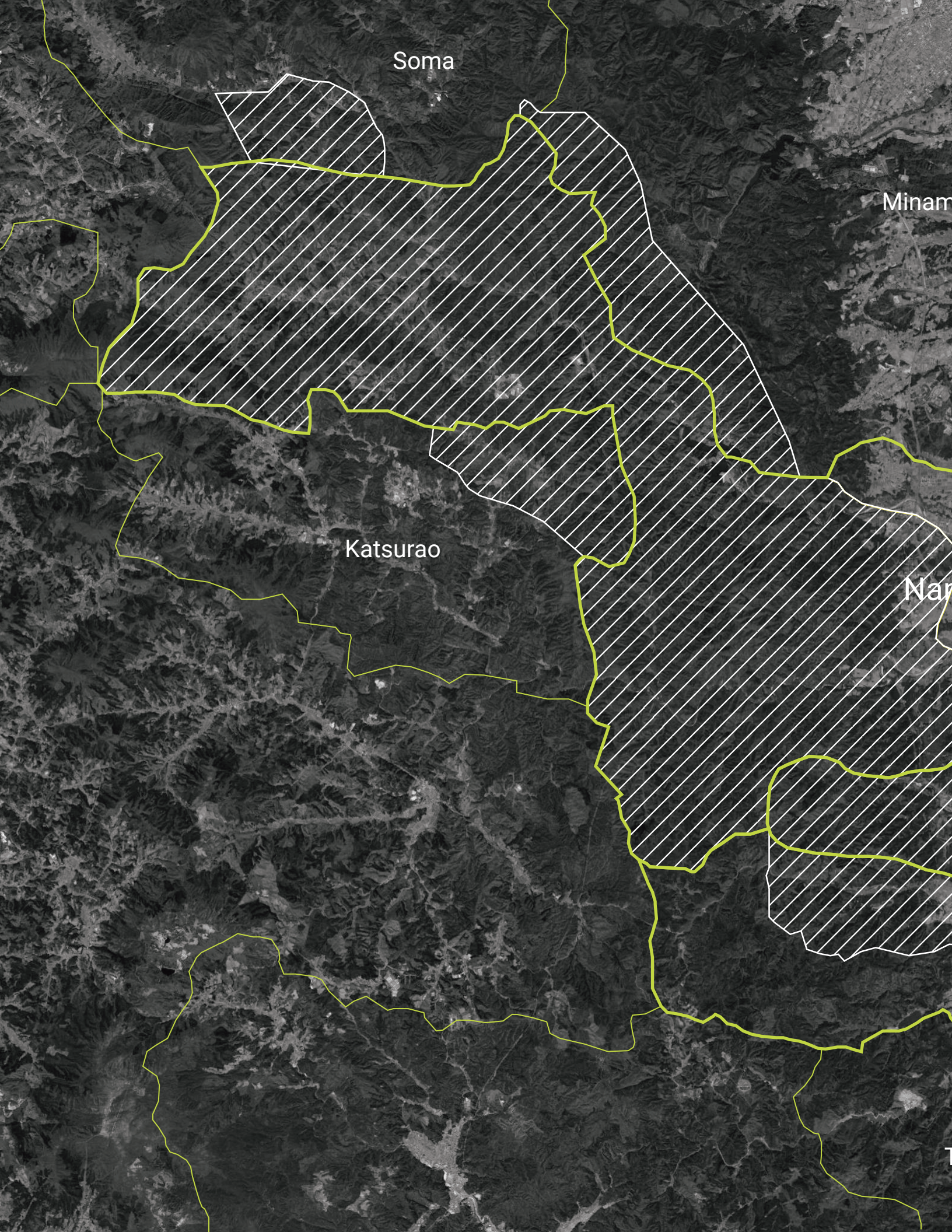

Difficult to Return Zone
2 km
10 km
20 km
30 km
Evacuation Order/Cancellation Preparation Zone
Evacuation Order -lifted Areas



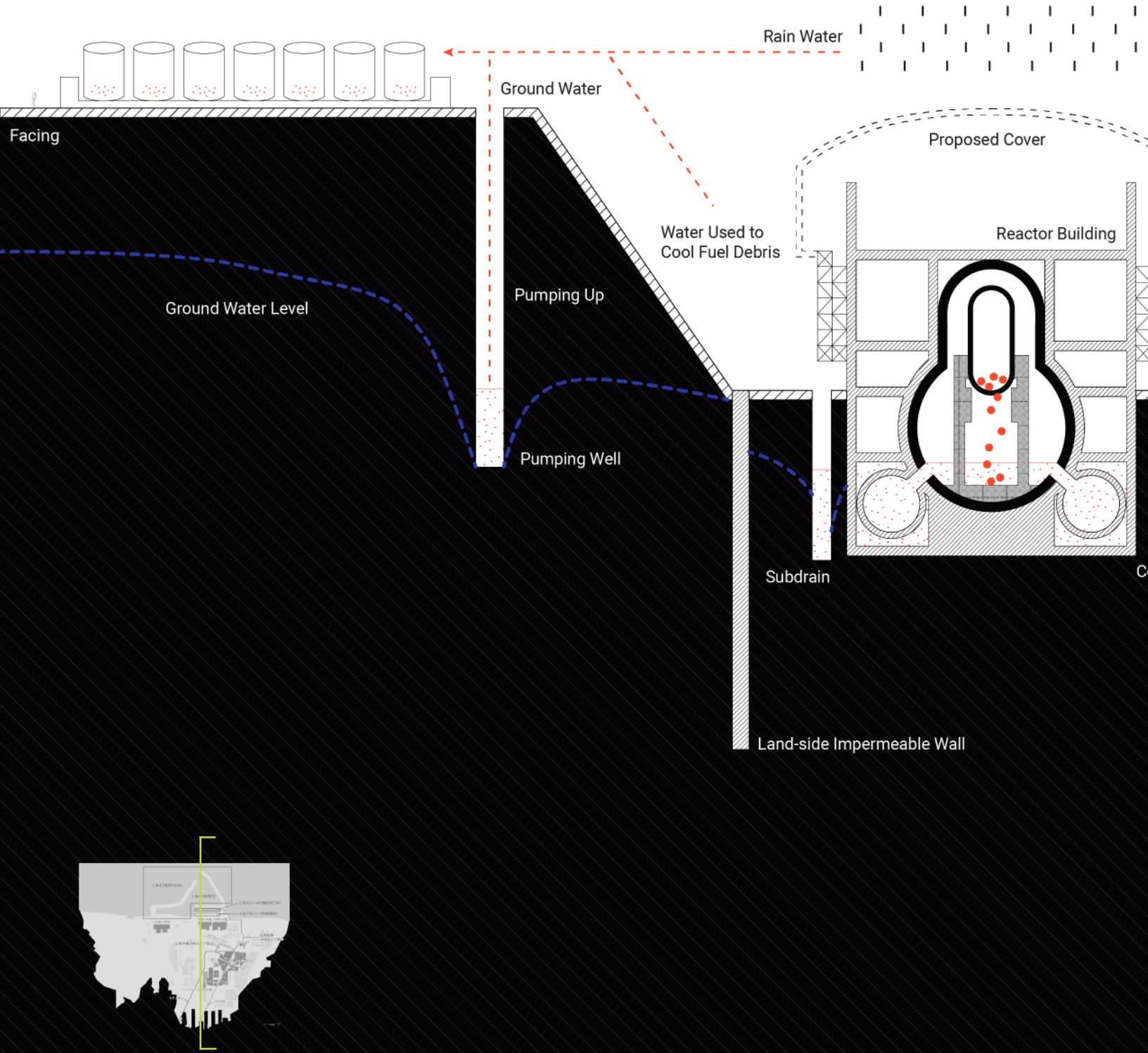
Fukushima Exclusion Zone

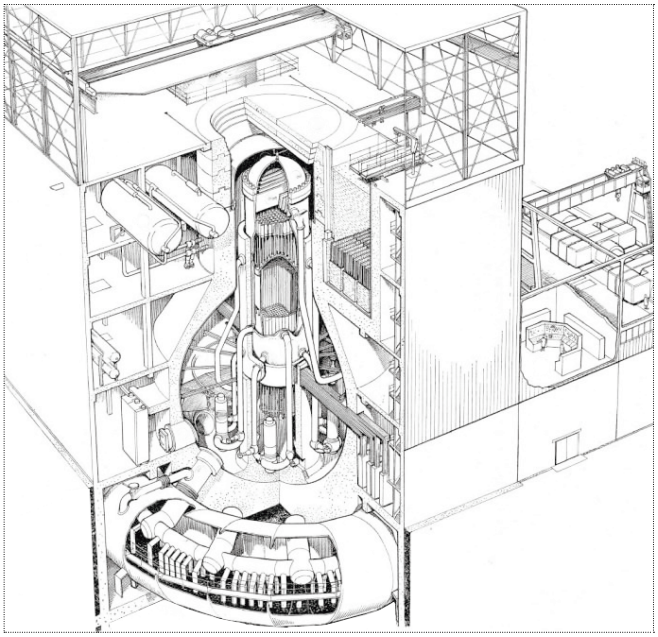
After the Fukushima nuclear accident in March 2011, the evacuation order was issued within a 3-kilometer radius of the Fukushi ma Daiichi Nuclear Power Plants. Three types of evacuation zones were divided by the Japanese Government: Difficult-to Return Zone, Restricted Residence Zone, and Evacuation Order Cancellation Preparation Zone. More than 150,000 people were evacuated from this area. According to the cleaning process and radiation dose, some areas have slowly opened up.

Fukushima Nuclear Power Plant is located at the boundary between Futaba Town and Okuma Town. It used to be the main source of economy and employment for these two towns.

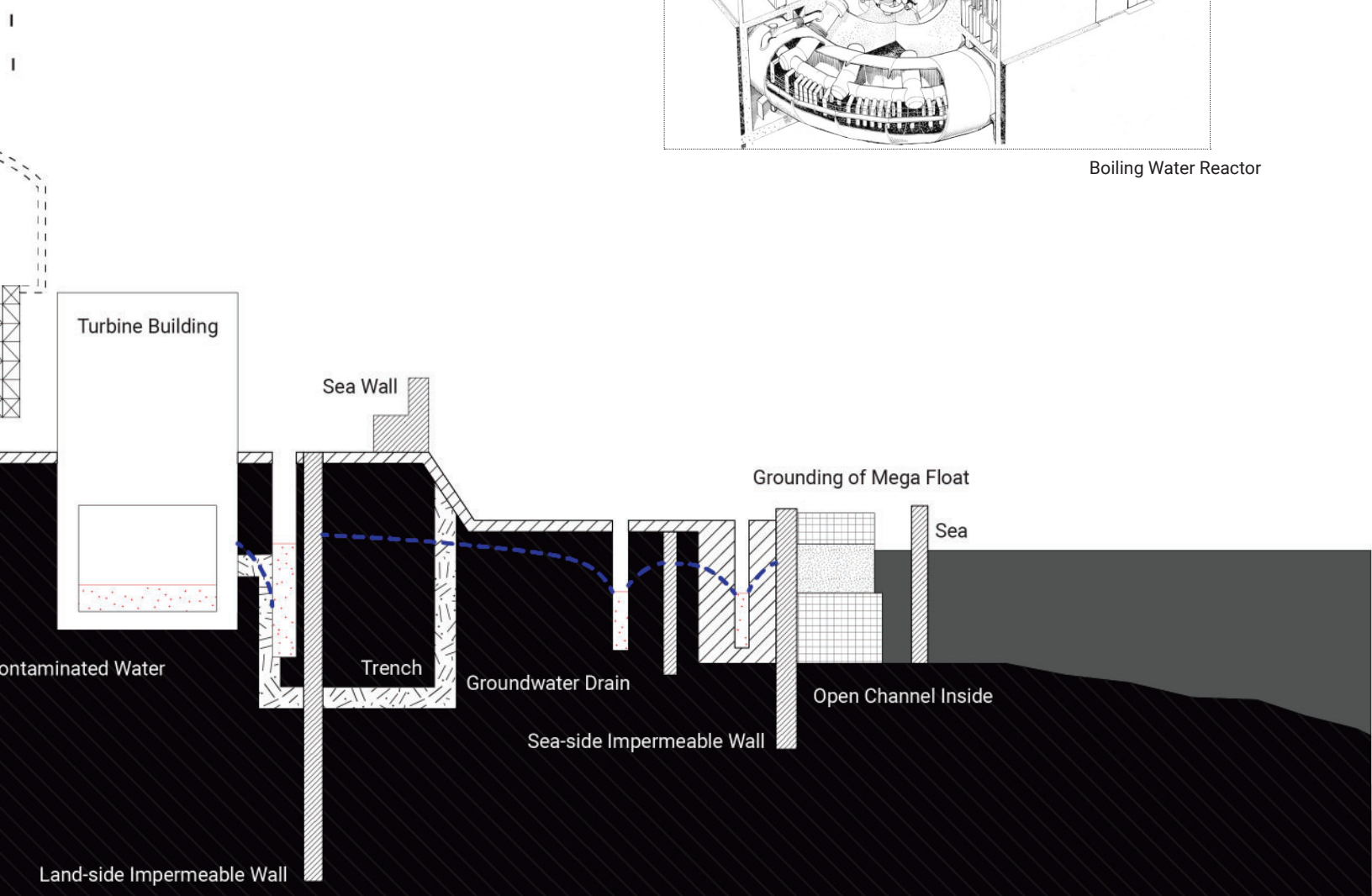

Soma
Minam
Katsurao
Nar

There are seven towns in the Fukushima Exclusion Zone, and three of them have been impacted the most: Futaba, Okuma, and Namie. The average returned population is 30% in all of these areas, but for some towns, such as Namie, is less than 10%, and many of them are the older generation. Futaba is the closest town to the accident, only 4% of the town has been opened, and visitors are allowed to stay there in few hours.

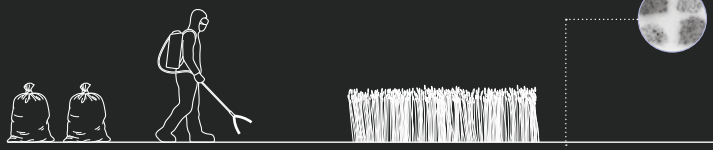

Rain Water
Ground Water
Facing
Proposed Cover
Water Used to
Cool Fuel Debris
Reactor Building
Ground Water Level
Pumping Up
Pumping Well
Subdrain
Land-side Impermeable Wall



Boiling Water Reactor

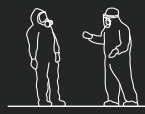


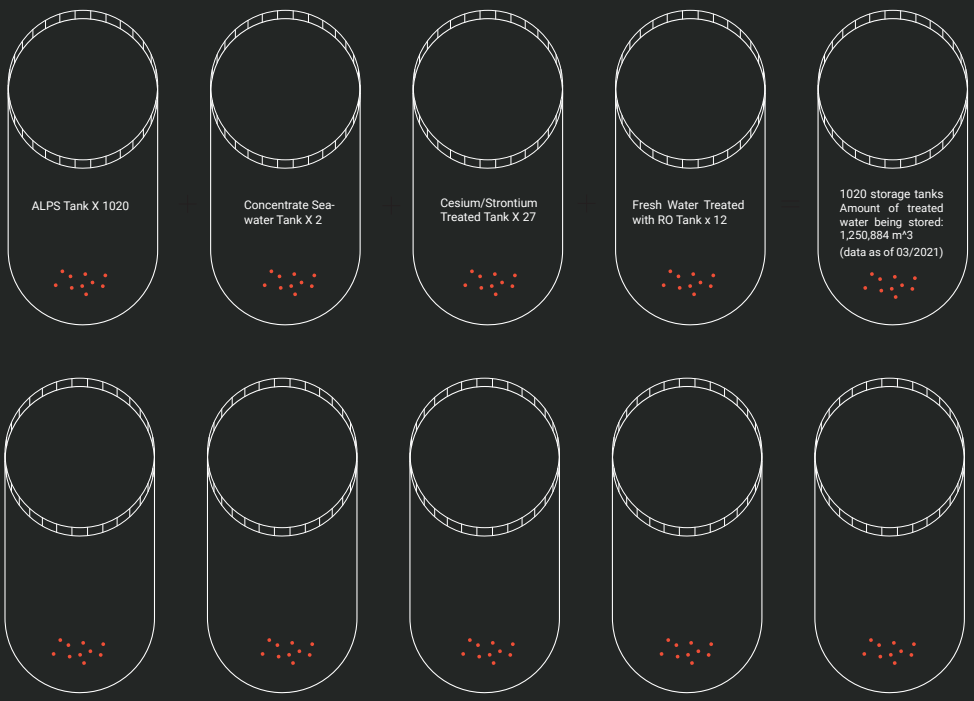
In the accident, after losing the cooling water, the overheated nuclear fuel melted down the reactor, and led to the radiation being exposed to the environment. There are two main forms of contamination from the Fukushima accident: liquid (the waste water)and solid (the waste debris and fallout). In the section of the nuclear power plants, the red lines show how the nuclear waste water continue to be generated on the site, from rain water, the water used to cool nuclear fuel and debris, and the groundwater. Pumping wells and impermeable walls were built to prevent the exposure of the contaminated water to the environment.



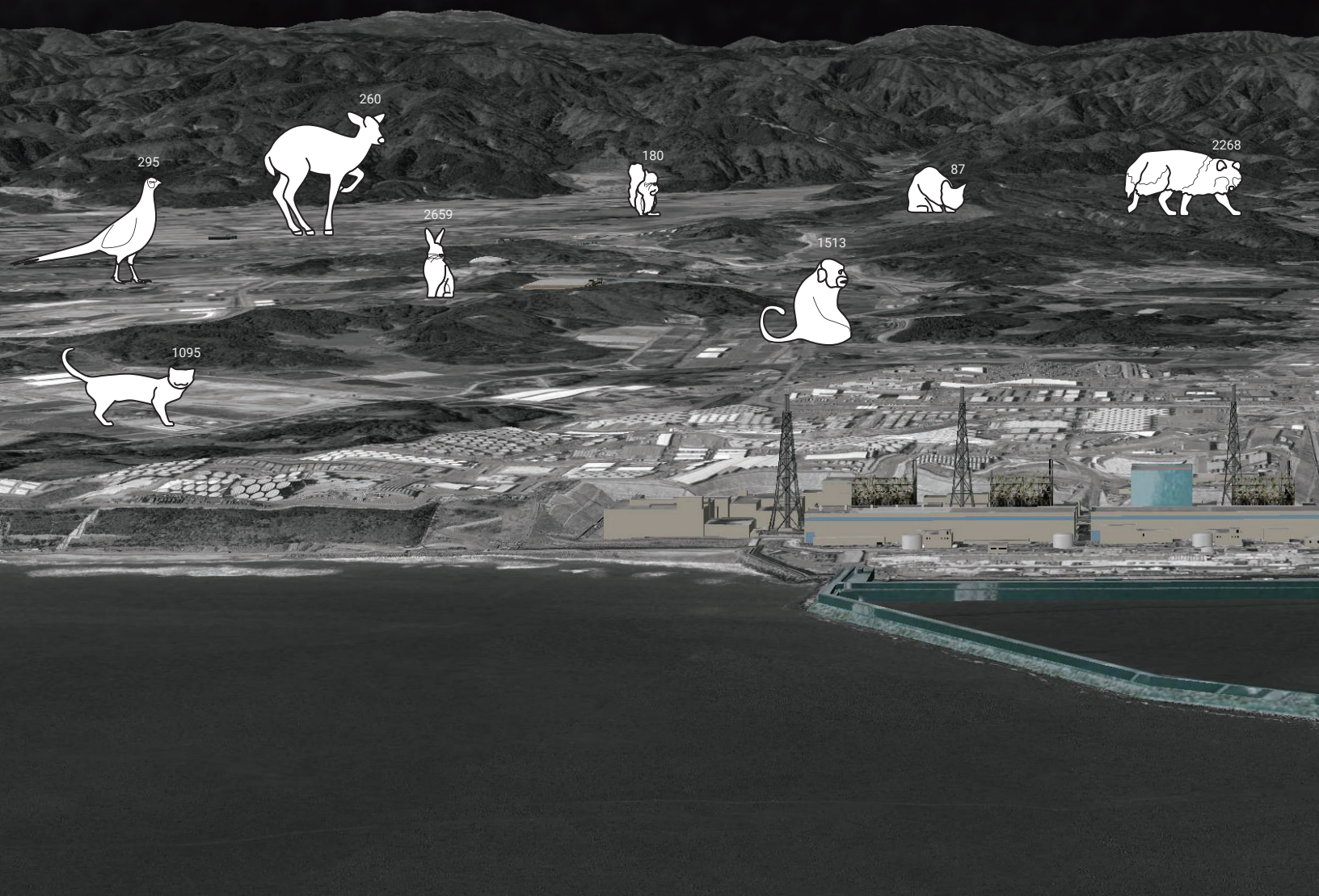
The radioactive solid waste, including soil and debris, are packed into bags in Fukushima exclusion zone.

At the Fukushima Daiichi Nuclear Power Station, the radioactive substances in contaminated water are removed using a multi-nuclide removal equipment (ALPS) and the resulting treated water is stored in tanks on site along with Cesium/Strontium-treated water. There are 1020 tanks on the site, that stored 1 million cubic meter waste water inside. The Japanese government announced that they decided to pour the nuclear waste water into the sea. Although Tokyo electric power company claims that these nuclear waste waters have been treated, there are some radioactive elements can't be removed, such as tritium. In addition, there has not been such a large amount of nuclear waste water dumping in to the sea in the history. Although the radiation will be diluted by the sea, there are many of unknown impacts from ecosystem level.

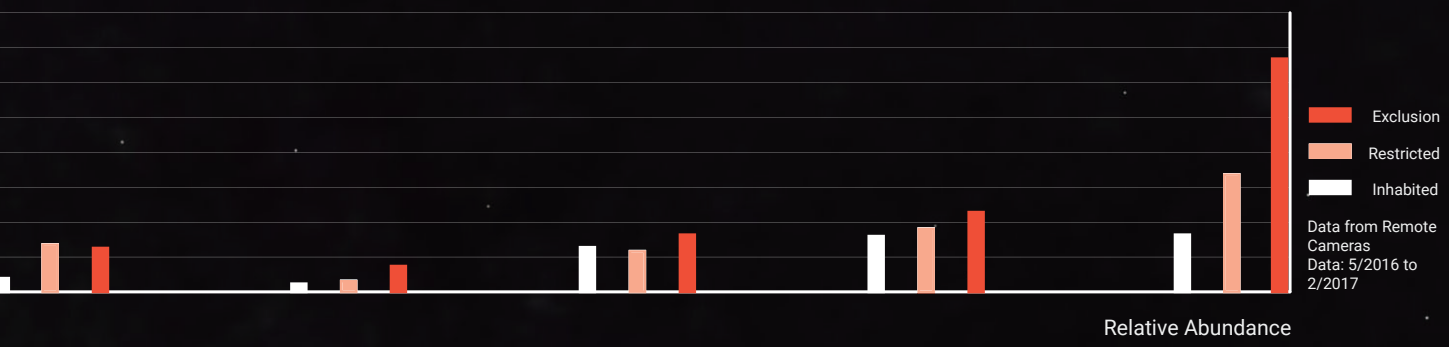


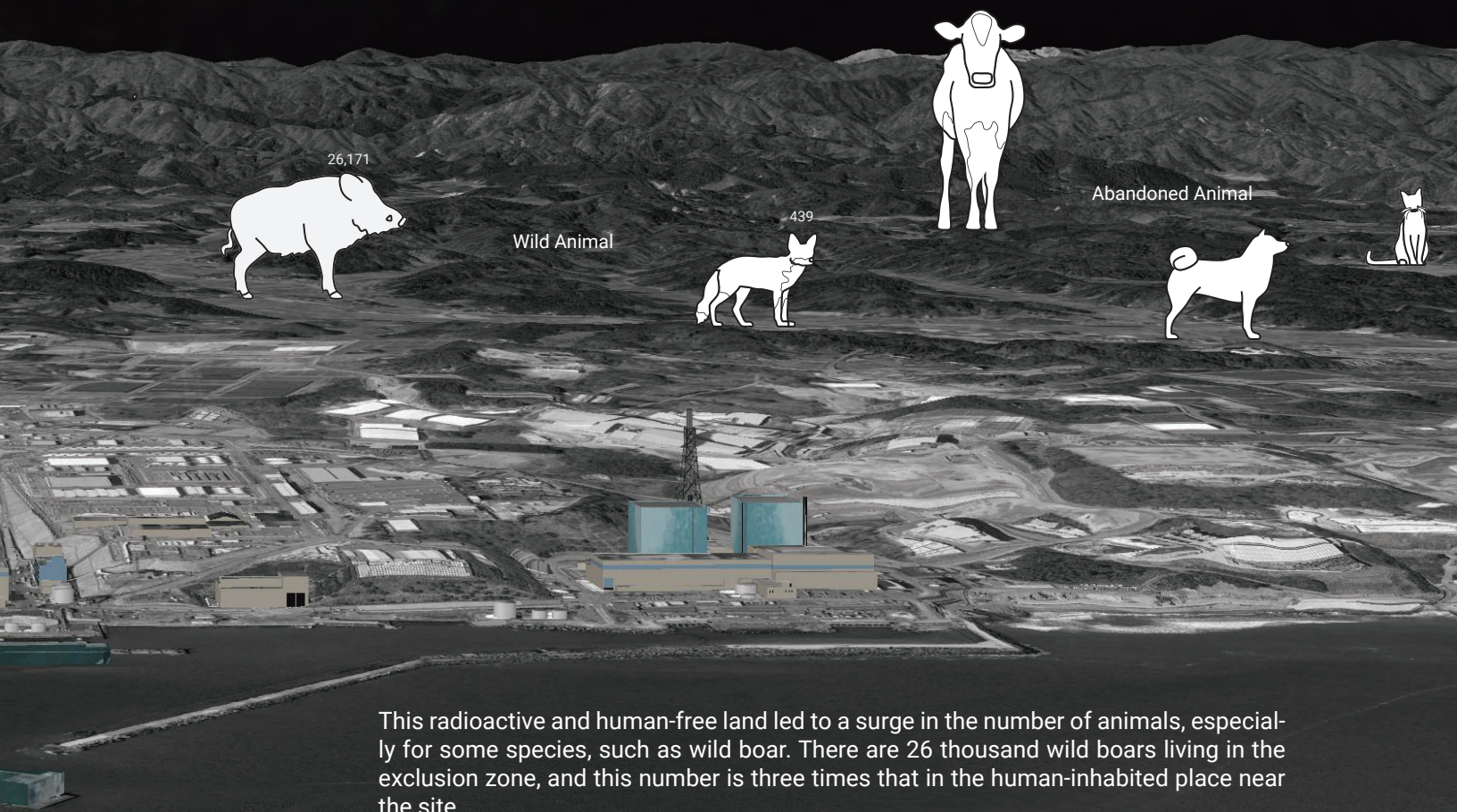


Serow	Raccoon Dog	Fox	Squirrel	Marten
260	2268	439	180	87
213	2117	539	72	95
1402	3981	415	61	39



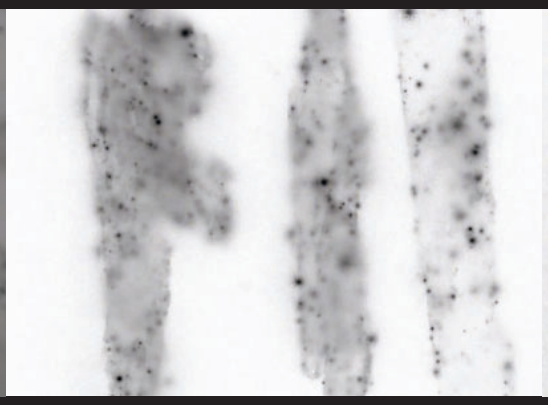
Macaque	Green Pheasant	Civet	Hare	Wild Boar	Wild Animal
1513	295	1095	2659	26,171	
2341	107	797	1796	13,361	
342	24	887	2050	7234	



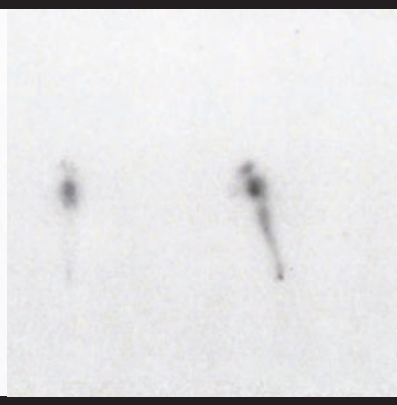


This radioactive and human-free land led to a surge in the number of animals, especially for some species, such as wild boar. There are 26 thousand wild boars living in the exclusion zone, and this number is three times that in the human-inhabited place near the site.

Cedar Leaves



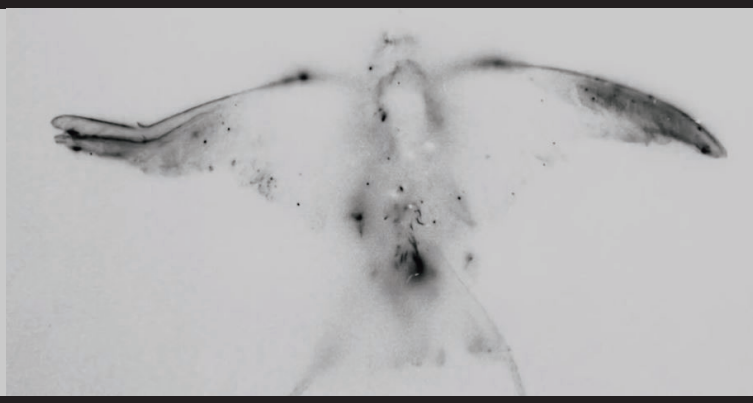
Cedar Bark



Dragon

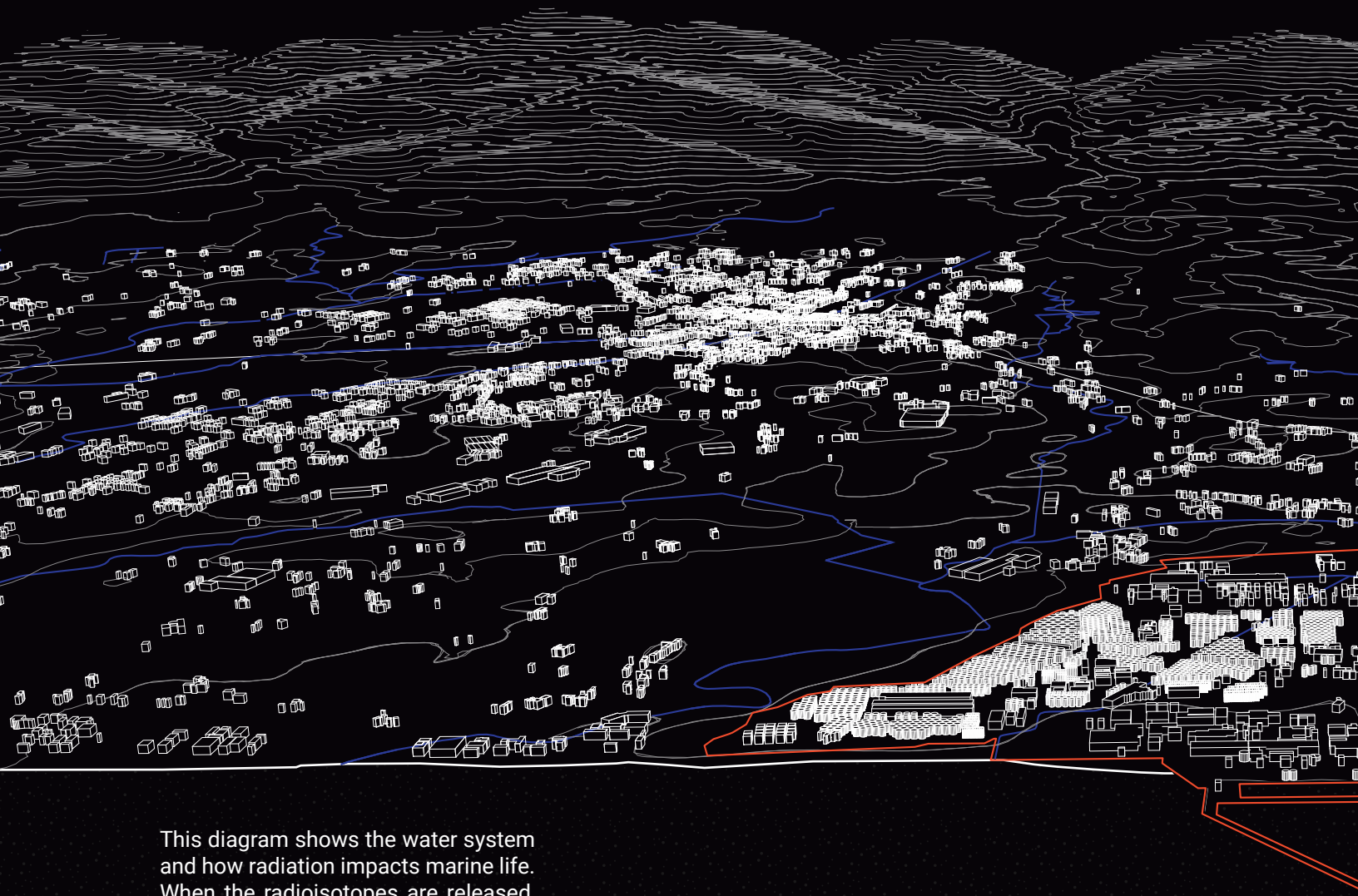
flies

Japanese pit viper

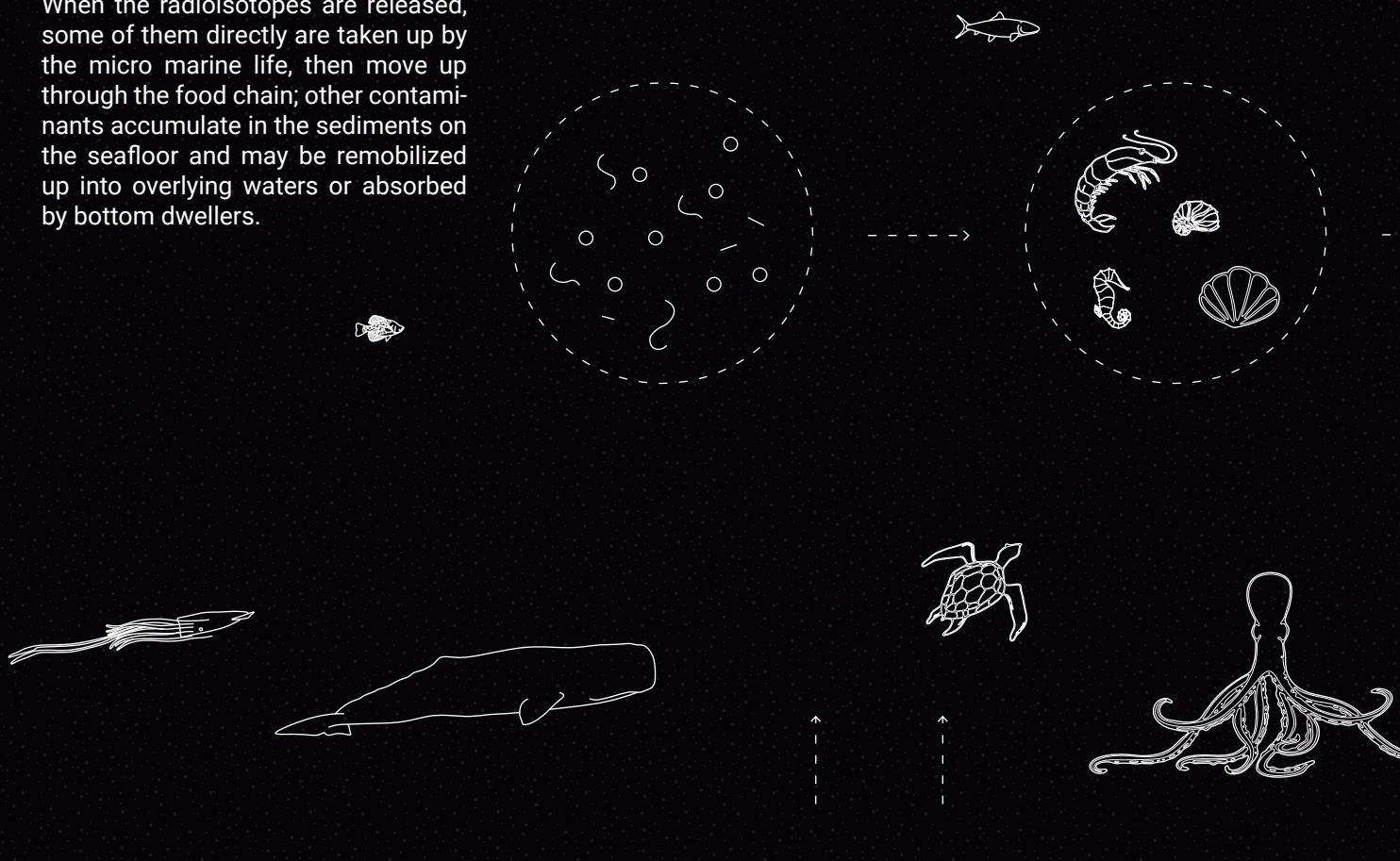


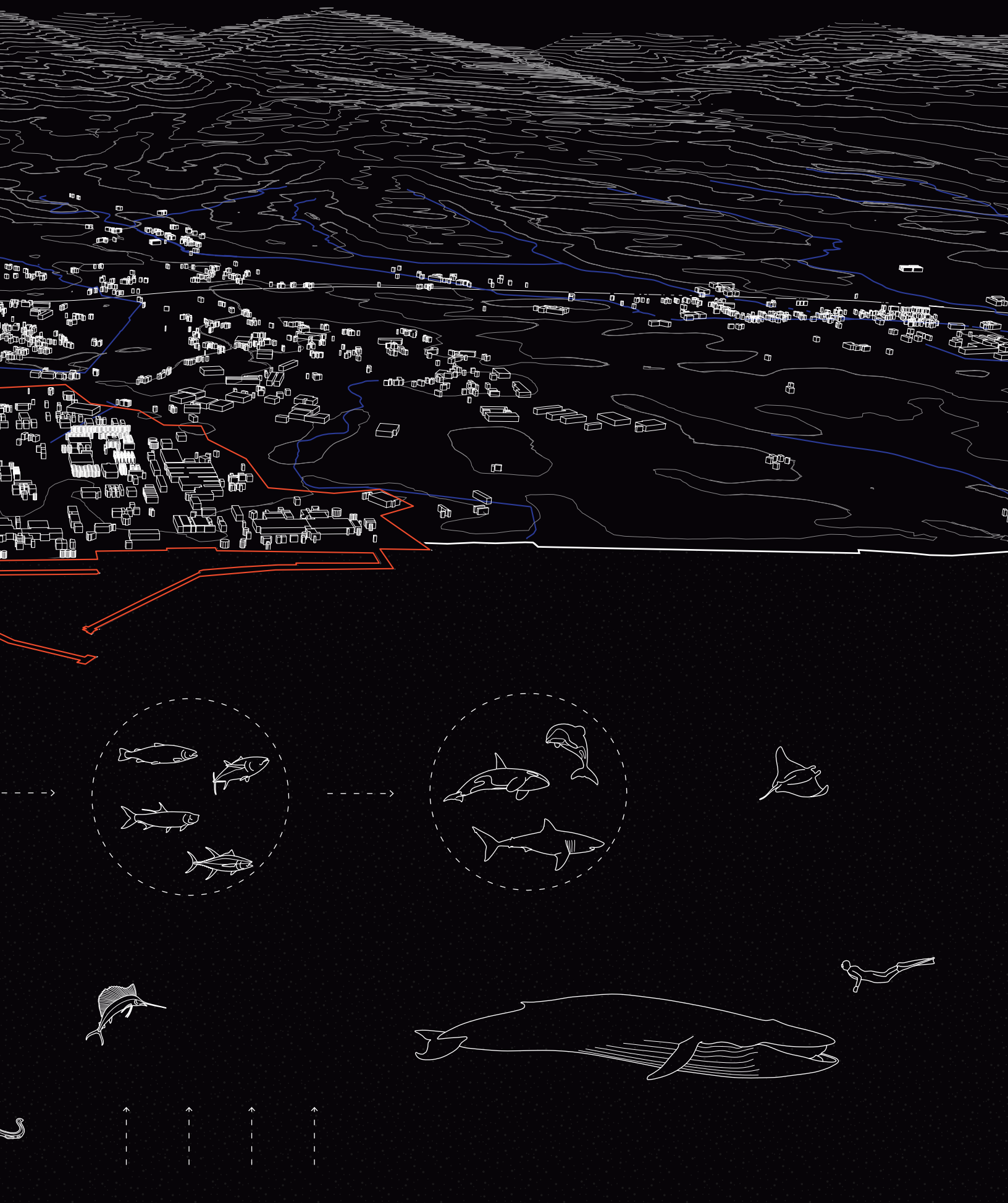
Bird

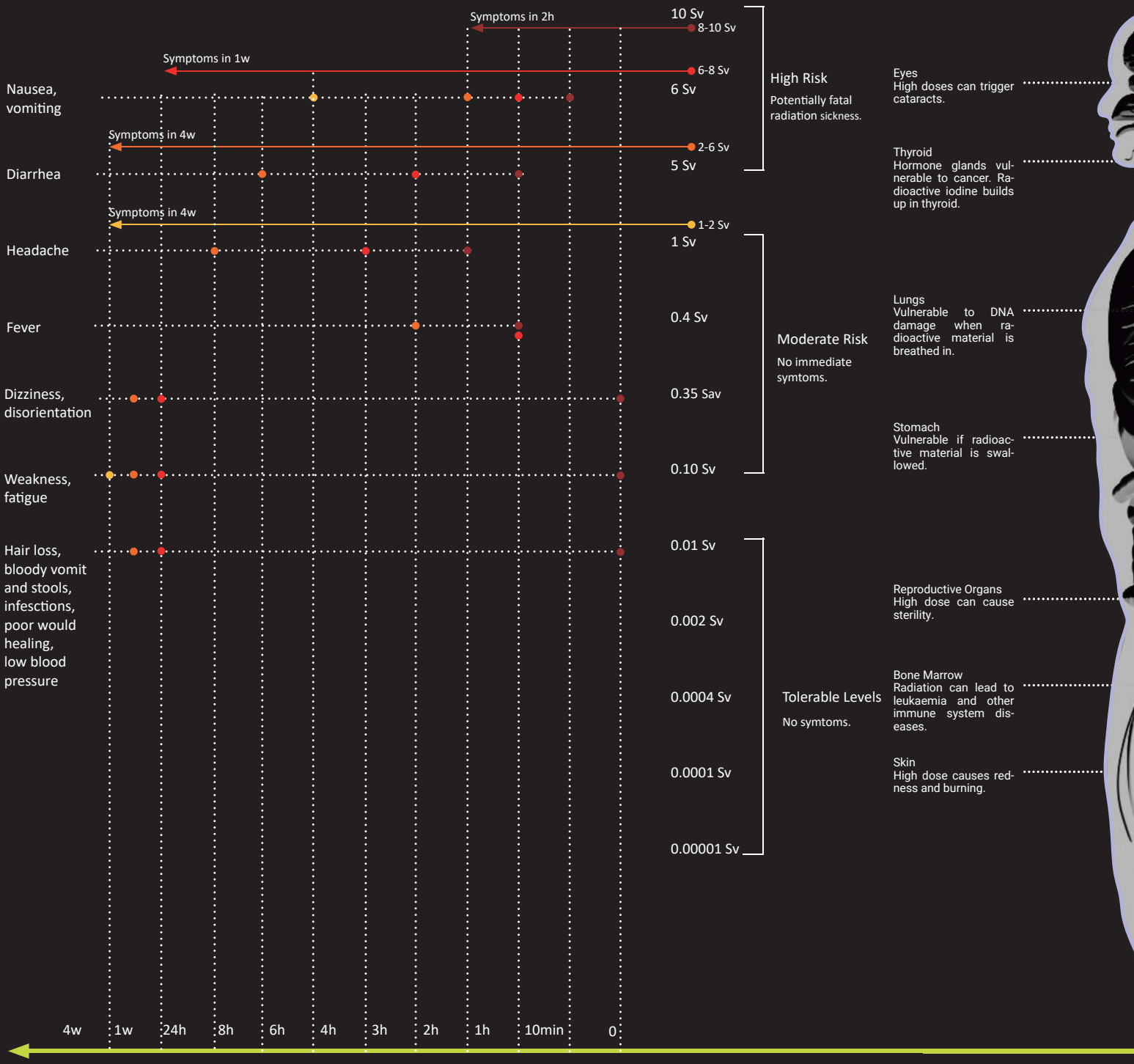
The samples with a special film that reacts to radioactivity shows contamination: the black parts. The radioactive particles that fell in the forest remains on the cedar tree bark and cedar leaves. Shadows and spots appear in the shape of the leaves and the branch, indicating that flora absorbed radioactive matter and mistook it for nutrients. The chemical properties of radioactive element Cesium, are similar to those of the nutrient Potassium, so plants absorb cesium easily. For insects and animals their and body, their bodies also have taken in radioactive mater.
(Photograph: NHK)



This diagram shows the water system and how radiation impacts marine life. When the radioisotopes are released, some of them directly are taken up by the micro marine life, then move up through the food chain; other contaminants accumulate in the sediments on the seafloor and may be remobilized up into overlying waters or absorbed by bottom dwellers.

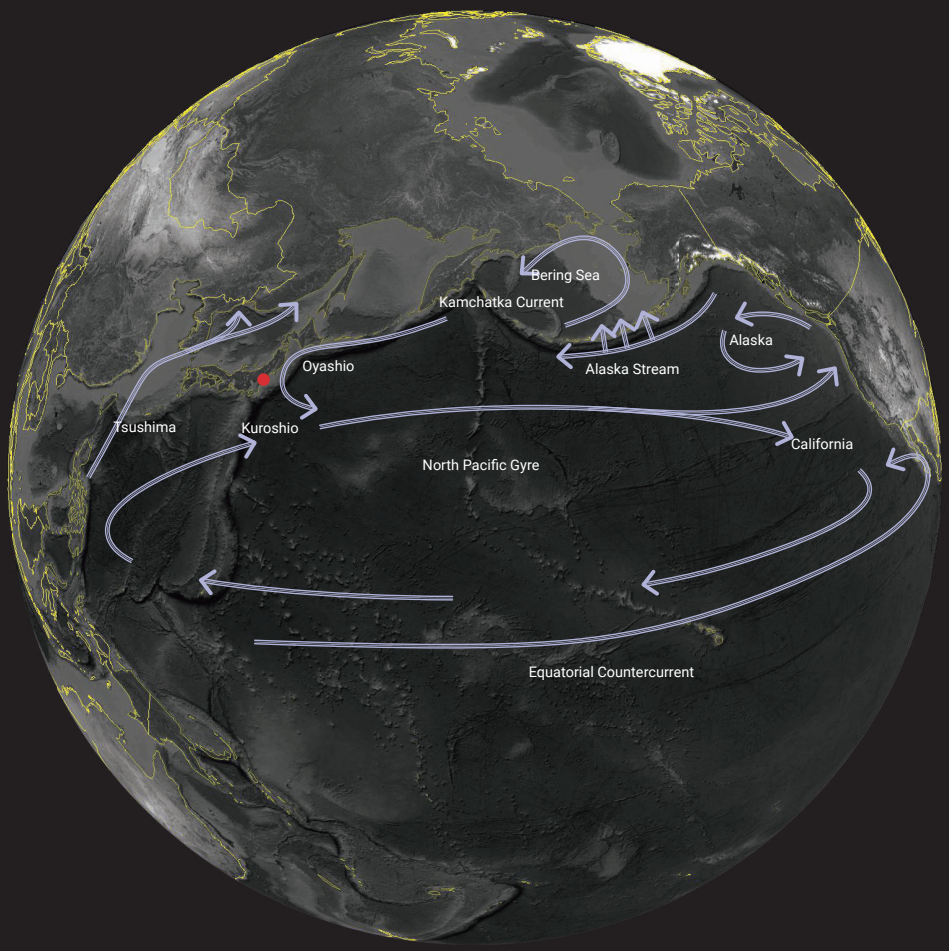




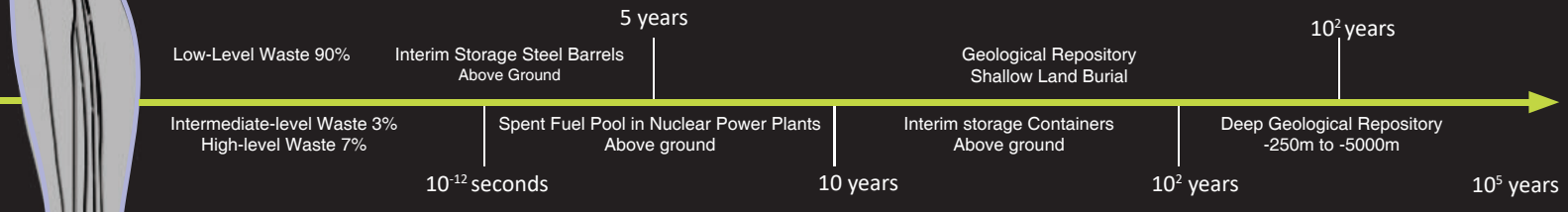


Effects of Radioactive Exposure on the Human Body

Ocean currents will bring the radiation to all the countries around. Finally, everyone will be impacted more or less, sooner or later. For a single human body, some of our organs are especially vulnerable to radiation, such as thyroid and eyes. The left chart describes different symptoms based on the radiation dose and time. The right bottom timeline shows the nuclear waste repository process which takes more than 10,000 years. Therefore, after ten years, the Fukushima Nuclear Accident is not over, and it won't end.



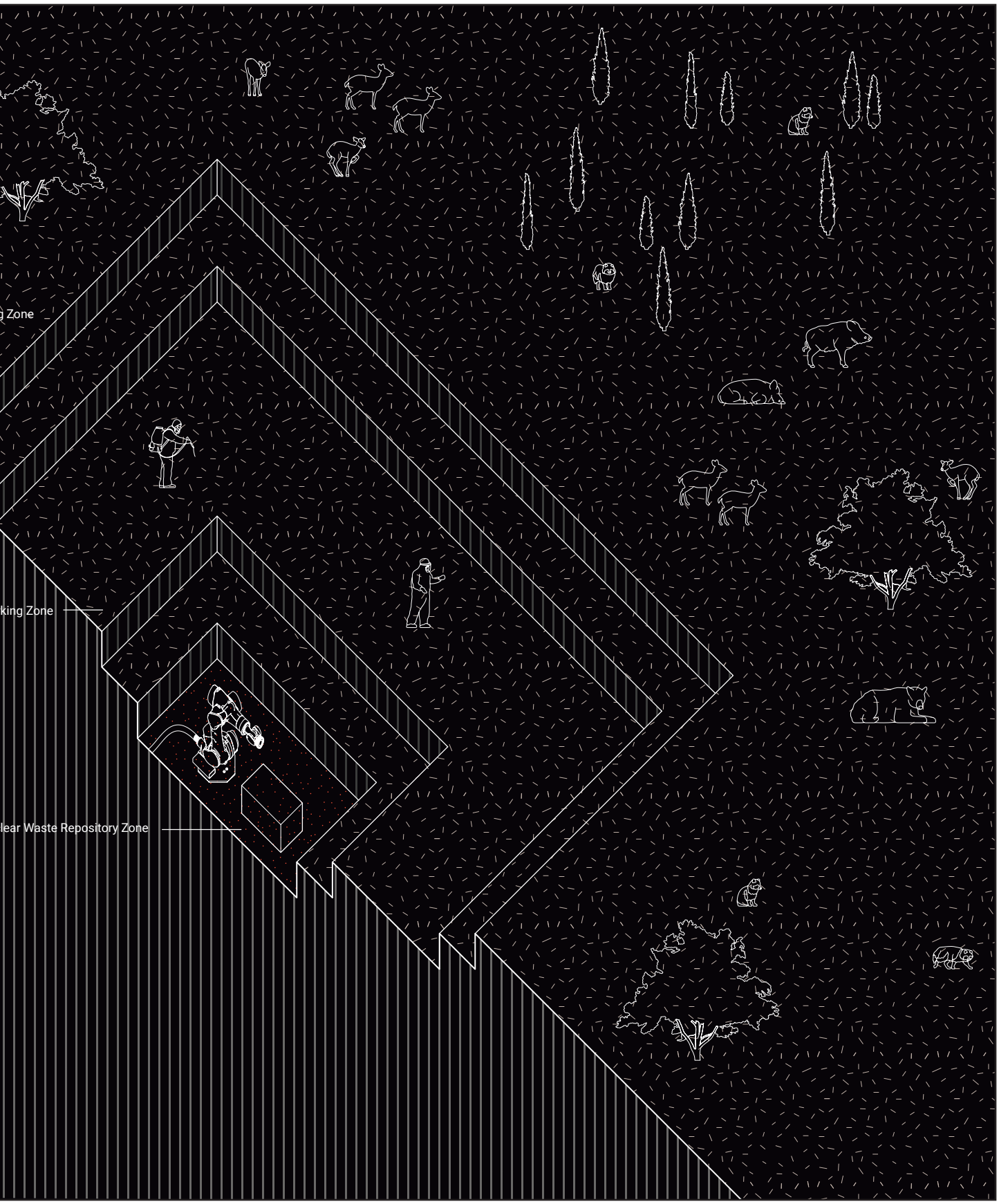
Radiation from Fukushima Travels through Ocean Currents



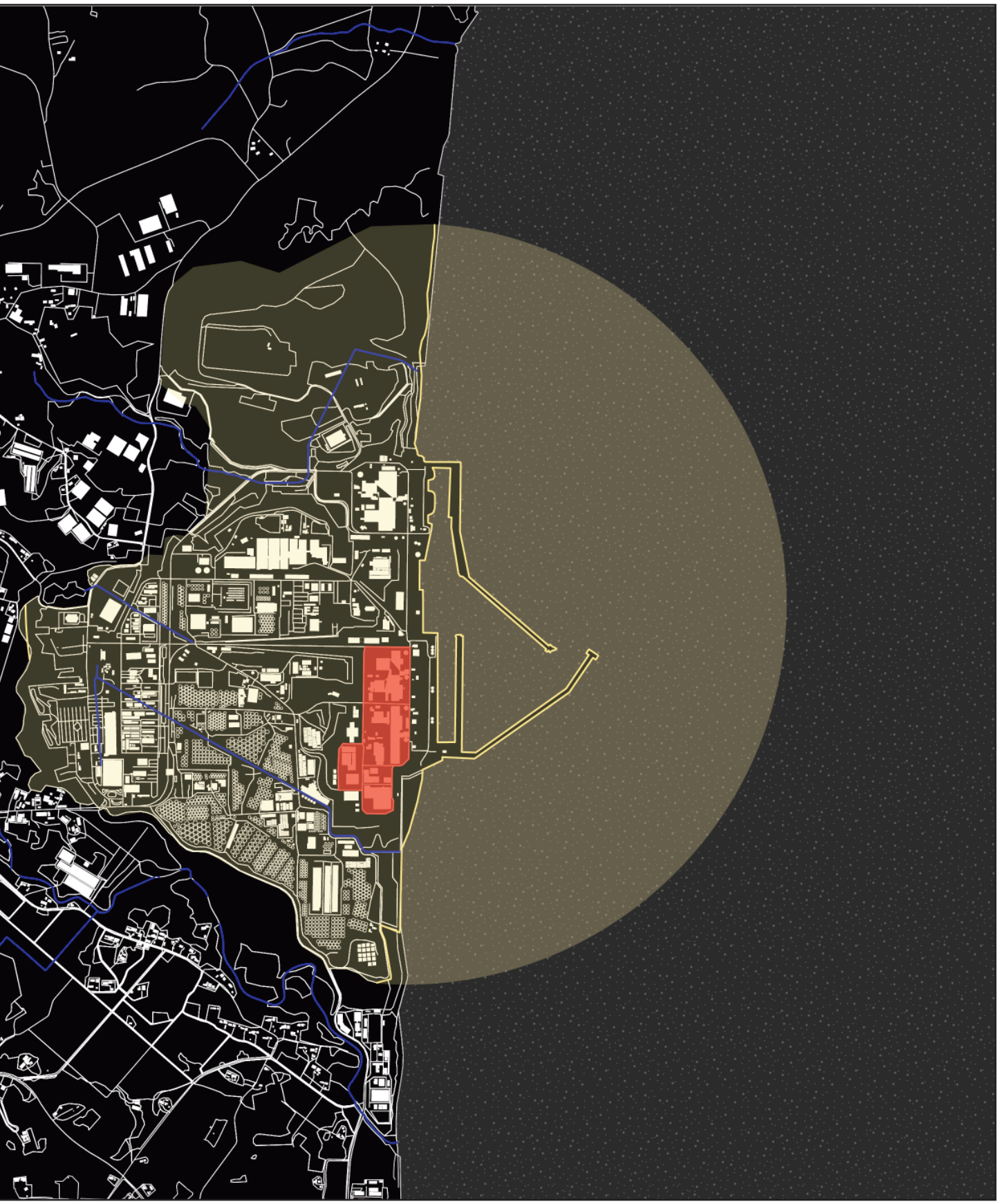
Chapter Two What-if Postcards

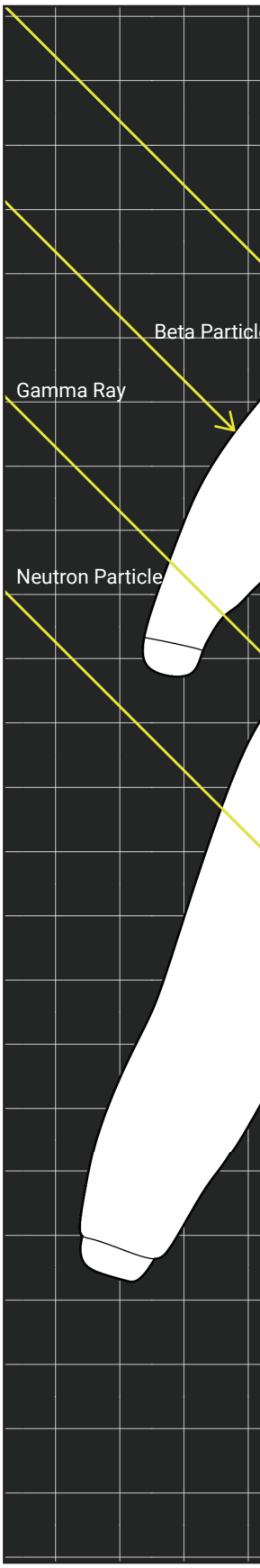
These what-if postcards show some initial ideas about how human and non-human life might look in the future radioactive world. By narrating daily life in Fukushima Exclusion Zone, these designs explore whether we could live in a radioactive world and how we could do so, as a human, a land animal, a plant, a marine life form, or nuclear waste, from the atom to body to building to landscape scale, during a time span ranging from an almost negligible nuclear reaction time to the whole nuclear waste decay period, lasting more than 10,000 years.

Division of Nuclear Waste Repository Zone, Buffer Zone and Living Zone
According to the radiation dose, the area is divided into a center waste storage area in which only robots can work, a buffer area in which humans can work, and a living area.

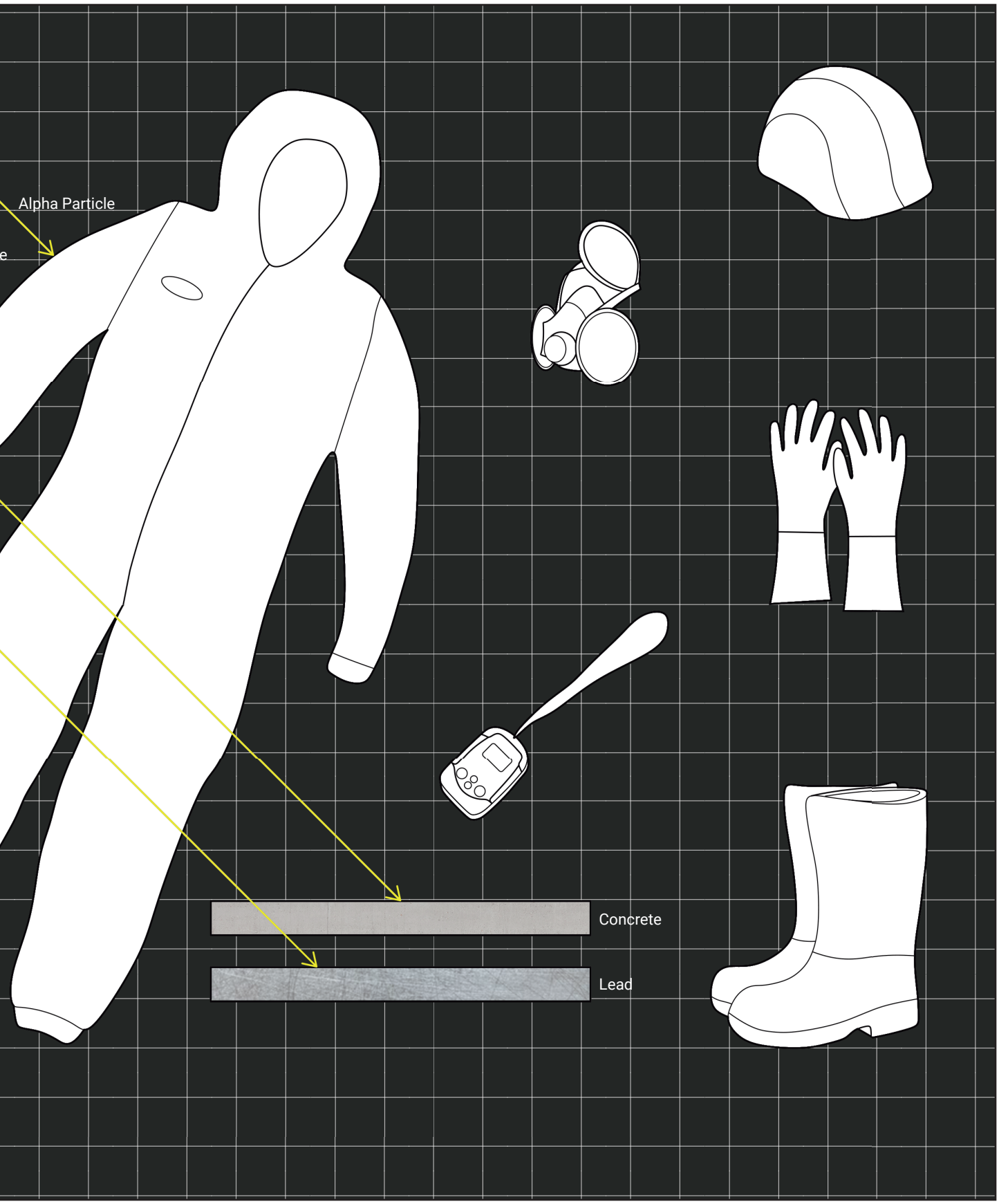

g Zone
king Zone
lear Waste Repository Zone

Zone Plan
Based on the actual zoning plan of the Fukushima Exclusion Zone, the red area shows the working zone for robots(nuclear waste repository zone), and the yellow area represents the working area for humans(buffer zone).





Personal Protective Equipment for Humans
In the Fukushima Exclusion Zone, there are strict PPE wearing standards to protect humans.

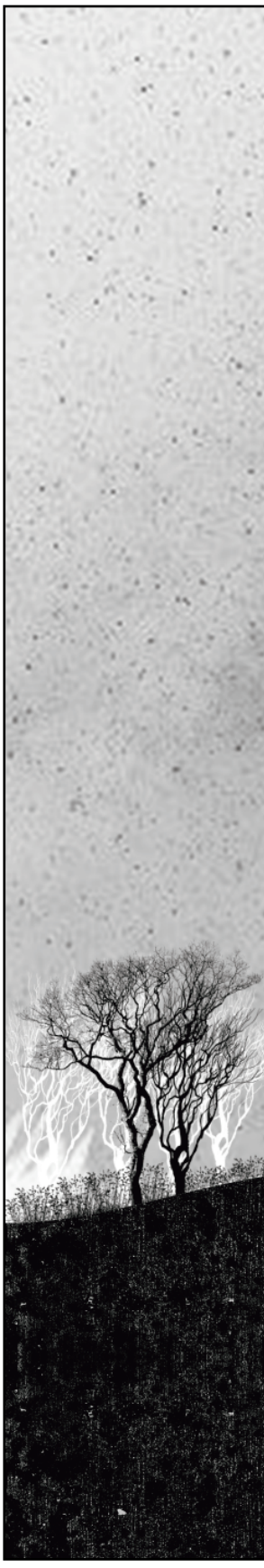

Alpha Particle
Concrete
Lead

Going to the Fukushima Exclusion Zone
Every day, people wear protective clothing in the changing rooms on the boundary of the Fukushima Exclusion Zone. Dosimeters are everywhere in all these areas to measure the radiation.

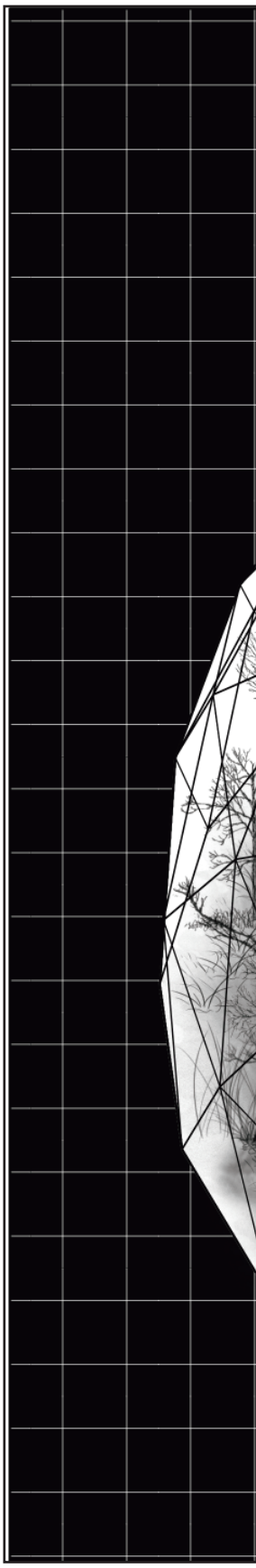
Housing: Lift-up Living Units with Solar Panels
Lift-up living units use upper and lower spaces to distinguish the realms of animals and humans, that moderates the territorial dispute between them. Solar panels installed on the roof provide self-sufficient energy. The use of the materials to construct buildings in this area consider their radiation protection, such as concrete, steel, and radiation shielding glass.

Portable Radiation Protection Devices

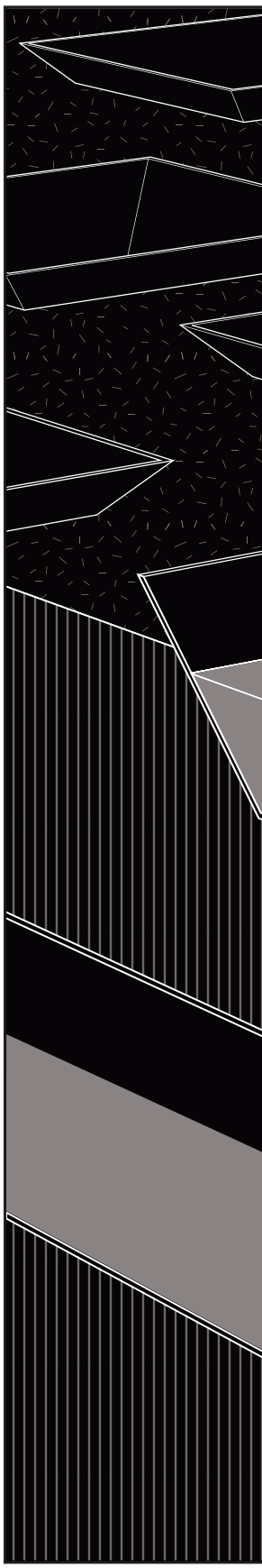
As a traditional custom in local Fukushima, cherry blossom viewing has a new form in the radioactive world through portable devices which provide users with radiation protection. These devices are designed to be used individually or in pairs via the ring-shaped buckle located on the sphere.



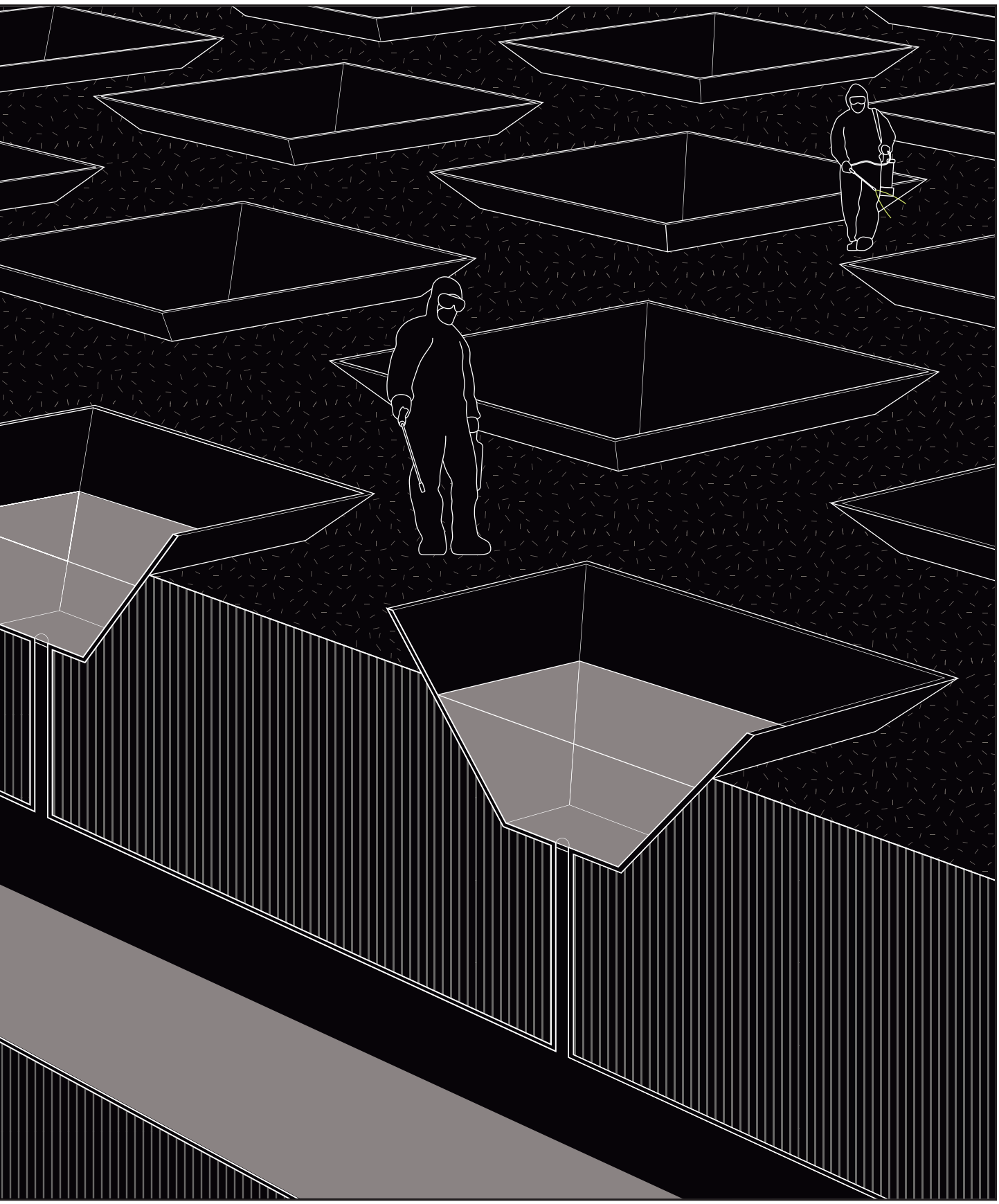
Inflatable Room
Inflatable room design engages with terrain design to provide a special and safe space for people.

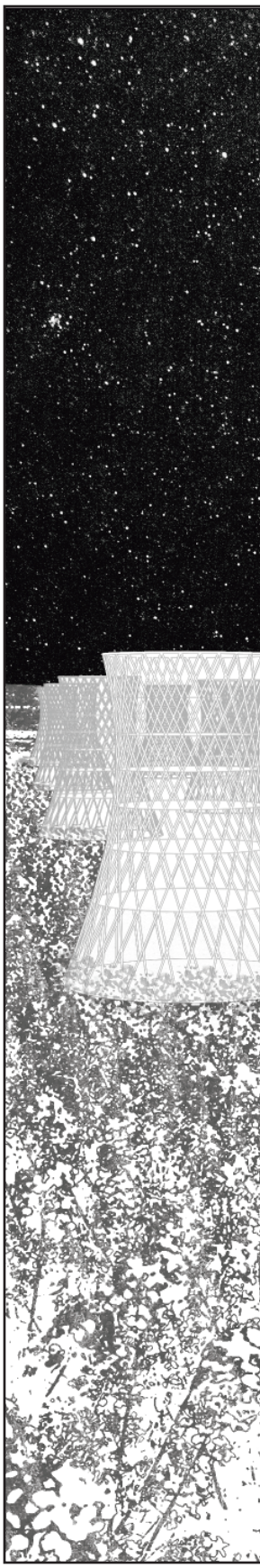


Indoor Garden
Want to walk freely in a garden? Indoor gardens will be the only choice for residents in Fukushima Exclusion Zone. In areas with high radiation doses, people are allowed to stay in the garden with a timelimit.



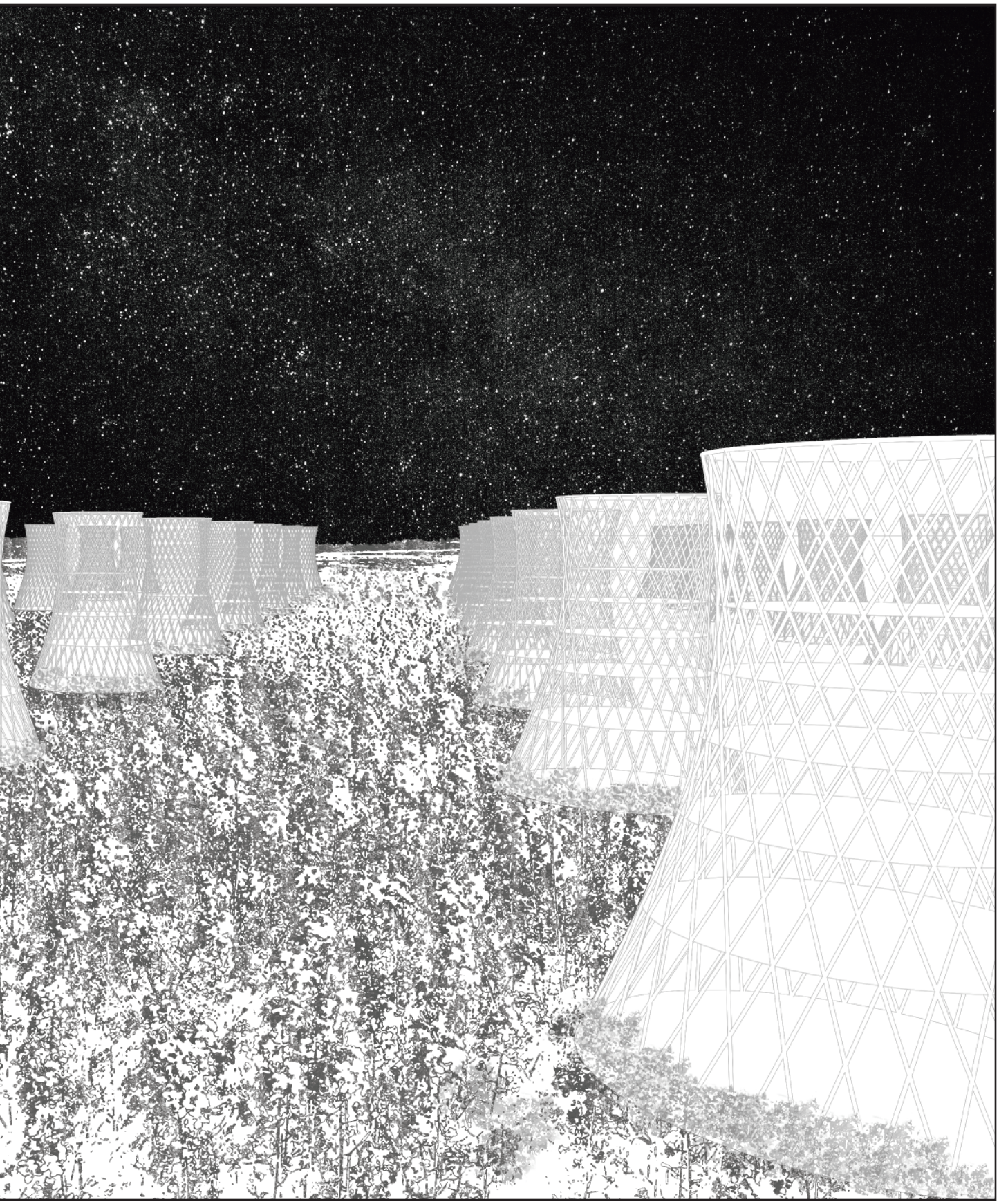
Water Collection System
Rainwater becomes the only choice of domestic water since the ground-water in the area is polluted by radiation.

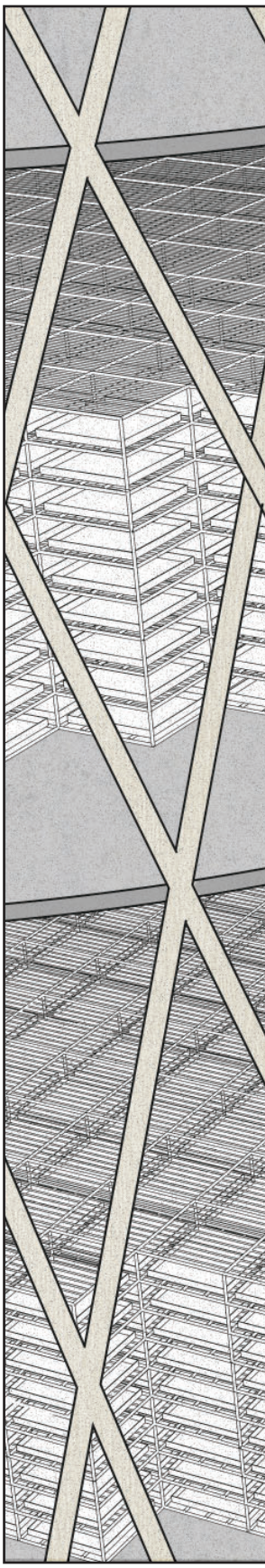




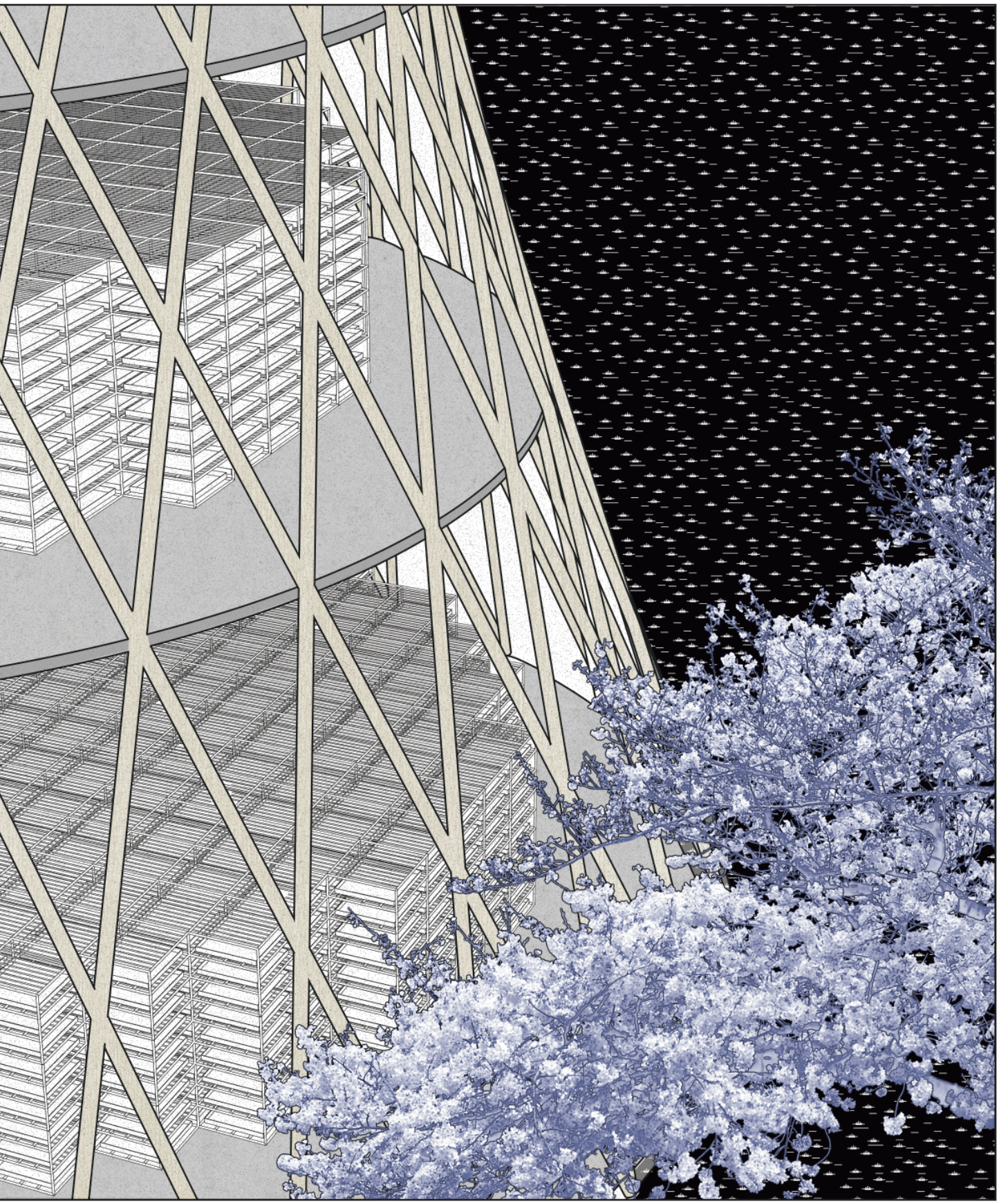
Farming Towers

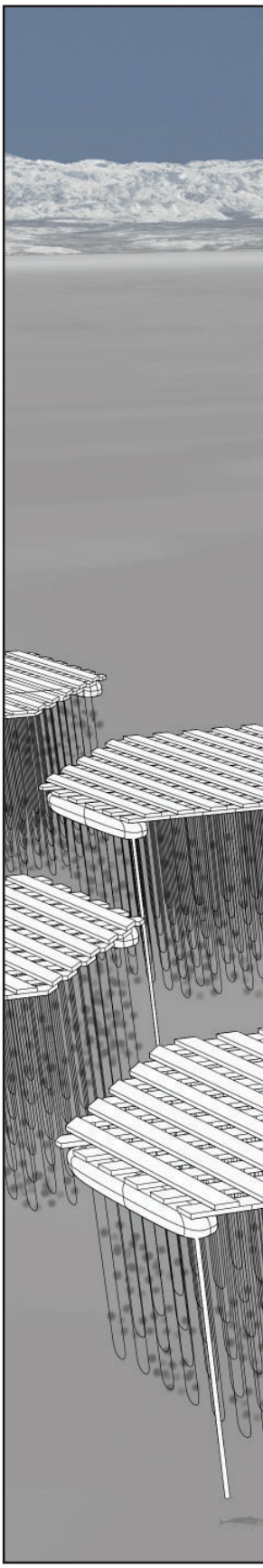
In the Fukushima Exclusion Zone, the soil is contaminated by radiation, so most of the crops cannot be grown in this area. With the exception of rapeseed, this plant has been experimentally planted in the Chernobyl Exclusion Zone, and the edible oil produced by it does not contain radioactive substances. All other crops are grown in farming towers by aeroponics, and solar energy helps provide artificial light for the growing process. These farming towers, which take the geometry of the most iconic building in nuclear power plants–water towers, have become an agricultural planting center to provide food for the radiation world. The rapeseed flowers planted between these farming towers can not only produce edible oil, but also create a unique landscape view for the local area.





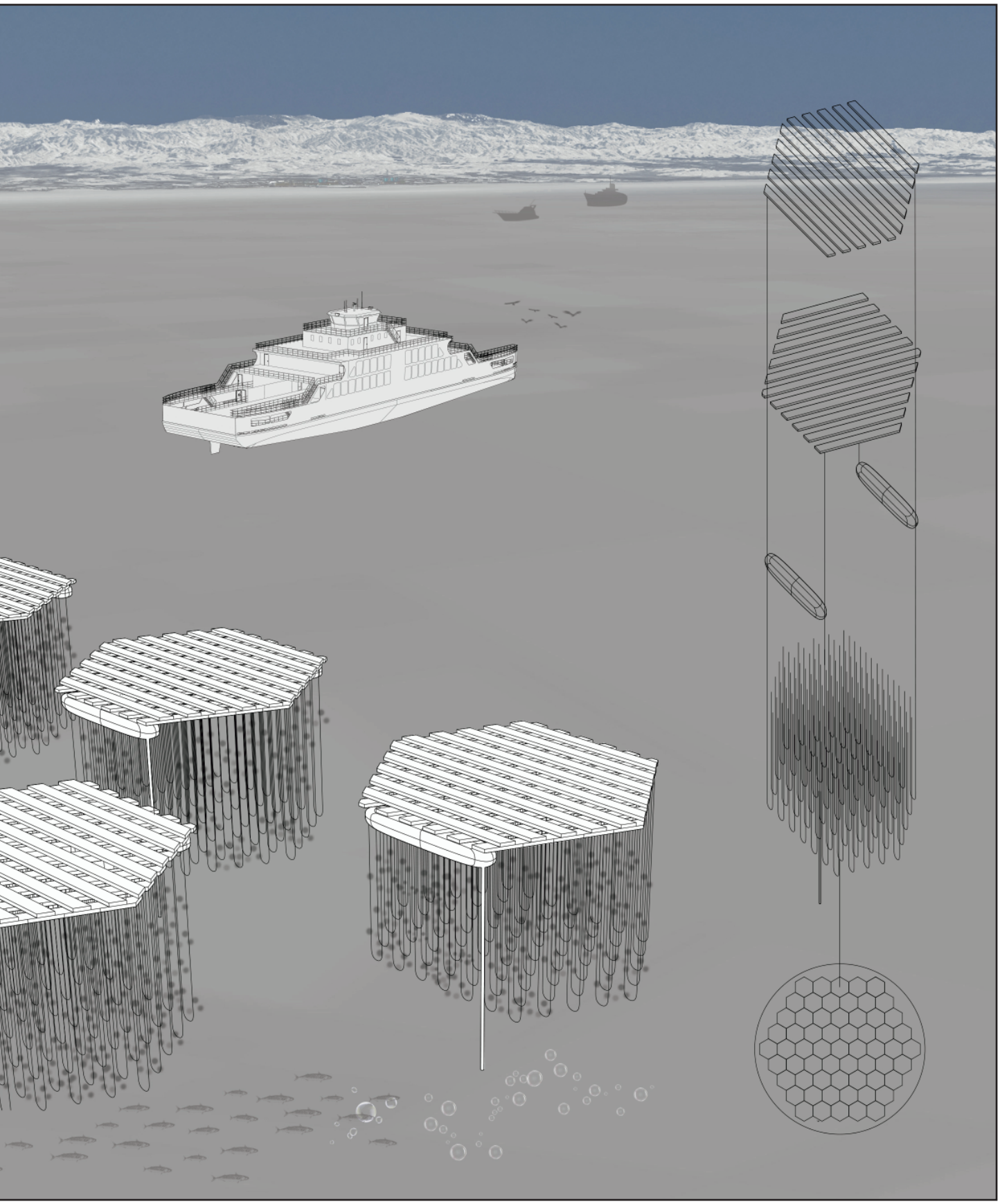
Farming Tower Details

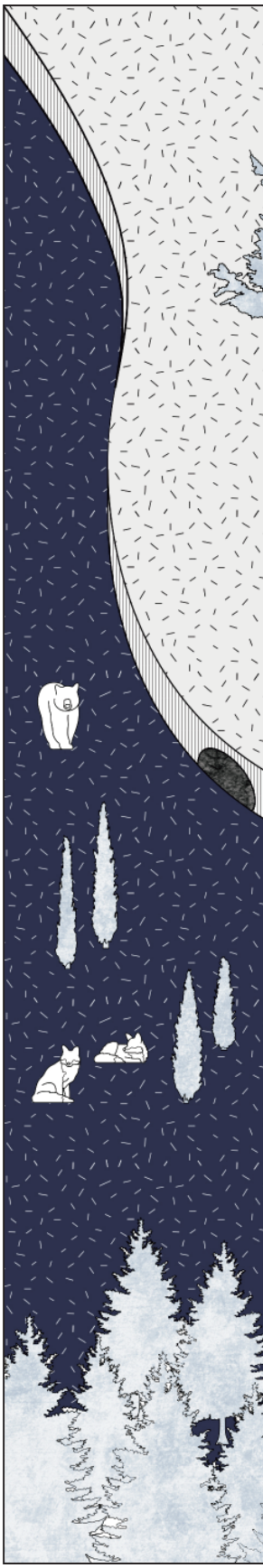




Floating Sea Farms

In order to avoid radioactivity near the contaminated areas, floating sea farms are set up far away from the land. These floating farms provide the local residents with fresh seafood and transport it back by ships. Inspired by the hexagon nuclear fuel assembly layout, the floating farms are designed as modules that can operate individually or easily be assembled into a whole.



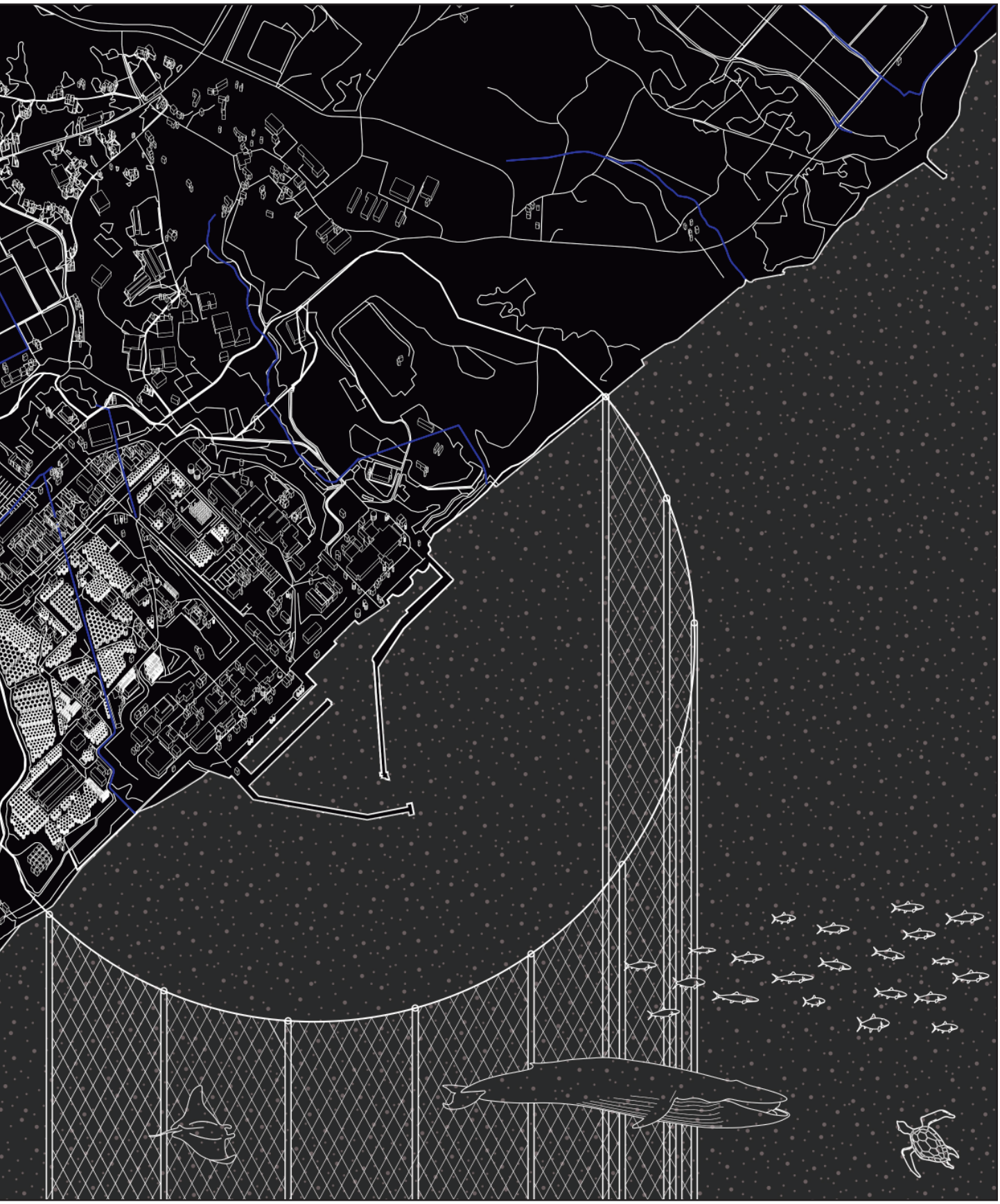


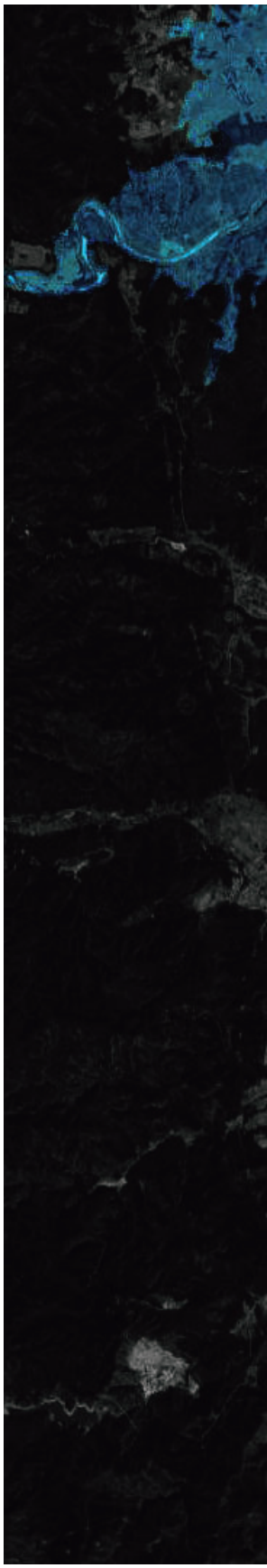
Navigating Nature
In the radioactive world, landscape design allows animals and plants to live better in specific areas, prevents them from being damaged by strong radiation, and moderates conflicts between them and humans. In these landscape designs, planting, food and water sources, barries, nests, sound...and other elements are designed to achieve the goals.

Nets in the Sea

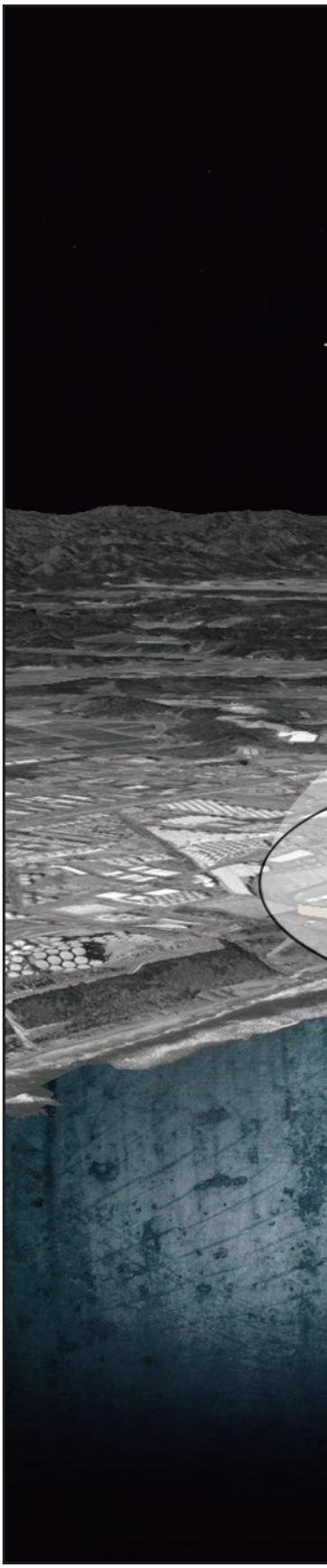
A cod from Hokkaido was tested and found to contain excessive amounts of radiation, because the cod swims through the Fukushima Exclusion Zone. Huge nets are implemented in the sea to ensure that marine life cannot enter these high-radiation areas.

*Hokkaido is in the northeast part of Japan, that is far from Fukushima

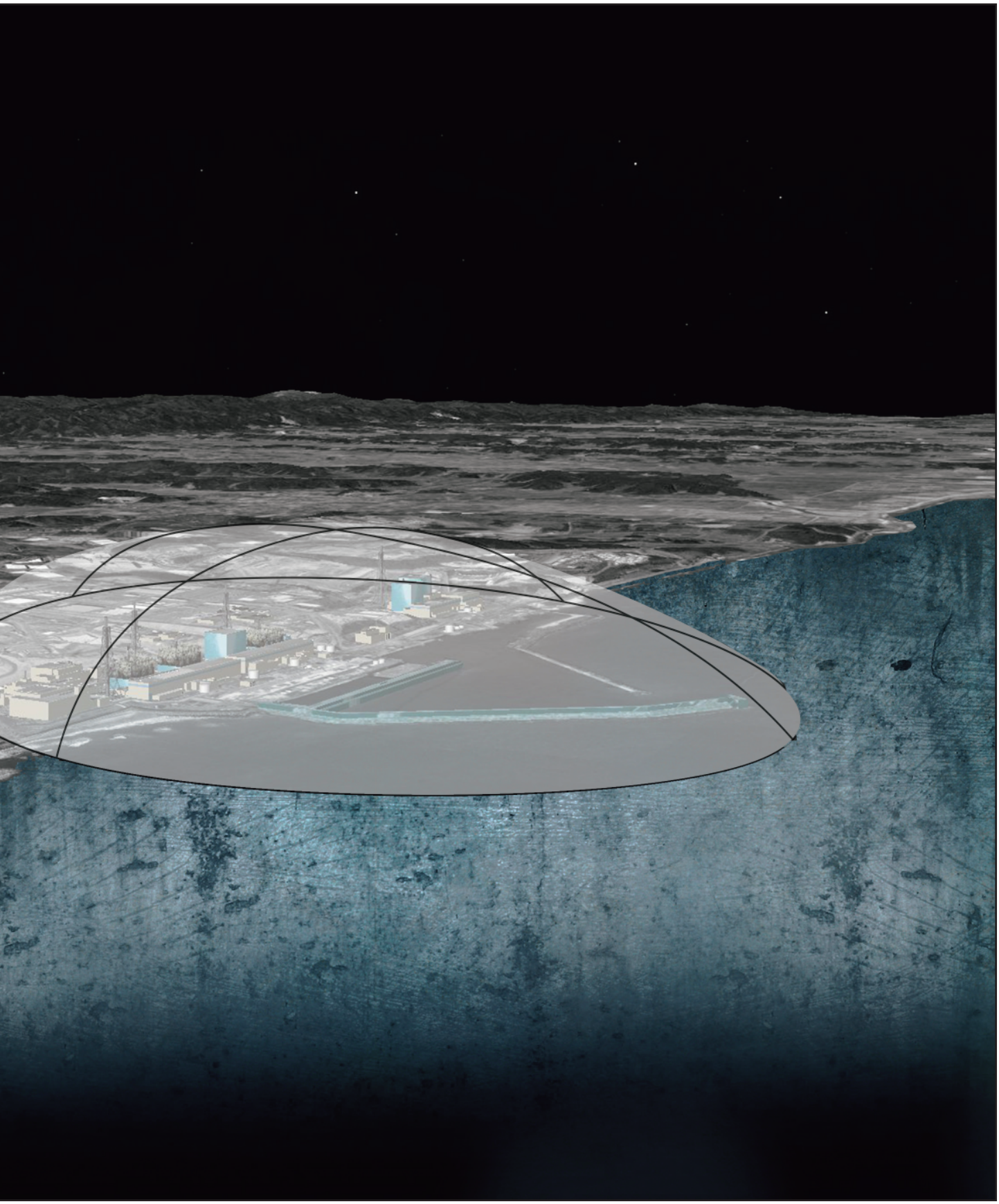


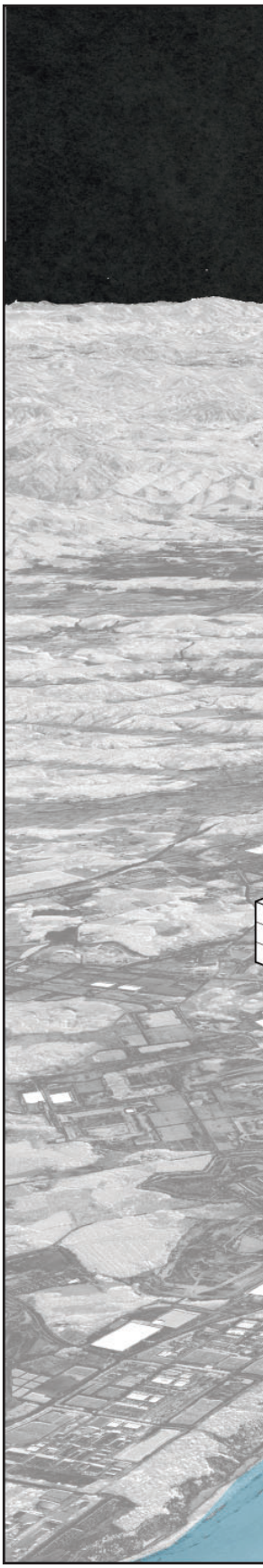


Climate Change Impacts
Due to sea level rise caused by climate change, the ruins of the Fukushima Daiichi Nuclear Power Plants with high radioactivity and the surrounding areas will be gradually submerged in seawater in the next 20,000 years, based on sea level simulation and data from NASA.

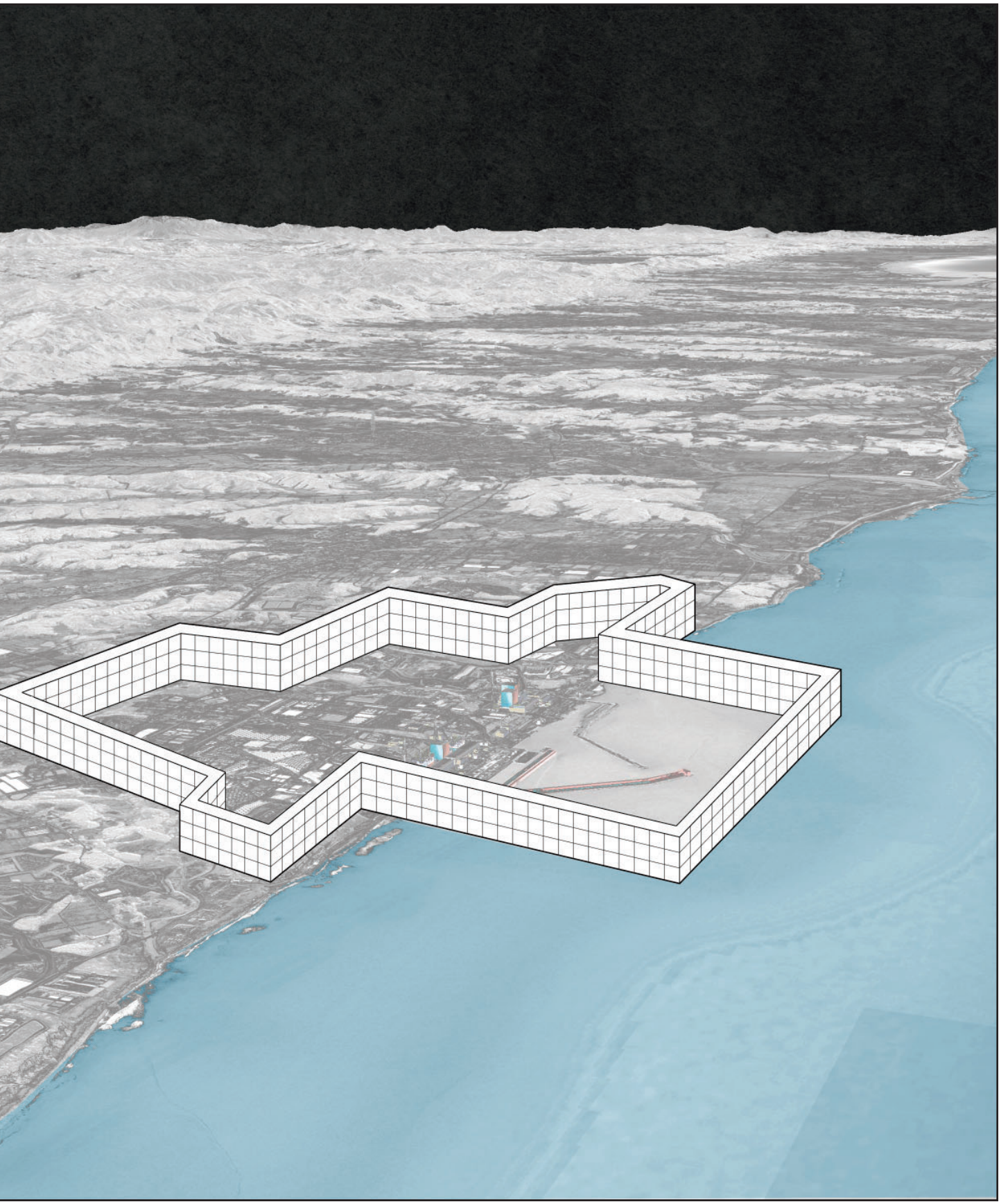


Design for 10,000 Years Scheme 1
High-radiation areas are covered to prevent the ocean from being polluted by large amounts of radioactive substances.

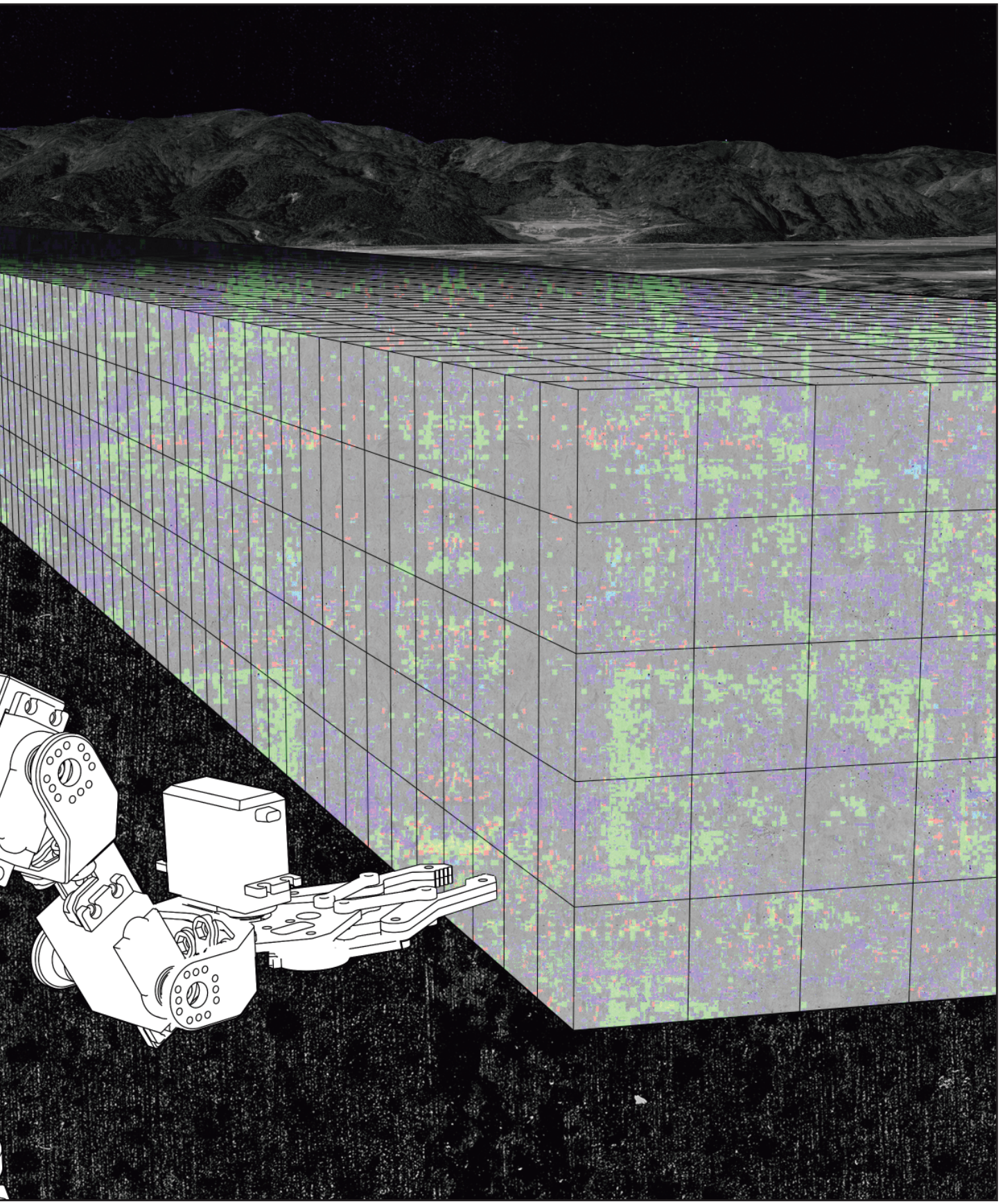




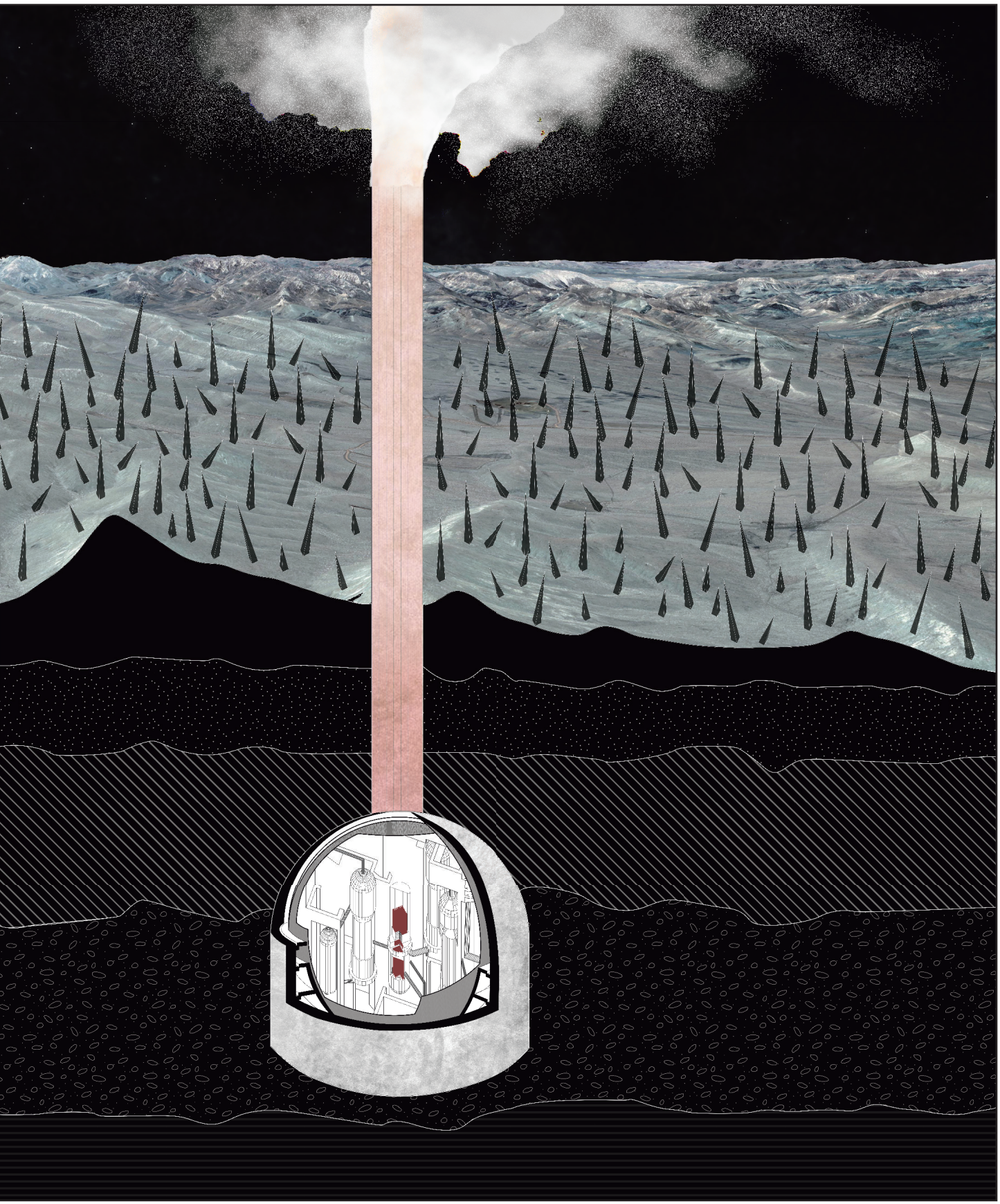
Design for 10,000 Years Scheme 2
The high radiation area is protected by high walls far above sea level.

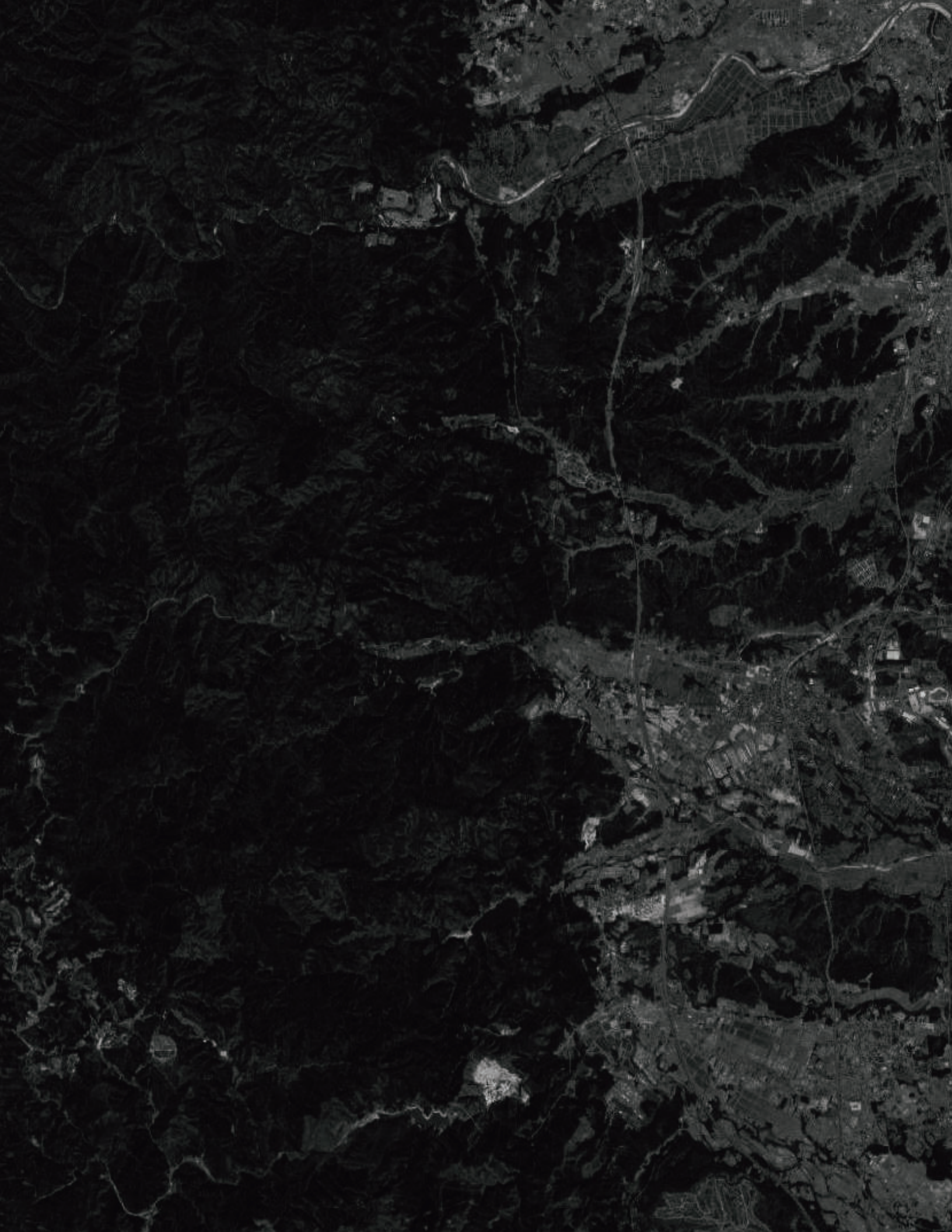


Design for 10,000 Years Scheme 3
Robots pack the radioactive substances from the ruins of Fukushima Daiichi Nuclear Power Plants and store them in a safe place.



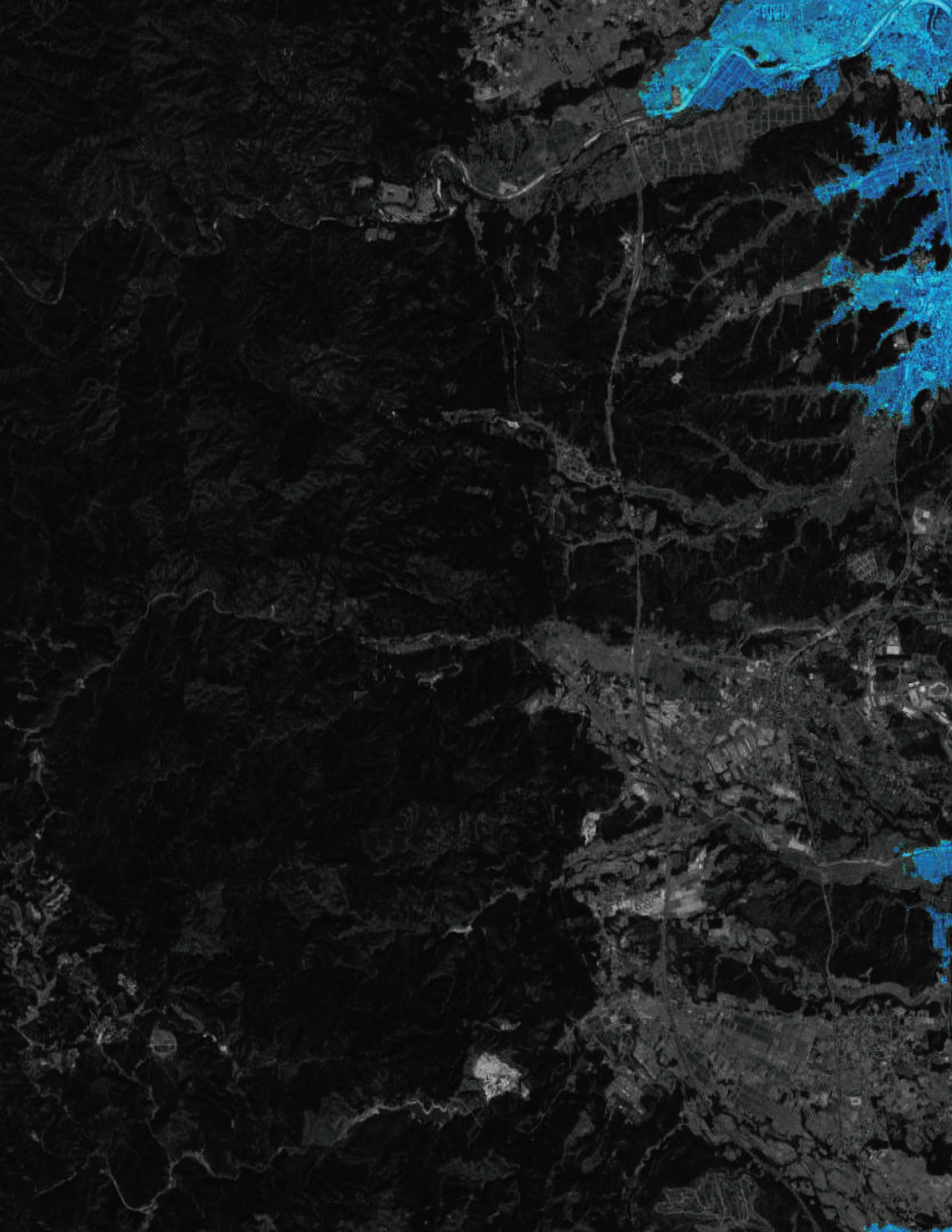
Nuclear Waste Repository Site and Decay Energy Reuse
This contaminated area will be used as a nuclear repository site, which is supplied by the decay heat energy and considered nuclear semiotics in the landscape design for more than 10,000 years.

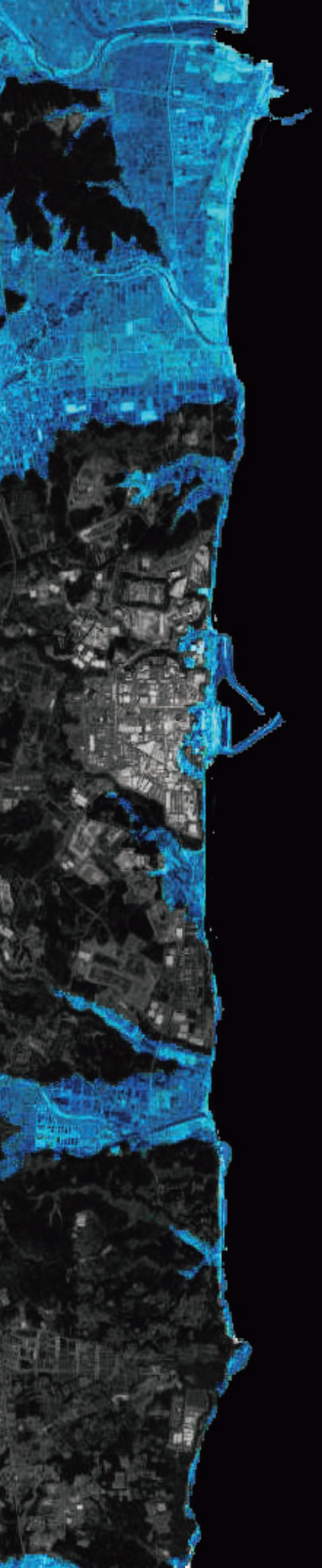




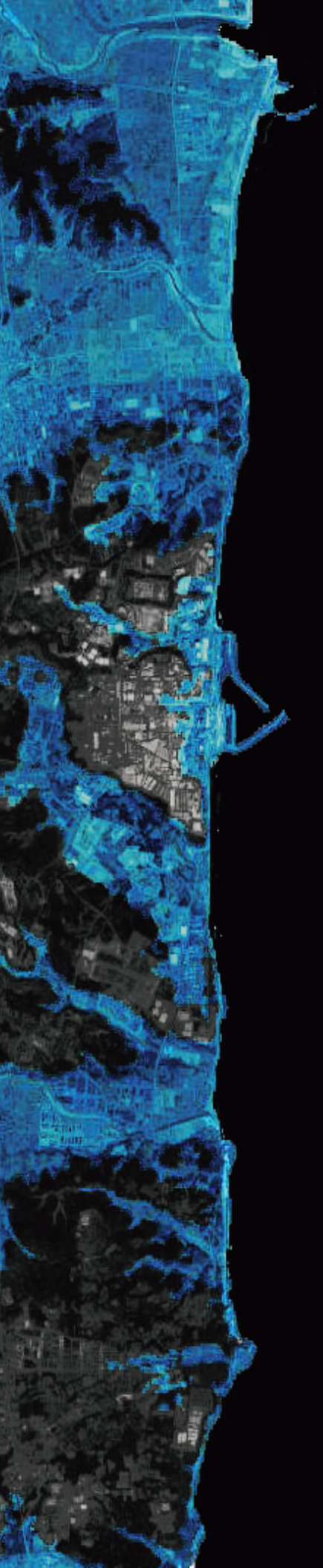
500 years

1000 years

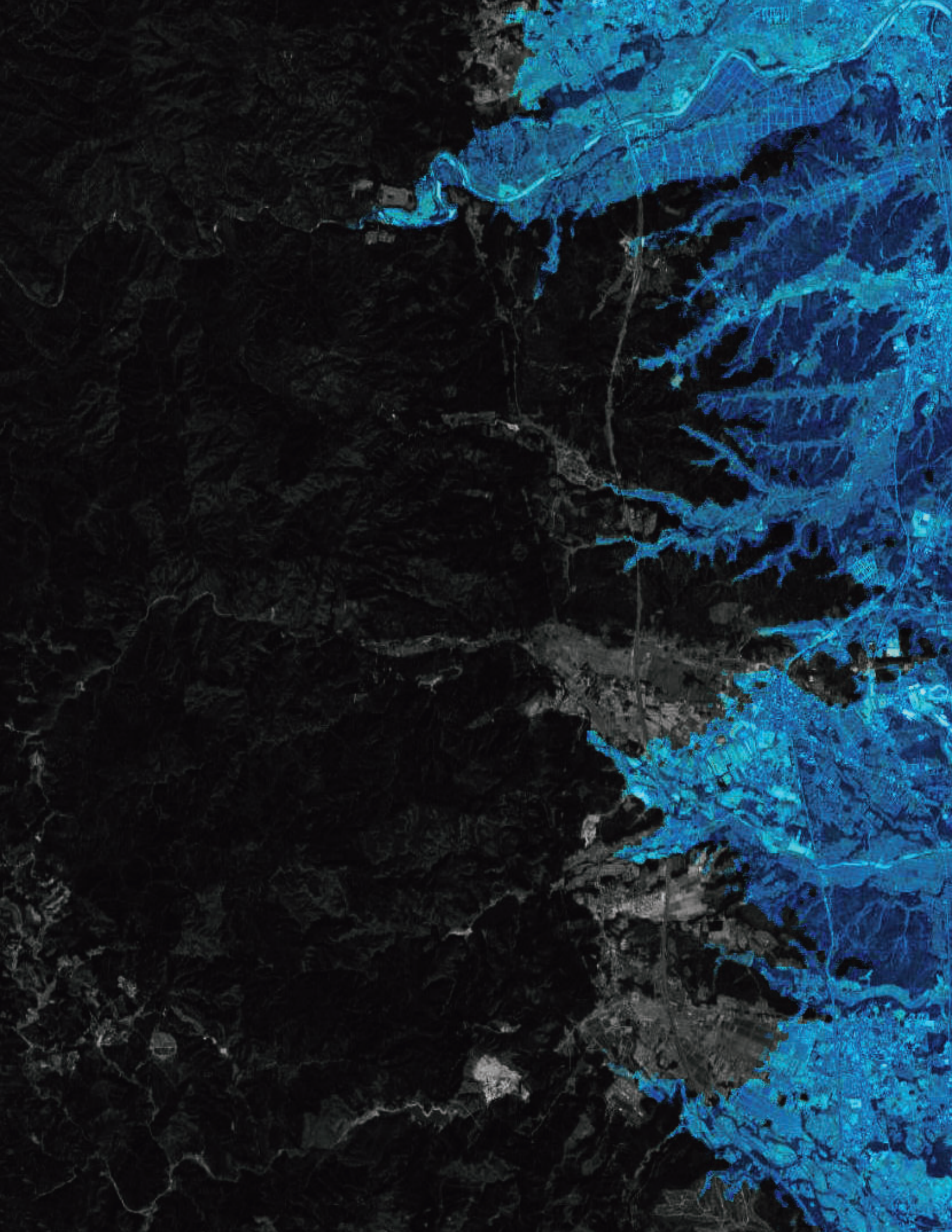


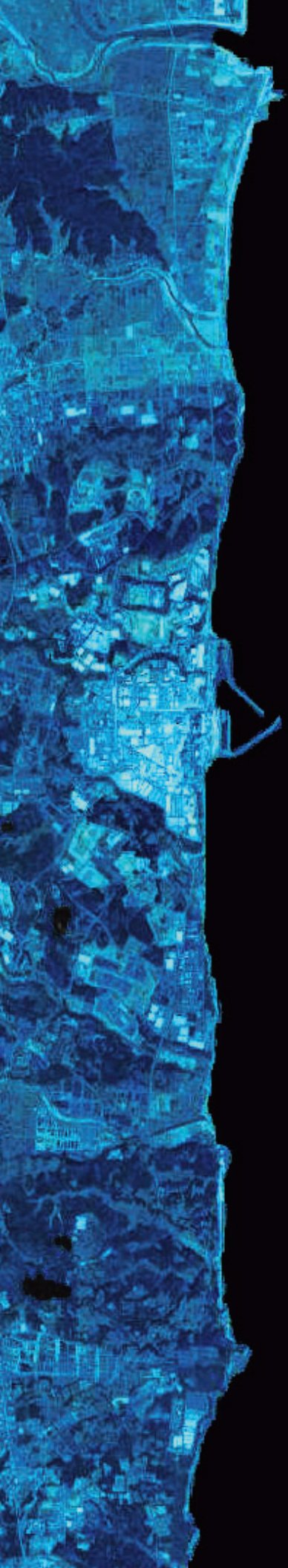


5000 years



10000 years



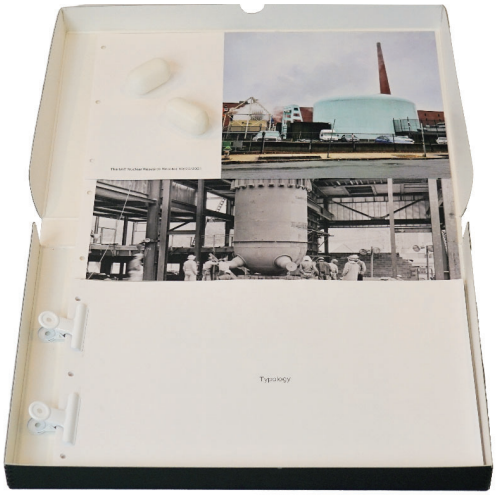


20000 years

Chapter Three
Lab Research Dossier

3.1 MQ’s Story(about myself)
3.2 Typology Study
3.3 Radiation Protection
3.4 Materials Research

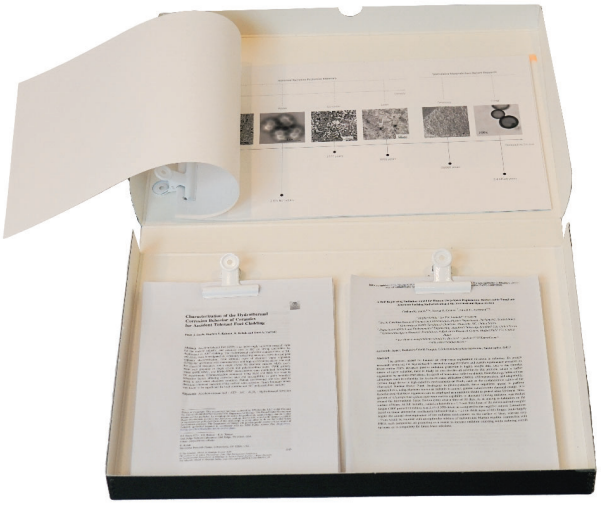

The University of Michigan
Mengqiao Zhao
Master of Science in Engineering


Typology


MQ


Typology

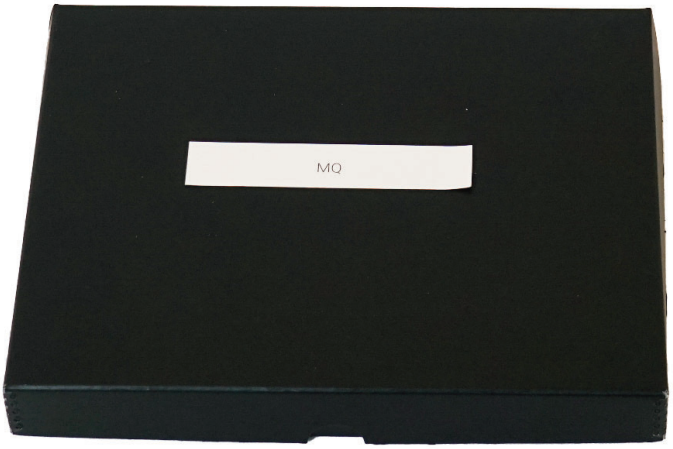

Radiation & Protection




Radiation & Protection


Materials


The University of Michigan
Mengqiao Zhao
Master of Science in Engineering
(Nuclear Engineering and Radiological Sciences)
my husband's photography book
UNIVERSITY OF MICHIGAN
ANN ARBOR
Expires Nov 20, 2019
MENGQIAO

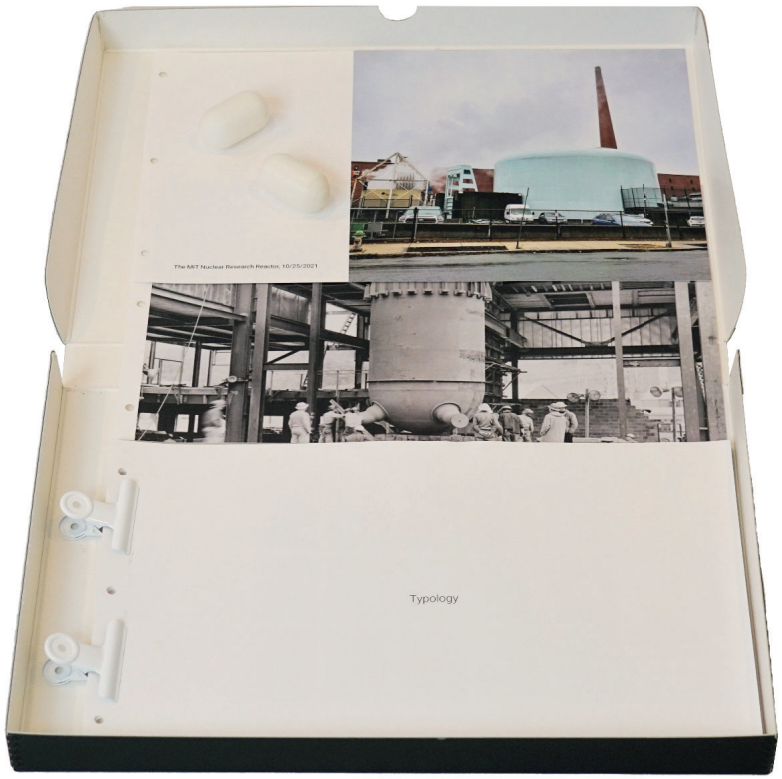

MQ

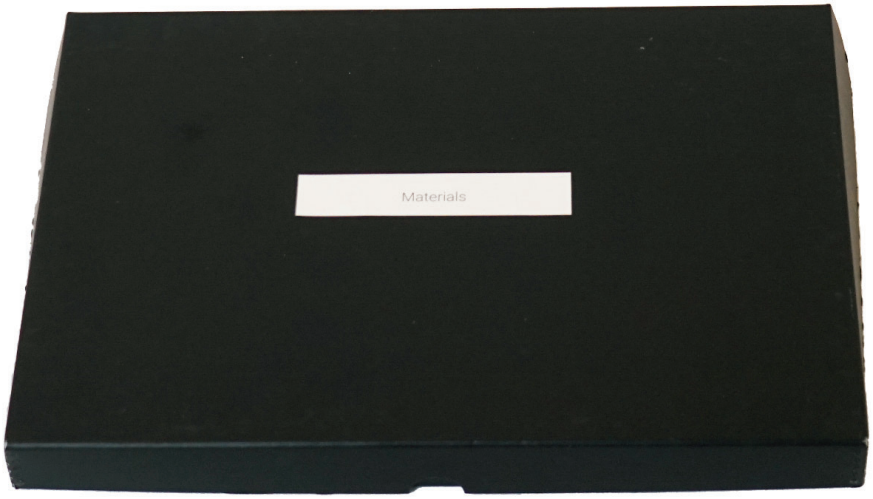
1. MQ's Story

This project started with my own experience. I grew up in a small nuclear town in southwest China. Thinking back on my childhood, I often remember my friends and I playing in a little garden outside our parents' working lab, waiting for them to get off work. The lab included a nuclear reactor, and sometimes our parents discussed the results of their experiments in front of us after work, telling stories about their experiments succeeding or failing.

Therefore, perhaps inevitably, before I came to MIT to study architecture, I studied and worked in the nuclear field for 8 years. But when the accident at the Fukushima Daiichi nuclear power plant happened, it caused all nuclear industries throughout the world to temporarily stop all projects, I decided to quit my job and get a graduate degree in nuclear engineering, and then also in architecture.

The impact from this accident was personal for me, but it is felt far beyond those of us who were directly related to the industry. More or less, sooner or later, because air and especially the ocean currents and weather patterns distribute radiation all around our world. Radioactivity has no boundaries. It does not care about nation state borders, or species differences: all life is impacted, human and nonhuman, land and marine.


The MIT Nuclear Research Reactor, 10/25/2021
Typology

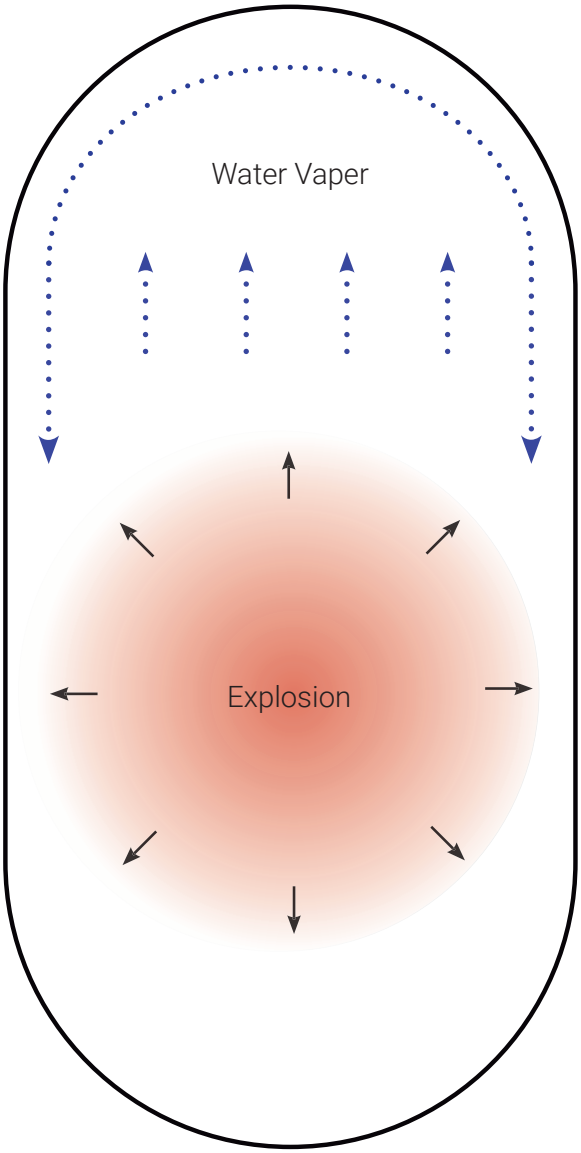

Materials

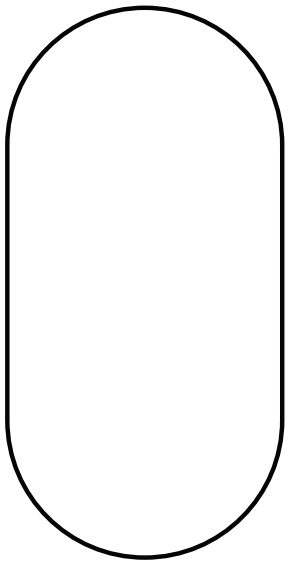
2. Typology Study

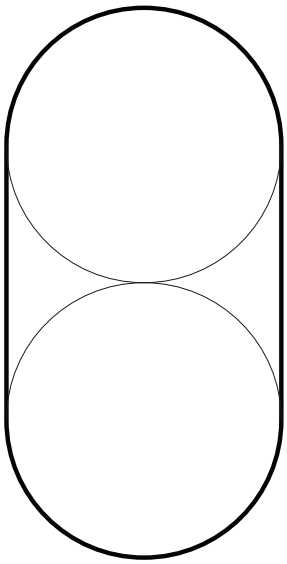
There are many nuclear power plants, like the one in Fukushima, operating all around us, such as the nuclear reactor at MIT. The documentary photos of nuclear power plants show that all containment buildings have cylinders on the bottom and spheres on the top, to protect the public from any explosions occurring inside the nuclear power plants. This shape is also engineered to protect the nuclear reactor from being damaged in case of any impact. Not only the containment buildings, but also all the main equipment, such as reactor, steam generator, pressurizer, in nuclear power plants follow the same pill form.

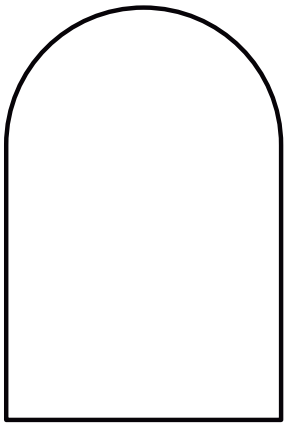
The MIT Nuclear Research Reactor, 10/25/2021

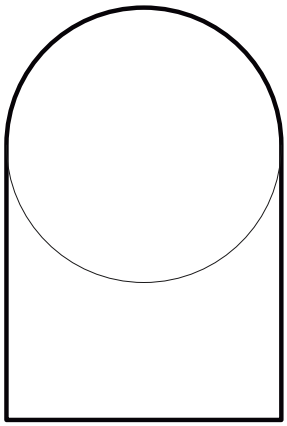
Crash



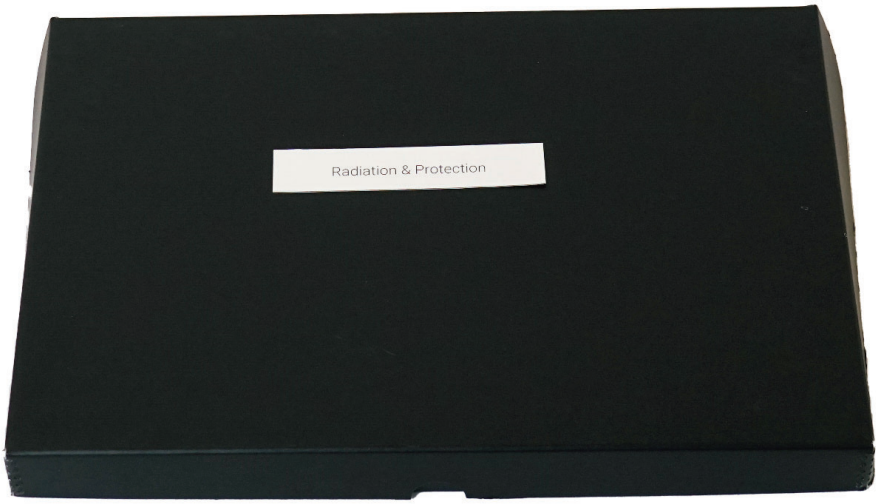






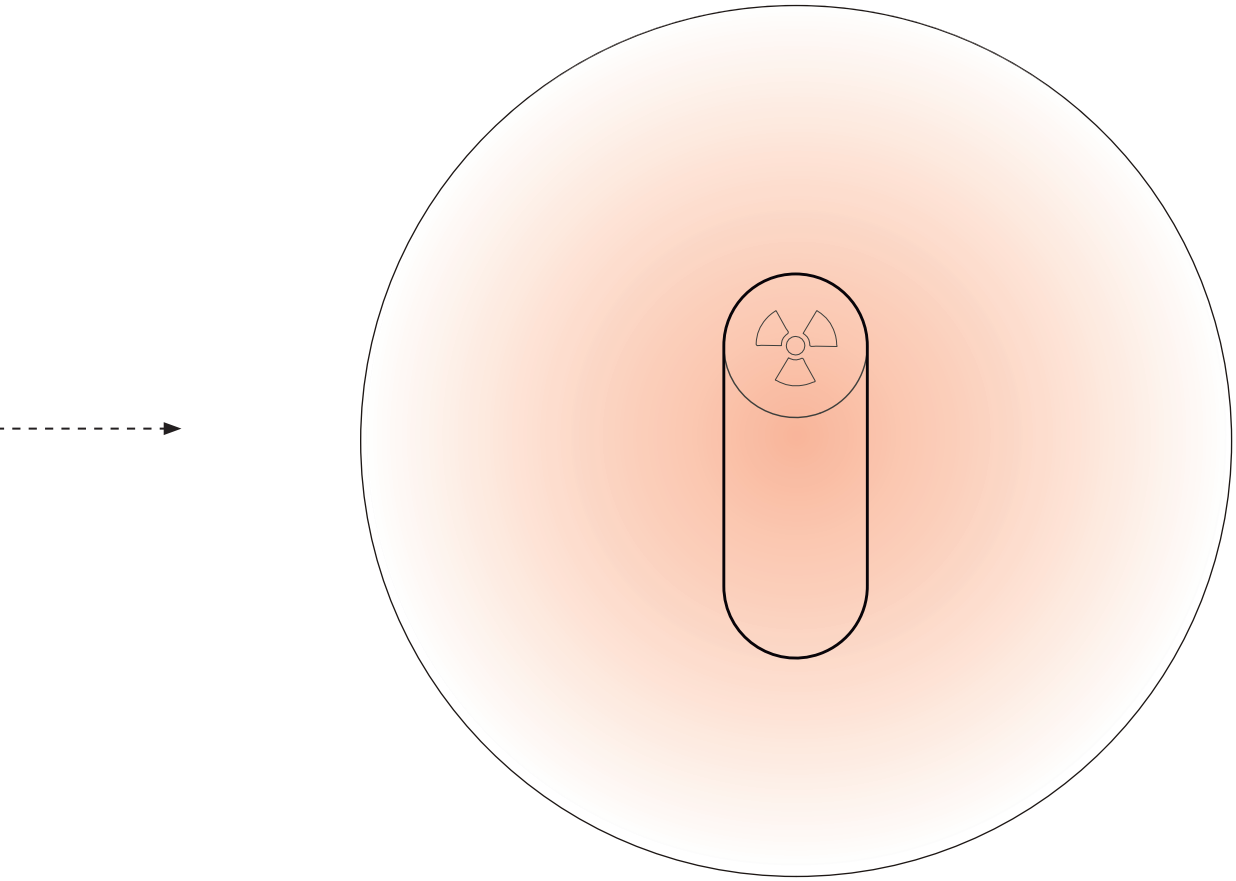


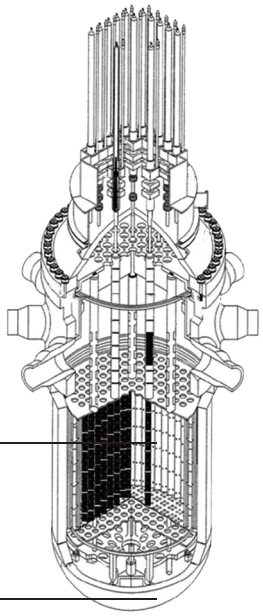

Radiation & Protection


Radiation & Protection

3. Radiation & Protection

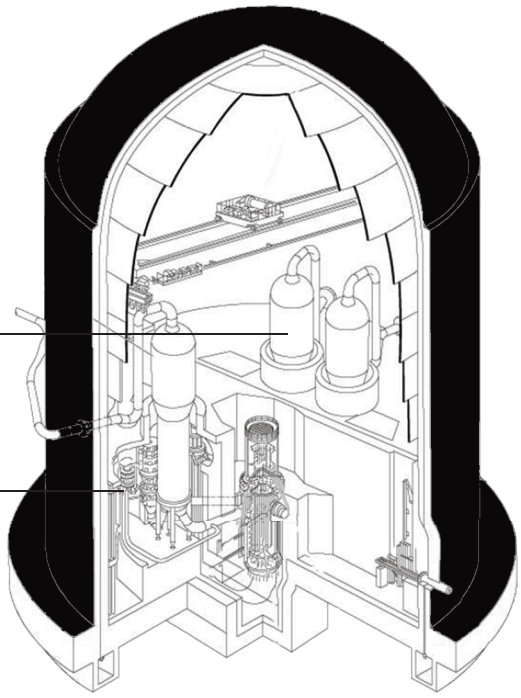
There are two ways to protect humans from radiation damage. One is to isolate the radiation source, and the other is to isolate ourselves. These case studies related to radiation and protection include: the quadruple protection barriers in nuclear power plants, the process of nuclear waste repository, the treatment of serious nuclear accidents, and the history of hazmat suite.





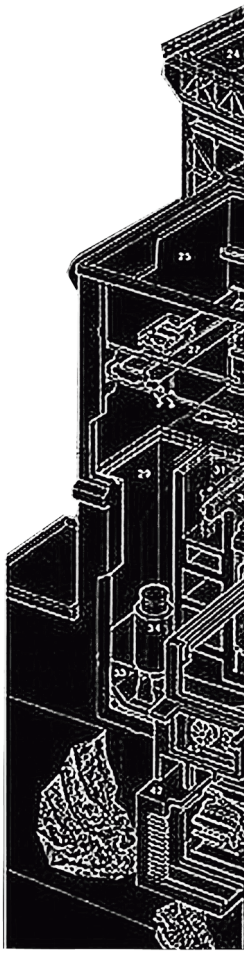
First Barrier
Nuclear Fuel Pellet
and Cladding

Second Barrier
Reactor Pressure Vessel

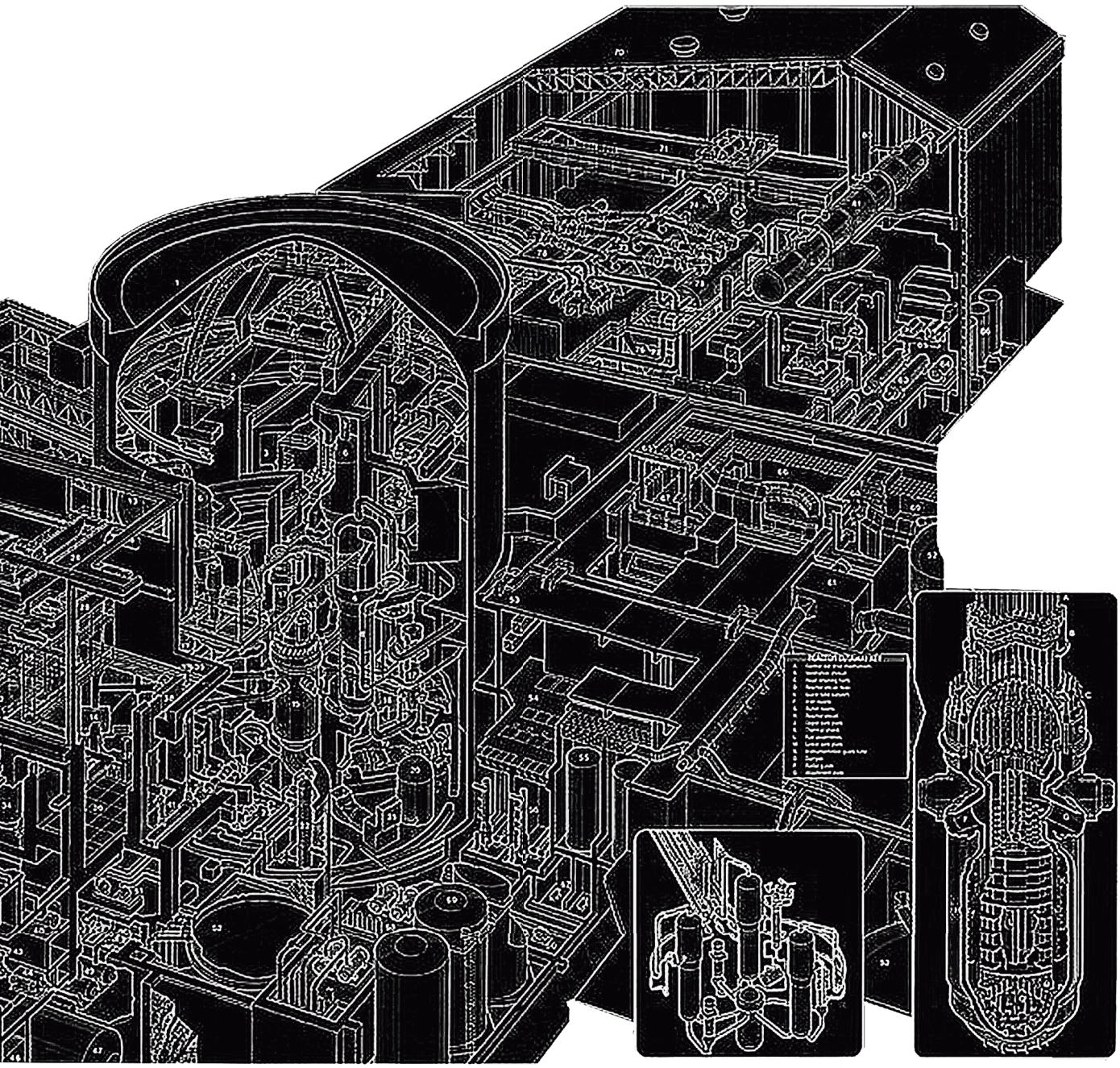


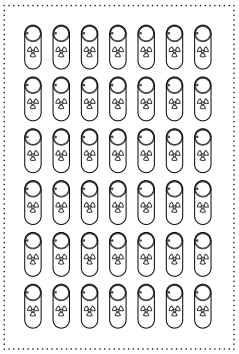
Third Barrier
Primary Loop

Fourth Barrier
Containment Building



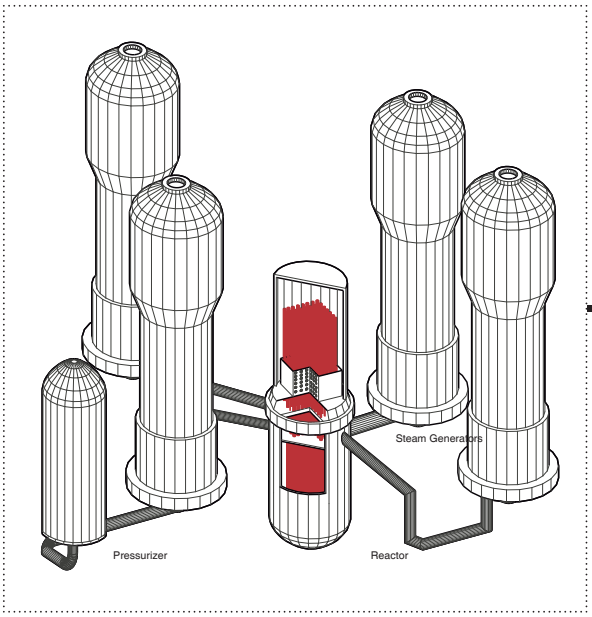
Safty Barriers for Radiation In nuclear Power Plants





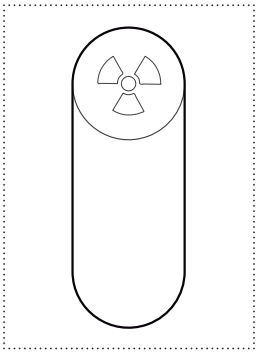
Low-Level Waste 90%

Interim Storage Steel Barrels above Ground



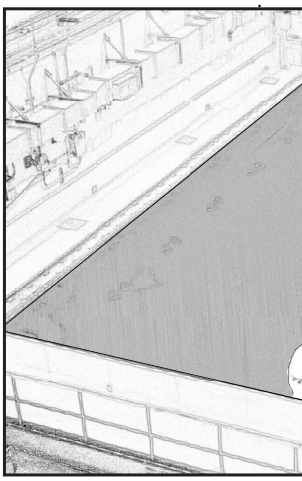
Nuclear Fuel

Intermediate-level Waste 3%
High-level Waste 7%

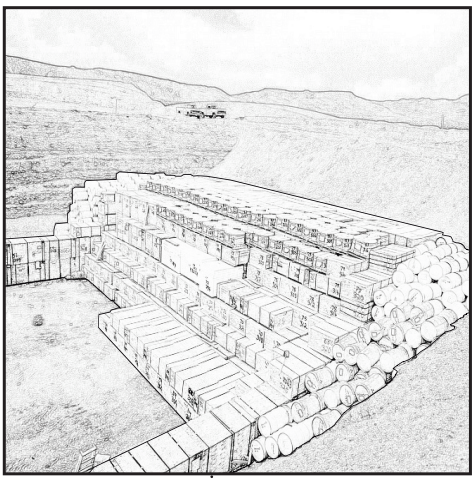


10^{-12} seconds

Spent Fuel Pool
Plants abo



Nuclear Waste Repository Process



5 years

10^2 years

Geological Repository
Shallow Land Burial

in Nuclear Power
ove Ground

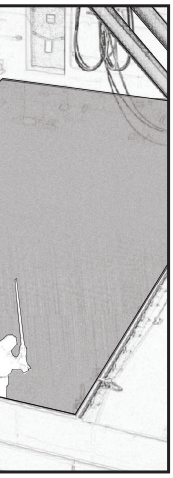
Interim storage Containers
Above Ground

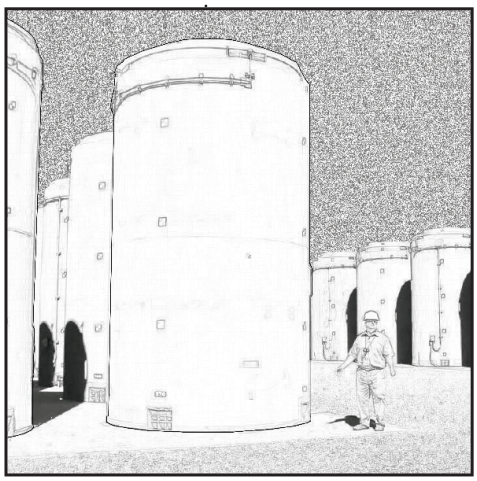
Deep Geological Repository
-250m to -5000m

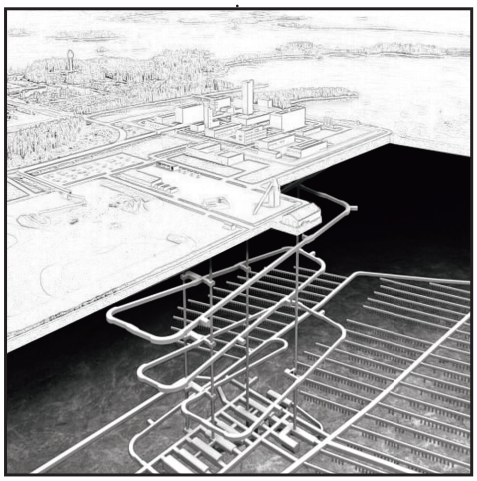
10 years

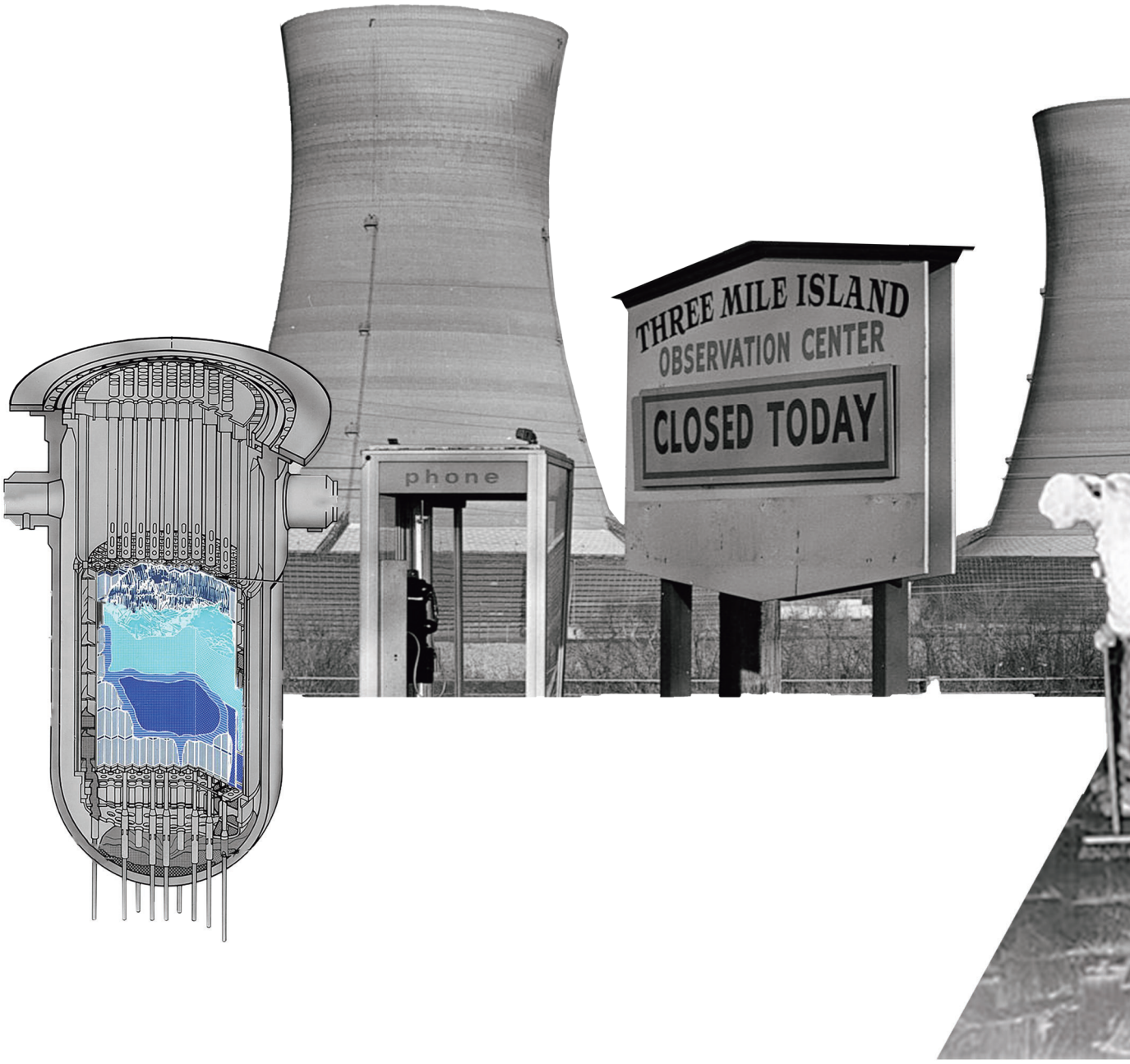
10^2 years

10^5 years



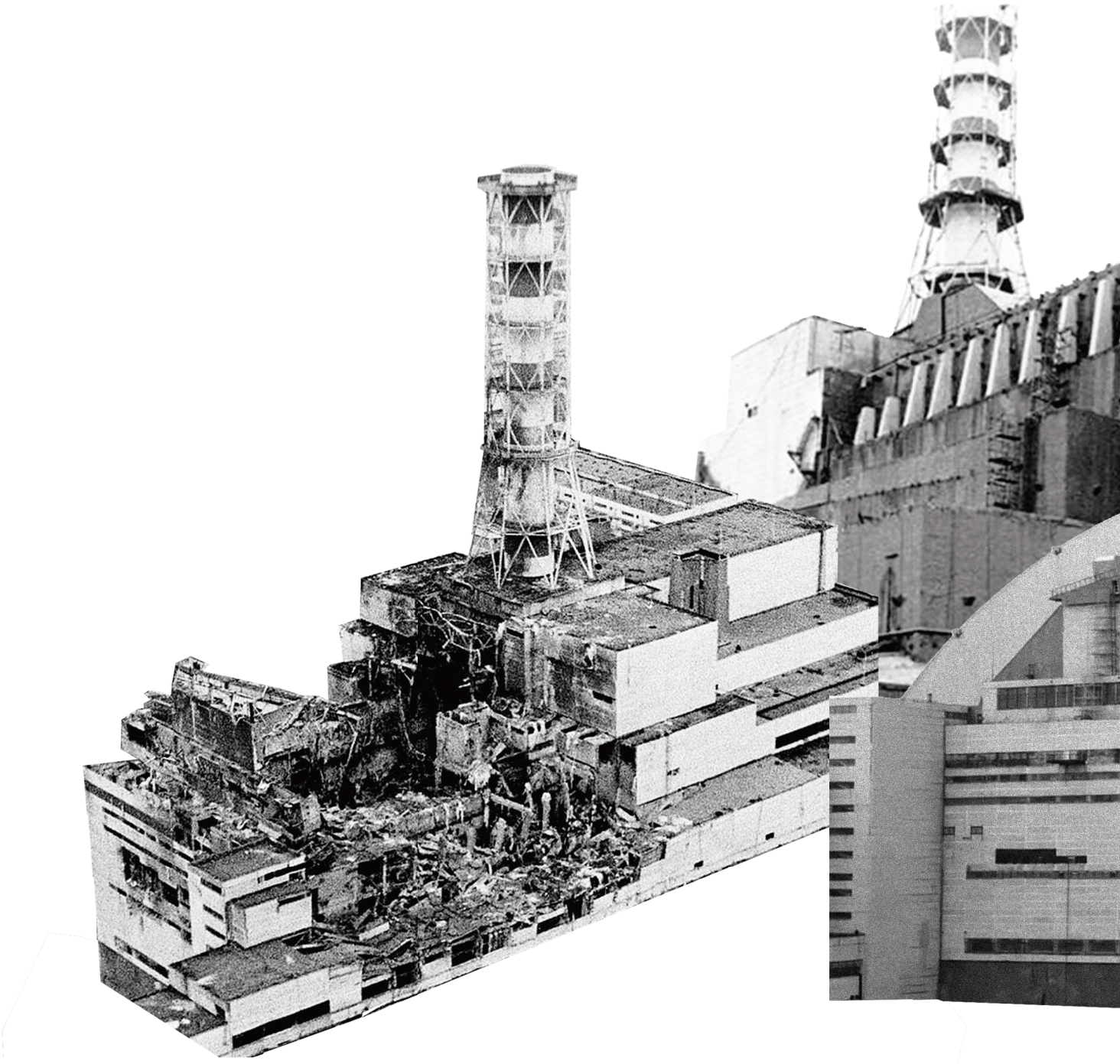




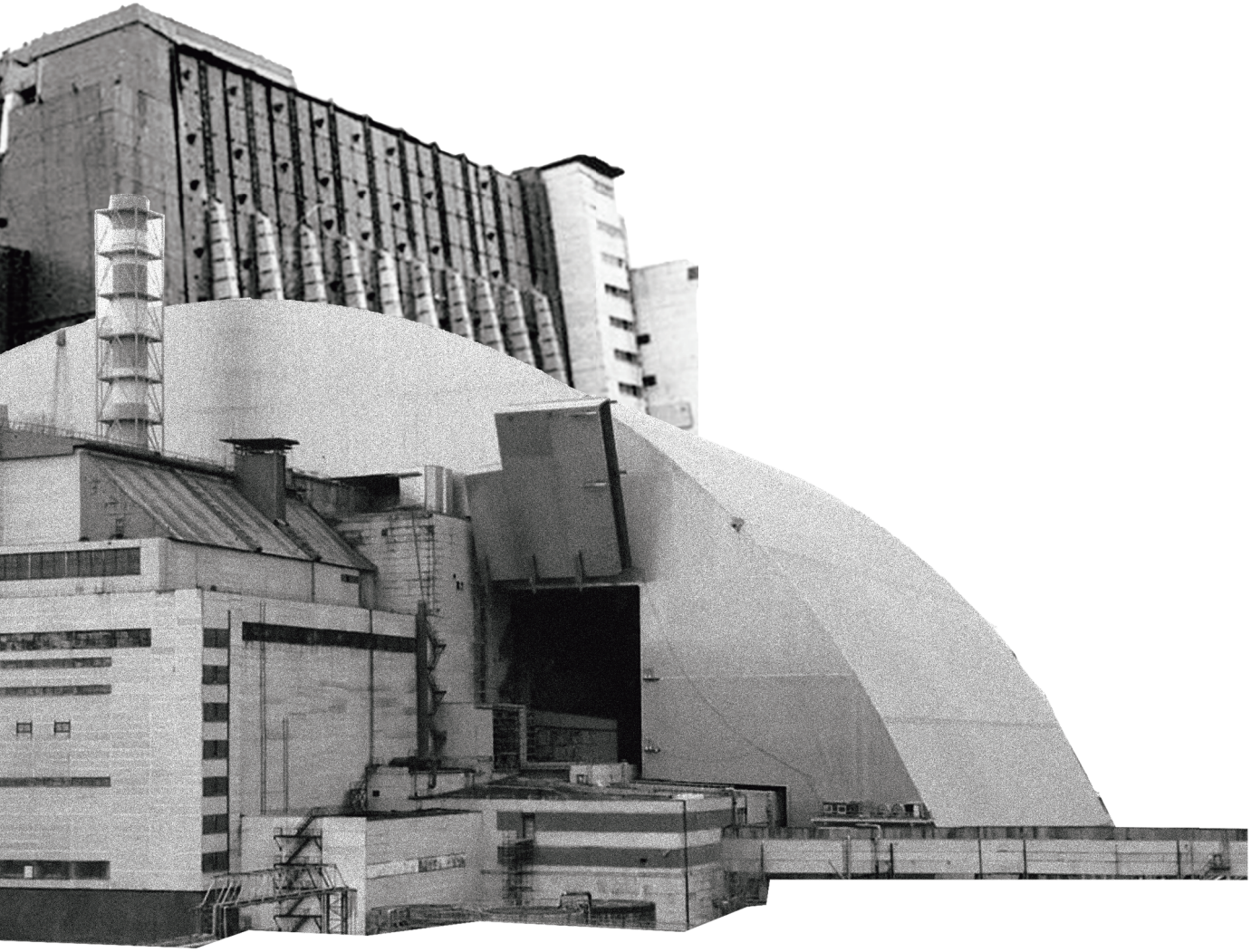


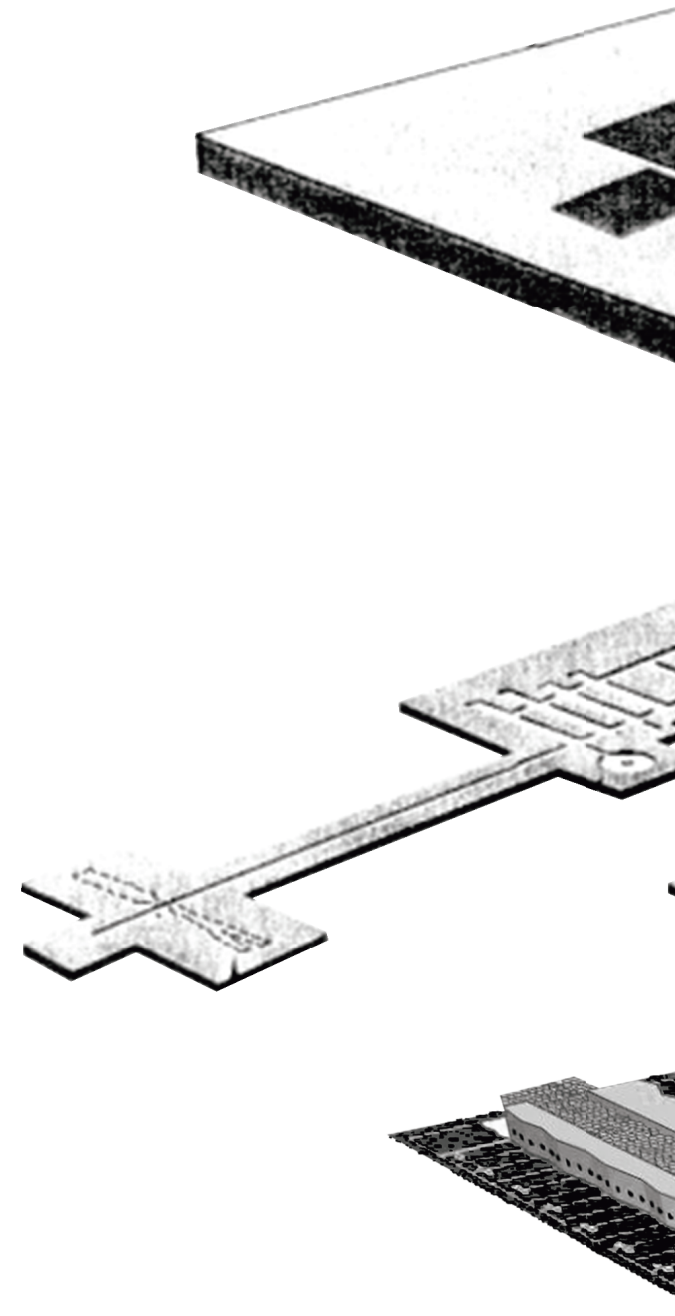
Three Mile Island Nuclear Accident
Pennsylvania, U.S.A. 1979


LIVE
WITH
LESS
NERGY
SHUT
DOWN
T.M.I.
BURY MET-ED
NOT US!
SHUT
TMI
DOWN
FOREVER!

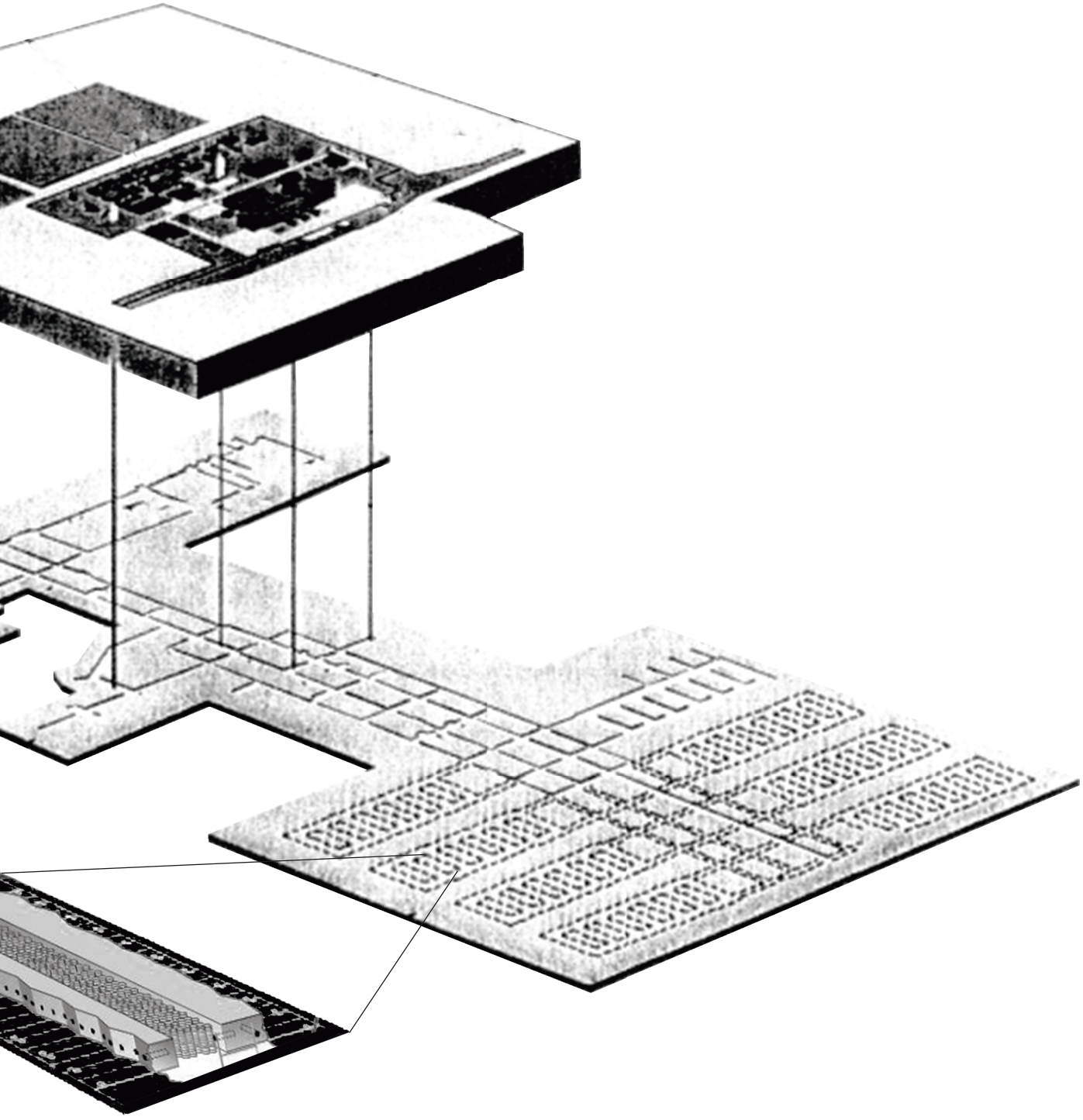


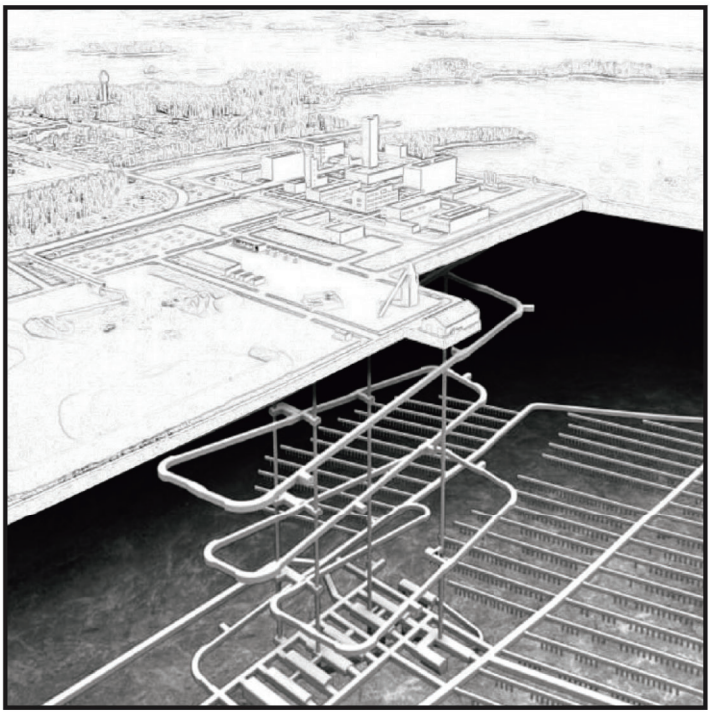
Chernobyl Nuclear Accident
Pripyat, Ukraine 1986

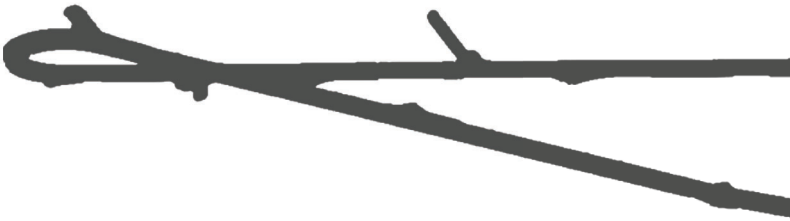




Waste Isolation Pilot Plant WIPP
New Mexico, U.S.A. 1999



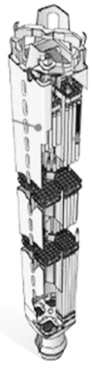




Final Repository

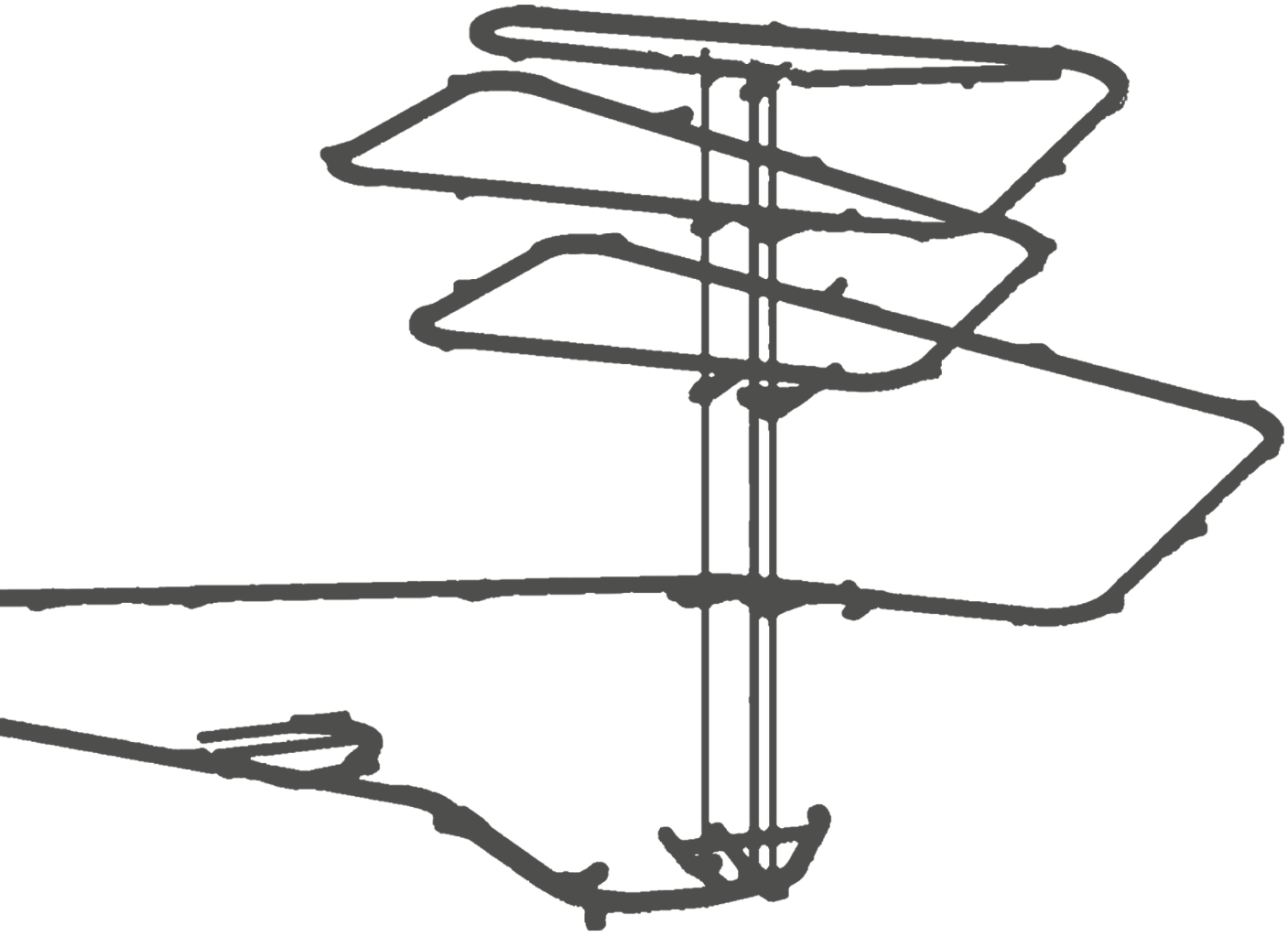
Cryrstalline Bedrock and Inside Bentonite Clay

Copper Canister and Nodular Iron Insert

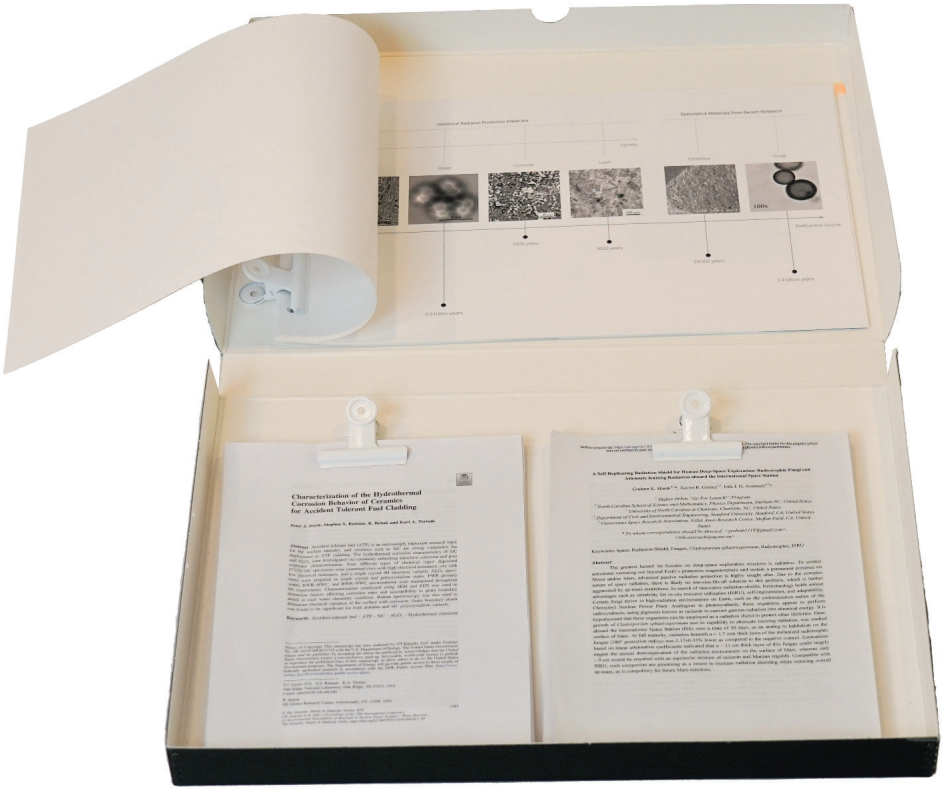


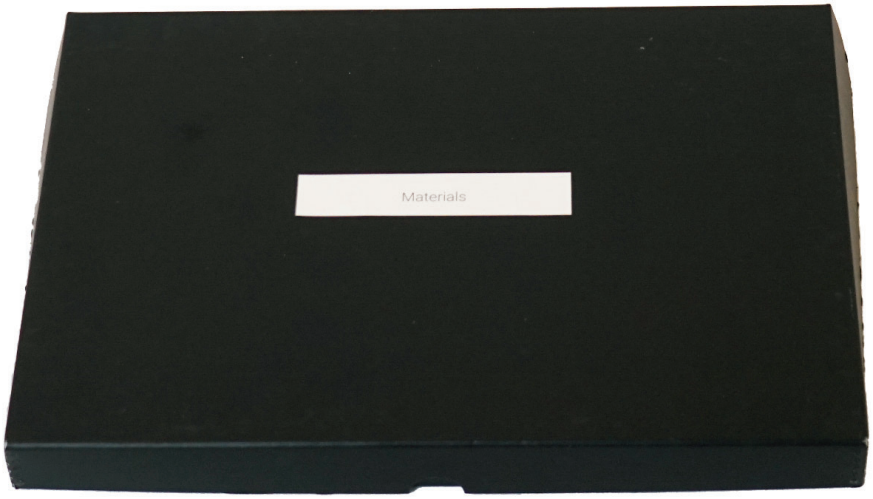
Spend Nuclear Fuel Assembly

Fuel Pellet and Cladding Tube



Onkalo Spent Nuclear Fuel Repository
Eurajoki, Finland 2025


Historical Radiation Protection Materials
Speculative Materials from Recent Research
Water
Concrete
Steel
Ceramics
Fungi
100s
Radioactive Source
Water years
1000 years
28,000 years
2.4 billion years
2.4 billion years


Materials

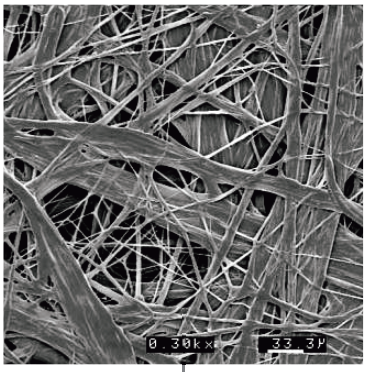
4. Materials Research

My work is based on the study of both historical radiation protection materials (concrete, lead and Tyvek), and most recently the research of new materials (fungi and ceramics). I am working through and speculating on ways of coexisting with radiation instead of traditional problem-solving methods that focus on overcoming, solving, remediating and isolating.

For the new materials: the research from NASA last year shows that a special radiotrophic fungi which survived in the Chernobyl nuclear power plant contains melanin and can absorb radiation. These experiments proved that this fungus reduced the radiation in the space station by 2%. Ceramic material is another potential radiation protection material in the future. Research shows that it can be used as cladding for nuclear fuel to contain radiation inside.

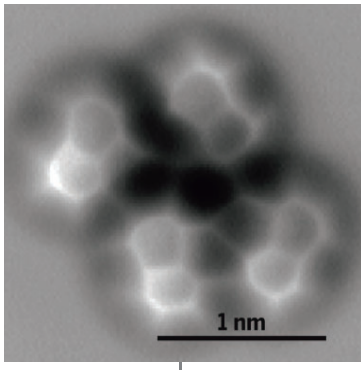
Historical Radiation Protection Materials

Tyvek



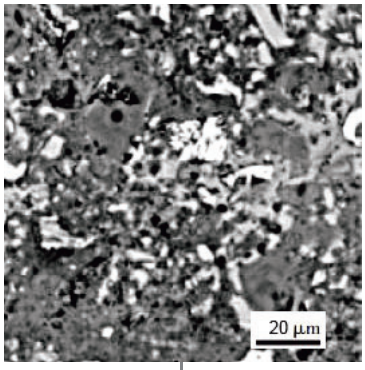
66 years

Water



3.8 billion years

Concrete

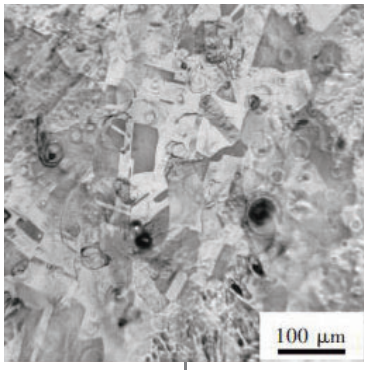


3300 years

Speculative Materials from Recent Research

Density

Lead

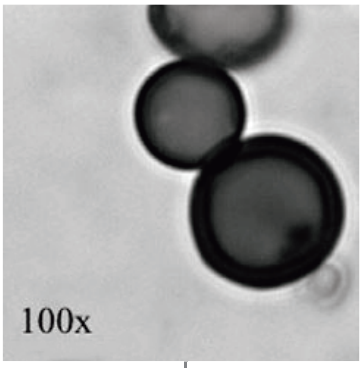


5000 years

Ceramics

28,000 years

Fungi



2.4 billion years

Radioactive Source

Tyvek (Image Source: DuPont)
Water (Image Source: Science)
Concrete (Image Source: Belgian Nuclear Research Centre)
Lead (Image Source: Nonferrous Metals Science and Engineering)
Ceramics (Image Source: Kleopatra)
Fungi (Image Source: Microbial Biotechnology)

Material Study Models

Fungi Growing Study

Week 0






Week 1-2

Week 3-4

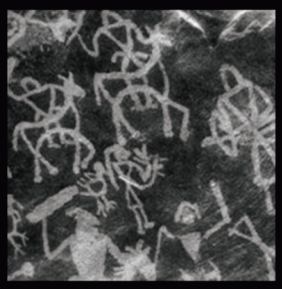
Chapter Four Timeline

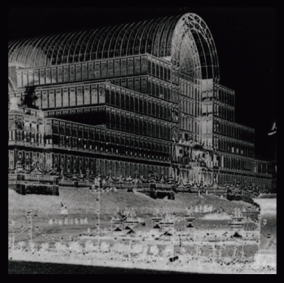
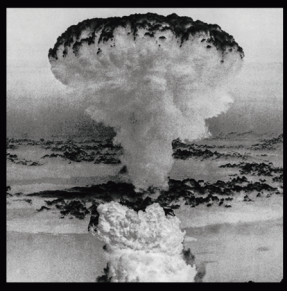
Considering design related to radiation from nuclear waste, the timeframe becomes a key subject. The whole nuclear waste decay period lasts more than 10,000 years, so it is useful to take time as an index in the form of an exponential axis: for individuals, it's less than 100 years; for species, it's hundreds of years; for industry, it's thousands of years; and for nuclear waste, it is more than 10,000 years. In order to begin to envision a future a hundred times longer out than a single human life, we may have to look backward. From events 10,000 years ago, only symbols and the broken ceramic pieces are now left to study. Thousands of years ago, we had the pyramids, the Great Wall, the water system for cities, and ritual stones left. In the past hundred years, industrial revolutions have changed our life but also brought environmental issues. In the last decades, we have already seen the impact of climate change, the Atomic Age, we extended our path to the moon, and we created another non-human species: the AI. Learning from the past helps us imagine the future.

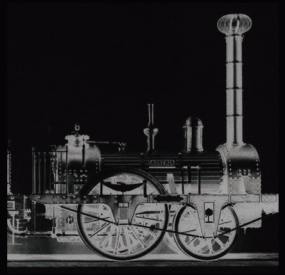
-10^4 -10^3 -10^2 0

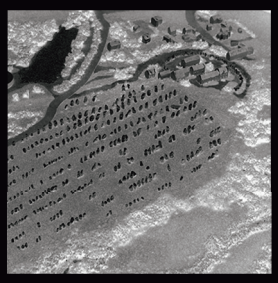
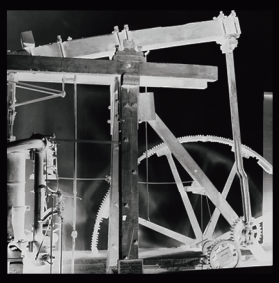


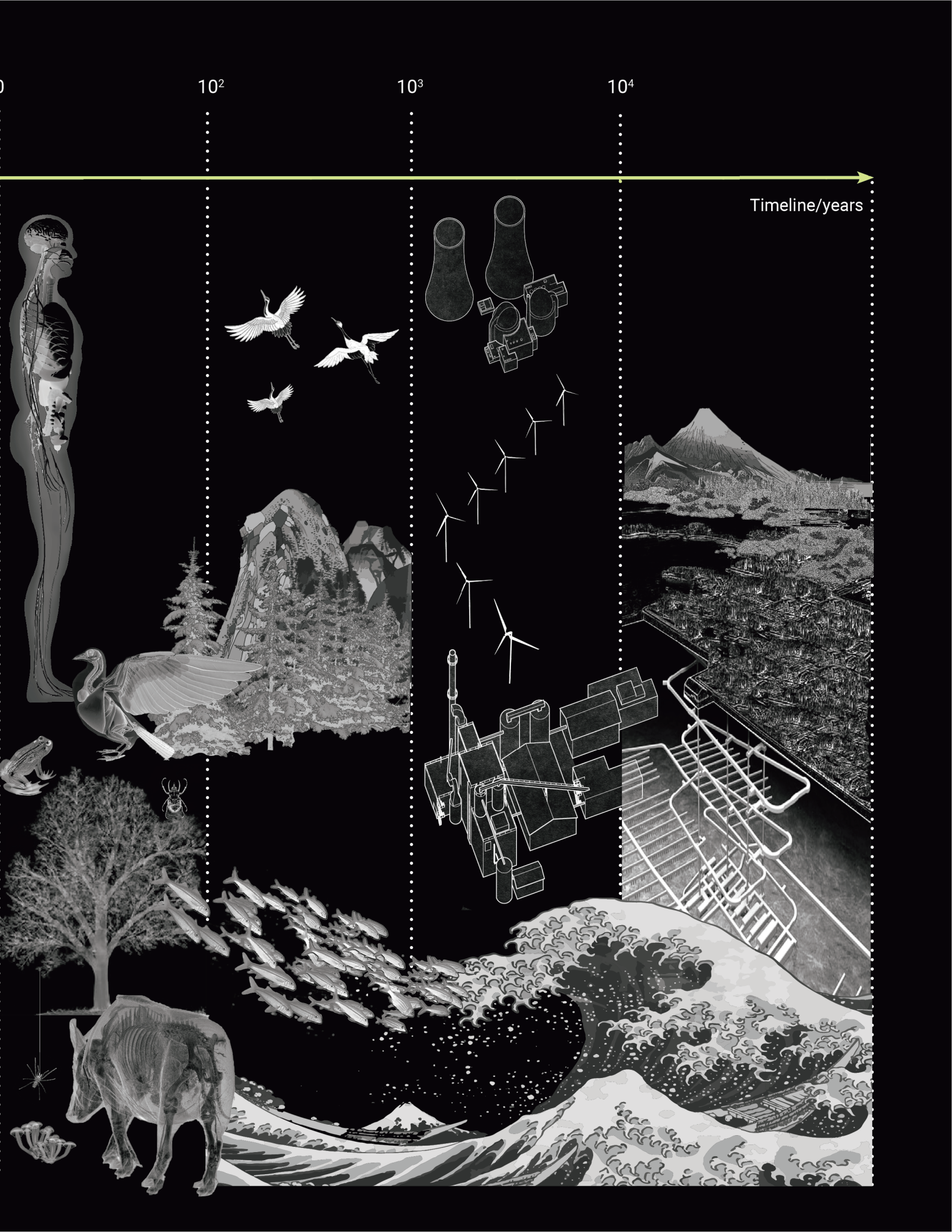




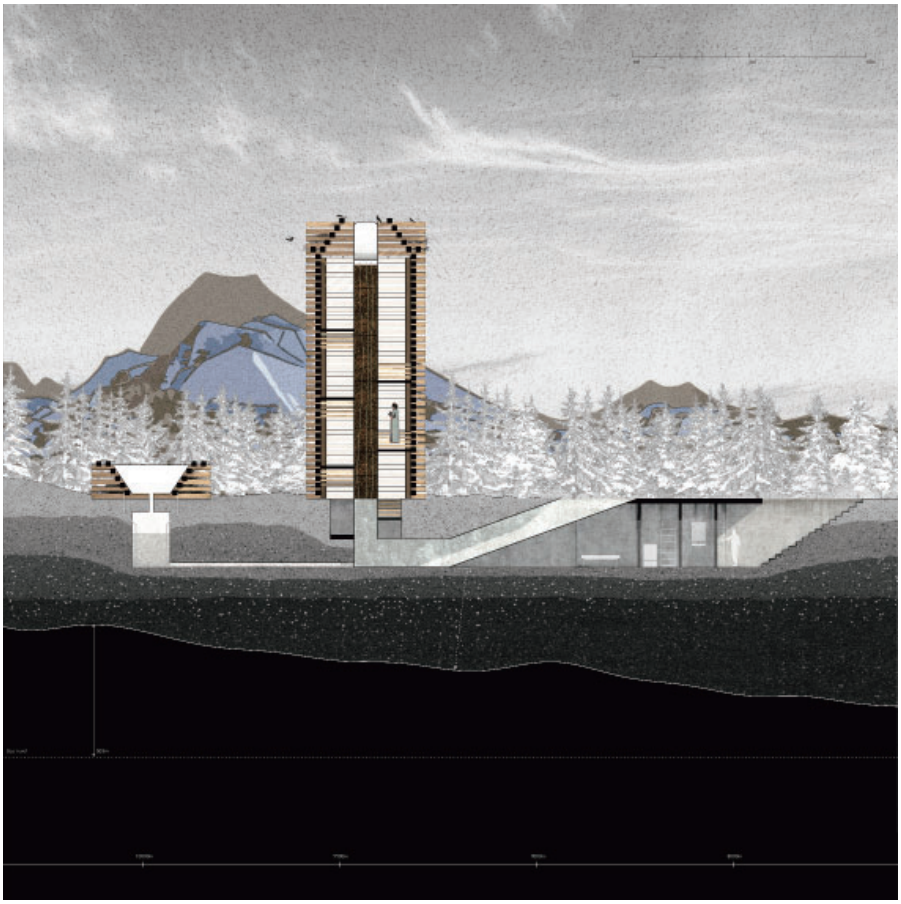






0
10²
10³
10⁴
Timeline/years

Chapter Five
Living in the Radioactive World

The speculations in this project address both the near future and long-term future. For the near future, the relations between humans, nonhumans, and nuclear waste are considered. However, there is another long duration process that is competing with the 10,000 years of nuclear toxicity: the sea level rise will submerge this area of Japan before the radioactive materials have decayed. Therefore, nuclear waste and climate change are the main concerns in the long-term future.

I am speculating on the future of cohabitating with radiation on three different sites surrounding the site of the Fukushima Daiichi Nuclear Power Plants. They are places where humans work and live, and they also support some nonhuman species' life in the Fukushima exclusion zone. I chose different materials to correspond with the functions of places and their distance from the radiation source.

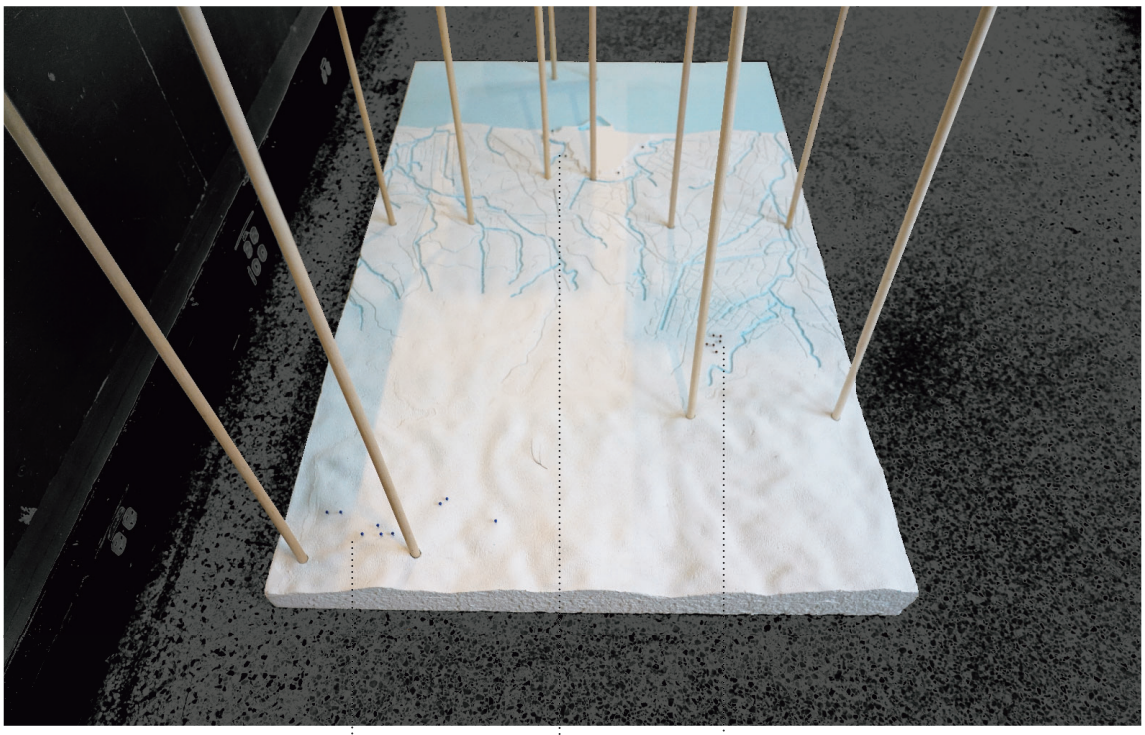


Fungi Cultivation Tower

Pill Livin

g Space

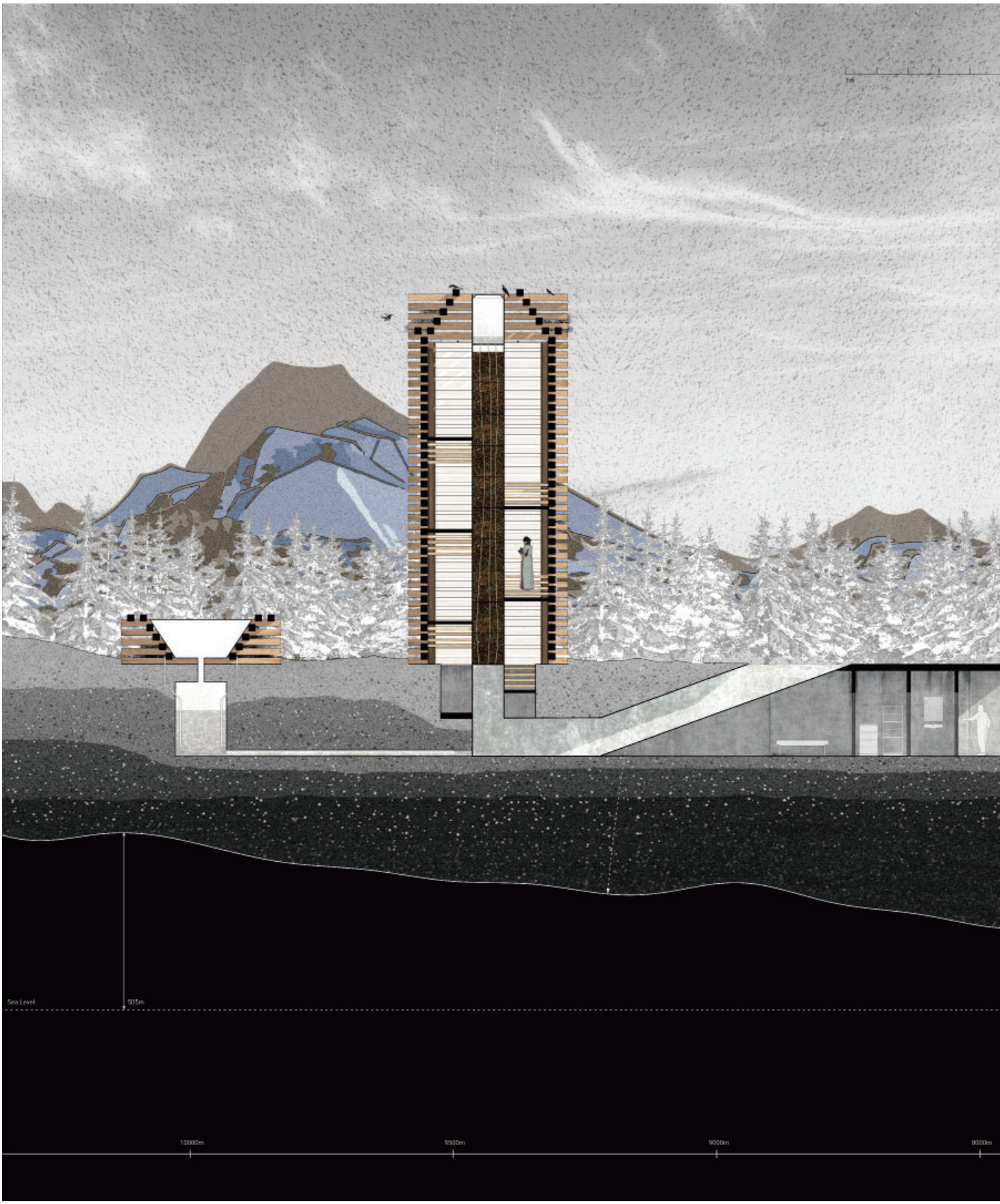
Ceramic Wall

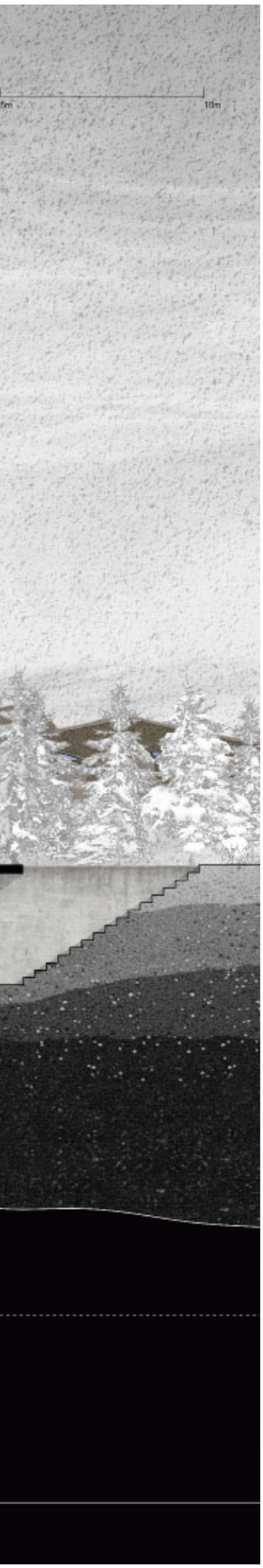


Montain Area
Fungi Cultivation Tower

Edge of the Fukushima NPP
Ceramic Wall

Former Farmland
Pill Living Space

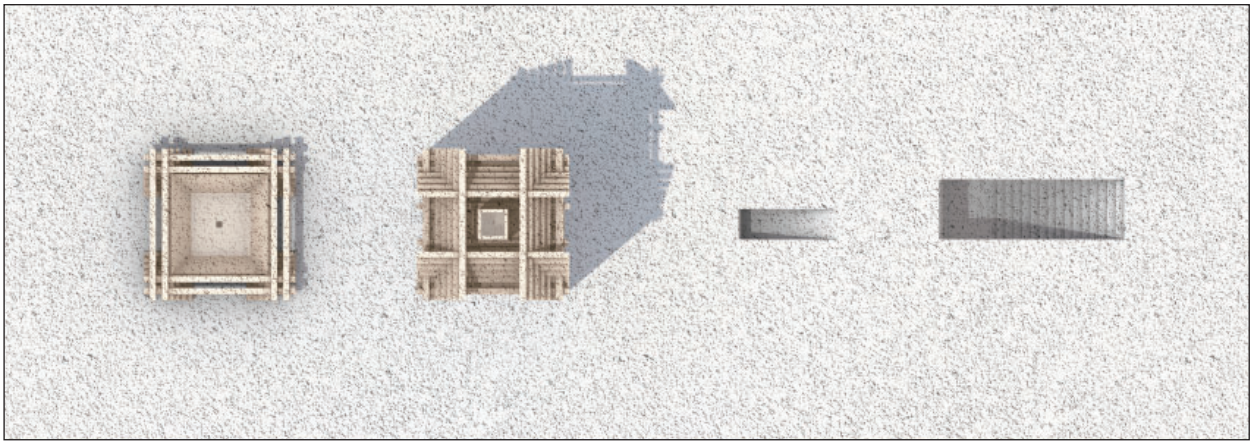

Sea Level
505m
10000m
9500m
9000m
8000m

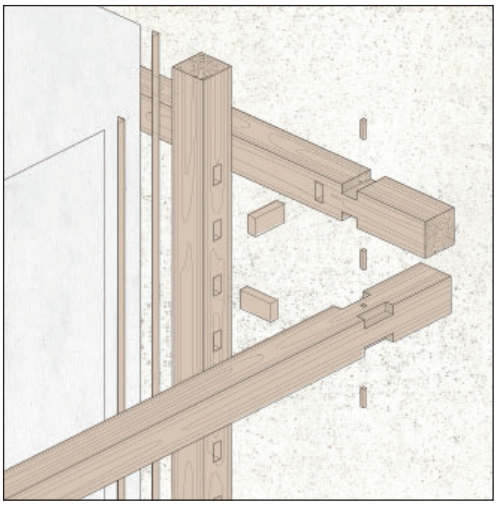


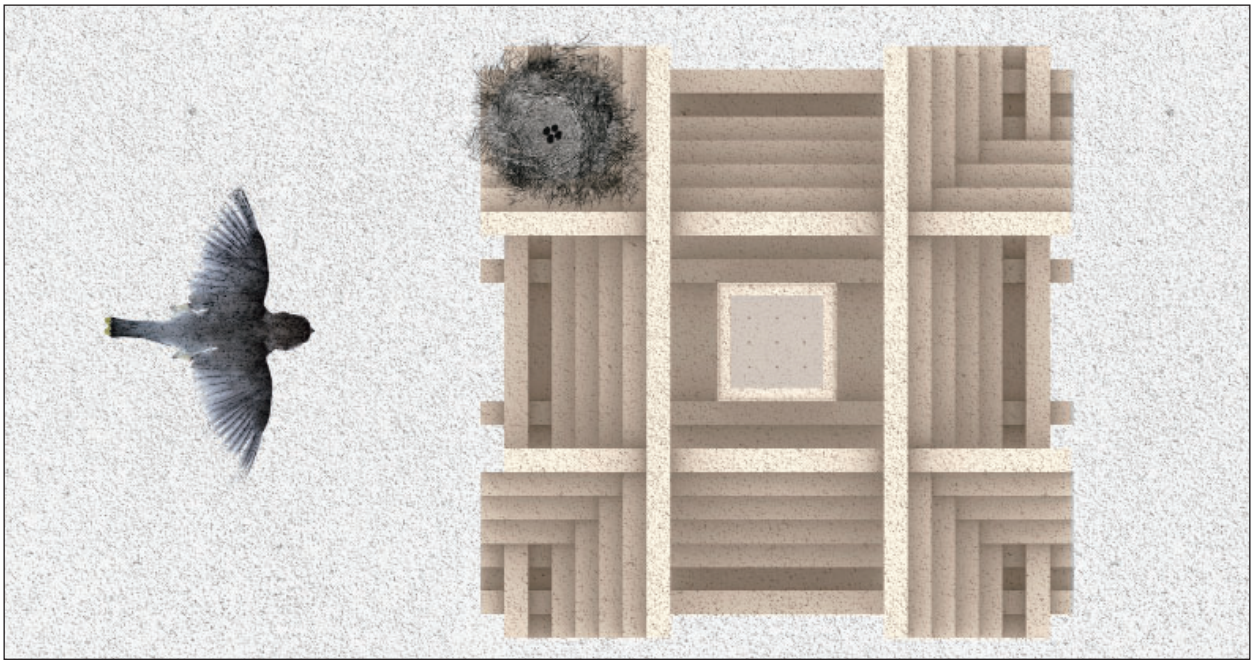
1. Fungi Cultivation

Fungi cultivation towers are located in the mountain area. After cultivation, these fungi bricks will be moved out through the tunnel and placed in the nuclear power plant to absorb radiation. Everyday, workers come here to check the growth of the fungi. They need to wear Hazmat suits in the outdoor space, go through the shower room to remove radioactive ions on their body, and then enter the workplace through the changing room.

The top water storage tank and the underground water storage tank provide water for the growth of the fungi. They also provide water to the surrounding animals. Because all the groundwater is polluted by radiation, rainwater is a relatively safe water source. The half-built nests on the top of the tower will be completed by birds, similar to the bottom dens for small animals. At night, light will attract insects to feed the birds.







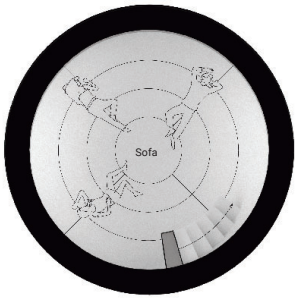
Left:
Night View
Roof Plan
Tyvek and Wood Connections
Right:
Half-buit Bird Nests


Sea Level
45m
7500m
7000m
6500m
5500m

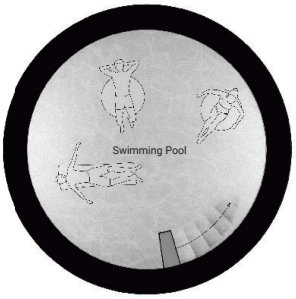
2. Pill Living Space

The living space is located in the former farmland near the foot of the mountains. There is a cluster of pills, with individual pills scattered around. The heavy concrete walls are designed to protect the people living inside. For the individual living units, the water in the basement offers a swimming pool for the residents and weight for the pill to stand. Pills in the corners of the cluster are designed to support the whole structure. The lifted-up living units use upper and lower spaces to distinguish the realms of animals and humans. The spaces let animals go through and moderate territorial disputes. The staircase in the middle leads to the shared platform on the second floor. Everyday, when workers go back home, the first step is taking off the Hazmat suit, then taking a shower to wash off the radiation on their body. Walking through the surrounding stairs, they pass the kitchen, dining room, a transformable space with a rotating wall, to the top bedroom with a dome ceiling. Here, neighbors talk with each other virtually in a new way because they need to minimize their time outside.

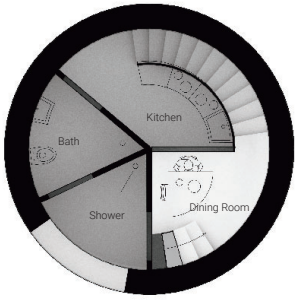
After being temporarily used by humans, these pills will be placed in the Fukushima Daiichi nuclear power plant to store nuclear waste in the long-term future. This geometry is also designed to prevent explosions caused by the high temperature inside the nuclear waste.



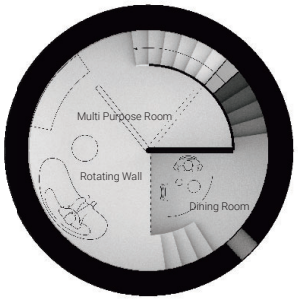
Basement 1



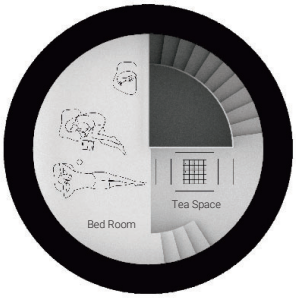
Basement 2



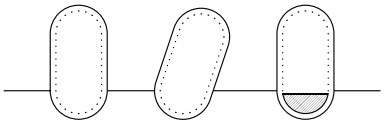
1F



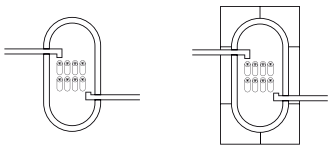
2F



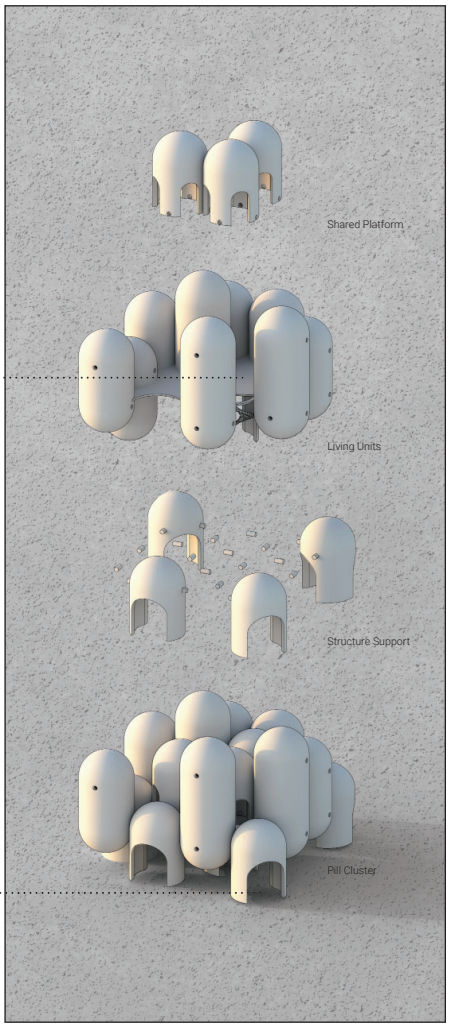
3F



Single Living Pill



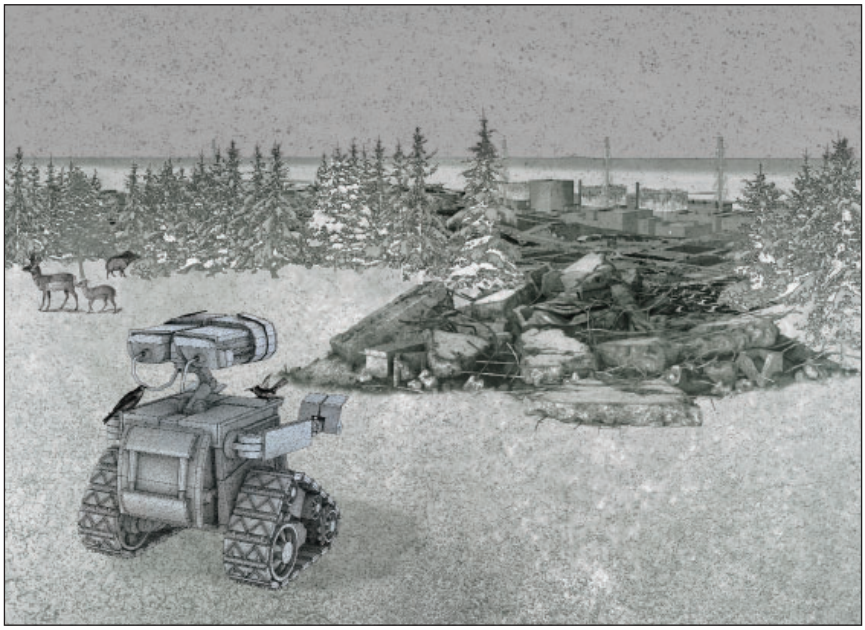
Longterm Nuclear Waste Storage Space With Fungi Bricks


Shared Platform
Living Units
Structure Support
Pill Cluster

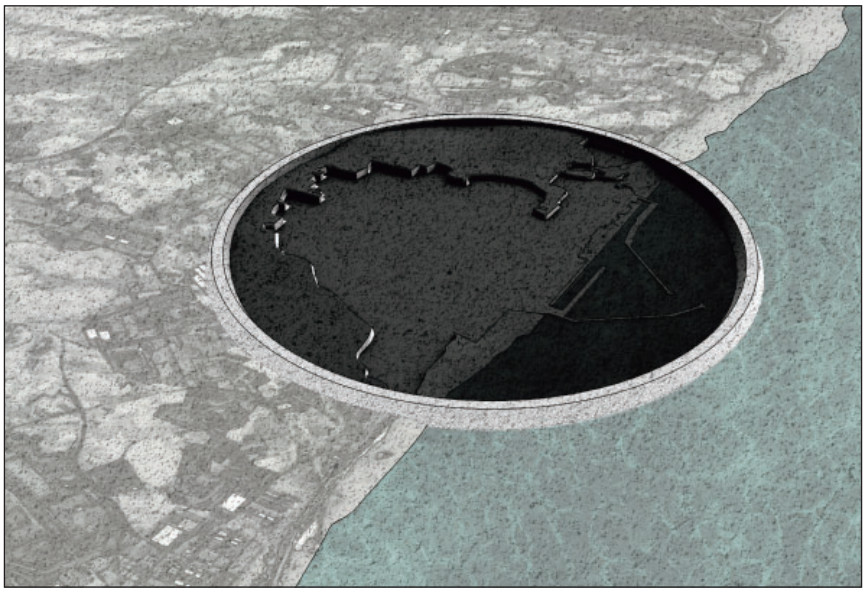

1m
Sea Level
35m
500m
0m
500m

3. Ceramic Wall

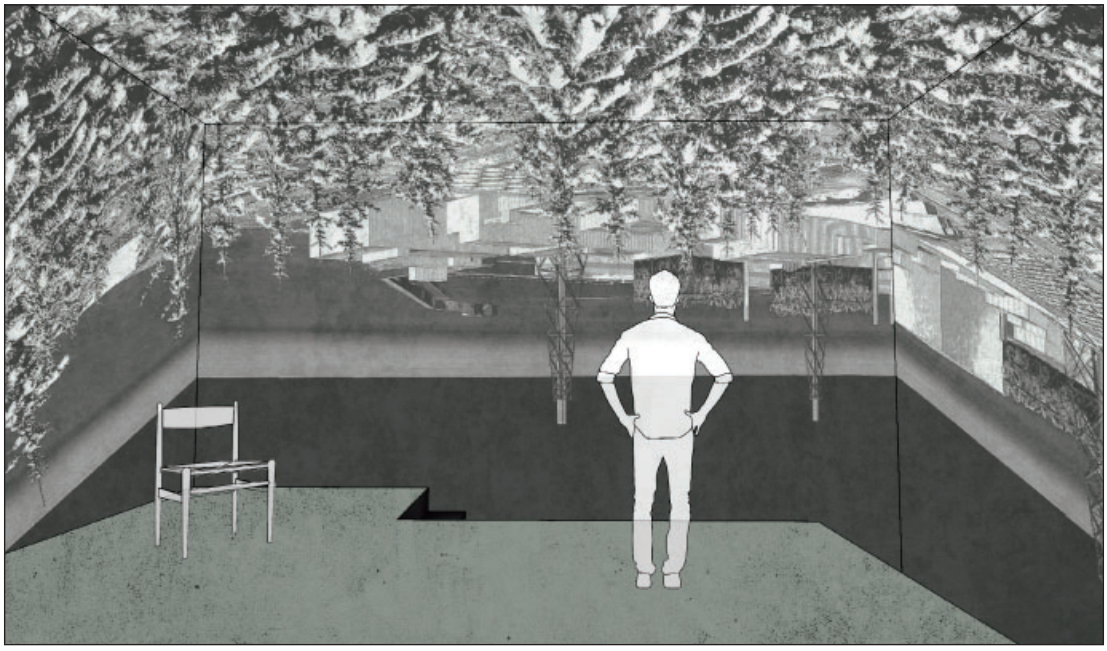
On the edge of the Fukushima nuclear power plant, lead-brick workplaces were designed for humans to manipulate robots to work in high-radiation areas. Instead of windows, the small pinhole in the inclined walls provides the workers with a view of the outside and ensures protection from the high radiation doses. The robot pushes the building rubble from the surrounding abandoned cities and pours concrete into walls built from the ceramic coated bricks to resist sea level rise.



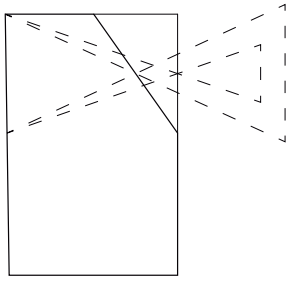
Working Robot



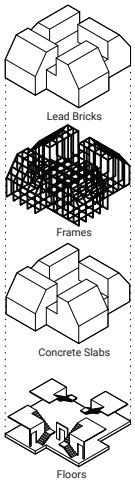
Ceramic Wall to Resist Sea Level Rise

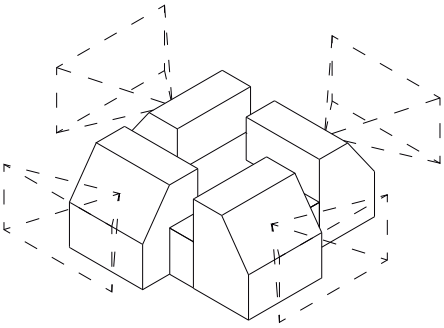


Pinhole Room



Pinhole Camera





Pinhole Camera Projected in Different Directions

The wall will be under construction for a while; this is a story without an ending. Thinking on the 10,000-year scale is both beyond human cognition because of our own ignorance and incompetence, and it includes all kinds of uncertainties external to humans, so the design can't be verified by true or false, right or wrong, and good or bad. In this timescale, the narrative is broken. Maybe all my tests will fail. However, I put the lab on the table, and I grab some pieces from this lab to negotiate with radiation based on my experience, memories, knowledge and imagination. I offer these fragments as clues for the possible futures and for others to trigger their memories and thoughts based on their understanding of the radioactive world.

Chapter Six Final Review

Photo Credits:
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Page 193 Daisy Zhang, Feiyue Chen
Page 194-195 Joel Cunningham
Page 196-197 Daisy Zhang
Page 198-199 Daisy Zhang, Jin Gao

Videos

1. History and Fukushima Now https://www.youtube.com/watch?v=1WLhblZ2IqM

2. Fungi Cultivation: https://www.youtube.com/watch?v=69nPlmmv5J0

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