AUTOPOIETIC LANDSCAPES :

The Architectural Implications of Mining the Marcellus Shale

by Catherine Winfield

B.S. Interior Design
Endicott College, 2007

Submitted to the Department of Architecture, February 2013
in partial fulfillment of the requirements for the degree of
Master of Architecture at the Massachusetts Institute of Technology

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Abstract

Hydraulic fracturing, a form of natural gas extraction, is a process deeply embedded in the networks of politics, power, economics, energy, infrastructure, and land use. Hydraulic fracturing has become a standard practice by energy companies looking to capitalize of dwindling resources. This coupled with the discovery of 2.2 trillion cubic feet of natural gas within the United States has expanded the practice of hydraulic fracturing at an alarming rate.

This thesis explores the impacts of this process through the design of a series of site interventions based on the conceptual exploitation of its current failures. The failures of the system exploited include the deregulation of the industry and the risk that such large scale toxic processes create.

These site interventions varying in scale, impact, execution, and discipline. As fracking proliferates, these interventions become more legible across the landscape, indicators of contamination. This thesis does not seek to demonize the practice of hydraulic fracturing. Rather this thesis seeks to produce a "fracked urbanism" which has embedded these atmospheric indicators, reflecting the multivalent impacts of hydraulic fracturing. Therefore, creating an autopoietic landscape, a landscape whose architectural, technological and infrastructural components ebb and flow with the presence of the fracking's failures.

Thesis Supervisor : Sheila Kennedy
Title: Professor of the Practice

Acknowledgments

I would like to thank the faculty, staff and students of the Department of Architecture who have supported and motivated me over the past three and half years. I am truly grateful to have been a part of such an amazing community.

My sincerest gratitude is also extended to my committee all of whom have guided me during my entire education at MIT. Sheila, thank you for your confidence, patience and humour. Ana, thank you for going above and beyond the description of reader, your guidance was unparalleled. Skylar, thank you for your time and interest in my work as early as my first semester.

Lastly, I would like to thank Sara Hirschman, Juan Jofre, Kyle Barker, Moe Amaya and Andrew Manto who all helped me in that last sprint to the final.

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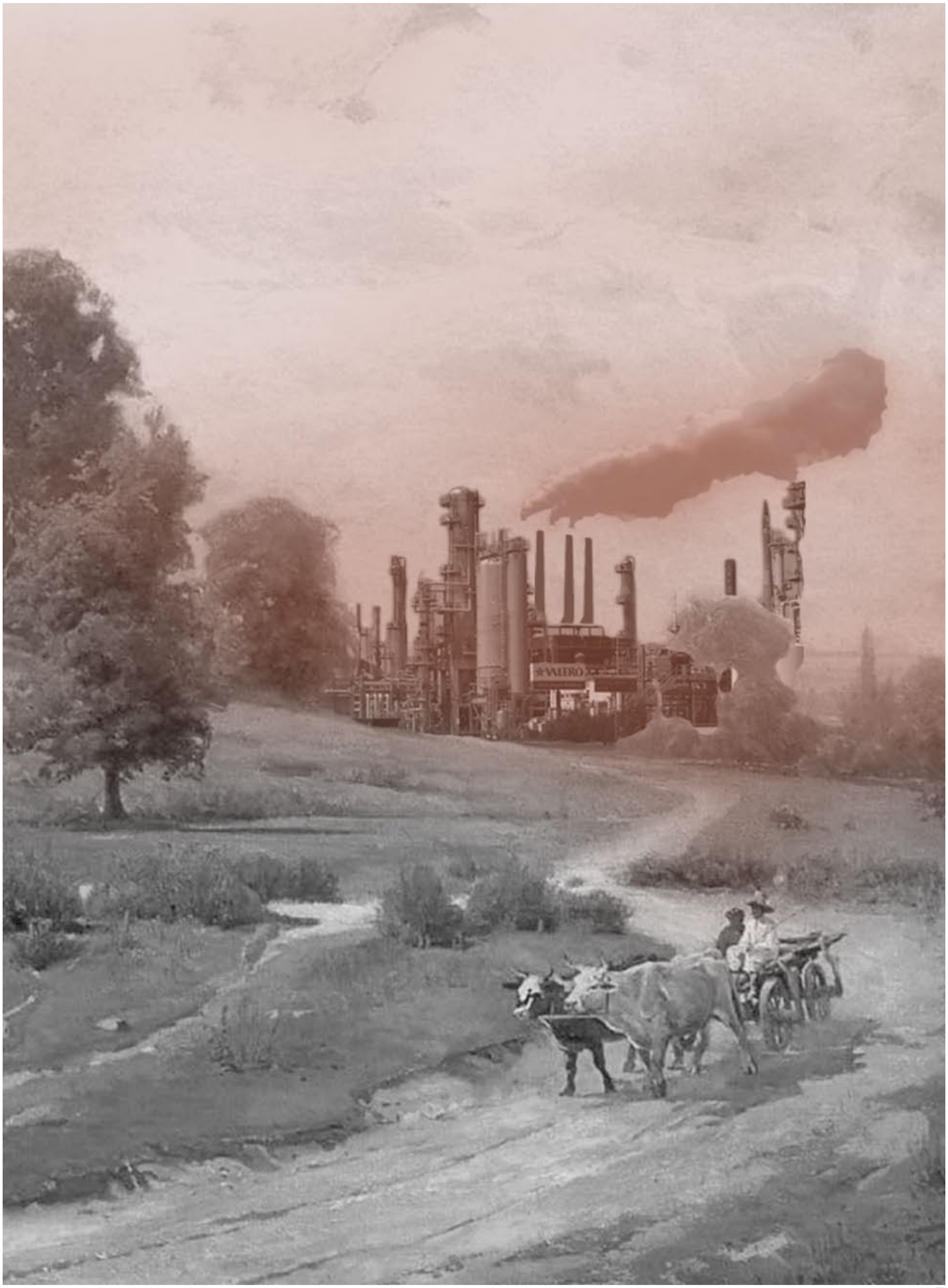
THE DISCOVERY

Hydraulic fracturing, better known as fracking is the process by which natural gas is mined from shale rock formations. The process of hydraulic fracturing is not new. The technology has been around for just over a hundred years. However, prior to the year 2000 many drill tests were required throughout a region to determine the location of the natural gas far below the surface. This was costly and labor intensive, as well as requiring lengthy agreements with local municipalities since finding a desirable location to drill was complicated.

In 2000 Halliburton developed the process now known as horizontal fracking. This procedure allowed drillers to drill a single hole, and at a desirable depth move the drill from a vertical orientation to a horizontal one. This meant that drillers could "dig around" for awhile until they located a suitable source. As a result energy companies could negotiate with a single large land owner to have access to an entire region's gas supply.

This technological advance happened to coincide with a 2004 report published by the University of Pennsylvania announcing the discovery of 2.2 trillion cubic feet of natural gas trapped in shale rock formations in the US. This discovery signaled energy and economic hope for the United States.

Natural gas has the potential at least to cause a paradigm shift in the fueling of North America's energy future. Shale gas accounted for only 1 percent of US natural gas supply in 2000; today it is 20 percent. By 2035 it could be 50 percent. Another argument espoused by pro-natural gas supporters is that the abundance of natural gas in the United States means that costs of energy for Americans will drop significantly over the next few years. IHS Global Insight forecasts that the typical U.S. household will save $926 annually in disposable income from 2012 to 2015 thanks to cost savings that result from this new age of shale gas abundance. These savings are forecast to rise to nearly $2,000 by 2035.



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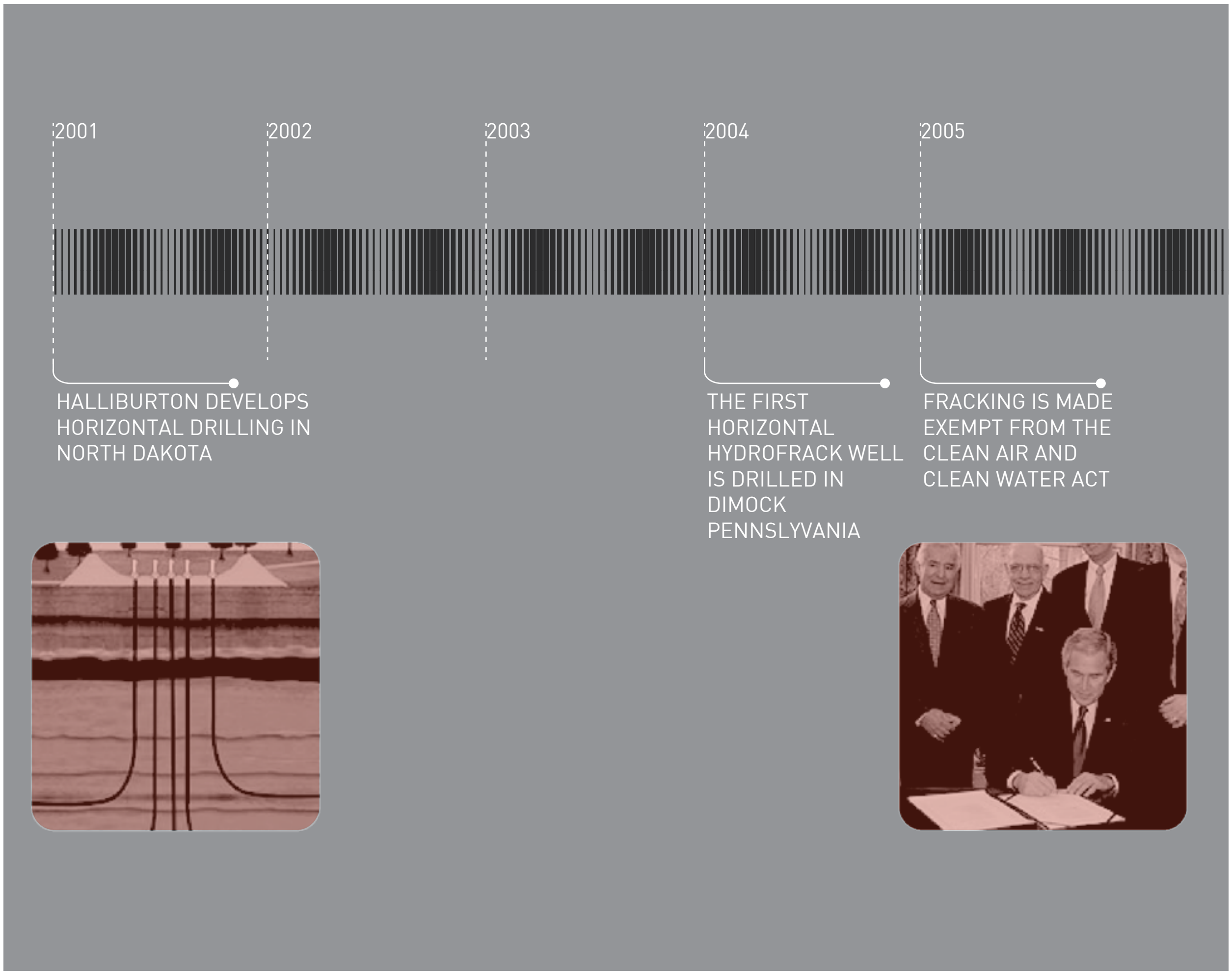
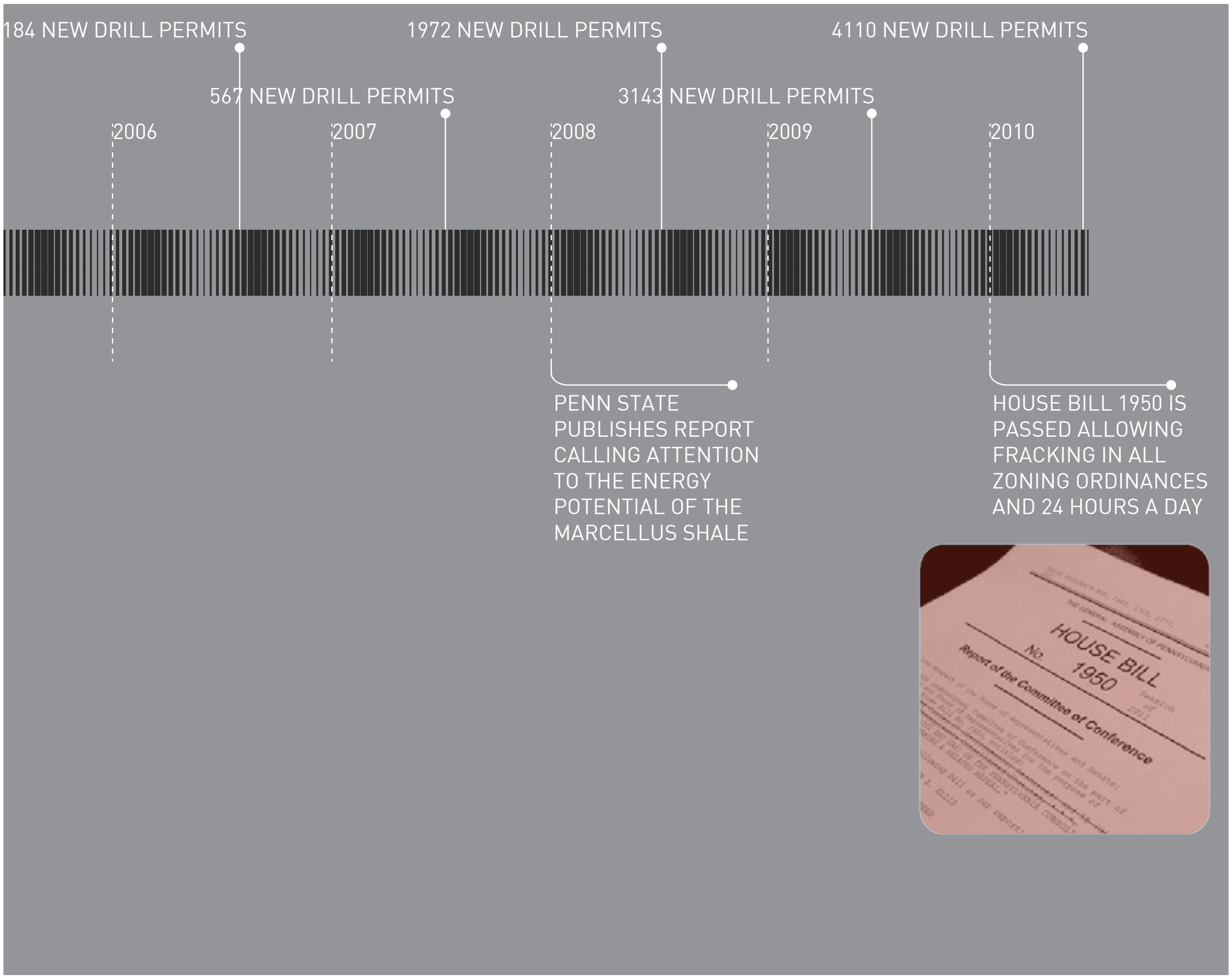


As the permitting for fracked wells began in the early 2000s many states standing to gain from natural gas extraction began rapidly deregulated the industry.

Perhaps the most impressive example of industry deregulation is that of House Bill 1950 also known as the Marcellus Shale Act. The bill states that the process of hydraulic fracturing can be extracted in any zoning ordinance at any time, in the state of Pennsylvania. This literally means that energy companies can conduct business whenever and wherever they see fit. This meant that the number of natural gas wells within the state exploded.

However, the most significant piece of legislature pertaining to hydraulic fracturing is the amendment to the Clean Air and Clean Water Act. In 2005 the process of hydraulic fracturing and its associated chemicals were removed from the Clean Air and Clean Water Acts by President George Bush. As a result the act of fracking and its multitude of environmental impacts are not regulated by the EPA or the DEP. Additionally, many of the procedures and chemicals used in the process are considered proprietary and such information can not be shared with governing bodies or the public, even in the face of documented corruption.

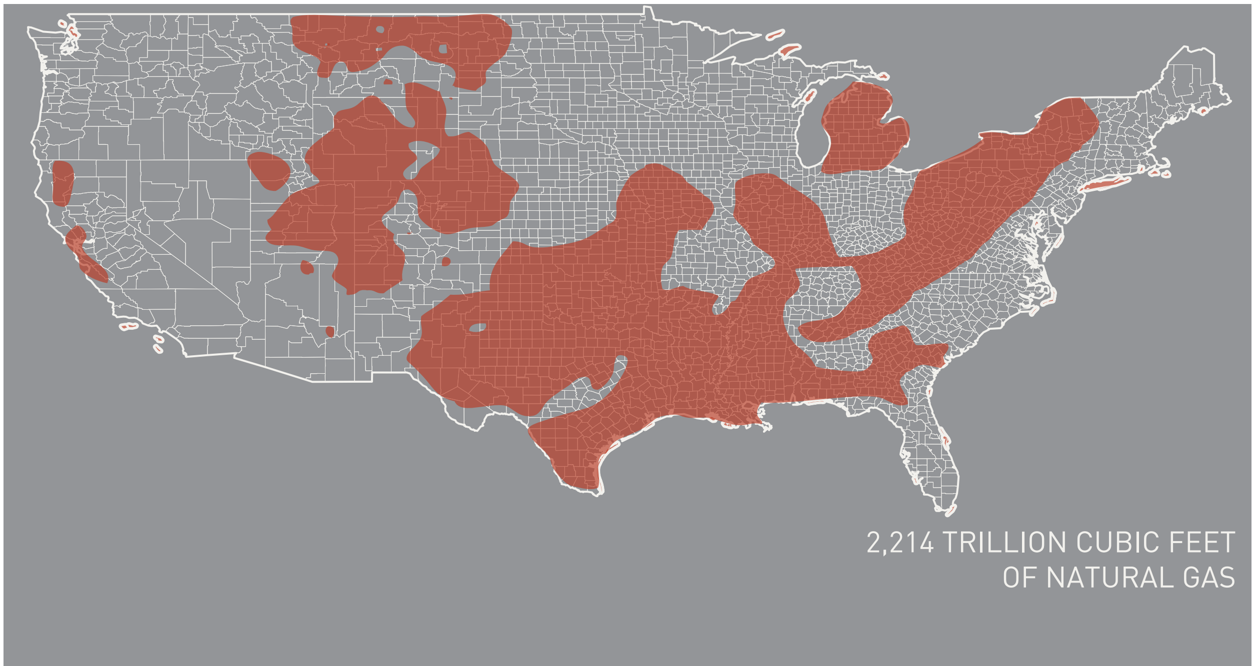


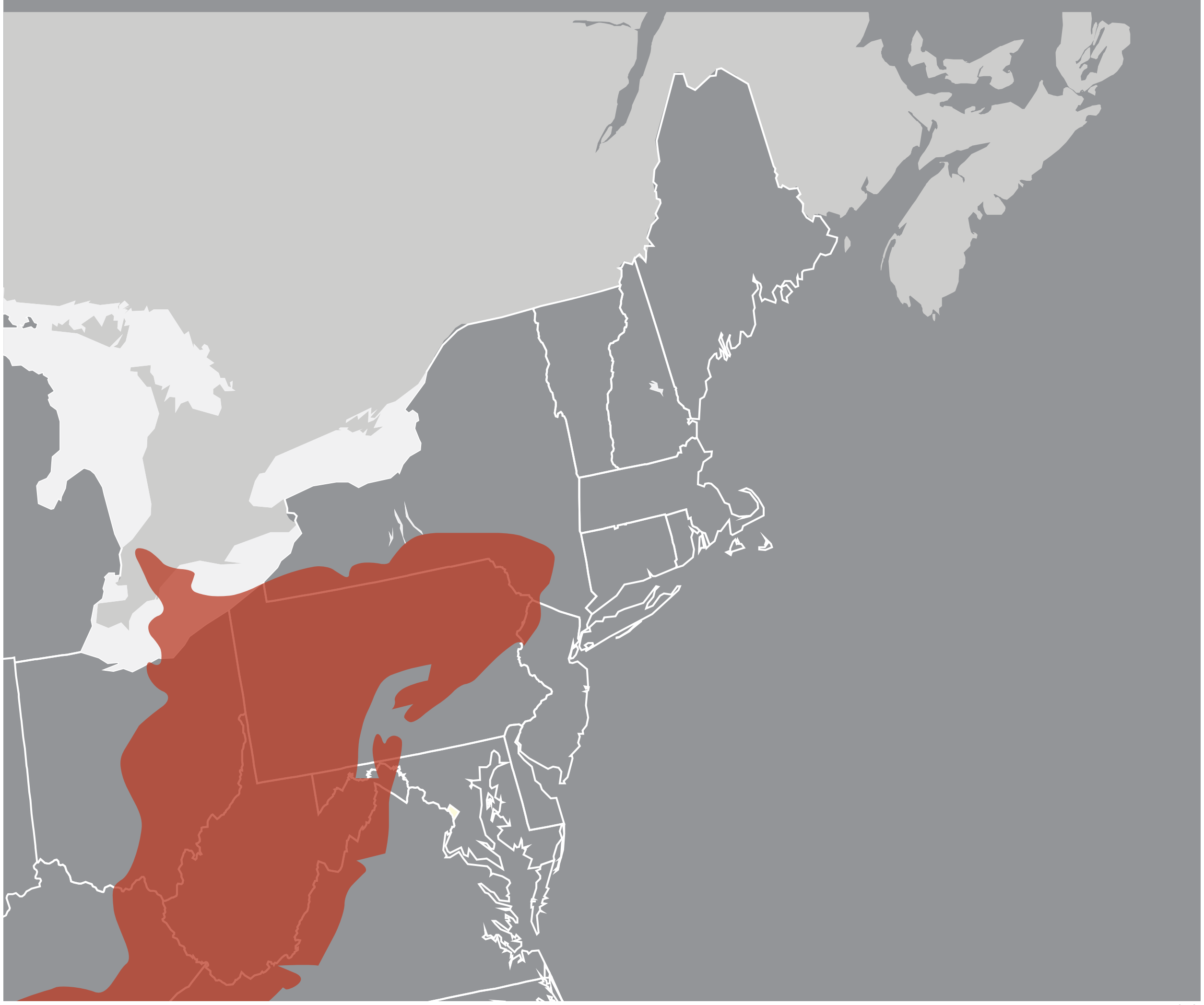
A clear example of the protection of industry procedures and chemicals is the Physician Gag Order of 2012. As a result of this act doctors who are treating patients with symptoms that are an alleged result of fracking pollution can receive a list of the chemicals used near that patient from energy companies. However, in order to obtain this list they must sign a nondisclosure agreement promising not to release the list of chemicals (seen as proprietary) to the patient or the public. Additionally, they cannot aggregate data about patients, or pass patient information to legal counsel even when patients have waived attorney client privilege.

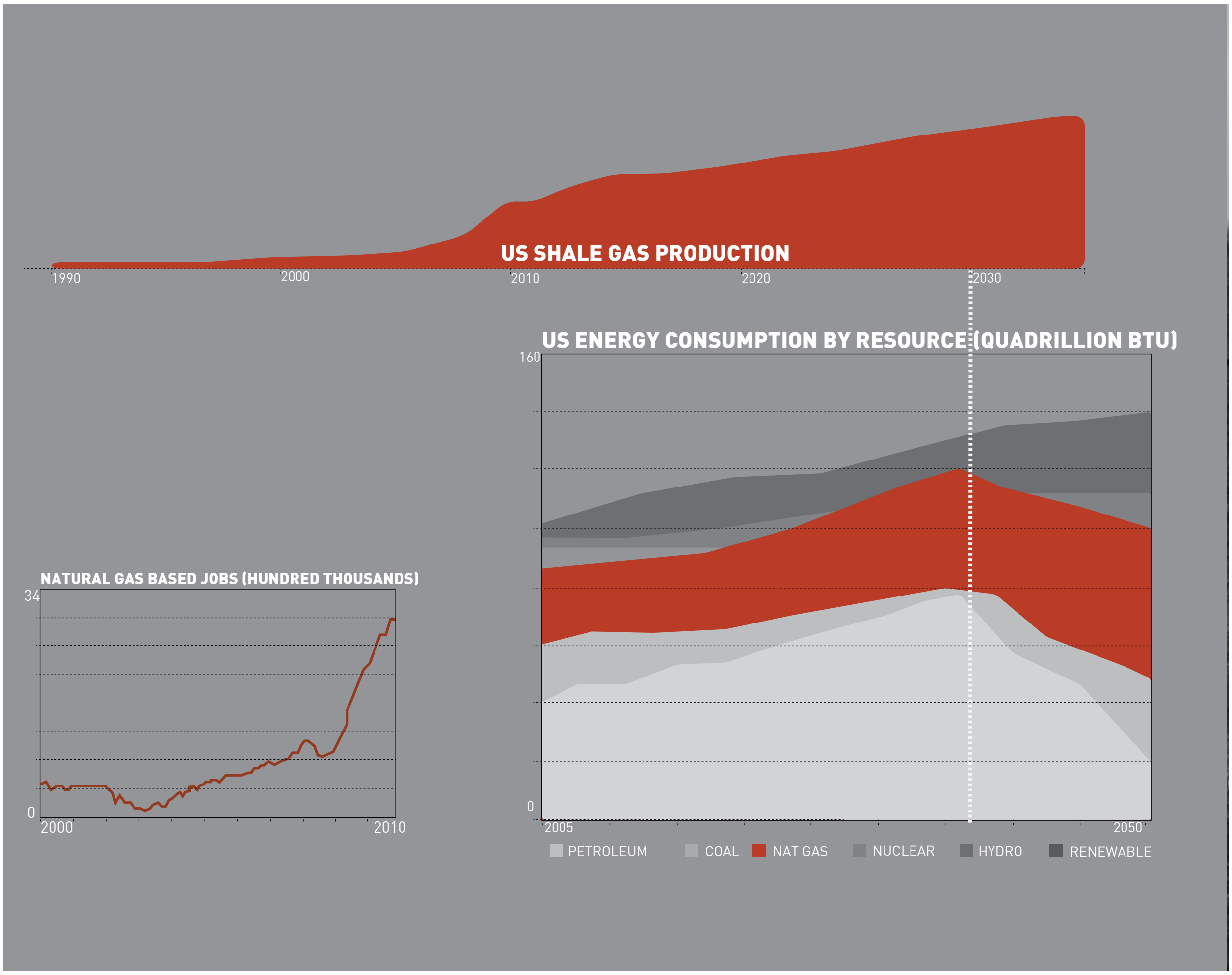
The 2.2 trillion cubic feet of natural gas discussed in the 2004 report published by the University of Pennsylvania also describes in detail the shale rock formations containing the gas.

One of the largest shale formations containing natural gas is that of the Marcellus Shale. Spanning upstate New York to Ohio this formation contains approximately 10% of all natural gas reserves in the United States. The Marcellus is not the only shale to experience a rush of extraction. The Barnett Shale in Texas and Niobrara in Colorado have both seen a boom in natural gas extraction. However, neither region has the population density that the Marcellus does. Additionally, the portion of the Marcellus located in upstate New York falls directly within the Catskill watershed. The largest unfiltered watershed in the United States. Its waterways serve 19.2 million residents in the greater New York metro area.

Assuming the United States does not sell or trade the reserves and that energy consumption remains the same or lower, the 2.2 trillion cubic feet of natural gas predicted would last this country approximately 90 years.


2,214 TRILLION CUBIC FEET
OF NATURAL GAS





Natural gas poses an exciting opportunity in the United States. At a time when the economy is suffering and fuel prices are rising the abundance of natural gas in the United States represents potential jobs and energy independence. Natural gas reserves can provide energy security for the United States. Its extraction could jump start regional economies through job creation, and its abundance could lower fuel prices nationally. Natural gas is also a significantly cleaner burning fuel than either oil or coal, and vehicles running on natural gas produce fewer emissions as well.

A recent study by PriceWaterhouse-Cooper and the National Association of Manufacturers found that U.S. manufacturing companies could employ one million more workers by 2025 as a result of the 2004 shale gas discovery.

Natural gas is also known for being a significantly cleaner burning fuel than oil. When burned to produce electricity no mercury is produced, and natural gas vehicles produce 25% fewer carbon emissions. According to the Congressional Research Service, if the United States doubled the utilization of our combined cycle natural gas capacity to 85%, we could displace about 19% of the CO2 emissions associated with coal power, or approximately 636 million metric tons of C02. This amounts to an 8.8% reduction of all C02 emissions in the United States.

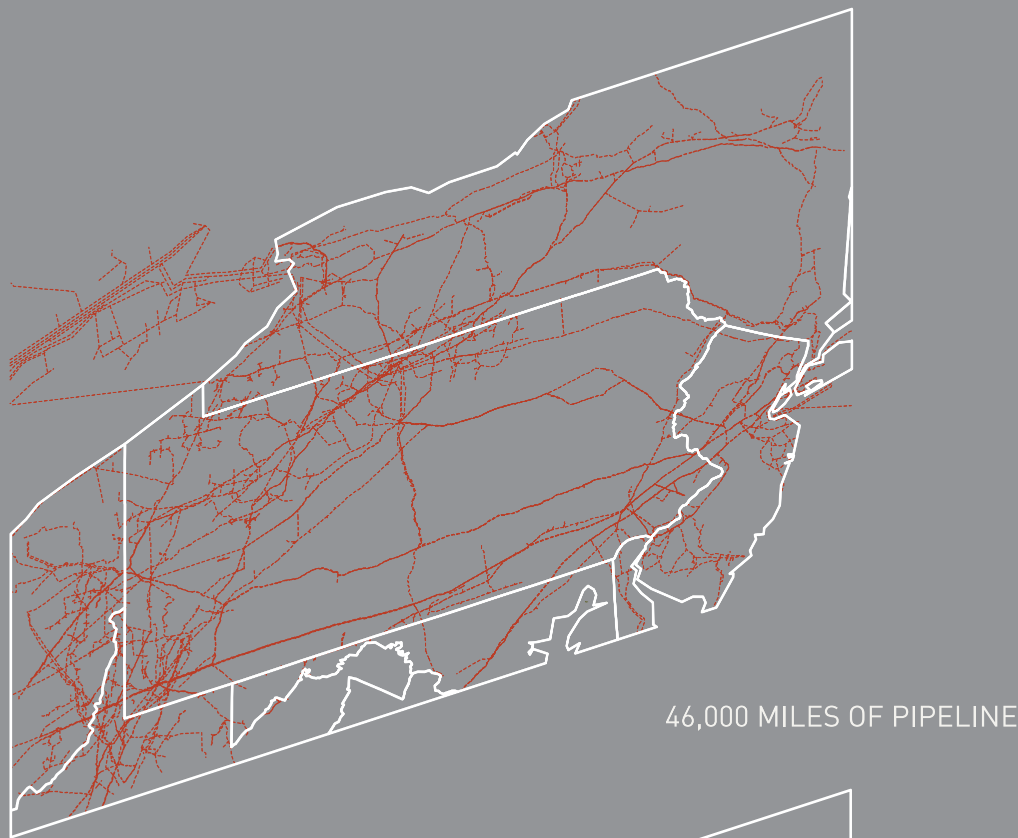
It is easy to see why there is such a rush in the attempt to extract natural gas given its potential as an energy source and the resultant potential of its extraction methods.

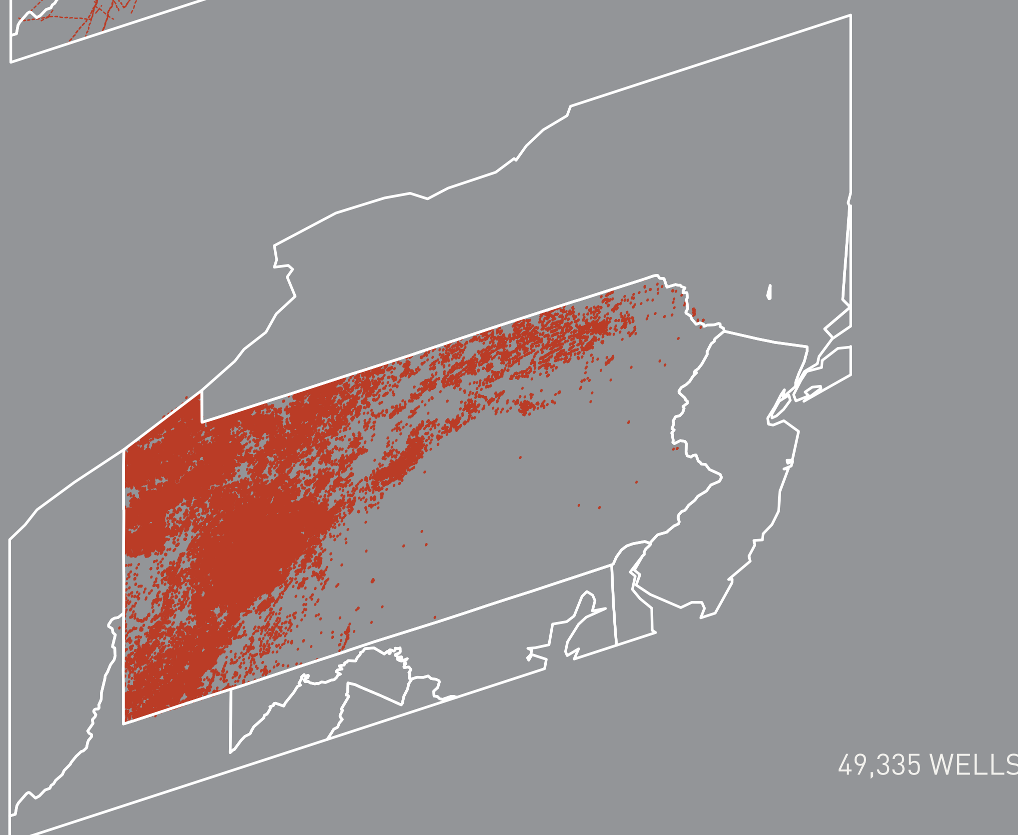
THE SITE

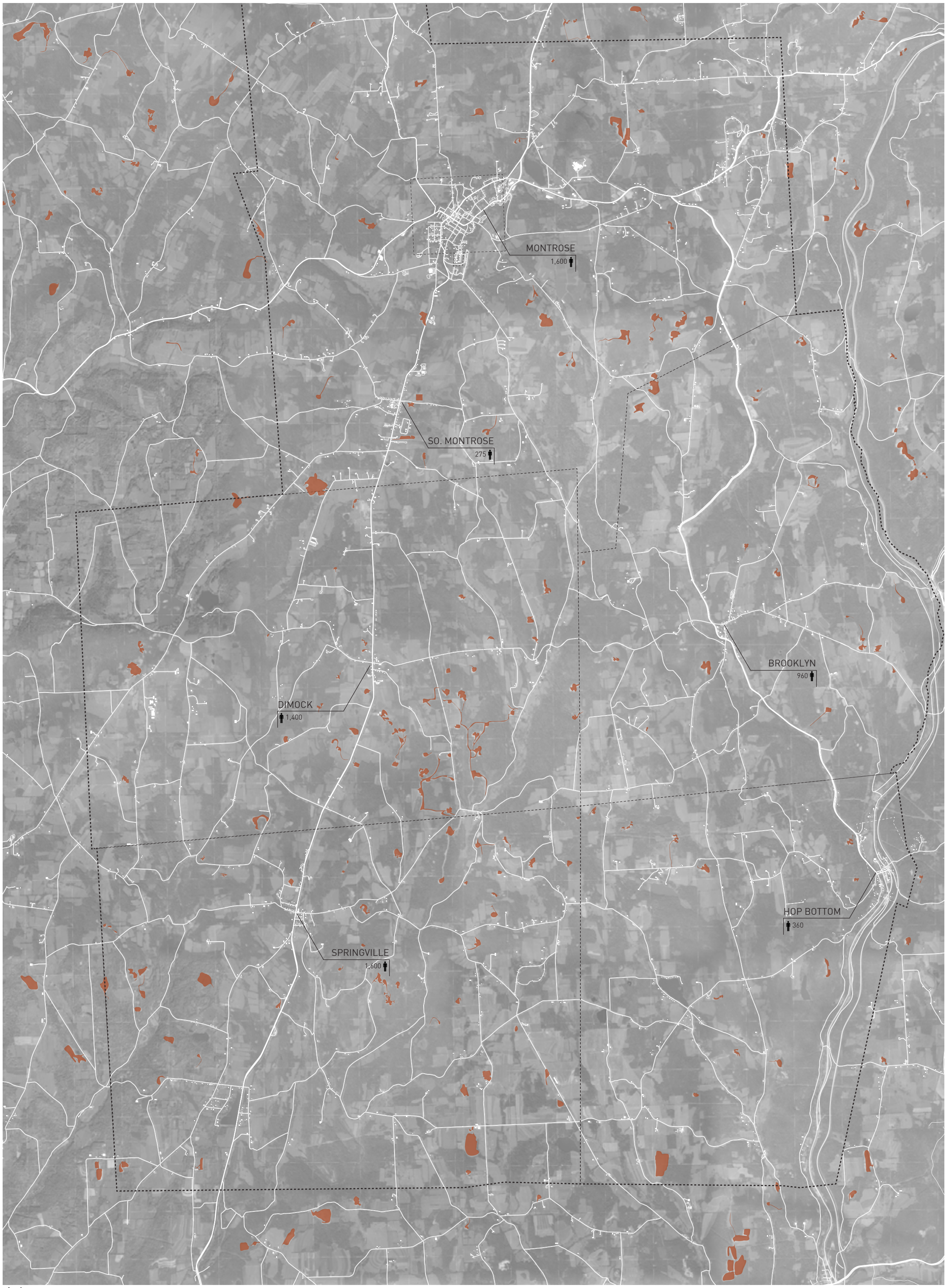
Of the states positioned to profit from the harvesting of natural gas in the Marcellus Shale formation Pennsylvania serves as a unique case study. The state is no stranger to natural resource extraction and has been home to a number of boom and bust cycles such as coal and steel. Both industries, now dead, leave the state looking for new economic opportunities.

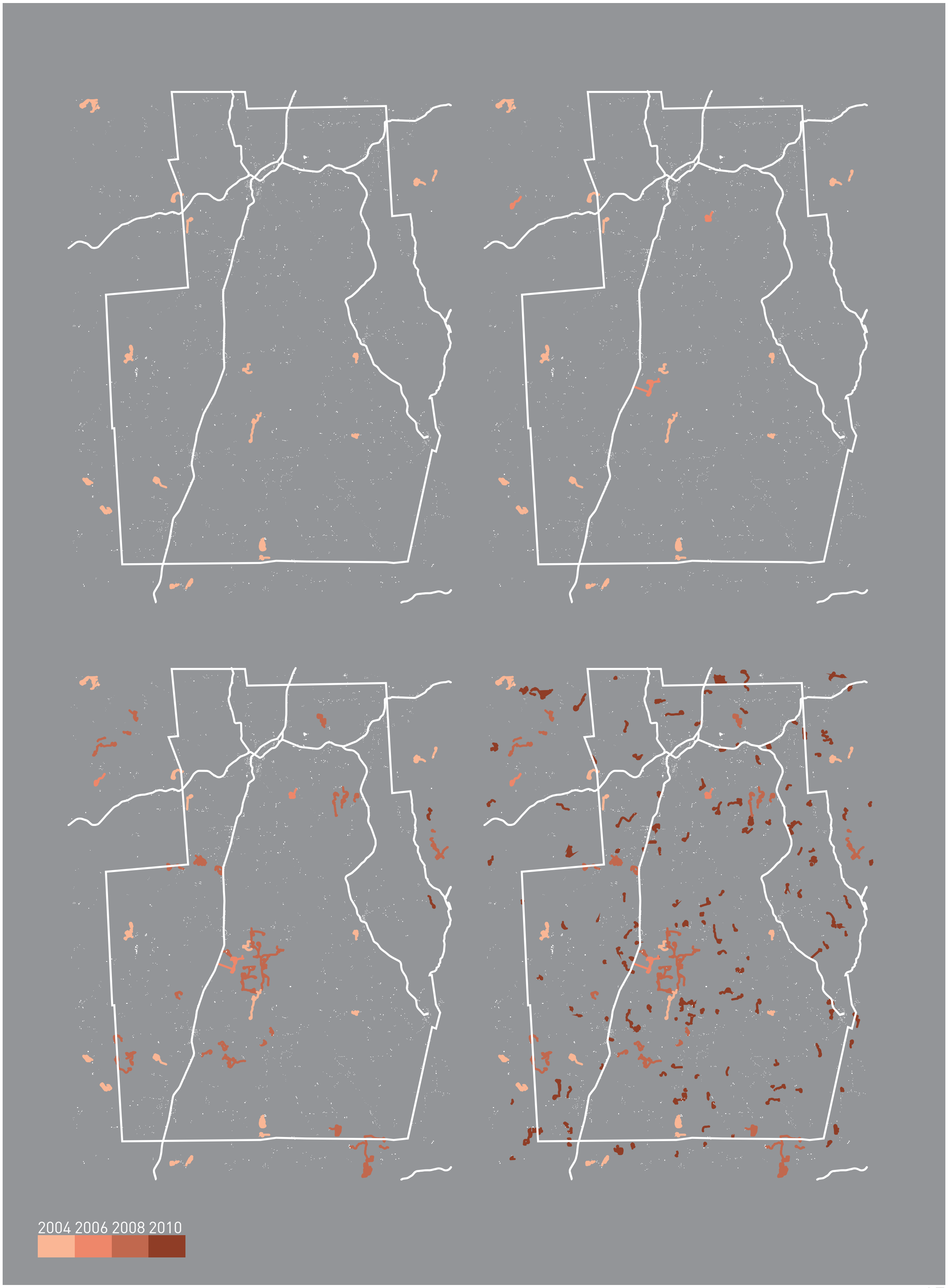
Within Pennsylvania several small communities have become "ground zeros" for fracking. These communities, were the first to have wells dug and now serve as case studies for impacts of the extraction.

Once such community is that of Dimock, Pennsylvania. Located in Susquehanna County, in the state's northwest region the township is perhaps the most well-known community in the state. The township torn by opposing sides on the fracking debate has been vocal nationally and globally. The township also starred in the 2010 documentary Gasland. The documentary certainly sensationalized the region and in search of a more realistic portrayal of the issues at stake in the processing of fracking, this site was selected.


46,000 MILES OF PIPELINE


49,335 WELLS


MONTROSE
1,600
SO. MONTROSE
275
BROOKLYN
960
DIMOCK
1,400
HOP BOTTOM
360
SPRINGVILLE
1,600

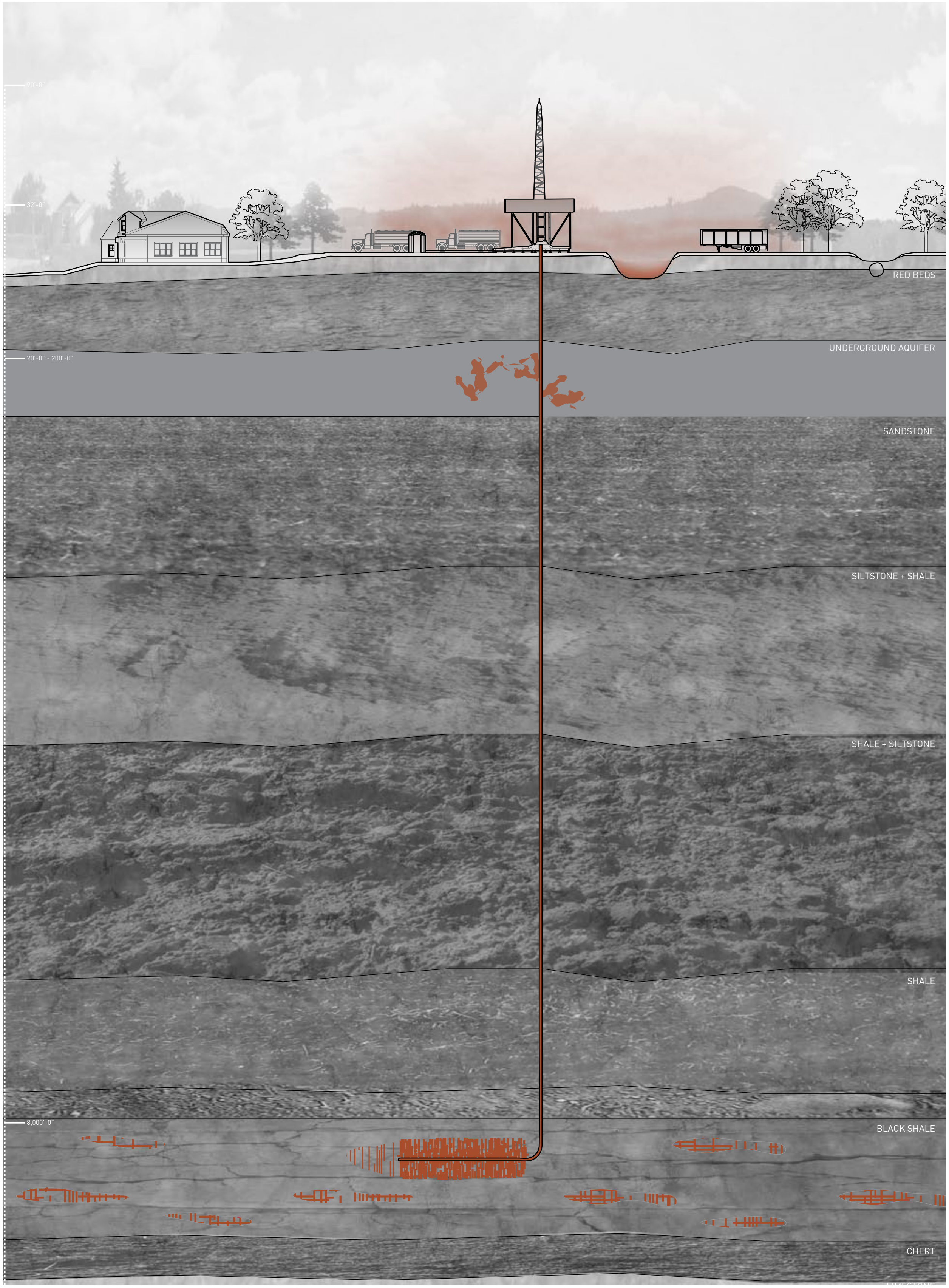

2004 2006 2008 2010

THE ANATOMY OF A FRACK

The process of fracking is a relatively short one; taking only nine to twelve months. Small well pads approximately three hundred by five hundred feet are clear cut, and a small hole approximately three feet in diameter is drilled into the ground. The depth of the drill is anywhere from two thousand to eight thousand feet below the surface.

Nine-hundred million gallons of water are then mixed with a toxic cocktail (including lead, arsenic, mercury, and radioactive isotopes) and pumped into the ground. This fluid is used to create enormous amounts of pressure within the hole that has been drilled. As the pressure builds within the shale rock it fractures and the natural gas is released and siphoned up the well.

As the natural gas comes up so does the fluid originally pumped into the ground. This regurgitated fluid, known as produced water, is then set aside to be treated or corruptly dumped. The storage methods of this fluid vary. In more responsible cases the fluid is set aside in large storage tanks. However, the prevailing practice is to dump the fluid into deep pits dug next to the well. These pits are lined with think plastic tarps and called evaporation pits because the fluid is left uncovered in them for the purpose of evaporating.



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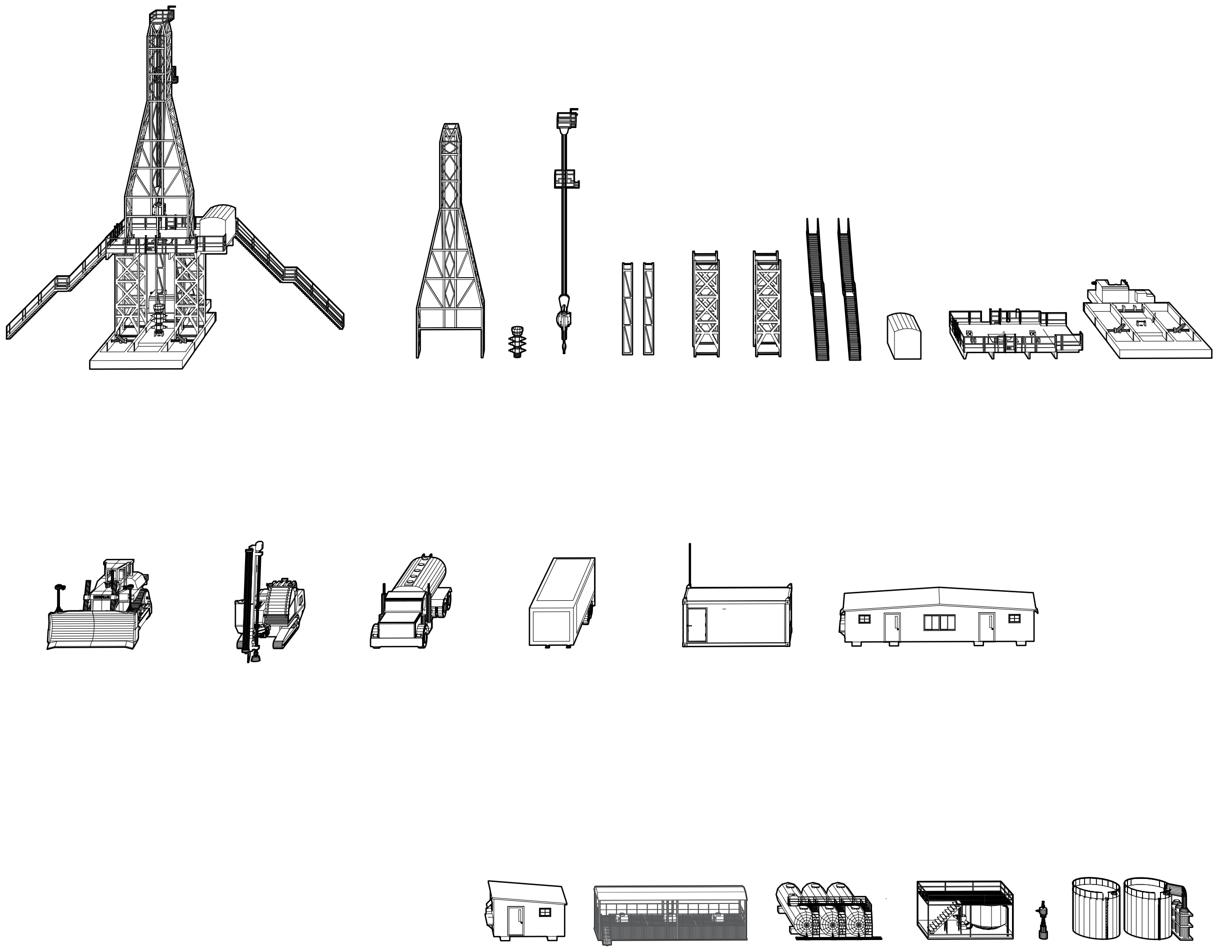
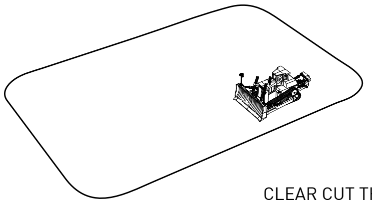
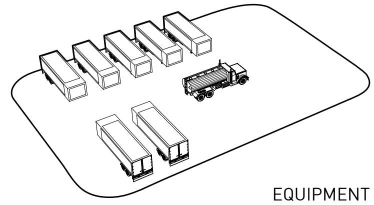


Derricks, rigs, drills, clear cutting equipment, etc. are normal parts of an extraction site. However, included in the equipment brought in for a frack is that of housing trailers for the workers. Crews of transient workers often live on site for the duration of a frack.

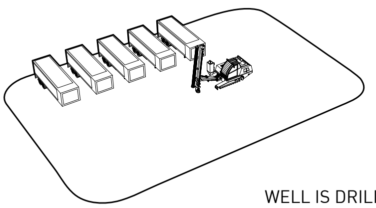
The teams are predominantly males between 18 – 40 years of age. As a result of the multitude of inherent job hazards (such as repeated exposure to toxic chemicals and equipment which is prone to explode) those who work on these teams generally carry six-figure salaries.



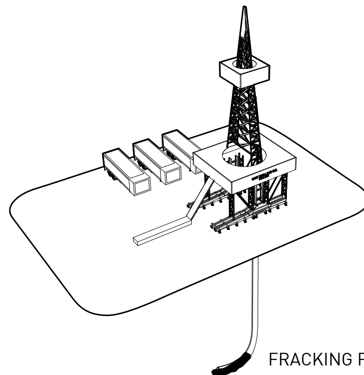
CLEAR CUT THE WELL PAD



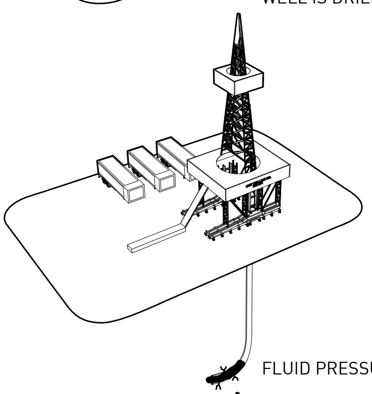
EQUIPMENT IS TRUCKED IN



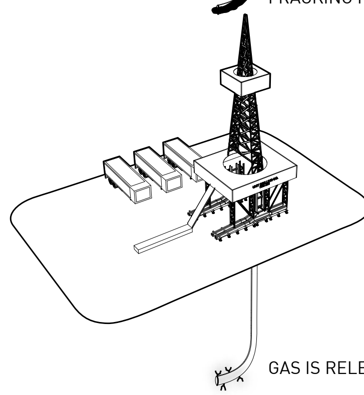
WELL IS DRILLED



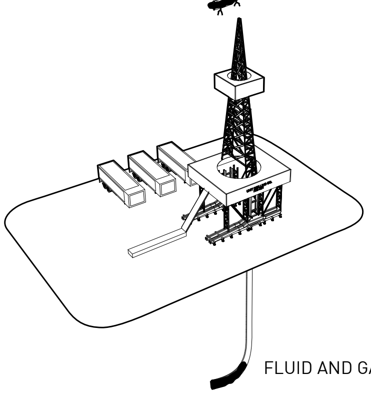
FRACKING FLUID IS PUMPED IN



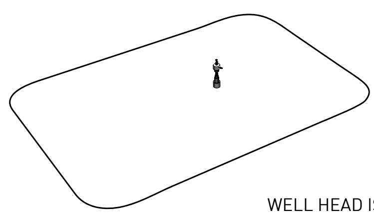
FLUID PRESSURE CREATES CRACKS



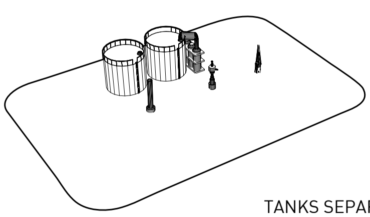
GAS IS RELEASED



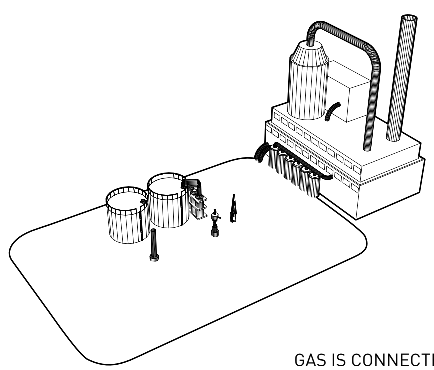
FLUID AND GAS IS PULLED UP THE WELL



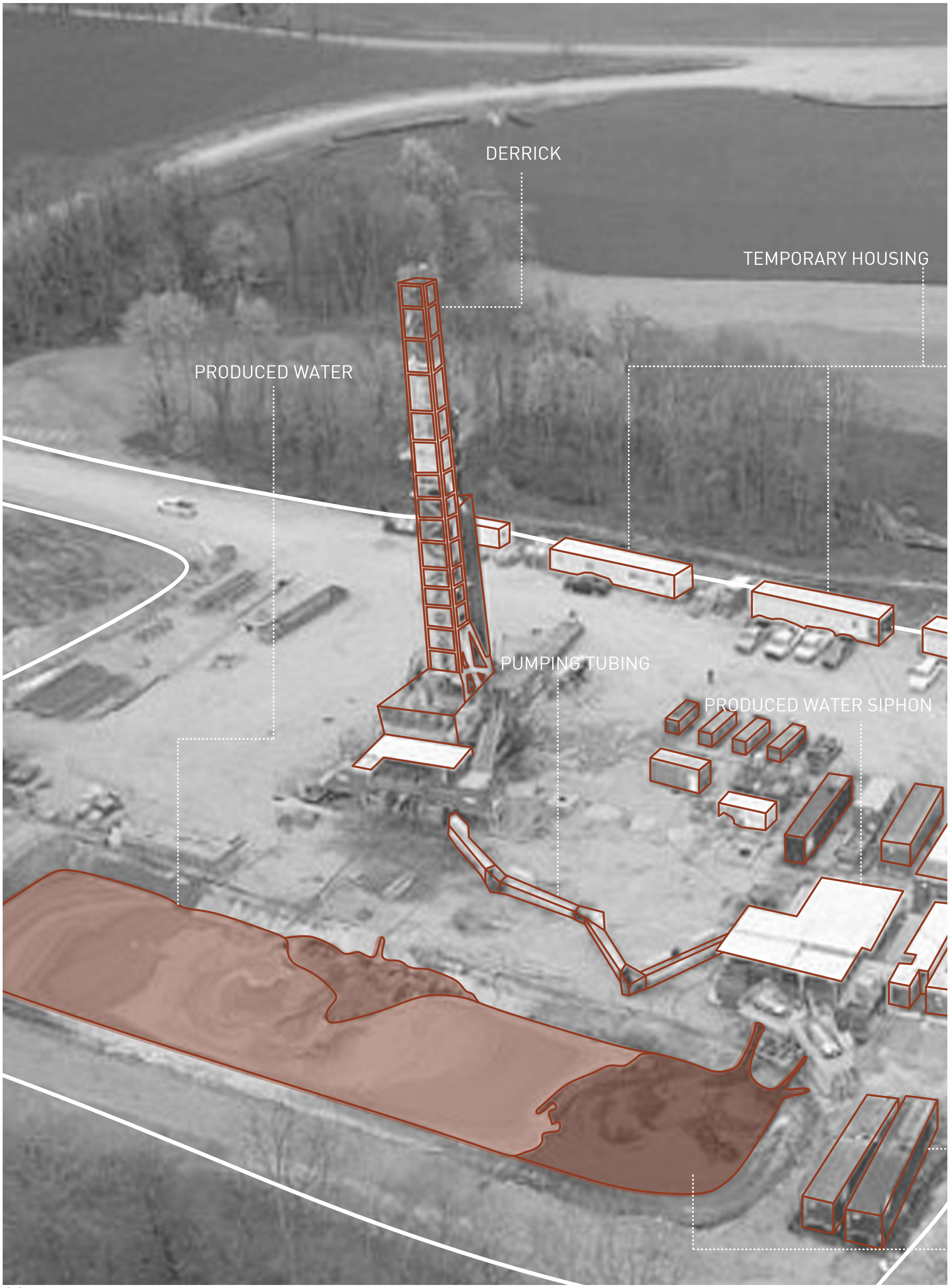
WELL HEAD IS PLACED



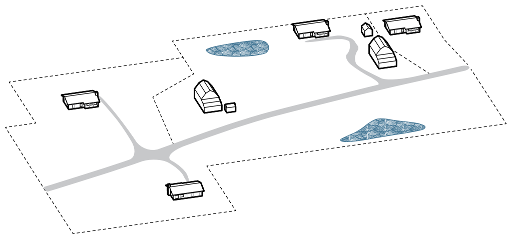
TANKS SEPARATE GAS FROM FLUID



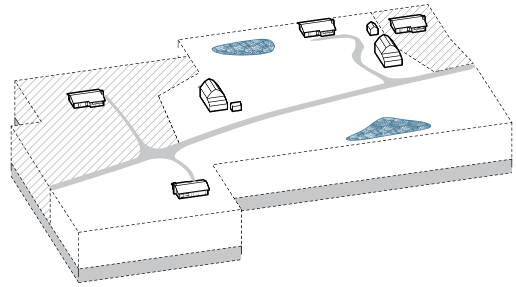
GAS IS CONNECTED TO PIPELINE


DERRICK
TEMPORARY HOUSING
PRODUCED WATER
PUMPING TUBING
PRODUCED WATER SIPHON

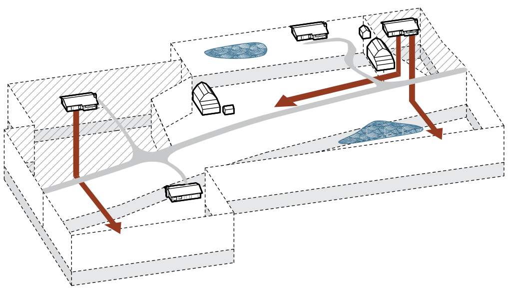

Acetic Acid
Acetic Anhydride
Acetylene
Alcohol Ethoxylated
Alkyl benzene sulfonic acid
Ammonia (aqueous)
Ammonium Bifluoride
Ammonium Persulfate
Ammonium Bisulfite
Ammonium chloride
Ammonium Salt (alkylpolyether sulfate)
Amorphous silica
Benzoic Acid
Boric Acid
Boric Oxide
Calcium Chloride
Calcium Oxide
carboxymethylhydroxypropyl guar
blendCholine Chloride
Cinnamaldehyde
Citric Acid
Complex polyamine salt
Crystalline Silica: Cristobalite
Crystalline Silica: Quartz
Cupric chloride dihydrate
Cured resin
Cyclohexanes
Dazomet
Diethylene Glycol
Ethoxylated Alcohol
Ethyl Acetate
Ethyl Alcohol
Ethylbenzene
Ethylbenzen
Ethylene Glycol
Formic AcidGluconic Acid
Glutaraldehyde
Glycerol
Glycol Ethers
Guar Gum
Hydrochloric Acid
Hydrochloric Acid 3% – 35%
Isopropanol
Isopropyl Alcohol
lead
Methanol
Methyl Alcohol
Methyl Salicylate
n-butanol
Nitrilotriacetamide
Phenolic Resin
Polyethylene Glycol
Polyethylene Glycol Mixture
Polyoxylalkylene sulfate
Polysaccharide Blend
Potassium Carbonate
Potassium Chloride
Potassium Hydroxide
Propargyl Alcohol
Propylene Glycol
Silica
Sodium Bicarbonate
Sodium Bromide
Sodium Hydroxide
Sodium Persulphate
Sodium Xylene Sulfonate
Sulfuric Acid
Surfactants
Talc
Tetrakis(hydroxymethyl)phosphonium sulfate
Tetramethyl ammonium Chloride
PRODUCED WATER SIPHON
EQUIPMENT STORAGE



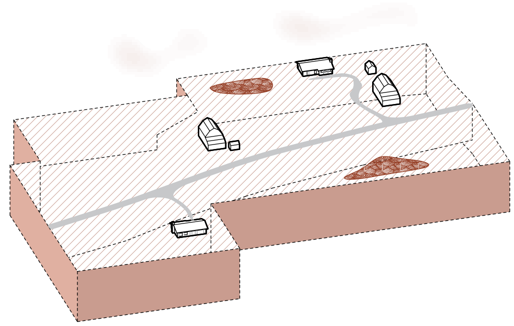
PROPERTY LINES



MINERAL RIGHTS



NEGOTIATION



CONTAMINATION

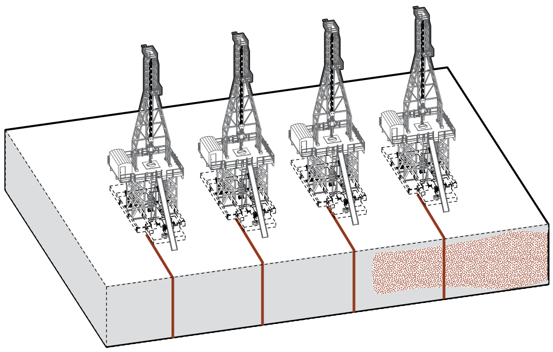
"COME AND LISTEN TO A STORY
ABOUT A MAN NAMED JED
A POOR MOUNTAINEER, BARELY
KEPT HIS FAMILY FED
...

THEN ONE DAY HE WAS
SHOOTIN AT SOME FOOD
AND UP THROUGH THE GROUND
CAME A BUBBLIN CRUDE.
OIL THAT IS, BLACK GOLD, TEXAS TEA."

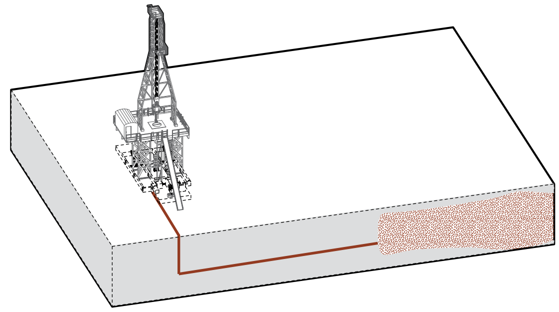
The largest indirect impact of the fracking is that of the community polarization and economic instability. As aforementioned, the technological advancement of horizontal fracking means that energy companies looking to drill in a region need now only deal with a handful of landowners in order to access the entire region's gas supply. These landowners are selected and approached by energy companies based on the ownership of their mineral rights.

Mineral rights are the rights to access and attain economic gain from mineral resources located under the properties. Unless mineral rights are severed, whoever owns the surface property outright owns everything below the surface, limited only by the extent of the surface rights (because oil and gas are fluids, they may flow in the subsurface across property boundaries). In this way, an operator may permissibly extract oil and gas from beneath the land of another, if the extraction is lawfully conducted on his own property. An operator may not, however, angle a well to penetrate beneath property not owned by or leased to him.

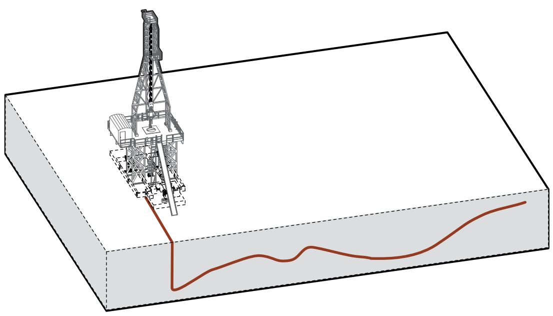
A traditional land ownership title only provides ownership to the surface of your land. Therefore, only those who own their mineral rights (usually residents who have had the property in their family prior to the institution of mineral rights, or those already wealthy enough to purchase them) can lease their land to energy companies to drill and mine for natural gas.



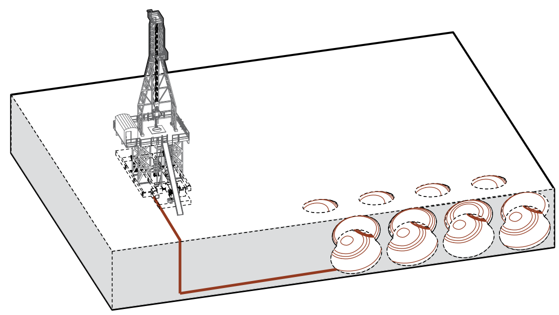
PREVIOUS METHOD OF FRACKING TO DISCOVER OIL



THE INVENTION OF HORIZONTAL FRACKING

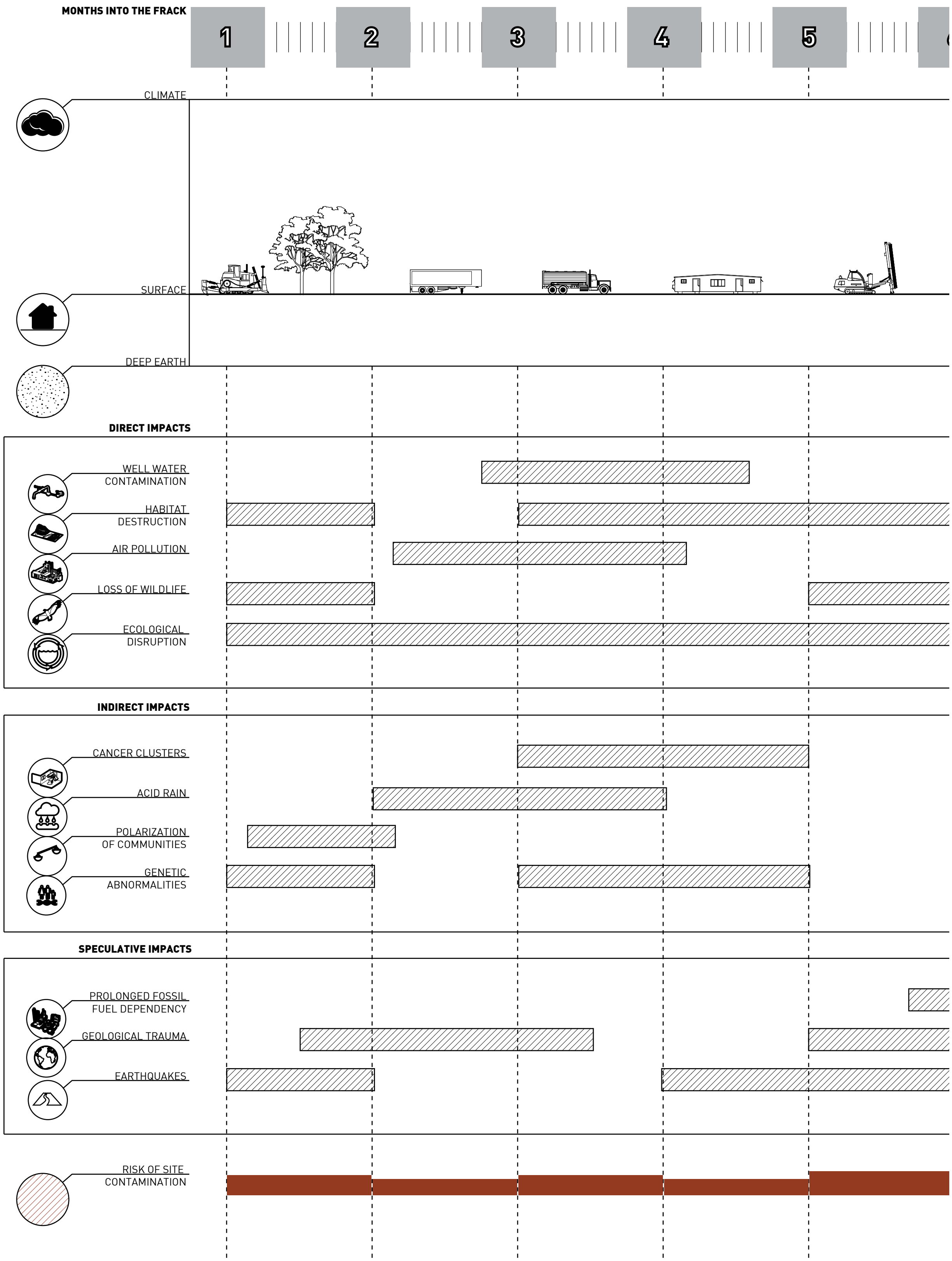


THE POTENTIAL OF HORIZONTAL FRACKING

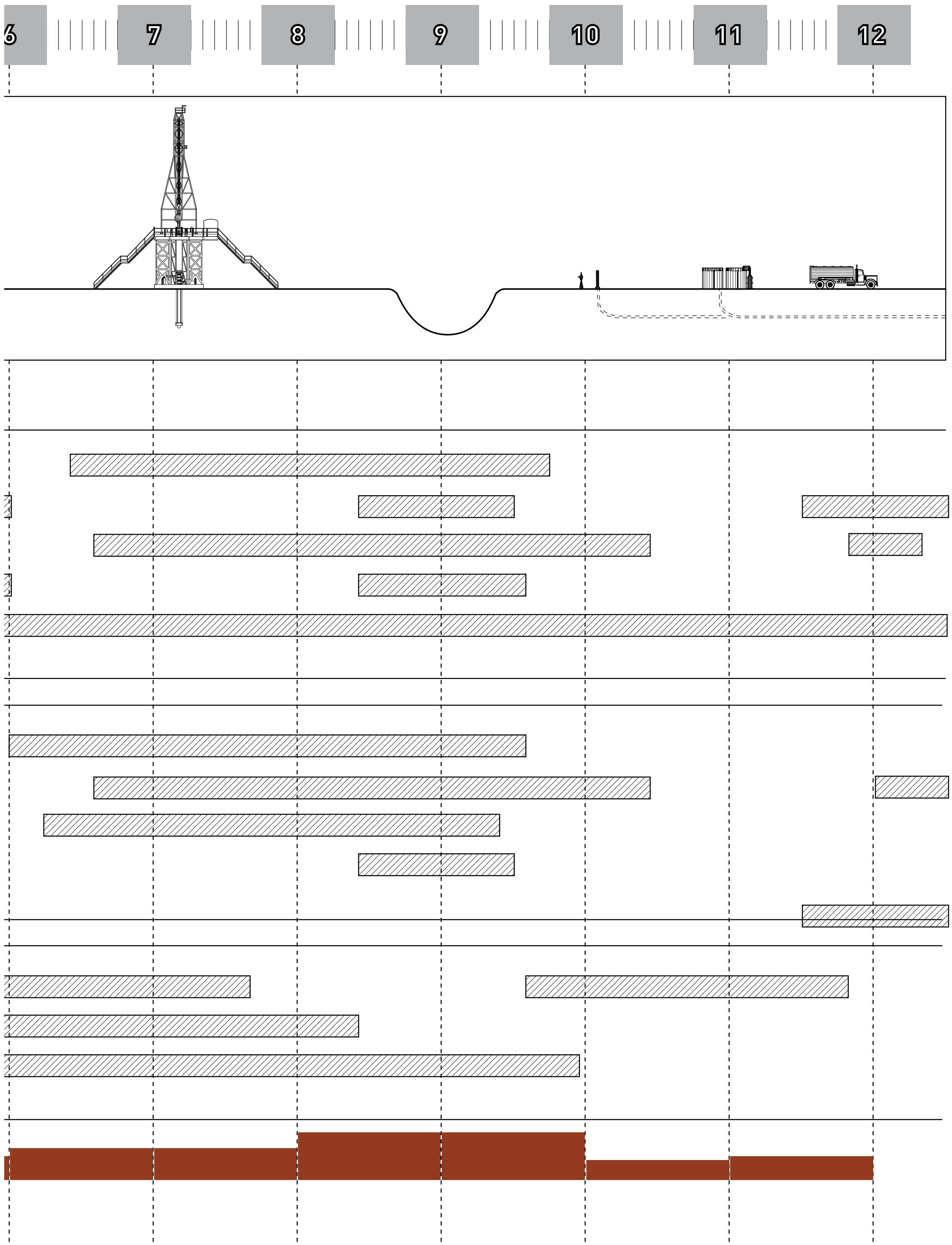


THE ARCHITECTURAL POTENTIAL OF HORIZONTAL FRACKING

Banks or insurance companies then often hold mineral rights on other properties. This is commonly the case with residents who have liens, or mortgages on their land, or just neglected to “read the fine print”. Thus, the energy company can lease these mineral rights from the bank directly without telling the resident who lives on the surface. Then the energy company will lease the mineral and surface rights from the resident next door, who owns their own mineral rights, and collect the gas from the entire area. This pits neighbor against neighbor and holds residents without their mineral rights hostage in the polluted landscape.



MONTHS INTO THE FRACK
1
2
3
4
5
CLIMATE
SURFACE
DEEP EARTH
DIRECT IMPACTS
WELL WATER CONTAMINATION
HABITAT DESTRUCTION
AIR POLLUTION
LOSS OF WILDLIFE
ECOLOGICAL DISRUPTION
INDIRECT IMPACTS
CANCER CLUSTERS
ACID RAIN
POLARIZATION OF COMMUNITIES
GENETIC ABNORMALITIES
SPECULATIVE IMPACTS
PROLONGED FOSSIL FUEL DEPENDENCY
GEOLOGICAL TRAUMA
EARTHQUAKES
RISK OF SITE CONTAMINATION


6
7
8
9
10
11
12

THE IMPLICATIONS OF MINING THE MARCELLUS SHALE

The environmental and ecological implications of hydraulic fracturing are many and wide ranging. First, the most significant environmental impact surrounding fracking is that of water contamination and wastewater management. The fluid injected into the ground contains 78 chemicals, most of which are seen as proprietary by energy companies. Some of the known chemicals include Crystalline Silica, Methanol, Isopropanol, Hydrotreated Light Distillate, Ethylene Glycol, Diesel, Sodium Hydroxide, Naphthalene, Lead, Radioactive Isotopes and Methane, just to name a few. These chemicals can be found in household cleaners, jet fuel, and chemical weapons. If ingested the impacts are perhaps obvious but nonetheless deserve stating. Some so-called side effects of ingestion can include poisoning, cancers, bone marrow loss, brain damage, hallucinations, hair loss, skin irritations and death. Each well can be fracked three times and there can be up to 5 wells per well pad. This means that each well pad can produce 900 million gallons of fracked water. To put this into perspective each well utilizes approximately 12 Olympic sized swimming pools worth of water.

The fracking fluid pumped into the ground to produce the frack can seep directly into underground aquifers and soil. Once the groundwater has been contaminated wells and pipes in houses have been known to explode. This is what produces the "flaming faucets" effect that has created a national media buzz. It is predicted that only 60% of the water injected into the ground actually returns up to the well head. This widely accepted margin of error is proof enough that much of this fluid enters regional water resources.

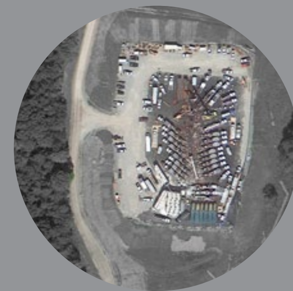
The remaining water that does come back up the well is stored to await wastewater treatment. However, the chemicals in the water are so toxic, and there is so much of this poison fluid, that few treatment facilities accept the water. For those that do there is currently a predicted and astonishing 800 year back up within Pennsylvania. This leaves many energy companies attempting to evaporate the toxic fluid by storing it in outdoor pits, often with fans or heat directed at it. Even worse, some of the energy companies simply dump the water into local rivers and streams. The immediate repercussions are a lack of clean drinking water for rural residents and severe damage to flora and fauna.

A second albeit no less serious consideration is air pollution. The air quality in fracked regions is significantly poor for three reasons. The evaporation pits used to dispose of toxic fluid are successful, and those chemicals are absorbed into the air. Many of these regions have dirt roads and the hundreds of trucks bringing fluid and equipment to and from well pads bring with them contaminated, toxic, radioactive particles.

THE SITES OF A FRACK

WELL PAD PREPARATION

DRILLING

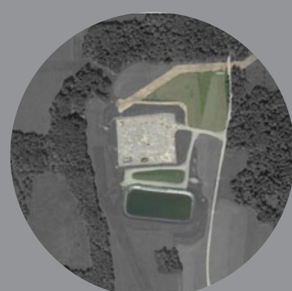


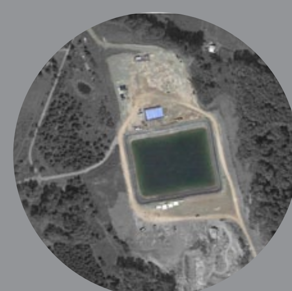
THE FRACK

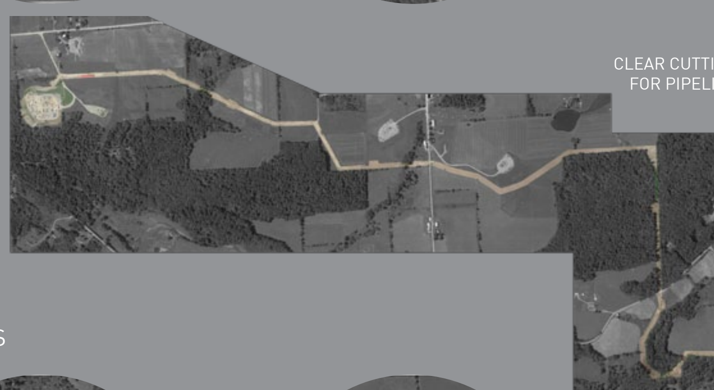
PRODUCING WELL

RESPONSIBLE WASTE
WATER STORAGE

EVAPORATION PITS

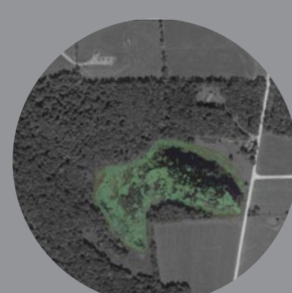


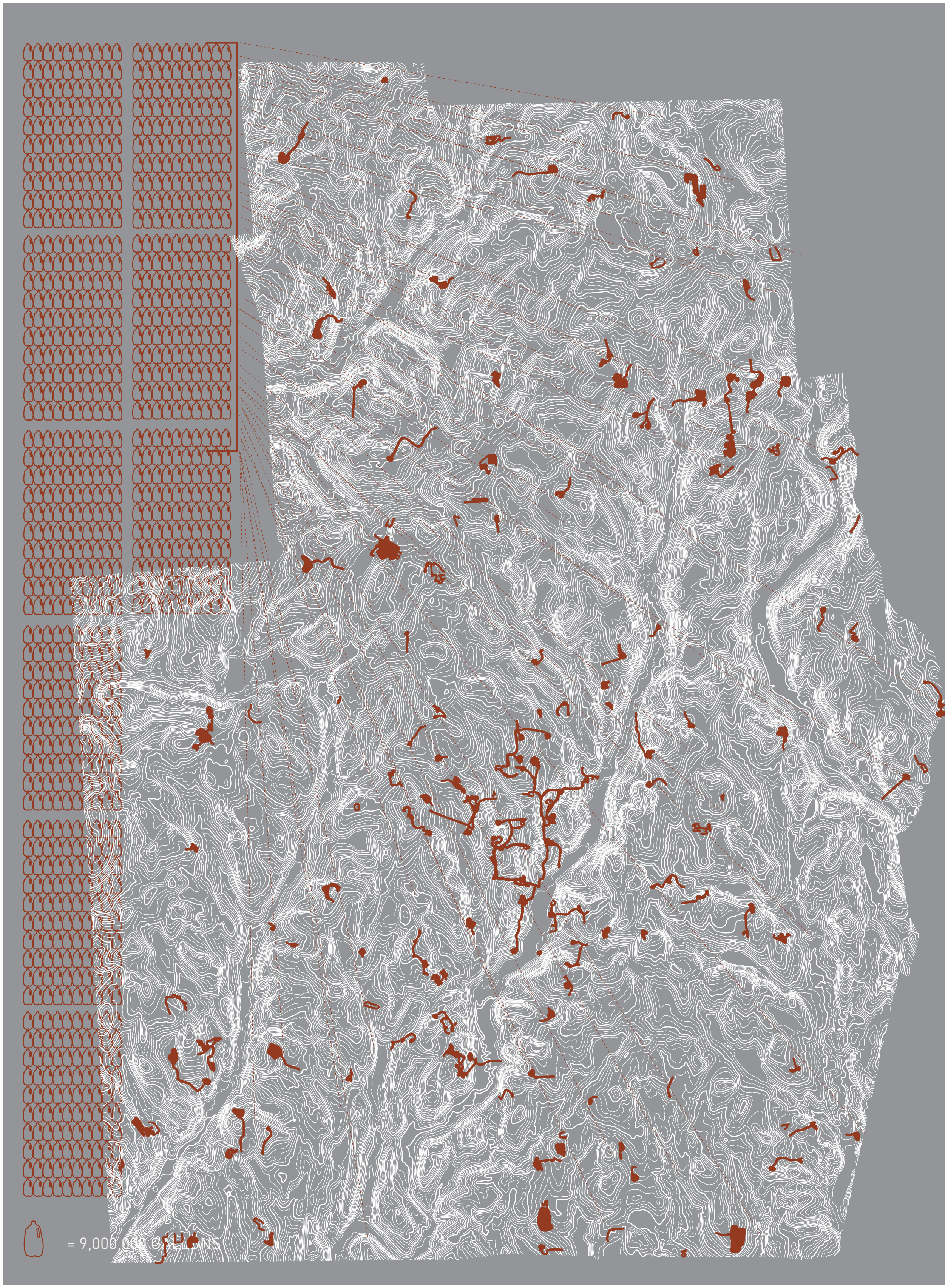


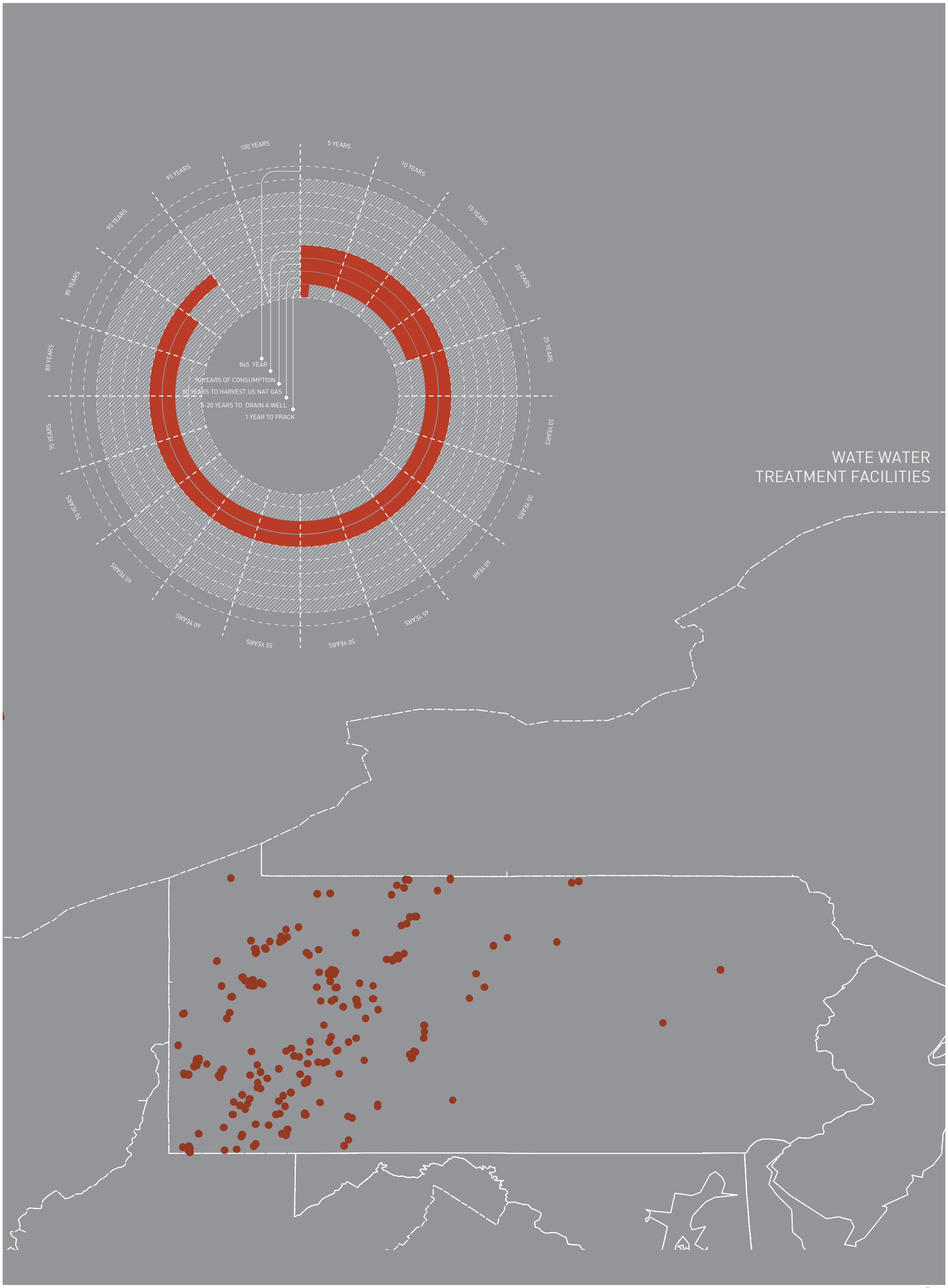


CLEAR CUTTING
FOR PIPELINE

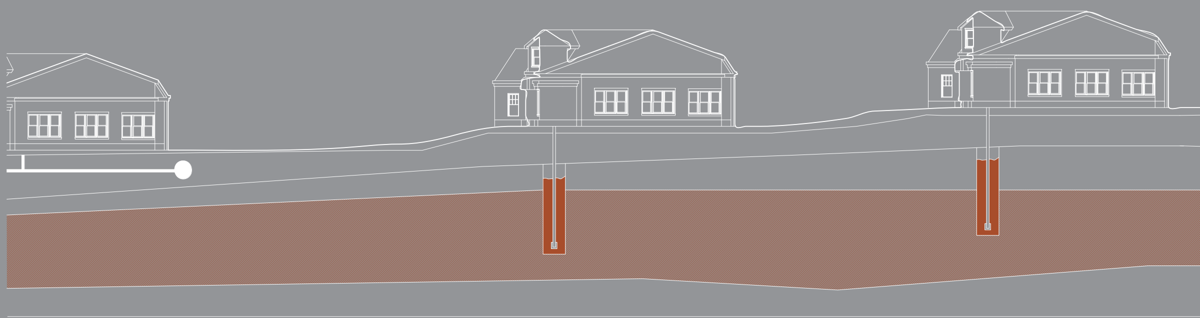
CONTAMINATED HYDROLOGICAL FEATURES

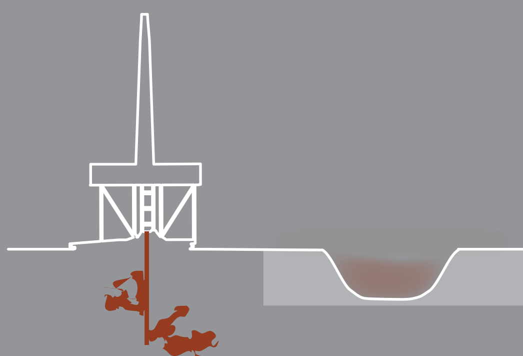


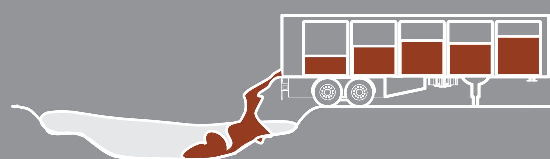

= 9,000,000 GALLONS


5 YEARS
10 YEARS
15 YEARS
20 YEARS
25 YEARS
30 YEARS
35 YEARS
40 YEAR
45 YEARS
50 YEARS
55 YEARS
60 YEARS
65 YEARS
70 YEARS
75 YEARS
80 YEARS
85 YEARS
90 YEARS
95 YEARS
100 YEARS
865 YEAR
90 YEARS OF CONSUMPTION
80 YEARS TO HARVEST US NAT GAS
5-20 YEARS TO DRAIN A WELL
1 YEAR TO FRACK
WATE WATER
TREATMENT FACILITIES


CONTAMINATED UNDERGROUND AQUIFERS
WATER PIPELINE







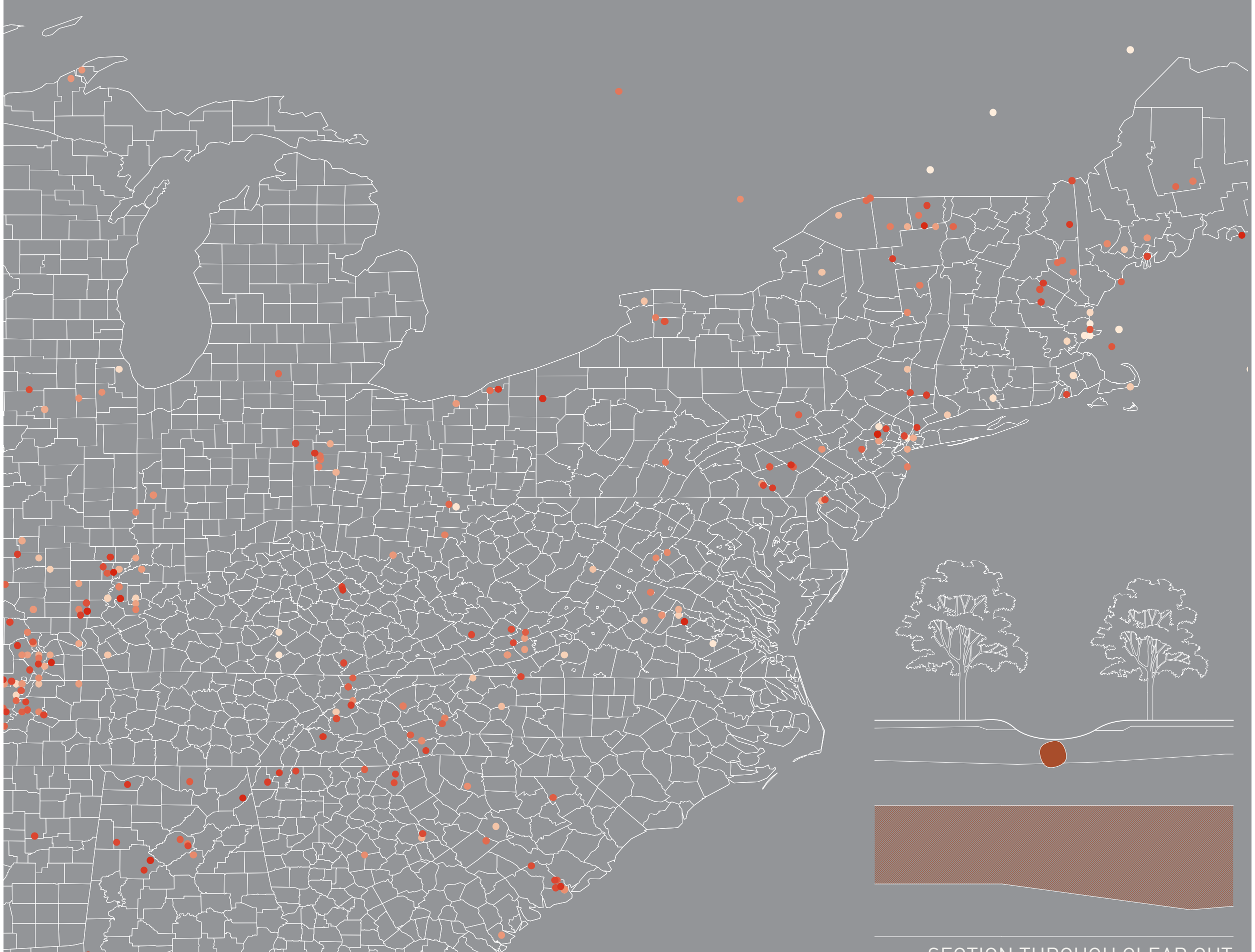
TAP WATER ON FIRE

METHANE ICE ON FIRE


TREES
CLEAR CUT CONNECTIONS
GAS PIPELINES

CLEAR CUTTING FOR PIPELINE

EARTHQUAKES IN THE LAST 10 YEARS



SECTION THROUGH CLEAR CUT

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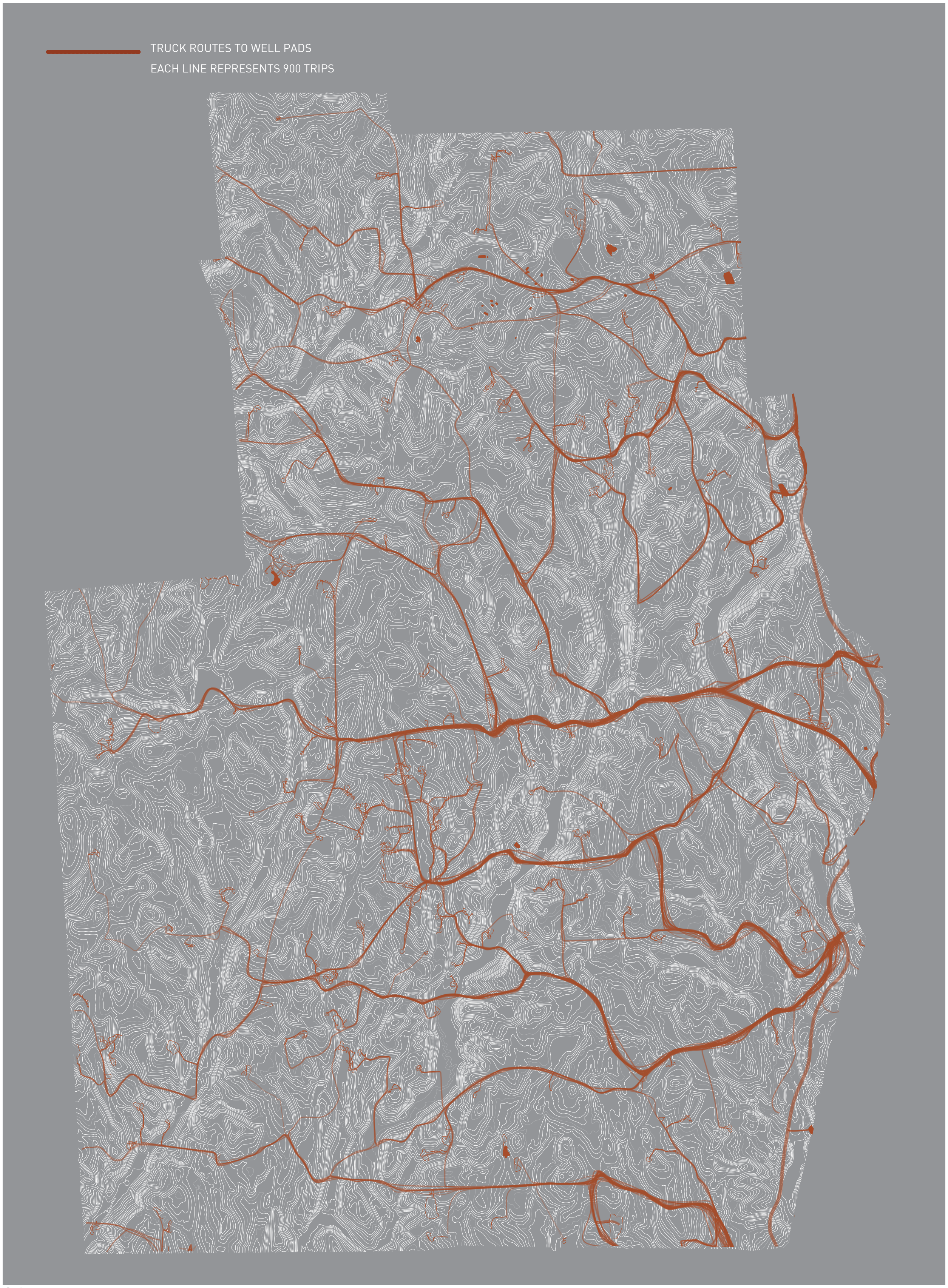
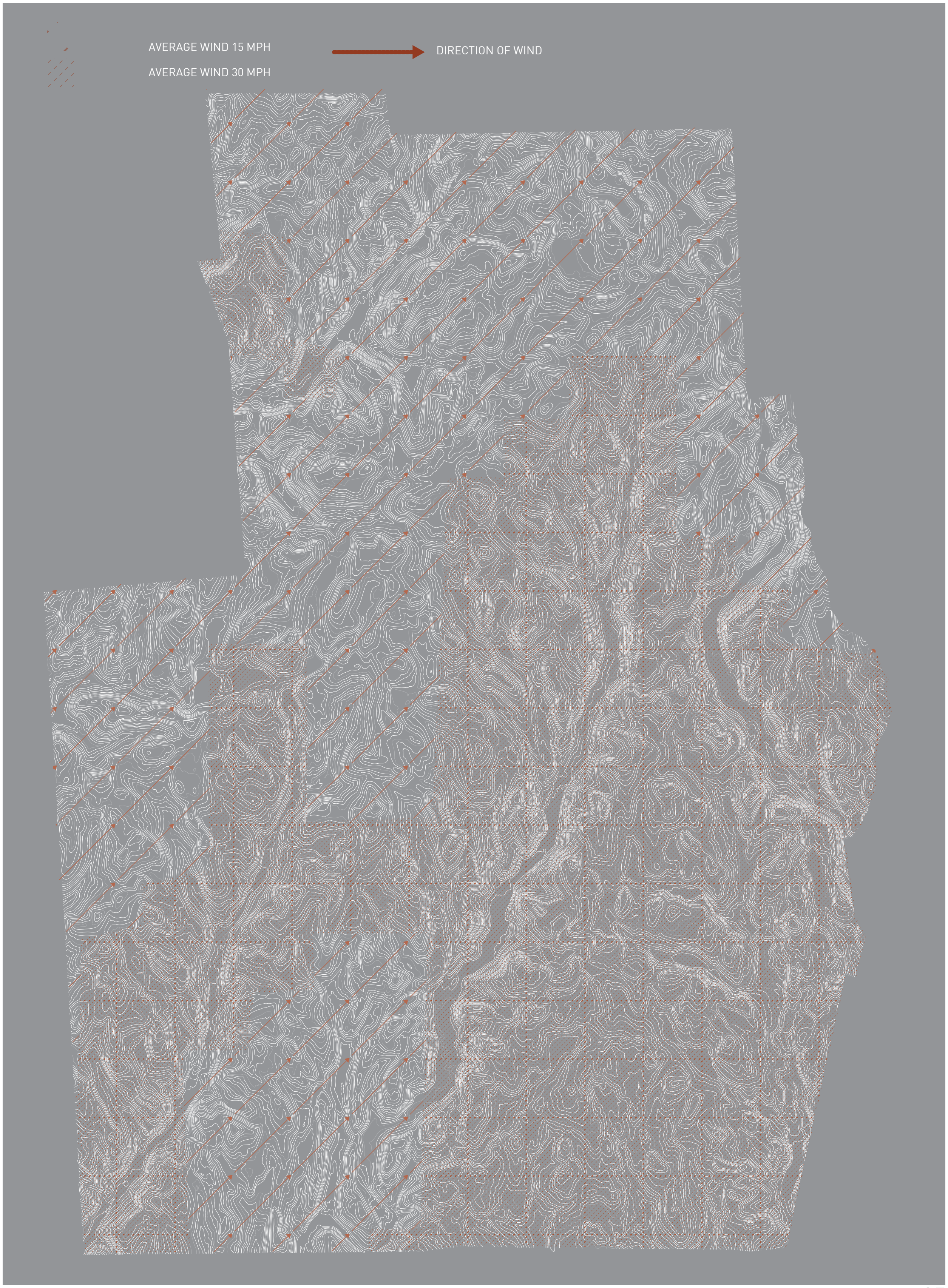

TRUCK ROUTES TO WELL PADS
EACH LINE REPRESENTS 900 TRIPS



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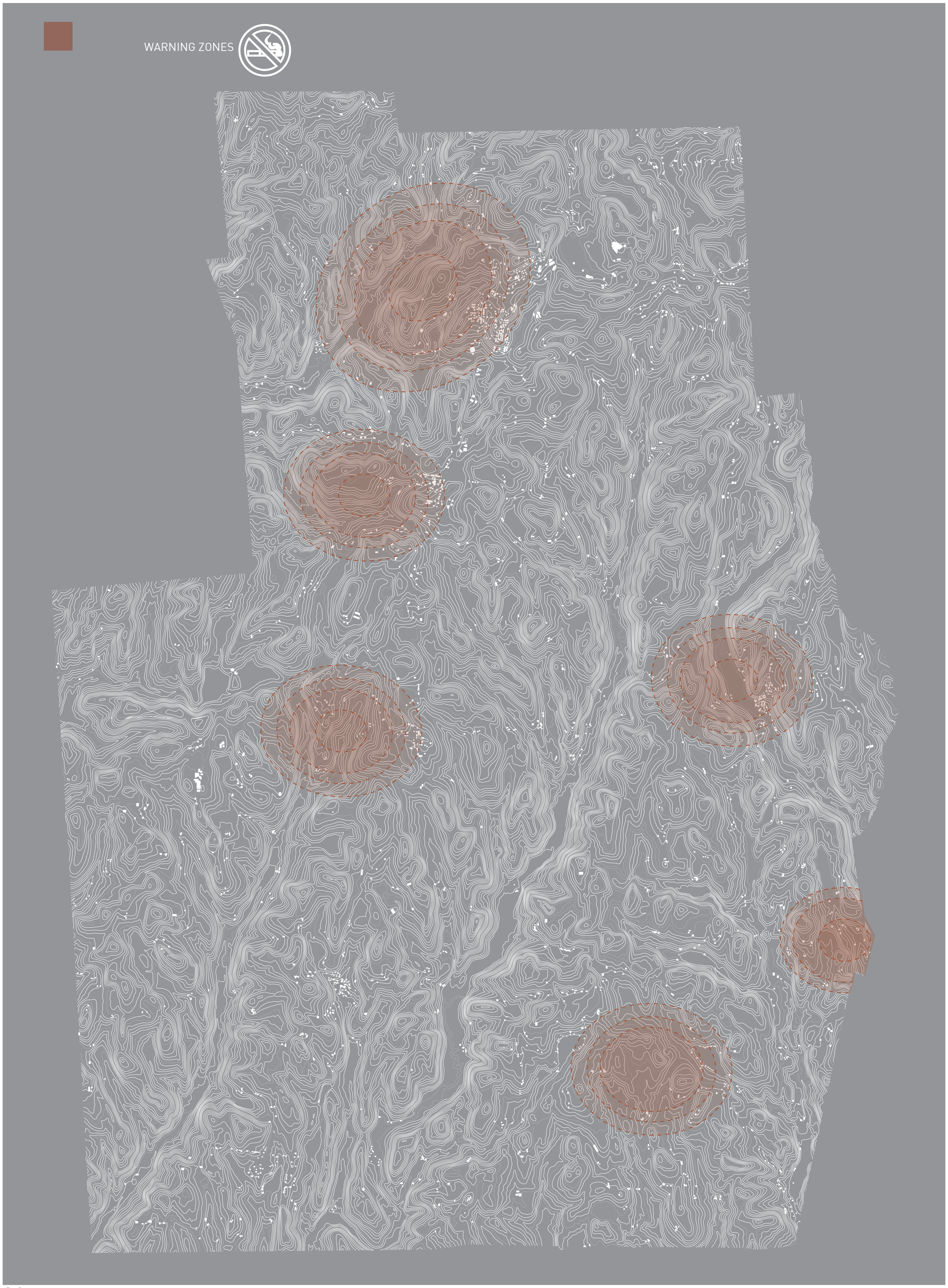
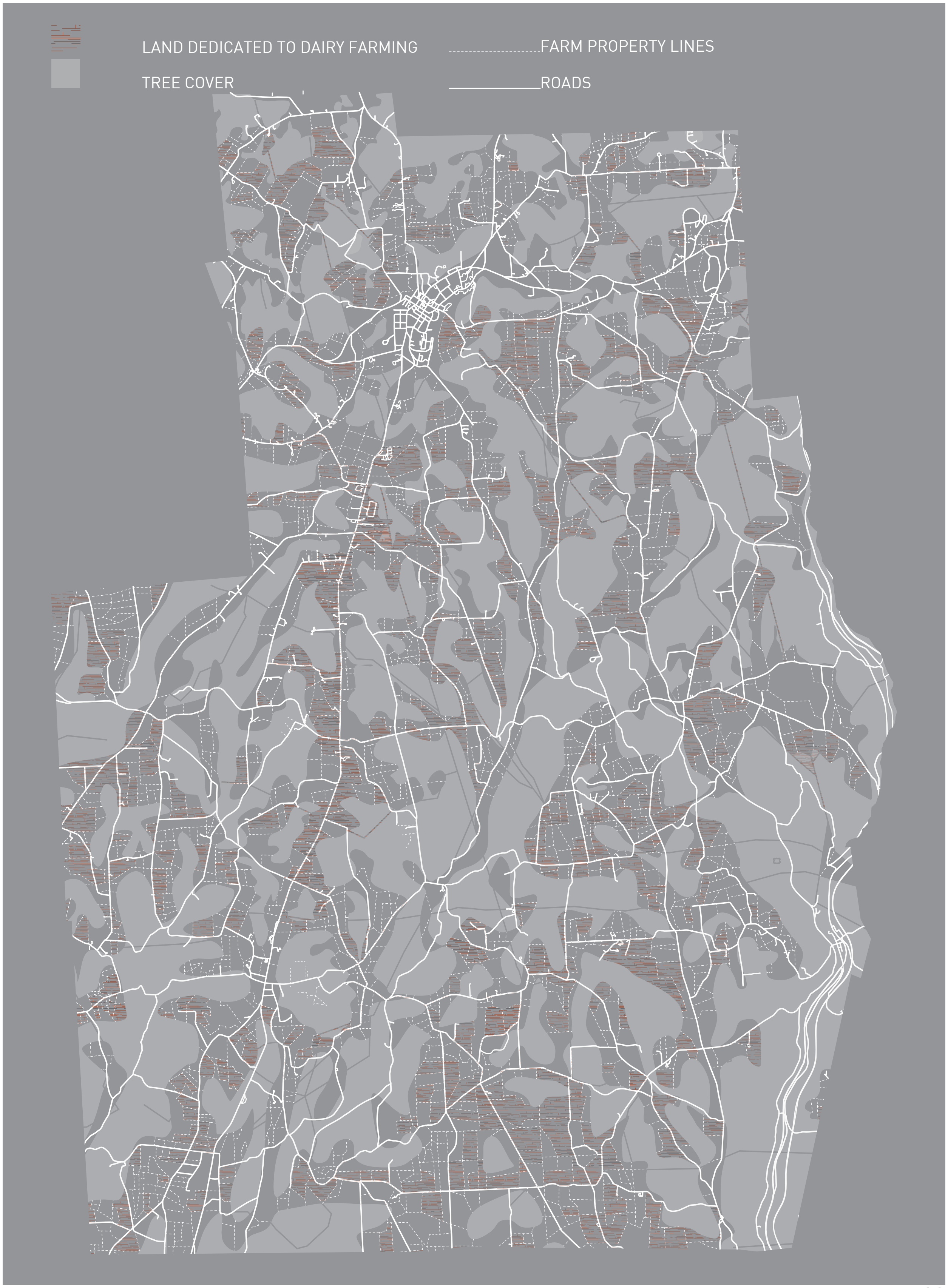
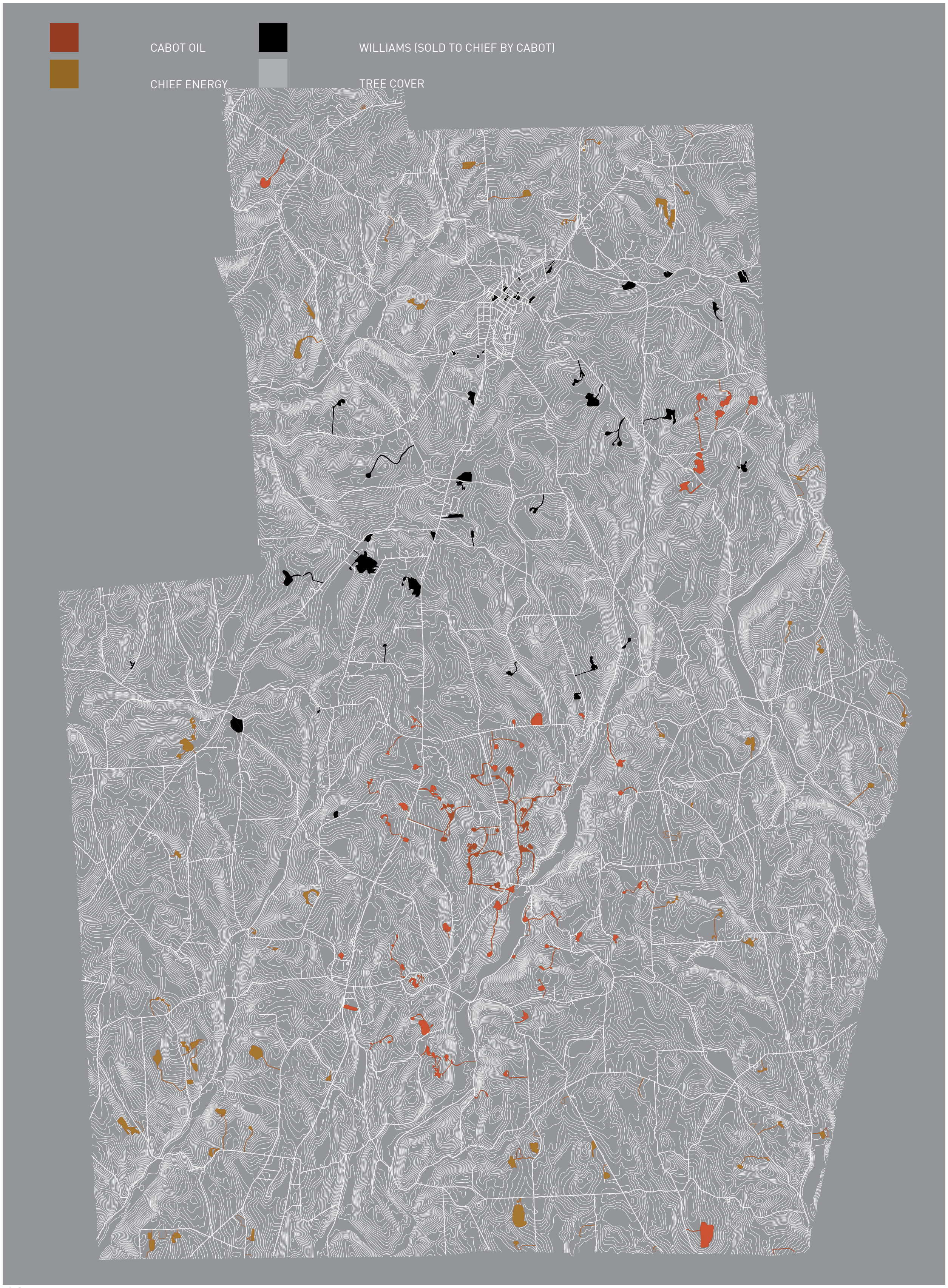
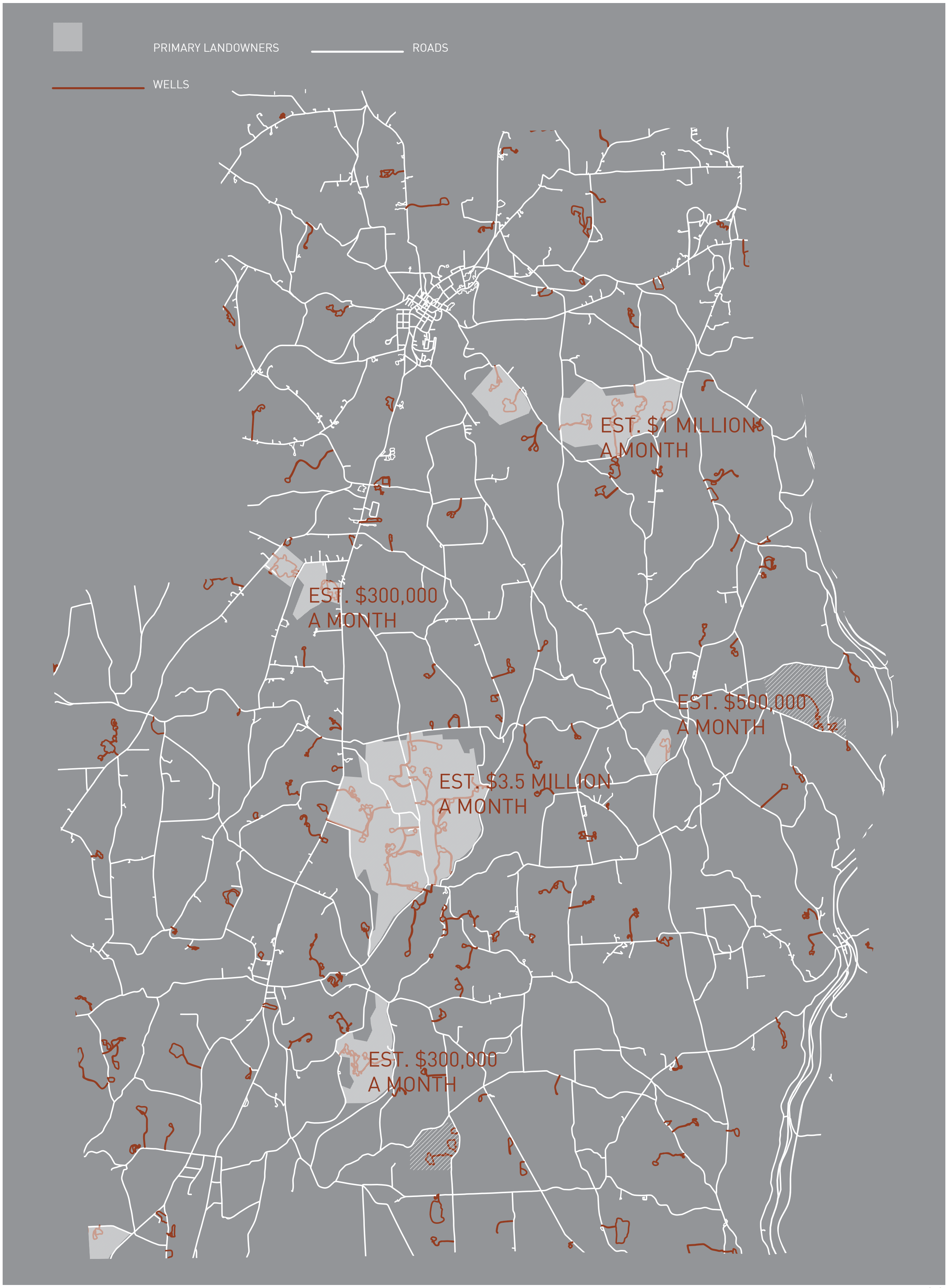

WARNING ZONES


LAND DEDICATED TO DAIRY FARMING
FARM PROPERTY LINES
TREE COVER
ROADS


CABOT OIL
CHIEF ENERGY
WILLIAMS (SOLD TO CHIEF BY CABOT)
TREE COVER


PRIMARY LANDOWNERS
ROADS
WELLS
EST. $1 MILLION A MONTH
EST. $300,000 A MONTH
EST. $500,000 A MONTH
EST. $3.5 MILLION A MONTH
EST. $300,000 A MONTH

Additionally, to prevent a pressure build up in many wells, these wells need to be burped. This burping means a direct burn off of extra methane gas. Thus, the burning of the methane leads to additional contamination in the air. So terrible is the air quality in fracked regions that clouds of explosive dust can form during dry parts of the year, and many towns ban well burps, outdoor grills and even smoking.

Aside from the direct contamination of the region infrastructural failure, geological trauma and economic instability follows the natural gas extraction. Small town roads cannot withstand the impact made by the large number and frequent movement of large tanker trucks, tractor-trailer trucks, and any number of other large pieces of construction equipment. These roads often become unsafe to traverse from overuse due to potholes or even the dangers incurred by attempting to share a very small road with a much larger truck. Additionally, it is currently predicted that the increase in earthquakes in the Northeast region of the United States is the result of the repetitive drilling and pressurized fissures deep in the earth.

The regional woodland resources are also clear-cut for the placement of pipeline. This creates wide gashes in the earth and tree cover. Through these paths, often wider than most roads, contamination is easily carried from well pad to well pad. The loss of wild-life habitat has large implications for a region once known for dairy farming.

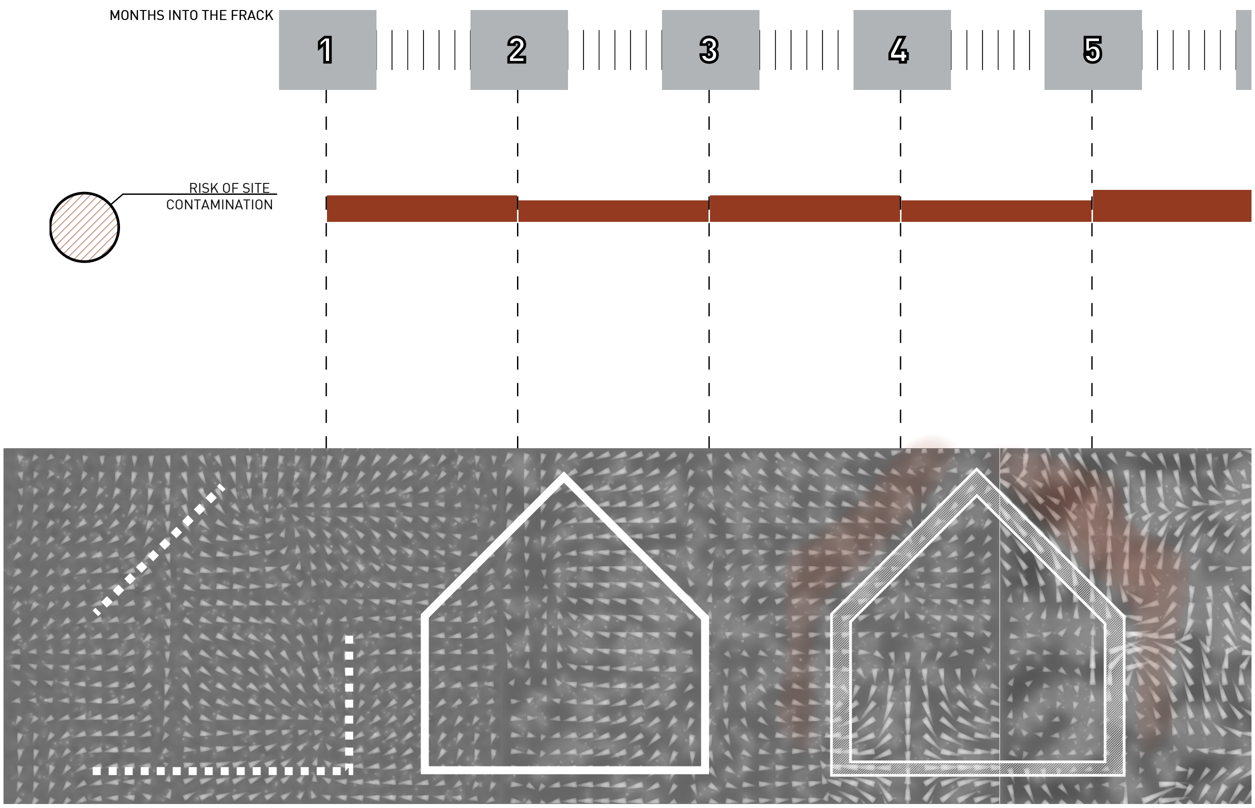
Those residents without their mineral rights, and who are living on polluted land, cannot afford to water their crops or cattle with purchased bottle water. As a result their livelihood is being ripped away. Cows continually fed the polluted groundwater develop cancer, and there have even been documented cases of radioactive milk as a result.

Although the region is losing its agricultural resources, many farmers are hopeful that money can be made working on one of the extraction teams. However, despite the promise of jobs, energy companies bring in their own teams. These men are already trained and much less likely to blow the whistle on malpractice since they are not tied to the region and its impacts personally. Inversely, those with access to their mineral rights reap millions of dollars, often abandoning their land and moving to cleaner and wealthier regions.

Of the people spoken to, one of the most impressive stories gleaned was from a former dairy farmer who had leased his land to energy companies to be fracked. He currently holds the largest tract of land in the four surrounding townships. With over 45 wells on his land, as well as a compressor station, 2 evaporation pits and several miles of pipeline he claims to be making over 3.5 million dollars each month. Once a dairy farmer, he has sold all his cattle and agricultural equipment. He has since abandoned his land and relocated his family to Cabo San Lucas, Mexico. He only returns to the land once in a while to check on the progress of the construction.

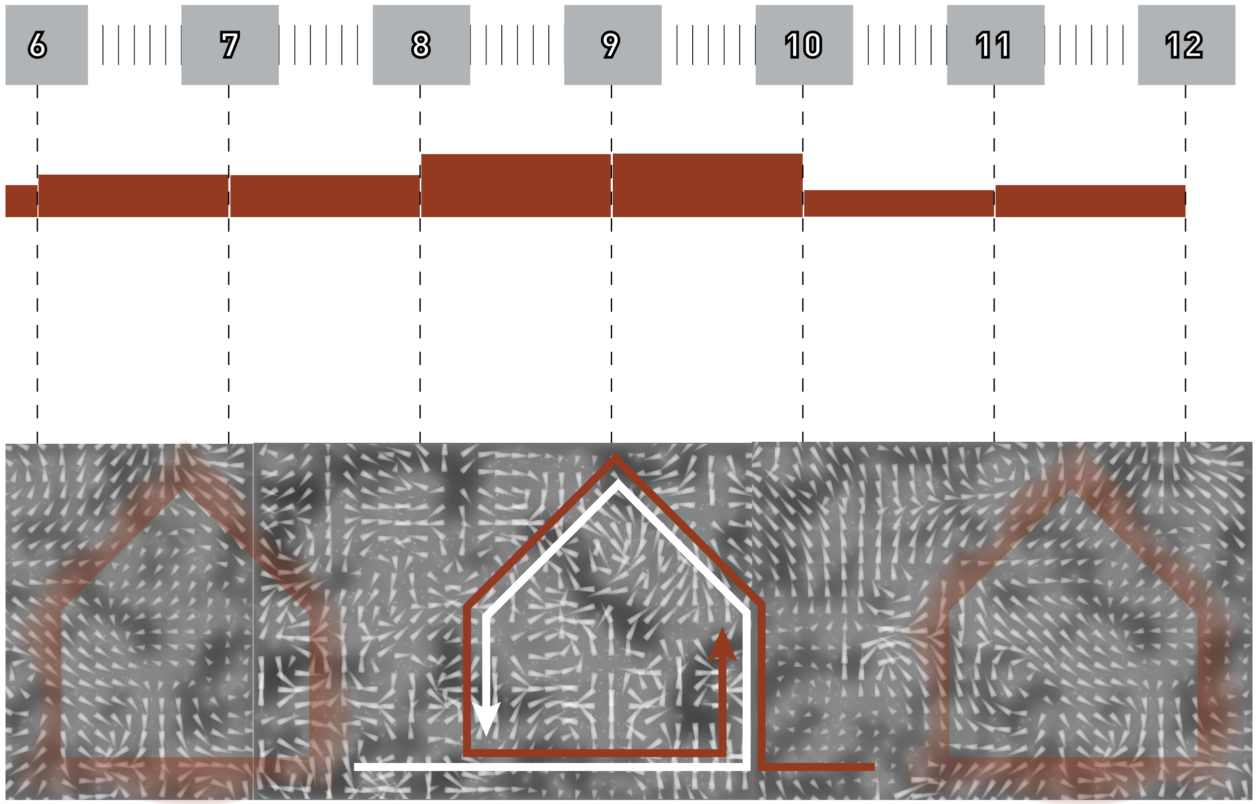
It is clear how the battle over mineral rights creates a socio-economic disparity among local residents and results in civil unrest. Those who lease their land wish to benefit from their land just as they did while farming and often believe those who protest its environmental impacts as extremists.

AUTOPOIETIC LANDSCAPES



Given the environmental and ecological implications at stack when fracking for natural gas, this thesis seeks to design a series of site interventions that act as atmospheric indicators of pollution. It is this conceptual exploitation of fracking's failure (deregulation of the industry, corruption, and risk) that produces a series of fracking specific site interventions.

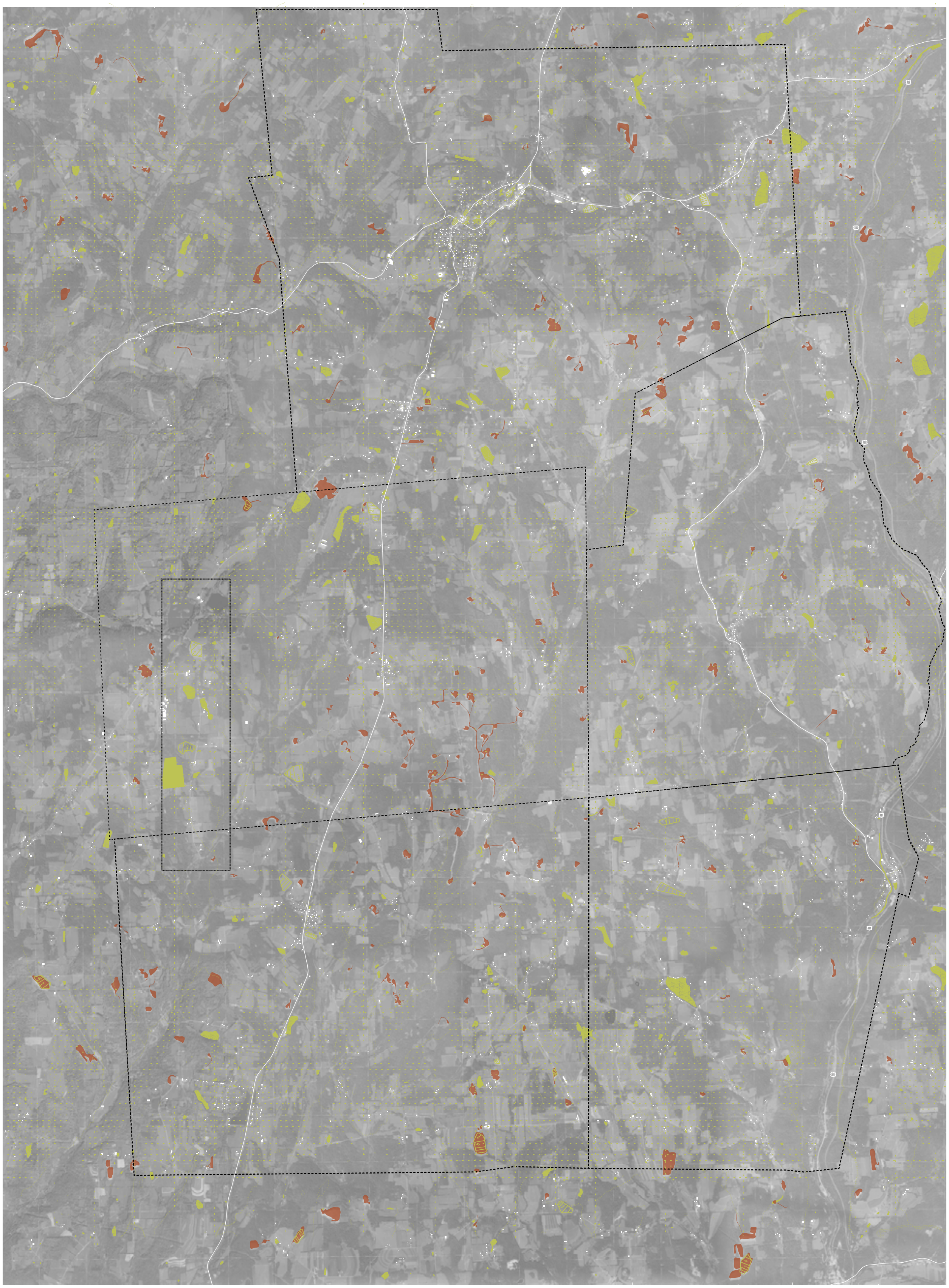
These site interventions varying in scale, impact, execution, and discipline. As fracking proliferates, these interventions become more legible across the landscape, indicators of contamination. This thesis does not seek to demonize the practice of hydraulic fracturing. Rather this thesis seeks to produce a "fracked urbanism" which has embedded these atmospheric indicators, reflecting the multivalent impacts of hydraulic fracturing. Therefore, creating an autopoietic landscape, a landscape whose architectural, technological and infrastructural components ebb and flow with the presence of the fracking's failures.

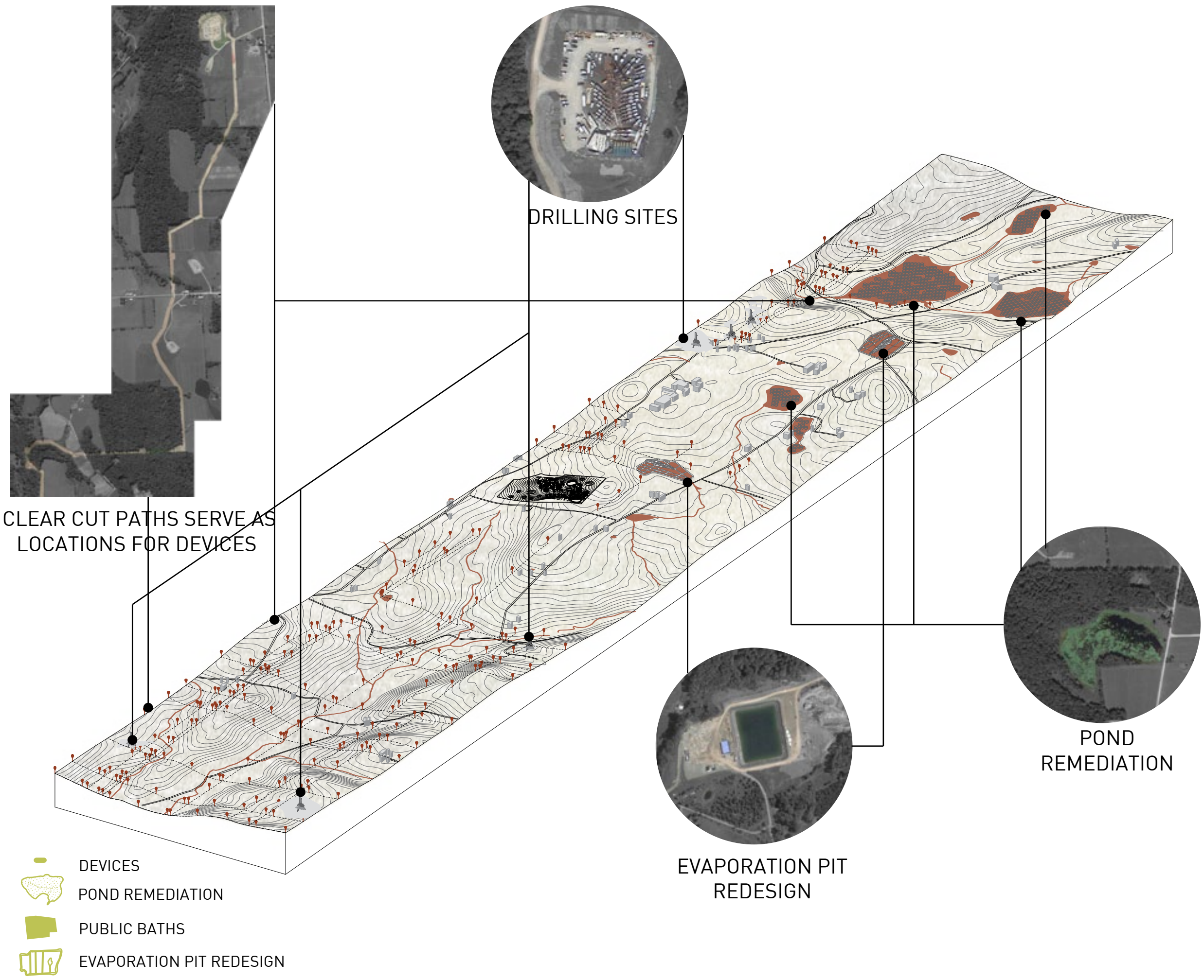


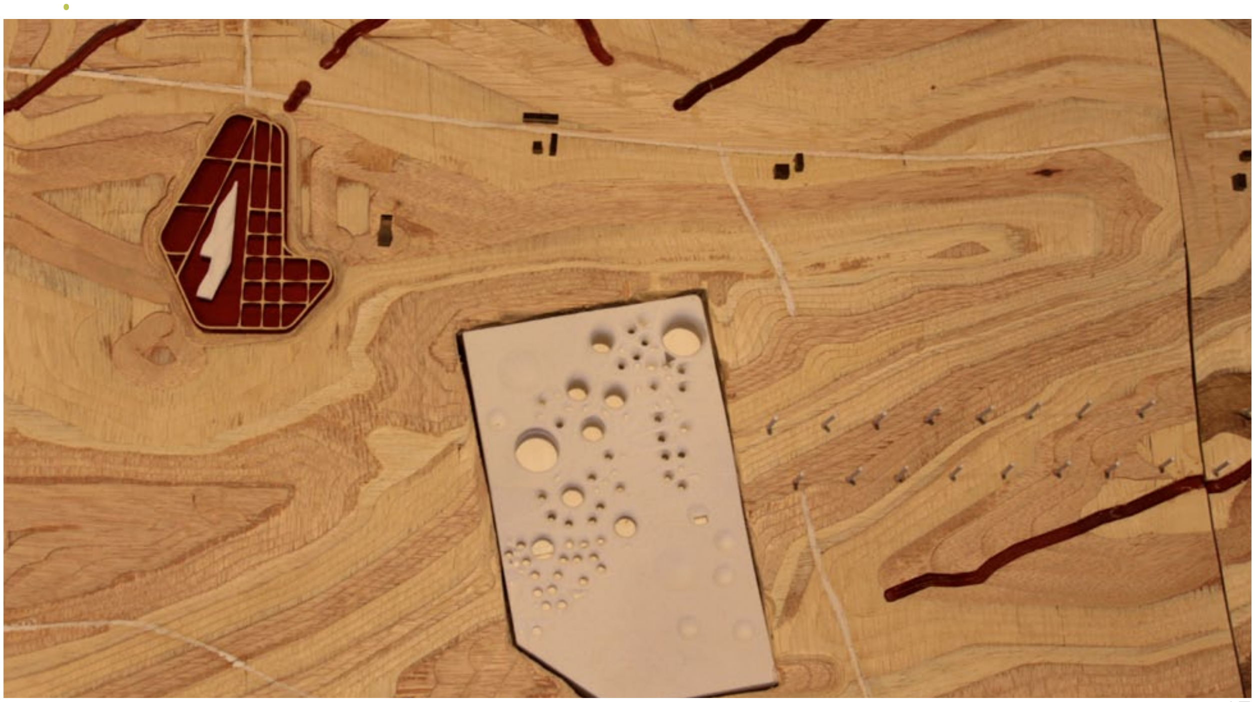
Autopoiesis refers to a network of processes of production (transformation and destruction) through which a machine's interactions and transformations continuously regenerate and realize the network of processes that produced them; and constitute the machine as a concrete unity. Meaning an Autopoeitic machine is one that self replicates in a responsive and resilient way.

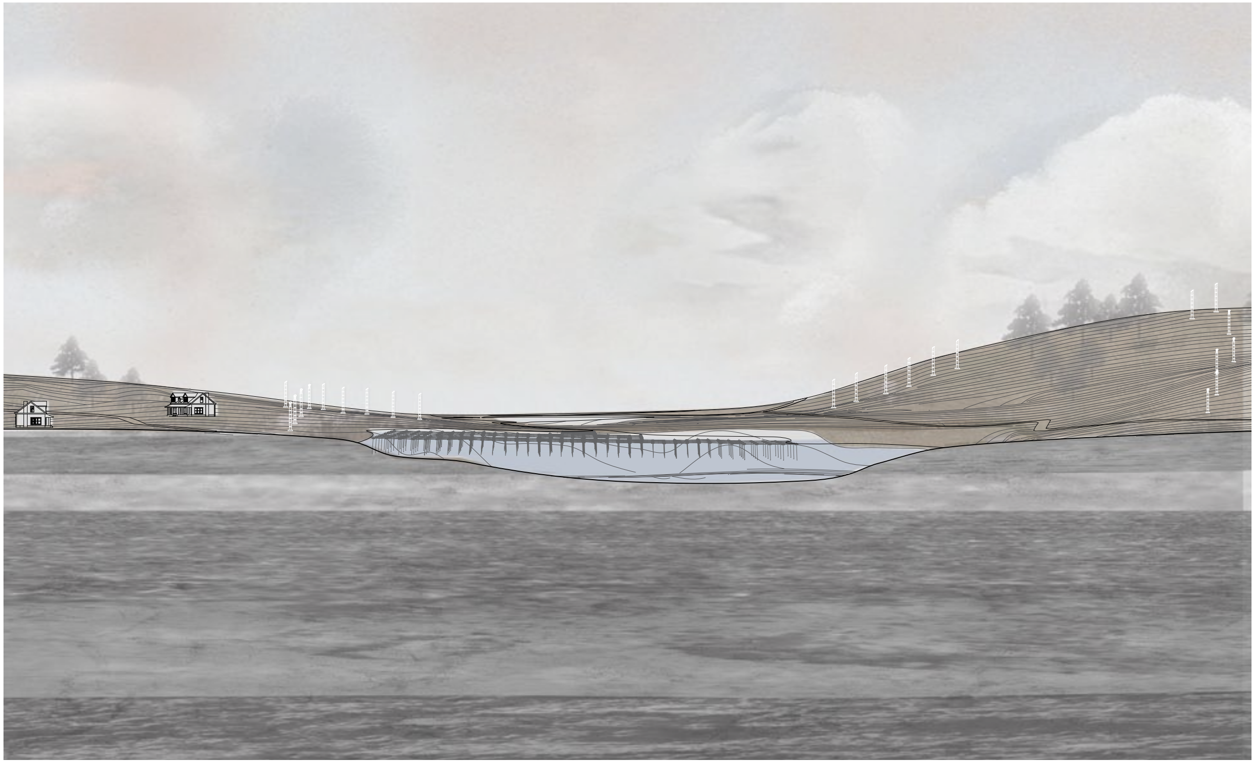
Ideas of autopoiesis are encapsulated within these landscapes through the continued connection between conceptual contamination (the failures previously mentioned) and the thresholds of the interventions. The various site interventions are present on the site as the specific threshold for contamination is crossed. Therefore, the system of fracking produces conditions necessitating that intervention. An intervention that in turn will in some way address the contamination but not prevent it. In this way the landscapes too replicates in a responsive and resilient way.

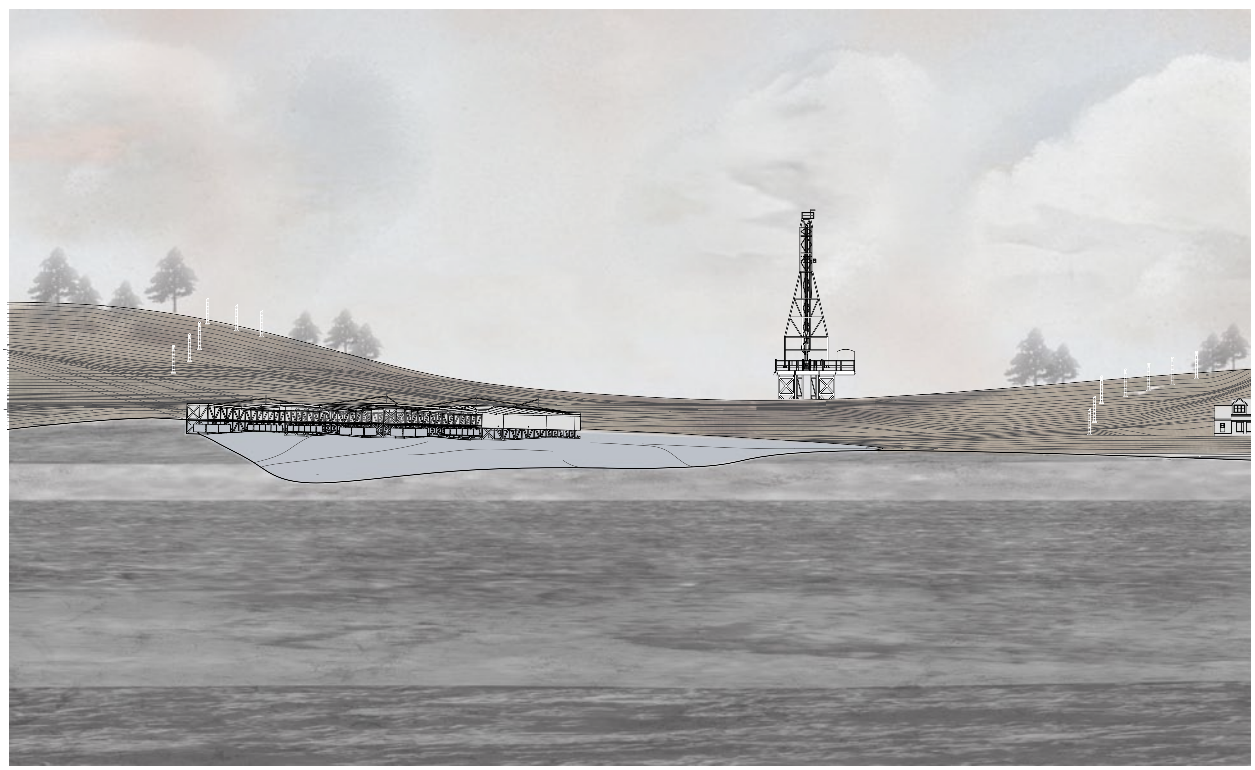
The site interventions themselves are organized into scenarios. These scenarios encapsulate an position on the site and its conditions. Each scenario is different in the disciplinary practices they engage : landscape, architecture, technology, infrastructure. And each scenario is designed to be deployed by various players engaged in networks on the site. Some are intended to be deployed by local activists, others by farmers, large municipalities and even the energy companies themselves.

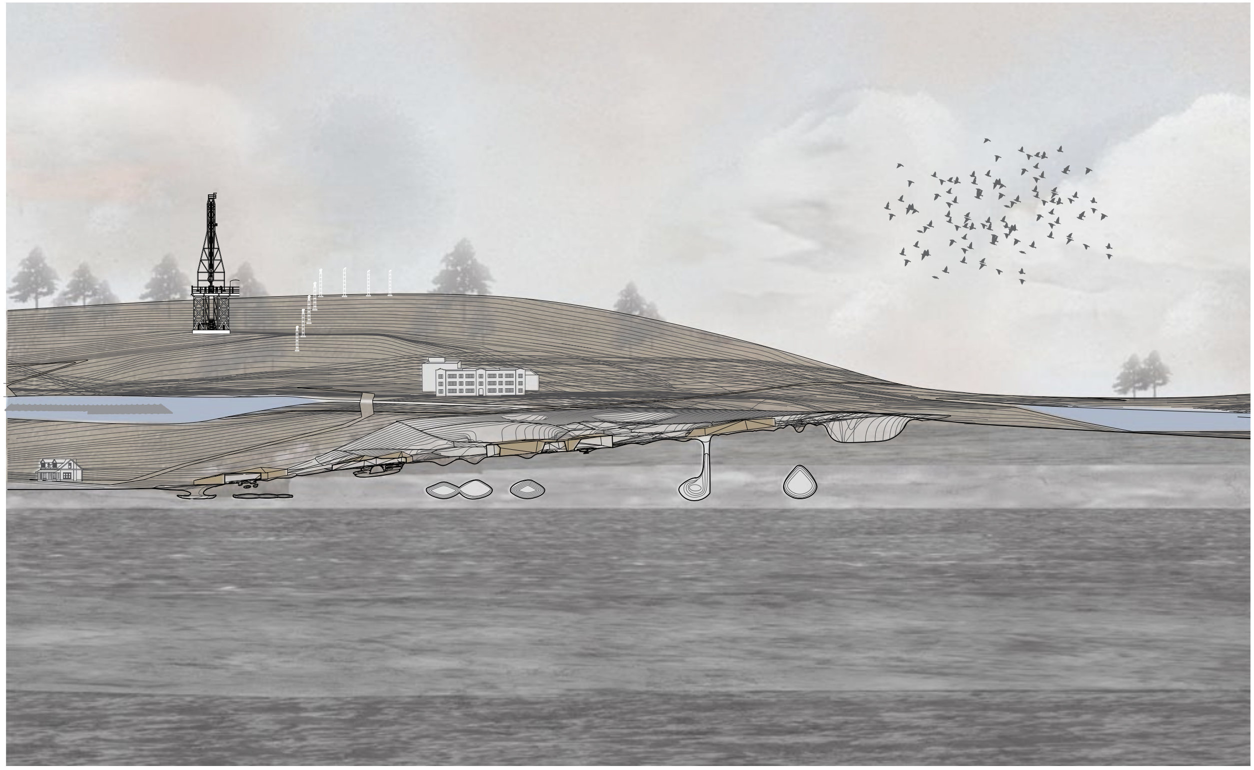


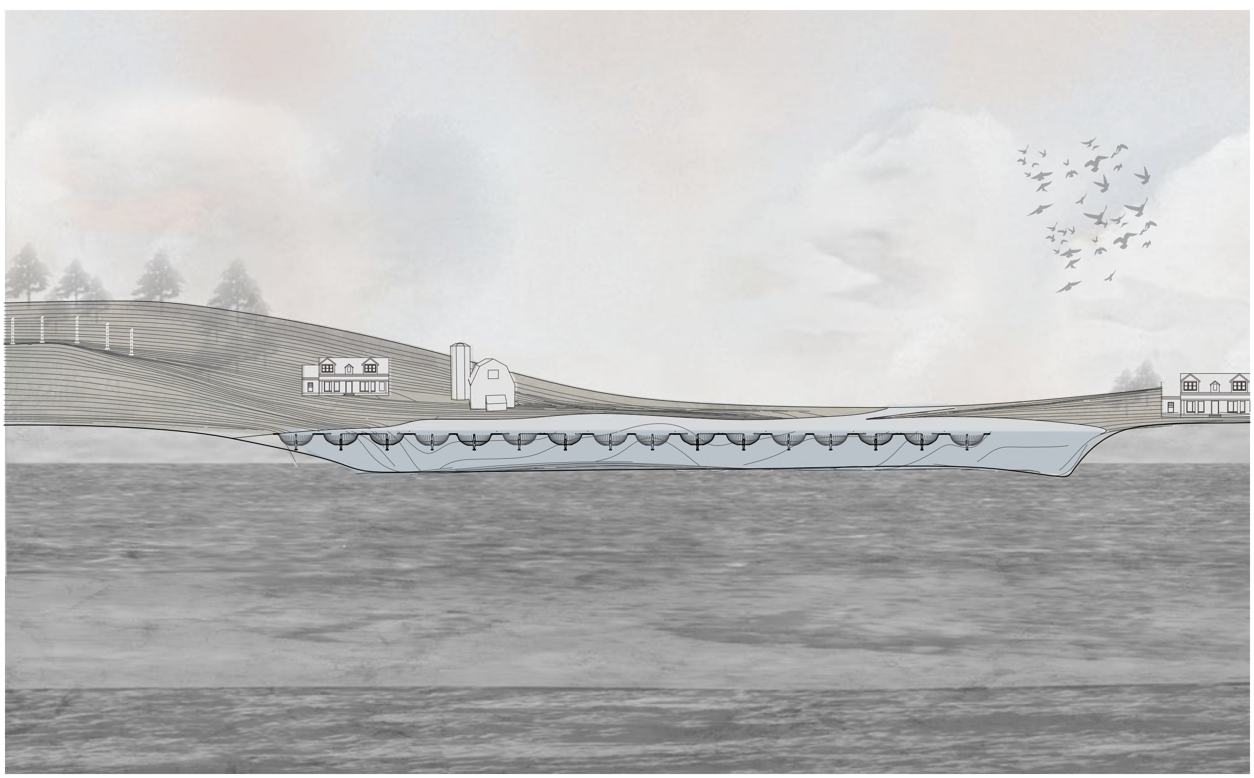

DRILLING SITES
CLEAR CUT PATHS SERVE AS
LOCATIONS FOR DEVICES
POND
REMEDIATION
EVAPORATION PIT
REDESIGN
DEVICES
POND REMEDIATION
PUBLIC BATHS
EVAPORATION PIT REDESIGN











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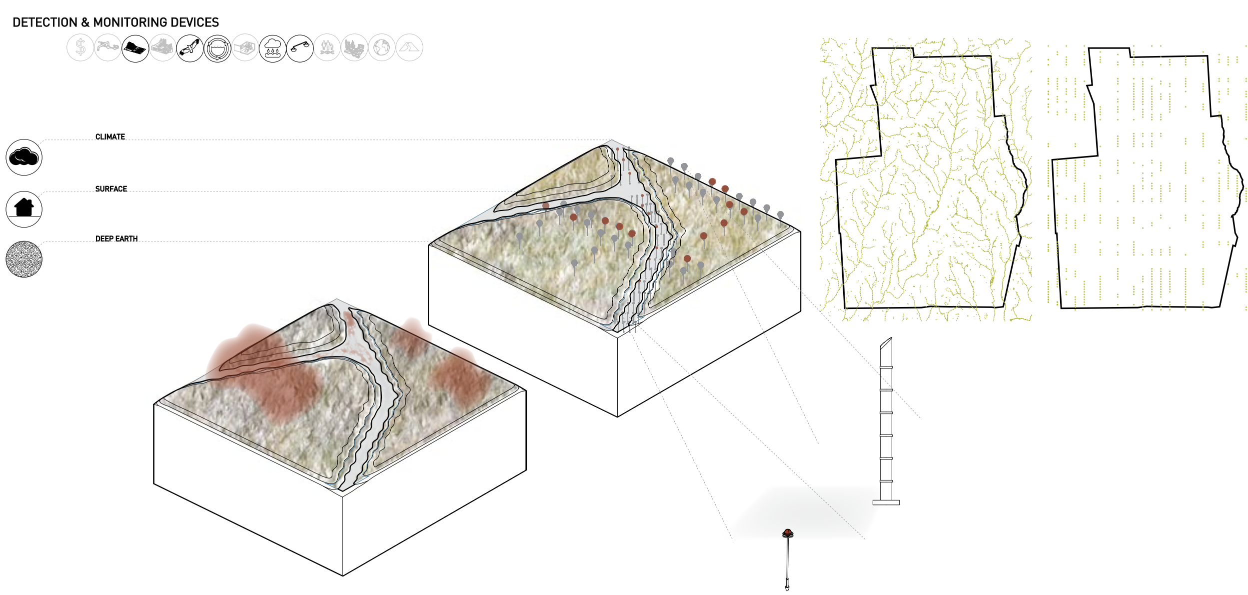
SCENARIO 1: MONITORING

Intervention One is comprised of contamination monitoring devices. These devices are located in both bodies of water and open areas of land. As a result of the amendments made to the Clean Air and Clean Water Act monitoring of contamination is not conducted in regions where fracking exists. These devices act as an ad-hoc system for the region. Deployable by local activists they provide a clear reading of contamination within the landscape. Their threshold is clear as the pollution moves and flows across the site the devices provide a clear path as to the location and movement of the contamination. As simple as a true or false statement the lights provide a glowing hazy atmosphere within the region.



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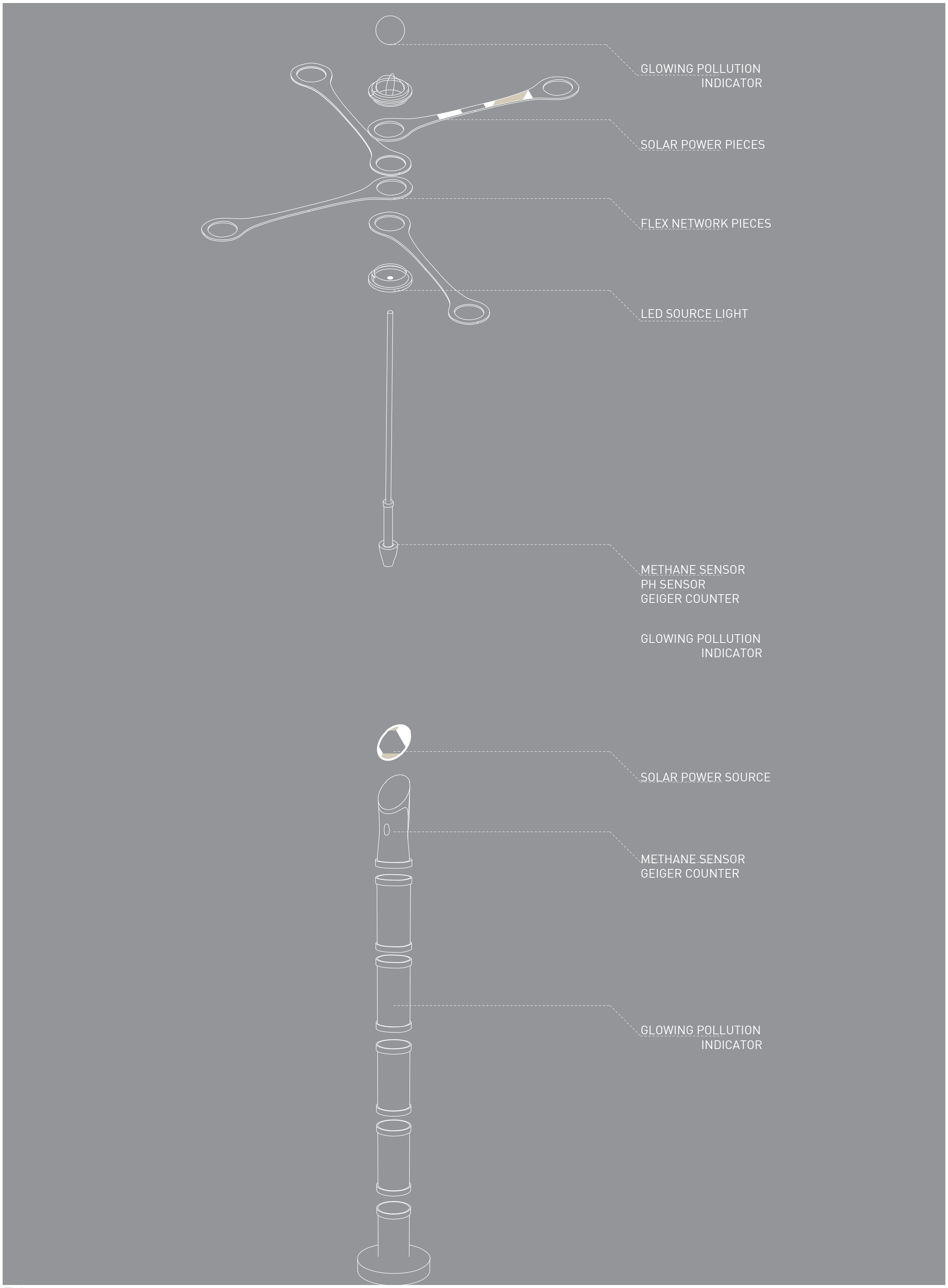
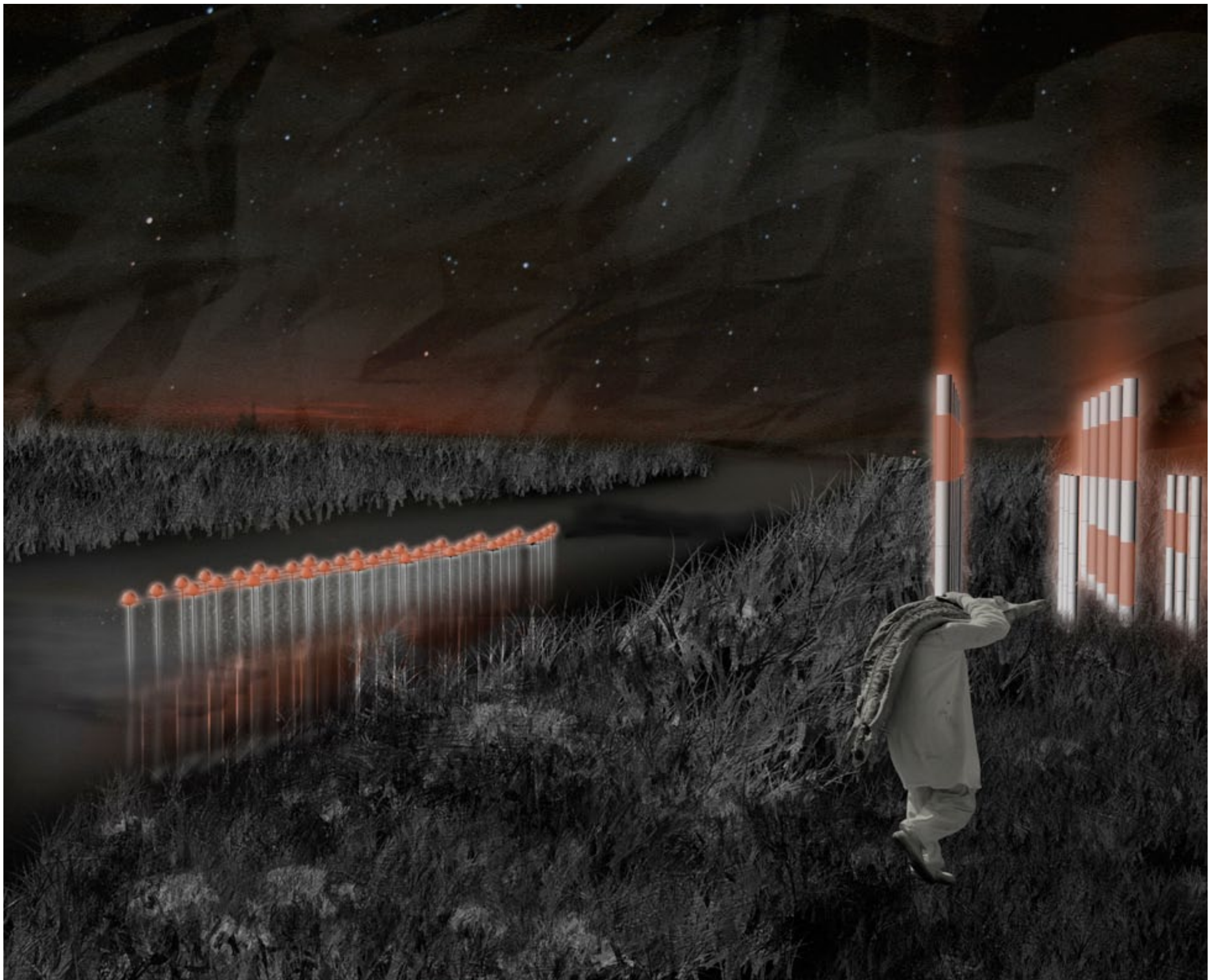
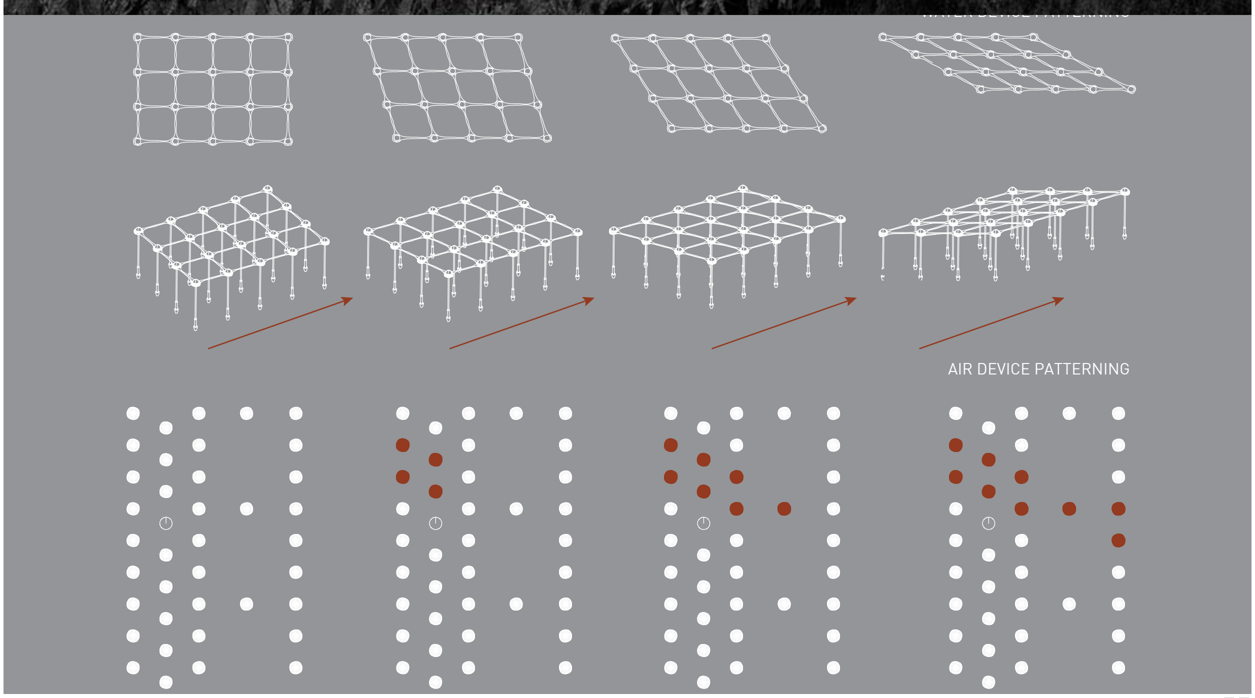

GLOWING POLLUTION INDICATOR
SOLAR POWER PIECES
FLEX NETWORK PIECES
LED SOURCE LIGHT
METHANE SENSOR
PH SENSOR
GEIGER COUNTER
GLOWING POLLUTION INDICATOR
SOLAR POWER SOURCE
METHANE SENSOR
GEIGER COUNTER
GLOWING POLLUTION INDICATOR





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SCENARIO 2: FLAMING FAUCETS

The water situation within the site is dire. Energy companies when found guilty of contaminating underground aquifers are only required to provide clean water deliveries for 3 years. Certainly not longer enough for residents to find new water sources. Additionally, as a result of the flammability of the water within pipes, pipes within the houses are shut off meaning the deliveries do not solves issues of water pressure or renewable resources.

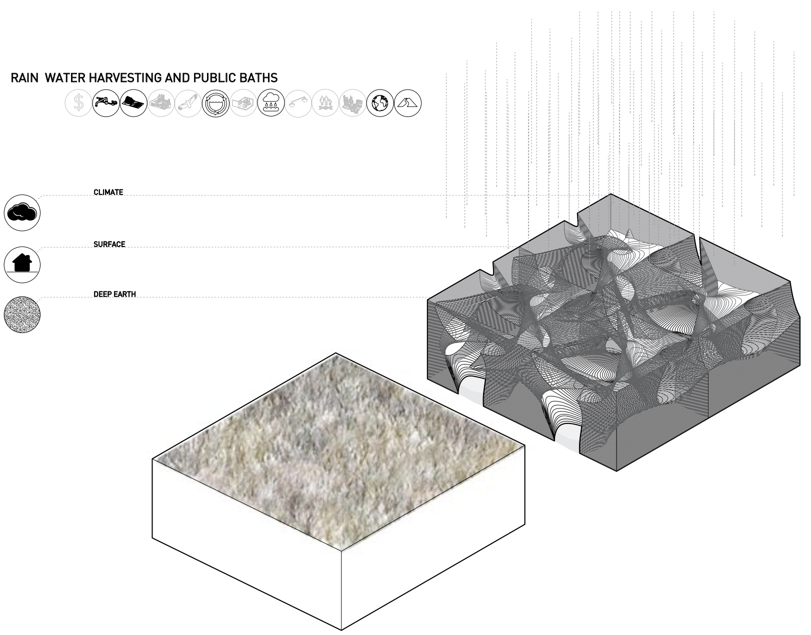
Currently, as small group of residents has taken to stealing water from local municipalities with access to clean water. Several individuals from the rural community will drive to an area with water piped in from a safe source, open the hydrants in town and steal the water, returning it to the rural residents without clean water.

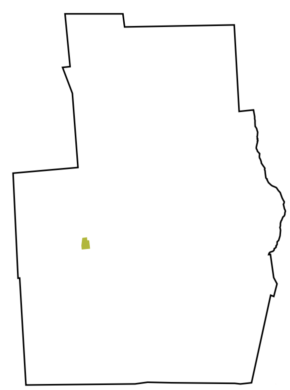
The second site intervention attempts to address this complex network of ecological, environmental, safety, health and social processes. It is part landscape, part water-filtration, part-bathhouse. The intent is to create a landscape that collects rainwater, filters and purifies it through heat and then this heater water can be collected by residents or bathed in. In this way a new community is also created surrounding the water.

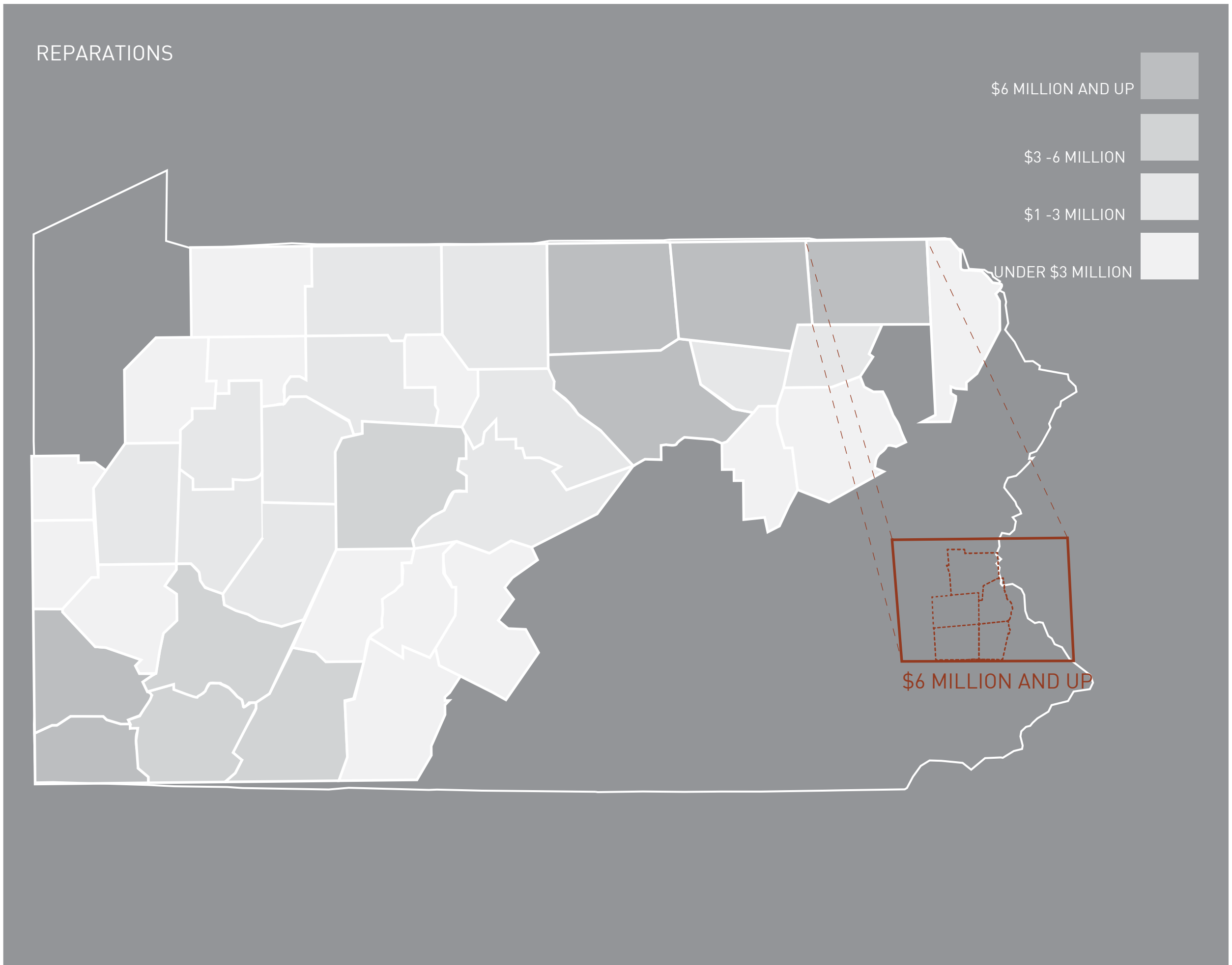
A significant aspect of this intervention is its construction method. Taking inspiration from slurry wall construction the intended walls of the bath house are to be poured concrete using excavated form-work, excavated using fracking equipment. The same equipment used the contaminate the earth will now be used to hermetically seal rain water from said contaminated earth. This method taking advantage of horizontal fracking technology also affords the structure sweeping forms.

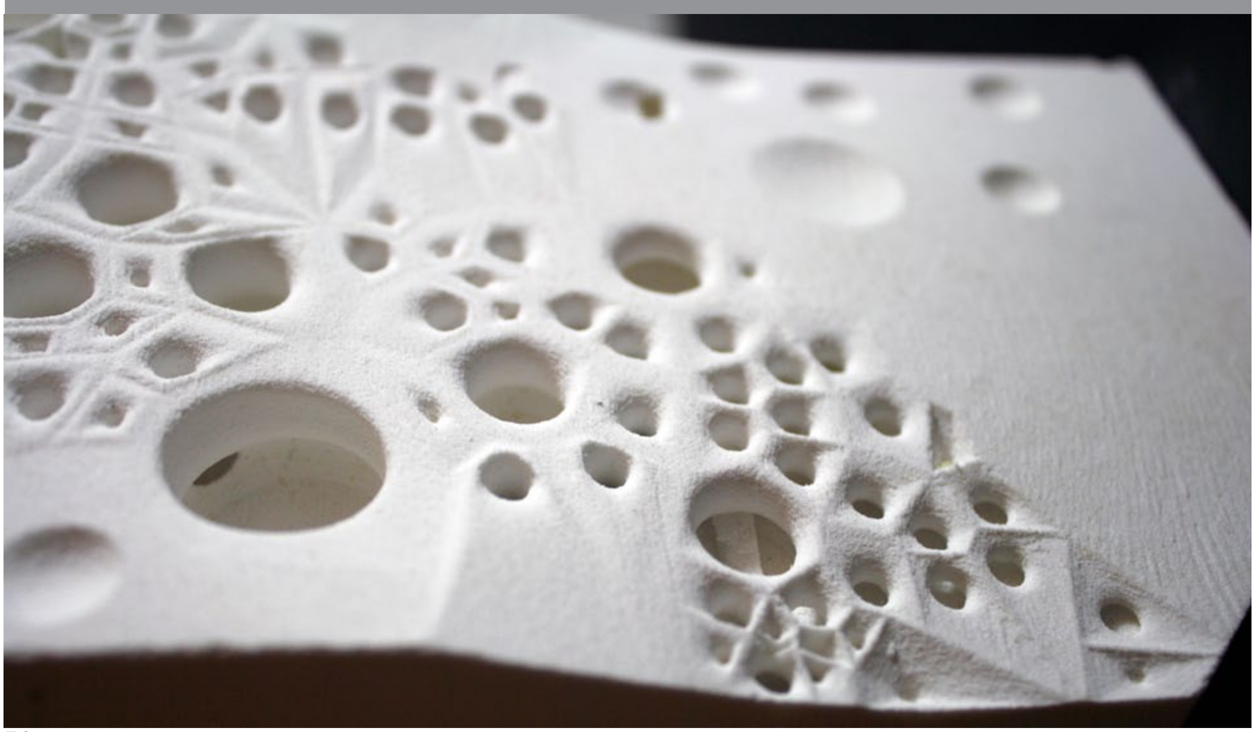
Additionally, in October of 2012 Pennsylvania instituted the Impact Fee. This new policy stipulates that energy companies must pay $50,000 to the state per well drilled in addition to any lease agreements that energy companies may hold with property holders. This policy was ground breaking. Because traditional mineral rights lease agreements are held between the energy companies and the landowner in question state and local municipalities never see the financial benefits of natural gas extraction within their state. Payments to the local counties will be made in $500,000 installments over the next 5 years. Additionally, fees will continue to be collected as drilling continues within the state. This impact fee could easily be utilized for large scale construction projects such as a public bath.

RAIN WATER HARVESTING AND PUBLIC BATHS

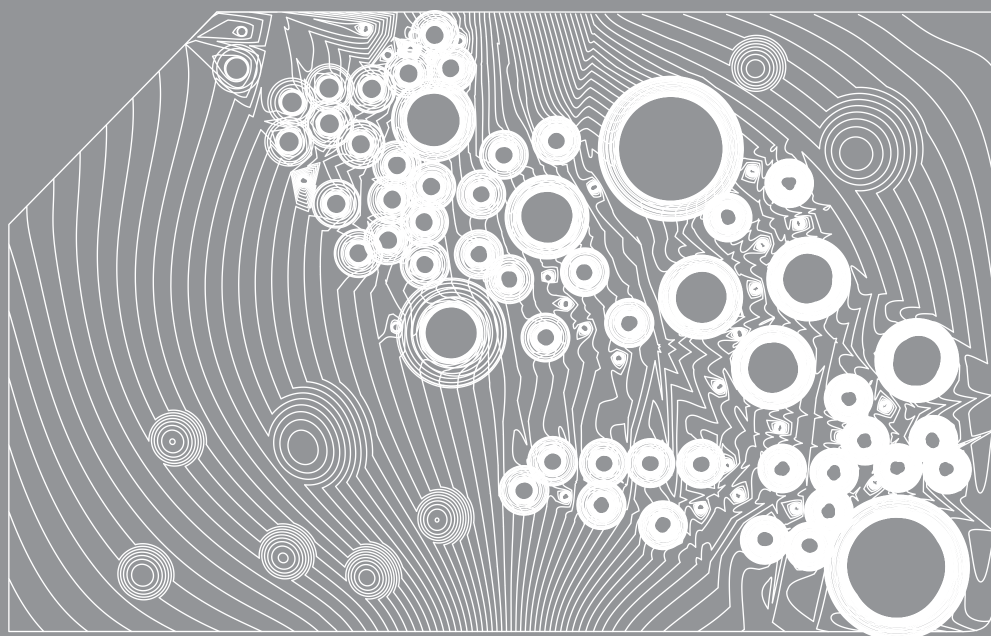


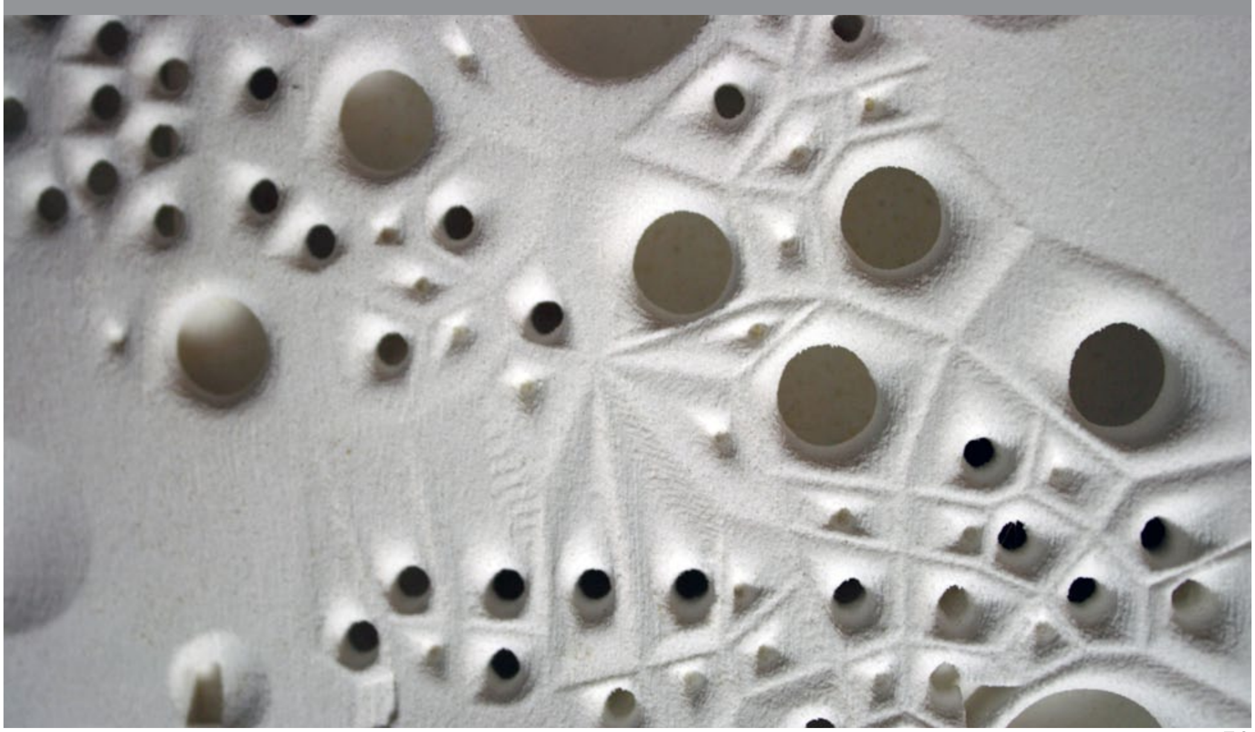



REPARATIONS
$6 MILLION AND UP
$3 -6 MILLION
$1 -3 MILLION
UNDER $3 MILLION
$6 MILLION AND UP



RAINWATER HARVESTING LANDSCAPE





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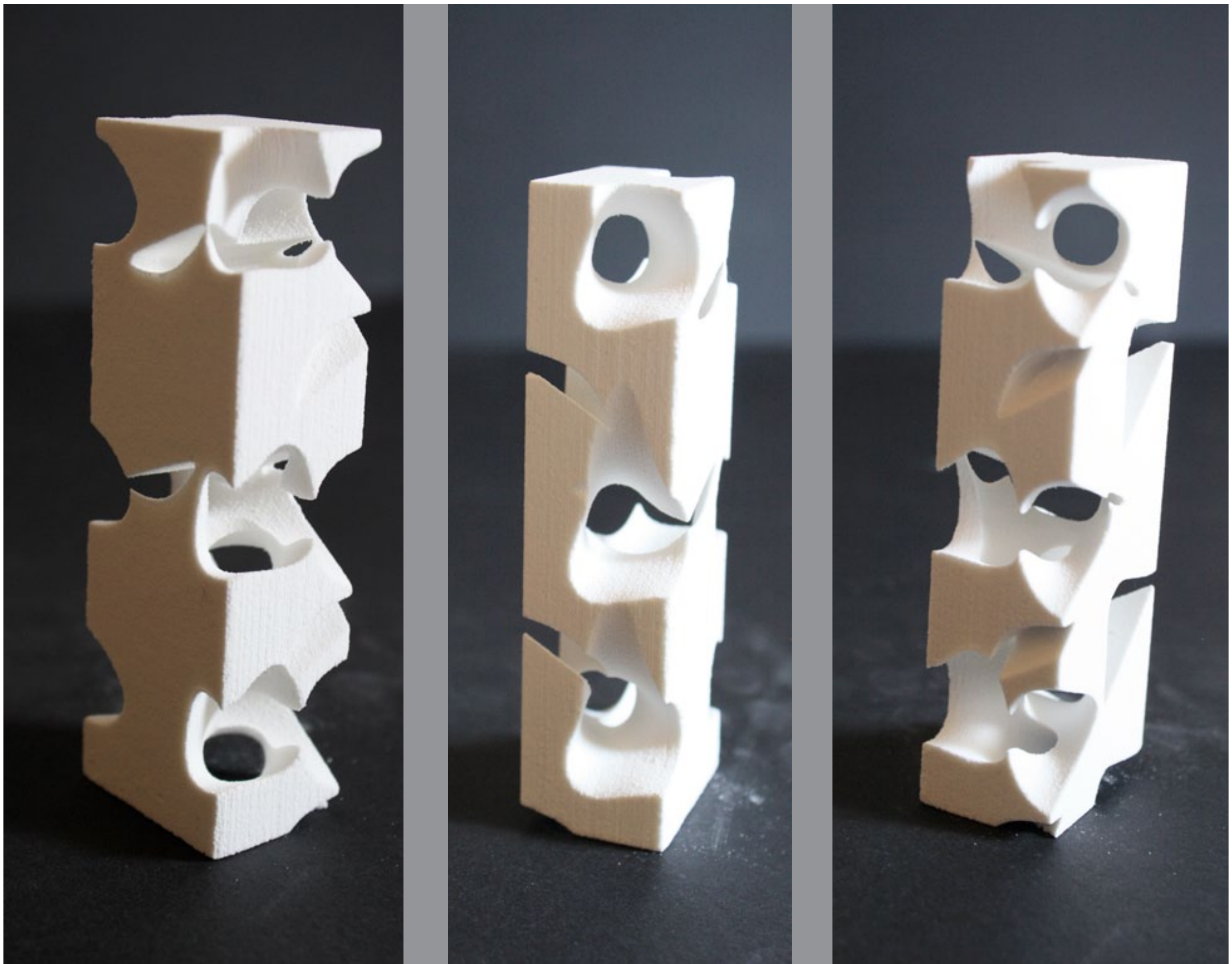
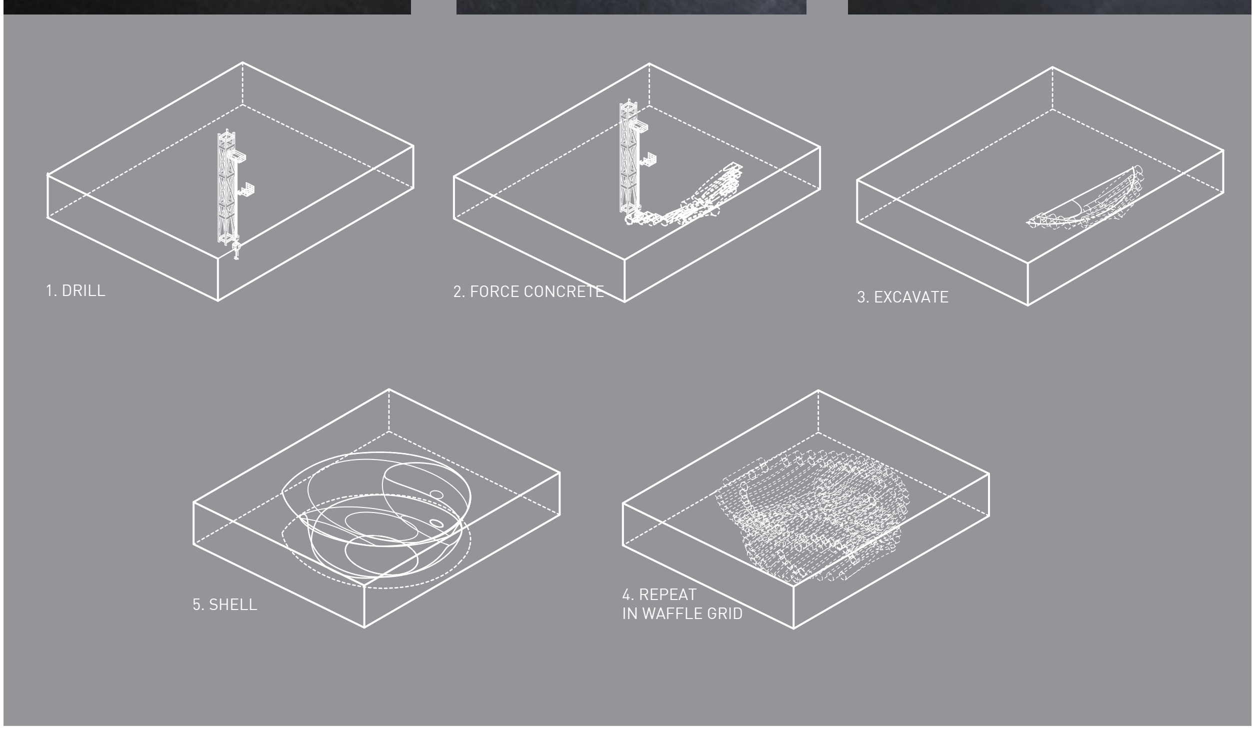
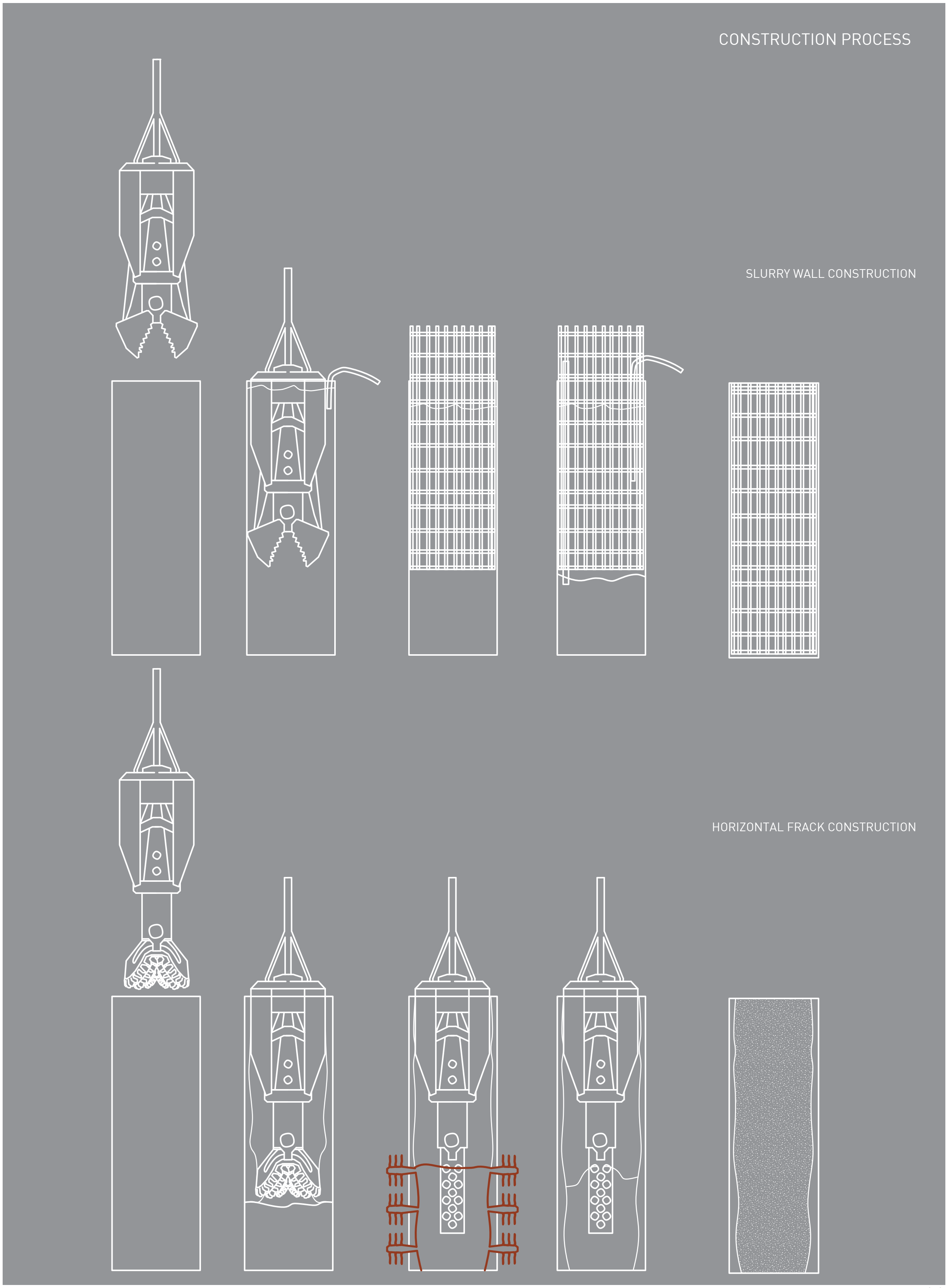
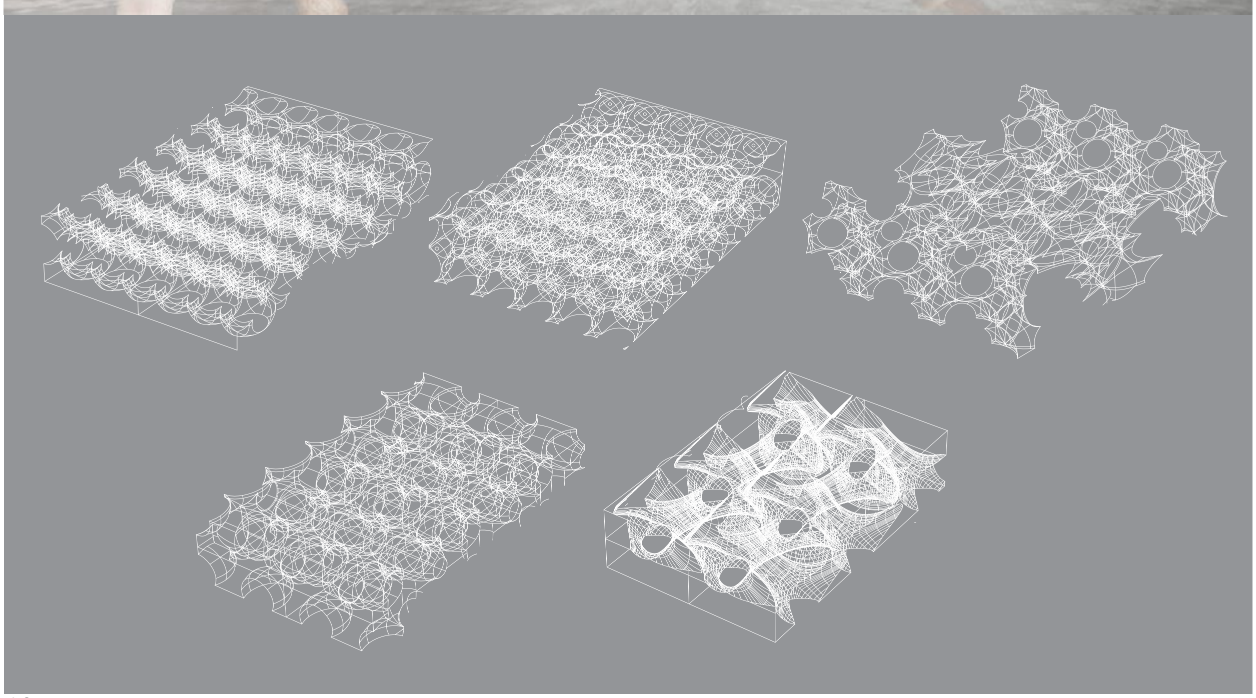
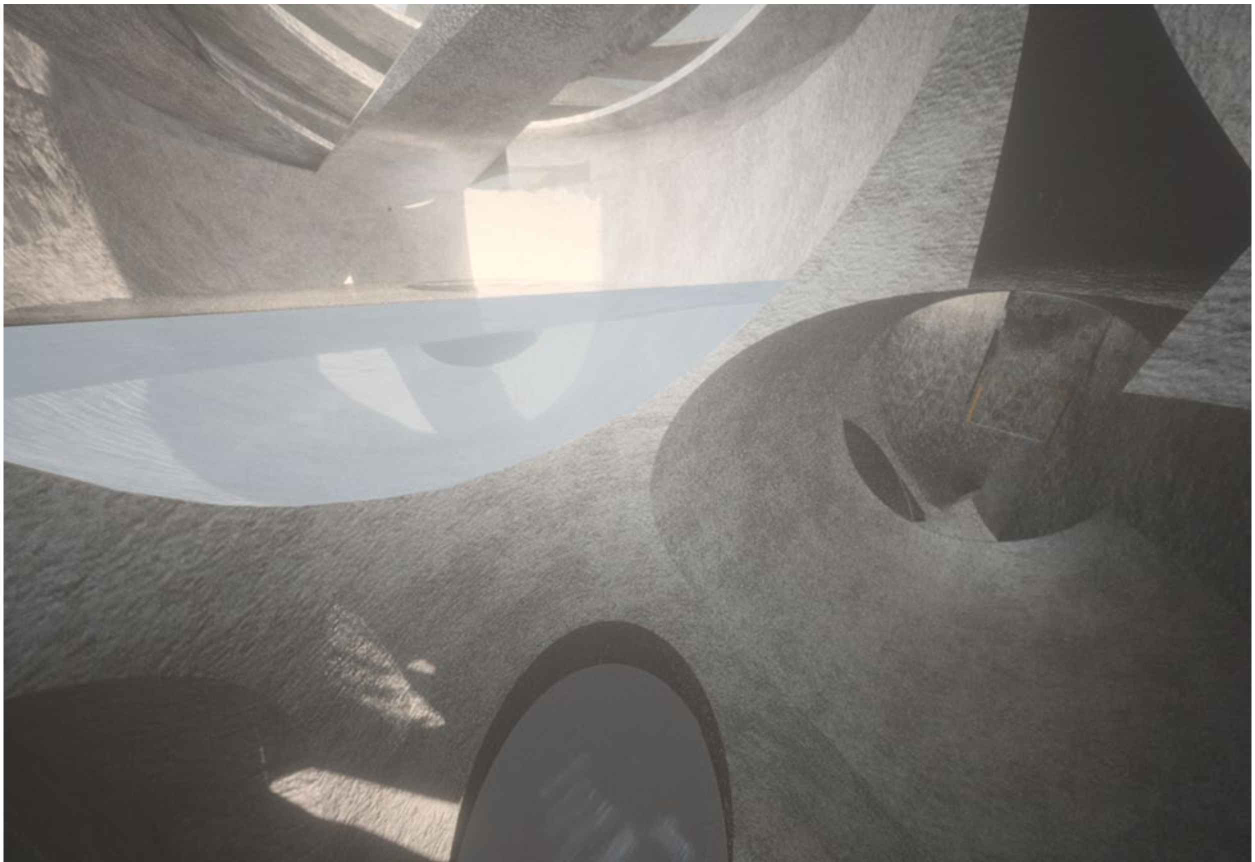
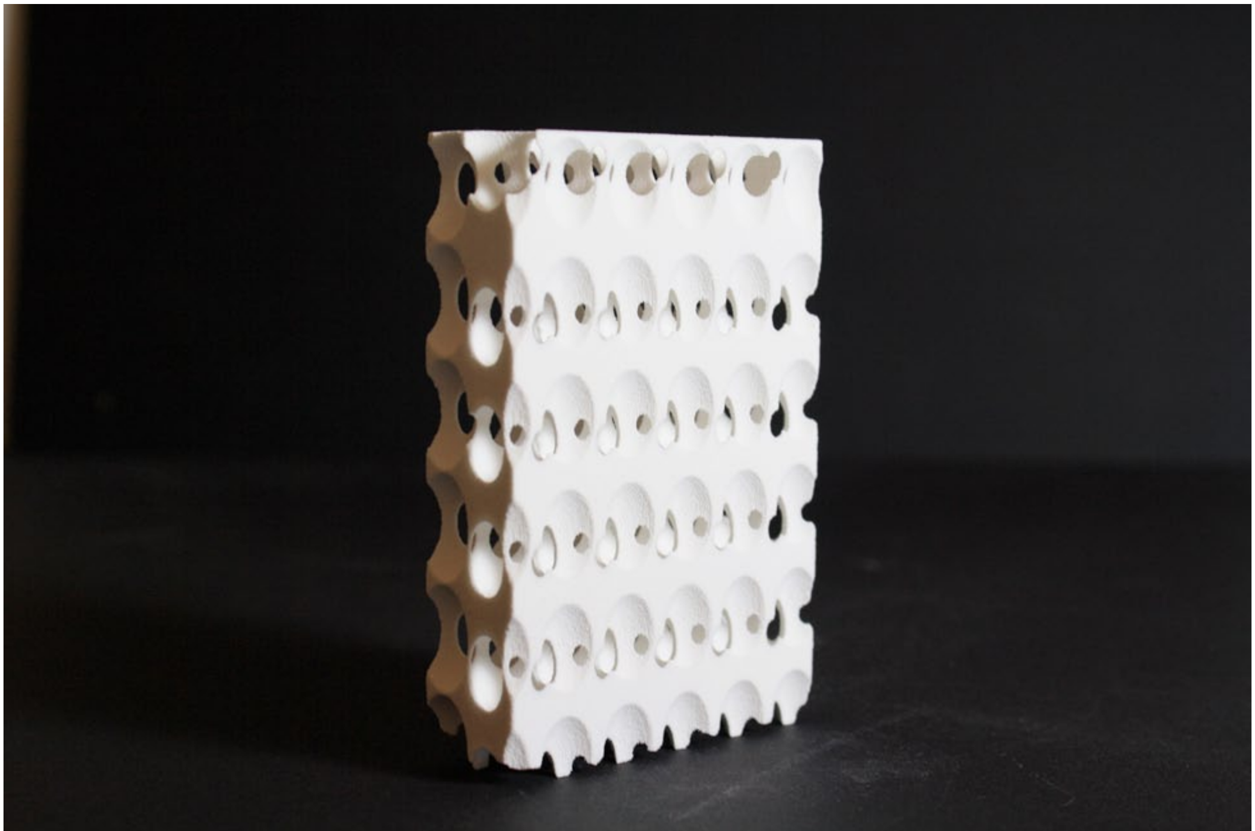


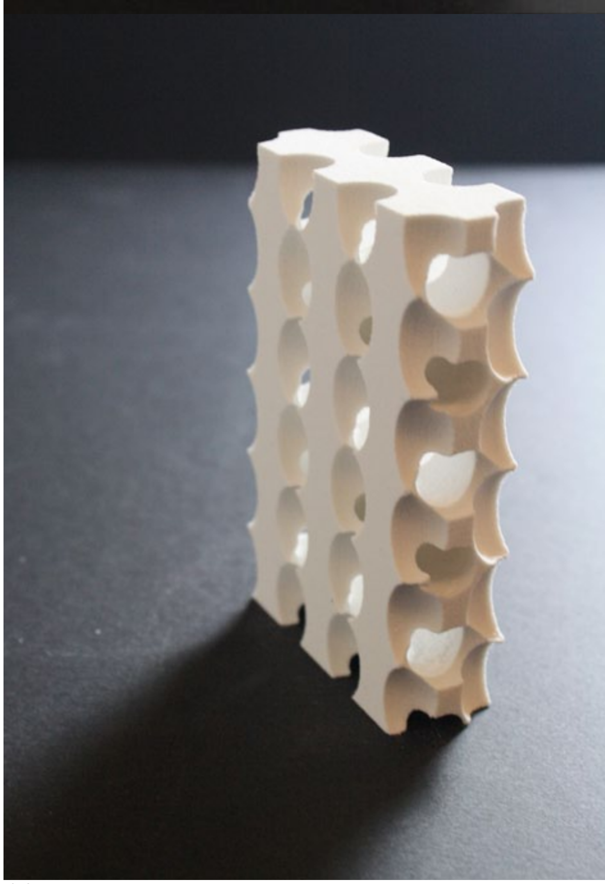

1. DRILL
2. FORCE CONCRETE
3. EXCAVATE
5. SHELL
4. REPEAT
IN WAFFLE GRID

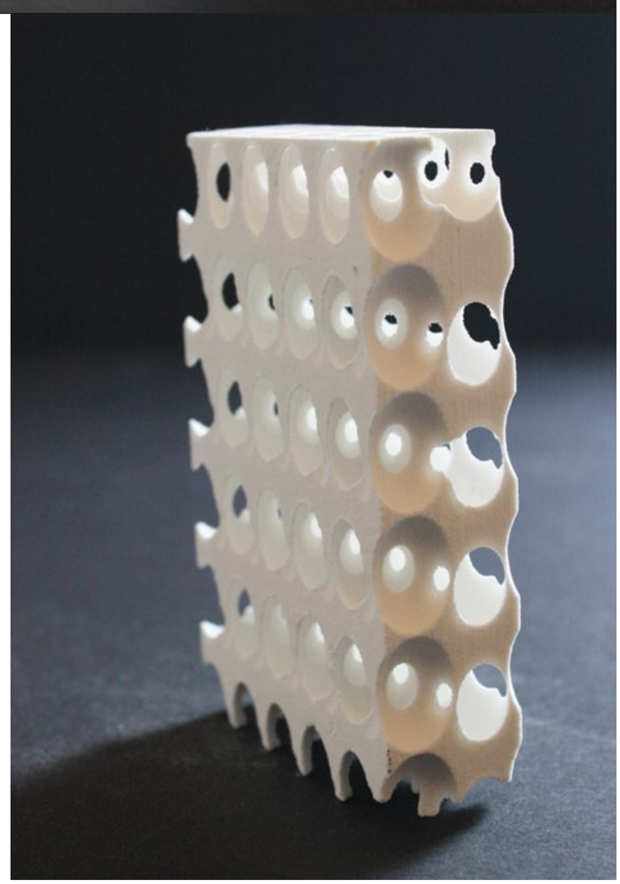

CONSTRUCTION PROCESS
SLURRY WALL CONSTRUCTION
HORIZONTAL FRACK CONSTRUCTION

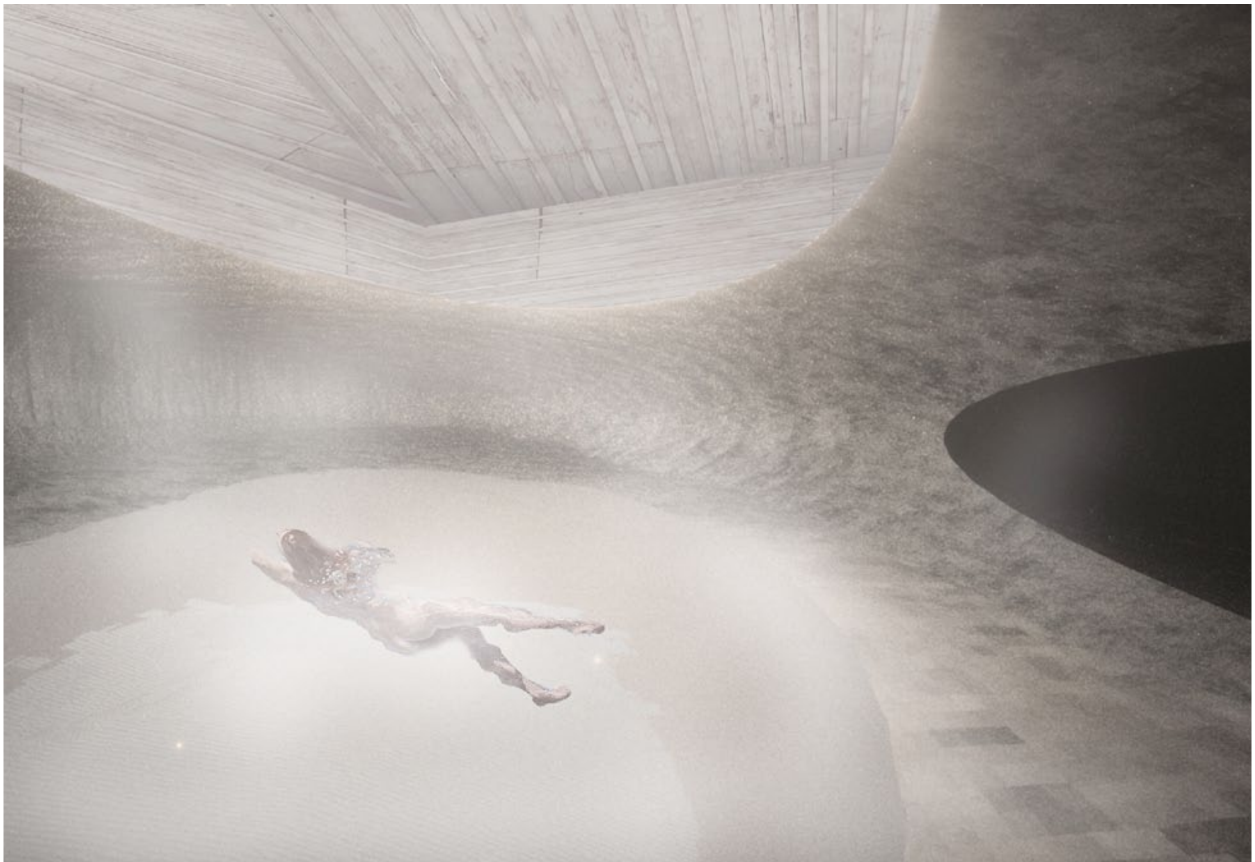


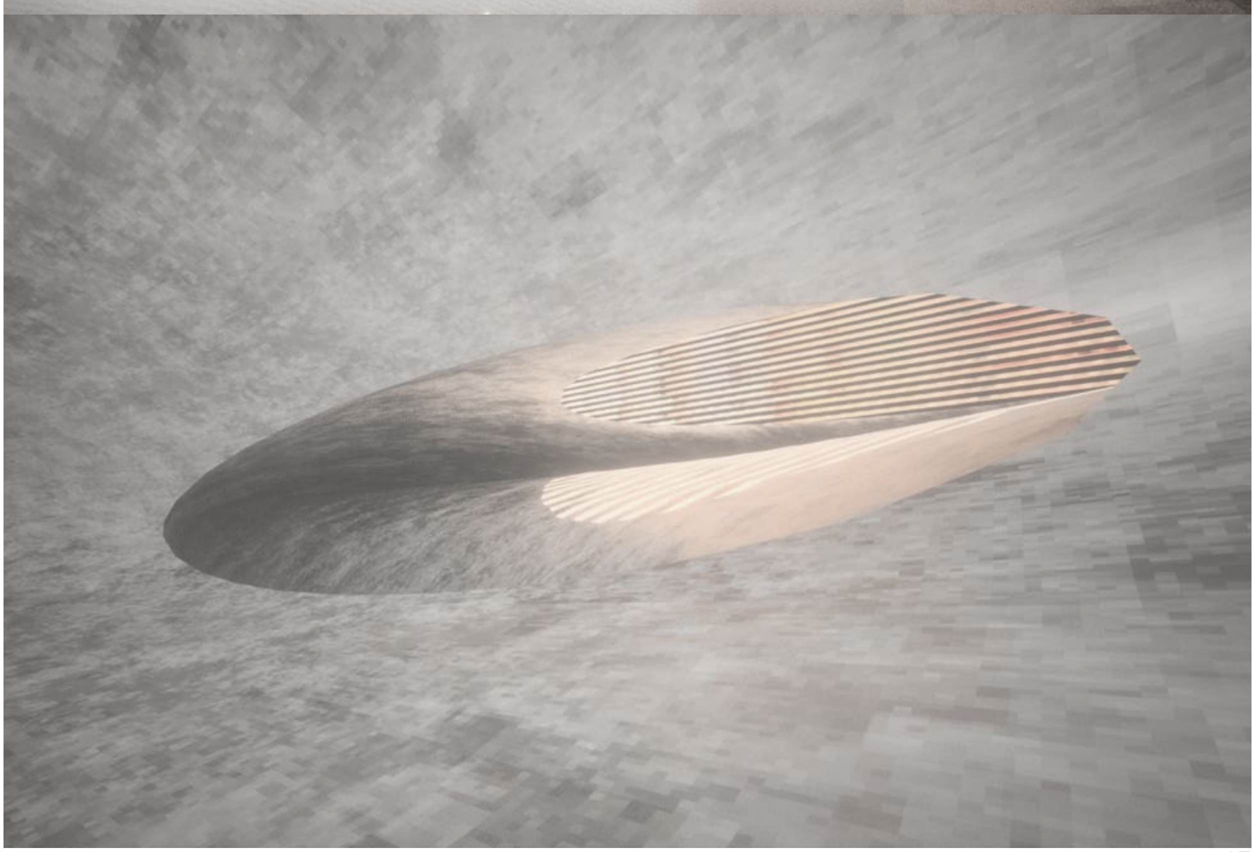












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SCENARIO 3: RADIOACTIVE MILK

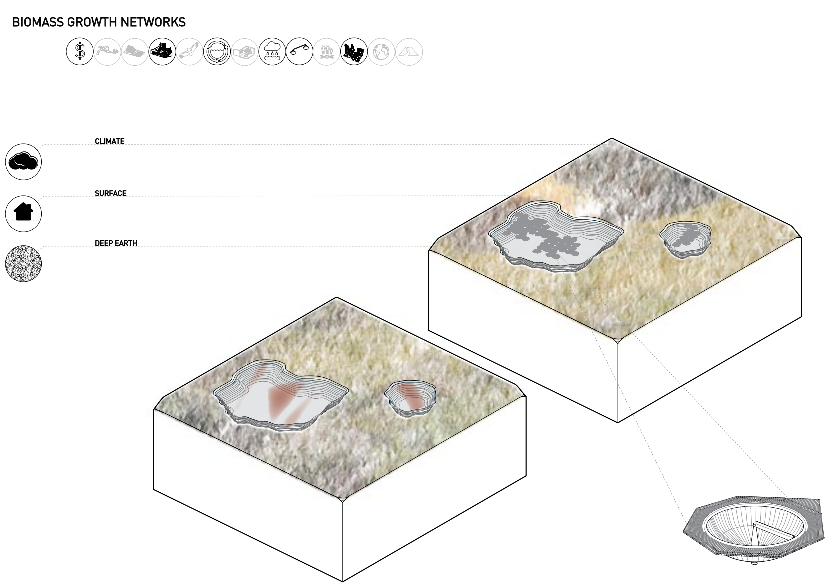
Perhaps the most radical intervention to be made in case for fracking reparations is that of algae. Site intervention three and four take on algae as an additional layer of energy and economic production within the region.

In recent years there has been a large amount of research and development in bio fuels in general and, in algae in particular. Unfortunately, algae requires a large amount of water to grow successfully. Some of the most successful algae ponds are located in the southwestern portion of the United States. Large tracts of desert land can be converted into ponds where surface area and access to sun (two of the most significant properties needed to grow algae) can be maximized.

By looking at El Dorado Biofuels LLC in New Mexico an argument can be made for the utilization of algae in the remediation of produced water from fracking. El Dorado is launching a pilot project this month in Lea County, in the heart of southeast New Mexico's oil patch, to clean the toxins out of produced water and use it to grow algae for biofuels. El Dorado expects to pump about $2 million into the project to eventually reach 20 acres of biofuel production.

The company, which lists Frank Yates of Yates Petroleum Corporation as one of its backers, has invested about $500,000 to launch operations. It also received a three-year, $500,000 grant from the U.S. Department of Energy through the National Alliance for Advanced Biofuels and Bio products, a coalition of national laboratories, research universities and private companies that formed last year with $49 million in DOE backing. El Dorado is one of 12 biofuel businesses working with the NAABB. Using produced water to grow algae provides many benefits. It resolves the need for massive amounts of water to grow algae on a commercial scale in New Mexico's water-strapped, arid environment. It also provides a separate revenue stream for El Dorado from oil and gas operators, who will pay to get rid of produced water, rather than treat it themselves and pump it back underground.

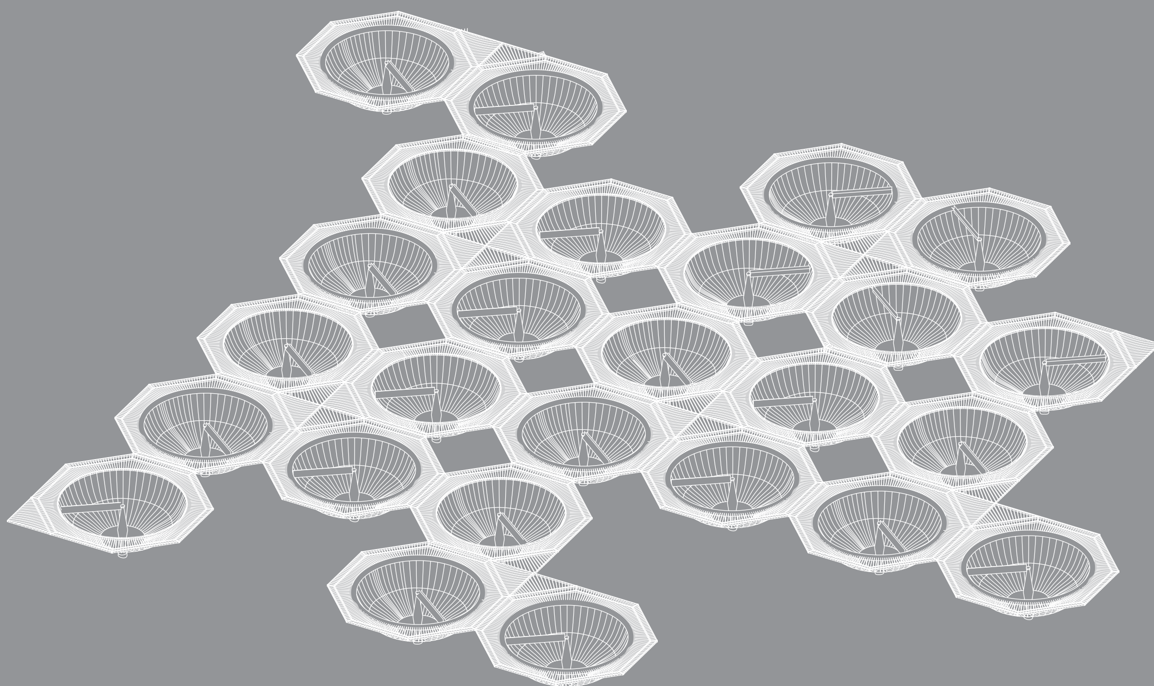
Such extra revenue is critical to make commercial-scale algae biofuel operations economical. There is ample sunshine and land to grow algae in New Mexico, but the missing component is water for thousands of acres of algae production. The key is using produced water from the oil and gas industry. El Dorado could attract a lot of interest from operators looking to cut costs when disposing of produced water.

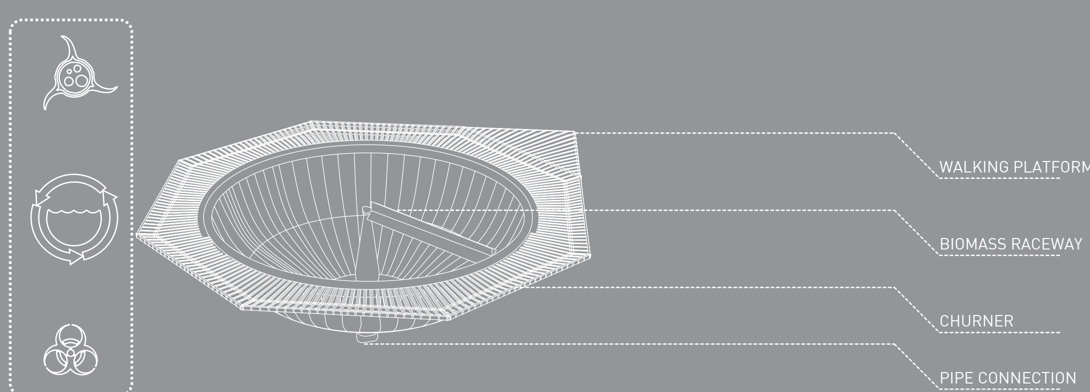


BIOMASS GROWTH NETWORKS
CLIMATE
SURFACE
DEEP EARTH

NETWORKED BIOMASS GROWTH

REFINERIES ACT AS NODES
FOR THE BIOMASS NETWORK





Catherine Winfield, Massachusetts Institute of Technology

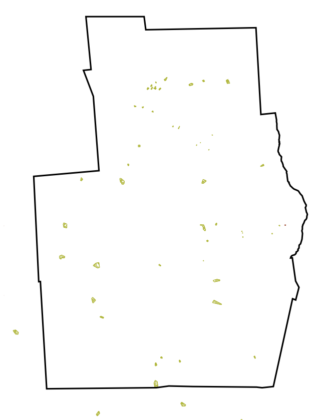
Depending on contamination levels, costs between $1 and $3.50 for each barrel of produced water injected back underground (In New Mexico they inject produced water back into the oil formation rather than rely on evaporation pits as in Pennsylvania). That is a huge expense for Lea County energy companies who dispose of about 400 million barrels of produced water every year according to the DOE's Natural Energy Technology Laboratory. Economically growing and converting algae to biofuel on a commercial scale will be challenging. To date, no technology startup has demonstrated an ability to produce algae-based biofuels at a cost competitive with oil, currently about $100 a barrel. But with oil prices climbing algae-based biofuels will become more economical.

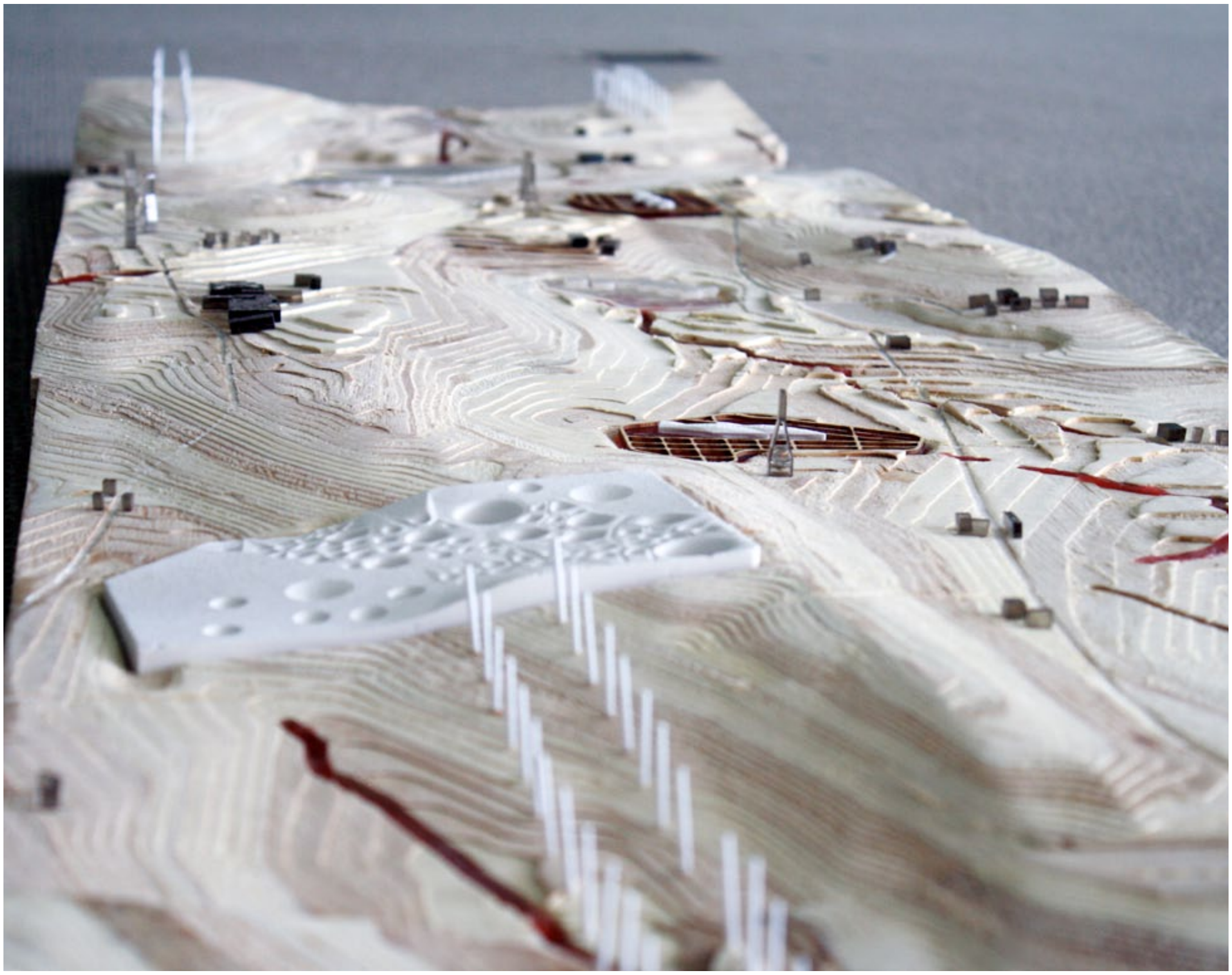
So while Pennsylvania does not have the open desert environment ideal for algae production it does have millions of gallons of produced water in need of treatment. If this process were more cost effective, safer and faster than traditional methods it would appear as the right direction to develop. El Dorado isn't the only one looking at this type of a solution. Origin Oil is another United States based company looking at the issue of produced water and algae. They are currently designing and testing a system that would connect directly with the pumping system set up by energy companies to remove the fracked fluid from the well once it has been injected.

Their latest endeavor used sewage (or black water) to grow algae while simultaneously treating the water. Origin Oil is geared up for the commercial rollout of its oil and gas wastewater cleanup systems this year. These are designed to help process up to 1 barrel of "frack flow back" water per minute, or up to 60,000 gallons per day. This type of system would be better suited for a Pennsylvania deployment as it does not require large tracts of land and would still function well in the Northeast's temperate climate.

The use of algae in Dimock is particularly appealing because it could add an additional layer of jobs for those left behind in the gas rush. Those former dairy farmers could rent out small tracts of their land for these systems. Origin Oil and other companies experimenting with these technologies could hire locals to install the systems, maintain them and truck algae oil to refineries.
The location of a biofuel based farming infrastructure could enliven the region for those without income. It would remediate the worst after-effect of fracking and it would produce a second layer of energy on the landscape.

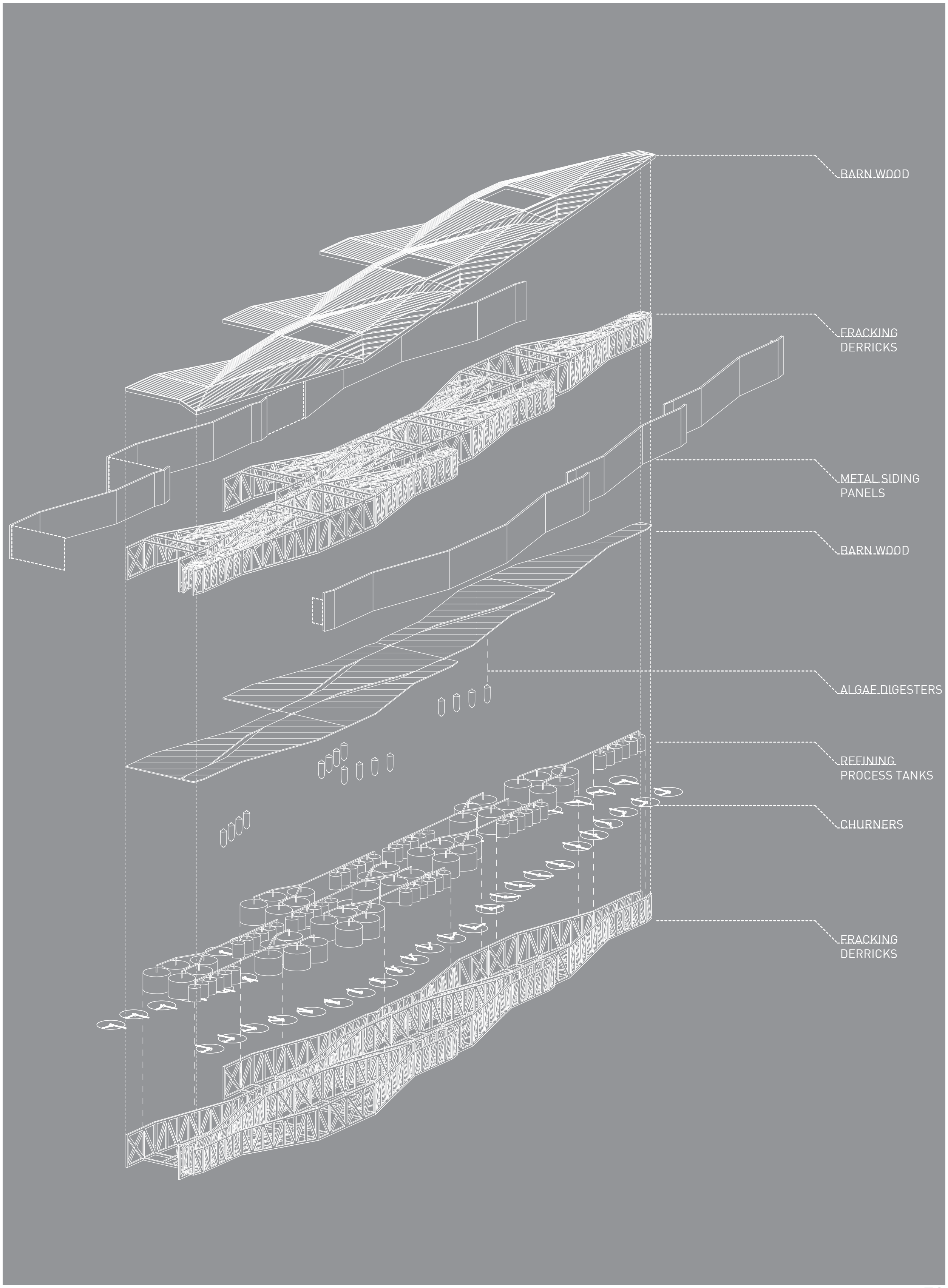
BIOFUEL REFINERY





These site interventions manage the growth of algae through a network of devices to be deployed by farmers in need of a new source of income. The material grown through these devices can sold to refineries with the region that produce biofuel.

These refineries are comprised of discarded fracking components. Located on existing evaporation ponds then utilize the manage the algae growth on evaporation ponds remediating the water below. The intent here is to redesign the evaporation pit to a site typology offering resiliency. The refinery here would be deployed by energy companies as a means of offseting the impact fee.

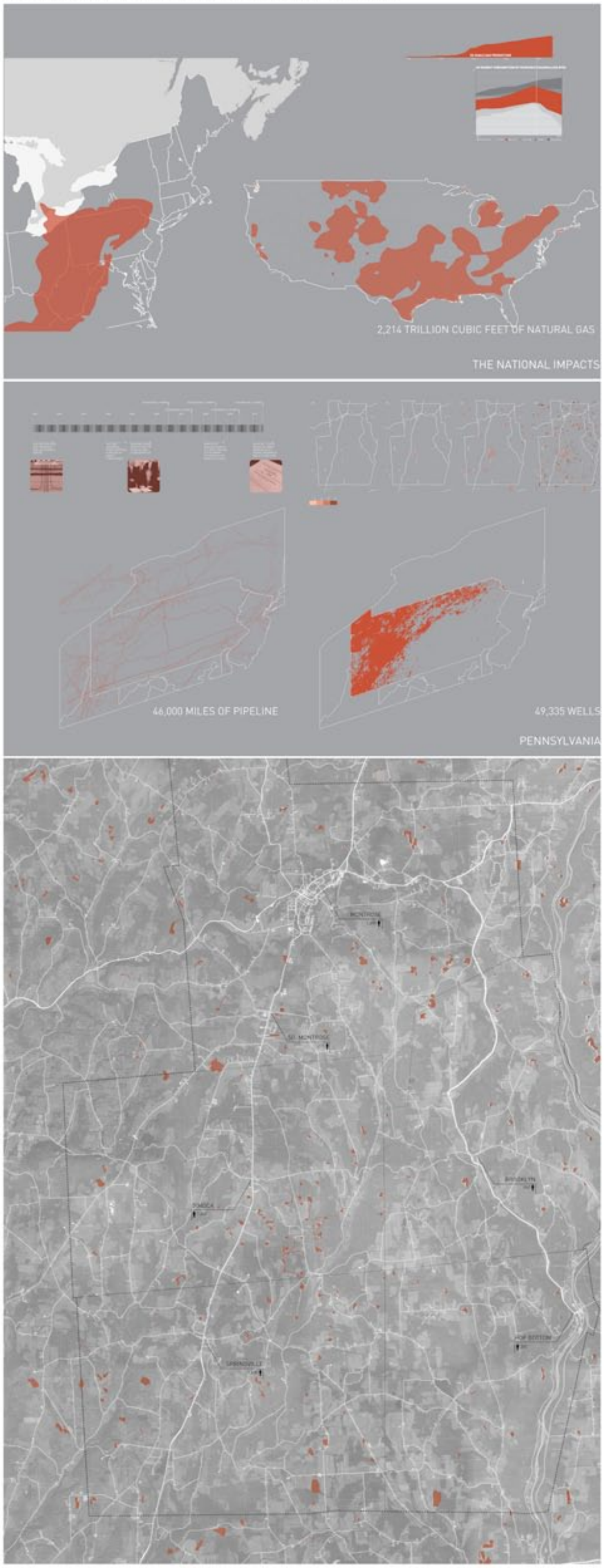


Catherine Winfield, Massachusetts Institute of Technology

APPENDIX : THE THESIS DEFENSE

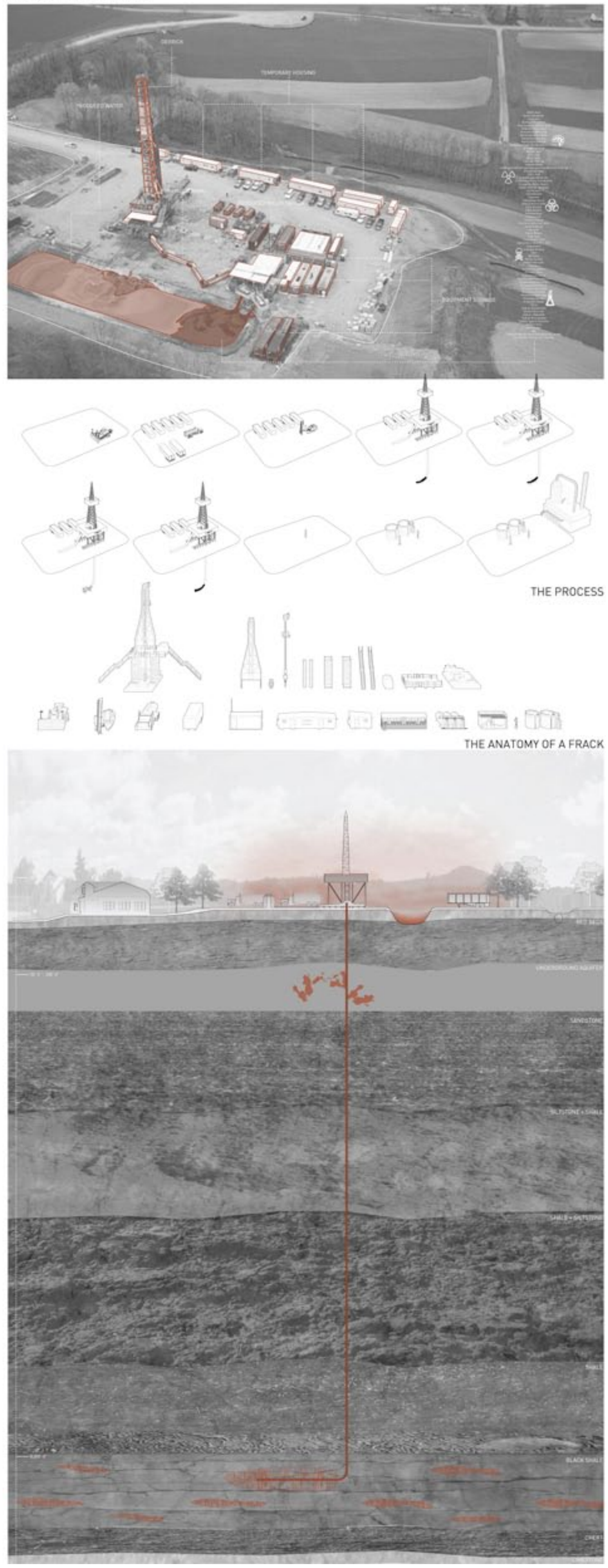
AUTOPOIETIC LANDSCAPES : THE ARCHITECTURAL IMPLICATIONS OF MINING THE MARCELLUS SHALE

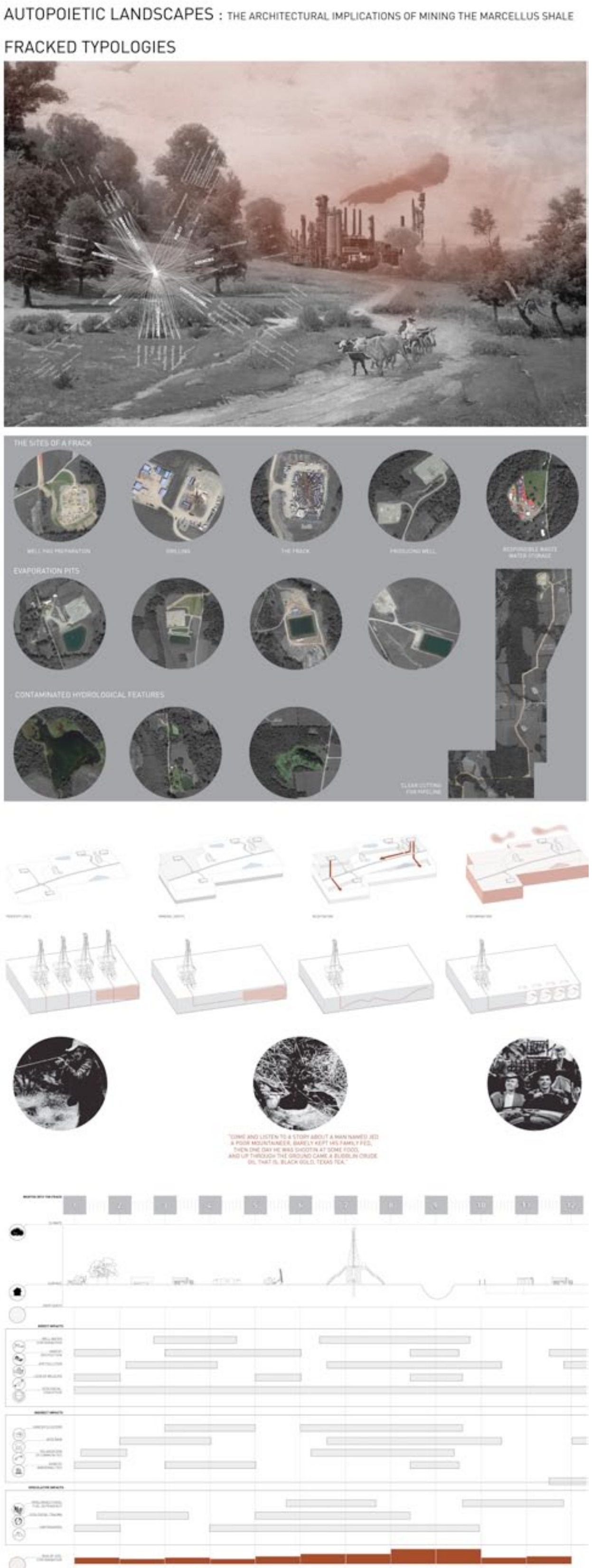
THE SCALE OF THE IMPACT: TIME AND GEOGRAPHY

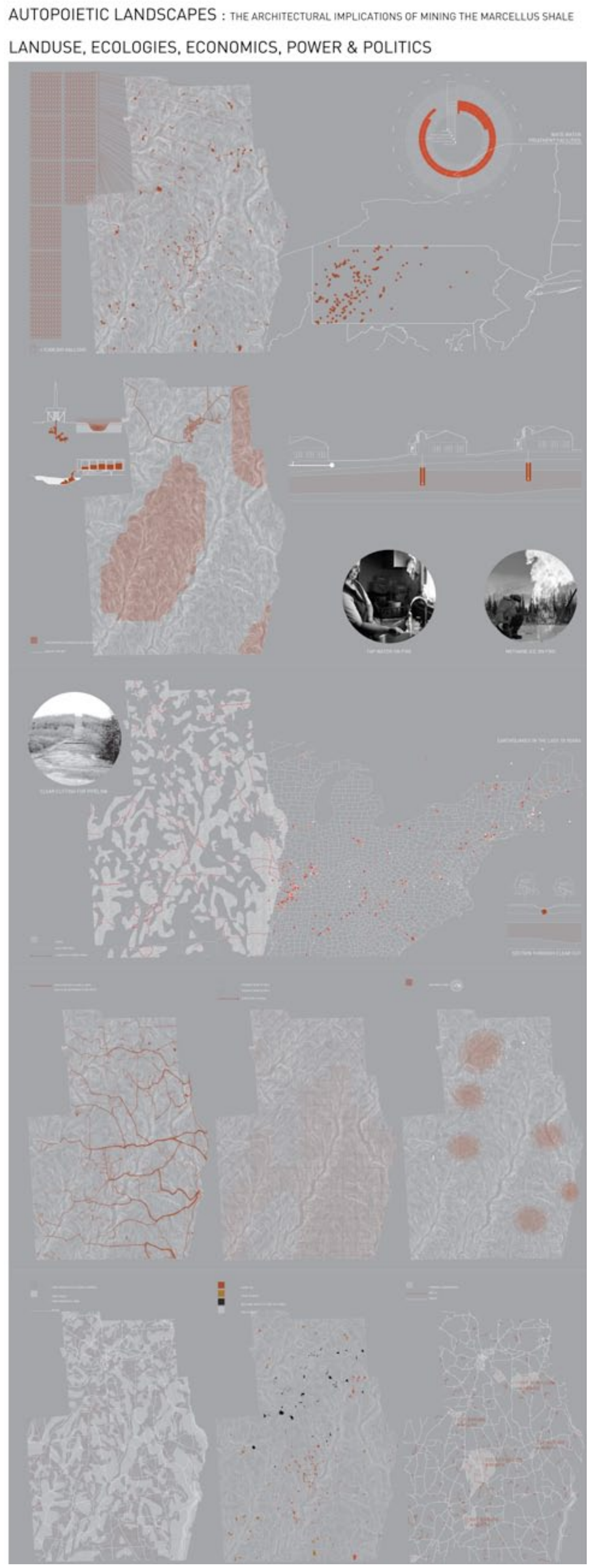


AUTOPOIETIC LANDSCAPES : THE ARCHITECTURAL IMPLICATIONS OF MINING THE MARCELLUS SHALE

WHAT THE FRACK?

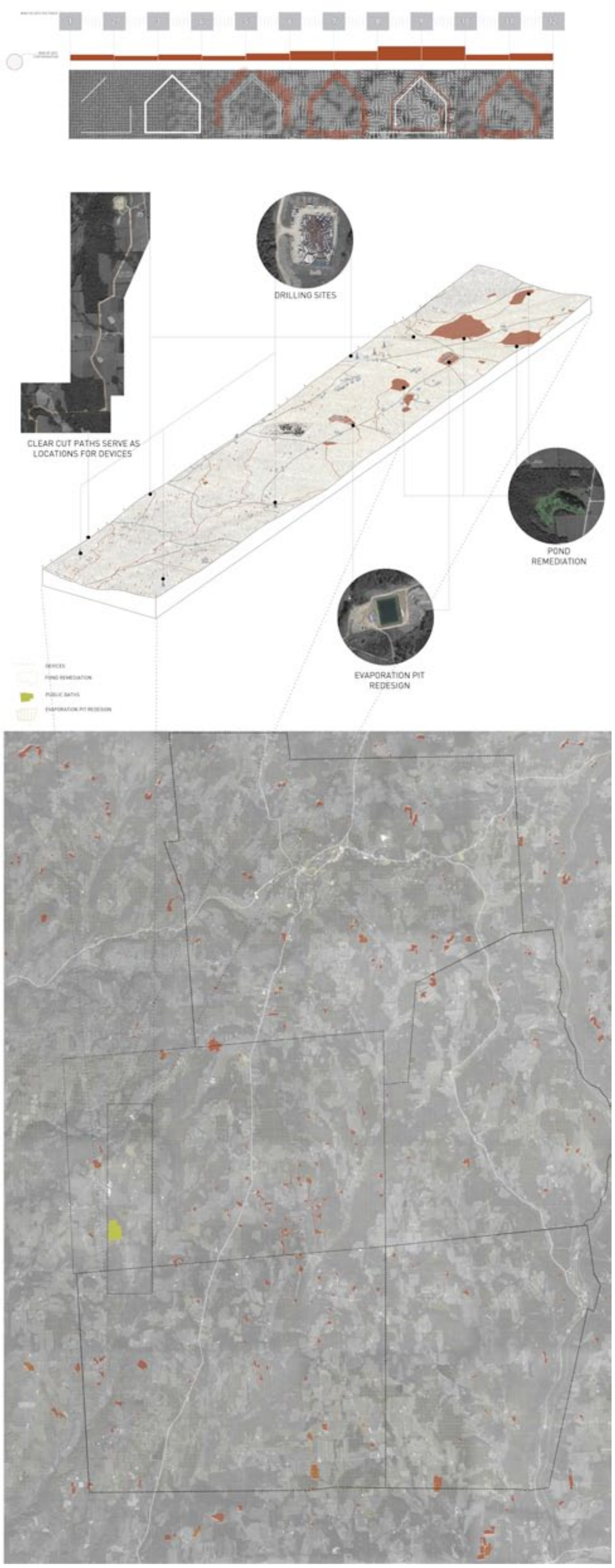



AUTOPOIETIC LANDSCAPES : THE ARCHITECTURAL IMPLICATIONS OF MINING THE MARCELLUS SHALE
FRACKED TYPOLOGIES
THE SITES OF A FRACK
WELL PAD PREPARATION
DRILLING
THE FRACK
PRODUCING WELL
EVAPORATION PITS
CONTAMINATED HYDROLOGICAL FEATURES
CLEAR CUTTING FOR PIPELINE
"COME AND LISTEN TO A STORY ABOUT A MAN NAMED JED
A POOR MOUNTAINEER, BARELY KEPT HIS FAMILY FED,
THEN ONE DAY HE WAS SHOOTIN AT SOME FOOD,
AND UP THROUGH THE GROUND CAME A BUBBLIN CRUDE
OIL THAT IS, BLACK GOLD, TEXAS TEA."


AUTOPOIETIC LANDSCAPES : THE ARCHITECTURAL IMPLICATIONS OF MINING THE MARCELLUS SHALE
LANDUSE, ECOLOGIES, ECONOMICS, POWER & POLITICS
CLEAR CUTTING FOR PIPELINE

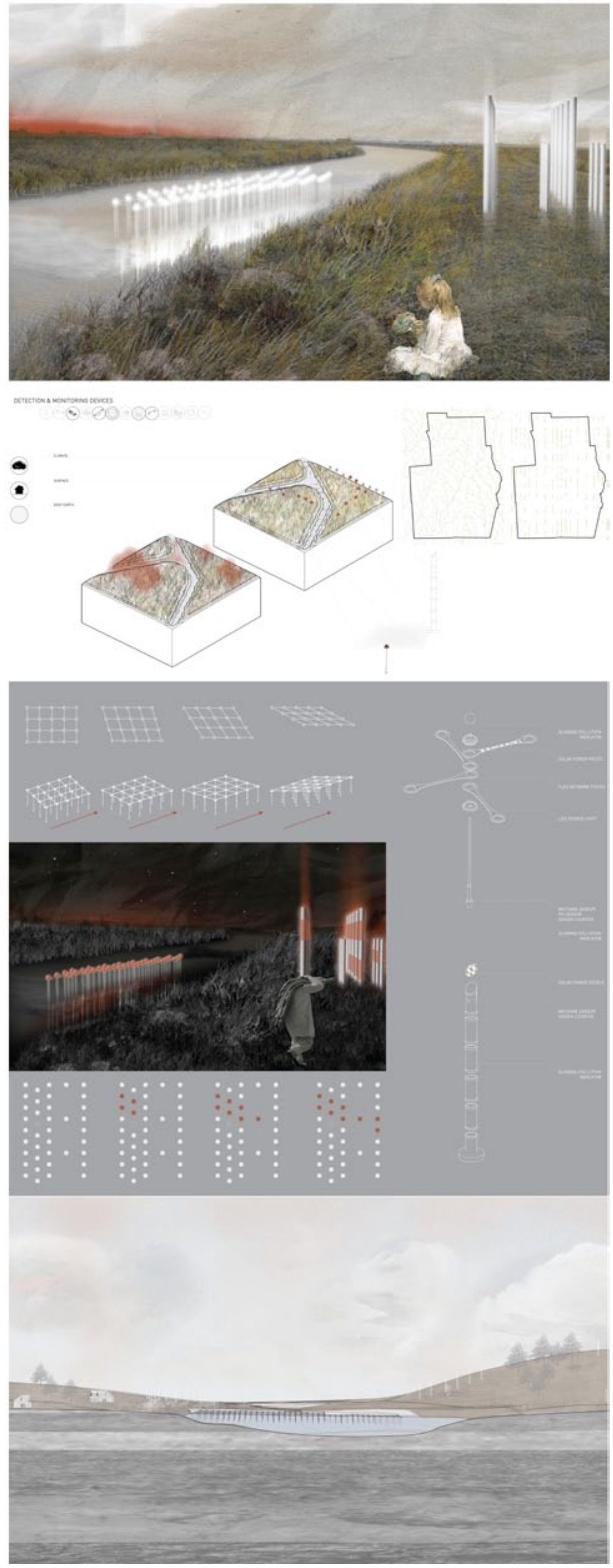
AUTOPOIETIC LANDSCAPES : THE ARCHITECTURAL IMPLICATIONS OF MINING THE MARCELLUS SHALE

FRACKED URBANISM



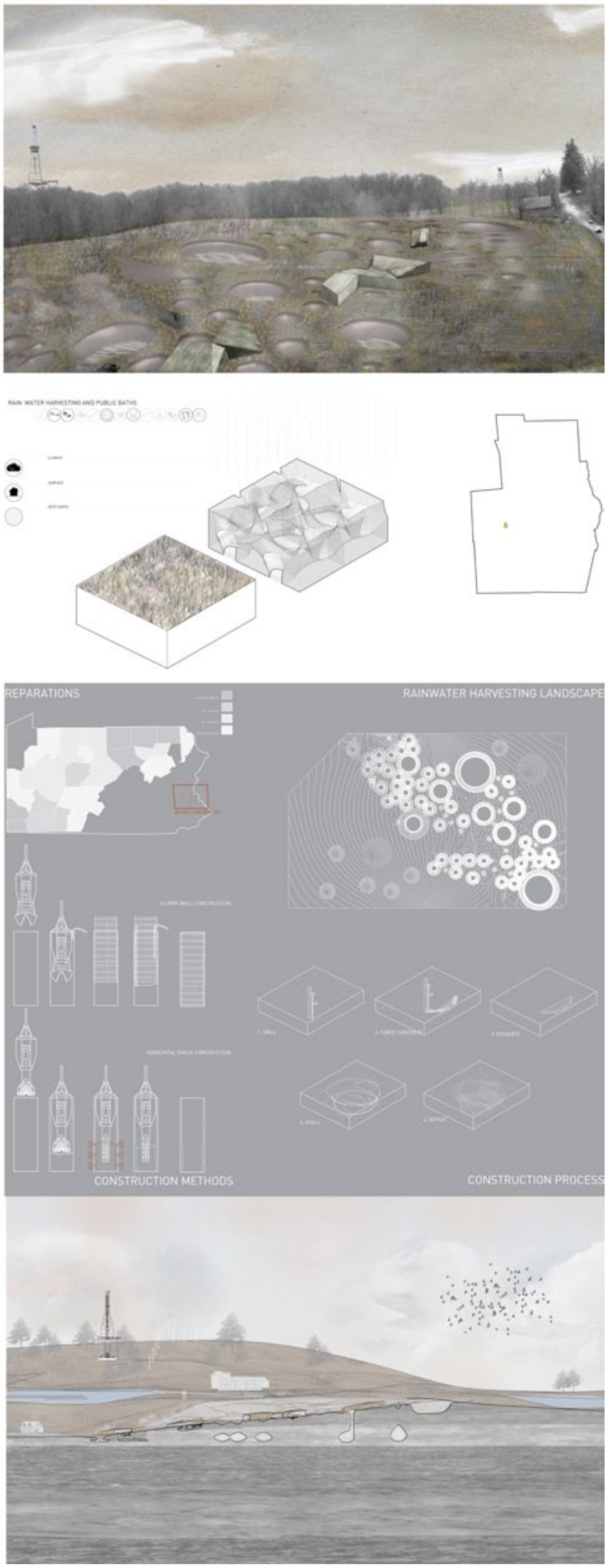
AUTOPOIETIC LANDSCAPES : THE ARCHITECTURAL IMPLICATIONS OF MINING THE MARCELLUS SHALE

DETECTION, MONITORING & RESPONSIBILITY



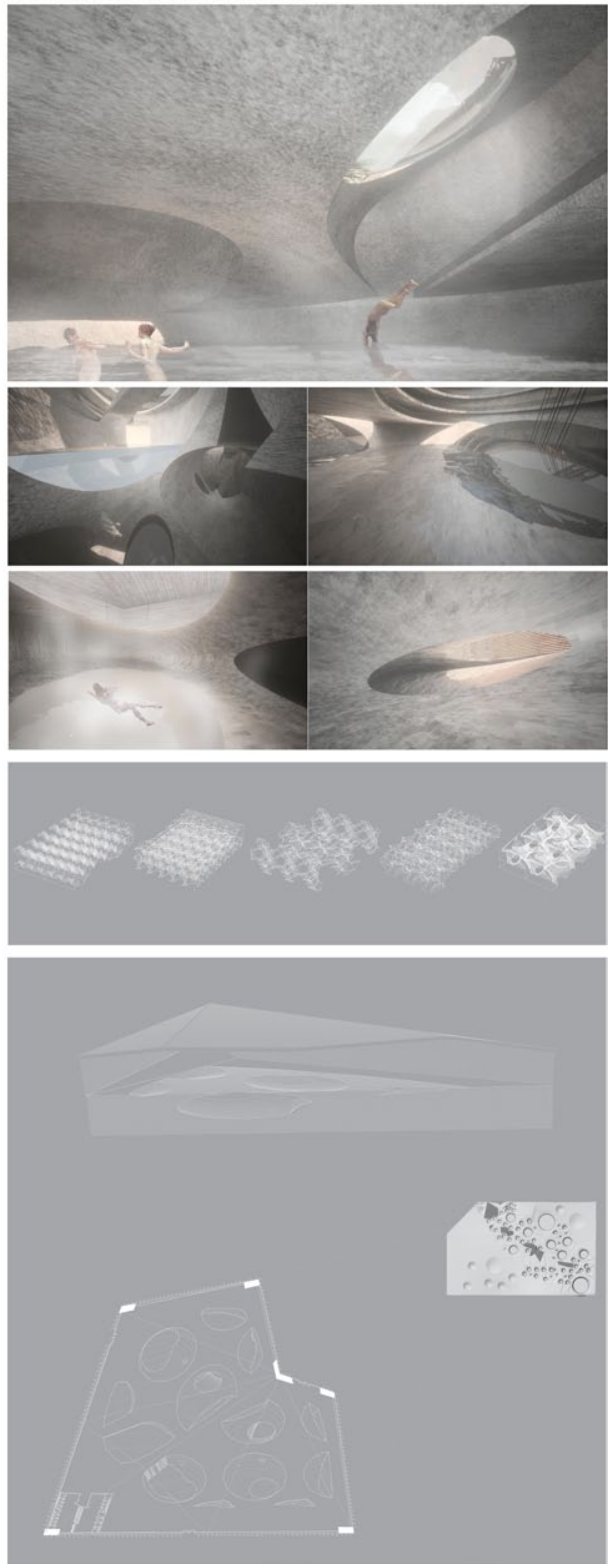
AUTOPOIETIC LANDSCAPES : THE ARCHITECTURAL IMPLICATIONS OF MINING THE MARCELLUS SHALE

FLAMING FAUCETS : RAIN WATER HARVESTING



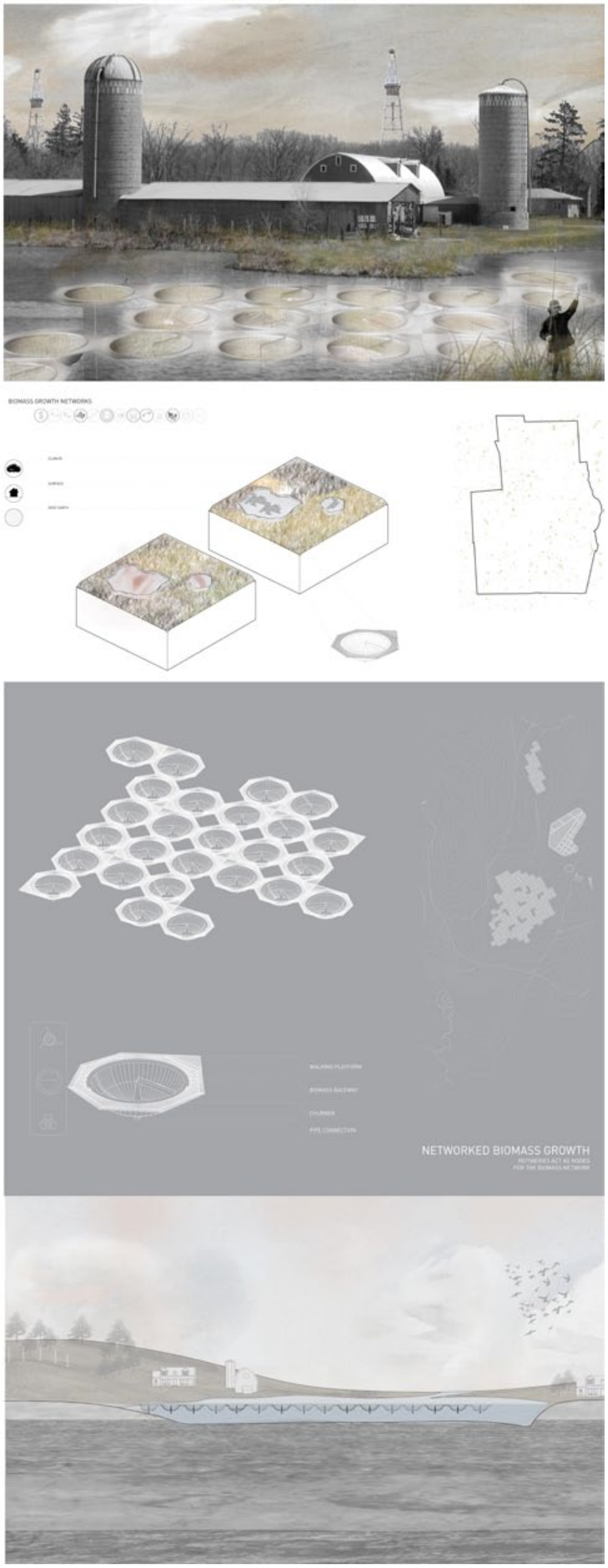
AUTOPOIETIC LANDSCAPES : THE ARCHITECTURAL IMPLICATIONS OF MINING THE MARCELLUS SHALE

FLAMING FAUCETS: THE PUBLIC BATH



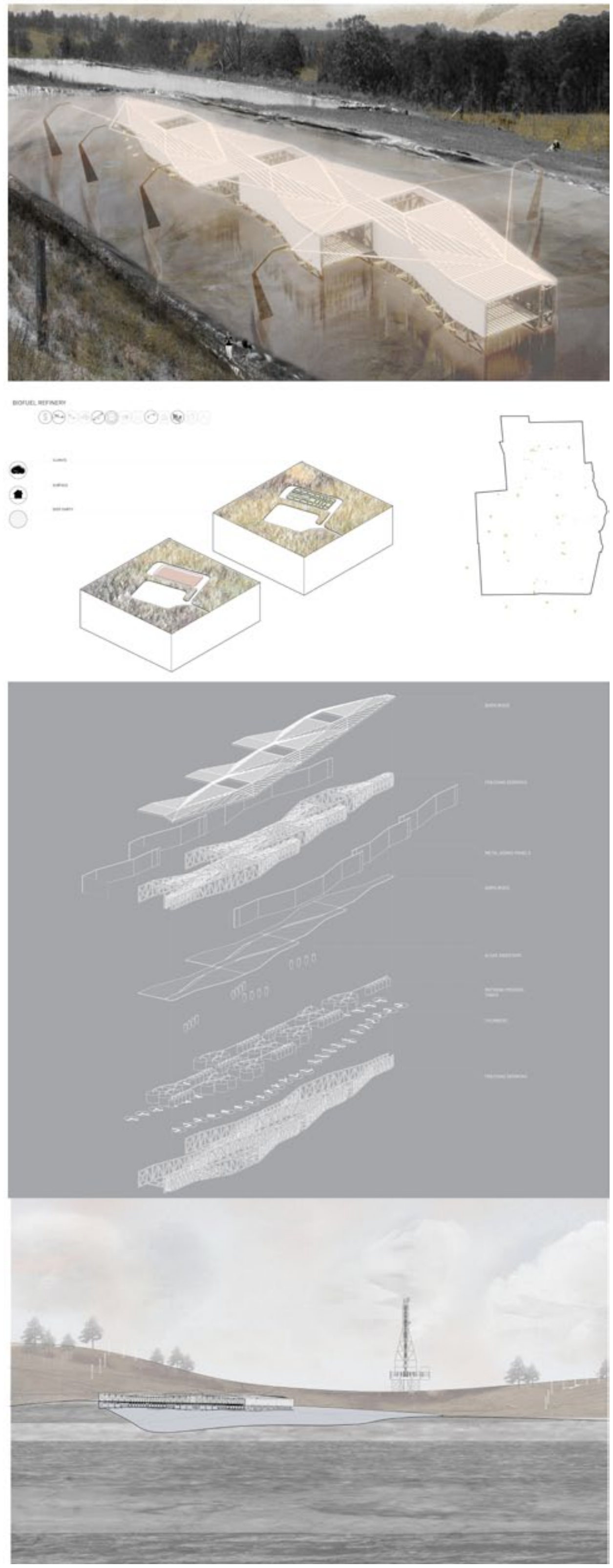
AUTOPOIETIC LANDSCAPES : THE ARCHITECTURAL IMPLICATIONS OF MINING THE MARCELLUS SHALE

RADIOACTIVE MILK : PRODUCTIVE LANDSCAPES



AUTOPOIETIC LANDSCAPES : THE ARCHITECTURAL IMPLICATIONS OF MINING THE MARCELLUS SHALE

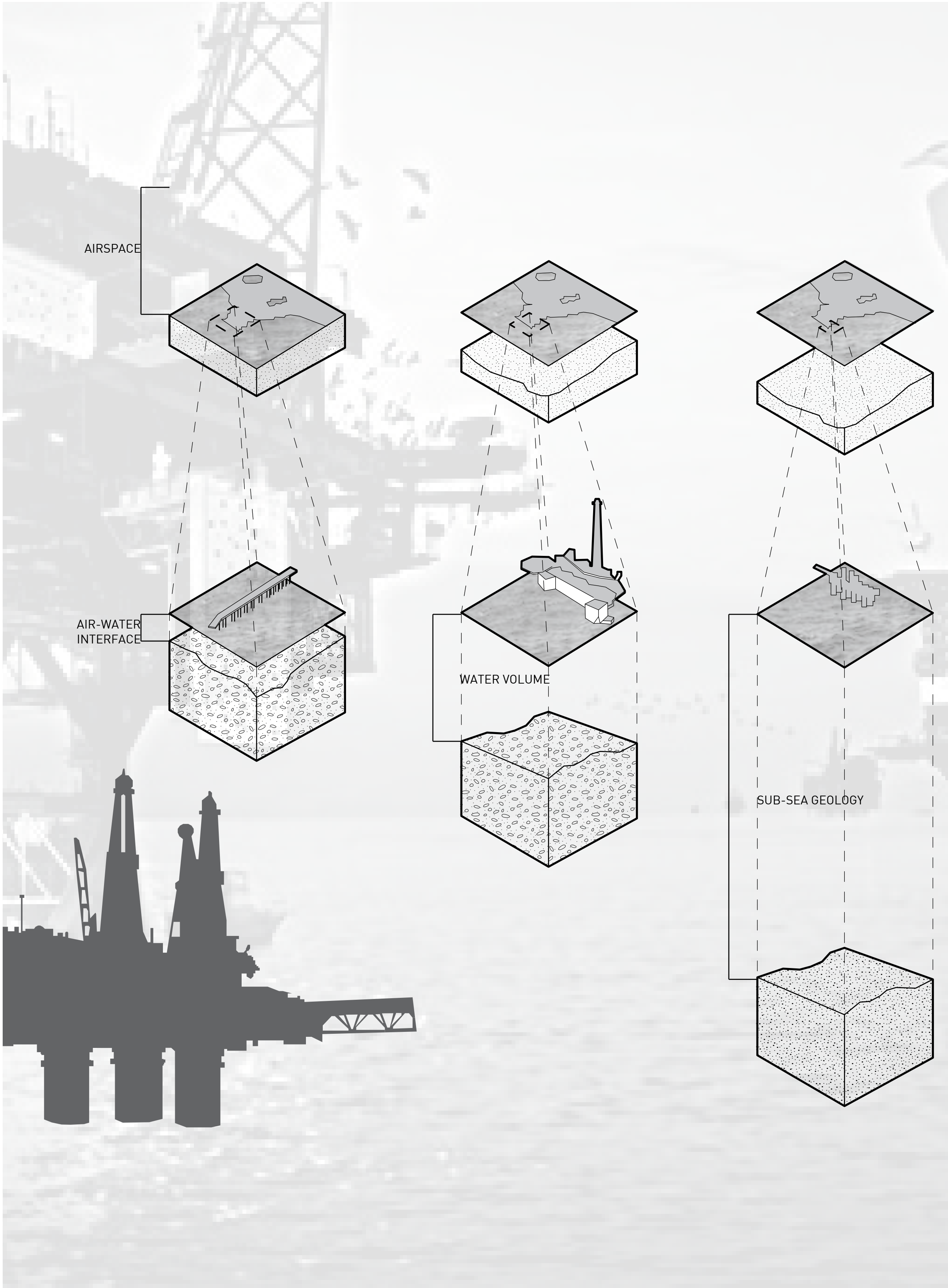
RADIOACTIVE MILK : BIOFUEL REFINERY



APPENDIX : PRECEDENTS

Re-Rigging is an ambitious proposal that seeks to develop the offshore oil excavation infrastructure for the Caspian Sea. The project seeks to render this infrastructure such that potentials embedded at the design stage can be actualized when the rigs eventually become derelict and are left behind (oil extraction has been given a very short lifespan there, hitting its peak between 2020 and 2030). After the oil is used up, the built structures would serve new functions as recreational sites, bird sanctuaries, and the like. What is astonishing in this is that the depletion of petroleum is naturalized as empirical fact—as if it had already happened—and design can only be relevant by factoring that into the process. This is the project's pragmatic realism. A coming decimated landscape—the end point of a process so natural that it can be accounted for before it is even set in motion—becomes a determinant factor in the architectural production of the present.

Within this proposal two key elements of precedent can be observed for this thesis. First is the obvious, installing infrastructure in such a way so that it can be reused and repurposed artfully upon the abandonment of the infrastructure. Secondly, and in some ways more importantly, this project conceptualizes and spatializes the importance of policy and ownership within the policies and processes of energy extraction.



Catherine Winfield, Massachusetts Institute of Technology

The dust dresses the city and her biotope, even going so far as to modify the climate. Within this fog of specs and particles, Bangkok becomes the melting pot of hypertrophic human activity with convulsing with exchanges of energy, where visibility becomes its greatest charm. At the antipodes of the canons of modern urbanism and its panoply of instruments lies, the city of Bangkok, ectoplasmic, super fluid to quote Kipnis. She is conceived in between aleatory rhizomes where the arborescent growth is at the same time a factor of her transformation and her operational mode. The project for the future museum B-mu feeds off of the climatic opposition between the urban environment's protuberant energy and the indoor subdued and subject to the museum conditioning procedures (white cube). We are talking here of two distinct geometric structures: one is Euclidian, globalization incased, where cultural merchandises are circulated in an aseptic and deterritorialized universe, and the other typology, plunged in a intoxicating urban chaos.

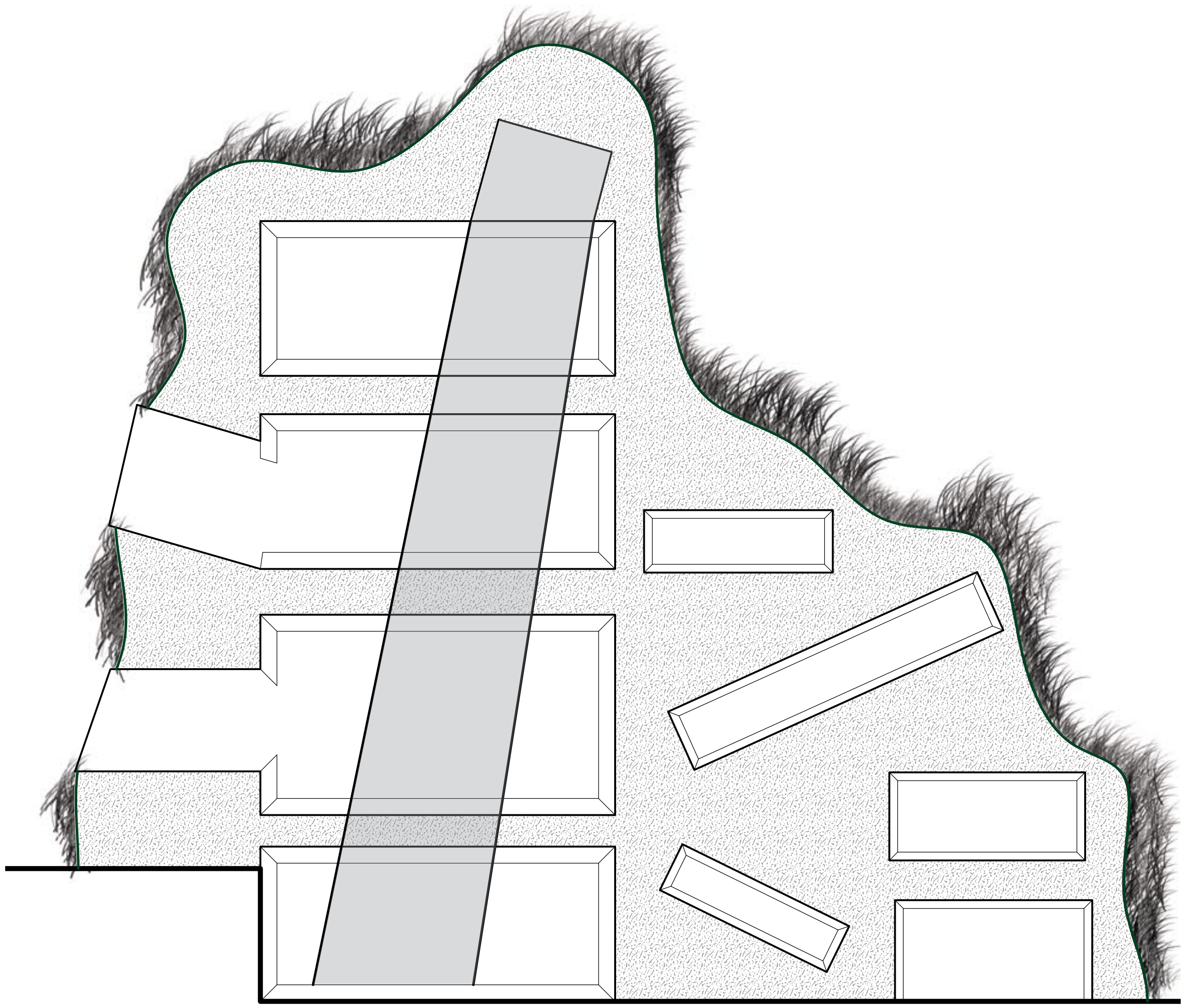
The future museum of Bangkok reflects this schizophrenia :

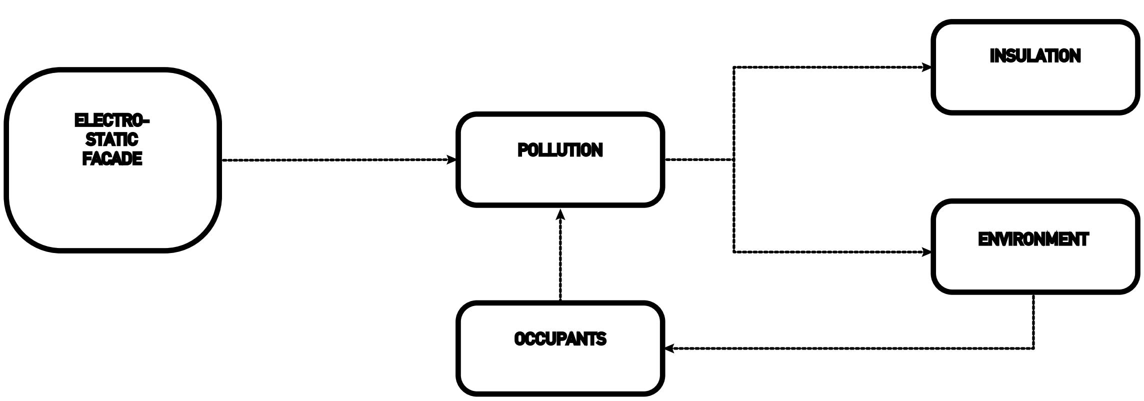
- the ghost emergence of "breeding the dust" (1) or in other words a dust breeding farm through electrostatic emergence, like the exacerbation of a localization.

- A white climatology like in the codified relational support system of the "running on the world" art scene.

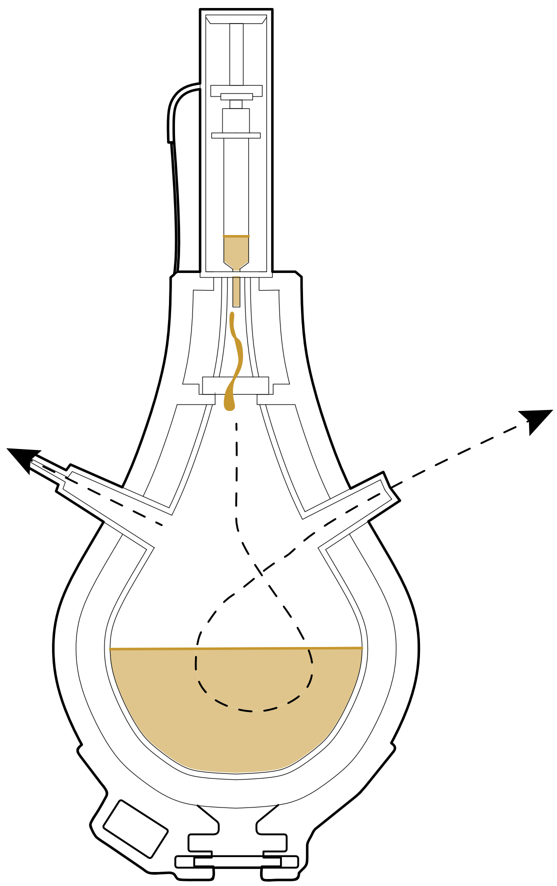
The exchanges born out of this duality (interface management, progresses, advances...) create the substance of the visitors skyzo perception. The B-mu is a trans door, in the sense that SF Simmons used the word, here just from local to global.

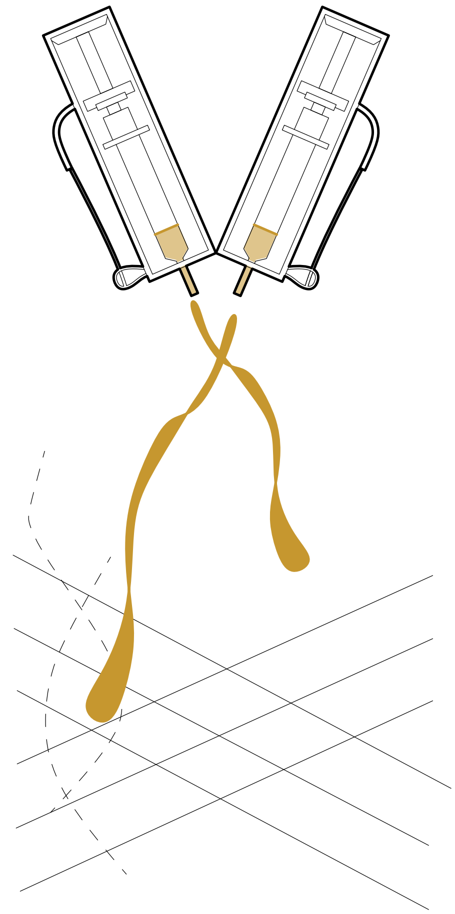
Dusty Relief uses an electroc-static facade to extract pollution from the air. The strategy of pollution as architecture stands as a clear precedent for this thesis.



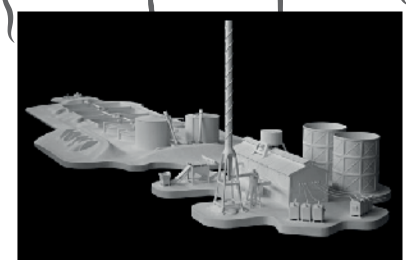


ELECTRO-
STATIC
FACADE
POLLUTION
INSULATION
ENVIRONMENT
OCCUPANTS





Orpheus Filter, presented in 2004 at The Building Centre Trust in England, is a hybrid 'geotextile' equipped with layers of miniature valves and clamping mechanisms that slowly digest and convert surrounding material to form a porous network. The array is organized in a cohesive structure using shifting patterns of non-repeating geometry. Later used as part of the Hylozoic Ground installation at the Venice Biennale the Filter used polluted Venice Canal water to self replicate. Injecting plastic from itself and actually growing from the pollution.



SlaveCity can be described as a sinister dystopian project, which is very rational, efficient and profitable (7 billion euro net profit per year). Values, ethics, aesthetics, moral, food, energy, economics, organization, management and market are turned upside-down, mixed and reformulated and designed into a town of 200.000 inhabitants. The 'inhabitants' work for seven hours each day in office jobs and seven hours in the fields of inside the workshop, before being allowed three hours of relaxation before they sleep for seven hours. SlaveCity is the first 'zero energy' town; it is a green town where everything is recycled and a city that does not squander the world's resources.

As an example of a design solution carried to its logical extreme SlaveCity serves as a precedent for this thesis in terms of it potential for ironic commentary.

APPENDIX : PHOTOGRAPHY

The photos on the following pages were taken as part of primary research for this thesis. During a week-long trip in Dimock Pennslyvania, interviews, water samples and these photos were collected. The photo on the last page of this appendix is the photo of a report. The report was the output of a well water sample taken in Dimock Pennsylvania.


DIMOCK
TOWNSHIP

Cabot Oil & Gas
CONSUMPTIVE WATER USE
Smith P3, Dimock Twp., Susquehanna Co., PA
SRBC ABR No. 20090554
Effective Date of Approval: 05/27/2009
Expiration Date: 05/27/2014
Peak Day Consumptive Use: 3.575 million gallons per day
Contact: Susquehanna River Basin Commission
1721 North Front Street
Harrisburg, Pennsylvania
Phone (717) 238-0425
Cabot Oil & Gas
NOTICE!
ACCESS to this location IS
RESTRICTED
to
ONLY!
WARNING
CONSTRUCTION SITE AHEAD
Cabot Oil & Gas
GAS WELL DRILLING
BEYOND THIS POINT
Cabot Oil & Gas


SMITHOLM FARM


FRESH WATER
536


911
Cabot Oil & Gas
WARNING
NOTICE!
Cabot Oil & Gas
CONSUMPTIVE WATER USE


911
COSNER
15771 STRICKLAND HILL RD
SPRINGVILLE, PA 18844
Cabot Oil & Gas
WELL NAME / NUMBER: COSNER 2-H/3-H/4-H/5-H
County: SUSQUEHANNA District: SPRINGVILLE State: PA
2-H 3-H 4-H 5-H
EMERGENCY CONTACTS:
NOTICE!
ACCESS to this location IS
RESTRICTED
to
AUTHORIZED PERSONNEL
ONLY!
WARNING
CONSTRUCTION SITE AHEAD
Cabot Oil & Gas
Cabot Oil & Gas
Cabot Oil & Gas
CONSUMPTIVE WATER USE
Cosner R P1, Springville Twp., Susquehanna Co., PA
SRBC ABR No. 201000047
Effective Date of Approval: 9/10/2010
Expiration Date: 9/10/2015
Peak Day Consumptive Use: 3.575 million gallons per day
Contact: Susquehanna River Basin Commission
1721 North Front Street
Harrisburg, Pennsylvania
Phone (717) 238-0425


YOU MAY BE IN VIOLATION OF COMPANY POLICY
THE FOLLOWING RULES REQUIRE YOUR COMPLIANCE. NO EXCEPTIONS.
1. NO UNAUTHORIZED PERSONS ALLOWED.
2. ABSOLUTELY NO FIREARMS, ILLEGAL DRUGS OR ALCOHOL PERMITTED.
3. ALL PERSONS, VEHICLES AND PERSONAL ITEMS ARE SUBJECT TO SEARCH.
4. ALL EMPLOYEES, CONTRACTORS AND VISITORS ARE SUBJECT TO DRUG TESTING.
5. ANYONE USING OFF-ROAD FUEL IN AN INAPPROPRIATE MANNER WILL BE SUBJECT TO TERMINATION AND POSSIBLE CIVIL FINES. ALL VEHICLES AND AUXILIARY CONTAINERS ARE SUBJECT TO SEARCH AT ANY TIME.
ANY AND ALL DRILLING SITES, PRODUCTION LOCATIONS, LEASE SITES AND FACILITIES OPERATED BY CHIEF OIL & GAS OR ITS SUBSIDIARY COMPANIES, REQUIRE COMPLIANCE OF THE ABOVE RULES. FAILURE TO DO SO MAY RESULT IN DISCIPLINARY ACTION AND/OR PROSECUTION.
NO EXCEPTIONS!
CALL 866-947-6447 TO REPORT SUSPECTED VIOLATIONS
CHIEF OIL & GAS LLC EMERGENCY ANSWERING SERVICE
CHIEF OIL & GAS LLC
•NO TRESPASSING
•AUTHORIZED PERSONNEL ONLY
•NO SMOKING
•PPE REQUIRED BEYOND THIS POINT
-HARD HATS
-SAFETY GLASSES
-STEEL TOE BOOTS
STOP
CHIEF OIL & GAS LLC
KERR UNIT LEASE
Emergency No. 866-947-6447
NO SMOKING
NO TRESPASSING
CHIEF OIL & GAS LLC
CONSUMPTIVE WATER USE
Kerr Drilling Pad #1
14526 DIMOCK TO NICHOLSON RD


CAT
320C


They said it was safe
to drill in the Gulf too
NO
DRILL
NO
SPILL
Friends of
CLEAN AIR
AND WATER
Join us!
www.NYRAD.org
FRACKING
OUT OF
OUR TOWNS
Don't
FRACK
with our water.
www.catskillmountainkeeper.org

Cabot Oil & Gas
CONSUMPTIVE WATER USE
Costello P1, Dimock Twp., Susquehanna Co., PA
SRBC ABR No. 20080707
Effective Date of Approval: 07/11/2008
Expiration Date: 01/11/2010
Peak Day Consumptive Use: 3.575 million gallons per day
Contact: Susquehanna River Basin Commission
1721 North Front Street
NOTICE!
ACCESS to this location IS
RESTRICTED
to
AUTHORIZED PERSONNEL
ONLY!
Cabot Oil & Gas
EMERGENCY CONTACTS:
WARNING
GAS WELL DRILLING AHEAD
NO OPEN FLAMES OR LIGHTS
BEYOND THIS POINT
Cabot Oil & Gas


WARNING
NATURAL GAS
PIPELINE
HIGH PRESSURE


CABOT


J-W MEASUREMENT COMPANY
CASPER, WY (307) 234-9761
FLOW COIL
Year Built
2009
Coil
M.A.W.P.
PSIG
4 PASS
2 XXH
6000
WELL INLET


BRINE WATER

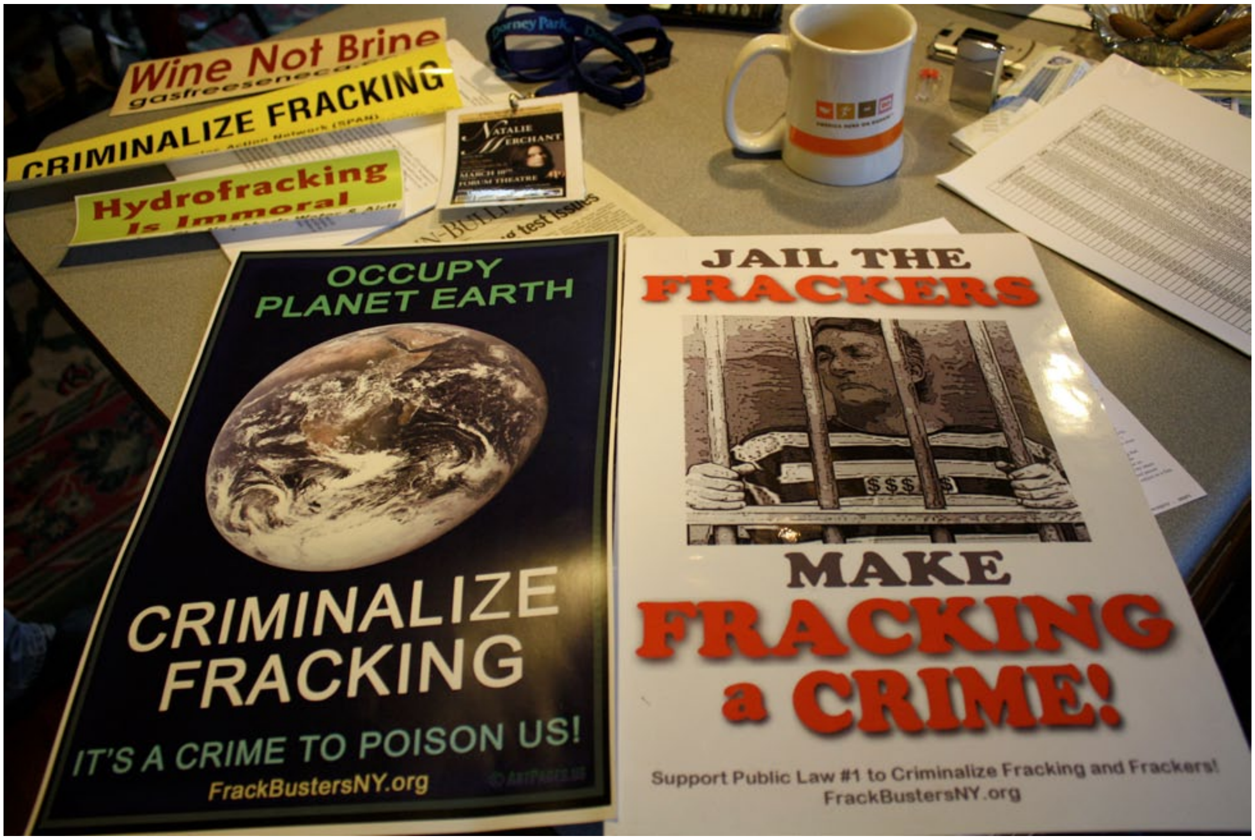

FIX IT!
THREE YEARS OF
CONTAMINATED WATER


SIMMONS
TRANSPORT INC.
Branchville, N.J. 201-875-4133
Exclusive Hauler Of
POTABLE WATER
SIMMONS TRANSPORT INC.
POTABLE WATER
BRANCHVILLE,N.J. 201-875-4133
CAUTION!
OUR FUTURE IS
WATER
PURE
OUR FUTURE IS
WATER
PURE


FIX IT!
FRACK
GDACoalition.org


DON'T FRACK
WITH OUR
WATER!
BAN HYDROFRACKING
NO
SPILL


Amid fracking dispute, EPA heightens scrutiny
Agencies: Actions by UHS were legal
Nurse's aide faces surveillance charge
By Steve Reilly
Dimock, Pa., resident Ray Kemble pumps drinking water into tanks next to his home Feb. 13. Federal regulators are expected this week to release the first results of water tests conducted in the area. ASSOCIATED PRESS
Residents near gas wells raising concerns over water safety
By Michael Rubinkam
ON PAGE 6A
» EPA water test results expected this week.
A contractor for Cabot Oil & Gas collects a water sample Feb. 13 from a resident's


Wine Not Brine
CRIMINALIZE FRACKING
Hydrofracking
OCCUPY
PLANET EARTH
CRIMINALIZE
FRACKING
IT'S A CRIME TO POISON US!
FrackBustersNY.org
JAIL THE
FRACKERS
MAKE
FRACKING
a CRIME!
Support Public Law #1 to Criminalize Fracking and Frackers!
FrackBustersNY.org

Jun. 25. 2008 8:45AM NEEL No. 1950 P. 6

northeastern environmental laboratories, inc.

1620 north main avenue • scranton, pennsylvania 18508 • ph.: 570-348-0775 • fax: 570-347-4139
PADEP Lab No: 35-00302 www.neelaboratories.com • neenvironmental@epix.net

Report Date: 06/20/08

Client: T.S. CALKINS & ASSOCIATES, INC.
OIL AND GAS PROPERTIES
PO BOX 198 / 9 FORMAN STREET
BRADFORD, PA 16701

Sample Location: COSTELLO #1 / RAYMOND KEMBLE
RR6 BOX 6177
MONTROSE PA 18801

Sample Description: WELL WATER
Sample Date: 05/28/08
Sample Time: 1145
Sample Type: GRAB
Sample Collector: FARNHAM & ASSOCIATES / DF

LABORATORY ANALYTICAL RESULTS

Parameter:	Analytical Method	Analysis Date	Lab. Tech	Detection Limit	UNITS	RESULTS
pH*	SM 4500 H+B	05/28/08	DF	0.1	SU	7.3
TEMPERATURE***	SM 2550	05/28/08	AN	0.1	°C	21.0
FECAL COLIFORM	SM 9222 D	05/28/08	JB	1	cfu /100ml	0
TOTAL SUSPENDED SOLIDS	I376585	06/02/08	BC	5	mg/L	<5
TOTAL DISSOLVED SOLIDS	SM 2540C	06/04/08	SB	5	mg/L	148
CHLORIDE	4110B	06/04/08	CH	0.1	mg/L	5.4
IRON	200.7	06/02/08	DW	0.05	mg/L	0.07
MAGNESIUM	200.7	06/02/08	DW	0.05	mg/L	5.76
SULFIDE	376.2	06/03/08	AI	0.05	mg/L	<0.05
SURFACTANTS	425.1	05/30/08	HW	0.05	mg/L	0.07
OIL & GREASE	1664A	06/03/08	JL	5	mg/L	<5
MTBE	8260B	06/11/08	AI	0.002	mg/L	<0.002
BENZENE	8260B	06/11/08	AI	0.002	mg/L	0.002
ETHYLBENZENE	8260B	06/11/08	AI	0.002	mg/L	<0.002
TOLUENE	8260B	06/11/08	AI	0.002	mg/L	0.003
TOTAL XYLENES	8260B	06/11/08	AI	0.010	mg/L	<0.010

Sample Comments :

Field Notes : LEL (Lower Explosive Limit) monitoring performed with QRAE 027 LEL Monitor
Results : No HC (Hydrocarbons) detected

Reviewed by: ____________________

environmental management specialists

Enclosure

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