LANDSCAPES OF EXPOSURE

Reframing the Connection Between
Body + Environment

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A thesis submitted in partial fulfillment of the requirements for the Master of Landscape Architecture Degree in the Department of Landscape Architecture of the Rhode Island School of Design, Providence, Rhode Island.

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23 May 2020

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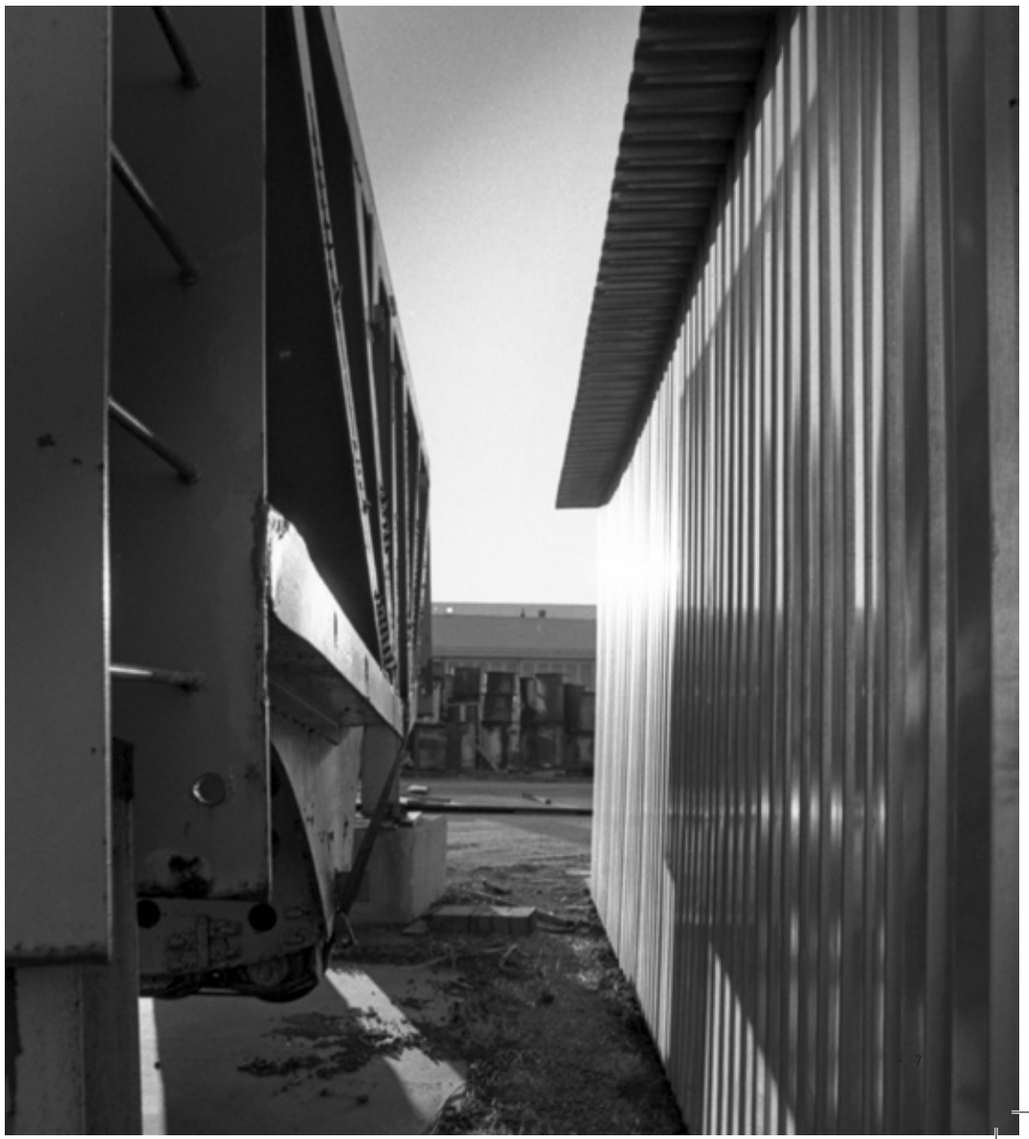



Rhode Island National Guard
WARNING

CONTENTS

This project explores new relationships of the body to the landscape through understanding how the environment imprints, molecularly, on the body and how that information is stored and inherited. In this age of ***postgenomics***, a time that is defined by big-data and technology driven approaches to medicine and public health, it is imperative that we work interdisciplinarily to address mounting health and ecological concerns.

As shapers of natural and social systems, I believe that ***landscape architects*** can bridge scales, from the molecular to the ecological, to draw new conclusions about how humans impact ecological systems and how these impacts are taken back up by humans.

This thesis seeks to develop new ways of visualizing complex chemical exposures in our everyday lives in hopes of creating ***greater awareness and advocacy*** around issues of environmental health and justice.

INTRODUCTION

IS THERE A BIOLOGICAL CONNECTION BETWEEN OUR BODY + OUR ENVIRONMENT?

IMPRINT

HOW DOES THE ENVIRONMENT IMPRINT ON OUR BODIES?

POSTGENOMICS

GENE-ENVIRONMENT INTERACTIONS

EPIGENETICS

WHAT CAUSES EPIGENETIC MODIFICATIONS?

ENVIRONMENTAL PHENOMENA

CAN BE INHERITED

CAN TURN GENES ON OR OFF

WHAT TYPE OF POLLUTANTS EXIST IN OUR COMMUNITIES THAT HAVE BEEN FOUND TO CAUSE EPIGENETIC MODIFICATIONS?

AIR POLLUTION

MERCURY

PFAS: per- and poly-flouroalkyl substances

PESTICIDES

DIOXIN

HOW ARE PFAS CURRENTLY BEING STUDIED? WHAT IS MISSING?

TOXICOLOGY

EPIDEMIOLOGY

SOCIOLOGY

ENVIRONMENTAL ENGINEERING

CAN A LANDSCAPE APPROACH BENEFIT THIS RESEARCH?

MULTI-SCALAR

TRANS-DISCIPLINARY

COUPLED ECOLOGICAL + SOCIAL SYSTEMS

HOLISTIC

DYNAMIC + ADAPTABLE

PARTICIPATORY

LANDSCAPES OF EXPOSURE

As Landscape Architects, we view the world through an ecosystem lens. We search for ways to analyze and understand the past, seeing how it can inform our future. We marry the work of scientists and sociologists in designs that seek to engage the human and promote ecologies. We engage the notion of the body in space and we seek to find new ways of revealing what we believe is remarkable, yet hidden in our environment. We, landscape architects, should be positioned among other experts in this age of postgenomics, looking to understand the influence of our environments on our bodies, from social structure down to genetic modification.

When the Human Genome Project (HGP) was completed in 2003, it became obvious that our disease risk and health outcomes were controlled by forces beyond our DNA. This opened the door to biological research in the "omes." Each -ome refers to the study of a specific set of characteristics external to our DNA; the exposome looks at the biological markers left behind by each exposure throughout our lifetimes, the microbiome investigates the 1 kilogram of microbial organisms that call the human body home, the epigenome looks at how these exposures imprint, molecularly, and regulate gene expression.

The postgenomic era is governed by the belief that this more expansive view of our biology will lead to a more just and equal future. Genetic determinism, the notion that our DNA is the sole indicator of our disease risk, is now regarded as a reductionist view of our complex beings. Postgenomics, with its focus on the plasticity-- rather than rigidity-- of systems, acts as the natural antidote to a formerly deterministic viewpoint. However, it would be naive to believe that postgenomics and its associated sciences can only be used by those with good intentions. Epigenetics, the study of gene-environment interactions and their persistence across time and generations, has become a booming bioscience field over the last fifteen years. Studies have shown that environmental conditions such as stress, toxins, socio-economic status, racism and the lifestyles of our parents and grandparents leave traces that have the ability to turn genes on and off[1].

Our understanding of epigenetics has deeply changed the nature vs. nurture debate. If it is possible to improve the functioning of everyone's genetic infrastructure with the right environment, then one might believe that a deeper understanding of epigenetics could lead to a more just and equal society. While the implications of this data necessitate stronger social infrastructure systems and further justify reparations, it can just as easily, and terrifyingly, be used to justify eugenic belief systems. The idea that exposure to certain environments can leave behind traces that persist for generations is not an idea that is new to the postgenomic era. During the 1920s, some people believed that the environment could influence inheritance. These ideas took an incredibly negative twist when they were adopted by eugenicists who believed that less desirable traits could be removed from a society by preventing certain populations from marrying and even forcing sterilization. It is important to take into account recent human history, specifically the ideas around eugenics that led to catastrophic loss of life and harm to fellow humans, when discussing epigenetics. Labeling a group of people as exposed to certain conditions and therefore predisposed to certain disease outcomes, has the potential to cause more harm than good. This is an important fact of genomic sciences which must be acknowledged at the onset of any discussion of epigenetics and gene-environment interactions.

In our investigation of the body and space, it is time landscape architects engage the scientific disciplines that investigate gene-environment interactions. We must continue our multi-scalar approach to healthy design, thinking not just about the visible, but also the invisible aspects of what makes us who we are.

As we have seen from the current Coronavirus pandemic, the health of our species is determined by the most vulnerable among us. It has also once again become abundantly clear that economic progress is tightly tied to human health. We must consider how our environment impacts health to begin to address the disparities that exist among people and places.

This thesis proposes that landscape architects act as mediators and communicators of postgenomic thinking among disciplines and the public. This thesis utilizes landscape tools of mapping and analysis to begin to explore the spatial implications of groundwater contamination and toxicity. Incorporating data from public health, environmental management and planning sources, this thesis aims to create a multi-scalar tool to understand groundwater's relationship to the human body.

1. Meloni, Maurizio. "If We're Not Careful, Epigenetics May Bring Back Eugenic Thinking." The Conversation. Accessed May 19, 2020. http://theconversation.com/if-were-not-careful-epigenetics-may-bring-back-eugenic-thinking-56169.

HISTORY OF ENVIRONMENTAL JUSTICE + PUBLIC HEALTH + URBAN DESIGN

HEALTH + DESIGN

There is a direct correlation between advancements in biological research, public health events and the design of our built environment. This visual timeline explores the relationship between the events that led to changes in planning policy and how these policy changes caused social shifts for better and worse.

LEXICON

AFFF

Aqueous Film-Forming Foam is a synthetic concentrate of chemicals that, when mixed with water and air, form a foam blanket that works to snuff out hydrocarbon fuel fires. The combination was developed by the company 3M, in conjunction with the Navy, during the 1960s. AFFF has been used regularly in emergency response and training at Department of Defense and Fire Training bases nationwide. AFFF and its derivatives are known to contain PFAS which accumulate in the human body and can survive, indefinitely, in the environment.

ENVIRONMENTAL JUSTICE

All people and communities have the right to equal environmental protection under the law, and the right to live, work and play in communities that are safe, healthy and free of life-threatening conditions.

PFAS

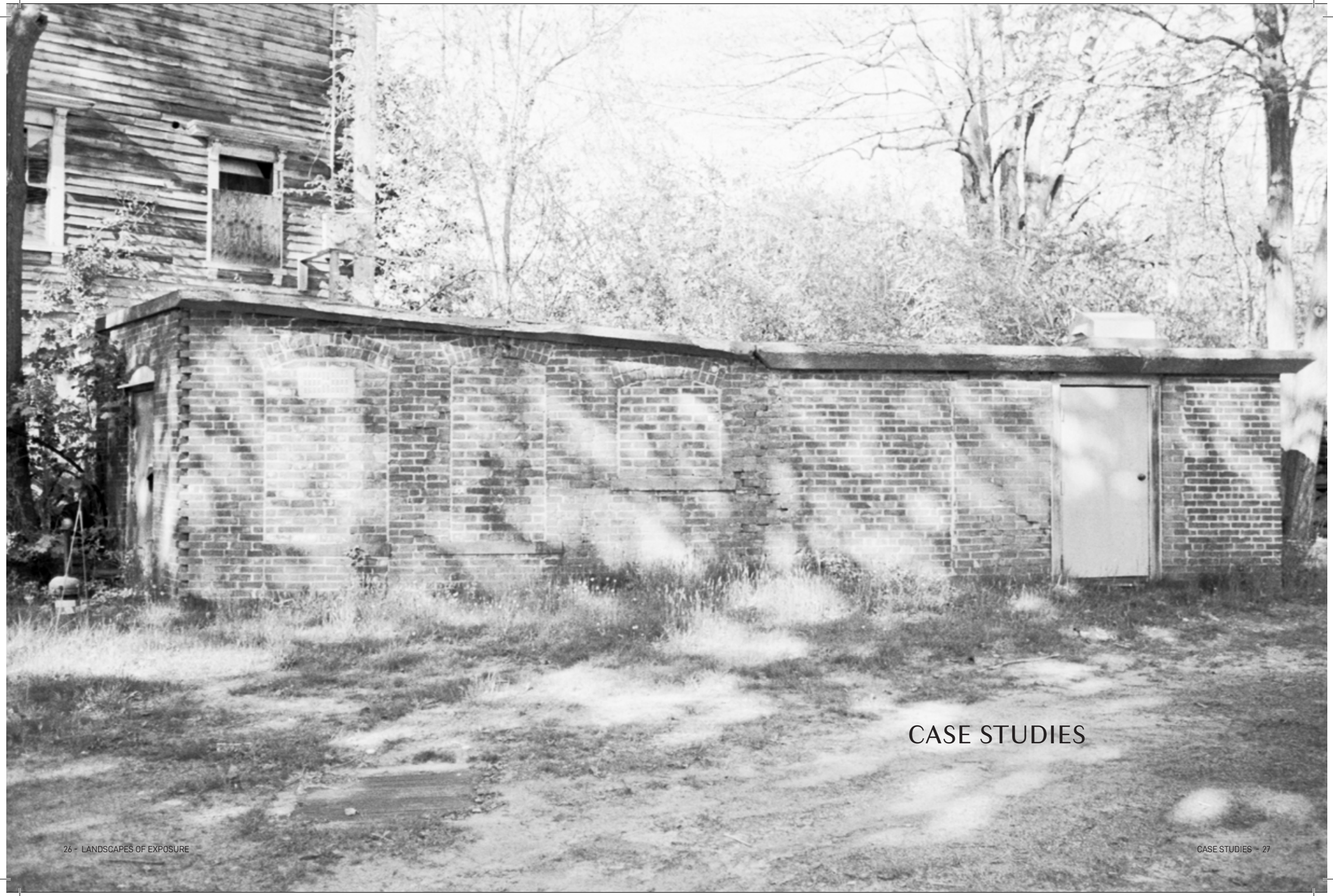
Per- and polyfluoroalkyl substances (PFAS) are a group of man-made chemicals that includes PFOA, PFOS, GenX, among many others. PFAS have been manufactured and used in a variety of industries around the globe, including in the United States since the 1940s. PFOA and PFOS have been the most extensively produced and studied of these chemicals. Both chemicals are very persistent in the environment and in the human body – meaning they don't break down and they can accumulate over time. There is evidence that exposure to PFAS can lead to adverse human health effects.[3]

POSTGENOMICS

Postgenomics is used to refer to the era of biological research following the sequencing of the human genome. It was upon completion of this sequencing that notions of gene-environment interaction were finally proven since many of the diseases we have come to understand were not able to be traced to specific copy mutations within the DNA. Postgenomics also refers to the many sciences that are attempting to understand gene-environment interactions and how our bodies store this exposure data.

SOCIO-EXPOSOME

The socio-exposome is a play on the term exposome, first coined by Christopher Wild in 2005. The goal of exposome research is to characterize life course environmental exposures (including lifestyle factors) from the prenatal period onward.[1] The socio-exposome creates a multidimensional framework oriented around three axes: individual, local, and global, and suggest some sociomarkers and data sources that could identify exposures at each level. It also creates a predictive framework that helps communities understand the repercussions of corporate and regulatory practices for public health and social justice.[2]



CASE STUDIES

AIR OF THE ANTHROPOCENE

LONG EXPOSURE PHOTOGRAPHY TO VISUALIZE PM2.5 CONCENTRATION

Air of the Anthropocene is a project developed by the artist, Dr. Robin Price, in conjunction with an environmental scientist from the University of Birminham, Dr. Francis Pope. Through a program at Birminham Open Media Lab, the duo developed a sensor that could be used in conjunction with a camera to create a visual representation of current air pollution readings.

The mechanism worked by drawing air in on one end, shining a laser through that air, and reading the particulate matter of both PM 2.5 and PM 10. The sensor was connected to a string of LED lights whose flashing increased with increasing pollution. The artist connected the string of LEDs to a sound boom and quickly moved the lights through the frame. These lights were captured in the frame and provided a spatial, relative reading of air pollution exposure.

Landscapes of Exposure is excited by this interdisciplinary project which was able to both measure and visualize exposure in real time. Eventually, Landscapes of Exposure hopes to express contamination readings in an instaneous, visual format.

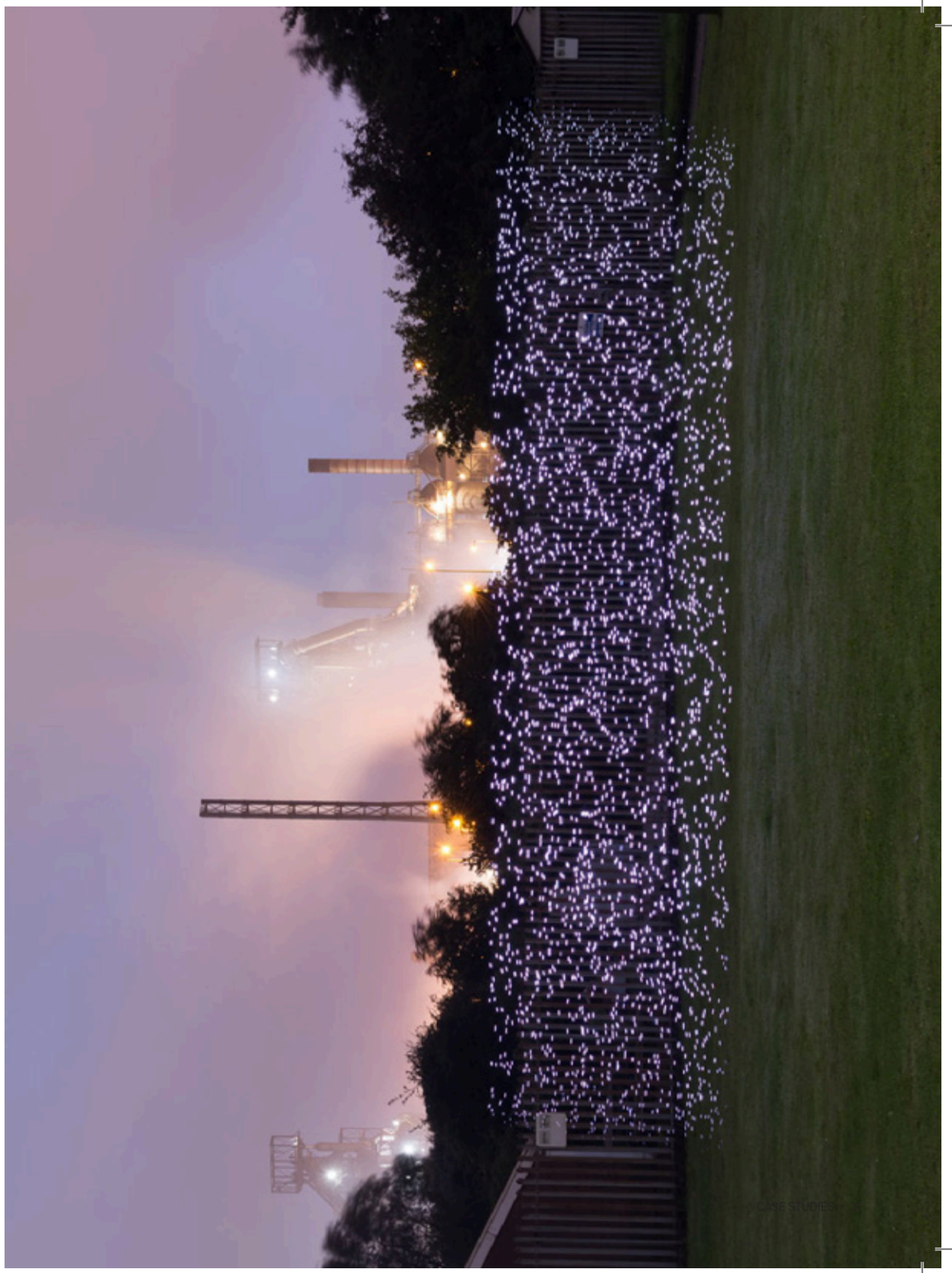
PROJECT TEAM

ARTIST
DR. ROBIN PRICE
NONPROFIT
BIRMINGHAM OPEN MEDIA LAB
ACADEMIC PARTNER
DR. FRANCIS POPE

PORT TALBOT, WALES >>
Image Credit: Robin Price
Llewllyn Street Port Talbot, Wales
PM 2.5 Reading: 10- 20mcg/ m^3

NEAR KG MARG URBAN CANYON, DELHI, INDIA ^^
Image Credit: Robin Price
Llewllyn Street Port Talbot, Wales
PM 2.5 Reading: 500-600mcg/ m^3

PRINCE STREET AIR QUALITY MONITORING SITE, PORT TALBOT, WALES >>
Image Credit: Robin Price
Llewllyn Street Port Talbot, Wales
PM 2.5 Reading: 30-40mcg/ m^3



PUBLIC LAB

PHOTO PAPER TO DETECT H_2S

Public Lab is a non-profit and community tool which was developed in response to the BP oil spill in the Gulf of Mexico in 2010. Concerned residents came together to document the extent of the contamination using weather balloons and digital cameras. The community satellites used this photographic data to create maps and images that were shared with media around the world.

Public lab continies to expand upon issues of environmental contamination by fostering an open source, citizen-science platform where tools and ideas can be shared around the world. Public Lab Environmental Monitoring Tools aim to answer two questions: what is the concentration of the pollutant in the community of interest and where did it come from? The community is then instructed to analyze the technique accuracy and sample precision of each study to ensure the most accurate and complete results.

Through low-cost approaches to environmental health monitoring, communities have the ability to not only trace their exposure, but also be equipped with the scientific evidence that validates their experience.

PROJECT TEAM

DESIGNER
DR. SARA WYLIE

NONPROFIT
PUBLIC LAB
SAN JUAN CITIZENS ALLIANCE

ACADEMIC PARTNER
NORTHEASTERN UNIVERSITY
RHODE ISLAND SCHOOL OF DESIGN

SHIRLEY "SUG" MCNALL, RESIDENT OF AZTEC, NEW MEXICO >>
Image Credit: The Durango Herald
Shirley McNall leads, "Toxic Tours of Hell" raising awareness about the dangers of the oil drilling and fracking industries in the San Juan County, NM area. Her activism has brough researchers and scientists to her area. Aztec, NM is one of Public Lab's test sites.

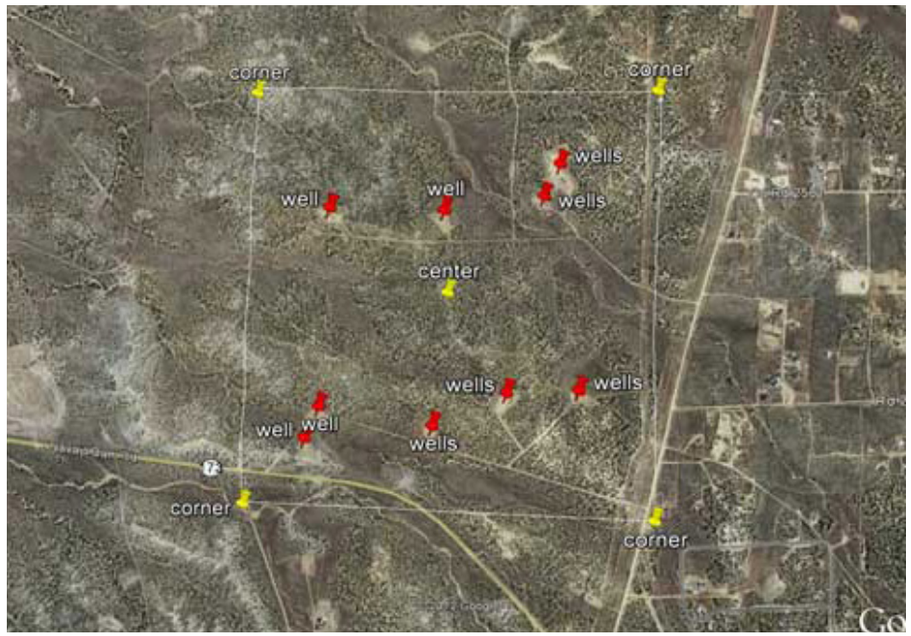
Hydrogen Sulfide, a common, largely under researched byproduct of the fracking process, has been shown to have many adverse health effects. Beginning in 2011, oil and gas companies were required to record emissions of the noxious gas to the Toxics Release Inventory (TRI), but are not required to stop them.

This project explored alternatives to Hydrogen Sulfide grab tests using reactive photo paper. Based on a research project conducted in 2004 by Horwell et al., this tehcnique is based on the reactive nature of hydrogen sulfide and it's ability to tarnish exposed metals. Black and white photo paper is covered with a then, even coating of silver which is exposed to light and forms the image during development. This method uses photo paper, coated in a thin glycerol solution to keep it stable, in the field around a site of interest to record Hydrogen Sulfide exposure over the course of weeks. The film paper strips are then developed, exposing the extent of the tarnish and therefore the release of hydrogen sulfide over the study period.

Public Lab tested this photo paper technique in the fracking heavy area of San Juan County, New Mexico. Two experiments were conducted in Aztec, New Mexico where fracking wells are intermingled with residential communities. The Public Lab team tested Hydrogen sulfide concentrations around 3 wells known to be in operation from data by the Bureau of Land Management.

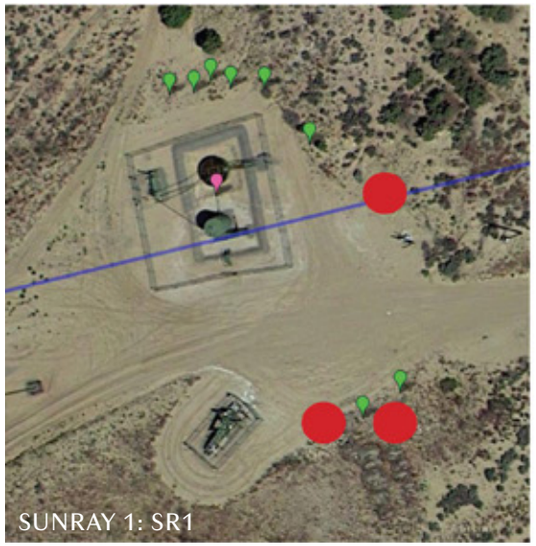
These tests resulted in a visual analysis of the hydrogen sulfide gas near the wells. While this data was not quantitative, it laid a foundation by which a more strategic collection method could be established.

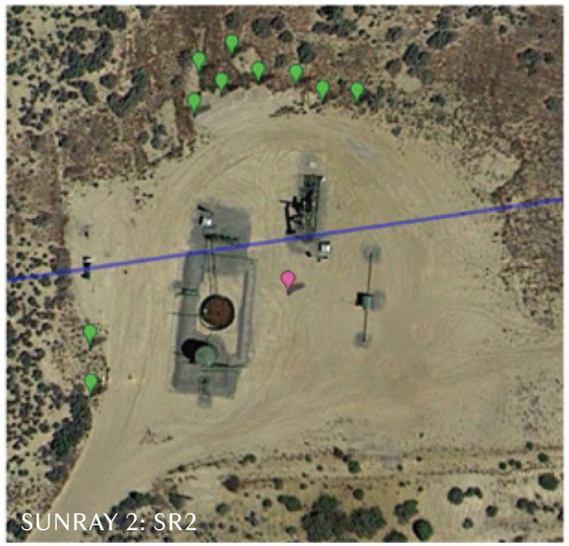
Public Lab's open source platform and transparent research methods make this type of tool accessible to many communities. Landscapes of Exposure was inspired by Public Lab's use of experimental strategies, such as this photo paper tool, to conduct exposure monitoring. This type of science-powered, grassroots activism is what Landscapes of Exposure hopes to be able to someday emulate with PFAS field testing in affected communities.

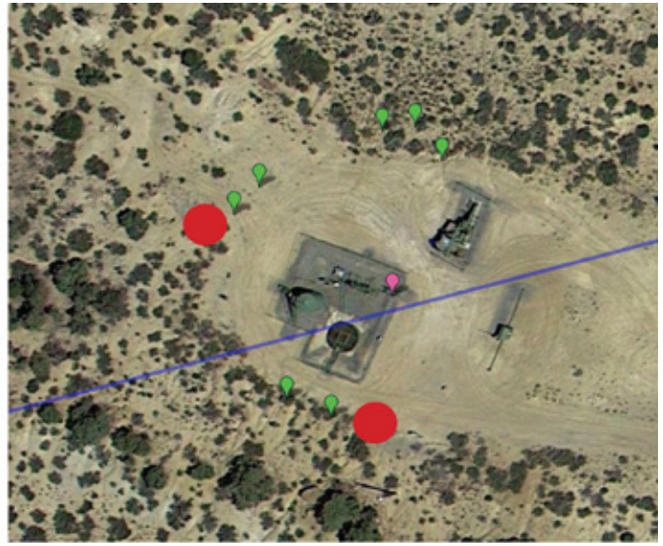


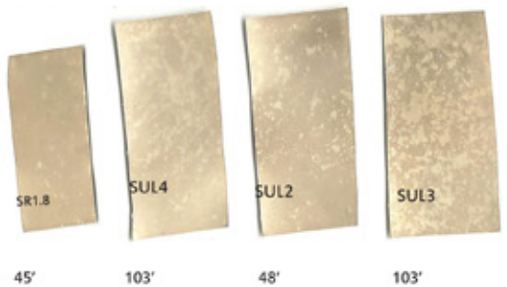
WELL LOCATIONS

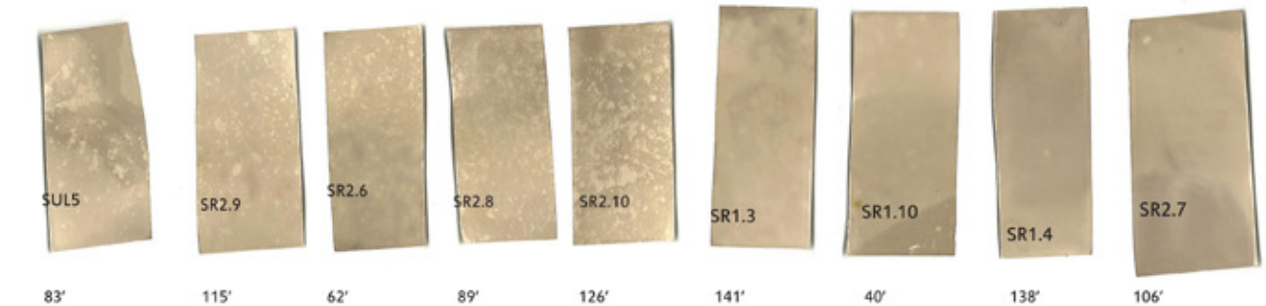
Well sites were chosen by locating spaces that were on Bureau of Land Managament (BLM) land and still being actively used. Wells were filtered by those that had ever recorded releases of hydrogen sulfide >100ppm.

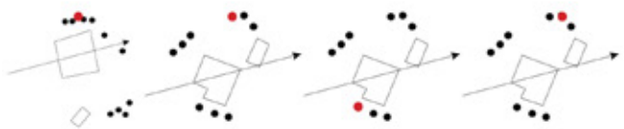


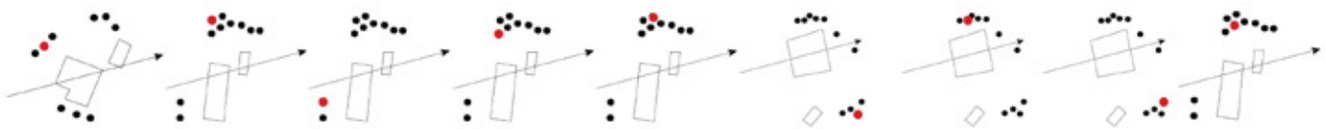












AZTEC, NM HYDROGEN SULFIDE TESTING

The Public Lab team selected well sites that were still in operation. They arranged the photo paper test strip canisters in locations both upwind and downwind of well sites. Canisters were positioned vertically and horizontally to test whether positioning changed the outcome and extent of tarnishing. The distance from between well and collection site is referenced for each sheet.

BK BIOREACTOR

INVESTIGATING THE UNSEEN MICROBIOLOGY OF THE GOWANUS CANAL

The BK BioReactor project was a collaborative, interdisciplinary effort by Nelson Byrd Woltz Landscape Architects, GenSpace, the Gowanus Canal Conservancy, and Landscape Metrics. This project began with the Gowanus Canal, a historic waterway in Brooklyn, NY, being designated as an EPA Superfund site. The plan was for the canal to be dredged and a subaquatic cap placed in order to manage water pollution. The BK BioReactor team set out to document and identify the organisms that called this toxic waterway home.

The core and volunteer team developed DIY instruments to sample 14 sites and their microbiota along the canal. Sites were selected based on a variety of attributes including turbidity, light exposure, depth and salinity to ensure that different conditions were being studied. GenSpace, a nonprofit dedicated to promoting citizen science and access to biotechnology, extracted the DNA of the microorganisms. The institute for Computational Biomedicine at Weill Cornell Medical College sequenced the extracted DNA and identified the individual microbes and their function within the canal ecosystem.

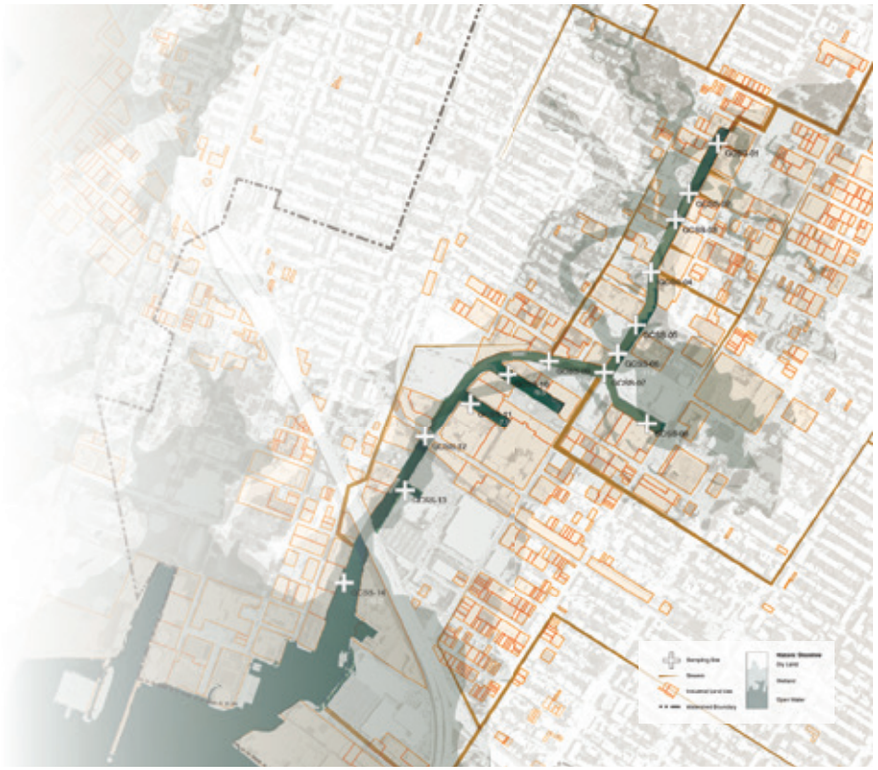
PROJECT TEAM

LANDSCAPE ARCHITECTURE
NELSON BYRD WOLTZ
LANDSCAPE METRICS
NONPROFIT
GENSPACE
GOWANUS CANAL CONSERVANCY
ACADEMIC PARTNER
WEILL CORNELL MEDICAL COLLEGE

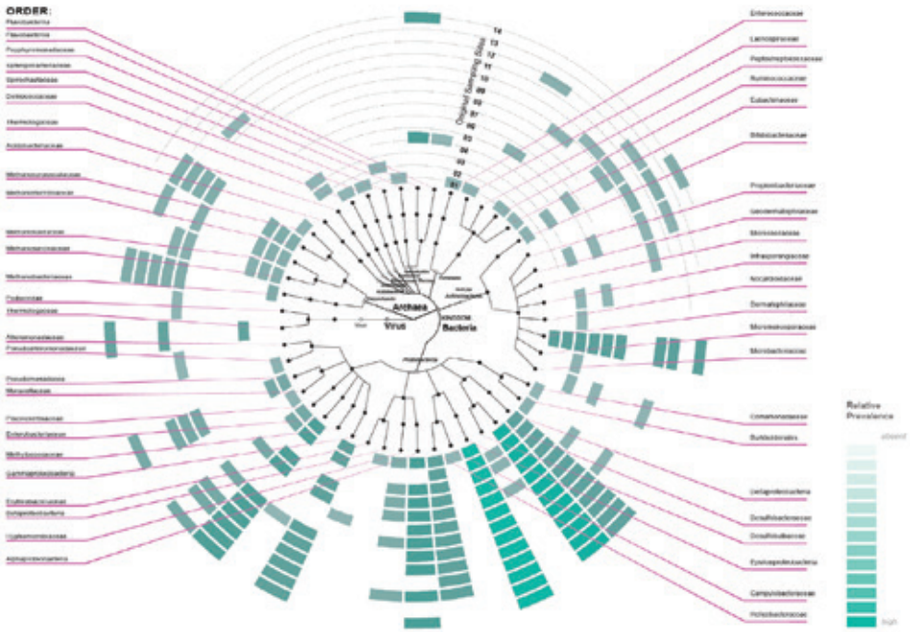
BK BIOREACTOR TEAM >>
Image Credit: BK BioReactor, Jack Johnson.
The research team used boats to access collection points along the Gowanus Canal. Water samples were collected to analyze microbiota that had adapted to living in the harsh, polluted conditions of the Gowanus.

The interdisciplinary BK BioReactor team was able to conduct in-depth biological reserach due to academic and nonprofit partners. The team was able to connect across scales, attributing the presence of specific microbiota to human actions. Landscape architects then visualized this data and turned this analysis into impetus for a new, interactive landscape.

Landscapes of Exposure has been influenced by the BK BioReactor's connection between biological process and site. Their project was also investigating the association between genetics and environmental conditions. The visualizations of genetic mapping were something that this project hopes to be able to incorporate at some point in the future. While biological remediation is still being investigated for PFAS contamination, it is exciting to think about the types of ecological communities that may be existing or even thriving in these environments.



INDUSTRIAL CONTEXT OF THE GOWANUS CANAL ^^
The Gowanus Canal is a highly industrialized waterway. Like many cities, New York utilized its waterways to move manufactured materials. This map shows the historic shoreline and its association with the city. During the expansion of the city, the canal was pushed into the hard edge form that it takes today.

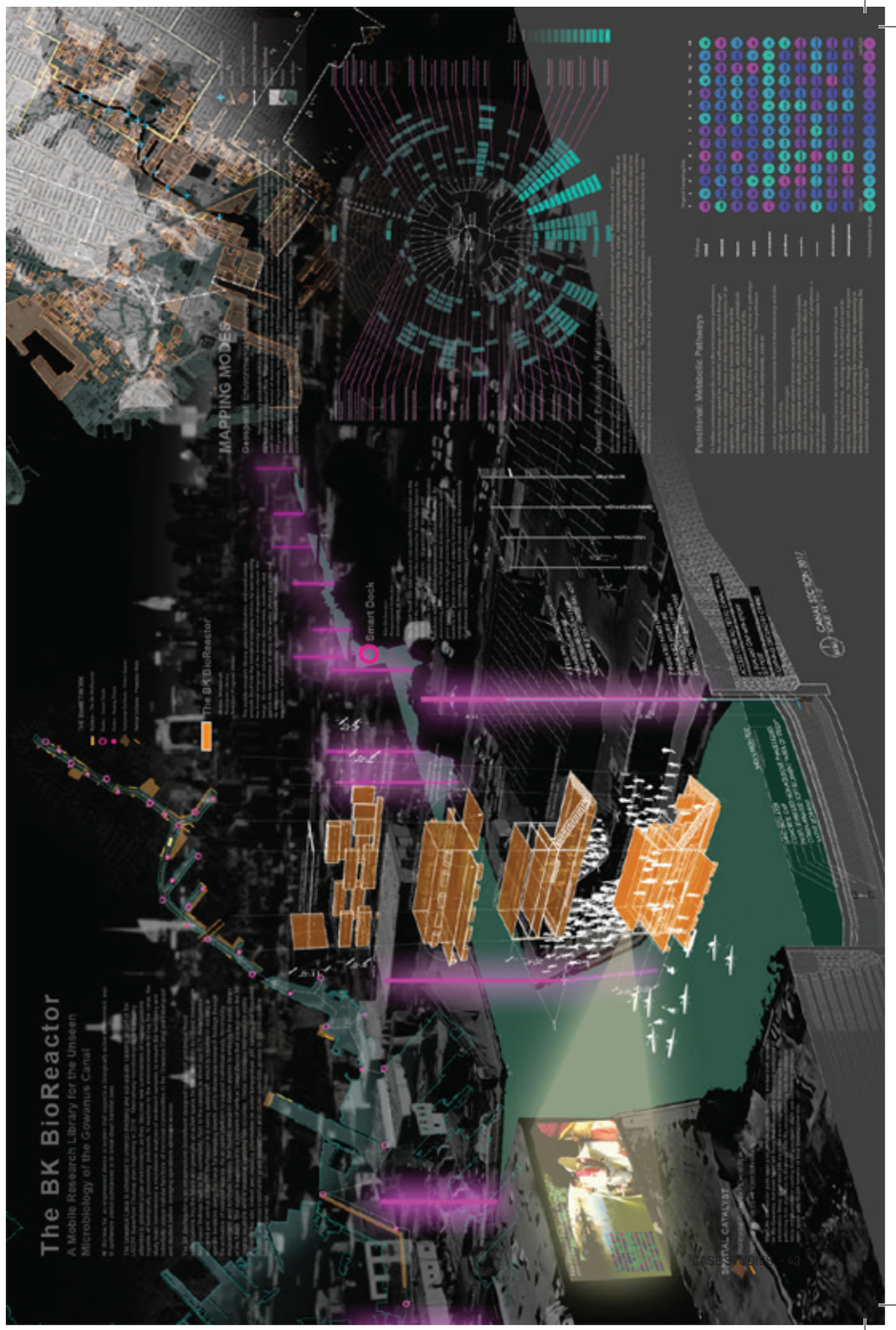


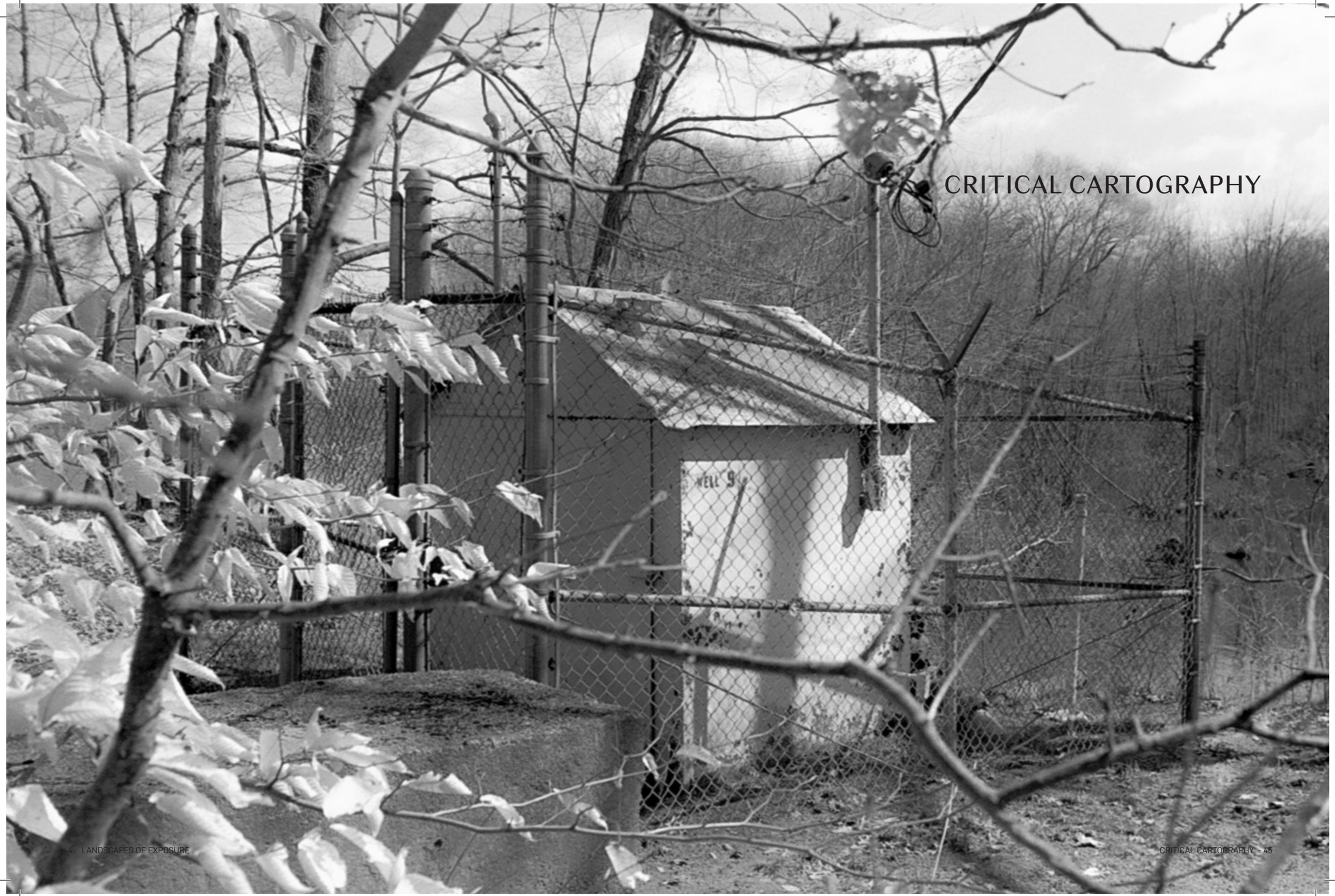
EVOLUTIONARY RELATIONSHIPS ^^

Sampling of sediment at 14 sites along the Gowanus Canal resulted in the classification of a large number of microbiota, adapted to living in this extreme, urban environment. Data graphics were an important method for communicating the findings of this project with the public. This phlogenetic tree visualizes the evolutionry history of each microorganism and describes its habitat within the canal.

BK BIOREACTOR >>

Rendered site design.





CRITICAL CARTOGRAPHY

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SITE OBSERVATIONS

PFAS TESTED SITES
RHODE ISLAND

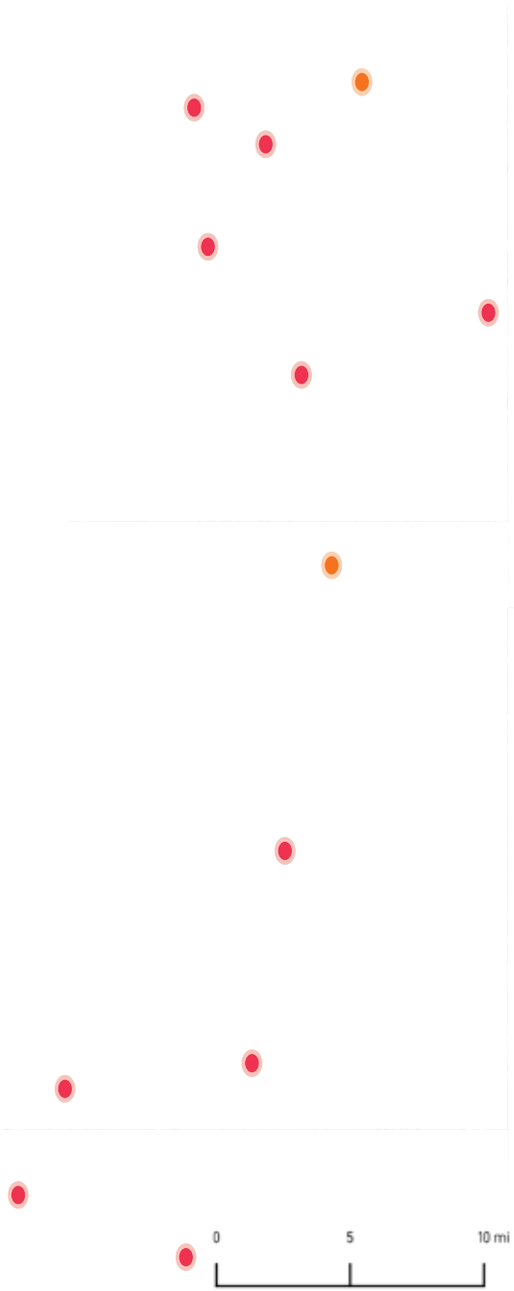
PFAS IN RHODE ISLAND

Beginning in 2017 the RI Department of Health, in collaboration with Brown University, began testing all of Rhode Island's public water supplies for PFAS. This testing also covered community wells that were thought to be of particular concern including wells in close proximity to military sites and vulnerable communities, such as schools and childcare facilities.

The testing was in response to the EPA issuing an advisory for PFOA and PFOS. Health advisories are developed to provide information on contaminants that can cause human health effects and are known or anticipated to occur in drinking water. In 2017, the EPA issued a health advisory for PFOS and PFOA levels of 70ppt[1]-- the equivalent of about 70 grains of sand in an olympic sized swimming pool. A health advisory is not the same as a regulation. This number is meant to provide states and tribes with information they need to help protect people's health. Therefore, this is not an enforceable drinking water standard at this time. On December 3, 2019, the EPA began the process of setting a regulatory standard for PFOA and PFOS under the Safe Drinking Water Act.

Meanwhile, the Environmental Working Group, an American activist group specializing in research and advocacy, has proposed that regulatory standards be set at 1ppt since they believe there is no safe amount of PFAS that can be consumed through drinking water sources. Many activists also call for regulatory standards to address all PFAS chemicals, not just PFOS and PFOA, the most studied of the group. PFAS contamination of drinking water is emblematic of a

1. US EPA, OA. "Aggressively Addressing PFAS at EPA." Speeches, Testimony and Transcripts. US EPA, January 7, 2020. https://www.epa.gov/newsreleases/aggressively-addressing-pfas-epa.
2. Egeghy, Peter P., Richard Judson, Sumit Gangwal, Shad Mosher, Doris Smith, James Vail, and Elaine A. Cohen Hubal. "The Exposure Data Landscape for Manufactured Chemicals." The Science of the Total Environment 414 (January 1, 2012): 159–66. https://doi.org/10.1016/j.scitotenv.2011.10.046.



87%

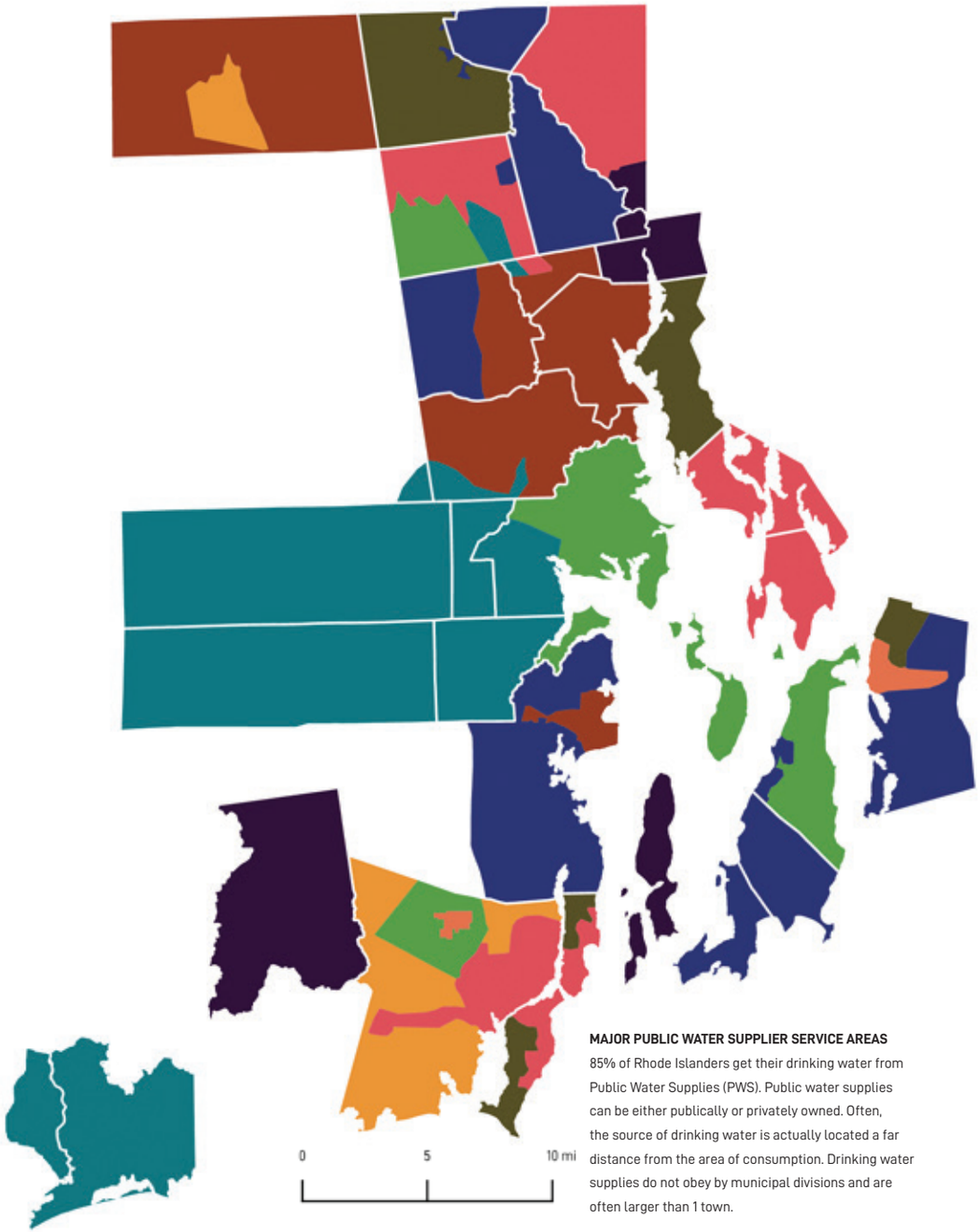
OF RHODE ISLANDERS HAD THEIR PRIMARY WATER SOURCE TESTED FOR PFAS IN 2019

DRINKING WATER SYSTEM

MILITARY SITE NON-DRINKING WATER SYSTEM

EWG PFAS CONTAMINATION MAP 2019

The RIDOH conducted water assessments of suspected contamination sites around the state. Areas of particular concern included drinking water wells in close proximity to military sites as well as vulnerable communities, such as schools and childcare facilities.



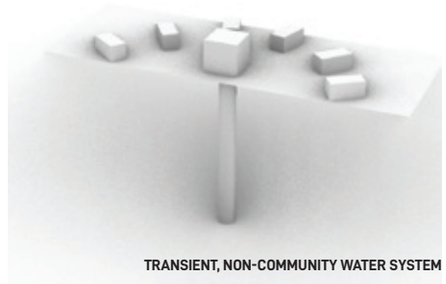
MAJOR PUBLIC WATER SUPPLIER SERVICE AREAS
85% of Rhode Islanders get their drinking water from Public Water Supplies (PWS). Public water supplies can be either publically or privately owned. Often, the source of drinking water is actually located a far distance from the area of consumption. Drinking water supplies do not obey by municipal divisions and are often larger than 1 town.

larger issue, which is the lack of regulation and environmental testing of the majority of commercially available chemicals. There are over 8 million commercially available chemicals world-wide. Of the 100,000 chemicals have been inventoried in the U.S. with toxicity related data, only 20% have any exposure-related information available. Only a tiny fraction of these chemicals have any data available on their concentrations in environmental media: 1,153 chemicals in water, 788 chemicals tested in soil, 720 chemicals in food, 670 chemicals in air, and 390 chemicals tested in people (through biomonitoring)[2].

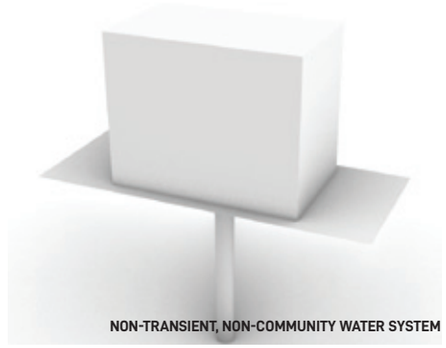
While PFAS are being investigated at a state and national level, I believe it is important to understand both the context in which this pollution is based and the type of water system that it affects. PFAS contamination is hard to detect because drinking water systems have largely been removed from the public realm. Maps of our public water infrastructure were made private after the events of 9/11. Security has taken precedence over public knowledge and has made information regarding drinking water quality harder for the consumer to gather. To complete this research process it was necessary to speculate on the exact locations of some drinking water wells and the potential sources of pollution.

This project explores the connection between issue and context. The sites chosen for this project were based on data available through public sources. As this is a rapidly expanding research area, these figures are likely to change.

COMMUNITY WATER SYSTEM

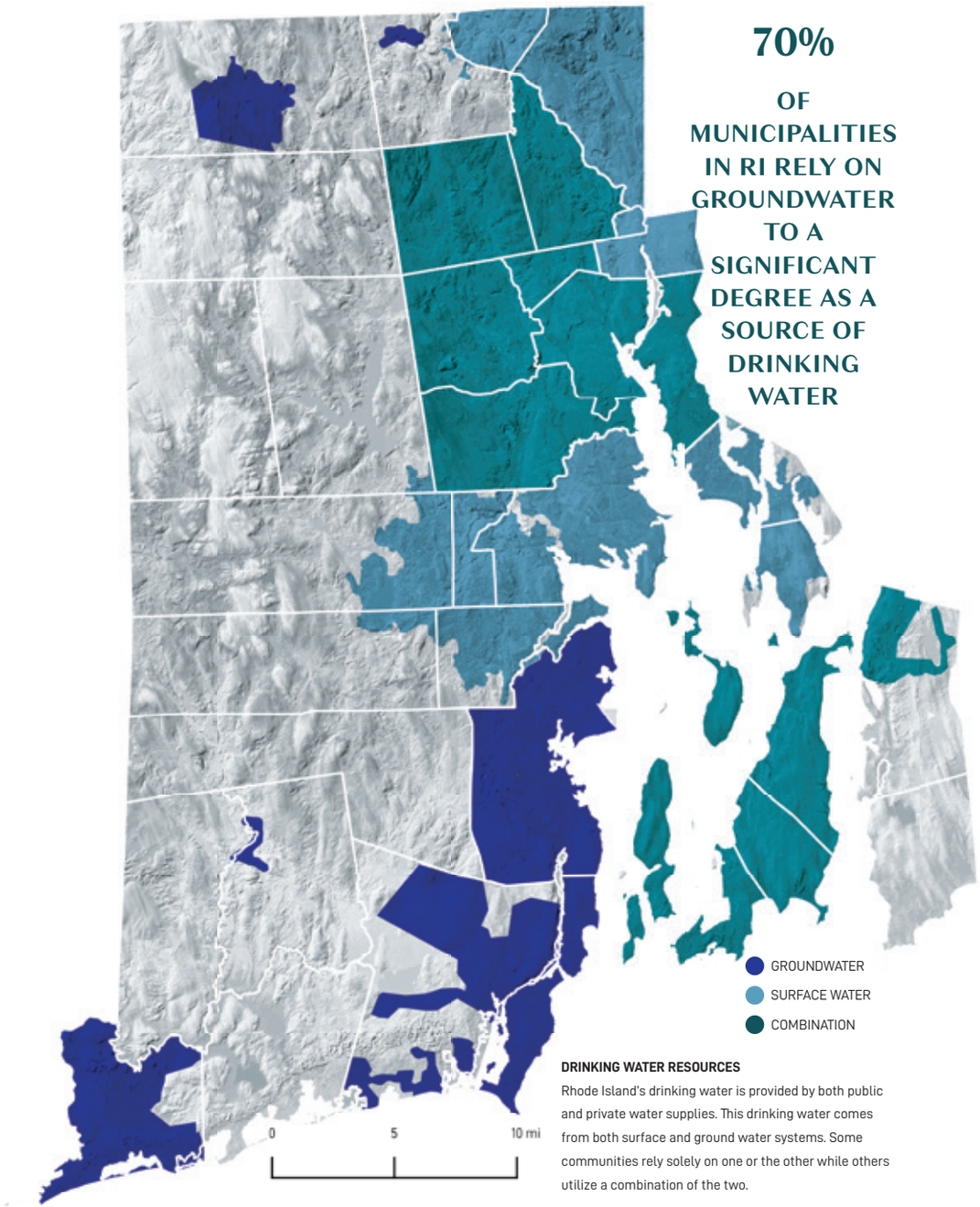


TRANSIENT, NON-COMMUNITY WATER SYSTEM



NON-TRANSIENT, NON-COMMUNITY WATER SYSTEM

PUBLIC WATER SYSTEM TYPOLOGIES
A community water system supplies water to at least 25 people (or 15 residences) at their primary residence, year-round. A non-community system can be composed to transient or non-transient systems.
A transient, non-community system provides water to 25 or more people for at least 60 days/ year, but not to the same people on a regular basis (ie: campgrounds, gas stations, etc).
A non-transient, non-community water system supplies water to at least 25 of the same people at least six months per year, but not year round (ie: schools, factories, office buildings, hospitals).

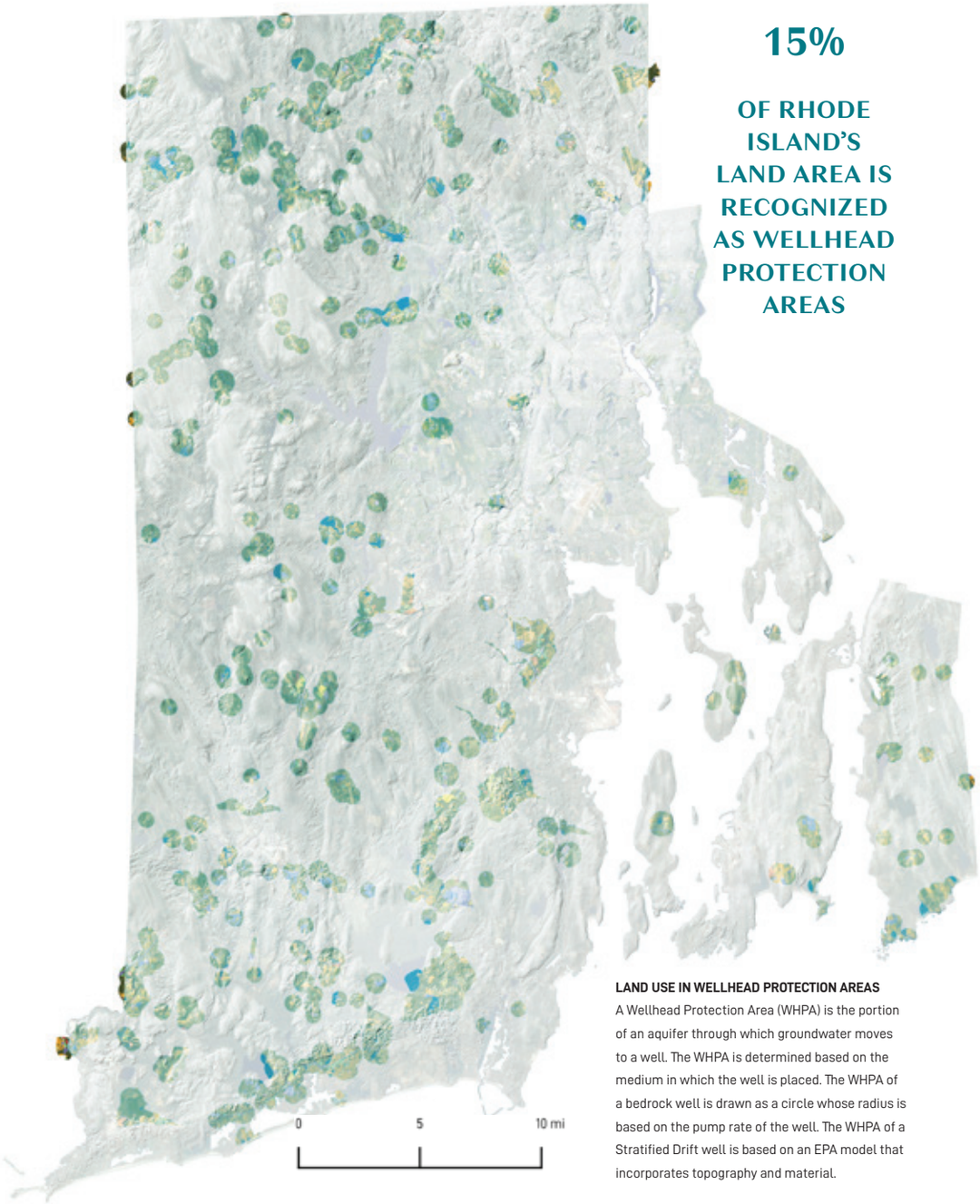


70%

OF MUNICIPALITIES IN RI RELY ON GROUNDWATER TO A SIGNIFICANT DEGREE AS A SOURCE OF DRINKING WATER

DRINKING WATER RESOURCES

Rhode Island's drinking water is provided by both public and private water supplies. This drinking water comes from both surface and ground water systems. Some communities rely solely on one or the other while others utilize a combination of the two.



15%

OF RHODE ISLAND'S LAND AREA IS RECOGNIZED AS WELLHEAD PROTECTION AREAS

LAND USE IN WELLHEAD PROTECTION AREAS

A Wellhead Protection Area (WHPA) is the portion of an aquifer through which groundwater moves to a well. The WHPA is determined based on the medium in which the well is placed. The WHPA of a bedrock well is drawn as a circle whose radius is based on the pump rate of the well. The WHPA of a Stratified Drift well is based on an EPA model that incorporates topography and material.

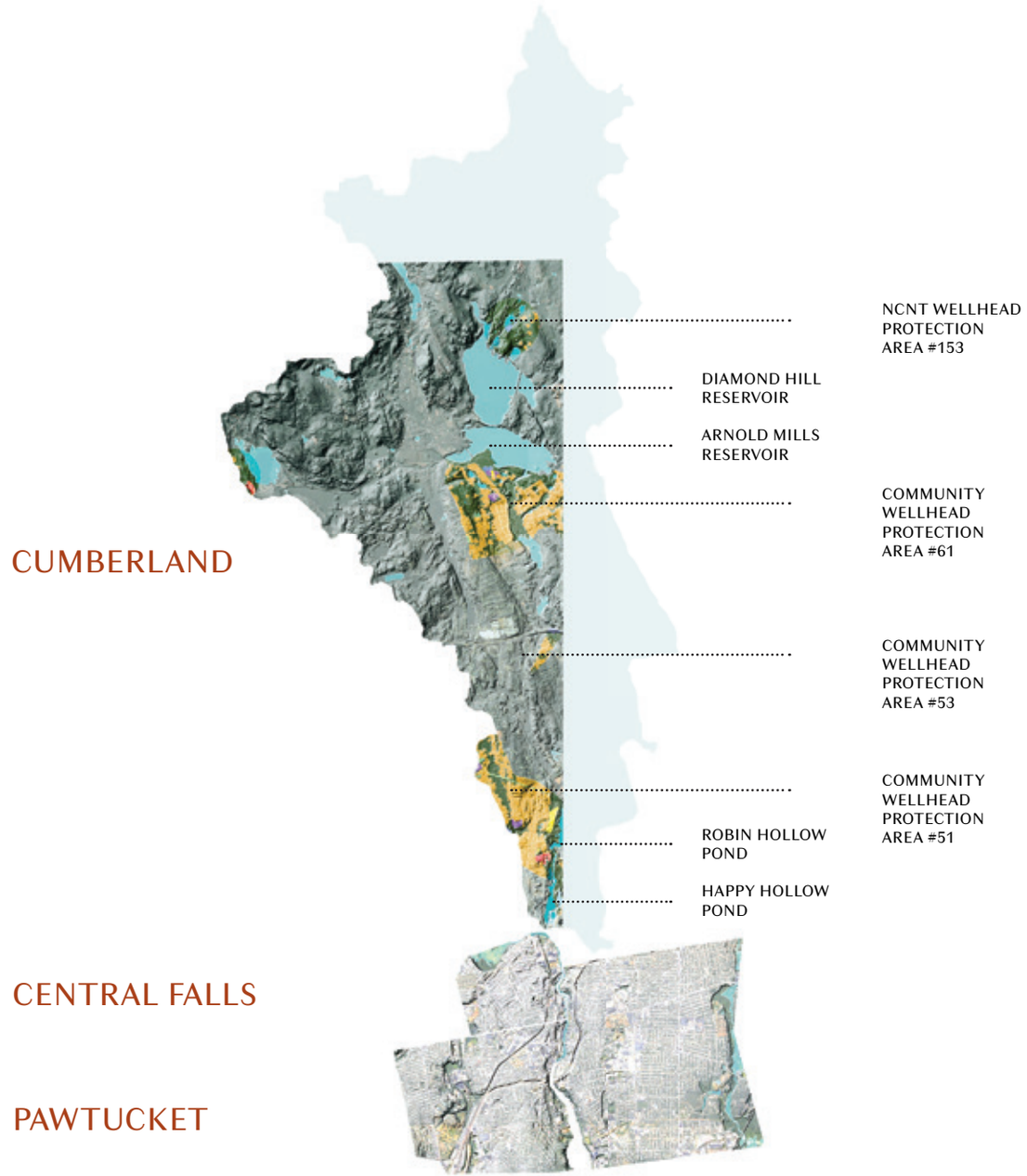
GROUNDWATER + SURFACE WATER
COMMUNITY WATER SYSTEM
PAWTUCKET WATER SUPPLY
CUMBERLAND, RI

PRESENCE OF PFAS CONTAMINATED WELL WITHIN A COMBINED, COMMUNITY WATER SYSTEM

Pawtucket, RI sits just north of Providence with a population of 70,000. The town is highly developed and therefore sources its drinking water from nearby communities. The Pawtucket Water Supply, the main supplier for the area, services 100,000 residents in the communities of Pawtucket, Central Falls and the Valley Falls region of Cumberland.

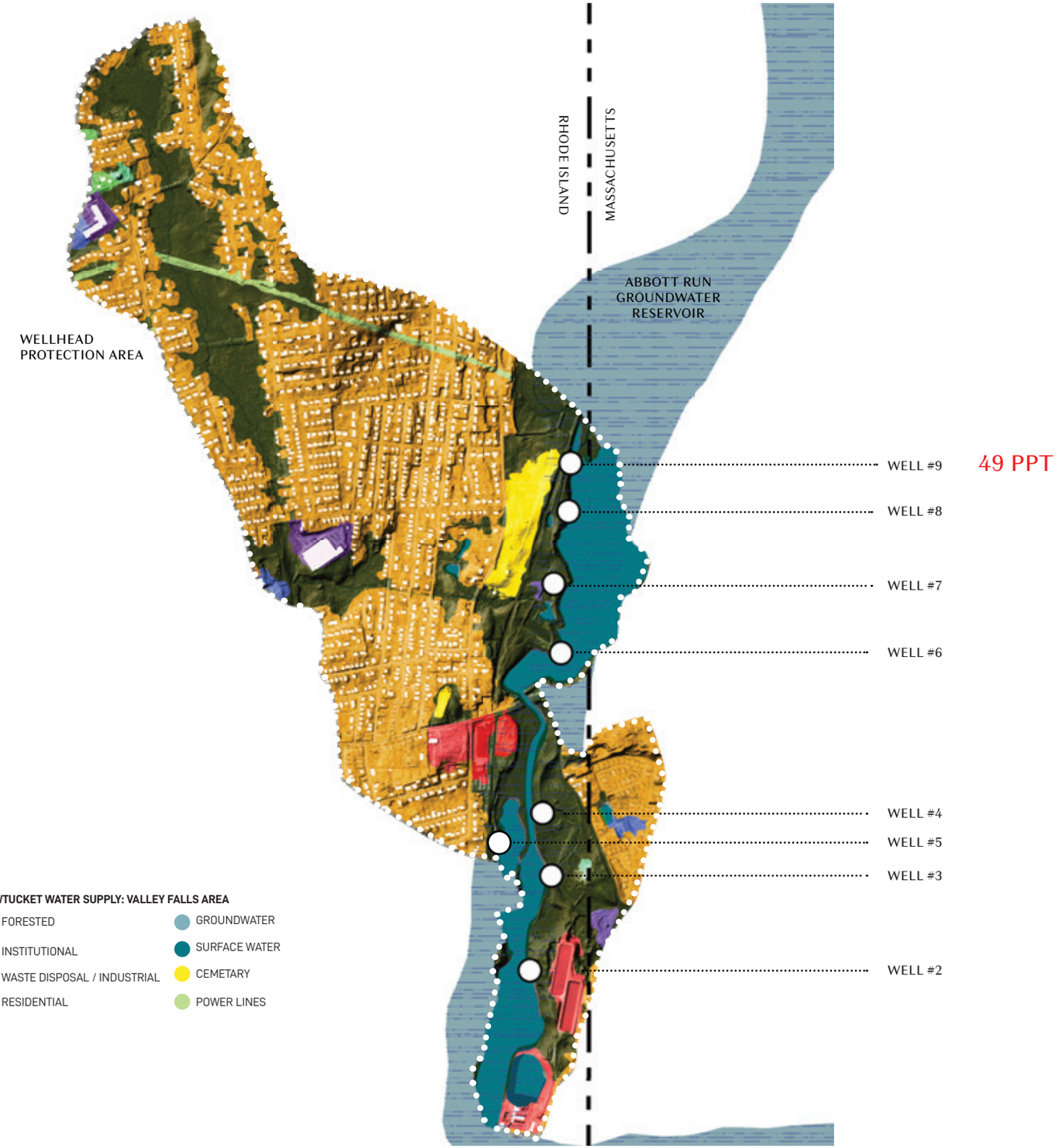
Valley Falls and Abbott Run were the former home of many extensive textile and sawmills. This area was utilized for industrial milling until the early 20th century. The groundwater wells in this area are positioned along what was formerly the rail corridor moving goods from the mills to the city. There is little remaining visual connection between the Abbott Run brook and surrounding residential community.

The drinking water for these communities comes from a combination of four surface water reservoirs and eight groundwater wells that are all pumped to the new treatment plant built in Cumberland in 2008. The Abbott Run watershed supplies water to both the surface and groundwater supplies of this system. The drainage area of this watershed is relatively small, at 28 square miles. The groundwater reservoir utilized by the wells in the system tap into the Abbott Run stratified drift groundwater reservoir, which is saturated to depths of 40-80' below the Abbott Run stream valley. The availability of groundwater is based on the amount of recharge supplied by the heavily utilized surface water sources.



PAWTUCKET WATER SUPPLY AREA

Pawtucket Water Supply Board services the cities of Pawtucket, Central Falls, and the Valley Falls region of Cumberland, RI. The drinking water for these communities is drawn from a combination of surface and groundwater sources in the Abbott Run watershed, including 4 reservoirs and 8 groundwater wells. Other local municipalities pull from groundwater sources further upstream in the watershed.



PAWTUCKET WELL #9

Pawtucket city well #9 is located adjacent to Robin Hollow along the Rhode Island and Massachusetts border. This well is among 8 other wells that utilize the groundwater reservoir in this area of Cumberland, known as Valley Falls. The well is situated behind a local cemetery along a former railroad corridor. Well #9 is among is the northern most of 9 wells in this area. The wells are utilized by the Pawtucket Water Supply and service the communities of Pawtucket, Central Falls and Cumberland.

PAWTUCKET WATER SUPPLY: VALLEY FALLS AREA

- FORESTED
- INSTITUTIONAL
- WASTE DISPOSAL / INDUSTRIAL
- RESIDENTIAL
- GROUNDWATER
- SURFACE WATER
- CEMETARY
- POWER LINES


WELL 9


NO TRESPASSING
WELL 8

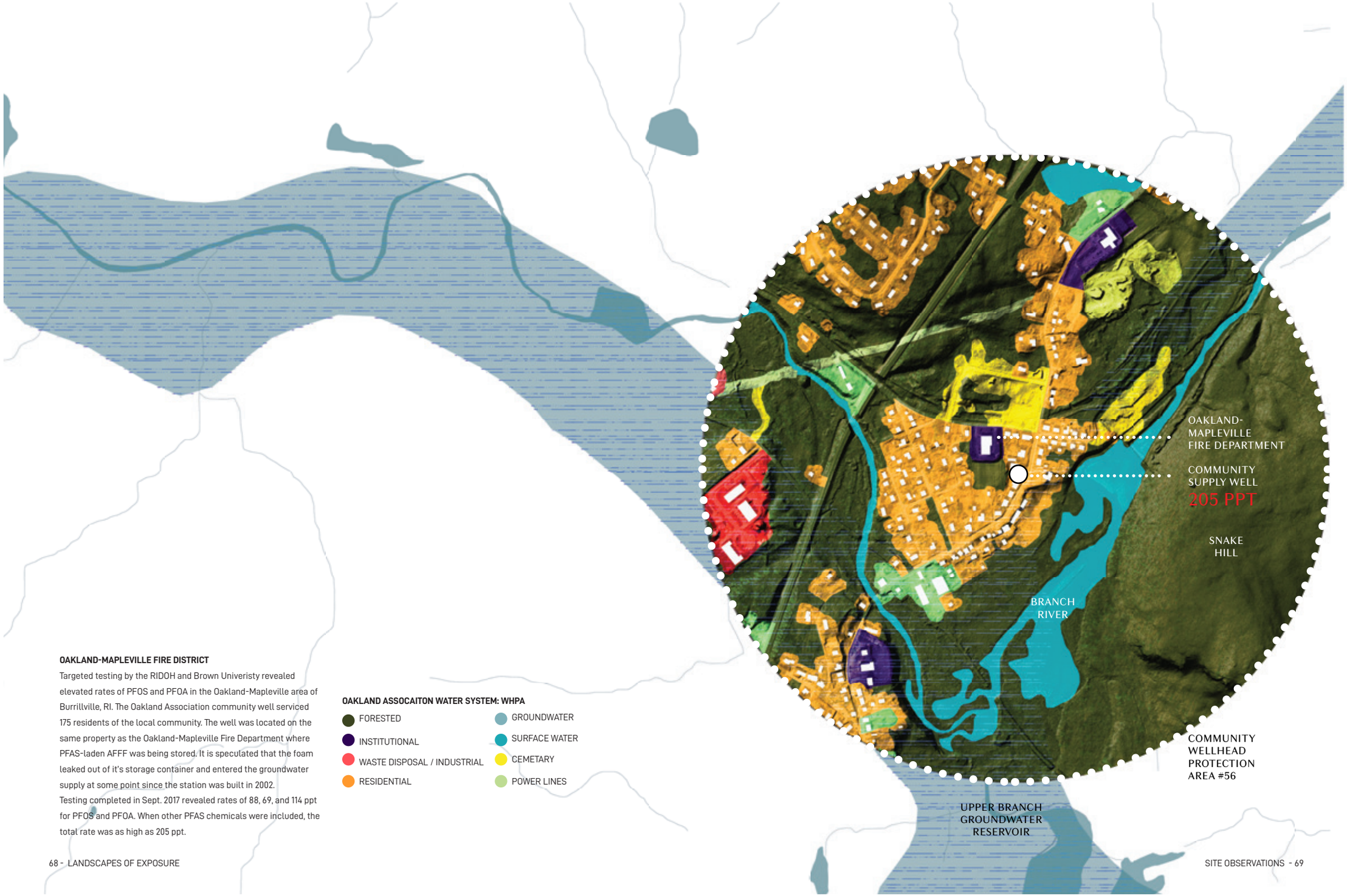
GROUNDWATER
COMMUNITY WATER SYSTEM
OAKLAND ASSOCIATION
BURRIVILLE, RI

PRESENCE OF PFAS CONTAMINATED WELL WITHIN A GROUNDWATER COMMUNITY WATER SYSTEM

Oakland VIllage, a historic district, sits at the heart of Burrillville, Rhode Island in the northwest corner of the state. The village was founded around 1850 around the stone textile mills at the confluence of the Clear and Branch Rivers. Oakland, 20 miles northwest of Providence, was originally serviced by the Woonsocket- Pascoag trolley system which moved people and goods from the mill districts toward the city. The town was originally built to house workers for the mills. While some redevelopment has happened during the mid-twentieth century, the village has largely remained the same, with most of the original housing still standing1.

While this area is surrounded by the meandering Clear and Branch Rivers, the visual connection to the water is currently obstructed. The rivers and groundwater reservoirs below are part of the Branch River Basin, the largest tributary of the Blackstone River. Steep, till covered bedrock hills form much of the landscape throughout the Branch River basin. This area is mostly undeveloped besides some small pockets of industrial settlements. Many of the residents are serviced by private wells or small public well systems, such as the one that existed in Oakland Village. The Upper Branch groundwater reservoir sits below the Branch river. The groundwater here is saturated to a depth of around 60' though Oakland's public supply well was drilled into the bedrock to a depth of 200' for drinking water2.

1. Jones, Robert O., "Oakland Historic District," National Register of Historic Places Nomination Form (Washington, DC: U.S. Department of the Interior, National Park Service, 1987).
2. Todd Trench, Elaine. "Ground-Water Resources of Rhode Island." Open-File Report. Open-File Report, 1991.

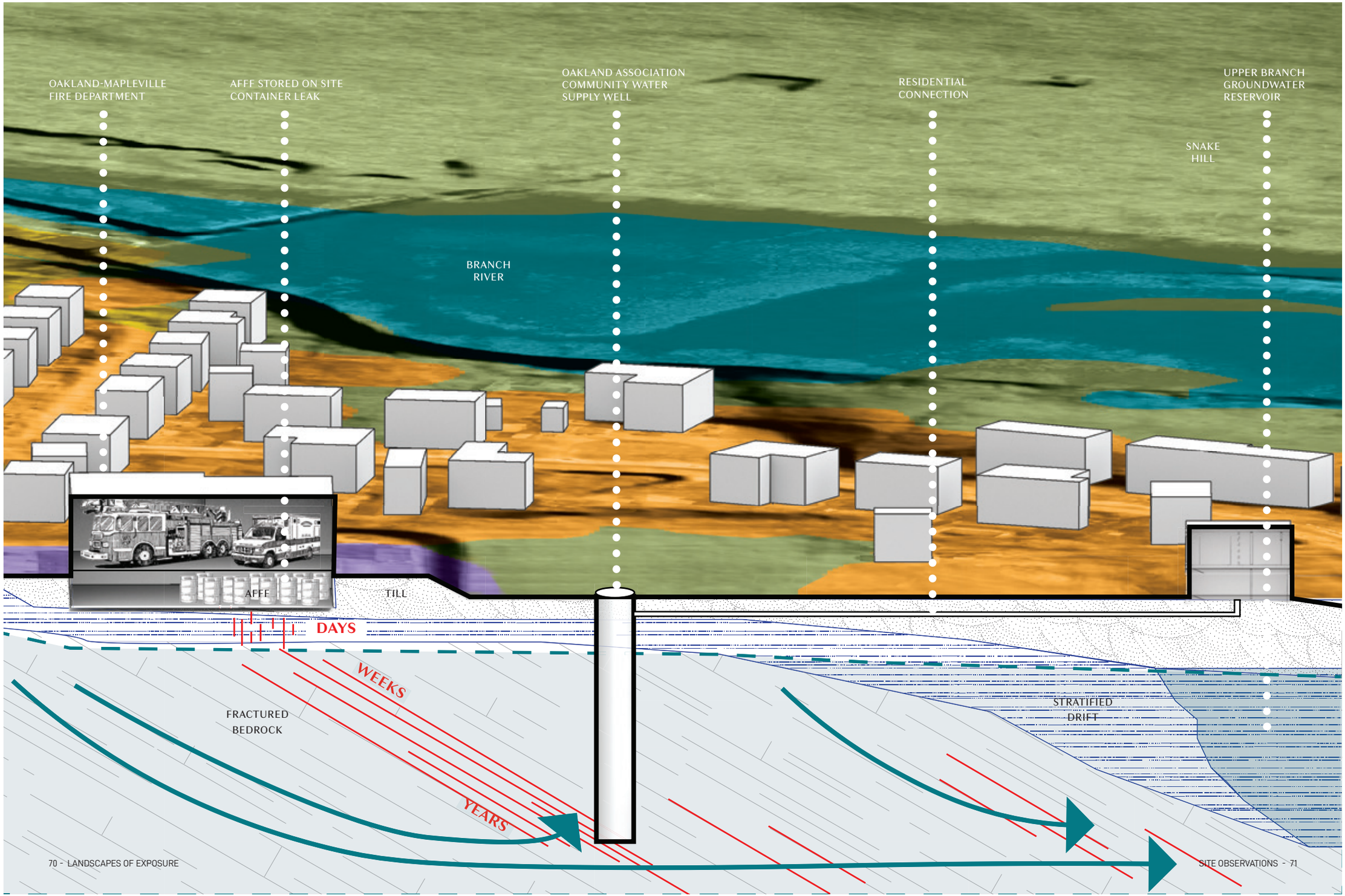


OAKLAND-MAPLEVILLE FIRE DISTRICT

Targeted testing by the RIDOH and Brown Univeristy revealed elevated rates of PFOS and PFOA in the Oakland-Mapleville area of Burrillville, RI. The Oakland Association community well serviced 175 residents of the local community. The well was located on the same property as the Oakland-Mapleville Fire Department where PFAS-laden AFFF was being stored. It is speculated that the foam leaked out of it's storage container and entered the groundwater supply at some point since the station was built in 2002.
Testing completed in Sept. 2017 revealed rates of 88, 69, and 114 ppt for PFOS and PFOA. When other PFAS chemicals were included, the total rate was as high as 205 ppt.

OAKLAND ASSOCAITON WATER SYSTEM: WHPA

- FORESTED
- INSTITUTIONAL
- WASTE DISPOSAL / INDUSTRIAL
- RESIDENTIAL
- GROUNDWATER
- SURFACE WATER
- CEMETARY
- POWER LINES


OAKLAND-MAPLEVILLE FIRE DEPARTMENT
AFFF STORED ON SITE CONTAINER LEAK
OAKLAND ASSOCIATION COMMUNITY WATER SUPPLY WELL
RESIDENTIAL CONNECTION
UPPER BRANCH GROUNDWATER RESERVOIR
SNAKE HILL
BRANCH RIVER
AFFF
TILL
DAYS
WEEKS
YEARS
FRACTURED BEDROCK
STRATIFIED DRIFT


THIS PROJECT IS FUNDED BY THE
EPA
STATE REVOLVING FUND
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Gina M. Raimondo Governor
Nicole Alexander-Scott, MD, MPH Director - RIDOH
"Dedicated To Protecting And Preserving Our State's Most Important Resource...Clean Water"


1264
237-1

GROUNDWATER
NON-TRANSIENT, NON-COMMUNITY
WATER SYSTEM
LADD CENTER
EXETER, RI

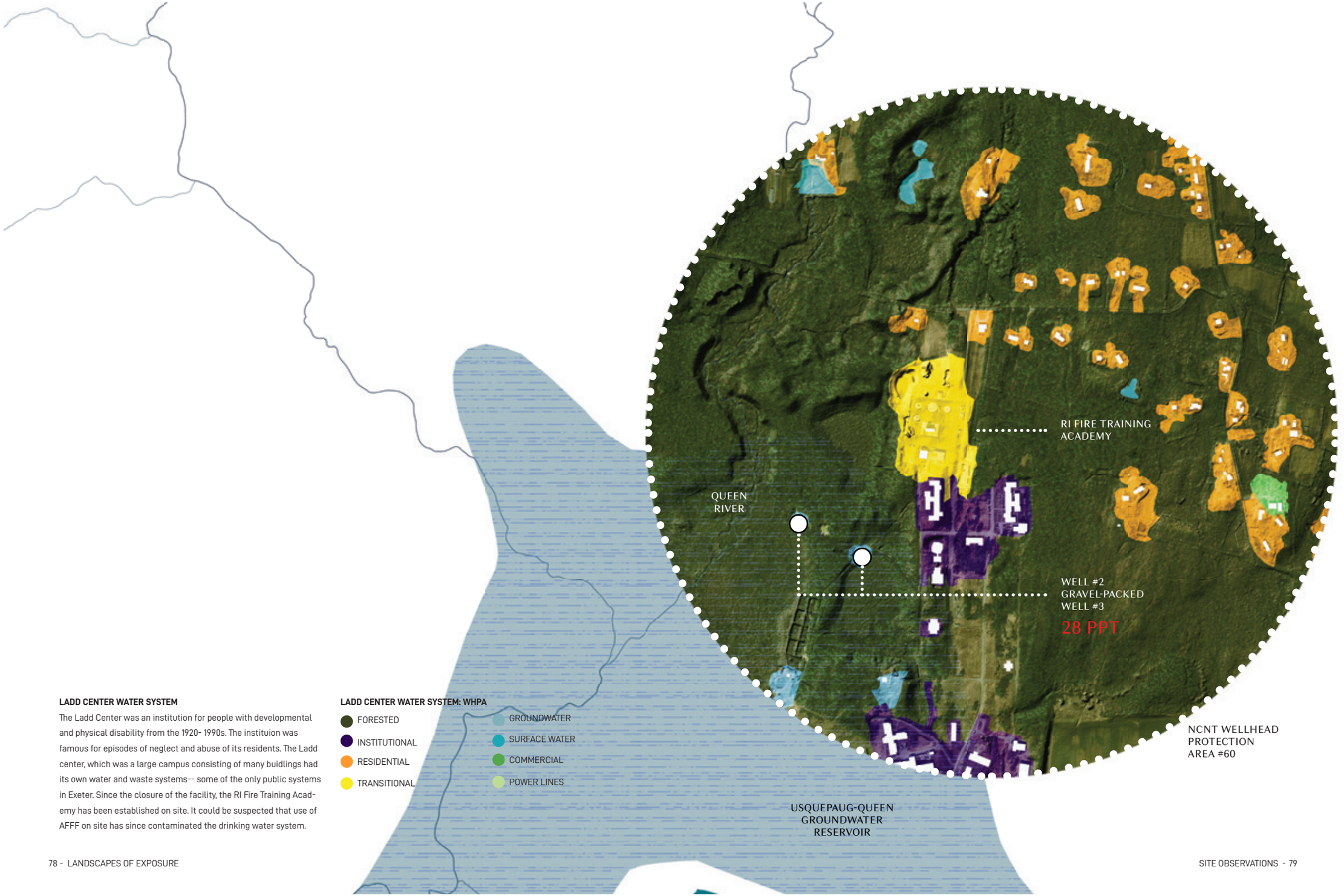
PRESENCE OF PFAS CONTAMINATED WELL WITHIN A NON-TRANSIENT, NON-COMMUNITY WATER SYSTEM

The Ladd Center property sits at the south-east corner of Exeter, Rhode Island, in the southern portion of the state. Exeter is a rural community in which most of its residents rely on private wells for their drinking water supplies. The Ladd Center was formerly run as an institution for people with disabilities. The center had repeated complaints against it and was finally shuttered in the 1990s. Many of the original buildings have been razed, but the original water infrastructure, one of the only community supplies in the town, remains functional and operational.

This area is part of the Pawcatuck River Basin which drains 317 square miles of Rhode Island and Connecticut. The site sits atop the Usquepaug-Queen groundwater reservoir which it utilizes for its drinking water supply1. Planning documents for Exeter mention the possibility of using and expanding on this existing water infrastructure to begin to grow a public water supply for the town.

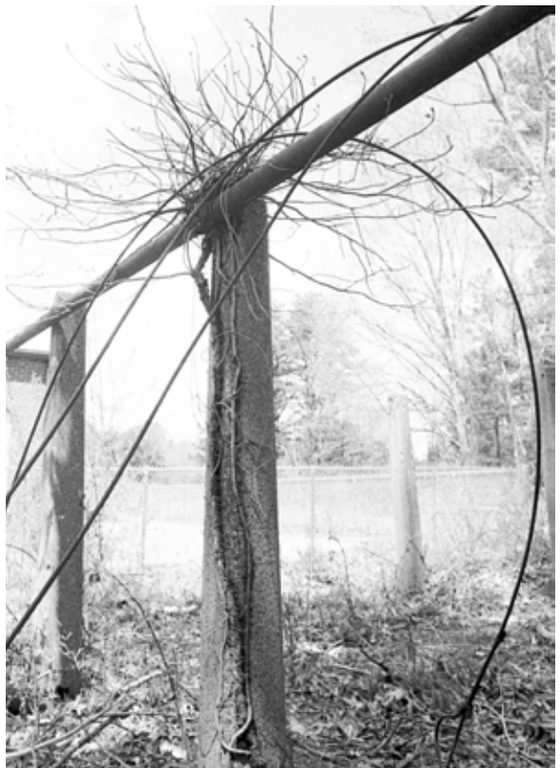
The Ladd Center property is the current home of the RI Fire Training Academy.

1. Todd Trench, Elaine. "Ground-Water Resources of Rhode Island." Open-File Report. Open-File Report, 1991.



LADD CENTER WATER SYSTEM

The Ladd Center was an institution for people with developmental and physical disability from the 1920- 1990s. The instituion was famous for episodes of neglect and abuse of its residents. The Ladd center, which was a large campus consisting of many buidlings had its own water and waste systems-- some of the only public systems in Exeter. Since the closure of the facility, the RI Fire Training Academy has been established on site. It could be suspected that use of AFFF on site has since contaminated the drinking water system.

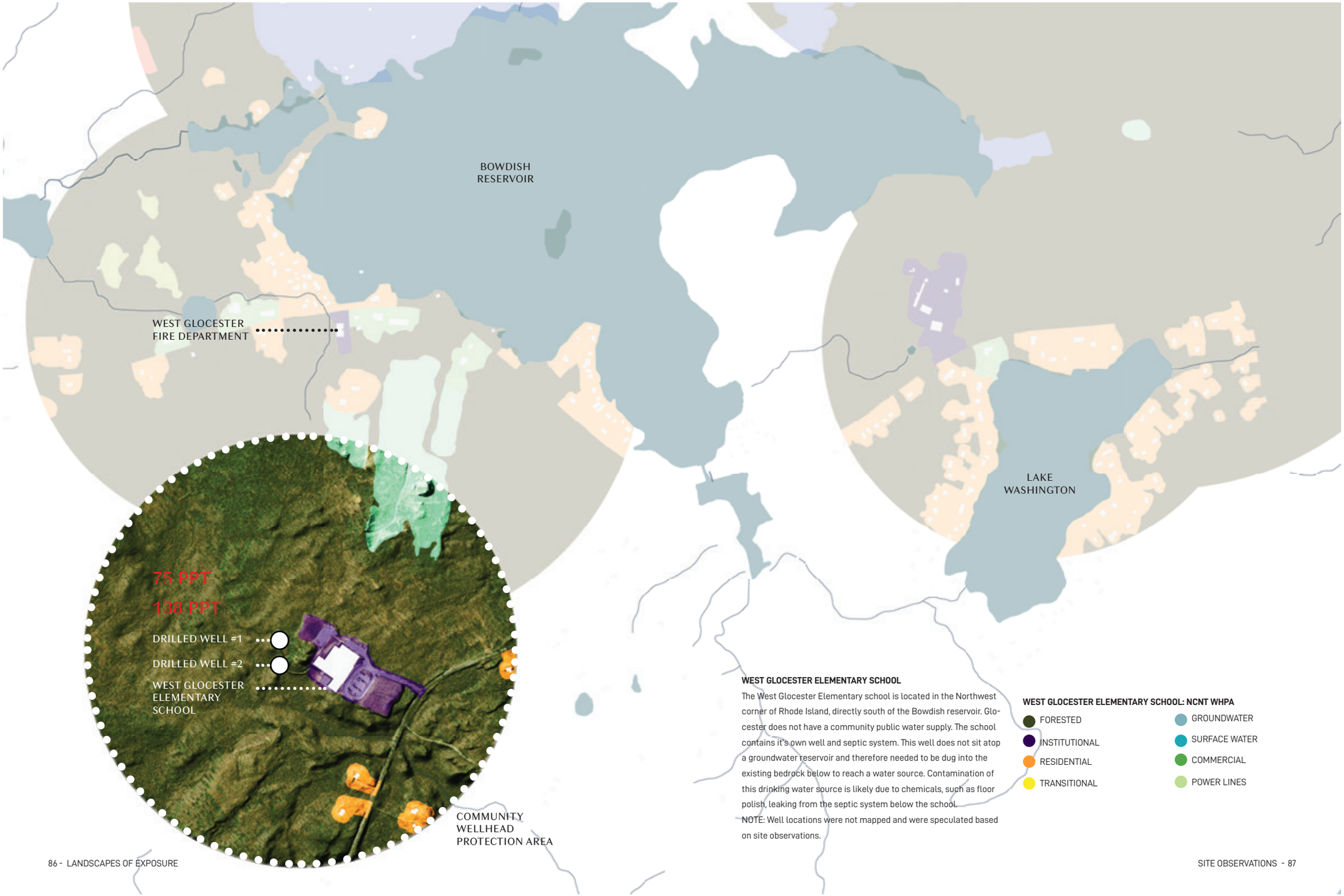


GROUNDWATER
NON-TRANSIENT, NON-COMMUNITY
WATER SYSTEM
WEST GLOCESTER ELEMENTARY SCHOOL
GLOCESTER, RI

PRESENCE OF PFAS CONTAMINATED WELL IN A NON-TRANSIENT, NON-COMMUNITY SYSTEM

Glocester, which sits in the northwest corner of the state, is a rural community of 10,000. Glocester does not have a public water supply and all of its residents rely solely on groundwater for their drinking water. This, coupled with the fact that Glocester does not have a centralized wastewater treatment plant, means that the groundwater supply is incredibly susceptible to pollution.

Glocester's main method of wastewater treatment is through individual sewage disposal systems (ISDSs). Improper installation or maintenance of these systems can easily lead to leachate escaping this on-site infrastructure. West Glocester Elementary, like many schools in Rhode Island, maintains its own drinking water supply well on site. It is possible that wastewater, including PFAS laden floor polish, was able to escape the on-site septic system and enter the groundwater that the drinking water supply is drawn from.



WEST GLOCESTER ELEMENTARY SCHOOL

The West Glocester Elementary school is located in the Northwest corner of Rhode Island, directly south of the Bowdish reservoir. Glocester does not have a community public water supply. The school contains it's own well and septic system. This well does not sit atop a groundwater reservoir and therefore needed to be dug into the existing bedrock below to reach a water source. Contamination of this drinking water source is likely due to chemicals, such as floor polish, leaking from the septic system below the school.
NOTE: Well locations were not mapped and were speculated based on site observations.

WEST GLOCESTER ELEMENTARY SCHOOL: NCNT WHPA

- FORESTED
- INSTITUTIONAL
- RESIDENTIAL
- TRANSITIONAL
- GROUNDWATER
- SURFACE WATER
- COMMERCIAL
- POWER LINES


WEST GLOCESTER
ELEMENTARY SCHOOL

CONCLUSIONS

The goal of this thesis research project was to begin to position landscape architecture among the sciences that are investigating gene-environment interactions. This project began with an interest in how it is that our environment shapes who we become. It looked to the literature of epigenetics and the social sciences to understand the effect that environmental conditions, from inside our cells to our built environment, have on our health outcomes.

PFAS have become ubiquitous in our environment since they were introduced almost 60 years ago. As of 2019, the Environmental Working Group reports that PFAS contaminants have been found in drinking water systems in 49 states, affecting 19 million Americans. The EWG also reports that unreleased federal data shows that 110 million Americans may be exposed to PFAS contaminated drinking water. While the toxic effects of these compounds are just coming into mainstream media, their environmental toxicity has been noted by their manufacturers since the early 1970s. 3M and Dupont...

Research conducted in 2019 suggests that PFAS chemicals migrate through subsurface materials at slower rates than originally thought. Since PFAS have been in production for over 70 years, it is believed that we are just seeing the tip-of-the-iceberg when it comes to PFAS contamination of groundwater supplies. It is likely that the majority of PFAS chemicals are slowly making their way through the soil towards our water supplies. While much of the focus to date has been on remediating polluted water bodies, there will likely be a shift in the near future to how to isolate and extract these chemicals from the ground.

Much of the data referenced in this book was current as of May 2020, but will continue to be updated as it becomes available.

It questions how a multi-scalar approach to an environmental issue can help reframe the connection to the human body.

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