WEBSITE LAUNCH

After a year in development, the redesigned Rice Design Alliance (RDA) website is live and ready to welcome all who have an interest in Houston's built environment. The new site features commentary and podcasts from RDA civic forums and lectures, a calendar of RDA events and events sponsored by other area organizations, travel journals from RDA city tours, and several resources including a pdf archive of *Cite* 71, The Hurricane Issue, and links to OffCite.org, the *Cite* blog.

From left: View from Hearst Tower; Tour Group in front of Alice Tully Hall; 2009 Galveston charrette.

> RICE UNIVERSITY NAMES DEAN OF ARCHITECTURE

Sarah Whiting, a member of the Princeton University School of Architecture faculty, has been named Dean of the Rice School of Architecture. Whiting will take the helm January 1 from John Casbarian, the school's longtime associate dean who is serving as dean until December 31. Lars Lerup stepped down as dean earlier this year after 16 years and will return to Rice in 2010 as a professor.

Before joining Princeton in 2005, Whiting taught at the Harvard University Graduate School of Design for six years. Prior to that, she taught at the University of Kentucky, the Illinois Institute of Technology, and the University of Florida. She earned her Bachelor of Arts at Yale, a Master of Architecture at Princeton and her Ph.D. in the history, theory and criticism of art, architecture, and urban form at the Massachusetts Institute of Technology.

> NEW YORK – HEART OF GLASS AND STEEL

Kathryn Fosdick, Associate Director of Programs, recalls the four-day RDA tour of New York City in June.

New York- I was struck by a sense of homecoming when we arrived. I was born and spent my first five years in New York and have since felt a special connection to the place. For me, the city is like an eccentric aunt who is best taken in limited doses but, nonetheless, leaves you with vivid, brightly-colored memories. The group of roughly 30 RDA members stayed at the Desmond Tutu Center, a simple but refined Seminary/Hotel on 10th Avenue between 21st and 22nd Streets. Breakfast in the Refractory was a special treat.

Visit ricedesignalliance.org to read the full account of the New York tour.

> GALVESTON CHARRETTE

The RDA's 2009 charrette, held August 8, challenged teams of architects, designers, and engineers to design a structure along the Seawall of Galveston Island, which is still reeling from the hit by Hurricane Ike. The website shows the winning entries.

> POST HURRICANE IKE PLANNING

RDA held a three-part forum on Post-Hurricane Ike Planning. Eric Berger, the SciGuy of the *Houston Chronicle*, moderated the July 15 event, which featured scientists and engineers whom mayors and governors call when a hurricane is heading for the coast. Their message was clear. We dodged the bullet with Ike. The August 19th forum offered design solutions, including "Ike Dikes," and the final forum focused on recovery.

Find commentary on and copies of the presentations on the web.

> RDA GALA

The 23rd annual Rice Design Alliance Gala will be held at the Hilton Americas Hotel, 1600 Lamar. This year RDA will honor Phoebe and Bobby Tudor and celebrate philanthropy. The evening will include dinner, a silent auction, and dancing to the music of Fried Ice Cream. Bobby is co-chair of Rice's Centennial Campaign which has a $1 billion fundraising strategy to launch Rice into its second century. Phoebe Tudor holds a Masters degree in historic preservation from Columbia University and is chair of the Julia Ideson Library Preservation Partners.

Visit ricedesignalliance.org to join 1,000 architects, design professionals, engineers, contractors, developers, and RDA members at this popular annual event.

GALVESTON PHOTOGRAPH KATHRYN FOSDICK; PHOTO OF TOUR GEORGE FLUKE; CHARRETTE RAJ MANKAD

IN RESPONSE TO CITE 78, MAY 2009

I am a second-generation Houston architect, locally educated. I have also been a member of RDA for many years. In addition, I am always looking forward to reaching into my mailbox and finding that my current issue of *Cite* has arrived.

However, I have recently been quite disappointed by the contents inside. Is this not our presentation of local Houston architecture any longer? I often hope to find something within the (few) pages that I am not aware, or have accidentally driven by without notice while my kids are frantically being themselves.

As members of AIA, we all receive our state and national publications; yet, I depend on RDA and *Cite* to focus on Houston.

Let's get back to our basics....as well as ourselves.

Sincerely,

Kirk Gant, AIA
BGK Architects

IN RESPONSE TO "DOWNTOWN'S DOWNTOWN: HOUSTON PAVILIONS AND AN URBAN DILEMMA" BY MAX PAGE, CITE 77, FEBRUARY 2009

I wish to clarify comments attributed to me in your article on the Houston Pavilions.

The writer of the article states that I "lamented" the choice to build the retail along a central spine. This choice of words to describe my words is the author's, not mine. It is true that we had other compelling ideas, as most architects do, but in the end the design team collectively felt that the scheme we developed was the best one, the most compelling one.

Further the author states that the choice of the scheme was selected because it more closely resembled traditional covered malls. Here I believe the author betrays a lack of understanding of how a retail project of this magnitude actually works, and the urban fabric of downtown Houston into which it fits. There are many significant urban retail projects in well established cities, such as Milan, Amsterdam, London, Istanbul, dating back to more than a century, where a mid block, central spine of retail works in tandem with active streets. These are the models our team had in mind when choosing this option. To compare the scheme to a mall misses the point quite entirely. Our solution, we believe, enhances life at the street, creates porous edges along the block edges and corners, and establishes a framework for a vibrant and dynamic destination for retail. We are optimistic that this project sets a precedent for a higher density retail Downtown, which is essential to enhancing our livable city.

Please continue your work of architectural criticism, our city needs it.

Thank you,

Roger Soto, AIA, LEED AP
President and Director of Design, Odell Associates
Formerly Sr. Vice President, Design Director, HOK

IN RESPONSE TO "ASTRODOME: WHAT IS TO BE DONE?" OFFCITE.ORG, AUGUST 2009

There are two things to keep in mind about the dome. First, its essence is that mega-sized, ineluctable, air-conditioned, volume inside. Second is the fact that the dome is fundamentally useless, a claim similar to the one Roland Barthe makes for the Eiffel Tower. Its inutility is a scandal. But once you get over it you realize that trying to turn the dome into a shopping mall, a parking garage, a hotel, or maybe a mega church for the Osteens who seem to appreciate the ecclesiastical potentials for ever larger houses of worship, is never going to be a money maker or a good, functional, business solution to anything. Leaving aside the fact that in accomplishing these schemes there would be very little dome left. This leaves the perfectly reasonable, unreasonable idea to simply preserve it and hold it in reserve, a little world apart: A place of wonder, where you can take an air-conditioned walk, watch a movie with 30,000 others, climb, dream of a plan to snare the Olympics, play every game known to humankind, invent some new ones, provide shelter for the population of a medium-sized city. Speculate.

Professor Bruce Webb
Gerald D. Hines College of Architecture,
University of Houston

LET US HEAR FROM YOU

Cite welcomes and encouragrs readers to send letters, including critical ones, to citemail@rice.edu.

CORRECTION

The article "Dallas Reaches for the Stars: The Metroplex Gets a New Center for the Performing Arts" did not properly credit the design and construction of the Wyly Theatre. The architects were REX/OMA, Joshua Prince-Ramus and Rem Koolhaas; Kendall/Heaton Associates Inc. The contractors were McCarthy Building Companies, Inc.

citings

CALENDAR

RDA LECTURES

GETTING HIGH: TOWERS IN ARCHITECTURE
Brown Auditorium ,The Museum of Fine Arts, Houston
1001 Bissonnet (Enter via the Main Street door)
7p.m. | 713.348.4876 | ricedesignalliance.org

PETER BUCHANAN
ARCHITECTURE CRITIC, LONDON
Wednesday, September 16

ALI RAHIM
DIRECTOR, CONTEMPORARY ARCHITECTURE PRACTICE, NEW YORK CITY
Wednesday, September 23

WINKA DUBBELDAM
PRINCIPAL, ARCHITECTONICS, NEW YORK CITY
Wednesday, September 30

ROSS WIMER
DESIGN PARTNER, SOM, CHICAGO
Wednesday, October 7

RDA GALA

Hilton Americas | November 14, 2009
Honoring Phoebe and Bobby Tudor

UNIVERSITY OF HOUSTON

Gerald D. Hines College of Architecture, Room 150
3p.m. | arch.uh.edu | 713.743.2400

DAVID FANO | September 24, 2009

MARY MCLEOD | October 6, 2009

ROBERT KELLY | October 13, 2009

MIMI HOANG | October 20, 2009

MARLON BLACKWELL | October 27, 2009

RICE UNIVERSITY

Rice School of Architecture
Farish Gallery, Anderson Hall
5p.m. | arch.rice.edu | 713.348.4864

BLAINE BROWNE II | September 14

STEVEN EHRLICH | September 21

JENNIFER SEGAL | October 5

AMALE ANDRAOS AND DAN WOOD | October 19

CHRIS REED | October 26

KEVIN ALTER | November 2

RAVI SUNDARAM | November 9

TEXAS SOCIETY OF ARCHITECTS CONVENTION

George R. Brown Convention Center
Houston, Texas | October 22–24, 2009

LEGALIZING WALKING

Houston's new Transit Corridor Ordinance

WALKING IN HOUSTON IS OFTEN ALIENATING AND DANGEROUS. Poles, hydrants, meters, and other obstacles block the narrow sidewalks. Outside the Central Business District, the law requires a large building setback along major thoroughfares that all but mandates strip centers with parking in the front. After eight years of effort, a Transit Corridor Ordinance is now before City Council for approval that may begin to change this situation.

When Guy Hagstette was working with Central Houston Inc. and the Urban Land Institute in 2001, he presented a similar proposal to the City Planning Commission. "The idea behind the Transit Corridors proposal was that there could be a different set of rules along the light rail lines to promote pedestrian friendly developments. But the Planning Commission in those days did not consider the proposal. It was controversial," explains Hagstette.

After Mayor White was elected in 2003, however, a new Planning Commission was formed. Hagstette became the Mayor's advisor on urban design and planning, and Dr. Carol Lewis was appointed chair of the Commission. In Hagstette's words, "Carol Lewis knew the public process and created subcommittees that included all parties. There was a renewed effort."

Initially the process involved public input. "The idea was for us to create consensus through a series of community workshops. Successful implementation of the initiative required the stakeholder's participation," explains Keiji Asakura, whose firm Asakura Robinson Company was selected along with the Planning Partnership from Toronto to create the Urban Corridor studies for all six light rail lines. The resulting report included ambitious recommendations.

The next step involved a twelve-member committee that crafted the actual ordinance and included six developers; four consulting architects, engineers, and planners; one governmental representative; and one advocate from a nonprofit. The ordinance was more limited in scope than what the public process yielded.

Nonetheless, the Planning Department has described a "new paradigm" for development in Houston, one where mixed-use development can create sidewalk life. Any new sidewalk in Houston, not just those near light rail, will now have to be five feet wide instead of four feet; a revision to the street design standards that is being revised concurrently with the implementation of the transit ordinance. On August 19, 2009, City Council passed the transit corridors ordinance after a delay for review due to a technical conflict between the new street design standards and the ordinance.

"The greatest possibility in urban design lies in the gray area, or public realm," says Asakura, "and that is what we created for the Urban Corridors." In urban planning lingo, the public realm refers to the public right of way between property lines: streets, sidewalks, and open space.

The Transit Corridor Ordinance can be broken down into a requirement and an option:

Requirement: The sidewalk width requirement along transit corridors is six feet. The urban corridor study proposed even wider, eight foot sidewalks. "The proposed eight foot wide sidewalks were not going to be accepted," says Steve Spillette, who assumed control of the project for the City after Hagstette became the president of Discovery Green.

Option: On the streets that have light rail and on streets perpendicular to and within a quarter mile from the rail stations—developers have the option to plat a property with a building line that is 15 feet from the curb. The 10 additional feet available to the developer are tied to a series of required parameters shown in the accompanying graphic.

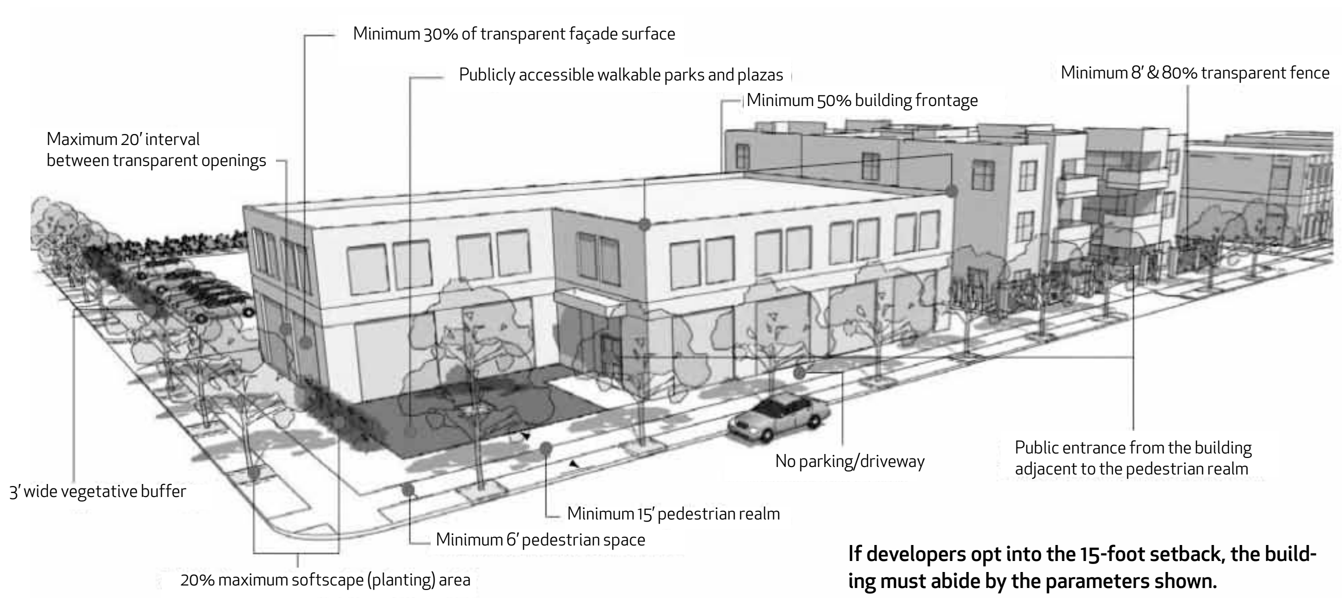
According to Rick Merrill with the Planning Partnership, which recently received an American Society of Landscape Architects Honor Award for the Urban Corridor Studies they created for Houston, the 15-foot realm and reduced property line setback "should be mandated, there needs to be stronger controls and an ordinance that offers incentives." Merrill explains that, in most cities, a reduced building line is a great incentive for developers.

But Kendall Miller with Houstonians for Responsible Growth (HRG) disagrees. "We could not have supported the original urban corridor guidelines but we can in their current form." HRG believes Houston's prosperity has been driven by a lack of regulations. Miller believes the ordinance "should thrive or fail on its own merits, the market is going to tell us pretty quick if it is meant to happen." But which developer will test the market? According to Miller, "we need to advertise this ordinance around the country, and let developers know that Houston has low barriers to entry and you don't need to be friends with the mayor to get a mixed-use development built."

A major component left out of the ordinance is parking. The absence of a comprehensive parking plan and reduced parking requirements in the ordinance has drawn criticism. "It's a shame," laments Hagstette, "it would have been so easy to do, and it would have been a great incentive." But according to Spillette, "Parking was too complicated an issue to deal with in the ordinance. I'm sure it will be revisited in the future."

Parking issues aside, there is an ordinance in Houston that allows for the creation of a public realm and transit oriented development. Even though the ordinance did not go far enough for some, in the end, it is a major step. Asakura summarizes, "For sure [the ordinance] didn't go far enough. This town is not planning friendly. But of course I'm happy. We believed transit oriented development could transform Houston. We still believe it."

–Camilo Parra



If developers opt into the 15-foot setback, the building must abide by the parameters shown.

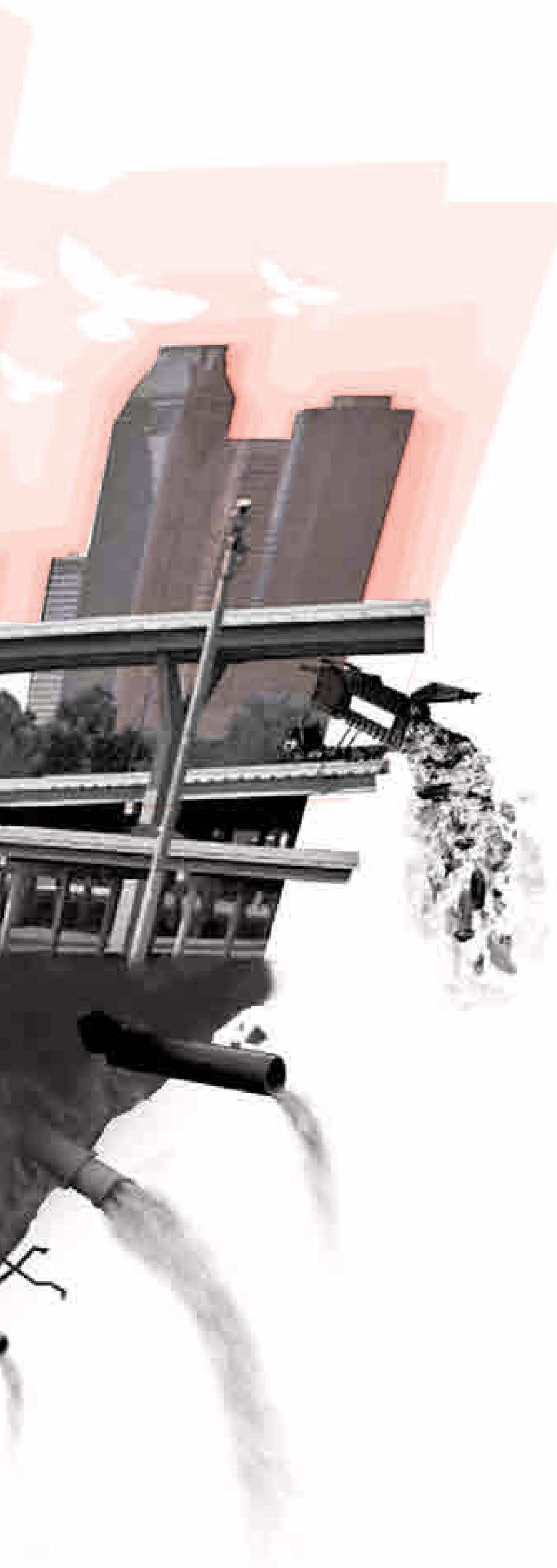
CITY OF HOUSTON

THE HIDDEN MACHINE

Views from above, below, and within.

ILLUSTRATION OBIE AND SALLY DÍAZ

BY THOMAS COLBERT AND CHRISTOF SPIELER



ONE OF THE MOST EXTRAORDINARY ASPECTS OF URBAN LIFE TODAY is the vast number of infrastructure systems and networks that are required to support our seemingly simple lifestyles, and the armies (sometimes literally) of people needed to maintain them.

These networks are like umbilical cords that keep us nourished, but they are so woven into the fabric of the city in such great numbers that the umbilical cord metaphor immediately breaks down. Weaving itself may provide a more realistic model for the way these floating, flowing, flying, rolling, buzzing, pressurized, and sometimes roaring networks make their way through the city. But in the case of Houston, the infrastructure that surrounds us suggests a rather threadbare carpet. From Katy to Baytown, the thick strands of these systems seem unattached to the city around them. In many places they dominate the neighborhoods that they run through. And some quite large precincts are places of infrastructure alone.

Maybe there is no adequate metaphor for the place of infrastructure in our lives. For that or some other reason, many of the enormous artifacts that surround us and that we are utterly dependent on usually go unnoticed, and apparently unconsidered, as a part of the experience and design of the city. We tuck our infrastructure behind buildings. We bury it. When possible, we push it into someone else's neighborhood. Where it is visible, we have trained our eyes to not see it. As these systems have grown larger and more complex, they have become more and more automated, reducing even further the human connections to the machine.

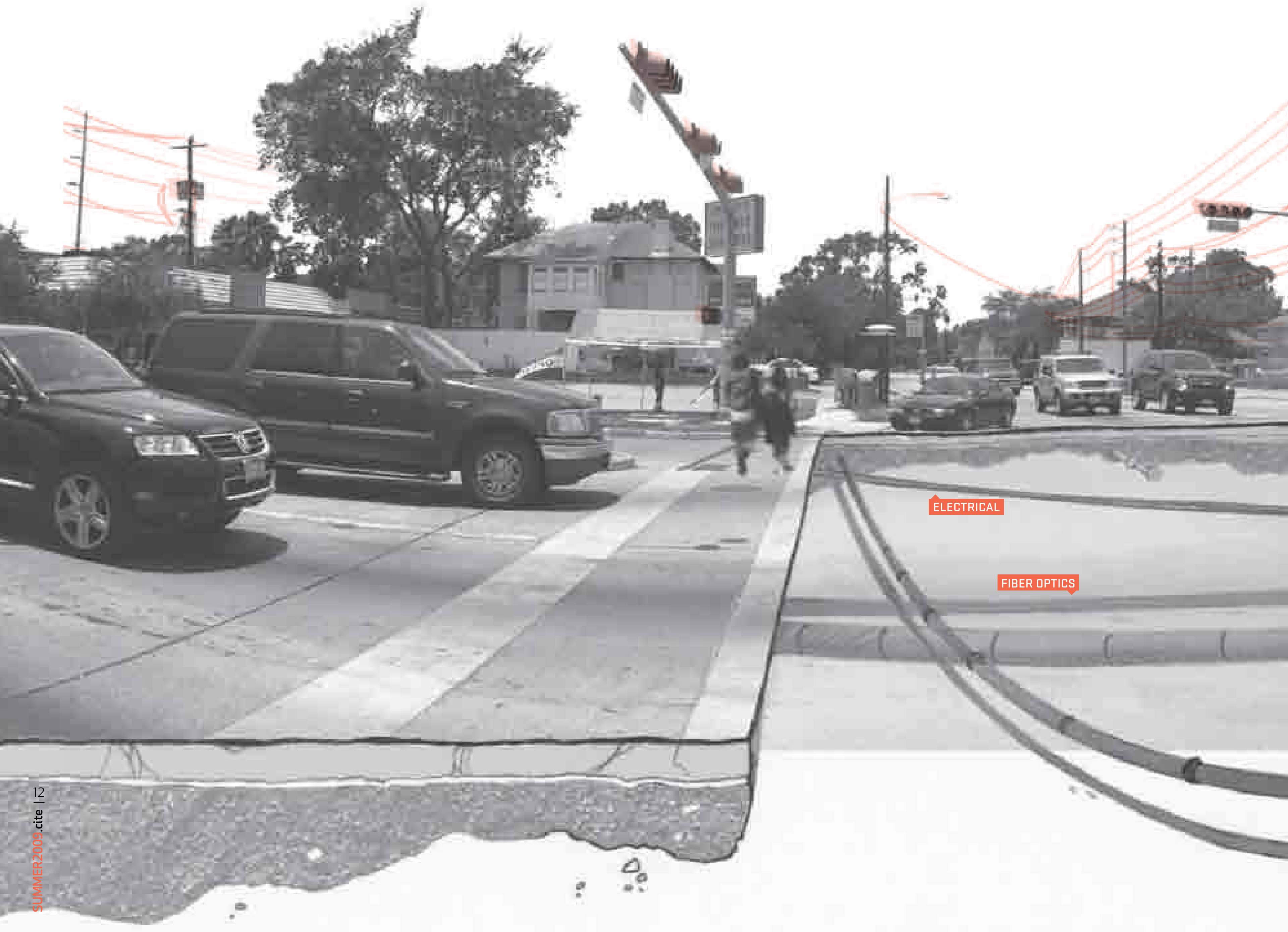
This issue of *Cite* is devoted to making the infrastructure that surrounds us more visible and more accountable. What is the architecture of infrastructure? What does its appearance tell us about our attitudes of the city? What are the design implications of the startling adjacencies that are all around us? What are the trade-offs and investments needed to keep it going? As long as we continue to think of Houston as a collection of scenic neighborhoods and photogenic monuments while ignoring the networks that make these neighborhoods and buildings possible, we will continue to blind ourselves to an important part of the complex reality that is Houston.

THE INFRASTRUCTURE OF A TYPICAL STREET CORNER IN ALL ITS BLINKING, PULSING, GURGLING, AND OVERFLOWING COMPLEXITY.

anatomy of an INTERSECTION

by **Zeke Minaya**

ILLUSTRATION OBIE AND SALLY DÍAZ



For most of the more than half-century that Gibbs Boat Company has sat on the corner of Montrose and West Gray, Marie Brocato has worked there. For 34 years, the manager of the boat-selling company has looked out the showroom windows and watched as a steady march of development has enveloped the once sleepy intersection. Few would argue with Brocato's knowledge of the corner, but she readily admits that she has not once wondered, in 34 years, about the pipes buried under foot, the wires and power lines hanging over head, and the traffic signals guiding car and pedestrian traffic. "I don't pay attention to it and nobody does," she said of the surrounding infrastructure. "If everything is running smoothly, no one is going to notice those things." Mark Loethen, City Engineer with Houston's Department of Public Works and Engineering, said that the corner of West Gray and Montrose had infrastructure common to most street corners in any major American city.

"Yeah, this is typical," he said looking up and down the street. "Most major urban cities have this level of complexity."

In fact, Loethen stood under the stinging heat of the noontime sun at West Gray and Montrose precisely because the street corner is so average and, therefore, representative of the roughly 6,400 miles of streets that make up Houston. Across the street from Gibbs, in front of Christy's Donuts, Loethen prepared to take *Cite* on a tour of the intersection.

"The electrical grid is like the nervous system, the water pipes are like the circulatory system, wastewater is like the digestive system," he said.

And these intricacies are hidden in plain sight.

Vasculature "You see that fire hydrant," Loethen said. "The fact that it's got a green cap on it tells me that there's anywhere from a 12- to 20-inch water line along this section of West Gray."

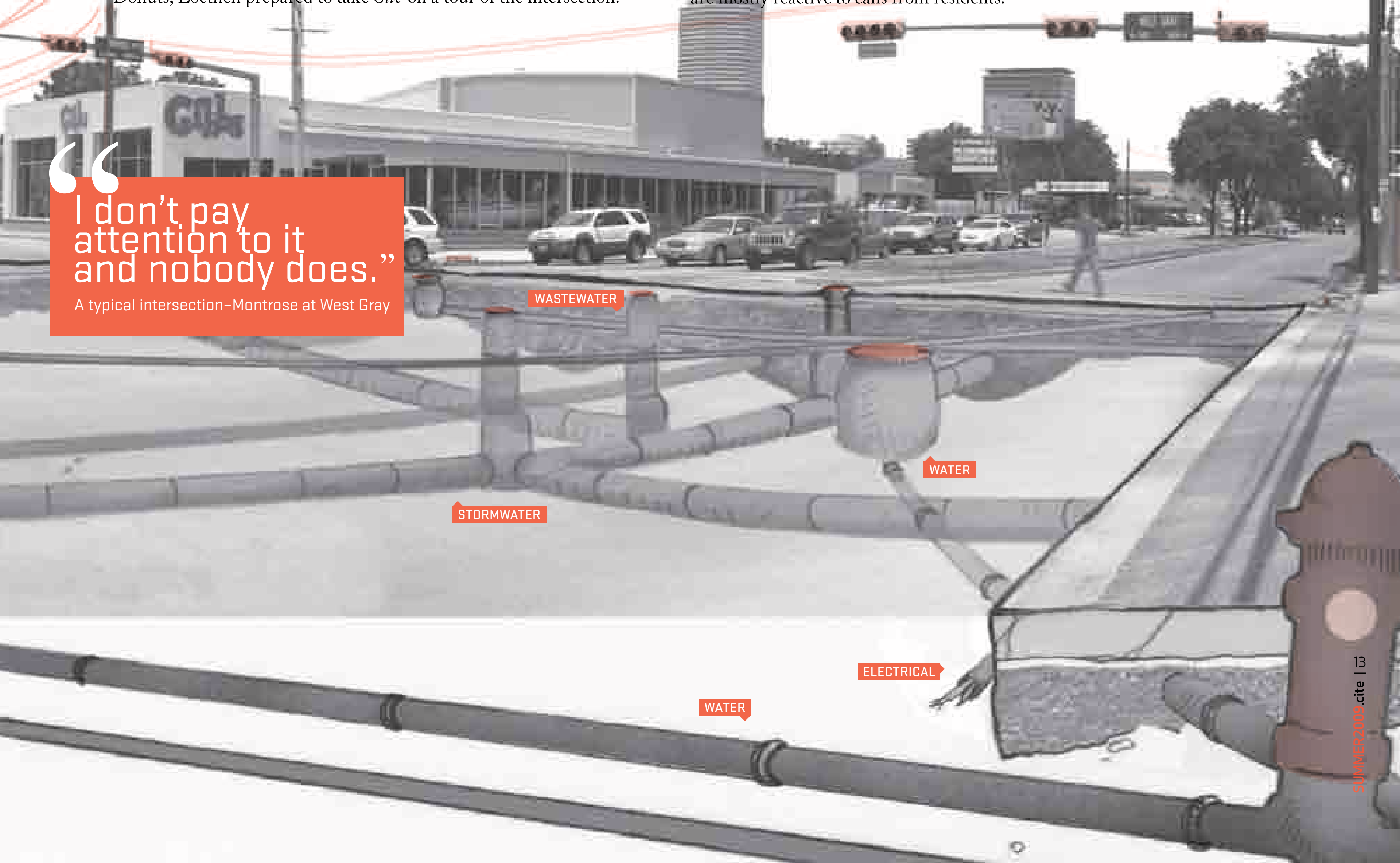
The Houston fire department crews need to know the size of the waterline they are attaching to, Loethen said, or they run the risk of sucking water lines dry.

Water lines, which are typically about six feet under ground, are as big as 66 inches in diameter and, at times, even larger.

"Our water production plants are on the east side of town because that's where the water is," he said. "But to get it all to the west side we send it through large pipes. Over on the east side we even have an 84-inch pipe." The amount of water that a pipe can move is a function of size and the operating pressure or speed with which the water is driven through the pipe. The faster water is pushed through, the greater the amount of water. But increased pressure also means more wear-and-tear, he said. "I lose pressure over time because of friction," Loethen said.

He pointed to a worn metal disc about half the size of a Frisbee on the ground. "You see this little thing right here," he said. "That means we have a water valve underneath there. By law, nobody is allowed to touch those except the city."

Valves are placed in key locations, he said, to allow repair crews to isolate city blocks and avoid shutting off water to whole neighborhoods. "We put these things in all major intersections." According to city officials, there are anywhere from 30 to 45 water main breaks a day. There are programs to rehabilitate a certain small percentage of the city's water lines annually, but with a system as large as Houston's, city crews are mostly reactive to calls from residents.



"I don't pay attention to it and nobody does."

A typical intersection–Montrose at West Gray

Gastrointestinal Loethan points to an open slot alongside the curb. “That’s a stormwater inlet,” he said.

If any part of the city infrastructure catches the public’s attention in Houston, it is the storm sewer system. With the heavy rainfall in the city, backed-up storm drains are a common complaint.

“We design our storm sewer system for a two-year storm event,” Loethen said using the statistical jargon meaning that there is a 50-50 chance during any year that the drain pipes in the ground will be exceeded.

The stormwater runs off into the bayous. Looking at the corner of West Gray and Montrose, Loethen said, “if I have to guess, the closest bayou is Buffalo.”

Inlets getting blocked after a storm are “one of the biggest problems we face,” Loethen said. “We have people that blow their grass clipping into the street, it ends up in the storm sewer and the pipe that connects these are probably 18 to 20 inches to start with.”

Loethen said that the city can run cameras through the drain to try and pinpoint problems. But, he said, the size of the city does not allow for a regularly scheduled cleaning program. “We have about 6,000 miles of storm sewer system,” he said. “To inspect that on an annual basis would take a lot of effort, even on a biannual or triennial basis.”

Houston differs from some East Coast cities in having separate waste and stormwater systems, Loethen said. Cities like Chicago and Boston have combined sewers, “meaning that all the water that goes into the storm inlets gets mixed with potty water.”

“Having them separate is a good thing,” he continued. “It allows for both waters to be treated differently. He said that rainwater has distinct pollution issues that range from the errant plastic bag to the oil and grease of automobiles to the dirt and sediment from construction sites.

IF any part of the city infrastructure catches the public’s attention in Houston, it is the storm sewer system. With the heavy rainfall in the city, backed up storm drains are a common complaint.

Nervous Continuing the tour, Loethen moved farther above ground and pointed out the extensive wiring that corresponded to the traffic signals. He gestured toward a metal-gray, locker-type box on one of the intersection’s corners. “The cabinet that you see over there is basically a minicomputer, a controller cabinet,” Loethen said.

Some street corners have timed signals, changing the color of the traffic lights after a preordained period. Other signals are activated, reactive to the traffic, Loethen said. “Standard signals go between green, yellow and red at standard time intervals,” Loethen said. “Activated signals are triggered in one of two ways; wires in the pavement and video cameras that detect the flow of traffic.” The traffic light at Montrose and West Gray also has a black, soda-can shaped cylinder nearing the hanging signal. Loethen called this device an Opticon, which detects an infrared pulse coming from emergency vehicles, like police cars and fire department trucks, and changes the traffic signal accordingly.

Loethen ran through notable items of above-ground infrastructure with a rapid-fire delivery. “Sidewalk, pavement, bus shelters, power poles, trees, street signs, street lights and traffic signals,” he rattled off. “There is stuff hanging off the poles,” he continued, “communication, cable TV, high voltage cans.” Streetlights are triggered by solar cells.

“The enemies of infrastructure are the relentlessness of mother nature and the carelessness of man,” Loethen said. The location has seen its share of wind, rain, and heat, as well as car collisions with hydrants and power poles.

Several utilities that the city does not own run underground. Loethen calls them “dry utilities” and these include gas lines, cable television, telephone, and other telecommunications. Electricity, also outside city authority, sometimes runs underground.

Sick City? There is a great deal of popular attention paid to the ethereal qualities of a city, the intangible qualities that make a city *feel* like itself and gives a city its character. More city residents would likely pay attention to a proposed noise ordinance or smoking ban over the placement of a new water line or traffic signal. But this amounts to Cartesian dualism on an urban scale, with residents guarding a city’s soul while neglecting its blood and body.

“Infrastructure creates the quality of life that you enjoy every day,” said Edwin C. Friedrichs, the president of the infrastructure division of Walter P Moore, an engineering consulting firm. And when it comes to infrastructure, Friedrichs said, there is no such thing as benign neglect. “You are going to pay one way or another.”

City of Houston officials, he said, are not giving infrastructure – waste water lines, storm outlets, traffic signs -- the time or money it needs to keep up with growth. “We’re so big, we’re growing so fast and we’re not putting enough money in to infrastructure,” he said. “If you are looking at Houston, its infrastructure is almost all post WWII.” Which means, Friedrichs noted, that much of its water lines are living on borrowed time.

“I’m not saying the public works department is doing a bad job,” Friedrichs said. “They just don’t have enough money.”

In particular, Friedrichs sees the limitations of the storm sewer system as a shortcoming. “We have some of the most intense rainfall, high intensity rainfall… in the world,” he said, adding that design for two-year events “is just not practical.”

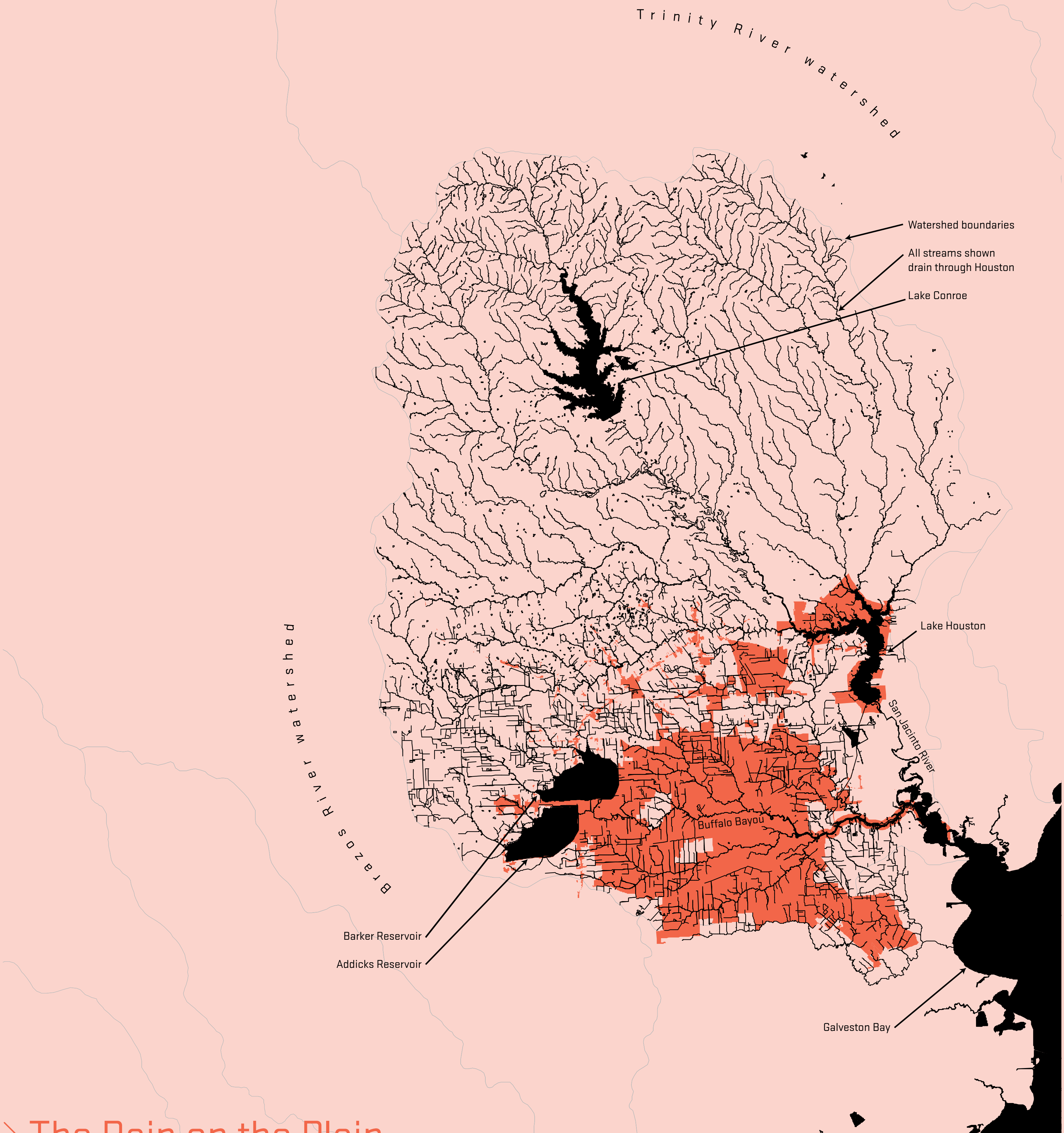
Nicole Herzog has been a manager at the Bobbitt Glass Company for 11 years and sits at a desk with a view out into the intersection. Unlike Brocato across the street at the boat dealership, Herzog has paid close attention to the infrastructure there and has a less glowing assessment. A transformer periodically sparks across the street from the Glass Company and a leaking water pipe behind the store caused headaches for weeks before the city made repairs.

Her most heated complaints concern flooding. “When it rains here, the flooding is just, wow,” Herzog said. “The water from the street reaches the door.”

Alvin Wright, a spokesman for the city’s public works department and senior staff analyst, said that with resources tight, spending has to prioritize for more immediate needs. “If you spend so much money to build a storm system to withstand a weather event that doesn’t happen for another 50 years, is that money well spent?” he asked. That is the kind of question Friedrichs wishes would be put to voters along with a greater effort to educate the average resident on the importance of infrastructure.

Like most residents of major American cities, Houstonians take their city’s infrastructure for granted until there is a problem. “We are seeing flood damage to buildings and cars, causing insurances rates to go higher,” Friedrichs said. “How many times do you drive in Houston and go down streets that are bumpy or riddled with potholes. Mobility is impaired and pollution goes up.” He said that the limitation of infrastructure could stand in the way of the projected population explosion that experts have said awaits Houston in the decades to come.

“Infrastructure is a basic requirement of economic growth,” Friedrichs said. Without improvements, he warned, “people will just stop coming here.”



GIS DATA FROM CITY OF HOUSTON (CITY LIMITS), TEXAS COMMISSION ON ENVIRONMENTAL QUALITY (STREAMS AND WATERSHEDS), HARRIS COUNTY FLOOD CONTROL DISTRICT (WATER CHANNELS), BUREAU OF TRANSPORTATION STATISTICS NATIONAL TRANSPORTATION ATLAS DATABASE (WATER BODIES), AND TEXAS WATER DEVELOPMENT BOARD (WATER BODIES.)

→ The Rain on the Plain

by CHRISTOF SPIELER

Houston's rainfall patterns are natural. But what happens to the rain when it hits the ground is anything but. In its natural state, the coastal prairie flooded readily, holding water in vegetation and the undulations of the ground and releasing it slowly into lazy bayous.

The bayous have largely been straightened and concrete lined; some have been buried in culverts. The land itself has changed even more dramatically: pavement and roofs shed water quickly, and storm drains hurry it onwards. Water now reaches the bayous more quickly, compressing the water from a single rainstorm into a shorter period and thus raising water levels. Braes Bayou, designed to carry a 100-year flood when West Houston was still farmland, could carry only a 10-year flood when Tropical Storm Allison hit. It's now being widened.

To reduce the load on the bayous, current policy puts emphasis on detention ponds, which hold water and release it slowly just as the prairie once did. Addicks and Barker reservoirs, in the upper reach of Buffalo Bayou, serve the same function.

Most of Houston is drained by the tributaries of Buffalo Bayou, including Sims Bayou, Braes Bayou, White Oak Bayou, and Greens Bayou. The area north of Beltway 8, though, is drained by the San Jacinto River, whose watershed extends as far as Huntsville and Cleveland. Thus, Houston sees not only its own stormwater but that of its upstream neighbors.

Standing on Fishes

A HISTORY OF SUPPLYING WATER TO HOUSTON

What is perhaps most striking about the Wallisville Lake Project is that there is no lake. The dam is modest in size and generally unimpressive. The pumps on the Trinity River that supply Houston lie upstream and Lake Livingston, further upstream, serves as a massive reservoir. The gates of the dam are kept up, allowing bay water to enter the marshes when the force of the incoming tide outmatches the river flow, unless the salinity at the water pumps gets too high.

by **Martin V. Melosi**

The tranquility of the site belies the legal war fought over the area from 1963 to 1987—a war involving Congress, the U.S. Army Corps of Engineers, and the Sierra Club. A few quotes from papers of the time give a sense of the debate. In *Houston Post* articles from 1986 and 1987, opponents of the Wallisville Dam called the project "a fraud," "a monumental rip-off," "an economic blunder," and "a slowly growing cancer," citing the environmental risks.

Even in the seemingly water-rich Houston region, which sits atop massive aquifers and is straddled by the Neches, Colorado, Brazos, San Marcos, Trinity, and Sabine rivers, a water war raged as if Houston were in drought-prone West Texas. Understanding why this happened—and how we have reached a point where the decision to build a sewer pipe or a freeway ramp outside Katy affects the lives of herons and shrimpers 75 miles away in Anahuac—calls for a deeper history of Houston's water supply.

WATER SUPPLY BEFORE 1945: THE ERA OF ARTESIAN WELLS

During its frontier days, Houston depended upon underground brick cisterns, overhead cypress tanks, and private wells for both drinking water and fire protection. Initially water from the bayous was considered good for drinking. Bud A. Randolph, in his 1927 work "The History of Houston's Water Supply," tells of bucket brigades tapping cisterns and shallow wells when fires broke out.

Houston developed its first public water supply system in 1876. It was unique in that the city relied exclusively on groundwater from countless wells until the 1940s. Water was drawn from the Chicot and Evangeline aquifers, running southeast to northwest from the Gulf Coast through Harris County's western half and into Montgomery and Grimes Counties.

In 1884 local business interests, headed by former mayor and wealthy property holder Thomas H. Scanlan, purchased the Houston Water Works Company, and in 1888 the company drilled its first artesian well. No one had known that Houston sat atop one of the largest artesian reservoirs in the United States. This new source of clean water was heralded as the solution to Houston's long-term water needs.

But the company soon discovered that a supposedly bottomless pool of pure water did not solve all of the problems of operating a water system. Bayou water frequently had to be pumped into the city reservoir to meet increased demand when fires broke out, making the water unfit to drink for days afterward. Legal action against this practice led in 1904 to the U.S. Supreme Court's ruling that the company cease pumping bayou water into the mains, and artesian wells became the sole source for the Houston distribution system.

As the population grew, so did complaints about water quality, poor fire protection, and inadequate extension of distribution mains. In a 1905 annual report, Mayor Hugh Baldwin Rice concluded that while he had been doubtful of public ownership of utilities, "when it comes to the question of water, the very life and essence of a community, it would be far better for the City of Houston to own and operate its own water system." Municipal ownership improved service and efficiency, but the long-term viability of

COURTESY HOUSTON DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

LEFT: The onset of World War II pushed Houston towards a regional system supplied by surface water.
RIGHT: A cormorant suns itself near the Wallisville Dam.
RIGHT BELOW: Gap around the pad of an old Baytown well demonstrates original height of the ground before subsidence.

a water system based solely on artesian wells was ignored. Even the new industry along the Ship Channel drew from the aquifer.

AFTER WORLD WAR II: DAMMING THE RIVERS

After World War II, the city could no longer fool itself into thinking artesian wells alone would suffice as a water supply, but city leaders—because of either political expediency or their inability to see the incredible population explosion just ahead—moved too slowly.

Through the 1930s, Houston had been the largest city in North America to rely exclusively on wells for its water. With increased industrial pumping along the Ship Channel for cooling and other purposes, the static level (the depth at which pumps could retrieve water) of the wells worsened, leading many industries and owners of commercial buildings to compound the problem by bypassing the city and drilling more of their own wells. Taking water from the ground also led to a series of unintended consequences, chiefly subsidence. The ground sinks as surrounding clay deep underground collapses and compacts, breaking pipes, clogging sewers, encouraging saltwater encroachment, and increasing potential flooding. By 1978, subsidence of up to ten feet had been measured along the Ship Channel.

The onset of World War II finally pushed Houston to initiate projects creating a surface supply. In July 1942, the War Production Board authorized the San Jacinto River Conservation and Reclamation District to build a reservoir. Construction of Sheldon Reservoir (located on a tributary of Buffalo Bayou) began in December 1942 to assure the delivery of water to industries at Baytown and in the Pasadena area.

It was in the postwar era, however, that aggressive annexations and unrelenting sprawl tested the integrity and functionality of Houston's water supply system. Pipes connecting an annexed area to the Houston system often led to a leapfrog pattern of suburban development. As a result, water services ended up connected to a variety of watersheds as well as to Galveston Bay. A Spring Branch dishwasher became interlinked with a Trinity Bay estuary. One woman's shower was interconnected with a distant bird's nesting ground. The water for one man's watered lawn was the stuff of some shrimper's living.

The development of the San Jacinto River in 1942 to supply water for defense industries along the Ship Channel joined with the existing groundwater supply to produce a dual water system for urban, industrial, and agricultural users in the Houston metropolitan area. Completed in 1954, Lake Houston—which replaced Sheldon Lake as the city's prime source of surface water—provided water for both the City of Houston and the industrial complex stretching from Houston to Baytown, and it also supported local irrigation for various agricultural products, including rice. By 1970, treated surface water met about 40 percent of the demand of the municipal system. Other sources on the Trinity, Brazos, Colorado, and Neches Rivers continued to be explored.

The San Jacinto projects and other shifts to surface water produced a different set of contentious environmental issues—bringing our story back to the Wallisville Dam. Authorized by Congress in 1962, construction began in 1966 at the mouth of the Trinity River located approximately 40 miles east of Houston. Visualized as a multipurpose project, proponents claimed that it would increase the industrial water supply for Houston, control saltwater intrusion into the river, improve navigation, and enhance the habitat for fish and wildlife. But as Frank Fuller wrote in a 1995 study, "Stripped of its bells and whistles… Wallisville is at its core a water supply project."

Litigation prompted by environmental concerns, including the discovery of nesting bald eagles, halted construction and delayed the project for many years. Opponents argued it would reduce shrimp harvests by 65 percent, and damage or destroy saltwater ecosystems. After a revision of the plan and a court decision in favor of the government, the project was completed in 1999 in its current form—a set of levees, a small dam across the Trinity, a navigation lock and engineered navigation channel, a gated control structure, administrative buildings, and recreation areas.

The design compromise at Wallisville appears well conceived. To an untrained eye, the surrounding wetlands seem pristine. But the roseate spoonbills and herons (and the bird watchers who follow them), the wild grasses, and the alligators screen a still simmering controversy. While a shift to surface water had been inevitable for Houston in the wake of its breathtaking growth, in the case of Wallisville a public battle was waged that produced, at best, a temporary solution to the city's water needs, and comes at a price that some people are not willing to pay.

How many more times will controversies over surface water projects materialize as Houston continues to grow? The panacea of surface water did not magically solve the problems of subsidence and groundwater depletion, but instead shifted the challenge of meeting water demand from below the ground to above, and from a local concern to a regional issue. Linking water supply to urban growth has resulted in a series of unintended consequences—the drying up of the supposed never-ending supply of groundwater, subsidence, threats to water quality, and chronic jurisdictional battles—that make the provisions for a safe and bountiful water supply a major challenge for Houston.

[By 1978, **subsidence** of up to ten feet had been measured along the Ship Channel.

WALLISVILLE DAM: RAJ MANKAD; WELL: COURTESY HARRIS-GALVESTON SUBSIDENCE DISTRICT

GIS DATA FROM CITY OF HOUSTON (CITY LIMITS), TEXAS DEPARTMENT OF TRANSPORTATION (STREAMS AND WATERSHEDS), BUREAU OF TRANSPORTATION STATISTICS NATIONAL TRANSPORTATION ATLAS DATABASE (WATER BODIES), AND TEXAS WATER DEVELOPMENT BOARD (WATER BODIES.)

→ Downstream from Dallas

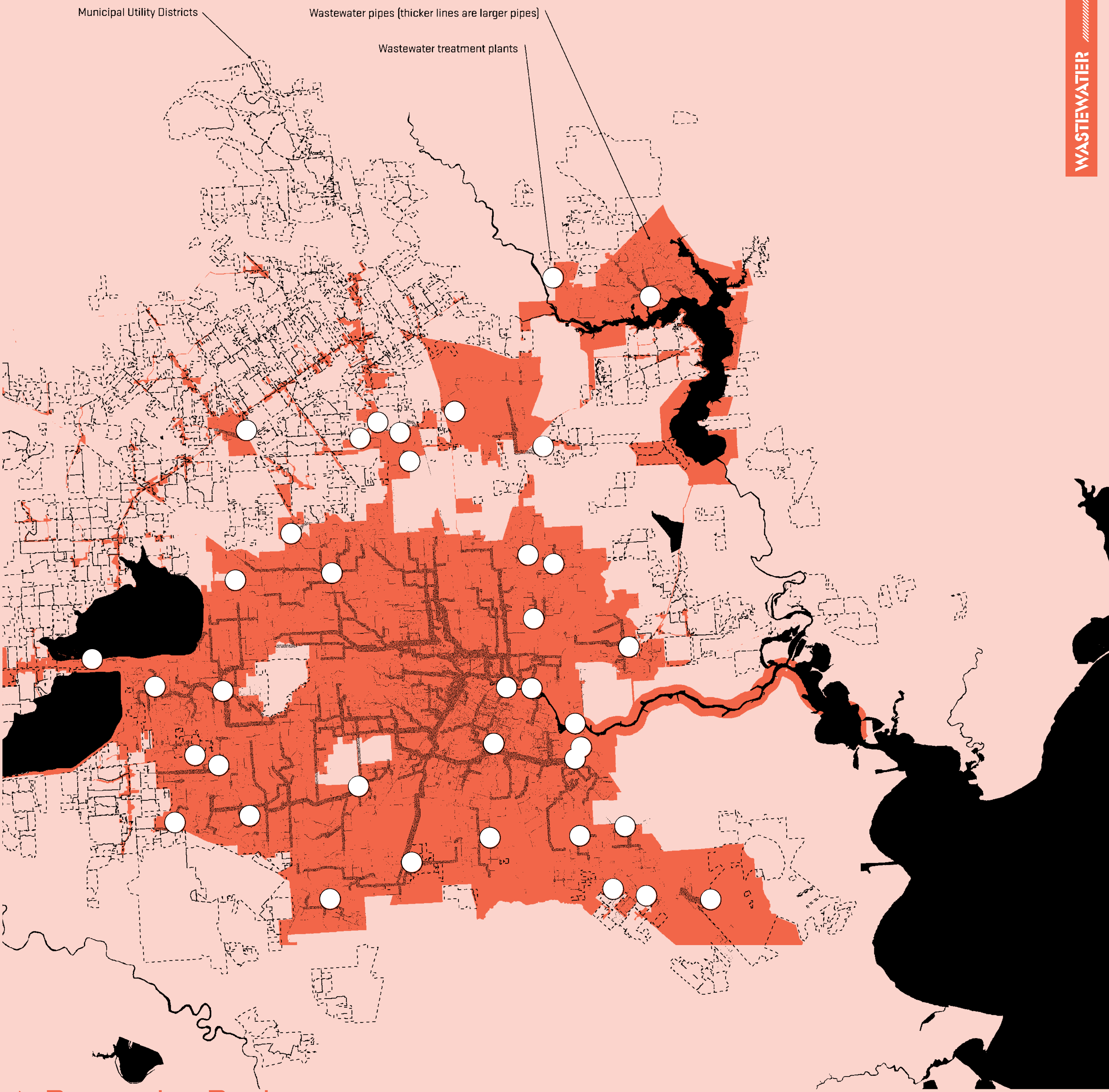
by CHRISTOF SPIELER

El Paso gets only 9 inches of rain a year, Austin gets 32, but Houston gets 50. That rain fills rivers and refills underground aquifers; Houston gets its water from both.

The surface water comes from the San Jacinto River and the Trinity River. Because rainfall is uneven, reservoirs store that water. On the San Jacinto, the city directly pumps from Lake Houston and uses Lake Conroe, upstream, to store more water. On the Trinity, the water is pumped directly from the river near Crosby; Lake Livingston further upstream stores water. Since these watersheds include agricultural land and cities like Conroe and Dallas, the water needs to be filtered in one of three purification plants which then pump water through a 7,000 mile network of pressurized pipes, some 8 feet in diameter.

Groundwater is filtered by layers of sand and rock. But it comes with a catch. Enough water (and oil) was pumped from under Houston from the 1880s through the 1970s to literally drop the ground beneath our feet. That led the legislature to form the Harris Galveston Subsidence District, which has required the city to reduce groundwater use to 20 percent of its supply by 2030; today, groundwater is 29 percent of the city's supply, from 92 wells scattered through the city.

Houston is using 392 million gallons a day of surface water but owns rights to 1.2 billion gallons, including a future reservoir on the Brazos River.



GIS DATA FROM CITY OF HOUSTON (WASTEWATER LINES, CITY LIMITS), TEXAS COMMISSION ON ENVIRONMENTAL QUALITY (TREATMENT PLANTS), BUREAU OF TRANSPORTATION STATISTICS NATIONAL TRANSPORTATION ATLAS DATABASE (WATER BODIES), AND TEXAS WATER DEVELOPMENT BOARD (WATER BODIES.)

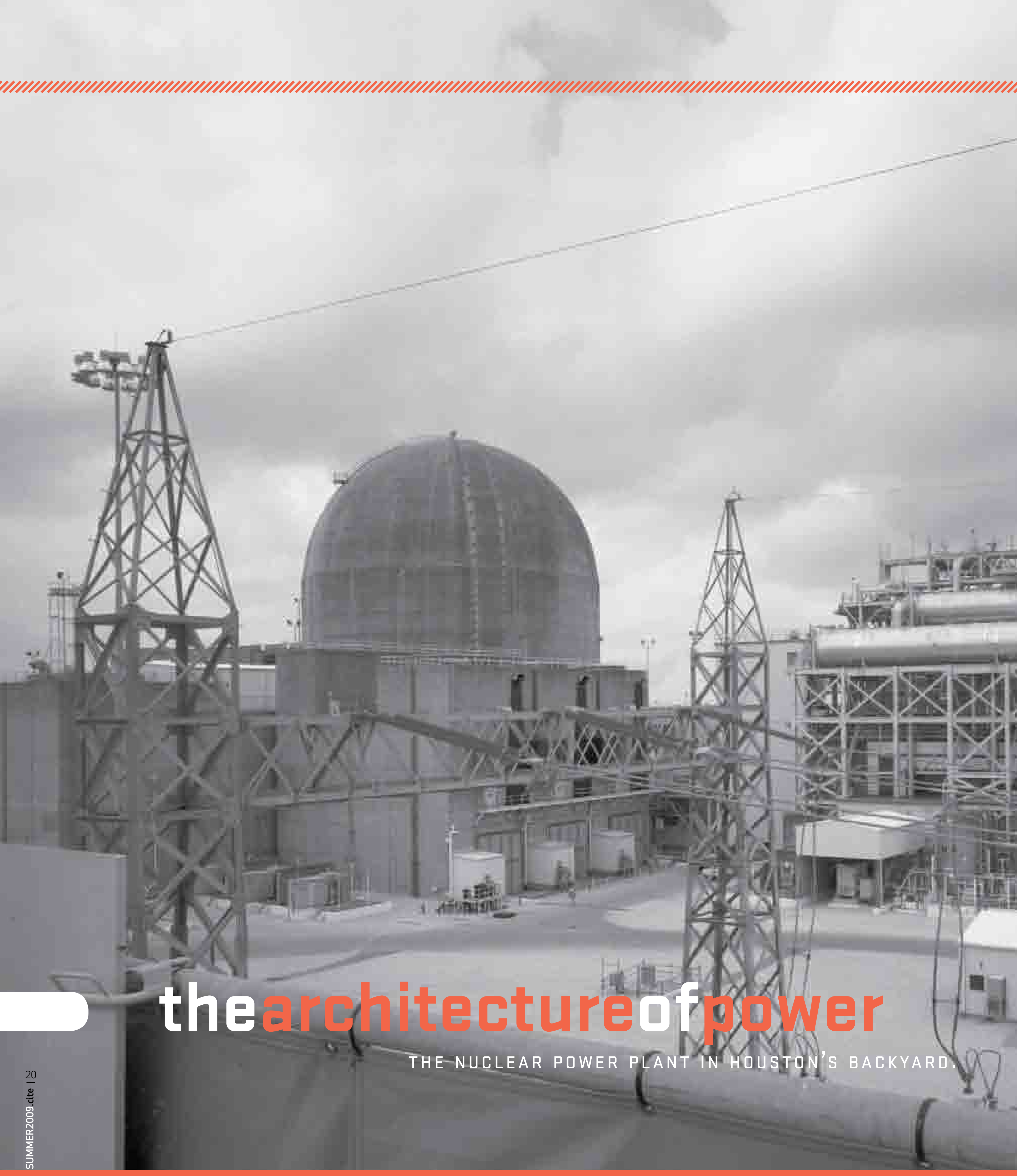
→ Down the Drain

by CHRISTOF SPIELER

Much of the water that goes into a house goes back out the drain. The water supply system is duplicated in reverse to bring wastewater back to treatment plants. Houston has 40 plants, treating 277 million gallons a day and discharging the water into the bayous.

Sewage treatment plants are a well-established technology; by the time the water has made it through primary, secondary, and tertiary treatment, it's often cleaner than the rest of the bayou water. The real challenge in Houston is getting sewage to the plants. Most cities rely entirely on gravity to move sewage; Houston is too flat for that. Instead, neighborhood pipes sloping at 14 feet a mile carry sewage to 420 lift stations, where pumps feed the sewage into pressurized pipes called force mains. Many of the force mains, which can be 50 feet underground, were tunneled in a $1.2 billion program in the 1990s designed to eliminate places where sewage overflowed directly into bayous (see "The Houston Underground," *Cite* 49).

On the edges of the city, sewage (and water supply) is handled by numerous small municipal utility districts. Most have their own small sewage treatment plants. This infrastructure, built by developers when the neighborhoods were new, is now wearing out. Replacing it will be one of the biggest infrastructure challenges of the near future.



thearchitectureofpower

THE NUCLEAR POWER PLANT IN HOUSTON'S BACKYARD.

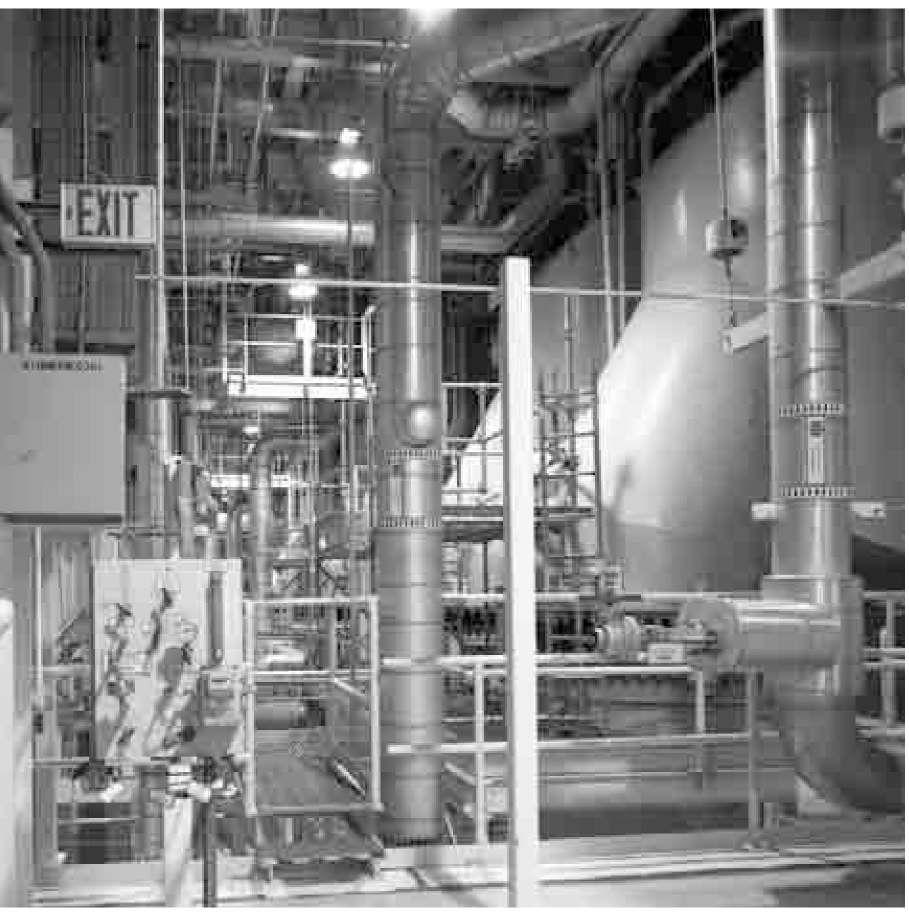
View of Unit 2 from roof of Unit 1.

by Thomas Colbert

Photography Shannon Stoney

WHEN you turn on an overhead light in the living room or a toaster in the kitchen, you probably don't think about where the electricity comes from. Few people do. But behind that flip of a switch lies a vast industry and one of the most impressive infrastructure systems in the world. Yet the artifacts of this system are almost invisible. Electric wiring is buried inside the walls of buildings. The spiderweb of overhead distribution lines connecting buildings to local substations is hidden in alleys and screened behind trees.

The substations themselves, where transmission lines connect to the much larger and much higher-voltage distribution lines, are simply overlooked, as are the towering high-voltage transmission lines. The power plants that dot the countryside around our cities are perhaps the most expensive buildings ever built, but passing motorists seldom notice them on the skyline, framed in the windshield, as the car speeds down the highway.



TOP: **Machinery and guardhouse on the roof of Unit 1, Turbine Building.**
ABOVE: **Inside the Turbine Building.**

THE GRID Electric power plants are huge and foreboding places. Seen in the distance, they sometimes resemble the medieval fortifications of Europe, like Mont Saint Michel perhaps, or ships on the horizon (but on a much larger scale). They billow plumes of smoke and steam, and cast arrays of wires in all directions, wires that step down in voltage and in height as they make their way to the electric meters on our homes. These wires and the armada of electric generating plants that feed them are known as "the grid."

The grid is enormous. It covers North America, linking thousands of power generation plants, bringing electricity to every home, office, factory, and streetlight. It begins at the power plant and ends at the electric meter. Generation plants today are located in remote areas for the most part, well away from population centers and freeways. But in the past, electric generation plants were proudly displayed in our cities. Like the great train stations of the nineteenth century, they were faced in brick and stone, and given architectural facades. The Battersea Power Station in London is the most famous example of such a building. In Houston, the ruins of such places still exist. The McKee Street Power Plant near downtown is one example. Power plants in rural areas also used to be points of civic and even national pride. After the engineering was complete, even the Hoover Dam received an Art Deco appliqué from Gordon B. Kaufmann, so that its style would be fitting for such an important public building and tourist destination. Things are different today. The architecture of power plants now assumes an unremittingly pragmatic, industrial style.

Most electric plants in Texas are powered by coal and natural gas. Only two are powered by nuclear energy. No matter what the fuel source, all electric plants are much the same, except in the way they create the steam that turns their turbines. The most remote and mysterious of the power plants that surround Houston is the South Texas Project. Located a little over 90 miles southwest of Houston near Matagorda Bay, the South Texas Project is a nuclear power plant. Driving there, one passes fields of oil drilling pipe and oversized outsider-art sculptures of cowboys, rockets, and airplanes. These are followed by scattered suburban neighborhoods, many built within the past decade and some still under construction. Once you turn off of State Highway 288, the landscape quickly becomes more rural. Overgrown pastures alternate with bands of aging farmhouses and trailer home sites with abandoned cars, machinery, and children's plastic pools strewn under groves of trees. This is a region where vultures don't look up from their meal as cars pass by.

A few miles beyond the tiny town of Wadsworth, Texas, the roadway suddenly opens up, briefly revealing the twin domes of the South Texas Project. After that, the plant remains largely hidden until you reach its gate.

THE SITE The entrance to the South Texas Project could be the entrance to almost any corporate office park. Two low, curving masonry walls and an oversized American flag flank the entrance road. They frame a panoramic view of the half mile of flat, treeless lawn that separates the outer security fence of the plant from the more heavily fortified inner perimeter. The only buildings between the two fences are a small training facility near the entrance, a guardhouse where you present your papers, and a nondescript five-floor office building close to the plant itself; this is where the permanent records of plant operations are kept and where the administration of this 12,000-acre, 1,200-employee facility is housed. The guardhouse, however, isn't like the guardhouses at corporate office parks. It is heavily protected by bollards, vehicle barriers, and bulletproof construction. The small window through which papers are passed, like identical openings on the

other four sides of the small building, was designed to also serve as a gun port.

The horizontality of the site is unexpected. The iconic, high-waisted cooling towers normally associated with a nuclear plant weren't used here. Instead, a 7,000-acre cooling reservoir (and alligator habitat) occupies the southern half of the site. Centered on the north shore of this reservoir, the two reactor units and their ancillary buildings are protected within the inner security barrier. Just outside of that security perimeter to the north is the switchyard that connects the South Texas Project site to the rest of the grid. From here, rows of towering transmission lines cut a swath several hundred yards wide through the countryside, eventually forking toward Houston, Austin, and San Antonio. These wires carry such high-voltage electricity (345,000 volts) that you can hear the hissing and crackling sound created by the electrons passing over the insulators from which they are hung hundreds of yards away. Near the switchyard (also just outside of the inner security perimeter) are a large pump house and a heavily engineered pond with specially treated water ready to instantly flood the containment building in the event of an accident.

The inner security perimeter is composed of two razor wire-topped chain link fences with a broad bed of coarse gray gravel between them. Dozens upon dozens of motion detectors, television cameras, and darkened glass guardhouses monitor every inch of this no-man's-land and the space on either side of it.

To enter the high security zone where the nuclear reactors are, one parks and walks between massive concrete vehicle barriers, through the chain link fences and their gatehouse, and into the narrow lobby of the big, metal pre-engineered Maintenance Operations Building. This is where identification is rechecked, and metal and explosives detectors are put to use, as are heavily guarded revolving security gates. Going through this gauntlet of security, you can anticipate but are never really prepared for the experience of leaving the building on its other side. Like Alice at the other end of the rabbit hole, everything is suddenly at the wrong scale. Workers in hard hats seem tiny at the foot of the looming concrete mass of the reactor buildings on one side and the equally large but intriguingly tectonic Turbine Building on the other. Taken together, these comprise one of the South Texas Project's two power generation "units." The reactor buildings have no expansion or control joints, no formwork markings, no fenestration, and no visible doors. There is nothing to give them scale. They rise 200 feet into the air and press 50 feet into the ground on top of an 18-foot thick foundation slab. After entering the Turbine Building through an innocuous double door, you suddenly find yourself in a machine world.

TURBINE BUILDING The Turbine Building is where steam created in the reactor buildings next door is sent

TOP: **Machinery on the roof of Unit 1 Turbine Building. Electrical generator on the right. Dome of Containment building beyond.**
ABOVE: **View of cooling reservoir on the left, pipes circulating cold water to the Containment Building Center. Containment Building on the right.**

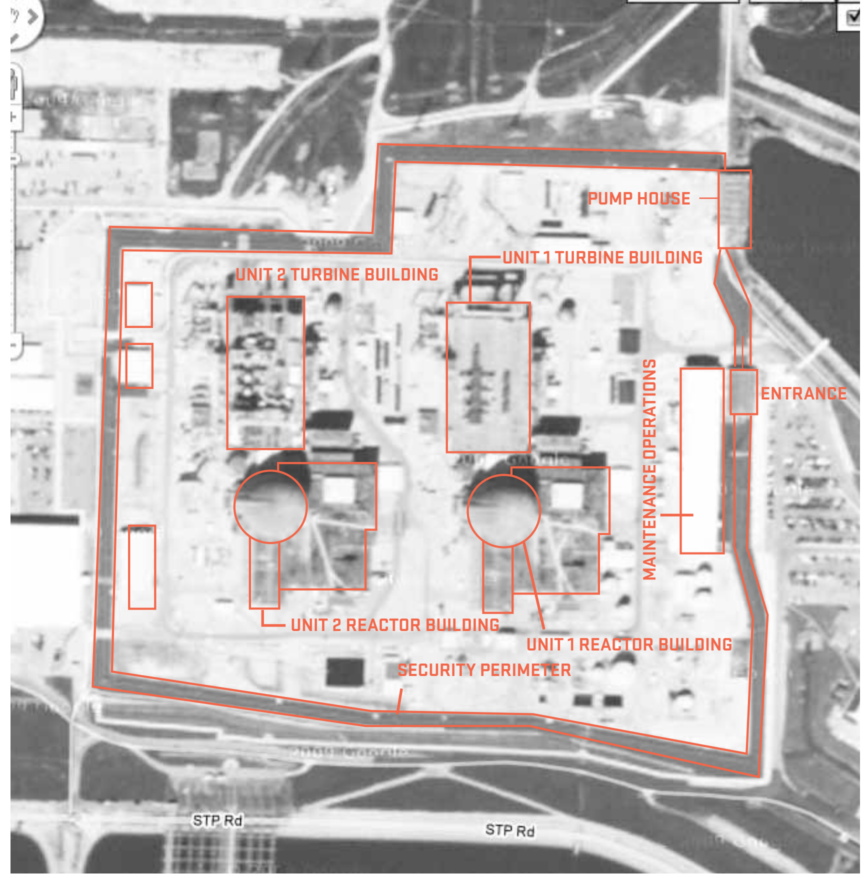
to turbines that drive a generator to produce electricity. The Turbine Building is an enclosed, three-dimensional labyrinth of wires, pipes, pressure gauges, and structure. Floors and walls throb with the pulse of the steam generators and the mammoth heat exchangers and condensers. Multiple pipes, 12 to 15 feet in diameter, bring cool water from the reservoir to the condensing unit and back. Smaller (but still very large) pipes carry steam to the turbines that share the building's rooftop with the generator. Tens of thousands of circuits of control, power, backup power, and sensor wiring, as well as pipes of every conceivable size, cascade through space with no predictable order and no apparent end. Being here is like being inside a huge beast with no flesh to hide its color-coded veins and nervous system. It is a profoundly noisy beast to be inside. Even muffled by ear protection, the roar can be felt through your bones. This is a place where industrial lighting, gusts of hot air driven by strangely located fans, and the noise of pumps and turbines create an almost overwhelmingly intense sensory experience. It is with relief that you exit onto the roof.

Unless a 20-year extension is granted, the buildings will be demolished and the rubble hauled off to nuclear waste sites.

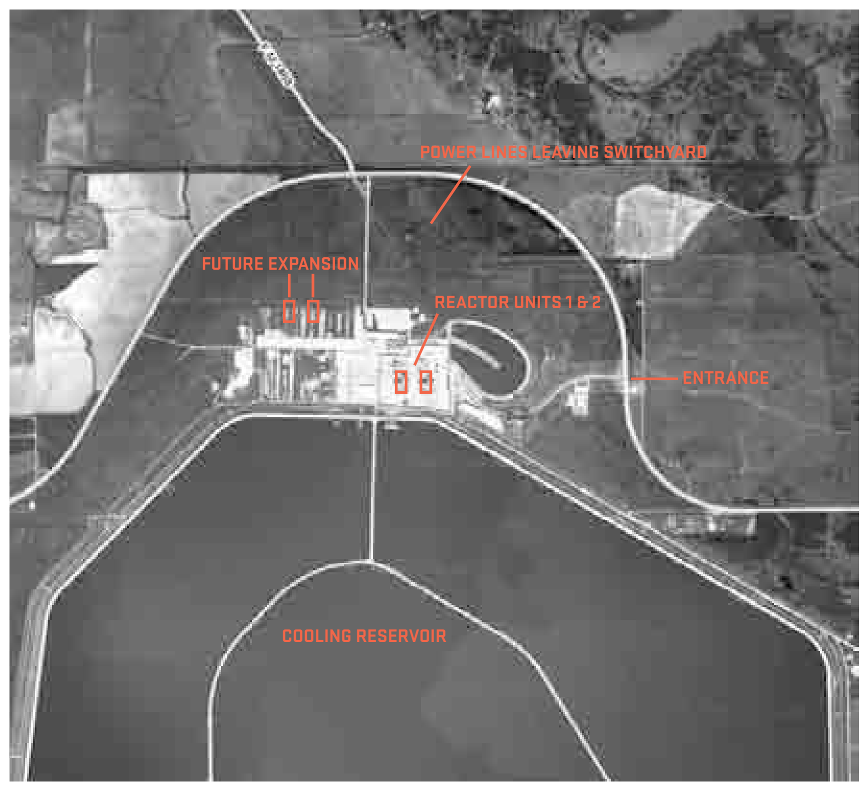
The rooftop is flat and open. The horizon is visible in all directions, except where the domes of the two reactor buildings block it. Near the center of the roof, the bright blue steam turbines and the generator line up along a common axis. These pieces of equipment are surprisingly small. The rotor of the generator, the heart of the entire plant, is only 5.5 feet wide and 48 feet long. Spinning at 1,800 revolutions per minute, it generates enough electricity to power 600,000 homes in the middle of the summer or twice that many in winter. In a coal-fired plant, this would require 20 million tons of coal a year. Electricity leaves the generator at 25,000 volts.

A permanently installed gantry crane dominates the roof. It is there to allow inspectors to open up the turbines and generator every 18 months while the fuel rods are being changed out in the reactor building. The crane and the brightly

Unit 1 Control Room.



RIGHT: **Detailed aerial view of the plant.** BELOW: **Aerial views of the South Texas Nuclear Plant showing cooling reservoir and surrounding area.**



COURTESY GOOGLE EARTH

colored turbines and generator give the building a playful, almost Archigram-like appearance, but without the aesthetic pretension or any sense of showmanship.

REACTOR BUILDINGS The reinforced concrete structure containing the reactor is divided into three separate areas. The Containment, Fuel Storage, and Mechanical Auxiliary buildings, as these sections of the building are called, are separated from one another by extraordinarily thick concrete walls and massive steel doors. You enter via an underground tunnel that passes through the complex's five-foot thick exterior wall. The interior, a rabbit warren of rooms, industrial spaces, and passageways, is strangely quiet in comparison to the Turbine Building. Its muted gray walls and color-coded beige, mint green, and baby blue floors are kept immaculately clean. At the center is the reactor itself. Together with the steam generator, the reactor occupies the dome-topped Containment Building, whose steel-lined, five-foot thick concrete walls separate it from the surrounding wings of the building. This is where the reactor heats water to 600 degrees. That water is then pumped at 2,300 pounds per square inch to the steam generator that makes the 15 million pounds of steam per hour that are needed to drive the turbines next door.

Surrounding and attached to the cylindrical, dome-topped Containment Building are the Mechanical Auxiliary and Fuel Storage buildings. These contain the spent reactor fuel, new fuel assemblies, and areas where workers control and monitor the operation of the plant. The Control Room is also here. Its analog dials and manual switches evoke a 1950s era high-tech style that seems out of place today.

The Fuel Storage Building is contained within concrete walls that vary in thickness from five to seven feet and an equally thick concrete roof slab. Almost 200 feet long and 100 feet wide, the Fuel Storage Building extends 93 feet above and 57 feet below grade. This is where new fuel assemblies arrive and are prepared for insertion into the reactor. It is also where spent fuel is kept in a 40-foot-deep stainless-steel-lined pool. This was supposed to be a temporary storage location, a place to hold nuclear material until the recently cancelled Yucca Mountain Nuclear Waste Repository became operational. Now it has apparently become a permanent storage facility. Overhead in the dimly lit, cavelike room that is the main space of the building, yet another massive crane sits silently awaiting the next fuel service cycle. A smaller crane hovers near the foot of the pool. The water within the pool is perfectly pure and clear. At first it appears to be black. Its mirror-like surface, undisturbed by even the faintest ripple, nearly masks the dark matrix of fuel assemblies far below.

PEOPLE The people who work here include administrators, industrial workers, and guards. Most of these people seem to have worked at the plant for many years. Some have been here since before the plant's opening over 20 years ago. Administrators and workers greet each other in ways that seem overly familiar or cheerful to those accustomed to other workplaces. But the guards pass by in silence, not talking to anyone. Heavily armed, they patrol on foot, wearing body armor and carrying automatic weapons. They wear sunglasses and keep watch in armored guardhouses behind darkened glass and gun ports. They have the bearing of soldiers. Plant workers, on the other hand, are older. Their color-coded uniforms—polo shirts or button-down shirts in blue and maroon, worn with khaki pants—reflect the part of the plant they are assigned to.

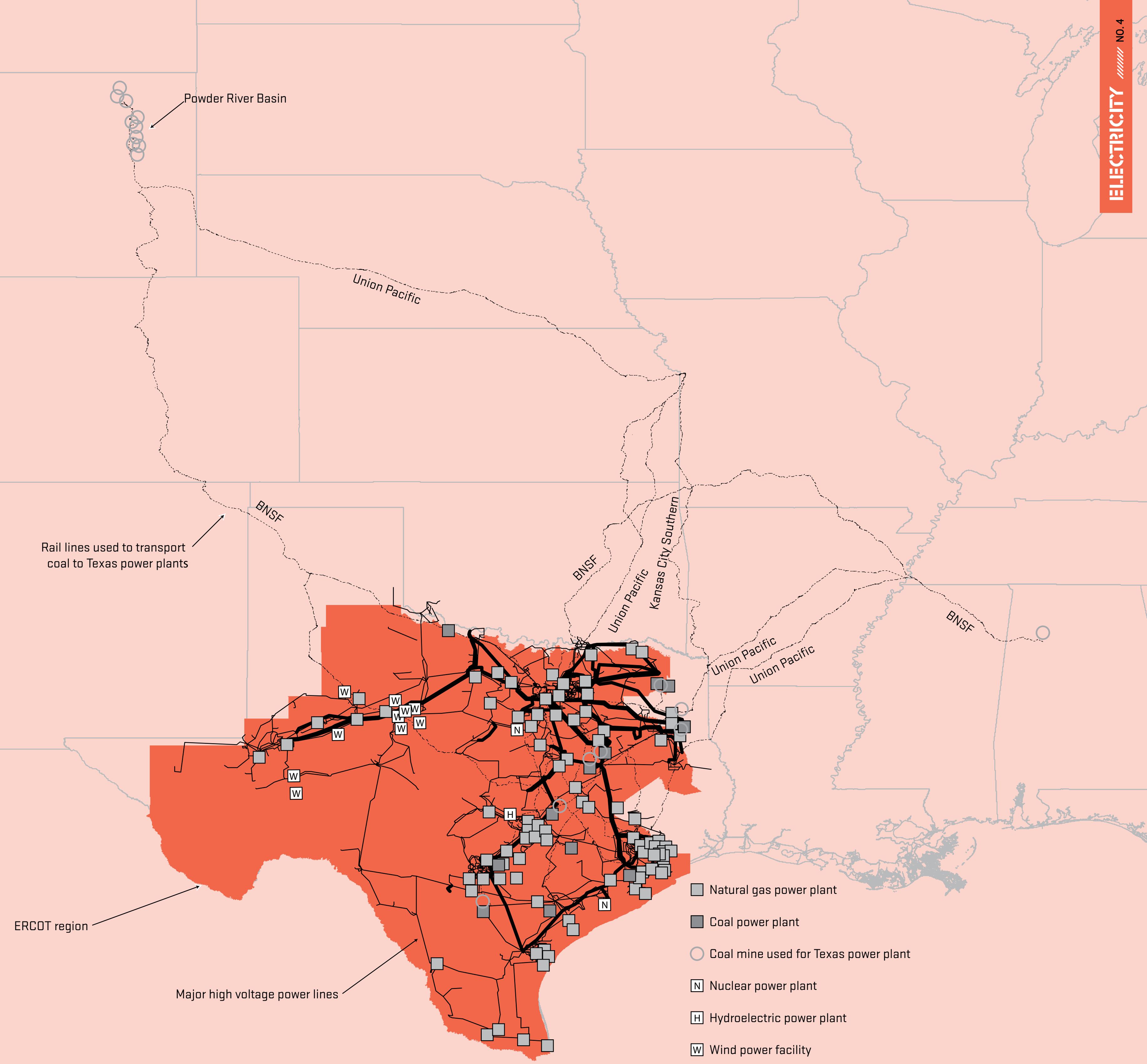
CONSTRUCTION Construction began on the South Texas Project

LEFT: **Spent fuel storage pool.**

The brooding heaviness and foreboding quality of electric generation plants come from their scale, from the frightening quality of their product

in 1975. Initially, Brown & Root was the "architect" and the builder. Six years later, when the project was four years behind schedule and far over budget, Bechtel Corporation replaced Brown & Root as architect, and Ebasco Constructors took over construction. The plant eventually came online in 1988, seven years behind schedule and costing almost $6 billion, 400-plus percent over budget. Due to technical problems, both units were shut down in 1993 for over a year. Today the South Texas Plant is over halfway through its 40-year license to operate. When that license runs out, the facility will be decommissioned. Unless a 20-year extension is granted, the buildings will be demolished and the rubble hauled off to nuclear waste sites. Even as the two existing reactors are approaching the end of their life expectancy, two new units are being planned. These advanced boiling water reactors, costing an estimated $10 billion to build, will be slightly more powerful that the existing units. They will share the cooling reservoir, as well as the transmission corridor and transmission towers, with the existing units.

The brooding heaviness and foreboding quality of electric generation plants come from their scale, from the frightening quality of their product—electricity at very high voltages—and from their obscurity. Nuclear plants carry the extra burden of their radioactive fuel, the long-term safety of which remains questionable at best. As a result, the most expensive and extraordinary buildings in history are kept hidden from the public that they serve. This fact calls into question the more romantic images of aesthetic and cultural life usually associated with architecture, reminding us of the many invisible worlds that our society builds and is dependent on. The electrical grid that powers our cities is only one of these worlds.



GIS DATA FROM BUREAU OF TRANSPORTATION STATISTICS NATIONAL TRANSPORTATION ATLAS DATABASE (STATES, RAIL LINES), CENSUS BUREAU (COUNTY LINES, USED TO MARK ERCOT BOUNDARIES), AND FEDERAL EMERGENCY MANAGEMENT ADMINISTRATION (POWER LINES). POWER PLANT LOCATIONS FROM ENERGY INFORMATION ADMINISTRATION, COAL MINES FROM FEDERAL ENERGY REGULATORY COMMISSION.

→ A Grid of Our Own

by CHRISTOF SPIELER

The United States and Canada are covered mostly by two power grids: the Eastern Interconnection and the Western Interconnection. But three places have separated themselves, just as they occasionally talk of seceding from their respective countries: Alaska, Quebec, and Texas. Within each of these 5 zones, power flows freely, with every generator, motor, and light bulb within the zone alternating to the same rhythm. Between zones, power travels only across a handful of controlled connections. The Texas network is managed by the Electric Reliability Council of Texas (ERCOT), a private nonprofit regulated by the state.

But Texas is not as independent as the power grid might suggest. The fuel for Texas power plants can come from far afield. Half of Texas electricity comes from natural gas largely from local production since Texas is a natural gas exporter. A third of the state's electricity comes from coal. Texas has its own coal, but it is low grade and inefficient. It's burned in power plants directly at the mine to minimize transport costs. But two thirds of Texas coal comes from elsewhere, primarily from Wyoming's Power River Basin. The two major western railroads compete aggressively for contracts to move it. The W.A. Parish station in Fort Bend County alone needs 36,000 tons a day, carried in three 115-car trains. The rest of Texas electricity comes from two nuclear power plants (13 percent), hydroelectricity (less than 1 percent), petroleum (less than 1 percent), and a growing share of renewable, especially wind (6 percent).

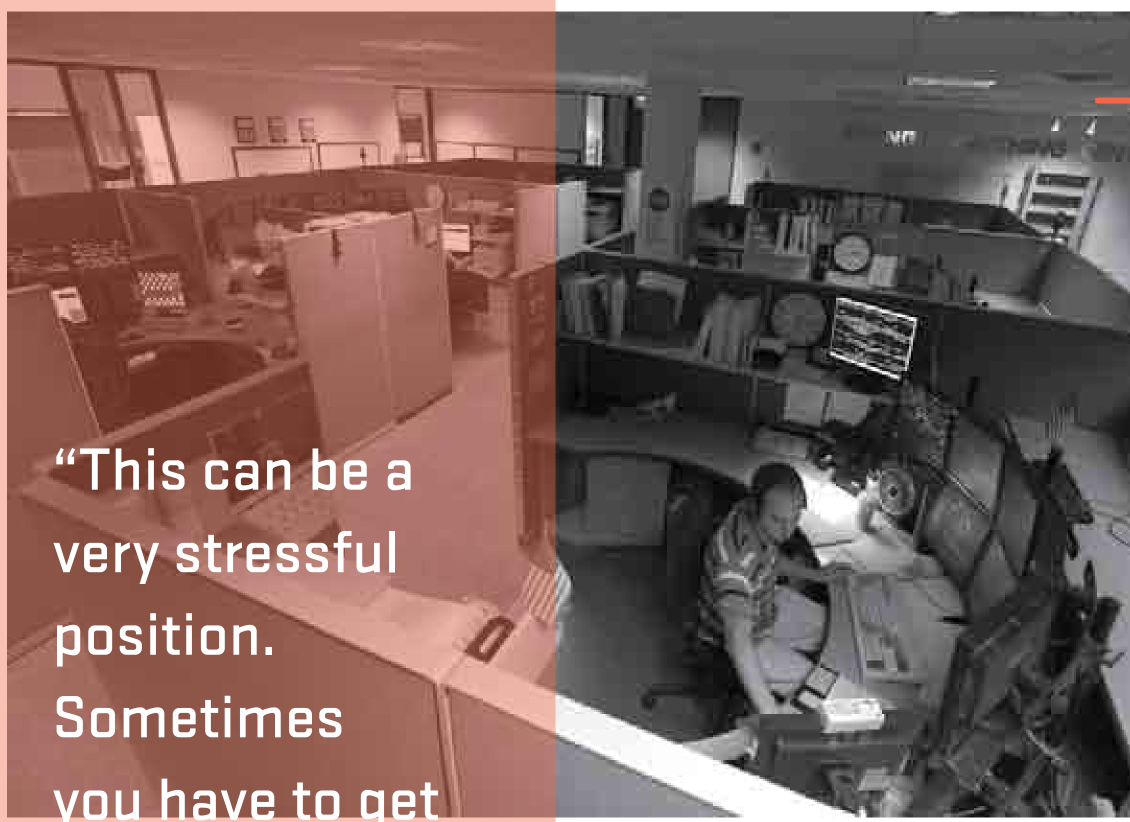
The Texas power grid is already shifting as energy production changes: the Public Utilities Commission is planning new power lines to carry electricity from the wind fields of West Texas to Dallas and Houston. Texas also has room for conservation: electricity use per capita is 20 percent above the national average, and a third of that is used in homes.

NASA Mission Control Center during Gemini 5 flight, Houston, Texas 1965.

Rooms With A View

Mission Control, with its rows of people in front of computers, was the ultimate in high technology. Forty years later, that image is routine.

By Christof Spieler



> "This can be a very stressful position. Sometimes you have to get up and walk around."

Across Texas and the whole country, largely anonymous men and women sit in dim rooms, controlling the infrastructure that supports our lives.

In a nondescript office building in Spring, Texas, two dozen **Union Pacific (UP) dispatchers,** corridor managers, superintendents, and directors control 200 trains a day on 5,000 miles of track, from Alpine and Laredo to New Orleans, Texarkana, and Oklahoma City. The same room holds BNSF and Kansas City Southern dispatchers who control those companies' trains, coordinating with UP where they share track.

Other control rooms are scattered across Houston. Freeway signs, traffic cameras, signals, safeclear tow trucks, and METRO buses are controlled by Transtar off Old Katy Road. A windowless building on the road into George Bush Intercontinental Airport holds Houston Air Route Traffic Control

MISSION CONTROL COURTESY NASA; ALL OTHER PHOTOGRAPHS THIS SPREAD SHARÓN STEINMANN

Center, which controls the airspace over south Texas, Louisiana, and the Gulf Coast of Alabama and Mississippi. On Clinton Drive, the Coast Guard's Houston Vessel Traffic Service uses radio, camera, and armed patrol boats to monitor all traffic in the Houston Ship Channel, from kayaks to tankers. Downtown, the city's SCADA control room operates wastewater lift stations and treatment plants. The pipeline companies have their own control rooms, as does every chemical plant. And some Houston infrastructure is monitored from afar: the Texas electric grid is supervised from the ERCOT facility in Taylor, far from hurricane country, and there's a backup control room in Austin if it's ever needed.

In 1912, Italian Futurist Antonio Sant'Elia rhapsodized about power stations: "Many millions of kilowatts are distributed, broadcast in fertilizing abundance, but governed by switches under the fingers of engineers. Engineers who pass their days in high tension chambers where 100,000 volts shimmer between panes of glass." In a time where many of us spend our days in front of shimmering glass screens, that image no longer holds the same drama. But there are more switches than ever.

The screens behind **Tim Wooley** show every track and every train inside Beltway 8. David Ritchley: "This can be a very stressful position. Sometimes you have to get up and walk around."

Stephen Foyt's headset is for radio communications with train crews. David Ritchley: "Everything you do on the railroad is marked with initials, like signing a document. The largest problem is readback/hearback on the radio. We're trying to eliminate that. We can now send track crews authority over laptops."

Tony Wronko, dispatcher:
"I just talked to this guy: 'You're going to meet two trains.' He knows he's meeting one at Waco. He knows that as soon as that train clears he'll get a signal. If he doesn't get a signal he'll call me."

"Right here, that's Downtown Austin—it doesn't look like anything [on the screen]. But you get to know it. We have the entire railroad on digital movies. They send you on road trips. You learn about the hills, the bad spots."

A Journey Into THE GREAT BELOW

HOUSTON IS AT THE HEART OF AN INTERNATIONAL NETWORK OF **PIPELINES** AND RESERVOIRS THAT BOOSTS THE LOCAL ECONOMY. BUT IS IT SAFE?

by Raj Mankad

Fred Hild sits at a gray folding table. The blue glow of dual 30-inch computer displays reflects off his glasses as he clicks his mouse. First the outline of North America appears on the screen. A spidery network of lines representing underground pipes works its way south from Alaska, Canada, and the Atlantic coast and north from Mexico. The lines become denser in California and Oklahoma, but they really thicken from Oklahoma into Texas. Harris County fills in solid—seen on the cover of this issue—as if the state rests not atop dirt and rock but a giant network of pipelines.

"It just so happens that Oklahoma, Louisiana, and Texas were blessed," Hild says. His Southern idiom fades when he delves into technical intricacies but returns strong when he presents information in simpler terms. "All states have oil and gas with the exception of the far Northeast. Them Yankees up there don't have nothing." He points to the gathering lines "streaming" from Canada to big California cities, but for the most part all pipelines appear to lead to or from Texas.

Thomas Colbert, an architecture professor and co-guest editor of this issue, long heard murmurings, rumors, and vague allusions to a vast underground network of pipes and old oil fields underneath Houston, whole zones of land undeveloped because of the danger below. He accompanied me to Hild's League City office. The man we found was more Oracle than human.

Drilling a natural gas well in the Kilgore system? Hild can tell you exactly where all the closest pipelines are, what distribution points you can connect with and who owns them, the risk of flooding, and what school district might tax you. Give him a set of coordinates—any spot in North America—and he can show you all this plus the rivers, lakes, bays, and swamps; power plants, substations, and transmission lines; railroads and refineries; compressor stations, receipt and delivery points, meter stations, oil pumping stations, oil reservoirs, underground gas storage, and above ground gas storage.

"My company, HTSI, scans any data we can get and then brings it into ArcGIS," Hild says. "We digitize all the lines, correct them according to aerial photographs, and make them just as accurate as we can." Often it is his own customers, including Shell, who supply him with data.

Above: Homes near the Bammel Gas Storage Facility

When Hild finally zooms in on Harris County, the solid purple resolves into distinct if incomprehensible complexes of lines. I ask about one thick band. On closer inspection, it turns out to be 42 *separate* gas lines—not segments or pieces of the same line. Hild moves his mouse over the area. "If I click on that pipeline, then it tells me that the pipeline belongs to DCP Midstream Limited Partnership, it is a nine-inch natural gas line, it is active, the subsystem is owned and operated by Anadarko, and it is a gathering line."

What appears to be the very thickest concentration of pipelines along a single right-of-way is at the Ship Channel where Pasadena Freeway and Beltway 8 cross. Hild zooms in—there are 274 completely separate pipelines in this easement.

As Colbert and I drive back to Houston proper, it is as if we have been taught to recognize birds or leaves for the first time. At a stretch of "undeveloped" land between two strip malls, we notice the little signs we have ignored most of our lives warning of butadiene, butene, oxygen gas, natural gas, and petroleum lines below. The J-shaped pipes and small sheds now seem obvious.

The visit to the Oracle of League City is the revelation Tom sought. New York is defined by the collective experience of its underground. Underneath Houston is this thing of even greater national importance that does not even have a name. Throbbing veins and arteries come to mind. A bodily metaphor seems right because the pipelines are incomprehensible, though they are not a body but a machine built and maintained by humans at enormous expense, a vast hidden machine.

Like Hild, Ken Beckman, Senior Vice President of Cardinal Gas Storage Partners, works from a nondescript office building off the highway, this time in northwest Houston near Wilcrest. He takes us into a conference room. All along the window sills and wall shelving are core samples from beneath the surface of the Earth.

"Within Houston, we have five underground gas reservoirs," he says. I imagine giant cavernous spaces, but he picks up one of the core samples to demonstrate otherwise. "This particular sandstone comes from about 3,000 feet below the ground in Mississippi." For a second, he gives the rock a messy kiss. I know geologists are a curious breed.

SHARON STEINMANN

They deal in geologic time, they speak the poetry of ages. Even so, of all scientists their work is among the most practical, gritty, and sought after by industry. But making out with a rock might be expected at an ashram, not a reputable office. Beckman inhales and exhales with the rock to his lips. "You can breath through it," he says. "And that means you can flow gas and oil through it."

Parts of the city, then, sit atop porous rock packed with high-pressure gas. The first questions we ask: do people live on top of these sites, do they know, and how long before the giant inferno?

"People live on top of Bammel gas storage field," Beckman said. And before getting into the details of safety, he makes clear his own comfort level. "I actually live very close to the Bammel field, if not on top. It is a World War I vintage gas cycling operation on the north side of town at Kuykendahl and FM 1960 that was converted over to storage in the 1960s. The community has grown out over it since then." Most of the reservoirs in fact are old, used-up oil and gas fields that have been recycled as storage.

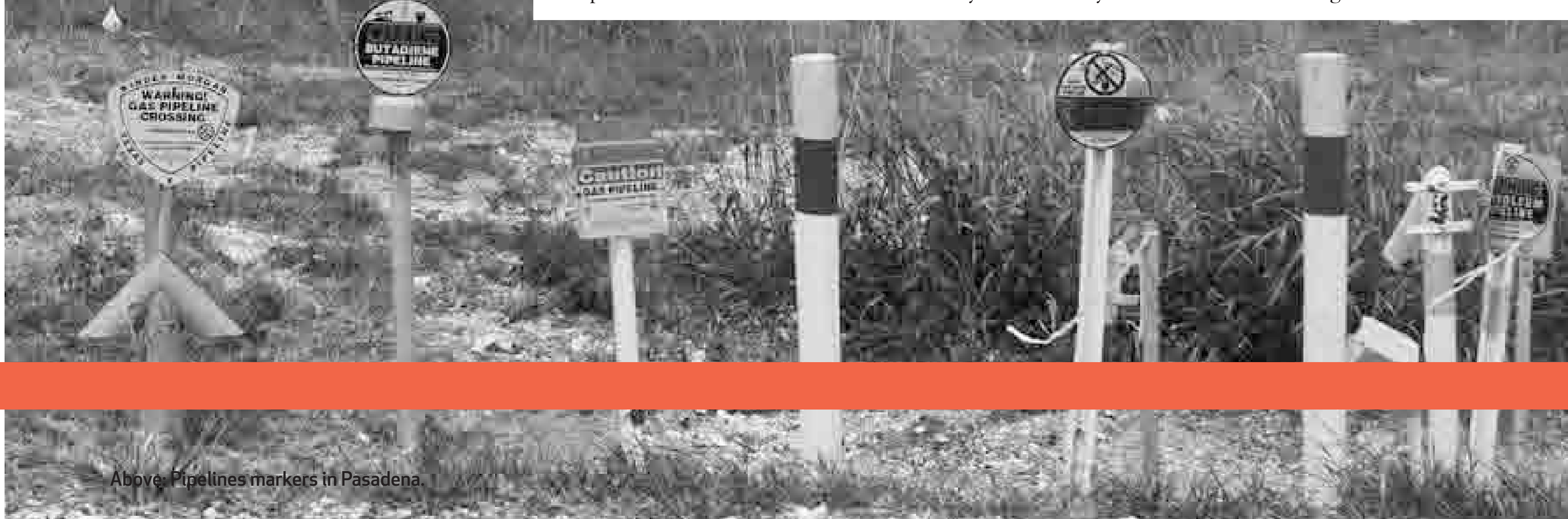
The other facilities are West Clear Lake, off I-45 and Nasa Road, and Katy Gas Storage at Pin Oak Road. In addition there is gas storage at salt domes in Liberty County, Moss Bluff, North Dayton, Pierce Junction, Spindletop, High Island, and Cote Blanche. Beckman confesses that even he has a hard time spotting the locations above ground. For example, the Katy reservoir is a wooded area marked by a berm, or mound of earth, planted with pine trees. "You wouldn't know it was there except for the fancy gate they have in front of it." Unlike Bammel, the Katy facility came into use after residential development and was heavily fought by residents at the time.

Perhaps the most persuasive point about safety—besides Beckman's willingness to live on top of a reservoir—is that the fields held hydrocarbons for millions of years before human beings drilled into them. Old gas fields are normally used to store gas. The locations of the well bores, the pressure at which the fields once held gas, and how much gas they held are all known from the days of extraction. The danger is exactly at the points where humans breached the millennial geologic structures. The last accident in the area occurred at Moss Bluff when a wellhead failed. "It looked like a giant blow torch," Beckman said. "They had to repaint the compressor barn and nobody got hurt. It scared the well operator."

The worst incident he could recall occurred in Hutchinson, Kansas in 2001. Damage to the casing of a reservoir well allowed gas to escape and migrate underground seven miles into the city of Hutchinson, popping up through abandoned salt mines and forgotten wells. Two people, John and Mary Ann Hahn, died when an old well beneath their mobile home exploded.

Headlines do not celebrate the lives gas storage saves. It serves two major functions: supplying gas during periods of very high demand and moderating swings in price caused by panic buying and selling. All in all, there are 4.2 trillion cubic feet of working gas space in the United States, of which approximately 3.6 trillion cubic feet is filled annually. The United States uses around 23 trillion cubic feet per year, so storage capacity is a fraction of total consumption. Natural gas, for the most part, is burned to heat water for hot showers and tea or to supply industry needs as soon as it is produced. It takes about a day for Oklahoma gas to reach Houston and two more days for it to reach New York through pipelines.

The storage consulting Beckman performs for utilities almost entirely concerns the ten coldest days in the north: the 30-degree-below winters



Above: Pipelines markers in Pasadena.

Harris County. Thickness of lines indicates the number of individual pipelines.

that strike the Yankees. He is like the stingy uncle always reminding you to save, as he prepares for the coldest day that strikes once every decade or two—the kind of person who is mocked until the streets freeze over and heat is a matter of survival.

If Hollywood ever makes an apocalyptic movie about Houston, the trailer will show the petrochemical complex exploding, the ship channel turning to a river of flame, scenes already familiar from news about pipeline attacks in Nigeria, Columbia, Mexico, and Iraq.

In a post-September 11 world, should not pipeline maps and gas reservoirs locations be treated as secrets? It almost seems Houston has done all the work except lighting the fuse.

According to Hild, the ubiquity of danger has a paradoxical effect. The sheer number of pipelines in Houston—marked with signs at each street crossing—not only makes them unguardable but also less valuable as targets. Damage to a few pipes would not bring down the whole system. “It’s not like you are going through [a Central Asian country] and there’s one 40-inch pipeline,” he says. “If you were a terrorist, you would get very tired blowing up pipelines here and not getting nothing done.”

Nonetheless, the September 11 attacks had a chilling effect on the willingness of the government and industry to share information about infrastructure. This trend worries Beckman. He argues that transparency is necessary for a healthy democracy with an informed citizenry capable of understanding the costs and advantages of pipeline and storage infrastructure.

Beckman’s neighborhood alone is sitting above 450 million dollars worth of gas and storage facilities at Bammel.

If cap-and-trade rules are passed by the U.S. Congress, CO_2 could be captured at industrial sites and piped into old oil wells, packed in at high pressures to be kept out of the atmosphere. The expertise of men like Hild and Beckman will be even more in demand.

Natural gas is stored beneath Beckman’s neighborhood.

“We live and die by pipelines,” Hild says. And in the pragmatic way of speaking that seems to permeate energy industry engineers, he adds, “I’m no advocate or whatever, but the reason the Houston economy is going strong is those pipelines. They keep our gas flowing. The national economy might be going to hell but you’ve still got to move those fluids.”

The September 11 attacks had a CHILLING effect on the willingness of the government and industry to share information about infrastructure.

PHOTOGRAPH: SHARON STEINMANN; MAP: HTSI DATA

GIS DATA FROM HTSI (PIPELINES INCLUDING PETROLEUM) AND TELE ATLAS NORTH AMERICA / ESRI (WATER). LNG IMPORT LOCATIONS FROM FEDERAL ENERGY REGULATORY COMMISSION.

→ All pipelines lead to Texas

by CHRISTOF SPIELER

North America's network of gas pipelines maps out production and consumption. The densest webs are in the gas fields. North America's leading producers are Texas, Alberta, Alaska, Wyoming, and Oklahoma. From there, long straight lines lead to the population centers of the Northeast and the Upper Midwest, where gas heats homes and businesses, generates electricity, and produces other chemicals.

The pipeline industry was once a closely regulated, reliably profitable utility. Pipeline firms bought gas from wells, transported the gas, and resold it. When gas prices were deregulated in 1978, pipeline companies signed huge long-term contracts for gas. When gas prices fell, they were left buying high and selling low. The resulting upheaval finally lead to the separation of transport and production; today pipeline companies simply sell space in their pipes.

About three percent of U.S. natural gas comes from abroad in liquid (LNG) form on ships equipped with huge spherical presssurized tanks. But that share is increasing. Some of the terminals that handle these imports are near consumption areas—the one 2 miles from Downtown Boston got media attention post-9/11 for its security risk—but production areas like Texas work, too, because of their excellent pipeline connections. An LNG terminal in Freeport went online in 2008.

Gushers, Reservoirs, and Pipelines

TRACING HOUSTON'S RISE TO ENERGY PROMINENCE

by James McSwain

THE FIRST BIG DISCOVERIES of oil in the United States were in Pennsylvania not Texas. As late as 1900, Texas produced a fraction of the total United States output. Standard Oil, based on the East Coast, held a near monopoly on oil production, refining, and marketing. By 1908, however, Texas was well on its way to energy prominence with Houston as a major center of the industry.

At the intersection of industrial archaeology and the transportation of petroleum in the twentieth century is the enormous complex of pipelines that run under and around Houston. What is little understood is how this complex took root in the metropolitan area, making Houston the epicenter of a nationwide network of pipelines and therefore the center of the petrochemical industry.

Joseph Cullinan (1860-1937) is often the lead character in early histories of Texas oil, and archival material available on him is extensive. But many of the most important players operated quietly and few records remain. The material history provides crucial details. What follows is a history of the astonishingly rapid development of the prospecting, production, and transportation of crude oil along the Texas-Louisiana Gulf coast at the beginning of the twentieth century.

Gushers and Earthen Ponds

The history of this enormous industrial and engineering achievement begins in January 1901 when A. F. Lucas, an experienced mining engineer, along with veteran oil men James M. Guffey and John H. Galey, brought in the famous Spindletop or Lucas Well in a sandy area south of Beaumont. Crude oil shot high above the derrick, poured downhill, and backed up against a railroad grade forming a lagoon. It soon caught fire from the spark of a passing train. Production estimates ranged from 45,000-76,000 barrels per day.

> The oil shot high above the derrick, poured downhill, and backed up against a railroad grade forming a lagoon. It soon caught fire from the spark of a passing train.

Others quickly tapped the same source from nearby locations. D. R. Beatty, for instance, brought in a huge gusher for Texas Western in March, only two months after the Lucas well came in. The district was soon covered in a forest of wooden derricks.

Storage at Spindletop was an immediate problem because most of the companies in the field were not heavily capitalized. Operators were disinclined to build expensive steel tanks until they were certain they had a producing well. Production pressures and steel-tank costs led many oil firms to use earthen in-ground reservoirs, which were sometimes lined with clay, lumber, or concrete. In the early days of the Spindletop field, Sun Oil Company built an earthen reservoir that could hold 110,000 barrels. Workers soon excavated large craters that in one instance could hold up to 200,000 barrels. They lined them with several layers of lumber and topped them off with a waterproof covering.

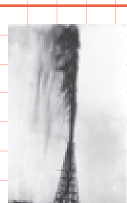
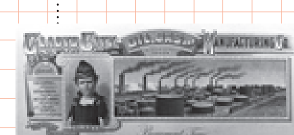
In August of 1901, Alamo Oil began work on a 250,000 barrel reservoir. In March 1902, George A. Burt, allegedly a front man for Standard Oil, arranged to have a reservoir built to hold 500,000 barrels of oil. The following May he closed a contract for the construction of 10,000,000 barrels of earthen storage.

Pipelines

Pipelines had been in use for decades outside of Texas and on a small scale within the state; however, the unprecedented and prodigious volume of oil at Spindletop required massive pipeline investments.

Production companies needed crude oil storage and pipeline transportation, first to railroad tankcar racks at Gladys City, and then to deep water wharfage at Port Arthur and Sabine, Texas, where steamers could take on oil bound for the East Coast and Europe. Beatty told the 1901 meeting of the Trans-Mississippi Congress that, since the Beaumont field was only 20 miles from deep water, "competing pipe lines" would soon traverse this distance. He predicted that oil-burning steamers would eventually carry "our commodities all over the world" with manufacturers following in their wake.

KEY DEVELOPMENTS 1901-1908

TIMEFRAME	JANUARY 1901	MARCH-MAY 1901	AUGUST 1901	AUGUST 1901	NOVEMBER 1901	NOVEMBER 1901
PLAYERS	A. F. LUCAS, JAMES M. GUFFEY, JOHN H. GALEY 	D. R. BEATTY AND TEXAS WESTERN; LONE STAR AND CRESCENT OIL COMPANY; SCOTT HEYWOOD; JAMES S. HOGG & JAMES W. SWAYNE OIL.	ALAMO OIL	NATIONAL OIL AND PIPELINE	PATILLO HIGGINS 	SUN OIL
MATERIALS	OIL DERRICKS REACH GUSHER AT SPINDLETOP NEAR BEAUMONT.	MORE BIG GUSHERS AT SPINDLETOP, MAJOR DIFFICULTIES WITH STORAGE AND DISTRIBUTION	COMMENCEMENT OF WORK ON A 250,000 BARREL EARTHEN RESERVOIR	COMPLETION OF SIX-INCH PIPELINE FROM SPINDLETOP TO PORT ARTHUR	$10 MILLION INVESTMENT FOR PIPELINE FROM BEAUMONT TO HOUSTON	PIPELINE TO PORT ARTHUR, PURCHASE OF LONE STAR AND CRESCENT OIL PIPELINES

ABOVE: **Pipeline construction crew.**
LEFT: **Humble oil field.**

At the end of August 1901, seven months after the Spindletop discovery, National Oil & Pipeline Company completed a six-inch pipeline from the Spindletop field to storage tanks in Port Arthur. Spokesmen for the company said that this represented "one of the most important points in the material development of shipping facilities of the field."

The J. M. Guffey Petroleum Company, later known as Gulf Oil, completed its pipeline to Port Arthur and deepwater access in May 1901 so it could penetrate Gulf coast, Atlantic coast, and European markets by means of tank steamers.

In November, Patillo Higgins and associates organized a company capitalized at $10,000,000 to build a pipeline from Beaumont to Houston. Several other companies invested in pipelines as well. (See Key Developments, below.)

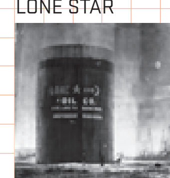
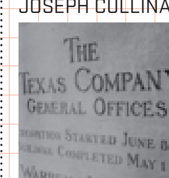
Joseph Cullinan was also instrumental in setting up the Gulf Coast pipeline system. He learned oilfield work from the age of fourteen in Pennsylvania, moving up the managerial ranks of Standard Oil. He came to Texas in 1898, before Spindletop, to build gathering lines to service the comparatively small wells around Corsicana. After the Lucas Well gusher, Cullinan bought up crude production and constructed feeder pipelines and storage tanks in the Beaumont-Port Arthur area through his Texas Fuel Company.

Production declined from late 1902 to 1909 in Gulf Coast fields and attention shifted to the lucrative Indian Territory field, an area that would become part of the new state of Oklahoma, where Robert Galbreath and Frank Chesley found the famous Glenn Pool. Cullinan finished a pipeline from Oklahoma to the Texas Fuel Company's Port Arthur refinery in January 1908. This line ran southwest through Fort Worth-Dallas and then southeast to the Humble field near Houston. The company tacked on an additional twenty-mile line to the Houston Ship Channel and open water access. Accordingly, in 1908, Cullinan moved headquarters of the company from Beaumont to Houston, because he foresaw Houston's role as the center of the southwestern oil business. Shortly thereafter, the Texas Fuel Company became Texaco. Cullinan also developed the neighborhood of Shadyside for his friends, family, and business associates.

From Production to Command Post

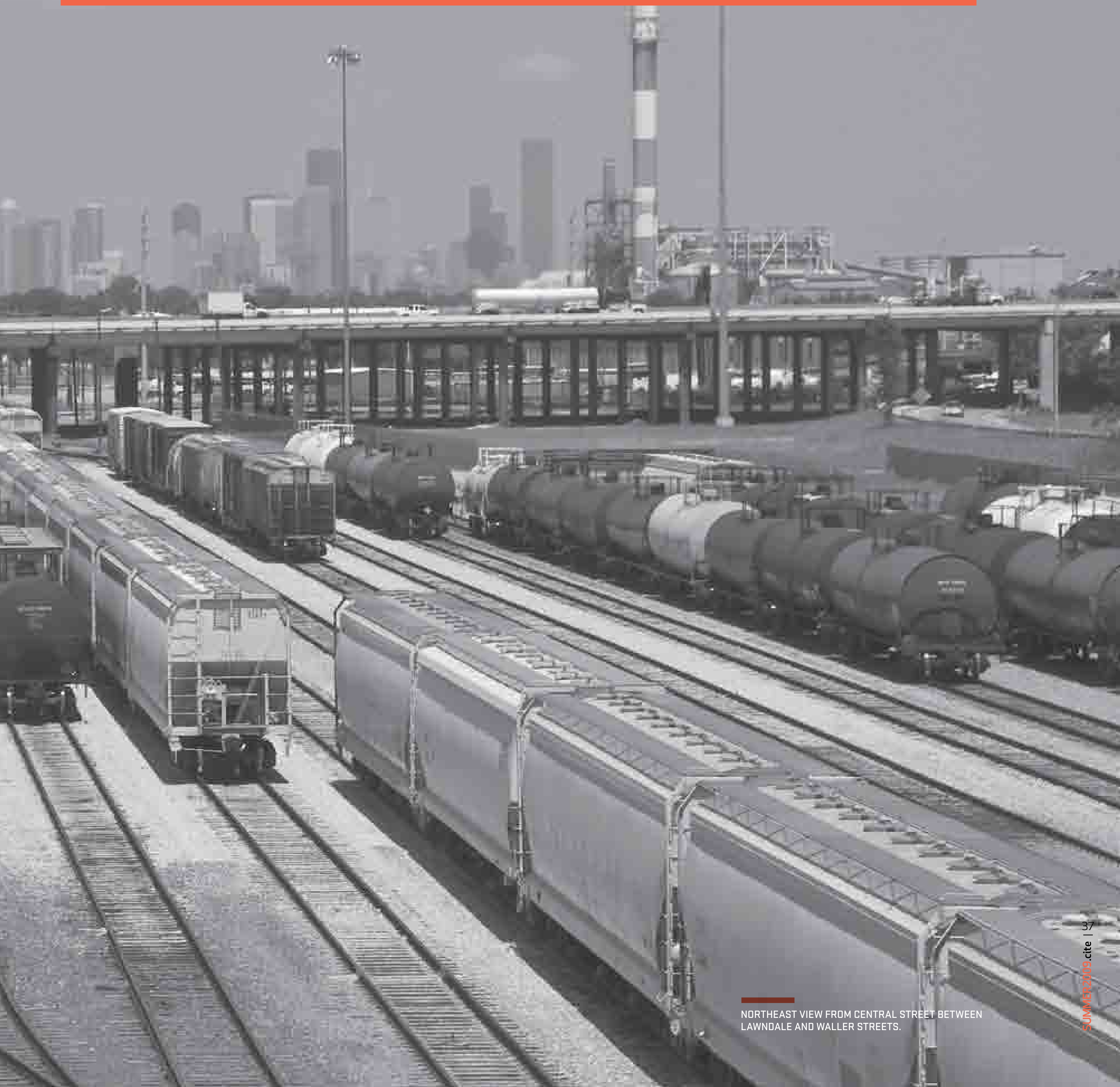
On the eve of WWII Houston had 1,200 oil companies, oil-equipment manufacturers, and suppliers. Long-distance trunk pipelines constructed in the 1920s and natural gas lines built from 1926 to 1938 connected the Midwest to Houston's burgeoning refining and oil production capacity. By 1939 the Houston area received via pipelines twelve percent of U.S. oil production for refining and distribution. War-time energy demands led to the construction of the *Little Inch* pipeline linking the Northeast to the Houston-Gulf Coast refining area. Today, the enormous number of pipelines in the Houston area remain instrumental to the city's central role in energy enterprise.

As the twentieth century passed, many oil companies placed central or regional offices in Houston to take advantage of investment capital, oil-field expertise, extensive railroad and pipeline infrastructure, and talented entrepreneurs. The infrastructure created to transport oil produced in the region set the stage for Houston as the nation's preeminent hub for refining oil, turning fuel into petrochemicals, and distributing a variety of hydrocarbons.

JANUARY 1902	FEBRUARY 1902	MARCH-MAY 1902	MARCH 1902	LATE 1902-1909	LATE 1908
PATILLO HIGGINS	VICTOR OIL COMPANY	GEORGE BURT	LONE STAR	LONE STAR	JOSEPH CULLINAN
					
TENTH STEEL STORAGE TANK OUT OF A PLANNED TWELVE	ANNOUNCE PLANS TO BUILD SEVERAL MILLION BARRELS OF EARTHEN RESERVOIRS.	BUILDING OF 10,000,000 PLUS BARRELS OF EARTHEN STORAGE	OIL-DELIVERY WHARF IN NEW ORLEANS AND PIPELINE FROM PORT ARTHUR TO SABINE PASS	DECLINE OF GULF COAST OIL PRODUCTION AND RISE OF PRODUCTION IN OKLAHOMA	PIPELINE FROM OKLAHOMA TO PORT ARTHUR COMPLETED. 20-MILE LINE CONNECTS TO HOUSTON SHIP CHANNEL AND OPEN WATER ACCESS. TEXAS COMPANY HEADQUARTERS MOVED TO HOUSTON

Rail horns, heard in the deep of night, are a ghostly reminder of a world not seen. Though infrastructure is rarely built with respect to human scale, the mind colludes with even the most minor attempts to disguise and shield huge storage tanks and towers, sprawling railroad yards and pipeline right-of-ways that occupy vast tracts of the city. The machines are increasingly automated. They are easy to forget. But if one's eyes are open to the adjacencies and jagged edges, the veil quickly falls. | photography Paul Hester

Edge Conditions



NORTHEAST VIEW FROM CENTRAL STREET BETWEEN LAWNDALE AND WALLER STREETS.

The "fields of honor" at San Jacinto are now surrounded by pipelines, rail lines, power pylons, and tankers: all monuments to interdependence. History gives way to infrastructure.

SAN JACINTO STATE PARK.

PASADENA BUFFALO BAYOU TRIBUTARY.

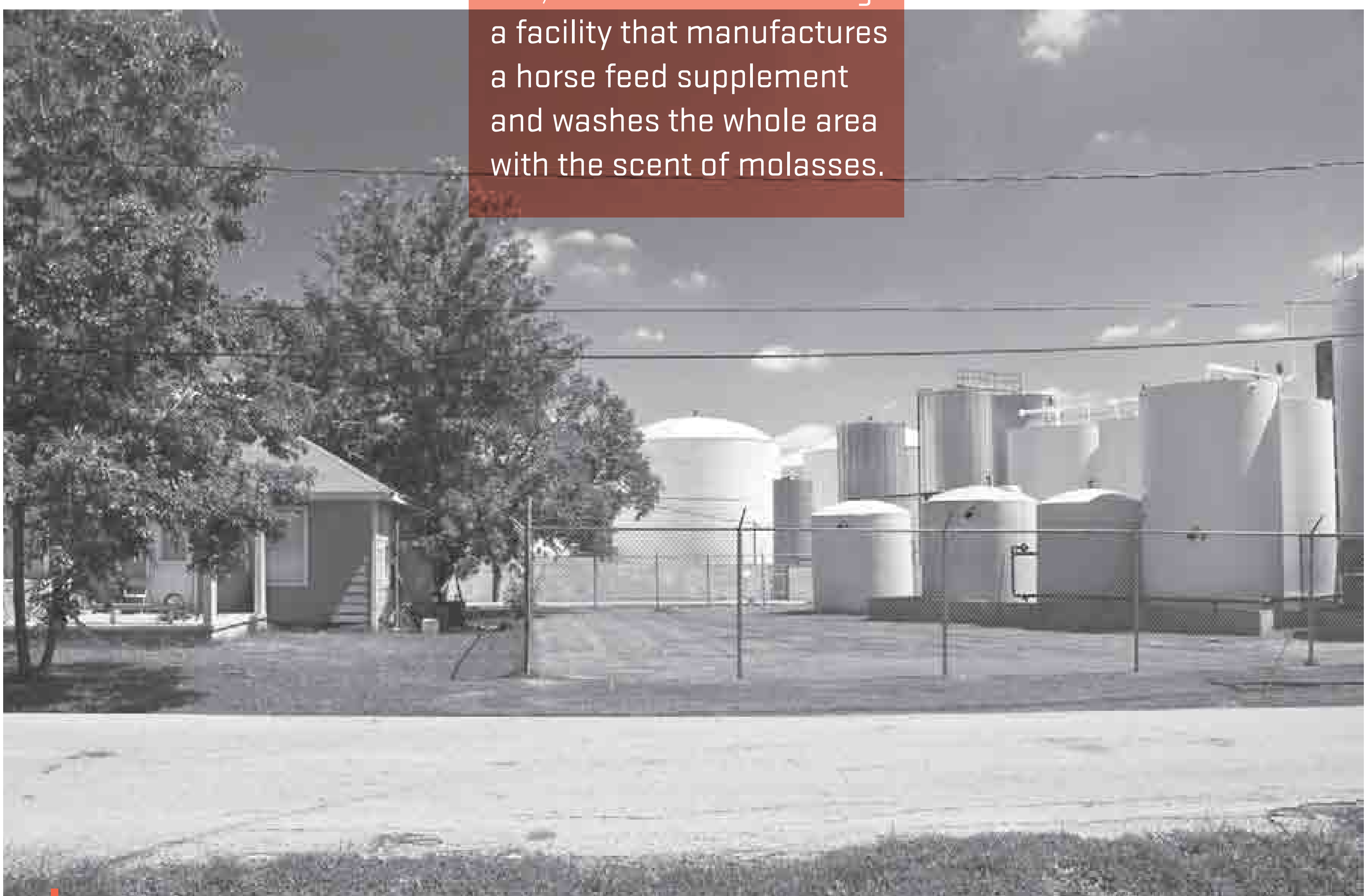
CELL PHONE TOWER, ALABAMA STREET BETWEEN HUTCHINS AND BASTROP STREETS.

SAN JACINTO STATE PARK.

HILLCROFT TRANSIT CENTER AT ARMPIT OF THE SOUTHWEST FREEWAY AND WESTPARK TOLLROAD.

RIVER OAKS SHOPPING DISTRICT, WEST GRAY AND DUNLAVY STREETS.

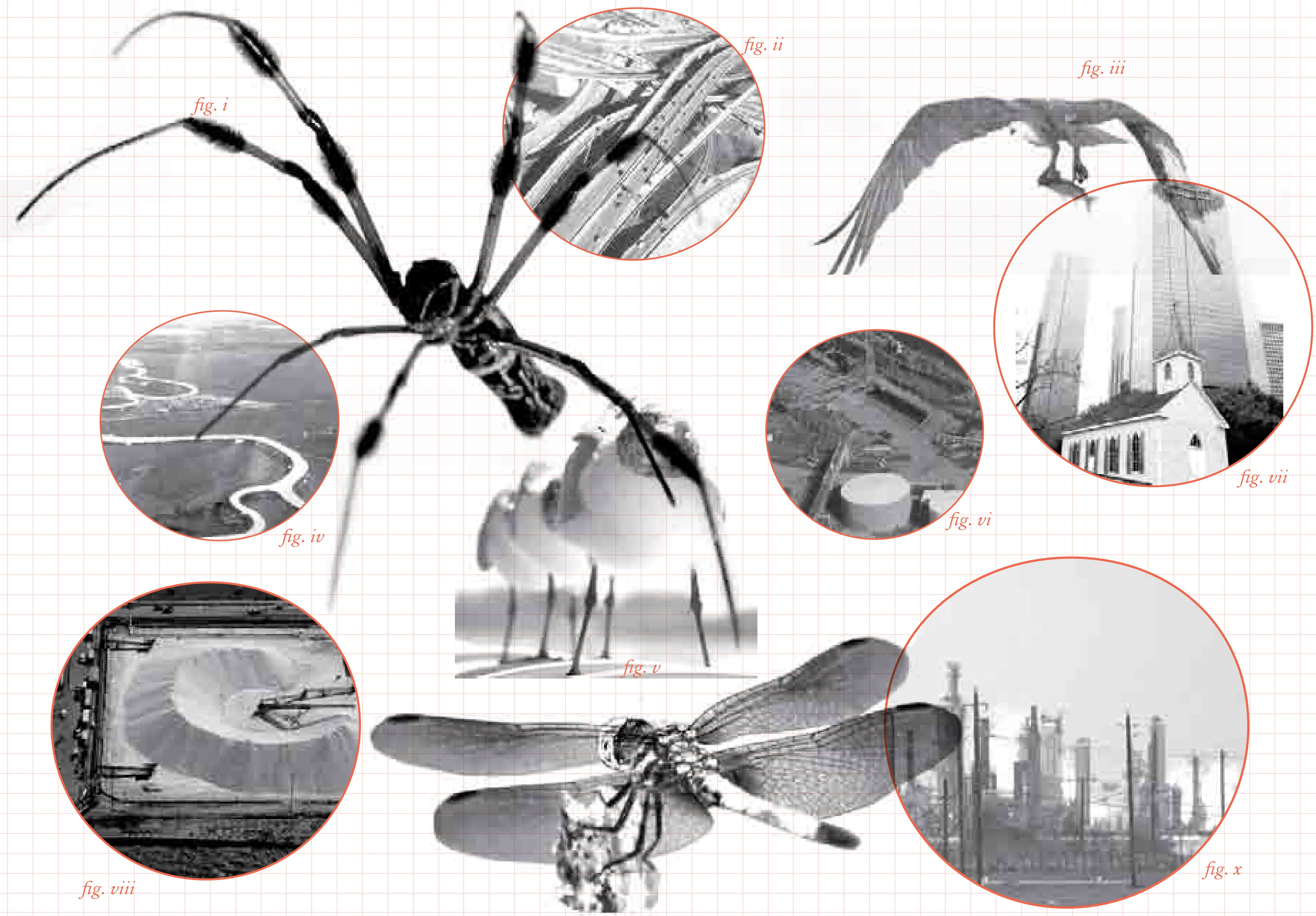
On one side of Hartman Park, the 610 Loop begins its soaring arc over the Ship Channel. On another side, storage tanks tower over houses. The two remaining sides are bounded by railroad tracks. Every minute or two, a breeze blows through a facility that manufactures a horse feed supplement and washes the whole area with the scent of molasses.



EAST AVENUE R LOOKING NORTH FROM HARTMAN PARK.

MORE THAN A SUM OF PARTS

HOUSTON, INFRASTRUCTURE, AND IDENTITY | words and photography by **John H. Lienhard**



BEFORE we delve into infrastructure, I offer a bit of autobiography: a particular arrangement of living cells first saw the light of day in 1930, and it was named John Lienhard.

The soft tissue cells in that gaggle have died and been replaced countless times since then. Many are replaced more than once daily. Only skeletal cells last for years. As a result, nothing of that 1930 cellular gaggle is left today and very little remains even from the late 20th century.

The present me has almost nothing material in common with the 1930 me. Yet those cells, each with a very rudimentary form of intelligence, have succeeded in forming an ongoing system. They die, but the system in some sense survives. It constantly changes, yet its identity persists because its cells are linked by something that doesn't have a proper name—call it institutional memory or a collective presence. Maybe this is what infrastructure really is.

The flow of material (and of matériel) is blood in our city's veins, its spiritual as well as its physical nourishment. Anyone who takes time to walk Houston's wharves comes away with a deep awareness of this driving pulse.

We humans (and other creatures as well) are cells in another organism—that which we call the city. But since you and I are Homo technologicus, the city has cells of an additional kind. More than any living creature, we need the help of a huge exoskeleton to survive. That exoskeleton is the sum of our technologies. Our intelligence is not contained in our brains and ganglia alone; it is also contained in the engines, buildings, and artifacts of our ingenuity. They form a very real external memory and are part of a collective intelligence that we comprise together with them. The same, of course, is true of any other overarching infrastructure we comprise—say, for example, the clan, the nation, or the world. But our concern is Houston.

Houston was founded in 1836. The oldest of its remaining architectural "cells" is possibly the 1847 Kellum-Noble House. It still stands where it was built in today's downtown, occupying land that has become Sam Houston Park. Other old houses and one old church have been moved into the park to keep it company. There they lie in the shadow of the skyscrapers that rose up around them years later (fig. vii). Every animate being in Houston was born after these denizens of Sam Houston Park were built. How many people living in Houston remember even as far back as the outbreak of World War I? I doubt that any do.

So, Houston's identity as a city persists despite the ongoing replacement of its people, its buildings, its electric and sewage systems, and its roads and bridges. It persists just as you and I persist despite the ongoing replacement of our cells. The sort of individual factors that allowed me to recognize classmates at my 60th high school reunion are the same that allow Houston's unique personality to outlive us. And Houston does have a personality—its own special continuity of texture and style. Outwardly one is struck by its unique drive toward ongoing renewal, resting as it does upon deep-seated egalitarianism and pride in hands-on functionality. Functional renewal is manifest in making buildings and in making music—in creating art, goods, and hardware—but "function" is the key. *Doing* trumps all else.

This uniquely functional personality arises for a reason: it grows out of several accidents of geography. Most important is Houston's window to the sea: Buffalo Bayou. Though an inland city, Houston is defined by its role as a seaport. It gives the city cosmopolitanism, diversity, and vitality. Geography grounds Houston solidly in the material world of commerce and industry. That's why the taproot of Houston's infrastructure—or rather its aorta—is its Ship Channel (fig. vi). The city's identity grows out of the vast industrial sprawl that lines the Channel for fifty miles. Oil refineries at present dominate the Channel's industrial presence (fig. x), but other products have also loomed large along it.

From the Civil War until World War II, millions upon millions of bales of cotton flowed through Houston to the sea. Meanwhile, in the early 20th century, the Frasch process gave us access to previously inaccessible coastal sulfur deposits. Houston became the sulfur capital of America, and still today, at the lower end of the Channel, we find great shining hills of pure sulfur (fig. viii). So the material has varied, while the shipping industry has steadily burgeoned. Houston is America's fourth-largest port and its largest international port. The flow of material (and of matériel) is blood in our city's veins, its spiritual as well as its physical nourishment. Anyone who takes time to walk Houston's wharves comes away with a deep awareness of this driving pulse.

And when we do that, we see more than just shipping and offshore oil rigs—more than outgoing sulfur and incoming automobiles (fig. ii). On the wharves especially, we are also struck by the living creatures that are everywhere.

For Houston is marked by the trees, flowers, birds, bugs, and animals indigenous to the upper Texas Gulf Coast. In birds alone, we are uncommonly rich. Pelicans hurtle down from out of the sky to dine on our plentiful fish, while cormorants simply submerge like submarines to catch them. We are surrounded by egrets and ibises, gulls and spoonbills, by a vast diversity of hawks that feed upon fish, vermin, and pretty songbirds alike (fig iii, v). Birds wreathe the ships, coming and going. They ride on their cargo and clean up their garbage. Other birds come and go in great migrations as seasons change.

But is it right to call birds and bugs part of our infrastructure? Do they define our personality? They surely do, both by playing their part in shaping our ecology and by taking a large subjective role in forming our perception of place. By analogy, microbial creatures in our own bodies play a huge role in shaping us. A few bacteria make us ill, but most help to secure our health. They are essential to digestion, they stem acid reflux and eczema, they improve our immune system. Moreover, your particular stable of bacteria sets you apart from me. Our city's body likewise has cockroaches, dragonflies (fig. ix), golden silk orbweaver spiders (fig. i), bats…. All might bother most of us at some level. But the cockroaches clean up organic debris and help to pollinate flowers. Those large, gentle spiders are a mixed blessing: we're

>> Oyster Creek Bayou

This great **SPRAWLING SYSTEM** is no less beautiful than an egret landing on the bayou, the wings of a dragonfly, or the soul-settling calm of our sultry salmon sunsets.

pleased when they eat flies and less happy when they kill bees. Bats keep the mosquito population down.

People and plazas; bats, birds, and bugs; music and museums—all those microelements ultimately shape themselves around geography. And the single geographic feature that sets Houston apart from other cities is its system of bayous. Here in the flat landscape of coastal Texas, the land is laced with lazy watercourses (fig. iv). They fill after every rainfall and carry water off our flat surfaces to the ocean. They are richly laden with birds and fish, and they lay their own gentle rhythm on the city. They shape transportation corridors and identify neighborhoods. Each forms a long winding city park that serves everyone near it.

Natural bayous meander about the landscape in crazy loops and flourishes. Our urban bayous, in contrast, have been contained—frozen in place with concrete banks. We're tempted to call them a composite of nature and human technology, but to do so would miss a very important point. Once we realize that we humans and our actions are a part of nature—that nature adapts to our presence just as we adapt to it—the whole concept of unspoiled nature falls apart. Take, for example, that fine piece of "unspoiled nature," Africa's Serengeti Plains. What we celebrate as pristine is, in fact, the result of African land clearance and management that goes back over the past two thousand years. William Blake understood this without knowing anything of the Serengeti when he wrote, "Without man, Nature is barren."

The fact that inanimate nature and living creatures always adapt to one another brings us directly back to the slippery concept of infrastructure, defined in the Oxford English Dictionary (2nd ed., 1991) as "a collective term for the subordinate parts of an undertaking; substructure, foundation…." That is exactly what I've been describing.

Yet, despite the fact, obvious when we think about it, that the whole system is nothing but its skeins of infrastructure, we try to talk about specific infrastructures as appendages to larger reference systems. If the system is an army camp, infrastructure might mean mess tents and latrines. If it's a university, perhaps food service and dormitories. The word is of little use to us until we elevate one function to primacy and regard all else as service to that one.

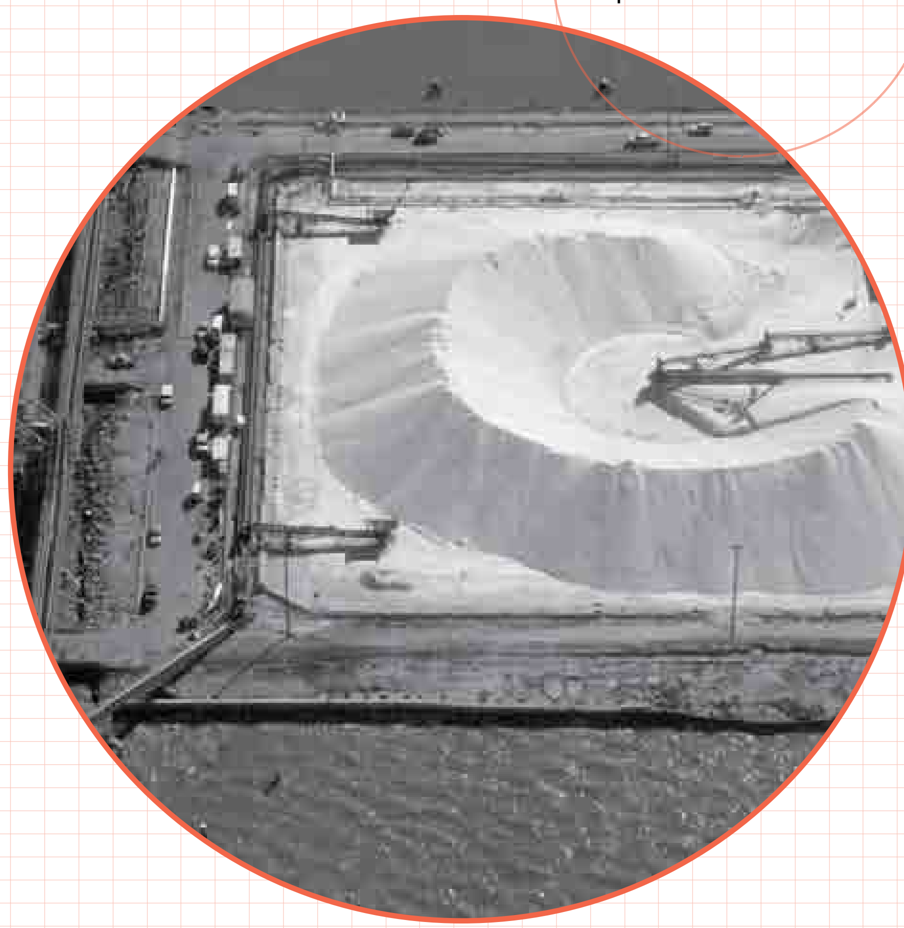
Yet that is precisely what is impossible to do when we look at Houston. Once we regard bugs, birds, cats, and dolphins as co-equal members of a larger animate symbiosis, girded about with an inanimate technological exoskeleton and resting in a geography with which every element interacts, we realize that we have nothing other than infrastructure. Problems always follow when we try to isolate a part of that infrastructure to the exclusion of the rest. Yet none of us is wise enough to digest it all at once.

Consider this example: Hitler set out to bomb London into submission in 1940. He failed. Then we set out on a much larger scale to bomb German cites into submission. They kept right on going until our armies walked into Berlin. When we tried to bomb Hanoi into submission, we lost Vietnam. Even Hiroshima is still a living city. Cities are oddly indestructible, and historian J. W. Konvitz talks about our failed assumption that they ought to be. Ever since we've had airplanes, he points out, analysts have been telling generals that their bombs could destroy cities by destroying their "infrastructures." A 1931 expert flatly said that cities were too fragile to weather aerial assaults—they were too dependent on transportation and supply systems, on electricity and plumbing. A 1938 British book, *The Air Defence of Britain*, announced London's vulnerability: "If it had been done deliberately, we couldn't ... have produced a social pattern ... more favorable for aggression from the air. Our millions are bottle-fed ... by a system ... so intricate, and so haphazardly evolved, that once dislocated beyond the power of immediate repair, they would be as helpless as newborn babes...."

Of course, London, Berlin, Hanoi, and even Hiroshima proved far tougher than that. At first, that seems to defy all reason. Then we look at the way cities evolve in symbiosis with the people who shape them. Just as a human brain can suffer great damage and continue functioning by rewiring its own processes, so too can a city. The city is an element of nature as robust as any of the creatures that nature evolves—as robust as a cockroach, robust as a human being. Cities can and do die, of course, but they die of old age. They die from within, just as some human beings die of old age long before they stop walking about. We can all think of examples. When cities do die, it is with a whimper, never a bang.

But Houston is so very much alive. And as we view its aggregate infrastructural sinews and synapses, the same way we view those of any living creature, we're struck not only by the robustness but also by the ever-shifting beauty of that aggregate. It is the beauty of function, the beauty of synchronicity, the beauty of mental youth. This great sprawling system is no less beautiful than an egret landing on the bayou, the wings of a dragonfly, or the soul-settling calm of our sultry salmon sunsets. For it is all of a piece.

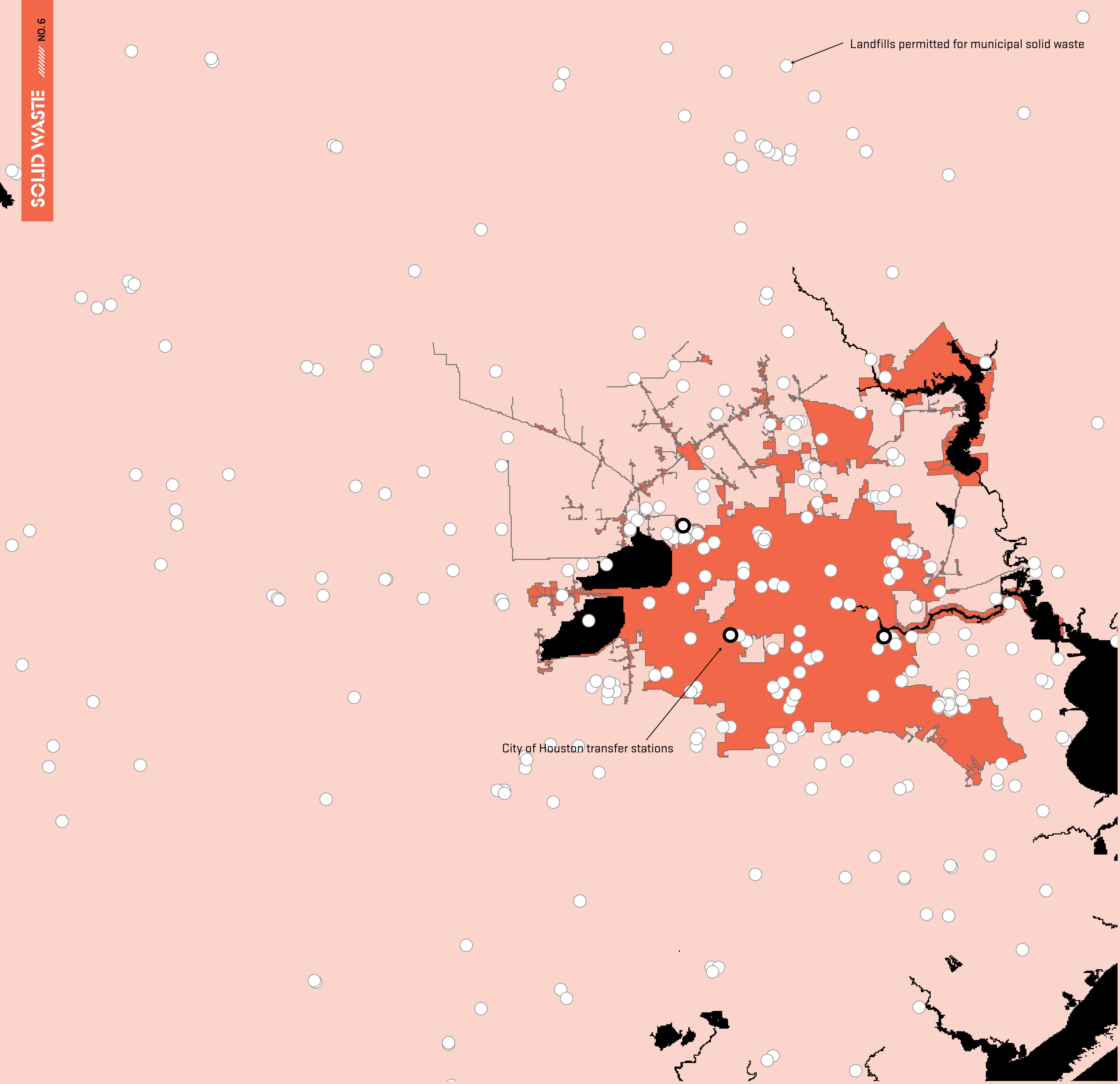
>> Sulfur at the lower end of the Ship Channel.



CAROL LIENHARD

... For nature then
(The coarser pleasures of my boyish days, and their glad animal movements all gone by)
To me was all in all...

William Wordsworth, Tintern Abbey



GIS DATA FROM CITY OF HOUSTON (CITY LIMITS), TEXAS COMMISION ON ENVIRONMENTAL QUALITY (LANDFILLS), BUREAU OF TRANSPORTATION STATISTICS NATIONAL TRANSPORTATION ATLAS DATABASE (WATER BODIES), AND TEXAS WATER DEVELOPMENT BOARD (WATER BODIES). TRANSFER STATION LOCATIONS FROM HOUSTON-GALVESTON AREA COUNCIL.

Manmade mountains

by CHRISTOF SPIELER

Once it is picked up at the curb, our trash is far from our minds. But it doesn't actually go very far. There are several dozen landfills in city limits, and more all over the region. In the flat coastal plain, these manmade mountains aren't hard to find if you look.

Houston's trash collection is an odd mix of socialism and capitalism. Unlike most Americans, Houstonians don't pay trash bills. The city's Solid Waste Management Department gets its budget from general revenues. But that service only extends to the roughly half of Houstonians who live in single-family houses and complexes of less than four units. Larger complexes have to contract for their trash service. Thus, apartment and condominium residents subsidize single-family residents with their property and sales taxes.

Once the trash has been picked up, though, the free market rules. The City of Houston does not operate a landfill, only three transfer stations, where neighborhood trash trucks drive up a ramp and dump their loads into a huge bin fom which larger transfer trucks are loaded for trips to privately-owned landfills. Disposal is up for bids. Whichever firm charges the least is paid to pick up the trash from the transfer stations and bring it to any permitted landfill they choose. Waste is a big (and recession-resistant) business. The nation's largest trash company, Waste Management, which is headquartered in Downtown Houston, just reported $2.95 billion in quarterly revenue

Perhaps due to the easy availability of landfills, Houston has been a laggard in recycling; only 10,000 single family homes are served with a pilot curbside recycling program, and public recycling bins are uncommon.

THE *heroic* ENGINEER

by Christof Spieler

ON THE VICTORIA EMBANKMENT IN LONDON, THERE'S A statue of an engineer. Isambard Kingdom Brunel advanced the state of the art in railroads, in tunnels, in bridges, in long-span buildings, and even in steamships. We will almost surely never see his like again: technology has advanced so far that no one person can excel in so many fields. We also won't see an engineer capture the public imagination as Brunel did.

The era of the heroic engineer began early in the 1800s with road and canal builders like Thomas Telford; it moved on to railroad builders like John Stephenson, structural engineers like Gustave Eiffel, bridge designers like John Roebling, and electrical engineers like George Westinghouse. It culminated, perhaps, with the moon landings, which made Wernher von Braun a household name. But by then engineers were fading from the public mind.

The era of the heroic engineer was the era of heroic infrastructure. In 50 years, the time it took to travel from New York to Philadelphia went from 2 days to 2 hours; the time it took information to travel that same distance went from 2 days to less than a second. *The New York Times* dedicated an entire section to the opening of Grand Central Terminal. Children played with erector sets and electrical kits. Magazines like *Popular Mechanics* featured updates on the latest steamships, bridges, and power plants. Giant dams and rural electrification were the emblems of recovery from the Great Depression. People flocked to highway dioramas at the 1939 World's Fair.

Along with the interest in technology came the veneration of engineers, the men who harnessed all that power. The progressive movement of the 1890s through the 1920s often tried to take policy power from corrupt politicians and grant it to technical experts. Engineers were trusted, as doctors still are, as experts who dealt in hard facts.

Infrastructure from the heroic era still reflects a deep sense of pride. The architectural details of power plants and substations were as considered as those of banks. The quality of construction reflects that pride, too: it is amazing how many bridges from the 1920s or even the 1880s still do their job while similar structures from the 1970s are already crumbling.

We continue building massive, world-changing infrastructure. The fiber optic cables that were tunneled through the country in the 1990s made YouTube possible. Massive docks in Hong Kong and Los Angeles, equipped with cranes the size of skyscrapers and operated by a single man, move cheap consumer goods to our homes.

But, aside from those who follow niche cable channels and specialist web sites about these projects, we don't seem to care. The "Technology" section of the paper covers new cell phones and antivirus tips.

Isambard Kingdom Brunel, 1857.

Highways, airplanes, and railroads get attention mainly for their failures. When technology is featured in movies, it's often technology run amuck. More students are studying business, and fewer engineering.

Perhaps we have become jaded to constant change. We are surely ambivalent: we know from Love Canal, global warming, and numerous other examples that technology can harm the world just as it can improve it. We don't trust technocrats anymore: highway engineers destroyed neighborhoods and the "best and brightest" led us into Vietnam. We've lost our personal connection. Once nearly everyone knew someone who worked for a railroad, a factory, or the power company; today, we're a nation of office and retail workers.

It's also no coincidence that infrastructure is doing its best to hide from us. Industry has moved from city centers to vast out-of-the-way tracts. Post-9/11 restrictions have closed off much of what was once visible. In the minds of those who operate our infrastructure, the public is a nuisance, perhaps even a danger. At best, infrastructure is utilitarian; at worst, it is disguised as in the case of cell phone towers in the guise of church steeples.

Engineers, too, do their best to stay anonymous. Technology has gotten so complex that there is no one designer: products and infrastructure are created by massive teams that integrate hundreds of technologies and components. Of course, that's true for nearly everything in our world, but engineering education and culture values modesty.

There are still heroes today, of course. And some of them even deal with infrastructure. But they're likely to be financial masterminds, not engineers. Enron's pipelines and power plants never got much attention, but the profits they claimed to make did. Had anyone built a statue for Enron, it would have been of Ken Lay, the financier. Likewise, the biggest story in highways in the past decade was toll road privatization. The Trans-Texas Corridor represented ordinary engineering, but it was heroic finance. The stimulus bill seemed to follow the pattern: talk of smart grids and high-speed rail fairly quickly gave way to news of negotiations and political deals over dollar amounts. We live in a cynical time.

Perhaps it is a testament to the quality of our infrastructure that we do not pay attention; electricity comes on demand, water is clean, and data instantly makes its way to our computers. But inattention comes at a cost. What we ignore can easily come around to harm us: the toll road through our neighborhood, the chemicals in the air, the rising oceans. We are starting to pay attention again. We talk about the origins of our food, about recycling our waste, and about reducing our carbon footprints. The pipes in our ground, the tracks and docks linking us to the world, and the plants that purify our water and filter our waste deserve the same attention. Whether we pay attention or not, engineers are shaping every moment of our lives. If we want to make our world better, we ought to pay attention.

ROBERT HOWLETT

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