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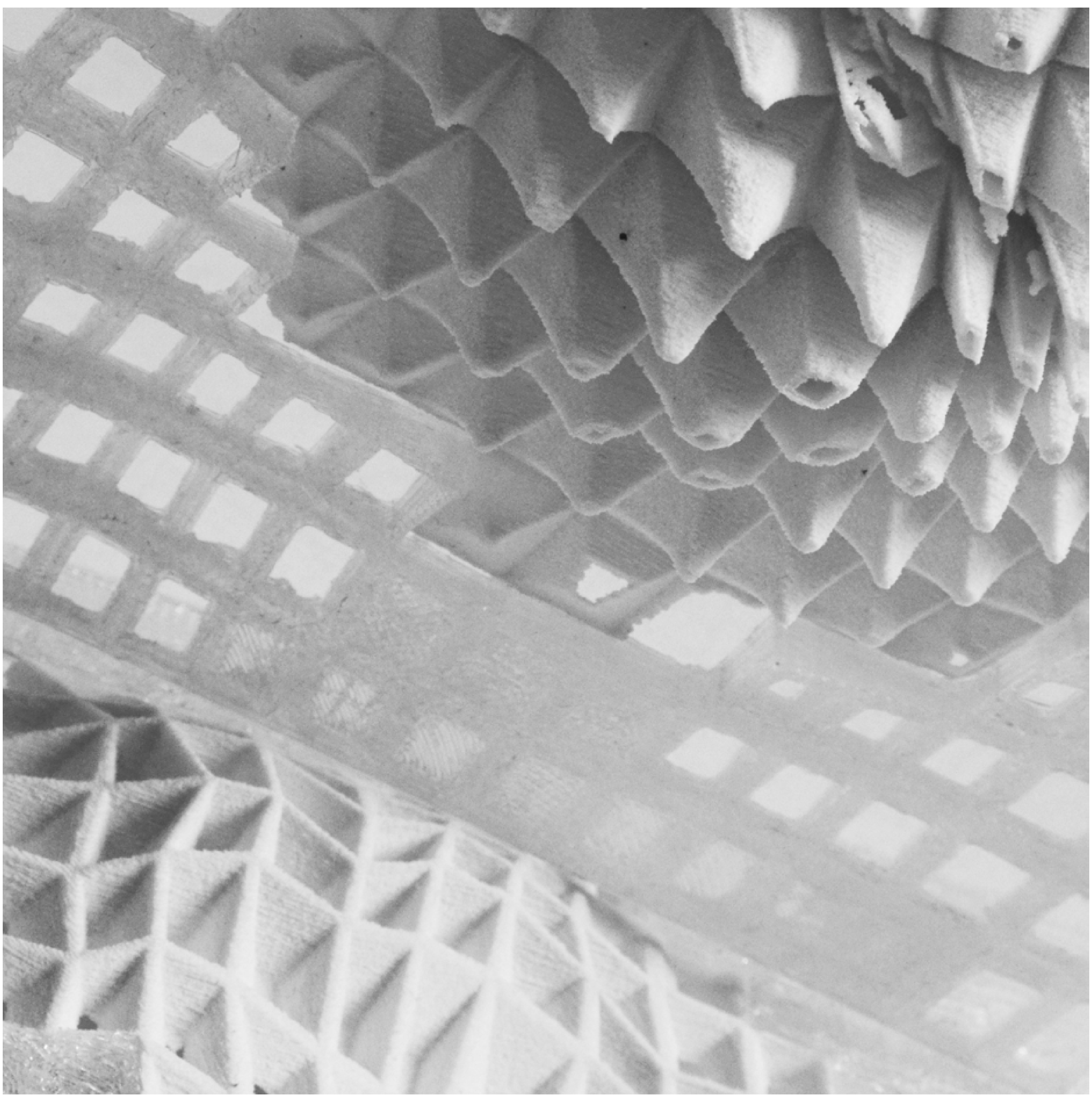
Thick matters: De-optimizing Infrastructural Redundancies, Pt. 1

Marco Ravini

THICK MATTERS

De-optimizing Infrastructural Redundancies

Senior Thesis by Marco Antonio Ravini *Primary Advisor: Julie Larsen*



Closed system design methodologies have produced infrastructures that anticipate only a single lifetime use. This approach has burdened many urban areas with defective infrastructures in need of perpetual modification and repair. Rather than continue to over-engineer these vital frameworks to *resist* the inevitable failure of individual components, the next generation of public infrastructure needs to exceed its technical specifications and seek ways to create spatial reciprocity among systems.

This thesis calls for a renewed understanding of redundancy in order to strategically infuse infrastructure with public agency and diverse utility. Such an approach has the potential to yield greater systemic outputs and a more productive lifespan, allowing future infrastructures to be positioned both as a collective good and a resilient service.

Infrastructures are inextricably linked to the development of cities and the delivery of improved living standards. These ideals are embedded within the typology of the bridge – a structure critical to the efficacy of transportation networks. Optimized to facilitate the continuous flow of people and goods, the present state of bridges forecasts a future of urban dysfunction. Over the last decade, bridges in the United States have become a significant feature in the growing crisis of public infrastructure. Built during the post-war era when the growth of transportation networks was less of an expansion and more of an explosion, many bridges have now exceeded their 50-year lifespan.

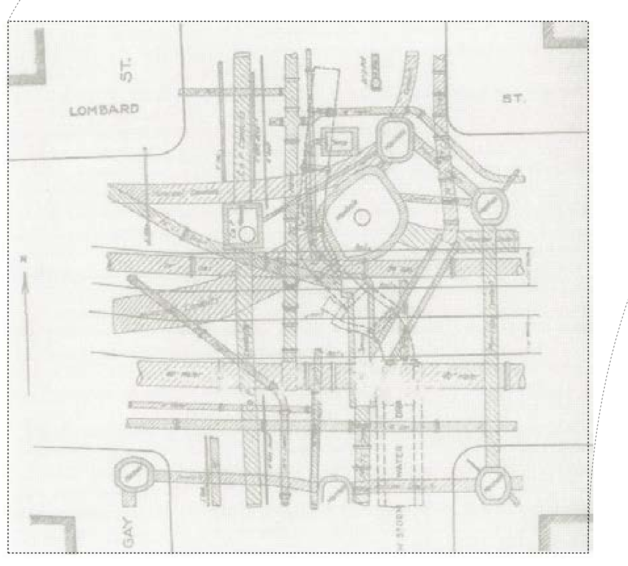
Via the prototyping and design of a new Liberty Bridge in Pittsburgh, Pennsylvania, this thesis aims to demonstrate how infrastructural thickening might enable the next generation of public works to perform as resilient systems rather than standalone structures.

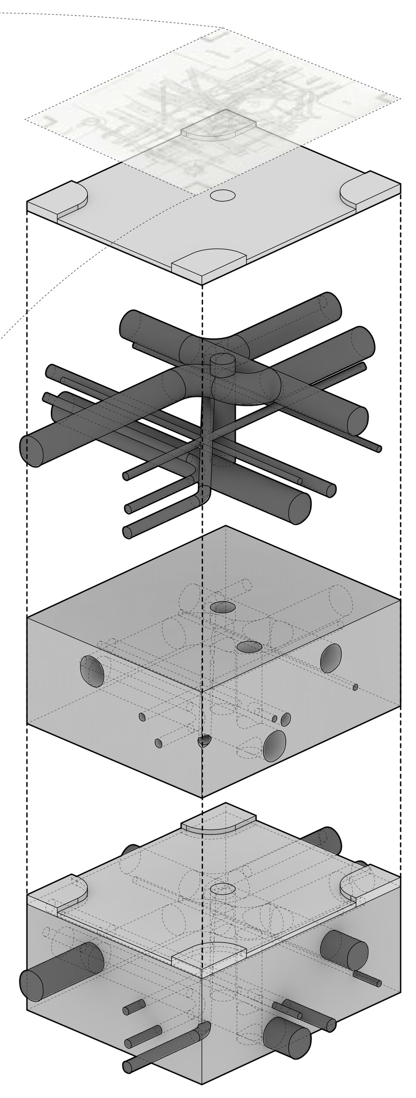
Infrastructural Thickening is the term I propose to describe a strategy that aims to modify the spatial, systemic and experiential utility of infrastructure – a strategy that works towards shifting the understanding of infrastructure from line to volume. This shift is achieved by virtue of de-optimization, a design technique that seeks to augment engineered specifications into scenarios for inhabitation, participation and added value.

In pursuit of infrastructural thickening, this thesis explores relationships between structure, space and form as a means to generate redundancies that have the capacity to address issues beyond the bridge's physical footprint. Topics such as storm water run-off, waste management, and public space are central to the design agenda. In response to these urgent issues, a system of structural cones is deployed that mediate flows of water, cars and people into a unified, heterogeneous interlace.

This thesis envisions the next generation of infrastructure as thick matter – a new public territory that provides people the oppurtunity to engage and participate in mutually productive dialogues with issues of urban, spatial and environmental urgency.

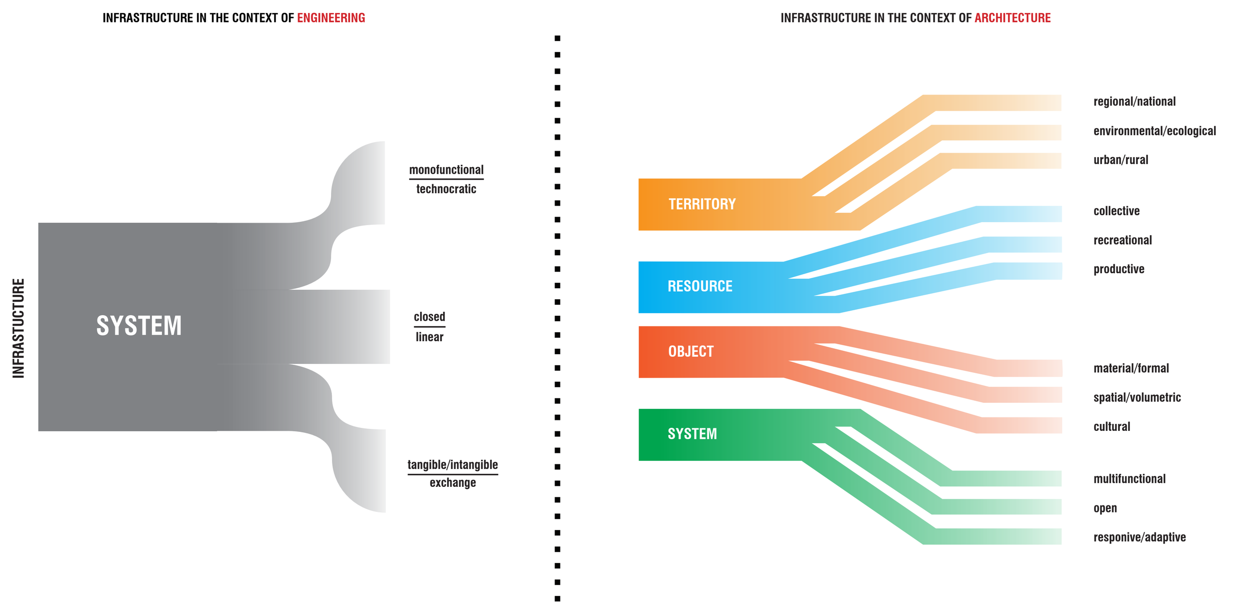
Founding Diagram: The invisible city of Infrastructure





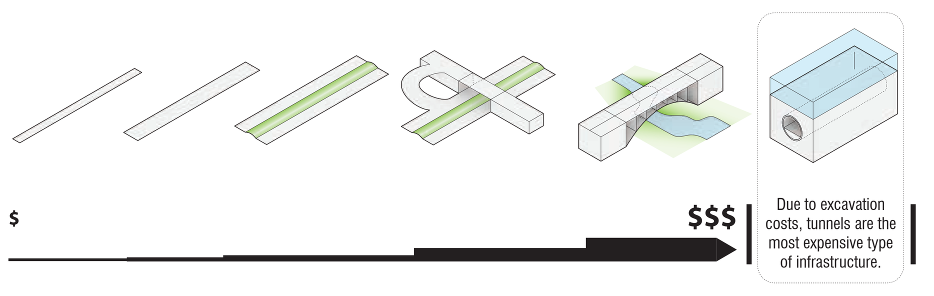
Lewis Mumford's Invisible City (*note: The hidden pipes and conduits at the junction of Gay and Lombard Streets in Baltimore, 1908)

Contextualizing Infrastructure

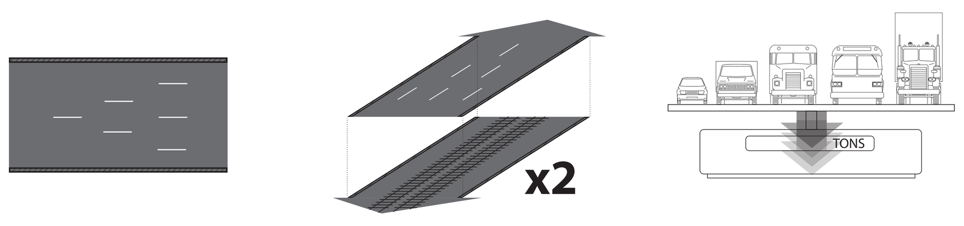


The Bridge Problem

WHY THE BRIDGE?



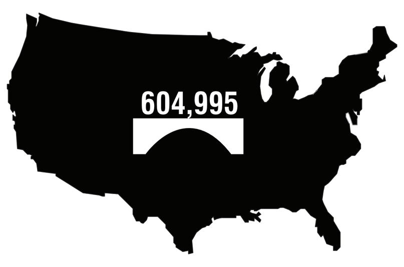
It is the highest cost per mile of the system (after tunnels)



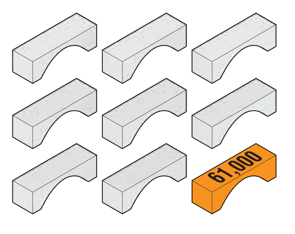
It controls the capacity of the system (Type, Weight and Volume)

If the bridge fails, the system FAILS

Bridge Crisis in the U.S.



National Highway System Bridge Inventory

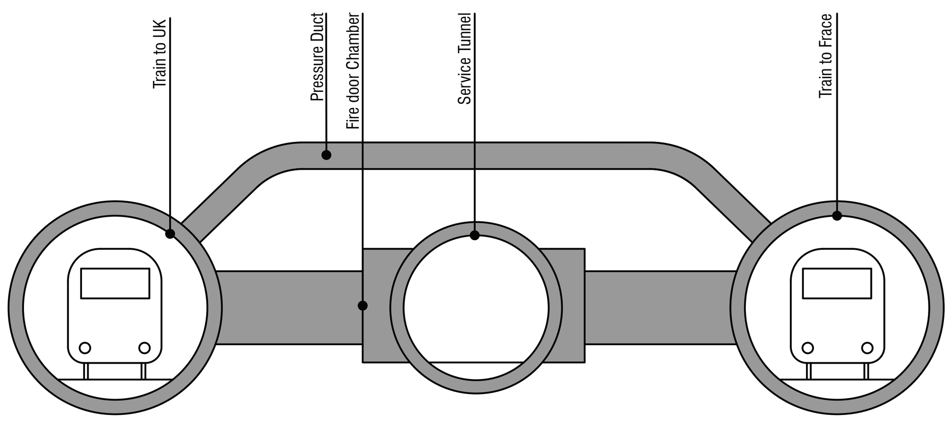


1/9 Ratio bridges is structurally deficient (SD)

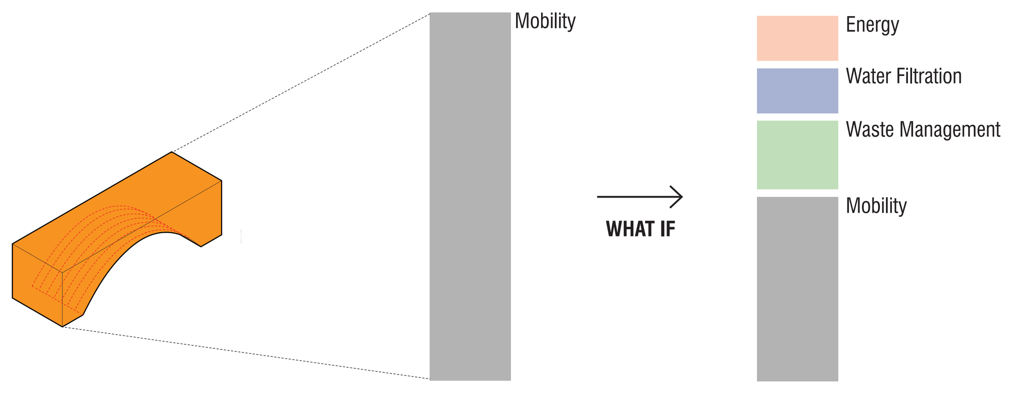
Average Age of Bridges (yrs)

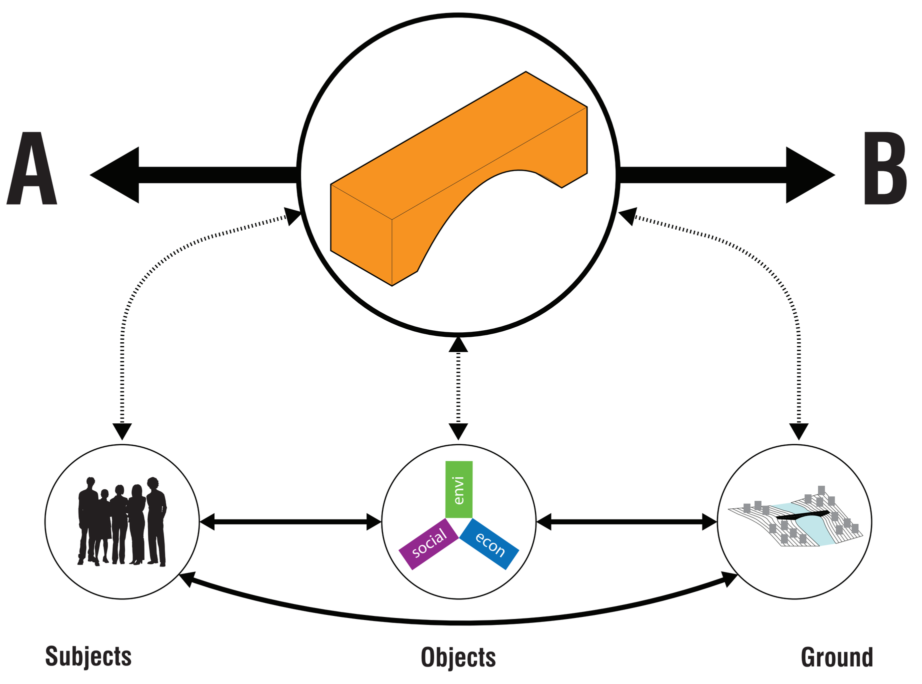
Engineered Redundancies

Designing the Chunnel



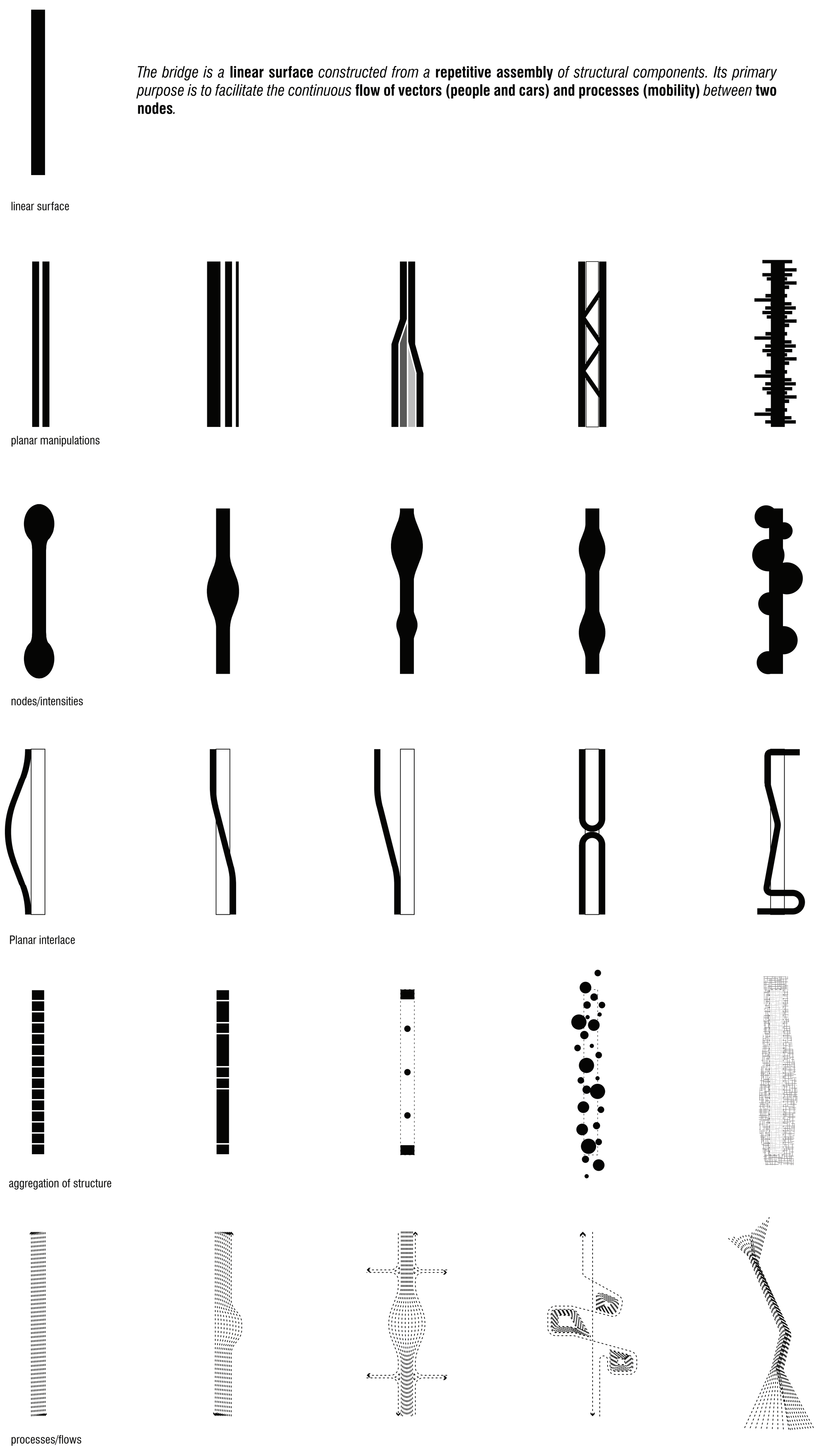
Redundancies beyond idleness



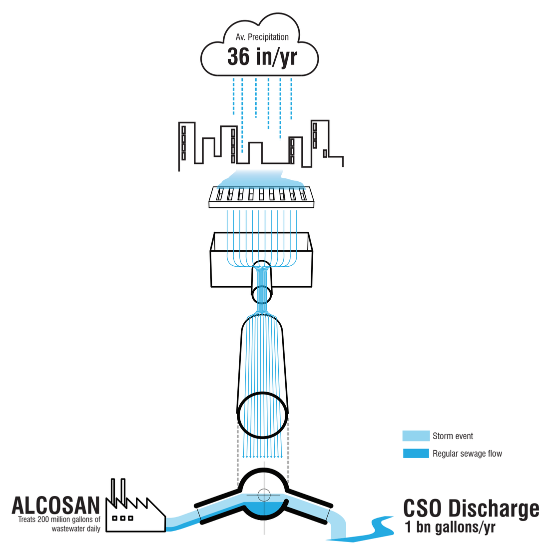


Design Technique: De-Optimization

The bridge is a **linear surface** *constructed from a* **repetitive assembly** *of structural components. Its primary purpose is to facilitate the continuous* **flow of vectors (people and cars) and processes (mobility)** *between* **two nodes.**



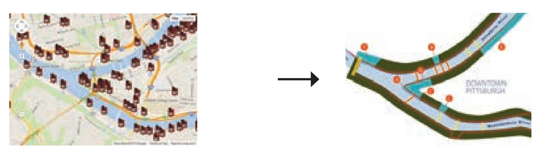
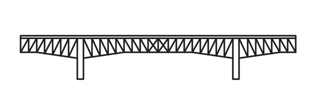
Pittsburgh: City of Bridges...and aging sewer systems



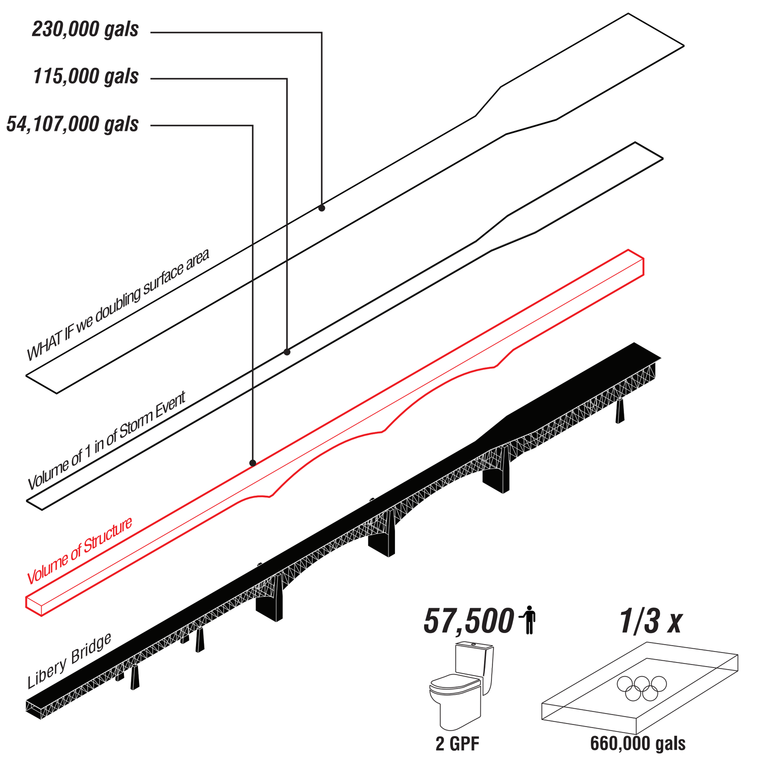
CSO is burden by 36 in of annual rainfall

Liberty Bridge is being prepped by an advertising campaing to pressure congress ito increase its investmenet for infrastructure

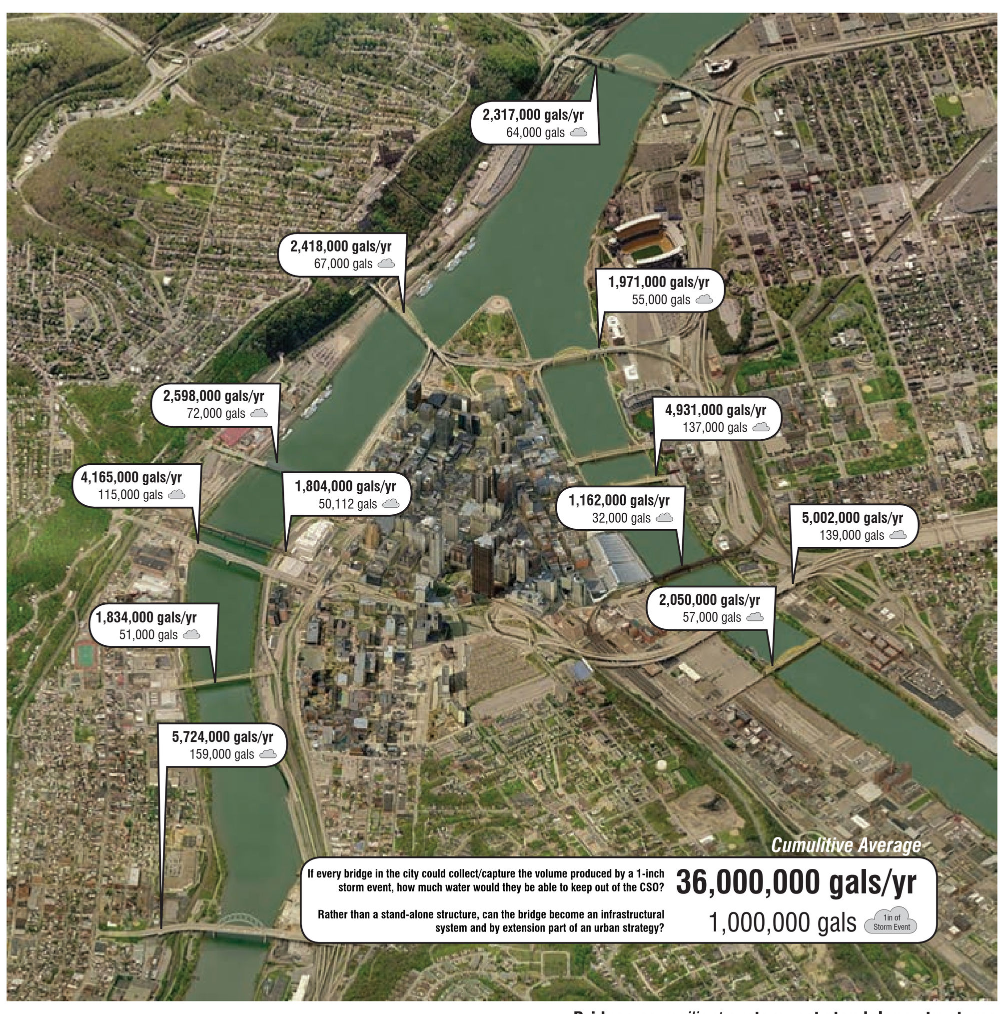
Changing Perceptions

PAST			PRESENT
Steel Production		→	Technology, Healthcare and Education
Riverfront with heavy industry		→	Riverfront Revitalization
Industrial Typology		→ ?????	Post-industrial era

Bridge Prototype: Storm water run-off, Waste management, and Public Space

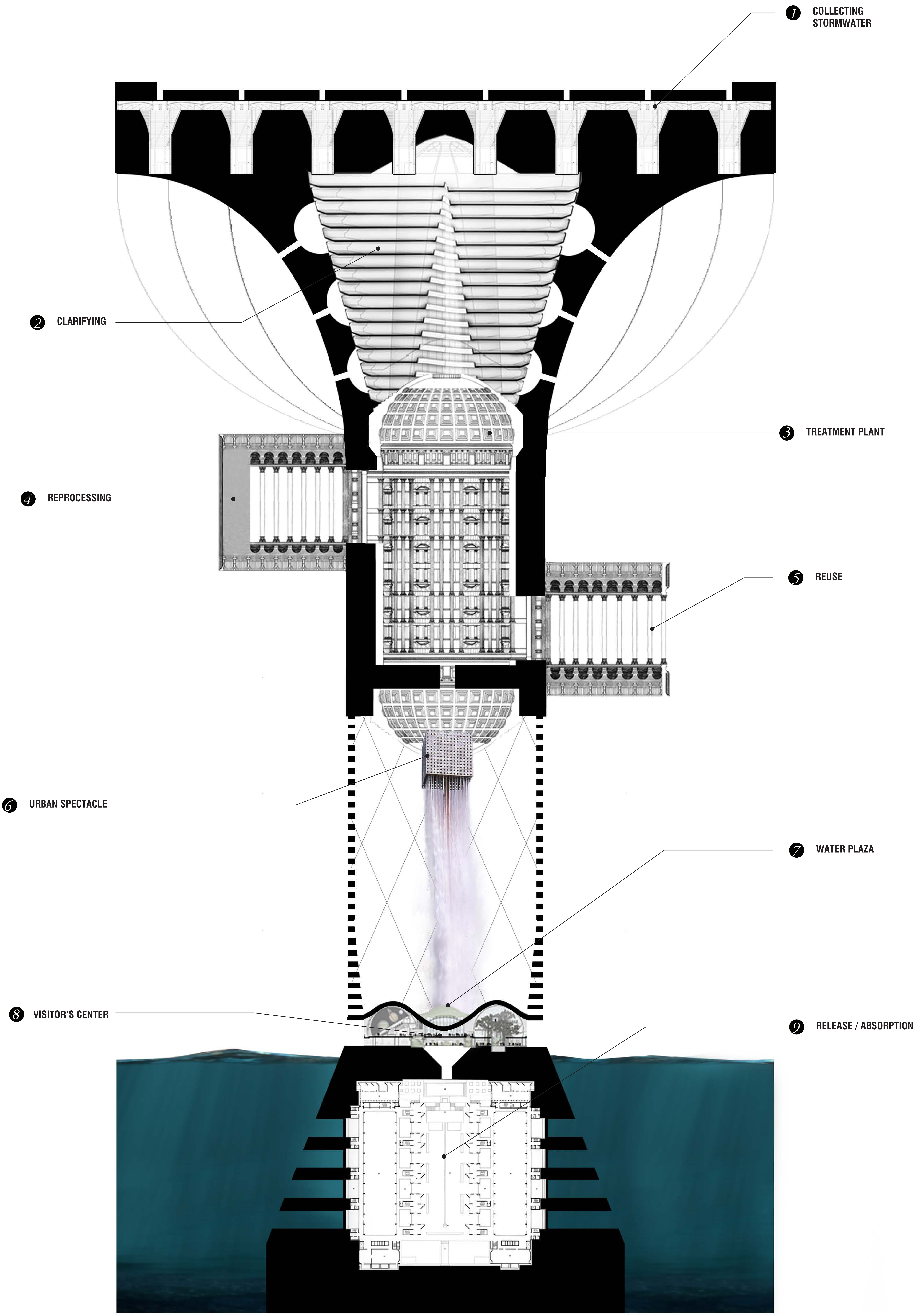


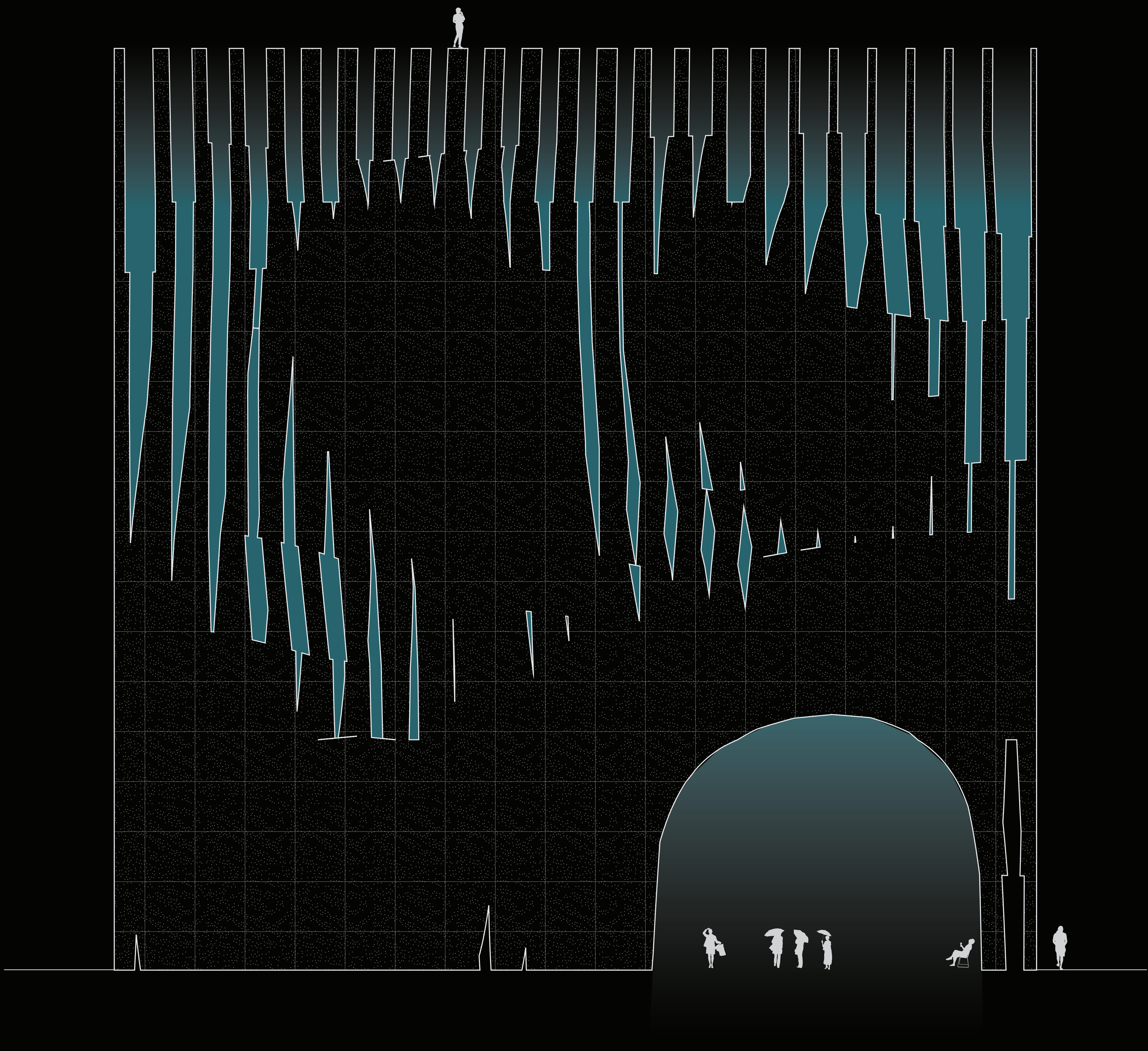
Could a bridge go beyond its physical footprint and address issues that have urban, ecological and spatial implications?

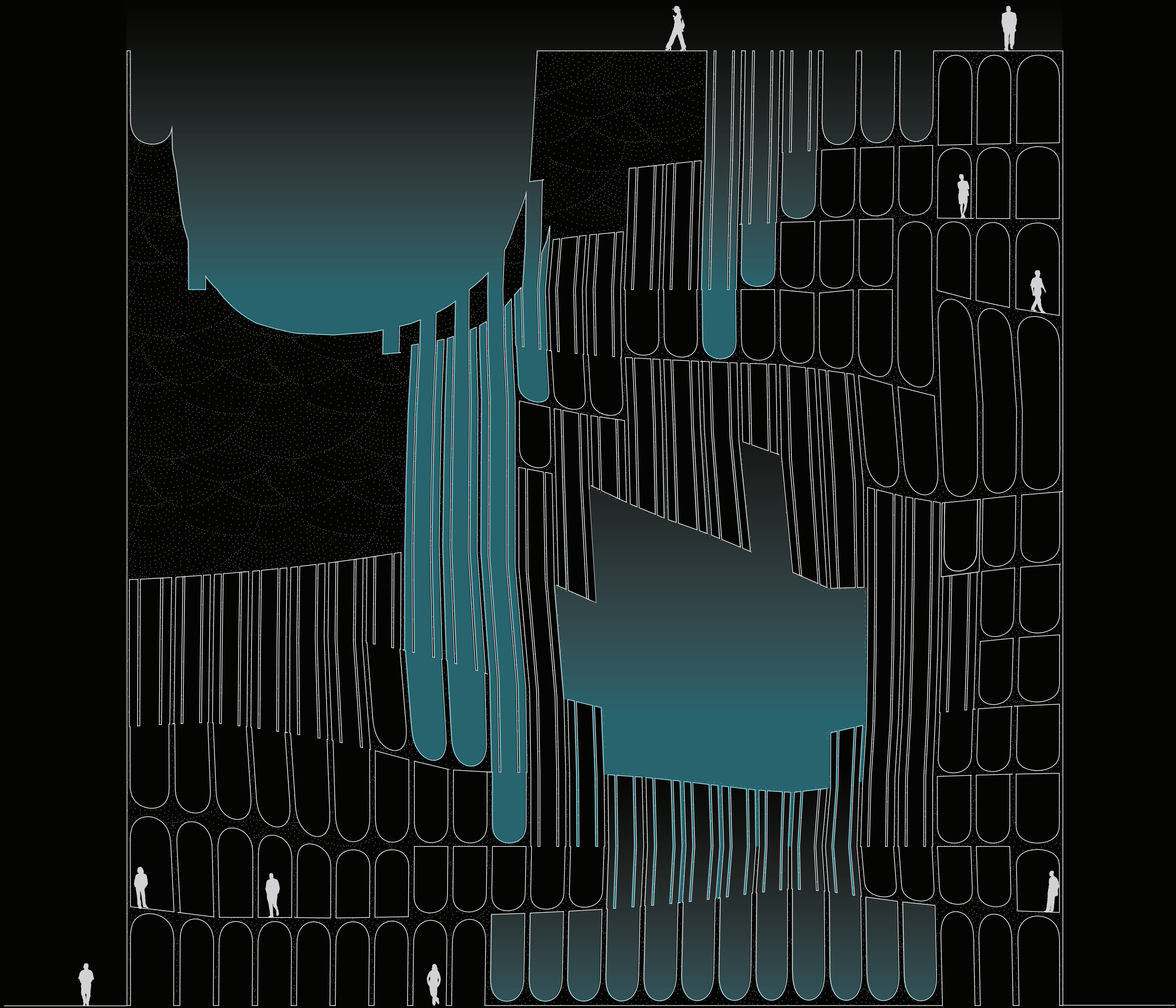


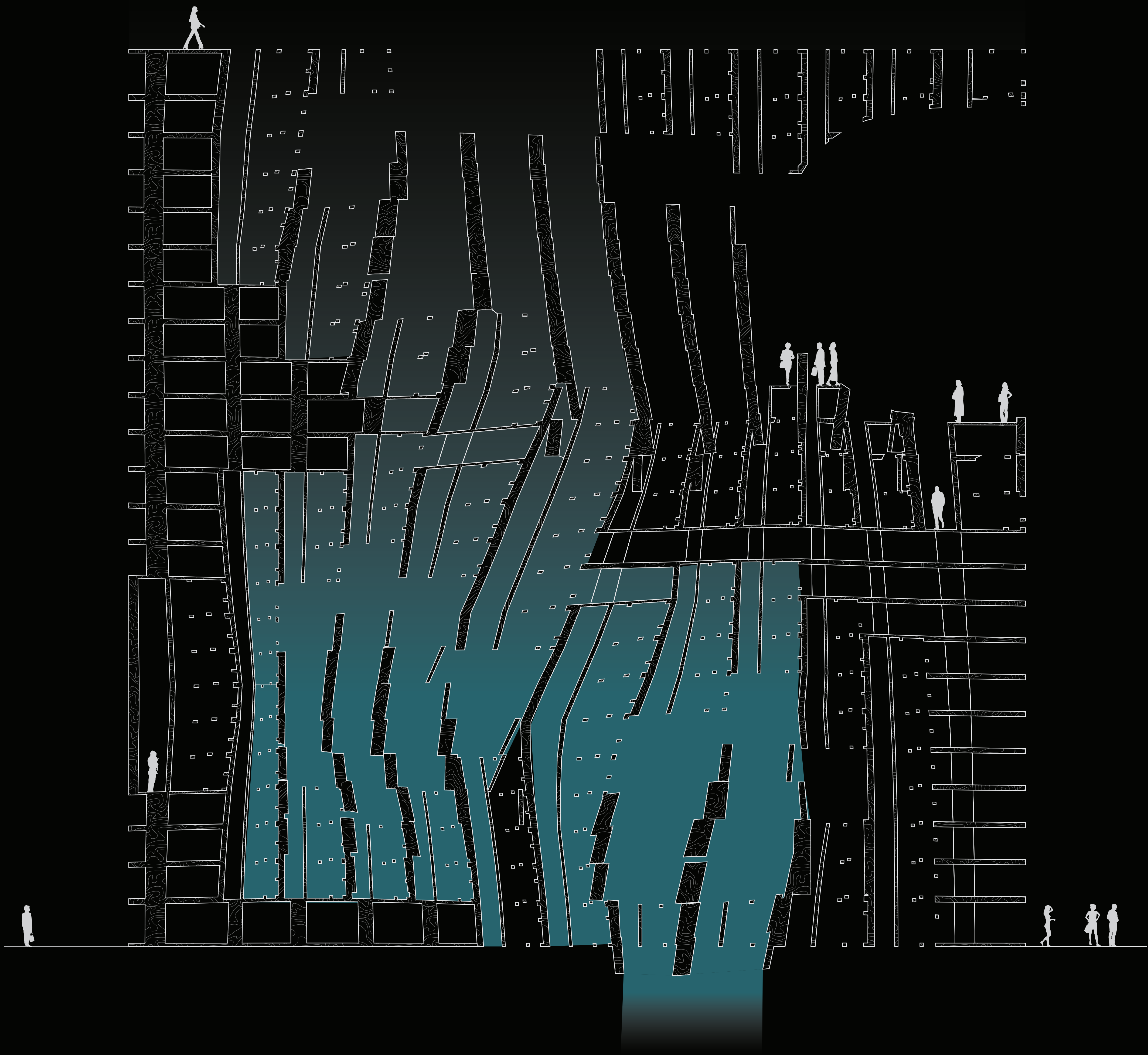
Bridges as *resilient* system, not standalone structures

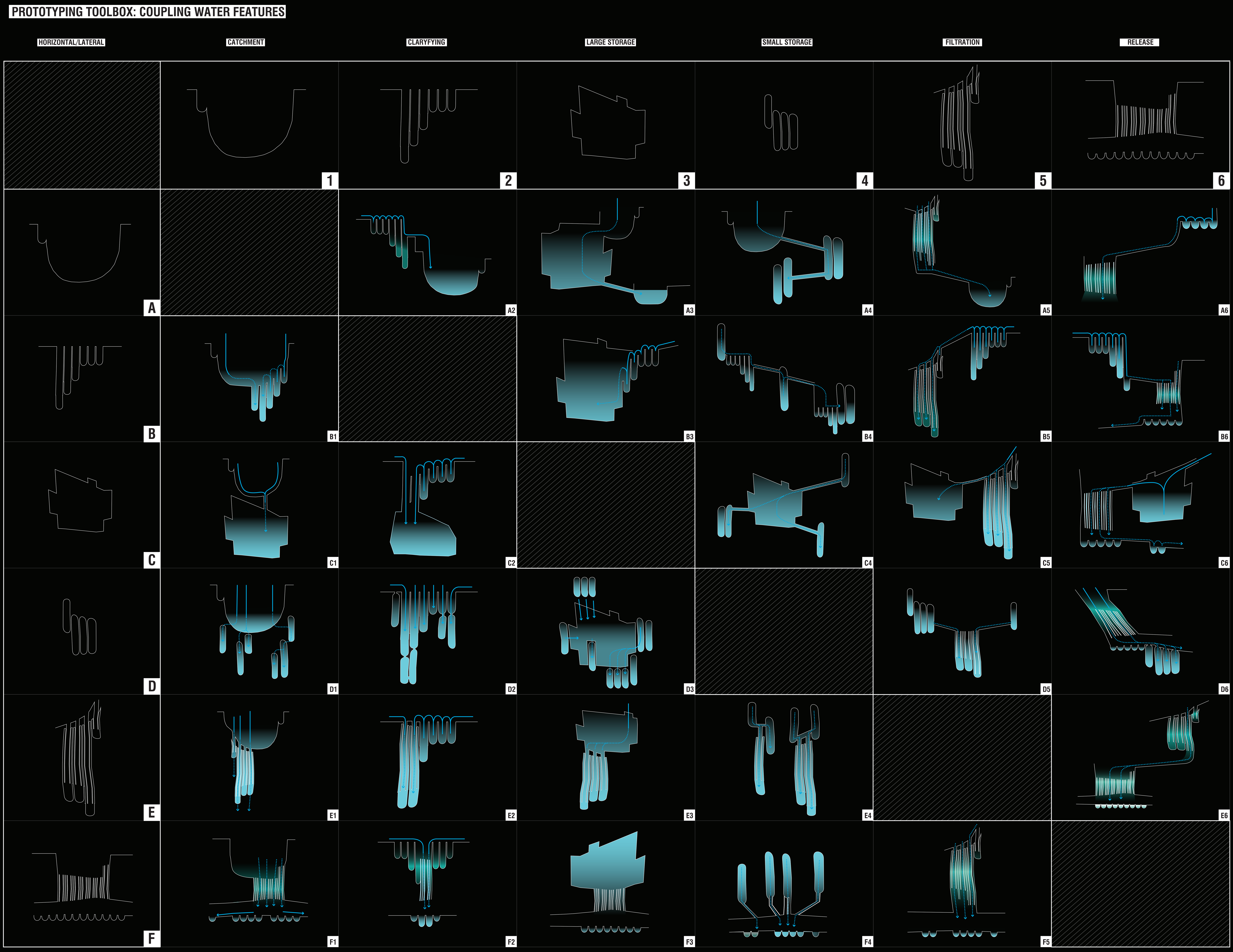
MECHANIZING THE PIER










PROTOTYPING TOOLBOX: COUPLING WATER FEATURES
HORIZONTAL/LATERAL
CATCHMENT
CLARYFYING
LARGE STORAGE
SMALL STORAGE
FILTRATION
RELEASE
VERTICAL
CATCHMENT
CLARYFYING
LARGE STORAGE
SMALL STORAGE
FILTRATION
RELEASE
1
2
3
4
5
6
A
A2
A3
A4
A5
A6
B
B1
B3
B4
B5
B6
C
C1
C2
C4
C5
C6
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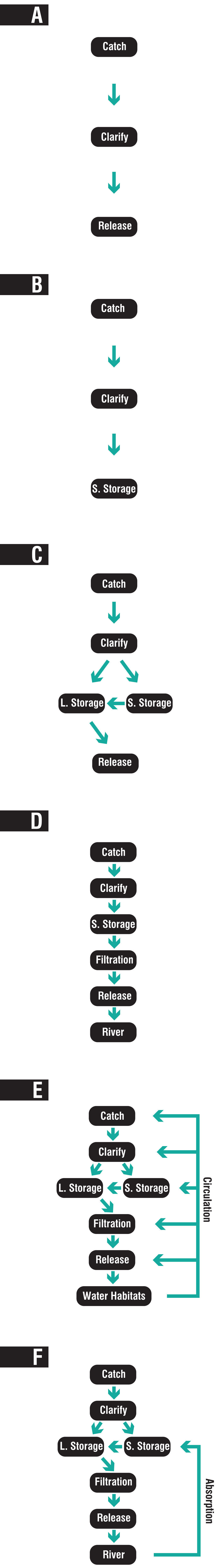
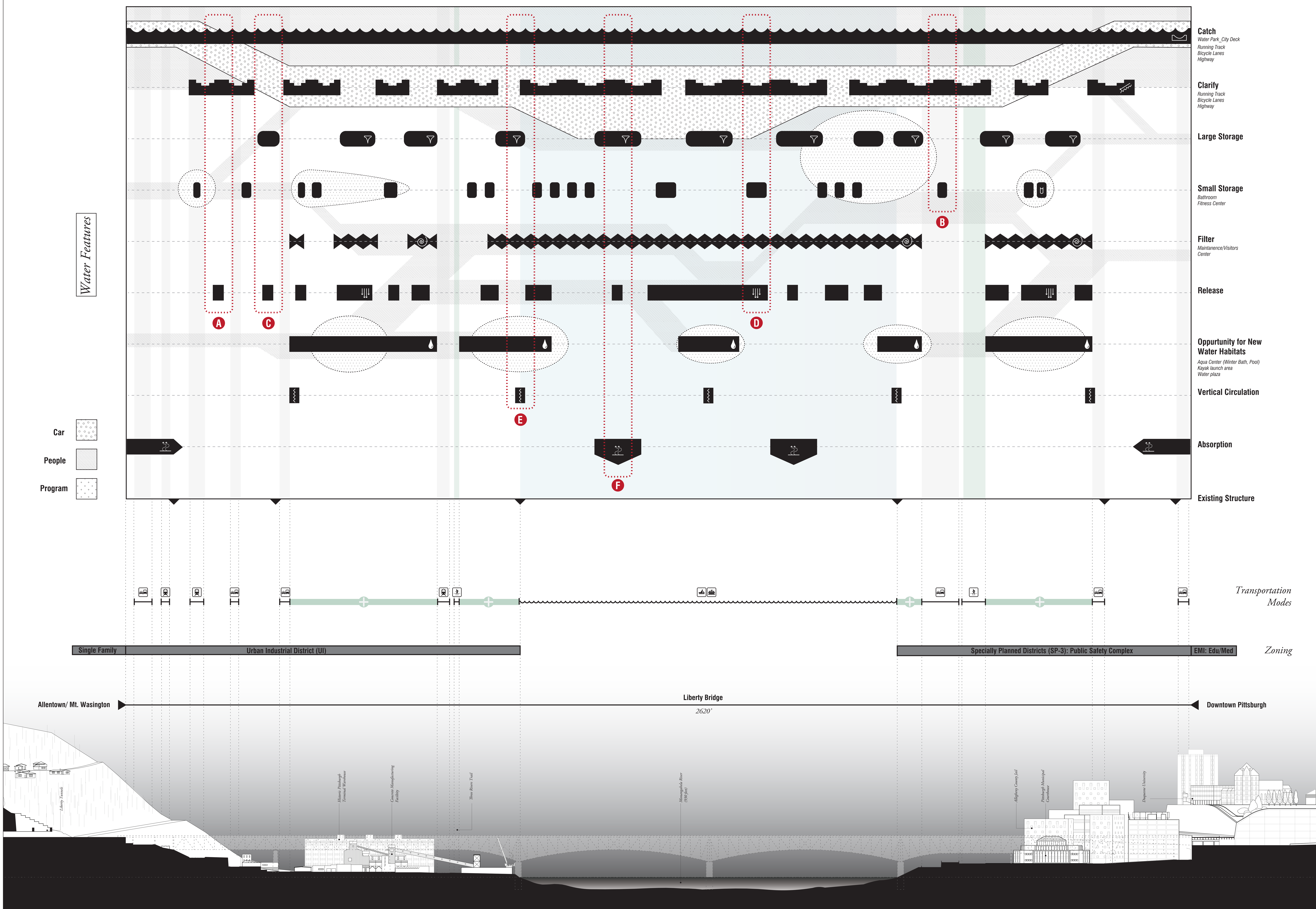
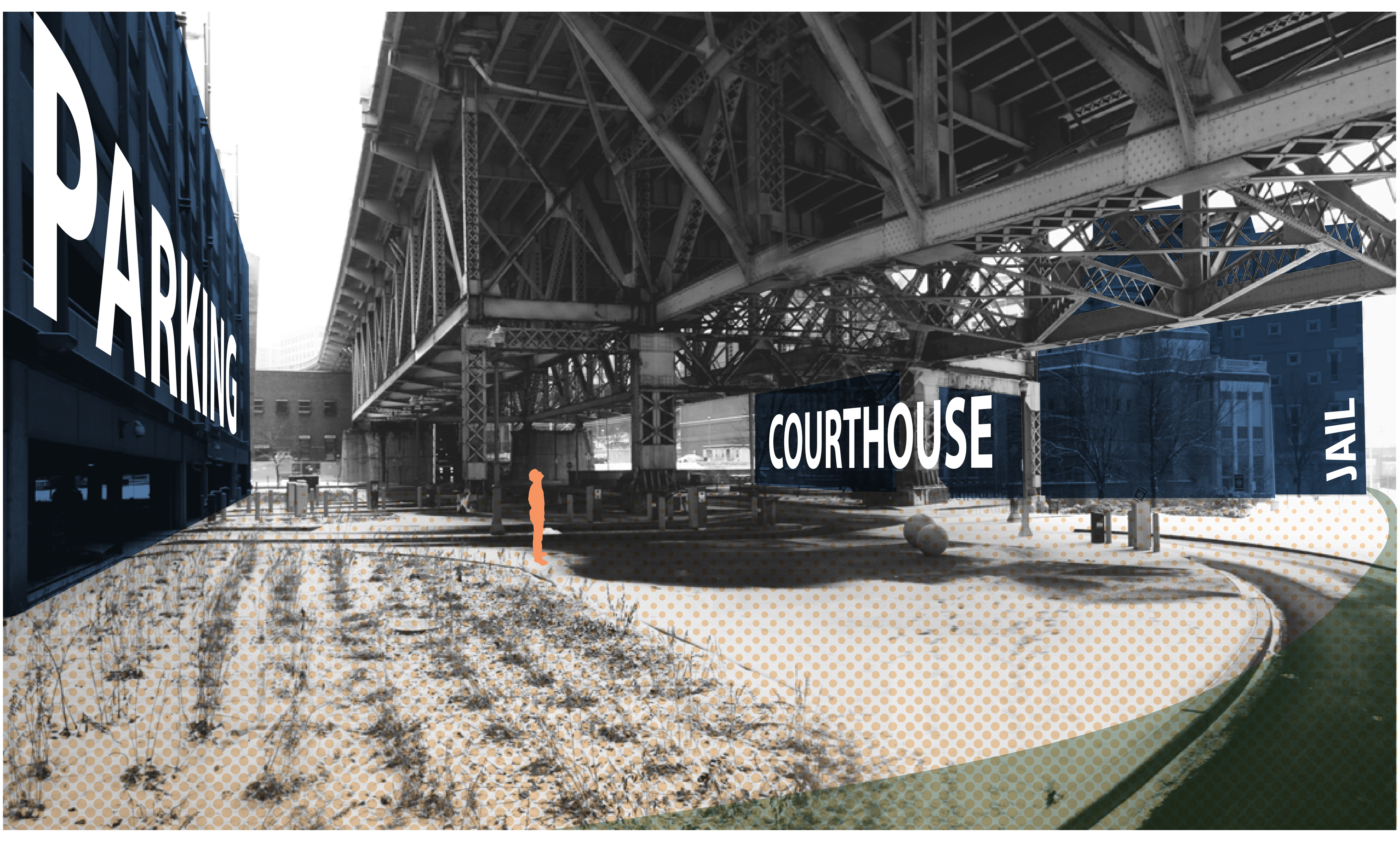
F5

TAXONOMY OF WATER FEATURES: Speculating Systemic, Spatial and Programmatic Synergies






PARKING
COURTHOUSE
JAIL

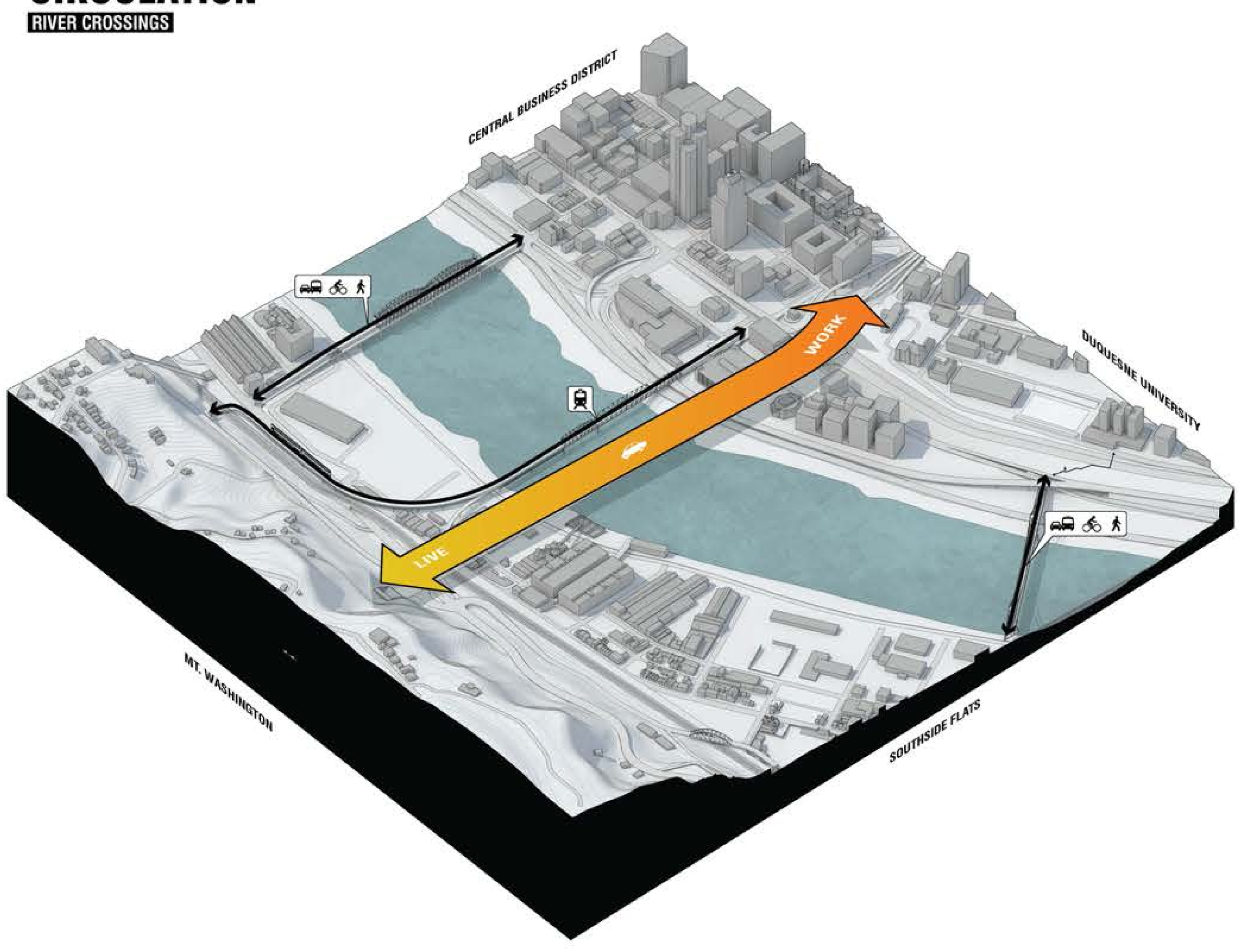

RAINWATER / SNOWMELT
RUN-OFF
CSO


STATION SQ.
DOWNTOWN
PARKING
JAIL
DUQUESNE UNI.

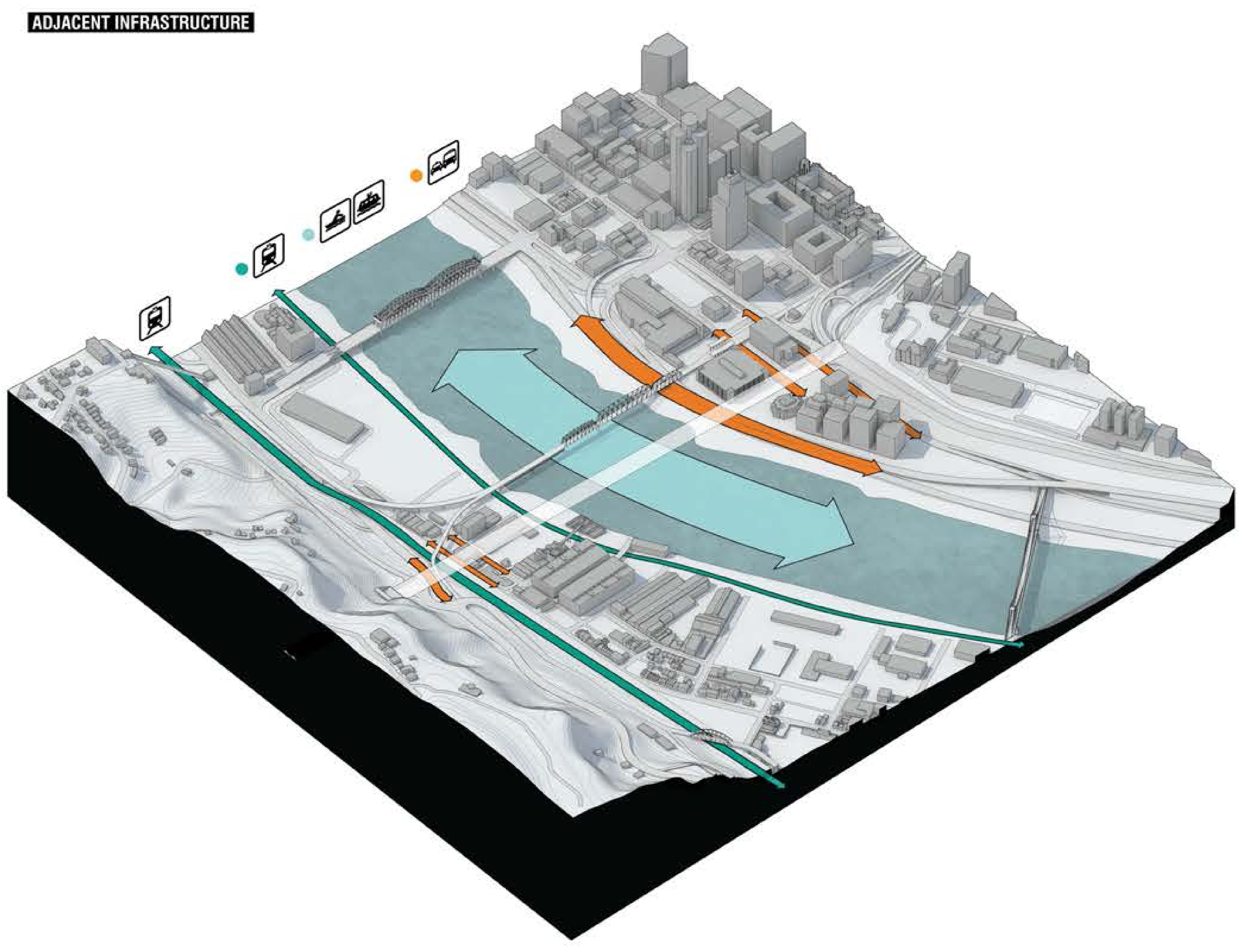

THREE RIVERS PARK TRAIL


TERMINAL BUILDING
STORAGE WAREHOUSE

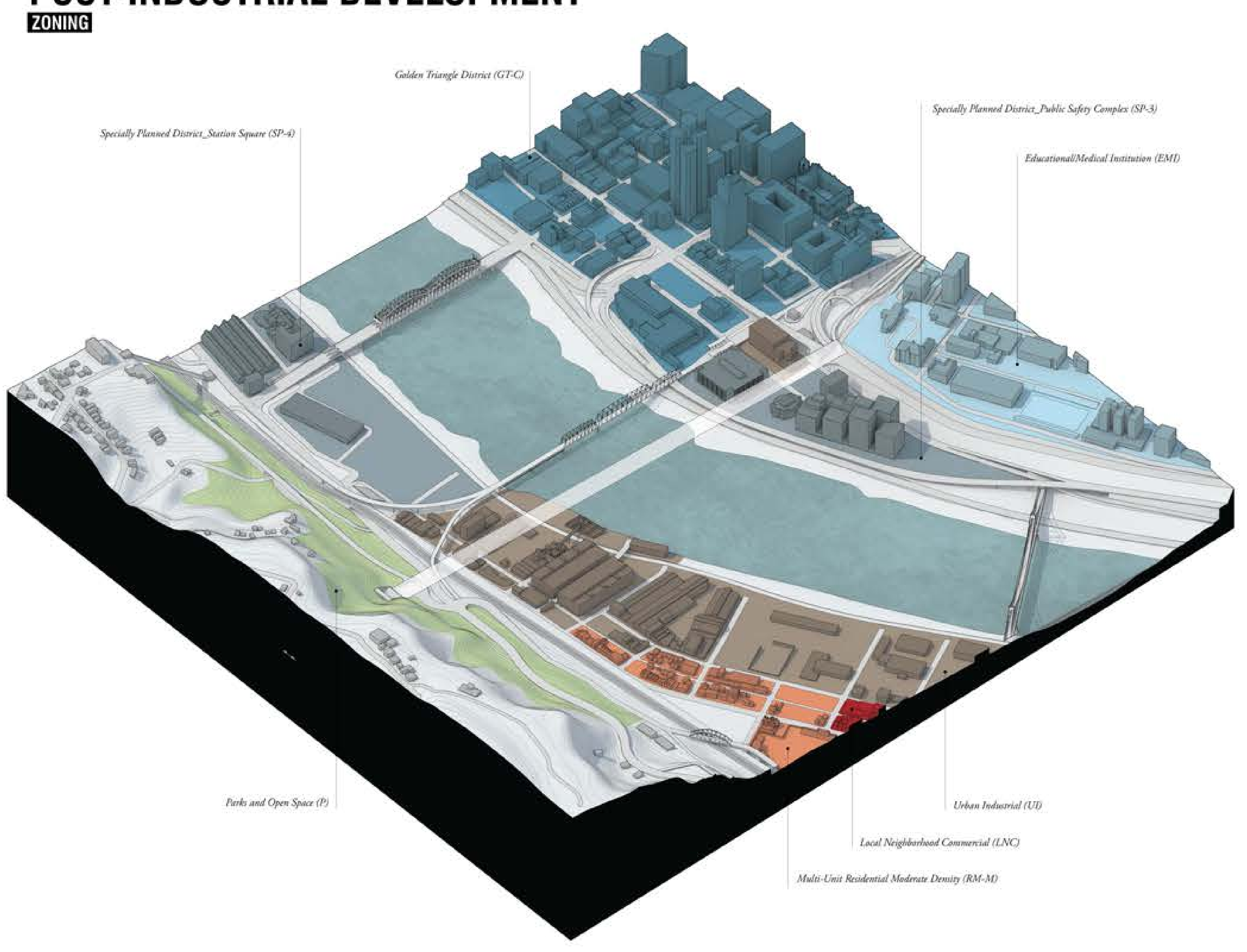
CIRCULATION
RIVER CROSSINGS



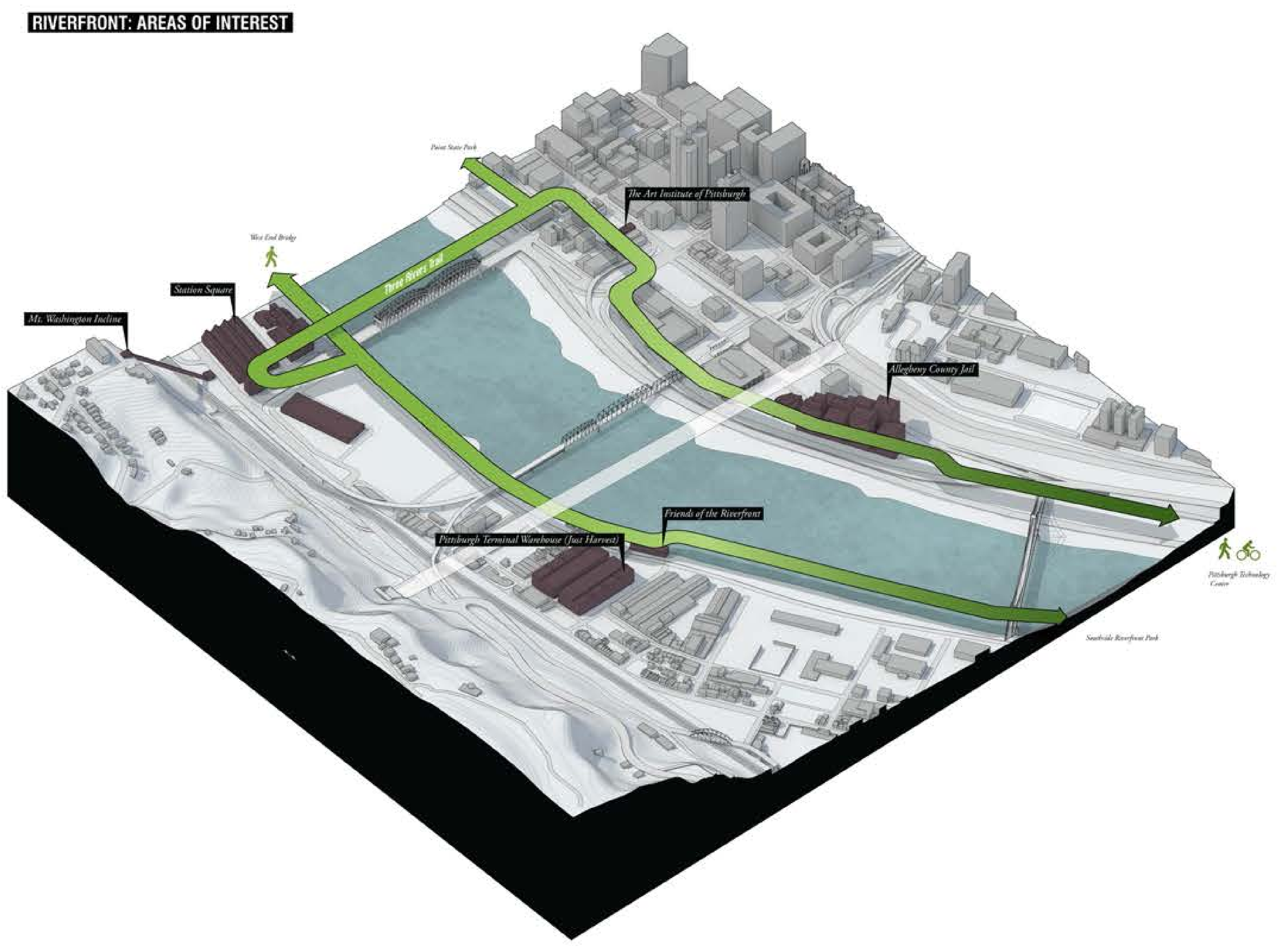
ADJACENT INFRASTRUCTURE



POST-INDUSTRIAL DEVELOPMENT
ZONING



RIVERFRONT: AREAS OF INTEREST



SANITATION and RUN-OFF ISSUES
SURFACE HYDROLOGY

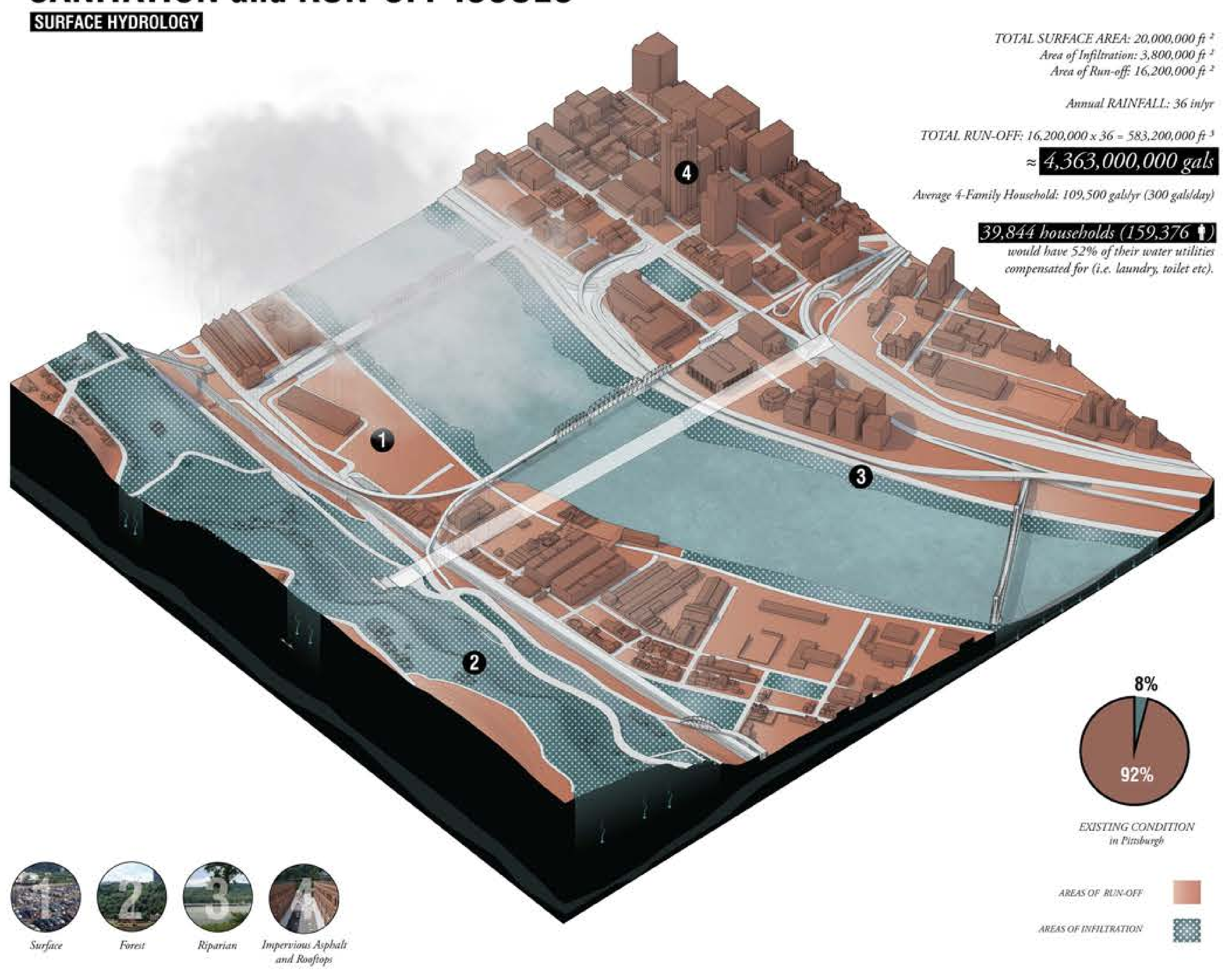
TOTAL SURFACE AREA: 20,000,000 ft^2
Area of Infiltration: 3,800,000 ft^2
Area of Run-off: 16,200,000 ft^2

Annual RAINFALL: 36 in/yr

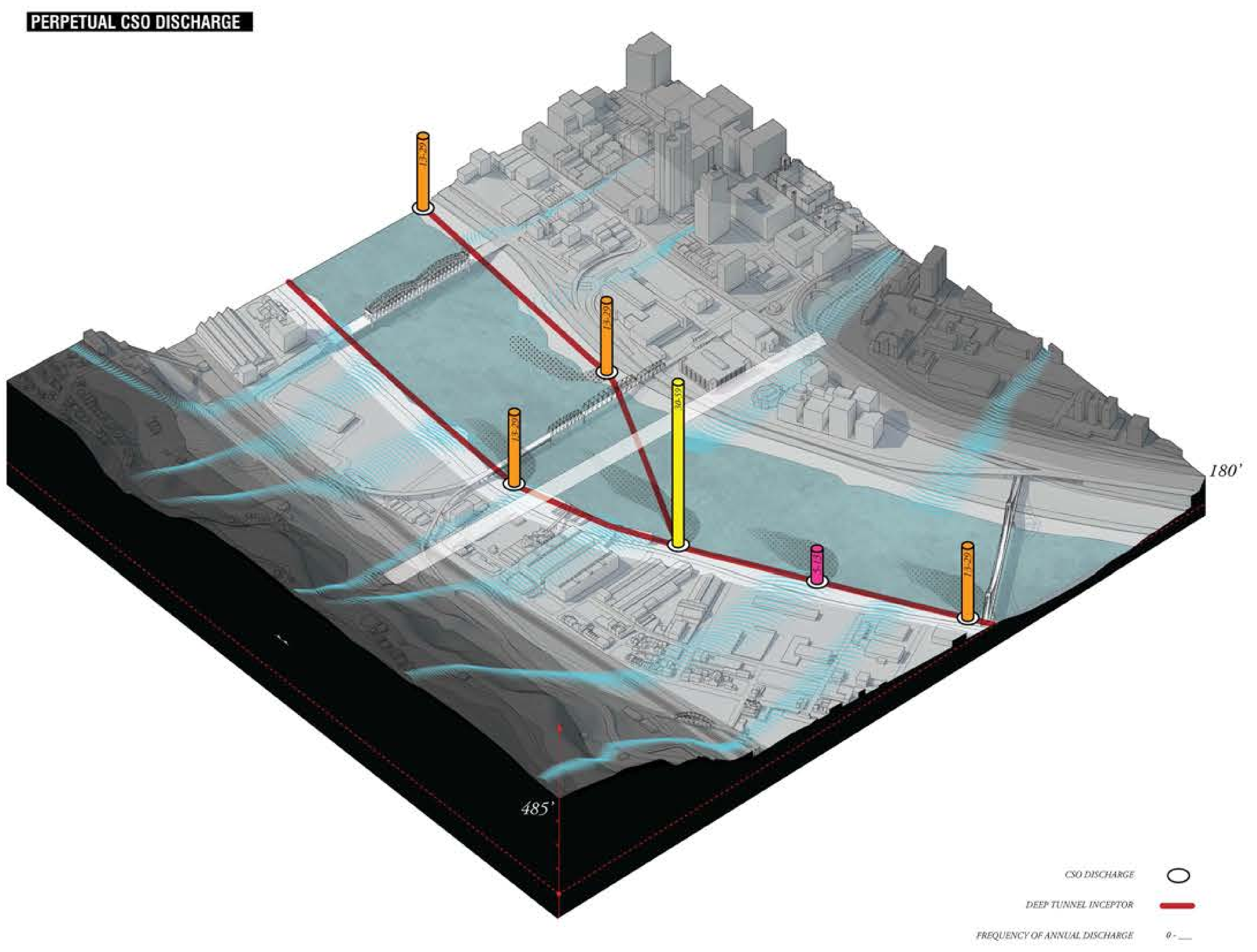
TOTAL RUN-OFF: 16,200,000 x 36 = 583,200,000 ft^3
≈ 4,363,000,000 gals

Average 4-Family Household: 109,500 gals/yr (300 gals/day)

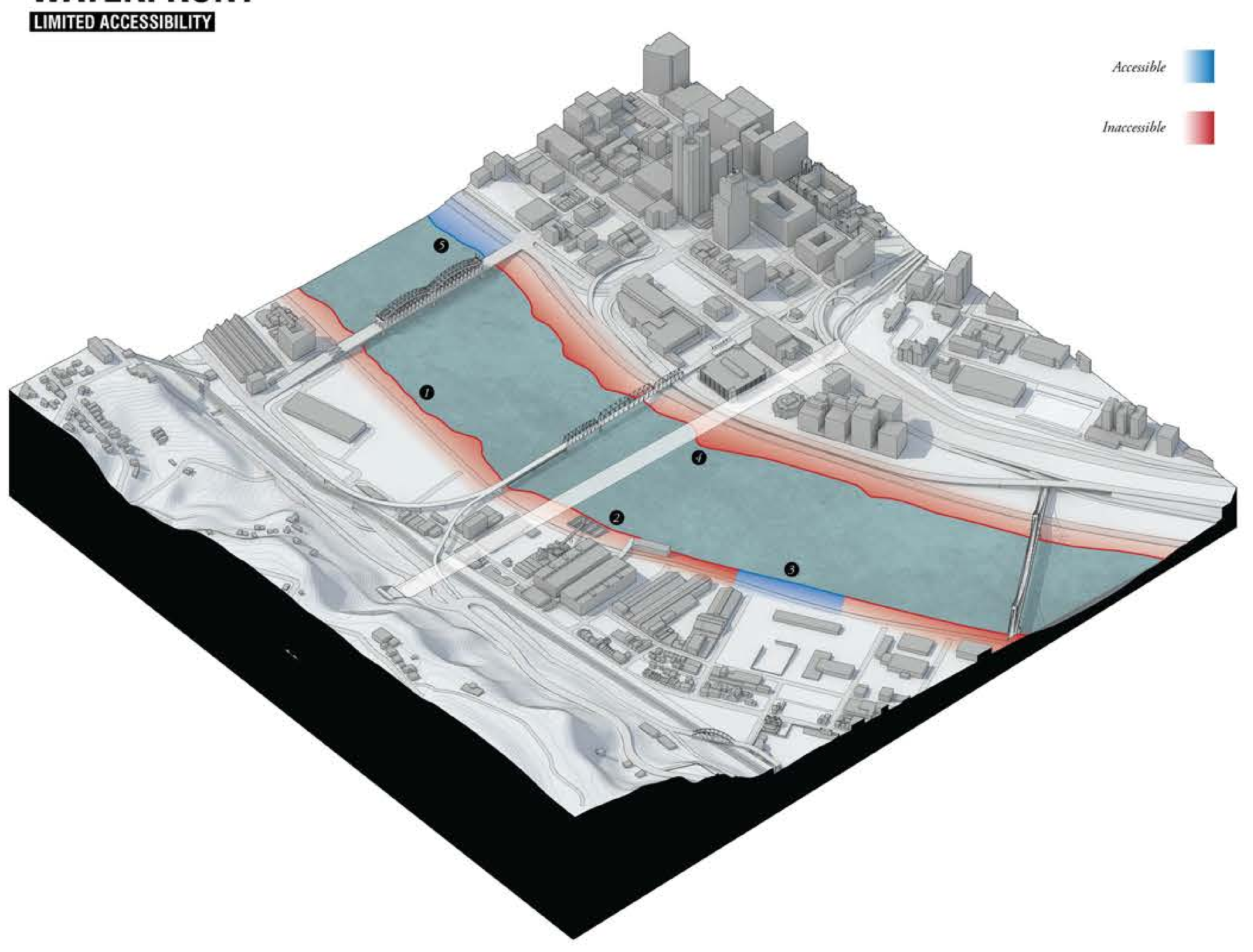
39,844 households (159,376)
would have 52% of their water utilities compensated for (i.e. laundry, toilet etc).

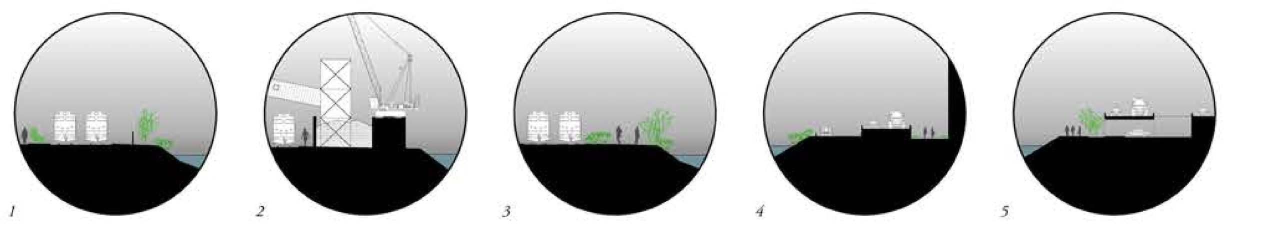


PERPETUAL CSO DISCHARGE

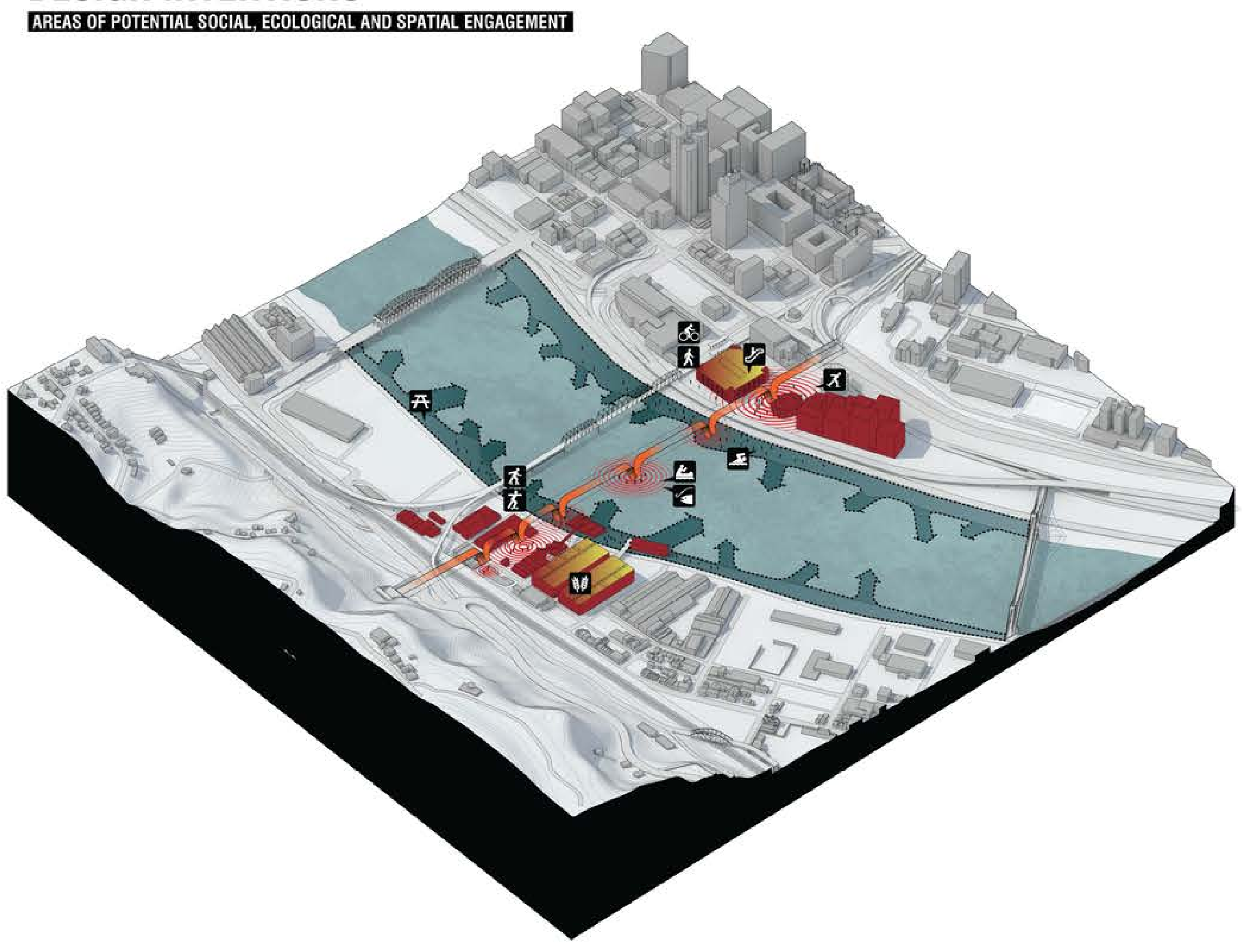


WATERFRONT
LIMITED ACCESSIBILITY

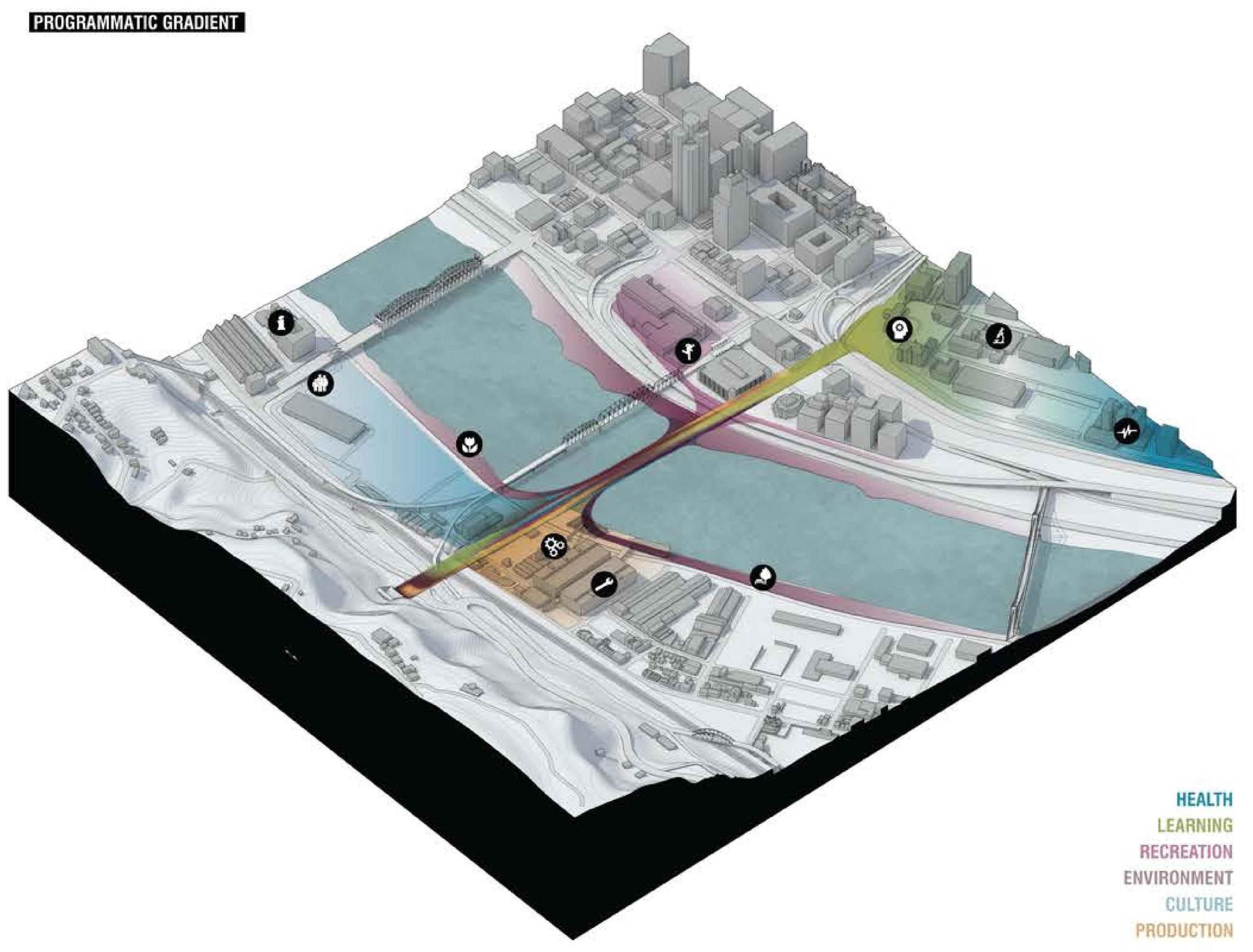




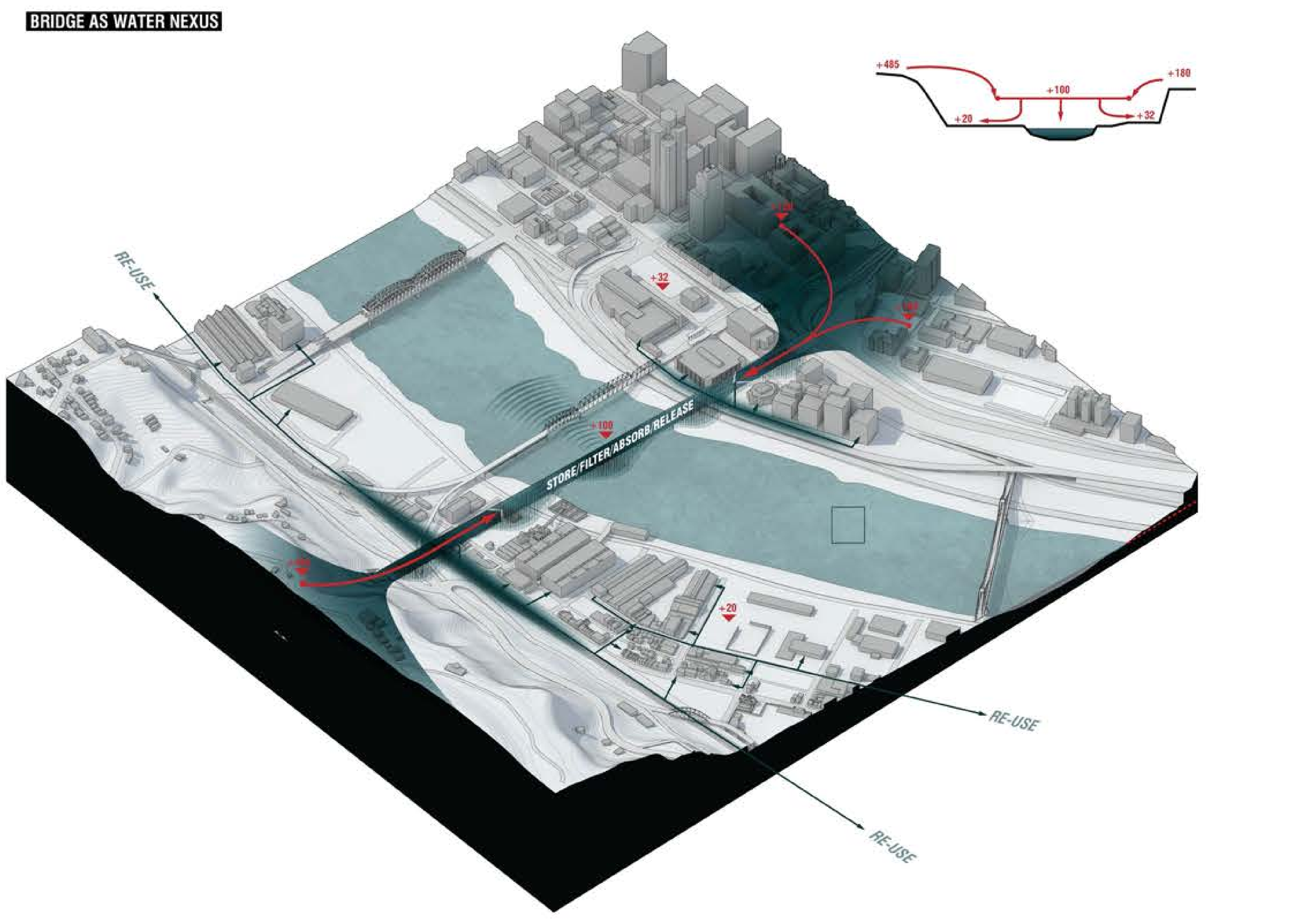
DESIGN INTENTIONS
AREAS OF POTENTIAL SOCIAL, ECOLOGICAL AND SPATIAL ENGAGEMENT



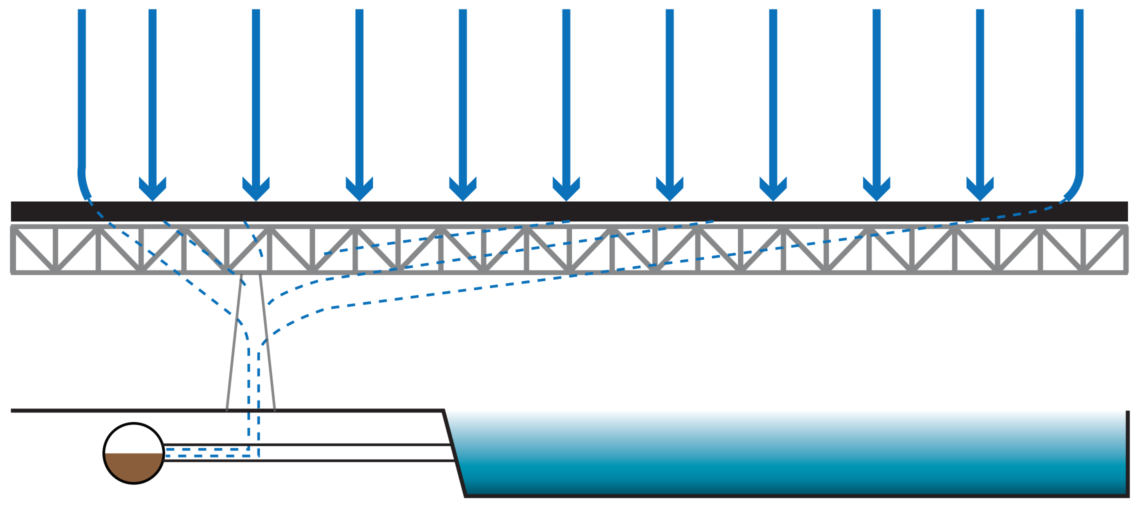
PROGRAMMATIC GRADIENT



BRIDGE AS WATER NEXUS



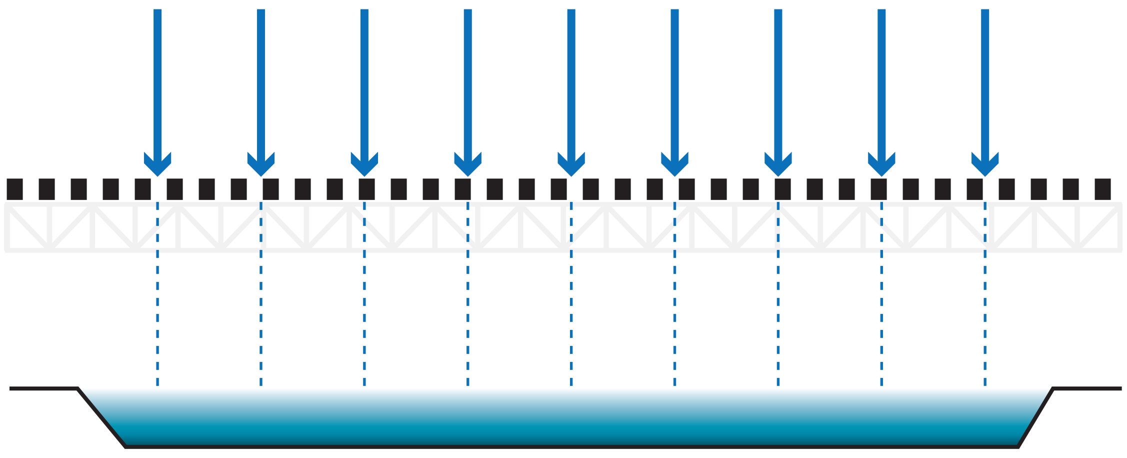
BRIDGE DE-OPTIMIZATION

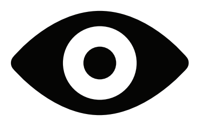


WHAT RAINWATER IS FORCED TO DO...

HIDDEN

EXISTING



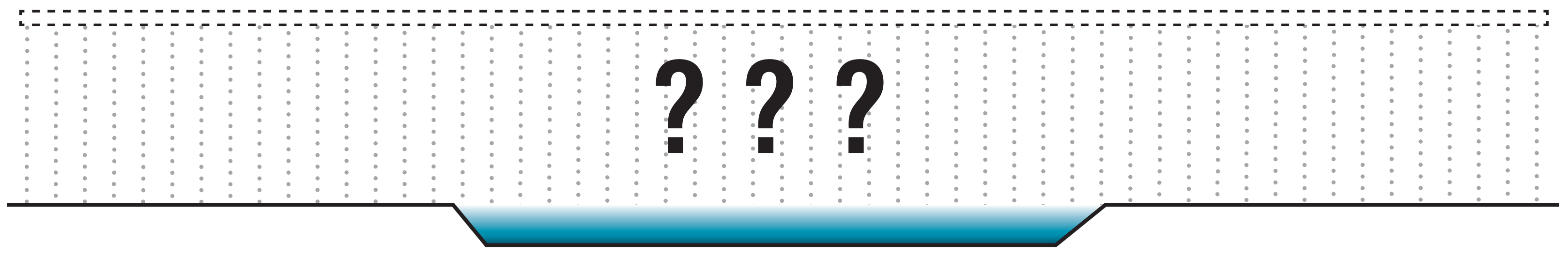


WHAT RAINWATER **WANTS** TO DO...

Percolate vertically and re-enter the hydrological system in order to recharge the aquifer

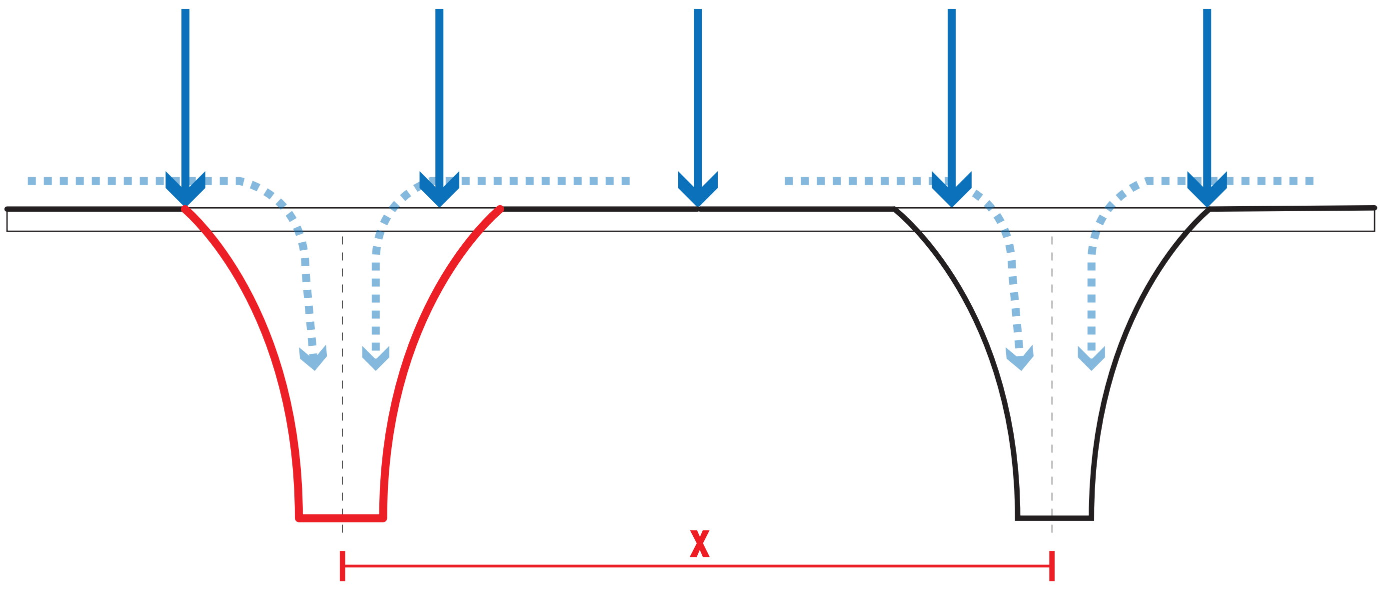
VISIBLE

PROPOSED



Since a bridge is fundamentally an aggregate of structural modules, how can we utilize structure to maximize surface porosity and also facilitate rainwater flow?

Approach: Utilize existing spacing of **vertical superstructure** to capture, convey, store, filter and release rainwater run-off

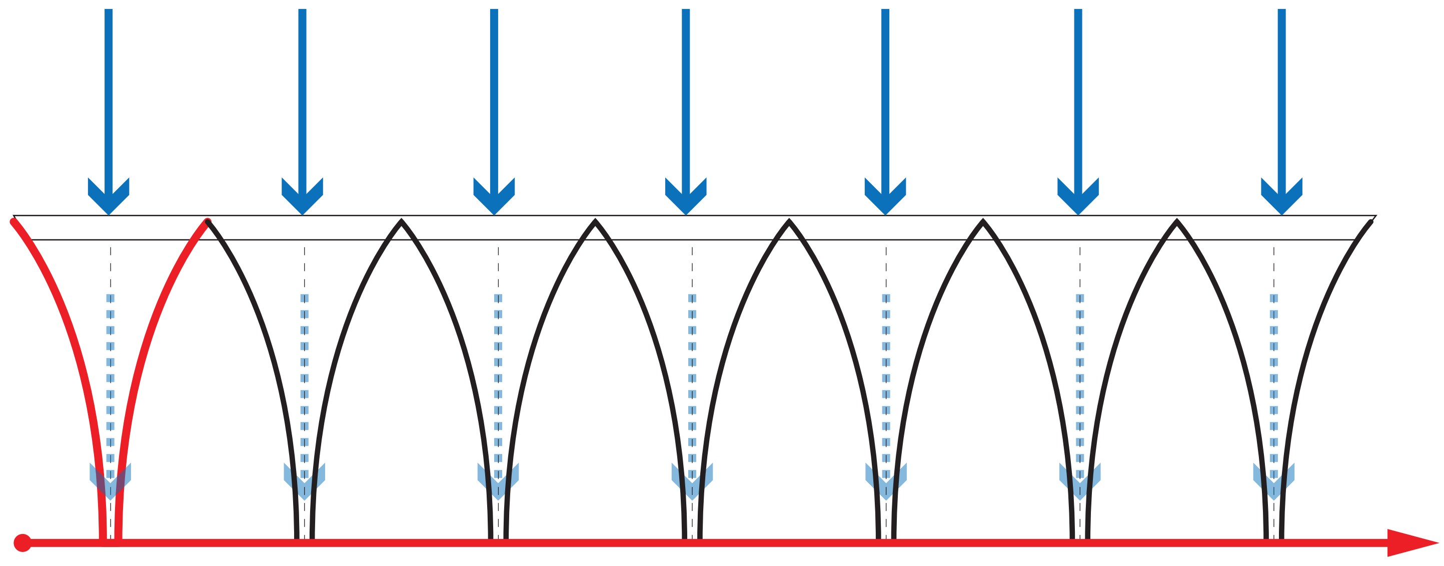


Mimicking the existing trabeated pier spacing

Increases Surface Porosity BUT forces the Structural footprint to Increase

(Maintains some horizontality for vehicular and people)

OPTION 1



Horizontal aggregation of vertical elements

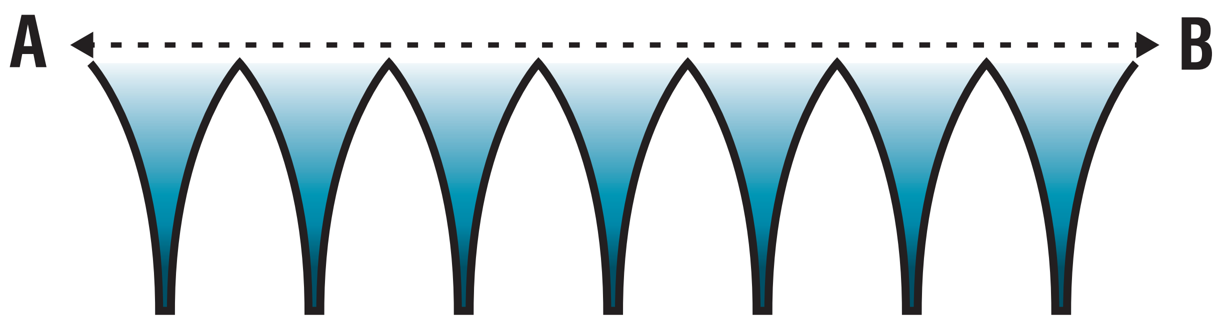
Maximizes Surface Porosity, Minimizes Structural Footprint

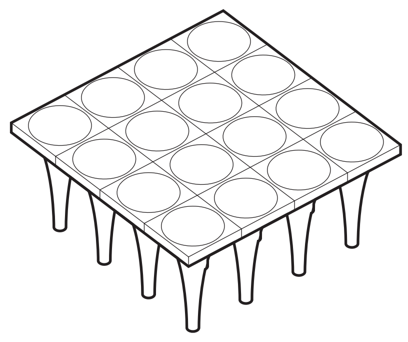
(However, it dissolves horizontality, halts flow of people and cars)

OPTION 2

INFRASTRUCTURAL *THICKENING*

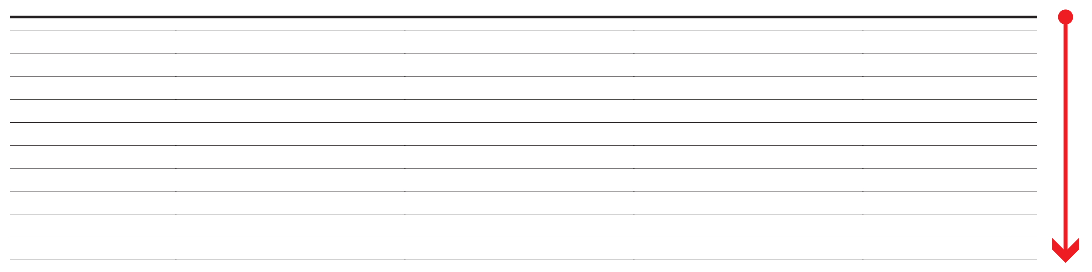
Shifting from Line to Volume

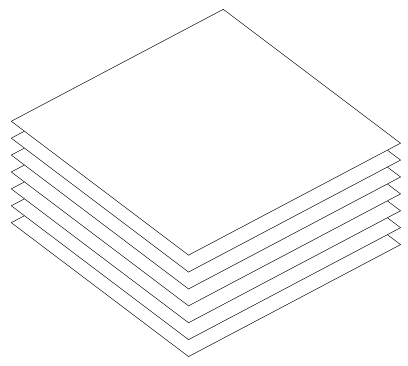




Structure, Water and Porosity

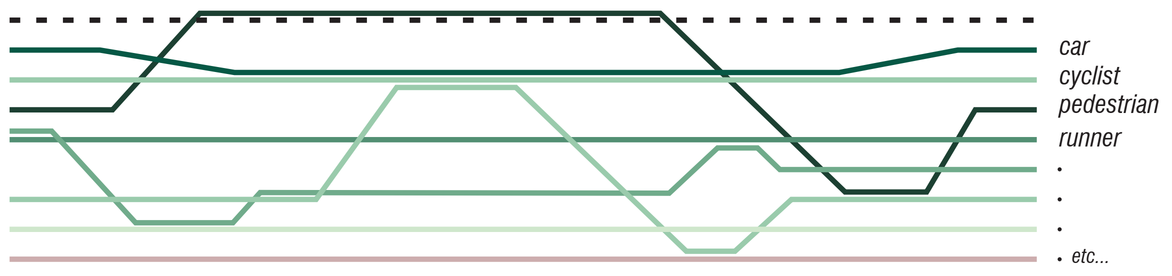
If water is the space for water, where do cars and people emerge?

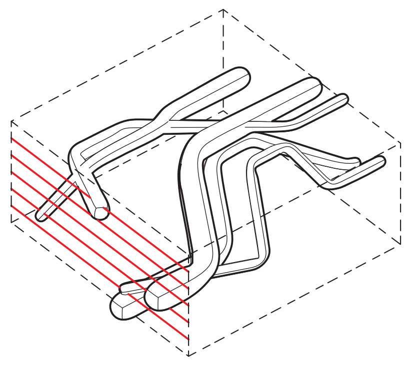




Linear Volume

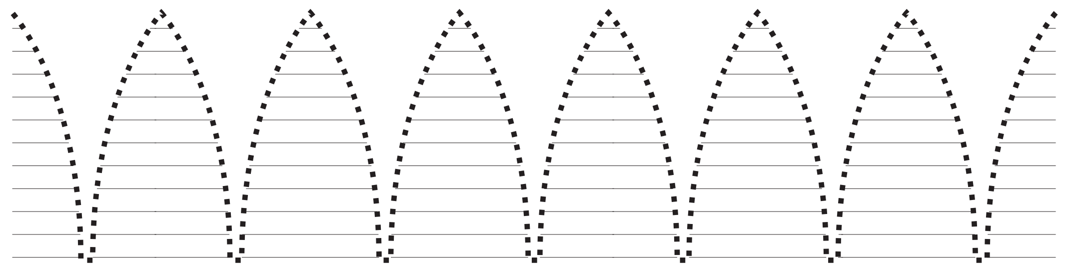
Vertical aggregation of horizontal planes allows for infrastructure to shift from a line to a volume.

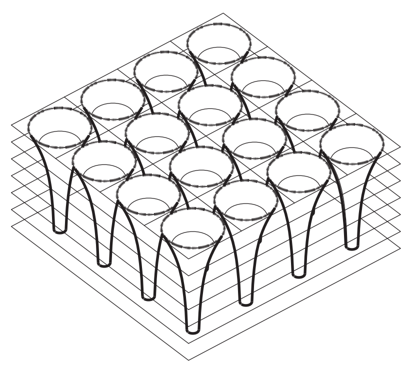




Unified Interlace

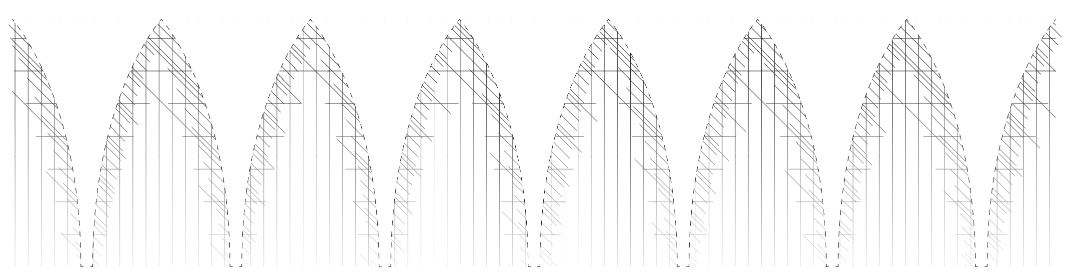
Multiplicity of horizontal planes allows for various flows to weave and traverse both in plan and in section.

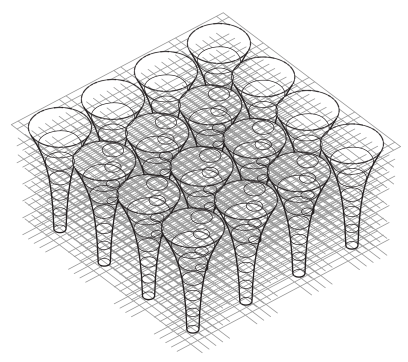




Composite Structure

Merging cones with horizontal structure

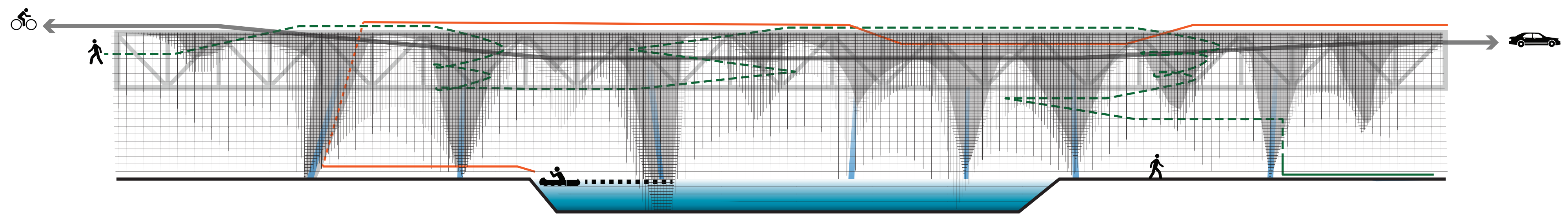




Structural Gradation (x, y, z)

Add structure where needed, remove where not needed

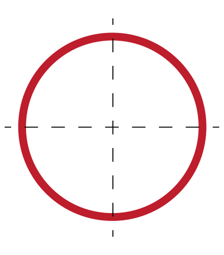
The structure is no longer distinguished by its basic subdivisions. Instead, through the process of infrastrucrural thickening, the bridge begins to express a whole-to-whole relationship; a fine grained structural lattice that enables people, water and cars to participate in the issue of volume.

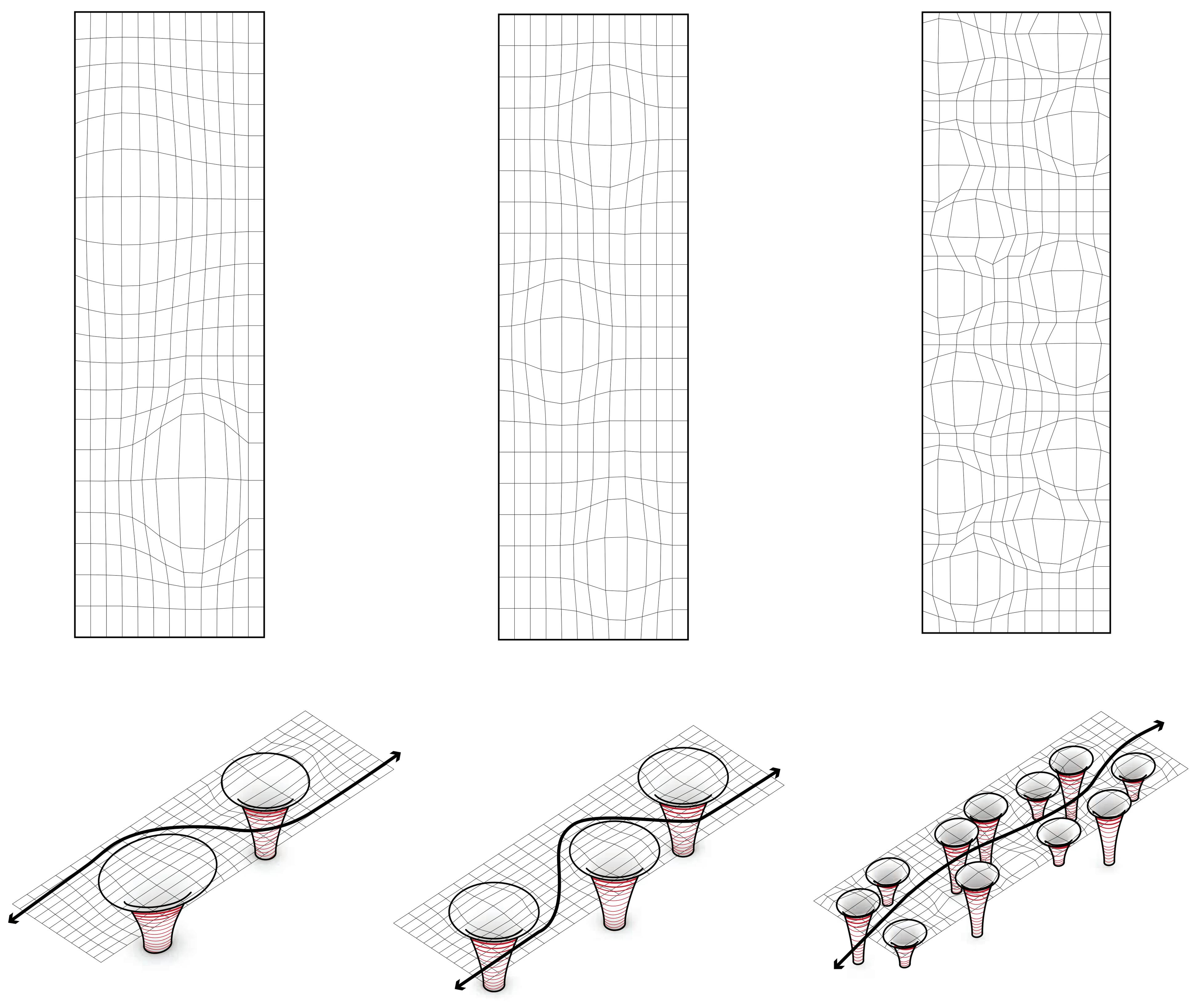


STRUCTURE, POROSITY and FLOWS

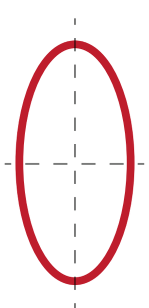
The Pier: Grid Manipulations

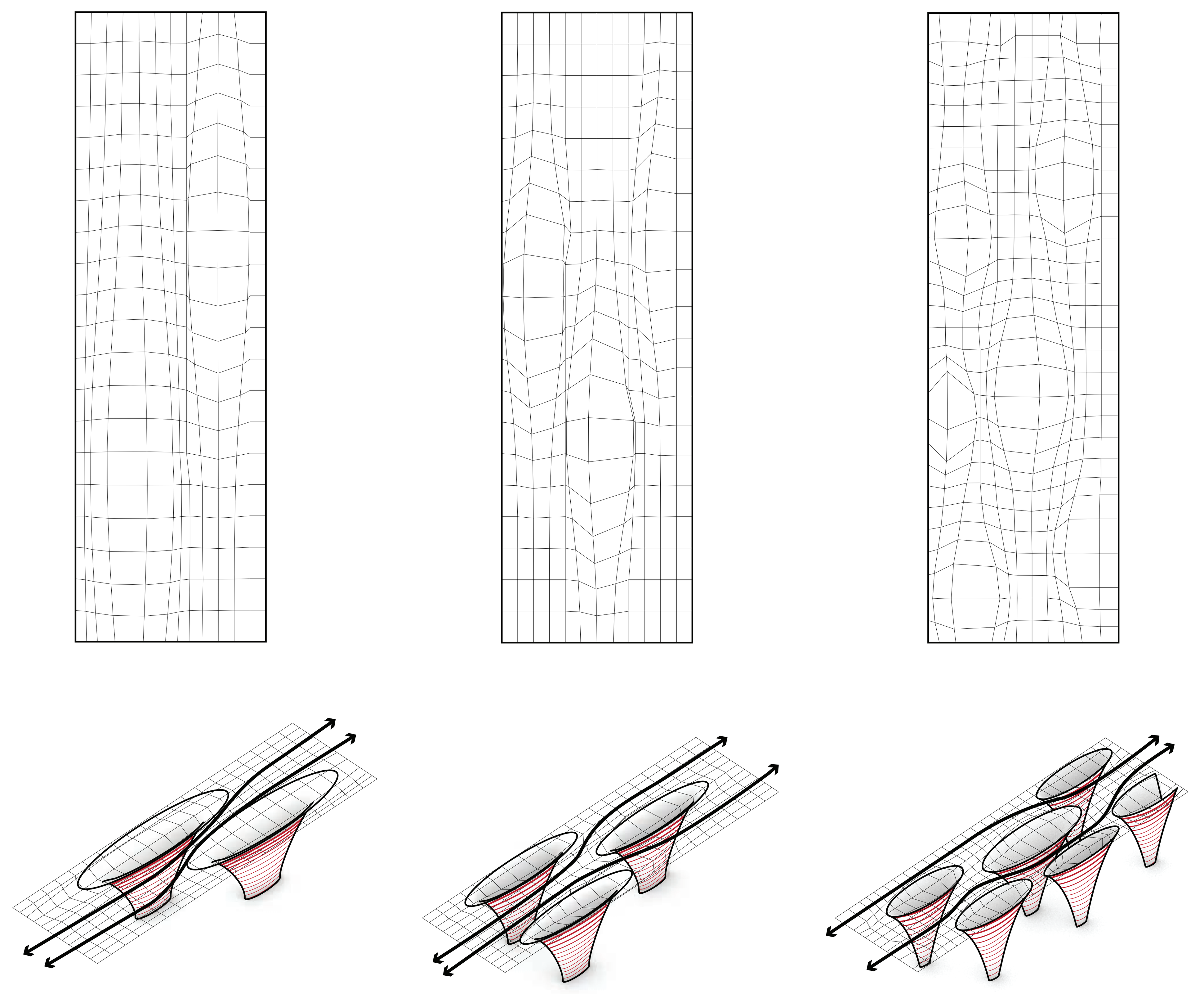
Circle



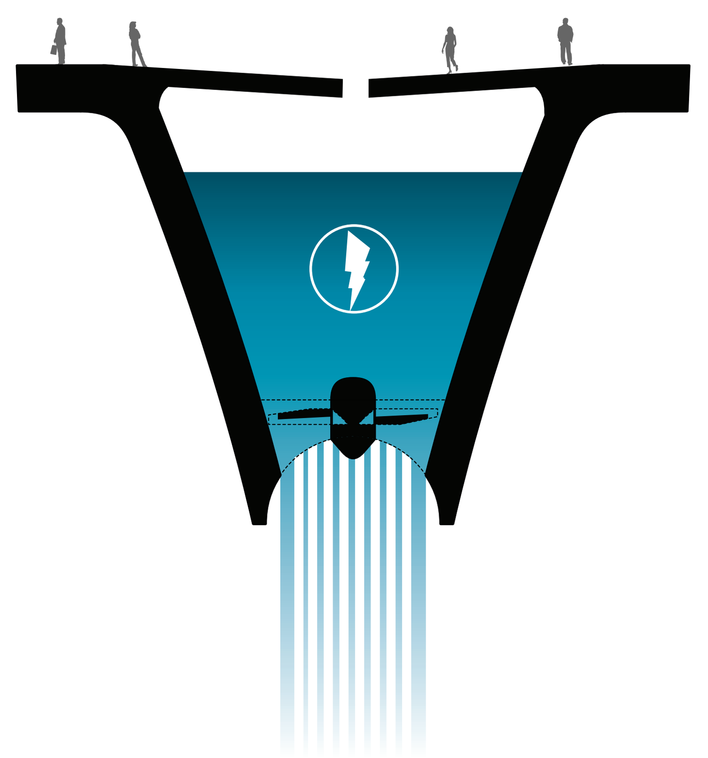


Ellipse

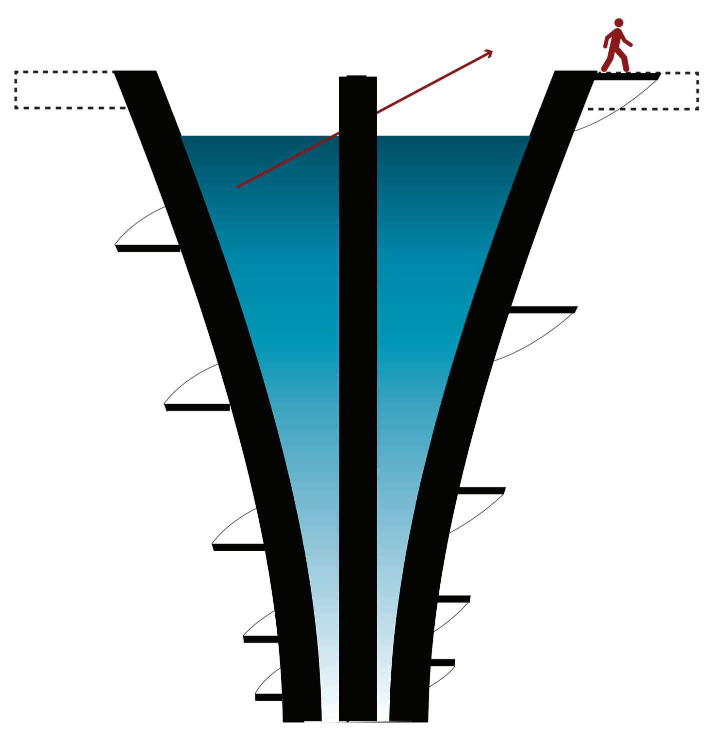




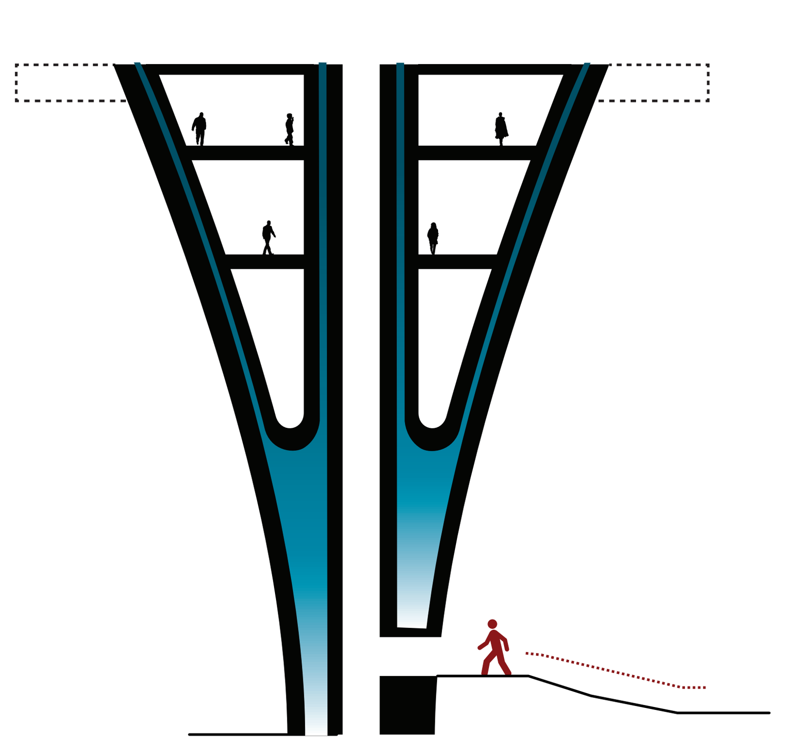
Pier *Types*



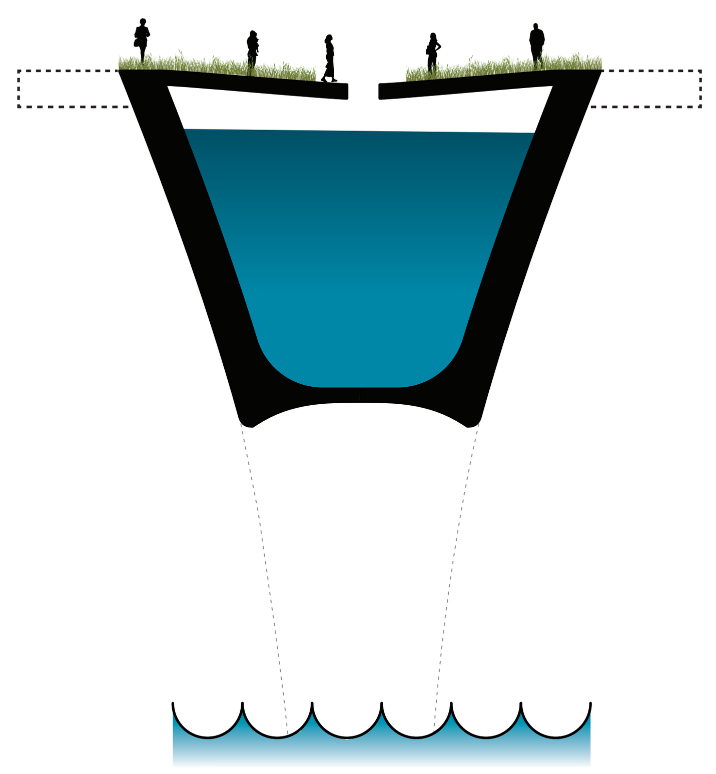
Water Generator



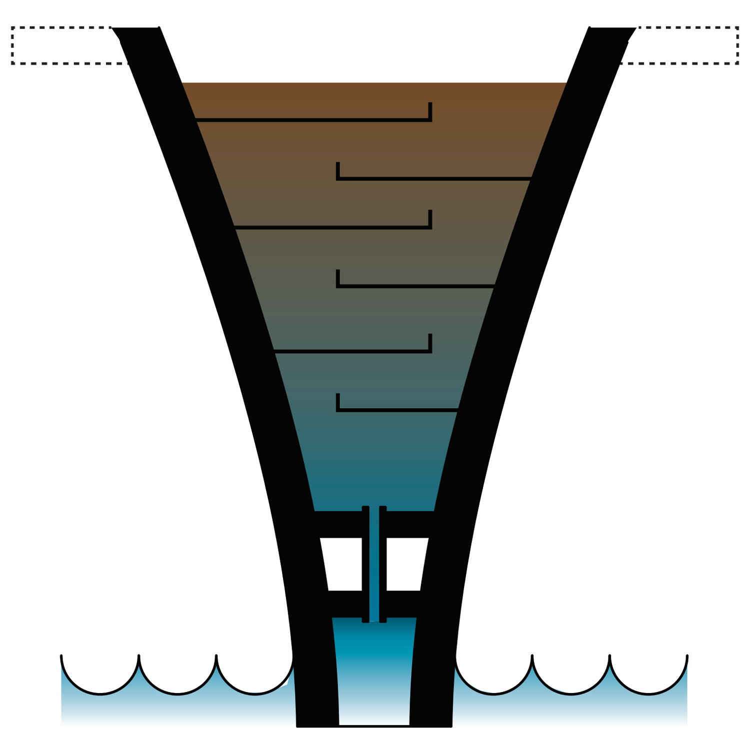
Circulation Core + Water Cistern



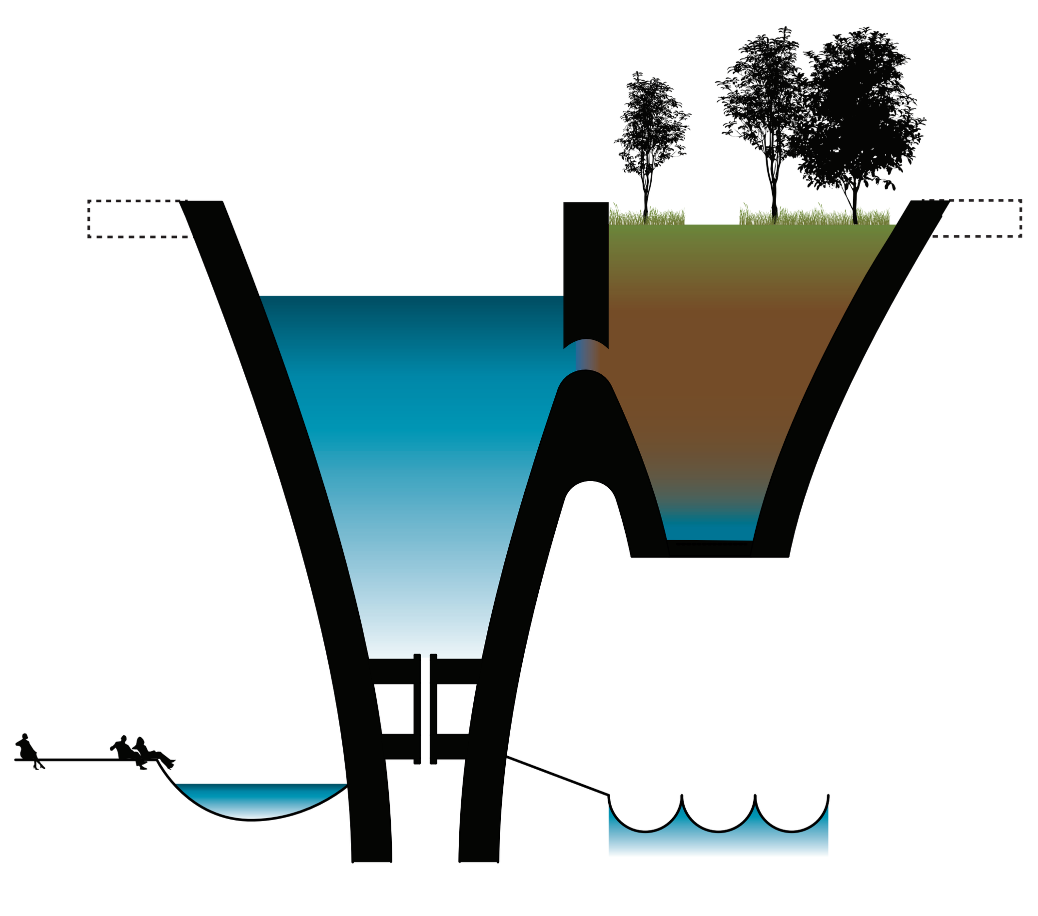
Program



Water Tank



Filter / Absorption



Coupling Processes
(Water tank + Bio filtration swale)

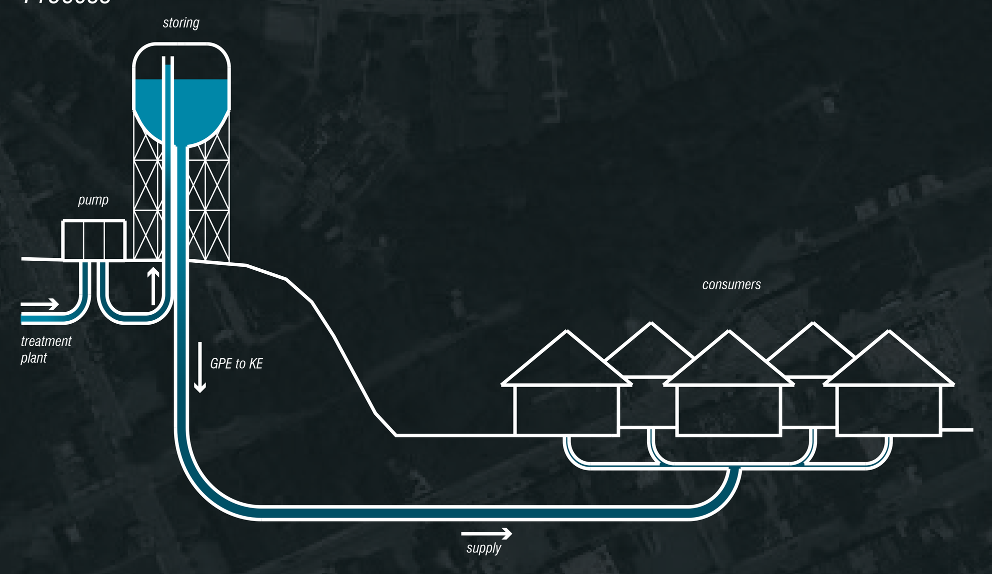
Generating Porosity

URBAN STRATEGY: Expanding the bridge's *physical* + *virtual* footprint

A shift from stand-alone structure to infrastructural system

LESSONS LEARNED FROM WATER TOWERS

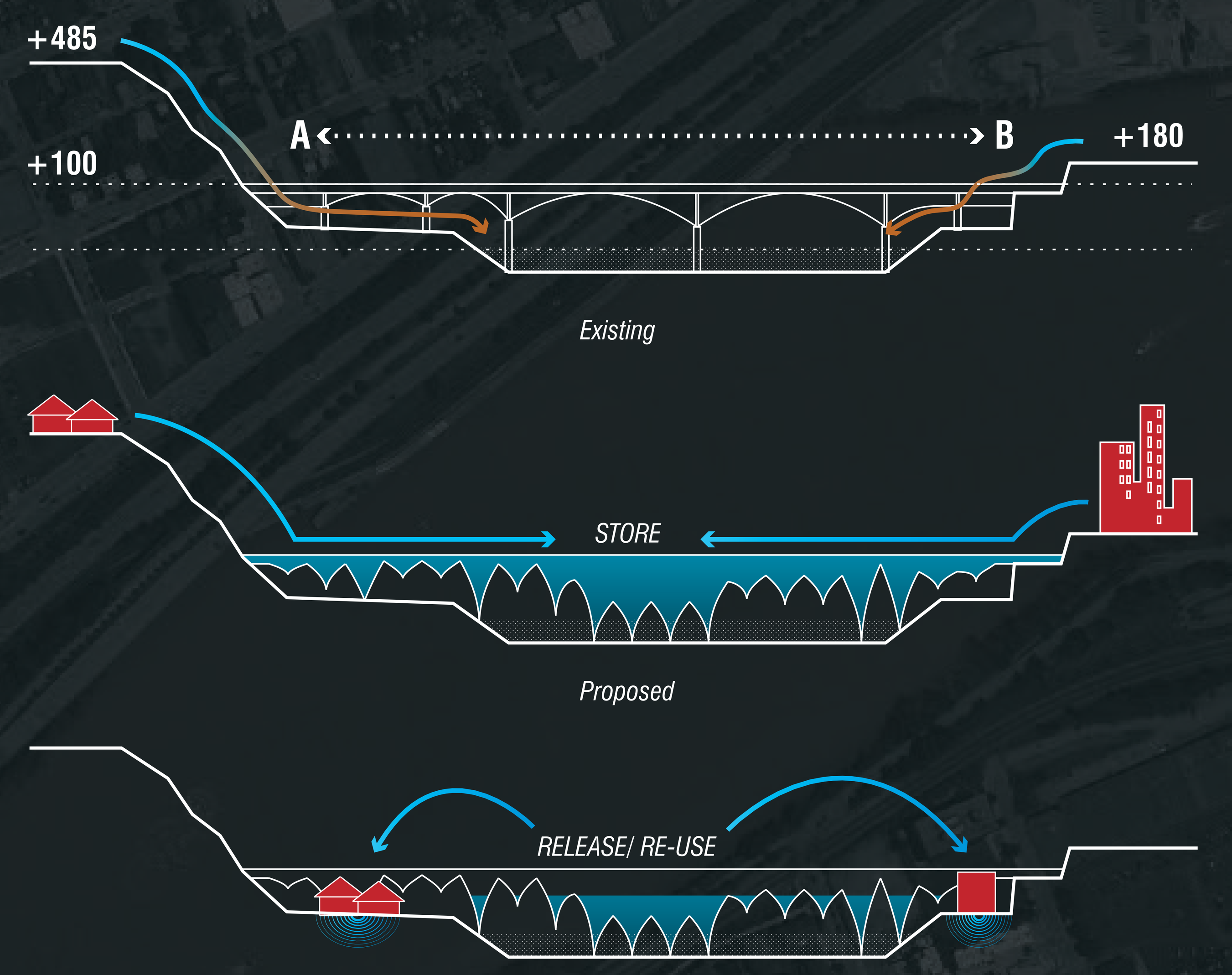
Process



FOOTPRINT

BRIDGE AS WATER NEXUS

Process



1 The site of old 28-acre Mellon Area has been proposed to be transformed into a mixed-use development. Utilizing the elevation of the site, rainwater run-off could be channeled to the bridge for collection and processing.

2 This convergence of highway ramps is bounded between Duquesne University and the Downtown area. Further accumulation of rainwater can be guided to the bridge structure for storing and processing.

3 This underutilized and crucial public space nested between the Municipal Courthouse and the country Jail has the potential to become part of the systemic logic of the bridge. Water based activities and habitats can be introduced in order to create a more productive space for public engagement.

BRIDGE

4 The 14-acre "East Parcel" of Station Square is proposed to be transformed into a mixed-use residential and office development. Utilizing the elevation of the Mt. Washington Neighbourhoo

5 Housing the headquarters for *Friends of the River* and *Just Harvest*, the Terminal Warehouse next to the bridge sets the tone for the kinds of activites that could complement these prominent humanitarian organizations (i.e. urban agriculture, water plaza, a visitors center etc)

6 Utilizing the 485' elevation of Mt. Washington,U, rainwater run-off can converge on the bridge where it can be stored, processed, re-used and/or released.