THE SUBSURFACE

A Collective Geography

Designing Underground Space for Urban Systems Integration (Amsterdam, NL)

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Graduation Thesis | MSc. Urbanism
TU Delft

We had an expansive run in the 60s and the 70s exploring the cosmos. Eventually, we pulled inwards, subjected to the fragility of our planet.

These days, there seems no expanse left to traverse beyond the thin crust of the planet we call home. We sent out ships named after gods to look for worlds to reside in, to inject life into, and soon realized that Earth is all we have. Such future oriented projects bear a reminder of society's potential to realize ***Fiction****, exploring dimensions of the urban realm* ***beyond the surface*** *of planet Earth.*

- Carl Sagan (Age Exploration)

Fiction, in addition to visualizing mankind's wonderous gaze, also provides imaginative solutions to questions posed for distant decades. What if the surface is not enough for us in the future? And most importantly....

Where will we live when we run out of space?

01 **Notions and Problem Field**

02 **Problem Focus**

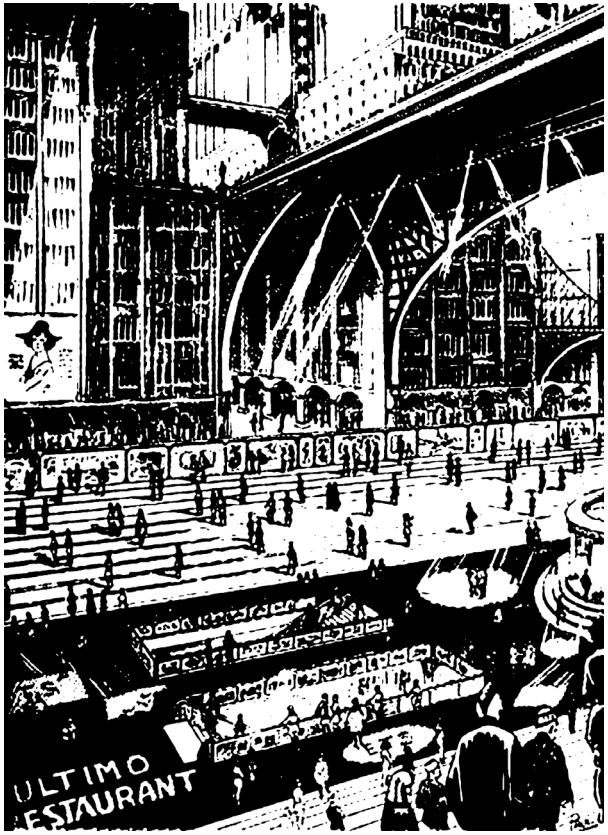
03 **Research Questions**

04 **Devising Methodology**

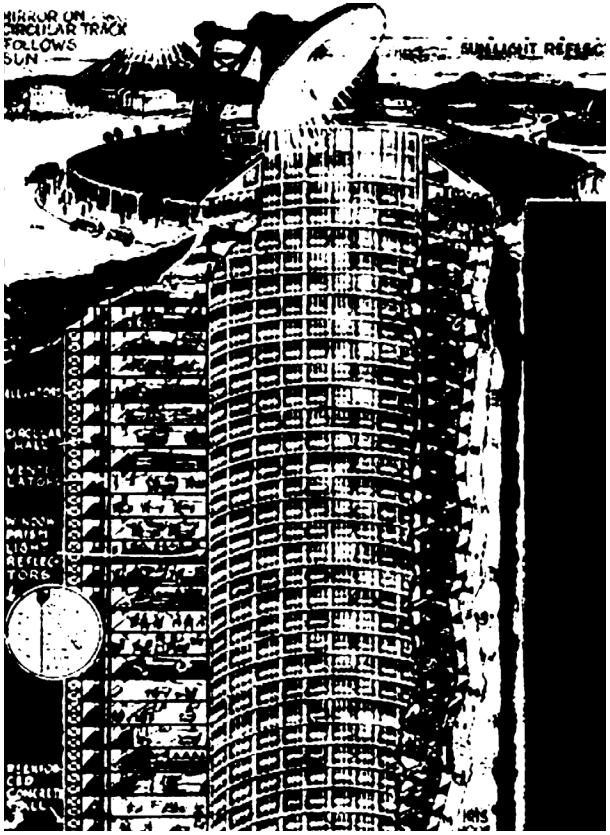
05 **Revealing the Subsurface**

06 **Contextualizing Methodology**

UNDERGROUND SPACES: **FICTION**

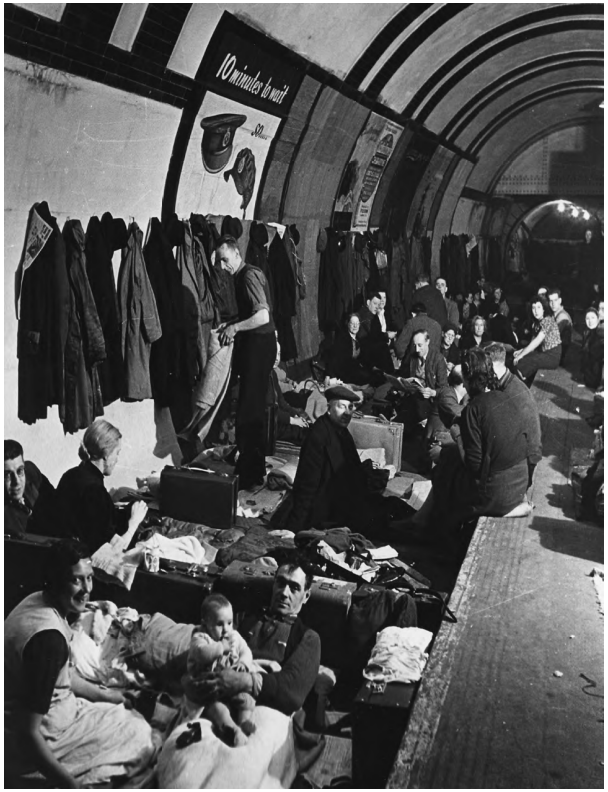


Fiction : New York Underground

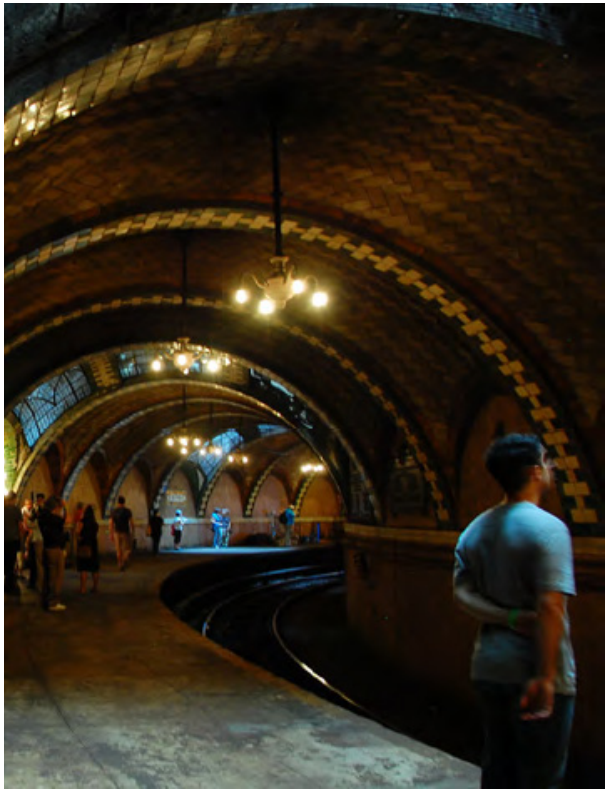


Fiction: Depthscrapers

PERCEPTION OF UNDERGROUND SPACES



London Underground Station Air Raider Shelter



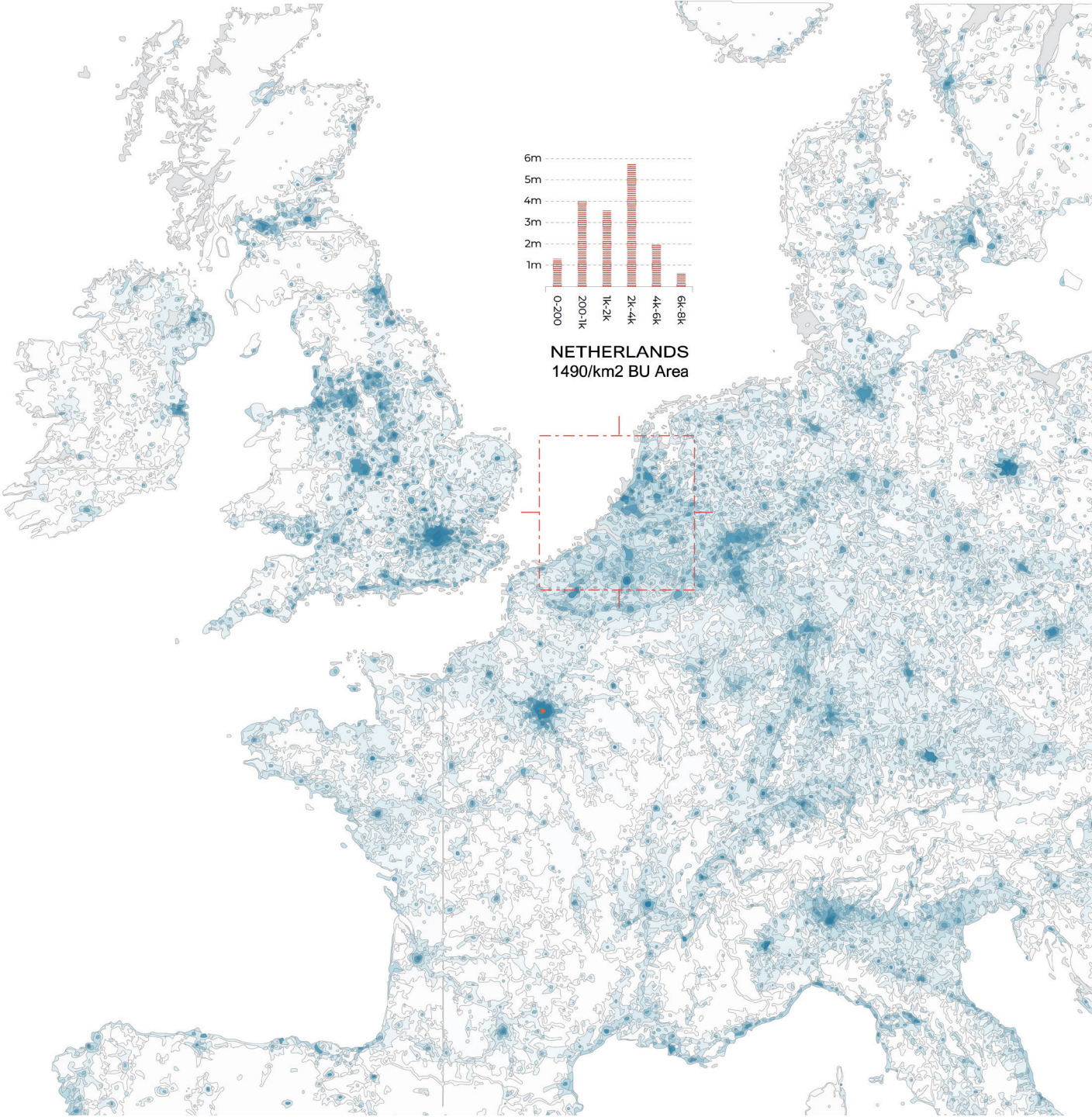
City Hall Subway station, New York

WHY UNDERGROUND?

By the end of the 20th century, urbanization posed considerable threats and concerns for forms of city growth.

These urban areas demand active access to the city center as a result of being driven by global economic models. (Reynolds, 2020) A context of regulation that allows vertical growth above the surface only has propelled urban expansion in these centers to a large degree, leaving the subsurface with monofunctional and independent construction projects

SDG GOALS & SUBSURFACE



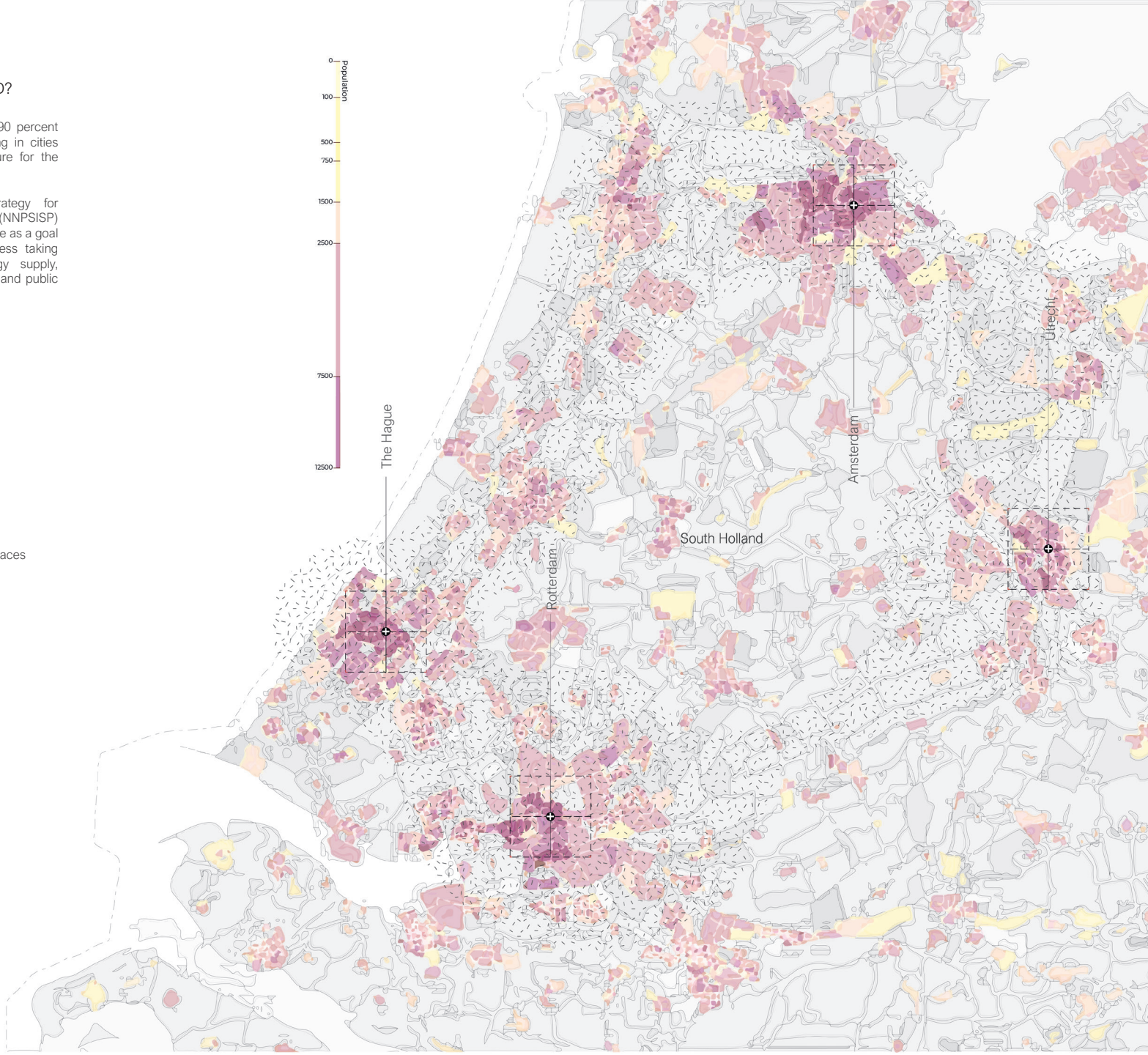
WHY UNDERGROUND?

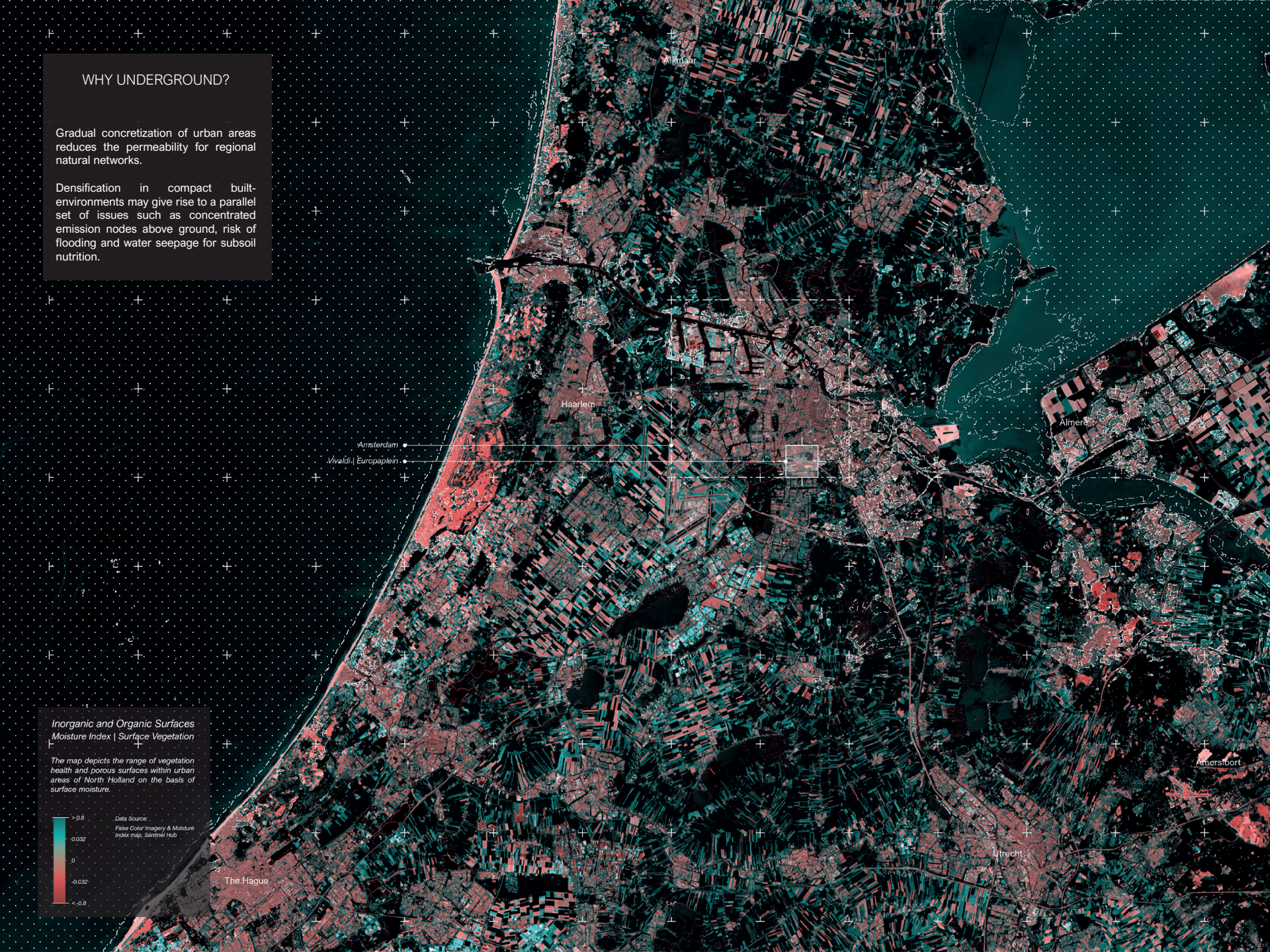
In the Netherlands, approximately 90 percent of the population has been residing in cities since 2018. The lived density figure for the Netherlands is 546 people per km².

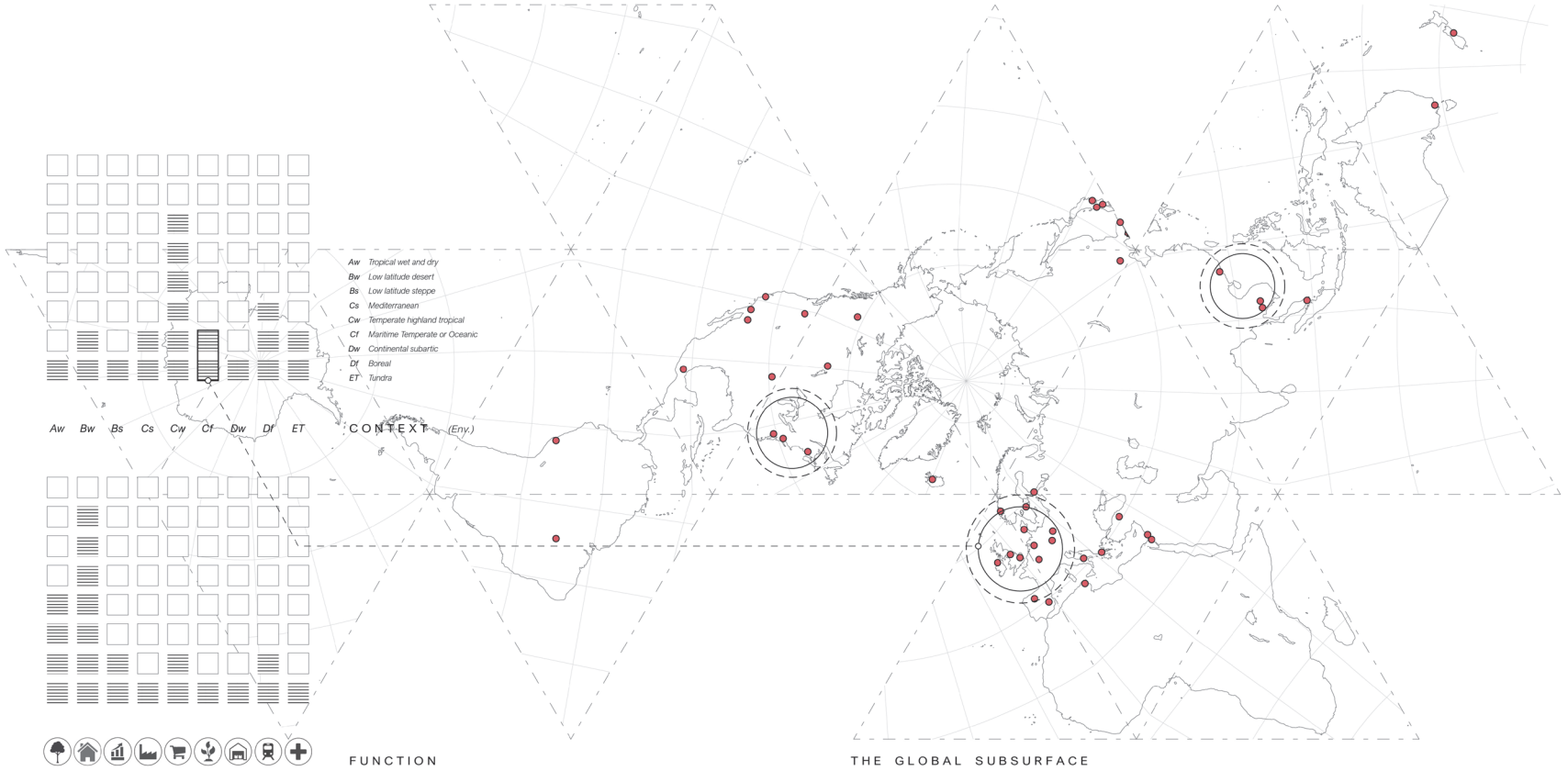
Netherlands National Policy Strategy for Infrastructure and Spatial Planning (NNPSISP) recognizes efficient use of subsurface as a goal to maintain resource competitiveness taking into account groundwater, energy supply, minerals, infrastructure and utilities and public spaces.

CONTEXT

1. Growing Cities
2. Urban Connectivity
3. Land Values
4. Heritage Constraints
5. Resilience of Underground Spaces




WHY UNDERGROUND?
Gradual concretization of urban areas reduces the permeability for regional natural networks.
Densification in compact built-environments may give rise to a parallel set of issues such as concentrated emission nodes above ground, risk of flooding and water seepage for subsoil nutrition.
Alkmaar
Haarlem
Amsterdam
Vivaldi | Europaplein
Almere
Amersfoort
Utrecht
The Hague
Inorganic and Organic Surfaces
Moisture Index | Surface Vegetation
The map depicts the range of vegetation health and porous surfaces within urban areas of North Holland on the basis of surface moisture.
> 0.8
0.032
0
-0.032
< -0.8
Data Source:
False Color Imagery & Molsture Index map, Sentinel Hub



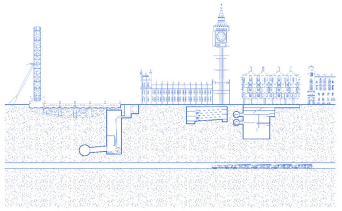
U.G. SPACES AROUND THE WORLD

The complexity of form decreases with increase in scale of underground spaces subject to construction challenges.

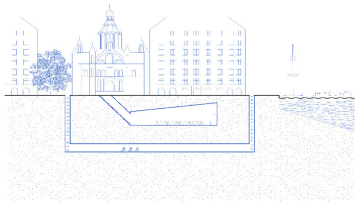
The lowest concentration of these spaces is seen in areas with Maritime temperate and oceanic regions due to environmental risk, Netherlands being a part of this context.

REASONS TO GO UNDERGROUND

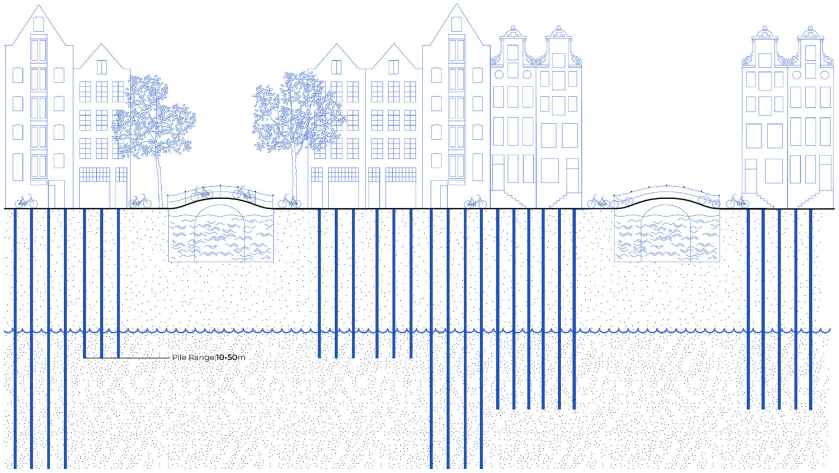
- Taking away/ reducing nuisance and thereby improving liveability
- Reducing/ eliminating the security risks and damage to the environment
- Complex infrastructural/ environmental planning problems, especially in areas where space is limited
- Strategic consideration



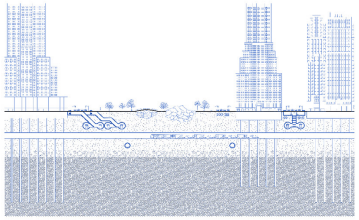
London



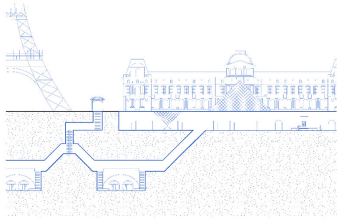
Helsinki



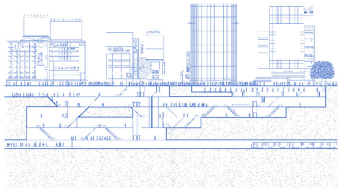
Amsterdam



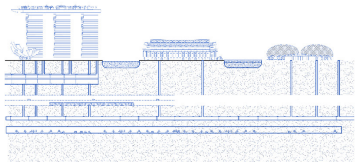
New York



Paris



Tokyo



Singapore

Source: Underground Urbanism by Elizabeth Reynolds

a Sensitive Landscape

The Dutch landscape is especially delicate to respond to subsurface use at such scale, given risk of subsidence, risk to water table and existing pile foundations.

01 Notions and Problem Field

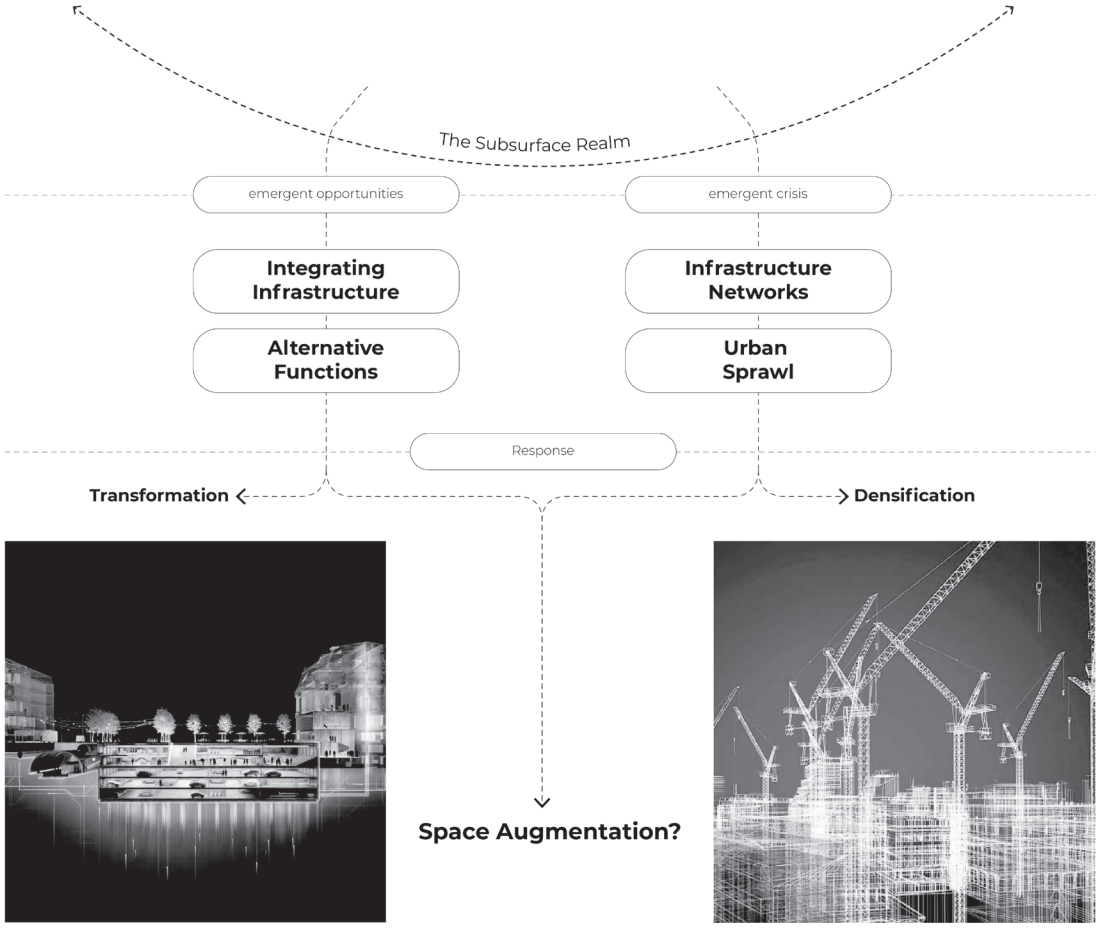
02 Problem Focus

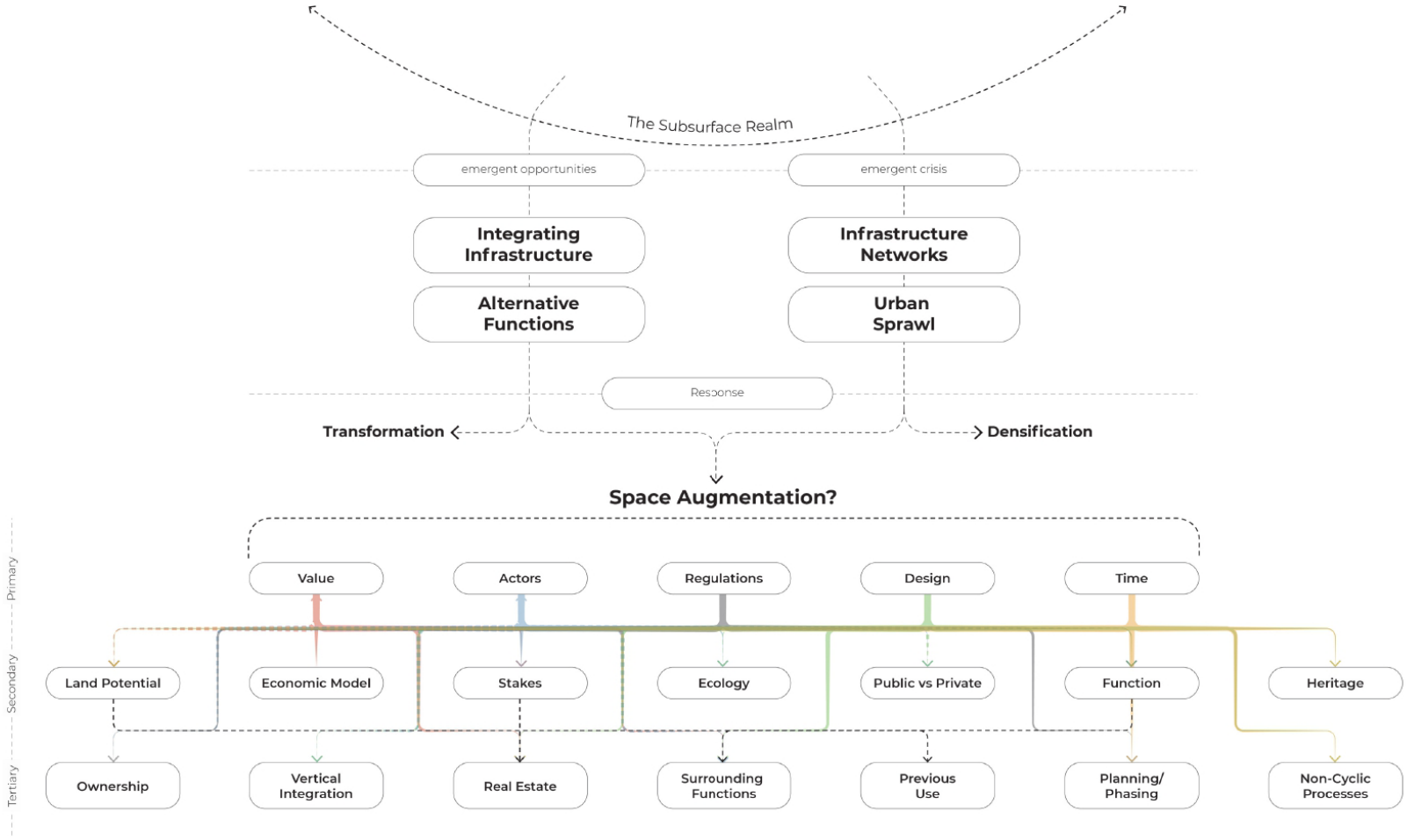
03 Research Questions

04 Devising Methodology

05 Revealing the Subsurface

06 Contextualizing Methodology


The Subsurface Realm
emergent opportunities
emergent crisis
Integrating Infrastructure
Infrastructure Networks
Alternative Functions
Urban Sprawl
Response
Transformation
Densification
Space Augmentation?


The Subsurface Realm
emergent opportunities
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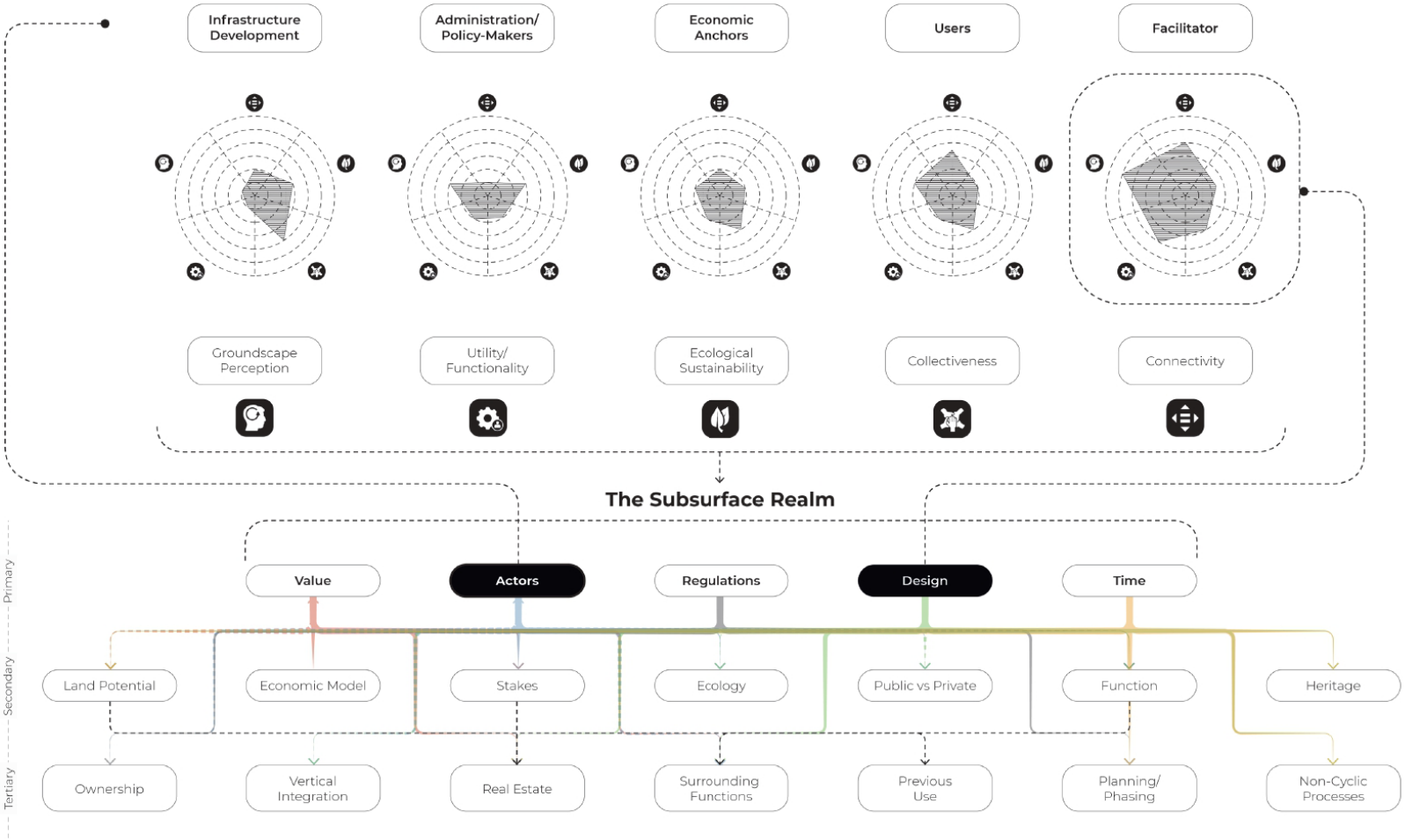
Space Augmentation?
Primary
Secondary
Tertiary
Value
Actors
Regulations
Design
Time
Land Potential
Economic Model
Stakes
Ecology
Public vs Private
Function
Heritage
Ownership
Vertical Integration
Real Estate
Surrounding Functions
Previous Use
Planning/ Phasing
Non-Cyclic Processes


Infrastructure Development
Administration/ Policy-Makers
Economic Anchors
Users
Facilitator
Groundscape Perception
Utility/ Functionality
Ecological Sustainability
Collectiveness
Connectivity
The Subsurface Realm
Primary
Secondary
Tertiary
Value
Actors
Regulations
Design
Time
Land Potential
Economic Model
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Primary Question

How can the existing isolated subsurface uses be integrated to form

a Collective Functional Geography composed of

Integrated Urban Underground Systems

through design interventions?

Assessing the potential and planning for zone-based underground space development as a Collective functional geography in the city of Amsterdam

How much underground already exists?

How do you Percieve the Void?

What about the existing Heritage?

Who Owns the Subsurface?

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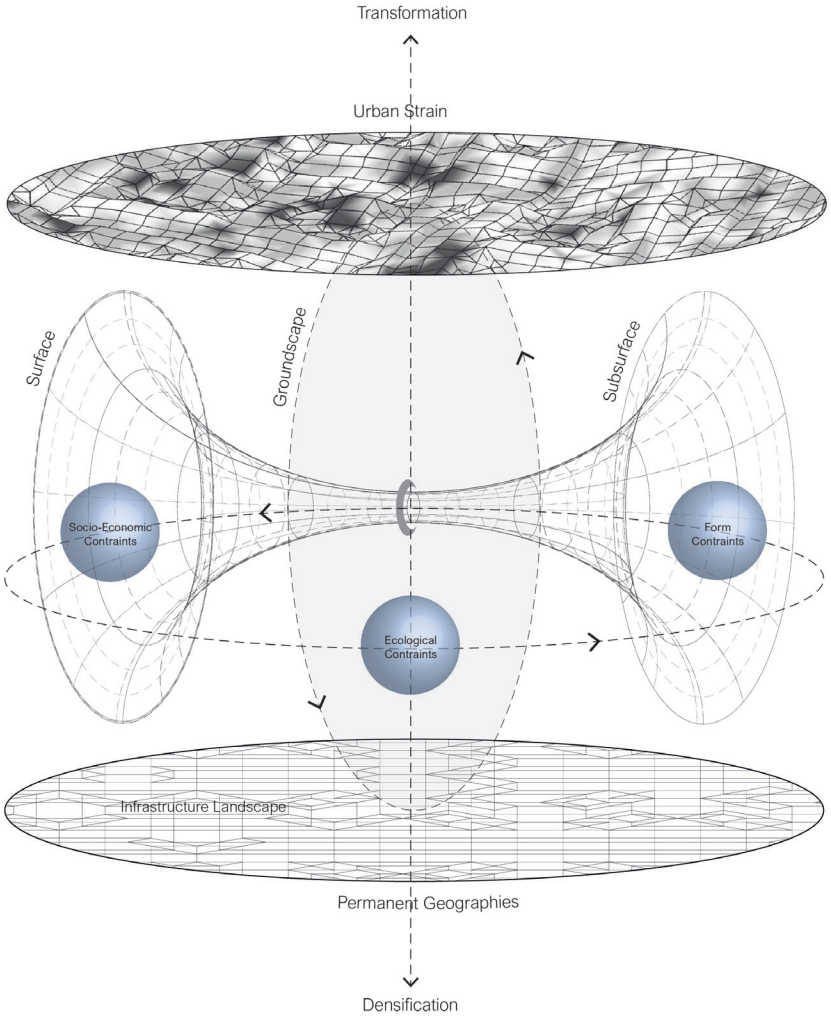
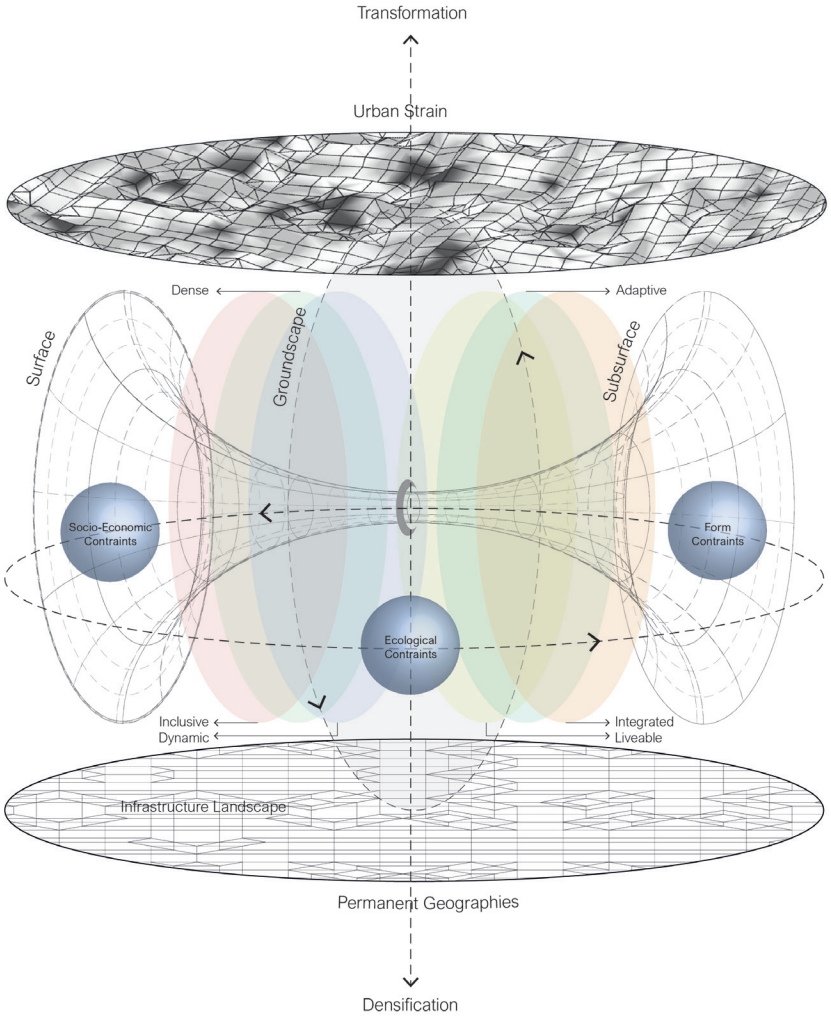
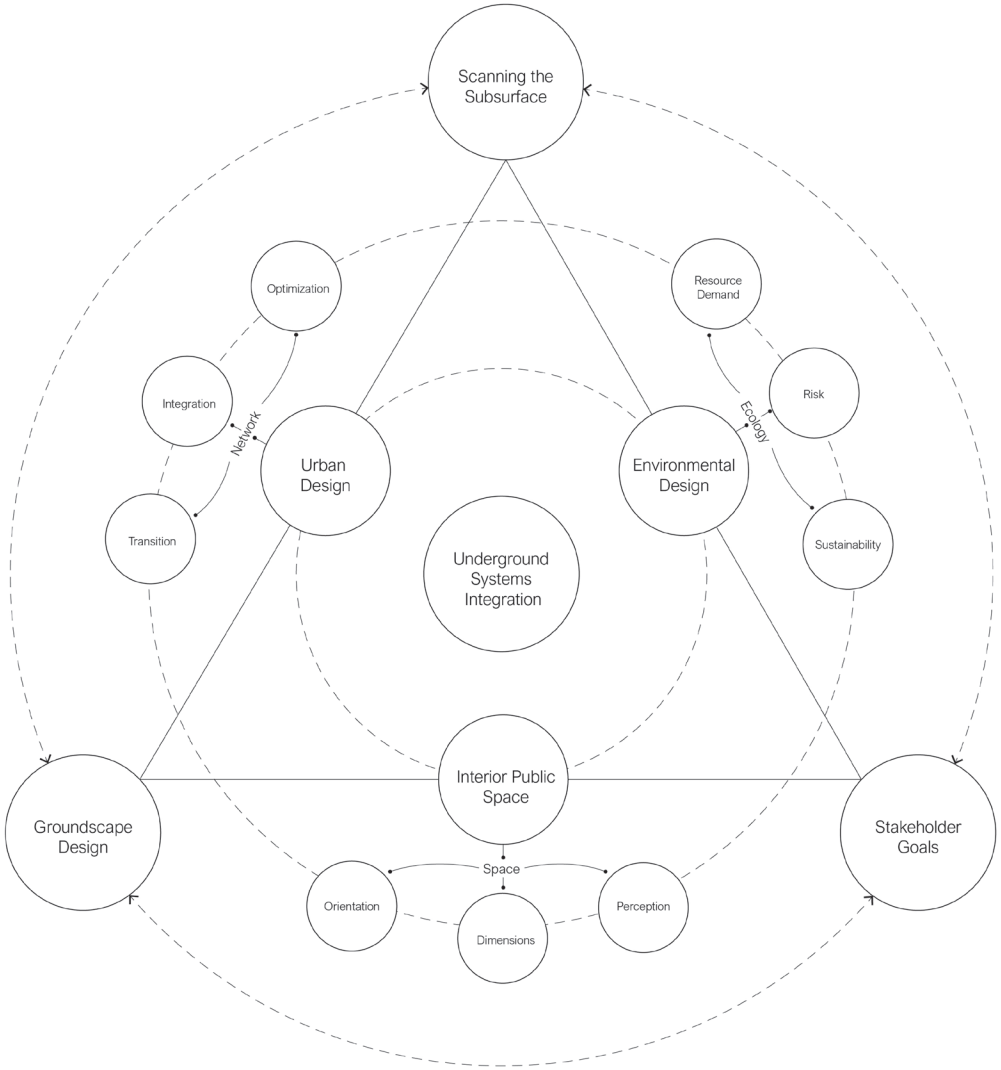


CONCEPTUAL FRAMEWORK



ANALYTICAL FRAMEWORK

THEORETICAL FRAMEWORK



Process for balancing Public vs Private spaces while planning for Holistic Underground Resources:

1. Mapping the existing 3-dimensional Subsurface Inventory
2. Identifying User Perception and Goals from U.G. Spaces
3. Designing the Groundscape

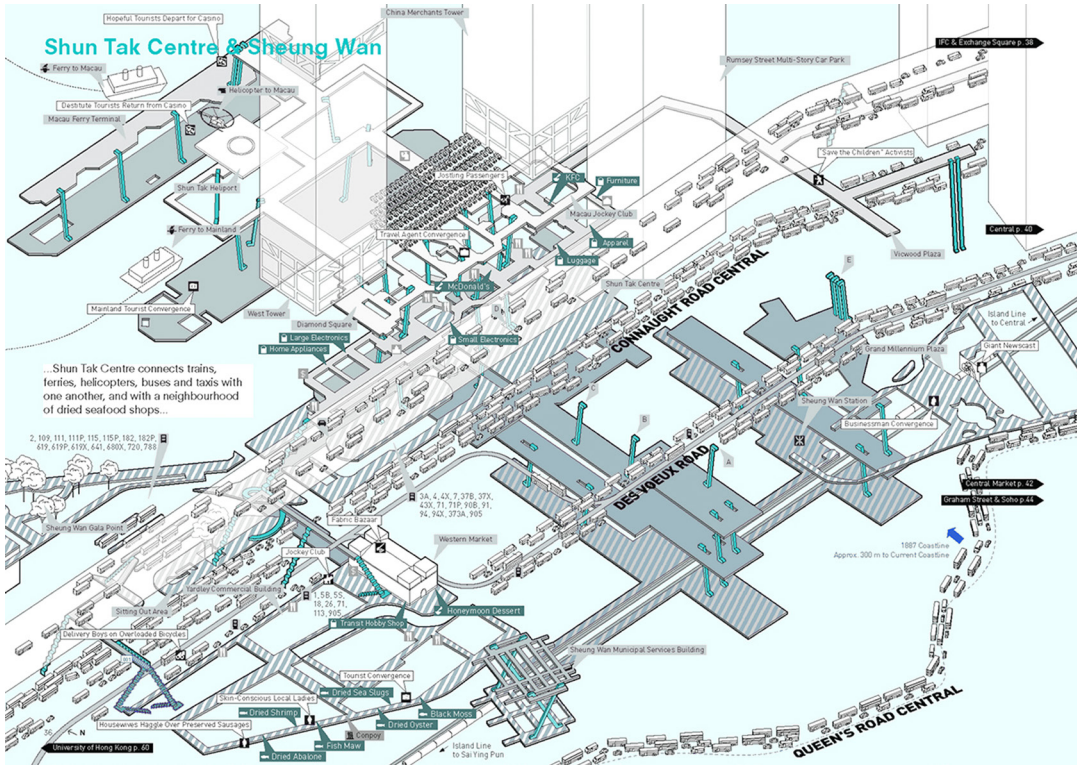
MAPPING THE GROUNDSCAPE

Mapping a system of Point and Lines at an Urban scale to understand Accessibility of spaces per each vertical level

Mapping the connection of vertical infrastructure networks and volumes with each other to identify potentials of integration.

Subways and Public Space
Interior on the Street
Additional Skyways

Subway System, Toronto (Source: Interior Public Space by Maurice Harteveld)



Shun Tak Center visualized as a vertical system of functions(Source: Cities without Ground: A Hong Kong Guidebook)

THE GROUNSCAPE METHOD: *Concept by Dominique Perrault*

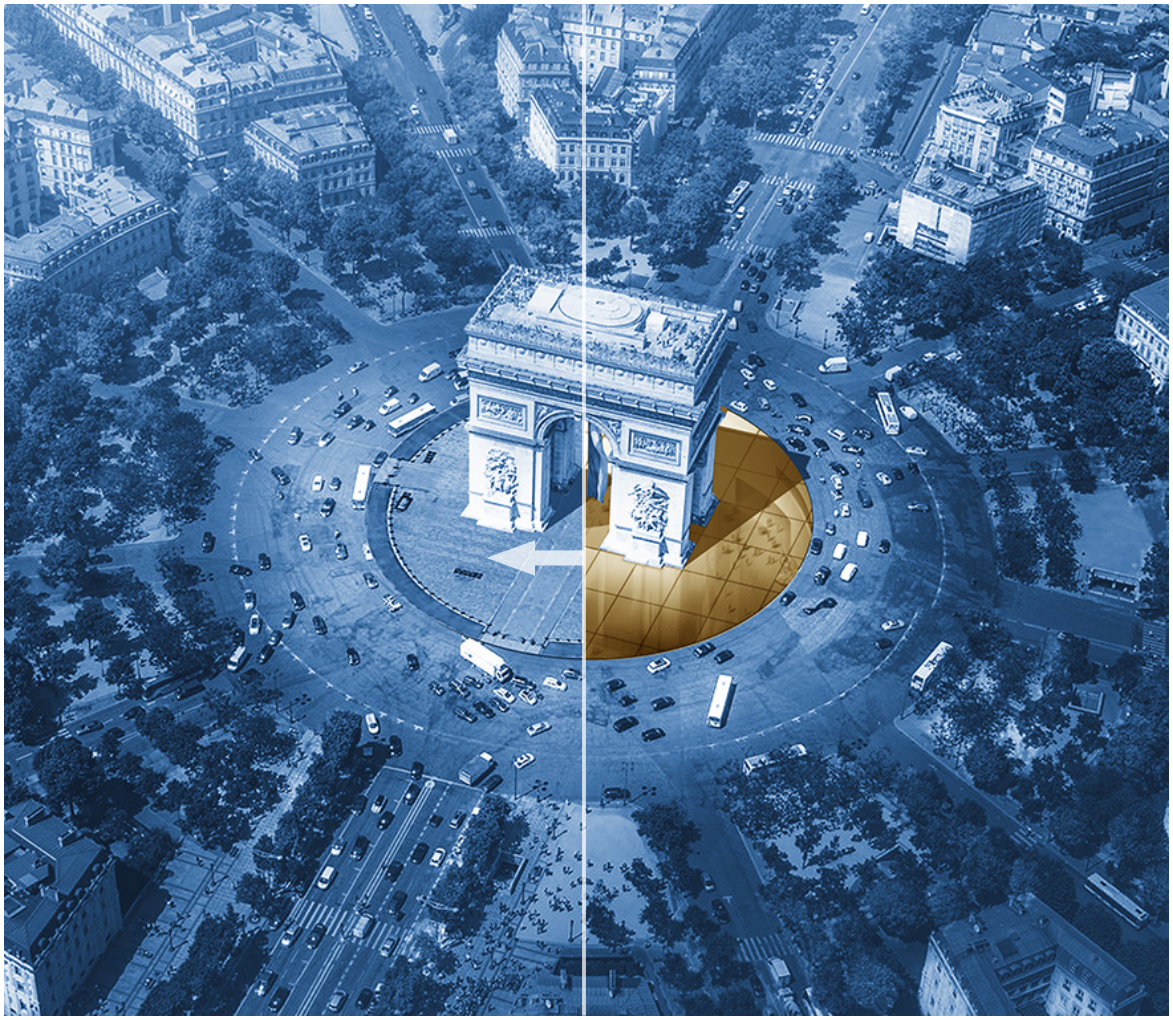
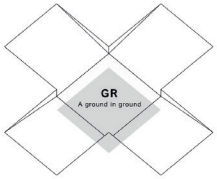


Image Source: Groundscape Manifest, DPA

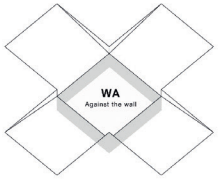
Reconfiguring the geography of built environment in addition to Buildings

ELEMENTS OF GROUNDSCAPE

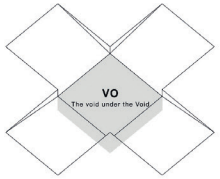
A **Ground** in Ground



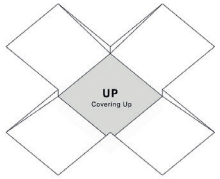
Against the **Wall**



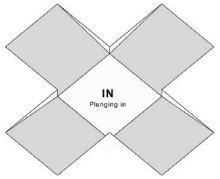
Into the **Void**



Covering **Up**



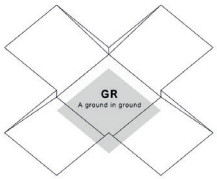
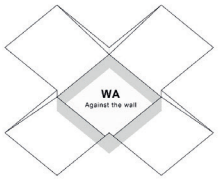
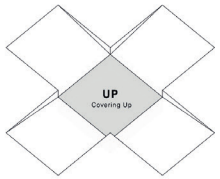
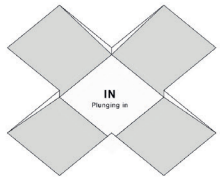
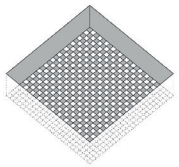
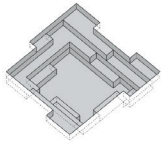
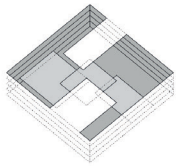
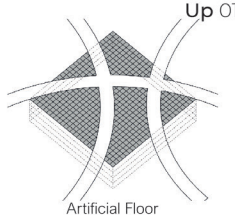
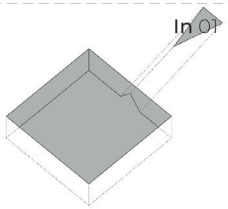
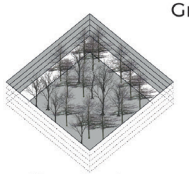
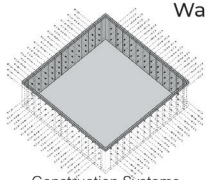
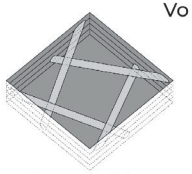
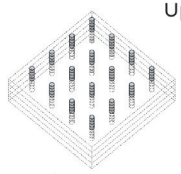
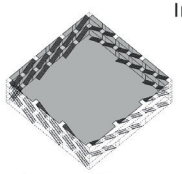
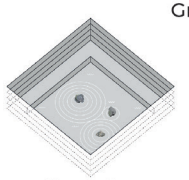
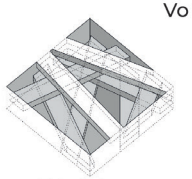
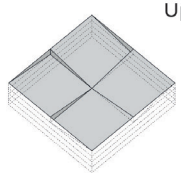
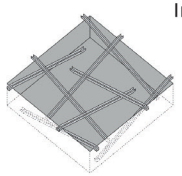
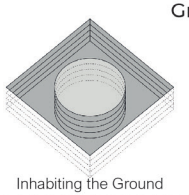
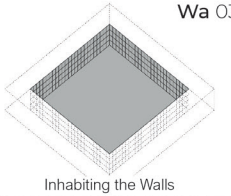
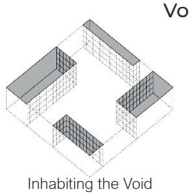
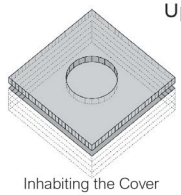
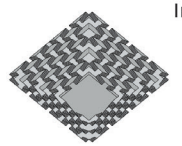
Plunging **In**



Methods to Engage with Groundscape:

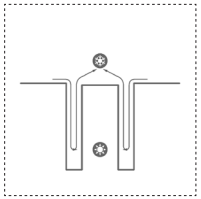
1. Protrusions
2. Exhibition
3. Experience
4. Habitation

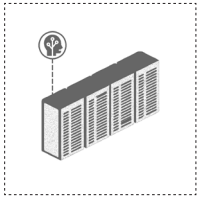
GROUNDSCAPE DESIGN METHODS: FORM AND GEOGRAPHY

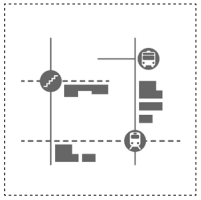
	A **Ground** in Ground	Against the **Wall**	Into the **Void**	Covering **Up**	Plunging **In**
					
Protrusions	Gr 01  Activity Frame	Wa 01  Earth as Material	Vo 01  Floating Platforms	Up 01  Artificial Floor	In 01  Detached Descent
Exhibition	Gr 02  Hortus Conslusus	Wa 02  Construction Systems	Vo 02  Connecting Tubes	Up 02  Instruments	In 02  Integrated Descent
Experience	Gr 03  Phreatic Sea		Vo 03  Flying Volumes	Up 03  Geography	In 03  Through the Void
Habitation	Gr 04  Inhabiting the Ground	Wa 03  Inhabiting the Walls	Vo 04  Inhabiting the Void	Up 04  Inhabiting the Cover	In 04  Inclined Plane

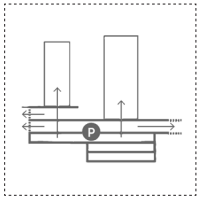
STAKEHOLDER GOALS

Infrastructure

I1

Heat/ Cold Storage

I2

Data Storage/ Servers

I1

Integrated Transit

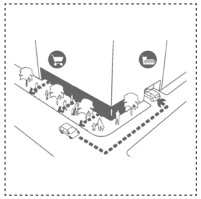
I3


Parking Networks

Users

U1

Social Safety

U2

Active Frontages

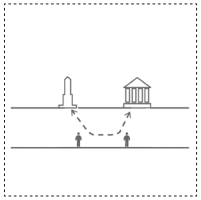
U3

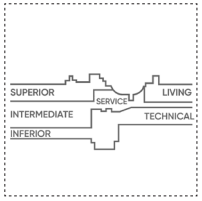
Link to Surface

Facilitators

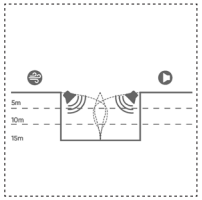
F1

Instrument: Light

F2

Extending Heritage

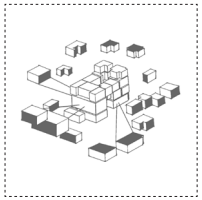
F3


Function vs Depth

F4


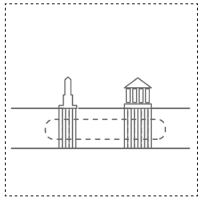
Terra Epidermis

Administration

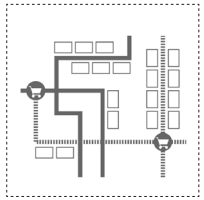
A1

4D Building Envelope

A2

Ownership Models

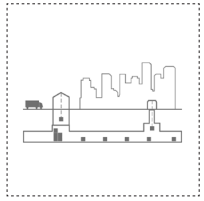
A3

Conserving Heritage

Commercial Anchors

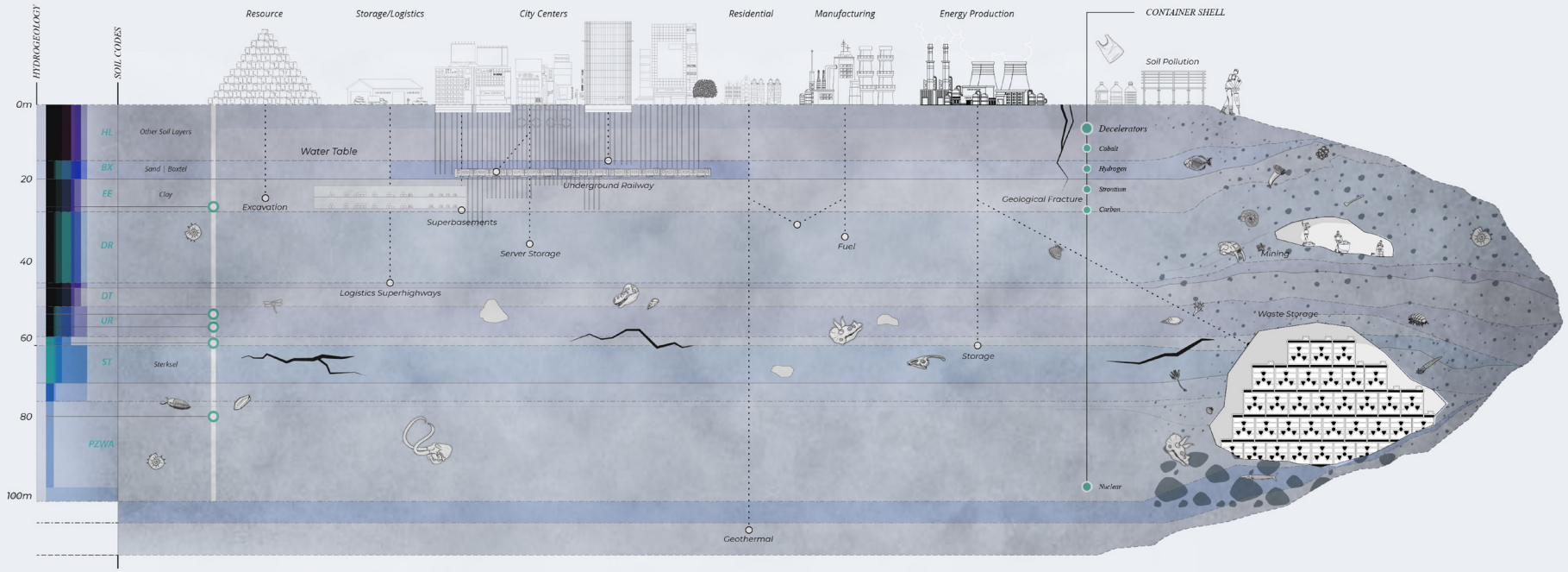
C1

Linear Retail

C2


Primacy of Location

C3

Extending Logistics

ENVISIONING THE SUBSOIL WITH GROUNDSCAPE



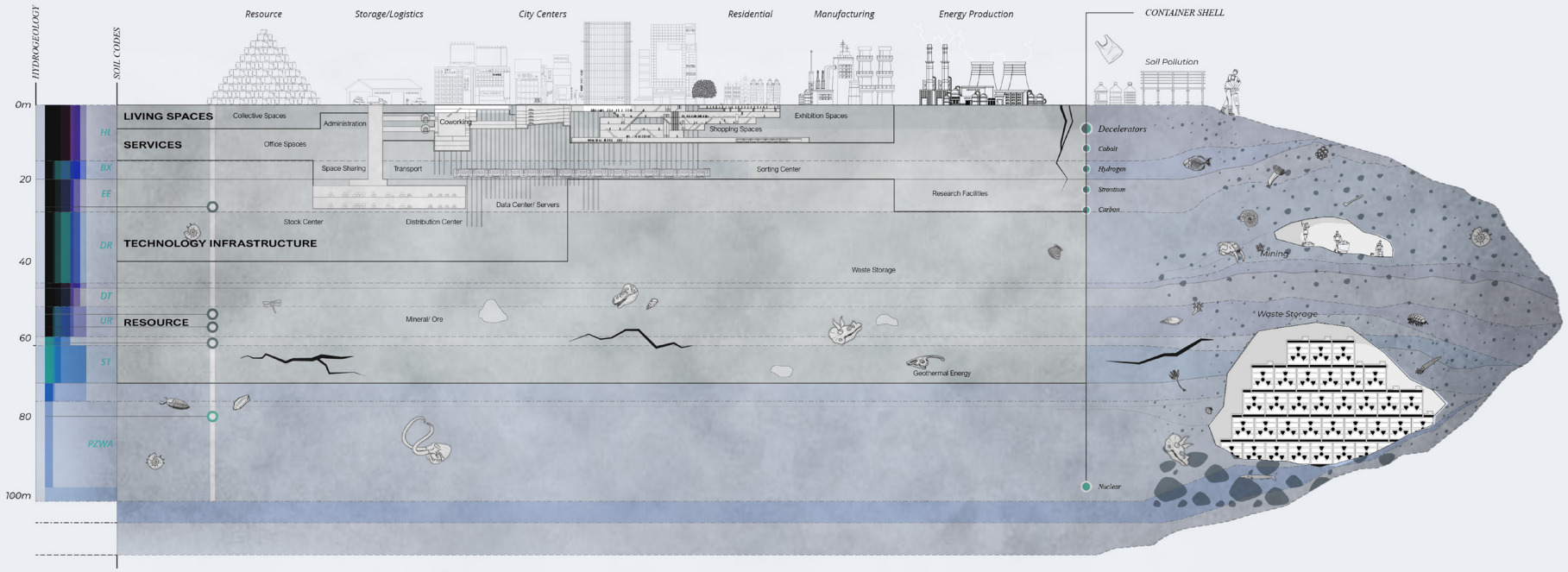
Source: Author

0-12m : Ecological benefits offered by subsurface including temperature and acoustics, are progressive in nature.

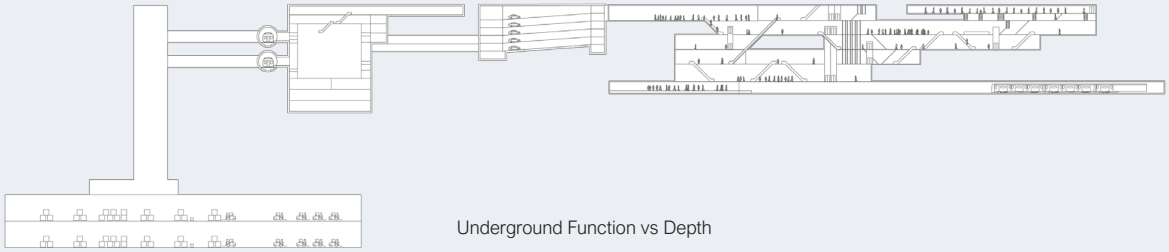
12-20m : Since construction requires substantially extra mechanical input and extraction for ventilation, ownership of such volumes is only feasible under private entities

40-100m : The functional profile at this depth belongs to long-term service-based uses operational for drawing national resource value including minerals and energy.

Envisioning the Subsoil with Groundscape



Source: Author



Underground Function vs Depth

Since vertical depth is an inversely proportional parameter of accessibility, construction of groundscape must be conscious of the value of these 3 resources. They must be directed, driven and distributed as a gradient within the subsoil. Hence, the functions vary with availability of light and volume, placing public programs within the immediate underground while functions related to services and infrastructure are shifted deeper where private sector can bear their feasibility.

01 Notions and Problem Field

02 Problem Focus

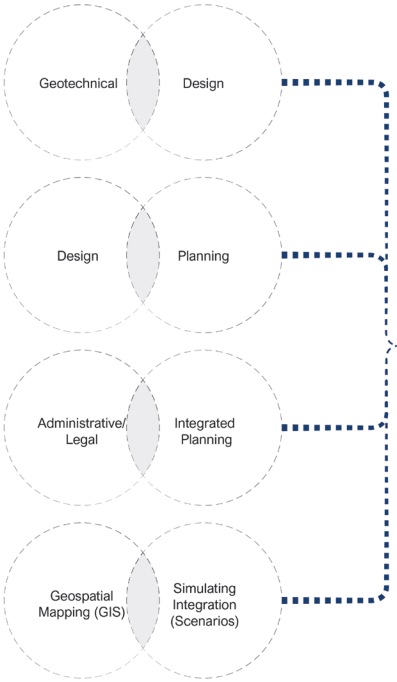
03 Research Questions

04 Devising Methodology

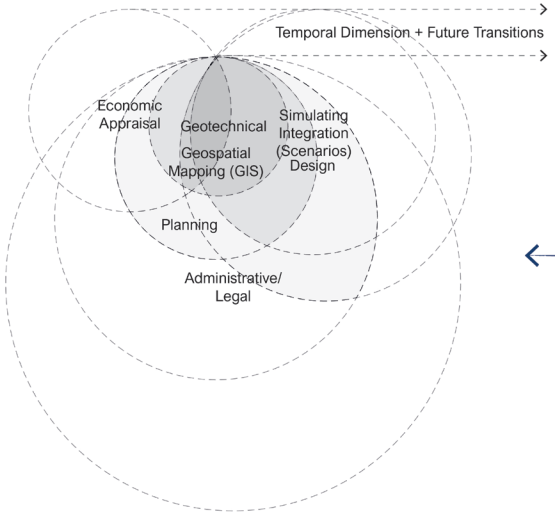
05 Revealing the Subsurface

06 Contextualizing Methodology

Isolated Field of Activities



Integrated System of Activities



Research Gaps

Development Projects undertaken at point-scale without considering wider urban impacts and opportunities.

Risk of exploitation: Subsurface regulations are still a relatively unchartered field.

Who are the Users?
Existing notions of subsurface yield an unstable mix of public vs private users

U.G. construction is a permanent change in geography. Current functions neglect the need of transition.

Research Aims

Platform Generation: Interdisciplinarity in designing and planning for underground spaces.

Volumetric Planning: Urban development projects should consider 3D phasing and design.

Perception Study: Identifying needs of different typologies of users to be served by subsurface functions.

Designing U.G. spaces and functions that are conscious of future transitions and transformability.

How can the existing isolated subsurface uses be integrated to form a collective functional geography composed of integrated urban underground systems through design interventions?

What is the extent of current Underground space inventory in the city of Amsterdam?

How to map and visualize the existing underground assets in a participatory manner?

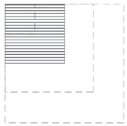
How to integrate isolated project-based underground development into a collective subsurface network?

How to phase and design the Groundscape according to the needs of public life and infrastructure development?

How to strategize balanced use of underground space at a city-scale?

Akhilesh Shisodia | 5490375

RESEARCH METHODOLOGY

Primary Research Question	Sub-Research Question	Scope of Study	Methods	Expected Outcomes	Scale
How can the existing isolated subsurface uses can be integrated to form a **Collective Functional Geography** composed of **Integrated Urban Underground Systems** through Design Interventions?	What is the extent of current Underground space inventory in the city of Amsterdam?	Analyzing current surface vs underground supply scenario Establishing dimensions of Underground space Planning Developing prototypical methods to spatialize existing underground spaces Mapping usable underground space within identified areas of interest	Literature Review, LiDAR Scanning and Digital Twins (GIS), Expert interviews, Secondary Data	Sizeable underground workable area with respect to opportunity and constraints Methods to reveal underground spaces for perception study	
	How to map and visualize the existing underground assets in a participatory manner?	Identifying gaps and potential nodes for connections with respect to function Identifying symbiotic current and future functions to be connected Designing typologies of urban underground corridors	Suitability Analysis (GIS), Expert interviews and Collaboration, Case Studies	Types of underground spaces suitable to influence demand including MRTS Time-based potential use for delineated space within site	
	How to integrate isolated project-based underground development into a collective subsurface network?	Testing existing parameters to design chosen case Analyzing context based constraints with respect to chosen geography Augmenting the existing inventory of patterns by micro-scale design and atmosphere definition	Technical Profile Analysis, Research by Design	Micro-scale Urban Design project to produce revised parameters of design directed towards integrating system of activities	
	How to Phase and Design the Groundscape according to the needs of public life and infrastructure development?	Preparing a parameters of design for context-specific subsurface interventions Testing devised typologies and aligning functions with future transitions for remaining cases Allocating functions to promote collective surface and U.G. use	Learning from literature, Developing Scenarios, Collaboration Workshop, Actor interviews (Perception study)	Context-specific toolbox to design underground spaces Suitable Volumetric functions	
	How to strategize balanced use of underground space at the city scale?	Integrating zone-based surface and subsurface development strategy	Literature review, Research by Design, Stakeholder Consultation	Comprehensive Zone-based development strategies inclusive of subsurface functions	

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Grids of Subsurface Development

1 Macro Scale

- Context-based Parameters for District Selection
- Type of Subsurface Development

Urbanist/ Urban Planner

Location of Space

3 Micro Scale

- Parameters of Quality of Space
- Function Allocation techniques and typologies
- Groundscape Design
- Type of Subsurface Interventions

Architect | Environmental Planner

Experience of Space

2 Meso Scale

- Parameters of Workable Underground Delineation
- Urban Design strategies
- Quantification of Functions and Volume
- Type of Subsurface Construction

Urban Designer | Environmental Planner

Amount of Space

Grids of Subsurface Development

1 Macro Scale

- Context-based Parameters for District Selection
- Type of Subsurface Development

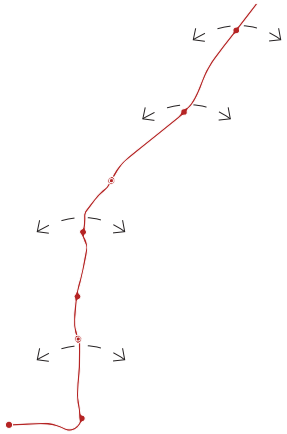
Urbanist/ Urban Planner

Location of Space

AMSTERDAM UNDERGROUND: SYSTEM OF POINTS AND LINES

Amsterdam exists in complex state of presevation and flux given the sensitive landscape combined with globalized urban spaces. Recent design projects have explored alternative locations for construction beyond the surface i.e., in the form of urban islands on water bodies and underground.

- Previously, underground spaces in the city have only existed as isolated local basements or parking spaces for business centers.
- Subsurface use as a system of point and lines where the distances between the nodes is not walkable.

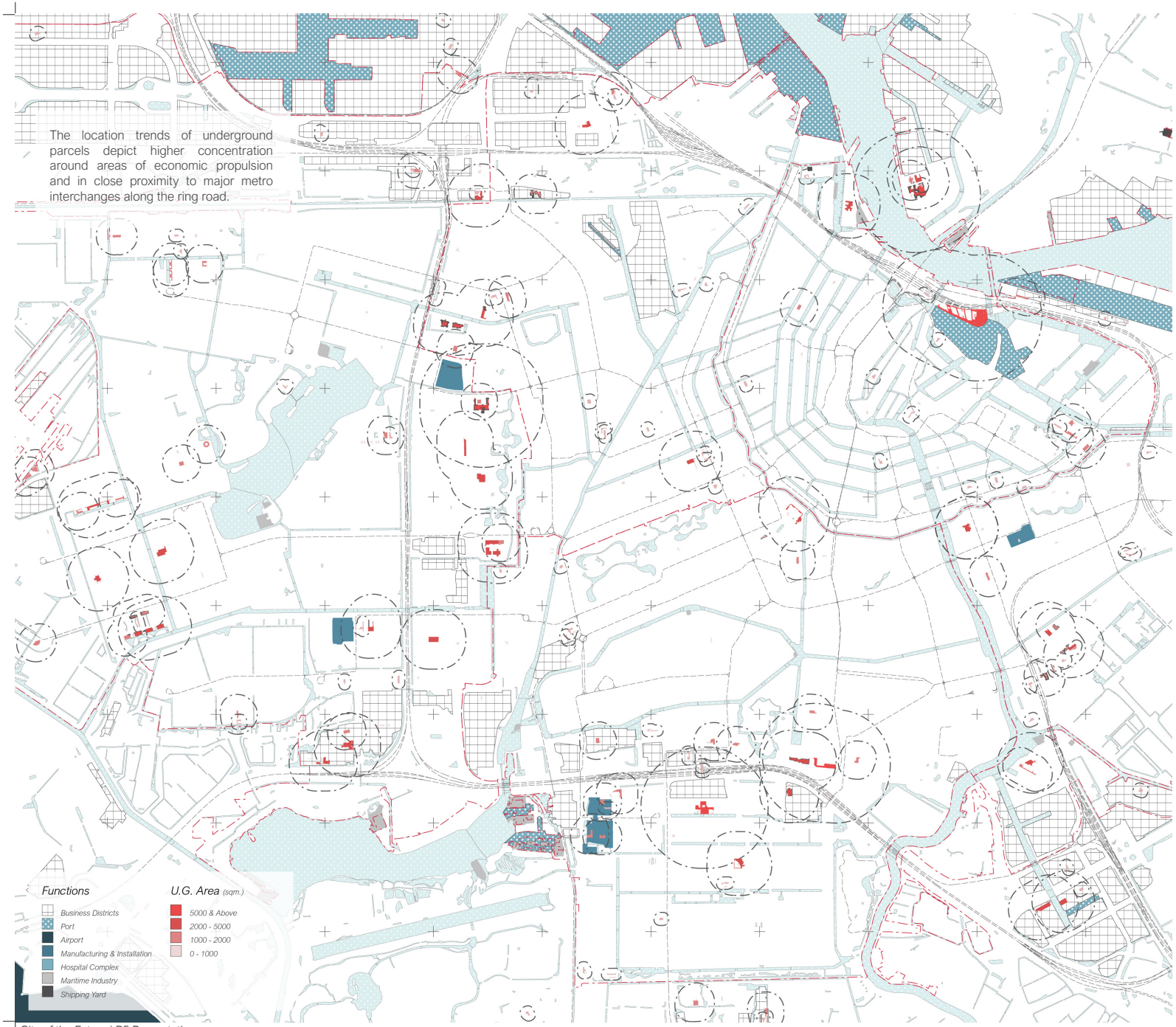


Map showing Amsterdam's Superground vs Underground profile
Source: Author

Source: Author

CITY-SCALE SUBSURFACE INVENTORY

The location trends of underground parcels depict higher concentration around areas of economic propulsion and in close proximity to major metro interchanges along the ring road.



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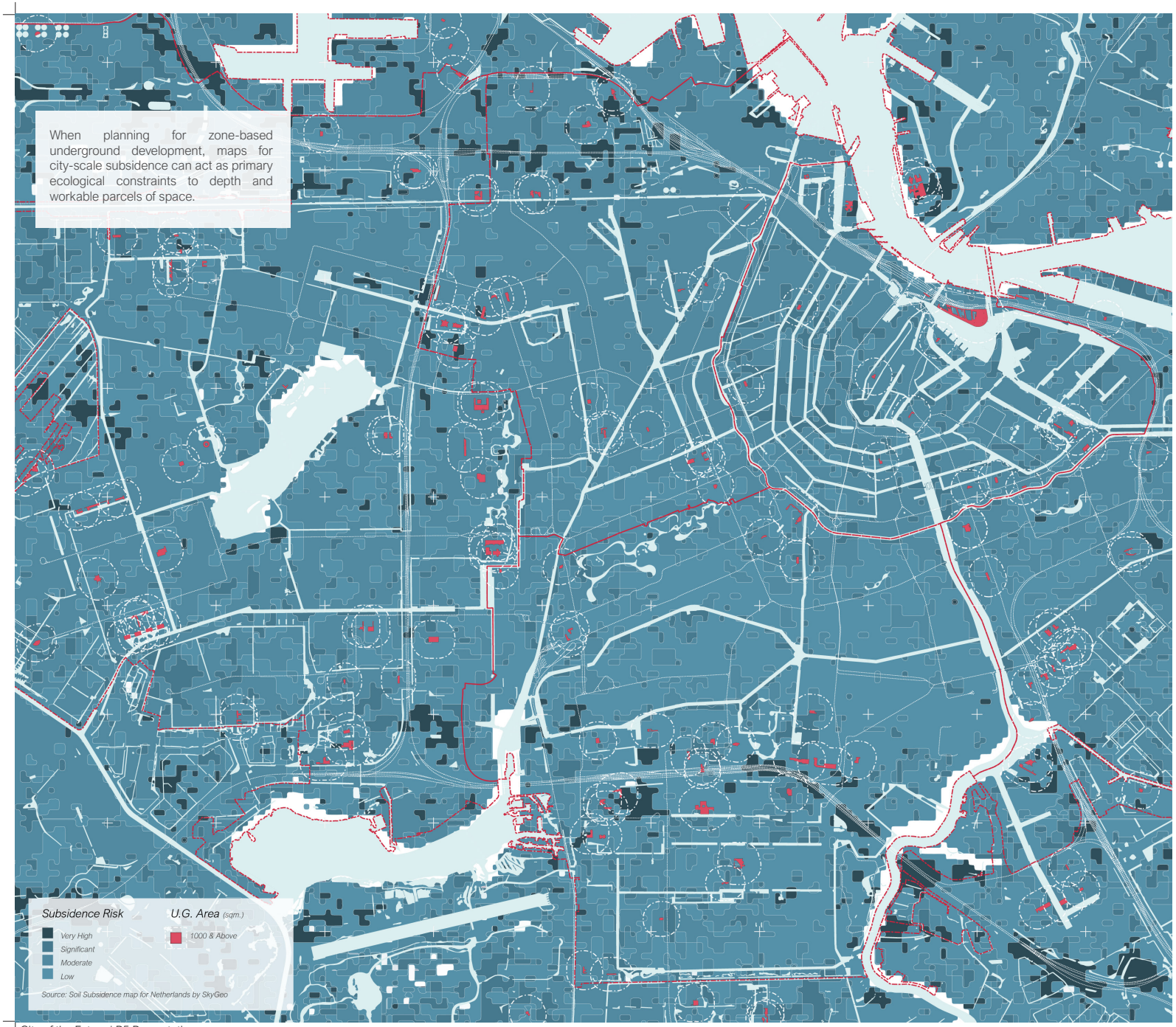
RISK OF SUBSIDENCE

When planning for zone-based underground development, maps for city-scale subsidence can act as primary ecological constraints to depth and workable parcels of space.



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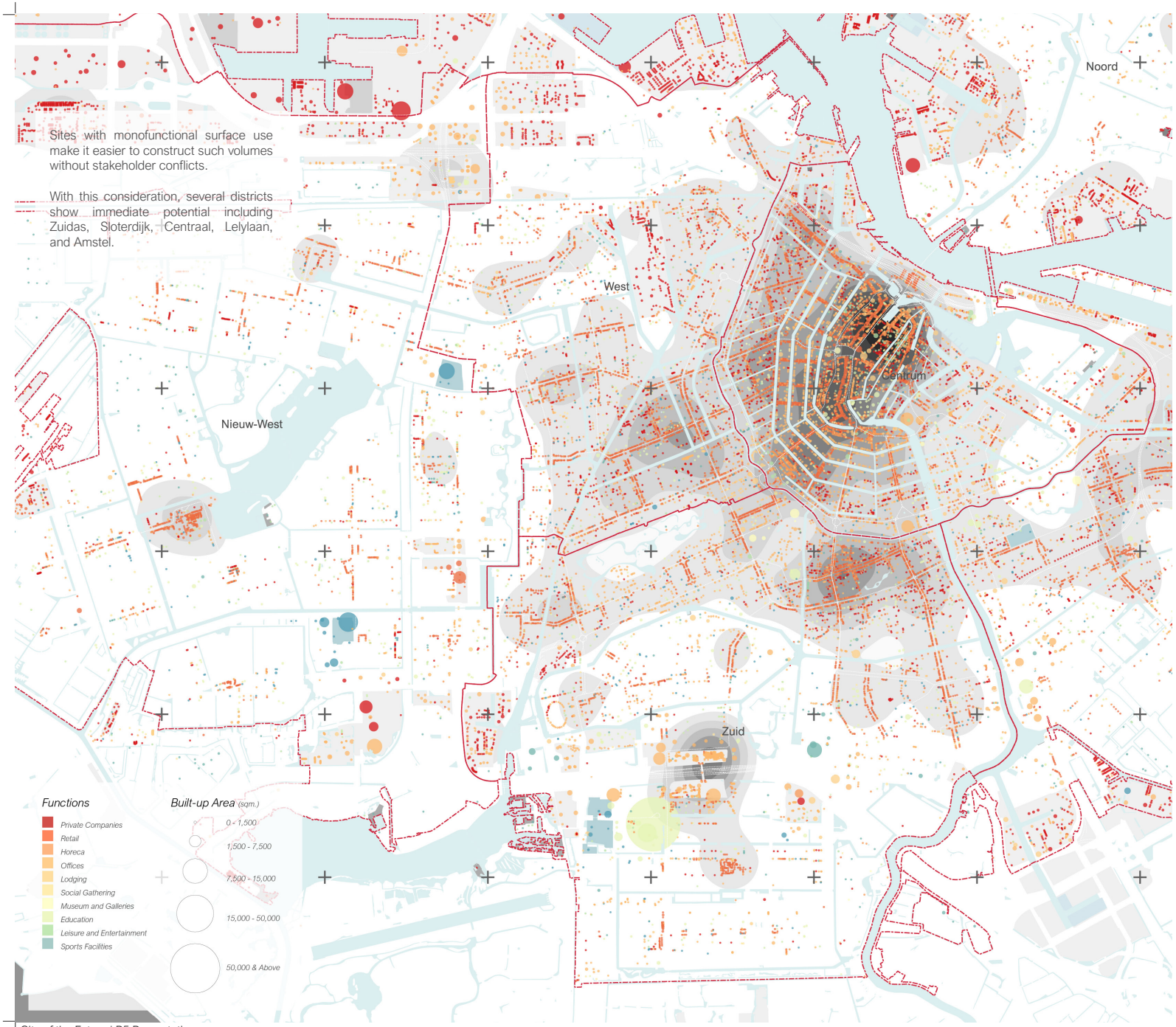

NON-RESIDENTIAL NODES

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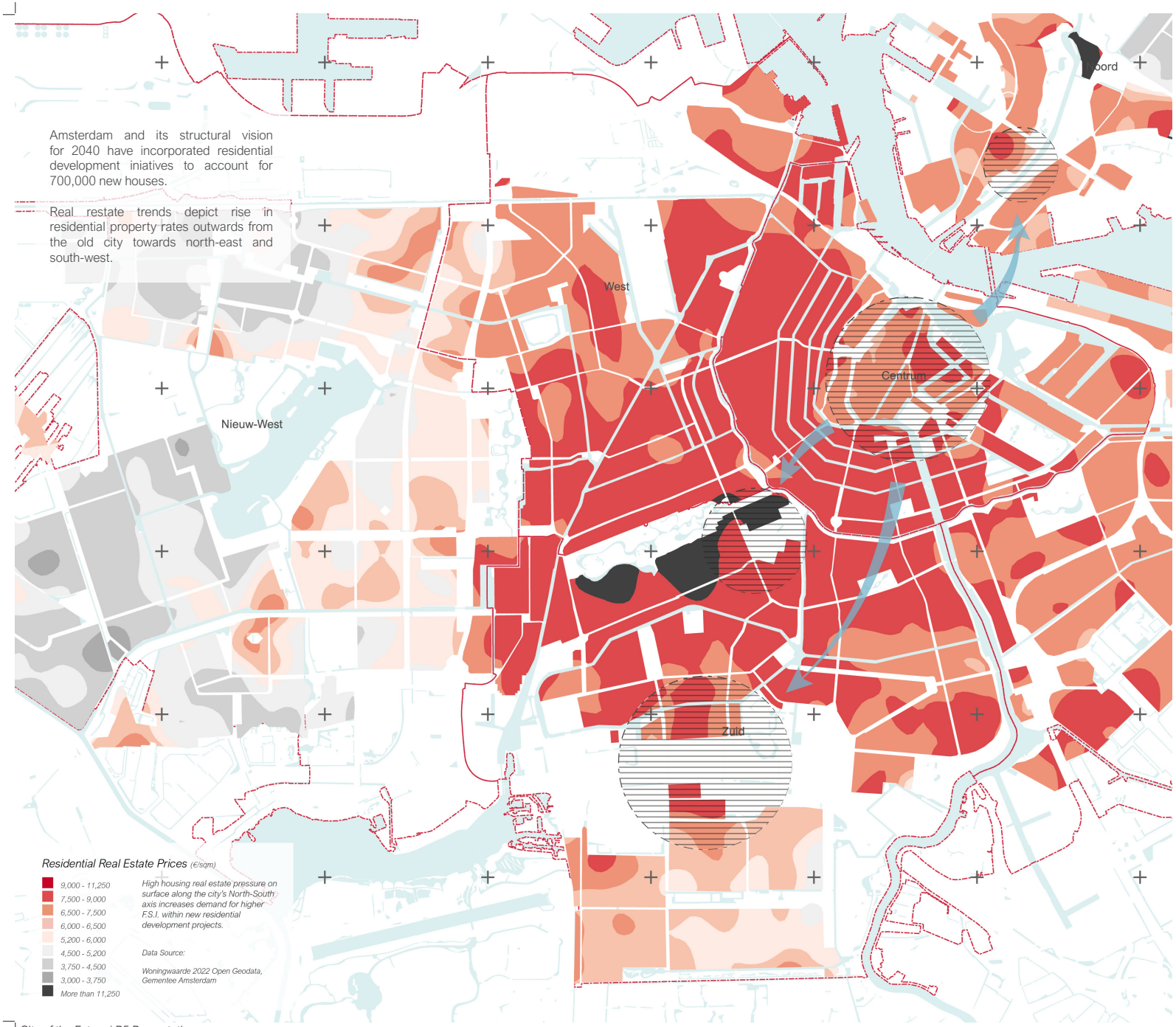
RESIDENTIAL POTENTIAL ON SURFACE

Amsterdam and its structural vision for 2040 have incorporated residential development iniatives to account for 700,000 new houses.

Real restate trends depict rise in residential property rates outwards from the old city towards north-east and south-west.



Residential Real Estate Prices (€/sqm)

- 9,000 - 11,250
- 7,500 - 9,000
- 6,500 - 7,500
- 6,000 - 6,500
- 5,200 - 6,000
- 4,500 - 5,200
- 3,750 - 4,500
- 3,000 - 3,750
- More than 11,250

High housing real estate pressure on surface along the city's North-South axis increases demand for higher F.S.I. within new residential development projects.

Data Source:

Woningwaarde 2022 Open Geodata, Gemeentee Amsterdam

N 1km

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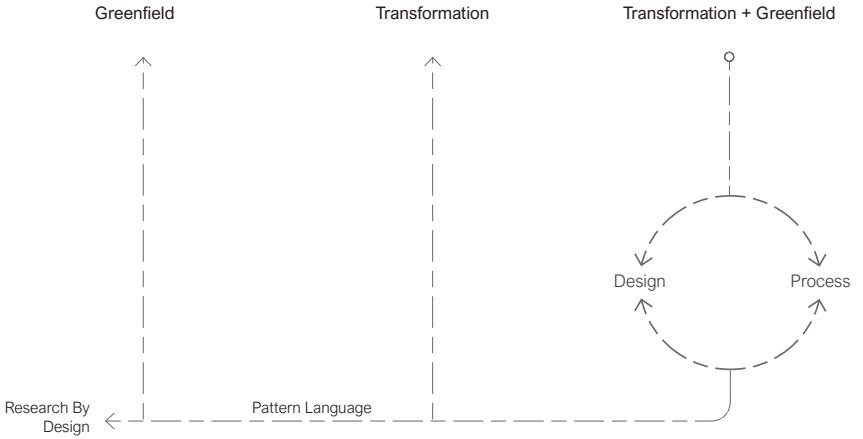
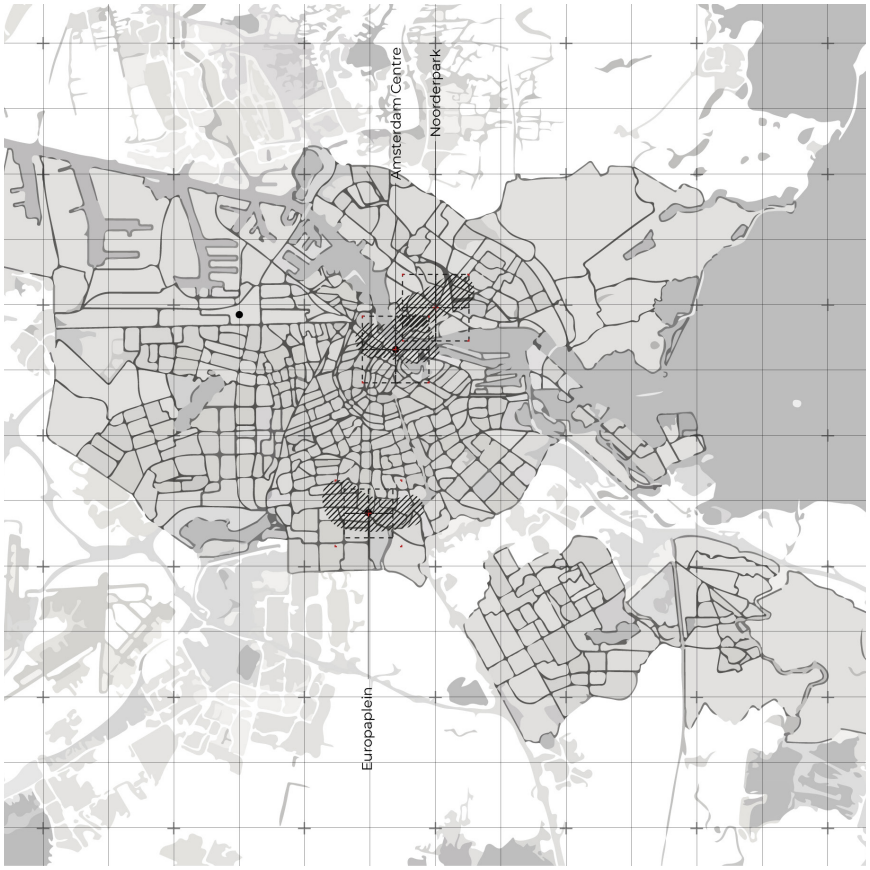
Contextual Parameters

1. Residential
2. Greenfield
3. Limited Transit Infrastructure
4. Moderate Subsidence Risk

1. Commercial + Institutional
2. Brownfield
3. Dense Transit Infrastructure
4. High Subsidence Risk

1. Residential + Commericial
2. Greenfield + Brownfield
3. Dense Transit Infrastructure
4. Low Subsisdence Risk

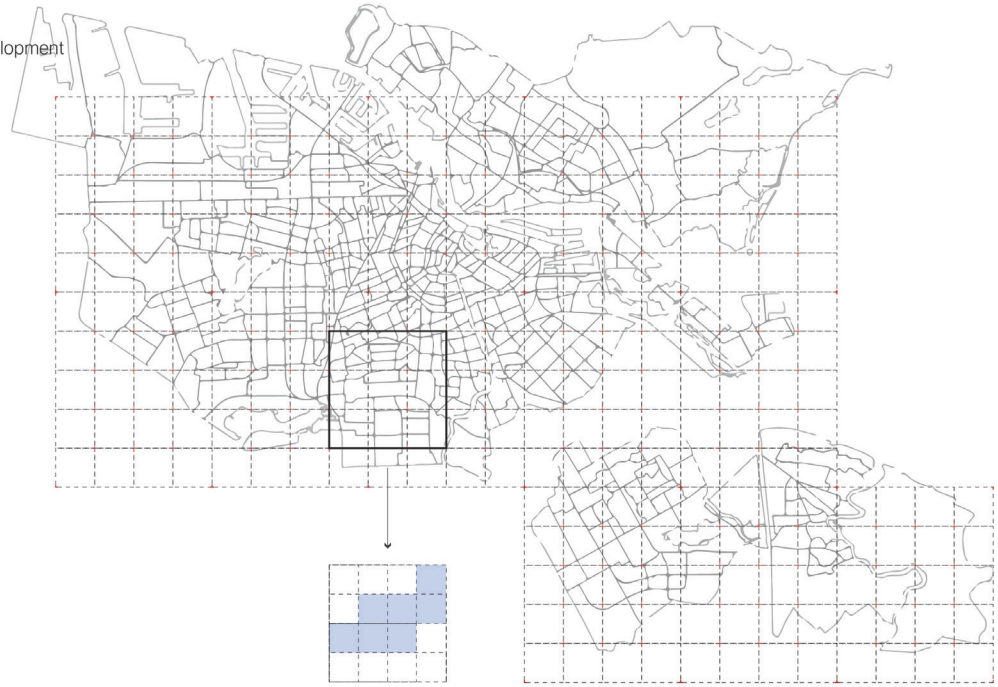




AREAS OF INTEREST

The chosen test sites for this study are located at three different stations along the metro line, catering to surrounding neighborhoods of distinct character and respective nature of possible underground construction.

Grids of Subsurface Development



2 Meso Scale

- Parameters of Workable Underground Delineation
- Urban Design strategies
- Quantification of Functions and Volume
- Type of Subsurface Construction

Urban Designer | Environmental Planner

Amount of Space

01 Notions and Problem Field

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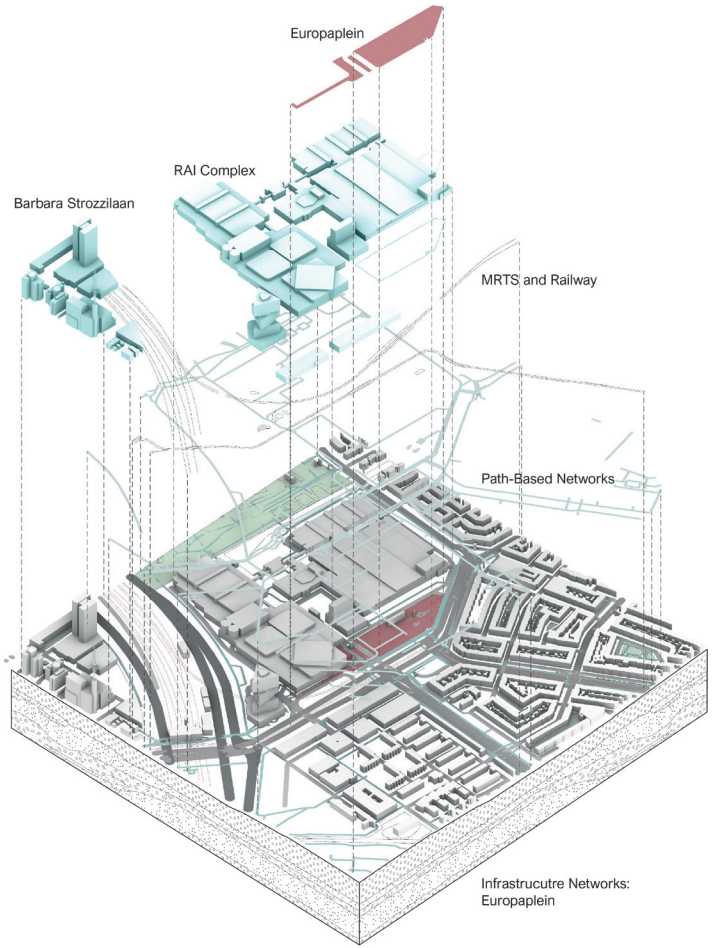
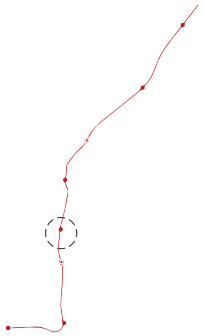
Transformation + Greenfield

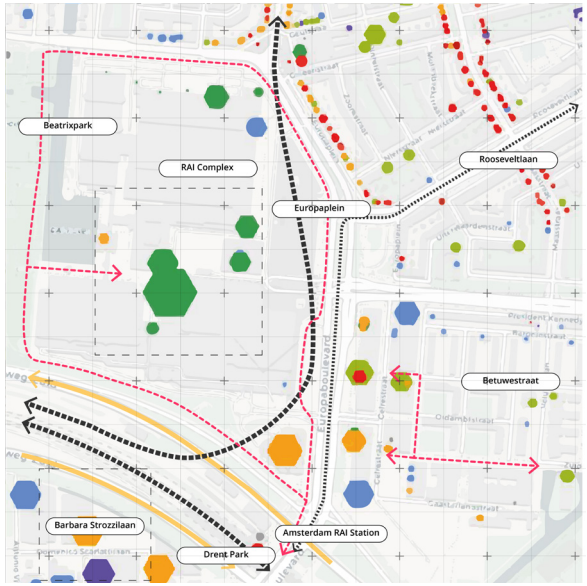




ZUIDAS | EUROPAPLEIN | VIVALDI

- The site lies outside the old city with large office spaces, cultural spaces and parks in the vicinity. Hence the context is composed of high-value real estate.
- Well-connected by Tram, metro and bicycle networks.
- Located adjacent to the South Ring road and Amsterdam RAI Station.
- Parks and open spaces provide a suitable context for redevelopment of UUS construction, augmentation and infrastructural integration.

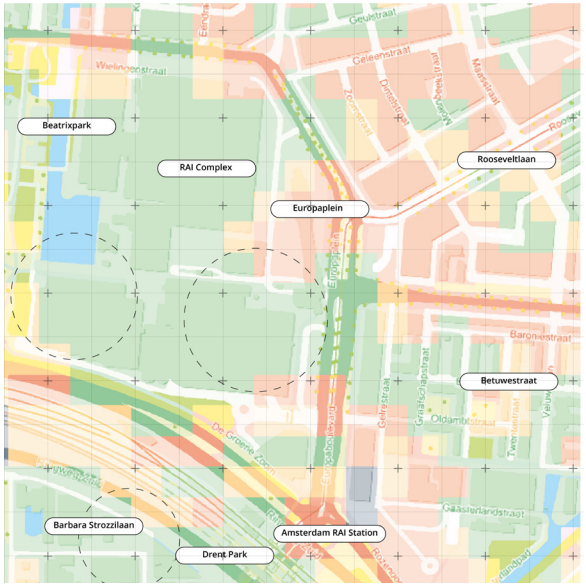
Map Source: Klimaatkart.nl



Legend: Public Functions

- Retail
- FnB
- Offices
- Businesses
- Social Gathering
- Pedestrians
- Highway Traffic
- Railway/Metro
- Tram
- Museum/Leisure

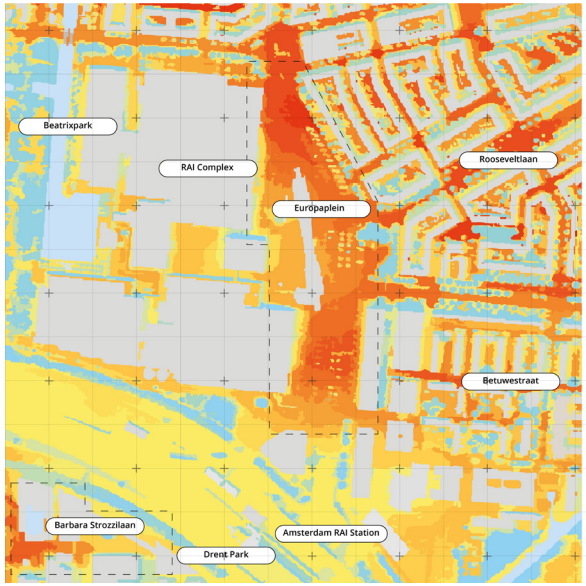
N 100m



Legend: Subsidence Risk

- Low risk
- Moderate Risk
- Significant Risk
- High Risk

N 100m



Legend: Heatstress

49°C 48°C 47°C 46°C 45°C 44°C 43°C 42°C 41°C 40°C 39°C 38°C 37°C 36°C 35°C 34°C 33°C 32°C 31°C 30°C 29°C 28°C 27°C 26°C of lager

N 100m

Opportunity: Linking Public Functions

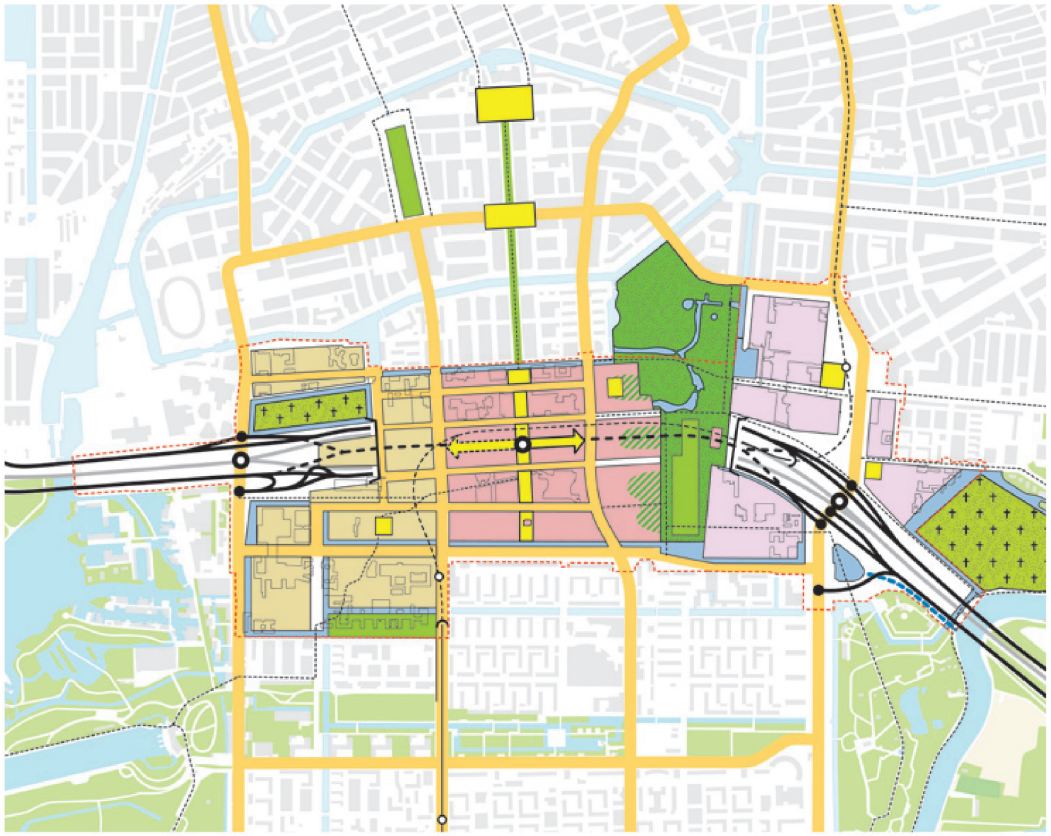
- To bring the functions around Europaplein closer to human-scale while increasing range of functions, underground spaces can incorporate linear corridors for pedestrians, retail spaces and FnB outlets.
- To overcome physical barriers such as ring road on surface, subsurface augmentation can help in integrating isolated functions.

Subsidence and Redevelopment

- In the past 5 years, RAI and Barbara Strozzilaan show least risk of subsidence. Hence, suitable for underground urban corridors as connective tissue.
- Using public spaces in vicinity as sites for redevelopment to construct subsurface nodes reduces cost threshold.

Opportunity: Reduced Heatstress

- Subsurface spaces offer higher interstitial mass and atmospheric stability with low energy input.
- To reduce heat stress, several functions can be shifted underground to make space for green spaces on surface instead of paved.



Zuidas Vision

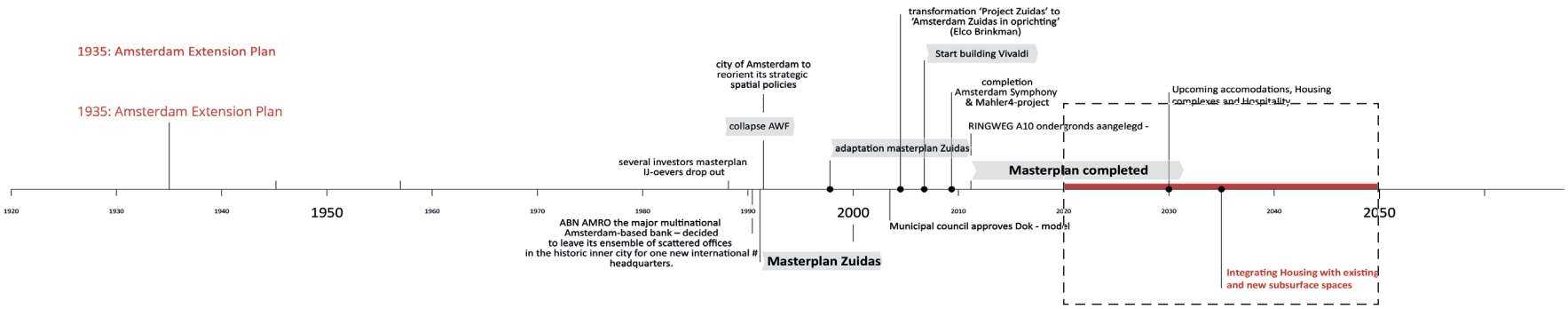
September 2009

- Plan area
- Zuidas West
- Zuidas Centre
- Zuidas East
- Water
- City and park as one
- Beatrixpark
- Cemetery
- Sports fields
- Public space
- Visual-spatial relationship
- A10 motorway
- Underground access route
- Urban street
- Secondary route
- Rail and metro
- Station
- Noord-Zuid metro line with stop
- Connection with River Amstel
- Existing/planned construction

N

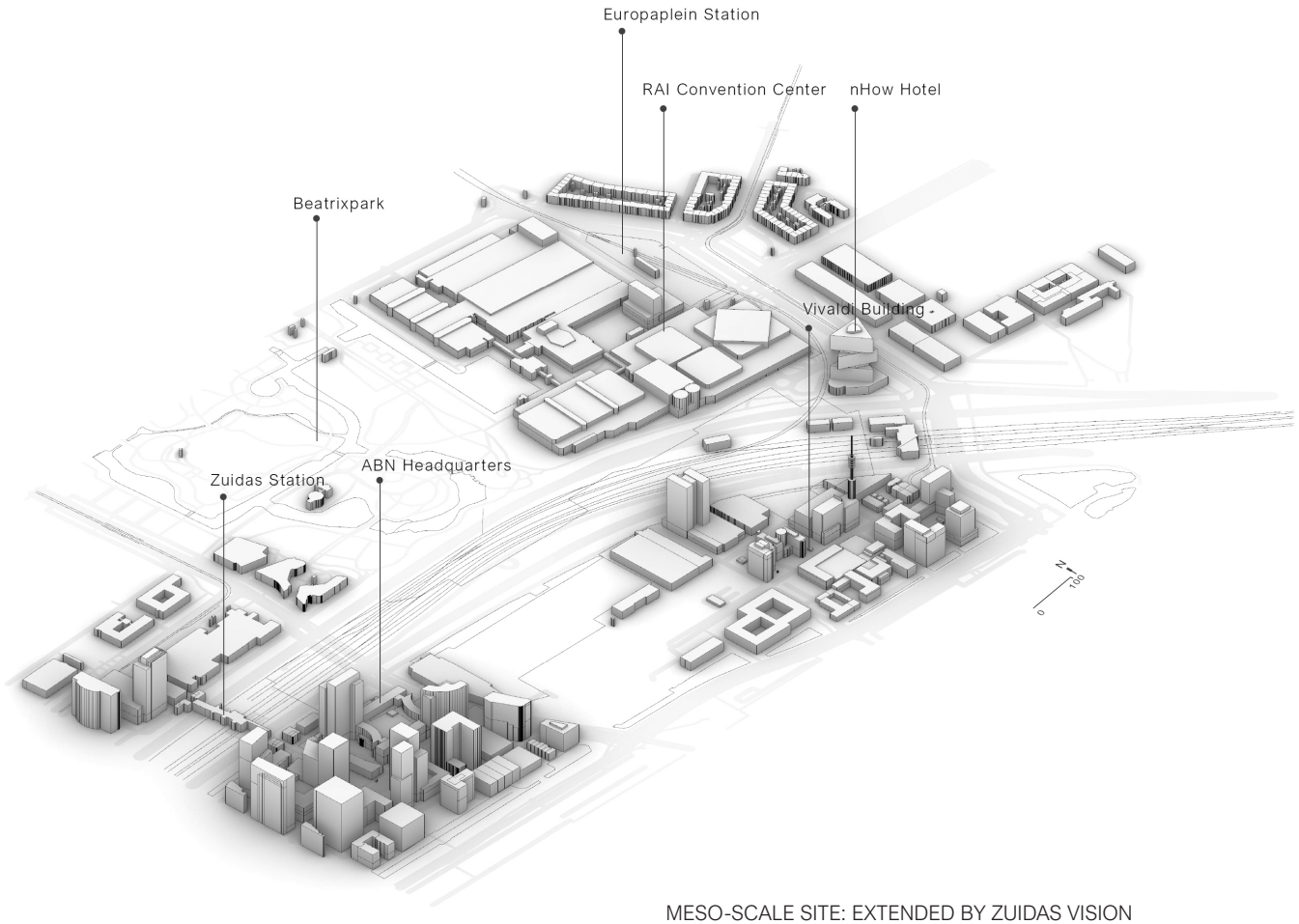
0 100 250 500m

Source: Zuidas Vision 2050 Document

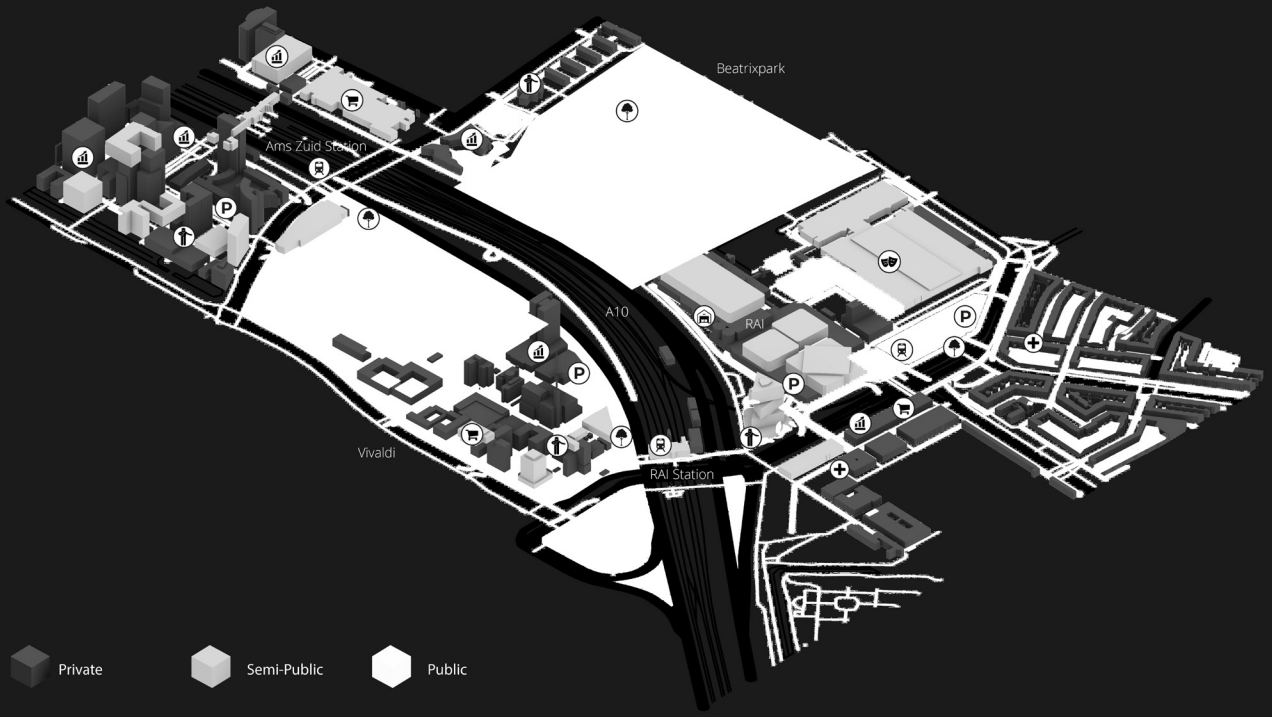


Source: Zuidas Vision 2050 Document

ZUIDAS VISION TIMELINE: SUBSURFACE EXPLORATION



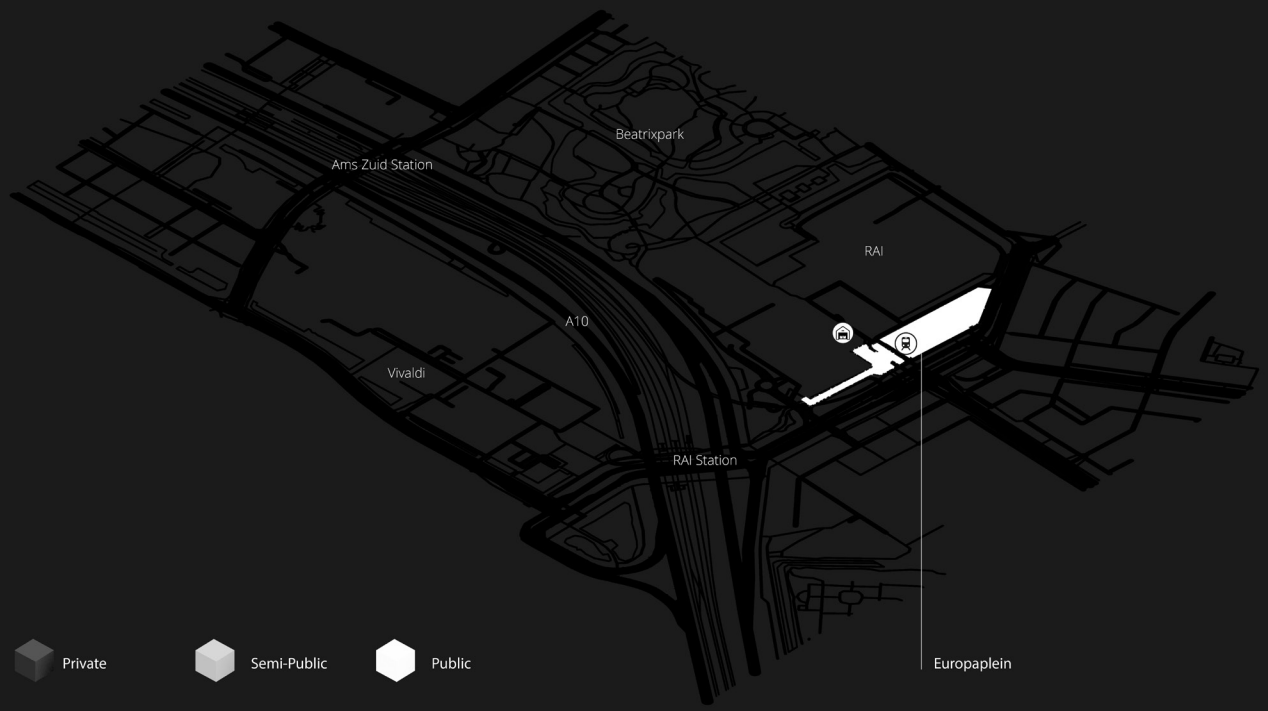
MESO-SCALE SITE: EXTENDED BY ZUIDAS VISION

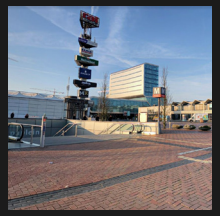


The site lies outside the old city with large office spaces, cultural nodes, and parks in the vicinity. Hence the context is composed of high value real estate. Europaplein is well-connected by tram , metro and bicycle networks and located adjacent to the South Ring road which is a major thoroughfare producing physical barriers for pedestrians.

SURFACE ACCESSIBILITY

- Large-scale Non-residential uses include Cultural spaces, offices, hotels, churches, parks, shopping centers and parks.
- Ring Road and Vehicular + Railway infrastructure acts as a barrier leading to a disjoint system and monofunctional spaces.
- Different typologies on infrastructure networks intersect including logistics, railway and public paths, leading to conflicts.

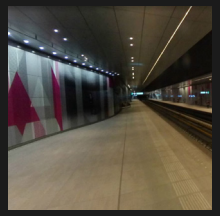




① North-Side Entrance

② Entrance Gates

③ Access to Platform



④ Platform

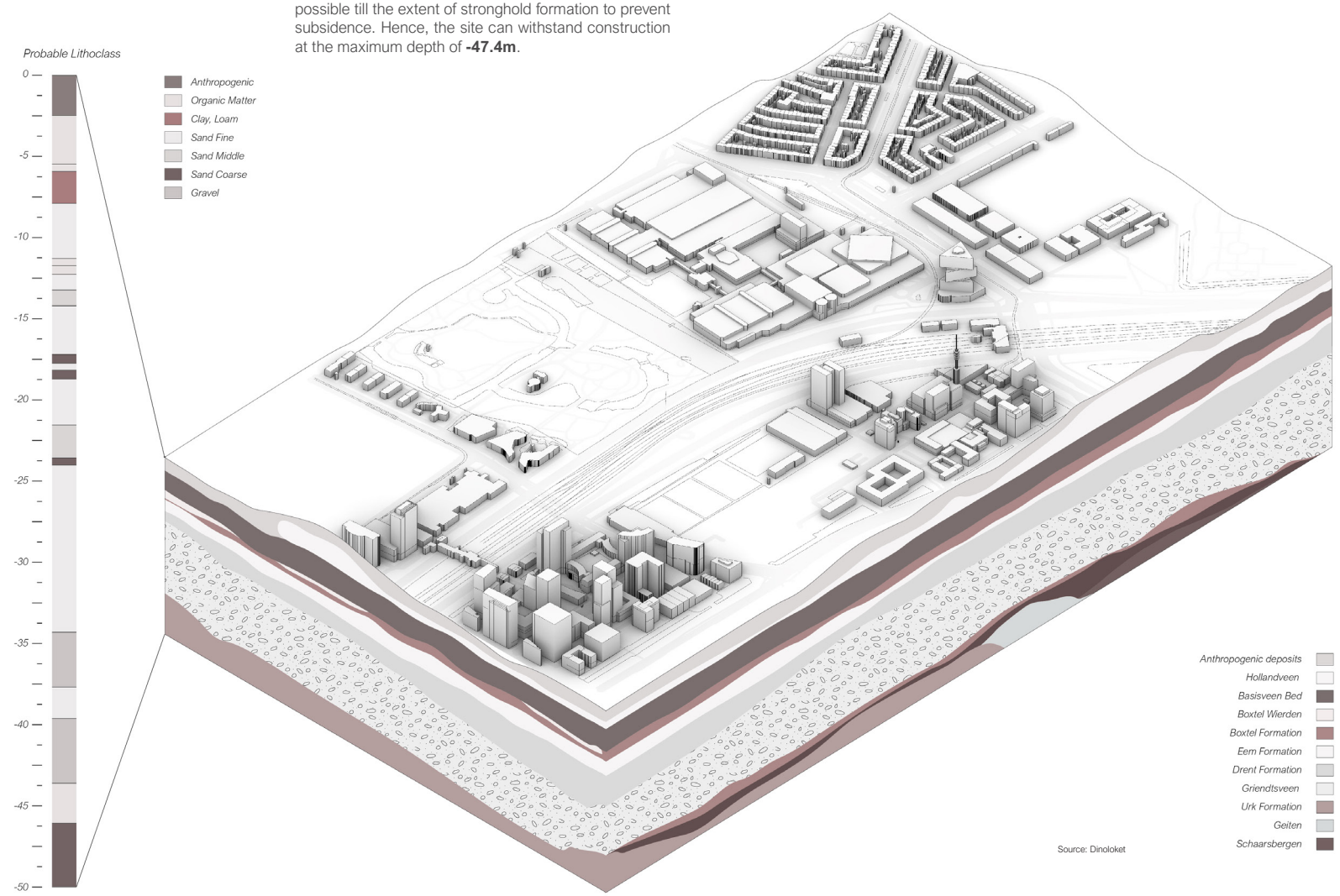
Interior Spaces: Europaplein Station

SUBSURFACE ACCESSIBILITY

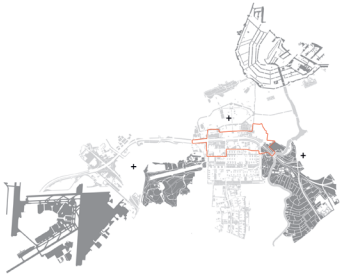
- The subsurface use is dominated by parking spaces, warehouses, public transport (Monofunctional)
- Underground spaces are not connected, subject to ownership by public and private sectors.
- The spaces do not connect with RAI or Barbara Strozzilaan Business center.

SUBSOIL AND SUBSIDENCE

The technical profile of the site descibes primary layers of sand, boxtel and clay at the depth of 0-12m. Underground construction in this soil profile is only possible till the extent of stronghold formation to prevent subsidence. Hence, the site can withstand construction at the maximum depth of **-47.4m**.



Meso-Scale: Europaplein

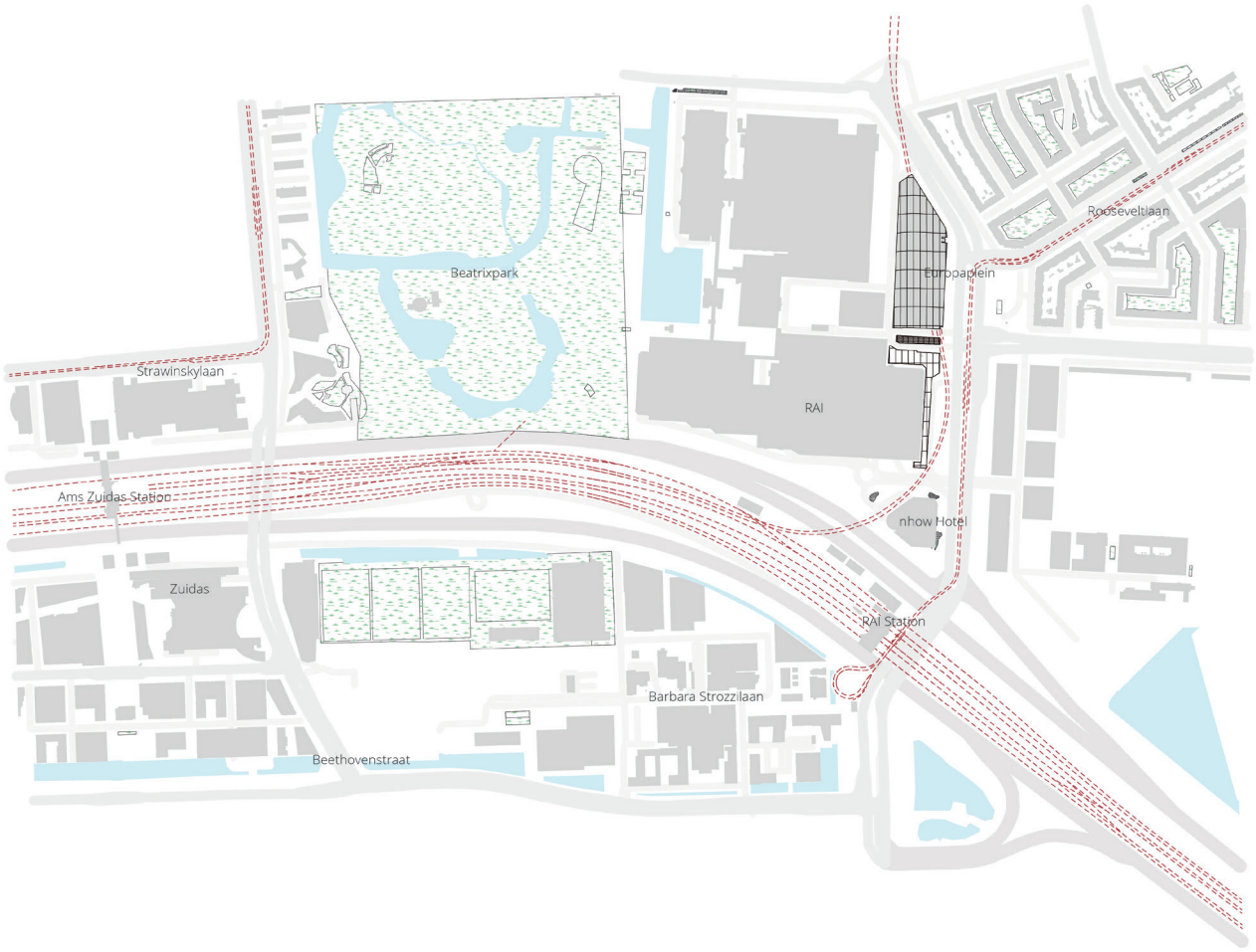


keymap

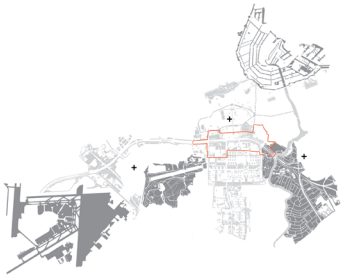
Legend

- Public Parks
- Buildings
- Highway
- Water Bodies
- Railway/Tram
- Underground Expansion
- U.G. to Surface Transition
- U.G. Movement

N 150m



Workable Underground: Subsidence Risk

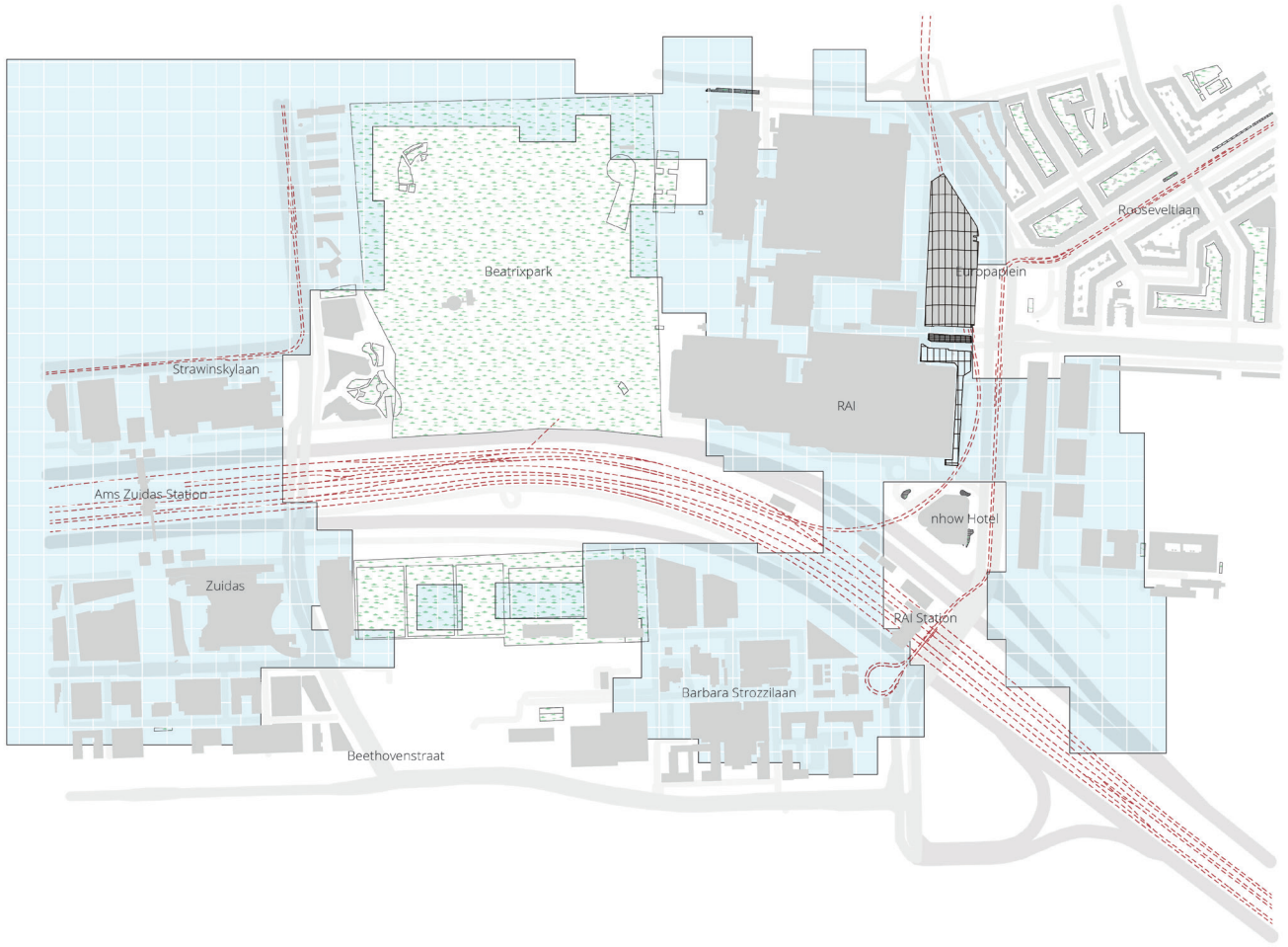


keymap

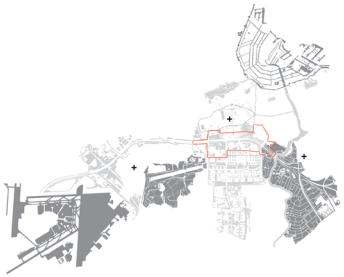
Legend

- Public Parks
- Buildings
- Highway
- Low Subsidence Risk
- Railway/Tram

N 150m



Expandable Corridors

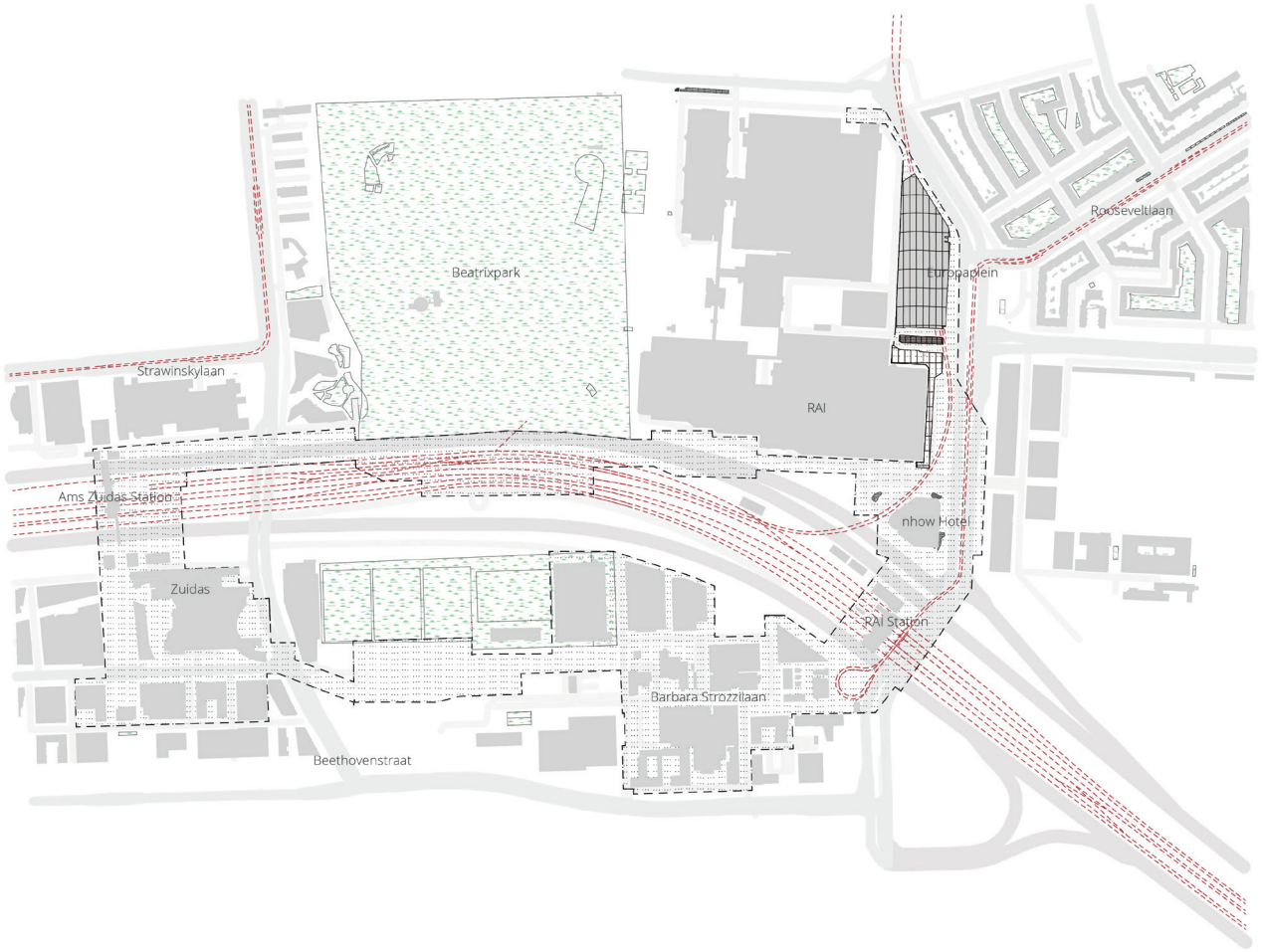


keymap

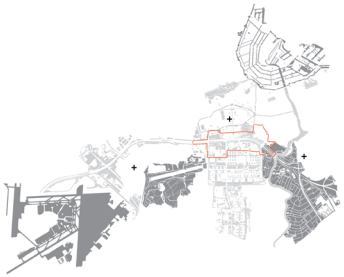
Legend

- Public Parks
- Underground Expansion
- Buildings
- Highway
- Water Bodies
- Railway/Tram

N 150m



Nodes and Corridors

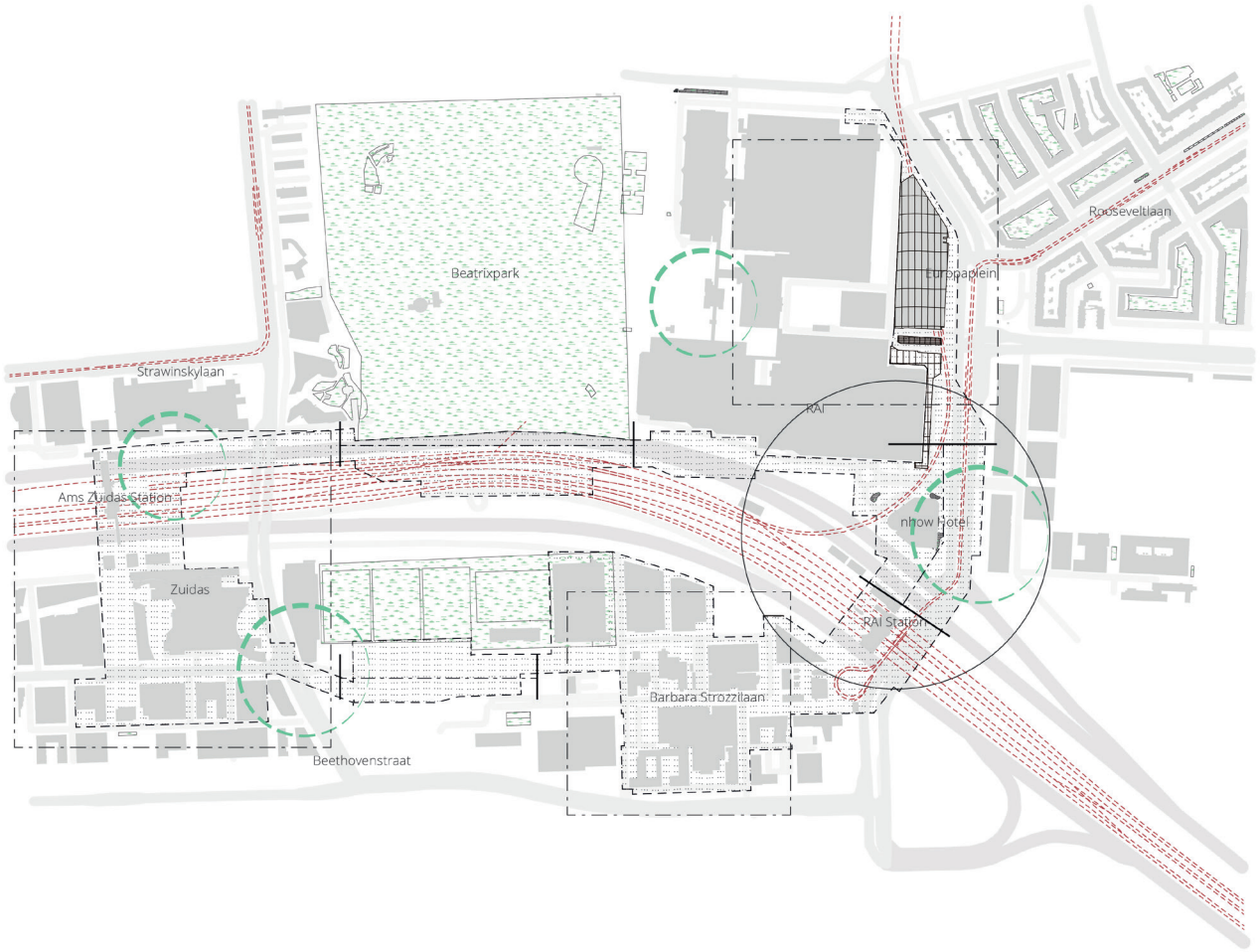


keymap

Legend

- Public Parks
- Underground Expansion
- Buildings
- Highway
- Water Bodies
- Railway/Tram

N 150m



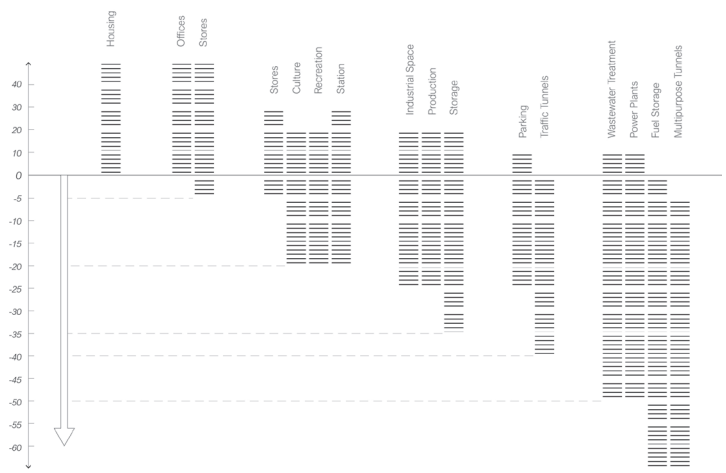
Linking Surface and Subsurface

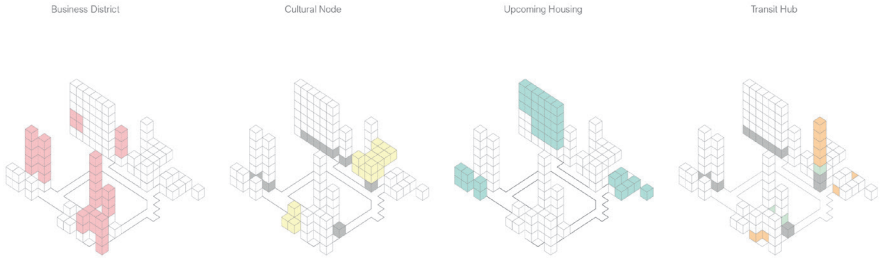
keymap

Legend

- Public Parks
- Buildings
- Highway
- Water Bodies
- Railway/Tram
- Underground Expansion
- U.G. to Surface Transition
- U.G. Movement

N 150m

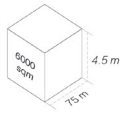




QUANTIFYING VOLUME OF FUNCTIONS

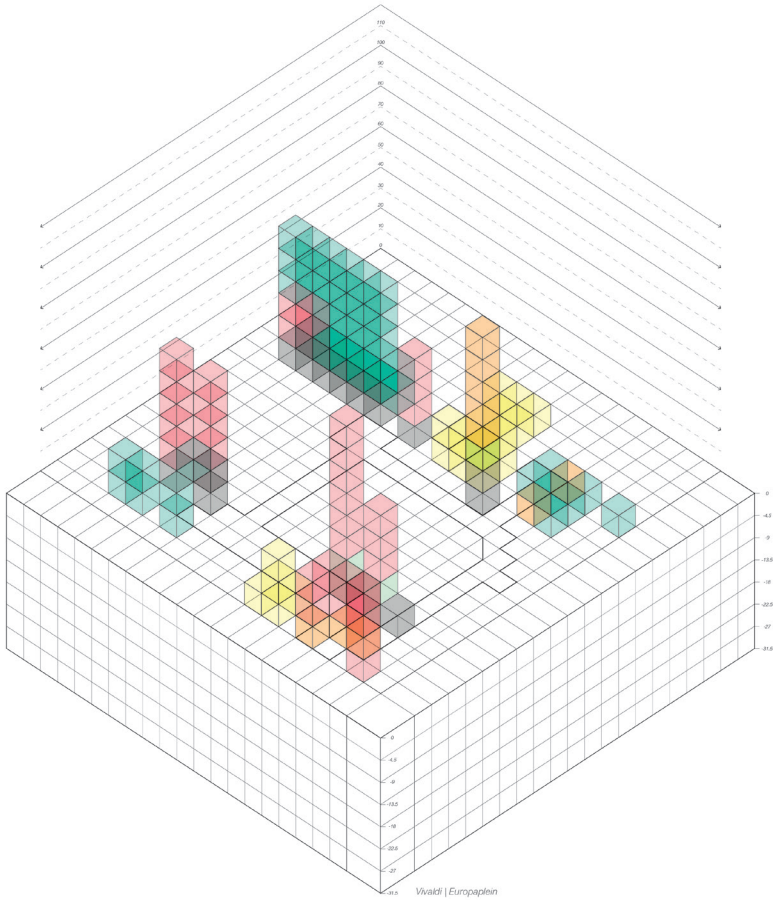
The vision document for Zuidas indicates the need of an additional 350,000 sqm of base area based on the projections of space required.

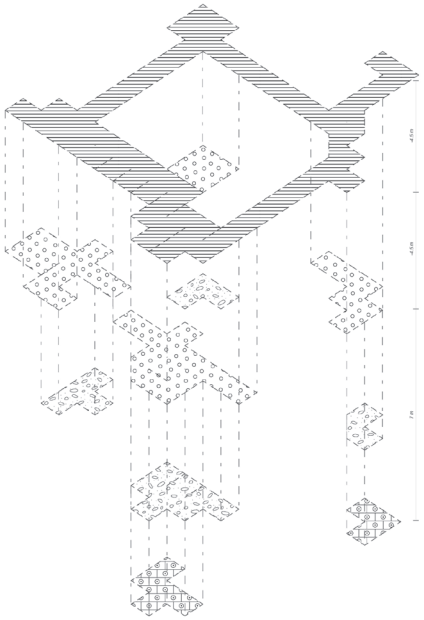
- Maximum Depth : **-47.5 m**
- Achievable Depth: **-20.5 m**
- Total Built-up Area: **550,000 sqm**
- Average F.S.I.**: 1.55**

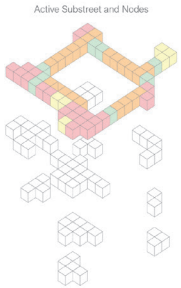


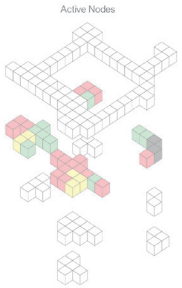
Volumetric Split

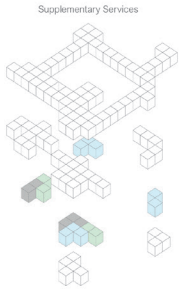
- Office
- Retail/ Commercial
- Cultural/ Leisure
- Parking
- Amenities
- Residential

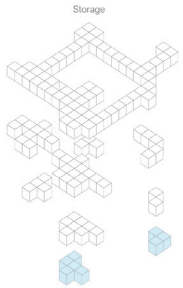










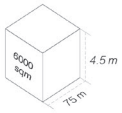


ALLOCATION WITHIN ACHIEVABLE DEPTH

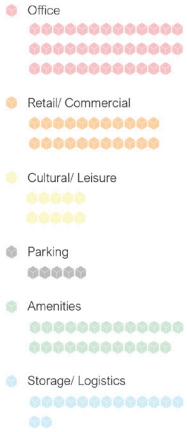
The quanitification of underground volumetric split results in levels of 4 different characters:

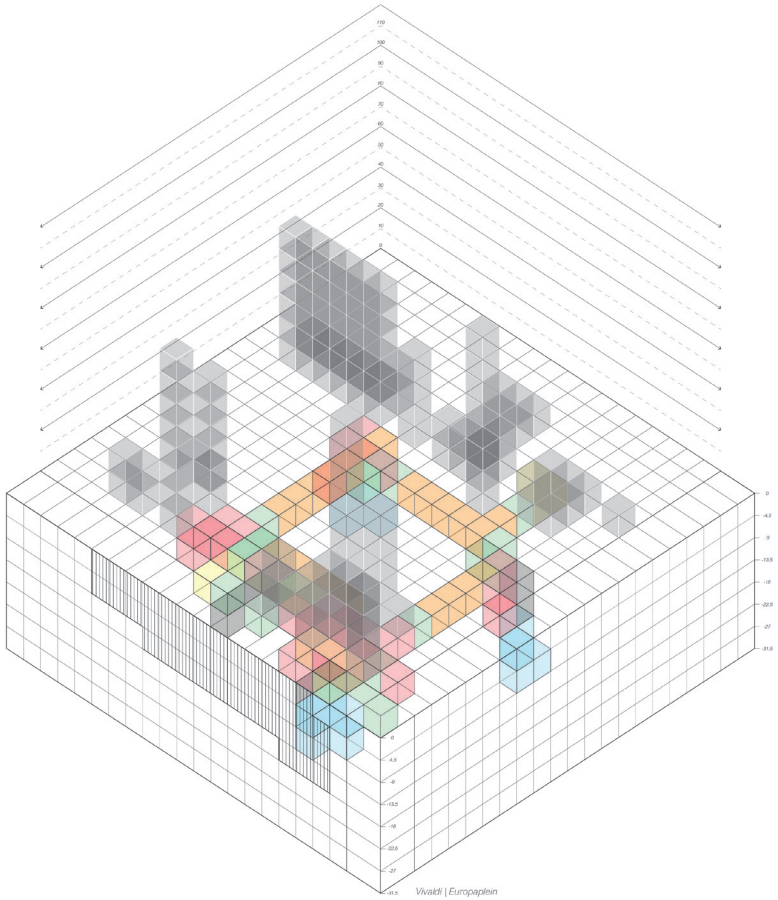
1. Active substreet and nodes
2. Active Nodes
3. Supplementary services
4. Storage

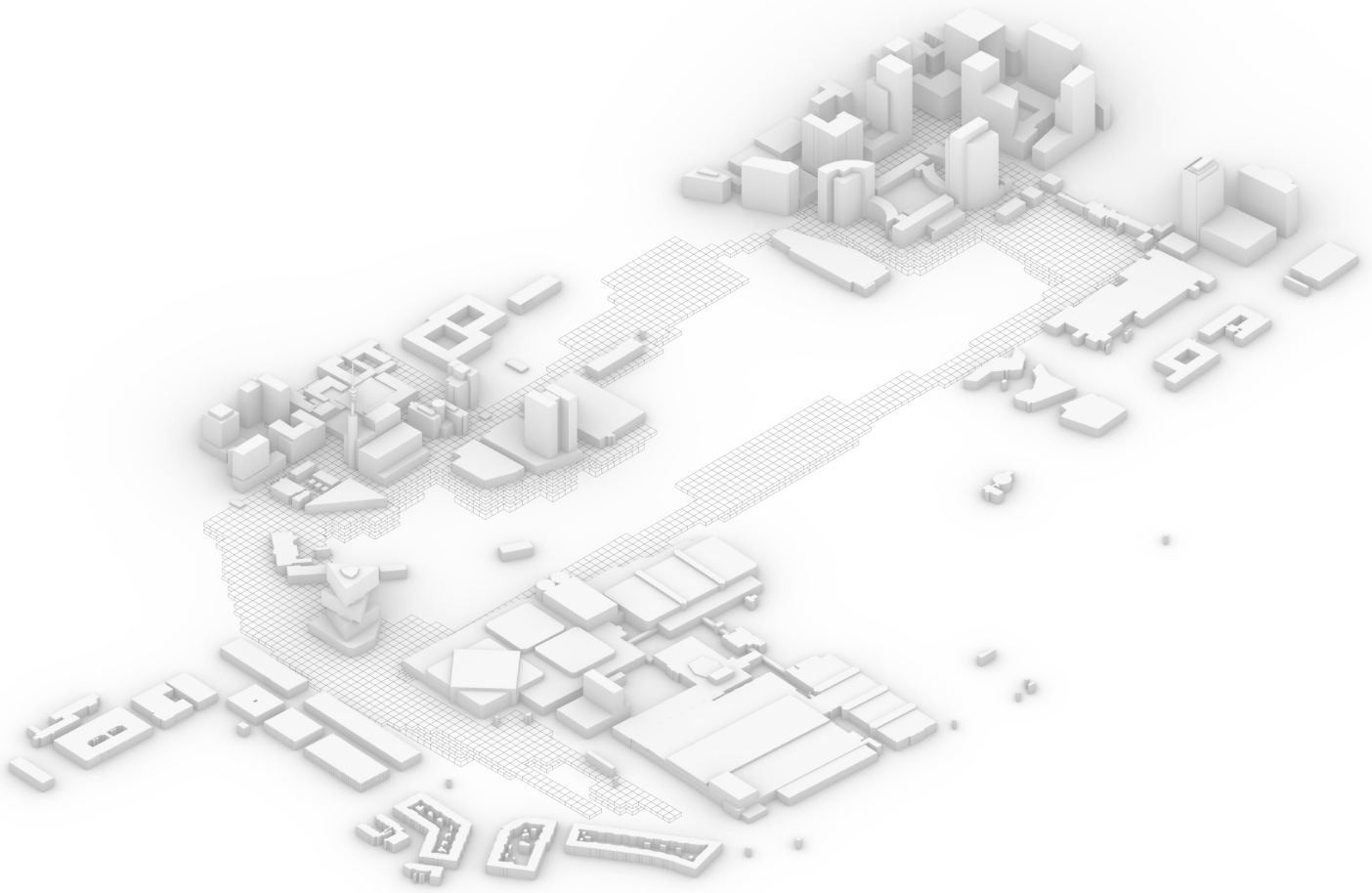
- Amenities (30%)
- Business Areas (33%)
- Retail | Leisure | Cultural (32%)
- Parking (5%)



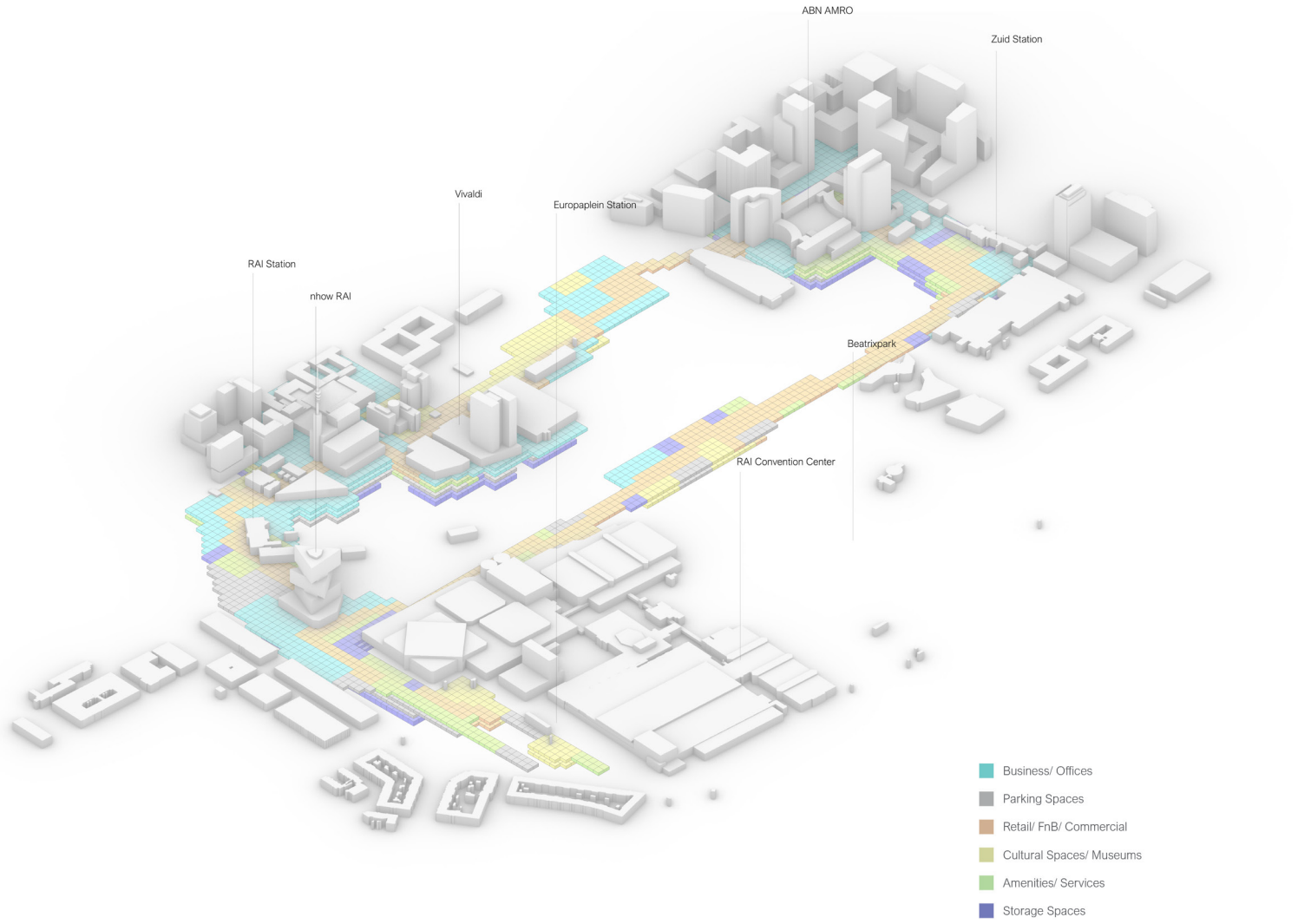
Volumetric Split



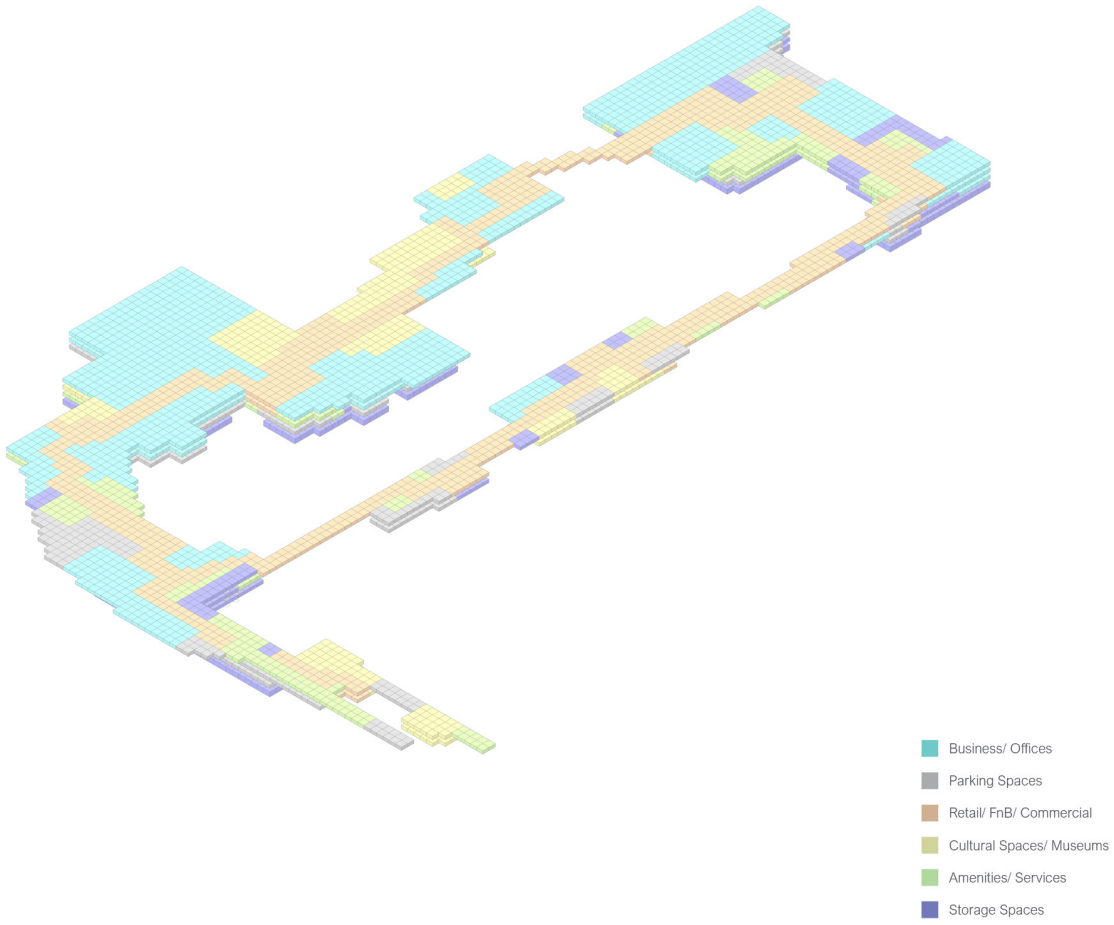




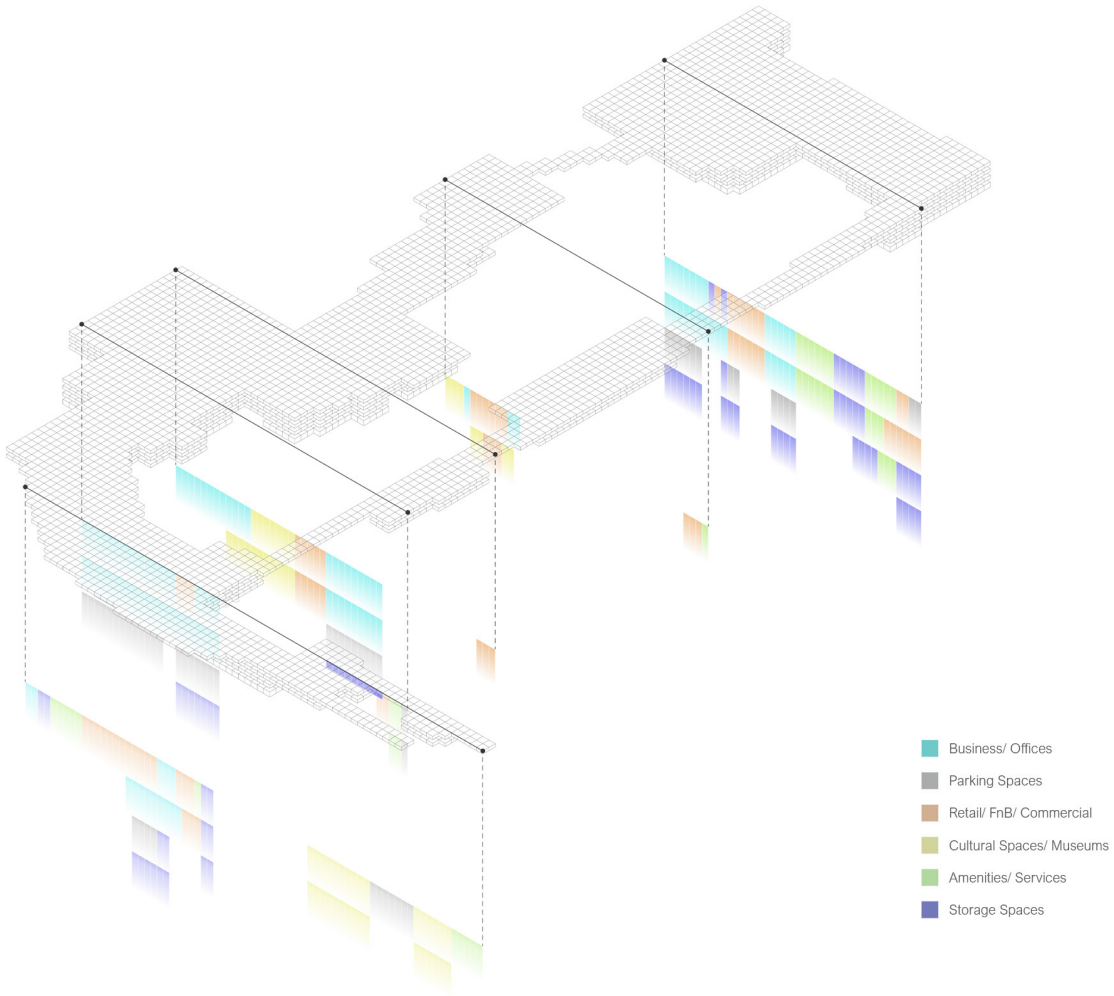
SUBSURFACE GRID: MESO SCALE



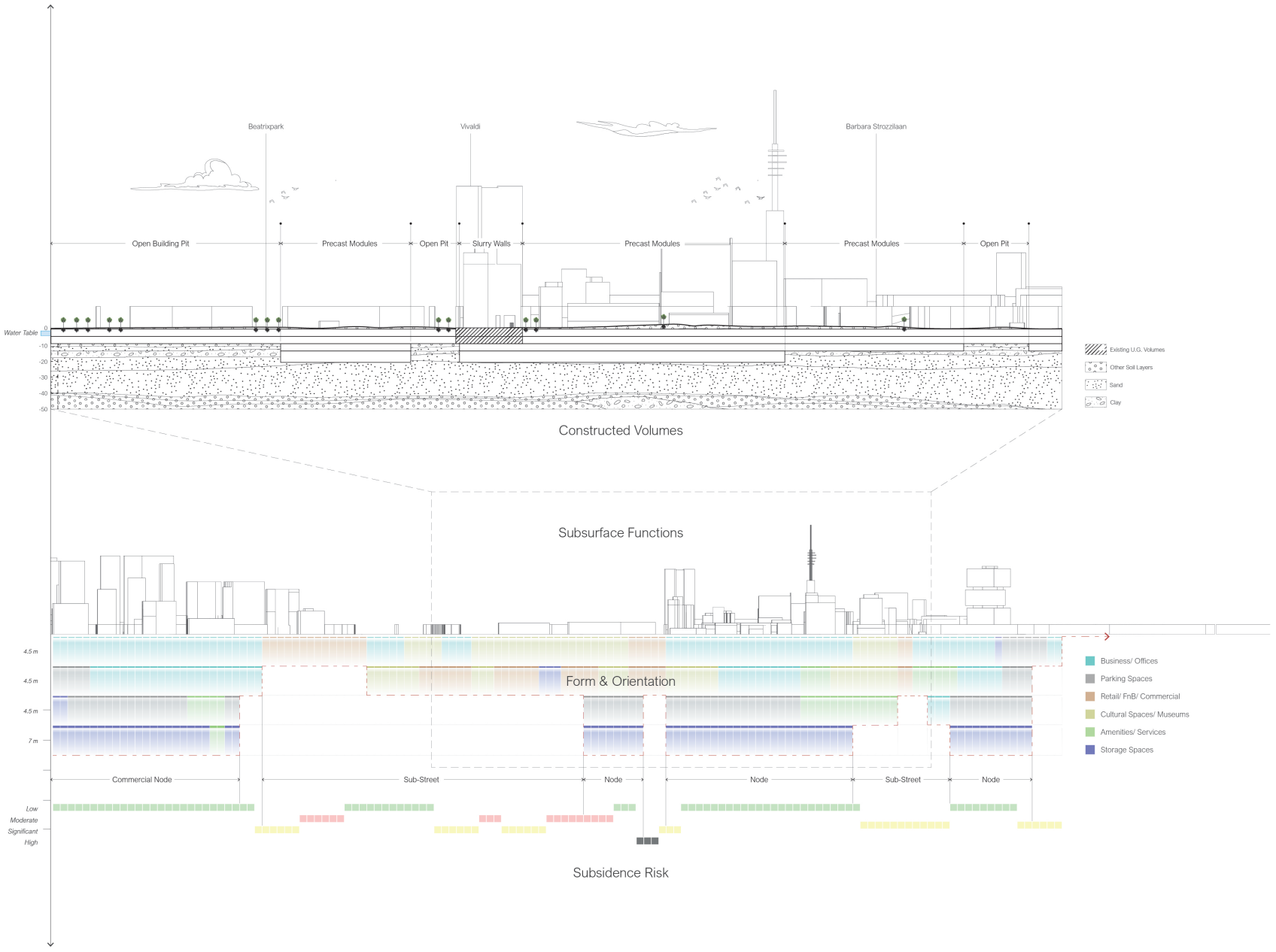
SUBSURFACE GRID: MESO SCALE



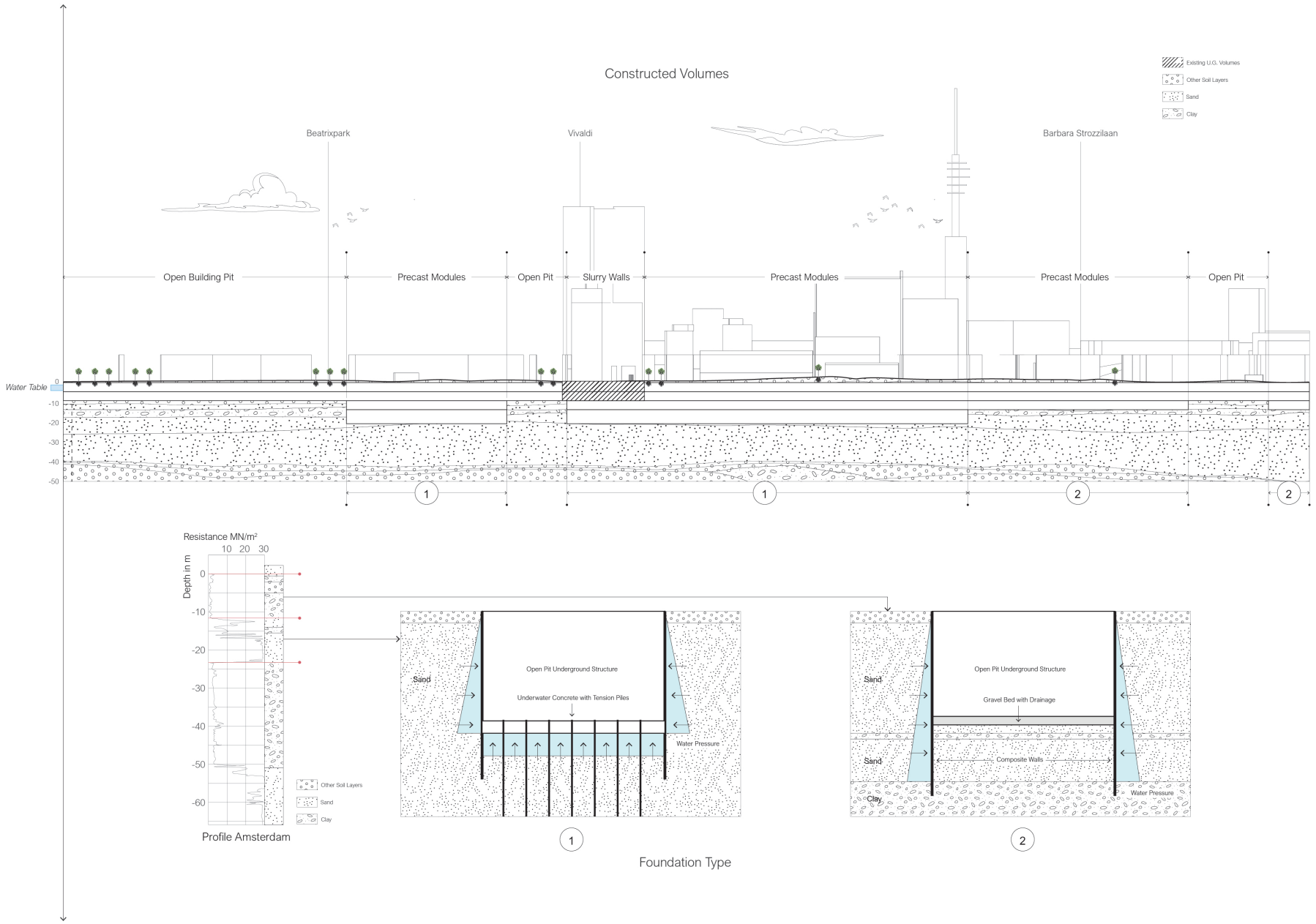
SUBSURFACE GRID: MESO SCALE



SUBSURFACE GRID: MESO SCALE



Akhilesh Shisodia | 5490375


Constructed Volumes
Existing U.G. Volumes
Other Soil Layers
Sand
Clay
Beatrixpark
Vivaldi
Barbara Strozzilaan
Open Building Pit
Precast Modules
Open Pit
Slurry Walls
Precast Modules
Precast Modules
Open Pit
Water Table
0
-10
-20
-30
-40
-50
1
1
2
2
Resistance MN/m²
10 20 30
Depth in m
0
-10
-20
-30
-40
-50
-60
Other Soil Layers
Sand
Clay
Profile Amsterdam
Sand
Open Pit Underground Structure
Underwater Concrete with Tension Piles
Water Pressure
1
Sand
Open Pit Underground Structure
Gravel Bed with Drainage
Sand
Composite Walls
Clay
Water Pressure
2
Foundation Type

Designing with Socio-economic Parameters

Infrastructure

Integrated Transit
Parking Networks
Server Storage
Parking Integrated with Commercial
Excavated Resorces

Facility

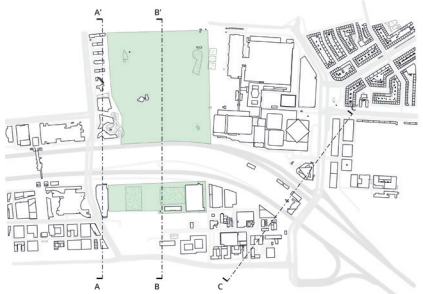
Light as an instrument
Functions w.r.t. Depth
Groundscape Configuration
Acoustics
Landscaping to Assist Transition
Alternating Levels
Soft Borders

User

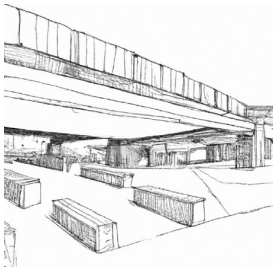
Active Frontages
Public Spaces on surface
Social Safety and Orientation
Link to Surface
Well-lit and Legible entrances
Shelter from Heatstress

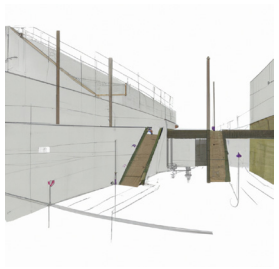
Commercial

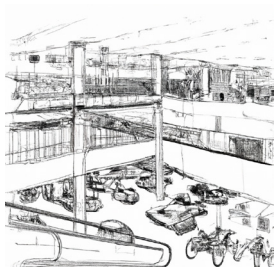
Linear Retail
Virtual Offices
4D Building Envelope for Real Estate
Extended Logistics
Shell-based Volumes

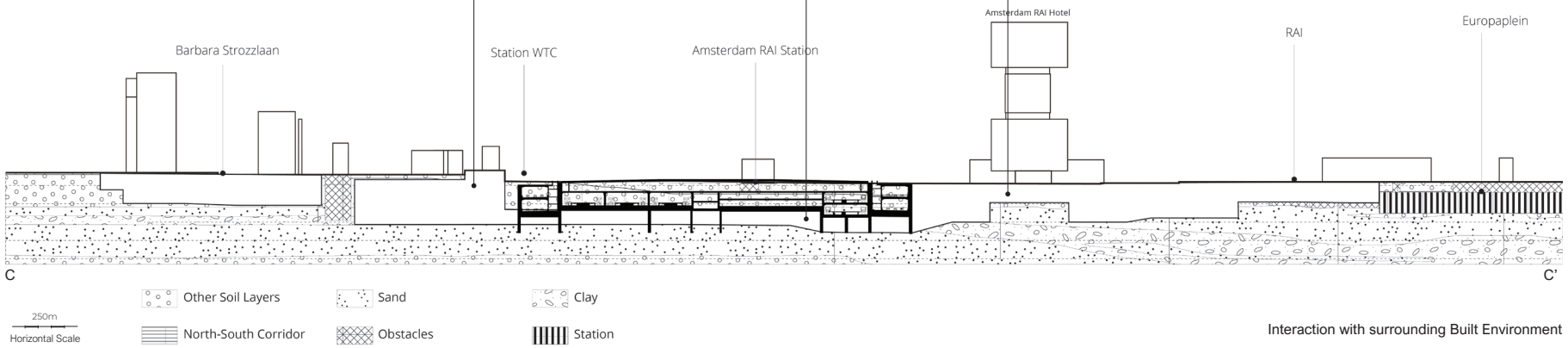


keymap


Shelter for pedestrians from heatstress

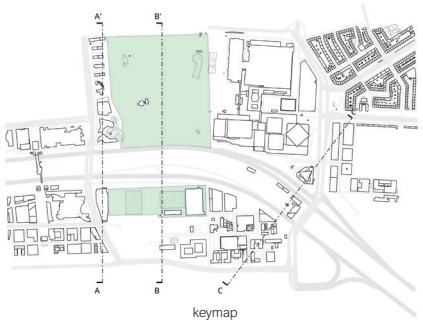

Linear walkable corridors


Shell-based volumes instead of individual plots



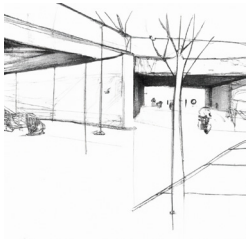
Interaction with surrounding Built Environment

DESIGN PRINCIPLES: MESO SCALE

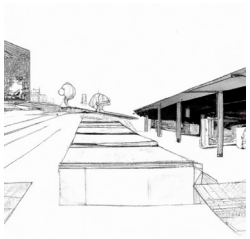


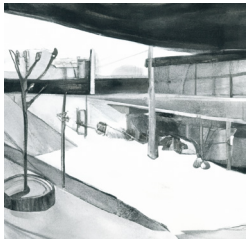
keymap

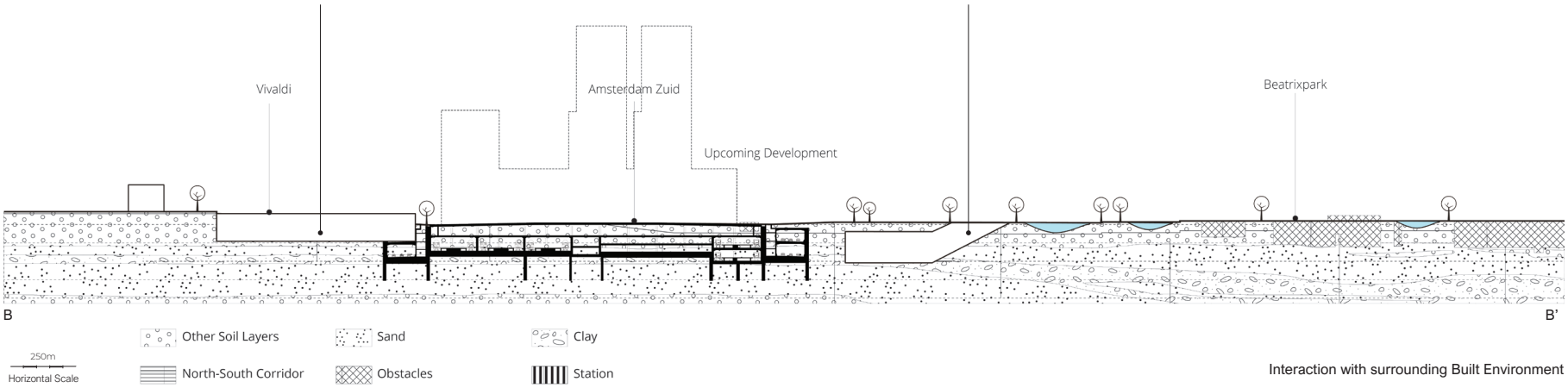
Groundscape Experience and Interior Spaces


Alternating Levels


Well-lit and legible entrances


Transition: Soft-border Geography


Landscaping to Assist Transition



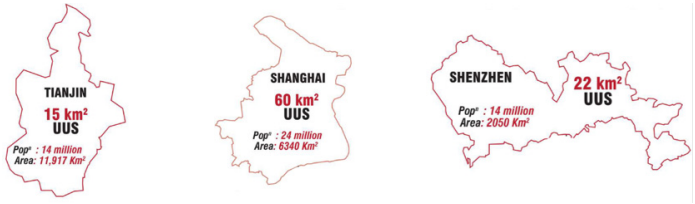
Interaction with surrounding Built Environment

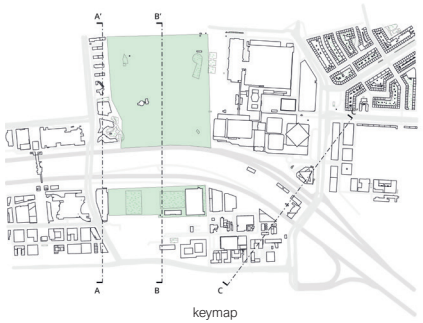
GENERATING REAL ESTATE

A comparative split of functions through case studies results in the composition of division of activities according to different vertical levels.

The excavated resources and soil can be utilized for economic purposes and to restructure the geography and landscaping around the site.

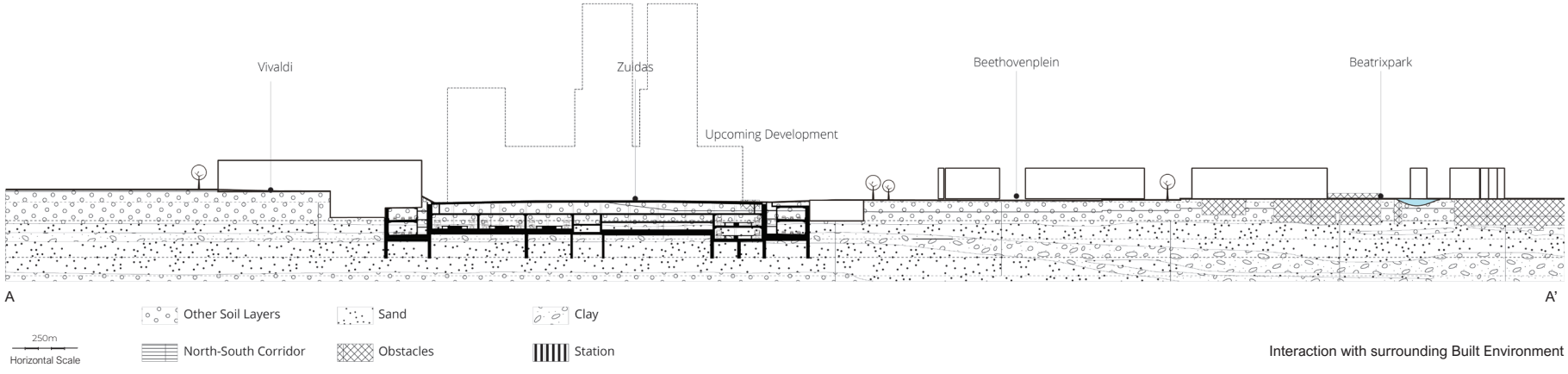
Comaprative Cases Studies for U.G. Construction



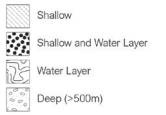


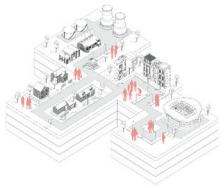
Case Studies	Tianjin	Shanghai	Shenzhen
City Area (Sq.km)	11917	6340	2050
Population (million)	14.5	24.2	14.1
Utilized UUS (Sq.km)	15	60	22

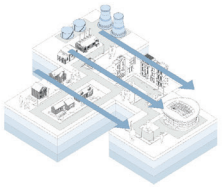
Average UG Real Estate (% Use)	Parking	Retail	Commercial	Hospitality
Level -1	20.96	40.56	37.91	0.57
Level -2	31.96	59.1	8.81	0.13
Level -3	85.55	7.67	0	0

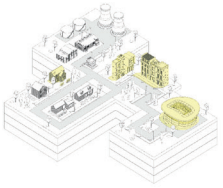


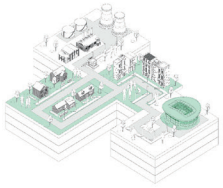
Interaction with surrounding Built Environment

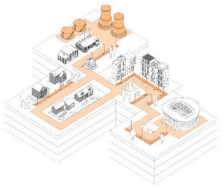


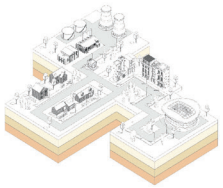












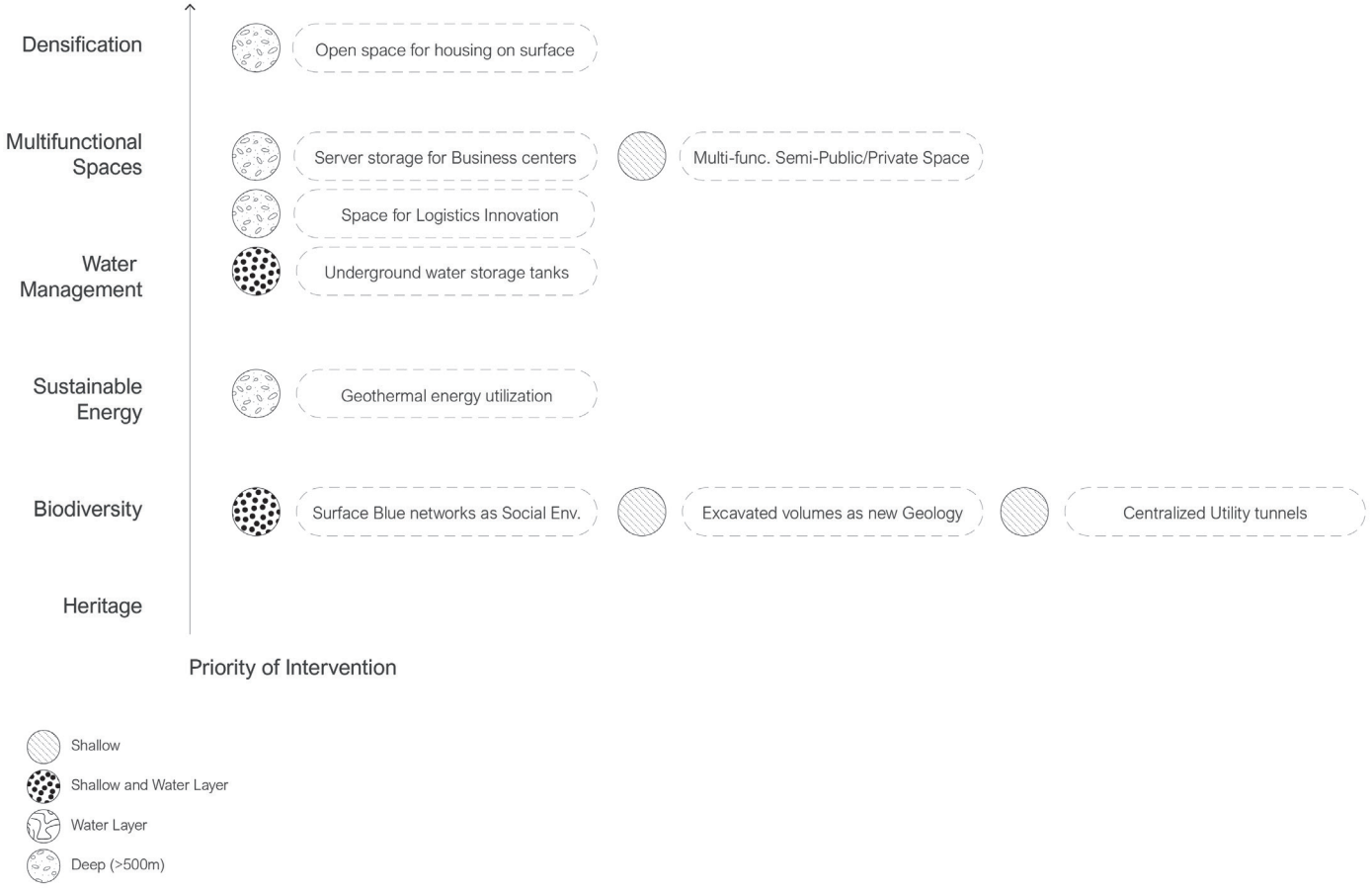
Subsurface/ Subsoil	People	Metabolism	Buildings	Public Space	Infrastructure	Subsurface
Civil Constructions						
Archaeology				Amstelpark, Beatrixpark eco-reserves		
Explosives						
Underground Building	Less Visual Connection to U.G.		Parking spaces adjacent to tunnels	U.G. walkable public spaces needed	Multi-levels tunnels below Ringroad	
Cables and Pipes	Utilitarian capacity for Residents		*MENZ* loop added in Zuidas	80% U.G. cable networks cleared		
Carrying Capacity	Prominent future M.R.T. Node	Foundation Code 1,2 (Safe)	Moderate subsidence in Built areas		Widening A10, Viaduct construction	
Subsurface						
Clean Soil				Heavily polluted soil at1-2 m depth		
Subsoil/ Crop Capacity				Limited space for roots to grow		
Geomorphological Quality	Preparation: Hazards/ Climate crisis					
Ecological Diversity	Green spaces enable Social Env.	Transit barriers vs Ecology		<5% tree-cover per neighborhood	A10: barrier to ecological metabolism	
Soil as Resource		Excavated soil as new Geography				
Subsurface Storage	Basements as Additional Real Estate	Water storage and filtration assets	Server storage for Business centers	Peat and Clay located at 10 m depth	Demand for freight storage space	
Energy						
Aquifer Thermal Energy		Multiple systems installed in vicinity	Avg. Building Energy Label: A, B			
Geothermal Energy	Energy requirements for new Housing	Aquifer >10m; may affect soil stability	Data center nodes require high energy		U.G. infrastructure requires less energy	
Fossil Fuels						
Water						
Water Filtering Capacity		Water Seepage 0.1-0.5 mm/day	Avg. Flood Depth: 13-15 cm (140 mm)	Avg. Groundwater depth: 1.2-2 m	U.G. tunnels limit water filteration	
Water Storage Capacity	Surface Blue networks as Social Env.	Low Flood probability within site	Underground water storage tanks	Subsurface storage: 150-250 mm		
Drinking Water Resources						

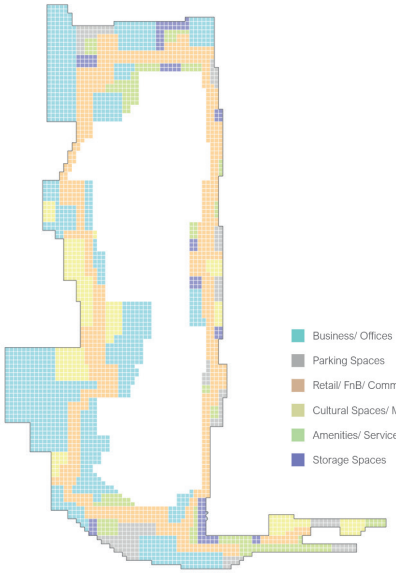
IDENTIFYING TECHNOLOGICAL AND ECOLOGICAL NEEDS

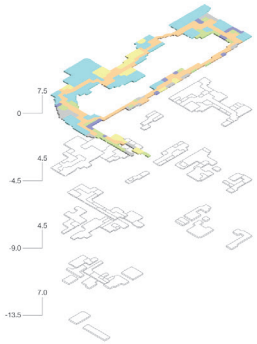
PRIORITIZING STRATEGIES

The strategies framed from previous matrix are prioritized on the basis of immediate and long term needs of the site and its users.

It refines workable areas by laying limitations beyond analyzing Ecological Risks.







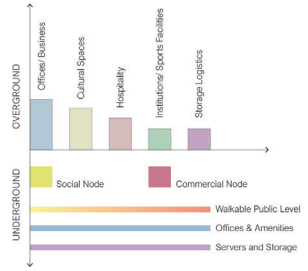
Level 1: Macro Nodes and Streets

LEVEL 1: MACRO NODES AND STREETS

Depth: 0 to -4.5 m

Surface Funtions Supplemented:

- Educational Institutes
- Convention Center
- Business Centers
- Hospitality
- Commercial Spaces



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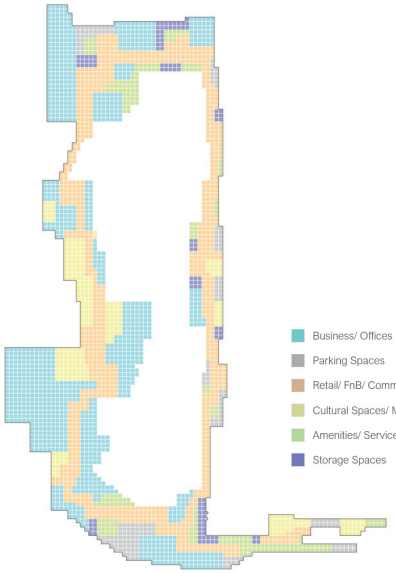
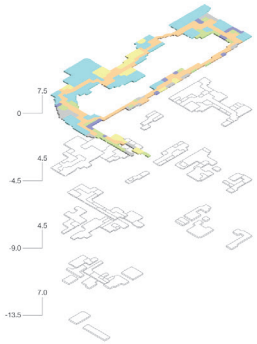
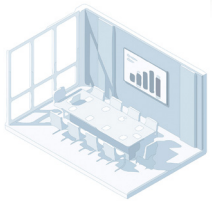




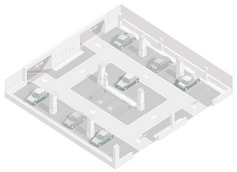
Level 1: Macro Nodes and Streets

Offices

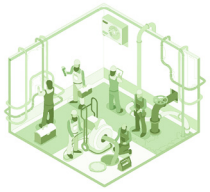
Conference Spaces



Parking Spaces



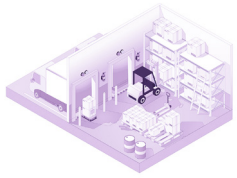
Utility & Services

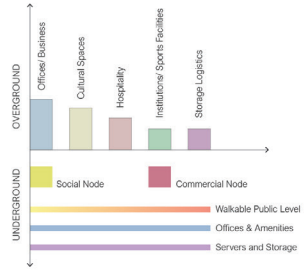


Exhibition Spaces

Linear Retail

Logistics & Storage





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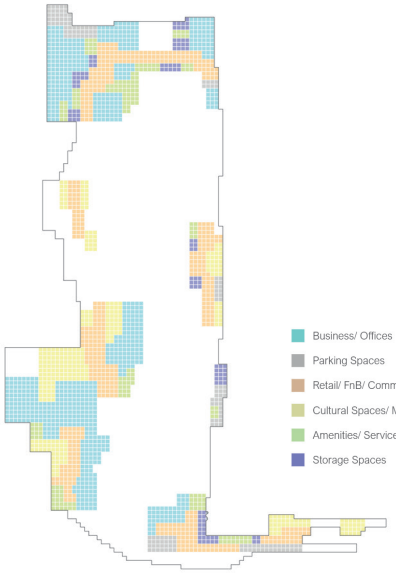
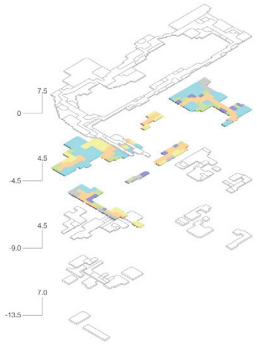




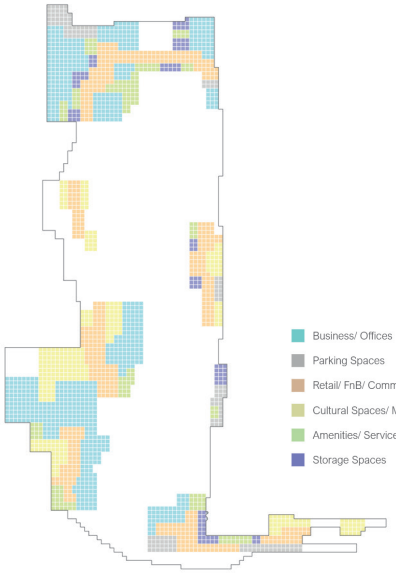
Level 2: Local Nodes and Streets

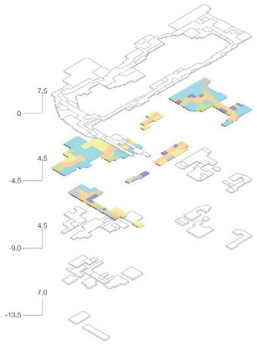
LEVEL 2: LOCAL NODES AND STREETS

Depth: -4.5 to -9 m

Surface Funtions Supplemented:

- Educational Institutes
- Convention Center
- Business Centers
- Hospitality
- Commercial Spaces

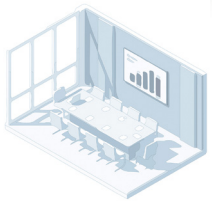




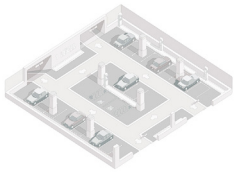
Level 2: Local Nodes and Streets

Offices

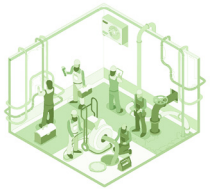
Conference Spaces



Parking Spaces

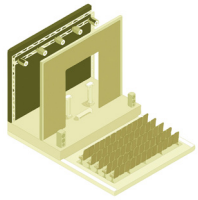


Utility & Services



Exhibition Spaces

Auditoriums



FnB Spaces

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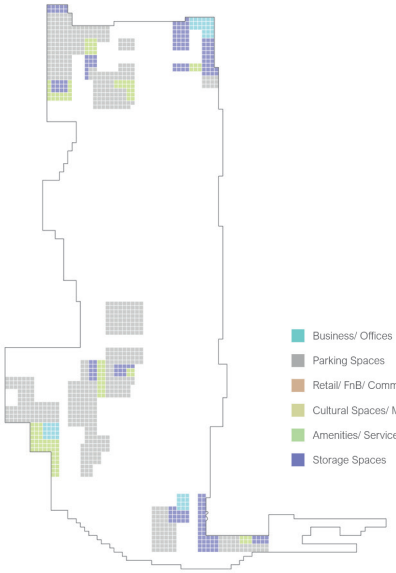
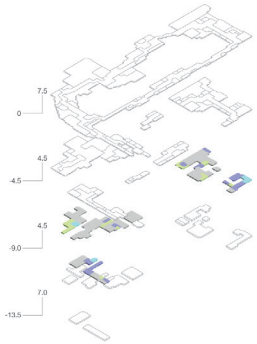




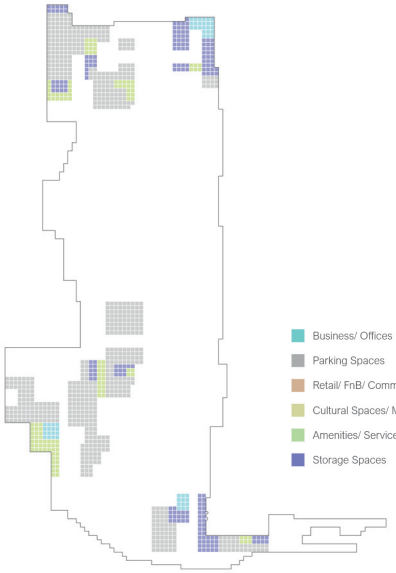
Level 3: Services and Amenities

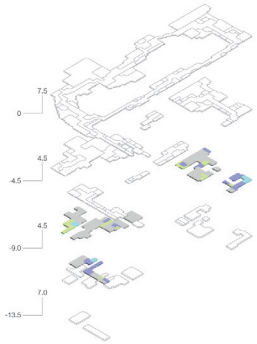
LEVEL 3: SERVICES AND UTILITIES

Depth: -9 to -13.5 m

Surface Funtions Supplemented:

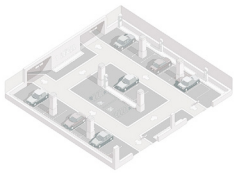
- Educational Institutes
- Convention Center
- Business Centers



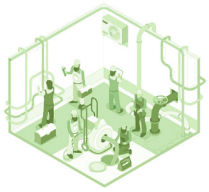


Level 3: Services and Amenities

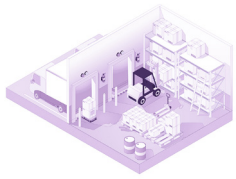
Parking Spaces

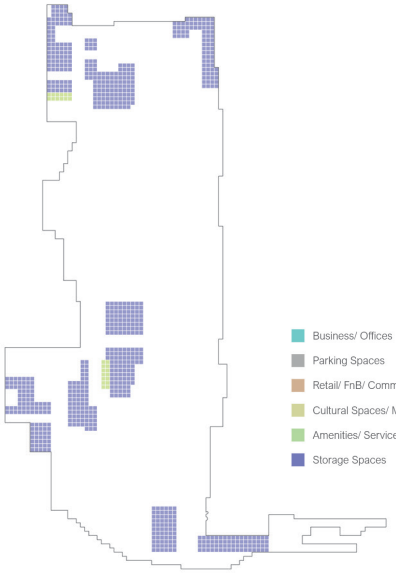


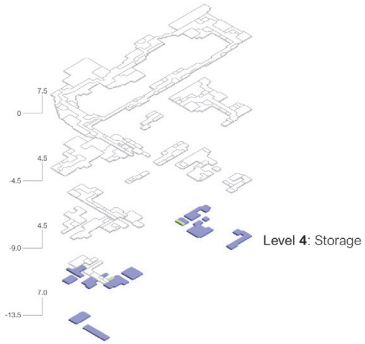
Utility & Services



Logistics & Storage





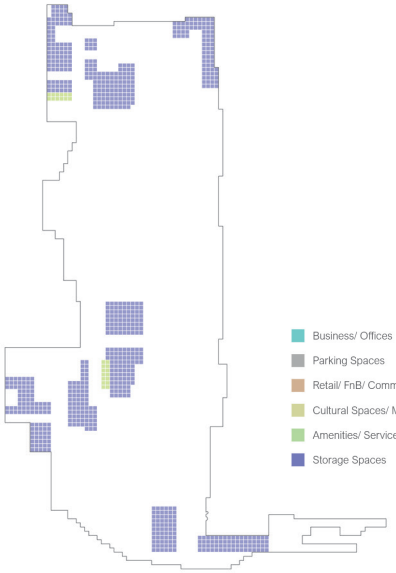


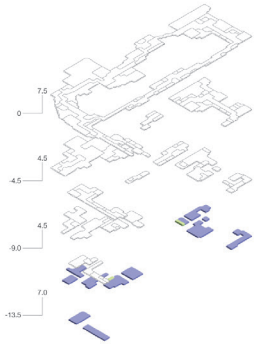
LEVEL 4: STORAGE | NON-HUMAN INDUSTRIES

Depth: -13.5 to -20.5 m

Surface Funtions Supplemented:

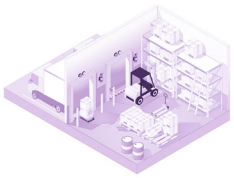
- Educational Institutes
- Convention Center
- Business Centers





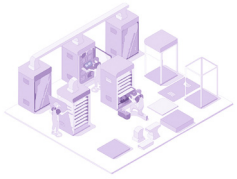
Level 4: Storage

Logistics & Storage



Research Facilities

Data Servers



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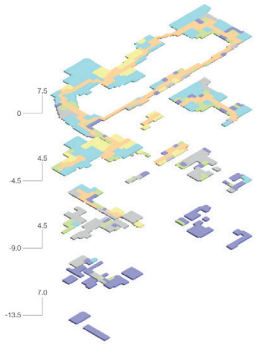


INTEGRATED VERTICAL SYSTEMS

A gradient of programs is obtained where depth is inversely proportional to concentration of liveable spaces.

Level 1 and 2 act as extension of groundscape to different vertical levels in

Grids of Subsurface Development

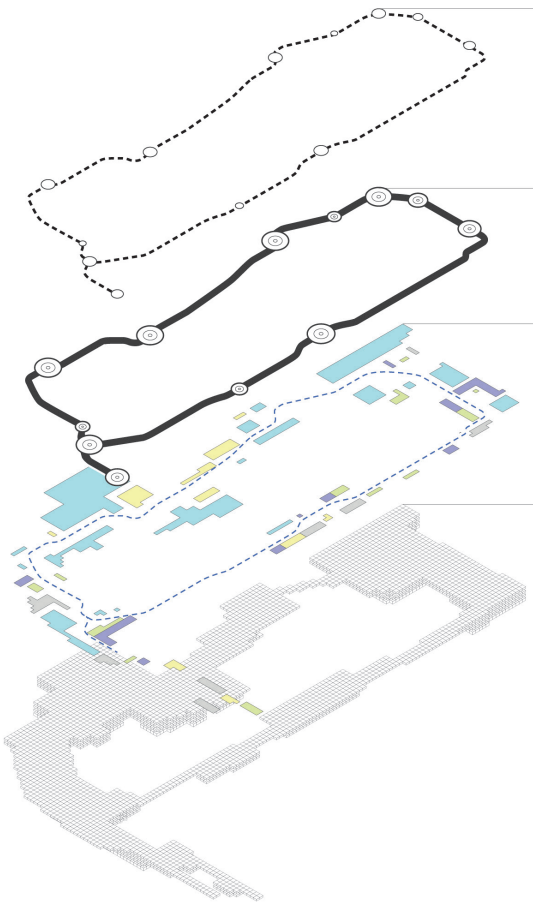
3 Micro Scale

Meso Scale

- Parameters of Quality of Space
- Function Allocation techniques and typologies
- Groundscape Design
- Type of Subsurface Interventions

Architect | Environmental Planner

Experience of Space



- Urban Corridors

  - Sense of Orientation
  - Inertia of Movement
  - Active Frontages

- System of Nodes & Planes

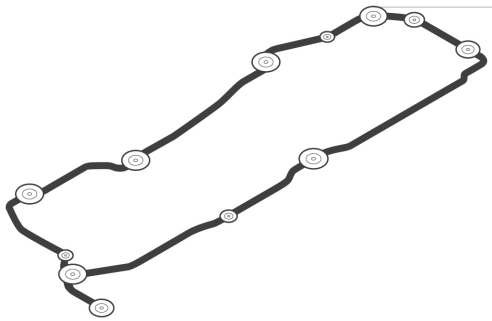
  - Sense of Volume
  - Points of Attraction
  - Groundscape Entry Design

- Anchors

  Supplementing and extending dominant programs overground with buffer volumes

- Workable Design Grid

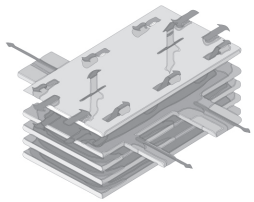
  Distributing projected functional volumes to obtain achievable vertical system.

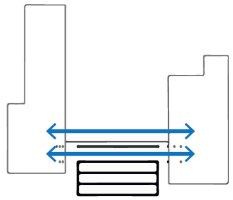


- System of Nodes & Planes

- Sense of Volume
- Points of Attraction
- Groundscape Entry Design

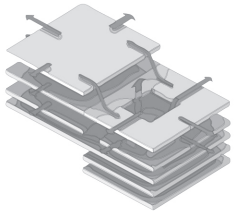
DEEP AVENUE

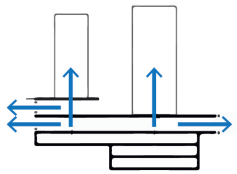




- Flexible 'Twin-street' Level
- Linear Spatial Principle
- High Circulation
- Vertical Access Points
- Connection to Businesses in Vicinity

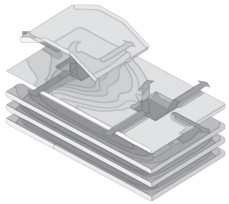
DEEP GROUND

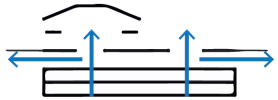




- Scalable Building to Blocks
- ReaL Estate extension
- Collective Utility Plinth
- Continuity of connections

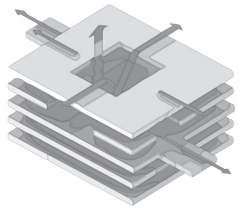
DEEP SQUARE

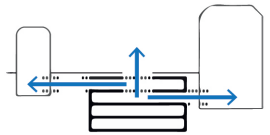




- Public Square with UG Amenities
- Multi-functional Markethall
- Programmatic Flexibility
- Pendular Parking Access

PROGRAM DIVERSIFICATION

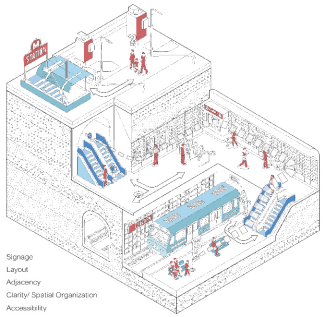




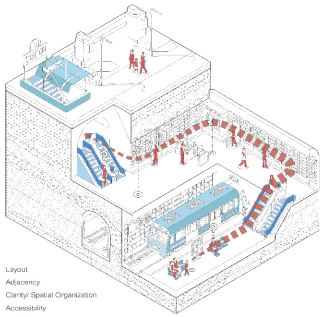
- Reconversion of existing Infrastructure
- Connection to street, transit
- Slab Opening and Reinforcements
- Programmatic Diversity

PERCEPTION OF U.G.: DEPENDABLE VARIABLES

USER SAFETY

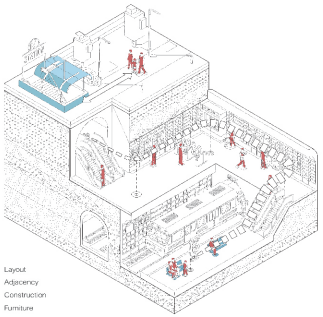


WAYFINDING

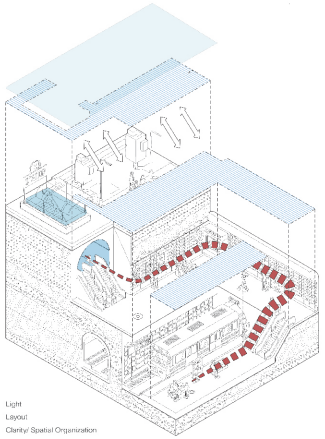


ESCAPE

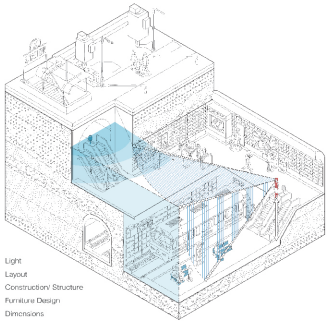
USER COMFORT



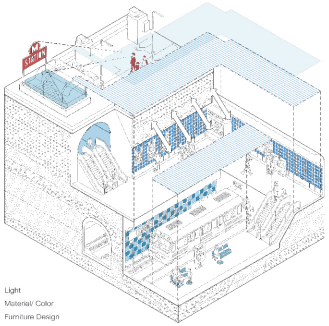
SURVEILLANCE



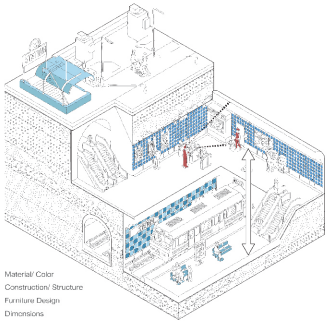
LIGHT AS AN INSTRUMENT



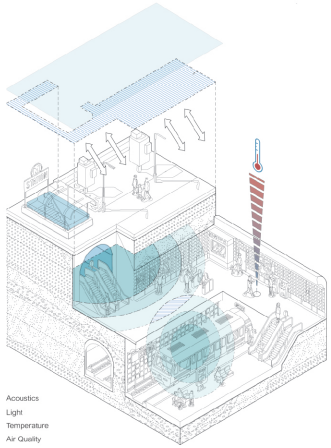
OVERVIEW



VISIBILITY



ATTRACTIVENESS

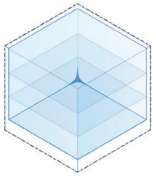


PHYSIOLOGICAL COMFORT

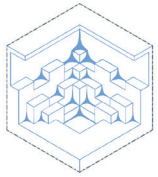
Pedestrian Comfort

Pedestrian Safety

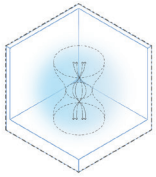
PERCEPTION OF INTERIOR SPACE: SUB-PARAMETERS



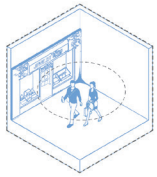
Temperature



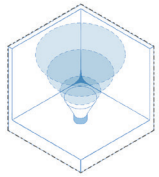
Construction



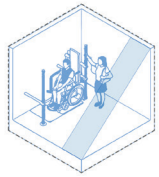
Air Quality



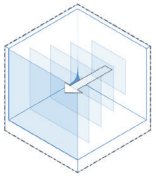
Adjacency



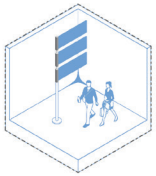
Acoustics



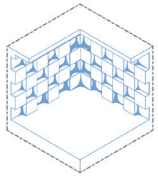
Accessibility



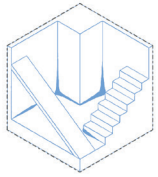
Continuity



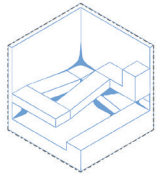
Signage



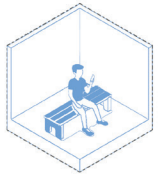
Material/ Color



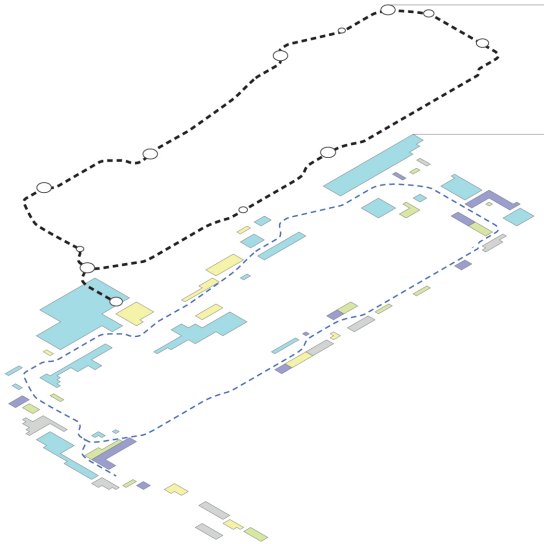
Dimensions



Layout



Furniture

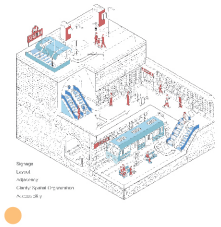


Urban Corridors

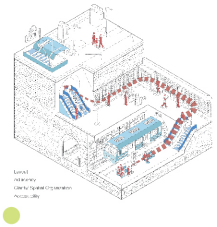
- Sense of Orientation
- Inertia of Movement
- Active Frontages

Anchors

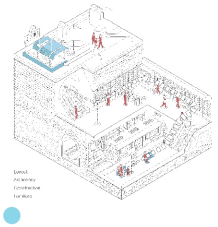
Supplementing and extending dominant programs overground with buffer volumes



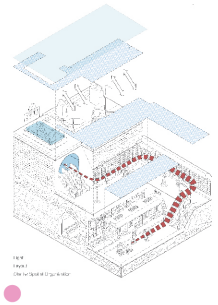
WAYFINDING



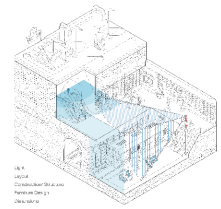
ESCAPE



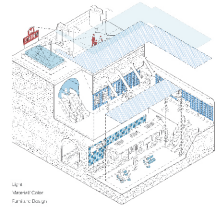
SURVEILLANCE



LIGHT AS AN INSTRUMENT

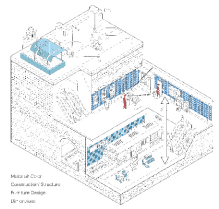


OVERVIEW

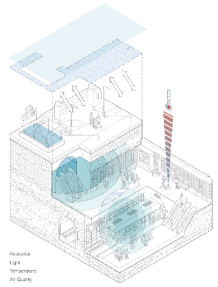


VISIBILITY

Pedestrian Comfort

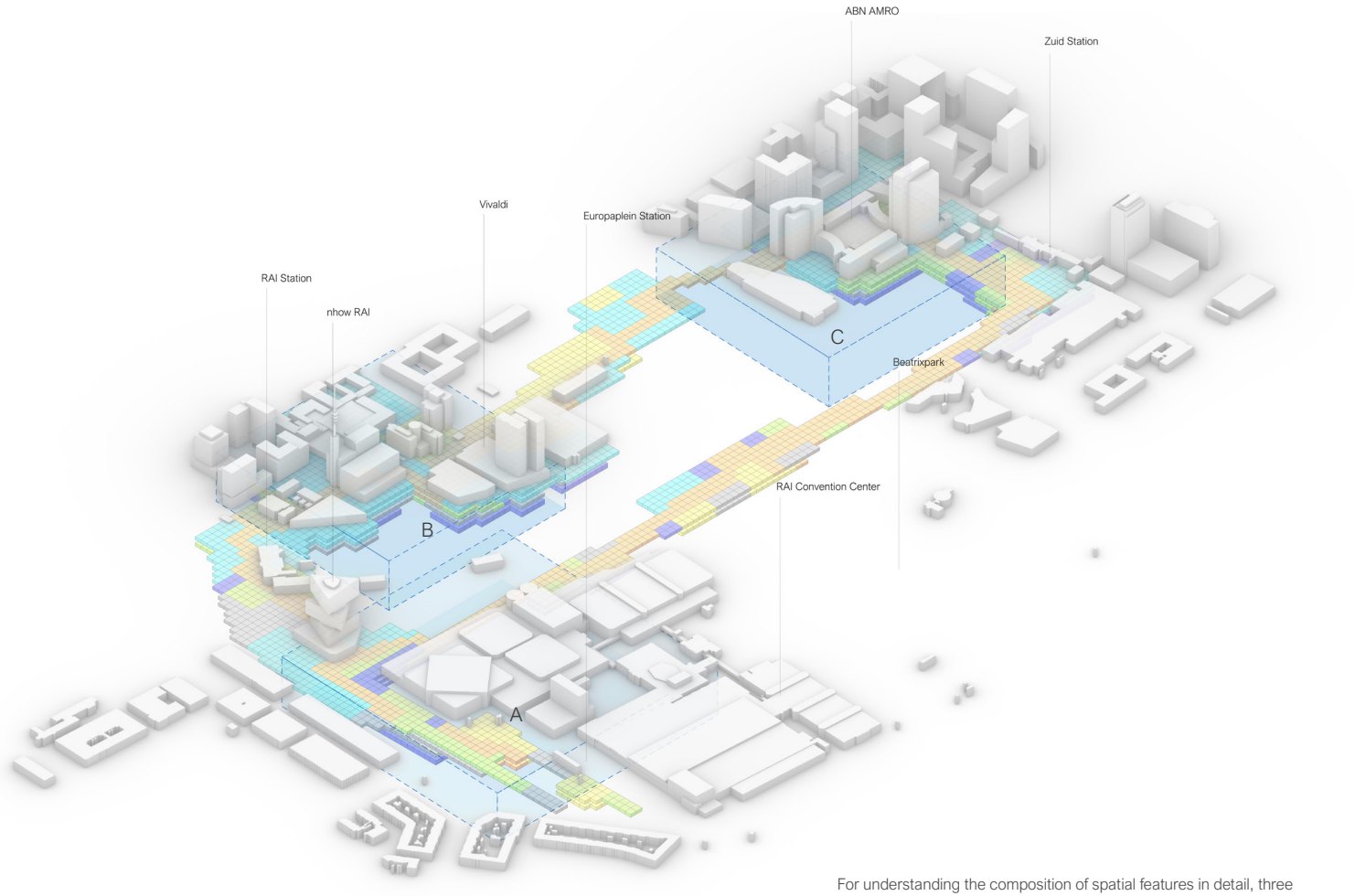


ATTRACTIVENESS



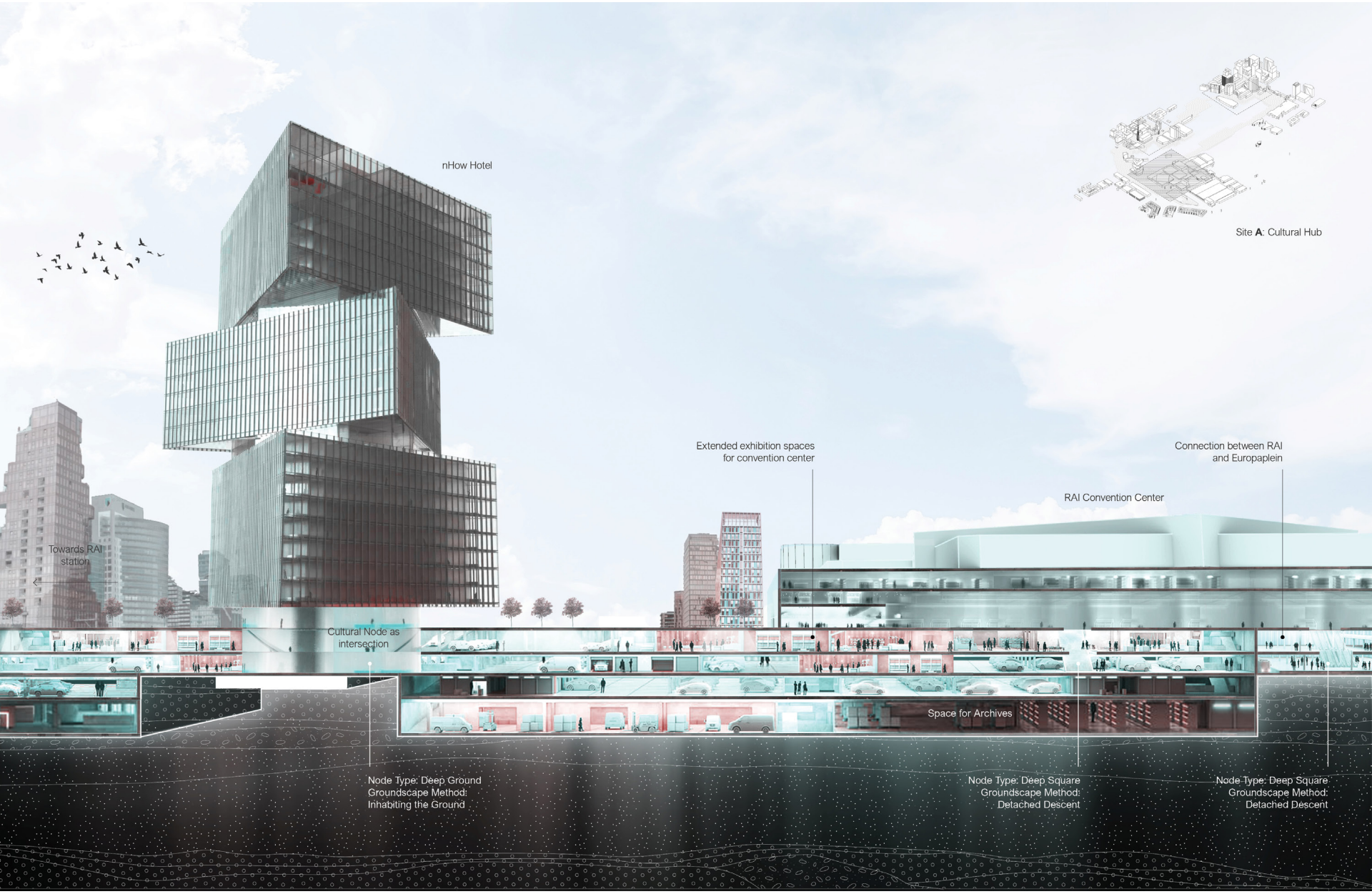
PHYSIOLOGICAL COMFORT

Pedestrian Safety

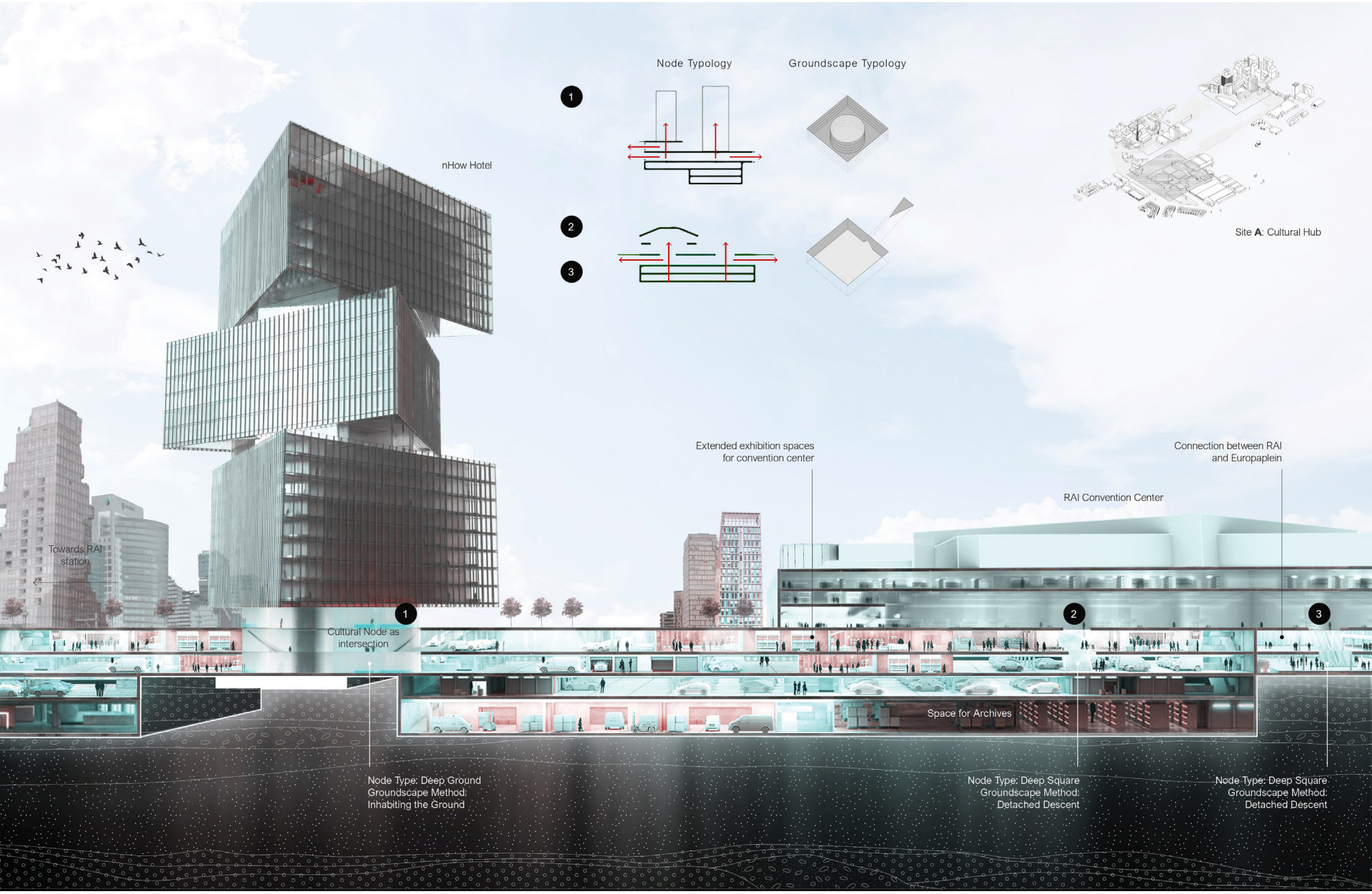


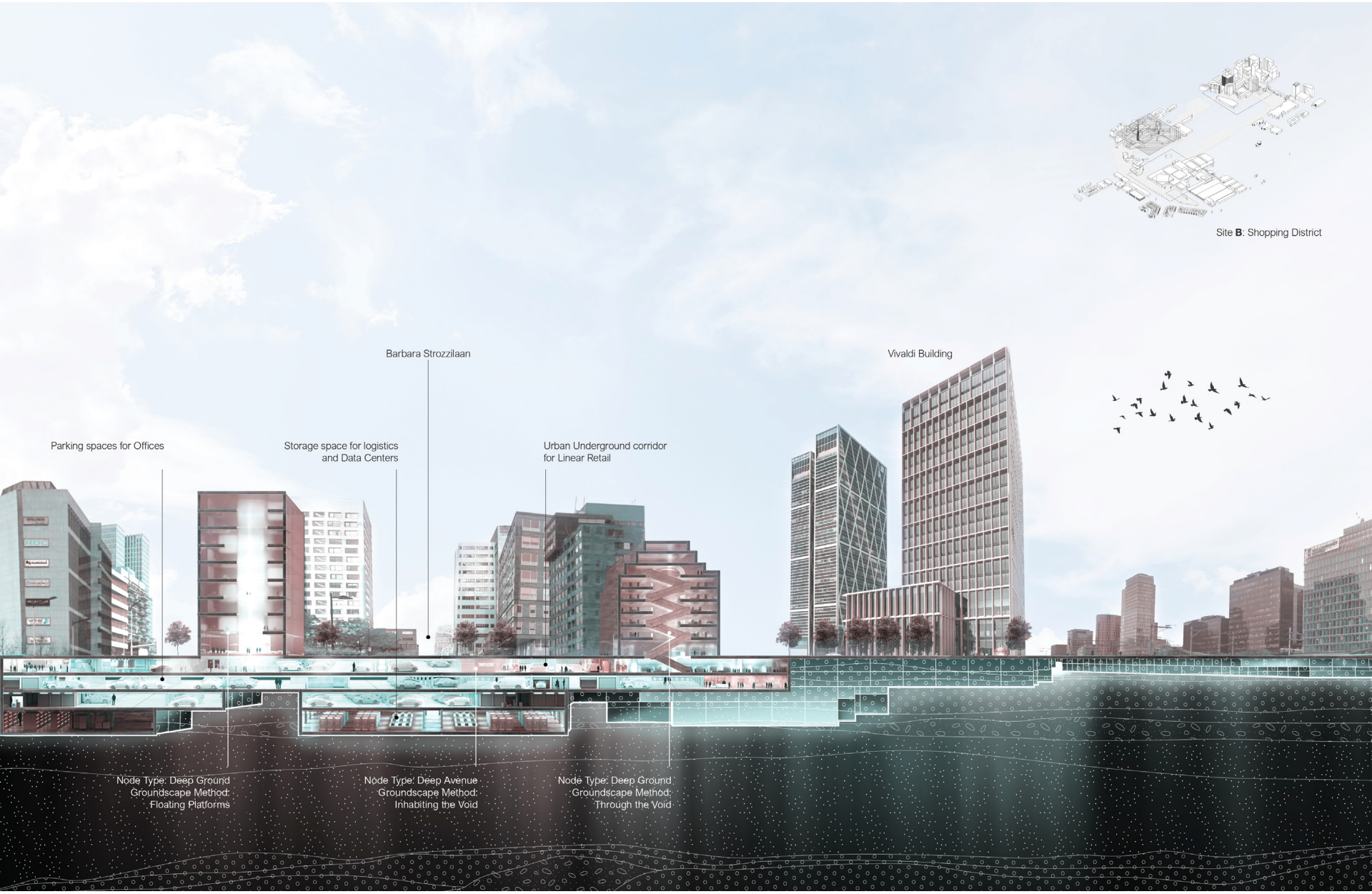
For understanding the composition of spatial features in detail, three areas of distinct dominant functions were chosen:

- Site A: Cultural Hub
- Site B: Shopping District
- Site C: Business Center

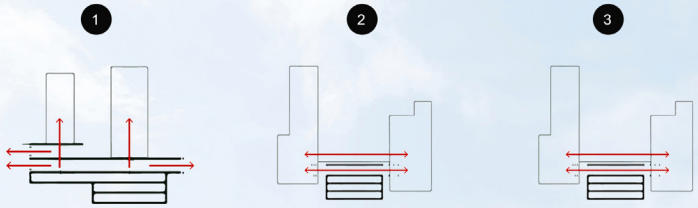


Site **A**: Cultural Hub

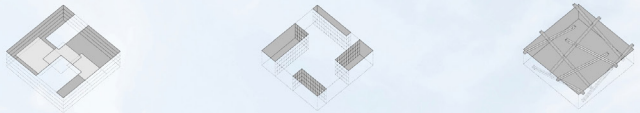

Node Typology
Groundscape Typology
1
2
3
nHow Hotel
Site A: Cultural Hub
Towards RAI station
Extended exhibition spaces for convention center
Connection between RAI and Europaplein
RAI Convention Center
1
2
3
Cultural Node as intersection
Space for Archives
Node Type: Deep Ground
Groundscape Method:
Inhabiting the Ground
Node Type: Deep Square
Groundscape Method:
Detached Descent
Node Type: Deep Square
Groundscape Method:
Detached Descent

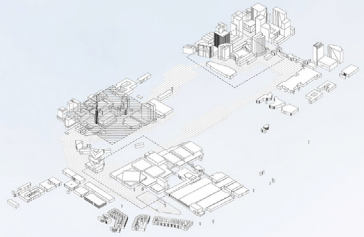

Site **B**: Shopping District
Barbara Strozzilaan
Vivaldi Building
Parking spaces for Offices
Storage space for logistics and Data Centers
Urban Underground corridor for Linear Retail
Node Type: Deep Ground
Groundscape Method:
Floating Platforms
Node Type: Deep Avenue
Groundscape Method:
Inhabiting the Void
Node Type: Deep Ground
Groundscape Method:
Through the Void

Node Typology

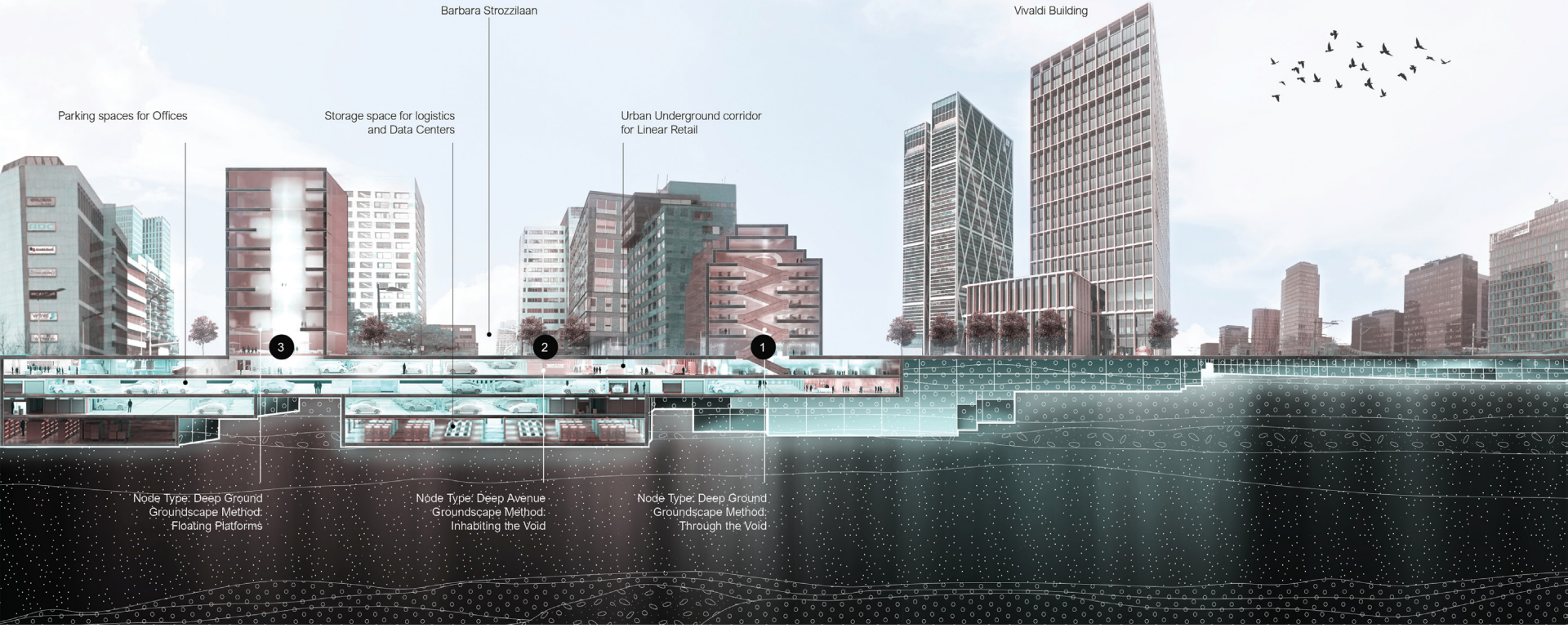


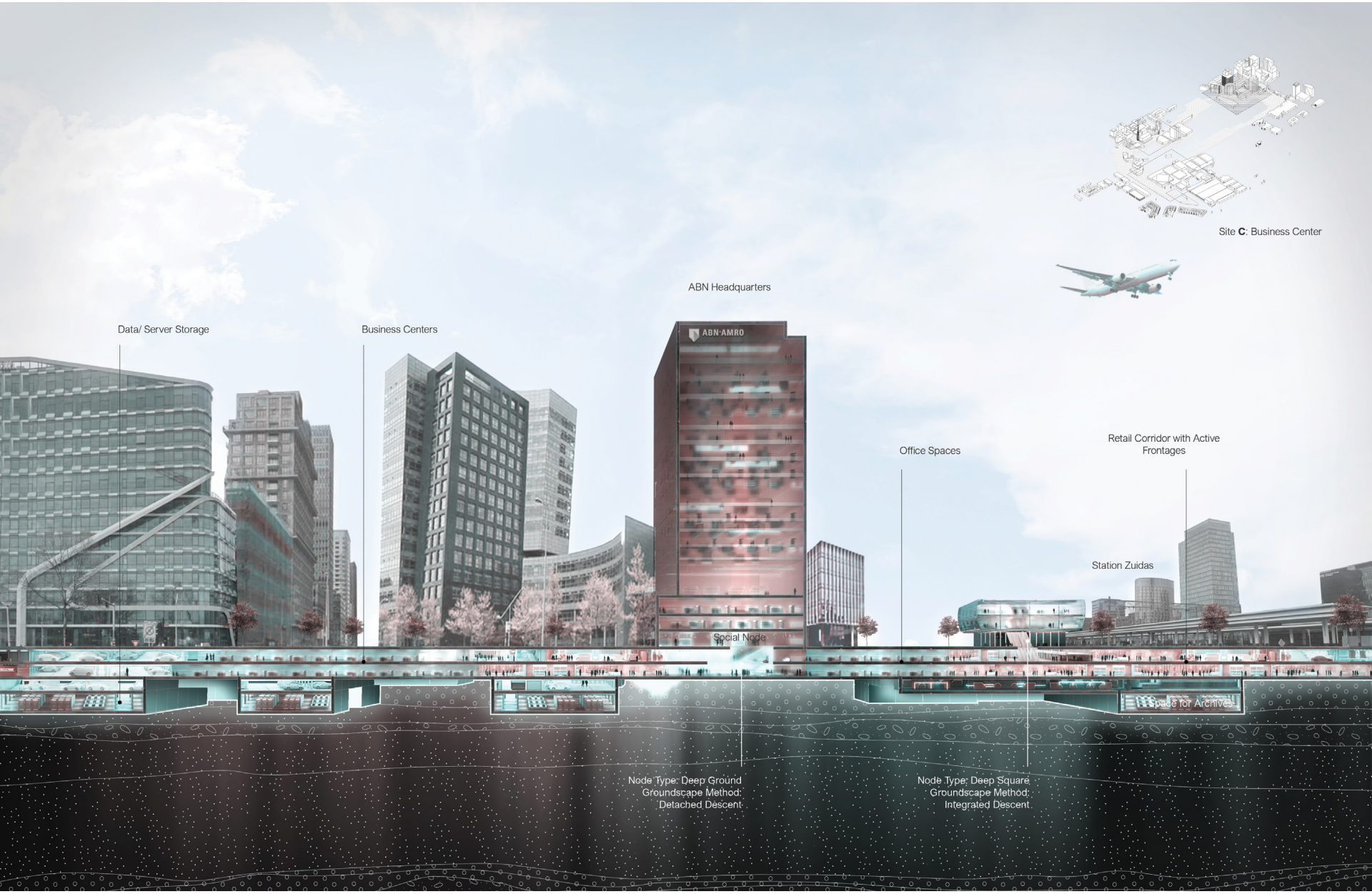
Groundscape Typology

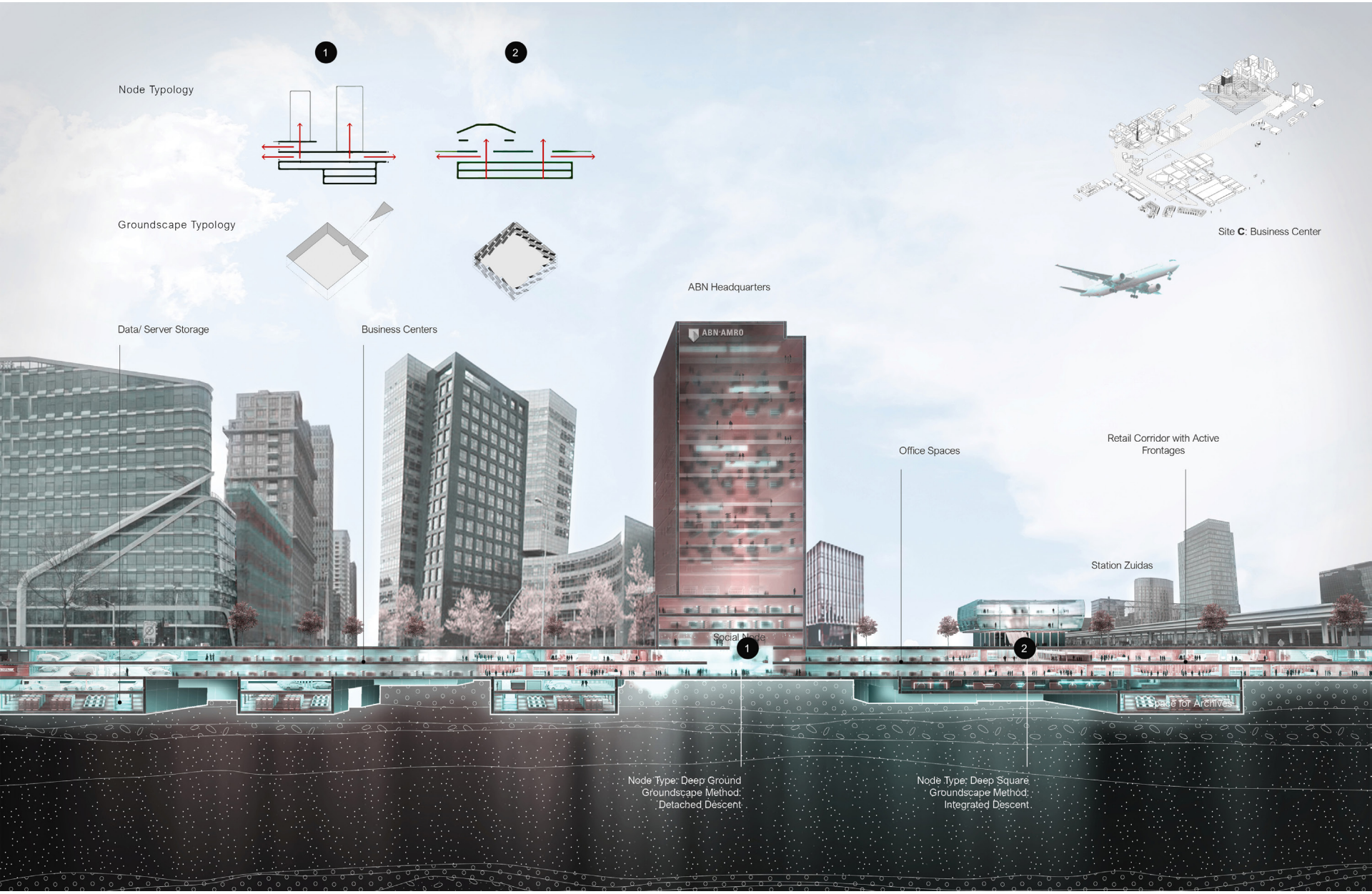




Site **B**: Shopping District




Site **C**: Business Center
ABN Headquarters
Data/ Server Storage
Business Centers
ABN·AMRO
Office Spaces
Retail Corridor with Active Frontages
Station Zuidas
Social Node
Space for Archives
Node Type: Deep Ground
Groundscape Method:
Detached Descent
Node Type: Deep Square
Groundscape Method:
Integrated Descent


1
2
Node Typology
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Grids of Subsurface Development

Macro Scale

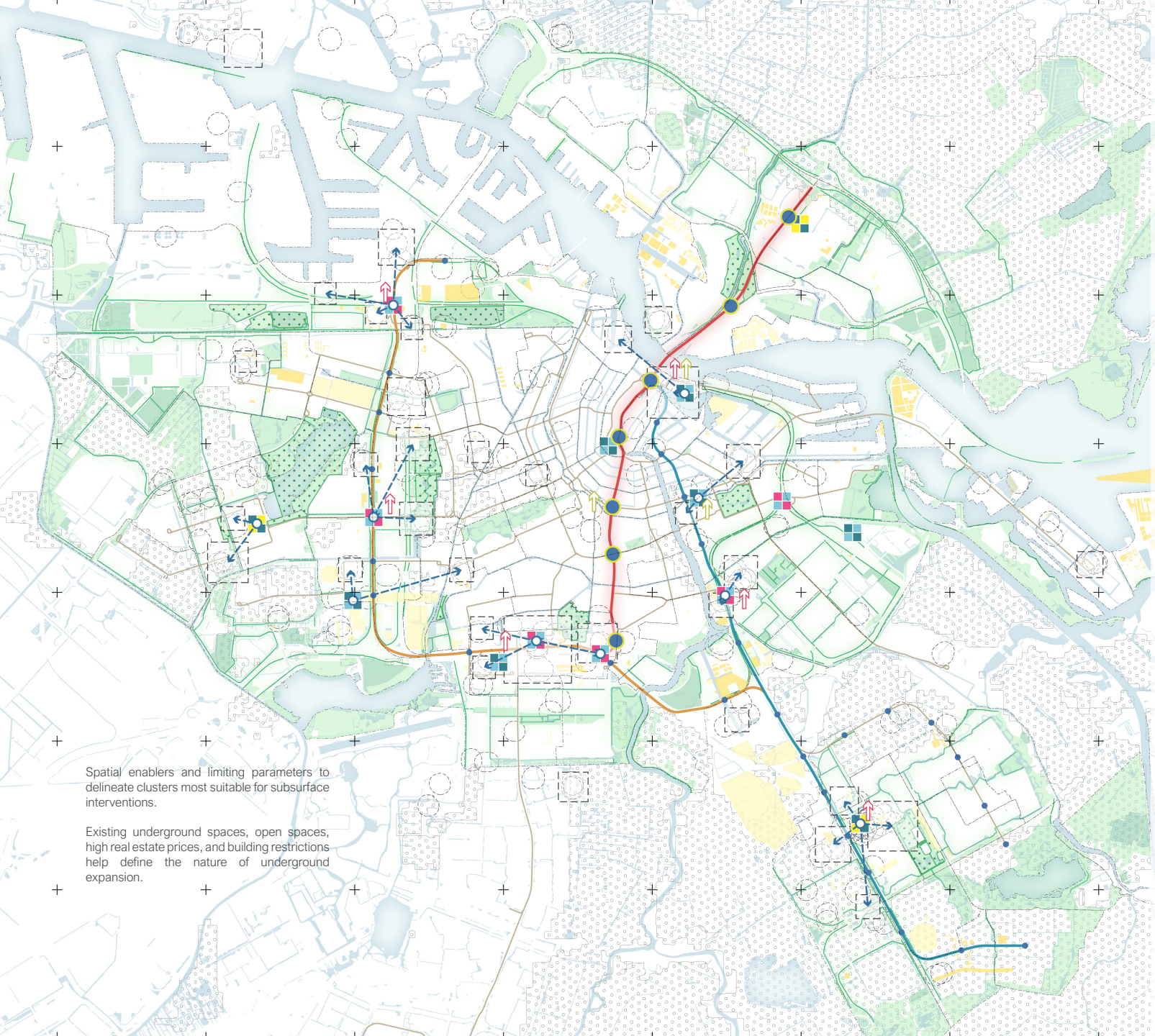
- Context-based Parameters for District Selection
- Type of Subsurface Development

Urbanist/ Urban Planner

TOWARDS UNDERGROUND URBANISM

Projecting Research by Design for City of Amsterdam

Akhilesh Shisodia | 5490375



Legend

Contextual Parameters

- Waterbodies
- Green Connection
- Garden Parks
- Subsurface Clusters
- Redevelopable Open spaces
- Subsurface Parcels
- Housing Projects (Invested)
- Housing Projects (Proposed)
- Risk of Subsidence >5cm

Node Character

- Knowledge Node
- Station Complex
- Urban Center

Infrastructure Networks

- Metro and Tram Lines
- N-S Metro Line
- Line 50
- Line 54
- N-S Metro Stations
- Metro Stations
- Potential U.G. Corridors

Context Built-Up

- Real Estate Pressure
- Heritage Restrictions

N

0 2.5 km

Spatial enablers and limiting parameters to delineate clusters most suitable for subsurface interventions.

Existing underground spaces, open spaces, high real estate prices, and building restrictions help define the nature of underground expansion.

Nature of U.G. Development

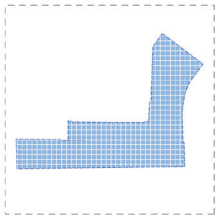
Transformation + Greenfield

Greenfield U.G. Development

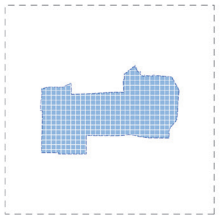
Transformation existing U.G.

These were chosen on the basis of projections for metropolitan urban programs, upcoming housing projects as delineated by Amsterdam's structural vision 2040 and the city's Environmental Vision.

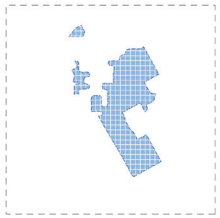
Workable Underground Loops



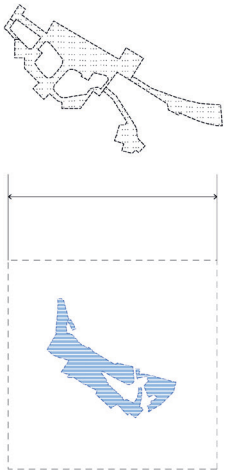
Amsterdam Sloterdijk



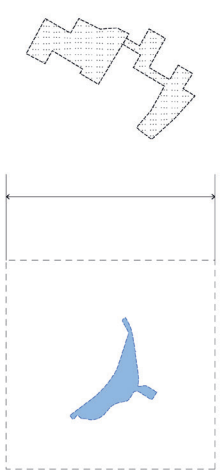
Zuidas



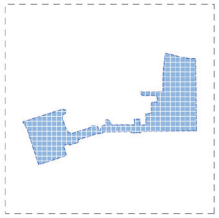
Amsterdam Port e.o.



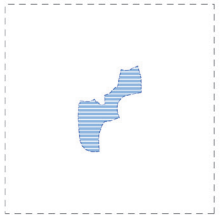
Amsterdam Centraal



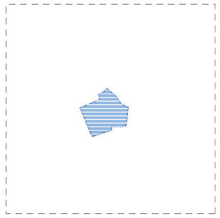
IJplein/Vogelbuurt



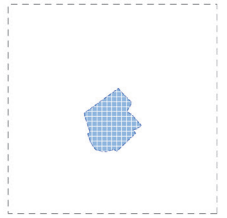
Osdorp-East



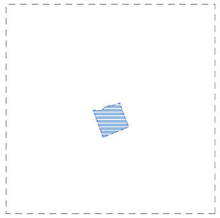
Zuidas



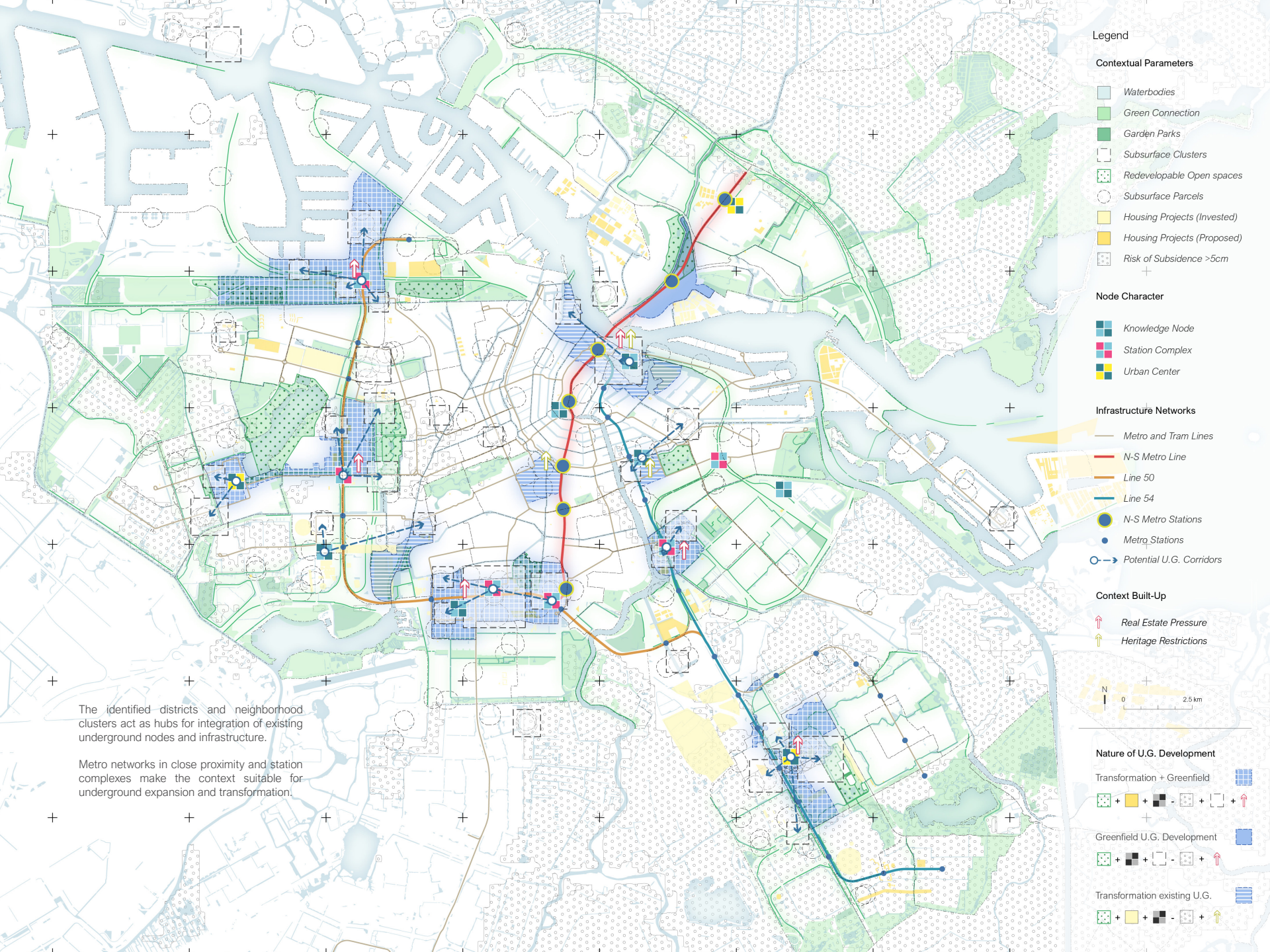
Museum Quarter



Frankendael



Oosterparkbuurt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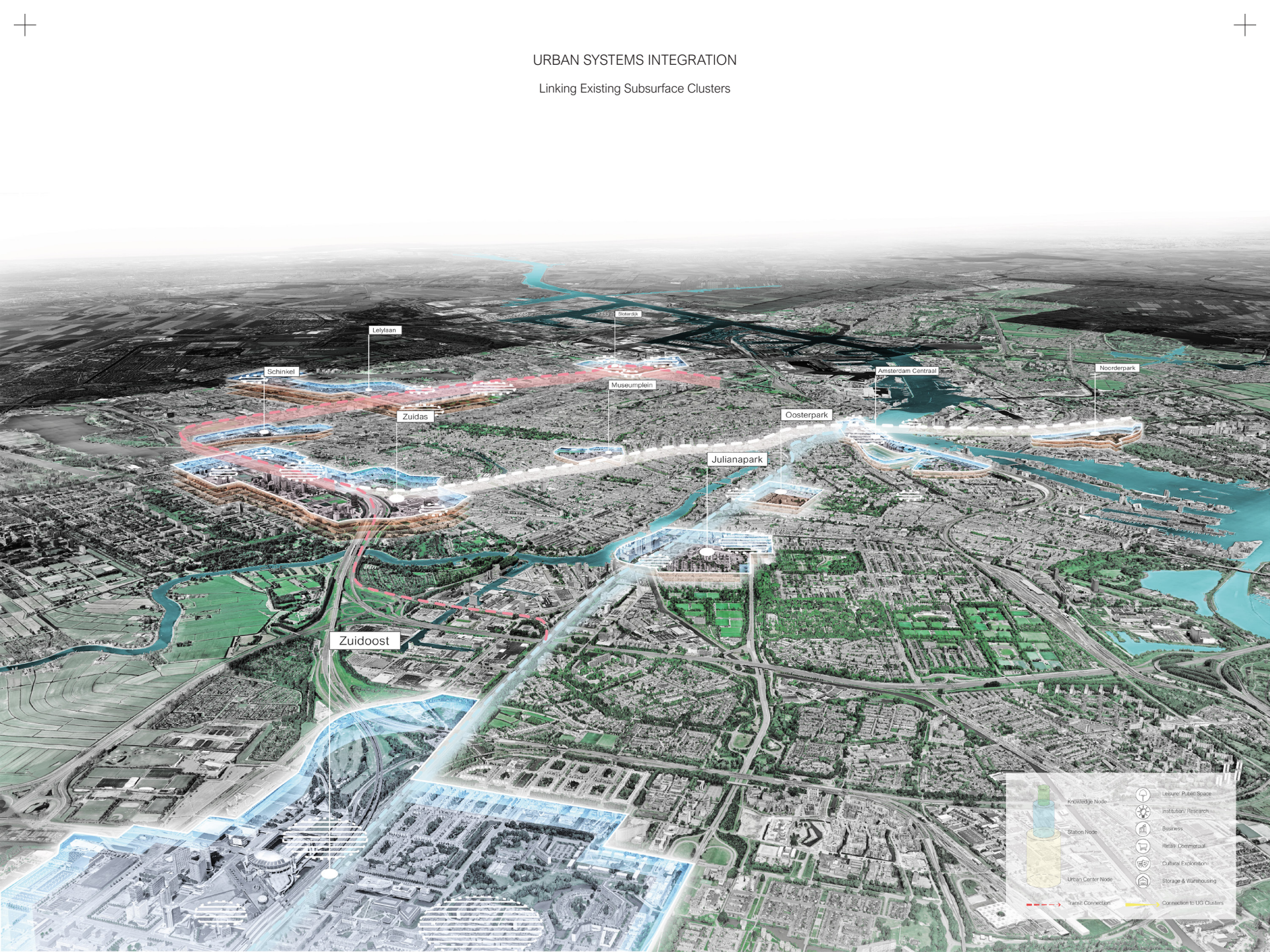
Redevelopable Open spaces
Subsurface Parcels
Housing Projects (Invested)
Housing Projects (Proposed)
Risk of Subsidence >5cm
Node Character
Knowledge Node
Station Complex
Urban Center
Infrastructure Networks
Metro and Tram Lines
N-S Metro Line
Line 50
Line 54
N-S Metro Stations
Metro Stations
Potential U.G. Corridors
Context Built-Up
Real Estate Pressure
Heritage Restrictions
N
0
2.5 km
Nature of U.G. Development
Transformation + Greenfield
Greenfield U.G. Development
Transformation existing U.G.
The identified districts and neighborhood clusters act as hubs for integration of existing underground nodes and infrastructure.
Metro networks in close proximity and station complexes make the context suitable for underground expansion and transformation.

URBAN SYSTEMS INTEGRATION

Linking Subsurface Districts to Transportation Infrastructure

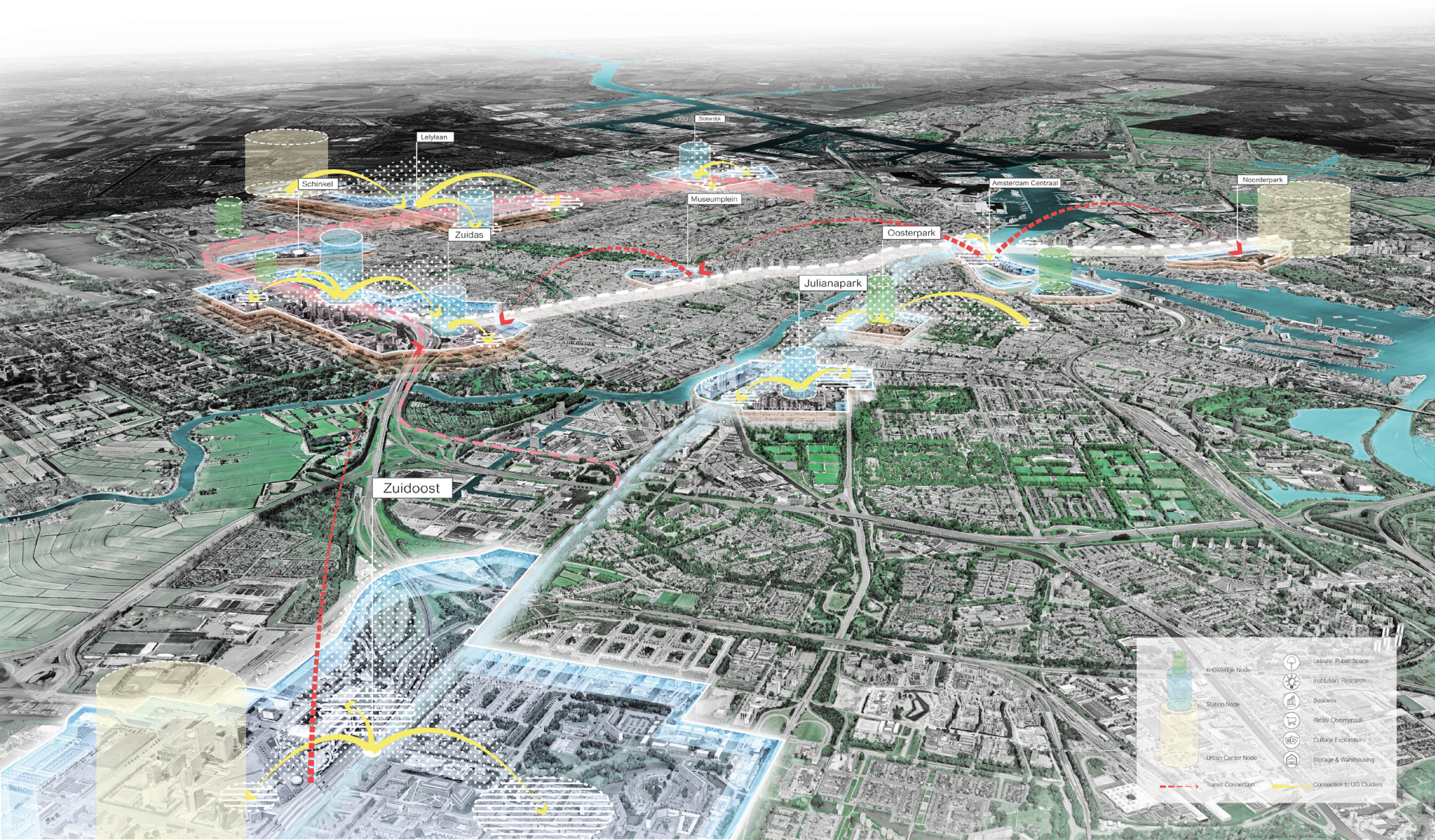
URBAN SYSTEMS INTEGRATION

Linking Existing Subsurface Clusters

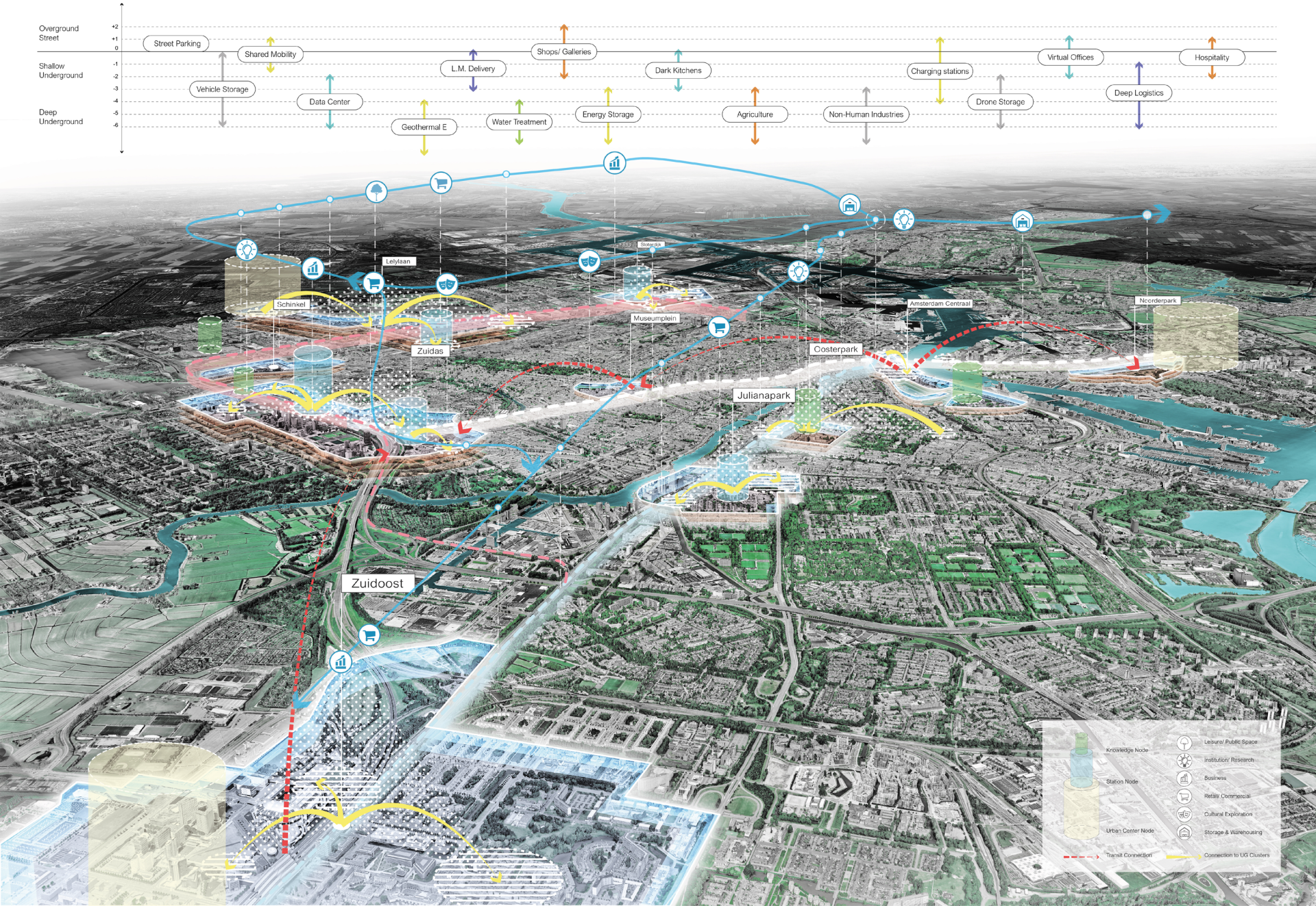


URBAN SYSTEMS INTEGRATION

Establishing Local centers and Functional character supplemented by Underground Spaces



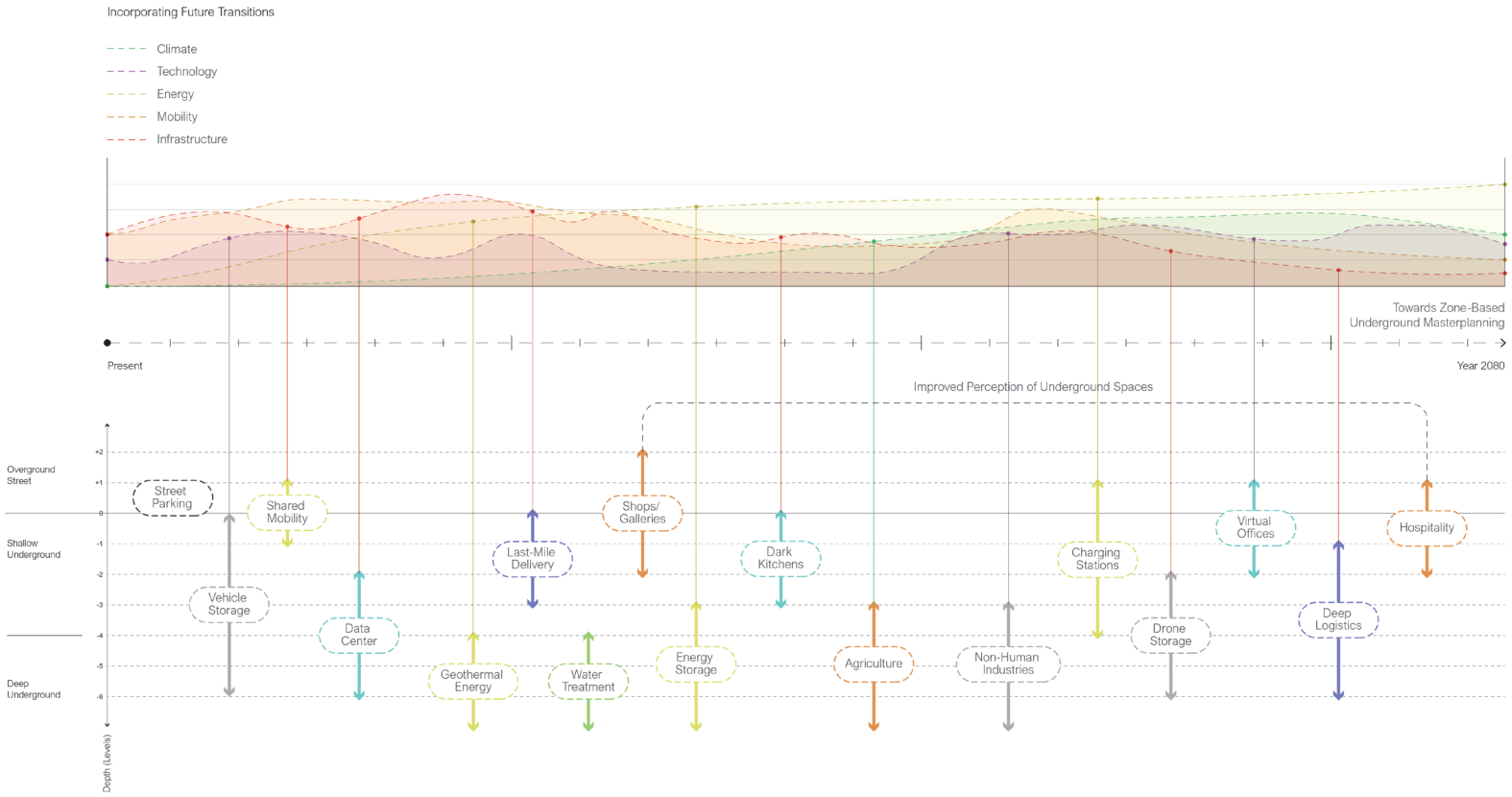
INCORPORATING FUTURE TRANSITIONS



INCORPORATING FUTURE TRANSITIONS

Categorizing Underground realm and Groundscape in gradients of Liveability

Since underground construction is a relatively permanent change in city's geography, the assigned functions need to be open ended and progressional in nature.



Way forward to Underground Cities

Amsterdam exists in a state of constant flux.

However, with development plans envisioning layered regional integration, there are numerous upcoming local centers with promising demand and low vacany rates. These local zones present a unique opportunity for integrated vertical masterplanning.

A city-scale subsurface regulatory framework is imperative, generated as a product of consistent and effective collaboration of disciplines beyond design and civil engineering.

Further research goals should entail policy frameworks to regulate structurally stable, cohesive and vibrant public realms circulated along the future groundscapes of Amsterdam.

Image Source: Scanvision, Matthias Vollmer

THE **SUBSURFACE** : A **Collective** Geography

Designing the Subsurface is a permanent change of Geography. For it to be Future-proof, the void needs to be a shell incorporating urban transitions.

Hence, it is essential for this Untapped realm to be:

A Collective Geography.