

X M A H A K A M

Reviving the Extracted Landscape of East Kalimantan

Indonesia

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Thank you, Steffen Nijhuis and Víctor Muñoz Sanz for your
inspiring and steadfast presence throughout this project,
and for encouraging me to trust my design instincts
within uncertain research grounds.

I am grateful to those closest to me
for remaining by my side
throughout all stages of this endeavour.

abstract

This thesis investigates how landscape architecture can operate within territories shaped by long-term extraction, where hydrological systems, ecological processes, and patterns of inhabitation have become spatially fragmented and environmentally unstable. Developed through the case of Samarinda and the Lower Mahakam Basin in East Kalimantan, Indonesia, the project examines how more than 520 mine lakes and the extensive territorial infrastructures of coal extraction might be reinterpreted not as isolated remnants requiring technical reclamation alone, but as active components of a socio-ecological watershed system.

Through fieldwork, territorial mapping, and research-by-design methodologies, the study shows that the apparently chaotic mosaic of degraded forests, mining pits, agricultural plots, and unstable ridge systems is in fact structurally organized by the geological distribution of coal deposits and consequently the operational logics of extraction. This discovery becomes the foundation of the design proposal. Rather than erasing the territorial mechanisms of extraction, the project partially reappropriates them: excavation, terracing, hydrological manipulation, sediment redistribution, and infrastructural corridors are redirected toward regeneration instead of depletion.

The proposal reorganizes the regional watershed through a system of "hydroedaphic gradients", where ridge systems operate as distributed hydrological "sponges" capable of

retaining water, sediments, nutrients, and organic matter before gradually redistributing them across the landscape. Through selective terracing, agroforestry retention systems, wetlands, and staged mine-lake remediation, the project establishes interconnected ecological corridors that support reforestation, aquaculture, wet agriculture, biodiversity recovery, and new forms of inhabitation. Mine lakes gradually evolve through distinct stages of chemical containment and stabilization that function as forms of post-extractive ecological succession, progressively becoming one with the surrounding territorial systems.

Beyond ecological recovery alone, the project positions regeneration as a territorial and social process. Agroforestry landscapes are simultaneously productive ecologies and mechanisms of continuous occupation, stewardship, and tenurial reclamation across vulnerable concession landscapes. Extraction off-road routes are reappropriated to draw settlement toward mine and new fishing lakes, productive forests, and remediated lake systems, transforming the logistical infrastructures of extraction into connective frameworks for public life and ecological care.

Rather than proposing a singular technical solution, the thesis frames remediation as a long-term, multi-scalar, and adaptive territorial process. It links upstream hydrological regulation to downstream urban resilience, agricultural productivity, and public occupation, and proposes an alternative model for post-extractive landscapes – one in which ecological recovery, infrastructural reuse, and collective inhabitation become mutually reinforcing components of territorial regeneration.



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CONTEXTUAL UNDERSTANDING

INTRO

The Lower Mahakam Basin in East Kalimantan, Borneo, is a landscape of sharp contrasts. Lush tropical forests, crocodile swamps, meandering river channels, rice terraces, and fruit gardens persist within one of Indonesia's most intensively mined territories. To this day, overlapping waves of extraction continue to produce a fragmented mosaic of bare landforms and pit lakes, interspersed with remnant patches of nature and human settlement.

Samarinda, the regional capital of East Kalimantan, is a striking example of a city growing within the conflicting grounds of extraction. Hundreds of fluorescent mine lakes form a massive hydrological chain running perpendicular to the Mahakam River and tightly interwoven with the city's suburban edge. A series of vivid blue, milky

green, and orange lakes now occupy vast tracts of land that were once rainforest.

These lakes occupy an ambiguous position in the urban imagination. On one hand, they are feared as hazardous landscapes associated with contamination, fatalities and strict prohibition. On the other hand, their strange beauty and the persistent public demand for water, fishing, and open space increasingly draw people toward them. Although much of Samarinda has developed in detachment from this operational territory, it is precisely the one - extending immediately beside the city - that should serve as its primary biophysical anchor: its source of water, food, ecological stability, and open space.

This thesis began as an exploration of how Samarinda's abandoned mine lakes could be gradually remediated and integrated into

broader landscape systems to support new ecological, productive, and spatial relationships across the region.

SITE DESCRIPTION

The Mahakam River begins its course high in the Müller Mountains of Borneo, at elevations exceeding 1,500 meters above sea level. Flowing eastward, it cuts through the island's tectonic folds, feeds inland lake basins and swampy floodplains and finally spreads into the extensive, sediment-rich Mahakam Delta along the Makassar Strait.

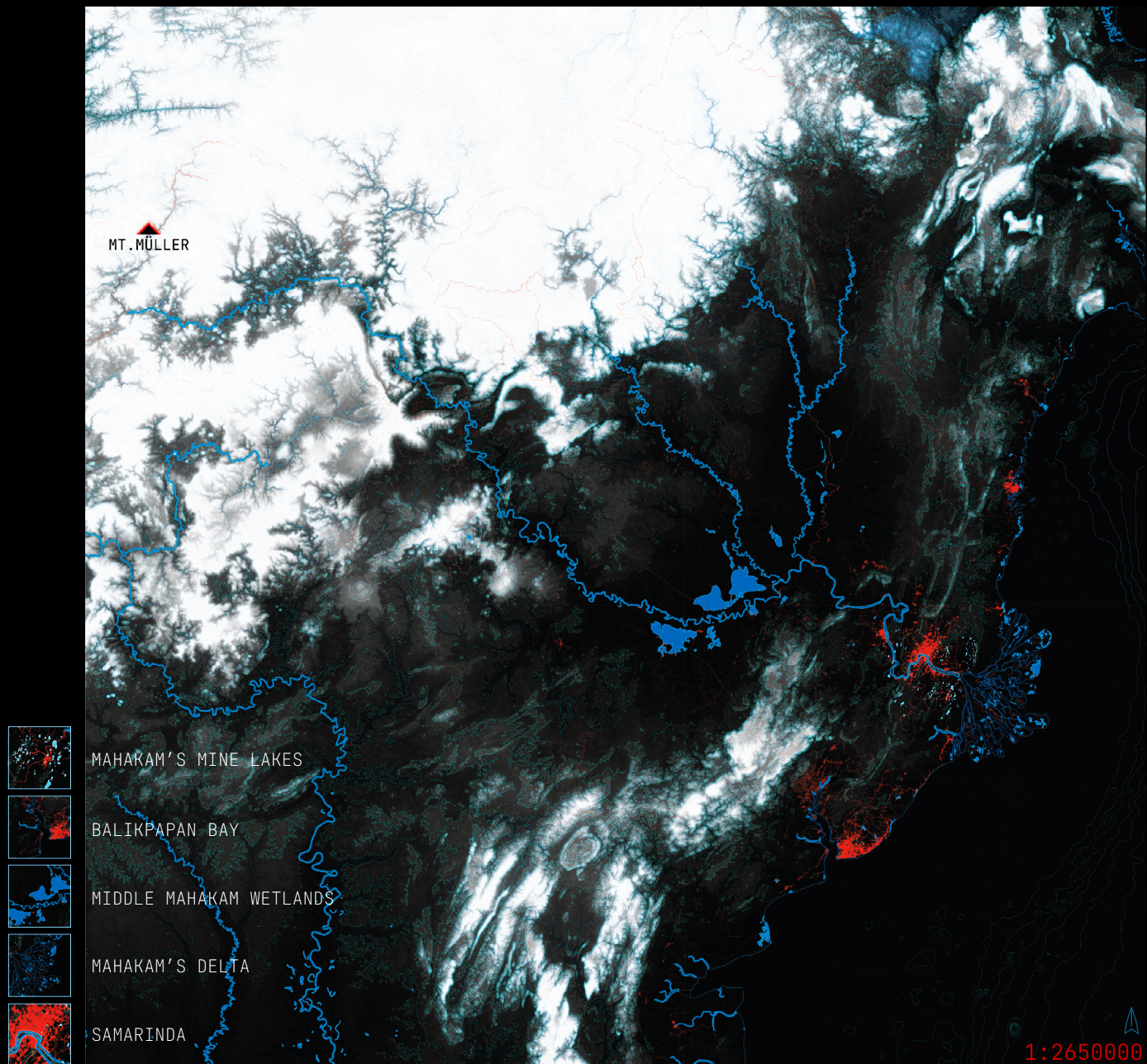
Along its lower floodplains lie Kutai Kartanegara Regency and Samarinda, the capital of East Kalimantan Province. Located approximately 60 kilometers upstream from the Mahakam Delta, the city occupies a critical threshold where mineral- and fossil-rich geological formations inland converge with the sediment-rich deltaic lowlands of the Mahakam estuary.

The region's once extensive tropical landscapes have been profoundly transformed by successive waves of logging, coal mining, oil palm cultivation, and intensive aquaculture. The river flow traversing Samarinda

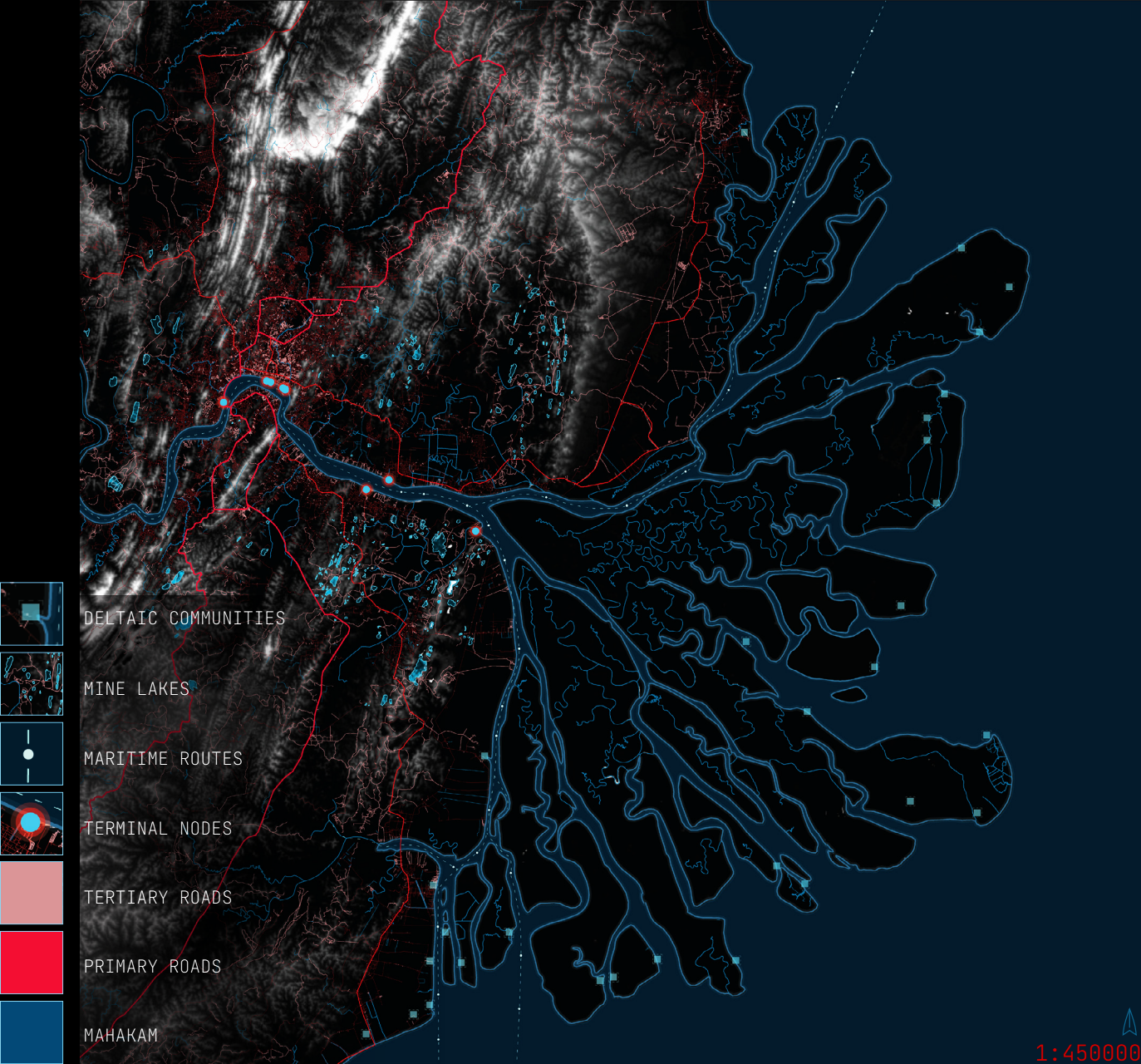
and its outskirts once structured ecological processes and riverine livelihoods, while today it carries the cumulative effects of habitat fragmentation, erosion, and pollution (MacKinnon et al., 1996; Joshi et al., 2004; McCarthy et al., 2012). Timber, oil, gas, and coal continue to move downstream toward national and international markets through the river's dense logistical networks (Moh. Noor et al., 1986; Setiadi et al., 2025).

Samarinda developed as a gateway between forest and delta, extraction and trade. To its north and south, ridge systems containing extensive coal deposits have been transformed into an ominous landscape of active and abandoned mines and their pit lakes. From west to east, the waters and sediments of the Mahakam River permeate the urban territory, flowing beneath the constant movement of coal barges and the narrow "ketinting" boats commuting between floating neighborhoods (Alam et al., 2010; Pratiwi et al., 2021; Toumbourou et al., 2020).

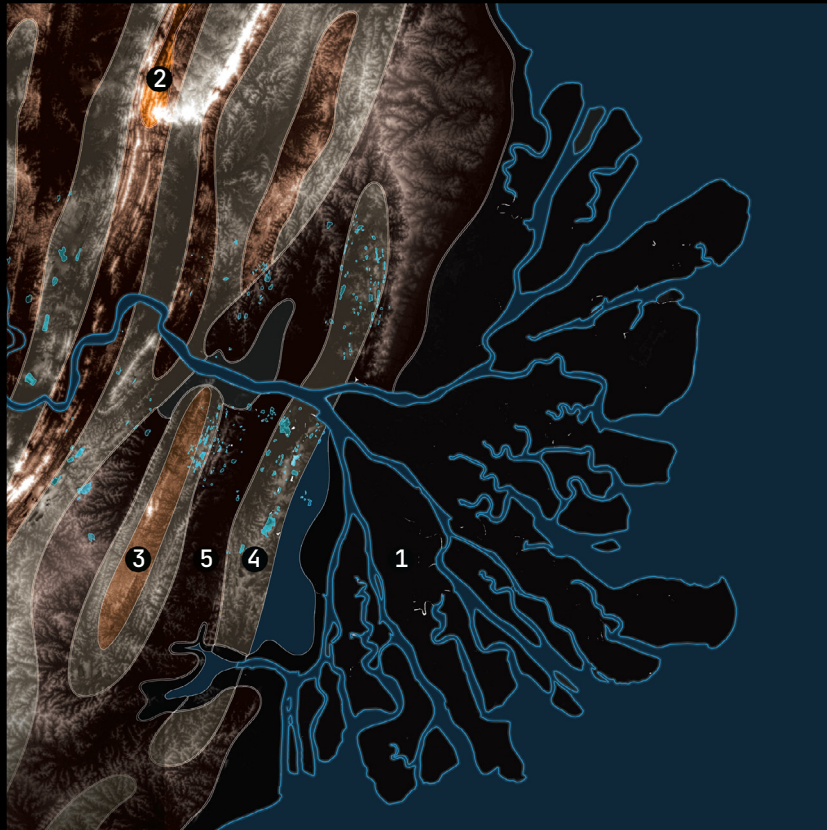
MAHAKAM-SAMARINDA



SAMARINDA'S INFRASTRUCTURE

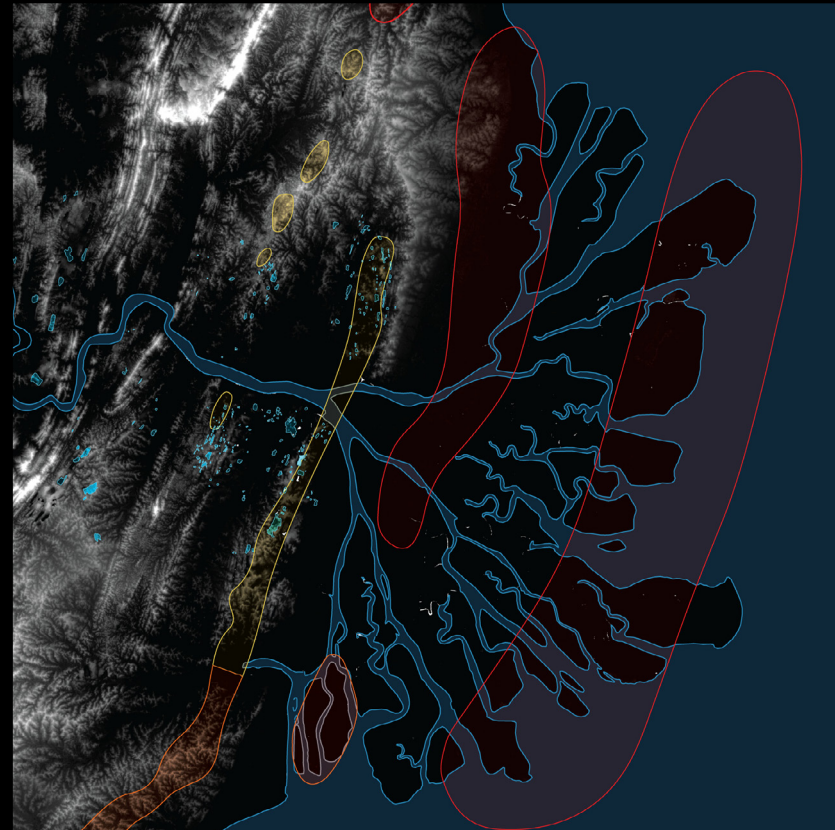


GEOLOGY/RESOURCES



Depositional Environments

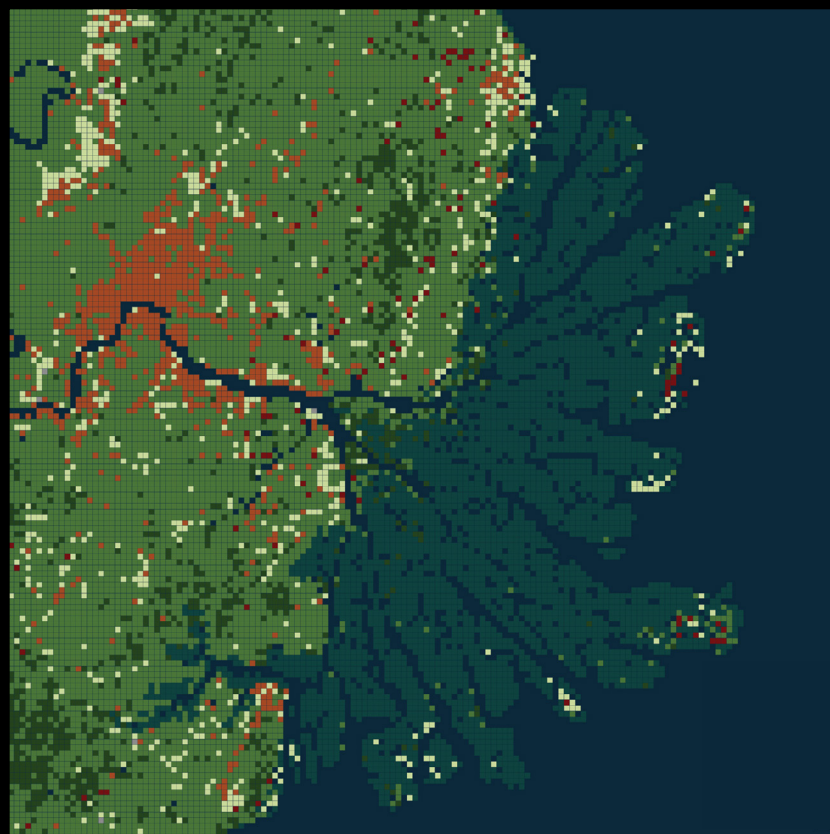
- 1. ALLUVIUM
- 2. SHALLOW MARINE
- 3. TERRESTRIAL TO SHALLOW MARINE
- 4. REGRESSION OF DELTA FRONT TO DELTA PLAIN
- 5. DELTAIC TO SHALLOW MARINE



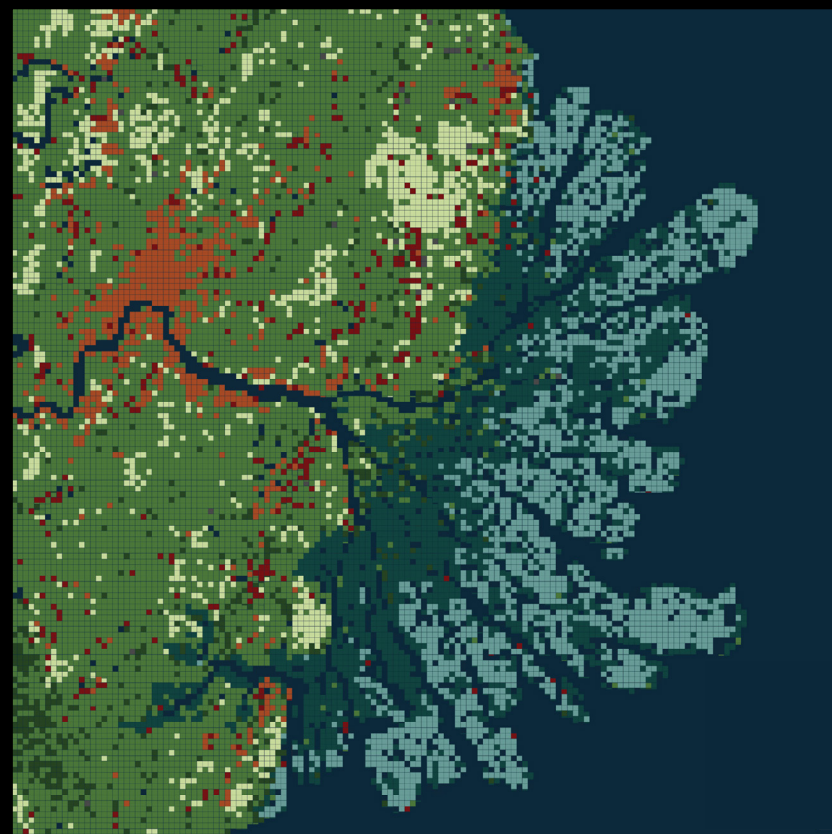
Fossil Fuel Bubbles

- OIL + GAS
- OIL
- GAS

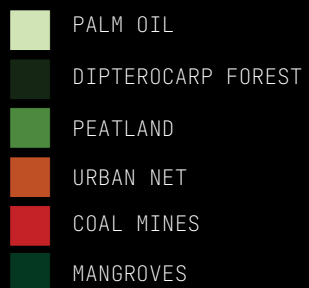
BIODIVERSITY LOSS



1993

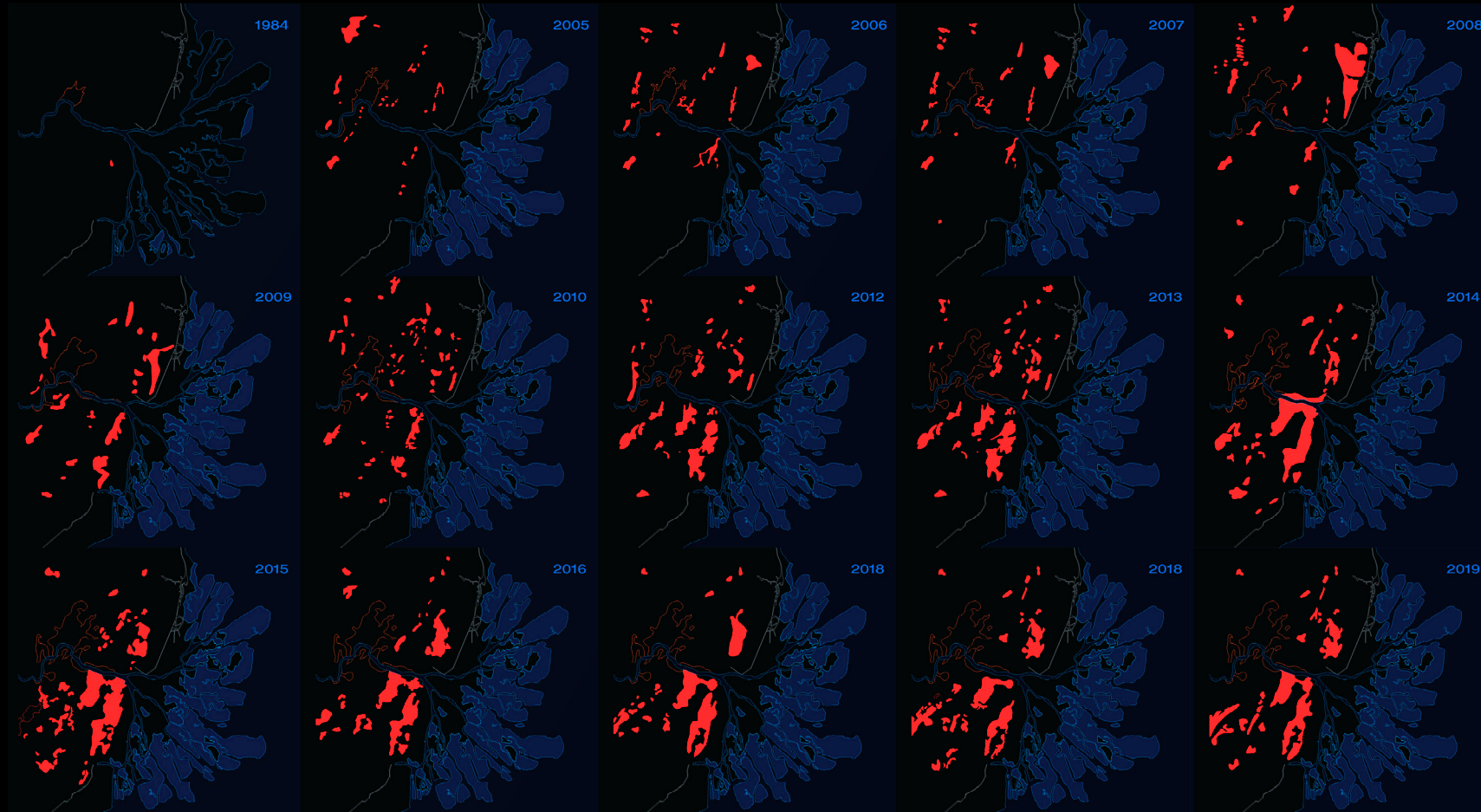


2018

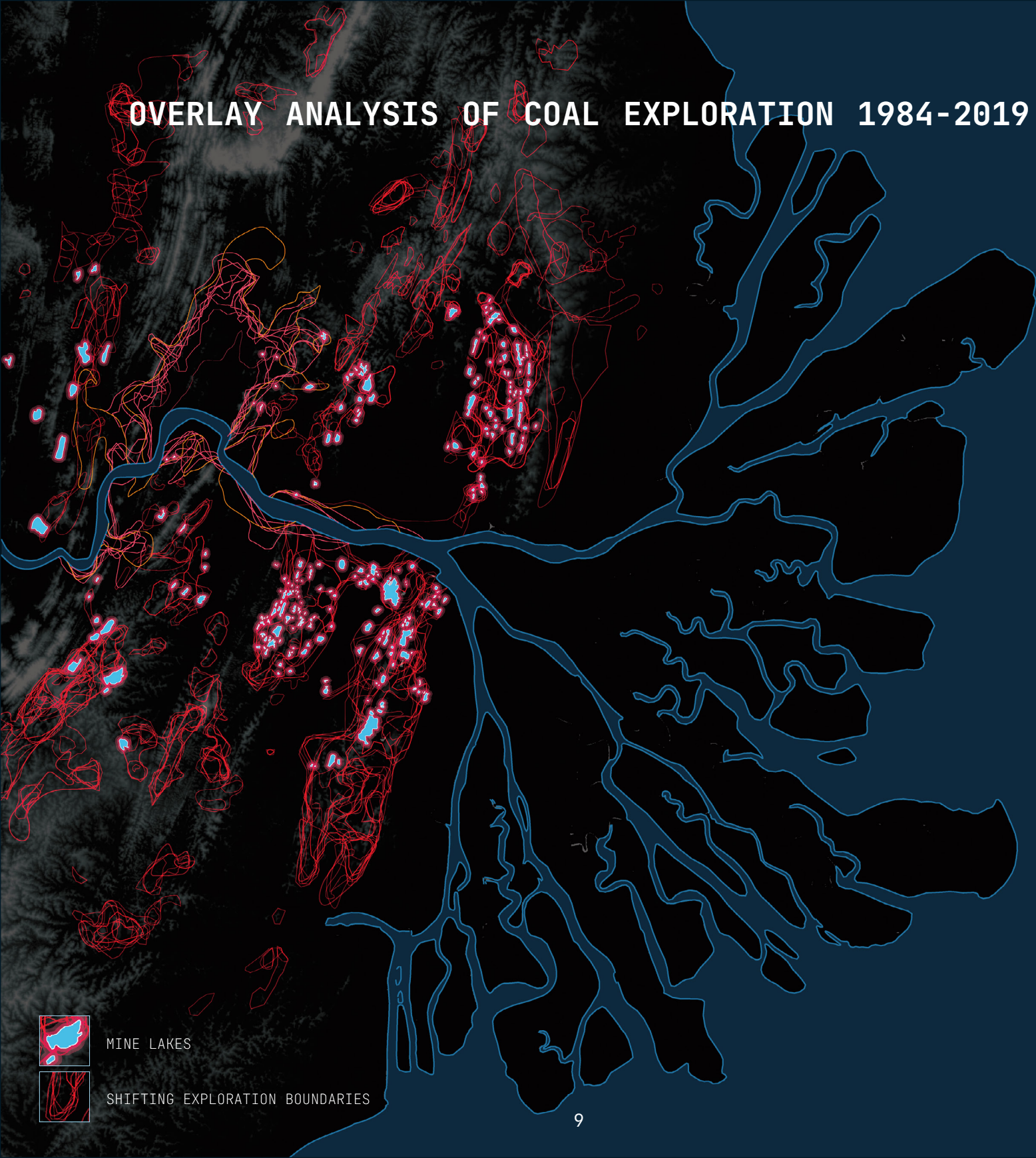




SPATIAL TIMELINE OF OVERLAPPING CONCESSIONS



OVERLAY ANALYSIS OF COAL EXPLORATION 1984-2019



MINE LAKES



SHIFTING EXPLORATION BOUNDARIES

TRANSECTS OF THE MAHAKAM AND ITS TRIBUTARIES



THE PROBLEM

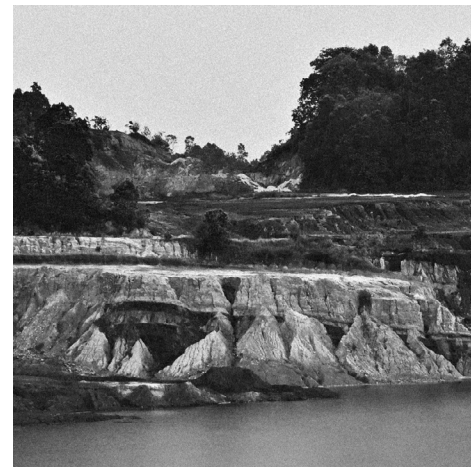
A series of elongated ridge volumes structure the territory behind the flood plains of the Mahakam River. Running in near-parallel formations - perpendicular to the river, these ridges encircle Samarinda's alluvial lowlands.

While rich in coal deposits - that made them prime targets for extraction, their upper layers are composed of fragile lateritic soils, highly prone to erosion and drainage incision. The systematic stripping of their anchoring forest structures, through decades of logging and repeated mining penetrations deeply destabilized these formations, leaving them as a series of naked slopes and water-filled voids across the landscape.

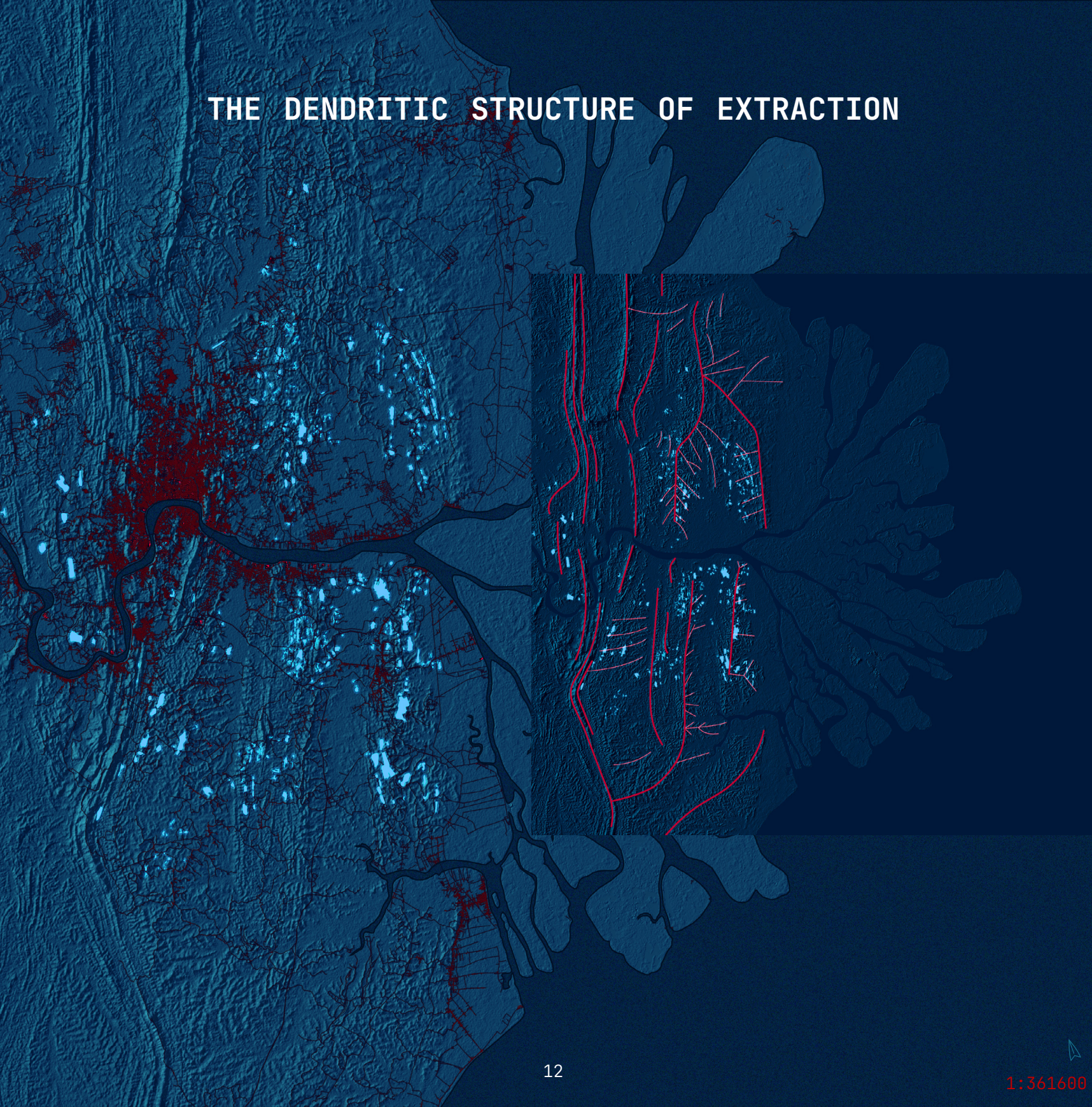
More than five hundred mine lakes now occupy the excavated ridges, forming a fragmented hydrological chain interwoven with Samarinda's expanding urban fringes. Many of the pit lakes remain abandoned, while unmanaged runoff and pollutants spread between bare slopes and downstream waterways. At the same time, eroded sediments from the destabilized ridges accumulate within the city's watershed infrastructure. North of the city, continuous

sediment accumulation has reduced the original water retention capacity of the Benanga Reservoir, by nearly one third, further intensifying recurrent flooding during periods of heavy tropical rainfall (Nur & Fadlin, 2024).

These extracted upland corridors, still contain extensive land and water resources embedded directly beside Samarinda's net. Distributed across varying elevations and degrees of wetness, the ridge volumes, with their remaining forest patches, mine lakes and wetlands form a latent hydrological structure capable of intercepting, storing, filtering, and redistributing water across the basin. Yet despite their potential value, they are ecologically discontinuous and profoundly detached from public life.



THE DENDRITIC STRUCTURE OF EXTRACTION



SEDIMENTARY PROFILE OF THE RIDGES

PULAU BALANG

PULAU BALANG

900M

BALIKPAPAN

sandstone
claystone/shale
marl
thin coal seams

BALIKPAPAN

1000M

deltaic sandstone
claystone
conglomerates

KAMPUNGBARU

KAMPUNGBARU

500M

sandstone
siltstone
claystone
mudstone
coal
lignite

ALLUVIUM

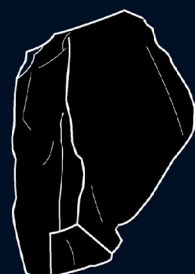
ALLUVIUM

20M

sand
silt
clay
gravel
organic materials



1 LIGNITE



2 SILTSTONE



3 CONGLOMERATES

13



4 COAL



5 CLAYSTONE

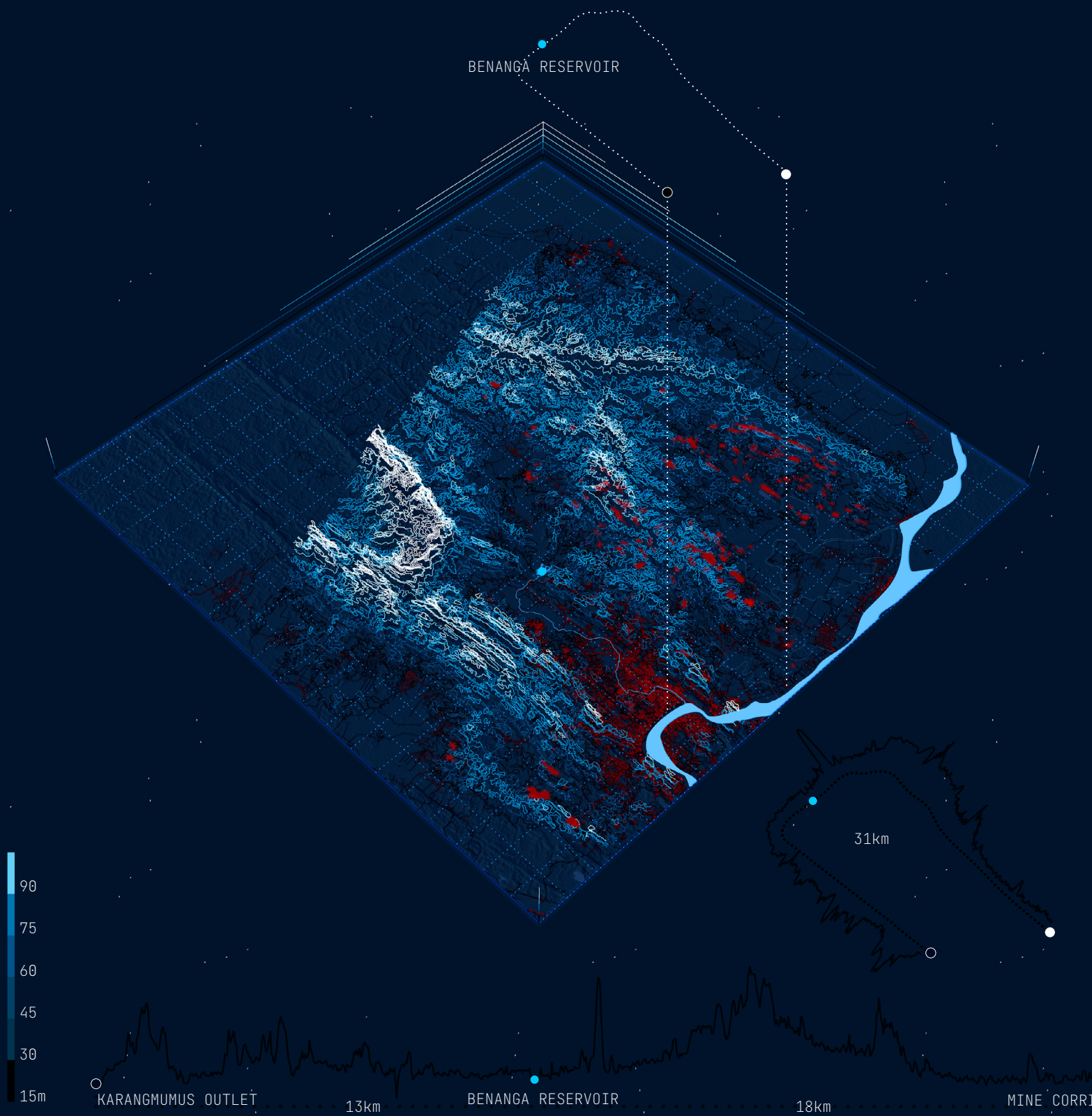


6 SANDSTONE

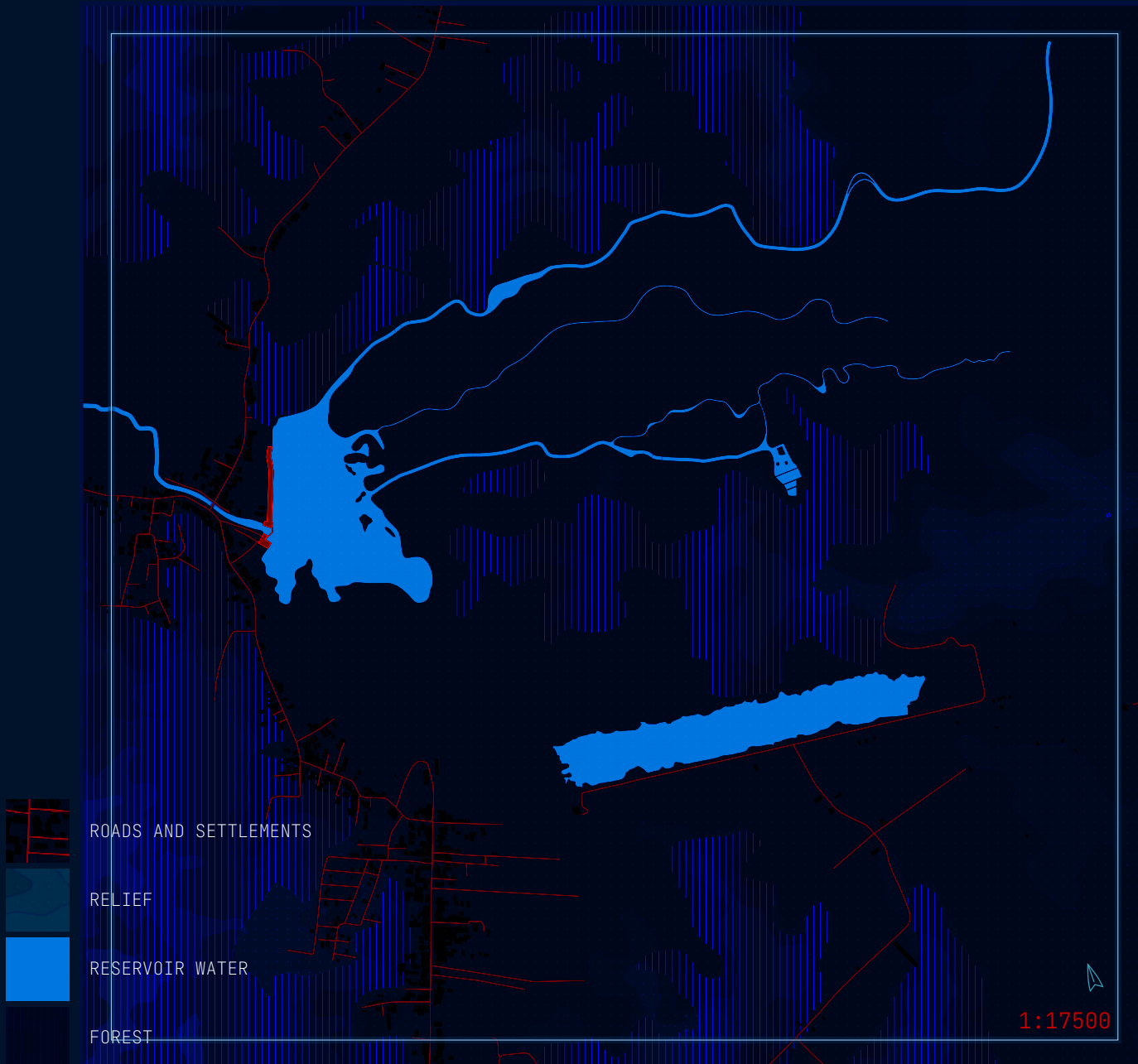


TECTONIC PROFILE OF THE RIDGES





BENANGA RESERVOIR



RESEARCH QUESTION

Through these territorial observations, the thesis arrived at the following guiding question:

“Could Samarinda’s extracted ridge systems - with their abandoned mine lakes - be transformed into a continuous landscape infrastructure, where hydroedaphic gradients drive water regulation, ecological remediation and succession, productive regeneration, and civic life?”

Addressing this question requires a conceptual shift in how the post-extraction landscape is understood. At this stage, the thesis departs from framing extraction merely as a condition of loss and fragmentation. Viewed through the lens of emergence, the landscape is approached as an evolving palimpsest in which disrupted hydrological rhythms, excavated voids, and fragmented ecologies begin to reveal the foundations of a new spatial order. Rather than resisting these altered conditions, the project operates within them, allowing new ecological and territorial relationships to emerge from the reorganization of existing landscape patterns.

SUB-QUESTIONS

To address the main research question, the thesis is subdivided into a series of interrelated sub-questions that move from territorial analysis toward spatial and ecological proposition. These questions investigate the hydrological, ecological, productive, and spatial dynamics of Samarinda’s extracted landscapes across multiple scales, while gradually constructing the hydroedaphic-gradient framework that guides the design process.

- 1.What biophysical and human intervention conditions structure the landscape?
- 2.How do ridges, water and mine lakes interact across the territory’s hydroedaphic-gradient and how can they become regenerative infrastructure?
- 3.Which spatial typologies and ecological processes can catalyze remediation, productive regeneration, and public life?
- 4.How can the proposed hydroedaphic-gradient framework be applied to other post-extraction landscapes?

MAIN THEORETICAL FRAMEWORK

Anchored in a landscape-based reading of the territory, this research binds hydrological, ecological, productive, and urban systems into interwoven spatial processes. The extracted landscapes surrounding Samarinda are understood not as residual wastelands, but as infrastructural assets with the capacity to support water regulation, ecological succession, food production, and feed public life.

The theoretical framework positions landscape-based urbanism, landscape as infrastructure, research-through-design, and hydroedaphic-gradient thinking as the primary conceptual foundations of the project. Supporting lenses including extractivism, political ecology, metabolism, reclamation, rewilding, and productive landscapes are introduced to contextualize extraction and inform the strategies developed throughout the thesis.

To begin with, landscape-based urbanism establishes the primary territorial lens of this project. It understands landscape as an active scenery through which settlements, infrastructure, ecology, and production emerge, are spatially organized, evolve and change. Across scales and over-

time, hydrology, geomorphology, edaphology, and vegetation structure the conditions under which urban areas develop. Urbanization unfolds in continuous negotiation with nature and fundamentally depends on its performance, resilience, and spatial organization. For this thesis, landscape-based urbanism stands as a design tool for reading and reprojecting the extracted land into its territory.

The concept of landscape as infrastructure approaches landscape as a performative system capable of carrying ecological, hydrological, productive, and social functions traditionally assigned to engineered infrastructure. Within the extracted territories surrounding Samarinda, ridge systems, wetlands, mine lakes, and vegetated corridors are therefore repositioned as infrastructural landscapes capable of retaining water, filtering sediments, supporting ecological succession, producing resources, and structuring public space. Rather than relying on technical engineering solutions, the thesis investigates how existing landscape processes can operate as agents of territorial remediation and urban resilience (Nijhuis & Jauslin, 2015).

Within a pragmatist framework, research through design is employed as an explorato-

ry and synthetic method for generating spatial principles, territorial strategies, and ecological typologies. Responding to rapidly transforming extractive landscapes requires more than the restoration of past conditions; it demands site-specific forms of reinvention capable of engaging the territorial palimpsest while projecting future scenarios.

Within this thesis, research through design operates through iterative cycles of mapping, analysis, speculative projection, and spatial testing in order to uncover latent relationships and develop adaptive regenerative strategies for the extracted landscapes surrounding Samarinda. Historical and ecological insights therefore inform the design process without constraining it, allowing interventions to remain both context-specific and adaptable to evolving territorial conditions (Nijhuis & de Vries, 2019).

The hydroedaphic-gradient framework developed within this design research emerges as an extension of the gradient paradigm in landscape ecology (Cushman et al., 2010). Rather than flattening the complexity of real landscapes into ecologically distinct fragments – as patch-based models tend to propose – this thesis approaches water,

soils, topography, vegetation, ecological succession, and human inhabitation as mutually reinforcing systems that continuously reorganize the landscape across multiple scales and states of saturation (Winter, 2001; Corner, 2006).

Together, these theoretical positions construct a process-based territorial approach for engaging extracted landscapes. Landscape-based urbanism frames the territory as an evolving ecological and geomorphological system; landscape as infrastructure repositions landscape processes as performative agents of remediation and urban resilience; research through design enables iterative spatial testing across uncertain futures; while the hydroedaphic-gradient framework operationalizes the continuous interactions between water, soils, vegetation, topography, and human inhabitation across the territory. Supporting lenses including extractivism, political ecology, metabolism, reclamation, rewilding, and productive landscapes further contextualize the territorial consequences of extraction while informing regenerative and adaptive strategies throughout the project.

Through the convergence of these frameworks, the thesis approaches Samarinda's extracted ridge-mine lake systems not as

isolated remnants of degradation, but as interconnected territorial systems capable of supporting phased ecological regeneration, productive landscapes, hydrological resilience, and civic life.

SUPPORTING THEORETICAL LENSES

1. Political ecology

Political ecology reads landscapes as narratives of power, conflict, and negotiation, where environmental conditions translate into social inequalities and vice versa. Extraction sites, beyond layers of ecological degradation, reveal forms of community displacement and their internal conflicts. All transformations are embedded in the structure of either functional or abandoned infrastructures, flows, and human history (D'Alisa, Demaria, & Kallis, 2015).

2. Extractivism

Extractivism is examined as an ecopolitical catalyst. Beyond the simple removal of resources - as the term extraction denotes - extractivism organizes labor, capital, and nature, into systems of control, often producing "sacrifice zones" where ecological and social capacities are stripped away (Klein, 2014; Willow, 2018). Rooted in colonial and imperial regimes, extraction reflects persistent inequities between

local communities and distant beneficiaries, as observed often in the Global South, while restructuring local ecologies to feed global circuits (Nijhuis & Jauslin, 2015; Yusoff, 2013). Viewed through the political ecology lens, these processes reveal the intertwined dynamics of power, economy, and ecology, revealing landscapes as sites of contestation between external control and local stewardship (Durante, Kröger, & LaFleur, 2021; Willow, 2019).

3. Commons

The notion of the commons functions as a lens for understanding how collective practices shape and sustain landscapes. It draws attention to shared forms of use, care, and governance that emerge through social relations rather than individual ownership. Historical and contemporary conditions, including Indigenous practices and everyday collective routines, reveal how landscapes are produced and maintained through cooperation and mutual responsibility. Self-organization, food sovereignty, and collaboration among multiple actors, generate both tangible and intangible values inside the landscape (Ferretti & Favargiotti, 2021).

4. Reclamation

Reclamation is a complex intervention in

post-extraction landscapes, operating at the intersection of ecology, society, and culture. It is shaped by policies, environmental assessments, and institutional management directives, yet these interventions often reproduce existing power relations, privileging technocratic solutions over local knowledge and community agency. Traditional reclamation prioritizes hazard mitigation, topographical stabilization, and the removal of toxic materials, frequently at the cost of erasing material traces of past labor, industry, cultural identity, and, crucially, the antecedent landscape, often scarred or barely visible. Ethical reclamation challenges this erasure, foregrounding the legibility of layered histories, the co-production of human and nonhuman processes, and the negotiation of contested values. Reclamation is thus a site of entanglement: it manages pollution and ecological risk while mediating the political and cultural stakes of landscape memory. When approached as a process of landscape identity reconfiguration, rather than restoration and redevelopment, post-extraction landscapes become dynamic and discursive sites, where past, present, and potential futures merge to inform collective stewardship (Langhorst & Bolton, 2017).

HOW DOES THEORY INFORM DESIGN?

1. Biophysical Reading

Design begins with the analysis of biophysical and infrastructural relationships between Samarinda and its extracted surroundings. Hydrology, geology, vegetation, and human production patterns are translated into schematic and synthetic mappings that reveal how environmental processes structure the landscape.

2. Working Through the Territorial Palimpsest

Mine lakes, altered slopes, waterways, residential and mobility corridors, productive zones, and their historical traces are treated as operative landscape structures. The extractive blueprint is therefore not erased, but reorganized into ecological, productive, and public systems. Through opportunity and synthetic mappings, design identifies the spatial relationships, sequences, and functions capable of supporting this territorial transformation.

3. Multi-scalar Design Research

Design testing operates simultaneously across territorial and human scales. From regional hydrological frameworks to localized water-management techniques, ecological corridors between the city and mining

landscapes, productive forest slopes, and inundated croplands are reinterpreted across multiple scales in order to establish interconnected spatial threads throughout the territory.

4. Process-Based Thinking

Interventions are phased according to local hydrological dynamics, sedimentation patterns, ecological succession, and remediation capacity. Rather than producing fixed end-states, the project develops adaptive landscape mechanisms capable of evolving over time in response to changing environmental conditions and regeneration demands.



THEORETICAL LENSES

LANDSCAPE BASED URBANISM
LANDSCAPE AS INFRASTRUCTURE
RESEARCH THROUGH DESIGN

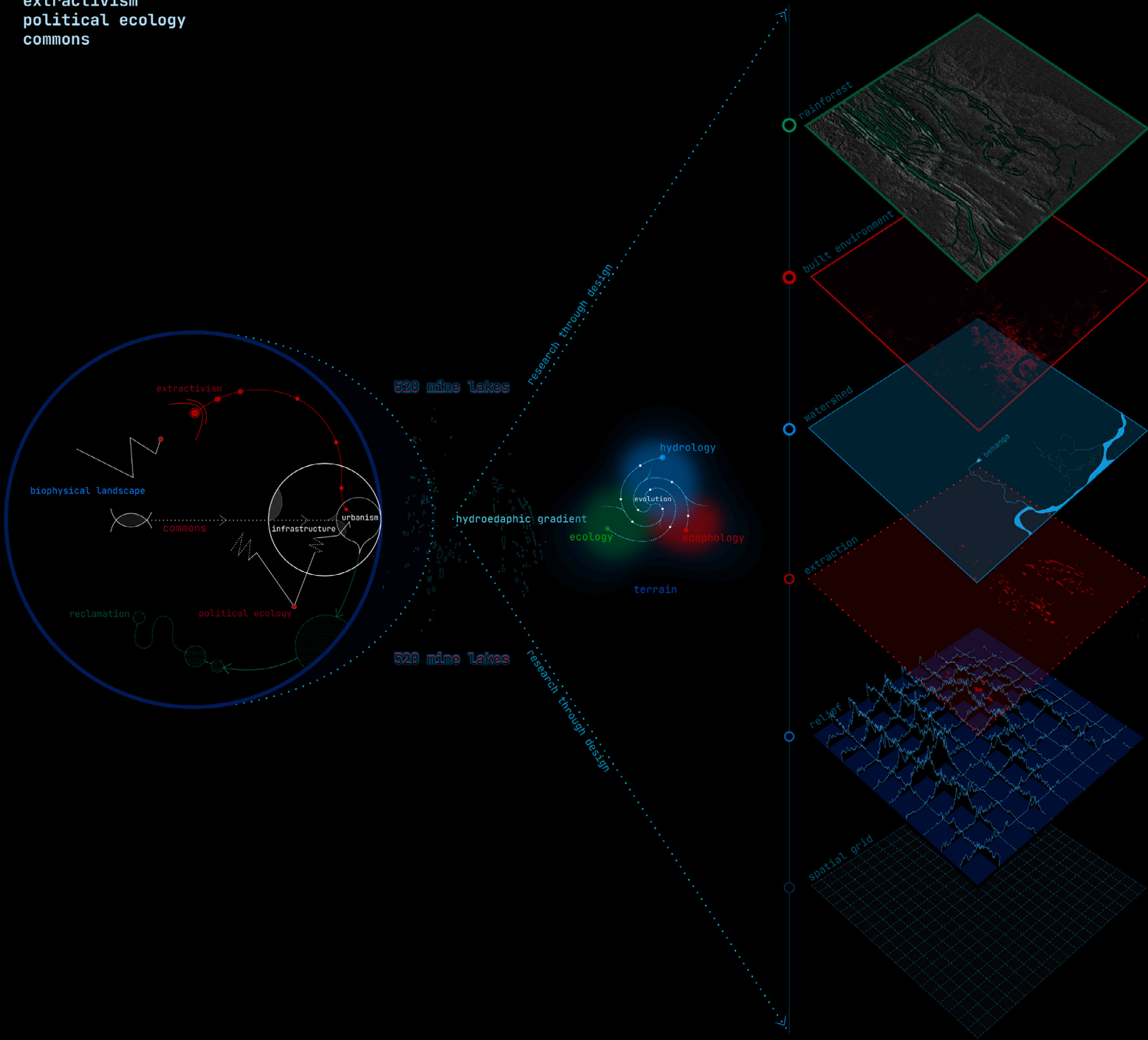
extractivism
political ecology
commons

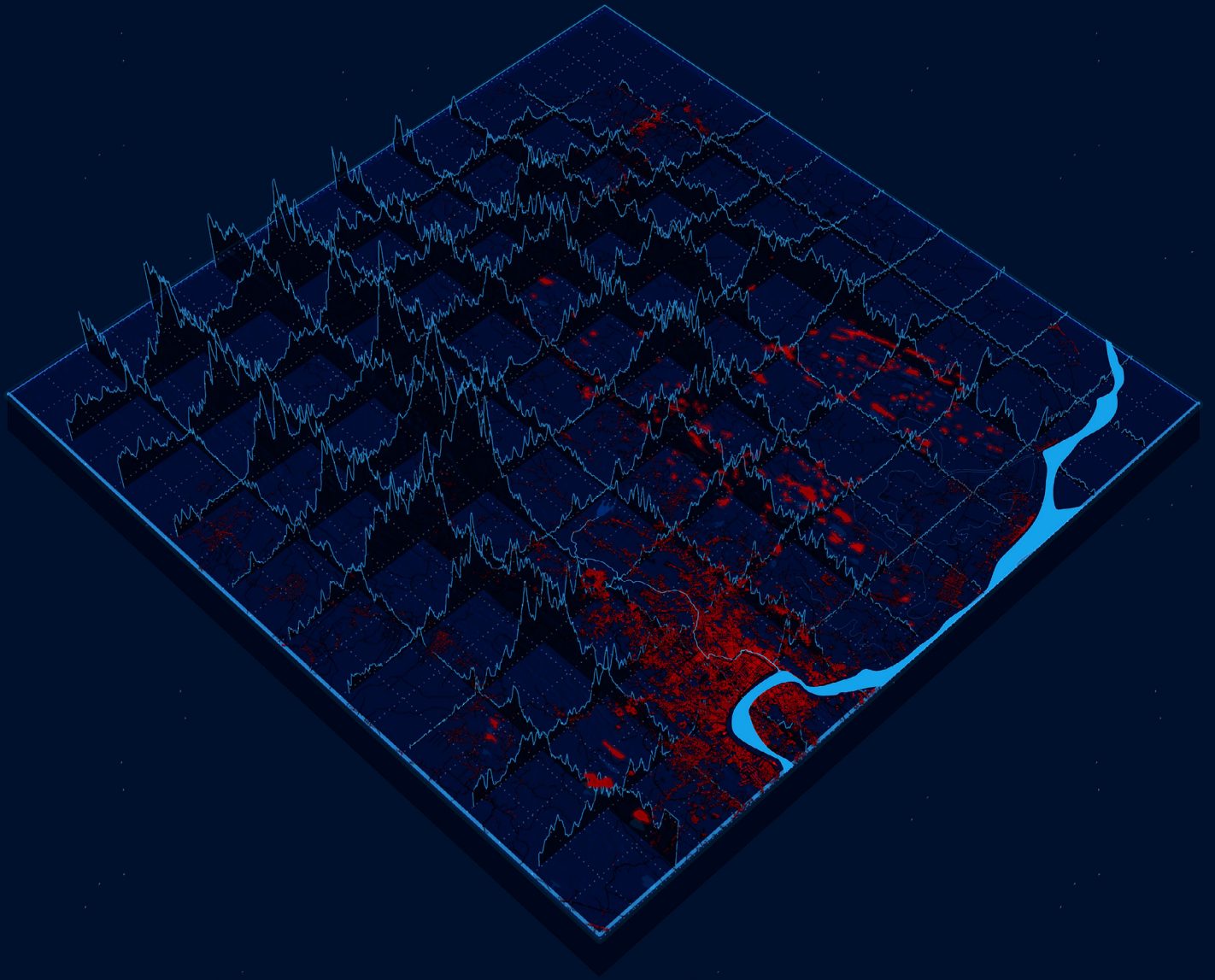
CONSTRUCTED LENS

HYDROEDAPHIC GRADIENT

TERRITORIAL SYSTEMS

IN EXPLOSION





PRECEDENT STUDIES

1. Post-Extraction Sandpit Lakes, Nebraska (Karle, 2024)

In the “Journal of Interdisciplinary Studies in Architecture and Urbanism”, Karle (2024) examines Nebraska’s sand and gravel extraction landscapes as examples of post-extraction urbanism, where industrial operations leave behind peri-urban sites that are socially and materially constructed. In Grand Island, sandpits above the Ogallala Aquifer naturally filled with water, have formed lakes that became catalysts for urban expansion, residential development, and public recreation. These sandpit lakes, collectively known as the I-80 Lakes, show how post-extraction sites can integrate ecological, social, and economic functions while redefining the traditional reliance on orthogonal Jeffersonian grids.

The Nebraska case is about understanding extraction landscapes through material, form, and process. Lakes take diverse morphologies: fragmented, horseshoe, peninsula, and uniform, reflecting intentional, as well as ad hoc formation, during extraction. GIS and parcel data analysis create links between lake formation, land

ownership, and post-extraction use, revealing a pattern where planned lakes become residential or park amenities, while unplanned lakes retain ecological or undeveloped character. The reclamation process integrates hydrological, ecological, and architectural considerations, creating constructed ecologies that support wildlife, including endangered species, alongside human occupation.

This precedent highlights the potential of design-led, interdisciplinary interventions in post-extraction landscapes. Through visualization of the transformations’ timeline and leveraging ecological and social programming, reclaimed sites can provide multifunctional value: housing, recreation, and biodiversity, while challenging the notion that such landscapes are residual or purely economic. Designers play a critical role in anticipating post-extraction futures, balancing urban expansion with ecological restoration.

While Nebraska’s temperate, peri-urban context differs from the tropical, deltaic Lower Mahakam Basin, the case demonstrates how post-extraction sites can become hybrid landscapes that integrate industrial legacy, natural systems, and urban growth, offering transferable strategies for regen-

erative, multi-scalar design in resource-depleted regions.

2. Managing and Reforesting Degraded Post-Mining Landscapes, Indonesia (Pratiwi et al., 2021)

In Land, Pratiwi et al. (2021) synthesize science based practices and field applications for reclaiming open pit coal and mineral extraction landscapes across Indonesia's humid tropics, focusing on landscape engineering, soil rebuilding, and ecological succession as the core mechanisms of restoration.

Their framework begins with technical mining and soil handling protocols that are legally mandated before extraction: topsoil and "overburden" materials are systematically peeled, stockpiled, and categorized by their acid forming potential. Proper stockpile management, including cover cropping with legumes and grasses, limits erosion and nutrient loss, preserving biological capital for later reclamation.

At the landscaping stage, "overburden" recontouring prioritizes stable slopes, encapsulation of toxic substances with inert materials or limestone to prevent acid mine drainage (AMD), and construction

of engineered drainage systems, settling lakes, dry dams, and constructed wetlands using species like "*Eleocharis dulcis*" and "*Typha angustifolia*" for passive water treatment.

Soil rebuilding recognizes that mine soils are inherently poor in structure and nutrients. Final land surfaces receive 50-125 cm of topsoil amendments, composted manure, charcoal, NPK fertilization, and mycorrhizal fungi, to enhance porosity, organic matter, and microbial activity essential for root establishment.

Revegetation is multi-tiered: fast growing pioneer and legume cover crops establish canopy cover and generate microclimatic conditions, followed by mixed planting with native hardwoods to accelerate succession and biodiversity recovery. Hydroseeding, jute nets on steep slopes, and careful spacing are applied to minimize erosion and boost survival rates. Monitoring regimes use measurable, reportable and verifiable (MRV) criteria, survival rates, canopy cover, soil stability, and AMD control, to officially finalize the reclamation process. Despite its technical focus, this precedent demonstrates that holistic reclamation, integrating engineering, soil science, and ecology can transform degraded

post mining terrain into functional forest landscapes, productive ecosystems, and water resources, offering transferable design strategies for the restoration of the Lower Mahakam Basin.

CONCLUSION

The previous analyses suggest that the extracted landscapes surrounding Samarinda can be approached as a continuous territorial system that runs on interactions between hydrology, topography, ecological succession, and human activity. Design objective is a “hydroedaphic-gradient” that creates links between isolated ridges, mine lakes and productive landscapes, to establish a new territorial order.

Through literature review, media scanning, analytical mapping, field observations, precedent studies, and iterative design, the thesis investigates relationships between systems, processes, and functions that conventional reclamation approaches often overlook. Instead of treating post-extraction landscapes as areas awaiting official technical restoration, the thesis proposes a design strategy for their long-term nature-based recovery and their eventual emergence as social constructs.

Through phased interventions, water-management systems, productive forest planning, ecological remediation, and landscape infrastructure, the project aims to support the long-term reclamation of Samarinda’s extracted ridges and abandoned mine lakes until they can sustain hydroedaphic balance, biodiversity, regenerative production, civic life.



ANALYSIS

SAMARINDA'S ANTICLINORIUM AND LANDSLIDES

Samarinda lies within one of the richest geological formations of East Kalimantan. The city is situated on the Samarinda Anticlinorium (Alam et al., 2010), a folded sedimentary structure containing extensive coal-bearing strata. As revealed through the overlay of topographic maps and concession boundaries, coal seams are concentrated along the ridges' spines, where mining operations have systematically removed forest cover, topsoil, and "overburden" to access subsurface deposits. The resulting landforms are steep excavated basins, often with unstable and unconsolidated slopes that are highly susceptible to erosion and landslides.

SPATIAL LOGIC OF KALIMANTAN'S EXTRACTION

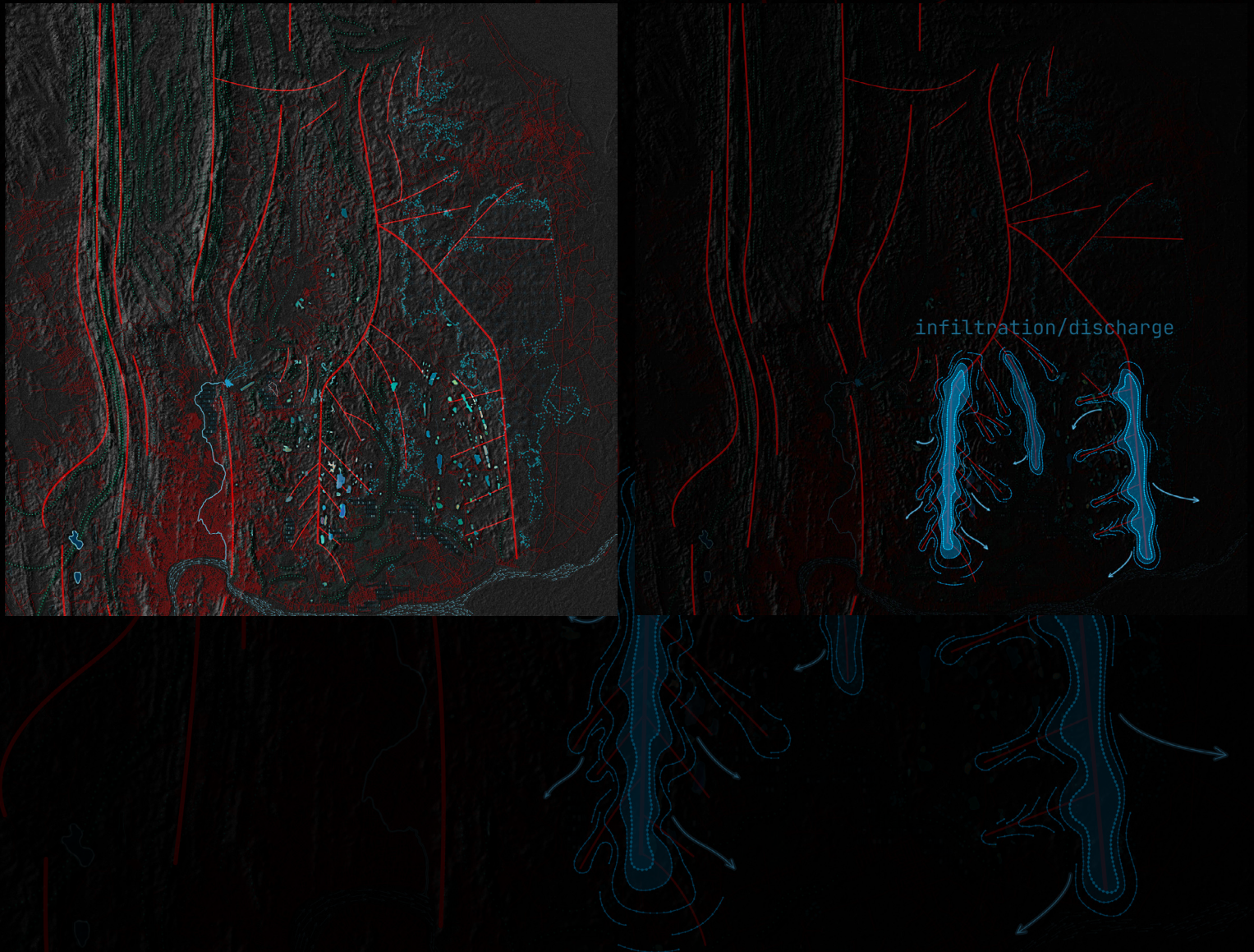
Across Samarinda's hinterland, these excavations have produced a dense matrix of artificial lakes MAP5 (mine lakes entire

axis). Through cartographic analysis (QGIS), five hundred and twenty mine pits were identified, arranged in an elongated north-south corridor that intersects the Mahakam River perpendicularly. These lakes have permanently inscribed the upland extensions of Mahakam's floodplains, through the spatial logic of extraction. Their distribution offers a striking inversion of the region's former topography: areas once covered by dense tropical forest are now marked by a constellation of water bodies and their stripped surroundings - extensive catchment vessels of impermeable clay and siltstone walls, that are abundantly charged by monsoonal rainfall, surface runoff, and shallow seepage (Devy & Sarungallo, 2018; Syarifuddin et al., 2024).

LANDUSE MAP

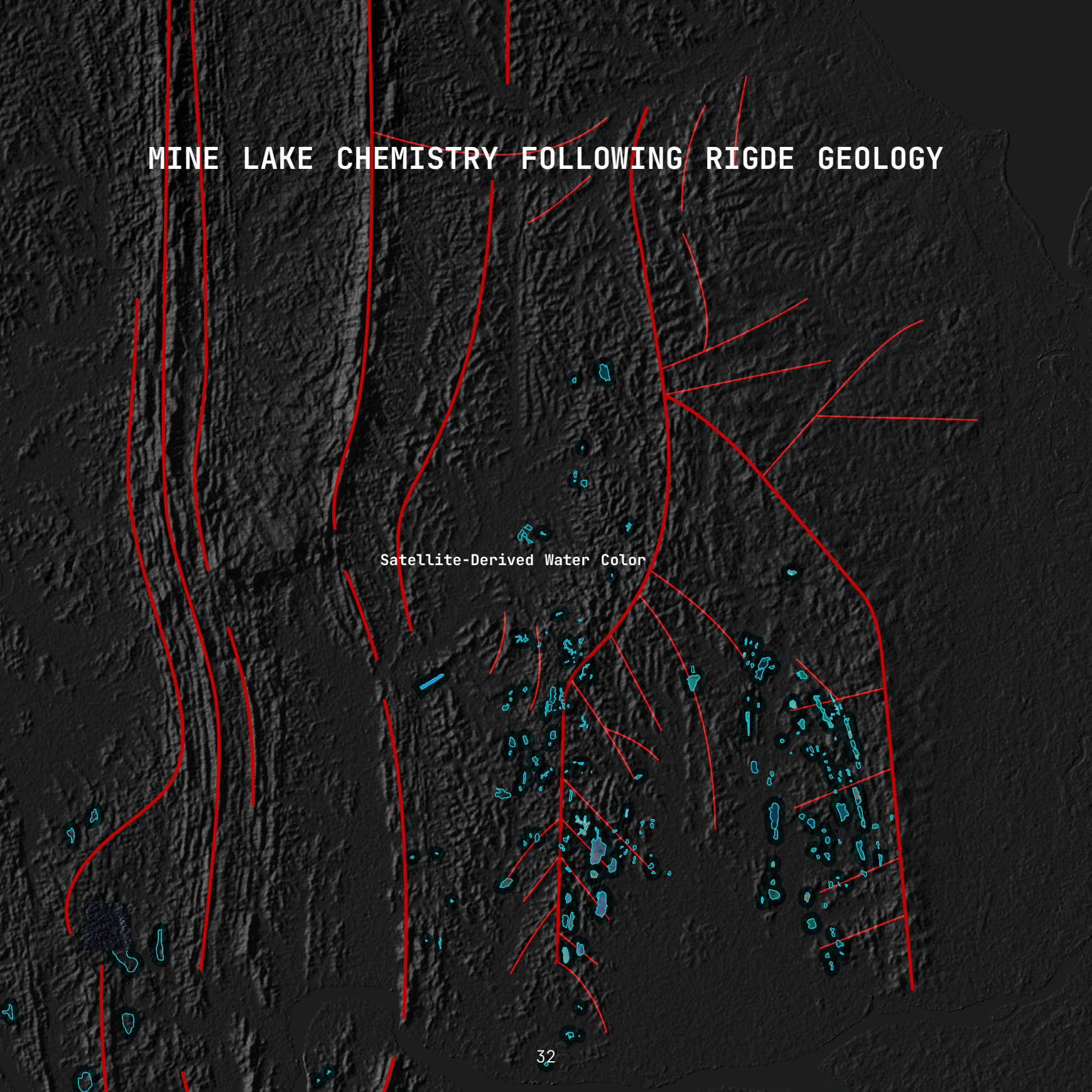


DRAINAGE PATTERN PROJECTED ON LANDUSE RIDGE AS HYDROEDAPHIC INFRASTRUCTURE



MINE LAKE CHEMISTRY FOLLOWING RIGDE GEOLOGY

Satellite-Derived Water Color



MINE LAKE CHEMISTRY

Due to restricted access to mining territories and the political sensitivity surrounding extraction landscapes in East Kalimantan, direct water and soil sampling during fieldwork was not possible. As a result, the lakes were interpreted primarily through visual observation alongside existing literature on post-mining hydrochemistry.

The lakes vary considerably in size, depth, and chemical composition. Their distinctive colours, ranging from deep cobalt blue to milky green, ochre, and reddish tones, indicate pronounced differences in water chemistry, influenced by mineral oxidation, suspended sediments, acidity, and organic decomposition. According to existing literature on mine lakes geochemistry, reds suggest iron-rich acidity and extremely low pH, ochres are linked to the deposition of ferric precipitates in sulfate-laden waters, milky greens indicate suspended clays and aluminum-rich conditions in transition, while deep cobalt blues show a relatively stable chemical condition (Eary & Castendyk, 2013). The chromatic variation serves as an immediate diagnostic framework for the lakes' geochemistry and helping to identify which of them are most suitable

for early intervention, which require continued monitoring, and which must remain isolated until further remediation becomes possible.

MINE LAKES AS LIVING AGENTS

Satellite imagery demonstrates that the morphology and volume of these lakes remain highly dynamic after abandonment. Rainfall patterns, slope failures, runoff, and groundwater fluctuations cause some pits to expand, merge with neighboring basins, or partially contract through sediment infill and revegetation. Others remain hydrologically intact despite their close proximity, maintaining sharply contrasting water colours over many years. These patterns suggest that each lake functions as a distinct hydrochemical system, governed by highly diverse geological conditions, drainage patterns, and the degree of exposure to surrounding catchments.

The lakes operate as living vessels - they accumulate water, sediments, nutrients, contaminants, and organic matter; stratify and mix in response to rainfall cycles; and progressively host microbial, aquatic, and terrestrial communities along their margins. Each lake is an ongoing negotiation between geology, hydrology, chemistry, and

biological succession. Therefore, the mine lakes are not inert voids, but evolving metabolisms whose conditions simultaneously reveal both the palimpsest of extraction and the potential for ecological regeneration.

CURRENT IDENTITY OF MINE LAKES

Although originally unintended by-products of mining, these water bodies have increasingly entered public life. Where pits are accessible and located near settlements, residents gradually test their suitability for irrigation, particularly in rice-growing areas where water neutrality is essential for cultivation. Elsewhere, the intensely colored lakes attract spontaneous recreational uses including swimming, fishing, and informal camping. In some cases, wildlife has begun to colonize these environments, with local reports of crocodiles inhabiting larger and more remote pits.

LETHAL LANDSCAPES

At the same time, the lakes pose significant environmental and social risks. Their water quality remains uncertain, while steep banks and unstable edges make many of them physically hazardous. Fatal accidents are frequent; official reports indicate

that 168 deaths - the majority of them children - have occurred in abandoned mining pits across Indonesia, with East Kalimantan accounting for the highest share (Jong, 2021; Mahy, 2016). Kalimantan's mine lakes are landscapes of profound ambiguity: suspended between latent potential and diffuse accountability, they simultaneously harbor eco-social dynamism and persistent risk.

SAMARINDA'S PRESSURING TRIFOLD

Only a few infrastructural nodes away from these extractive relics, Samarinda confronts the enduring pressures of a continuing dependence on extraction. The provincial capital remains economically tethered to extraction, while local agricultural systems show limited signs of development - despite the region's ecological capacity. In a region once sustained by river and forest, the food system is now organized around imported goods, wage labour, and logistics. Opportunities for local food provisioning and direct engagement with the natural landscape remain remarkably low. (Abu et al., 2021; Murjani & Wiratama, 2025; Toumbourou et al., 2022).

Before extraction, food systems across Kalimantan were closely tied to forest management, swidden cultivation, agroforestry,

fishing, and rotational land-management practices developed by generations of Dayak communities. Swidden cultivation operated as an adaptive response to the non-volcanic, at parts nutrient-poor and highly leached tropical soils of Borneo, relying on forest succession, biomass cycling, and rotational clearing to temporarily restore fertility and sustain cultivation cycles (Thaler, 2016). Extensive literature documents the gradual loss of collective land tenure through decades of extractive expansion, land privatization, overlapping concessions, and industrial development, all of which radically transformed traditional food systems and their cultural imprints (Thaler, 2016;).

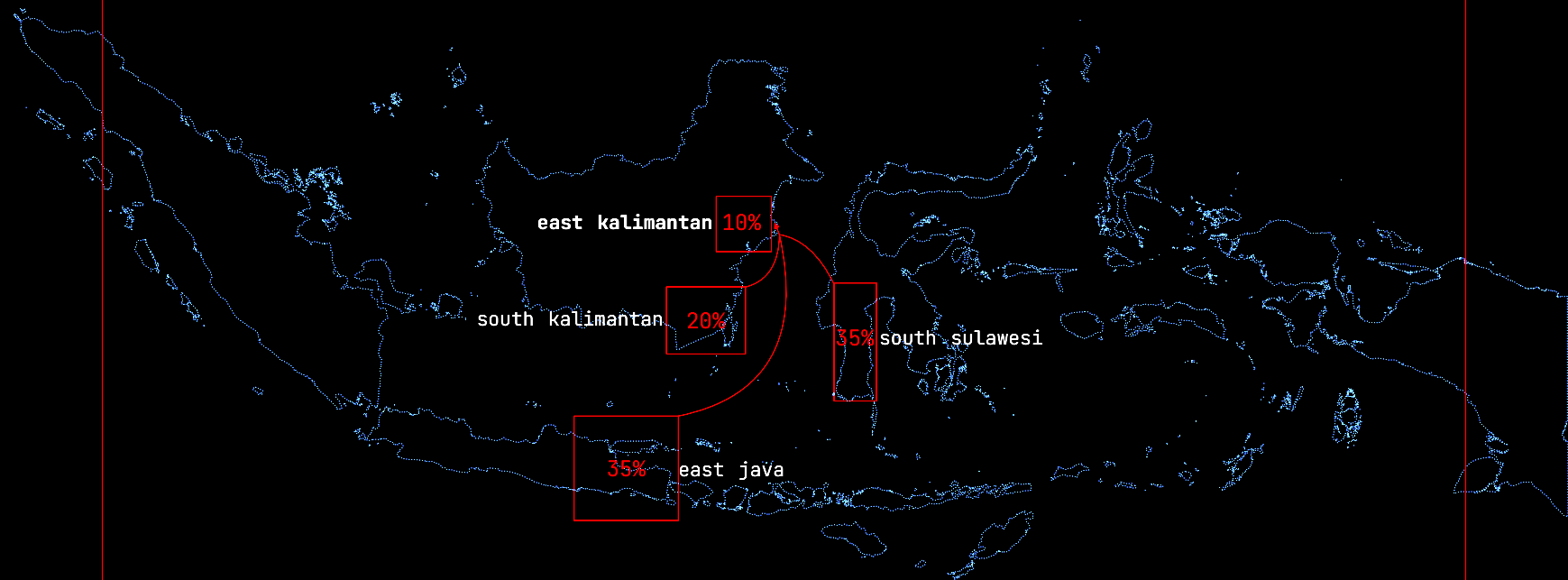
Today, East Kalimantan's food system remains heavily dependent on long interprovincial supply chains while local agricultural capacity continues to decline under pressures from mining expansion, land conversion, and rapid urban growth. Along with the emergence of the new capital Nusantara, food-security strategies increasingly emphasize the rehabilitation of marginal and post-mining lands as critical territorial resources for future production. Soil restoration, irrigation infrastructure, and the productive reuse of ex-mining landscapes are recognized as key components of

a food-resilient future (JAFSCD, 2026).

PARADOXICAL SUSTENANCE ON SAMARINDA'S OUTSKIRTS

Narrow vegetable, fruit and rice plots persist within the residual spaces between mining concessions, suggesting transformed continuities of earlier forest-based cultivation systems. At the urban periphery of Samarinda, between coal grounds and luminous lakes, families continue to cultivate narrow plots of rice, vegetables, and fruit trees. These practices persist, despite the marginal position of agriculture within Samarinda's economy, where trade, construction, and services now dominate urban employment (Abu et al., 2021). Field observation revealed that the households that continue to supply local markets largely depend on goods distributed through national and regional trade networks. This complex geography of sustenance is mirrored across generations: older farmers defend livelihoods rooted in cultivation and self-provisioning, while younger people are drawn to Samarinda's service economy. The result is a landscape suspended between persistence and departure.

RICE SUPPLY TO EAST KALIMANTAN 2024



Source: Agustian et al., 2026

URBAN STRESS

The city offers few spaces for civic interaction with open landscape. Athletic activities, like running take place along the narrow shoulders of high-speed roads - improvised strips of movement, in the absence of parks, promenades, and public grounds designed for physical interaction. This spatial scarcity is reflected in the city's broader urban structure: formal green space occupies only a fraction of Samarinda's area, remaining well below the 30 percent target - established by Indonesian planning regulations (Setyasih et al., 2024). In a city encircled by forest, wetland, and water, public interactions are confined to infrastructure's residual spaces, prompting once more a crucial question: How could the surrounding landscapes improve urban life?

The absence of accessible ecological infrastructure is further intensified by the environmental pressures generated through extraction. Research conducted in Bontang, the city located 115 km northeast of Samarinda - indicates that open-pit coal mining landscapes contribute to local heat island effects, dust pollution, and high climatic stress across surrounding urban environments (Nisaa & Fawzi, 2023). Extensive

barren mining terrains absorb and radiate heat at significantly higher rates than vegetated surfaces, while the removal of forest cover, strips the landscape of its climatic buffering capacity. In this context, revegetation and mined-land restoration are not only ecological remediation strategies, but critical forms of public-health infrastructure.

WATERSHED FAILURE

Water, meanwhile, repeatedly returns as a reminder of a profound ecological derailment. In northern Samarinda, Benanga Reservoir - the city's principal water provisioning and flood control basin - has been filled by sediment eroded from upstream deforestation and mining activity.

Designed to store approximately 1.6 million cubic meters of water, Benanga's effective capacity has at times been reduced to nearly one-third of that volume, substantially diminishing its ability to moderate peak flows. During periods of intense monsoonal rainfall, water overtops the constrained system and spreads through low-lying districts, flooding neighborhoods to knee height.

Over the past decades, flooding has become

one of the city's defining seasonal events, exposing the cumulative consequences of an ineffective watershed management (Ariesta et al., 2024; Fincapes Project, 2025).

Environmental agencies like WWF, directly attribute Samarinda's recurrent flooding to the cumulative hydrological impacts of open-pit coal mining throughout the Mahakam Basin. Open-pit extraction is widely recognized as a highly water-intensive industry, requiring extensive groundwater use and large-scale hydrological manipulation throughout the process. Large-scale slope clearing, deforestation, and topsoil removal, are all linked to the progressive destabilization of watershed systems. Farmers and residents across the region say that water tables essential for rice cultivation are "drained". Mining operations appear to be responsible for the accelerated runoff, declining water quality, sediment build-up throughout lakes and rivers, and broader downstream degradation linked to wastewater discharge activities and coal transport throughout the basin (Ives, 2015).

DESIGN AXES

NEED FOR BIOPHYSICAL RELINK

The city of Samarinda remains economically dependent on extraction and persistently disconnected from the ecological richness that surrounds it. This condition is not incidental, but structural. Mining and quarrying represent one of the dominant sectors of East Kalimantan's regional economy, with coal extraction remaining a primary driver of regional GDP and export activity.

This condition reflects the much broader economic structure of Indonesia itself, where coal remains one of the country's dominant export commodities, accounting for nearly 87% of all mining exports (BPS Kaltim, 2025). Like many other extractive urban centers worldwide, Samarinda's growth has been shaped by short-term economic gain rather than long-term territorial resilience. The logic of rapid conversion of forests, soils and minerals into profit,

has been both the generator of Samarinda, and its destabilizer. The city is now "floating" on an unstable territory whose capacity to provide food, water, stable living is precariously low.

MINE LAKES AS ASSETS?

However, the abandoned legacy of the mine lakes might suggest a new landscape narrative. What appears to be dispersed and out of commission, could be the spatial opportunity for territorial renewal. Rather than treating these water bodies as residual hazards left in suspension, until official remediation takes place, they can be reinterpreted as latent territorial assets.

Strategically integrated into a wider watershed, they could be the response to both the conditions that extraction has produced, and the needs of Samarinda: by becoming devices for hydrological regulation, ecological remediation, agricultural

production, and last but not least, places for public life.

REGIONILIZING SMALL-SCALE INTERVENTIONS

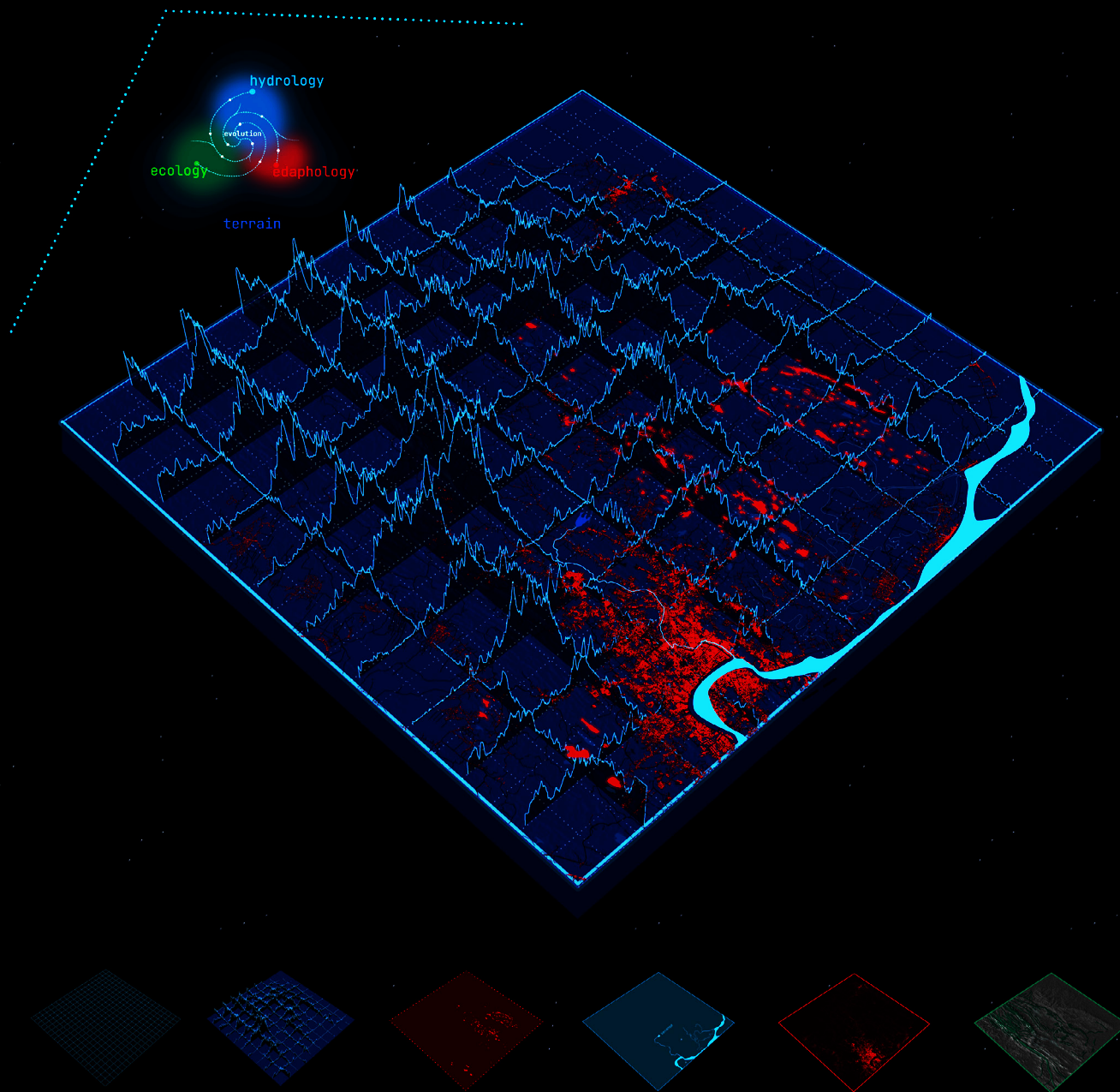
The central design proposition is therefore not to create discrete “restoration projects” for remote areas, but to construct relationships of dependency between regional life and their post-extraction surroundings. Productive systems, settlement patterns, recreational practices, and ecological succession could become mutually reinforcing, allowing the mine lakes to participate in a daily metabolism. This would mark a shift in perspective: from a socio-economic logic based on extraction, depletion, and resource removal, toward a landscape logic of ecological, spatial, social and economic regeneration (Corner, 1999; Waldheim, 2016; Bélanger, 2016). Operability could become the catalyst for recovery, and restoration the consequence of renewed interdependence.

THE NEED FOR INCENTIVE

Most mine lakes remain hidden behind ridges slopes and publicly unseen. Ecological remediation alone is unlikely to attract sufficient political, economic, or social commitment. Their spatial marginality

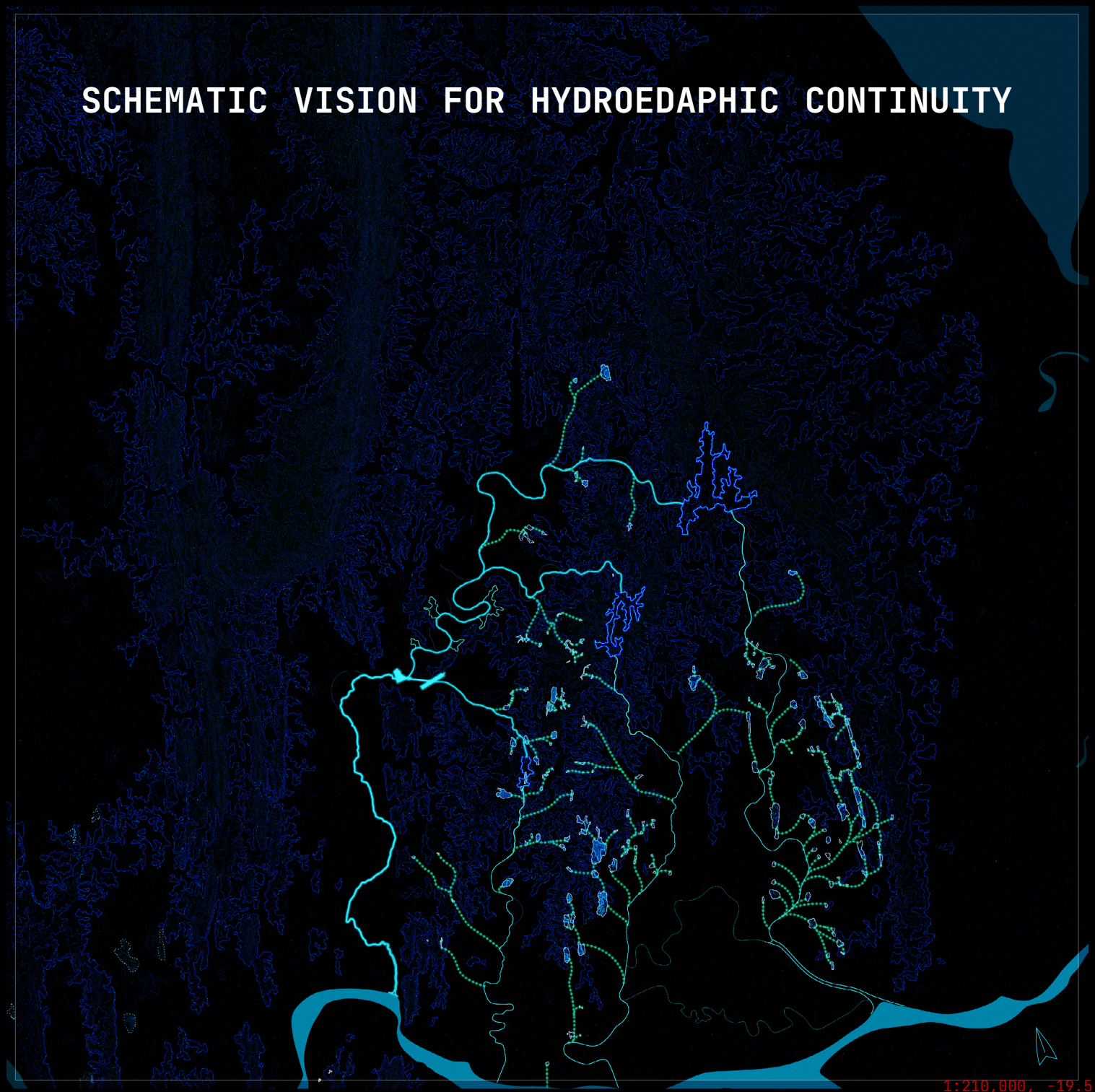
reduces the urgency of intervention, keeping them outside the agendas of public institutions or the community’s shared vision. In this context, remediation as a purely environmental objective would struggle to gain long-term support - not because its ecological state is not critical, but because it lacks an immediate and tangible relevance to other priorities.

An incentive is required to make these landscapes visible and operational. By linking their remediation directly to watershed management, flood mitigation, food production, and recreation, the lakes acquire clear and measurable benefits for both Samarinda and its suburban clusters. Once integrated into systems that people begin to build their lives around, and gradually depend upon, post-extraction landscapes can become active territorial assets. This shift, transforms restoration from an isolated environmental obligation into a socially and economically grounded process, capable of repetitively inducing forms of ecological recovery.





SCHEMATIC VISION FOR HYDROEDAPHIC CONTINUITY



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DESIGN PROPOSAL

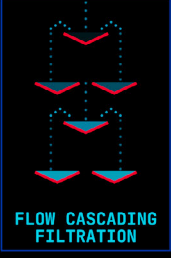
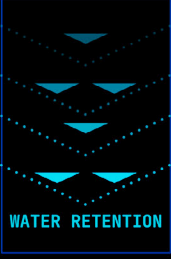
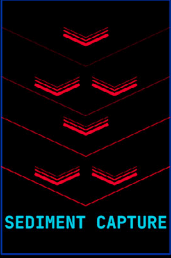
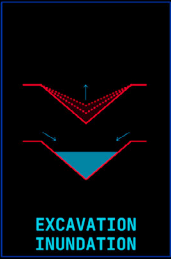
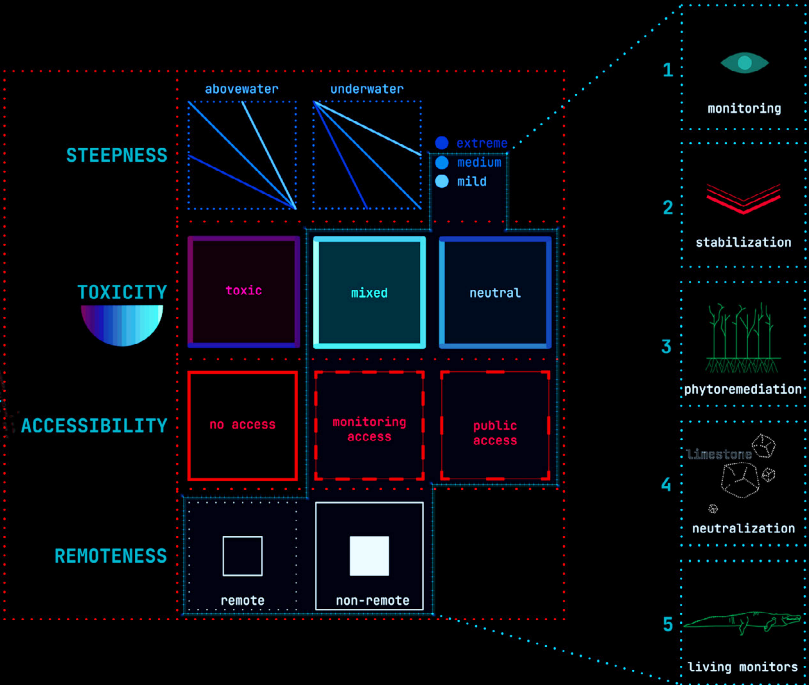
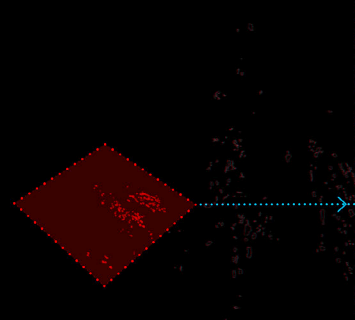
THE HIDDEN LOGIC OF REMEDIATION

The sheer concentration of more than 520 abandoned mine lakes across Samarinda constitutes a territorial phenomenon, rarely encountered elsewhere at this scale. The environmental, hydrological, and social conditions generated by this extensive legacy, cannot be resolved through a piecemeal, pit-by-pit reclamation approach, but require a territorial watershed-planning approach. In this thesis, the proposed strategy is the reorganization of the regional watershed through the invented logic of hydroedaphic-gradients. It begins from the recognition that the functions once performed by the continuous tropical forest - infiltration, evapotranspiration, and gradual release of runoff - have been aggressively halted, by deforestation and mining.

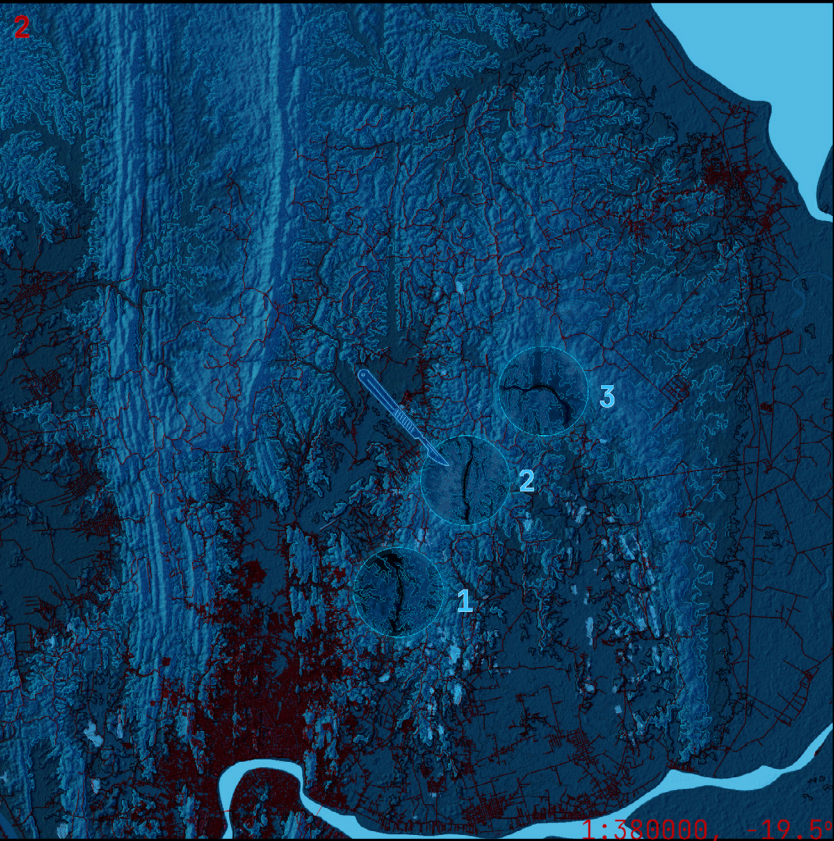
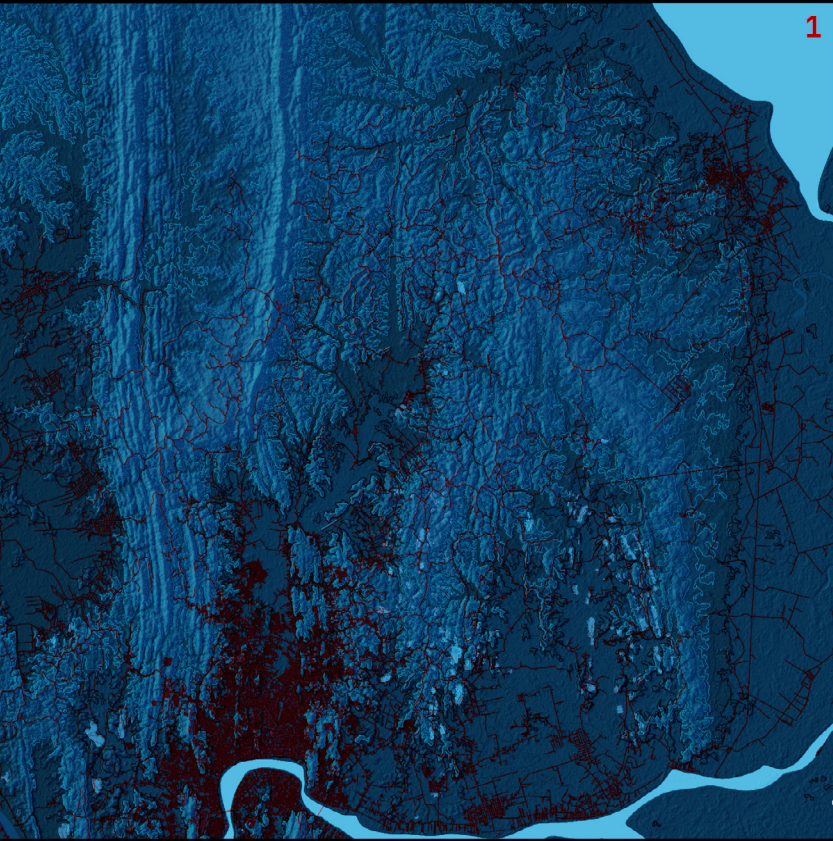
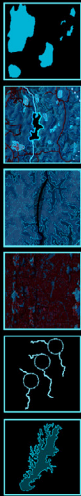
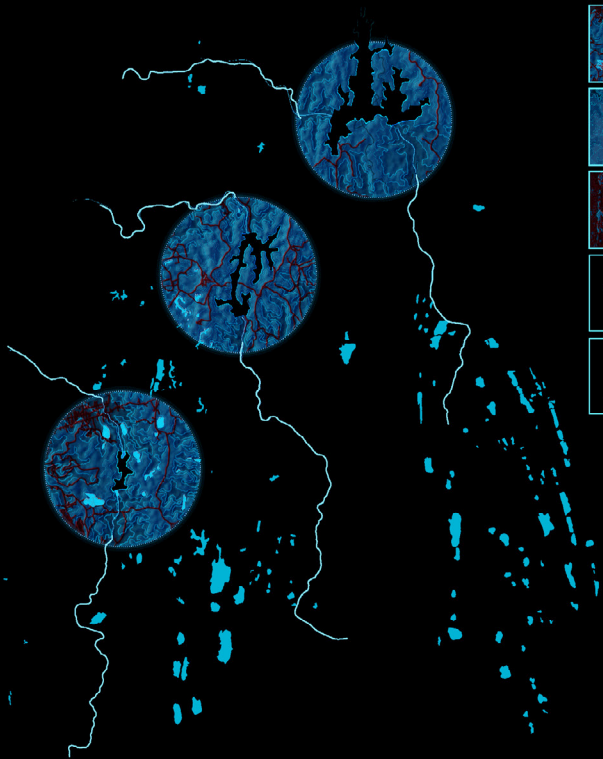
In their place remains a mosaic of forest patches, crop farming, rainwater filled pits, compacted acid soils, and dehydrated

ridges, whose spatial and functioning logic looks erratic on the map. Beneath this visual complexity however, design research revealed that structural organization exists, and that it is closely following the geological distribution of coal deposits concentrated along the ridge volumes. This revelation became the foundational insight of the design research, and the ridges - which direct water, sediment, and the constantly fluctuating boundaries of extractive concessions - emerged as the dominant spatial agent of the project.

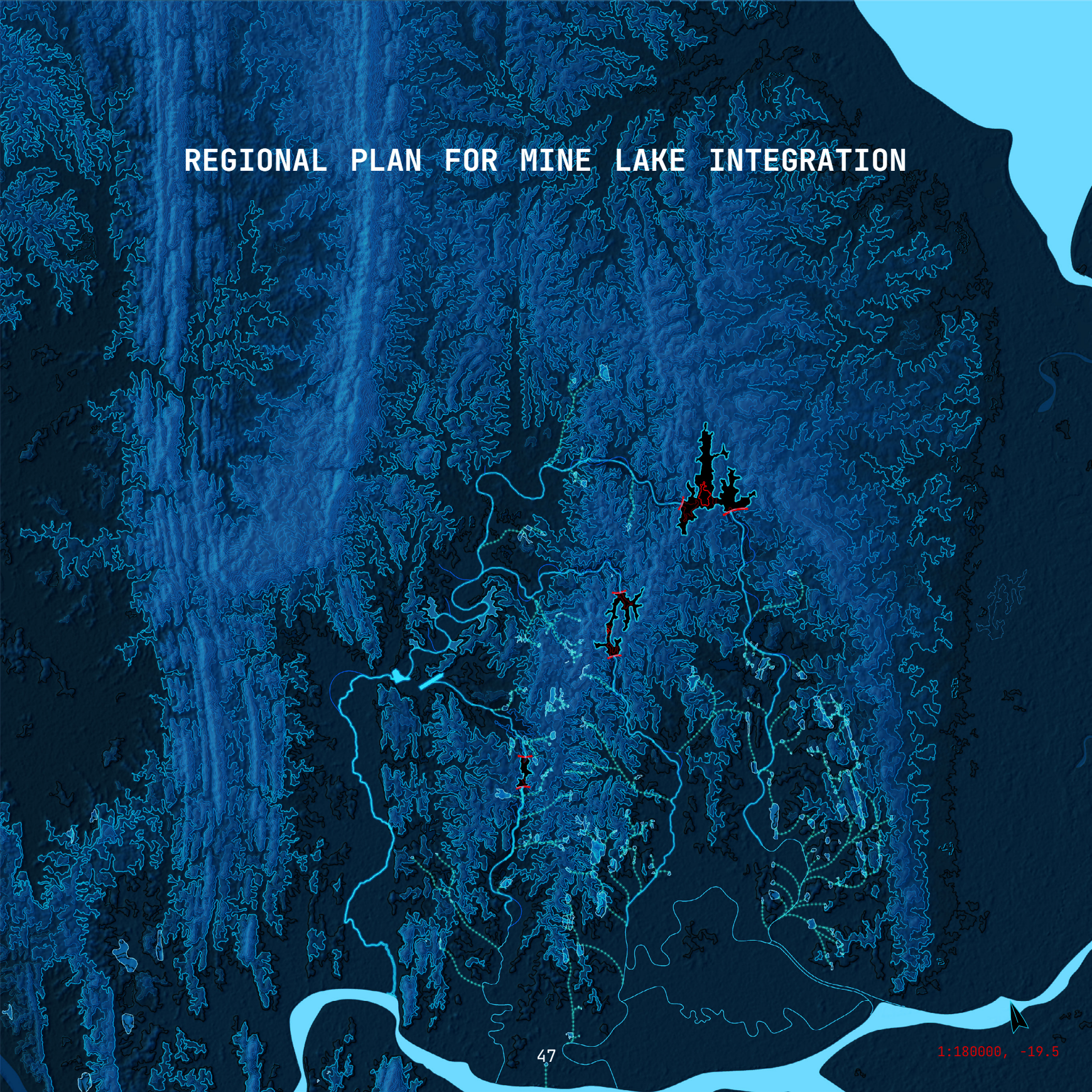
MINE LAKE REMEDIATION VS HYDROEDAPHIC OPERATIONS



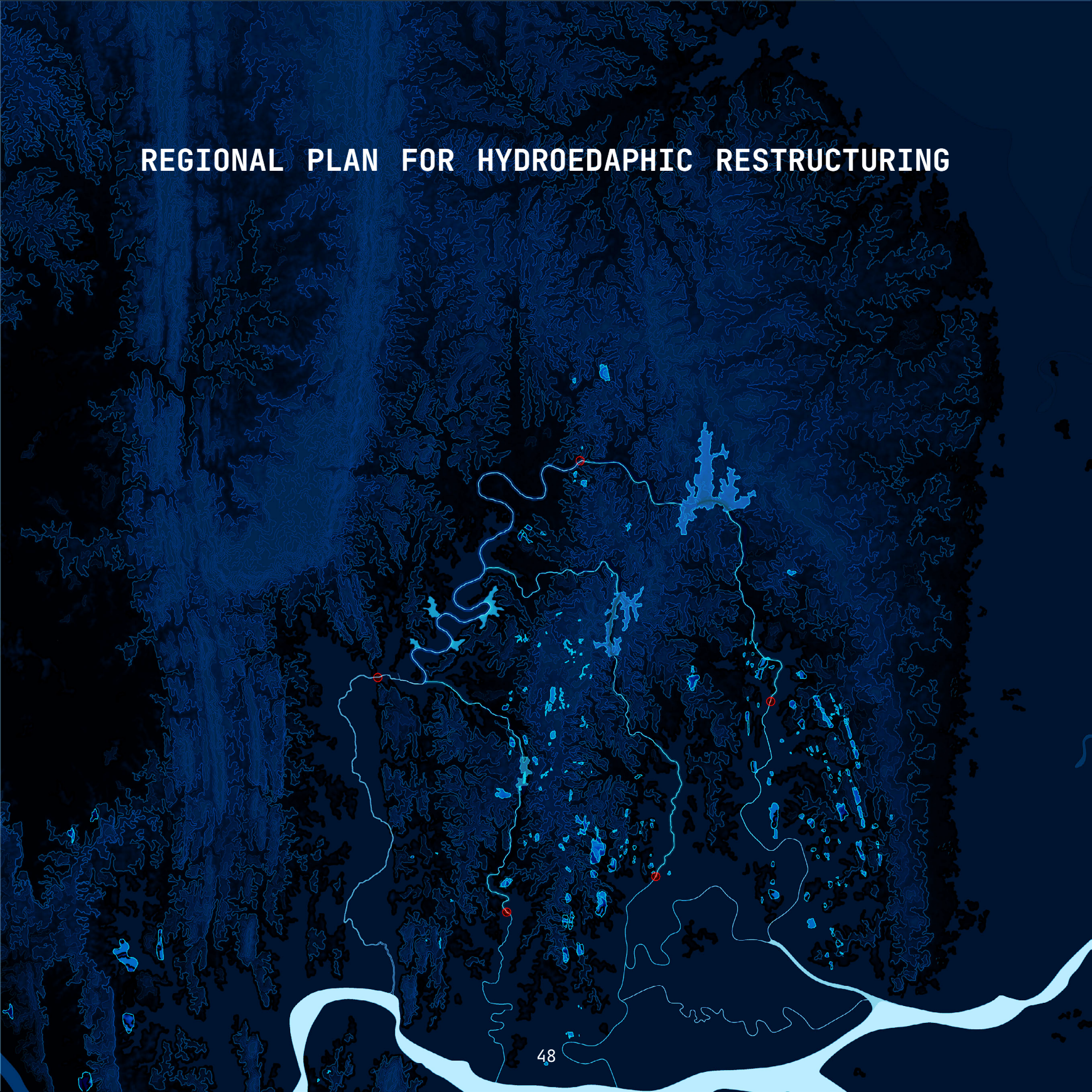
INCISION TO PROTOTYPING STRATEGY



REGIONAL PLAN FOR MINE LAKE INTEGRATION



REGIONAL PLAN FOR HYDROEDAPHIC RESTRUCTURING



EXTRACTION LOGIC EMBEDDED INTO DESIGN

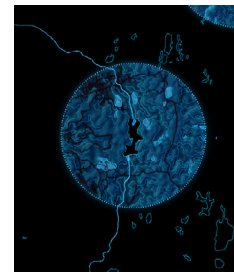
One could read this project as an inversion of the extraction logic; or, more provocatively, as a partial reappropriation of it - where this time, terraforming operations are directed toward regeneration, rather than depletion. Mild excavation, water manipulation, terracing, timber cultivation, sediment deposition, and landform restructuring are deployed for hydrological recharge, erosion control, ecological succession, productivity, and new forms of decentralized life. The same territorial mechanisms once used to exhaust the landscape, are reinterpreted as instruments for its long-term ecological and social recovery. By strategically managing the movement of water, soil, and vegetation across the territory, the project establishes a framework through which ecological processes can take the lead over time.

This thesis attempts to stretch the concept of remediation from a conventional technical intervention into a long-term, multi-scalar process of ecological reactivation and territorial transformation. Through this lens, and within the context of Samarinda, abandoned mine lakes become functioning components of a broader socio-ecological network. As these systems

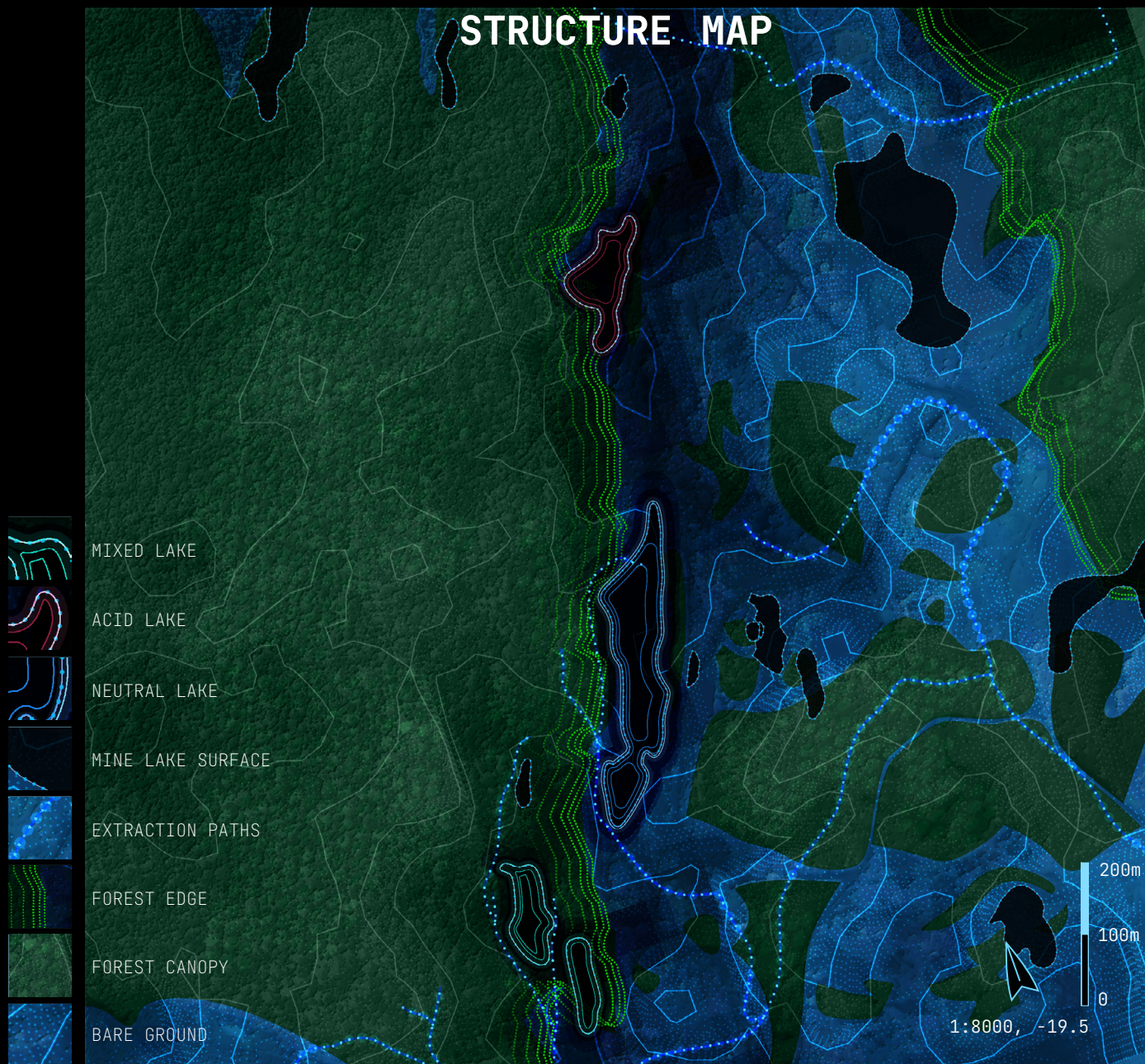
gain ecological and economic momentum, they establish the spatial and institutional conditions necessary for long-term stewardship, official governmental engagement, and the sustained involvement of mining actors in processes of territorial care.

DOWNSCALING TO RIDGE PROTOTYPES

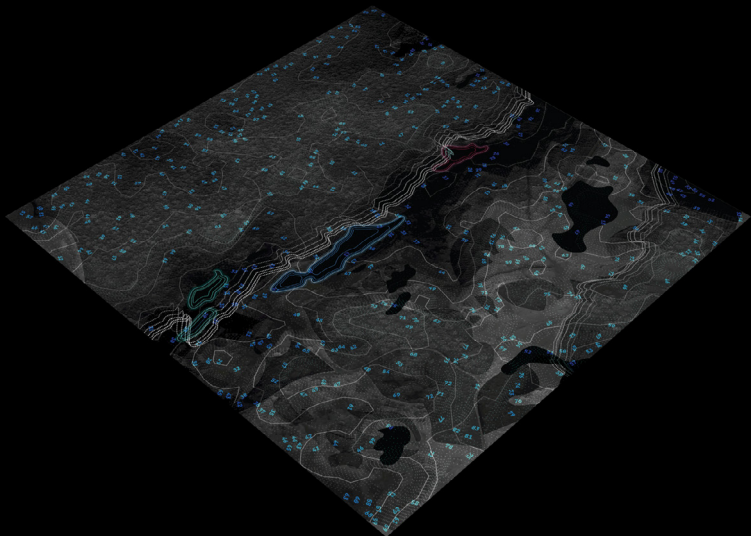
The territorial logic developed through the hydroedaphic gradient is proposed for three selected ridge points located along the highest elevations of the ridge spines separating Samarinda, Benanga Reservoir, and the extraction landscapes. These operate as intervention capsules: condensed points of reference through which the territorial scale takes material character. Through them, the project continuously oscillates between regional-scale strategy and site-specific design resolution. Regarding the local scale, the project focuses on the first ridge point as shown in "Incisions to Prototyping Strategy", Map 2.



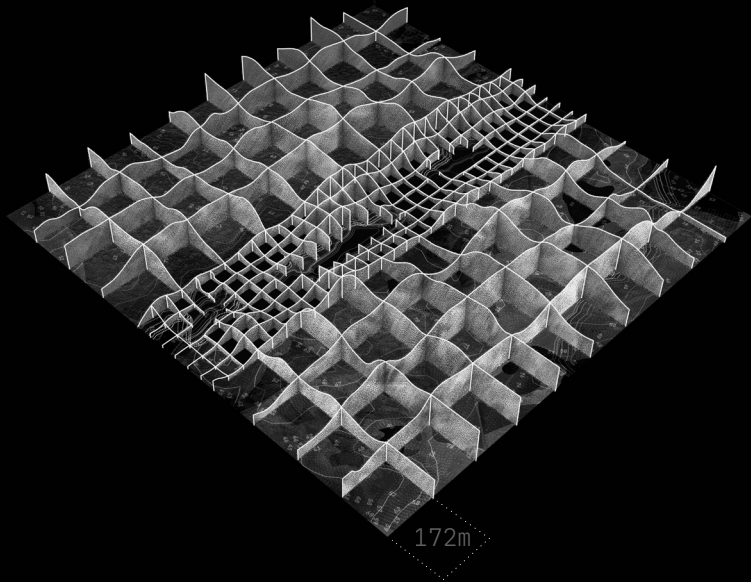




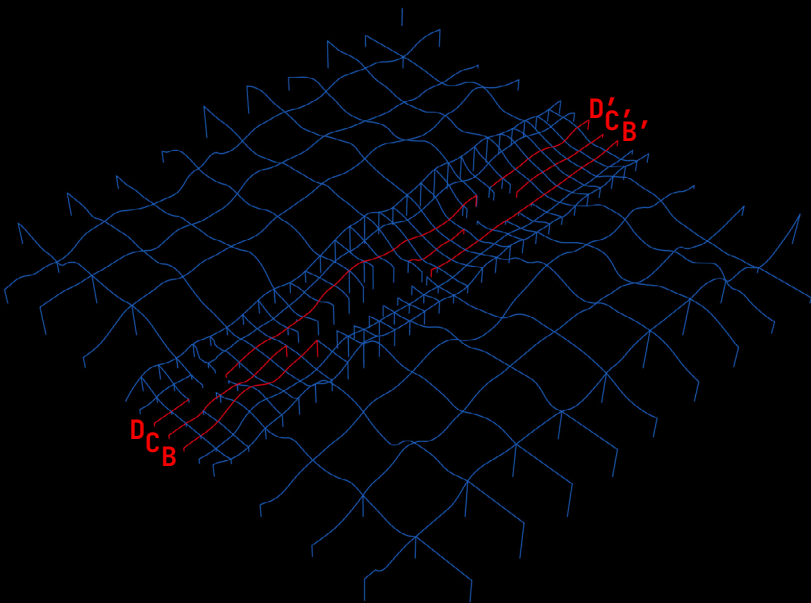
TOPOGRAPHIC OBLIQUE OF THE STRUCTURE MAP



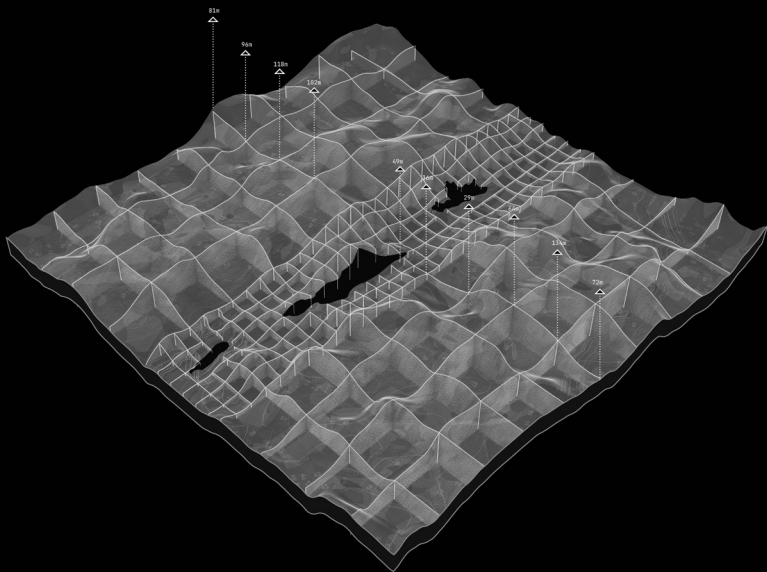
LANDFORM MESH



SECTION MESH: FURTHER ANALYSIS OF SECTION LINES B,C,D

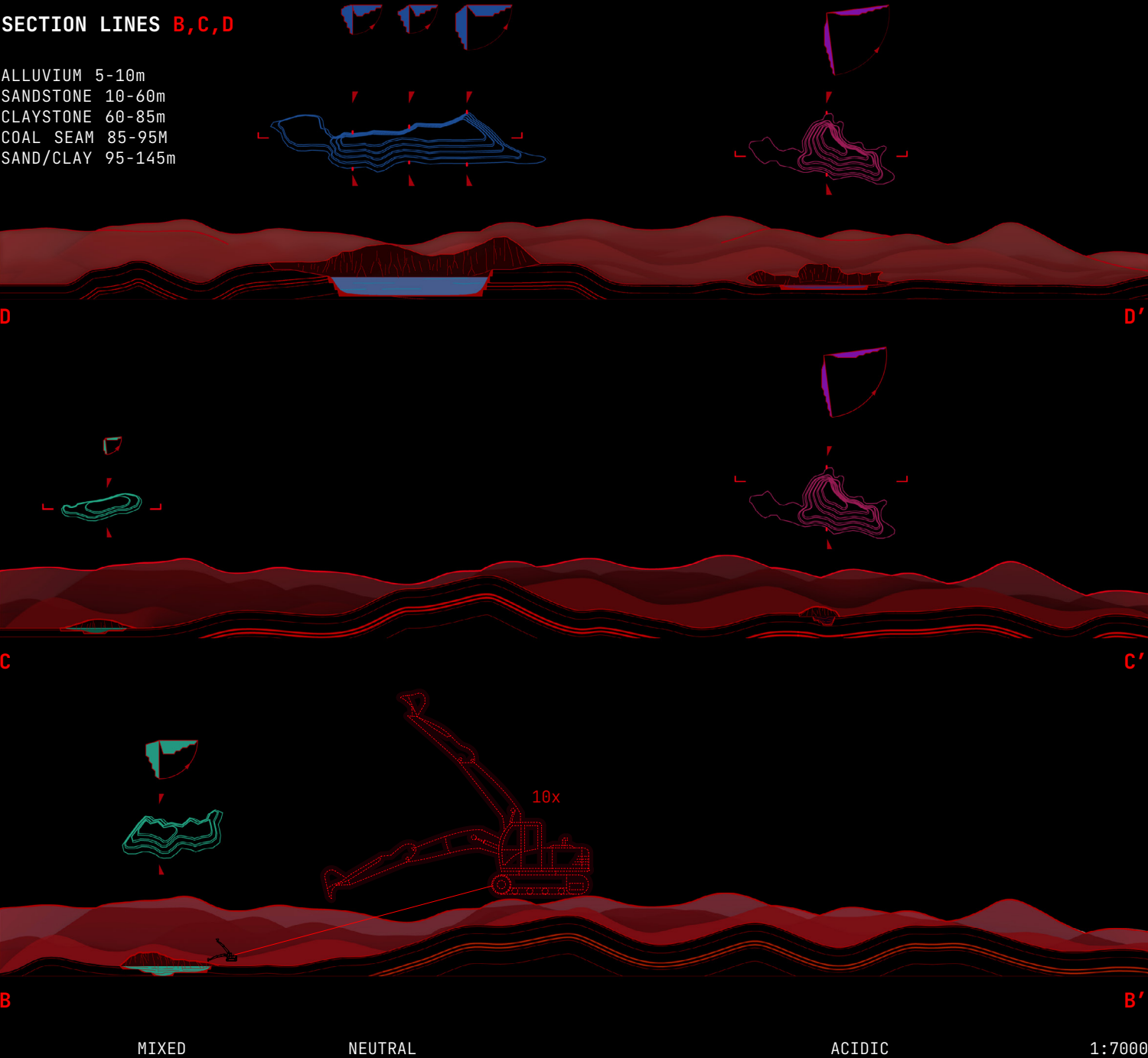


TERRAIN SURFACE

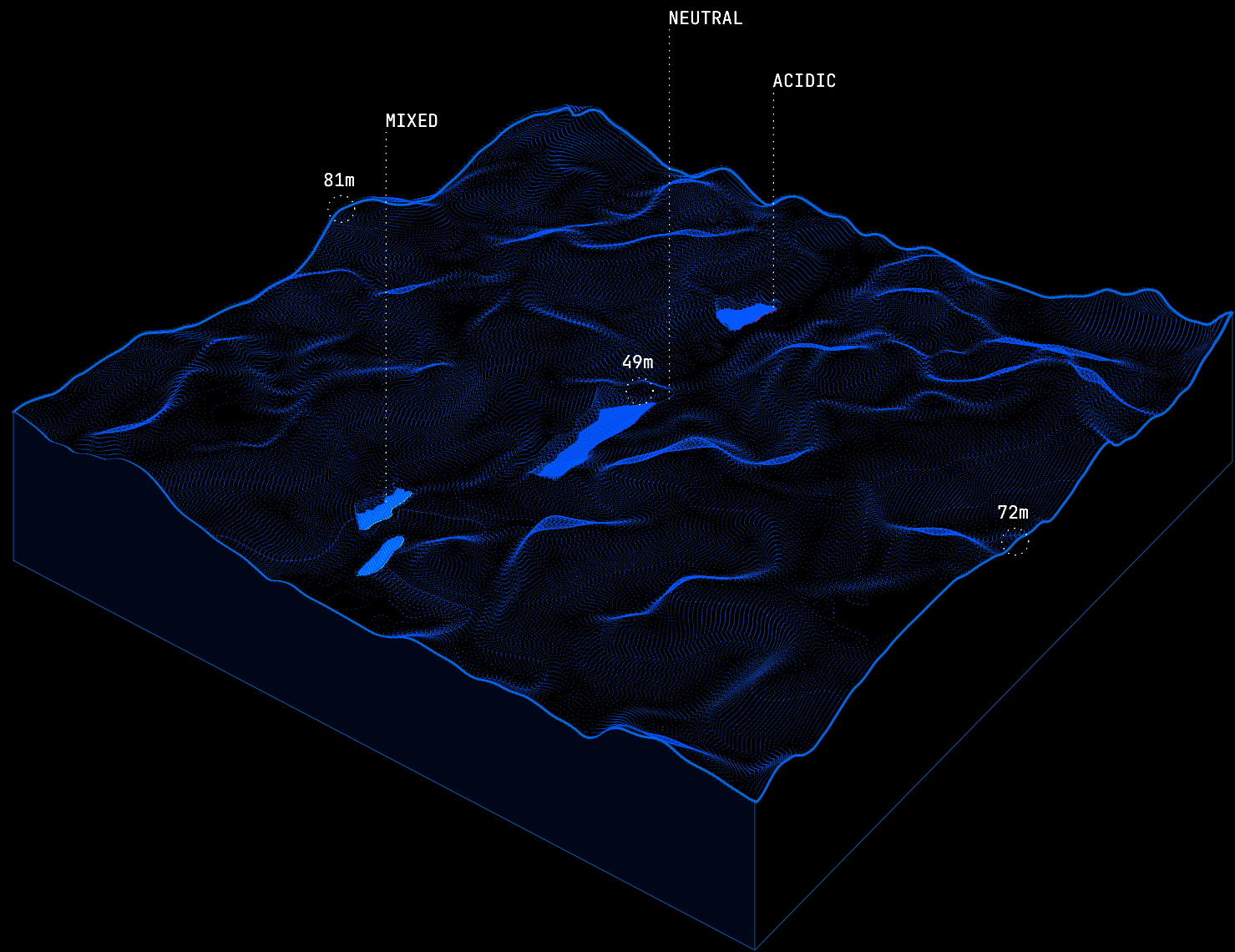


SECTION LINES B,C,D

ALLUVIUM 5-10m
SANDSTONE 10-60m
CLAYSTONE 60-85m
COAL SEAM 85-95m
SAND/CLAY 95-145m



3D LANDFORM TILE OF RIDGE PROTOTYPE 1

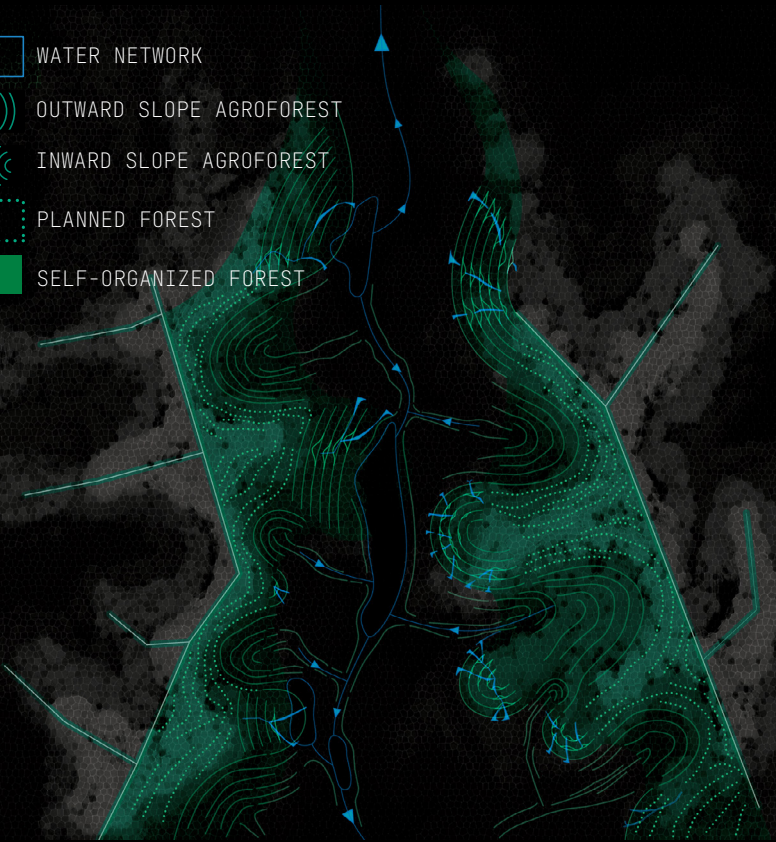


RIDGE AS LANDSCAPE INFRASTRUCTURE

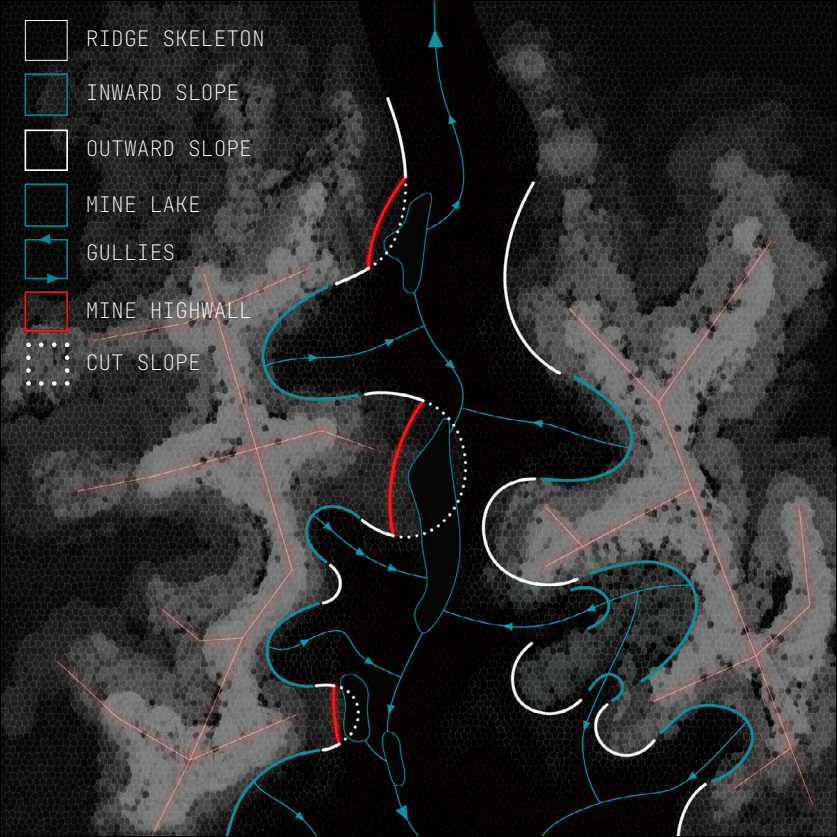
In territorial scale, the ridge dividing Samarinda and the mining corridor - is redefined as a mediating system between water, soil, vegetation and living beings. Along selected drainage corridors, where erosion and gully formation already reveal a natural runoff, a series of elevated retention basins - or else, agroforestry pockets - are introduced to intercept, store, and gradually release water to both sides of the ridge landscape. Existing gullies are transformed from deep and unstable cuts, into calibrated channels of distribution, allowing wetness to be absorbed and then progressively flow across the territory. Weathered soils regain moisture, vegetation density, and productive capacity. Eventually, more stable microclimatic conditions emerge, capable of supporting reforestation, agroforestry, aquaculture, and new forms of inhabitation throughout the interconnected lake-corridor system.

HYDROEDAPHIC CONTINUITY SCHEMES

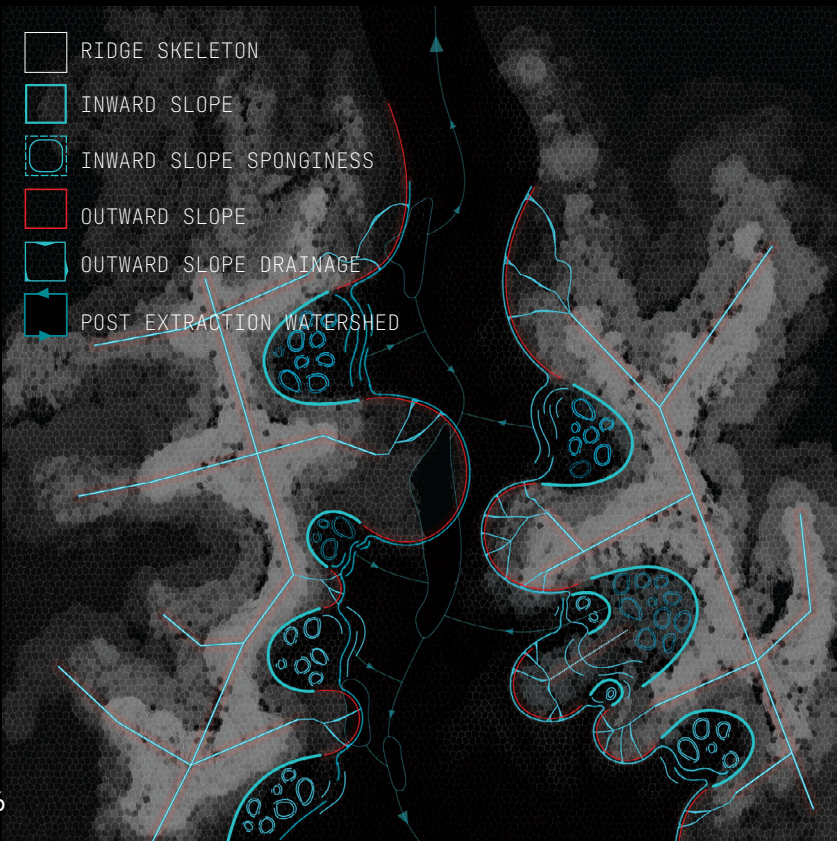
- WATER NETWORK
- OUTWARD SLOPE AGROFOREST
- INWARD SLOPE AGROFOREST
- PLANNED FOREST
- SELF-ORGANIZED FOREST



- RIDGE SKELETON
- INWARD SLOPE
- OUTWARD SLOPE
- MINE LAKE
- GULLIES
- MINE HIGHWALL
- CUT SLOPE



- RIDGE SKELETON
- INWARD SLOPE
- INWARD SLOPE SPONGINESS
- OUTWARD SLOPE
- OUTWARD SLOPE DRAINAGE
- POST EXTRACTION WATERSHED



CONCEPT MAP



CRIB WALL



NEW STREAMS FOR CONTROLLED
- CONTINUOUS HYDROLOGY



RETENTION BERMS



BAMBOO CHECK DAMS



AGROFORESTRY ON SLOPES <60°



FOREST ON SLOPES >60°



30M CONTOUR



45M CONTOUR



MIXED MINE LAKE



ACIDIC MINE LAKE



NEUTRAL MINE LAKE



NEW WETLAND LAKES



CONTOURS 1M



NEW LAKES IN EXISTING DEPRESSION



RIDGE PEAKS

RIDGE CELLS AS PROTOTYPES

Operating simultaneously across territorial and site-specific scales, this intervention transforms the terrain between the mining landscapes, Benanga Reservoir, and Samarinda from a system of landslides and flooding into a regulated hydro-edaphic landscape. Rather than being rapidly flushed downstream during flood events, water, nutrient-rich sediments, and organic matter are retained within the distributed network of sponge-like retention cells embedded throughout the ridge spines, and progressively redistributed toward downstream croplands, including rice paddies and orchards near residential settlements. Contaminated surface flows are intercepted and treated through constructed wetlands that limit the spread of pollutants between basins. Through this process, a reciprocal relationship emerges between city and hinterland, where the hydrological reorganization of the extracted landscape simultaneously enhances urban resilience, agricultural productivity, and the long-term remediation of mined territories.

MINE LAKES CHEMICAL CLASSIFICATION AND PHASED INTEGRATION

The development of the ridges as hydroed-

aphic retention infrastructures, raises a consequential question for the project: how can mine lakes be gradually remediated once they reach conditions suitable for ecological and social integration? By designing landform, remediation hydrology, and edge conditions for the mine lakes, a distinct form of ecological succession is activated, one that unfolds through stages of chemical containment and stabilization. The transformation is guided by both natural succession and phased human intervention.

The mine lakes are reorganized as a staged remediation field in which the intensity of intervention is determined by slope profile, water chemistry, and indicators of vegetation recovery. Steeper and less stable areas function as containment and isolation zones for highly toxic (red) lakes, while gentler slopes are monitored till chemically stabilized. As water quality improves and vegetation becomes established on weathered soils, these areas shift into partial integration zones, where mine lakes are no longer treated as isolated failures but as recovering hydrological assets.

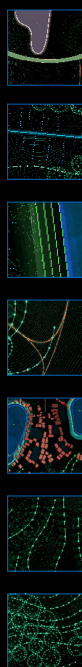
This establishes a clear operational sequence: 1. isolation for highly toxic systems, 2. monitoring for uncertain condi-

tions, and 3. integration for vegetated and chemically recovering lakes. Each stage corresponds to measurable ecological thresholds and progressively higher levels of intervention and interaction. The extracted landscape thus becomes a remediation gradient that parallels the water capturing ridge system, linking topographic form, hydrochemistry, and biological succession within a single operational framework. Along the stream corridor, this logic unfolds through a series of distinct but interconnected scenarios.

Within the intervention corridor, the remediation framework is speculatively tested through three mine lakes exhibiting visibly distinct chromatic and geomorphological conditions observed across the site. Interpreted as representing different degrees and types of contamination – ranging from dark blue and chemically stabilized systems, to brown-red acidic conditions, and lighter milky-green suspended-water bodies – the lakes are assigned differentiated remediation and edge-management strategies. Slope inclination, shoreline accessibility, and vegetation establishment are calibrated according to these interpreted hydrochemical conditions. More vertical and abrupt edge conditions are maintained around the relatively neutral systems, while gentler

and more controlled slopes accompany lakes assumed to contain higher levels of toxicity or unstable sediment conditions. Through this approach, the project develops a speculative operational framework capable of testing multiple remediation trajectories simultaneously within one interconnected hydrological landscape.

MASTERPLAN



ISOLATION EARTH BERM

WATER RETENTION INTERVENTIONS

CRIB WALL

ROAD

NEW FISHING VILLAGES

FOREST

AGROFOREST

200m

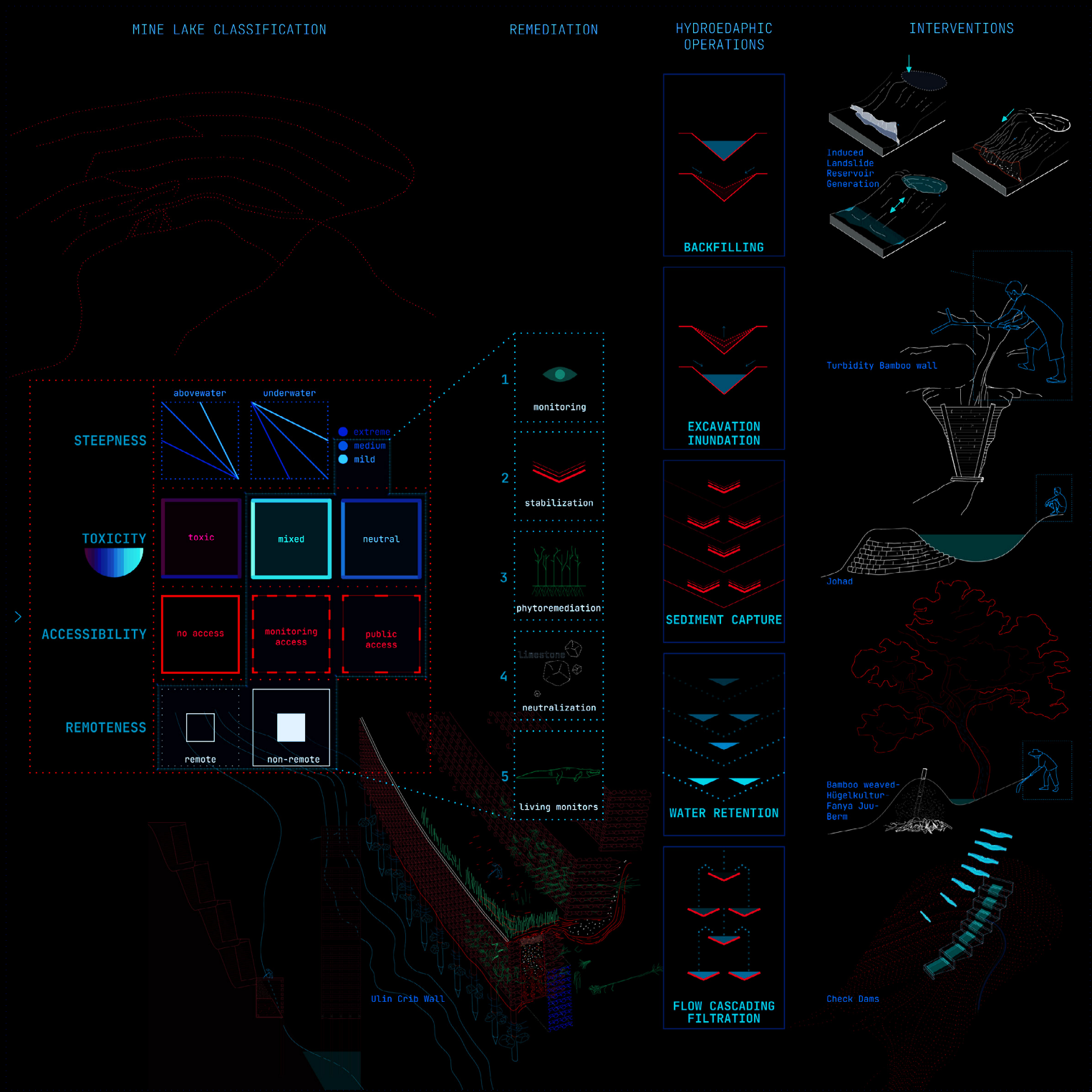
100m

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SPECULATIVE REMEDIATION TYPOLOGIES

Within the intervention corridor, the remediation framework is tested through three mine lakes exhibiting distinct chromatic conditions, speculatively interpreted as corresponding to different hydrochemical states. Rather than functioning as fixed scientific classifications, these interpretations establish three experimental remediation typologies through which varying edge conditions, stabilization strategies, and ecological integration scenarios can be spatially tested in relation to the surrounding topography. This speculative operational framework allows multiple remediation trajectories to coexist within one interconnected hydrological landscape.



SELECTIVE TERRACING: THROUGHOUT THE SCALES

Across scales, from watershed to site-specific level and vice versa, one continuous intervention comes to materialize the landform in a productive way. Slopes below a 60-degree inclination threshold are selectively terraced, to restructure runoff dynamics while amplifying the terrain's capacity for water and soil retention. Existing depressions beneath forest cover are deepened, while agroforestry terraces and check dam stitch together gullies, drainage lines, and erosion corridors into a continuous hydrological cascade. Through this process, the ridges begin to operate as large ecological buffer corridors that retain water, sediment, and organic matter before gradually redistributing them across both sides of the watershed: toward the Benanga Reservoir and Samarinda floodplain on one side, and toward the agroforestry systems, mine landscapes, and Mahakam floodplains on the other.

Rather than constructing conventional reservoirs such as dams – which store water as isolated and largely monofunctional bodies – the project distributes a fine grain of tiered catchments across the elevational range of the ridges, increasing the landscape's regenerative capacity. Within this

broader hydrological system, the thesis primarily focuses on the typology of ridge retention cells as the principal spatial and operational prototype. Distribution canals and their surrounding productive landscapes are acknowledged as equally important components of the wider watershed framework, although their detailed development remains beyond the scope and timeframe of the project.

PRODUCTIVE FOREST AND TENURIAL RIGHTS

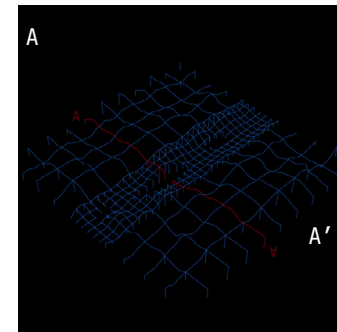
Agroforestry clusters are organized uniformly along the small-scale retention cells to stabilize soils, regulate moisture, and support long-term regeneration across the ridge slopes. Inspired by the logic of Fanya Juu terraces (Kiome & Stocking, 1995), the cells operate simultaneously through excavation and accumulation: shallow depressions carved into the slope intercept runoff, while displaced soils accumulate downslope behind woven retaining edges embedded into the terrain.

Constructed from densely interwoven bamboo structures, these permeable retaining berms slow runoff, trap sediments, and retain moisture across the slope surface. Coconut husks and other biodegradable agricultural byproducts are integrated within these

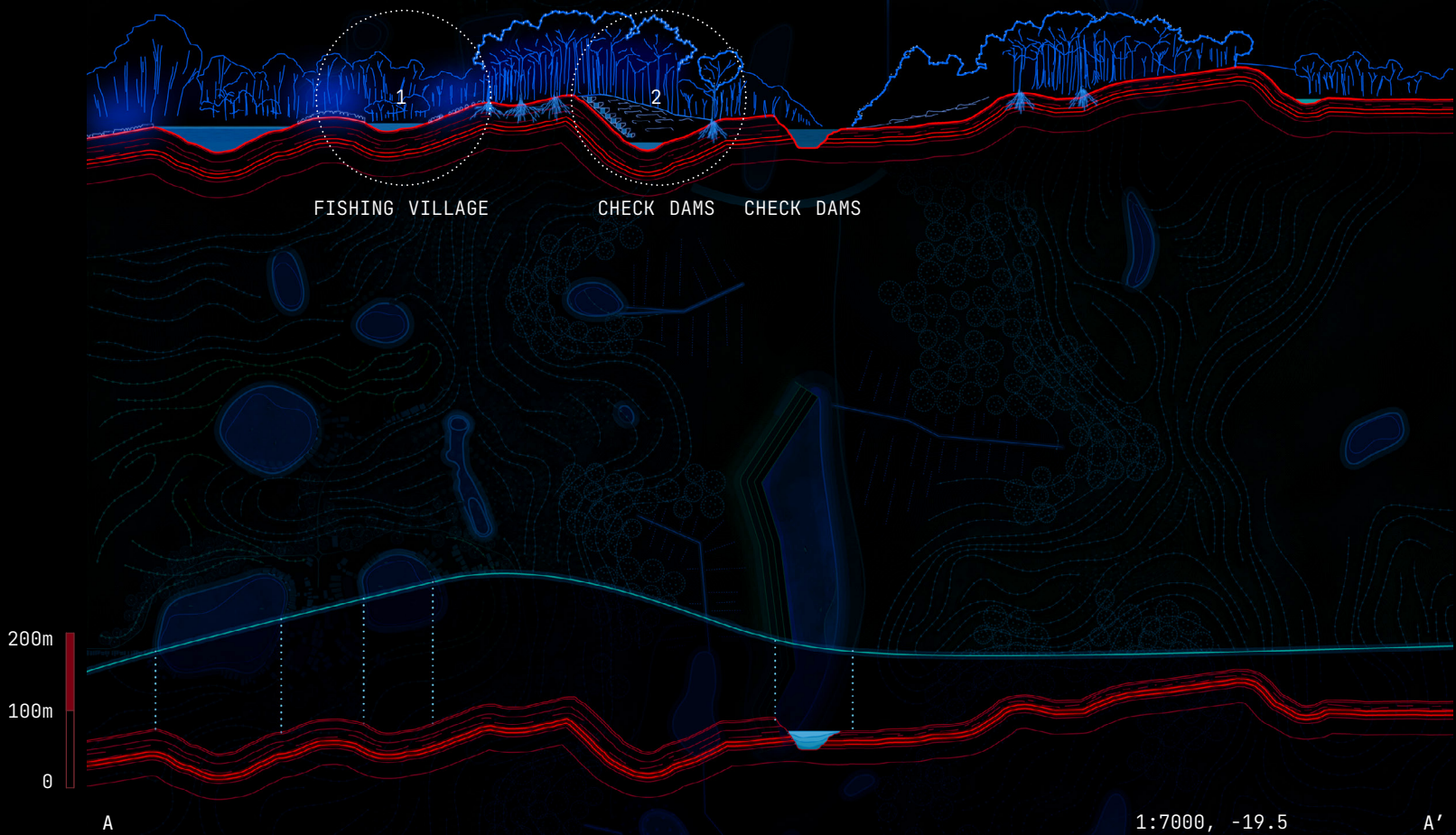
three-sided bamboo container-walls to increase infiltration and gradually decompose into organic soil matter. Positioned directly behind the retaining berms, the agroforestry clusters benefit from the accumulated moisture and nutrient-rich sediments while progressively reinforcing slope stability through root establishment. Over time, these localized hydrological ecologies begin attracting insects, aquatic species, and wildlife throughout the ridge systems.

The agroforestry systems alternate with areas of assisted large-scale forest regeneration and existing upland forest concentrated along the ridge peaks, both within the intervention corridors and throughout the broader ridge landscape, forming a calibrated gradient from cultivation to rewilding. Positioned upslope, the forested areas function as nutrient-generating and hydrological batteries, that offer ecological stability to the agroforestry systems below. The distribution is guided primarily by slope and accessibility: flatter and more accessible terrain accommodates productive use and public interaction, while steeper and less stable areas transition into minimally disturbed forest systems subject to restricted access and safety regulations.

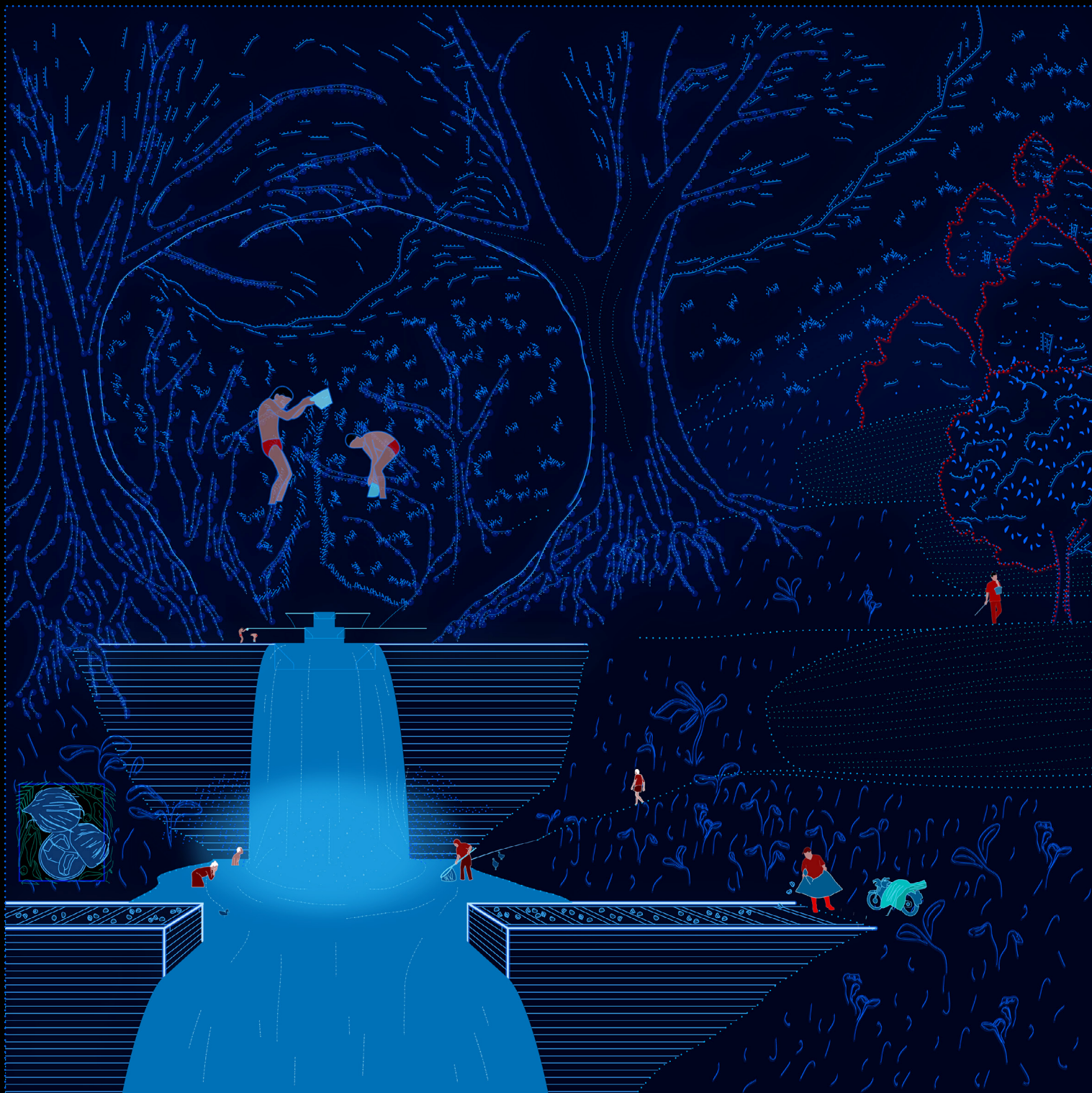
Agroforestry operates as something far greater than productive ecology alone: it becomes a territorial mechanism of continuous occupation and stewardship. In contrast to the temporality and historical mobility of swidden systems - whose cyclical movement often left territories vulnerable to land grabbing and concessionary expansion (OPM et al., 2011; Persoon & Simarmata, 2014) - these productive forest landscapes establish long-term forms of community presence, care, and tenurial reclamation across the ridge systems. For the involved communities, regeneration no longer occurs through continual movement in search of fertile land, but through regenerative forms of inhabitation embedded directly within ecological processes. At the same time, this renewed territorial presence acts as a form of collective guardianship, limiting further extractive encroachment and reinforcing the long-term protection of the landscape.



SECTION AA'







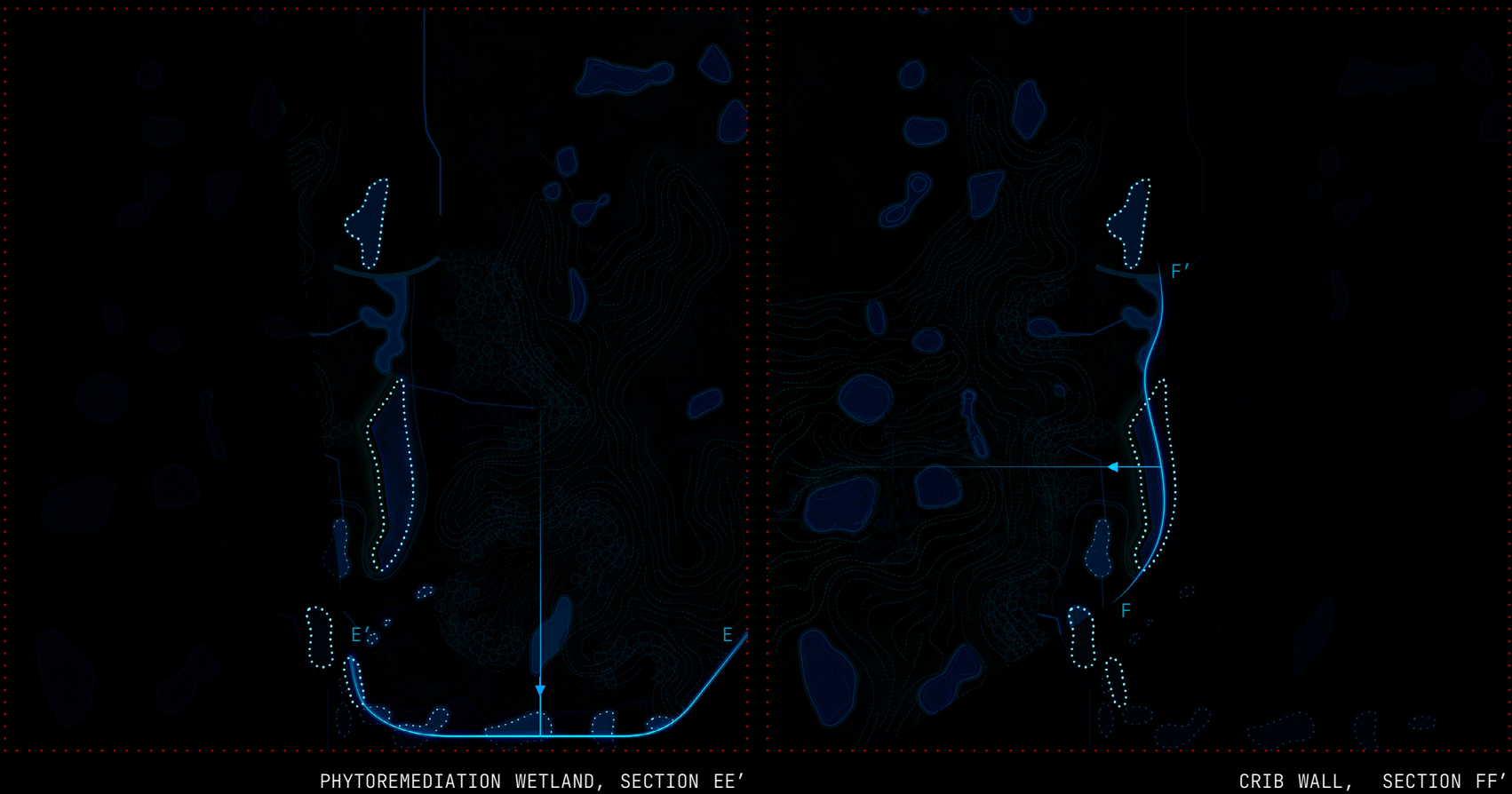
BAMBOO CHECK DAMS, SECTION AA' DETAIL 2

As a final extension of the terraforming processes operating across the ridge systems – and more specifically within the selected intervention corridor – one structural addition responds directly to the nearly vertical façade of the speculatively classified neutral mine lake. Timber crib walls constructed from local hardwood species, including Ulin timber (*Eusideroxylon zwageri*), are anchored deep within the loose mine soils, which they gradually stabilize through retained sediment, weight, and root establishment. Over time, vegetation further integrates the structures into the mine walls, allowing them to either become permanently embedded within the landscape or eventually collapse and back-fill portions of the lakes. These crib-weave systems are a low-tech response to the instability of steep mining edges and remain inaccessible during the initial stages of recovery to allow structural failure.

Finally, among the multiple layers of extractive logic reappropriated by the project are the road networks that once diverted movement away from the river and toward the mining ridges. Formerly used for concessionary access and material transport, these corridors are progressively redirected toward fishing communities,

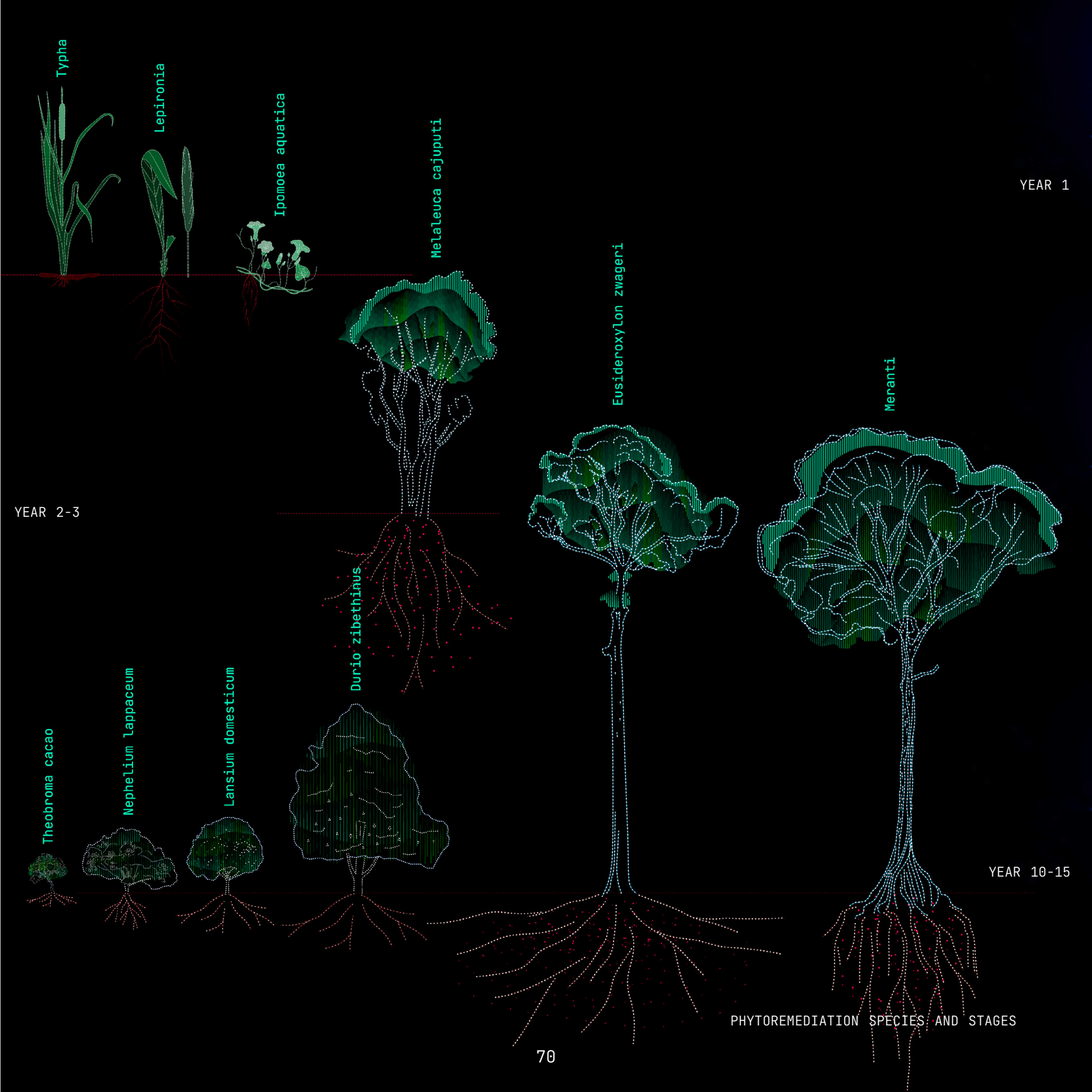
remediated lakes, productive forests, and regenerating ecological systems distributed throughout the watershed. Within the selected intervention corridors, these infrastructural conversions materialize through localized access routes connecting the ridge systems to the recovering lake landscapes and newly introduced productive ecologies.

Zooming out once again to evaluate the broader ecological balance generated by the proposed landscape system, nutrients produced within the agroforestry uplands gradually move downslope through water flow and gravity, contributing to the fertility of downstream croplands. Through infrastructural provisions such as irrigation networks and saturation fields, these productive lowlands operate as hydrological interception zones that redirect flows, trap sediments, retain nutrients, and support agricultural production simultaneously. The result is a continuous hydro-edaphic relationship between the productive mine uplands and the cultivated floodplains below.



PHYTOREMEDIATION WETLAND, SECTION EE'

CRIB WALL, SECTION FF'



CATCHMENT
BASIN

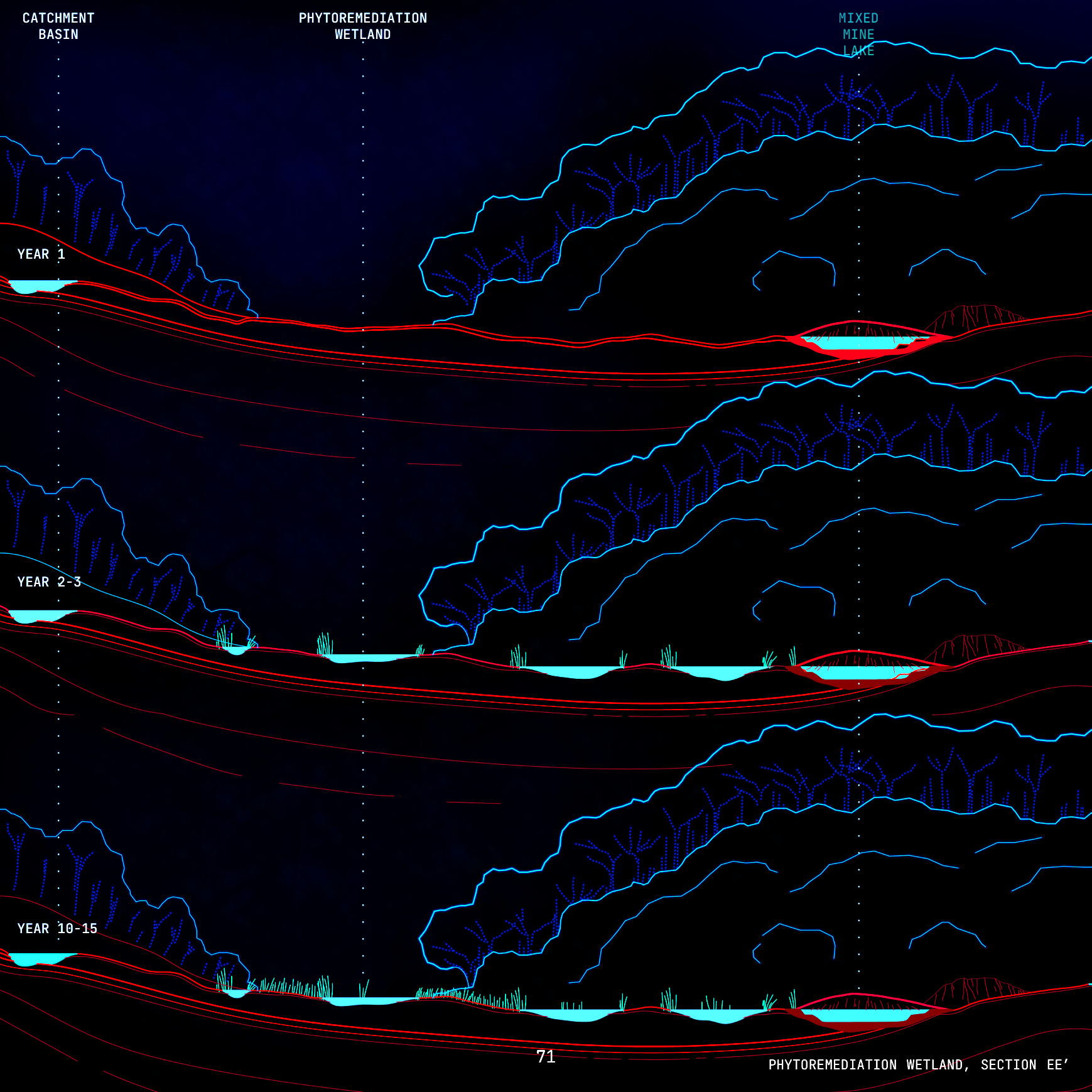
PHYTOREMEDIATION
WETLAND

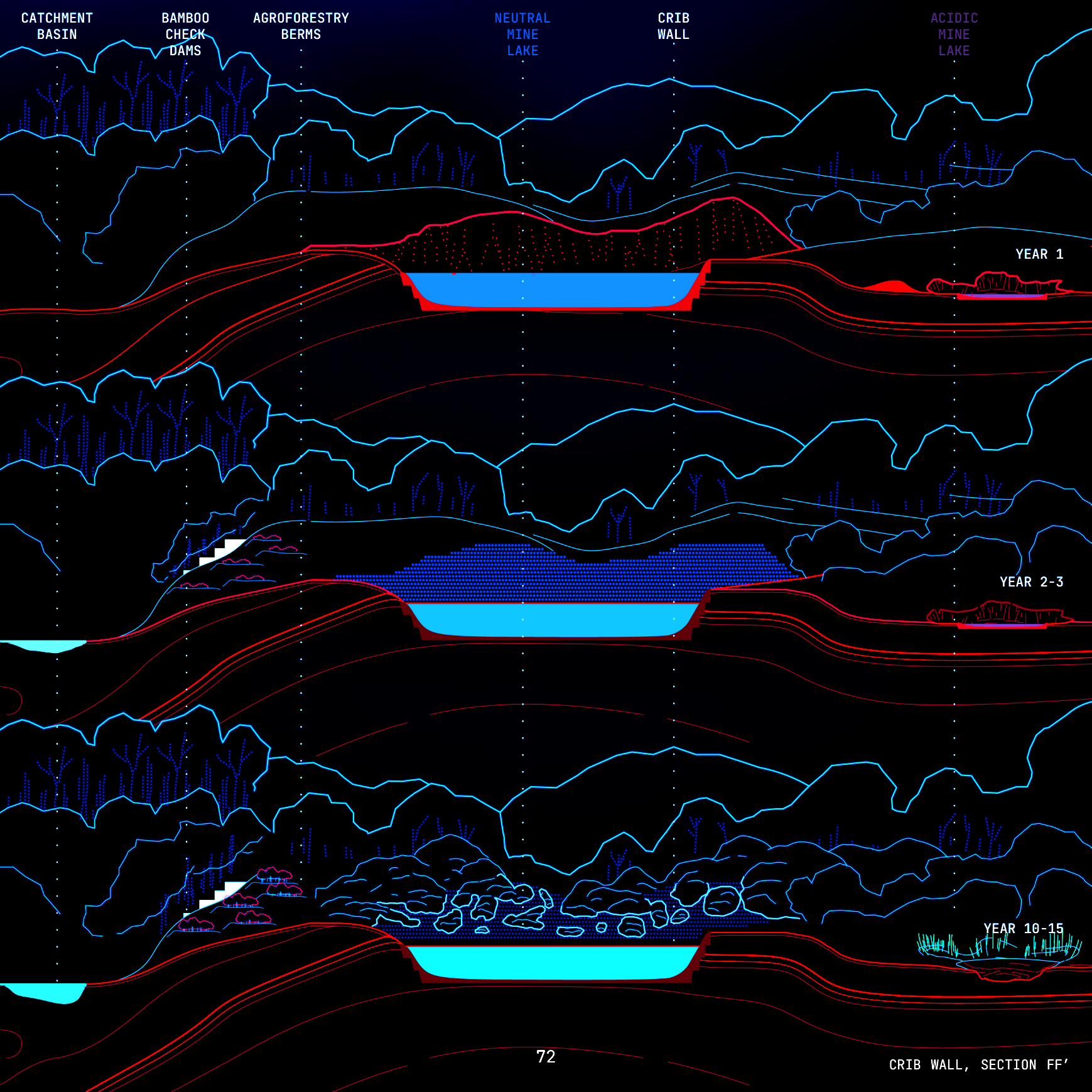
MIXED
MINE
LAKE

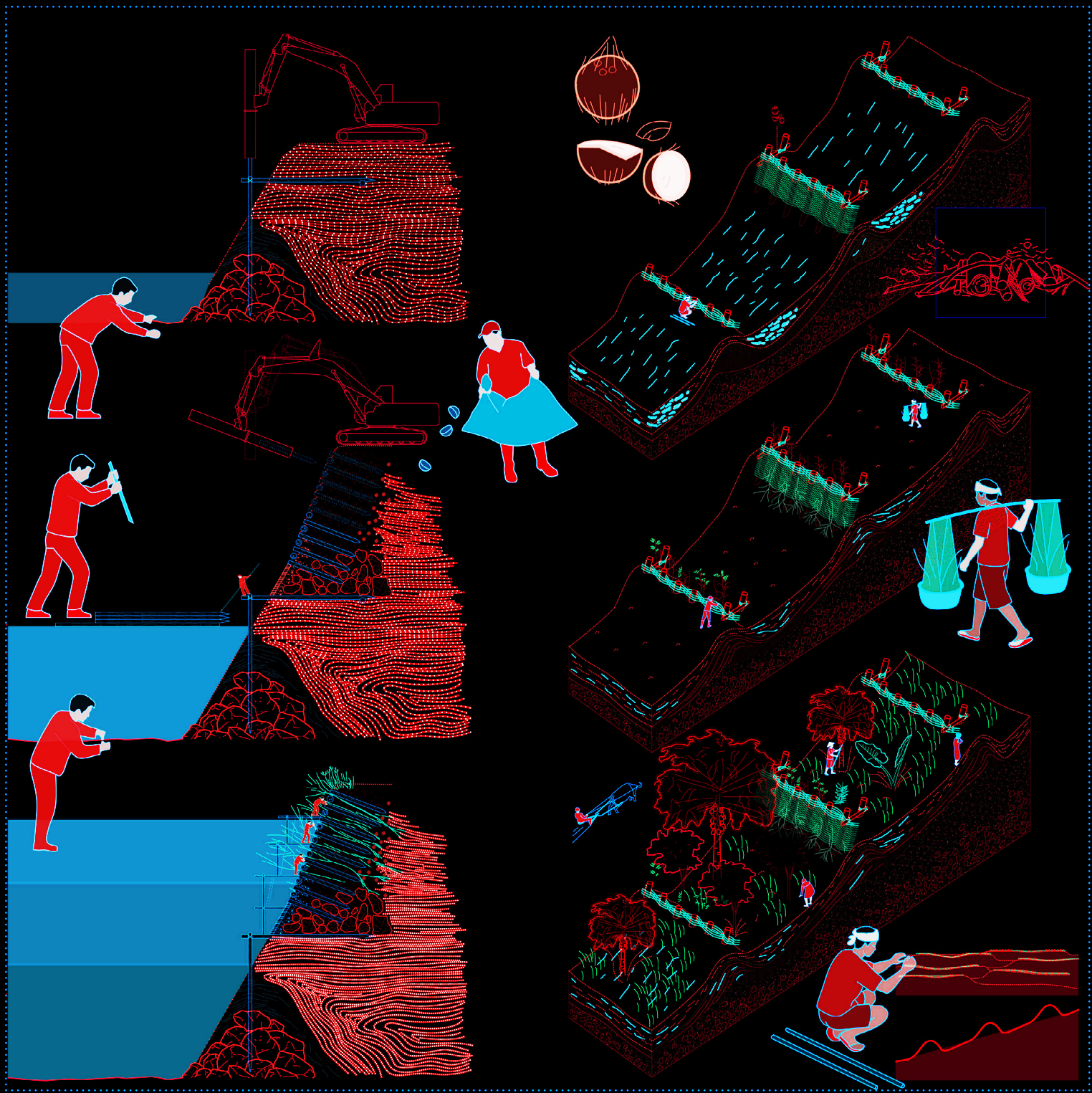
YEAR 1

YEAR 2-3

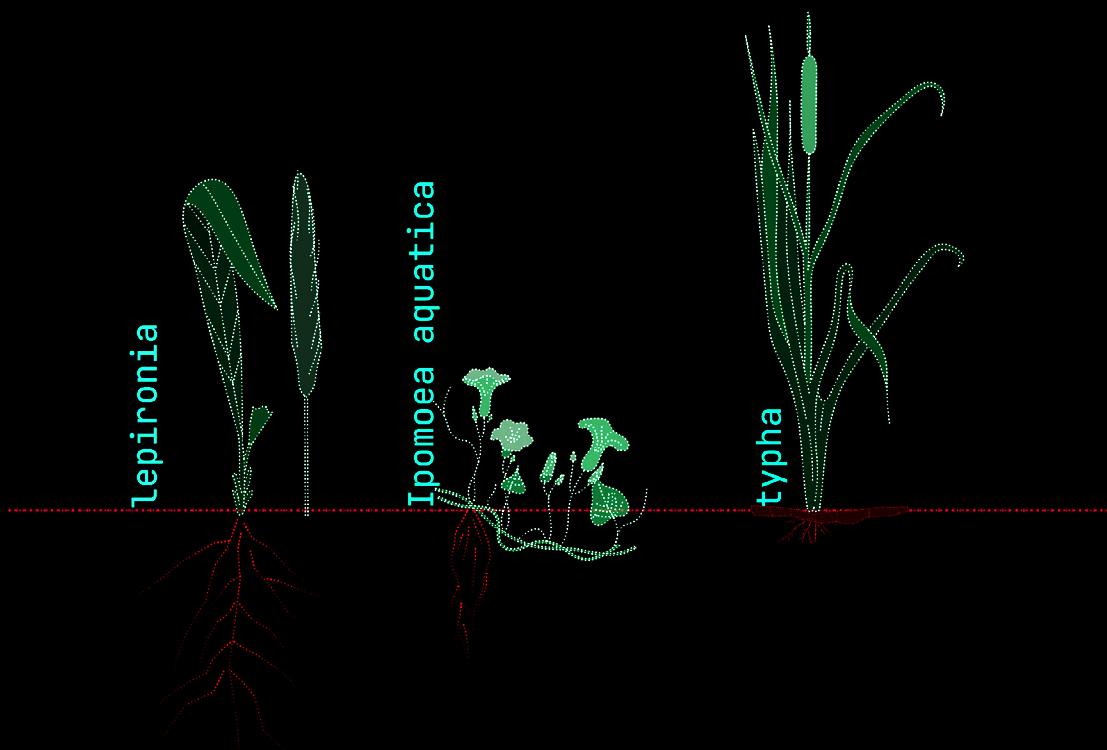
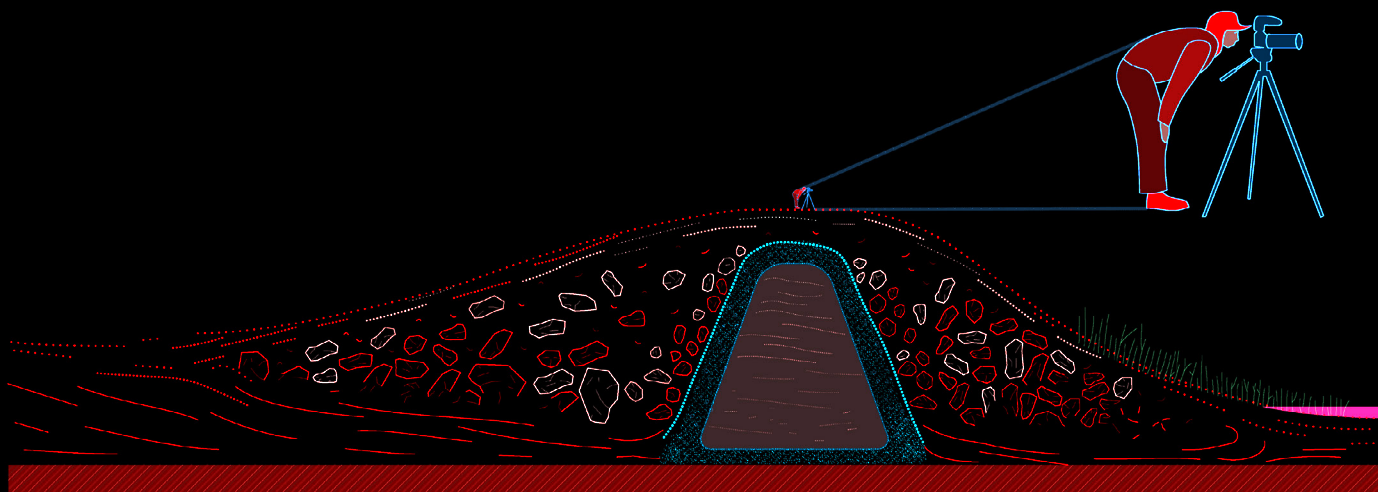
YEAR 10-15







CONSTRUCTION OF THE CRIB WALL AND AGROFORESTRY BERMS



BENANGA REDEFINED

Finally, moving downhill toward the Benanga Reservoir – where sedimentation has significantly reduced flood-storage capacity and intensified flooding in Samarinda – more advanced systems of filtration, sediment control, and water-quality monitoring are introduced so that water entering the urban system progressively approaches potable standards. Further downstream, irrigation networks inspired by the distributive and communally managed logic of systems such as the Balinese Subak could gradually establish continuous relationships between waterways, cultivated fields, and settlement. While the detailed development of these systems remains beyond the scope of the thesis, they indicate how the broader hydro-edaphic framework could eventually extend toward more integrated forms of water management, agriculture, and inhabitation linked to downstream urban resilience.

CONCLUSION

The project establishes a remediation framework operating across multiple scales of the Samarinda watershed. Rather than treating mine lakes as isolated technical problems, the proposal reconnects ridge systems, water flows, productive landscapes, and urban flooding through a continuous hydrological network. Water retention, agroforestry, wetlands, and staged mine-lake recovery work together as a distributed system that gradually supports new ecological, productive, and social conditions.

Through selective terracing and ridge retention systems, runoff is slowed, infiltrated, and redistributed before reaching the lower urban areas. This reduces sediment pressure on Benanga Reservoir while restoring moisture, vegetation, and productive capacity across degraded uplands. Existing extraction infrastructures – including roads, terraces, and drainage corridors – are gradually reused for ecological management, productive use, and public access across the watershed.

Rather than erasing the landscapes of extraction, the project redirects their existing structures toward long-term regen-

eration. Mine lakes gradually transition through stages of stabilization and ecological recovery, while agroforestry and productive landscapes establish continuous forms of occupation and care across previously fragmented territories. In this way, remediation becomes not a singular technical act, but the gradual rebuilding of relationships between water, landscape, infrastructure, and inhabitation.



AI-ASSISTED POST-PROCESSING OF ORIGINAL 3D DESIGN WORK AND FIELD PHOTOGRAPHY



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AI-ASSISTED POST-PROCESSING OF ORIGINAL 3D DESIGN WORK AND FIELD PHOTOGRAPHY

CONTRIBUTION TO THE FIELD

While the proposal is developed within the specific territorial, ecological, and socio-political condition of Samarinda and the Lower Mahakam Basin, its methodological structure is intended to operate beyond the immediate case study. Rather than proposing a fixed remediation model dependent on singular technologies, the project develops a transferable territorial framework grounded in hydrology, geomorphology, ecological succession, and infrastructural adaptation. Its applicability to other post-extractive regions lies in its capacity to work with existing territorial conditions rather than against them, treating degraded landscapes not as isolated sites requiring technical closure, but as dynamic systems capable of gradual ecological and socio-spatial reorganization.

The framework is constructed through a series of interrelated low-tech and landscape-based interventions drawn from different environmental and socio-economic contexts. Many of these systems are inspired from water-management and erosion-control practices already operating across Asia and other extraction-affected regions. Check dams adapted from watershed management practices on China's on the Loess Plateau, are used to slow runoff,

trap sediments, and increase infiltration across degraded slopes. Bamboo flow-management systems respond specifically to the erosion-prone soils of Kalimantan, stabilizing runoff while simultaneously establishing biodegradable structural reinforcement. Coconut-husk retention vessels, inspired by practices widely found across Southeast Asia, function as porous infiltration structures that retain moisture, trap organic matter, and gradually decompose into soil-building material. The agro-forestry berm systems similarly draw from the logic of Johads, Indian water-harvesting infrastructures that combine topography, infiltration, and stewardship.

Last but not least, the proposal also draws extensively from forms of low-tech environmental knowledge embedded within Dayak communities and forest-dwelling populations across Kalimantan. Many of these practices are not formally codified as engineered systems, nor visually legible as infrastructural interventions, yet they contain sophisticated understandings of water movement, soil behavior, forest succession, seasonal cycles, and territorial occupation accumulated through long-term inhabitation of tropical landscapes. Rather than treating indigenous and local practices as symbolic references, the project attempts to reinterpret their underlying environmental

logics within a contemporary territorial framework. In this sense, the proposal combines landscape-based design methodologies with situated ecological knowledge systems that have historically operated through adaptation, observation, material frugality, and continuous negotiation with unstable environmental conditions.

The integration of these precedents demonstrates how territorial remediation can emerge through the reinterpretation and recombination of already existing ecological practices rather than through high-technology engineering systems. Their low-tech nature is particularly significant in regions where large-scale remediation funding, technical maintenance capacity, or centralized environmental governance remain limited. Because these interventions rely on locally accessible materials, ecological processes, and community participation, they allow remediation to operate incrementally and adaptively through time.

At a larger scale, the project combines these localized interventions into a continuous hydro-edaphic gradient: a territorial framework organized through the interaction between hydrological flows, soil formation, sediment movement, moisture retention, and ecological succession across the watershed. Linking ridge retention, agroforestry, wetland filtration, produc-

tive lowlands, and staged mine-lake recovery, the gradient operates as a continuous environmental system rather than a series of isolated remediation sites. The proposal therefore becomes transferable through a process-based methodology capable of adapting to different hydrological regimes, climatic systems, material cultures, and extraction landscapes. Erosion, unstable soils, watershed fragmentation, contamination, and infrastructural abandonment are recurring conditions across post-extractive territories globally, and the project attempts to demonstrate how such conditions can be reorganized into frameworks of ecological recovery, productive occupation, and long-term territorial stewardship.

Reflection

Upon my professor's encouragement to work within a deeply unfamiliar international context – one that would demand the decoding of entirely unknown ecological, cultural, and territorial conditions – I joined a thesis laboratory focused on Indonesia and the development of the future capital, Nusantara. Rather than working directly on the new capital itself, however, I became increasingly drawn toward Samarinda and the surrounding extraction landscapes that already sustain and condition the region. Working within such an unfamiliar territorial context demanded the decoding of ecological, cultural, and spatial conditions that initially appeared almost unreadable. Having never visited Indonesia before, possessing no prior relationship to the territory, and encountering very limited accessible spatial data, the project required a different mode of engagement grounded in gradual mapping, historical research, media scanning, political speculation, fieldwork, and continuous satellite scanning. In many ways, I came to understand the process as an attempt to construct territorial understanding from fragments – not through complete datasets or predefined frameworks, but through continuous acts of decoding. Within this landscape, I found condensed

many ecological, infrastructural, and political contradictions embedded within a fragmented and at times unreadable territorial history.

Moving continuously between regional systems and small-scale spatial patterns, I realized that remediation could not remain understood as an isolated technical operation. I began instead to perceive it as a broader landscape condition: one concerned not only with water filtration or engineered compensation systems, but with the reorganization of entire territorial relationships between water, soil, infrastructure, urbanization, and inhabitation.

The mining landscapes surrounding Samarinda embody these contradictions intensely. They produce severe erosion, contaminated water systems, unstable soils, landslides, and fragmented ecologies, while simultaneously generating strangely alluring and visually powerful spaces. The deadly beauty of the mine lakes became deeply important to me during the fieldwork. Many of these lakes remain inaccessible, feared, and publicly disconnected from the city, despite their overwhelming territorial presence. Children have drowned in them. Water systems have been contaminated by them. Entire landscapes have become socially invisible because of them. Yet at the same time, I could not ignore their atmospheric and spa-

tial power, nor the possibility that they might eventually become part of a different territorial future.

Initially, I struggled to understand how these isolated and politically sensitive landscapes could realistically become integrated into urban and public life. Remediating individual pits alone felt insufficient, both spatially and economically. The scale of extraction demanded a broader and more gradual territorial strategy. Instead of beginning directly with the lakes themselves, I turned toward a problem already deeply embedded within the daily experience of Samarinda: flooding. The overflowing of Benanga Reservoir became an entry point through which the larger watershed could be reconsidered. By redirecting, slowing, infiltrating, and redistributing water across the ridge systems, the project attempts to simultaneously reduce urban flooding, restore ecological processes, and gradually construct new conditions for inhabitation, productivity, and public engagement within the extracted landscape. My methods may appear direct and rough, but they carry no greater violence than extraction itself. The difference is that the same operations – excavation, terracing, sediment manipulation, hydrological control, and infrastructural construction – are redirected toward regeneration rather

than depletion. The project attempts to give structure to a landscape already fragmented and vulnerable to collapse, allowing the hidden territorial logic of the mine systems to become visible and potentially productive again.

One conversation during the fieldwork remained particularly significant to me. South of Samarinda, within the mining territory below the Mahakam River, we spoke with a fruit grower who had lost nearly everything. He described black petroleum-colored water flowing from household taps, the disappearance of hunting landscapes he once depended on as a child, and the increasing impossibility of food self-sufficiency. When asked what he would do if the land were suddenly returned to him, he answered that the presence of mining and the fear surrounding these territories had never allowed him to imagine such a possibility. The landscape had ceased to exist as something people could project futures onto.

This project emerged partly from that realization. Its intention is not simply to repair damaged sites, but to reconstruct the territorial conditions through which new relationships with the landscape might once again become imaginable. By working with water flows, organic matter accumulation, slope stabilization, wet agriculture,

agroforestry, and ecological succession, the proposal attempts to create a productive palette through which local communities can gradually re-engage with landscapes long defined only through extraction.

Kalimantan's tropical soils are fragile, shallow, and deeply tied to geomorphological and mineral conditions that demand caution when redirecting water or cultivating land. Yet perhaps through careful accumulation, sediment redistribution, and ecological management, new forms of productivity and inhabitation can slowly emerge again from within the extracted terrain itself.



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