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大地舞台：面向未来的废弃土地修复

EARTH CHOREOGRAPHER: REMEDIATING OBSOLETE GROUNDS OF THE FUTURE

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摘要

作为一种设计方法，“大地舞台”聚焦于废弃油田景观的规划设计与功能重构。本文所介绍的项目以此方法命名，探讨了废弃工业用地修复和再利用的迫切需求与机遇，以在未来几十年间——乃至工业用地达到预期使用年限后——不断发掘土地的开发潜力，制定相应的预景，并在设计过程中保留场地和景观曾遭受破坏的痕迹。在技术不断发展、自然资源危机日益加剧的背景下，本文回答了以下问题：1）生产性景观的“一手保护，一手重建”意味着什么？2）如何描绘一个不断被机械重塑的地平面，以及随之变化的人类与非人类活动区域的边界？3）一片不断自我消解和重建的场地是什么样？

该项目采用动态设计方法提出了2025~2080年的若干预景设计，使场地能够根据不断变化的使用者需求和利益取向持续发展，回应气候变化和资源枯竭危机，为废弃景观的改造和复兴提供原型参考。

关键词

石油开采；废弃景观；修复；再利用；原型；夯土

ABSTRACT

Earth Choreographer is a design methodology that focuses on choreographing, scoring, and de-territorializing the landscape of an obsolete oil field. The project introduced in this article, titled Earth Choreographer, explores the imperatives and opportunities in remediation and repurposing of obsolete industrial sites, aiming to continuously investigate the potential of the land and possible scenarios over decades—even when the intended life cycle of the industrial site is over. It presents a design process that recognizes the ruination of the ground and the landscape. By acknowledging the evolving technologies and ever-increasing preoccupation with natural resources, it answers the following questions: 1) What happens when a productive landscape is sought to be both partially preserved and recreated? 2) How to represent a ground plane that is being constantly reconfigured by machines with ever-changing boundaries of spaces for human and non-human occupation? And 3) what does a site that constantly erases and reconstructs itself look like?

With several scenarios from 2025 to 2080, this project acts as a prototype for inhabiting obsolete landscapes by addressing climate change and depletion of resources. Its dynamic design methodology allows the site to constantly evolve and change over time based on the needs and interests of its occupiers.

KEYWORDS

Oil Extraction; Obsolete Landscape; Remediation; Repurposing; Prototype; Rammed Earth

1 废弃

化石燃料产业是全世界最主要的能源制造者之一，但由于自然资源的日趋枯竭和化石燃料对气候变化的负面影响，未来人类将逐渐降低对这一产业的依赖。对于许多工业场地而言，生产活动的结束即意味着它们将面临被遗弃的境遇[1]。随着技术的不断进步、相关监管和环境政策的日益完善，以及关注自然资源的共识越发广泛，建筑师们不断致力于改造废弃的后工业场地，以使其重获新生。“大地舞台”项目首先研究了那些一达到预期使用寿命即被改作他用的工业用地，并将不同类型的废弃设施——如水塔、储气罐、地下矿坑隧道、油罐及防空洞等——整理汇编，以便分析比较改造后的场地用途。结果表明，大多数废弃工业设施及场所都被改造成了娱乐休闲设施[2]。然而，此类改造方式无法解决当代的环境问题，而且这些一成不变的设计和项目也终将废弃。本项目意在打破这种先例，提出可应对持续变化的动态设计方案。

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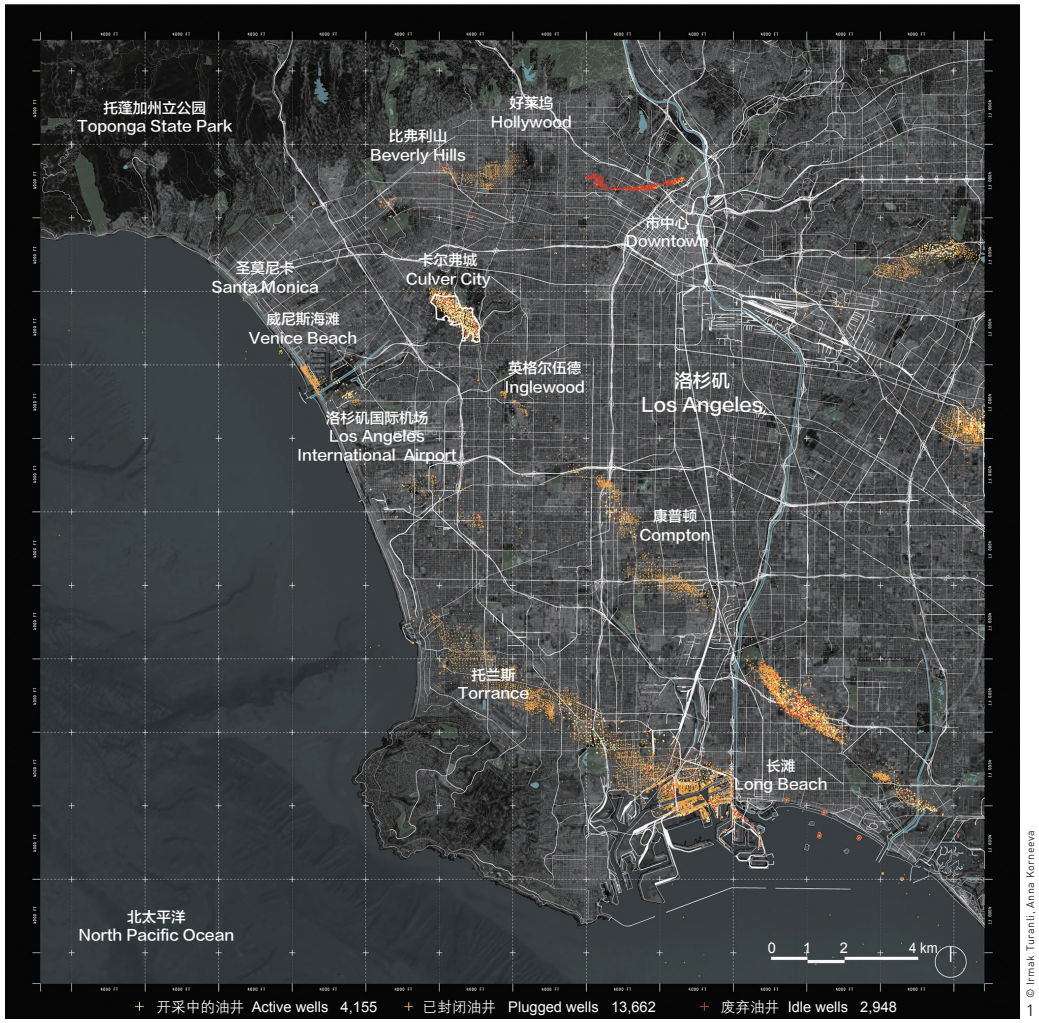
EDITED BY WANG Yinyu **TRANSLATED BY** LI Huiyan WANG Yinyu

1. 加利福尼亚州洛杉矶市的油井分布

1. The distribution of oil wells in Los Angeles, California

2 选址

随后，项目选取位于加利福尼亚州洛杉矶市中心的美国最大连片城市油田——英格尔伍德油田为设计场地（图1）。该油田发现于1924年，于同年投入开采，至今已产油近4亿桶。油田按照传统方式开采，即在钻井平台上安装独立的抽油机，整个场地完全开放、一览无遗，场地附近还有许多住宅、学校和休闲公园。如今，油田占地约4km^2，共有1 601座油井，其中696座仍在运转，但这处油田很快可能因石油枯竭而停产[3]。于是，“大地舞台”提出了针对废弃后的英格尔伍德油田的修复方案。加利福尼亚州曾是美国最大的石油产地之一，但其石油工业一直在走下坡路，因此英格尔伍德油田将不是唯一面临此种命运的油田[4]（图2）。面对越来越多的废弃油田，本项目可作为一种修复原型，帮助应对气候变化和资源枯竭等环境问题。



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3 核心问题

为了制定场地修复方案，项目首先调研了石油生产过程对场地造成的影响，即分析石油生产造成的土壤毒化与污染情况，并确定这些有害物质的分布（图3）。截至2020年，场地上仍有相当多的废弃油井未被妥善封顶[4]。由于这些油井可能会向土壤中释放毒素，项目提出采用物理、生物和化学的综合性方法净化土壤，并封闭油井（图4）。

上述工作的重要目的之一是解决土壤资源（包括已挖出的土方和未经开挖的土壤）有限这一难题。因此，项目提出将场地上的既有土方加工成夯土，可作为主要建筑材料。采用“随挖随填”的方法，可就地加工钻探油井时产生的多余土方，无需从他处获取建筑材料（图4）。

在基于土地现状明确了现有景观的改造优先级之后，笔者提出项目应该在灵活适应现有场地的同时，响应气候变化和资源枯竭危机，并决定将场地打造为一个服务于美国国家航空航天局，以及特斯拉和欧特克等未来科技公司的试验场，为化石燃料等有限资源的替代品研发提供支持（图5）。

试验场将提供多种配套工作空间，如用于装配和实体建模的创客工厂，以及空中交通模拟实验室。这些空间的规模和形式可根据公司需要量身定制，并依循被石油生产活动塑造的地表而建，以纪念场地的原始景观及其变迁。

4 预景

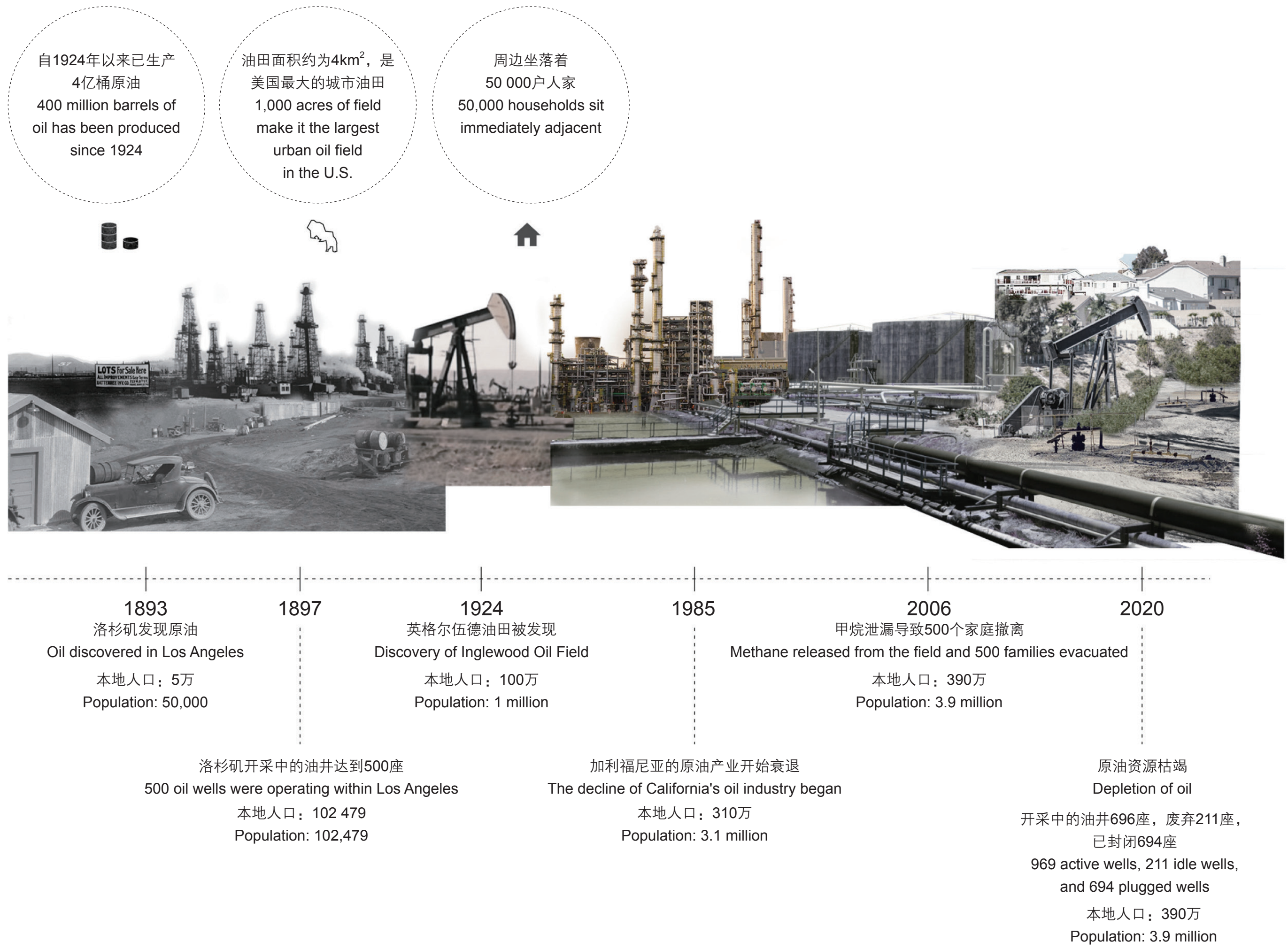
在未来数十年间，现有油田将逐渐荒废，闲置土地不断增多，由此可逐步重构油田景观，并不断推广这种新的改造模式。本次研究采用时间—情境设计方法模拟了一系列针对废弃场地的动态响应，以展示在人类及非人类主体的共同作用下，场地如何通过建造永久性构筑物、资源重组，以及重置功能区划实现持续的重构。

笔者用基于未来特定时间和地点的若干切片来展示设计策略，并逐一细化这些预景，用不同类型的线条代表每个切片中的地形、地理和时间信息。未来每一个新的发展阶段都会引入新线条，表示新的主体开始发挥作用。首个预景设定于2025年，重构活动将首先从远离石油生产区、人口最为稠密的已封闭油井区开始（图6）。

2030年，设计重点将转移到现状炼油厂附近的试验场。虽然最终整个场地都将被改造，但部分已达到设计使用年限的能源基础设施仍将按原貌保留下来，以强调过去和未来的并存。项目意在正面展示场地上废弃石油基础设施留下的痕迹，而场地修复的实现不仅需要情怀，更需要新技术的多管齐下。

鉴于油田的使用主体将不断变化，这一过程离不开多种机器人、无人机和机械的参与，以及人类和非人类主体的共同作用。不同主体将分组承担不同的任务，合作建造试验场。

到2040年，既有的休闲公园和生产性景观将在场地内共存（图7）。项目提出在紧邻现有石油基础设施的地方建造一座更具可持续性的能



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2. 英格尔伍德油田发展历程

2. A timeline showing the development of Inglewood Oil Field's Oil Production

源生产设施，以在新、旧能源生产设施之间形成对比。

在地面上，富有活力的休闲公园和重工业建设场地比邻而立。这促使团队进一步思考如何妥善处理两者之间的边界，从而确保人类活动与非人类主体的施工作业互不干扰（图8）。

项目将地面作为协调地上和地下能源生产的媒介：在地上安装太阳能能源装置并设计一个可将健身脚踏车产生的动能转化为电能的健身房，地下则是废弃石油基础设施的遗迹。在本项目中，原本隐于地下的传统能源基础设施通过图绘形式得以展现，并在大地表面与未来的能源生产模式碰撞交汇，形成鲜明的对比。

到2060年，参与项目建设的人类劳动力数量有望大幅减少（图9）。随着机器人和人工智能技术的发展，原本由人类主导的工作将逐步由机器人承担，大部分人力将转而从事无人机和机器人的维护工作，并对机器人进行编程与分组，使其可以利用夯土建造构筑物[5]。这一转变不仅可解决本项目中建筑工人稀缺的问题，也为整个建造行业面临的人力资源短缺提供了解决方案，展现了建造场景下人类与非人类主体之间的新型互动关系（图10）。

2080年，项目将关注场地邻近城市的区域，此处的建筑形式设计应使试验场的一部分对场地外的公众可见，使未来科技公司的工作在一定程度上得到监督。

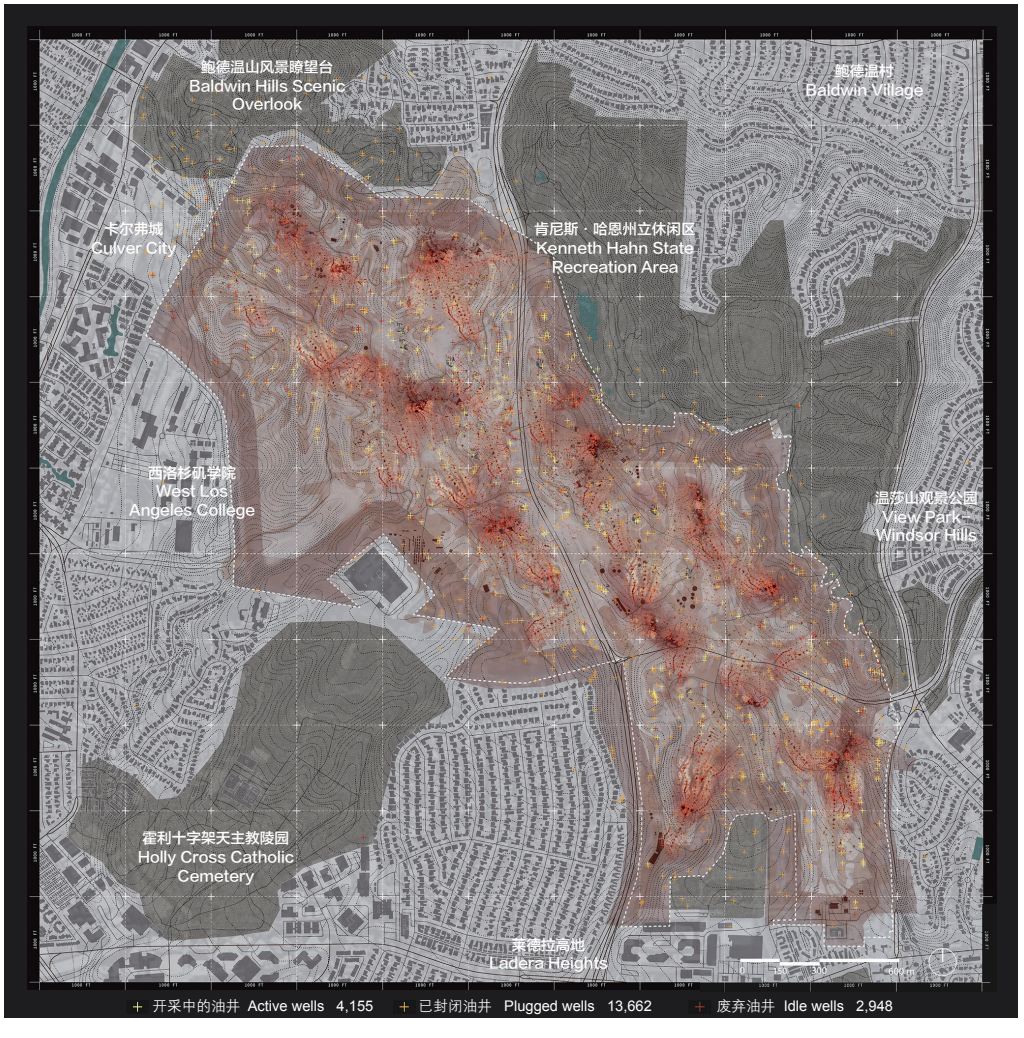
5 原型

虽然洛杉矶当前仍然是美国最大的产油城市，但其石油工业已然走向衰落，大片油田的废弃将成为必然。本项目为此类场地的复兴提供了一个原型范例，展示了利用废弃景观的新方式（图11）。

“大地舞台”项目深受动态设计方法论的影响，可根据场地使用者的需求与利益取向，随时间推移不断变化。该项目通过时间–情境设计方法展示了废弃场地的动态未来，是一种可从根本上修复并重构废弃景观功能的关键性途径。LAF

3. 英格尔伍德油田毒化土壤分布图

3. The map of soil toxicity for Inglewood Oil Field



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1 The Obsolescence

Although fossil fuel industries are some of the largest energy producers in the world, the dependency on these industries is expected to decrease because of the depletion of natural resources and their negative effects on climate change. As the activities on the industrial sites will come to an end, many sites will soon become obsolete[1]. With evolving technologies, more complex regulatory and environmental policies and ever-increasing preoccupation with natural resources, architects have been designing new lives for obsolete post-industrial sites. This project, Earth Choreographer, began with the investigation of those industrial sites that are used outside of their original purpose once they reach the end of the intended life cycle. To analyze and compare them, a catalog of obsolete industrial facility types was produced to show the new programs deployed at post-industrial sites. The catalog included water towers, gasometers, tunnels of underground coal mines, oil tanks, air raid shelters and more. Most of these sites were repurposed for recreation and pleasure purposes[2]. Such uses fail to embrace contemporary environmental issues and their static, non-flexible designs and programs are also bound to eventually become obsolete. Therefore, the project is focused on a dynamic design that is constantly in flux as opposed to previously seen static examples.

2 The Location

After investigating various obsolete precedents, Inglewood Oil Field, the largest contiguous urban oil field in the U.S. located in the center of Los Angeles, California (Fig. 1), was selected. Discovered in 1924 and in continuous production ever since, it has produced almost 400 million barrels of oil. The oil field is visually entirely open to the public, and it was developed in the traditional manner of individual pump jacks on drilling pads. There are many homes, schools, and recreational parks adjacent to the oil field. Today, the oil field covers approximately 1,000 acres and there are a total of 1,601 wells, 696 of which are still active. However, it is now reaching the end of its lifetime as the oil in the field is almost depleted[3]. The project proposes Inglewood Oil Field's remediation once its oil extraction comes to an end. Although California used to be one of the biggest oil producers in the U.S., its oil industry has been in decline and therefore Inglewood Oil Field will not be the only field that is reaching its intended life cycle[4] (Fig. 2). Earth Choreographer acts as a prototype for the remediation of an increasing number of obsolete oil fields by addressing climate change and depletion of resources.

3 The Parameters

In order to choreograph the remediation of the site, the existing land conditions and materials created by the oil production process were investigated. Firstly, the toxicity and the contamination of the soil were analyzed and located (Fig. 3). As of 2020, there are a significant number of idle wells on the site that are not yet properly capped[4]. As they might be emitting toxins to the soil, a combination of physical, biological, and chemical strategies were deployed in order to decontaminate the soil and plug the well (Fig. 4).

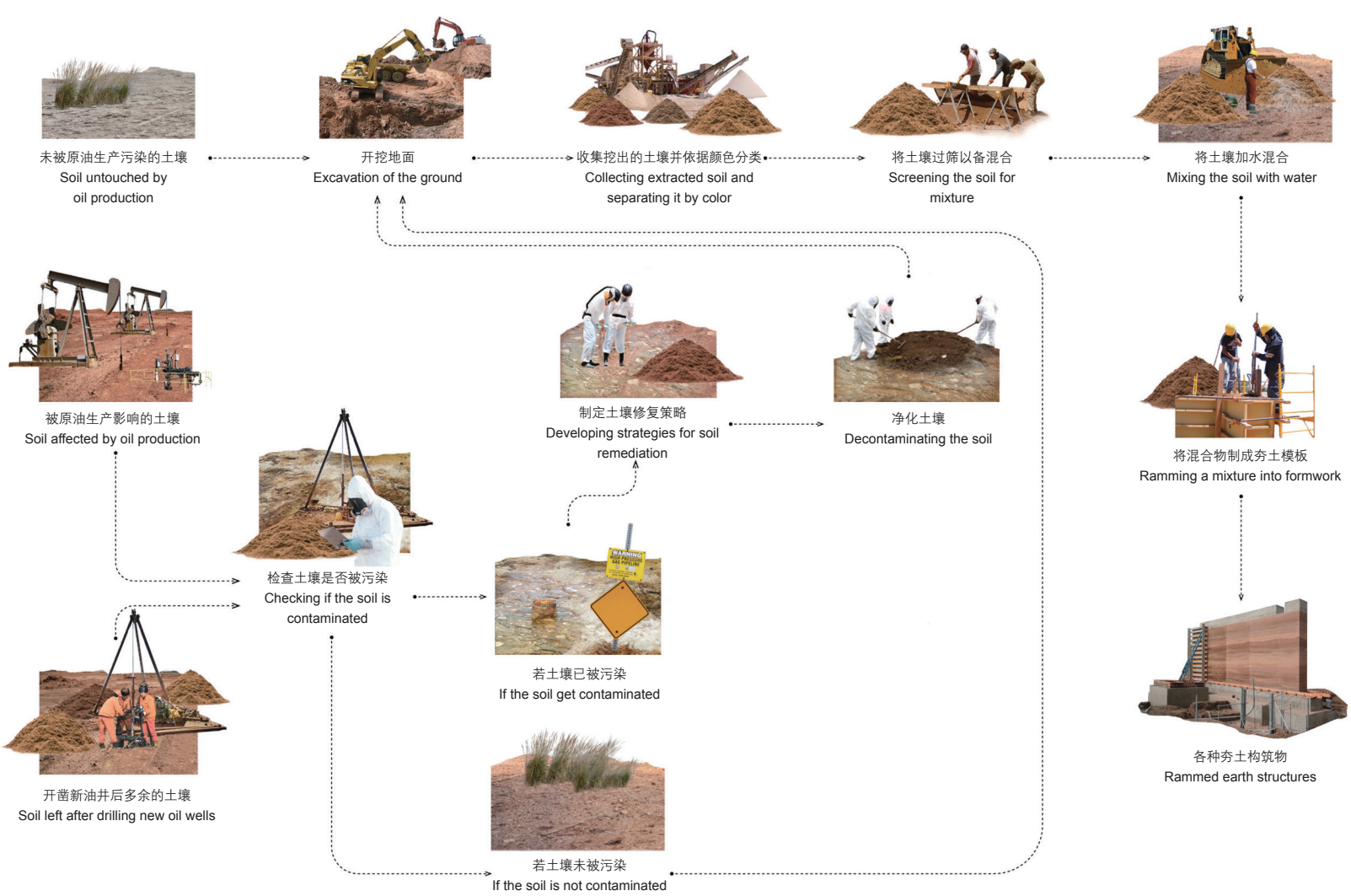
An important goal of such work was to acknowledge and address the finite supply of the earth resources in terms of both extracted and raw materials. Therefore, Earth Choreographer used already extracted soil on the site and converted it into rammed earth which is intended to be the primary construction material. For this purpose, the “cut and fill” method was deployed to directly turn extracted excess soil from the drilling sites of oil wells into rammed earth as construction materials, instead of bringing new soil from elsewhere (Fig. 4).

After analyzing the existing land conditions and determining the priorities while working with the existing landscape, it was concluded that the project should be flexible to adapt to the existing site conditions while responding to climate change and depletion of resources. The project is intended to be an experimental testing ground targeted for future technology institutes and companies such as NASA, Tesla, and Autodesk which work on new technologies as substitutes for fossil fuels and other resources in depletion (Fig. 5).

The testing ground will be designed to include various programs for these companies, such as makerspaces for fabrication and mock-ups, and simulation labs for air mobility. Their scales and forms will vary depending on the type of space the companies need, and follow the existing topography which has been already altered and traced by the oil production industry, giving tribute to the original landscape and its alterations.

4. 土壤修复流程框架

4. Soil remediation framework



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5. 2030年预景下的场地透视图

5. A perspective of the scenario in 2030

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4 The Choreography

This project proposes a constant reconfiguration of the oil field's landscape which will be reclaimed parcel by parcel as it becomes available, and continue growing and extending in phases over the coming decades. Therefore, Earth Choreographer exemplifies a temporal-situational design methodology to simulate a kinetic response to obsolete sites, which presents the ideas of continuous reformatting through permanent construction, reconfiguration, and de-territorialization of the ground by human and non-human agencies.

The proposed choreography of the site was shown as frames picked from certain times and locations. Layers of lines in each frame represent the topographic, geographic, and temporal mechanical information. With each phase new

lines are introduced to represent the new actors starting to play out in this process. Starting in 2025, the speculation for choreographing the earth will begin from the most populated areas of capped wells, farthest from the active ones (Fig. 6).

In 2030, the focus will be relocated to the testing ground close to the existing oil refinery. Although the whole site will be reclaimed, some energy infrastructures for oil production will remain untouched even after they reach the end of intended life cycle. By suggesting such a remediation strategy, the juxtaposition between the past and the future was emphasized. This was intended to reveal the traces left by obsolete oil infrastructures on the site, arguing that reclamation of the site can be achieved through radical technological juxtapositions without having to be nostalgic.

As the oil field is permanently choreographed for its changing occupiers, a variety of robots, drones, and machines will contribute to this process. Both human and non-human actors will work on the site. The actors are choreographed according to the specific tasks they are assigned to, working collaboratively towards constructing the testing ground.

As the focus moves to 2040, the site will be a juxtaposition of the existing recreational park and the productive landscape (Fig. 7). A more sustainable energy production facility adjacent to the existing oil infrastructure is proposed, creating a tension between old and new energy production facilities.

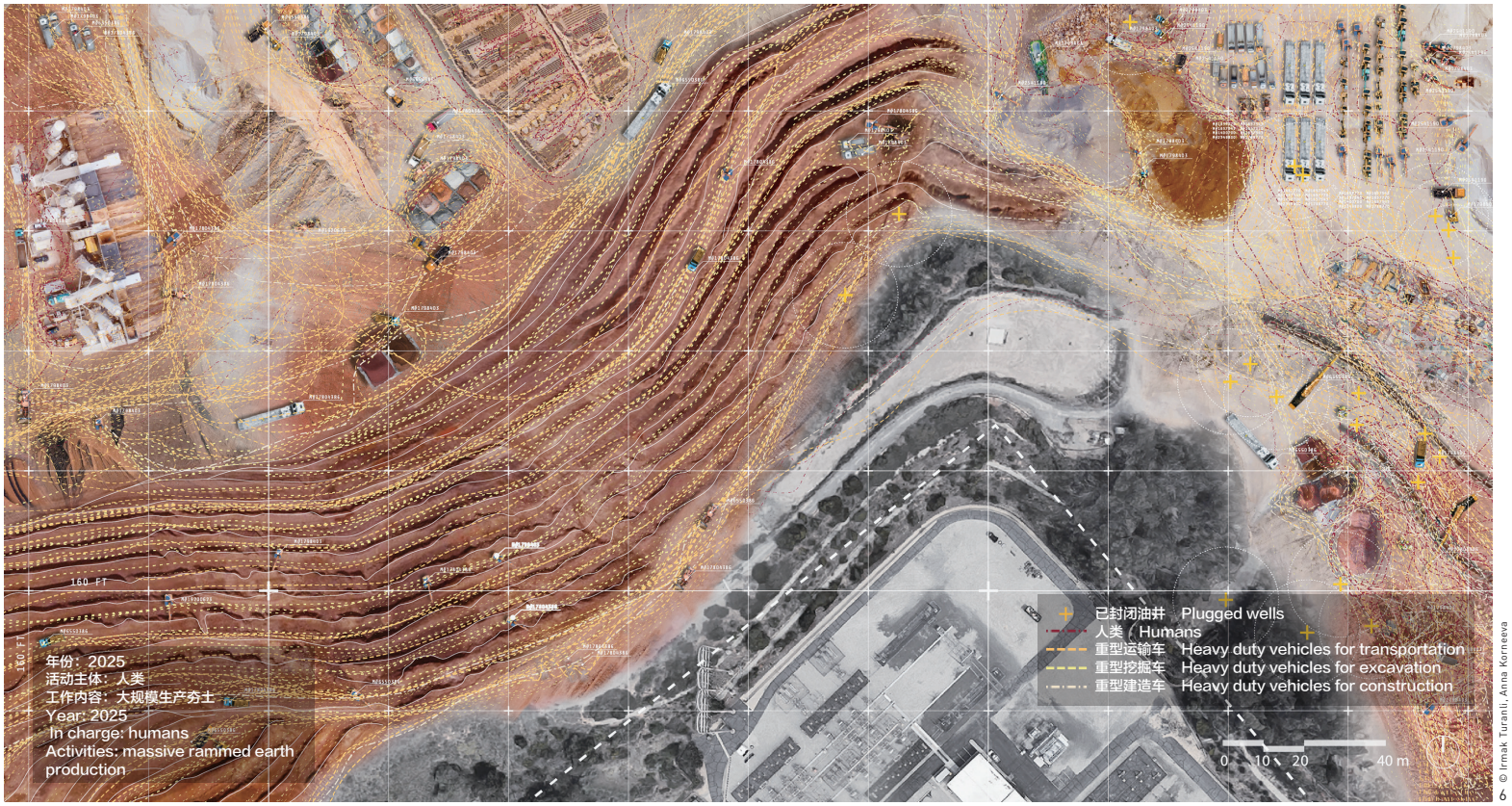
Above the ground, there is the juxtaposition between the active recreational park and the heavy industrial construction site. This leads to further investigation about how to deal with the boundary of public active spaces in close proximity to construction sites and how to sustain a boundary between human and non-human actors (Fig. 8).

The ground will become the medium for negotiating the energy production above and below the ground. Above, solar energy will be harnessed and electric power will be generated by the kinetic energy of the stationary bikes in a gym, while below the traces of the obsolete oil infrastructure can be observed. These traces of past and future energy sources will collide and entangle at the surface of the Earth. This collision is exposed by revealing invisible infrastructure through the graphic representation used throughout this project.

By the year of 2060, Earth Choreographer expects to have fewer people involved in the construction field (Fig. 9). With the

6. 2025年预景下的场地鸟瞰图

6. A bird's eye view of the scenario in 2025



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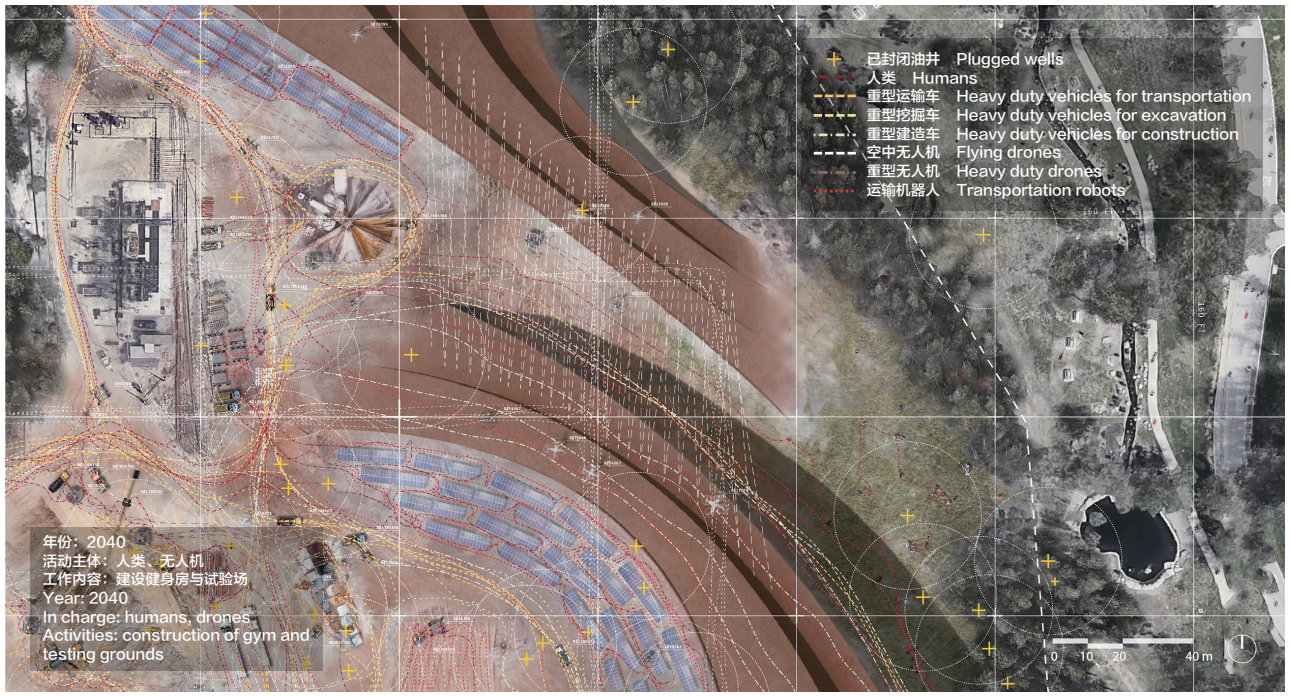
7. 2040年预景下的场地鸟瞰图
8. 2040年预景下的场地透视图

7. A bird's eye view of the scenario in 2040
8. A perspective of the scenario in 2040



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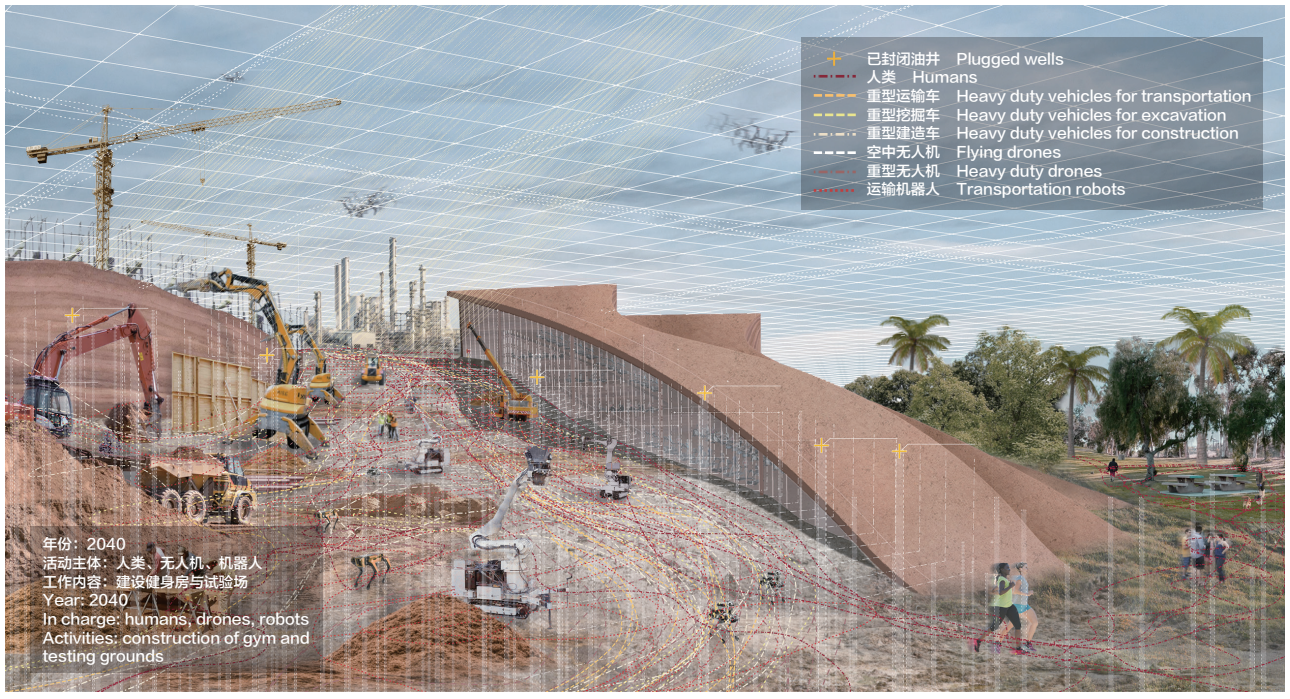

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evolving robotic and AI technologies, there will be a shift from human labor to robotics in the construction industry. Most of the human labor will be shifted towards maintaining drones and robots which will be programmed to work in teams to build structures using rammed earth[5]. This shift can address the scarcity of human labors in this project and in the construction industry, showing how new relationships and interactions between human and non-human will be choreographed in the construction site (Fig. 10).

In 2080, the focus will be shifted to the area adjacent to the city fabric, where the building form is designed to allow the testing ground to be partially exposed to the public.This allows

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9. 2060年预景下的场地鸟瞰图
10. 2060年预景下的场地透视图

9. A bird's eye view of the scenario in 2060
10. A perspective of the scenario in 2060

the work of the future technology companies to be transparent to a certain extent.

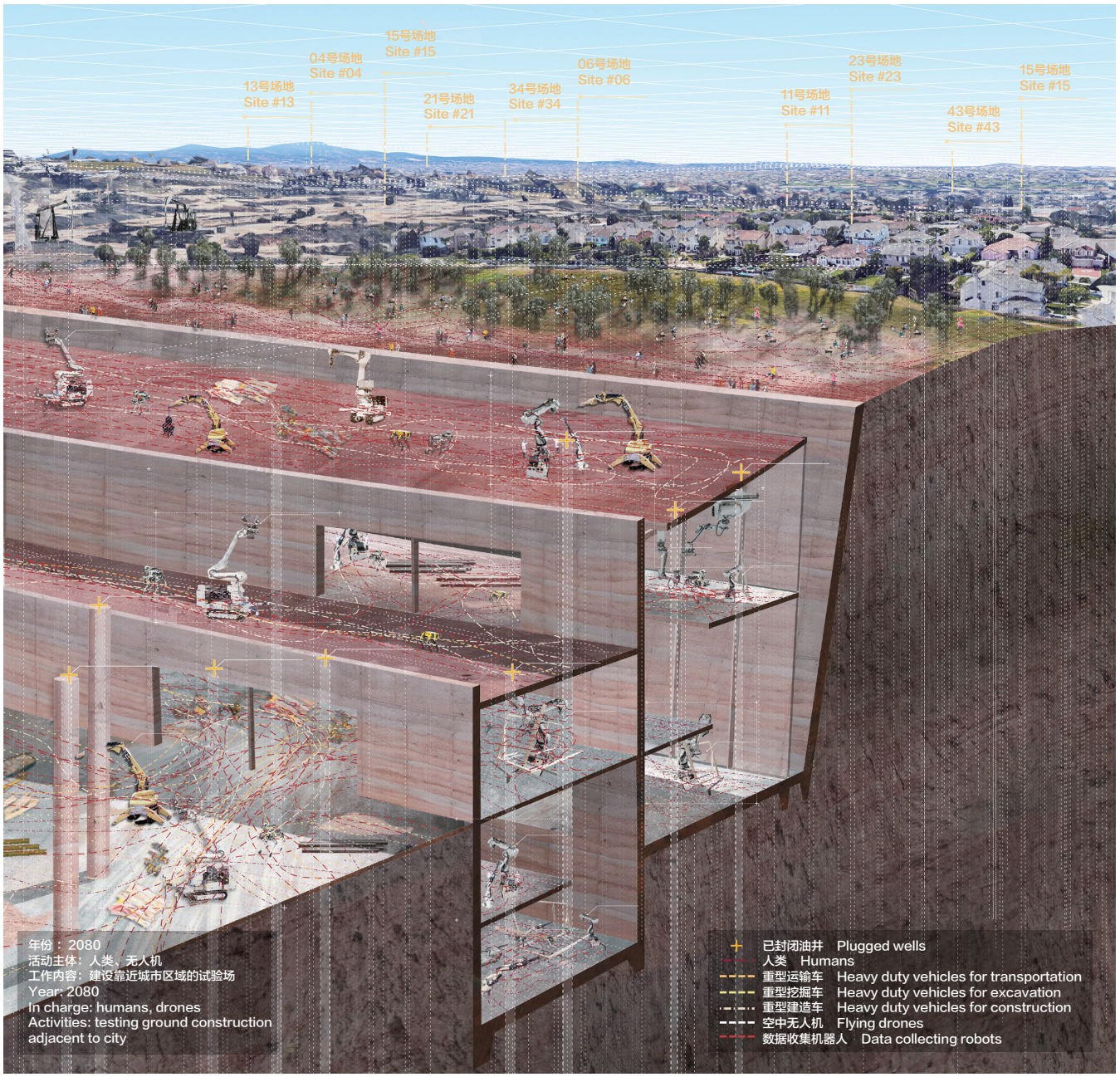
5 The Prototype

Although Los Angeles remains as the largest urban oil field in the US, currently its oil industry is in decline and will ultimately result in an abundance of obsolete sites. This project is meant to be a prototype for those sites by exemplifying new ways of inhabiting obsolete landscapes of the future (Fig. 11).

Earth Choreographer is heavily influenced by a dynamic design methodology and acts as a prototype by constantly evolving and changing over time based on the needs and interests of its occupiers. By emphasizing a temporal-situational

11. 2080年预景下的场地轴测剖面图

11. An isometric section of the scenario in 2080



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design methodology, it seeks to bring a kinetic response to obsolete sites, providing a pivotal speculation for radically remediating and reprogramming obsolete landscapes of the future. **LAF**

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