弹性的防洪基础设施：
纽约市东海岸弹性修复计划

RESILIENT FLOOD PROTECTION INFRASTRUCTURE:
THE EAST SIDE COASTAL RESILIENCY PROJECT OF NEW YORK CITY

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摘要

为应对飓风侵袭及海平面上升等问题，BIG建筑事务所提出了针对曼哈顿主岛滨水区的U型保护系统，以为该区域的未来弹性海岸建设和城市发展描绘出崭新的图景。作为该大型项目的第一阶段任务，东海岸弹性修复（ESCR）项目旨在探索如何使防洪基础设施激发更多的社会效益。这一变革性的城市转型项目不仅可以满足当前社区的特定需求，更能够根据城市未来发展状况进行调整和完善。ESCR项目集结了来自社会各界的力量，通过典型材料的运用和对细节特征的把控来打造一种多样化的滨海城市景观空间。在此过程中，景观亦充分展现了它作为教育载体的意义。

关键词

弹性；基础设施；防洪；适应性；社会效益

ABSTRACT

As a response to the issues of hurricane attack and sea level rise, the BIG U imagines a new future of coastal resiliency and urbanism for Manhattan's waterfront. The East Side Coastal Resiliency (ESCR) project is the first phase of this huge project, showing how flood protection infrastructure could have more social effects. This radical urban transformation not only responds to the specific needs of communities today, but also remains flexible enough to develop over time, as urban conditions continue to change. ESCR gets designers, communities, and city agencies united, and creates a diversified city coastal landscape with a toolbox of materials and details that are typical of the city's past. In this process, landscape is the medium that expresses educational aspects.

KEY WORDS

Resilience; Infrastructure; Flood Protection; Adaptability; Social Effects

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EDITED BY Xiaojie TIAN Ying WANG
TRANSLATED BY Angus ZHANG

项目地址：
美国纽约市曼哈顿区
项目面积：
29hm²
项目委托：
纽约市修复与弹性市长办公室、纽约市设计与建设部、纽约市经济发展局、纽约市公园与娱乐管理局、纽约市交通部、纽约市城市规划局、纽约市环境保护部
项目合作：
AKRF环境工程咨询公司、Arcadis设计咨询公司、CH2M环境工程咨询公司、Matthews Nielsen景观设计事务所、One Architecture建筑事务所、SiteWorks景观设计事务所
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设计时间：
2016年5月至今

LOCATION:
Manhattan, New York City, USA
AREA (SIZE):
72 Acres
CLIENTS:
NYC Mayor's Office of Recovery and Resiliency, NYC Department of Design and Construction, NYC Economic Development Corporation, NYC Department of Parks and Recreation, NYC Department of Transportation, NYC City Planning, NYC Department of Environmental Protection
COLLABORATORS:
AKRF, Arcadis, CH2M, Matthews Nielsen Landscape Architects, One Architecture, SiteWorks
PARTNERS IN CHARGE:
Bjarke Ingels, Kai-Uwe Bergmann, Daniel Sundlin
PROJECT LEADERS:
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PROJECT TEAM:
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DESIGN PERIOD:
May 2016 to Present

1. 纽约市漏斗状的海湾地形加剧了飓风对城市腹地的侵袭。
2. 一半的城市都处于风险中

1. New York "Bight" acts as a funnel, directing storm surge directly into the heart of the city.
2. 50% of the city was at risk

项目背景

近年来，老旧基础设施常被改造为公共社会文化场所。例如，位于曼哈顿的废弃铁轨被改造为如今纽约市最受欢迎的城市公园之一——高线公园，而伦敦泰特现代美术馆的前身也是一座废弃的发电厂。渐渐地，这些开拓性的工业基础设施改造影响了主流建筑的设计方向。然而，与其被动等待这些基础设施老化、退役，而后将其改造为全新的社会性项目，我们可否有意识地打造自建成伊始就具有一定社会效益的公共基础设施？

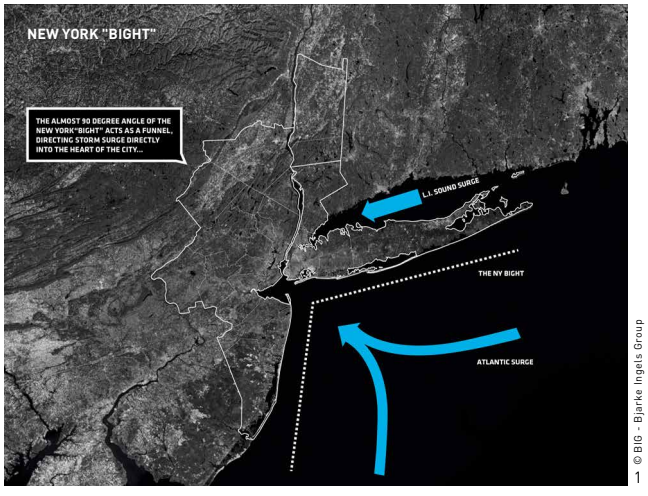
2012年，超级飓风桑迪对纽约市造成了严重破坏。这一突发性气候事件也将整个纽约市年久失修的基础设施以及存在于低收入和老龄化社区中的问题暴露无遗。作为对这些问题的直接回应，BIG建筑事务所提出U型保护系统方案（BIG U），以为曼哈顿滨水区的未来弹性海岸建设和城市发展描绘出崭新的图景。在BIG U愿景规划中，设计团队就如何在曼哈顿复杂的城市环境中整合防洪基础设施以提升社会福祉展开了研究。在该方案赢得“为重建而设计”竞赛后，美国住房与城市发展部及纽约市政府于2014年6月宣布，将斥资逾3.35亿美元支持项目第一阶段的设计和建造工作，即东海岸弹性修复（ESCR）项目。ESCR项目目前正从初期规划阶段转入设计阶段，随后将启动首个新滨水区的建设，项目将为曼哈顿长约3.5km的海岸线提供防洪基础设施。

设计策略与合作

ESCR项目沿曼哈顿东区展开，覆盖蒙哥马利街与东23街之间约29hm²的区域。项目旨在为11万余个以低收入家庭为主的住宅单元提供庇护，同时建设4座公园，将城市的防洪功能整合到公共空间之中。

ESCR项目不仅回应了沿海区域的防护需求，也意在满足使用者对于自然环境的当前需求和未来期许。在充分认识到项目必须适应未来的气候变化和社区转型后，设计团队提出了一系列问题：场地能否成为一个具有高度适应性的城市框架？项目如何加强城市与滨水区之间的联系？一条崭新的世界级城市海岸线最终将会呈现出怎样一番景象？在纽约这一人口密度位居世界前列的城市中，它将如何体现公共空间的多样性？它将如何应对不断发展变化的自然、生态和社会环境？

基于以上问题，设计团队提出了“社交性公共基础设施”方案——一个应用了先进技术的大规模沿海防洪网络。该方案可适应不同社区特点，在实现规划类型多样化的同时，加强社区间的联系。考虑到海平面上升、气候变化及城市发展中的不确定因素等，防洪网络不仅可以满足当前社区的特定需



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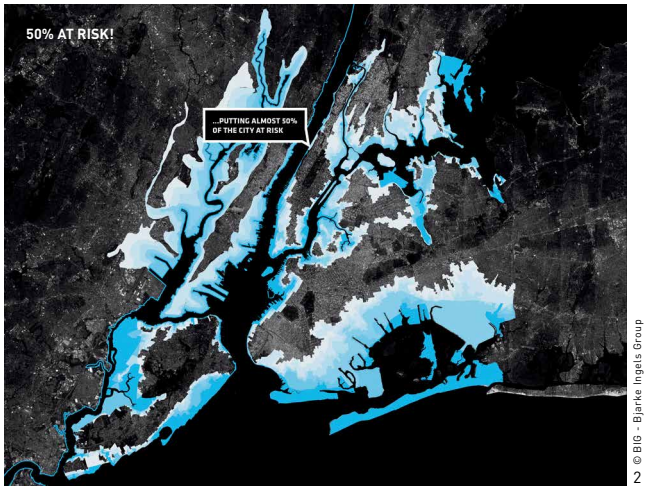

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求，更能够根据情况的转变而进行调整和完善。随着项目的深入，设计团队也逐渐认识到了适应性设计在弹性环境设计中的重要作用。

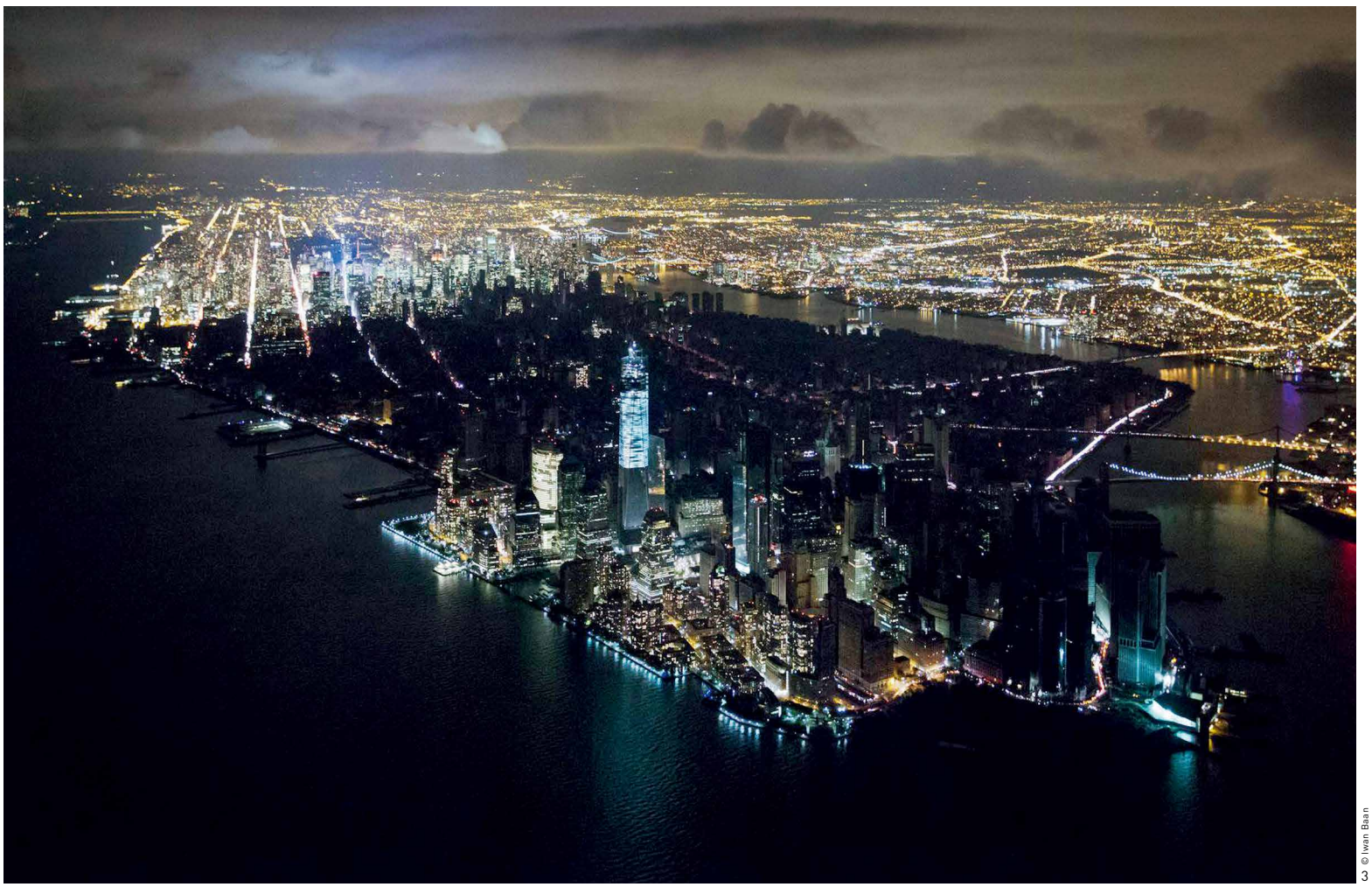
鉴于ESCR项目规模之大、情况之复杂，设计团队组建了一支跨学科团队，涵盖了来自当地和所属地区的众多城市生态学、社区参与、都市主义、建筑学、景观设计学以及基础设施工程专家。同时，团队通过与当地社区及城市管理机构紧密合作，形成了灵活的设计方案，以适应不断变化的使用需求和气候条件。

由于ESCR项目的独特性，纽约市政府亦积极参与并给予了大力支持。在纽约市修复与弹性市长办公室的监督下及设计与建设部的管理下，7个市政府机构最终共同确定了设计、维护、运营和社区外展活动等事务的优先级。

此外，为满足这一复杂公共空间项目的需求，设计团队调整原有工作模式，组建了由景观设计师及对城市未来与发展战略具有极高热忱的有识之士组成的“BIG景观”团队。这一举措也反映出设计团队不断完善的基本设计理念，即不同尺度、不同形式的建成环境都应起到改善自然和生态环境、提升居住者生活品质的作用。这一理念在BIG建筑事务所的多个建成项目中均有体现，例如，位于丹麦的8字住宅（8-House）和超级线性公园（Superkilen Park）项目不仅从多角度展现了当地的本土文化，更呈现了一种具有多元文化属性的新型城市生活模式。正是这样的设计态度指引着BIG建筑事务所不断拓展其景观设计与城市设计实践，以及ESCR项目在未来的落地。

3. 超级飓风桑迪侵袭之后的曼哈顿中心
4. 炮台公园护道
5. BIG U是根据曼哈顿社区的需求而量身打造的一个防护系统。该项目沿曼哈顿西57街展开，南至炮台公园，北至东42街，可对绵延16km的低洼区域进行保护。ESCR是该项目的第一阶段，建成后可使长达4km的城市海岸线及11万个住宅单元免受洪水侵害。

3. Downtown Manhattan in the after hours of superstorm Sandy
4. Battery Park berm
5. BIG U is a protective system around Manhattan, tailored to the needs and concerns of its communities. Stretching from West 57th Street south to The Battery Park and up to East 42nd Street, the BIG U protects 10 continuous miles of low-lying geography. ESCR is the first phase protecting 2.5 miles and 110, 000 residences.



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基础设施与社交空间弹性框架

ESCR项目是城市防洪系统中的一个“缓冲区”，用以保护社区免受风暴潮和海平面上升的侵害。该“缓冲区”的设计为未来其他功能区块与之衔接预留了空间，以使其形成辐射范围更广的防洪体系。该设计囊括了贯穿整个项目的多种防洪基础设施，包括防洪墙、防洪闸和防洪堤。该设施位于海平面以上约5.0m高的地方，垂直高度约2.4m。

这些防洪设施不仅没有阻隔城市与滨水区间的联系，反而积极推动了城市的发展。东河公园（East River Park）是ESCR项目的核心，而设施匮乏等问题却使得这处占地约23hm^{2}的区域性运动场地既无法满足专业运动队的需求，也无法成为一处激发城市活力的社交场所。项目计划将原有可淹没的东河公园整体抬高，并在其中建造防洪墙和防洪堤。这一举措不仅可使公园自身得以远离洪水的侵袭，更可对园中的树木、设施和建筑物等进行保护。而重新架设于邻近的罗斯福高速公路上的桥梁，则可提升东河公园的可达性，以及城市与滨水区的连通性。重新设计的道路指示系统与入口设施被赋予了更多教育功能，行人和骑行者能够更好地在其间通行。

设计方案将东河公园设想为一个由数座岛屿组成的“公园群岛”。路径系统和岛屿的重新排布为场地提供了颇具适应性的架构，使得场地能够被不断抬高，场地功能亦能根据社区的需求不断更新。同时，公园群岛将开展各种滨海特色活动，以吸引更多居民和游客前来。

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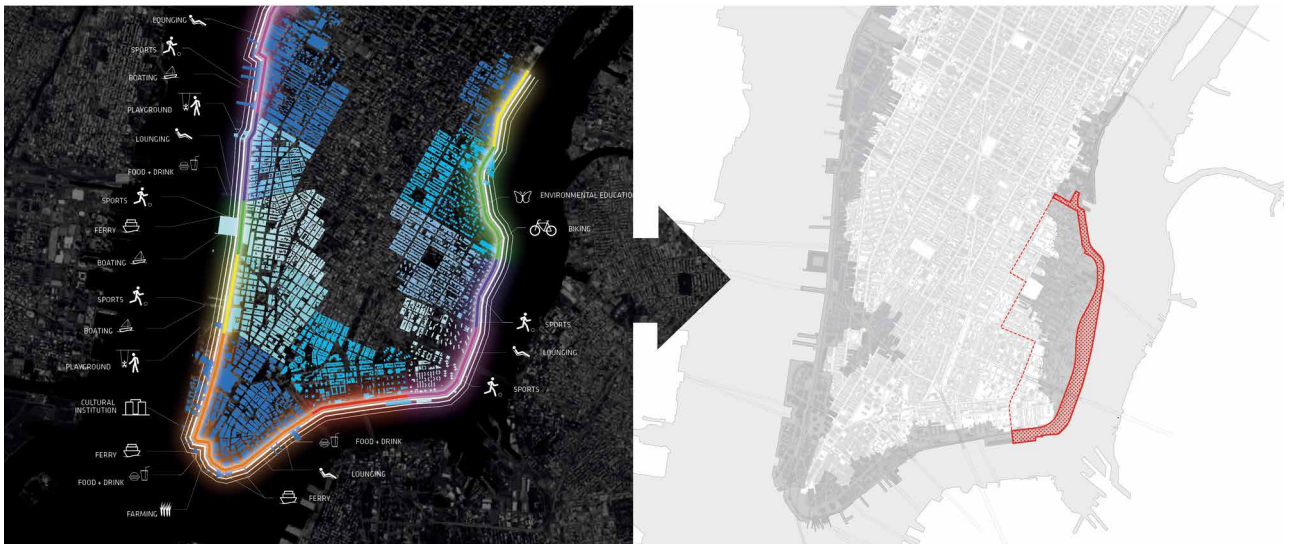

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场地弹性、材料特性与公共项目

尽管ESCR项目意在打造曼哈顿区的全新滨水区，但其也需要从城市的过往中汲取灵感，体现能够代表城市特色的典型材料和细节特征。这些持久耐用且易于维护的材料将由多个城市管理机构共同确定。ESCR项目通过选用合适的材料来满足刚性的基础设施需求，同时增强使用者的体验感。通过路面铺装、园内设施的改善以及其他公园特征的打造，防洪设施将逐渐具备社会服务的功能。

ESCR项目人文尺度的核心体验在于能够让使用者切身体会到城市海岸带的脆弱性。在敏感的沿海环境中，毫厘之差也可能导致灾难。为加强人们对这一事实的认知，设计团队在主环路中采用带状铺装，以展现场地的地形地貌，同时唤起人们对典型的纽约海滩的记忆。由此，公园成为了一条教育廊道，父母可以向子女介绍曾受飓风侵袭的海岸，以及未来海平面上升将达到何种高度。公园中还引入了海滩石块和本地沿海植物，以呼应周边环境。堆砌的石块取代了传统的公园边界，将场地抬高至洪水位之上，既发挥了防洪设施的功能，也保护了植被，同时能够更加清晰地指引养护车辆通行。石块的应用更展现了纽约传统海岸带的地貌特征，

进一步强化了人们从城市到滨水区的不同感受。此外，植物的选择也充分考虑了海水侵蚀的可能。通过以上设计，场地的生态环境将得到极大改善，公园也将更具活力。

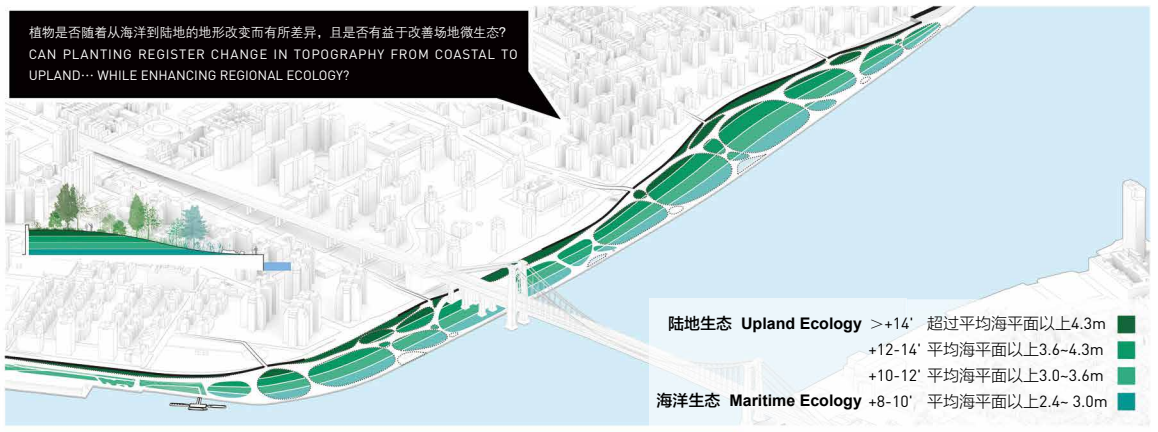
基于此，公园中各类不同尺度的元素不仅彼此促进了功能的实现，更提供了丰富的教育式体验。如果将适应性设计视为弹性设计的核心，那么打造一种有助于人们理解场地脆弱性与灾害风险的环境同样重要。而景观正是这样一种既能突出场地耐久性、可持续性和适应性，亦能体现公园教育功能的媒介。

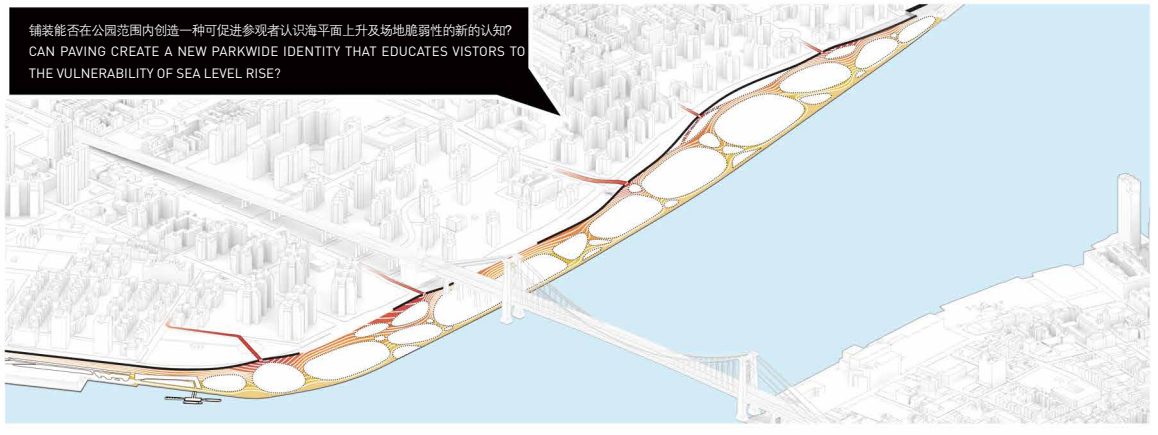
结语

占据着大量公共预算的运输、能源生产、废物处理、供水、防洪等公共基础设施往往是城市地图上的灰色区域。它们如同城市肌理中的黑洞，成为遮挡人们视线的障碍物。

通过积极推动这些公共基础设施与社会项目相结合，新的城市生活方式将被注入到城市的中心地带，而借助这一过程节省的数十亿预算将可用于支持社会慈善事业。系统的活动规划、公园和运动场等将发挥新型基础设施的作用，产生积极的社会效益，将少数人的投资转化为可供多数人享用的空间。在不久的将来，以实用性为主的基础设施将转变为更具社会价值和体验感的综合性城市设施。

景观设计师、建筑师和城市规划师通常会在设计中预留空间以应对不断扩张的社区，并努力缓解由气候变化所引发的问题。而基于曼哈顿滨水区设计的ESCR项目却将带来变革性的城市转型，它大力加强了城市与海滨之间的联系，不仅为邻近社区提供了户外空间和便利设施，也向人们展示了将城市发展与海平面上升问题共同纳入适应性策略的必要性。项目在维持当地自然海洋环境多样性的同时，也将场地流线和活动规划加以统一。在设计过程中，通过与社区居民互动合作，设计团队期待能够为公园未来的使用者带来持久的影响和裨益。而鼓励人们主动参与到对未来城市及自然环境的塑造中是ESCR项目的核心所在。**LAF**





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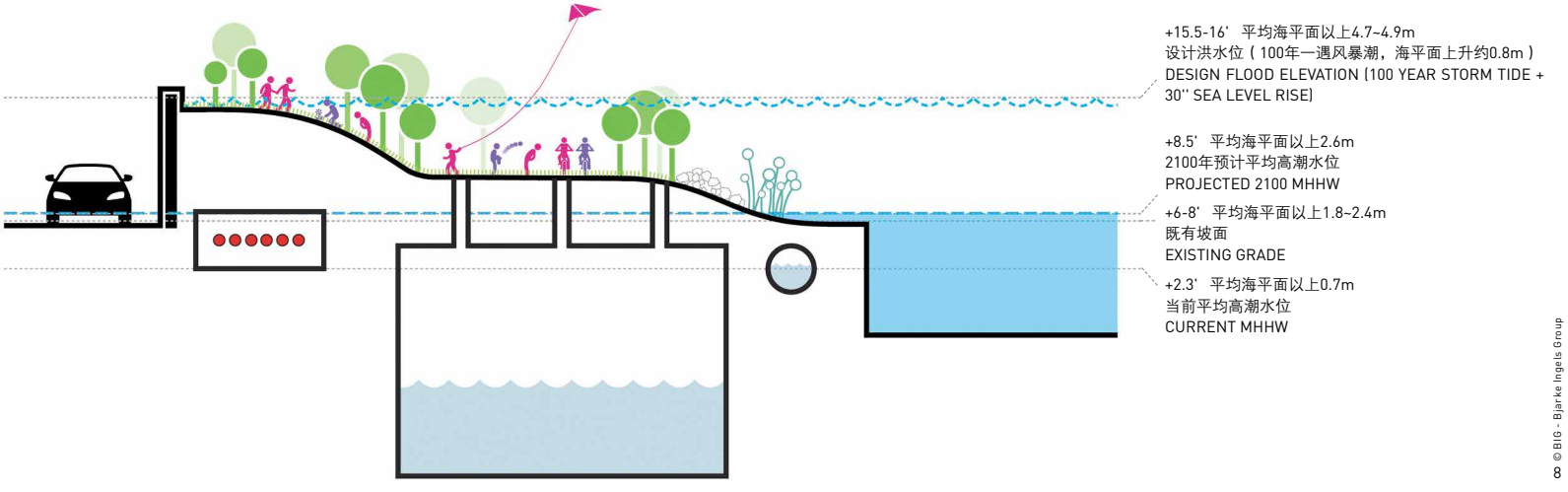
具有弹性的新型地下基础设施可应对不断增多的限制因素
INCREASED LIMIT OF WORK ALSO ALLOWS DESIGN TO ACCOMMODATE NEW RESILIENT SUB-SURFACE INFRASTRUCTURE



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6. 公园群岛：一个弹性框架
7. 公众参与
8. 新型弹性基础设施概念图

6. "Park-ipelago": A flexible framework
7. Public engagement
8. Concept diagram of the new resilient infrastructure

Background

The infrastructure of the past is commonly appropriated as the framework for social and cultural life of the present. For instance, Manhattan's old train tracks turn into the High Line — one of the most popular parks of New York City today; the Tate Modern in London is an old power plant reinvented. Somehow the pioneering industrial infrastructure paves the path for mainstream architecture. Rather than waiting for infrastructure of the past to become decommissioned and reborn with a new social program — could we conceive of our public infrastructures to come with intended social effects from day one?

The BIG U imagines a new future of coastal resiliency and urbanism for Manhattan's waterfront, as a direct response to Superstorm Sandy's devastating impact on New York

City in 2012. Sandy was a shocking climate event that revealed critical vulnerabilities throughout New York City, from weakening infrastructure to low-income and elderly communities. As a visioning proposal, the Big U sought to understand how Manhattan's complex urban environment might integrate flood protection infrastructure in a way that enhances the social realm. After being named the winning proposal in the Rebuild by Design competition, in June 2014 U.S. Housing and Urban Development and the municipal government of New York announced the award of over USD 335 million to design and construct the project's first phase: the East Side Coastal Resiliency (ESCR) project. ESCR is now moving from planning, to design, and soon to the construction of the first 2.2 miles of Manhattan's new waterfront.

Design Strategies and Cooperation

ESCR runs along the East Side of Manhattan, from Montgomery Street to East 23rd Street, and encompasses 72 acres. It is designed to protect over 110,000 mostly low-income, residential units. Re-imagining four city parks, it combines flood protection with public space.

ESCR responds to the precise needs for coastal protection while creating a physical environment that can reflect the wishes and needs of its users, both current and future. Knowing that the project would have to accommodate shifting climates as well as shifting communities, the BIG team asked themselves: could this site become an adaptive urban framework? How could the project actively enhance the city's relationship to the waterfront? What would a new world-class city

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9. 海滨公园运用了乡土植物和材料。
10. 在儿童戏水区中加入沿海林地元素。
11. 从威廉斯堡大桥鸟瞰——暴雨前及暴雨时对比

9. Native plants and materials characterize the coastal park.
10. Children's water play area is embedded in the coastal woodland material palette.
11. Proposed aerial from Williamsburg Bridge — before and during storm

coastline look like? How could it embody the diversity of one of the world's densest and most populous cities? And how could it anticipate a constantly evolving physical, ecological and social environment?

In response, the design team proposed a piece of "social infrastructure" — a network of large scale, state-of-the-art coastal flood protection adapted to the character of each neighborhood it protects. It enhances programmatic diversity while strengthening connectivity. It responds to the specific needs of communities today but remains flexible enough to develop over time, as sea level, climate, and urban conditions continue to change. As the team has learned, adaptability is essential to the design of resilient environments.

To deal with the broad-reaching complexities of this large urban project, the design team brought together a multi-disciplinary team of local and regional experts. The collaboration combined urban ecology, community engagement, urbanism, architecture, landscape architecture and infrastructure engineering. The team worked with local communities and city stewards while developing a design flexible enough to accommodate changing uses and climatic conditions.

For the city of New York, the novel ESCR project also resulted in a unique, and expanded city team. Overseen by the Mayor's office of Recovery and Resiliency, and managed by the Department of Design and Construction, seven city agencies are brought together to assign priorities in terms of design, maintenance, operations and community outreach.

BIG has also adjusted its own design practice to meet the demands

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of a complex public space project. A group of landscape architects, urban visionaries, and strategic thinkers forms "BIG Landscape." This reflects the continued growth of BIG's fundamental approach to design: the built environments of all scales and media should improve the physical and ecological environment, as well as the lives of those who occupy it. This thinking is already evident in several of BIG's built projects, such as the 8-House, and Superkilen park in Denmark, which portray a diverse cross-section of local culture and, in turn, serve as a new model of innovative multi-cultural city life. It is this attitude to design that informs the future of BIG's expanding practice of landscape architecture and urban design, as well as the specifics of ESCR.

A Flexible Framework for Infrastructure and Social Space

ESCR is an urban flood protection "compartment," protecting communities from storm surge and sea-level rise. As a "compartment," it is designed for future "compartments" to be linked up to it, to create longer stretches of flood protection. The design proposes flood protection infrastructure, from walls, to gates, to levees, running the length of the project, at a vertical height of approximately 8-feet with an elevation set at 16.5-feet above sea level.

Rather than acting as an urban barrier between city and waterfront, the flood protection becomes an urban design driver. East River Park, the most significant part of ESCR, is a 57-acre regional sports destination that caters to the needs of organized sports teams, but it currently falls short of the program diversity which is necessary to stimulate a dynamic social destination suitable for contemporary city life. The existing East River Park is to be raised, hybridizing occupiable park with walls and levees, while also becoming a self-protecting park that raises itself above future inundation for the safeguarding of trees, equipment and buildings. Accessibility is improved through re-design of bridges over the adjacent FDR Highway, thereby strengthening urban connectivity to the waterfront. Wayfinding and thresholds are re-defined as educational amenities, all combining to improve the movement of pedestrians and bicyclists between city and waterfront.

East River Park is imagined as a "Park-ipelago" to become a network of island destinations. The organization of paths and islands provides an adaptable framework, allowing fields to be raised over time to avoid future inundation, and allowing program destinations to change as the needs of the community evolve. At the same time, this Park-ipelago forms a cohesive waterfront identity that invites a broader range of residents and visitors through its broader range of program.

Resilience, Materiality, and Public Projects

While ESCR imagines a new waterfront for Manhattan, it must do so with a toolbox of materials and details that are typical of the city's past. This toolbox is established by the city's agencies, and its advantages are durability and easy maintenance. ESCR utilizes materials as an opportunity to satisfy rigid infrastructural requirements while enhancing user experience. Pavement, furnishing, and a host of additional park features transform elements of flood protection into social amenity.

The core of the human-scale experience is the desire to educate park users about the specific vulnerabilities of the city's coastal edge. A few feet, or even inches, mean the difference between safety and disaster in a sensitive coastal environment. To heighten awareness of this fact, banded paving expresses topography along primary circulation paths, recalling the phenomena that are typical of New York's beaches. In this way, the park becomes an educational promenade; parents can point out to their children where Sandy hit, and where future sea level rise will be. Similarly, the park is characterized by coastal stone and native coastal planting. Stone is used in place of traditional park edging, managing the infrastructural needs of raising fields above flood elevation, protecting planting, and marking the path for maintenance vehicles. At the same time, this stone palette grounds the site in the traditional material palette of a New York coastline, enhancing the experience of moving from city to water's edge. Planting is also selected for the eventual inundation of salt water. Local ecology will return to this site, bringing vitality and richness to the park experience.

As thus, park elements exist at multiple scales, enhancing functions while promoting opportunities for educational experience. If adaptability is at the heart of resilient design, so as an environment that teaches about vulnerability and risks. Effectively, landscape is the medium that expresses educational aspects of the park while emphasizing durability, sustainability, and adaptability.

Conclusion

Our public infrastructures for transport, energy, waste, water, flood protection, etc. are major investments in our public budgets. However, they too-often appear as grey areas on the city map. Like black holes in the urban fabric lost for the public realm — they are ugly walls that cast shadows on the neighbors or block the views.

By proactively cross-breeding public infrastructure with social programs, we can inject new urban life forms into the heart of our cities and seize billions of dollars to the shrinking budgets for urban social philanthropy. New infrastructure can instead have positive social effects in the forms of nested programs, parks, and playgrounds — turning the investments by the few into the enjoyment for the many. Pragmatism becomes hedonism in the social infrastructure for the city of our future.

As landscape architects, architects, and urban planners, we often anticipate change by designing for growing communities while mitigating issues caused by climate change. For the Manhattan waterfront, ESCR is a radical urban transformation that effectively enhances the city's relationship to the waterfront. It defines the need for hybridizing urban adaptation strategies for growth and sea level rise while providing adjacent communities open-space amenities. It supports the diversity of its natural maritime surroundings while unifying circulation and program. It engages with communities through its design process to benefit future generations of park visitors. At its core, ESCR has the opportunity to grow the consciousness of future stewards of our urban and natural environments. **LAF**

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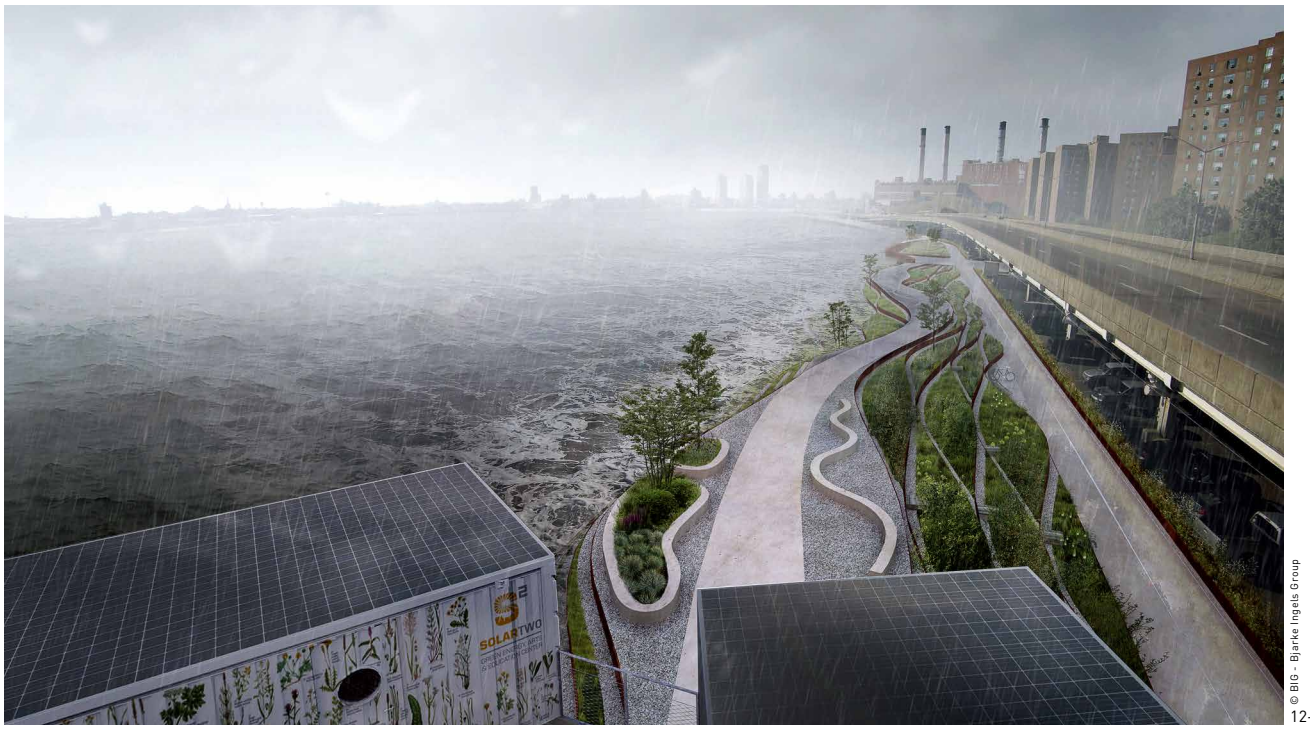

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12. 史蒂文斯湾暴雨前及暴雨时对比

12. Stuyvesant cove — before and during storm