STREAM DAYLIGHTING:
AN OPERATIVE LANDSCAPE INFRASTRUCTURE FOR ANKARA

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

ÖZGE İDALİ ÖZDEN

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
URBAN DESIGN IN CITY AND REGIONAL PLANNING

SEPTEMBER 2020

Approval of the thesis:

STREAM DAYLIGHTING:
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ABSTRACT

STREAM DAYLIGHTING: AN OPERATIVE LANDSCAPE INFRASTRUCTURE FOR ANKARA

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September 2020, 160 pages

While politicians prefer to make investments on visible projects, sanitary and ecological infrastructure projects are not generally preferred or postponed due to their long-term results. Infrastructure investments, which are realized by spending a large amount of public taxes, are mostly considered problems that engineers have to solve and do not attract most people, including designers. The most crucial infrastructure problem for cities is Urban Water. For instance, water flows when we turn on the tap and discharges when we flush the toilet; however, we do not think where the water comes from and where it goes to unless a problem occurs. Nevertheless, urban morphological transformations are guided by urban water infrastructures. In this context, the relation between natural waterways, the essential component of the geomorphological process in the city, and the urban remains distant, too. For example, the streams, which have played an important role in the formation of the settlements of Ankara, are now disappeared.

Throughout the 20th century, it was common for small streams to be channelized first, then covered and turned into a sewer line. However, the alarming condition of ecological phenomena like global warming, climate change, and depletion of resources in the 21st century has more clearly revealed the fact that resources should be used sustainably. The tension between economy and ecology has caused political decisions to be taken in favour of economic interests. However, it has appeared that engineering and infrastructure solutions that serve economic interests are not profitable in the long term, and ecology-oriented engineering and design solutions have begun to be implemented in the cities through the lens of landscape infrastructure. Stream daylighting projects have started to be implemented in several metropolises of the world, where the streams are channelized, transformed into a sewage line, and covered in the cities. These projects serve purposes such as flood prevention, transition to separate sewage systems, efficient use of treatment facilities, human-nature interaction, and increasing biodiversity.

Hydrological features of Ankara have been neglected in the formation of the city since the 1960s. The capital, which has been struggling with flood and infrastructure problems due to rapid urbanization, is studied in terms of stream daylighting. The disappearance of waterways, which were once a determinant of urban formation, is considered as an urban planning, design, and infrastructure problem. In the 21st century, policies and infrastructure solutions for urban streams are developed not only by engineers but also by design and ecology-oriented disciplines collectively. This study investigates the historical relationship between infrastructure and urban streams through Ankara case by using city maps and various reports. It presents the "Disappeared Streams Map of Ankara" for 100 km^2 area within the city center. Moreover, the criteria for stream daylighting were identified, and the sites, which can be applied, were evaluated, and the potential sites were determined for Ankara.

Keywords: Infrastructure, Landscape Infrastructure, Stream Daylighting, Disappeared Streams, Ankara

ÖZ

DERELERİN GÜNYÜZÜNE ÇIKARILMASI: ANKARA İÇİN ETKİN BİR PEYZAJ ALTYAPISI

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Eylül 2020, 160 sayfa

Politikacılar görünür uygulamalara yatırım yapmayı tercih ederken, sıhhi ve ekolojik altyapı uygulamaları uzun vadeli sonuçları nedeniyle çoğunlukla tercih edilmeyen ya da ertelenen yatırımlardır. Büyük miktarlarda kamu vergisi harcanarak gerçekleştirilen altyapı yatırımları daha çok mühendislerin çözmesi gereken problemler olarak düşünülür ve tasarımcılar dâhil, çoğu kişinin ilgisini çekmez. Şehirler için en önemli altyapı problemi Kentsel Su'dur. Örneğin; su, musluğu açtığımızda gelir ve tuvalet sifonunu çektiğimizde gider ancak biz bu suyun nereden gelip nereye gittiğini bir sorun çıkmadıkça pek de düşünmeyiz. Hâlbuki kentin morfolojik değişimlerine yön veren özellikle kentsel su altyapılarıdır. Bu bağlamda kentteki jeomorfolojik süreçlerin en temel bileşeni olan doğal suyolları ile kentlerin ilişkisi de mesafelidir. Örneğin, Ankara'daki yerleşimlerin oluşumunda önemli rol oynayan dereler artık görünmezdir.

20. yüzyıl boyunca küçük akarsuların önce menfeze alınması, daha sonra kapatılması ve bir kanalizasyon hattına dönüşmesi dünya genelinde çok yaygındı. Ancak 21. yüzyılda hissedilmeye başlayan küresel ısınma, iklim değişikliği ve kaynakların tükenmesi gibi ekolojik olayların endişe verici seviyelere çıkması, kaynakların

sürdürülebilir bir şekilde kullanılması gerektiği gerçeğini daha net ortaya çıkarmıştır. Ekonomi ve ekoloji arasındaki gerginlik, politik kararların genelde ekonomik çıkarlar lehine verilmesine yol açmıştır. Ancak ekonomik çıkara hizmet eden mühendislik ve altyapı çözümlerinin uzun vadede karlı olmadığı ortaya çıkmış, ekoloji odaklı mühendislik ve tasarım çözümleri peyzaj altyapısı yaklaşımıyla kentlere uygulanmaya başlamıştır. Kent içerisinde, kanallara alınarak bir kanalizasyon hattına dönüşmüş ve üzeri kapatılmış derelerin, tekrar açılması dünyanın çeşitli metropollerinde hayata geçirilmiştir. Bu projeler, taşkın önleme, ayrık kanalizasyon sistemine geçme, arıtma tesislerini verimli kullanma, insan-doğa etkileşimini ve biyoçeşitliliği arttırma gibi amaçlara hizmet etmektedir.

Ankara'nın hidrolojik özellikleri, 1960'lı yıllardan itibaren kentsel oluşum sürecinde ihmal edilmiştir. Hızlı kentleşme sonucu birçok taşkın ve altyapı sorunlarıyla boğuşan başkent derelerin günyüzüne çıkarılması açısından incelenmiştir. Bir zamanlar kentsel oluşumun belirleyici unsuru olan su yollarının kaybolması, bir kentsel planlama, tasarım ve altyapı problemi olarak düşünülmüştür. 21. yüzyılda, kentsel akarsular için politikalar ve altyapı tasarım çözümleri, sadece mühendisler tarafından değil, tasarım ve ekoloji odaklı disiplinler tarafından kolektif olarak geliştirilmektedir. Bu çalışma, Ankara örneği üzerinden altyapı ve kentsel akarsuların tarihsel ilişkisini şehir haritaları ve çeşitli raporları üzerinden incelemiştir. Kent merkezini içine alan 100 km^2’lik bir alanda “Ankara’nın Kaybolan Dereler Haritası”nı ortaya çıkarmıştır. Ayrıca, derelerin günyüzüne çıkarılma kriterleri saptanarak Ankara’da bu olgunun mümkün olabileceği alanlar saptanmış ve potansiyel alanların değerlendirmesi yapılmıştır.

Anahtar Kelimeler: Altyapı, Peyzaj Altyapısı, Derelerin Günyüzüne Çıkartılması, Kayıp Dereler, Ankara

To the blue

ACKNOWLEDGMENTS

I would like to express my deepest gratitude to my supervisor, Prof. Dr. Adnan Barlas, not just for his incredible support, guidance, and patience throughout this research but also for his sincere conversations during the graduate study. I would also like to thank Dr. Funda Baş Bütüner for her suggestions and comments from the beginning of this research; she enlightened me with her directions. I am grateful to the members of the examining committee, Assoc. Prof. Dr. Meltem Şenol Balaban and Dr. Cansu Canaran for their valuable suggestions and contributions to the thesis.

I would like to express my earnest gratitude to Onur Bektaş, who generously opened his entire archive to me and answered all my questions during the case research. It would be harder to reach all the data I needed, especially in these days of the pandemic. Moreover, I would like to extend my gratitude to the lovers of Ankara, Hasan Akyar, and Ahmet Soyak. They make great effort voluntarily for protecting the natural sources of Ankara and share their knowledge.

I would like to offer my special thanks to Assoc. Prof. Dr. Olgu Çalışkan for his encouraging and friendly attitude from the beginning of my master's process in METU, and Prof. Dr. Adnan Kaplan, the member of the Department of Landscape Architecture in Ege University, who first spoke to me about Landscape Infrastructure concept and helped to spark new ideas in my mind.

Last but upmost, I would like to thank my significant other, Deniz Özden, who has shared the most pleasant conversations in my life and provided the most generous support throughout this research.

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ABBREVIATIONS

ASKİ	Ankara Water and Sewerage Administration
BAKAY	The Great Ankara Sewer Project
CSOs	Combined Sewer Overflows
DSİ	State Hydraulic Works

CHAPTER 1

INTRODUCTION

> "A land ethic, of course, cannot prevent the alteration, management, and use of these 'resources' but it does affirm their right to continued existence, and, at least in spots, their continued existence in a natural state."
>
> Aldo Leopold, 1949

1.1 Problem Statement

Today, 55% of the world's population lives in urban areas, and this number is expected to increase to 68% by 2050.[1] While we have become an urban species, "*Homo sapiens urbanus*"[2], infrastructure is an integral part of the urban realm that enable growth of cultures. Rivers, mountains, forests, animals, and other components of nature meet the needs of human life such as freshwater, air, food, clothing, shelter, and hygiene through infrastructural systems. In the meantime, the recycling feature of nature is utilized in order to eliminate the waste left from our consumption. However, compared with the cities of ancient times, it is seen that the technological and mechanical development of 20th century infrastructure systems and the degradation of natural areas progress in proportion.

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[1] United Nations (2018). 68% of the world population projected to live in urban areas by 2050. See: https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html accessed on March 2020.

[2] Forman, R., Infrastructure and Nature: Reciprocal Effects and Patterns for Our Future. In Spiro Pollalis, Daniel Schodek, Andreas Georgoulias and Stephen J. Ramos (Ed.). *Infrastructure, Sustainability & Design*. (276-315). London: Routledge. p.44.

The resources are limited, and water is the most important one for humans in providing freshwater and hygiene. Considering the amount of water worldwide, only 2.5% of it is freshwater, and 70% of this water is hidden in glaciers.[3] In other words, the amount of accessible freshwater is even less than 1% of the world's total water presence. Since the fundamental freshwater resources are streams, lakes and groundwater that consist of low concentrations of dissolved salts, historically, the settlements near a water source are not a surprise.

However, during the last 150 years, streams have disappeared from urban surfaces because of water pollution and infrastructural interventions. As cities became industrialized, water pollution from factories and flushing toilets from households discharged into the streams without treatment. It causes oxygen depression into the water bodies and results in dead zones. The urban streams became open sewage lines. The epidemics of waterborne diseases have led to the decimation of large human populations. In the meantime, the dense settlements along the floodplains faced with flooding. In order to prevent diseases and mitigate flood risk, channelizing and covering of urban small and medium streams became very common for almost every city in the world. Hence, buried urban streams became sewer and land to construct roads and buildings.

Today, with ecological awareness, water resources started to be handled on a watershed basis. Accordingly, in developed countries, the treatment of industrial and domestic wastewater has become obligatory and large-scale treatment plants have been established. However, there is still a close relationship between infrastructure and urban streams. Streams are still a part of sewer and transportation infrastructure as flowing in the culverts. They carry stormwater and wastewater to treatment plants through combined sewer system. The amount of wastewater that is received by the treatment plant gives rise to the problem of processing of solid material, since combined sewer system conveys both stormwater and wastewater. On the other

[3] WWF. (2014) Türkiye'nin Su Riskleri Raporu. Ofset Yapımevi. İstanbul.

hand, impervious surfaces cause the floods in cities by decreasing infiltration of precipitation and increasing surface runoff. During rainy days, the capacity of pipes/culverts cannot be sufficient, causing flooding or combined sewer overflows.

This end-of-pipe technology is required high cost investments and maintenance for both the treatment plant and long-distance piping system. The situation is neither economic nor ecological. Changing city's morphology by covering the streams limited the hydrological cycle and social opportunities that support public amenities. The streams, creeks and rivers were as if they have been living, just as the name of streets and roads, and urban dwellers have no idea that streams run underneath their feet. They become out of sight, out of mind while contained safely in a concrete box or pipe.

External economy of urbanization and traditional engineering methods have resulted in an isolated, mono-functional and unilateral relationship between the urban streams and infrastructure. The streams of Ankara, which were the determinant of the geomorphology of the city, have been neglected and covered by the practice of urbanization. They have become sewer lines and roads today. In the process of urban formation, the disappearing of the streams has changed the hydrology of Ankara since 1960s. The city has faced against floods, which has resulted with loss of lives and property for long time and the sewerage infrastructure cannot handle excessive precipitations. In addition, the ignorance of the natural waterways debar urbanites from human-nature interaction.

In this regard, this thesis sees the covering and disappearing of the streams as a disadvantageous urban and therefore problematic practice, in ecological, economic and social terms, specifically in the case of Ankara. By reviewing the practice of stream daylighting, the lost streams of Ankara is traced historically and evaluated as an infrastructure problem in urban agenda, finally potential sites for stream daylighting are specified through the lens of landscape infrastructure.

1.2 Aim of the Study and Research Questions

The study aims to show that the relationship between the urban streams and urban infrastructure, and to discuss ecology-economy tension in terms of urban water infrastructure problems, which arise by covering or ignoring the urban streams, finally to raise a public awareness for taking a step toward long term plans for stream rehabilitation in the context of landscape infrastructure approach. The natural structure of urban stream landscapes has economic, ecological, and social benefits beyond aesthetic values by mitigating floods, heat island, and increasing biodiversity, human-nature interaction and climate qualities. In that sense, stream daylighting is suggested for building natural drainage area by giving opportunities for new urban morphologies. This will sustain the inherent functions and qualities of streams to render them become the components of urban landscapes, instead of burying them into culverts or pipes. Landscape Infrastructure is a theoretical lens for improving existing limited resources and creating flexible, multifunctional, and sustainable infrastructures through design while anthropogenic change continues. In addition, it emphasizes the disconnection of infrastructure operation with planning and design practices.

At this juncture, this study targets to unfold the importance of disappeared urban streams by taking an issue the water infrastructure and urban ecology economically. The study takes Ankara as a case for determining its lost streams during the urban formation process by neglecting the hydrological characteristic as an urban space. In order to reach the study objective, the main research question is:

“How can disappeared streams bring back to urban fabric as a part of landscape infrastructure?”

In accordance with the research question, sub-questions seeks for answering as follows:

1. What are the critical role and services of streams in urban areas?
2. Why did urban streams disappear from the urban surface?

3. What is stream daylighting? What are the challenges and benefits of it?
4. How have Ankara Streams disappeared from the urban surface within 50 years?
5. Are Ankara Streams eligible for daylighting?

1.3 Method of the Study

The major reason to choose Ankara as the case of the study is the urban geomorphology, which formed by streams and later disappeared from the surface in the process of urban formation. Accordingly, the main goal of the study is to determine the disappeared streams of Ankara and detect whether the stream daylighting project can be applied for these streams. Various methods have been used for reaching this goal: Mapping, Determining the Feasibility Assessment, and Spatial Overlay Assessment.

The process and feasibility assessment of a stream daylighting project are specified in Table 3.1. The illustration of the existing situation, assessment for the site, design, and construction are the main issues for a stream daylighting process. For the determination of disappeared streams, geographical and historical analysis was examined. Thus, urban water problems were unfolded during the urban formation of Ankara. Accordingly, it was created the "Disappeared Streams Map", which is essential to illustrate for being aware of the built environment. Since Ankara is the capital of Turkey, its borders have expanded, which is why not all lost streams could be studied in this thesis. The core of the city and urban formation is considered, and 10x10 km of the study area determined for mapping. Also, the limited database about streams and infrastructure history of the city directed the author toward the determined study area in the core of the urban. The streams that unfolded in the "Disappeared Streams Map" are not the only lost streams of Ankara, of course. However, the visits made in January to ASKİ for obtaining the routes of the culverted streams have been inconclusive. In addition, there is almost no publication about Ankara streams except "Suda Suretimiz Çıkıyor" by Erman Tamur. Another recent study, "Under the road, the river!" documentary, which traces the lost streams of Ankara, has been a guide by raising awareness.[4] Eventually, the determination process of the disappeared streams of Ankara is based on the book of Erman Tamur, city maps, the institution reports, BAKAY project sheets, and documentation, done by volunteers[5]. After all, more time and site-survey is required for a broader study area.

According to Table 3.1, the second step was assessments for site selection and watershed. When disappeared streams paths determined in the study area, rapid urbanization, non-ecological and insufficient infrastructure solutions, and flood-risk were found as the main existing problems along the culverted streams. The feasibility criteria were determined according to the infrastructural and planning data. *Flood-risk, land use, parks, potential green areas, and commercial areas* were considered to choose potential sites. These feasibility assessment criteria were overlaid by mapping.

Finally, Spatial Overlay Assessment indicates the sites with the most potential and feasible to be daylighted. The all assessment criteria identified in Table 3.1, such as depth of the overburden, types of the culverts or pipes, and community support, could not be included in the determination of potential sites for daylighting in Ankara. The main reason for that is the limited databases on the sewerage infrastructure, both historically and currently. Besides, the detailed site survey data was required for the research, which necessitates a broader time frame. However, a chart was created by using the maps and data to understand and evaluate the potential sites spatially.

The determination of disappeared streams and the potential sites for stream daylighting, different types of sources, and maps are instrumentalized. Various materials and software products are integrated into the mapping process (Figure 1.1).

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[4] Semiz, Y. (2019) "Under the road, the river!" Luwi Film. Trailer of the documentary: youtube.com/watch?v=FXACGsb1OdU accessed on July 2020.
[5] Ahmet Soyak, Youtube Channel. https://www.youtube.com/user/ahmetsoyak1 accessed on July 2020.

The outputs that are obtained from the mapping processes are the major research material in this study. Thus, public awareness-raising, encouraging actors for dialogue, and taking a step towards long-term plans for the rehabilitation of streams were aimed with these maps.

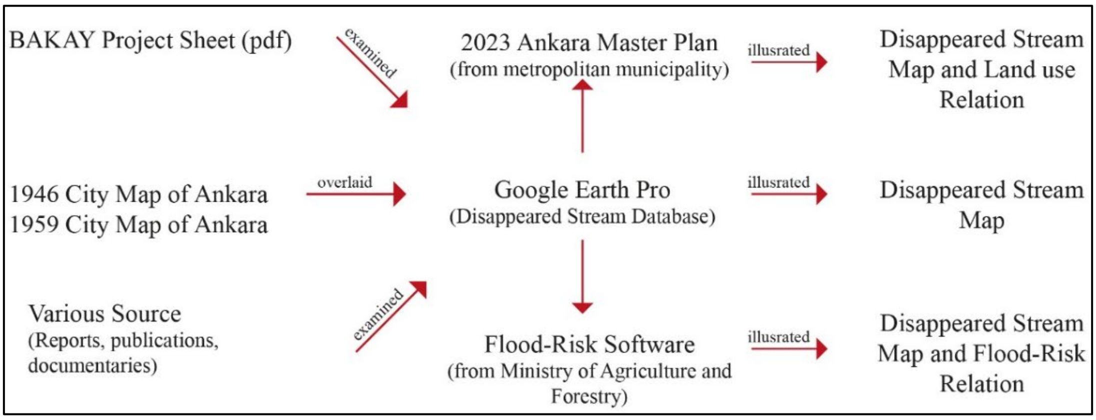

Figure 1.1. Mapping Process of the Study Area

1.4 Structure of the Study

The study consists of five chapters, including the introduction and conclusion. The structure of the study has three main phases: Literature review, analysis of daylighting and the precedent projects, and the case study analysis, evaluation, and mapping (Figure 1.2). These phases of the study enabled the author to determine the disappeared streams and the potential sites for stream daylighting in Ankara. Moreover, the findings of the study have demonstrated the necessity of stream daylighting as physical and social infrastructure in Ankara.

The first phase of the study is based on an extensive literature review by focusing on the disconnection of design practices with urban infrastructure and sustainable infrastructure approaches, including "Landscape Infrastructure". First, the water infrastructure, urban streams, functions, and alterations were reviewed widely, relating to the research questions to build a theoretical framework to address urban streams as landscape infrastructure in Chapter II. Accordingly, it was evaluated the historical transformation of urban streams about urban sewerage infrastructure from the beginning of industrialization to present, and outcomes of the alterations of stream in terms of economy and ecology. After depicting the problems, the new urbanism approaches, landscape infrastructure is evaluated. Thus, the link between urban streams and water infrastructure is unfolded by presenting the historical infrastructure practices, the loss of streams from urban surfaces, and economic and ecological problems. For that purpose, existing data were gathered from journals, books, reports, electronic documents, dissertations, documentaries, and plans.

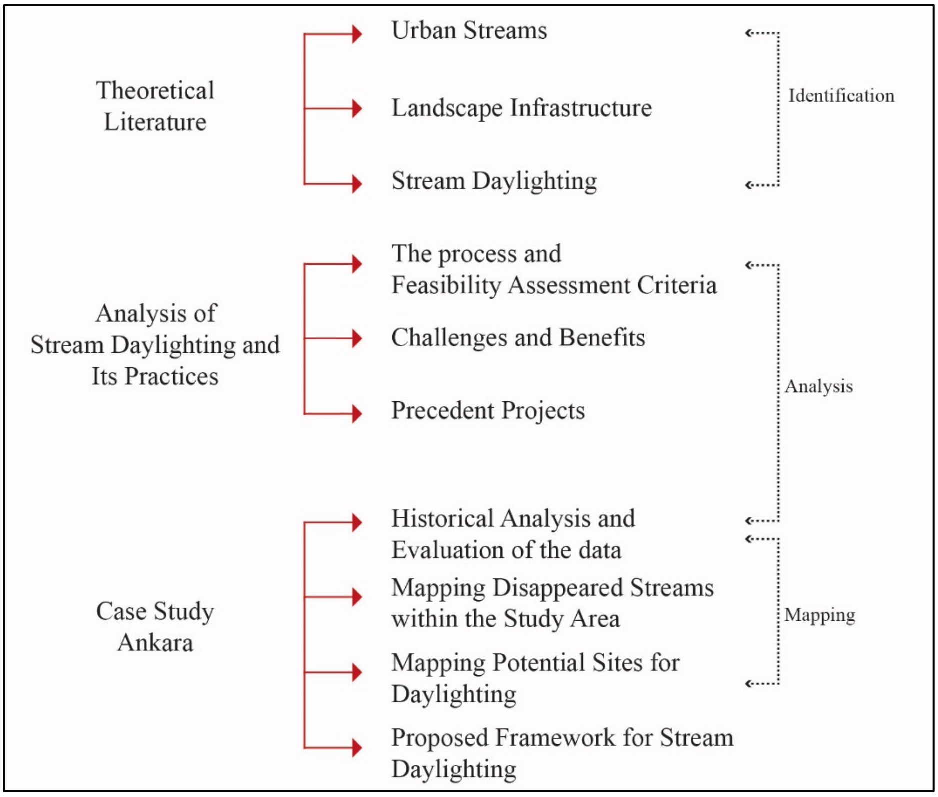

Figure 1.2. The Structure of the Study

As a radical stream rehabilitation method, the *"stream daylighting process"* was examined with its challenges, benefits, and precedent projects in the second phase of the study. In addition to the theoretical literature review, the feasibility assessments for site selection, design, and construction suggestions were determined by analyzing the relevant literature and implemented projects to obtain an initial guide in the third chapter of the thesis. The process and feasibility assessments were listed considering the daylighting projects in *Table 3.1*. The implemented projects from worldwide -

Strawberry Creek, Berkeley; Zurich Stream Daylighting Program; Cheonggyecheon River, Seoul, Korea; and Oslo Reopening Waterways, Norway- are included in the research. According to the various targets of stream daylighting, these projects are chosen, such as mitigating flood, separating the combined sewer system, and supporting public amenity.

In the third phase of the study, Ankara was taken as the case of this thesis. A historical and geographical analysis of Ankara streams about urban infrastructure is unfolded in Chapter IV. It was investigated to determine the reasons and objectives for stream daylighting in Ankara, and potential sites unfolded according to the initial feasibility assessment table. First, the disappeared streams were traced back; their causes and results were determined in terms of urban infrastructure. The "Disappeared Streams Map" was created to be aware of the lost hydro morphology of Ankara. According to the stream daylighting feasibility assessments, potential sites for stream daylighting were unfolded by map overlay technic and evaluated spatially. Finally, the proposed framework for planners, policymakers, and designers was given according to the feasibility assessment criteria and implemented project analysis.

In Chapter V, the conclusion gives a brief explanation of the findings of the research. It contains the problems of the relationship between water and the city (Ankara) in terms of urban design. The benefits are determined about the possibility of stream daylighting in Ankara and how the inclusivity of the potential daylighting sites can be improved regarding planning and urban design policies.

CHAPTER 2

URBAN STREAM AND LANDSCAPE INFRASTRUCTURE

This chapter presents an overview of the basic definitions and functions related to urban streams and urban infrastructure. First, the functions of water streams are evaluated in biological, chemical, and geomorphological terms to introduce the life cycle network. Second, the alterations and loss of water streams are investigated in the context of urban infrastructure. Ecological outcomes of the relation between streams and sewer infrastructure enable us to understand human intervention impacts.

With the increase in anthropogenic effects, new approaches came into the urban agenda considering ecological and morphological aspects. A new urbanization approach comes into view through the rethinking of traditional urban infrastructural systems by means of amalgaming "landscape infrastructure" and streams as urban landscape infrastructure. Water bodies, one of the essential components of the cities, are addressed as components of urban landscape infrastructure to understand how to sustain them ecologically, socially, and economically.

2.1 Stream and Related Geography

If all the water on the earth is to be put in a 5-liter bottle, the amount of freshwater available to us humans is only 0, 05 lt., which is approximately one tablespoon.[6] Water streams, lakes, and groundwater are the primary freshwater resources that

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[6] WWF. (2014) Türkiye'nin Su Riskleri Raporu. Ofset Yapımevi. İstanbul. p.5.

consist of low concentrations of dissolved salts and other total dissolved solids. Even if the amount of water in the earth is stable and constant, the water quality and accessibility are changing due to anthropogenic effects. This degradation of natural landscapes has increased rapidly since there is an intense and dominant use related to industrialization that does not allow the self-repair process of nature. The global loss of freshwater wetlands, which have a unique capacity to filter and improve water quality, is of particular concern; it is estimated that 64–71% of wetland extent has been lost since 1900.[7] Within the framework of the current climate change scenario, approximately half of the world's population is estimated to suffer from water shortage in 2030.[8]

2.1.1 Stream-Related Terminology

A body of running water (such as a river or creek) flowing on the earth is a simple definition of **streams**. The streams flow into the sea or a lake or confluence with another water stream depending on its magnitude. If the stream has a smaller body, it is called a creek or brook and if larger and deeper, it is called a river.

The water in streams come from **precipitation** such as drizzle, rain and snowmelt that runs down a mountainside. Some of the water is filtered by soil and leads to **groundwater**. Groundwater, in aquifers, flows and meets streams, lakes, or seas depending on its level. When the amount of precipitation exceeds the soil's saturation rate, water starts to flow as **surface runoff**. A small springhead, or a depression accumulated with water after each rain flows and feeds the stream below.

Some small streams like creeks can be seasonal and do not flow all the time. Small streams, including those that do not flow regularly, compose the majority of the

[7] Davidson, N. C. 2014. How much wetland has the world lost? Long-term and recent trends in global wetland area. Marine and Freshwater Research, Vol. 65, No. 10, pp. 934–941.
[8] IPCC Report Global Warming of 1.5 ºC. 2018, Chapter 3. pp.197-207.

region water.[9] These water sources, referred to as **headwater** streams, are considered insignificant and even not marked on maps; however, the health of small streams is critical since they feed the entire river basin.[10] Rivers as large water bodies start much smaller tributaries, creeks, and streams combining, just as micro capillaries in a human body to generate larger blood-carrying arteries and veins. Strahler's method shows the order of streams by beginning with the shortest one in Figure 2.1.

The rate of the water movement; in other words, the velocity of a stream depends on the morphology of the area, slopes, soil type, and vegetation and precipitation rate. Linearization increases the velocity of a stream and changes its hydrological characteristics.

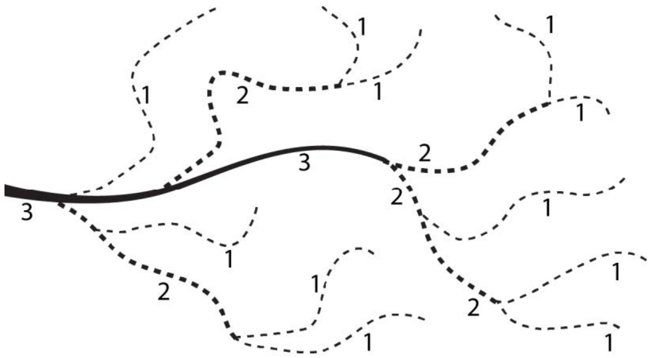

Figure 2.1. Strahler's Stream Order
[Source: Strahler (1952)]

A **watershed,** also known as a drainage basin, is an area of land that captures water in any form, such as rain, snow, and drains to a common water body like stream, river, or lake. While **watershed** is a higher ground, a dividing ridge between drainage areas, **basin** is the entire land drained by a river and its tributaries.[11] They make up a river system together. Reimhold classifies basin, sub-basin, watershed,

[9] Streams. US Environmental Protection Agency. https://archive.epa.gov/water/archive/web/html/streams.html accessed on March 2020.
[10] Ibid.
[11] Merriam Webster Dictionary.

subwatershed, and catchment area as a water basin.[12] An urban watershed area may extend several square miles (1 mile=1.6 km) and contain several major stream systems (Figure 2.2).[13]

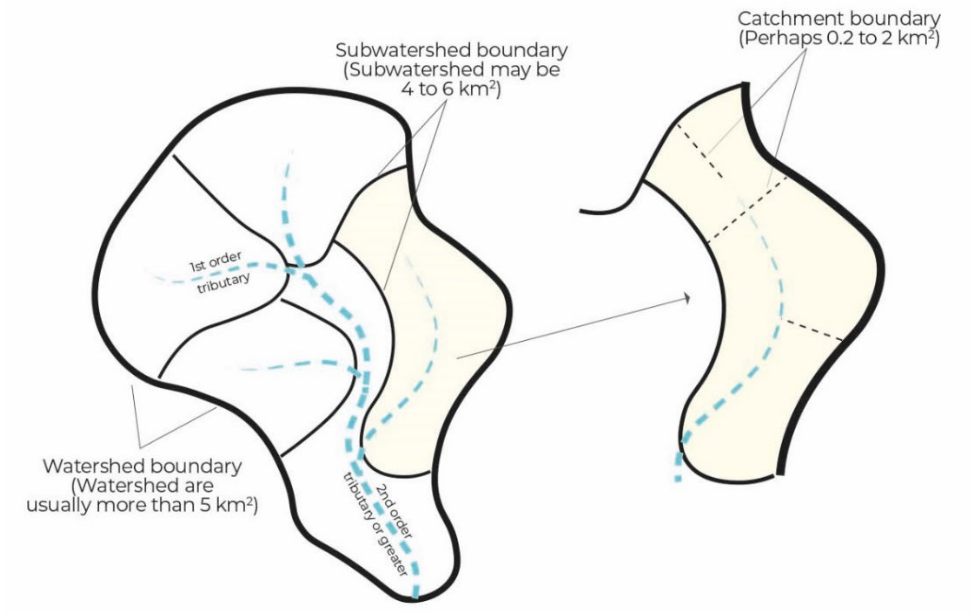

Figure 2.2. Watershed scale: Watershed, Subwatershed, and Catchment

[Reproduced from Claytor, R. (2000)]

On the other hand, a stream base consists of three zones: stream channel, floodplains and slopes.[14] When the flow reaches between the channel and its floodplain, it is named as **bankfull discharge** (Figure 2.3), and it is morphologically very significant due to moving sediments, forming or removing banks and changing meanders.[15] The

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[12] Reimold, R. J. (1998). Watersheds-an Introduction. In Robert J. Reimold (Ed.), *Watershed Management, Practice, Policies, and Coordination* (pp. 1–5).
[13] Claytor, R. 2000. Assessing the Potential for Urban Watershed Restoration: The Practice of Watershed Protection. Center for Watershed Protection, Ellicott City, MD. (Pages 705-711). p.9.
[14] Şahin, Ş., Perçin, H., Kurum, E. ve Memlük, Y., 2014. Akarsu Koridorlarında Peyzaj Onarımı ve Doğaya Yeniden Kazandırma Teknik Kılavuzu. T.C. Orman ve Su İşleri Bakanlığı, Doğa Koruma ve Milli Parklar Genel Müdürlüğü adına BEL-DA Belde Proje ve Dan. Tic. Ltd. Şti., Ankara.p. 15.
[15] Mulvihill, C.I., Baldigo, B.P., Miller, S.J., DeKoskie, Douglas, and DuBois, Joel, 2009, Bankfull discharge and channel characteristics of streams in New York State: U.S. Geological Survey Scientific Investigations Report. pp.1-2

analysis of stream depth, velocity, and cross-sectional area can give the bankfull discharge and channel characteristics curves.[16]

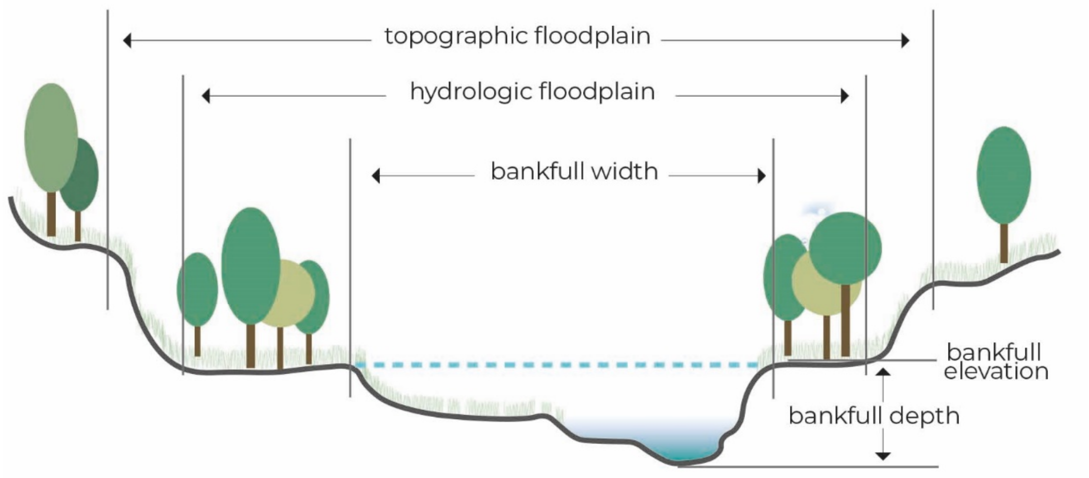

Figure 2.3. Bankfull discharge

[Reproduced from Federal Interagency Stream Restoration Working Group (1998)]

A river system is a **hydrological system** as well as an ecological system with its *running* and *dry* branches and balances groundwater level and naturally vegetated surroundings by collecting and draining the stormwater.[17]

The water movement in the earth, in other words, **water cycle,** is an important motion that keeps the ecosystem sustainable. It is the circulation of the water molecules (H_2O); solid, liquid and gaseous states of water converted into each other on earth. This cycle, also called the hydrological cycle, consists of complex physical, chemical, and biological processes that sustain life such as flora, fauna, fungi, etc.

Hydrological cycle, shown in Figure 2.4, is composed of falling of the water to the earth by precipitation, holding of it in the soil by plants, leaking of it in permeable areas, storing some of it as groundwater, and overflowing to streams as runoff to

[16] Ibid.

[17] Dinç, H. (2015) *İstanbul Derelerinin Fiziki Değişimi ve Arazi Kullanım İlişkisi,* Unpublished PHD Thesis; Şehir ve Bölge Planlaması Anabilim Dalı, İTÜ, İstanbul. p.4.

meet the basin below.[18] Eventually the water cycle is repeated with evaporation and transpiration. During this process, water carries a large amount of sediment and nutrients and creates changes on the surface of the earth through erosion and accumulation.[19]

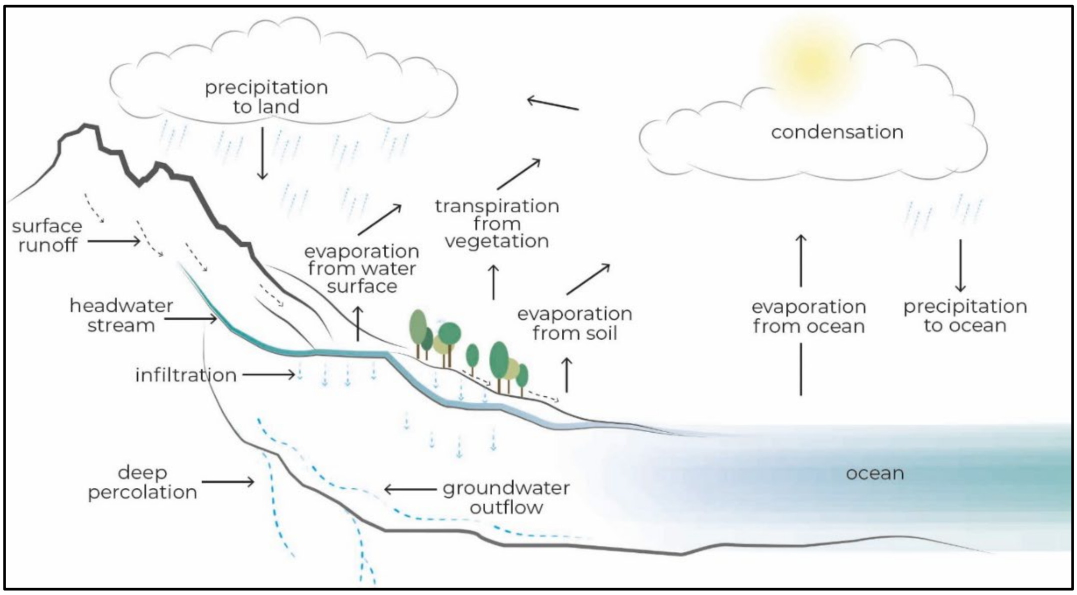

Figure 2.4. In the hydrologic cycle, water is transferred between the land surface, the ocean, and the atmosphere. [Reproduced from britannica.com/science/water-cycle (accessed November 2020)]

The crucial point for a healthy water cycle is a land use plan with respect to catchment areas, which are the smallest recharge basin for the hydrologic process. Human actions such as channelization or covering the surface of the soil impinge on the **hydrological connectivity** between precipitation and streams, whereby mostly resulting in decreases and collapses, finally giving way to increased water pollution, erosion, flood, and water scarcity.

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[18] Şahin, Ş., Perçin, H., Kurum, E. ve Memlük, Y., 2014. Akarsu Koridorlarında Peyzaj Onarımı ve Doğaya Yeniden Kazandırma Teknik Kılavuzu. T.C. Orman ve Su İşleri Bakanlığı, Doğa Koruma ve Milli Parklar Genel Müdürlüğü adına BEL-DA Belde Proje ve Dan. Tic. Ltd. Şti., Ankara.p. 12.
[19] Dunne, T. and Leopold, L.B. (1978) Water in environmental planning. W.H. Freeman and Co., New York.

The water cycle drives other cycles that involve different molecules circulating through the ecosystem, which are essential for life. The carbon (C), nitrogen (N), phosphorus (P), etc., which are the backbones of DNA, are recycled through biogeochemical cycles.[20] As energy comes from the sun and flows as heat, chemical elements recycle between its various forms from the non-living (abiotic) components of the biosphere to the living (biotic) components. This event is called the **biogeochemical cycle** (Figure 2.5).[21]

In other words, **substance turnover** or cycling of substance involves the water, carbon, nitrogen, phosphorus, and sulphur cycles, which are vital for living organisms.[22] Biogeochemical processes regulate and synchronize the release and uptake of nutrients by microorganisms, plants, and other complex organisms. It reflects the importance of chemistry and geology as well as biology in helping us understand these cycles.[23]

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[20] Biogeochemical cycle, Encyclopaedia Britannica. britannica.com/science/biogeochemical-cycle accessed on March 2020.
[21] Ibid.
[22] Ibid.
[23] No author (2017). Intro to biogeochemical cycles. https://www.khanacademy.org/science/biology/ecology/biogeochemical-cycles/a/introduction-to-biogeochemical-cycles

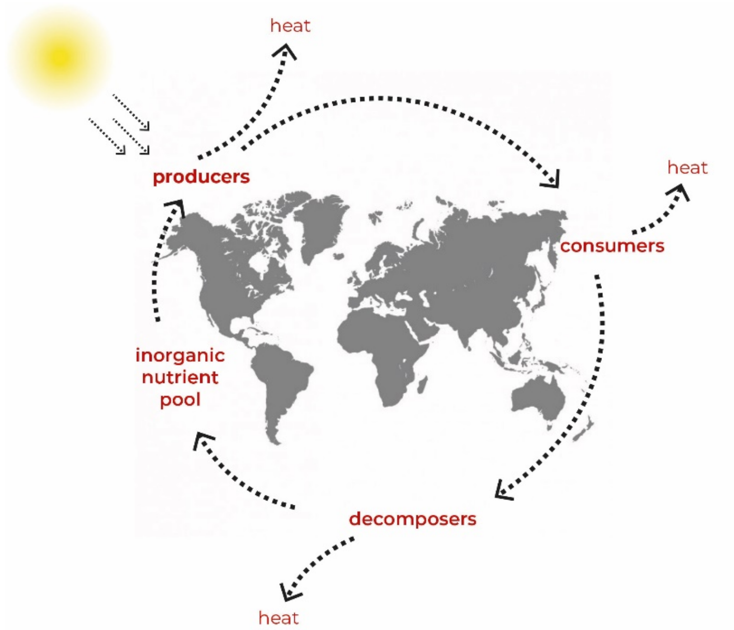

Figure 2.5. The flow of energy lost in the unusable form of heat and chemical nutrients continues as a biogeochemical cycle. (Reproduced from khanacademy.org, accessed November 2020)

2.1.2 Functions of Streams

Freshwater resources: rivers, lakes, and underground aquifers are deeply connected with its watershed, where water is harvested from its several forms. The Watershed is a place where hydrologic, atmospheric, biological, and geomorphic processes occur in complex ways. The water is **captured, stored, used, cleaned, and recycled** in watersheds by many parameters like soil, plant, bacteria, etc.

A stream with its vegetative riparian is the basic part of the water cycle. The water cycle helps the **nutrient cycle**, consisting of some vital elements such as N, C, and P. These elements travel from land to ocean and include **abiotic** and **biotic processes** through fixing bacteria to plants, plants to animals in the biosphere. After the death of an organism like a plant or an animal, the elements in its body are released to the environment through the decomposers' activities (decay organism such as bacteria, insects, and fungi), and become available for other living organisms.

According to Alberti, streams and the watersheds play an important role in a sustainable **water cycle**, which drives other cycles. Therefore, it is crucial to understand the role of the cities in the cycling of chemicals and how the distinctive spatial heterogeneity caused by human choices, including patterns of urban land use and infrastructure, define urban biogeochemistry.[24]

After precipitation or snowmelt, the water is intercepted by vegetation, soil, or buildings. If the water can move into the soil, **infiltration** starts and continues until the water meets aquifers. The infiltration rate depends on the amount of precipitation, surface slope, and soil's permeability and saturation.[25] Heavy clay, steep slopes, and impervious surfaces in cities decrease infiltration and increase surface runoff (Figure 2.6). Water velocity may increase depending on the slickness and permeability of the surface. There are some consequences of runoff; soil loss, erosion, pollution, flooding, etc. causing deaths and economic damage.

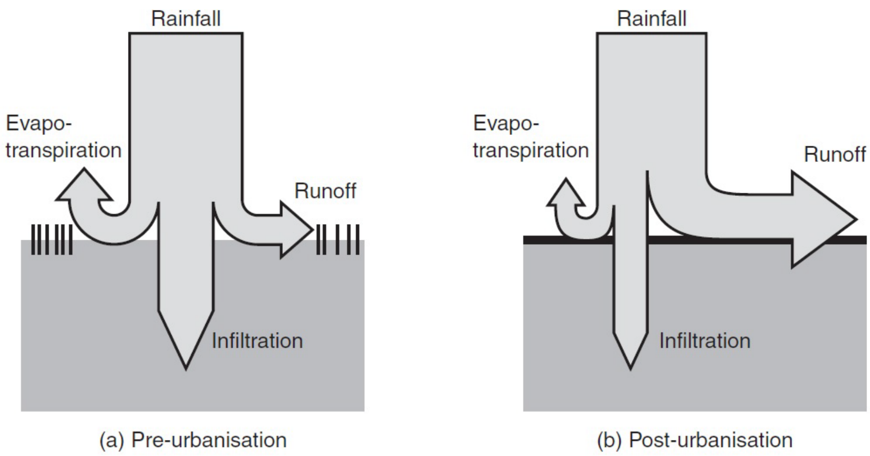

Figure 2.6. Effect of urbanization on rainfall movement
[Source: Butler, D., Davies, JW. (2004)]

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[24] Alberti, M. (2008) Hydrological Processes. In: Advances in Urban Ecology. Springer, Boston, MA. p.165.
[25] Ibid.p.133.

However, during the filtration, plants, and soil have a crucial role in **purifying** water from toxins and sediments.[26] Besides helping purification, **vegetation** mitigates the surface runoff and soil loss and provides appropriate habitat for **biotic communities**. For example, channelizing has weakened the vegetative environment due to its reduction of the relationship between water and soil; thus, biotic diversity is directly affected as regards riparian vegetation.[27] Hydrological processes support aquatic habitats for a variety of species through biological and geomorphic processes, which are interacted by soil, vegetation dynamics, and nutrient circulation.[28] While watershed is a fundamental unit of these processes, humans redefine it through *urban infrastructure* by altering the fundamental elements that manage water drainage across the landscape.[29]

Invertebrate life is especially affected by organic pollutants like wastewater discharge, combined sewer overflows (CSOs), etc. In addition, impervious surfaces that cause to reduce their diversity dramatically, resulting in an increased community of Chironomidae (diptera) and oligochaetes.[30] However, invertebrates with a wide range of species (insects, bees, snails, earthworms, octopus, jellyfish, sponge, etc.) serve as a key in the food chain and some of them provide decomposing green wastes. Wilson describes invertebrates' significant role in ecosystem as *"the little things that run the world"* and continue; "If invertebrates were to disappear, I doubt that the human species could last more than a few months. Most of the fishes, amphibians, birds, and mammals would crash to extinction about the same time."[31]

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[26] Alberti, M. (2008) Hydrological Processes. In: Advances in Urban Ecology. Springer, Boston, MA.p.142.
[27] Ibid. p.17.
[28] Ibid. p.143.
[29] Ibid. p.137.
[30] Paul, M. J. and J. L. Meyer (2001) "Streams in the Urban Landscape," Annual Review of Ecological Systematics 32, pp. 333–365
[31] Wilson, E. O. The Little Things That Run the World. Conservation Biology, Vol. 1, No. 4 (Dec., 1987), pp. 344-346

Nevertheless, urban streams with their natural surroundings are very significant to reduce the **heat island** effect and improving the climate quality.[32] Luke Howard notes the phenomenon of the urban heat island for the first time in 1833 in London.[33] Since that time, human activities have been causing an even more increase in heat islands. As a result of this, cities demand **more energy** for cooling, which increases **greenhouse gas** emissions. According to the research, which examined 51 urbanized watersheds by Dow and DeWalle, the water evaporates less from the urbanized area, while the sensible heat increases.[34] In other words, todays urban planning and architectural practices cause an increase in impervious surfaces, that results in more heat.

The large green areas of the cities provide positive **microclimate**, less **air pollution** and local carbon storage fluxes.[35] Thus, they enable the generation of *microcosms*[36] in the urban ecosystem. Air pollution decreases in conjunct with **carbon sequestration** of the plants and soil.[37] Wetland restoration also helps to sequester carbon and provide freshwater resources. Urban streams with a green bank on both sides are the backbone of the urban ecosystem by supporting ecological sustainability.

These characteristics of urban streams are appealing for urbanites and provide for the **socio-cultural** needs of humans as well. It is an integration between natural processes and modern human life. In this respect, Olmsted was a great pioneer who introduced in his Boston Emerald Necklace Park plan how an urban development that serves as drainage and water retention system can be utilized from the natural

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[32] Lei, Z., Guanghe, W., 2008. Urban River Plays Key Role in City Landscape Planning Culture Legacy and Ecological Development. College of Urban and Rural Construction, Hebei Agricultural University, Baoding 071001, PR China. p.331.
[33] Landsberg, H. E. 1981. The Urban Climate. In International Geophysics Series (Vol. 28), p.4.
[34] Dow, C. L., and D. R. DeWalle. 2000. Trends in evaporation and Bowen ratio on urbanizing watersheds in eastern United States. Water Resources Research 36(7):1835–1843.
[35] Alberti, M. (2008) Hydrological Processes.p.81.
[36] *Little world*. https://www.merriam-webster.com/dictionary/microcosmos
[37] Alberti, M. (2008) Hydrological Processes. pp. 167-170

morphology of the area.[38] While the site can be attractive and support biotic communities, it can also be a part of economic and sustainable solutions for urban infrastructure systems. Thus, natural water streams can be considered as components of an ecological infrastructure system (Figure 2.7).

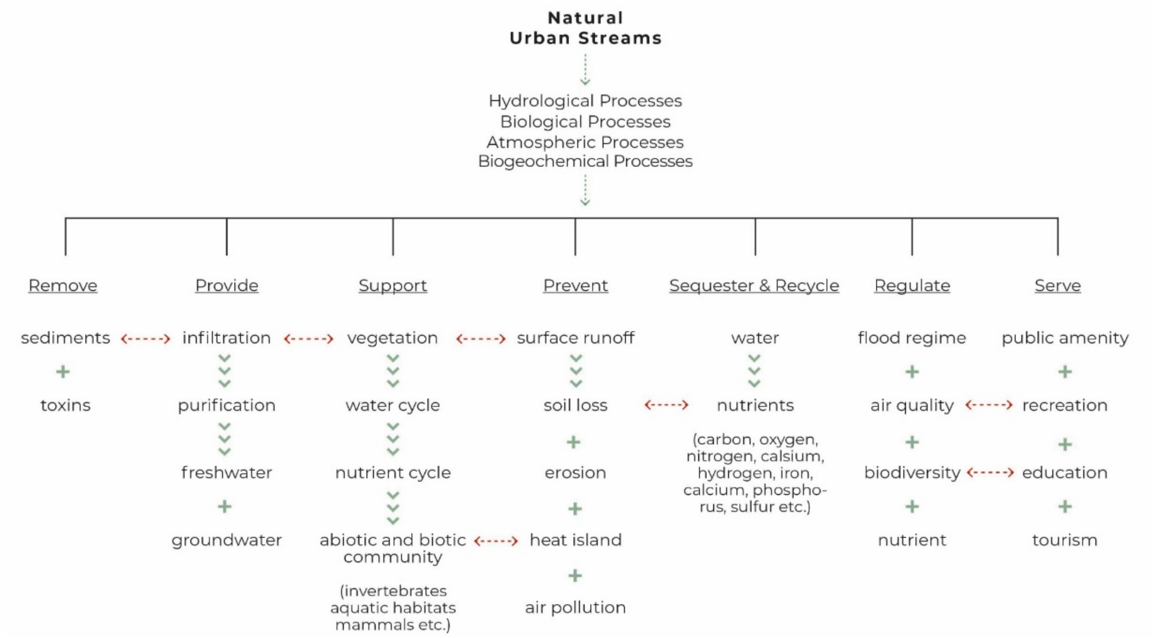

Figure 2.7. Ecological Infrastructure Services of Natural Water Streams

[Produced by the author from Alberti (2008)]

2.1.3 Loss of Urban Streams: Why Were They Covered?

Today, human intervention to streams has a close relationship with infrastructure systems. Significantly sewerage and transportation infrastructure have affected the streams directly. For a long time, scientists and experts have recognized these interventions' harmful effects on the overall environment ecologically, economically, and socially. Nevertheless, including Turkey, the sustainability of the

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[38] Tjallingii, S. (2015) Planning with water and traffic networks. In Steffen Nijhuis, Daniel Jauslin, Frank van der Hoeven(ed). *Flowscapes: Designing infrastructure as landscape*. Published by TU Delft, Delft, NL. p. 61

natural structure of creeks and streambeds is still seen as an area that restricts and hinders economic activities.[39] The dominant reason for it is the water consumption pattern of the modern world and traditional engineering strategies for infrastructure systems, which are needed to be scrutinized.

In order to understand the difference of the notions about water infrastructure, some definitions are specified below:

Sewage is wastewater, which contains human excreta and other forms of wastewater from the kitchen, bath, and laundry.[40] It consists of many disease-causing organisms. **Sewer** is artificial; usually, a subterranean conduit to carry off sewage and sometimes surface water (as from rainfall).[41] Sanitary (wastewater) sewer is the system that carries sewages, while storm sewer carries rainfall runoff.[42] However, the word **sewerage** refers to the whole infrastructure system, including pipes, manholes, structures, pumping stations, etc.[43] There are basically two types of conventional sewerage system: "a *combined* system in which wastewater and stormwater flow together in the same pipe, and a *separate* system in which wastewater and stormwater are kept in separate pipes."[44]

2.1.3.1 A Brief History of Urban Water

The existence of cities has been dependent on freshwater bodies since the very beginning. Water is used for drinking and hygiene by developing artificial drainage systems since human beings started to control their environments. Water is also used

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[39] Dinç, H. (2015) *İstanbul Derelerinin Fiziki Değişimi ve Arazi Kullanım İlişkisi,* Unpublished PHD Thesis; Şehir ve Bölge Planlaması Anabilim Dalı, İTÜ, İstanbul. p.4.
[40] Blackett, I. (2015) Building urban sewerage infrastructure – but where is the sewage? blogs.worldbank.org/water/building-urban-sewerage-infrastructure-where-sewage accessed on July 2020.
[41] merriam-webster.com/dictionary/sewer accessed on July 2020.
[42] MSU Water (2014) http://msu-water.msu.edu/wp-content/uploads/2014/06/Storm-vs.pdf accessed on July 2020.
[43] Butler D, Davies JW (2004). Urban Drainage, 2nd edn. Span Press, London/New York, p.6.
[44] Ibid.

for irrigation purposes in agricultural activities. Aqueducts were built in ancient cities according to engineering principles that incorporated **water supply**, **drainage,** and **irrigation,** but urban runoff that carries feces of animals and people were seen as a problem.[45] The most well-known **sewer** system, "cloaca maxima" was built in the 6th century BC by the Romans[46]; however, it did not cover the whole of Rome.

From the 19th century and during the 20th century, the condition of urban water resources worsened, even when compared to ancient times. The population of the cities grew very fast as a result of industrialization. Steam, coal, and oil revolutionized the production of energy, while clean energy like water wheels and windmills dramatically became defunct.[47] The production methods changed with the mechanical and technological inventions, which caused the rural population, making their living in agriculture, migrate to the cities to work mostly in factories.

Urban waste was increasing in proportion to the population and energy demand. Domestic and industrial waste was discharged directly into streams without treatment. Since urban water bodies serve for both water supply and wastewater disposal, sewage cross-linking and contamination of wells and drinking water sources have caused widespread *epidemics* of waterborne diseases.[48] The response of engineers and planners to this situation was; covering the urban streams to convey polluted water.

However, human excreta (waste) was valuable as a raw material once and this was preventing environmental pollution at least at the domestic level. From 1790 to 1850, Parisian engineers were processing waste, and they were not only improving urban hygiene but also producing the fertilizers needed in the rural surroundings for

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[45] Novotny, V., Ahern, J. & Brown, P. (2010). Water Centric Sustainable Communities. New Jersey: John Wiley & Sons. p.8.
[46] Butler D, Davies JW (2004). Urban Drainage. p.6.
[47] Novotny, V., Ahern, J. & Brown, P. (2010). Water Centric Sustainable Communities. p.15.
[48] Ibid. p.15.

agriculture.[49] Barles remarks that the water and excreta consumption pattern changed after the 1860s in Paris by supplying the domestic water from distant springs (some of which over 100 km from Paris) because of the high population and demand of bourgeoisie for comfort, resulting in gradual liquidification of "the night soil[50], thereby difficult to handle and to turn into fertilizer".[51] By 1817, with its one million population, London was the initiator to allow cesspit overflow to be connected sewers and discharged it to the streams – eventually, River Thames.[52]

Londoner and Parisian Engineers advocated for a dual system of drainage to keep the human waste as the sewage for soil while discharging rainwater to the rivers; however, this idea of the separated system was thought to be complex and costly.[53] Thus, with the beginning of the 20th century, the traditional water supply and *combined sewer* system were founded in the cities, which led to the abandonment of cesspool and collection tanks. Providing potable water from upstream and releasing the wastewater to downstream from the towns was a solution against potential disease.

Since the end of the 19th century, urban drinking and wastewater management administrations have made a massive investment in sewers and dams. On the one hand, dams were built on many rivers to control their flow and supply water and energy to the cities to provide for the daily needs of humans. On the other hand, the urban creeks that flow inside the towns were covered and became sewage lines to discharge wastewaters from residential and industrial areas. The effort to bury Mill Creek in a 21-foot (6.4 m) sewer pipe is shown in Figure 2.8.

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[49] Barles, S. (2007) Urban metabolism and river systems: an historical perspective – Paris and the Seine, 1790–1970. Hydrology and Earth System Sciences Discussions, European Geosciences Union. Pp.1757-1769.
[50] *Human feces used especially for fertilizing the soil.* See: https://www.merriam-webster.com/dictionary/night%20soil
[51] Barles, S. (2007) Urban metabolism and river systems: an historical perspective – Paris and the Seine, 1790–1970. p.1757
[52] Butler D, Davies JW (2004). Urban Drainage. p.6.
[53] Butler D, Davies JW (2004). Urban Drainage. p.6., and see: Barles, S. (2007) Urban metabolism and river systems: an historical perspective – Paris and the Seine. p.1767

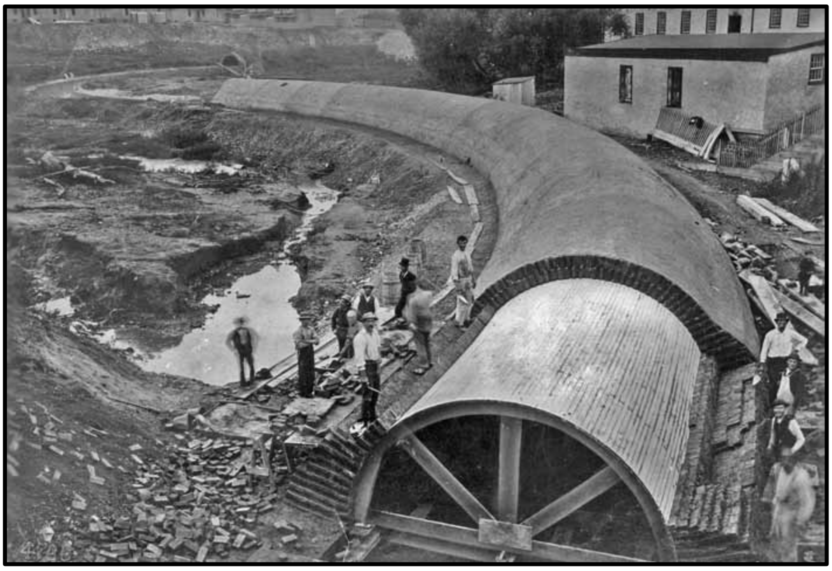

Figure 2.8. Converting Mill Creek into a sewer in Philadelphia, the US in 1883.
(Source: collaborativehistory.gse.upenn.edu/stories/nineteenth-century-transformation-industrial-stream-buried-sewer accessed on January 2020)

Covering of urban small and medium streams was common almost for every city in the world. The increasing **impervious pavement** in the cities prevented infiltration, causing the withdrawal of water from streams and became **effluent dominated** during dry weather while carrying mostly sewage.[54] Therefore, the first reason why municipalities placed the streams inside the pipes was that it was the easiest and inexpensive way to cover polluted water and prevent contagious diseases. The aim was to connect the stormwater and wastewater, remove a large amount of polluted water as soon as possible, and discharge it without treatment into downstream, which is called *fast conveyance urban drainage*.[55] In that, both domestic and industrial wastewater treatment was considered costly, and administrations made no profit from it until the last quarter of the 20th century.

The second reason why policymakers cover and linearize water streams is to make land available for the development of housing, schools, and business activities on

[54] Novotny, V., Ahern, J. & Brown, P. (2010). Water Centric Sustainable Communities. p.17.
[55] Ibid.

floodplains (Figure 2.9). With the increasing population, land speculation has become one of the consequences of modern capitalist urbanization. Hence, floodplains were encroached, minimized, and lined by cities to increase their velocity and capacity, carrying more flow.[56] However, to channelize or cover a water stream, straightening, deepening, or widening the streambed changes the amount of precipitation, flow regime, drainage pathways and increases runoff and sediments.[57]

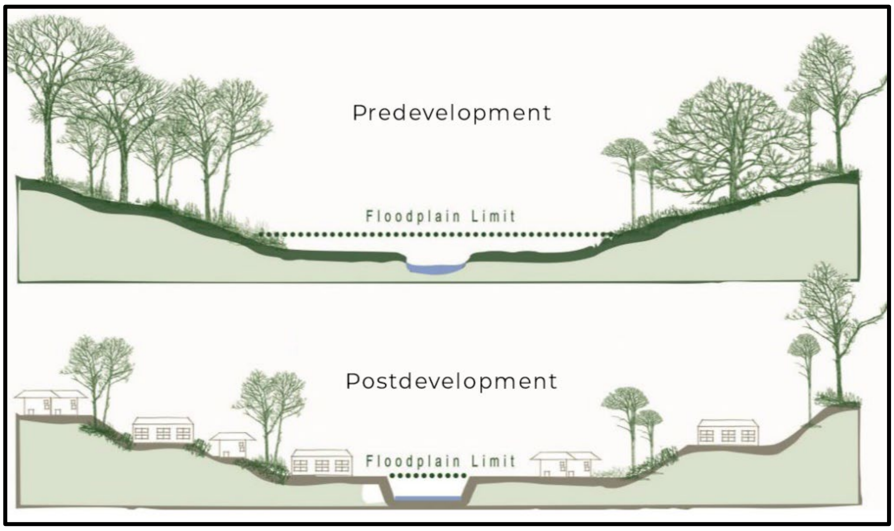

Figure 2.9. Channelizing and covering streams for land use. (Source: Aksoy, S., 2016)

Especially, the ecological importance of the headwaters (the beginning part of a stream that is relatively smaller) was ignored by early 20th century urban planning practice, and they were preferred to be buried into culverts or pipes, as it was economically the most feasible method.[58] According to the research conducted by Elmore and Kaushal, headwater streams are covered much more widely than larger streams in all levels of urban development; for example, in Baltimore City, the proportion of headwater streams that have been buried is over 70%.[59] The catchment area of the streams cannot infiltrate precipitation due to impervious pavements.

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[56] Novotny, V., Ahern, J. & Brown, P. (2010). Water Centric Sustainable Communities. p.22

[57] Alberti, M. (2008) Hydrological Processes. In: Advances in Urban Ecology. p.144.

[58] Elmore, A.J., Kaushal, S.S., 2008. Disappearing headwaters: patterns of stream burial due to urbanization. Front Ecol Environ. 6, 308–312. p. 308. https://doi.org/10.1890/070101 accessed on March 2020.

[59] Ibid. p.311.

Runoff directly enters the sewer system instead of percolating into groundwater, which influences thermal regimes. Cities thus turned into parasites for ecosystems.[60]

In the meantime, the 1960s was the year of the awareness of ecology. Many rivers were contaminated by wastewaters of industries, and people campaigned against water pollution, especially in developed countries such as the US. Since 1960, the international basin and water policies started to be developed, but the heavy pressure of the economy caused these policies to be delayed. However, in 1972, the United Nations Conference on the Human Environment (Stockholm Conference) aimed to comply with the environmental rules to eliminate distortions that prevent the formation of a competitive market economy.[61] In addition, technological developments allowed scientists to conduct comprehensive studies on natural resources and ecosystems. The improvements lead them to take into account the whole watershed and water system with its hydrological regime that affects water flow and quality. On the other hand, the water became an economic good by transferring the management of water resources from the state to the companies with an approach such as “demand management”, “cost recovery” and the principles of “polluter pays” and “participatory management models”.[62]

At the end of the 20th century, the Water Framework Directive was enacted by the European Parliament. It was a shift from preventing diseases and deaths to the well-being of people and aquatic biota, and that required enormous investments to treatment plants for both drinking water and wastewater.[63] This phenomenon is called the **end-of-pipe** control paradigm related to wastewater treatment plants, which is a control point at the end of the pipe before discharge to receiving (water)

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[60] Odum, E. P. (1989) Ecology and Our Endangered Life-Support Systems. Sinauer Associates, Sunderland, Mass.

[61] Dinç, H. (2015) *İstanbul Derelerinin Fiziki Değişimi ve Arazi Kullanım İlişkisi,* Unpublished PHD Thesis; Şehir ve Bölge Planlaması Anabilim Dalı, İTÜ, İstanbul. pp.31-32.

[62] Görer N. (2003) Commercialization and Privatization of Urban Water and Sewerage Services In Turkey: Poverty Reduction View. In: Olcay Ünver İ.H., Gupta R.K., Kibaroğlu A. (eds) Water Development and Poverty Reduction. Natural Resource Management and Policy, vol 25. Springer, Boston, MA. p. 177.

[63] Novotny, V., Ahern, J. & Brown, P. (2010). Water Centric Sustainable Communities. New Jersey: John Wiley & Sons. p.25

body.[64] Although some local, rudimentary treatment plants were active before, it is thought that the new large-scale activated sludge treatment facilities offered better efficiency, and many smaller treatment plants were abandoned in the 1970s. Today, the treatment plants are necessarily considering reusing the treated wastewater for agricultural irrigation and industrial cooling and producing fertilizer from sludge.

Nevertheless, the **centralized** end-of-pipe technology is required high-cost investments, energy, and maintenance by bringing water from long distances to the city and conveying the wastewater to miles away for the treatment plants to discharge into the receiving body of natural water. Moreover, wastewater pollution could still be significant during dry weather. For example, after the Second World War, although most cities in the UK had efficient wastewater treatment plants, pollution was remarkable in dry weather.[65] This means the treatment plants are not good enough to recycle wastewater. On the other hand, the water without touching the soil because of piping and impervious urban surface causes the alteration in the whole watershed's character and hydrology (Figure 2.10). The other important problem is that the system which is operative under stable conditions is actually not resilient to any extreme event, which causes flooding. These extreme events will most probably occur more frequently because of urbanization and climate crises.

Carrying stormwater, relatively clean, to the treatment plants by using sewers does not make sense.[66] Because in rainy days the system requires to discharge excess flows into a nearby stream, which is named **combined sewer overflows (CSOs)** (Figure 2.11). Therefore, combined sewer system has been separated instead of retrofitting or renewing by some city governments or constructed as separated systems in the new settlements. Thus, almost a hundred years later, after the

[64] Ibid. p.26
[65] Butler D, Davies JW (2004). Urban Drainage. p.7.
[66] Novotny, V., Ahern, J. & Brown, P. (2010). Water Centric Sustainable Communities. p.109

disapproved project by Parisian and Londoner engineers of the 19th century, a return to the dual system was launched.

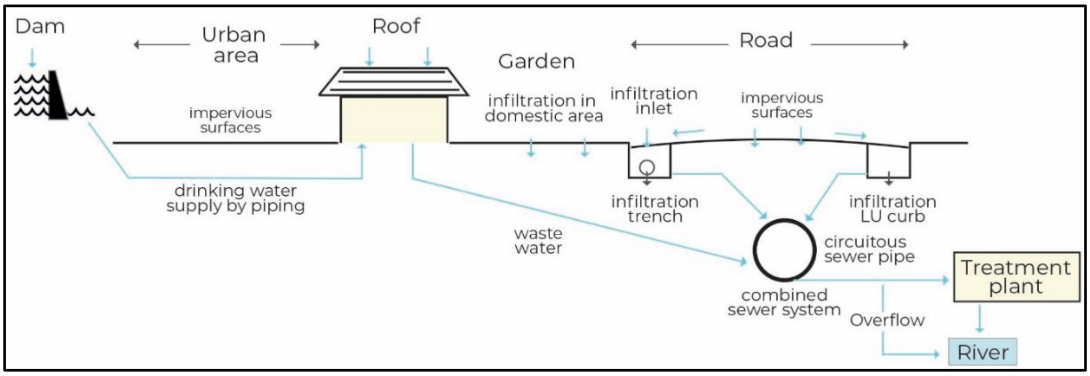

Figure 2.10. The journey of water in urban areas (Produced by the author)

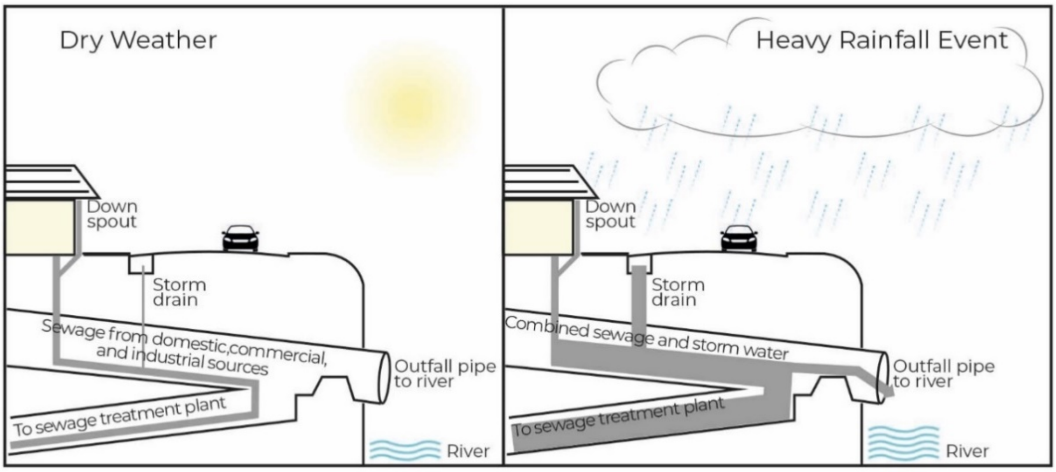

Figure 2.11. Combined Sewer Overflows (Reproduced by the author from beachapedia.org/Combined_Sewer_Overflows, accessed on January 2020)

Today, there are commonly two types of conventional sewerage systems: "a *combined* system in which wastewater and stormwater flow together in the same conduits, and a *separate* system in which wastewater and stormwater are kept in separate conduits."(Figure 2.12). However, a considerable amount of sewer systems are still combined; even in developed countries such as in the UK, Germany, France, about 70% is combined, and in Denmark, 45% is combined.[67] Also, in most cities of Turkey, the stormwater is mostly connected to combined sewer, and the system faces the challenge of heavy rain, which generally causes floods and damages. [68]

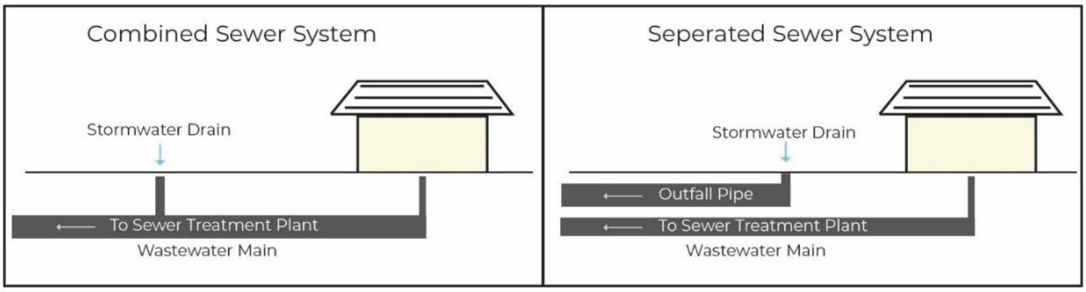

Figure 2.12. Conventional Sewerage Systems: Combined and Separated Sewer System (Reproduced from amwater.com/paaw/water-information/green-infrastructure)

Storm drainage aims to remove the fluids from the built environment as soon as possible and directs the water to the natural resources via the piping system by gravity. Some crucial advantages of a separated system are the abatement of pollution that is caused by CSOs. Besides, there is no need for large treatment plants, and smaller wastewater pipes are enough than larger combined sewer pipes.[69] However, modern stormwater sewer consists of a vast and costly piping network, and its only object is to carry the water to natural waterways while increasing impervious surface in the urban site. The technological developments help to find better solutions by modeling and simulating sewerage infrastructure. Yet, there is no absolute answer as to which type of sewer system is better (Table 2.1).

When considering urban streams are still buried throughout the world cities, the separation of stormwater from wastewater provides more advantages that enable designers and engineers to create more nature-friendly projects such as *daylighting*

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[67] Butler D, Davies JW (2004). Urban drainage.p.18.

[68] Kentel, E., Yanmaz, M. (2007) Kanalizasyon Sistemlerinin İşletimiyle İlgili Sorunların Değerlendirilmesi, 5. Kentsel Altyapı Ulusal Sempozyumu, İMO.

[69] Butler D, Davies JW (2004). Urban drainage. p.24.

streams, producing biomass energy, and fertilizers from treatment plants. Rather than invest in end-of-pipe solutions for water problems, more natural drainage methods started to be preferred using the infiltration and storage properties of semi-natural features. [70]

Table 2.1. Advantages and disadvantages of the separate and combined systems
[Source: Butler, D., Davies, JW. (2004)]

Separated System Advantages	**Combined System Disadvantages**
No CSOs – potentially less pollution of watercourses.	CSOs necessary to keep main sewers and treatment works to feasible size. May cause serious pollution of watercourses.
Smaller wastewater treatment works.	Larger treatment works inlets necessary, probably with provision for stormwater diversion and storage.
Stormwater pumped only if necessary.	Higher pumping costs if pumping of flow to treatment is necessary.
Wastewater and storm sewers may follow own optimum line and depth (for example, stormwater to nearby outfall).	Line is a compromise, and may necessitate long branch connections. Optimum depth for stormwater collection may not suit wastewater.
Wastewater sewer small, and greater velocities maintained at low flows.	Slow, shallow flow in large sewers in dry weather flow may cause deposition and decomposition of solids.
Less variation in flow and strength of wastewater.	Wide variation in flow to pumps, and in flow and strength of wastewater to treatment works.
No road grit in wastewater sewers.	Grit removal necessary.
Any flooding will be by stormwater only.	If flooding and surcharge of manholes occurs, foul conditions will be caused.
Separated System Disadvantages	**Combined System Advantages**
Extra cost of two pipes.	Lower pipe construction costs.
Additional space occupied in narrow streets in built-up areas.	Economical in space.
More house drains, with risk of wrong connections.	House drainage simpler and cheaper.
No flushing of deposited wastewater solids by stormwater.	Deposited wastewater solids flushed out in times of storm.
No treatment of stormwater.	Some treatment of stormwater.

2.1.3.2 Ecological Outcomes and Sustainability of Streams

There are many interventions by humans that change the hydrological, ecological, atmospheric, and morphological processes of the water streams and watersheds,

[70] Butler D, Davies JW (2004). Urban drainage. p.17.

causing pollution. Some important interventions that alter these processes are: **draining** and **filling** the seasonal creeks or wetlands, **covering** catchment areas with impervious surfaces, **straightening** and/or **burying** streams, **storing** and **piping** the water for long distances and **discharging** industrial and domestic wastewater and stormwater to the receive water body, resulting many negative effects on ecosystems (Figure 2.13).

In order to reopen an urban stream, the sewerage system must be separated first; however, other polluters and parameters may prevent to have a sustainable water ecosystem too. In modern cities, water infrastructure is closely related to transportation and sewerage infrastructure; there are streams and pipes under the roads where people and cars move today. Urban sewerage and transportation infrastructure, to a large extent, have resulted in **impervious surfaces** such as concrete, asphalt roadways, which prevent rainfall infiltration and result in a decrease in groundwater level and nutrient cycles. Urban streams and riparian zones are occupied almost completely by impervious zones. These impervious zones end in the decrease of vegetation that causes urban heat island, air pollution, and more energy consumption. In order to have a functional and sustainable urban ecosystem, *microcosms* should be created to interconnect to the land and the streams. In other words, the continuity of biotic areas provides an ecosystem in urban.

Discharging the wastewater to streams or rivers without any treatment was seen as an easy and inexpensive method mentioned above. It causes "bodies of water devoid of oxygen and smelly due to hydrogen sulphide emanating from decomposing anoxic sediments and water."[71] Without oxygen, the wildlife habitat, which is a living space (biotope) for animals, plants, and microorganisms, gradually vanishes. It is a danger for human health since water is in a cycle, and some species are in danger of extinction because of pollution. The use of pesticides and fertilizers in agricultural or recreational activities constitute a much larger share among the causes of both

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[71] Novotny, V., Ahern, J. & Brown, P. (2010). Water Centric Sustainable Communities.. p.2.

surface and groundwater pollution. Two elements, *nitrogen,* and *phosphorus*, which have a significant role in the nutrient cycle, are used in industrial agriculture as fertilizer to get more yield from the soil. These elements are very crucial for producers, but their overuse poses a danger for both human and aquatic life.

In large-scale agricultural production, the irrigation of the soil causes considerable leaching of nitrogen and phosphorus into water bodies or returns to the atmosphere, sometimes in the form of the long-lived greenhouse gas nitrogen oxide (N_2O), which is also involved in stratospheric ozone depletion.[72] Percolation of nitrogen and phosphorus into streams and groundwater causes overabundance of algae, which is named "**eutrophication**" (well-nourished).[73] When algae die, their decomposition process consumes oxygen in the water, resulting in dead zones, where fish and shells cannot survive. Not only fertilizers but also any discharge of nitrate or phosphorus contained in industrial or domestic sewage into an aquatic system leads to *eutrophication.* So, streams should be protected from eutrophication for potable water quality.

According to the ecological outcomes, the 20th century infrastructure approach cannot sustain because of[74,75]

- Increasing population (demand for urban)
- Increasing living standard (demand for more food, water, etc.)
- Increasing "natural disasters" (such as flooding, hurricane, etc.)
- Energy shortages (running out of oil)
- Water scarcity (demand for new resources)
- Global warming, climate crises
- The production method that caused water and air pollution

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72 Alberti, M. (2008) Hydrological Processes. In: Advances in Urban Ecology. pp.172-176
73 Ibid. p.174.
74 Novotny, V., Ahern, J. & Brown, P. (2010). Water Centric Sustainable Communities.. p.98.
75 IPCC Report Global Warming of 1.5 ºC.

Sustainability is simply to have a capacity to continue[76] , and it is engaged with two different social views: First, the anthropogenic view that is related to nature as a resource to be improved for economic gains, and second the biocentric view that is related to preservation and restoration of nature as the essential goal for human life.[77] Most people demand for both of these two contradictive views. [78] They want to benefit from resources economically and to be in nature for living in more "green" areas. According to Novotny, sustainability is neither just a preference for economic development nor a leading green "no impact" development is. It implies a balance for all values symbiotically for present and future generations.[79] After all, Aldo Leopold explains it very clearly:

> "A land ethic of course cannot prevent the alteration, management, and use of these 'resources' but it does affirm their right to continued existence, and, at least in spots, their continued existence in a natural state".[80]

Developing sustainability science in water and wastewater enables practitioners to create spaces integrated with the urban infrastructure system and harmony with nature. One of the best management practices recommends to mimic nature,[81] urban drainage, and the river watersheds began to be considered with all its units adopting an ecological engineering approach by finding alternatives to end-of pipes and centralized infrastructure systems.

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[76] Novotny, V., Ahern, J. & Brown, P. (2010). Water Centric Sustainable Communities. p.80.
[77] Ibid. p.83.
[78] Ibid.
[79] Novotny, V., Ahern, J. & Brown, P. (2010). Water Centric Sustainable Communities. p.81-83.
[80] Leopold, A. (1989) A Sand County Almanac. Special commemorative ed. Oxford University Press.
[81] Novotny, V., Ahern, J. & Brown, P. (2010). Water Centric Sustainable Communities. p.112

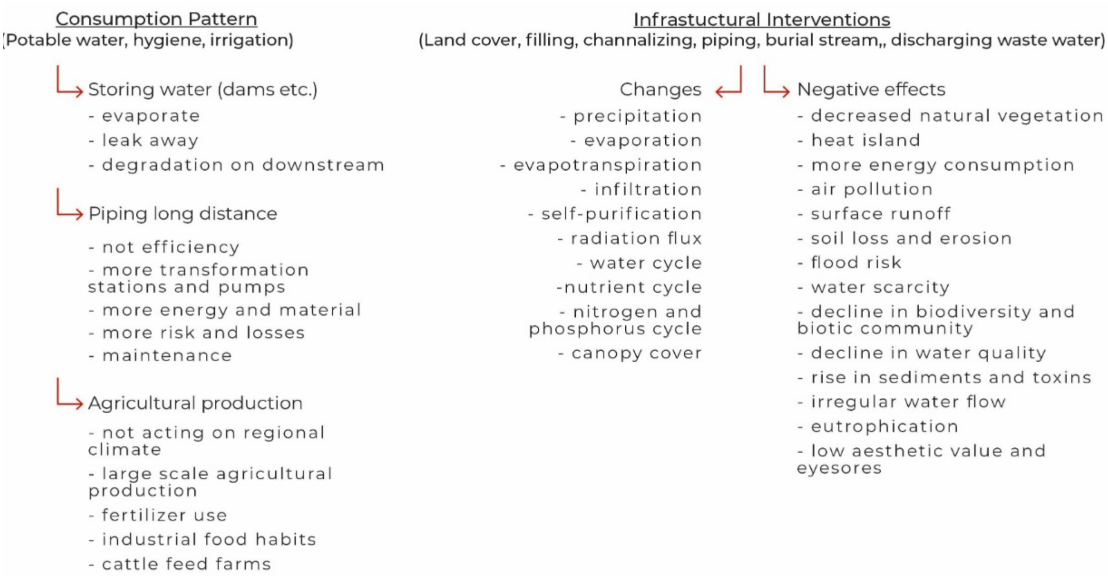

Figure 2.13. Consumption pattern of water and impacts of infrastructural interventions on urban streams [Produced by the author from Alberti (2008)]

2.2 Towards a Hybrid Infrastructure: Landscape Infrastructure

How little we, as the public, know about the infrastructure systems aimed for public utilization. Today, millions of dollars are transferred to the infrastructure systems to build as monocentric big enterprises from the taxes we pay. Streams are closely related to infrastructure systems, just as other natural resources. Therefore, new infrastructure approaches with ecological focus should be reviewed to adopt a sustainable resource management approach regarding new urban morphologies.

2.2.1 Rethinking Infrastructure

The word “infrastructure” is a combination of Latin prefix *infra,* meaning below and French word *structure.* It is defined as “the basic systems and services, such as transport and power supplies, that a country or organization uses in order to work effectively."[82] The wide range of infrastructure types is categorized as *soft* and *hard* or *green* and *grey* or *physical* and *social* infrastructure. World Bank refers to hard infrastructure as physical components like ports, roads, industrial networks, etc., while soft infrastructure as social like customs management, the business environment, and other institutional aspects that are abstract.[83] However, it is difficult to confirm what exactly is specified by *soft* or *hard* and *green* or *grey* by default.

Edwards specifies infrastructure as "Mature technological systems -*cars, roads, municipal water supplies, sewers, telephones, railroads, weather forecasting, buildings, even computers in the majority of their uses*- that reside in a naturalized background, as ordinary and unremarkable to us as trees, daylight, and dirt."[84] He indicates that even if we are dependent on infrastructural elements strongly, we do not notice them in daily life until they fail. However, they are the guts and nerves of the cities and the global economic system. There is a direct connection between urbanization and infrastructure, which is shaped by modernity.

According to Harvey, infrastructural constructions absorbed the capital and labor accumulation of the capitalist system.[85] *"Creative destruction"*[86] of modernity contains innovation and creativity as a result of the conventional rebuttal. While the capitalist economy provides it, infrastructure becomes the locomotive of the economy. As the transport and communication infrastructure system developed, cities are reshaped both economically and socially. Thus, land speculation has become one of the consequences of modern capitalist urbanization. "As urban land

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[82] https://dictionary.cambridge.org/dictionary/english/infrastructure accessed on October 2019.
[83] The World Bank Development Research Group (2010). *Export Performance and Trade Facilitation Reform: Hard and Soft Infrastructure.* p.2.
[84] Edwards, P. N. (2003). Infrastructure and Modernity. In Thomas J. M., Philip Brey, and Andrew Feenberg (Ed). *Modernity and Technology*. (185-225). Cambridge, MA: MIT Press. p.185.
[85] Harvey, D. (2003) Paris, Capital of Modernity, by Routledge, New York. pp.102-105.
[86] Harvey, D. (2003) Paris, Capital of Modernity. p.1. For more detail, see: Berman, M. 1982. *"All That Is Solid Melts into Air",* Published by the Penguin Group.

gets scarce and population increases, attempts to make the most profit out of the available land stock become a prevailing theme in the urban stage."[87]

Consequently, since the 19th century, most urban creeks and rivers have been degraded by industrial and domestic wastewater and transformed for the sake of land profit. Thus, they mostly disappeared from the city surface. According to the European Commission, infrastructure is the key to investments made by public authorities[88], and water infrastructures are a big part of these investments. A public-private partnership generally implements these investments. In the capitalist system, this public-private collaboration may lead to corruption if they are not controlled by an organization sensitive to public funding. Shannon explains its importance; "…in a world where urbanization is increasingly produced by private capital, infrastructure appears as the backbone onto which these building initiatives can be grafted."[89]

The involvement of private capital into the design of infrastructure also has the potential to manage the urban growth for the aim of the capital increase, and it also lacks a multi-disciplinary approach. Şahin remarks that the impact of market-oriented reform policies (neoliberal policies) can be seen in the urban planning process, which becomes "a mechanism of re-distributing urban rents via urban projects", and infrastructure investments.[90] This urban transformation causes degraded landscapes, a vulnerable ecosystem, and a narrow point of view regarding urban morphology.

In fact, infrastructural elements were key for *city planning* once. Frederick Law Olmsted, who integrated public space and infrastructure by using together, sanitation, housing, and park reforms, was a pioneer in planning.[91] On the other hand,

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[87] Barlas, M. A. (2014) Urban Streets and Urban Rituals, Faculty of Architecture, METU. p. 104.
[88] European Commission (2011) A growth package for integrated European infrastructures. Brussels.
[89] Shannon, M., Smeths. M. (2010) *The Landscape of Contemporary Infrastructure*, NAi Publishers, Rotterdam. p.9
[90] Şahin, Z., Kent Planlama Süreci ile Kentsel Altyapı Yatırımlarının İlişkisi: Ankara Örneği, Planlama 2018;28(1):6-11, doi: 10.14744/planlama.2018.43255. p.6.
[91] Neuman, M., & Smith, S. (2010). City planning and infrastructure: Once and future partners. *Journal of Planning History*, 9(1). 21–42. p.25.

"Benevolo describes Baron Haussmann's planning work in Paris and Ildefons Cerdá in Barcelona in the middle of the nineteenth century, which is shown as an example of early urban planning by taking the concept of infrastructure in its broadest sense as infrastructure planning studies. This kind of statement has the effect of accepting the spatial qualities of the urban physical environment as infrastructure."[92] However, by 1920, aesthetic concerns started to replace with the administration to control private property by zoning. Planning practice focused on handling the use of the motorcar and master plans administrated by new commissions, which included architects, landscape architects, and engineers before, was now composed of lawyers and new professionals called city planners.[93]

Developed technologies, which are now supported by large mechanical systems instead of human force, allow construction of large-scale projects. This situation may cause a shift from qualified, aesthetic concerns to functional, economic interests. For example, it is seen that the structures and aesthetic qualities of sewages, aqueducts, roads, cisterns, and many other elements in Roman Cities are prominent.[94] Today, the infrastructure elements are generally viewed as an eyesore because of aesthetic concerns, and they are preferred to be buried. It is possible to mention an *invisible* and *single-purpose* infrastructure system, which is mostly disconnected from architecture, landscape, and planning.

Belanger states that scientific positivism (based on a rational logic of modernism), which is closely attached to linear forms of the Taylorist management and Fordist production, creates an engineering practice, which has become central to the design of urban environments.[95] However, this engineering practice does not have critical discourse "compared to other fields of design such as architecture and urban design

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[92] Şahin, Z. (2012) Kent Planlama Süreci ile Kentsel Altyapı Yatırımlarının İlişkisi: Ankara Örneği. p.7.
[93] Neuman, M., & Smith, S. (2010). City planning and infrastructure: Once and future partners. p.28.
[94] Şahin, Z. (2012) Kent Planlama Süreci ile Kentsel Altyapı Yatırımlarının İlişkisi: Ankara Örneği. p.7.
[95] Belanger, P. (2012). Landscape Infrastructure: Urbanism Beyond Engineering. In Spiro Pollalis, Daniel Schodek, Andreas Georgoulias and Stephen J. Ramos (Ed.). *Infrastructure, Sustainability & Design*. (276-315). London: Routledge. pp.276-279.

or the social sciences and regional planning that are arguably over-theorized."[96] Therefore, infrastructure concerns architects, landscape architects, planners, engineers, ecologists, economists, and important politicians as an emergent matter within the larger conversation about urbanism.[97]

Moreover, the lack of public knowledge on how infrastructural elements operate leads to more problems such as using a culvert as a landfill or drawing water from pipes for irrigation. The public is required to be informed about the infrastructure that it is a connection between biological and technological world, "because rarely do we actually see the entire watershed that supplies the water that we drink or bathe in, nor do we see the subsurface soils that we walk on that underlies roads or regions, nor do we see the power of a coal mine from a power plant that generates the electricity when we turn the lights on."[98]

After all, the undeniable fact is the tension between an expansionist *economy* and *ecology*, which causes logistic, industrial, and waste landscapes. During the last century, large and small crises have resulted from man-made infrastructural systems such as bridge breaking, nuclear power plant explosion, water and food shortages, and coastal floods. At the end of the 20th century, facing environmental hazards and failures of modern technological infrastructures and the alarm of the ecological capacity of the regions cause to reveal new infrastructure and urbanism approaches in post-industrial cities.

2.2.2 Landscape Infrastructure: Conceptual Ground

While Landscape Infrastructure is a term that emerged in recent decades in academia, some approaches lead the way to the idea of landscape as infrastructure. Gary Strang

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96 Ibid.

97 Strang, G. (1996) Infrastructure as landscape; Allen, S. (1999) Infrastructural Urbanism; Belanger, P. (2012). Landscape Infrastructure: Urbanism Beyond Engineering

98 Belanger, P. (2012). Landscape Infrastructure: Urbanism Beyond Engineering. p.278.

is one of the pioneers by discussing "Infrastructure as landscape and landscape as infrastructure" in 1996. He states that the role of infrastructural systems in architectural and urban formation is generally ignored and suggests that the network of significant sources requires being legible in the landscape.[99] He continues:

> "Designers have most often been charged with hiding, screening and cosmetically mitigating infrastructure in order to maintain the image of the untouched natural surroundings of an earlier era. They are rarely asked to consider infrastructure as an opportunity, as a fundamental component of urban and regional form. As early as 1924, social critic Lewis Mumford castigated modern architects for romanticizing new technologies while ignoring the potential for making civil architecture from the important, everyday elements of the city, such as water towers and subways."[100]

He also indicates that human-made infrastructural systems tend for a *singular purpose,* which is *non-economic* at all. The system, under the buildings, roads, and parking lots, is as complex as nature itself, which is unpredictable and uncontrollable; however, nature is flexible, resilient, and multi-functional, which is sustainable and economical.

Yu Hung, who is a member of The Infrastructure Research Initiative, states that "the US as a society, has traditionally placed a high value on the design of monofunctional infrastructural systems, engineered to maximize efficiency at a given time to fulfill a single purpose, but failing to provide a consistent level of efficiency throughout their lifespans".[101] As mentioned before, the streams and rainwater, for instance, are mostly connected to combined sewer pipes in metropolitan cities, fail in heavy rain, and cause floods and damages. On the other hand, in separate sewerage systems, a vast and costly network of the underground system is built, which only drains the stormwater to natural waterways. The sole purpose of this network is to control

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[99] Strang, G. (1996) Infrastructure as landscape. In Places Journal (Vol. 10, No. 3, pp. 8-15). p.14. escholarship.org/uc/item/6nc8k21m accessed on September,2019.
[100] Ibid. p.11.
[101] Ying-Yu Hung (2013) Landscape Infrastructure: Systems of Contingency. in Ying-Yu Hung (ed). *Landscape Infrastructure: Case Studies by SWA.* Birkhauser Verlag GMBH, Basel, P.O. Box 4009, Basel, Switzerland. p.16.

runoff by preventing the ecological processes, thereby limiting this system of infrastructure to a single-purpose.[102]

Stan Allen, who identified "Infrastructural Urbanism" in 1999, discusses the role of architects and designers while describing infrastructure and design practices. He states that urban infrastructures are artificial ecologies that manage the flows of energy and resources on a site and determine the density and distribution of human and natural habitat.[103] However, he remarks that architecture is more concerned about images or meaning or even with objects, while material practices (ecology or engineering) are more interested in *performance*.[104] Architecture, which is indirect to its material, mostly assumes that form is important, but it must be important not because of how it looks like, but more for what it can do.[105] On the other hand, he indicates that architecture and design disciplines can actualize social and cultural concepts, where they can contribute something to infrastructural design that the strictly technical disciplines such as engineering cannot.[106] Infrastructural Urbanism encourages going beyond stylistic or formal problems and proposes a new understanding and practice model using architectural potentials to structure flexible cities.

Almost at the same period, "Landscape Urbanism" was discussed as a new understanding for post-industrial cities that consider landscape as a medium to operate the fields. It was first introduced in 1997 at a symposium organized by Charles Waldheim. The concept of Landscape Urbanism was presented in his book, *The Landscape Urbanism Reader*, in which he claims that the advantages of the concept are "the conflation, integration, and fluid exchange between (natural)

[102] Steven Ronald Clarke (1999) Rethinking Infrastructure. Unpublished Master Thesis. The university of Manitoba, Faculty of Graduate Studies. p:15.
[103] Allen, S. (1999) Infrastructural Urbanism. In *Points + Lines. Diagrams and Projects for the City*. Princeton Architectural Press, NewYork. p.57.
[104] Ibid. pp.52-53
[105] Ibid.. p.57.
[106] Allen, S. (1999) Infrastructural Urbanism. pp.53-54.

environmental and (engineered) infrastructural systems".[107] In this respect, Stan Allen also indicates the potential of landscape as a model for urbanism by using its materiality and performance.[108] Landscape Urbanism and Landscape Infrastructure has overlapped in their concerns: process-based approach; focusing on flow and infrastructure; envisioning ecology as an agent of change; an alternative response to urban interventions; a call for interdisciplinarity of practice, particularly between landscape architecture and criticality of urban planning and civil engineering.[109]

One of the earliest ideas for a new infrastructure practice is called "Green Infrastructure". It was raised in 2002 by two planners, Edward McMahon and Mark Benedict. Green Infrastructure is an ecological planning framework for supporting natural systems. It emphasizes "natural infrastructures" such as greenways, parks, wetlands, farms, forests, etc. also act as infrastructures for the public to improve alternative technics to implement instead of traditional "grey infrastructure" technics.[110] Mark Benedict and Edward McMahon state that Green Infrastructure is a new term, but it is not a new idea, and it represents the idea of protection and restoration of the nation's natural living systems, which is a necessity instead of just an amenity.[111]

Moreover, the color of nature in the city does not have to be *green*, but also *grey* in some cases, such as the design of Sulzer-Areal in Switzerland (Figure 2.14).[112] This *color-fixed* understanding is risky for the cooperation of disciplines such as engineering, urban planning, or ecologists, all of which are supposed to be interested

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107 Waldheim, C. (2006) The Landscape Urbanism Reader. New York: Princeton Architectural Press. p. 43.
108 Allen, S. (2001) Mat Urbanism: The Thick 2D. In Hashim Sarkis (ed), *CASE: Le Corbusier's Venice Hospital,* Munich: Prestel. p.124.
109 Michalak, J. N., 2014. Infrastructural Landscape: Strategies for Post-Industrial Reuse. Unpublished Master Thesis. University of Washington. p. 19.
110 Benedict, M. A.& McMahon, E. T. (2002) Green Infrastructure: Smart Conservation for the 21st Century. Renewable Resources Journal, (20): 12-17.
111 Benedict, M. A.& McMahon, E. T.(2002) Green Infrastructure: Smart Conservation for the 21st Century. Sprawl Watch Clearinghouse, Washington D.C. pp.6-8
112 Weilacher, U. Green Infrastructure and Landscape Architecture. Originally published in Garten+Landschaft, 3/2015 landezine.com/index.php/2017/05/green-infrastructure-and-landscape-architecture/ accessed on April 2020.

in “urban”, no matter if green, grey, blue, or of any other color.[113] Hybrid and flexible networks are more important for working multi-functional infrastructures. “Live, ecological systems can be designed as infrastructures that shape contemporary urban economies”[114] is the fundamental allegation of Landscape Infrastructure.

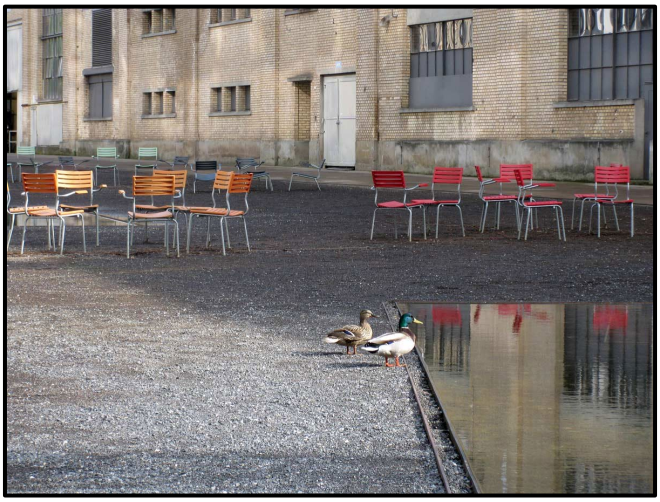

Figure 2.14. An industrial park with a “grey” but permeable ground (Source:landezine.com/index.php/2017/05/green-infrastructure-and-landscape-architecture/ accessed on April 2020)

The term, **landscape** is “an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors”.[115] On the other hand, **infrastructure** refers “to the basic physical and organizational structures such as roads, power lines, and water mains needed for the material and organizational aspects of modernity”.[116] As such, infrastructure is a tool of human to alter the natural environment, while landscape is the one affected by it.[117] However, the intersection between landscape and infrastructure ranges from design spaces to

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[113] Ibid.

[114] Bélanger, P. (2013) Landscape infrastructure: Urbanism beyond engineering. Published Phd Thesis. Wageningen University. NL. p.8

[115] Council of Europe (2000) European Landscape Convention. Florence (European Treaty Series 176)

[116] Gandy, M. (2011). Landscape and Infrastructure in the Late - Modern Metropolis. In Bridge G., Watson S. (ed), *Companion to the City*. Blackwell. p. 58.

[117] Nijhuis, S., & Jauslin, D. (2015). Urban landscape infrastructures. Research In Urbanism Series, 3(1), 13-34. doi.org/10.7480/rius.3.874 p. 18.

utilitarian structures[118] , and their combination offers an opportunity to define operative landscape structures that serve multi-functional ends[119].

Belanger (2009) and The Infrastructure Research Initiative at SWA (2011) introduced the term Landscape Infrastructure by redefining the singular, centralized, and inflexible infrastructures as an integrated alternative. They have actualized Landscape Infrastructure projects in five major infrastructure systems; *waste, water, transportation, energy,* and *food*, to address economic and ecological flows in urban regions. Belanger describes Landscape Infrastructure as in the following:

> "Emerging from these ecological imperatives and economic exigencies, the project of landscape infrastructure proposes an expanded operating system for contemporary cities where the full complexity of biodynamic processes and resources are visualized and deployed across the full footprint of urbanism and the lifecycles of infrastructure."[120]

Belanger states that there is inevitable progress to landscape infrastructure projects due to the negative outcomes of the 20th century engineering and planning practices. These practices, which are shaped with the linear forms of this Taylorist management and Fordist production, can shift to a new model of practice, in which landscape architecture, civil engineering, and urban planning work together by focusing on ecological processes, multi-functionality, and visible *flows*. In this respect, he believes that the dominance of engineering on infrastructure systems should be questioned and shared with designers.

Landscape infrastructure offers *decentralizing* urban structures to increase response diversity and modularity, and perform multiple functions, habitat creation, and revitalization of the communities. Spatial distributions that range from agricultural production to water management should meet new and existing demands with

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[118] Gandy, M. (2011). Landscape and Infrastructure in the Late - Modern Metropolis. p. 57.

[119] Nijhuis, S., & Jauslin, D. (2015). Urban landscape infrastructures. p. 18.

[120] Belanger, P. (2012) Infrastructural Ecologies. In Spiro N. Pollalis, Daniel Schodek, Andreas Georgoulias and Stephen J. Ramos (ed). *Infrastructure, Sustainability & Design.* London: Routledge, 276-315. p.290.

current resources. As mentioned earlier, for example, the large-centralized wastewater treatment plants require more energy and maintenance for receiving the wastewater from the sewer system for kilometers. Floods occur when heavy rain falls in urban areas where urban streams are covered. However, in order to drain stormwater, more pipes are laid, increasing impervious surfaces.

As the cities expand, these centralized solutions, which were once economic, become now inconvenient and non-ecologic. Novotny explains this contradiction with the trinity of factors; cities expand rural regions, and rural start to consume wilderness, however, without environmental sustainability, it is hard to mention society, and without society, there is no economy (Figure 2.15).[121]

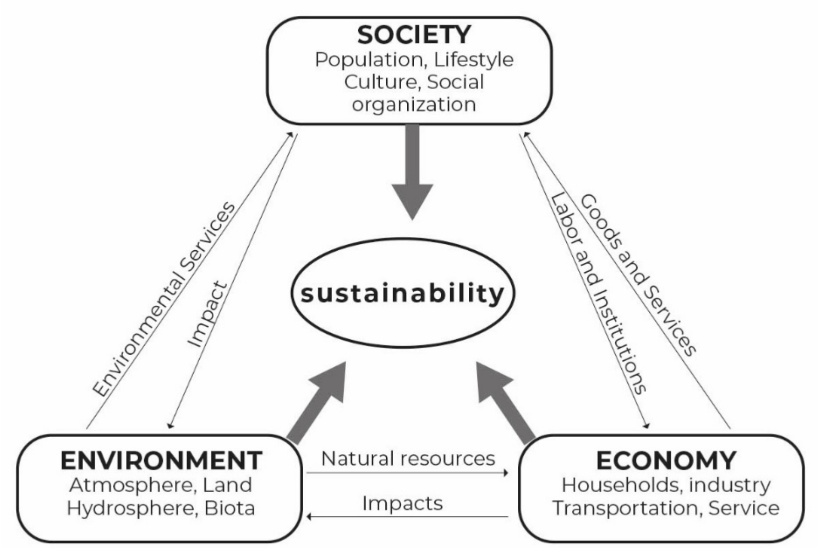

Figure 2.15. The trinity of factors and impacts determining the sustainability

[Source: Novotny, V., Ahern, J. & Brown, P. (2010)]

The success of Landscape Infrastructure is to render the visibility of the living systems that sustain urban economies by mapping the complex levels of information as a tool of infrastructure and ecology.[122] The purpose of infrastructure is to organize

[121] Novotny, V., Ahern, J. & Brown, P. (2010). Water Centric Sustainable Communities. pp.73-75
[122] Belanger, P. (2012) Infrastructural Ecologies. p.292.

the site instead of building a particular structure.[123] Urban design, an interdisciplinary practice to respond to urban problems, has a systemic approach similar to that of Landscape Infrastructure, by connecting planning and design. However, Belanger criticizes that it has generally focused on the design of buildings, blocks, and streets as the locus of urban development while underestimating the potential of infrastructure as "the glue of urbanization".[124]

To sum up, some important points are stated below:

1. Infrastructure is a tool that causes urbanization and affects not only build environment but also the landscapes, which contain biophysical and biogeochemical[125] processes that provide life cycle.
2. Landscape Infrastructure supports the flows of *waste, water, transportation, energy,* and *food* ecologically as well as economically.
3. Moving beyond aesthetic concerns of ecology as "green" can radically transform the traditional approaches of infrastructure engineering and land use planning.
4. The urban land categorization in planning (residential, commercial, industrial, institutional) can be designed as flexible, multi-functional, connected, and hybrid areas; thus, while the city can be resilient, the new economies of the future can arise.
5. Rather than centralization, a structural approach for decentralized development can bridge the gap between ecology and economy; thus, new urban morphologies can be created in the future.
6. The contribution of different professional practices is crucial to put design and infrastructure into operation for reshaping urban patterns as ecologically, socially, and economically.

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[123] Allen, S. (1999) Infrastructural Urbanism. In *Points + Lines. Diagrams and Projects for the City*. p.54.
[124] Bélanger, P. (2013) Landscape infrastructure. Urbanism beyond engineering. p.281
[125] See: Chapter II, 2.1.Urban Streams.

7. Shaping landscapes instead of specific technical construction in a landscape can bring possibilities and opportunities for regional design and local interventions by establishing a connection between process and form.

2.2.3 Streams as Urban Landscape Infrastructure

Urban landscape infrastructure design operates in a wide range of scales from regional to local and aims to maintain the relationship between nature and city. Water landscape infrastructure includes coast and streams rehabilitation and management, beach nourishment, stabilization of sand dunes and improvement of flood forest, and estuarine wetlands to create multi-functional landscapes.[126] It also focuses on flood control systems such as dikes, levees, pumping stations; drainage systems like stormwater sewers and ditches; water storages and irrigation systems; sewage collection, and treatment plants.

Edward states that traditional infrastructure functions between a certain range of natural variability, however more flexible systems work in a wider range to deal with "unusual natural events", such as in Netherland, where dikes and pumping stations are built to keep the ocean from reclaiming the land.[127] McHarg also emphasizes that Dutch have preferred flexible construction such as dikes, which are not built like concrete defense structures.[128] A more natural means of solutions for water problems are underlined rather than investing in "hard" infrastructure solutions.

Since the beginning of the 20th century, landscape characteristics and ecological functions of streams have been transformed by hard infrastructure approach. The covering of streams is a result of these infrastructural interventions, lacking a landscape-oriented approach. However, with an understanding of infrastructure as operating the basic systems and services physically, the landscapes, which are

[126] Nijhuis, S., & Jauslin, D. (2015). Urban landscape infrastructures. p. 25.
[127] Edwards, P. N. (2003). Infrastructure and Modernity. p.193.
[128] McHarg, I. (1969) Design with Nature. John Wiley & Sons. USA. p.7.

affected by it, can be defined as “infrastructural terrain”.[129] A stream as infrastructural terrain can support generative spaces in urban morphology, where participants can experience multi-functional and flexible landscapes. The infrastructural potentials and functions of streams have been underestimated by engineering practice; however, from reducing flood damage to improving potable water quality, streams serve urban landscapes and urban infrastructure.

The historical and practical reasons for this disparagement are, first, it is thought that restoring the urban streams and its watersheds is not possible because of degraded landscapes that are altered irreversibly to support naturally functioning systems; second, it is prohibitively expensive to restore a land ecologically while the land uses are more valuable than streams; and third, an open, uncontrolled dynamic system will be unacceptable by the public.[130] However, even in dense urban areas that are covered with impervious surfaces from 60 to 70 percent, restoration of the streams is not impossible.[131] According to the ecological outcomes and environmental hazards and failures, urban density should not privilege roads and streets over underground pipes. During the last one hundred years, the change of urban geography is enormous. The geomorphology of the city once consisted of streams flowing through hills, is now covered with impermeable pavements for conveying wastewater. Butler states that combining wastewater and stormwater is fundamentally irrational and a historical accident.[132] Moreover, the urban streams in which smaller ones are mostly buried and flow in combined sewers.

After all, streams as landscape infrastructure consists of various foci for solving infrastructural problems. *Stream daylighting* is one of them while handling the buried

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[129] Baş Bütüner, F. Et al. (2020) Decoding infrastructural terrain: the landscape fabric along the Sincan-Kayaş commuter line in Ankara, Landscape Research. p.4.
[130] Riley, L. A. (2016) Restoring Neighborhood Streams *Planning, Design, and Construction.* Island Press. p.1.
[131] Claytor, R. 2000. Assessing the Potential for Urban Watershed Restoration: The Practice of Watershed Protection. p.9.
[132] Butler D., Davies JW. (2004). Urban Drainage. p.26

streams. Combined sewer system carries extraneous water to the treatment plant such as stream water, house drains, and stormwater, resulting in more problems.[133] On the other hand, creating a new infrastructure system by separating only rainwater is a costly and non-ecological solution. By liberating the stream, an economic and ecological solution is achieved as well as good management of stormwater system. Therefore, streams are required to be taken as urban landscape infrastructure. In Chapter III, how to reopen lost urban streams and integrate with urban infrastructure is examined.

[133] Conradin, F., Buchli, R. (2004) The Zurich Stream-Daylighting Program. In J. Marsalek et al. (eds.),*Enhancing Urban Environment by Environmental Upgrading and Restoration,* 277-288.Kluwer Academic Publishers. p. 277

CHAPTER 3

STREAM DAYLIGHTING

The historical changes and covering of streams were evaluated while examining the new ecology oriented infrastructural approaches to urban areas in Chapter II. In this Chapter, how to bring them back was investigated. The challenges, opportunities, and benefits of stream daylighting are introduced by exemplifying practices for urban infrastructure with a new understanding.

3.1 Terminology

Ecosystem treatment methods are restoration, rehabilitation, and reclamation. Landscape **restoration** is a repair and maintenance to re-establish the former landscape character; while **rehabilitation** is a revitalization of landscapes, where it is not possible to restore its previous state before degradation or intervention; and the attempt to characterize the land by new natural and cultural features is **reclamation**.[134]

Stream daylighting can be defined as a radical rehabilitation method that revitalizes the degraded natural waterway and its riparian zone. Bringing a part or the whole of a buried stream to the surface is named as **daylighting** in the US or **deculverting** mostly in the UK. Daylighting projects recreate not just streams also; it can be designed to actualize ponds, wetlands, or estuaries.[135]

[134] Şahin, Ş., Perçin, H., Kurum, E. ve Memlük, Y., 2014. Akarsu Koridorlarında Peyzaj Onarımı ve Doğaya Yeniden Kazandırma Teknik Kılavuzu. T.C. Orman ve Su İşleri Bakanlığı, Doğa Koruma ve Milli Parklar Genel Müdürlüğü adına BEL-DA Belde Proje ve Dan. Tic. Ltd. Şti., Ankara.p. 11.
[135] Pinkham, R. (2000) Daylighting: new life for buried streams. Rocky Mountain Institute, Colorado. p.IV.

Stream daylighting is the act of unearthing the missing part of the living system. The creeks, brooks, and rivers have been living as the names of many streets and roads today. They become out of sight, out of mind, while contained safely in a concrete box or pipe. However, daylighting enables the streams to sustain their inherent functions, it allows the urbanites to be linked to the characteristic landscape of the city; thus, stream daylighting can become a future planning strategy for both natural and human systems.[136]

The term "daylighting" originally refers to the illumination of indoor spaces by natural light, and most people may confuse at first; however, almost for 30 years, the term is used for bringing a buried stream or pond to the surface is also called "daylighting". In 1984, the first "official" stream daylighting project was realized along a part of Strawberry Creek, at a park in Berkeley, California, USA and since that time, daylighting activity has consistently increased across the United States.[137] In parts of Europe such as Zurich, it became even more common, by daylighting over 14 km. small and large streams and storm drains since 1988.[138] In addition, in South Korea and China, decision-makers have attached importance to stream daylighting in the last two decades. In light of the research about functions and alterations of streams mentioned in Chapter II, we are directed to pay attention to the importance of reopening covered streams. Stream daylighting projects began at the end of the 20th century. Today, along with the clean-up of urban runoff and separation of combined sewers, stream restoration, and daylighting projects are being implemented in many cities.

While communities experience the negative effects of covered streams ecologically, the costly maintenance of the sewer and stormwater infrastructures push the governments to invest in nature-oriented engineering. "Many communities are

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[136] Buchholz, T. A. et al. (2016) Stream Restoration in Urban Environments: Concept, Design Principles, and Case Studies of Stream Daylighting. In T. Younos, T.E. Parece (ed). *Sustainable Water Management in Urban* Environments. Springer International Publishing, Switzerland. p.123.
[137] Ibid. p.127.
[138] Pinkham, R. (2000) Daylighting: new life for buried streams. P.IV.

finding that the costs associated with 'daylighting' a stream can be less than designing new pipes and re-burying the stream."[139] Thus, stream daylighting can be considered as a *landscape infrastructure* project by providing not only ecosystems but also economic revitalization with stormwater management while enhancing the built environment socially and aesthetically.

The success of the daylighting process is required to contribute various stakeholders to the rehabilitation decision from the beginning. The previous land use of the site is a matter of concern, whether in urban or rural areas. The benefits, functions, and outcomes of the daylighting project should be shared with the community clearly, and feedback should be received. Impervious surfaces, pollution, etc. inhibit the hydrological process. In order to initiate a positive change for an ecological process, the technical, economic, institutional, and other relevant variables should be assessed on the site. As the ecological transformation of the landscape is accomplished, its positive effects on the economy and society will be more visible.

3.2 The Process

Daylighting projects have been implemented in all kinds of situations: "from small ephemeral creeks to true rivers, in watersheds tiny and large, on rural farmland and in the central business districts of cities."[140] However, most urban dwellers have no idea that streams are under their feet, and they can be shocked and unprepared to consider the value of the stream daylighting project. Therefore, to unfold the existing situation and raise public consciousness, developing a "Disappeared Streams Map" is essential for the beginning of the process.[141] The map should show the paths of buried or disappeared streams in the city before deciding for the potential sites for

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[139] National Park Service (Undated) Giving new life to streams in rural city centers. http://npshistory.com/publications/rtca/city-center-streams.pdf accessed on April,2020.
[140] Pinkham, R. (2000) Daylighting: new life for buried streams. Rocky Mountain Institute, Colorado. p.6.
[141] Ibid.

daylighting. The assessment of the site and watershed is crucial for a successful daylighting project.

Nevertheless, the function of the site can be many. Some of them can be sorted as follows:

- Parking lots;
- Brownfield sites;
- Industrial areas;
- Dead spaces;
- Former railyards;
- Private properties;
- Residential backyards;
- Open space and playing fields at parks;
- Farmlands;
- Roads, streets;
- Commercial properties

In addition to land use, daylighting projects require different implementations depending on where they are located in an urban or rural area. The process and feasibility assessment of a stream daylighting project include considering steps such as mapping disappeared streams, site selection, watershed assessments, channel and stream banks design, and finally, construction (Table 3.1).

Watershed is an integral part of the stream systems, and a stream daylighting project involves its watershed rehabilitation, too. Therefore, it is required to make the feasibility assessment of the watershed before investing. An urban watershed area can be several square kilometers, as mentioned in Chapter II, and may include several stream systems. In dense urban areas, watersheds are probably covered by impervious surfaces by up to 60 to 70%, where the restoring process can take longer. Therefore, the subwatershed scale shall be considered "to improve the aquatic system while still contributing improvements to the watershed as a whole".[142] Following that, subwatersheds are divided into catchment areas; thus, drainage units are mapped.[143] The feasibility of the site shall be determined to divert stormwater. In a highly urbanized area, the streams are usually in a culvert; for instance, a metal or concrete pipe or arch culvert, or a concrete box culvert. The level of intervention shall be determined, and the information on the stream type shall be obtained via observing the upstream in the course of the channel design.[144]

The streams are generally combined with the sewer system. If the stream is connected with a sewer system, so the first main objective is to separate the stream from the combined sewer system and use it as a clean water system. As mentioned in Chapter II, the **separation** of wastewater from streams and stormwater gives designers and engineers some advantages to create soft infrastructure solutions while saving energy with smaller treatment plants and producing biogas from organics in waste. If wastewater threat is under control or eliminated, the channel geometry can be designed to be a part of the surface drainage system.

Bankfull discharge (mentioned in Chapter II) is the key to designing the geometry, cross-section and profile of the stream successfully.[145] Because, bankfull discharge determination and channel-characteristics curves help to identify depth, velocity and cross-sectional area of the stream, which are criteria for designing the geometry of the stream.[146] Moreover, the streambed and banks can be reinforced with some materials such as boulders, riprap, and cobbles to reduce velocity; but most importantly, appropriate **vegetation** helps to facilitate stable stream flow; thus, sediment erosion is prevented as well. If bankfull is the key of a natural stream

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[142] Claytor, R. 2000. Assessing the Potential for Urban Watershed Restoration: The Practice of Watershed Protection. p.9.
[143] Ibid. p.11
[144] Buchholz, T. A. et al. (2016) Stream Restoration in Urban Environments: Concept, Design Principles, and Case Studies of Stream Daylighting. p.133.
[145] Ibid. p.135.
[146] Mulvihill, C.I., Baldigo, B.P., Miller, S.J., DeKoskie, Douglas, and DuBois, Joel (2009) Bankfull discharge and channel characteristics of streams in New York State: U.S. Geological Survey Scientific Investigations Report. p.2.

channel design, vegetation is the glue of naturalized stream to hold it together. The water body of the stream cannot be separated from its surroundings; depending on the bankfull width of the stream, it forms a stream corridor that consists of floodplain, oxbow lakes (abandoned channels), sloughs (puddles), forest and buffers (Figure 3.1).[147] The equilibrium of sediment that entering the stream and leaving from the stream determines the success of the living system.

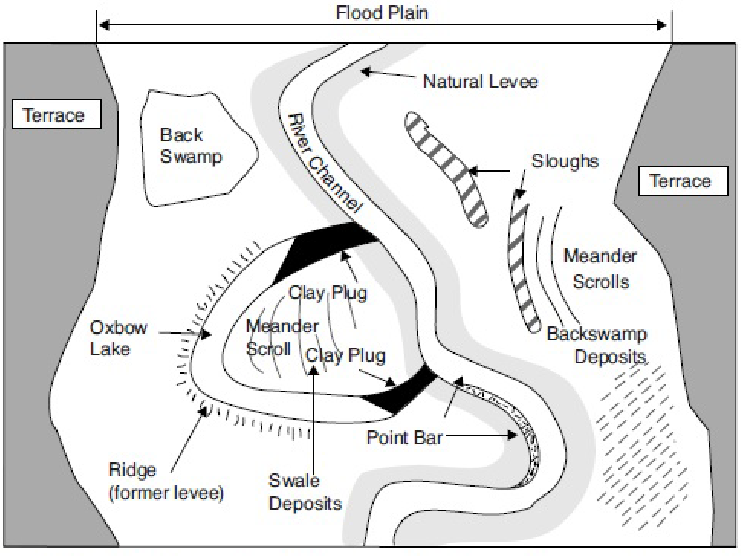

Figure 3.1. Typical layout of a natural stream
[Source: Mitsch, W. J. and J. G. Gosselink (2000)]

Bed material of stream is a very important decision for the following process of design. For example, in the banks and/or streambeds often uses artificial materials such as concrete, resulting in the disappearing of the wetland, which is supposed to provide filtration and self-purification, and ensure habitat for aquatic life.[148] Using artificial materials causes water pollution and dead zones for aquatic life.[149] In this case, naturalized streambed, composed of riffles and pools, helps regulate and control water flow and sediment accumulation. Thus, the drainage potential of naturalized streams acts as a stormwater infrastructure.

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147 Novotny, V., Ahern, J. & Brown, P. (2010). Water Centric Sustainable Communities.p.442
148 Lei, Z., Guanghe, W., 2008. Urban River Plays Key Role in City Landscape Planning Culture Legacy and Ecological Development. p.333.
149 Ibid.

Geological survey and using the GIS (Geographic Information System) technics help for converting information to digital data. From the beginning of the project to the end of the construction, it requires a multi-disciplinary approach. After the implementation, the changes can be detected by biological and habitat monitoring to control whether there is a stress factor.[150]

Table 3.1. The process and feasibility assessments of a stream daylighting project. [Produced by the author from Pinkham, R. (2000) and Buchholz, T. A. et al. (2016)]

Illustration of Existing Situation	
Historical Analysis	Tracing the history of disappeared streams
Mapping	Determination of the disappeared streams from the city surface
Assessments for Site Selection	
Past and current land use of the area	Is any usurpation necessary? Business and residential areas, nodes and axes of the areas…
Stakeholders determination	Surrounding buildings and its users should convince to embrace the project.
The reason for burial stream	Why did it bury? Is there a connection with the sewer or stormwater system?
Classifying the stream	Determination of streamflow characteristics.
Types of the culverts or pipes	Material, diameter, etc.
Water table situation	Does groundwater clean? Connection with an open stream
Existing green areas, natural or cultural features	Trees, rocks, monuments, etc.
Flow regime	Flow rates of the stream
Obstructions	Are there any obstructions in culverts or pipes?
Flood frequency	Damages of floods in the area
Depth of the overburden	Approximate excavation calculation
Assessments for Watershed	
Sedimentation problem	All streams move sediment. Equilibrium of in and out amount of sediments are aimed.
Mapping	Determining subwatersheds and catchment areas
Topography	The slope of the area
Riparian vegetation	How successful is the vegetation for removing pollutants
Other pollutants	Is there any need for biofiltration?
Watershed size	For a healthy infiltration area, percolation of water, permeable surfaces are important.
Impervious surface size	
Geological information	For a healthy hydrological cycle
Existing biological community	Biological communities, such as macroinvertebrates or fish may be conducted.
Drainage plan	Storm water management should plan for the terrain

150 Novotny, V., Ahern, J. & Brown, P. (2010). Water Centric Sustainable Communities. p.443

Table 3.1. (cont.)	
Design of the Site and Channel	
Original meanders geometry	The re-establishment possibility of the original stream sinuosity
The proper geometry of the stream	Flow volume per unit time need to be examined for channel cross and sinuosity of the stream
Gage site information	Observations for bankfull discharge
The links	Is there any need for a bridge?
The habitat	Flora and fauna requirements. Will there be fishes in the water?
In-channel structures	The necessity of in-channel structures for regulating depth, direction or velocity. (Boulders, riprap, and cobble, and plants)
Types of the soil	Any contamination
The precipitation regime	Envisioning the infiltration area and the saturation of the soil
The objectives of the area	Recreation, education, flood mitigation…
Design requirements	Things that are needed or wanted
The future projection strategies	Future plans for the area
Stream Bank and Floodplain	
The essential floodplain area	The safe area should reserve for hydrological processes
Stabilization of the banks	What technic will be used? Bioengineering technics can determine.
Native species for re-vegetation	Best and economic plants and planting methods need to state.
Hard and soft landscape decisions	Trees, bushes, walking paths, pavements, furniture…
The precipitation regime	Envisioning the infiltration area and the saturation of the soil
Construction	
The appropriate season for construction	
Logistic support and costs	
Will it be a requirement for diversion of the water flows?	
The amount of excavation, filling and backfilling of the soil	
Will be any demolition of surrounding structures?	
Removal of hard lining constructed in the past	
Grading strategy	
Time – Channel hydraulics work quickly, but ecological functions require time for stabilization of the slopes and growing of plants	
Maintenance tasks	

3.3 Challenges

Design. The artificial and burial streams are usually constructed in highly urbanized areas, which limit the space for a meandering and planted streambed. In this narrow movement area, social and institutional negotiations can be very important. While a covered stream follows a path designed with respect to the plots of the development plan, developing a natural streambed requires a meandering path in order to arrange the velocity and sediment accumulation. This challenge may pose a problem in the relations of property ownership.

A vegetated stream with a pond will obviously attract the invertebrates, which are the essential life form for the nutrient cycles and aim of the project. However, at some point, insects such as mosquitoes can be disturbing. According to Butler mosquito breeding is easier to control than in closed drains.[151] Also, the appropriate food chain can overcome the problem.

Another challenge is that the stream can be connected to the combined sewer system. This is required first, a design process for the separation of wastewater. In addition, human interventions to the upstream can affect the ecologic design, for example, holding the water can cause the lack of base flow or discharging pollutants or excessive water, which results in continuing stream bank erosion.

Social. The first problem you have to overcome for a daylighting project is the **fear** which Wolfe and Mason did as the designer and coordinator in the first "official" daylighting project in Berkeley, California.[152] People are not afraid of water that flows beneath their foot in the pipe, but they might be anxious about open flowing water. While hydraulic performance is a matter of concern for public works departments and municipalities, neighborhoods and citizens may believe that the open stream could be a danger for children.[153]

The construction can be disruptive for local businesses, which can cause reluctance to the community. Even when the construction is finished, the process of vegetation and equilibrium of the stream continues, since ecological processes need time. To prevent it, *Disappeared Streams Map* should be prepared to raise public

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[151] Butler D, Davies JW (2004). Urban Drainage. p.515.
[152] Riley, L. A. (2016) Restoring Neighborhood Streams *Planning, Design, and Construction.* pp.54-57
[153] Pinkham, R. (2000) Daylighting: new life for buried streams. p.8.

consciousness, encourage dialogue, and move toward long-term plans for urban waterway restoration.[154] Community support is important to overcome the obstacles.

Institutional. While the problems of the process can change depending on the government policy, the private properties can be affected if expropriation is necessary. The ownership of the new channel can be an issue. In addition, maintenance of the area should detect and monitor the biological integrity of the area. The revitalized ecosystem will likely adjust itself, but five years is recommended for monitoring after construction.[155] The relationship between institutions shall be ensured; thus, the coordination of the project can progress effectively. The process can be driven by good leaders, including governmental and local citizens, which make it visible and embraced by folk.[156]

Cost. A stream daylighting involves many work items; technical, design, construction and logistics, and it is not a cheap endeavor. Experienced practitioners assume the costs of daylighting to range from $300 - $1,000 per linear foot.[157] On the other hand, traditional pipe engineering can be more expensive when compared with stream daylighting in some cases. For example, in "Darbee Brook, which costs $9,000 for a length of 330 linear feet, daylighting proved to be far more affordable than installing a new culvert (estimated at $45,000 - $50,000)."[158]

3.4 Benefits beyond Aesthetic Values

Richard Pinkham, who actualized daylighting projects in the Rocky Mountain Institute, asks, "Why anyone would go to the trouble of digging up a culvert and

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[154] Pinkham, R. (2000) Daylighting: new life for buried streams. p.6.
[155] Keystone Stream Team (2003) Guidelines for natural stream channel design for Pennsylvania waterways. Alliance for the Chesapeake Bay.Pennsylvania. p.9-2.
[156] Pinkham, R. (2000) Daylighting: New life for buried streams. pp.8-9
[157] Ibid.
[158] Buchholz, T., Bork, D., Younos, T. (2007) Urban Stream Daylighting Design Application to Stroubles Creek, Blacksburg, Virginia. Virginia Water Resources Research Center. p.52.

recreating a surface waterway”.[159] Although stream daylighting projects are required to be struggling with many actors and outcomes, they have considerable benefits. An ecosystem treatment can mostly be seen as an effort for aesthetic values of the built environment that is not a rational investment to spend money; however, according to outcomes of daylighting projects, these are positive functionally, economically and socially. The right analysis and objectives bring higher chances of measurable success.

Some of the outstanding benefits of stream daylighting are listed below:

Infrastructural.

- If the stream is connected with a combined sewer system, it flows with the wastewater along the pipes, and during rainy days, the capacity of pipes/culverts cannot be sufficient, causing flooding or CSOs (Chapter II). By separating the stream and stormwater from sewer, the hydrological processes are provided, and wastewater can easily be conveyed to treatment plants.
- If only wastewater is conveyed to the treatment plants, the pipes and culverts diameter will be smaller than combined sewer pipes and even stormwater sewer pipes, which is economical.[160]
- In traditional separated systems, stormwater drainage construction is more complex and expensive than open drains.[161] Therefore, an open stream ecosystem, which has a better capacity to drain the precipitation, is cheaper than to build a vast underground stormwater sewer system.[162]
- Bringing the streams back to the surface provides the better capacity to manage flows.[163]

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[159] Pinkham, R. (2000) Daylighting: New life for buried streams. p.IV.
[160] Butler D, Davies JW (2004). Urban Drainage. p.20
[161] Ibid. p.515.
[162] Pinkham, R. (2000) Daylighting: New life for buried streams. p.IV.
[163] Novotny, V., Ahern, J. & Brown, P. (2010). Water Centric Sustainable Communities. p.109

- It is easier to monitor an open drainage system as well as its repair.[164]
- Surface runoff from the surrounding area can be canalized to the floodplain, where vegetated storage ponds, wetlands, and buffers are provided. Thus, runoff velocity will be mitigated.
- The centralized, large scale, end-of-pipe technology is required high-cost investments and maintenance by bringing water from long distances to the city and conveying the wastewater to miles away treatment plants. However, wastewater without combining stormwater or any streamflow can be economical and efficient by building smaller treatment plants to reuse the wastewater and/or produce biomass or fertilizers, which helps save energy.[165]
- Under-capacity culverts may lead to choke points and flooding problems, it can be overcome by stream daylighting.[166]
- Integrated Watershed Management (Chapter II) approach will be supported by restoring the small and urban streams as well as by helping groundwater supply.

Ecological.

- There are huge ecological differences between a stream that flows in a culvert and under the sunlight. Sunlight, air and soil allows growth of riparian flora and fauna while improving water quality by infiltrating the water.
- Rehabilitated and renaturalized floodplain with ponds, puddles, and plants provide the water cycle; thus, the hydrological, atmospheric, and biogeochemical processes (Chapter II) will start and continue.
- In the meantime, the plants will support the natural bank stabilization by their root mass and prevent soil loss and erosion.[167]

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[164] Pinkham, R. (2000) Daylighting: New life for buried streams. p.IV.
[165] Novotny, V., Ahern, J. & Brown, P. (2010). Water Centric Sustainable Communities..p.109
[166] Pinkham, R. (2000) Daylighting: New life for buried streams. p.IV.
[167] Ibid.

- Air pollution decreases by means of carbon sequestration of the plants and soil.[168] Wetland restoration also helps to sequester carbon and provide freshwater resources.
- The urban heat island has negative effects on the growth and decomposition rates of plants and *microbes.*[169] An urban stream corridor with its vegetated areas improves the climate quality and decreases the effects of urban heat islands and will decrease energy consumption.[170]
- Vegetation supports water and nutrient cycles, including carbon, oxygen, hydrogen, phosphorus, nitrogen, etc. for organisms and non-living organisms (Chapter I).
- Stream daylighting increases the invertebrate community and fish diversity.[171]

Social.

- Ecology-oriented infrastructural solutions raise awareness of citizens about water conservation.
- Stream restoration projects generally consist of labor-intensive but infrastructure inexpensive; therefore, the use of funds for these projects has significant benefits for creating numerous job opportunities.[172]
- Planning and implementing a stream daylighting project can bring many actors together, which lead to revitalize communities and reconnect them.
- An ecological stream corridor is more than being an amenity for the public, stream and landscape can be respected the life supporter of the public through infrastructure. Water is a resource that people connect physically, socially, and even psychologically.

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[168] Alberti, M. (2008) Hydrological Processes. In: Advances in Urban Ecology. pp. 167-170
[169] Ibid. p.177
[170] Lei, Z., Guanghe, W., 2008. Urban River Plays Key Role in City Landscape Planning Culture Legacy and Ecological Development.. p.331.
[171] Pinkham, R. (2000), and Neale, M.W., Moffett, E.R. (2015)
[172] Novotny, V., Ahern, J. & Brown, P. (2010). Water Centric Sustainable Communities. p.440

Spatial.

- While re-opened streams may motivate investments in nearby properties, tourism potential can be driven by economic activities like one of the famous cases, Cheonggyecheon River, Seoul Korea.
- There will be a place where urbanites can be close to nature and experience it while observing and providing educational services.
- The area can become an "infrastructural terrain" that provides human-nature interaction by integrating the unexplored potential of covered streams to urban landscape in the city.[173]
- The separation of the wastewater system can allow the removal of water from combined sewer systems and build smaller treatment works that lead *decentralization* of water infrastructure, as mentioned in Chapter II. Thus, new urban morphologies can be created by providing opportunities and capabilities of decentralization in the future.[174]

3.5 Precedent Projects and Implementations

3.5.1 Strawberry Creek, Berkeley, USA

Watershed:	2 square miles (5.2 km^2), urban and university campus
Flow rates:	2-6 cubic feet per second (cfs) (0.05-0.15 m^3/s) average seasonal flow 800-1000 cfs (22.6-28.3 m^3/s) 100-year peak flow
Park acreage:	4 acres (16.000 m^2)
Removed culvert:	125 feet long (38 m)
Length daylighted:	200 feet new channel (61 m)
Width daylighted:	About 17 feet (5 m)
Depth:	About 1.3 feet (40 cm)
Project Year:	1984
Objectives:	Creating park and an open public amenity

[173] Baş Bütüner, F. Et al. (2020) Decoding infrastructural terrain: the landscape fabric along the Sincan-Kayaş commuter line in Ankara. p.4.
[174] Belanger, P. (2012). Landscape Infrastructure: Urbanism Beyond Engineering. p.290

In 1984, the first "official" stream daylighting project has been realized along a part of Strawberry Creek, at a park in Berkeley, California, USA.[175] It is now a popular urban park in mixed density residential area of Berkeley. The stream flows from Strawberry Canyon, by passing through the University of California today, to San Francisco Bay for 5.2 miles (~8.5 km) that shown in Figure 3.2 with the project site location. The area was an abandoned freight rail, which become a railroad with a long culvert in 1904. The area did not contain any developed use to attract people, and it neglected until 1982 (Figure 3.3). The citywide vision was to create parks and open spaces to identify neighborhoods in Berkeley. Sooner, the landscape architects, Doug Wolfe and Gary Mason, suggested that the park should involve the creek and feature with it.[176] However, the Berkeley Parks Department was abstained from the idea of daylighting until the public displayed their support to the project. Finally, public meetings ended up by voting unanimously in favor of daylighting the creek, including Berkeley Parks Commission.[177]

The park site was 4 acre (~16.000 m^2), and the design program consisted of open park space; quiet, peaceful, rest areas for seniors who live in senior housing next to the park; picnic space; tennis courts; and, basketball courts to attract use by teenagers.[178] At that time, designers did not have a chance of utilizing a modern watershed analysis program and fluvial engineering tools, so they gave their attention very carefully to observe the upstream of the creek and determine the proper channel geometry for the reopened creek. In addition, while the creek was excavated, the original location of the creek channel appeared with its darkened soil by the groundwater movement.

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[175] Buchholz, T. A. et al. (2016) Stream Restoration in Urban Environments: Concept, Design Principles, and Case Studies of Stream Daylighting. p.127.
[176] Riley, L. A. (2016) Restoring Neighborhood Streams *Planning, Design, and Construction.* Island Press. p.56
[177] Pinkham, R. (2000) Daylighting: New life for buried streams. p.18.
[178] Riley, L. A. (2016) Restoring Neighborhood Streams *Planning, Design, and Construction.* p.54

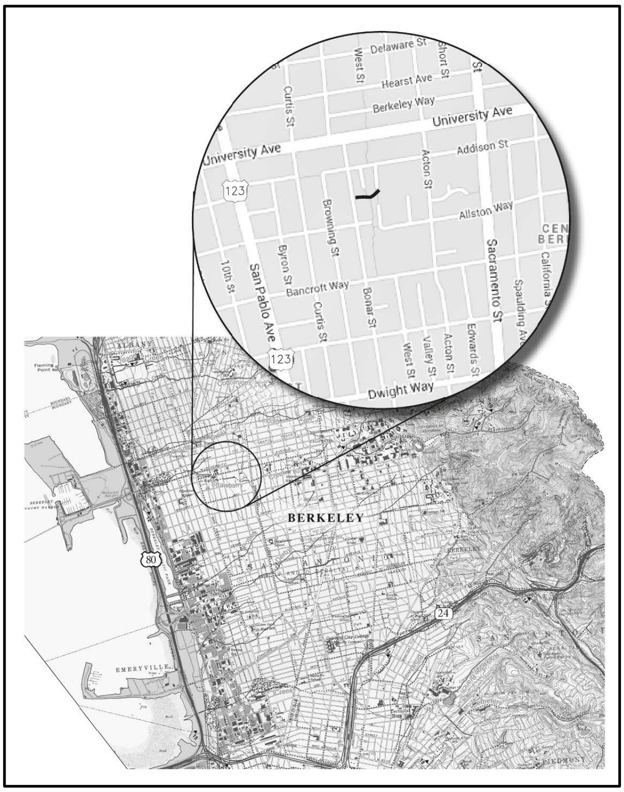

Figure 3.2. The Creek flows from Strawberry Canyon in the Berkeley Hills to San Francisco Bay [Source: Riley, L. A. (2016)]

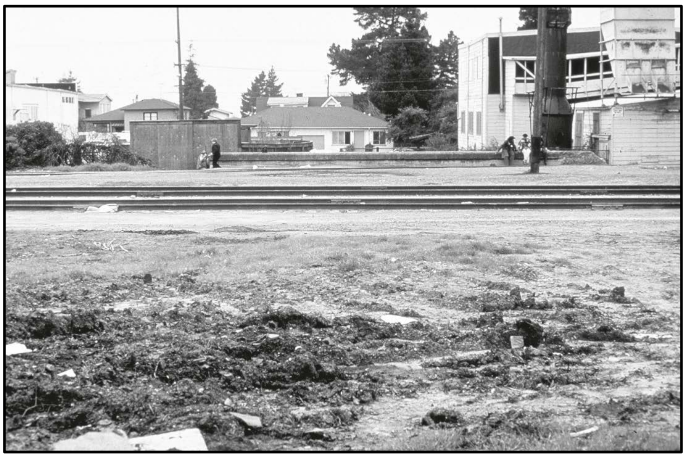

Figure 3.3. The Strawberry Creek Park was an abandoned railyard and industrial wood working building before daylighting. [Source: Gary Mason of Wolfe Mason Associates (1984)]

Designers reused the old culverts after digging them out as steps to reach the water and rip-rap (enrockment) to protect the stream bank (Figure 3.4). The depth between the ground surface and the bottom of the culvert was about 6 m, which meant considerable excavation.[179] However, designers used the soil, left from the excavation, very creatively and eliminated it as hillocks, where was also built swales for carrying runoff to the new creek.[180] For minimum maintenance and irrigation, native species such as willows, cottonwoods, pines have been used along the creek and park. Another pioneering feature of the project was that a youth program was put into force for the maintenance of the creek corridor in order to help the disadvantaged young people by including them to have income, which became a mutual interest for the city as well.

The entire project was completed for $580,000 in 1984, while creek daylighting was less than 10 percent of the cost, and a pedestrian bridge was included to the restoration of the creek cost.[181] **The significance of this project** lies in the fact that nobody died, nor was injured when a stream is opened. The community has revitalized and property values in the neighborhood increased. The project with its naturalized stream, resonated greatly in other counties and organizations and sooner led to many similar projects.

Figure 3.4. In the Strawberry Creek construction, the culverts were reused as steps to improve the stream bank [Source: Gary Mason of Wolfe Mason Associates (1984)]

[179] Ibid. p.58.
[180] Pinkham, R. (2000) Daylighting: New life for buried streams. p.27
[181] Ibid. p.28

3.5.2 Zurich Stream Daylighting Program, Switzerland

Watershed:	Citywide
Flow rates:	Varying between 0.01-0.10 m^3/s in seasonal flow Varying between 0.2-0.8 m^3/s the bankfull discharge
Removed culvert:	Over 20 km
Length daylighted:	Over 20 km
Project Year:	1988-1998
Objectives:	Having more efficient treatment plants by separating the streams from combined sewer system and creating public amenity by restoring degraded landscape ecology.

The significance of this project is the separation of the streams and stormwater from *combined sewer system*. Since the traditional way to deal with small streams was burying them in urban areas, during the last 130 years of city development, Zurich lost about 100 km of numerous small and large streams from the surface.[182] The main driving force that led the reopening of Zurich streams was the city's two treatment plants tried to deal with large quantities of clean runoff, which caused increasing operational costs and decreased the productivity of the wastewater treatment process. In addition, the degraded landscapes and loss of public amenity were other reasons to reopen streams. Zurich Stream Daylighting Program was started to conduct under the City Council and announced to the press and the public as a policy in 1988.
Accordingly, Zurich urban drainage master planning has been prepared by tracing the buried streams via old maps of the city.[183] After the feasibility of the buried streams and sewer system, the following cases were taken into the program for daylighting and revitalizing:[184]

- Stream daylighting for 20 cases, which are in pipes/culverts (10-15 km)
- Stream daylighting for 30 cases, which flow in combined sewer system (20-25 km)

[182] Conradin, F., Buchli, R. (2004) The Zurich Stream-Daylighting Program. p.277
[183] Conradin, F., Buchli, R. (2008) The Zurich Stream-Daylighting Program. p.49.
[184] Ibid.

- Stream revitalizing for 10 cases (10-15 km)

The interesting thing in this citywide project is even the ephemeral (dry) streams are considered for daylighting because large amount of extraneous water was entering into the sewer system. Thus, streams, which will be daylighted, were distributed throughout the city (Figure 3.5)

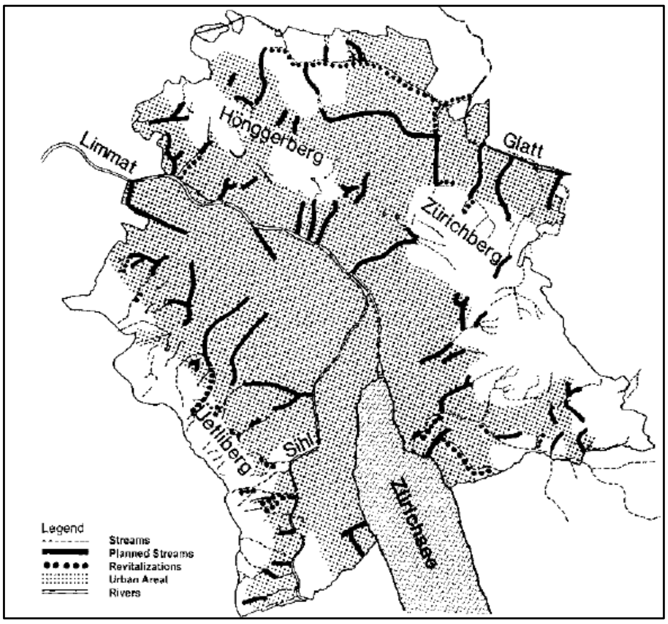

Figure 3.5. Planned streams for daylighting and revitalizing.

[Source: Conradin, F., Buchli, R. (2008)]

This stream daylighting program of Zurich has brought over 20 km of the stream back in more than 40 projects and reduced the estimated 0.8 m^3/s total extraneous water that enters in the sewer system to 0.5 m^3/s.[185] That means approximately 37% of surface water runoff from combined sewer system diverted into new daylighted streams, resulting the treatment plant less charged. Zurich's sewer system can be seen in Figure 3.6 as before and after the implementation of stream daylighting.

[185] Conradin, F., Buchli, R. (2008) The Zurich Stream-Daylighting Program. pp.50-51

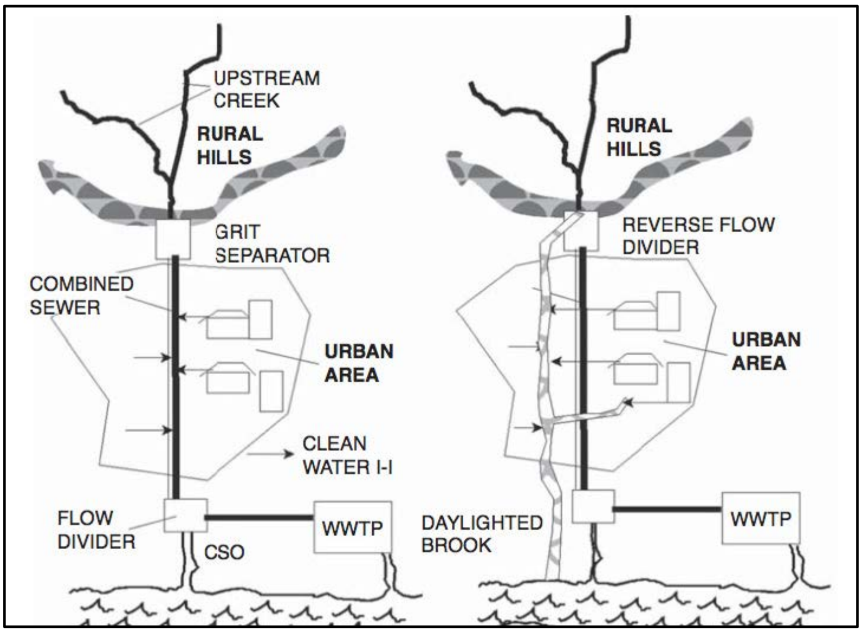

Figure 3.6. Zurich's sewer system before and after implementing the stream daylighting program.
[Source: Novotny, V., Ahern, J. & Brown, P. (2010)]

The economic advantages of daylighting make it attractive to be preferred. According to an estimation made by Entsorgung + Recycling Zurich, the cost of the maintenance and operation of the sewer system, including the treatment plant's expenditure is approximately \$5 million per continuously flowing m^3/s annually.[186] In this case, a profit such as \$1,5 million can be mentioned if 37% of surface water runoff separated from sewer system. Thus, instead of using the budget for the renewal of old stream pipelines and broader facilities for sewage treatment plants, daylighting can be a very reasonable solution that is more economical as well as ecological.[187]

Some cases that are implemented in Zurich are below:

***Döltschibach**:*

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[186] Conradin, F., Buchli, R. (2008) The Zurich Stream-Daylighting Program. p.58.
[187] Ibid.

Figure 3.7. The stream flows along sidewalks.

[Source: Conradin, F., Buchli, R. (2008)]

The length of daylighted portion of the stream is 2 km in 1993-1996. It was flowing in the combined sewer with wastewater to the treatment plant. Although the street and sidewalk limit the bank of the stream, it was implemented with 0.2 m^3/s capacity (Figure 3.7). The stream also collects the rainwater diverted from roofs and sidewalks by channeling the overflow into sewer.

Albisrieder Dorfbach:

Figure 3.8. Before and after of Albisrieder Dorfbach

[Source: Conradin, F., Buchli, R. (2008)]

The Albisrieder Dorfbach was reopened along 2.5 km and the construction took almost 3 years in 1989-1991. Before daylighting, as shown in Figure 3.8, the stream was buried in a private residential area. While the stream built according to 0.2 m^3/s capacity, the medium flow is 0.01-0.02 m^3/s.[188] The support of residents enabled the stream daylighting to implement even in private areas. When compared before and after landscape features of the site, it is seen monotone turf has replaced with a landscape that contain various plant species, including a variety of animal. While adults enjoy walking along the stream, children are the most attracted by this vitality of the nature.

After all, the success of Zurich Stream Daylighting cases display that authorities should be open to new ideas, otherwise many project such as stream daylighting cannot be actualized because of the holding the same line with the earlier engineering paradigms.[189]

3.5.3 Cheonggyecheon River, Seoul, South Korea

Watershed:	Cheonggyecheon River Watershed
Flow rates:	118mm/hr. (Provides flood protection for up to a 200-year flood event)
Removed culvert:	6 km
Length daylighted:	4 km
Project Year:	2002-2005
Objectives:	Recreation, economic revitalization, tourism

One of the very radical stream daylighting projects is Cheonggyecheon Stream daylighting. The river is in the heart of Seoul with a rich history. The Stream has been deepened, widened with dykes since the 15th century. Over time people built along the stream and pollution increased heavily. For the sanitation issues, the government decided to cover 6 km with concrete roads.[190] In the 1960s, private car

188 Conradin, F., Buchli, R. (2008) The Zurich Stream-Daylighting Program. p.53
189 Ibid.
190 Bocarejo, J. P., LeCompte, M. C., & Zhou, J. (2012). Case Study: Cheonggyecheon, Seoul, South Korea. In *the Life and Death of Urban Highways* (p. 27). Institute for Transportation & Development Policy and

ownership increased rapidly, and an elevated expressway was built to reduce traffic jams.[191] About 1.5 million vehicles were entering or leaving in the Cheonggyecheon Expressway each day.[192] Therefore, this highly urbanized area lost its attractiveness and value of properties. The government decided to bring the stream back to life. The difference before and after is very dramatic (Figure 3.9).

Figure 3.9. Before and After Cheonggyecheon River
[Source: Landscape Architecture Foundation (2010)]

The public supported the project with a high proportion of %79.[193] The cost of the project was $380 million, provided by the South Korean Government. The road was demolished and ripped out, then 4 km of the stream daylighted and constructed landscape design between the years 2003-2005. Thus, the elevated highway was transformed into a pedestrian-friendly open space (Figure 3.10). While the biodiversity of fauna and flora increased along the stream, urban heat island has decreased by 3.3° to 5.9°C compared to a parallel road 4-7 blocks away.[194] In addition, the price of land increased by almost 30-50% for properties within 50 meters of the restoration project.[195] The Project is criticized as the water currently

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EMBARQ. wrirosscities.org/sites/default/files/Life-Death-Urban-Highways-EMBARQ.pdf accessed on July 2020
[191] Ibid.
[192] Ibid.
[193] Trice, A. (Undated) Daylighting Streams: Breathing Life into Urban Streams and Communities. American Rivers.p.23
[194] Landscape Architecture Foundation. (2010). Cheonggyecheon Stream Restoration Project. landscapeperformance.org/case-study-briefs/cheonggyecheon-stream-restoration accessed on July 2020.
[195] Ibid.

pumped from the Han River, which is not energy-friendly; however, it is preferred over that of a freeway.

Figure 3.10. Cheonggyecheon Stream [Source: Mikyoung Kim Design (2009)]

3.5.4 Oslo Reopening Waterways, Norway

Watershed:	Citywide
Flow rates:	Various streams from 0.01 m^3/s to 10 m^3/s
Removed culvert:	N/A
Length daylighted:	3 km (more 8 km is the target for next 10 years)
Project Year:	2006-present
Objectives:	Flood control, provide vital ecosystem services, and create recreational opportunities.

Oslo City, inspired by international stream daylighting trends and organizations, started to reopen its waterways. Today they have been reopened 2.810 m of stream and plan to daylight 30 more stretches in the future (Figure 3.11).[196] According to the City of Oslo, the first reason of stream daylighting is to mitigate flooding and deal with increased rainfall because of climate change.[197] The buried stream capacity (culvert) is limited to manage the water. Especially during peak times, rainfall can overburden the water infrastructure and cause flood events, which results in financial and emotional damage.[198]

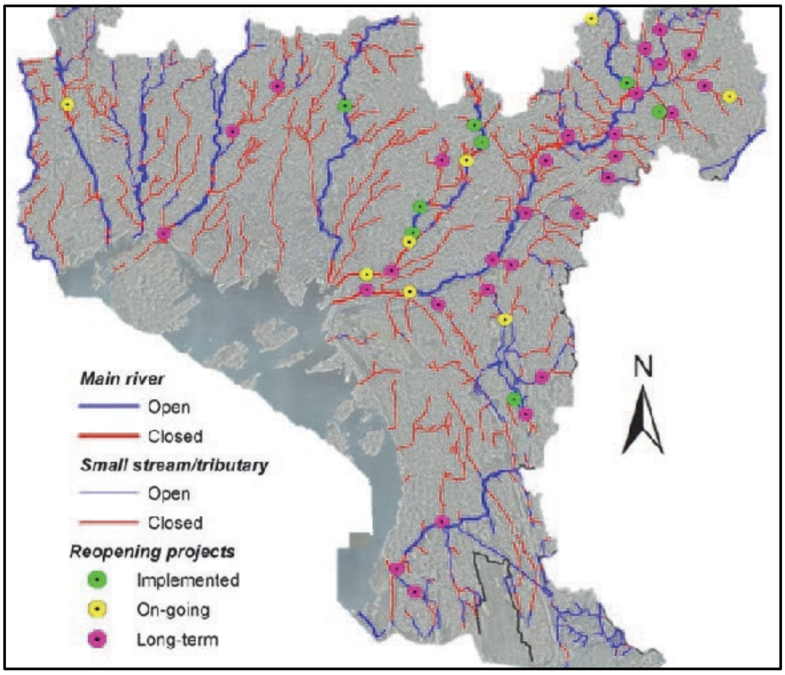

Figure 3.11. Oslo Plan for Stream Daylighting

[Source: European Green Capital Award 2019, City of Oslo Application (2017)]

In 2006, the City Investment Budget set aside €11.7 million for reopening projects throughout Oslo and municipal agencies developed a list of "principles for reopening projects" that prioritizes projects.[199]Also, the regulation of Oslo Action Plan for Stormwater Management was adapted according to the need for reopening projects.

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[196] Oslo Reopening Waterways (2018) European Green Capital Award. webgate.ec.europa.eu/greencitytool/resources/docs/best_practices/Oslo_Reopening_Waterways_A02.pdf accessed on May 2020.
[197] Ibid.
[198] Ibid.
[199] Ibid

The other policy strategy was made provision in the Municipal Master Plan (2015) to prevent construction pollution. They decided the residential zone would be starting 20 m away from the main waterways and 12 m away from tributaries.[200] The three crucial steps are indicates *planning, monitoring, and collaboration* by the City of Oslo.

Some of the successful projects are Hovin Stream in a neighborhood park in the Bjerke district, Hvals Stream suffered from floods for a long time, and Skytterdalen, culverted combined sewer ones. Hovin Stream was daylighted for 300 m with footpaths along its banks and a swimming pond with a sandy beach in 2013. In order to build the streambed as naturally as possible, stones of various sizes such as sand, silt, clay were used[201] (Figure 3.12, Figure 3.13). Thus, water can infiltrate groundwater. The plantation is very important to avoid erosion problem, so in the first 2-3 years, vegetation maintenance is very important (Figure 3.14)

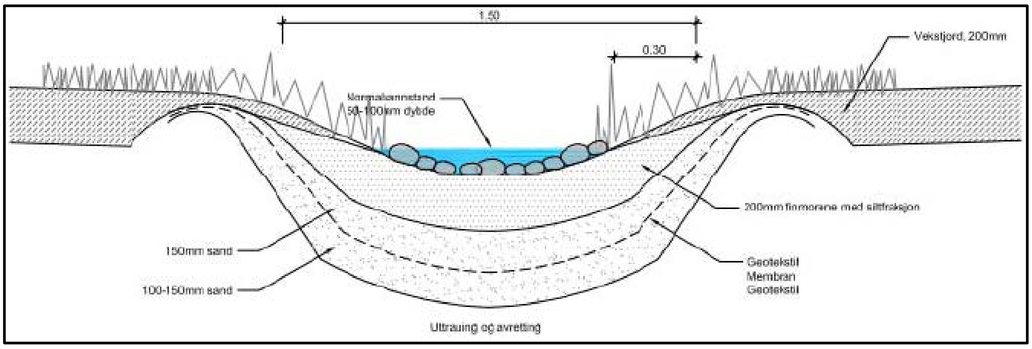

Figure 3.12. Structure of the bank of a streambed, Julsberg Stream Project.

[Source: Rapp, O. (2019)]

[200] Ibid.

[201] Rapp, O. (2019) Reopening of culverted streams and rivers. novatech.graie.org/documents/auteurs/1A1P-041RAP.pdf accessed on July 2020.

Figure 3.13. Construction of streambed for providing infiltration function, Julsberg Stream Project. [Source: Rapp, O. (2019)]

Figure 3.14. Vegetation maintenance in the streambed [Source: Rapp, O. (2019)]

CHAPTER 4

ENVISIONING A FRAMEWORK FOR STREAM DAYLIGHTING IN ANKARA

4.1 A Brief History of Urban Water in Turkey

Many aqueducts and sewer channels were made in Turkey before the Republic. Some of them are from the Byzantine period and some from the Seljuk and Ottoman periods. The attempt to establish the first sewerage system in the modern sense was planned for Istanbul before World War I. The project, which was going to be carried out by the French, could not be concluded due to the war.[202] In the Republican period, this duty was given to local authorities by the Municipalities Law, which was enacted in 1930. However, municipalities could not make it due to insufficient technical knowledge, financial issues, and lack of employees; therefore, water supply and sewer investments are mostly handled by Iller Bank.[203] The investments of İller Bank, which were made primarily to supply drinking water and establish drinking water facilities, have continued until the 1950s.

In the 1970s, in most of Anatolia, especially in towns, human excreta was still accumulated in pits and then used in fields or discharged to a remote area. [204] At the same time, wastewater that was used in laundry and kitchen works was being used for gardening.[205] On the other hand, the municipalities that had better facilities, combined kitchen, bathroom, and toilet waters and connected them to the sewers, discharging into the nearest *stream*, *sea,* or again septic pits.[206] In fact, in order to

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[202] T.C. Başbakanlık Devlet Planlama Teşkilatı. (1977) IV. Beş Yıllık Kalkınma Planı, İçme Suyu ve Kanalizasyon Özel İhtisas Komisyonu Raporu. DTP:1547-ÖİK:239. p.43
[203] Develi, E. S. (2014) İllerin Gelişiminde Altyapı Yatırımlarının Önemi Ve İller Bankası'nın Rolü. Non-published Master Thesis. İktisat Anabilim Dalı, Sosyal Bilimler Enstitüsü, Çukurova Üniversitesi.
[204] T.C. Başbakanlık Devlet Planlama Teşkilatı. (1977) p.44
[205] Ibid.
[206] Ibid. p.45

establish a modern sewer system, the drinking water system must be properly connected to the buildings so that there would be enough water in the pipes to transmit human feces trough pipes to the receiving water body.[207]

In the 1970s, separated system plans were launched for Istanbul and Ankara. However, the wastewater discharge was often devoid of treatment. For example, the master plan for Istanbul between 1968 and 1970, the wastewater planned to be discharged directly into Bosphorus and Marmara Sea by pipelines in sufficient depth and distance, instead of the treatment facilities.[208] The wastewater collected in Ankara was also given to the streams without any treatment.[209] Later on, these streams were covered by DSI and Municipality due to sanitary concerns.

The rate of the population served by the sewerage system in total municipal population over time and the rate of the population served by wastewater treatment plants in total municipal population over time is shown in Figure 4.1. The amount of wastewater discharged from the municipal sewer system by receiving bodies between 1994-2018 is shown in Figure 4.2. In addition to domestic wastewater, industrial wastewater is characterized depending on the sectors, and the most polluting sectors are textile, leather, chemical, petrochemical, fertilizer, pharmaceutical, and mining industries.[210]

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[207] Ibid. p.50
[208] T.C. Başbakanlık Devlet Planlama Teşkilatı. (1977) p.45
[209] Ibid. p.46
[210] Yararbaş, Ö. Atıksu Arıtımında Türkiye'nin Genel Görünümü. İMO. http://www.imo.org.tr/resimler/ekutuphane/pdf/890.pdf accessed on May 2020.

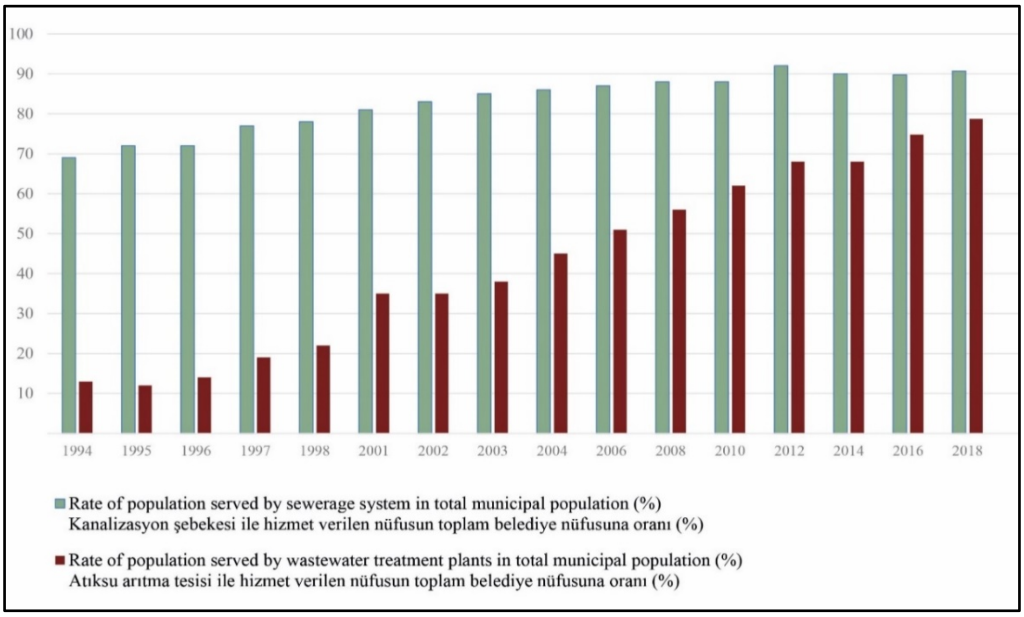

Figure 4.1. The rate of the populations for infrastructure (Source:TÜİK, 2020)

Today, 72% of the freshwater consumption of Turkey is related to agricultural irrigation, while 16% is domestic, and 12% is industrial consumption.[211] Lack of efficient agricultural irrigation and illegal wells results in a great amount of water decrease by evaporation and infiltration. In addition, as the average of all cities in Turkey, 42% of freshwater is lost in piping systems during conveyance causing loss of money for the government.[212] On the other hand, the downstream is polluted by wastewaters. While the population of Turkey is 81 million in 2017, the annual water amount calculated as 1.383 m^3 per capita is expected to decrease to 1.287 m^3 with the assumption that the population will be 87 million in 2023.[213] These numbers and IPCC (The Intergovernmental Panel on Climate Change) Report[214] indicate that Turkey is under the water stress and start to feel the impact of decreasing freshwater resources soon. Water potentials in river basins per capita can be seen in Figure 4.3.

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211 Sarıkaya, H. Z. (2015) Dünyada ve Türkiye'de Suyun Fiyatlandırılması. T.C. Orman ve Su İşleri Bakanlığı. Ankara. p.14.
212 Coşkun Dilcan, Ç. et al. 2018. İçme Suyu Şebekelerinde Görülen Su Kayıplarının Dünyada ve Ülkemizdeki Durumu. Anahtar Dergisi:06/2018. p.12.
213 Ibid.
214 IPCC Report Global Warming of 1.5 ºC. Chapter 3. 2018. pp.197-207.

Amount of wastewater discharged from municipal sewerage by receiving bodies 1994-2018
Alıcı ortamlara göre belediye şebekesinden deşarj edilen atıksu miktarı, 1994-2018

Thousand m3 - Bin m³

	1994		1998		2003		2008		2014		2018	
	Amount Miktar	%	Amount Miktar	%	Amount Miktar	%	Amount Miktar	%	Amount Miktar	%	Amount Miktar	%
Amount of wastewater discharged Deşarj edilen atıksu miktarı	**1 509 651**	**100,0**	**2 096 714**	**100,0**	**2 860 980**	**100,0**	**3 261 455**	**100,0**	**4 296 851**	**100,0**	**4 795 130**	**100,0**
Treated - Arıtılan	150 061	9,9	589 515	28,1	1 586 551	55,5	2 251 581	69,0	3 483 846	81,1	4 236 419	88,3
Untreated - Arıtılmayan	1 359 590	90,1	1 507 198	71,9	1 274 429	44,5	1 009 874	31,0	813 005	18,9	558 711	11,7
Sea - Denize	**556 912**	**36,9**	**795 402**	**37,9**	**1 173 734**	**41,0**	**1 458 461**	**44,7**	**1 915 294**	**44,6**	**1 949 475**	**40,7**
Treated - Arıtılan	87 156	15,6	282 319	35,5	892 638	76,1	1 231 880	84,5	1 759 461	91,9	1 883 205	96,6
Untreated - Arıtılmayan	469 756	84,4	513 084	64,5	281 096	23,9	226 581	15,5	155 833	8,1	66 270	3,4
Lake/Artificial lake - Göle/Gölete	**53 082**	**3,5**	**87 240**	**4,2**	**44 571**	**1,6**	**67 193**	**2,1**	**93 596**	**2,2**	**67 935**	**1,4**
Treated - Arıtılan	3 515	6,6	18 165	20,8	24 880	55,8	48 295	71,9	47 893	51,2	53 363	78,6
Untreated - Arıtılmayan	49 567	93,4	69 075	79,2	19 691	44,2	18 899	28,1	45 703	48,8	14 571	21,4
River - Akarsuya	**796 509**	**52,8**	**1 007 213**	**48,0**	**1 407 402**	**49,2**	**1 404 164**	**43,1**	**1 898 895**	**44,2**	**2 248 589**	**46,9**
Treated - Arıtılan	47 871	6,0	273 213	27,1	618 694	44,0	778 293	55,4	1 409 633	74,2	1 911 078	85,0
Untreated - Arıtılmayan	748 638	94,0	734 000	72,9	788 708	56,0	625 871	44,6	489 262	25,8	337 511	15,0
Dam - **Baraja**	**58 023**	**3,8**	**54 409**	**2,6**	**96 267**	**3,4**	**115 405**	**3,5**	**120 781**	**2,8**	**148 735**	**3,1**
Treated - Arıtılan	9 784	16,9	13 347	24,5	22 613	23,5	84 375	73,1	61 843	51,2	104 292	70,1
Untreated - Arıtılmayan	48 239	83,1	41 062	75,5	73 653	76,5	31 030	26,9	58 938	48,8	44 443	29,9
Land - Araziye	**40 702**	**2,7**	**55 780**	**2,7**	**43 364**	**1,5**	**50 374**	**1,5**	**17 954**	**0,4**	**19 052**	**0,4**
Treated - Arıtılan	1 734	4,3	2 472	4,4	6 081	14,0	14 108	28,0	8 367	46,6	13 173	69,1
Untreated - Arıtılmayan	38 969	95,7	53 308	95,6	37 283	86,0	36 266	72,0	9 587	53,4	5 878	30,9
Other - Diğer ortamlara	**4 421**	**0,3**	**96 670**	**4,6**	**95 643**	**3,3**	**165 857**	**5,1**	**250 332**	**5,8**	**361 346**	**7,5**
Treated - Arıtılan	0	0,0	0	0,0	21 645	22,6	94 631	57,1	196 649	78,6	271 307	75,1
Untreated - Arıtılmayan	4 421	100,0	96 670	100,0	73 998	77,4	71 226	42,9	53 683	21,4	90 038	24,9

Note: Includes the amount of wastewater treated outside the municipal treatment plants.
Not: Belediye tesisleri dışında arıtılan atıksu miktarı dahildir.

Figure 4.2. Amount of wastewater discharged from municipal sewerage by receiving bodies between 1994 and 2018.

(Source: TUİK, 2020)

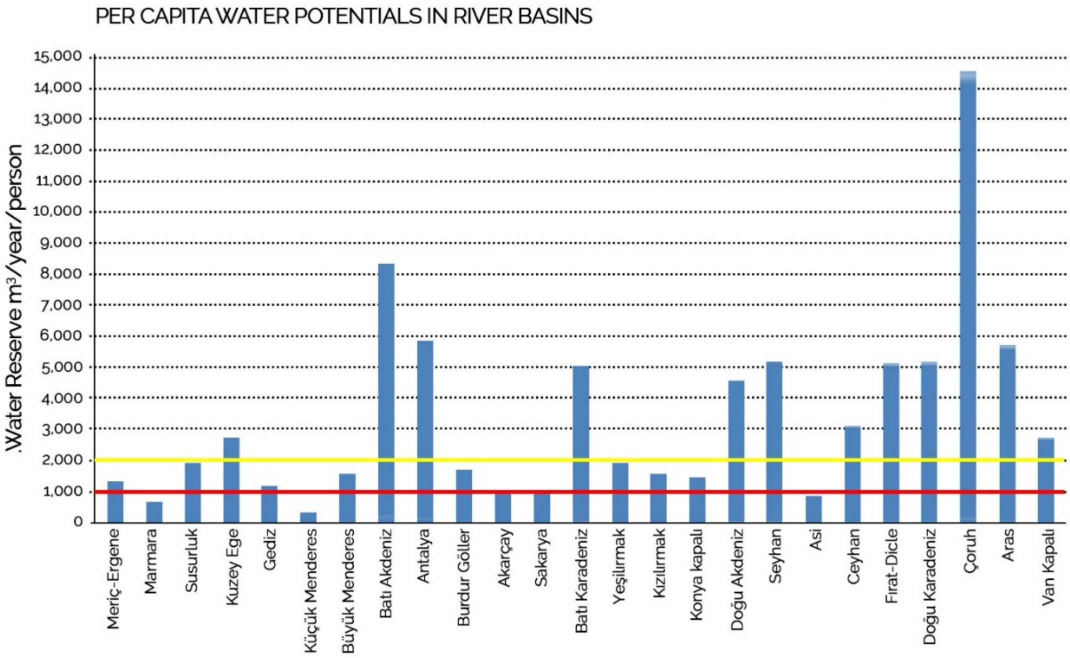

Figure 4.3. Per capita water potentials in river basins.
[Source: T.C. Kalkınma Bakanlığı (2018)]

While the commercialization and privatization of water supply and sewerage services have become a profit-driven water policy under the influence of global liberal policies after the 1980s[215], the sustainability of the natural structure of creeks and streambeds are considered as areas that restrict and hinder economic activities.[216] Land use changes in favor of people constantly. Turkey has become a part of some international agreements for the conversation of wetlands and streams. Important ones are Ramsar Convention, European Union Water Framework Directive, European Landscape Convention, and Agenda 21. On the national scale, water basins and their subunits (after 2011) are monitored only via physico-chemical parameters (without biological and hydro morphological parameters) in water resources and

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[215] Görer N. (2003) Commercialization and Privatization of Urban Water and Sewerage Services In Turkey: Poverty Reduction View. p. 181.
[216] Dinç, H. (2015) *İstanbul Derelerinin Fiziki Değişimi ve Arazi Kullanım İlişkisi,* Unpublished PHD Thesis; Şehir ve Bölge Planlaması Anabilim Dalı, İTÜ, İstanbul. p.4.

water quality classification.[217] Also, the streams, such as relatively smaller ones, are not included in-laws and regulations.[218] Most treatment plants are not enough to protect the water resources and their biotic community or operate efficiently. This approach lacks an Integrated Watershed Management, a comprehensive study that considers all aspects of a watershed including physical, chemical, and biological, as well as socioeconomic and political factors, resulting in vulnerable national landscapes in Turkey.

The 11th Development Plan, Water Resources Management and Safety, Special Expert Commission Report states: "The water quality monitoring studies carried out by many institutions and organizations in our country do not meet the requirements of the European Union Water Framework Directive."[219] Kentel and Yanmaz summarize the problems of Environmental Management Plans in Turkey as lacking an integrated and comprehensive approach and continue:

> "The policies followed, the rules introduced, the institutions established or the actions taken were developed to respond to emerging problems or international requirements. The main problem is that many different units provide services in the provision of water services. The fact that more than one institution regulating the same field has the same authority in the same location causes overlapping responsibilities and gaps in authority. Another important problem is the absence of trained, experienced and well-equipped engineers, technical personnel and workers who must work during the design, construction and operation of the system".[220]

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[217] T.C. Kalkınma Bakanlığı (2018) 11. Kalkınma Planı, Su Kaynakları Yönetimi ve Güvenliği, Özel İhtisas Komisyonu Raporu. p.51.

[218] Dinç, H. (2015) *İstanbul Derelerinin Fiziki Değişimi ve Arazi Kullanım İlişkisi,* Unpublished PHD Thesis; Şehir ve Bölge Planlaması Anabilim Dalı, İTÜ, İstanbul. P.39

[219] T.C.Kalkınma Bakanlığı (2018) 11. Kalkınma Planı, Su Kaynakları Yönetimi ve Güvenliği, Özel İhtisas Komisyonu Raporu. p.51.

[220] Kentel, E., Yanmaz, M. (2007) Kanalizasyon Sistemlerinin İşletimiyle İlgili Sorunların Değerlendirilmesi. pp.68-76.

4.2 Geographical Location and Stream Basin of Ankara

Ankara city is located on a plateau between 850-1200 meters of elevation as a topographic calyx surrounded by mountains and hills on the north, east and south sides. The borders of the city of Ankara remain within three river basins; Kızılırmak basin, Sakarya basin, and a tiny part of Konya closed basin. Curves, drawn by the rivers Kızılırmak River in the east and Sakarya River in the west, characterize the plateau of Ankara. Other small and medium streams are the tributaries of these rivers. Sakarya basin is one of the basins with the most intense industrial activities in Turkey. Industrial organizations of several different sectors operate in almost all the basin, especially Ankara, Eskişehir and Sakarya. One of the sub-basins of Sakarya Basin, Ankara Stream Sub-basin is 7178 km^2 (Figure 4.4). Ankara city center and districts are in the Ankara Stream Sub-basin. Therefore, the underground water in the basin is under heavy demand primarily for drinking and utility water, industrial uses, and irrigation.[221]

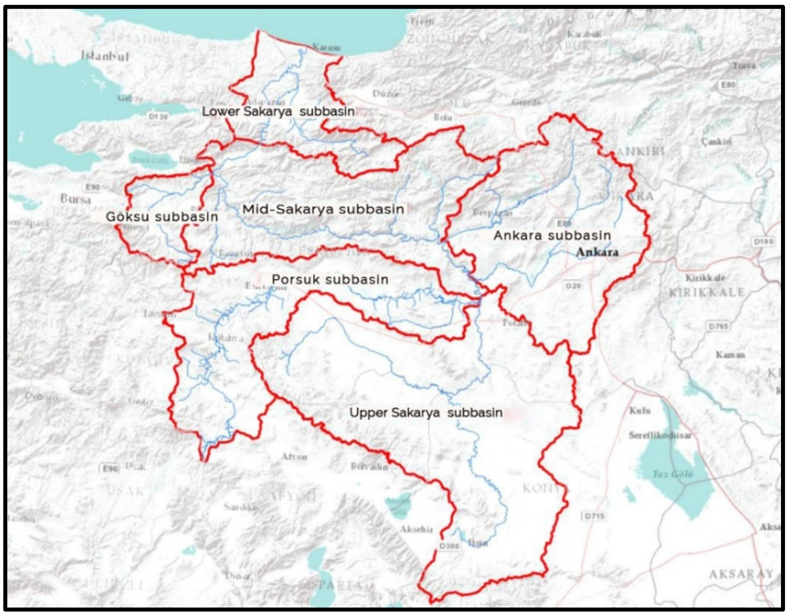

Figure 4.4. Sub-basins of Sakarya Basin [Source: Sakarya Master Plan Nihai Raporu (2017)]

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[221] HidroDizayn & NFB (2017) Sakarya Master Plan Nihai Raporu. DSİ Genel Müdürlüğü, Ankara. p.4-5

One of the first images of Ankara, in the Sakarya Basin was produced by a German cartographer Heinrich Kiepert in 1890-1892 (Figure 4.5). 1 / 250.000 scale map defined as "Continuation Angora Railroad" provides information about railways, streams and landform of Sakarya basin. The three main streams of Ankara, Hatip (Tabakhane), İncesu (İndje su) and Çubuk (Chibuk), flow through the valleys by collecting headwaters and after combining around Akköprü, they are named the Ankara Stream. Ankara Stream (Engüri Su) and Kirmir Stream, coming from the north through Beypazarı and Ayaş, flow into the Sakarya River in the western part of Asia Minor. This macro-scale map drawn in 1890 demonstrate the topography of the area and hydrological connectivity, which is transport of matter, energy and organisms through water cycle[222], before urban development.

Figure 4.5. Kiepert Map, 1890

(Source: The University of Chicago Map Collection, accessed on May 2020)

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222 Freeman, M.C., Pringle, C.M., Jackson, R.C., 2007. Hydraulic connectivity and the contribution of stream headwaters to ecological integrity at regional scales. Journal of the American Water Resources Association 43 (1), 5–14. p.1.

The city of Ankara (Angora) developed around the Citadel. The intersection of three main streams can be seen in Figure 4.6 signed with a red circle: Hatip Stream (Tabakhane Suyu) to the Çubuk Stream (Chibuk Suyu) and later İncesu (İndje Su). After merging these streams, it is named Ankara Stream (Engüri Suyu), followed by the railroad toward the west. The streams that flow into Ankara City are included in Sakarya basin. The land characteristic of Ankara is shaped by many small waterways feeding these four streams. Especially, on the west side of İncesu Stream, where the City's backbone would be built in the future, involves many small streams flowing towards the core of the city such as Dikmen and Kavaklıdere Streams. The spatial configuration of settlements is shaped along the valley and plain systems, which is generated by these streams. So, the formation of the settlement pattern of Ankara reflects a systematic composition based on geomorphological qualities of terrain, not a coincidental formation.[223]

Figure 4.6. Adopted from Kiepert Map, Ankara City, 1890 (Source: The University of Chicago Map Collection, accessed on May 2020)

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[223] Yavuz, I. (2018) Calyx: A Geomorphological Approach to Formation of Urban Space in The Context of Ankara. Unpublished Master Thesis. Department of City and Regional Planning, METU, Ankara.p.76

4.3 Historical Framework for Changing Streams

Ankara has been subjected to rapid migration inflow after becoming the capital city. Unplanned growth of the city led to geomorphological, ecological, and hydrological degradation. Infrastructure investments, which are the most important indicator of a developing city, have been insufficient for a long time. Number of flood disasters, population growth, and urban area extension result in investments for sewer systems, drinking water, and flood prevention projects began as late as in the 1960s. As mentioned above, geomorphological and hydro morphological factors played a crucial role in the establishment of settlements, and the city has begun to be developed accordingly. However, Ankara, which is among the planned cities, has lost control because of the dense population, lack of capital, and insufficient infrastructure.

It is aimed to examine the maps of the city produced by several institutions within the scope of city infrastructure and to identify the geomorphological and hydro morphological alterations. By all means, investigation of all the ephemeral and perennial streams requests a wider scope and multidisciplinary research, as explained in the first chapter. Therefore, "Disappeared Streams Map" as the main component of a daylighting project was prepared. Public awareness raising, an incentive for dialogue, and taking a step towards long term plans for rehabilitation of urban waterways were aimed with this map.

4.3.1 1924 City Map

As a historical city, Ankara has hosted many civilizations. It was a transition point between the east and west of Anatolia and thus it has always been active in terms of commerce. After the World War I, The Ottoman Empire was ended, and the new parliament of Turkey established in 1920. Subsequently, the Republic was declared, and Ankara became the capital of Turkey in 1923. The political authority devoted themselves to create a modern westernized capital city. However, the 1924 map offers us the Ankara before the great transformations, which was brought due to its capital status.

In 1924 Map of Ankara City (Figure 4.7), the streams and settlements can be seen clearly in 1/4000 scale. It is seen that some planning decisions have been made on the road from Taşhan to the Train Station[224]; however, the capital was not a planned modern city yet. A large marsh area can be seen in front of the Train Station that occurred by İncesu Stream. The drainage channels were built for reclamation by Ahmet Reşit Bey, who was the governor of Ankara in 1907.[225] Ankara was suffering from malaria spreading from the swamp at that period, and Ahmet Reşit Bey found the solution in opening drainage channels for discharging the water. In the future, improvement of this flat land where İncesu Stream floods would be one of the priority targets, and part of it would be turned into a city park called Youth Park.

On the other hand, Hatip Stream (Bentderesi) flows with a curve behind the citadel, which is located on a dominating hill. There are swamp, fruit, and vegetable gardens and cemeteries on the land with the curved stream. Çubuk Stream was not included in the map, however Hatip Stream and İncesu meets with it and constitutes Ankara Stream. Armenian and Jewish Neighborhoods were nearly completely destroyed in the 1916 fire.[226] This area was shown as Harik Neighborhood on the map. Washing and dyeing processes of the angora wool, which was the main element of the economic life of Ankara in the 16th and 17th centuries, was made by the Hatip Stream.[227] Another livelihood, tanning stage in leather production, which requires a serious amount of water, were carried out at the tanners by the Hatip Stream.[228] As

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224 Cengizkan, A. (2004). Ankara'nın ilk planı 1924-25 Lörcher Planı. Ankara Enstitüsü Vakfı Yayınları, Ankara. p.21

225 Tamur, E. (2012) Suda Suretimiz Çıkıyor. Kebikeç yayınları, Ankara. p.104

226 Günel, G., Kılcı, A. (2015) Ankara Şehri 1924 Haritası: Eski Bir Haritada Ankara'yı Tanımak. Ankara Araştırmaları Dergisi 3(1), 78-104.

227 Tamur, E. (2012) Suda Suretimiz Çıkıyor. p.12

228 Ibid.

indicated in the legend of the map, there were mills on the stream. Most of them are for grinding cereals.

Romans seized the control of Ankara at the end of 1st century BC. Stone pipes and various clay water pipes related to the water infrastructure of Romans for bringing water from Elmadağ were identified in this respect.[229] However, this plumbing was used until the 4th century; later, the weir built on the Hatip Stream by the Romans acted as a dam and used to carry water to specific areas of the city with gravity.[230] Thus, Hatip Stream is also called "Bentderesi" in Turkish, meaning the stream with weir. In the 19th century water was brought from the springs at the heights such as Elmadağ and Kayaş by Governor Abidin Pasha.[231] However, as the water need increased, in 1925, a catchment was built on the Kusunlar tributary of the Hatip Stream and 10 km of piping was installed.[232]

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229 Fıratlı, N. (1951) Ankara'nın İlk Çağdaki Su Tesisatı. Belleten Cilt: XV,59. p.350.
230 Ibid. p.359
231 Bayındırlık Bakanlığı Devlet Su İşleri Genel Müdürlüğü (1963) Ankara Taşkın Projesi Planlama Raporu. p.26
232 Bayındırlık Bakanlığı Devlet Su İşleri Genel Müdürlüğü (1963) Ankara Taşkın Projesi Planlama Raporu. p.26

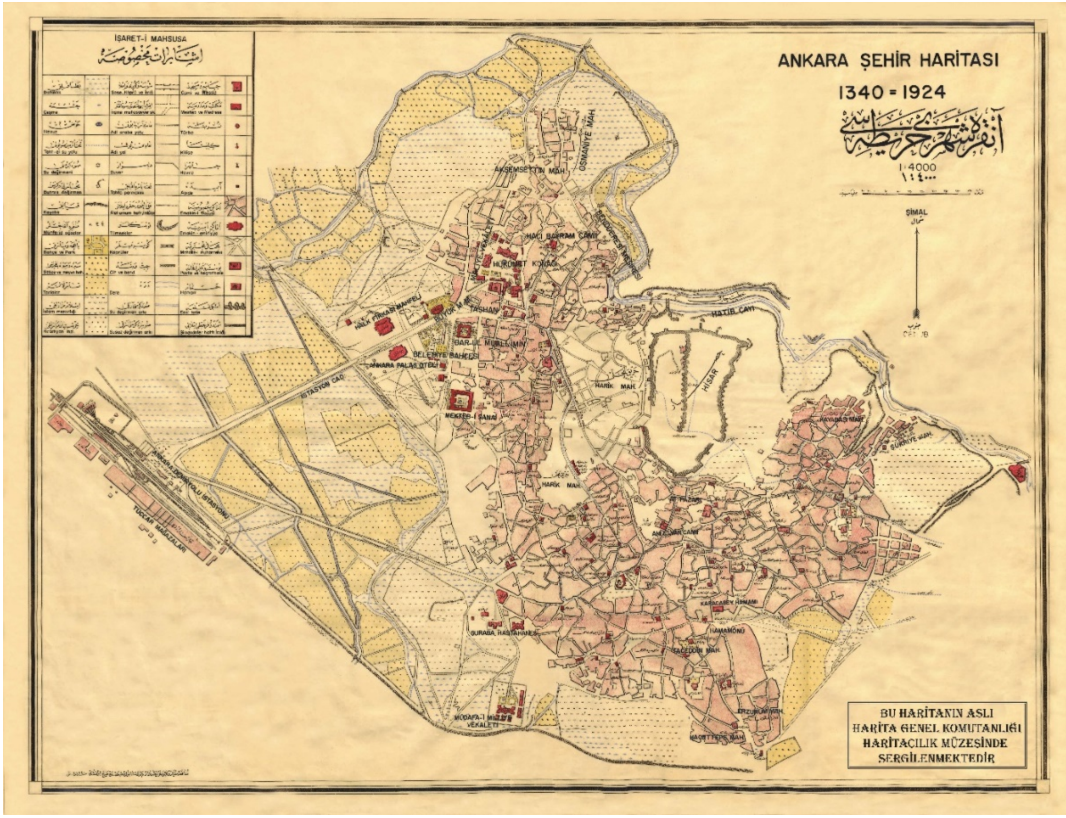

Figure 4.7. 1924 City Map. (Source: General Directorate of Mapping)

As mentioned in the historical summary on the relationship between the city streams and sanitary infrastructure, Western countries began to use the modern sewerage system at the end of the 19th century while in Turkey and especially in Anatolia, it was utilized around the mid-20th century.[233] In fact, in 1963, in Ankara, nearly 10% of the city had a modern sewerage system.[234] The reason is that drinking water infrastructure was connected to the settlement areas with delay because, for a modern sewer system, kitchen, bath, and toilet water should be transferred to the pipes in total so that human feces are carried to the receiving water body.[235] Although some wastewaters of the settlement at the Citadel and its surroundings were discharged to

233 T.C. Başbakanlık Devlet Planlama Teşkilatı. (1977) IV. Beş Yıllık Kalkınma Planı, İçme Suyu ve Kanalizasyon Özel İhtisas Komisyonu Raporu. DTP:1547-ÖİK:239. p.44

234 Bayındırlık Bakanlığı Devlet Su İşleri Genel Müdürlüğü (1963) Ankara Taşkın Projesi Planlama Raporu. p.2

235 T.C. Başbakanlık Devlet Planlama Teşkilatı. (1977) IV. Beş Yıllık Kalkınma Planı, İçme Suyu ve Kanalizasyon Özel İhtisas Komisyonu Raporu. DTP:1547-ÖİK:239. p.50

the streams, the use of septic tanks and cesspool was widespread at the beginning of the 20th century. When these tanks or pools were full, they were emptied by those occupied with this business, and the waste was taken to either a field or somewhere distant.[236]

4.3.2 1944 and 1946 City Maps

One of the critical map in which we see the Ankara streams and its geomorphology in detail is the 1944 Map (Figure 4.8, 4.9), prepared with two parts in 1/8000 scale. The other significant map is the 1946 Ankara City Plan (Figure 4.10) with a 1/20,000 scale. 1944 City Map was prepared by the General Directorate of Maps, and it has neighborhood and street names on it. The 1946 Map is the third volume annex of the 33-volume Turkish Encyclopedia, also known as the İnönü Encyclopedia series, published by the Ministry of Education. Neighborhood and street names are printed separately on tracing paper. The two maps have almost the same content.

Almost 20 years later, from the 1924 City Map, the difference between the old city pattern, which is located around the Citadel, and the new city, shaped in the south, can be recognized easily. Various plans were prepared to create a modern and western capital. Lörcher Plan (1924) is the initial planning schemas for historic core and the new city; however, Jansen Plan (1932) fundamentally directed urban development is the first planning experience for the capital city of modern Turkey.[237] He aimed public health as a social policy, which could be ensured by an open system-plan schema. So, sports plans and recreation areas such as Youth Park, Stadium, and Hippodrome are located in front of the Station, where were once marshes.

The first serious interventions on the İncesu Stream, which run from the south-east direction to the north west direction, can easily be noticed. On the map, Bülbülderesi

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[236] Ibid. p.44
[237] Çalışkan, O. (2004) Urban Compactness: *A Study Of Ankara Urban Form.* Published Master Thesis. Department of City and Regional Planning, METU, Ankara. p.155

Stream is added to İncesu just before Kazım Özalp Street (Ziya Gökalp Street) at the end of today's Libya Street in 1944 Map. Just before Kazım Özalp Street, it is channelized and run towards Atatürk Boulevard. On its right side remains the Fidanlık (today's Kurtuluş Park). Following that, Abdi İpekçi Park will also be located at the intersection with Boulevard. After advancing about 800 meters on Atatürk Boulevard, it proceeds through the canal to join Çubuk Stream through the uPark, Stadium and Hippodrome. It can be said that Jansen formed a *green corridor* along İncesu Stream. This green corridor provided both a solution to the rehabilitation of the swamp area and the opportunity to create a physical environment that supports public health and pleasure.

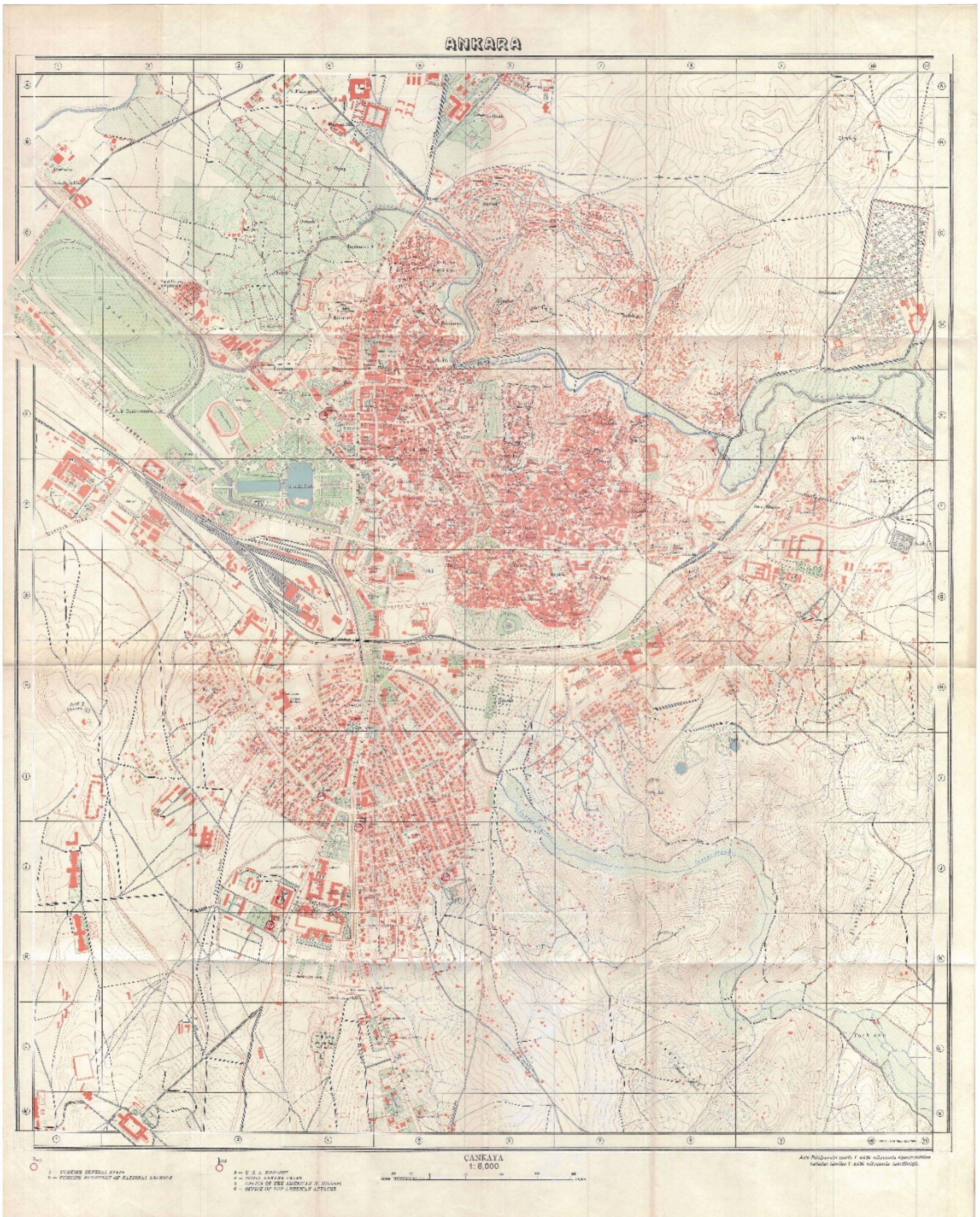

Figure 4.8. 1944 City Map- I (Source: Onur Bektaş Archive)

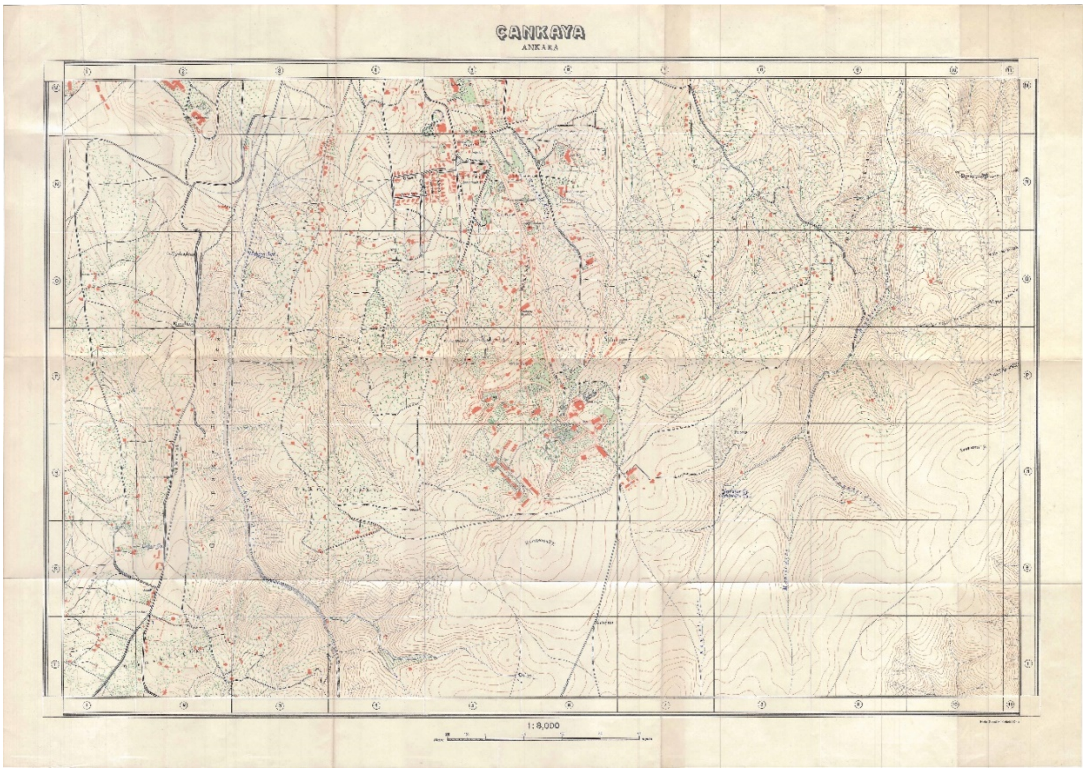

Figure 4.9. 1944 City Map, Çankaya Part (Source: Onur Bektaş Archive)

Hatip Stream is treated on the same channel as İncesu, beginning from Istanbul Street and proceeds along the Hippodrome. Unlike the 1924 map, the eastern side of Hatip Stream and Cebeci Asri Cemetery still exists today in the north of the stream, can be seen. The design of the cemetery, prepared as a result of a competition opened in 1935, reflects the modernization ideal of the period.[238] The railway that is seen below the Hatip Stream is the Sincan-Kayaş commuter line. Hatip stream runs along the isolated railway within a channel to the Bayındır Dam, today. In the early years, the line was highly integrated with the stream and its landscape fabric; however, after the 1950s, the rural landscape and geomorphology were fragmented related to the changes in land use and planning strategies.[239]

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[238] "Cebeci Mezarlığı". 2010. Bir Başkentin Oluşumu. Goethe Enstitüsü. Accessed on June 2020.
[239] Baş Bütüner, F. Et al. (2020) Decoding infrastructural terrain: the landscape fabric along the Sincan-Kayaş commuter line in Ankara. p.6.

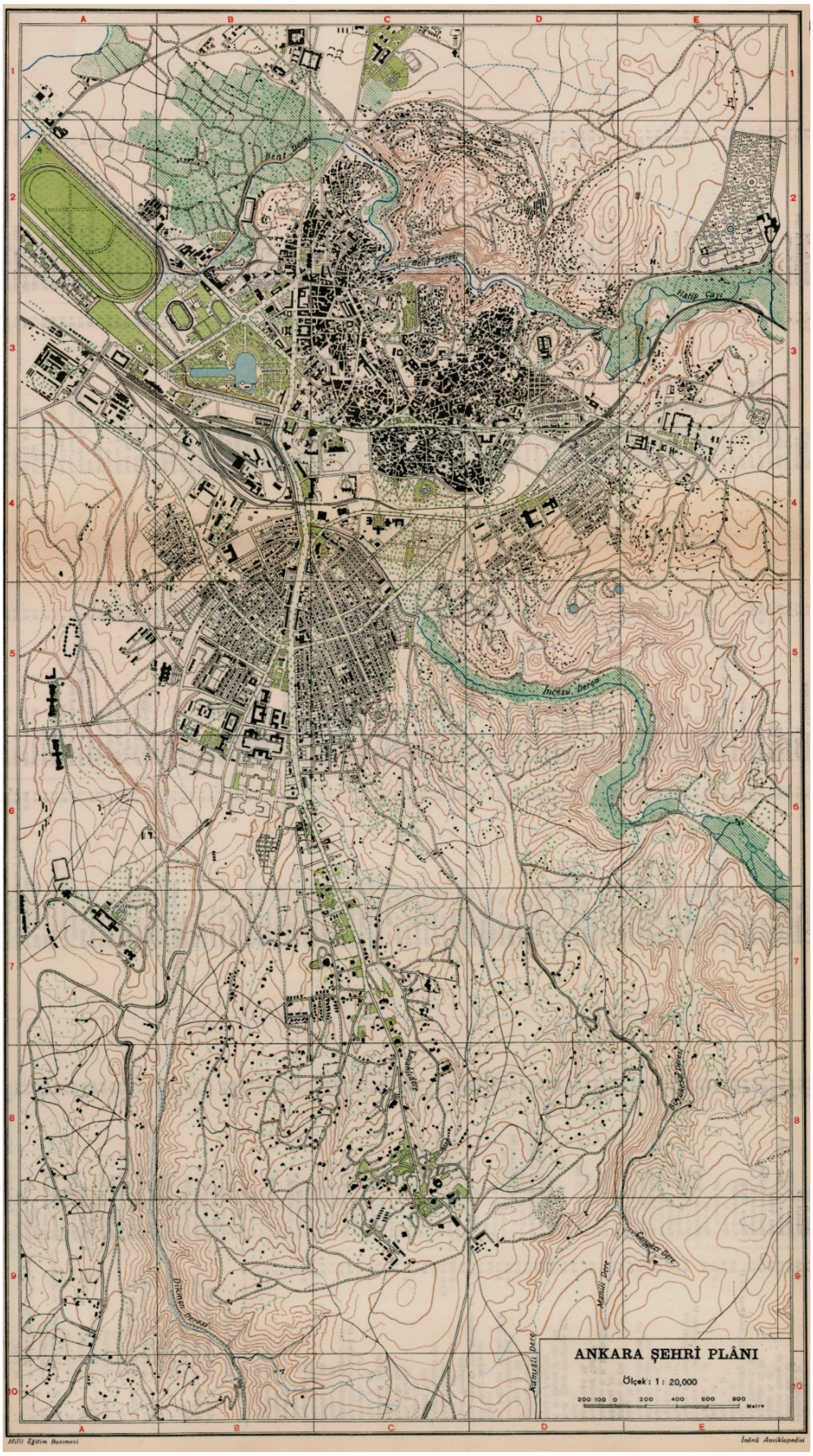

Figure 4.10. 1946 City Map . (Source: Onur Bektaş Archive)

Part of the Çubuk Stream can be seen in the upper left corner of both maps. Çubuk Stream is selected as a fertile source to meet the drinking water of Ankara, and Çubuk Dam is built at the site where it forms a narrow strait 11 km away from the city.[240] It was completed in 1936 and met Ankara's drinking water and occasional agricultural irrigation needs until the 1960s. When the water supplied from the Çubuk Dam was not sufficient to meet the needs of the city, the municipality opened up 119 wells between 1950-69 and made use of groundwater.[241]

As it can be understood from the map, apart from three main streams of Ankara, many large and small streams flow seasonally in the city. An important one of these is Dikmen Stream, which can be easily seen in the left south part of both the 1946 Map and 1944 Çankaya Map. As it is understood from the contour lines, the stream running between the steep slopes can be seen running towards the Military Academy. Although Dikmen Stream is a small creek, it used to cause floods in some seasons.[242] It remained natural until the 1970s but was later invaded by slum houses.[243] The stream was flowing towards Saraçoğlu Neighborhood direction in those times. Since the 1960s, it would be diverted to Anıtkabir-Bahçelievler, beginning from Military Academy.[244]

Another stream is Kavaklıdere, some of which is flowing in the Seğmenler Valley today. It is seen that it springs from the Çankaya Mansion complex at the south of both the 1946 Map and 1944 Çankaya Map. Today, from the Polish Embassy at the end of the Seğmenler Park, Kavaklıdere flows through the culvert along Tunus Street. Running along Ayrancı, Hoşdere Street also takes its name from a stream. In the valley indicated as Orta Ayrancı and Yukarı Ayrancı in the Çankaya part of the 1944 Map, the unnamed stream flowing parallel to the Dikmen Stream is Hoşdere.

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240 Tamur, E. (2012) Suda Suretimiz Çıkıyor. p.113
241 Tekeli, İ., Altaban, Ö., Güvenç, M., Türel, Ali., Günay, B., Bademli, R. (1987). Ankara 1985'den - 2015'e.Ankara Büyükşehir Belediyesi EGO Genel Müdürlüğü, Ajans İletim, Ankara. p.75.
242 Tamur, E. (2012) Suda Suretimiz Çıkıyor. p.145
243 Ibid.
244 Bayındırlık Bakanlığı Devlet Su İşleri Genel Müdürlüğü (1963) Ankara Taşkın Projesi Planlama Raporu. p.4

A part of the Valley today has been preserved as a park called the Portakal Çiçeği Valley. The route of Hoşdere Stream is Kuzgun Street of today. Small streams in the west, such as Kirazlıdere, Öveçler Stream, Cevizlidere, parallel to Dikmen Stream, flowing from the southern slopes of Ankara to the Ankara calyx, is not seen on the map. The valley was entirely zoned for development and exposed to intense construction. Çetin Emeç Boulevard has interrupted the valleys of these streams. Kirazlıdere and Öveçler Stream partially flow uncovered in the area around Military Academy and Military Facilities.[245]

Jansen has drawn a sewerage plan for Ankara core (Figure 4.11). In this plan, three main streams, stormwater, and wastewater pipes are seen. While only stormwater is discharged into streams, wastewater is collected in three main pipes and diverted to the treatment facility located at the beginning of Ankara Stream. After the treatment, the wastewater is discharged into Ankara Stream. Unfortunately, this plan could not be implemented. As mentioned earlier, septic tanks were used in most parts of the city, and the wastewater was discharged to streams. Although the Ministry of Public Works prepared a comprehensive sewerage report in 1940, the problem of the city was mostly addressed as seasonal due to stinking smell of the stream in summer.[246] Because the flow rate of the streams is very low in the summer months. The lack of sewer infrastructure would be an increasing problem day by day because of the expanding population and uncoordinated densification.

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[245] Tamur, E. (2012) Suda Suretimiz Çıkıyor. p.147
[246] Ankara Metropolitan Municipality (2007) 2023 Ankara Master Plan Report. p.489.

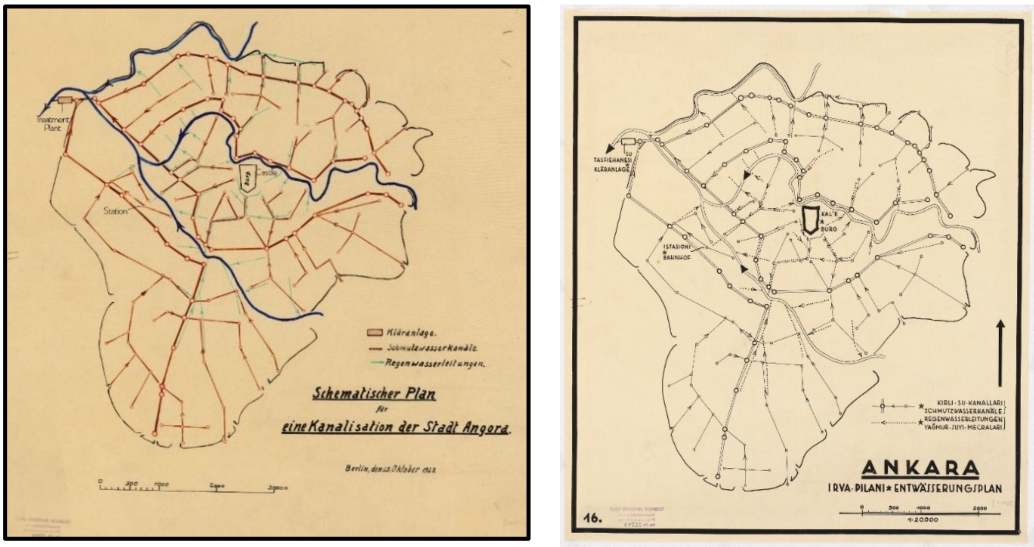

Figure 4.11. Sewerage Plans for Ankara, H. Jansen, 1948. (Source: Onur Bektaş Archive)

4.3.3 1959 City Map

The population of Ankara was 288 thousand in 1950 and 650 thousand in 1960.[247] In 10 years, the population has doubled. Ankara has entered a rapid urbanization process during this period, and the rate of immigration remained around 70% until 1975. The population envisaged in the Jansen Plan in 1980 was reached in the early 1950s. In 1955, a competition for the Ankara Master Plan was opened, and architect Nihat Yücel and Raşit Uybadin won this contest. The plan report stated that İncesu and Bentderesi Streams are part of the sewer system, and emphasis was placed on improving hygiene conditions.[248] On the other hand, the aim was to maintain urban development within the municipal boundaries, and Kızılay was considered as a center, eventually, in 1961, the parcels were combined in the center to increase the density.[249] This occasion meant an extra load on the already limited infrastructure.

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[247] State Institute of Statistics (DİE), 2000. Genel Nüfus Sayımı İdari Bölünüş

[248] 1957 Yücel-Uybadin's Master Plan Report.

[249] Yazman, D. (2009) Planlı Geçmişten Plansız Geleceğe. Arkitera. https://v3.arkitera.com/h46008-planli-gecmisten-plansiz-gelecege.html accessed on June 2020.

In this period, depending on the urbanization, we see that urban streams were partially culverted in the 1959 Ankara City Plan with 1/15.000 scale prepared by the General Directorate of Maps (Figure 4.12). The beginning of the Ankara Stream, where İncesu and Hatip Stream meet around Akköprü and join the Çubuk Stream is clearly observed in this plan. Fewer interventions were made to Ankara Stream bed compared to other streams. The most important reason for this is that the Stream locates Atatürk Forest Farm, established by Gazi Mustafa Kemal in the city. However, although it runs in the green area, the bed would be channelized and straightened in the future. Another change is that İncesu Stream channel was narrowed down by building a wall along Atatürk Boulevard during the widening of the boulevard (Figure 4.13).[250] In addition, irrigation weirs and wastes discharged to the upstream bed have also decreased the streambed capacity by increasing sediment accumulation.

[250] Bayındırlık Bakanlığı Devlet Su İşleri Genel Müdürlüğü (1963) Ankara Taşkın Projesi Planlama Raporu. p.16

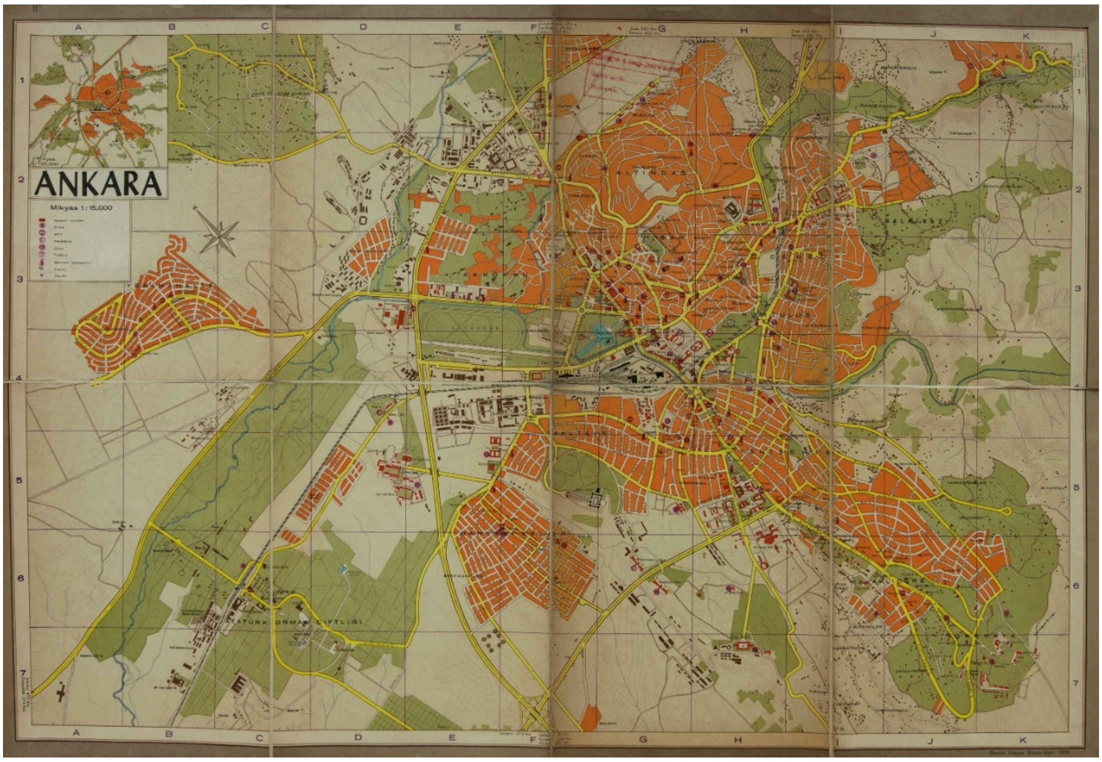

Figure 4.12. 1959 City Map. (Source: Koç University, VEKAM Archive)

Figure 4.13. İncesu Stream is in the channel along the Atatürk Boulevard in the 1960s. (Source: antolojiankara, instagram.com/p/B-mEih-AJKO/ accessed on May 2020)

The crucial detail on the map is most of the Hatip Stream (Bentderesi) flowing with a curve behind Citadel is no longer visible. Along the street, named Bentderesi, it was diverted to a concrete-based culvert in accordance with the 145 m^3/s flow. The reason for this is the flood disaster on September 11, 1957 (Figure 4.14). While there was no rain in the city center, Hasanoğlan, Lalahan, Kayaş and Mamak regions located in the catchment area of Hatip Stream received rainfall for 1.5 hours.[251] As the precipitation increased, the water exceeded the bankfull discharge of the streambed and occupied the floodplain on the Kayaş-Dışkapı route, destroying and dragging everything. The flood, which had caused the greatest damage up to that time, caused more than 20 million liras damage and 165 deaths.[252] This disaster can be regarded as the beginning of radical interventions in Ankara's geomorphological and hydrological structure. This flood, which is seen as a "natural" disaster, is actually a result of human-made infrastructure, as emphasized during the study.


Ankara'daki büyük sel felâketi
Hürriyet
Perşembe 12 EYLÜL
Meclis dün seçim kararı vererek dağıldı
Seçim Kanunu sert münakaşalardan sonra tadil edildi
İşbirliğine çalan Bayura İnönü cevap verirken bir kavga çıktı
Muhalefet-iktidar mebusları sille, tokat birbirine girdiler
H. Bayur kimdir?
Dolu ve şiddetli yağmurdan sonra seller önüne çıkan herşeyi götürdü
Tehlisci papas New York'a bugün varıyor
Münakaşa bekleniyordu ama tekme, tokat akla gelmiyordu..
Elbise temizlenirken benzin infilâk etti, 4 kişi ağır surette yaralandı
F. Belen 6 ay evvel D. P. den istifa ettiğini dün açıkladı


Ankara Dün Sel Felâketine Uğradı
Elmadağdan gelen seller Kayaş, Şaime kadın, Demirlibahçe, Bentderesi, Varlık Mahallesi ve Akköprü'yü sular altında bıraktı
Yüzlerce ölü var
SEL FELAKETINE UGRAYAN BÖLGEDEKI BUTUN AHŞAP EVLER YIKILDI
Azgın sularla ümitsiz bir mücadele yapıldı
Ekiplerin bütün gayret ve çalışmalarına rağmen sel bölgesinde maalesef büyük can kayıpları oldu
Can kaybının kesin sayısı belli değil
Kızılay derhal harekete geçti
Kurtarma işine projektörlerin ışığında devam ediliyor
Ani dolu yağışı yüzünden Hatip Çayı taşmıştır
Açık Teşekkür
ŞEKER SIGORTA
MAJESTIK
Dikkat - Dikkat
Ulus, dürlü sel felâketinde can ve mal kaybına uğrayan yurttaşlarımızın acısını paylaşır

Figure 4.14. Hürriyet and Ulus Newspaper dated September 12, 1957. [Source: Kaynar, İ. S. (2017)]

[251] Tamur, E. (2012) Suda Suretimiz Çıkıyor. p.88
[252] Ibid.

According to the 1963 DSİ Planning Report, one third of the city population was living in slums at that time, and these slums were built on the watercourse and slopes.[253] These constructions increase the sediment movement and cause decreasing of the streambed capacities.[254] In the 1957 flood, the rise in the density of housing on the floodplains, not only along Bentderesi but also by other streams of Ankara, has increased loss of life and property. Moreover, as stated in the Report, the main causes of flooding are related to infrastructure: "The lack of vegetation on the drainage areas of the streams, misuse of the land, conducting agricultural activities without taking soil conservation measures, and the spillage of various wastes to the fields have completely disrupted the infiltration and increased the flood's repetition and severity."[255] According to the report, an estimated 25 million liras was spent for the rehabilitation of the city streams up to that day, but since the conditions of upstream and downstream were bad, no benefit could be obtained. [256]

On the other hand, the wastewater and rainwater system covers only one tenth of the city: A separated sewer system was built by the German Hochtiff Company for Yenişehir, Maltepe, and Mebus Evleri neighborhoods.[257] While the stormwater was discharged to İncesu stream, wastewater to Çubuk Stream around Fişekhane.[258] In the rest of the neighborhoods, septic tanks were available. It is stated in the Municipality's Work Reports in the 1950s that headmen were given cement pipes in many neighbourhoods and a sewerage line was laid through collective work of citizens.[259] However, due to ignorance and lack of administration, it was observed that sewer connections were made even to the telephone manhole of PTT.[260]

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[253] Bayındırlık Bakanlığı Devlet Su İşleri Genel Müdürlüğü (1963) Ankara Taşkın Projesi Planlama Raporu. p.23
[254] Ibid.
[255] Ibid. p.3
[256] Ibid. p.25
[257] Ibid. p.28
[258] Ibid.
[259] Ankara Belediyesi (1952) 1952 Yılı Çalışma Raporu. p.31., Ankara Belediyesi (1953) 1953 Yılı Çalışma Raporu. Doğuş Matbaa. Ankara p.37
[260] Bayındırlık Bakanlığı Devlet Su İşleri Genel Müdürlüğü (1963) Ankara Taşkın Projesi Planlama Raporu. p.34

Wastewater was discharged directly to the nearest stream without any treatment, "so that all streams passing through the city flow in an open sewage channel"[261].

The Çubuk I Dam, built in front of Çubuk Stream, provided about 98% of Ankara's drinking and utility water in those years, and the water previously supplied for agricultural irrigation was stopped due to population growth.[262] However, it is stated that stream was still used in irrigation, although it consisted of wastewaters, especially in summer.[263] From this point of view, we understand that wastewater was discharged to stream channels without treatment in those years and that uncontrolled settlement decreased streambed capacities.

To mention other streams found on the map of 1959, Hoşdere, flowing from the slopes of Yukari Ayranci, is indicated as a thin line at today's Portakal Çiçeği Valley. After passing through the Military Academy, Dikmen Stream was diverted to the Kirazlıdere stream that flows parallel to it in the west through the Gülhane Military Hospital (today's Military Facility) bridge, and its previous bed was towards Saraçoğlu Neighborhood was changed.[264] The two streams running along Anıtkabir disappear beginning from Bahçelievler Street (Figure 4.15).

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261 Bayındırlık Bakanlığı Devlet Su İşleri Genel Müdürlüğü (1963) Ankara Taşkın Projesi Planlama Raporu. p.31

262 Ibid. p.18

263 Ibid.

264 Batukan, İ. (1967) Ankara Taşkın Projesi Tatbikatı. Türkiye Mühendislik Haberleri. p.65

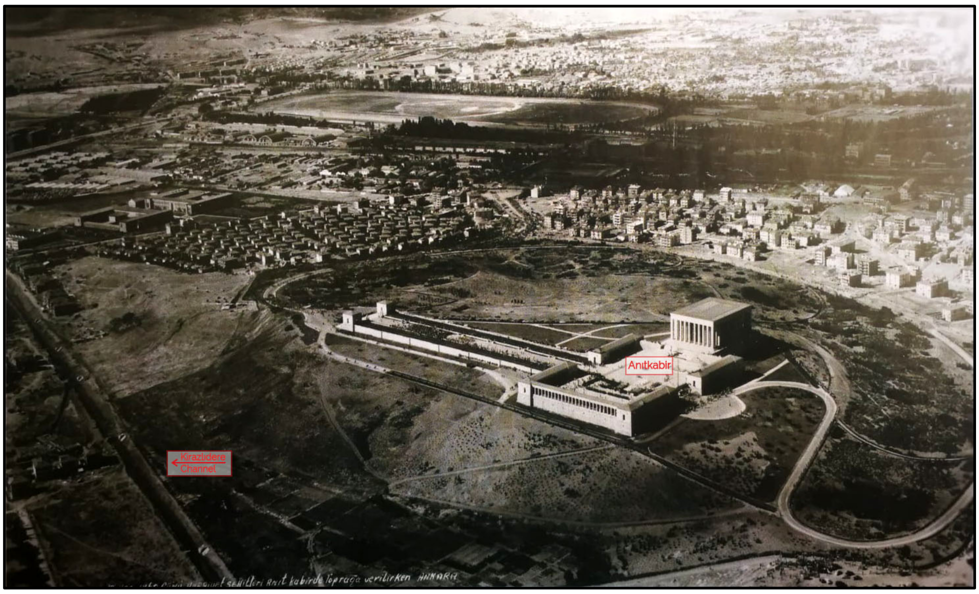

Figure 4.15. Kirazlıdere channel in 1960, covered by Mareşal Fevzi Çakmak Street today. [Source: Tamur, E. (2012)]

Kavaklıdere flows uncovered in the green area (today's Seğmenler Park) to the north of the Çankaya Mansion passes through embassies. It slowly flows into the calyx, İncesu watershed. Bülbülderesi has also disappeared from the city surface. There is no dense urban area yet in Seyranbağları and Büyükesat. In this area with vineyard houses, large and small streams flow through small valleys. Likewise, Şişkinderebağları and Samanlık Bağları on the upper part of İncesu stream have not lost their vineyards and streams yet.

4.3.4 1976 City Map

After the flood in 1957, there was another major flood in 1961, where life and property loss were seen again. These two floods alone caused 172 deaths and 40 million liras of material damage.[265] The reason for losses describes as "timeless and excessive precipitation". [266] However, the damages are the people that disrupt the

[265] Ibid. p.7
[266] Ibid.

natural structure of the flood areas and open them to the settlement. In order to prevent the floods and the effluent dominated waterways running in the urban areas, the streams were covered by channelizing with a concrete-lined ditch in various locations. However, as the possibility of flooding was still high, detention ponds were built by the DSİ on the tributaries of Hatip Stream, between 1963-1968. Thus, it was preferred to provide flood control by constructing detention ponds, which serve like a small dam, considered to be more economical, rather than giving up land values by expanding the streambeds.

The first planned work to meet Ankara's long-term water need, the "Ankara Project Report on Feasibility and Master Plan for Water Supply", was prepared Camp-Harris-Mesera (CHM) Consulting Engineers in 1969. This report can be considered as the first step of the plans for sustainability based on the sewer system and basin in the 1980s. However, the early 1970s were the years when the streams were covered, and roads were built over them.[267]

On the 1/10.000 scaled 1976 Ankara Map, it is clearly perceived that the city has rapidly densified in 20 years (Figure 4.16). The first noticeable changes on the map are the following: a part of Hatip Stream was previously covered along Bentderesi Street and now it is no longer visible in the city. The vineyards of the Seyranbağları were opened to settlement. İncesu stream was covered until the Hippodrome. Çubuk Stream, which forms the Ankara Stream by merging with İncesu and Hatip Stream in Akköprü just before Atatürk Forest Farm, was rehabilitated and channelized. In addition, a second dam was built on Çubuk Stream for the capital with water shortage. In the Farm, the Ankara Stream no longer meandered as it was in the 1959 Map; instead, it flows by forming more flat and wider curves. The Dikmen detention pond previously planned in the Aşağı Ayrancı is seen on the map, and the Dikmen Valley become an area with dense slums.

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[267] Ankara Metropolitan Municipality (2007) 2023 Ankara Master Plan Report. p.490

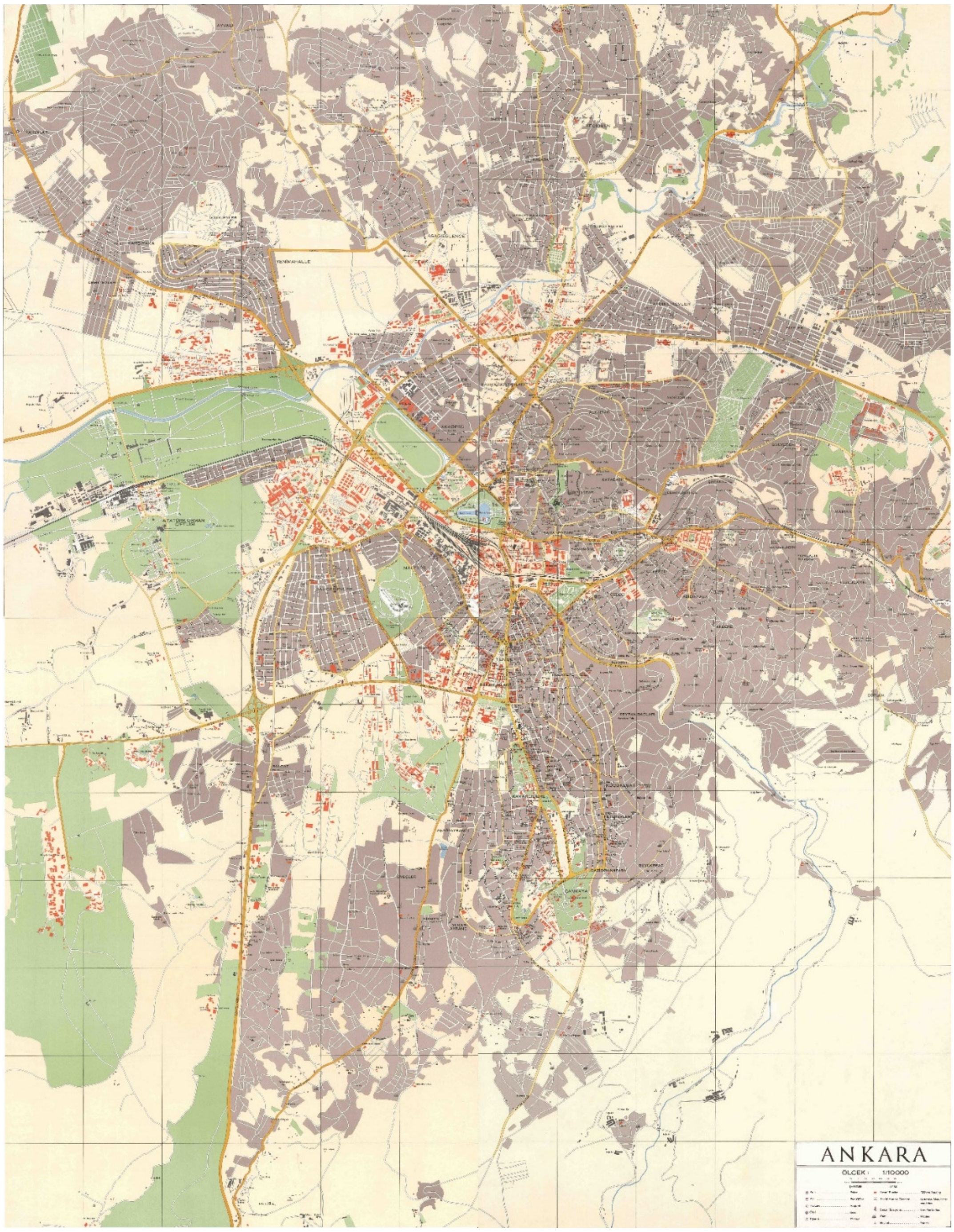

Figure 4.16. 1976 City Map (Source: Onur Bektaş Archive)

The reasons for the Ankara Stream arrangement are stated as the narrowness of its bed, the recession curves due to dense meandering and flooding of the agricultural areas and the zoo.[268] It was aimed to reduce the coastal erosion by reducing bed curves, and the streambed was sloped and strengthened with stone filling and plantation (Figure 4.17). Since other streams meeting in Akköprü carry all the waste to the Ankara Stream, the use of irrigation water has been reduced, and the irrigation needs of the Farm have been tried to be fulfilled by opening wells instead.[269]

Figure 4.17. Ankara Stream while strengthening with stone filling and plantation
[Source: Batukan, İ. (1968)]

It is seen that Hatip Stream was covered along Bentderesi Street in the 1959 Map. This line between Aktaş and Dışkapı is called the Part I. Within the scope of flood control and hygiene, DSI arranged the other parts of the city by channeling or culverting. Between the years 1962-1964, two culvert boxes of 2x2 m width were built along 1.5 km between Dışkapı and Etlik, known as the Part II, which connects to the Çubuk Stream[270] (Figure 4.18). In order to prevent the connection of the sewer pipes randomly, 50 cm concrete pipe is installed on the right side of the culvert.[271] Built-in 1964-1970 between Aktaş-Saimekadın bridge within the scope of Part III is approximately 2 km and it was channelized with a quay wall.[272] Although this section is still open on the 1972 Map, it is understood that it was covered later than

[268] Batukan, İ. (1968) Ankara Taşkın Projesi Tatbikatı. pp.13-15
[269] Ibid. p.11
[270] Ibid. p.1
[271] Ibid. p.1
[272] Ibid. p.36

the 1976 Map. The 7 km distance between Saimekadın-Mamak bridges is planned to be channelized later and this channel would be extended until Kayaş.[273] As Hatip Stream comes from the spring to the city, its bed narrows down. It has many tributaries, so the damage caused by the flood has been more severe. DSI constructed five detention ponds and one dam (Üreğil, Kusunlar, Karabayır, Lalahan, Nenek Sel Traps and Bayındır Dam) on tributary of the Hatip Stream for flood control instead of expanding the streambed in the city.[274] Thus, Hatip Stream was neglected without expropriating the lands in the city, without giving up the land values, and considering that new recreation areas were built outside the city. Decisions affecting the entire hydrological and geomorphological structure of the city were made without long term planning due to "economic" reasons. The investment cost of detention ponds, dams and concrete channels was approximately 43 million liras at that time.[275] On the other hand, Ankara still did not have a sewer system.

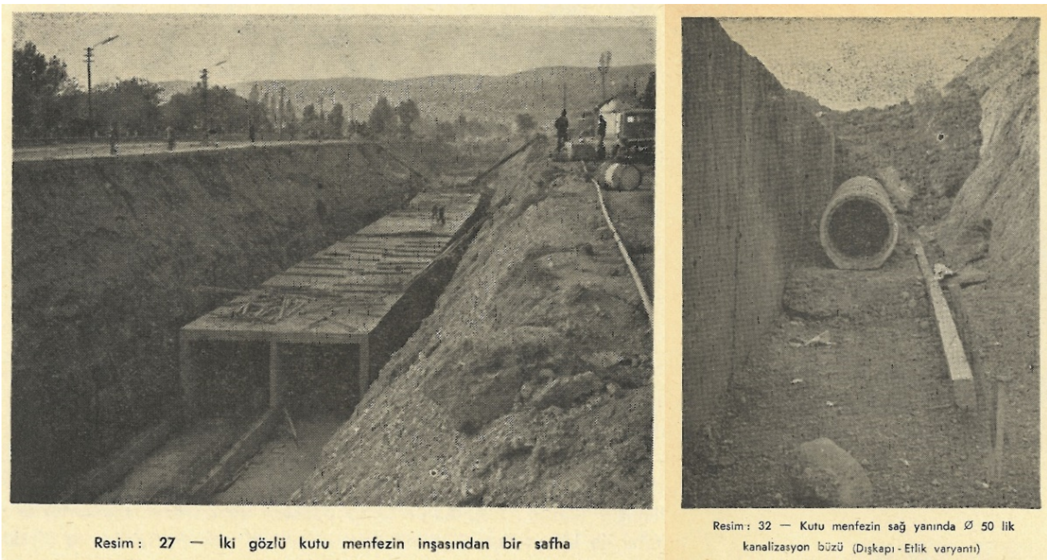

Figure 4.18. Concrete culvert while building for Hatip Stream and concrete pipe for wastewater. [Source: Batukan, İ. (1968)]

[273] Ibid. p.37
[274] Ibid. pp.38-57
[275] Ibid. p.58

Although İncesu Stream springs close to Eymir Lake, its water does not flow into the lake, but in those years (and sometimes today) a regulator that supplied water to Lake Eymir was used as a flood control method. When Eymir Lake became the property of Middle East Technical University, the facilities on its coasts and several brick factories in the vicinity restricted the water supply to the lake. A similar system was then considered for Mogan Lake. As mentioned in Chapter II regarding the importance of wetlands, vegetative riparian, marshy, and reedy areas are fertile spots as fish breeding and bird feeding areas that support the ecological cycle. When the water level increases, reeds, which are breeding and feeding areas, disappear. In infrastructure planning, ignoring ecological planning, sometimes due to economic reasons, and sometimes lack of information stands out throughout the whole process within the scope of flood control.

More than 11 km of İncesu Stream passes through the city. It passes through crowded areas such as Atatürk Boulevard and Sıhhiye market and important amusement and recreation sites such as Youth Park, 19 Mayıs Stadium and Hippodrome. In previous years, the trapezoidal concrete channel capacity between Akköprü and Kolej Bridge was 45 m^3/s. It flows with almost one third of Hatip Stream capacity. As it became an open sewer line in the summer months, it posed a health hazard and used to flood basement floors with the rising waters.[276] In the first stage, the area where Ankara College (TED) is located, between Ziya Gökalp Street and Tuna Street, is covered.[277] Because, in this area, children were going into the channel up to their knees for reasons such as finding their lost balls. The section between Akköprü and Kolej will be covered in 1972.[278] As a matter of fact, İncesu stream can only be seen along the Hippodrome in the 1976 Map.

[276] Ibid.
[277] Ibid. p.60
[278] Ankara Belediyesi (1972) 1971-1972 Çalışma Raporu. p.139

However, İncesu was arranged to allow it to be closed from the Kolej Bridge to the upstream. Today it is culverted under İncesu Street, which appears as Hasan Ali Yücel Street in the 1976 Map. It was planned to build lines for wastewater on both sides of the bed, thus saving from sewer facility cost and time, but it has not been realized. [279] Therefore, we understand that the covered streams, which have roads built on it, are generally sewer lines. For the culvert construction and the İncesu detention pond in Türközü, an investment price table of more than 10 million liras is specified in the 1968 Implementation Report.[280]

Dikmen Stream was connected to Kirazlıdere Stream at the intersection of K.K.K. (Land Forces Command) on the map that used to be called Gülhane Military Hospital and diverted towards Beşevler via Mareşal Fevzi Çakmak Street. As in İncesu Stream, in Bahçelievler and Beşevler neighborhoods where the city population is dense, many apartment sewer systems were connected to this channel, and the stream began to carry sewage.[281] In the 1961 flood, wastewaters, which overflew from the drainpipes as a result of the rise in the water level of the channel, flooded the basement floors.[282] The channel, where the two streams meet, was culverted to the quay walled concrete channel between the Beşevler and Çiftlik, to be covered in the future, and diverted to Ankara Stream.[283] After a short while, as the regional density increased, this channel was also covered to prevent wastewater flow openly. On the other hand, improvements have been made in the concrete and soil channels priory built between the Beşevler-Dikmen Bridge. As the capacity of these channels is 20-15 m^3/s and it was insufficient in the flood in 1961, a detention pond was built in the district of Aşağı Ayrancı (which corresponds to today's Çetin Emeç road). The detention pond, covered later, appears very clear on the 1976 Map. According to the report dated 1968 by DSI for these arrangements, a total investment cost of 4.5

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[279] Bayındırlık Bakanlığı Devlet Su İşleri Genel Müdürlüğü (1963) Ankara Taşkın Projesi Planlama Raporu. p.43
[280] Batukan, İ. (1968) Ankara Taşkın Projesi Tatbikatı. p.64
[281] Ibid. p.65
[282] Ibid.
[283] Ibid.

million lira was calculated for Dikmen Stream channel improvements and detention pond.[284]

4.3.5 1993 City Map

Large floods between 1957 and 1988 caused many losses of life and property (Table 4.1). Even if DSI's improvement efforts to protect the city from floods and to provide urban hygiene was sufficient for a while, it was not enough to meet the needs of Ankara for sewer and rainwater systems. In the 1970s, Iller Bank conducted two important master plans and feasibility studies, but only a few of these studies were carried out. In the early 80s, in some districts such as Çankaya, Altındağ, Yenimahalle, Batıkent, partial improvement works have started and in newly developing districts such as Demetevler sewer infrastructure works were launched.[285]

Table 4.1. The Historical Floods of Ankara

[Source: Ankara Alt Havzası Master Plan Raporu (2016)]

Date	The Site of the Flood	The Stream Caused the Flood	Loss of Life	Loss of Property (₺)	Loss of Property (2015 unit price ₺)
11.09.1957	Centre of Ankara	Hatip Stream	169	21,458,649	37,712,916
18.06.1961-21.06.1961	Centre of Ankara	Hatip, İncesu, Dikmen, KirazlıStreams	3	3,587,957	6,305,724
12.03.1968	Centre and its surroundings	Çubuk Stream	7	18,129,000	23,153,257
12.03.1968	Centre of Ankara	Hatip Stream		70,000	89,400
17.02.1969	Gölbaşı	Mogan Lake		800,000	958,084
01.03.1969	Centre of Ankara	İncesu Stream	1	3,000,000	3,592,814
12.06.1988	Kayaş, Abidinpaşa,Gülveren	İncesu and Hatip Stream	13	N/A	

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284 Ibid. p.69

285 Ankara Belediyesi (1983) Eylül 1980 Aralık 1983 Dönemi Çalışma Raporu. p.118

Based on the plan developed by CHM Company in 1969, "Preliminary Report on Planning for Ankara Water Supply Project" was prepared by DSI in 1983. In addition to drinking water supply, the report envisaged the target of 2020 for the transition to a separate system and building a wastewater treatment plant.[286] Thus, wastewater treatment plant and sustainable basin approaches, which have begun at the beginning of the 20th century and later become compulsory, became a current issue in Turkey in the mid-1980s. In the meantime, the pollution threatening drinking water basins had reached high levels. According to the Metropolitan Municipality administration established after 1980, water and sewer organizations affiliated to municipalities were assigned to the relevant units of the municipality. Ankara Water and Sewerage Administration (ASKİ) was established in 1987 and assumed the position in 1989. In the same year, the Great Ankara Sewer Project (BAKAY) was developed, and it was planned to switch to a separate system and to construct a Wastewater Treatment Plant in Tatlar. Attempts were made to obtain foreign financing from the World Bank and Germany, and aid was granted.

Within BAKAY, it is aimed to lay 6750 km of lines for 6 million people until 2025. Between the years 1989-1997, a total of 2229 km of pipes, including 1578 km of wastewater, 329 km of rainwater and 322 km of combined sewer system was constructed.[287] In other words, 34% of the targeted 5625 km wastewater pipe, 29% of the 1125 km stormwater pipe, and 54% of the total projected 6750 km, including the pipes built before ASKİ were accomplished.[288] Wastewater Treatment Plant was put into service in Sincan - Tatlar Village in 1997.

However, separating wastewater from streams was not easy, both technically and economically. Lack of experienced and well-equipped technical personnel and workers who will work and supervise during the design and implementation phase

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[286] Köle, M. M. (2014) Ankara Örneklemi Üzerinde Cumhuriyet Dönemi Su Kaynakları Yönetim Modelleri. Türkiye Sosyal Araştırmalar Dergisi, 18:1. p.77
[287] Ankara Metropolitan Municipality (2017) 2038 Ankara Environmental Plan Report. p.541.
[288] Ankara Metropolitan Municipality (2007) 2023 Ankara Master Plan Report. p.491

are one of the main problems in the implementation of sewer systems. As a matter of fact, there have been problems in implementations and incidents like connection of rainwater lines to wastewater and wastewater lines to rainwater lines were seen.

In the 1993 City Map (Figure 4.19), it seems that there has been urban growth to the north of the Çubuk Stream. Çubuk Stream has lost its function due to wastewater connections from settlements, particularly Çubuk District, Çubuk I Dam has completely lost its drinking water potential since 1994.[289] Çubuk Treatment Plant was launched in 2009, but because the discharge of extra water such as industrial wastes damaged the bacteria enabling biological treatment, wastewater is discharged to Çubuk Stream without treatment.[290]

The only waterway visible on the map is the İncesu Stream, which springs near Eymir Lake in the southeast of the city and culverted at the entrance of Mutlu Neighborhood. The region known as İmrahor Valley resists the urbanization pressure as the only wetland of the Ankara Stream basin not zoned for construction yet. However, channelization of it is being considered.[291] Straightening the streams with a concrete channel system not only ends the ecological life but also increases the velocity of the water, which results in floods and damages economically.

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[289] HidroDizayn & NFB (2016) Ankara Alt Havzası Master Plan Raporu. DSİ Genel Müdürlüğü. p.16-19
[290] Ibid. p.9-156
[291] Ankara'nın Vadileri ve Dereleri Çalışma Grubu (2020) İmrahor Vadisi Bilgi Notu. Şehir Plancıları Odası Ankara Şubesi. spo.org.tr/resimler/ekler/3f2f853eea753bb_ek.pdf?tipi=2&turu=X&sube=1

Figure 4.19. 1993 City Map (Source: Koç University, VEKAM Archive)

Since 1990, progress has been made on the improvement of streams and the sewer system. However, there are still many wastewater lines connected to the covered streams, which are supposed to carry stormwater. Ankara Metropolitan Municipality started an urban transformation project in Dikmen Valley in 1989, and slums were destroyed in stages and mass houses were built instead. A rich landscape project was built by constructing an artificial concrete watercourse at the base of the valley. Tragically, under the artificial watercourse, the stream itself flows in the culvert and carries wastewater.[292] The accumulation of sediments and the amount of water increase lead to ecological degradation and floods. Cleaning the inside of the covered culverts is much more costly and risky in terms of occupational safety compared to open systems (Chapter III).

4.4 Mapping Disappeared Streams

The story of rapidly growing Ankara, which began modern and planned, changed after the 1960s. In areas developed with considerable planning, development rights, and densities were increased, and especially between 1961 and 1975, an urban transformation process (demolish and build) was carried out in these areas.[293] Actions were taken without considering the incomplete sewerage infrastructure in this process, and the streams have become sewer lines. DSI reports[294], which suggested that the streambeds should be left as green areas, were not taken into consideration, and the Municipality gave priority to different infrastructure facilities in the ranking of needs by stating that their resources were insufficient[295].

The fact that Ankara streams are part of the sewer system is an urban infrastructure problem. Tekeli summarizes the infrastructure problem of the late developing countries like Turkey as in the following: "The arrival of the rural population to the city means too much capital accumulation demand, but for a country with limited

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[292] See for artificial watercourse and : Soyak, A. (2020) Dikmen Deresi. https://www.youtube.com/watch?v=K5Wrc4qajnY accessed on June 2020.
[293] Tekeli, İ. (1987). Ankara Kent Mokroformunun Değerlendirilmesi. In *Ankara 1985'den - 2015'e*. p.170
[294] Bayındırlık Bakanlığı Devlet Su İşleri Genel Müdürlüğü (1963) Ankara Taşkın Projesi Planlama Raporu. p.76
[295] Ankara Belediyesi (1972) 1971-1972 Çalışma Raporu. p.102

capital accumulation, industrialization and creating employment opportunities for the rural population and at the same time making infrastructure, housing etc. investments in the city is extremely challenging. In that case, the country trying to develop with the "scarcity of infrastructure" has to accept situations that do not comply with the required technical and administrative conditions. Dolmush lines and slums are the solutions that come out of this scarcity."[296] Efforts to discharge wastewater and stormwater at the lowest cost from the 1950s to the early 1990s also corresponds to non-holistic infrastructure policy. The geomorphology of the city has undergone a great change. Ankara, known as the steppe city, has lost water resources that flowed through it. However, the memory of the city 70 years ago is completely different. In addition to ecological destruction, the losses in every flood and sewer problem show that the "modern" engineering method preferred economically is not sustainable.

Ankara maps of various scales, books, reports, and archives were examined, and the city center was taken into consideration, and an area of 10x10 km was determined within this framework (Figure 4.20). In Figure 4.16, streams with white color flowing in natural beds and the channels indicated by DSI. Also, the study area is shown with the red frame. As one of the main steps of the Stream Daylighting Project, the disappeared streams are shown with blue lines according to the boundaries of the study area on the map (Figure 4.21).

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[296] Tekeli, İ. (2007) Günümüzde Kentsel Altyapı Sorunsalına Genel Bir Bakış. 5. Kentsel Altyapı Ulusal Sempozyumu Bildiri Kitabı, İMO. p.274. imo.org.tr/resimler/ekutuphane/pdf/13774.pdf accessed on May 2020.

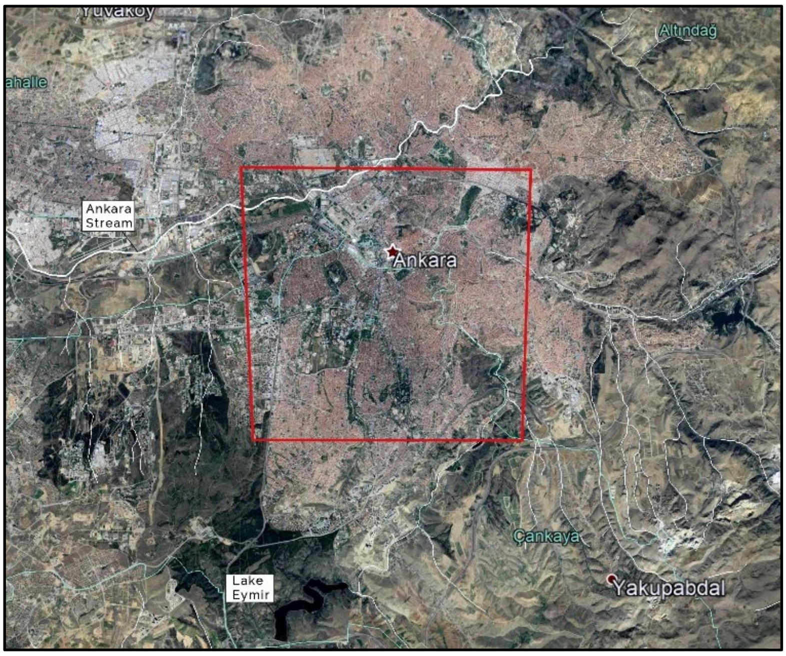

Figure 4.20. Study Area and Surrounding Streams of Ankara.

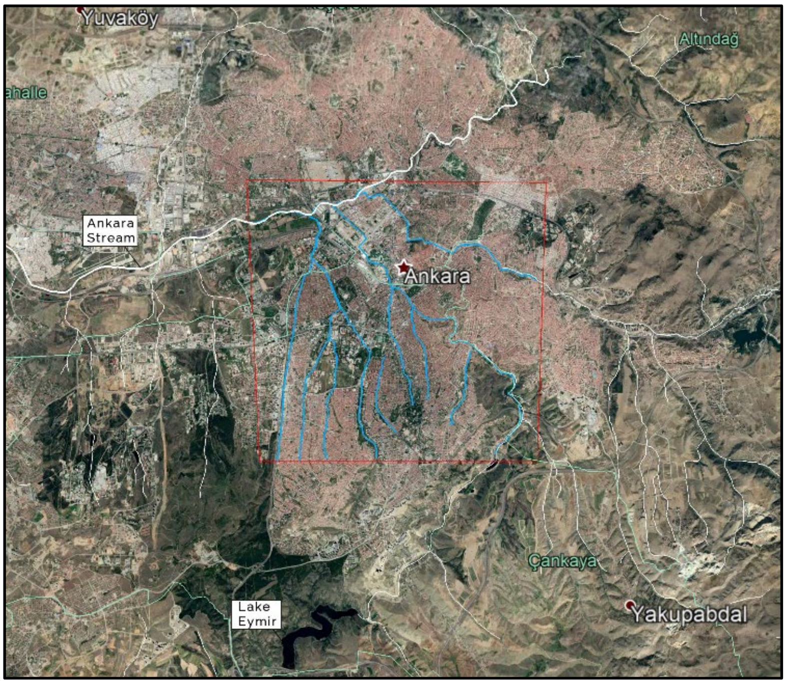

Figure 4.21. Disappeared Urban Streams of Ankara within the Study Area

In Figure 4.22, "Disappeared Streams Map of Ankara" is visualized by drawing the channelized streams, covered streams, the streams flowing in the natural bed, and the changes made in the streambeds. Accordingly, it is seen that a total of 56 km of stream within the 100 km^2 of area, which was determined focusing on the Ankara city center, was disappeared from the surface by either culverting or diverting to the stormwater pipes under the roads (Table 4.2). Natural streambeds of the streams were changed and mostly straightened while catchment areas are exposed to dense settlements.

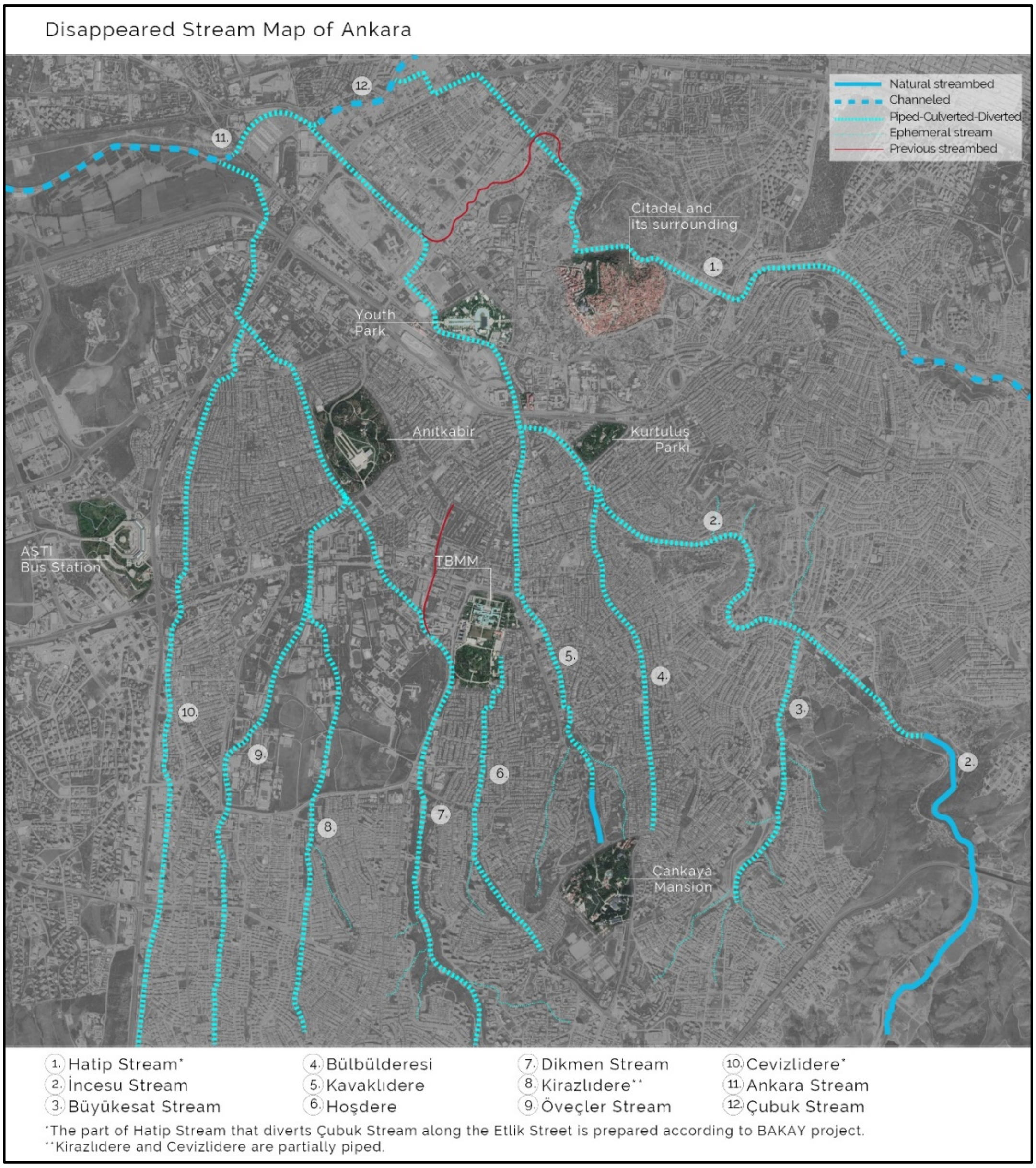

Figure 4.22. Disappeared Streams Map of Ankara.

As mentioned before, Hatip and İncesu Streams combine to Çubuk Stream and name Ankara Stream. These three streams have a larger flow rate than others, and the watershed area of them can be seen in Figure 4.19. Büyükesat, Bülbülderesi, Kavaklıdere, Hoşdere and until 1960 Dikmen Streams are tributes of İncesu Stream. Dikmen Stream diverted to Kirazlıdere in the 1960s. Today, the watershed area is separated as Dikmen Watershed and İncesu Watershed, which is shown in Figure 4.23.

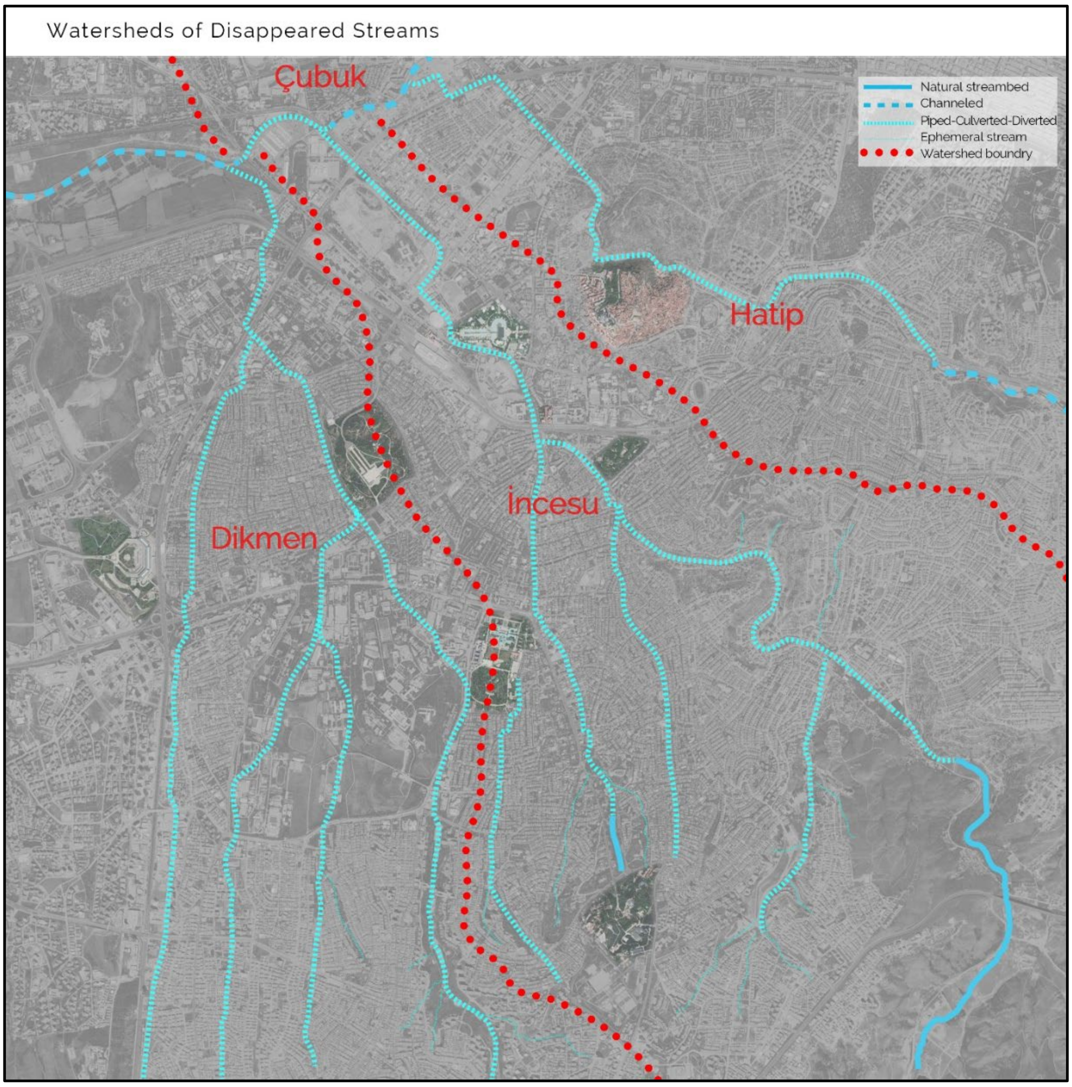

Figure 4.23. Watersheds of Disappeared Streams.

In the Ankara Sub-Basin, there are generally springs with a flow rate ranging from 1–10 lt/s (0.001 – 0.01 m^3/s), accordingly, there is no spring with exposed to continuous and regular measurement by DSI.[297] In the previous reports of DSI, the min-max flows of the streams mentioned above are not specified. However, except for Hatip and Çubuk Stream, *slow-flowing* springs are almost dry in summer and start flowing again in winter and spring. Therefore, under normal conditions, they flow by covering a water surface below the bankfull discharge. For a stream with an average flow of 0.01-0.02 m^3/s, an average cross-section of 2 meters can be mentioned.[298] This means that 56 km long watercourse has disappeared from the surface, and the city center is deprived of a water surface of approximately 112,000 m^2.

Table 4.2. The distance of Disappeared Streams in the Study Area

Stream Name	Existing Situation in Study Area	Site	Km.
Hatip	Channeled (Concrete-lined ditch)	Mamak	1.4
Hatip	Culverted	From Necmeddin Erbakan Congress Centre to Edremit Street	6.9
İncesu	Natural streambed	İmrahor Valley	3.5
İncesu	Culverted	From Türközü to Ankamall	9.8
Büyükesat	Filled and Diverted to storm drain	Şemsettin Günaltay Street to İncesu	3
Bülbülderesi	Piped and Diverted to storm drain	Bülbülderesi Street to İncesu	3.4
Kavaklıdere	Natural Streambed	Seğmenler Parkı	1.1
Kavaklıdere	Diverted to storm drain / Culverted	From Seğmenler to Sıhhiye	3.3
Hoşdere	Diverted to storm drain / Culverted	Portakal Çiçeği Valley– Kuzgun Street – Güvenlik Street	3
Dikmen	Diverted to storm drain / Culverted	Kirazlıdere	5.7
Kirazlıdere	Diverted to storm drain / Culverted / Some part in KKK. flows openly	From Dikmen Street to Fevzi Çakmak Street	5.4
Kirazlıdere	Diverted to storm drain / Culverted	From Fevzi Çakmak Street to Ankara Stream	3.9
Öveçler	Diverted to storm drain	Until KKK.	4.4
Cevizlidere	Diverted to storm drain / Culverted	Along the Mevlana Boulevard – Emek Neighborhood	7
Çubuk	Channeled (Concrete-lined ditch)	Gümüşdere Neighborhood	2

297 HidroDizayn & NFB (2016) Ankara Alt Havzası Master Plan Raporu. DSİ Genel Müdürlüğü. p.43.
298 It is based on the examples in The Zurich Stream-Daylighting Program, Conradin, F., Buchli, R. (2008).

Another result of this degradation of the riparian zone is the impervious surface increase and prevention of leaks to the groundwater. Precipitation that cannot be infiltrated in the city quickly flows from impervious surfaces to the valley floors, in other words, to streambeds, resulting in floods.

4.4.1 Disappeared Streams and Flood-Risk Area

Opening floodplain areas are to settlements and diverting the streams to concrete-lined ditches increases in the velocity of the water and leads to severe damage. In the 25 years after BAKAY, sewer infrastructure problems are not over and floods recur from time to time. When the stormwater flowing fast through the sloping asphalt roads in the valleys cannot be collected with gutters, it remains on the road and leads to financial and emotional damage. Some flood news of various years is presented in Table 4.3:

Table 4.3. Various Flood News from Ankara City

Date	Flood Site	Resources
16.06.2011	Çetin Emeç Boulevard - 70 Gün Underpass, Mevlana Boulevard	https://www.milliyet.com.tr/gundem/alt-gecitte-can-pazari-1403278
12.08.2011	Keçiören, Mamak	https://www.sabah.com.tr/yasam/2011/08/12/ankarayi-su-basti
04.07.2014	Çetin Emeç Boulevard - 70 Gün Underpass	https://www.aa.com.tr/tr/turkiye/ankarada-alt-gecidi-su-basti/145305
17.10.2014	Çetin Emeç Boulevard - 70 Gün Underpass	https://www.yenisafak.com/gundem/ankarada-alt-gecitleri-su-basti-693466
21.08.2015	Kızılay, Söğütözü, Çayyolu Metro Stations	https://www.sozcu.com.tr/2015/gunun-icinden/ankarada-sel-manzaralari-916178/
28.08.2016	Sokullu, Dikmen and Akay Streets	https://www.gazeteduvar.com.tr/gundem/2016/08/28/ankarayi-sel-basti-gokcek-gezicilere-catti/
07.08.2017	Mamak	https://www.sabah.com.tr/ankara-baskent/2017/08/07/mamakta-sel-zarari-buyuk
06.05.2018	Mamak-Boğaziçi Neighborhood, Keçiören-Fatih Street	https://www.evrensel.net/haber/351761/ankarada-sel-araclari-onune-katip-surukledi
20.05.2018	Atatürk Boulevard, Mamak-Çağlayan Neighborhood	https://www.evrensel.net/haber/352937/ankarada-belediyecilik-yine-sinifta-kaldi
28.05.2018	Hippodrome and Çetin Emeç Boulevard - 70 Gün Underpass	https://www.ntv.com.tr/turkiye/ankara-yine-sular-altinda,ZIjmUwL8eEW9hL2Dsc-DXw
21.06.2018	Mamak, Çankaya – Turan Güneş Boulevard, AŞTİ - Mevlana Boulevard	https://www.sozcu.com.tr/2018/gundem/ankarada-yine-sel-2478876/

Table 4.3. (cont)

10.06.2019	Etimesgut, Çankaya	http://bianet.org/bianet/insan-haklari/209196-ankara-da-sel-uc-kisi-yasamini-yitirdi
12.06.2020	Various settlements	https://www.hurriyet.com.tr/gundem/ankaradaki-saganakta-250-ev-ve-is-yerini-su-basti-41539920

Melih Gökçek, who had been the mayor of Ankara metropolitan municipality for nearly 25 years, explained the floods as in the following: "The incidents are not normal precipitation, not something related to infrastructure. No infrastructure can overcome this situation."[299] However, according to Table 4.1, almost every year, similar floods occur. The total damage costs of the floods could not be reached, but only in the flood of 05.05.2018, the government paid a total of 1.2 million liras to victims of damaged homes, workplaces or vehicles.[300] According to Pinkham's cost calculations[301], from 60 m to 250 m stream daylighting construction can be possible with this price. These problems are not just related to excessive precipitations but also related to urban infrastructure. However, traditional engineering methods (wider piping, larger culverts, detention ponds...) do not reduce the problems even after years. On the contrary, it creates ecological destruction in the landscapes and economically dead investments.

The flood risk map of Ankara, which was also published online in the Ministry of Agriculture and Forestry website, brought a new insight to the research. Accordingly, in Figure 4.24, the areas with flood risk are overlapped with the disappeared streams. In the first image, Ankara province can be seen within the streams in Sakarya and Kızılırmak Basin. The second image demonstrates disappeared streams within the study area to understand its location in the basin. The third image shows the flood-risk areas (according to flood depth map Q100) and disappeared streams. Finally, in the fourth image, flood-risk buildings (according to flood risk/damage map Q100)

[299] https://www.milliyet.com.tr/gundem/alt-gecitte-can-pazari-1403278 accessed on July 2020
[300] https://www.trthaber.com/haber/turkiye/ankaradaki-selde-ev-ve-is-yerleri-zarar-gorenlere-odemeler-basladi-364145.html accessed on July 2020.
[301] Pinkham, R. (2000) Daylighting: New life for buried streams.

and the disappeared streams were overlapped. In Figure 4.25, the relationship between disappeared streams and flood-risk areas can be seen closely.

As mentioned earlier, it is aimed to transform the streams into the stormwater collection lines with the BAKAY project, which are taken into the channels made by DSİ in 1950-60 against the flood risk that are thought to be able to cope with the high flow rates. The stormwater is collected by the main lines, which are İncesu, Hatip, Dikmen and Kirazlıdere streams. However, the culverts cannot compete with the stormwater flows that come from local pipes and impervious surfaces. Precipitation first meets the roofs of the buildings in the urban area. The waters descending from the roofs flow as surface runoff on the impervious surfaces such as squares and roads and reaches to the pipes under the main streets or culverts (in which streams flow) from local roads in order to be discharged. When the routes of the disappeared streams, overlaid with the flood risk analysis is followed, it is understood that the flood risk is very high along this route.

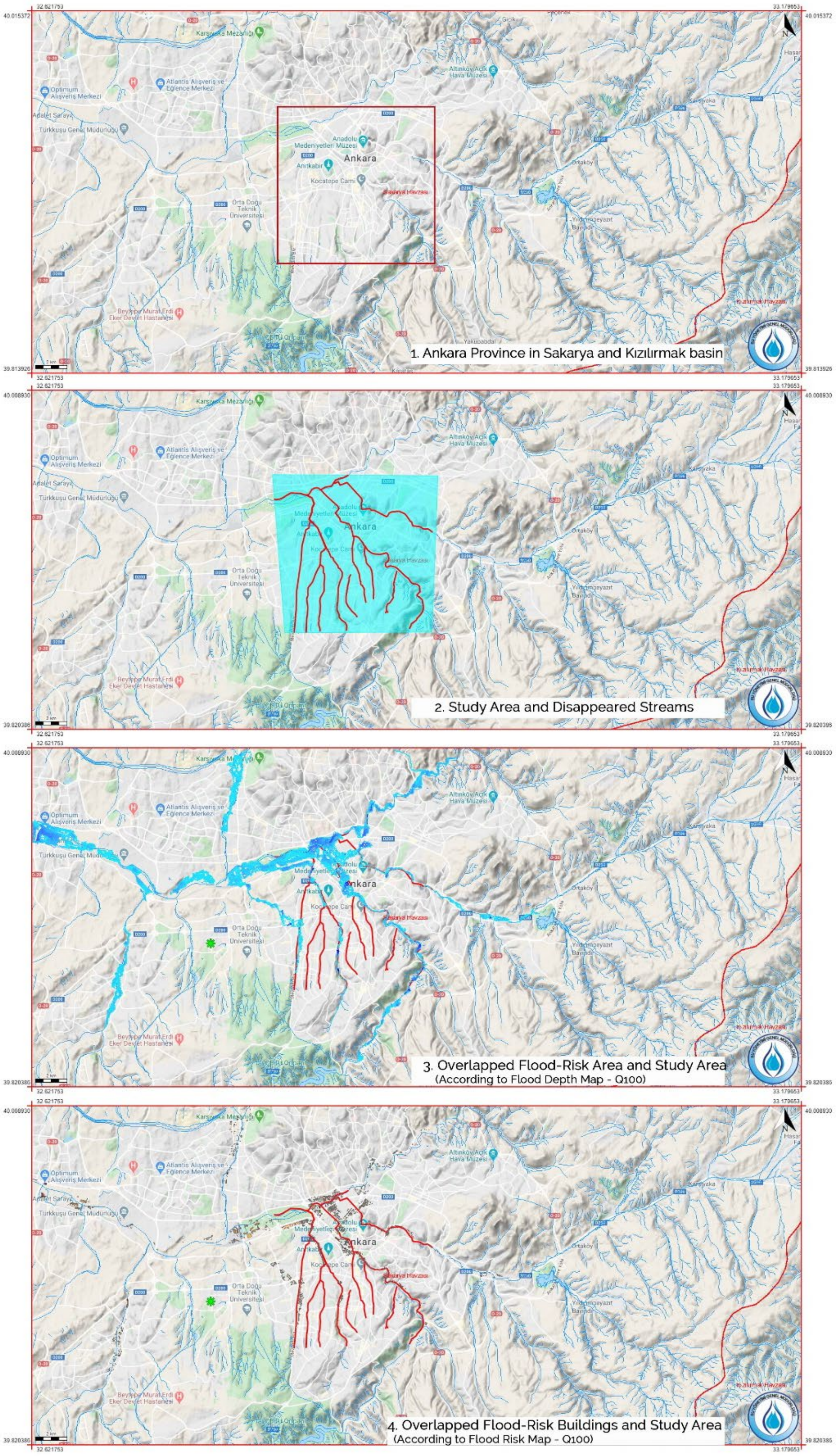

Figure 4.24. Disappeared Streams and Flood-Risk Area-1

[Source: Su Yönetimi, taskinyonetimiportal.tarimorman.gov.tr/# (accessed on July 2020)]

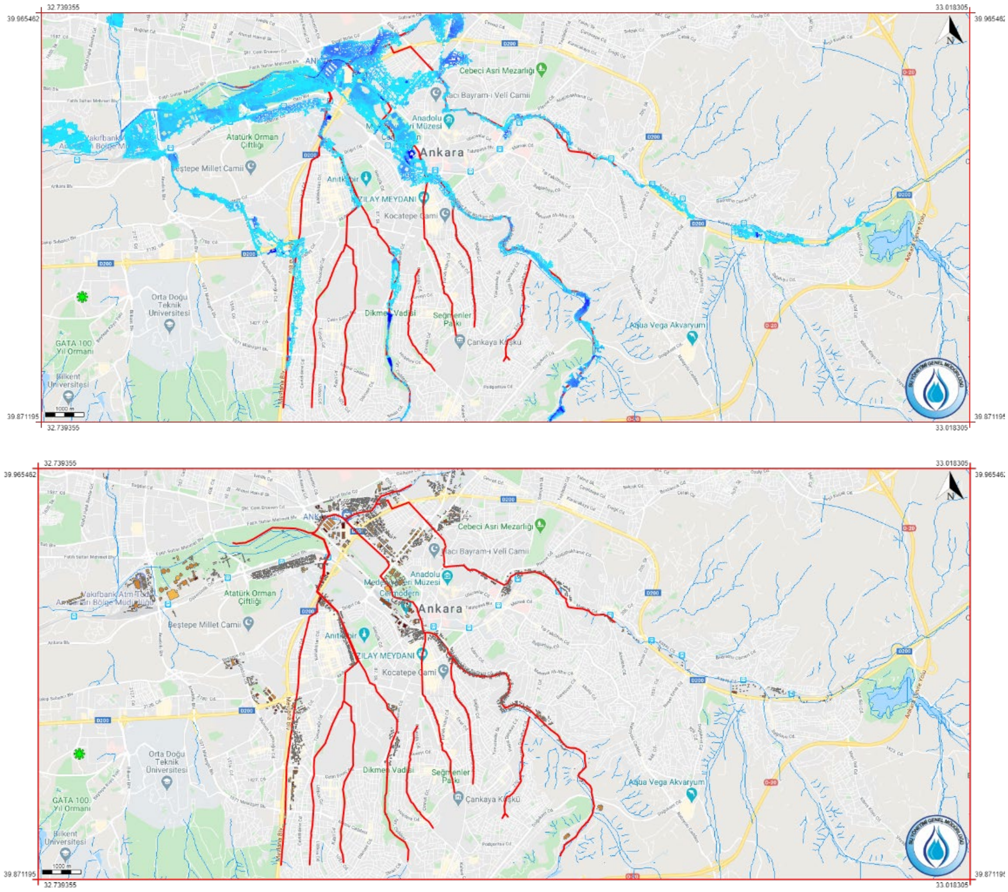

Figure 4.25. Disappeared Streams and Flood-Risk Area-2.

[Source: Su Yönetimi, taskinyonetimiportal.tarimorman.gov.tr/# (accessed on July 2020)]

In particular, we see that all settlements along the Hatip streams are at risk. These areas, in the urban sprawl, along the streams, serve mostly to low-income groups. Dikmen Valley, where Dikmen stream flows and the route of Cevizlidere, Mevlana Boulevard and Emek District, also appear as risky areas. Dikmen stream, which was combined with Kirazlıdere in the 1960s along the Mareşal Fevzi Çakmak Street, is a threat to Beşevler Neighborhood. In addition, the flood news mentioned in Table 4.3 also points to the same routes. The water collected along Atatürk Boulevard intersects with the waters come from İncesu sewer line in Sıhhiye. With the obstruction of Sıhhiye, floods frequently occur at Atatürk Boulevard, Akay junction, and Tunus Street. Accordingly, if the damages occur almost every year due to floods, it is not possible to mention only "unusual natural events".

4.4.2 Evaluation and Conclusion

First, some of the closed or open streams planned to carry stormwater, according to the BAKAY project, still carry wastewater. Wastewater connections are made to the streams passing through the city.[302] Wastewater treatment plants have been built to prevent wastewater discharges to Çubuk Stream, Hatip Stream, and Ova Stream, some of the most important sources of Ankara Stream.[303] However, as mentioned earlier, Çubuk treatment plant cannot operate overflow wastewater, comes from the industrial area, and discharges the wastewater directly to Stream.[304] Around the İncesu Detention Pond, the stream flows openly, and it was documented that the sewage of the surrounding buildings flowed into the stream.[305] In the Ankara Sub-Basin Master Plan Report, according to the general evaluation of the measurement results of water quality for Ankara Stream is designated as class IV (very polluted).[306,307] The cause of pollution is stated in the following: "The fact that ammonia nitrogen is higher than nitrate nitrogen indicates that sewage wastes are discharged into the stream, and high levels of inorganic parameters indicate industrial pollution."[308] In addition to the wastewater lines mixed with the stormwater lines, the other reason for the pollution is that although Tatlar Central Wastewater Treatment Plant is planned to carry out nitrogen and phosphorus removal, it is not the case.[309] However, in the 2017 ASKI Annual Report, it is written that "In order to prevent the environmental pollution caused by wastewater in Ankara, the wastewater was treated at the wastewater treatment plant and discharged

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[302] HidroDizayn & NFB (2016) Ankara Alt Havzası Master Plan Raporu. p.10-39
[303] Ibid p.9-156
[304] Ibid. pp.9-156 – 9-157
[305] Soyak, A. (2020) İmrahor Vadisi ve İncesu Deresi. youtube.com/watch?v=3K9DZyQ6nv8 accessed on July 2020.
[306] HidroDizayn & NFB (2016) Ankara Alt Havzası Master Plan Raporu. p.47, 9-61
[307] Soyak, A. (2020) Ankara Çayı Neden Kirli Akıyor? youtube.com/watch?v=4WF1_H4kF6w accessed on June 2020.
[308] HidroDizayn & NFB (2016) Ankara Alt Havzası Master Plan Raporu. p.9-61
[309] Ibid.

to the receiving environment in accordance with the standards." [310] The declaration made by ASKI is not compatible with the Ankara Sub-Basin Master Plan Report in terms of the pollution level of the discharged water. With the addition of the Ankara Stream to the Sakarya River, the quality class of the river drops to IV.[311] Tragically, from the Sarıyar Dam, where the Sakarya River flows, the water need of the Anatolian side of Istanbul is met. In addition, although it is prohibited due to pollution, water from Ankara and Çubuk Stream is used for agricultural irrigation purposes. In such situations that threaten public health, prove the importance of the Integrated Watershed Management approach. On the other hand, although a separate system was aimed at the BAKAY project, the targeted piping has not been reached yet. The city areas with combined sewer system should be identified and separated. Because the stormwater reaching the Tatlar Treatment Plant is treated, although it is relatively clean, by increasing the energy use and reducing the efficiency.[312]

Second, large investments have been made to remove stormwater from the city; detention ponds have been built; pipelines have been laid for kilometers; streambeds have been channelized, straightened, and covered to date. However, Ankara lives with a flood-risk for every spring and autumn. This risk is a factor that affects the property value of the region as well as financial damages and loss of lives. In covered channels, it is difficult to predict the current circumstances. It is costly to clean when sediment accumulation or something prevents the flow of water. On the other hand, an open stream ecosystem infiltrates the precipitation more effectively, and it is easier to follow and respond to possible setbacks.[313] Also, it is cheaper than building an underground stormwater sewer system or upsizing of the lines. [314] Instead of diverting stormwater to covered culverts or pipes, it is more socio-economically

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[310] ASKİ Genel Müdürlüğü (2018) 2017 Mali Yılı Faaliyet Raporu. p.99
[311] Çevre Mühendisleri Odası, İstanbul Şubesi (2014) İstanbul'un Yeni Su Kaynağı Sakarya Nehri ve Su Alma Yapısı Teknik Tespit Görüşü. cmo.org.tr/resimler/ekler/d3e33ec9040ff70_ek.pdf?tipi=67&turu=H&sube=2
[312] Novotny, V., Ahern, J. & Brown, P. (2010). Water Centric Sustainable Communities. p.109
[313] Pinkham, R. (2000) Daylighting: New life for buried streams. p.IV.
[314] Ibid.

advantageous to divert it to green stream corridors that are open, controllable, and create an ecological living space, which revitalizes economic activities.

Main lines, Hatip, İncesu, and Dikmen culverts, have a pressure when the flood-risk map and the flood news area was examined. Local lines that consist of smaller streams such as Tunus Street, Güvenlik Street and Bülbülderesi Street connect to main lines, increasing the water level. In order to mitigate the water pressure on main lines, local lines can be considered daylighting partially. Best stormwater management practices recommend mimicking nature instead of traditional infrastructure approaches[315], which is only considered the end-of-pipe and centralized infrastructure systems. Stream daylighting as a landscape infrastructure project presents flexible, decentralized, multi-functional alternative systems.

Third, it is determined that the effect of urban heat island is seen in summer months in Ankara.[316] The main reason for this is that since the Jansen plan, the number of urban green areas has decreased day by day while the rate of construction and the impervious surfaces has increased. As a result of urban heat island, energy consumption and ecological degradation increases. However, an urban stream corridor with its vegetated areas decreases the effects of urban heat island and, accordingly, energy consumption.

Lastly, as mentioned before, sewer systems and covered streams have a close relationship in city infrastructure. These "hard" infrastructure decisions are critical policy, planning, and engineering implementations that also determine the urban fabric. Landscape Infrastructure aims to solve problems based on the potential of landscapes for urban design by using its materiality and performance. In this term, stream daylighting is an alternative for new urban morphologies, which can provide human-nature interaction, revitalize communities, and drive economic activities.

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[315] Novotny, V., Ahern, J. & Brown, P. (2010). Water Centric Sustainable Communities. p.112

[316] Duman Yüksel, Ü., Yılmaz, O. (2008) Ankara Kentinde Kentsel Isı Adası Etkisinin Yaz Aylarında Uzaktan Algılama ve Meteorolojik Gözlemlere Dayalı Olarak Saptanması ve Değerlendirilmesi. J. Fac. Eng. Arch. Gazi Univ. Vol 23, No 4, 937-952.

4.5 Mapping Potential Sites for Stream Daylighting

Small streams and headwaters provide a wide array of benefits to communities, such as nutrient and pollution removal, groundwater recharge, and flood mitigation.[317] Although Ankara is very rich in terms of small streams and headwaters, the city cannot benefit from them; on the contrary, in trouble with them. A wide range of reasons can be for daylighting a stream, as examined in the cases in Chapter III. In this study, the primary problem of Ankara is addressed flood-risk in terms of economy, therefore reopening of the culverted streams or bringing back the diverted "disappeared" streams should consider preventing flood risks.

The stream daylighting projects are implementing in various places and districts, from small creeks to rivers, on rural areas in the central districts of cities. However, as Pinkham stated, not every hidden waterway can or should be daylighted, or even if daylighted, not each one can be highly naturalized.[318] After the disappeared streams map and determination of flood risk area, the next step is to decide for the most appropriate daylighting sites. For an initial feasibility assessment, **flood-risk**, **land use, parks, potential green areas, and commercial areas** were taken consider by overlaying to determine potential sites for daylighting.

4.5.1 Initial Feasibility Assessments for Stream Daylighting

Flood Risk

Disappeared Streams Map and Flood Map was overlapped in Figure 4.26. Reducing the load on the main lines shall be easier and appropriate to relieve areas with flood risk. Therefore, it is recommended to daylight the streams with lower flow rate, from

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[317] Trice, A. (Undated) Daylighting Streams: Breathing Life into Urban Streams and Communities. American Rivers

[318] Pinkham, R. (2000) Daylighting: New life for buried streams. p.6.

dense settlements such as Cevizlidere, Bülbülderesi, Büyükesat, Kavaklıdere, Dikmen partially. Because high dense settlements with impervious surfaces cause flooding problems by under-capacity culverts[319], and they force the main lines.

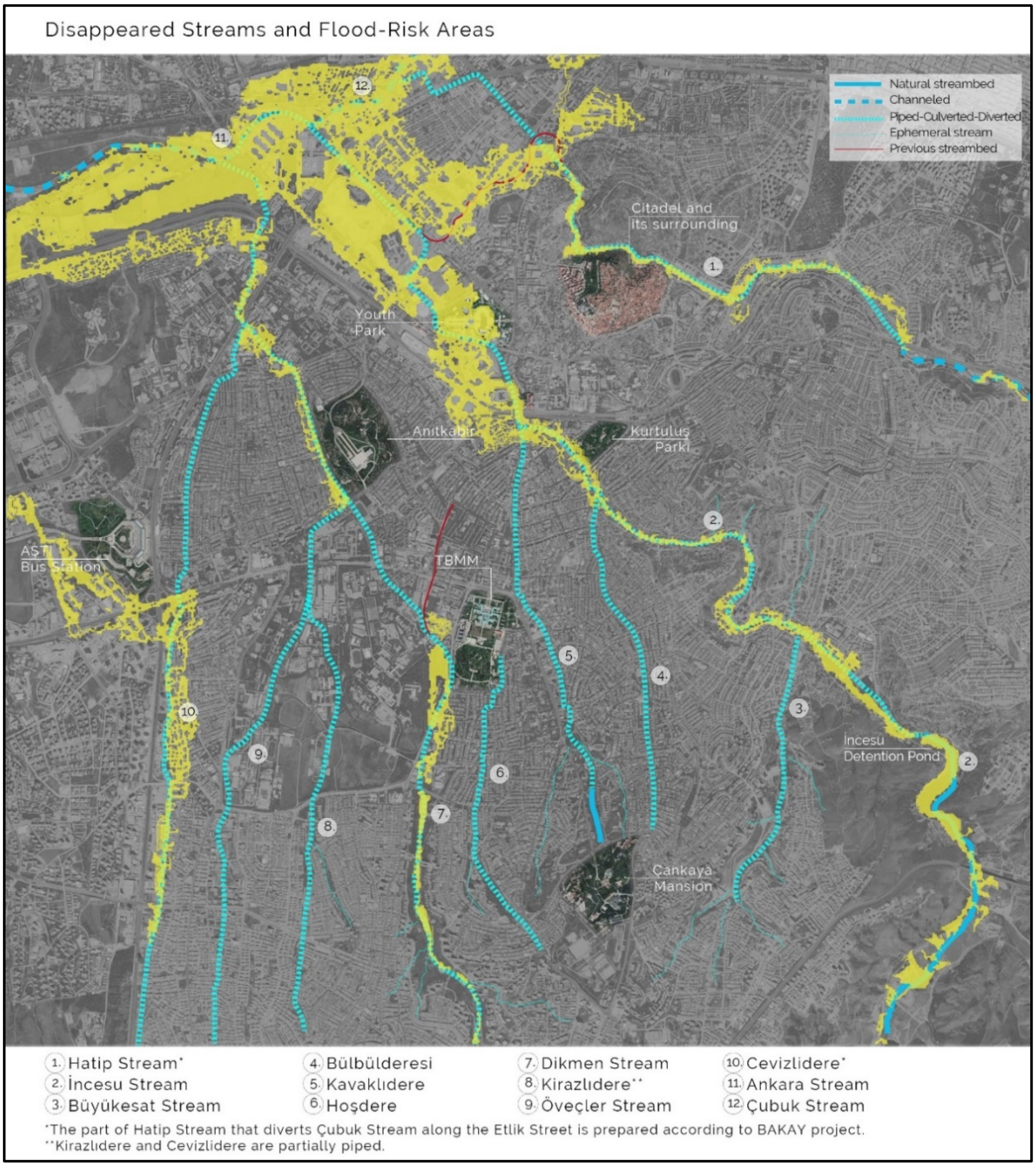

Figure 4.26. Disappeared Streams and Flood-Risk Area-3
(According to depth map-Q100, http://taskinyonetimiportal.tarimorman.gov.tr/#)

319 Ibid. p.IV.

Land use

Land use planning is crucial for a healthy water cycle with respect to catchment areas, which are the smallest recharge basin. Patterns of urban land use and infrastructure define urban biogeochemistry. The disappeared streams map and 2023 Master Plan with 1/25.000 scale were overlapped in Figure 4.27.

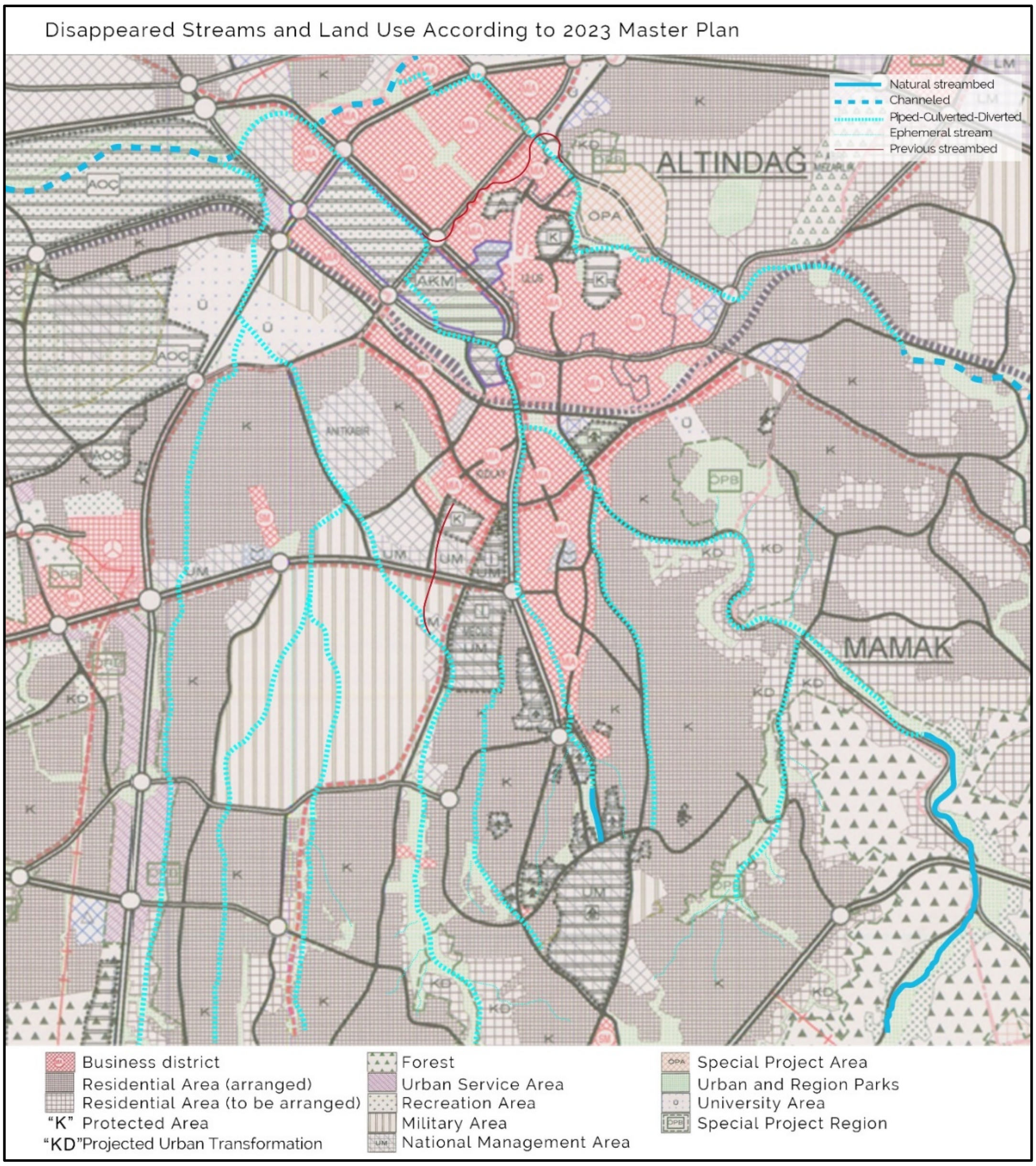

Figure 4.27. Disappeared Streams and Land Use (According to 2023 Master Plan)

Hence, a direct relationship between urban land use and increased flood risks on communities can be seen. In a stream daylighting project, usurpation is not preferred due to high property costs, which can make the project economically infeasible. However, depending on the need of floodplain, it can be necessary. The upstream land use is also important in terms of sediment movement and pollution.

Green and Commercial Areas

Green areas present a potential stream daylighting site to ensure enough floodplain storage, and a healthy channel geometry to be a part of surface drainage system. To simplify the analysis, commercial and green areas, including existing parks, campus, and as projected urban transformation, are identified as locations with sufficient buffer areas in Figure 4.28.

Some daylighting projects, such as Jolly Giant Creek implemented in a high school garden or Blackberry Creek in Berkeley, constructed within an environmental education program. Daylighting projects, at the parks or university campus can help to educate children and adults alike about the workings and values of stream corridors and wetlands. On the other hand, the increased amenity value at residential and commercial site is considered an economic development benefit of the stream daylighting project.

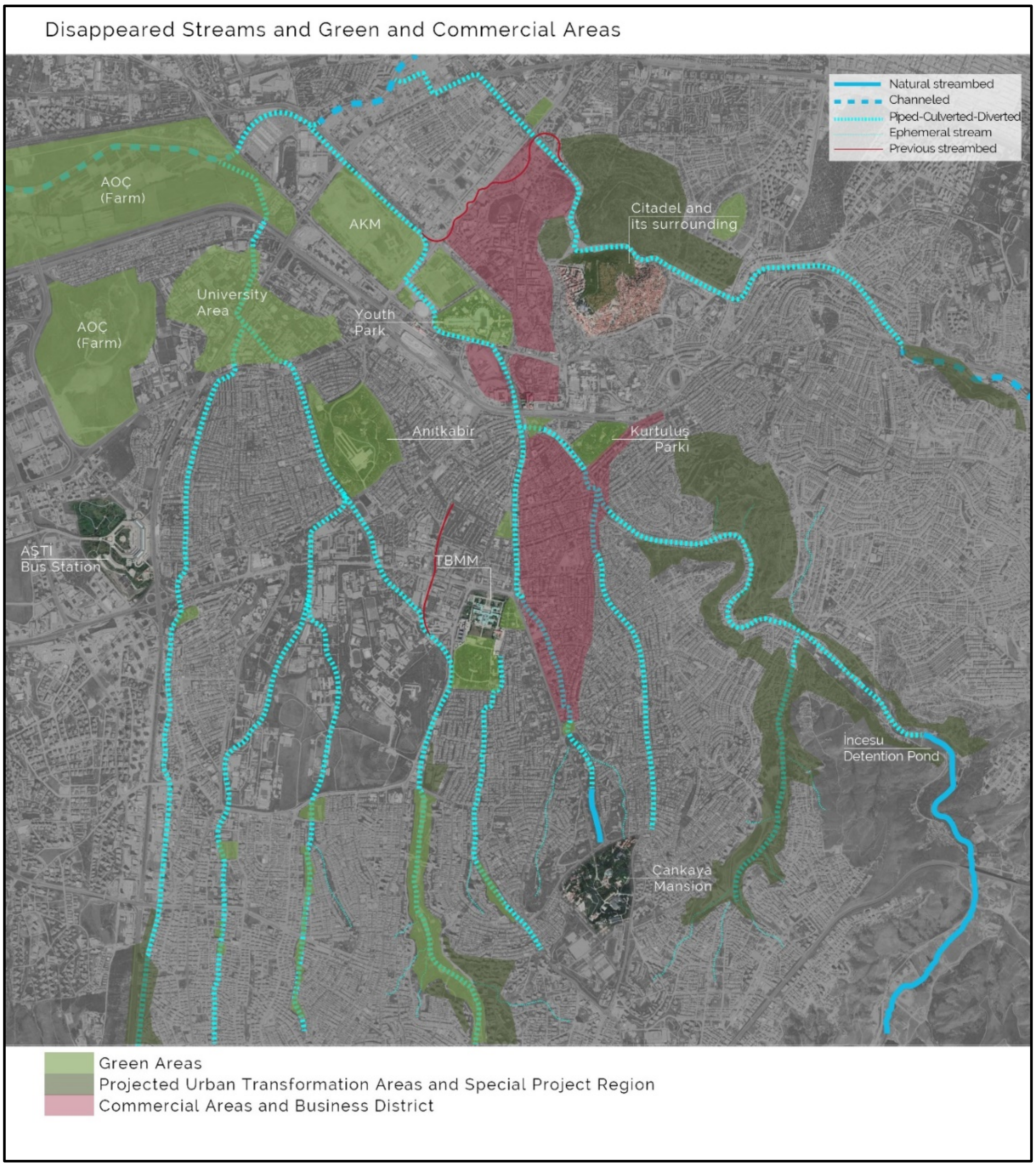

Figure 4.28. Disappeared Streams and Commercial and Green Areas.

<u>Spatial Overlay Assessment</u>

Initial feasibility assessment criteria are identified and overlaid to present potential daylighting sites. The result indicates the most potential and feasible sites to be daylighted (Figure 4.29). Overall, potential sites in Ankara for daylighting projects are *green areas*, intersect with flood areas. Thus, the project area can give the opportunity to design a natural streambed for mitigating floods while providing recreational and economic activities. In addition, *the projected urban transformation areas* are an opportunity for stream daylighting in order to build the wastewater and stormwater infrastructure properly. Mixed-use area, such as Tunus Street involve Kavaklıdere Stream, is also a potential site for daylighting, because of the vitality of the area and decreasing the flood in Atatürk Boulevard.

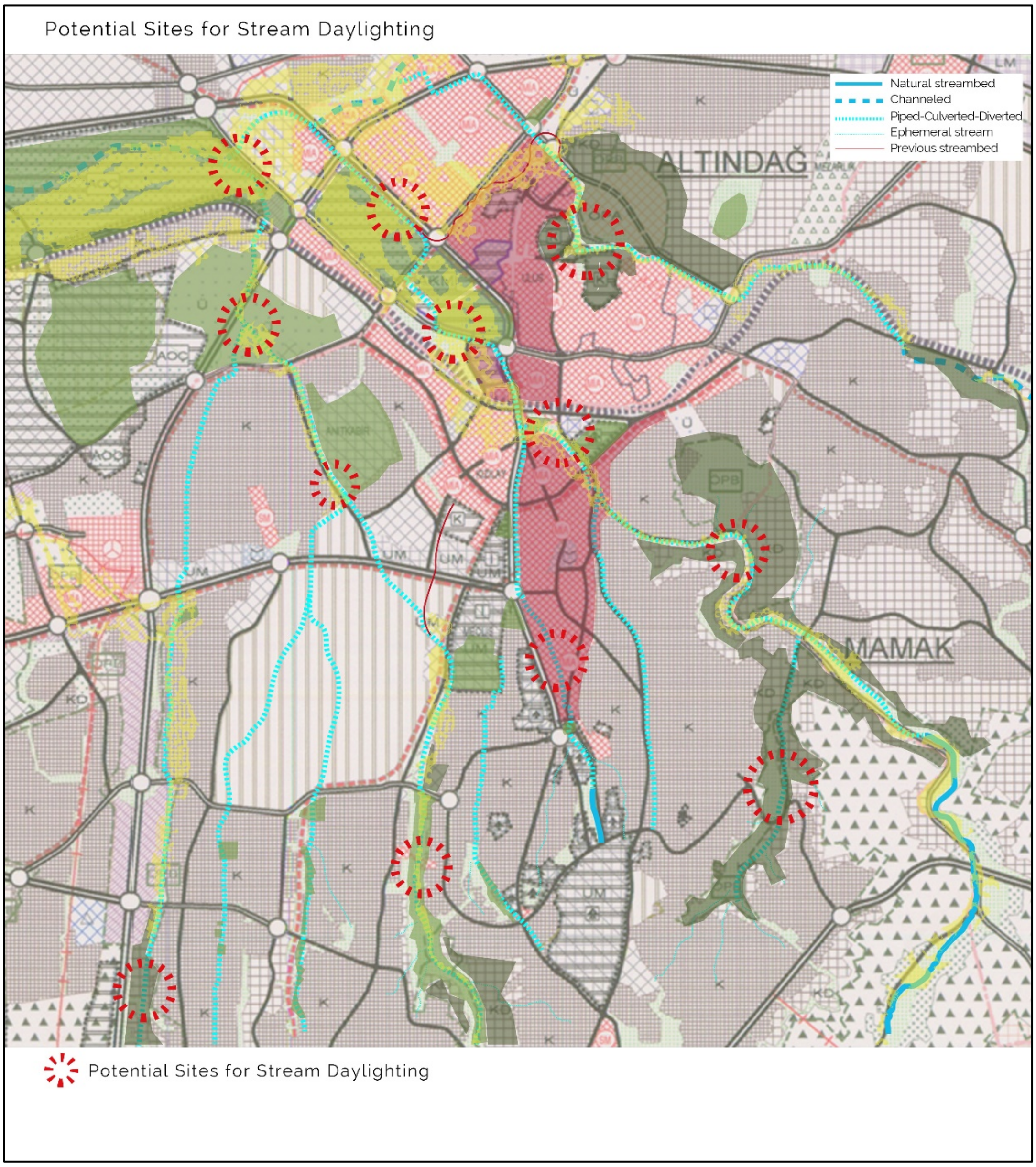

Figure 4.29. Potential Sites for Stream Daylighting in Ankara

However, the spatial overlay assessment does not include the additional criteria identified in Table 3.1, such as sewer system, pipe diameter, pipe depth, and community support, which require detailed site survey data unavailable for the current research. These factors are also important and essential for the implementation of stream daylighting projects. They should be analyzed in more detail when conducting site-specific studies.

4.5.2 Evaluation of Potential Sites

Twelve potential sites were identified within the study area, and they are named in Figure 4.30. A comparison was required to perceive and understand these areas spatially. For this, old maps and Google Earth were used. The current situation and suggestions were explained better by taking sections from the appropriate places. As a result, to see the difference from the past to the present, a chart was created according to the sections; 1946 City Map, 1952 Aerial Photo, 1976 City Map, 2020 Google Earth Image, Road Network, Land Use, Flood risk, Existing and Proposed Cross, and Inferences (Figure 4.31).

In Figure 4.31, the comparative chart of potential sites demonstrates the development process of the city and the streams. According to the Chart, the sites can be categorized into three typologies;

- Urban Transformation Areas with flood-risk
- Historical, Cultural and Commercial Areas with flood-risk
- Green Areas with flood-risk

In this respect, all sites have the potential to reduce the flood-risk. Nevertheless, the infrastructural features such as sewer system type and depth are crucial for deciding the project area. Eventually, the project area should be selected according to the cost and other priorities, depending on policy-makers.

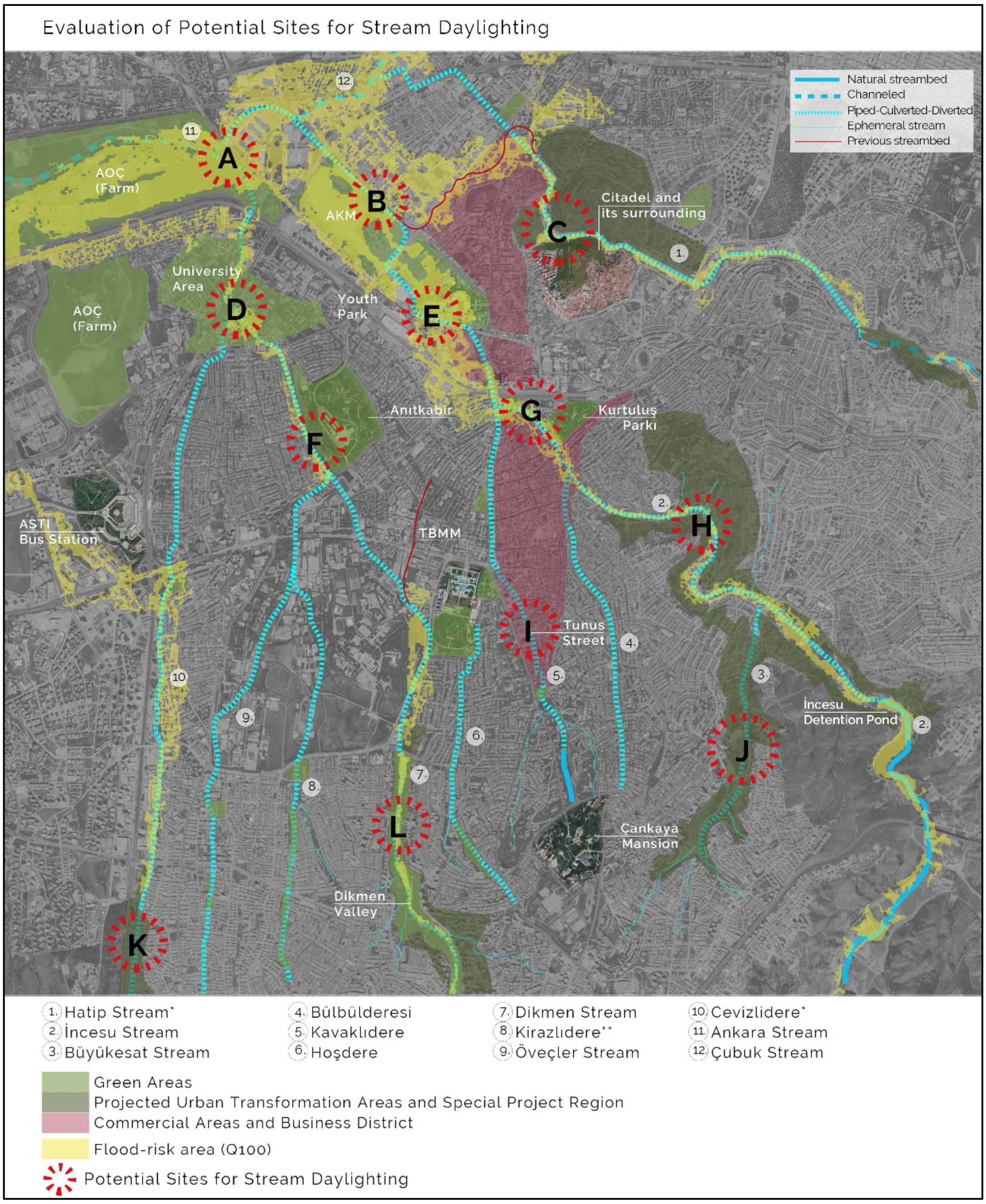

Figure 4.30. Evaluation of Potential Sites

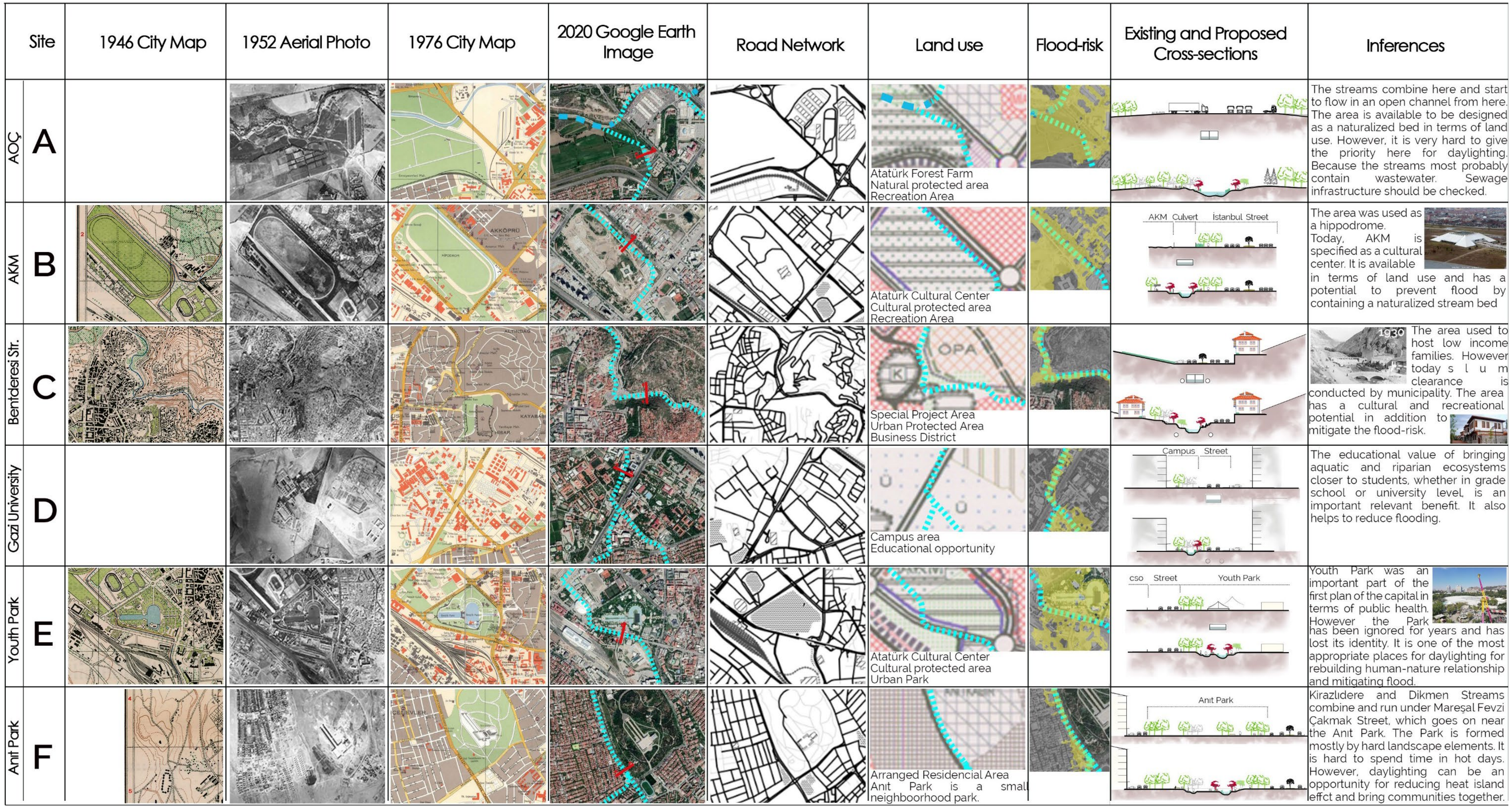

Figure 4.31. Comparative Chart of Potential Sites

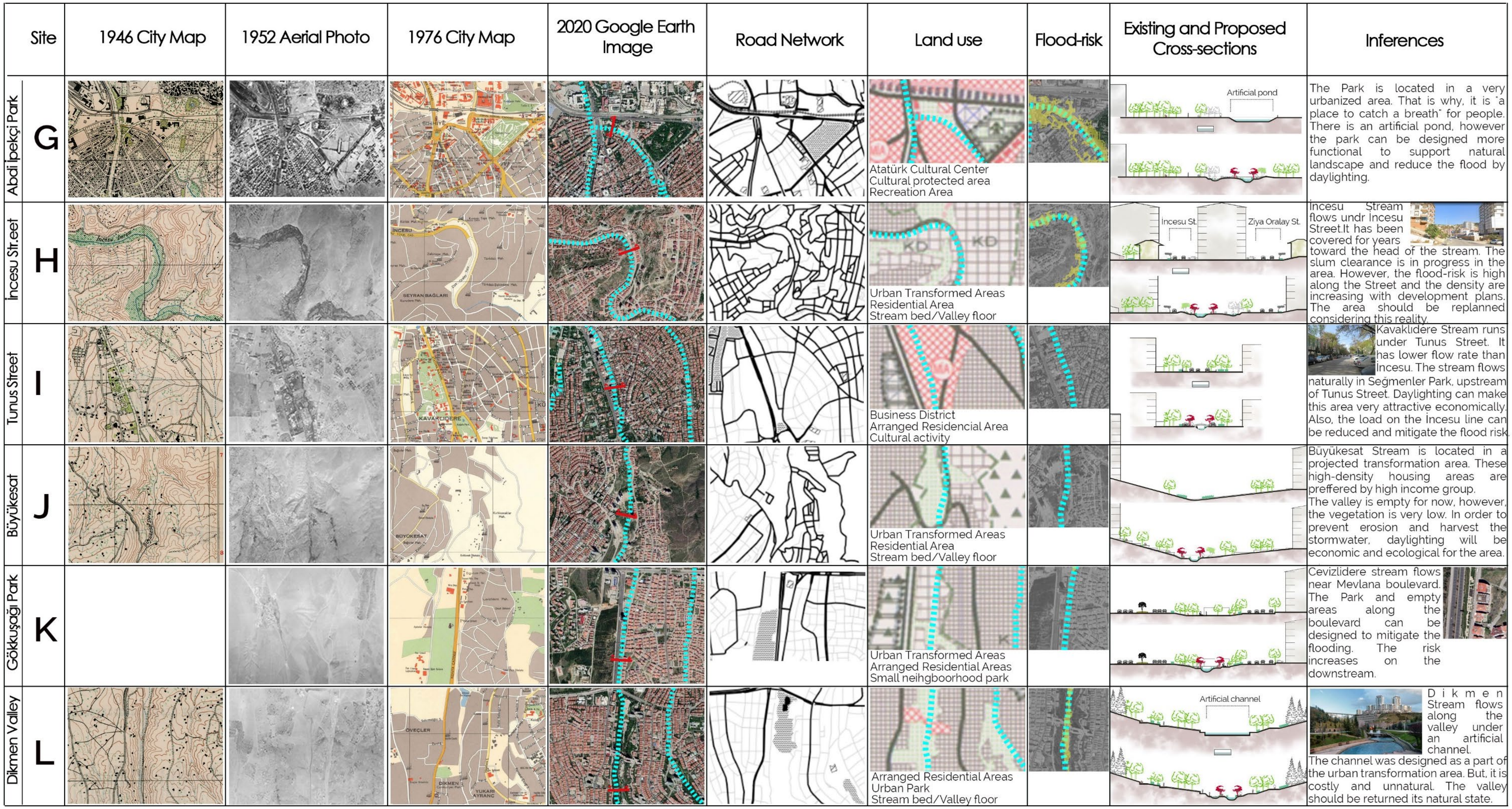

Figure 4.31. Comparative Chart of Potential Sites

4.6 Proposed Framework for Stream Daylighting

Stream daylighting is required a holistic approach to urban planning and design considering infrastructure, watersheds, policy, and multi-disciplinary approach. By taking into consideration, the process and feasibility assessments of daylighting identified in ***Table 3.1***, the proposed framework for Ankara has been determined in terms of planning and designing.

4.6.1 Selecting Appropriate Area

- Current land use of the areas should be determined and mapped along the disappeared streams.
- The land use, which causes pollution from agriculture, industrial or residential, should be determined and limited in the watershed-scale.
- Impervious surfaces and permeable surfaces should be mapped.
- Surrounding buildings of the potential daylighting areas and its users should be identified to know stakeholders.
- Sewerage infrastructure should be examined and mapped as separated and combined sewer system. If the stream culvert is a line of combined sewer system, the separation of the system can be considered for daylighting. Thus, it can be provided mitigating flood risk, revitalizing economic activities and community, and saving energy for the Wastewater Treatment Plant.
- The watersheds can be divided into subwatersheds, which makes it easier to map drainage units.
- The slope index map should be prepared; accordingly, the catchment areas should be monitored after the precipitation due to determine the problematic, insufficient areas by comparing with the existing flood-risk map.
- Reducing the load on the main lines in the first place shall be easier and appropriate to relieve areas with flood risk.

- Groundwater resources need to be considered in the project for the hydrological cycle.
- Streams' flow characteristics should be classified.
- Sedimentation problem area should be determined. While sedimentation is very useful for the nutrient cycle, in some cases, there may be a problem. Especially uncontrolled and abnormal sediment flow from upstream can create obstructions in downstream.
- The depth of pipes/culvert should be determined. According to depth, approximate excavation can calculate.
- Existing natural or cultural features of the areas should be determined because they can contribute to social and economic activities.
- Case studies show that daylighting projects obviate choke points and flooding problems in under-capacity culverts. It is a way to divert urban runoff from the sewerage system to prevent burdening the capacity of the system.

4.6.2 Integrated Planning Strategies

- Citywide planning efforts shall be adopted on the scale of watersheds.
- Despite its important role in reducing floods, daylighting or maintaining small streams does not depend on a law or regulation. Protection of headwater streams or restoration efforts such as daylighting can be regulated.
- Regulation on Stormwater Collection, Storage, and Discharge Systems[320] is only considered piping or channelizing; however, it should accord with landscape infrastructure technics and stream daylighting projects. A stream that flows in a culvert and under the sunlight has huge ecological differences

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[320] Yağmursuyu Toplama Depolama Ve Deşarj Sistemleri Hakkında Yönetmelik (2017) Çevre ve Şehircilik Bakanlığı resmigazete.gov.tr/eskiler/2017/06/20170623-8.htm accessed on July 2020

in terms of improving water quality. Hence, the pressure on the main lines can be reduced in a more economical way by infiltrating the water.

- The policy strategy is required to make provision in the Municipal Master Plan to prevent construction pollution along to small streams at least 12 m, main streams 20 m like Oslo City actualized as one of the best practices in stream daylighting.

4.6.3 Multi-disciplinary Process

- Restoration has been defined by the several perspectives associated with fluvial geomorphology, hydraulic engineering, ecology, plant ecology, wildlife biology, and floodplain management.[321]
- Stream Daylighting design process may involve a wide range of scale from regional to neighborhood. A healthy and sustainable ecological corridor and urban infrastructure can be achieved with the contribution of different practices.
- In order to maximize results, additional scientific research and comprehensive monitoring are required. It is needed to include various disciplines such as ecologists, biologists, or ecology engineers to the project.
- For a naturalized streambed, the stabilization techniques are important. The bioengineering techniques shall be determined to stabilize of the banks. So, it concerns not just civil engineers, but also landscape architects and urban designers.

[321] Riley, L. A. (2016) Restoring Neighborhood Streams *Planning, Design, and Construction*. p.43

4.6.4 Literacy on Disappeared Streams and Community Involvement

- There is various way to galvanize community involvement and reconnecting people to streams. Including social disciplines can help to raise awareness of buried streams and to talk about the problems in society.
- In neighborhood settings, designers need to listen to the public and people's fears about creating a new natural space in their environment. The balance of the daylighting objectives and public needs should be the main target for adopting and protecting the project by public. Because they have no way of knowing that the creeks provide important water quality services if well-vegetated until we inform them. Landscape architects or planners who do not fully understand these aspects of stream restoration can take help from fish, birds, and water quality biologists who can be part of the design and communication teams.[322]

[322] Ibid. p.241

CHAPTER 5

CONCLUSION

While politicians prefer to invest in visible applications, infrastructure may seem mostly unremarkable, and the investments are postponed because of long-term results. The water, in the cities used by people in daily life comes from the tap and goes by flushing in the toilets, and nobody thinks about it until it is broken. The modern person is too busy to think about where the water comes from or goes. Accordingly, the relationship between water and the cities is also disconnected. As the study emphasizes, the streams that play an essential role in the formation of the settlements in Ankara are now invisible. The relationship of the citizens is very limited to waterways.

As pointed out during the study, engineering practices applied throughout the 20th century have involved a harsh struggle with nature to be economical. Covering the streams was very common during the 20th century throughout the world. However, at the end of 100 years, these applications have turned against humanity as environmental hazards and failures; natural landscapes have been degraded. It has been proven scientifically that there will be a water scarcity in the near future. The alarming levels of global warming, climate change, and resource depletion obligate humans to value the ecology of landscapes. It became a matter of policy now. Between economy and ecology have always been a tension; however, ecology oriented design approaches give better solutions today in terms of economic. As mentioned in the Landscape Infrastructure approach, the visibility of the infrastructure will also prevent the public from giving credit to populist practices. Water management should be taken into account new infrastructure approaches, which propose that the ecological is economical in the long term.

Daylighting the streams can be seen as an unimaginable possibility today. However, perhaps, to regain our water resources, making them visible in the city is the target that should be adopted. Thus, the pressure can be put on political decisions to make necessary investments for a separated sewer system and healthy water infrastructure. The functions of the streams provide economic benefits besides the ecological and social benefits of stormwater management. Instead of removing water by piping, creating infiltrate solutions that are compatible with nature will be in favor of future global climate scenarios.

The hydrological characteristic of Ankara has been neglected in the process of urban formation since the 1960s. The loss of the determinant component of the urban formation was considered as urban planning, design, and infrastructure problem in this study. In this sense, stream daylighting offers solutions for the physical and social infrastructure problems of the rapidly urbanized Ankara. As the city suffers from flood-risk and lack of planned green areas, the sewerage infrastructure system is under pressure. In about 50 years, the city lost most of its urban streams and drainage areas. Interventions on closed channels are limited and costly. On the other hand, the treatment plants, including Tatlar Wastewater Treatment Plant are forced by the combined sewer system. By separating the stream and stormwater from the sewer, the hydrological processes are provided, and only wastewater can convey to treatment plants. An open stream ecosystem, which has a better capacity to drain the precipitation, is cheaper than to build a vast underground stormwater sewer system.[323] In addition, smaller treatment plants can be made leading to the decentralization of water infrastructure, as mentioned in Chapter II.

By looking from urban design perspective, the stated potential sites for stream daylighting for Ankara can be an opportunity in order to build the wastewater and stormwater infrastructure properly to prevent flooding while providing public amenities and economic revitalization. A stream corridor and its banks can provide significant changes in urban form. The meander of a stream can support new property lines and create new urban morphology in terms of urban design. While a stream and

[323] Pinkham, R. (2000) Daylighting: New life for buried streams. p.IV.

its landscape can be respected the life supporter of the public through infrastructure, the lost values of Ankara may unfold new vistas and paths of blue and green.

Before having the last word, it is also important to mention an ironic picture of city development in the area examined in this study. If we consider “Disappeared Streams Map of Ankara”, the relationship between water and the city consists of artificial concrete pools, while the natural ones are buried and disappeared from the surface. Youth Park (Gençlik Parkı) concrete pool was constructed in the early Republican era (Figure 5.1), and İncesu Stream, once ran inside the Park as shown in the plan in Figure 5.2, was transformed into a sewer line and buried completely around the 70s. The Dikmen Valley, shown in Figure 5.3, has not yet been subjected to dense construction in the early 1990s. The Stream was flowing in a channel, and Çetin Emeç Boulevard has been constructed over the Dikmen Detention Pond, resulting in the disconnection of the valley system. Afterward, a concrete waterway was constructed in Dikmen Valley within a landscape project during the urban transformation in the 90s (Figure 5.4). Now, Dikmen Stream flows under the concrete waterway, as shown in the plan in Figure 5.5.

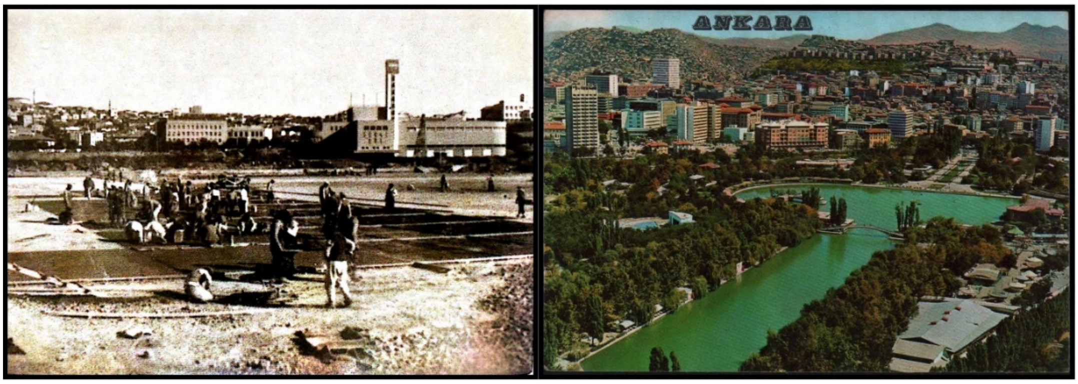

Figure 5.1. While the Youth Park pool was under the construction and after construction.

[Source: Tamur, E. (2012) and Gökçe Collection (2020)]

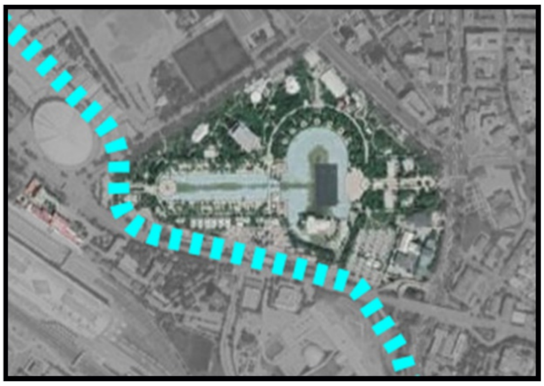

Figure 5.2. The part of İncesu Stream that used to run inside the Youth Park before buried.

Artificial streams, ponds, or pools are usually accomplished in a highly built urban environment where the space is not available for a meandering, vegetated streambed.[324] Nevertheless, in two examples, Dikmen Valley and Youth Park, the area has enough green space to design naturalized streams. The function of the artificial structures is akin to traditional urban drainage by controlling water flow and they have a little ecological function. They mostly provide cultural functions for the city. However, this single-function approach is neither ecological nor economical. The maintenance of these artificial structures is costly and not sustainable. The benefits of naturalized streams are significant with a multi-functional design approach as mentioned in Chapter III.

[324] Buchholz, T. A. et al. (2016) Stream Restoration in Urban Environments: Concept, Design Principles, and Case Studies of Stream Daylighting. p.131.

Figure 5.3. Dikmen Valley in the early 1990s. [Source: antolojiankara, (instagram.com/p/CCwEvymAt7b/?utm_source=ig_web_copy_link accessed on July 2020)]

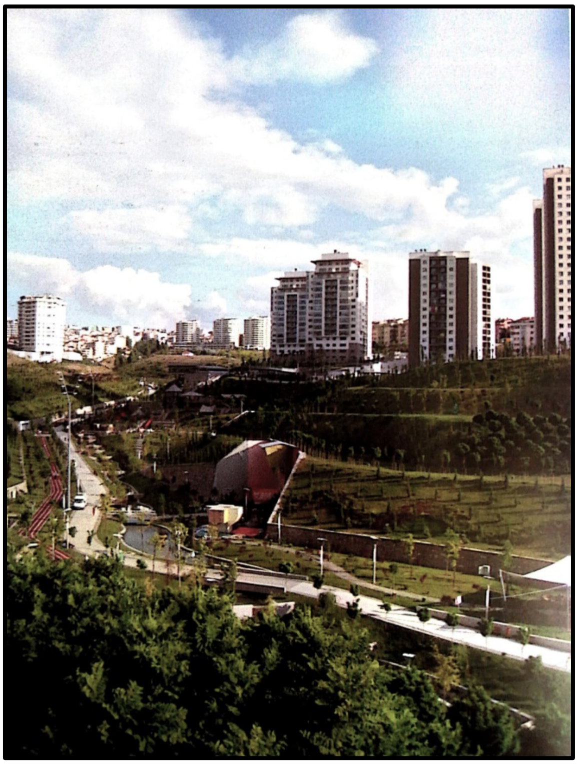

Figure 5.4. Dikmen Valley, after the urban transformation project. [Source: Tamur, E. (2012)]

Figure 5.5. The part of Dikmen Stream that used to run inside the Dikmen Valley before buried.

To conclude, Ankara can retrieve its streams through daylighting projects. Thus, the risk of flooding can be reduced, hydrological and ecological measures against water shortage can be taken, and incomplete green corridors, where the public amenities may be provided to improve socio-economic inclusion, can be created. 21st century policies and infrastructure design solutions are developed for urban streams collectively by various disciplines, not only engineers. Stream daylighting is one of them. Public awareness raising, encouraging actors for dialogue, and taking a step towards long-term plans for rehabilitation of streams of Ankara were aimed with this thesis. In this sense, the analysis of the study area in this thesis is hoped to provide a basis for future studies focusing on Ankara, and the disappeared streams, which are the lost values of cities, can be addressed as a key to urban agenda.

REFERENCES

Aksoy, S. (2016) Reclaiming ecological sustainability of urban streams by use of green infrastructure techniques. Unpublished Master Thesis; Department of City and Regional Planning, İzmir Institute of Technology.

Alberti, M. (2008) Hydrological Processes. In: Advances in Urban Ecology. Springer, Boston, MA.

Allen, S. (1999) Infrastructural Urbanism. In Points + Lines. Diagrams and Projects for the City. Princeton Architectural Press, NewYork.

Allen, S. (2001) Mat Urbanism: The Thick 2D. In Hashim Sarkis (ed), CASE: Le Corbusier's Venice Hospital, Munich: Prestel.

Ankara Belediyesi (1952) 1952 Yılı Çalışma Raporu. Doğuş Matbaa. Ankara

Ankara Belediyesi (1953) 1953 Yılı Çalışma Raporu. Doğuş Matbaa. Ankara

Ankara Belediyesi (1972) 1971-1972 Çalışma Raporu. Ankara.

Ankara Belediyesi (1983) Eylül 1980 Aralık 1983 Dönemi Çalışma Raporu. Ankara.

Ankara Metropolitan Municipality (2007) 2023 Başkent Ankara Nazım İmar Planı Raporu.

Ankara Metropolitan Municipality (2017) 2038 Ankara Environmental Plan Report.

Ankara'nın Vadileri ve Dereleri Çalışma Grubu (2020) İmrahor Vadisi Bilgi Notu. Şehir Plancıları Odası Ankara Şubesi. http://www.spo.org.tr/resimler/ekler/3f2f853eea753bb_ek.pdf?tipi=2&turu=X&sube=1

ASKİ Genel Müdürlüğü (2018) 2017 Mali Yılı Faaliyet Raporu. Ankara.

Barlas, M. A. (2014) Urban Streets and Urban Rituals, Faculty of Architecture, METU.

Barles, S. (2007) Urban metabolism and river systems: an historical perspective – Paris and the Seine, 1790– 1970. Hydrology and Earth System Sciences Discussions, European Geosciences Union. Pp.1757-1769.

Batukan, İ. (1967) Ankara Taşkın Projesi Tatbikatı. Türkiye Mühendislik Haberleri.

Belanger, P. (2012) Infrastructural Ecologies. In Spiro N. Pollalis, Daniel Schodek, Andreas Georgoulias and Stephen J. Ramos (ed). Infrastructure, Sustainability & Design. London: Routledge, 276-315.

Belanger, P. (2012). Landscape Infrastructure: Urbanism Beyond Engineering. In Spiro Pollalis, Daniel Schodek, Andreas Georgoulias and Stephen J. Ramos (Ed.). Infrastructure, Sustainability & Design. (276-315). London: Routledge.

Bélanger, P. (2013) Landscape infrastructure: Urbanism beyond engineering. Published Phd Thesis. Wageningen University. NL.

Benedict, M. A.& McMahon, E. T. 2002. Green Infrastructure: Smart Conservation for the 21st Century. Renewable Resources Journal, (20): 12-17.

Benedict, M. A.& McMahon, E. T.(2002) Green Infrastructure: Smart Conservation for the 21st Century. Sprawl Watch Clearinghouse, Washington D.C. https://conservationtools-production.s3.amazonaws.com/library_item_files/478/513/GI_SC21C.pdf?AWSAccessKeyId=AKIAIQFJLILYGVDR4AMQ&Expires=1597606596&Signature=ITEKv9FdO13cvaqsAW0zjk67N94%3D

Bocarejo, J. P., LeCompte, M. C., & Zhou, J. (2012). Case Study: Cheonggyecheon, Seoul, South Korea. In the Life and Death of Urban Highways (p. 27). Institute for Transportation & Development Policy and EMBARQ. https://www.wrirosscities.org/sites/default/files/Life-Death-Urban-Highways-EMBARQ.pdf

Buchholz, T. A. et al. (2016) Stream Restoration in Urban Environments: Concept, Design Principles, and Case Studies of Stream Daylighting. In T. Younos, T.E. Parece (ed). Sustainable Water Management in Urban Environments. Springer International Publishing, Switzerland.

Buchholz, T., Bork, D., Younos, T. (2007) Urban Stream Daylighting Design Application to Stroubles Creek, Blacksburg, Virginia. Virginia Water Resources Research Center.

Butler D, Davies JW (2004). Urban Drainage, 2nd edn. Span Press, London/New York

Cebeci Mezarlığı (2010) Bir Başkentin Oluşumu. Goethe Enstitüsü. http://www.goethe.de/ins/tr/ank/prj/urs/geb/res/fri/trindex.htm

Cengizkan, A. (2004). Ankara'nın ilk planı 1924-25 Lörcher Planı. Ankara Enstitüsü Vakfı Yayınları, Ankara.

Claytor, R. 2000. Assessing the Potential for Urban Watershed Restoration: The Practice of Watershed Protection. Center for Watershed Protection, Ellicott City, MD. (Pages 705-711).

Conradin, F., Buchli, R. (2004) The Zurich Stream-Daylighting Program. In J. Marsalek et al. (eds.),Enhancing Urban Environment by Environmental Upgrading and Restoration, 277-288.Kluwer Academic Publishers.

Coşkun Dilcan, Ç., Çapar G., Korkmaz, A., İritaş, Ö., Karaaslan, Y., Selek, B. 2018. İçme Suyu Şebekelerinde Görülen Su Kayıplarının Dünyada ve Ülkemizdeki Durumu. Anahtar Dergisi:06/2018.

Council of Europe (2000) European Landscape Convention. Florence (European Treaty Series 176)

Çalışkan, O. (2004) Urban Compactness: A Study Of Ankara Urban Form. Published Master Thesis. Department of City and Regional Planning, METU, Ankara.

Çevre Mühendisleri Odası, İstanbul Şubesi (2014) İstanbul'un Yeni Su Kaynağı Sakarya Nehri ve Su Alma Yapısı Teknik Tespit Görüşü. http://www.cmo.org.tr/resimler/ekler/d3e33ec9040ff70_ek.pdf?tipi=67&turu=H&sube=2

Davidson, N. C. 2014. How much wetland has the world lost? Long-term and recent trends in global wetland area. Marine and Freshwater Research, Vol. 65, No. 10, pp. 934–941.

Develi, E. S. (2014) İllerin Gelişiminde Altyapı Yatırımlarının Önemi Ve İller Bankası'nın Rolü. Non-published Master Thesis. İktisat Anabilim Dalı, Sosyal Bilimler Enstitüsü, Çukurova Üniversitesi.

Dinç, H. (2015) İstanbul Derelerinin Fiziki Değişimi ve Arazi Kullanım İlişkisi, Unpublished PHD Thesis; Şehir ve Bölge Planlaması Anabilim Dalı, İTÜ.

Dow, C. L., and D. R. DeWalle. 2000. Trends in evaporation and Bowen ratio on urbanizing watersheds in eastern United States. Water Resources Research 36(7):1835–1843.

Duman Yüksel, Ü., Yılmaz, O. (2008) Ankara Kentinde Kentsel Isı Adası Etkisinin Yaz Aylarında Uzaktan Algılama ve Meteorolojik Gözlemlere Dayalı Olarak Saptanması ve Değerlendirilmesi. J. Fac. Eng. Arch. Gazi Univ. Vol 23, No 4, 937-952.

Dunne, T. and Leopold, L.B. (1978) Water in environmental planning. W.H. Freeman and Co., New York.

Edwards, P. N. (2003). Infrastructure and Modernity. In Thomas J. M., Philip Brey, and Andrew Feenberg (Ed). Modernity and Technology. (185-225). Cambridge, MA: MIT Press.

Encyclopaedia Britannica (2011) Water cycle. britannica.com/science/water-cycle

Encyclopaedia Britannica (2016) Biogeochemical cycle. britannica.com/science/biogeochemical-cycle

European Commission (2011) A growth package for integrated European infrastructures. Brussels.

Fıratlı, N. (1951) Ankara'nın İlk Çağdaki Su Tesisatı. Belleten Cilt: XV,59.

Forman, R., Infrastructure and Nature: Reciprocal Effects and Patterns for Our Future. In Spiro Pollalis, Daniel Schodek, Andreas Georgoulias and Stephen J. Ramos (Ed.). Infrastructure, Sustainability & Design. (276-315). London: Routledge

Freeman, M.C., Pringle, C.M., Jackson, R.C., 2007. Hydraulic connectivity and the contribution of stream headwaters to ecological integrity at regional scales. Journal of the American Water Resources Association 43 (1), 5–14.

Gandy, M. (2011). Landscape and Infrastructure in the Late - Modern Metropolis. In Bridge G., Watson S. (ed), Companion to the City. Blackwell.

Görer N. (2003) Commercialization and Privatization of Urban Water and Sewerage Services In Turkey: Poverty Reduction View. In: Olcay Ünver İ.H., Gupta R.K., Kibaroğlu A. (eds) Water Development and Poverty Reduction. Natural Resource Management and Policy, vol 25. Springer, Boston, MA.

Günel, G., Kılcı, A. (2015) Ankara Şehri 1924 Haritası: Eski Bir Haritada Ankara'yı Tanımak. Ankara Araştırmaları Dergisi 3(1), 78-104

Harvey, D. (2003) “Paris, Capital of Modernity”, by Routledge, New York.

HidroDizayn & NFB (2016) Ankara Alt Havzası Master Plan Raporu. DSİ Genel Müdürlüğü.

HidroDizayn & NFB (2017) Sakarya Master Plan Nihai Raporu. DSİ Genel Müdürlüğü, Ankara.

IPCC Report Global Warming of 1.5 ºC. (2018) Chapter 3.

Kentel, E., Yanmaz, M. (2007) Kanalizasyon Sistemlerinin İşletimiyle İlgili Sorunların Değerlendirilmesi, 5. Kentsel Altyapı Ulusal Sempozyumu, İMO.

Keystone Stream Team (2003) Guidelines for natural stream channel design for Pennsylvania waterways. Alliance for the Chesapeake Bay.Pennsylvania.

Köle, M. M. (2014) Ankara Örneklemi Üzerinde Cumhuriyet Dönemi Su Kaynakları Yönetim Modelleri. Türkiye Sosyal Araştırmalar Dergisi, 18:1.

Landsberg, H. E. 1981. The Urban Climate. In International Geophysics Series (Vol. 28)

Landscape Architecture Foundation. (2010). Cheonggyecheon Stream Restoration Project. https://www.landscapeperformance.org/case-study-briefs/cheonggyecheon-stream-restoration

Lei, Z., Guanghe, W., 2008. Urban River Plays Key Role in City Landscape Planning Culture Legacy and Ecological Development. College of Urban and Rural Construction, Hebei Agricultural University, Baoding 071001, PR China.

McHarg, I. (1969) Design with Nature. John Wiley & Sons. USA

Michalak, J. N., 2014. Infrastructural Landscape: Strategies for Post-Industrial Reuse. Unpublished Master Thesis. University of Washington.

Mulvihill, C.I., Baldigo, B.P., Miller, S.J., DeKoskie, Douglas, and DuBois, Joel (2009) Bankfull discharge and channel characteristics of streams in New York State: U.S. Geological Survey Scientific Investigations Report.

National Park Service (Undated) Giving new life to streams in rural city centers. http://npshistory.com/publications/rtca/city-center-streams.pdf

Neuman, M., & Smith, S. (2010). City planning and infrastructure: Once and future partners. Journal of Planning History, 9(1). 21–42.

Nijhuis, S., & Jauslin, D. (2015). Urban landscape infrastructures. Research In Urbanism Series, 3(1), 13-34. doi.org/10.7480/rius.3.874

Novotny, V., Ahern, J. & Brown, P. (2010). Water Centric Sustainable Communities. New Jersey: John Wiley & Sons.

Odum, E. P. (1989) Ecology and Our Endangered Life-Support Systems. Sinauer Associates, Sunderland, Mass.

Oslo Reopening Waterways (2018) European Green Capital Award. https://webgate.ec.europa.eu/greencitytool/resources/docs/best_practices/Oslo_Reopening_Waterways_A02.pdf

Paul, M. J. and J. L. Meyer (2001) Streams in the Urban Landscape. Annual Review of Ecological Systematics 32. pp. 333–365.

Pinkham, R. (2000) Daylighting: new life for buried streams. Rocky Mountain Institute, Colorado.

Rapp, O. (2019) Reopening of culverted streams and rivers. http://www.novatech.graie.org/documents/auteurs/1A1P-041RAP.pdf

Reimold, R. J. (1998). Watersheds-an Introduction. In Robert J. Reimold (Ed.), Watershed Management, Practice, Policies, and Coordination (pp. 1–5).

Riley, L. A. (2016) Restoring Neighborhood Streams Planning, Design, and Construction. Island Press

Sarıkaya, H. Z. (2015) Dünyada ve Türkiye'de Suyun Fiyatlandırılması. T.C. Orman ve Su İşleri Bakanlığı. Ankara.

Semiz, Y. (2019) "Under the road, the river!" Luwi Film. Trailer of the documentary: https://www.youtube.com/watch?v=FXACGsb1OdU

Shannon, M., Smeths. M. (2010) The Landscape of Contemporary Infrastructure, NAi Publishers, Rotterdam.

Soyak, A. (2020) Ankara Çayı Neden Kirli Akıyor? https://www.youtube.com/watch?v=4WF1_H4kF6w

Soyak, A. (2020) Dikmen Deresi. https://www.youtube.com/watch?v=K5Wrc4qajnY

Soyak, A. (2020) İmrahor Vadisi ve İncesu Deresi. https://www.youtube.com/watch?v=3K9DZyQ6nv8

Steven Ronald Clarke (1999) Rethinking Infrastructure. Unpublished Master Thesis. The university of Manitoba, Faculty of Graduate Studies.

Strang, G. (1996) Infrastructure as landscape. In Places Journal (Vol. 10, No. 3, pp. 8-15). https://www.escholarship.org/uc/item/6nc8k21m

Streams. US Environmental Protection Agency. https://archive.epa.gov/water/archive/web/html/streams.html

Şahin, Ş., Perçin, H., Kurum, E. ve Memlük, Y., 2014. Akarsu Koridorlarında Peyzaj Onarımı ve Doğaya Yeniden Kazandırma Teknik Kılavuzu. T.C. Orman ve Su İşleri Bakanlığı, Doğa Koruma ve Milli Parklar Genel Müdürlüğü adına BEL-DA Belde Proje ve Dan. Tic. Ltd. Şti., Ankara.

Şahin, Z., Kent Planlama Süreci ile Kentsel Altyapı Yatırımlarının İlişkisi: Ankara Örneği, Planlama 2018;28(1):6-11.

T.C. Başbakanlık Devlet Planlama Teşkilatı (1977) IV. Beş Yıllık Kalkınma Planı, İçme Suyu ve Kanalizasyon Özel İhtisas Komisyonu Raporu. DTP:1547-ÖİK:239.

T.C. Kalkınma Bakanlığı (2018) 11. Kalkınma Planı, Su Kaynakları Yönetimi ve Güvenliği, Özel İhtisas Komisyonu Raporu.

Tamur, E. (2012) Suda Suretimiz Çıkıyor. Kebikeç yayınları, Ankara.

Tekeli, İ., Altaban, Ö., Güvenç, M., Türel, Ali., Günay, B., Bademli, R. (1987). Ankara 1985'den - 2015'e.Ankara Büyükşehir Belediyesi EGO Genel Müdürlüğü, Ajans İletim, Ankara.

The World Bank Development Research Group (2010). Export Performance and Trade Facilitation Reform: Hard and Soft Infrastructure.

Trice, A. (Undated) Daylighting Streams: Breathing Life into Urban Streams and Communities. American Rivers.

United Nations (2018) 68% of the world population projected to live in urban areas by 2050. https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

Waldheim, C. (2006) The Landscape Urbanism Reader. New York: Princeton Architectural Press.

Weilacher, U. Green Infrastructure and Landscape Architecture. Originally published in Garten+Landschaft, 3/2015 https://www.landezine.com/index.php/2017/05/green-infrastructure-and-landscape-architecture/

Wilson, E. O. The Little Things That Run the World. Conservation Biology, Vol. 1, No. 4 (Dec., 1987), pp. 344-346

WWF. (2014) Türkiye'nin Su Riskleri Raporu. Ofset Yapımevi. İstanbul.

Yağmursuyu Toplama Depolama Ve Deşarj Sistemleri Hakkında Yönetmelik (2017) Çevre ve Şehircilik Bakanlığı https://www.resmigazete.gov.tr/eskiler/2017/06/20170623-8.htm

Yararbaş, Ö. Atıksu Arıtımında Türkiye'nin Genel Görünümü. İMO. http://www.imo.org.tr/resimler/ekutuphane/pdf/890.pdf

Yavuz, I. (2018) Calyx: A Geomorphological Approach to Formation of Urban Space in The Context of Ankara. Unpublished Master Thesis. Department of City and Regional Planning, METU, Ankara.

Yazman, D. (2009) Planlı Geçmişten Plansız Geleceğe. Arkitera. https://v3.arkitera.com/h46008-planli-gecmisten-plansiz-gelecege.html

Ying-Yu Hung (2013) Landscape Infrastructure: Systems of Contingency. In Ying-Yu Hung (ed). Landscape Infrastructure: Case Studies by SWA. Birkhauser Verlag GMBH, Basel, P.O. Box 4009, Basel, Switzerland.