EVALUATING DALLAS COUNTY LANDFILLS FOR PUBLIC AMENITY: REPURPOSING THE CITY OF GRAND PRAIRIE LANDFILL THROUGH LANDSCAPE ARCHITECTURE

by

ELENA E. NACCARI

Presented to the Faculty of the Graduate

School of The University of Texas at Arlington

in Partial Fulfillment of the Requirements

for the Degree of

MASTER OF LANDSCAPE ARCHITECTURE

May 2021

SUPERVISING COMMITTEE:

Dr. Taner R. Özdil, Ph.D., ASLA, Supervising Professor
Dr. Amy A. Archambeau, Ph.D.
Nick Nelson, RLA, LEED AP

ACKNOWLEDGEMENTS

This research would not be complete without accurate documentation of those who have guided and supported me through the master thesis process, as well as these three years of master's studies. To Dr. Özdil, who has given every effort to lead my understanding and interest for the research topic at hand and our profession of Landscape Architecture overall in these three years. To my committee members, Dr. Archambeau for all of her support and enthusiasm in each new area discovered; to Nick Nelson for taking on an extra task in excitement and guiding me through the design process.

I would like to thank all of my professors throughout these three years, it is quite amazing the time and effort you all have put into my personal education and it is certainly appreciated. To Dr. Diane Jones Allen and Dr. Austin Allen, I truly appreciate the opportunities and mentorship you both have given me, this is something that has and will continue to steer me throughout my time as a professional in our field. To my interview participants for setting aside time to further research concerning the landfill industry, and to my fellow students for becoming lasting friends, colleagues, and providers of constructive criticism.

An essential thank you to my parents for allowing me to gain this education and for supporting me.

ABSTRACT

POST-CLOSURE LANDFILL REPURPOSING FOR PUBLIC AMENITY THROUGH THE PRACTICE OF LANDSCAPE ARCHITECTURE

Elena E. Naccari, MLA Candidate

The University of Texas at Arlington, 2021

Chair: Dr. Taner R. Özdil

The state of Texas produced more than 36 million tons of waste in 2019. Currently there are 198 active landfills of varying size and capacity in the entire state. Overall landfill capacity within the state is decreasing over time, while the size of landfills on average is increasing, creating quite the contradiction and clear picture of the average consumer's increase in waste production (Municipal Solid Waste, 2019).

The state of Texas is on an unfortunate path to meet landfill capacity in 53 years (Municipal Solid Waste, 2019). Of the almost 800 landfill sites (active and inactive) in the state of Texas 66% are publicly owned. Most landfills sit with unrealized potential after closure because of possible liability issues, rather than exploring the opportunities for public amenity/benefit. Therefore, closed landfills can be regarded as potential amenity opportunities for the citizens of Texas (Municipal Solid Waste, 2019). Repurposing closed landfill land would help mend segments of the now fractured ecosystem that were once designated for waste storage. Prioritizing such land in a rapidly increasingly metropolitan area, like Dallas- Fort Worth, is critical to the health and livelihood of the public.

The objective of this master's design thesis is to assess opportunities to repurpose public landfill sites in Dallas County, Texas and propose design recommendations for one of the five active Subtitle D landfill sites to be implemented at close.

This study utilizes both qualitative and quantitative data and methods (Deming & Swaffield, 2011). It systematically reviews the state of Texas' data in concurrence with weighted overlay analysis to locate an application site (Steiner, 2008; McHarg, 1992). Case studies are examined and investigated for each known repurposing strategy. Both the case studies, and site suitability analysis provide a variety of intervention opportunities for the landfill land post-closure. Closed landfill data of the state of Texas are researched, analyzed, and applied to a closer analysis of the site Interviews are conducted with professionals to gain a wider knowledge of the landfill industry and to evaluate the current landfill situation of the proposed site (Glaser & Strauss 1980). This Institutional Review Board approved study acquires perspective for repurposing strategies from those who work within the active landfill process (planning, engineers, workers, etc.). Findings are used to inform planning and design of a proposed landfill site in Dallas, Texas.

The results of this research produce recommendations and criteria to be used as a template for each landfill site that applies, and an overview of the suitability options for optimal repurposing of the landscape components especially within the context of Dallas County, Texas. Possibilities may exist to extend or better the wildlife habitat restoration strategy, implemented by Waste Management, Inc. to continue repair of the bionetwork damage (Wildlife Habitat Sites, n.d.). Verifying landfill history enables research for such repurposing to begin and provides a window into connecting human activity to these landscapes. The goal of this research is to create a model that can be reproduced and considered in the landfill process at the end of its active lifecycle, through landscape architecture, to address the loss of land caused by production and storage of waste.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Introduction

The state of Texas produced more than 36 million tons of waste in 2019. As of mid-2020 there are 198 active landfills of varying size and capacity in the entire state, not including acknowledged permits (permits being processed and not yet active) or illegal and unpermitted dump sites, and 590 closed and post closure landfills. Overall landfill capacity within the state is decreasing over time, while the size of landfills on average is increasing, creating quite the contradiction and clear picture of the average consumer's increase in waste production (Municipal Solid Waste, 2019).

The state of Texas is on an unfortunate path to meet landfill capacity in 53 years (TCEQ Municipal Solid Waste, 2019). Of the almost 800 landfill sites (active and inactive) in the state of Texas 66% are publicly owned. Therefore, closed landfills can be regarded as potential amenity opportunities for the citizens of Texas (Municipal Solid Waste, 2019). Repurposing closed landfill land would help mend segments of the now fractured ecosystem that were once designated for waste storage.

1.2 Problem Statement

Most landfills sit with unrealized potential after closure because of possible liability issues, rather than exploring the opportunities for public amenity/benefit. Especially in a growing metropolitan area such as Dallas-Fort Worth, the value of prioritizing such land is critical. These publicly owned sites are key for creating open green spaces for the communities and their livelihood. Utilizing such land in urban areas can combat the loss of native vegetations and corridors, as well as address the larger issue of climate change. Additionally, within the context of climate change these sites could confront subjects such as stormwater management and heat island effect. Repurposing closed landfill land would help mend segments of the now fractured ecosystem that were once designated for waste storage.

1.3 Purpose Statement

The objective of this master's design thesis is to assess opportunities to repurpose public landfill sites in Dallas County, Texas and propose a design for one of the five active landfill sites to be implemented at close. This research will identify criteria for optimal design and planning strategies in the landfill closure and post-closure process (pertaining to landscape architecture). This will in turn provides suitable options for communal programming of closed landfill sites including enabling restoration of ecosystem conditions to become more comparable to pre-landfill use. Other public amenity opportunities also exist for landfill reuse through landscape architecture contributions, including stormwater management, recreation, pedestrian connection, education, agriculture, etc.

This research uses Subtitle D landfill site data, interviews, and case studies of repurposed landfills, in order to produce a model of optimal landscape architecture repurposing strategies for execution at end of the active stage in the public landfill lifecycle.

1.4 Research Questions

- How can Subtitle D landfills in a large urban area be repurposed for public outdoor use to extend amenity opportunities on public lands?
- What design/planning criteria can be used to repurpose Subtitle D landfill landscapes in Dallas County?
- What are the major lessons learned from repurposing/redesigning a landfill site for outdoor use?

- What makes a public space successful within the context of Landfill sites?
- How would an additional outdoor public space impact Dallas County?

1.5 Key Terms

Capacity- "The maximum amount or number that can be contained or accommodated" (Dictionary, 2020, para. 2a).

Landfill- "…well engineered and managed facilities for the disposal of solid waste" (Basic Information, 2020, para. 1).

Leachate- "Formed when rainwater filters through wastes placed in a landfill. When this liquid comes in contact with buried wastes, it leaches, or draws out, chemicals or constituents from those wastes" (Municipal Solid Waste Landfills, 2021, para. 2).

Municipal solid waste landfill- "A discrete area of land or excavation that receives household waste" (Municipal Solid Waste Landfills, 2020, para. 1).

Native- "Living or growing naturally in a particular region" (Dictionary, 2020, para. 6b).

Public- "Accessible to or shared by all members of the community" / "Supported by public funds and private contributions rather than by income from commercials" (Dictionary, 2020, para. 6a).

Private- "Intended for or restricted to the use of a particular person, group, or class" "belonging to or concerning an individual person, company, or interest" (Dictionary, 2020, para. 1a).

Regulation- "A rule or order issued by executive authority or regulatory agency of a government and having the force of law" (Dictionary, 2020, para. 2b).

Rehabilitation- "The restoration of something damaged or deteriorated to a prior good condition" (Dictionary, 2020, para. c).

Restoration- “A bringing back to a former position or condition” (Dictionary, 2020, para. 1a).

Repurpose- “To give new purpose or use to” (Dictionary, 2020, para. 1).

Site analysis- “Site analysis is a predesign research activity which focuses on existing and potential conditions on and around the building site. It is an inventory of the site factors and forces, and how they coexist and interact. The purpose of the analysis is to provide thorough information about the site assets and liabilities prior to starting the design process. Only in this way can concepts be developed that incorporate meaningful responses to the external conditions of the site” (Lynch, 1984).

Site inventory- “Gathering and categorizing data and information on natural and human features in an area proposed for a planning project” (Christenson, 2005).

Stormwater management- “The control and use of stormwater runoff. It includes planning for runoff, maintaining stormwater systems, and regulating the collection, storage, and movement of stormwater” (Holm, 2014).

Suitability analysis- “A type of analysis used in GIS to determine the best place or site for something” (Overview of Weighted Analysis, 2014).

Subtitle D- “Focuses on state and local governments as the primary planning, regulating and implementing entities for the management of nonhazardous solid waste, such as household garbage and nonhazardous industrial solid waste” (Basic Information, 2020, para. 4).

Transfer Station- “A processing facility used for transferring solid waste from collection vehicles to long haul; may include material recovery and recycling but does not include disposal of waste” (Municipal Solid Waste Landfills, 2021, para. 7).

Type 1 Landfill- “May accept all types of municipal solid waste, and some non-hazardous industrial waste” (Municipal Solid Waste Permits, 2021, para. 2).

Type IV Landfill- "May only accept brush, construction, or demolition waste, and rubbish" (Municipal Solid Waste Permits, 2021, para. 2).

1.6 Methodology Summary

This study utilizes a multi-method approach encompassing both qualitative and quantitative research paradigms and methods (Deming & Swaffield, 2011). The research uses primary and secondary data to assess the suitability of repurposing public Subtitle D category landfill sites for public landscape interventions. Specifically, the study draws on archival or secondary data such as: Geospatial inventory and analysis of Dallas County data, case studies of existing projects, and interviews with key stakeholders. Additional interviews may be conducted after site selection to evaluate the current landfill situation of the proposed site to gain perspective from those who work within the active landfill process (planning, engineers, workers, etc.).

While data collected through secondary sources are analyzed using reporting techniques, descriptive statistics, and analytical maps (GIS), the case studies are analyzed through Francis' Case Study Method (Francis, 2001). Interview results are analyzed to draw critical themes by Grounded Theory (Glaser & Strauss, 1980). Data systematically collected through these methods are synthesized using data triangulation methods to inform the decision-making process of planning/design for closed landfill sites (Patton, 1990).

1.7 Significance, Limitations, and Assumptions

The results of this research are intended to inform specific criteria to be utilized as a template for each public Subtitle D landfill site that applies, and an overview of the suitability options for optimal repurposing of the landscape components. The objective is to identify areas for additional public amenity through these Subtitle D landfill sites though, possibilities may exist to extend or better the wildlife habitat restoration strategy, implemented by Waste Management, to continue repair of the bionetwork damage. Verifying landfill history enables research for such repurposing to begin and provides a window into connecting human activity to these landscapes. The goal of this research is to create a model that can be reproduced and considered in the landfill process at the end of its active lifecycle, through landscape architecture, to address the loss of land caused by production and storage of waste.

Overall, from looking into the data of the Texas Commission of Environmental Quality report of municipal solid waste landfills from 2018, it can be readily assumed that landfills in Texas will continue to become larger in height and acreage (Municipal Solid Waste, 2018). From the research into Waste Management and their practices, it is assumed that the implementation of wildlife habitat restoration continues on most landfill sites they manage. An understandable assumption based on generic research into the repurposing of landfills, and the climate of year 2020, is the need for more public outdoor amenities.

One limitation of this study is the fairly inadequate data available on the few repurposed landfills in Texas, and in turn the regional connection to this research may suffer. The data available on landfills currently closed in Texas is relatively limited and vague. Repurposed landfill case studies may lack in direct connection to this study because of the landfill type. Another is the ability to find knowledgeable experts willing to participate and therefore complete interviews. Closed landfill environmental impact studies are fairly scarce, which would state the true result of the repurposing and restoration.

1.8 Chapter Summary

The purpose of this master's design thesis is to assess opportunities to repurpose public landfill sites in Dallas County, Texas and propose a design for one of the five active Subtitle D landfill sites to be implemented at close. This master's design thesis is organized into the following chapters, (1) Introduction, (2) Literature Review, (3) Methodology, (4) Analysis and Findings, (5) Planning and Design, and (6) Conclusion. Chapter 1 defines the research problem and purpose as well as procedures and advantages of the study. Chapter 2 provides a literature review on the landfill industry in general, federal regulations for landfills, waste data for the state of Texas, Dallas County landfill regulations and introductions to primary research case studies. Chapter 3 outlines the research methodology strategy used in this thesis. Chapter 4 identifies and analyzes the data collected from the literature review, geospatial analysis using GIS, a group of professional interviews, and two levels of case studies. Chapter 5 discusses the process for evaluating a landfill site for selection as public amenity in Dallas County and suitable planning and design considerations for the chosen site. Chapter 6 summarizes the research and discusses the implications of method adoption within the landfill process. Future opportunities for research into this topic are also presented in the concluding chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter systematically reviews the existing literature on and adjacent to the landfill and waste industry. The review focuses on planning, policy, history, and existing data of landfills generally and pertaining to the State of Texas. Case studies are introduced in this chapter to thread the generalities of the landfill process to more specific sites at and after close of the cycle. The section suggests disciplinary collaboration throughout, from initial planning to post-closure repurposing. The literature review illustrates quantitative and qualitative data from the Municipal Solid Waste Year in Review, as well as the Environmental Protection Agency's regulations on landfill planning and life cycle. This review is then examined through the perspective of the landscape architecture discipline.

2.2 What are Landfills?

What exactly is a landfill? According to Merriam-Webster dictionary a landfill is "a system of trash and garbage disposal in which the waste is buried between layers of earth to build up low-lying land" (Landfill, 2020, para. 2). These disposal sites can be thought of simply as large storage containers made from the natural landscape for waste products, though in reality they are much more complex. Landfills are managed facilities that are intricately engineered. While they store and hide unwanted items, they also comply with Federal policies to protect the environment from contamination produced by the decomposition process. These facilities are placed in stable environments, which is continually monitored for breaches in stability/health (gas leaks, groundwater contamination, leachate, etc.) of said environments.

2.3 Typologies of Landfills

There are seven basic forms of landfills: Municipal Solid Waste Landfills, Bioreactor Landfills, Industrial Waste Landfill, Construction and Demolition Debris Landfill, Coal Combustion Residual Landfill, Hazardous Waste Landfill, and Polychlorinated Biphenyl Landfill (Basic Information about Landfills, 2020). Though only five of the above stated landfills are Subtitle D (managing non-hazardous waste), while Hazardous Waste Landfills fall under Subtitle C and Polychlorinated Biphenyl Landfills are their own category structured by the Toxic Substances Control Act.

The focus of this research is Municipal Solid Waste Landfills (MSW), specifically the most common Subtitle D: "…a discrete area of land or excavation that receives household waste" (Municipal Solid Waste Landfills, 2020, para. 4). These facilities can also receive other types of nonhazardous waste, generally at limited amounts. Each of these sites is managed and operated by the state in which they are located. All Municipal Solid Waste Landfills have engineering requirements, location/placement restrictions, monitoring systems, and financial guarantee (Municipal Solid Waste Landfills, 2020). These landfills have progressed greatly in technology and compliance with environmental rules and regulations thanks to the Environmental Protection Agency and government funding.

The Solid Waste Association of North America (SWANA) is an entity championing the initiative of resource management rather than mere solid waste management. This large organization has been operating for over 50 years with more than 10,000 public and private entities involved. It supports the landfill industry by providing certifications, holding conferences, and conducting training courses. By providing research and education opportunities SWANA "…is a major policy and technical representative of solid waste management practitioners, executives, companies, and government organizations" (Technical and

Management Policies, 2020, para. 3). This association is more than relevant to the industry, it is vital because of its resource management practices and safety education. Some of SWANA's technical policies include: Solid waste reduction, alternative daily cover of landfills, long term management of MSW landfills, strategic planning, and environmental justice equity in siting MSW facilities (Technical and Management Policies, 2020).

2.4 Environmental Protection Agency Landfill Regulations

In the Electronic Code of Federal Regulations criteria for municipal solid waste there are set restrictions for location of landfill sites and set criteria for closure and post-closure of landfill sites (eCFR, 2020). These regulations are essential knowledge to understand the cycle in which landfills rotate, therefore critical for the success of the repurposing aspect at the end of its' active life.

2.4.1 Airports

Municipal Solid Waste sites cannot be located within 10,000 feet of a runway used by turbojet aircraft, or 5,000 feet of a runway used by piston type aircraft. If proposing an MSW site within a five-mile radius the airport and the Federal Aviation Administration (FAA) must be notified. This radius boundary is also put into place as to prevent creation of bird hazard to the aircrafts (eCFR, 2020).

2.4.2 Floodplains

Municipal Solid Waste sites placed in 100-year floodplains must not restrict the water flow of the possible 100-year flood. The storage capacity of the floodplain cannot be reduced due to the addition of the MSW landfill. Flooding cannot result in the washout of solid waste. The passing of these regulations must be demonstrated, logged on record, and then given to the State Director of said environmental regulations (eCFR, 2020).

2.4.3 Fault Lines

Municipal Solid Waste sites cannot be placed within 200 feet of a fault that has had displacement in Holocene time. MSW facilities cannot be placed in seismic impact zones unless demonstrated to State Director that all structures and systems are designed to withstand and resist the maximum horizontal impact and placed on record (eCFR, 2020).

2.4.4 Unstable Areas

Municipal Solid Waste sites located in areas deemed unstable must demonstrate the engineering measures taken to ensure the stability of the structures and systems on site. They also must notify the State Director and place it on record. At a minimum, when determining whether an area is unstable:

(1) On-site or local soil conditions that may result in significant differential settling.

(2) On-site or local geologic or geomorphologic features.

(3) On-site or local human-made features or events (both surface and subsurface).

(eCFR, 2020)

2.4.5 Wetlands

Municipal Solid Waste sites cannot be located in wetland areas. The site cannot violate any State water quality standard. It cannot jeopardize endangered or threatened species, nor modify the habitats of said species. The site must not violate the Clean Water Act. It cannot contribute or cause degradation of wetland area. Creation of significant changes in PH levels or impact the fish, wildlife, and aquatic resources is prohibited. This has to be demonstrated and placed on record (eCFR, 2020).

2.4.6 Closure

A final cover system has to be designed and installed to minimize water infiltration and erosion of protective layers. The State Director has to approve the final design of the landfill cover, and once in place needs approval from an engineer. A closure plan must be prepared, which describes all steps necessary to close the MSW landfill site (eCFR, 2020).

2.4.7 Post-Closure

Post-closure care has to be conducted for 30 years once the Municipal Solid Waste site is closed, this includes: monitoring and maintaining the final cover's integrity, maintaining, and operating the leachate collection system, monitoring the groundwater, maintaining, and operating the gas monitoring system. A description of the monitoring and maintenance systems are required with the frequency in which performed. The owner/operator must provide name, address, and telephone number to contact about the facility during the post-closure period, and a plan for the uses of the property in the post-closure period. Post-closure uses cannot jeopardize the integrity of the final cover, liner(s), or any system necessary for containment. A State Director must be supplied with these records and approve (eCFR, 2020).

These regulations apply to this research as standards or guidelines for eventual repurposing elements. Though some of the rules above are much larger scale aspects of original planning and site placement (floodplains, etc.), they can still be utilized in a restorative sense for design guidelines. The *Closure* and *Post-Closure* regulations relate more directly to the repurposing planning and design potential range.

2.5 Texas Landfill Data and History

Established in 1991, the Federal Resource Conservation and Recovery Act (RCRA) Subtitle D regulation hold Municipal Solid Waste Landfills to required environmental standard practices. This act requires upgrades to designs, operating practices, and closure specifications.

This included: location restrictions, liner installations, groundwater monitoring and other monitoring systems. The development of Subtitle D led to the closure of 591 authorized MSW landfills between 1991 and 1994. There were 790 authorized MSW landfills in 1986, 199 in 1994, and 198 according to the Municipal Solid Waste in Texas: A Year in Review 2019 Data Summary and Analysis. There are 24 Regional Planning Commissions or Councils of Governments (COGs) responsible for the planning of MSW Facilities. The Texas Commission of Environmental Quality oversees all Municipal Solid Waste Landfills in the state of Texas, though not all are owned by government entities (cities and counties). As shown in Figure 2.1, some landfill facilities are owned by corporations or private companies. In 2019, 130 out of 198 MSW active landfills and 110 processing and composting facilities were publicly owned (Municipal Solid Waste, 2019). These publicly owned sites received 35 percent of the state's waste and contain 42 percent of the state's residual capacity.

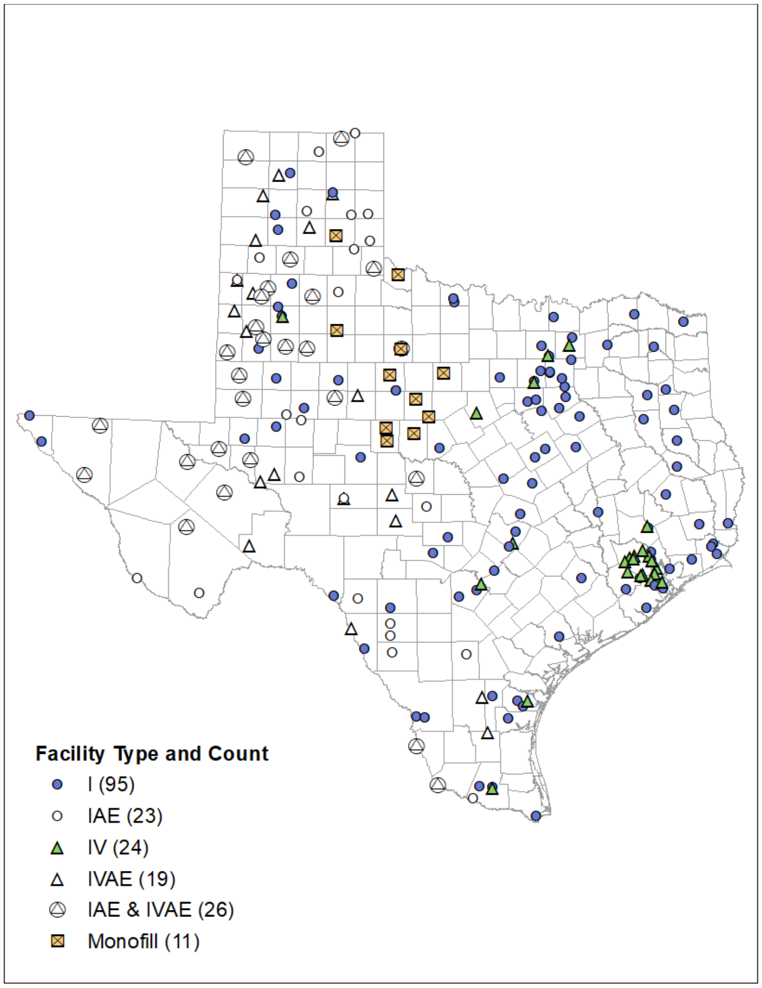


Figure 2.1 Active Texas MSW Landfills in 2019 (Municipal Solid Waste, 2019)

According to the MSW 2019 Year in Review, the state of Texas has a remaining landfill capacity of 1.93 billion tons. This equals about 53 years until present authorized and permitted landfills are compacted and full, as illustrated in Figure 2.2. This is considering a constant of 36.80 million tons disposed of per year, which is the amount of waste the MSW landfills received in 2019. This residual space does not include monofills (landfills that only accept one specific type of waste). That being said, the statewide capacity in tons increased by 0.6 percent from 2018 to 2019. The MSW Year in Review states, "Although remaining capacity was not evenly distributed, the state appeared to have an adequate reserve of MSW landfill capacity (10 years or more) in 2019" (Municipal Solid Waste in Texas, 2019). Texas is the second largest state in the country, and it has a remaining capacity of 53 years.

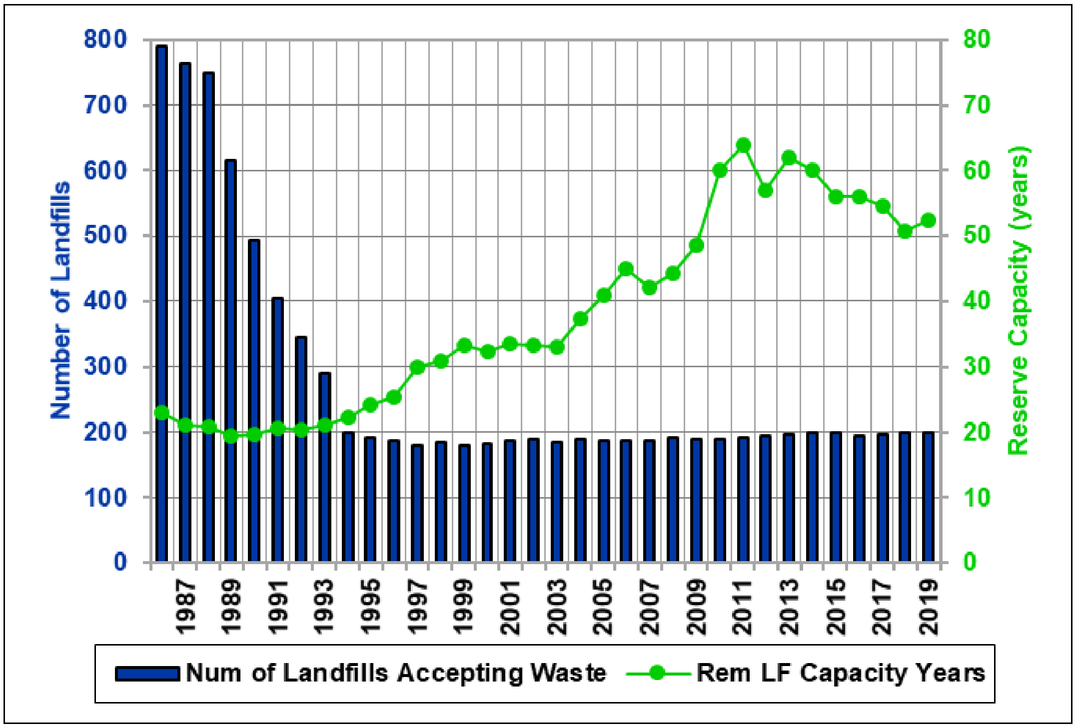
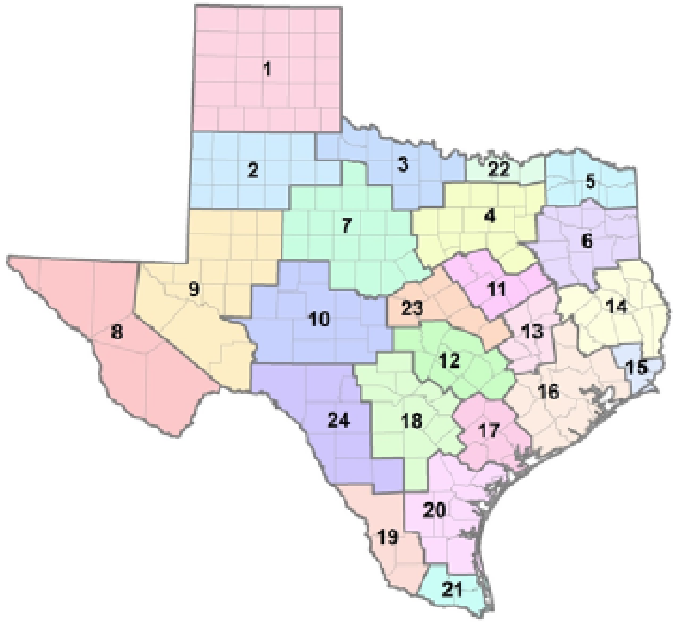


Figure 2.2 Active Landfills vs. Remaining Capacity Years (Municipal Solid Waste, 2019)

Population and major climate or weather events are factors in the residual landfill space for each state. Out of the total amount of accepted waste in Texas it is estimated that the average waste produced per person was 6.96 pounds per day in 2019. This average decreased from 2018 7.22 pounds per person, over the subject time period (Municipal Solid Waste in Texas, 2018).

2.6 North Central Texas Regional Landfills

North Central Texas Council of Governments (NTCOG) has a Materials Management program, which is overseen by the Texas Commission on Environmental Quality (TCEQ), Figure 2.3 portrays the Council of Government Divisions of landfill responsibility in Texas. "In 2017, the Texas Commission on Environmental Quality reported that annual landfill disposal reached approximately 33.3 million tons of waste across the state of Texas, equivalent to 6.84 pounds per Texan per day. In the North Central Texas region alone, 10.7 million tons of waste were disposed of in landfills in 2017, making it the highest out of 24 different regions, and accounting for almost 30% of the state's total waste" (Closed Landfill Inventory, 2020). There would be about 39 years residual space in the 21 active North Central Texas landfills if the consumption and production of waste continues at the present rate. This falls in line with the data collected from the Municipal Solid Waste 2019 Year in Review. The growing population in the North Central Texas region is affecting the capacity levels of landfills greatly, especially because the MSW landfills are the primary disposal option. "Considering this data, it is expected that a number of communities will face challenges regarding municipal solid waste (MSW) in the near future" (TCEQ, 2017). More recently, the Central Texas COG region (seven counties north of Austin, TX) had the least amount of reserve capacity, according to the 2019 MSW Year in Review, at 13 years.



No.	Abbrev.	COG Name	No.	Abbrev.	COG Name
1	PRPC	Panhandle Regional Planning Commission	13	BVCOG	Brazos Valley Council of Governments
2	SPAG	South Plains Association of Governments	14	DETCOG	Deep East Texas Council of Governments
3	NRPC	Nortex Regional Planning Commission	15	SETRPC	South East Texas Regional Planning Commission
4	NCTCOG	North Central Texas Council of Governments	16	H-GAC	Houston-Galveston Area Council
5	ATCOG	Ark-Tex Council of Governments	17	GCRPC	Golden Crescent Regional Planning Commission
6	ETCOG	East Texas Council of Governments	18	AACOG	Alamo Area Council of Governments
7	WCTCOG	West Central Texas Council of Governments	19	STDC	South Texas Development Council
8	RGCOG	Rio Grande Council of Governments	20	CBCOG	Coastal Bend Council of Governments
9	PBRPC	Permian Basin Regional Planning Commission	21	LRGVDC	Lower Rio Grande Valley Development Council
10	CVCOG	Concho Valley Council of Governments	22	TCOG	Texoma Council of Governments
11	HOTCOG	Heart of Texas Council of Governments	23	CTCOG	Central Texas Council of Governments
12	CAPCOG	Capital Area Council of Governments	24	MRGDC	Middle Rio Grande Development Council

Figure 2.3 Council of Government Division (Municipal Solid Waste, 2019)

The North Central Texas Council of Governments (NCTCOG) maintains an inventory of closed and abandoned landfills in the region, which is updated regularly, NCTCOG shown in Figure 2.3 as number 4. Southwest Texas State University was contracted by the Texas Commission on Environmental Quality (TCEQ), and in partner with the 24 regional Council of Governments throughout Texas, created a complete inventory of the abandoned and closed landfills within the state. The report stated, “A total of 623 sites are located within the North Central Texas region. Of these sites, 136 were permitted by the state and 487 were unauthorized and are now considered abandoned” (Closed Landfill Inventory, 2020). Each of these closed sites encompassed by the regulations in NCTCOG relate to number of spaces and or acreage of sites available for repurposing as public amenity and or benefit.

2.7 Dallas County Landfills

Dallas County is home to five currently active MSW landfills, 26 permitted MSW landfills that are now closed, and 126 unauthorized landfill sites that are now closed or abandoned. The active sites include: Hunter Ferrell Landfill, Charles M. Hinton Jr. Regional Landfill, City of Dallas McCommas Bluff Landfill, City of Grand Prairie Landfill, and Waste Management Skyline Landfill. Only three of the active sites in Dallas County recover landfill gas for beneficial use: City of Grand Prairie Landfill Gas to Energy Facility, Skyline Landfill Gas to Electric Facility, McCommas Bluff Landfill Gas to Energy Facility shown in Figure 2.4. The five active landfill acreage in Dallas County totals to more than 1,200 (Municipal Solid Waste in Texas, 2019).

In Dallas County, the landfill sites stated above (both active and inactive or closed) are all eligible for analysis and repurposing as public amenity and or benefit. In this thesis each of these Dallas County sites are analyzed in a multi-scale geospatial site inventory, which in turn produced one site for public amenity repurposing.

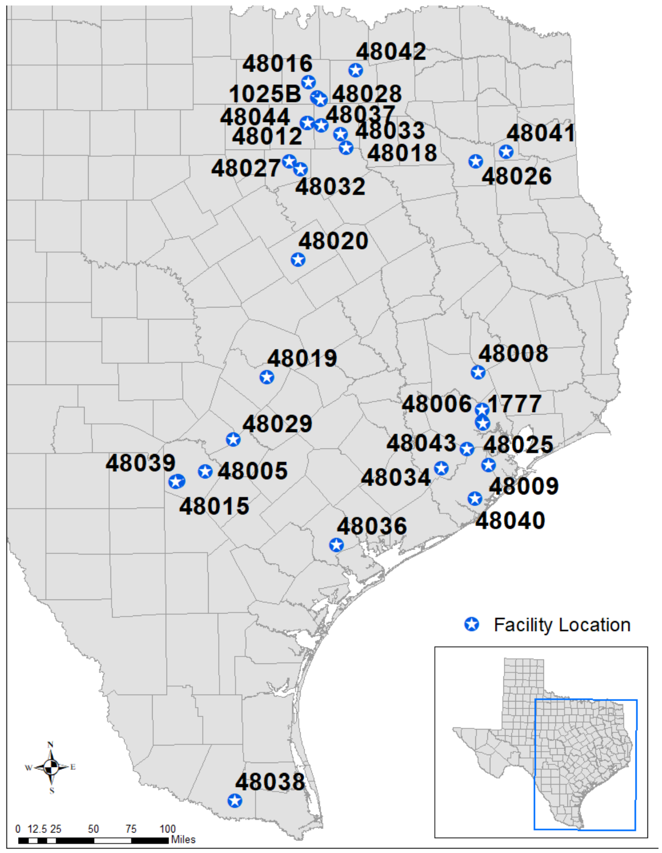


Figure 2.4 Locations of Facilities Recovering Landfill Gas (Municipal Solid Waste, 2019)

2.2 Subtitle D Landfill Case Studies

This section introduces each of the *Full* and *Project Abstract* level case studies reviewed in this thesis during Chapter 4 (Francis, 2001). The Findings and Analysis chapter show more depth and detail for each case study.

Twin Wells Landfill is a closed and repurposed landfill in Irving, Texas. The landfill was transformed in 1988 and now serves the public as the Irving Golf Club. The club is a city owned entity and amenity for the public through the Irving Parks and Recreation department. The landfill has little available research of its size and capacity, though its' proximity to the Trinity River is very obvious. The Golf course has had many issues with flooding, while this definitely involves the river adjacency it also alludes to the settlement and subsidence factor of landfills.

MoneyGram Soccer Park at Elmfork is located on a Type 1 landfill (accepted all types of municipal solid waste) in Dallas, Texas. The previous City of Walnut Hill/Dallas landfill accepted municipal solid waste for 28 years, from 1954 to 1982. As an active site, according to the North Central Texas Council of Government's GIS database of closed landfills, the landfill accepted on average 1,450 tons of waste per day. The Northeast Dallas site is 501 acres and largely repurposed as a soccer park today (Closed Landfill Inventory, 2019).

Freshkills Park, 2,200 acres, was originally a landfill on Staten Island, New York. It is now a model for reclamation and public green space. The closure of this landfill in 1996 was incredibly well received by the public because it had truly outlived its bounds of collecting municipal solid waste at 53 years of age. The master plan was then chosen in 2006 after a competition for the park. The construction is spaced out in phases and is ongoing (Freshkills Park, 2015).

Freshkills Park plan is being constructed in phases; landfills are complex landscapes most of the area is closed off unless already constructed. The perimeter took priority in the master plan because of its' proximity to the surrounding communities. Immediate access for the public was important because of the struggle they had gone through for 53 years (Landfill Engineering Archive, 2010).

Mount Trashmore Park, located in Virginia Beach, Virginia, is a repurposed sanitary landfill. "Sanitary landfills are sites where waste is isolated from the environment until it is safe" (What is a Sanitary Landfill?). The landfill accepted waste from most of the east coast and retired in 1971, though the transformation may have begun in the 1960's. By 1973 the 165-acre site was open to the public. The landfill was the first in the United States to be transformed into a public park. It held roughly 640,000 tons of waste (Mount Trashmore, 2020). According to Freshkills Park blog, “high costs of filling and limited capacity led to the landfill’s closure…” (Mount Trashmore, 2010). The sanitary landfill was converted into not just a public park, but mountains as a major labeled programmatic element.

Red Rock Canyon Open Space was home to multiple quarries and a landfill, but is now a public amenity in Colorado Springs, Colorado. The property was first rezoned for landfill use in 1970 for just 7.34 acres. The landfill grew after numerous rezoning actions and finally closed in 1986 at a total of 90.89 acres, though the closed landfill only encompasses about 61.69 acres of the zoned property (The Landfill, 2000). “The landfill site had become the most extensive remnant of human activity in the Red Rock Canyon area, dwarfing the stone quarries of a century ago,” stated by the Friends of Red Rock Canyon (The Landfill, 2000). The closure plan for the now filled canyon consisted of water quality and methane gas monitoring of four years total. The landfill was reportedly not compacted and only suitable to be repurposed as open space or recreation.

Austin Community Landfill is an active landfill opened in 1970 in Austin, Texas serving six cities within Travis County. The Type 1 landfill was acquired by Waste Management in 1980 and sits mostly on 360 acres of once deserted agricultural property. The facility acreage totals at 420 and serves as a private landfill for municipal waste produced by the county. According to the Municipal Solid Waste Year in Review, the Austin Community Landfill took in 982,600 tons in 2018, which leaves capacity for 6,225,764 tons equaling 7 years remaining (Municipal Solid Waste in Texas, 2019). Currently on the site are 128 wells collecting methane gas to provide energy for 4,000 - 6,000 homes a year (Austin Fact Sheet, 2017). The Austin Community Landfill was certified by the Wildlife Habitat Council in 2006.

Mesquite Creek Wildlife Habitat Area lies adjacent to the active Mesquite Creek Type 1 landfill. The Mesquite Creek Landfill accepted 444,039 tons of municipal solid waste in 2018, per the year in review, making the remaining capacity 9,118, 934 projected to close in 16 years (Municipal Solid Waste in Texas, 2019). This landfill is the only Type 1 landfill in Comal County. There is limited information on the size and current practices of the New Braunfels landfill site. The 275 acres of habitat area previously used for cattle grazing was acquisitioned by Waste Management and set aside for wildlife restoration.

Westside Closed Landfill and Active Transfer Station was opened in 1977 thirteen miles West of downtown Fort Worth, Texas. Waste Management purchased the Type 1 landfill in 1983 with a total acreage of 325. The site closed in 2007 with a full capacity of 17 million cubic yards of municipal waste. There is a presently active transfer station on the premises, which transferred 192,301 tons of waste in 2018 (Municipal Solid Waste in Texas, 2019). The landfill also a gas to energy site where 95 methane wells generate enough energy for 2,700 homes a year. The Wildlife Habitat Site stands on 290 of the 325 acres made up of closed landfill.

2.7 Contradictions and Issues

The Municipal Solid Waste Year in Review states, “If Texas had used the EPA definition of MSW for 2018, the average disposal rate would have been less, at approximately 4.88 pounds per person per day,” versus the 7.22 pounds per person stated earlier (Municipal Solid Waste in Texas, 2019). The numbers calculated for 7.22 pounds per person include “…construction or demolition waste and municipal wastewater treatment sludge,” providing a better figure of

Texas' residual MSW capacity. This raises the question of whether other states do the same, and why the EPA would not include these factors if it were a more accurate representation. More than ten years capacity for a state is considered adequate.

The general landfill size has steadily increased. For example, "In 1986, the statewide average landfill size was 50 acres with an average height of 13 feet. In 2018, the statewide average landfill size was 251 acres with an average height of 87 feet" (Municipal Solid Waste in Texas, 2019).

The compaction rate has slowly increased over time. For example, in year 2000 it was approximately 1,000 pounds per cubic yard and by 2018 it had grown to 1,095 pounds per cubic yard. Tying this together with the increasing acreage and height of MSW Landfills highlights the increasing consumption and production of waste in the state of Texas. It also highlights the amount of land used in this process, and begs the question: can landscapes be changed/repurposed in a positive and public manner?

Another raised question is that of the decomposition timeline. No estimation of time for the complete decomposition of a landfill has been found in this research. It seems feasible to assume an incredibly large number of years (based on the scientific experiments of artificially increased decomposition), though it has not been fully tested with site specific environmental factors. With this being said, would the surface placed on top of this changed geology survive the decreasing elevation? Would it become a sinkhole? What are the dangers? What are the benefits? Through research of Freshkills Park, it is feasible to state that the site could be settling for 30 plus years. It is also feasible to state that this uncertainty is the reason most landfill land is not sold once closed because of liability issues.

The sheer amount of land taken by these unnatural waste storage containers creates quite an enigma. Take Dallas County for example, where five active landfills occupy over 1,200 acres. Now, apply that figure to the 152 closed or abandoned landfills in the county, that is upwards of 45,000 acres of land. At the very least, some of the acreage from these sites is likely eligible for repurposing, even if that purpose is simply wildlife and habitat restoration with no access to the public it creates a positive impact on a damaged and or vacant area.

The EPA has a general set of guidelines that become more specific when discussing the capping process (engineered), the placement of Municipal Solid Waste Landfills (to protect ecology and environment), and everything in between, but where the Agency falls short is during the post-closure process, according to the Electronic Code of Federal Regulations criteria for municipal solid waste. The code does explicitly state regulations for maintaining the capping integrity and operating the gas and groundwater systems during post-closure, though when discussing the purpose/use of the landfill after close merely states to provide, "A description of planned uses of the land during the post-closure care period…" (eCFR, 2020, para. 8). This leaves quite a gap in possibilities or the opposite, nothing at all. It also raises the question of whether the purpose of the landfill determined prior to post closure could reduce cost, time, and damage to the site.

2.8 Summary

This literature review is a collection of secondary data on landfill policy history and data specific to the state of Texas scaled down to the smaller site within Dallas County. Landfills are complex engineered sensitive environments, which prove to be growing in size over time in the state of Texas (Municipal Solid Waste, 2019). Though they are highly managed and monitored, the duration of stability for these sites is unpredictable. The Post-Closure process for programming and planning is vague and, in most cases, undetermined. These landscapes are vast and eligible for analysis and repurposing. This collection helps determine a background history of Subtitle D landfills and therefore enables research progression.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The research in this master's design thesis stems from comprehensive data collection and analysis techniques, procedures, and methods, a collaboration not unlike landscape architecture as a whole. These approaches analyze data which determines findings, to then synthesize and compile suitable criteria for repurposing public landfill land in Dallas County, Texas.

3.2 Research Design

The multi-method approach is most appropriate for this study in order to gain a wide variety of data. The multi-method approach in this study utilizes both qualitative and quantitative research paradigms and methods (Deming & Swaffield, 2011). These methods include, though are not limited to archival/secondary data collection and analysis, case study reviews (Francis' Case Study Method) and geospatial analysis using GIS, analysis (Steiner, 2008; McHarg 1992), and interview analysis (Glaser & Strauss, 1980). Each of these methods is described in more detail below. As this tripartite multi-method approach progresses, triangulation (also described in more detail below) and synthesis of the analysis findings take place simultaneously (using triangulation, following a thread, and mixed method matrices), as portrayed in Figure 3.1. This produces design criteria and program implications.

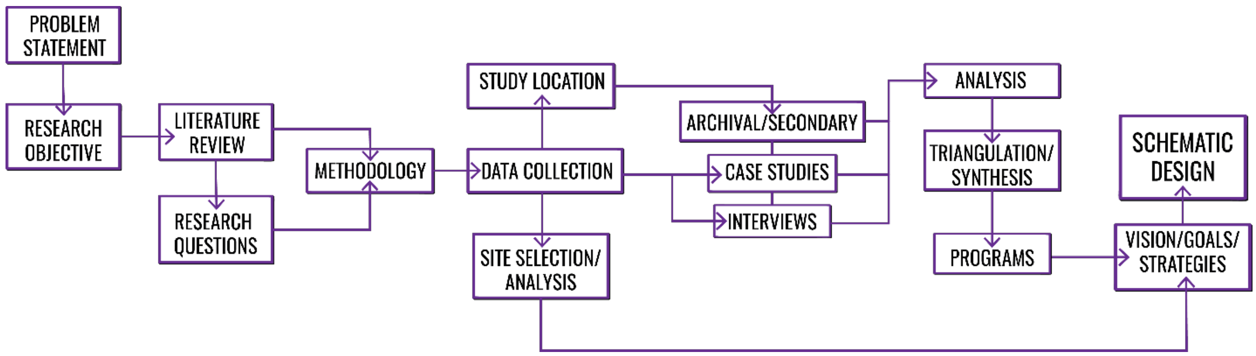


Figure 3.1 Research Design

3.3 Study Population and Location

It is critical to examine the physical region of North Central Texas and Dallas County to determine significant features for the suitability framework of a public amenity, though the data is not limited to just these bounds. The physical inventory includes landcover, land-use, geology, ecoregion, native flora, and fauna. The North Central Texas Council of Governments, the Dallas County demographics, and Census data of 2019 are utilized in this research to determine the social element or areas in need of public outdoor amenity (measured using McHarg's Overlay Method), therefore this information is crucial to determining the major categories within the site selection framework.

The study population is specifically set as citizens of or those living in Dallas County, Texas. The interview study conducted employs the perspectives and experience of landfill industry professionals in the North Central Texas region and Dallas County. This research focuses on public lands and their ability to be repurposed and serve as public amenity and benefit for the communities within the County of Dallas.

3.4 Data Collection Methods

3.4.1 Introduction

The research uses primary and secondary data collected directly by the researcher or information already made readily available, to assess the suitability of repurposing public Subtitle D category landfill sites for landscape interventions. Specifically, the study utilizes archival or secondary data (such as GIS maps and layers), case studies of existing landfill repurposing projects, and primary research interviews with sources such as key stakeholders/landfill subject matter experts.

3.4.2 Archival and Secondary Data Collection

The secondary or archival data collection includes data from online databases, journal articles, books or physical resources, and geospatial data.

This data is largely compiled and laid out within the Literature Review in Chapter 2 to gain insight into the landfill industry, function, and processes. The geospatial data is shown throughout Chapter 5 because of its' role in the geospatial inventory and analysis. This data was collected from federal, state, and county resources like organizations or city online open databases.

3.4.3 Primary Data Collection

The primary data within this research comes from the approved Institutional Review Board study and two levels of case studies (Francis, 2001).

The purpose of this Institutional Review Board (IRB) approved research is to gather primary data/information, in order to better understand the planning, policy, and day-to-day attributes within the Subtitle D landfill industry. The "Primary Research Study for Landfill Repurposing Design Thesis" consisted of a tripartite interview: profile questions, in-depth questions, and additional questions, shown below. The primary investigator recruited participants through convenience sampling and snowball effect, on a volunteer basis. The researcher has conducted six interviews with professionals, through a virtually recorded interview platform, who have a combined experience of 130+ years working in the landfill industry (multiple districts, companies, and positions).

Primary Research Study for Landfill Repurposing Design Thesis

Section 1- Profile Questions

1. What is your educational background?
2. What is your professional background?
3. How long have you worked within this industry?
4. What is your experience or knowledge about the landfill process? In the landfill industry what fields or functions have you been involved with? (Design, Planning, Policy, On-Site, etc.)

Section 2- In-depth Questions:

1. Do you believe that Subtitle D landfills can be repurposed for public use? In urban areas?
2. How can Subtitle D landfills be repurposed for public use in your view?
3. What would be the benefit of repurposing Subtitle D landfill land?
4. What would be the pros/cons of repurposing Subtitle D sites for public outdoor use?
5. What outdoor or recreational amenities do you feel Dallas County needs? Essentially is there a hole that needs filling and what are they?
6. What do you feel are the most/least successful repurposing programs for closed landfill land?
7. Do you feel, with the growth DFW is supposed to ascertain in years to come, there are enough public outdoor spaces in Dallas County?
8. Is there anything else you would like to add regarding my research?
9. Is there anyone you could recommend I speak with to further my research?
10. Are there any online or physical resources you feel would be helpful with my research?

Section 3- Additional Questions:

1. What are the environmental advantages of landfills?
2. What are the criteria for designating land as landfill?
3. When a landfill is nearing closure, what is the procedure?
4. What are the monitoring procedures for a post-closure landfill?
5. Is there a day-to-day or engineering practice you feel was pivotal for the landfill industry/field?
6. In Dallas County, do each of the 5 active Subtitle D Landfills operate similarly day-to-day?
    a. Are there day-to-day practices, in an active landfill, you feel are more effective for the health of the land post-closure?
7. What are the most common issues in day-to-day work at an active Subtitle D landfill?
    a. How are they usually resolved?
8. What outdoor spaces do you utilize in Dallas County? Why do you prefer these spaces?

The case study research is also classified as primary research through its' analysis. The primary investigator/researcher has compiled and analyzed three *Full* case studies (outside the site region) and five *Project Abstract* case studies (in the site region) to compare design categories and elements. A *Full* case study is an extended version, though not as thorough as an "In-Depth" case study (Francis, 2001). A *Project Abstract* is a condensed form of case study. (Francis, 2001). This informs the planning and design of future landfill land repurposing projects.

First, it systematically reviews the state of Texas' data to document the status of landfill typologies and site conditions including, identification of pre-landfill native landscape conditions. Then, the study reviews and examines a set of case studies to document best practices from existing landfill repurposing projects. Finally, interviews are conducted with landfill experts to gain a wider knowledge of landfill planning and processing, as well as repurposing strategies. Additional interviews may be conducted after site selection to evaluate the current landfill situation of the proposed site to gain perspective from those who work within the active landfill process (planning, engineers, workers, etc.).

3.5 Data Analysis Methods

3.5.1 Introduction

While data collected through secondary sources are analyzed using reporting techniques, descriptive statistics, and analytical maps (GIS), the case studies are analyzed through Francis' Case Study Method (Francis, 2001). Interview results are analyzed to draw critical themes by Grounded Theory (Glaser & Strauss, 1980). Data systematically collected through these methods are synthesized using data triangulation methods to inform the decision-making process of planning/design for closed landfill sites (Patton, 1990).

3.5.2 Secondary and Archival Data Analysis Methods

The data collected through secondary sources are analyzed using reporting techniques (triangulation, following a thread, mixed method matrices), descriptive statistics, and analytical maps following the graphic overlay method and geospatial data analysis techniques using GIS (McHarg, 1992; Steiner, 2008).

Using the geospatial data collected in a graphic overlay method, the data is analyzed looking through Ian McHarg's layer cake levels: Biotic, Abiotic, and human. Then the data is portrayed through a weighted overlay method. The weighted overlay technique stems from using the synthesized data to create overlays, while scoring each dataset in order to create a weight reducing the area to categories of suitability (McHarg, 1992; Steiner, 2008).

3.5.3 Case Study Analysis Methods

The case studies are analyzed through methods following Mark Francis' A Case Study Method for Landscape Architecture (Francis, 2001).

The primary investigator/researcher has compiled and analyzed three *Full* case studies (outside the site region) and five *Project Abstract* case studies (in the site region) to compare design categories and elements. This informs the planning and design of future landfill land repurposing projects. A *Full* case study is an extended version, though not as thorough as an "In-Depth" case study. A *Full* case study usually includes, but is not limited to, a range of information from background to program elements to generalizable features and lessons (Francis, 2001). These case studies provide an inventory of viable programs, as well as being analyzed for the extent that they were programmed by a designer: fully programmed and on site, not programmed and on site, not programmed and not on site.

A *Project Abstract* is a condensed form of case study. It is limited to a maximum of three pages containing majority project background and project significance (Francis, 2001). These case studies are analyzed as a group by program category, which simply states whether the site has a category of programs or it does not. This grouping of case studies has also produced a specific inventory of programs.

3.5.4 Interview Analysis Methods

Interview results are analyzed through Grounded Theory method, which is largely a qualitative method that closely draws from the empirical data, or "ground up," for confirmation of critical themes (Glaser & Strauss, 1980).

The interview data is collected and analyzed simultaneously (through reinterpretation of recordings), to which management of data analysis is necessary and results in an abstract theoretical framework to explain the overall process. Data systematically collected through these methods are synthesized using data triangulation methods to inform the decision-making process for site selection, programming, planning and design (Glaser & Strauss, 1980; Patton, 1990). The triangulation process of a mixed method study arises in the stage of interpretation when all sets of data have been collected and analyzed separately by method for each component to produce a set of findings. Attempts are then made to combine or synthesize these findings; this synthesis is the result of triangulation. A simple definition of the triangulation term is as follows, "A corroboration between two sets of findings or to describe a process of studying a problem using different methods to gain a more complete picture" (Research Methods & Reporting, 2011).

3.6 Planning and Design Process

The planning and design process begins in Chapter 4, with the case study analysis section of the methodology, which highlights successful features and programs that are possible for the selected site utilizing Francis' (2001) method for landscape architecture. This process also employs the precedence of site, user, and program to design, from Kevin Lynch and Gary Hack's Site Planning (1984).

The literature review, case study, interview, and geospatial analysis findings are used to develop design recommendations for the selected site as public outdoor amenity. The design was shaped through these findings and recommendations in both Chapters 4 and 5. The criteria stated in the weighted overlay site selection and the detailed suitability analyses inform the optimal program placement and ultimately the design recommendations. The programmatic elements highlighted through these methods are a significant feature of this base template for repurposing landfill land.

3.7 Site Selection Process

The site selection process initiates during the triangulation and synthesis portion of the methodology, by using the synthesized data to create overlays to assess the suitability of a site as a public amenity using the graphic overlay method (McHarg, 1992). The geospatial data collected for inventory is given purpose in Chapter 5 visibly showing the data through GIS weighted overlay at the regional or county level, in which a site is chosen through prioritization of higher weighted data categories/sets. This transitions to the detailed site inventory and analysis necessary once one of the five active sites in Dallas County are selected as most suitable for a public outdoor amenity.

3.8 Methodological Significance and Limitations

Possible limitations in the methodology exist through unequal factors of each method approach. The mixed-method approach also includes biases because of the tailored methodology based on the researcher's beliefs in the best suitable methods for clear and accurate findings (Deming & Swaffield, 2011). Convenience sampling may cause limitation or error when triangulating findings. The secondary data has inherent biases, especially the geospatial analysis. The geospatial analysis is created using the weighted overlay method, which includes a scored and rated criterion based off of the investigator/researcher's priorities (McHarg, 1992; Steiner, 2008). The geospatial analysis also relies on the GIS software and its' accuracy. Human error is always a potential factor. This multi-method approach provides great flexibility in collecting the data necessary for thorough planning and design.

3.9 Summary

This research uses the qualitative and quantitative methods, stated earlier, to study and assess active Subtitle D landfill sites for optimal use as public outdoor amenity. Chapter 3 discussed the research design, study population and location, data collection and analysis methods, methodological significance and error, and the planning and design process. This research benefited from secondary data, literature review, two levels of case studies, and geospatial inventory and analysis to document, triangulate, and synthesize design elements to inform the planning and design of an active Subtitle D landfill in Dallas County to implement at close. This research design is an example to create a base template for repurposing Subtitle D landfill land. Chapter 4 explores the analysis and findings of the research process outlined in this chapter.

CHAPTER 4

ANALYSIS AND FINDINGS

4.1 Introduction

This chapter presents analysis and findings from case studies, interviews, and geospatial data analysis of archival and secondary data with GIS. It also offers data from literature and other sources. The data reviewed is derived from secondary source documentation and primary sources/research, including: first account interviews with professionals, three *Full* case studies and five *Project Abstract* case studies. The findings are later synthesized and triangulated to produce optimal design criteria and program elements for the repurposing of a Subtitle D landfill for public outdoor amenity.

4.2 Interview Analysis and Findings

This portion of analysis and findings assesses interviews performed to analyze the experiences and perceptions of professionals in the landfill industry for repurposing Subtitle D landfills as public amenity. The purpose of this Institutional Review Board (IRB) approved research is to gather primary data/information, in order to better understand the planning, policy, and day-to-day attributes within the Subtitle D landfill industry.

4.2.1 Summary Findings by Question

The primary investigator compiled each answer from the study participants into Table 4.1. This creates a quicker coding process for the Grounded Theory Method (Glaser & Strauss, 1980). The findings are organized by interview question.

Questions:	Condensed Answers
What is your educational background?	• Agricultural Finance & Construction • Public Administration • Civil and Environmental Engineering

	• Environmental Policy and Management, Aeronautics, Military • High School Degree and Higher education/training courses • High School Degree
What is your Professional Background?	• Agricultural and Commercial Finance, Mid-level management in Post-Collection • Environmental Project Manager, Municipal Solid Waste • Senior Engineer • Transportation, Storage, and Disposal Scale House Environmental Group and ISI, Landfill Operations Manager • Entrepreneur, Director of Education for Bicycle Coalitions, Texas Trail Network, Planning Consultant, Special Projects at Planning and Landscape Architecture Division • Self-employment, Commercial Excavation, General Contractor, Senior District Manager, Class A Operator's License
How long have you worked within the landfill industry?	• 12 years • 35 years • 21 years • 21 years • 30+ years • 11 years
What is your experience or knowledge about the landfill process? In the landfill industry what fields or functions have you been involved with? (Design, Planning, Policy, On-Site, etc.)	• Day-to-day operations, short/long term planning, permit and policy compliance, construction management. Contractor supervision, financial performance management • Site selection, permitting, public engagement, design and construction, closure. • Planning, permitting, design, construction, design and construction of containment systems, leachate collection systems

	• Construction and design, cell construction, clay floors, liner systems, leachate collection systems, customer service and operations. • Planning and Design of repurposing/conversion • Cell Construction and design, liner system, gas system, daily operations, closure
Do you believe that Subtitle D landfills can be repurposed for public use? In urban areas?	• Possibly, not during the 30-year post-closure period. • Yes, as long as those uses are compatible with the closure requirements. • Yes, it is feasible for inactive, closed landfills to be repurposed for public uses. Including in urban areas • Yes. • Yes, absolutely. • Yes, after the 30-years maintenance/monitoring it can be for public use.
How can Subtitle D landfills be repurposed for public use in your view?	• Outdoor Activities: Walking, hiking trails, parks, not permanent buildings. • Public open spaces, parks, soccer fields, park type options. • Open spaces, passive recreation (walking, running, cycling, birdwatching). Any improvements that are permitted through the proper channels and compatible with landfill topography and infrastructure. • Wildlife habitats, parkways, walkways, jogging paths. Depends on location and geography. • Open space, natural ecology, indigenous species, trails, eco-tourism, paddling, restoration, buffer space, birdwatching • Wildlife habitat or restoration, hiking trails, gas collection, education, lakes/ponds.
What would the benefit of repurposing Subtitle D landfill land?	• Can serve as open spaces that provide an opportunity for a community to connect with nature in urban areas. Cover systems can be

	designed and managed to include a variety of vegetation for restoration and wildlife habitat. • More open spaces for the public. Creates a use for the land that would otherwise not be used. • Open spaces, connect with nature and wildlife habitat. • Giving it back and making use of it. • Bringing natural ecology or at least remediated habitat areas to the city. • The restoration aspect, energy production.
What would be the pros/cons of repurposing Subtitle D sites for public outdoor use?	• Pros: Provide a substitute for green areas lost to urban sprawl. Slopes and vegetation can prove beneficial. Ability to use land that would otherwise be dormant. Opens up other uses for green spaces in the city. Provide public park-like functionalities The system is running as intended when Congress passed the legislation, meant to be given back, used for permitted purpose and then given back. Can bring restoration of ecology back to cities. The antibody is open space, or the negative of occupancy. Giving it back to the communities. • Cons: Topography and LFG extraction wells could be a disadvantage to some outdoor activities. Safety, needs proper design for safety. Requirements for systems and infrastructure. Investment required for the land to be put in a situation where it can be used as public space. Needs to be compatible and safe with landfill infrastructure. Permitting and retrofitting of infrastructure may be cost prohibitive. States and cities are hesitant to release the land due to liability.

	Repurposing or converting is meticulous, supervision is necessary for each stage in order to hold on to the established or native good on the site. The capped portion will most likely need to be fenced off for the monitoring period. It is constantly moving; it is a living thing.
What outdoor or recreational amenities do you feel Dallas County needs?	• The population growth has created a need for more parks with areas for many outdoor activities. • Open space. Sports facilities and youth amenities, parks. • I am not familiar with the specific needs of Dallas County. • I do not have a comment on what the city should be doing with respect to open space. • Multi-modal access points and routes. There is always a need for native ecology and open space. • Hiking, walking or nature trails are always beneficial to the public
What do you feel are the most/least successful repurposing programs for closed landfill land?	• **Most:** those that require the least effort to facilitate safe public access and compatibility. • **Most**: Park, Festivals, open space, sports facilities, youth amenities, buffer zone **Least**: golf courses, A lot of Trees, Buildings • **Most** successful programs facilitate safety of the public, mostly passive recreation, and open space **Least:** those that ignore permitted regulatory agencies and monitoring system • **Most** would be trails, walking, baseball, soccer. Energy. **Least:** Structures, neighborhoods, institutional. • **Most** would be habitat restoration and passive recreation, maybe playing fields if there is enough space on the parcel outside of the capped portion. **Least** the more programmed the more disturbed the area becomes, which is quite possibly the opposite of full remediation for the land. • **Most** would be trails, restoration, energy. **Least** would be structures and anything that would bring a large amount of vehicular traffic (danger to wildlife).

Do you feel, with the growth DFW is supposed to ascertain in years to come, there are enough public outdoor spaces in Dallas County?	• The population growth has created a need for more parks with areas for many outdoor activities. • There is always room for more open space and outdoor amenities. • I am not familiar with the specific needs of Dallas County. • If the public determines it is necessary. Every piece of every step you step on is owned by somebody. If there is a need for open space it is going to at least need to be purchased. If the population rises, how am I going to create more open space? • There are never enough in the cities. • We need to be careful to hold on to or keep what we have, we could easily lose these areas. Currently I believe we have enough, but as we grow, we need to be careful not to shift the focus on just creating new spaces.
What are the environmental advantages of landfills?	• They are a critical piece of our waste management infrastructure and provide a safe location for long term disposal of solid wastes. Without landfills, solid waste would be discarded in an uncontrolled, environmentally irresponsible manner that would lead to pollution releases to our environment. • It is a place to put waste that is in an environmentally acceptable manner. Otherwise, you do not have any place to put it. Nobody likes them. But there is not much of an alternative right now unless you are willing to pay. Waste to energy facilities can eliminate probably 90% of the waste stream. The costs are about $25 a ton to put it in, to build it, and pay for it, to do that same thing, but a waste to energy facility, you are talking about $100 a ton. Recycling is unable to capture nearly enough waste to eliminate landfills. From waste generation trends, they are not decreasing in generation per capita. • A safe location for solid wastes. Without landfills, it would currently result in an environmentally irresponsible disposing manner • Yes, landfills are one of the most efficient way currently used to deal with the 4.7 pounds per day, per person in this country. These are highly engineered landfills where we have a high density, polyethylene liner system with leachate collection underneath that are kept title five, A more

	environmentally conscious way than the alternatives of our grandparents with when it comes to open pit burning, just filling up Creek beds with trash and never covering. I think that the landfill system that is currently in use in the United States is actually a very environmentally conscious system • The groundwater and subsurface environment protection. They address visual blight and control odor. Production of energy. • We can look through history and it keeps people from putting waste everywhere, which unfortunately includes fields and rivers and streams. The advantages come with safety regulations, the liner systems that we use, everything that we put inside, the landfill leachate we capture and the water that is created is processed. The gas is processed. So, it is a place to deal with all of these things that should otherwise be a hazard and history teaches us this, without there is illness, sickness, disease comes from not managing your waste properly.
What are the criteria for designating land as landfill?	• Landfills should be located a safe distance away from environmentally sensitive areas like floodplains and karst aquifers. Landfills should be located in areas compatible with surrounding land uses. To be cost-effective, landfills typically need to be located relatively close to where people are generating waste such as cities and towns. • Many requirements, distancing from threatened ecosystems, distancing from communities, though close enough for transfers. • That has changed to the generations before, the NIMBY mentality, not in my backyard. They pushed them to the outskirts of the suburbs at the time in the middle of nowhere. But as sprawl catches up to you, that early site was great and now it is not. Planning can go a long way. How forward thinking do you want to be? Predict where the population's going to be in 50 years. Good luck. You might be right. But if you are wrong, you are very expensively wrong. • A very long process that I have not been involved in that part of it. The licensing process and our permitting process that you go through with the state and it is quite extensive. They look at

	surrounding the water, the community, how deep is the water table, are you in a floodplain. There is a lot of criteria that they go through before you are granted a permit.
When a landfill is nearing closure, what is the procedure?	• An engineered final cover system and other infrastructure is constructed to provide long term containment of waste, stormwater management, gas management, leachate management, etc.. • Long term containment cover system, stormwater management, gas management, leachate management, etc..
What are the monitoring procedures for a post-closure landfill?	• Periodic checking of groundwater monitoring wells, inspection of the final cover system, and other landfill infrastructure. • Monitor gas. Each year for 30 years after they have closed that site, they have to maintain their leachate collection system, which means pumping out leachate and making sure that that is properly treated over that same 30-year period. Site properly drains, minimal erosion, no water or the cap of landfill does not infiltrate into the landfill and any stormwater that comes off is clean. • Monitoring groundwater, the final cover system, and other landfill infrastructure. • The requirements are similar, but the frequency changes. Still monitoring groundwater, gas, title five permits. The main changes are the frequency and surface settlement, which equals more vegetation work. You are not doing cover anymore unless you see some settlement you may want to adjust. • Continued as it was open. Probes all the way around the outside of the landfill. The groundwater is monitored, the water monitored, and the air and gas is monitored for 30 years.
Is there a day-to-day or engineering practice you feel was pivotal for the landfill industry/field?	• RCRA Subtitle D containment system design and construction requirements were pivotal for achieving the high level of environmental protection we see today. • The biggest change came when they did Subtitle D rules. • RCRA Subtitle D • Subtitle D, title 5 • The gas to energy technology and planning.

In Dallas County, do each of the 5 active Subtitle D Landfills operate similarly day-to-day? Are there day-to-day practices, in an active landfill, you feel are more effective for the health of the land post-closure?	• Properly managing liquids, gas, and solid waste compaction on a day-to-day basis will lead to a landfill that is easier to manage in the long run. For example, placement of daily cover will result in less leachate generation, and greater compaction of waste will result in less differential settlement. • Leachate, gas, compaction on a day-to-day basis, placement of daily cover • They are all Subtitle D, yes, a fairly similar day-to-day. Probably plus or minus a few areas like composting, recycling, customer service, etc.
What are the most common issues in day-to-day work at an active Subtitle D landfill? a. How are they usually resolved?	• Most common daily challenges on a typical landfill are: Containment of windblown waste - Resolution: Place stationary and/or portable fences downwind of the active area Maintain stormwater controls - Resolutions: Pre-planning waste placement and fill sequence/apply diversion berms/use adequate cover soil Minimize airspace usage - Resolutions: Use properly sized compaction equipment/ utilize sufficient level of trained heave equipment operators/reclaim portion of previous days cover soil when possible/ prevent excessive usage of cover soil • This question is more applicable for a landfill operator • The most common issues are that of stormwater and cover, and system monitoring for most landfills, or open to residents. This creates more of a climate of customer service and with that complaints or customer driven issues. • Public nuisances like birds and odors. Trying to blend the industry with the neighbors and keeping them happy.
What outdoor spaces do you utilize in Dallas County? Why do you prefer these spaces?	• Outdoors on bike paths along greenbelts and in parks. I prefer to ride my bike and exercise on paths away from cars/roads because I feel safer, plus I enjoy being in natural areas. • Golf courses, the Trinity River, sometimes hiking, primarily hiking or golf, but if I had kids still, we would be at a soccer field, softball fields. Trail Systems, Nature Preserves. • Biking, greenbelts, parks. Natural Areas. • Army Corps retention ponds that have parks and walkways

	• Hiking, Biking, walking trails. • Fishing mostly, the downtown area, walking.
Is there anything else you would like to add regarding my research?	• No • Potential on the pre-subtitle D landfills, and not as much on the subtitle D landfills, because they are going to be an operation as long as they possibly can. The Western part of the North central Texas region is running out of capacity, a couple of them will be closing like the one in Weatherford in the next year or two and Fort Worth has about 16 years. Disaster Sites. Disaster Debris Plans, satellites areas for the debris to be taken to a landfill. McCommas will probably expand from its current design, possible additional capacity. Citizen convenience station. Transfer Stations. • No • There's acreage at play that does not have any current function, for most landfills. • McCommas Bluff is a very historic area. There is a trail planned for that area. Paddling trails and having access to that area. National paddling trail designated by the national park service late last year for the city. Dallas has been the toughest to get on board with the accommodating the paddlers, there is the old lock house down there. It was quite a bluff overlook and they sculpted it down, made it a three to one or four to one slope. The beauty of a trail is that it can be a linear construct along the edges of the periphery of contaminated areas that do not need much space to have the experience from being alongside or even slightly within the area. Landfills mitigated could become good buffer space for area separation between highway noises and the space that might be otherwise used by people on bikes or on foot exploring nature. • We are licensed through the state, anyone that operates a landfill has a license. Each landfill site has a different set of issues or different set of problems and a different community. You do not want to be in a floodplain. What happens is a lot of your landfills are close to rivers where in the past, they made gravel. Many are old sand pits and gravel pits or quarries. They mine or grab it in the beginning and years ago when they were done with it, people start putting trash in. Skyline in Ferris for instance, was an old brick yard where they dug

	clay and took the clay to make the brick. From the beginning the landfills were following industry, finding another use for the land.
Are there any online or physical resources you feel would be helpful with my research?	• Websites for EPA, TCEQ, SWANA • The closed landfill inventory. • Websites for EPA, TCEQ, SWANA • Waste Dive, SWANA • the Dallas County trail plan, Veloweb • TCEQ

Table 4.1 Research Interview Findings

4.2.2 Interview Analysis-Coding

After closer examination of the data, the primary investigator has found that the study resulted in many insights for the planning and design of post-closure Subtitle D landfill land. The most frequently recommended programs for the land are that of passive recreation and restoration of the natural area. As Dallas County grows in population, a majority of the respondents suggest a need of public open space. The most frequent concerns are that of post-closure policy for safety regulations and timeline. The pivotal moment or practice for the landfill industry is the Subtitle D regulations. Following these requirements, it is a general consensus among subjects that Subtitle D landfills are an environmental advantage by providing a safer, more environmentally and fiscally responsible location for disposal of solid waste.

Some interesting possibilities are transfer stations, to provide a substitute for green areas lost to urban sprawl, citizen convenience station, buffer space, disaster processing site, and to open up other uses for green spaces in the city. Other insights noted: landfill locations have historically followed other industry like quarries or sand pits, which is usually the reason for sitting in a floodplain; the more disturbance or overly programmed areas on the remediated site may prove unsuccessful; landfill sites have excess functionless acreage outside of the cell area;

McCommas Bluff Landfill most likely has plans to expand its permitted bounds; most currently active landfills that are within urban areas were caught by sprawl; the antibody is open space, or the negative of occupancy.

4.2.3 A Grounded Theory for Repurposing Landfills

Through systematically analyzing the interview transcripts through grounded theory methods, the research produced a grounded theory for repurposing landfills (Glaser & Strauss, 1980). Based on the data the primary investigator concluded that repurposing landfill land should prioritize four simplified parts: where, when, why, and what.

Where is the site? Location and environment determine whether it can and should be repurposed for public use. When will the site close and when can the planning begin? A timeline provides feasible control over repurposing options and can be the most important component to ensure the success of the repurposed space. Why does this process need a timeline and why should this land be repurposed? The policy and regulations set by Subtitle D and the EPA create monitoring procedures for post-closure landfills at 30 years minimum. This ensures the health, safety, and welfare of the public. This public land should be repurposed because it was permitted for industry by legislation with cyclical intent. What should the repurposed land include? The programs that the public space includes depends on the previous three parts and their thoroughness and success. The interview research conducted has produced a list of programs, shown below in Table 4.2.

Programs Recommended	**Programs Not Recommended:**
Walking/running paths	Structures
Hiking trails	Buildings
Biking trails/paths	Golf Courses

Open space	Too Many Trees
Park	Neighborhoods
Soccer fields	Institutional
Baseball/Softball Fields	Too Many Programs = Too disturbed
Birdwatching	Vehicular Traffic
Wildlife habitat	Programs that are extensively maintained
Parkways	
Eco-tourism	
Paddling/Water activities	
Restoration	
Buffer Space	
Gas Collection/Energy production	
Education	
Lakes/Ponds-Fishing	
Disaster Processing site	
Transfer Station	
Youth amenities	
Multi-Modal Access	
Citizen Convenience Station	

Table 4.2 Programs Derived from Interview Research

4.2.4 Qualitative Interview Findings

The interview study consisted of landfill industry professionals who currently or have worked within the industry. The participants individual experiences within the industry range from on-site excavation, management, engineering of landfill cells, site planning, and post-closure repurposing. The 6 participants work individually, 1 from municipal management, 3 from private management, and 2 from private outside firms. Each participant gave a great effort in answering and elaborating on the questionnaire, as well as extending their time for the interview study. The volunteers showed genuine interest in the field they reside and the principal investigator's education of the landfill industry today (2021). Every individual felt strongly in the belief of repurposing landfill land post-closure and the possibilities for public outdoor open space. One participant explained this comparatively, "The antibody is open space, or the negative of occupancy." A main element each volunteer mentioned purposely, and numerous times was safety and regulations. The participants wanted to make sure on record to state that landfills have regulations and safety requirements during closure and post-closure process. One interviewee stated, "Landfills are living things, and we need to pay close attention to their integrity and timeline." The interviewees were very interested in the primary investigators ideas for repurposing the land and the research design. The municipal management and private outside firm participants were less forthcoming for specific questions than that of the private management participants. An assumption is made that this closed off nature is due to employer or client privacy/privileges.

4.3 Case Study Analysis and Findings

The next section reviews case studies done to analyze program elements of landfills repurposed for public outdoor amenity (Francis, 2001). The purpose of these studies is to depict the design, gather data, obtain insight from constructed projects, and focus on suitable design elements under the categories of passive and active recreation to develop a potential program for a Subtitle D planning and design for a Dallas County site. The primary investigator/researcher has compiled and analyzed three *Full* case studies (outside the site region) and five *Project Abstract* case studies (in the site region) to compare design categories and elements. This data is analyzed using the "Case Study Method for Landscape Architecture" (Francis, 2001). This informs the planning and design of future landfill land repurposing projects.

4.3.1 *Full* Case Studies

A *Full* case study is an extended version, though not as thorough as an "In-Depth" case study. A *Full* case study usually includes, but is not limited to, a range of information from background to program elements to generalizable features and lessons (Francis, 2001). These case studies provide an inventory of viable programs, as well as being analyzed for the extent that they were programmed by a designer: fully programmed and on site, not programmed and on site, not programmed and not on site.

4.3.1.1 Freshkills Park

Project Name: Freshkills Park

Location: Staten Island, New York

Date Designed/Planned: 2006 through master plan competition.

Construction Completed: Most phases are complete by 2020 though some projected to finish 2036.

Construction Cost: Upwards of $1 billion

Size: 2,200 Acres

Landscape Architect(s): James Corner Field Operations in collaboration with:

Hamilton, Rabinovitz & Alschuler, AKRF, Inc., Applied Ecological Services, Arup, GeoSyntec Skidmore, Owings & Merrill, Stan Allen Architect, L'Observatoire International, Tomato, Richard Lynch, Curry & Kerlinger, Mierle Laderman Ukeles

Client/Developer: New York City: New York City Department of City Planning, Amanda M. Burden, Director, New York City Department of Parks & Recreation, New York City Department of Sanitation, New York City Department of Cultural Affairs, New York City Department of Transportation, Office of the Staten Island Borough President

New York State Department of State, New York State Department of Environmental Conservation, New York State Department of Transportation, Municipal Art Society

Managed By: New York City Department of Sanitation & Parks and Recreation

Context

Initial Zoning: November 1951 proposal for development at Fresh Kills issued by Parks Commissioner Robert Moses. The City of New York began filling in Fresh Kills in 1948, initially with the idea of depositing "clean fill" there for three years to make the land developable. This plan proposed a multiple use of the area: 100 acres of parks, arterials, and public works, 100 acres of private residential development and industrial zone along the west shore. Some aspects of the plan were eventually adopted, like the construction of the West Shore Expressway (Moses was the force behind construction of most of the city's expressways), but most were not.

U.S. Census 2019 data for Richmond County (Staten Island):

Median Household Income: $82,783, Persons/Household: 2.82, Persons in Poverty: 9.1%, Households: 166,246, White: 74.5%, Hispanic: 18.6%, African American: 11.6%, Asian: 10.9%, Female: 51%, Male: 49%

Zoning in the area today is much like the 1951 proposal in the three main groups of parks, industry, and residential. Though it is noticeable here, Freshkills Park being mostly park and industry bound by residential zones on 3 sides and Arthur Kill on the other closest to New Jersey. On this same graphic a blue line to the east side of Staten island is the only subway route running through and back to NYC.

These transportation plans are taken from the Draft Master Plan of 2006 and are still remarkably similar to construction and plans today. These plans are very thorough, including vehicular, vehicle parking areas, non-vehicular pathways for biking hiking walking and water transport. It is important to note that the plan here is to open each side of the park to non-vehicular transport with multiple entrances/exits.

<u>Project Background and History</u>

Brief: Freshkills Park, 2,200 acres, was originally a landfill on Staten Island, New York. It is now a model for reclamation and public amenity. “Fresh Kills” is a Dutch term meaning riverbed or water-channel. The native and natural area, prior to landfill opening in 1948, was predominantly tidal creeks, coastal marsh, streams, and freshwater estuary. The landfill was marked to live only 3 years. Unfortunately approved for 15 more years, as well as ran across many setbacks like, natural disasters and the closure of municipal solid waste facilities serving the same or adjacent communities. The closure mandate of this landfill in 1996, post lawsuit of Clean Air Act violations, was incredibly well received by the public because it had truly outlived its bounds of collecting municipal solid waste at 53 years of age (Freshkills Park, 2011).

Staten Island Borough is considered Richmond County, which as of 2019 has a population of 476, 143 with 9.1 persons in poverty %. The site location is centered between 3 communities, 2 parks, and 1 wildlife refuge; with the Arthur Kill separating the site from New Jersey on the west side. The construction is spaced out in phases and is ongoing.

Major Landfill Dates and Setbacks: In 1955, Fresh Kills became the largest landfill in the world serving as the primary landfill for Household waste in NYC. The landfill took a hit when the Bronx Landfill closed in 1971 and made Fresh Kills take on half of NYC. After the consent to close order in 1990, the site met its’ peak operating days at 29,000 tons a day with 680 employees, when a landfill closed in Queens. Making Fresh Kills the only active Type 1 landfill for Household waste in NYC. Before closure, the landfill had already begun capping areas, specifically the South Mound and the North Mound. At the end of 2001, the site accepted its' last barge of waste and began a master plan competition for the site. During this year, the awful event of September 11th occurred and pushed the timeline for the landfill back with temporary acceptance of the World Trade Center wreckage (Freshkills Park Timeline, 2019).

Genesis of Project

At the end of 2001, the international Design competition continued and revealed 3 finalists out of the 6 chosen to compete:

First Place: Field Operations – Philadelphia, PA and New York, NY

Second Place: JMP Landscape and John McAslan + Partners – London, England, UK

Third Place: RIOS Associates, Inc. – Los Angeles, CA

In 2003, Field Operations officially chosen as planning and design consultant for Freshkills Park. A draft of the master plan was announced to begin the process.

In order for this project to become actual it involves quite a bit of engineering. The Landfill has different layers of soil, geotextiles, and a geomembrane. These layers stabilize the landfill, part the waste from the above environment and its' visitors, while preventing the leakage of landfill gas, though this landfill, like many others, captures the natural gas in order to create energy. Along with the landfill cap, a collection of stormwater management practices like swales, down chutes, and retention ponds receive and manage stormwater to prevent the meeting of the cap and rainwater. An engineered cap is required per New York City law.

Design Development Process

Freshkills is a public park and entity. The initial allotment for Phase 1 was $100 million from the city, in addition to this the Department of Sanitation added $260 Million during the same period of time for landfill closure and $150 Million for post-closure monitoring and maintenance. By the full completion of Freshkills Park its' current cost estimate is upwards of $1 billion.

Field Operations stated, "It is reasonable to assume that the annual operating cost to maintain Fresh Kills Park at full build-out would range between $15,000 and $30,000 per acre, 2." As you can see a majority of this cost goes into the earlier landfill stages and the restoration or habitat diversity in order to ensure growth and a functional base for the public amenity.
The research for habitat diversity and ecology was a main focus for this site's reclamation and connection of the fractured ecosystem.

2012 Schmul Park, the first complete park project, opened in the Travis Neighborhood. The project included renovating the playground, new handball and basketball courts, creating a tree-lined entrance to North Park, and building a comfort station with water and energy saving measures.

Main Creek Wetland Restoration pilot project completed, which stabilized the shoreline, created new salt marsh habitat, and removed invasive species. With the help of goat grazing and community members.

In 2013, Owl Hollow fields opened with 4 soccer fields and landscaping in a 20-acre area closest to Arden Heights community. Includes a parking lot and a walking loop.

Construction on the 3.2-mile New Springville Greenway was completed in the summer of 2015. This path along the eastern edge of Freshkills Park creates north/south bike access parallel with Richmond Avenue. This development included stormwater management techniques, drainage systems and sidewalk creation and repair.

North Park Phase 1 is designed as a 21-acre swath of land connecting visitors to spectacular views of Main Creek and the adjacent William T. Davis Wildlife Refuge. With 7 acres of seed plots, expected to be open to the public this year.

Owl Hollow Park House currently is designed to be a LEED certified building next to the soccer fields with facilities and seating areas as well as storage for maintenance. It is currently in Design.

Apart of the Anchor Parks initiative, $30 million was given to South park by the City. The plans include two multi-purpose fields and trails, vehicular and pedestrian access, connections to the Owl Hollow Soccer Fields, adult fitness equipment, parking and a comfort station and plaza.

The 482-acre East Park along Staten Island's major commercial corridor is bordered by the New Springville Greenway. This Park design has trails, wetland overlooks, and educational programming about wetlands.

A public transportation system, once actualized, provides access to the different areas of the park, and create a connection to open the park, provide site access, and address transportation needs of the community. This infrastructure incorporates landfill needs as well as stormwater management.

<u>Role of Landscape Architect</u>

The role of a Landscape Architect in Freshkills Park is many. James Corner Field Operations took on the role of primary consultant and head of the landfill to public amenity project. The Landscape Architecture firm organized, led community engagement, planned, and designed. The firm collaborated with the Sanitation Department and other municipal departments to tackle the landfill and stigma remediation, which took an intense amount of education and communication.

Program Elements

The site has both passive and active recreational areas, as well as restoration sections closed to the public/foot traffic. The park includes hiking trails, biking trails, paved walking paths, playgrounds, kayaking, birdwatching, public art, ball fields, creeks, wetlands, education, parking, multi-modal connections, and landfill monitoring.

Maintenance and Management

Maintenance and management is provided by the Sanitation Department and the Parks and Recreation Department of New York City. Field Operations stated, "It is reasonable to assume that the annual operating cost to maintain Fresh Kills Park at full build-out would range between $15,000 and $30,000 per acre."

Criticism

One point of criticism is lack of writing specific to the existing public railway on Staten Island, and the access to and from this major piece of infrastructure.

Significance and Uniqueness

The obvious value Freshkills Park brings is more public outdoor amenities.
One overarching theme is the necessity for community engagement because of this site's history, though using community engagement throughout the process has become a massive strength for to change the perception of this area and ultimately ensure success and ownership.

The graphics produced for Freshkills park are very well done. The style and readability, but also reasoning behind the renderings or diagrams is very clear.

The planning and phasing of this project was and is crucial because of its sensitive nature. It needs to be re-addressed after each project or phase to ensure stability, though a few setbacks with funds, plant growth and Covid19 the project is moving forward.

New York City has been very generous in funds for this project, partly for obvious reconciliations, as the project has become a model across the world and a major asset in function as climate change continues, and in public amenity as everyone notes the outdoors as essential. Circulation is a more significant underlying feature. In non-vehicular access alone, it is planned to connect all sides of Staten Island in a safe manor. The vehicular access is being updated with pedestrians and planting in mind as well.

Monitoring and maintenance are another huge value for this area because of the landfill. These systems are a massive value because of their attention to detail in resource quality this brings the landfill into half strength half weakness.

The site capped off, monitored, and restored offers the development on Staten Island and New Jersey a perfect buffer zone for natural disasters paired with climate change. Superstorm Sandy is an example of this.

Education is within each of the values already said. Through Circulation more people are able to access this project and what it has to offer, including educational facilities aside from general learning. The ability to learn about the monitoring systems and energy systems to the issues landfills also bring. Education on ecology, water systems, and management overall.

Limitations

Though it is the reason for publicity and the entire project, the landfill areas (45%) are a huge weakness in maintenance, possible liability, and undetermined future issues.

The timeline for this project is very well thought out and researched, but as time moves forward the public begin to lose enthusiasm. This is a common issue in municipal projects, and Freshkills park is putting a great effort to offer events and publicize.

Generalizable Features and Lessons

The water and stormwater management had to be creatively placed and understood in order to protect the landfill cap and its monitoring systems. Use of Swales and stormwater basins throughout the park as larger elements in collaboration with the wetland and shoreline restorations.

The restoration and Habitat diversity is incredibly well researched and planned. Specific usage of nearby organizations and schools to help with the process is and was a necessary act to ensure ownership of local communities. The phasing of the overall research into plant and habitat diversity and growth is the densest piece of this project. Field Operations and their collaborators saw the necessity of a healthy base landscape in order to truly reclaim this landscape and its function.

Future Issues/Plans

Cost and eventual revenue. Freshkills Park has captured the eye of the whole world and with that perception it needs to complete and roll out a full maintenance plan for areas that need higher care. These financial aspects are becoming more of an issue now that some of the built areas are not seeing a large return in funds. This could change in years to come with the ability to host fundraising events in full capacity. The gas capture to energy method does bring in quite a bit of revenue, but will it be enough? Will the solar addition to the park bring in additional funds to supplement the need?

Through decomposition there is settlement or subsidence in the land, “because of this landfill settlement, the height of the mounds decreases by 10 to 15 percent over time. Approximately half of this settlement is supposed to occur in the first five to ten years after the final waste is placed, with further settlement continuing at a decreasing rate for at least another 20 years” (Landfill Engineering Archive, 2017). It is anticipated that a minimum of thirty years before gas production and settlement associated with decomposition cease and leachate fully drains from the site. As these processes occur, there is a continuing need for regular maintenance, monitoring and evaluation of the site and systems that have been put into place primarily the final cover, landfill gas (LFG) and leachate systems, and the extensive network of monitoring wells. It is essential that access to these systems be preserved during this time for inspection, maintenance, and repair.

Recommendations and Implications

Field Operations has done an incredible job with this massive project. Recommendations are more set towards finished products, community engagement/events, and maintenance plans. The finished products are currently being publicized and opened with the help of the community or with events to do so. The lack of continuation of this type of celebration years later could become an issue. Once the entire project is finished, detailed phasing plans for each program by the client and developer should be created. This guarantees the success of the programs and reduce the possibility of being forgotten.

Events and celebrations are a fine way to involve the community. Field Operations and New York City have developed many programs to ensure ownership of the surrounding area, but these need to continue even after the final construction. The other necessity, in terms of engagement for Landscape Architecture’s sake, is the as-built engagement to understand how the final products work or not in day-to-day life. This brings the long-standing landfill stigma full-circle and metaphorically remediate it.

Maintenance Plans are crucial to the success and function of Freshkills in its' entirety. The positive about the history of this project is the landfill aspect. It meshes and doubles the maintenance factor in terms of organizations/departments, but it also doubles the stress and money for maintenance. It is a long-term investment for the city. Included in this plan should be natural disaster relief and strategy. Freshkills has already seen some of its' ability to act as a buffer, and this proves its' natural need to function. In preparation for these everchanging and more frequent natural disasters the operation of its' natural programs has to be high and without question.

Future Research Issues

Future Land-Use could be an issue for research in the future because of its changing demographics. This would become a huge limitation for finding the park's success over time. The proximity for use could change drastically.

Public documentation has so far been priority for this project because of its 'origin, but this could change as enthusiasm lowers and time moves forward. Available documentation of subsidence and settling of the landfill portion and overall natural disaster effects would be necessary in terms of this projects status as a reclamation model across the world.

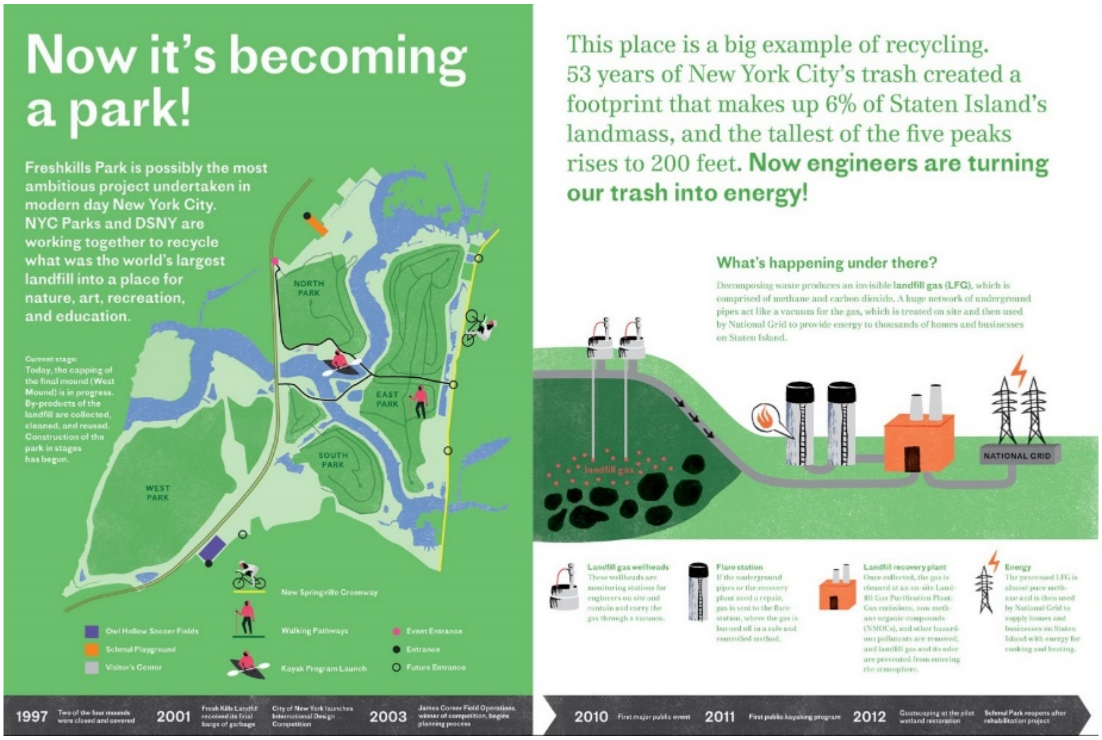


Figure 4.1 Freshkills Park Timeline and Programs, (Landfill Engineering Archive, 2017)

Program Category	Extent Programmed ● ● ○
Passive Recreation	●
Active Recreation	●
Restoration	●
Access	●
Community	●
Education	●

Table 4.3 Freshkills Park Categories of Program Extent

Program Inventory
Trails
Paved Paths
Playgrounds
Sports-Recreation
Kayaking
Birdwatching
Public Art
Multi-Modal Connections
Open Space
Parking
Landfill Monitoring

Table 4.4 Freshkills Park Program Inventory

4.3.1.2 Mount Trashmore Park

Project Name: Mount Trashmore Park

Location: 310 Edwin Drive Virginia Beach, VA 23462

Date Designed/Planned: Possibly 1960's, Plans continuing 1966, Closure in 1971.

Construction Completed: Initial Phase – 1973/ Full Completion – 2015, Ongoing additions

Construction Cost: $1.1 Million without additions

Size: 165 Acres

Landscape Architect(s): Virginia Beach – Roland E. Dorer, Department of Health, Insect and Vector Control, created the initial idea/plan. Carried out by city employees (Landscape Architects, Engineers, Sanitation, etc.)

Client/Developer: Municipality: The City of Virginia Beach

Managed By: Virginia Beach Sanitation and Parks and Recreation Departments

Context

Virginia Beach is one of the seven cities that make up an area known as America's First Region, settled by the British in 1607 making it a very historic area. There is a shallow 6-8-foot-deep water table that is found in coastal Virginia. Located eight miles west of downtown Virginia Beach.

Project Background and History

Prior to 1966, the landfill utilized a semi-open trench and cover operation which was costing the city $75,000 annually and was expected to have a short life span because of the shallow water table. The landfill accepted waste from most of the east coast and retired in 1971, though the transformation may have begun in the 1960's. By 1973 the 165-acre site was open to the public. The landfill was the first in the United States to be transformed into a public park. It held roughly 640,000 tons of waste (Mount Trashmore, 2020). According to Freshkills Park blog, “high costs of filling and limited capacity led to the landfill’s closure…” (Mount Trashmore, 2010). The landfill, which once served the entire Virginia Beach municipality, was capped in 1971 and converted in 1972 (City of Virginia Beach Memo, 2015).

Genesis of Project

By 1966, officials in Virginia Beach, Virginia, were moving ahead with plans to convert the existing dumpsite into a viable recreational area. Roland E. Dorer, Director of the State Department of Health, Insect and Vector Control, initiated the plan to have the once open trench converted into a mountain of trash. The plan was to purchase the area surrounding the landfill to allow for a recreational facility. The plan, which included a 5,000-seat amphitheater, freshwater lake, jogging and walking path, and parking, was approved by the Department of Health, Education and Welfare for an initial grant of $192, 674. into a successful recreational park, Mount Trashmore Park.

Design Development Process

There is little known public information about the Design Development Process other than what is stated above regarding initial ideas and potential and past financial statements. The plan included an amphitheater, a lake, and a walking and jogging track, at an estimated cost of $192,674. Work on the project started in 1966. Problems were encountered with odors, and with gas due to the creation of landfill gas during decomposition. Seven seepage points were dug into the landfill to allow the gas to escape. There has been one fire at the site due to gas, in 1972. The odor problem was resolved by taking the waste on conveyor belts from the pit to the mound during rain. Adding soil and water to the landfill eliminated odor.

No more trash was dumped at the site after 1971. The “mountain” was compacted, and soil was laid on top. The park opened in 1973.

Role of Landscape Architect

In this case, the Landscape Architect became vital during and after the initial Design Development phase. There is little known about the Landscape Architect's role in the progress of Mount Trashmore Park, though it is known they were employees of the city and collaborated with the Sanitation, Engineering, Planning, and Parks and Recreation departments. It is assumed in this instance; the Landscape Architects were influential in the design details and programming of the park.

Program Elements

Mount Trashmore Park consists of both passive and active recreational areas, shown in the map in Figure 4.2. Specific programming includes man-made mountains, lakes, playgrounds, skate park, multi-use pathways, fishing, picnic areas, concessions and restrooms, ball courts, and outdoor fitness stations. The largest mountain on the park also spans eight hundred feet. There is also a smaller mountain named Encore Hill. The park also hosts two lakes, a brackish (Lake Windsor) and a freshwater (Lake Trashmore). The freshwater lake is stocked, and fishing is permitted, though swimming and water sports are not. Many picnic and pavilion areas scatter throughout along trails, as well as a playground (renovated 2010) and a 24,000 square foot skatepark, Figure 4.2 displays the layout of these programs. There is underground infrastructure for collecting gas, though it releases it at safe intervals instead of converting into energy like many more recently transformed landfill sites. Mount Trashmore park is highly successful with 67% usage from the surrounding community annually equaling about one million visitors annually (Mount Trashmore, 2020).

Maintenance and Management

The City of Virginia Beach Parks and Recreation Department maintains the site.

Criticism

There seems to be no community engagement in this process.

Significance and Uniqueness

It has the distinction of being the world's first park built on a landfill. The mountain of trash is the highest spot in the city.

Limitations

The water table was a limitation for this project but proved to be an opportunity rather than constraint.

Generalizable Features and Lessons

The park holds many programs, though it is notable that the people of Virginia Beach welcomed the elevation change. The massively popular skate-park is a feature/program that is easily reproduced.

Future Issues/Plans

Being one of the first parks built on a landfill, this park either has had issues that were not publicized or future issues to come. There is little information on the settlement of decomposition in the man-made mountains. The reason for allowing fishing, but no swimming alludes to problems as well.

Recommendations and Implications

The Parks and Recreation Department need to look into more multi-modal connections or longer distanced trails for future design additions. Mount Trashmore should continue the path it is on, there are no other indications for it to stop.

Future Research Issues

A current research limitation is the amount of open public information on the project and its development. The only available information is pulled from news articles, Virginia municipal websites, and published university projects.

Figure 4.2 Mount Trashmore Program Map, (Mount Trashmore Park, 2010)

Program Category	**Extent Programmed** ● ● (light) ○
Passive Recreation	●
Active Recreation	●
Restoration	● (light)
Access	●
Community	● (light)
Education	●

Table 4.5 Mt. Trashmore Park Categories of Program Extent

Program Inventory
Trails
Paved Paths
Playgrounds
Sports-Recreation
Fishing
Birdwatching
Skate-Park
Picnic/Pavilion Areas
Open Space
Parking
Landfill Monitoring

Table 4.6 Mt. Trashmore Park Program Inventory

4.3.1.2 Red Rock Canyon Open Space

Project Name: Red Rock Canyon Open Space

Location: 3550 W. High Street, Colorado Springs, Colorado 80904

Date Designed/Planned: 2004-2013

Construction Completed: Phases through land acquirements, 2003-2021

Construction Cost: The Master Plans do not delve into the individual construction costs; it is known through internet sources upwards of $600,000.

Size: 1,476.82 Acres

Landscape Architect(s): The City of Colorado Springs Parks, Recreation and Cultural Services in collaboration with: Tapis Associates, Inc. Kezziah Watkins, ERO Resources Corporation, Mountain High Tree, Donley and Associates, Inc.

Client/Developer: City of Colorado Springs, Colorado

Managed By: City of Colorado Springs, Parks Recreation and Cultural Services

Context

Red Rock Canyon Open Space sits between the Great Plains and the Rocky Mountains. Red Rock Canyon is a series of canyons and ridges created through the erosion process. It is a varied terrain of about 240 million years of sedimentary geology. The area includes part of the Ute Pass Fault in Section 16 (acquired land). The different topography and geology supply habitats for various plants and wildlife.

Project Background and History

It was home to multiple quarries and a landfill, but is now a public amenity in Colorado Springs, Colorado. The property was first rezoned for landfill use in 1970 for just 7.34 acres. The landfill grew after numerous rezoning actions and finally closed in 1986 at a total of 90.89 acres, though the closed landfill only encompasses about 61.69 acres of the zoned property (The

Landfill, 2000). “The landfill site had become the most extensive remnant of human activity in the Red Rock Canyon area, dwarfing the stone quarries of a century ago,” stated by the Friends of Red Rock Canyon (The Landfill, 2000). The closure plan for the now filled canyon consisted of water quality and methane gas monitoring of four years total. The landfill was reportedly not compacted and only suitable to be repurposed as open space or recreation. Coincidentally the property owner felt a golf course would best suit the canyon, “Land is not suitable for development as a deep canyon exists but has good potential when filled, the Landfill area will probably be a part of a very fine golf course and recreation area” (The Landfill, 2000). The landfill owner, who audaciously thought a canyon should be filled, also dammed the confluence of Gypsum Canyon in his filling attempt.

Genesis of Project

In 2003 the City of Colorado Springs bought 789 acres though the Trail, Open Space, and Parks Program (TOPS), 653 (including the landfill) of which were to be used as passive recreation because of its sensitive environment. The project was birthed through community/public meetings, which led to other properties being added over concern for development in the area.

Design Development Process

The Red Rock Canyon Open Space was included in 2003 on the master plan, but a community engagement effort was put forth in 2007 for the planning process. There were multiple community engagement events attended by large numbers. Each master plan has included the Planning and Public Process. These engagement events directly connect to the planning and design process in this project. The community is very involved and passionate about this land. Three master plans have been created, each after the construction of most if not all stated in the previous documents, and then reconsidered for management and maintenance in the next. Within these master plans there are mapping resources that are a large part of the design development, to locate elevations, drainage, restoration, species, easements, etc.

Role of Landscape Architect

The role of the Landscape Architect in this project is seen in preservation, conservation, design guidelines, safety, health, and welfare of the public. The Red Rock Canyon is a sensitive environment with a rich history, which is where preservation and conservation enters. Part of these two includes design guidelines, the areas' natural and man-made history needs to be seen as well as respected. The design guidelines can include everything from planning to materials to maintenance methods. The Landscape Architect has an ethical responsibility to monitor the closed landfill for safety, health, and welfare of the public. The safety portion also applies to the elevation differences in this area, it changes rapidly, and the Landscape Architect takes this into consideration with safety in mind.

Program Elements

Red Rock Canyon Open Space is now repurposed as a passive recreation park, seen in Figure 4.3. This includes hiking and through trails, mountain biking, horse-riding, rock climbing, paragliding, open space, and picnic areas, various elevations, and viewpoints.

Maintenance and Management

The Red Rock Canyon Open Space 2013 Master Plan and Management Plan is the first joint plan of this nature to occur. The management plan is very thorough including vegetation management, wildlife and habitat protection, archeological and paleontological resource protection, forest health management, and trail sustainability and management. These sections are condensed into prioritized implementations. The Parks, Recreation and Cultural Services Department of Colorado Springs oversees all actions of maintenance and management.

The landfill standards and monitoring controls are put into place by the Colorado Department of Public Health and Environment.

There are revenue and marketing opportunities within the master plan document including municipal support, fundraising opportunities, and donations.

Criticism

The Red Rock Canyon Open Space is a very impressive large project. The only criticism to note is additional planning in reference to climate change and geological movements/tendencies.

Significance and Uniqueness

There is uniqueness in the continual post-closure of the landfill, though the area surrounding is still immensely successful. The area is not lacking in aesthetic natural beauty. There is great significance in such a passionate community and organizations like The Friends of Red Rock Canyon.

Limitations

The Landfill area closed in 1986 is still shown as "off-limits," portrayed in Figure 4.3 (Red Rock Canyon Master Plan, 2013). The Master Plan of 2013 states, "These requirements will remain in place until the monitoring results meet state thresholds," referring to the fence surrounding the 61.69 acres (Red Rock Canyon Master Plan, 2013). This information shows that the landfill area, though closed and sealed, has damaged the natural environment and almost 40 years-time is not enough for restoration/reconciliation.

Generalizable Features and Lessons

A joint Master and Management Plan creates clarity through all channels rather than sifting through many documents later during additional planning and design. Access to plans via public channels is a crucial element for gathering community interest and sense of ownership, especially in a project so rooted in preservation and conservation. Though the landfill land is closed to the public the design team utilizes the peripheral spaces for passive recreation and public engagement.

Future Issues/Plans

Based on current available resources, the only issue might be mapping for documentation of problems in the area. Some of the older "infrastructures" or changes seem to create issues, planning or foreseeing those areas and predicting the problems can help mitigate quickly.

Recommendations and Implications

The landfill area, if ever released from post-closure, should have a plan in place before this occurs. Its' suitability seems to fit well with the passive recreation nature of the land and would work well as open space.

Future Research Issues

There is more than adequate public information about the site, this should be continued.

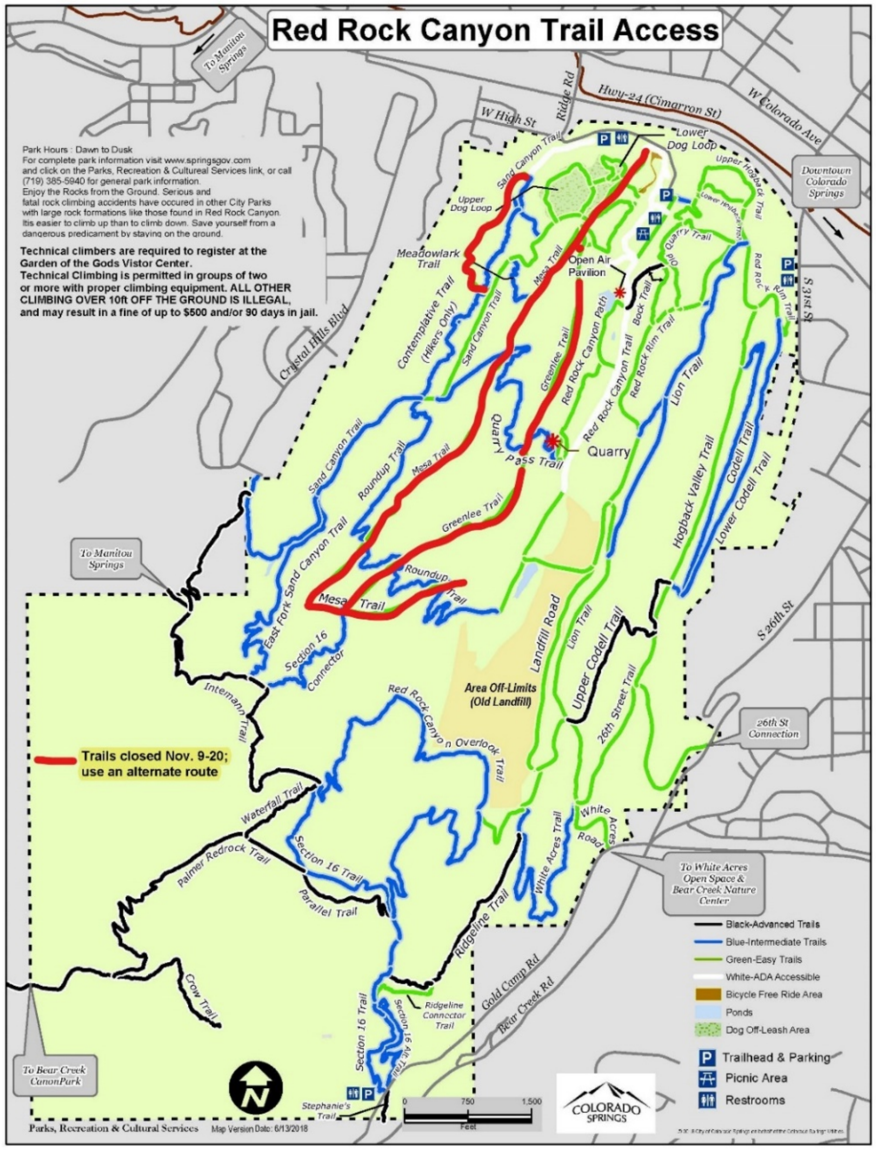


Figure 4.3. Red Rock Canyon Trail Access Plan, (The Landfill, 2000)

Program Category	Extent Programmed ● ◍ ○
Passive Recreation	●
Active Recreation	●
Restoration	○
Access	●
Community	●
Education	●

Table 4.7 Red Rock Canyon Open Space Categories of Program Extent

Program Inventory
Trails
Paved Paths
Mountain-Biking
Picnic Areas
Rock Climbing
Birdwatching
Open Space
Horseback Riding
Parking
Landfill Monitoring
Landfill Closed to Public

Table 4.8 Red Rock Canyon Open Space Program Inventory

4.3.2 *Project Abstract* Case Studies

A *Project Abstract* is a condensed form of case study. It is limited to a maximum of three pages containing majority project background and project significance (Francis, 2001). These case studies are analyzed as a group by program category, which simply states whether the site has a category of programs or it does not. This grouping of case studies has also produced a specific inventory of programs.

4.3.2.1 Twin Wells Landfill

Twin Wells Landfill is a closed and repurposed Type 1 landfill in Irving, Texas. The landfill opened in August of 1973 and closed just over ten years later in June of 1989 (Closed Landfill Inventory, 2010). The 234 acres now serves the public as Twin Wells Park, though having some ballfields and trails the signage and major activity comes from the Irving Golf Club. The club is a city owned entity and amenity for the public through the Irving Parks and Recreation department. The Closed Landfill Inventory through TCEQ shows that this landfill took in 740 tons of municipal solid waste per day (Closed Landfill Inventory, 2010). Twin Wells Landfill is very close in proximity to the Trinity River. The golf course has been the victim of many floods, while this definitely involves the river adjacency it also alludes to the settlement and subsidence factor of landfills. The city has recently placed more financial investment into this public amenity through proper irrigation, drainage, and grading. This city amenity's history is fairly difficult to access through public channels, therefore its' closure could be a result of the Subtitle D regulations.

An observation study was done of the Irving Golf Club on February 15, 2020, which revealed fairly little about the landfill's past or repurposing. On a Saturday early afternoon, the golf club is very popular holding around 50 vehicles in the parking lot. Most patrons were of male gender and looked to be adults or above high school age. The only sign of the previous

Twin Wells Landfill is the rolling topography, seen in Figure 4.4. A couple of old signs illegible, though there stood three or more new signs signifying the city or golf club. While surveying the area the income level is fairly noticeable (lower-middle class), which unfortunately correlates with pre-Subtitle D landfill sites showing issues of equal justice and quality of life. Other than these two indications the landfill would be unidentifiable.

Lessons Learned: This site to some degree is successfully repurposed landfill land just by sheer numbers at the golf club. It is programmed with mostly active recreation: golf course, softball, and baseball fields. There is passive recreation in the form of a paved walking path that connects with another nearby park River Hills. This public amenity offers insight into the maintenance and intricacy that active recreation requires when programmed on landfill land in a floodplain.

Figure 4.4 Twin Wells Park, (Elena Naccari, 2020)

4.3.2.2 MoneyGram Soccer Park at Elmfork

MoneyGram Soccer Park at Elmfork is located on a Type 1 landfill (accepted all types of municipal solid waste) in Dallas, Texas. The previous City of Walnut Hill/Dallas landfill accepted municipal solid waste for 28 years, from 1955 to 1982 (Closed Landfill Inventory, 2019). As an active site, according to the North Central Texas Council of Government's GIS database of closed landfills, the landfill accepted on average 1,450 tons of waste per day. The Northeast Dallas site is 501 acres and largely repurposed as a soccer park today. In the year 2000, this site held a gravel operation within a largely commercial surrounding area (Closed Landfill Inventory, 2019) The park at Elmfork Athletic Complex is approximately "109.6-acre special use park, established in 2005" (Dallas Park and Recreation Board, 2015). The plan began in 2007 and finished in 2014 with the results consisting of 14 full-size soccer fields and five junior fields, as shown in Figure 4.5. The project was long delayed over a decade and included funds from three city-bond programs. The recreationally repurposed complex houses 19 soccer fields, three parking areas, walking trails, and two pavilions. MoneyGram is managed by the Major League Soccer Team FC Dallas and draws in a return from the international tournaments it hosts.

The active recreation complex has proven to be demanding in maintenance aspects with the ground constantly changing a level playing surface, "the field was renovated in mid-2017 to alleviate the challenge of watering soil and roots underneath a one-inch layer of thick clay sod and a six-inch sand cap. The field, which held Bermuda grass now has just a six-inch sand cap that can withstand almost double the field usage hours of other fields and shows few signs of wear and tear" (Miller, 2018).

Lessons Learned: This site was able to acquire and reacquire funds in order to provide the maintenance required for the active recreation (soccer fields). The complex is able to create a return with their tournament play, which is a financial aspect needed to pay for its' self-sufficiency. The landfill property or boundary is 501 acres, though the complex only utilizes close to a fifth of that land. It could be possible to program the remaining acreage for restoration.

Figure 4.5 MoneyGram Soccer Park Master Plan, (Miller 2018)

4.3.2.3 Austin Community Landfill

Austin Community Landfill is an active landfill opened in 1970 in Austin, Texas serving six cities within Travis County. The Type 1 landfill was acquired by Waste Management in 1980 and sits mostly on 360 acres of once deserted agricultural property. The facility acreage totals at 420 and serves as a private landfill for municipal waste produced by the county. According to the Municipal Solid Waste Year in Review, the Austin Community Landfill took in 982,600 tons in

2018, which leaves capacity for 6,225,764 tons equaling 7 years remaining (Municipal Solid Waste in Texas, 2019). Currently on the site are 128 wells collecting methane gas to provide energy for 4,000 - 6,000 homes a year (Austin Fact Sheet, 2018).

The Austin Community Landfill was certified by the Wildlife Habitat Council in 2006 for at least 2,800 square feet of pollinator garden, though the Wildlife Habitat Site has since grown. The property is majority grassland but holds two acres of freshwater wetland and ten acres of Texas wildflower meadow, seen in Figure 4.6. Before 2006, the need for wildlife habitat restoration and protection became apparent with the then recent urban expansion. Waste Management gathered a wildlife team and developed a management plan for the active landfill to increase biodiversity with one, three, and five-year goals. The goals incorporated suburban community relations and environmentally conscious operation. The plans were implemented in 2005 starting with a species inventory (Wildlife Habitat Sites, 2020).

Currently the active waste storage site includes aspects of habitat restoration and protection such as: butterfly gardens, a migration stopover for hummingbirds, a bee garden and prairie, wildflower prairie and meadow with an expansion to one acre of on-facility wildflower planting (seeded twice annually), monitored and maintained nest boxes, a chimney swift tower (for roosting), bat-houses, a 2.1-mile nature trail open to the public.

Community involvement with the ever-growing habitat site is successful. There is an annual winter cleanup, which involves local students and the wildlife team. The Travis Audubon Society, neighbors, and Texas Naturalists partner with the site to continue education and monitor progress.

Lessons Learned: This site utilizes its’ land adjacency and covered sections to repair the ecosystem daily. This creates a significant change in timeline for post-closure planning and repair. By incorporating the community in the projects, it creates a sense of ownership and makes a true impact in perception of the site. Austin Community Landfill is an example of programming with dual purpose, which can serve both as public amenity and benefit to the area through mending of habitats.

Figure 4.6 Austin Community Landfill Wildlife Habitat Site (Waste Management, 2017)

4.3.2.4 Mesquite Creek Wildlife Habitat Area

Mesquite Creek Wildlife Habitat Site lies adjacent to the active Mesquite Creek Type 1 landfill. The Mesquite Creek Landfill accepted 444,039 tons of municipal solid waste in 2018, per the year in review, making the remaining capacity 9,118, 934 projected to close in 16 years (Municipal Solid Waste, 2018). This landfill is the only Type 1 landfill in Comal County. There is limited information on the size and current practices of the New Braunfels landfill site.

The 275 acres of habitat area previously used for cattle grazing was acquisitioned by Waste Management and set aside for wildlife restoration, shown in Figure 4.7. Rolling hills and valleys on the area encompass biodiversity: grasslands, forest, brush, prairie, and seasonal floodplains. The Mesquite Creek runs through the south side of the property to a 26-acre man-made lake. Regionally characteristic cattle tanks now serve as biodiverse ponds for the site after being cleared of cattails and reshaping the banks. Basking logs and floating islands provide extra habitat areas in the turtle pond with the extra assurance of solar powered aeration system and cold-water microbes and enzymes added to improve water quality. Species inventory produced fifteen native species to be kept in hopes to remain an established ecosystem for pollinators etc. The pollinator garden was created in 2009 with an extensive list of native and adapted pollinators (70 plus). A diverse mix of plants were added for all spaces, while targeting and documenting invasive species on the site using survey techniques and GIS (Wildlife Habitat Sites, 2020).

The habitat site prides itself on public outreach and education with many local volunteers, Boy and Girl Scout troops participating in the annual plant and bird inventory and usage of the outdoor classroom (Wildlife Habitat Sites, 2020).

Lessons Learned: Mesquite Creek is a significant study for the topic of repurposing because of its historic Texas characteristics and its use as a buffer for communities. It is an example of how the Landfill Industry can provide conservation alongside the landfill properties, which in turn shortens the land planning and mending process after closure.

Figure 4.7 Mesquite Creek Wildlife Habitat Wetlands (Appendix D-R6, 2021)

4.3.2.5 Westside Closed Landfill and Active Transfer Station

Westside Closed Landfill and Active Transfer Station was opened in 1977 thirteen miles West of downtown Fort Worth, Texas. Waste Management purchased the Type 1 landfill in 1983 with a total acreage of 325. The site closed in 2007 with a full capacity of 17 million cubic yards of municipal waste. There is a presently active transfer station on the premises, which transferred 192,301 tons of waste in 2018 (Municipal Solid Waste, 2019). The landfill is also a gas to energy site where 95 methane wells generate enough energy for around 2,700 homes a year.

The Wildlife Habitat Site, Figure 4.8, stands on 290 of the 325 acres made up of closed landfill, adjacent buffer, and a soil borrow area used during active stages. Plans for overall restoration and wetland habitat were begun before close in 2007. The Westside facility was charged to revegetate the neighboring spaces to the soil borrow area with specific plants (Indian grass, Big Bluestem, Side Oats Grama, Illinois Bundleflower). During restoration and development of the habitat site, three food plots were placed to supplement for the damage of the ecosystem (mostly for deer). Perennial seeding expansion became a necessary precedent as food source during improvement. The management included switch grass in order to create transition zones between the new 47 acre constructed lake, on the soil borrow area, and the prairie. The lake was created to imitate natural conditions using shelves, benches, slopes, depths, and vegetation. In 2008, when stable, the lake was stocked with fish for ecosystem purposes, as well as recreation. In the same year, 2008, the wetland planting progress was found to be extremely slow to launch and new plants were added. The reason for slow establishment not noted, though certification from the Wildlife Habitat Council was provided in 2008 following these additions. The closed landfill area, specifically, was given a soil cover, graded to drain properly, and seeded with vegetation to stabilize the new soil (Wildlife Habitat Sites, 2020).

Today, Westside Closed Landfill is home to 290 acres of certified wildlife habitat containing: a 47-acre man-made lake (Figure 4.8), bird boxes, small wetlands, grass transition zones, a prairie, 13 acres of native grasses on old stockpile area, native grasses on landfill cap, signage, no mow areas (Wildlife Habitat Sites, 2020).

The site plans to continue its public engagement with the Boy Scouts of the area, as well as expand with an environmental learning center. Other future goals include enhancement and management and a wild turkey management program (Wildlife Habitat Sites, 2020).

Lessons Learned: Westside Closed Landfill offers a perspective on timeline of landfill repurposing after closure, as well as plant palette suggestions for the Dallas Fort Worth area. Like both of the other Waste Management Habitat Sites, this shows the versatility of the land in programming for both public amenity and benefit of native ecosystem. By using methane wells it provides a positive impact on the public with energy to power homes.

Figure 4.8 Westside Closed Landfill Wildlife Habitat Site (Waste Management, 2017)

4.3.2.6 *Project Abstract* Case Study Findings

The *Project Abstract* case studies provide a variety of programs that directly link to the selected region, which creates an overall likelihood of suitable features. Table 4.4 states a generic inventory of program strategies, and Table 4.5 gives specific options for suitable programs for each of the five *Project Abstract* case studies.

Site	Passive	Active	Restoration	Access	Community	Education
Twin Wells	●	●		●		
MoneyGram	●	●	●	●	●	
Austin Co.	●		●	●	●	●
Mesquite			●		●	●
Westside	●		●	●	●	●

Table 4.9 *Project Abstract* Program Inventory by Category

Specific Programs
Trails
Paved Paths
Playgrounds
Sports-Recreation
Fishing
Birdwatching
Parking
Landfill Monitoring

Table 4.10 Suitable Program Options

4.4 Synthesis of Findings

This section synthesizes the findings from the multi-method research approach described. After analyzing the data collection and findings the following considerations are addressed in the planning and design of the City of Grand Prairie Landfill land post-closure, chosen through the site selection process shown in Chapter 5:

1. Public outdoor spaces are necessary amenities.
2. Subtitle D landfill land can and should be repurposed for public use, following requirements and safety regulations.

3. Passive recreation has a higher likelihood of success, rather than active recreation, on landfill land.
4. Not all repurposed spaces on closed landfill land need public access or disturbance.
5. The Grounded Theory for Repurposing Landfills using four simplified parts: where, when, why, and what, should apply to all landfill sites, not just Subtitle D, approaching closure (Glaser & Strauss, 1980).
6. Generalizable features and lessons learned can be viable programs or options for planning and design no matter the region.

Programs Recommended
Walking/running paths
Hiking trails
Biking trails/paths
Open space
Park
Soccer fields
Baseball/Softball Fields
Birdwatching
Wildlife habitat
Parkways
Eco-tourism
Paddling/Water activities
Restoration
Buffer Space
Gas Collection/Energy production
Education
Lakes/Ponds-Fishing
Disaster Processing site

Transfer Station
Youth amenities
Multi-Modal Access
Citizen Convenience Station

Table 4.11 Synthesized Program Elements

4.5 Summary of Findings

This chapter discussed the findings from the research data collected in the multi-method approach (Deming & Swaffield, 2011). The data was analyzed using Mark Francis' A Case Study Method for Landscape Architecture (Francis, 2001), and the Grounded Theory Method (Glaser & Strauss, 1980). These findings were then synthesized to inform the repurposing of the City of Grand Prairie Landfill in Dallas County post-closure. The process used to collect these findings, as well as the findings themselves can be employed by those researching the repurposing of a post-closure landfill for public amenity. The following chapter focuses on applying these synthesized findings accumulated to plan and design Subtitle D landfills in Dallas County post-closure.

CHAPTER 5

PLANNING AND DESIGN

5.1 Introduction

This chapter presents the regional suitability and site selection criteria and recommended planning and design strategies for the Dallas County Subtitle D landfill selection derived from the synthesis of data from the literature review, interview research with landfill industry professionals, and case study research in Chapter 4. This chapter presents geospatial inventory and suitability analysis both at regional and site scale. A site inventory and analysis of the City of Grand Prairie Landfill, documenting the existing conditions and providing a detailed GIS suitability analysis of the site for programming. Programmatic elements, conceptual, and schematic design graphics are illustrated to demonstrate the planning and design strategies for the landfill turned public outdoor amenity.

5.2 Regional Review, Site Selection, and Analysis

The researcher collected and analyzed data on the five active Subtitle D landfills in Dallas County, Texas for best suitability as a public outdoor amenity post-closure. The sites include Charles M. Hinton Jr. Regional Landfill, Irving Hunter Ferrell Landfill, The City of Grand Prairie Landfill, The City of Dallas McCommas Bluff Landfill, and Waste Management Skyline Landfill.

The regional analysis and site selection process initiated during the triangulation and synthesis portion of the methodology, by using ArcGIS data, Figures 5.1-5.8, to create weighted overlay, Figure 5.14, to assess the suitability of a site as a public outdoor amenity using McHarg's Layer Cake or Graphic Overlay (1969) method. This method is later fine-tuned using Steiner's suitability criteria as a model, which is tailored to recreation categories for this research (Steiner, 2008). Once the regional suitability analysis at County level is completed for site selection, the analysis transitions to a detailed site inventory and analysis. necessary once one of the five active sites in Dallas County are selected as most suitable for a public outdoor amenity.

5.2.1 County Inventory

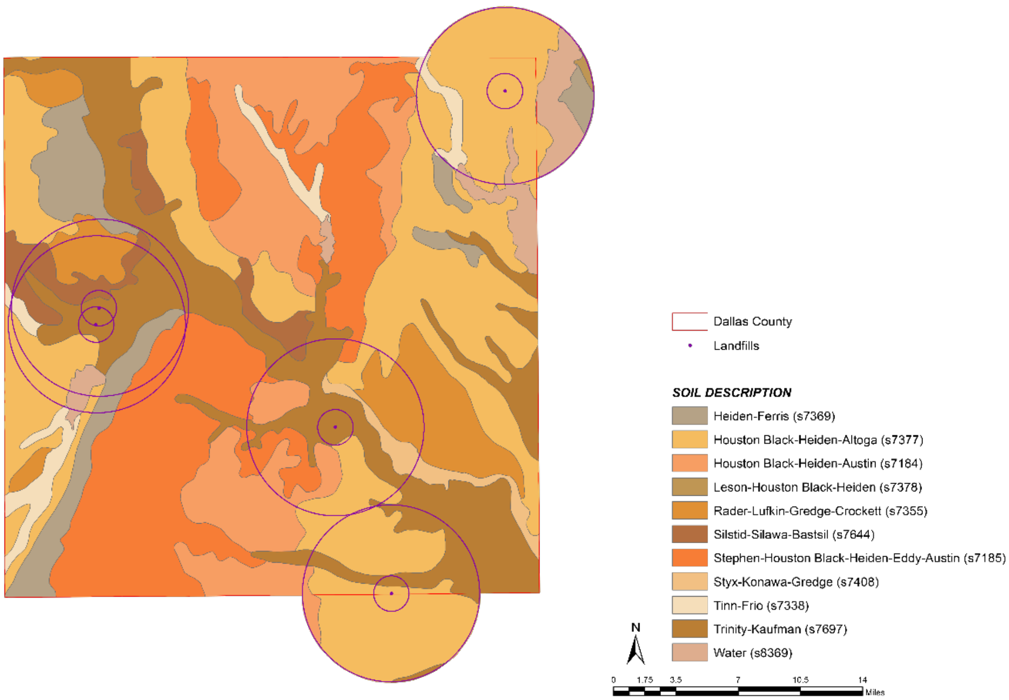


Figure 5.1 Dallas County Soils

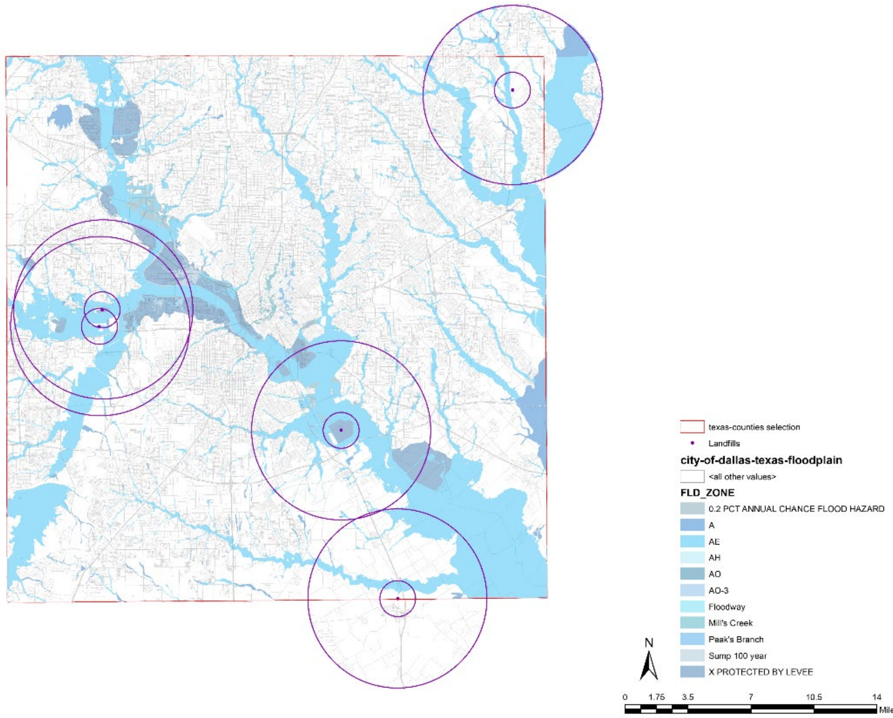


Figure 5.2 Dallas County Hydrology

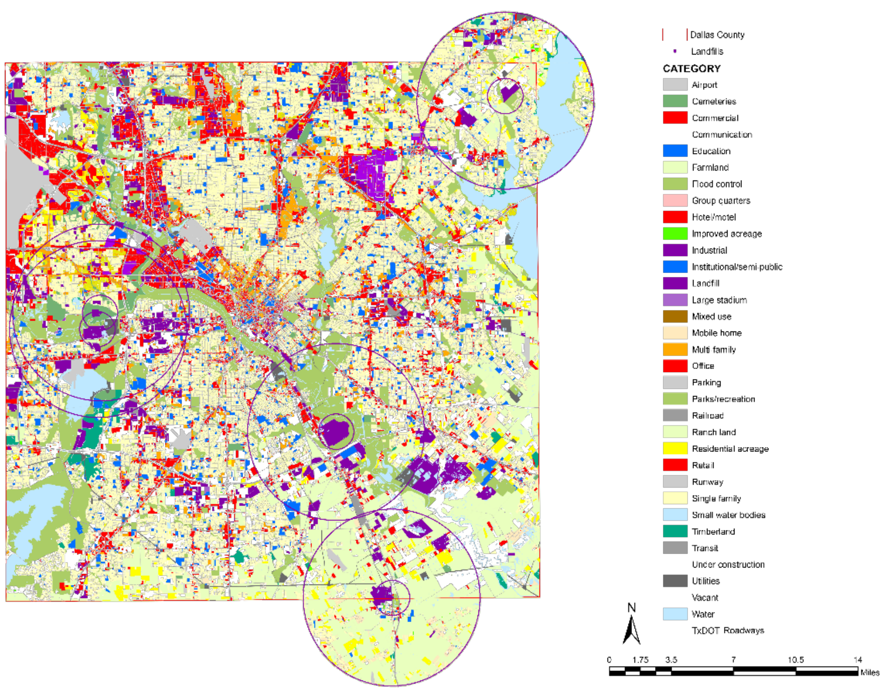


Figure 5.3 Dallas County Land-Use

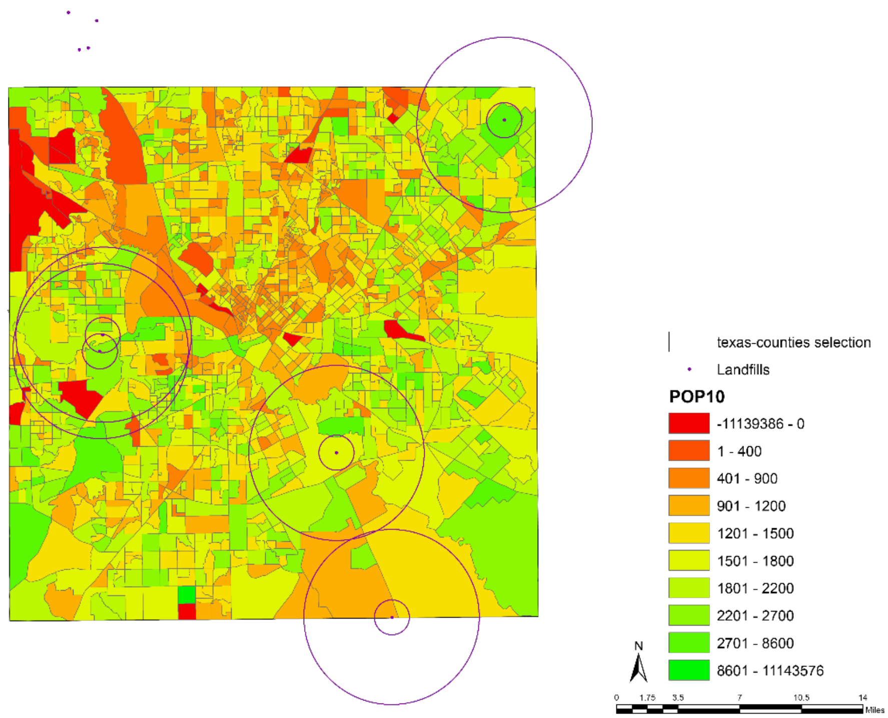


Figure 5.4 Dallas County Census Block Group

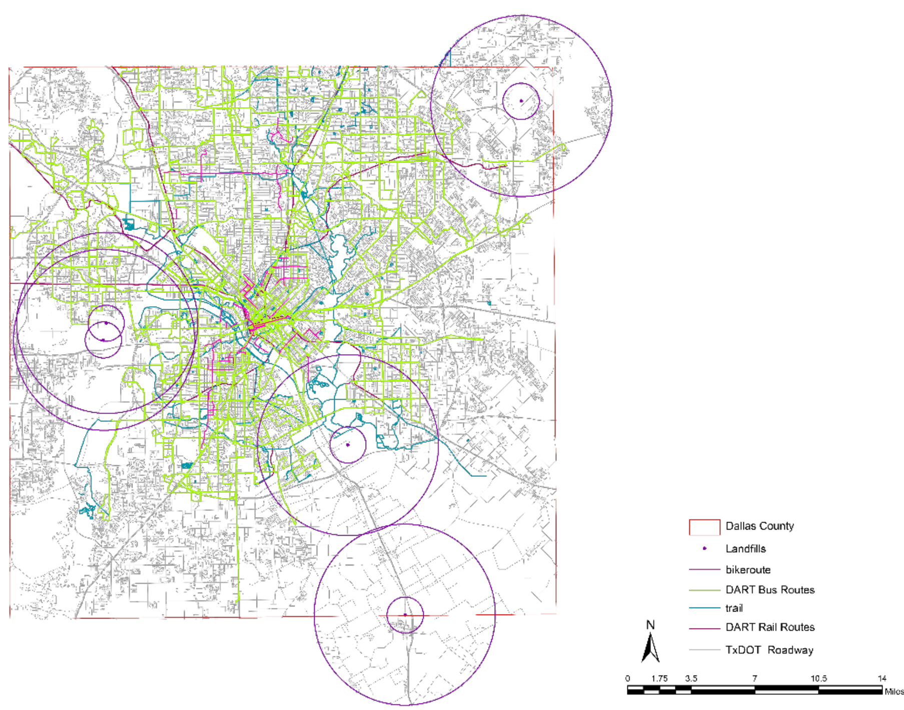


Figure 5.5 Dallas County Access and Circulation

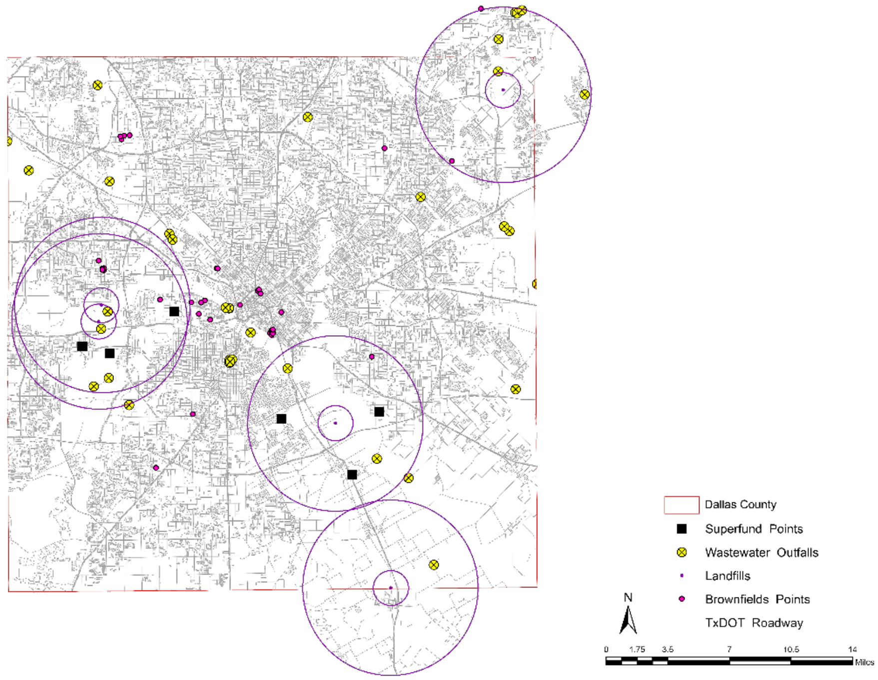


Figure 5.6 Dallas County Reclamation Sites

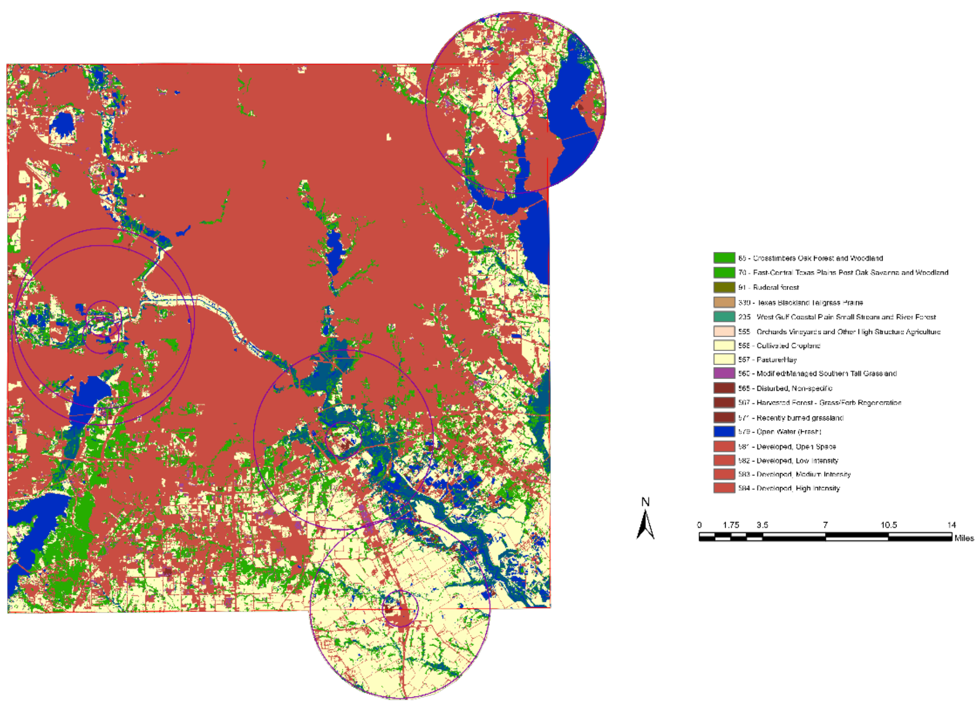


Figure 5.7 Dallas County Landcover Data

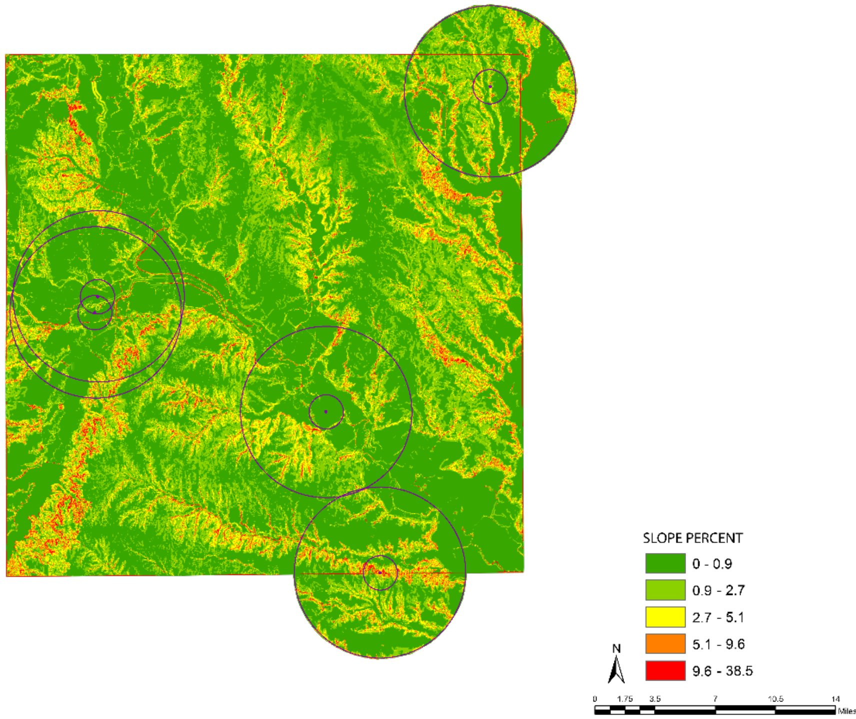


Figure 5.8 Dallas County Slope Analysis

5.2.2 Five-Mile-Radius Inventory

Figures 5.9-13 show a five-mile radius inventory of each of the Dallas County landfill sites in question.

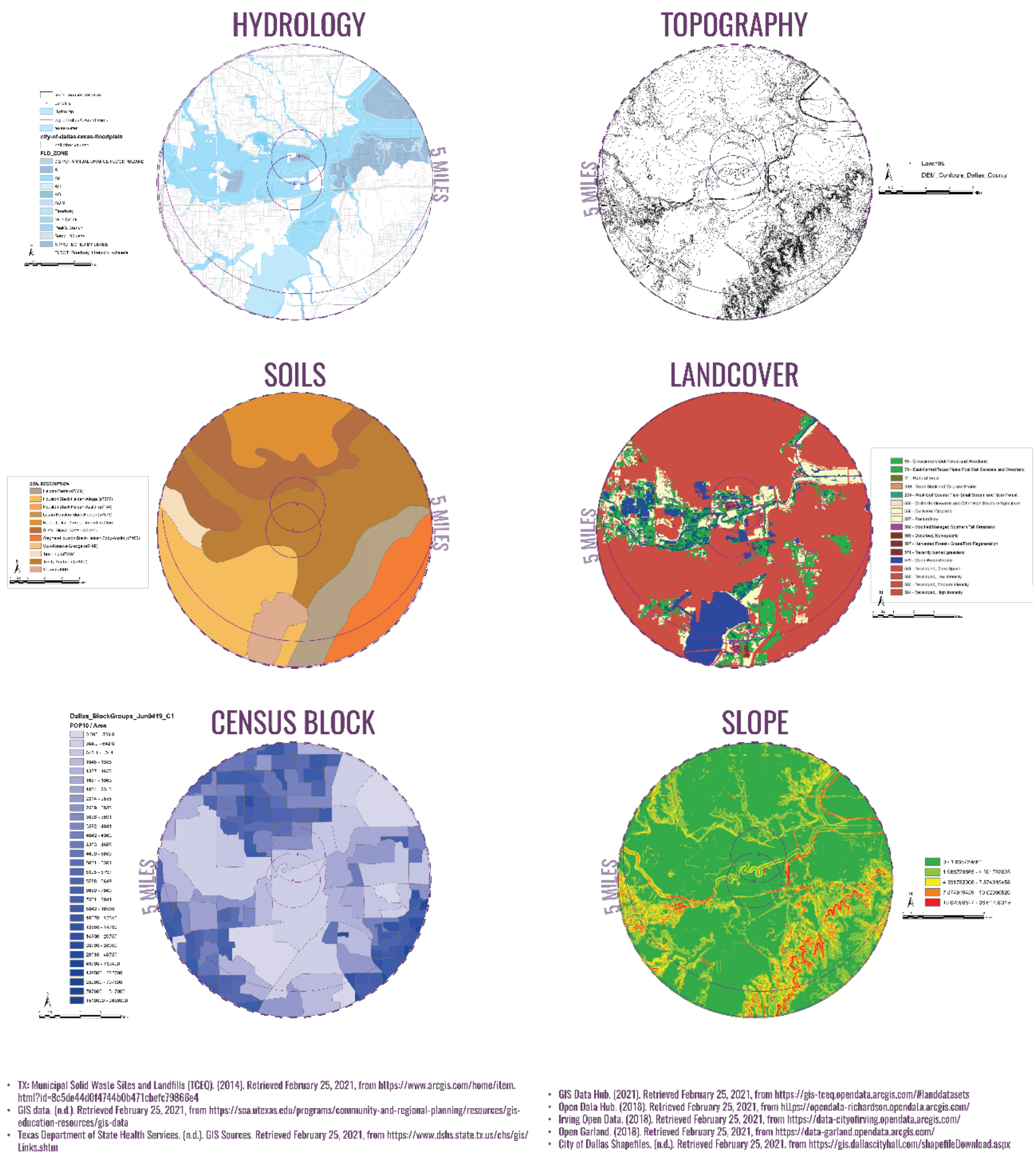
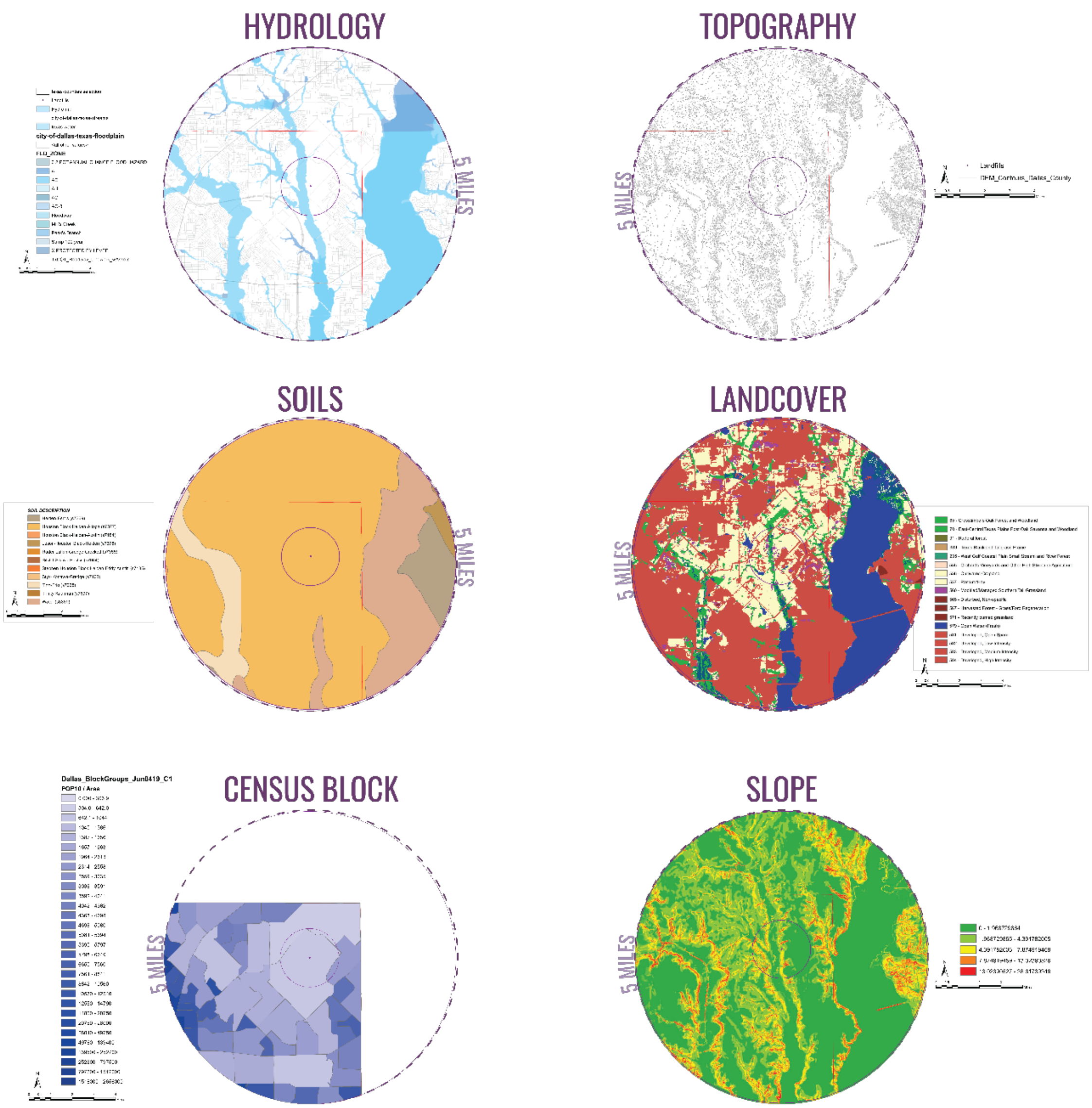
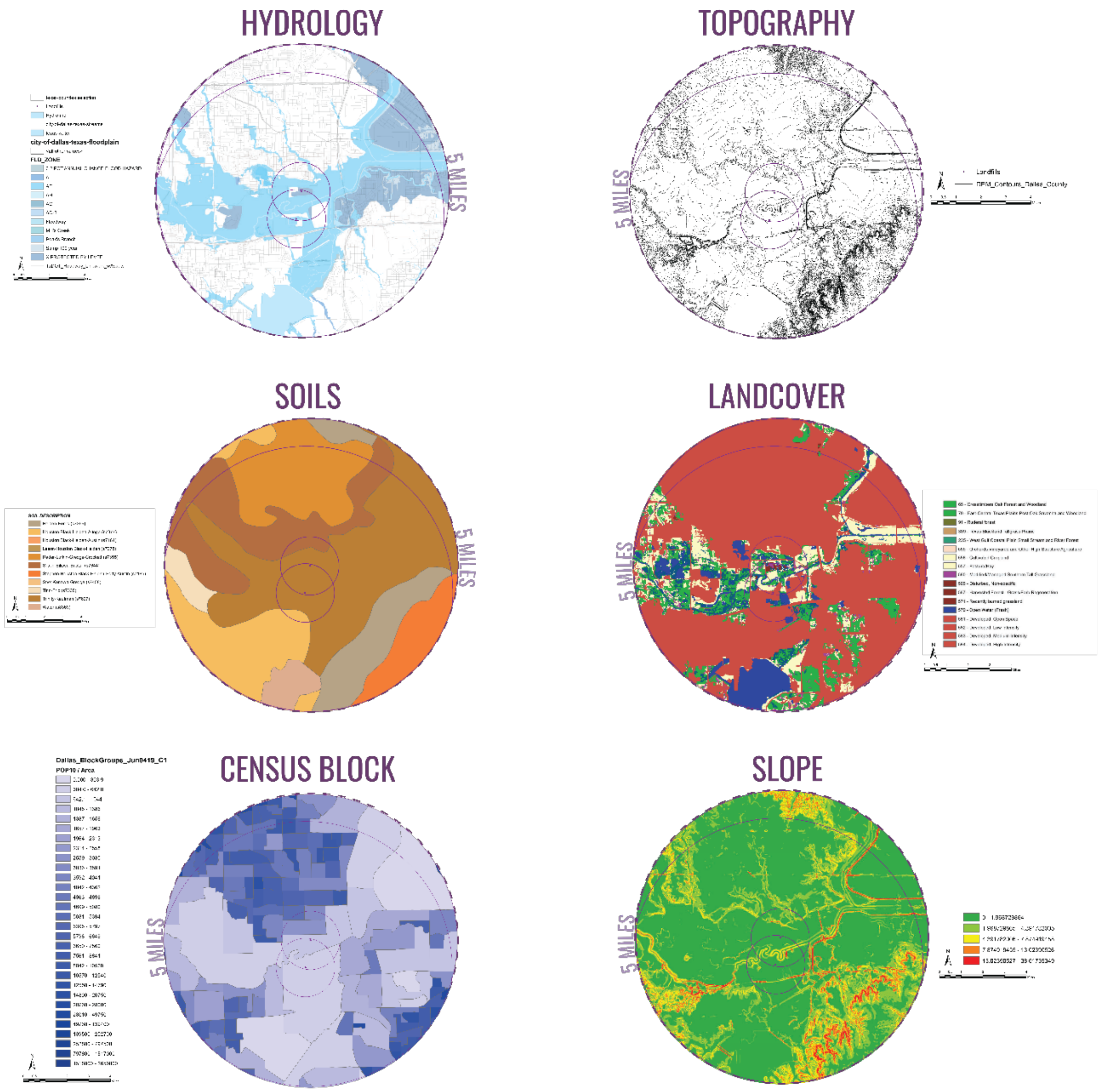


Figure 5.9 City of Grand Prairie Landfill 5-Mile Inventory



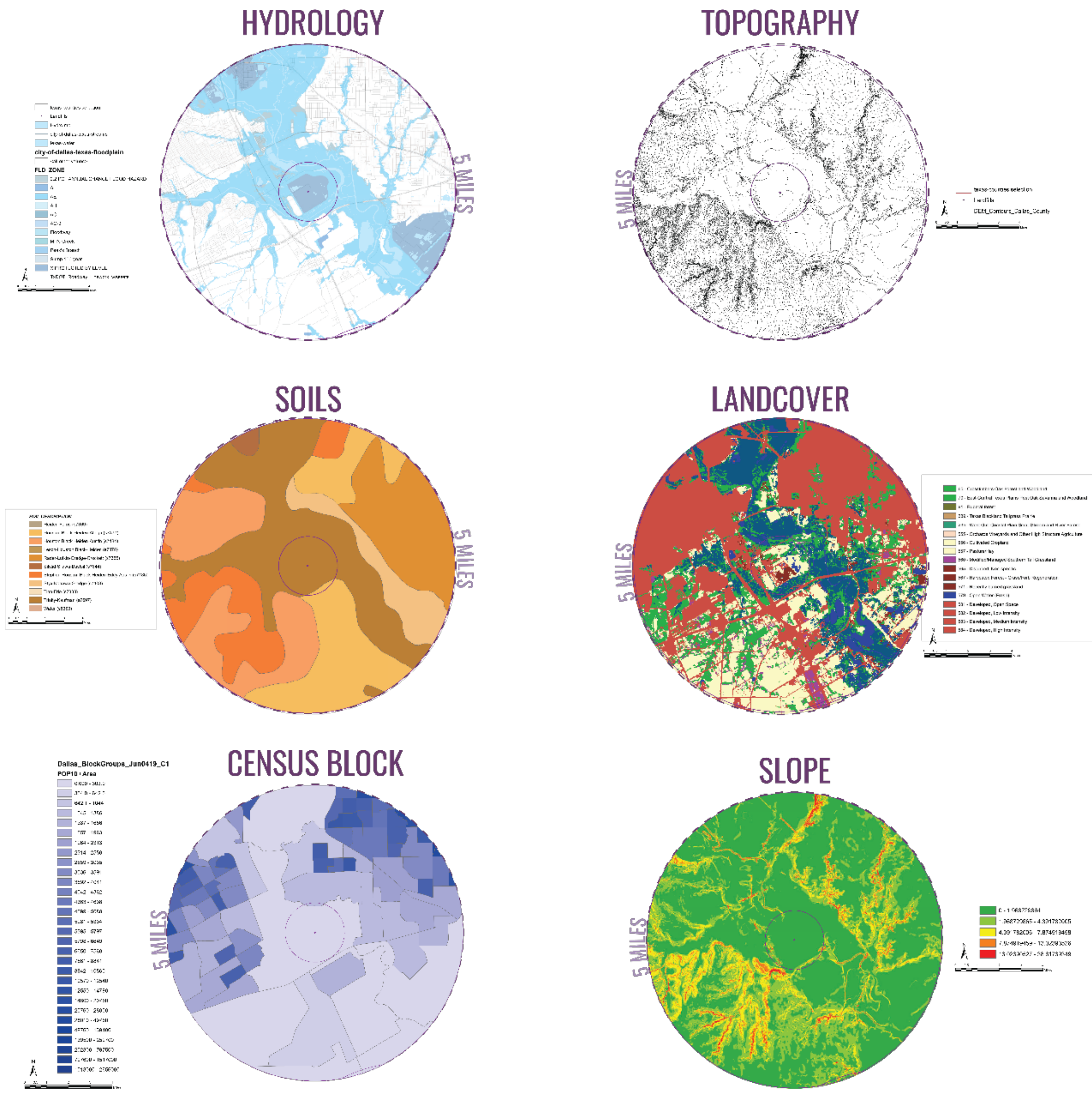
- TX: Municipal Solid Waste Sites and Landfills (TCEQ). (2014). Retrieved February 25, 2021, from https://www.arcgis.com/home/item.html?id=8c5de44d0f4744b0b471cbefc79866e4
- GIS data. (n.d.). Retrieved February 25, 2021, from https://soa.utexas.edu/programs/community-and-regional-planning/resources/gis-education-resources/gis-data
- Texas Department of State Health Services. (n.d.). GIS Sources. Retrieved February 25, 2021, from https://www.dshs.state.tx.us/chs/gis/Links.shtm
- GIS Data Hub. (2021). Retrieved February 25. 2021, from https://gis-tceq.opendata.arcgis.com/#landdatasets
- Open Data Hub. (2018). Retrieved February 25, 2021, from https://opendata-richardson.opendata.arcgis.com/
- Irving Open Data. (2018). Retrieved February 25, 2021, from https://data-cityofirving.opendata.arcgis.com/
- Open Garland. (2018). Retrieved February 25, 2021, from https://data-garland.opendata.arcgis.com/
- City of Dallas Shapefiles. (n.d.). Retrieved February 25, 2021, from https://gis.dallascityhall.com/shapefileDownload.aspx

Figure 5.10 Charles M. Hinton Jr. Regional Landfill 5-Mile Inventory



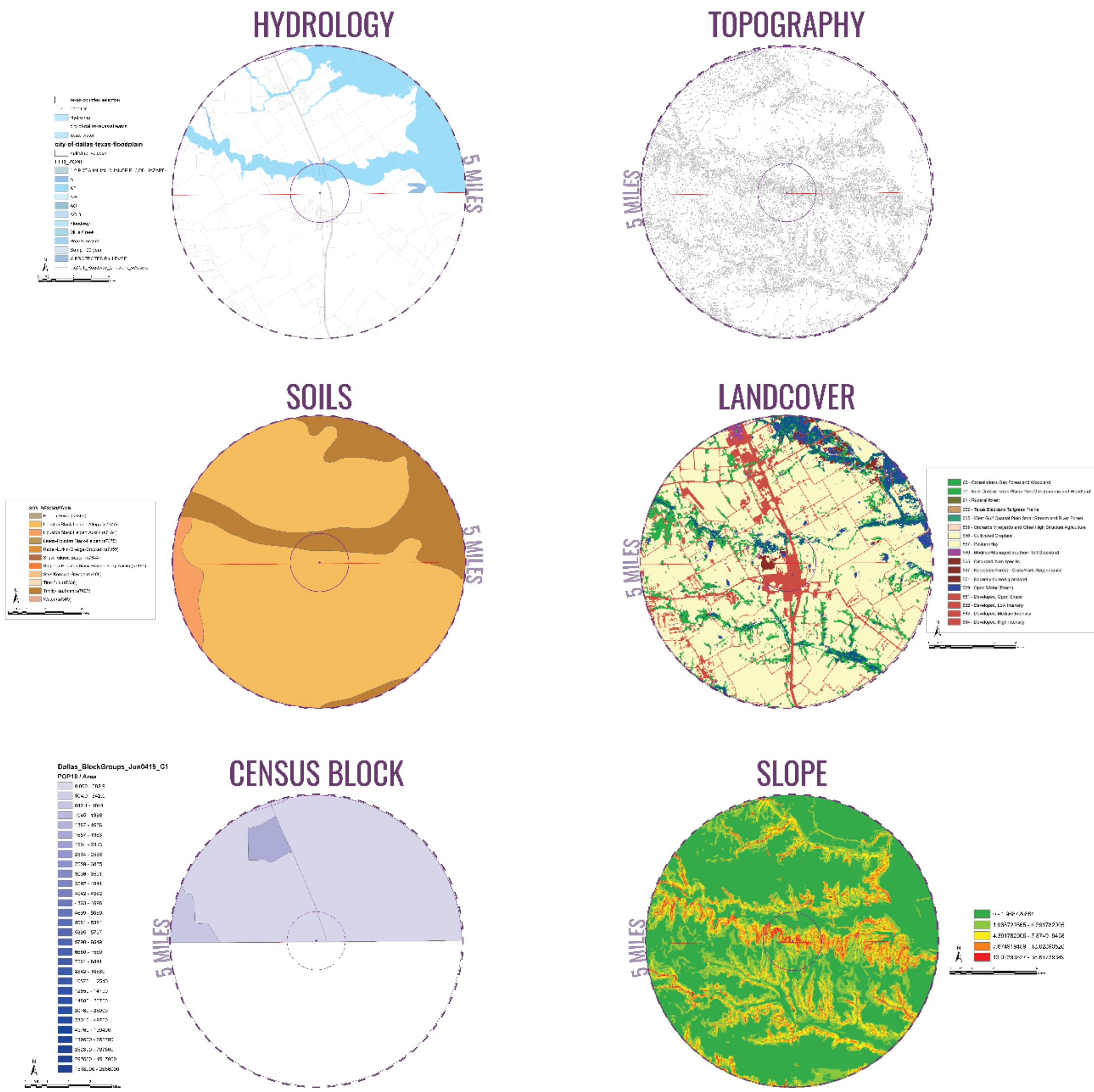
- TX: Municipal Solid Waste Sites and Landfills (TCEQ). (2014). Retrieved February 25, 2021, from https://www.arcgis.com/home/item.html?id=8c5de44d0f4744b0b471cbefc79866e4
- GIS data. (n.d.). Retrieved February 25, 2021, from https://soa.utexas.edu/programs/community-and-regional-planning/resources/gis-education-resources/gis-data
- Texas Department of State Health Services. (n.d.). GIS Sources. Retrieved February 25, 2021, from https://www.dshs.state.tx.us/chs/gis/Links.shtm
- GIS Data Hub. (2021). Retrieved February 25, 2021, from https://gis-tceq.opendata.arcgis.com/#landdatasets
- Open Data Hub. (2018). Retrieved February 25, 2021, from https://opendata-richardson.opendata.arcgis.com/
- Irving Open Data. (2018). Retrieved February 25, 2021, from https://data-cityofirving.opendata.arcgis.com/
- Open Garland. (2018). Retrieved February 25, 2021, from https://data-garland.opendata.arcgis.com/
- City of Dallas Shapefiles. (n.d.). Retrieved February 25, 2021, from https://gis.dallascityhall.com/shapefileDownload.aspx

Figure 5.11 Irving Hunter Ferrell Landfill 5-Mile Inventory



- TX: Municipal Solid Waste Sites and Landfills (TCEQ). (2014). Retrieved February 25, 2021, from https://www.arcgis.com/home/item.html?id=8c5de44d0f4744b0b471cbefc79866e4
- GIS data. (n.d.). Retrieved February 25, 2021, from https://soa.utexas.edu/programs/community-and-regional-planning/resources/gis-education-resources/gis-data
- Texas Department of State Health Services. (n.d.). GIS Sources. Retrieved February 25, 2021, from https://www.dshs.state.tx.us/chs/gis/Links.shtm
- GIS Data Hub. (2021). Retrieved February 25, 2021, from https://gis-tceq.opendata.arcgis.com/#landdatasets
- Open Data Hub. (2018). Retrieved February 25, 2021, from https://opendata-richardson.opendata.arcgis.com/
- Irving Open Data. (2018). Retrieved February 25, 2021, from https://data-cityofirving.opendata.arcgis.com/
- Open Garland. (2018). Retrieved February 25, 2021, from https://data-garland.opendata.arcgis.com/
- City of Dallas Shapefiles. (n.d.). Retrieved February 25, 2021, from https://gis.dallascityhall.com/shapefileDownload.aspx

Figure 5.12 McCommas Bluff Landfill 5-Mile Inventory



- TX: Municipal Solid Waste Sites and Landfills (TCEQ). (2014). Retrieved February 25, 2021, from https://www.arcgis.com/home/item.html?id=8c5de44d0f4744b0b471cbefc79866e4
- GIS data. (n.d.). Retrieved February 25, 2021, from https://soa.utexas.edu/programs/community-and-regional-planning/resources/gis-education-resources/gis-data
- Texas Department of State Health Services. (n.d.). GIS Sources. Retrieved February 25, 2021, from https://www.dshs.state.tx.us/chs/gis/Links.shtm
- GIS Data Hub. (2021). Retrieved February 25, 2021, from https://gis-tceq.opendata.arcgis.com/#landdatasets
- Open Data Hub. (2018). Retrieved February 25, 2021, from https://opendata-richardson.opendata.arcgis.com/
- Irving Open Data. (2018). Retrieved February 25, 2021, from https://data-cityofirving.opendata.arcgis.com/
- Open Garland. (2018). Retrieved February 25, 2021, from https://data-garland.opendata.arcgis.com/
- City of Dallas Shapefiles. (n.d.). Retrieved February 25, 2021, from https://gis.dallascityhall.com/shapefileDownload.aspx

Figure 5.13 Skyline Landfill 5-Mile Inventory

5.2.3 Weighted Overlay

The Weighted Overlay technique stems from using the synthesized data to create overlays, while scoring each dataset in order to create a weight reducing the area to categories of suitability, shown in Figure 5.14 (McHarg, 1992; Steiner, 2008).

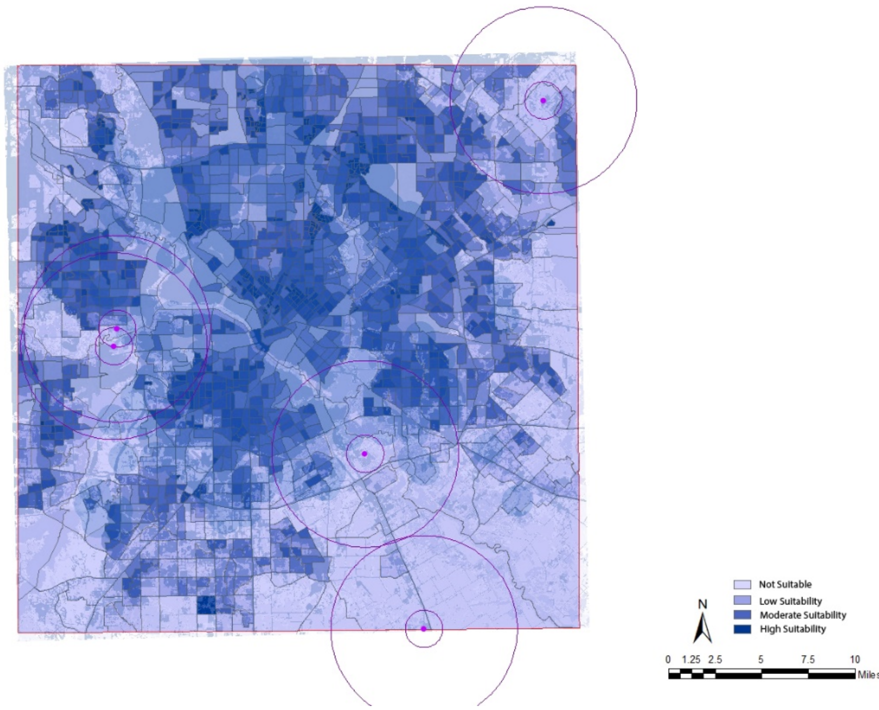


Figure 5.14 Site Selection Overlay

5.2.4 Site Selection

Based on the information collected it is reasonable to state that both Skyline and Charles M. Hinton Jr. Landfills are eliminated from selection: their radii exceed Dallas County limits, therefore it would not solely and efficiently serve the singular county; the inability to gather updated data from outside of Dallas County creates limitation and errors occur more frequently.

The site selection is then between McCommas Bluff Landfill, Irving Hunter Ferrell Landfill, and the City of Grand Prairie Landfill for planning and design considerations. The City of Grand Prairie is selected as best suitable for public amenity, based on a sampling of the inventory data, prioritizing the landcover data and population density through Census Block data. This site is visibly pronounced through geospatial analysis and weighted overlay to serve a greater numerical population and repair a piece of a larger ecological system within the West Fork of the Trinity River.

5.3 City of Grand Prairie Landfill Site Inventory and Analysis

The site selected, the City of Grand Prairie Landfill, is brought into a more detailed suitability analysis using weighted overlay in ArcGIS, conveyed in Figures 5.17 & 5.18. The researcher focused on understanding the physical aspects of the site and its' surroundings in its' current state (years 2020-2021). The inventory is largely in the earlier site selection process, as well as in the GIS data. Geospatial data analysis representing the existing condition of the City of Grand Prairie landfill is reviewed and synthesized to find suitable areas in the site for programmatic elements. Site inventory and analysis furthers the understanding of the existing site condition including opportunities and constraints, which directly impacts the proposed planning and design. The suitability criteria are based on the researcher's point of view through thorough examination of the data collected. This detailed analysis criteria in Tables 5.1-5.2 are subject to change, within the base template for repurposing Subtitle D landfills, depending on the site and directed focus of the project at hand.

The site is first reviewed in a contextual inventory through GIS data and Google Earth History, which highlights the surroundings in terms of ownership and proximity to current physical features and amenities. Figure 5.15 visibly explains the proximity of the City of Grand Prairie Landfill to the active Irving Hunter Ferrell Landfill, the West Fork of the Trinity River, other existing industrial sites, vacant lands, utilities, water bodies, and pedestrian accessible paths. In Figure 5.16 it shows the land and acreage owned municipally and by the Trinity River Authority, which could more easily be transformed into public amenity without acquisition.

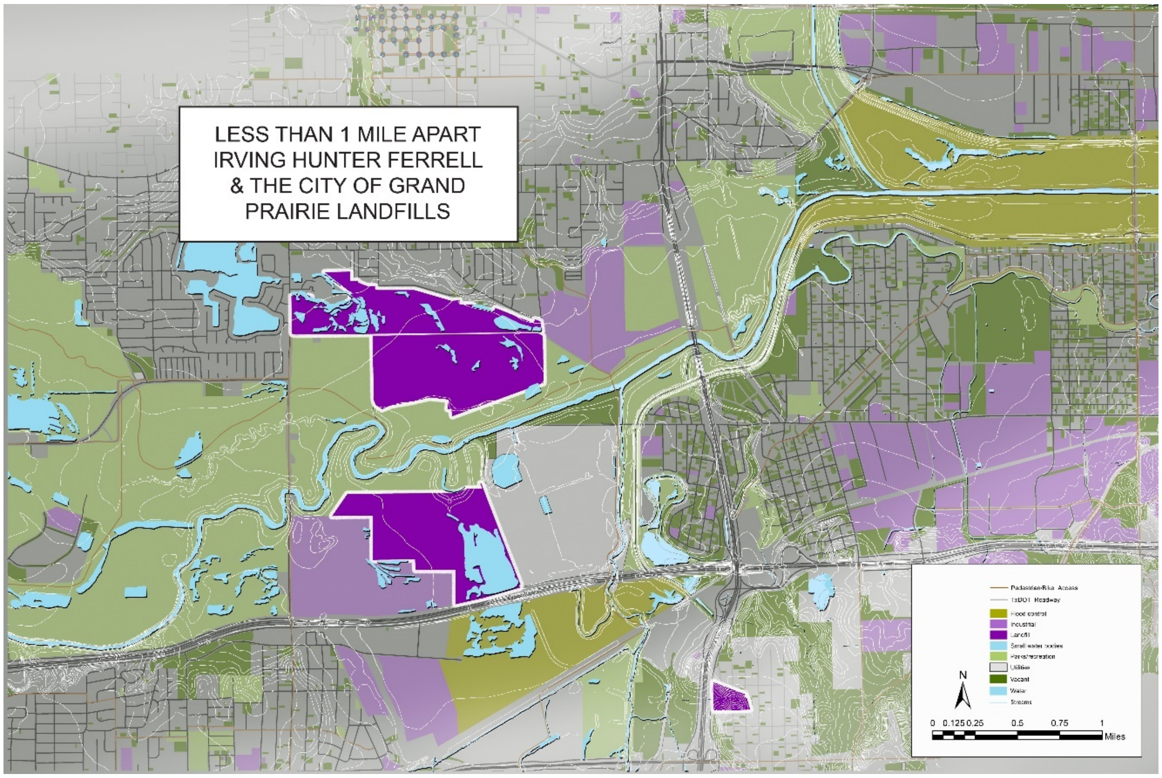


Figure 5.15 Landfill Proximity

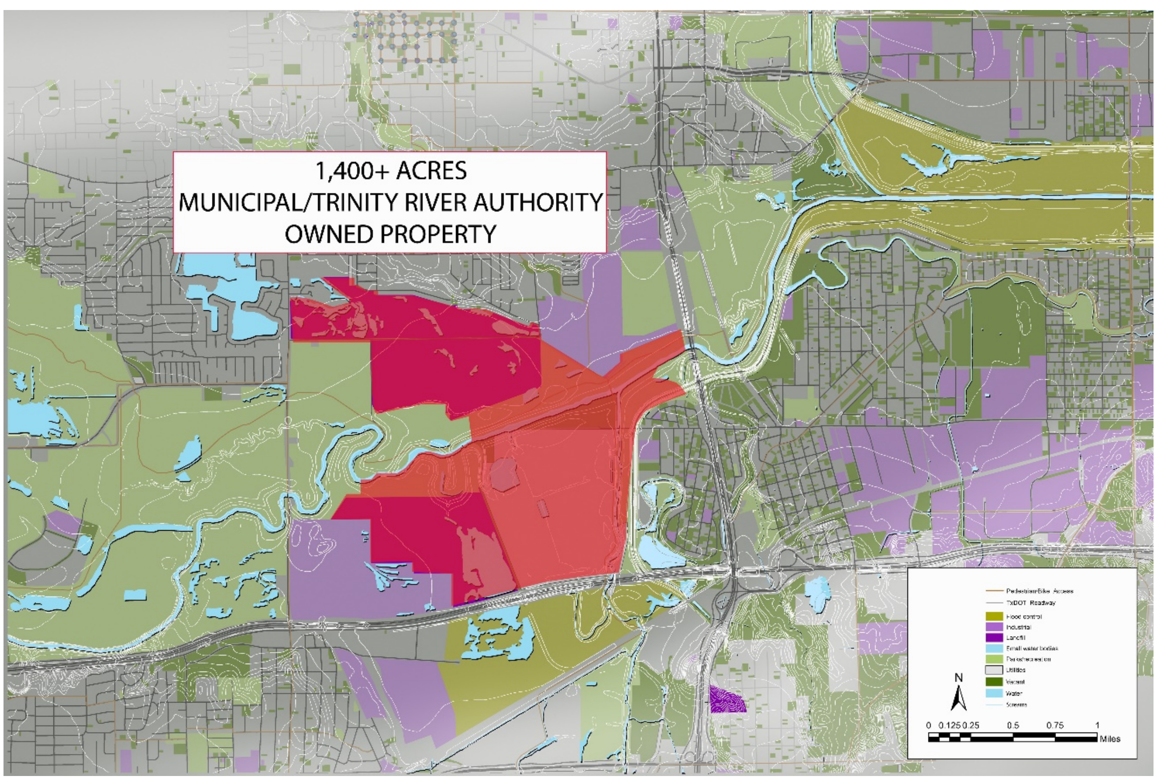


Figure 5.16 Property Ownership Connection

5.3.1 Active Recreation Suitability

The suitability of active recreation is determined by using a scoring and rating weighted suitability through geospatial data analysis (GIS). Each of these categories is derived from the layer-cake or overlay method (McHarg, 1992; Steiner, 2008). The ratings and scorings are determined through knowledge of existing active recreational sites and safety perimeters. This section is shown through Table 5.1 for consideration and use as a model for interchanging necessary criteria depending on the specific landfill site. The product of the Active Recreation Suitability Criteria, Table 5.1, is the Active Recreation Suitability Map, Figure 5.17.

Suitable Categories	Sub-Categories	Rating	Scoring	Weight
Slope	Slope %	0-5%	1.0	.15
		6%-10%	.7	
		11%-15%	.5	
		16%-20%	.3	
		>20%	.1	
Hydrology	Floodplain	100	.1	.05
		500	.5	
		Clear	1.0	
Vegetation	Landcover	584	.1	.5
		565	.3	
		583	.5	
		582	.7	
		581	1.0	
Human	Roads/Highways	0.05 Miles	.1	.3
		0.1 Miles	1.0	
		0.5 Miles	.7	
		>1.0 Miles	.3	
Total				1.0

Table 5.1 Active Recreation Suitability Criteria

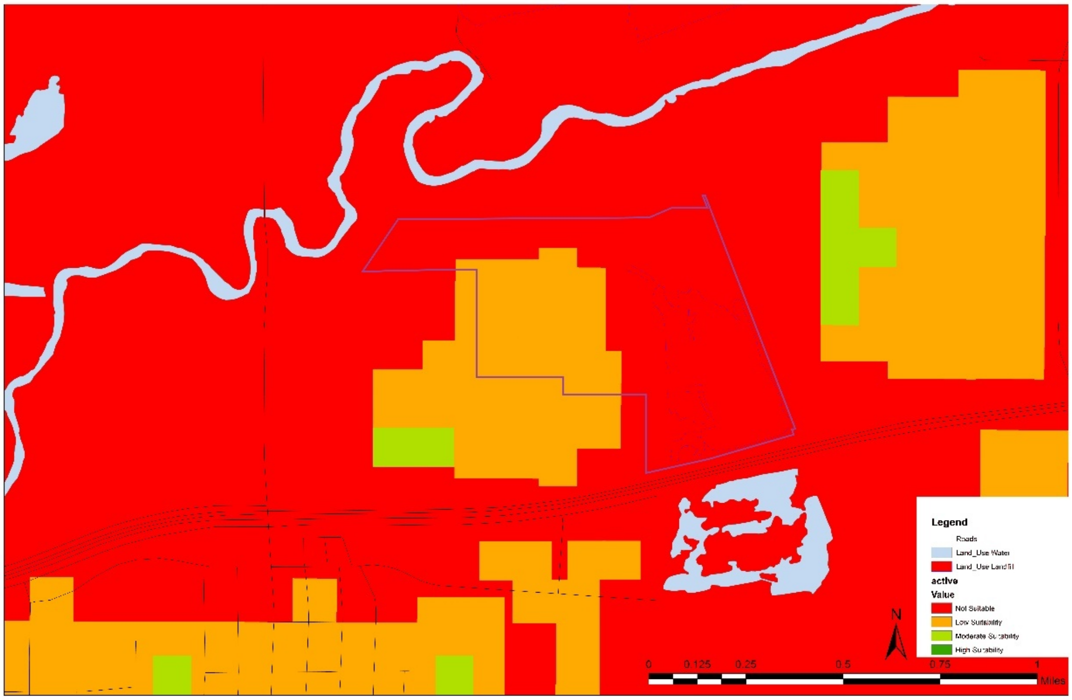


Figure 5.17 Active Recreation Suitability Map

5.3.2 Passive Recreation Suitability

The suitability of passive recreation, similar to the active criteria, determined by using a scoring and rating weighted suitability through geospatial data analysis (GIS). Each of these categories is derived from the layer-cake or overlay method (McHarg, 1992; Steiner, 2008). The ratings and scorings are determined through knowledge of existing passive recreational sites and safety parameters. This section is shown through Table 5.2 for consideration and use as a model for interchanging necessary criteria depending on the specific landfill site. The product of the Passive Recreation Suitability Criteria, Table 5.2, is the Passive Recreation Suitability Map, Figure 5.18.

Suitable Categories	Sub-Categories	Rating	Scoring	Weight
Slope	Slope %	0-5%	1.0	.05
		6%-10%	.7	
		11%-15%	.7	
		16%-20%	.7	
		>20%	.7	
Hydrology	Floodplain	100	1.0	.05
		500	.7	
	Water Bodies	<0.1 Mile	1.0	.15
		.1-.25 Mile	.7	
		.25-.5 Mile	.5	
	Small Water Bodies	<0.1 Mile	1.0	.15
		.1-.25 Mile	.7	
		.25-.5 Mile	.5	
Vegetation	Woodland	<.1 Mile	1.0	.1
(Landcover)		.1-.25 Miles	.7	
		.25-.5 Miles	.5	
		>.5 Miles	.3	
	Wetland	<.1 Mile	1.0	.1
		.1-.25 Miles	.7	
		.25-.5 Miles	.5	
		>.5 Miles	.3	
Human	Roads/Highways	0.05 Miles	.1	.05
		0.1 Miles	1	
		0.5 Miles	.7	
		>1.0 Miles	.3	
	Existing Parks	<.1 Mile	1.0	.20
		.1-.25 Miles	.7	
		.25-.5 Miles	.5	
		>.5 Miles	.3	
	Veloweb	<.1 Mile	1.0	.15
		.1-.25 Miles	.7	
		.25-.5 Miles	.5	
Total				1.0

Table 5.2 Passive Recreation Suitability Criteria

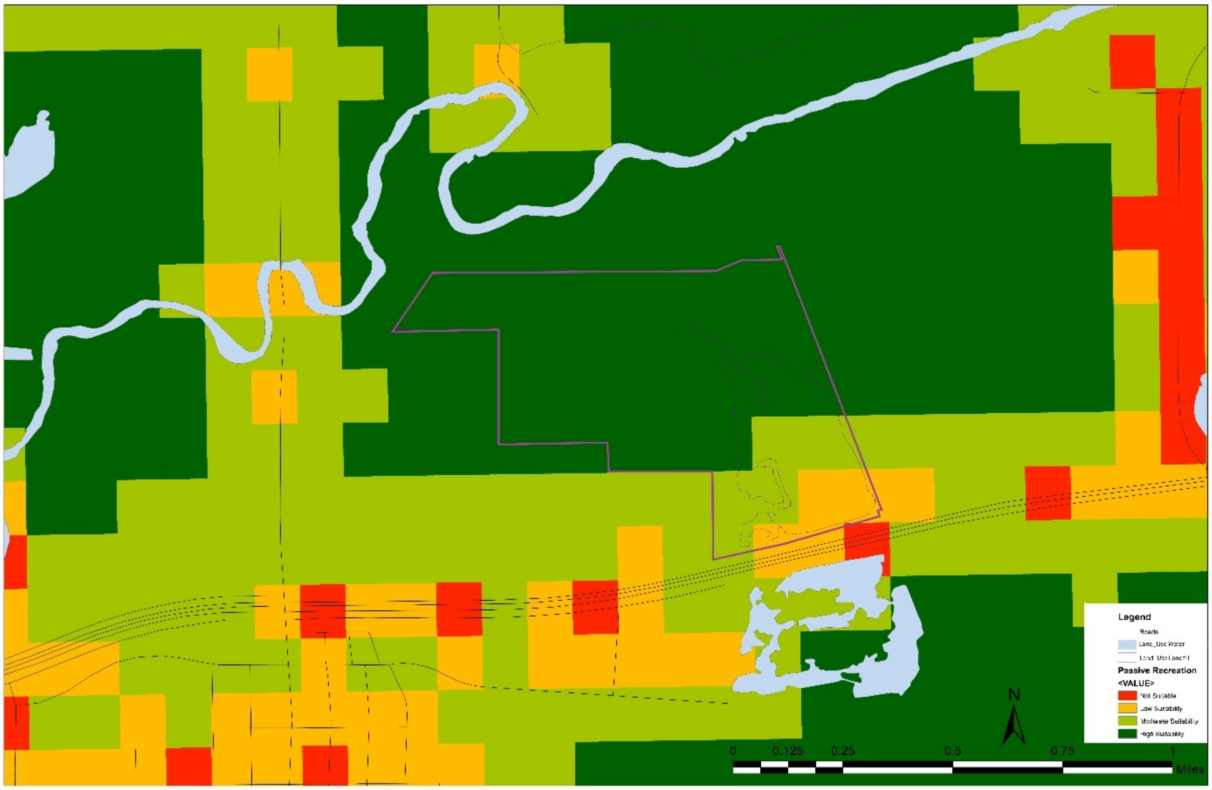


Figure 5.18 Passive Recreation Suitability Map

5.3.3 City of Grand Prairie Landfill Native Flora

Understanding the native plant palette for North Central Texas is crucial to the planning and design of this landfill site because of its' need for remediation and restoration. This sensitive engineered land also needs to be evaluated based on its specific liners and caps for a thorough planting plan. Each landfill site is different and explicit. The Riparian Restoration and Wetland plant lists, Figures 5.19-20, for this site source from the *Project Abstract* case studies, Lady Bird Johnson Wildflower Center Native Databases, and Texas Parks and Wildlife.

Latin Name	Common Name	Latin Name	Common Name
Aesculus pavia	Scarlet Buckeye	Maclura pomifera	Osage Orange
Amblyolepsis setigera	Huisache Daisy	Morus rubra	Red Mulberry
Bouteloua hirsuta	Hairy Grama	Chasmanthium Latifolium	Inland Sea Oats
Bothriochloa laguroides	Silver Bluestem	Andropogon glomeratus	Bushy Bluestem
Bouteloua rigidiseta	Texas Grama	Cephalanthus occidentalus	Common Buttonbush
Celtis ehrenbergiana	Desert Hackberry	Schizachrium scoparium	Little Bluestem
Chloris cucullata	Hooded Windmill Grass	Sorghastrum nutans	Indiangrass
Chamaecrista fasciculata	Partridge Pea	Tripsacum dactyloides	Eastern Gamagrass
Cooperia drummondii	Evening Rain lily	Panicum virgatum	Switchgrass
Condalia hookeri	Bluewood Condalia	Hilaria belangeri var. belangeri	Curly-mesquite
Desmanthus virgatus	Prostrate Bundleflower	Leptochloa dubia	Green Sprangletop
Elymus Canadensis	Canada Wild Rye	Bouteloua curtipendula	Sideoats Grama
Gaillardia pulchella	Indian Blanket	Bouteloua dactyloides	Buffalo Grass
Helianthus maximiliani	Maximilian Sunflower	Taxodium distichum	Bald Cypress
Panicum obtusum	Vine Mesquite	Ulmus americana	American Elm
Salvia coccinea	Scarlet Sage	Ulmus Crassifolia	Cedar elm
Salix nigra	Black Willow	Quercus fusiformis	Escarpment Live Oak
Solidago altissima	Tall Goldenrod	Quercus macrocarpa	Bur Oak
Trichloris plurflora	Multi-flowered False-rhodesgrass	Platanus occidentalis	American Sycamore
Vachellia farnesiana	Huisache	Prosopsis glandulosa	Honey Mesquite
Viguiera dentata	Plateau Goldeneye	Juglans nigra	Black Walnut
Wedelia acapulcensis var. hispida	Zexmenia	Diospyros texana	Texas Persimmon
Phyla nodiflora	Texas Frogfruit	Carya Illinoinensis	Pecan
Populus deltoides ssp. Deltoides	Eastern Cottonwood	Acer negundo	Box Elder

Figure 5.19 Riparian Restoration Plant List

Latin Name	Common Name	Latin Name	Common Name
Andropogon glomeratus	Bushy Bluestem	Morus rubra	Red Mulberry
Arisaema dracontium	Green Dragon	Muhlenbergia schreberi	Nimblewill
Carex blanda	Eastern Woodland Sedge	Nymphaea odorata	American White Water-lily
Chasmanthium Latifolium	Inland Sea Oats	Physostegia intermedia	Spring Obedient Plant
Conoclinium coelestinum	Blue Mistflower	Phyla nodiflora	Texas Frogfruit
Cyperus retroflexus	Oneflower Flatsedge	Populus deltoides ssp. Deltoides	Eastern Cottonwood
Equisetum hymale var. affine	Scouring-rush Horsetail	Pteridium aquilinum	Western Bracken Fern
Equisetum laevigatum	Smooth Horsetail	Ptelea trifoliata	Wafer Ash
Erythrina herbacea	Coralbean	Sagittaria lancifolia	Lanceleaf Arrowhead
Fraxinus pennsylvanica	Green ash	Sabal Minor	Dwarf Palmetto
Hibiscus moscheutos	Crimson-eyed Rosemallow	Sambucus nigra ssp. Canadensis	Common Elderberry
Iris brevicaulis	Zigzag Iris	Schoenoplectus californicus	California Bulrush
Iris virginica	Virginia Iris	Tilia americana var. caroliniana	Carolina Basswood
Kosteletzkya virginica	Virginia Saltmarsh Mallow	Rhus aromatica	Fragrant Sumac
Lobelia cardinalis	Cardinal Flower	Amorpha fruticosa	Indigo Bush
Ludwigia peploides	Creepinga Water-primrose	Ulmus Crassifolia	Cedar elm
Malvaviscus arboreus var. drummondii	Turks Cap	Taxodium distichum	Bald Cypress
Marsilea macropoda	Bigfoot Water-clover	Quercus macrocarpa	Bur Oak
Maclura pomifera	Osage Orange	Prunus mexicana	Mexican Plum
		Platanus occidentalis	American Sycamore

Figure 5.20 Wetland Plant List

5.3.4 Native Fauna

Awareness of the native fauna within North Texas is equally as important as the native flora. Understanding what lives or is supposed to inhabit this site helps increase the percentage of biodiversity and ultimately success for the restoration of the closed landfill. This inventory also creates an awareness of the threatened or endangered fauna in the area. The sources for this native and local fauna are Texas Parks and Wildlife, and A Natural History of North Central Texas Animal Life.

Latin Name	Common Name	Latin Name	Common Name
Anaxyrus woodhousii	Woodhouse's toad	Gambusia affinis	Western Mosquito Fish
Pseudacris streckeri	Strecker's chorus frog	Pomoxis annularis	Juvenile White Crappie
Plegadis chihi	white-faced ibis	Cyprinella lutrensis	Red Shiner
Mycteria americana	wood stork	Micropterus salmoides	Largemouth Bass
Haliaeetus leucocephalus	bald eagle	Ictiobus bubalus	Smallmouth Buffalo
Laterallus jamaicensis	Black Rail	Aplodinotus grunniens	Freshwater Drum
Grus americana	Whooping crane	Ictalurus furcatus	Blue Catfish
Charadrius melodus	Piping plover	Notropis shumardi	Silverband Shiner
Calidris canutus rufa	Rufa Red Knot	Morone chrysops	White Bass
Leucophaeus pipixcan	Franklin's gull	Percina sciera	Dusky Darter
Sternula antillarum athalassos	Interior least tern	Puma concolor	Mountain lion
Athene cunicularia hypugaea	Western burrowing owl	Macrochelys temminckii	Alligator snapping turtle
Vireo atricapilla	Black-capped vireo	Terrapene carolina	Eastern box turtle
Setophaga chrysoparia	Golden-cheeked warbler	Terrapene ornata	Western box turtle
Anguilla rostrata	American eel	Ophisaurus attenuatus	Slender glass lizard
Myotis austroriparius	Southeastern myotis bat	Phrynosoma cornutum	Texas horned lizard
Myotis velifer	Cave myotis bat	Thamnophis sirtalis annectens	Texas garter snake
Perimyotis subflavus	Tricolored bat	Crotalus horridus	Timber (canebrake) rattlesnake
Eptesicus fuscus	Big brown bat	Sistrurus tergeminus	Western massasauga
Sylvilagus aquaticus	Swamp rabbit	Bombus pensylvanicus	American bumblebee
Microtus pinetorum	Woodland vole	Pogonomyrmex comanche	Comanche harvester ant
Mustela frenata	Long-tailed weasel	Arethaea ambulator	No accepted common name
Spilogale putorius	Eastern spotted skunk	Lampsilis satura	Sandbank Pocketbook
Conepatus leuconotus	Western hog-nosed skunk	Pleurobema riddellii	Louisiana Pigtoe
Odocoileus virginianus	White-tailed Deer	Potamilus amphichaenus	Texas Heelsplitter

Figure 5.21 Local Fauna List

5.4 Design Questions

- What makes a public space successful?
- How can public access and restoration coexist?
- How much of the sensitive site should be accessible?
- What programs can be placed directly on the landfill area?
- Are there additional peripheral amenities to link?

5.5 Conceptual and Schematic Design

The researcher focused on understanding the history of the site through landcover data, current accessibility/circulation, existing adjacent land-uses and ownerships, the detailed suitability maps (Figures 5.17 & 5.18), and research findings of analysis methods to recommend design elements and planning strategies.

5.5.1 Function and Programmatic Elements

The programmatic elements and their functions create a public amenity. These aspects are derived from the data collection and analysis methods earlier in the research. Figure 5.22 shows the synthesis of elements in a simple equation format resulting in a function diagram.

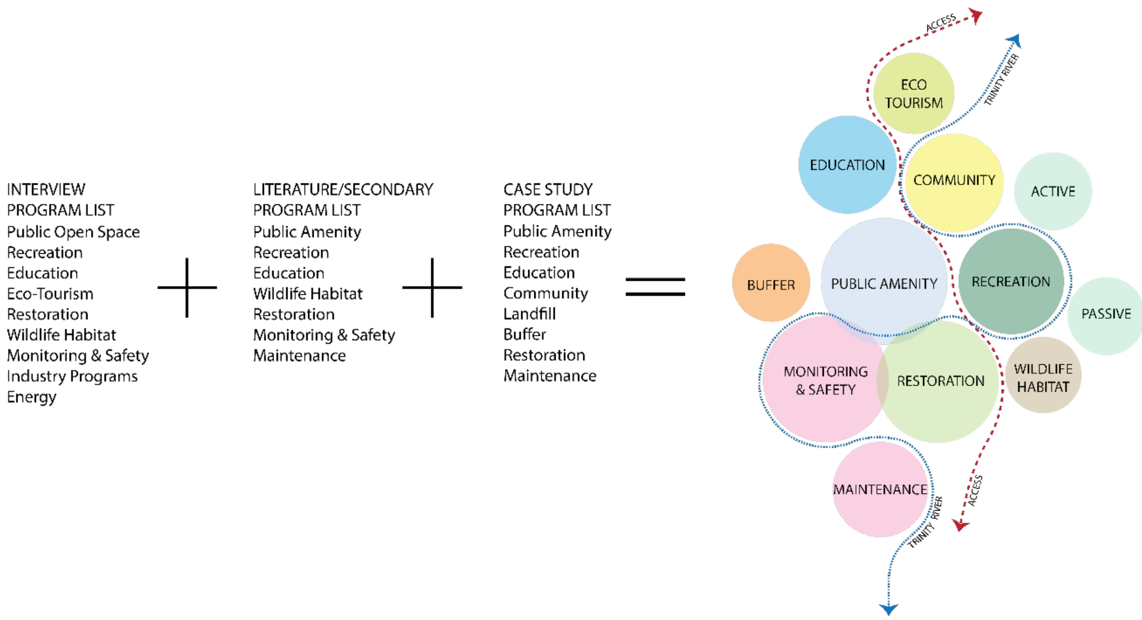


Figure 5.22 Synthesis of Function Diagram

5.5.2 Concept

The conceptual plan diagram, in Figure 5.23, visualizes the synthesized function diagram, in Figure 5.22, from ideas to the City of Grand Prairie Landfill site. The concept holds priority to restoration of the post-closure landfill site and mostly passive recreation such as trails and paths. The conceptual design also meets the results from Chapter 4's synthesis and findings:

1. Public outdoor spaces are necessary amenities.
2. Subtitle D landfill land can and should be repurposed for public use, following requirements and safety regulations.
3. Passive recreation has a higher likelihood of success, rather than active recreation, on landfill land.
4. Not all repurposed spaces on closed landfill land need public access or disturbance.

5. The Grounded Theory for Repurposing Landfills using four simplified parts: where, when, why, and what, should apply to all landfill sites, not just Subtitle D, approaching closure (Glaser & Strauss, 1980).
6. Generalizable features and lessons learned can be viable programs or options for planning and design no matter the region.

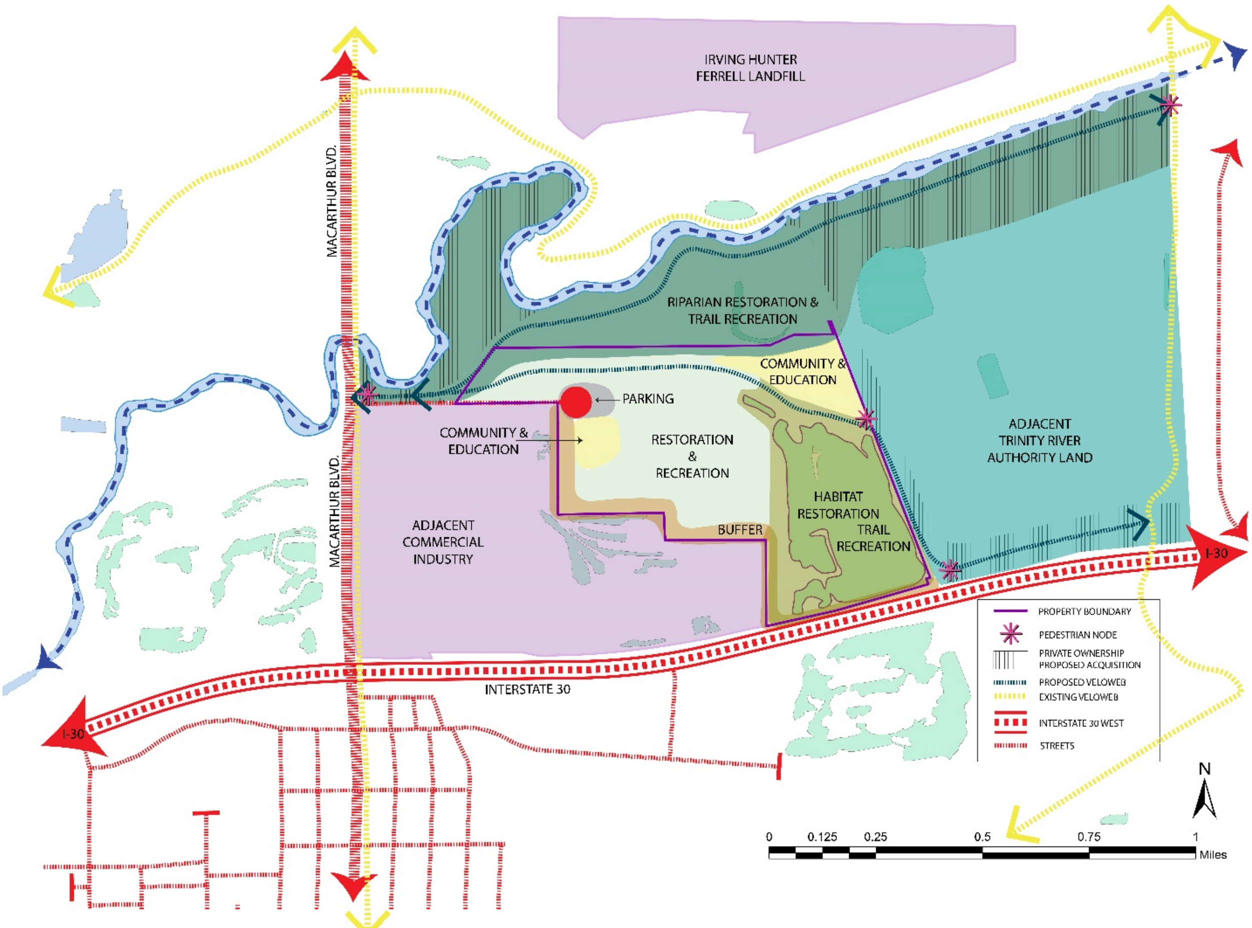


Figure 5.23 Conceptual Design Diagram

5.5.4 Schematic Design

The Schematic Design, Figure 5.24, embodies the conceptual diagram in all programmatic elements and contextual aspects. The design is site specific to the City of Grand Prairie Landfill and the West Fork of the Trinity River. The priorities of the design are restoration and public access. The passive recreation trails on the original property boundary mimic the circulation of the once active site, history of waste production and management is an important aspect to feed into this design process. The regional Veloweb is an important consideration for pedestrian and cycling transportation, which this design assures new connections and signature nodes to add to the map. The newfound elevation of the land is an advantage for public viewing of the new restored areas, the higher topography creates an opportunity for overlook and education spaces. The features within the design are generalizable, suiting the research in this thesis as a template for repurposing Subtitle D landfills, this ensures the visibility of such features and the realized potential of the site and its' surroundings.

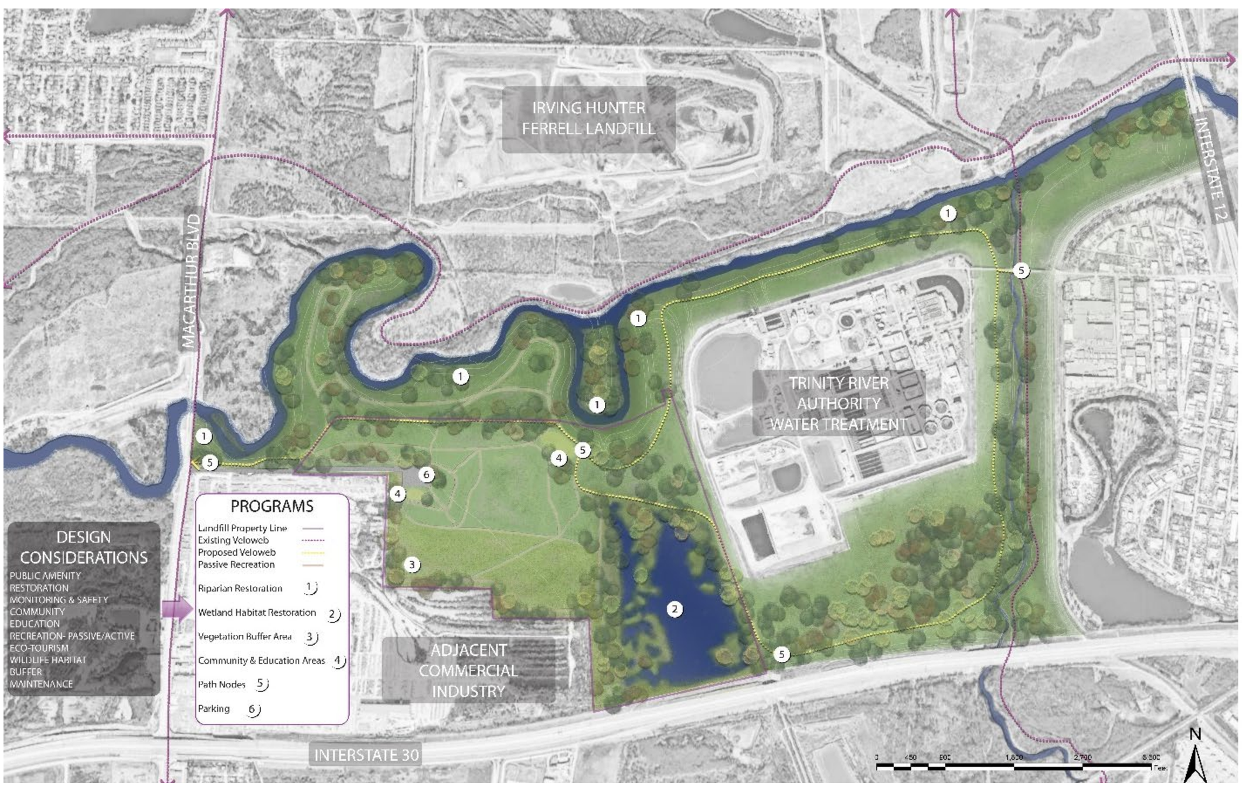


Figure 5.24 Schematic Design for the City of Grand Prairie Landfill

5.6 Design Details

The design details for this research are conceptual conclusions to visibly recognize the findings. These details show possibilities from the recommended programs specifically for the City of Grand Prairie Landfill in Dallas County, Texas.

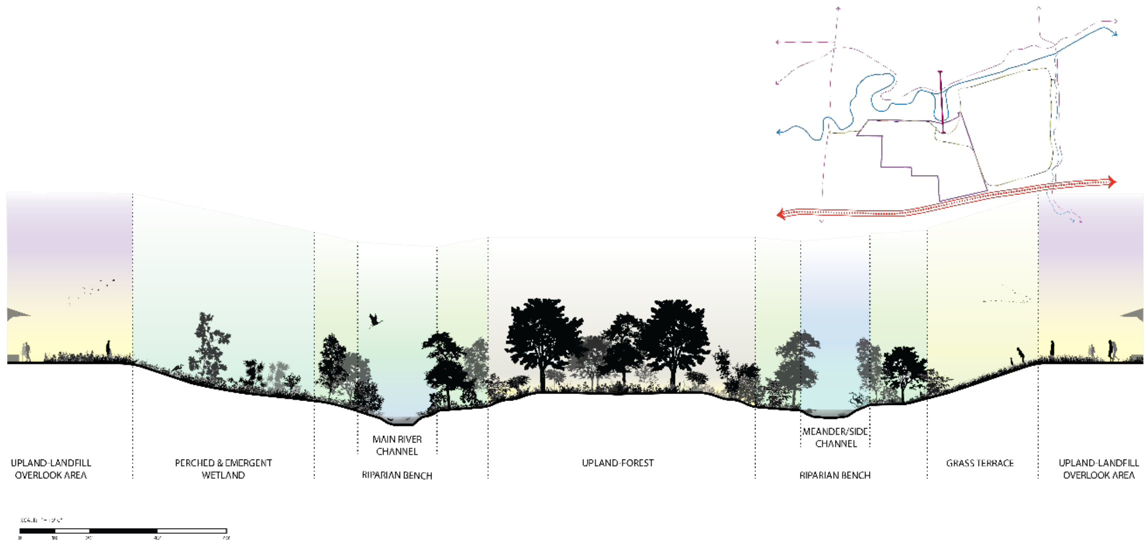


Figure 5.25 Trinity River and Riparian Restoration Elevation

Figure 5.26 Community and Education Area

Figure 5.27 Pedestrian Path Node

Figure 5.28 Trailhead and Buffer Area

5.7 Planning & Design Summary

This chapter reviews the synthesis of data collected in Chapter 4, which are the regional and site selection criteria and suggested design strategies for the City of Grand Prairie Landfill. This chapter also discusses the detailed geospatial suitability analysis conducted for the City of Grand Prairie Landfill, which highlights the existing conditions such as vehicular and pedestrian circulation. This information is intended to inform recommended design criteria and how they apply to the site.

This planning and design proposal repurposes a Subtitle D landfill in Dallas County, the City of Grand Prairie Landfill, along the West Fork of the Trinity River. These recommendations stem from researching the larger scale of Dallas County to the 5-mile radius scale and down to the 1-mile radius scale. The suitability of the programmatic elements is consistent with the findings from the analysis methods in Chapter 4, prioritizing restoration and passive recreation for public outdoor amenity and benefit. From this approach, the contextual links, opportunities, and constraints became visible and design solutions deliverable, which shows results of using the elements and criteria stated within the base template for repurposing Subtitle D landfill land.

CHAPTER 6

CONCLUSION

6.1 Introduction

Public outdoor amenities are a vital part of cities, whether big or small they contribute to a healthy livelihood. Post-closure landfill land, as stated and found in this research, is a solution to the depleting green open spaces and natural corridors within urban environments. Landscape architects play a vital role in this repurposing transition of landfill to amenity especially in the Subtitle D landfills in the North Texas region.

The following section briefly reviews the research questions studied within this master's design thesis, the implications for landscape architecture, and future areas of research.

6.2 Responses to Research Questions

The objective of this master's design thesis is to assess opportunities to repurpose public landfill sites in Dallas County, Texas and propose a design for one of the five active landfill sites to be implemented at close. This research identified criteria for optimal design and planning strategies in the landfill closure and post-closure process (pertaining to landscape architecture). This in turn provided suitable options for communal programming of closed landfill sites including enabling restoration of ecosystem conditions to become more comparable to pre-landfill use.

How can Subtitle D landfills in a large urban area be repurposed for public outdoor use to extend amenity opportunities on public lands?

Through literature review, analysis of archival and secondary data through geospatial analysis, case study reviews, and interview research it is determined that Subtitle D landfills can be repurposed in large urban areas for at least open green space, restoration, and passive recreation. Chapter 4 reviews the findings for design program recommendations, while Chapter 5 employs and applies the findings to the repurposing of the City of Grand Prairie landfill. The findings state that each major impact site, such as these, can be repurposed for public outdoor use following regulations. Each landfill site is different and holds varying capabilities.

What design/planning criteria can be used to repurpose Subtitle D landfill landscapes in Dallas County?

A tailored and detailed ArcGIS suitability analysis is effective tools in producing broad categories of criteria, and processes to design and plan such sites. The Environmental Protection Agency and Resource Conservation and Recovery Act (RCRA) Subtitle D dictate the planning timeline of certain landfills and landfill areas. This does not stop the design or planning process, just lengthens the actuality or construction of a full site.

What are major lessons learned from repurposing/redesigning a landfill site for public outdoor use?

Major lessons learned from redesigning a landfill site are connectivity and context, as well as the difficulty of how much accessibility should there be on the site. These sensitive areas need aid and time to cycle themselves back to pre-landfill functioning landscapes.

Additional response: It is clear through GIS inventory, analysis, and interview research that Dallas County desperately needs to preserve and maintain the natural public outdoor spaces that exist, as well as continue to produce new public outdoor amenities for the increasing population it is supposed to ascertain.

6.3 Template for Repurposing Subtitle D Landfill Land

This master's design thesis reveals a base template for repurposing Subtitle D landfill land. The base includes: A Grounded Theory for Repurposing Landfills, site selection through geospatial data inventory and analysis from large to small scales, a detailed site suitability analysis to inform programmatic recreational elements, and synthesis of function and program elements to inform conceptual and schematic design (Glaser& Strauss, 1980; Steiner, 2008; McHarg, 1992). This template is flexible and built to be modified and or expanded depending on the area and site.

6.4 Discussion

Landfills seem untouchable. These sites hold a stigma from the pre-Subtitle D era and the nature of the industry in general, but there has been a shift over the years. Especially through the year 2020, the need for more public outdoor or open space has become very apparent in urban areas, which also follows ecological, environmental and climate change related concerns.

Currently, Subtitle D sites are eligible for repurposing, but pre-closure there is a need for rigorous planning and design initiation. These plans and designs established pre-closure, enable evolution and revision as the 30-year monitoring period moves, thus allowing the landscape to move with the time rather than it stand still fractured. The feasibility of these projects begins to increase as the planning continues because of the lengthy timeline for safety and regulation. It may be a difficult task to keep the public interested and enthused with the project over the duration, but nonetheless essential and critical pieces of land to restore and open for the public in growing cities.

6.5 Implication for Landscape Architecture

The ground has already been broken, so to speak, for the role of the Landscape Architect in the repurposing of landfill land. That being said, it is also realized through this research that the published information on this topic from landscape architecture resources or perspectives are fairly limited. It is believed that interventions through the discipline and profession of landscape architecture can bring new life to these vast stagnant and conventionally absolute environments especially within metropolitan landscapes.

It is also realized that there are repurposed landfills that exist as public parks, wildlife habitat sites, energy production sites, and those repurposed for additional industry use or a hybrid with public amenities. From this research, it is evident that the implication for the Landscape Architect has evolved from breaking ground into the remediation, repurposing, and having success to availability, suitability, and frequency. Landscape Architecture professionals should be aware of these landscapes and their timeline, therefore providing opportunities before they are truly available for repurposing. If professionals have knowledge of this timeline, it opens doors early enough for research into suitability of programming, which in turn produces feasibility and frequency. The frequency of which these properties are cycled back to functional landscapes is slowly increasing, which is a call to action for landscape architecture professionals to mend these often dormant and broken environments, potentially through the template created in this research.

6.6 Future Research

The repurposing of landfills involves many professional fields (engineering, landscape architecture, horticultural, sanitation, etc.), creating special considerable topics of future research. Through interviews with professionals and case study research a selection emerged to the forefront. It is known by those in the industry for closed landfills to function in additional industry use, like disaster processing or holding sites, transfer stations, and citizen convenience stations. Each of these industry related purposes have action plans associated with the function and can coexist with a more natural or environmental amenity. Further industry uses or hybrid with environmental elements is a topic for landscape architects to explore when repurposing these spaces.

Another topic is pre-Subtitle D closed landfills. These landfills are large in number because of their history of closure after RCRA Subtitle D regulations were put into place, and most sit dormant with unactualized potential. These landscapes are difficult to assess because thorough documentation of their past is limited. Numerous, varying in size, and location resulting in overflow of prospective function.

Lastly, Dallas County has the potential for a catalyst project with the City of Grand Prairie Landfill in connection with the Irving Hunter Ferrell Landfill directly across the West Fork of the Trinity River within a mile of each other. These landfills are projected to close just two years apart. Rather than claiming or expanding permits these municipalities should consider the repurposing options and its' potential for massive public amenity and benefit. If the cities begin planning and design on these properties hastily, based on the research concluded from this thesis, it greatly affects the timeline and the financial components. Repairing these wetland clad industrial lands and prioritizing them for benefit in an environmental sense sets a tone for the quality of life of these increasing populations of Dallas County, Texas.

REFERENCES

Abichou, T., Musagasa, J., Yuan, L., Chanton, J., Tawfiq, K., Rockwood, D., & Licht, L. (2012). Field performance of alternative landfill covers vegetated with cottonwood and eucalyptus trees. *International Journal of Phytoremediation*, *14 Suppl 1*, 47–60. Retrieved from https://search.ebscohost.com/login.aspx?direct=true&db=cmedm&AN=22574380&site=ehost-live

Aluko, & Sridhar MK. (2005). Application of Constructed Wetlands to the Treatment of Leachates from a Municipal Solid Waste Landfill in Ibadan, Nigeria. *Journal of Environmental Health*, *67*(10), 58–62. Retrieved from https://search.ebscohost.com/login.aspx?direct=true&db=ccm&AN=106085607&site=ehost-live

Basic Information about Landfills. (2020, March 2). Retrieved from https://www.epa.gov/landfills/basic-information-about-landfills#whatis

Carlson, M. C., Koepke, J., & Hanson, M. P. (2011). From Pits and Piles to Lakes and Landscapes. *Landscape Journal*, *30*(1), 35–52. https://doi.org/10.3368/lj.30.1.35

Charmaz, K. (2014). *Constructing Grounded Theory* (Second ed.). London, United Kingdom: Sage.

Christensen, A. J. (2005). *Dictionary of Landscape Architecture and Construction*. New York, NY: McGraw-Hill.

Closed Landfill Inventory. (2020). Retrieved from https://www.nctcog.org/envir/materials-management/closed-landfill-inventory

The Landfill. (2000, June). Retrieved November 09, 2020, from https://redrockcanyonopenspace.org/education/history/the-landfill/

eCFR - Code of Federal Regulations. (2020, May 7). Retrieved from https://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title40/40cfr258_main_02.tpl

Deming, M. E., & Swaffield, S. (2011). *Landscape Architectural Research: Inquiry, Strategy, Design*. Hoboken, NJ: John Wiley & Sons.

Dictionary by Merriam-Webster: America's most-trusted online dictionary. (2020). Retrieved December 13, 2020, from https://www.merriam-webster.com/

Engler, M. (1997). Repulsive Matter: Landscapes of Waste in the American Middle-Class Residential Domain. *Landscape Journal*, *16*(1), 60. https://doi.org/10.3368/lj.16.1.60

EPA's final rule on pharmaceutical waste material effective August 21. (2019). *PPS Alert for Long-Term Care*, *22*(5), 4–7.

EPA issues final rule on hazardous waste handling. (2019). *Healthcare Life Safety Compliance*, *22*(5), 4–7.

EPA Officially Stays Landfill Methane Rules. (2017). *Waste360*, 1.

EPA Re-Proposes Revisions to the RCRA Definition of Solid Waste. (2007). *Hazardous Waste Consultant*, *25*(3), 2.1-2.10.

EPA Studies MSW Composition at U.S. Virgin Islands Landfills. (2019). *Waste360*, N.PAG.

Francis, M. (2001). A Case Study Method for Landscape Architecture. *Landscape Journal, 20*(1), 15-29. doi:10.3368/lj.20.1.15

Francis, C., & Marcus, C. C. (2003). *People Places: Design Guidelines for Urban Open Space* (Second ed.). New York City, NY: John Wiley & Sons.

Francis, M. (2003). *Urban Open Space: Designing for User Needs*. Washington, DC: Island Press.

Galatowitsch, S. M. (1998). Ecological Design for Environmental Problem Solving. *Landscape Journal*, *17*(2), 99. https://doi.org/10.3368/lj.17.Special_Issue.99

Glaser, B. G., & Strauss, A. L. (1980). *The Discovery of Grounded Theory: Strategies for Qualitative Research*. Hawthorne, NY: Aldine Publishing Company.

Heater Jr., R. T., Blazej, N. J., & Moore, I. S. (1999). Whose Wild? Resolving Cultural and Biological Diversity Conflicts in Urban Wilderness. *Landscape Journal*, *18*(2), 137. https://doi.org/10.3368/lj.18.2.137

Holm, B. A., Holm, K. E., Shelton, D. P., Rodie, S. N., Feehan, K. A., & Franti, T. G. (2014). *Stormwater Management: What Stormwater Management Is and Why It Is Important* [PDF]. Lincoln: University of Nebraska-Lincoln.

Humphreys, R. (2019, August 12). Newly-named and redesigned Irving Golf Club to open this month. Retrieved from https://www.golfcoursearchitecture.net/content/newly-named-and-redesigned-irving-golf-club-to-open-this-month

Knotts, A. M. (2005, November 04). *A Landfill Reclamation Project: An Observatory that Observes the Self* [PDF]. Alexandria: Virginia Polytechnic Institute and State University.

Landfill Engineering Archive. (2017, January 3). Retrieved from https://freshkillspark.org/landfill-engineering

Landfill. (2020, May 10). Retrieved May 10, 2020, from https://www.merriam-webster.com/dictionary/landfill

Limón, E. (2019, August 25). Irving will spend millions to plug Twin Wells Golf Course flooding issues. Retrieved from https://www.dallasnews.com/news/2017/05/05/irving-will-spend-millions-to-plug-twin-wells-golf-course-flooding-issues/

Lynch, K. (1965). *The Image of the City*. Cambridge, MA: The M. I. T. Press.

Lynch, K., & Hack, G. (1984). *Site Planning* (Third ed.). Cambridge, MA: Cambridge University Press.

McHarg, Ian L. (1992). *Design with Nature*. New York, NY: John Wiley & Sons.

Miller, G. (2018, January 10). MoneyGram Soccer Park Named Field of the Year by SportsTurf Magazine. Retrieved November 09, 2020, from https://www.fcdallas.com/post/2018/01/10/moneygram-soccer-park-named-field-year-sportsturf-magazine

Moses, R. (1951). *Fresh Kills Landfill* [PDF]. New York City: City of New York.

Mount Trashmore: Landfill to Landmark. (n.d.). Retrieved November 09, 2020, from https://www.vbgov.com/government/departments/parks-recreation/parks-trails/city-parks/pages/mount-trashmore-park.aspx

Mount Trashmore Park, Virginia Beach, VA. (2010, May 19). Retrieved November 09, 2020, from https://freshkillspark.org/blog/mount-trashmore-park-virginia-beach-va

Municipal Solid Waste Landfills. (2020, March 26). Retrieved from https://www.epa.gov/landfills/municipal-solid-waste-landfills#regs

Municipal Solid Waste Permits: Learning More. (2019, December 10). Retrieved November 09, 2020, from https://www.tceq.texas.gov/agency/decisions/participation/permitting-participation/msw-type1-landfill

Municipal Solid Waste in Texas: A Year in Review, Data Summary and Analysis. Retrieved from https://www.tceq.texas.gov/assets/public/comm_exec/pubs/as/187-19.pdf

Ogata, Y., Ishigaki, T., Ebie, Y., Sutthasil, N., Witthayaphirom, C., Chiemchaisri, C., & Yamada, M. (2018). Design considerations of constructed wetlands to reduce landfill leachate contamination in tropical regions. *Journal of Material Cycles & Waste Management*, *20*(4), 1961–1968. https://doi.org/10.1007/s10163-018-0755-0

Park, S. Y., Brown, K. W., & Thomas, J. C. (2004). The Use of Biofilters to Reduce Atmospheric Methane Emissions from Landfills: Part I. Biofilter Design. *Water, Air & Soil Pollution*, *155*(1–4), 63–85. https://doi.org/10.1023/B:WATE.0000026522.36984.42

Patton, M. Q. (1990). *Qualitative Evaluation and Research Methods: Integrating Theory and Practice*. Sage Publications.

Pearce, C. (2015, December 06). History of Mount Trashmore Park, Virginia Beach, VA. Retrieved March 22, 2021, from https://chrispearce52.wordpress.com/2015/12/06/history-of-mount-trashmore-park-virginia-beach-va/#:~:text=Roland%20E.,an%20estimated%20cost%20of%20%24192%2C674.

Red Rock Canyon Open Space. (2021, February 23). Retrieved April 12, 2021, from https://coloradosprings.gov/parks/page/red-rock-canyon-open-space

Red Rock Canyon Master and Management Plan 2013 [PDF]. (2013, January). City of Colorado Springs: Parks, Recreation, and Cultural Services Department.

Rules and Regulations: ENVIRONMENTAL PROTECTION AGENCY. (2014). *Federal Register (National Archives & Records Service, Office of the Federal Register)*, *79*(72), 21137–21148.

Sánchez-Arias, M., Riojas-Rodríguez, H., Catalán-Vázquez, M., Terrazas-Meraz, M. A., Rosas, I., Espinosa-García, A. C., Santos-Luna, R., & Siebe, C. (2019). Socio-environmental assessment of a landfill using a mixed study design: A case study from México. *Waste Management*, *85*, 42–59. https://doi.org/10.1016/j.wasman.2018.12.012

Solid Waste Glossary. (n.d.). Retrieved from https://swana.org/resources/solid-waste-glossary

Technical and Management Policies. (2020). Retrieved from https://swana.org/advocacy/technical-management-policies

Steiner, F. R. (2008). *The Living Landscape: An Ecological Approach to Landscape Planning*. Island Press.

U.S. census bureau Quickfacts: Richmond County (STATEN Island BOROUGH), New York. (2019). Retrieved March 10, 2021, from https://www.census.gov/quickfacts/fact/table/richmondcountystatenislandboroughnewyork/INC110219

What is a Sanitary Landfill? (n.d.). Retrieved November 09, 2020, from http://web.mit.edu/urbanupgrading/urbanenvironment/sectors/solid-waste-landfills.html

Wildlife Habitat Sites. (n.d.). Retrieved November 09, 2020, from https://www.wm.com/about/community/whc/wildlife-habitat-sites.jsp