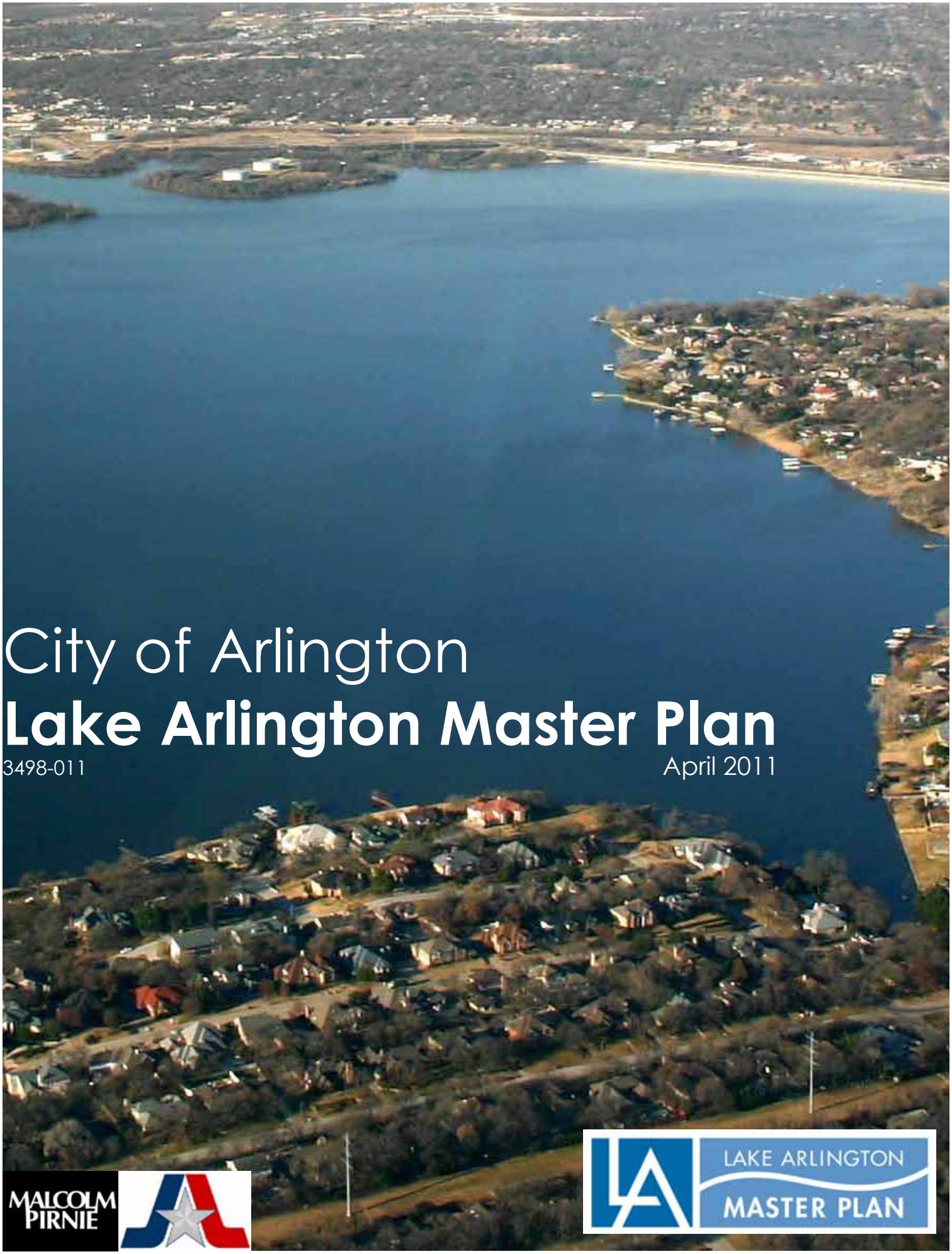

City of Arlington
Lake Arlington Master Plan

3498-011

April 2011

MALCOLM PIRNIE

LAKE ARLINGTON MASTER PLAN

Lake Arlington Master Plan
City of Arlington

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City of Arlington
As the sponsors of this Master Plan, the City of Arlington, Councilmembers and staff actively participated in the development of the Master Plan by participating in Roundtable Discussion Meetings, attending Public Meetings and speaking with stakeholders, and providing input and assistance for the study team throughout the planning process. The City of Arlington served as a vital informational tool throughout this process, and their support and participation are greatly appreciated.

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City of Fort Worth
The City of Fort Worth has been an active partner in the creation of the Lake Arlington Master Plan. City Councilmember Frank Moss, whose district includes the lake front property on the west (Fort Worth) side of the lake, served as a strong advocate for the Lake Arlington Vision and the collaboration with Fort Worth staff. We would like to specifically recognize the following:

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Dana Burghdoff
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Al Godwin
Halff & Associates

North Central Texas Council of Governments (NCTCOG)
The Malcolm Pirnie team worked with the NCTCOG staff and shared information as it was gathered through the Master Plan process, including data for watershed modeling. The NCTCOG also co-hosted two regional meetings with the thirteen cities and two counties within the Village Creek watershed. Their coordination involved two regional meetings with the cities and counties within the watershed.

John Promise, PE
Jack Tidwell
Erin Blackman

Table of Contents

Section 1: Executive Summary **7**
1.1: Purposes of the Project 9
1.2: Vision Statement 9
1.3: Outcomes of the Planning Process 9
1.4: Summary of Recommendations 14
1.5: Implementation 15

Section 2: Introduction **17**
2.1: Introduction 18
2.2: Arlington's Goals and Objectives 20
2.3: The Need for Watershed Management 20
2.4: Influence of Land Use Change 21
2.5: Watershed Protection Planning 25
2.6: Planning Process Highlights 26

Section 3: Scope of Services **28**
3.1: Data Collection 29
3.2: Source Water Protection and Watershed Management 29
3.3: Recreation, Open Space and Development 30
3.4: Public Involvement 32
3.5: Funding Sources 32

Section 4: Description of Planning Process **33**
4.1: Planning Process 34
4.2: Public Involvement Program 35

Section 5: Coordination **43**
5.1: Introduction 44
5.2: Fort Worth Coordination 44
5.3: Involvement with Other Water Organizations 45

Section 6: Description of Lake Arlington and the Watershed **48**
6.1: History of Lake Arlington 49
6.2: Uses of Water 49
6.3: Description of Lake and Immediate Surrounding Area 49
6.4: Dam and Lake Operations 50
6.5: Flowage Easement 54
6.6: Lake Arlington Ordinances 54
6.7: Description of Watershed 54
6.8: Discussion of Potential Sources of Indirect Reuse 54

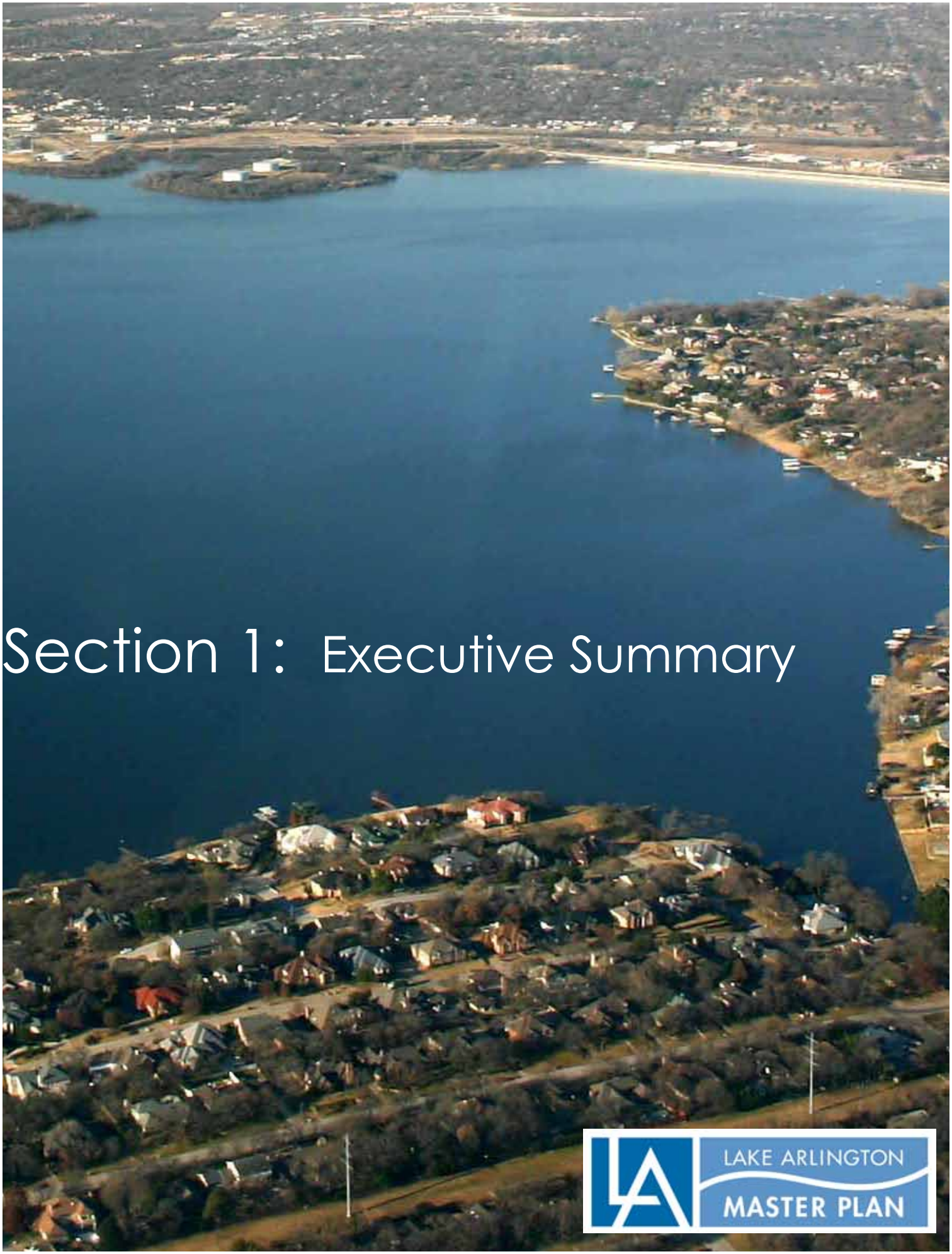
Section 7: Source Water Protection and Watershed Management **60**
7.1: Rationale for Watershed Protection 61
7.2: Data Sources and Quality 65
7.3: Existing Resource Conditions 68
7.4: Likely Pollution Sources 74

7.5: Description of Models 78
7.6: Description and Delineation of Lake Arlington Watershed and Sub-watersheds 81
7.7: Model Results 87
7.8: Facility Impact Assessment 96
7.9: Existing Watershed Management Practices 98
7.10: Conclusions and Recommendations 102

Section 8: Vision Plan 150
8.1: Introduction 151
8.2: Determination of Study Area 151
8.3: Analysis of Study Area 153
8.4: Coordination with the city of Fort Worth 158
8.5: Workshops and Vision Planning 159
8.6: Land Use Strategy 167
8.7: Parks and Open Space 172
8.8: Trails and Linear Parks 176
8.9: Street Framework 176
8.10: Dredging 183
8.11: Development of Design Guidelines and Standards 189
8.12: Boating Capacity Study 222

Section 9: Recommendations and Implementation Plan 230
9.1: Principles, Recommendations and Implementation Plan 231
9.2: Implementation Plan 237

Appendices 246
Appendix 4.1-A: Public Involvement Plan 246
Appendix 4.1-B: Watershed Sign 291
Appendix 4.1-C: Comment Log/E-mail Log 293
Appendix 4.1.D: Fact Sheet, FAQ's and Progress Report 338
Appendix 6.6: Lake Arlington Chapter Ordinance 350
Appendix 7.3-A: Technical Memorandum 383
Appendix 7.3-B: Review of Lake Arlington Water Quality 436
Appendix 7.3-C: Lake Arlington Rainfall Analysis 442
Appendix 7.3-D: Water Quality Modeling – Existing Conditions 452
Appendix 7.6: Water Quality Modeling - Future Conditions 493
Appendix 7.8: Review of Lake Arlington Water Quality 520
Appendix 7.10-A: Trash Reduction 523
Appendix 7.10-B: Model Illicit Discharge Detection and Elimination Ordinance 528
Appendix 7.10-C: Arlington Guide to Stormwater Pollution and Prevention 558
Appendix 8.11: Approved Plant List 626
Appendix 8.12-A: Boating Capacity Study Final Report 630
Appendix 8.12-B: Summary of the 2007 Nationwide Permits 682
Appendix 9.2: Spill/Water Quality Event Response Protocol 690



Section 1: Executive Summary

LAKE ARLINGTON MASTER PLAN

1. Executive Summary

In December 2009, the City of Arlington engaged the environmental engineering and science consulting firm of Malcolm Pirnie to assist the City in developing a master plan for Lake Arlington (the "Project"). Over a period of fifteen months, the study team used a holistic and collaborative process with a very significant amount of agency and public involvement to develop the Lake Arlington Master Plan.

Lake Arlington serves as the source of drinking water for over 500,000 people in Arlington and surrounding communities. Although the Tarrent Regional Water District supplies the majority of the Lake's supply, a significant portion of the drinking water initially comes from springs, stormwater runoff and tributaries within the Village Creek watershed, and drains into Lake Arlington. Figure 1.0-1 is a map of the Village Creek watershed and Lake Arlington. The watershed is approximately 143-square miles in size, however the impacts of activity immediately around the reservoir were also considered in the planning process. While the east side of the reservoir is located within the city limits of Arlington, the west side is predominantly within the City of Fort Worth. In the process of evaluating opportunities for recreational enhancements and land development, and in the development of standards for shoreline activities, the overriding consideration was the effect of those activities on the quality of Lake Arlington's water.

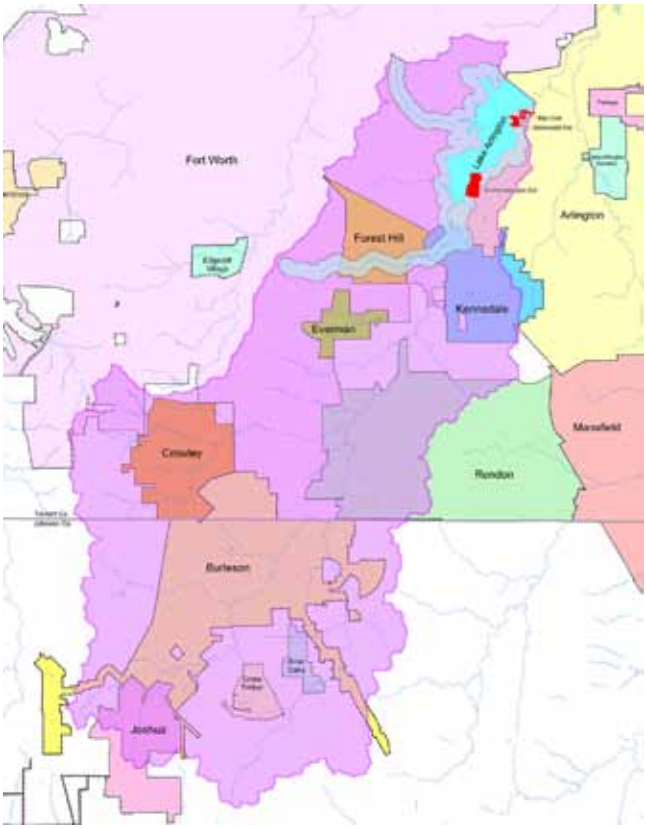


Figure 1.0-1: Village Creek Watershed

Although private property owners own the land surrounding Lake Arlington, the City of Arlington retains a peripheral easement for the temporary storage of flood waters (the "Flowage Easement"). The Flowage Easement of Lake Arlington is the area surrounding the lake between the elevation 560.0 feet above msl contour line and the lake (normally elevation 550.0 feet msl). A theoretical cross section of the Flowage Easement is shown below in Figure 1.0-2. Because of the importance of the Flowage Easement to the operation of Lake Arlington, the City of Arlington exercises considerable control over the activities within that area, both within Arlington and on the west side of the lake in the City of Fort Worth.

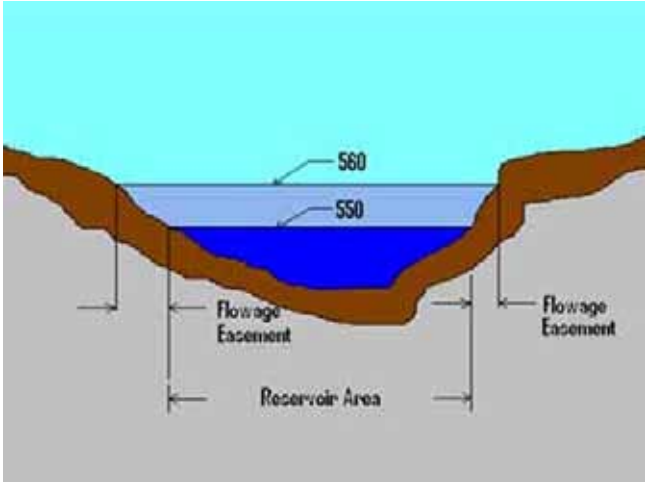


Figure 1.0-2: The Flowage Easement is generally defined as land adjacent to Lake Arl;ington that lies between elevations 550' and 560'.

There are eleven incorporated communities and two counties represented within the Lake Arlington watershed. In order to protect the quality of the water in the lake, it is important to manage the stormwater runoff originating from these various jurisdictions.

1.1 Purposes of the Project

The City's major overall goals of this Project were to:

- Protect the water quality of Lake Arlington
- Serve as both a short-term and a long-term planning tool
- Optimize the recreational use of the Lake and manage the related ecosystems
- Identify the impacts of future development

1.2 Vision Statement

The vision for Lake Arlington is to provide a safe drinking water supply and to protect the Lake and its surroundings by identifying and promoting sustainable uses and watershed management practices that enhance the beauty and the value of Lake Arlington to the community.

Key elements of a sustainable Vision include:

- Protecting lake water quality
- Promoting compatible quality development that strengthens neighborhoods
- Promoting walking, biking, hiking and paddling trails adjacent to the lake
- Enhancing compatible wildlife preservation and fisheries
- Developing watershed best management practices
- Maintaining safety and quality of lake activities
- Promoting natural open space, buffers and parks

1.3 Outcomes of the Planning Process

1.3.1 ***Fort Worth Coordination – included monthly meetings, support for permitting and code enforcement, sharing data, public meetings, Lakeshore Drive Project and use of aesthetics/Best Management Practices (BMPs) on that project. During the public meetings, most of the input received from both sides of the lake was consistent, and there were no major conflicting comments or recommendations.***

Lake Arlington is owned by the City of Arlington, but it is situated between the City of Arlington and the City of Fort Worth, making collaboration a necessity during the development of the Master Plan. Staff from both municipalities worked together during the planning process by sharing data, ideas and participating in monthly coordination meetings.

Arlington staff worked with Fort Worth staff to incorporate previous Fort Worth planning efforts into the development of the Vision Plan for the west side of the lake. An important part of Fort Worth's vision has been to spur economic development in the area by improving the street grid to create greater access to vacant parcels of land.

Lakeshore Drive is envisioned as a new roadway alignment that will provide improved north-south access on the Fort Worth side of Lake Arlington. Because a portion of the roadway would be within the Lake Arlington flowage easement, the City of Arlington provided a set of water quality protection and construction Best Management Practices to Fort Worth.

While future construction of Lakeshore Drive depends on the availability of funds, the Master Plan includes and details Fort Worth's approach to a two-lane road way that has bike lanes and pedestrian access.

In addition to Arlington's collaboration with staff from Fort Worth, citizens in Fort Worth were given an opportunity to provide input into the Lake Arlington Master plan through a series of public meetings. "It was very gratifying to see that residents on both sides of the lake shared similar views about how future development should occur," says Erich Dohrer, lead planner on the Master Plan project.

"Overall, we are very pleased," says Julia Hunt, P.E., Director of Arlington Water Utilities, "because we have worked really hard and well together to develop a Master Plan that addresses the needs of both communities while protecting the water quality of Lake Arlington."

1.3.2 *Linear Parks and Open Spaces Systems/Arlington, Kennedale, and Fort Worth–to protect water quality, natural land uses are envisioned around Lake Arlington, including new trails proposed to connect to the surrounding city systems, including upstream and downstream of Lake Arlington along Village Creek.*

Part of the vision for Lake Arlington spells out a parks, trails and open spaces system around the lake that can be used by walkers, joggers and bicyclers. Although the neighboring community of Kennedale began work on the concept of a comprehensive trail system before the Lake Arlington Master Plan process started, the two ideas quickly merged.

Because Village Creek and some of its tributaries within Kennedale flow into Lake Arlington, it is in Arlington's interest to see them protected and kept in a natural state in order to protect water quality. Kennedale is proactively planning for future growth, with emphasis on its town center, and the "old town" area that includes an historic rail stop along Hwy 287 Business.

The trails would follow along streams and waterways to connect the Kennedale community. The Kennedale trails would merge with a potential Lake Arlington trails system at the upstream end of the lake. This entire proposed connected trail system would allow a trail user to access many miles of trails, parks and open spaces around Lake Arlington, adjacent to Village Creek and along the Kennedale creeks.

Kennedale was invited by the City of Arlington to participate in coordination meetings to share its progress of the trails initiatives. Another opportunity that arose from these discussions is the potential to have Kennedale and Arlington jointly work with the US Army Corps of Engineers on a Village Creek eco-restoration project, which would be a long term effort to restore the creek and

Figure 1.3-1: Regional Trail Alignment Strategy

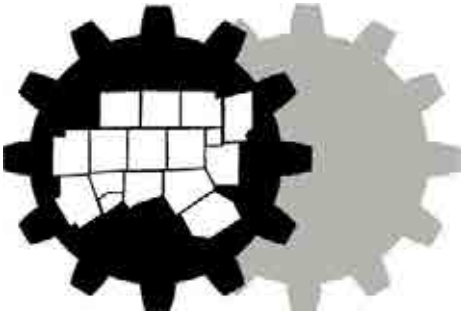
evaluate flood management options.

1.3.3 ***Collaboration with NCTCOG – included sharing data, hosting regional meetings, and "Greenprinting". These activities are an integral part of the implementation because of the NCTCOG's emphasis on planning and implementation on a watershed basis.***

The City of Arlington worked closely with the North Central Texas Council of Governments (NCTCOG) to develop several key aspects of the Master Plan related to watershed management. The NCTCOG has an emphasis on planning and implementation of watershed protection and management strategies for watersheds and lakes within North Central Texas.

The NCTCOG is a voluntary association of, by and for local governments, established to assist local governments in planning for common needs, cooperating for mutual benefit, and coordinating for sound regional development.

Lake Arlington is a partner of one of the 21 "Regional Watersheds" within the 12-county Metropolitan Planning Area served by the NCTCOG.



To support the City of Arlington's efforts to protect the watershed, the NCTCOG shared data that Malcolm Pirnie used for water quality modeling and helped to facilitate a series of meetings with representatives from the 13 cities and two counties within the Village Creek watershed. The NCTCOG also provided information on the "Greenprinting" process that is being conducted by the Trust for Public Land, a national nonprofit organization working to protect land as parks and open space. That program can be used as an implementation step for the Master Plan by providing recommendations on the most cost-effective locations for the purchase of conservation easements and other land management practices.

John Promise, P.E., Director of Environment and Development for the NCTCOG, provided data necessary to develop the watershed modeling and Best Management Practices (BMPs) described in the Master Plan. "We immediately recognized the value of this unique approach to watershed planning and are excited about the benefits all of the cities in the watershed will receive as a result.

We wanted to help the team developing the Lake Arlington Master Plan find out what other cities were doing to protect the watershed and discuss different approaches with them."

"This type of collaboration can become a model for watershed protection planning for other areas of the state and country," adds Promise.

1.3.4 ***Water Quality Modeling/Approach to Best Management Practices (BMPs) – describes how management measures raise the bar for watershed protection within the region; this is accomplished throug forward-thinking concepts that support watershed cities by providing BMPs and low impact development recommendations that can be incorporated into future stormwater permitting***.

It is no accident that the City of Arlington enjoys a "superior" water quality rating by the Texas Commission on Environmental Quality (TCEQ). In order to maintain that quality and safety of drinking water for more than half a million citizens in North Central Texas, there must be planning and guideline development. That is where Best Management Practices (BMPs) come into play. BMPs describe technical standards and procedures that governments, businesses and individuals may take to keep pollution out of receiving waters.

In the planning process, Malcolm Pirnie evaluated the present standards, policies and guidelines, and used computer models to determine the potential impacts of current and planned development on the lake. The team then developed a watershed management strategy that includes BMPs to share with all of the cities within the Lake Arlington watershed.

"The BMPs and management measures included in the Lake Arlington Master Plan are forward thinking and give us the best strategic approach to watershed protection," says Ms. Hunt. "If we are able to successfully employ these practices, our modeling effort has shown that we will eliminate a significant percentage of the potential pollutants projected to reach Lake Arlington over the next 15 to 20 years, allowing us to protect our drinking water quality and avoid additional treatment costs. This helps us keep our costs as low as possible for the delivery of quality drinking water to our customers."

Each of the eleven cities within the watershed will benefit from the use of BMPs outlined in the Master Plan because adoption and use of the source water protection practices should keep them in compliance with future state and federal watershed protection regulations.

These BMPs include ideas and guidelines such as:

- Ordinances for stormwater management in areas of development and significant redevelopment
- Illicit discharge detection and elimination ordinances and programs
- Trash mitigation programs
- Recommended practices for oil and gas well drilling and exploration near Lake Arlington and Village Creek
- Management practices for construction in and near Lake Arlington and Village Creek
- Public involvement, education and outreach
- Pollution prevention and good housekeeping for municipal operations

1.3.5 *Boating Capacity Study – provided an understanding of how the lake is being used for recreation, the characteristics of users and their opinions about how the lake should be managed.*

Although Lake Arlington was developed to serve as a source of drinking water for Arlington and other Texas communities, the lake is also a place for recreational activities including boating, fishing and skiing. In order to more clearly understand how recreational users viewed the lake and to get their opinion on future needs and how Lake Arlington is managed, a comprehensive boating capacity study was conducted as part of the Lake Arlington Master Plan.

"We really needed to get the user's perspective on boating-related recreational use of the lake so that they can be planned for and managed," says Hunt. "The boating capacity study helped us to characterize the existing uses and identify areas that may require management to address safety and water quality needs."

Of 1,200 surveys sent out, over 450 lake users and adjacent property owners indicated that they were primarily interested in the amount of litter along the shoreline, shallow water issues, variability in the lake level, and fish habitat. The respondents indicated that crowding and conflicts were not major concerns. This information is useful because it helped the Planning Team to make better decisions and understand the impact of those decisions to property owners along the lakefront and other users.

1.3.6 ***Property Database – the Arlington Water Utilities Department initiated a data-collection project to provide updated information on the lake and to make it more efficient to implement the recommendations in the Master Plan.***

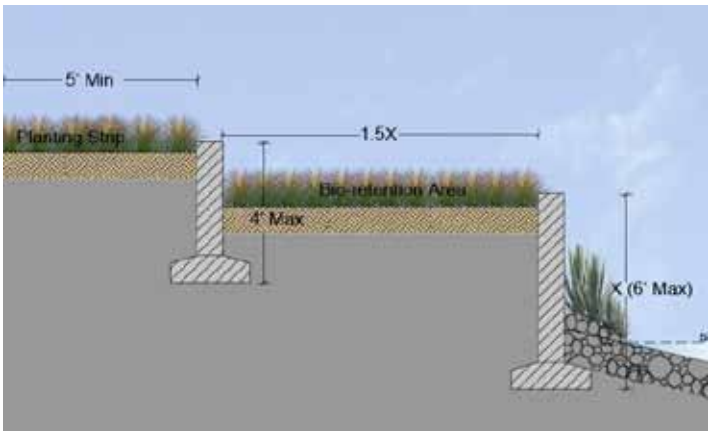
During the course of the Master Planning process, the Arlington Water Utilities Department gathered a significant amount of data about structures and development along the shoreline of the lake. Photographs of each structure and property were organized into a Geographic Information System (GIS) database. This database will serve as a valuable tool for future management of the lake.

1.3.7 ***Standards and Guidelines – provide a uniform set of policies for development around the shoreline of Lake Arlington and within the Flowage Easement.***

A new set of guidelines and standards for docks, piers, retaining walls and marinas are included in the Lake Arlington Master Plan. The purpose of the guidelines and standards are to protect the water quality of Lake Arlington, to protect private and public property values, and to maintain the storage capacity of Lake Arlington.

Once adopted by Arlington and Fort Worth City Councils, the new standards and guidelines are also envisioned as a way to protect the integrity of the lake's shoreline by only permitting sustainable structures and improvements that are well-designed and capable of being properly maintained. The standards also help to support habitat for fish and other wildlife. In addition, the proposed new standards provide incentives to property owners to protect water quality by maintaining or enhancing natural areas immediately around the lake, such as the shoreline.

Included in the standards are simple measures such as adding an address plate and reflectors to all boat docks, to more detailed guidelines for the construction methods and materials to be used in building retaining walls, docks and piers.



1.3.8 ***Public Involvement--public meetings and roundtables produced valuable information beyond just the input needed for the Master Planning process—for both the cities of Arlington and Fort Worth—value added.***

Creating a document that articulates the vision for Lake Arlington included technical and scientific "number crunching" as well as input from stakeholders who had an interest in decision making for the protection and management of Lake Arlington.

The City of Arlington proactively engaged citizens on both sides of Lake Arlington in the Master Plan on issues such as:

- BMPs for water quality protection
- Standards for docks, piers, retaining walls, and marinas
- Ideas for new trails and open spaces
- Recreational uses on the lake
- Future development opportunities
- Enhancements to existing parks

There were five public meetings, in addition to regular agency coordination meetings, and a series of small roundtable discussions all geared at sharing data and listening to stakeholders.

"Our public input process was designed to accommodate as much one-on-one conversation and direct interaction with citizens as possible. We believe it is a better way to learn from each other," says Valery Jean-Bart, P.E., Civil Engineer in the Water Utilities Department and Lake Arlington Master Plan project manager. Public meetings were held in both Arlington and Fort Worth.

Jean-Bart added that "we were pleased to learn that citizens on both sides of the lake shared similar concerns and wanted to see development occur in a similar fashion. Our team certainly learned a lot and really appreciated the comments we received from stakeholders who participated in the public input process either at one of our meetings or on-line."

In addition, information about the Master Plan was posted on the project website (www.arlingtontx.gov/water/lakearlingtonmasterplan.html) and a display was mounted at the Lake Arlington Public Library.

1.4 Summary of Recommendations

Section 9 of the Final Report describes in detail all of the Master Plan recommendations. In summary, the Master Plan has recommended the following prioritized principles with regard to implementation:

1.4.1 Organizational Structures and On-going Processes

An organizational structure (shown below in Figure 1.5-1) and on-going processes/programs are needed

to assure the protection and enhancement of Lake Arlington's water quality. Ongoing public involvement and communication are integral to the successful implementation of the Master Plan.

1.4.2 Area of Primary Influence

The Area of Primary Influence (API) is located immediately around and within 1,000 feet of Lake Arlington. Within the API, the Master Plan recommends the implementation of specific projects, processes and programs that protect and enhance the quality of the lake.

1.4.3 Watershed

Within the remainder of the Lake Arlington watershed, work collaboratively with other cities, the counties, and other entities, including the NCTCOG, to implement projects, processes and programs that protect and enhance the quality of stormwater runoff into the lake.

1.4.4 Funding

Continue to pursue funding from a variety of sources in order to expeditiously implement projects, processes, and programs that protect and enhance the quality of Lake Arlington. To be successful, it is recommended that the City tailor its funding efforts to specific agencies and sources, while continually looking for new program.

1.5 Implementation—What is next?

Both Arlington and Fort Worth City Councils will be provided with the opportunity to adopt the Master Plan as part of each city's Comprehensive Plan. In addition, many players will have a role in continuing to carry out the vision. Malcolm Pirnie developed a recommended organizational structure to guide the implementation processes.

The Arlington Water Utilities Department is interested in implementing parts of the Master Plan that focus on protecting water quality. Many other municipal departments will also be involved in carrying out the Vision and associated plans, policies, procedures and ordinances. The City of Fort Worth will be directly involved in implementing parts of the Master Plan related to development on the west side of the lake. In addition, the eleven cities and two counties within the Lake Arlington watershed will have an opportunity to address how they can reduce potential sources of pollution and manage storm water.

Private developers can now put together a more specific plan and funding programs to develop vacant land or new projects as part of the overall vision. These projects would follow the normal review and permitting processes of both Arlington and Fort Worth.

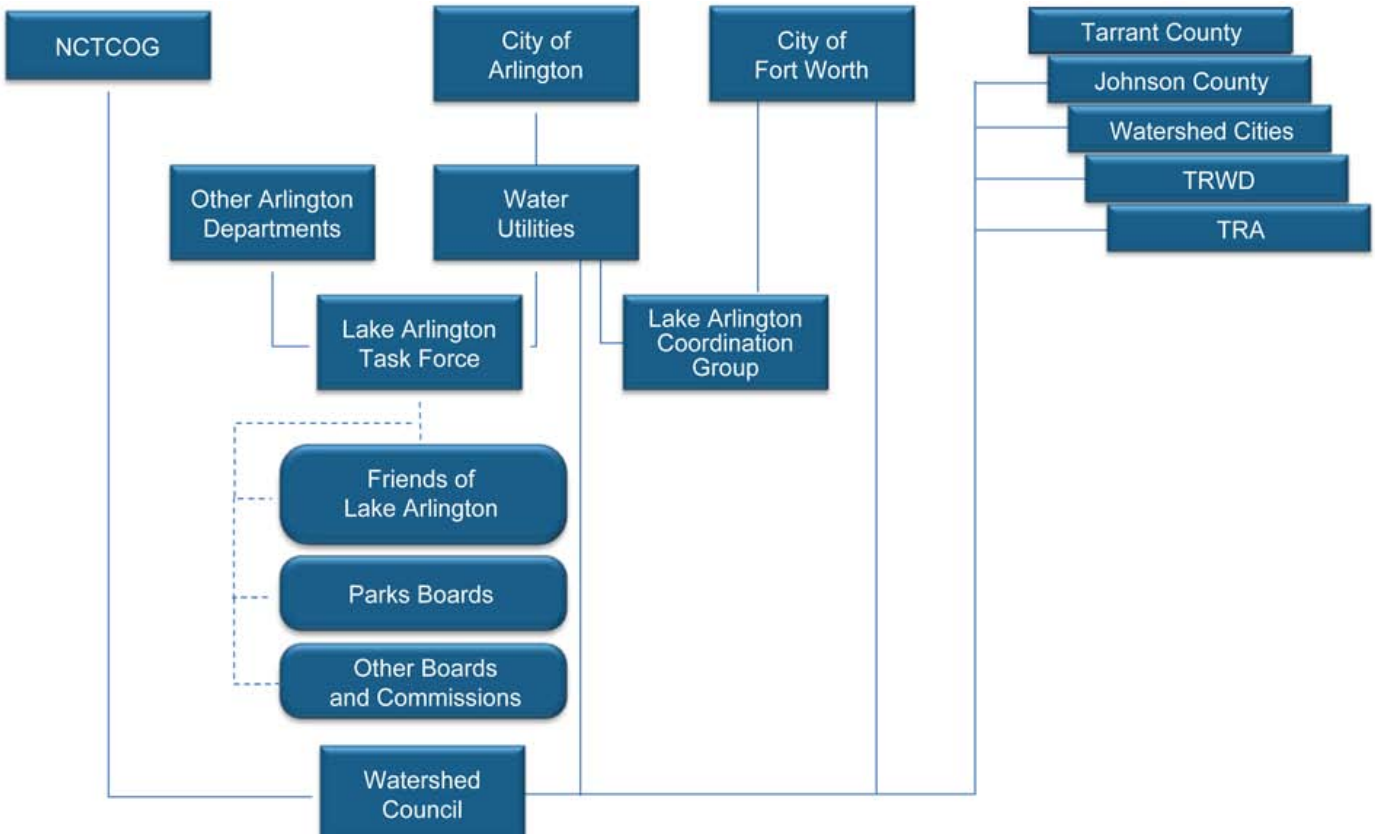
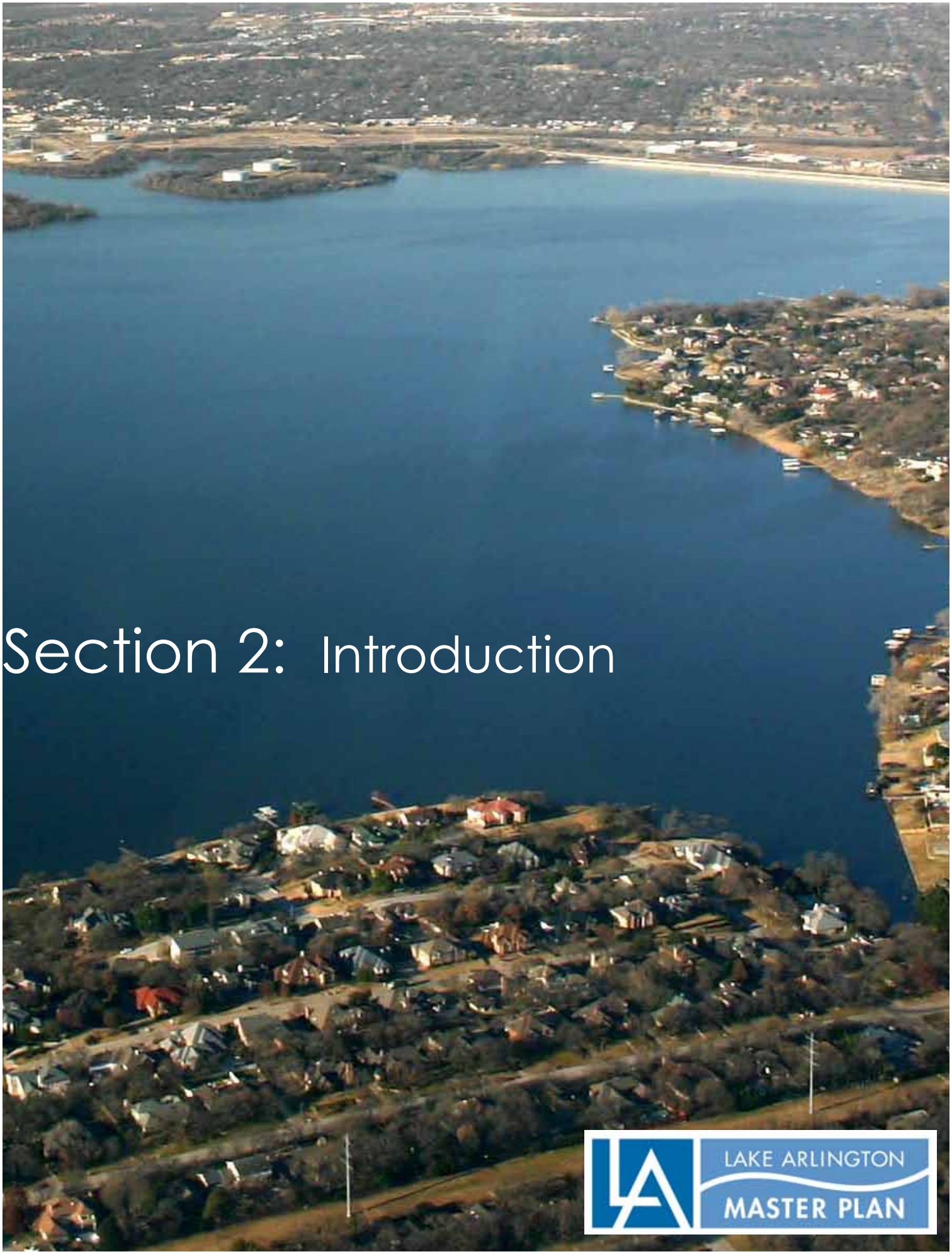


Figure 1.5-1: Organizational Structure



Section 2: Introduction

LAKE ARLINGTON MASTER PLAN

2. Introduction

2.1 Introduction

The City of Arlington (the "City" or "Arlington") has actively managed Lake Arlington since the reservoir was constructed in the late 1950's. Arlington has a significant interest in protecting the water quality in the reservoir because the Lake serves as a water supply source for the City and other communities. The Lake also serves as a cooling pond for an electric generating station. Because the Lake also provides significant recreation opportunities for the area, the City is very concerned about maximizing the aesthetic aspects of the reservoir. The City's Water Utilities Department recognized the need for a planning tool to guide the future management of the Lake, and on December 16, 2009 the City engaged Malcolm Pirnie, Inc. to prepare a Master Plan for Lake Arlington (the "Project"). The Project schedule called for the Master Plan to be finished by the Spring of 2011.

A master plan is a comprehensive long range (10-20 years) plan intended to guide growth and development. It includes analysis, recommendations, and proposals. It is normally based on public input, surveys, and an analysis of planning initiatives, existing conditions and development, physical characteristics, and social and economic conditions. Although conceptual site plans, schematics and renderings are usually shown, master plans are not intended to address issues related to detailed implementation, engineering, detailed design or operations. Cost estimates are normally given in ranges and are conceptual in nature.

Conceptually, the benefits for having a master plan usually include:

1. Consistency in decision making - the plan gives decision makers a steady point of reference for future actions.

2. Ability to make informed decisions - the plan provides facts on existing conditions and trends, and recommendations for future activities, enabling decision makers to better understand the impact of their decisions versus relying on a "gut instinct."

3. Achieving predictability - the plan describes where and what type of development the community desires. This information allows individuals to plan for the purchase, development and use of property consistent with community goals.

4. Wise use of resources - the plan includes information from numerous sources. This information can be used in deciding and prioritizing which projects to undertake. It also can be used to direct the location of future projects and improvements.

5. Preserving community character - the plan describes a community's vision for the future and establishes its existing and intended growth. It permits the community to identify what is important and how it should be protected.

6. Producing positive economic development - planning helps residents and businesses owners better predict the future development of the study area. This prediction creates a comfort zone of knowing what to expect on neighboring properties.

The following diagram illustrates a typical master planning process, and it closely represents the process used for the Lake Arlington Master Plan.

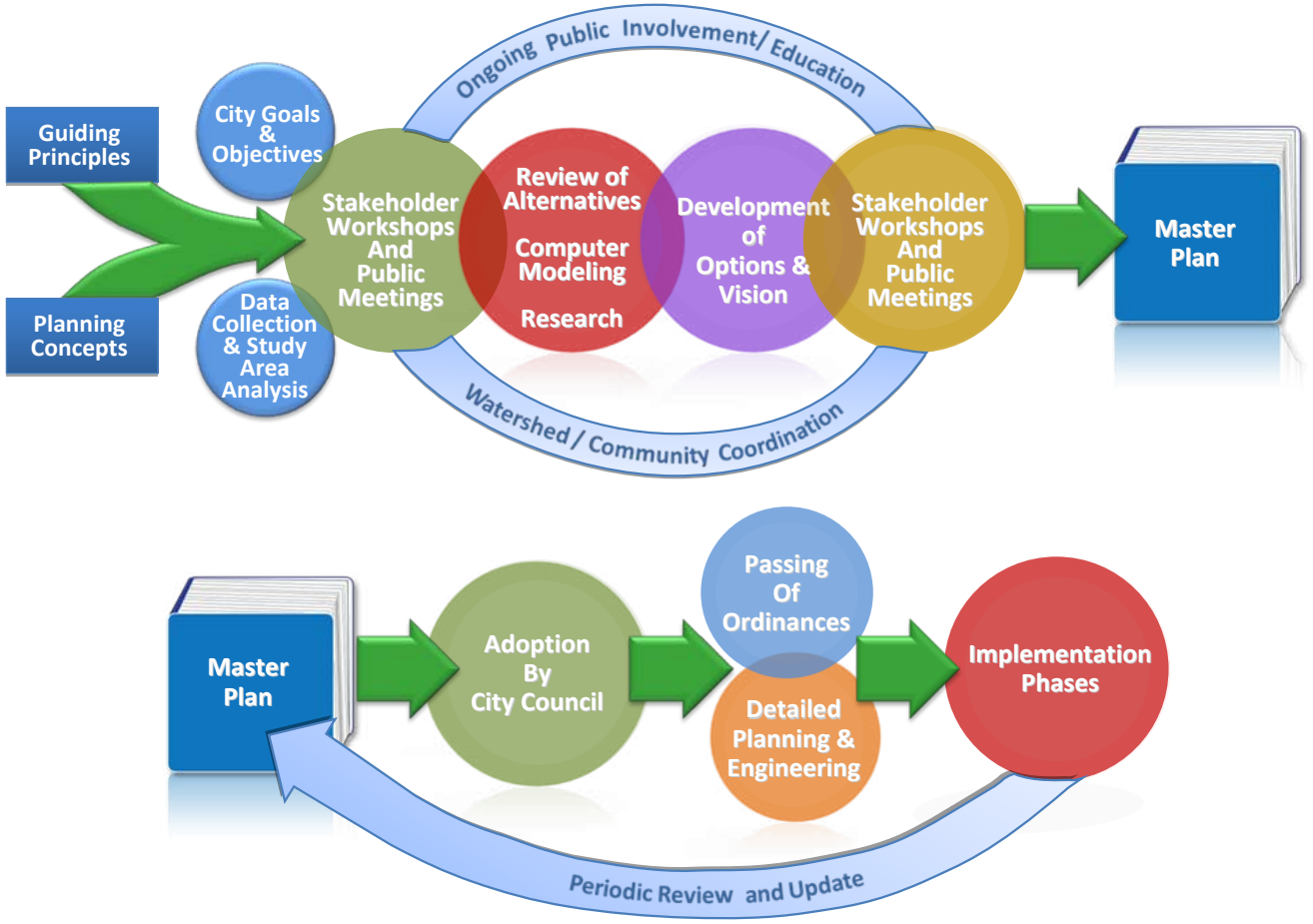


Figure 2.1-1: Master Planning Process for Lake Arlington

In preparing for Lake Arlington planning process, the City identified a number of major issues that needed to be addressed in the Master Plan. Those issues included:

- Drinking water quality
- Drilling of natural gas wells in proximity to the lake
- Trash and debris entering the lake
- Boating and recreational capacity
- Fishing and wildlife
- Standards for the construction and maintenance of shoreline features such as docks, piers and retaining walls
- Dredging

This master planning process included some very technical aspects such as: water quality computer modeling; the development of Best Management Practices (BMPs) for water quality protection; the preparation of standards and guidelines for activities around the Lake; planning for recreational activities and open space; and the determination of the Lake's capacity for boating. The process also included a very signifi-

cant public education and outreach component. The significant public involvement aspect included: the development of a website for the Project; monthly coordination meetings with the City of Fort Worth ("Fort Worth") and other communities; a series of focus group workshops and public meetings; and two meetings with the NCTCOG and the cities in the Village Creek watershed.

This Master Plan Final Report is the result of that planning process. It serves as the planning tool and guidance manual for the future management of Lake Arlington.

2.2 Arlington's Goals and Objectives

As owner and manager of Lake Arlington, the City's overall objective is to protect its drinking water supply by protecting the quality of the source water. Although all surface water requires treatment before use, protecting the source water is an important part of providing safe drinking water to the public. The City has two surface water treatment plants, but only the Pierce-Burch Water Treatment Plant uses raw water from Lake Arlington. In addition, the Trinity River Authority (TRA) diverts raw water from Lake Arlington for its water treatment plant.

The underlying principle of source water protection is that it costs much less to protect a potable water supply than to restore water quality if it becomes compromised. According to the American Water Works Association, cleanup costs range from 30 to 200 times the cost of preventing contamination.

From the City's perspective, the major overall goals of this Project were to:

- Protect the water quality of Lake Arlington
- Serve as both a short-term and a long-term planning tool
- Optimize the recreational use of the Lake and manage the related ecosystems
- Identify opportunities for development and enhancement
- Identify the impacts of future development

Because all of the goals revolved around the primary goal of water quality protection, the remainder of this introductory section focuses on the goal of water quality protection and watershed management, and how this goal impacted the development of the Master Plan.

2.3 The Need for Watershed Management

The need for stormwater and watershed management within the area that drains into Lake Arlington is driven by several common themes:

- Stormwater runoff and potential impacts are directly linked to land use change within the watershed.
- Control of stormwater runoff quantity and quality is necessary to minimize property damage, stream degradation, and water quality impacts.
- A long-term goal of mimicking natural hydrologic conditions will help address potential impacts from stormwater runoff.
- Multiple regulatory requirements and regional programs have evolved to address the increasing importance of stormwater management and water quality protection and improvement.
- Integration of the existing programs and requirements and working collaboratively with other communities in the watershed will reduce duplication of effort and associated costs. Such integration and collaboration will also improve implementation of a comprehensive program for watershed management.

Existing regulatory requirements serve as the framework for watershed management and protection. Federal and State regulations serve to protect and improve water quality by establishing and enforcing standards and by regulating discharge of pollutants into waters of the United States. In addition, the North Central Texas Council of Governments (NCTCOG) has begun a stormwater management program that provides valuable data and recommended processes.

The recommendations found in the Lake Arlington Master Plan serve to fill in areas of watershed protection that are not covered by Federal or State regulations, current programs developed by the NCTCOG, and the activities of cities in the watershed. The recommended policies and programs will serve to define the concepts of a watershed protection plan that can be implemented to protect the quality of Lake Arlington. The Master Plan will also serve to establish watershed protection standards, BMPs and approved activities within the Lake Arlington watershed and immediately around the reservoir.

2.4 Influence of Land Use Change

In general, as land use changes from rural to urban purposes, the effect on water quality within a watershed also changes. While population growth can be beneficial for economic reasons, the pace and type of growth present challenges for reservoir owners. An increasing population requires more water from available surface waters while increasing the amount of wastewater and stormwater pollutants (point and non-point source) that flow into streams, rivers and lakes. Additionally, when land is developed, the hydrology, or the natural cycle of water, is altered. Clearing removes the vegetation that intercepts, slows and returns rainfall to the air through evaporation and transpiration. Grading flattens hilly terrain and fills in natural depressions that would otherwise slow and provide temporary storage for rainfall. The topsoil and sponge-like layers of humus are scraped and removed and the remaining subsoil is compacted. Rainfall that once seeped into the ground now runs off the surface. The addition of buildings, roadways, parking lots, and other surfaces that are impervious to rainfall further reduces infiltration and increases runoff.

Much of the water that is stored in Lake Arlington originates from the land area that drains downstream into the Lake. A significant portion of the drinking water that the citizens of Arlington receive from the Water Utilities Department ultimately comes from springs, stormwater runoff and tributaries within the Village Creek watershed that drains into Lake Arlington. Figure 2.4-1 is a map of the Village Creek watershed and Lake Arlington. The watershed is approximately 143-square miles in size, however the impacts of activity immediately around the reservoir must also be considered. While the east side of the reservoir is located within the city limits of Arlington, the west side is predominantly within the City of Fort Worth. In the process of evaluating opportunities for recreational enhancements and land development, and in the development of standards for shoreline activities, the overriding consideration was the effect of those activities on the quality of Lake Arlington's water.

The sections below describe why protecting drinking water sources requires the combined efforts of many partners. For Lake Arlington, these partners include Tarrant and Johnson Counties, Fort Worth and the other municipalities within the watershed, land developers, construction contractors, agricultural operators, and private landowners. There are thirteen municipalities within the Village Creek watershed. Because two of the municipalities (Pantego and Dalworthington Gardens) are located downstream of the Lake, there are eleven municipalities in the segment of the watershed that drains into Lake Arlington.

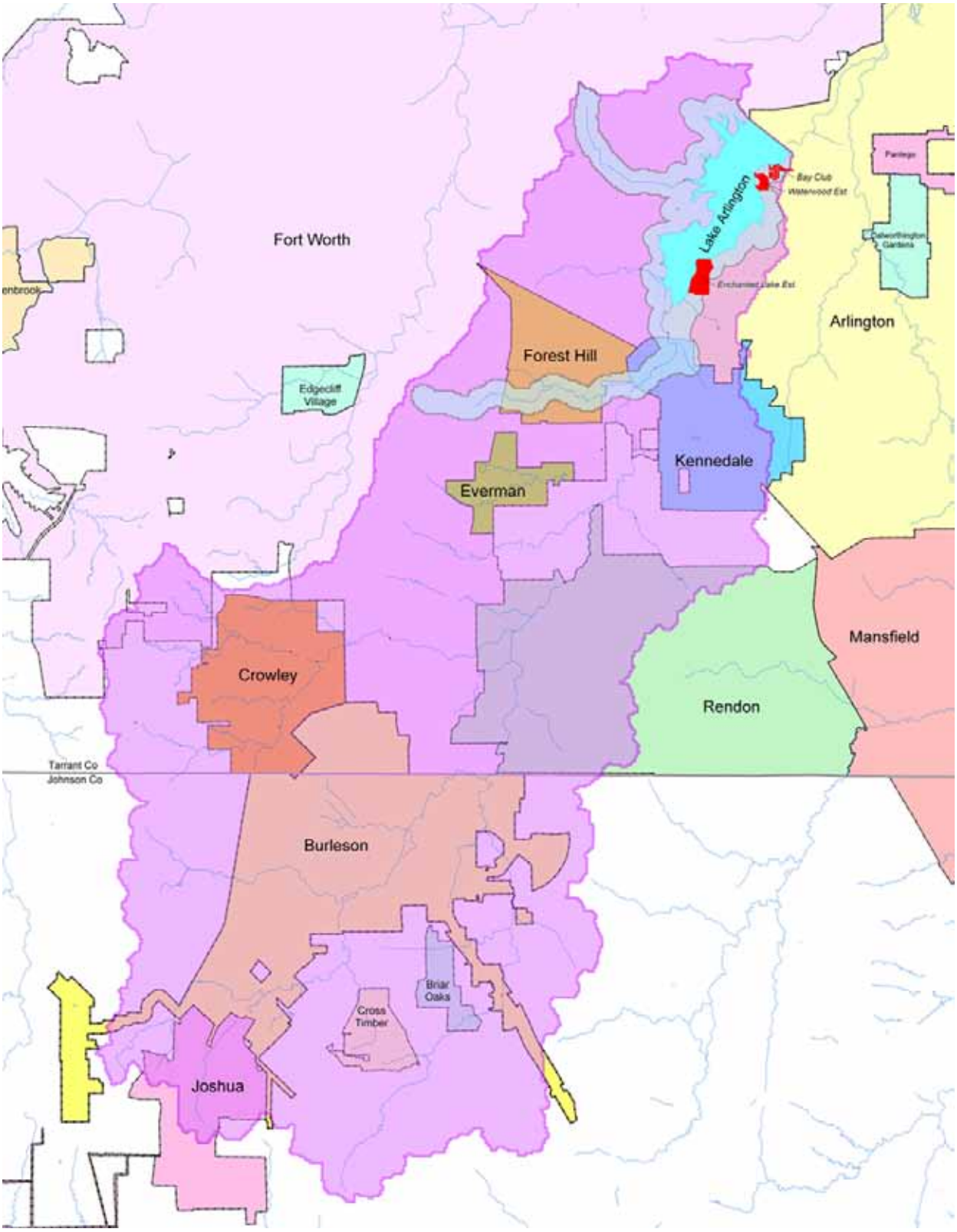


Figure 2.4-1: Village Creek Watershed

2.4.1 Where Rainfall Goes Before and After Development

Figure 2.4.1 illustrates how the water balance changes when natural cover is replaced by residential and urban development. The example percentages in the drawing highlight the magnitude of the additional volume of water that must be handled by a drainage system after land is cleared. The actual percentages vary from region to region, but the relationships are universal.

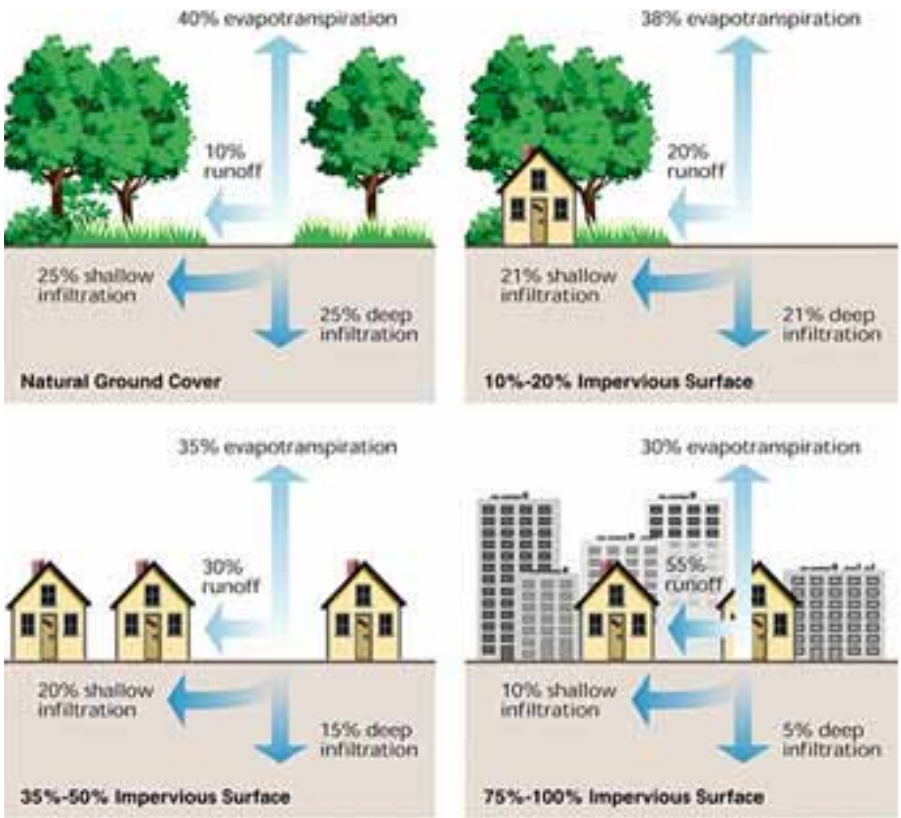


Figure 2.4-2: Where Rainfall Goes Before and After Development

On an annual basis, surface runoff from a naturally vegetated watershed is normally expected to be minimal as a proportion of total water volume. Before development, the flow observed in streams (base flow) results from interflow, or water passing through the unsaturated soil zone. After development, flow in streams typically originates as surface runoff. As interflow is replaced by runoff as the most significant component of flow, base flow is reduced (SMRC, 2002).

As a watershed is developed, surface runoff volume increases in proportion to the percentage of impervious surface area, defined as non-infiltrating surfaces (e.g., concrete, asphalt, rooftops, compacted soils, and exposed rock). Once a stormwater collection pipe system is installed to drain these impervious areas, the rainfall results in runoff.

The cumulative effects of these changes in land use include significant shifts in storm water quantity and quality. These changes in stormwater runoff characteristics and the resulting effects are observed across the nation. The primary impacts include:

- Changes in stream flow – increased runoff volumes, increased peak discharges, greater runoff

velocities, increased flooding, and lower dry weather stream flows.

- Changes in stream geometry – stream widening and down-cutting, loss of riparian tree cover, sedimentation in the channel, and increased flood elevations.
- Degradation of aquatic habitat – degradation of habitat structure, loss of pool-riffle structure, reduced stream base flows, increased temperatures, and reduced abundance and diversity of aquatic life.
- Water quality impacts – reduced dissolved oxygen (DO) and increases in nutrient enrichment, microbial contamination, hydrocarbons (oils and grease), toxic materials (pesticides, metal, organic contaminants), sedimentation, temperature, and trash/debris.

2.4.2 Relationship between Hydrology and Watershed Health

There is a logical link between changes in watershed land use and the cumulative impacts of stormwater runoff on watershed health, whether those impacts are in the form of flooding, streambank erosion, aquatic habitat degradation, or declining water quality. The link is the change in the volume and timing of surface runoff that is created as the result of alteration of the natural landscape. Figure 2.4.2 illustrates a developed watershed that is more prone to flooding due to a greater rate and volume of runoff compared to an undeveloped watershed (Schueler, 1995)

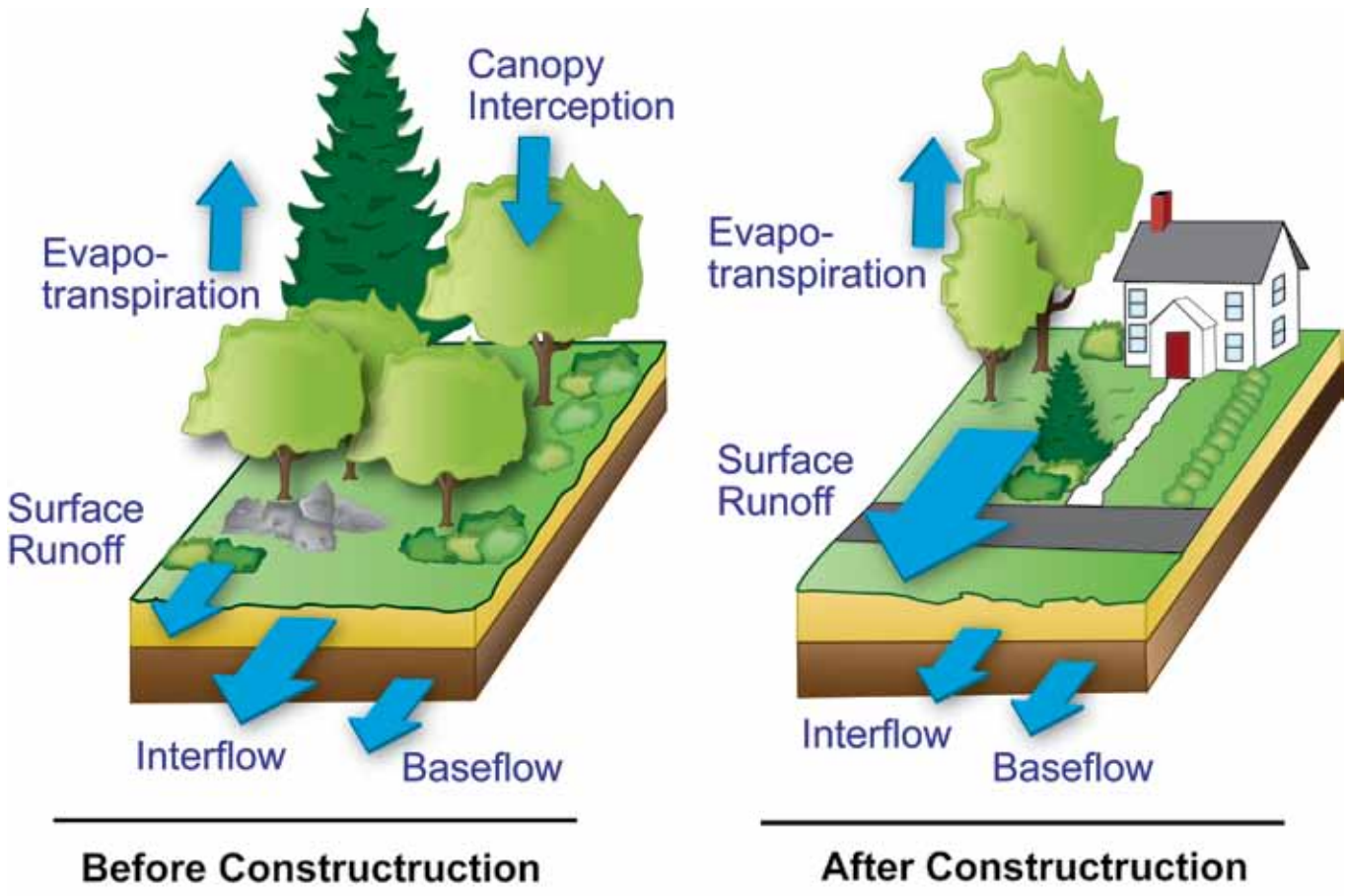


Figure 2.4-3: Effects of Development on the Floodplain

Impacts of uncontrolled stormwater runoff can also have socio-economic impacts on communities, including:

- Impairment of Drinking Water Supplies
- Increased Cost of Water Supply Treatment
- Loss of Recreational Opportunities
- Loss of Fisheries
- Increased Litigation
- Reduction in Quality of Life
- Flooding

2.4.3 What is Impervious Surface?

As noted previously, "impervious surface" refers to land cover, both natural and man-made, that does not allow rainfall to soak or infiltrate into the soil. Consequently, precipitation that falls on impervious surfaces either runs off to a pervious area where all or a portion of the runoff infiltrates into the soil, or it continues to flow until conveyed to a ditch, a storm drain network, or a receiving waterbody such as Lake Arlingon. Impervious cover in a watershed can be organized into two main categories:

- Rooftops – Impervious cover created by buildings, homes, garages, stores, warehouses, and other structures with roofs.
- Roadways and Parking – Impervious cover created by structures such as roads, highways, driveways, and parking lots.

Generally, the roadways and parking component occupies a larger percentage of land than the rooftops component.

2.5 Watershed Protection Planning

2.5.1 Addressing Stormwater Runoff and Maintaining Watershed Health

Stormwater management involves both the prevention and mitigation of stormwater runoff impacts through a variety of methods and mechanisms. A key to protecting watershed health is to maintain as close to the natural hydrologic and water quality conditions and water balance as is achievable and practicable. This can be achieved through one or more of the following:

- Developing land in a way that minimizes its impact on a watershed and reduces both the amount of runoff and pollutants generated.
- Using the most current and effective erosion and sedimentation best management practices (BMPs) during the construction phase of development.
- Using BMPs to control stormwater runoff peaks, volumes, and velocities to prevent both downstream flooding and streambank/channel erosion.
- Treating post-development stormwater runoff before it is discharged to a waterway.
- Implementing pollution prevention practices to prevent stormwater from becoming contaminated in the first place.
- Using various techniques to encourage groundwater recharge.

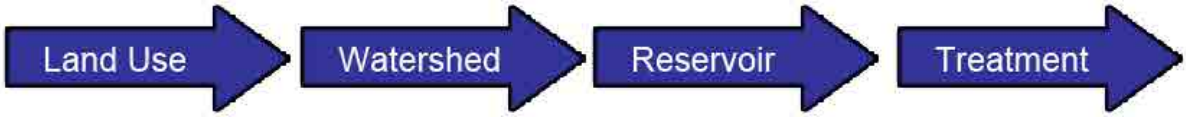
There are a variety of structural, nonstructural, and site design measures which can be used on an individual site for achieving the goal of water quality improvement. In addition, it is important to assess the larger scale of the entire watershed through considerations of land use and planning.

2.5.2 Watershed Protection Planning

One of the major objectives of this master planning process was the development of BMPs and recommended policies to protect the quality of Lake Arlington's water supply. A step-wise approach with significant stakeholder involvement was used to develop the recommended protection measures and BMPs for Lake Arlington. This approach was designed to facilitate an open process that focused on the City's specific goals for water resource protection and maximized the use of existing information.
The primary steps in this process included:

Development of goals – Goals for the development of the watershed protection task in the Lake Arlington Master Plan were developed in coordination with the City. Those goals are as follows:

- Develop an integrated modeling approach that links changes in land use with potential operational and economic impacts to the treatment facilities.



- Analyze various future development and land use condition scenarios.
- Develop quantitative and qualitative methodologies for assessing the impacts of each future land use scenario on the source water and ultimately the treatment facilities.
- Develop recommended policies that support long-term protection of the Lake Arlington source water.

Characterization of existing watershed conditions – Available data and studies were used to evaluate existing conditions in the Lake Arlington watershed with the use of the PLOAD Model. Similar data were used to evaluate the conditions of the Lake itself using the BATHTUB Model.

Development of pollutant loading and water quality models to estimate existing and future pollutant loads – The pollutant loading model of the entire watershed and the reservoir model were developed to assist in estimating the existing and future pollutant loads and water quality with and without source water protection policies.

Evaluation of the impact of development on the existing water treatment facilities - An assessment of the impacts on the source of water for the Pierce-Burch Water Treatment Plant was made.

Development of the recommended Lake Arlington BMPs and policies - The watershed protection sections of the Lake Arlington Master Plan were the culmination of the previous planning steps. These recommendations take into consideration activities in the watershed and immediately around the Lake. The recommendations also take into consideration the development and recreation concepts described in other parts of this Master Plan.

2.6 Planning Process Highlights

Because the City had multiple goals for this Master Plan, this planning process was much more involved than a traditional watershed study or water resources master plan. The Malcolm Pirnie Team and the City staff were in almost daily contact throughout the planning process, and the cities of Arlington and Fort Worth worked very closely together on a wide variety of issues - some of which were not even anticipated

when the planning process began. The two cities and the Pirnie Team held monthly coordination meetings to discuss the Master Plan, as well as ancillary issues related to Lake Arlington. These issues included the City of Fort Worth Lake Shore Drive Project, gas well drilling on properties adjacent to the lake, and opportunities to develop a trail system that fits into regional plans. In all of these areas, the communities worked collaboratively to make enhancements that truly improved the quality of proposed activities, and resulted in a Master Plan that can really serve as a guidance document for development around the Lake and within the watershed. For example, the proposed alignment and amenities for Lake Shore Drive were reviewed by Arlington and the Pirnie Team, and Fort Worth readily accepted suggestions. Both cities worked with gas well drillers to improve the aesthetics of the drilling areas and lay the groundwork for future use of the properties for potential trails and recreation facilities. There was very significant involvement by communities in the watershed, and they readily provided data, land use plans and other documents that greatly increased the accuracy of the water quality modeling. The NCTCOG provided invaluable assistance by organizing community meetings and providing data.

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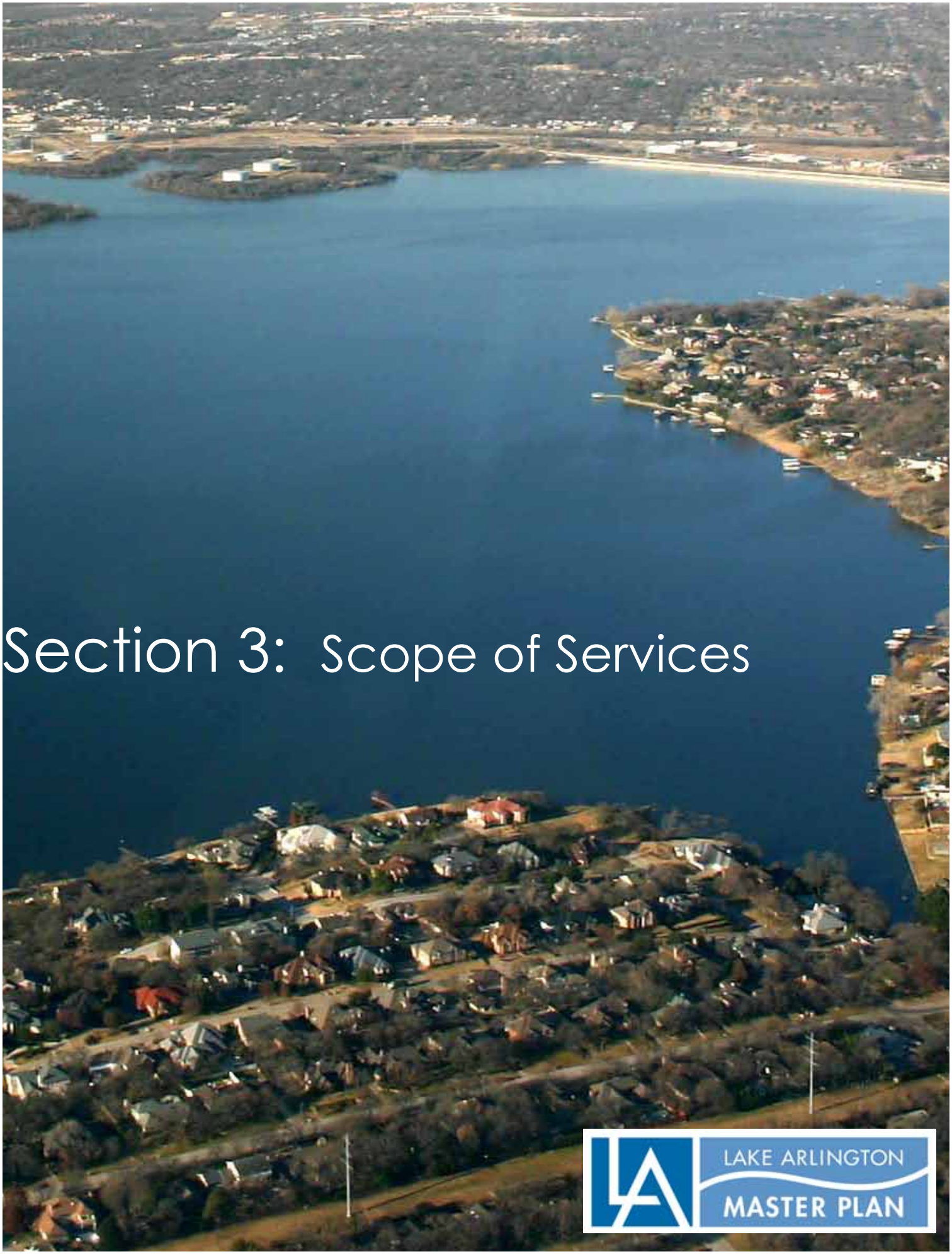


Section 3: Scope of Services

LAKE ARLINGTON MASTER PLAN

3. Summary of Scope of Services

In an Engineering Services Contract dated December 16, 2009, the City of Arlington engaged Malcolm Pirnie to prepare a Master Plan for Lake Arlington. The primary objective of the Master Plan and the planning process was to prepare a guidance document for the protection of the water quality in Lake Arlington. However, this planning effort went far beyond the traditional aspects of a source water protection and watershed management document. As described in more detail below, the Lake Arlington Master Plan process included components related to land use and urban planning, recreation and open space development and management, and public education and outreach. The planning process included five specific tasks.

3.1 Data Collection

Data collection was the first major task in the Project because all of the other work was founded on data and information. Because of the many facets of the planning process, data collection went on throughout the Project. Data was obtained from a wide variety of sources. Data was obtained from all of the entities participating or involved in the planning process, especially the cities of Arlington and Fort Worth, the NCTCOG, communities within the watershed, Tarrant Regional Water District (TRWD), Trinity River Authority (TRA), Texas Parks & Wildlife Department (TPWD), U.S. Geologic Survey (USGS), Texas Commission on Environmental Quality (TCEQ), and other public and private sources. Much of these data were obtained in GIS format.

Some of the more important documents and sources of information included:

- Relevant policies and ordinances of the cities and towns in the watershed
- Stormwater program documentation
- Water quality and watershed data
- USGS monitoring data
- TCEQ water quality data
- TCEQ NPDES discharge data
- TMDL implementation plans
- Master plans, economic development plans and comprehensive plans from the cities in the watershed
- Existing land uses (including natural gas drilling)
- Zoning maps
- Population data
- Conservation plans
- Inventories of natural resources and soils
- Meteorological data
- Current MS 4 NPDES permits and annual reports
- Stormwater management plans

3.2 Source Water Protection and Watershed Management

The objective of the source water protection and watershed management task was to develop a plan aimed at minimizing the negative impacts to water quality that may occur from future development within the watershed. This was accomplished by developing standards, policies and BMPs that can be implemented by cities, counties, construction contractors and developers. Public education was also a major component of the recommended guidelines. In order to accomplish this task, the Malcolm Pirnie Team was required to assess the current standards, policies and management practices, and then determine the

potential impacts of current and planned development activities on lake water quality.
More specifically, this portion of the work consisted of the following major subtasks:

- Review of lake water quality and likely pollutant sources
- Review of current standards, policies and guidelines within the watershed
- Review of BMPs currently being implemented
- Computer modeling of the watershed and Lake Arlington
- Development of recommended standards and guidelines
- Development of recommended BMPs

3.3 Recreation, Open Space and Development

This portion of the work focused on identifying open space and recreational improvements, land development opportunities, and guidelines that will regulate new construction and development on and adjacent to, Lake Arlington. Public involvement activities associated with these steps was directed toward developing consensus with area stakeholders and land owners. Included in this task is a boating capacity study for the Lake. The following sections describe the four sections of this task.

3.3.1 Project Initiation and Study Area Analysis

During this task the Project Team reviewed past efforts and key features related to Lake Arlington, and with input from the City defined the study area. The study area for this task is shown on Figure 3.3.1. The Project Team reviewed the Lake Arlington Ordinance, and previous planning efforts by both Arlington and Fort Worth. Information was also obtained from other cities near the study area to understand past goals and to place our future efforts in the context of previous studies. Next, the Team analyzed existing city codes and zoning to understand potential barriers to redevelopment. In tandem with the previous efforts, the Project Team conducted a field analysis of the study area and tours of the Lake.

3.3.2 Public Workshops & Vision Planning

The Project Team acted as a facilitator at focus group and public workshops to share the background data assembled and to solicit public input regarding goals and desires for the study area. During the first phase of the workshops, the Project Team used a visual preference exercise. Through this process, we were able to gather the group's preferences for desirable planning approaches towards forging stronger linkages and development strategies.

Based on the planning process and public input, the Project Team prepared a vision plan that illustrates the ideas generated in the public workshop, with an emphasis on market-based realities, goals and objectives, visions and preferences. The Master Plan incorporates the vision for development around Lake Arlington, and forms the foundation for recommendations for design guidelines. The Master Plan includes a prioritized list of action items to be completed around the Lake, and proposed modifications to the Lake Ordinance.

3.3.3 Design Guidelines

Based upon the vision plan created in the previous two subtasks, the Project Team prepared design guidelines that focused upon establishing quality standards for four major areas:

- Parks and open spaces
- Lake Arlington Flowage Easement
- New development around the lake
- Shoreline-related development (docks, marinas, piers and retaining walls)

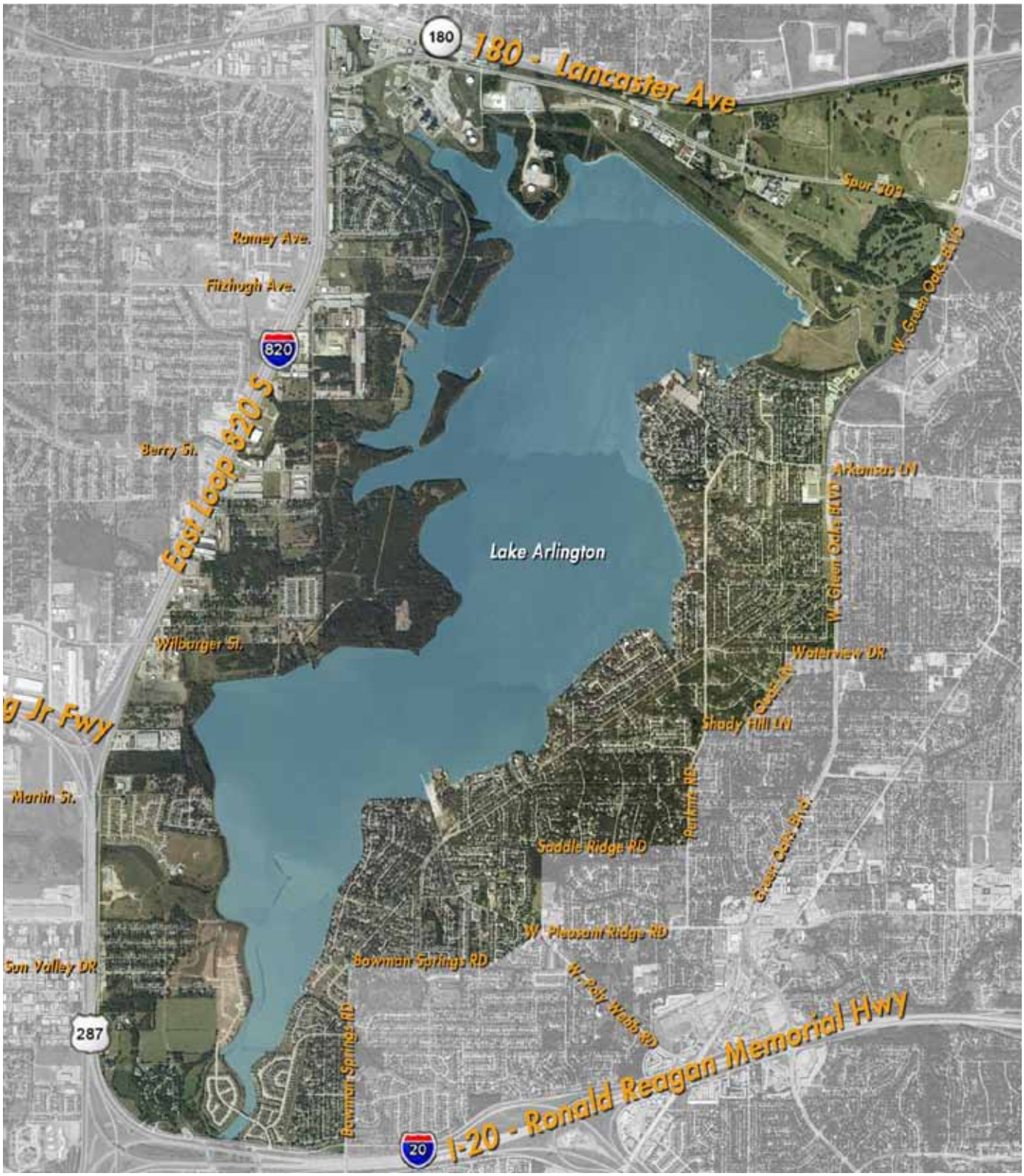


Figure 3.3-1: Lake Arlington Study Area

3.3.4 Boating Capacity Study

The objectives of this subtask were to: characterize existing uses of Lake Arlington; identify areas of use, conflict and displacement across the Lake and among boating groups; identify areas of the Lake that might require additional management; and identify areas around the Lake suitable for potential shoreline development.

The boating capacity study was conducted by Texas AgriLife Research (a branch of the Texas A&M University System) using a team of professors and graduate students from the Department of Recreation, Park and Tourism Sciences at Texas A&M in College Station. The capacity study recommendations were based on a site visit and a survey administered to calendar year 2009 annual and daily Lake Arlington permit holders, and landowners around the Lake. Additional respondents were also drawn from residents living within five miles of the Lake.

3.4 Public Involvement

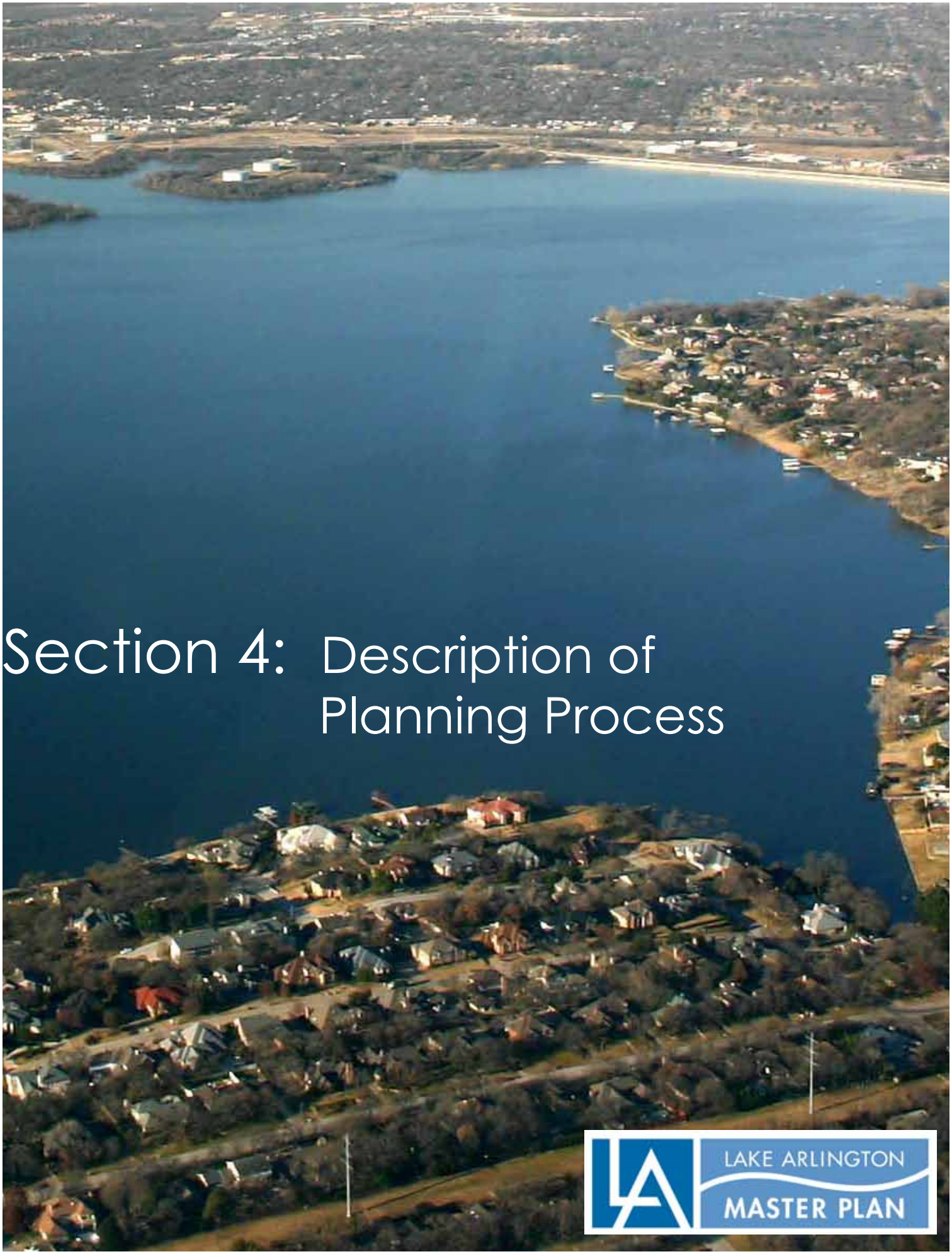
Public education and outreach was a major component of the project, and it was an integral part of everything we did. The Project Team, especially Adisa Communications, worked closely with City staff to develop and implement an effective Public Involvement Plan that informed and engaged affected stakeholders in the Lake Arlington Master Plan. The plan focused on the identified internal and external audiences with the goal of informing and engaging them about the Project. The Malcolm Pirnie Team worked with City staff to frame messages, create engagement opportunities, and anticipate and respond to communications issues. The team developed a project identity, including a Lake Arlington Master Plan logo that was used consistently throughout the project.

The Malcolm Pirnie Team worked with the City to plan and implement effective stakeholder meetings that engaged citizens on the Master Plan project. Citizens of Arlington and Fort Worth were specifically targeted. The meetings included both Focus Group Workshops with small groups of individuals with specific interests in the project, and public meetings for anyone with a general interest in the project.

The Team also developed project related materials such as press releases and fact sheets. These materials, maps and Frequently Asked Questions (FAQs) were used to populate a webpage for the project that provided information on public meetings, the Master Plan process and the schedule.

3.5 Funding Sources

The Malcolm Pirnie Team identified potential funding sources for both planning and implementation. These sources included federal, state and local public/private opportunities. The Team also assisted the City by reviewing applications and commenting on materials developed by others.



Section 4: Description of Planning Process

LAKE ARLINGTON MASTER PLAN

4. Description of the Planning Process

4.1 Planning Process

The planning component to the Lake Arlington Master Plan is meant to develop a template for long-term future growth within the lake area. The master plan provides a series of recommendations relating to future land use, parks and open spaces, and streets. The study outlines opportunities as they relate to existing and new development within the study area, as well as provides the basis for the design guidelines (Section 8.13).

4.1.1 Research, Resource Inventory, & Assessment

The first step of the planning process was a multi-faceted research effort that included:

- Review all previous planning efforts
- Analysis existing city codes and zoning
- Field analysis
- Compilation of existing base data
- Study of the history of the lake
- Determination of the study area
- Analysis of potential opportunities and constraints

This step was crutcial in determining the parameters of the planning study and understanding the most important issues related to further analysis of the issues relating the the study area.

4.1.2 Focus Group Roundtables and Public Meetings

After studying the preliminary findings, a series of roundtables and public meetings were conducted to gauge stakeholder's interest in a variety of planning issues. A visual preference survey was conducted where stakeholder's were presented initial findings of the physical analysis. Next, a visual preference exercise was conducted in which a carefully selected series of photographs were presented addressing such issues such as: land use, building type, streetscape, parks and outdoor space, recreational amenities, water quality improvement, and infill options. Each category displayed a range of strategies, densities, and approaches.

Public meeting attendees were asked to place their individual markers by category for those images/approaches they like the most, and those they least prefer. Through this method, the group's preferences for desirable planning approaches were expressed. Section 4.2 details the categories of issues presented to the public and outlines general public comments and concerns. The results of the visual preference exercise provided a basis for the design team to better understand the opportunities, issues, and public's vision for future development around Lake Arlington.

Figure 4.1-1: Example of Visual Preference Voting Board

The next set of focus group and public meetings focused on a discussion of specific opportunites and constraints. The variety of issues and questions presented to the public were a direct result of the previous visual preference exercise and designed to garner a more detailed understanding of the preferences of the public.

4.1.3 Vision Plan

The vision plan is the physical design of the master plan, meant to illustrate the ideas generated in the public workshop. An emphasis was placed on creating design strategies based on market realities, goals and objectives of the City of Arlington, and the visions and preferences of the public. Section 8 highlights the vision plan and presents recommendations in the following categories:

- Land Use Strategy
- Parks and Open Space Strategy
- Street Framework Strategy

4.1.4 Design Guidelines

Based upon the framework established in the vision plan design guidelines were created that focus upon establishing quality standards and outline specifications for elements within the Flowage Easement. These guidelines describe detailed standards and establish a base against which future development and site improvements can be judged.

4.2 Public Involvement Program

4.2.1 Public Involvement Program

An essential component of the Lake Arlington Master Plan was public information, education and outreach. In order to create an open and transparent planning and decision-making process, stakeholders were proactively engaged and asked to provide ideas, feedback and to ask critical questions throughout the year-long planning process.

The main goal of the Public Involvement Program was to engage Arlington and Fort Worth citizens and those stakeholders directly affected by the Master Plan in order to obtain public input and participation in the development of the Lake Arlington Master Plan. The second goal was to provide timely, factual information to the general public about the Master Plan.

The following objectives were identified in support of the Public Involvement goals:

- Foster a relationship with the community to engage them in the planning process
- Host a series of Roundtable Discussions with stakeholders in the Development/Business Community, Parks and Recreation Advocates, and Neighborhood and Adjacent Property Owners
- Host a series of Public Meetings in Arlington and Fort Worth
- Create informative handouts and visual presentations for meetings
- Create a web page to provide public information and receive public feedback
- Establish a local phone number to receive community feedback

Public involvement activities provided several formal feedback mechanisms including:

- Public Meetings
- Focus Group Roundtables
- One on One Meetings

- Website feedback form
- Project phone line

The Water Utilities Department took the lead in ensuring that the goals and objectives of the public involvement program were met. Regular coordination meetings with the Malcolm Pirnie team were part of the internal implementation of the public involvement program, and included the discussion of issues, progress and next steps for the Master Plan.

Prior to the initiation of a Public Involvement program, the Malcolm Pirnie team worked with City staff to define an effective public involvement strategy for Lake Arlington's Master Plan. During this kickoff meeting the City of Arlington and Malcolm Pirnie agreed upon:

- Overview of overall project schedule
- Specific public involvement deliverables
- Identification of key stakeholders and groups impacted by the Master Plan
- Strategy for Focus Groups and Public Meetings

The initial meeting and the ongoing coordination laid an important foundation for the implementation of an effective public involvement program.

Communications protocols were also established and observed that supported the public involvement process. These protocols included a process for collaboration on all materials and information being presented to the public. There was an internal review of all materials by the Water Utilities staff and other City Departments impacted by the Master Plan. As necessary, the City of Fort Worth staff was also asked to provide comments and feedback on the ideas and materials before they were presented in public forums.

Over the course of the interaction with the public and stakeholders throughout the Master Planning process, key issues were identified and addressed as part of the public involvement program. During each public forum, the City of Arlington staff provided information about these issues in an attempt to both gather ideas and opinions to include in the Master Plan, and to educate stakeholders. The key issues included:

- Drinking water quality
- Natural gas drilling
- Trash
- Lake's capacity to support boating and recreation
- Fishing and wildlife
- Development along the lakefront
- Standards for docks and piers
- Dredging
- Potential for increased water treatment costs

4.2.2 Focus Group Roundtables and Public Meetings

A. Focus Group Roundtables

The City of Arlington provided two types of forums designed to provide face to face interaction with stakeholders for the Master Plan. A series of small focus group meetings, called Roundtable Discussions, were held with the Arlington business and developer community, parks and recreation advocates/users, and neighborhood groups and property owners. The focus groups provided an opportu-

nity for more in-depth discussion and idea sharing about the Master Plan.

The small representative groups of 15-25 people met several times during the project to provide comments on key elements of the Master Plan including potential development ideas, opportunities and constraints, water quality protection and the Vision for the Master Plan.

The Project Team arranged the meetings and facilitated the discussion so that each person in attendance could provide his or her ideas and opinions, as well as ask questions about the planning process. The meetings were generally 1.5 hours and included a formal presentation of 15-20 minutes.

The business/developer focus group met twice and they were interested in:

- Desire to make Lake Arlington a point of interest by redesigning existing or new facilities
- Costs associated with the development of lakeshore properties and who would pay for compliance with new standards
- Protecting water quality
- Development opportunities on the Fort Worth side of the lake, and if Fort Worth was interested in development
- Site constraints on the Fort Worth side: some of the vacant land is low lying and marshy, therefore, not conducive to new development
- More information on standards for docks, piers, and retaining walls
- Creating public/private partnerships as a potential funding source
- Beautification along the lake, and who would be responsible for maintaining this
- Negative impacts to water quality from dredging
- Creating incentives to rehabilitate housing developments as they age, and looking for opportunities to upgrade development
- Implementing a good mix of residential, commercial, and open space along Lake Arlington

The parks and recreation focus group met three times (after the first meeting of this group participants were included in the Neighborhood group) and they were interested in:

- More control on visitation to the lake during evening hours
- Replacing the Simpson Park Lake House with a similar multi-purpose building
- Improving Richard Simpson Park
- Existing traffic on the Arlington side of the lake – participants did not want additional traffic to result from any development around the lake
- Limitations to new development in Arlington due to existing neighborhoods
- Concern about herbicide/pesticide use around the lake
- Vision of additional access to the waterfront, more events organized by the city, and a way to utlize the vacant land on the Fort Worth side for public and passive open spaces
- Concern that lake level fluctuation can limit use of the lake
- Potential for a linear park upstream of the lake along Village Creek
- Protecting water quality with green spaces and wetlands
- Enhancing wildlife management, especially waterfowl

The neighborhood/property owner focus group met three times and they were interested in:

- Concern about an increase in traffic with the development of a new marina

- The need for dredging
- Development along the Fort Worth side of the lake, and who would be responsible for implementing this
- Desire for retail and restaurants, and a marina as a destination – combine this destination with an emphasis on wildlife/nature tours
- Non-motorized watercraft being able to use/access the shallow end of the lake
- Standards and guidelines for docks, piers, and retaining walls
- Safety at Richard Simpson Park, and the need for this park to be patrolled 24 hours a day
- Better dock fishing access, and the need for more fish structures

One set of recommendations included in the Master Plan are Standards and Guidelines for Docks, Piers and Retaining walls. Prior finalizing these specific guidelines the Planning Team brought together a group of contractors, architects and property owners to review the proposed standards. Attendees were asked to comment on the ideas presented and to share what they thought about the proposed standards and guidelines in terms of constructability, costs and marketability. From this discussion the Planning Team made revisions to several of the guidelines for docks, piers and retaining walls

B. Public Meetings

In addition to the focus group meetings, the project team organized and hosted five public meetings. The purpose of these meetings was to involve the Arlington and Fort Worth communities in the Master Plan in an engaging and constructive environment. The project team was responsible for the meeting strategy and logistics, as well the creation of all the necessary meeting materials.

1. Public Meetings 1 and 2 – Visual Preferences

   The City of Arlington wanted to get a sense of what the public wanted to see in terms of future development along the lakefront and within the study area. The first two public meetings, one held in Arlington (3/30/10) and the other in Fort Worth (4/5/10), were designed to present the findings of the team's preliminary data gathering and physical analysis and to discuss the impacts of this analysis on potential development around the lake. Meeting participants were able to participate in a visual preference exercise based on a series of photographs depicting options and opportunities related to:

   - Docks and piers
   - Marinas
   - Water's Edge Character
   - Retaining Walls
   - Open Space
   - Streets
   - Residential Development
   - Commercial Development

   Stakeholders were asked to indicate their preferences by category for those images/approaches they liked the most, and those they preferred the least. Through this method, the Project Team was able to gather preferences for desirable planning approaches towards forging stronger linkages and development strategies.

   From the visual preference exercise, the Project Team was able to ascertain the types of develop-

ment and open spaces that attendees preferred. There was significant consensus between the Arlington and Fort Worth meetings. Lower density and passive open space areas were preferred in both meetings. Specifically, when asked about how Open Spaces should be developed or maintained, stakeholders indicated a preference for community parks that are passive rather than active, and the creation of a natural buffer/water oriented park system between the water's edge and new streets or development.

In terms of potential development there was general opposition to commercial streets and boulevards and a preference for Single-family/ Residential clusters and lifestyle retail such as a village-scale development.

For elements within the flowage easement stakeholders expressed a preference for terraced, masonry walls over concrete or gabion walls. Covered docks and piers were also favored.

2. Public Meeting 3 – Opportunities and Constraints
The third meeting (9/13/10) gave the public an opportunity to review and comment on the draft Vision for Lake Arlington that was developed on the basis of the physical analysis and the input from the first round of public meetings. The City of Arlington and project team shared the potential opportunities and constraints for development within the study area, answered questions about the ideas presented and collected citizen feedback.

The format of the meeting was designed to encourage interaction between the project staff/planners and citizens. Both Arlington and Fort Worth citizens were invited to the third meeting. After a brief presentation, participants spent the remainder of time in one-on-one discussions at the information stations that were set up around the room. These stations focused on:
- Lake Arlington Master Plan Vision
- Water Quality
- Opportunities and Constraints
- Feedback from previous public meetings

Participants were concerned about an increase in noise and traffic with any new development along Lake Arlington, and the need for patrolled parks in the Lake Arlington area. Some commented on the importance of maintaining water quality and wildlife in the lake, and the importance of maintaining the integrity of residential areas on Lake Arlington. Participants also requested a better method of cleaning up the lake area and having a trash pickup plan to do so. Others agreed that there are opportunities for development on the Fort Worth side of the lake; however, some participants expressed concern that the City of Arlington would be responsible for the costs of this development. Attendees were happy to have the opportunity to be informed at these public meetings, and provide input and comments to the study team to be considered throughout the LAMP process.

3. Public Meetings 4 and 5 – Vision Plan
The final round of public meetings included separate meetings, one in Arlington (2/15/11) and one in Fort Worth (2/17/11). The Project Team presented the vision plan illustrations, shoreline design standards and guidelines recommendations, and watershed BMPs during these workshops. The presentations revisited the process performed to date, focusing on the refinements made leading to

the preferred planning approach.

4.2.3 Lakeshore Drive Alignment

As part of its master thoroughfare planning, the City of Fort Worth has proposed to build a four-lane divided arterial (Shoreline Drive) within the Lake Arlington study area. The proposed roadway is designed to address mobility needs and to spur development in Southeast Fort Worth. Because portions of the roadway alignment would be within the Lake Arlington Flowage Easement, the City of Arlington began coordination with City of Fort Worth staff and roadway consultants in early 2010 as part of the Master Planning process.

Development and improvements within the Arlington Flowage Easement were reviewed and approved by the Arlington Water Utilities Department. The City of Arlington was primarily concerned with the runoff and potential pollutants caused by a roadway within the flowage easement, and on potential reductions in the flood storage capacity of the reservoir.

On June 23, 2010, the City of Arlington provided testimony to the City of Fort Worth Planning Board in support of the Lakeshore Drive project and later provided recommendations on best management practices for roadway construction within the Lake Arlington Flowage Easement. The first phase of Lakeshore Drive has been approved for design and construction from Berry Street south to Wilbarger Street.

4.2.4 Gas Well Development

Over the years there has been public concern about the safety, potential pollution and visual impacts of natural gas drilling operations that are located near Lake Arlington. During the Lake Arlington Master Plan process, representatives from the gas well development companies participated in discussions regarding runoff/pollution control measures and aesthetic practices. As part of the process the planning team provided recommendations for aesthetic practices to be incorporated in permits given to drillers. These areas include screening, vegetation and plantings and restoration once a site has been abandoned. In addition, the planning team developed recommendations for lakeside trail routings through properties owned by the drilling companies. These recommendations were provided by the City to the drilling companies. The Master Plan also includes BMPs for water quality protection to specifically address gas well drilling operations.

4.2.5 Involvement of NCTCOG

The NCTCOG hosted two multi-jurisdictional watershed briefings to encourage collaboration on source water protection issues and potential stormwater BMPs. Representatives from the 15 political subdivisions within the Village Creek watershed were invited to participate in this regional dialogue so that planners could better understand how to prepare for and manage growth in a manner that promotes economic development while protecting our land and water resources.

One of the key benefits of the Lake Arlington Master Plan was that it provided valuable modeling data about the impacts of this growth and how to mitigate the degradation of the water that flows into Lake Arlington. The watershed modeling study includes a screening level pollutant loading and reservoir eutrophication model (oxygen depletion due to algae, etc.) for the entire watershed. The intent is to use information observed in the model to develop recommended BMPs for source water protection. However, it will be up to each individual government to implement those protections.

A set of Management Measures and Best Management Practices have been developed based on meeting state and federal regulations/new requirements for watershed management.

4.2.6 Website

The Malcolm Pirnie Team developed a webpage for the Master Plan, which was located on the City of Arlington website, on the Water Utilities Department page. The website describes the purpose of the Master Plan, displayed a map of the study area, provided information on Lake Arlington, and contained a link to the Frequently Asked Questions document developed by the team. Each time the Frequently Asked Questions document was updated throughout the Master Planning process, an updated document was then posted online. The website also provided updates on upcoming public meetings, and provided contact information so that those interested in speaking with a team member had the option of emailing or calling the team, and the opportunity to get involved in the Master Plan process.

The website also contained a link to an online survey that visitors could complete, which was automatically submitted to the study team for consideration throughout the Master Plan process. The survey asked questions about one's current use for the lake, what one would like to see/would not like to see happen on the lake, their thoughts on development around the lake and opportunities for development, and the opportunity to provide overall, general comments. Once the Vision for Lake Arlington was created and presented to the public, visitors to the website also then had the opportunity to go online and comment on this Vision, and on the identified opportunities and constraints. The study team considered all comments submitted by stakeholders from the online survey, and kept record of every comment in a survey log. The images below display the online survey from the website.

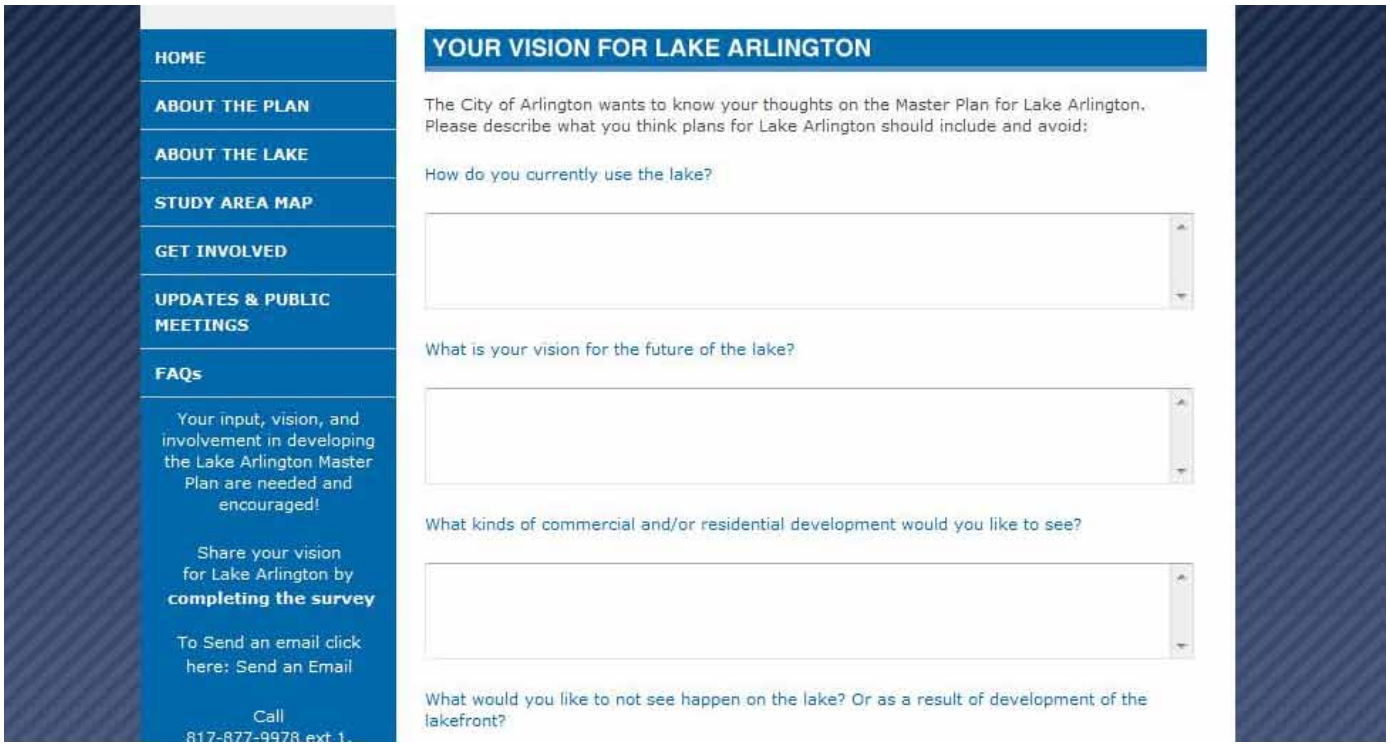
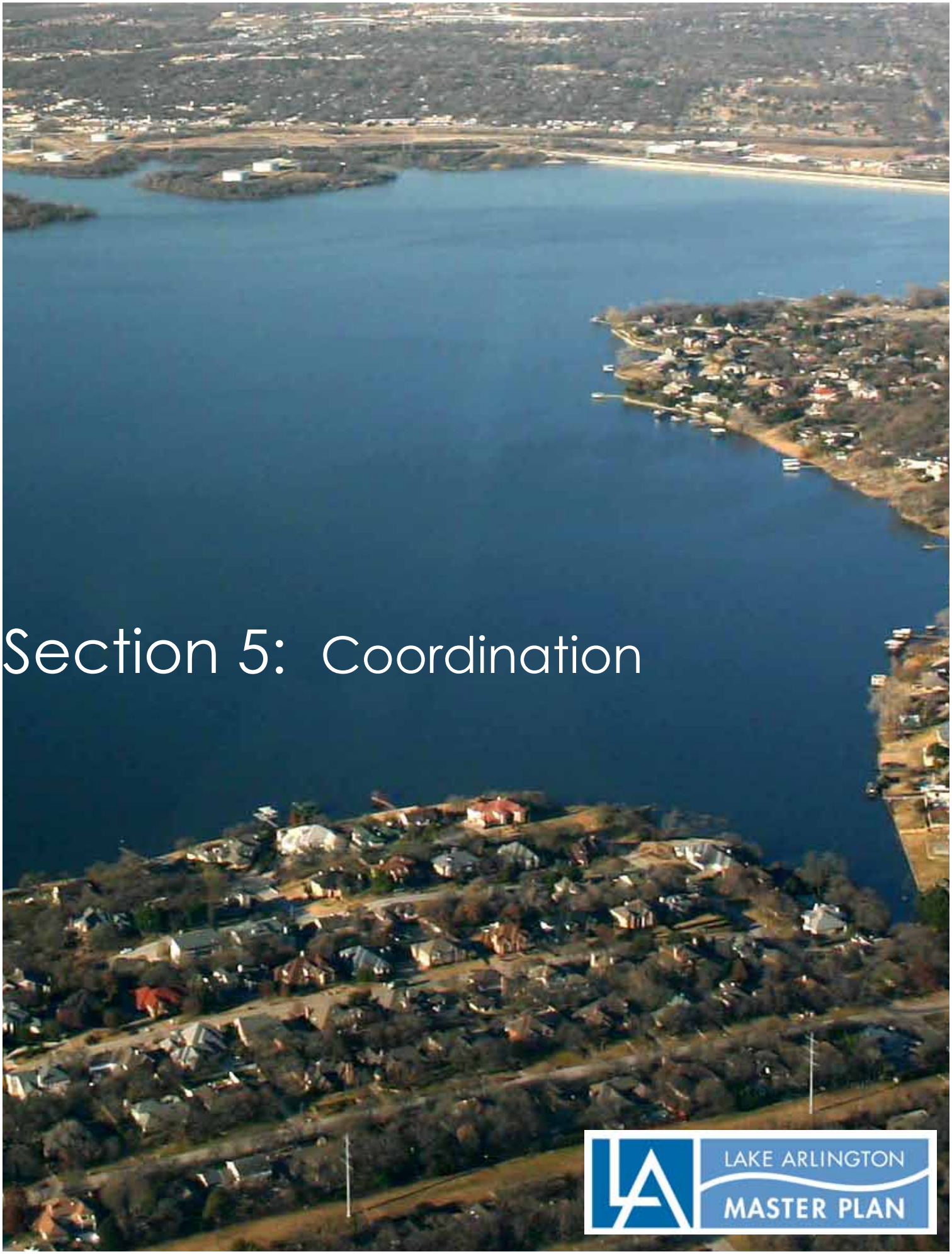


Figure 4.2-1: Lake Arlington Master Plan Website



Section 5: Coordination

LAKE ARLINGTON MASTER PLAN

5. Coordination and Acknowledgements

5.1 Introduction

The uniqueness of the Lake Arlington Master Plan approach required coordination across City of Arlington departments, with water resource entities, and planning agencies at regional and state levels, and collaboration between all 13 cities and the two counties within the Lake Arlington watershed.

Because the Master Plan addresses both water quality and land use development, multiple departments within the City of Arlington participated in the planning process. Each department contributed expertise and insight in order to address the numerous issues related to the protection of water quality, while at the same time laying out a vision for sustainable development within the planning area. Representatives from Water Utilities, Parks and Recreation, Community Development and Planning, Public Works, Communications, Community Services and Police each played a significant role in the development of the Master Plan.

Arlington's neighboring city, Fort Worth, is located on the west side of Lake Arlington. The City of Arlington proactively sought the participation and input from City of Fort Worth staff in the master planning process because of the immediate impact of any decisions to Fort Worth city government and residents along the lakefront. Monthly coordination meetings were held to address how to create a vision that took into account the needs of the City of Fort Worth, and the citizens and property owners on the lake front side of Fort Worth. Fort Worth councilmembers and staff were given tours of Lake Arlington. Two public meetings on the Master Plan were held in Fort Worth to engage its residents, property owners and citizens.

On a regional and statewide level, organizations such as the North Central Texas Council of Governments (NCTCOG), Tarrant Regional Water District (TRWD), Trinity River Authority (TRA) and the Fort Worth District of the U.S. Army Corps of Engineers (USACE) provided important data for use in watershed modeling as well staff support towards the development of the Master Plan. The NCTCOG played a major role in bringing together the political jurisdictions within the watershed to brief them on the Master Plan and to discuss ways to protect water quality.

5.2 Fort Worth Coordination

Staff from both the City of Arlington and the City of Fort Worth worked together during the planning process by sharing data, ideas and participating in monthly coordination meetings.

The monthly coordination meetings, which began in March 2010, became the cornerstone of the collaborative efforts between Fort Worth and Arlington. During these meetings staff were able to provide data and guidance on how to best develop the vision and to work through specific issues. Information and data that were provided included planning information, trails and parks information, similar studies on Lake Worth, stormwater management plans and trash collection, databases and contacts.

One specific issue addressed during the coordination process was the best way to align and design the proposed Lakeshore Drive without negatively impacting Lake Arlington water quality. The City of Arlington provided Fort Worth with best management practices for roadway construction and aesthetics for use within the Lake Arlington flowage easement. Gas well drilling sites was another issue on which the two cities worked collaboratively to set specific guidelines for how these drilling sites within the Lake Arlington planning area could be developed without negatively impacting future development and redevelopment ac-

tivities. The cities worked with the drilling companies to address how the sites could be used in the future to benefit the lake and surrounding properties.

Another key issue that benefitted from the two-way dialogue between cities was related to the creation of new standards for docks, piers and retaining walls. Each city had to ascertain how to handle permitting requests and construction inspections for development within the Lake Arlington flowage easement on the Fort Worth side of the lake.

There was also communication between the cities at the Council level. The City of Arlington presented briefings to the Fort Worth City Council. These briefings helped to ensure that all levels of City of Fort Worth decision makers were included in the process.

Fort Worth residents and property owners were also invited to engage in the master planning process in order to give their input and opinions. Two public meetings were held in Fort Worth on the Master Plan, and Fort Worth residents were invited to a joint meeting in Arlington in the middle of the planning process. The input received from Fort Worth citizens was found to be very similar to ideas and opinions expressed by Arlington residents.

Overall the enhanced communication and collaboration facilitated the creation of a Master Plan that addresses the needs of both communities. It is anticipated that the collaboration between Arlington and Fort Worth will continue during the implementation of the Lake Arlington Master Plan.

5.3 Involvement with Other Water Organizations

5.3.1 General

During the planning process, the Malcolm Pirnie Team and the City of Arlington continually coordinated with regional, state and national organizations that currently impact or could impact the watershed and Lake Arlington. We greatly appreciate the cooperation and assistance provided by each of these agencies.

5.3.2 Tarrant Regional Water District

Lake Arlington is owned and operated by the City of Arlington; however because the reservoir is part of the Tarrant Regional Water District (TRWD) regional water system, TRWD plays a significant role in the water quality aspects of the reservoir, and in the lake level. A more detailed description of the lake operations is provided in Section 6.4.

TRWD owns and operates two East Texas surface water reservoirs that are used to supply make-up water to Lake Arlington. Pump stations and pipelines from Richland-Chambers Lake and Cedar Creek Lake supply raw water to Lake Arlington, as shown in Figure 5.3-1. These facilities allow TRWD to operate the reservoirs and Lake Arlington as a system in order to maximize the availability of water while minimizing the cost of power.

TRWD provided water quantity and quality data that greatly benefited the project. TRWD staff members also provided information on the operation of their reservoirs and the land management and shoreline permitting programs in place on the two reservoirs.

5.3.3 Trinity River Authority

Lake Arlington is used as a raw water supply source for the Trinity River Authority (TRA) for treatment at its Tarrant County Water Supply Project water treatment plant. This project serves as a primary water supply for the communities of Bedford, Colleyville, Euless, Grapevine, and North Richland Hills. The treatment plant went into operation in 1974. It has been expanded six times to its present capacity of 87 mgd. During calendar year 2009, the average daily flow was approximately 28 mgd, with a peak day flow of 64 mgd.

5.3.4 U.S. Army Corps of Engineers

The Fort Worth District of the U.S. Army Corps of Engineers (USACE) was established in 1950 after disastrous floods in the area. It is responsible for water resources development in two-thirds of Texas, and military design and construction in Texas and parts of Louisiana and New Mexico.

Representatives of the Environmental Resources Branch of the Fort Worth District attended meetings related to the Lake Arlington Master Plan, and provided information on proposed planning activities within the Village Creek watershed. At the present time, the District is working with the cities of Kennedale and Arlington, as well as the NCTCOG on a proposed eco-restoration project for Village Creek. The agencies are working on a preliminary Project Management Plan (PMP) that will include a scope of work that has yet to be defined.

5.3.5 Coordination with North Central Texas Council of Governments

Throughout the planning process, the Pirnie Team coordinated with the North Central Texas Council of Governments (NCTCOG), and their cooperation and assistance is much appreciated. The NCTCOG provided valuable data for use during the planning process.

In developing this Master Plan, planners referenced regional documents such as Vision North Texas and the North Texas Alternative Futures Plan. The planners attempted to link the recommendations and action items in those types of documents to the proposed plan for Lake Arlington. For example, major components of the Master Plan conform to regional planning elements such as pedestrian design elements; conservation development; preservation of undeveloped areas; use of programs such as iSWM; transfer of development rights through techniques such as conservation easements; and taking a holistic approach to developing the Master Plan.

5.3.6 Coordination with Texas Parks and Wildlife

Texas Parks and Wildlife Department (TPWD) representatives attended roundtable and public meetings, and actively participated in discussions. TPWD also provided information on fishing and waterfowl activities on Lake Arlington, and boating safety issues on the lake.

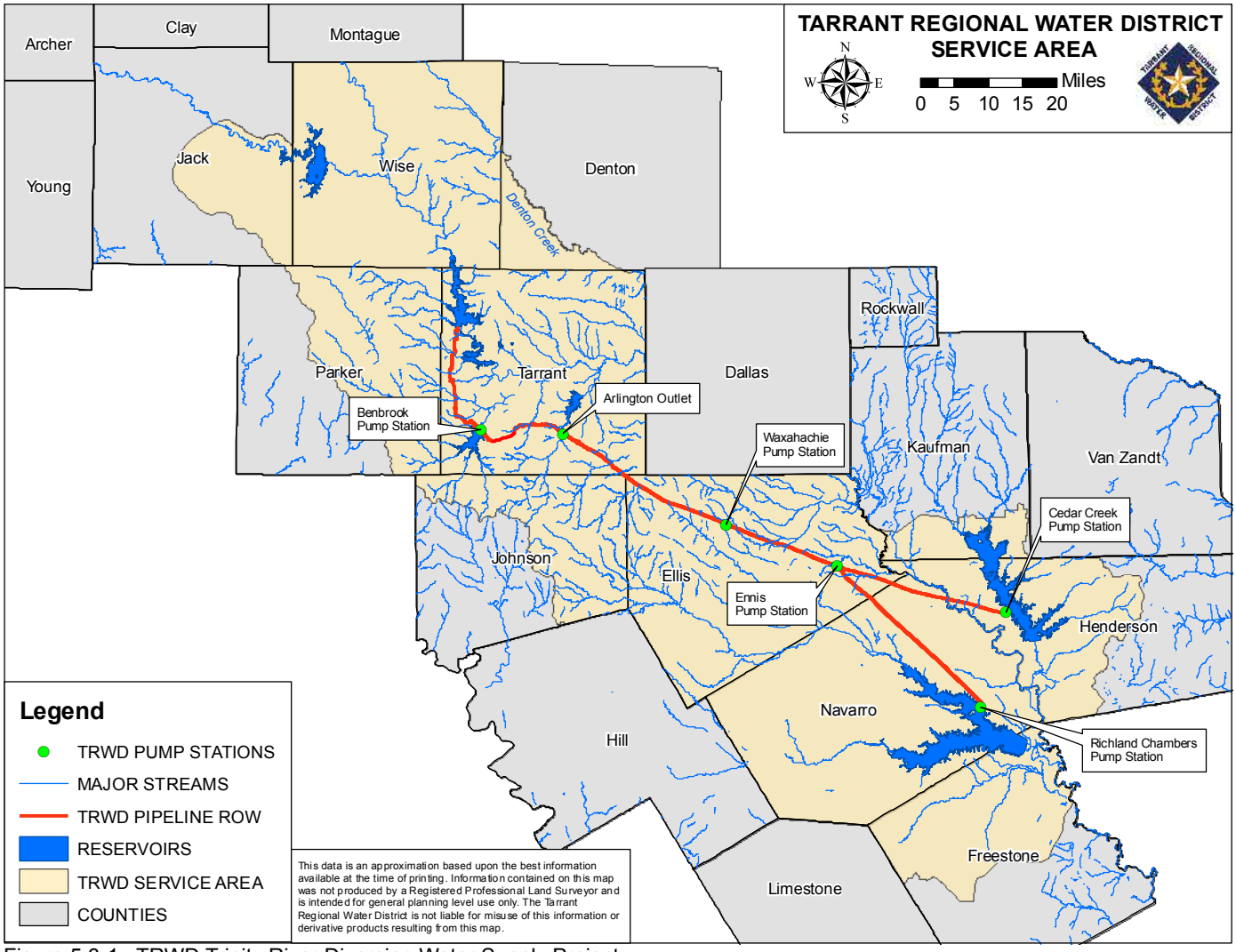
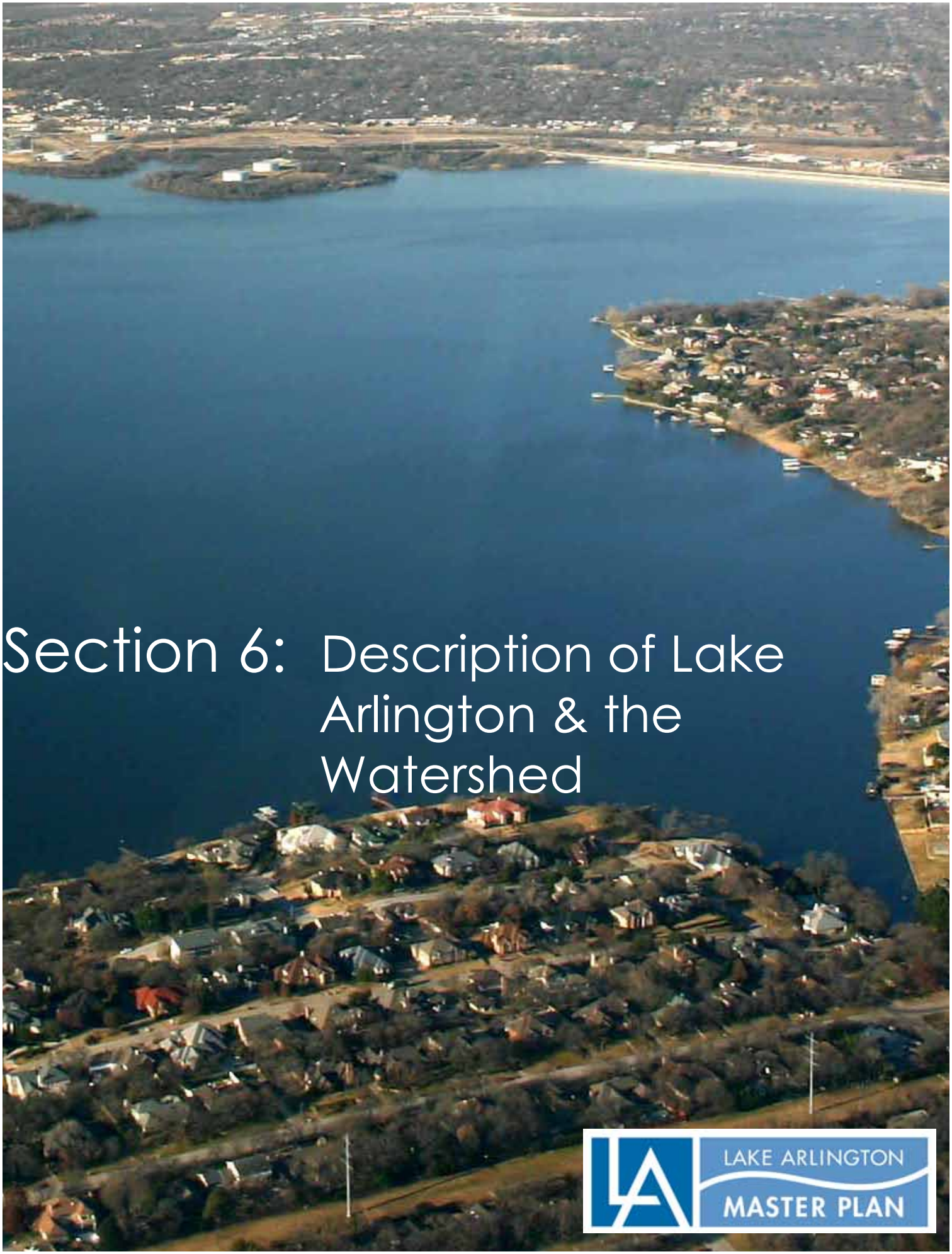


Figure 5.3-1: TRWD Trinity River Diversion Water Supply Project



Section 6: Description of Lake Arlington & the Watershed

LAKE ARLINGTON MASTER PLAN

6. Description of Lake Arlington and the Watershed

6.1 History of Lake Arlington

In the early 1950s Arlington's mayor, Mr. Tom Vandergriff, proposed building a reservoir to ensure an adequate water supply for a growing city and an increasing industrial base. The lake was built in the Village Creek watershed and incorporated a smaller reservoir called Lake Erie that had provided cooling for an electric generating plant. The generating plant was located in the community of Handley and had originally powered the Interurban trolley system.

Construction of Lake Arlington was completed in 1957, near the end of the 1950's drought. In many parts of Texas, including the Dallas-Fort Worth Metroplex, the 1950's drought has been considered the "drought of record." This term means that the ten-year drought from 1946 through 1957 is considered the worst drought in recorded history. Following this drought, many communities constructed reservoirs or developed alternatives sources to provide a more reliable supply of water.

A 100-year rainfall event in the spring of 1957 filled Lake Arlington in 30 days, ending the debates that usually accompany reservoir projects. Today the lake receives supplemental water piped in from East Texas water supply reservoirs managed by the Tarrant Regional Water District (TRWD). Lake Arlington is now operated as a terminal storage reservoir within the TRWD regional raw water system.

6.2 Uses of Water

Water from Lake Arlington is used for municipal and industrial (cooling) purposes. In addition, the reservoir is used for public recreation and as wildlife habitat. Lake Arlington is foremost a water supply reservoir, providing a source of drinking water to approximately 500,000 people in the City of Arlington, and other communities. Water from Lake Arlington supplies the Pierce-Burch Water Treatment Plant (WTP), owned and operated by the City of Arlington, and the Tarrant County Water Supply Project (TCWSP) WTP, owned and operated by the Trinity River Authority (TRA). The Pierce-Burch and TCWSP WTPs intakes are at the northeast end of the Lake near the east end of the dam. There are two treatment facilities at Pierce-Burch. The north plant has a current rated capacity of 75 million gallons of water per day (mgd)and the south plant has a current rated capacity of 34 mgd for a total of 109 mgd. The TCWSP WTP treats up to 72 mgd of raw water from Lake Arlington and has planned expansions to 100 mgd.

Table 6.4.1 provides a summary of the sources of supply and uses of water within the reservoir system. The average annual evaporation based on TRWD daily evaporation data from 2005 to 2009 is 4.32 feet.

6.3 Description of Lake and Immediate Surrounding Area

Lake Arlington covers approximately 2,000 surface acres and is located at the northeast end of the Village Creek watershed. As described above, Lake Arlington receives water from runoff within the Village Creek watershed and from TRWD's Richland-Chambers and Cedar Creek Reservoirs through 72-inch and 90-inch pipelines. TRWD also has a pipeline connection to Lake Benbrook as well. The area immediately around the reservoir is a mix of urbanized and natural land uses. On the east (Arlington) side of the reservoir, the area is predominantly residential, with two public parks located on the lake. On the west (Fort Worth) side of the reservoir, the area is predominantly natural opens space, with some residential development on the south (upstream) end of the reservoir. The Exelon Handley Power Plant dominates the land use in the northwest corner of the reservoir near the dam. Current land use activities in the Village Creek watershed include a mix of urban and rural, with some pastureland.

Lake Arlington Supplies and Uses	Average Annual Inflows	Average Annual Withdrawals
Natural supply from watershed	50,995 acre-ft(1)	N/A
City of Arlington Pierce-Burch WTP	N/A	32,800 acre-ft(2)
Trinity River Authority TCWSP WTP	N/A	34,000 acre-ft(2)
Exelon Handley Power Plant	N/A	4,000(3)
Tarrant Regional Water District Discharge from Cedar Creek and Richland Chambers Reservoirs to Village Creek	43,500 acre-ft(4)	N/A

Table 6.4-1: Sources of Supply and Uses of Water

N/A – not applicable
(1) Based on rainfall data from 1992 – 2009 and PLOAD model projections. Estimated annual inflow includes baseflow from Village Creek (2,735 acre-ft) and estimated surface runoff. See Water Quality Modeling Report – Existing Conditions.
(2) Average annual withdrawal between 2009 and 2010.
(3) Projected 2010 net demand, taking into consideration diversions and return flows. (Source: TRWD, 1998)
(4) Average of monitored discharges between 2005 and 2009.

6.4 Dam and Lake Operations

6.4.1 Background

Lake Arlington is located on Village Creek, a tributary of the Trinity River. It is located between the cities of Arlington and Fort Worth, approximately seven miles from downtown Arlington. The normal conservation level of the lake and the normal shoreline is elevation 550.0 feet above mean sea level (msl) (NGDV 29). A flood storage easement (the "Flowage Easement") held by the City of Arlington extends from the lake up to elevation 560.0 feet. The 2007 volumetric survey performed by the TWDB indicated that Lake Arlington has a total reservoir capacity of 40,188 acre-feet and a surface area of 1,926 acres at its normal conservation pool elevation.

The Lake Arlington dam is an earthfill structure with a total length of 6,482 feet (1.2 miles) and a height of 83 feet. The top of the embankment is 572.0 feet above msl, but according to the TWDB volumetric survey, a parapet wall was added to the dam making the top elevation 577.5 feet above msl.

The service spillway or outlet structure is used to release water when the elevation of the lake is above the normal conservation level. The outlet is an uncontrolled "morning glory" type circular drop inlet set at elevation 550.0 feet msl. The discharge conduit is 10-feet in diameter. Figure 6.4-1 shows the drop inlet structure.

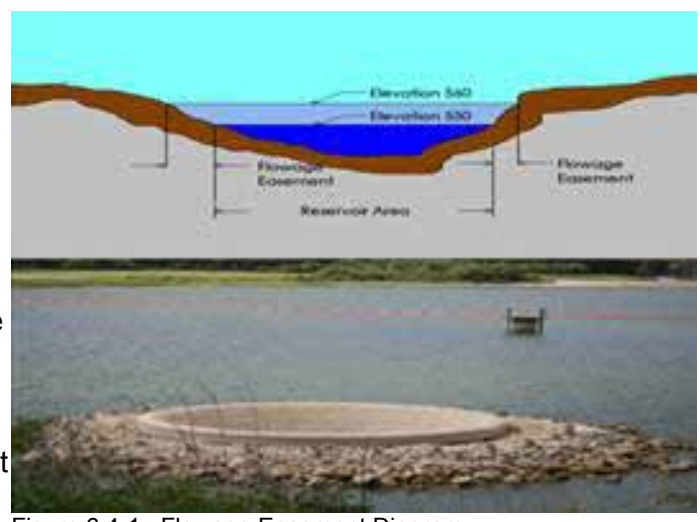


Figure 6.4-1: Flowage Easement Diagram

An emergency spillway is used to release water during flood events when the elevation of the lake rises above the outlet structure and the inflow exceeds the capacity of the discharge conduit. The uncontrolled emergency spillway is a cut in the right (or east) end of the embankment. It has a length of 882 feet and a crest elevation of 559.7 feet above msl, which is 9.7 feet above the lip of the drop inlet structure.

The drainage area of Lake Arlington is 143 square miles in size. According to an April 1999 Memorandum Report Investigation of Lake Arlington Operation Policies prepared for the Tarrant Regional Water District (TRWD), the average inflow into the reservoir from the watershed is approximately 30,000 acre-feet per year, however, the 1978 inflow was only 2,720 acre-feet. The average annual evaporation from the reservoir is 3.09 feet. The 1999 Memorandum Report states that the calculated firm yield of Lake Arlington is approximately 6,000 acre-feet per year (ac-ft/yr).

6.4.2 Operating Criteria

Lake Arlington is a source of water to three primary users: (i) the City of Arlington's Pierce-Burch Water Treatment Plant; (ii) the Trinity River Authority's water treatment plant (a component of its Tarrant County Water Project); and (iii) the Handley Generating Station. The Handley power plant is operated by Exelon Power, which is a business unit of Exelon Generation Corporation ("Exelon"). It is a 5-unit, 1,441 mega-Watt (MW) fossil power plant that provides electricity on an as needed basis to customers in the Electric Reliability Council of Texas (ERCOT) grid system.

The water rights used for the operation of Lake Arlington are held by the City and Exelon (the power plant was formerly owned by Texas Utilities Electric Company). Certificate of Adjudication (COA) 08-3391 authorizes the City and Exelon to impound up to 45,710 acre-feet of water in the reservoir. The City is authorized to divert and use up to 13,000 ac-ft/yr (an average of 11.6 mgd) for municipal purposes, and Exelon is authorized to divert and use up to 10,120 ac-ft/yr for industrial (cooling) purposes. Therefore, the City owns 56% of the conservation capacity and firm yield of the reservoir.

The Trinity River Authority (TRA) diverts water from the lake under contractual arrangements with TRWD, and that water is actually supplied from TRWD's East Texas reservoirs, not from the yield of Lake Arlington.

The operation of Lake Arlington is predicated on four major factors: (i) inflows into the reservoir; (ii) evaporation from the surface of the reservoir; (iii) diversion/use of water from the reservoir by the City, Exelon and TRA; and (iv) makeup water supplied by TRWD from Richland-Chambers and Cedar Creek reservoirs through TRWD's East Texas pipeline system, and potentially from Lake Benbrook. See Figure 6.4-2. The difference between the Lake Arlington yield, and total water demand and evaporation is provided by TRWD from the two East Texas reservoirs. The water from East Texas is discharged into Village Creek just upstream of Lake Arlington. Therefore, Lake Arlington serves as a terminal storage reservoir in the TRWD water supply system. TRWD uses an operational computer model to determine monthly targets for delivery of water to Lake Arlington from East Texas. The model is designed to optimize the operation of the TRWD system to meet water supply demands and contractual obligations while minimizing the cost of electric power and the other operations and maintenance expenses related to the TRWD system.

The operation of the lake and the water level (especially during the summer months) is also a function of contractual relationships between TRWD and the various entities using water. Because Exelon does not have a significant amount of consumptive water use and one of its major concerns is the water temperature of the lake, its contractual relationship with TRWD is based on minimum lake levels. Under a 1971

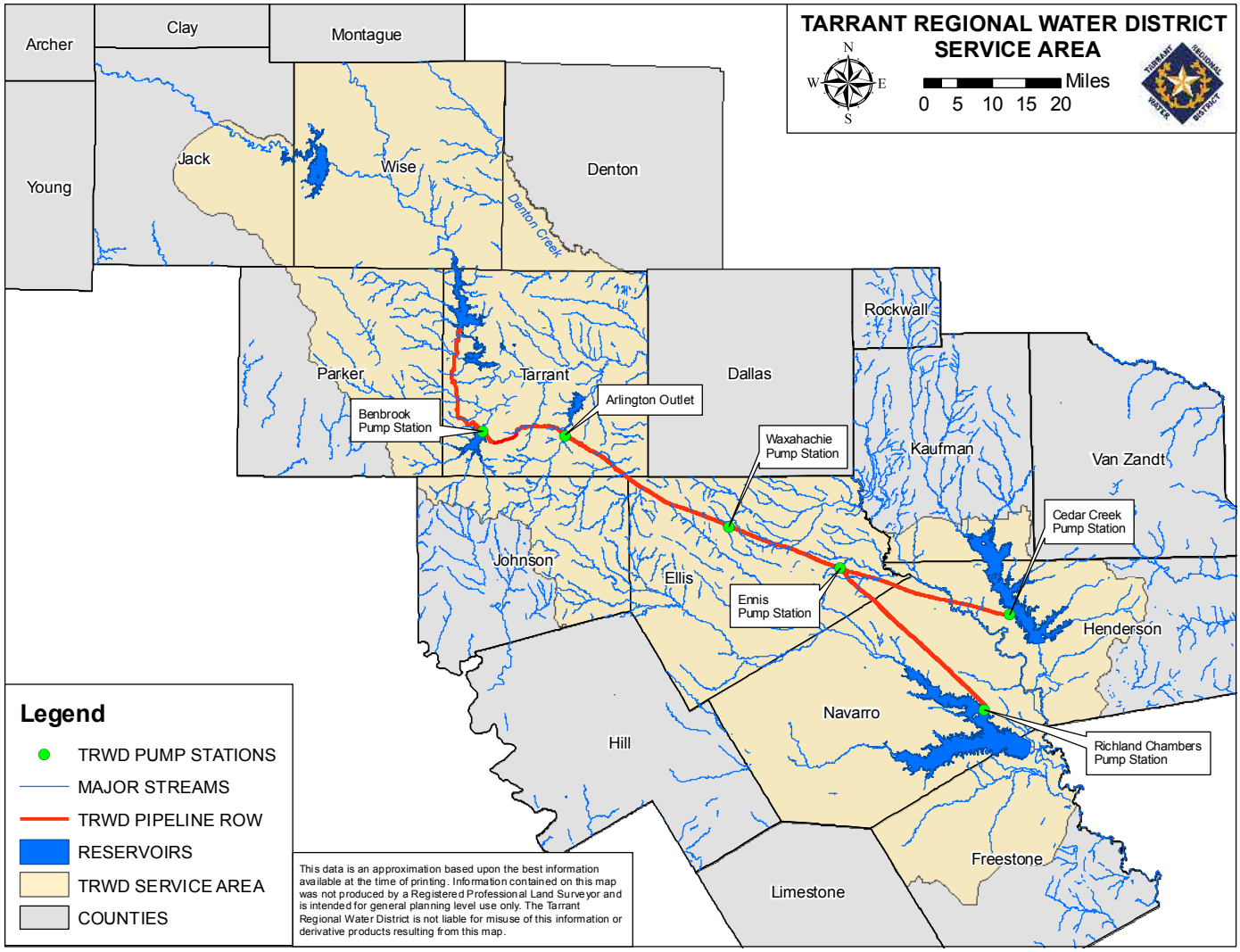


Figure 6.4-2: TRWD Service Area

agreement, TRWD has agreed to "use its best efforts" to maintain specified water levels. The required minimum water elevations are 540 feet (10 feet below normal pool) from June 1 through September 1; 535 feet (15 feet below normal) from September 1 to September 30; and 535 feet at all other times (September 30 to June 1).

There is also a water supply agreement between the City of Arlington and TRWD. Under that 1982 agreement, TRWD agrees to supply all of the City's raw water requirements for the life of the TRWD system, and Arlington agrees to take all of its raw water from TRWD. All of the water diverted by Arlington from the lake is considered to be TRWD system water, and TRWD has the right to use the lake for the storage of its water. That agreement also requires TRWD to maintain the lake level at or above elevation 531 feet at all times. Therefore, the Exelon contract (referenced above) currently controls the minimum water level of the lake.

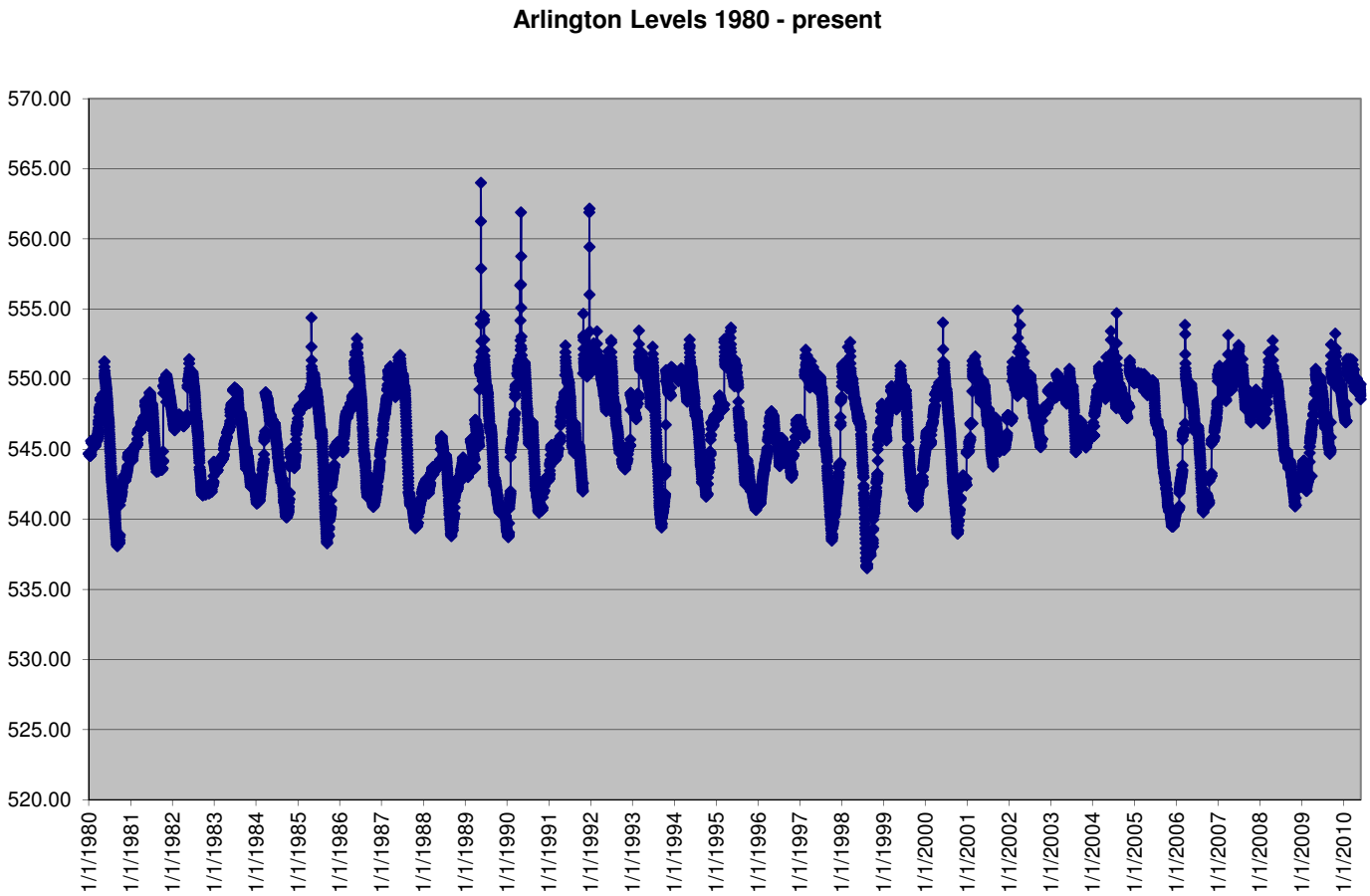


Figure 6.4-3: Lake Arlington Historic Level Since 1980

6.4.3 Lake Level Impacts

Figure 6.4-3 shows the historic level of Lake Arlington since 1980. The graph shows the regular fluctuation in lake levels, predominantly during the summer months.

Lake Arlington is an integral part of the City's water supply and utility system, and it serves a valuable purpose as a regional storage reservoir. From a water supply standpoint, lake level fluctuations do not affect availability because the City is not dependent upon the reservoir for its firm supply of raw water. TRWD is contractually obligated to supply the needs of the City and TRA. Because of the agreements between the City and TRWD, Lake Arlington is now a storage reservoir within the TRWD raw water supply system, and the level of the lake is determined by TRWD's system operations.

The water level of Lake Arlington remains an issue for some recreational users and shoreline property owners who would like to see higher lake elevations closer to 550.0 feet msl. Some boat ramps become difficult to use at elevation 542.0 feet. The upstream (south) end of the lake becomes very shallow at lower lake levels, and this reduces access to portions of the lake. At lower elevations, obstacles such as tree stumps are exposed, posing safety hazards and reducing the area that can be used for skiing and boating.

At the same time, during this planning process there were some reported benefits from lower lake levels. The exposed islands and mud flats in the upstream end of the reservoir create recurring habitat for water-

fowl, and some lake users said that they appreciate the fact that lower levels force boaters to slow down in some sections of the lake.

6.5 Flowage Easement

Although private property owners own the land surrounding Lake Arlington, the City retains a peripheral"flowage and soakage" easement for the storage of flood waters (the "Flowage Easement"). The Flowage Easement of Lake Arlington is the area surrounding the lake between the elevation 560.0 feet above msl contour line and the lake (normally elevation 550.0 feet msl). This is the area that is used to temporarily store flood waters during a high flow event within the watershed. A theoretical cross section of the Flowage Easement is shown in Figure 6.4-1.

Because of the importance of the Flowage Easement to the operation of Lake Arlington, the City exercises considerable control on the activities within that area, both within the City of Arlington and the City of Fort Worth. For example, Arlington requires that property owners obtain a permit from the City prior to constructing, repairing or modifying structures within the Flowage Easement. Recommended standards for those activities are discussed in detail in other Section 8.11 of this Master Plan.

6.6 Lake Arlington Ordinances

The City of Arlington has enacted a series of ordinances to regulate activities in, on and around the lake, and establish procedures for management of this resource. The current ordinances are shown in Appendix 6.6.

The ordinances deal with a variety of issues and activities, including: the use of watercraft; fishing; construction, repair and modification of buildings and other structures; docks, piers and boathouses; and sanitation. Swimming is currently prohibited in Lake Arlington, and certain fishing activities are regulated. Permits are required for many activities within the lake and the Flowage Easement.

In February 2010, the Arlington City Council passed a resolution temporarily suspending the issuance of permits for structures (docks, piers, retaining walls, etc) and earthwork in Lake Arlington and the Flowage Easement. This suspension was enacted in order to give the City Council an opportunity to review the recommendations contained within this Master Plan and to make informed decisions concerning permitting of future improvements in the Lake Arlington area.

6.7 Description of Watershed

The following figures describe general conditions within the watershed.

6.8 Discussion of Potential Sources of Indirect Reuse

At the current time, the only two sources of supply for Lake Arlington are natural runoff from the Village Creek watershed and make-up water from the TRWD regional water system. In the future, as the population continues to grow in the watershed, it might be possible to add highly treated wastewater ("reclaimed water") as a source of supply. The dedication of reclaimed water discharges could be a source of indirect reuse water that would augment the other sources.

6.7.1 General Description

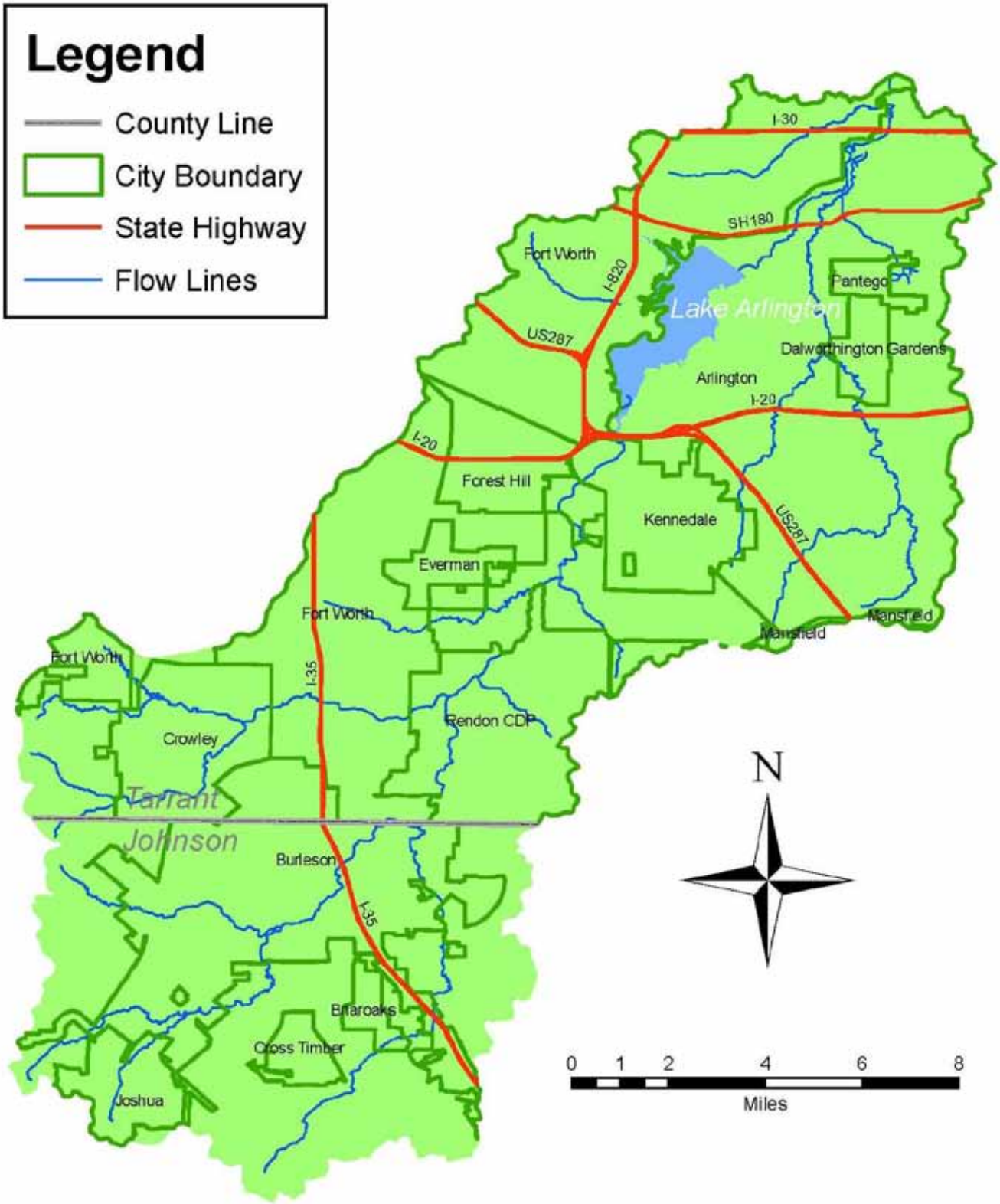


Figure 6.6-1: General Description

6.7.2 Geology

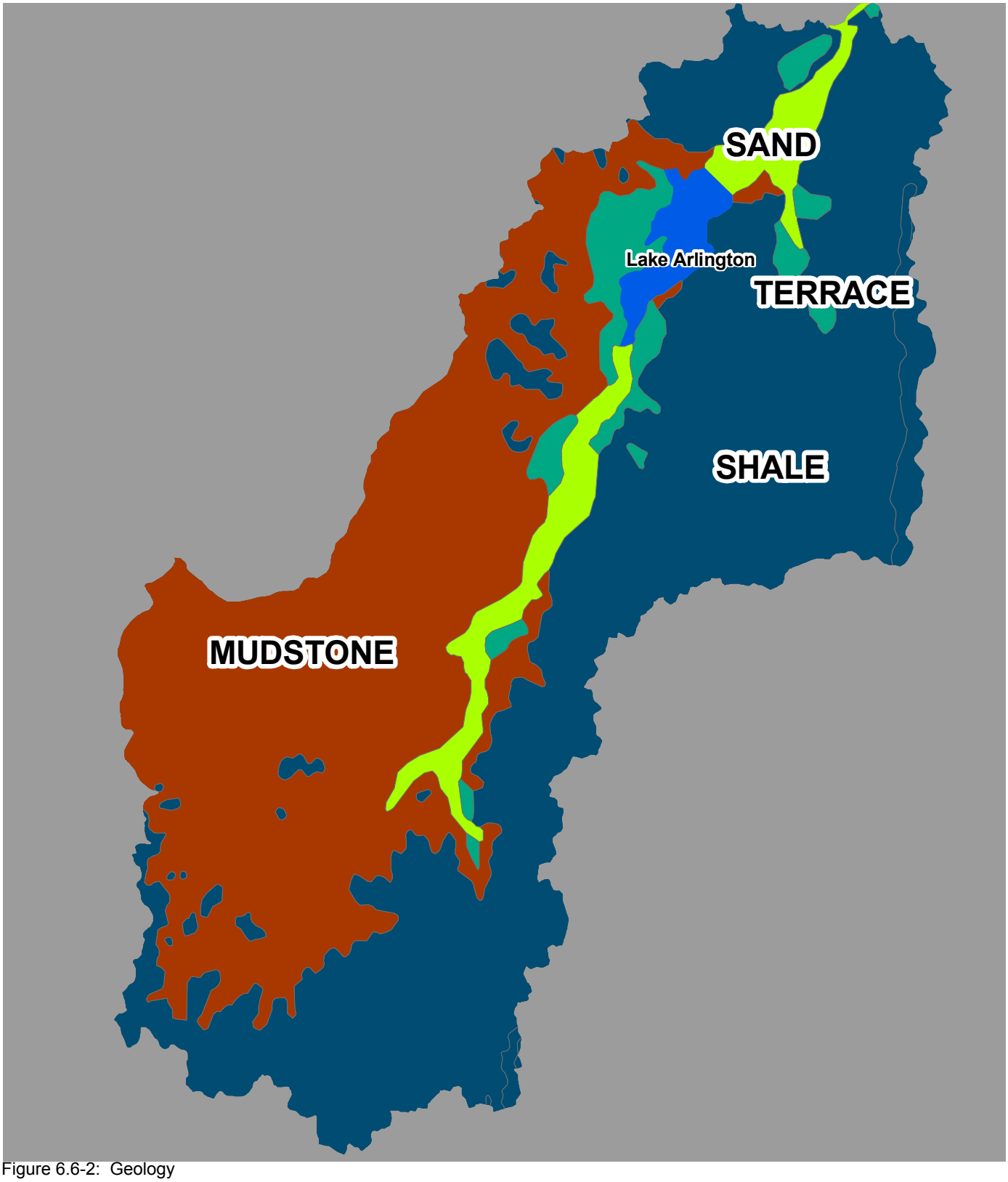


Figure 6.6-2: Geology

6.7.3 Topography

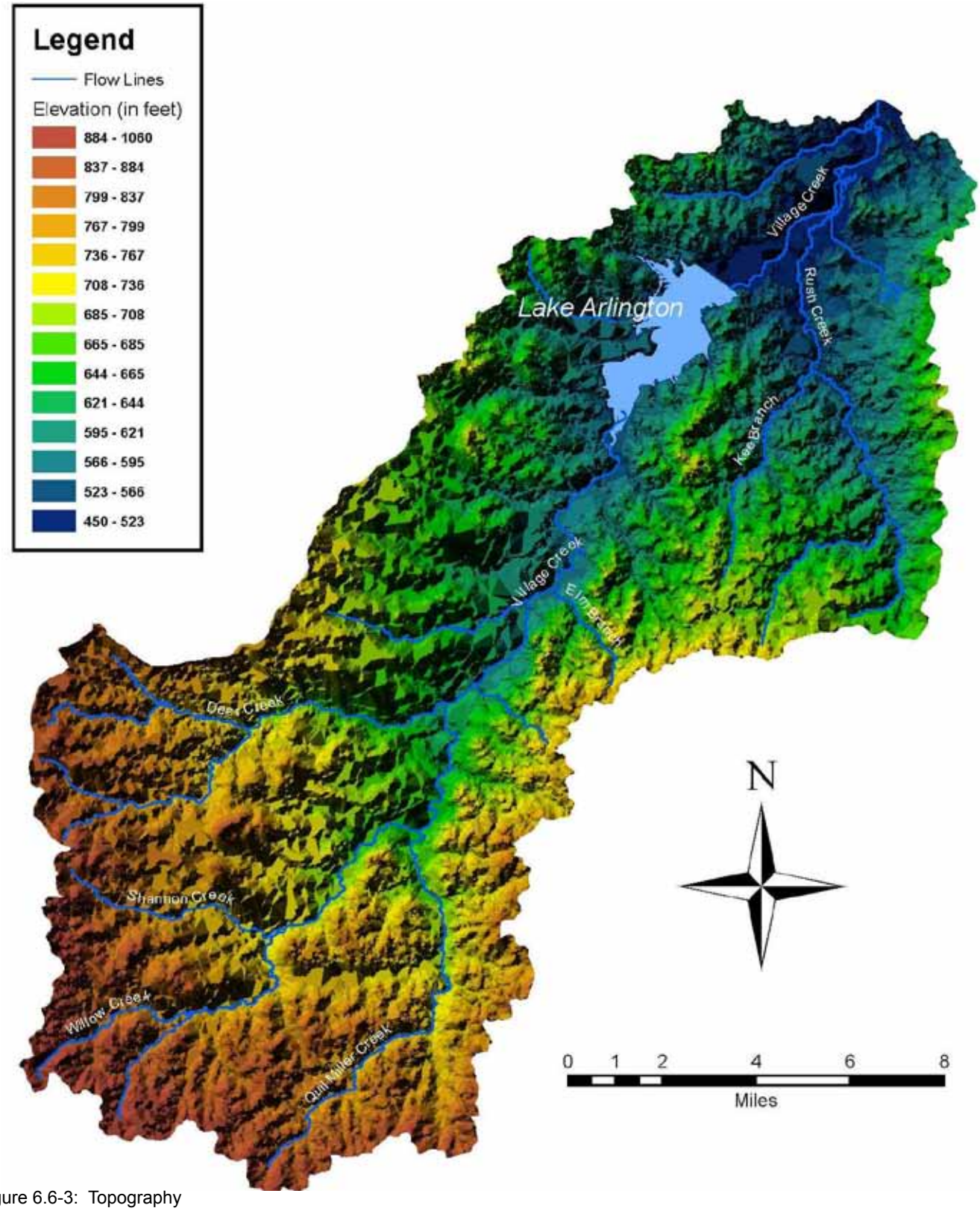


Figure 6.6-3: Topography

6.7.4 Precipitation

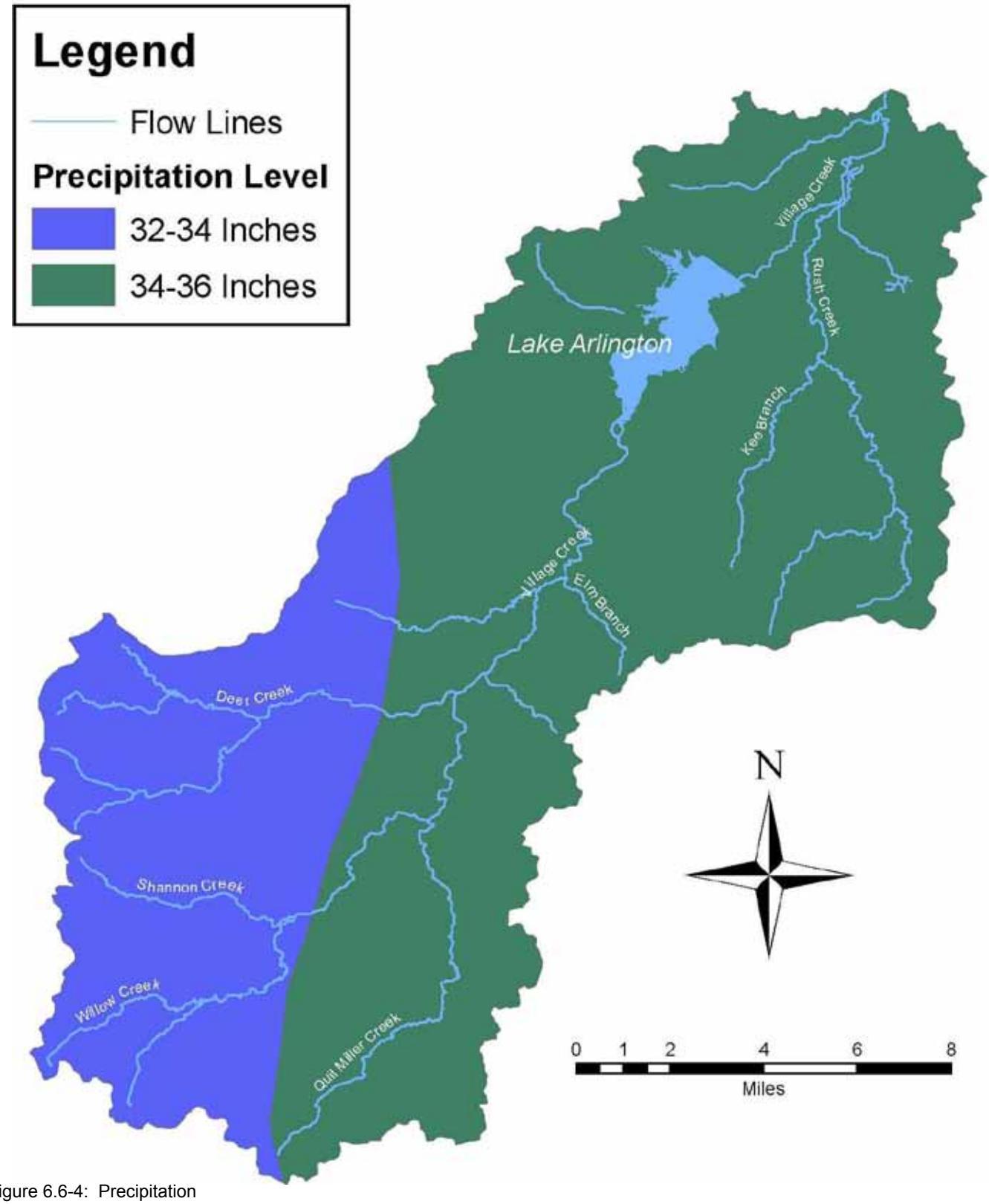


Figure 6.6-4: Precipitation

6.7.5 Land Use

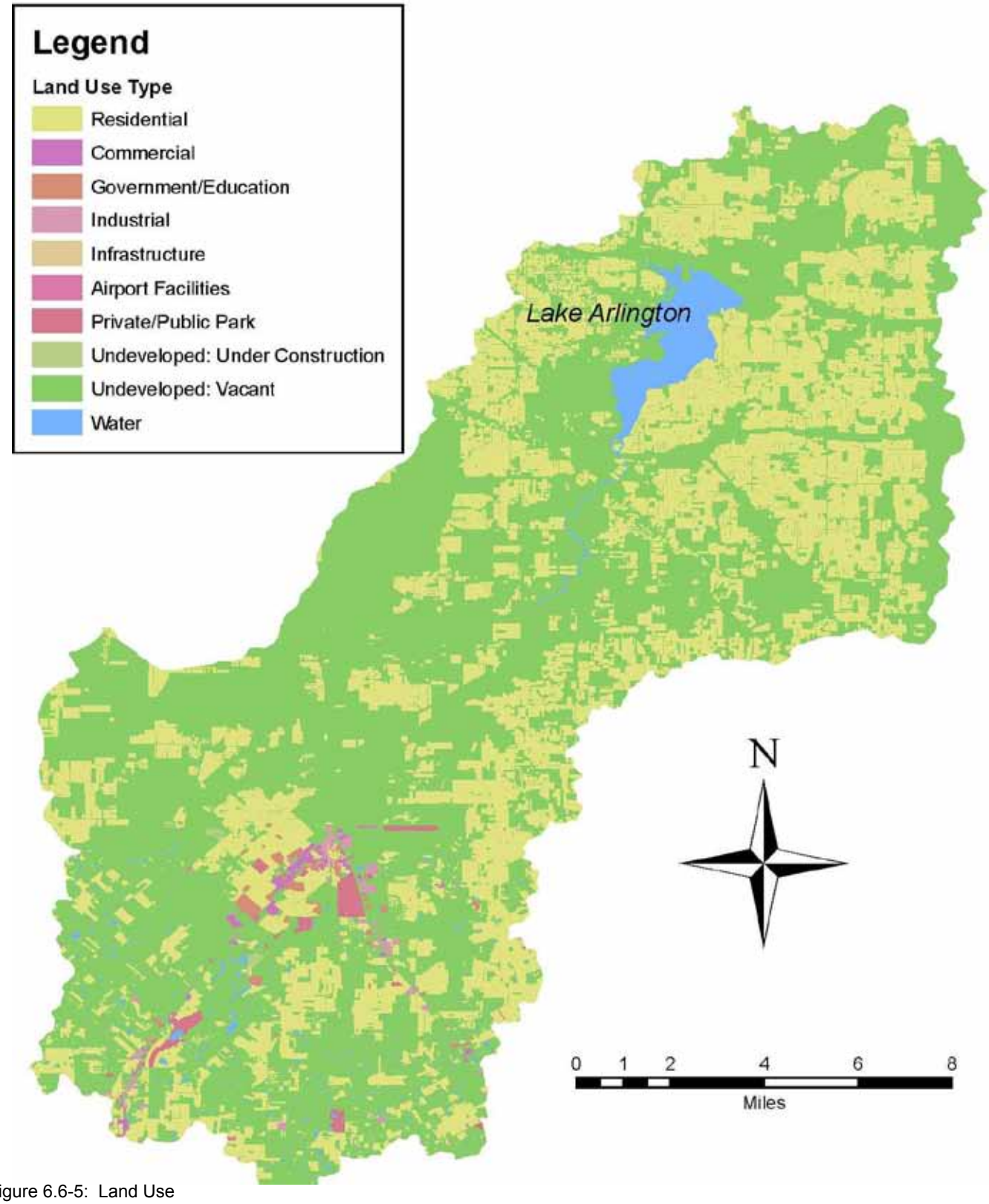
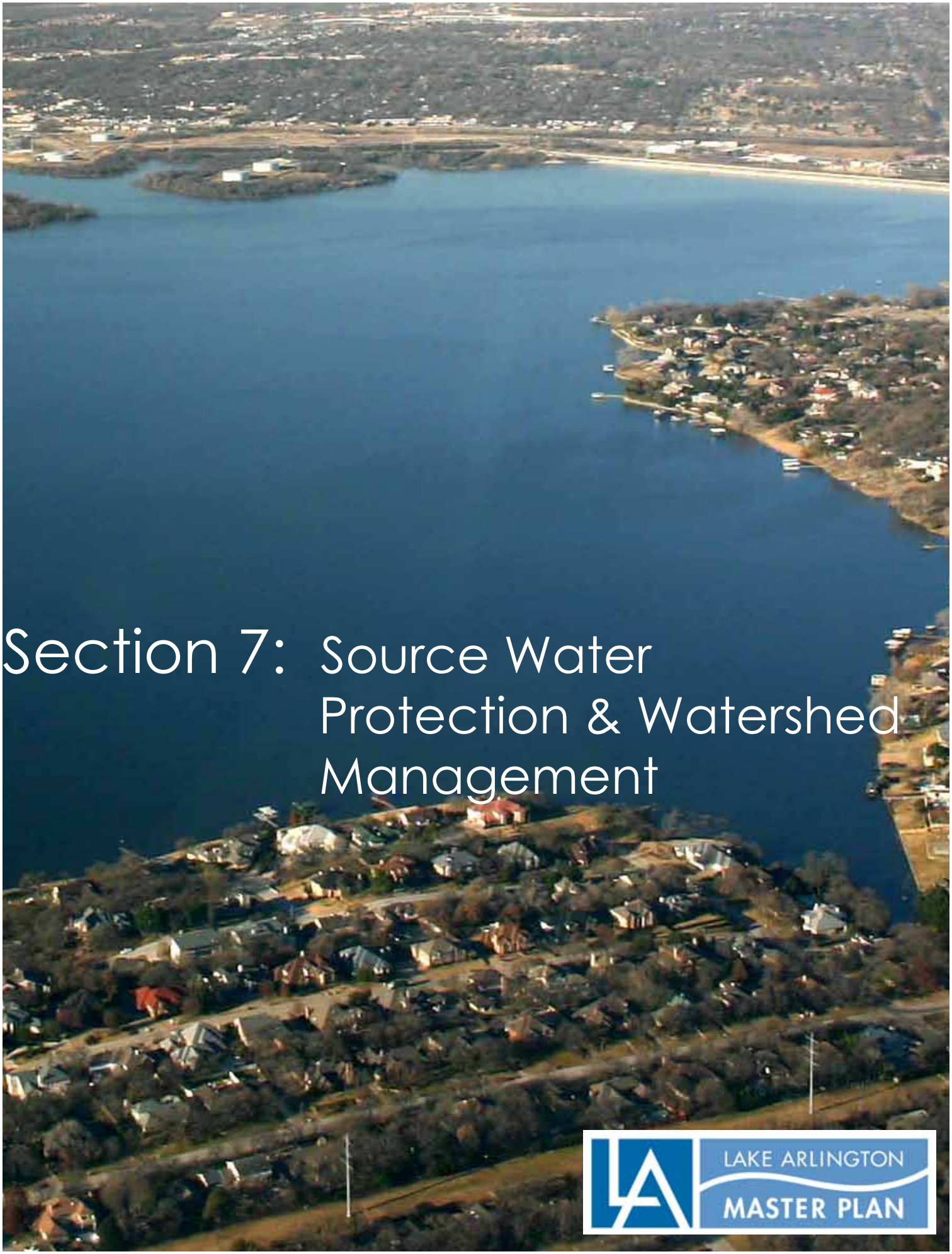


Figure 6.6-5: Land Use



Section 7: Source Water Protection & Watershed Management

LAKE ARLINGTON MASTER PLAN

7. Source Water Protection and Watershed Management

7.1 Rationale for Watershed Protection

7.1.1 Need for Protecting Lake Arlington

Lake Arlington supplies a substantial amount of raw water for public use as treated drinking water, and for industry. The quality of this water supply is critical to the public health, safety and general welfare of the community. Land uses and activities in the Lake Arlington watershed can affect the quality of water supply due to potential pollutants from various land use practices. High impact land uses and unmanaged development can contribute to the degradation of water quality of Village Creek and Lake Arlington both directly and indirectly through the degradation of contributing waters.

7.1.2 Common Themes for Watershed Management

The need for stormwater and watershed management is driven by several common themes:

- Stormwater runoff and potential impacts are directly linked to land use change.
- Control of stormwater runoff quantity and quality is necessary to minimize property damage, stream degradation, and water quality impacts.
- A long-term goal of mimicking natural hydrologic conditions will help address potential impacts from stormwater runoff.
- Multiple regulatory requirements are evolving to address the increasing importance of stormwater management and water quality protection and improvement.

Regulatory requirements serve as the framework for watershed management and protection. Federal and State regulations serve to protect and improve water quality by establishing and enforcing water quality standards and by regulating discharge of pollutants into waters of the United States. Federal regulations include the Clean Water Act and the Safe Drinking Water Act. These regulations are typically becoming more stringent.

The recommendations for watershed management strategies for the Lake Arlington watershed discussed in this document serve to assist watershed municipalities in watershed protection. The recommendations are goals that will serve to define a long-term watershed protection strategy in order to control runoff associated with land development, control construction site erosion and sedimentation, control trash and debris and other sources of pollution, and protect the public water supply. The recommended strategies also provide guidance on development policies, illicit discharge detection and elimination ordinances, establishment of environmentally sensitive areas, riparian corridor and conservation subdivision policies, public education programs, and permit reviews for proposed or upgraded wastewater treatment plants (WWTP). The recommended policies and programs will require additional review before they are adopted. The City of Arlington plans to work with other jurisdictions in the watershed to encourage the implementation of these requirements.

7.1.3 Regulatory Compliance

This section outlines the Federal and State regulatory requirements that provide much of the impetus for implementing the recommended watershed strategies in this document for the Village Creek/Lake Arlington watershed. These Federal and State regulations protect and improve water quality by establishing and enforcing water quality standards and by regulating discharge of pollutants into bodies of water.

A. Federal Water Protection Programs

Clean Water Act

The Federal Water Pollution Control Act of 1972, as amended by the Clean Water Act of 1977 (CWA), and the Federal Safe Drinking Water Act (SDWA) of 1986 are the primary federal regulatory drivers behind protecting and improving water quality. Administration and enforcement of these programs are delegated to the Texas Commission on Environmental Quality (TCEQ) by U.S. Environmental Protection Agency (EPA).

NPDES Program

The National Pollutant Discharge Elimination System (NPDES) permit program was established under the CWA to control water pollution by regulating the discharge of pollutants into waters of the United States. The NPDES program covers several pollutant sources that are regulated by permits issued by the TCEQ. These include:

- Municipal Wastewater Treatment Facilities
- Sanitary Sewer Overflows (SSOs)
- Combined Sewer Overflows (CSOs)
- Industrial and Commercial Wastewater Discharges
- Pretreatment Facilities
- Concentrated Animal Feeding Operations (CAFOs)
- Municipal Storm Sewer Discharges
- Industrial Stormwater
- Stormwater Permits for Construction Areas

Each of these programs has a role in protecting water quality and must be considered in a watershed management program. The following is a discussion of the major regulatory requirements for local governments under the NPDES program and implications for watershed and stormwater management. Several of the NPDES permit program areas affect how municipalities within the watershed handle sanitary wastewater flows. Regulations address publicly-owned treatment works (POTWs), separate and combined wastewater sewer systems, sludge and biosolids handling, and pretreatment requirements for industrial users discharging into a municipal wastewater system. Typical permits establish discharge levels (e.g., pollutant-specific limits and waste loads), monitoring requirements, and reporting requirements.

Under TCEQ's Municipal Separate Storm Sewer System (MS4) permit program, local governments in regulated areas are required to establish a comprehensive stormwater management program (SWMP) and to develop a plan and program to control stormwater pollution discharges to waters of the State to the maximum extent practical and to prevent non-stormwater discharges from entering the stormwater system.

This is accomplished through a local program which includes such measures as structural and non-structural stormwater controls, Best Management Practices (BMPs), regular inspections, enforcement activities, stormwater monitoring, and public education efforts. Stormwater management ordinances, erosion and sedimentation control ordinances, development regulations, and other local regulations provide the legal authority necessary to implement the stormwater management programs.

Federal and state regulations regarding discharges of stormwater require operators and owners to ap-

ply for and obtain NPDES permit coverage prior to conducting regulated construction disturbance and/or initial operation of small non-coal, nonmetallic mining sites, and associated land disturbance activities. These rules require that a Construction Best Management Practices Plan (CBMPP), prepared by a qualified credentialed professional (QCP), that is designed to minimize pollutant discharges in stormwater runoff to the maximum extent practicable during land disturbance activities, be fully implemented and effectively maintained.

In addition to technical and administrative requirements, the rules require that regular inspections be performed by a QCP, a trained person under the direct supervision of a QCP, or a qualified credentialed inspector (QCI) trained through the Qualified Credentialed Inspection Program (QCIP).

The registrant, owner, operator, contractor, or other responsible entity, separately or collectively, must retain NPDES registration coverage for regulated projects until existing disturbance activity and future proposed disturbance activity is complete and all disturbed areas have been reclaimed and/or effective stormwater quality has been remediation achieved.

Figure 7.1-1 illustrates the municipalities in the Village Creek watershed that are permitted by TCEQ under the Phase I or Phase II Stormwater Program. The cities with Phase I permits inlcude Arlington and Fort Worth. The entities with Phase II permits include: Burleson, Crowley, Everman, Forest Hill, Kennedale, Mansfield, Pantego, Dalworthington Gardens, Tarrant County, and Johnson County.

Total Maximum Daily Loads (TDML)

The Total Maximum Daily Load (TMDL) program specifies the maximum amount of a specific pollutant of concern that a designated segment of a waterbody can receive and still meet water quality standards. The TMDL also allocates pollutant loadings among point and nonpoint pollutant sources, including stormwater runoff based on waste load allocation, load allocation, and a margin of safety. Under Section 303 (d) of the CWA, TCEQ is required to develop a list of impaired waters that do not meet water quality standards.

Screening Levels for Nutrient Levels

In compliance with Sections 305(b) and 303(d) of the CWA, TCEQ evaluates water bodies in the state and identifies those that do not meet uses and criteria defined in the Texas Surface Water Quality Standards (TSWQS). Guidance developed by the EPA directs each state to document and submit the results of its evaluation to the EPA biennially, in even-numbered years. The TCEQ also publishes the results on its website as the Texas Water Quality Inventory and 303(d) List (the “Integrated Report”) prepared by the TCEQ and submitted biennially to the EPA. The Integrated Report is also published on the TCEQ Web site.

The Integrated Report describes the status of water quality in all surface water bodies of the state that were evaluated for a given assessment period. The TCEQ uses data collected during the most recent seven-year period in making its assessment. The data are gathered by many different organizations that all operate according to approved quality control guidelines and sample collection procedures. The quality of waters described in the Integrated Report represents a snapshot of conditions during the specific time period considered in the assessment. In most circumstances, the period of record for water quality data and information used in preparing the Integrated Report is the most recent seven years.

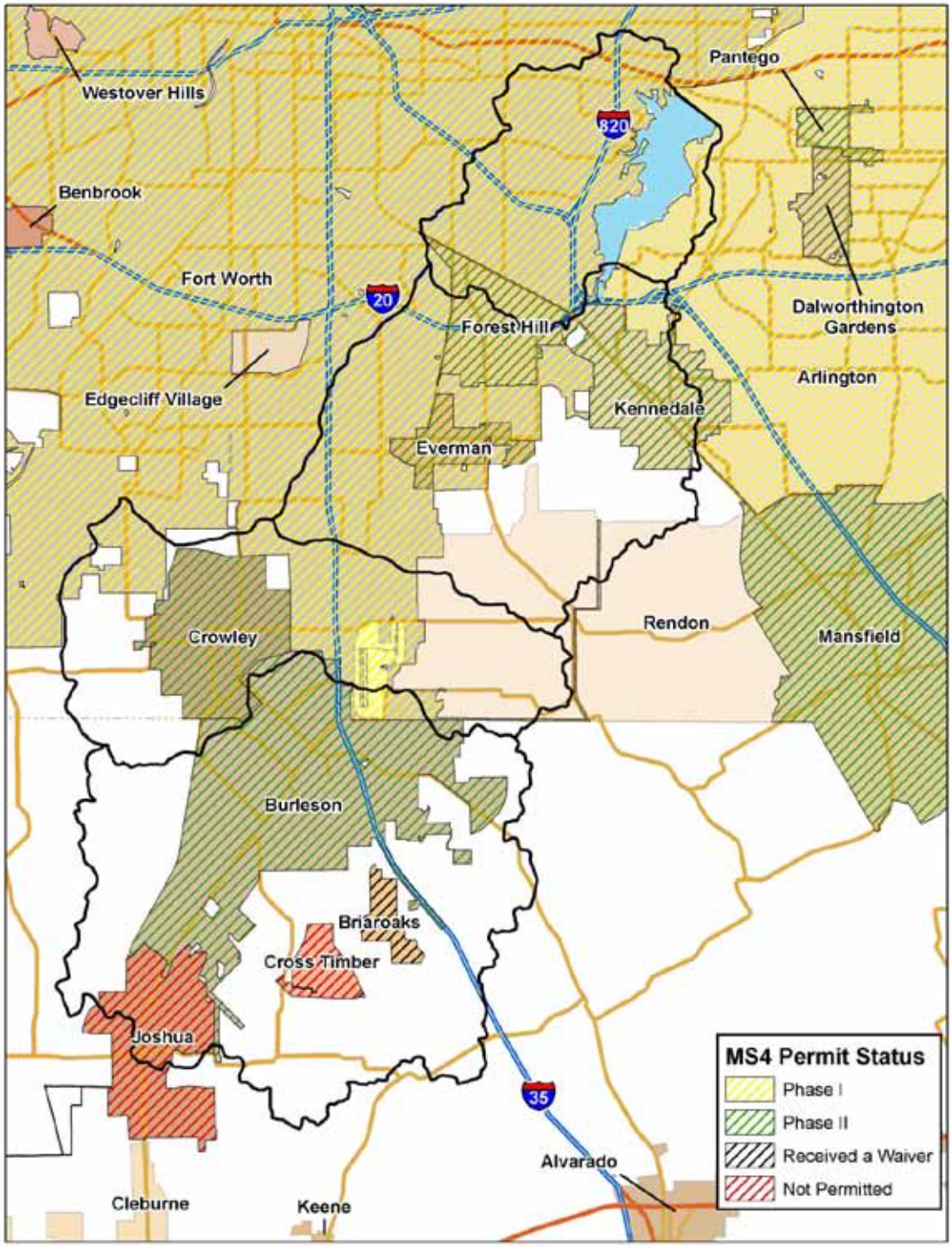


Figure 7.1-1: MS4 Designations in the Watershed *It is important to note that the Cities of Dalworthington Gardens and Pantego are in the Village Creek Watershed downstream of Lake Arlington

TCEQ has drafted the Integrated Report for 2010. *The Draft 2010 Texas Water Quality Inventory: Water Bodies with Concerns for Use Attainment and Screening Levels* lists Lake Arlington as a water-body of concern. More specifically, portions of the lake are listed as having a concern for water quality based on screening levels of chlorophyll-a, which is 26.7 ug/L.

B. Safe Drinking Water Act (SWDA)

The 1996 amendments to the Federal SDWA of 1986 (USC 42 Public Health and Welfare 300f – 300j) brought about significant changes in pollution prevention and protection for public water suppliers, as well as the State and Federal governments. One element of these amendments led EPA to require States to submit a program for development of Source Water Assessment Plans (SWAPs), with a national goal that SWAPs would be completed for watersheds serving the majority of the population by mid-2003. EPA anticipated that the assessment information would lead to the development of source water protection plans.

The benefits of a source water protection plan include:

- A more secure and safe drinking water supply.
- Possible reduction in treatment and monitoring costs.
- General cost reduction through pollution prevention.

In Texas, source water protection is a voluntary program that helps public water systems protect their drinking water sources and to ensure its continued reliability. Locally controlled and implemented, a source water protection program is designed to protect drinking water sources from potential sources of contamination.

The program involves the public water system conducting a site-specific survey to identify the potential sources of contamination near water supply wells or intakes. This inventory is conducted, at a minimum, within the area of primary influence (API) for surface water intakes. Nearby Public Water Supplies may share the same API and/or watershed. The API is based upon a 1000-foot buffer from a waterbody shoreline. It may extend upstream for PWS intakes drawing from rivers or streams. How far upstream the API extends depends upon a two-hour time of travel. These areas are referred to as source water protection areas (SWPAs).

7.2 Data sources and quality

7.2.1- GIS Data

Geographic Information Systems (GIS) was used to identify data needs and to locate good quality data sources. Most of the GIS data obtained for this project effort were provided to the Project Team by the North Central Texas Council of Governments (NCTCOG) Research Information Services department. Other sources include both public and private domain data providers. Due to large file sizes, significant data deliveries were provided via external hard drive, ftp sites, and DVDs. All of the available geographic information was then stored in a centralized location and disseminated to a secure ftp site for permitted users.

Current water and wastewater service area polygons	Texas Commission on Environmental Quality (TCEQ)
Land use layer with accompanying land use codes	North Central Texas Council of Governments (NCTCOG)
Wetlands layer	US Fish and Wildlife Service (USFWS)
Current aerial imagery	NCTCOG
Natural feature layers such as open spaces, parks, etc.	NCTCOG
10-digit and 12-digit HUC layers for the Village Creek Watershed	NCTCOG
Topographic layers (least interval contours)	NCTCOG
County soil data	United States Department of Agriculture (USDA) Natural Resources Conservation Sources (NRCS)
Natural gas well locations	Railroad Commission of Texas (RRC)
City coverage layer within watershed	Texas Natural Resources Information System (TNRIS)
Cultural features within the watershed (recreational facilities, schools, churches, etc.)	NCTCOG
Hydrography layer	NCTCOG
Surface water quality monitoring points	TCEQ
Surface water flow monitoring points	NCTCOG
Shapefile of Texas Pollutant Discharge Elimination System (TPDES) permitted dischargers and outfalls	TCEQ
Shapefile of industrial and hazardous waste sites	TCEQ
Shapefile of TPDES permitted water supply diversion points	TCEQ
Toxic Release Inventory (TRI) locations within watershed	TCEQ
Shapefile of Superfund sites within watershed	TCEQ
100-yr and 500-yr floodplain layers	NCTCOG
Floodway layer	NCTCOG
Tarrant and Johnson Counties Tax Assessor parcel data (shapefiles and associated owner information)	Tarrant Appraisal District (TAD)
Street centerline files	NCTCOG
Lake Arlington bathymetric layer	Texas Water Development Board (TWDB)

7.2.2- Policies, Regulations, and Procedures

Masterplans, land use policies, zoning ordinances, and development ordinances were obtained from the cities, townships, and counties that occupy the watershed, when available. NCTCOG provided a master contact list to the Project Team and every avenue was pursued to obtain supporting documentation for this effort.

Current masterplans and Comprehensive plans from the cities in the watershed	NCTCOG
Land use policies	City of Mansfield
Flood plain zoning ordinances	The City of Joshua
Subdivision and commercial development ordinances	NCTCOG Franklin Legal Publishing City of Mansfield

7.2.3- Other Electronic Data

Lake water quality data, water quality reports from the Handley Steam Generating Power Station, historic rainfall data, and population demographic data were obtained through public and private sources.

Regional stormwater removal efficiency data	TCEQ
Lake Arlington water quality data	TCEQ
Water quality data/reports from Handley Steam Generating Power Station	Post, Buckley, Schuh & Jernigan, Inc. (PBS&J) Hungerford, Thomas and Raphael Brock
Historical rainfall and reservoir evaporation data	National Oceanic and Atmospheric Administration (NOAA)
Population/ demographic information	NCTCOG Understanding Our Options for Growth

7.2.4- Carrying Capacity Information

Permitted dock owners and shoreline landowners were determined through the assistance of the City of Arlington and through the use of Tarrant County Appraisal District information.

List of dock permit holders	City of Arlington
List of shoreline property owners	City of Arlington
List of shoreline property owners	TAD

7.2.5- Other Reports and Information

Extensive research was performed at the Texas Commission on Environmental Quality to obtain multiple reports from overlying municipalities and industries that may impact the watershed.

WWTP annual reports for the City of Arlington for the past 3 years	TCEQ
Discharge monitoring reports for industrial facilities for the past 3 years	TCEQ
Lake level data	City of Arlington
WWTP annual reports for the cities of Ft. Worth, Kennedale, and Johnson County FWSD No. 1 for the past 3 years	TCEQ
Stormwater management plans	TCEQ
2008 and 2009 MS4 annual reports and permits	TCEQ

7.2.6- Public Involvement Information

All public involvement information was gathered with the help of both the NCTCOG and the City of Arlington.

7.3 Existing Resource Conditions

7.3.1 Lake Arlington

The primary use of Lake Arlington is for fresh water for potable purposes. Thus, the following review of lake water quality data focuses primarily on parameters of importance for water treatment plant operations and for compliance with U.S. Environmental Protection Agency (USEPA) and TCEQ primary drinking water standards. Water quality parameters of interest from a recreational and lakeshore aesthetics perspective are included in the discussion. The Review of Lake Arlington Water Quality technical memorandum (Appendix 7.3-A) provides information on the data sources reviewed for the Lake Arlington Master Plan.

Water quality in Lake Arlington is generally of good quality. Table 7.6-1 lists measured concentrations for various general physical, chemical, and microbial parameters in the lake[5]. Drinking water maximum contaminant levels (MCLs) and secondary MCLs are provided for reference. Note, however that the listed average, minimum, and maximum concentrations are for raw water samples; treatment is applied at the City of Arlington Pierce-Burch WTP and the TRA TCWSP WTP to meet the MCL requirements in finished water.

Raw water from Lake Arlington is characterized by moderate alkalinity, hardness, and pH. Average concentrations of salts in Lake Arlington water are low, with total dissolved solids (TDS) and chloride concentrations significantly below the SMCLs. At an average of 5.7 milligrams per liter (mg/L), total organic carbon (TOC) concentrations in Lake Arlington are fairly typical for surface water. Microbial characteristics of the raw water and concentrations of other parameters are discussed in the following paragraphs.

5 Data presented in the table were downloaded from the TCEQ Surface Water Quality Monitoring Information System (SWQMIS), which includes data for more than 270 different parameters. Data are compiled from USGS and other monitoring stations.

Microbiological Characteristics

E. coli and fecal coliform concentrations are also listed in Table CG-1, (Appendix 7.3-B). While E. coli and fecal coliform do not present a direct public health risk, their occurrence in water samples is an indication of animal or human fecal contamination and the potential presence of pathogenic microorganisms that do exert a health concern (e.g., *Giardia*). The average *E. coli* and fecal coliform concentrations in Lake Arlington samples are within range of expected values for surface water with upstream discharges from wastewater treatment plants and nonpoint sources of pollution (e.g., stormwater runoff, etc.). *Cryptosporidium* samples collected at the Pierce-Burch WTP raw water intake between January 2009 and November 2011 were non-detect and the Pierce-Burch WTP has been classified as Bin 1 under the LT2ESWTR based on data previously reported to TCEQ. The Pierce-Burch and TCWSP WTPs are designed to meet 4-log virus removal (i.e., 99.99% removal) and 3-log *Giardia* removal (i.e., 99.9% removal) to prevent exposure to pathogens that may be present in the source water.

In addition to pathogens, the presence of other microorganisms, such as algae, can also be a concern. Acceptable algal concentrations in drinking water are not explicitly specified in water quality standards. Algae are considered indirectly through non-specific parameters such as turbidity, color, or TOC. However, it is possible that finished water that meets regulatory standards may still contain a relatively high algal load.

Chlorophyll a is a pigment found in algae; chlorophyll a concentrations above 10 micrograms per liter (ug/L) can be used as a guideline for algal activity in water. The average chlorophyll a concentration in samples collected from USGS Site AC (see Figure CG-1, Appendix 7.3-B) between April 2005 and November 2008 (37.5 ug/L, see Table CG-1, Appendix 7.3-B), indicates significant algal activity in the lake. Complications associated with algae include:

- Presence of algal by-products, such as geosmin and methylisoborneol (MIB), impacting the taste and odor of WTP finished water.
- Lake eutrophication, leading to anoxic conditions and the potential release of dissolved iron and manganese from lake sediments.
- Increased chlorine demand with potential implications on drinking water treatment efficiency and operations, including clogging of intake screens, flow disruption and shortened filter run times.
- Presence of certain algal toxins (e.g., cyanobacterial secretions) that have been linked to fish kills, poisoning of shellfish, and illness in humans.
- Biological growth in the distribution system if algae pass through the filters.
- Increased DBP precursors concentrations leading to the formation of trihalomethanes, haloacetonitriles, and other halogenated by-products that may have adverse health effects.

Taste and odor concerns associated with the release of geosmin, and iron and manganese during anoxic conditions are likely the most pressing concerns related to algal growth for Lake Arlington. Geosmin is a metabolite of blue-green algae that imparts a characteristic earthy/beet odor to water. The odor threshold concentration (OTC) for geosmin is 10 nanograms per liter (ng/L); at concentrations above the OTC, sensitive portions of the population can usually detect the characteristic odor in water.

Figure CG-2, (Appendix 7.3-B) shows geosmin concentrations in samples collected from the Lake Arlington intake. As expected based on the relatively high chlorophyll a concentrations in Lake Arlington, geosmin concentrations above the OTC were routinely detected in samples collected between November 2007 and March 2008. The Pierce-Burch and TCWSP WTPs use ozone and biological filtrationto remove geosminand control taste and odor in the finished water. However, additional barriers my be needed if

geosim concentrations increase and reach peak concentrations of several hundred ng/L.

Nutrients
Table CG-1, (Appendix 7.3-B) lists total ammonia, nitrate, and phosphorus concentrations in samples collected at the Pierce-Burch WTP intake. Ammonia and nitrate concentrations in Lake Arlington are low. However, average phosphorus concentrations are above the 0.039 mg/L draft criteria for total phosphorus established by the TCEQ Water Quality Standards Workgroup for Lake Arlington (see Attachment 3). TCEQ is establishing phosphorus (and chlorophyll a) standards for different water bodies in Texas to minimize algal growth and the potential for eutrophication and associated deterioration in water quality.

Inorganic Contaminants
Average iron and manganese concentrations in the lake exceed the SMCLs (Table [CG-1]), leading to potential aesthetic concerns if the metals are not removed through the WTPs. Elevated manganese concentrations are a well-studied water quality issue for both the City of Arlington and TRA. While iron and manganese do not present a health risk at concentrations found in drinking water, elevated concentrations of both metals can lead to colored water complaints due to a reddish appearance associated with iron precipitation and black particles associated with manganese precipitation. Dissolved manganese can also impart a yellow tint in water.

Iron and manganese are naturally-occurring metals. Village Creek flows through the iron-rich sandy soils of the Eastern Cross Timbers Region and is likely picking up both metals which then may accumulate in the sediments in Lake Arlington. As the water column becomes anoxic in summer months, iron and manganese are released from the sediments, leading to elevated concentrations at the TRA and City of Arlington raw water intakes (Figure CG-3, Appendix 7.3-B).

Table [CG-1] also lists average and maximum arsenic concentrations in lake samples collected from USGS Site AC between April 2005 and November 2008. Concentrations were below the 10 ug/L MCL. Arsenic is a naturally-occurring metal and elevated concentrations in Lake Arlington water are likely attributed to the mineralogy of the watershed.

Organic Contaminants
In addition to naturally-occurring organic matter (NOM), organic chemicals derived from human activities may enter the watershed either via direct point sources or from street runoff (e.g., polyaromatic hydrocarbons from vehicular traffic), agricultural runoff (e.g., herbicides/pesticides), or other contaminant routes. Organic chemicals can generally be defined within one or more of the following categories:

- Volatile organic compounds (VOCs),
- Other synthetic organic compounds (SOCs), or
- Pharmaceuticals and personal care products (PPCPs)

The TCEQ SWQMIS website only provided data on herbicides/pesticides that would likely enter the watershed via agricultural runoff. Data from a Handley Power Plant were also reviewed for potential point source contribution of organic compounds. Appendix 7.3-D lists concentrations for parameters analyzed in four samples collected from Outfall 001 on June 17, 2008. Compliance data for all of the organic compounds showed concentrations below the maximum acceptable level (MAL) established by TCEQ for the discharge location. However, the data are from only one day of sampling; additional data would be needed to further review organics concentrations in the power plant effluent.

Table [CG-2] lists minimum, average, and maximum concentrations of regulated organic compounds measured in finished water samples collected at the Pierce-Burch WTP in 2009. For all of the listed organic compounds, measured concentrations were below the MCL. The use of ozone could reduce concentrations of some organic compounds if present in the raw water; however, if the lake became contaminated with synthetic or volatile organic compounds, additional treatment would likely be required for regulatory compliance.

In 1986, USGS monitored for several organic compounds at the sites shown on Figure [CG-1]. Specifically, USGS monitoring data for the following compounds were available through the TCEQ SWQMIS website: 2,4-D, endrin, lindane, methoxychlor, silvex, and toxaphene. All six compounds are used either as a pesticide, insecticide, or herbicide. Several are currently regulated (or banned) herbicides that likely entered the watershed before the regulations were enacted. Concentrations of silvex and 2,4-D were detected at all three USGS sample sites. Concentrations of the other four organic compounds were below the detection limit.

Spatial Variations in Water Quality

Water quality data for samples collected in the northern, middle, and southern portions of the lake were reviewed for any spatial trends in water quality. Table [CG-3] lists the average concentrations of select parameters for samples collected from each location between April 2005 and November 2008. Several potential trends are worth noting:

- Turbidity is higher and transparency is lower in the southern portion of the lake, indicating particle settling across the length of the reservoir. While particle sedimentation improves influent water quality to the water treatment plant, the settled particles lead to gradual accumulation of sediments in the lake and reduced lake storage capacity.
- The average pH is lower at the dam (northern portion) where both of the WTP intakes are located. The pH is affected by various chemical and biological processes in the lake.
- The conductivity is slightly higher at the dam (northern portion). However, conductivity, which is an indirect measure of total dissolved solids concentrations, is relatively low throughout the lake.
- Fecal coliform concentrations are lower at the dam (northern portion), potentially due to particle settling, microbial inactivation from UV exposure, and/or dilution.
- Chlorophyll-A concentrations are lower at the dam (northern portion) than in other portions of the lake (Table [CG-3]). In contrast, the 2004 Village Creek Assessment report similarly showed chlorophyll a concentrations increasing through the reservoir.[6] Further assessment is required to confirm spatial trends in algal growth through the lake. Generally, chlorophyll a concentrations are high and the TCEQ draft chlorophyll a criteria (Attachment 3) for Lake Arlington are exceeded.
- Iron concentrations appear to be slightly higher in the southern portions of the lake.
- Average concentrations of 2,4-D, a regulated herbicide were highest in the southern portion of the lake, whereas concentrations of silvex (a banned herbicide) were highest at the dam. Agricultural activities are limited to the southern (upstream) portion of the watershed. The presence of the two herbicides in the lake is likely attributable to contamination from agricultural activities conducted prior to the regulation of or ban on those two chemicals. Accumulation of the herbicides in the lake sediments could also be contributing to release into the raw water.

6 2004 Water Quality Assessment Results for Individual Water Bodies (Segment 828 Lake Arlington).

Summary of Lake Water Quality

Water quality in Lake Arlington is generally good, with only a few specific issues of concern:

- Temperature. TCEQ's 303(d) report issued in 2002 lists high temperatures for Lake Arlington at several locations.[7] TCEQ's 2004 Assessment Report states that "additional data are needed to determine whether natural conditions alone can cause elevated temperatures in the lake or whether the Handley Power Plant is a significant contributing factor."
- Manganese. Manganese (Mn) concentrations increase during the late summer months due to anoxic conditions in the lake hypolimnium. The City of Arlington has the ability to vary intake levels to withdraw source water with lower manganese concentrations for the Pierce-Burch WTP. Oxidation followed by sedimentation and filtration reduces manganese concentrations in the finished water. However, if manganese concentrations increase and/or anoxic conditions occur at shallower depths, management of Mn in the WTP source water and at the WTP may become more challenging.
- Algae. The Village Creek screening level for chlorophyll a is exceeded[8] and concentrations in the reservoir indicate significant algal activity. Geosmin concentrations close to two orders of magnitude above the 10 ng/L odor threshold concentration were measured in samples collected at the Lake Arlington intake in 2008. Ozone addition at the Pierce-Burch WTP helps control taste and odor in the finished water.
- Synthetic Organic Compounds (SOC). A round of monitoring for all SOCs, including 2,4-D and silvex should be conducted to establish the current benchmark water quality. Monitoring should also include contaminants targeted for near term regulatory determination (e.g. nitrosamincs, carcinogenic VOCs) and of public concern (e.g. pharmaceuticals). Updated data on 2,4-Dand silvex should be reviewed to assess current concentrations since the 1986 USGS data showed detectable levels of both herbicides.

Current water quality conditions provide a baseline by which to consider future impacts to lake water quality under proposed developed scenarios. In particular, development activities that exacerbate the issues above should be mitigated through the implantation of best management practices. Future impacts to lake water quality and proposed best management practices are discussed in Section 7.7 through 7.10.

7.3.2 Watershed

Lake Arlington covers approximately three square miles and is located at the end (northeast portion) of the Village Creek Watershed. The tributary watershed area upstream of Lake Arlington, illustrated in Figure 7.3-1, is about 140 square miles. Since Lake Arlington is located at the downstream end of the Village Creek watershed, its water quality will be affected by human-induced activities in the overland area upstream on Village Creek and its tributaries. Measures need to be planned prior to future development of the watershed to prevent increased pollution in Village Creek and ultimately Lake Arlington. Current land use activities in the Village Creek Watershed include a mix of urban and rural with some pastureland. A brief review of potential pollutant sources in Village Creek Watershed and the area surrounding Lake Arlington is presented in the Section 7.4 of this report.

Watershed characteristics (e.g., soil type, terrain) and land use patterns impact water quality and provide an indication of potential contaminants that could be a concern for a given area. For example, animal and human activities in the watershed can impact microbial water quality, contribute chemical contaminants to

7 2002 Water Quality Assessments for Individual Water Bodies, http://www.tceq.state.tx.us/compliance/monitoring/water/quality/data/02twqi/02_305b.html

8 2004 Water Quality Assessment Results for Individual Water Bodies (Segment 828 Lake Arlington).

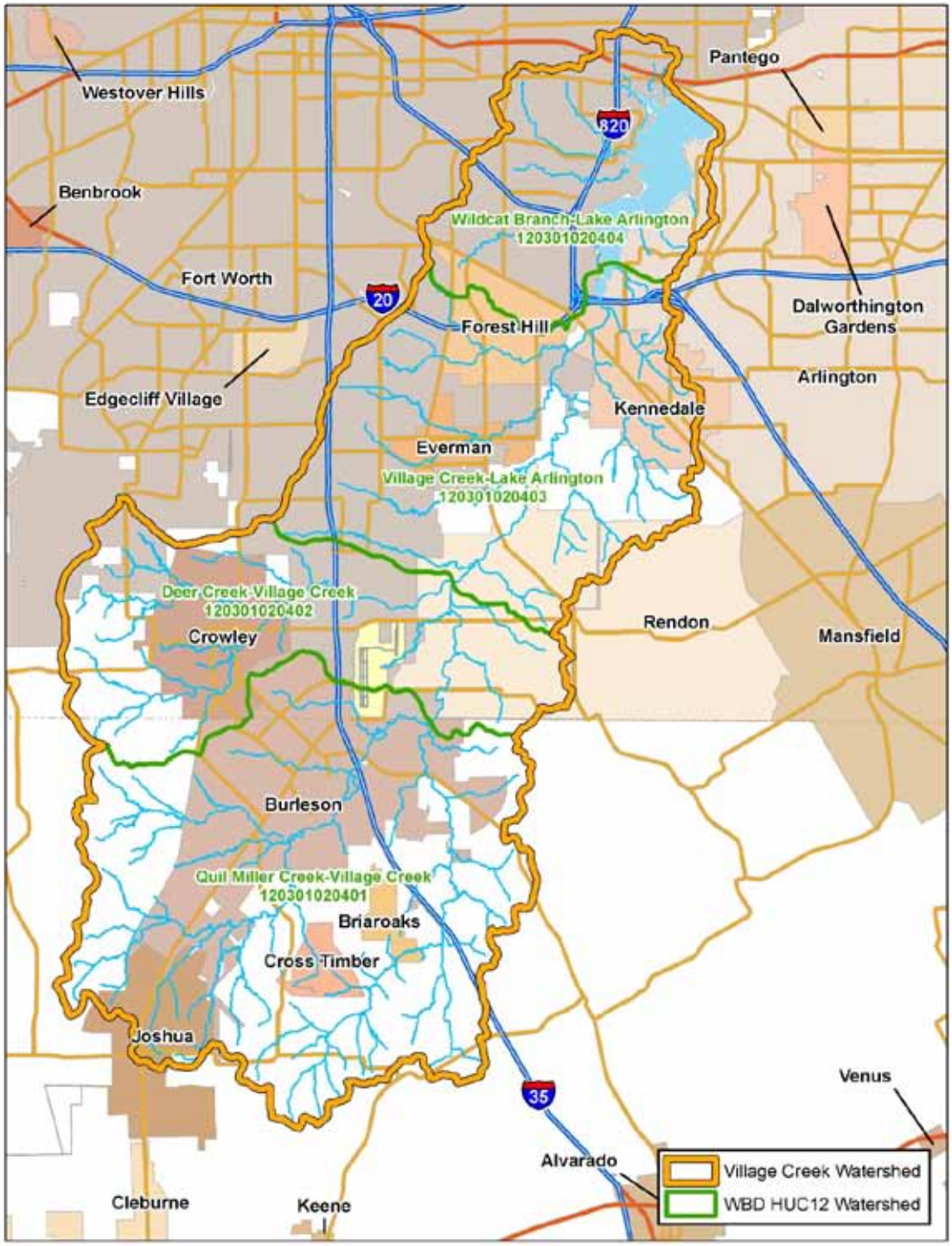


Figure 7.3-1: Lake Arlington HUC12 (Hydrological Unit Code 12) Watershed

the water, and can impact disinfection by-product precursor concentrations, affecting water quality issues resulting from treatment and distribution. Currently the watershed has about 1.9 million people and is projected to grow to approximately 2.5 million by 2030. Urban runoff during storm events can be a source of polyaromatic hydrocarbons (PAHs, from roads), pathogens (e.g., from pet excrements), metals (e.g., zinc from roofs), and other synthetic organic compounds (SOCs) used for basic human activities (i.e., cleaning products,herbicides used on lawns, etc.). Non-point source pollution from agricultural activities can contribute nutrients from fertilizers, pesticides (e.g., atrazine), animal pathogens, and growth hormones (e.g., endocrine disrupting compounds) to the watershed. Agricultural activities in the Village Creek Watershed are limited, occurring primarily near the watershed headwaters, and are not expected to have a significant impact on lake water quality. In fact, over time, agricultural activities can be expected to decrease with urbanization.

The industrial footprint in the Village Creek Watershed, in terms of land use, is relatively limited. Nevertheless, a variety of industrial activities are conducted within the watershed, with the potential to impact water quality. The Handley Generating Station, located on the northwest shore of Lake Arlington, has a TPDES permit allowing discharge of treated wastes into the reservoir. The permit specifies discharge limitations associated with temperature, total and free chlorine concentrations, total suspended solids, and oil and grease at two outfall locations (Outfall 001 and 201). One superfund site (Tricon America, Inc.) and one hazardous waste site (Everett Kates, Incorporated) are also located in the watershed. Five municipal wastewater treatment plants (WWTPs) currently discharge treated effluent into directly into Lake Arlington or its tributaries. Gas well development in the watershed is increasing as a point source load of TSS to the Lake Arlington and its tributaries.

The daily rainfall data monitored at the Dallas-Fort Worth International Airport rain gauge station by the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) has shown an average annual rainfall of 35.2 inches. Since this station is in close proximity to the Lake Arlington watershed, the monitored data at the station should represent the rainfall patterns in the watershed. The period of rainfall data record used in the analysis included the years 1976 through 2009, a total of thirty-four years. These rainfall data were assessed for temporal trends and average annual rainfall depth. The year 1980 had the lowest number of days with rain (56), whereas 2007 had the highest number of rainy days (142). The maximum recorded daily rainfall depth of 4.4 inches occurred in 2002 for the period of record. On average, there were 93 average days with recorded rainfall per year. The maximum annual rainfall of 52 inches occurred in 1991 and the lowest annual total rainfall of 19.0 inches occurred in 2005. Figure 2 displays the annual total rainfall depths for the period of record. The rainfall data analysis details can be found in Attachment 1, Lake Arlington Rainfall Analysis (Malcolm Pirnie, August 2010) technical memorandum. Analysis daily flows record of USGS stream flow gauge station 08048970 at Everman has shown annual mean flow of about 26.300 ac-ft and mean annual baseflow of about 2,700 ac-ft. The data period for the analysis included the years from 1992 through 2009. The stream flow data analysis details can be found in Attachment 2, Water Quality Modeling Report – Existing Conditions (Malcolm Pirnie, December 2010).

7.4 Likely Pollution Sources

The City of Arlington is a participant in TCEQ's Source Water Protection Program (SWPP), which provides public water systems an opportunity to take an active role in maintaining source water quality. As a participant in the SWPP, the City conducted a survey in August 31, 2002 to identify potential sources of contamination to the water supply. The following paragraphs discuss potential point and non-point sources of

pollution to the watershed.

7.4.1 Wastewater treatment plants

Figure [CG-X] shows known point source (TPDES-permitted) discharges in the Village Creek Watershed. Five municipal wastewater treatment plants (WWTPs) currently discharge treated effluent into Village Creek or its tributaries in the headwaters of the watershed. Treated wastewater from a motel/restaurant and from a Texas Department of Transportation (TXDOT) rest area is also discharged within the watershed. While treated to meet strict discharge standards, wastewater effluent can contain pathogens, nutrients, pharmaceuticals and personal care products (PPCPs), and organic precursors that are either unregulated or present at concentrations below the permit limits. Attachment 1 lists the name, status, permit number, and discharge limits (e.g., flow, nutrient concentrations, etc.) for the permitted sites.

All the pollutant discharge loads from WWTPs may not transport to Lake Arlington because they are a considerable distance from the Lake. For an example, a considerable BOD5 load will have decayed prior to reaching the Lake. Similarly, loads of nitrogen and phosphorus will be partially attenuated by settling and biological uptake in Village Creek and its tributaries, and then partially remobilized during higher flows or algal sloughing events. The delivery ratios for nutrients is not precisely quantified for the watershed but the majority of WWTPs nutrient load would be expected to eventually reach Lake Arlington.

7.4.2 Septic systems

The number and flow of septic systems in the Lake Arlington watershed cannot be precisely determined. However, most wastewater in the watershed was estimated to be treated by septic system. For an example, 2008 population of Tarrant and Johnson Counties, which cover the Lake Arlington watershed area, is estimated to be approximately 1.9 million, based on the U.S. Census Bureau's Population Estimates Program (PEP). Using a typical per capita wastewater generation rate of 70 gallons per day, the present population in the two counties would generate approximately 133 MGD. The WWTPs in the counties have capacity to treat about 0.5 MGD. It is assumed that at any given time, 2 percent of the BOD5, TSS, TP and fecal coliform from septic systems were delivered to Lake Arlington. Therefore, it was assumed that the wastewater in the watershed is primarily treated by septic systems. All of Arlington and Kennedale are presumed to have accessible organized wastewater service, but not all the septic waste in the service area is currently is believed to be treated by the wastewater treatment plants. Where the City might have an official certificated area that gives them the "authority" to provide wastewater treatment service, but it doesn't necessarily mean that service within that area is not via individual septic systems. The integrity of that assumption would break down if one were trying to determine areas treated by septic systems and areas served by the Arlington wastewater collection system.

Properly designed and functioning septic systems would be negligible sources of BOD5, TSS, and TP to surface waters. However, poorly designed or maintained subsurface disposal systems can fail, resulting in exfiltration (i.e., surface breakout) of septic tank effluent. Most nitrogen from subsurface disposal systems is nitrified in the soil and continues to be mobile in the environment, even if the system is working properly. When septic effluent is drained to drainfield (trench), the water slowly infiltrates into the underlying soil and evaporates in some instances. The amount of the septic effluent reaching surface water depends on different factors including soil type, proximity to surface waters, groundwater direction. Though no such information for the watershed is available, some time the effluents from drainfield are directed nearest stream through pipe.

7.4.3 Underground storage tanks

Leaking underground storage tanks (USTs) containing hazardous liquids, primarily petroleum products such as gasoline, diesel, kerosene, or oil have high potential for contaminating groundwater and eventually seeping to surface waters. Gasoline at gas stations is usually stored underground in tanks made of bare steel, which were not protected from corrosion—the oxidation, or rusting, of other metals as well as iron metal in steel that can cause metals to crack or disintegrate and leak. TCEQ publishes current and historic information about known leaking petroleum storage tanks in Texas and it updates the information on weekly basis. For the Tarrant County and Johnson County together there were 1,771 known leaked petroleum storage tanks as of January 06, 2010 updated TCEQ database. The most hazardous components of petroleum products when they are leaked can post high treat to the water pollution are the BTEX compounds—benzene, toluene, ethylbenzene, and xylenes. Another potentially hazardous compound in gasoline is methyl tertiary butyl ether (MTBE). Even at very low concentrations, MTBE makes drinking water unfit for human consumption with potential to cause cancer.

7.4.4 Water wells—active and abandoned

Poor construction and maintenance of wells can be primary reason for groundwater contamination. Toxic material spilled or dumped near a well can leach into the well's aquifer. Polluted water can leak through the walls of poorly maintained or shoddily constructed wells. Wells can get contaminated from septic tanks placed too close or abandoned wells in the area. Flood events can also impact the quality of groundwater. Contaminants that enter a well are introduced directly into the aquifer with no opportunity for natural filtration by soils or geologic materials. In cases, water in the polluted groundwater can eventually seep into nearby surface water. Abandoned wells are also a threat to water and public safety. Abandoned wells provide a direct channel for contaminants to pollute the aquifer below. Texas law makes the landowner responsible for plugging abandoned wells and liable for any water contamination or injury. TCEQ maintains the permitting authority for the water wells construction in the region. As obtained from the web based TCEQ Water Well Report Viewer (accessed on January 06, 2011), there are 315 water wells in the Tarrant County and 161 in the Johnson County.

7.4.5 Gas well drilling, operations and pipelines

Over 95 natural gas wells have recently been constructed in the watershed (Figure [CG-X]). As the development of the Barnett Shale natural gas field continues, plans for additional gas drilling sites and pipelines are anticipated. EPA published a report in 2004 evaluating the impacts of hydraulic fracturing on underground sources of drinking water. The study concluded that the process was safe; however, it did identify data gaps regarding the potential for migration of fracturing fluid through the subsurface. EPA has initiated a new study on hydraulic fracturing to further assess any relationships between the process and contamination of drinking water. The report is due to be released in 2012. The Railroad Commission of Texas (TRRC) oversees installation and operation of gas wells in Texas.

Natural gas wells are considered potential point sources of surface runoff pollution. Construction of the drilling pad, which is similar to constructing a residential or commercial building, is the major activity at the natural gas well site which contributes TSS to runoff during rain events. Once the construction phase of developing a natural gas well is finished, most of the disturbed area will be reclaimed to near natural condition. After construction of the drilling pad, other major pollutant contributors at the site may include oils and greases which may leak from the machinery operating at the site, illegal dumping of the material, wastes from the gas well, transportation pipelines, etc. Data containing the locations and categories of active natural gas and oil well sites were obtained from the NCTCOG. Dry holes, horizontal drain holes,

permitted locations, plugged oil wells, service wells, shut-in wells (oil) and sidetrack wells present in the watershed were considered in estimating gas well point sources for PLOAD modeling. According to the data, approximately 1,150 wells were constructed over an assumed 5 year period.

The City of Denton, Texas and EPA (2007) monitored the stormwater runoff from three natural gas sites in North Central Texas. The monitoring results indicated high concentrations of TSS and are in the typical order expected for construction sites. The observed TSS concentrations ranged from 394 mg/L to 9,898 mg/L with average median concentrations from three sites of 2,745 mg/L. The monitored concentration for manganese ranged from below detection limit to 1.31 mg/L, with an average median concentration of 0.29 mg/L. Additionally most of the metals monitored at the site had higher concentrations than expected from natural undisturbed sites. Construction vehicles, oil and grease leaks at the site and waste from the gas well are expected to contribute to the stormwater runoff from the natural gas well sites. However, the monitored runoff quality in the North Central Texas study found that total petroleum hydrocarbons (TPH) concentrations were below detection limits for all collected samples, indicating that TPH contribution from site activities were negligible.

7.4.6 Fertilizer and pesticide application

Non-point source pollution from agricultural activities can contribute nutrients from fertilizers, pesticides (e.g., atrazine), animal pathogens, and growth hormones (e.g., endocrine disrupting compounds) to the watershed. Agricultural activities in the Village Creek Watershed are limited, occurring primarily near the watershed headwaters, and are not expected to have a significant impact on lake water quality. In fact, over time, agricultural activities can be expected to decrease with urbanization.

7.4.7 Industrial and Commercial Operations

The industrial footprint in the Village Creek Watershed, in terms of land use, is relatively limited. Nevertheless, a variety of industrial activities are conducted within the watershed, with the potential to impact water quality. The Handley Generating Station, located on the northwest shore of Lake Arlington, has a TPDES permit (WQ0000552000) allowing discharge of treated wastes into the reservoir. The permit specifies discharge limitations associated with temperature, total and free chlorine concentrations, total suspended solids, and oil and grease at two outfall locations (Outfall 001 and 201). Table [CG-X] summarizes the discharge limitations for each outfall. The 2002 Texas Water Quality Inventory lists a July 25, 1997 historical fish kill near the Handley Plant hot pond, with approximately 50 fish killed. The suspected cause of the kill was temperature. Based on the report, exceedances were reported for temperature, ammonia nitrogen, nitrite+nitrate nitrogen, and orthophosphorus in samples collected from the lake between 1996 and 2001.

7.4.8 Urban Runoff

Urban runoff during storm events can be a source of polyaromatic hydrocarbons (PAHs, from roads), pathogens (e.g., from pet excrements), and other synthetic organic compounds (SOCs) used for basic human activities (i.e., cleaning products, etc.). Figure [CG-X] shows turbidity levels before and after a September 10, 2010 rain event. The data illustrate the influence of stormwater runoff on particle loading in the source water to the Pierce-Burch WTP. Land use changes associated with development around Lake Arlington and their impacts on surface runoff and lake water quality are being assessed as part of the Master Planning process. For example, Fort Worth's proposed Lakeshore Drive project was reviewed, and BMPs were proposed to minimize impacts to the Lake. As the project goes into final design and construction it will be necessary for Arlington to stay closely involved.

7.4.9 Recreational Activities In and Around Lake Arlington (including fueling operations)—marinas, boat ramps, watercraft use

Recreational lake activities also have the potential to impact water quality. For example, the marina fueling station could be a source of polyaromatic hydrocarbons (PAHs) if spills occur during refueling. A 2003 EPA Handbook for Marina Operators and Recreational Boaters lists boat maintenance, discharge of sewage from boats, and fuel release during refueling or recreational boating as the primary sources of pollution from boating.

7.5 Description of Models

7.5.1 Watershed pollutant load modeling

Watershed loading models can range from simple, representing only a few measured or estimated input parameters, to complex, dynamic models that require significant data for set-up and calibration. An example of simple models includes PLOAD which is based on the Simple Method, and examples of complex models include the Storm Water Management Model (SWMM), the Hydrological Simulation Program-FORTRAN (HSPF), etc. The Source Loading and Management Model (SLAMM) is an example of simple to moderately complex watershed model which requires a detailed analysis of source areas and a fair amount of input data, and is more applicable for small storm hydrology. There are many computer models available for watershed modeling some which are public domain and others which are proprietary software. Often times it is confusing to choose a model for a specific purpose, but the right model is the one that: 1) the user thoroughly understands; 2) gives adequately accurate and clearly displayed answers to the key questions; 3) minimizes time and cost; and, 4) uses readily available or collected information. The goal of Lake Arlington watershed modeling effort is to develop an approach that stays within the constraints dictated while providing supporting information to meet the identified objectives of the project. As stated above, the modeling effort for this project is to develop a screening level tool to assess proposed development versus existing conditions of the watershed and predicted lake water quality. Detailed short time increment predictions of pollutographs are not necessary for the assessment of receiving water quality in this project. Such details may be required if the objective of a study is to understand the variation in pollutant loads in the runoff along the length of a rain event, for example comparing the pollutant load in first flush versus pollutant load in the runoff from a fully developed event. But the overall objective of modeling for this paroject is to predict the Lake water quality from expected stormwater pollutant loads from its watershed. Hence, the total storm event loads are adequate for that purpose.

The SWMM, HSPF and SLAMM models may provide detailed analyses of the watershed but such detail analyses is seldom required for planning level work such as this project. Also as these models have high demand for input parameters, the input data collection task will require more time and cost. Simple spreadsheet-based loading models involving an estimate of the runoff volume which, when multiplied by an event mean concentration, provides an estimate of pollution loading. But such simple models lack the ability of calibration for the physical parameters of the watershed. However, the accuracy of simple model predictions can be improved when the predictions are averaged over longer periods, such as annual averages instead of event averages or daily averages.

For the reasons mentioned above, the PLOAD model was employed as the non-point source pollutant load model (USEPA, 2001) for modeling the Lake Arlington watershed. PLOAD is an extension of Better Assessment Science Integrating point and Non-point Sources (BASINS) model. It was developed by U.S. Environmental Protection Agency (U.S. EPA). BASINS is a decision support system for multipurpose environmental analysis by regional, state, and local agencies for watershed and water quality based studies.

PLOAD is one of three extension models in BASINS that can be used for constituent estimation in runoff from a specified watershed, and the other two BASINS extension models that are used for runoff pollutant load estimation are Soil and Water Assessment Tool (SWAT) and HSPF. SWAT is mostly applicable for agricultural and rural watersheds and may not serve the purpose of this project, and as already mentioned above HSPF is considered to be a complex model with a high demand for input parameters. PLOAD is a GIS-based model that can be used to calculate non-point source pollutant loads generated within a watershed. PLOAD estimates non-point constituent loads on an annual average basis, for any user-specified pollutant, relying on land-cover-specific runoff coefficients and pollutant concentrations. The PLOAD model is considered as an exploratory screening and planning level analysis rather than a calibrated model of non-point source loads. Within PLOAD, the Simple Method approach was chosen for calculation of pollutant loads. This technique requires a modest amount of information, including the watershed drainage area and impervious cover, stormwater runoff pollutant concentrations, and annual precipitation.

The PLOAD tool is capable of analyzing the watershed for pollutant loads using one of two methods, the Exponent Coefficient Method and the Simple Method. For modeling the Lake Arlington watershed, the Simple Method was used. Under this method, pollutant loads are calculated using the following equation:

$$LP = \sum u\ (P * PJ * RVU * CU * AU * 2.72 / 12)$$

Where:
- LP = Pollutant load, lbs
- P = Precipitation, inches/year
- PJ = Ratio of storms producing runoff (default = 0.9)
- RVU= Runoff Coefficient for land use type u, inchesrun/inchesrain
- CU = Event Mean Concentration for land use type u, milligrams/liter
- AU = Area of land use type u, acres

Consistent with the purpose of LAMP modeling, the purpose of PLOAD model is to provide a general planning estimate of the likely increase in pollutant loads from the watershed for various future land use scenarios when compared to the existing conditions of the watershed. The PLOAD model is appropriate for comparing the changes in relative storm flow pollutant loads from various land use scenarios with proposed regulations. PLOAD estimates are considered more accurate when modeled for long periods rather than short periods. As a screening level tool, PLOAD may not be calibrated against observed data, but attempts are made to adjust the model input parameters to better represent the monitored data. The pollutant contributions caused by base-flows are estimated by the separation technique.

7.5.2 Reservoir model

The BATHTUB model was selected to analyze the water quality issues related to Lake Arlington itself. The BATHTUB model provides the capability for calibration to observed lake data, but it does not have extensive data requirements (and can therefore be applied with existing data). BATHTUB is recognized as an effective tool for lake and reservoir water quality assessment and management, particularly where data are limited (Ernst et al., 1994).

BATHTUB is a software program used primarily for estimating nutrient loading to lakes and reservoirs, summarizing information on in-lake water quality data, and predicting the lake/reservoir response to nutrient loading (Walker 1986). It was developed and is distributed by the U.S. Army Corps of Engineers. BATHTUB contains a number of regression equations that have been calibrated using a wide range of

lake and reservoir data sets. It can treat the lake or reservoir as a continuously stirred, mixed reactor, or it can predict longitudinal gradients in trophic state variables in a reservoir or narrow lake. These trophic state variables include in-lake total and ortho-phosphorus, organic nitrogen, hypolimnetic dissolved oxygen, metalimnetic dissolved oxygen, chlorophyll concentrations, and Secchi depth (transparency).

BATHTUB's nutrient balance procedure assumes that the net accumulation of nutrients in a lake is the difference between: (i) nutrient loadings into the lake (from various sources) less (ii) the nutrients carried out through outflow and the losses of nutrients through whatever decay process occurs inside the lake. The net accumulation (of phosphorus) in the lake is calculated using the following equation:

Net accumulation = Inflow – Outflow – Decay

Input data requirements for BATHTUB include: physical characteristics of the lake morphology (e.g., surface area, mean depth, length, mixed layer depth), flow and nutrient loading from various pollutant sources, precipitation and phosphorus concentrations in precipitation (measured or estimated), and measured lake water quality data (e.g., total phosphorus concentrations).

7.6 Description and Delineation of Lake Arlington Watershed and Sub-watersheds.

7.6.1 Watershed and subwatersheds

The Lake Arlington watershed is approximately 143 square miles in size. Since the Simple Method was developed to predict the pollutant loads for smaller watersheds, the Lake Arlington watershed area was sub-divided to create 55 smaller sub-basins. The sub-basins in the project watershed were numbered from 1 to 55. A shape file provided by North Central Texas Council of Governments (NCTCOG) of the watershed boundary was used as a reference to delineate the watershed into sub-watersheds. The delineation was performed using manual delineation techniques in ESRI's ArcMap software, version 9.1. Figure 7.6-1 illustrates the watershed boundary with delineated sub-watersheds.

Average annual precipitation based on rain gauge data from Dallas-Fort Worth International Airport for a 34 year period of record was used in the model. Point sources consisting of wastewater treatment plants (WWTPs) and gas well sites were included in the model. Information about inventory, location and type of point source was obtained from the cities in the watershed. WWTPs discharge pollutant loads used in the model were estimated from the Discharge Monitoring Reports (DMRs), and other literature was used for modeling the gas well site pollutant loads. Because they are the major sources of make-up water, discharges from Cedar Creek and Richland Chambers Reservoirs to Village Creek were also considered point sources and annual pollutant loads were estimated from their discharge reports and literature values. Assuming the same level of discharge will be maintained from these two reservoirs to Lake Arlington in the future, the estimated annual pollutant loads used in the existing conditions model are used in the future conditions model. Water supplied from Lake Benbrook and from the future connection to Lake Palestine were not modeled. Additional parameters and input data used for modeling include land use, impervious factors and event mean concentrations (EMC) of pollutants. Regulatory requirements and best management practice (BMP) effectiveness was considered in the modeling, and the same level of treatment from these considerations is used when modeling the future watershed conditions. The EMCs of the modeled pollutants for major land use categories are summarized in the Table 7.6-1 and the changes in major land uses is illustrated in Figure 7.6-2.

Land Use	Pollutant EMC					
	TSS (mg/L)	TN (mg/L)	TP (mg/L)	COD (mg/L)	BOD (mg/L)	Fecal Coliform (cfu/100ml)
Residential	54	1.8	0.35	49	8.3	7580
Commercial	40	1.7	0.17	53	12.3	5480
Industrial	67	1.5	0.21	53	7.2	5425
Open Space	60	2.2	0.16	32	4.0	2500
Roads	74	1.9	0.22	59	6.4	1470

Table 7.6-1: Pollutants EMCs by Land Use Category used in PLOAD Model

Sub-Basin	TSS	TN	TP	COD	BOD	FC (counts/ac/yr)
1	249.0	3.6	0.5	94.8	16.3	5.28E+10
2	65.9	2.4	0.3	48.5	7.4	2.77E+10
3	98.2	3.2	0.4	90.8	15.3	4.14E+10
4	971.7	5.7	0.6	155.5	28.1	7.03E+10
5	109.3	3.4	0.5	89.0	13.5	4.77E+10
6	103.2	3.2	0.4	82.2	13.0	4.03E+10
7	69.2	2.4	0.3	47.4	7.0	2.52E+10
8	130.0	1.5	0.5	59.2	11.3	3.08E+10
9	75.3	2.9	0.4	61.0	9.7	3.35E+10
10	70.2	2.4	0.4	62.2	10.3	4.22E+10
11	29.5	1.1	0.1	15.7	1.9	5.49E+09
12	71.5	2.4	0.4	64.1	10.7	4.34E+10
13	563.2	1.2	0.1	19.7	2.5	7.68E+09
14	75.4	2.5	0.5	68.6	12.0	4.63E+10
15	235.5	3.7	0.4	89.7	13.5	3.62E+10
16	72.6	2.5	0.4	62.9	10.5	4.17E+10
17	155.1	3.1	0.5	84.2	12.7	4.11E+10
18	70.4	2.6	0.4	57.9	9.4	3.70E+10
19	118.4	3.0	0.4	73.2	11.6	4.03E+10
20	58.6	2.0	0.2	36.3	5.1	1.77E+10
21	72.1	2.6	0.3	46.8	6.6	2.21E+10
22	145.4	3.5	0.4	114.9	13.7	2.82E+10
23	98.5	3.0	0.4	64.8	10.0	3.56E+10
24	80.1	2.5	0.4	63.7	9.5	3.18E+10
25	148.3	3.7	0.4	81.4	12.8	4.25E+10
26	128.2	3.1	0.4	70.2	11.0	3.25E+10
27	132.2	2.1	0.2	44.6	7.5	2.06E+10
28	197.5	3.8	0.4	76.8	10.7	3.32E+10
29	181.3	4.6	0.5	99.3	13.7	4.42E+10
30	101.2	1.7	0.1	27.3	3.7	1.09E+10
31	112.6	2.4	0.3	43.0	7.5	2.34E+10
32	110.5	1.9	0.2	31.3	4.2	1.24E+10
33	100.5	2.4	0.3	44.9	6.6	2.33E+10
34	102.8	2.1	0.2	40.2	5.8	1.96E+10
35	256.1	2.7	0.3	57.3	9.1	3.08E+10
36	151.2	2.7	0.3	52.5	7.6	2.46E+10

Table 7.6-2: Lake Arlington Existing Conditions Load Estimations

Sub-Basin	TSS	TN	TP	COD	BOD	FC (counts/ac/yr)
37	104.2	2.3	0.2	45.5	6.7	1.90E+10
38	111.0	2.3	0.2	40.1	5.6	1.70E+10
39	124.8	4.3	0.5	95.1	14.9	4.98E+10
40	70.3	2.4	0.2	45.1	6.2	2.09E+10
41	126.1	3.8	0.5	90.9	12.9	4.51E+10
42	148.4	2.8	0.3	50.9	7.4	2.36E+10
43	82.0	1.6	0.2	28.1	3.9	1.27E+10
44	125.1	2.2	0.2	40.5	3.8	1.93E+10
45	109.4	2.2	0.3	44.6	6.7	2.47E+10
46	139.3	3.0	0.3	61.5	9.3	2.99E+10
47	122.3	2.0	0.2	39.2	5.7	1.98E+10
48	130.1	2.8	0.3	59.0	9.3	3.07E+10
49	102.2	1.7	0.1	27.9	3.8	1.19E+10
50	108.9	1.9	0.2	35.7	5.8	1.77E+10
51	108.3	1.8	0.2	30.3	4.2	1.38E+10
52	138.3	2.8	0.3	58.6	9.0	3.08E+10
53	118.6	2.2	0.3	45.4	8.0	2.51E+10
54	90.3	1.7	0.2	30.2	4.6	1.37E+10
55	104.7	1.7	0.2	30.4	4.2	1.38E+10

(Point source loads from East Texas Reservoirs, WWTPs and septic systems were excluded in the estimation of pollutant load rates)

Table 7.6-2: Lake Arlington Existing Conditions Load Estimations

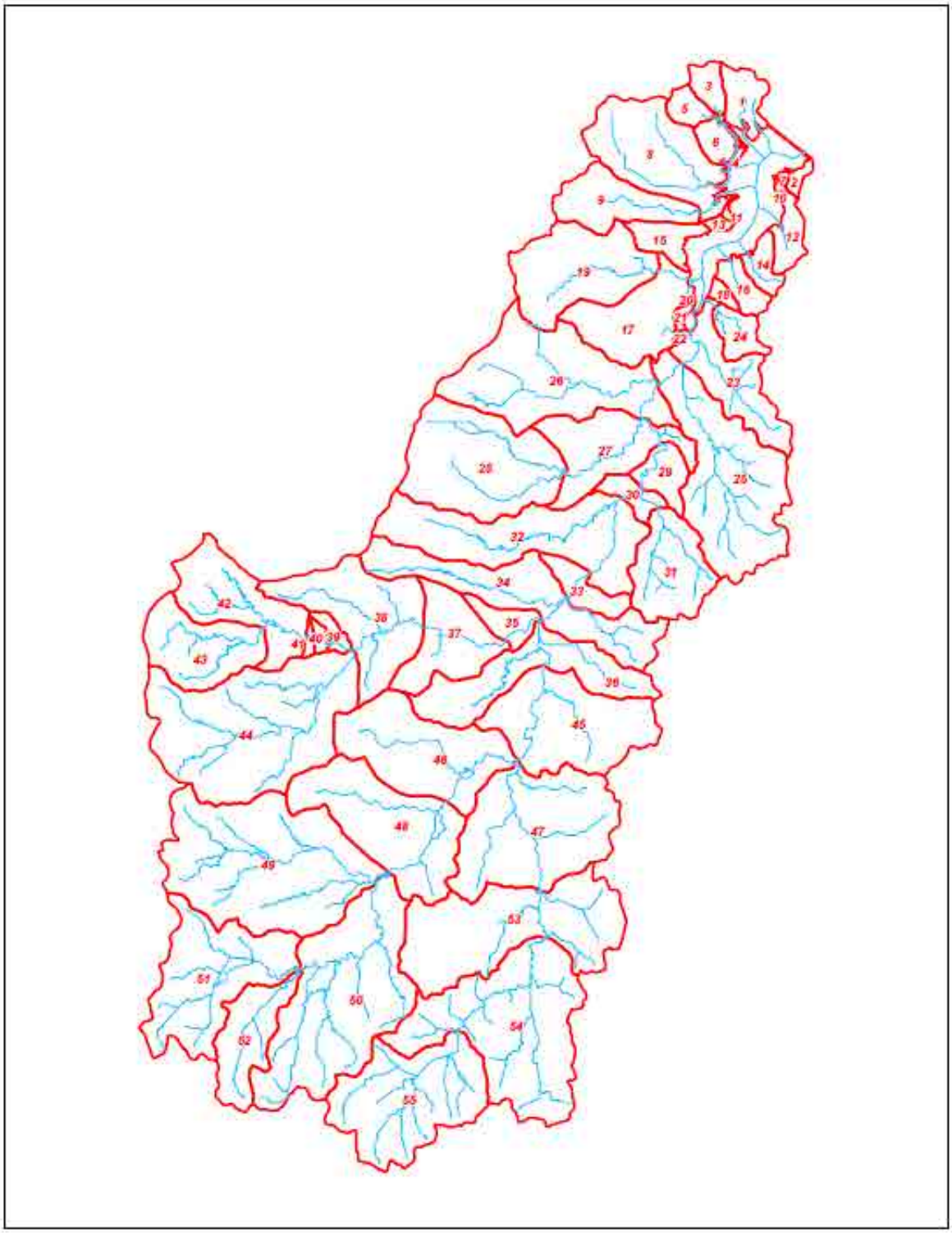


Figure 7.6-1: Modeled Sub-Basins of Lake Arlington Watershed

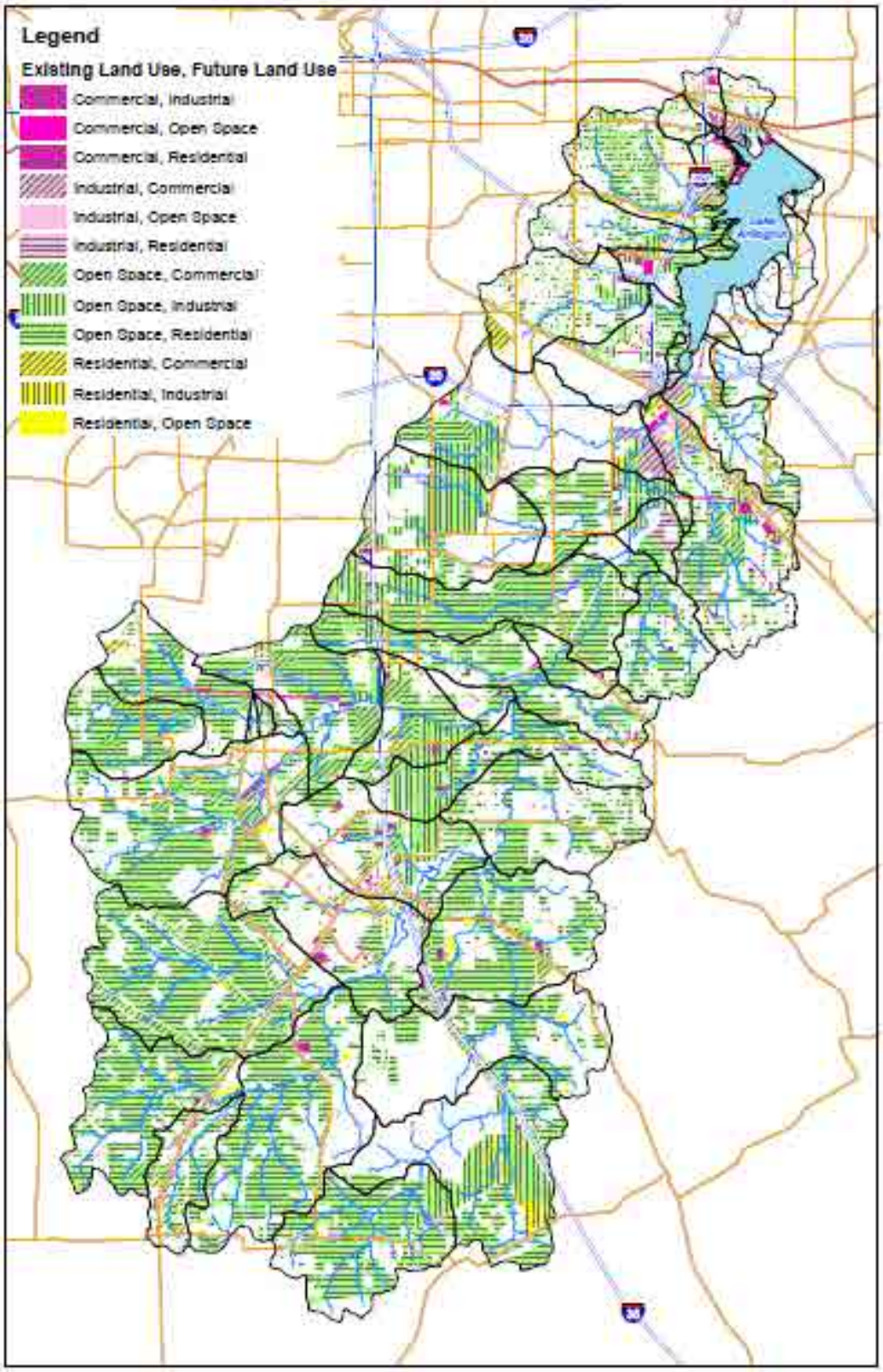


Figure 7.6-2: GIS Map of Projected Land Use Changes of Watershed

7.6.2 Model scenarios

Scenario 1: Lake Future Water Quality with Exiting Management Strategies
Scenario 1 evaluates the future water quality with projected land uses under existing stormwater management ordinances and other watershed management strategies currently in place for new development and re-development sites. The municipalities within the watershed have ordinances for stormwater management. In most cases, however, these ordinances are designed to reduce downstream flooding through the use of stormwater detention facilities. Such facilities are not designed to protect water quality or prevent excessive stream channel erosion, and are generally not effective in performing these functions. Rather, they are typically designed to limit post-development peak runoff rates to less than or equal to the predevelopment rates for specific return-interval storms. Even if peak flow rates of flow are properly controlled, the total volume of runoff from the site will still be much larger than under pre-development conditions. Following the intent of EPA's MS4 NPDES stormwater program and other related regulations to reduce non-point source pollution in the form of stormwater to receiving waters, it was assumed that the best management practices (BMPs) commonly promoted and implemented by municipalities in the watershed could, on average, reduce pollutant levels in runoff by approximately 20%. Under this scenario, the 20% reduction in the non-point source pollution was applied to all future developed areas, except open lands and water bodies in the watershed.

Under this scenario, all point source discharges including discharges from WWTPs, septic systems and gas well sites were modeled as having the same concentrations and loads of pollutants modeled in the existing watershed conditions simulation. The WWTP discharge loads from existing plants and future additional WWTP discharges based on projected population growth to the Lake are summarized in Table 7.6-3.

Location or Permittee	EPA ID	Annual Loads (lb) to Lake			
		BOD5	Nitrogen, ammonia total (as N)	Phosphorus, Total	TSS
Johnson County Special Utility District WWTP	TX0124923	2.18E+03	1.62E+04	9.70E+02	2.72E+04
Mayfair WWTP	TX0105872	3.01E+02	6.34E+02	9.95E+01	7.61E+02
Oak Ridge Square MHP WWTP	TX0102806	2.12E+02	7.54E+01	1.89E+01	4.89E+02
RV Ranch WWTP	TX0128490	1.77E+02	7.84E+01	1.96E+01	5.44E+02
Briarhaven Wastewater Treatment Facility	TX0128503	6.22E+02	2.23E+02	5.60E+01	9.95E+02

Table 7.6-3: WWTPs Pollutant Discharge Loads to Lake Arlington

The calculated annual total suspended solids (TSS) load from the natural gas well sites is presented in Table 7.6-4. It was assumed in this model, that gas well sites are projected to develop at same rate as in the existing watershed conditions model. Discharges from eastern reservoirs and Handley Power Plant are modeled the same as the existing conditions reservoir model.

Parameter	Concentration (mg/L)	Load (lb)
TSS (mg/L)	2,745	19,684

Table 7.6-4: Natural Gas Wells Point Source TSS Loads

Scenario 2: Lake Future Water Quality with Proposed Management Strategies
In Scenario 2 the proposed measures include a requirement to capture excess runoff corresponding to the 90th percentile of rain events depth and treat the remaining runoff corresponding to 1.5 inches of rainfall, and point source (WWTPs, septic systems, industrial dischrages and gas well sites) discharge control. In addition, a 20% pollutant load reduction was applied, giving consideration to existing stormwater management BMPs applied for all other developed areas. This will cover the pollutant load reduction from continuous implementation of existing BMPs, both structural (eg. detention ponds or wet lands) and non-structural (eg. street sweeping, public education, etc).

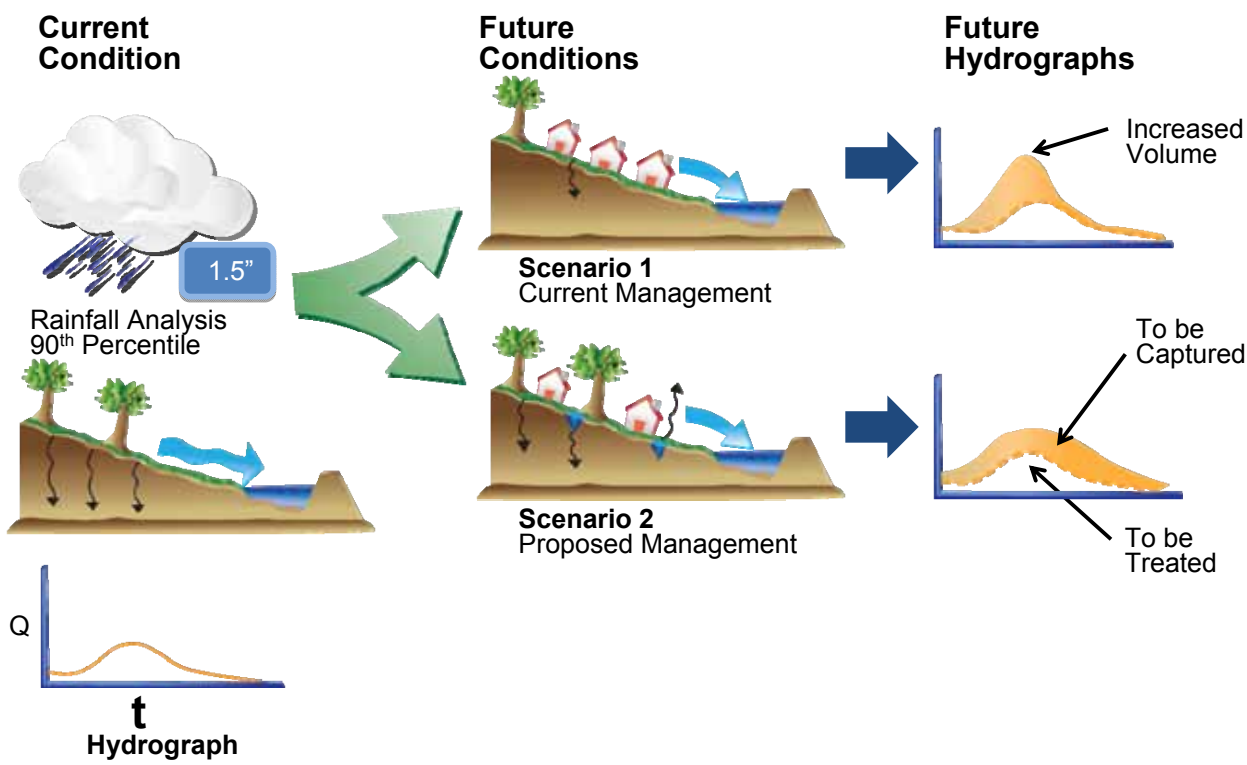


Figure 7.6-3: Lake Arlington Master Plan Watershed Modeling and Management

Details of the modeling approach, inputs and results of the models can be found in Appendix 7.3-D Water Quality Modeling.

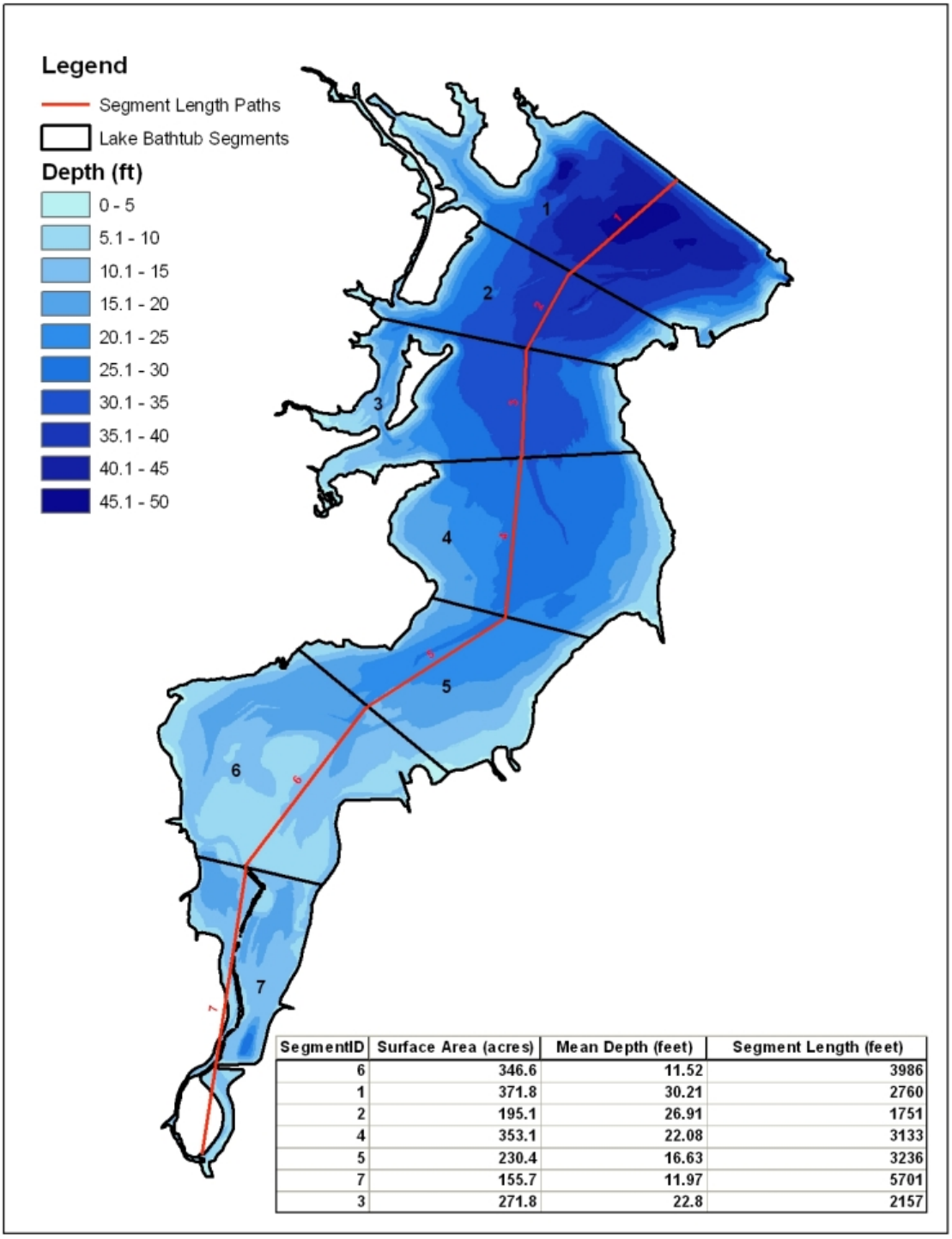
7.7 Model Results

Table 4 summarizes the existing and post-development PLOAD-predicted pollutant loads to Lake Arlington by BATHTUB-modeled segment. The segments of Lake Arlington are illustrated in Figure 7.6-3.
The predicted pollutant loads to the lake showed significant increase over existing conditions for all pol-

lutants, except biochemical oxygen demand (BOD), modeled under Scenario 1 (Table 7.6-6). Scenario 2 has resulted in decreases in TSS and BOD annual load to the lake with a moderately low increase in total nitrogen (TN) and carbonaceous oxygen demand (COD). Whereas total phosphorus (TP) and fecal coliform showed moderate increases over existing conditions, the magnitude of increase was much lower in Scenario 2 than Scenario 1 (Table 7.6-6). A considerable portion (32%) of increased TP load under Scenario 2 was predicted to be the result of increased future WWTP discharges.

Compared to Scenario 1, Scenario 2 was predicted to decrease a considerable pollutant load to the lake, being approximately 31% of TN and 70% of TP (Table 7.6-7). It is important to note that control of nutrient loads to the lake is essential for controlling the algal bloom and eutrophic conditions. From the predictions, it is very obvious that for future watershed conditions with no additional management policies in place, nutrient loads to the lake will increase very significantly and therefore the lake may turn highly eutrophic. Point source nutrient loads were predicted to contribute a major portion of the total nutrient load to the lake, even under Scenario 2 which assumed lower discharge concentrations from the WWTPs. Since WWTPs are expected to provide better treatment of wastewater, in the future, if some of the septic system loads within the watershed are treated by WWTPs, the nutrient loads (especially for TN) can be expected to be reduced below the values predicted by the model. Additionally, by using tertiary treatment, the nitrogen levels in the WWTP discharges may be further reduced to 3 mg/L or less, which can yield further reduction of nutrient loads from WWTPs to Lake Arlington.

Segment 7 of Lake Arlington receives discharges from the major stem of Village Creek, which has most of drainage area in the Lake Arlington watershed. Therefore, the quality of discharges to segment 7 is expected to be impacted more from future development than the discharges into any other lake segment. Additionally, the projected wastewater discharges from future population growth, for both Scenarios 1 and 2, was assumed to be discharging into segment 7, so the predicted pollutant load increase was more for segment 7 than others. But not all the additional wastewater may be discharged into segment 7. In that case, the model predictions for future conditions are conservative for pollutant loads to segment 7.



SegmentID	Surface Area (acres)	Mean Depth (feet)	Segment Length (feet)
6	346.6	11.52	3986
1	371.8	30.21	2760
2	195.1	26.91	1751
4	353.1	22.08	3133
5	230.4	16.63	3236
7	155.7	11.97	5701
3	271.8	22.8	2157

Figure 7.6-3: Modeled BATHTUB Segments

Scenario	Lake Segment	TSS (lb/yr)	TN (lb/yr)	TP (lb/yr)	COD (lb/yr)	BOD (lb/yr)	FC (counts/yr)
Existing	1	1.55E+05	5.64E+04	1.19E+03	5.92E+04	2.84E+04	3.30E+13
	2	1.55E+05	7.81E+04	1.65E+03	8.93E+04	3.99E+04	4.38E+13
	3	8.90E+06	2.88E+05	6.19E+03	2.18E+05	1.35E+05	1.16E+14
	4	3.89E+04	4.88E+04	9.60E+02	2.84E+04	2.10E+04	1.90E+13
	5	7.36E+04	4.30E+04	8.41E+02	2.52E+04	1.86E+04	1.66E+13
	6	1.54E+05	6.93E+04	1.43E+03	6.86E+04	3.34E+04	3.40E+13
	7	1.41E+07	3.73E+06	8.88E+04	3.95E+06	3.73E+06	2.19E+15
Scenario 1	1	1.46E+05	5.61E+04	1.18E+03	5.80E+04	2.92E+04	3.39E+13
	2	1.06E+05	7.65E+04	1.46E+03	4.92E+04	3.34E+04	2.56E+13
	3	8.17E+06	3.21E+05	1.20E+04	5.33E+06	1.67E+05	7.29E+14
	4	3.09E+04	4.86E+04	9.22E+02	2.21E+04	2.00E+04	1.55E+13
	5	6.18E+04	4.25E+04	7.77E+02	1.55E+04	1.70E+04	1.05E+13
	6	1.50E+05	6.93E+04	1.51E+03	8.52E+04	3.53E+04	4.36E+13
	7	5.37E+07	6.40E+06	4.36E+05	4.10E+07	1.12E+07	2.56E+16
Scenario 2	1	8.66E+04	5.59E+04	1.25E+03	5.02E+04	2.75E+04	3.14E+13
	2	1.24E+05	7.80E+04	1.67E+03	8.88E+04	3.94E+04	5.25E+13
	3	8.78E+06	2.90E+05	6.24E+03	2.53E+05	1.40E+05	1.72E+14
	4	3.59E+04	4.88E+04	9.62E+02	2.76E+04	2.09E+04	1.58E+13
	5	4.47E+04	4.29E+04	8.38E+02	2.40E+04	1.84E+04	1.44E+13
	6	1.13E+05	6.91E+04	1.77E+03	7.81E+04	3.42E+04	5.27E+13
	7	1.07E+07	4.29E+06	1.25E+05	4.33E+06	2.23E+06	3.95E+15

Table 7.6-5: Pollutant Loads by Lake Segments for Modeled Scenarios

Scenario	TSS	TN	TP	COD	BOD	FC
1	165%	63%	349%	950%	188%	980%
2	-16%	13%	36%	9%	-37%	75%

Table 7.6-6: Predicted Increase in Constituent Loads to Lake from Existing Conditions

TSS	TN	TP	COD	BOD	FC
68%	31%	70%	90%	78%	84%

Table 7.6-7: Predicted Decrease in Scenario 2 Constituent Loads to Lake from Scenario 1

Table 7.6-8 presents the post-development PLOAD-predicted pollutant concentrations to Lake Arlington by BATHTUB segment.

Segment	Scenario 1				Scenario 2			
	Flow (MG)	Flow (hm^3)	TN (µg/L)	TP (µg/L)	Flow (MG)	Flow (hm^3)	TN (µg/L)	TP (µg/L)
1	1786	6.76	4264	143	1781	6.74	4262	139
2	740	2.80	12366	238	721	2.73	12956	235
3	85552	323.85	449	17	85288	322.85	407	14
4	388	1.47	14961	286	383	1.45	15274	287
5	343	1.30	14791	272	338	1.28	15243	275
6	695	2.63	11978	263	631	2.39	13150	266
7	74198	280.87	8081	513	66484	251.67	6556	206

Table 7.6-8: Predicted Decrease in Scenario 2 Constituent Loads to Lake from Scenario 1

Table 7.6-9 summarizes the predicted BATHTUB-modeled reservoir water quality for the existing and future scenarios. The BATHTUB model was calibrated for total phosphorus, chlorophyll a and secchi depth. The model calibration was discussed in the existing water quality conditions modeling report. The following paragraphs discuss the results summarized in Table 7.6-9.

Under existing conditions, Lake Arlington can be considered eutrophic with a predicted area weighted mean phosphorus concentration of about 68 ug/L and a chlorophyll-a concentration of about 36 ug/L. In Scenario 1, with no additional management strategies, apart from the controls required by existing policies, the mean phosphorus concentration was predicted to increase by up to 119 % of the existing concentration, with a maximum predicted phosphorus concentration of about 277 ug/L in segment 7 and an area weighted concentration of about 140 ug/L. Similarly, the total nitrogen concentration under Scenario 1 was predicted to increase by 15% with a maximum concentration of 4,212 ug/L predicted in segment 7 of the reservoir where most of the watershed drainage discharges into the lake. The area weighted average for TN under Scenario 1 was predicted to be 2,493 ug/L, which is about 10 % higher than existing conditions.

The mean chlorophyll-a concentration under Scenario 1 was predicted to increase up to 52% over the existing concentration with 34 ug/L and 93 ug/L in segments 1 and 7, respectively. The area weighted average of about 51 ug/L is 41 % higher than the existing conditions. Similarly, the secchi depth is predicted to decrease under Scenario 1 with a maximum reduction of 0.3 meters (m) for segment 6.

For segment 1, the predicted hypolimnetic oxygen depletion rate (HOD), which is measure of rate of oxygen depletion below the thermocline, was predicted during the approximate growing season. The lake hypolimnetic depth of 2.5 m was expected to increase by 19 % with 625 mg/m3-day under Scenario 1 compared to existing conditions.

The BATHTUB model is generally recommended for predicting HOD in the segment near a reservoir's dam, and the HOD predictions in the segments away from the dam are reliable only if the model is calibrated with observed data for the sections. Due to lack of monitored HOD data for Lake Arlington, no HOD predictions were made for segments of the lake other than segment 1. For this Master Plan, that is not a major concern because the drinking water intakes are located in segment 1.

Similarly, the frequency of exceedance, presented in the Table 7.6-11, of a given concentration of chlorophyll a was predicted to increase considerably under Scenario1 compared to the frequency predicted for existing conditions. For example, for a given threshold concentration for chlorophyll a of 30 ug/L, the area weighted frequency of exceedance was predicted to increase from 47 % for existing conditions to 66 % for Scenario 1.

Under Scenario 2—with additional controls for runoff capture and treatment—the mean phosphorus concentration was predicted to have a moderately low increase of about 2-14 %, with area weighted mean increase of 11 %. The predicted TP concentration increase in Scenario 2 was significantly lower than predicted for Scenario 1. Similarly, a very minimal increase of up to about 7% was predicted for chlorophyll a, except for segment 7 which was predicted to decrease in chlorophyll a concentration, as expected under Scenario 2. The predicted HOD under Scenario 2 for segment 1 was within 2% of the existing conditions, with predicted HOD of about 537 mg/m3-day. The predicted secchi depth for segments 1 – 6 was within 0.1 m of the existing conditions of the lake. For segment 7, the predicted secchi depth is the same as the existing conditions, which is expected. Under Scenario 2, the TN concentration showed a considerable decrease over the existing conditions for all segments, with a maximum decrease of about 18 % for segment 7.

Since, segment 7 receives discharges from the largest portion of the watershed, it is obvious that the future land use scenario may have a greater influence on the lake water quality in that segment or other portions of the lake near segment 7. However, for modeling purposes, all the additional wastewater discharges from future population growth, about 44 million gallons per day (mgd), were modeled to discharge to segment 7. Even under Scenario 2, with proposed enhanced nutrient treatment levels at the WWTP discharges, major portions of the nutrient loads to the lake were predicted to originate from the WWTPs. Therefore the high predicted nutrient loads from future additional wastewater discharges are expected to influence the water quality in segment 7 of the lake. Realistically, in the future, the additional discharges may or may not enter segment 7 of the Lake, so the water quality of this segment of the lake may be better than the model predicted.

Considering all the modeling results, it can be concluded that the trophic state of Lake Arlington can be

controlled with additional controls of potential pollutants. However, the degree of lake's potential water quality degradation would vary greatly depending on the level of controls implemented. Segment 1, where the drinking water intakes are located, is more buffered from increased nutrient loadings from the upstream end of the lake. Segment 1 should not experience significant increases in algal biomass with pollution control implementation in the watershed.

Overall, Scenario 2 has predicted that current water quality conditions in Lake Arlington will be maintained, and the existing pollutant reduction BMPs and implementation of additional BMPs in the watershed are expected to further improve water quality. The model predictions for watershed pollutant loads and lake pollutant concentrations under Scenario 2 are considered conservative as these models did not include the possible pollutant load reduction from other BMPs proposed in other sections of the Lake Arlington Master Plan. For example, the Master Plan proposes: the implementation of riparian corridors and conservation development for the floodways and floodplains; a recommended model ordinance for illicit discharge detection and elimination; and proposed new management strategies for construction site runoff control. These measures would be expected to reduce the pollutant loads to receiving waters, but they are not explicitly considered in this modeling task.

Lake Segment	Existing Conditions					Scenario 1					Scenario 2				
	TP (ppb)	TN (ppb)	Chl a (ppb)	Secchi (M)	HOD (mg/m^3-day)	TP (ppb)	TN (ppb)	Chl a (ppb)	Secchi (M)	HOD (mg/m^3-day)	TP (ppb)	TN (ppb)	Chl a (ppb)	Secchi (M)	HOD (mg/m^3-day)
1	58.7	1925	25.7	0.8	526.7	117.7	2207	34.1	0.5	624.7	66.7	1872	27.0	0.7	537.2
2	58.8	1930	27	0.8	NA	118.2	2212	36.7	0.5	NA	66.9	1877	28.6	0.7	NA
3	59	1936	30.3	0.8	NA	118.9	2220	43.0	0.5	NA	67.1	1882	32.3	0.7	NA
4	61.7	2029	31.3	0.8	NA	124.5	2298	43.7	0.5	NA	69.5	1948	33.1	0.7	NA
5	68.1	2250	38.2	0.7	NA	138.6	2486	54.9	0.5	NA	75.3	2106	40.0	0.7	NA
6	72.1	2387	46.5	0.7	NA	147.7	2604	70.8	0.4	NA	78.9	2203	48.7	0.6	NA
7	126	4273	70.9	0.4	NA	276.6	4212	92.9	0.3	NA	128.3	3518	69.1	0.4	NA
Area Wtd Mean	68.3	2258	36.4	0.7	NA	139.9	2493	51.2	0.5	NA	75.5	2109	37.9	0.7	NA

NA: No prediction were made

Table 7.6-9: BATHTUB Model Predictions by Lake Segment

Lake Segment	Scenario 1				Scenario 2			
	TP	TN	Chl a	HOD	TP	TN	Chl a	HOD
1	101%	15%	33%	19%	13.7%	-2.7%	5.1%	2%
2	101%	15%	36%	NA	13.8%	-2.8%	5.8%	NA
3	101%	15%	42%	NA	13.7%	-2.8%	6.7%	NA
4	102%	13%	40%	NA	12.7%	-4.0%	5.7%	NA
5	104%	11%	44%	NA	10.6%	-6.4%	4.7%	NA
6	105%	9%	52%	NA	9.4%	-7.7%	4.7%	NA
7	119%	-1%	31%	NA	1.5%	-17.7%	-2.5%	NA
Area Wtd Mean	105%	10%	41%	NA	10.5%	-6.6%	4.0%	NA

Table 7.6-10: Predicted Percentage Change in Constituents Concentration by Lake Segments Over Existing Conditions

Scenario	Conc. (ug/L)	Lake Segment							
		1	2	3	4	5	6	7	Area Wtd Mean
Existing	CHA>10	88.7	90.2	93.0	93.7	96.8	98.5	99.8	94.0
	CHA>20	53.7	57.0	64.1	66.1	76.9	85.4	95.8	69.6
	CHA>30	28.7	31.6	38.4	40.5	53.2	65.5	85.9	46.7
	CHA>40	15.3	17.3	22.4	24.1	35.1	47.3	73.0	30.9
	CHA>50	8.3	9.6	13.2	14.4	22.9	33.5	60.0	20.7
	CHA>60	4.7	5.5	7.9	8.7	15.0	23.6	48.4	14.1
Scenario 1	CHA>10	95.2	96.3	98.0	98.1	99.3	99.8	99.9	97.9
	CHA>20	70.9	74.8	82.3	82.9	90.6	95.8	98.5	84.2
	CHA>30	45.8	50.6	60.7	61.7	74.7	85.9	93.5	65.8
	CHA>40	28.5	32.7	42.4	43.3	57.9	72.9	85.3	49.7
	CHA>50	17.7	20.9	29.0	29.9	43.6	59.9	75.4	37.2
	CHA>60	11.1	13.5	19.9	20.6	32.5	48.3	65.3	28.0

Table 7.6-11: Predicted Frequency (%) of Chlorophyll a Exceeds te Stated Concentration

Scenario 2	CHA>10	90.2	91.7	94.3	94.7	97.3	98.8	99.8	94.9
	CHA>20	56.9	60.4	67.9	69.2	79.0	87.0	95.5	72.3
	CHA>30	31.6	34.8	42.5	43.9	56.1	68.1	85.0	49.6
	CHA>40	17.3	19.7	25.7	26.9	37.8	50.3	71.6	33.3
	CHA>50	9.6	11.2	15.5	16.4	25.1	36.2	58.4	22.5
	CHA>60	5.5	6.6	9.6	10.2	16.7	25.9	46.7	15.4

CHA>10-60: Percent of time during growing season that chlorophyll *a* exceeds bloom criteria of 10, 20, 30, 40, 50, or 60 ug/L

Table 7.6-11: Predicted Frequency (%) of Chlorophyll a Exceeds te Stated Concentration

Section 7.8 Facility Impact Assessment

The modeling results for Model Scenarios 1 and 2 were qualitatively reviewed for potential impacts to the Pierce-Burch and TCWSP WTP source water quality and treatment plant operations. Under Scenario 1, solids (TSS), nutrients (total nitrogen and phosphorus), chemical oxygen demand, and fecal loading to the lake are estimated to increase (Table Cg-4, Appendix 7.8). These increased contaminant loads present the following primary concerns for the drinking water supply and plant operations:

- Increased solids loading to the plant. An increase in the influent plant turbidity would result in an increase in solids handling requirements. The frequency of filter backwashes could also increase, depending on the degree of particulate removal through sedimentation, resulting in a decrease in overall plant production efficiency. Chemical usage could increase if a higher coagulant dose is required to achieve turbidity goals in the settled water. Increased operational oversight may also be required to monitor turbidity removal to meet the Surface Water Treatment Rule.

- Increased manganese concentrations in the source water. Under current conditions, manganese concentrations in the source water can be over an order of magnitude above the SMCL. The Pierce-Burch and TRA TCWSP WTPs currently remove manganese through oxidation, followed by oxidant sedimentation and filtration. An increase in the manganese concentrations could result in increased oxidant demand and dose, a potential increase in customer complaints, and potential need for additional treatment in the manganese is not adequately removed through current processes.

- Increased MIB and geosmin concentrations in the source water. Geosmin concentrations are currently substantially above the 10 ng/L odor threshold concentration, but are reduced at the Pierce-Burch and TCWSP WTPs through ozonation. A future increased in MIB and geosmin concentrations could result in a need to increase the ozone dose, with potential impacts to bromate formation and mitigation requirements, or need for additional treatment barriers for MIB and geosmin. Increased influent geosmin and MIB concentrations could lead to increased taste and odor complaints if concentrations are not adequately reduced through the WTPs.

- Increased wastewater impacts to the WTPs. Scenario 1 model results predict a 10-fold increase in

fecal coliform loading to Lake Arlington. Fecal coliform concentrations serve as an indicator of the potential presence of pathogenic microorganisms, such as *Giardia*, *Cryptospordium*, and viruses, in a water supply. The Pierce-Burch and TCWSP WTPs have been classified as Bin 1 systems under the LT2ESWTR based on grandfathered *Cryptosporidium* data. If *Cryptosporidium* concentrations in the water supply increase in the future, both water treatment plants could be reclassified in higher bins, with subsequent requirements to reduce *Cryptosporidium* concentrations through various potential control measures.

As shown in Table CG-5 (Appendix 7.8), future water quality is not predicted to change substantially if BMPs recommended under Scenario 2 modeling are implemented. The principal source water quality and treatability concerns associated with water quality changes predicted under Scenario 2 are attributed to increased wastewater impacts to the watershed. , Increased wastewater discharges could result in increased concentrations of pathogenic microorganisms in the water supply if the wastewater is not adequately treated prior to discharge. Increased wastewater discharge to the watershed can also be a concern due to potential increased concentrations of unregulated emerging contaminants, such as pharmaceutical and personal care products (PPCPs), endocrine disrupting compounds (EDCs), or nitrosamine precursors. A regulatory determination on n-nitrosodimethylamine (NDMA) and other nitrosamines is expected in the near-term. If nitrosamines are regulated, increased precursor concentrations from wastewater discharges to the watershed will need to be carefully considered from a water supply treatability perspective.

Many micro-pollutants are not currently regulated and are not removed through conventional wastewater treatment processes. Advanced wastewater treatment would be required to reduce concentrations of organic micro-pollutants. Alternatively, various drinking water treatment processes could be implemented as part of a future CIP program if concentrations of micro-pollutants in the source water supply were a concern.

Table CG-4 and Table CG-5 lists some of the mitigations strategies that could be implemented at the Pierce-Burch and TCWSP WTPs in response to future changes in source water quality. Long-term facility planning would need to be conducted to identify optimal approaches to address the following key water quality issues:

- Ammonia. Mitigation strategies include watershed management programs, such as BMPs identified in this report to reduce nutrient loading from wastewater discharges, and public education.
- Manganese. Mitigation strategies include source water control (e.g., hypolimnetic oxygenation or changes to the plant intake structure) or pre-sedimentation with pre-oxidant addition.
- Taste and odor (MIB, geosmin). Advanced treatment such as GAC contactors or advanced oxidation (ozone/peroxide or UV/peroxide) would be required to provide additional barriers for taste and odor. Powdered activated carbon (PAC) could also be used to mitigate intermittent taste and odor events.
- *Cryptosporidium* and emerging pathogens. Treatment alternatives include pre-sedimentation with coagulant addition, UV disinfection, or microfiltration depending on the pathogen size.
- Micro-pollutants. Treatment alternatives include GAC contactors and advance oxidative processes (ozone/peroxide or UV/peroxide).

More than one mitigation approach is possible for the various water quality issues; as part of long-range planning, the City and TRA would need to take into account site-specific considerations (e.g., site layout, operator preferences, integration with existing technologies) to determine the best alternatives.

The paragraphs above focus on the impact of future lake water quality on treatment plant operations. Future changes to water quality in Lake Arlington can also impact downstream uses of the Trinity River. If recommended BMPs (Scenario 2) are implemented, water quality is anticipated to remain similar to current conditions, with the exception of increased fecal coliform concentrations and increased concentrations of other unregulated constituents associated wastewater discharges (e.g., dissolved organic nitrogen, pharmaceuticals and personal care products). To protect water quality in Lake Arlington and in downstream portions of the Trinity River, advanced wastewater treatment processes will need to be carefully considered and implemented as needed. Septic tanks will also need to be maintained to minimize discharge of nutrients, fecal material, and unregulated contaminants to the watershed.

7.9 Existing Watershed Management Practices

The municipalities in the Lake Arlington watershed include the Cities of Arlington, Briar Oaks, Burleson, Cross Timber, Crowley, Edgecliff Village, Everman, Forest Hill, Fort Worth, Joshua, Kennedale, Mansfield and the Rendon CDP. In addition, the Cities of Pantego and Dalworthington Gardens are in the watershed of Village Creek, but downstream of the lake. At the recommendation of the NCTCPG, these two cities were included in the planning process. These cities are in Johnson and Tarrant Counties. In addition to local governments' policies and regulations, the watershed is subject to state and federal regulations with respect to stormwater management and water quality protection.

The purpose of this section is to review the current stormwater and water quality policies and regulations affecting the watershed. Copies of the various ordinances, policies, and regulations were obtained from the governments in the watershed, and appropriate state and federal agencies. The existing ordinances and polices vary from one municipality to another depending on their level of service required, available resources, political commitments, implementation policies, etc. Sometimes these varying requirements may impact the common goal of implementation of management practices for protecting the overall water quality. A Summary of the existing management policies of the municipal governments, of which were made available to the project team, are presented below.

7.9.1 Municipal NPDES Permits

As described earlier in the Section 7.1, the NPDES permit program was established under the CWA to control water pollution by regulating the discharge of pollutants into waters of the United States. The NPDES program covers several pollutant sources that are regulated by permits issued by the TCEQ. Under TCEQ's MS4 permit program, local governments in regulated areas are required to establish a comprehensive SWMP and to develop a plan and program to control stormwater pollution discharges to waters of the State to the maximum extent practical and to prevent non-stormwater discharges from entering the stormwater system. All cities but three in the watershed are permitted by the State MS4 NPDES program, and the existing general permit is scheduled to expire in 2012. For the areas in the watershed that are not currently permitted, evaluations in the State may require they be permitted in the upcoming permit cycle beginning in 2012. The cities and counties and their MS4 NPDES permit type (Phase I and Phase II) are listed below and illustrated in Figure 7.9-1.

Phase I:
1. Arlington
2. Fort Worth

Phase II:
1. Burleson

2. Crowley
3. Dalworthington Gardens
4. Everman
5. Forest Hill
6. Kennedale
7. Mansfield
8. Pantego
9. Tarrant County
10. Johnson County

Un-permitted

1. Joshua
2. Cross Timber
3. Briaroaks

* It is important to note that the Cities of Dalworthington Gardens and Pantego are in the Village Creek Watershed downstream of Lake Arlington

7.9.2 Erosion and Sedimentation Control, Runoff Reduction and Flood Control Requirements

Most cities in the Village Creek watershed have generally adopted floodplain ordinances with a focus on controlling the development near major waterways. Similarly, the construction runoff related ordinances of the municipal governments are primarily focused on the implementation of traditional BMPs such as dry detention ponds in order to meet local peak flow requirements. Such controls may be effective in controlling the increased peak runoff rates, but they do not mitigate the runoff volumes associated with longer storm durations, increased runoff volumes, or decreased infiltration (lack of groundwater recharge). All of the cities which the project team reviewed have an ordinance in place for flood damage reduction or floodplain development. All municipalities in the watershed restrict development in the floodways.

7.9.3 Stormwater Management Regulations

All the Phase I and Phase II permitted cities have developed, or are in the process of developing stormwater management programs in accordance with the NPDES permit. It appears that cities in the watershed are in the process of reviewing their existing ordinances in order to include stormwater management elements. The cities in the watershed have different levels of requirement for stormwater management, and not all cities require an analysis of downstream impacts. For example, the City of Arlington requires the developer to consider post development BMPs that could help reduce potential pollution from the development site, but not all cities in the watershed require this.

7.9.4 City of Mansfield

Mansfield has adopted its Stormwater Quality Protection Ordinance which includes components requiring construction runoff controls, illicit discharge detection and elimination, and post development runoff water quality control requirements. The City controls development within its major waterways through the implementation of the Flood Damage Prevention Ordinance. The City implements public education programs as part of its stormwater management program. The City's practices do not include requirements for runoff reduction from new development and re-development sites.

7.9.5 City of Arlington

Lake Arlington is owned and operated by the City of Arlington. The City also has a Flowage Easement in

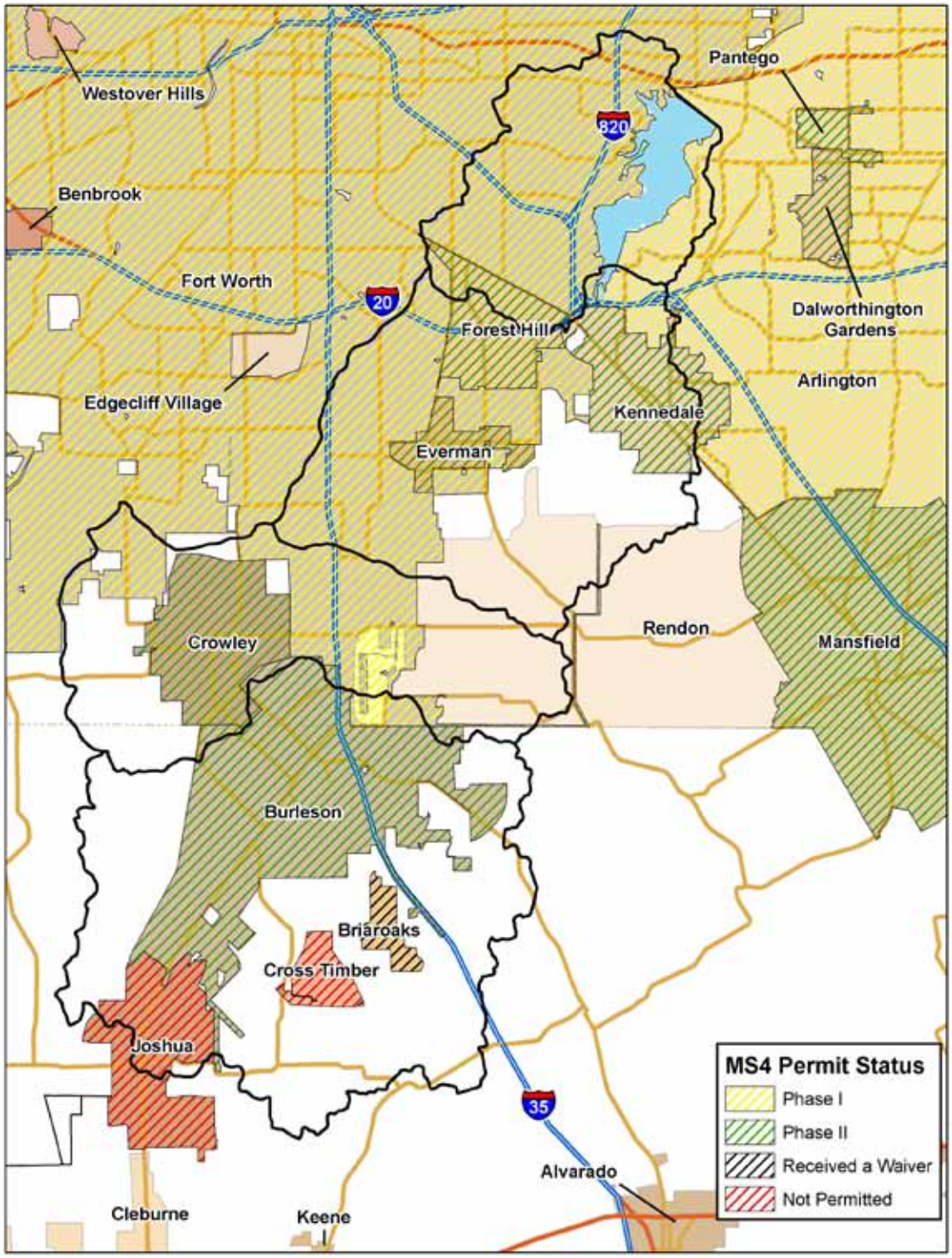


Figure 7.9-1: MS4 Designations in the Watershed *It is important to note that the Cities of Dalworthington Gardens and Pantego are in the Village Creek Watershed downstream of Lake Arlington

the area between elevations 550 and 560. For any earthwork proposed in Lake Arlington or the Flowage Easement, the property owner must obtain permission from the Director of Water Utilities and the USACE. The City controls development in the within major waterways through implementation of its Flood Damage Prevention Ordinance. The City subdivision regulations require developers to implement BMPs that are effective for runoff volume and rate control with no specific requirement on post development runoff quantities. The regulations also require protecting natural creeks and assessing the development plan for possible Low Impact Development (LID) practices. The City requires construction site operators to implement runoff erosion controls through the City Stormwater Pollution Prevention Ordinance. Projects that disturb one acre or more must comply with the requirements in the TCEQ Regulated Construction Projects. Residential projects that disturb less than 12,000 square feet and are not part of a larger plan of development are exempt from these requirements. The City's Gas Drilling and Production Ordinance does not include any specific requirements for runoff control from the gas well sites.

7.9.6 City of Burleson

The City controls development in the floodway and floodplain areas through its Flood Damage Prevention ordinance. The ordinance doesn't restrict development in any part of the floodplain but it does in the major floodway. The City requires developing a Stormwater Management Site Plan for development sites that disturb a surface area of 12,000 square feet or more, and create or add 5,000 square feet or more impervious cover. The City subdivision regulations require developers to implement BMPs that are effective for runoff volume and rate control with no specific requirement on post development runoff quantities. There are no specific requirements for gas well construction sites runoff control.

7.9.7 City of Crowley

The City construction site runoff control regulations require the implementation of temporary controls designed for a ten year storm return frequency. This ordinance also requires developers to install permanent erosion controls. All development within the 100 year floodplain requires a special permit for development from the City. The City also requires gas well construction site operators to submit a SWPP as required by EPA. There are no specific water quality or runoff reduction requirements for site post development conditions.

7.9.8 City of Fort Worth

The City requires construction site operators to implement runoff erosion and sediment controls in compliance with the TCEQ construction general permit; additionally the City requires gas well construction site operators to develop a SWPP. The City has a Stormwater Protection Ordinance which prohibits illicit discharges to its MS4. The City also requires developers to assess the effects on downstream hydrology from proposed development. Peak discharge requirements, runoff controls, and water quality standards in Forth Worth were not determined. At the time of this report, Ft. Worth was using the 2006 iSWM Criteria Manual for development controls and design standards. The 2010 iSWM Criteria Manual was being considered during this same time period.

7.9.9 City of Forest Hill

The City Gas Well Ordinance requires the gas well operator to develop a SWPPP as required by TCEQ. The flood hazard element of the City's Code of Ordinances restricts development in the floodways.

7.9.10 City of Joshua

There were no water quality, peak flow or runoff volume reduction requirements specified in the Develop-

ment Code Manual reviewed by the project team.

7.9.11 City of Kennedale

The City Code for Planning and Land Development requires that the site developer be responsible for all runoff from fully developed property upstream of the proposed development to the extent that improvements required for the runoff are roughly proportional to the drainage capacity demand created by the proposed development. Similarly, where a drainage study indicates that additional runoff from the developing property will overload downstream drainage facilities and result in hazardous conditions, the developer is responsible for making provisions necessary to accommodate downstream hydrology. Development in the floodway is not allowed in the City. The City requires that gas well site operators develop erosion control in compliance with all local, state and federal requirements, and the operator must file a copy of the site stormwater pollution plan, if required by the EPA. The City does not allow gas well development in the floodplain.

7.9.12 City of Pantego

The City of Pantego restricts development in the floodway and prohibits encroachments until and unless such encroachments are proven not to increase the base flood elevations. It is important to note that the City of Pantego is in the Village Creek Watershed downstream of Lake Arlington.

7.9.13 Tarrant County

Tarrant County requires that detention ponds shall be designed to control drainage from the proposed development area so that the peak discharge rate is equal to or less than when the property was in its natural state. Also it requires a separate permit when the construction is proposed in the floodplain.

7.10 Conclusions and Recommendations

This section outlines the recommended long-term strategies for addressing the watershed and water quality goals and objectives for Lake Arlington. The City of Arlington's goals and objectives have been used to evaluate the impact of various development scenarios on lake water quality and to develop the best management practices (BMPs) that would be needed to maintain the target water quality. The BMPs that make up this collective strategy provide the basis for a comprehensive watershed-wide cooperative effort.

The water quality in Lake Arlington is generally good, with only a few specific issues of concern:

- Temperature. TCEQ's 303(d) report issued in 2002 lists high temperatures for Lake Arlington. TCEQ's 2004 Assessment Report1 states that "additional data are needed to determine whether natural conditions alone can cause elevated temperatures in the lake or whether the Handley Power Plant is a significant contributing factor."
- Manganese. Manganese concentrations increase during the late summer months due to anoxic conditions in the lake hypolimnium. The City of Arlington has the ability to vary intake levels to withdraw source water with lower manganese concentrations for the Pierce-Burch Water Treatment Plant (WTP). Oxidation followed by sedimentation and filtration reduces manganese concentrations in the finished water, however, if manganese concentrations increase and/or anoxic conditions occur at shallower depths, management of manganese in the WTP source water and at the WTP may become more challenging.
- Algae. The Village Creek screening level for chlorophyll-a is exceeded and concentrations in the reservoir indicate significant algal activity. Geosmin concentrations close to two orders of magnitude above the 10 ng/L odor threshold concentration were measured in samples collected at the Lake Arlington intake in 2008.

Other lake water quality issues include trash in the lake from tributary discharges and direct releases to the lake, and sediment loading. With low ammonia concentrations, low nitrate concentrations, and low phosphorus concentrations, nutrient loading does not currently present a significant concern with regard to lake water quality, even though, the lake has significant algal activity.

Future development in the watershed would cause large increases in loads of constituents to Lake Arlington unless control measures are implemented. Both point and non-point loads of most constituents are expected to increase to an extent, even with advanced management measures and controls. However, the increases can be small to moderate with advanced management measures and controls. The segment of Lake Arlington that receives loading from most of the watershed (Segment 7, see Section 7.7) is expected to be more sensitive to watershed development conditions, requiring more advanced pollution controls to prevent significant increases in algal bloom conditions.

The existing pollution control requirements are limited in the watershed, and most are primarily designed to control the peak flows, but not for protecting water quality from new and redevelopment sites. Relying on existing management strategies for future watershed development conditions may not be sufficient to protect the water quality of the lake so that the two water treatment plants can operate economically and meet the treatment levels and standards.

Chlorophyll-a concentrations have long been used as a general indicator of the trophic state of a water body. Lake Arlington is expected to be most sensitive to phosphorus loads. Increases in phosphorus loads could be kept to a moderate level by a combination of stormwater management practices, the establishment of environmentally sensitive areas and a set of standards to be used in those areas, and either advanced wastewater treatment discharge practices or other point source controls. Without control measures, watershed development conditions are expected to cause Lake Arlington to transition from existing eutrophic to elevated eutrophic conditions. The incidence of algal blooms could increase in the reservoir. With pollution control measures, the segment of Lake Arlington near the dam is expected to experience only a slight increase in eutrophication and bloom conditions with buffering conditions of upper segments of the Lake.

Arlington's Pierce-Burch WTP and the Trinity River Authority (TRA) WTP currently meet all microbial and chemical drinking water standards; however, any future drinking water regulations (e.g., Long-Term 2 Enhanced Surface Water Treatment Rule) should be closely monitored within the context of development plans for the lake. Additionally, changes to raw water quality due to watershed development could impact operations at the WTPs (e.g., coagulant and disinfectant doses, etc.) and the continued ability to meet drinking water standards without the addition of new or modified treatment processes. The proposed BMPs for the watershed should assist in minimizing the impact from the future development in the watershed and help maintain and improve the Lake water quality.

To protect and enhance water quality, the following watershed management framework includes several different measures, some of which have already been implemented by municipalities within the Lake Arlington watershed.

- Stormwater Runoff Volume Reduction and Pollution Control Measures
  - Runoff Reduction Requirements for Subdivision/Development Regulations
  - Stormwater Treatment Requirements

- BMPs for Reducing Runoff Volume
- Establishment of Environmentally Sensitive Areas
- Establishment of Floodplain Corridors

- Construction Site Runoff Control
  - Legal Authority
  - BMPs for Construction Sites
  - Controls for Natural Gas and Oil Exploration Sites

- Trash and Litter Control
  - Trash Control and Anti Littering Campaigns
  - Municipal Operations
  - In-stream and Municipal Infrastructure Trash Reduction Methods

- Other Stormwater Management Measures
  - Illicit Discharge Detection and Elimination Programs
  - Public Education and Outreach Programs

As discussed in Section 7.1, these recommended programs provide the municipalities in the watershed with a basic framework that will assist them in the development of their Phase I and Phase II MS4 NPDES permits issued by TCEQ, and compliance with those program regulations. The State is currently evaluating its MS4 program and this may result in cities that are not currently regulated under the Phase II program being issued permits (See Figure 7.1-1). The recommendations made in this document allow for regional cooperation with respect to stormwater management, but it also allows the municipal governments to remain autonomous and manage their own programs.

7.10.1 Stormwater Runoff Volume Reduction and Pollution Control Measures

A. Proposed Runoff Reduction Requirements

Background
In addition to the protection of the water quality in Lake Arlington for purposes of improving treatability, the NPDES Phase I and Phase II regulations require that the municipalities in the watershed develop, implement, and enforce a stormwater management program that reduces the discharge of pollutants from the regulated jurisdiction “to the maximum extent practicable (MEP)”. Using guidance provided in this report, the municipalities of the watershed can achieve the MEP standard by instituting a stormwater management program that implements and requires BMPs designed to protect water quality.

Control measures 2 and 5 of the NPDES Phase I and Phase II permits, respectively, issued to the municipalities in the watershed by the Texas Commission on Environmental Quality (TCEQ) presents the requirements for the control of post-construction (i.e., after development) stormwater runoff.

Quoting directly from the Phase I (large MS4) NPDES permit, the municipalities must:

> *Implement a comprehensive master planning process (or equivalent) to develop, implement, and enforce controls to minimize the discharge of pollutants from areas of new development and significant redevelopment after construction is completed. The goals of such controls shall include:*

1. *New development – limiting increases in the discharge of pollutants in stormwater as a result of development; and*
2. *Redevelopment – reducing the discharge of pollutants in stormwater.*

Quoting directly from the Phase II (small MS4) NPDES permit, the municipalities must,

Develop, implement and enforce a program to address stormwater runoff from new development and redevelopment projects that disturb greater than or equal to one acre of land, including projects less than one acre that are part of a larger common plan of development or sale that will result in disturbance of one or more acres, that discharge into the small MS4. The program must ensure that controls are in place that would prevent or minimize water quality impacts. The permittee shall:

1. *Develop and implement strategies which include a combination of structural and/or non-structural BMPs appropriate for the community;*
2. *Use an ordinance or other regulatory mechanism to address post-construction runoff from new development and redevelopment project to the extent allowable under state and local law; and*
3. *Ensure adequate long-term operation and maintenance of BMPs.*

As a result of these requirements, the municipalities in the watershed should implement regulations within their jurisdictions that include a requirement for new developments and redevelopments to control stormwater quality.

The North Central Texas Council of Governments (NCTCOG's) Integrated Stormwater Management (iSWM) Technical Manual for Site Development and Construction has recommended the following design criteria for site development in North Central Texas, which includes the Lake Arlington watershed:

- Water Quality Protection: Remove pollutants in stormwater runoff to protect water quality. This criterion is based on a volume of 1.5 inches of rainfall, not a storm frequency.
- Streambank Protection: Regulate discharge from the site to minimize downstream bank and channel erosion. This criterion is based on the 1-year, 24-hour storm event.
- Flood Mitigation and Conveyance: Control runoff within and from the site to minimize flood risk to people and properties for the "conveyance storm" as well as the 100-year storm event. The conveyance requirement is for a 25-year, 24-hour storm event.

A recent regulatory trend is to base stormwater control requirements on the total volume of stormwater runoff from a site, rather than on runoff rates or a specific pollutant removal rate. This trend is based on a growing body of research that concludes that volume-based controls attain the concurrent benefits of pollutant reduction, peak flow reduction, and base flow protection. The focus on runoff volume as the common currency for BMP evaluation is gaining wider acceptance across the country. Clearly, the concept of runoff reduction marks an important philosophical milestone that will help define the next generation of stormwater design. The promise of runoff reduction is that the benefits go beyond water quality improvement. If site and stormwater designs can successfully implement runoff reduction strategies, then they will do a better job of replicating a more natural (or predevelopment) hydrologic condition. This not only includes peak rate controls to address runoff volume, but it also addresses duration, velocity, frequency, groundwater recharge, and protection of stream channels from erosion. The following paragraphs describe some of the BMPs being used or considered by utilities and stormwater management entities in the United States.

Some local governments are controlling runoff volumes from new and redevelopment sites by requiring the implementation of low impact development (LID) practices to maximum extent possible. For an example, the DuPage County, Illinois DuPage County Countywide Stormwater and Flood Plain Ordinance, requires developers to incorporate BMPs such as impervious area disconnection to vegetated areas, the use of infiltration techniques and the use of vegetated swales for stormwater conveyance as part of the water quality stormwater treatment to treat the 2 year, 24-hour event (generally 3.04 inch rainfall) over the drainage area for development sites. Such practices are also believed to be effective for runoff volume control along with pollutant loads and discharge rate reduction. Dupage County also has a stormwater release rate standard which must be considered for the 100-year, 24-hour storm when calculating the stormwater storage capacity.

The Runoff Reduction Method was originally developed in tandem with the Virginia Department of Conservation and Recreation (DCR) efforts to update the stormwater regulations and handbook, and the concept is widely applicable to other state and local stormwater planning procedures. Currently, within the Chesapeake Bay Watershed, the States of Delaware, Maryland, Virginia, and the District of Columbia are considering incorporating the concept of runoff reduction into updated stormwater regulations and design manuals (Capiella et al., 2007; DeBlander et al., 2008; MSC, 2008). The Pennsylvania Stormwater Best Management Practices Manual (PA DEP, 2006) already incorporates standards for volume control achieved by structural and nonstructural BMPs.

As described in the Staff Report on a Proposed Amendment to the Dane County Water Plan, Adopting a Volume Control Standard for Urban Service Area Amendments, 2010, there are several examples of approaches to volume control standards. The Capital Region Watershed District in Minnesota requires that the first 1-inch of runoff from impervious areas be controlled (CRWD, 2006). The Pennsylvania Department of Environmental Protection (PDEP, 2006) has a two volume control guideline. The first recommendation where site conditions allow, is to not increase the post-development total runoff volume for any storm equal to or less than the 2-year, 24-hour event. The second recommended requirement, if the first cannot be met, is that at least the first 1-inch of runoff from new impervious surfaces shall be permanently removed from the runoff flow. Another approach that the regulators are considering is to maintain the infiltration rate (groundwater recharge) as a predevelopment condition for the site area, even with post-development conditions. This approach may require increasing the infiltration rates of pervious areas in the site area to compensate for the lost infiltration quantities that are caused as result of development. All new federal facilities are required to maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of flow (US EPA, 2009).

Proposed Runoff Reduction Requirements for the Village Creek – Lake Arlington Watershed
The more runoff reduction that standards require, the harder it is to comply at individual sites, particularly with higher levels of development intensity. Also it will be a challenge for developers to adapt to any sudden changes in the regulatory requirements. With these considerations in mind, the Pirnie Team recommends that municipalities in the watershed require new development and redevelopment projects to maintain predevelopment runoff volumes for rainfall depths equal to 90% of expected rainfall events. Under this proposed requirement, the excess runoff caused by changes in the land cover for a rainfall event with a depth corresponding to 90% of expected rainfall events must be retained on the site by appropriate BMPs. Therefore, the total allowable runoff for the site with post-development conditions would be the sum of: (i) the expected runoff for predevelopment conditions, plus (ii) the additional runoff produced by a change

in land use for rainfall events of more than 90% of the rainfall events depths. The rationale for using the 90th percentile event is that it represents the majority of runoff volume on an annual basis, and that larger events would be very difficult and costly to control for the same level of water quality protection. It is important to note that the proposed 90th percentile (1.46 inch rainfall depth) captures the first flush runoff (runoff corresponding to first 0.5 inch of rainfall is widely accepted as first flush) which is expected to carry most of the runoff pollutant load.
In other words, the required runoff volume retention is equal to the post development runoff volume for the 90th percentile storm event minus the pre-development runoff volume for the 90th percentile storm event.
Advantages of Proposed Requirements

These proposed runoff volume reduction requirements (in addition to recommended treatment volume, flood and conveyance requirements in the NCTCOG iSWM Technical Manual) have several distinct advantages when it comes to evaluating runoff reduction practices and sizing BMPs:

- By capturing the required runoff volume, the proposed requirements provide effective stormwater treatment from the site corresponding to 90% annual rainfall events, and larger storms will be partially captured.
- Since the required runoff reduction is a direct function of impervious cover, this creates incentives to conserve pastures, open space and other natural conditions, reduces mass grading, and provides a defensible basis for computing lower runoff reduction volumes for these practices.
- The 90th percentile volume reduction will help treat all the first flush runoff which is expected to have higher pollutant concentrations (Pitt et al 2005).
- Runoff reduction volumes will help reduce the treatment volumes and therefore the size of BMPs, as well as the volumes of flow for channel protection or flood reduction purposes.
- The requirements help maintain the same ground water re-charge rates as predevelopment.
- The requirements help protect downstream water quality and channel geometry and also minimize the need for downstream flood control measures.

Determining the Required Runoff Volume Reduction
Runoff volumes corresponding to predevelopment and post-development hydrology for a site can be calculated by multiplying the 90th percentile annual rainfall event by the runoff volumetric runoff coefficient (Rv) and the site area.

Rv is defined as:

$$Rv = 0.05 + 0.009(I)$$

Where:
I = percent of impervious cover (%)

A similar procedure has been recommended by the iSWM Technical Manual developed by the NCTCOG for calculating the Water Quality Protection Volume (WQv), and the procedure is detailed in the iSWM Manual.

A frequency distribution of the long term daily rainfall data recorded at the Dallas-Fort Worth International Airport has shown that the 90th percentile annual rainfall (i.e., the storm event that is greater than 90% of the storms that occur) is approximately 1.5 inches (1.46 inches).

Therefore, runoff volume can be calculated using the following formula:

Runoff Volume (acre-feet) = (1.5/12)* Rv* A
where,
Rv = volumetric runoff coefficient
A = total drainage area (acres)

Runoff volume can be expressed in inches using the following formula:
Runoff Volume (inches) = 1.5(Rv) (1.3)

Measuring Impervious Area: The area of impervious cover can be taken directly off of a set of plans or by using appropriate mapping tools. Where this is impractical, the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Technical Release 55, or NRCS TR-55, land use/impervious cover relationships can be used to estimate impervious cover. "I" is expressed as a percent value, not a fraction (e.g., I = 30 for 30% impervious cover).

Multiple Drainage Areas: When a development project contains or is divided into multiple outfalls, runoff volume should be calculated and addressed separately for each outfall.

Once the runoff volume corresponding to 90th percentile event has been determined for both predevelopment and post-development conditions, the difference (post-development runoff – predevelopment runoff) in the calculated volumes is the runoff volume that needs to be controlled. If the post-development runoff volume is calculated to be less than the predevelopment runoff, no further volume reduction is required.

Recommendations for Implementation of Proposed Requirement
Implementation of the proposed runoff reduction requirements at new development and redevelopment sites can best be accomplished through regulatory enforcement. Regulatory enforcement in the form of an ordinance may require new projects to implement low impact development (LID) practices for controlling and treating stormwater runoff from the site. Low impact development is a comprehensive land planning and engineering design approach with a goal of maintaining the pre-development hydrologic characteristics of developing watersheds.

Additionally, the Pirnie Team recommends that entities periodically review and modify, as necessary, development ordinances to reduce the amount of impervious surface permitted in new development. The review process should evaluate potential changes to the following: (i) roadway width; (ii) parking requirements; (iii) setbacks; and (iv) curb and gutter requirements. As a first step, ordinances for each jurisdiction should be reviewed to identify all requirements that impact the amount of impervious surfaces installed on properties and hence controlling the runoff volume. These requirements will then be compared with model ordinance language that allows for LID and other green infrastructure strategies and therefore greater runoff reduction. The next step is to review the results of these comparisons and develop an ordinance tailored to each of the Lake Arlington watershed counties and municipalities. In particular, these ordinances may include potential changes to minimum street widths, minimum parking requirements, curb and gutter requirements, and minimum setback requirements.

B. Proposed Stormwater Treatment Requirements
The NCTCOG iSWM Technical Manual (the "Manual") includes a recommendation for water quality protection. In addition to the proposed stormwater volume reduction requirement outlined above, it is recommended that the remaining runoff (after volume reduction) be treated in order to comply with the water

quality design standards of the Manual. Those standards are that pollutants in stormwater runoff be removed in order to protect water quality. The criterion is based on a volume of 1.5 inches of rainfall, not a storm frequency. Therefore after the volume has been reduced by infiltration and low impact development, the developer should capture to comply with the standard of removing the pollutants (or treating) the runoff associated with the runoff from up to and including 1.5 inches of rainfall.
Water Quality Protection Volume can be calculated as follows:
WQV = Runoff volume from the developed condition of the site corresponding to 1.5 inch rainfall depth - Runoff volume reduced as part of runoff reduction requirement for developed conditions of the site.

Runoff volumes are calculated as described above in the runoff reduction requirements section of the report.

See Attachment A for a proposed model runoff reduction and treatment ordinance.

Recommended BMPs for Reducing Runoff Volume

Runoff Reduction BMPs: Runoff reduction methods from a post-construction site can be classified as either source controls or structural controls.

Source controls are post-construction control measures that reduce the amount of runoff generated by a reduction of impervious surfaces. Source control of the runoff can be maximized by better design of the site. For better design of the site, the designer has to undergo an iterative process looking for opportunities to reduce the impervious cover. Whenever possible, the designer has to reduce steep slopes to slow down the runoff and give additional time for the runoff to infiltrate. Overall, the designer may need to follow these four steps.

Step 1: Apply Early Standard Practices: During site layout, designers should look at a site map of environmental and soil features to find the easy opportunities to minimize creation of needless impervious cover or mass grading, and maximize protection of permeable soils, forest or grassland cover and other natural features.

Step 2: Compute Post Development Land Cover: Designers then use the resulting impervious cover and determine total runoff reduction requirements at the site.

Step 3: Apply Runoff Reduction Practices: The designer should then experiment with combinations of different runoff reduction practices on the site, such as the use of BMPs, conservation subdivision or landscape designs promoting tree canopy and undisturbed vegetation. In each case, they will estimate the spatial area to be treated by each runoff reduction practice, and “chip away” at the required runoff reduction volume for the site.

Step 4: Determine if Further Reduction is Needed: In the last step, the designer checks whether the runoff reduction has been achieved at the site.

Structural controls and BMPs involve controlling the increase in runoff generated from a developed site. Various BMPs are capable of reducing the volume of runoff based on the post-development condition. Historically, BMP performance has been evaluated according to the pollutant removal efficiency of a practice.

However, in some cases, this under-reported the full capabilities of BMPs to reduce pollutant loads. More recent BMP performance research has focused on runoff reduction as well as overall pollutant removal. One such research project is by the Center for Watershed Protection (CWP), as part of Virginia's Stormwater Regulations and Handbook Technical Assistance. The reduction values presented in the following table will provide expected performance guidelines.

PRACTICE	RUNOFF REDUCTION (%)
Green Roof	*45 to 60*
Rooftop Disconnection	*25 to 50*
Raintanks and Cisterns	*40*
Permeable Pavement	*45 to 75*
Grass Channel	*10 to 20*
Bioretention	*40 to 80*
Dry Swale	*40 to 60*
Wet Swale	*0*
Infiltration	*50 to 90*
Extended Detention Pond	*0 to 15*
Soil Amendments	*50 to 75*
Sheetflow to Open Space	*50 to 75*
Filtering Practice	*0*
Constructed Wetland	*0*
Wet Pond	*0*
Range of values is for Level 1 and Level 2 designs	

Table 7.10-1 Runoff Reduction for Various BMPs (Adapted from technical memorandum on the Runoff Reduction Method, CWP (2008)).

Illustrations of the LID practices described in Table 11 are seen below.

Green Roof

Rooftop Disconnection

Raintanks & Cisterns

Permeable Pavement

Grass Channel

Bioretention

Bioretention

Infiltration

A range of values represents the median and 75th percentile runoff reduction rates based on the literature search. Level 1 can be considered a “standard” design (achieves the median value of runoff reduction), and Level 2 an enhanced design (achieves the 75th percentile values).

Considerations

One has to understand that not all sites have same opportunities for runoff reduction. The reduction options may be more limited for an area with high intensity development than the available opportunities for

low intensity developments. For sites with high intensity development, the option is to use conventional stormwater practices which usually have limited runoff reduction capabilities. These practices may also help meet some of the regulatory requirements. For an example, depending on the available space a developer may choose to retrofit the site with a wetland or extended detention basin or a dry detention pond. It is advised that the developer chose the retrofit stormwater BMP that can provide maximum runoff reduction and water quality treatment benefits among the possible BMPs for the site. For an example, choosing a wetland over a dry detention pond will help reduce runoff to an extent through infiltration and evapotranspiration, and at the same time help meet to reduce the peak discharges similar to a dry detention pond. Similarly, for the development sites with relatively impermeable soils containing clay and silt, some of the infiltration BMPs such as infiltration trenches are not suitable. For such cases, the developer may choose to implement BMPs with amended soils for higher filtration rates and amended soils in combination with under drain option to reduce runoff. For the sites with relatively impermeable soils the developer may also chose to select BMPs that can be used to store rainwater such as cisterns for roof runoff and use for non-potable purposes and BMPs that reduce runoff through evapotranspiration. The Lake Arlington watershed has mixed group of soils that range high potential for infiltration to very low infiltration potential. The soil groups of the watershed are illustrated in Figure 7.10-1 and following are soil groups as defined by the NRCS.

A = (Low runoff potential) Soils having low runoff potential and high infiltration rates, even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.

B = (Moderately low runoff potential). Soils having moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

C = (Moderately high runoff potential). Soils having low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine textures. These soils have a low rate of water transmission

D = (High runoff potential). Soils having high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a hardpan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission

It is important to note that the sites with relatively impermeable soils may require reducing relatively smaller quantities of post-development runoff when compared to a similar size and development site with relatively high permeable soils. This is because the site is expected have high runoff even before its development due to relative impervious nature of the site and hence the relative increase in the runoff for post development conditions will be minimal. Even after selecting all possible LID techniques, if the site is still not meeting the runoff reduction requirements then the developer can demonstrate the fact and choose to go with traditional treatment techniques. Developers are advised to follow the procedure mentioned earlier when selecting traditional BMPs for the site.

Another important consideration for infiltration BMPs for runoff reduction is that the infiltration of polluted stormwater runoff is not always desirable or even possible at some development sites. Therefore, most

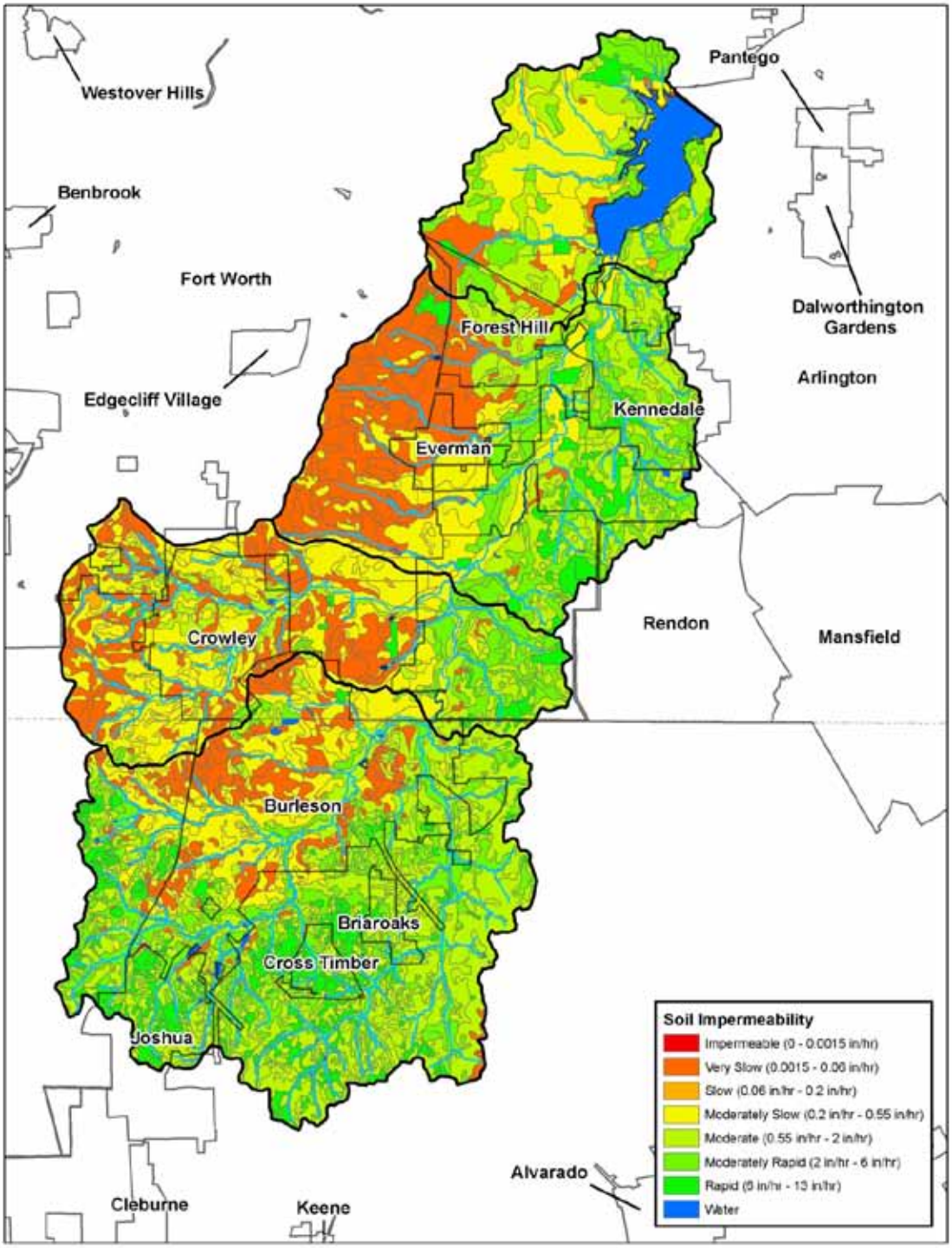


Figure 7.10-1: Soil Impermeability in the Watershed

infiltration management practices include criteria to reflect special site conditions, protection of groundwater quality, and avoiding common nuisance issues. For example, they may require:

- The pretreatment of stormwater runoff prior to infiltration in some land use categories or pollution source areas (e.g. parking lots, roadways).
- That recharge be restricted or prohibited at specific industrial, commercial and transport related operations designated as potential stormwater hotspots.
- That recharge be prohibited or otherwise restricted within the vicinity of wellhead protection areas, individual water wells, structures, and basins.

C. Establishment of Environmentally Sensitive Areas

To further assist in the protection of water quality in Lake Arlington and to achieve the 20% pollutant reduction that was modeled during this Project, environmentally sensitive areas (ESAs) should be designated around the waterways in the watershed. The purpose of the establishment of the ESAs is to not restrict development or other activities, but to give the entities in the watershed an area of focus for the implementation of pollutant reducing activities.

Management practices in the ESAs should include the following:

- Limited use of pesticides, herbicides and fertilizers on public lands.
- Additional recommendations for the implementation of construction site runoff BMPs (as presented below).
- Targeting this area for trash reduction and anti-littering public education campaigns.
- More frequent monitoring of industrial and high risk commercial facilities and operations.
- Development of a conservation subdivision policy for ESAs.
- Signage to designate the watershed as an ESA.
- Additional land conservation.

The proposed definition of ESAs for this project is the 100-year floodplain of the Village Creek watershed upstream of Lake Arlington. The 100-year floodplain is shown on Figure 7.10-2 below.

Conservation Subdivision Policy for ESAs

Conservation subdivision practices is a method that can be employed by developers to assist with achieving the standards proposed for stormwater runoff reduction and stormwater treatment. The general purpose of conservation subdivision policies is to reduce the amount of impervious cover by preserving open space while accommodating the development project. Conservation subdivision practices seek to facilitate development while still maintaining the most valuable natural features and functions of the site.

For the municipalities and counties in the watershed it is recommended that such a policy be developed as part of each entity's subdivision regulations that will require the following:

- The proposed conservation subdivision policy should be applied to all new development and redevelopment sites in the watershed that within 600 feet of the Lake or its tributary banks.
- Within the ESA, a conservation area around the development (natural, undisturbed) should be calculated as 50 feet plus 2 feet per 1 % of slope, as measured perpendicular to the water body and extended to the water bank. Slope can be determined by measuring the difference in elevation between the stream bank and a point approximately 300 feet inland perpendicular to the stream bank.

In 2005 the Lady Bird Johnson Wildflower Center in Austin, Texas published Conservation Development

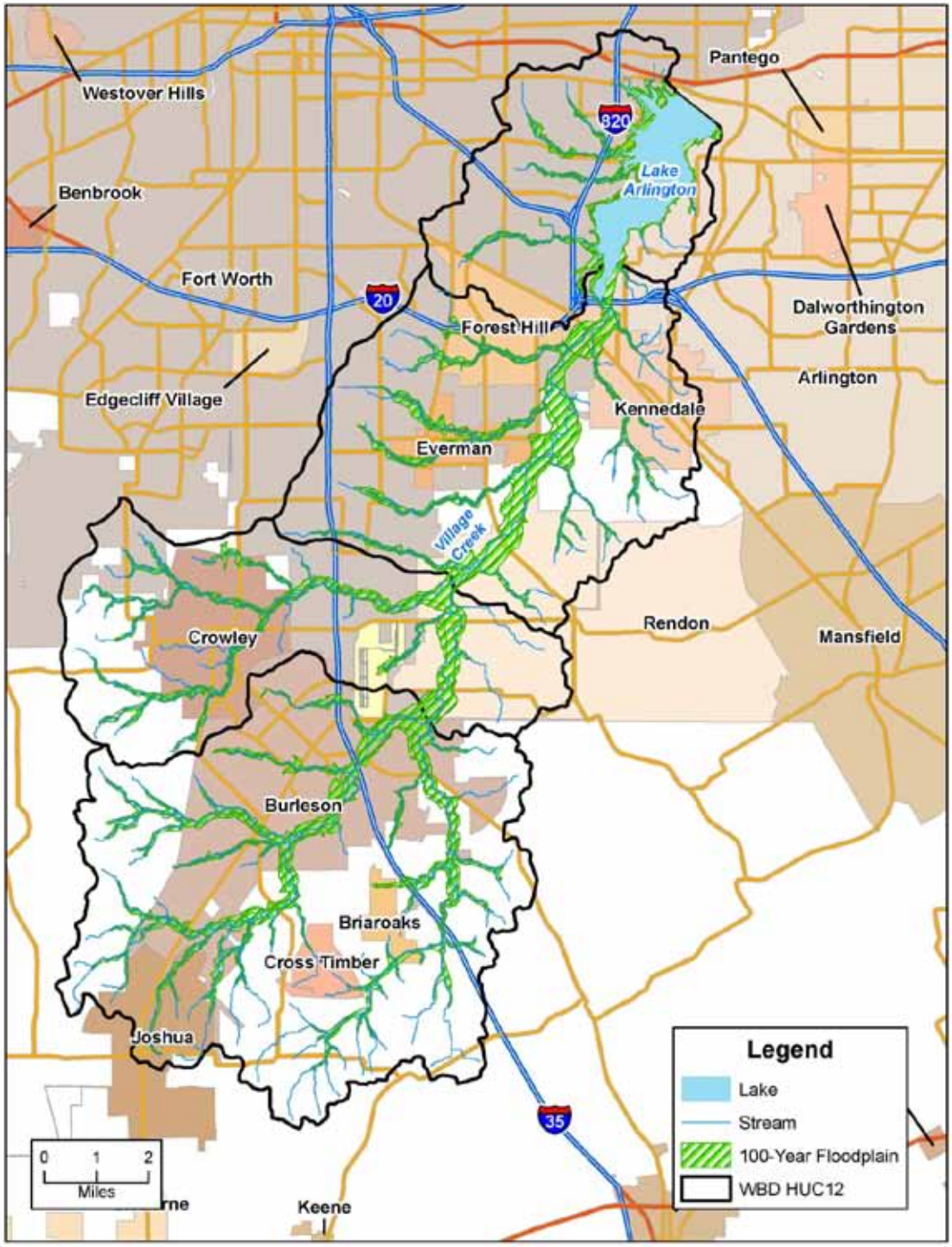


Figure 7.10-2: Proposed Environmentally Sensitive Areas (ESAs)

in Texas: a Primer for Government Officials, Developers and Land Planners. This resource outlines the theory, economic value and legal basis of conservation development. This publication is available on line at http://www.hillcountryalliance.org/uploads/HCA/ConDevelPrimer.pdf.

Conserving lands in the floodplain protect and improve water quality by preventing sediment and nutrient-laden runoff from entering waterbodies because:

- The vegetation helps reduce near and in-stream erosion.
- Plants take up excess nutrient loads.
- The cover soaks up some of the flow, reducing flashiness and restoring base flow conditions.

These undisturbed floodplains are assumed to reduce total phosphorus (TP) and total suspended solids (TSS) concentrations in runoff from adjacent land. The removal efficiency is dependent on the average floodplain width. For these areas to be effective at removing pollutants, runoff from the contributing area must enter the floodplain as sheet flow. This means that only areas near the floodplain are treated. Table 7.10-2 demonstrates the pollutant removal efficiency of buffer areas of various widths.

CORRIDOR WIDTH (ft)	TSS REMOVAL EFFICIENCY (%)[a]	TP REMOVAL EFFICIENCY (%)[b]	NOTES
50[c]	50	20	[a]Values calculated using linear interpolation between 50 and 100 feet as well as between 100 and 200 feet. Corridor widths above 200 feet were assigned a 95% removal efficiency. [b] Values calculated using linear interpolation between 50 and 100 feet. Corridor widths from 110 feet up to and including 200 feet were calculated as a percentage of TSS removal efficiency using the TP/TSS removal efficiency ratio at the 100 foot width. Corridor widths above 200 feet were assigned a 52% removal efficiency. [c]Values given in the Georgia Stormwater Management Manual, Volume 2 for Grass Filter Strips [d]Values given in the City of Newport News, Virginia's Code for undisturbed corridors [e]Value given in "A review of Scientific Literature on Riparian corridor Width, Extent and Vegetation," by Seth Wenger
60	55	24	
70	60	28	
80	65	32	
90	70	36	
100[d]	75	40	
110	77	42	
120	79	43	
130	81	45	
140	83	46	
150	85	47	
160	87	48	
170	89	49	
180	91	50	
190	93	51	
200	95[e]	52	

Table 7.10-2: TSS and TP Removal Efficiencies for Various Corridor Widths

From Table 7.10-2 it is observed that pollutant removal efficiencies for corridors greater than 100 feet in width have a diminished return in value beyond that width.

Additional Land Conservation
In an effort to protect the Central Texas region's water supply lakes, the NCTCOG has partnered with the Trust for Public Land to "Greenprint" the Lake Arlington watershed. Greenprinting is defined as an approach for identifying areas that offer the highest conservation benefit for water quality protection and other regional resource priorities. This project is being funded through a grant provided by the EPA through the TCEQ. The purpose of the Greenprint modeling is to identify areas within the watershed that provide water quality benefits and are the highest priority for protection through the purchase of conservation easements from willing participants, and other methods.

The conservation of natural lands that have been identified in this NCTCOG project will serve as one of the implementation steps to conserve land in the watershed that will provide water quality benefits.

The Greenprinting project was initiated in December 2010. Through March 2011 it is expected that a Technical Advisory Team will meet to refine the Greenprint model framework, identify best data sources, and create the Greenprint model. Afterward stakeholders from the watershed will convene to gather and provide information that will serve to weight the model criteria and discuss parcel scoring considerations. In the months of April and May 2011, the parcel scoring and overlay analysis will be completed and the maps, report and prioritized parcel spreadsheets will be delivered to the NCTCOG.

The City of Arlington has a goal to protect Lake Arlington and aquatic resources from the short and long term impacts of development activities within the watershed. Therefore, the recommended requirements and ordinances should prohibit certain activities within a floodplain. Under no circumstances should any part of a private, on-site sewage system, including field lines, wastewater irrigation, wastewater collection or treatment systems, or golf courses, be located in a floodplain.

7.10.2 Construction Site Runoff Control

A. Construction Site Erosion Control
The objective of construction site runoff control measures is to reduce soil erosion from active development sites and to enforce applicable erosion and sedimentation control provisions to reduce impacts to watershed health. Erosion control measures are required when land-disturbing activities expose the soil and subject it to accelerated erosion.

The NPDES Phase I and Phase II regulations require that the regulated municipalities in the watershed develop, implement and enforce erosion and sediment control requirements for active construction and land disturbance activities. The Phase I NPDES permit requires the following:

The permittees shall implement a program to reduce the discharge of pollutants into the MS4 from construction sites. This program shall include:

a. *Requirements for the use and maintenance of appropriate structural and nonstructural control measures into the MS4 from construction sites;*
b. *Inspection of construction sites and enforcement of control measure requirements;*
c. *Appropriate education and training measures for construction site operators; and*
d. *Notification, as appropriate, to building permit applicants of their potential responsibilities under the NPDES/TPDES permitting regulations and permits for construction site runoff.*

The Phase II NPDES permit requires:

> *The MS4 operator, to the extent allowable under State and local law, must develop, implement, and enforce a program to reduce pollutants in any stormwater runoff to the small MS4 from construction activities that result in a land disturbance of greater than or equal to one acre of if that construction activity is part of a larger common plan of development or sale that would disturb one acre or more of land. The MS4 operator is not required to develop, implement, and/or enforce a program to reduce pollutant discharges from sites where the construction site operator has obtained a waiver from permit requirements under NPDES or TPDES construction permitting requirements based on a low potential for erosion.*
>
> *a. The program must include the development and implementation of, at a minimum, an ordinance or other regulatory mechanism to require erosion and sediment controls, as well as sanctions to ensure compliance, to the extent allowable under state and local law.*
> *b. Requirements for construction site contractors, at a minimum:*
> *1. implement appropriate erosion and sediment control BMPs; and*
> *2. control waste such as discarded building materials, concrete truck washout water, chemicals, litter, and sanitary waste at the construction site that may cause adverse impacts to water quality.*
> *c. The MS4 operator must develop procedures for:*
> *1. site plan review which incorporate consideration of potential water quality impacts;*
> *2. receipt and consideration of information submitted by the public; and*
> *3. site inspection and enforcement of control measures to the extent allowable under state and local law.*

It is recommended that the municipalities in the watershed adopt the integrated Construction Criteria that is detailed in the iSWM Criteria Manual developed by the NCTCOG. This will serve as the legal authority necessary to implement a construction site runoff control program. Included in this documentation is a checklist for plan preparation and review that should also be used by contractors and city staff. Attachment 5 includes a fact sheet for developers to explain their responsibilities and an inspection worksheet for municipal construction site inspectors.

The municipalities in the watershed should have documented construction site runoff control programs that include adequate erosion and sediment control ordinances to provide the appropriate authority and standard operating procedures for permitting, inspections and enforcement. The standard operating procedures should include the following key items:

- A plan review process, which includes the plan review checklist, and the consideration of the NCTCOG Construction Controls section of the iSWM Technical Manual.
- Notification to permit applicants of their potential responsibilities under the NPDES permitting program for construction site runoff.
- Procedures for conducting site inspections, including an inspection checklist.
- Procedures for providing permittees with written notification of inspection findings.
- Procedures for escalating enforcement actions.

The construction site program should also include an appropriate training and education program for contractors and construction site operators. The education program should inform them of their responsibili-

ties and various options for satisfying permit conditions. In order to maximize participation in any training program, the local watershed municipalities may consider offering an incentive for attending the training each year.
The NCTCOG offers a 6 hour course designed more for municipal inspectors, but is also appropriate for contractors, engineers, and other personnel with responsibility for preventing stormwater pollution during construction activities. Upcoming classes are scheduled for May 5, 2011 and August 22, 2011. Additional information can be found at http://www.nctcog.org/envir/SEEclean/stormwater/program-areas/construction/index.asp. All of the NCTCOG training offerings are posted at http://www.nctcog.org/cs/rtc/admin_services.asp.

The Regional Stormwater Management Program's Public Education Task Force is in the process of developing a field guide designed for the construction site superintendents to help them prevent stormwater pollution at construction sites (mainly homebuilding sites). Over the next few years, the NCTCOG would like to have regional training targeting superintendents and contractors, but the feasibility and logistics of this is yet to be determined.

B. Recommended BMPs for Construction Sites
For all construction sites in the Lake Arlington watershed, developers and contractors shall consult the iSWM Technical Manual for BMPs appropriate for complying with erosion and sediment control regulations and to reduce to the maximum extent practicable the runoff of sediments from disturbed land.

For construction sites located in the environmentally sensitive areas (ESAs), which are defined in Section 7.10.1, there should be consideration of the following BMPs detailed below with the purpose of protecting the water quality of Lake Arlington.

The information outlined below provides general guidance for personnel working on projects being constructed in the ESAs delineated earlier in this document.

The general management practices/operations include:
1. Erosion and Sediment Control
2. Managing Watercourses
3. Managing the Work Area
4. Managing Spoil
5. Ground Stabilization
6. Site Clean Up

1. Erosion and Sediment Control
   Several specific methods of erosion and sediment control are provided below. However, the following general measures should be employed as appropriate:
   - Install erosion and sediment control measures prior to any land disturbing activity, including clearing and grubbing.
   - Sediment control measures are installed both within the work area and on the outside limits of the work area to control runoff from disturbed areas before it leaves the site.
   - Remove erosion and sediment controls measures after the graded project area is complete and stable, which should typically occur within a two year time period.

rosion and Sediment Control BMPs

a. Temporary Silt Fence
The purpose of a temporary silt fence is to intercept water flow from the site, decrease velocity, and cause suspended particles to settle. The use of temporary silt fencing applies below small disturbed areas less than ¼ acre per 100 feet of fence, and where runoff can accumulate behind the sediment fence without damaging the fence or the inundated area behind the fence. This practice shall not be installed across streams, ditches, waterways or areas that have concentrated flow.

b. Special Sediment Control Fence
A special sediment control fence is hardware cloth with sediment control stone at the base and contained by wire mesh fence. Water from the site drains through the sediment control stone causing sediment to be trapped or causing it to settle.

The use of special sediment control fencing applies where the volume of water is too extensive for a silt fence, and where inadequate right of way is available for a silt ditch. This practice does not apply where topography forces water to run along the base of the sediment control stone instead of allowing the water to pond up and flow through the stone.

Figure 7.10-4: Sediment Control Fence

c. Temporary Silt Ditch
This practice is recommended for use in place of a silt fence where room allows, and should be used in conjunction with fiber check dams with polyacrylamide (PAM, with rock sediment dams or other measures to contain sediment at the outlet.

This practice applies at the toe of fill slopes where fill exceeds 3 feet (1 meter) in vertical height, adjacent to streams to intercept flow and/or divert to a controlled outlet, and along project perimeters to minimize sediment loss from the site. This practice does not apply within jurisdictional waters and wetlands, or when access is difficult due to high fill slope.

Figure 7.10-5: Temporary Silt Ditch

d. Fiber Check Dams and Polyacrylamide
On most construction sites, channels are installed to route runoff into sediment control basins. To keep the channels from eroding, check dams are usually installed to pool the water so it moves from pool to pool down the slope. The most common practice is to place large stone in the channel with a weir, or low spot, in the center. The purpose of using fiber check dams (FCD) and PAM is to reduce soil erosion through soil binding.

The use of FCD and PAM is applicable when they are installed perpendicular to flow with a weir, or low point, that can pass the design flow without overtopping the channel or circumvent-

Figure 7.10-6: Fiber Check Dam

ing the FCD ends. It is best used when fine silts and clays are present on the jobsite because PAM is a synthetic polymer that acts as a highly effective binding agent with those soil types. PAM-treated runoff should be directed into a sediment basin or similar device prior to discharge in order to trap the flocculated material.

e. Temporary Rock Sediment Dam
Typically, temporary rock sediment dams (or check dams) are used at the outlets of roadside ditches or channels to impound and settle runoff prior to entering streams or exiting the site.

Check dams are most applicable at outlets of temporary diversions, temporary silt ditches, channels, and temporary slope drains, in locations where dam can be cleaned and maintained on a regular basis, in locations where runoff is exiting the construction site, and in small natural drainage turnouts.

Figure 7.10-7: Temporary Rock Sediment Dam

2. Managing Watercourses
The work area must be isolated from the normal flow of a stream and the flow that occurs during minor rainfall events. When a stream must be diverted on a project, the watercourse should be managed to minimize adverse impacts to the jurisdictional waters.

The following general measures should be employed as appropriate:
- The stream's normal flow and flow during minor rainfall events should be maintained near normal downstream flow conditions without mixing with untreated water from the work area. This can be accomplished by diverting the stream around or through the work area.
- Where the construction time is anticipated to be less than one day and little or no base flow occurs in the channel, an impervious dike may be utilized to create an impoundment upstream of the work area.
- The watercourse should be managed to minimize any flooding of the work area.

<u>Flow Diverson</u>

a. Piped Diversion
In a pipe diversion, the operator will install a temporary pipe to divert the flow of the watercourse around the work area without the use of pumping operations. While the cost is higher for this operation, the probability of offsite sediment loss is much lower than with an open diversion channel.

Figure 7.10-8: Piped Diversion

A pipe diversion is most applicable where adequate slope and space exist between the upstream and downstream ends of the diversion. This practice is not applicable when the pipe would adversely impact the aquatic habitat migration.

b. Fabric Lined Diversion Channel
A fabric lined diversion channel is used to divert the normal flow and small storm events around the work area without the use of pumping operations. The diversion channel is typically constructed adja-

cent to the work area and is lined with a poly-fabric to prevent erosion of the diversion channel.

A fabric lined diversion is most applicable when adequate space and slopes exist adjacent to the work area.

Figure 7.10-9: Fabric Lined Diversion Channel

Impervious Dikes

c. Stone with Impervious Fabric
A stone dike encapsulated with a high tensile impervious geotextile fabric material creates a temporary impervious barrier that will either impound or divert water. This barrier can be constructed to the shape of the existing channel.

Figure 7.10-410: Stone with Impervious Fabric

d. Sand Bags
Filter bags filled with sand can be manually stacked to form a temporary impervious dike when encapsulated with an impervious poly-fabric liner. This impervious dike can be used to impound or divert water and can be easily removed.

Sand bag and impervious fabric dikes are best used when low flow rates exist, when the height of the dike is less than 15 feet, and when heavy equipment cannot be utilized.

Figure 7.10-11: Sand Bags

e. Sheet Piles
Sheet piles are flat cross-section piling that is driven into the ground and interlocked to create a wall or bulkhead. Sheet piles can be used to detain water in low-flow situations or coupled with bypass pumps to keep a site moderately dry during construction.

Sheet pile installation is most applicable where minimum channel disturbance is required. It does not apply where there is a small channel with little or no flow, where the access to drive piles requires more disturbance to jurisdictional areas than other impervious dikes, or in locations where rocks and other obstructions prevent piles from being driven.

Figure 7.10-12: Sheet Piles

3. Managing the Work Area
The work area consists of the area necessary to perform the construction or maintenance activity within or adjacent to jurisdictional areas. They include, but are not limited to, excavation and storage of material offsite in upland disposal sites, construction, and the maneuvering of equipment and manpower.

The following general measures should be employed as appropriate:

- All land disturbing activities should be confined to the work area as shown in the permit drawings, including equipment staging and access.
- All runoff from the work area should drain through a sediment control BMP or a dewatering device BMP prior to entering jurisdictional waters.
- BMPs should be maintained throughout the life of the project.
- Multiple small work areas in lieu of one large work area may be established to minimize the disturbance of jurisdictional waters.

Figure 7.10-13: Silting Basins

Dewatering of Work Areas

Stilling basins are used at sites where dewatering of the work area is required to perform work. The effluent is pumped into the stilling basin to allow the heavier particles to settle out prior to being discharged.

Stilling basins are most applicable where there is enough room in the work area to form or excavate the basin. They are not applicable where large volumes of water will be pumped from the work area.

Figure 7.10-14: Temporary Mulch and Seeding

4. Managing Spoil

Excavated material or spoil should either be:

- Contained within the work area.
- Stockpiled near the work area and contained by an appropriate erosion and sediment control BMP.
- Removed from the site and disposed of properly.

Spoil material should not be placed in wetlands, protected riparian buffers, or other jurisdictional areas or used for re-establishing ground cover.

5. Ground Stabilization

After completion of construction or land disturbing activities, all disturbed areas must be stabilized to prevent future erosion. Establishing a good vegetative cover helps protect soil from the impact of raindrops and reduces the erosive forces of runoff. Hard armor such as rip-rap helps protect areas that cannot be stabilized with vegetation.

The following general measures should be employed as appropriate:

- When construction/repairs are complete, remove all construction debris, including old concrete, asphalt, and stockpiled material.
- Notify the seeding crews in advance when final grading is to be performed.
- Dress and fine grade disturbed areas.
- Maintain erosion control BMPs until vegetation is well established, which can be highly varied and due in part to the state's diverse regional climates, soils, and plant communities.
- Perform temporary seeding, which is planting appropriate rapidly growing vegetation on disturbed/

denuded soil areas, or mulching if the project is to remain idle for longer than 15 working days.

Ground Stabilization
To prevent erosion of exposed soil material, cover with mulch and quick germinating seed mixture. Disturbed areas may need planting of woody species, in addition to seeding.

Temporary seeding and mulching is best applied when work areas will not be active for more than 15 days, and prior to anticipated precipitation events which will severely damage work performed on or near jurisdictional areas. This practice is not intended for permanent stabilization or areas permanently under water.

6. Site Clean Up
When temporary fill is approved, it should be completely removed and the affected area restored to the pre-project conditions upon completion of the construction activity. After re-establishment of the groundcover vegetation, all sediment control BMPs should be removed and the ground should be restored to pre-project conditions and stabilized. Where there are exposed, erodible areas, continue to spot seed and mulch those areas.

C. Natural Gas and Oil Exploration Sites
The City of Denton, TX, with the funding from the EPA through a Water Quality Cooperative Agreement [104 (b).3 grant] has researched stormwater runoff associated with natural gas exploration and production, and provided guidance on how to manage these sites from a regulatory standpoint (USEPA 2007). As part of this research, stormwater samples from the gas well sites were analyzed for a variety of water quality parameters and evaluated.

The results show that Event Mean Concentrations (EMC) of total dissolved solids (TDS), TSS, turbidity, conductivity, calcium, chlorides, hardness, alkalinity and pH were higher at gas well sites compared to reference sites, and that differences were statistically significant for all parameters except conductivity. Generally, the presence of metals was higher at gas well sites compared to reference sites and EMCs were statistically significantly greater for iron (Fe), manganese (Mn), and nickel (Ni). A number of storm EMCs at gas well sites were above national drinking water standards and aquatic life criteria for some constituents. The concentrations of metals also tended to be higher at gas well sites compared to nearby reference sites and stormwater runoff from local mixed use watersheds.

Total petroleum hydrocarbons (TPH) were not detected in any of the samples collected at gas well sites or reference sites. The median TSS EMC at gas well sites was 136 times greater than the median EMC at reference sites. Compared to the median EMCs of storm sampled near the outlet of the Hickory Creek Watershed by the City of Denton's Watershed Protection Program, the gas well site median EMC was 36 times greater. These results indicated that gas well site construction activities greatly increase the rate of sedimentation compared to predevelopment conditions, and that these increases are similar in magnitude to typical construction sites that are currently regulated under the federal NPDES program.

The City of Denton established a series of additional environmental regulations for those gas wells located in the floodplain fringe. These regulatory restrictions are required to be supported by an engineering study, and must demonstrate that the proposed activity will have no adverse impact on the carrying capacity of the adjacent waterway and will not cause any increase in the water elevations established for the floodplain.

According to the research report, in general, the slope of a given property, the erodibility of the site's soils, and the proximity of that property to surface water conveyances are all important considerations for minimizing gas well impacts to surface water resources. Flat, heavily vegetated areas that are located long distances from surface water resources tend to be less of a concern than those areas close to streams or lakes, located on highly erodible soils with little vegetation, and situated on steeper slopes. The research also recommended that, regardless of whether a municipality decides to allow drilling in the floodplain fringe or not, management practices should be designed to ensure that areas with greater potential stormwater impact are managed appropriately.

Overall, the findings of the research suggest that gas well sites have the potential to negatively impact the aquatic environment due to site activities that result in increased sedimentation rates and an increase in the presence of metals in stormwater runoff. While these activities do not appear to result in high concentrations of petroleum hydrocarbons in stormwater runoff, accidental spills and leaks are still a potential source of impact. The research team recommended that in lieu of federal stormwater requirements for natural gas exploration and development sites, state and local governments should consider some form of regulation, perhaps similar to current Phase I and Phase II NDPES requirements for construction sites, to reduce the potential impact of stormwater runoff from these sites. According to the research recommendations, regulatory requirements should include stormwater pollution and prevention plans, erosion and sediment control BMPs, provisions for containing spills and leaks, procedures for site inspections and enforcement of control measures, and sanctions to ensure compliance.

Management practices similar to those used at residential and commercial construction sites are often sufficient to meet target sediment reduction goals. The research team also recommended that site operation standards can be used to create a cleaner overall site and hence minimizing the stormwater pollution from the site. Municipalities can consider simple site management standards for incorporation into local regulatory requirements. For example, drip pans or oil absorbing materials should be placed underneath all tanks, containers, and other equipment that has a potential to leak. Chemical materials should be stored on pallets or other appropriate devices to prevent contact between the ground and containers, and should be protected from stormwater and other weather elements. Depending on the type and quantity of materials, secondary containment and other similar strategies may be appropriate. A hazardous materials management plan should be created for all sites, and all materials should be adequately labeled, contained, and have appropriate material safety data sheets available. The overall goal for the site should be to devise a plan that ensures that all chemical materials can be stored as safely as possible on the site, and any accidental spills, leaks, or discharges of materials can be remediated as quickly and safely as possible.

D. Recommended BMPs for Natural Gas and Oil Exploration Sites

According to the Denton report, it is recommended that all municipalities strongly consider addition of erosion and sediment control provisions to local codes. Sediment impacts from gas well development and production sites can be substantial if unmanaged and unregulated. The same BMPs used at construction sites and outlined in the iSWM Technical Manual should be used at all natural gas and oil exploration sites in the watershed. It is also recommended as a consideration to the establishment of Environmentally Sensitive Areas (see Section 7.10.1.C) that no natural gas or oil exploration sites be located within 600 feet of Lake Arlington.

Currently, the municipalities in the watershed that are experiencing oil and gas exploration have ordinanc-

es that require the acquisition of a permit. These ordinances generally deal with the methods of drilling allowed, prevention of petroleum and other hazardous material spills and general safety issues. They do not adequately address soil erosion and sedimentation as a result of the exploration.

Drilling sites should be located not closer than 600 feet from the lake. In addition to any Emergency Action Response Plans typically required by the existing gas well ordinances, for natural gas and oil drilling sites located in the ESAs, there should also be consideration of the following BMPs detailed below with the purpose of protecting the water quality of Lake Arlington.

Figure 7.10-15: Earth Dike

Controlling Stormwater Run-On

Stormwater run-on is simply runoff that flows from another property onto the gas well drilling site. Uncontrolled run-on increases the volume of stormwater to be managed on the project. Additional stormwater flowing on the construction site can impact the effectiveness of on-site BMPs and for this reason the methods for managing run-on should be addressed in the erosion and sediment control plans for those sites. The site operator should place BMPs, such as those described below, so that diverted water is safely directed to an inlet, temporary conveyance or infiltrated into a vegetated area.

Figure 7.10-15: Fiber Rolls

1. Earth Dikes/Drainage Swales
   Diversion berms or some other suitable method for controlling run-on should be constructed on the upstream side of all natural gas well or oil drilling sites. Earth dikes and drainage swales are suitable at the base or top of slopes for diverting run-on from adjacent or undisturbed slopes.

   It may be necessary to use other soil stabilization and sediment controls, such as check dams, plastics, and blankets, to prevent scour and erosion in newly graded dikes, swales and ditches.

2. Sand Bags or Fiber Rolls
   A sandbag barrier or fiber rolls are temporary linear barriers consisting of stacked sandbags or properly staked fiber rolls, respectively, designed to intercept sheet flow runoff. They are best applied along the perimeter of a site and at the top or at the base of slopes. The drainage area being diverted by the barrier should be limited to 5 acres.

Figure 7.10-16: Vegetated Filter Strip

Erosion and Sediment Control BMPs

The following methods are recommended for controlling erosion and sedimentation on natural gas and oil drilling sites.

3. Vegetated Filter Strips
   A vegetative filter strip is a band of vegetation located between the gas well drilling site and off-site areas designed to provide runoff treatment of conventional pollutants such as sediments. The key is to use dense vegetation, typically grass, and allowing only overland sheet flow to cross the strip, while avoiding concentrated flows. A vegetated filter strip should not be used for conveyance of larger storms because of the need to maintain sheet flow conditions. They should also not receive concentrated flow discharges as they will be rendered ineffective and the potential for erosion could cause them to become sources of pollution.

Figure 7.10-17: Temporary Seeding

4. Seeding
   To prevent erosion of exposed soil material, cover with mulch and quick germinating seed mixture. Disturbed areas may need planting of woody species, in addition to seeding. Temporary seeding and mulching is best applied when work areas will not be active for more than 15 days, and prior to anticipated precipitation events which will severely damage work performed on or near jurisdictional areas. This practice is not intended for permanent stabilization or areas permanently under water.

5. Special Sediment Control Fence – see the description above

6. Fiber Check Dams and Polyacrylamide – see the description above

7.10.3 Trash and Litter Control

A. Trash and Anti-Littering Campaigns

Educational campaigns must be carefully structured if they are to be effective. A study performed by Los Angeles County in 1997 characterized the residents of the County into six different categories of behavior related to litter and other potential stormwater pollutants. The study identified a category called the "rubbish rebels" as the group most likely to engage in littering. Rubbish rebels are generally single males in their teens and twenties. In Los Angeles, one-third of the members of this group are unemployed and most are not college graduates. In 2002 the City of Los Angeles Stormwater Public Education Program conducted a survey designed to obtain additional information about rubbish rebels and the messages and public education strategies most likely to affect behavior change. That study concluded that the best mode for conveying anti-littering messages is through mass media advertising, and that brochures, leaflets and flyers should be avoided as they have a high likelihood of being littered.

Catch basin marking, which has been universally employed as a public education tool, should also be considered during the development of a public education plan for the municipalities in the watershed. A strategic plan for the placement of no dumping signs in areas of known trash accumulation should be developed. This should include not only areas immediately around Lake Arlington such as parks, docks and piers, but it should also include areas throughout the watershed. The areas in the watershed should be identified using the methods outlined in the illegal dumping discussion in Section 7.10.1.B

Cost and effectiveness may vary depending on the extent of program implementation. It is believed that

public education is effective for trash control. Market surveys suggest that media campaigns and intensive training such as workshops can produce a 10 to 20 percent improvement in selected watershed behaviors in targeted populations.[5] Because they are complimentary, both techniques can be used in most watersheds. For example, media campaigns cost just a few cents per watershed reached, while intensive training can cost several dollars per each resident actually influenced. Media campaigns are generally better at increasing awareness and sending messages about detrimental watershed behaviors. On the other hand, intensive training is better at changing individual practices in and around the home and community.

San Bernardino County, California conducted an in-depth survey to measure the impact of the program's messages and educational tips in 2002.[6] The San Bernardino County Stormwater Program released findings from its strategic stormwater research study of county residents and their knowledge and opinions regarding this environmental issue. Some key findings from "2002 San Bernardino County Stormwater Program Study" revealed the following:

- Residents are concerned about water and storm drain pollution. In fact, 58% of those surveyed stated that pollution of local beaches is a serious problem, and 44% said pollution of local storm drains is a serious problem.
- Residents want to learn more. According to the survey, more than 25% of people are very interested in learning how to reduce pollution.
- Sixty-two percent said they would definitely change their behavior if they learned they were polluting waterways.
- Those who recall seeing information and advertising about storm drain pollution were more concerned about pollution. Nearly half (48%) of the adult residents in the county say they have seen, read, or heard something in the past year about the storm drain system and the pollution of local waters. This number has doubled since the last survey in 1997, when the number was 23%.

The Cities of Arlington and Fort Worth bound Lake Arlington and the median age of each city is 30.1 and 31.6 years old respectively. Arlington residents under the age of 19 make up 35% of the population, and Fort Worth residents under the age of 18 make up 28.2% of the residents. Understanding this information, the municipalities in the watershed can certainly begin to tailor their anti-littering campaigns to target the demographic that seems to litter most. It is perhaps a good approach to try reaching citizens while they are in their cars, which is perhaps when most littering occurs. This can be accomplished through billboards, bus stop and bus advertising, posters, brochures, television advertising, radio public service announcements.

B. Municipal Operations

Source controls are aimed at reducing the litter loads entering the drainage system by dealing with pollution at source. Source controls can include any combination of public education, street sweeping, site erosion control, catch-basin modifications and cleaning programs, and industrial pretreatment. The following actions are examples of source controls:

- Upgrade cleaning operations by, for example, the better placement and design of litter bins, more frequent collection of litter, monitoring street sweeping methods to ensure that litter is not swept into catch basins, and ensuring that communal trash collection depots are appropriately placed.

5 EPA Water Division. EPA Menu of BMPs, Landscaping and Lawn Care Fact Sheet. http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=browse&Rbutton=detail&bmp=97&minmeasure=1

6 Miller, Lori E. San Bernardino County Stormwater Public Education Program Scores an A With Residents and Bussinesses. Stormwater. ForesterPress: Santa Barbara, CA. March-April 2004.

- Control construction activity by ensuring that site management plans are in place to prevent contaminant spills and rubble from reaching the drainage system. This activity can be coordinated with MS4 NPDES programs.
- Use the industrial and high risk commercial inspection program discussed in Section 7.10.4 to conduct business surveys to determine the nature and extent of activities likely to generate litter that can reach the stormwater system. This could lead to, among other things, encouraging manufacturers to move to more environmentally-friendly packaging, or to charge deposits on containers to encourage their return.
- Run litter education campaigns targeted at businesses and households informing them how the streets, stormwater drainage system, rivers and oceans are interconnected and how daily activities affect stormwater quality. Typical activities include organized clean-ups which serve the dual purpose of creating awareness and reducing the amount of litter, "adopt-a-block" programs, or encouraging the separation of litter into different types. This activity can be coordinated with MS4 NPDES programs.

Illegal Dumping

Coordinated efforts among municipal departments can be a no cost, best management practice for trash and floatables control in the Lake Arlington watershed. Through an innovative program to coordinate existing efforts of the various MS4 NPDES Permits, each municipality's Departments of Public Works and other relevant departments can improve ability to control floatables and possibly other pollutants in the watershed. This type of program can develop a framework for cooperation between previously uncoordinated efforts of city departments and, as such, represents a true best management practice. In short, the program can take advantage of one city department's field presence to garner and transmit valuable information to another city department for enforcement and cleanup.

For an example, agencies and/or departments conducting routine water quality monitoring can look for illegal dumping activities along the waterways, and if any such activities are noticed, the observing employees can notify the proper city department. Best of all, the program is operating at virtually no additional cost to the City. Similar programs have been established to control floatables in New York City, and the information collected formed a valuable resource for the city to monitor and reduce illegal dumping activity. In its first few months, the program was directly responsible for initiating action that is anticipated to reduce the number of illegal dumping sites by 15 percent.[7]

Street Sweeping

The major objective of street cleaning is to enhance the aesthetic appearance of streets by periodically removing litter, debris, dust, and dirt, while preventing these pollutants from entering storm or combined sewers. Common methods of street cleaning are manual, mechanical and vacuum sweepers, and street flushing. A regular street-sweeping program will help to clean and maintain the attractiveness of communities and enhance business viability and residential values. A regular sweeping program will reduce the amount of material accumulating in catch basins and stormwater facilities, reducing the need for frequent cleaning. Along with silt and trash, total suspended solids (TSS), hydrocarbons, excessive nutrients such as phosphorous and nitrogen, and other chemicals from the roadside are removed by street sweeping.

Street sweeping, vacuuming, and flushing, collects and disposes of pollutants before they enter the sewer system at the catch basins. Sidewalks, traffic islands, and congested street parking areas are difficult to

7 Newman, Thomas L. and Robert Gaffoglio. A No Cost, Best Management Practice for Floatables Control in New York City. http://www.hydroqual.com/Papers/tnewman/03/p_tln_03.pdf

clean with a traditional street sweeper, but smaller equipment is available that combines brushing, washing, and vacuum technologies, enabling greater accessibility and cleaning effectiveness. Other alternatives for hard-to-access areas include personal street-sweeping (walk-along) devices and manual cleaning with broom, scoop, and disposal bin.

In a 2005 study produced by HydroQual (Mahwah, N.J.), the Department of Sanitation of New York City examined a 450-ac (182-ha) section of Brooklyn which was swept six times per week. The test used two mechanical sweeps and four manual sweeps per week. Results for a 2-month period showed a 42% reduction in street floatables on an item basis, a 51% reduction on a surface area basis, and a 64% reduction on a weight basis.

Figure 7.10-18: Catch Basin Opening Cover

Cost Considerations

Street-sweeping units come in many different sizes, each with different applications. Small walk behind or ride-on units that clean smaller areas, such as small parking lots and sidewalks, can be purchased for less than $10,000. For larger areas, such as parking lots and small street applications, small truck sweepers are used, at a cost of $70,000 to $90,000 new or $35,000 to $55,000 refurbished. The cost of a standard municipal street sweeper ranges from $100,000 to $170,000. The most expensive models are dustless, which enables the sweeper to meet stringent air quality standards by removing dust, dirt, and debris from the swept surface.

Figure 7.10-19: Catch Basin Insert

In addition to operator labor, there are normal vehicle servicing requirements including checking and replacing the engine oil and filter, cleaning the sweeper engine, checking and replacing hydraulic and water filters, greasing fan bearings and fittings, cleaning the hopper and screen between uses, and other normal truck servicing requirements. On mechanical sweepers, the main broom should be replaced after roughly 200 hours of operation. Brooms on vacuum sweepers should be replaced after roughly 80 to 100 hours of operation.

C. In-Stream and Municipal Infrastructure Trash Reduction Measures

Introduction

No single BMP provides a comprehensive solution for floatables control in stormwater runoff. Most municipalities that are addressing trash and debris in urban runoff are using a combination of structural controls and institutional controls. Street sweeping and public education are the most common non-structural or institutional BMPs for trash and floatables control. There are several categories of structural BMPs that are being used to control floatables and trash, including:

- Catch basin opening covers.
- Catch basin inserts.
- Hydrodynamic separators/vortex separators/nutrient separating baffle

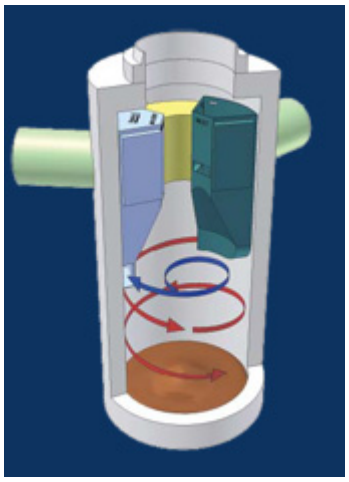


Figure 7.10-20: Nutrient Separating Baffle Box

boxes.
- End-of-pipe screening, basket and netting devices.
- Litter booms.

Figure 7.10-21 End-of-pipe Netting Device

In-System Controls
In-system controls are placed within the stormwater sewer system to capture pollutants at a particular point within the system, such as at a regulator diversion or a grit pit along an interceptor. Baffles, hydrodynamic separators, bar racks are some of the examples of the kind. These kinds are mostly used for solids separation in the stormwater sewer system.

Structural Controls or End-Of-Pipe – Litter Traps
Since it is difficult to prevent all the litter from reaching the drainage system, the balance will probably have to be trapped and removed at the end of pipe or along the water-course. Nets are most common end of pipe controls. End-of-pipe nets are installed directly at the end of the outfall pipe or on an apron extended from the outfall. Nets on the end of elevated outfall pipes are highly effective as long as velocities are not too high to damage the nets, but they are not as effective on closed level outfalls. Boom controls are the most common trash traps in waterways, although booms may not be effective at high velocities.

Figure 7.10-22: Litter Boom

End-Of-Pipe Controls
Nets and booms are most commonly used by municipalities to control the trash at the end of pipe or in the flowing streams. Containment booms are specially fabricated flotation structures with or without suspended curtains designed to capture buoyant materials. Booms typically are moored to a shoreline structure or to the bottom of the receiving water, and they skim floatables from the surface. Booms can be made of an elastomer or plastic and can include absorbent material to collect fats, oils, and grease.

Boom materials and configurations vary widely but have limited uses, mainly at the head of a dead-end stream with quiescent conditions. Booms do not keep floatables from entering the watercourse. In fact, they use a portion of the watercourse for storage until cleaning can be completed. Therefore, booms may exacerbate the aesthetic issues related to floatables, especially near the collection point. Rough or fast-moving water can submerge a boom for a short period or damage it, allowing floatables to pass. Also, winds can disperse floatables back upstream, depositing them along the shoreline and making removal ineffective.

A two-year pilot study of containment booms conducted for the City of New York Department of Environmental Protection Bureau of Engineering Design and Construction in Jamaica Bay indicated that the booms provided a retention efficiency of about 75%. After a rain event, collected materials can be removed

using either a skimmer vessel or a land based vacuum truck. Booms require periodic maintenance to repair damaged or missing sections or to re-anchor at locations that have become unattached from their moorings. Much of the maintenance can be done by tying off one side of the boom to a long rope and pulling the boom over to the other side to perform maintenance.

However, at least a small boat will be necessary if the boom becomes completely severed or if pieces dislodge and have to be retrieved downstream.

Costs of installing and maintaining booms can vary widely. Booms moored to the shore can cost as little as $10,000 each, whereas a system attached to specially sunk permanent piles can cost more than $100,000 each.

In-reservoir Debris Removal Systems

Lake Arlington is not unique in having periodic problems with large debris getting into the reservoir. This debris can include large logs and portions of trees, dead livestock, appliances and other items that come into the lake during high-flow and flood events. During the planning process, the Malcolm Pirnie Team repeatedly heard stakeholders and the public recommend that the City develop a program for removing this debris that creates unique issues, not typical of urban trash and litter management.

Most river systems and reservoirs have some degree of problem with log jams and debris following flood and high-water events. The problems often occur in situations where stream hydraulics create lower velocities, such as the upper end of reservoirs and river segments near the coast. Agencies such as the U.S. Army Corps of Engineers have been involved in “snagging” operations on major rivers such as the Mississippi since before the Civil War. The solutions are seldom easy or inexpensive because of the magnitude, size and weight of the material to be removed, the unique shapes and sizes, and the intermittent nature of these operations. It is difficult to organize for these types of operations, and the required equipment is normally unique and expensive.

Several Texas river authorities and water districts are involved in log-jamming and debris-removal operations. In rural areas, the debris is usually removed from the river bank or shore using heavy equipment such as a track-hoe or dragline, stacked with a bulldozer, and eventually burned or hauled to a landfill. When the debris has accumulated in more inaccessible locations, some type of snagging boat is used to push the debris or move it downstream to an appropriate location for removal.

The following images (provided by the Guadalupe-Blanco River Authority) show examples of such operations. In this case the shallow-draft, hydraulically powered snagging boat is designed in a catamaran shape so that a small trackhoe can reach logs positioned in between the two hulls. The boat was constructed in 2004 by Bollinger Shipyard in Houston, TX at a cost of approximately $300,000. Because of the intermittent nature of these operations, the trackhoe is only rented when the utility is engaged in log jam removal operations.

Log Jam Removal Boat

Log Jam Removal Operations on the San Antonio River in Refugio County, TX

Debris Removed From San Antonio River, Refugio County, TX

1.1 PRACTICE	EASE OF IMPLEMENTATION	1.2 COST	1.3 BENEFIT
Mid-drain Structural device retrofit	Not easy in many situations	H	H
Start-of-pipe structural device retrofit (e.g. catch basin opening screens and excluders)	Moderately easy in many situations	M	H
End-of-pipe structural device retrofit (e.g. trash racks, fabric mesh socks and wire screens)	Very easy in certain situations	M/L	H
Hydraulic disconnection and/or replacement of impervious surfaces	Disconnection: Moderately easy in some situations Repaving: Moderately easy for public areas	M	L/H
Street sweeping	Moderately easy	M	H
Adjustment of street sweeping routes; stricter enforcement of no-parking during street sweeping days; and, encouraging /sponsoring more public cleanup events.	Moderately easy	L	M
Open channel sweeping	Moderately easy	M/H	H
Performance-based open channel trash removal contracts	Easy	L	H
Private and public parking lot sweeping	Moderately difficult for private lots, moderately easy for public lots	M	H
Retrofit of catch basins on private parking lots	Moderately difficult	L/H	H
Increased or focused public education	Moderately easy	M	M
Dedicated hot line and response	Very easy	M	M
No-litter laws prohibiting certain products at recreational areas, such as cigarette butts, styrofoam cups, etc.	Moderately difficult	M	M
Product market-based reduction incentives and product substitution.	Moderately difficult	M	M
Sub-regional trash control facilities	Moderately easy in new development, difficult in developed areas	H	H

Table 7.10-3: Trash Control BMPs Relative Ease of Implementation, Cost, and Benefits

L-low; M-moderate; H-High

(Adopted from County of Los Angeles Department of Public Works Technical Report on Trash Best Management Practices Aug. 5, 2004 Pages 16 &17)

Effectiveness[5]

While the ultimate goal of any BMP is to improve the quality of water bodies which receive stormwater, it can be very difficult to show the linkages between BMP implementation and changes in receiving water quality due to spatial and temporal variability in water quality parameters. Therefore, the measure of effectiveness of a single or combination of BMPs is typically dependent on the BMP and the level of change that the BMP is expected to make in water quality.

For BMPs designed to reduce or prevent trash from entering water bodies, assessments can be conducted on the type BMP implemented. All BMPs can be considered and assessed at Level 1 which shall mean documenting activities. Assessments of Levels 2 and 3, raising awareness and changing behavior respectively, are typical of public education and outreach efforts. Level 4 assessments correspond to reducing pollutant loads at the source and are a result of BMPs that prevent pollutants from entering the storm system. Effectiveness of treatment BMPs (in-system controls or end of pipe) results in a Level 5 outcome which is an improvement in water quality. Changes in receiving water quality (Level 6 assessements) are typically a measure of the effectiveness of an overall pollutant mitigation program, but instream trash collection can be assessed at this level because it immediately changes the quality of the receiving water with respect to trash.

BMP Category	Most Applicable Effectiveness Assessment Outcome Levels					
	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
	Documenting Activities	Raising Awareness	Changing Behavior	Reducing Loads from Sources	Improving Runoff Quality	Protecting Receiving Water Quality
Infrastructure BMPs						
Racks and Screens	X				X	
Hydrodynamic Separators	X				X	
Litter Booms	X					X
Catch Basin Inserts	X				X	
Netting Devices	X				X	
Municipal Operations						
Street Sweeping	X			X		
Education and Outreach	X	X	X			
Regulations	X					

Table 7.10-4: BMP Implementation Effectiveness

With respect to the operation and maintenance of trash removal BMPs there are a few considerations that must be made. It is expected that municipal operations and most infrastructure BMPs would be installed, operated and maintained by the local government. If the local government requires a developer to install infrastructure BMPs or perform street sweeping in and around a commercial development for instance, an agreement would need to be executed between the municipality and the owner of the property to ensure that the BMP will be operated and maintained in to perpetuity by the owner of the property.

4 Santa Clara Valley Urban Runoff Pollution Prevention Program. Trash BMP Tool Box. September 2007.

Structural Control Selection

Unfortunately, the ideal trash control device does not exist. All designs and each type of equipment represent some sort of compromise. It is the utility's task to choose the most appropriate structure to fit the circumstances. Ideally this should form just one part of a total litter removal strategy that also takes into account planning and source controls. The data presented in this section is a result of literature studies and professional experience. The City of Fort Worth, Texas is conducting a trash control pilot study that will offer more empirical data in the area of the Lake Arlington watershed.

The City of Fort Worth initiated the pilot study in October 2010. The study will evaluate retractable screens, lateral screens, booms, sediment traps and bioswales. This is expected to be a two-year study, and quarterly reports will be prepared by the City of Fort Worth.

One of the biggest problems facing the designer of a litter trap is that litter can be just about anything - any size, any shape, any density, and any hardness. Furthermore, the physical characteristics of individual items sometimes changes as they move through the drainage system. Plastic bags deform and tear, bottles break, and aluminium cans fill with water and / or sediment. The high degree of variability in litter characteristics makes it extremely difficult for the designer to design a structure that will cater for every eventuality. Many litter trapping structures work extremely well in low, but not in high flows – or vice versa – or work well with certain types of litter, but not with others. Many litter traps pose major cleaning problems.

The ideal trap would have the following features (Armitage et al, 1998):

- Reliability.
- Reasonable cost to construct, operate and maintain.
- No moving parts.
- No external power source requirement.
- Minimal water head requirement (i.e. it can be used in association with flat gradients).
- Does not increase flood levels in the vicinity of the structure.
- High trash removal efficiency.

The methods typically employed in determining which BMPs to implement in particular locales typically include:

- Identifying the trash "hot spots" and spatial distribution of trash throughout the targeted watershed.
- Determining the land-uses associated with the hot spots and other areas where trash enters the storm drain system.
- Determining the neighborhood characteristics in the areas where trash enters the storm drain system.
- Tailoring the implemented BMPs to the surrounding land-uses and neighborhoods in high trash generating areas.

To select the most appropriate and effective BMPs, it is important to thoughtfully study the specific situation for Lake Arlington. A program plan should be developed to study areas in the Lake Arlington watershed that generate the best results from utilizing trash reduction measures. The first step is to identify the areas where the largest benefit will be realized. The question has to be answered, "Where is most of the trash that ends up in the lake coming from?" Visual observation seems to indicate that most of the trash originates from upstream (the south end of the lake) and from the west side of the lake. However, other areas may also contribute significant amounts.

This question can be answered in several different ways. One is to review the street sweeping routes and records. Which routes are yielding the most trash in terms of weight or volume? These routes can be colored coded in GIS to highlight where most of the trash is coming from.

The next step in the process is to overlay those routes with the stormwater drainage system. Determine the number of inlets and the types, if any. Select the appropriate retrofit device based on inlet type and have those devices installed.

The Attachment 6 presents the list of vendors and the type of BMPs they supply. There is more than one vendor or trademark device available in each type of trash control BMP. This gives us the option to compare and choose the most appropriate device from among them. Attachment 7 also presents comparison matrix for the in-stream trash control BMPs.

7.10.4 Other Stormwater Management Measures

A. Illicit Discharge Detection and Elimination Programs

Federal regulations define an illicit discharge as any discharge to a Municipal Storm Sewer System (MS4) that is not composed entirely of stormwater, with some exceptions. These exceptions include discharges from NPDES-permitted industrial and municipal sources and discharges from fire-fighting activities. Additionally, the illicit discharge detection and elimination (IDDE) program does not need to address the following categories of non-stormwater discharges or flows unless the MS4 identifies them as significant contributors of pollutants to its MS4 (EPA Fact Sheet 2.5, 2000, rev.2005).

- Water line flushing
- Landscape irrigation
- Diverted stream flow
- Uncontaminated ground water infiltration
- Pure pumped ground water
- Discharges from potable water sources
- Foundation drains
- Air conditioning condensation
- Irrigation water
- Springs
- Water from crawl space pumps
- Footing drains
- Lawn watering
- Individual residential car washing
- Flows from riparian habitats and wetlands
- Dechlorinated swimming pool discharges
- Street wash water

Dry weather flows resulting from illicit/inappropriate discharges and connections to the MS4 are a major contributing factor to receiving water pollution. These sources can introduce pollutants such as heavy metals, toxics, oil, grease, solvents, nutrients, viruses, and bacteria. Discharges of high pollutant levels to creeks and streams adversely affect water quality, the ecosystem, and human health (EPA, 2005). The municipalities in the watershed should develop IDDE Programs per the recommendation of EPA to include:

1. Outfall Identification and Investigation: Each municipality should identify and map its stormwater outfalls and inspect 20% of those outfalls each year for extraneous flows during dry weather when no flow should be present. Information regarding the location and physical attributes of these outfalls should be identified on a map or GIS system, and tracked in a database. Outfall inspection activities are documented through an outfall reconnaissance inventory/sample collection field sheet.

2. Regulatory Requirements. A program should be developed for each community in the watershed to effectively identify and eliminate any illicit discharges. Non-stormwater discharges to the MS4 shall be effectively prohibited (and exceptions to the prohibition must be identified). The basis of this program will be an IDDE ordinance. The municipalities should establish the necessary legal authority to implement an effective IDDE program which prohibits illicit discharges from entering the MS4 system, controls disposal of materials other than stormwater into the MS4, and enables the MS4 to requires compliance with conditions and carry out all inspections, surveillance, and monitoring procedures necessary to determine compliance. There also needs to be an escalated enforcement remedy in response to repeat violations against illicit discharges from commercial, industrial, municipal or residential sources. A model ordinance can be found in Attachment 7.

3. Dry Weather Screening. If flow is observed during outfall inspections, field screening analysis of the dry weather discharge should be observed for ammonia, pH, temperature, total chlorine, total copper, total phenol, detergents or surfactants, and turbidity along with a description of the flow rate. Also, when any flow is observed, two grab samples should be collected during a 24-hour period with a minimum period of four hours between samples. The results of these field tests will begin to frame what the source of an illicit discharge, if any, may be. The table below summarizes the potential pollutant sources with respect to pollutants identified during such field testing.

   Follow-up to eliminate illicit discharges may be prioritized based on the magnitude and nature of suspected discharges, sensitivity of receiving waters, and other relevant factors. The municipalities should establish priorities and schedules for screening the entire system at least once every five years. Facility inspections may be carried out in conjunction with other municipal programs (e.g., pretreatment, health inspections, fire inspections, etc...). The investigation of potential illicit discharges should specify the equipment used to find illicit discharges (i.e., video camera, smoke test, etc.). An enforcement response plan should be developed by the municipalities for use when an illicit discharge source has been located to ensure timely and appropriate enforcement. IDDE investigation processes need to be fully documented with a complete paperwork trail for any illicit discharge event observed and for any unusual field observation. Attachment 7 includes an example outfall inspection worksheet.

   The municipality's IDDE programs should allow elimination of illicit discharges as expeditiously as possible and the immediate cessation of improper disposal practices upon identification of responsible parties. If it is not possible to eliminate an illicit discharge within ten days, the municipalities should require an expeditious schedule for removal of the illicit discharge, and in the interim should require the owner or operator to take all reasonable measures to minimize the discharge of pollutants to the MS4.

4. Industrial and High Risk Monitoring Program. The main purpose of the industrial and high risk monitoring program is to identify and control pollutants originating from municipal landfills; other treatment, storage or disposal facilities for municipal wastes (e.g. transfer stations, incinerators, etc.); hazardous waste treatment, storage, disposal, and recovery facilities and facilities that are subject to EPCRA Title

PARAMETER	BENCHMARKS	EVALUATION	FIELD TASK
Ammonia	0.3 mg/L for illicit discharges and 0.5 mg/L (Industrial)	Indicator of sewage, since its concentration is much higher than groundwater or tap water. High ammonia concentrations may also indicate liquid wastes from industrial sites.	Outfalls and Possible Illicit Discharge
pH	The normal pH range for stormwater runoff is between 6 and 8, with 7 being neutral.	pH is a relatively good indicator of liquid wastes from industries, which can have very high or low pH values (ranging from 3 to 12). The pH of residential and commercial washwater tends to be 8 or 9.	Outfalls and Possible Illicit Discharge
Temperature	Elevated baseflow temperatures (compared to baseflows at other sites being screened) could be an indicator of substantial contamination by sanitary wastewater or cooling water.	Useful where the screening activities are conducted during cold months	Outfalls and Possible Illicit Discharge
Flow	Presence/Absence	If flow is present, other parameters have to be taken. If no flow, no illicit charge is present.	Outfalls and Possible Illicit Discharge
Total Chlorine	Presence/Absence	Additional parameter to distinguish between a natural or potable water source. High chlorine levels may indicate a water line break, swimming pool discharge, or industrial discharge such as a chlorine bleaching process.	Possible Illicit Discharge

PARAMETER	BENCHMARKS	EVALUATION	FIELD TASK
Total Phenols	Presence/Absence	Can be stored in oil and petroleum storage tanks or facilities, can result in tainting of fish tissue, and can cause taste and odor (organoleptic) problems in drinking water. In addition, phenol discharged from those facilities could combine with chlorine in water treatment facilities to form chlorinated phenols.	Possible Illicit Discharge
Total Copper	Presence/Absence	High levels of copper may indicate presence of contamination from metal industrial wastes	Possible Illicit Discharge
Detergents (Surfactants)	0.1 mg/L	Detergents may indicate sewage or washwater discharges. The presence of detergents, combined with their absence in natural water or tap water, may signify illegal dumping, an illicit connection, or a leaking sewer. (Sewage and washwater discharges contain detergents used to clean clothes or dishes.) ~ 1 - 20 mg/L in sewage discharge	Possible Illicit Discharge
Turbidity	280 NTUs	Runoff for construction sites of 10 acres or greater.	Possible Illicit Discharge

Table 7.10-5: Outfall Monitoring Parameters[5]

5 Pitt, Robert and the Center for Watershed Protection. Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessments. October 2004.
City of Canon City. Illicit Discharge Detection and Elimination Manual. Engineering Department.
New England Interstate Water Pollution Control Commission. Illicit Discharge Detection and Elimination Manual: A Handbook for Municipalities. January 2003.

III, Section 313; and any other industrial or commercial discharge that a watershed municipality determines has the potential to contribute a substantial pollutant load to the MS4.

This program should have as its foundation language in the Illicit Discharge Detection and Elimination Ordinance that allows the municipal government to inspect and monitor industrial and high risk commercial facilities. The inspections should consist of a brief review of the facility's spill prevention and countermeasures control (SPCC) plan and whether the facility has effectively implemented that plan.

In addition, a training program for municipal staff should be developed on municipal good housekeeping and illicit discharge detection and elimination. The employees that are outside and have the ability to serve as the eyes and ears of the municipal government should be considered as the first line of defense for water quality. This training program should include the identification of illicit discharges identified in the field during routine work assignments, making the determination of sources of discovered illicit discharges and the protocols for illicit discharge elimination. The NCTCOG offers a number of tools for municipalities with respect to training municipal staff on the subject of stormwater management. This material is available on their website at http://www.nctcog.org/envir/SEEclean/stormwater/program-areas/pollution_prevention/CD/Version_1/P2_Training_Materials.asp. The website has presentations for materials storage and spill cleanup; parks and grounds maintenance; fleet maintenance; streets and drainage maintenance; land disturbances; and, solid waste operations. The NCTCOG also has training modules for municipal trainers, quizzes and a stormwater pollution prevention video available.

Sanitary Sewer Overflows. The municipalities should develop protocols within their sanitary sewer departments to identify and track all sanitary sewer overflows. Protocols should also be developed to immediately eliminate those overflows upon discovery to the maximum extent practicable. As the sanitary sewer department tracks those overflows, the causes and the remedies, that data should be shared with the respective stormwater departments for reporting purposes. TCEQ administers a voluntary program aimed at eliminating sanitary sewer overflows. The goals of the initiative are to reduce the number of SSOs that occur each year in Texas and to address SSOs before they harm human health, safety, or the environment and before they become enforcement issues.[6]

5. System Mapping: In order to effectively trace and eliminate any illicit discharge identified, municipalities need a good mapping tool with adequate information on the MS4 connectivity. This may require a comprehensive system survey in order to collect the data needed to develop a mapping tool of this sort.

B. Public Education and Outreach Programs

Proper Use, Storage, and Disposal of Pesticides, Herbicides, and Fertilizers[7]
The stormwater program administered by the TCEQ and EPA requires that municipalities regulated under the Phase I and Phase II MS4 permits must develop public education programs that address the proper use, storage, and disposal of pesticides, herbicides and fertilizers. This is important for the entire water-

6 TCEQ General Information. Field Operations Support Division. GI-389. Sanitary Sewer Overflow Initiative: Information for Prospective Participants. June 2008. http://www.tceq.state.tx.us/publications/gi/gi-389.html/at_download/file

7 University of Michigan, Occupational Safety and Environmental Health, Proper Use of Pesticides, Herbicides and Fertilizers. http://www.oseh.umich.edu/stormwater/Pesticides%20and%20Fertilizers.pdf

shed and it is more critical for the area immediately around Lake Arlington.

The municipalities in the watershed have varying land uses ranging from range land and pasture to industrial, and including many urban open spaces such as athletic fields, golf courses, parks, and residential lawns. More important are the often overlooked small grass surfaces, planting beds, and those small areas of remaining vegetation. Both large and small open spaces are potential sites for contaminated water runoff or infiltration. It is obvious that silt and debris can potentially contaminate stormwater runoff from these areas; however, the less obvious contamination that can result from chemical applications is also a major concern.

Chemicals that can potentially migrate into drinking water supplies are pesticides, herbicides, and fertilizers. In all cases, stormwater runoff containing these chemicals causes problems. Surface runoff of pesticides and herbicides into water bodies changes natural ecosystems by killing or damaging a wide variety of organisms. Fertilizer can also disrupt natural biological communities by increasing plant and microbial growth. This condition, known as eutrophication, can drastically change natural water ecosystems and create new pollution conditions.

Improper application of pesticides, herbicides, and fertilizers can also have an impact on stormwater infiltration into groundwater. When these contaminants dissolve in stormwater they find their way into the groundwater or into surface waters, such as ponds, streams, rivers, and lakes. The infiltration of these chemicals may also contaminate soil and deeper groundwater aquifers. For these reasons, this master plan encourages floodplain corridors adjacent to Village Creek and Lake Arlington (See Section 7.10.1.C) The following information should be the focus of materials distributed to citizens about lawn chemical application, storage and disposal.

Using Pesticides and Herbicides

The risk of using pesticides and herbicides is greatest when the label directions are not followed exactly. Product labels contain information about the persistence and toxicity of the chemical. The words “natural,” “organic,” or “biodegradable” do not guarantee that it is safe. Users should always choose a “pest-specific” pesticide or herbicide that is designed to kill only the pest causing the damage and avoid pesticides with half-lives longer than 21 days.

Integrated pest management techniques are used to reduce pest populations to acceptable levels while minimizing the potential impact of pesticides and herbicides upon humans and the environment.

Mixing and Use of Pesticides and Herbicides

The mixing of pesticides and herbicides is of major concern because this is the time at which many spills occur. It is critical to exactly follow instructions for mixing and use. Be concerned with cleanup and disposal at all times during the use process. Any leftover chemical, the storage containers used in all stages of the application process, and the application equipment must be considered in the cleanup process. Guidance when using pesticides and herbicides should include:

General

- Take precautions to prevent spills. For example, close containers tightly after each use, even if you plan to reopen them soon.
- Know what to do if a spill occurs.

- Mix only the amount needed for the job.
- Follow the directions on the label exactly.

Application and Cleanup
- Avoid spraying over impervious surfaces.
- Do not spray on a windy day.
- Do not apply to bare or eroding soil.
- Reduce cleaning and waste by clustering jobs that use the same solution.
- Reuse rinse water or properly dispose as described below.

Pesticide and Herbicide Storage
Keep pesticides and herbicides in their original containers so you know what they are and how to use them. Mark the date of purchase on each container and use older materials first.

If possible, store pesticides and herbicides indoors in a clearly marked area, designed as secondary containment. Storage areas should be located at least 150 feet from any drinking water well and at least 200 feet from any area that holds water, even intermittently, such as a drainage ditch, dry retention pond, or Lake Arlington.

Cleaning and Disposing of Empty Pesticide and Herbicide Containers
The best method for cleaning containers and equipment is to triple rinse. To triple rinse: allow the concentrate to drain from the empty pesticide container for 30 seconds. Fill one-quarter of the container, replace the lid, and shake the container so that all interior surfaces are rinsed. Drain the rinse water into the spray tank for at least 30 seconds. Repeat the process twice for a total of three rinses. Rinse water must be collected and applied to a compatible site at or below the labeled rate.

In general, small containers that are used in the home can be disposed of in the trash pickup after they have been rendered unusable and then wrapped in plastic.

Using Fertilizers
Applying unnecessary amounts of fertilizer is not only a waste of money; it can also be detrimental to water quality. Excess fertilizers can wash into waterways, stimulating nuisance weed and algae growth. Excessive plant growth can choke slow moving waters, take up oxygen needed by fish and other aquatic life, and release ammonia which is toxic to fish. Before applying fertilizer, the user should have the soil tested to determine what nutrients must be added. Residential soil testing can be done for the homeowner by the Texas A&M System AgriLife Extension (www.soiltesting.tamu.edu). Fertilizers should be applied only in accordance with soil test results and recommendations.

When applying fertilizers, follow the directions exactly and keep fertilizers off paved areas. If a liquid fertilizer is used, be careful to avoid over spray and drift. Sweep granular fertilizer back onto the grass to keep it from being washed into the stormwater drainage system.

For information regarding products that can help protect water quality see the Citizens Guide to Stormwater Pollution Prevention and other printed materials published by the City of Arlington are found in Appendix 7.10-C.

Stormwater Reporting Hotlines

Regulators and authorities often encourage the public to help stop water polluters. Community hotlines provide a means for concerned citizens and agencies to contact the appropriate authority when they see people creating water quality problems. A hotline can be a toll-free telephone number or an electronic form linked directly to a utility or government agency, such as the City or TCEQ. A typical call might report a leaking automobile, concrete wash-out dumped on the street, paint in a creek, or organic debris (including pet waste) in a drainage system or waterway.

Generally, an investigation team promptly responds to a hotline call and, in most cases, visits the problem site. If a responsible party can be identified, the team informs the party of the problem, offers alternatives for future disposal, and instructs the party to resolve the problem. If the issue is not resolved by the responsible party (or if the party cannot be identified), the proper authority takes action to remediate the situation and prevent future violations.

All educational materials should include pollution hotline numbers and information. Typically, hotlines are advertised on materials concerned with water quality, such as flyers, door hangers, and brochures. The hotline could also be publicized on “permanent” materials such as bumper stickers and refrigerator magnets, where the number can be retained and easily located.

A stormwater hotline is effective when its number is easily remembered (i.e., has a catchy name) or is easily accessible. Most important, however, is the responsiveness of the hotline. If a citizen reports an illegal dumping but no action is taken by the appropriate authority, that citizen could lose faith in the hotline and might not call back with future information.

A hotline can serve as a link between the citizens and the municipality’s government. It can be an avenue for citizens to feel more involved in their community. It also can be a great way to catch illegal polluters or to stop accidental spills that might otherwise go unnoticed.

In the City of Arlington a citizen may call 817-459-6599 to report pollution. Other cities in the watershed also have stormwater reporting hotlines and many other public education initiatives similar to those discussed below which are implemented in the City of Arlington.

The City of Arlington has implemented a comprehensive public education program aimed at improving water quality. The programs include curbside recycling, composting and leaf management classes, household hazardous waste collection, and other programs to aid in the education of citizens on the subject of stormwater management. The Citizens Guide to Stormwater Pollution Prevention and other printed materials published by the City of Arlington are found in Appendix 7.10-C.

To date, the effectiveness of pollution prevention programs designed to educate residents on stormwater pollution prevention practices has not been well documented. However, the need for such programs is evident.

Market surveys suggest that media campaigns and intensive training such as workshops can produce a 10 to 20% improvement in selected watershed behaviors in targeted populations.[8] Because they are compli-

8 EPA Water Division. EPA Menu of BMPs, Landscaping and Lawn Care Fact Sheet. http://cfpub.epa.gov/npdes/stormwa-

mentary, both techniques can be used in most watersheds. For example, media campaigns cost just a few cents per watershed reached, while intensive training can cost several dollars per each resident actually influenced. Media campaigns are generally better at increasing awareness and sending messages about detrimental watershed behaviors. On the other hand, intensive training is better at changing individual practices in and around the home and community.

7.10.5 Adaptive Management

Utilizing an adaptive plan management strategy, this set of recommendations aims to implement a watershed management strategy to preserve not only the quality of the watershed area but also the aesthetics of the Lake Arlington watershed with an economically sustainable approach.

Assessing the effectiveness of the implementation of the watershed management strategies over time is important to meeting water quality and ecological protection and improvement goals. Also, by tracking management practices and monitoring water quality changes, the means are in hand to assess and redefine goals and priorities. Some of the other benefits to watershed management provided by monitoring are:

- Enabling water quality managers to further identify existing or emerging water quality issues and concerns.
- Facilitating responses to emergencies such as spills and floods and help water quality managers target specific pollution prevention or remediation programs to address these problems.
- Determining whether program goals, such as compliance with pollution regulation or implementation of effective pollution control actions, are being met.

Adaptive management is a systematic approach for improving management strategies by learning from implementation outcomes[9] (Murray, C.). It involves exploring alternative methods to meet plan objectives, predicting the outcomes of each alternative based on the current state of knowledge, implementing one or more of these alternatives, monitoring to learn which alternative best meets the management objectives (and testing predictions), and then using these results to update knowledge and adjust management actions.

ter/menuofbmps/index.cfm?action=browse&Rbutton=detail&bmp=97&minmeasure=1

9 Murray, Carol; and David Marmorek (2003). “Adaptive management and ecological restoration”. In in Peter Friederici (ed.),. Ecological Restoration of Southwestern Ponderosa Pine Forests. Washington, D.C.: Island Press. pp. 417–428. ISBN 1-55963-652-1. http://www.essa.com/downloads/Murray_&_Marmorek_Ponderosa_Pine_2003.pdf.

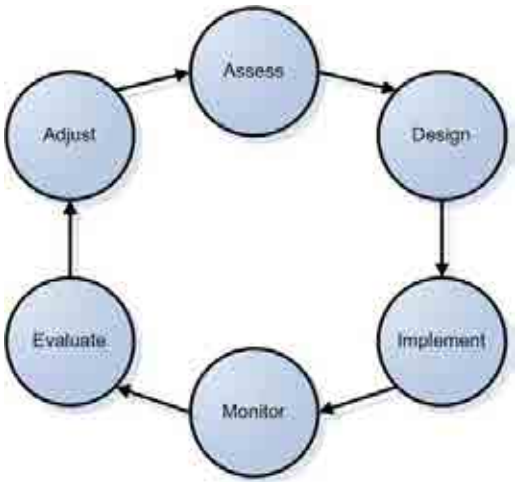


Table 7.10.5: BMP Implementation Effectiveness[10]

The first two steps of adaptive management, assessment of the issues, and design of management alternatives have been addressed in the Lake Arlington Master Plan. The development of implementation strategies has been partially discussed in this document. This section addresses the monitoring, evaluation, and adjustments of management strategy.

A. Monitor the Results

Two types of monitoring are important for accurate interpretation of the results. Implementation monitoring is needed to ensure that the activities were undertaken as recommended. Implementation monitoring documents not only what the municipalities are doing, but also the actions of others where they have the potential to influence the achievement of the management objectives. Effectiveness monitoring is needed to learn whether the activities were effective. It targets the indicators listed in model application and results, and allows an assessment of the actual indicator responses, versus predicted responses, to the management strategies.

In the case of Lake Arlington the most appropriate indicators from the watershed and reservoir are sediments, nutrients, and fecal coliform in the watershed and chlorophyll a and total nutrients in the reservoir. Trash is another indicator that was not included in the model, but there should be some measurement of observed amounts of floatables in the streams and the lake.

Since there will be varying amounts and types of BMPs implemented, the method of evaluating progress towards the goals and objectives of this Master Plan will have to be grouped into categories that can be applied to multiple BMPs. A summary of the evaluation measure for each group of BMPs that aim to meet the goal and objectives of this plan include:

Indirect Measures

- Programmatic Indicators/ BMP Results.
- Photographic Surveys.

10 Nyberg, B., 1999. Implementing adaptive management of British Columbia's forests – Where have we gone wrong and right? In: McDonald, Fraser and Gray (eds). Adaptive Management Forum: Linking Management and Science to Achieve Ecological Sustainability. Ontario Ministry of Natural Resources, Peterborough, Ontario, Canada, pp. 17-20.

- Stakeholder Surveys/Social Indicators.

Direct Measures
- Water Quality Indicators.
- Ecological Indicators.

B. Implementatin Monitoring

Programmatic Indicators/ BMP Results

One of the primary means to measure progress towards the achievement of the long-term goals of this Master Plan will be through the compilation of the total number of BMPs that are implemented by each municipality throughout the watershed. This will be accomplished by tabulating the BMPs that are completed annually. The most efficient way to compile this information will be for each municipality to include that information in their individual MS4 annual reports. For simplicity, only BMPs that have been "completed", meaning that they have been implemented during the review period, should be tabulated.

Photographic Surveys

As projects are implemented and BMPs installed, photographs should be taken to illustrate the "before and after" results that may indicate improved aesthetics, or provide visual indicators of reduced pollutant loadings, such as a reduction in the amount of trash observed in Lake Arlington, reduced algae blooms (reduced nutrient inputs), and/or improved habitat (increased in-stream vegetation or riparian vegetation). This type of media is useful to provide the public a means of visually understanding the aesthetic and water quality improvements that can come from the implementation of watershed management strategies. These photographs should be included with the MS4 annual reports as part of BMP implementation evaluation.

Stakeholder Surveys/ Social Indicators

The politics of the region and the overall public attitude about BMPs and various policies will certainly impact the individual municipality's ability to implement the LAMP. These are external stimuli to the management approach and should be considered in the evaluation of the strategy and adjustments should be made as necessary.

C. Effectiveness Monitoring

Baseline conditions have been established by TCEQ's monitoring program and with the modeling effort. Continued monitoring will certainly assist in the evaluation of any BMPs implemented in the short term. The instream monitoring which may be a part of watershed community MS4 NPDES stormwater management plans is a means to evaluating water quality in the long-term.

D. Adjust the Strategy (Policies and Practices)

This stage most distinguishes adaptive management from traditional watershed management by explicitly prompting changes based on what has been learned. Ideally, the management responses to each possible outcome of the experiment should be pre-planned before the experiment is implemented as part of the design. This will help serve as a "reality check" regarding what types of adjustments are possible.

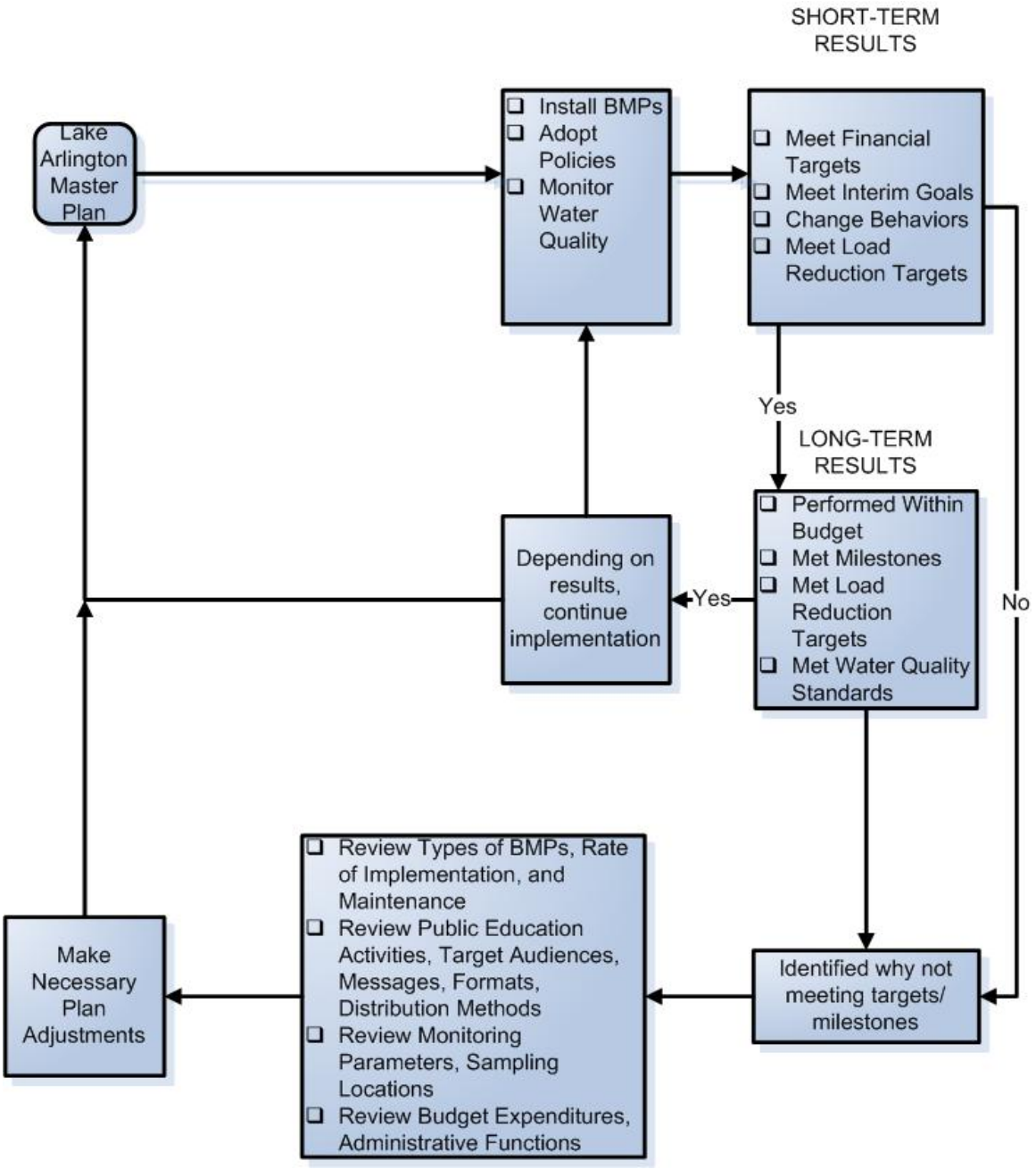
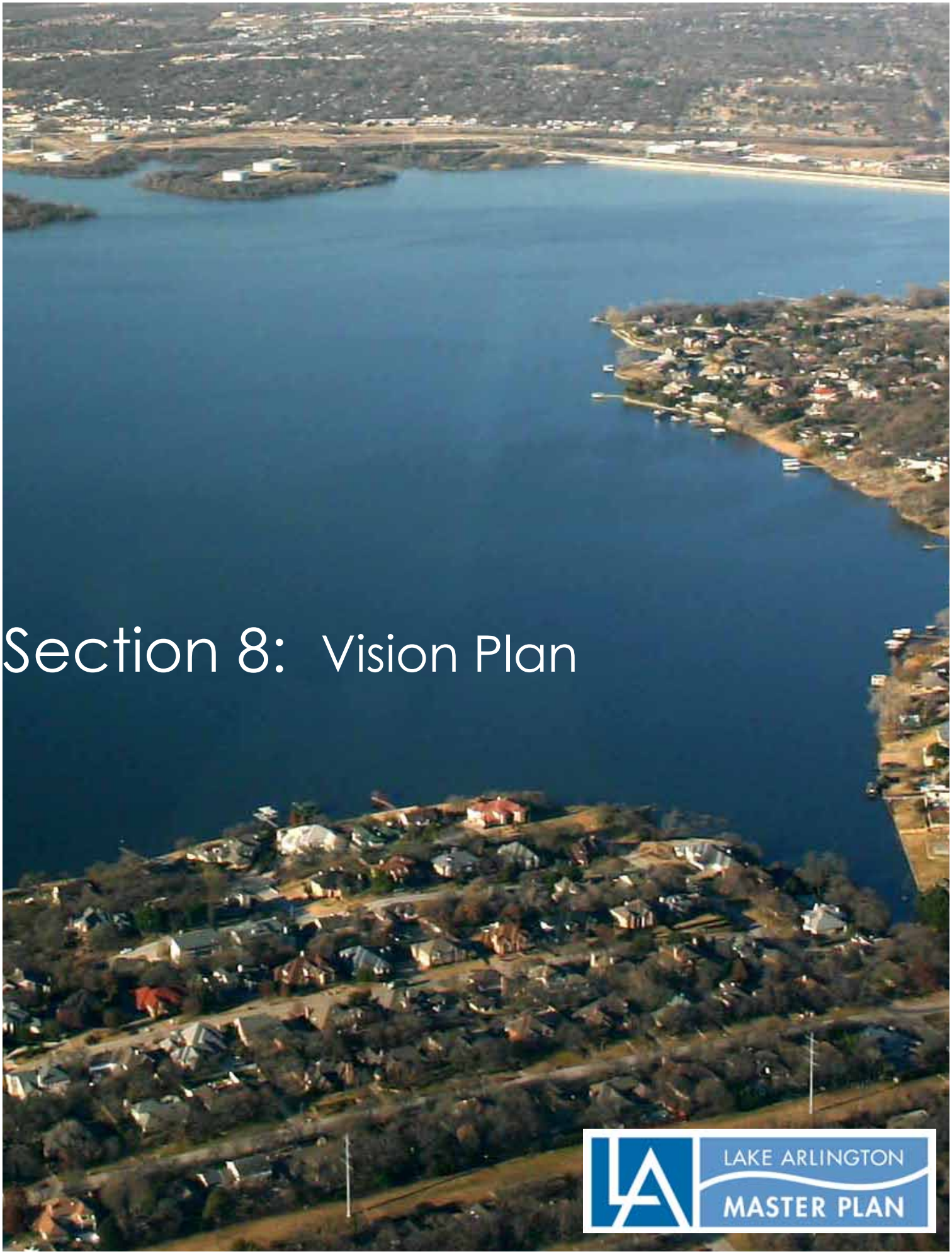


Table 7.10.5D: Watershed Management Strategy Adjustment



Section 8: Vision Plan

LAKE ARLINGTON MASTER PLAN

8.1 Introduction

The Lake Arlington Vision plan is a two-fold effort to provide recommendations to guide the long term growth of the study, as well as to provide guidelines for improvements within the Lake Arlington Flowage Easement.

The Vision Plan is intended to create a foundation for future growth and to assist the cities of Arlington and Fort Worth and its residents in prioritizing future planning efforts. Additionally, the Vision Plan is meant to provide flexibility to allow for changes over time based upon market realities and/or public need. To that end, the study focuses on the following areas:

- Land Use
- Parks and Open Space
- Trails
- Street Framework

The design guidelines are a set of specific requirements and recommendations that apply to all improvements or additions located within the Flowage Easement. The guidelines will provide a baseline level of quality and sustainability while providing flexibility in design, construction, and price. The design guidelines address the following:

- Retaining Walls
- Docks, Piers and Boathouses
- Marinas
- Trails and Linear Parks

Consensus Building

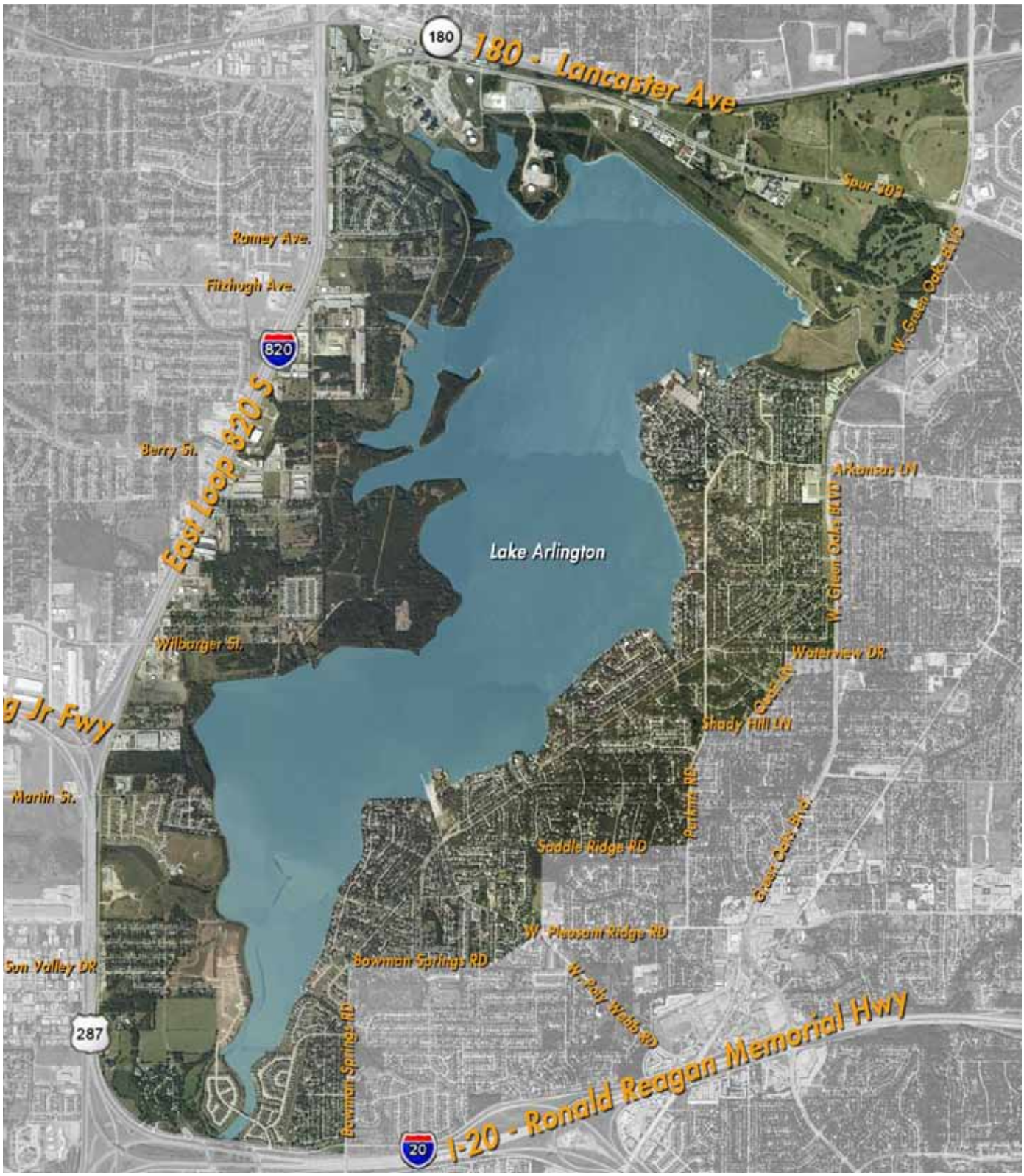
Essential to the design process was working across city departments, municipalities, and interacting with the public to build a consensus on important issues based upon stated goals and objectives, market-based realities, and sound planning and urban design principles. Section 5, 8.4 and 8.5 describe in detail the methodology behind building a broad-based consensus that provided the base principles for the design effort.

8.2 Determination of the Study Area

The urban planning study area for the Lake Arlington Master Plan was determined utilizing logical boundaries to establish areas directly impacted by the lake. As such, the study area encompasses land that is in both the City of Arlington and the City of Fort Worth.

To define the study area, Lancaster Avenue creates the northern boundary, while Interstate 820 and Interstate 20 form the western and southern boundaries, respectively. The eastern boundary is more complex, utilizing a variety of streets in the City of Arlington to establish a study area that is impacted by development associated with Lake Arlington. The extents of the study area are:

- The intersection of 180-Lancaster Avenue and East Loop 820S marks the northwest corner of the study areas. Moving south along the east line of East Loop 820 S to the intersection of East Loop 820S and I-20 marking the South West corner of the study area.
- East along the north edge of I-20 to the intersection of Bowman Springs Road and I-20 Ronald Reagan Memorial Hwy.
- North along the west line of Bowman Springs Road, turn toward east along the north line of Bowman



8.2: Lake Arlington Study Area

Springs Road to the west end of W. Pleasant Ridge Road.
- North along the north line of W Pleasant Ridge Road to the intersection of W. Poly Webb Road.
- North on W. Poly Webb Road at the intersection of W. Pleasant Ridge Road and W. Poly Webb Road to Saddle Ridge Road.
- East along the north line of Saddle Ridge Road to Perkins Road.
- North from the west line of Perkins Road to the intersection of Shady Hill Lane and Perkins Road.
- East on Quail Lane from the intersection of Quail Lane and Shady Hill Lane.
- North along the west line of Quail Lane to the intersection of Waterview Drive and Quail Lane.
- East along the north line of Waterview Drive to the intersection of W. Green Oaks Boulevard.
- North at the intersection along the west line of W. Green Oaks Boulevard to the intersection of 180-Lancaster Avenue and W. Green Oaks Boulevard; said point being the North East corner of the study area.
- West along the south line of 180 Lancaster Avenue, to the intersection of East Loop 820S and 180 Lancaster Avenue (the point of beginning).

8.3 Analysis of Study Area

8.3.1 Existing Conditions

The Lake Arlington Master Plan site includes land located in the City of Arlington and the City of Fort Worth. For the western edge of the lake at elevation 550' marks the city limits between Arlington and Fort Worth.

Land Use

The eastern and western sides of the lake offer two differing existing conditions. The Arlington side of the lake on the east is dominated by single family neighborhoods that are primarily built out. The northeastern portions of the site are primarily open space, including the Lake Arlington dam and spillway, and the Lake Arlington Golf Course.

The western side of the lake is comprised primarily of large tracts of undeveloped land adjacent to the lake. The southern extent of the site includes single family development adjacent to the lake; moving north, commercial development that transition into single family development has occurred adjacent to Interstate 820, while leaving large tracts of primarily undeveloped land along the lake. Within these vacant tracts natural gas drilling sites have been created. The Exelon Handley Power Station dominates the north west corner of the lake. See Figure 8.3-1.

Parks and Open Space

The Arlington portion of the study area includes two city-owned parks, Richard W. Simpson Park to the north and Bowman Springs Park to the south. These parks represent the only public access to the lake in Arlington. Fort Worth includes one park, Eugene McCray Park, with public access to the lake. The vast majority of Fort Worth's lake frontage is undeveloped land, but offers no access to the water as it is all private property. See Figure 8-3.2.

Street Framework

The neighborhoods located within the Arlington side of the study area include a comprehensive street framework that adequately serves local and regional traffic. Fort Worth's street framework is more disjointed and incomplete, reflecting the lack of development in the area. Individual parcels and neighborhoods

Single family development at southern end of lake

Water's edge at southern end of lake

View of power plant from Richard Simpson Park

I-820 frontage in Fort Worth

Existing development in Fort Worth

Natural gas development in Fort Worth

Vacant land in Fort Worth

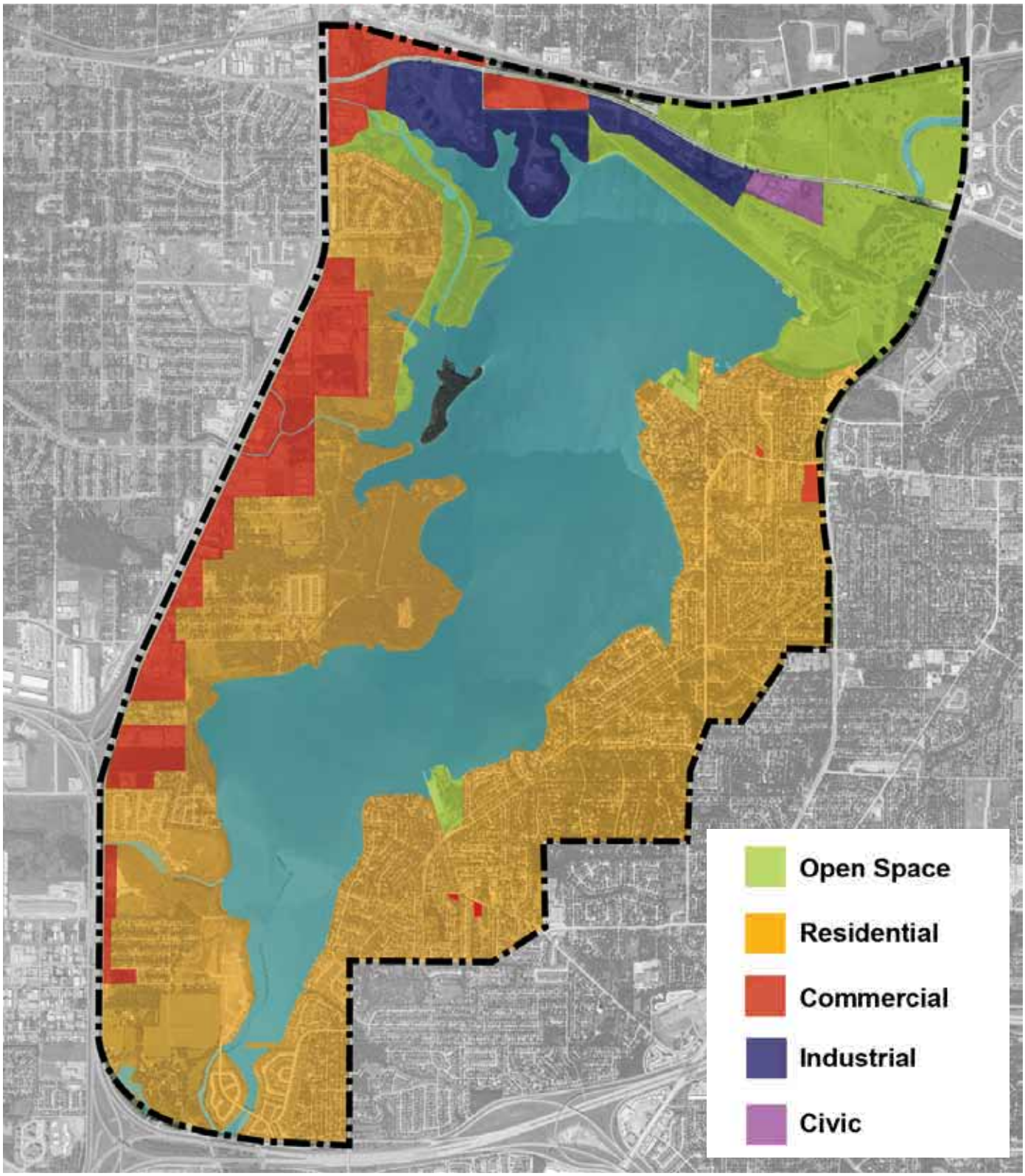


Figure 8.3.1: Existing Land Use

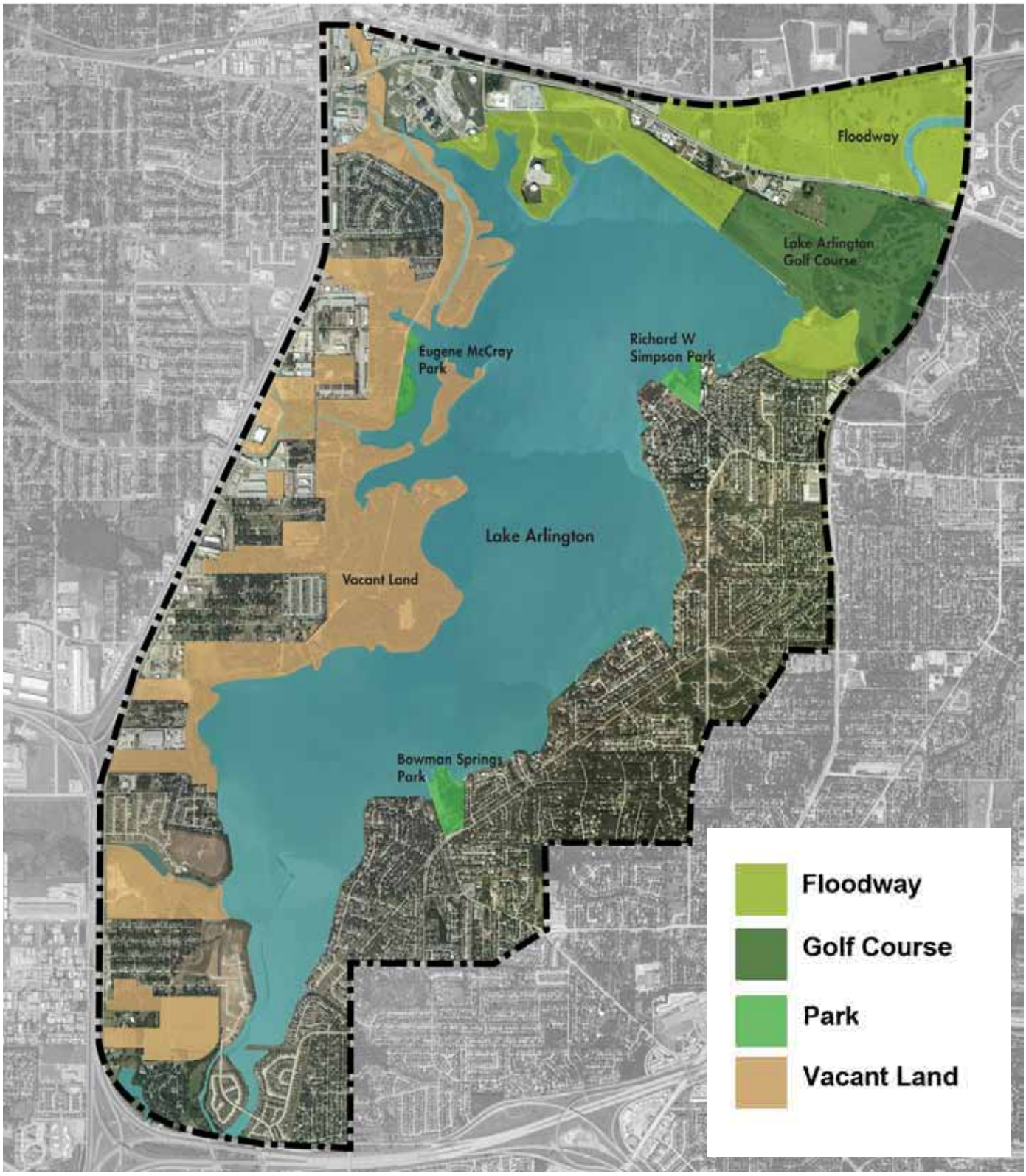


Figure 8.3.1: Existing Parks and Open Space

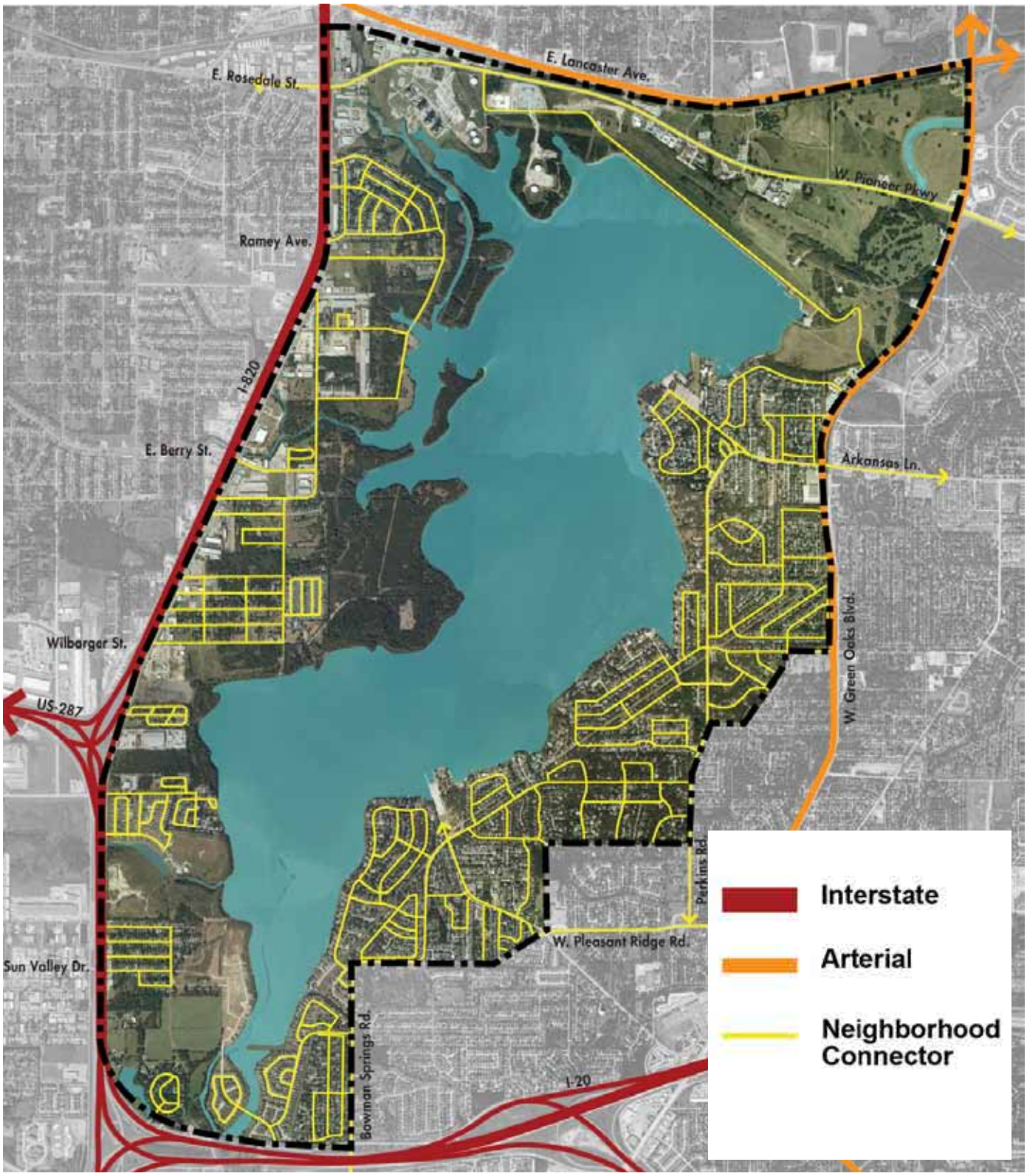


Figure 8.3.1: Existing Street Network

are adequately served, and Interstate 820 offers regional access, but a comprehensive street framework that ties the entire district together is lacking. See Figure 8.3-3.

8.4 Coordination with the City of Forth Worth

8.4.1 Regulatory Relationship between Arlington and Fort Worth

The Lake Arlington Master Plan study area includes the jurisdictions of the City of Arlington and the City of Fort Worth. Lake Arlington is located within the city boundary of Arlington to the 550' elevation and all areas west of this line are located within the City of Fort Worth. The Flowage Easement, located between elevations 550' and 560' fall under the jurisdiction of the City of Arlington Water Utilities Department in both the City of Arlington and the City of Fort Worth.

The complex arrangement between multiple jurisdictions has necessitated coordination between the City of Arlington and Fort Worth. In order to create a master plan vision that has lasting value, the City of Arlington Water Utilities Department focused upon building a consensus between the two cities regarding the long term vision for the area. In order to facilitate this effort, a regularly scheduled coordination meeting was conducted to share information, understand important issues affecting the project, and solidify a vision for the future of Lake Arlington. This coordination effort is described in more detail in Section 5.2.

Ultimately the City of Arlington and the City of Fort Worth will regulate their respective portions of the study area separately. The Vision Plan is meant to provide a tool for both cities to guide development and site improvements in the future.

8.4.2 Fort Worth Planning Efforts

The City of Fort Worth has a long history of studying the areas associated with Lake Arlington. Beginning in 1972 with the Southeast Section Plan, Fort Worth has focused on planning efforts and providing various tools for the development of the lake area. These past studies provided valuable tools and insight into the Vision Plan for Lake Arlington.

A. Southeast Sector General Plan - 1972
The Southeast Sector Plan identified the potential for lakeside recreational development along Lake Arlington. Utilizing vast areas of vacant land, the plan recommends a lakefront linear park that creates public access to the water and allows for new development to front onto the park and the lake.

Figure 8.4.2A: Southeast Sector General Plan

B. Southeast Fort Worth Action Plan - 2000
The Southeast Fort Worth Action Plan, conducted in 2000 recommends the development of residential clusters. These clusters would take advantage of land that is suitable for development, while leaving floodplain and lake front areas to be developed as public amenities. Additionally, the study recommends adding a north/south collector street to organize and unify the district.

C. Council-initiated Zoning Changes - 2001
In 2001, Fort Worth City Council initiated a zoning change at Lake Arlington that rezoned non-consis-

tent zoning districts in accordance with land use recommendations from the Southeast Fort Worth Action Plan of 2000.

D. Lake Arlington Conceptual Residential Plan - 2003
The Lake Arlington conceptual residential Plan recommends developing a range of residential densities in the Lake Arlington Study Area. This study determined that low density residential is the highest and best use of the site. As with previous studies, a recommendation for a north/south arterial between Wilbarger and Ramey is presented.

E. Lake Arlington Neighborhood Empowerment Zone (NEZ)
On February 3, 2004, Fort Worth City Council designated the Lake Arlington NEZ. This study recommends adding residential along Lake Arlington while developing open space areas to include public trails and parks along the water's edge. The study also recommends utilizing commercial developments to define major gateways from Interstate 820 and determining the feasibility of an elementary school at Lake Arlington. Finally, the study recommends a north/south arterial, consistent with previous studies.

Figure 8.4.2D: Lake Arlington Conceptual Residential Plan

8.4.3 Lakeshore Drive

The original Southeast Sector General Plan of 1972 recommended a north/south arterial in the Lake Arlington area. The arterial concept is a strong theme repeated consistently in past studies. The arterial is needed to organize the west side of the study area and to create a logical circulation pattern. Currently, only the Interstate 820 Frontage Road allows north/south travel across the entirety of the Lake Arlington area.

In 2003 Fort Worth City Staff developed preliminary cost estimates to design and construct Lakeshore Drive and in 2008, voters approved $6.9 million in the bond program for this effort. The design consultant, along with the City of Fort Worth and the Arlington Water Utilities Department developed a general consensus on the alignment of the initial phase of Lakeshore Drive as part of this Vision Plan exercise. The alignment is meant to provide a north/south arterial through the Lake Arlington district in Fort Worth, while providing access to undeveloped land and providing a framework for a future linear park and trail system along the lake edge.

Figure 8.4.3: Lakeshore Drive Preliminary Conceptual Layout

8.5 Workshops and Vision Planning

An important aspect of understanding the opportunity associated with the Lake Arlington Vision Plan is gathering input from the community. Working directly with community members living within the

study area helped to establish the parameters of the planning exercise and to better understand existing conditions, neighborhood concerns, and how the lake is used by residents.

8.5.1 Visual Preference Exercise

The first round of public meetings focused on a visual preference exercise where the public was asked to evaluate a range of categories dealing with parks, new development, the character of the water's edge, streets, and elements within the Flowage Easement. This process provided a sense of what types of development would be preferred in the study area, and helped to narrow down potential options and opportunities. See Section 4.3 for details of the public meeting process and the outcome of those meetings. The specific categories presented in the public meeting are as follows:

- Docks and Piers
- Marinas
- Water's Edge Character
- Retaining Walls
- Parks
- Streets
- Residential Development
- Commercial Devlopment

The figures on the following pages show the compilation of results from the public meeting in Arlington and Fort Worth. The green dot represents the preferred option for each category.

8.5.2 Visual Preference Analysis

A. Docks and Piers

The Docks and Piers category voting trended toward smaller scale and individual structures suitable for single family applications. Uncovered docks were perceived negatively

B. Marinas

The Marinas Integrated with Commercial category was a clear favorite in Arlington, while the Marina Integrated with Residential was a favorite in Fort Worth. In both meetings strong opposition to a stand-alone commercial marina was expressed.

C. Water's Edge Character

The Water's Edge category trended toward a 'Naturalistic' approach. This implies the desire for lower density, access to water, and a public edge to the waterfront.

D. Retaining Walls

Terraced retaining walls were voted upon favorably, implying a desire to see retaining walls that have a reduced visual impact on the lake front.

E. Parks

Parks that are geared toward community gathering and passive recreation were favored. Voter preference trended toward parks similar to existing parks in the study area.

F. Streets

The strong appeal of the Commercial Street category was a reaction to the desire for gathering places

and small, village-scale commercial development.

G. Residential Development
The majority of votes in favor of the Single Family category implied a desire to continue development patterns with a similar scale and density as existing neighborhoods in the study area.

H. Commercial Development
The selection of the Lifestyle Retail category suggest that a new development that focuses upon the creation of a destination rather than a traditional, auto-oriented retail center is preferred.

8.5.3 Opportunities and Constraints Workshop

After the Visual Preference Exercise voting results were tallied and analyzed, a discussion regarding the opportunities and constraints of the study area was facilitated with the public. The purpose of this discussion was to develop a greater understanding of the public's perception of the Lake Arlington study area, and to better understand the public's desire for the future of the area.

In addition to the Opportunities and Constraints categories, the public was presented and asked to comment on a Vision Statement for Lake Arlington.

"The VISION for Lake Arlington is to provide a safe drinking water supply and to protect the lake and its surroundings by identifying and promoting sustainable uses and watershed management practices that enhance the beauty and the value of Lake Arlington to the community."

Each opportunity or constraint was presented to the public in order to facilitate a conversation. The public was asked to comment according to the following parameters:

- Please comment on the draft vision.
- What are your thoughts on the opportunities and constraints?
- Are there specific issues of concerns you have about the opportunities and constraints?
- What do you think the top priority should be for the City of Arlington?
- Additional Comments?

The following opportunities and constraints categories were presented to the public:

- Improve and update existing parks
- Unify shoreline standards
- Improve street access
- Create hike and bike trails
- New development
- Wildlife preservation areas
- New development to buffer freeway
- Stormwater BMPs and trash management
- Increase lake storage capacity
- Maintain protection of intake structures
- Marina/Commercial development
- Expand paddling trail
- Improve fish habitat

Figure 8.5-1: Visual Preference Results - Docks and Piers

Figure 8.5-2: Visual Preference Results - Marinas

Figure 8.5-3: Visual Preference Results - Water's Edge Character

Figure 8.5-4: Visual Preference Results - Retaining Walls

Figure 8.5-5: Visual Preference Results - Parks and Open Space

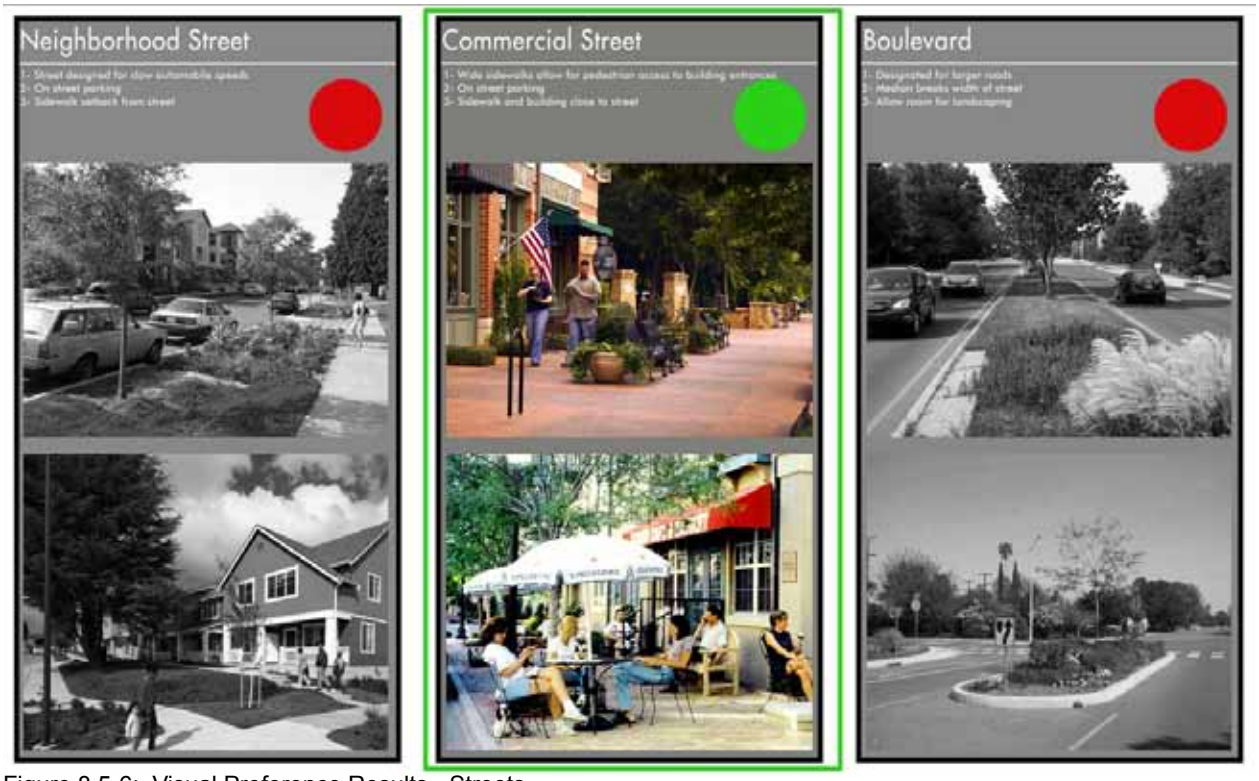


Figure 8.5-6: Visual Preference Results - Streets

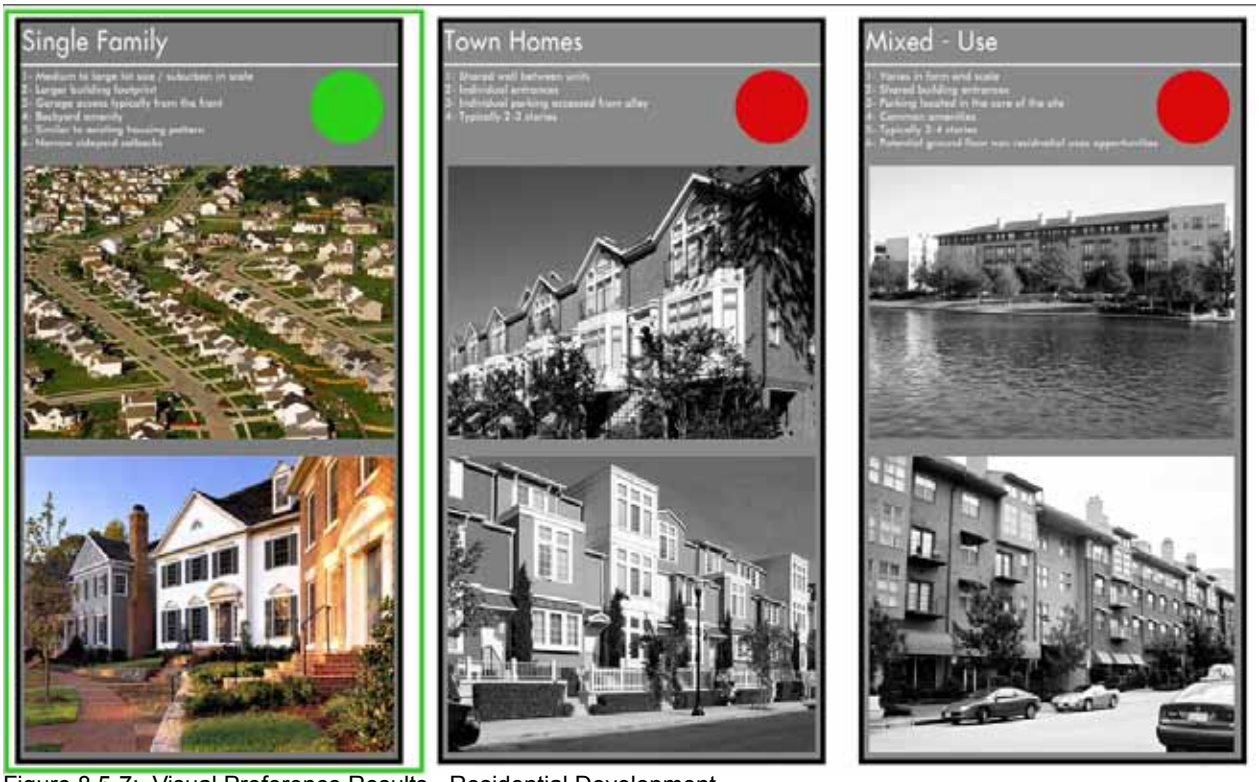
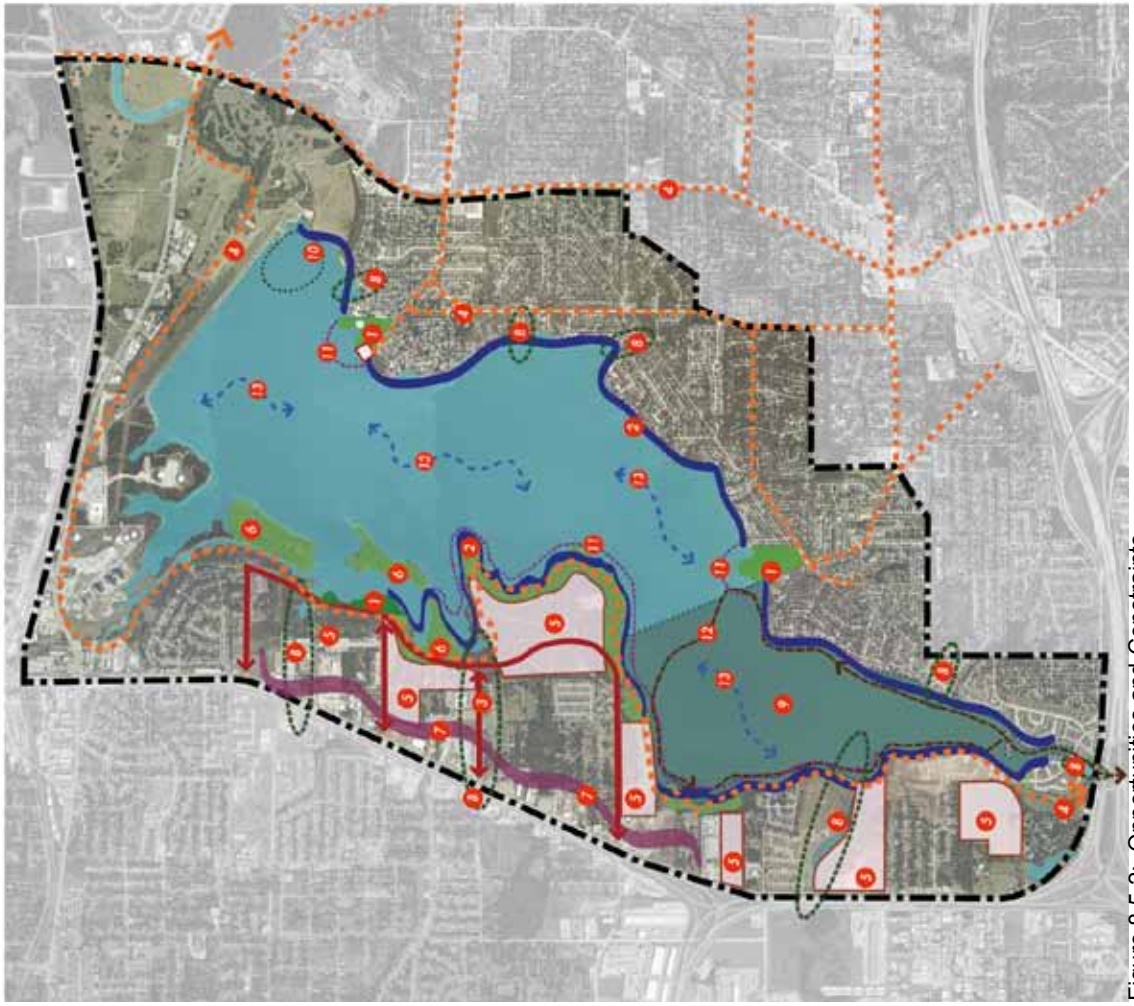


Figure 8.5-7: Visual Preference Results - Residential Development

Figure 8.5-8: Visual Preference Results - Commercial Development



Opportunities:

1. *Improve and update existing parks*
2. *Unify shoreline standards*
3. *Improve street access*
4. *Create hike and bike trails*
5. *New development*
6. *Wildlife preservation areas*
7. *Potential new development to buffer freeway*
8. *Stormwater BMPs and trash management/collection*
9. *Increase lake storage capacity/potential dredging*
10. *Maintain protection of intake structures*
11. *Potential marinas/commercial development*
12. *Expand paddling trail*
13. *Improve fish habitat*

Figure 8.5-2: Opportunities and Constraints

8.6 Land Use Strategy

The Land Use Strategy for Lake Arlington primarily affects the Fort Worth side of the study area. The Fort Worth side of the study area contains large undeveloped tracts of land and development that represents a 'piece meal' approach over time. Existing development is often isolated and divided by vacant areas. The Arlington side of the study area consists of well established residential neighborhoods and will not be affected by land use recommendations

The Land Use Strategy makes the following recommendations:

Arlington

- Do not change existing land use patterns

Fort Worth

- Keep residential land use for existing neighborhoods.
- Utilize vacant land primarily for new residential development
- Strategically locate an area for waterfront development
- Utilize Berry Street as a gateway into study area. Allow mixed use, village scale development to create a 'center' of the community.
- Utilize Flowage Easement and Shoreline Protection areas along the waterfront as a linear park and trail system.
- Transition freeway fronting uses to local and regional commercial development

8.6.1 Highway Frontage Mixed-Use

The Highway Frontage Mixed-Use areas adjacent to Interstate 820 offer an opportunity to reposition the existing commercial tracts in the study area. Currently, these commercial properties are made up of predominately small warehouses, light manufacturing, and other distribution type uses. The land use plan recommends transitioning these uses into regional and local retail establishments, small office, hotel, and other commercial uses that take advantage of the visibility and access afforded by proximity to the interstate. These new uses will serve the regional market and create a suitable transition from the activity of the interstate to the residential neighborhoods and parks adjacent to the water's edge.

Figure 8.4.1: Examples of Highway Frontage Mixed-Use

8.6.2 Berry Street Mixed Use

Berry Street presents an opportunity to create a gateway into the Lake Arlington study area and to create a village scaled center for the community. In order to achieve a village center, buildings should be organized in order to address the street. Buildings should be sited toward the street while parking and other service uses should be located at the back of the site.

Berry Street should be designed to accommodate automobile traffic, allow for on-street parking on either side of the street, and ample sidewalks to support commercial uses. Areas for outdoor dining, outdoor retailing and public gathering should be accommodated

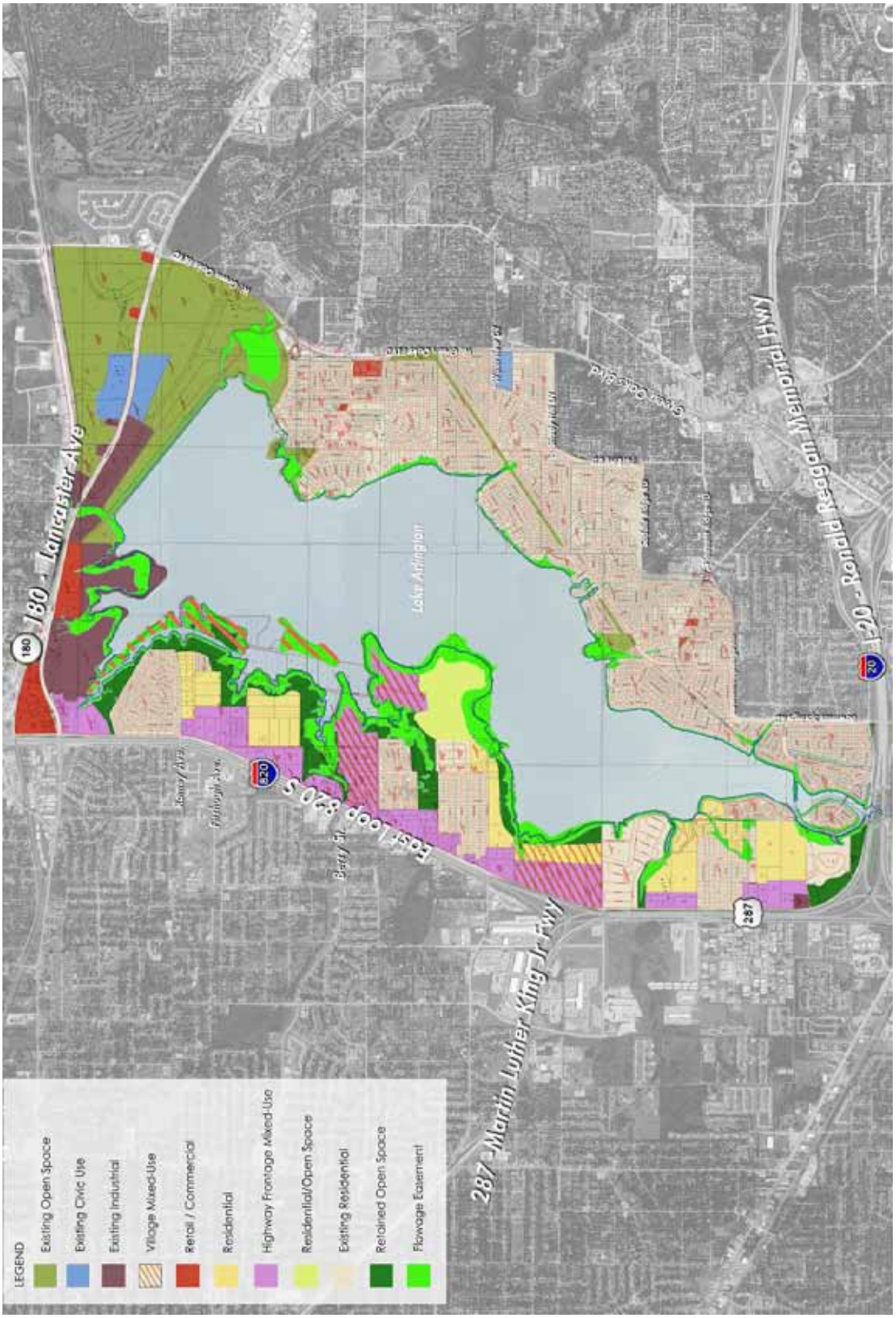


Figure 8.6-2: Concpetual Land Use Plan

Figure 8.6-3: Concpetual Plan for Berry Street Village Center and Waterfront Development

within the street-space as well.

The buildings should be designed to accommodate multiple uses (i.e. retail, restaurant, office, and residential) in order to provide a diversity of use and users within the center. New residential uses should be placed at the south of the site to create a transition between the village center and existing residential.

8.6.3 Waterfront Development

Across Lakeshore Drive and to the south of Berry Street is the proposed location for a waterfront development. This site is ideal for a development with increased density and height because of the direct adjacency to Berry Street. Additionally, due to the configuration of the lake edge at this location, the development's impact on views from across the lake will be minimized.

The waterfront development could be integrated with a small, 20 slip marina. The shops, restaurants, and small office make up the ground floor of the buildings and are accessed from a waterfront promenade. This promenade creates a transition zone between the marina and the development. The upper floors of the buildings should be designed to accommodate residential, office or hotel uses.

Figure 8.6-4: Conceptual Plan for New Residential Development and Linear Park

8.6.4 New Residential Development

The vacant land on the Fort Worth side of the study area offers an opportunity for new single family residential development. This new development will create an opportunity to solidify linkages, fill 'holes' in the urban fabric, and unify the west side of Lake Arlington into a cohesive neighborhood.

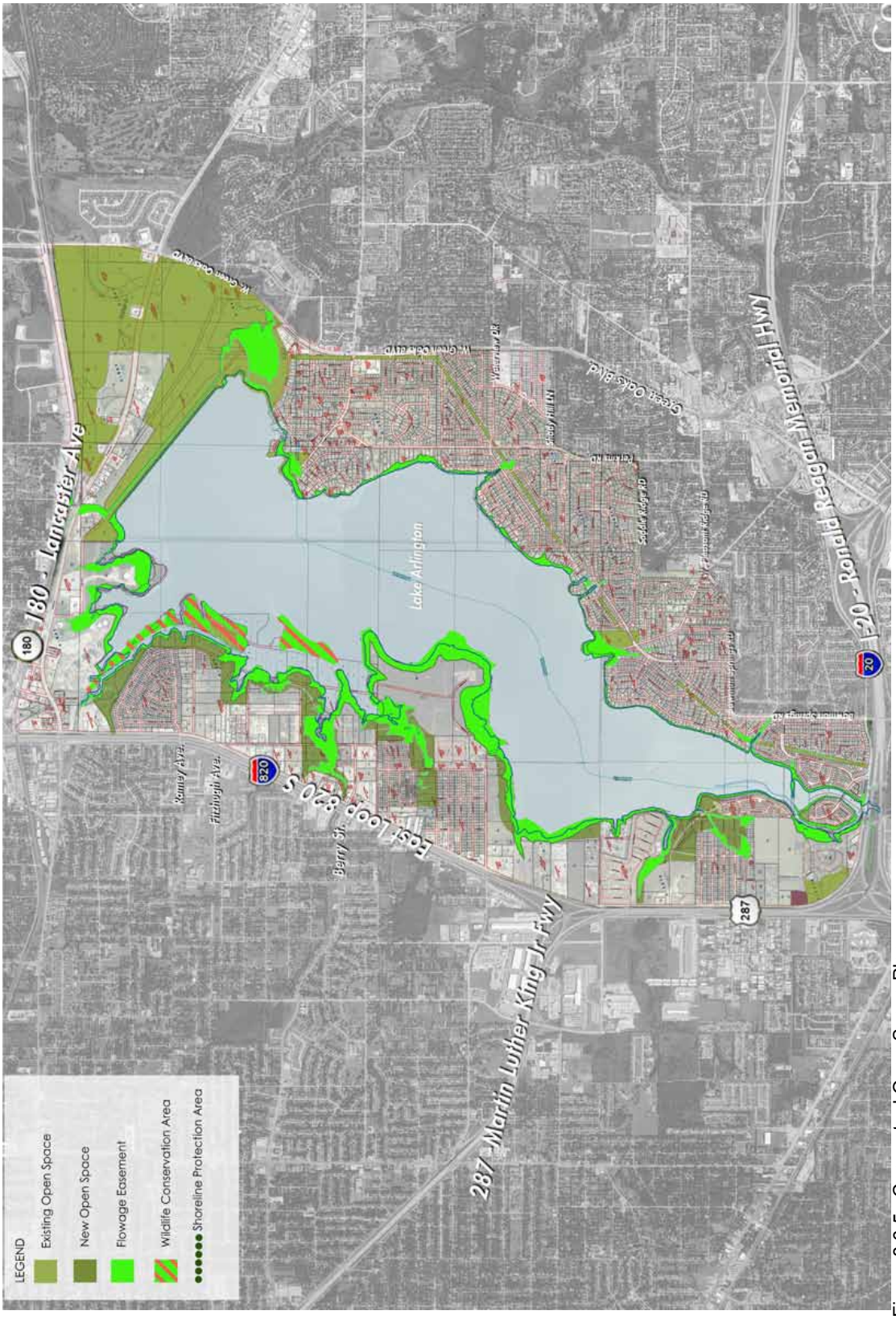


Figure 8.6-5: Concpetual Open Space Plan

An important key to this new development is the treatment of the water's edge. The linear park and trail system described in Section 8.8 will create a public edge to the water. New residential uses should take advantage of this park frontage by siting homes to face the park rather than back up to it. By facing homes toward the park, utilizing alleys to serve garages from the rear of the lot rather than the front, and adding porches or other features to the front of the house; views to the lake will be preserved as a public resource.

8.7 Parks and Open Space

Arlington has two parks (Richard W. Simpson and Bowman Springs Park) on Lake Arlington that serve as the only public access to the water front in Arlington. The parks are an important resource to the community for that reason and should be redesigned to accommodate a wide range of use and amenity. Additionally, the City of Arlington owns a piece of land on the northern tip of Enchanted Island that should be utilized for a neighborhood park.

8.7.1 Richard W. Simpson Park

The following are recommendations to consider when redesigning Richard Simpson Park:

- Construct a new multi-purpose lake house out of the Flowage Easement
- Close connection of Royaloak Drive and Arkansas Lane to eliminate park traffic in neighborhoods to the south
- Build a new fence and landscape buffer to screen Lake Arlington Yacht Club boat storage
- Utilize land between the yacht club and existing residential for a playground and improved access to the water.
- Add landscape features and bioswales in parking lot to reduce the visual scale of the lot and filter rainwater
- Add a limited access gate to eastern edge of parking lot and repave that section of the lot with grasscrete. Utilize the lot for overflow parking and temporary boat storage in flood event. The grasscrete paving will capture run-off and provide a visual buffer for existing residential
- Reduce the pavement width of Arkansas Lane and use special pavement or a raised crosswalk to slow down vehicular traffic.

8.7.2 Bowman Springs Park

The following are recommendations to consider when redesigning Bowman Springs Park:

- Consider siting a future community multi-use building in the park
- Add landscape features and bioswales in parking lot to reduce the visual scale of the lot and filter rainwater
- Create a community garden to create a new entrance to the park and to break down the visual scale of the parking lot and the boat ramp
- Provide a landscaped area near the western pier for a fishing area
- Add a texas native or adapted garden near the waterfront to provide a low maintenance buffer for storm water run-off into the lake

8.7.3 Enchanted Island Park

The City of Arlington owned land at the northern tip of Enchanted Island should be utilized as a neighborhood park with a focus on passive recreation.

- Add a covered seating area that takes advantage of lake views.

Figure 8.6-6: Conceptual Plan for Richard W. Simpson Park

1. New multi-purpose Lake House built out of the Flowage Easement.
2. Lake Arlington Yacht Club
3. New fence and landscape buffer for Yacht Club boat storage.
4. Park area redesigned for playground and seating area at lake front.
5. Landscaped parking areas break down the visual scale of the lots and capture storm water.
6. Fenced grasscrete parking area to be used for temporary boat storage during flood events and special event parking.
7. Special paving slows traffic and connects Lake House to park.

Figure 8.6-7: Conceptual Plan for Bowman Springs Park

1. Site for future community multi-use building.
2. Landscaped parking areas break down visual scale and capture storm water.
3. Landscaped fishing area.
4. Community garden breaks down scale of parking and boat ramp, and creates a new entrance to the park.
5. Texas native planting walk showcases native plants and provides low maintenance buffer for storm water runoff into the lake.

Figure 8.6-8: Conceptual Plan for Enchanted Island Park

1. Covered seating area.
2. Trail to the lake front.
3. Lake front seating area designed to withstand periodic flooding.
4. Landscape buffer to existing homes.
5. Natural lake front stabilized for erosion control.
6. Nature area.

- Provide a lake front seating area that is designed to withstand periodic flooding
- Provide natural landscape areas to buffer existing residential and stabilize the water's edge
- Provide on-street parallel parking

8.7.4 Eugene McCray Park

Eugene McCray Park, located within the City of Fort Worth, was not included in the scope of work for evaluation or recommendation.

8.8 Trails and Linear Parks

In 2010 the City of Arlington completed the city-wide Arlington Hike and Bike Trails System Master Plan. This plan includes the Lake Arlington study area and is reflected in Figure 8.7-1. It is important to the success of this system master plan in the Lake Arlington study area to logically connect to trail systems in Fort Worth and Kennedale to create a comprehensive system around the lake. Because this trail system will be constructed through both existing neighborhoods and vacant properties, a variety of trail types must be utilized. A system that utilizes off-street trails and bike lanes built within existing street rights-of-way will be the most effective means of creating a comprehensive trail system. See Section 8.11.5 for more information on trails and trail types.

8.9 Street Network

As with issues relating to land use, the street network strategy deals with differing issues between Arlington and Fort Worth. Arlington's street network within the study area is comprehensive and needs no additional streets to serve the community. Fort Worth on the other hand, requires new streets to better interconnect existing development and to unlock the development potential of vacant sites.

In Arlington, the recommendations pertaining to the street network revolve around reconfiguring existing streets to reduce vehicle speeds and to create more room devoted to pedestrian and bicycle traffic. Figures 8.9-2 - 8.9-5 show how typical arterial streets within the study area can be reconfigured within the existing right-of-way to better balance the needs of automobiles, pedestrians, and bicycles.

In the Fort Worth side of the study area, a detailed street network plan should be established to create a comprehensive street system. Figure 8.9-1 presents a strategy of improving existing streets and creating new streets to improve access and connections within the study area. Important to achieving this goal is Lakeshore Drive. This arterial will provide the main north/south connection through the study area and will become the organizing street that creates future development opportunities. Figure 8.9-6 shows a typical section through Lakeshore Drive. Figure 8.9-8 shows improvements to Berry Street that accommodate a the village center concept described in Section 8.6.1.

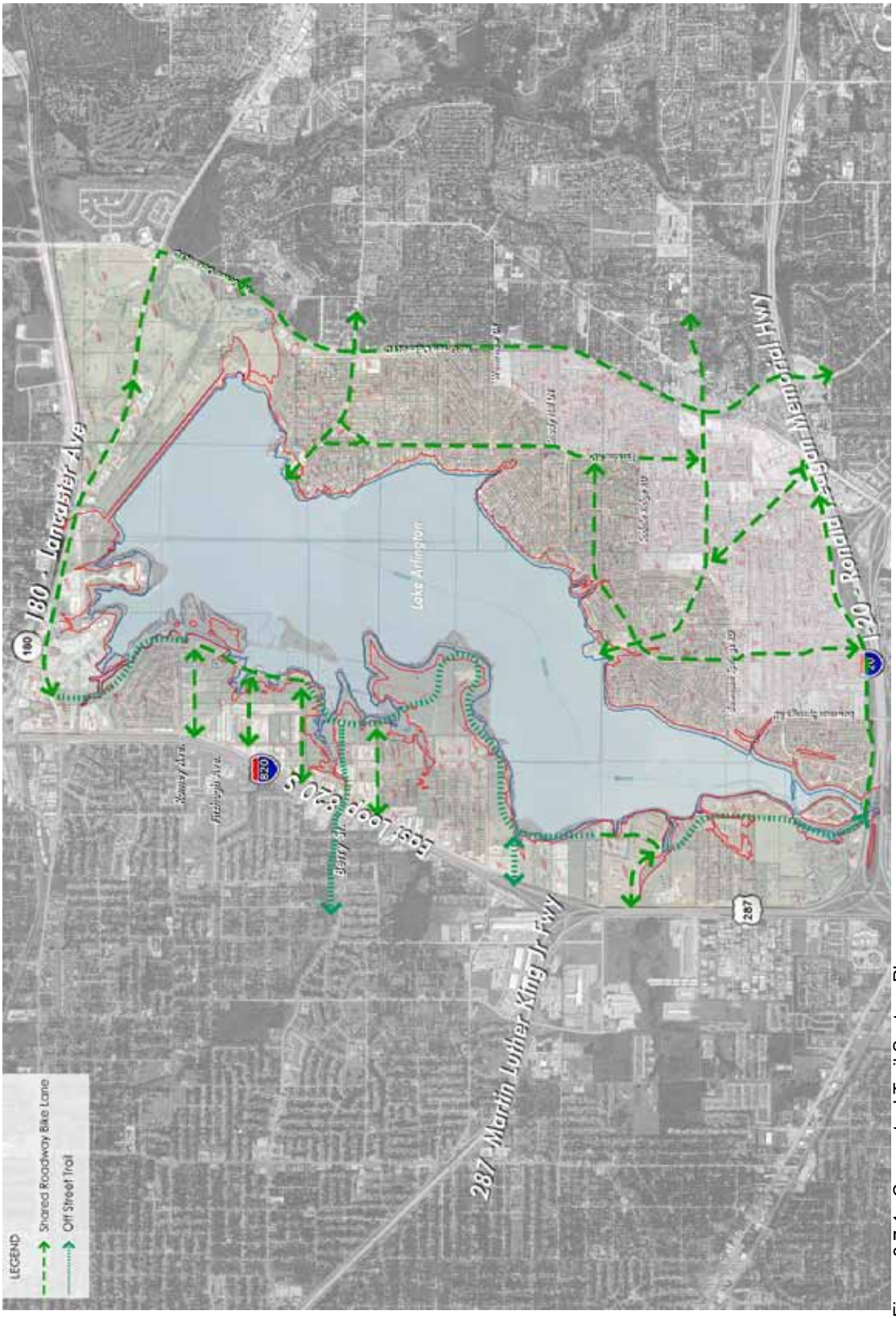


Figure 8.7-1: Concpetual Trail System Plan

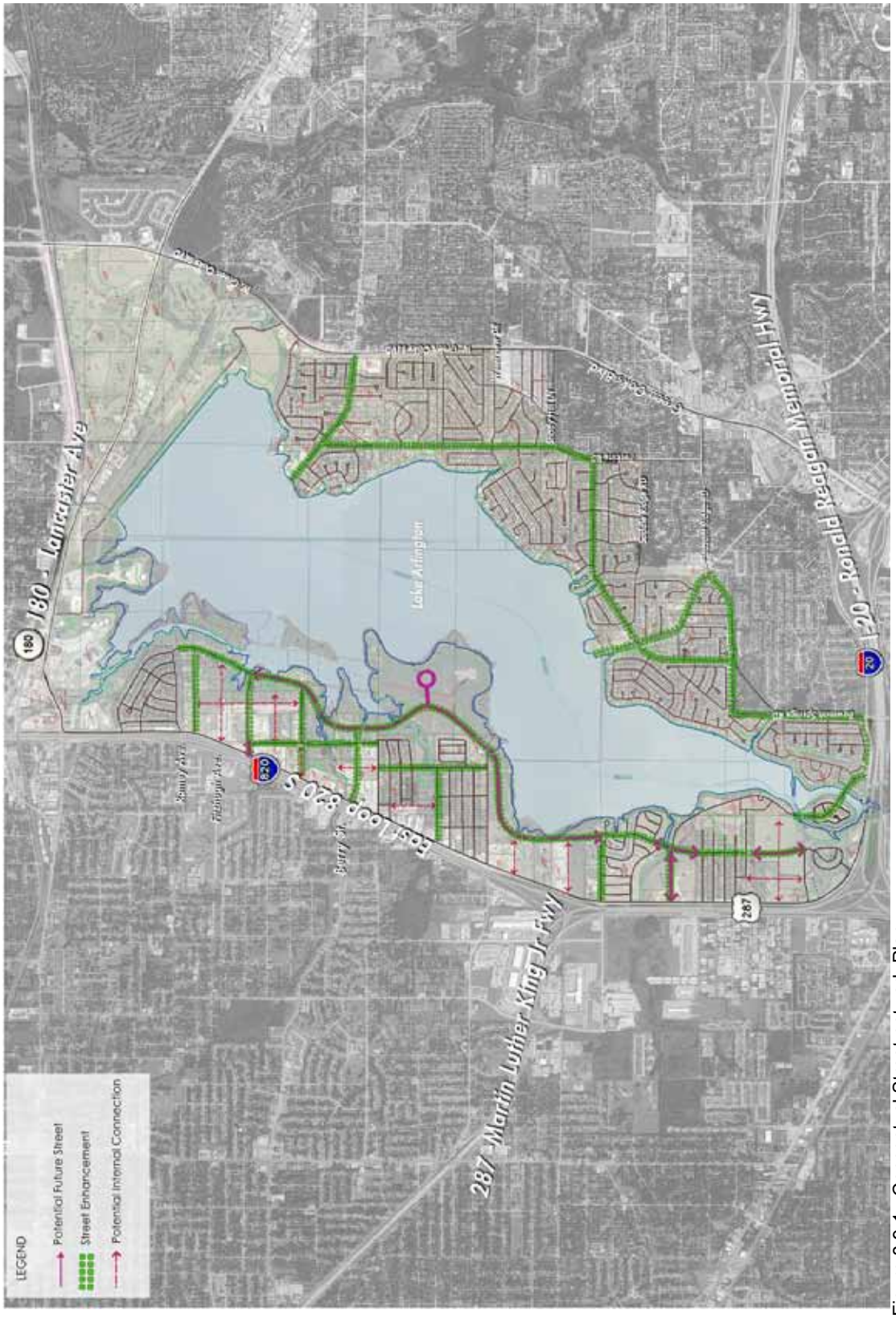


Figure 8.9-1: Concpetual Street network Plan

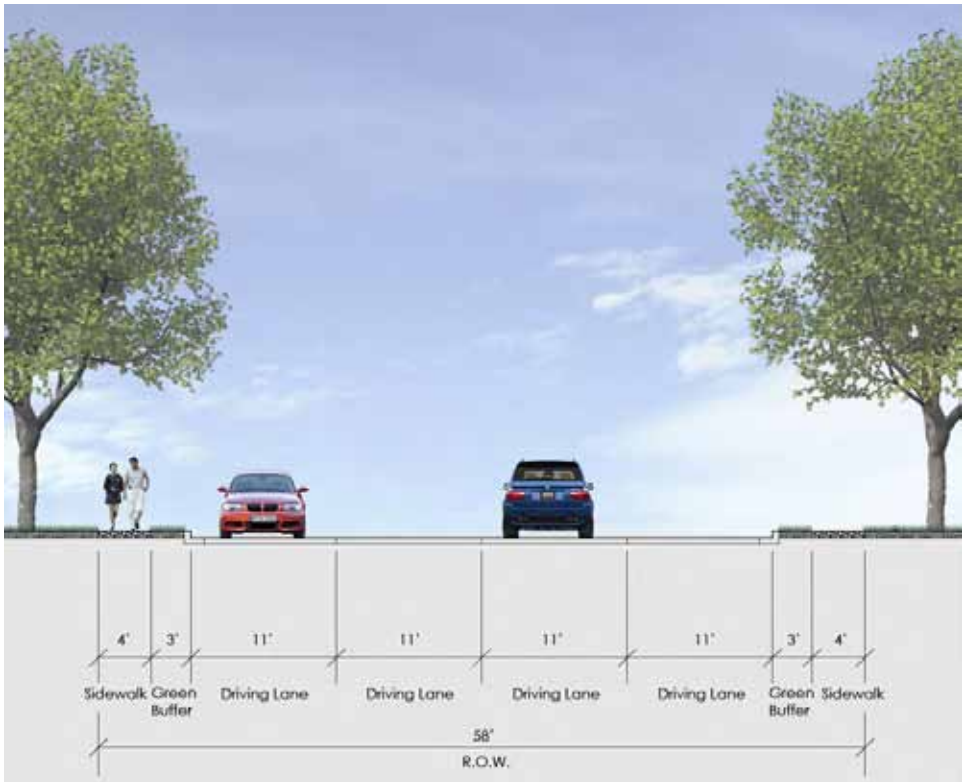


Figure 8.9-2: Existing Street Section - Typical 4 Lane, Undivided Arterial Road - Arlington

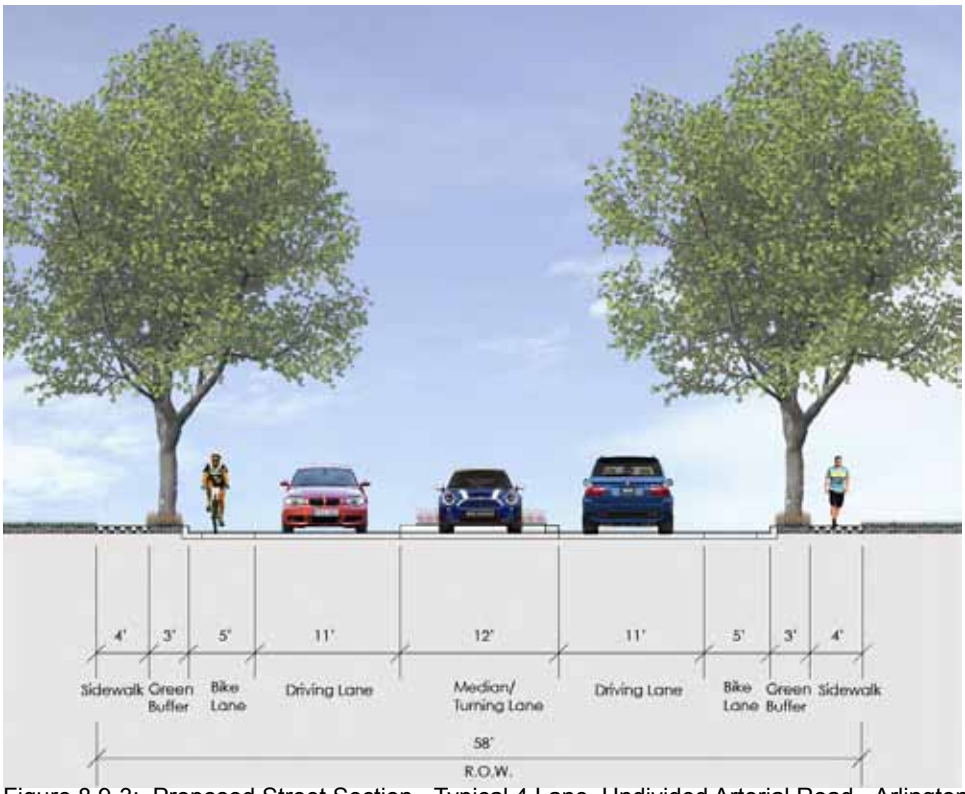


Figure 8.9-3: Proposed Street Section - Typical 4 Lane, Undivided Arterial Road - Arlington

Figure 8.9-4: Existing Street Section - Typical 4 Lane, Divided Arterial Road - Arlington

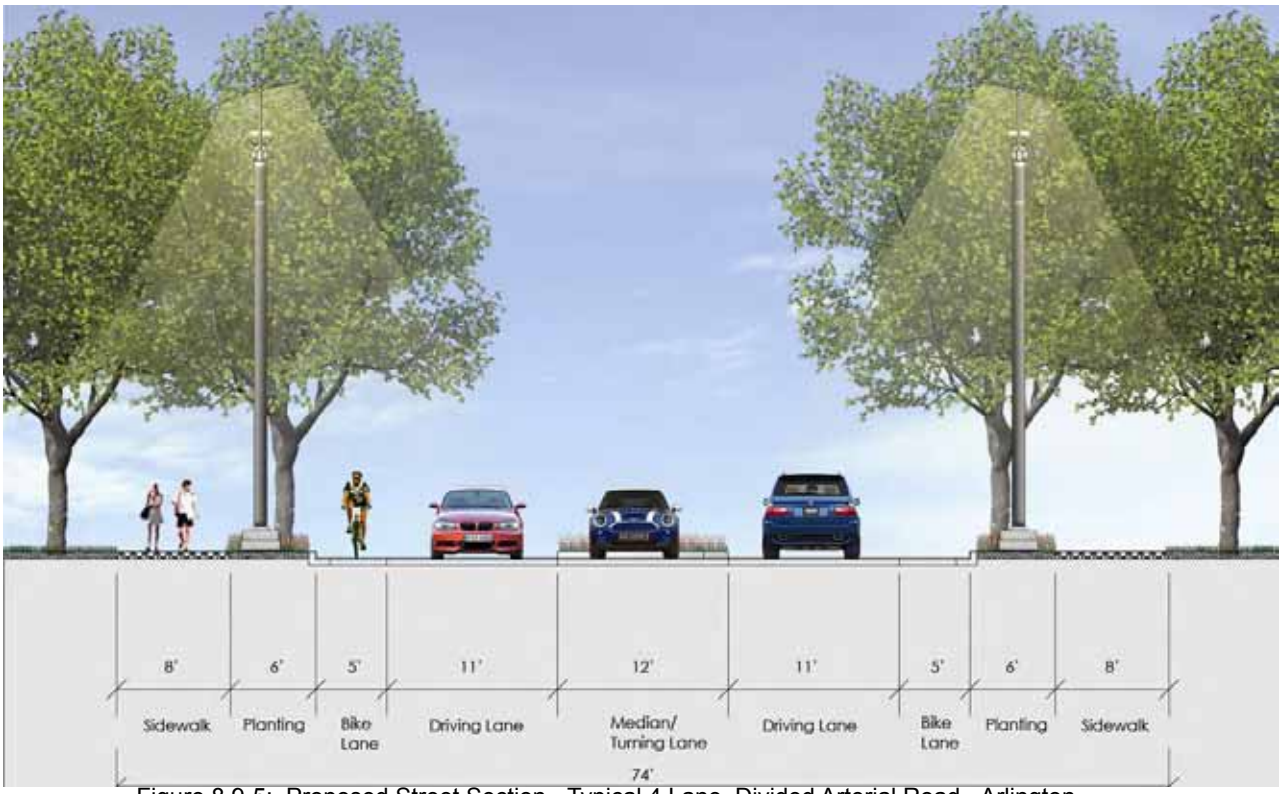


Figure 8.9-5: Proposed Street Section - Typical 4 Lane, Divided Arterial Road - Arlington

Figure 8.9-6: Proposed Street Section - Lakeshore Drive - Fort Worth

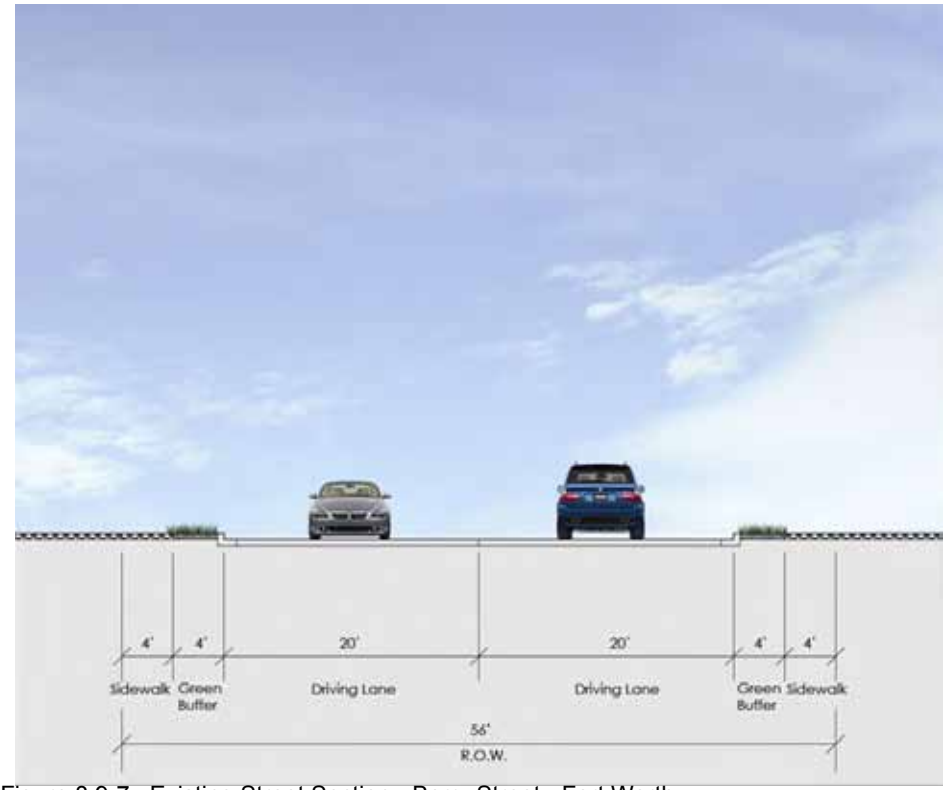


Figure 8.9-7: Existing Street Section - Berry Street - Fort Worth

Figure 8.9-8: Proposed Street Section - Berry Street - Fort Worth

8.10 Dredging

8.10.1 Applicable Regulations

The regulations applicable to, and the authorizations required for, dredging and disposal of material from inland freshwater lakes such as Lake Arlington are discussed below.

The permitting requirements associated with the removal of accumulated sediments from Lake Arlington are dependent upon the regulatory status of the lake and the sediments to be removed. This summary assumes the most stringent requirements - that Lake Arlington is classified as a Navigable Waterway and a Water of the United States, and that the accumulated sediments in the upstream end of the lake at the mouth of Village Creek could meet the criteria as federally-regulated wetlands. As part of any dredging project, a wetlands delineation study should be one of the first tasks performed in the preliminary analysis.

A. Regulations that apply to work in Waters of the U.S.:

1. Section 404 of the Clean Water Act – Regulates the deposition of fill or mechanized land clearing in Waters of the U. S., including wetlands

2. Section 401 of the Clean Water Act – Water Quality Certification from the State of Texas through the Texas Commission on Environmental Quality (TCEQ)

3. Section 10 of the Rivers and Harbors Act – regulates “all work” below the Ordinary High Water Elevation (OWHE) of a Navigable Water

B. Activities to be performed to determine regulatory jurisdiction will include the following tasks:

1. Identification of the OHWE of Lake Arlington
   - Review of long-term lake level monitoring data
   - Field identification of indicators of the OHWE
   - Determine if accumulated sediment removal will occur below the OHWE

2. Determine if accumulated sediments are regulated wetlands
   - Evaluate soil, vegetation, and hydrology characteristics of the accumulated sediments to determine if they meet the federal criteria for wetlands
   - If not wetlands, the work will be regulated under Section 10
   - If wetlands:
     - Determine the size and environmental functions of the wetland to be excavated
     - Identify areas in the watershed to mitigate the lost functions and values. Such mitigation could include:
       - Restoration of wetlands on lakeshore
       - Creation of wetlands on lakeshore
       - Enhancement of wetlands on lakeshore
       - Preservation of existing wetlands in danger of loss
       - Restoration, creation, or enhancement of wetlands in the Lake Arlington watershed

3. Determine if there are any cultural resources associated with the accumulated sediments

4. Determine if accumulated sediments support or provide habitat for rare, threatened or endangered plant or animal species, or critical habitats.

5. Develop a wetland mitigation plan for impacts resulting from dredging activities.
   - Identify and delineate boundaries of existing wetlands, or endangered species or cultural resources in mitigation location
   - Develop water budget for mitigation wetland (Such a water budget would include an evaluation of and technical support for the designed hydrology of the mitigation wetland. It is a critical component of the wetland design. The water budget defines the quantity and duration of water in the proposed mitigation wetland based on: (i) water table fluctuations; (ii) precipitation; (iii) wetland water elevation fluctuations; (iv) inlet and outlet elevations; and (v) evaporation.)
   - Develop grading plan and construction drawings for mitigation wetland
   - Prepare bid documents to obtain construction bids
   - Select contractor
   - Construct mitigation wetland
     - Grading
     - Seeding
     - Planting

6. Monitor mitigation wetland for 5 years for the following:
   - Vegetation survival and development
   - Hydrologic characteristics
   - Weed evaluation
   - Performance of annual maintenance activities

C. Identify the location(s) for final disposition of dredged sediments, and permits and authorizations required for disposal

1. Determine if wetlands, endangered species, or cultural resources are present in the proposed disposal location.

2. Determine if a temporary TCEQ permit (NPDES/TPDES) is required for discharge of leachate from the dewatering of the dredged material.

8.10.2 Project Tasks

The issues and factors to be considered, and the typical steps to be taken by the City of Arlington (or a private developer authorized by the City) in permitting and implementation of an inland dredging project are discussed below.

The evaluation of a potential dredging project involves several strongly interdependent components, including:

- an engineering and environmental assessment of the site and sediment conditions,
- the selection of dredging equipment and operational approach,
- evaluation of complex processes such as sediment resuspension, and
- development of monitoring and management plans for implementation.

A recent United States Army Corps of Engineers (USACE) document entitled *Technical Guidelines for Environmental Dredging* (USACE, 2008) provides a good source of information related to the evaluation of dredging projects. The paragraphs below are a summary of the ten-step process described in that document for environmental dredging projects. While potential dredging from Lake Arlington may not be "environmental dredging," many of the same principals apply. The process described below has been revised to be pertinent to Lake Arlington.

Define Dredging Objectives - The first step in the dredging evaluation sequence is to define the project objectives. This begins by identifying the processes and defining the objectives of importance for the City of Arlington. These processes, described in more detail in the USACE document, would include sediment removal, resuspension of sediments, and generation of residuals. Objectives would include sufficient accuracy in the evaluations, reasonable time for completion, impact on the public during operations, compatibility with on-site disposal, quantity and rate of resuspension to the water column and the quantity of residual sediment.

Conduct Initial Evaluations - An early initial evaluation of the feasibility of dredging portions of Lake Arlington should be conducted in order to collect necessary data for further evaluation of dredging. The initial evaluations would include comparison of known site conditions, sediment characteristics, and project requirements to those conducive to a dredging project. More detailed evaluations can then be conducted including identification of major constraints such as non-availability of on-site disposal, the presence of hard substrate, boulders and debris, or the presence of endangered species. If site conditions or institutional constraints indicate that full dredging is not feasible, a reduced dredging project may also be considered.

Identify Data Gaps - The initial evaluations described above would also provide a basis for determining any data gaps pertaining to the feasibility evaluation and for the preparation of cost estimates. Data gaps can be identified by comparing the existing information to the information needed to develop a proper dredging plan. These data gaps would need to be filled in order to complete the evaluations.

Understand Site Conditions: During the collection of data it is important to gather information on physical characteristics of the water body, water body uses, the presence and nature of major infrastructure such as pipelines and electric transmission towers, the presence and nature of debris in the sediments, and geotechnical information. The process of filling data gaps may be iterative in that several tiers or phases of investigations may be needed in order to fully understand the site conditions.

Characterize Sediments: Sediments under consideration for dredging and any sediment layers adjacent to or below the target material must be characterized. This evaluation includes the physical and chemical characteristics of the sediments. These characteristics should be determined both horizontally and vertically. The results of the characterization will determine the potential areal extent and depths to be dredged.

Determine Dredgeability and Removal Requirements - Based on the previous tasks, the feasibility, constraints, and dredging prism requirements can be determined. [The dredging "prism" is the three-dimensional volume of sediment identified for removal, including the cut depth and the side slopes.] Dredgeability evaluations focus on the ability of various equipment types to effectively remove the sediments, and include consideration of factors such as the presence of and extent of debris, the shear strength, and density of sediments, the presence of underlying hardpan or rock bottoms. A separate debris

removal operation may be considered at this point. The removal requirements include accurately defining areas slated for dredging; thicknesses of sediment layers to be dredged; water and sediment depths, over burden, slopes, need for step cuts, side slopes, and overdredge allowance; limits on precision removal; and an estimate of the total volume of material to be dredged.

Develop Preliminary Performance Standards - Performance standards may include applicable water quality and air quality standards; limitations on or minimum requirements for productions; limitations related to quality of life considerations (noise, light, traffic, etc.); limitations on resuspension; and goals for effectiveness.

Select Equipment Type for Evaluation - There are two primary types of equipment used for dredging of inland water bodies—mechanical and hydraulic. The City should select the type of equipment based on the pertinent equipment capabilities and the compatibility of equipment with site and sediment conditions, transport and rehandling requirements, and disposal options. In most cases, both mechanical and hydraulic dredging approaches should be evaluated and compared.

Evaluate Production Rate, Project Duration, and Transport Needs - Dredging "production" refers to the rate of sediment volume removal, and it is usually measured in terms of in-situ sediment removed per unit of time. An evaluation of production rates will determine the size and number of dredges needed to meet the removal objectives, duration, and transportation needs. Estimates of the average operating production rate will depend on the equipment characteristics, site conditions, sediment properties, thickness or face of material to be removed, continuity of sediment removal areas, location, and the type of disposal site(s) and needed rehandling facilities. If there are no specific production-related performance standards, the project duration can be evaluated in terms of reasonable time frame for completion.

Evaluate Sediment Resuspension - Once the size and number of dredges are selected, an evaluation of sediment resuspension is possible. Resuspension evaluations usually rely on an estimate of the resuspension sources and "source strengths," which include the estimated production rate, sediment characteristics, dredge size and type, removal mechanism (bucket, cutterhead, or open suction), and operating characteristics. The source strength is expressed as the mass of sediment resuspended per unit time throughout the water column. The source strengths are coupled with a model for prediction of suspended solids concentrations in the water column as a function of distance and time. Results can then be compared to performance standards for resuspension or water quality standards for suspended sediments and turbidity. The need for control measures (such as restrictions on the rate and timing of operations or deployment of silt curtain containment) can then be determined.

Evaluate Residuals - "Residuals" refers to the mass (thickness and density) of sediments left in or adjacent to the dredging footprint at the completion of the dredging operation. Residuals can be generated by the dredging operation as "fallback," sloughing from the dredge cutface, and/or resettlement of the resuspended solids. Residuals can also include potentially undredged inventory. Although there are presently no standardized methods, prediction of residual amounts can be based on field experience at other inland lake sites with similar dredging operations, and the characteristics of the sediment profile to be dredged. An estimate of residuals can also determine the potential need for additional dredge passes.

Determine the Need for and Effectiveness of Control Measures - The results of the evaluations of sediment resuspension and residual sediments should be compared with any pertinent performance stan-

dards to determine if control measures are needed. Operational controls can include those associated with the dredging itself, as well as engineering controls such as structural containments. If controls are determined to be necessary and potentially effective, such controls should be included in the design, and the impacts to the operational plan and schedule should be considered.

Develop Operations Strategy - At this stage, a formal written Operations Plan should be developed. The plan should include a detailed dredging prism or sediment layer trace (the specific layer of sediment or geologic formation); delineation of dredging management units; description of dredge cuts and side slopes; a sequence of operations; a detailed mobilization – demobilization and construction timelines; complete description of all equipment to be used; design and use of control measures; and methods for monitoring progress and payment.

Develop Monitoring and Management Plans - Written Monitoring and Management Plans should be developed to verify that performance standards are met. Elements of the plans should address processes related to both short-term and long-term effectiveness. The Monitoring Plan should be a detailed document including monitoring equipment and techniques to be used; the protocols for sampling, handling, and testing of samples; and a description of how the monitoring data will be interpreted. The Management Plan should describe specific actions to be taken based on the results of the monitoring. Management actions would typically be developed in a tiered fashion depending on the monitoring results, and may include provisions for additional or more intensive monitoring, a slow-down or cessation of operations or implementation of control measures.

Summary and Integration - The overall success and acceptability of the dredging design can be evaluated in terms of meeting performance standards, being implementable, and providing effectiveness. If evaluations indicate that the proposed dredging design is not feasible, other dredging designs or options could be evaluated.

8.10.3 Problems and Challenges

The problems or challenges that should be anticipated, and typical means to mitigate these problems or issues are briefly discussed below.

Dredging project problems or challenges are discussed along with typical mitigation measures in the ten steps described above. In addition, sediment disposal represents a large uncertainty related to cost. If the material is clean it may be able to be beneficially reused as an agricultural soil amendment. If the dredged material meets certain geotechnical requirements, it may be able to be beneficially reused for purposes such as daily cover for a landfill. These alternatives are the least expensive disposal alternatives. However, if the sediment does not meet geotechnical requirements and no nearby agricultural uses are identified, construction of an onsite confined disposal facility (CDF) must be considered. This alternative represents the moderate cost disposal alternative. If the material is contaminated, it may need to be stabilized onsite and sent to an approved off-site landfill. This represents the greatest cost alternative.

8.10.4 Potential Unit Costs

The unit cost (in $ per cubic yard) for typical dredging projects varies considerably depending primarily on dredging method, transportation, and disposal location. According to the USACE Dredging Information System, during Fiscal Year 2009, the average cost of new dredging work using a non-hopper dredge (i.e., mechanical or hydraulic dredge) was $23 per cubic yard (cy). However, this cost assumes onsite trans-

port and placement of sediment on land adjacent to the water body. If chemical analysis determines that the sediment will require transportation to and disposal at an offsite facility, the cost per cubic yard would increase substantially. Unit costs ranging from $100 to $500/cy are not uncommon.

8.11 Development of Design Guidelines and Standards

8.11.1 General

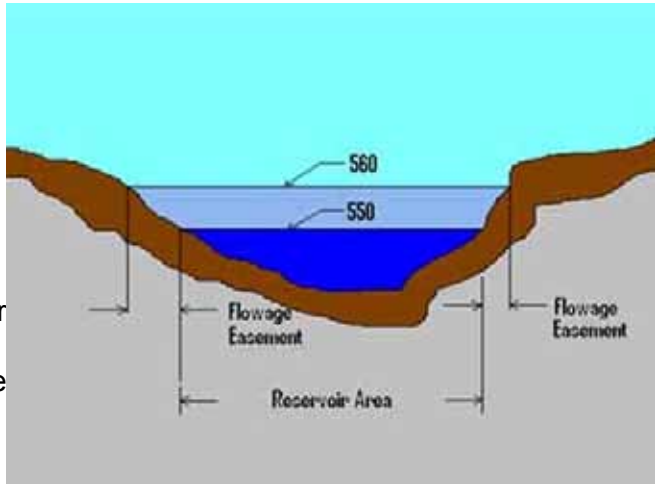
This Master Plan provides general guidance on the Design Guidelines and Standards that should be used for the development of specific permit requirements and ordinances related to Lake Arlington. The provisions of the Lake Arlington Master Plan Design Guidelines and Standards apply to structures located within Lake Arlington and the Lake Arlington flowage easement (the "Flowage Easement"). The Flowage Easement is generally defined as land adjacent to Lake Arlington that lies between elevations 550' and 560'. For the purposes of these guidelines and standards, the "shoreline" of the Lake is at elevation 550'.The purposes of the Guidelines and Standards are to protect the water quality of Lake Arlington; to maintain or enhance the storage capacity of Lake Arlington; to protect the integrity of the Lake's shoreline by only permitting structures and improvements that are well-designed and capable of being properly maintained; to promote a sustainable lake habitat; and to protect the value of private and public property. Areas outside of the Flowage Easement on the west side of the lake is largely within the City of Fort Worth jurisdiction.

The City recognizes that water quality is enhanced by retaining or enhancing natural areas immediately around Lake Arlington. Within these Guidelines and Standards there are incentives for landowners to keep natural areas and/or replace retaining walls with more natural shorelines.

All structures constructed within Lake Arlington and the Flowage Easement are subject to permitting by the City of Arlington (the "City" or "Arlington"). Persons seeking to construct or maintain a structure in Lake Arlington or within the Flowage Easement must submit to the City an application and any project plans. The applicant will also pay any required fees.

When an existing structure within the Flowage Easement will be used as part of the newly proposed improvements, the project plans must include a complete description of the existing structure(s). If more than 50% of the length of a retaining wall or volumetric area of other existing structures, such as docks and piers, are to be repaired, extended, or replaced, then the existing structures must also be brought into compliance with these regulations. This requirement generally follows the guidelines for modifications of existing structures used by the Federal Emergency Management Agency (FEMA) and others.

The project plans must include a description of the site that shows the location of the primary lot, the extension of property lines out into the water area (if applicable), a survey depicting the 550' and 560' elevation (the extent of the Flowage Easement), and a key plan, either included on the site plan or on a separate sheet, to show the location of the property and its relation to Lake Arlington.



8.11.1: Flowage Easement Diagram

Improvements in and adjacent to Lake Arlington will be in accordance with the normal pool elevation

and flowage easement elevation, see Figure 8.11.1. Lake Arlington's normal pool elevation is listed at elevation 550' and the flowage easement elevation is listed at 560' from the Lake Arlington design plans of 1950.

In consideration of the fact that surveyors, engineers and developers could use various elevation benchmarks to survey, design and construct improvements, the normal pool elevation of the lake and flowage easement elevation should be determined by a qualified Registered Professional Land Surveyor and tied to one standard. It is recommended that the top of the Lake Arlington Morning Glory (lake elevation control and discharge structure) be surveyed with high order survey equipment and tied to the current National American Vertical Datum (NAVD).

A review of FEMA floodplain and floodway maps of the creeks connecting to Lake Arlington show 100-year flood elevations in excess of elevation 560. Improvements in and adjacent to Lake Arlington must also consider that flowing water during a significant flood event is expected to be higher than the flowage easement elevation and the crest of the emergency spillway. Designers, surveyors, engineers and developers of improvements must consider the flood elevations as shown on FEMA maps.

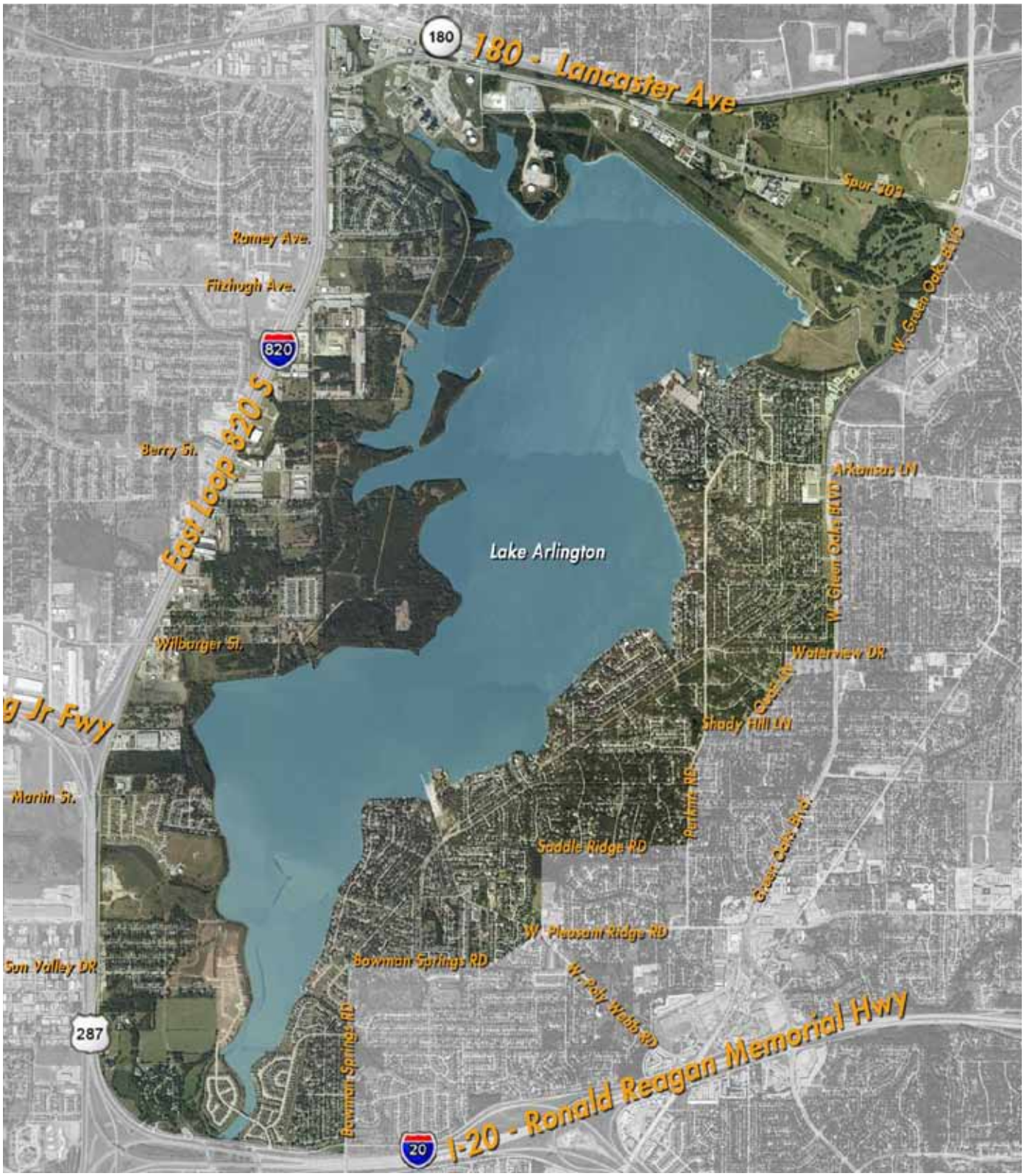
Project plans must be signed and sealed by a Texas State Licensed Engineer and contain a statement that the proposed improvements comply with the specifications set forth in this section. Any and all structural designs must comply with the provisions in the City of Arlington's building code (the "Building Code").

Each project plan set must also include a copy of the manufacturer's certified plans for any components that will be part of the improvements, such as decking, railing, or awning systems.

The project plans and manufacturer's certified plans must be based upon the actual conditions at the site of the proposed improvements.

A person may not begin construction of any improvements until a permit for the structure or activities has been issued by the City.

Once all of the required information is submitted on a permit, it shall be reviewed for compliance. All structures, modifications and maintenance activities shall be installed and/or performed in compliance with the City's regulations and with the information shown on the approved site plan and wall construction permit. The applicant shall contact the City to request a final inspection upon completion of the structure and/or improvements. If the inspector determines that the activities were performed in accordance with the requirements contained in this section and the approved permit, a Certificate of Occupancy or final inspection approval will be issued to the applicant. If the structure and/or improvement does not pass the inspection, the inspector shall prepare an inspection report detailing the deficiencies.


180
180 - Lancaster Ave
Spur 303
Ramey Ave.
Fitzhugh Ave.
820
East Loop 820 S
Berry St.
Lake Arlington
W. Green Oaks BLVD
Arkansas LN
Wilbarger St.
Waterview DR
Oak St.
Shady Hill LN
Martin St.
Parkins RD
Saddle Ridge RD
Green Oaks Blvd.
W. Pleasant Ridge RD
Sun Valley DR
Bowman Springs RD
W. Poly Webb RD
287
Bowman Springs RD
I-20 - Ronald Reagan Memorial Hwy
20

Study Area

8.11.2 Retaining Walls

8.11.2.A1: Example of terraced retaining wall

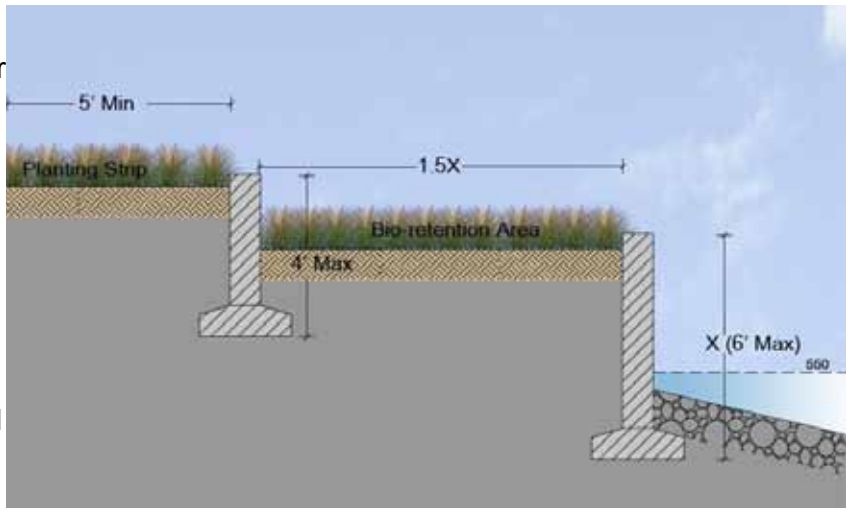
A. Guidelines
Over the long-term, the design of retaining walls should be consistent with the character of retaining walls described in this section, which ultimately should be similar on contiguous parcels surrounding the lake. Retaining walls should provide a strong visual element which unifies the waterfront currently characterized on the east (Arlington) side of the reservoir by a variety of architectural styles. The intent is to encourage the construction of retaining walls which are divided into a series of less visually-prominent monolithic structures (i.e. terraced to reduce the wall's visual prominence and provide space for appropriate landscaping and storm water detention and filtration).

1. Retaining walls should ideally be constructed in stepped or terraced fashion with a maximum height for the wall segment closest to the water's edge of no more than six (6) feet, and all other terraces no more than four (4) feet in height, unless physical limitations on the site or structural engineering conditions make terracing unfeasible. Any single retaining wall in excess of a total six (6) feet vertically is prohibited, unless otherwise approved by the City.

2. The height of a retaining wall shall be measured from the bottom of the footing/pier to the top of the proposed retaining wall.

3. When walls are terraced, the upper wall should be located a minimum of five feet (5') from the lower wall. A wall built in tiers shall be considered a single wall in developed height when the base of the upper tier is set back from the base of the lower tier less than 1.5 times the developed height of the wall section below.

4. To help filter stormwater and improve water quality in the lake, a bio-retention planting strip is required in the areas between terraced retaining walls, and behind the top of the retaining wall. The planting strip shall extend a minimum five feet (5') from the back of the retaining wall and shall be planted with deep rooted native or adapted grasses, ground cover, and/or shrubs. See Appendix



8.11.2.A3: Retaining wall standard dimensions

8.11 - Approved Plant List.

a. Plantings between retaining wall terraces or in the planting strip above the top retaining wall shall be spaced according to nursery standards for the specific plant species, and planted in sufficient number to stabilize soils and provide consistent coverage across the length of the retaining wall.

b. The slope of natural or re-graded ground behind the top retaining wall shall be no steeper than 4:1 (horizontal:vertical) unless specifically approved by a Texas state licensed engineer.

8.11.2.A5: Rip-rap wall

5. The following materials are allowable for the construction or veneer of retaining walls:
   - Interlocking masonry, stone, or brick
   - Poured concrete designed specifically for shoreline retaining wall applications. The Lake-side design must be aesthetically pleasing and approved in advance by the City.
   - Aesthetic sheet piling designed specifically for shoreline retaining walls. See figure 8.11.2.A5.
   - Rock gabion walls or rip-rap (Allowed to extend only one vertical(1) foot above and/or below normal water level (elevation 550')

8.11.2.A5: Masonry retaining wall

6. Concrete bags, commercial sheet piles, other metal, or wood retaining walls are prohibited.

7. In order for Lake Arlington to serve its water supply function, the storage capacity of the reservoir must be protected. The capacity of the Flowage Easement must also be maintained. Therefore, retaining walls shall not normally be constructed into Lake Arlington at its normal pool elevation (below elevation 550'). If a portion of a retaining wall is required to be located within the reservoir shoreline at normal water level, an equal amount of area (by volume) on the same property must be dedicated by the property owner. Such trade-offs will be determined by the City on a case-by-case basis.

   The City recognizes there are times when it may be appropriate for the City to approve a permit for construction activities that encroach into the Flowage Easement or into the reservoir below elevation 560 feet. However, placing

8.11.2.A5: Aesthetic sheet wall

fill material into the Flowage Easement or lake reduces the flood storage capacity and cross-sectional area of the reservoir. Additionally, retaining walls on the lake reduce the water supply storage capacity of the reservoir and increase velocities and wave action. Retaining walls can also degrade fish habitat and other ecosystems within the lake. The loss to the City from such activities is both: (i) monetary from a property or asset perspective; and (ii) operational in terms of the velocity with which flood waters will flow through the reservoir and the rate at which water supply capacity must be added to the lake. The loss from a few individual activities is minor, but the cumulative effects of long-term encroachment must be considered. Therefore, it is appropriate for the City to be compensated for such activities.

If the City decides to permit encroachments into the Lake and its flowage easement, it is appropriate for the City to establish a fee for such encroachment as compensation for its losses. Compensation should be determined by calculating the volume of fill placed below elevation 560', and establishing a fee approximately equal to the cost of removing the same amount of material from the Flowage Easement and lake. The cost to remove this material could be determined using data from sources such as the U.S. Army Corps of Engineers (USACE) Dredging Information System. In 2009 the USACE reported that dredging costs nationwide ranged from approximately $25 to $500 per cubic yard. Therefore, an average cost for replacing lost Flowage Easement or lake storage capacity by dredging is approximately $260 per cubic yard. This rate should be applied to any approved encroachment into the volume of Lake Arlington and/or its Flowage Easement. Each encroachment should be evaluated and permitted individually, and the City may deny the encroachment. The rate should be reviewed periodically and revised as necessary to reflect changes in the cost of dredging. Any revision of the fee should be established in the city's standard fee schedule. In addition, the maximum allowable volume of any approved encroachment should be limited. Initially, it is recommended that the volume be limited to 0.5 cubic yards per front foot of private property adjacent to the lake.

B. Shoreline Restoration & Preservation
In order to protect water quality, improve fish habitat, and control storm water run-off; the restoration or preservation of "natural" shoreline areas at Lake Arlington is strongly encouraged, provided that any restoration project does not:

- Remove storage volume from the reservoir or the Flowage Easement
- Increase sediment run-off into the lake (during construction, interim periods while plants are being established, or after the project is complete)
- Increase soil erosion of the shoreline

1. Shoreline restoration may be achieved utilizing a number of approved techniques for erosion control depending on the severity of the slope. For slopes greater than 2:1, shoreline tie-backs or other erosion control systems will be required in addition to planting.

2. In cases where a shoreline is to be preserved, existing trees and other plant material may be thinned to create view corridors, remove invasive plants, or provide access to the lake provided that soils are stablized utilizing plantings or other means.
   a. Within fifty feet (50') of the shoreline, no more than 50% of all existing trees may be removed.

b. In areas where existing trees are removed, sufficient plantings to stabilize soils and prevent erosion must be provided.

3. Appendix 8.11 - Approved Plant List applies to both shoreline restoration and shoreline preservation

4. For property owners agreeing to remove existing retaining walls in favor of natural shoreline restoration, an additional 25% of dock space will be allowable on the affected property. See Section 8.11.3.2 Size and Setback Limitations for more information.

C. Permitting Processes and Requirements
For terraced retaining walls, each tier is considered to be a separate retaining wall as long as the horizontal distance between the upper tier and the lower tier is equal to or greater than 1.5 times the height of the wall segment closest to the Lake. See Figure 8.11.2.A3. However, only one permit is required for such terraced walls constructed on the same property.

8.11.2.B: Natural shoreline

8.11.3 Docks, Piers, and Boat Houses

The photographs in this section are for general example only. They do not necessarily reflect design standards or City Building Code requirements in all cases.

8.11.3.A5: Single story boathouse

A. General Provisions

1. No person shall erect, construct, enlarge, alter, or remove any dock, pier, boathouse or walkway in Lake Arlington or the Flowage Easement without the approval of the City. The requirements in Section 8.11.1 apply to all applications for approval.

2. A person who wishes to erect, construct, enlarge, alter, or remove any dock, pier, boathouse or walkway in Lake Arlington shall comply with all design and construction standards provided in this section and shall also comply with any applicable sections of the Building Code. If there is a conflict between the Building Code and a provision in this section, the more restrictive requirement shall apply.

3. Any person who wishes to erect, construct, enlarge, alter, or remove any dock, pier, boathouse or walkway in Lake Arlington shall have liability insurance or use a private contractor with liability insurance. The coverage limitation of such insurance shall be established by the City from time to time in its permit requirements.

4. On private property, all docks, piers, boathouse or walkways in Lake Arlington shall be considered accessory structures. A primary structure must be present on the lot to which a dock, pier, boathouse and/or walkway is attached.

8.11.3.A5: Boathouse With sundeck

5. A boathouse is a structure on or adjacent to a body of water used to store boats and boat equipment. Boathouses shall be limited to a single story (lower deck) and a sundeck (upper deck) or roof.

   a. All roof structures shall have a maximum vertical clearance of thirteen (13) feet from the top of the decking.

   b. Sloped roofs shall have a roof pitch no greater than 3:12.

   c. Upper level sundecks shall have a minimum of 1/2:12 pitch for drainage and include a safety railing. The upper deck may not have a permanent roof or covering. A deck shall be constructed in accordance with the Building Code.

6. Enclosed boathouses with side walls are prohibited. Boathouses must be open on all sides as shown

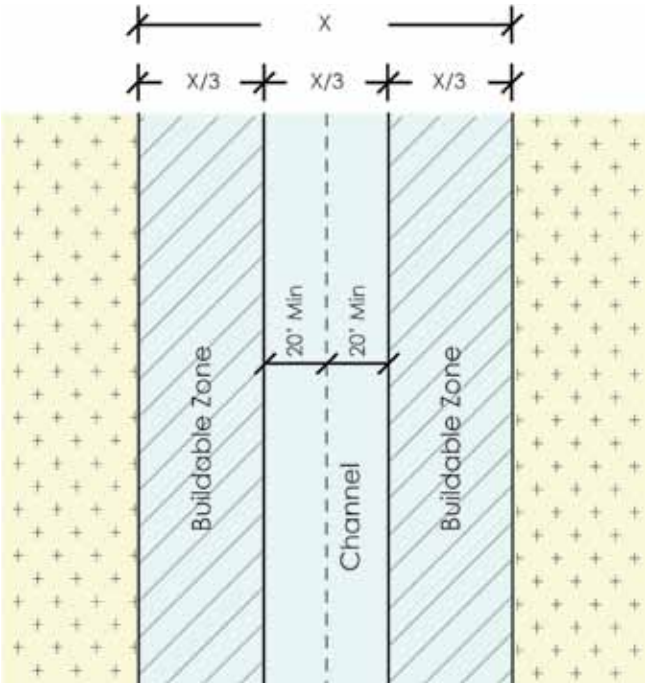
in Figure 8.11.3.A5. To protect a raised boat within a boathouse from the elements, solid sides on the boathouse are permitted at a maximum of two (2) feet downward from the point where the ceiling joist meets the top plate. No additional materials (i.e. lattice, fencing, bars, screen fabric, doors, glass, etc.) may be installed below the two (2) foot sidewalls. Safety railings attached to the deck may extend upward a maximum of thirty nine (39) inches.

7. No toilet facilities of any type shall be allowed on any boathouse or structure built on Lake Arlington or within the Flowage Easement. A potable water supply can be plumbed to the first floor (lower deck) provided that backflow prevention devices are installed and inspected in accordance with the applicable Building Code.

8. Fuel containers exceeding 2 1/2 gallons are not allowed on structures within Lake Arlington or in the Flowage Easement. No fuel containers shall be stored in the Flowage Easement.

9. Structures may extend to a maximum point 100 feet into Lake Arlington (measured from the normal elevation of 550'), or to the point at which the elevation of the land lying under Lake Arlington is not less than 545', But in no instance shall permitted improvements be allowed to extend further than 150 feet from the shoreline into the waters of Lake Arlington. In narrow areas of the reservoir, no structure shall occupy more than one-third (1/3) of the channel width and in no case shall a structure extend out into the reservoir to a point that is more than 20 feet from the centerline of the channel. For the purposes of this provision, the channel width is measured from water's edge at the normal lake elevation of 550'.

   a. Property owners who remove existing retaining walls and undergo a shoreline restoration effort or those that choose to preserve existing natural shoreline areas to the standards provided in Section 8.13.2.2 shall be allowed to extend structures to a maximum point 125 feet into Lake Arlington (measured from the normal elevation of



8.11.3.9: Allowable buildable area in a narrow channel

8.11.3.9: Areas of the lake with narrow channels.

550').

10. All docks, piers and boathouses must have reflectors on both sides of the structure. On each side, one reflector shall be at the ends of the structure. Any boathouse that extends into Lake Arlington more than 75 feet from the shoreline at the normal elevation of the reservoir shall be equipped with a white photocell light of no less than 200 lumens that operates continually from dusk to dawn. Such lighting shall be provided with a cover on the top of the light to minimize light dispersion upward. The City may require that similar lighting be placed on structures less than 100 feet from the shoreline when the City decides it is warranted to ensure boating safety. It is the Dock owner's responsibility to ensure that all required reflectors and lighting are properly maintained and operational at all times.

8.11.3.A10: Illuminated boat dock

11. All structures must have an address placard stating the street address and street name of the primary residence associated with the structure. The lettering shall be a minimum of 6" high and be made of reflective material so that the address can be read at night. Placards shall be made of cast aluminum and be rectangular in shape. The placard shall be mounted to be clearly visible from the lake side of the structure.

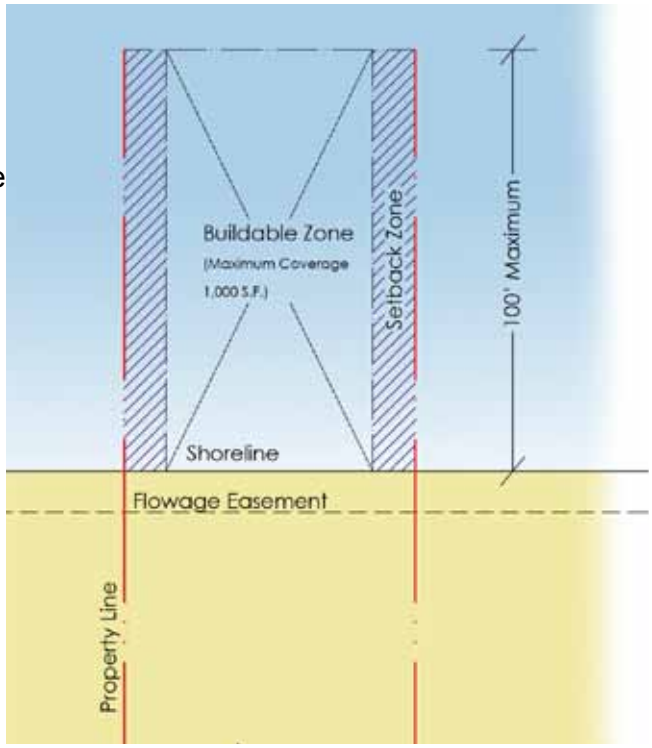
8.11.3.A11: Address placard

B. Size and Setback Limitations

1. Permitted structures on a single property shall be allowed a maximum coverage area of 1,000 square feet, excluding walkways.

2. Property owners who remove existing retaining walls and undergo a shoreline restoration effort or those that choose to preserve existing natural shoreline areas to the standards provided in Section 8.13.2.2 shall be allowed a maximum coverage area of 1,250 square feet, excluding walkways.

3. The minimum setback from a side yard line (as projected into the lake) shall be based on the width of the property at the Flowage Easement as follows:



8.11.3.B: Dock placement relative to property lines.

Lot Width	Setback
Less than 50 feet	5 feet
50-69 feet	10 feet
70-99 feet	15 feet
100 feet or more	20 feet

Site setbacks may be adjusted to address specific site constraints. All adjustments to site setbacks are subject to approval by the City.

4. All walkways shall be a minimum four (4) feet wide and a maximum of six (6) feet wide.

C. Design Loads
In addition to the provisions of this section, the applicant must comply with any additional provisions of the Building Code. Where there are conflicts, the more restrictive regulations shall apply. The applicant's engineer shall apply the appropriate loads when doing calculations related to the design of structures to be permitted under this section. Such factors shall include, but not be limited to:
- Dead load;
- Live load;
- Roof load; and
- Wind load and wave action; which should be considered as simultaneously applied.
- When intended to have boats attached to a dock for storage, the effects of such estimated loads, such as wind and wave, on the boat that are transferred to the dock shall also be considered.
- Surface areas at and above the water line, when authorized.

D. Design Minimums
In addition to complying with the Building Code (unless otherwise stated herein), all docks, piers, boathouses or walkways shall comply with the following provisions:

1. Wood piles are prohibited.

2. All docks, piers, boathouse or walkways (or combination thereof) shall be designed to withstand the Loads as specified in the Building Code, based upon the occupancy classification as assigned by the City's building official.

3. Structures must withstand a minimum of four (4) foot high wave action. Floating docks must be designed with anchorage footing and piers to remain in place without floating above elevation 562'.

4. Cables and chains used in anchoring systems shall be designed with a minimum working load safety factor of 3.0 for cable and 2.0 for chains.

8.11.3.E1: Metal piles

5. Walkways and Bridges shall have a maximum slope under dead Load of a 4:1 ratio to any direction at the lake level of 560'.
6. Flotation devices for Boathouses, Walkways and Bridges shall be designed to support the Dead Load and Live Load as a fixed Structure.

8.11.3.E4: Wood decking

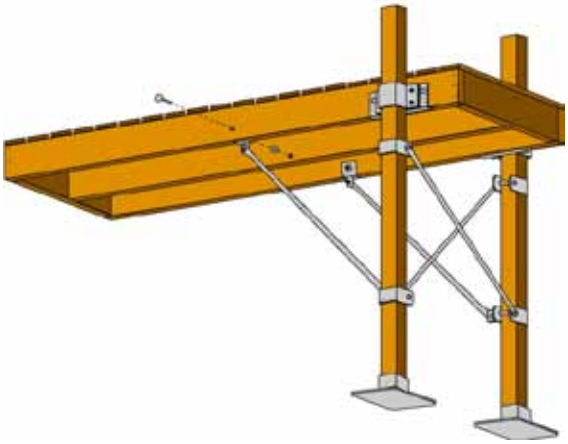
E. Dock and Pier Construction
The proposed design shall incorporate the following minimum provisions:

1. Metal piles shall be a minimum of three (3) inches inside diameter (ID) pipe. Such piles shall be driven to a minimum depth of twenty-four (24) inches below the lowest layer of silt and resistence is felt. Such piles shall be driven in pairs, one on either side of the platform, and braced as required by section 8.11.5.A-C. Such piles shall not be spaced apart more than ten (10) feet center to center.

2. Beams: Beams shall be defined as those members which connect to piles to support the stringers. All beams when of wood shall be a minimum 2-inch material.

3. Stringers: Stringers shall be defined as those members usually supporting the decking. All stringers when of wood shall be of a minimum 2-inch material. Pipe stringers shall be a nominal 2-1/2-inch I.D. and spaced not more than eighteen (18) inches O.C.

4. Decking: Wooden platform decking shall be of a minimum nominal 2-inch thickness. Other materials, to include lightweight concrete, metal, or composite decking may be used when approved by the City. Such decking shall meet the load requirements of the Building Code.


8.11.3.E5: Cross or "X" bracing

5. Bracing: All wooden bracing shall be of a minimum nominal 2-inch material. Bracing shall be accomplished by one or more of the following methods:

   a. Cross or "X" bracing may be used on each set of piers.

   b. Beams may be used as bracing, provided the connections give sufficient support to resist horizontal forces equivalent to that of cross or "X" bracing.

   c. Knee bracing shall be used on each pier attached to and paralleling the platform deck. Pipe knee bracing

8.11.3.E6: Dock connection to pile

shall be a nominal 2-1/2 inch I.D.

6. Attachment of Deck: Attachment of the platform deck to beams and piles shall be accompanied by one or more of the following methods:

   a. By attaching the beams to the piles by corrosion resistant lag bolts.

   b. By caps: Wood caps shall be a minimum nominal 4-inch material and anchored by corrosion resistant bolts and welded.

7. Flotation structures shall be anchored with solid units that will provide the following anchorage:

   a. Docks and piers less than fifty (50) feet in length: An anchor on each corner that will support one-fourth of the total dead load plus one-eighth the total live load.

   b. Docks and piers fifty (50) feet or more in length shall include anchors at the midpoint of the piers.

   c. All docks and piers shall be anchored to the shoreline.

   d. All anchors shall be of masonry, concrete, or steel and shall be securely fastened to the dock or pier by cable, chain, or other approved methods.

8.11.3.F: Floating dock

8. Required Water Proofing: All wood below one (1) foot above Flowage Easement elevation (560') shall be treated lumber. Creosote is not allowed. All metal, including all bolts and fasteners, shall be galvanized or painted with paints of similar materials approved for immersion in water.

   Construction of boathouses or other structures shall meet or exceed the requirements for framing and coverage as specified in the Building Code. When, in the opinion of the City's building official, the load of the intended use exceeds the capability of the minimum construction design, plans and specification may be required to be designed by a Texas state licensed engineer.

8.11.3.F3: Encased flotation material

F. Floating Structures and Flotation Material

1. Floating piers and docks are permitted. Flotation material shall be extruded polystyrene, expanded polystyrene, or a copolymer of polyethylene and polystyrene and shall have a minimum density of 0.9 pounds per cubic foot, and be of consistent quality throughout the float. Beads shall be firmly fused together,and there shall be no voids inside the encasement. Flotation material shall have a water rate absorption of less than 3.0 pounds per cubic foot over seven (7) days when tested by the Hunt Absorption Test. Other flotation material may be considered if it meets all of

the requirements set forth in this section.

2. Flotation material shall be encased in solid polyethylene or a polyurethane type coating, both of which shall be watertight and have a nominal thickness of 0.125 inches.

3. Drums made of plastic, whether new or recycled, or metal shall not be used for encasements or floats.

4. All floats shall be warranted for a minimum of fifteen (15) years against sinking, becoming waterlogged, cracking, peeling, fragmenting, or losing beads, and shall not be prone to damage by animals.

5. Floats that are punctured, exposing the foam to erosion or deterioration, shall be replaced immediately.

6. Because floating structures are more prone to damage, the City may require that such structures be removed periodically for maintenance by the owner and possible re-permitting by the City. The City may initiate an annual fee for the inspection and repermitting of floating structures.

8.11.4 Marinas

A. Purpose
The purpose of this section is to provide minimum standards for the design, construction, operation and maintenance of marinas on Lake Arlington. These minimum standards are intended to protect water quality, public use, access and safety. For purposes of these standards, a marina is defined as a public or commercial facility with docks or berthing structures for six (6) boats or more.

B. Location and Configuration

1. The City of Arlington shall have sole discretion in determining when and where to permit marinas on Lake Arlington, how far a marina may extend into the main body of the reservoir, and the total number of slips.

2. No marina shall extend into Lake Arlington to such a distance that such would constitute a navigational hazard, a safety hazard, a flood management hindrance or would occupy more than the following amount of surface area:

   a. No marina, at anytime, shall extend such a distance so as to preclude the maintenance of navigable passage of a cove or arm of the reservoir. The facility shall not be within forty (40) feet of the centerline between parallel or converging shorelines. The City reserves and shall have sole discretion in interpreting this provision.

   b. No structure within a marina shall be constructed so that it can extend to a height of more than thirty five (35) feet above the normal surface of the water (measured at 550' elevation).

3. Marinas shall be located over property which is owned or leased by the commercial facility owner or operator. The City retains the right to review and approve the provisions of any lease used for the construction, operation and maintenance of a marina.

4. No marina shall be nearer than twenty (20) feet to any property line of the lot or parcel of land on which the facility is located.

5. Relocation or alteration of a marina must be permitted by the City.

6. If the marina developer intends to dredge any portion of the reservoir for the marina or for access channels a separate dredging permit must be obtained from the City in addition to any other authorizations needed from regulatory agencies.

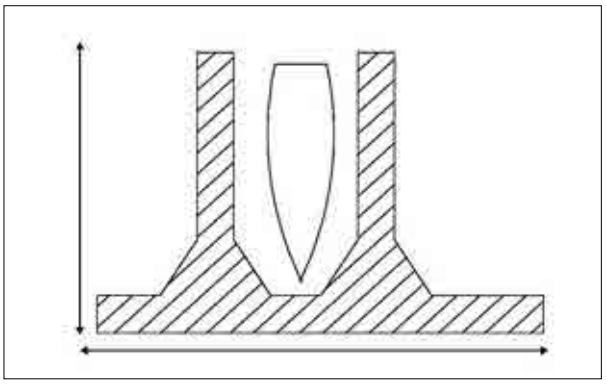
C. Water Areas

1. Channel Design: The design depths and widths of structures and water areas within a marina must take into consideration the following factors: the sizes and types of boats expected to use the marina; wave action; currents; water level fluctuations; boat traffic; silt deposition rates; and anticipated frequencies of dredging needed to maintain design water depths. Recommended design depths are exclusive of site-specific requirements for additional depths necessary to store estimated silt accretion that occurs between scheduled dredging intervals.

a. Channel Design Criteria
   - Design depths for a marina must be based on a design low water elevation determined from water level data obtained from the Arlington Water Utilities Department.
   - Required minimum depths below design low water must be determined on the basis of the type (power or sail), length and draft of the boats expected to be berthed in a marina. The City accepts no responsibility for accessibility to any permitted marina, and the City reserves the right to alter the water elevation of the reservoir at any time, and from time to time.
   - Channels shall be designed based upon local, state, or national standards. The depth and width of channels should accommodate the largest anticipated boats, while providing additional room for maneuverability and safety.

D. Berthing

1. Due to fluctuations in water levels at Lake Arlington, floating berths are required. Floating moorings are usually pontoons arranged to provide walkways to vessels. These walkways may be located by means of guide piles or cables/chains (attached to anchor blocks), allowing free vertical movement. The boats may be moored in either single or double berths, separated by finger pontoons.



8.11.4.D: Berth orientation

2. The design and layout of berthing areas should consider the following:

   a. Berthing areas shall be designed based upon local, state, or national standards, The length and width should accommodate the largest anticipated boats while providing adequate room for maneuverability, safe berthing, and safe access from the boat to the marina.

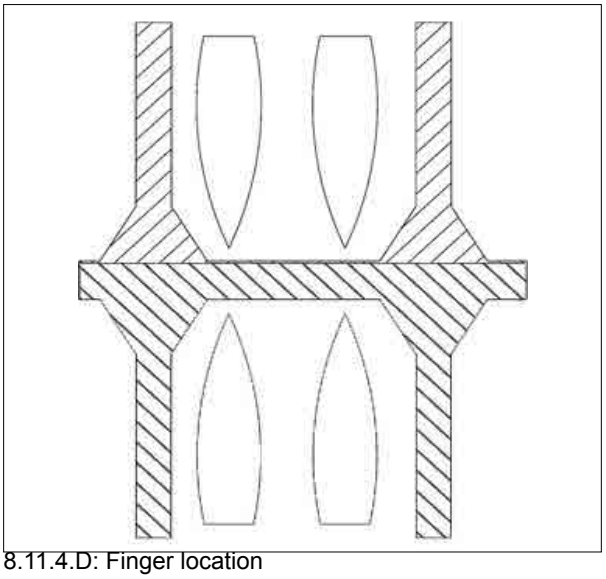
   b. Turning areas should be provided, particularly adjacent to dead-end channels.

   c. Water area for turning, entering and leaving berths should be 2.25 times the length of the longest boat.

   d. Berths should be orientated at right-angles to the walkway to reduce maneuvering difficulties.

   e. Berths should be arranged so that, wherever possible, fingers are symmetrically located on opposite sides of the walkway.

   f. Smaller berths should generally be located closer to the shore.



8.11.4.D: Finger location

3. Dimensional Criteria: Recommended berth dimensions are:

   a. Fingerfloats – Fingerfloats are floating structures that attach perpendicular to a main walkway, and provide direct access to and from a boat in the berth.

Minimum Width	Length of Fingerfloat
5.0 ft	all accessible finger floats
2.5 ft	less than 20 ft
3.0 ft	20 ft & over
4.0 ft	36 ft & over
5.0 ft	60 ft & over

   Minimum fingerfloat width dimensions are considered to be "clear" widths. Cleats or rings along the top edge of a fingerfloat, and hoses and power cords connected to utility pedestals, should not be considered to be reductions of the clear width of fingerfloats.

   b. Main Walkways – Maximum Length: No main walkway shall exceed 300 feet in length. Clear width of the walkway shall be a minimum eight (8) feet.

   c. Marginal Walkways – Maximum Lengths: No marginal walkway shall exceed 400 feet in length. Clear width of the walkway shall be a minimum 6 feet.

   d. Maximum cross slopes of any walkways shall not exceed ¼ inch per foot.

8.11.4.D3: Fingerfloat

4. Structural Requirements
   a. All structures shall comply with applicable portions of all local, state, and national building codes, and shall have structural integrity capable of withstanding prolonged exposure to wave action and winds associated with Lake Arlington. It is the marina developers responsibility to research the necessary data to determine the design criteria for marina components.

   b. All structures shall be securely anchored or moored at all times in such a manner that will insure stability and integrity during prolonged exposure to wave action and high winds normally associated with Lake Arlington.

   c. All flotation devices must comply with applicable Local, State, and Federal regulations, and must be

8.11.4.D3: Main walkway

capable of withstanding prolonged exposure to wave action, UV rays or customary and foreseeable weather conditions. The flotation devices, at a minimum, will comply with the provisions of Section 8.11.3 (floating docks section).

5. Loading Requirements

a. Dead Load (DL): The total dead load of a floating dock system is the combination of concentrated and uniformly distributed weights of all framing, decking, nuts, bolts, washers, connectors, flotation pontoons, and all permanently attached equipment such as pipes, lines, pumps, utilities, fire suppression systems, gangways, lighting, storage boxes, and utility cabinets. The determination of total dead loads should also include the estimated weight of items that will be stored in storage boxes, and the weight of the fluids in various utility lines and related equipment.

- Care must be taken in locating various dead load elements to insure that flat and reasonably level deck surfaces are maintained throughout the service life of the dock system. Overloaded storage boxes or large diameter water lines on only one side of a dock can alter the freeboard and deck slopes.

- Cross slopes under dead load only shall not exceed 2% (1:50) on docks that are part of an accessible route.

- The dead weight of lumber and wood timbers utilized in a floating dock system should be assumed to weigh not less than 35 lbs. per cubic foot at specified moisture contents following pressure treatment.

b. Uniform Live Load (ULL) shall be 25 pounds per sq ft minimum.

- Floating docks in marinas should meet all freeboard and deck slope guidelines under the minimum ULL.

- ULL of forty (40) pounds/square foot may be necessary for design purposes if floating dock systems are subjected to regular and repeated high volumes of pedestrian traffic.

c. Live Point Load (LPL) shall be 400 pounds minimum. Floating docks in marinas are to meet all freeboard and deck slope requirements under a minimum LPL of 400 pounds, applied at any point on the deck not closer than 12” from any edge. This addresses the center of gravity of the general array of heavy objects that may be rolled over the surface of, or temporarily placed upon a marina dock.

d. Lateral Loads: Lateral loads on a dock system may result from winds, currents, waves, and impacts. Such loads may be imparted to docks, boats tied up to docks, or both concurrently. All proposed marinas must take into consideration the following conditions and the respective loads calculated accordingly:
- Wind loads
- Current loads
- Wave loads

- Impact loads

e. Freeboard Under DL only: Minimum Freeboard when floatation devices are fully loaded is 10 inches. Maximum freeboard is 24 inches.

8.11.4.D5e: Freeboard dimensions allow safe access to marina from boats

6. Pontoons: Pontoons in floating marina berthing systems are the components that provide the flotation capacity to support all loads that may occur during the service life of a marina. The heavier the combined loadings, the greater the required pontoon capacity to maintain required freeboard, cross slopes, etc.

   a. Pontoons may be constructed using the following materials:
      - concrete,
      - polyethylene plastic,
      - fiberglass,
      - aluminum
      - steel

      The following materials are prohibited:
      - Metal drums
      - Non-encapsulated polystyrene or Styrofoam
      - Hollow containers

8.11.4.D6.a: Polyethylene pontoon

   b. Pontoon material selection must include consideration of environmental influences, the nature of the berthing frame system, pontoon flotation characteristics, availability and cost. Environmental influences include water, currents, waves, flooding, wind, storms, extreme temperatures, ultraviolet exposure, and impacts.

   c. Pontoons must be selected and designed to be compatible with the dock frame regarding fastening details, ease of repair and/or replacement if necessary, flexibility/stiffness, and performance.

   d. Where polyethylene pontoons are used, the following guidelines shall be used in the specifications:
      - Method: Roto-Cast
      - Material: Linear Low Polyethylene
      - Nominal Wall Thickness: 0.150 inches

7. Decking
   a. Decking can be attached to a structural frame, or it can be part of the structural frame as in the case of cast concrete floats.

   b. Allowable decking materials include:
      - pressure treated wood
      - recycled plastic lumber products
      - metal extrusions
      - fiberglass
      - concrete

   c. Decking shall be chosen that allows for traction in wet conditions. Materials that are slippery in wet conditions should not be considered.

8.11.4.D7: Plastic composite decking

E. Guide Piles
Marina guide piles must be provided at appropriate locations and in sufficient numbers to reliably retain a floating dock system in place under all design loadings, conditions and circumstances. It is important to determine in advance exactly what these factors are for a given site. Consideration must be given to forces applied to the floating berths, guide piles and the boats occupying the berths. These forces include wind, waves, currents, flood flows, impacts from boats underway, and debris. Some of these forces may occur concurrently.

8.11.4.D7: Metal decking

1. Design Criteria
   a. Marina guide piles must be placed at the ends of all fingerfloats adjacent to channels.

   b. Cut-off elevations for guide piles must be not less than 4 ft above the deck of a floating dock at an elevation of 560', not including the height of pile caps.

   c. Guide pile caps must be provided. Acceptable materials include: fiberglass, polyethylene or other ultraviolet resistant plastic materials.

2. Material Pile Types
   Marina guide and mooring piles shall be concrete, steel, or composites.

8.11.4.E: Concrete guide pile

F. Lighting

1. All structures extending more than fifty (50) feet from the shoreline at normal reservoir elevation (550') shall provide continuous and adequate lighting from thirty (30) minutes before sunset to thirty (30) minutes after sunrise.

2. A minimum of one (1) light station is required along each exterior side of a marina, except that side which faces the shore. Some circumstances may require additional lighting as determined by the City in its sole discretion.

3. If only one (1) light station, per exterior side, is required, the light station shall be on the end of the structure farthest from the shoreline.

8.11.4.F: Lighting

4. The wiring method shall be one or more of the following, per the National Electric Code:
   - Rigid conduit.
   - Seal-tight flexible conduit with appropriate fittings and boxes.
   - Direct-burial UF cable, in protected areas.

5. The lighting fixtures must be installed so that they do not cast beams of light outward from the structure in such a manner as to constitute a hazard to safe boating or a nuisance to the general public.

6. Low voltage (24 volt or lower AC or DC) lighting may be used on commercial facilities. Low voltage lighting shall be wired in accordance with the more stringent of the National Electric Code (NEC) or the Building Code.

7. Weatherproof lamp holders and weatherproof junction boxes shall be used for placement of the light fixtures at each light station.

8. The City may require that marina lighting shall focus illumination downward and follow recommendations of the International Dark Skies Association.

G. Utilities

1. General
   a. The City reserves the right to review the design of landside utility design and construction standards within the Flowage Easement as such utilities relate to the marina. Utility design and construction shall follow the Building Code.

   b. Utility lines on shore within the Flowage Easement must be located underground.

2. Sewer and Trash Facilities
   a. On-site facilities shall be provided for the collection of any garbage and trash that might be generated at the marina, and arrangements for the timely removal of such collections shall be

made by the commercial facility owner or operator.

b. All trash and service facilities must be screened from parking areas, marina facilities, the waterfront, and adjacent properties by a minimum six (6) foot high solid masonry wall.

3. Fueling Facilities
   a. The City must specifically approve the design and installation of fueling facilities adjacent to or on Lake Arlington. The City reserves the right to decline to approve such facilities in its sole discretion. If the City decides to approve a fueling facility, it must be located such that it is easily accessible, without the need for access through the main berthing area of the marina, and fuel tanks must be located outside the Flowage Easement.

   b. All fueling facilities shall comply with the currently-adopted International Fire Code with amendments (the "Fire Code").

   c. Fire extinguishers of a minimum rating of 20 B:C shall be visible in convenient, accessible locations near the fueling facility. All extinguishers shall be U.S. Coast Guard approved and maintained fully charged.

   d. Fuel storage areas shall be clearly marked.

   e. Fuel facilities shall be isolated from mooring docks and shall be, if necessary, protected by adequate breakwater facilities.

   f. Fuel dispensing nozzles shall not be equipped with trigger locks.

   g. Underground storage tanks at marinas and in the Flowage Easement are prohibited.

   h. Above Ground Storage Tanks
      - In all Above Ground Storage Tanks (AST) installations there must be a solid, impermeable containment structure surrounding the tank designed to hold 1.5 times the volume of the tank.
      - If the dispenser on the AST system is housed outside of the bermed area, there must be a solenoid valve or a manual disconnect/shutoff device on the line prior to the point at which the line leaves the berm.
      - In all fuel installations there must be a pullaway type valve located in the flexible hose between the dispenser and the nozzle, as close to the nozzle as possible.
      - Tank fill ports will be located above the Flowage Easement elevation (560') of Lake Arlington. (The dispenser for the tanks may be located below the Flowage Easement elevation).
      - Product lines which may not be located outside the bermed area.

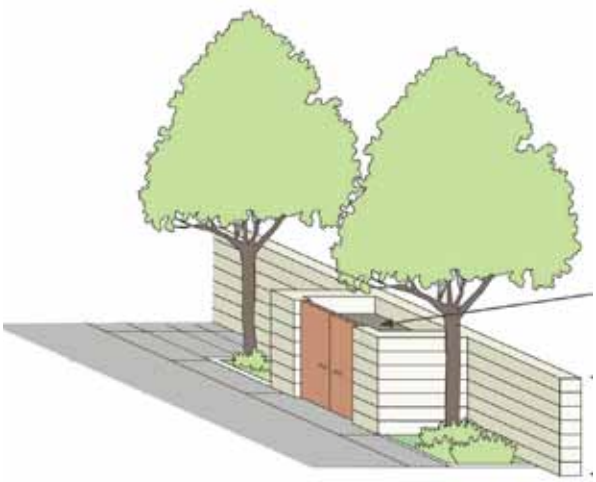
4. Utilities in Marina Berthing Structures
   a. All utility lines in marina berthing structures must be installed to provide maximum public safety as well as protection from impacts, mechanical wear and damage, and environmental elements such as heat, water and rodents.

   b. No utility lines shall be located on and attached to the deck surface of marina docks. Electrical

outlets and water supply hose bibbs are usable only with lines, cords and hoses that are connected between utility boxes and berthed boats.

c. Utility lines in a floating dock system shall have at least 6 inches minimum clearance above the water surface.

d. Where utility lines pass through structural members within a floating dock system, the holes in the structural members must be free of rough edges and abrasive surfaces that will cause accelerated wear on the utility lines.



8.11.4.G4: Trash screening

5. Potable Water Service on Marina Docks
   a. Potable water piping that is attached to docks, walkwalks and boat slips shall be galvanized steel material with appropriate fittings and valves. The piping shall be clearly marked as “Potable Water”.

   b. All potable water lines on marina docks shall be equipped at the shore end with appropriate anti-siphon devices to prevent back flows.

   c. Dedicated potable water and fire suppression lines shall be provided on marina dock systems. Potable water and fire suppression lines shall not be combined.

   d. Utility hoses and/or lines, whether permanent or temporary, shall not be allowed across the deck of main walkways or marginal walkways.

   e. Where a fingerfloat is part of an accessible route, utility hoses and lines shall not be allowed across the fingerfloat.

   f. Backflow prevention devices shall be installed and inspected in accordance with the applicable Building Code.

6. Fire Suppression Systems on Marina Dock Systems
   It is required that marinas have equipment, systems and sustainable water resources to suppress, control and extinguish fires on boats, docks, buildings, fueling stations and other marina service centers. All such facilities shall comply with the Fire Code. It is recommended that the City fire marshal be included in all stages of marina design.

8.11.4.G7: Utility boxes

7. Electrical Power Services on Marina Dock Systems
   a. Marina electrical systems must be adequate to supply

the power demands for boat slips (if provided), lighting, fuel stations, and maintenance and repair-work.

b. Marine grade electrical outlets designed and manufactured for reliable use in water environments shall be used.

c. Electrical outlets shall be installed in dock storage boxes or electrical power centers located along the edge of walkways and at the head of fingerfloats. Water supply and electrical services shall not be installed in the same dock storage box.

H. Shoreline Structures

1. Piers
   a. Piers and gangways that are used only for pedestrian access to gangways and floating docks shall be designed to support a minimum live load of 50 pounds per square foot.

   b. Appropriately-designed guard railings shall be provided on all piers which are more than 30 inches above grade.

   c. The height of the top rail of guard railings shall be not less than 39 inches, measured from the finished deck surface to the top of the top rail.

   d. Openings in guard rails shall not permit the passage of a 4 inch diameter sphere. This shall be accomplished by use of intermediate rails, pickets and/or ornamental components.

8.11.4.H2: Gangway

2. Gangways
   a. For any marina over 25 berths, two gangway exits shall be provided for emergency access.

   b. Uniform Live Loads
      - 100 pounds/square foot minimum ULL shall be used for gangway structural design.
      - 50 pounds/square foot minimum shall be used for ULL transferred to floating docks.

   c. Loadings transferred from a gangway to a floating dock system include appropriate portions of both the gangway DL and ULL.

   d. The minimum clear gangway width is 36 inches.

   e. Gangway Railings shall have a minimum height of 42 inches. Openings in guard rails shall not permit the passage of a 4 inch diameter sphere. This can be accomplished by use of intermediate rails, pickets and/or ornamental components.

8.11.4.H2e: Gangway railing

Handrails shall be provided on both sides of all gangways.

f. Gangway decks must have a durable non-skid surface to provide traction, especially when wet, and when gangways are at steeper slopes.

g. The use of cleats on gangway decks to improve traction is to be avoided. However, where gangways remain at steep slopes for long periods of time, gangway cleats may be deemed necessary to develop improved traction.

   Gangway cleats shall meet the following criteria:
   - be attached perpendicular to the long axis of the gangway
   - spaced on 12 to 16 inch centers
   - maximum width of 1 inch
   - maximum height of ½ inch
   - greater than ¼ inch high, all edges above ¼ inch to be beveled at 45 degrees

h. Maximum gangway slopes shall be 2:1.

i. All marina facilities at Lake Arlington, including gangways, are required to comply with federal and state accessibility guidelines which apply to each newly designed or newly constructed marina facility.

3. Vehicle Parking
   a. Adequate parking for the number of boat slips shall be provided. Parking shall accommodate both single vehicle parking and parking for vehicles with boat trailers.

   b. Accessible spaces shall be provided for both types of parking spaces that are provided in a marina, including van accessible parking spaces.

   c. Marina parking areas shall be located outside the Flowage Easement.

   d. Large visual expanses of paved areas shall be avoided. Parking areas shall be designed with a minimum 10' landscape bioswale located between parking aisles. Drainage from paved areas shall be routed to the landscape bioswale for retention and natural percolation of stormwater. A minimum of one (1) shade tree, with a minimum four (4) caliper inches at the time of planting, will be planted per parking space provided. The tree may be clustered within the bioswale area or planted within the parking grid. Use of permeable pavement approved by the city with jurisdiction is encouraged.

8.11.4.H4: Restroom facility

4. Restroom Facilities
   a. Restroom facilities shall be provided at any marina with more than 20 berths. Restrooms may be shared

or combined with restrooms required for other uses on site.

b. Restroom facilities must comply with all public health and safety requirements of local, state and federal agencies.

5. Boat Launching Facilities
   a. Boat launching facilities that are a component of a marina complex should be located so as to minimize conflicts in vehicle and boat traffic, as well as boater use patterns.

   b. Boat ramps shall be located away from sensitive areas such as fish or wildlife habitat. Preferred areas are shorelines without wetland vegetation and adjacent to waters with adequate navigation depths.

   c. Ramp slope shall be 1:10. Lane width minimums are 14 feet (single lane) and 12 feet (multiple lanes).

   d. Adequate water depths at the toe of the ramp at low water should allow boat launching.

I. Licenses

1. General
   All required licenses and permits shall be obtained, renewed and displayed in open view to the public by the owner of the marina.

2. Operating License
   a. The operator of the marina shall obtain an Operating License from the City, and such License shall be renewed annually. The Operating License is required to operate a marina on Lake Arlington.

   b. The Operating License may be issued by the City after:
      - the required application has been completed and reviewed;
      - the marina, has been inspected by the City and found to be in compliance with the initial marina permit, and all applicable City regulations; and
      - the required fee has been paid.

   c. The City requires that the marina be maintained in a clean and attractive condition and appearance and that operational facilities be in a good and safe working condition, as determined by the City in its sole discretion. Marinas failing to meet such standards will be classified by the City as noncompliant with the terms of its regulations and the Operating License may be revoked.

8.11.5 Trails and Linear Park Facilities

A. Purpose
The purpose of this section is to recommend standards for the design and construction of linear parks, trails, and bike paths in areas adjacent to and near Lake Arlington. These standards are intended to promote the development of a comprehensive trail system around Lake Arlington while protecting water quality, and enhancing public recreational use, and public access and safety. These standards are intended to supplement previous studies conducted by the cities of Arlington, Fort Worth, and Kennedale. If a conflict arises between these standards and any regulations set forth in previous studies, the most applicable standard from the AASHTO Guide for Development of Bicycle Facilities may be used as an alternative to either competing local standard. Where bicycle facilities are to be constructed on land owned by the City of Arlington or on land within its flowage easement, the City of Arlington will have the right to review and approve such bicycle facilities at its own discretion.

In addition to hike and bike trails, there has been interest expressed in the development of equestrian trails on the west side of the lake. That opportunity should be studied in more detail during the implementation phase.

8.11.5.B1.a: Off-Street Trail

B. Routing and Design
Trails shall comply with the Design Guidelines included in Arlington's Hike and Bike System Master Plan. Trail designs shall comply with the requirements of the Americans with Disabilities Act (ADA).

1. Hike and Bicycle System: In order to develop a comprehensive trail system at Lake Arlington, trails must be designed to address a variety of existing conditions. Trails at Lake Arlington most likely will fall into three categories: off-street trails, bike lanes on existing or new streets, and signed shared roadway routes. In addition, sidewalks should be constructed on new road ways.

   a. Off-Street Trails: Off-street trails are most appropriate where sufficient right-of-way can be aquired. Around Lake Arlington, these areas are typically located where there is limited or no existing development, or where off-street trails are preferred for pedestrian and/or bicycle use. These trails and linear parks should focus priority on creating access to the lake, providing overlooks and rest areas in strategic locations, and linking larger parks and open spaces.

   b. Bike Lanes: Bike lanes should be utilized on new or existing streets in areas of existing development where an off-street trail is not feasible or desired. Adequate right-of-

8.11.5.B1.b: Bike Lane

way must be in place on existing streets to provide a bike lane without negatively impacting existing vehicular movement.

c. Signed Shared Roadway: A Signed Shared Roadway is a new or existing street that utilizes the right-of-way to share between automobile and bicycle traffic. These integrated routes should be utilized only when an off-street trail or bike lane is not possible. In these cases shared roadways shall only occur on streets with limited automobile traffic. Existing traffic volume and patterns must be studied to ensure that the route is appropriate and safe for trail users. All Shared Roadway routes should follow guidlines for signage placement included in the Hike and Bike System Master Plan.

8.11.5.B1.c: Signed Shared Roadway

2. Design Speed
   a. All trails shall be designed for speeds up to 15 miles per hour in order to provide a safe layout for the hike and bike trails. By designing for faster speeds than required, gentle curves, increased sight distances, and reduced slopes will reduce trail accidents and increase user security.

   b. All minimum standards for curve radii, vertical curves (hills), lateral clearances on horizontal curves, and stopping sight distances should be designed in accordance with the recommendations of the American Association of State Highway and Transportation Officials (AASHTO) Guide for the Development of Bicycle Facilities - 1999.

3. Drainage
   a. Trails should be designed to prevent the pooling of water and the flow of stream across the trail. Ideally, water should flow across the trail in sheets.

      - Swales should be used on all hillside trails and cross sections where a hill intersects with a trail and shall have a maximum slope of 1:4 (vertical:horizontal).

      - Culverts should be used to drain small streams, swales, and low places under the trail and shall be made of galvanized steel or concrete with a minimum slope of two (2) percent.

   b. To minimize storm water run off from flowing across the trail, drainage swales should be placed on the higher side and designed to adequately store all run off. Using swales in this situation will also require culverts that are designed to handle the water flow, are safe (relative to the trail users), and have low maintenance.

   c. Care should be taken in designing stormwater collection systems that do not negatively impact Bike Lanes and Shared Roadway conditions with back up and pooling of water within the bike lane areas.

   d. Where storm drainage elements occur, recessed curb inlets are preferred over drain grates. If

grates must be used, they must be bicycle- and wheelchair-safe with openings no wider than 1 by 2 inches.

e. Grates and manhole covers should be flush with the surface and be maintained in a flush state when the roadway is resurfaced.

C. Trail Elements
All trails, linear parks, and bike lanes will have a variety of elements and amenities depending on the type and configuration of the route. Where possible, amenities should be clustered together and located for ease of use and maintenance. The following criteria only apply if the referenced element is utilized.

1. Trail Head Location: Trail heads should be located at the beginning and end of a linear trail, or associated with other (existing or new) parks and open spaces in a loop trail. Trail heads shall be located in areas that are convenient to access by automobile, bicycle, or on foot and should allow enough area to include the following amenities:
   - Paved Parking (appropriate permeable pavement is encouraged)
   - Bicycle Racks or Lean-rails
   - Lighting
   - Drinking Fountain
   - Kiosk or Information Board
   - Trail System Map with Mileage Chart
   - Landscaping/Shade Trees
   - Restroom Facilities (optional – should be monitored)

2. Parking
   1. Parking requirements will vary depending on use patterns, location, and overall development of the trail system. Where possible, locate shared parking with existing park facilities or provide on-street parking (provided the parking does not negatively impact adjacent neighborhoods).

   2. All off-street parking areas will be concrete, asphalt is prohibited. Appropriate permeable pavement is encouraged

   3. For any off-street parking area created exclusively for trails, one tree (4 inch caliper at the time of planting) will be required for every five (5) parking spaces. Trees should be placed so as to maximize shade on the parking area and to support long-term tree health.

3. Bicycle Parking
Secure bicycle parking shall be provided at all trailhead locations and any other location that provides for an extended stop. Bicycle racks should be located adjacent to other trail elements.

4. Lighting
   a. All off-street trails should include lighting at all at-grade crossings. Bike Lanes and Shared Roadways should include lighting at all intersections. If proper lighting does not exist as a part of a vehicular thoroughfare, lighting should be installed prior to the creation of a bike route.

b. On all trails and routes, areas of steep slopes, tight corners, steep drop-off from the edge of the trail, or any other existing condition that might pose a hazard to bicyclists or joggers should be illuminated by pedestrian scale lighting.
c. The horizontal illumination levels should maintain an average between 0.5 and 2 foot candles. Where special security concerns exist (e.g., tunnels, underpasses), a photometric study is required indicating a minimum average of 1 foot candle.

d. Light poles and fixtures should be in scale with bicyclists and joggers except at at-grade street crossings.

e. At street crossings, light poles shall be a minimum ten feet (10') in height.

f. All trail lighting should conform to the "Dark Skies" ordinance.

g. All light fixtures should have sharp cut-off or side cut-off features to prevent spill-over of light into neighboring properties.

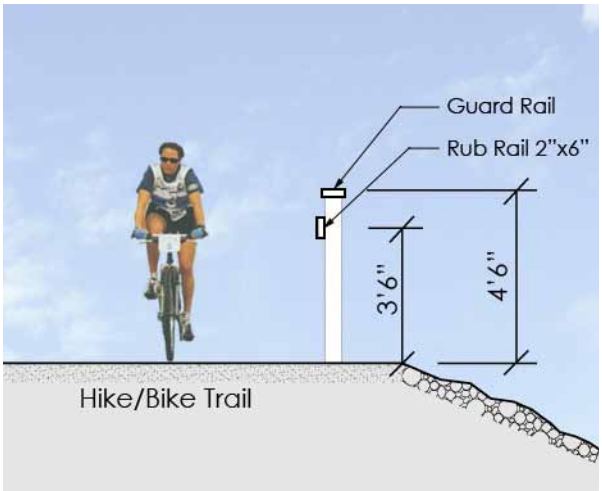
5. Railings
   a. Railings should be provided for bridges, overlook areas and steep drop-offs from the edge of the trail.

   b. All railings shall be a minimum of four and one half feet (4.5)' in height and have a smooth "rub rail" attached to it. The rub rail should be of 2 inch x 6 inch rectangular tubing (12 gauge steel) placed three and one half feet (3.5') above the surface of the trail.

   c. The use of chain-link fencing is prohibited.

6. Water Fountains
   a. Water fountains, faucets, and other water sources should be located on the downhill side of the trail to eliminate water flow across the trail that could create a slipping hazard.

   b. Water fountains should be located every 1 to 2 miles for trails in linear parks. The water fountains



8.11.5.C5: Railing

8.11.5.C6: Water fountain

8.11.5.C7: Bench

should be "freeze-proof" with a top spigot at two levels per ADA requirements and a lower faucet for water bottles and animals. The lower faucet needs to be spring-loaded to ensure that it shuts off after use.

8.11.5.C8: Trash receptacle

7. Benches
   a. Benches are not required, but if they are used they shall be located in areas that trail users would logically stop (e.g. near water fountains, overlook areas, parks); or located every 1 to 2 miles along a trail.

   b. Benches should be designed to prevent people from laying down.

   c. Benches should be made of metal, concrete, or other durable materials.

   d. Bench seating should be of a typical height of 18 - 19 inches.

8. Trash Receptacles
   a. Trash receptacles should be located in areas that are convenient for users and easy to maintain.

   b. Trash receptacles should be made of metal, concrete, or other durable materials; and shall be designed to prevent tipping over by animals.

8.11.5.D1.a: Warning sign and traffic sign

D. Signs
   Signage should be utilized to communicate to trail users and motorists the appropriate regulatory messages, to warn of potential conflicts, and to designate routes in Shared Roadway conditions.

   All trail signs must conform to the Texas Manual of Uniform Traffic Devices – Part 9 Traffic Control for Bicycle Facilities.

1. Signage Types: Trail signage should include the following types:

   a. Warning Signs: Warning signs shall be used to alert trail users of a safety threat such as sharp curves, approaching intersections, or steep drop-offs. Typically, these signs are yellow and diamond-shaped with black lettering.

   b. Information Signs: These signs typically provide the trail user with useful or important information.

   c. Regulatory Signs: These signs shall be white and rectangular with black lettering. Regulatory

signs give instructions on trail use and etiquette.

d. Identification Markers: These signs identify trails and streets that cross the trails. All intersections and street crossings should have a sign identifying the street for trail users and a sign identifying the trail for road users.

e. Trail Maps and Mileage Markers: Trail maps and the name of the trail should be located at the beginning and end of each trail, adjacent to parking lots and other trail facilities, and at major street intersections along the trail.

   a. Mile markers shall be located every 0.25 mile on off-street trails and bike lanes.

8.11.5.D1.e: Example of trail map

f. Directional Markers: Directional markers should use arrows or wording to indicate which direction to travel in the following conditions:
   - At the intersection of multiple trails
   - At street intersections
   - At points where trail types converge (e.g. an off-street trail transitions to a bike lane)
   - Along Shared Roadway Trails

g. Kiosks: Information bulletin boards or kiosks should be located near parking areas, water fountains, restrooms, or other areas where people have a reason to stop.

8.11.5.D1.h: Information sign

h. Information Signs: Information signs shall be placed within the first 150 feet of the trail. Specific trail names, length of the trail, and regulations concerning trail use are included on information signs.

i. Route Signs: Route identification signs are required for all Bike Lanes and Shared Roadways. The following criteria should be used to develop these signs:
   - Bike route signs should be W11-1 diamond shaped, bicycle warning sign with a W16-1 or W16-7p companion rectangular shape SHARE THE ROAD sign, color, and size shall conform to Texas MUTCD.
   - All bike route signage should adhere to Texas

8.11.5.D1.i: Route sign

Manual on Uniform Traffic Control Devices - MUTCD (Global) standards.

- All bike route signage should be reflectorized.
- Bike route signs should be placed wherever bike routes cross other bike routes and major thoroughfares and at the beginning and end of each route.
- To confirm that the bicyclist is still on the bike route, signs are provided every 0.5 to 1 mile intervals.

8.12 Boating Capacity Study

8.12.1 Boating Capacity Study

The scope of work for the Lake Arlington Master Plan included an assessment of the carrying capacity of the lake, specifically directed at evaluating boating activity. The specific technical nature of this task required expertise in two areas: water-related recreation use assessment; and the use of appropriate survey techniques. For this purpose, Malcolm Pirnie engaged Texas AgriLife Research, a division of the Texas A&M University System. The study team included professionals from the Human Dimensions of Natural Resources Lab in the Department of Recreation, Park and Tourism Sciences at Texas A&M University.

The study is summarized below. The entire study report is found in Appendix 8.12-A.

8.12.2 Study Objectives

The objectives of the Lake Arlington boating capacity study were to:

- Characterize existing use occurring on Lake Arlington;
- Identify areas of use, conflict, and displacement across the lake and among boating groups;
- Identify areas on the lake that might require new or additional managerial attention; and
- Identify areas around the lake for potential shoreline development projects.

8.12.3 Methology

A. Site Visit
On February 26, 2010 the Texas AgriLife Research study team conducted a boat tour of Lake Arlington and a site visit of the surrounding area. The team also met with staff members of the City of Arlington to kick off the study effort, clarify the scope of work, and initiate data collection. The site visit and tour also provided an opportunity to make professional observations and develop perceptions of Lake Arlington's size and configuration, shoreline characteristics, recreation and access facilities, and geographic nature.

B. Study Area
The study area included Lake Arlington and the immediate area within a five-mile radius.

C. Sampling
The major basis for this study effort and the findings was a survey of lake users and potential users. The survey examined how recreationists are currently using the lake, their perceptions of future development and lake management, and their future needs. Data for the survey were collected from two sources: 1) a City of Arlington-supplied mailing list of 2009 permit holders, and 2) a random sample of lakeshore property owners and residents living near the lake.

The City of Arlington provided names and postal addresses for 1,471 people who had purchased a day use or annual boating permit for Lake Arlington in 2009. The entire list was included in this sample. The second portion of the sample was drawn from the 2010 Certified County Appraisal Rolls for Tarrant County using a random systematic method. The county tax roll was filtered to identify residential property owners to create a 100 foot buffer around Lake Arlington in order to target shoreline property

owners. From this list, 191 residents were selected. The tax roll was also used to create a five mile buffer to target a wider potential user group (1,200 of these names were selected).

From this sample group, potential respondents were given the option of completing a survey online or receiving a hard copy survey in the mail. A total of 454 completed surveys were returned for an overall response rate of 16.4%. Final calculations indicated that 21.5% of lake permit holders responded, 26% of lakeshore property owners responded, and 9% of property owners within five miles responded. Within the overall 454 returned surveys:

- Lake Arlington boat permit holders made up 65.5%
- Property owners within five miles of Lake Arlington made up 23.5%
- Property owners within 100 feet of Lake Arlington made up 11%

Response rates were consistent with past research targeting the "general population" and offer reliable estimates of the target population within plus/minus five percent (5%). A blank copy of each version of the survey form is found in the full report.

8.12.4 Analysis and Results

The surveys were tabulated and analyzed by professionals from Human Dimensions of Natural Resources Lab at Texas A&M University. There were several questions that asked about boating experiences on Lake Arlington. Most respondents (83%) had boated on Lake Arlington and had been boating on the lake for an average of just over 12 years. Respondents indicated they had boated an average of approximately 27 days on Lake Arlington in the past 12 months.

A. Boating Experience

There were a number of different types of watercraft used on the lake. Fishing and/or bass boats were the most common, followed by ski boats, personal watercraft (PWC) such as jet skis, kayaks and sail boats. Most respondents said their boating activity related to fishing (42%), with the next highest use being cruising up and down the lake (20%).

Almost two-thirds (63%) of the respondents indicated they were not boating as often as they would have liked. Lack of available time and work commitments appear to have been the main reasons. Two other factors also inhibited some users. These factors were water depth and litter. Forty-four percent (44%) of respondents believe that the lake is too shallow and 32% believe that there was too much litter in the water.

On average respondents travelled about five miles to use Lake Arlington and 63% of the respondents used the lake with family and friends in a group size that averaged between three and four people.

More than 50% of the users enjoyed Lake Arlington because of how "close" the lake was to home which made using it "convenient" and "easy to access." Many residents clearly see the lake as a local resource and appreciate that it is close to home. There were also a number of responses related to the lack of crowds, feeling safe while boating, appreciation for the no alcohol policy, enjoying socializing with friends and family, and fishing.

Answers to the "what you like least" question were more varied. However, there were many responses

related to the small size of the lake, the shallow and/or fluctuating water level, and litter and other debris on the shore and floating in the water. Fifteen (15) respondents commented that the no swimming rule was something they did not like.

When asked about the number of people encountered on the lake, most (72%) felt there were neither too many nor too few. This suggests that the number was acceptable. About 19% of the respondents would like to have seen fewer people. The number of people they encountered was also what most respondents (60%) expected to encounter, while 20% indicated that there were fewer people on the lake than they had expected. Most respondents also indicated that the number they saw either had no influence on their enjoyment (62%) or that it "detracted a little" from their enjoyment (22%).

The number of boats on the lake does not appear to have made people feel unsafe because 96% of the respondents indicated feeling at least "moderately safe" with 68% feeling very to "extremely safe." Most respondents (66%) did not feel there was an area of the lake where they felt unsafe. The 34% who did feel unsafe indicated they felt unsafe in the far western and southern zones of Lake Arlington (Zones 1 and 6 on the map shown below).

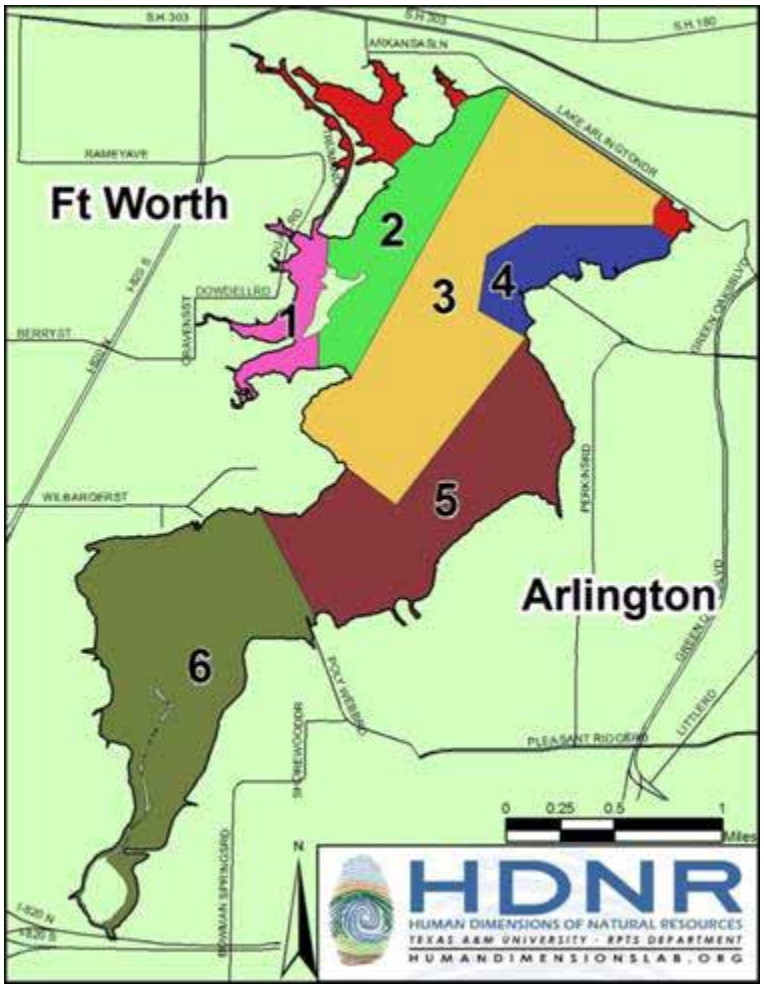


Figure 8.12-1: Lake Arlington Use Zones

B. Use of Lake Arlington

In general respondents did not feel that activities should be restricted to certain areas of Lake Arlington. Seventy-one percent (71%) said they would not want activities restricted by zone. Among the 29% who did feel that activity should be restricted to zones, there was support for restricting jet skis, high performance boats and skiing/wakeboarding across all zones with the highest counts related to Zone 6. Zone 6 is the shallowest area of Lake Arlington and is currently a no skiing zone. Most respondents (78%) also felt that Lake Arlington should be managed for all types of recreational boating. Among the 22% who felt there was some need for restriction, almost all (82%) felt that high performance boats were not suitable on the lake. There was almost no opposition to canoeing/kayaking, sailing or fishing as lake activities.

Respondents did not feel that conditions were crowded out on the water or at access points on Lake Arlington. Over 75% felt that conditions on the water were only moderately crowded or less, and 65% felt that conditions were moderately crowded, or less so, at access points

C. Management Issues

Respondents were asked to score 16 items on a scale from “strongly oppose” to “strongly support” related to possible management actions on Lake Arlington. The actions that received the most support were related to developing the fish stock and dredging the lake to improve depth. Respondents also tended to agree that training should be required for operating PWC and that development standards should be set for shoreline retaining walls, docks and piers. On the other hand, respondents were not supportive of restricting activities. With regard to marina development as a management action, there was no strong consensus for or against development, with 22% of the respondents being neutral. There was also no strong support of the installation of more boat ramps.

While a small majority (55%) of respondents felt that current facilities were adequate, many (45%) felt that some additional services and facilities should be available to users. A large majority (80%) would support up to a 20% increase in the fees to support services and upkeep of Lake Arlington. Litter pick up, park amenities and code enforcement were all seen as reasonable ways to spend additional fee revenues. A small majority (57%) felt that marina development was acceptable on Lake Arlington. Among those who felt it was acceptable, just over 60% felt that 40 slips or less would be an acceptable capacity size for a marina.

Respondents were asked about 17 possible issues (developed through input during public meetings and previous research) and to what extent each may present a problem associated with Lake Arlington. The major issues identified were fish habitat improvement, change in the lake’s water level and litter on shoreline. Poorly constructed bulkheads and polluted water were scored as moderate problems, while pulling inflatable toys, engine noise and public access were identified as slight problems.

D Shoreline Property

Property owners adjacent to the lake were asked about issues that would apply only to them. Seventy (16% of total) respondents indicated that they had a home on Lake Arlington and, for all 70, it was their primary residence. Homes had been owned an average of 10 years, and thirty-nine respondents (56%) had a bulkhead, dock or slip associated with their property. Twenty (51%) of the 39 who had a bulkhead indicated that it had been damaged sometime in the past. However, there was little detailed information about the nature or cause of that damage.

Related to two homeowner issues, questions were asked about whether they displayed a home address on their dock or slip, and if they were aware of the "flowage easement" that extends into lake front property. Of the 23 who indicated having a dock or slip, only three (8%) said that they have their street address posted on the structure. Awareness of the "flowage easement" was split evenly among the shoreline property owners, with 52% indicating that they were not aware of the easement.

8.12.5 Conclusions and Recommendations

A. Conclusions

1. Respondents' Use of Lake Arlington

   a. Most respondents had boated on Lake Arlington. Of those who had, most had boated within the last 12 months.

   b. The most popular watercraft used by respondents were fishing or bass boats, ski boats, and personal watercraft (PWC).

   c. The most popular activities on the lake were fishing, cruising, towing inflatables, and wakeboarding.

   d. Respondents most often boated with family and friends.

2. Areas of Use, Conflict and Displacement

   a. Overall, there was little indication of crowding, conflict and/or displacement in the use of Lake Arlington by boaters.

   b. Areas that respondents most often avoided were Zone 6 and Zone 1, the far south and west segments.

   c. Areas that respondents most often felt unsafe were Zone 6 and Zone 1, the far south and west segments.

   d. Respondents indicated the depth of the water, submerged obstacles, and "rowdy" people as reasons for avoiding these areas of the lake and/or for feeling unsafe.

   e. In response to encountering others on Lake Arlington over the 2009 boating season, for the most part, respondents indicated not feeling crowded. Additionally, they indicated that the number of other boaters encountered was:

      - Consistent with what they had expected;
      - Had little effect on their enjoyment; and
      - Did not significantly impact their perceived safety.

f. When asked if some activities should be restricted to certain areas of the lake, most respondents indicated that they were comfortable with the current activity use patterns occurring on the lake. The only boat type considered inappropriate was “high performance boats”.

3. Areas of Lake Arlington Requiring Potential Managerial Action

   a. Most respondents did not feel additional controls were required to manage conflict on or damage to the lake.

   b. The most salient issues that respondents felt were problematic on the lake were:

      - Litter along the shoreline;
      - Shallow water
      - Changes in the lake’s water level; and
      - Fish habitat.

   c. Potential management actions receiving strongest support focused on:

      - Requiring training for the operation of PWC;
      - Developing fish stock to improve fishing on the lake; and
      - Dredging the lake to improve depth.

   d. There was strong support for up to a 20% increase in permit fees that would generate revenue to be spent on litter collection, upgrading park amenities, and code enforcement.

   e. There was no strong opposition to the development of standards or guidelines for shoreline structures such as retaining walls, docks and piers.

4. Suitable Development on Lake Arlington

   a. Respondents were somewhat split on the issue of providing additional facilities or services on Lake Arlington. Specifically, with regard to marina development, a slight majority were accepting of the proposition. Of these, most were in favor of a development that had a capacity of 40 boat slips or less. the City may decide to start with approval of fewer slips.

B. Recommendations
Based on the survey and analysis described above, the site visit to Lake Arlington, and the team’s professional experience on similar projects, the following recommendations are offered for consideration:

1. Overall, the current management practices being used for Lake Arlington are providing a satisfactory recreational experience and a safe environment for users of the lake. At this time, it does not appear necessary to implement additional zoning or more intensive use restrictions (except with regard to two types of watercraft as discussed below).

2. We recommend that the best management practices (BMPs) discussed elsewhere in this report be implemented in order to minimize litter. We also recommend that the City increase its litter and trash

disposal activities around the lake, such as adding more “no dumping” signs and more trash cans at access points. We also recommend that related public education be increased. This education could include signs directly around the lake and within the watershed.

3. In the survey, lake users indicated a willingness to pay higher user fees, if the related revenues were used for the direct benefit of Lake Arlington. We recommend that the City implement regular, periodic user fee rate increases in order to fund at least a portion of the improvements and enhancements described below. These rate increases should be based upon a cost-of-service approach that clearly describes and defines the funded activities, as well as the beneficiaries.

4. In order to fund projects and enhancements that have more broad-based beneficiaries, the City should consider using money from its General Fund or other sources. The survey showed that users and residents appreciate the proximity and quality of Lake Arlington. The City might also consider the implementation of a “flowage easement” fee associated with the land around the lake where additional operations or enforcement activities are needed.

5. The survey identified the need to make improvements and enhancements to the three existing parks on Lake Arlington. We understand that the Arlington and Fort Worth parks departments have, or are in the process of developing, master plans for these parks. We recommend that improvements be made in accordance with those plans, as funds permit.

6. Logs and other large debris were identified as safety hazards and detrimental factors affecting recreational boating on Lake Arlington. We recommend that the City consider the implementation of a program to periodically patrol the lake, remove such debris, and properly dispose of it.

7. We recommend that the City work with Texas Parks & Wildlife Department (TPWD) to continue conducting periodic fish habitat studies of Lake Arlington. Such studies would identify means and methods for improving the fishing by enhanced construction of structures (such as rock placed along the bottom of retaining walls) and public education. Although State funding for stocking programs is becoming more limited, many lake owners develop cooperative agreements and stocking programs with fishing organizations such as Trout Unlimited and bass clubs.

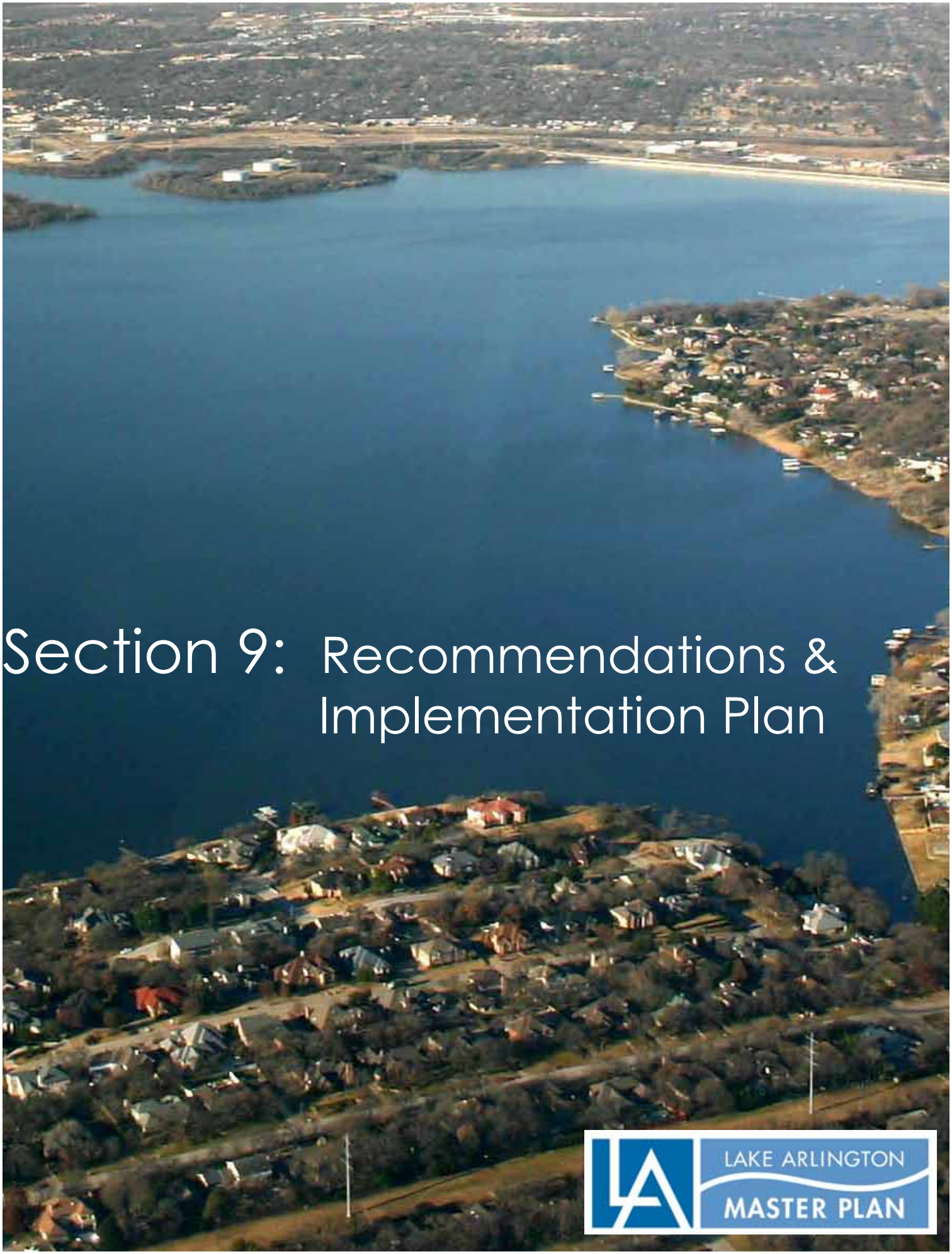
8. The survey determined that lakeshore owners are not generally opposed to development of uniform standards for structures such as piers, docks and retaining walls. Other members of the Master Planning team are developing recommended standards and templates. We recommend that the City adopt policies and procedures implementing those standards in order to enhance the recreational experience by boaters and other lake users, and to protect the investment made by the City and private property owners. We also recommend the City actively educate property owners about the flowage easement, and communicate to lakeshore property owners the standards governing the construction of shoreline structures and shoreline improvements.

9. We understand that the water level of Lake Arlington is determined by the amount of water diverted from the lake for treatment purposes, and the City’s contract with the Tarrant Regional Water District (which operates a regional system of reservoirs), and possibly others. Per that contract, the City does not have control over the lake level. We recommend that the City continually look for opportunities to keep a more stable lake level.

10. The south end of Lake Arlington has been identified as an area that is very shallow, especially when the lake is below elevation 543.0 feet. Although this shallow depth and debris lodged in the area produce safety issues, the area also exhibits some beneficial characteristics. We understand that during some months, waterfowl inhabit the area, and the shallow areas are enjoyed by kayakers, canoeists and fishermen. Dredging activities are very expensive because of the costs associated with permitting, materials handling and spoil disposal. Unless there are significant water quality or quantity reasons, it may not be practical or advisable to dredge a large portion of Lake Arlington. However, the City should study the feasibility of dredging access lanes or canals in the southern portion of the lake in order to improve access and water flow.

11. The only new regulations or use restrictions that were widely supported in the survey relate to “high performance boats” and training for PWC operators. We recommend that the City study such a regulation in consultation with City police and/or TPWD game wardens that would be responsible for enforcing a related ordinance. We also recommend that the City work with TPWD and the US Coast Guard Auxiliary on the establishment of educational programs, training programs and possibly licensing for PWC operators.

12. The survey results indicate that there is little opposition to, and possibly some justification for, the development of a marina on Lake Arlington, especially if that marina provides additional services to boaters using the lake. The most logical location for a new marina would be on the west side of the lake. If the marina is located on the southwest side of the lake in the shallower areas, we recommend that the developer be required to dredge and maintain a safe access channel from the marina into open water. The City should maintain its authority to approve the number, location and size of marinas located on the lake. Because of the speculative nature of marinas, we also recommend that the City approve and permit such facilities on an incremental basis so that each phase proves its viability before a new phase or increment is approved. If requested, we recommend that the City consider approving a marina within a range of 20 to 40 boat slips as a logical first phase of development.



Section 9: Recommendations & Implementation Plan

LAKE ARLINGTON MASTER PLAN

9. Recommendations and Implementation Plan

9.1 Principles, Recommendations and Implementation Plan

Specific technical recommendations for each project task are found within the previous sections of this Master Plan, including recommended programs, BMPs, standards, and design guidelines. Those detailed recommendations are not repeated in this section. This section describes the principle segments of the recommended programs and projects, and the guidance required to implement the detailed recommendations.

9.1.1 Principle: Organizational Structures and Processes

Develop organizational structures and on-going processes/programs that assure the protection and enhancement of Lake Arlington's water quality. To implement this principle, the following recommendations are provided:

A. Within the City of Arlington, establish a permanent Lake Arlington Task Force that will meet on a monthly basis to address the implementation of this Master Plan and the management of Lake Arlington. The Task Force should be chaired by the Director of the Water Utilities Department. The following departments should be included: Water Utilities; Community Development and Planning; Community Services; Parks & Recreation; Police; and Public Works.

B. The City of Arlington and the City of Fort Worth should continue to meet regularly as a continuation of the regular Coordination Meetings held during this planning process. The meetings should be held quarterly for the first few years at which time, the meetings can be scheduled biannually. The major issues to be addressed include: shoreline standards and permitting; development within the Flowage Easement; detailed planning within the area around the lake, including development of trails systems and natural areas; and the implementation of the Lakeshore Drive Project.

C. In conjunction with the NCTCOG, the City of Arlington should develop a Watershed Council for the Lake Arlington watershed for the purposes of implementing the Master Plan recommendations related to BMPs, storm water planning and MS4 permitting, and the purchase and maintenance of conservation easements. The representatives on the Council should include the cities and counties within the watershed, TRWD, and TRA. The Council may also want to periodically coordinate with the Tarrant County Mayors Council.

D. The Cities of Arlington and Fort Worth should consider establishing a non-profit group to support the management and enhancement of Lake Arlington by advocacy, fund raising, education, and promotion. Such a "Friends of Lake Arlington" type group could serve an advisory role, similar to the focus groups used in the planning process. The group could also raise awareness about lake issues and needs, and raise funds for projects that cannot be funded by the cities.

E. Public involvement and education is a critically important aspect of implementing the Master Plan. The following paragraphs summarize the key recommendations.

Within the Watershed

<u>BMP Education Program</u> – Work with the NCTCOG to develop and implement a comprehensive public education program designed to inform citizens within the watershed about BMPs that they can be

responsible for in their daily personal and work activities. The public education program should be ongoing and can emphasize "good partners" through some type of recognition program.

Events and Celebrations - Celebrate worthy activities that are a result of the planning and collaboration from the Master Plan. For example, plan a groundbreaking and dedication of the Linear Park System and include officials from throughout the North Central Texas Region.

Signage – Post signage throughout the watershed to educate citizens that they are within the Village Creek/Lake Arlington watershed.

Public Officials Information Packet – Develop an informational packet about the Master Plan for elected officials for all cities and counties in the watershed. The packet can include a cover letter, project fact sheet, and project summary newsletter.

Immediately Around the Lake
Create a "Friends of Lake Arlington" group and possibly "adopt-a-shoreline" groups – Develop citizen led groups that can take ownership of the ongoing collaboration and community support necessary to effectively implement a long-term vision plan. Members of the existing business, community, and parks roundtables are a good database from which to draw.

Fort Worth
Provide regular updates to the Fort Worth City Council – Provide Master Plan updates to the City Council.

Arlington
Assign a Staff Person to LAMP Public Involvement Implementation – As part of the Task Force, designate staff time and responsibility to person(s) who can provide leadership and coordination of public involvement related activities.

Signage – Make sure that the Lake Arlington Master Plan logo is included on construction signage for any new development and redevelopment projects within the study area.

Provide regular updates to Arlington City Council – Provide Master Plan updates to the City Council. Updates should be provided every three months.

Property Owners and Affected Residents

Bill Stuffers – Include periodic updates on the progress of the Master Plan in Arlington and Fort Worth utility bills.

School Outreach Programs – Coordinate with local schools in the Lake Arlington area to develop a learning opportunity centered on water quality, the Master Plan recommendations, and park activities.

Maintain the existing website and update materials including:

- Project Talking Points – Write key messages and informational points for city staff to use when discussing the implementation. These should be updated monthly.

- Project Fact Sheet – Update the brief final summary of the Master Plan, process, timeline, recommendations, and contact information. This fact sheet can be placed at local businesses and used in the media kit and Public Officials Information Packet.
- Project Summary Newsletter – Update the final summary of the Master Plan, process, timeline, recommendations, and contact information. This can be sent to all contacts via email from the Project database, with copies provided for cities in the watershed.
- Update Library Display – Update the library display with recommendations, final overview/summary of the Master Plan process. Provide fact sheets that individuals can take with them at this display.
- Content for City Webpage – Provide contacts for the City of Arlington website related to the project and recommendations. This should be updated every three months.
- Mailing List/Database – Research and compile updated stakeholder databases to include elected officials, key influencers, and property owners affected by the Master Plan. This should be updated monthly.
- Email/Hotline Monitoring and Response – Set up and monitor an email and hotline for interested parties to leave questions or comments about the Master Plan.

Traditional Media and Social Media

Host Editorial Board Meetings – Periodically sit down with the editorial boards and or reporters to brief them on the results of the Master Plan and ask them to take a position of support of the Plan.

Media Kit – Develop a media kit for local media outlets to provide them with information on findings, recommendations, the Master Plan process, and contact information. This kit should include the Fact Sheet and Project Summary Newsletter.

Lake Arlington Facebook Page – Create a facebook page for Lake Arlington. By this means the City can provide information on the Master Plan process, updates, contact information, and it can serve as a way for stakeholders to post questions, comments, etc.

9.1.2 Principle: Area of Primary Influence

Within the Area of Primary Influence (API) immediately around and within 1,000 feet of Lake Arlington, implement projects, processes, and programs that protect and enhance the quality of the lake. To implement this principle, the following recommendations are provided:

A. The City of Arlington should continue to monitor the Fort Worth trash collection and management pilot program over the next two years. The data collected in that study will provide implementation guidance for the development of such systems in Arlington and within the watershed. In addition the City of Arlington should monitor the Lakeshore Drive Project to insure that the recommended BMPs are included in the final design.

B. The Cities of Arlington and Fort Worth should document with photographs, GIS mapping, and data collection the sections of the cities most affected by trash and debris. This documentation can then be used to guide the efficient implementation of BMPs.

C. As soon as practical, the City of Arlington should adopt the latest versions of the NCTCOG Integrated Storm Water Management (iSWM) Program for Construction and Development. As a cooperative initiative that assists cities and counties within the watershed to achieve goals of water quality and

streambank protection, and flood mitigation, the program can serve as an incentive to get participation throughout the watershed. The program can also help communities meet their construction and post-construction obligations under state stormwater permits.

D. The Cities of Arlington and Fort Worth should develop requirements for the proper application of recommended herbicides and pesticides on public land within the API. With regard to the application of herbicides and pesticides on private property, the cities should develop educational programs to promote the proper use of chemicals that will prevent degradation of the lake.

E. The City of Arlington should immediately adopt the standards and design guidelines recommended in this Master Plan. Following such adoption, the city should begin training the staffs of both Arlington and Fort Worth, as well as developers, contractors, and the public. At that time, the city can begin to implement a code enforcement process (using the city's new GIS photo database).

F. Using the coordination meeting process recommended in the prior section, the Cities of Arlington and Fort Worth should begin more detailed comprehensive planning for development within the study area, for improvements at existing parks, and for the development of the trails systems recommended in the Master Plan. These planning efforts should be coordinated with Kennedale and other communities that could be linked to the hike and bike trails system. Such detailed planning documents can then become the basis for funding efforts.

G. Based on the BMPs and potential enhancements recommended in the Master Plan, the cities of Arlington and Fort Worth should develop amended permit requirements for future gas drilling activities within the API.

H. If the City of Arlington desires to implement dredging projects in the lake, more detailed studies are recommended. Dredging within selected areas of Lake Arlington is one of the enhancements recommended in the public meetings and the Boating Capacity Study. Dredging can be implemented in two ways: by the City of Arlington as part of a general program to increase the depth and storage capacity in the upstream end of the lake; or by private individuals or developers interested in improving access to specific shoreline properties.

In either case, dredging must be approached cautiously because of potential water quality issues and because of the high cost of permitting, implementation, and maintenance. Detailed sediment sampling and water quality analysis will be needed in any areas proposed for dredging. In addition, it is important to implement sediment transport BMPs within the watershed in order to protect the investment made in any dredging projects.

I. In order to implement specific recommendations from Boating Capacity Study, the Pirnie Team provides the following guidance:
- The City of Arlington should work with Texas Parks & Wildlife Department (TRWD) to continue conducting periodic fish habitat studies of Lake Arlington.
- The City of Arlington should continually look for opportunities to keep a more stable lake level. This could be achieved by continually discussing the issue with TRWD, and by exploring other sources of inflow such as dedicated highly treated water from upstream water reclamation plants.
- We recommend that the City study the regulation of high performance boats in consultation with

City police and/or TPWD game wardens. We also recommend that the City work with TPWD and the US Coast Guard Auxiliary on the establishment of educational programs, training programs, and possibly licensing for PWC operators.

J. The City's Lake Arlington Task Force should meet regularly with Exelon to look for additional opportunities to involve the electric generator in the implementation of the Master Plan. There is the potential to work collaboratively on the implementation of trash and debris collection and management because we know that Exelon has experienced its own problems. Working on this mutual issue should serve as an avenue to get other initiatives implemented, such as using parts of the Exelon property for trails and/or protecting natural habitat.

K. The City of Arlington should continue to work with Kennedale and the USACE on the Village Creek eco-restoration study. The two cities should play an active role in the study process, and they should consider negotiating a management role in the implementation of any projects that result from the studies.

9.1.3 Principle: Watershed

Within the remainder of the Lake Arlington watershed, work collaboratively with other cities, the counties, and other entities to implement projects, processes, and programs that protect and enhance the quality of the lake. To implement this principle, the following recommendations are provided:

A. The City of Arlington should work collaboratively with the NCTCOG and its Stormwater Council to use the Master Plan as a guidance document for MS4 permitting with cities and counties within the watershed. This communication and coordination process should include the development of programs to educate watershed entities on the benefits of working collaboratively and using the BMPs recommended in the Master Plan.

B. The City of Arlington should consider using an adaptive management approach to implementing BMPs within the watershed. This approach would involve monitoring and documenting water quality within the watershed, documenting the implementation of BMPs within the watershed, and funding periodic studies to evaluate the cost effectiveness of the programs and standards being implemented.

C. The City of Arlington should continue to use the data developed in the Master Plan process to assist the NCTCOG and the Trust for Public Land in the Greenprinting project for the Lake Arlington watershed, and then use the results of the Greenprinting modeling to guide the acquisition of conservation easements within the watershed. Develop agreements for acquisition and maintenance by the appropriate agencies. Funds from the TWDB SRF loan can be used to purchase the easements or to obtain development rights by other means.

D. It is very important that the City of Arlington continues to stay actively involved in the TCEQ processes related to the permitting and renewal of industrial and municipal wastewater discharge permits within the watershed. The water quality modeling performed in the planning process has documented the importance of nutrient removal in order to minimize potential treatability problems. Therefore, the primary objectives should be nutrient renewal with a phosphorus limitation of 1.0 mg/L; compliance with TCEQ's requirements for the "Lake Arlington water quality area" as found in 30 TAC 311.61-311.66 (including filtration); and plant operations by a competent entity, ideally one of the municipalities in the watershed or the TRA.

Although each permit process must be assessed individually, the city's involvement should generally follow these steps:

- Validate and document the proposed permit conditions or permit changes for flow rate, constituents regulated and permit limits (max month, annual);
- If there are major concerns based on the new or proposed conditions, the City should model the load increases to determine the potential impacts on Lake Arlington;
- In that modeling effort, the City should estimate and document the impact to water quality with the assumption that the City might need to use this information in a contested hearing process before TCEQ and/or the State Office of Administrative Hearings (SOAH);
- Compare the impacts against the lake's assimilative capacity threshold levels for the permit parameters of concern; and
- Elevate concerns within the City and with key stakeholders for additional action, if the new limits exceed the assimilative capacity.

E. The City of Arlington should continue to be a participant in the TCEQ's Source Water Protection program and update the Detailed Survey of Pollution Sources at least once every five years.

F. The City of Arlington should work with TxDOT to erect watershed protection signs on major roads throughout the watershed. If the signs meet TxDOT criteria, TxDOT will pay for the manufacture and installation of the signs. However, if Arlington wants a more unique sign of its own design, it will have to pay for the signs and work with TxDOT for installation.

G. The Pirnie Team recommends that the Cities of Arlington and Fort Worth initiate a program to educate developers, engineers, planners, and watershed cities on methods related to conservation development and low impact development (LID). These educational programs can be coordinated with environmental organizations such as the Sierra Club and the Audubon Society, as well as public entities such as NCTCOG and the USDA Natural Resource Conservation Service.

9.1.4 Principle: Funding

Continue to pursue funding from a variety of sources in order to expeditiously implement projects, processes, and programs that protect and enhance the quality of Lake Arlington. To be successful, it is recommended that the City tailor its funding efforts to specific agencies and sources, while continually looking for new programs. To implement this principle, the following recommendations are provided:

A. The City of Arlington has applied to the TWDB for funding through SRF. In this current application the funds are to be used for specific Lake Arlington projects such as dredging and debris removal, and for future projects such as acquisition of conservation easements. The TWDB, under both the Clean Water and the Drinking Water programs will continue to be a good source of low interest loans (and possibly grants from time to time) for source water protection projects.

B. CWA Section 319 funding through the SSWCB is also available for conservation easements and for the implementation of watershed BMPs.

C. TPWD is the most likely source of funding (typically matching 50% grants) for parks improvements, trails projects, and for the purchase/protection of natural areas around the lake and within the watershed.

D. The City of Arlington should continue to work with Fort Worth and other entities such as Kennedale on

potential sources of federal funds. For example, Arlington and Kennedale should continue to pursue the USACE eco-restoration project for Village Creek. There may also be federal funds available because Fort Worth has an established Neighborhood Empowerment Zone on the west side of the lake. Federal programs such as the USACE projects can be frustrating because of the time and initial expense involved during the study phases. The payback comes in the form of federal funds for implementation, but that often requires specific appropriations.

E. The Pirnie Team recommend that the City of Arlington implement regular, periodic user fee rate increases in order to fund at least a portion of the improvements and enhancements described above.

F. In order to fund projects and enhancements that have more broad-based beneficiaries, the City should consider using money from its General Fund or other sources such as the Tomorrow Fund Foundation. The City might also consider the implementation of a "flowage easement" fee associated with the land around the lake where additional operations or enforcement activities are needed.

G. The City of Arlington should continue to work collaboratively with entities that have a vested interest in the protection and enhancement of Lake Arlington. These entities include TRWD, TRA and Exelon.

9.2 Implementation Plan

9.2.1 Emergency Plan

This Master Plan provides short-term and long-term strategies and recommendations for the protection of the water quality in Lake Arlington, such as the implementation of BMPs within the watershed to reduce potential pollution. However, water quality problems can result from activities and actions that occur more rapidly than more gradual changes such as land uses moving from rural to urban. Emergencies such as a train derailment or overturned truck can be catalysts for pollution of the lake if hazardous chemicals are discharged into Village Creek or one of its tributaries. Therefore, emergency planning must be mentioned as one component of overall water quality protection.

The Arlington Water Utilities Department has a Water Resource Services Division that manages a watershed protection program for Lake Arlington and Village Creek. As a part of this program Division staff members conduct regular surveillance of the watershed. These employees conduct visual inspections and field sampling of the main tributaries to detect active and potential sources of pollution. The Division also coordinates its activities with state, county, and local regulatory agencies, as well as the Tarrant Regional Water District. It works to stop illegal or improper dumping through educational activities and by reporting violations to Tarrant and Johnson County officials, and TCEQ.

The City has established emergency procedures that include protocols for protecting the water supply in case of potential contamination. At the current time, the policy states: "In case of contamination – or articulated threat of contamination with unspecified materials – of the source water, sampling should be increased at or near the system intakes and, if possible, the source water should be isolated."

As part of the City's emergency planning, the Water Resource Services Division also maintains a list of contact telephone numbers so that emergencies can be quickly reported to the proper regulatory authorities, as well as other Water Department personnel. This list is periodically updated. Appendix 9.2 provides a recommended protocol for handling reported emergencies.

The City also has considered the possibility of needing to isolate a source of upstream contamination in an emergency. For example, it might be necessary to install booms, absorbent materials or temporary earthen coffer dams to prevent a source of contamination from flowing downstream during a rain event. The Arlington Fire Department has containment booms on hand, and the City's Environmental Services Department has a contract with a hazmat/clean-up firm. The City also has an established dispatch procedure.

9.2.2 Organizational Structure

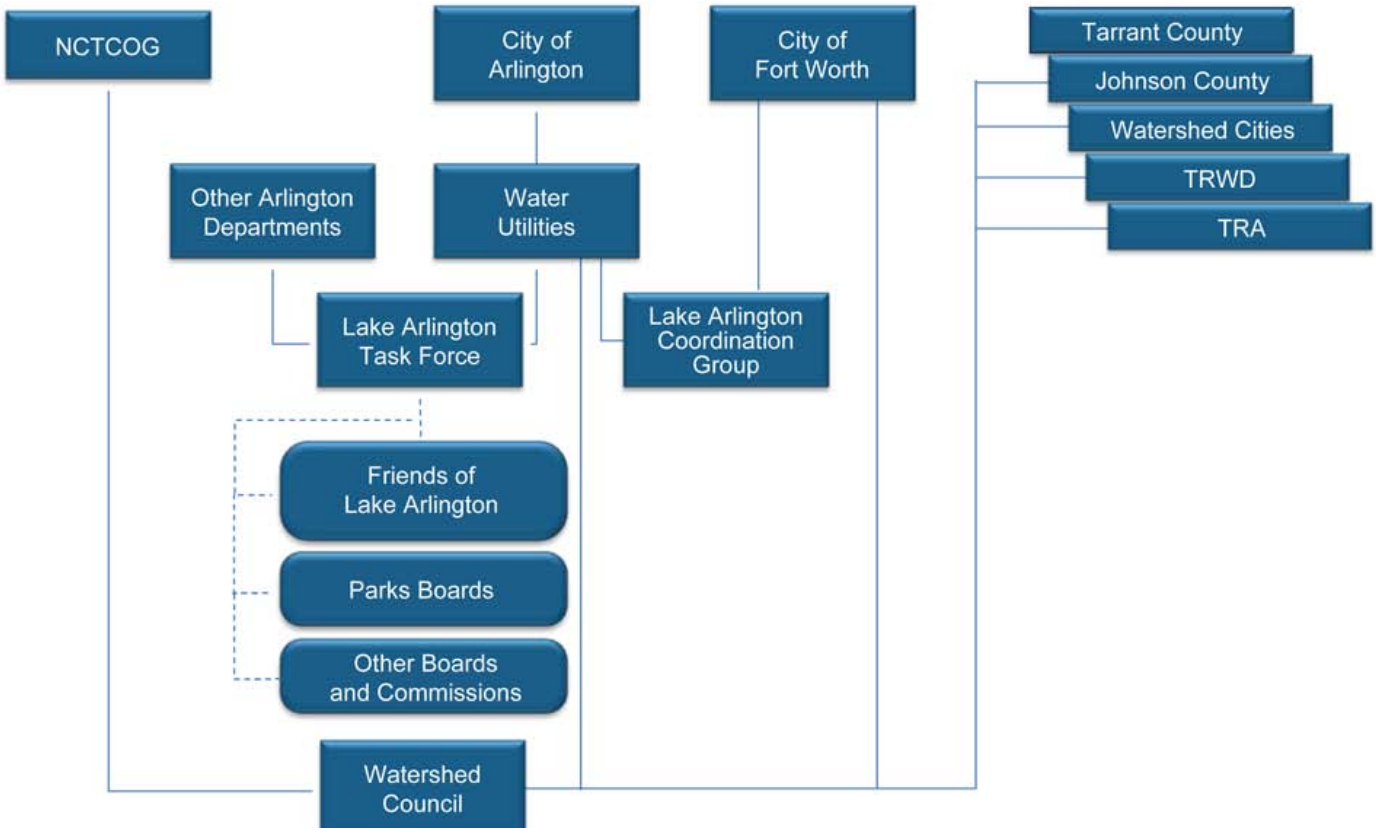


Figure 9.2-1: Organizational Structure

9.2.3 Implementation Steps and Action Plan

Because of the integrated nature of this Master Plan and the various tasks involved in the planning process, the implementation of the Plan can seem overwhelming. Therefore, the Pirnie Team recommends that the City of Arlington work in a logical manner on the most important projects and programs that will have the greatest immediate benefit to Lake Arlington. The Team recommends that the following key tasks be implemented first:

- To keep the momentum of the Master Plan process, the Cities of Arlington and Fort Worth should implement the recommended organizational structures and processes found in Section 9.1.1 above. Each of the groups and processes plays an important role in overall implementation of the various technical recommendations found in the Master Plan.
- In the Master Plan, there are a number of recommendations related to trash and debris collection and management. These recommendations range from monitoring the Fort Worth pilot project to

purchasing a boat to begin removing logs and large debris from the lake. The trash and debris collection recommendations are extremely important even though they may not seem as critical to water quality as other measures. Trash and debris issues were continuously mentioned during public meetings, in the Boating Capacity Study survey, and by study team members. Some trash and debris has the potential to cause degradation of water quality, and it definitely affects the public's perception of its water supply reservoir.

- The shoreline standards and design guidelines should be adopted by the Arlington City Council as soon as possible. Not only do these standards affect the ability of City residents to move ahead with modifications and improvements around the lake, they also serve to protect water quality and safety.
- Within the watershed, it is important to begin implementing BMPs and measures to protect water quality. The implementation of some of these BMPs will require the cooperation and participation of other municipalities and/or the two counties, and it is important for the City of Arlington to begin working cooperatively with the NCTCOG to achieve this cooperation, as described above. However, the City of Arlington is in a position to implement other important programs, such as the purchase of conservation easements, and the involvement in the permitting processes for wastewater discharges in the watershed.

9.2.4 Responsibilities

The organizational chart in Section 9.2.2 describes the overall structure necessary to implement this Master Plan. Within the City of Arlington, the overall responsibility resides with the Water Utilities Department. However, the cooperation of many other city departments is absolutely essential to successful implementation. Because of the nature of watershed protection, all of the entities, and ultimately those who reside in the watershed, must be involved. The Master Plan provides guidance on how to get cooperation and involvement from these other participants in the process.

9.2.5 Potential Funding Sources

The following sections describe potential funding sources (grants and/or low interest loans) for implementation of the Master Plan.

A. Source Water Protection

The following Table 9.2-1 shows a list of state and federal funding programs that are designed to prevent pollution of source waters. Public entities in Texas such as the City of Arlington and the communities in the watershed are eligible to apply for all of these funding sources.

The following paragraphs describe in more detail some of the referenced funding sources that might have direct applicability to the implementation of the Lake Arlington Master Plan.

1. Brownfields Cleanup Revolving Loan Fund:
   The objective of the Brownfields Cleanup Loan Fund program is to capitalize loan funds that can make loans or grants to facilitate cleanup of brownfield sites contaminated with hazardous substances or petroleum products, as well as 'drug labs.' Eligible organizations include businesses, nonprofit groups, local governments, state/territorial agencies, or tribal agencies. For more information, see: http://www.epa.gov/brownfields.

	Polluted Runoff Control						Resource Protection and Restoration						Wastewater Treatment	
	Agriculture	Forestry	Mining	Brownfields	Storage tanks	Landfills	Hydromodification / Habitat Modification	Wetlands / Riparian Zone	Land Acquisition / Conservation Easements	Groundwater Protection Measures	Land Use Controls	Public Education	Stormwater	On-Site Sewage
Funding Sources														
Brownfields Cleanup Revolving Loan Fund Pilots			•	•								•		
Clean Water State Revolving Fund Loans	•	•	•	•	•	•	•	•	•	•		•	•	•
Drinking Water State Revolving Fund Set-Asides	•	•	•	•	•	•	•	•	•	•		•	•	•
Nonpoint (319) Source Implementation Grants	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Pollution Prevention Incentives for States										•	•	•		
Water Pollution Control (106) Program Support	•									•	•	•	•	
Water Quality Cooperative Agreements	•	•	•	•	•	•	•	•		•		•	•	•
Watershed Assistance Grants										•		•		
Wetlands Program Development Grants		•					•	•				•	•	
Watershed Processes and Water Resources Program	•	•												
Watershed Protection and Flood Prevention Program	•						•	•		•	•	•		
Land and Water Conservation Fund	•	•	•				•	•	•		•			
Partners for Fish and Wildlife Program	•	•						•	•			•		

Table 9.2-1: State and Federal Funding Programs

2. Clean Water State Revolving Fund Loans:
   Funds are used to make low interest loans to communities, individuals, and others for water-quality improvement activities. Traditionally the funds have been used for wastewater treatment facilities, however loans are used increasingly for other water quality management activities including nonpoint source and estuary projects (Nonpoint Source Pollution Loan and Estuary Program). In Texas, this program is administered by the Texas Water Development Board (TWDB), and the City is familiar with the application procedures.

3. Drinking Water State Revolving Fund Loans:
   Under the Safe Drinking Water Act, up to 15% of the DWSRF funds may be used for set-aside activities including loans for the acquisition of land or easements for source water protection or for implementation of source water protection measures, or direct assistance for wellhead protection programs. This program is also administered by the TWDB, however source water protection applications are ranked by the Texas Commission on Environmental Quality (TCEQ). The current TCEQ contact for source water programs is Mr. Sean Ables (512-239-1758). Projects must be consistent with the State Water Plan.

   The City has submitted an application to TWDB for projects related to protecting the water quality of Lake Arlington and implementing this Master Plan. A more detailed description of that application is discussed below.

   On January 7, 2010, the City submitted information to the TWDB in order to be included in the 2011 DWSRF Intended Use Plan for Capital Improvements Projects. In response to a request from TWDB, the City submitted on October 27, 2010 TWDB Form 0163 (Green Reserve Information Worksheet) with a list of proposed projects totaling $8,963,120. The following paragraphs describe the projects proposed by the City for implementation of this Master Plan.

a. Bioretention Structures and Wetlands. Bioretention structures and constructed wetlands are recommended for new construction of roads and major infrastructure projects. The most beneficial locations will be determined by detailed, site specific studies. The wetlands will be maintained by public entities or through landowner cooperative agreements. Requested: $1,763,120.

b. Dredging. Dredging in selected areas of Lake Arlington could improve water quality in the lake. The exact location, design, and cost will be determined by site specific studies. The City or private cooperators will maintain the dredged channels and areas. Requested: $2,800,000.

c. Riparian Corridors. Permanent riparian areas would be acquired from willing landowners through conservation easements. The most beneficial locations could be selected during the “Greenprinting” modeling process currently being conducted by the North Central Texas Council of Governments and the Trust for Public Land. Based on subwatershed data developed in the Master Plan process, the TPL will use the Greenprinting model to select the most beneficial properties for conservation easements. The easement areas will be maintained by public entities or through cooperative agreements with the landowners. Requested: $2,000,000.

d. Debris Removal Equipment. A significant quantity of debris and trash with potential contaminants currently enters the lake. BMPs will be recommended to collect and reduce the quantity of debris and

trash, however the problem cannot be completely eliminated. A debris collection and removal boat could be used on the lake to continually remove potential sources of contamination from the water. Requested: $400,000.

e. BMPs. A major component of this Master Plan is the implementation of watershed BMPs to reduce potential sources of nonpoint pollution. Because most of these BMPs will be implemented within the watershed but outside the City of Arlington, the City may need to provide financial incentives to other entities. For example, under interlocal agreements, the City may construct BMPs in areas of the watershed outside of its jurisdiction. The maintenance of the BMPs will be provided by public entities or under cooperative agreements with landowners. Requested: $2,000,000.

4. Nonpoint [Clean Water Act 319 (h)] Source Implementation Grants:
This program provides grants to states to implement nonpoint source projects and programs. These include Best Management Practices (BMP) installations for animal wastes and sediment, pesticide and fertilizer control, stream bank restoration, lake protection/restoration, septic system restoration, and management. Beneficiaries are generally required to provide 40% of the total project or program costs.

In Texas, the program is administered through the Texas State Soil and Water Conservation Board. The Board periodically requests proposals for watershed assessment, planning, implementation, demonstration, and education projects seeking funding under the program. Proposed projects should focus on agricultural and/or silvicultural nonpoint source pollution prevention and abatement activities within the boundaries of impaired or threatened watersheds but may also include unimpaired watersheds. Proposals must focus on the restoration and protection of water quality, and a competitive proposal process is used for selection.

Specific activities that can be funded with §319(h) grants include: development of detailed watershed protection plans including the formation and facilitation of stakeholder groups; surface water quality monitoring; data analysis and modeling; implementation of nine-element watershed protection plans and the nonpoint source portion of total maximum daily load implementation plans; demonstration of innovative BMPs; technical assistance to landowners for conservation planning; public outreach/education, and monitoring activities to determine the effectiveness of specific pollution prevention methods.

More information is available at: http://www.tsswcb.state.tx.us or by contacting the Board at (254) 773-2250.

5. Pollution Prevention Incentives for States:
This program provides grants focused on institutionalizing multimedia (air, water, land) pollution prevention techniques. Eligible entities include state and local agencies, universities, nonprofit organizations, and private business. Projects include technical assistance, data collection, education and outreach, training, environmental auditing, demonstration projects, and the integration of pollution prevention into state regulatory programs. For more information, see: http://www.epa.gov/p2/grants/.

6. Water Pollution Control (106) Program Support:
This program provides grants to states, tribes, and interstate water pollution control agencies to sup-

port the prevention and abatement of surface and groundwater pollution from point and nonpoint sources. Eligible activities include water quality planning, monitoring, permitting, surveillance, enforcement, advice, and assistance to local agencies, etc. for the purpose of establishing and maintaining water pollution control programs. For more information, see: http://www.epa.gov/owm/cwfinance/pollutioncontrol.htm.

7. Water Quality Cooperative Agreements [104(b)(3) Grants]:
   This program provides grants to support innovative demonstration projects for addressing stormwater, combined sewer overflows, sludge, pretreatment, mining, animal feeding operations, and other sources relating to the National Pollutant Discharge Elimination System (NPDES) program. This includes research, investigations, experiments, training, surveys, and studies related to the causes, effects, and prevention of pollution. For more information, see: http://www.epa.gov/owm/cwfinance/waterquality.htm.

8. Watershed Assistance Grants (WAG):
   The purpose of this program is to build cooperative agreements between nonprofit organizations and other eligible entities to support watershed partnerships and long-term effectiveness. Funding then supports organizational development and capacity building for watershed partnerships with a diverse membership. Grants will be distributed to a pool of applicants, which are diverse in terms of geography, watershed issues, the type of partnership, and approaches. For more information, see: http://www.rivernetwork.org/howwecanhelp/index.cfm?doc_id=94#wag.

9. Wetlands Program Development Grants:
   Provides financial assistance to states, tribes, and local governments to support development or enhancement of wetland protection, management or restoration programs. Projects must demonstrate a direct link to an increase in the states, tribes, or local governments' ability to protect wetland resources. Funding may only be used to enhance and develop new and existing state wetlands programs, not for their operational support. For more information, see: http://www.epa.gov/owow/wetlands/grantguidelines.

10. Watershed Processes and Water Resources Program: These programs sponsor research that address two areas: 1) understanding fundamental processes controlling source areas, the flow pathways of water, and the fate of water, sediment, and organisms within forest, rangeland, and agricultural environments as they are influenced by watershed characteristics; and 2) developing appropriate technology and management practices for improving the effective use of water and water quality for agricultural and forestry production. For more information, see: http://www.reeusda.gov/.

11. Farmland Protection Program: This program provides matching funds to existing farmland protection programs for the purchase of conservation easements. Eligible property includes farm or ranch lands that have prime, unique, statewide, or locally important soil and includes all cropland, rangeland, grassland, pasture land, incidental forest land, or wetlands. For more information, see: http://www.usda.gov/farmbill.

12. Watershed Protection and Flood Prevention Program: The 'Watershed,' or 'PL 566,' program provides technical and financial assistance for water resource challenges on a watershed basis. Projects related to flood mitigation, water supply, water quality, erosion and sediment control, wetland creation

and restoration, fish and wildlife habitat enhancement, and public recreation are eligible for assistance. Technical and financial assistance is also available for planning new watershed surveys. While this program has been severely underfunded in recent years, there are periodic opportunities. Therefore, it is recommended that the City maintain continual contact with the U.S. Department of Agriculture's Natural Resource Conservation Service. For more information, see: http://www.nrcs.usda.gov/programs/watershed/.

13. Land and Water Conservation Fund (LWCF): LWCF uses offshore oil leasing revenues to support grants to States, and through States, local units of government for the acquisition and development of state and local park and recreation areas that guarantee public use in perpetuity. All funded projects must be available for public recreational use. Texas Parks & Wildlife is the administrative agency in Texas, and the City is familiar with this program.

14. Partners for Fish and Wildlife Program: Since 1987, the program has partnered with more than 28,725 landowners to restore over 639,000 acres of wetlands; 1,070,000 acres of prairie, native grassland, and other upland habitats; and 4,740 miles of in-stream aquatic and riparian habitat. In addition, the program has reopened more than 300 miles of stream habitat for fish and other aquatic species by removing barriers to passage. For more information, see: http://partners.fws.gov/.

B. Studies, Capital Improvements and Operations

1. U.S. Army Corps of Engineers Programs: In recent years the U.S. Army Corps of Engineers (USACE) has placed special emphasis on stream restoration and flood mitigation studies and projects, with co-operation and financial contributions from local non-Federal interests. In most cases, the federal share during the study phase of a project is 50%, but funding is dependent upon federal appropriations or inclusion within general legislation related to the USACE. With regard to Village Creek, a federal effort would be authorized under previous Trinity River legislation, but it would be dependent upon the actual appropriation of funds. The study effort for Village Creek is referenced in the NCTCOG's Vision North Texas Plan.

   Over the last year, the City of Kennedale and the City of Arlington have been in discussions with the USACE regarding a water quality enhancement study of Village Creek. If those studies are funded and show a positive benefit-cost ratio, implementation funding could be appropriated in order to implement one or more projects. To date, there has been no appropriation.

   While the federal contribution during the design and construction phases is greater than 50%, using the Corps as a funding source is a long and complicated process.

2. Arlington Tomorrow Fund Foundation: In 2007, the City of Arlington created a non-profit foundation to invest, manage, and distribute revenues generated from natural gas leases on City property. The foundation receives 90% of the bonus payment and 50% of the royalties. Twice each year, the foundation makes matching grants to city departments, non-profit agencies, and eligible community groups. As of January 2010, the foundation was managing a $55 million endowment.

   Given the importance of Lake Arlington as a multi-purpose resource, it is logical for the City to use grants from the Tomorrow Fund for important projects related to implementing the Master Plan.

3. Cooperative Agreements with Fort Worth, TRWD, TRA, and NCTCOG: Many of the recommendations developed in the planning process, provide benefits beyond the City of Arlington. Watershed and storm water planning and management, and the implementation of BMPs in the Village Creek watershed are closely aligned with the purposes, goals, and objectives of the City of Fort Worth, Tarrant Regional Water District (TRWD), the Trinity River Authority (TRA), and the NCTCOG. It makes sense for the City to develop cooperative agreements with these three agencies to produce mutual benefits and funding arrangements that take advantage of economies of scale.

4. Rate Increases for Permit Fees: The Boating Capacity Study effort found that there was general acceptance of rate increases when the additional revenues were used directly for the benefit of Lake Arlington and "…to assist in the upkeep of the lake." Eighty percent (80%) of the respondents supported an increase of 20% in the permit rates. Those who supported a rate increase recommended the following uses for the additional revenue: litter pickup; upgrading park amenities; code enforcement; fish stocking; dredging; removing trees and stumps.

   In order to make efficient use of rate increases, it is important to show users and constituents that the new revenues are being used effectively and efficiently. It is also recommended that regular, smaller increases in rates be implemented rather than infrequent large increases.

5. Special Service Fees: If the City implements the recommendation such as the purchase and operation of a "snagging" boat for the removal of large debris such as logs, there may be an opportunity to establish a special service fee for certain activities. When the City assists shoreline residents by removing large debris from their private property, the City is actually providing a specific service using very specialized equipment. It might be appropriate to establish a special fee for such services, especially on the Fort Worth side of the reservoir where Arlington does not benefit from any tax revenues. There may be other examples of ways to generate additional revenue from ancillary activities related to the operation of the lake.

9.2.6 Future Costs

Within each section of the Master Plan, there are cost ranges for implementation of specific technical recommendations. Given the breadth of this Master Plan, it is not possible to determine an overall total cost estimate to achieve the objectives of protecting the water quality of Lake Arlington. However, it is well known that source water protection is much cheaper than treatment of degraded water supplies. The most cost effective recommendations within the Master Plan include protection of natural areas around Lake Arlington and within the watershed, and incorporation of nutrient removal in future wastewater treatment plant permits. Protection of natural areas can best be achieved by the purchase of conservation easement on selected areas and maintenance of riparian corridors along major tributaries. Shown above is a description of the process that is recommended for the City of Arlington's continued involvement in the permitting and renewal of wastewater discharges within the watershed.