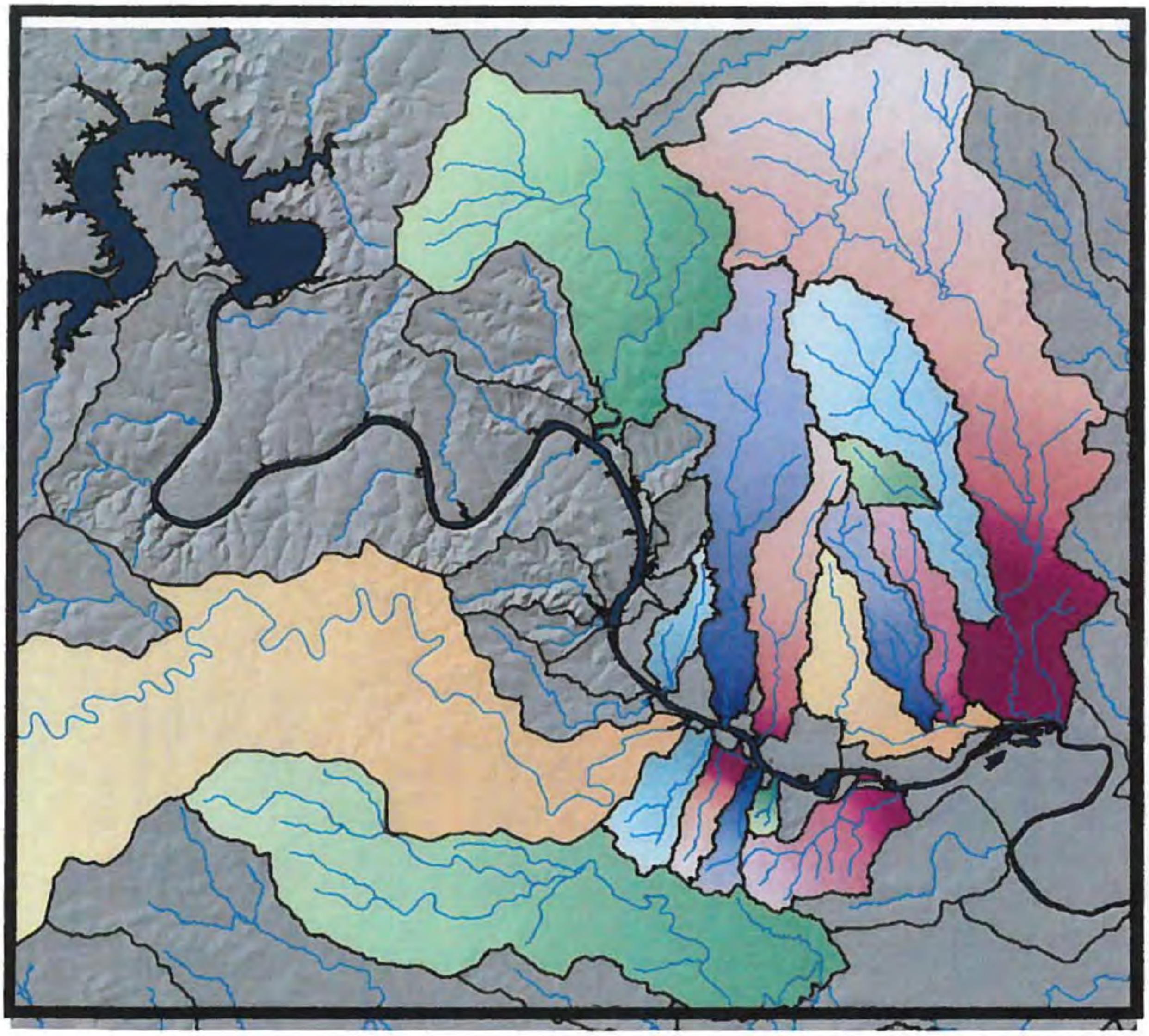
WATERSHED PROTECTION MASTER PLAN

Phase I Watersheds Report



FLOOD • EROSION • WATER QUALITY

City of Austin
Watershed Protection Department

Watershed Protection

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Section 9

Inventory of Potential Solutions

9.1 Overview

After the Phase I problem assessments were completed, the master planning effort then focused on the task of developing integrated solutions for identified flood, erosion and water quality problem areas. An "integrated" solution refers to the ideal situation where a proposed solution would effectively promote the attainment of each of the watershed protection goals for a targeted location.

An inventory of all potential solution types was needed to document the range of available solutions types, their general levels of effectiveness, their cost, and other implementation considerations. To compile the complete inventory of solution types, information was gathered on various controls from a variety of sources including the City of Austin, Lower Colorado River Authority, Center for Research in Water Resources (CRWR) and other local/state/national resources. Solutions were grouped into three categories:

- Capital Projects - commonly involve the construction or improvement of infrastructure
- Operating Programs – drainage fee funded watershed protection activities implemented by City staff and funded through the operating budget (e.g., storm drain system maintenance)
- Regulations – involve the application and enforcement of City codes and rules (e.g., drainage design criteria)

This section presents an inventory of watershed management solutions considered for use during the Master Plan. Not all the potential solutions included in this inventory were selected as Master Plan Solutions. Sections 10 and 11 describe the solution selection process, and present the solution recommendations. The inventory describes the basic characteristics of available capital project technologies, operating programs, and regulations (Loomis Austin, Inc., 2000).

9.2 Inventory of Capital Projects

Capital Projects are those involving construction of City-owned infrastructure elements such as storm drain systems, storm water controls, and purchase of land. These typically involve engineering design, construction plans development, bidding services, and construction. Capital projects are best used to solve existing problems such as: (1) Type 1 and 2 erosion, (2) flooding of the creek and local drain system, (3) existing flood plain development, (4) existing storm drain conveyance, and (5) several aspects of water quality problems.

The Capital Projects Inventory presents options that involve construction of structural elements or controls. The solutions presented here are grouped under one of the three WPD missions. Capital projects are commonly funded using bond monies, transfer of WPD's normal operating funds, as well as other sources such as the Urban Water Quality Ordinance (UWO) Fee and the Regional Storm Water Management Participation (RSMP) Fee.

9.2.1 Flood Control Capital Projects

Flood control capital projects are grouped into two categories: (1) nonstructural solutions and (2) structural solutions. Nonstructural solutions focus on removing personal property (e.g., a home, a business) from flood prone areas. Structural solutions focus on either storing or diverting flood flows.

Nonstructural Flood Control Solutions

Nonstructural flood mitigation strategies are those which do not involve the construction of structures intended to reduce flood damage. Since the late 1960s, flood control efforts across the U.S. have shifted away from "hard" structural solutions and toward nonstructural solutions. The Federal Emergency Management Agency (FEMA) has in recent years promoted the removal of homes and even entire communities from low, flood-prone areas. This approach can also satisfy "multi-objective" floodplain management strategies, in that the land acquired can be used for public recreation and as a natural buffer to protect riparian ecosystems. Nonstructural approaches offer the prospect for integration and fulfillment of all three Watershed Protection missions - flood control, erosion control, and enhancement of water quality.

Two different approaches can be used to acquire properties: (1) through property condemnation and forced buyout and (2) through voluntary, gradual buyouts. Whether the buyout is mandatory or voluntary affects the relative cost and the degree to which acquired land can be dedicated to public use.

Property Acquisition by Condemnation

Property acquisition by condemnation allows the City to require that all habitable structures be relocated out of a floodplain area for safety reasons. The City has the flexibility to define the extent of the area condemned (e.g., the 10-, 25-, or 100-year floodplain). By law, anyone relocated in this manner must be adequately compensated for their property and be relocated to equivalent (or better) housing. Relocation assistance is available for all displaced owners and tenants. The entire condemnation and relocation process can take many months (or even years) to accomplish, especially in large-scale condemnation proceedings.

Property Acquisition by Phased, Voluntary Property Buy-Out

In a voluntary buyout, the City gives residents of a target floodplain area the choice to move or to stay. Since no one is forced to move, the City pays the "fair market value" for all properties acquired and negotiation expenses are minimized. The relocation and legal expenses associated with condemnation are effectively eliminated. Since all transactions would be voluntary, the City would not be obliged to purchase any properties it considers too expensive. Overall costs for this approach are much lower than for condemnation.

Structural Flood Control Solutions

Structural solutions are engineered modifications to waterways designed to reduce flood risk. Unlike buyouts, they offer the option of leaving existing development in place.

They can be used in combination with nonstructural buyout strategies to gain a lower cost solution to a flooding problem. The technologies presented in this section are assumed to be implemented on a regional or large-scale basis and, as such, they are generally more effective than multiple, privately owned smaller-scale applications. Large scale flood detention projects also offer the opportunity for customized design of the inflow and outflow structures, to allow for multiple-use application of the facility. Northwest Park, which is an offline flood detention facility, is an excellent example of effective dual-purpose application of a regional facility. The structural controls included in this inventory are shown in Table 9 – 1.

Table 9 – 1

Inventory of Structural Flood Control Solutions

Flood Detention	Channel Modification
Structure Raising	Storm drain Upgrades
Flow Diversion	Removal of Constrictions
Levees and Floodwalls	

Flood Detention

Detention ponds are structures that capture and hold storm runoff for a limited period of time. They are designed to store flows during the most critical part of the flood and release the stored water as the flood subsides. While detention does not reduce the total volume of runoff from a flood event, it does reduce the peak flow rate and peak water depths, thus reducing flood risks downstream. The principal design considerations for detention ponds are storage volume and the size of inlet and outlet structures. The inlet regulates the rate of storm water inflow. The flood storage volume is usually created by excavation, enclosing an open area with earthen berms or structural walls. The outlet structure restricts outflow rates to acceptable levels assuming the storage volume is large enough to store the difference between the rate of flow into and out of the pond.

Figure 9 – 1.1

On-line Detention Facility

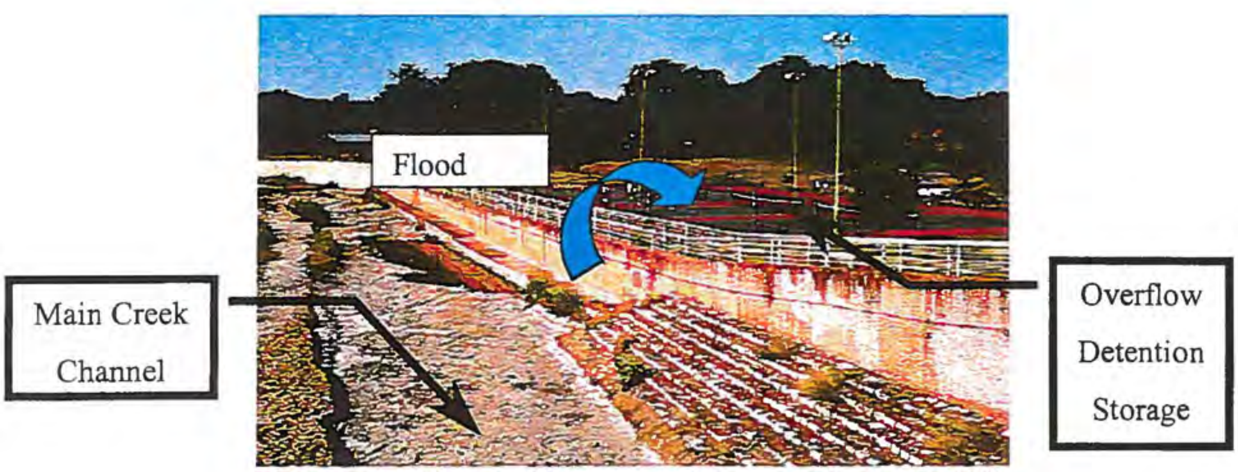
Typical on-line flood detention facility near RR 2222 Source: Loomis&Moore, 1999

There are two basic configurations for detention ponds: on-line and off-line. On-line ponds are positioned directly in the flowpath with all flow, including flood flows, passing entirely through the facility. Figure 9 – 1.1 presents a photograph of a typical on-line detention facility.

Off-line detention ponds are located to the side of waterways. They remain empty until flood flows reach critical levels when excess flood flows are diverted into the detention pond. After the flood recedes, the stored volume drains into the channel. Figure 9-1.2 presents a photograph of the Northwest Park off-line detention facility.

Figure 9-1.2

Off-line Detention Facility



Shoal Creek at Northwest Park *Source: Loomis & Moore, 1999*

Channel Modification

Channel modification can increase flow capacity (conveyance) by changing the existing waterway geometry and/or cross-section. Increased capacity reduces water depths and the potential for flooding.

Figure 9 – 2

Flood Channel modification

Shoal Creek *Source: Loomis & Moore, 1999*

Channel modification may be accomplished using the same side slope revetment techniques used for erosion control projects. To the extent that more natural channel revetment technologies are employed, the adverse environmental impacts are reduced. However, these more natural techniques may not provide for an effective increase in conveyance in some instances. Figure 9 – 2 presents a channel modification project on Shoal Creek.

Structure Raising

"Structure raising" physically removes threatened structures from the floodplain by elevating them with fill material or some form of piers, posts or columns. In some cases, floodplain restrictions will not allow the use of fill materials if they impair floodplain conveyance. The use of piers, posts, or columns typically will not significantly impact floodplain conveyance or flood elevations.

Storm Drain System Upgrades

Storm drain system upgrades consist of replacement or renovation of the existing storm drain system. This Capital project solution is an extension of the Storm Drain System Repair and Rehabilitation program. This flood mitigation approach targets localized nuisance flooding caused by inadequate size or structural degradation of storm drains.

Upgrades are made in response to storm drain system inspections, citizen complaints, and/or updated modeling of the system.

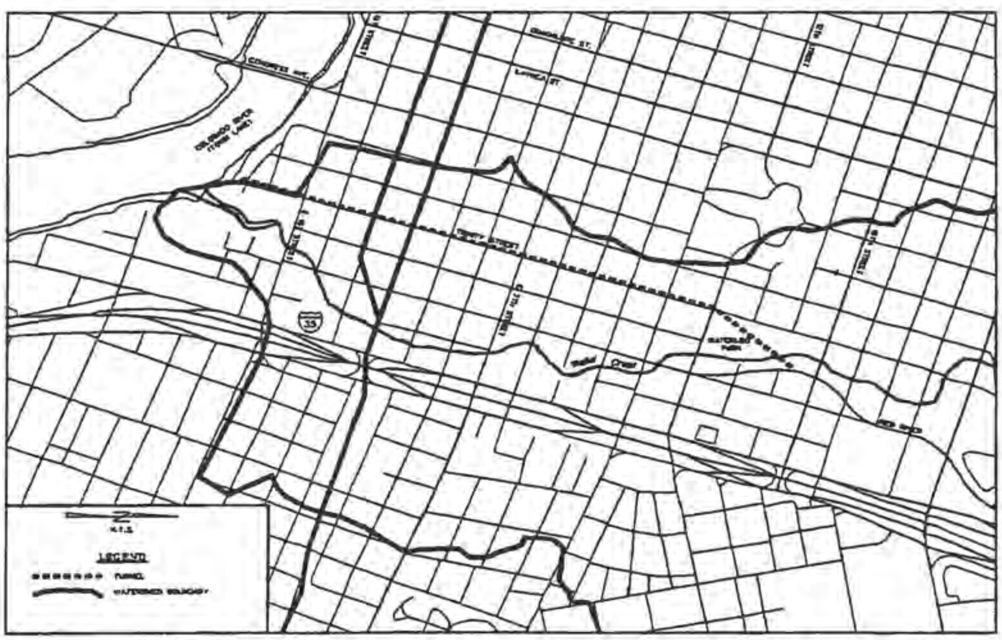
Flow Diversion

Flow diversion, such as channels and tunnels, directs a portion of the peak flood flow to an alternate path. Excess flows are carried online or offline, either along an open channel diversion or through a closed pipe (tunnel) path. The diversion may rejoin its original channel or proceed to a different location. Online systems divide all flow between two paths. Offline systems pass all flow through the original path until a specified flood elevation is reached, when a control diverts excess flow to the diversion path.

Open channel diversions require sufficient space in the overall flood conveyance path. Diversion tunnels can be built deep below the ground surface but are quite expensive. Figures 9 – 3 and 9 – 4 present schematic representations of the proposed Waller Creek flood diversion tunnel.

Figure 9 – 3

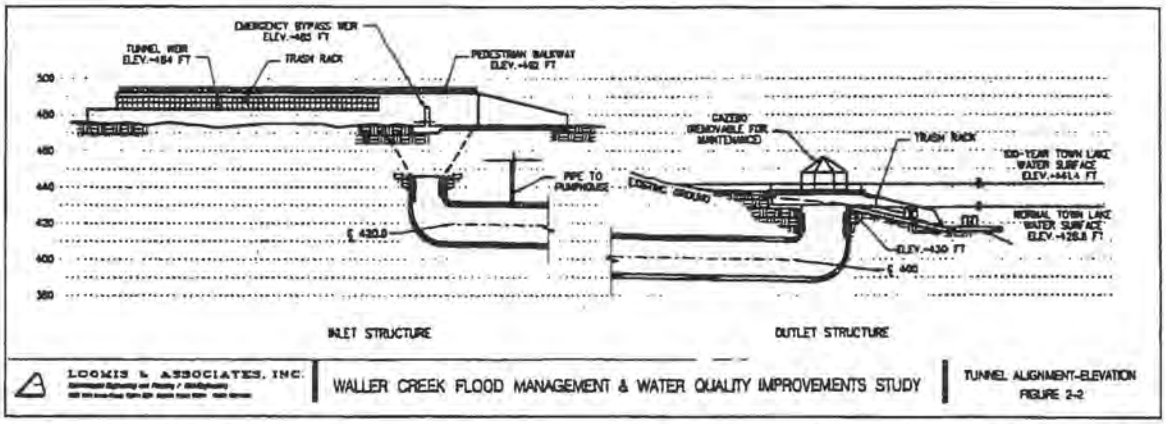
Proposed Flood Diversion Tunnel



Schematic of Waller Creek tunnel path *Source: Loomis & Moore, 1999*

Figure 9 – 4

Cross-section of Proposed Flood Diversion Tunnel



Cross-section of Waller Creek tunnel *Source: Loomis & Moore, 1999*

Removal of Structural Constrictions

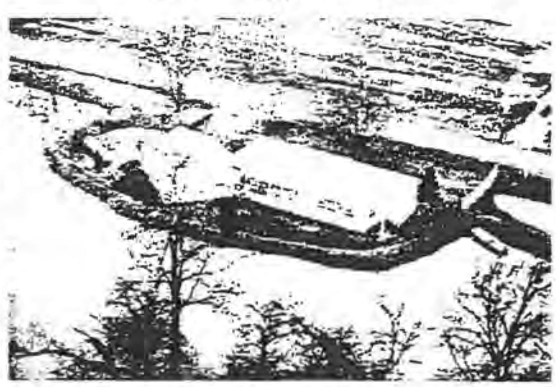
Culverts, bridges, low water crossings, and other structures often create local constrictions in streams. The originally designed conveyance through these structures may not be adequate and energy losses associated with the constriction cause increased flooding upstream. Replacing undersized structures or removing constrictions reduces upstream water surface elevations. This approach is best applied where a structure constriction is creating localized flooding and/or scour.

Levees and Floodwalls

Levees and floodwalls are man-made barriers that prevent flood waters from spilling into flood-vulnerable areas. Figure 9 – 5 presents a levee application for a single residential structure. Levees are generally constructed of compacted soils. They require gentle embankment slopes (typically 3:1) for stability. Floodwalls are generally constructed using masonry block and poured concrete and require substantial lateral footings and steel

Figure 9 – 5

Levee Application



Source: FEMA, 1986

reinforcement. Levees and floodwalls are most applicable where floodwaters encroach upon structures but the overbank region is not required for local conveyance.

9.2.2 Erosion Control Capital Projects

Erosion Control Capital projects typically focus on reinforcing the stream bed channel or slowing the velocity of flow. They are used to prevent the loss of property (land or structure) to bank erosion. The Erosion Control Capital projects presented include:

- Property Acquisition
- Storm Water Detention
- Bank Protection/Rehabilitation
- Measures for Localized Problems
- Geomorphically-Referenced River Engineering (or Natural Channel Design)

Property Acquisition for Erosion Control

Properties and structures vulnerable to erosion may be removed from the threat of erosion through direct acquisition of land or structures in the problem area. As with flood control, erosion control acquisitions can be made through condemnation or with the voluntary cooperation of the landowner.

Bank Protection/ Rehabilitation: Side Slope Treatments

Side slope treatments are techniques that directly reinforce channel banks for stabilization and erosion control. They are typically used to prevent the loss of property, addressing Type 1 and 2 erosion problems. Side slope treatments range from vegetative revetment to concrete coverings. They can be applied along an entire length of channel or at isolated trouble spots. As a general rule, the toe of a bank (foundation of bank slope) or other high shear stress area requires a hard reinforcement such as rock or gabions. Upper banks can often be stabilized with "soft" reinforcements such as vegetation or reinforced earth. The goal for bank stabilization is to establish a long-term equilibrium for erosion control such that future bank rehabilitation is not necessary. Any bank protection schemes must include planning for future changes in channel shape and migration of materials through the creek. Where stormflows are projected to increase substantially in the future, bank stabilization should be combined with detention, channel modification, and other techniques at the watershed level. See Table 9 – 2 for techniques included in this inventory category.

Table 9 – 2

Bank Protection/Rehabilitation Techniques

Reinforced Earth	Vegetative Bioengineering
Vegetation Reinforcement	Placed Rock Riprap
Big Rock Toe Treatments	Gabions
Concrete Riprap	Mortared Rock

Reinforced Earth

Figure 9 – 6

Reinforced Earth

Pecan Springs, Ft. Branch Watershed

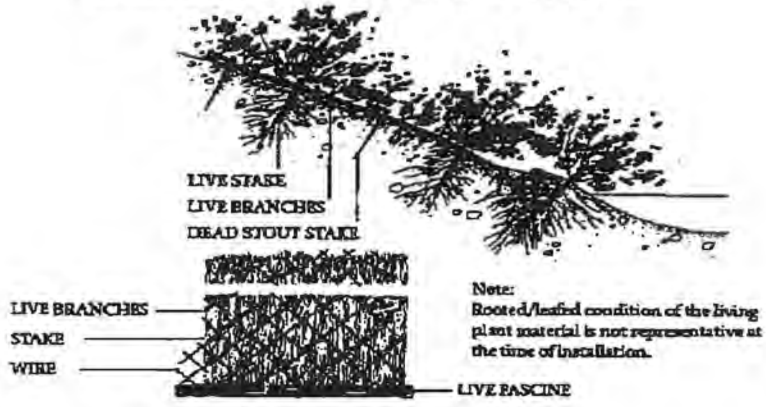
Reinforced earth can provide support for a vegetated surface treatment. Alternating soil lifts with reinforcing layers of geotextile fabric provides slope stabilization. This approach can be structurally stable at slopes as steep as 0.5:1. Reinforced earth applications include: (1) narrow, deep channels (confined channel systems); (2) parkland; (3) protection of structures and roadways along the channel; (4) high velocity and high shear stress streams; and (5) severe channel bends. Figure 9 – 6 shows a typical reinforced earth project.

Vegetative Bioengineering

Bioengineering uses vegetative plantings introduced into soil backfill and slopes to provide erosion resistance, strength, and support from the plant root network. Typical plantings include dormant tree stakes or shoots or brush placed either horizontally into banks. Plants are selected for extensive root systems, resiliency to flows and inundation, and capacity of self-support and self-repair. Plant survival is crucial to the usefulness of this technology. Figure 9 – 7 shows a typical vegetative bioengineering technique.

Figure 9 – 7

Brushmattress-Biorevetment Technique



Source: Robbin B. Satir & Associates, 1994

Vegetation Reinforcement Techniques

Vegetation reinforcement refers to the integration of slope vegetation with materials such as rock riprap, flexible channel liners or fiber rolls, or other similar materials.

Long-term stability of these measures along stream courses depends on establishing a dense, self-perpetuating plant community. Vegetation reinforcement techniques provide protection and support to the vegetative cover both during initial establishment and during periods of high erosive flows and channel shear stress. Figure 9 – 8 presents a typical approach to vegetative reinforcement.

Figure 9 – 8

Turf Reinforcement Mat

Reed Park - Taylor Slough South Watershed
After installation (left) and with established vegetation (right)

Placed Rock Riprap

Rock riprap refers to loose, unconsolidated rocks that are placed along eroding side slopes. Placed rock riprap can be used in extended segments or in isolated trouble spots. Although more labor intensive, hand-placed riprap provides better protection than dumped riprap. High shear stress areas usually require rocks 18-inches in diameter or larger. Riprap performs well in conjunction with vegetative slope protection techniques. When used to stabilize the toe of a slope, the rock must be sized so that its weight can resist applicable shear forces. Typical application areas include: (1) severe channel bends; (2) near structures and roadways; and (3) transitions into and out of culverts, bridges, and channel improvements.

Big Rock Toe Treatments

"Big Rock" treatments offer erosion protection to the particularly vulnerable "toe" or foundation of a slope in the stream cross-section. This "toe" can be undermined by scour. Localized scour typically occurs at the outside of a bend, in the area downstream of a storm water outlet, at bridge piers, and along wastewater lines. This toe treatment is often used in conjunction with other stabilization and revetment methods. In streams with frequent high shear stress flows and high velocities, the rock toe can be extended to the active channel depth to maximize erosion prevention. Figure 9 – 9 presents a typical big rock toe treatment.

Figure 9 – 9

Big Rock Toe Treatment

Gillis Park

Figure 9 – 10

Gabion Channel Revetment

Gabions on Shoal Creek   Source: Loomis & Moore, 1999

Gabions (Rock and Wire Baskets)

Gabions are coarse, PVC-coated wire mesh baskets filled with stone and rock. The term "gabion" is actually a trademark name for a specific type of rock and wire basket but has been commonly used to refer to all stone filled wire baskets. Gabions can be configured in a variety of ways, either stacked or blanketed, and provide very high levels of erosion protection, including situations with slopes as steep as 0.5:1 H:V. They are typically used in high velocity channel reaches; at bridge and culvert constrictions; in situations where the ability to slope the bank is limited; and for construction to extreme heights. Figure 9 – 10 illustrates a gabion channel revetment application on relatively steep slopes.

Concrete Riprap

Concrete riprap is concrete slope paving used for surface protection in erosion-prone areas, but is generally not designed to provide structural stability. Concrete riprap should be limited to channel sideslopes with ratios no greater than 1.5:1 H:V. Concrete riprap is usually steel-reinforced to limit cracking and structural failure of the paving surface. Widespread use of concrete riprap channels for flood control can result in reduced overbank flood storage and higher downstream peak flow rates. Concrete riprap in combination with concrete walls has been used for large channel stabilization projects in

Austin (e.g., Boggy Creek, Tannehill Branch). Figure 9 – 11 illustrates a typical channel revetment application for concrete riprap.

Figure 9 – 11

Channel Revetment Application

Loop 360 at Bull Creek   Source : Loomis & Moore, 1999

Mortared Rock

Mortared rock revetment is stacked rock cemented with mortar and, like concrete riprap, is used for surface protection in erodable streams. Figure 9 – 12 presents a mortared rock embankment. The primary advantage of mortared rock is its relatively high aesthetic value in maintaining a natural appearance, although it is generally considered less reliable than concrete riprap, gabions, or reinforced earth. Mortared rock provides moderate channel friction and is often used in narrow, confined channel areas where high conveyance and aesthetic treatments are desired, but vegetative revetment is impractical. WPD staff recommends avoiding the use of mortared rock side slope treatments as a Capital Erosion control solution due to a history of structural failure of these systems in Austin.

Figure 9 – 12

Mortared Rock Embankment

Bull Creek Watershed

Geomorphically-Referenced River Engineering

Geomorphically-referenced river engineering (GRRE), also known as natural channel design, refers to the engineered modification of streams to achieve long-term stability of channel cross section, profile and planform while maintaining natural channel bed and streambanks. GRRE is a holistic approach to stream restoration to develop a stable, low maintenance, ecologically diverse riparian corridor within the context of the watershed. These goals are achieved by configuring a frequent flow channel complete with riffles and pools that will maintain itself. GRRE solutions seek to address systematic problems in the stream network that result in large scale channel erosion. They consider the interaction of adjacent channel sections in the design of solutions to channel erosion problems. This reflects a change from past piece meal approaches to solutions which acted as band-aids that fixed a localized problem with no consideration of the stream system as a whole. These methods can have a favorable impact on restoring creek system integrity, overbank storage, and water quality. Table 9 – 3 presents descriptions of techniques commonly employed by GRRE:

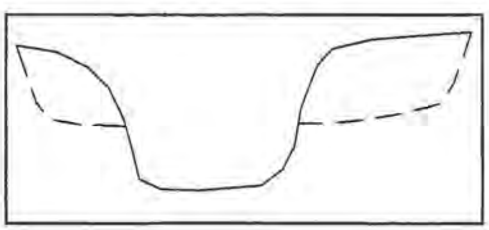
Table 9 – 3

GRRE Techniques

Terracing	Side Channel Construction
Re-meandering	Raising the Channel Bed
Artificial Shoals	

Terracing

Terracing promotes re-connection of a deeply cut channel to its floodplain through excavation of a floodplain area adjacent to the impacted channel. The terrace is cut to allow the inset channel to carry the 1- to 2-year storm, and the floodplain provides relief for larger storms. The most significant drawback to terracing is loss of trees or other desirable vegetation. But in many cases, impending channel degradation may already threaten the existing vegetation, and terracing can provide a stable platform for re-vegetation.

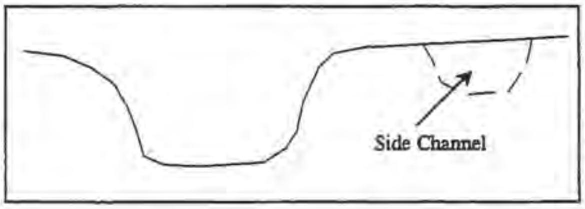


Section view of terracing (dashed line) to reconnect a channel (solid line) to its floodplain

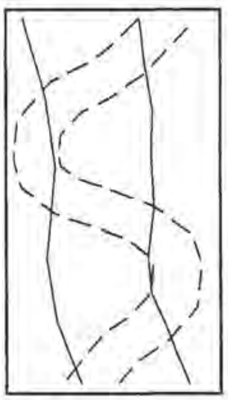
Source: Loomis & Moore, 1999

Side Channel Construction

Side channel construction reduces water surface elevations and flow velocities by providing a flow route parallel to the main channel. The side channel, which typically remains dry during low flows, is established with native vegetation, and provides additional conveyance and storage during stormflows. As with terracing, side channel construction may eliminate existing riparian vegetation.



Section view of side channel
Source: Loomis & Moore, 1999



Source: Loomis & Moore, 1999

Re-meandering

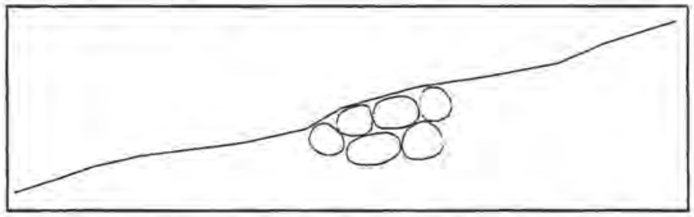
Re-meandering refers to restoration of the natural meandering channel flow path to increase stream length and reduce channel slope. This technology is typically employed as a restoration measure for streams that have been straightened and armored. The resulting flow has lower stream energy and therefore lower erosion potential. Typically, the restored channel provides less conveyance than the "improved" channel, with increased floodplain conveyance compensating for the reduction in channel conveyance.

Raising the Channel Bed

A highly entrenched channel contains a broad range of low flow and higher flow events. Before the channel became entrenched, the floodplain provided relief for the larger floods. Raising the channel bed returns high flow events to the floodplain and reduces channel shear stress. Drawbacks include temporary loss of habitat and higher flow depths. If the floodplain cannot carry extreme events due to new hydrologic conditions, then raising the channel bed can create new flooding problems.

Artificial Shoals

When watershed conditions create a channel degradation problem, the channel tends to downcut until it encounters a non-erodable material. Where the limiting substrate is deep below the original natural creek bed, it may be advisable to arrest further downcutting through creation of artificial shoals. A common application of this approach involves the use of large rocks (18 inch or greater diameter) buried beneath the channel flowline to form a barrier to downcutting. Artificial shoals are designed for grade control to prevent head cuts from migrating upstream. Scour holes may form, but artificial shoals must be keyed-in at the head cut and along the side slopes to prevent undercutting and widening of the channel.



Buried rocks form an artificial shoal *Source: Loomis & Moore, 1999*

Storm Water Detention for Erosion Control

Storm water detention offers a means of regulating peak flow rates to promote channel stability for urbanizing watersheds with significant expected future erosion and enlargement of the channel cross-section. Storm water detention is generally designed to mimic the pre-development frequency of channel-forming runoff events (those frequent, short duration storm events that cause most of the bank erosion) by temporarily storing the storm runoff volume, and regulating discharge flow rates. Outlets must be sized for release rates that consider downstream shear stress thresholds to avoid channel instability. Storm water runoff detention is effective in preventing future erosion problems, but is not generally useful for remediation of current active erosion. Runoff detention for erosion control generally requires capture and control of the 6-month to 2-year runoff volume, depending upon downstream channel conditions (i.e. rock-controlled vs. alluvial). Consequently, substantial land area for online or offline runoff storage is necessary for this approach.

Measures for Localized Erosion Problems

There are several erosion control measures that are particularly effective in addressing localized problems. These measures focus on dissipating the energy of storm water flow. They include:

- Outlet protection at storm drain outfalls
- Flow deflectors

Outlet Protection at Storm Drain Outfalls

Outflow from storm drains and culverts often create localized scour due to high flow velocities. High velocities occur when outfall pipes are steep or pipe flow is pressurized. The following list describes measures for reducing outlet scour:

Baffles - an array of concrete blocks that slow outlet flows by creating turbulence.

Flattening the Outfall Pipe Slope – Steeper pipe slopes result in higher flow velocities. Flattening the outfall section pipe slope will slow the flow velocity before the flow leaves the pipe and prevent additional scour.

Roughening the Outlet Section - Forming slats or small baffles within the outfall pipe creates roughness within the pipe that slows the velocity at the outlet.

Extended Concrete Apron - An extended section of concrete at the outfall provides protection to the streambed where the outfall flow transitions to stream flow. The use of rock riprap around the edges prevents undermining and creates a roughened surface to minimize channel erosion.

Flow Deflectors

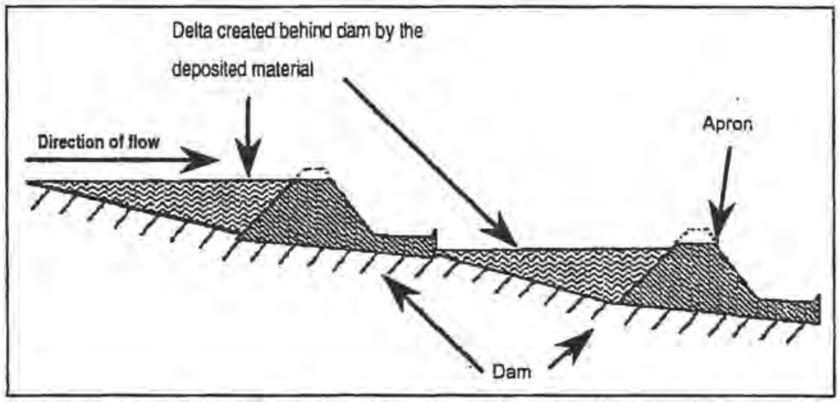
Flow deflectors provide bank protection by promoting sediment deposition. Flow deflectors are constructed by placing boulders, gabions, railroad ties or other objects along a channel segment. Sediment deposits behind the deflectors can generate vegetation growth and promote additional stability. Location of channel deflectors on the outside of a channel bend is generally intended to keep the deepest portion of the channel toward the middle of the channel, reducing high, erosive velocities on the outside bank.

Check Dams

Check dams (Figure 9 – 13) are small, low head dams installed at multiple locations along drainage channels and urban creeks. In general, they function to reduce the energy and erosive capacity of runoff flows. Debris and sediment trapped in the check dam pool can provide grade stabilization.

Figure 9 – 13

Check Dam



Cross-sectional view of a gully check dam *Source: Gray and Leiser, 1989*

9.2.3 Water Quality Protection Capital Projects

Water quality protection capital projects are intended to limit the impact of non-point source (NPS) pollution on receiving waters. NPS pollution originates from diffuse, usually urbanized, runoff sources. Pollutants typically occur in relatively low concentrations; however, due to the large number of non-point sources, they usually constitute a significant portion of the overall pollutant load delivered to receiving waters. There are four groups of water quality control Capital project solutions:

Source Controls	Property Acquisition
Treatment Controls	Rangeland Management

All four groups of solutions focus on reduction of pollutant loads to receiving streams. Property acquisition and rangeland management strategies were originally considered under Capital Project solutions, but were referred to Programmatic Solutions as they lend themselves better to implementation via one of the City programs.

Source Controls

Source controls are those which attempt to limit the pollutant load contribution near the point of generation. For example, inlet filters capture trash, debris and coarse sediment within a few hundred feet of their original location in the watershed. There are 11 identified source controls for water quality as shown in Table 9 – 4.

Table 9 – 4

Water Quality Source Controls

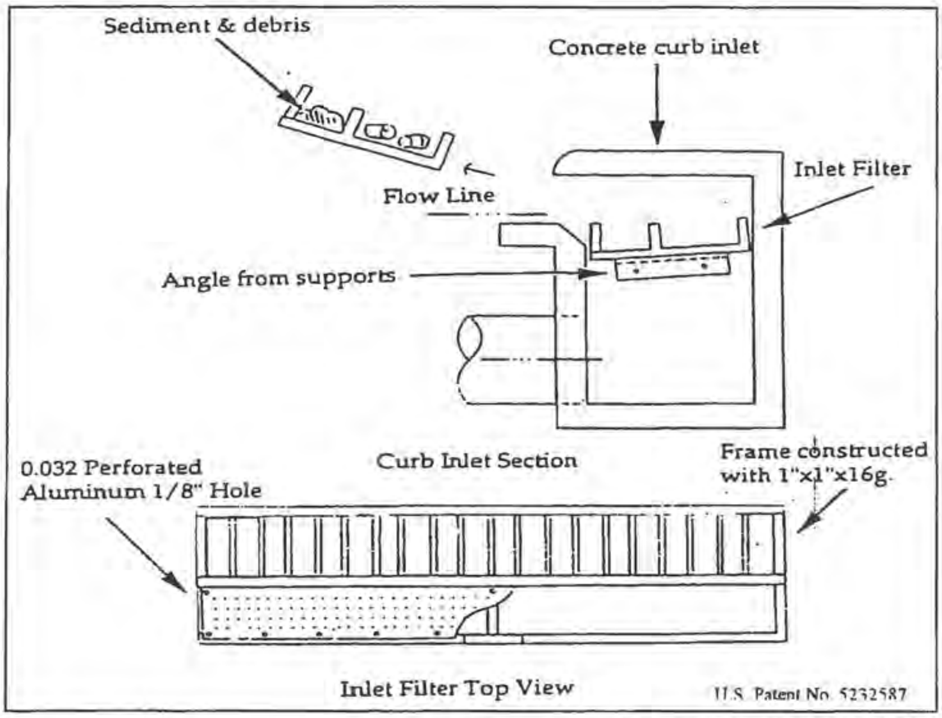
Inlet Filters	Trash and Debris Booms	Retrofit of Ponds for Trash Removal
Impervious Cover Removal	Impervious Cover Disconnection	Bioretention
Infiltration Basins	Infiltration Trenches	Porous Pavement
Rainwater Harvesting	Hazardous Materials Traps	

Inlet Filters

Storm water inlet filters are fabricated from tubular steel and perforated aluminum, and are inserted inside storm drain inlets to trap trash and other debris. The filter can easily be removed through the curb opening for service, and then re-installed for the next storm event. Monitoring has indicated that some sediment and other pollutants are collected on the screen portion of the filter. Inlet filters are typically retrofit into existing storm drain inlets. Inlet filters are generally not as useful in single-family residential areas due to the lower concentrations of trash and litter, except in areas with high pedestrian activity or near businesses such as convenience stores. Figure 9 – 14 illustrates the inlet filter design used by the City of Austin.

Figure 9 – 14

Inlet Filter



Source: City of Austin, 1999

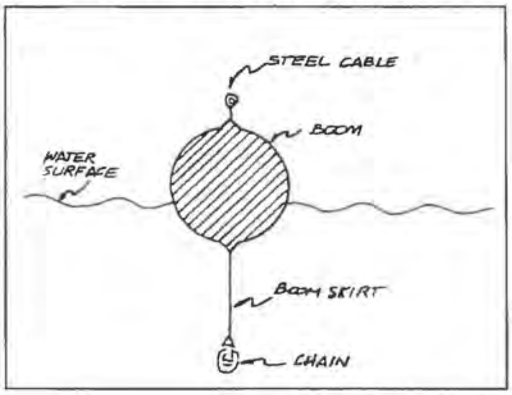
Trash and Debris Booms

Trash and debris booms are modified oil spill containment booms placed across urban creeks (generally near the confluence with a downstream river or lake) to catch floatable trash and organic debris. Booms are secured so that they are not destroyed by the full-force of high velocity flows. By capturing floatable trash and woody-organic debris, booms target the most obvious, visual signs of non-point source pollution. Experience in Austin has shown that trash booms on urban creeks can catch an average of more than 60 gallons of trash and debris per storm event. Booms must be maintained frequently to avoid aesthetic concerns, since booms accumulate floating debris in and on the surface of the receiving water. Figure 9 – 15 presents a trash and debris boom deployed in Shoal Creek. Figure 9 – 16 presents a cross-section view of a trash and debris boom.

Figure 9 – 15
Trash and Debris Boom

Trash Boom on Shoal Creek

Figure 9 – 16
Trash Boom Schematic



Source: City of Austin, 1999

Retrofitting of Existing Storm Water Management Ponds for Trash Removal (Trash Screens)

The use of trash screens in existing water quality ponds is generally applied as an added non-point source control feature, used in conjunction with the primary water quality or flood control purposes of the ponds. Retrofitting an existing storm water management pond usually involves placing a screening device at the outflow structure to assure that trash and debris is captured and stored in the pond. It is important to assure that trash accumulation does not impact the intended flow characteristics of the outflow structure, or impair the original function of the facility.

Impervious Cover Removal

Impervious cover removal involves removing impervious surfaces and replacing them with stabilized, vegetated, pervious cover. The new pervious surface reduces runoff and increases infiltration. This approach can be used where impervious cover is over-built for its intended purpose, or has become obsolete through site abandonment. Application of this approach would best be implemented as a Citywide program because, prior to capital implementation, this approach will require significant investigation of practical applicability, land ownership constraints, and cost/benefit issues. Example applications include removing parking lot pavement, replacing it either with pervious pavements or pervious landscaped areas (see "Porous Pavement" below).

Impervious Cover Disconnection

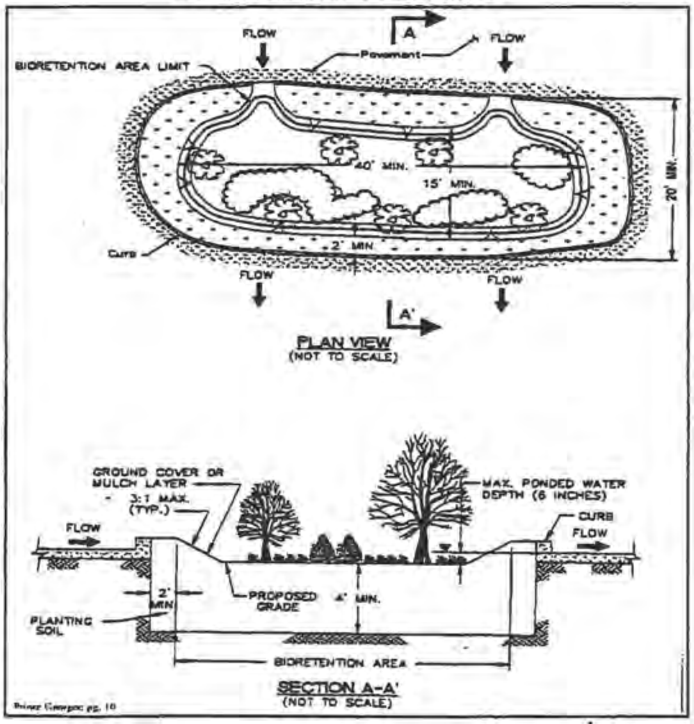
Disconnection of impervious cover is a retrofit technique involving removal of the direct path of storm water flow between impervious cover and waterways. This practice operates on the principle that the negative impacts of impervious cover on water quality and quantity can be reduced if runoff from these areas is redirected over pervious areas for possible storage, energy dissipation, and filtration/infiltration. Conventional site designs often encourage water to exit as rapidly as possible via impervious conveyance paths (storm drains, storm drains, concrete-lined channels, etc.). This technique calls for reconfiguring drainage structures to direct runoff from rooftops, roadways, and parking lots across landscaped or other pervious areas prior to discharging into waterways.

Bioretention

Bioretention is a water quality practice in which runoff from smaller impervious areas is captured and retained in a depressed, vegetated area. Figure 9 – 17 shows plan and profile schematics of a bioretention facility. The soil in the storage area is selected or conditioned to promote infiltration. Facilities typically are designed to contain the first flush of runoff (typically defined as the first half inch); maximum water depths are typically shallow. The use of vegetation in this system is modeled

Figure 9 – 17

Bioretention Schematic



Source: Prince Georges Co.

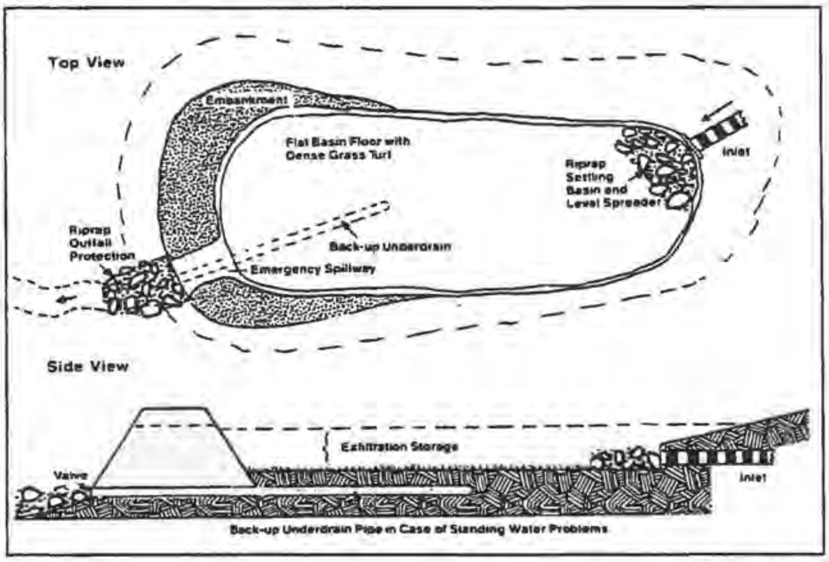
after the properties of a terrestrial forest ecosystem. To mimic this natural system, a successful BMP design should include a mature tree canopy, an understory layer of smaller and/or younger trees, a shrub layer, and a groundcover layer. Bioretention is typically used to treat urban areas or roadways with relatively high impervious cover and is usually placed offline to avoid erosion during large storm events.

Infiltration Basins

Infiltration basins are designed to capture runoff and allow it to infiltrate directly to the soil, rather than discharging to receiving waters. Figure 9 – 18 shows a schematic infiltration basin design. As water migrates through porous soil and rock, pollutants are removed via precipitation, sorption, physical filtration, and microbial biodegradation. This solution type is intended to mimic the natural water-retaining and infiltration characteristics of undeveloped watersheds. Basins can be dug from native alluvial soils, built with structural walls, or created with berms. They are almost exclusively built off-line and are located adjacent to waterways, rather than on-line, or within the channel. Runoff is diverted into them until the desired storage treatment volume is reached. Excess flow continues on to the receiving waters. These basins have a very high removal efficiency if functioning correctly. Typical designs allow for complete basin draining to occur within two to three days.

Figure 9 – 18

Infiltration Basin Schematic



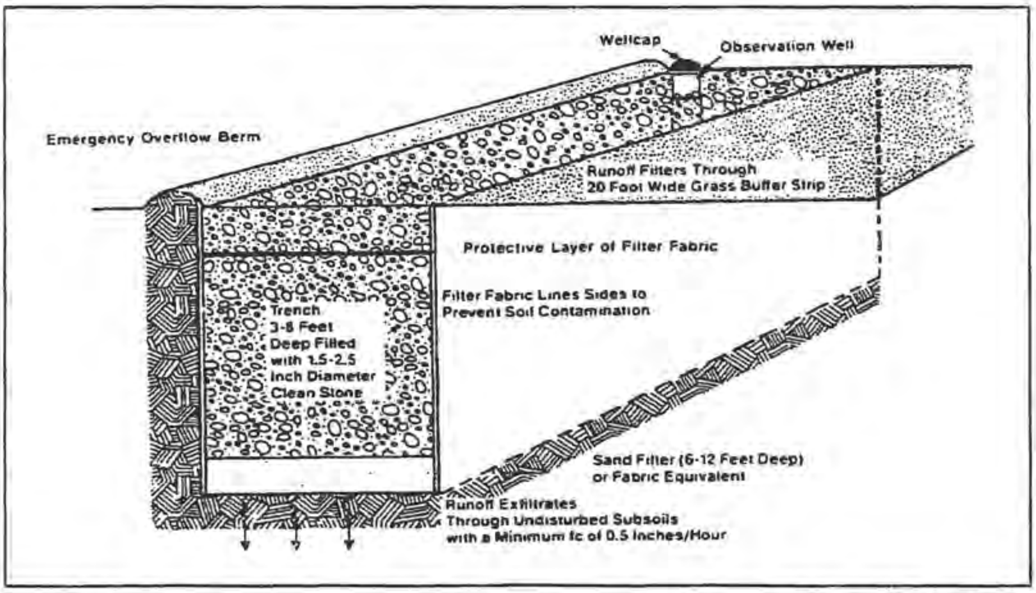
Source: Schueler, 1987

The use of infiltration basins can be limited by numerous site factors including soils, slope, water table and contributing watershed area. The use of this design is geographically limited in Austin, since recharged waters from these facilities may impact groundwater quality.

Infiltration Trenches

Infiltration trenches are shallow (3-8 feet deep), excavated trenches which are backfilled with stone to create an underground storm water storage reservoir for storm water infiltration and treatment. Figure 9 – 19 shows a diagram of an infiltration trench. Runoff either enters directly at the surface or flows into underground trenches through a pipe drainage system. Captured runoff is assumed to infiltrate into the adjacent subsoil. Surface runoff flows are typically filtered through a grass buffer to trap fine particulates, to limit the potential for clogging the trench. Despite this design, high failure rate due to clogging has been reported. Infiltration trenches are generally used only with small drainage areas. Like infiltration basins, the applicability of infiltration trenches can be highly restricted by poorly drained soils or a high water table.

Figure 9 – 19
Infiltration Trench Schematic



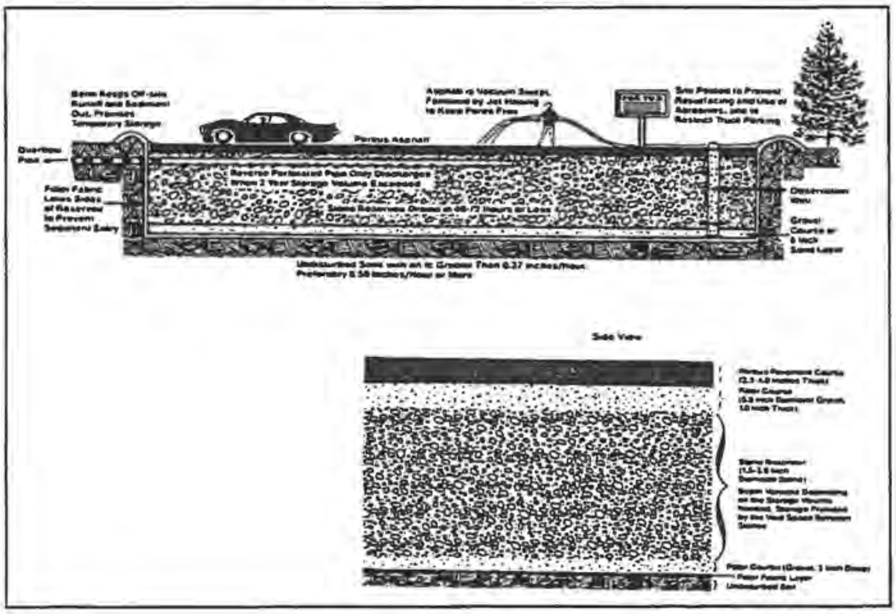
Source: Schueler, 1987

Porous Pavement

Porous pavement describes a variety of alternative techniques used to construct roadways, parking lots, and other transportation surfaces that promote water infiltration. They are a substitute for conventional, impervious concrete and asphalt surfaces. When properly designed and installed, porous pavement can have load bearing strength and longevity similar to conventional pavement; however porous pavement systems are generally most useful with light-duty traffic. This solution removes storm water pollutants (principally via subsequent soil infiltration), helps maintain the pre-development flow regime of a creek by reducing peak flows and enhancing creek baseflow. Design options include: (1) porous pavement with underground storage/recharge beds; (2) concrete pavers infilled with soil/gravel and vegetated with grass; or (3) plastic or metal grid infilled with gravel or equivalent. Figure 9 – 20 presents a schematic design for a typical porous pavement configuration.

Figure 9 – 20

Porous Pavement Schematic



Source: Schueler, 1987

Rainwater Harvesting

Figure 9 – 21

Rainwater Harvesting

Shoal Creek Watershed

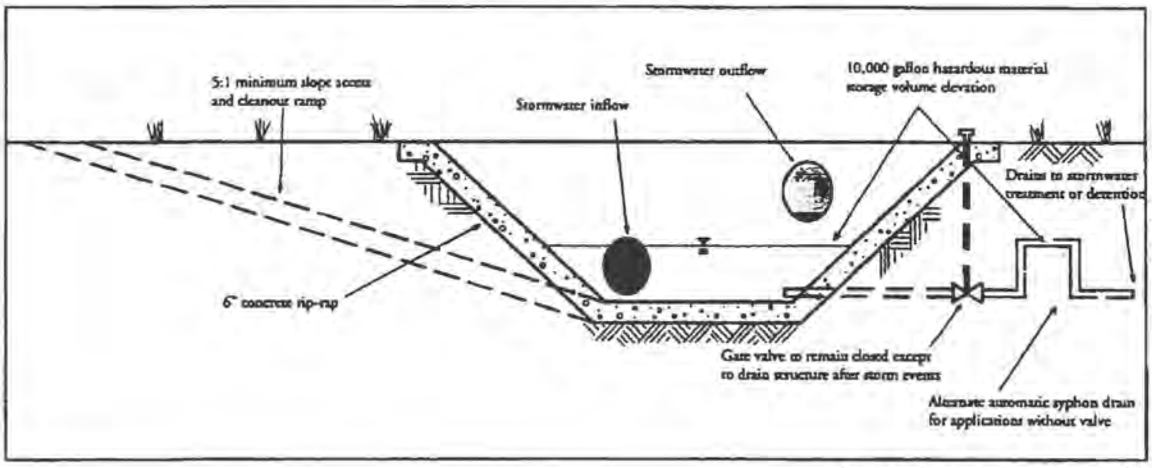
Rainwater harvesting systems divert storm water runoff from building roofs into a holding tank or cistern via gutters and pipes. Stored water is irrigated during dry weather onto landscapes or other pervious surfaces such that little or no runoff occurs. This technology reduces peak runoff flows, enhances vegetative growth, and promotes infiltration. Rainwater systems usually take runoff exclusively from rooftops. This water is relatively clean compared with road or fertilized turf runoff. The high quality of the captured water makes rainwater harvesting suitable for water reuse and consumption. Rainwater harvesting systems are widely applicable for residential or commercial properties where there is sufficient pervious area for irrigation, or sufficient potable water need. Rainwater harvesting systems can be relatively simple to install on existing structures, and require only a small area for the tank and pump house. Figure 9 – 21 shows a home with a rainwater harvesting tank.

Hazardous Materials Traps

Hazardous materials traps (HMTs) are retention basins designed to capture hazardous material spills along roadways. HMTs are sized to hold the contents of a standard tanker truck or rail car (approximately 8,000 gallons). To function as intended, HMTs must be empty at the time of a spill. Most are fitted with an inverted siphon to drain captured storm water. Figure 9 – 22 presents a schematic of a typical hazardous materials trap.

Figure 9 – 22

Hazardous Materials Trap Schematic



Source: Loomis & Moore, 1999

Storm Water Treatment Measures

Treatment controls are those that capture and remove pollutant loads generated by multiple sources. They are typically located on-line or off-line along creeks and tributaries and involve capture of at least the first half-inch to inch of storm water runoff (often called the first flush). Storm water treatment measures may be placed individually, or in series with similar or different control technologies. They are most effective when they are able to treat multiple pollutant types and be multi-purpose in operation. For example, a wet pond can incorporate baseflow storage and provide erosion control volume while addressing multiple pollutant types. Table 9 – 5 shows water quality treatment solutions presented below.

Table 9 – 5

Water Quality Control Treatment Solutions

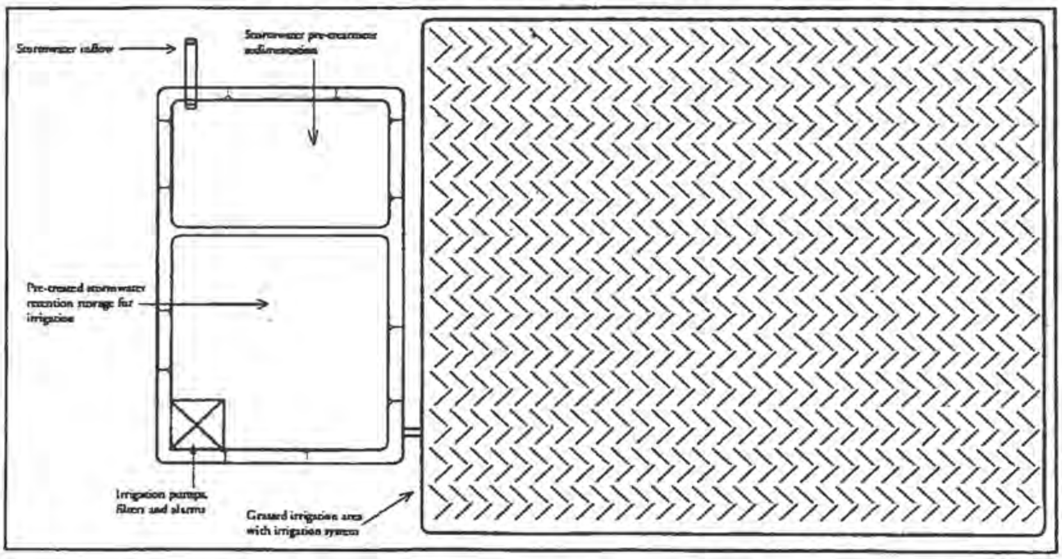
Retention-Irrigation	Wet Ponds
Constructed Storm Water Wetlands	Sedimentation/Sand Filtration
Extended Detention	Grassed Swales
Vegetated Filter Strips	Oil Grit Separators and Water Quality Inlets
Multi-Chambered Treatment Trains	Inlet Adsorbents

Retention-Irrigation

Retention-irrigation refers to the capture of storm water runoff in a holding pond, and the subsequent use of the captured volume for irrigating landscape or natural pervious areas. This technology is highly effective as a water quality control and results in very high storm water pollutant removal efficiencies. This technology mimics natural undeveloped watershed conditions. Retention-irrigation facilities function to remove pollutants by capture and vegetative uptake in the upper soil profile and shallow root zone. Storm water can be captured in almost any kind of runoff storage facility. These facilities are typically offline. The pump and wet well are automated with a level sensor, rainfall sensor, and timer to provide irrigation within a specific period of time following a rainfall event. A spray irrigation system is required to provide an adequate flow rate for distributing the water quality volume. Although water quality performance is excellent, maintenance requirements and construction costs for retention-irrigation systems are high. Land availability is also an issue. This approach is most often applied in sensitive watersheds (e.g. the Barton Springs Zone) as a means of achieving storm water non-degradation. Figure 9 – 23 presents a schematic design for a typical retention-irrigation system.

Figure 9 – 23

Retention-Irrigation System Schematic



Source: Loomis & Moore, 1999

Wet Ponds

Figure 9 – 24

Wet Pond System

St Elmo Wet Pond, Williamson Creek Watershed

Wet ponds maintain a permanent wet pool to detain and treat storm water runoff. This technology provides potentially excellent storm water quality enhancement for a wide range of pollutants. Wet ponds are designed to encourage the maintenance of healthy emergent and submerged aquatic vegetation, and an active microbial community capable of dissolved pollutant breakdown. If properly designed and sized, sedimentation processes can capture a significant amount of the particulate fraction. Permanent wet storage may serve as a stand alone treatment, or may be used in conjunction with other measures such as erosion control, flood control or baseflow. Additional benefits include creation of aquatic, wetland, and terrestrial habitat, and high community acceptance for aesthetic value.

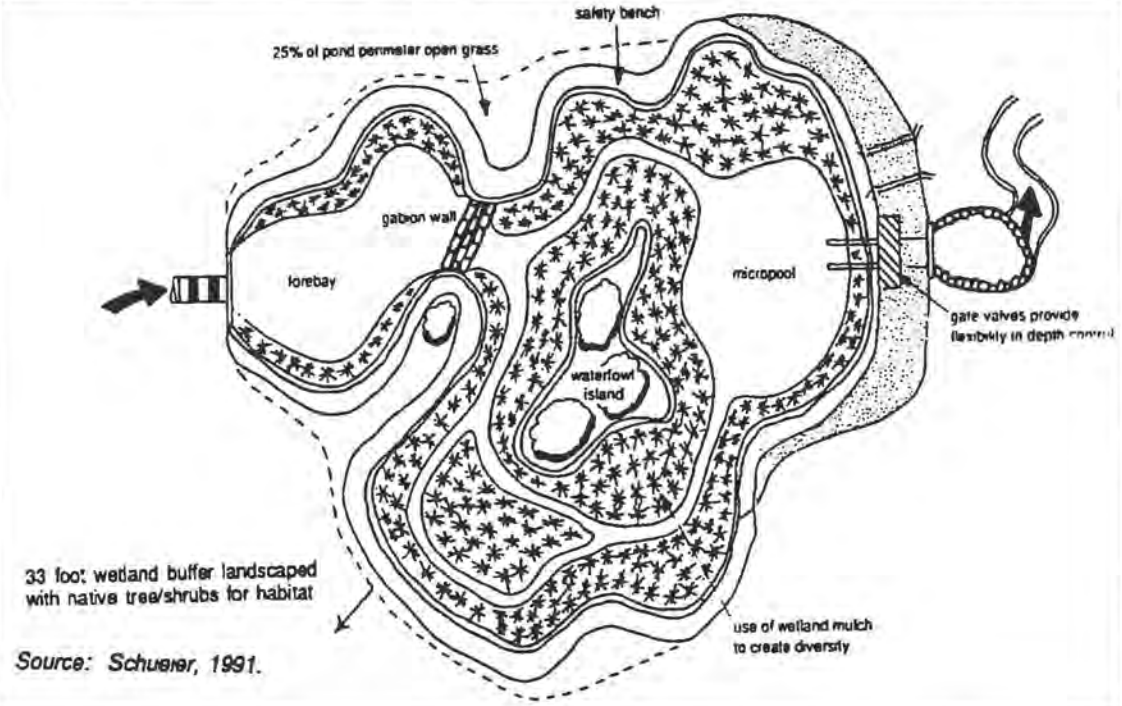
Wet ponds may be constructed on- or off-line and can be sited at feasible locations along established drainage patterns. They are best suited to small subwatersheds with residential land uses or other uses where high nutrient loads are expected (such as golf courses). Figure 9 – 24 presents a wet pond system.

Constructed Storm Water Wetlands

Constructed storm water wetlands are shallow, vegetated ponds that are engineered and constructed to mimic the structure, water quality function, wildlife habitat, and aesthetic value of naturally occurring wetlands. Figure 9 – 25 presents a schematic diagram of a typical constructed wetland solution.

Figure 9 – 25

Constructed Wetland Schematic



Source: Schueler, 1991.

Constructed wetlands generally feature uniformly-vegetated areas with depths of one foot or less, and open water areas as deep as 4 feet. Wetland vegetation is made up of native aquatic plant species. Constructed wetlands can be designed on-line or off-line and usually serve smaller drainage areas than wet ponds. Constructed storm water wetlands need sufficient baseflow, groundwater, and/or contributing drainage area to maintain year-round wet conditions for survival of aquatic vegetation.

Natural wetlands can be modified to handle additional inflows of pollutant loads and water volumes from new developments. In the Austin area such modification is usually limited to old stock ponds that have developed over time as wetlands

Sedimentation/Sand Filtration

Sedimentation/filtration ponds are storm water capture structures that provide two-stage treatment of storm water. Two designs, full and partial sedimentation, are allowed by the Environmental Criteria Manual. The full sedimentation basin detains the first flush runoff, generally at least the first ½ inch with a minimum draw-down time of about 24 hours. The partial sedimentation system stores the captured water in both the sedimentation and filtration portions of the facility, but requires a larger filter area. Effluent is discharged to the filtration basin, which includes a sand filter, a geotextile layer, and gravel. A perforated PVC piping system drains filtered flows from the filtration basin. Pollutant removal is primarily through physical filtration.

Sedimentation/filtration ponds are built as off-line systems, and are typically used to treat runoff from small, newly developed sub-watersheds. Off-line sedimentation/sand filtration can achieve high levels of average annual load removal for suspended solids and associated toxic load. Figure 9 – 26 shows an actual system in place. Figure 9 – 27 presents a schematic of a sedimentation-filtration system as typically implemented in Austin .

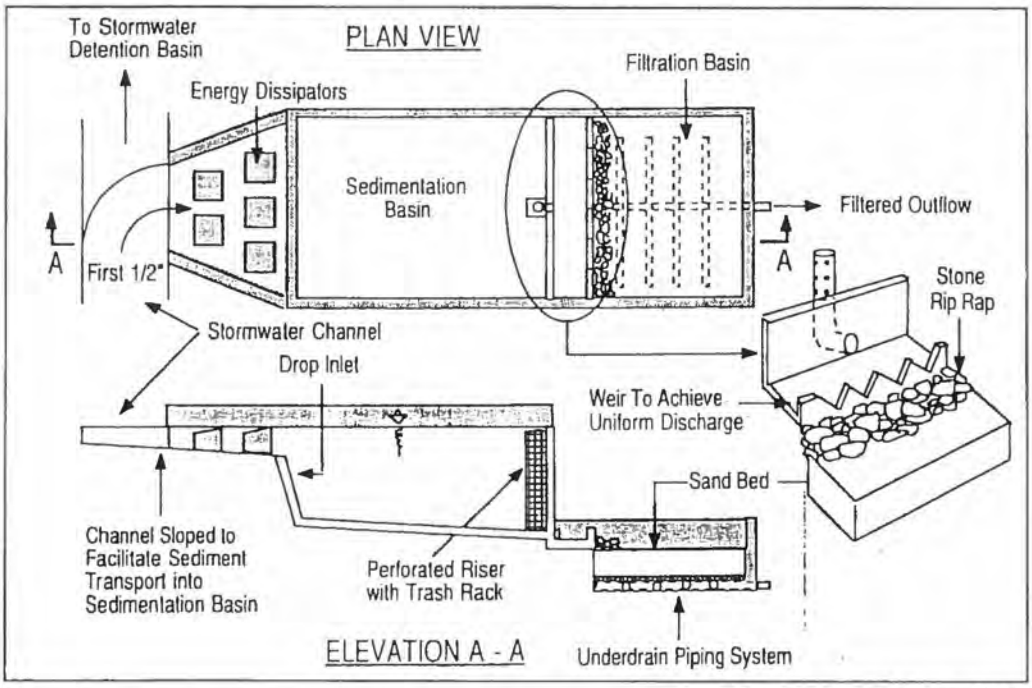
Figure 9 – 26

Sedimentation-Filtration Pond

Austin American Statesman, Town Lake Watershed

Figure 9 – 27

Sedimentation-Filtration System Schematic



Source: City of Austin. 1988

Extended Detention

Extended detention (ED) refers to the capture and slowly release of storm water runoff. ED facilities can be on or off-line. Figure 9 – 28 presents an extended detention system. Off-line ED facilities are typically designed to remain dry between runoff events. However, like wet ponds, this approach can be used to target multiple storm water missions, including water quality, erosion control, baseflow enhancement, and flood control for higher frequency events. ED ponds can be designed in conjunction with other structural storm water practices such as wetponds, or as stand-

Figure 9 – 28

Extended Detention System

St. Edward's University, Blunn Creek

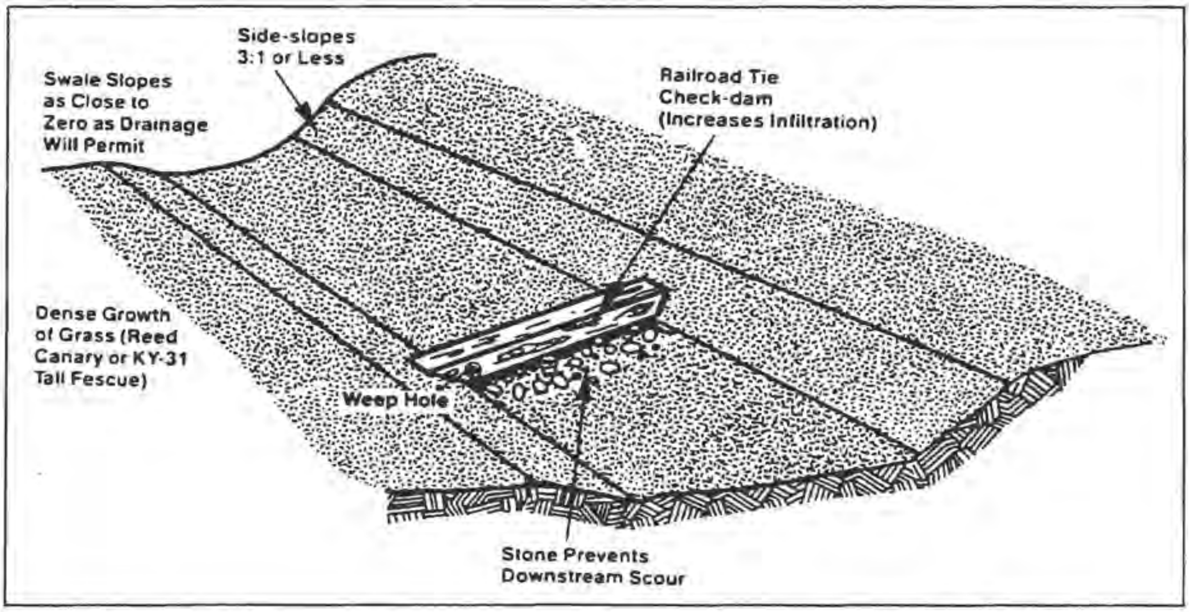
alone facilities. Extended detention technologies require sufficient open land with a grade that allows placement of a storm water storage facility. Depending on detention time, ED ponds used alone generally provide moderate to high (although variable) particulate pollutant removal, but poor removal for dissolved constituents.

Grassed Swales

Grassed swales are vegetated, graded, open channel systems designed to convey runoff as low velocity, overland flow. They require dense vegetative cover. As an alternative to curb and gutter systems, swales are designed to convey runoff while promoting infiltration, settling and capture of particulates. Performance is directly proportional to contact time; thus longer swales with slower velocities provide greater water quality enhancement. They can also be used as a passive solution for site development drainage and as an alternative to curb/gutter storm drain systems. Performance can be severely compromised if slopes are excessive or if erosion along the swale concentrates flows. Figure 9 – 29 presents a typical grassed swale schematic.

Figure 9 – 29

Typical Grassed Swale Schematic



Source: Schueler, 1987

Vegetated Filter Strips

Vegetated filter strips are vegetated areas designed to accept runoff as overland sheet flow from developed land uses. Vegetation can vary from grassy meadows to woodlands and can be existing, natural vegetated buffers or engineered vegetative filter strips. The use of existing vegetative filters is limited to gently sloping areas where shallow flow characteristics are possible. Filter strips provide water quality enhancement through infiltration, settling and capture of particulates, biological uptake process, and physical filtration. They mimic natural watershed conditions by promoting localized runoff storage and infiltration. Filter strips can be vegetated or maintained to preserve the character of riparian corridors, prevent Stream Erosion and preserve habitat quality. If adequately vegetated, graded and maintained, vegetated filter strips are effective and reliable as water quality measures. They are passive and aesthetic in comparison to structural water quality control measures. Figure 9 – 30 presents a typical vegetated filter strip.

Figure 9 – 30

Vegetated Filter Strip

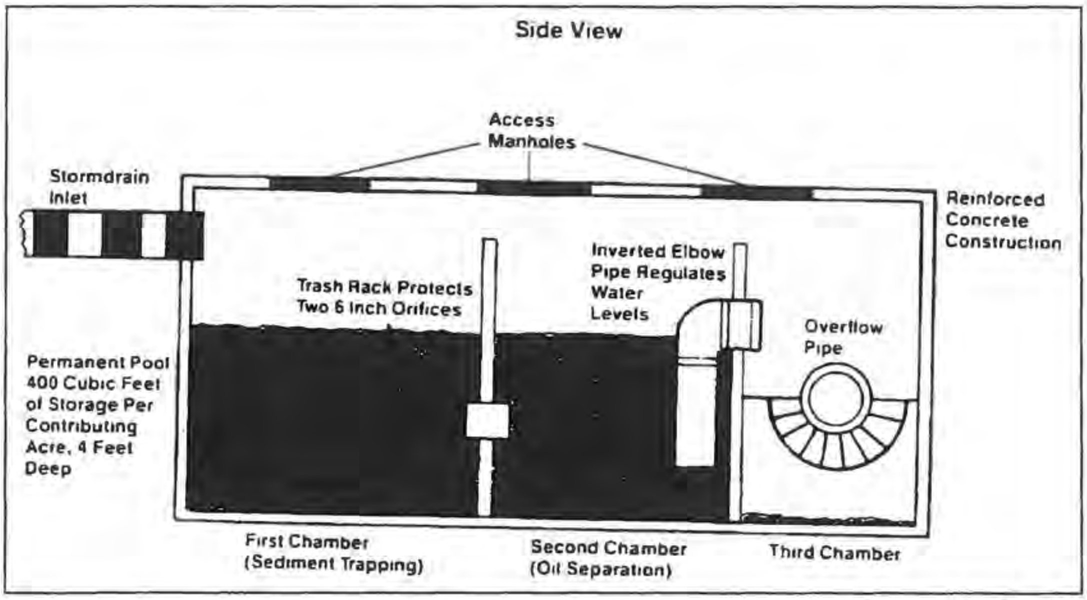
Bartholemew Park, Tannehill Branch

Oil/Grit Separators and Water Quality Inlets

Oil/grit separators (OGS) are typically two- or three-chambered, underground retention systems that remove pollutants from roadways and parking lots. The first chamber is used for gravity settling of heavy particulates, adsorbed hydrocarbons, and heavy metals. The second chamber provides separation by floatation of fresh oil and other emulsified petroleum products. A third chamber usually provides additional storage volume, sediment settling capacity, and houses the storm drain outlet pipe. Figure 9 – 31 presents a schematic representation of a three-chamber oil/grit separator.

Figure 9 – 31

Typical Schematic for Oil/Grit Separator



Source: Schueler, 1987

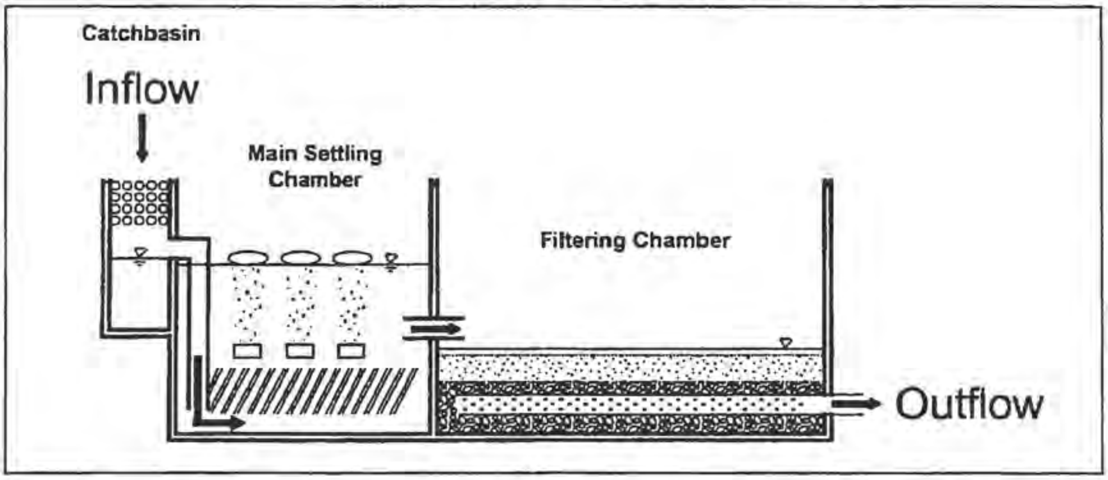
The use of OGS systems is usually restricted to small, highly impervious basins of about two acres or less, and is particularly appropriate for sites expected to receive high amounts of vehicular traffic or petroleum inputs, such as gas stations, roads and loading areas. They can also be used as pre-treatment for wet storage facilities to prevent visible oil on the surface of the permanent pool.

Multi-Chambered Treatment Trains (MCTT)

The Multi-Chambered Treatment Train (MCTT) is a relatively new, site-level storm water treatment technology developed at the University of Alabama-Birmingham. Similar to an oil-grit separator, the MCTT targets toxic storm water loadings from urban "hot spot" areas such as automotive repair or industrial facilities. The MCTT offers improved performance as compared to the oil/grit separator. The MCTT is a concrete device consisting of three chambers, each targeting specific components of the toxic load. Pollutant removal mechanisms include settling, aeration, absorption and filtration in a sand/peat media. Prototype MCTT units have typically been sized to contain the runoff from a 0.5 inch rainfall from a typical 0.5-acre gas station. If developed for general production, the MCTT device can be provided as a completely contained, prefabricated unit ready for placement at the developed site. Figure 9 – 32 presents a schematic representation of an MCTT system.

Figure 9 – 32

Schematic of a Multi-Chambered Treatment Train



Source: Loomis & Moore, 1999

Inlet Adsorbents

Inlet adsorbents are a retrofit technique to place adsorbent filters, pillows, sheets or socks in storm water inlets to remove oil and grease from storm water before it enters the storm drain system. Because the petroleum hydrocarbon component is virtually impossible to remove through settling, inlet adsorbent materials are one of few effective techniques. Inlet adsorbents can be installed in conventional storm water inlets and are a logical companion to inlet filters.

Property Acquisition for Enhancement of Water Quality Control

There are four property acquisition options that can be used for water quality control purposes. Table 9 – 6 outlines those four techniques.

Table 9 – 6

Property Acquisition Techniques

Land Acquisition	Riparian Vegetated Buffers
Conservation Easements	Urban Forestry

Land Acquisition

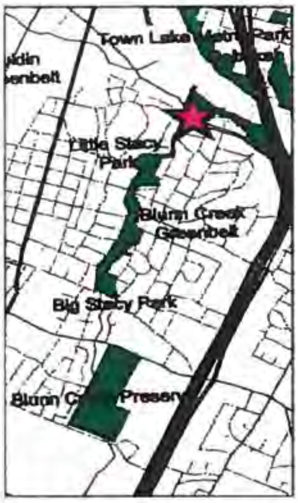
Land acquisition for water quality protection involves the purchase of strategically sensitive lands, protecting raw lands from being developed, and therefore maintaining low, pre-developed pollutant loads in perpetuity. Purchases are made from willing sellers and do not involve condemnation. Land to be considered for acquisition should have several characteristics: (1) relatively high degree of long term development pressure; (2) high environmental value (inherent value or value as a prospective site for future water quality controls); and (3) an owner who is willing to sell. Acquired lands may provide other indirect benefits such as endangered species protection or preservation of baseflow and aquifer recharge.

Conservation Easements

Conservation easements for water quality protection are legal agreements with property owners to limit development of properties covered by the easements. Development restrictions can range from partial to total purchase of development rights. Conservation easements differ from land acquisition in that the property owner maintains legal possession of the land, while the easement holder acquires the raw land development value. This option is most feasible for undeveloped land, but may be applicable in some situations on land with low-density development.

Riparian Vegetated Buffers

Riparian vegetated buffers are vegetated lands purchased and set aside in perpetuity along creek channels and waterways. Buffers can function as overbank erosion protection during peak flows and can also serve as a vegetated filter strip for local runoff. They can preclude development in close proximity to waterways, further disconnecting impervious surfaces from direct conveyance to the creek. A native plant or xeriscaped buffer strip minimizes the need for supplemental fertilizer, pesticides, or watering. Buffer areas also provide recreational, aesthetic, erosion control, and wildlife habitat value. The Stacy Park and Blunn Creek Preserve buffer help protect much of the Blunn Creek watershed in Austin.



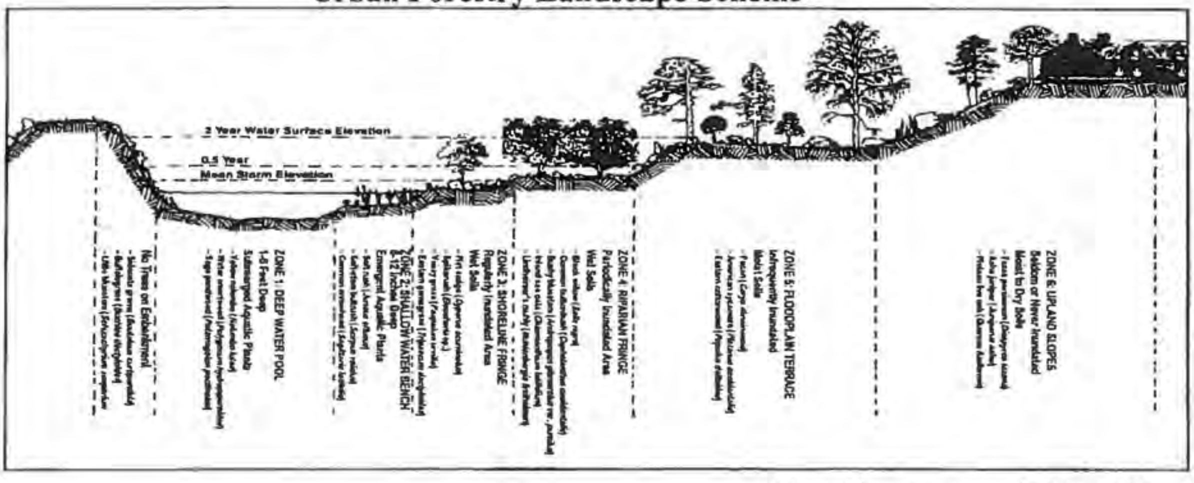
Stacey Park/Blunn Creek Greenbelt
Source: City of Austin, 1999

Urban Forestry

Urban forestry includes landscaping practices such as the preservation of trees during construction, planting of trees after site clearing, infilling of additional trees on developed sites, and homeowner landscaping after subdivision development. Trees, shrubs and ground cover intercept rainfall and create a permeable layer that promotes infiltration of runoff. Urban forestry is considered to provide a limited degree of pollutant removal; however, it does provide shade, wind breaks, moderation of local air temperatures, and habitat for wildlife. Typically, as much as 50% of a residential lot can be converted into a natural setting of trees, shrubs and ground covers. Figure 9 – 33 depicts a typical urban forestry application.

Figure 9 – 33

Urban Forestry Landscape Scheme



Adapted from Wittans and Weiss, 1985

Rangeland Management Strategies

Ranchers have traditionally used rangelands in central Texas for grazing cattle, goats, and sheep. Rangelands represent the predominant land use in Austin's outlying watersheds to the west. Due to their large contributing drainage area, the condition of these lands may have a significant effect on water quantity and quality. Poor management practices have left much of this area in a deteriorated condition. Recent research shows that improved management of rangelands can stabilize soils, restore vegetation, increase rainfall infiltration, augment creek baseflows, and reduce sedimentation and nutrient export. Table 9 – 7 presents three rangeland management strategies.

Table 9 – 7

Rangeland Management Strategies

Native Grassland Establishment	Specialized Grazing Systems
Control of Livestock in Riparian Areas	

Native Grassland Establishment

Grassland establishment involves clearing undesirable brush species (such as juniper and cedar) and planting native bunch grasses. The presence of undesirable brush species can result in substantial interception of rainfall, reduction in infiltration (and thus baseflow), and suppression of ground-cover vegetation. Bunch grasses form a thick ground cover with extensive root systems, a combination that serves to impede overland flow, reduce sediment movement, and increase infiltration and resulting creek baseflow.

Not all rangelands are suitable for grassland establishment. Many areas with cedar are habitat for the endangered golden-cheeked warbler, which the Balcones Canyonlands Preserve seeks to protect. Juniper is a well-adapted native in the Texas Hill Country, and its historic place in steep, rugged, canyons should be preserved. Removal of junipers from these areas could significantly increase erosion and sedimentation. Some flatter, more upland stands of cedar should also be left intact. The selection of areas for grassland establishment should be carefully determined on a site-by-site basis.

Control of Livestock in Riparian Areas

Riparian areas constitute critical buffer zones for creek protection. Overuse by livestock in these areas causes damage to the stream channel and to protective riparian vegetation. Cattle and other livestock prefer to remain in close proximity to waterways as they provide drinking water, shade, and locally cooler temperatures. Vulnerable areas along riparian areas should be protected from over-use by livestock with fencing, rotational grazing, and other methods. Control of livestock in riparian areas is widely applicable in ranchlands.

Use of Specialized Grazing Systems

Many experts contend that rangelands are best served by management systems that control the number and location of livestock on a given property. Traditionally, livestock herds have been maintained at low intensities on a given site for extended periods of time. In many cases, highly desirable grazing areas, such as riparian zones, are heavily used and are not permitted sufficient opportunity to recover. Management theories have been proposed indicating that rangelands are best used intensively for short periods with long periods of rest. These theories maintain that short grazing regimes mimic natural patterns of herd animal behavior, thereby stimulating native vegetative systems, which in turn protect soil and water resources. While specialized grazing systems are applicable throughout the ranch lands of Central Texas, given the trend toward subdivision of large ranches into smaller rural parcels, it may be necessary for ranchers and other landowners to work collaboratively.

9.3 Operating Programs

Operating Programs are implemented as City operating programs involving ongoing storm water management activities with a long term budgetary commitment. Examples of operating programs include infrastructure maintenance, emergency spills and complaints response, design review and inspection for new development, the flood early warning system, and water quality monitoring. Programmatic solutions are applicable to virtually all watershed problems.

The Inventory of Programmatic Solutions summarizes the existing and potential solutions implemented as City programs funded through the Watershed Protection Department's (WPD) annual operating budget. Programs are administered by the three divisions within the Watershed Protection Department. Table 9 – 8 provides a list of all existing programs. Programs are generally categorized by the three WPD missions: erosion, flood, and water quality control. Some programs are considered to be integrated, i.e., they address all three program areas.

Table 9 – 8

Existing WPD Programmatic Inventory Listing

FLOOD CONTROL	WATER QUALITY CONTROL
Flood Project Planning, Implementation & Field Eng.	Federal Storm Water Permit
Channel Vegetation Control	Water Quality Assessment
Pond Vegetation Control	Land Use Water Quality Monitoring
Open Waterway Maintenance	Structural Controls Monitoring
Bridge and Culvert Cleaning	Environmental Impact Assessments
Storm Drain System Repair and Rehabilitation	Water Quality Control Design
Storm Drain System Cleaning	Storm Sewer Discharge Permits
Hydrologic & Hydraulic Modeling	Emergency Spills & Complaints
Flood Plain Office	Contaminated Site Cleanup
Flood Early Warning System (FEWS)	Water Quality Education
Flood Hazard Public Education	Pond Operating Permits
Watershed Management and Facilities Planning	Underground Storage Tanks
EROSION CONTROL	Commercial Pond Inspection
Erosion Project Planning, Implementation, & Field Engineering	Town Lake Cleanup
Erosion Control Crew	
INTEGRATED PROGRAMS	
Detention and Water Quality Pond Maintenance and Repair	
Review and Inspection of Development	
Watershed Master Planning	
Geographic Information Systems (GIS) and Database Management	

The Inventory also identified potential new programs which are identified in Table 9 – 9, and discussed at the end of the program inventory. Several new integrated program elements were identified from during the course of the Master Plan to address specific problems or to implement Capital project solutions.

Table 9 – 9

Proposed Potential Program Elements

Flood and Erosion Property Acquisition	Small Scale Urban Water Quality Retrofit and Baseflow Enhancement
Conservation Easement/Land Acquisition	"Grow Green" Landscape Program

9.3.1 Existing Flood Control Programs

Flood control programs focus on effective conveyance of storm water flows and minimization of impact from flood-stage waters, and include programs shown in Table 9 – 10.

Table 9 – 10

Existing Flood Control Operating Programs

Flood Project Planning, Implementation and Field Eng.	Storm Drain System Cleaning
Channel Vegetation Control	Hydrologic & Hydraulic Modeling
Pond Vegetation Control	Flood Plain Office
Open Water Way Maintenance	Flood Early Warning System
Bridge and Culvert Cleaning	Flood Hazard Public Education
Storm Drain System Repair and Rehabilitation	Watershed Management and Facilities Planning

Flood Project Planning, Implementation and Field Engineering

The Flood Project Planning, Implementation and Field Engineering Program is responsible for identifying and assessing drainage problems, planning appropriate solutions, designing selected projects, and implementing projects through bidding and construction. This program also manages customer drainage complaints, databases, inspection reporting, and other information-related project matters. Flood control assessments typically include management/performance of flood problem inventories with hydrologic and hydraulic modeling to confirm flood problems. Based on these assessments, major Capital projects and smaller-scale projects are prioritized and scheduled for design or remediation. Staff also performs site specific drainage assessments in response to citizen complaints.

Walnut Creek

Channel Vegetation Control

The Channel Vegetation Control program provides flood control through removal of excessive vegetation in channels through a contract with the Texas Industries for the Blind and Handicapped, in conjunction with the Capital Area Easter Seals organization. The Capital Area Easter Seals adult work program performs most of the removal work. Although contracted to an external entity, this program does not require a bidding process, because it assists the blind and handicapped by providing jobs through Texas Industries for the Blind and Handicapped. In this manner, the program is efficiently implemented with reasonably low costs. Cuts are made approximately three to four times annually.

Pond Vegetation Control

The Pond Vegetation Control program provides flood control, water quality benefits and aesthetic benefits through proper management of excessive vegetation in City-maintained storm water ponds. It is contracted in the same manner as the Channel Vegetation Control program. Cuts are made approximately three to four times annually

Open Waterways Maintenance

The Open Waterways Maintenance (OWM) program provides removal of accumulated sediments, debris, trees, brush and other obstructions to storm water flow from creekbeds to increase capacity. This program involves more rugged work, requiring heavy equipment and skilled City staff in response to storm clean-up needs and citizen complaints.

Williamson Creek Watershed

Bridge and Culvert Clearing

The Bridge and Culvert Clearing program provides removal of accumulated sediments, debris, litter, trees, brush, and other obstructions to bridges and culverts generally in the aftermath of significant storm events.

Storm Drain System Repair and Rehabilitation

The Storm Drain System Repair and Rehabilitation program provides for installation and repair of storm drains and inlets and maintenance of the storm drain system in order to keep it in reliable and working order. The program addresses unplanned, minor storm drain improvements needs required for new Public Works projects and upgrades to existing infrastructure in order to mitigate flooding. These projects result from citizen complaint.

Storm Drain System Cleaning

The Storm Drain System Cleaning program provides inspection and cleaning services for the City's estimated 18,000 inlets and associated storm drains, and maintenance for bar ditches along roadways. The goal of this program is to reduce street flooding and to protect water quality by removing accumulated sediment and trash.

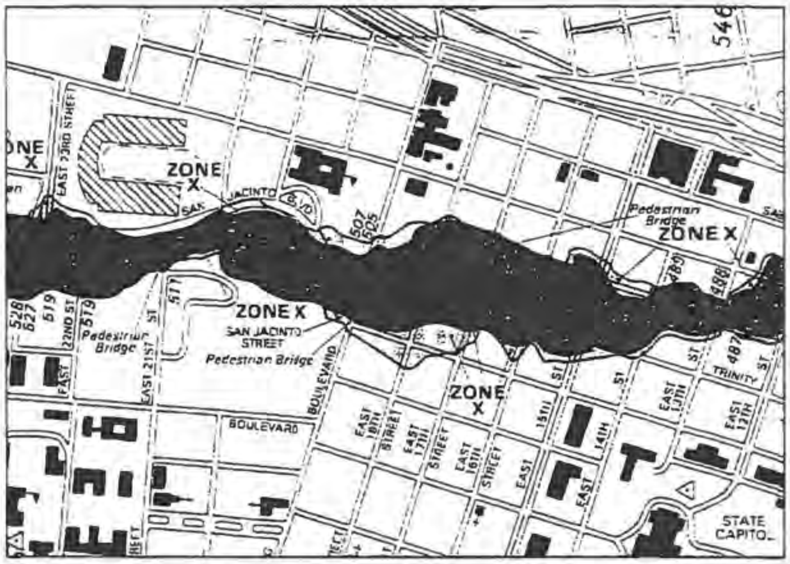
Approximately 4,000 inlets are inspected each year. Of the 4,000 inlets inspected each year, approximately 2,000 experience chronic problems and are inspected annually. The other inlets are inspected and maintained in response to citizen complaints or on a regular rotation. All inlet filters are inspected weekly and/or following large rainfall events and cleaned if necessary.

Downtown Austin

Watershed Hydrologic and Hydraulic Modeling

The Hydrologic and Hydraulic Modeling Program is responsible for model development and management of Austin's hydrologic and hydraulic watershed channel models used to determine flood flow rates, water surface elevations, and flood boundaries. This program supports solutions assessment and project development; determination of flood threats; in-house project design; erosion, flood and water quality studies and planning initiatives; and a wide range of planning initiatives. This program provides the City with the flexibility to perform a variety of necessary hydrologic and hydraulic investigations in house. A large number and variety of modeling needs are satisfied through this program.

Floodplain Office



Source: FEMA

The City's Floodplain Office serves as the community representative for the National Flood Insurance Program (NFIP) in Austin. The NFIP provides flood insurance backed by the Federal Emergency Management Agency (FEMA). In order to be a participant in the NFIP, a community must adopt and enforce a floodplain management ordinance to regulate development in flood hazard areas. The City of Austin's current floodplain program places it among the top 5% of flood control communities in the nation and allows for a 15% reduction in flood insurance costs. This reduction in insurance costs reflects local community actions taken to reduce flood threats.

As the community representative for the NFIP in Austin, the City Floodplain Office provides:

- Flood Plain determination
- Review of development plans
- Updating Flood Insurance Rate Maps (FIRMs);
- Review vacation of easements and rights of way (ROW)s, and
- Public education initiatives

Flood Early Warning System (FEWS)

The Flood Early Warning System (FEWS) program gathers real time rainfall and streamflow stage data. This information is analyzed by FEWS operators and is used to provide advance warning of potential flood conditions for emergency response personnel. The FEWS program was initiated in 1986 in response to the devastating 1981 flood on Shoal Creek It has improved the City's emergency response capabilities with respect to road closings, evacuation of flood-prone areas, and public notification of hazardous conditions. The primary goal of this program is to enhance public safety.

Flood Hazard Public Information

Flood hazard public education efforts are implemented in conjunction with the Flood Early Warning System. This program provides floodplain status information and a basic understanding of flood threats and options for citizens living in regulatory floodplain areas. This program also targets avoidance of dangerous behaviors (e.g., driving through overtopped low water crossings) during extreme events.

Watershed Management and Facilities Planning

This program provides an opportunity to participate in jointly funded regional storm water management facilities in lieu of providing on-site flood detention. The program manages the Regional Storm Water Management Program (RSMP) Fund used to plan, purchase property, design and construct regional storm water facilities, channel improvements, and culvert and storm drain upgrades for flood control. The program also provides preliminary engineering assessments for regional facilities, provides project planning and design, provides oversight and review of master plan hydrologic and hydraulic models, and provides drainage analysis for site developments.

9.3.2 Existing Erosion Control Programs

There are currently two programs that address erosion control issues. They are:

- Erosion Project Planning, Implementation and Field Engineering
- Erosion Control Crew

Erosion Project Planning, Implementation and Field Engineering

The Erosion Project Planning, Implementation and Field Engineering Program is responsible for identification and assessment of erosion problems, planning appropriate solutions (projects), designing and managing consultant performance of selected projects, and implementing solutions through bidding and construction. This program manages customer erosion problem complaints, problem databases, inspection reporting and other information-related matters. This program is responsible for design and management of projects for both large-scale Capital projects and smaller erosion projects constructed by the Erosion Control Crew.

Erosion Control Crew

The Erosion Control Crew (ECC) program performs regular maintenance and installation for small erosion control projects, and favors use of natural engineering designs and biorevetment procedures when possible. Small-scale erosion problems located in waterways with a drainage less than 1.0 square mile are currently identified through citizen complaints or in conjunction with site inspections. The ECC allows for rapid response to high priority, small-scale projects in tributary watersheds. The Erosion Project Planning, Implementation and Field Engineering staff selects and oversees the projects carried out by the Erosion Control Crew.

Gillis Park, East Bouldin Creek Watershed

9.3.3 Existing Water Quality Programs

Programs targeting Water Quality solutions are those that attempt to limit the introduction of pollutants to receiving waters or prevent accidental contamination, and are listed in Table 9 – 11.

Table 9 – 11

Existing Water Quality Protection

Operating Programs

Federal Storm Water Permit	Emergency Spills and Complaints
Water Quality Assessment	Contaminated Site Cleanup
Land Use Water Quality Monitoring	Water Quality Education
Structural Controls Monitoring	Pond Operating Permits
Environmental Impact Assessments	Underground Storage Tanks
Water Quality Control Design	Commercial Pond Inspection
Storm Sewer Discharge Permits	Town Lake Cleanup

Federal Permit Compliance

This program is intended to assure compliance with all Federal permits, including the City's current Municipal Storm Water National Pollutant Discharge Elimination System (NPDES) permit and all federal requirements regarding endangered species. The City's NPDES permit is a requirement of the Federal Clean Water Act. The permit requires the City to prohibit non-storm water discharges into the municipal storm drain system, and to implement controls to reduce the discharge of pollutants in storm water runoff to the maximum extent practicable. This permit requires coordination and interaction with existing Industrial and Construction NPDES permits held by public and private entities. This program also includes elements to insure the City's compliance with Federal endangered species regulations.


Walnut Creek

Water Quality Assessments

Water Quality Assessments program staff conduct and supervise water quality investigations to determine the state of the ecological health of the City's water resources. The program monitors Austin's creeks, Town Lake, the Edwards Aquifer, local springs, and salamander habitat. Flow, water and sediment chemistry, aquatic biology, and related data are collected and evaluated. The assessments performed under this program are designed to evaluate water quality conditions, identify pollution sources, recommend solutions to problems, and track effectiveness of water quality protection efforts. The Water Quality Assessments program is required under the City's NPDES permit, with annual reports of results to be provided for Town Lake, Lake Austin, and Barton Creek. Environmental Integrity Index (EII) assessments along creek reaches will be developed on an annual schedule, rotating to complete a Citywide assessment every three years. The City uses information from this program to focus its efforts toward protection and restoration of its biological, chemical, sediment and groundwater resources. This program also provides support to the WPD master plan and state planning agencies.

Land Use Water Quality Monitoring

The Land Use Water Quality Monitoring program monitors particular land uses to determine the quality and quantity of storm water runoff from various types of developed and undeveloped land. Flow and water quality data is collected to describe existing water quality conditions and temporal trends, and to comply with the requirements of the City's Federal Storm Water Permit (NPDES). The Land Use Water Quality Monitoring program also includes a cooperative monitoring program with the U. S. Geological Survey (USGS) on the major creeks in Austin. This program has been operating since 1975.

Structural Controls Monitoring

Structural pollution controls are monitored to determine pollution removal effectiveness. This program investigates both alternative and commonly applied structural water quality measures. Local monitoring requirements for alternative approaches is decided on a case-by-case basis by program staff. This program is effective at defining the advantages and limitations of structural water quality controls. The City of Austin's structural controls monitoring program is one of the most comprehensive in the nation.

Environmental Impact Assessments

The Environmental Impact Assessments program provides City review of development projects, Capital projects, Water Pollution Abatement Plans, permit applications for wastewater effluent irrigation, and Austin Transportation Study projects to assess potential environmental impacts to water resources. It also reviews federal/state/local legislation, regulations, ordinances, and planning documents to determine their effect on the City's water resources protection efforts and participates in intergovernmental review panels and committees.

Water Quality Control Design

The Water Quality Control Design program manages the design of structural water quality controls implemented as Capital projects. This program is responsible for the planning, design, and construction of urban water quality retrofits. Program staff supervise, coordinate, and review the work of consultants. The program facilitates the movement of funds (paid as fees in lieu of providing on-site controls in the urban watersheds) from development project permits to the Capital project budget for the purpose of constructing urban retrofit projects for water quality.

Storm Sewer Discharge Permits

The Storm Sewer Discharge Permits (SSDP) Program is primarily responsible for inspection and permitting of specific commercial and industrial businesses a within the Austin City limits to prevent or mitigate polluting discharges to the City storm drains and waterways. Site inspections are conducted to evaluate waste handling, storage, and disposal practices, maintenance activities, and operational condition of water quality controls. This program is also responsible for review of non-storm water discharges to the city storm drain system and waterways to prevent polluting discharges.

Emergency Spills and Complaints Response

The Emergency Spills and Complaints Response Program (ESCP) responds to hazardous and non-hazardous material spills and citizen pollution complaints within the Austin

City limits and the 5-mile ETJ to prevent and mitigate polluting discharges to City storm drains and waterways. ESCP staff manage a 24-hour Environmental Hotline to ensure rapid response and reduce potential environmental impact. Program staff assesses the potential environmental impact, determine the responsible party, identifying the pollutant(s), and ensure that corrective action and preventive measures are taken. ESCP staff request and review sample results and remediation plans as needed.

Harris Branch Watershed

Contaminated Site Cleanup

The Contaminated Site Cleanup Program (CSC) is operated in conjunction with the Emergency Spills and Complaints Program. The CSC program provides remediation and disposal of hazardous/toxic materials found abandoned on City road rights-of-way, on City properties not operated by a specific department when the responsible party can not be located. The CSC program also responds when a responsible party can ultimately be found but the situation is critical and cleanup must be done quickly. The program consists of a spill remediation contract and a spill material disposal contract with private waste management firms. These contracts are managed on an as-needed basis by the ESCP staff.

Water Quality Education

This program functions to increase City wide awareness of the causes of non-point source (NPS) pollution and to encourage the reduction of toxic pesticide and herbicide use and pollutant loads entering the local receiving waters. The Water Quality Education program sponsors storm inlet marking, denoting inlets that drain to creeks. Program elements include:

Source: City of Austin, 2000

- NPS Pollution education campaigns and initiative;
- Earth Camp for Elementary students
- City wide Integrated Pest Management (IPM) program; and
- Grow Green Landscape program

Pond Operating Permits

The Pond Operating Permits program ensures that water quality controls within the Barton Springs Zone are maintained regularly and meeting pollutant concentration requirements. Permits are required for water quality controls that treat newer commercial development in the Barton Springs Zone and Barton Creek Watershed. This program was developed in conjunction with the City of Austin's 1991 Composite Ordinance to protect the Springs and Creek. At present, permits are required only within the Barton Creek Watershed and the Barton Springs Zone. The program goal is to prevent recharge water quality degradation with respect to toxics, nutrients, organics and sediment.

Underground Storage Tank Management

The Underground Storage Tank program establishes standards and inspection procedures for safe storage of hazardous substances in underground storage tank (UST) systems. Plans for all UST sites must be reviewed, and all UST's must be registered. Inspections are conducted during system testing, as well as during alteration, removal, and/or construction of UST systems. Tank construction activities are inspected during groundbreaking, pipe installation, tank installation, console installation, and during final acceptance. There is also a public education component, focusing on best management practices (BMP) for safe handling and storage of hazardous materials. This program maintains a complete database of historical information, as well as a current inventory with leak detection results.

Williamson Creek Watershed

The City of Austin's UST program is part of the City's Water Pollution Abatement Plan as required by the Texas Water Code Section 26.177 and by the Hazardous Materials Storage and Registration Ordinance. It is also required under the current NPDES permit and the Uniform Fire Code.

Town Lake Cleanup

The Town Lake Cleanup program provides removal of trash and debris on and around Town Lake. The Town Lake Clean-up program has a full-time crew of three people who work every day barring inclement weather, or if upstream floodgates are open.

Town Lake

In addition, a motor-driven barge/skimmer is used to gather floating debris. Although the impact on water quality is primarily aesthetic, this program has high public acceptance because of the prominent visual pollution that is removed. Staff reports significantly reduced public complaints regarding trash on Town Lake since the program was instituted.

Integrated Programs

Integrated programs are those that address more than one of the WPD missions. There are five integrated programs currently in operation, as shown in Table 9 – 12.

Table 9 – 12
Existing Integrated Operating Programs

Detention and Water Quality Pond Maintenance and Repair	Watershed Master Planning
Review and Inspection of Development	Geographic Information Systems (GIS) and Database Management

Detention and Water Quality Pond Maintenance and Repair

The Detention and Water Quality Pond Maintenance and Repair program provides regular maintenance and repair of flood detention and water quality ponds managed by the City of Austin. This program performs critical maintenance tasks. The goals of this program are to maintain proper function and efficiency of flood detention and water quality ponds. The program includes flood detention ponds, sedimentation basins, sedimentation/filtration ponds, extended detention ponds, and wet ponds. Clogging of flood detention and water quality facilities is common and can lead to severely reduced functioning. Citizen complaint calls are typically in regards to mosquito problems.

Residential and Commercial Pond Inspection

This program operates to ensure that the many structural flood, erosion and water quality controls required by City ordinance continue to function properly to protect waterways, lives and property. The Residential and Commercial Pond Inspection program inspects both commercial and residential ponds annually. Information from inspections is entered into the pond database. Commercial pond maintenance is the responsibility of the property owner. A "Notice of Violation" letter is mailed to the non-compliant property owner. Pond maintenance items for residential ponds are forwarded to WPD Field Operations to be addressed. It also conducts FEMA Creek Inspections as a component of the Nation Flood Insurance Program.

Review and Inspection of New Development

This program seeks to achieve regulatory compliance for land development activities by enforcing the requirements of the City's Land Development Code (LDC), the Environmental Criteria Manual (ECM), and the Drainage Criteria Manual (DCM). The Environmental Review and Inspection Division (ERID) of WPD conducts most review activities with support from the Environmental Resource Management Division. This combined staff is responsible for reviewing and approving plans for permits and other requests for approval for land development activities.

Barton Creek Watershed

The Water Quality Engineering/Permit Review section provides engineering and construction review for preliminary plans, final plats, subdivision construction plans, and site plans in accordance with the LDC and ECM and DCM. This program is essential to the maintenance of Austin's high water quality, flood control, erosion control, environmental protection, and aesthetic standards and practices.

The Environmental Review section manages the environmental related activities of the Development Assistance Center (DAC) and provides water quality, tree protection and landscape review, and inspection for all site development. The Environmental Inspection section performs environmental site inspections during construction and following completion of development projects, including red-tagging development out of compliance. This group oversees the proper installation and maintenance of temporary and permanent erosion and sedimentation controls on construction sites.

Watershed Master Planning

The Watershed Master Planning program involves coordination of comprehensive master planning initiatives for storm water management at the watershed level. This program is implemented by WPD staff and includes evaluation, planning and coordination of:

- technical investigations;
- watershed planning and analysis activities;
- operating programs;
- compliance with City regulations;
- storm water management goals; and
- solution integration.

The Watershed Master Planning program promotes implementation of optimal management solutions that integrate, to the extent possible, all storm water programs missions.

Geographic Information Systems (GIS) and Database Management

The Geographic Information Systems (GIS) and Database Management program is a general support program for the WPD. GIS systems link digital map information with database information to allow for efficient spatial analyses. City staff expects that GIS systems will eventually serve as the central tool for information management. Some GIS systems development and management is provided by the Infrastructure Systems Support (ISS) Department; however staff members within the WPD provide GIS system development and management for the erosion, flood, and water quality mission groups. The immediate goal of this program is to compile and maintain accurate and complete digital map information and corresponding database information for WPD missions and functions, using consistent mapping, database structures, and GIS platforms. The Database Management provides accurate and consistent data storage and retrieval, often in relation to GIS systems. The development of useful and accurate GIS systems requires consistent, accurate, and well-designed supporting databases. The Database Management program identifies all databases currently used, organizes them within a single, consistent database platform, and integrates them into an appropriate GIS. Ongoing activities involve updating and managing those databases and GIS systems.

9.3.4 Potential Program Elements

Several new integrated program elements were identified during the course of the Master Plan to address specific problems or to implement Capital project solutions. A summary of the potential program elements is listed below.

- Flood and Erosion Hazard Property Acquisition
- Conservation Easement/Land Acquisition Program
- Small Scale Urban Water Quality Retrofit and Baseflow Enhancement
- Grow Green Landscape Program for Water Quality
- Street Sweeping for Toxic Control
- Trash and Debris Control Team

Flood and Erosion Hazard Property Acquisition

This program element is proposed to implement the Capital project solutions Property Acquisition for Erosion and Flood Control, and Land Acquisition for Water Quality Control (see the Capital Projects section of this report for more details on these solutions. This program would work to acquire properties currently in the 25 or 100 year floodplain on a voluntary basis. Once vacated, a structure would be removed and the floodplain reclaimed as a portion of the natural buffer.

Conservation Easement/Land Acquisition Program

This program element is proposed to implement the Capital project solution Conservation Easements for Water Quality Control (see the Capital project section of this report for details on this solution type). This program would identify, facilitate acquisition of, and maintain strategic land properties. Application of this program for riparian buffer acquisition could be coordinated with the Flood and Erosion Hazard Acquisition Program.

Small-Scaled Urban Water Quality Retrofit and Baseflow Enhancement

This program element was identified as a potential program element that would be targeted to employ site-specific structural controls (see the Capital project solutions inventory for more details on controls) to intercept and retain toxics in runoff water and from accidental spills. All of the 17 Phase I watersheds have land uses which are potential sources of toxics and other hazardous substances. Bridge locations at creek crossings are particularly favorable for hazardous materials traps. Oil/grit separators and multi-chambered treatment trains are useful in businesses that use petroleum, oil, and lubricant (POL) products. Sand filters can be installed in commercial or industrial areas with no existing storm water controls. This program would also employ controls that serve to promote the retention of rainfall on-site, which has the corollary benefit of reducing peak flows, erosion, and sedimentation. These structural solutions include impervious cover removal/disconnection, grassed swales/filter strips, and rainwater harvesting. These solutions are well suited to urban retrofit because they either occupy very little physical space or involve the actual removal or modification of existing impervious cover.

"Grow Green " Landscape Program for Water Quality

A new Grow Green Landscape element was proposed as a potential program element to be introduced into the existing Water Quality Education program that would promote and implement environmentally beneficial landscaping in Austin. Since the onset of the Master Plan, the Grow Green Landscape program has been initiated as a part of the Water Quality Education program. Program elements include community education for citizens and local landscape retailers on less toxic alternatives to treat local landscape problems.

Street Sweeping for Toxics Control

Street sweeping was proposed as a potential program element. It is required under the City's NPDES permit and is currently performed through the Solid Waste Services Department. While street sweeping is not directly related to water quality control, the use of vacuum technologies instead of the currently used brush technologies can provide increased water quality benefits. Fine particulates tend to be associated with a disproportionate fraction of the overall street toxics load and can be much more effectively captured with vacuum sweepers. Street sweeping is beneficial for both aesthetic concerns and water quality control.

Trash and Debris Control Team

A newly formed Trash and Debris Control Team was proposed as a potential program element that would be targeted at identifying, deploying, and maintaining site-specific structural trash control measures. The team would also collect trash dumped in City waterways, which often results in citizen complaints and aesthetic problems. The Trash and Debris Control Team could serve to remove accumulated trash at locations where new inlet filters, trash debris booms, and pond retrofits have been constructed. The use of a dedicated Trash and Debris Control Team could be an effective and relatively inexpensive means of addressing this problem. The team could work in cooperation with the Environmental Hotline for illegal dumping in storm drains and creeks (499-2550). This crew could be combined and administered through the Watershed Engineering Division.

Rural Watershed Restoration

This new proposed program element would encourage and provide assistance to local landowners willing to restore degraded rangeland areas. This program is recommended to implement the Rangeland Management Strategies of Native Grassland establishment, Specialized Grazing Systems and Control of Livestock that are listed in the Capital project solution section of this report. (See the Capital project section of this report for more details on these solution types). This program would be generally applicable in the undeveloped ranchlands on the periphery of urbanized Austin. It would be best employed in conjunction with conservation easements, land acquisition, endangered species protection regulations, and other measures.

9.4 Regulations

Regulations are implemented through application and enforcement of the City of Austin's administrative codes and rules. Typical examples of regulations include impervious cover limits for new development, drainage design criteria, and industrial storm sewer discharge permitting. Regulatory solutions are effective in preventing or minimizing future problems such as: (1) creek stability and erosion, and (2) water quality degradation (3) future flood plain development, (4) and managing future flood prevention.

The regulatory solutions inventory is a description of existing and potential future City regulations and rules that directly affect the erosion, flood, and water quality protection missions of the Watershed Protection Department are described in this section. The following inventory of existing regulations was taken from Austin City Code Chapters 4, 10, 12, 14, 18 and 25 (see Table 9 – 13 for summary of chapters and purpose). The majority of the regulations enforced by the Watershed Protection Department are found in Volume 2 Chapter 25 of the City Code, also known as the Land Development Code

(LDC), which contains all regulations affecting the development or redevelopment of land.

Table 9 – 13

Existing City Regulations Affecting Watershed Protection

Code Chapter	Purpose
Volume 1 - Chapter 4	Restricts discharges into a watercourse, and outlines federal and state requirements.
Volume 1 - Chapter 14	Restricts hazardous materials storage and underground storage facilities.
Volume 1 - Chapter 18	Relates to Drainage Utility and fee collection.
Volume 2- Chapter 25	Land Development regulations for erosion, flood, and water quality requirements, including subdivision and site development standards.

Potential regulations were identified from several sources including City staff, review of existing or draft regulations from selected municipal governments, and published literature.

City Code allows City departments to promulgate rules to provide uniform minimum standards for implementing the Land Development Code. Proposed rules must be posted and written notice provided to any person who requests the notice by mail and posts the required fee. Following a minimum 30-day comment period, a City department may adopt a proposed, modified, or portion of a proposed rule. Any person may appeal the adoption of a rule.

Adopted rules affecting the Watershed Protection Utility missions are contained within the City of Austin Environmental Criteria Manual and Drainage Criteria Manual. Where the code references these manuals, development is required to comply with their criteria. Since their approval is through an administrative process, the criteria manuals are an appropriate place for detailed technical requirements. The review and appeal processes protect the affected communities from arbitrary rules and from rules that are technically unsound.

Finally, methods of enforcing regulations are discussed, including incentives and other options to assist the regulated community and ensure compliance.

9.4.1 Overview

The development process is a key element in Austin's ability to achieve flood protection, erosion control, and to maintain water quality. Except for retrofit and regional projects, the entire infrastructure to achieve these drainage utility missions is planned, designed, and constructed as part of private land development. The Land Development Code and the Drainage and Environmental Criteria Manuals establish the standards under which the development occurs.

Land development regulations can be in the form of specific development regulations (e.g., a regulation specifying an impervious cover restriction), or in the form of development planning strategies. These two items work together, with the specific regulations ensuring that development is consistent with the Ctiy's overall development strategy.

City of Austin development regulations apply within the city limits. Many of the development regulations also apply within the City's extraterritorial jurisdiction. Land development ordinances differ among the following watershed groupings based on their relationship to Austin's drinking water supply. These groups are specified in the City of Austin Codes, and are shown in Figure 9 – 34.

In addition to the watershed protection zones described above, the City has further grouped watersheds for development regulations. The Desired Development Zone are watershed within the Suburban and Urban Watersheds. The Drinking Water Protection Zone includes all other watersheds in the City. Some development regulations are applied differently, depending upon the classification of the watershed in which the regulation is applied.

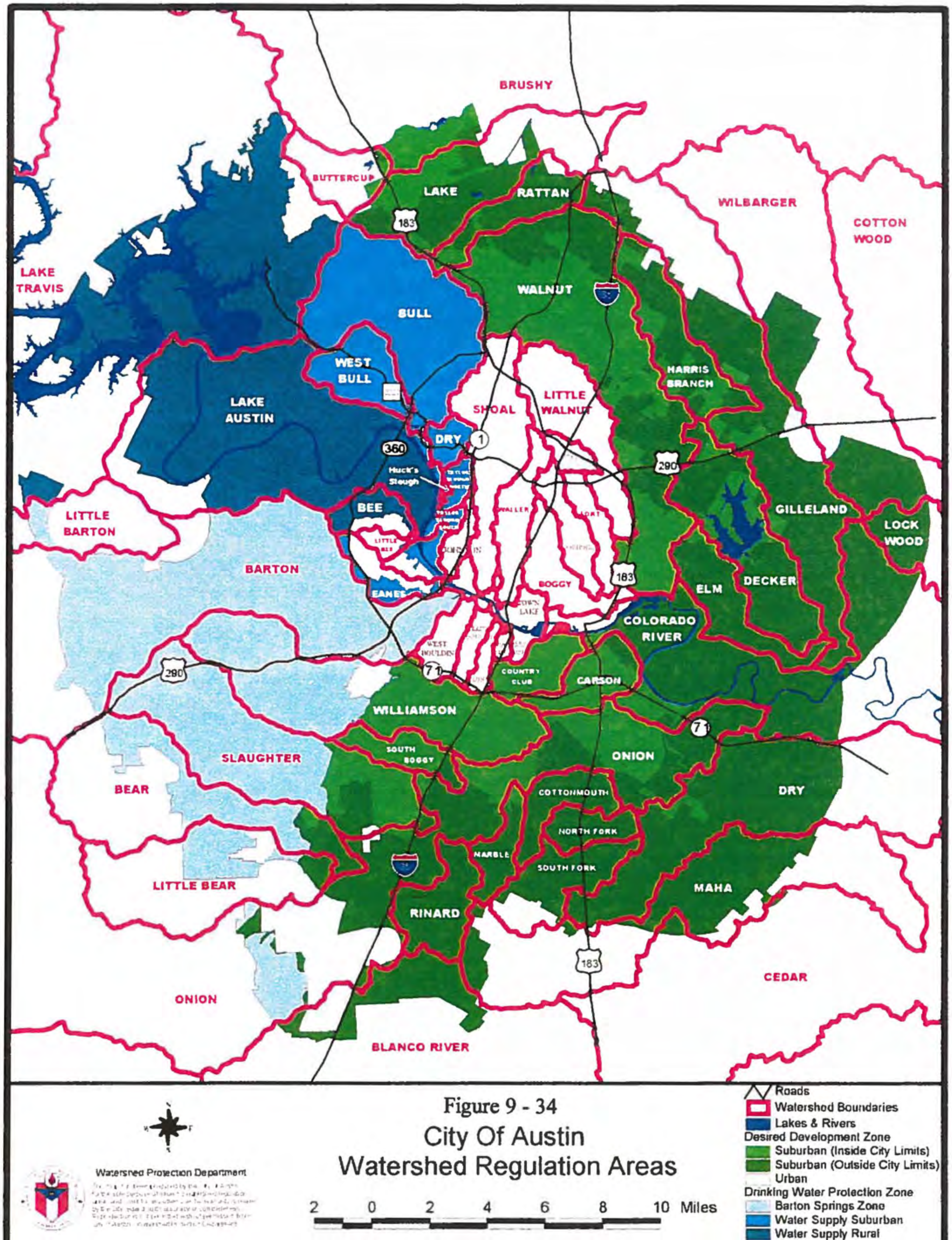


Figure 9 - 34

City Of Austin

Watershed Regulation Areas

Regulations in this inventory are divided into five categories, beginning with a discussion of factors affecting all WPD missions, followed by regulations affecting each of the three missions. The five categories are:

- Flood control;
- Erosion control;
- Water quality;
- Integrated regulations affecting all watershed protection missions; and
- Incentives

9.4.2 Flood Control

Drainage systems and flood control are essential elements of the developed environment. The drainage system consists of conveyance and storage facilities. In the undeveloped condition, storm water runoff storage is widely distributed across the landscape and within the soil. Development displaces some of this storage capacity and stormwater runoff travels more quickly into downstream conveyance and storage systems due to increased impervious cover. City ordinances and rules regarding flooding are contained within the Chapter 25-7 of the City Code and the Drainage Criteria Manual.

The City of Austin's drainage policy governs planning and design of storm drainage facilities within the City of Austin and its extraterritorial jurisdiction. Except for the obstruction prohibitions described above, the City's drainage regulations and rules are implemented through the land development process. Flood control regulations are listed in Table 9 – 14.

Table 9 – 14

Flood Control Regulations

Prohibitions on Obstructions to Waterways and Easements	Return Interval Standards
Peak Flow Limits	Contributing Area Assumptions
Flood Plain Development/Alteration Regulations	Drainage Easement Maintenance Criteria
Drainage Study, Flood Plain and Easement Delineation Standards	

Prohibitions on Obstructions to Waterways and Easements

Bull Creek

City Code prohibits flow obstructions in two contexts. Section 4-1-87 prohibits any storm drain or watercourse stoppage that results in an illegal discharge. The primary purpose of this section of the code is preservation of water quality. Sections 25-7-2 and 25-7-3 prohibit any obstruction to a waterway except as authorized by an approved site plan. The code currently prohibits flow obstructions in waterways. Current code does not, however, require maintenance of drainage easements in their original conditions (Heitz, 1997). Enforceable code language could be expanded to include flow obstructions in drainage easements.

Peak Flow Limits

City code regarding peak flow requires simply that any subdivision construction plan or site plan provide sufficient waterway for the design flood, determined in accordance with the Drainage Criteria Manual (Section 1.2.2 C). The Drainage Criteria Manual requires that peak flows shall not be increased at any locations for the 2-, 10-, 25-, or 100-year storm frequency that causes increased inundation of any building or roadway surface.

Peak flow regulation may be achieved by on-site or off-site storage, or by participation in the City's Regional Storm Water Management Program. Developments that discharge directly into Lake Travis, Lake Austin, Town Lake, or other portions of the Colorado River are exempt from the requirement for on-site detention.

City peak flow regulations could be changed to require peak flow controls regardless of whether there is any inundation of buildings or roadways. The City could implement these regulations to achieve this standard by requiring all development to provide detention so as not to increase peak flows above the existing condition.

Flood Plain Development/Alteration Regulations

Prohibition of construction in the 100-year flood plain preserves channel conveyance, reduces the potential for flood property damage, is federally required, and offers other integrated erosion and water quality benefits. City code (Section 25-7-92 B) prohibits site plan approval if any proposed building on the site plan encroaches into the 100-year floodplain based on fully developed watershed conditions.

Drainage Study, Flood Plain and Easement Delineation Standards

Of several methods for rainfall-runoff computations, the City of Austin allows designs based on approved methods depending on the size of the contributing area:

Contributing Area	Rainfall-Runoff Method
< 100 acres < 100 acres	Rational Variable Rainfall Intensity
Up to 400 acres	SCS Tabular/Graphical SCS TR-20 or HEC-1
> 400 acres	SCS TR-20 or HEC-1

Source: Loomis & Moore, 1999

Easement delineation during the land development process is currently based on the size of channel required assuming the channel is well maintained.

Drainage easements could be sized based on assumptions of a moderately or poorly maintained channel, rather than a well maintained channel. Assuming a moderately or poorly maintained channel could require the dedication of wider easements.

Return Interval Standards

Return interval standards for the design of storm runoff drainage influence the level of flood risk and the frequency of events for which parking areas, streets, and other land uses may become temporarily unusable due to flood storage. The greater the storm return interval used for a design, the less frequently it is likely to flood. However, the severity of a flood increases as the return interval increases. The impact of any storm, however, is also dependent upon the land area upstream of the site. Sites with larger contributing land area upstream are also more likely to flood (since more water can drain to the site). Assumptions regarding contributing land are discussed in the following section, with this section focusing on return intervals. The Drainage Criteria Manual (City of Austin, 1996) establishes these return interval standards for drainage facilities within the City of Austin and its extraterritorial jurisdiction:

Drainage System Element (Criteria)	Return Interval Design Standard
Street curbs, gutters, inlets, storm drains capacity	25-year
Conveyance (this is not an element)	100-year
Peak flow limits (this is not an element)	2-, 10-, 25-,and 100-year

Source: City of Austin, 1996

Contributing Area Assumptions

The Drainage Criteria Manual establishes flood plain and easement delineation standards, as discussed above in "Drainage Study, Floodplain, and Easement Delineation Standards." Flood plains must be delineated for any location with 64 acres or greater contributing area. The flood plain must be determined based on projected full development of the upstream contributing area. Zoning maps, future land use maps, and master plans are suggested sources of information regarding ultimate watershed development. While no floodplain is required to be defined for areas less than 64 acres, any concentrated flow requires the dedication of a drainage easement.

Drainage Easement Maintenance Criteria

Drainage easement maintenance is performed to clear brush and trees, excessive sediment and large objects (rocks and debris) from the channel and maintain conveyance capacity. The Drainage Criteria Manual establishes storm conveyance and flood control design and maintenance criteria. Criteria include specifications for component construction, box culvert and bridge construction, maximum roadway inundation during the 100-year storm, maintenance, access, landscaping, non-erosive conveyance, lining, mechanical systems, and signs. A professional engineer registered in the State of Texas must certify all designs.

The City of Austin currently removes vegetation and excessive sediment from open waterways to maintain a channel for unimpeded stormflows. The City could establish standards to require:

- A definition of flow impedance conditions that warrant extensive vegetation removal;
- An analysis to demonstrate that sediment accumulation, and not undersized culverts or storm water inlets, is the cause of flooding;
- A revegetation plan, including soil stabilization, replanting, and appropriate restrictions on fertilizer application; and
- Review of the vegetation removal proposal and the revegetation plan by City staff responsible for water quality and erosion control.

The advantages of an effective drainage maintenance policy are the maintenance of channel conveyance, enhanced channel vegetation and stream stability, a reduction in channel suspended solids, and maintenance of the physical integrity and natural stream character.

9.4.3 Erosion Control

Erosion occurs in stream banks, streambeds, and upland areas when sediment or other material is transported from its current location by wind or water. In Austin, erosion occurs primarily through water transport. The effects of erosion

Shoal Creek

include streambank destabilization and failure, loss of adjacent property, filling of receiving water bodies, increased channel maintenance requirements, and water quality degradation from increased suspended sediment and other pollutants. Regulations that impact erosion are listed in Table 9 – 15 and are discussed below.

Table 9 – 15

Erosion Control Regulations

Shoreline Modification and Dredging	Cut and Fill Limits
Construction Phase Controls	Design Storm Runoff Detention
Revegetation Requirements	Drainage Design Criteria

Shoreline Modification and Dredging

Shoreline modifications and dredging can contribute a significant load of soil and rock into the City's lakes. Existing regulations regarding shoreline modifications or dredging along Lake Austin, Town Lake, or Lake Walter E. Long require a review of any proposed modifications or dredging by the Parks and Recreation Board. Any relocation of earth material in the Colorado River below the 435 foot contour elevation requires approval by the City Council. Any proposal to place fill in Lake Austin, Town Lake, or Lake Walter E. Long must be reviewed by the Parks and Recreation Board.

The City may choose to review all dredge or fill proposals in terms of their final stability and impact on sediment migration. The City might also extend shoreline dredge and fill regulations to any segment of the Colorado River, including Lake Travis, within its extraterritorial jurisdiction.

Construction Phase Controls

The single most destructive period in the land development process may occur when vegetation is cleared and a site is graded to achieve a more buildable landscape (Schueler, 1995). Erosion increases due to the removal of the vegetative cover, disturbance of the natural soil structure, and changes in the soil slopes and location. Eroded soils are transported offsite into drainage ways, streams and potentially the Edwards Aquifer.

Current City of Austin Code and Environmental Criteria Manual both address construction phase controls. City rules are generally comprehensive, fairly current, and are widely used by design engineers in Austin's land development community. Current requirements address provisions for exposed soils, limitations on runoff through disturbed areas, and permanent site stabilization.

Walnut Creek Watershed

City rules regarding construction phase erosion controls are contained within the Environmental Criteria Manual. Much of the manual is written to allow, rather than require, analyses, designs and methods. Additional protection could be achieved by rewriting recommendations as requirements.

Existing City construction phase erosion and sedimentation rules might be expanded to provide specific design criteria. The City currently has no regulations specifically controlling the storage of polluting materials at a construction site.

Construction phase erosion and sedimentation requirements are not uniform across the City's planning jurisdiction. The highest standards have been promulgated for the Barton Springs Zone (LDC Section 25-8-184). Better construction phase erosion and sedimentation controls would be achieved by applying the highest standards uniformly across the City. Criteria could be written to define minimum standards that all construction phase erosion and sedimentation control plans must meet.

Revegetation Requirements

City code requires revegetation of areas disturbed by development activities. The City's current revegetation standards could be improved with regulations or rules to improve specifications with respect to revegetation timing, grading requirements, soil and seed mix specifications, and fertilizer application.

Cut and Fill Limits

Cut and fill limits are restrictions upon the depth and volume of material that can be excavated from or added to a site. These serve to discourage construction on excessively steep topography. Limiting development to flatter areas reduces upland suspended solids, nutrient, and toxic loads by reducing the potential for sediment migration.

Williamson Creek Watershed

City code Sections 25-8-341 and 342 prohibit cut and fill more than 4 feet deep, except for specified allow purposes, and except in the Urban watersheds.

A potential modification of this requirement might be to expand this restriction to include activities in the Urban watersheds.

Design Storm Runoff Detention Requirements

City regulations currently require development to install controls so that the 2-year post development peak flow in not greater than the 2-year pre-development peak flow. This requirement is typically met by providing runoff detention such that the runoff volume is released over a longer time interval.

Expanded regulations would require capture and retention such that there was no increase in the runoff volume for those storms determined to control channel morphology.

Research indicates that the controlling storm ranges between the 6 month to 2 year storm. The runoff volume for these storm events would depend on the impervious cover.

Drainage Design Criteria

The City's only rules or regulations requiring channel design to minimize erosion are for maximum velocity limits. An erosion control assessment could require specification of a design to limit erosion. The design could include geomorphic criteria for channel design, an inset channel for low flow storms within the larger overflow channel, criteria for the appropriate roughness coefficient, vegetation, and requirements to create channels that accommodate flows with natural vegetation so that maintenance requirements are reduced.

9.4.4 Water Quality Protection

Austin's quality of life is closely linked to the environmental integrity of its local water resources. As with flood and erosion , water quality problems primarily stem from changing land use conditions (i.e., urbanization) that modify watershed hydrology and the level of pollutants in local waterways. Regulations provide effective solutions for mitigating or preventing many future watershed problems resulting from development. Water quality protection regulations are listed in Table 9 – 16, and are discussed below.

Table 9 – 16
Water Quality Protection Regulations

Pollution Prohibition	Street Sweeping
Litter Laws	Industrial Storm Sewer discharge Permits
Animal Regulations	Hazardous Materials
Municipal Solid Waste	Wastewater Restrictions
Fertilizer and Pest Management Standards	Water Quality Controls

Pollution Prohibition

The City is required by NPDES regulations to have an effective prohibition on non-storm water discharges. Pollution prohibitions are contained mostly in Chapter 4-1. The form of the general prohibitions makes it unlawful or prohibits some activity (dump, throw, drain, place, or discharge) involving any material (sewage, urine, excrement, industrial waste, oil, effluent, waste, gas, liquid, herbicide, litter, soils, solid, any dead animal or person, filth, offal, or other unsound or offensive animal or vegetable, or other deleterious substance) in some specified place (into the city water supply within the county, in the Colorado river or any of its branches, above the city dam across the Colorado River within the City, the waters of Lake Austin or on land at a place which drains directly into Lake Austin) that results in unwanted outcome (unsanitary, odorous, polluted, discolored, contaminated, undesirable, or unfit waters). Existing code includes particular prohibitions related to marine toilets and holding tanks.

Bull Creek Watershed

The general prohibition on water pollution contains confusing references to different activities and locations within the City of Austin. An improvement would be to make simple and consistent references to water pollution-related activities, types of material, locations, and resulting conditions.

Litter Laws

Most litter decomposes. It creates oxygen demand when this decomposition occurs in water. Litter is also an aesthetic detraction. Research by Keep America Beautiful (Denver Urban Drainage and Flood Control District, 1992) shows people litter where litter has already accumulated. The City's litter regulations are contained primarily in Chapters 4-10 and 4-1 of the City Code.

Pedestrians and motorists account for less than 25% of litter. Other sources are household, commercial, and industrial waste, haulage vehicles, loading docks, and construction sites. The City of Austin could promulgate additional litter regulations directed to haulage vehicles, loading docks, and construction sites.

Animal Regulations

Code contained within Chapter 4-1 prohibits illegal discharges and dumping of animal waste. The City code could be revised to better and more clearly describe "pooper-scooper" requirements.

Municipal Solid Waste

Leachate or solids from municipal waste placed on streets, alleys, driveways, parking lots or sidewalks are particularly likely to enter the City's drainage system. There are three main sections of code related to solid waste:

- Chapter 12-3: Garbage and Trash
- Chapter 13-2: Land Use
- Chapter 13-8: Technical Codes

Existing regulations and services could be supplemented by the following requirements:

- A prohibition on improper storage or disposal of municipal waste; and
- A requirement to provide either a vegetative buffer or secondary containment for any waste storage capable of generating leachate.

Fertilizer and Pest Management Standards

Existing City code to regulate the application of fertilizers and pesticides is limited. Sections 25-8-425 and 25-8-455 require a plan to minimize the application of fertilizers and pesticides on lands used as golf courses or other recreational purposes in Water Quality Transition Zones as a condition of impervious cover transfer credit in water supply suburban and water supply rural watersheds. In Section 25-8-261, public or private parks or golf courses are allowed in the Critical Water Quality Zone only if they have an approved program for fertilizer, pesticide and herbicide use.

Local Austin Gardening Store

Within the Barton Spring Zone, rules to implement the SOS ordinance require the developer to prepare and submit an Integrated Pest Management (IPM) plan for all development.

The higher standards for the Barton Springs Zone could be established throughout the City. Landscaping requirements or incentives to use native plants also reduces the need for pesticides and fertilizers. Integrated Pest Management plan requirements could be expanded to require information regarding the proper application rates, timing, storage, and disposal of pesticides and fertilizers. The plan could identify pesticides and fertilizers that, due to their chemical characteristics, potentially contribute to water quality degradation.

Street Sweeping

The City implemented a street sweeping requirement as one of four optional pollution reduction measures in the revised Composite Ordinance promulgated for water quality protection in October 1991. The City has no other regulations requiring street sweeping.

The City of Austin could implement regulations requiring that owners of private parking lots (commercial land uses) regularly sweep their lots.

Industrial Storm Sewer Discharge Permits

City regulations prohibit discharge of a list of materials, of waste-containing materials in excess of specified concentrations, or wastes that cause or exert certain conditions in the receiving waters (Section 4-1-76). This prohibition appears to be in conflict with Section 4-1-82, which requires a storm sewer industrial waste permit prior to discharging industrial waste into a storm drain or watercourse. Permits must be renewed annually. The code specifies no criteria for approval or disapproval of the storm drain industrial waste permit application.

Expanded regulations would more clearly identify the criteria for approval or disapproval of an industrial storm sewer discharge permit. Non-storm water discharges could be categorized into those that would be acceptable, unacceptable, and acceptable under specified circumstances.

Hazardous Materials

Potential Regulations affecting use and storage of Hazardous materials include:

- Hazardous Material Storage and Spill Control
- Hazardous Materials
- Hazardous Material Traps
- Remediation Cleanup Standards

Hazardous Material Storage and Spill Control

City code addresses underground hazardous material storage facilities, containment and secondary containment requirements, and spill and drainage control.

Hazardous material storage regulations could be expanded to require proper storage of toxic and polluting chemicals that are not regulated as hazardous. Expanded regulations could address storage of chemicals (such as antifreeze and diesel) that are currently not regulated when stored in small quantities. The WPD has completed a draft of new expanded regulations regarding hazardous materials storage and spill prevention. The City's legal staff is currently reviewing the draft regulations.

Hazardous Material Traps

Hazardous material traps (HMTs) are structural devices that can be located at the stream crossings of major transportation routes to capture hazardous materials spills. The purpose of the traps is to capture any chemicals that would be released from accidental rupture of a cargo or tanker truck. (See Capital Project Inventory for a full description of HMTs.). The City currently has no requirements for hazardous material traps.

The City could implement regulations to require hazardous material traps at appropriate locations.

Remediation Cleanup Standards

The City of Austin currently imposes no remediation cleanup standards. Both state and federal legislation establish release reporting and cleanup requirements. Federal legislation addressing remediation includes the Emergency Planning and Community Right to Know Act (EPCRTKA), the Clean Water Act, the Resource Conservation and Recovery Act (RCRA), and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The Texas Water Code and the Texas Oil and Hazardous Substances Spill Contingency Plan also establish remediation standards. Texas Administrative Code Chapter 334 establishes standards for underground and aboveground petroleum storage tanks and Chapter 335 for industrial solid waste and municipal hazardous waste.

The City currently has authority and implements and enforces TNRCC rules within the City's jurisdiction. This City activity could be codified by adopting equivalent regulations, or by adopting TNRCC regulations by reference.

City regulations could also require certification for remediation contractors similar to the TNRCC Corrective Action Project Manager (CAPM) program.

Wastewater Regulations

Sections 25-9-64 and 25-9-65 of the Land Development Code list criteria under which the Director of the Water and Wastewater Utility may grant a wastewater service extension. The criteria do not currently include any environmental considerations. Methods of wastewater regulation include:

- Wastewater Line Construction
- Effluent Irrigation Standards
- Phosphorus Control

Wastewater Line Construction

Chapter 18 Article V requires property owners to repair or replace plumbing so that the maximum infiltration rate is less than 250 gallons per inch diameter of pipe per mile of pipe per day. This standard is written for the purpose of reducing excess flows into the wastewater collection system, rather than for the purpose of minimizing exfiltration into the environment. City code (Section 25-8-361) requires sewer systems within the Edwards Aquifer recharge zone to comply with the Utilities Criteria Manual.

City code further prohibits sewer lines within the critical water quality zone except as necessary for crossings. All wastewater line leakage is a violation of Texas Water Code.

City regulations or rules could be expanded to establish higher standards for wastewater line construction. Higher standards might include some of the elements required by TNRCC for wastewater line construction in the Edwards Aquifer recharge zone.

On-Site Sewage Facility Requirements

An on-site sewage facility (OSSF) is "one or more systems of treatment devices and disposal facilities that produce not more than 5,000 gallons of waste each day and are used only for disposal of sewage produced on the site where the system is located" (Camp Dresser & McKee, 1994). Texas grants authority to regulate On-Site Sewage Facilities (OSSF), including septic systems, to the TNRCC. Texas also grants TNRCC authority to designate authorized agents of OSSFs: a municipality, county, river authority, or special district.

Upon receiving status as an authorized agent of TNRCC, the City must adopt OSSF standards that meet the minimum TNRCC requirements in Title 30 Texas Administrative Code Chapter 285. These standards have been reviewed and approved by TNRCC. The city may adopt more stringent rules than those adopted by TNRCC. Both the City and County are in the process of changing the OSSF rules.

Effluent Irrigation Standards

Code requires at least 8,000 square feet of application area per living unit equivalent, or 7,000 square feet if 6 inches or more of topsoil is present. Irrigation is not permitted on slopes with a greater than 15% gradient, in the critical water quality zone, or in the 100 year floodplain. Storage capacity for 48 hours of discharge is required only for subsurface effluent disposal. Irrigation is prohibited during wet weather conditions. The storage capacity requirement for surface irrigation is 100 days. (Section 25-8-361).

Improved effluent irrigation standards could include the nitrogen loading requirements, improved management requirements for effluent irrigation of golf courses, and monitoring requirements.

Phosphorous Controls

Existing regulations for phosphorous controls are contained within Chapter 4-1, Article V. These regulations prohibit the sale or gift of household laundry detergent containing more than 0.5% phosphorus by weight within the City.

Water Quality Controls

Regulations affecting Water Quality Controls include a variety of components such as:

- Requirements for Controls
- Capture Volume
- Treatment Standards
- Maintenance of water Quality Controls

Requirements for Controls

Water quality controls are defined by the Land Development Code to be sedimentation/filtration, detention/sedimentation, retention/irrigation, retention, wet ponds, buffer zones, irrigation vegetative filter strips or other water quality control structures or systems requirement by the code to provide water quality benefits through treating storm water runoff. The code specifically encourages innovative runoff management practices for water quality (Section 25-8-151).

Land Development Code Section 25-8-211 describes conditions under which structural water quality controls are required. The remaining design element requirements are established within the City's criteria manuals. Design standards for water quality controls are found in both the Environmental Criteria Manual and the Drainage Criteria Manual. All water quality controls must be designed and constructed according to specifications in the Environmental Criteria Manual (Section 25-8-213) or else approved as an innovative runoff management practice (Section 25-8-151). The Drainage Criteria Manual (City of Austin, 1997) contains additional criteria for water quality controls.

The City should consider the design and adoption of one criteria manual for watershed protection containing design specifications for drainage and water quality controls. One manual could be more consistent and less confusing for both the applicant and City reviewer. Another improvement would be to include additional information regarding maintenance requirements.

<u>Capture Volume</u>

The water quality control capture volume determines the largest rainfall event, and the percentage of the total annual rainfall that will be captured and treated. Runoff volumes greater than the capture volume bypass the water quality control and are discharged without treatment.

All water quality controls within the City's jurisdiction must achieve a minimum capture volume of at least the first one-half inch of runoff from the contributing area once a site reaches 20% impervious cover (NSA), and the volume increases based on percent impervious cover. Under the SOS regulations in the Barton Springs Zone, higher capture volumes are required to meet the pollution reduction standard of no increase in the average annual pollutant load, and there is no minimum impervious cover trigger.

Capture volume requirements could be increased as a potential modification of requirements.

Treatment Standards

The City has established two treatment standards for water quality controls. At a minimum, controls must provide treatment equivalent to a sedimentation/filtration system designed in accordance with the Environmental Criteria Manual. In the Barton Springs Zone, the SOS Ordinance requirements set a higher treatment standard of no increase in the average annual pollutant load for 13 different constituent groups. The required treatment efficiency under the SOS ordinance must be determined from the estimated developed condition and baseline annual pollutant loads.

Expanded treatment regulations could establish a treatment standard higher than sedimentation/filtration for the City outside the Barton Springs Zone. Wet ponds, retention/re-irrigation or controls in series are technologies that would meet a higher standard.

Maintenance of Water Quality Controls

The City code currently requires the property owner to maintain water quality controls for multifamily, commercial, and industrial areas. The City maintains water quality controls for residential development. The City has current maintenance responsibilities for 486 residential ponds; this number continues to increase as new development occurs. Residents and businesses within the city limits support this service through payment of the drainage utility fee.

Design standards could be modified to better facilitate water quality control maintenance and to improve access into and out of the control. Minimum specifications for pumps in re-irrigation or other water quality controls are under development via a consultant contract. City of Austin design standards could be modified to improve pump reliability and facilitate effective pump failure response.

9.4.5 Integrated Regulations

Texas Local Government Code (Chapter 211) requires municipal zoning actions to be developed in accordance with a comprehensive plan. In 1979 The Austin City Council adopted the Austin Tomorrow Comprehensive Plan in accordance with Article X Section 5 of the City Charter. The Comprehensive Plan contains the City's policies of growth, development, transportation, and beautification within Austin's planning jurisdiction.

Comprehensive planning is a planning strategy that provides a mechanism to project, direct, and support development and redevelopment within a community. There are several ways in which the Comprehensive Plan can be implemented to affect flooding, erosion, and water quality. Regulations, zoning, park and conservation land acquisition, and infrastructure can be planned and implemented to direct development away from flood-prone, potentially erosion-prone, or environmentally sensitive areas. Development can be planned for areas where transportation, utilities, and services could be provided efficiently and with minimal environmental effects. Storage and conveyance can be designed and constructed for flows from anticipated land use.

There are several factors that limit the ability of Austin's comprehensive planning process to achieve its goals. One of the largest factors involves the City's jurisdictional area. A comprehensive planning process occurs for the geographical area within the City's jurisdiction. However, many of the watersheds extend into areas beyond the City's jurisdiction and include the areas in the city limits and extraterritorial jurisdictions of other municipalities, unincorporated Travis, Hays, and Williamson Counties, and special districts established by the Texas Legislature that are outside of Austin's planning processes.

Since adoption of the Austin Tomorrow Comprehensive Plan, the City and its citizens developed the AustinPlan (1988). Objectives of the AustinPlan related to the drainage utility mission included items for controlling creekbank erosion, preventing future development within floodplains, and addressing water quality problems through engineered controls, impervious cover limits and urban retrofit.

Another planning process by the City of Austin for the revitalization of Austin's urban core was the Regional/Urban Design Assistance Team (R/UDAT) (January 1991, revisited in 1997) study. This study formulated recommendations related to development of urban runoff controls to address flooding and water quality problems in the urban watersheds. The City has not adopted the goals of either the AustinPlan or the R/UDAT study as part of the official City planning document.

In addition to the City's Comprehensive Plan, the City has specific development integrated regulations designed to support the WPD's erosion, flood and water quality missions. These regulations are listed in table 9 – 17.

Table 9 – 17

Integrated Regulations

Impervious Cover Limits	Headwater Protection Zone Regulations
Impervious Cover Reduction via Development Regulations	Critical Environmental Features (CEF) Protection
Flow Volume Limits	Wetlands Protection
Disconnected Impervious Cover	Landscape Regulations
Steep Slope Limits	Tree Protection Standards
Stream Setbacks	Natural Channel Conveyance Requirements

Impervious Cover Limits

Impervious cover consists of surfaces that cannot be easily penetrated by water. Pavement, sidewalks, driveways and buildings are examples of impervious cover. There is a direct link between impervious cover in a watershed and stream degradation. Significant water quality and quantity changes associated with increasing impervious cover include increases in uplands washoff of total suspended solids and other polluting constituents, increases in stormflow volume and stream bank erosion, decreases in baseflow volume, channel enlargement and associated changes in the channel cross-section stability.

Impervious cover is typically measured as the percentage of ground surface that is impenetrable. If an area has an impervious cover of 70%, then water cannot penetrate or filter into 70% of the land area. Instead, it runs off, carrying with it any pollutants on the ground it encounters along the way.

Watersheds with as little as 10 to 15% impervious cover cannot support high quality streams in sensitive watersheds. As impervious cover increases from 15 to 20% of the watershed, dramatic changes in the stream flow regime and biology occur (Schueler, 1995). Impervious cover may be the single most important indicator of the effect of development on the stream system. Changes in the impervious cover in a watershed significantly change runoff volume, peak flow rate, flow duration, infiltration, baseflow volume, stream cross-section and flow line elevation, water temperature, water chemistry, and biodiversity (Schueler, 1995).

Estimated impervious cover in the 17 Phase I watersheds ranges from 11.9% in Barton Creek watershed to 67.8% in the Buttermilk Creek watershed (Center for Research in Water Resources, 1997).

Downtown Austin

City of Austin regulations directly affect impervious cover by establishing maximum impervious cover limits through both zoning and subdivision/site plan requirements by watershed. Discussion in this report is limited to watershed related impervious cover limits.

Watershed related impervious cover limits established by the City are a function of several factors: watershed classification, relationship to the City's drinking water supply, and type of development. The basis for calculating the allowable impervious cover is the net site area (NSA). Net site area is based on the "uplands zone," that area outside of the stream protection zones. It includes all areas with 0 to 15% slopes, 40% of areas with 15 to 25% slopes, and 20% of areas with 25 to 35% slopes. This formula discourages the construction of impervious cover on steep slopes, since larger portions of steeply sloped areas are discounted.

Allowable impervious cover may be increased up to certain limits based on a transfer of impervious cover from the stream protection zones. The code allows transfers of development rights based on dedication of the Critical Water Quality Zone (CWQZ) to the City, preservation of natural and undisturbed areas within the Water Quality Transition Zone (WQTZ), natural areas within the setback of a Critical Environmental Feature, and limited transfers for recreational uses and wastewater disposal.

Impervious cover limits are implemented for roadways and residential construction during the subdivision process based on the projected impervious cover. Impervious cover limits for commercial developments are regulated through the site plan process.

To further restrict impervious cover, the City could expand regulations to:

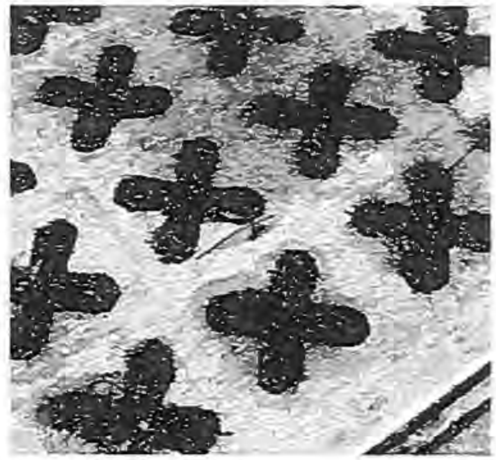
- reduce the allowable maximum impervious cover limit;
- reduce the allowable transfer credit for impervious cover; and/or
- further restrict the net site area basis for impervious cover calculations.

Impervious Cover Reductions via Development Regulations

The level of impervious cover is associated with the development size and design. Many of the City's development regulations increase the impervious cover required for parking, roadway width, sidewalks, cul-de-sac radii, etc. Impervious cover reduction ordinances would reduce the amount of impervious cover associated with development of a specific use intensity by allowing more flexible alternatives.

Impervious cover regulations address development requirements to achieve multiple purposes: to provide areas for living, working and playing, to provide safe and convenient access, to maintain green space, to provide adequate emergency access, to reduce noise, provide privacy, and to provide drainage.

The greatest potential for impervious cover reductions is associated with transportation-related infrastructure. Approximately 60% percent of the impervious cover in the urban environment may be associated with vehicle-oriented pavement, including streets, driveways, and parking lots.


Permeable Pavement

As a potential expansion, the City could implement regulatory changes geared at reducing transportation related impervious cover, in the urban environment such as:

- Narrower streets
- Use of pervious pavers for low traffic-use areas
- Reduce minimum parking requirements
- Use of diagonal parking, single one-way lanes between stalls, and smaller stalls
- Establish cooperative parking agreements
- Encourage underground, under building, and roof parking and multi-story garages
- Allow taller buildings to reduce building footprints
- Reduce cul-de-sac radii and require landscaped islands in cul-de-sacs

The City could also require cluster development to locate impervious cover closer together. Cluster development must be linked directly to permanently maintained natural buffer areas to be effective.

Regulations to support public transit systems by providing park and ride lots, bike lanes, bike parking and trails could be required. Growth management regulations to encourage infill of urban areas can also reduce the overall amount of impervious cover per person. Infill concepts encourage development of currently unused land that is already developed with impervious cover. These existing underused development areas are redeveloped, rather than building in areas that are not developed currently. These areas can include, for example, parking areas and vacant lots.

Flow Volume Limits

The City currently regulates the effect of development on flooding though peak flow rate limits. A peak flow rate limit places a cap on the peak rate of runoff flow from a developed site (City of Austin, 1996). In contrast, a flow volume limit would restrict the total volume of flow from a site post-development as opposed to simply restricting the rate of flow. Thus, for a given rain event, the total volume of storm water that runs off of a site will be restricted.

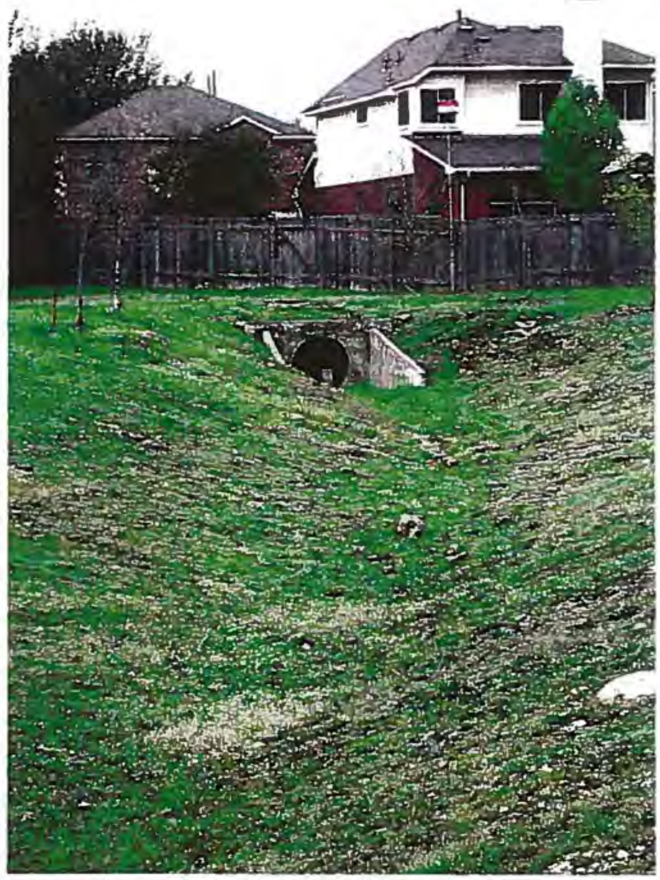
Impervious cover, site grading, and the provision of efficient pipe and lined drainage systems for land development all significantly increase the volume of runoff from a developed site compared to the same site in an undeveloped state. The increase in the total volume of runoff is reflected in the average annual runoff coefficient. The City of Austin has developed runoff coefficients as a function of impervious cover (City of Austin Environmental Criteria Manual).

Although there are regulations limiting peak flow rates and requiring water quality controls, the City currently places no restriction on the total volume of runoff from a site after development. City regulations could be expanded to limit the increase in the volume of stormflow from a site after development. Compliance with regulations limiting the total volume of runoff from a site can be achieved by a combination of restrictions on impervious cover and technology to retain and infiltrate storm water runoff on site. City code could be changed to require all or some fraction of storm runoff storage be provided on each site. Potential storage areas include rooftops, parking lots, ball fields, property line swales, parks, roadside swales and on-site ponds.

Disconnected Impervious Cover

The effect of impervious cover on water quality, storm runoff volume, and baseflow varies based on its connectedness, i.e., its location relative to waterways or other drainage conveyances. For example, a street in an urban area that directly abuts a stream would have more connected impervious cover than if, say, there was a grassy area between the channel and street. With the grassy area between the channel and street, these two areas would be more "disconnected," and runoff from the street would be better able to infiltrate into the soil before reaching the stream itself.

Where rooftops, parking lots and streets are connected to creeks through enclosed pipes or lined channels, all of the impervious cover is effective in changing the stream flow regime, quality, and biological integrity. The effective impervious cover is the fraction of surface that generates runoff into the storm water conveyance system rather than onto soil with sufficient infiltration capacity.



Slaughter Creek Watershed

Areas with lower impervious cover are more likely to include less effective impervious cover because there are more opportunities for directing runoff onto intervening soil between the impervious cover and the creek. Tables 9 – 18 and 9 – 19 present comparisons of total and effective impervious cover for different land uses. See also the discussion on "Impervious Cover Disconnection" in the Capital Project Inventory.

Table 9 – 18

Comparison of Total & Effective Impervious Cover (IC) by Land Use

Land Use	Total IC	Effective IC
Low-density residential: <1 unit/acre	10%	4%
High-density residential: 3 to 7 units/acre	40%	26%
Multifamily: 7 to 30 units/acre	60%	48%
Commercial and Industrial	90%	86%

Source: Based on City of Olympia, WA, 1994.

Table 9 – 19

Effective Impervious Cover for Residential Land Use

Uses	IC	Effective Fraction	Effective IC
Streets	16%	80%	12.8%
Sidewalks	3%	70%	2.1%
Parking and driveways	6%	60%	3.6%
Roofs	15%	35%	5.3%
Lawns & Landscaping	54%	5%	27%
Overall	40%		26.5%

Source: Based on City of Olympia, WA, 1994.

The City has no code that specifically requires disconnected impervious cover. There are, however, two code provisions that promote designs that result in disconnected impervious cover. Section 25-8-454 requires development in water supply rural watersheds to provide a natural buffer area to receive storm water runoff. Section 25-8-185 requires drainage designs to maintain infiltration and recharge, overland sheet flow, and natural drainage features wherever possible. Enclosed storm drains are allowed only where the City determines that they are preferred.

Disconnected impervious cover regulations would require designs that break up the efficient transport of water from impervious cover through pipes and lined channels into creeks. Runoff would be directed to landscaped areas, vegetated buffer strips, and swales.

Regulations that promote disconnected impervious cover could include:

- requirements to direct runoff from impervious areas and rooftops onto vegetated strips designed to retain and infiltrate runoff;
- prohibit direct connection to the storm drain system;
- requirements to provide grass-lined channels for storm water conveyance;
- requirements to provide "French drain" catchments that collect/intercept subsurface infiltration.

Steep Slope Limits

Areas of extremely slanted or steep ground surfaces are generally more vulnerable to erosion, soil loss, and associated water quality problems. Steep slope regulations limit activities in these areas with severe topographic grade and thereby avoid associated problems with erosion, sedimentation, and the disruption of natural landscape characteristics. The City regulates septic system, land development, and wastewater effluent irrigation on steep areas.

Steep slope limits do not currently apply within the City's Urban watersheds. A potential expansion of these regulations would be to extend them into these watersheds. Another potential expansion would be to prohibit utility line trenching on steep slopes where alternative locations exist. There may be some potential for increasing compliance with existing regulations for residential development.

Stream Setbacks

Stream setbacks (or "buffers") limit activities adjacent to creeks. City Code prohibits or limits activities adjacent to creeks within two area bands parallel to the creek: the Critical Water Quality Zone and the Water Quality Transition Zone. The criteria for establishing the width of the water quality zones depends upon the location of the creek within the City's watershed protection zones, and the contributing drainage area. The band closest to the creek is the Critical Water Quality Zone. Activities in this zone are the most restricted. Limited development is allowed in the Transition Zone, except where located over the South Edward's Aquifer.

The smallest drainage area delineation criteria establishes a minimum drainage area of 64 acres for classified waterways in urban, water supply rural, Barton, Little Bear, Onion, Bear, and Little Barton watersheds. In suburban watersheds, however, delineation criteria dictate a minimum drainage area of 320 acres for minor waterways. These criteria leave stream bank and headwater areas in suburban watersheds without setback protections.

Water quality controls are currently allowed within the Transition Zone in Suburban and Barton Springs Zone Watersheds, but not Water Supply Suburban or Rural Watersheds. Water quality controls are currently not allowed in the Critical Water Quality Zone except by variance. Variances are typically granted only for alternative inline controls such as wet ponds and are typically not granted for traditional controls such as sedimentation/ filtration ponds. Where controls in the critical water quality zone are appropriate, however, the required variance is administrative.

More protective regulations would require stream bank setbacks from all waters of the United States. Waters of the United States are defined as any watercourse forming a bed and bank (Lyday, 1998). Stream bank setbacks based on this definition would extend protection to stream headwaters, vegetated shallows, pools and riffles. Cumulatively these areas are extremely significant in protecting water quality, reducing flood flows, and providing habitat.

Additional protection and more consistent regulations could be achieved by standardizing the stream designation to eliminate or reduce variations within watersheds, or to base protection zone delineation on results of technical assessments that document problem areas within the watersheds. The City may wish to consider allowing an option for protection zone averaging. This concept allows the width of the buffer zone to change, as long as the average width is maintained. This flexibility might provide additional protection around small seeps, springs, and canyons important for stream baseflow and habitat.

Code language could be added to require water quality controls located in the Critical or Transition Zone must be located as close to upland areas as feasible. Vegetation goals for the stream protection zones could be established to promote native species and discourage managed turf grass or non-native species.

Water quality setbacks are recommended as buffers between golf course turf management and streams. Water quality monitoring data indicate significant differences in baseflow concentration of nitrate, ammonia, total dissolved solids, total suspended solids and turbidity concentrations associated with golf courses using treated wastewater effluent for irrigation. Storm water runoff samples indicate that tributaries associated with a golf course site are significantly higher in nitrates, ortho-phosphorus, and total dissolved solids and lower in pH than samples from tributaries associated with residential and rural land uses (City of Austin, 1997).

Headwater Buffer Zone Protection

Headwater streams are part of a network that drains each watershed. Streams within a watershed can be defined in terms of their order. First order streams are those that have no tributaries. A second order stream is created by the confluence of two first order streams. A third order stream is created by the confluence of two second order streams, and so forth. All first and second-order streams are headwater streams. Although they are short and drain relatively small areas, headwater streams comprise approximately 75% of the total stream and river length in the United States (Schueler, 1995).

The quality and character of headwater streams are a sensitive indicator of the health of the urban environment. Headwater streams are broadly distributed throughout Austin's watersheds. Protecting the quality of headwater streams is a significant step to preserving downstream creeks, riparian zones, lakes, and water supplies.

The City of Austin currently has no ordinances that provide direct protection to headwaters. Headwater creeks could be better protected through the stream setback requirement proposed in the preceding section.

Wetlands Protection

The City defines wetlands as lands that are transitional between terrestrial and aquatic systems where the water table is usually at or near the surface; or land is covered by shallow water. Wetlands classification is based on technical definitions established or used by the U. S. Army Corps of Engineers. A designated wetland is a critical environmental feature. City code requires protection for all wetlands except those within the Central Business Area (Section 25-8-282). Protection may include appropriate setbacks or wetland mitigation.


Little Walnut Creek Watershed

The following regulatory changes would provide additional wetlands protection:

- Changing of the stream setback criteria as recommended above to encompass all streams with a defined bed and bank would protect small wetland areas immediately adjacent or within stream channels. These wetland areas proximate to the stream are critical components of the system maintaining baseflow and supporting aquatic life. The Critical Water Quality Zone designation already provides protection for some of these wetland areas. The stream designations based on contributing areas of 64 to 320 acres, however, eliminate this protection for significant headwater areas.

- Flood control design standards can support the creation of constructed wetlands by requiring sufficient conveyance capacity to allow for the presence of wetland vegetation without causing flooding. These design standards reduce (actually just defer) maintenance requirements and allow for wetland revegetation.

Maintenance criteria for stream channels could be designed to protect the functions of wetland areas. Criteria would include limiting vegetation removal, sediment relocation, and the use of bulldozers and other heavy equipment. Mowing and obstruction removal, including flow-obstructing trees in certain circumstances would be allowed.

Critical Environmental Features (CEFs) Protection

City Code defines critical environmental features (CEFs) as "features determined to be of critical importance to the protection of one or more environmental resources, including without limitation bluffs, springs, canyon rimrocks, caves, sinkholes and wetlands". Protection includes setbacks, protection of drainage patterns to prevent degradation, exclusion of CEF 's within residential lots, and restricted activities within setbacks. (Section 25-8-281).

Onion Creek

In addition to those for wetlands above, regulations protecting critical environmental features could be expanded to address the following:

- Sinkholes, caverns, and features encountered during the construction process that were not detected during the environmental assessment of site engineering. Notification of the City and mitigation requirements could be a part of expanded regulations.
- The definition of critical environmental features could be expanded to protect stable stream features such as width/depth ratios, pools and riffles, and stable streambanks.

Landscape Regulations

Landscaping can lower nutrients and toxic concentrations in waterways by enhancing infiltration and supplementing baseflow. Effective landscaping practices can also reduce leached nutrients, pesticides and herbicides in creek flow and infiltrating groundwater.

City of Austin landscape regulations affect commercial and multifamily development by requiring street buffering, parking lot landscaping and a minimum level of landscaping between the buildings and street. Landscape criteria in the Environmental Criteria

Manual (ECM) encourages the use of native or xeriscape plants. City landscape regulations also require native landscape areas as a condition for impervious cover transfer credit, and maintenance of hillside vegetation on steep slopes.

Expanded landscape regulations to achieve the missions of the Watershed Protection Utility would improve incentives for limiting the application of landscape chemicals, and other landscape practices that reduce the effects of impervious cover of development such as stricter limit of construction areas, and requiring methods for soil improvement. Landscape credit could also be given for landscaping that is located to receive runoff from a developed area.

Tree Protection Standards


Barton Creek Watershed

Regulations require tree protection during construction as part of the erosion and sedimentation control plan for all development. Tree replacement may be required. A tree survey of all trees 8 inches or more in diameter is required as part of an environmental assessment.

Protected trees are those having a circumference of 60 inches or more, measured four and one-half feet above natural grade (Section 25-8-602). Removal of a protective tree is prohibited without securing approval from the City. Codes allow a requirement to plant replacement trees or other measures to mitigate as a condition of tree removal approval.

Tree protection could be further regulated to preserve larger blocks or groves of valuable trees. In Central Texas, live oak tree groves may provide a site amenity that could not be replaced within several lifetimes. Preservation requirements could also encompass tree groves as well as individual trees.

Tree protection regulations could more rigorously define and enforce a standard which includes areas beyond the drip-line for more complete root protection, given that a substantial portion of a tree's roots extend well beyond the drip line.

The City of Olympia (1995) has a landscape goal for parking lots of 40% tree canopy. The City might establish a percentage canopy coverage such as 60% as a site development standard.

Where tree replacement on a site is not feasible due to space limitations, the developer could be required to either pay a mitigation fee, or to place mitigation trees at some other location designated by the City.

Natural Channel Conveyance Requirements

The use of curb and gutters are restricted for streets located within the Critical Water Quality Zone and the Water Quality Transition Zone of water supply rural or water supply suburban watersheds. Within these watersheds, any roadway within the uplands zone may be designed without curbs and gutters. Within these watersheds, the transportation engineer may modify minimum street right-of-way widths to satisfy storm water drainage requirements and the general public welfare.

The code also requires development to preserve the natural and traditional character of land and waterways to the greatest extent feasible.

The code requirement to preserve the natural and traditional character of land and waterways to the greatest extent feasible presents problems in implementation. One potential regulatory expansion would be to provide additional definition of "natural and traditional character". The definition might include preservation of the existing flow regime, preservation of existing and natural stream geormorphology, preservation of native vegetation, stream shading, and biological components.

Expanded regulations would be requirements or incentives to provide drainage through swales. Regulations applicable to the water supply suburban and water supply rural watersheds could be extended throughout the City's watersheds.

9.4.6 Incentives and Enforcement

Sections below discuss aspects of City regulation related to incentives and enforcement to achieve the Watershed Protection Department flood control, erosion prevention, and water quality protection missions.

Williamson Creek Watershed

Regulatory Incentives

Regulatory incentives can include flexible implementation of regulations, fee waivers, tax abatement, access to city utilities, and streamlining the development review process. The City currently offers these incentives on a case-by-case basis.

Land Acquisitions and Conservation Easements

City of Austin regulations encouraging land acquisition or conservation easements are those that provide for a transfer of development rights to upland areas based on restricting development in sensitive areas. These regulations encourage transfer of the Critical Water Quality zone to the City in fee simple, and the maintenance of water quality transition zone and upland areas in a natural and undisturbed state. City regulations also require parkland dedication as a condition of development permits.

Undeveloped areas can be preserved by either fee simple purchase of undeveloped land, or by acquisition of the development rights and establishing a conservation easement. The City might implement regulations that would facilitate acquisition of conservation easements to preserve the existing rural character of Austin's undeveloped watershed areas. The City could also adopt regulations allowing uplands to uplands transfer of development rights in order to protect more sensitive tracts.

Variance Procedures

The City Code includes procedures for requesting variances from regulations. A variance can only be requested from when an application for a subdivision of land, or a site development permit has been filed. Some variances can be granted administratively, but most require approval from the Planning Commission. Strict findings must be met which attempt to weigh the justification for the variance, assess whether similar variances have been granted, and which evaluate the impact of the variance on the watershed.

Improvements to the existing variance process would be to require variance applications early in the land development project process. The variance needs to be considered early enough in the development process so that changes can be made to the project to meet variance conditions.

Operation and Maintenance Permits

The City currently requires operations and maintenance permits for water quality controls maintained by private entities within the Barton Springs Zone.

Continued enforcement, operation, and maintenance of source controls, structural, and nonstructural water quality controls may be the weakest element of Austin's watershed protection strategy. Significant improvements might be achieved by expanding the operating permit requirement.

Environmental Assessments

An environmental assessment is required for all development located over karst aquifers or within areas draining to a karst aquifer or a reservoir. Assessments are also required for tracts with slopes greater than 15%, or tracts with water quality transition or critical water quality zones. An environmental assessment must include a hydrogeologic element, a vegetative element, and a wastewater report.

Potential expansion of the environmental assessment requirements would include establishing standards for the biological and geological assessment components, establishing minimum qualifications for persons conducting assessments; and requiring a discussion of alternative designs (currently only required for wastewater projects). The Environmental Assessment process for City projects might be streamlined by requiring circulation of a project description for review prior to any budget hearing. A determination as to whether an environmental assessment is necessary could be part of this preliminary Capital project review process.


Bear Creek Watershed

Fee-in-Lieu Alternatives

The City of Austin uses a fee-in-lieu of construction for structural flood and water quality controls. In either situation, a developer can request to make a payment to the City and avoid land, capital, and operating costs of an on-site structural control. There are some differences between the programs for flood and water quality. They are discussed separately below.

The fee in lieu option for flood controls is available in some watersheds as part of the Regional Stormwater Management program (RSMP). The City has the option of either requiring the control or accepting the fee in lieu of the control.

The City's fee-in-lieu of construction of water quality controls is an option limited to development in the Urban Watersheds. The dollar amount was established based on a combination of bid estimates developed by the City's Public Works department and private engineering records for sedimentation/filtration controls in 1990 and 1991. Studies have shown that onsite sedimentation-filtration ponds provide a benefit of preventing future stream erosion (Chan, 1999). Potential regulatory modifications could include a requirement to demonstrate that no increased channel erosion downstream would result from payment of a fee-in-lieu for water quality controls. The City might require a downstream erosion analysis as part of a water quality control fee-in-lieu application. If downstream impacts are judged to be unacceptable using fee-in-lieu, the application would be denied.

Application of Standards to Single Residential Lot Construction on a Platted Lot

Application of the City's development rules and ordinances is generally occurring with the review process associated with approving a subdivision plat or granting a development permit for commercial development or subdivision infrastructure. Rules and ordinances can be applied through covenants, plat map conditions, or easements. Enforcement of development requirements on individual lots, however, occurs at the time of building permit application (inside the City only), and sometimes through financial lending institutions.

The Land Development Code could be amended to prohibit single family lot clearing until a building permit is issued within the City limits. Alternatively, where home construction is to occur simultaneously with subdivision infrastructure construction, the limits of construction for infrastructure could be expanded to include the home and driveway areas. The fiscal posting for erosion control and revegetation would be increased to include the additional area. A time limit between clearing and construction completion would be established. Either of these solutions would address erosion and sedimentation that results when cleared homesites remain vacant.

Application of Standards to Subdivision of Illegal Lots

Lots exist within the City that have never been part of a legal subdivision process. The subdivision process is required prior to receiving any permit from the City.

Redevelopment Standards

The City of Austin currently allows and promotes redevelopment of existing underused areas as a means of promoting infill development.

Waiving existing development standards is one mechanism to promote redevelopment. The City should, however, carefully consider the consequences of waiving development standards on achieving the type of high quality development that encourages infill. One consequence of waiving development standards is a worsening of inner city flooding, erosion, and water quality problems.

Legal Enforcement

The City's process for enforcing the Watershed Protection Ordinances consists of several steps. The first step is to notify the violator of the situation. The inspection department may leave notice through three stages: verbal notice, written notice, and red tagging the project. After notice is provided to the violator, the next step in the enforcement process is for the City to file a criminal complaint in municipal court. Penalties for code violations are specified in Section 25-1-462. Only where there is imminent danger to health and safety can the City receiving a temporary restraining order or injunction.

The code related to Watershed Protection has been written from the perspective of code defendants rather than from a prosecutor's perspective. Several of the sections are written so that enforcement is problematic. A potential modification could include modification of code language to allow for improved enforcement.

A potential alternative to the Municipal Court process would allow Austin Police Department officers to write a ticket for an environmental violation. Issuing a ticket for code violations, similar to a traffic ticket, would be quicker, easier, and result in increased enforcement of the City's code. Tickets cannot, however, be written for these violations without authorizing state legislation.

Section 10

Identifying Preferred Solutions

Preferred solutions for a given area were chosen from the solutions inventory based on the nature of the watershed problem and the effectiveness and limitations of the solution being considered. (Loomis Austin, Inc., 2000; Loomis & Moore, 1999a; Loomis & Moore, 1999b).

10.1 Protocols Established

To target solutions, a screening protocol, or set of procedures, was developed to identify specific capital, programmatic, or regulatory solutions from the full set of potential solutions presented in Section 9 that would be appropriate or applicable for solving identified problems. This protocol considered watershed characteristics and associated problems, potential limitations, and possible negative impacts of solutions.

To evaluate whether a particular targeted solution should be implemented, it was measured in terms of its ability to effectively achieve the WPD's management goals. Ideally, the preferred solution(s) should:

- meet flood, erosion and water quality objectives;
- maintain or improve the natural character of the creek;
- maintain or reduce required maintenance needs;
- ensure compliance with applicable local, state, federal permit and regulatory requirements; and
- foster additional beneficial uses of waterways and drainage facilities where possible.

10.2 Targeting Solutions Based on Watershed Types

Selecting the most appropriate solution for a specific problem area is heavily influenced by the development conditions of the watershed in which the target problem area is located. Therefore, solutions were initially screened to target watershed management solutions for a given watershed type. Three watershed types were considered:

- Rural
- Developing
- Urbanized/Developed

10.2.1 Rural Watersheds

Rural watersheds are those in which the vast majority of the land use coverage is undeveloped or developed to a low density (less than 10% impervious cover). Preventive regulatory approaches (including impervious cover restrictions, setbacks/buffers, and on-site water quality and erosion volume controls requirements) are highly applicable since new regulations could potentially be applied to undeveloped land not affected by exemptions due to grandfathering or state legislation. In rural watersheds, the impacts of development are generally isolated or not evident at all. Barton Creek is the only Phase I watershed that falls under this category. Specific programs, such as Rangeland Management are appropriate for rural watersheds, where sufficient undeveloped land is available for their application. Appropriate solution measures emphasize prevention of future erosion, flood, and water quality problems. The identification of preferred solutions for rural watersheds assumed:

- Erosion control is largely unnecessary given the very low degree of impact. Natural channel processes should be allowed to operate unconstrained by structural intervention.
- Retrofit water quality ponds may be considered in pockets of more intense development that were constructed without storm water controls.
- Retrofit flood detention storage is not likely to be necessary in the general absence of development near the flood plains. Regulatory prevention of construction in the 100-year floodplain is highly effective.

Solution options targeted for erosion and water quality control in rural watersheds include:

- Geomorphically-Referenced River Engineering
- Wet Ponds or Wetlands
- Retention-Irrigation Ponds

10.2.2 Developing Watersheds

The developing watersheds are those in which substantial development already exists, and in which significant additional development is projected to occur in the future. The Phase I developing watersheds includes Blunn, Bull, Country Club, Walnut, and Williamson. Regulations targeting erosion-volume capture on the site for new development are likely to be effective. The developing watersheds generally exhibit moderate existing impervious cover (between 10% and 50%) and a projected high net future impervious cover increase (greater than 10%). Erosion processes are active, including rapidly increasing channel widening, incision, and/or conveyance as represented by a high (greater than 25%) predicted future increase in channel size. The identification of preferred solutions for developing watersheds assumed:

- Construction of regional retrofit facilities to provide erosion detention control (generally in the headwaters) is likely to be appropriate.
- Localized slope stabilization measures are necessary, but may be ineffective over the long term if watershed-scale measures (e.g., erosion detention) to limit channel enlargement are not implemented.
- This development condition offers the best opportunity for integrated on-site and/or regional, structural, water quality/erosion capture/flood facilities.
- All flood technologies are considered to be viable since current flood problems exist, and the potential for future flood problems is high.
- Water quality pond technologies (e.g., wet ponds, wetlands, and wet ponds with baseflow augmentation) are generally not the preferred solution given that erosion processes, not uplands pollutants, dominate water quality problems (MacRae, 1998).

Solutions targeted for erosion and water quality control in developing watersheds include:

- Side-slope control solutions
  - Reinforced earth
  - Gabions/concrete riprap
  - GRRE (Refer to Capital Projects inventory Section 9)
- Detention/Retention pond solutions
  - Erosion detention as a stand alone solution or in combination with wet pond and/or baseflow extended detention, depending on individual watershed needs.
  - Retention-irrigation pond – only for Bull and Williamson Creeks in the Barton Springs zone given their sensitive nature.

Solutions targeted for flood control in developing watersheds include:

- Property buyout for flood prone areas
- Flood detention
- Channelization
- Site specific smaller scale solutions
  - Flow diversion – channels and/or tunnels
  - Replacement of structural constrictions
  - Levees and floodwalls

10.2.3 Urbanized/Developed Watersheds

In urban watersheds, development intensity is generally near full build-out, water quality degradation is significant, and channel enlargement processes are often nearly complete. In addition, regulatory solutions that are used for newly developing areas cannot generally provide additional significant erosion prevention benefits in areas already urbanized. The remaining 11 watersheds are included in this group. The urban watersheds generally exhibit high existing impervious cover and low projected future impervious cover increases. These watersheds also show quite advanced channel enlargement processes as represented by a low predicted future increase in channel size. Prefered solutions assumed:

- Erosion volume control technologies (e.g., erosion control detention ponds) are generally not the preferred solution given that most preventable channel enlargement has already occurred (MacRae, 1998).
- Localized slope stabilization technologies are appropriate and likely to be necessary to protect property along creeks. Property buyouts may be required.
- Water quality ponds should be considered to address water quality problems and augment baseflow.

Solutions targeted for erosion and water quality control in urban watersheds include:

- Side-slope control solutions
  - Reinforced earth
  - Gabions/concrete riprap
  - GRRE
- Detention/Retention pond solutions
  - Erosion detention (for Little Walnut and Shoal headwaters)
  - Wet Ponds or Wetlands
  - Wet Ponds in conjunction with baseflow extended detention

Solutions targeted for flood control in urban watersheds include:

- Property buyout for flood prone areas
- Flood detention
- Channelization
- Site specific smaller scale solutions
  - Flow diversion – channels and/or tunnels
  - Replacement of structural constrictions
  - Levees and Floodwalls

The City's Desired Development Zone includes several Phase I watersheds that are developing or urbanized. In support of the City's Smart Growth initiative, the Master Plan emphasizes the use of engineered strategies in the Desired Development Zone to minimize the need for additional regulations that may restrict development in that area.

Table 10 – 1 below summarizes solution preferences based on watershed type.

Table 10 - 1
Solution Preferences by Watershed Type

RURAL WATERSHEDS	DEVELOPING WATERSHEDS	URBANIZED WATERSHEDS
1. Barton Creek	1. Blunn Creek 2. Bull Creek 3. Country Club Creek 4. Walnut Creek 5. Williamson Creek	1. Buttermilk Creek 2. Boggy Creek 3. East Bouldin 4. Fort Branch 5. Harper's Branch 6. Johnson Creek 7. Little Walnut Creek 8. Shoal Creek 9. Tannehill Branch 10. West Bouldin Creek 11. Waller Creek
Rural Watershed Characteristics	**Developing Watershed Characteristics**	**Urbanized Watershed Characteristics**
Future Impervious Cover <15%	Existing Impervious Cover >15% Net Future Impervious Cover Increase >5%	Existing Impervious cover >50% Net Future Impervious Cover Increase <5%
Solution Options for Flood Control	**Solution Options for Flood Control**	**Solution Options for Flood Control**
No flooding problems in Barton Creek	- Property Acquisition (Buyouts) for Flood Control - Flood Detention - Channelization - Flow Diversion: Channels and Tunnels - Replacement of Structural Constrictions - Levees and Floodwalls	- Property Acquisition (Buyouts) for Flood Control - Flood Detention - Channelization - Flow Diversion: Channels and Tunnels - Replacement of Structural Constrictions - Levees and Floodwalls
Solution Options for Erosion and Water Quality	**Solution Options for Erosion and Water Quality**	**Solution Options for Erosion and Water Quality**
- Geomorphically-Referenced River Engineering (GRRE) - Wet Pond/Wetlands - Retention-Irrigation Ponds	- Reinforced Earth [erosion side-slope projects] - Gabions/Concrete Riprap [erosion side-slope proj.] - Geomorphically-Referenced River Engineering (GRRE) - Erosion Detention - Erosion Detention + Wet Ponds - Erosion Detention + Wet Ponds + Baseflow Extended Detention - Retention-Irrigation Ponds *[Bull; Williamson in BSZ]*	- Reinforced Earth [erosion side-slope projects] - Gabions/Concrete Riprap [erosion side-slope projects] - Geomorphically-Referenced River Engineering (GRRE) - Erosion Detention *[Little Walnut & Shoal headwaters]* - Wet Ponds/Wetlands - Wet Ponds + Baseflow Extended Detention

Source: Loomis Austin, Inc., 2000

10.3 Identifying Preferred Capital Solutions

Once the capital solution preferences based on watershed conditions were established, specific locations in the Phase I watersheds were identified where preferred erosion, flood and water quality solutions could potentially be constructed given apparent site constraints. In all, over 300 sites for potential projects were identified. Each potential project alternative received a limited analysis (focused on potential limiting factors associated with the site) to identify appropriate and feasible technologies for the particular site and problem. These conceptual projects were then evaluated to estimate benefits (in terms of the goals discussed in Section 2.3) and construction costs. Consideration was given to environmental constraints and neighborhood impacts in evaluating each site. Attempts were made to calculate rough estimates of storage and/or treatment volume that each site could provide. These assessments were very preliminary in nature due to limited site assessment data and project definition. Information resulting from this assessment is considered conceptual in nature, but sufficient for master planning purposes.

This effort resulted in three main categories of (Master Plan) capital solutions.

- Flood control solutions
- Erosion side-slope projects
- Erosion and water quality ponds

10.3.1 Preferred Flood Control Solutions

Available flood control techniques were considered for use at each flood problem area. These techniques include:

- Land and structure acquisition;
- Storm water detention;
- Bridge and culvert modifications;
- Channel conveyance modifications;
- Flood walls and/or levees;
- Flow diversion channels or tunnels; and
- Structure raising.

A "flood problem area" is a location where a flood control solution could likely be implemented as a single flood control project, addressing one or more flood problems in close proximity. Each problem area was ranked based on the overall flood problem scores within the flood problem area. The top 32 ranked problems were designated as "Level I" flood areas and were evaluated with a different protocol than the remaining 140 problem areas that were designated as "Level II" problem areas.

The identification of potential solutions for Level I flood areas began with a plot of HEC-RAS profiles to denote the extent of flooding. Each area was visited to assess site conditions and note pertinent field data. In all cases, property buy-out was considered as a stand-alone solution, as well as in combination with structural solutions. An assessment was made to determine if a bridge or culvert was causing the problem. Bridge and culvert modifications were considered when: (1) the crossing is overtopped by the 100-yr flood; (2) there is flooding immediately upstream of the bridge; and (3) the existing bridge or culvert opening does not span the entire drainage easement. If a bridge or culvert was determined to not be the cause, an assessment was made to determine if detention could solve the flooding problem. If detention could not mitigate the problem, channel modification was considered. If this still was not adequate to limit flooding problems, the following structural solutions were considered:

- Flow diversion;
- Levees and/or floodwalls; or
- Structure raising.

Level II flood problem areas were evaluated using a different protocol. Rather than plotting floodplain boundaries from model output, the boundaries of problem sites were determined based on estimates from existing floodplain data. Structure inundation depths were recorded for all sites for the 2-, 10-, 25-, and 100-year storm events. Bridge problem sites were evaluated in the field for possible replacement or additional culverts. For residential and commercial problem sites, channel modification was the only structural flood mitigation technology evaluated. Channel conveyance of the proposed solution was compared to the estimated conveyance required to remove all structures and roadways from the 100-year floodplain based on the Manning's equation analysis. In some cases the maximum conveyance associated with the proposed solution was less than the estimated required conveyance.

In addition, property acquisition was considered as a stand-alone solution. The potential for using upstream detention was evaluated based on previously proposed detention facilities and apparent availability of land for detention (Loomis Austin, Inc. 2000).

To address localized flooding problems, WPD completed a preliminary study of several local storm drainpipe networks to determine if current system capacity and pipe sizes are adequate. Each watershed sub-basin area was analyzed to compute excess runoff and size the main storm drain system (Figure 10 – 1).

Figure 10 – 1

Localized Drainage System Study Example*

*Suggested upgrades in red *Source: City of Austin, 2000*

10.3.2 Preferred Erosion Side-Slope Projects

Side-slope project identification began by combining Type 1, Type 2 and Type 3 erosion problem locations into project units. Project units are groupings of nearby erosion problems based upon physical proximity of localized erosion problems and reach characteristics. Initially, natural channel design using reinforced earth and hard design options, such as gabions, was considered. Topographic maps were reviewed and used to help select an appropriate technology for each location. An attempt is made to use soft technologies (such as biorevetment techniques) wherever conditions allow their implementation.

Nearly 100 erosion side-slope projects were identified on the main creek system. Because these projects target existing bank failure, side-slope projects are best applied in the urbanized and developing watersheds where there is a relatively high degree of development. These side-slope projects target Type 1 and 2 erosion problems (existing structures, fences, trees threatened by creek bank erosion). Side-slope technology varies from traditional gabions or concrete to biorevetment methods. Preference is given to softer technologies, such as biorevetment, because they are more sustainable and use natural products that promote revegetation and protect the natural character of the waterways. This minimizes future maintenance, and enhances a stable stream system. These techniques also allow for multiple use of waterways by facilitating recreational opportunities. A preliminary assessment of all proposed side-slope project locations was completed to identify possible locations where biorevetment might be appropriate.

10.3.3 Preferred Erosion and Water Quality Ponds

Although there are many erosion and water quality structural solutions that were identified in the capital project inventory, only those deemed suitable for implementation on a regional scale were initially considered for evaluation. Four technologies were selected for consideration:

- Erosion detention ponds
- Baseflow detention ponds
- Wet ponds and/or constructed wetlands
- Retention-irrigation

Initially, the focus was to identify possible pond locations based upon the location and severity of erosion and water quality problems. The difficulty of finding suitable sites in the largely urbanized Phase I watersheds led to a decision to identify as many available pond locations as possible. Topographic maps with identified designated open spaces were used to identify over 250 potential pond sites. Each site was field verified to assess site size and layout and potential constraints or opportunities. Almost half of the original sites were eliminated after field reconnaissance due to site constraints.

Six technology combinations were then considered at the remaining sites:

- Permanent wet pool only (wet ponds and/or constructed wetlands);
- Erosion detention only;
- Permanent wet pool with baseflow detention;
- Permanent wet pool with erosion detention;
- Permanent wet pool, erosion detention, and baseflow detention; and
- Retention-irrigation.

These combinations were then screened based on watershed type as presented in Section 10.2. Optimal erosion control and water quality control capture volumes were estimated and compared to total available facility size. In cases where the required storage volume was not available, a less-than-optimal volume configuration was calculated. Basic design parameters were estimated for each configuration at each site for cost and benefit determination.

Drainage area, impervious cover, water quality volume, and cost data was used in the pond evaluation procedure. Pollutant loads and removal efficiencies were also calculated. The dissolved phosphorous (DP) removal `efficiency is calculated as a function of wet pond hydraulic residence time, and will vary with impervious cover and water quality volume.

Due to the degree of future erosion predicted in the Walnut Creek watershed, a more detailed study of Walnut Creek was performed (Chan, 1999). This study gave insight into the level of problem reduction that additional structural controls could accomplish in promoting future reach stability. The impacts of varying impervious cover limits, and structural erosion and water quality control ponds were modeled for Walnut Creek in an attempt to evaluate the impact that structural controls could be expected to have. This study: 1) identified the benefit that sedimentation-filtration ponds have in preventing potential erosion, and 2) identified the need for additional ponds in the headwaters of Walnut Creek to help achieve future reach stability.

Projects under the Regional Storm Water Management Program (RSMP) were also considered for possible retrofit. Existing RSMP ponds were screened to select sites with minimal existing water quality controls located in the drainage area to the ponds. This screening method selects sites where retrofits would provide the greatest water quality benefit. Site retrofit design would incorporate wet ponds into the existing pond design.

Because the proposed regional solutions left a significant gap between goals and problem mitigation, additional, smaller scale solution options were also considered. The cost and benefit of retrofitting existing small-scale detention and water quality ponds (both RSMP and existing residential and commercial on-site ponds) to provide additional water quality treatment was evaluated, as well as the potential of using Low Impact Development (LID) design techniques in retrofitting existing development. These design techniques emphasize the use of alternative and innovative BMPs such as rainwater harvesting, soil restoration, and bioretention. WPD analysis (City of Austin, 2000) indicated that at least 25% of existing developed areas need to be treated to have a significant impact on water quality. For high priority receiving waters, preferably up to 50% should be treated. The number, type, location and drainage areas of potential retrofit ponds were determined using the City's pond database. The areas potentially treatable were compiled by watershed. Dissolved phosphorous (DP) was used in evaluating water quality retrofit possibilities. DP can be quantified with a relatively high degree of certainty and is a good overall indicator of receiving water conditions. This analysis represents a significant increase in potential retrofit opportunities over those of only providing regional water quality treatment. Further site specific investigations are needed to determine the feasibility of retrofitting ponds, and the ability to use alternative and innovative BMPs. More detailed, site specific investigations are needed to determine the best combinations of large scale regional water quality ponds, and existing pond retrofits.

10.3.4 Initial Integration of Capital Solutions

Each prospective pond project was evaluated to determine the potential to combine erosion, flood storage, and water quality components. Existing and proposed capital projects were evaluated by City staff to determine if it was possible to augment the project to eliminate any of the problems identified under the Master Plan and to determine integration potential.

There are a number of solution concept options that lend themselves to providing an integrated solution. Property acquisition is typically chosen to alleviate a flood control problem, however, this solution often provides water quality and erosion benefits in addition to the primary flood control benefit. Ponds also tend to be effective solutions for multiple purposes. They can provide: (1) stormflow detention that will benefit flood control and erosion control goals; (2) stormflow retention which can benefit baseflow augmentation, as well as mitigate flooding and erosion downstream; and (3) other water quality benefits derived from solids settling. In addition, erosion side-slope projects can be combined with flood channelization projects to provide dual benefit. Components to increase biological habitat and to promote a natural stream system can potentially be added to flood channelization and erosion side-slope projects to provide water quality benefits.

10.4 Assessing Benefits and Cost

Estimates were developed for benefits and costs of the various capital solution alternatives developed during the Master Plan. The initial feasibility determination for potential capital projects is based on very preliminary site investigations. Therefore, the estimation of benefits and costs should also be considered preliminary in nature. Additional study of these project concepts will be necessary during the preliminary engineering phases of the capital implementation process to define proposed project budgets and objectives.

10.4.1 Assessing Benefits

Benefit Estimates for Flood Control Solutions

Three types of capital solutions were evaluated for flood benefit: (1) structural projects under Level I investigations; (2) structural projects under Level II investigations; and (3) nonstructural property buyouts. Benefit for flood control solutions were assigned based upon reduction of the flood problem score and reflect the extent to which they would remove structures and bridges from the 2-, 10-, 25-, and 100-year flood plains.

Acquisition of flood plain properties allows the removal of structures threatened by flood events, creates a buffer between development and the waterway, and reclaims and re-naturalizes a portion of the floodplain to more of its original ecological function. Opportunities for public access along waterways can be increased, along with improved natural appearance and potential reductions in algae (from buffer effects) and litter. Flood plain property buyouts therefore were judged to have a positive impact upon four EII subindicators: Aquatic Life Support, Physical Integrity, Non-contact Recreation, and Water Quality. (Loomis Austin, Inc. 2000)

Benefit Estimates for Erosion Control Solutions

Benefits were estimated for two types of erosion control capital solutions: (1) side-slope projects, including flood channel modification; and (2) erosion detention storage. Benefit scores are based on the value of the problem score that could be eliminated as a result of the solution. Benefit calculation for side-slope projects accounted for the Type 1,Type 2, Type 3, that were fixed by a given side-slope project. Detention storage project benefit calculation assumed that only Type 3 and future reach stability problems located downstream of a pond would be corrected.

Erosion side-slope and channel modification projects serve to protect channel banks from erosion. These projects were therefore credited with lowering Total Suspended Solids (TSS) over the portion of each EII reach protected by the project. Side-slope and channelization projects can also impact the Aquatic Life Support (ALS) and Physical Integrity (PI) sub-indices of the EII. Therefore, benefits for these projects were estimated in terms of these factors. (Loomis Austin, Inc. 2000)

Benefit Estimates for Water Quality Solutions

Water quality benefits for regional water quality-erosion ponds were estimated for both watersheds and receiving waters. Solution benefit was calculated based on the solution's ability to improve Environmental Integrity Index (EII) scores. Negative impacts are also considered for solutions that could potentially impair water quality (such as channel modification or large scale detention that impacts riparian vegetation).

Each creek reach was assessed using predicted future conditions with and without solution implementation. Estimates of project benefits were made for each solution according to the solution's ability to improve conditions and close the gap between the predicted future EII score and the target goal. Benefits of the pond retrofit analysis was based on the overall acreage available for retrofit of existing ponds. (Loomis Austin, Inc. 2000)

10.4.2 Assessing Costs

General project costs were estimated based upon construction costs of the major project components. For each solution, the cost included initial capital construction costs and annual (O&M) costs. Annual O&M costs were assumed to be equal to 1% of the initial capital cost. Cost estimates are preliminary in nature and are of an overall master planning level based on preliminary site investigations. Contingency costs were assumed at 20% to 30% (Loomis Austin, 2000). Erosion side-slope project costs were based on an 'installation' cost per square foot plus an assumed cost per acre of land. Side-slope projects are assumed to cover both banks of the channel. In some cases, erosion side-slope projects costs were based on averaged total costs from similar past projects. (Loomis Austin, Inc. 2000).

Cost estimates for water quality and erosion pond projects are based on unit cost functions tied to the following characteristics (Loomis Austin, Inc. 2000):

- facility footprint (for land purchase estimation)
- land costs for site
- excavation/embankment requirements

- contributing watershed area treated
- on-line versus off-line facility
- facility configuration (e.g., erosion detention only, erosion plus baseflow, etc.)

In some cases, generalized pond costs were based on pond cost information as follows:

- Wet Ponds
  - ➢ If water quality volume (WQV, also known as permanent pool volume) <= 6 ac-ft then
    Cost ($) = 30332* WQV(ac-ft) + 238772
    (from City of Austin retrofit data; $r^2 = 0.75$)
  - ➢ If WQV > 6 ac-ft then
    Cost ($) = 56282*WQV (ac-ft) + 83451
    (Loomis & Moore and City of Austin data; $r^2 = 0.9$)
- Sand Filtration and Sedimentation Basin Retrofits
  - ➢ Cost ($) = 60142*Ln(WQV [ac-ft]) + 156297; minimum cost of $50,000/pond.

Flood control solution costs were estimated for Level I and Level II analysis projects, as well as buyout options. Level I solutions and buyout options included a 20% contingency cost, while Level II solutions assumed a 30% contingency cost. Costs were based on average costs for project materials, labor costs, and unit costs for the various elements of a given solution. Sizing for costing was based on gross design estimates made during solution evaluation. Property values for costing buyout options were obtained from the Travis Central Appraisal District database (1999-2000 values). A 2.2 multiplier was used to account for potential additional costs for acquiring property via condemnation. The preliminary cost estimates represent a general range of cost for solutions necessary within any given Phase I watershed, rather than an exact assessment of the cost of an individual project concept (Loomis Austin, Inc. 2000).

General estimates of capital solution costs for each potential capital technology were developed. Each site had more than one potential solution shown, yet only one solution could ultimately be chosen for each site. To provide a realistic estimate of total watershed cost, staff used the most desirable solution type identified for each site. For flood control projects, this generally meant that the cost for floodplain structure buyout was used, since this solution effectively solved the flooding problems while also providing riparian restoration opportunities that also yields benefits for the erosion and water quality missions. The flood project cost total of $444,980,000 is based on the selection of the alternative solution judged most desirable for each problem area using the initial project cost data. Urban and nonurban watershed costs for flood controls are $249,330,000 and $195,650,000 respectively.

The total $166,810,000 shown in Table 10 – 2 reflects the implementation of approximately 110 total side-slope projects (City of Austin, 2000). Erosion side-slope costs are generally the same for each site whether a hard method such as gabions or concrete is chosen, or a softer technique such as biorevetment.

For water quality ponds the most desirable solution type was the one with multiple components, such as wet pool, plus baseflow enhancement, plus erosion capture. Fourteen regional erosion detention ponds are proposed, including four ponds identified by a more detailed study of the Walnut Creek Watershed (City of Austin, 1999). Water quality solution costs include 38 regional water quality pond facilities, as well as the additional project costs developed for potential retrofits and Low-Impact designs. Proposed erosion and water quality pond projects total $263,240,000 and include varying configurations of wet pond, baseflow enhancement and erosion detention features. The combined cost for erosion and water quality controls (side-slope and ponds) for the urban and nonurban watersheds are approximately $185,440,000 and $244,610,000 respectively.

Once the initial solution development effort was completed, WPD continued to refine the project identification process by conducting additional investigations of specific projects, screening out less feasible projects and identifying additional capital solution alternatives to further promote goal attainment for each WPD mission. Table 10 – 2 presents the results of the cost analysis for each of the Phase I watersheds. As shown, a total of $875,030,000 in capital solutions was identified.

Table 10 – 2

Primary Drainage System Cost by Watershed

Watershed	Flood	Erosion Sideslope	Water Quality/ Erosion Ponds	Total
Barton	–	$2,640,000	$11,340,000	$13,980,000
Blunn	$4,820,000	$2,230,000	$2,230,000	$9,280,000
Buttermilk	–	$4,880,000	$2,660,000	$7,540,000
Boggy	$8,000,000	$8,710,000	$6,440,000	$23,150,000
Bull	$24,420,000	$10,850,000	$43,420,000	$78,690,000
Country Club	$15,810,000	$6,390,000	$7,950,000	$30,150,000
East Bouldin	$24,980,000	$5,740,000	$7,090,000	$37,810,000
Fort Branch	$7,820,000	$9,930,000	$3,240,000	$20,990,000
Harper's Branch	–	$260,000	$1,680,000	$1,940,000
Johnson	$4,300,000	$5,610,000	$1,010,000	$10,920,000
Little Walnut	$98,190,000	$13,440,000	$12,900,000	$124,530,000
Shoal	$69,690,000	$21,360,000	$29,450,000	$120,500,000
Tannehill	$2,120,000	$8,520,000	$3,210,000	$13,850,000
West Bouldin	$7,790,000	$3,140,000	$13,680,000	$24,610,000
Walnut	$54,380,000	$36,890,000	$55,910,000	$147,180,000
Waller	$21,620,000	$7,260,000	$10,770,000	$39,650,000
Williamson	$101,040,000	$18,960,000	$50,260,000	$170,240,000
Total	$444,980,000	$166,810,000	$263,240,000	$875,030,000

Source: City of Austin, 2000; Loomis Austin, Inc., 2000 *ENR construction cost index (1999) = 606*

Preliminary cost estimates for each storm drain system were prepared in order to obtain an estimate of the magnitude of required infrastructure needs. Table 10 – 3 summarizes the estimated project costs for each watershed. Ultimately, construction costs will depend on the results of final design configurations and the length of time required for implementation.

Table 10 - 3

Localized Drainage System Upgrade Estimates

	Watershed	Estimated Project Cost (Millions)	Suggested # of System Upgrades
Entire Watershed Studies*:			
	Boggy	$ 17.5	36
	Blunn	$ 5.2	24
	Buttermilk	$ 0	0
	Carson	$ 0	0
	Country Club	$13.3	21
	East Bouldin	$12.6	30
	Fort Branch	$19.3	48
	Harper's Branch	$ 2.6	5
	Johnson	$15.2	34
	Little Walnut	$10.4	27
	Shoal	$43.3	47
	Tannehill	$ 8.4	24
	Town Lake 1	$ 2.1	4
	Town Lake 2	$ 6.2	4
	Town Lake 3	$19.4	3
	Waller	$39.4	24
	West Bouldin	$23.0	50
Partial Watershed studies:			
	Barton	$ 0	0
	Bull	$ 0.8	2
	Eanes	$ 0.04	1
	Walnut	$ 0.35	2
	Williamson	$18.4	37
	Total:	$257.5 Million	423

Source: City of Austin, March, 2000 *ENR construction cost index = 6127, December 1999*

* Based on previous complaints received through December 1998.

10.5 Identifying Preferred Programs

Operating programs were evaluated in several ways. These primarily included (1) identifying geographic limitations, 2) developing a Level of Service Study, 3) benchmarking with similar areas of the country, and 4) identifying new programs or program elements to facilitate the implementation of small-scale capital solutions and technologies. Information gained from this evaluation was used to develop program enhancement recommendations.

10.5.1 Geographic Limitations

Geographic limitations were evaluated by analyzing both the applicability of a programmatic solution, as well as jurisdictional constraints. Applicability was related to the degree a given program was able to affect a problem score in a given watershed. For example, the storm sewer discharge permit program regulated discharges from commercial business's such as automotive repair shops. A rural watershed, such as Barton Creek, has limited commercial businesses with the potential for discharges, when compared to a more developed watershed with a higher percentage of commercial land-use, such as Williamson Creek or Shoal Creek. Conversely, a watershed that is not rural in nature would not benefit from a program aimed at rangeland management. "Jurisdiction" was related to the degree a program was applicable in a given watershed based on jurisdictional boundaries. Some watersheds, such as Barton Creek, have large areas outside the jurisdictional authority of the City of Austin. WPD programs have little to no benefit in terms of lowering the problem score of a watershed in areas outside City of Austin jurisdiction. (Loomis Austin, Inc., 2000)

10.5.2 Level of Service Study

The Programmatic Level of Service Analysis (Loomis & Moore, Aug. 1999) evaluates WPD operating programs. Each program was analyzed to determine the Essential, Current, Optimum, and Maximum level of service for each program. The levels of service that were considered are defined as follows:

- Current Level – This is the current level of service being provided by each program.
- Essential – This defined specific service changes for programs that are required immediately to address the most crucial WPD program needs, and to identify new program elements that are most important to goal attainment.
- Optimum Level – This is the target level of service for each program, where each program's minimum objectives are achieved. Target service levels were determined through a combination of benchmarking results and City staff input.
- Maximum Level – This is the maximum level of service that should be considered by the WPD for each program. The outputs associated with each program's maximum service level were determined through a combination of benchmarking results and City staff input.

Program activities were also related to the WPD goals and objectives they support. The interdependence between programmatic solutions was investigated. For example, an recommended increase in a program budget for Flood Project Implementation and Field Engineering that results in an increase in construction of capital projects such as detention ponds will have an impact on the future level of maintenance required. Programs that provide guidance or support (such as modeling, GIS and database management) to other WPD programs were also evaluated based on the recommended enhancements of the supported programs.

For some solutions, one or more of the recommendations for enhancements of the Essential, Optimum, Maximum or Current levels of service may not differ. For example, a program with no current deficiencies would have an Essential level of service recommendation identical to the current level of service. The Maximum level of service is defined in this report to provide a complete scope of the level of service information that was collected, however, cost information and program enhancements reflecting the Maximum level of service were not used in developing the Master Plan findings or recommendations.

Level of service information that was collected or derived included staff and operating budget needs. The level of service determination considered current program outputs (program yields, such as number of inspections completed, number of miles of pipe maintained or replaced) and current program resources. City staff was consulted to evaluate whether current output was considered to be sufficient. The benchmarking initiative was also considered in evaluation of program output and efficiency. Recommendations for increases to program output and efficiency improvements, as well as identification of areas that required further investigation were included in the Level of Service Report. Programmatic increases needed to meet the identified levels of service, as well as the associated budget required, are presented in Table 10 – 4.

Table 10 – 4
Programmatic Level of Service Study Results

PROGRAMS	STAFF (FTE Change from Current)			CURRENT BUDGET*	
	Current	Essential Service Level	Optimum Service Level	Annual Budget	Capital Budget
ASSETS MAINTENANCE (AM) PROGRAMS (Type C)					
Existing Flood Control					
Channel Vegetation Control	0	+ 0	+ 0	$ 1,100,000	$ -
Pond Vegetation Control	0	+ 0	+ 0	$ 514,155	$ -
Open Waterway Maintenance	21	+ 0	+ 12	$ 1,134,049	$ -
Bridge and Culvert Clearing	4	+ 0	+ 0	$ 230,000	$ -
Storm Drain System Repair and Rehabilitation	12	+ 4	+ 12	$ 708,770	$ -
Storm Drain System Cleaning	10	+ 0	+ 4	$ 579,903	$ -
Existing Water Quality					
Town Lake Cleanup	3	+ 0	+ 0	$ 169,000	$ -
Existing Integrated					
Detention & Water Quality Pond Maint. & Repair	7	+ 7	+ 7	$ 224,751	$ -
New Flood Control					
Dam Safety Inspection	0	+ 0	+ 1	$ -	$ -
GUIDANCE/SUPPORT PROGRAMS					
Erosion Control					
Erosion Project Planning/Implementation/Field Engr	5	+ 2	+ 6	$ 299,379	$ -
Flood Control					
Flood Plain Office	3.03	+ 0	+ 1	$ 187,429	$ 4,950
Watershed Management and Facilities Planning	3.27	+ 0	+ 0	$ 233,309	$ -
Watershed Hydrologic & Hydraulic Modeling	2.13	+ 0	+ 0.5	$ 162,436	$ 6,090
Flood Project Planning/Implementation/Field Engineering	7.5	+ 2	+ 5	$ 545,992	$ 16,690
Flood and Erosion Hazard Property Acquisition	0	+ 1	+ 1	$ -	$ -
Water Quality					
Federal Permit Compliance	3	+ 0	+ 0	$ 162,964	$ 4,800
Water Quality Assessments	10.13	+ 0	+ 0	$ 1,140,158	$ 10,445
Land Use Water Quality Monitoring	4	+ 0	+ 0	$ 472,548	$ 7,200
Structural Controls Monitoring	7	+ 0	+ 1	$ 840,084	$ 12,800
Environmental Impact Assessments	3.76	+ 0	+ 0	$ 289,056	$ 3,319
Water Quality Control Design	2.88	+ 0	+ 0	$ 180,685	$ 4,464
Dry Weather Flow Screening	0	+ 1	+ 1	$ -	$ -
Integrated					
Review & Inspection of Development	30.7	+ 3.5	+ 11	$ 1,721,084	$ 38,099
Watershed Master Planning	2.26	+ 0	+ 0	$ 172,928	$ 4,291
Programs Integration	0	+ 1	+ 2	$ -	$ -
Geographic Information Systems (GIS)	3.48	+ 1	+ 1	$ 211,282	$ 3,800
Database Management	3	+ 2	+ 2	$ 116,200	$ -
SLD PROGRAMS (Solutions with Limited Data) (Type C)					
Existing Flood Control					
Flood Hazard Public Information	0.53	+ 0.5	+ 0.47	$ 41,468	$ 450
Flood Early Warning System (FEWS)	4.28	+ 0	+ 1	$ 326,464	$ 4,000
Existing Water Quality					
Storm Sewer Discharge Permits	6	+ 0	+ 0	$ 380,382	$ 12,954
Emergency Spills & Complaints Response	6	+ 0	+ 0	$ 380,382	$ 12,954
Contaminated Site Cleanup	0	+ 0	+ 0	$ 50,000	$ -
Pond Operating Permits Program	0.5	+ 0	+ 0	$ 16,568	$ -
Residential and Commercial Pond Inspection	1.125	+ 0	+ 0.5	$ 94,601	$ -
Underground Storage Tanks	2	+ 0	+ 0	$ 92,820	$ -
Water Quality Education	2.5	+ 0.5	+ 1	$ 210,970	$ 233
New Water Quality					
Small-Scale Urban Water Quality Retrofit	0	+ 0	+ 0.5	$ -	$ -
Small-Scale Urban Retrofits for Baseflow Enhancement	0	+ 0	+ 0.5	$ -	$ -
"Grow Green" Landscape Program for Water Quality	0	+ 0	+ 0.5	$ -	$ -
Trash and Debris Control Team	0	+ 0	+ 2.25	$ -	$ -
New Integrated Programs					
Conservation Easement/Land Acquisition Program	0	+ 0.5	+ 1	$ -	$ -
Watershed Steward Program	0	+ 0	+ 0.25	$ -	$ -
TYPE A & B PROGRAMS					
Existing Erosion Control					
Erosion Control Crew	6	+ 6	+ 6	$ 288,623	
New Water Quality					
Street Sweeping for Toxics Control	0	+ 0	+ 3	$ -	$ -
New Integrated Programs					
Rural Watershed Restoration	0	+ 0.5	+ 1	$ -	$ -
Sums	177	+ 31.5	+ 85	$ 13,278,440	$ 147,539

*based on Fiscal year 99-00 budget

Source: Loomis Austin 2000

Table 10 – 4 continued

Programmatic Level of Service Study Results, continued

PROGRAMS	ESSENTIAL BUDGET		OPTIMUM BUDGET	
	Annual Budget	Capital Budget	Annual Budget	Capital Budget
ASSETS MAINTENANCE (AM) PROGRAMS (Type C)				
Existing Flood Control				
Channel Vegetation Control	$ 1,100,000	$ -	$ 1,155,000	$ -
Pond Vegetation Control	$ 514,155	$ -	$ 642,694	$ -
Open Waterway Maintenance	$ 1,134,049	$ -	$ 1,782,077	$ -
Bridge and Culvert Clearing	$ 230,000	$ -	$ 230,000	$ -
Storm Drain System Repair and Rehabilitation	$ 945,027	$ -	$ 1,417,540	$ -
Storm Drain System Cleaning	$ 579,903	$ -	$ 811,864	$ -
Existing Water Quality				
Town Lake Cleanup	$ 169,000	$ -	$ 169,000	$ -
Existing Integrated				
Detention and Water Quality Pond Maint. and Repair	$ 449,502	$ -	$ 449,502	$ -
New Flood Control				
Dam Safety Inspection	$ -	$ -	$ 62,513	$ 20,000
GUIDANCE/SUPPORT PROGRAMS				
Erosion Control				
Erosion Project Planning/Implementation/Field Engineering	$ 419,131	$ -	$ 658,634	$ -
Flood Control				
Flood Plain Office	$ 187,429	$ 4,950	$ 249,279	$ 6,584
Watershed Management and Facilities Planning	$ 233,309	$ -	$ 233,309	$ -
Watershed Hydrologic and Hydraulic Modeling	$ 162,436	$ 6,090	$ 200,567	$ 7,520
Flood Project Planning Implementation /Field Engineering	$ 691,590	$ 16,690	$ 909,987	$ 27,817
Flood and Erosion Hazard Property Acquisition	$ 80,510	$ -	$ 80,510	$ -
Water Quality				
Federal Permit Compliance	$ 162,964	$ 4,800	$ 162,964	$ 4,800
Water Quality Assessments	$ 1,140,158	$ 10,445	$ 1,140,158	$ 10,445
Land Use Water Quality Monitoring	$ 472,548	$ 7,200	$ 472,548	$ 7,200
Structural Controls Monitoring	$ 840,084	$ 12,800	$ 960,096	$ 14,629
Environmental Impact Assessments	$ 289,056	$ 3,319	$ 289,056	$ 3,319
Water Quality Control Design	$ 180,685	$ 4,464	$ 180,685	$ 4,464
Dry Weather Flow Screening	$ 121,815	$ 20,000	$ 121,815	$ 20,000
Integrated				
Review and Inspection of Development	$ 1,917,299	$ 38,099	$ 3,265,575	$ 72,289
Watershed Master Planning	$ 172,928	$ 4,291	$ 172,928	$ 4,291
Programs Integration	$ 39,500	$ -	$ 134,056	$ -
Geographic Information Systems (GIS)	$ 271,995	$ 3,800	$ 271,995	$ 4,892
Database Management	$ 348,600	$ -	$ 348,600	$ -
SLD PROGRAMS (Solutions with Limited Data) (Type C)				
Existing Flood Control				
Flood Hazard Public Information	$ 80,589	$ 450	$ 78,241	$ 849
Flood Early Warning System (FEWS)	$ 326,464	$ 4,000	$ 402,740	$ 4,935
Existing Water Quality				
Storm Sewer Discharge Permits	$ 380,382	$ 12,954	$ 380,382	$ 12,954
Emergency Spills an Complaints Response	$ 380,382	$ 12,954	$ 380,382	$ 12,954
Contaminated Site Cleanup	$ 50,000	$ -	$ 50,000	$ -
Pond Operating Permits Program	$ 16,568	$ -	$ 16,568	$ -
Residential and Commercial Pond Inspection	$ 94,601	$ -	$ 136,646	$ -
Underground Storage Tanks	$ 92,820	$ -	$ 92,820	$ -
Water Quality Education	$ 253,164	$ 233	$ 295,357	$ 326
New Water Quality				
Small-Scale Urban Water Quality Retrofit	$ -	$ -	$ 527,904	$ 500,000
Small-Scale Urban Retrofits for Baseflow Enhancement	$ -	$ -	$ 277,904	$ 250,000
"Grow Green" Landscape Program for Water Quality	$ -	$ -	$ 32,904	$ -
Trash and Debris Control Team	$ -	$ -	$ 96,796	$ 200,000
New Integrated Programs				
Conservation Easement/Land Acquisition Program	$ 27,755	$ -	$ 55,510	$ -
Watershed Steward Program	$ -	$ -	$ 37,904	$ -
TYPE A & B PROGRAMS				
Existing Erosion Control				
Erosion Control Crew	$ 577,246	$ -	$ 577,246	$ -
New Water Quality				
Street Sweeping for Toxics Control	$ -	$ -	$ 131,272	$ 300,000
New Integrated Programs				
Rural Watershed Restoration	$ 27,904	$ -	$ 55,807	$ -
Sums	$ 15,081,036	$ 167,539	$ 20,199,335	$ 1,490,268

*based on Fiscal year 99-00 budget

Source: Loomis Austin, Inc. 2000

10.5.3 Benchmarking

Program benchmarking helped determine how City of Austin programs compared to other areas, and helped define different levels of service. The following 10 jurisdictions were selected from which to collect benchmarking information:

- Tulsa, Oklahoma
- Prince George's County, Maryland
- Mecklenberg County (Charlotte), North Carolina
- King County (Seattle), Washington
- Portland, Oregon
- Ft. Worth, Texas
- Ft. Collins, Colorado
- Montgomery County, Maryland
- Orlando, Florida
- Toronto, Ontario, Canada

Benchmarking information on the following programs was requested. The programs were grouped into the categories below to assist the cities and counties in providing level of service information.

Assets Maintenance
- *Channel/Creek Conveyance*
  - Channel Vegetation Removal
  - Bridge and Culvert Clearing
  - Open Waterway Maintenance
- *Storm Sewer*
  - Storm Sewer and Inlet Cleaning
  - Storm Sewer Repair/Replacement
- *Ponds*
  - Pond Vegetation Removal
  - Enhanced Pond Vegetation Removal

Assessment
- *Water Quality*
  - Water Quality Assessments
  - Land Use Water Quality Monitoring
  - Structural Controls Monitoring
- *Flood Control*
  - Hydrologic & Hydraulic Modeling
  - Storm Sewer Hydraulic Modeling
  - Drainage Infrastructure Assessment
- *Erosion Control*
  - Erosion Control Assessment

Review and Inspection of Development
- Review and Inspection of Development

Information Technology
- Geographic Information System (GIS)
- Database Management

National Flood Insurance Program
- Flood Hazard Public Education
- Flood Early Warning System (FEWS)

Water Quality Education
- Water Quality Education

The cities/counties that were chosen for benchmarking represented similar populations, had similar development patterns, watershed problems or operating programs; some were selected due to the similarity in regulatory effort.

General program information requested from each jurisdiction included total budget of the benchmarked program, total labor, capital budget, revenue information (including sources of revenue), fee rates, and information on types of regulations enforced. In addition, each point of contact was requested to send information regarding program budget and staffing, performance measures, inputs, outputs, results, and perceived gaps in service (Loomis & Moore, Aug 1999).

Benchmarking Results

The level of response varied with the entities contacted. Orlando, Portland, Ft. Collins, Montgomery County, Mecklenberg County, and King County provided adequate detail to gain benchmarking information. Information available on some of the initially targeted programs listed above, such as Flood Control programs, was minimal. Benchmarking information will be continually updated as part of future Master Plan efforts, with supplemental information added periodically. Table 10 – 5 provides a general overview of the information obtained through benchmarking. A summary of the information gained from the benchmarking effort is summarized below.

Table 10 – 5

Summary Benchmarking Information

	City of Austin	King County	City of Portland	Ft. Collins	City of Orlando
Name of Department	*Watershed Protection Department*	*Dept of Natural Resources, Water & Land Resources Division*	*Bureau of Environmental Services*	*Storm Water Utility*	*Public Works Department, Storm Water Utility Bureau*
Department Budget	$23,903,860	$44,350,161	$79,113,785	$1,957,419	$10,395,400
Department FTEs	193	346.89	450	19	104
Capital Budget	$9,579,000		$77,715,863	$10,175,000	$5,329,000
Source of revenues	Drainage fee, general fund	Multiple sources	Sewer and storm water fees	Storm Drainage Utility Fee	Storm Water Service Charge
Fee rates [1]	residential $4.74 and commercial $51.12 per developed acre		Residential = $30/month Commercial rate based on ERU		$5.50 monthly per ERU
Average Annual Rainfall (inches)	33.8		10	15.00	49.24
Average Annual Snowfall (inches)	.68			51.00	
Population	567,566	1,500,000	503,000	106,000	182,986
Area Size (square miles)	225.0	2,200.0	130.0		100.2
Separate or combined storm water system	Separate	Separate	Both separate and combined	Both separate and combined	Separate
Character of Drainage Ways	Primarily natural	Primarily natural	Primarily natural	80% constructed	Both natural and constructed
Sunshine (% or days)	300			296	292
FEMA rating	7	6	Not rated	6	7

[1] Based on 1999-2000 drainage fee

Source: Loomis & Moore, 1999, as amended by City of Austin

Assets Maintenance

Comparison of the assets maintenance programs in the City of Austin with those implemented in King Country, Washington (the Seattle area) Orlando, Florida, and Ft.

Collins, Colorado indicates that Austin's level of service for channel vegetation maintenance is in the middle of a very wide range of channel maintenance service provided by the entities benchmarked. Austin maintains approximately 70 miles of creek channel three times yearly to provide flood control benefits. Orlando has a mixture of natural and constructed drainage ways, with an extensive maintenance program. Mowing occurs approximately 10 times per year. Application of herbicides in detention basins, open ditches and wetlands occurs 6 times per year. Channel mowing is avoided entirely in King County, Washington, if possible, to help protect its natural waterways and natural fisheries. Channel restoration work is extensive, however. In Ft. Collins channels are mostly constructed, and all channels and ponds are mowed 3-5 times/year to about ¾ inches, primarily for aesthetics. In addition to routine maintenance, Ft. Collins has staff conduct an annual walk-through of each facility and note what heavier–duty work needs to be done.

Water Quality Assessment

Benchmarking results indicate that Austin's water quality assessment activities excel in comparison to other similar locations. King County, Portland, and Orlando are all conducting water quality assessments, although none monitor groundwater. Orlando is planning a sediment monitoring program, but it does not plan to monitor baseflow. Portland is conducting limited bioassessments, and has conducted monitoring of BMP effectiveness and TMDL analysis for two subwatersheds. All of these locations except Ft. Collins have performed some degree of land use monitoring in preparation for their NPDES permit. Ft. Collins does not yet have an NPDES permit.

King County has extensive water quality controls in place in the form of retention/detention ponds, which are required for all new development. Water quality controls are not extensively required in Ft. Collins, although they are implementing BMPs through their capital projects plan. They are revising their criteria and will require water quality controls in the future. Detention is required for new development.

Review and Inspection of Development

The benchmarking information received from other jurisdictions indicates that the development function is primarily decentralized elsewhere, which makes it difficult to compare the level of activity with that of Austin.

Austin has a separate review process for site plan/development permits and building permits. Turn around time varies greatly depending on the location and type of project. Development review includes plan review to assure compliance with City rules and regulations, inspection during construction for compliance with approved construction plans, and also for compliance with erosion control, landscaping and tree protection requirements. Austin provides a Customer Assistance Center for Land Development and Permitting requirements. Austin also provides for enforcement for non-compliance with requirements during construction.

The City of Orlando is the only location benchmarked that has a consolidated development review function. Site development review and building plan review are consolidated. They have two teams of six staff, with each team consisting of a civil or site engineer, a transportation engineer, an building plans examiner, a fire protection expert, and two staff focused on land development and zoning. In addition, staff functions such as mechanical, electrical and plumbing review are shared between teams. The teams are able to turn-around a permit for a single family home in a maximum of two days. The turnaround for commercial development is four weeks. Inspections are reported to be adequate when fully staffed. The City of Orlando staff schedule predevelopment meetings to facilitate interaction with the developer. There is an appeals process, and a final decision is made by the senior staff appropriate for that specialty (i.e. the city engineer makes the final decision if the issue is related to engineering).

Information Technology

Based on information provided by benchmarking of GIS and database programs, Austin is behind other similar cities in its level of service for advanced information technology. King County, Portland and Orlando all have a higher budget and staff commitment to GIS and database programs than that of Austin.

Public Education

There are a variety of flood and water quality public education activities conducted in other jurisdictions. Orlando, King County, Ft. Collins and Portland have all committed resources and staff to both flood and water quality education. These jurisdictions all indicated that public education is a vital component of operations, and although no effectiveness studies have been done, there is a sense that relatively low funding for public education brings a high return.

Flood Early Warning Systems

The FEWS system in place in Austin is typical of the technology in use in similar situations throughout the country.

10.5.4 New Program Elements for Small Scale Capital Solutions

A number of new program elements were identified to address implementation of small scale capital solutions. Table 10 – 6 shows the proposed new program elements and the capital solutions to be addressed by each program. Section 9.3 Inventory of Capital Solutions, subsection on Water Quality Capital solutions, as well as Section 9.4 Operating Programs also contain information about these potential solutions.

After determining the service levels provided by current WPD programs, program enhancements as well as proposed new program elements were recommended to improve service levels (Loomis & Moore, Aug 1999) These enhancements included improvements to existing programs and the provision of additional services not currently provided by WPD. Generally recommendations were derived from comparisons of current level of service versus identified essential, and optimal levels of service, and the identification of service gaps for existing programs.

Table 10 – 6

New Potential Programs For Capital Project Technologies

Program Name	Capital Project Solutions Included
Trash and Debris Control Team	Inlet Filters Trash and Debris Booms Retrofit of Existing Ponds for Trash Removal
WQ Structural Retrofit for Baseflow Enhancement	Impervious Cover Removal or Disconnection Bioretention Porous Pavement Rainwater Harvesting Grassed Swales/Vegetative Filter Strips
WQ Structural Retrofit for Toxics & Spills Control	Hazardous Materials Traps Sedimentation/Sand Filtration Oil/Grit Separators & Water Quality Inlets Multi-Chambered Treatment Trains Inlet Adsorbents
Land & Conservation Easement Acquisition	Land Acquisition Conservation Easements Riparian Buffer Zones
"Grow Green" Program for Water Quality Education	Urban Forestry
Rural Watershed Restoration	Native Grassland Establishment Control of Livestock in Riparian Areas Use of Specialized Grazing Systems

Source: Loomis & Moore, 1999

Since the onset of the master planning effort, several existing WPD programs have already expanded their original objectives to include some of the proposed new program elements. For example, the proposed "grow-green" landscape education program has already been adopted by the Water Quality Public Education Program since the onset of this Master Plan. Table 10 – 7 includes those new program recommended for implementation.

Table 10 – 7

Watershed Protection Master Plan
Proposed New Programs

Program Name	Program Description
Conservation Easement and Land Acquisition	Proposed new program to identify, and facilitate acquisition of, and maintain strategic land properties in the Master Plan watersheds. Application of this program for riparian buffer acquisition could be coordinated with flood and erosion hazard property acquisition, which would deal with similarly located properties.
Dry Weather Field Screening	New program required by federal permit. Dry weather field screening and inspection of storm drain outlets must be performed to locate and eliminate illicit non-storm discharges. By monitoring during dry weather, illegal and problematic discharges can be detected, traced and disconnected to prevent pollution of creeks. Work to be performed by existing City staff.

Table 10 – 7 continued

**Watershed Protection Master Plan
Proposed New Programs**

Program Name	Program Description
Flood and Erosion Hazard Property Acquisition	Proposed new program would coordinate the acquisition of properties at risk of flooding and/or erosion on a voluntary basis. Pursue federal matching grants (Flood Mitigation Assistance Program, Hazard Mitigation Grant Program). Manage acquisition programs, projects and conversion of properties to greenbelt areas.
Rural Watershed Restoration	Proposed new program staff to encourage and provide assistance to local landowners willing to restore degraded rangeland areas. Generally applicable in the undeveloped ranchlands on the periphery of urbanized Austin. Best employed in conjunction with conservation easements, land acquisition, endangered species protection regulations, and other measures to promote water quality protection and baseflow enhancement.
Small Scale Retrofits for Water Quality and Baseflow Enhancement	Intercept and retain pollutants from non-point sources which promote enhancement of stormwater infiltration and baseflow. Widespread implementation of smaller-scale BMPs (usually retrofits) in areas where larger CIP projects are infeasible
Trash and Debris Control Team	Target cleanup of trash dumped in City waterways which often results in citizen complaints and aesthetic problems in creeks and lakes.

Source: City of Austin, 2000

The Level of Service information was reviewed to evaluate which of the identified levels of service (essential, optimum) would best help meet gaps in estimated goal attainment for the WPD missions. Table 10 – 8 provides a summary of proposed program enhancements.

Table 10 – 8

Proposed Program Enhancements

Program Name	Program Enhancement
Bridge and Culvert Clearing	Assess the level of clogging of structures with assistance from erosion and flood modeling, maintain an updated list of problem areas.
Channel Vegetation Control	Program expansion required to meet demand and customer requests. Erosion concerns need to be taken into consideration when maintenance is planned, seasonal scheduling is needed to avoid contributing to nutrient loading in algae season, public education target to shape public expectations of channel maintenance. (Increased contractual costs).
Contaminated Site Cleanup	Need a procedure to assign cleanup costs to identifiable responsible parties.
Detention and Water Quality Pond Maintenance and Rehabilitation	Additional staff (1 Pond Crew) to help with completion of short term, priority pond remediations in a timely manner, and provide for annual inspection and maintenance of City-maintained ponds once the short tepm work is completed. Currently 150 out of 450 ponds are maintained on a regular basis. Additional enhancements include establishing a regular maintenance schedule, tracking new ponds accepted by the City, and developing criteria/plan for wet pond maintenance.

Table 10 – 8 continued
Proposed Program Enhancements

Program Name	Program Enhancement
Emergency Spills and Complaints	Additional staff to address increased workload. Continue development of Interlocal agreements to improve communication and address jurisdictional and regulatory issues. Upgrade and improve design of database. Obtain adequate support of database. Achieve better coordination and training of other City Departments.
Environmental Impact Assessments	Require Citywide Capital projects to make environmental assessment reviews early in the design process. Expand hydrogeological review to support growing WPAP review needs, cave management plan review/coordination, and karst feature protection and mitigation reviews. Expand hydrogeological and biological review capabilities to account for additional Capital projects environmental assessments for review.
Erosion Control Crew	Additional staff (1 Crew) to help reduce the significant backlog of necessary erosion repairs within a reasonable timeframe.
Erosion Project Planning, Implementation and Field Engineering	Additional staff to plan, design and manage construction projects performed by new Erosion Control Crew and Utility contact for Capital projects.
Flood Early Warning System	Enhance emergency preparedness planning, decision support and response tools. Coordinate activities and support Project Impact (federal program to build disaster resistant communities). Integrate improved H&H modeling and flood plain mapping into FEWS. Enhance data sharing and coordinate flood warning activities with the National Weather Service and other agencies.
Flood Hazard Public Information	Current service levels are minimal to non-existent. Enhance planning and implementation of direct public education about 1) flood hazards 2) flood plain mapping 3) flood plain development regulations & procedures 4) National Flood Insurance Program. Coordinate with and support Project Impact.
Flood Plain Office	Additional staff to meet required actions involved with: (1) participation in federal Cooperating Technical Communities initiative to create Digital Flood Insurance Rate Maps based on digital GIS mapping and updated models (2) public notification of changes in flood plain status (flood insurance requirements); (3) review of development in the flood plain; (4) maintain community standing in the National Flood Insurance Program and Community Rating System.
Flood Project Planning, Implementation and Field Engineering	The additional staff to meet essential performance levels. Very old complaints and problems have not been addressed, necessary services need to be completed within a reasonable amount of time, and an inventory of existing storm drain locations is needed. Additional enhancements include the development of flood control designs that meet objectives of erosion and water quality missions as well as flood and incorporate buyouts through participation in FEMA Flood Mitigation Assistance Program. Enhance field engineering to include Utility Location Services as required by State Law.

Table 10 – 8 continued
Proposed Program Enhancements

Program Name	Program Enhancement
GIS and Database Management	Additional staff for the drainage infrastructure GIS database management program and facility inventory for support of maintenance activities. 2 FTE's will assist with the design and maintenance of database systems used by personnel throughout the WPD. 1 additional FTE would provide GIS support for the maintenance activities of the department. Other enhancements include location and condition inventory of the existing drainage infrastructure and coordination of GIS and required database needs, with guidelines being established to ensure proper linkage with GIS.
Land Use and Structural Controls Water Quality Monitoring	Coordinate more effectively with users of data. Refocus away from land use monitoring, where data is adequate, to monitoring of alternative water quality controls and micro controls.
Open Waterway Maintenance	Evaluation of channel dredging and sediment removal techniques should be performed. Coordination with erosion and flood staff to evaluate the level of sediment accumulation that warrants removal has already begun.
Pond Operating Permits	Should be expanded to other watersheds in the form of a registration requirement. See Proposed Regulation: Registration of Water Quality Controls
Pond Vegetation Control	Vegetation removal frequencies and methods should be evaluated. Increased frequency in maintenance would be beneficial. (Contractual Increase)
Residential and Commercial Pond Inspections	Additional staff to increase our ability to complete inspections of 429 Residential Ponds 3243 Commercial Ponds and 852 FEMA Creek Crossings.
Review and Inspection of Development	Additional staff to upgrade inspection and enforcement capabilities, improve customer assistance services, and provide assistance for the ERID manager with consultation on legal issues.
Storm Drain System Cleaning	ID and target areas with high tree litter for regular maintenance.
Storm Drain System Repair and Rehabilitation	Additional staff to provide an acceptable level of service. Currently, approximately one-tenth of needed repairs are performed each year. Repairs and replacement to the storm drain system are needed to prevent nuisance flooding problems and problems related to street flooding. Method to track storm drain condition and age to allow for systematic replacement is needed.
Storm Sewer Discharge Permits	Additional staff to address increased workload. Continue development of interlocal agreements to improve communication and address jurisdictional and regulatory issues. Improve coordination of efforts with the Development Review and Inspection Department, and with WPD's ERID staff of environmental reviewers concerning specific new and redevelopment projects. Upgrade and improve design of database (in progress). Research/test pollutant levels of typical discharges and applying discharge limits.
Town Lake Cleanup	Enhance public education with anti littering campaign
Underground Storage Tanks	Stagger permit renewals, enhance coordination with SSDP program, upgrade database (currently underway) and integrate UST permit with site permitting process

Table 10-8 continued
Proposed Program Enhancements

Program Name	Program Enhancement
Water Quality Assessments	Integrate water quality monitoring database with GIS. (Underway with ERM Site Table project), design and implement more effective monitoring of onsite wastewater treatment/disposal system impacts in cooperation with W&WW department ongoing studies, evaluate impact of leaking sewers on surface and groundwater quality, Expand hydrogeological assessments to better determine impacts of development policies on Edwards Aquifer and complete NPDES karst mapping requirement. Evaluate accumulated aquatic biological data with refined watershed characteristics and development history data. Support W&WW and PARD in managing hydrilla in Lake Austin to protect water quality downstream.
Water Quality Control Planning and Implementation	Additional staff are needed to implement expanded WQ retrofit program.
Water Quality Public Education	Additional staff to alleviate (1) a lack of production capabilities for graphic design, printing, and representation at environmental fairs (2) the lack of data regarding the effectiveness of the public education initiative. The addition of staff would ease production shortfalls and also allow the program to survey water quality knowledge before and after education initiatives. Survey results would allow targeting of the most effective education approaches and the best locations for education implementation.
Watershed Hydrologic and Hydraulic Modeling and Flood Plain Mapping	Additional staff is needed to effectively carry out program responsibilities including: (1) implementation of a systematic model maintenance and upgrade procedure; (2) updating of the existing watershed models; and (3) development of an efficient digital model storage and retrieval system; Inadequate floodplain mapping and intense growth of development increases possibility of new buildings in flood hazard areas. $150,000 Contractuals
Watershed Management and Facilities Planning	Additional staff is required to carry out the program responsibilities which include: (1) perform engineering assessments and preliminary engineering; (2) provide project planning and design; (3) provide sponsorship during construction for large scale flood control projects. Funds are needed to purchase land when available for flood control. Fee formula for RSMP is being reevaluated. *Upgrade modeling software to link data with GIS.*
Watershed Master Planning	Phase 2 funding necessary for watershed assessment and solution development (contractuals).

Source: City of Austin, 2000

10.6 Identifying Preferred Regulations

Based on the watershed problems identified in the Master Plan, an analysis of potential regulatory initiatives was performed to determine if: 1) enhancements to existing regulations would address identified watershed problems and help achieve WPD goals, and if 2) new regulations were needed to address identified watershed problems and achieve WPD goals.

To facilitate review, regulations were initially grouped by characteristics of those watersheds where the regulations would be most effective. Watersheds were categorized in terms of their general characteristics, similar to the evaluation done on capital projects described in Section 9.3.2 Targeting Solutions based on watershed types. Watersheds were grouped into the three categories identified in this section, Urbanized/Developed, Developing and Rural. This grouping helped identify areas where regulations could be expected to have an impact on the ability to meet the WPD goals, as well as identify areas that might benefit from new or modified regulations (Loomis & Moore, Aug 1999). Regulations were then screened using the following factors.

- Estimated Benefits based on problems identified for each mission – Very limited modeling was done on specific regulations. Impervious cover was analyzed to determine the effect of reduced impervious cover limits on individual watersheds. Flow volume limits and erosion design storm runoff detention were modeled in terms of "equivalent" impervious cover would result if these regulations were implemented. Other regulations that were not modeled were evaluated based on the general benefits that could be expected. (Loomis & Moore, Jun 1999). Additional regulations regarding peak flow limits were determined to not be needed based on a comparison of benefits from the existing regulation with expected benefits from a modified regulation. Some regulations were deferred for additional study to quantify the expected benefits. Natural Channel Conveyance is an example of such a regulation. It is intended to protect the natural channel drainage network by requiring that creeks be kept in their natural condition. This could potentially have the greatest impact to small stream systems that are not regulated as classified waterways. Further study is needed to understand the benefit of this option on future reach stability, and to also understand the potential impact on future development rights.

- Applicability- this relates to the area within a specific watershed that the regulation would apply to, such as onsite sewage facility regulations or effluent irrigation standards, which are limited in applicability to those watersheds that are somewhat rural in nature and do not have centralized wastewater service.

- Jurisdiction - this constraint identifies areas outside Austin's jurisdictional authority where the regulation would have no impact.

- Availability of data – Regulations were reviewed relative to the ability of the data to support the need, also weighing in the expected benefits to address watershed problems. Initial modeling done on measurable solutions such as impervious cover limits, capture volumes, and treatment standards did not attempt to include the potential synergistic effect of using more than one solution. Full evaluation of many of the initial regulatory options, such as further reductions of impervious cover limits, was deferred due to the lack of available data or resources to facilitate a reasonable analysis during this phase of the Master Plan.

- Requirements to implement and enforce – evaluation also included an analysis of whether the regulations could be reasonably implemented and enforced, relative to the benefits expected from the regulation. Flow volume limits, for example, would require that developments retain the site runoff to maintain pre-developed hydrologic conditions. It was determined that this regulation would be virtually impossible to meet due to the large amount of land required to retain the volume of runoff required. Modification of regulations affecting On-site sewage facility requirements was deferred to the Health Department for implementation. Some regulations were deferred for additional study, such as modification of fertilizer and pest management standards to apply to all development. This requirement would be difficult to enforce, and would rely on property management oversight once development is complete. The decision was made to first target residential areas for voluntary compliance prior to attempting to implement this option.

From this final screening, recommendations for regulatory modification were developed. After the screening process described above, the remaining regulatory solutions were grouped into the following benefit categories:

- **Incentives** – modifications to the City's current regulations that provide incentives to improve watershed protection through the use of alternative methods to achieve compliance. This group of proposed regulations includes:
    - **Landscape/Low Impact Development** – this proposed modifications would allow the landscape area required as part of the site plan to also

be used to locate low-impact development techniques such as micro-pooling in landscape islands and utilizing vegetated areas for methods of water quality treatment. Water Quality credit could be offered for such low-impact design alternatives.

- **Erosion Control/Site Management** – updates to the Environmental Criteria Manual would be made to incorporate improvements in materials and design standards to coordinate with the COA Standards Manual. Incentives such as reduction or early release of fiscal could be offered for those using improved site management techniques such as storing and reusing native topsoil, minimizing time between grading and revegetation, use of native or xeriscape plant material and seed mixes, and wash racks to control mud tracking.
- **Development Mitigation Policy** – Mitigation policies can benefit both the City and the landowners when transfer of development rights are allowed between different properties through mitigation that includes concepts such as: 1) the transfers result in less impervious cover than otherwise allowed, 2) transfers move development from more environmentally sensitive land to less sensitive land, 3) transfers move development to areas that can be served using existing public infrastructure, and 4) transfers are structured to preserve open space and natural areas within each watershed.

- **Public Service** – providing flexible and consistent criteria and tools for developers and other members of the public. This group of proposed regulations includes:
  - **Water Quality Design Criteria** – This would revise and expand the Environmental Criteria Manual to include standard design criteria and assessment methods for alternative water quality controls based on average annual pollutant load reductions.
  - **Erosion Control/NPDES Permit Provisions** – This would update the City of Austin erosion control criteria to include or reference Federal

NPDES construction permit requirements creating a consistent set to criteria for developers to follow.

- **Uniform Relocation Assistance** – This addresses relocation assistance in instances where residential or commercial property threatened by flooding or creek erosion is acquired by the City on a voluntary basis.

- **Infrastructure Management** – implementing changes to fees and criteria to improve the integrity of drainage infrastructure and reduce long-term maintenance demands. This group of proposed regulations includes:
    - **Revised RSMP and Urban WQ Control Fees** – Fees amounts have not been evaluated since the program origin in the 1980's for RSMP and 1990 for the WQ fee. Fees are currently being reviewed to determine if they adequately address increases in land and construction cost while still remaining low enough to encourage participation. This modification will also establish participation criteria for the WQ fee.
    - **Drainage System and Waterway Maintenance Criteria** – this proposed regulation could allow the maintenance of drainage easements in the original permitted design configuration and would help define conditions warranting vegetation removal in order to adequately convey stormwater flows. It would also set standards for maintenance performed within waterways, including soil stabilization and replanting.
    - **Drainage Study, Floodplain and Easement Delineation Standards-** The would require a drainage study , and would require drainage easements to be designed using an assumption of infrequent maintenance.
    - **Water Quality Control Registration** – Current requirements exist for operating and maintenance permits for the Barton Springs Zone. This would expand registration of Water Quality controls City wide as a prerequisite for getting reductions in the drainage fee to help track

location and ownership of controls. It would include actively publicizing the fee reduction/registration program.

- **Problem Prevention** – changes in regulations to avoid the creation of new problems in the future. This group of proposed regulations includes:
    - **Stream Setbacks** – Erosion control based stream setbacks would be established to provide property protection from the threat of erosion. This requirement would also maintain vegetation in the critical water quality zone using native plants without managed turf grass, pesticides, or unapproved fertilizers.
    - **Design Storm Runoff Detention for Stream Bank Erosion** – This would require developments to capture and detain the runoff volume greater than that released from the undeveloped site for those small and relatively frequent storms that control the channel size and shape. The smaller storms should be detained for an optimum detention period to prevent erosion damage to property and the stream system.
    - **Effluent Irrigation Standards** – This would require additional soil depth for effluent irrigation, and would specify maximum nitrogen loading, require a water balance analysis to determine wet weather storage, require setbacks from watercourses and Critical Environmental Features, and require monitoring for effluent constituents.
    - **Golf Course Management Plan** – this would require a management plan for all golf courses to include components for water balance, fertilizer loadings and monitoring, and would limit activities in the critical water quality zone.
    - **Drainage Design Criteria** – This would revise the Drainage Criteria Manual to ensure that new or altered channels are properly designed to minimize future erosion. Potential modification would include adding

permissible shear stress criteria for both the bottom and side slopes for the 1-, 2-, 10-, 25- & 100-year storm events.

- **Tree Protection Standards** – This would expand tree protection requirements to allow for specific circumference regulations for different tree species, require a percent of site be left in a natural area, protect significant groves of trees, evaluate establishing a minimum percent canopy cover for the site, and establish a mitigation fee system for tree replacement.

Table 10 – 9 summarizes the proposed regulatory changes for each of the categories listed above.

Table 10 – 9
Proposed Regulatory Modifications

Incentives	
Landscape-Low Impact Development	Allow for landscape credit to be given to developers who choose to use low-impact development techniques located within landscaped areas to receive runoff from their site. Water Quality credit could be offered for such low-impact design alternatives. See alternative WQ Design criteria under customer service/assistance below.
Erosion Control - Site Management	Update the Environmental Criteria Manual to incorporate improvements in materials and design standards to coordinate with the COA Standards Manual. Incentives such as reduction or early release of fiscal could be offered for those using improved site management techniques such as storing and reusing native topsoil, minimizing time between grading and revegetation, use of native or xeriscape plant material and seed mixes, and wash racks to control mud tracking.
Development Mitigation Policy	Mitigation Policies can benefit both the City and landowners when transfer of development rights are allowed between different properties through mitigation that includes concepts such as: 1) the transfer result in less impervious cover than otherwise allowed, 2) transfers move development from more environmentally sensitive land to less sensitive land, 3) transfers move development to areas that can be served using existing public infrastructure, and 4) transfers are structured to preserve open space and natural areas within each watershed.
Public Service/Assistance	
WQ Design Criteria	Revise and expand the Environmental Criteria Manual to include standard design criteria and assessment methods for alternative water quality controls based on average annual pollutant load reductions.
Erosion Control - NPDES Permit Provisions	Update City of Austin erosion control criteria to include or reference Federal NPDES construction permit requirements creating a consistent set of criteria for local developers to follow.

Table 10 – 9 continued
Proposed Regulatory Modifications

Uniform Relocation Assistance	Address relocation assistance in instances where residential or commercial property threatened by flooding or creek erosion is acquired by the City on a voluntary basis.
Infrastructure Management	
Revise RSMP and Urban WQ Control Fees	Fee amounts have not been evaluated since program origin in 1980's for RSMP and 1990 for WQ fee. Fees are currently being reviewed to determine if they adequately address increases in land and construction cost while still remaining low enough to encourage participation. Establish participation criteria for WQ fee-in-lieu-of.
Drainage System and Waterway Maintenance Criteria	Regulation to allow the maintenance of drainage easements in the original permitted design configuration and to define conditions warranting vegetation removal in order to adequately convey storm water flows. Set standards for maintenance performed within waterways, including soil stabilization and replanting.
Drainage Study, Floodplain and Easement Delineation Standards	Require drainage easements to be designed using an assumption of infrequent maintenance.
WQ Control Registration	Current requirements exist for operating and maintenance permits for the Barton Springs Zone. Expand registration of WQ controls City wide as a prerequisite for getting reductions in drainage fee to help track location and ownership of controls. Actively publicize fee reduction/registration program.
Problem Prevention	
Stream Setbacks	Establish erosion control based stream setbacks to provide property protection from the threat of erosion. Maintain vegetation in the critical water quality zone using native plants without managed turf grass, pesticides or unapproved fertilizers.
Design Storm Runoff Detention for Stream Bank Erosion	Require developments to capture and detain the runoff volume greater than that released from the undeveloped site for those small and relatively frequent storms that control the channel size and shape. The smaller storms should be detained for an optimum detention period to prevent erosion damage to property and the stream system.
Effluent Irrigation Standards	Require additional soil depth for effluent irrigation, to specify maximum nitrogen loading, to require additional wet weather storage, to require setbacks from watercourses and Critical Environmental Features, and to require monitoring for effluent constituents.
Golf Course Management Plan	Require a management plan for all golf courses to include components for water balance, fertilizer loadings and monitoring, and would limit activities in the critical water quality zone.
Drainage Design Criteria	Revise the Drainage Criteria Manual to ensure that new or altered channels are properly designed to minimize future erosion. Potential modification would include adding permissible shear stress criteria for both the bottom and side-slopes for the 1-, 2-, 10-, 25- & 100-year storm events.
Tree Protection Standards	Expand tree protection requirements to allow for specific circumference regulations for different tree species, to require a percent of site be left in a natural area, to protect significant groves of trees, to evaluate establishing a minimum percent canopy cover for a site, and to establish a mitigation fee system for tree replacement.

Costs for Regulations

Costs to the City for implementing regulations were assumed to be borne by the respective Guidance-Support or Assets Maintenance programs that administer them. WPD currently has staff in place to implement existing regulations. Modifications to or creation of new regulations were assumed to utilize existing staff. If further analysis reveals the need for additional staff to enforce new or modified regulations, these costs will be calculated and added to the cost of the respective programs.

Some regulations presented may have an added cost for developing land; these costs associated with the regulations will be felt by the regulated community, primarily land developers, businesses, and land owners. For example, if design storm runoff detention requirements are revised, this could require additional land area for the erosion detention controls, and could impact the number of saleable lots per unit of land, resulting in lower profit margins. During the development of Master Plan recommendations, the City attempted to develop incentive based controls, and to provide alternatives to conventional compliance as a potential means to be innovative and potentially reduce some development costs. The potential impact to the regulated community will have to be weighed by policymakers when considering regulatory adjustments (Loomis Austin, Inc., 2000).

Section 11

Recommendations

11.1 Estimating Goal Attainment

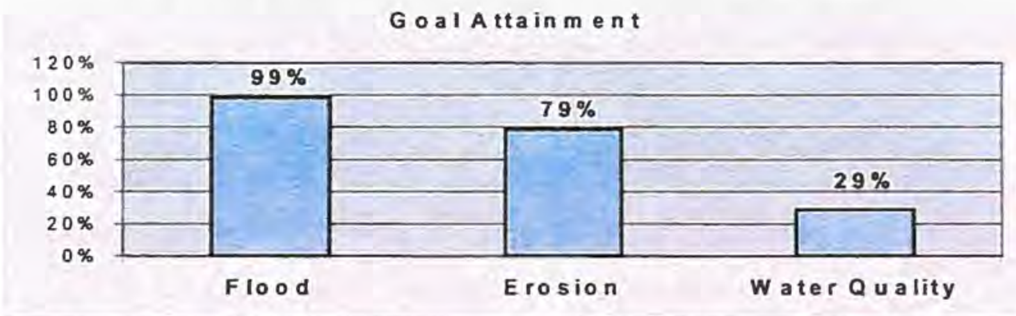
In order to gauge the cumulative benefits of proposed capital, regulatory and programmatic solutions, preliminary estimates of goal attainment for flood, erosion and water quality were developed. Methods of calculating benefits were discussed in Section 10. These estimates are considered preliminary in nature due to the conceptual nature of the capital solutions, and the inherent difficulty in estimating a numeric benefit for many of the programmatic and regulatory solutions. Goal attainment was also evaluated to help identify areas where additional solutions need to be developed to attain the goals established in the Master Plan process, which are discussed in Section 2.

Goal attainment was defined according to the flood, erosion and water quality objectives listed in Table 2 – 1 in Section 2. For each proposed capital project concept, a benefits estimate was calculated based on the specific characteristics of each project such as potential pond detention volumes, number of homes in the 100-year floodplain, contributing drainage area, etc. The benefits of certain programs and regulations were also included where estimating benefits was deemed reasonable based in part on the availability of data quantifying their effectiveness.

Goal attainment was calculated based on a best-case scenario which assumed that the most effective solution was feasible at each project site identified. The results are generalized for each mission, and are shown in Figure 11 – 1.

The majority of flood problems are addressed by the best-case scenario (99% goal attainment) since project concepts were estimated to fully alleviate 100-year flooding at most problem sites. A majority of the Type 1 and 2 erosion problems are addressed in the scenario depicted in Figure 11 – 1 (79% goal attainment). Some Type 3 and Future Reach Stability issues will require additional solutions, both capital and programmatic, to be developed.

Figure 11 – 1 Generalized Goal Attainment Results



Source: Loomis-Moore, 1999b

Of most concern for goal attainment is the low predicted attainment for water quality protection (29%). This low level of attainment is due to multiple factors. One primary factor is limited amount of undeveloped land available in the urban watersheds that is suitable for locating an effective regional water quality retrofit. There are typically too few adequate sites left in the urban watersheds to have many effective traditional regional water quality retrofits such as the Convention Center or the Central Market Wet Pond.

A second factor that limits goal attainment for water quality is the lack of water quality regulation or mitigation for the impact of new development in areas outside the City of Austin's jurisdiction. Specifically, for the Phase I watersheds 56% of the Barton Creek watershed is located outside of Austin's jurisdiction. The reach of Barton Creek located outside of the City of Austin has the highest score for overall water quality degradation due to the predicted impacts of unregulated future development.

The goal attainment values presented in Figure 11 – 1 represent a best case scenario that all of the identified project concepts are feasible for implementation. The potential that a site initially identified for a capital solution might instead be developed before the City of Austin has available funds to acquire it, was not included in the goal attainment evaluation. Other site constraints could also arise that might affect project viability, or the final benefit level achieved by the project. These factors make evaluation of actual goal attainment difficult, and reaffirm the conceptual nature of determining cumulative benefits.

Additional solutions were developed to increase potential goal attainment beyond the levels shown in Figure 11 – 1. Fifty additional sideslope projects were identified to provide solutions for all existing erosion (Type 1 and 2) problems. Alternative water quality strategies were also developed. Revised erosion and water quality estimates for goal attainment were developed to account for these additional solutions. However, the revised estimates for water quality are still low, ranging from 25-50%. (COA,2000)

Additional work is needed to identify alternative water quality opportunities, such as low impact designs focusing on retrofitting existing sites through elements including rainwater harvesting, micro pooling, enhanced landscape and natural areas design and management. These alternative controls primarily use multiple best-management practices (BMP's) throughout a developed watershed and rely on the cumulative small-scale benefits from numerous areas to have a positive impact on the overall water quality of a watershed.

For each mission, achieving the identified watershed protection goals discussed in Section 2 is dependent on the final feasibility of the project concepts identified, as well as the availability of funding to support their implementation.

11.2 Implementation Planning

Successful implementation of proposed watershed solutions relies heavily on public input and support. A public hearing sponsored by the Environmental Board and the Citizens Advisory Group was held in February 2001 to present the Master Plan findings and recommendations, and to obtain public input. All City of Austin Boards and Commissions were provided information summarizing the WPD Master Plan findings and recommendations. Boards and Commissions that oversee aspects of City government where opportunities for partnership on projects, such as the Water and Wastewater Commission, the Parks Board, and the Planning Commission were given a presentation of WPD Master Plan findings and recommendations. WPD continues to

In the future, capital projects and program enhancements will be implemented as funding is approved through the annual budgeting process, special bond elections, or other funding allocations. Both a short-term and a long-term implementation plan will be developed once such funding decisions are made. Regulatory changes will proceed through the appropriate public input process for development of final language, and then through the public review and adoption process.

11.2.1 Capital Projects

Assuming that funding is available, policy decisions must be made regarding the implementation of capital projects. Different prioritization processes were reviewed during the course of this Master Plan. Several included ranking factors such as cost-benefit, sustainability and neighborhood impacts. Ultimately, a "needs-based" approach was selected (with the support of the Citizens Advisory Group) to prioritize WPD recommendations for future project funding. A needs-based approach simply means that the worst problem areas [where the needs (risks) are greatest] will be considered first for project implementation.

Problem area severity ratings for the flood, erosion, water quality and integrated problem missions form the basis for the priority designation for capital project implementation. Often, the projects that will fix these "worst" problem areas are very expensive. Final implementation decisions will have to consider available resources. Some high priority but costly solutions may have to be delayed if funds are not available. This may result in less expensive lower priority projects being implemented first based on availability of funds. Project implementation is also affected by the source of the funding. Certain sources of revenue, such as RSMP or the urban water quality fund are targeted for specific missions and are limited geographically as to where their revenues can be spent. Still other projects may proceed based on "opportunity" considerations where land donations, grant funding, or cost sharing with other City projects reduces project cost.

A major tenet of this Master plan is to implement sustainable watershed protection strategies that integrate the flood, erosion and water quality missions. Past project experience has shown that "single mission" project planning strategies are more costly than multipurpose, integrated strategies. Integrated multi-mission projects also have greater benefits than do single mission, and can be better planned by including all components of a solution that affect its overall performance and sustainability. Single mission planning and implementation commonly creates unanticipated impacts on other missions. Ideally, multi-purpose integrated projects are designed concurrently to avoid project conflicts and enhance watershed benefits.

Determining the cumulative impact of implementing several multi-objective projects in the same watershed is very complex. Understanding the synergistic impact that projects have on each other is also very complex. These are, however, key elements necessary to proper long term watershed management planning. An understanding of stream dynamics is also necessary to optimize project benefits. Stream dynamics impact the way a creek responds to a given drainage improvement, including controls placed in a creek, channel improvements or construction done within or adjacent to a creek. An understanding of the long-term consequences of a project on a creek system is necessary to design and implement sustainable projects. For these reasons, WPD chose to use a watershed management area (WMA) approach for solution implementation. The WMA approach provides an improved basis for the development of comprehensive, coordinated watershed management plans.

This WMA system is based on the classification of creek segments or reaches into three categories (Table 11 – 1) based on the predictions of how the creek will respond to given drainage improvements (Chan, 1997). These three categories support a stream management approach that provides a watershed-scale perspective on the development of restoration programs. While the WMA concept considers the entire watershed, it allows for integration on a smaller project-scale basis. Watershed Management Areas were designated to encompass given reaches of a creek based on similar reaches. Following a systematic procedure to group similar reaches of the creek allows for better planned and integrated CIP solutions – designing and implementing them concurrently as a comprehensive strategy, rather than individually. This WMA approach will minimize the negative impacts of one project on another and will allow coordination of nearby projects to avoid conflict and minimize cost.

Table 11 – 1
Watershed Management Area Approach

Classification	Management Approach
Type A	Type A restoration involves specific reaches or lengths of the creek where the stabilization work can be implemented in isolation of upstream or downstream creek morphology; in other words, work done in one reach does not impact other reaches.
Type B	Type B restoration programs involve two or more reaches of the creek where work done in one reach affects or impact other reaches of the creek.
Type C	Type C restoration programs involve watershed-wide stabilization schemes because work done in any reach has impacts across the entire watershed.

Source: Raymond Chan & Associates, 1997

The WMA process did not guide storm drain improvement priorities since the majority of localized flooding occurs in areas beyond the boundaries of creek corridors. There will be a greater demand for adequate drainage as in-fill and redevelopment occurs in the urban core. As of spring 2000, WPD identified more than 420 problem areas in the Phase I watersheds needing upgrades as a result of inadequate capacity. Each localized flooding area requires further study to better determine potential integration opportunities and relative problem severity.

The needs-based prioritization system, as defined earlier, was applied to these larger watershed management areas. Five varying levels (or tiers) of problems were identified to prioritize each Watershed Management Area: Very Low, Low, Moderate, High and Very High. Table 11 – 2 shows the WMA designations for each watershed, along with the WMA selection approach based on creek characteristics and the tier ratings. Figures 11 – 2 to 11 – 5 graphically show the resulting prioritization of Watershed Management Areas into the five tiers identified above, based on highest problem severity score for each mission within each Watershed Management Area.

Allotment of funding for CIP projects based on the priority WMA Tier system began in the capital budget planning process in spring of 2001. Due to the limited budget available for transfer to capital projects, only one WMA received funding for FY

2001/2002. Funding was allotted for FOR-1, located from the confluence of Fort Branch with Boggy Creek, upstream to the Manor Road crossing. The allotted funding will allow preliminary engineering and design to proceed for solution concepts identified in that WMA. The funding for FOR-1 will also allow for integration of an existing flood and erosion CIP project currently underway, providing additional water quality benefits not included in the original design.

A multi-disciplinary team will be necessary during the design and construction phase of implementation to bring together an understanding of the impacts a particular solution has on each watershed mission (FC, EC, WQ). An integrated approach during design is essential to the success of future integrated solutions.

Finding a balance to fixing current problems and preventing future problems is essential to meeting the WPD goals. Regulations alone cannot prevent all future problems. As a result of State legislation, many new developments will not be subject to existing regulations, let alone new requirements. Results from the Water Supply Suburban Watershed Report (City of Austin, 1999) have provided a clear indication of the large number of exemptions and "grandfathering" to older regulations that are outstanding within the remaining undeveloped lands within and around Austin. Capital solutions will be a necessary part of addressing future problems. An emphasis on acquiring land now while it is still available must be made. Capital solutions can be planned and built in these locations later, when the land may not be available, or may be too expensive to purchase.

WPD must work actively and partner with other City Departments whose missions also affect the health and safety of our waterways, such as the Water and Wastewater Department, Parks and Recreation Department (PARD), Transportation Planning and Design Department, Public Works Department, and Neighborhood Planning and Zoning Department. Many of these Departments have projects within or adjacent to the waterways that impact the stream corridor and WPD mission goals. Some are involved in long term planning projects that also offer potential for

Table 11 – 2
WMA Description and Tier Ratings

Watershed	Watershed Management Area	Description	WMA Approach	WMA Tier Rating [1]			
				EC	FC	WQ	INT
BAR	1	Main Stem from Station 0 to Station 32120	C	5	5	3	4
BAR	2	Main Stem from Station 32120 to Station 264275	C	5	5	1	3
BLU	1	Main Stem from Station 0 to Station 2680	B	4	4	4	4
BLU	2	Main Stem from Station 2680 to Station 4330	A	4	4	4	4
BLU	3	Main Stem from Station 4330 to Station 12850	A, B	3	4	3	4
BMK	1	Main Stem from Station 0 to Station 8870	A, B	3	4	4	4
BMK	2	Main Stem from Station 8870 to 12265	A, B	5	4	2	3
BOG	1	Main Stem from Station 0 to Station 8140	B	3	3	4	3
BOG	2	Main Stem from Station 8140 to Station 19600	A	5	4	4	4
BOG	3	Main Stem from Station 19600 to Station 36660	A, B	1	2	4	3
BUL	1	Main Stem from Station 0 to Station 21280	A, C	5	1	1	3
BUL	2	Tributary 2 of Bull Creek	B, C	1	4	1	2
BUL	3	Main Stem from Station 21280 to Station 42880 plus Tributary 3	C	1	2	1	1
BUL	4	Main Stem from Station 42880 to Station 59735 plus Tributaries 4, 5, 6, 7, and 8	A, B, C	3	4	1	3
CNT	1	Main Stem from Station 0 to Station 12680 plus Tributaries 2 and 3	B	1	3	5	3
CNT	2	Main Stem from Station 12680 to Station 18860 plus Tributaries 4 and 5	C	1	4	5	4
CNT	3	Old Main Stem including Tributary 1	A, B, C	3	4	1	2
EBO	1	Main Stem from Station 0 to Station 6040	A	2	4	4	3
EBO	2	Main Stem from Station 6040 to Station 10131	A	2	4	4	3
EBO	3	Main Stem from Station 10131 to Station 17957	B	2	4	1	2
FOR	1	Main Stem from Station 0 to Station 19750	A, B	1	1	4	2
FOR	2	Main Stem from Station 19750 to Station 24210	A, B	1	3	4	3
FOR	3	Tributary 1 of Fort Branch	B	4	4	4	4
FOR	4	Main Stem from Station 24210 to Station 29310	A	5	3	3	4

Notes: (1) Tier 1 = Very High Problem Area, Tier 5 = Very Low Problem Area

Table 11 – 2 continued
WMA Description and Tier Ratings

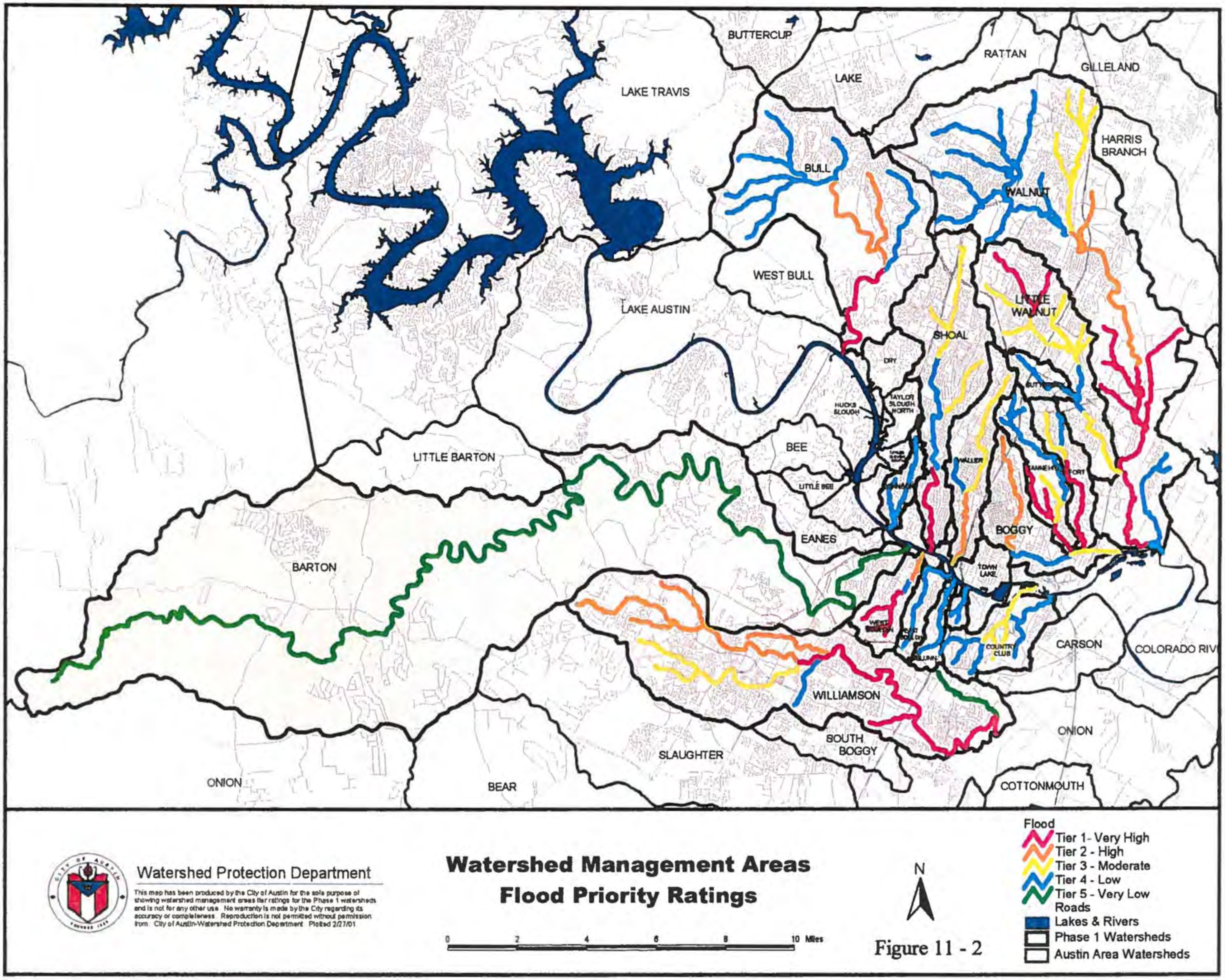
Watershed	Watershed Management Area	Description	WMA Approach	WMA Tier Rating [1]			
				EC	FC	WQ	INT
HRP	1	Main Stem plus Tributary 1	A, B	5	4	3	4
JOH	1	Main Stem from Station 0 to Station 4120	B	4	4	2	3
JOH	2	Possum Trot Tributary	A	5	4	2	4
JOH	3	Main Stem from Station 4120 to Station 12650	A	5	4	2	4
LWA	1	Main Stem from Station 0 to Station 13530	B	4	3	4	4
LWA	2	Main Stem from Station 13530 to Station 15985	A	5	4	4	4
LWA	3	Main Stem from Station 15985 to Station 21580	A	5	4	5	5
LWA	4	Main Stem from Station 21580 to Station 32680	B	4	3	4	4
LWA	5	Tributary 2 (plus it's Tributary 1) plus Tributaries 4 and 5	B	5	3	5	4
LWA	6	Main Stem from Station 32680 to Station 36000 plus Quali Creek Branch and Tributary 6	C	4	3	4	4
LWA	7	Main Stem from Station 36000 to Station 47210 plus Tributary 7	C	1	1	4	2
SHL	1	Main Stem from Station 0 to Station 14670	A,B	3	1	3	2
SHL	2	Main Stem from Station 14670 to Station 25960	A,B	4	4	4	4
SHL	3	Main Stem from Station 25960 to Station 29900	A	5	4	4	4
SHL	4	Main Stem from Station 29900 to Station 35870	A,B	5	4	4	4
SHL	5	Main Stem from Station 35870 to Station 52360 plus Fosters Branch Tributary	A,C	4	3	4	4
SHL	6	Hancock Branch Tributary	A	5	3	4	4
TAN	1	Main Stem from Station 0 to Station 6290 plus Givens Park Tributaries	A, B	5	3	5	4
TAN	2	Main Stem from Station 6290 to Station 10775 plus West Tannehil Branch Tributary	A	5	3	5	4
TAN	3	Main Stem from Station 10775 to Station 23330	B	1	4	4	3
TAN	4	Main Stem from Station 23330 to Station 30675 plus Tributaries 1 and 2	A	2	4	3	3
WBO	1	Main Stem from Station 0 to Station 4700	A	5	2	2	3
WBO	2	Main Stem from Station 4700 to Station 7270	B	1	4	2	2
WBO	3	Main Stem from Station 7270 to Station 8050	A	5	4	2	3
WBO	4	Main Stem from Station 8050 to Station 17516 plus North Fork Tributary and Tributary 1	A, B	5	3	2	3

Notes: (1) Tier 1 = Very High Problem Area, Tier 5 = Very Low Problem Area

Table 11 – 2 continued
WMA Description and Tier Ratings

Watershed	Watershed Management Area	Description	WMA Approach	WMA Tier Rating [1]			
				EC	FC	WQ	INT
WLN	1	Main Stem from Station 0 to Station 4440 plus Tributary 1 and it's tributary	A, C	2	4	3	3
WLN	2	Main Stem from Station 4440 to Station 49700 plus Tributaries 3, 4, and 5 plus its tributary	C	1	1	2	1
WLN	3	Main Stem from Station 49700 to Station 80810 plus Tributary 6	C	1	2	3	2
WLN	4	Wells Branch and its Tributaries 1, 2, and 3	C	1	3	4	3
WLN	5	Main Stem from Station 80810 to Station 120165 plus Tributary 7 (and its tributary); Tributaries 8, 9, and 10; Kramer Branch and Tar Branch	C	1	4	3	3
WLR	1	Main Stem from Station 0 to Station 12300	A, B	4	2	3	3
WLR	2	Main Stem from Station 12300 to Station 25740	A, B	5	3	5	4
WLR	3	Main Stem from Station 25740 to Station 34730	A, B	5	3	4	4
WLR	4	Hemphill Branch Tributary	A, B	4	4	5	4
WMS	1	Main Stem from Station 0 to Station 17900	C	2	1	4	3
WMS	2	Saint Elmo Branch Tributary	C	1	5	4	3
WMS	3	Main Stem from Station 17900 to Station 32160 plus Pleasant Hill Tributary	A, C	4	1	2	3
WMS	4	Main Stem from Station 32160 to Station 55560	C	2	1	2	2
WMS	5	Sunset Valley Tributary	A, C	4	2	2	3
WMS	6	Cherry Creek Tributary	A	4	4	2	3
WMS	7	Kincheon Branch and its tributary, Wheeler Branch	C	5	1	2	3
WMS	8	Main Stem from Station 55560 to Station 98000 plus Motorola Tributary and Scenic Brook	C	4	2	2	3

Notes: (1) Tier 1 = Very High Problem Area, Tier 5 = Very Low Problem Area


BUTTERCUP
RATTAN
GILLELAND
LAKE
LAKE TRAVIS
HARRIS BRANCH
BULL
WALNUT
WEST BULL
LAKE AUSTIN
LITTLE WALNUT
SHOAL
DRY
TAYLOR SLOUGH NORTH
HUCKS SLOUGH
BEE
LITTLE BARTON
WALLER
LITTLE BEE
BOGGY
EANES
BARTON
TOWN LAKE
CARSON
COLORADO RIV
COUNTRY CLUB
WILLIAMSON
ONION
SOUTH BOGGY
SLAUGHTER
ONION
BEAR
COTTONMOUTH
Watershed Protection Department
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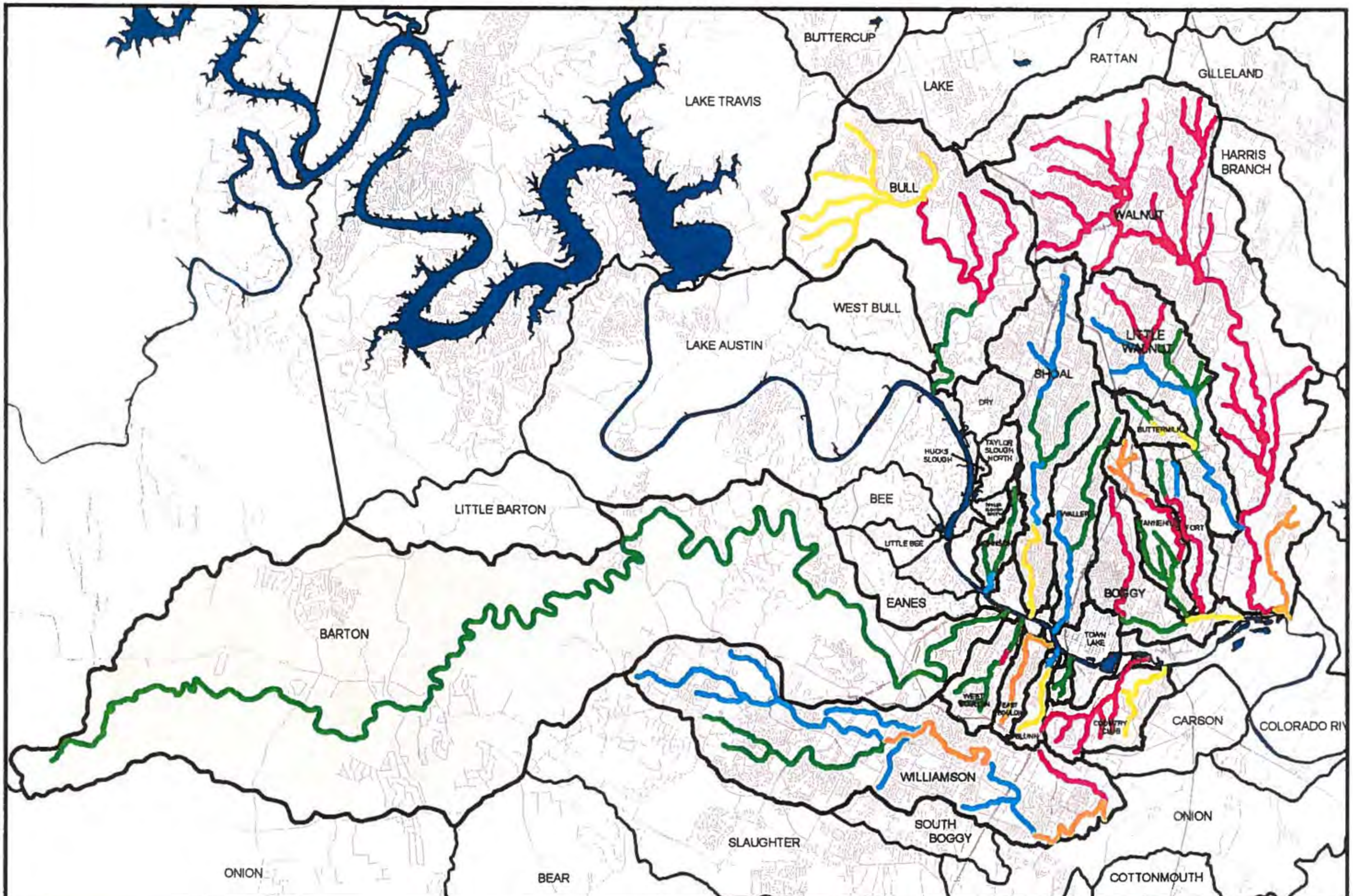
Watershed Management Areas
Flood Priority Ratings
0 2 4 6 8 10 Miles
N
Flood
Tier 1 - Very High
Tier 2 - High
Tier 3 - Moderate
Tier 4 - Low
Tier 5 - Very Low
Roads
Lakes & Rivers
Phase 1 Watersheds
Austin Area Watersheds

Figure 11 - 2



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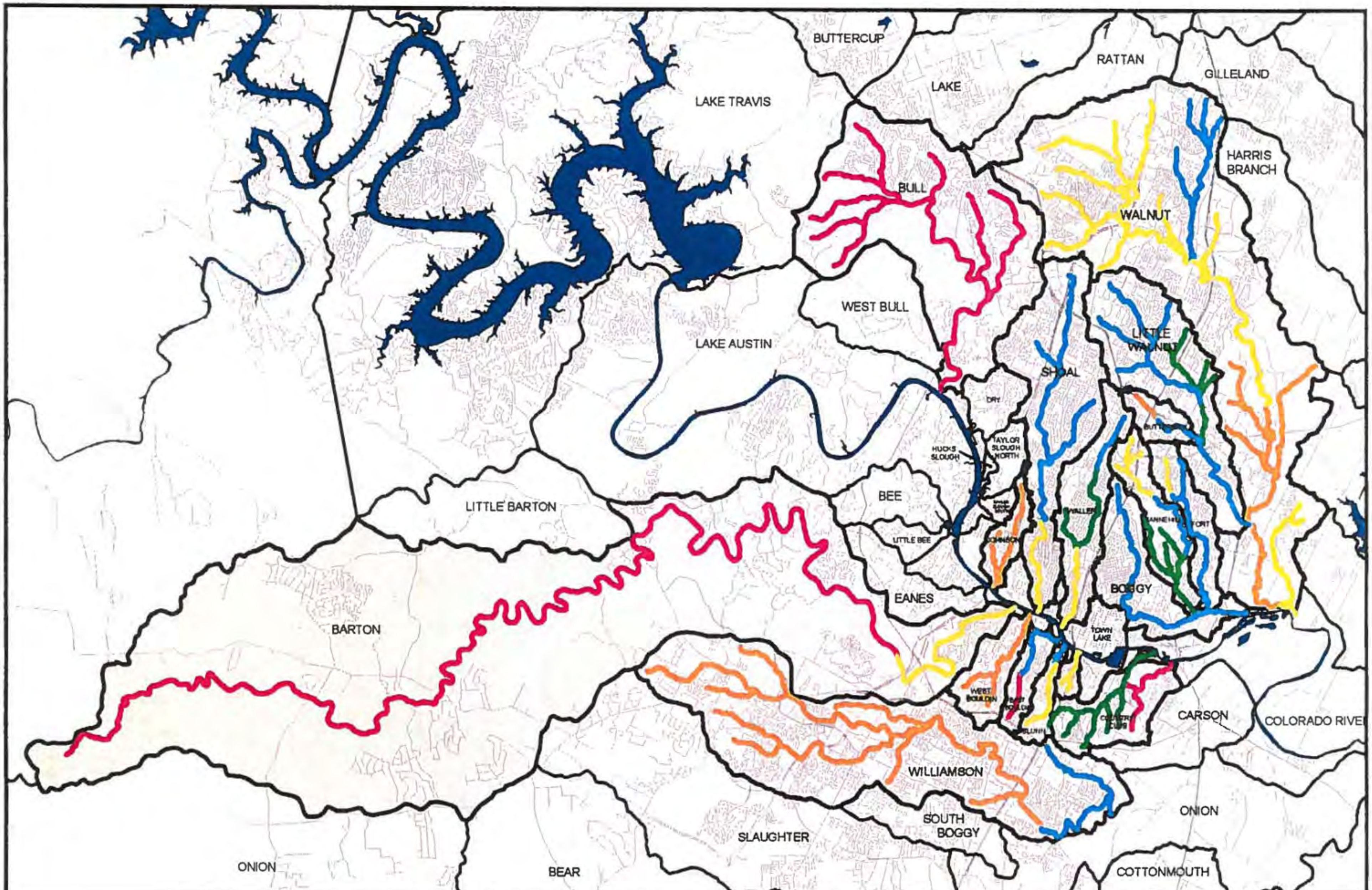
Watershed Management Areas
Erosion Priority Ratings

0 2 4 6 8 10 Miles

N

Erosion
- Tier 1- Very High
- Tier 2 - High
- Tier 3 - Moderate
- Tier 4 - Low
- Tier 5 - Very Low
- Roads
- Lakes & Rivers
- Phase 1 Watersheds
- Austin Area Watersheds

Figure 11 - 3



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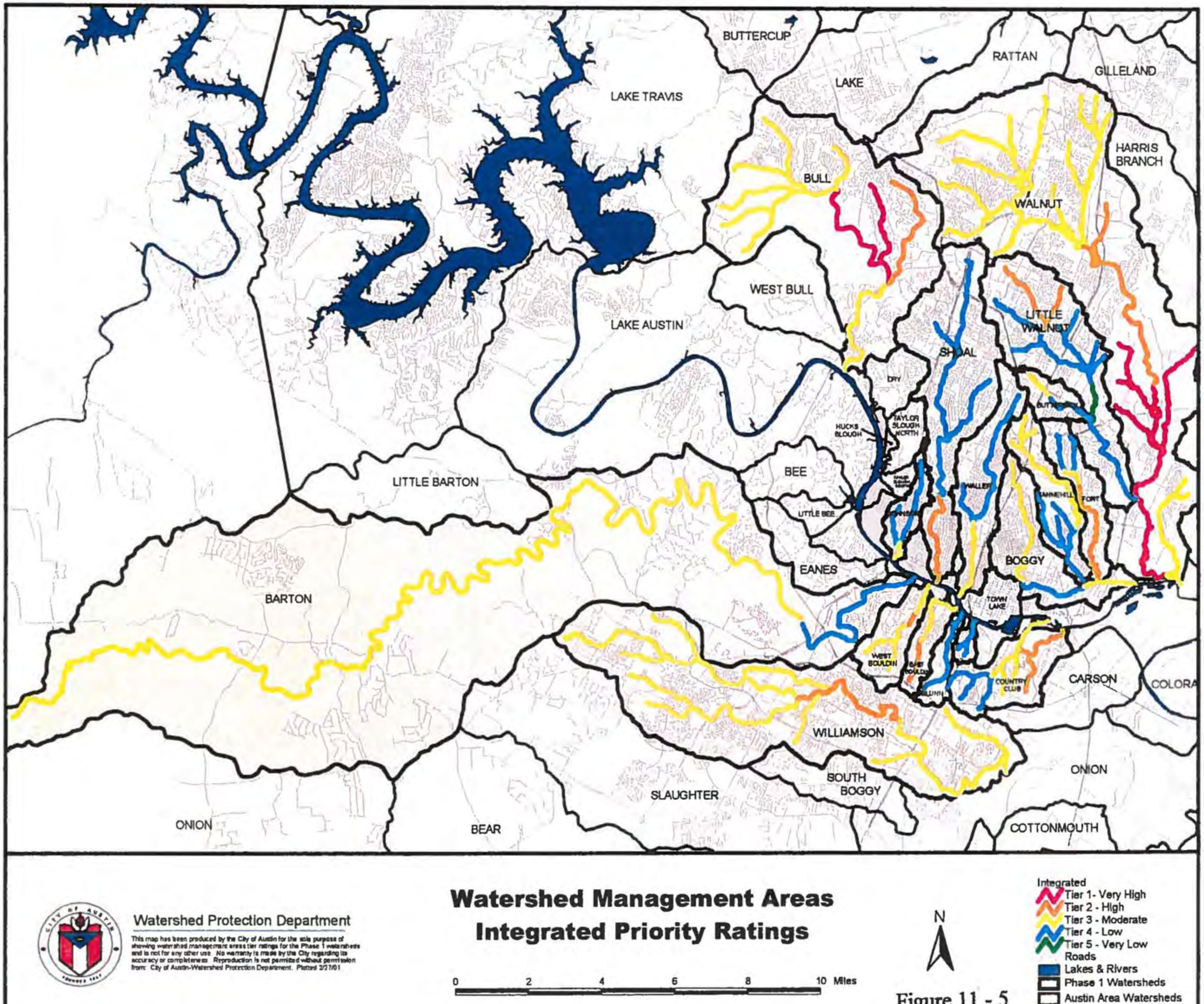
Watershed Management Areas
Water Quality Priority Ratings

0 2 4 6 8 10 Miles

N

Figure 11 - 4

Water Quality
- Tier 1- Very High
- Tier 2 - High
- Tier 3 - Moderate
- Tier 4 - Low
- Tier 5 - Very Low
- Roads
- Lakes & Rivers
- Phase 1 Watersheds
- Austin Area Watersheds



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Watershed Management Areas Integrated Priority Ratings

Figure 11 - 5

integration of missions and co-benefits. When acquiring land, whether for conservation easements or future capital solutions, WPD should pursue joint funding whenever possible for stream corridor restoration and greenbelt establishment.

11.2.2 Operating Programs

As discussed in Section 10, operating program enhancements were defined based on a level of service analysis. This analysis resulted in the identification and initial prioritization of needed WPD program enhancements. While some identified program enhancements do not require funding to implement, most will require additional funding approval through the City's annual budgeting process. WPD will propose budget enhancements incrementally as Council approves proposed increases in the drainage fee. Table 11 – 3 describes recommended budgetary and other program enhancements.

Table 11 – 3
Programs Recommended for Enhancement

Program Name	Program Enhancement
Bridge and Culvert Cleaning	Maintain an updated list of problem areas based on assessment of the level of clogging of structures.
Channel Vegetation Control	Program expansion including increased contractuals, required to meet demand and customer requests.
Contaminated Site Cleanup	Develop a procedure to assign cleanup costs to identified responsible party.
Detention and Water Quality Pond Maintenance and Rehabilitation	Additional staff to help with completion of short term, priority pond remediations in a timely manner, and provide for annual inspection and maintenance of City-maintained ponds once the short term work is completed. Currently 150 out of 450 ponds are maintained on a regular basis.
Emergency Spills and Complaints	Additional staff to address increased workload. Upgrade and improve design of database.
Environmental Impact Assessments	Additional staff to expand hydrogeological review to support growing WPAP review needs, cave management plan review/coordination, and karst feature protection and mitigation reviews.
Erosion Control Crew	Additional staff to help reduce the significant backlog of necessary erosion repairs within a reasonable timeframe.

Table 11 – 3 continued
Programs Recommended for Enhancement

Program Name	Program Enhancement
Erosion Project Planning, Implementation and Field Engineering	Additional staff to plan, design and manage construction projects performed by Erosion Control Crew and to provide Utility contact for CIP projects.
Flood Early Warning System	Additional staff to enhance emergency preparedness planning, decision support and response tools.
Flood Hazard Public Information	Additional staff to improve current customer service levels.
Flood Plain Office	Additional staff to create Digital Flood Insurance Rate Maps, to provide public notification of changes in floodplain status (flood insurance requirements), to review development in the floodplain.
Flood Project Planning, Implementation and Field Engineering	Additional staff to meet essential performance levels. Services need to be completed within a reasonable amount of time, and an inventory of existing storm drain locations is needed.
GIS and Database Management	Additional staff for the design and maintenance of database systems, and to provide GIS support for the maintenance activities of the department.
Land Use and Structural Controls Water Quality Monitoring	Coordinate more effectively with users of data. Refocus efforts to monitoring of alternate water quality controls and micro-controls.
Open Waterway Maintenance	Evaluation of channel dredging and sediment removal techniques. Continue coordination with other staff to evaluate the level of sediment accumulation that warrants removal.
Pond Operating Permits	Improve program to include other watersheds and increase pond tracking through a registration requirement.
Pond Vegetation Control	Contractual increase to provide increased frequency in maintenance. Other enhancements include evaluation of vegetation removal frequencies and methods.
Residential and Commercial Pond Inspections	Additional staff to increase ability to complete inspections of 429 Residential Ponds, 3243 Commercial Ponds, and 852 FEMA Creek Crossings.
Review and Inspection of Development	Additional staff to upgrade inspection and enforcement capabilities, improve customer assistance, and provide assistance with consultation on legal issues.
Storm Drain System Cleaning	Identify and target areas with high tree litter for regular maintenance.
Storm Drain System Repair and Rehabilitation	Additional staff to provide an improved level of service. Currently, approximately one-tenth of needed repairs are performed each year.

Table 11 – 3 continued
Programs Recommended for Enhancement

Program Name	Program Enhancement
Storm Sewer Discharge Permits	Additional staff to address increased workload.
Town Lake Cleanup	Enhance public education with anti-littering campaigns
Underground Storage Tanks	Stagger permit renewal, enhance coordination with SSDP program, upgrade database, and integrate UST permit with site permit process.
Water Quality Assessments	Additional staff to integrate water quality monitoring database with GIS, and to design and implement more effective monitoring of onsite wastewater treatment/disposal system impacts in cooperation with W&WW department ongoing studies, and evaluate impact of leaking sewers on surface and groundwater quality.
Water Quality Control Planning and Implementation	Additional staff to implement expanded WQ retrofit program.
Water Quality Public Education	Additional staff for graphic design, printing, and representation at environmental fairs, and to conduct surveys regarding the effectiveness of the public education initiative.
Watershed Hydrologic and Hydraulic Modeling and Flood Plain Mapping	Additional staff and contractual funding is needed for implementation of a systematic model maintenance and upgrade procedure updating of the existing watershed models; and for development of an efficient digital model storage and retrieval system.
Watershed Management and Facilities Planning	Additional staff to perform engineering assessments and preliminary engineering, provide project planning and design for large-scale projects.
Watershed Master Planning	Phase 2 funding necessary for watershed assessment and solution development.

11.2.3 Regulations

The proposed regulatory changes are merely proposals and planning level recommendations at this time. Each proposal will require drafting of code, regulation, and/or criteria language. These proposals will be drafted as changes to the Land Development Code and the Environmental and Drainage Criteria manuals. City code changes, including changes to the Land Development Code, require review by the appropriate City boards and commissions. These proposed changes would go through the standard public meetings process to obtain input from interested parties. The final step is the City Council hearing where action may be taken.

Proposed rule changes are subject to stakeholder review and a public review period. This includes proposed changes to Criteria manuals. After stakeholder review, the rule is posted for public comment prior to final adoption. Table 11 – 4 identifies the location for proposed rule changes.

Little Walnut Creek

Table 11 – 4
Location for Proposed Regulatory Modification

Regulatory Proposals (1)	**Location in Code/Criteria**
Reassess RSMP fees	Annual Fee Ordinance, Drainage Criteria Manual (DCM)
Reassess Urban Fees	Annual Fee Ordinance, Environmental Criteria Manual
Drainage System and Waterway Maintenance Criteria	Environmental/Drainage Criteria Manuals
Drainage Study, Floodplain and Easement Delineation Standards	Land Development Code (LDC) and Drainage Criteria Manual
Registration for WQ Controls	Land Development Code (LDC) and Drainage Criteria Manual
WQ Design Criteria	Environmental Criteria Manual
Erosion Control/NPDES	Land Development Code (LDC) and Environmental Criteria Manual
Uniform Relocation Assistance	Land Development Code
Landscape-Low Impact Development	Land Development Code (LDC) and Environmental Criteria Manual
Erosion Control-Site Management	Land Development Code (LDC) and Environmental Criteria Manual
Development Mitigation Policy	Land Development Code
Stream Setbacks	Land Development Code
Design Storm Runoff Detention for Stream Bank Erosion	Land Development Code and Environmental/Drainage Criteria Manuals
Effluent Irrigation Standards	Land Development Code
Drainage Design Criteria	Drainage Criteria Manual (DCM)
Golf Course Management Plan	Land Development Code (LDC) and Environmental Criteria Manual
Tree Protection Requirements	Land Development Code (LDC) and Environmental Criteria Manual

(1) See Section 10 for a description of each regulatory proposal

11.3 Findings and Recommendations

Findings were developed based on information gathered in each step of the Master Plan, including goal development, technical assessments, and integrated solution development. Goal development helped establish the direction toward which each mission will proceed. Technical assessments provided valuable information to allow WPD to measure the watershed problems against the watershed goals, and determine where the needs are greatest. Integrated solutions development helped define which solutions were potentially feasible, and provided general cost and benefit information upon which to gauge potential goal attainment. Based on these findings, recommendations were developed to guide WPD on future funding decisions for capital projects and operating programs, and to outline an implementation plan for future regulatory modifications.

11.3.1 Findings

1) In the Phase I watersheds, flood, erosion and water quality problems are widespread and are expected to worsen if corrective action is not taken.

2) Over the next 40 years, more than $800 million in capital funds are required to construct new or improved integrated watershed protection facilities including detention ponds, channel stabilization projects and other flood, erosion and water quality controls. This funding level is equivalent to approximately twice the historical capital spending rate.

3) Additional funding of $2 – 5 million per year is needed to provide essential levels of service for several City programs including infrastructure maintenance, environmental development review and inspection, public education and design support.

4) Various code and criteria changes are required to improve public service, provide developer incentives, reduce long-term maintenance demands, and prevent the creation of new watershed problems in the future.

5) Attainment of erosion and flood goals may be possible given sufficient funding.

6) Water quality goals are not attainable through implementation of solutions evaluated in the Master Plan. Limited regional retrofit opportunities in urban watersheds and inadequate regulatory controls in areas outside the City's jurisdiction are significant constraints.

11.3.2 Recommendations

1) Develop long–range funding proposals to support solution implementation.
2) Integrate watershed solutions to the extent possible to effectively promote watershed protection goals attainment.
3) Implement integrated capital projects using a needs-based, watershed management area approach as funding becomes available.
4) Develop collaborative multi-agency partnerships (that include federal, state, and local entities along with other City Departments, community groups and concerned citizens) to achieve watershed protection goals.
5) Use Master Plan results to assist in the development of proposed WPD budget increases to fund priority program enhancements.
6) Involve stakeholders in the comment and review process for proposed regulatory modifications before Council consideration as final language is developed.
7) Refine watershed protection goals based on continued public involvement and additional studies.
8) Continue development and evaluation of innovative water quality solutions to attain water quality goals. Lower or revise water quality goals to reflect additional evaluation and feasibility of solution implementation.
9) Update Phase I Master Plan information as better data becomes available and solutions are implemented.
10) Expand master planning efforts beyond the Phase I watersheds as funding allows.

11.4 Future Master Planning Efforts

The Watershed Protection Master Plan Report will be revised periodically to reflect updated information. WPD will continue to improve water quality modeling efforts by utilizing new information as it becomes available. As capital solutions are put in place, and existing problems are rectified, updates will also be made to the existing problem score to keep current information on high priority needs.

New water quality monitoring information will be used to update Environmental Integrity Index (EII) scores for both the Phase I watersheds, as well as other watersheds in the City of Austin which will be included in future master plan phases. This updated EII information will also be incorporated into the problem scores to keep all master plan data current.

Technical studies for Onion Creek are currently underway to provide the Flood and Erosion missions the data necessary to complete problem assessments. As funding becomes available, flood and erosion studies will be conducted on other Phase II watersheds.

WPD will continue to work with the public in developing sustainable watershed solutions for all watersheds in the City of Austin.

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APPENDIX A

Watershed Summaries

Barton Creek

General Characteristics

From its confluence with Town Lake at Zilker Park, the Barton Creek watershed stretches westward to encompass nearly 119.5 square miles of southwest Austin, Travis and Hays County. The watershed extends westward beyond Loop 360 and Highway 71. The northern watershed border is found just north of Barton Creek and the southern border lies just north of Highway 290. The eastern part of the watershed (approximately 5,000 acres) lies over the sensitive Edwards Aquifer Recharge Zone (COA, May 1998). Groundwater discharges from this aquifer at several springs, the best known of which is Barton Springs – home to the endangered Barton Springs Salamander.

Flood Problem Summary

The majority of the localized flooding complaints are located at the downstream end of the Barton Creek watershed. Barton Creek experiences relatively few flooding problems compared to the other Phase I watersheds. The overall flood problem score for Barton Creek is depicted in Figure 8-6 in Section 8.

Erosion Problem Summary

The Barton Creek Watershed Erosion Assessment (RCA 1997) presents detailed erosion data for the primary drainage system. Erosion problem ratings were based on the number and type of structures threatened by creekbank erosion, the severity of the erosion threat, and by the estimated future stability of the creek. Along Barton Creek, there were no Type 1 (threatened house, building or road) erosion problem sites identified. Relatively few low impact[C4] Type 2(other resources threatened) and Type 3 (Resources threatened by future erosion) erosion problems are found along Barton Creek when compared to the remaining Phase I watersheds. All ten reaches of Barton Creek received an erosion problem rating of "Very Low" indicating that erosion problems are not as large a concern when compared to other Phase I watersheds. Predicted future channel enlargement results for the Barton Creek Watershed indicate that the channel expansion is predicted to be "Low" (less than 40%) relative to the other Phase I watersheds. Figure 8-6 in Section 8 shows the overall erosion problem score by creek reach for Barton Creek. The overall problem score includes components for current erosion problems, depicted by Type 1 and 2 problems, as well as components for future erosion problems, depicted by Type 3 problems, and Future Reach Stability. The Current Erosion Score is depicted in Figure A-1.

Water Quality Problem Summary

Overall, the water quality conditions in Barton Creek are very good, but localized impacts in the lower portions of the watershed have been documented, and future development in the watershed is a significant concern. Water quality problem area determinations were based on water chemistry, biological, recreational, aesthetic, and physical condition factors, and included not only Barton Creek but the resources that are either located in or receive discharges from the Barton Creek watershed; the latter include Town Lake, the Edwards Aquifer, and Barton Springs Pool. The quality of Town Lake is highly influenced by Barton Creek and Barton Springs, which account for over 70% of the water discharged to the lake downstream of Lake Austin. The Barton Creek watershed is also a major source of water for the Edwards Aquifer, accounting for over 30% of the recharge volume.

An important measure of the current water quality conditions in Barton Creek is the Environmental Integrity Index (EII), which measures chemical, biological, physical, recreational, and aesthetic conditions. The EII problem score is based on the gap between the EII goal and current EII score. The EII goal for the five monitoring sites in Barton Creek is "Excellent." Four of the sites, one above Barton Creek Pool, one at Lost Creek Bridge, one below Barton Creek Boulevard, and one at Hwy 71 below Little Barton, achieved "Very Good" scores, while the site at Hwy 71 above Little Barton achieved an "Excellent" score (the only site among the 70 Phase 1 sites to achieve this rating). Future problem scores are based on predicted changes in watershed hydrology and amount of pollution (pollutant "loads"). Future problem scores are high in Barton Creek because of anticipated development in the watershed, most of which is located outside of the City's jurisdiction and, thus, not subject to the City's non-degradation water quality regulations. Stormwater runoff volumes and pollutant loads are predicted to increase significantly (over 100% in for some constituents). These increases could be detrimental to not only Barton Creek, but also the Edwards Aquifer, Barton Springs and Town Lake. The Water Quality Problem Scores shown on the adjacent Figure 8-6 in Section 8 reflect the current and future problem severity scores combined with the resource value for an overall water quality problem score. Compared against all other Phase 1 watersheds, the level of concern for Barton Creek ranges from "Low" to "Very High," reflecting the exceptional quality of resources located in or receiving discharges from the watershed, the protection afforded by the City's water quality programs, and predicted future changes, especially in the portion of the watershed outside the City's jurisdiction. The Current Water Quality Score is depicted in Figure A-2. Current scores reflect existing water quality conditions, and are all in the "Very Low" to "Moderate" range, indicating that future problems account for most of the overall water quality concerns for Barton Creek. Figure A-3 shows the breakout by creek reach of the overall water quality problem score for Barton Creek.

Watershed Solutions

While upper Barton Creek still retains the characteristics of a rural watershed, lower portions are beginning to show the effects of suburban development. The impacts of urbanization on creek flooding, erosion and water quality are still limited and isolated when compared to other Phase 1 Master Plan watersheds. Barton Creek has a mostly stable channel with minimal amounts of past channel enlargement. Preventative regulatory and land preservation approaches are the most effective solution since much of the land is yet to be developed. Water quality retrofits are appropriate in pockets of more intense existing development, and solutions being considered include regional ponds, retrofit of existing ponds, public education, and low impact development (LID) techniques. Due to limited flooding, and concerns about retaining the natural character of the watershed, regional on-line flood detention ponds are not expected to be an integral part of the watershed protection strategy for Barton Creek. The LID approach is a relatively new one, and focuses on smaller-scale projects that utilize open space and landscaped areas for detaining and/or infiltrating runoff.

Blunn Creek

General Characteristics

The Blunn Creek Watershed is one of the City's smaller urban watersheds. From its confluence with Town Lake just west of Interstate 35, the watershed stretches southward to encompass merely 1.5 square miles of south central Austin. The watershed is bordered roughly on the west by South Congress Ave and on the east by Interstate 35. The southern border is Highway 71 (also called Highway 290 at this stretch) and the watershed extends northward up to Town Lake. Because of its south central location, the Blunn Creek watershed falls under requirements for the city's "Urban Watersheds."

Flood Problem Summary

Flooding problems are quite sparse and of low severity when compared to other Phase I watersheds. All reaches are rated as either "Low" or "Very Low" problem areas when compared to flooding problems in the rest of the Phase I watersheds. Figure 8-7 in Section 8 depicts the overall Flood problem score for Blunn Creek.

The determination of problem areas in the secondary drainage system is currently based on the analysis of customer drainage complaints. Approximately 75 drainage complaints were located in the Blunn Creek Watershed. The majority of the localized flooding complaints are located at the downstream end of the watershed along and just south of Riverside Drive.

Erosion Problem Summary

The Blunn Creek Watershed Erosion Assessment (RCA 1997) presents detailed erosion data for the primary drainage system. Erosion problem ratings were based on the number and type of structures threatened by creekbank erosion, the severity of the erosion threat, and by the estimated future stability of the creek. Along Blunn Creek, there were no

Type 1 (threatened house, building or road) erosion problem sites identified. Several relatively significant *Type 2* (other resources threatened) and *Type 3* (resources threatened by future erosion) problem areas are scattered along the Blunn Creek main stem, mostly along Reaches 3, 4, and 5 collectively stretching from Woodland Ave. to the north end of Warehouse Row. Of the five erosion reaches in Blunn Creek, four were rated "Low", and Reach 3, from Woodland to Oltorf Street, has a "Moderate" erosion problem rating. Reach 3 also has the highest Future Reach Stability problem rating of the Watershed, with a moderate future channel enlargement of 40-100% anticipated. The remainder of the watershed has a low future channel enlargement of less than 40%. Figure 8-7 in Section 8 shows the overall erosion problem score by creek reach for Blunn Creek. The overall problem score includes components for current erosion problems, depicted by Type 1 and 2 problems, as well as components for future erosion problems, depicted by Type 3 problems, and Future Reach Stability. The Current Erosion Score is depicted in Figure A-4.

Water Quality Problem Summary

The water quality of Blunn Creek has been impacted by urbanization but the creek still retains many desirable characteristics, including baseflow, good stream habitat, aesthetic, and recreational qualities. Water quality problem area determinations are based on Environmental Integrity Index (EII) scores, future predicted changes in water quality and hydrology, and the watershed's contribution of pollutant loads to Town Lake. The primary indicator of current water quality conditions is the EII, which measures chemical, biological, physical, recreational, and aesthetic conditions. The EII problem score is based on the gap between the EII goal and the current EII score, for the four sampling sites in the creek. Two of the sites, one above Riverside and the other near the Blunn Creek Wilderness Preserve are currently rated as "Fair." The ideal goal rating for these two segments is "Good". The remaining two sites, one above Stacy Pool and one at Willow Run in the upper portion of the watershed are currently rated as "Good" with an EII narrative goal of "Very Good". There are concerns that impacts may increase in the future, as existing undeveloped areas are developed, and pollution is predicted to increase by 20% or more. These increases are predicted to be most pronounced in the upper watershed and, in addition to potentially impacting Blunn Creek, may also effect Town Lake. The Water Quality Problem Scores shown on Figure A8-7 in Section 8 reflect the current and future problem severity scores combined with the resource value for an overall water quality problem score. Compared against all other Phase 1 watersheds, the overall level of concern for Blunn Creek ranges from "Low" to "Moderate." The Current Water Quality Score for Blunn Creek is depicted in Figure A-5. Current scores reflect existing water quality conditions, and are all in the "Very Low" to "Low" range. Figure A-6 shows the breakout by creek reach of the overall water quality problem score for Blunn Creek.

Watershed Solutions

Blunn Creek has characteristics of a developing watershed with a moderate level of impervious cover, and a relatively high potential for a future impervious cover increase (greater than 5%). Blunn Creek is experiencing accelerated creek erosion, and shows signs of channel instability with a predicted increase in channel size greater than 25%.

Flood solutions may include property buyouts, detention, bridge or culvert replacement, and channel improvements. Construction of regional erosion detention facilities to provide erosion control has been identified as a possible solution, since the potential for future stream degradation due to channel instability is high. Sideslope stabilization measures are recommended to protect existing property threatened by creek erosion, but these measures will not be effective over the long-term if watershed-scale measures such as erosion detention ponds and stream corridor restoration are not implemented. Water quality solutions being considered include regional ponds, retrofit of existing ponds, public education, and low impact development (LID) techniques. These solutions should be designed to improve both water quality and watershed hydrology in order to benefit all three WPD missions. The LID approach is a relatively new one, and focuses on smaller-scale projects that utilize open space and landscaped areas for detaining and/or infiltrating runoff.

Boggy Creek

General Characteristics

The Boggy Creek Watershed is one of the largest of the City's urban watersheds. The confluence of the watershed with Town Lake is found just east of Highway 183 and just west of the Colorado River Greenbelt. The watershed stretches west from its confluence and then northward to encompass nearly 5.9 square miles of east Austin. The Fort and Tannehill Branches of Boggy Creek are considered as separate watersheds in this Master Plan. Collectively, Boggy Creek and its two major tributaries cover 13 square miles, forming one of the largest Urban watersheds in the City. The Boggy Creek watershed is bordered roughly on the west by Interstate 35 and on the east by Airport Blvd, although its far eastern portion stretches just beyond Highway 183. North of Town Lake, the watershed extends northward nearly to RM 2222.

Flood Problem Summary

Flooding problems occur in the main stem of Boggy Creek mainly between 12th St. and 38½ St. Boggy Creek between Manor Rd. and 38½ St. is rated as a "High" problem area with three areas, one from MLK Blvd. to Manor Rd., one from Holmes Ct. to 16th St., and one from Delwau Ln. to Shelton Rd. rated as "Moderate". The remaining reaches are rated as either "Low" or "Very Low" problem areas when compared to flooding problems in the rest of the Phase I watersheds. The overall Flood problem score is depicted in Figure 8-8 in Section 8 for Boggy Creek.

The determination of problem areas in the secondary drainage system is currently based on the analysis of customer drainage complaints. Approximately 400 drainage complaints were located in the Boggy Creek Watershed. Localized flooding complaints are not concentrated in any one area, but occur throughout the entire watershed.

Erosion Problem Summary

The Boggy Creek Watershed Erosion Assessment (RCA 1997) presents detailed erosion data for the primary drainage system. Erosion problem ratings were based on the number and type of structures threatened by creekbank erosion, the severity of the erosion threat, and by the estimated future stability of the creek. Along Boggy Creek, one (1) *Type 1* (threatened house, building or road) erosion problem site was identified, located approximately 300 feet downstream of Wilshire Boulevard in a segment of the main stem of Boggy Creek. *Type 2* (other resources threatened) and *Type 3* (resources threatened by future erosion) problem areas are scattered along Boggy Creek and are found mainly from the confluence with the Colorado River to Hwy 183 -- and the creek section collectively stretching from Pedernales St to Airport Blvd." Of the seven erosion reaches in Boggy Creek, three were classified with "Very Low" erosion control problem ratings, one reach was classified as "Low", one reach was classified as "Moderate," and two, Reach 5 and 7, were classified as "Very High. Reach 5 of the main stem runs from Webberville Road north to 14h Street. Reach 7 of the main stem is from 38^{th}1/2 north to the upper reaches of the watershed. Figure 8-8 shows the overall erosion problem score by creek reach for Boggy Creek. The overall problem score includes components for current erosion problems, depicted by Type 1 and 2 problems, as well as components for future erosion problems, depicted by Type 3 problems, and Future Reach Stability. The Current Erosion Score is depicted in Figure A-7.

Water Quality Problem Summary

The water quality, biology, physical habitat, recreation, and aesthetic conditions of Boggy Creek have all been significantly impacted by urban development. Water quality problem area determinations are based on Environmental Integrity Index (EII) scores, future predicted changes in water quality and hydrology, and the watershed's contribution of pollutants to the Colorado River below Town Lake. The primary indicator of current water quality conditions is the EII, which measures chemical, biological, physical, recreational, and aesthetic conditions. The EII problem score is based on the gap between the EII goal and the current EII score, for the four sampling sites in the creek. One of the sites from Nile Rd to Delwau Lane, is currently rated "Good" with a goal of "Very Good." Two of the sites, one from Airport Boulevard to Banton Road and the other from Banton Road to Nile Drive are currently rated as "Fair." One site above Airport Boulevard is currently rated "Marginal." All three of these sites have a goal of

"Good." As most of the watershed has been developed, future changes in water quality and hydrology are not anticipated to be significant. The Water Quality Problem Scores shown in Figure 8-8 in Section 8 reflect the current and future problem severity scores combined with the resource value for an overall water quality problem score. Compared against all other Phase 1 watersheds, the overall level of concern for Boggy Creek is "Low." The Current Water Quality Score for Boggy Creek is depicted in Figure A-8. Current scores reflect existing water quality conditions, and are all in the "Low" range. Figure A- 9 shows the breakout by creek reach of the overall water quality problem score for Boggy Creek.

Watershed Solutions

Boggy Creek has the characteristics of an urbanized watershed, with high existing impervious cover, and thus a lower potential for future development when compared to developing or rural watersheds with lower impervious cover. Infill and redevelopment are the most likely sources of future increases in impervious cover. Boggy Creek has already experienced significant channel enlargement in the past, and estimates of future enlargement are predictably low (less than 25%). Undeveloped land available for new regional erosion, flood or water quality ponds is severely limited. Large-scale erosion detention ponds are generally not considered effective solutions because most of the preventable creek enlargement has already occurred. Efforts in Boggy Creek should focus on channel restoration including sideslope stabilization, property buyouts, and riparian area restoration, together with retrofits of existing ponds for water quality and erosion benefits, public education, and low impact development (LID) techniques. The LID approach is a relatively new one, and focuses on smaller-scale projects that utilize open space and landscaped areas for detaining and/or infiltrating runoff. In addition to reducing pollutant loads, water quality solutions should be designed to augment baseflow and improve stream habitat quality and stability. Flood solutions are likely to include property buyouts, bridge replacement or channel improvements. However, flood detention may be an alternative where sufficient open space is available.

Bull Creek

General Characteristics

The Bull Creek Watershed is the largest of the Water Supply Suburban Watersheds. From its confluence with Town Lake just east of Loop 360, the watershed stretches northward and then more northwesterly to encompass nearly 25 square miles of northwest Austin. The watershed is bordered roughly on the west by RM 620 and RM 2222, and on the east by Mesa and Highway 183. Stretching north of Loop 360 and west of Highway 183, the Bull Creek Watershed reaches almost to Lake Travis. A few of the notable sites in the watershed include Stillhouse Hollow Springs, 3M Austin Headquarters, St. Edward's Park, Bull Creek Park, and the Arboretum.

Flood Problem Summary

Flooding problems occur mainly along the middle portion of the main stem of Bull Creek, as well as along a lower main stem reach near the intersection of Loop 360 and FM 2222. Bull Creek between FM 2222 and Lakewood Dr. is rated as a "Very High" problem area, the reach containing Spicewood Springs Crossing #4 is rated as a "High" problem, and the reaches containing Spicewood Springs Crossings # 1, 3, 5, 6, and 7 are all rated as "Moderate." The remaining creek reaches are rated as either "Low" or "Very Low" problem areas when compared to flooding problems in the rest of the Phase I watersheds. Overall Flood problem scores are depicted in Figure 8-9 in Section 8 for Bull Creek.

The determination of problem areas in the secondary drainage system is currently based on the analysis of customer drainage complaints. Approximately 330 were located in the Bull Creek Watershed. The majority of the localized flooding complaints are located at the upstream end of Tributary 2 in the Balcones Woods area south of 183.

Erosion Problem Summary

The Bull Creek Watershed Erosion Assessment (RCA 1997) presents detailed erosion data for the primary drainage system. Erosion problem ratings were based on the number and type of structures threatened by creekbank erosion, the severity of the erosion threat, and by the estimated future stability of the creek. Along Bull Creek, one (1) *Type 1* (threatened house, building or road) erosion problem site was identified; this threatened minor road erosion problem in located Reach 7 of the main stem between Spicewood Crossing #1 and Spicewood Crossing #5. Several *Type 2* (other resources threatened) and *Type 3* (resources threatened by future erosion) problem areas are scattered along Bull Creek and its tributaries. The majority of these problem areas were found in Reach 1 of Tributary 2 between the confluence with the main stem and Penny Creek Dr.

Of the 22 erosion reaches in Bull Creek, the majority (19) of creek reaches were classified with a "Very Low" or "Low" erosion problem rating. Two reaches had an erosion problem rating of "Very High". One reach is located along Tributary 2 from the confluence with the main stem east of Loop 360, north to just past Floral Park between Raining Oak Cove and Barker Vista. The second reach is along the main stem near Spicewood Springs Road from the confluence with Tributary 3 to between the 4th and 5th crossing of Spicewood west of the intersection with Yucca Mountain Road. One reach was classified with an erosion problem rating of "Moderate"; it is located on Tributary 4 from the confluence with the main stem to just past Gallanish Park at Wester Kirk. Most areas of the watershed have a future channel enlargement of "Very Low" to "Low" (0-40). Two areas have a "Moderate" (40%-10%) predicted future channel expansion, one area is the entirety of Tributary 2, and the other area is the lower half of Tributary 4. Figure 8-9 in Section 8 shows the overall erosion problem score by creek reach for Bull Creek. The overall problem score includes components for current erosion problems, depicted by Type 1 and 2 problems, as well as components for future erosion problems, depicted by Type 3 problems, and Future Reach Stability. The Current Erosion problem score is depicted in Figure A-10.

Water Quality Problem Summary

The current water quality conditions in Bull Creek are good to very good, and it is one of the most scenic and ecologically valuable creeks in the Austin area. Water quality problem area determinations are based on the Environmental Integrity Index (EII) scores, future predicted changes in water quality and hydrology, and the watershed's contribution of pollutant loads to Lake Austin. The primary indicator of current water quality conditions is the EII, which measures chemical, biological, physical, recreational, and aesthetic conditions. The EII problem score is based on the gap between the EII goal and the current EII score, for the four sampling sites in the creek. The sites are located near the intersection of Loop 360 and 2222, at Loop 360 near Lakewood Drive, above the dam at St. Edwards District Park, and on Tributary 6 west of Old Lampassas Trail. All four sites are currently rated "Very Good" while their goal is "Excellent." Because future development is still underway in much of the watershed, future impacts to water quality and hydrology may be significant. The Water Quality Problem Scores shown on Figure 8-9 in Section 8 reflect the current and future problem severity scores combined with the resource value for an overall water quality problem score. Compared against all other Phase 1 watersheds, the overall level of concern in Bull Creek ranges from "Low" to "Very High." The Current Water Quality Score is depicted in Figure A-11. Current scores reflect existing water quality conditions, and are in the "Very Low" to "Moderate". Figure A-12 shows the breakout by creek reach of the overall water quality problem score for Bull Creek.

Watershed Solutions

Bull Creek has characteristics of a developing watershed with a moderate level of impervious cover, and a relatively high potential for future impervious cover increase (greater than 5%). Bull Creek is experiencing accelerated creek erosion, and shows signs of channel instability with a predicted increase in channel size greater than 25%. Flood solutions include property buyouts, detention, bridge or culvert replacement, and channel improvements.

Construction of regional erosion detention facilities to provide erosion control has been identified as a possible solution, since the potential for future stream degradation due to channel instability is high. Sideslope stabilization measures are recommended to protect existing property threatened by creek erosion, but these measures will not be effective over the long-term if watershed-scale measures such as erosion detention ponds and stream corridor restoration are not implemented. Water quality solutions being considered include regional ponds, retrofit of existing ponds, public education, and low impact development (LID) techniques. These solutions should be designed to improve both water quality and watershed hydrology in order to benefit all three WPD missions. The LID approach is a relatively new one, and focuses on smaller-scale projects that utilize open space and landscaped areas for detaining and/or infiltrating runoff.

Buttermilk Creek

General Characteristics

The Buttermilk Creek Watershed is one of Austin's smallest Urban Watersheds. Encompassing only 1.7 square miles, the Buttermilk Creek Watershed is located just north east of downtown. Buttermilk watershed is, generally, the area just surrounding the intersection of Interstate 35 and Highway 183, not quite reaching as far south as Highway 290.

Flood Problem Summary

Flooding problems are not as severe in Buttermilk Creek watershed when compared to other Phase I watersheds. All reaches are rated as either "Low" or "Very Low" problem areas when compared to flooding problems in the rest of the Phase I watersheds. Overall Flood problem scores are depicted in Figure 8-10 in Section 8.

The determination of problem areas in the secondary drainage system is currently based on the analysis of customer drainage complaints. Approximately 60 drainage complaints relating to localized flooding were located in the Buttermilk Creek Watershed. The majority of the localized flooding complaints are located in the uppermost part of the watershed just south of the US 183/Lamar/Anderson Lane intersection.

Erosion Problem Summary

The Buttermilk Creek Watershed Erosion Assessment (RCA 1997) presents detailed erosion data for the primary drainage system. Erosion problem ratings were based on the number and type of structures threatened by creekbank erosion, the severity of the erosion threat, and by the estimated future stability of the creek. Along Buttermilk Creek, there were no *Type 1* (threatened house, building or road) erosion problem sites identified. *Type 2* (other resources threatened) and *Type 3* (resources threatened by future erosion) problem areas are scattered throughout the watershed, but are found mostly in Reach 1 from the confluence with Little Walnut Creek to Cameron Rd. Of the five erosion reaches in Buttermilk Creek, four reaches were classified with a "Low" or "Very Low" erosion problem rating. Reach 1 was classified as "Moderate ", and is located from the confluence with Little Walnut Creek north to just west of East Anderson Lane. Future channel enlargement results are predicted to be "Low" (less than 40%) relative to other Phase I watersheds. Figure 8-10 shows the overall erosion problem score by creek reach for Buttermilk Creek. The overall problem score includes components for current erosion problems, depicted by Type 1 and 2 problems, as well as components for future erosion problems, depicted by Type 3 problems, and Future Reach Stability. The Current Erosion Score is depicted in Figure A-13.

Water Quality Problem Summary

The water quality, biology, physical habitat, recreation, and aesthetic conditions of Buttermilk Creek have all been significantly impacted by urban development. Water quality problem area determinations are based on Environmental Integrity Index (EII) scores, future predicted changes in water quality and hydrology, and the watershed's contribution of pollutants to the Colorado River below Town Lake. The primary indicator of current water quality conditions is the EII, which measures chemical, biological, physical, recreational, and aesthetic conditions. The EII problem score is based on the gap between the EII goal and the current EII score, for the four sampling sites in the creek. Three of the sites-- at Little Walnut Creek, at Cameron Rd., and at Providence Ave. -- are currently rated as "Fair," and one -- at Chevy Chase Rd. -- is currently rated as "Marginal". The goal for all four sites is "Good." Future problem concerns are not as significant as current ones as the watershed has been mostly built out. The Water Quality Problem Scores shown on Figure 8-10 in Section 8 reflect the current and future problem severity scores combined with the resource value for an overall water quality problem score. Compared against all other Phase 1 watersheds, the overall level of concern for Buttermilk Creek ranges from "Very Low" to "High." The Current Water Quality Score for Buttermilk Creek is depicted in Figure A-14. Current scores reflect existing water quality conditions, and range from "Very Low" to "High. Figure A-15 shows the breakout by creek reach of the overall water quality problem score for Buttermilk Creek.

Watershed Solutions

Buttermilk Creek has the characteristics of an urbanized watershed, with a high existing impervious cover level, and thus a lower potential for future development when compared to developing or rural watersheds with lower impervious cover levels. Infill and redevelopment are the most likely sources of future increases in impervious cover. Buttermilk Creek has already experienced significant channel enlargement in the past, and estimates of future enlargement are predictably low (less than 25%). Undeveloped land available for new regional scale erosion, flood or water quality ponds is severely limited. Large-scale erosion detention ponds are generally not considered effective solutions because most of the preventable creek enlargement has already occurred. Efforts in Buttermilk Creek should focus on channel restoration including sideslope stabilization, property buyouts, and riparian restoration, together with retrofits of existing ponds for water quality and erosion benefits, public education, and low impact development (LID) techniques. The LID approach is a relatively new one, and focuses on smaller-scale projects that utilize open space and landscaped areas for detaining and/or infiltrating runoff. In addition to reducing pollutant loads, water quality solutions should be designed to augment baseflow and improve stream habitat quality and stability. Flood solutions are likely to include property buyouts, bridge replacement or channel improvements. However, flood detention may be an alternative where sufficient open space is available.

Country Club Creek

General Characteristics

The Country Club Creek Watershed is a moderate sized suburban Austin watershed. From its confluence with Town Lake just west of Highway 183, the watershed stretches in a southwesterly direction to encompass nearly 4.6 square miles of southeast Austin. A drainage project constructed in the 1980s diverted much of the upper watershed to a new discharge point, located below Town Lake near the Kreig softball fields complex. The watershed is bordered roughly on the west by Interstate 35 and on the east by Highway 183. Highway 71 (Ben White Blvd.) is basically the southern border while Town Lake borders it to the north.

Flood Problem Summary

Flooding problems occur mostly in Tributaries 2 and 3. The lower half of Tributary 3 is located near the intersection of Wickersham and Cromwell and is rated a "Moderate" flood control problem area. Tributary 2 at the upper end of the tributary near Riverside Farms Ln is also rated a "Moderate" flooding problem area. The remaining creek reaches are rated as either "Low" or "Very Low" problem areas when compared to flooding problems in the rest of the Phase I watersheds. Overall Flood problem scores are depicted in Figure 8-11 in Section 8.

The determination of problem areas in the secondary drainage system is currently based on the analysis of customer drainage complaints. Approximately 140 drainage complaints have been reported in the Country Club Creek Watershed, with the majority of the localized flooding complaints located east of the old main stem.

Erosion Problem Summary

The Country Club Creek Watershed Erosion Assessment (RCA 1997) presents detailed erosion data for the primary drainage system. Erosion problem ratings were based on the number and type of structures threatened by creekbank erosion, the severity of the erosion threat, and by the estimated future stability of the creek. Along Country Club Creek, one *Type 1* (threatened house, building or road) erosion problem site was identified in Reach 3 from Elmont Rd to Oltorf St. The concrete apron underneath the bridge is being undermined. *Type 2* (other resources threatened) and *Type 3* (resources threatened by future erosion) problem areas are scattered throughout the watershed, mainly in Reaches 4 and 5 of New Country Club Creek, collectively running from Oltorf St. to Old Burleson Rd.

Of the thirteen erosion reaches in Country Club Creek, six were classified with "Very High" erosion problem ratings. Those classified as "Very High" include Tributary 5, located from the confluence with the main stem at Burleson Road to the upper reaches of the tributary near I-35 and Woodward; Tributary 4, located from confluence with the main stem at Pleasant Valley Road and Riverside to the upper reaches just south of East Ben White Blvd.; Tributary 3 located from the confluence with the main stem near Cromwell Circle to the upper reaches just south of Oltorf; Tributary 2, located from the confluence with the main stem near Crossing Place to the upper reaches between Riverside Farms and Oltorf; and two reaches along the main stem from Burleson Road to the confluence with Old Country Club Creek at Crossing place. Three reaches were classified with "Moderate" erosion problem ratings, and two were classified as "Low". Future channel expansion predictions for the watershed were primarily "Medium" to "High" ranging from 39% to 131%. Figure 8-11 in Section 8 shows the overall erosion problem score by creek reach for Country Club Creek. The overall problem score includes components for current erosion problems, depicted by Type 1 and 2 problems, as well as components for future erosion problems, depicted by Type 3 problems, and Future Reach Stability. The Current Erosion Problem Score is depicted in Figure A-16.

Water Quality Problem Summary

The water quality of Country Creek has been significantly impacted by urban development. Water quality problem area determinations are based on Environmental Integrity Index (EII) scores, future predicted changes in water quality and hydrology, and the watershed's contribution of pollutants to the Colorado River below Town Lake. The primary indicator of current water quality conditions is the EII, which measures chemical, biological, physical, recreational, and aesthetic conditions. The EII problem score is based on the gap between the EII goal and the current EII score, for the three sampling sites in the creek. The site at East Oltorf Street is currently rated as "Fair," the site below Grove Drive is currently rated as "Poor," and the site at Crossing Place Drive is currently rated "Marginal." The goal for these is "Good." Because future development is still underway in much of the watershed, future impacts to water quality and hydrology may be significant. The Water Quality Problem Scores shown on Figure 8-11 in Section 8 reflect the current and future problem severity scores combined with the resource value for an overall water quality problem score. Compared against all other Phase 1 watersheds, the overall level of concern for Country Club Creek ranges from "Very Low" to "Very High." The Current Water Quality Score for Country Club Creek is depicted in Figure A-17. Current scores reflect existing water quality conditions, and are scattered in the "Very Low", and "Very High" range. Figure A-18 shows the breakout by creek reach of the overall water quality problem score for Country Club Creek.

Watershed Solutions

Country Club Creek has characteristics of a developing watershed with a moderate level of impervious cover, and a relatively high potential for future impervious cover increase (greater than 5%). Country Club Creek is experiencing accelerated creek erosion, and shows signs of channel instability with a predicted increase in channel size greater than 25%. Flood solutions may include property buyouts, detention, bridge, or culvert replacement, and channel improvements. Construction of regional erosion detention facilities to provide erosion control is identified as a possible solution, since the potential for future stream degradation due to channel instability is high. Sideslope stabilization measures are recommended to protect existing property threatened by creek erosion, but these measures will not be effective over the long-term if watershed-scale measures such as erosion detention ponds and stream corridor restoration are not implemented. Water quality solutions being considered include regional ponds, retrofit of existing ponds, public education, and low impact development (LID) techniques. These solutions should be designed to improve both water quality and watershed hydrology in order to benefit all three WPD missions. The LID approach is a relatively new one, and focuses on smaller-scale projects that utilize open space and landscaped areas for detaining and/or infiltrating runoff.

East Bouldin Creek

General Characteristics

The East Bouldin Creek Watershed is a small urban watershed. Its confluence with Town Lake is found just west of Interstate 35 within the East Bouldin Greenbelt. The watershed stretches in a south-southwesterly direction from Town Lake to Highway 71 (Ben White Blvd) to encompass nearly 1.8 square miles of south central Austin. The watershed stretches just west of South 1st St. and just east of Congress Ave. North of Highway 290, the watershed extends north to Town Lake. An underground tunnel diverts floodwaters from the lower part of East Bouldin Creek to Town Lake near the Stevie Ray Vaughn statue.

Flood Problem Summary

Flooding problems in the East Bouldin Creek watershed are not as severe as those in other Phase I watersheds. All creek reaches are rated as either "Low" or "Very Low" problem areas when compared to flooding problems in the rest of the Phase I watersheds. Overall Flood problem scores are depicted in Figure 8-12 in Section 8.

The determination of problem areas in the secondary drainage system is currently based on the analysis of customer drainage complaints. 150 were located in the East Bouldin Creek Watershed, with the majority of the localized flooding complaints located throughout the entire watershed.

Erosion Problem Summary

The East Bouldin Creek Watershed Erosion Assessment (RCA 1997) presents detailed erosion data for the primary drainage system. Erosion problem ratings were based on the number and type of structures threatened by creekbank erosion, the severity of the erosion threat, and by the estimated future stability of the creek. Along East Bouldin Creek, one (1) *Type 1* (threatened house, building or road) erosion problem site was identified. This threatened structure is found in Reach 3 between South 1st St. and West Mary St. Since the onset of the Master plan, this threatened *Type 1* structure has been stabilized by a sideslope project. *Type 2* (other resources threatened) and *Type 3* (resources threatened by future erosion) problem areas are scattered along East Bouldin Creek, with the majority of *Type* 2 problems found in Reach 4 from West Mary St. to Alpine Rd., and the majority of *Type* 3 problems found in Reach 1 from the confluence with Town Lake to Christopher Street." Of the four erosion reaches in East Bouldin Creek, only Reach 2 was identified as a "Very Low" erosion problem rating. Reach 3, from South 1st Street to West Mary, received "Very High" erosion problem rating. This is the same reach with the threatened *Type* 1 problem that has since been stabilized by a sideslope project, lowering the current erosion problem rating to Very Low. Two reaches, Reach 1 located from the confluence with Town Lake to Christopher Street, and Reach 4, from West Mary to Alpine Road, both were classified with a "High" erosion rating. All reaches within the watershed have a future channel expansion ranking of "Low" (0-40%). Figure 8-12 in Section 8 shows the overall erosion problem score by creek reach for East Bouldin Creek. The overall problem score includes components for current erosion problems, depicted by Type 1 and 2 problems, as well as components for future erosion problems, depicted by Type 3 problems, and Future Reach Stability. The Current Erosion Problem Score is depicted in Figure A-19.

Water Quality Problem Summary

The water quality of East Bouldin Creek has been significantly impacted by urban development. Water quality problem area determinations are based on Environmental Integrity Index (EII) scores, future predicted changes in water quality and hydrology, and the watershed's contribution of pollutants to Town Lake. The primary indicator of current water quality conditions is the EII, which measures chemical, biological, physical, recreational, and aesthetic conditions. The EII problem score is based on the gap between the EII goal and the current EII score, for the four sampling sites in the creek. Two of the sites -- at Riverside Dr. and at Alpine Rd. -- are currently rated as "Marginal," one site -- at South Austin Center -- is currently rated as "Poor," and the last site -- at Elizabeth St. -- is currently rated "Fair." The goal for these four sites is "Good." Future problem concerns are not as significant as current ones as the watershed has been mostly built out. The Water Quality Problem Scores shown on Figure 8-12 in Section 8 reflect the current and future problem severity scores combined with the resource value for an overall water quality problem score. Compared against all other Phase 1 watersheds, the overall level of concern for East Bouldin Creek ranges from "Very Low" to "Very High." The Current Water Quality Score for East Bouldin Creek is depicted in Figure A-20. Current scores reflect existing water quality conditions, and are all in the "Low" to the "Very High" range. Figure A-21 shows the breakout by creek reach of the overall water quality problem score for East Bouldin Creek.

Watershed Solutions

East Bouldin Creek has the characteristics of an urbanized watershed, with a high existing impervious cover level, and thus a lower potential for future development when compared to developing or rural watersheds with lower impervious cover. Infill and redevelopment are the most likely sources of future increases in impervious cover. East Bouldin Creek has already experienced significant channel enlargement in the past, and estimates of future enlargement are predictably low (less than 25%). Undeveloped land available for new regional scale erosion, flood or water quality ponds is severely limited. Large-scale erosion detention ponds are generally not considered effective solutions because most of the preventable creek enlargement has already occurred. Efforts in East Bouldin Creek should focus on channel restoration including sideslope stabilization, property buyouts, and riparian restoration, together with retrofits of existing ponds for water quality and erosion benefits, public education, and low impact development (LID) techniques. The LID approach is a relatively new one, and focuses on smaller-scale projects that utilize open space and landscaped areas for detaining and/or infiltrating runoff. In addition to reducing pollutant loads, water quality solutions should be designed to augment baseflow and improve stream habitat quality and stability. Several retrofits have already been implemented in the watershed, including the Alpine and St. Edwards University wet ponds and the Gillis Park sand filtration system. Flood solutions are likely to include property buyouts, bridge replacement or channel improvements. However, flood detention may be an alternative where sufficient open space is available.

Fort Branch

General Characteristics

The Fort Branch Watershed is a small Austin urban watershed. After winding through East Austin, Fort Branch has a confluence with Boggy Creek near Johnston High School, flowing into the Colorado River below Town Lake. The overall drainage area of the watershed is 3.3 square miles. The northern reach of the watershed is Highway 290 and the southern border is at the point of confluence with Boggy Creek.

Flood Problem Summary

Flood assessments were performed for the Phase I watersheds. As documented in the Flood Control Needs Assessment Models Study (Loomis & Moore 1997), Loomis & Moore conducted hydrologic and hydraulic modeling for the primary drainage system of the Fort Branch Watershed. Modeling was performed for the main stem of Fort Branch. Most creek reaches classified as a "Low" or "Very Low" flood problem area. One reach, located on the main stem from south of Harold Court to Eleanor and Hudson Street is classified "Very High". Two areas are classified as "Moderate" in problem severity. Overall Flood problem scores are depicted in Figure 8-13 in Section 8.

The determination of problem areas in the secondary drainage system is currently based on the analysis of customer drainage complaints. 324 were located in the Fort Branch Watershed, with the majority of the localized flooding complaints located in the upper reaches of the watershed.

Erosion Problem Summary

The Fort Branch Watershed Erosion Assessment (RCA 1997) presents detailed erosion data for the primary drainage system. Erosion problem ratings were based on the number and type of structures threatened by creekbank erosion, the severity of the erosion threat, and by the estimated future stability of the creek. Along Fort Branch, one (1) *Type 1* (threatened house, building or road) erosion problem site was identified. This threatened structure is found in Reach 5 between Manor Rd and the tributary at Westminster and Waterbrook. *Type 2* (other resources threatened) and *Type 3* (resources threatened by future erosion) problem areas are scattered along Fort Branch mainly in Reach 2 from MKT Railroad to Webberville Rd, Reach 3 from Webberville Rd to Springdale Rd, and Reach 5." Of the ten erosion reaches in the watershed, most are classified with a "Low" or "Very Low" erosion problem rating. Two reaches, Reach 2 from MKT Railroad to Webberville Road, and Reach 5, from Manor Road to just south of Rogge Lane, are classified as "Very High". One reach is classified as "Moderate". Reach 2 also has a future channel expansion prediction of "High" (100-160%), the worst within the watershed. Figure 8-13 in Section 8 shows the overall erosion problem score by creek reach for Fort Branch. The overall problem score includes components for current erosion problems, depicted by Type 1 and 2 problems, as well as components for future erosion problems, depicted by Type 3 problems, and Future Reach Stability. The Current Erosion Problem Score is depicted in Figure A-22.

Water Quality Problem Summary

The water quality of Fort Branch has been significantly impacted by urban development. Water quality problem area determinations are based on Environmental Integrity Index (EII) scores, future predicted changes in water quality and hydrology, and the watershed's contribution of pollutants to the Colorado River below Town Lake. The primary indicator of current water quality conditions is the EII, which measures chemical, biological, physical, recreational, and aesthetic conditions. The EII problem score is based on the gap between the EII goal and the current EII score, for the four sampling sites in the creek. One of the sites -- at Glencrest Drive -- is currently rated as "Poor," two of the sites --Single Shot and Manor Rd. -- are currently rated as "Fair", while the final site-- at Boggy Creek -- is currently rated as "Good." The goal for these four sites is "Good" to "Very Good". Future problem concerns are not as significant as current ones as the watershed has been mostly built out. The Water Quality Problem Scores shown on Figure 8-13 in Section 8 reflect the current and future problem severity scores combined with the resource value for an overall water quality problem score. Compared against all other Phase 1 watersheds, the overall level of concern for Fort Branch ranges from "Low" to "Moderate." The Current Water Quality Score for Fort Branch is depicted in Figure A-23. Current scores reflect existing water quality conditions, and range from the "Very Low" to "Moderate" range. Figure A- 24 shows the breakout by creek reach of the overall water quality problem score for Fort Branch.

Watershed Solutions

Fort Branch has the characteristics of an urbanized watershed, with a high existing impervious cover level, and thus a lower potential for future development when compared to developing or rural watersheds with lower impervious cover. Infill and redevelopment are the most likely sources of future increases in impervious cover. Fort Branch has already experienced significant channel enlargement in the past, and estimates of future enlargement are predictably low (less than 25%). Undeveloped land available for new regional scale erosion, flood or water quality ponds is severely limited. Large-scale erosion detention ponds are generally not considered an effective solution because most of the preventable creek enlargement has already occurred. Efforts in Fort Branch should focus on channel restoration including sideslope stabilization, property buyouts, and riparian restoration, together with retrofits of existing ponds for water quality and erosion benefits, public education, and low impact development (LID) techniques. The LID approach is a relatively new one, and focuses on smaller-scale projects that utilize open space and landscaped areas for detaining and/or infiltrating runoff. In addition to reducing pollutant loads, water quality solutions should be designed to augment baseflow and improve stream habitat quality and stability. Flood solutions are likely to include property buyouts, bridge replacement or channel improvements. However, flood detention may be an alternative where sufficient open space is available.

Harper's Branch

General Characteristics

The Harper's Branch Watershed is the City's urban watershed most impacted by urbanization. The confluence of Harper's Branch is right along the Interstate 35 corridor as it crosses the river, only encompassing 0.54 square miles of central Austin. The watershed is bordered roughly on the west by Travis Heights Blvd. and on the east by Parker Lane, straddling Interstate 35 north of Oltorf Street to Town Lake. At just over a half of a square mile, the Harper's Branch Watershed is the City's smallest watershed.

Flood Problem Summary

Flood assessments were performed for the Phase I watersheds. As documented in the Flood Control Needs Assessment Models Study (Loomis & Moore 1997), Loomis & Moore conducted hydrologic and hydraulic modeling for the primary drainage system of the Harper's Branch Watershed. Modeling was performed for the main stem of Harper's Branch. Flooding problems are sparse and of low severity when compared to other Phase I watersheds. All creek reaches are rated as "Low" problem areas. Overall Flood problem scores are depicted in Figure 8-14 in Section 8.

The determination of problem areas in the storm drain system is currently restricted to the evaluation of drainage complaints. Approximately 20 drainage complaints were located in the Harper's Branch Watershed. The majority of the localized flooding complaints are located toward the downstream end of the watershed.

Erosion Problem Summary

The Harper's Branch Watershed Erosion Assessment (RCA 1997) presents detailed erosion data for the primary drainage system of Harper's Branch. Erosion problem ratings were based on the number and type of structures threatened by creekbank erosion, the severity of the erosion threat, and by the estimated future stability of the creek. Along Harper's Branch, there are no *Type 1* (threatened house, building or road) erosion problem sites identified. *Type 2* (other resources threatened) and *Type 3* (resources threatened by future erosion) problem areas are scattered along Harper's Branch. The majority of *Type* 2 and *Type* 3 sites are found in Reach 2, from I-35 to Reagan Terrace. All reaches in Harper's Branch were identified with "Very Low" erosion problem ratings when compared to other Phase I watershed reaches. All of the reaches within the watershed have a future channel expansion prediction of "Very Low' (0%) or "Low"(0-40%). Figure 8-14 in Section 8 shows the overall erosion problem score by creek reach for Harper's Branch. The overall problem score includes components for current erosion problems, depicted by Type 1 and 2 problems, as well as components for future erosion problems, depicted by Type 3 problems, and Future Reach Stability.

Water Quality Problem Summary

The water quality of Harper's Branch has been significantly impacted by urban development. Water quality problem area determinations are based on Environmental Integrity Index (EII) scores, future predicted changes in water quality and hydrology, and the watershed's contribution of pollutants to Town Lake. The primary indicator of current water quality conditions is the EII, which measures chemical, biological, physical, recreational, and aesthetic conditions. The EII problem score is based on the gap between the EII goal and the current EII score, for the three sampling sites in the creek. Two of the sites -- at Woodland and at Riverside Dr. -- are currently rated as "Marginal," while the final site – at Windoak -- is currently rated as "Fair." The goal for these three sites is "Good." Future problem concerns are not as significant as current ones because the watershed has been mostly built out. The Water Quality Problem Scores shown on Figure 8-14 in Section 8 reflect the current and future problem severity scores combined with the resource value for an overall water quality problem score. Compared against all other Phase 1 watersheds, the overall level of concern for Harper's Branch ranges from "Very Low" to "Moderate." The Current Water Quality Score for Harper's Branch is depicted in Figure A-26. Current scores reflect existing water quality conditions, and are all in the "Very Low" to "High" range. Figure A-27 shows the breakout by creek reach of the overall water quality problem score for Harper's Branch.

Watershed Solutions

Harper's Branch has the characteristics of an urbanized watershed, with a high existing impervious cover level, and thus a lower potential for future development when compared to developing or rural watersheds with lower impervious cover. Infill and redevelopment are the most likely sources of future increases in impervious cover. Harper's Branch has already experienced significant channel enlargement in the past, and estimates of future enlargement are predictably low (less than 25%). Undeveloped land available for new regional scale erosion, flood or water quality ponds is severely limited. Large-scale erosion detention ponds are generally not considered effective solutions because most of the preventable creek enlargement has already occurred. Efforts in Harper's Branch should focus on channel restoration including sideslope stabilization, property buyouts, and riparian restoration, together with retrofits of existing ponds for water quality and erosion benefits, public education, and low impact development (LID) techniques. The LID approach is a relatively new one, and focuses on smaller-scale projects that utilize open space and landscaped areas for detaining and/or infiltrating runoff. In addition to reducing pollutant loads, water quality solutions should be designed to augment baseflow and improve stream habitat quality and stability. Flood solutions are likely to include property buyouts, bridge replacement or channel improvements. However, flood detention may be an alternative where sufficient open space is available.

Johnson Creek

General Characteristics

The Johnson Creek Watershed is one of the City's smaller urban watersheds. From its confluence with Town Lake just east of Loop 1 (MoPac), the watershed stretches northward to encompass nearly 1.7 square miles of west central Austin. The watershed is found in the area straddling Loop 1 (MoPac) from Town Lake north almost to 45th Street. MoPac Expressway divides the Johnson Creek Watershed along almost its entire length.

Flood Problem Summary

Flood assessments were performed for the Phase I watersheds. As documented in the Flood Control Needs Assessment Models Study (Loomis & Moore 1997), Loomis & Moore conducted hydrologic and hydraulic modeling for the primary drainage system of the Johnson Creek Watershed. Modeling was performed for the main stem of Johnson Creek and the Possum Trot Branch tributary. Flooding problems are quite sparse and of low severity when compared to other Phase I watersheds. All creek reaches are rated as either "Low" or "Very Low" problem areas when compared to flooding problems in the rest of the Phase I watersheds. Overall Flood problem scores are depicted in Figure 8-15 in Section 8.

The determination of problem areas in the secondary drainage system is currently based on the analysis of customer drainage complaints. Approximately 180 drainage complaints were located in the Johnson Creek Watershed. Localized flooding complaints are located throughout the entire watershed.

Erosion Problem Summary

The Johnson Creek Watershed Erosion Assessment (RCA 1997) presents detailed erosion data for the primary drainage system including Johnson Creek and Possum Trot Branch.

Erosion problem ratings were based on the number and type of structures threatened by creekbank erosion, the severity of the erosion threat, and by the estimated future stability of the creek. Along Johnson Creek, there were no *Type 1* (threatened house, building or road) erosion problem sites identified. *Type 2* (other resources threatened) and *Type 3* (resources threatened by future erosion) problem areas are scattered along Johnson Creek and Possum Trot Branch, on the main stem in Reach 1 from Town Lake to 7^{th} St, and Reach 5 from Woodmont Ave. to Windsor Road, as well as along Possum Trot Branch in Reach 2 from Menden Lane to Possum Trot Trail. Of the ten erosion reaches in Johnson Creek watershed, nine of the reaches were identified with "Very Low" erosion problem ratings, and one reach was classified with "Low" erosion problem ratings. Future channel expansion predictions for the watershed have all the segments in one of two categories, "Very Low" (0%) or "Low" (0-40%). Figure 8-15 in Section 8 shows the overall erosion problem score by creek reach for Johnson Creek. The overall problem score includes components for current erosion problems, depicted by Type 1 and 2 problems, as well as components for future erosion problems, depicted by Type 3 problems, and Future Reach Stability. The Current Erosion Problem Score is depicted Figure A-28.

Water Quality Problem Summary

The water quality of Johnson Creek has been significantly impacted by urban development. Water quality problem area determinations are based on Environmental Integrity Index (EII) scores, future predicted changes in water quality and hydrology, and the watershed's contribution of pollutants to Town Lake. The primary indicator of current water quality conditions is the EII, which measures chemical, biological, physical, recreational, and aesthetic conditions. The EII problem score is based on the gap between the EII goal and the current EII score, for the four sampling sites in the creek. Three of the four sites -- collectively running from Tarrytown to 1st St -- are currently rated as "Poor" and the final site -- in South Tarrytown -- is currently rated as "Fair." The goal for these four segments is "Good." Future problem concerns are much less significant than current ones as the watershed has been mostly built out. The Water Quality Problem Scores shown on Figure 8-15 in Section 8 reflect the current and future problem severity scores combined with the resource value for an overall water quality problem score. Compared against all other Phase 1 watersheds, the overall level of concern for Johnson Creek ranges from "Low" to "High." The Current Water Quality Score for Johnson Creek is depicted in Figure A-29. Current scores reflect existing water quality conditions, and range from "Low" to "Very High. Figure A-30 shows the breakout by creek reach of the overall water quality problem score for Johnson Creek.

Watershed Solutions

Johnson Creek has the characteristics of an urbanized watershed, with a high existing impervious cover level, and thus a lower potential for future development when compared to developing or rural watersheds with lower impervious cover. Infill and redevelopment are the most likely sources of future increases in impervious cover.

Johnson Creek has already experienced significant channel enlargement in the past, and estimates of future enlargement are predictably low (less than 25%). Undeveloped land available for new regional scale erosion, flood or water quality ponds is severely limited. Large-scale erosion detention ponds are generally not considered effective solutions because most of the preventable creek enlargement has already occurred. Efforts in Johnson Creek should focus on channel restoration including sideslope stabilization, property buyouts, and riparian restoration, together with retrofits of existing ponds for water quality and erosion benefits, public education, and low impact development (LID) techniques. The LID approach is a relatively new one, and focuses on smaller-scale projects that utilize open space and landscaped areas for detaining and/or infiltrating runoff. In addition to reducing pollutant loads, water quality solutions should be designed to augment baseflow and improve stream habitat quality and stability. Flood solutions are likely to include property buyouts, bridge replacement or channel improvements. However, flood detention may be an alternative where sufficient open space is available.

Little Walnut Creek

General Characteristics

The Little Walnut Creek Watershed is one of the City's larger urban watersheds. The watershed is found in the area just south and east of the intersection of Burnet Rd. and Braker Ln. It reaches as far east as Dessau Rd. and Ed Bluestein Blvd. (Highway 183) and as far south as 51^{st} St.

Flood Problem Summary

Flood assessments were performed for the Phase I watersheds. As documented in the Flood Control Needs Assessment Models Study (Loomis & Moore 1997), Loomis & Moore conducted hydrologic and hydraulic modeling for the primary drainage system of the Little Walnut Creek Watershed. Modeling was performed for the main stem of Little Walnut Creek, the Quail Branch Tributary, and Tributaries 1, 2, 3, 4, 5, and 6. One area was classified with a "Very High" flood problem rating, located on the main stem from

Mearns Meadow to Quail Valley Blvd. Three areas along the main stem were classified with a "Moderate" flood problem rating, and one area in the Quail Creek Branch near Rigsby Park, and one area on Tributary 4 at the confluence with the main stem near Cameron Road, were also classified with a "Moderate" flood problem rating. The remaining creek reaches are rated as either "Low," or "Very Low" problem areas when compared to flooding problems in the rest of the Phase I watersheds. Overall Flood problem scores are depicted in Figure 8-16 in Section 8.

The determination of problem areas in the secondary drainage system is currently based on the analysis of customer drainage complaints. Approximately 700 drainage complaints were located in the Little Walnut Creek Watershed. The majority of the localized flooding complaints are located the far upstream and far downstream ends of the watershed.

Erosion Problem Summary

The Little Walnut Creek Watershed Erosion Assessment (RCA 1997) presents detailed erosion data for the primary drainage system including Little Walnut Creek, the Quail Branch Tributary, and the Little Walnut Creek Tributary 2. Erosion problem ratings were based on the number and type of structures threatened by creekbank erosion, the severity of the erosion threat, and by the estimated future stability of the creek. One *Type 1* (threatened house, building or road) erosion problem site, a threatened roadway, was identified in Reach 9 from Creek Parkway to Parkfield Drive. Numerous Type 2 (other resources threatened) and Type 3 (resources threatened by future erosion) erosion problems sites were identified scattered throughout the watershed. Of the 22 erosion reaches in Little Walnut Creek, the majority of reaches were classified with a "Low" or "Very Low" erosion problem rating. Reach 9 between Creek Pkwy and Parkfield Dr. was classified with a "Very High" erosion problem rating. Under future conditions the channel expansion is predicted to be "Low" (less than 40%) for all of the reaches in the watershed. Figure 8-16 in Section 8 shows the overall erosion problem score by creek reach for Little Walnut Creek. The overall problem score includes components for current erosion problems, depicted by Type 1 and 2 problems, as well as components for future erosion problems, depicted by Type 3 problems, and Future Reach Stability. The Current Erosion Problem Score is depicted in Figure A-31.

Water Quality Problem Summary

The water quality of Little Walnut Creek has been impacted by urbanization but the creek still retains a number of desirable characteristics. Water quality problem area determinations are based on Environmental Integrity Index (EII) scores, future predicted changes in water quality and hydrology, and the watershed's contribution of pollutant loads to the Colorado River below Town Lake. The primary indicator of current water quality conditions is the EII, which measures chemical, biological, physical, recreational, and aesthetic conditions. The EII problem score is based on the gap between the EII goal and the current EII score, for the four sampling sites in the creek. Two of the sites (at US 290 and at Golden Meadow Rd) are currently rated as "Fair" with a goal of "Good". The remaining two sites (at US 183 and at Hermitage Rd) are currently rated as "Good" with a goal of "Very Good." Because development is still occurring in the watershed, some concerns exist about future water quality and hydrology conditions. The Water Quality Problem Scores shown Figure 8-16 in Section 8 for Little Walnut Creek reflect the current and future problem severity scores combined with the resource value for an overall water quality problem score. Compared against all other Phase 1 watersheds, the overall level of concern for Little Walnut Creek ranges from "Very Low" to "Low." The Current Water Quality Score for Little Walnut Creek is depicted in Figure A-32. Current scores reflect existing water quality conditions, and range from "Very Low" to "Low. Figure A-33 shows the breakout by creek reach of the overall water quality problem score for Little Walnut Creek.

Watershed Solutions

Little Walnut Creek has the characteristics of an urbanized watershed, with a high existing impervious cover level, and thus a lower potential for future development when compared to developing or rural watersheds with lower impervious cover. Infill and redevelopment are the most likely sources of future increases in impervious cover. Little Walnut Creek has already experienced significant channel enlargement in the past, and estimates of future enlargement are predictably low (less than 25%). Undeveloped land available for new regional scale erosion, flood or water quality ponds is severely limited. Large-scale erosion detention ponds are generally not considered effective solutions because most of the preventable creek enlargement has already occurred. Efforts in Little Walnut Creek should focus on channel restoration including sideslope stabilization, property buyouts, and riparian restoration, together with retrofits of existing ponds for water quality and erosion benefits, public education, and low impact development (LID) techniques. The LID approach is a relatively new one, and focuses on smaller-scale projects that utilize open space and landscaped areas for detaining and/or infiltrating runoff. In addition to reducing pollutant loads, water quality solutions should be designed to augment baseflow and improve stream habitat quality and stability. Several retrofit projects have been implemented are underway in the watershed, including the Rutland/Rundberg detention/sedimentation pond, and the Betty Cook and Met 94 wet ponds. Flood solutions are likely to include property buyouts, bridge replacement or channel improvements. However, flood detention may be an alternative where sufficient open space is available.

Shoal Creek

General Characteristics

The Shoal Creek Watershed is the largest of the city's urban watersheds. From its confluence with Town Lake near the Green Water Treatment Plant, the watershed stretches northward to encompass nearly 13 square miles of central Austin. The watershed is bordered roughly on the west by Loop 1 (MoPac) and on the east by Guadalupe St. and Lamar Blvd. North of Hancock Drive, the watershed extends west of MoPac and parallels the MoPac corridor to the watershed's northern boundary near Braker Lane and the J.J. Pickle Research Center. The Northern Edwards Aquifer Recharge Zone extends throughout the portion of the watershed west of MoPac.

Flood Problem Summary

Flood assessments were performed for the Phase I watersheds. As documented in the Flood Control Needs Assessment Models Study (Loomis & Moore 1997), Loomis & Moore conducted hydrologic and hydraulic modeling for the primary drainage system of the Shoal Creek Watershed. Modeling was performed for the main stem of Shoal Creek and the Foster and Hancock Branch tributaries. Flooding problems occur in the main stem of Shoal Creek and along the Foster and Hancock Branch Tributaries, but most severely along the main stem south of 15th St. Shoal Creek main stem between West 5th St. and West 15th St. is rated as a "Very High" problem area while Reach 1 of the Hancock Branch -- from Hillwin Cir. to Hancock Dr. -- is rated as "Moderate." The area along the main stem of Shoal Creek near Steck Lane is also classified as "Moderate". The remaining creek reaches are rated as either "Low" or "Very Low" problem areas when compared to flooding problems in the rest of the Phase I watersheds. Overall Flood problem scores are depicted in Figure 8-17 in Section 8.

The determination of problem areas in the secondary drainage system is currently based on the analysis of customer drainage complaints. Approximately 750 complaints were located in the Shoal Creek Watershed. The localized flooding complaints are located throughout the majority of the watershed.

Erosion Problem Summary

The Shoal Creek Watershed Erosion Assessment (RCA 1997) presents detailed erosion data for the primary drainage system including Shoal Creek and the Hancock Branch Tributary. Erosion problem ratings were based on the number and type of structures threatened by creekbank erosion, the severity of the erosion threat, and by the estimated future stability of the creek. Along Shoal Creek, one (1) *Type 1* (threatened house, building or road) erosion problem site was identified in Reach 3 from West 4th St to Martin Luther King Blvd. *Type 2* (other resources threatened) and *Type 3* (resources threatened by future erosion) problem areas are scattered along Shoal Creek and Hancock Branch. Reach 5, Windsor Rd. to West 29th St., and Reach 7 West 34th St. to West 45th St. have more *Type 2* and *Type 3* sites than other reaches. Of the 18 erosion reaches in

Shoal Creek, the majority were identified as "Low" or "Very Low" erosion problem areas. Reach 3 was rated a "Very High" problem area at the time the erosion assessments were done. The *Type 1* problem in this reach has been fixed since the onset of the Master Plan, which lowered the problem score to a "Moderate" due to the number of *Type 2* and *3* problems remaining in the reach. All reaches in the watershed are predicted to have a "Low" (0-40%) future channel expansion prediction except for the top portion of the watershed, from Foster Lane to U.S. Hwy 183, which has a Medium (40-100%) future channel expansion prediction. Figure 8-17 in Section 8 shows the overall erosion problem score by creek reach for Shoal Creek. The overall problem score includes components for current erosion problems, and include Type 1 and 2 problems, as well as components for future erosion problems, depicted by Type 3 problems, and Future Reach Stability. The Current Erosion Problem Score is depicted in Figure A-34.

Water Quality Problem Summary

The water quality of Shoal Creek has been impacted by urbanization but the creek still retains some desirable characteristics. Water quality problem area determinations are based on Environmental Integrity Index (EII) scores, future predicted changes in water quality and hydrology, and the watershed's contribution of pollutant loads to Town Lake. The primary indicator of current water quality conditions is the EII, which measures chemical, biological, physical, recreational, and aesthetic conditions. The EII problem score is based on the gap between the EII goal and the current EII score, for the four sampling sites in the creek. Two of the sites -- above Crosscreek Dr. and Edge Ct. to 24th St. -- are currently rated as "Fair," and one site -- above 1st St. -- is currently rated as "Marginal." The goal for these three sites is "Good." The remaining site -- Crosscreek Dr. to Edge Ct. -- is currently rated as "Good" with a goal of "Very Good." Future problem concerns are not as significant as current ones as the watershed has been mostly built out. The Water Quality Problem Scores shown on Figure 8-17 in Section 8 for Shoal Creek reflect the current and future problem severity scores combined with the resource value for an overall water quality problem score. Compared against all other Phase 1 watersheds, the overall level of concern for Shoal Creek ranges from "Low" to "Moderate." The Current Water Quality Score for Shoal Creek is depicted in Figure A-35 score for Shoal Creek. Figure A-36 shows the breakout by creek reach of the overall water quality problem score for Shoal Creek.

Watershed Solutions

Shoal Creek has the characteristics of an urbanized watershed, with a high existing impervious cover level, and thus a lower potential for future development when compared to developing or rural watersheds with lower impervious cover. Infill and redevelopment are the most likely sources of future increases in impervious cover. Shoal Creek has already experienced significant channel enlargement in the past, and estimates of future enlargement are predictably low (less than 25%). Undeveloped land available for new regional scale erosion, flood or water quality ponds is severely limited. Large-scale erosion detention ponds are generally not considered effective solutions because most of the preventable creek enlargement has already occurred. Efforts in Shoal Creek should focus on channel restoration including sideslope stabilization, property buyouts, and riparian restoration, together with retrofits of existing ponds for water quality and erosion benefits, public education, and low impact development (LID) techniques. The LID approach is a relatively new one, and focuses on smaller-scale projects that utilize open space and landscaped areas for detaining and/or infiltrating runoff. In addition to reducing pollutant loads, water quality solutions should be designed to augment baseflow and improve stream habitat quality and stability. Several retrofit projects have been implemented in the watershed, including the Thrushwood filtration pond, and the Far West, MoPac/Steck, and Upper Shoal wet ponds. Flood solutions are likely to include property buyouts, bridge replacement or channel improvements. However, flood detention may be an alternative where sufficient open space is available.

Tannehill Branch

General Characteristics

The Tannehill Branch Watershed is a moderate sized urban watershed. Its confluence is with Boggy Creek, which subsequently drains into the Colorado River. The watershed stretches from St. John's Ave. southward to Springdale Rd. to encompass 4 square miles of east Austin. The western border of the Tannehill Branch watershed is basically Airport Blvd. The intersection of Interstate 35 and Highway 290 is at the northern end of the Tannehill Branch Watershed.

Flood Problem Summary

Flood assessments were performed for the Phase I watersheds. As documented in the Flood Control Needs Assessment Models Study (Loomis & Moore 1997), Loomis & Moore conducted hydrologic and hydraulic modeling for the primary drainage system of the Tannehill Branch Watershed. Modeling was performed for the main stem of Tannehill Branch. Flooding problems occur in the lower main stem of Tannehill Branch, most severely between the confluence with Boggy Creek and Mark Street. Tannehill Branch between the confluence with Boggy Creek and Mark Street is rated as a "Very High" flooding problem area, while Tannehill Branch between Martin Luther King Blvd. and 12th St. is rated as a "Moderate" flooding problem area. The remaining creek reaches are rated as either "Low" or "Very Low" problem areas when compared to flooding problems in the rest of the Phase I watersheds. Overall Flood problem scores are depicted in Figure 8-18 in Section 8.

The determination of problem areas in the secondary drainage system is currently based on the analysis of customer drainage complaints. Approximately 250 complaints were located in the Tannehill Branch Watershed. The majority of the localized flooding complaints are in the vicinity of Givens Park and at the upstream end of the watershed.

Erosion Problem Summary

Watershed erosion assessments were performed for each of the Phase I watersheds. The Tannehill Branch Watershed Erosion Assessment (RCA 1997) presents detailed erosion data for the primary drainage system of the Tannehill Branch. Erosion problem ratings were based on the number and type of structures threatened by creekbank erosion, the severity of the erosion threat, and by the estimated future stability of the creek. Along Tannehill Branch, two (2) *Type 1* (threatened house, building or road) erosion problem sites were identified. Reach 5 from Martin Luther King Blvd. to Old Manor Rd., has a threatened bridge *Type 1* erosion site. Reach 7 from Berkman St. to I-35, has a threatened structure erosion problem site. *Type 2* (other resources threatened) and *Type 3* (resources threatened by future erosion) problem areas are scattered along Tannehill Branch with Reach 5 containing the largest number of problem sites. Of the thirteen erosion reaches in Tannehill Branch, all except two reaches were identified with "Very Low" erosion problem ratings. Reach 5, from MLK Blvd to 51st Street was classified with "Very High" erosion problem rating. Reach 7, from just north of Berkman to 1-35, was classified with a "High" Erosion Problem Rating. The future channel enlargement results for the Tannehill Branch Watershed indicate that channel expansion is predicted to be "Very Low" or "Low" (less than 40%). Figure 8-18 in Section 8 shows the overall erosion problem score by creek reach for Tannehill Branch. The overall problem score includes components for current erosion problems, depicted by Type 1 and 2 problems, as well as components for future erosion problems, depicted by Type 3 problems, and Future Reach Stability. The Current Erosion Problem Score is shown in Figure A-37.

Water Quality Problem Summary

The water quality of Tannehill Branch has been significantly impacted by urban development. Water quality problem area determinations are based on Environmental Integrity Index (EII) scores, future predicted changes in water quality and hydrology, and the watershed's contribution of pollutants to the Colorado River below Town Lake. The primary indicator of current water quality conditions is the EII, which measures chemical, biological, physical, recreational, and aesthetic conditions. The EII problem score is based on the gap between the EII goal and the current EII score, for the four sampling sites in the creek. Two of the sites – at Boggy Creek and at Bartholomew Park -- are currently rated as "Fair," and one – at Highland Mall -- is currently rated as "Marginal". The ideal goal rating for these three sites is "Good". The remaining sites – at Lovell Dr. -- is currently rated as "Good" with a goal of "Very Good." Future problem concerns are not as significant as current ones as the watershed has been mostly built out. The Water Quality Problem Scores shown on Figure 8-18 in Section 8 for Tannehill Branch reflect the current and future problem severity scores combined with the resource value for an overall water quality problem score. Compared against all other Phase 1 watersheds, the overall level of concern for Tannehill Branch ranges from "Very Low" to "Moderate." The Current Water Quality Score for Tannehill Branch is depicted in Figure A-38. Current scores reflect existing water quality conditions, and range from "Very Low" to "Moderate. Figure A-39 shows the breakout by creek reach of the overall water quality problem score for Tannehill Branch.

Watershed Solutions

Tannehill Branch has the characteristics of an urbanized watershed, with a high existing impervious cover level, and thus a lower potential for future development when compared to developing or rural watersheds with lower impervious cover. Infill and redevelopment are the most likely sources of future increases in impervious cover. Tannehill Branch has already experienced significant channel enlargement in the past, and estimates of future enlargement are predictably low (less than 25%). Undeveloped land available for new regional scale erosion, flood or water quality ponds is severely limited. Large-scale erosion detention ponds are generally not considered effective solutions because most of the preventable creek enlargement has already occurred. Efforts in Tannehill Branch should focus on channel restoration including sideslope stabilization, property buyouts, and riparian restoration, together with retrofits of existing ponds for water quality and erosion benefits, public education, and low impact development (LID) techniques. The LID approach is a relatively new one, and focuses on smaller-scale projects that utilize open space and landscaped areas for detaining and/or infiltrating runoff. In addition to reducing pollutant loads, water quality solutions should be designed to augment baseflow and improve stream habitat quality and stability. Flood solutions are likely to include property buyouts, bridge replacement or channel improvements. However, flood detention may be an alternative where sufficient open space is available.

Waller Creek

General Characteristics

The Waller Creek Watershed is the most developed of the City's urban watersheds. From its confluence with Town Lake just west of Interstate 35, the watershed stretches northward to encompass nearly 5.8 square miles of central Austin. The watershed is bordered on the west by Lamar Blvd. and on the east by Interstate 35. From the river, the watershed stretches north to the intersection of Highway 183 and Lamar Blvd.

Flood Problem Summary

Flood assessments were performed for the Phase I watersheds. As documented in the Flood Control Needs Assessment Models Study (Loomis & Moore 1997), Loomis & Moore conducted hydrologic and hydraulic modeling for the primary drainage system of the Waller Creek Watershed. Modeling was performed for the main stem of Waller Creek and the Hemphill Branch tributary. Flooding problems occur in the main stem of Waller Creek and along the Hemphill Branch Tributary. One area along the main stem of Waller Creek between E. 8th St. and E. 15th St. is rated as a "High" flooding problem area. Three areas are "Moderate", from E. 3rd St. to E. 8th St., from Park Blvd. to 46th Street, and from 51st Street to Skyview near Guadalupe. The remaining creek reaches are rated as either "Low" or "Very Low" problem areas when compared to flooding problems in the rest of the Phase I watersheds. Overall Flood problem scores are depicted on Figure 8-19 in Section 8.

The determination of problem areas in the secondary drainage system is currently based on the analysis of customer drainage complaints. Approximately 320 complaints were located in the Waller Creek Watershed. Localized flooding complaints are located throughout the entire watershed.

Erosion Problem Summary

The Waller Creek Watershed Erosion Assessment (RCA 1997) presents detailed erosion data for the primary drainage system. Erosion problem ratings were based on the number and type of structures threatened by creekbank erosion, the severity of the erosion threat, and by the estimated future stability of the creek. Watershed erosion assessments were performed for each of the Phase I watersheds. No *Type 1* (threatened house, building road) erosion problems were located on Waller Creek. *Type 2* (other resources threatened) and *Type 3* (resources threatened by future erosion) erosion problems were scattered throughout the watershed. Of the 12 erosion reaches in Waller Creek, all of the reaches were identified as "Low" or "Very Low" erosion problems. Based on Future conditions, all the reaches in the watershed are predicted to have a "Low" (0-40%) future channel enlargement. Figure 8-19 in Section 8 shows the overall erosion problem score by creek reach for Waller Creek. The overall problem score includes components for current erosion problems, depicted by Type 1 and 2 problems, as well as components for future erosion problems, depicted by Type 3 problems, and Future Reach Stability. The Current Erosion Problem Score is depicted in Figure A-40.

Water Quality Problem Summary

The water quality of Waller Creek has been impacted by urbanization but the creek still retains some desirable characteristics. Water quality problem area determinations are based on Environmental Integrity Index (EII) scores, future predicted changes in water quality and hydrology, and the watershed's contribution of pollutant loads to Town Lake. The primary indicator of current water quality conditions is the EII, which measures chemical, biological, physical, recreational, and aesthetic conditions. The EII problem score is based on the gap between the EII goal and the current EII score, for the four sampling sites in the creek. Two of the sites -- at 23rd St. and at Shipe Park -- are currently rated as "Fair" and one -- at Cesar Chavez -- is currently rated as "Marginal." The goal for these three sites is "Good". The remaining site -- at 51st St. -- is currently rated "Good" with a goal of "Very Good." Future problem concerns are not as significant as current ones because the watershed has been mostly built out. The Water Quality Problem Scores shown on Figure 8-19 in Section 8 for Waller Creek reflect the current and future problem severity scores combined with the resource value for an overall water quality problem score. Compared against all other Phase 1 watersheds, the overall level of concern for Waller Creek ranges from "Very Low" to "Moderate." The

Current Water Quality Score for Waller Creek is depicted in Figure A-41. Current scores reflect existing water quality conditions, and range from "Very Low" to "Moderate. Figure A-42 shows the breakout by creek reach of the overall water quality problem score for Waller Creek.

Watershed Solutions

Waller Creek has the characteristics of an urbanized watershed, with a high existing impervious cover level, and thus a lower potential for future development when compared to developing or rural watersheds with lower impervious cover. Infill and redevelopment are the most likely sources of future increases in impervious cover. Waller Creek has already experienced significant channel enlargement in the past, and estimates of future enlargement are predictably low (less than 25%). Undeveloped land available for new regional scale erosion, flood or water quality ponds is severely limited. Large-scale erosion detention ponds are generally not considered effective solutions because most of the preventable creek enlargement has already occurred. Efforts in Waller Creek should focus on channel restoration including sideslope stabilization, property buyouts, and riparian restoration, together with retrofits of existing ponds for water quality and erosion benefits, public education, and low impact development (LID) techniques. The LID approach is a relatively new one, and focuses on smaller-scale projects that utilize open space and landscaped areas for detaining and/or infiltrating runoff. In addition to reducing pollutant loads, water quality solutions should be designed to augment baseflow and improve stream habitat quality and stability. One retrofit completed in the watershed is the Central Park wet pond. Flood solutions are likely to include property buyouts, bridge replacement or channel improvements. However, flood detention may be an alternative where sufficient open space is available.

Walnut Creek

General Characteristics

The Walnut Creek Watershed is the largest of the City's suburban watersheds. From its confluence with Town Lake at the Colorado River Greenbelt, the watershed stretches northward to encompass nearly 56.5 square miles of central Austin. The watershed is bordered roughly on the west by Highway 183. The expansive watershed stretches north from the Colorado River all the way to the Travis and Williamson County borders, just east of Interstate 35.

Flood Problem Summary

Flood assessments were performed for the Phase I watersheds. As documented in the Flood Control Needs Assessment Models Study (Loomis & Moore 1997), Loomis & Moore conducted hydrologic and hydraulic modeling for the primary drainage system of the Walnut Creek Watershed. Modeling was performed for the main stem of Walnut Creek, Tributaries 1 through 11, Tar Branch, Ferguson Branch and Wells Branch tributaries. As shown on the maps provided, there are two flood control reaches rated as "Very High" flood control problem areas. Both are located on the main stem of Walnut Creek, one is the Austin Area Mobile Home Park just north of MLK Blvd along Johnny Morris Road, and the second is the Crystal Brook Neighborhood located just north of Loyola Lane. Four flood reaches on the main stem of Walnut Creek rated as "High", three of these were located in an area immediately north and south of Loyola Lane near the Crystal Brook Neighborhood, and one located just north of Dessau Lane along February Drive. The remaining creek reaches are rated as either "Moderate," "Low," or "Very Low" problem areas when compared to flooding problems in the rest of the Phase I watersheds. Overall Flood problem ratings are depicted on Figure 8-20 in Section 8.

The determination of problem areas in the secondary drainage system is currently based on the analysis of customer drainage complaints. Approximately 520 complaints were located in the Walnut Creek Watershed. The majority of the localized flooding complaints are located in a small area at the upper northwest end of the watershed.

Erosion Problem Summary

The <u>Walnut Creek Watershed Erosion Assessment</u> (RCA 1997) presents detailed erosion data for the primary drainage system. Watershed erosion assessments were performed for each of the Phase I watersheds. Erosion problem ratings were based on the number and type of structures threatened by creekbank erosion, the severity of the erosion threat, and by the estimated future stability of the creek. In the Walnut Creek watershed, two (2) *Type 1* (threatened house, building or road) erosion problem sites were identified. The first, a threatened minor road, is found in Reach 4 of the main stem between Purple Sage Dr. and Springdale Rd. Another *Type 1* site is located in Reach 2 of Wells Branch between Willow Wide Dr. and Parmer Ln. *Type 2* (other resources threatened) and *Type 3* (resources threatened by future erosion) problem areas are scattered along Walnut Creek and its tributaries throughout the watershed. Of the 46 erosion reaches in Walnut Creek watershed, two were given "Low" erosion problem ratings, two were rated "Very Low", 7 "Low", 17 "Moderate", 6 "High" and 14 "Very High". The top three ranked erosion problem reaches in the entire Phase I watersheds were located on Walnut Creek. One is located on the main stem of Walnut Creek from the Northeast District Park north to Hwy. 290 East. The other two reaches are located is along tributary 5, also known as Buttercup Branch, from Hwy. 290 north to the upper reaches of the tributary along Criswell Drive. Future channel enlargement predictions for the watershed have most of the reaches as "Very High" (160+%), with a few of the reaches within the main stem and tributaries predicted as "High" (100-160%) or "Medium (40-100%). Figure 8-20 in Section 8 shows the overall erosion problem score by creek reach for Walnut Creek. The overall problem score includes components for current erosion problems, depicted by Type 1 and 2 problems, as well as components for future erosion problems, depicted by Type 3 problems, and Future Reach Stability. The Current Erosion Problem Score is depicted in Figure A-43.

Water Quality Problem Summary

While some impacts to the water quality of Walnut Creek have occurred, this scenic and ecologically valuable creek retains many desirable characteristics, including base flow, riparian vegetation, aesthetics, and recreational qualities. Water quality problem area determinations are based on Environmental Integrity Index (EII) scores, future predicted changes in water quality and hydrology, and the watershed's contribution of pollutant loads to the Colorado River below Town Lake. The primary indicator of current water quality conditions is the EII, which measures chemical, biological, physical, recreational, and aesthetic conditions. The EII problem score is based on the gap between the EII goal and the current EII score, for the five sampling sites in the creek. The sites are located near Loyola Lane, Lamar Boulevard, IH 35, Springdale Road, and at the railroad bridge near the confluence with the Colorado River. All sites achieved "Good" scores, and have goals of "Very Good." Future problem concerns are very significant because the watershed is undergoing a rapid rate of development. The Water Quality Problem Scores shown on Figure 8-20 in Section 8 for Walnut Creek reflect the current and future problem severity scores combined with the resource value for an overall water quality problem score. Compared against all other Phase 1 watersheds, the overall level of concern for Walnut Creek ranges from "Low" to "High." The Current Water Quality Score for Walnut Creek is depicted in Figure A-44. Current scores reflect existing water quality conditions, and range from "Very Low" to "Moderate. Figure A-45 shows the breakout by creek reach of the overall water quality problem score for Walnut Creek.

Watershed Solutions

Walnut Creek has characteristics of a developing watershed with a moderate level of impervious cover, and a relatively high potential for future impervious cover increase (greater than 5%). Walnut Creek is experiencing accelerated creek erosion, and shows signs of channel instability with a predicted increase in channel size greater than 25%.

Flood solutions may include property buyouts, detention, bridge, or culvert replacement, and channel improvements. Construction of regional erosion detention facilities to provide erosion control is identified as an alternative, since the potential for future stream degradation due to channel instability is high. Sideslope stabilization measures are recommended to protect existing property threatened by creek erosion, but these measures will not be effective over the long-term if watershed-scale measures such as erosion detention ponds and stream corridor restoration are not implemented.

Water quality solutions being considered include regional ponds, retrofit of existing ponds, public education, and low impact development (LID) techniques. These solutions should be designed to improve both water quality and watershed hydrology in order to benefit all three WPD missions. The LID approach is a relatively new one, and focuses on smaller-scale projects that utilize open space and landscaped areas for detaining and/or infiltrating runoff.

West Bouldin Creek

General Characteristics

The West Bouldin Creek Watershed is one of the City's most populated urban watersheds. From its confluence with Town Lake Auditorium Shores, the watershed stretches southward to encompass nearly 2.9 square miles of central Austin. The watershed is bordered roughly on the west by Lamar Boulevard, which eventually cuts into the middle of the watershed, and on the east by South 1st St. North of Hwy 71 (Ben White Blvd.), the watershed extends north beyond Barton Springs Rd to its confluence at Auditorium Shores.

Flood Problem Summary

Flood assessments were performed for the Phase I watersheds. As documented in the Flood Control Needs Assessment Models Study (Loomis & Moore 1997), Loomis & Moore conducted hydrologic and hydraulic modeling for the primary drainage system of the West Bouldin Creek Watershed. Modeling was performed for the main stem of West Bouldin Creek and the North Fork Tributary. The worst flooding problems in the watershed is in area from West Live Oak to Cumberland Rd. (West Bouldin Mobile Home Park) which is rated as a "Very High" problem area. The lower portion of West Bouldin Creek from Town Lake to Post Oak St. is rated as a " High" problem area. The area from Birdwood Circle to S. Center St. reach is rated as "Moderate." The remaining reaches are rated as either "Low" or "Very Low" problem areas when compared to flooding problems in the rest of the Phase I watersheds. Overall Flood Problem Scores are depicted in Figure 8-21 in Section 8.

The determination of problem areas in the secondary drainage system is currently based on the analysis of customer drainage complaints. Approximately 250 complaints were located in the West Bouldin Creek Watershed. The majority of the localized flooding complaints are located at the upstream end of the watershed.

Erosion Problem Summary

The West Bouldin Creek Watershed Erosion Assessment (RCA 1997) presents detailed erosion data for the primary drainage system Watershed erosion assessments were performed for each of the Phase I watersheds. Erosion problem ratings were based on the number and type of structures threatened by creekbank erosion, the severity of the erosion threat, and by the estimated future stability of the creek. Along West Bouldin Creek, two (2) *Type 1* (threatened house, building or road) erosion problem sites were identified, one a threatened major road and one a threatened structure. Both *Type 1* erosion problems are found in Reach 2 between Jewell St. and West Mary St. *Type 2* (other resources threatened). *Type 3* (resources threatened by future erosion) problem areas are scattered along West Bouldin Creek, mainly in Reach 1 from Town Lake to Jewell St., and Reaches 2, and 4 from the Union Pacific RR to Taffy Court, with Reach 4 having only *Type 3* erosion problems. Of the six erosion reaches in West Bouldin Creek, all were identified as having "Very Low" erosion problem ratings, except Reach 2, between Jewell St. and West Mary St., which was rated a "Very High" problem area. The future channel expansion for all reaches within the watershed are predicted to be "Low" (0-40%). Figure 8-21 in Section 8 shows the overall erosion problem score by creek reach for West Bouldin Creek. The overall problem score includes components for current erosion problems, depicted by Type 1 and 2 problems, as well as components for future erosion problems, depicted by Type 3 problems, and Future Reach Stability. The Current Erosion Problem Score is depicted in Figure A-46.

Water Quality Problem Summary

The water quality of West Bouldin Creek has been significantly impacted by urban development. Water quality problem area determinations are based on Environmental Integrity Index (EII) scores, future predicted changes in water quality and hydrology, and the watershed's contribution of pollutants to Town Lake. The primary indicator of current water quality conditions is the EII, which measures chemical, biological, physical, recreational, and aesthetic conditions. The EII problem score is based on the gap between the EII goal and the current EII score, for the four sampling sites in the creek. Two of the sites -- at Riverside Dr. and at South Austin Park -- are currently rated as "Marginal," one -- at Jewell St. -- is currently rated as "Poor," and one -- at Guerrero Park -- is rated as "Fair." The goal for all four of these sites is "Good." Future problem concerns are not as significant as current ones because the watershed has been mostly built out. The Water Quality Problem Scores shown on Figure 8-21 in Section 8 for West Bouldin Creek reflect the current and future problem severity scores combined with the resource value for an overall water quality problem score. Compared against all other Phase 1 watersheds, the overall level of concern for West Bouldin Creek ranges from "Very Low" to "High." The Current Water Quality Score for West Bouldin Creek is depicted in Figure A-47. Current scores reflect existing water quality conditions, and range from "Very Low" to "High. Figure A-48 shows the breakout by creek reach of the overall water quality problem score for West Bouldin Creek.

Watershed Solutions

West Bouldin Creek, has the characteristics of an urbanized watershed, with a high existing impervious cover level, and thus a lower potential for future development when compared to developing or rural watersheds with lower existing impervious cover. West Bouldin Creek has already experienced significant channel enlargement in the past, and estimates of future enlargement are predictably low (less than 25%). Undeveloped land available for new regional scale erosion, flood or water quality ponds is severely limited. Large-scale erosion detention ponds are generally not considered effective solutions because most of the preventable creek enlargement has already occurred. Efforts in West Bouldin Creek should focus on channel restoration including sideslope stabilization, property buyouts, and riparian restoration, together with retrofits of existing ponds for water quality and erosion benefits, public education, and low impact development (LID) techniques. The LID approach is a relatively new one, and focuses on smaller-scale projects that utilize open space and landscaped areas for detaining and/or infiltrating runoff. In addition to reducing pollutant loads, water quality solutions should be designed to augment baseflow and improve stream habitat quality and stability. Flood solutions are likely to include property buyouts, bridge replacement or channel improvements. However, flood detention may be an alternative where sufficient open space is available.

Williamson Creek

General Characteristics

The Williamson Creek Watershed is the City's second largest suburban watershed, with Walnut Creek being the largest. Believed to have once been part of the Barton Creek watershed, the Williamson Creek watershed stretches across South Austin to encompass nearly 30.1 square miles. The watershed's southern border is found just north of Slaughter Lane, and the northern border is Southwest Parkway and Ben White Boulevard. The western border nearly reaches the intersection of Southwest Parkway and Highway 71 while the eastern border nearly reaches the intersection of Burleson Road and McKinney Falls Parkway. The upper reaches of the Williamson Creek recharge the Edwards Aquifer and Barton Springs.

Flood Problem Summary

Flood assessments were performed for the Phase I watersheds. As documented in the Flood Control Needs Assessment Models Study (Loomis & Moore 1997), Loomis & Moore conducted hydrologic and hydraulic modeling for the primary drainage system of the Williamson Creek Watershed. Modeling was performed for the main stem as well as the Cherry Creek, Sunset Valley, Motorola, Pleasant Hill, Scenic Brook, Kincheon Branch, and Wheeler Branch tributaries of Williamson Creek. Two areas received a "Very High" flood problem score. One is located on the main stem of Williamson Creek in the Creek Bend area from Pleasant Valley Road west to near Tee Wood Drive. The second area is also located on the main stem of Williamson Creek, just south of Jones Road from near the confluence with Cherry Creek Branch to the end of Reese Drive near Sunset Valley. Two areas received a "High" Flood problem score, one is a large area that includes a portion of the main stem of Williamson Creek running between Broken Bow and Arapaho south to Jones Road to the confluence with the Sunset Valley Tributary, and continuing on the Sunset Valley Tributary to Pillow Road in Sunset Valley. The second area is further west along the main stem, from near the confluence with the Motorola Tributary continuing along the main stem along McCarty Lane to just south of the intersection with 290 West. There are numerous areas that received a "Moderate" rating along both the Main stem and the Kincheon Branch of Williamson Creek. The highest concentration of creek flooding problems in the watershed occurs from Sunset Valley east to Congress Road. Overall Flood problem scores are depicted in Figure 8-22 in section 8.

The determination of problem areas in the secondary drainage system is currently based on the analysis of customer drainage complaints. Approximately 1,200 complaints were located in the Williamson Creek Watershed. The majority of the localized flooding complaints are located between Ben White and Manchaca.

Erosion Problem Summary

The Williamson Creek Watershed Erosion Assessment (RCA 1997) presents detailed erosion data for the primary drainage system. Watershed erosion assessments were performed for each of the Phase I watersheds. Erosion problem ratings were based on the number and type of structures threatened by creekbank erosion, the severity of the erosion threat, and by the estimated future stability of the creek. Along Williamson Creek and its tributaries, there were no *Type 1* (threatened house, building or road) erosion problem sites identified. *Type 2* (other resources threatened) and *Type 3* (resources threatened by erosion) erosion problem areas are scattered along Williamson Creek and its tributaries. The main stem of Williamson from just upstream of the confluence with St. Elmo tributary to Nuckols Crossing Rd. has the most *Type* 2 erosion problem sites, while the main stem area collectively from Nuckols Crossing Rd. to the intersection of Battle Bend Blvd. and Suburban Dr. has the most *Type* 3 erosion problems. Of the 22 erosion reaches in Williamson Creek watershed, seven were identified as having "Very Low" erosion problem ratings, and 12 had "Low" erosion problem ratings. Two reaches had "High" erosion problem ratings, both were located on the main stem of Williamson Creek, one near the confluence with Sunset Valley branch tributary, north of Jones Road to the end of Lone Oak Trail. The other reach rating "High" is located near the confluence with Onion Creek to Pleasant Valley Road. One reach rated "Very High", the St Elmo tributary, located from the confluence with the main stem south of Stassney to the upper reaches of the tributary along Governor's Row near the southeast intersection of I-35 and Hwy. The St. Elmo tributary is predicted to have "Very High" future channel enlargement. The Sunset Valley Branch is predicted to have a "Moderate" future channel enlargement. The remainder of the watershed is anticipated to have "Very Low" or "Low" future channel enlargement. Figure 8-22 in Section 8 shows the overall erosion problem score by creek reach for Williamson Creek. The overall problem score includes components for current erosion problems, depicted by Type 1 and 2 problems, as well as components for future erosion problems, depicted by Type 3 problems, and Future Reach Stability. The Current Erosion Problem Score is depicted in Figure A-49.

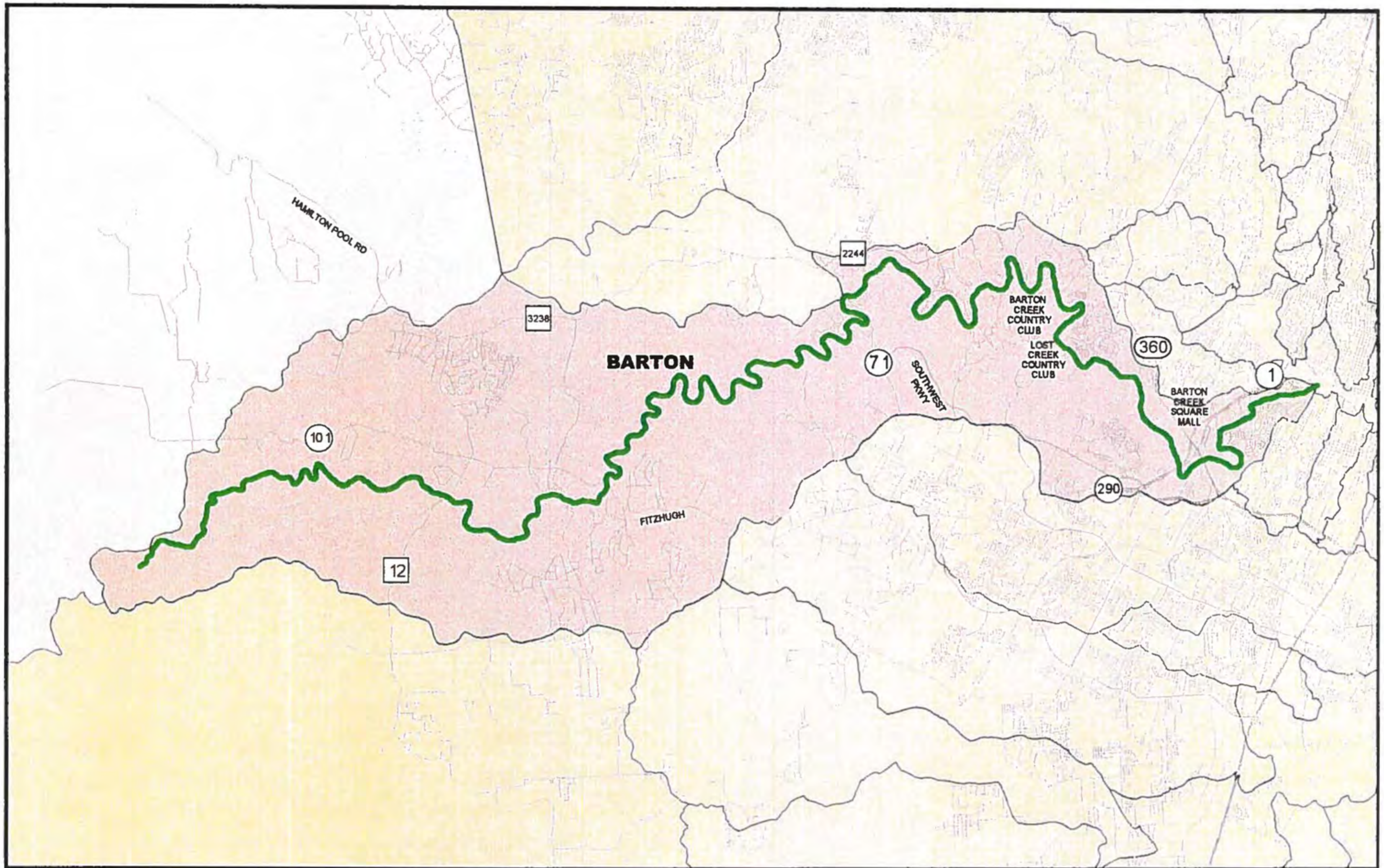
Water Quality Problem Summary

The water quality of Williamson Creek has been impacted by urban development. Water quality problem area determinations are based on Environmental Integrity Index (EII) scores, future predicted changes in water quality and hydrology, and the watershed's contribution of flow and pollutants to the Edwards Aquifer, Barton Springs and Pool, and McKinney Falls. The primary indicator of current water quality conditions is the EII, which measures chemical, biological, physical, recreational, and aesthetic conditions. The EII problem score is based on the gap between the EII goal and the current EII score, for the six sampling sites in the creek. Two of the sites – at McKinney Falls and at Pleasant Valley -- are currently rated as "Good" with a goal of "Very Good." One site -- at I-35 -- is currently rated as "Marginal," and the last three -- at Joe Tanner, at Hwy 71, and at Mowinkle -- are currently rated as "Fair." The goal for these sites is "Good." Because future development is still underway in much of the watershed, future impacts to water quality and hydrology may be significant. The Water Quality Problem Scores shown Figure 8-22 in Section 8 for Williamson Creek reflect the current and future problem severity scores combined with the resource value for an overall water quality problem score. Compared against all other Phase 1 watersheds, the overall level of concern for Williamson Creek ranges from "Low" to "High." The Current Water Quality Score for Williamson Creek is depicted in Figure A-50. Current scores reflect existing water quality conditions, and range from " Low" to "High. Figure A-51 shows the breakout by creek reach of the overall water quality problem score for Williamson Creek.

Watershed Solutions

Williamson Creek has characteristics of a developing watershed with a moderate level of impervious cover, and a relatively high potential for future impervious cover increase (greater than 5%). Williamson Creek is experiencing accelerated creek erosion, and shows signs of channel instability with a predicted increase in channel size greater than 25%. Flood solutions may include property buyouts, detention, bridge, or culvert replacement, and channel improvements. Construction of regional erosion detention facilities to provide erosion control is identified as a possible solution, since the potential for future stream degradation due to channel instability is high. Sideslope stabilization measures are recommended to protect existing property threatened by creek erosion, but these measures will not be effective over the long-term if watershed-scale measures such as erosion detention ponds and stream corridor restoration are not implemented. Water quality solutions being considered include regional ponds, retrofit of existing ponds, public education, and low impact development (LID) techniques. These solutions should be designed to improve both water quality and watershed hydrology in order to benefit all three WPD missions. The LID approach is a relatively new one, and focuses on smaller-scale projects that utilize open space and landscaped areas for detaining and/or infiltrating runoff.

APPENDIX A
FIGURES



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Plotted 2/13/01

Barton Creek Watershed
Current Errosion Problem Rating

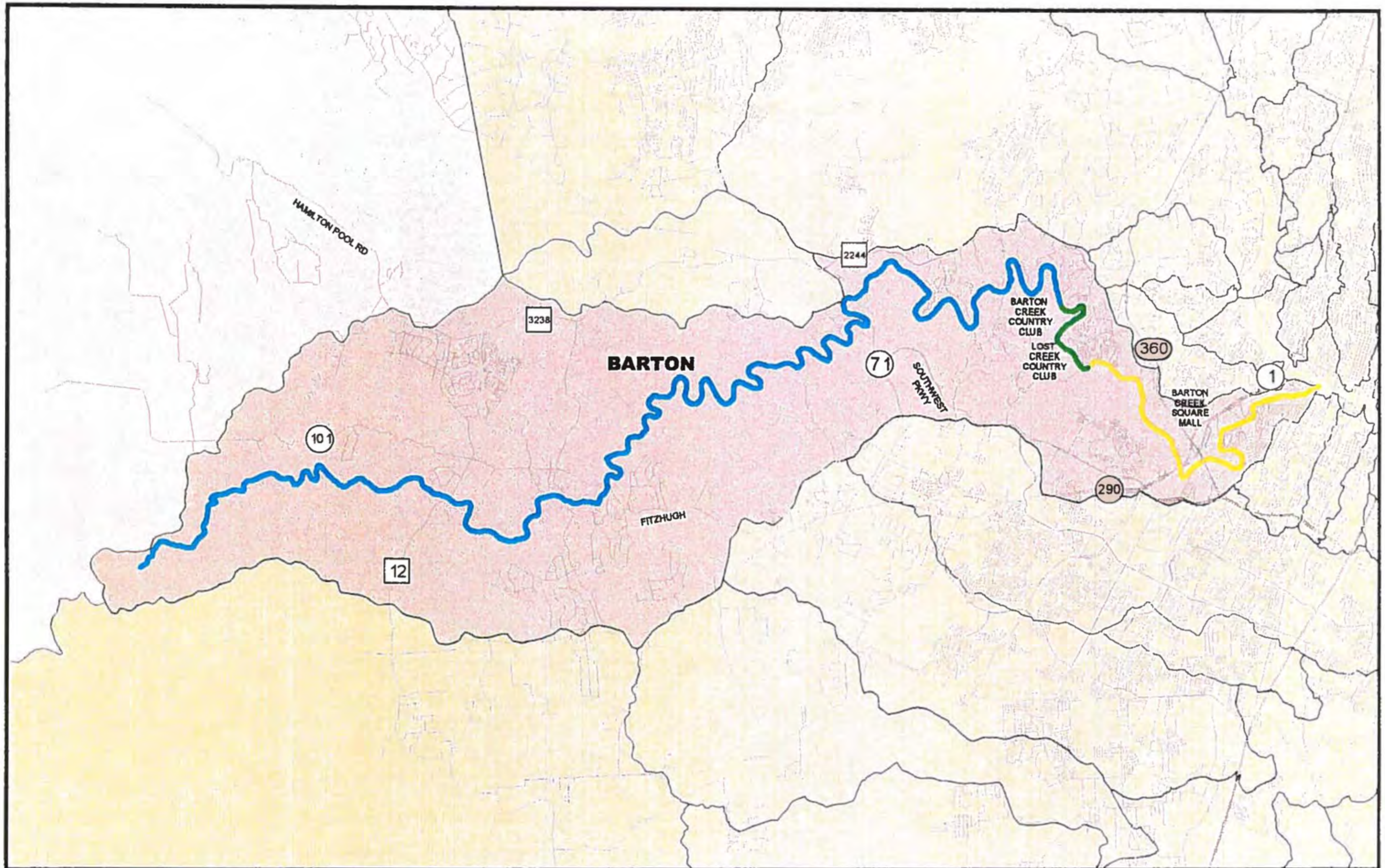
2 0 2 4 Miles

N

Figure A - 1

Current Erosion Problem Rating

- Very Low
- Low
- Moderate
- High
- Very High
- Lakes and Rivers
- Roads
- Phase 1 Watershed



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Barton Creek Watershed
Current Water Quality Problem Rating

2 0 2 4 Miles

N

Figure A - 2

Water Quality Rating
- Very Low
- Low
- Moderate
- High
- Very High
- Roads
- Lakes & Rivers
- Phase 1 Watersheds
- Austin Area Watersheds

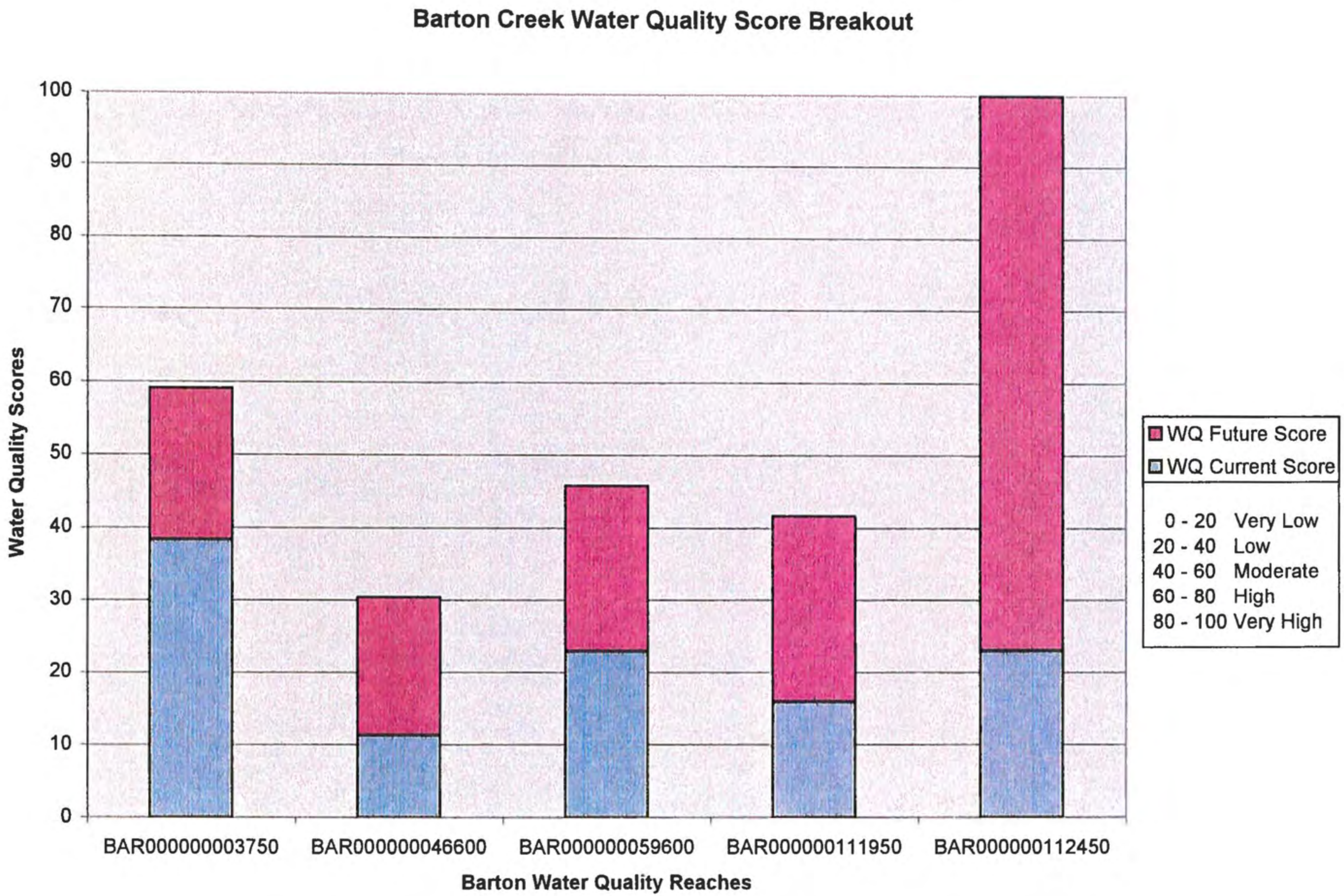
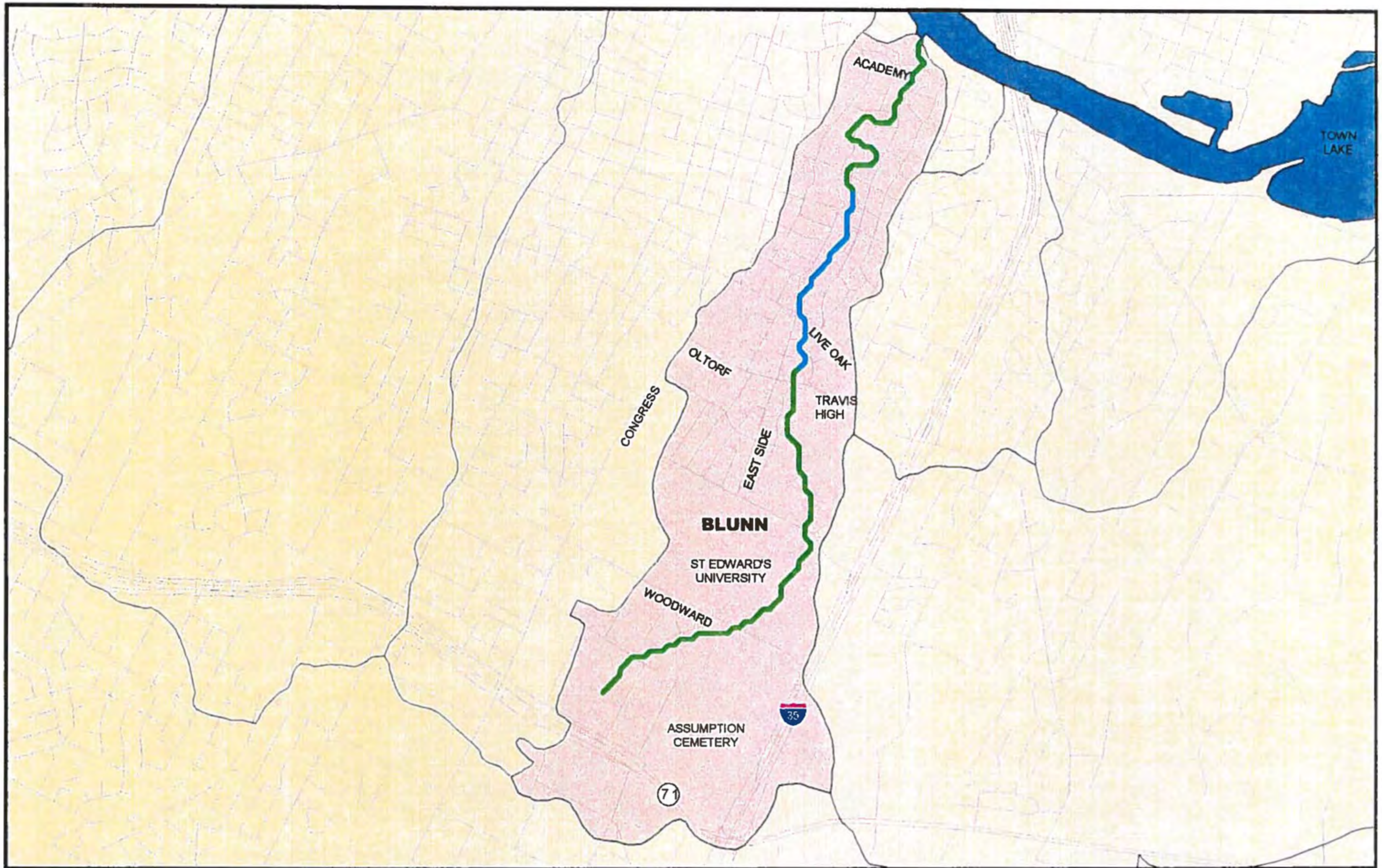

Barton Creek Water Quality Score Breakout
Water Quality Scores
100
90
80
70
60
50
40
30
20
10
0
BAR000000003750
BAR000000046600
BAR000000059600
BAR000000111950
BAR000000112450
Barton Water Quality Reaches
WQ Future Score
WQ Current Score
0 - 20 Very Low
20 - 40 Low
40 - 60 Moderate
60 - 80 High
80 - 100 Very High

Figure A - 3



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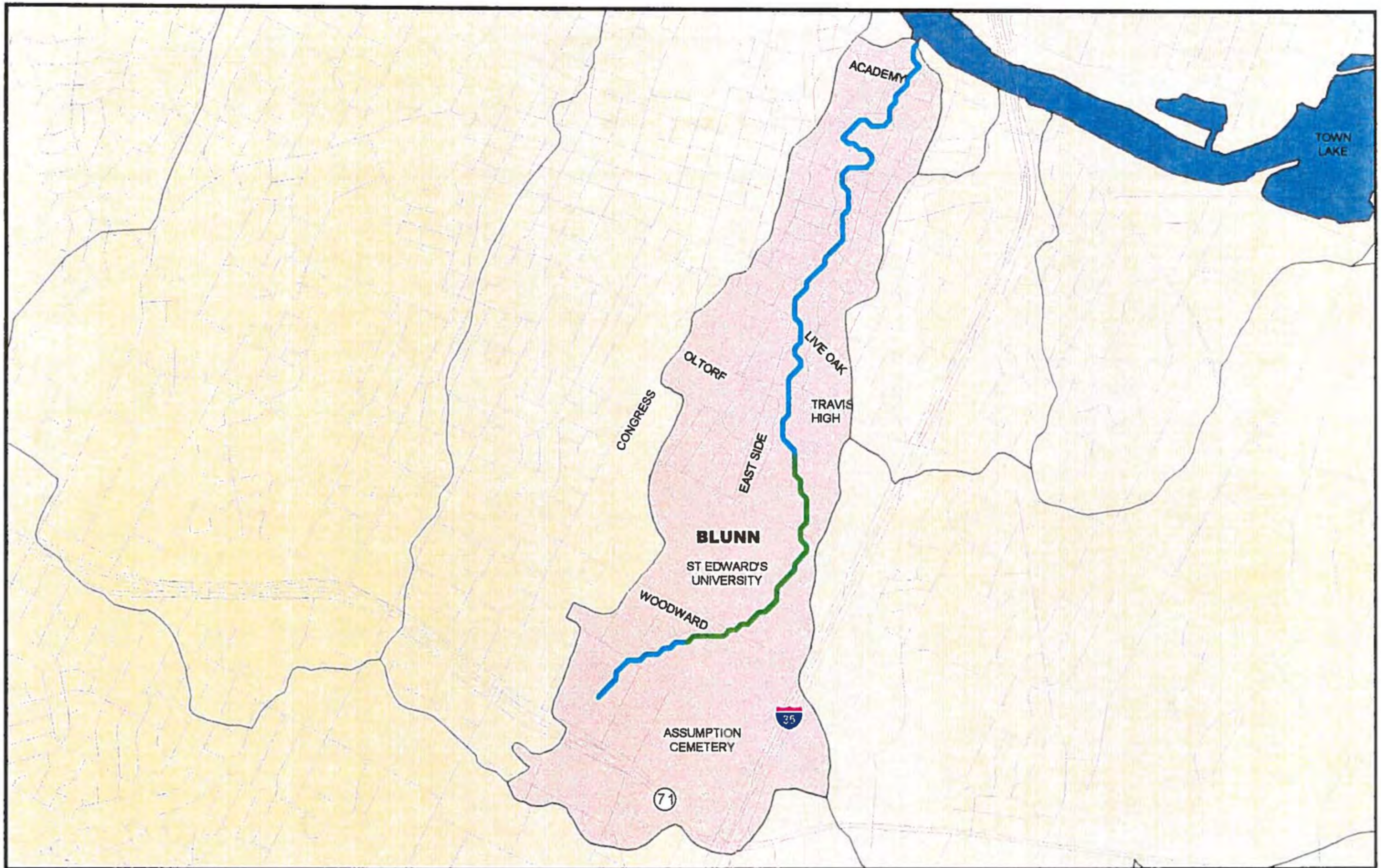
Blunn Creek Watershed
Current Erosion Problem Rating

0.3 0 0.3 0.6 Miles

N

Figure A - 4

Current Erosion Problem Rating
- Very Low
- Low
- Moderate
- High
- Very High
- Lakes and Rivers
- Roads
- Phase 1 Watershed
- Austin Area Watersheds



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Blunn Creek Watershed
Current Water Quality Problem Rating

0.3 0 0.3 0.6 Miles

N

Figure A - 5

Water Quality Rating
- Very Low
- Low
- Moderate
- High
- Very High
- Roads
- Lakes & Rivers
- Phase 1 Watersheds
- Austin Area Watersheds

Blunn Creek Water Quality Score Breakout

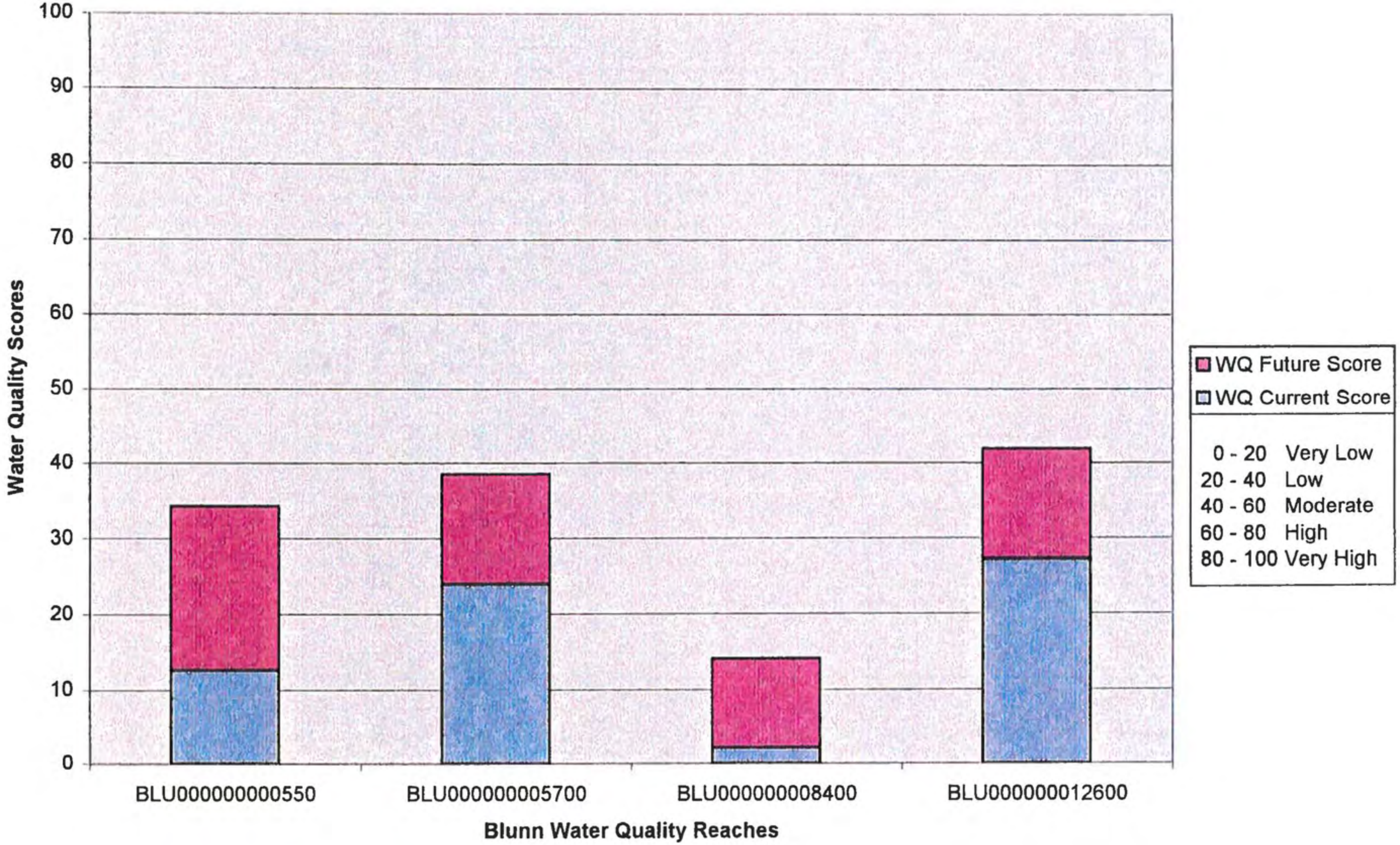
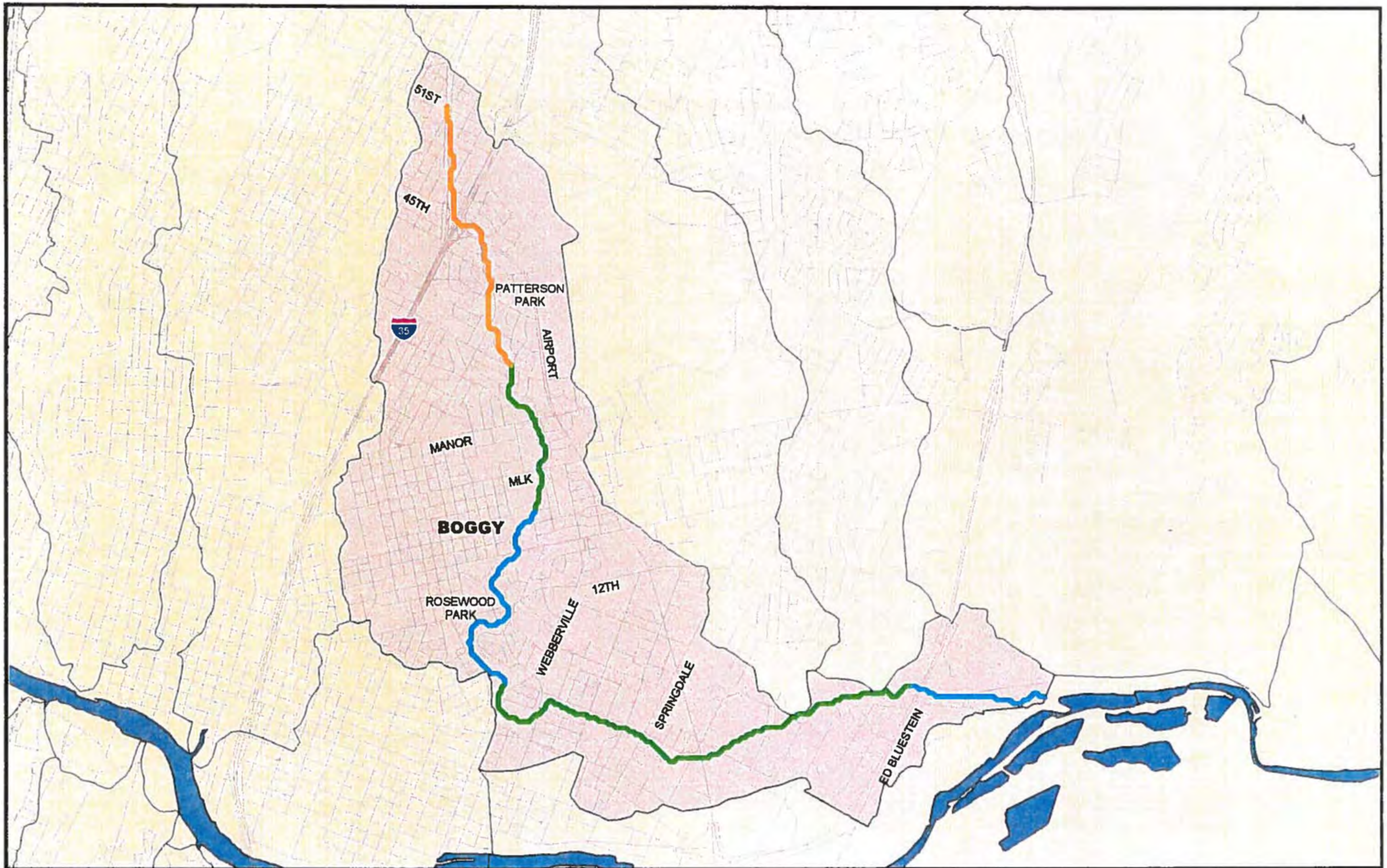


Figure A - 6



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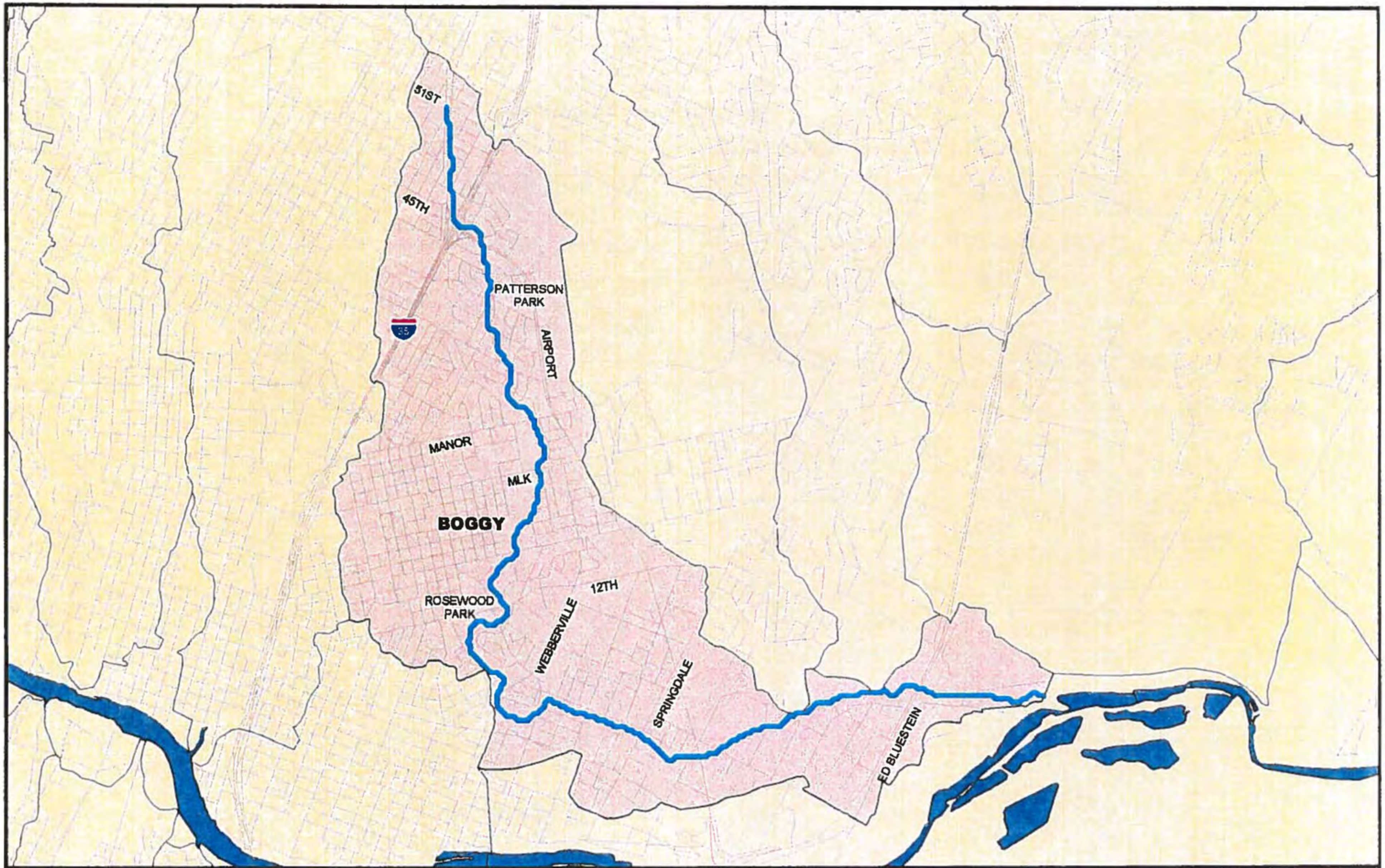
Boggy Creek Watershed
Current Erosion Problem Rating

1 0 1 Miles

N

Figure A - 7

Current Erosion Problem Rating
- Very Low
- Low
- Moderate
- High
- Very High
- Lakes and Rivers
- Roads
- Phase 1 Watershed
- Austin Area Watersheds



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Boggy Creek Watershed
Current Water Quality Problem Rating

1 0 1 Miles

N

Figure A - 8

Water Quality Rating
- Very Low
- Low
- Moderate
- High
- Very High
- Roads
- Lakes & Rivers
- Phase 1 Watersheds
- Austin Area Watersheds

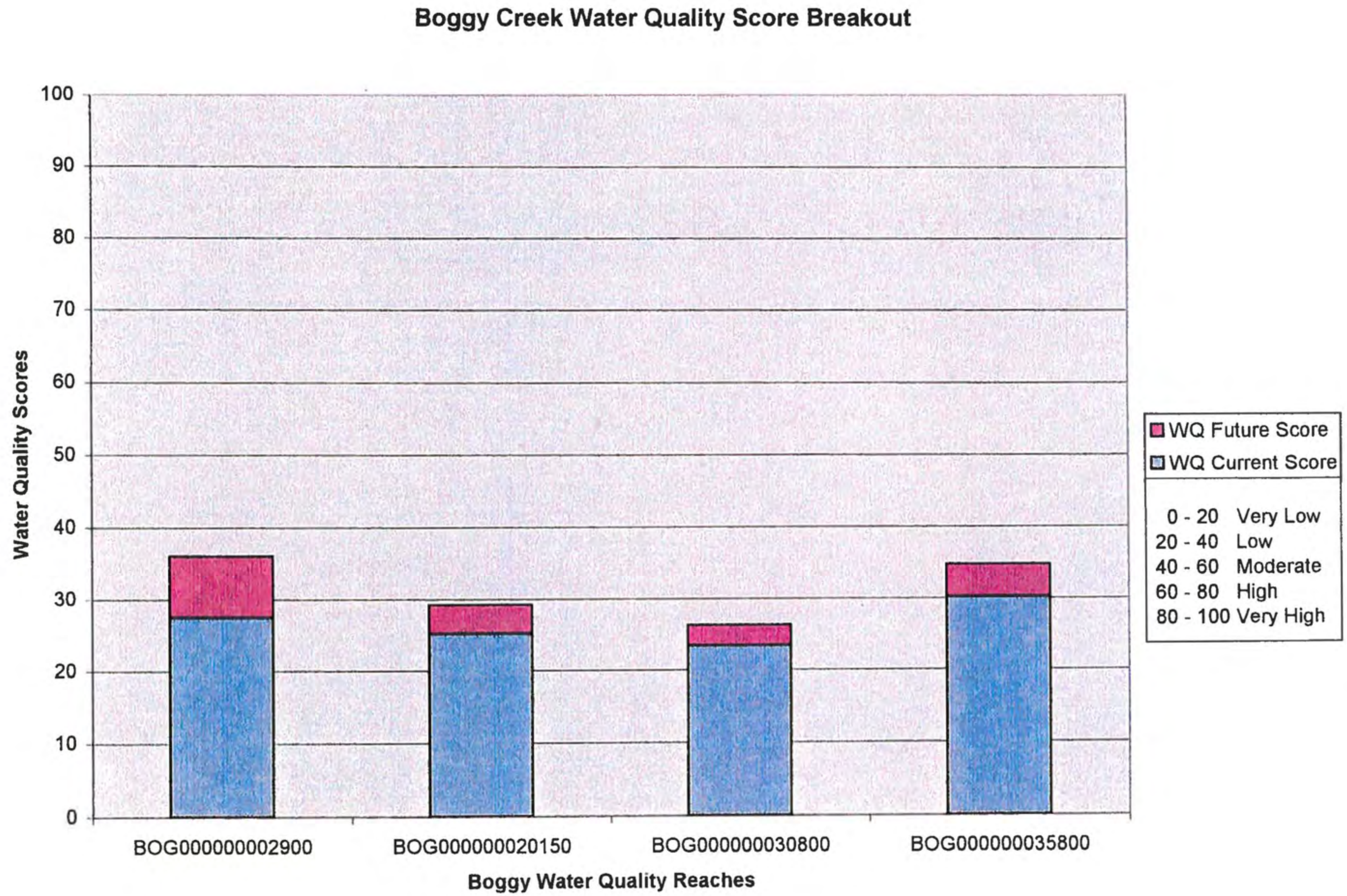
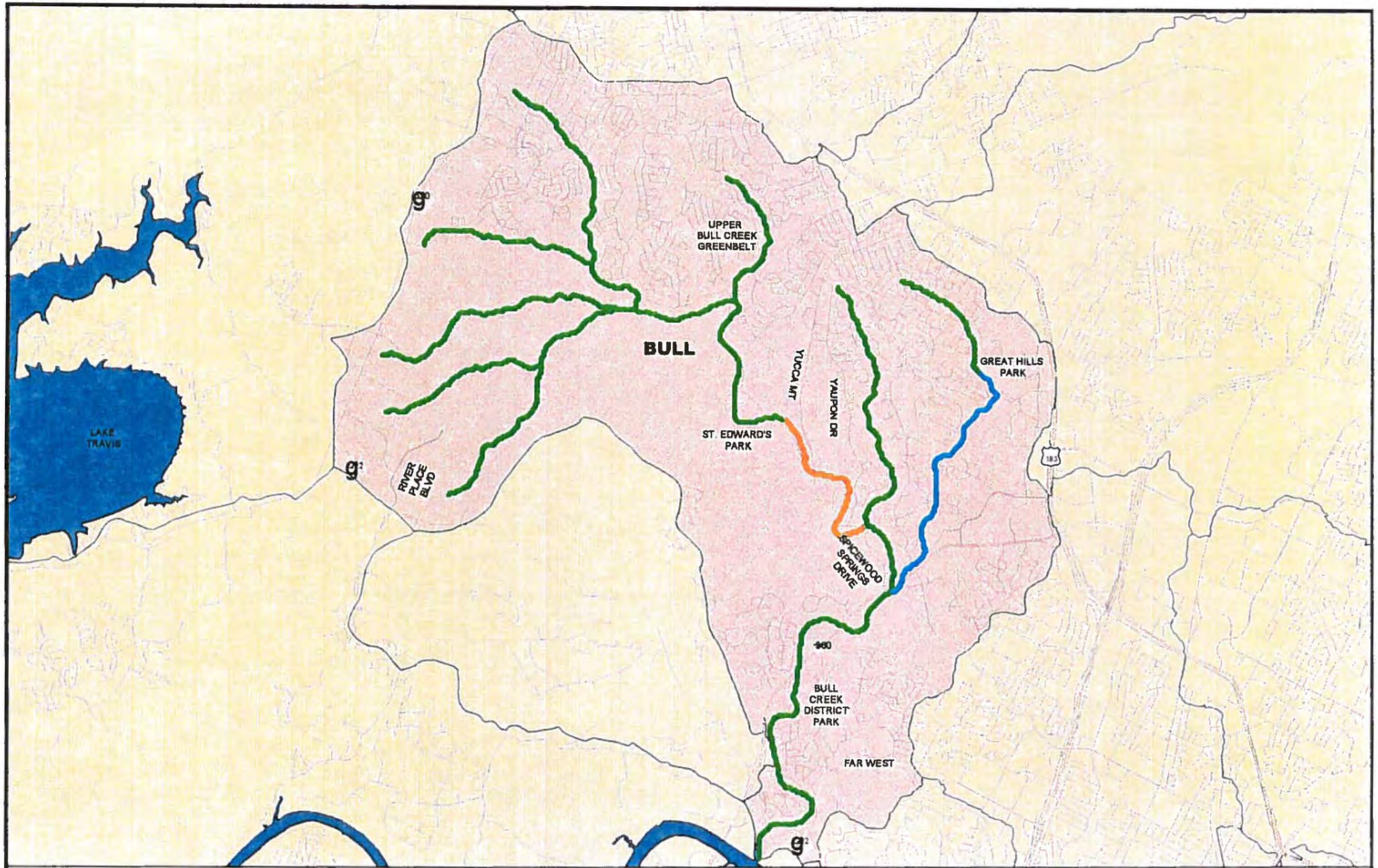

Boggy Creek Water Quality Score Breakout
100
90
80
70
60
50
40
30
20
10
0
Water Quality Scores
WQ Future Score
WQ Current Score
0 - 20 Very Low
20 - 40 Low
40 - 60 Moderate
60 - 80 High
80 - 100 Very High
BOG000000002900
BOG000000020150
BOG000000030800
BOG000000035800
Boggy Water Quality Reaches

Figure A - 9



Bull Creek Watershed
Current Erosion Problem Rating

1 0 1 2 Miles

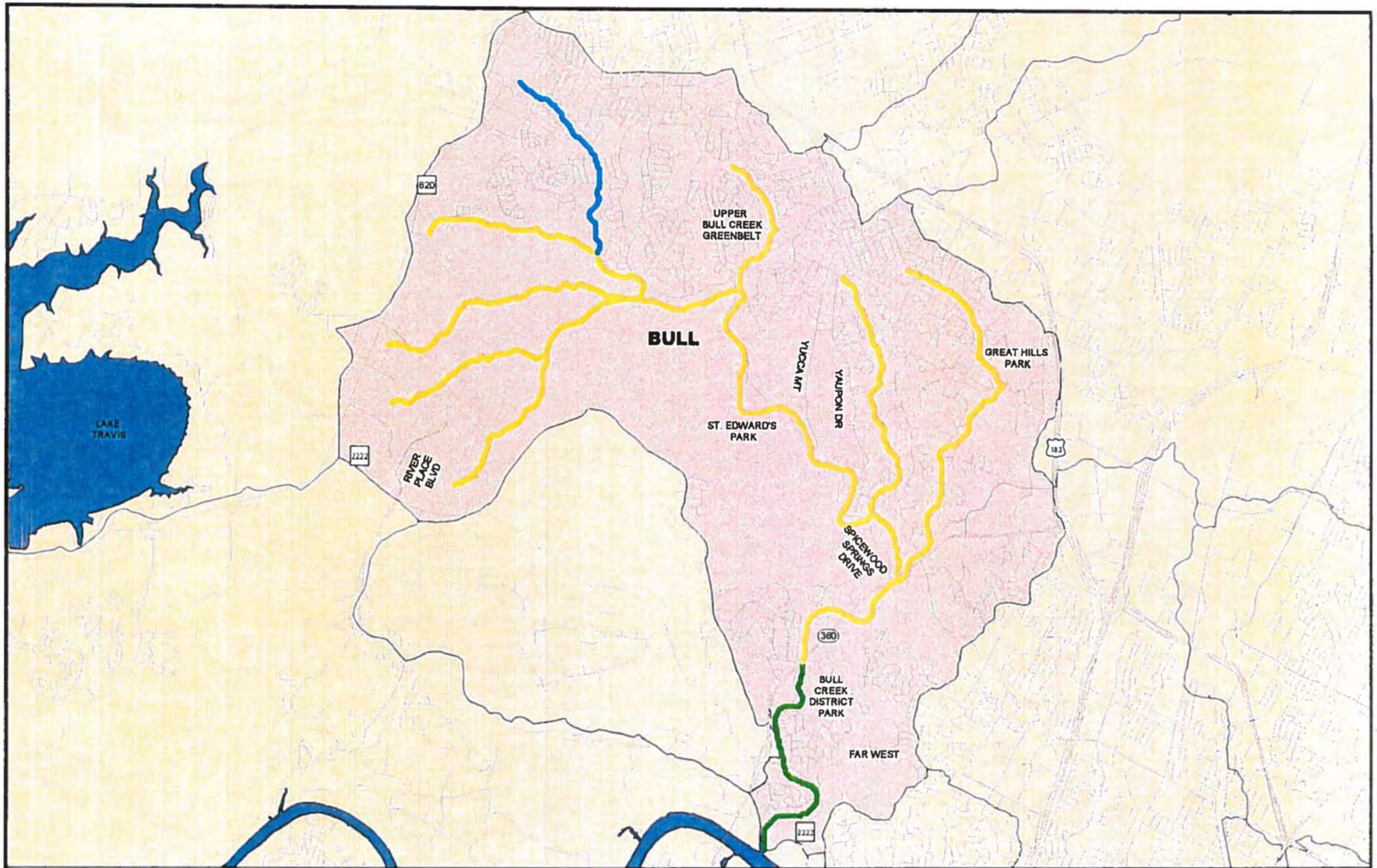
N

Figure A - 10

Current Erosion Problem Rating

- Very Low
- Low
- Moderate
- High
- Very High
- Lakes and Rivers
- Roads
- Phase 1 Watershed
- Austin Area Watersheds

Watershed Protection Department



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Bull Creek Watershed
Current Water Quality Problem Rating

1 0 1 2 Miles

N

Water Quality Rating
- Very Low
- Low
- Moderate
- High
- Very High
- Roads
- Lakes & Rivers
- Phase 1 Watersheds
- Austin Area Watersheds

Figure A - 11

Bull Creek Water Quality Score Breakout

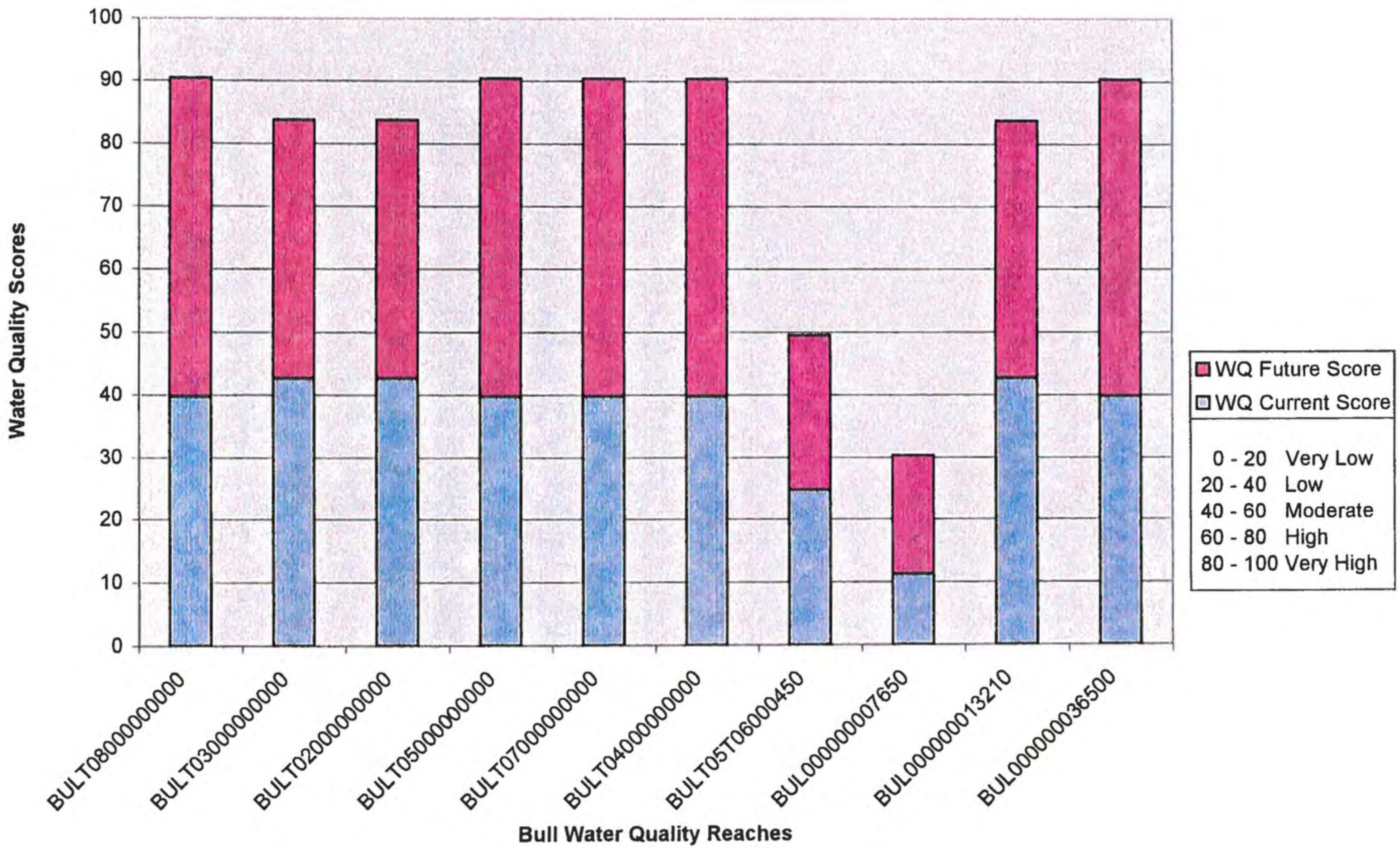
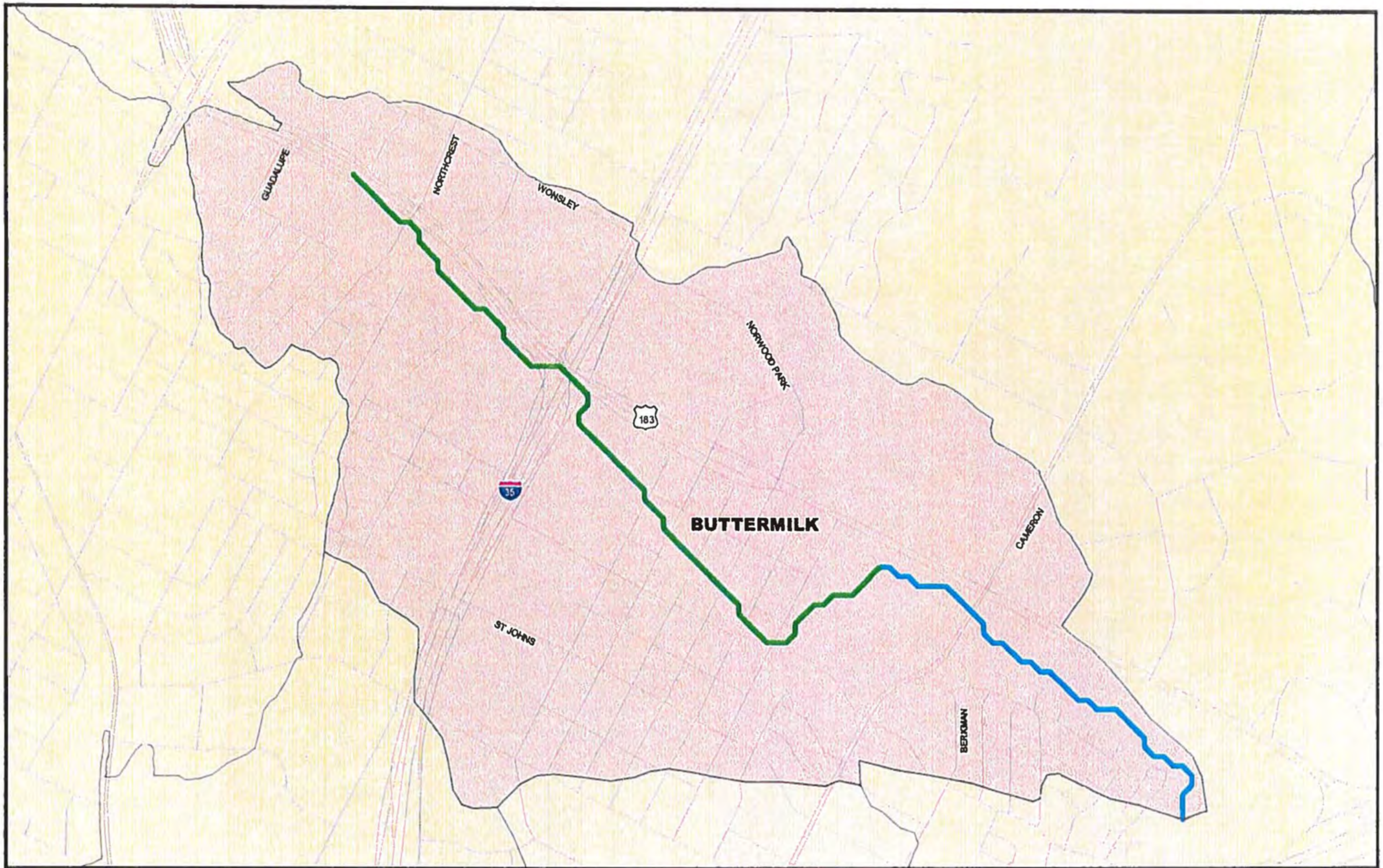


Figure A - 12



Watershed Protection Department

Buttermilk Creek Watershed
Current Erosion Problem Rating

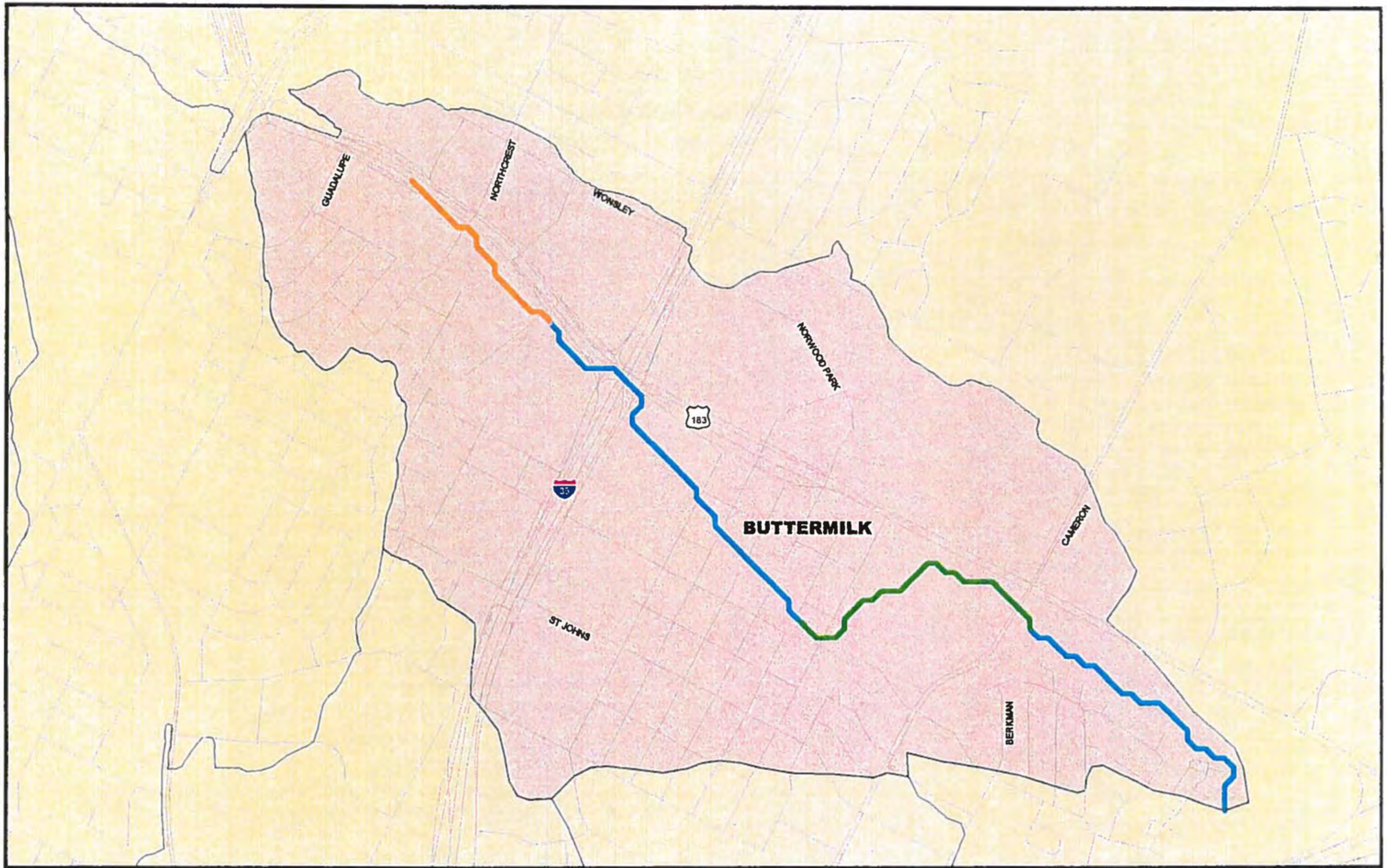
0.2 0 0.2 0.4 Miles

N

Figure A - 13

Current Erosion Problem Rating

- Very Low
- Low
- Moderate
- High
- Very High
- Lakes and Rivers
- Roads
- Phase 1 Watershed
- Austin Area Watersheds



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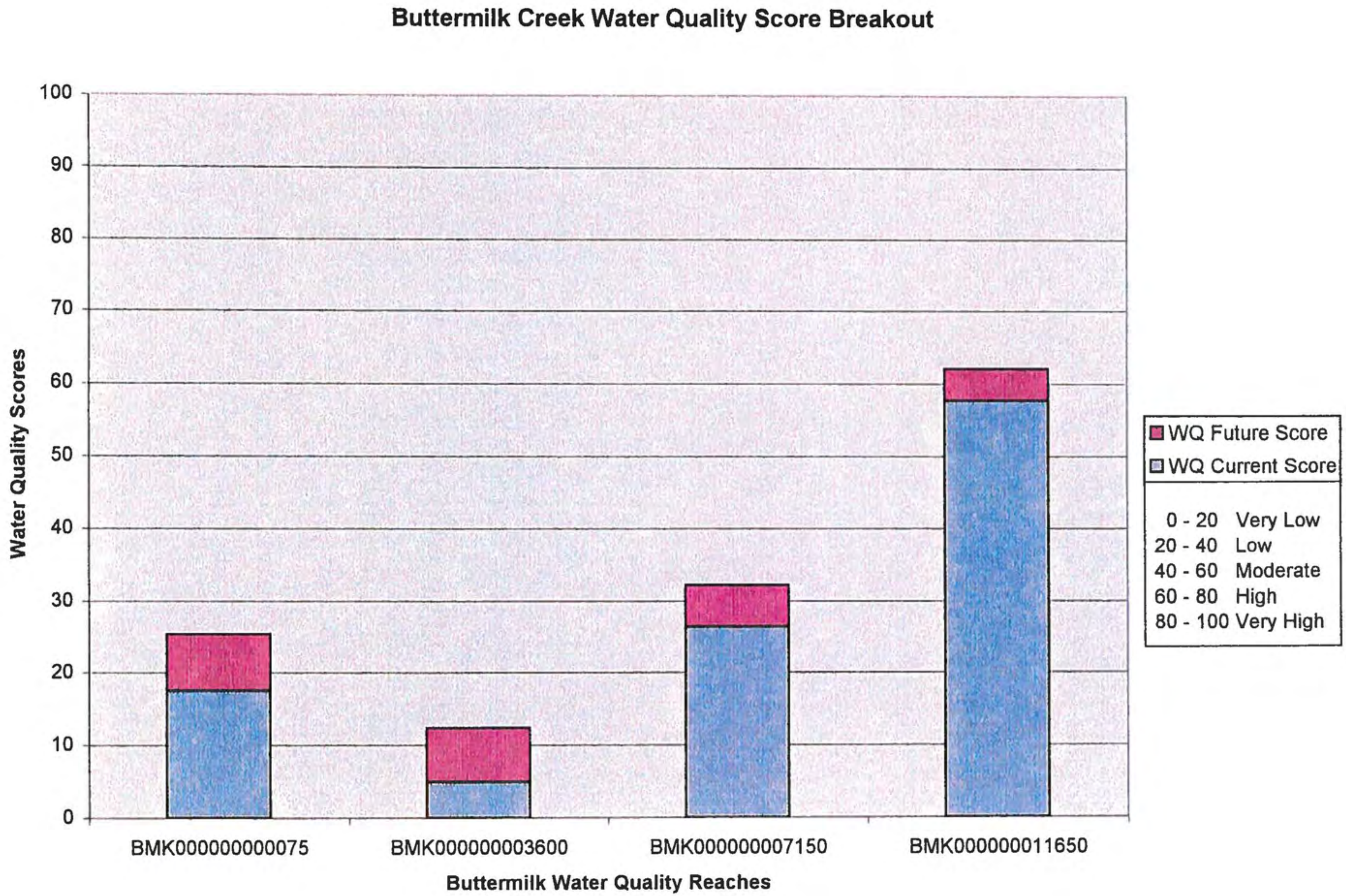
Buttermilk Creek Watershed
Current Water Quality Problem Rating

0.2 0 0.2 0.4 Miles

N

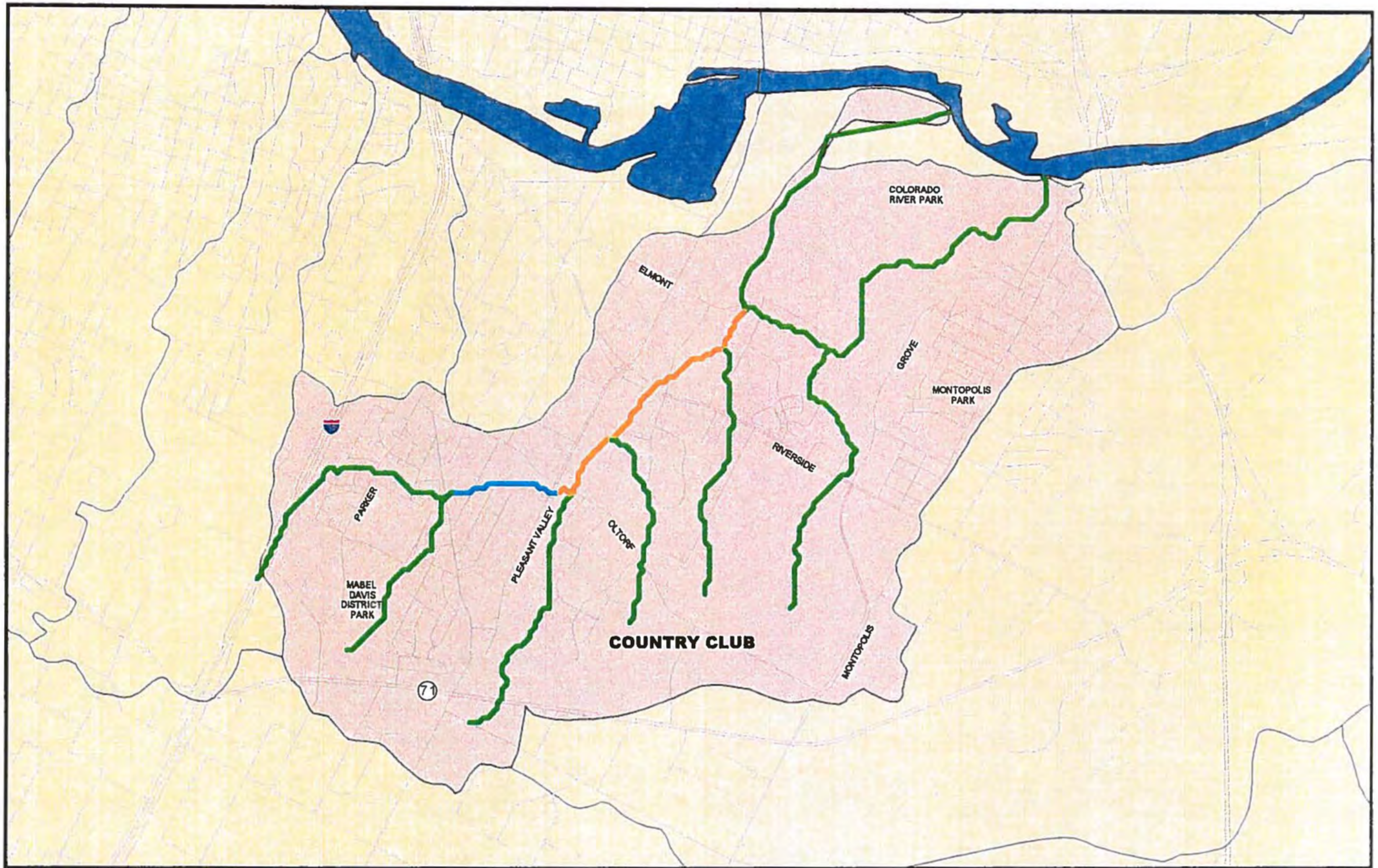
Figure A - 14

Water Quality Rating
- Very Low
- Low
- Moderate
- High
- Very High
- Roads
- Lakes & Rivers
- Phase 1 Watersheds
- Austin Area Watersheds



Buttermilk Creek Water Quality Score Breakout
Water Quality Scores
100
90
80
70
60
50
40
30
20
10
0
BMK000000000075
BMK000000003600
BMK000000007150
BMK000000011650
Buttermilk Water Quality Reaches
WQ Future Score
WQ Current Score
0 - 20 Very Low
20 - 40 Low
40 - 60 Moderate
60 - 80 High
80 - 100 Very High

Figure A - 15



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Country Club Creek Watershed
Current Erosion Problem Rating

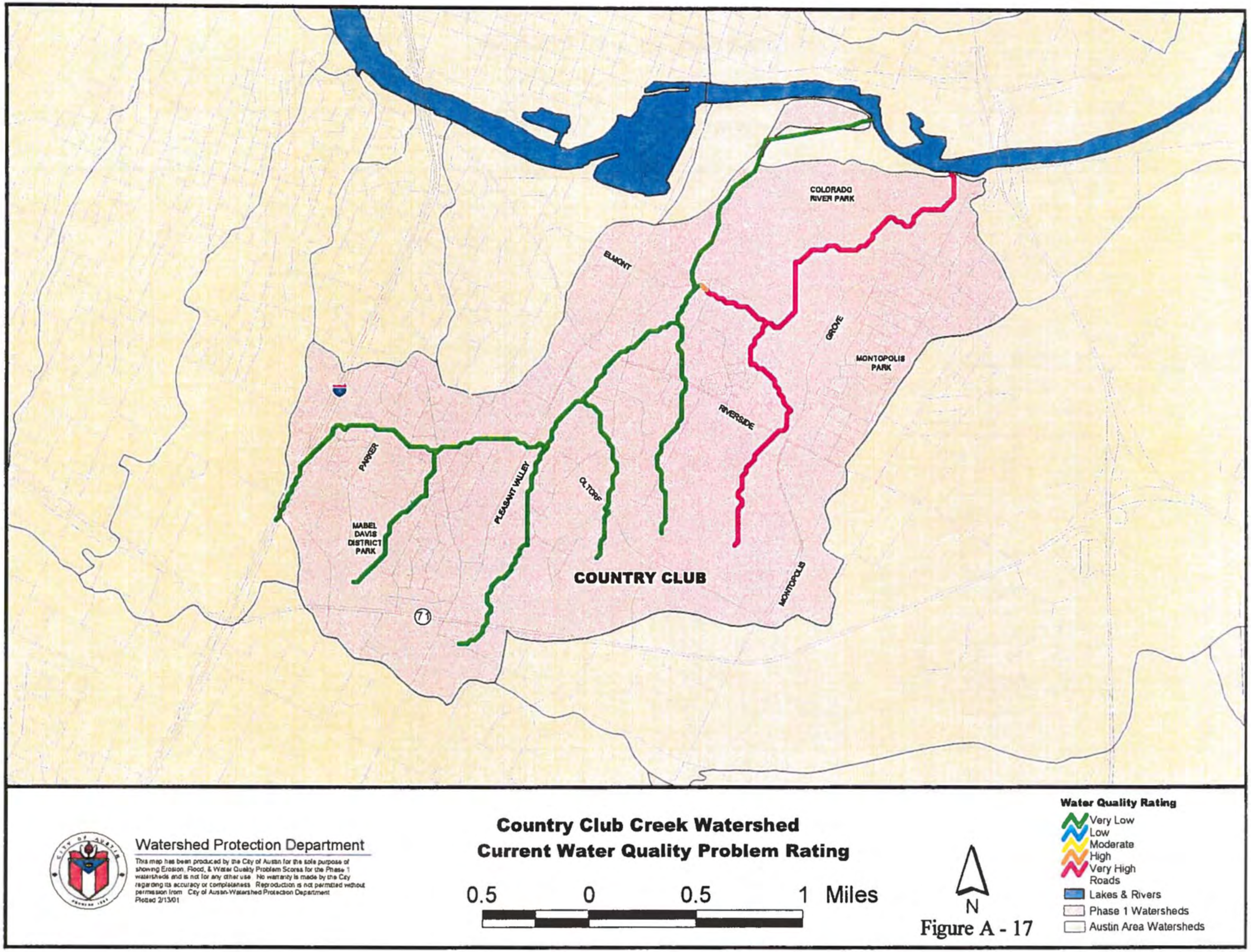
0.5 0 0.5 1 Miles

N

Figure A - 16

Current Erosion Problem Rating

- Very Low
- Low
- Moderate
- High
- Very High
- Lakes and Rivers
- Roads
- Phase 1 Watershed
- Austin Area Watersheds



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Country Club Creek Watershed
Current Water Quality Problem Rating

Figure A - 17

Country Club Creek Water Quality Score Breakout

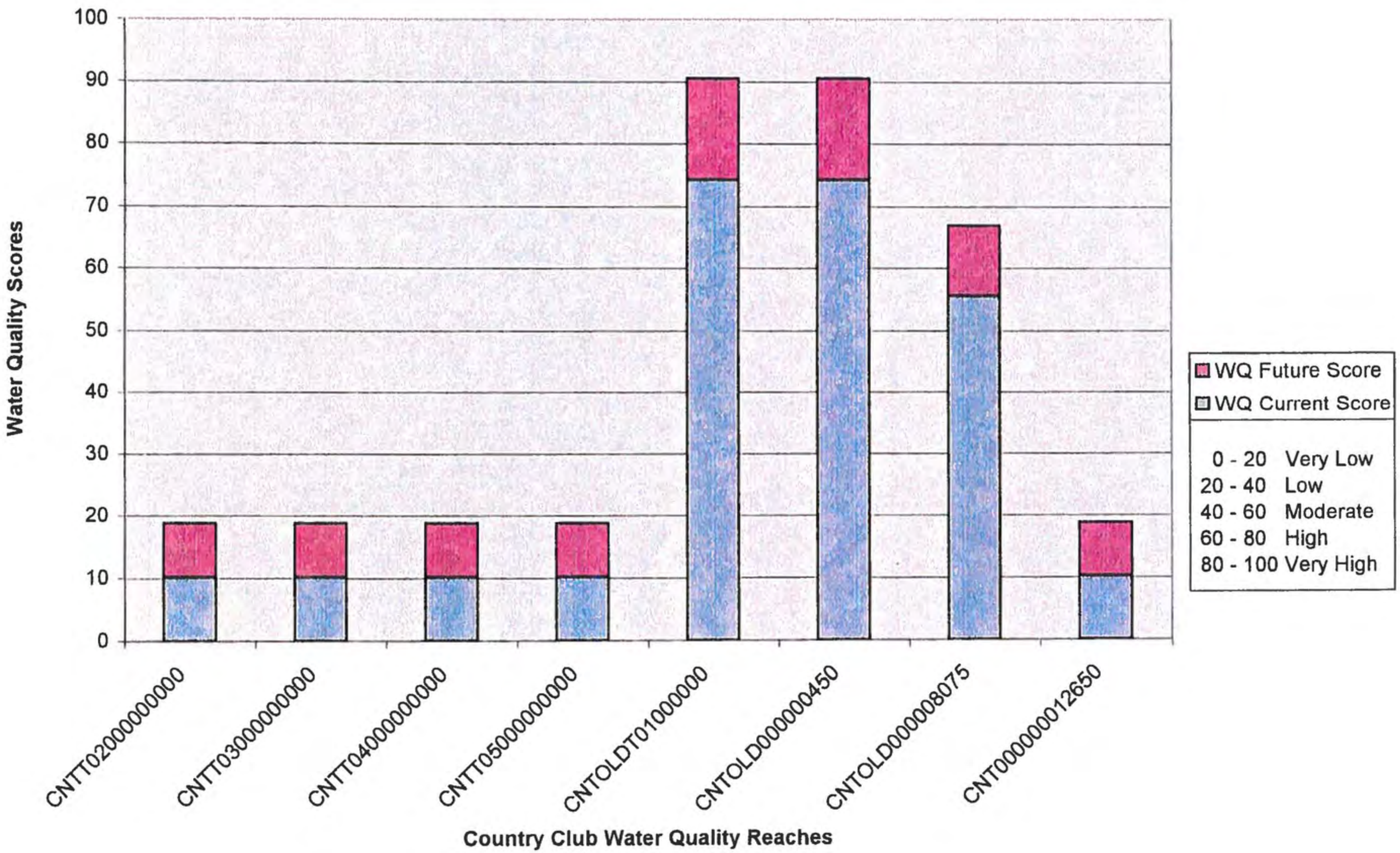
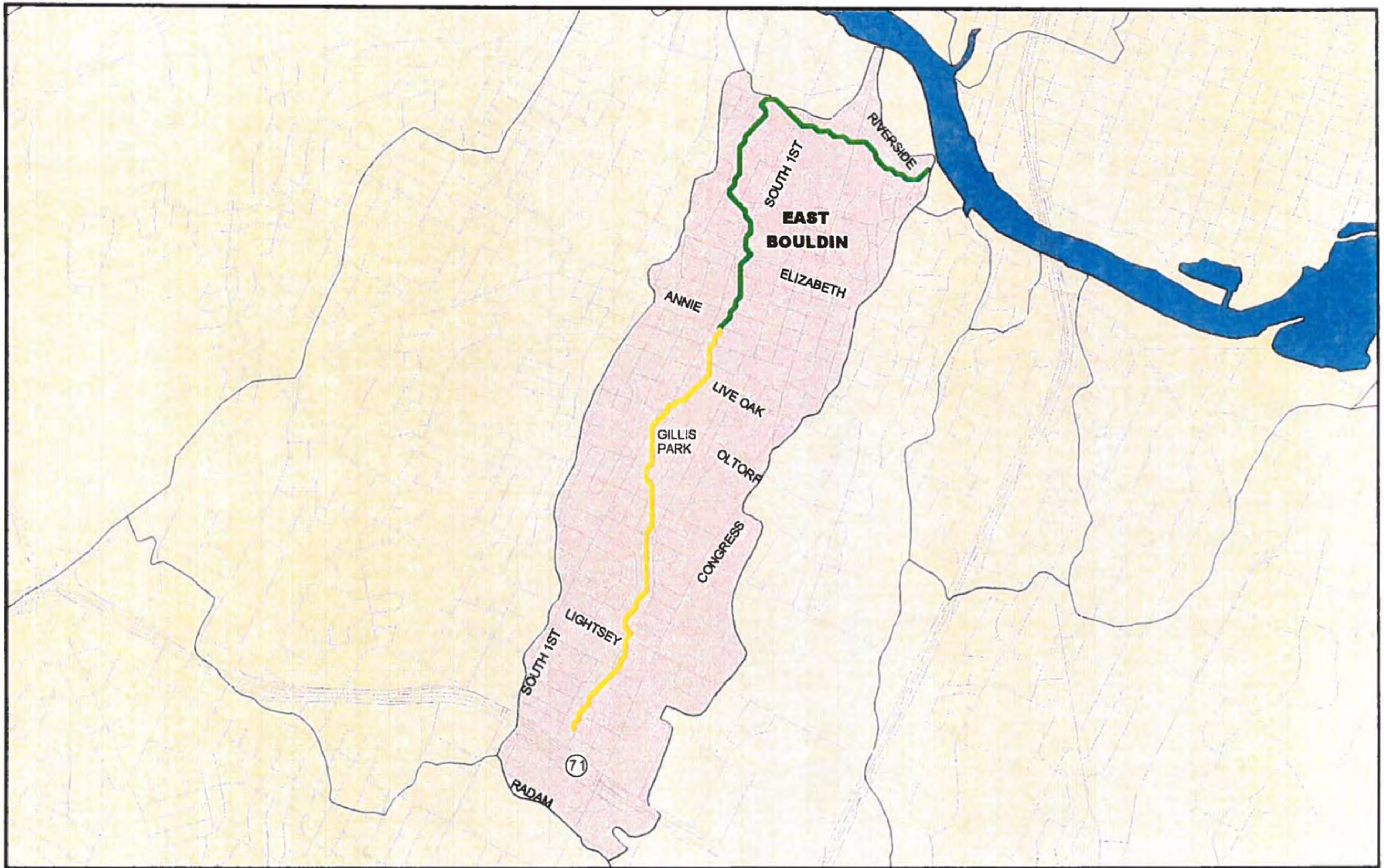


Figure A - 18



Watershed Protection Department

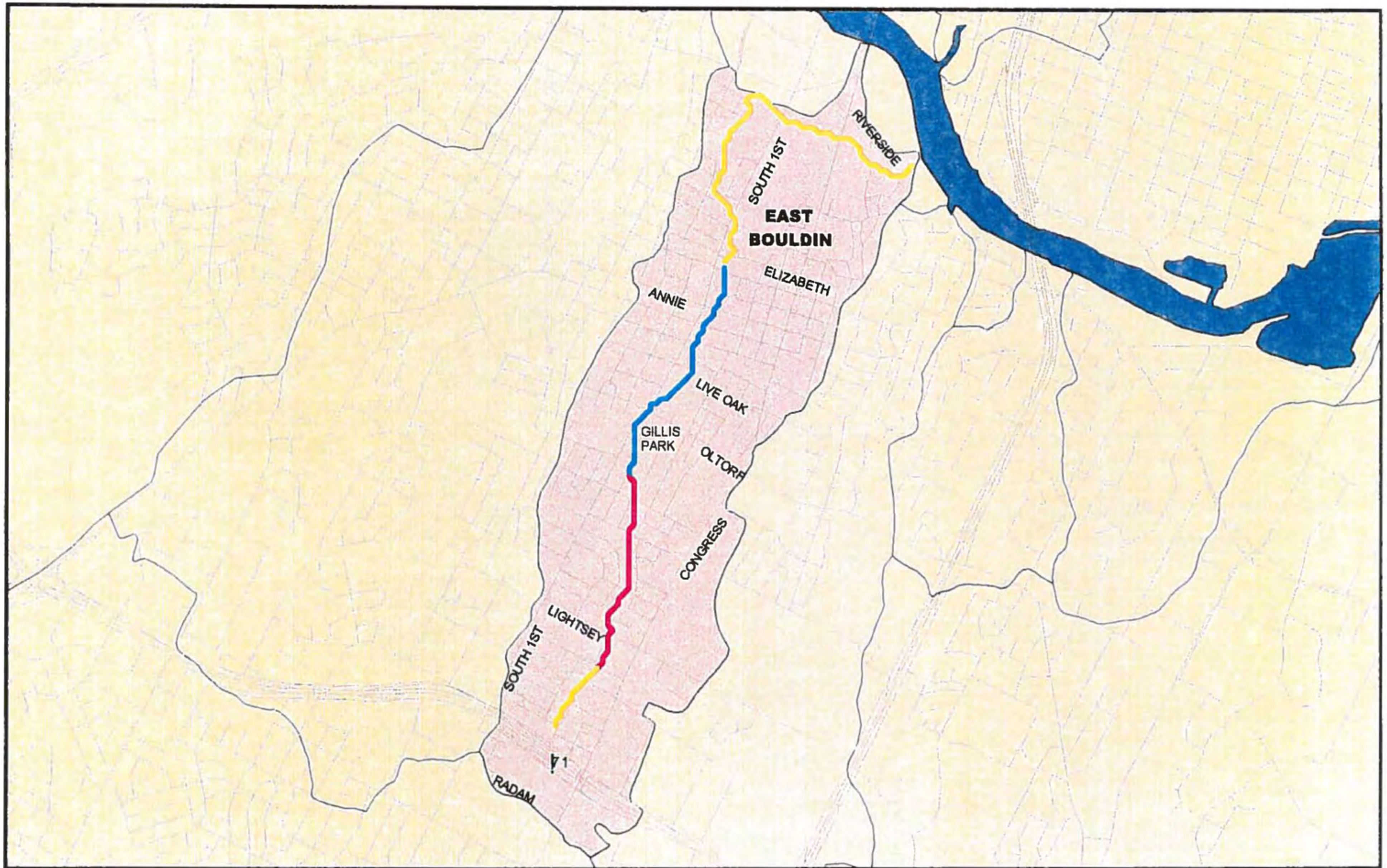
East Bouldin Creek Watershed
Current Erosion Problem Rating

0.5 0 0.5 1 Miles

N

Figure A - 19

Current Erosion Problem Rating
- Very Low
- Low
- Moderate
- High
- Very High
- Lakes and Rivers
- Roads
- Phase 1 Watershed
- Austin Area Watersheds



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East Bouldin Creek Watershed
Current Water Quality Problem Rating

0.5 0 0.5 1 Miles

N

Figure A - 20

Water Quality Rating
- Very Low
- Low
- Moderate
- High
- Very High
- Roads
- Lakes & Rivers
- Phase 1 Watersheds
- Austin Area Watersheds

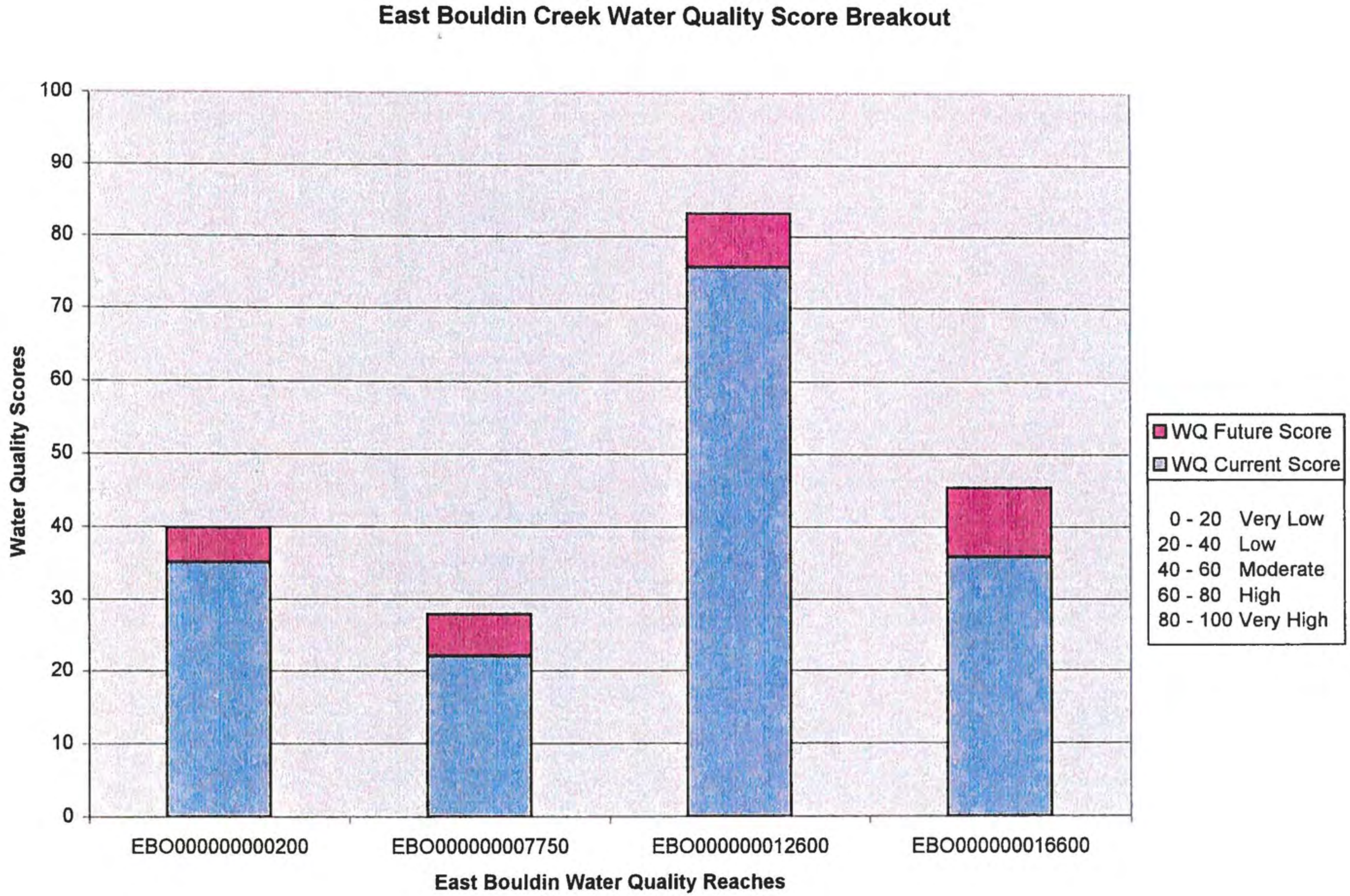
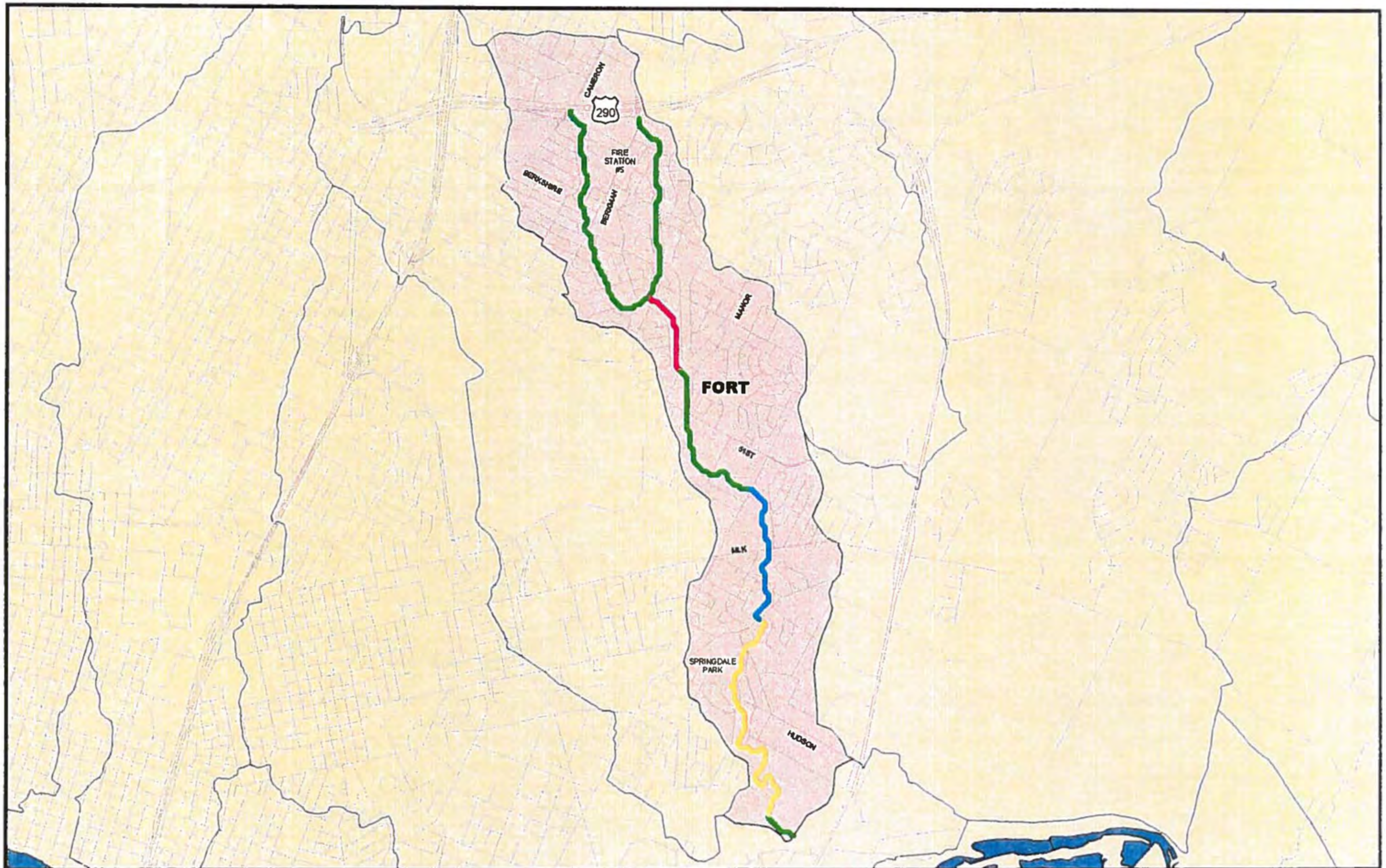

East Bouldin Creek Water Quality Score Breakout
Water Quality Scores
100
90
80
70
60
50
40
30
20
10
0
EBO000000000200
EBO000000007750
EBO000000012600
EBO000000016600
East Bouldin Water Quality Reaches
WQ Future Score
WQ Current Score
0 - 20 Very Low
20 - 40 Low
40 - 60 Moderate
60 - 80 High
80 - 100 Very High

Figure A - 21



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Fort Branch Watershed
Current Erosion Problem Rating

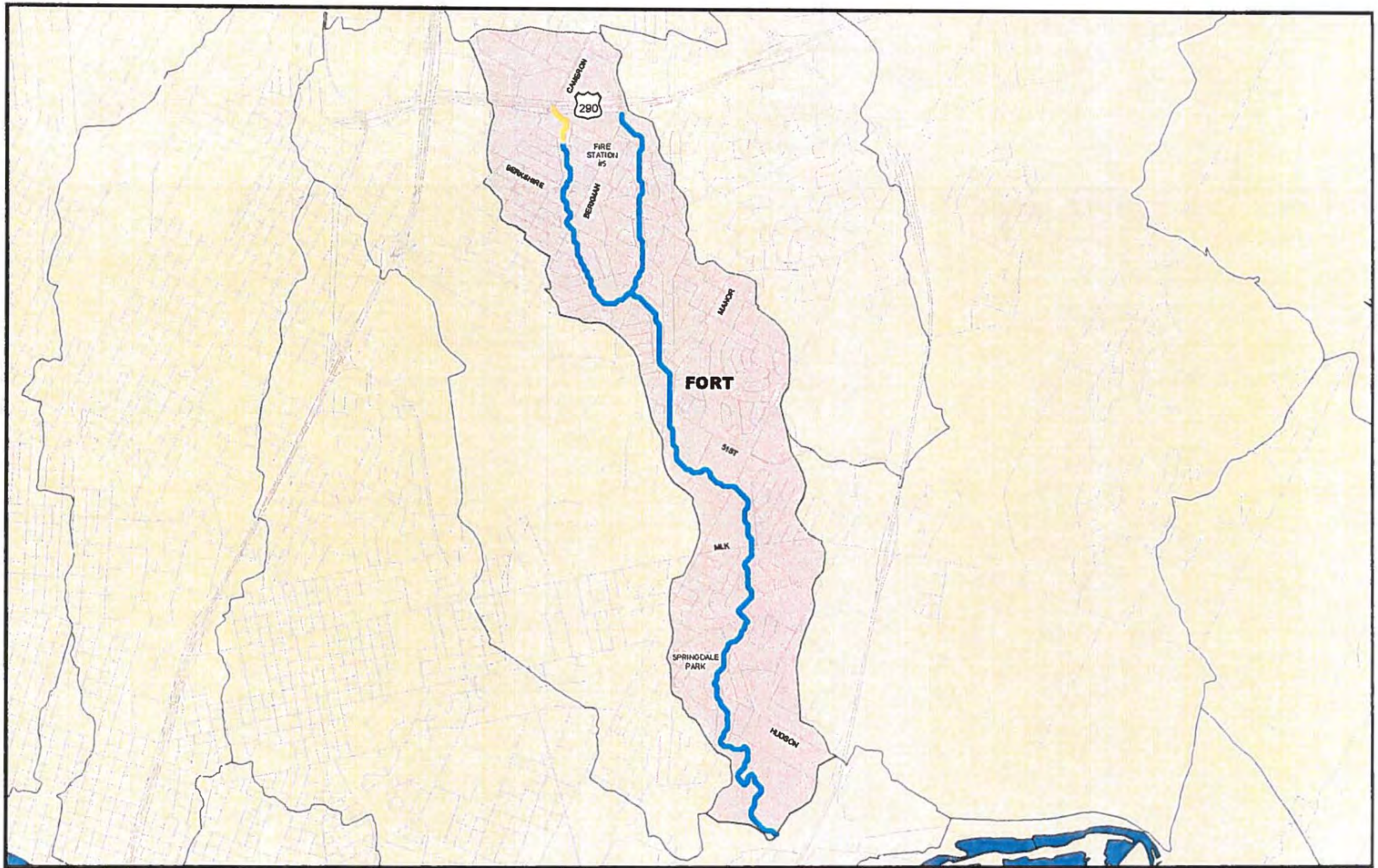
0.5 0 0.5 1 Miles

N

Figure A - 22

Current Erosion Problem Rating

- Very Low
- Low
- Moderate
- High
- Very High
- Lakes and Rivers
- Roads
- Phase 1 Watershed
- Austin Area Watersheds



Watershed Protection Department

Plotted 2/13/01

Fort Branch Watershed
Current Water Quality Problem Rating

0.5 0 0.5 1 Miles

N

Figure A - 23

Water Quality Rating
- Very Low
- Low
- Moderate
- High
- Very High
- Roads
- Lakes & Rivers
- Phase 1 Watersheds
- Austin Area Watersheds

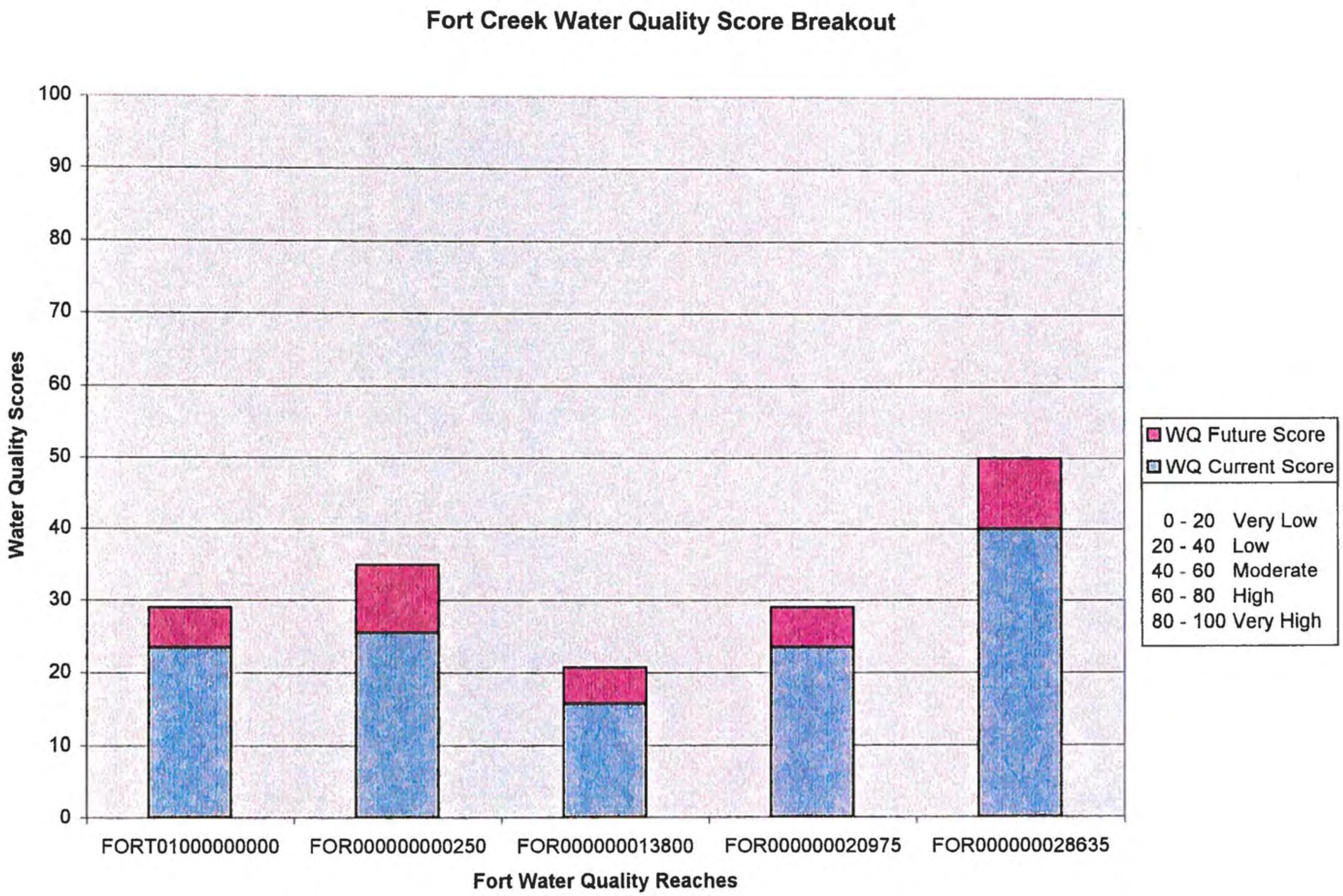
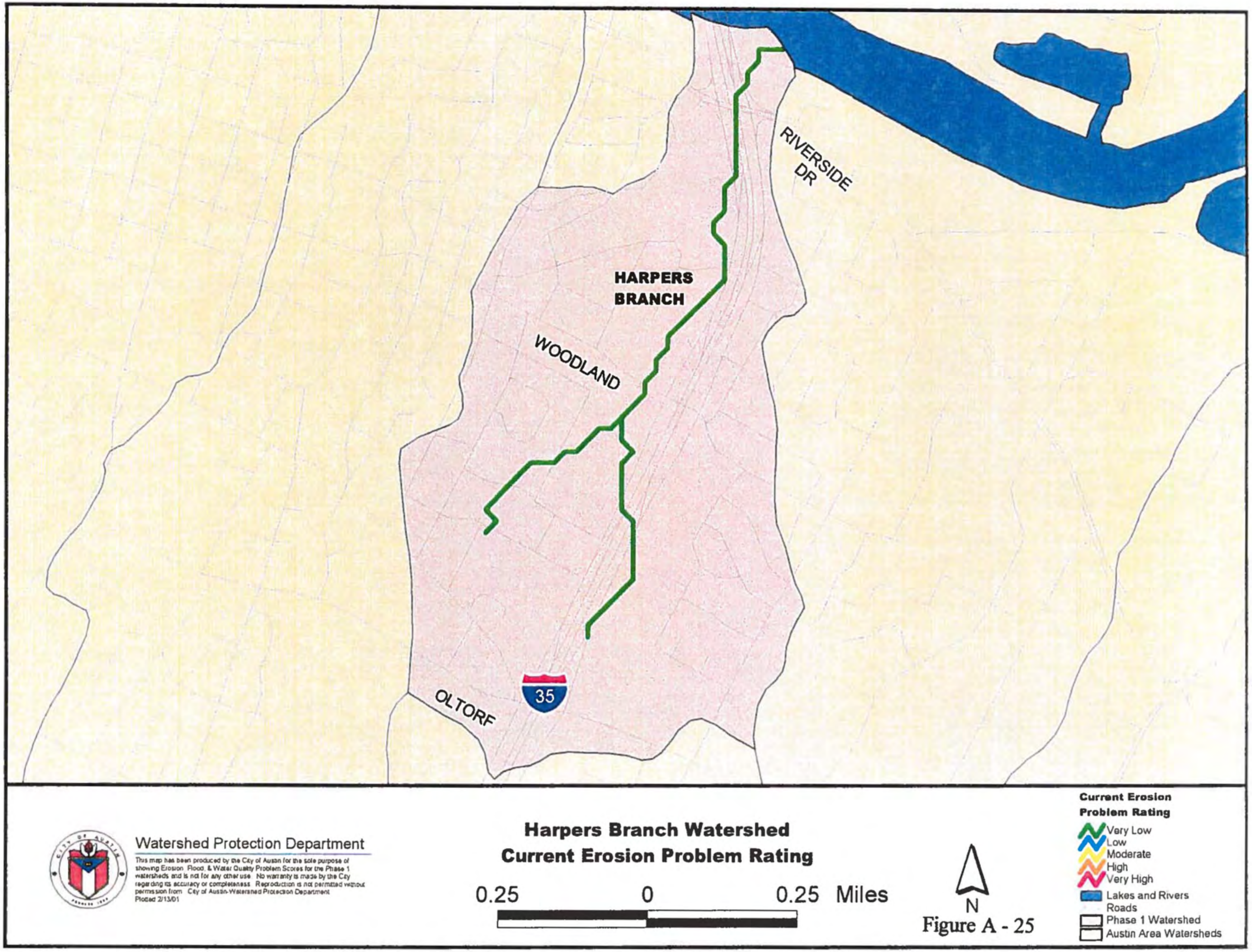

Fort Creek Water Quality Score Breakout
100
90
80
70
60
50
40
30
20
10
0
Water Quality Scores
WQ Future Score
WQ Current Score
0 - 20 Very Low
20 - 40 Low
40 - 60 Moderate
60 - 80 High
80 - 100 Very High
FORT01000000000
FOR000000000250
FOR000000013800
FOR000000020975
FOR000000028635
Fort Water Quality Reaches

Figure A - 24


RIVERSIDE DR
HARPERS BRANCH
WOODLAND
OLTORF
35
Watershed Protection Department
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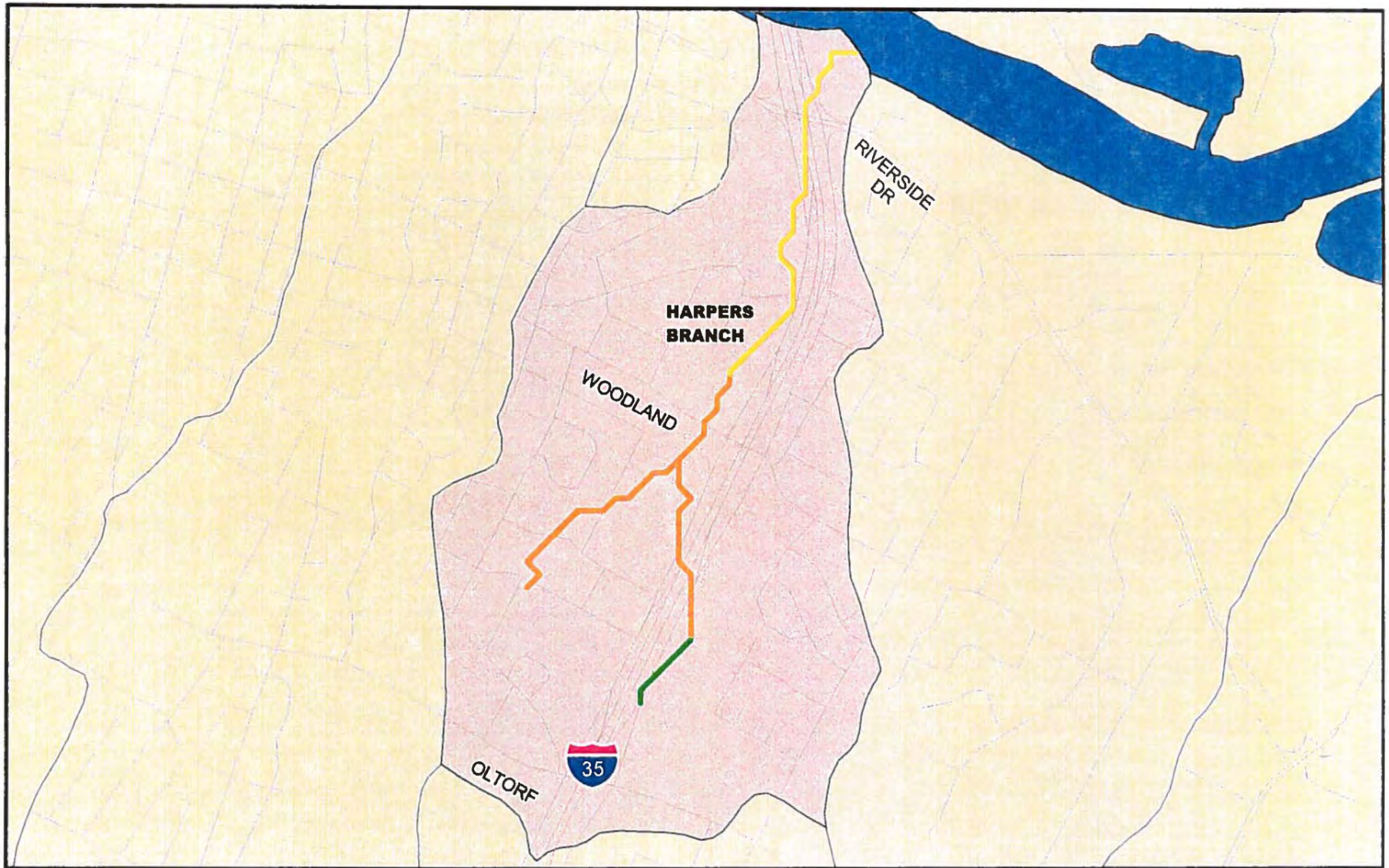
Plotted 2/13/01
Harpers Branch Watershed
Current Erosion Problem Rating
0.25 0 0.25 Miles
N
Current Erosion Problem Rating
Very Low
Low
Moderate
High
Very High
Lakes and Rivers
Roads
Phase 1 Watershed
Austin Area Watersheds

Figure A - 25



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Harpers Branch Watershed
Current Water Quality Problem Rating

0.25 0 0.25 Miles

N

Figure A - 26

Water Quality Rating
- Very Low
- Low
- Moderate
- High
- Very High
- Roads
- Lakes & Rivers
- Phase 1 Watersheds
- Austin Area Watersheds

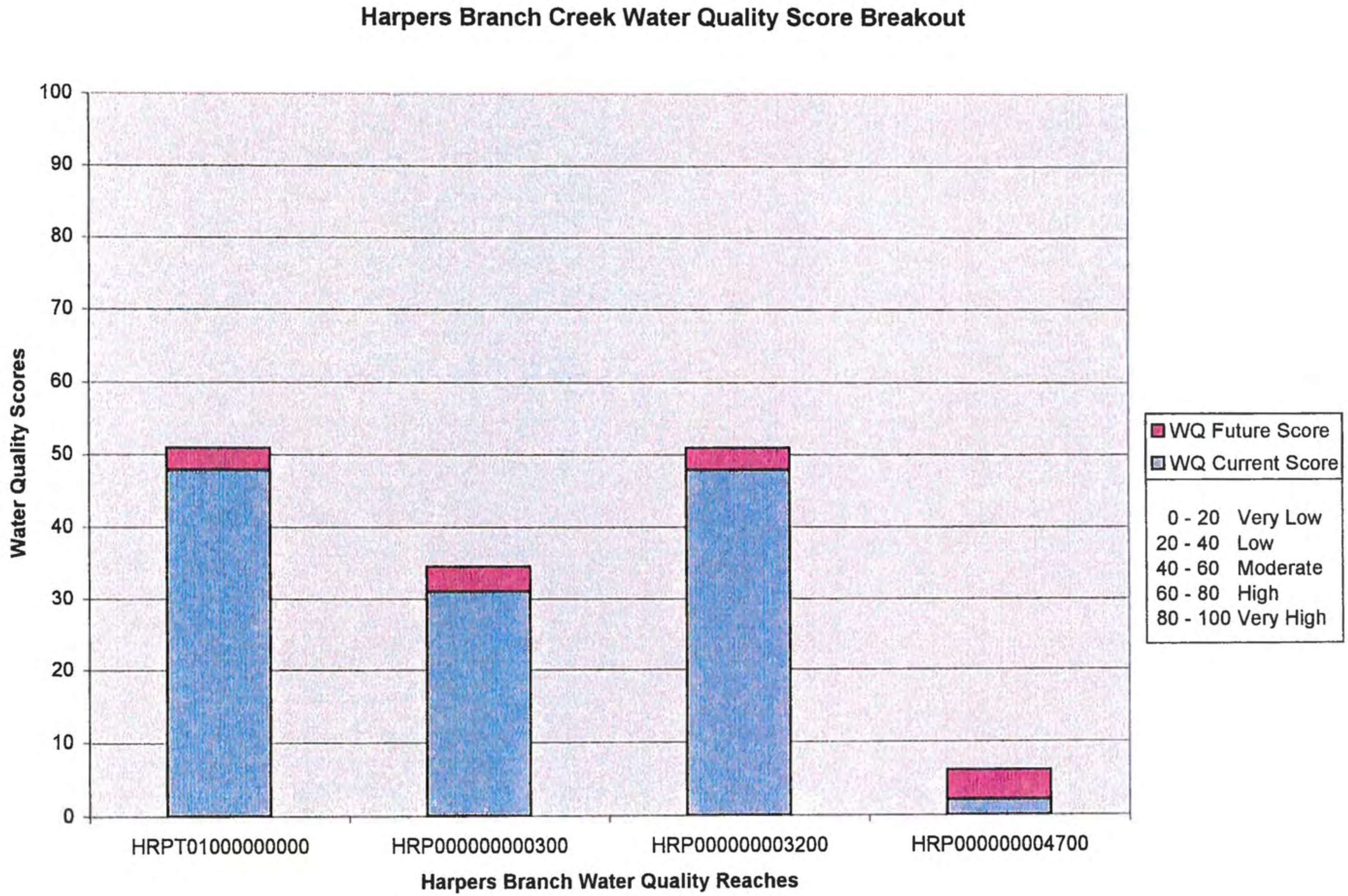
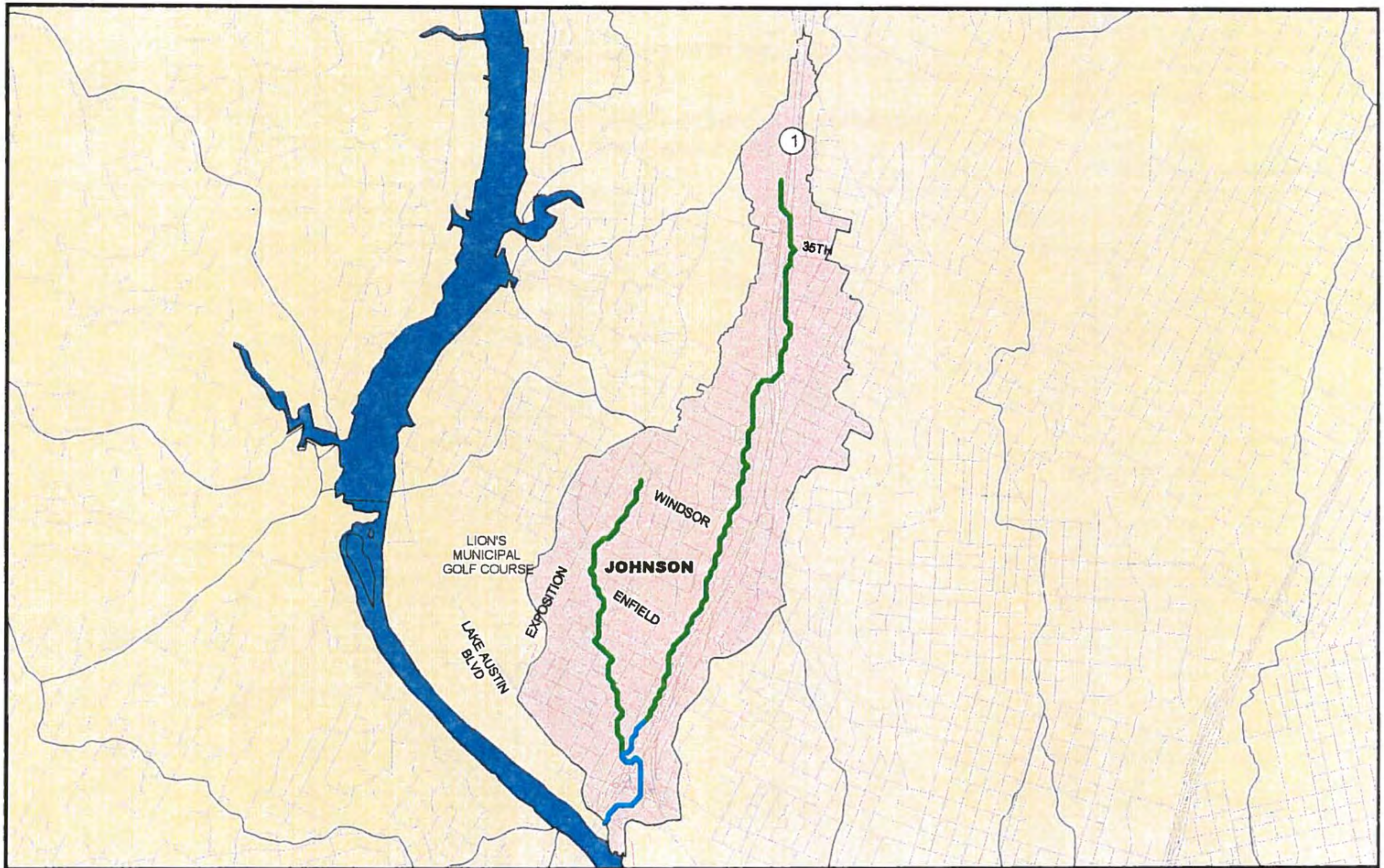

Harpers Branch Creek Water Quality Score Breakout
100
90
80
70
60
50
40
30
20
10
0
Water Quality Scores
WQ Future Score
WQ Current Score
0 - 20 Very Low
20 - 40 Low
40 - 60 Moderate
60 - 80 High
80 - 100 Very High
HRPT01000000000
HRP000000000300
HRP000000003200
HRP000000004700
Harpers Branch Water Quality Reaches

Figure A - 27



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Johnson Creek Watershed
Current Erosion Problem Rating

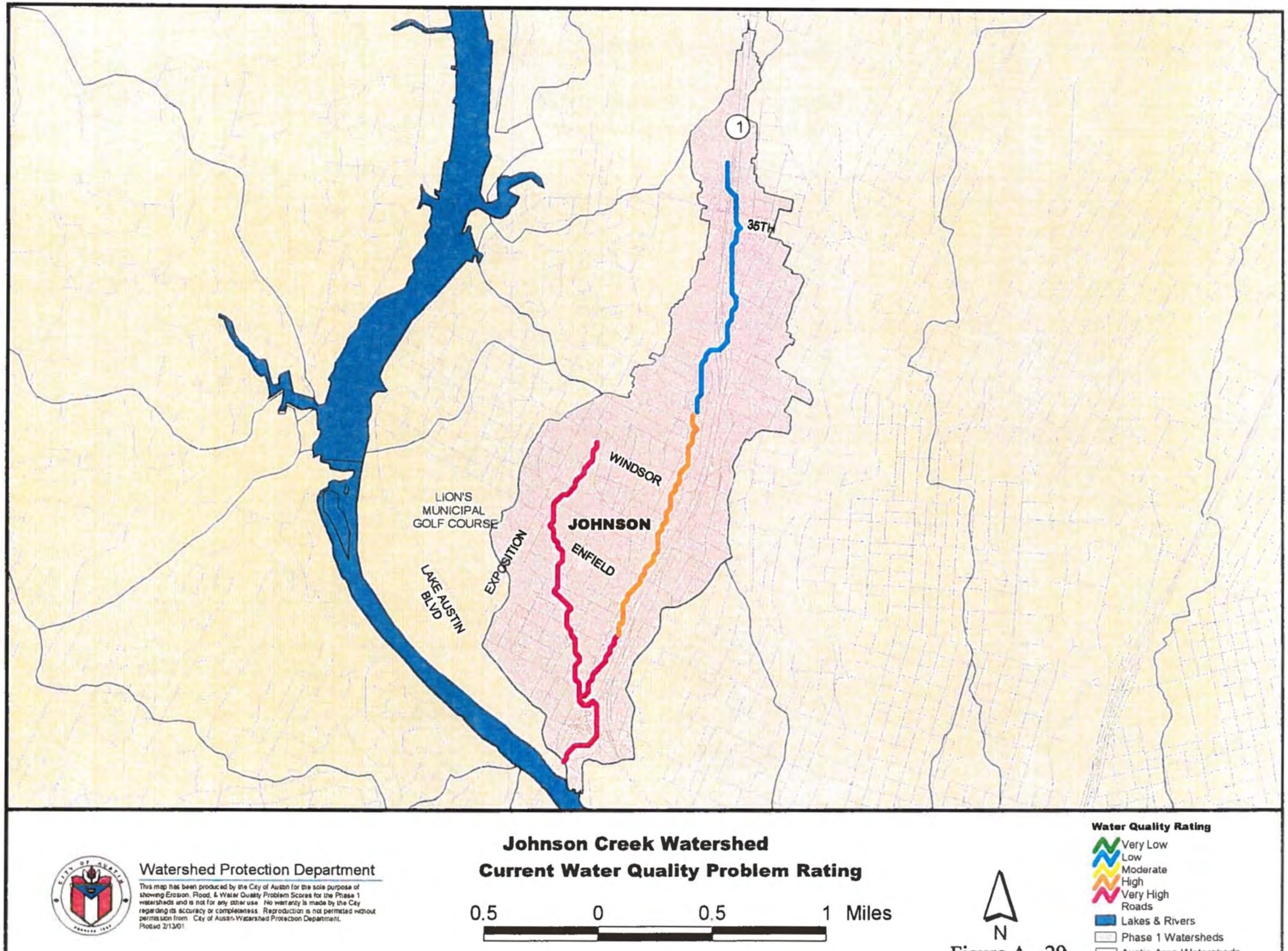
0.5 0 0.5 1 Miles

N

Figure A - 28

Current Erosion Problem Rating

Very Low
Low
Moderate
High
Very High
Lakes and Rivers
Roads
Phase 1 Watershed
Austin Area Watersheds


1
35TH
WINDSOR
LION'S
MUNICIPAL
GOLF COURSE
JOHNSON
ENFIELD
EXPOSITION
LAKE AUSTIN
BLVD
Watershed Protection Department
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Plotted 2/13/01
Johnson Creek Watershed
Current Water Quality Problem Rating
0.5 0 0.5 1 Miles
N
Water Quality Rating
Very Low
Low
Moderate
High
Very High
Roads
Lakes & Rivers
Phase 1 Watersheds
Austin Area Watersheds

Figure A - 29

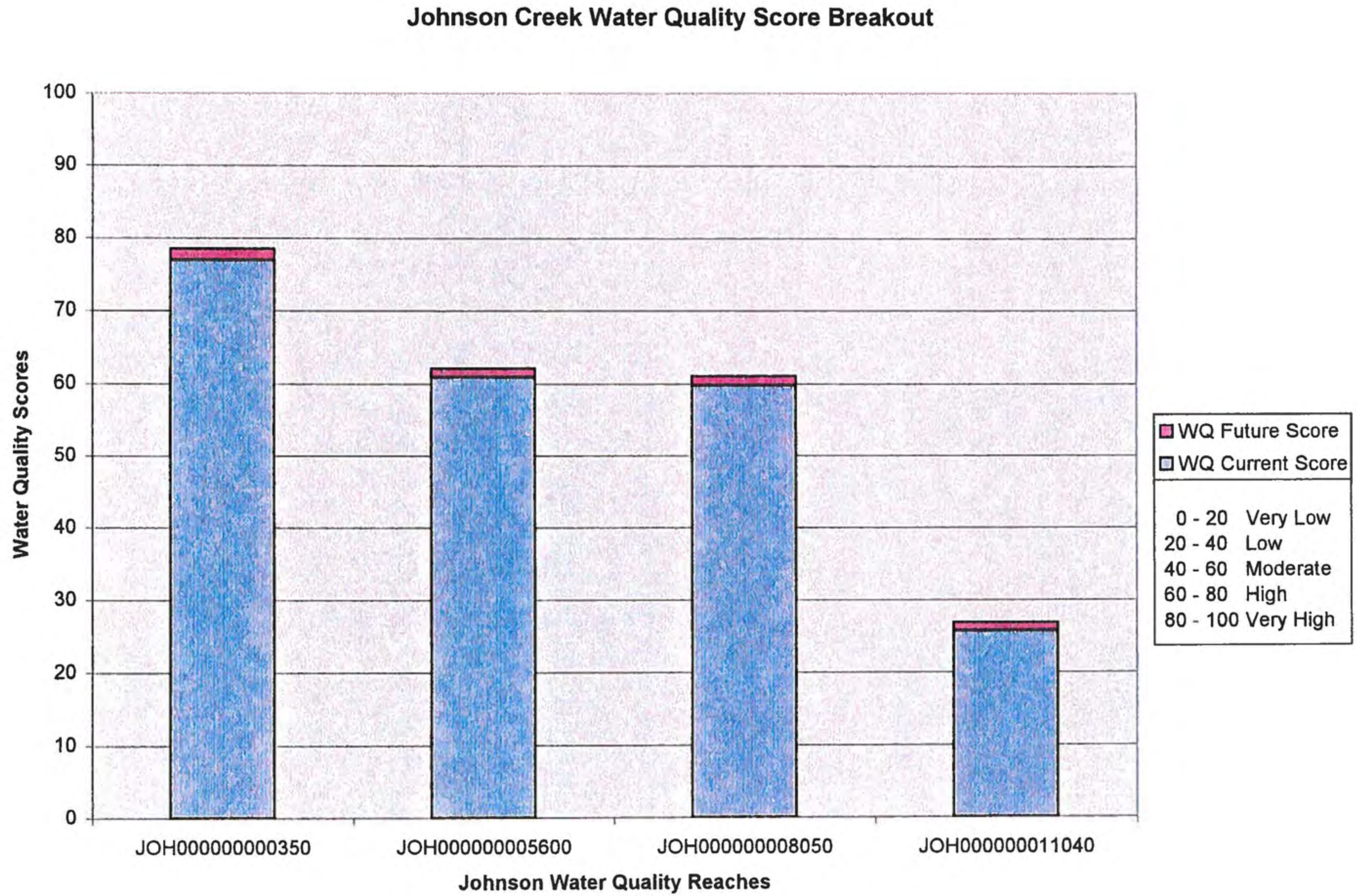
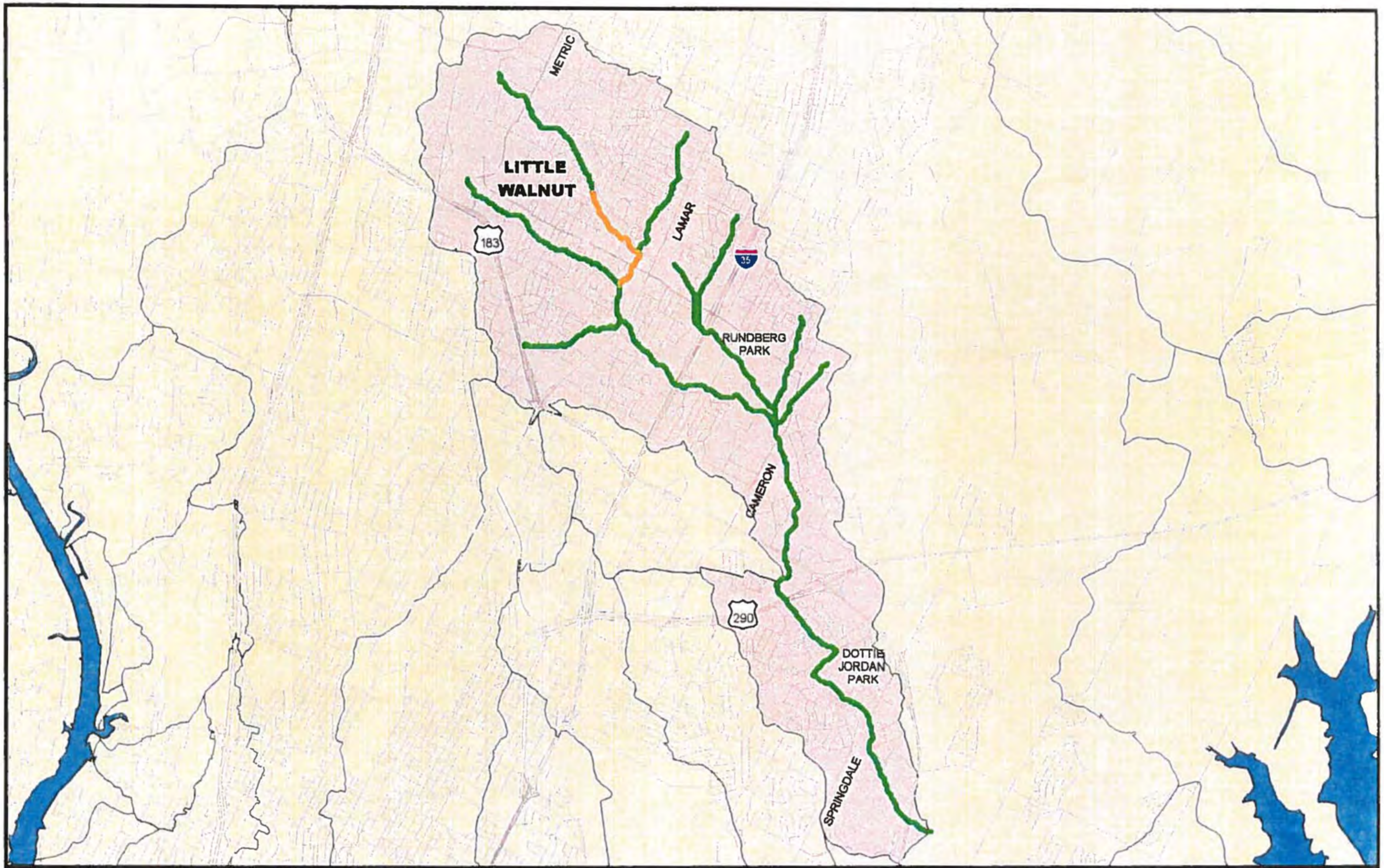

Johnson Creek Water Quality Score Breakout
100
90
80
70
60
50
40
30
20
10
0
Water Quality Scores
WQ Future Score
WQ Current Score
0 - 20 Very Low
20 - 40 Low
40 - 60 Moderate
60 - 80 High
80 - 100 Very High
JOH000000000350
JOH000000005600
JOH000000008050
JOH000000011040
Johnson Water Quality Reaches

Figure A - 30



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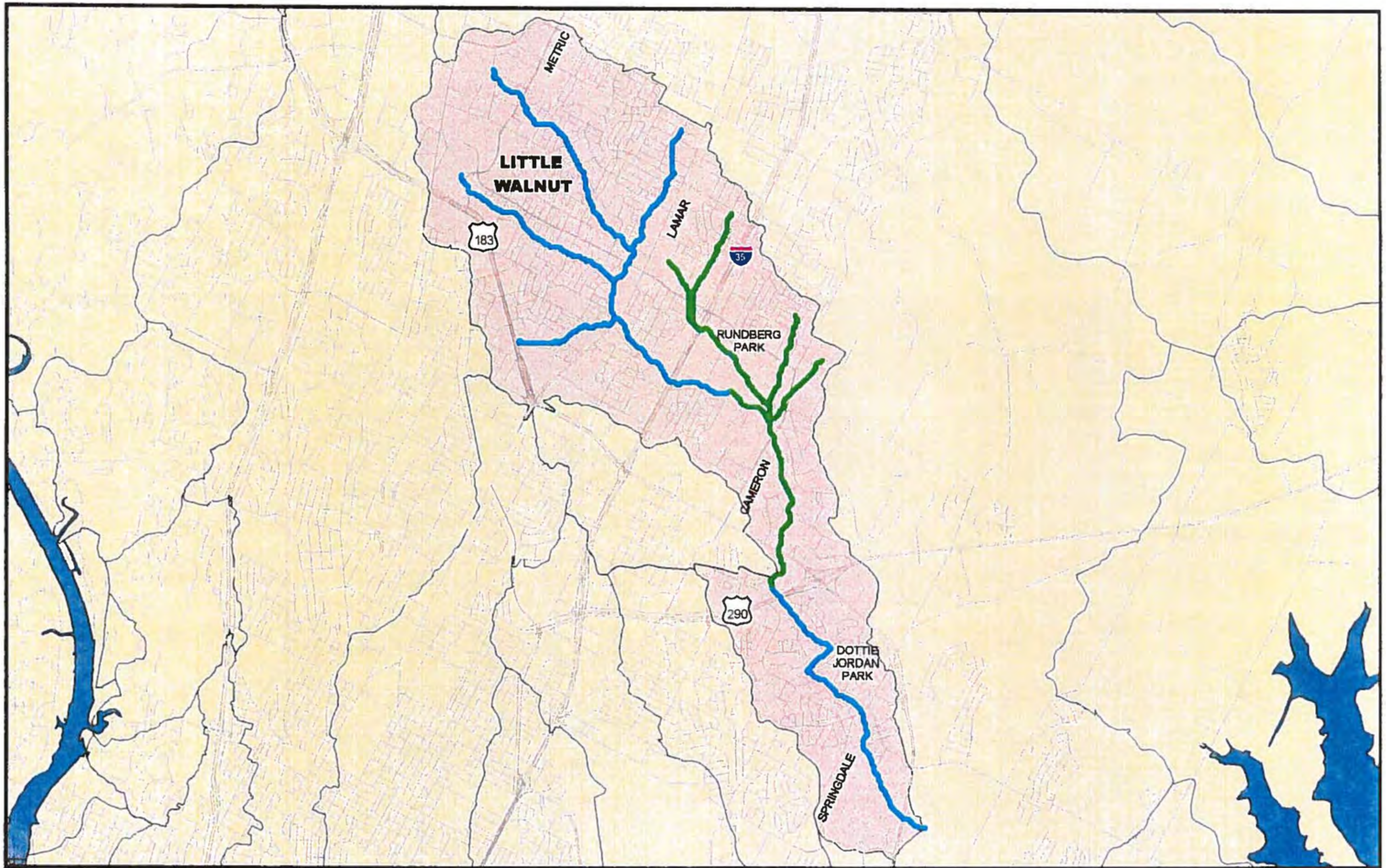
Little Walnut Creek Watershed
Current Erosion Problem Rating

1 0 1 2 Miles

N

Figure A - 31

Current Erosion Problem Rating
- Very Low
- Low
- Moderate
- High
- Very High
- Lakes and Rivers
- Roads
- Phase 1 Watershed
- Austin Area Watersheds



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Little Walnut Creek Watershed
Current Water Quality Problem Rating

1 0 1 2 Miles

N

Figure A - 32

Water Quality Rating
- Very Low
- Low
- Moderate
- High
- Very High
- Roads
- Lakes & Rivers
- Phase 1 Watersheds
- Austin Area Watersheds

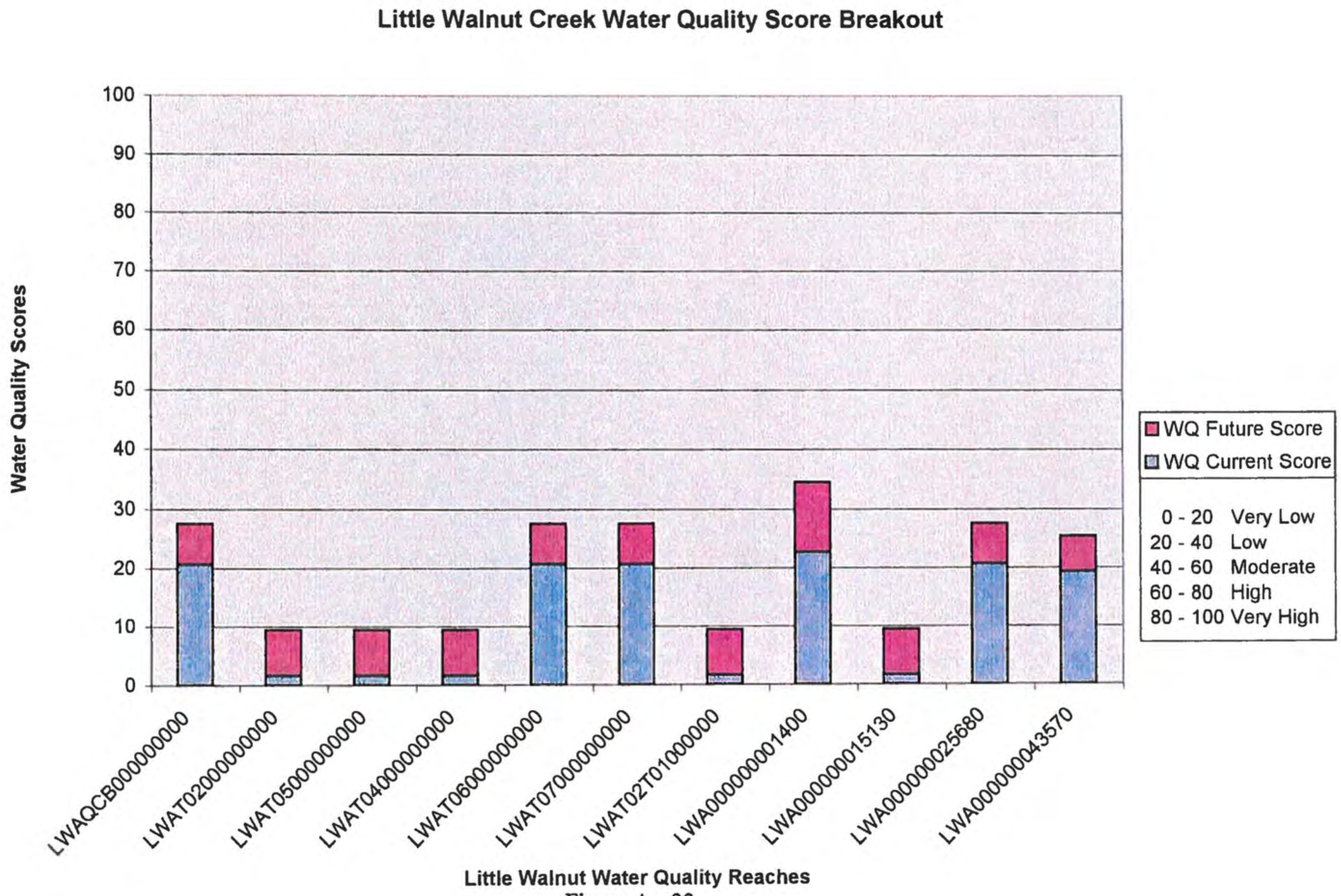
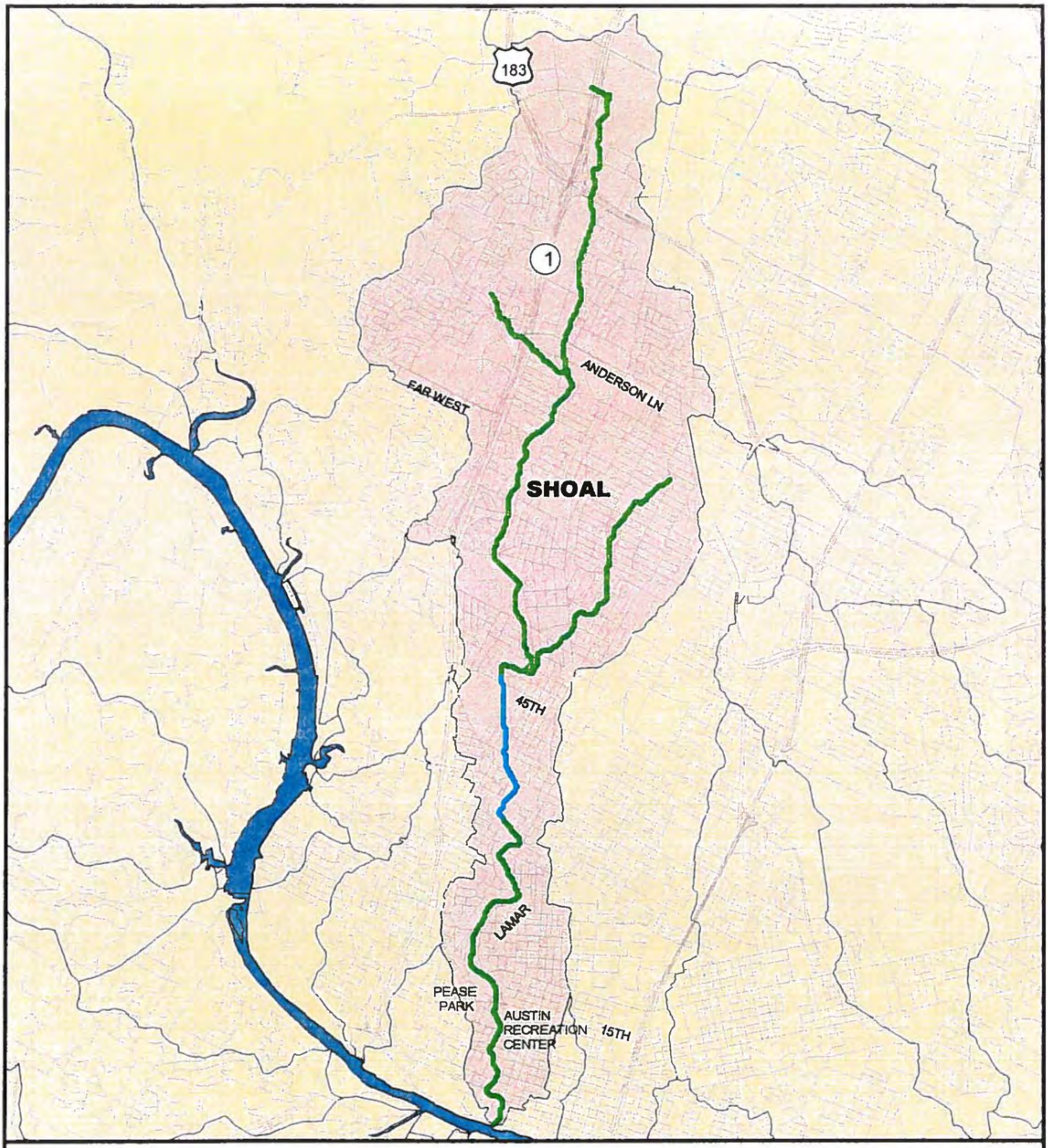

Little Walnut Creek Water Quality Score Breakout
Water Quality Scores
100
90
80
70
60
50
40
30
20
10
0
LWAQCB000000000
LWAT0200000000
LWAT0500000000
LWAT0400000000
LWAT0600000000
LWAT0700000000
LWAT02T01000000
LWA00000001400
LWA00000015130
LWA00000025680
LWA00000043570
Little Walnut Water Quality Reaches
WQ Future Score
WQ Current Score
0 - 20 Very Low
20 - 40 Low
40 - 60 Moderate
60 - 80 High
80 - 100 Very High

Figure A - 33



N

Figure A - 34

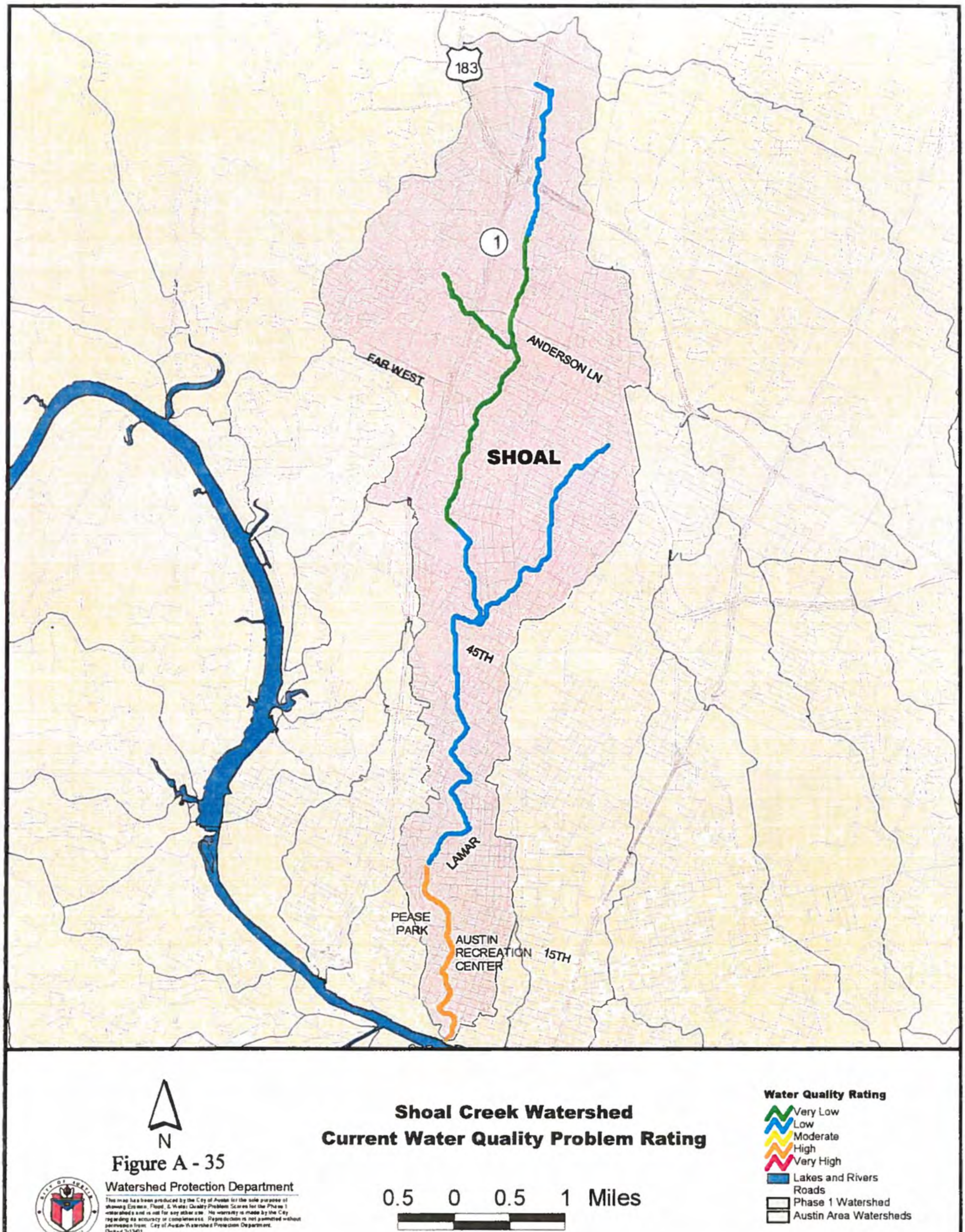
Watershed Protection Department

Shoal Creek Watershed
Current Erosion Problem Rating

0.5 0 0.5 1 Miles

Current Erosion Problem Rating

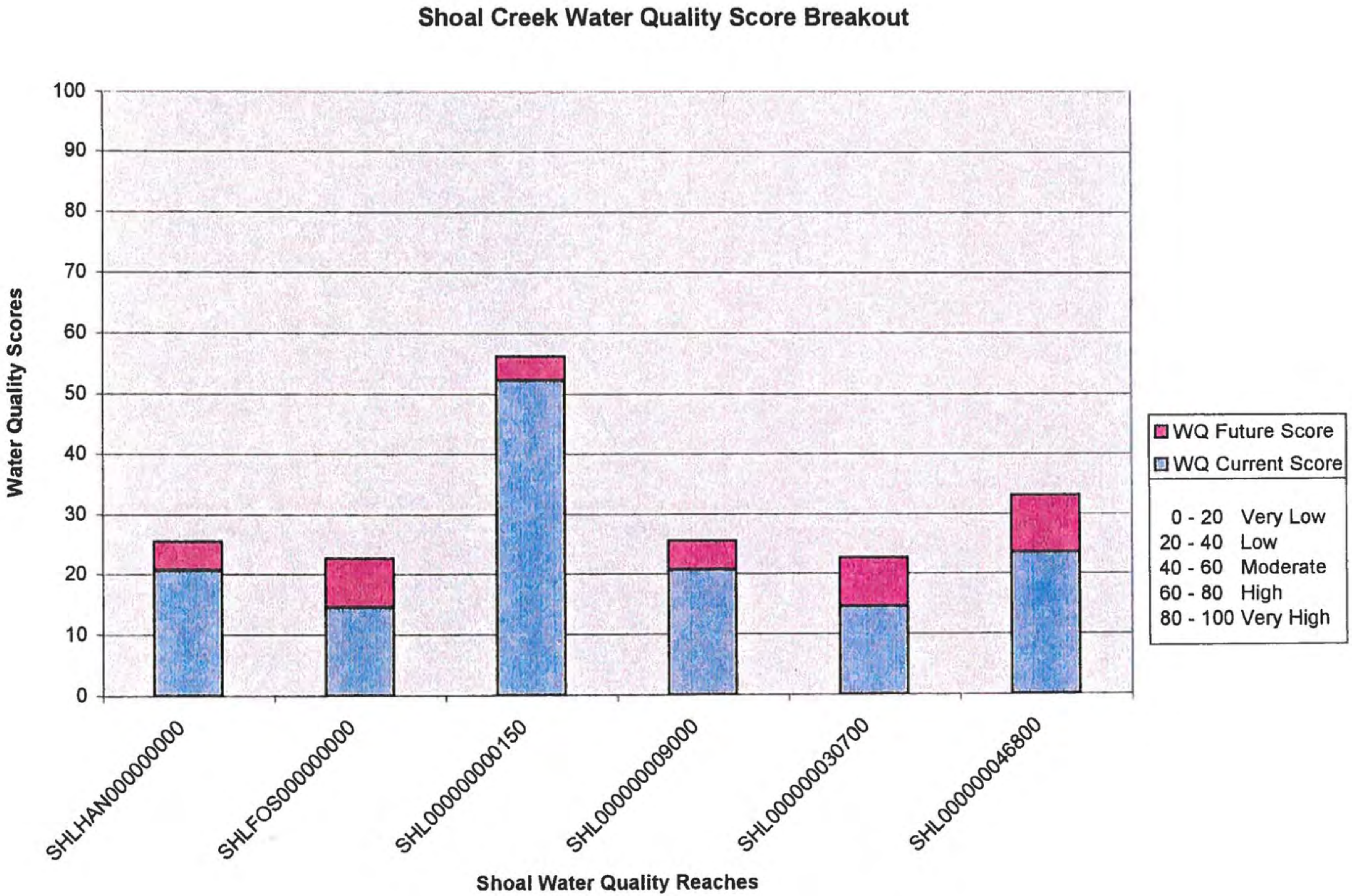
- Very Low
- Low
- Moderate
- High
- Very High
- Lakes and Rivers
- Roads
- Phase 1 Watershed
- Austin Area Watersheds



Shoal Creek Watershed
Current Water Quality Problem Rating

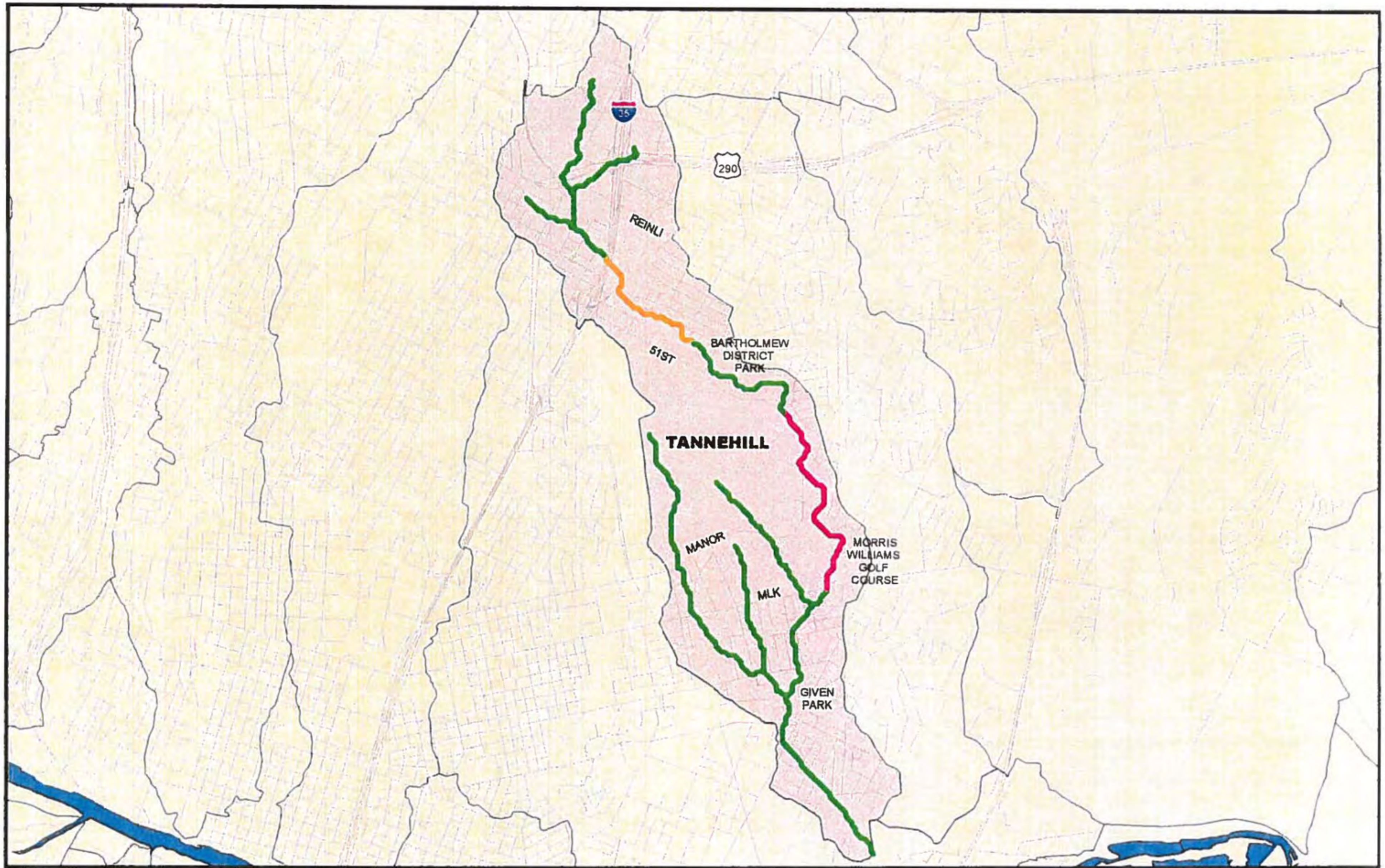
Figure A - 35

Watershed Protection Department



Shoal Creek Water Quality Score Breakout
Water Quality Scores
100
90
80
70
60
50
40
30
20
10
0
SHLHAN000000000
SHLFOS000000000
SHL000000000150
SHL000000009000
SHL000000030700
SHL000000046800
Shoal Water Quality Reaches
WQ Future Score
WQ Current Score
0 - 20 Very Low
20 - 40 Low
40 - 60 Moderate
60 - 80 High
80 - 100 Very High

Figure A - 36



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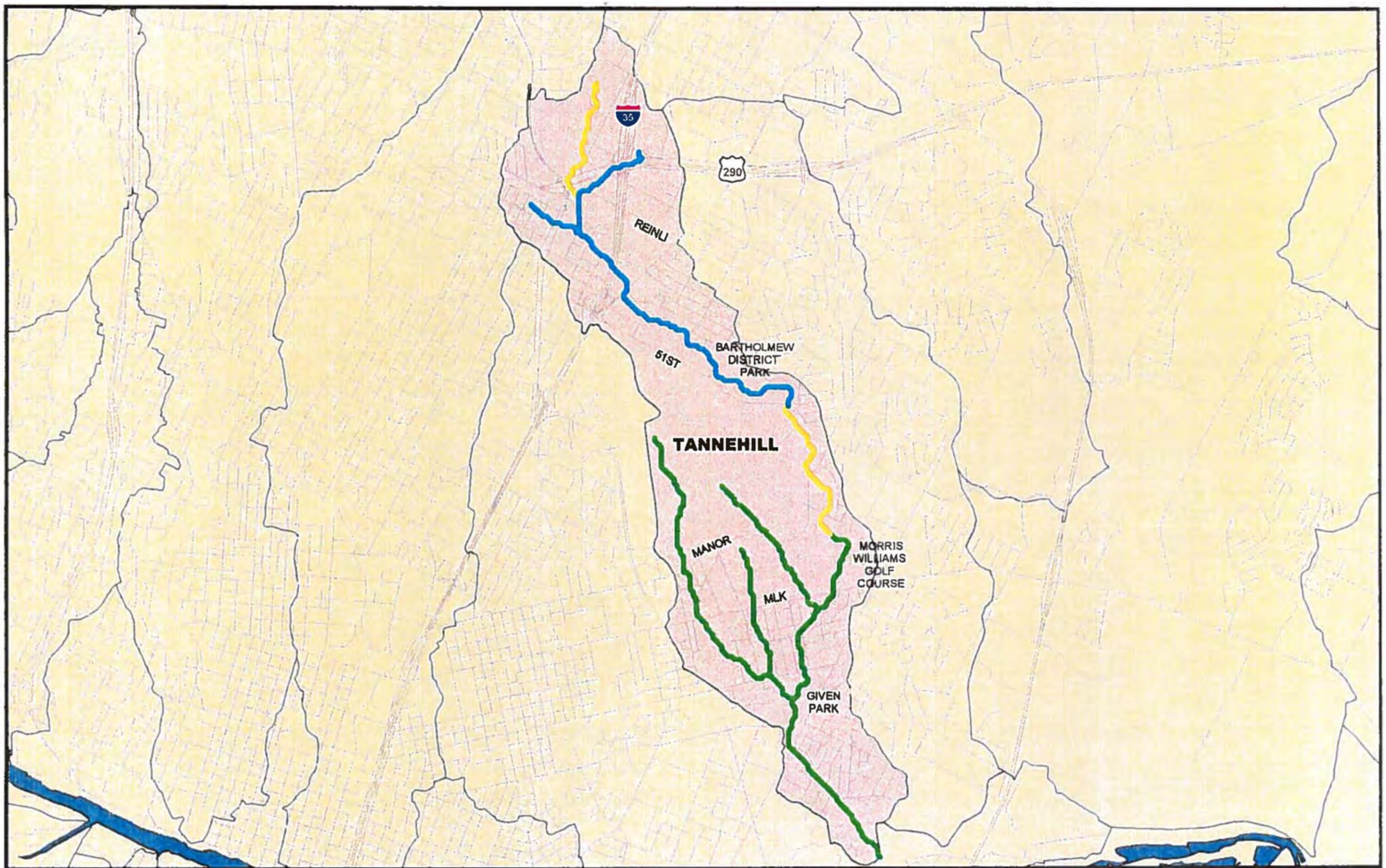
Tannehill Branch Watershed
Current Erosion Problem Rating

Figure A - 37



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Tannehill Branch Watershed
Current Water Quality Problem Rating

0.5 0 0.5 1 Miles

N

Water Quality Rating
- Very Low
- Low
- Moderate
- High
- Very High
- Roads
- Lakes & Rivers
- Phase 1 Watersheds
- Austin Area Watersheds

Figure A - 38

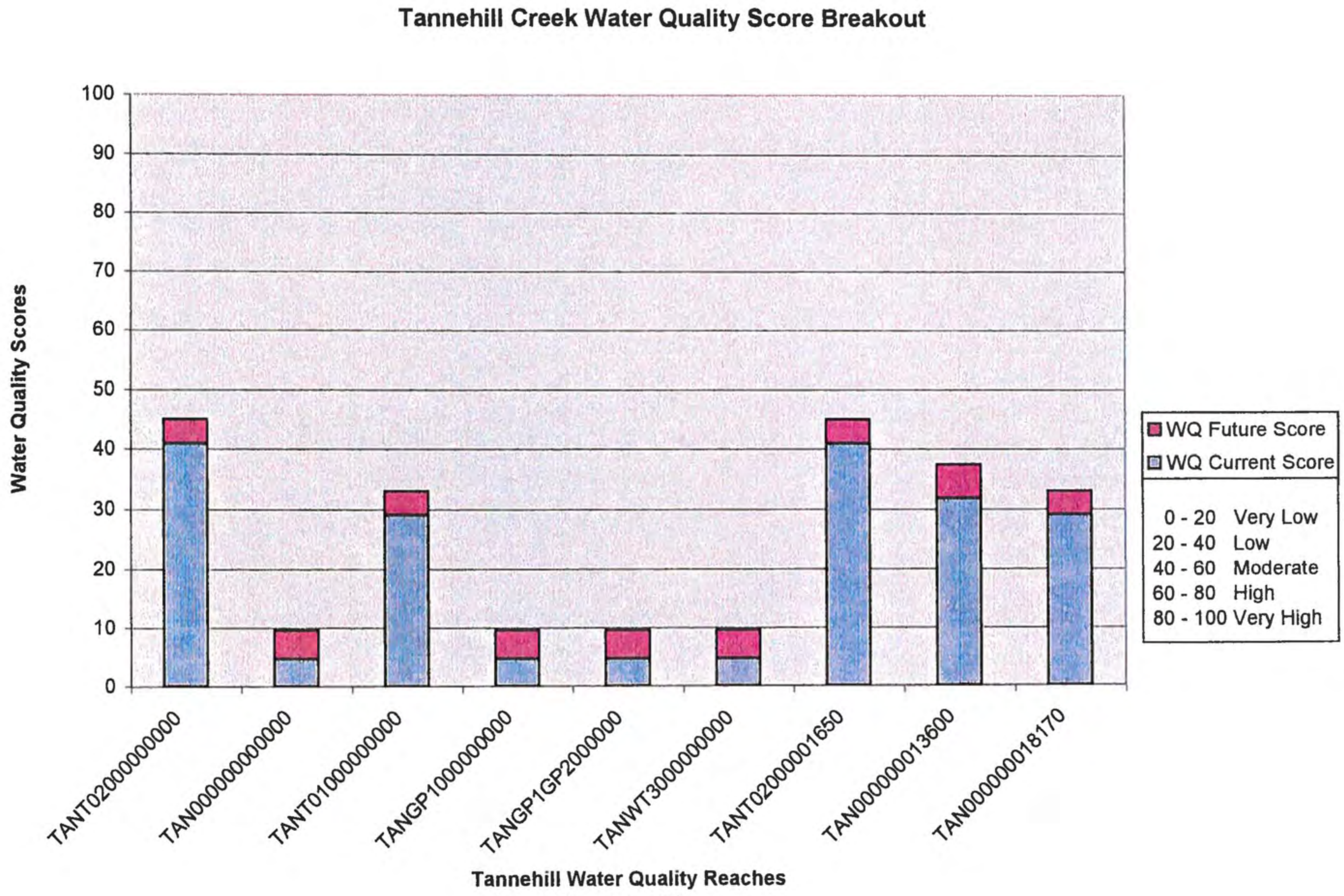
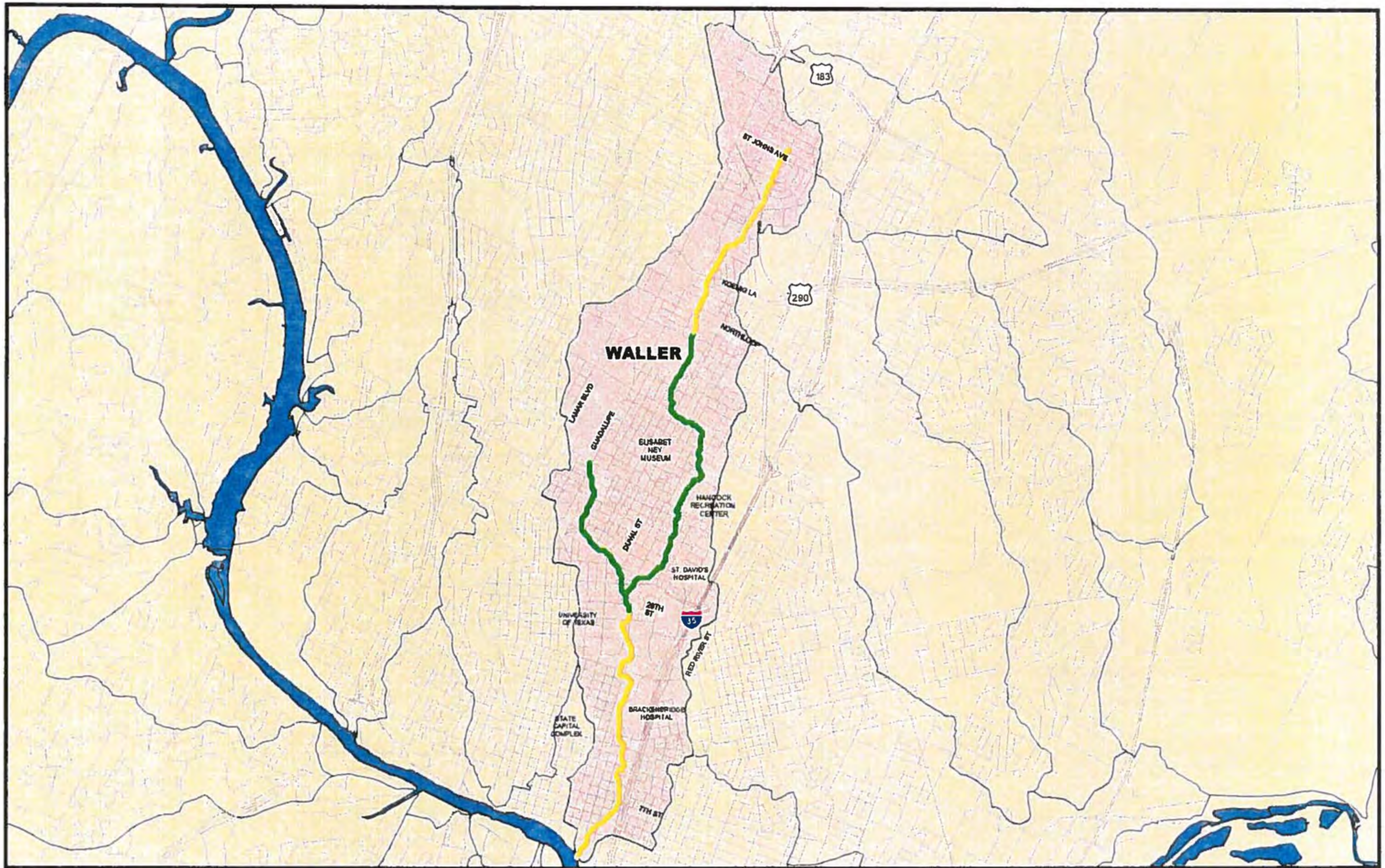

Tannehill Creek Water Quality Score Breakout
Water Quality Scores
100
90
80
70
60
50
40
30
20
10
0
TANT02000000000
TAN00000000000
TANT01000000000
TANGP1000000000
TANGP1GP2000000
TANWT3000000000
TANT02000001650
TAN00000013600
TAN00000018170
WQ Future Score
WQ Current Score
0 - 20 Very Low
20 - 40 Low
40 - 60 Moderate
60 - 80 High
80 - 100 Very High
Tannehill Water Quality Reaches

Figure A - 39



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Waller Creek Watershed
Current Water Quality Problem Rating

1 0 1 Miles

N

Figure A - 40

Water Quality Rating

- Very Low
- Low
- Moderate
- High
- Very High
- Roads
- Lakes & Rivers
- Phase 1 Watersheds
- Austin Area Watersheds

Waller Creek Water Quality Score Breakout

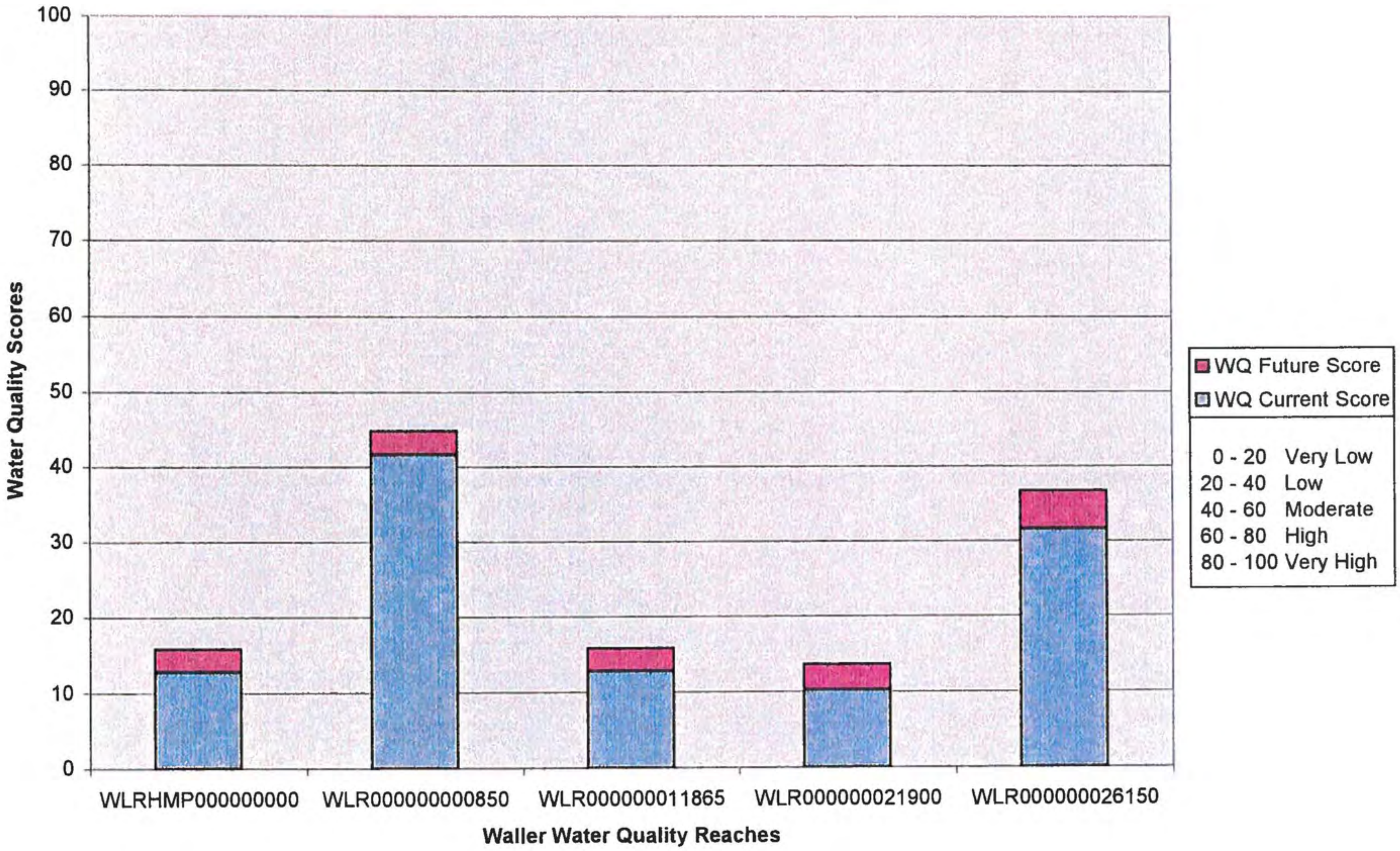
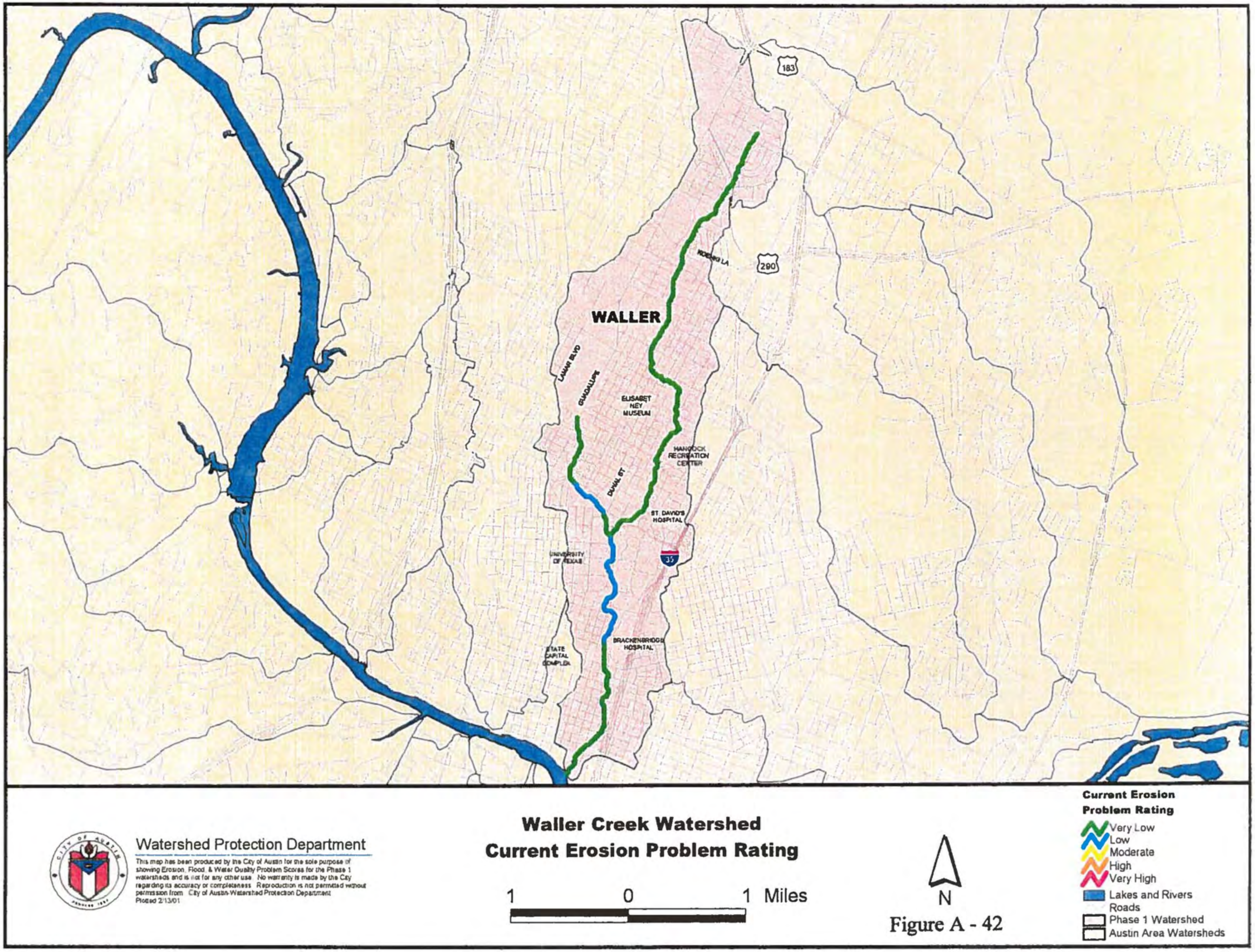


Figure A - 41



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Waller Creek Watershed
Current Erosion Problem Rating

Figure A - 42

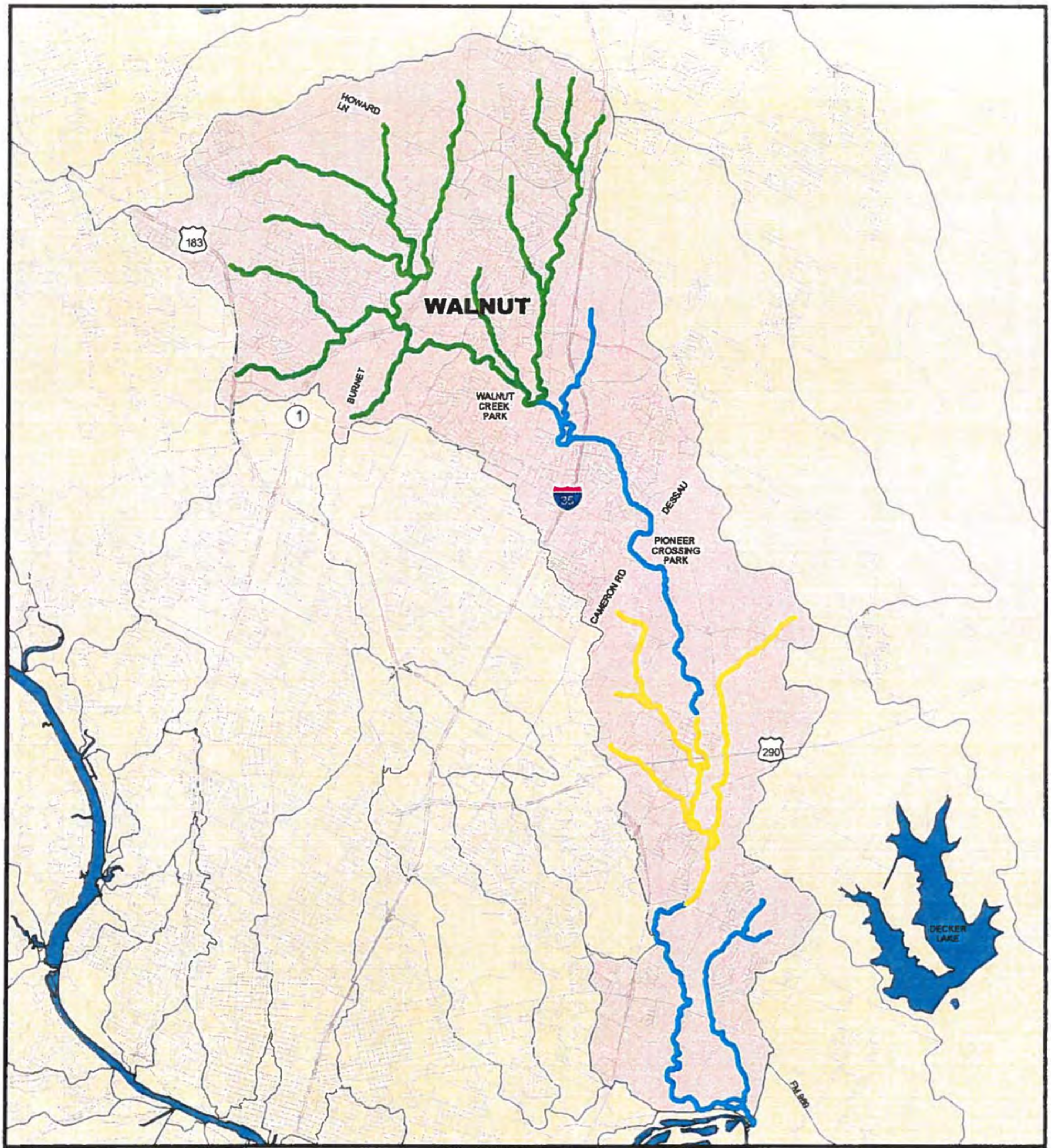

Figure A - 43

Walnut Creek Watershed
Current Water Quality Problem Rating

N

1 0 1 2 Miles

Water Quality Rating
- Very Low
- Low
- Moderate
- High
- Very High
- Lakes and Rivers
- Roads
- Phase 1 Watershed
- Austin Area Watersheds

Watershed Protection Department

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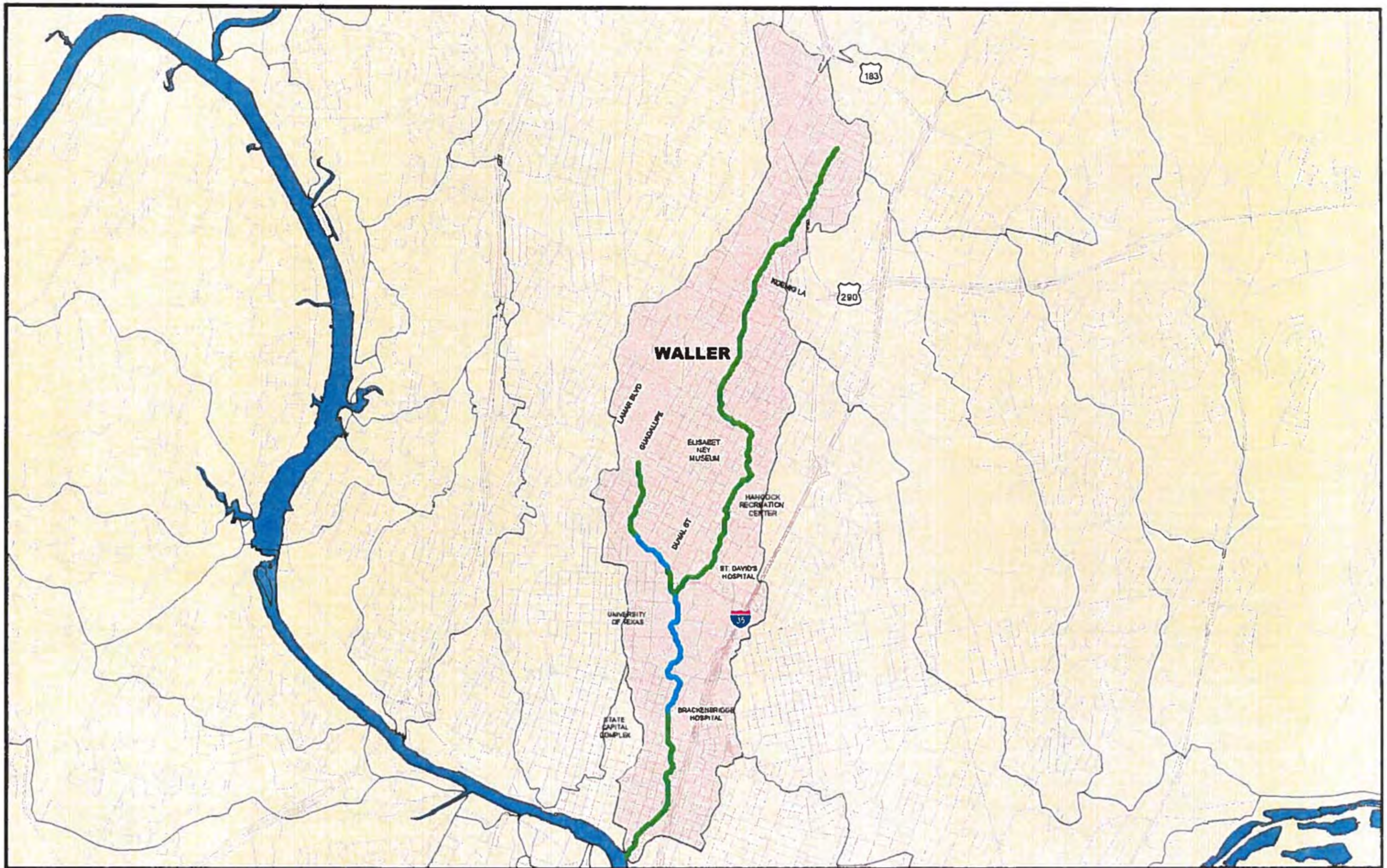

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Waller Creek Watershed
Current Erosion Problem Rating

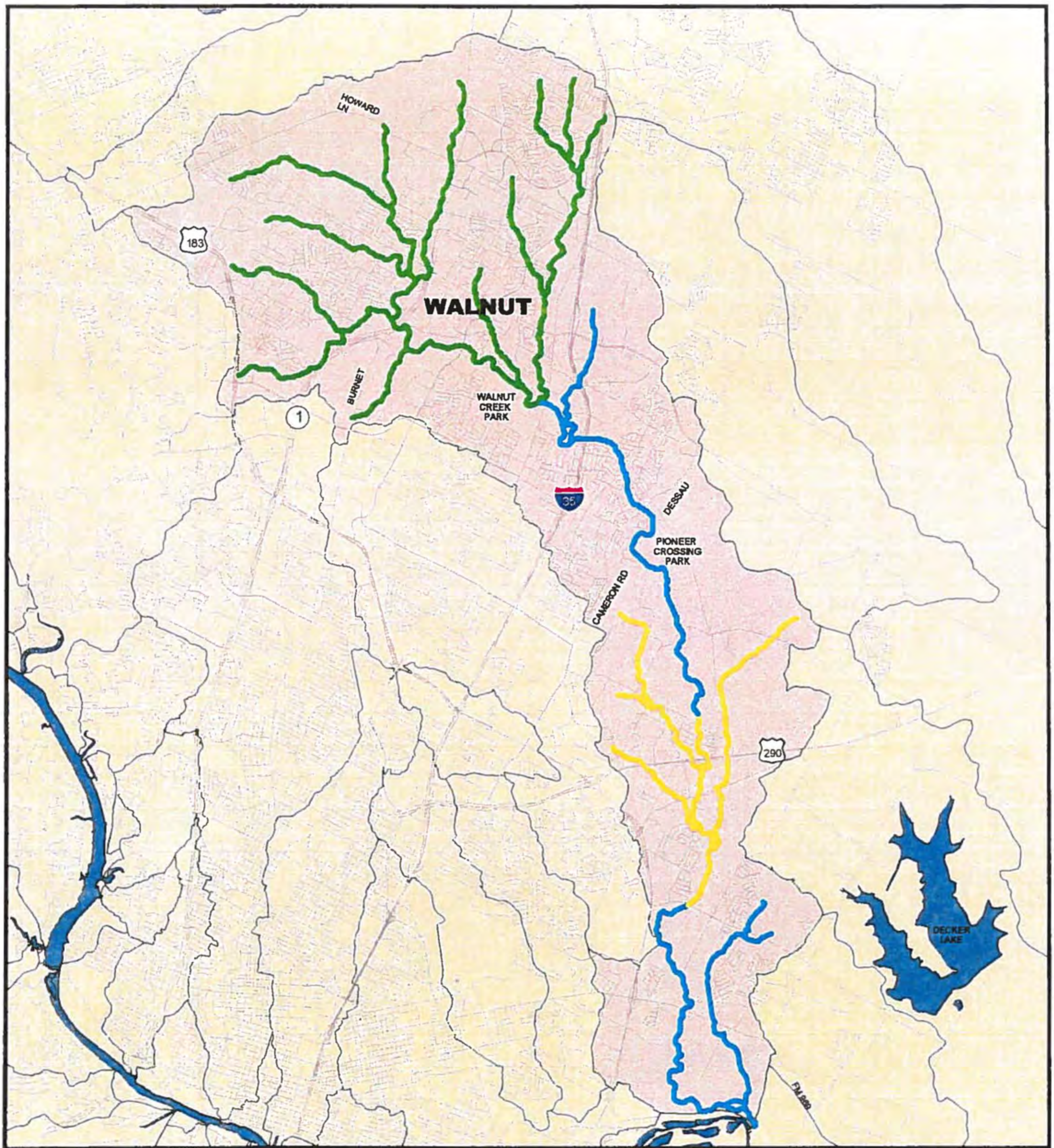
1 0 1 Miles

N

Figure A - 42

Current Erosion Problem Rating

Very Low
Low
Moderate
High
Very High
Lakes and Rivers
Roads
Phase 1 Watershed
Austin Area Watersheds



N

Figure A - 43

Watershed Protection Department

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Walnut Creek Watershed
Current Water Quality Problem Rating

1 0 1 2 Miles

Water Quality Rating

- Very Low
- Low
- Moderate
- High
- Very High
- Lakes and Rivers
- Roads
- Phase 1 Watershed
- Austin Area Watersheds

Walnut Creek Water Quality Score Breakout

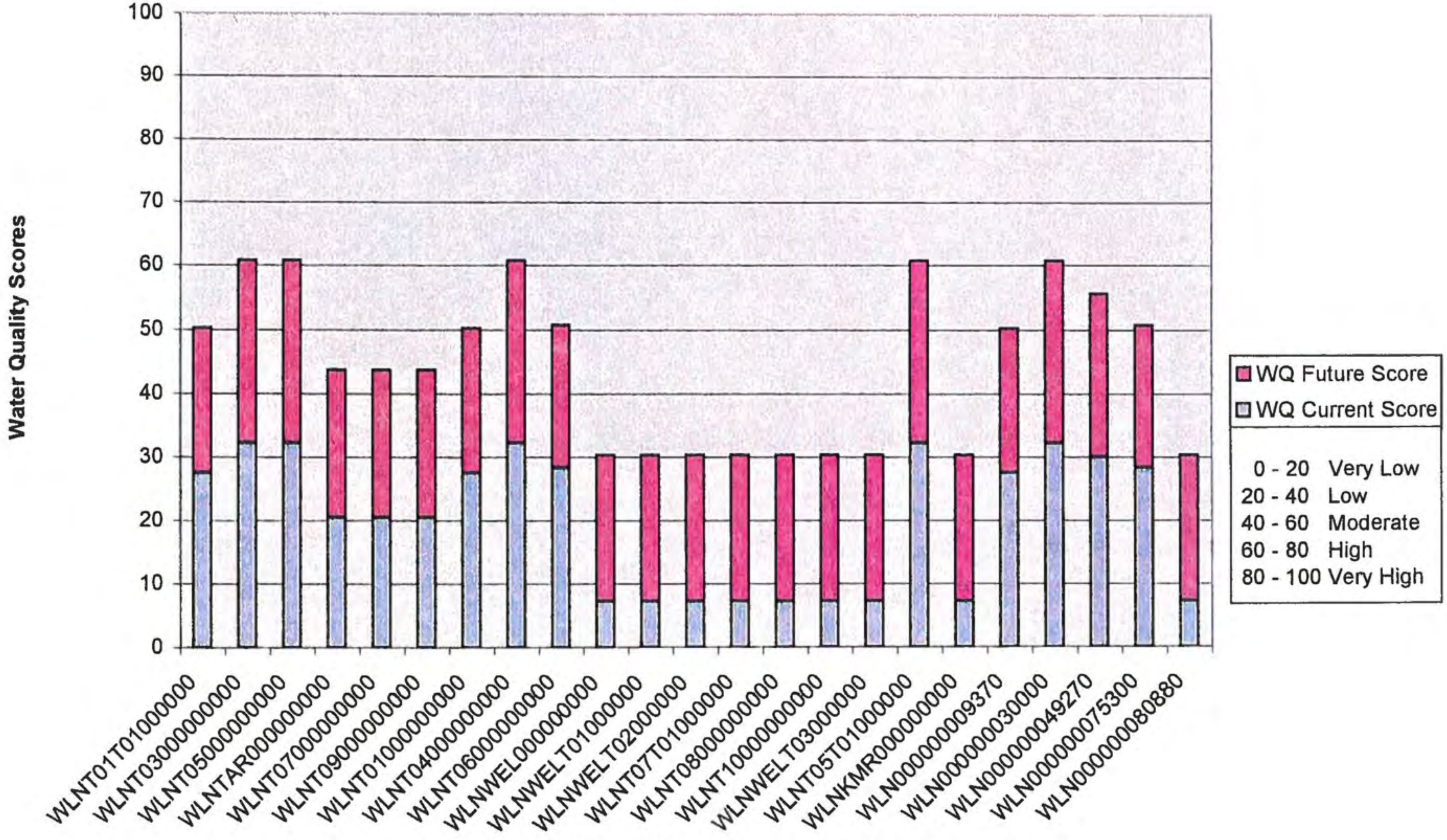
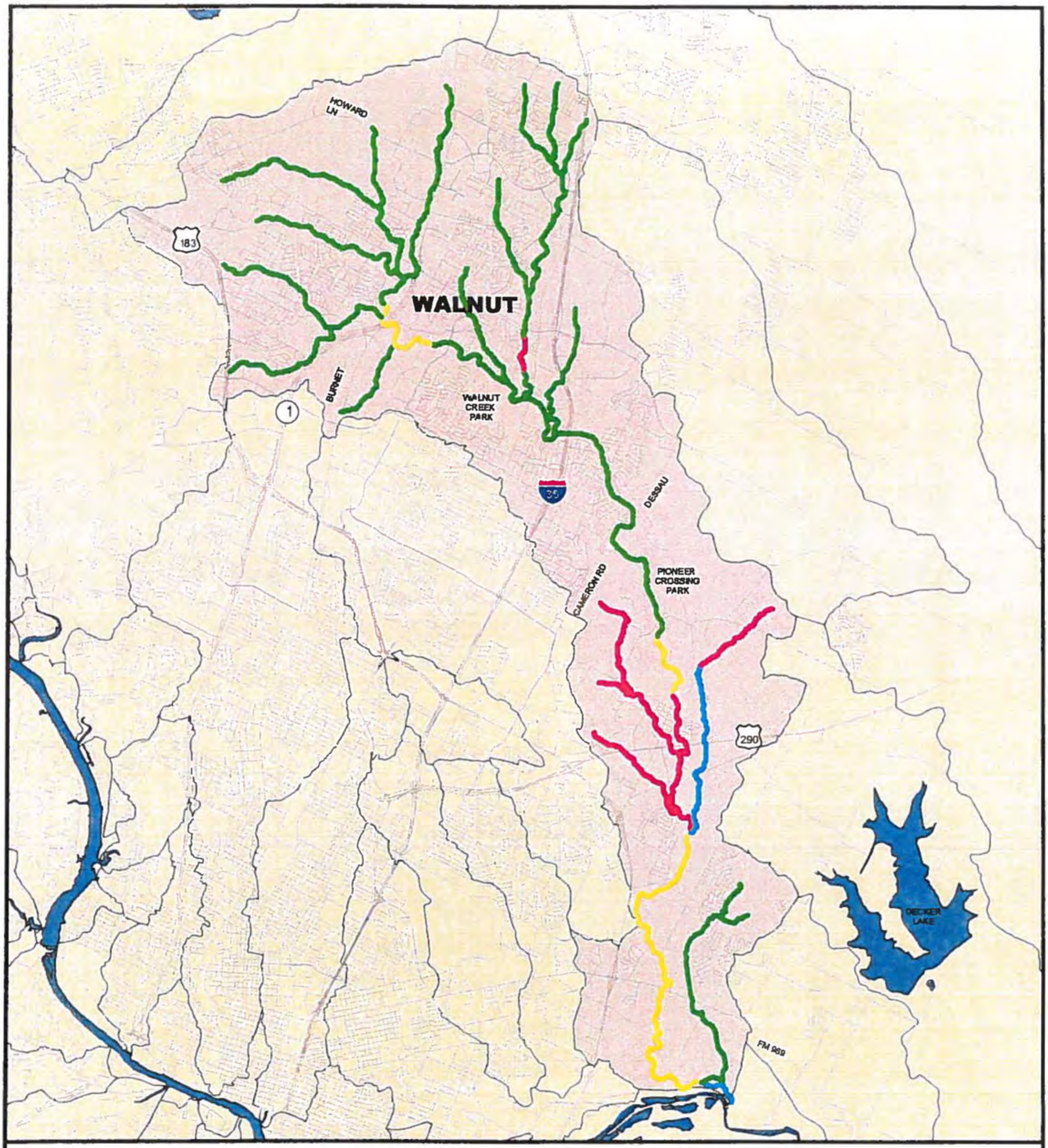


Figure A - 44



N

Figure A - 45

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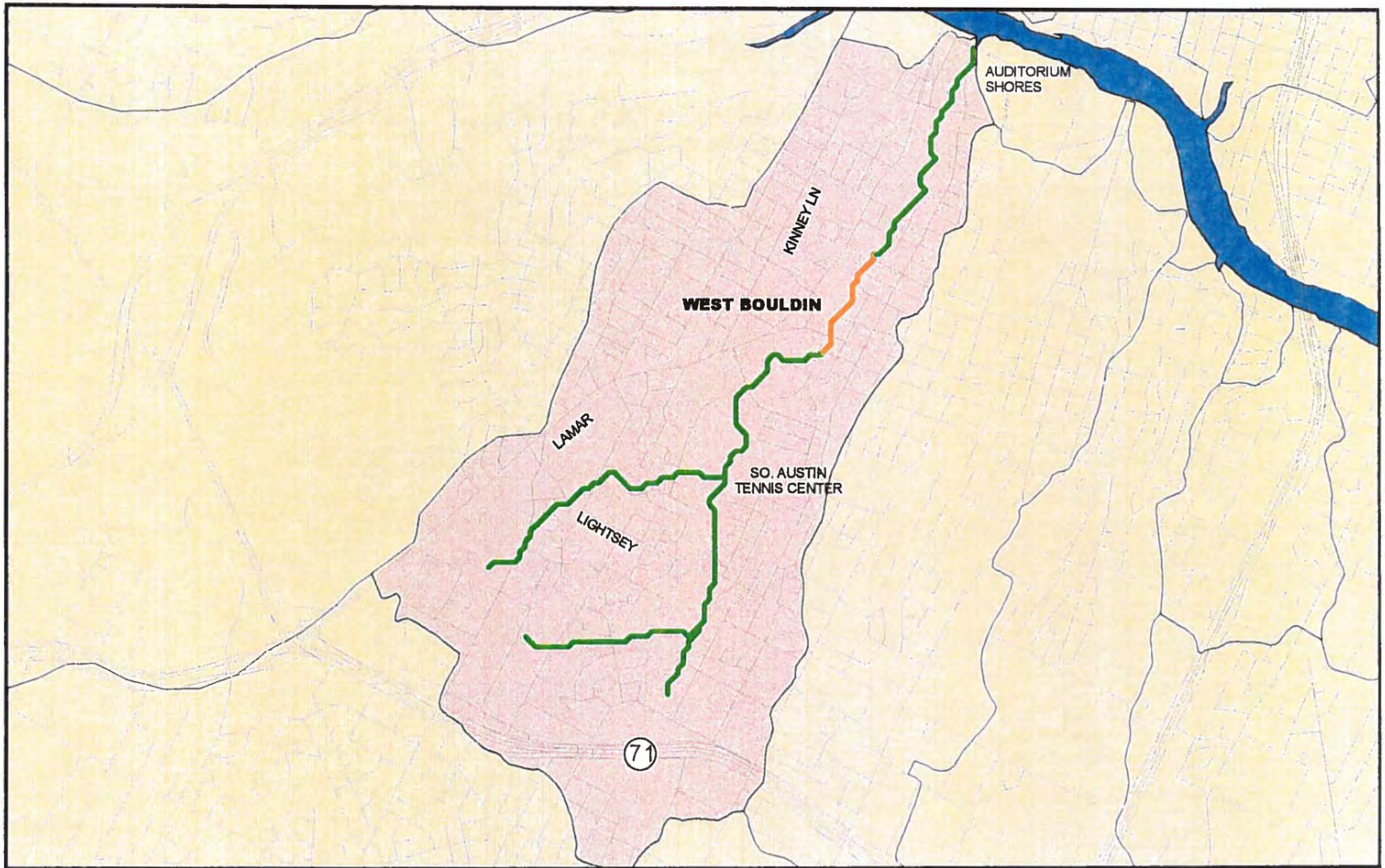
Walnut Creek Watershed
Current Erosion Problem Rating

1 0 1 2 Miles

Current Erosion Problem Rating

- Very Low
- Low
- Moderate
- High
- Very High
- Lakes and Rivers
- Roads
- Phase 1 Watershed
- Austin Area Watersheds



Watershed Protection Department

West Bouldin Creek Watershed
Current Erosion Problem Rating

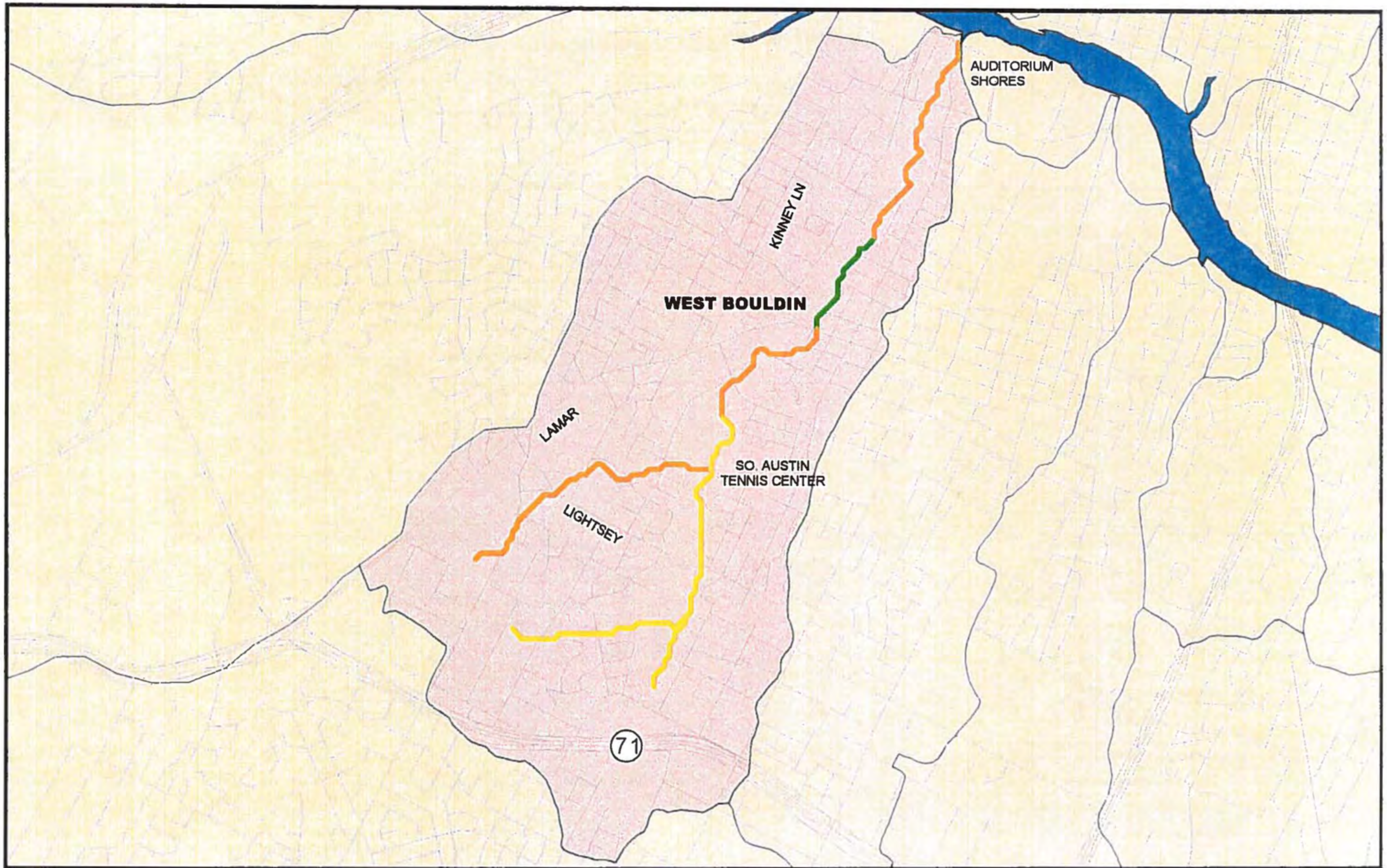
0.5 0 0.5 Miles

N

Figure A - 46

Current Erosion Problem Rating

- Very Low
- Low
- Moderate
- High
- Very High
- Lakes and Rivers
- Roads
- Phase 1 Watershed
- Austin Area Watersheds



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West Bouldin Creek Watershed
Current Water Quality Problem Rating

0.5 0 0.5 Miles

N

Figure A - 47

Water Quality Rating
- Very Low
- Low
- Moderate
- High
- Very High
- Roads
- Lakes & Rivers
- Phase 1 Watersheds
- Austin Area Watersheds

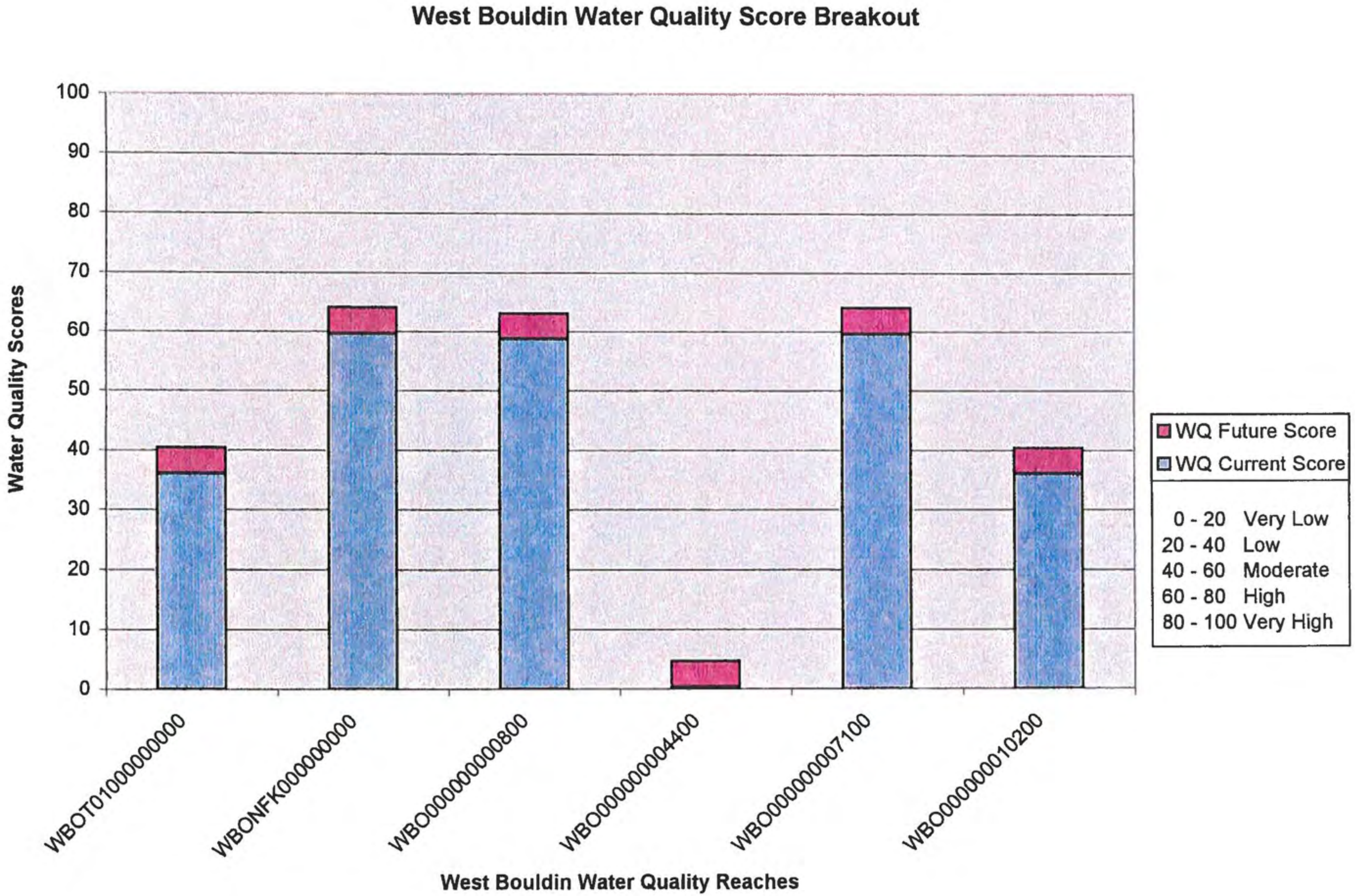
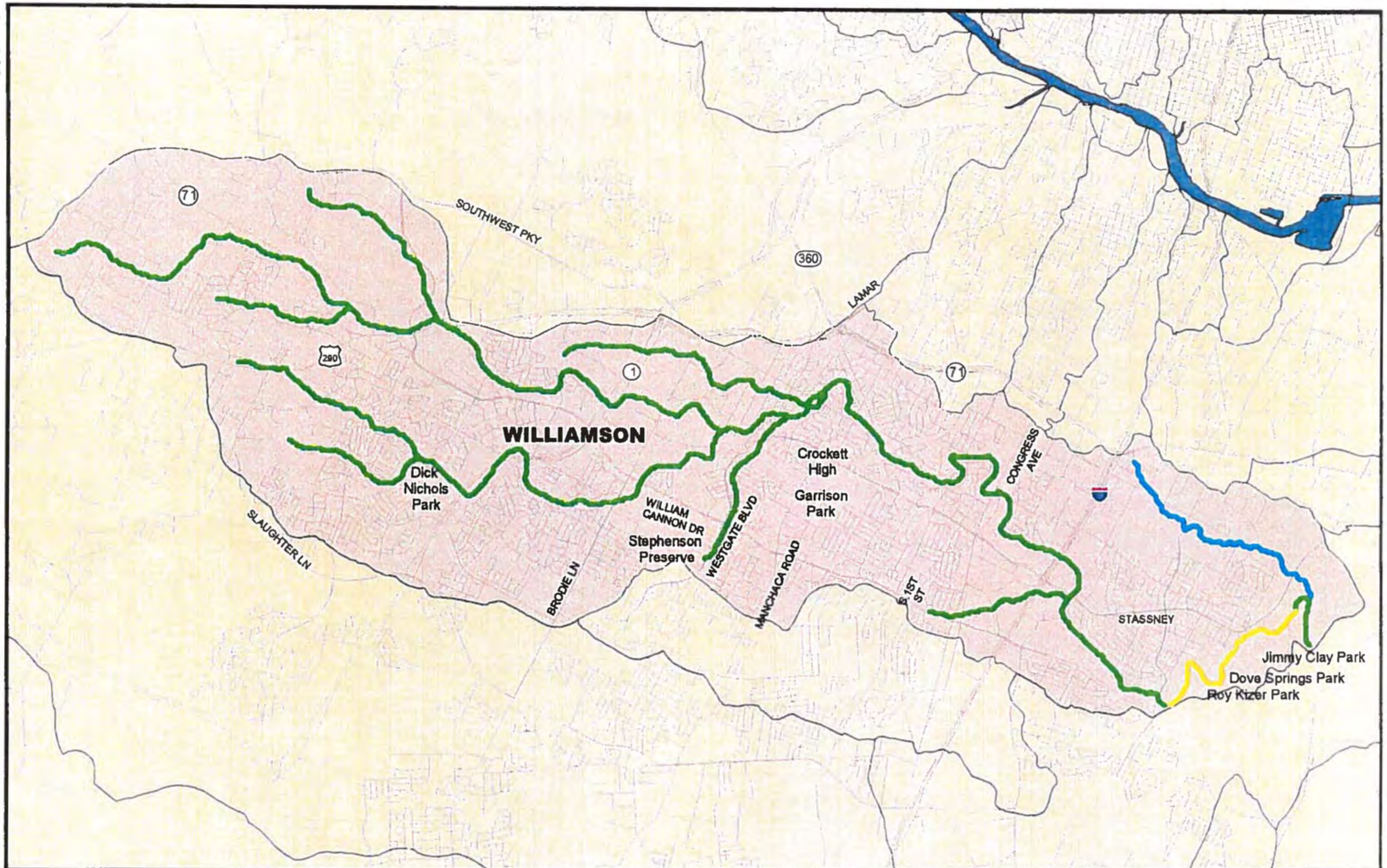

West Bouldin Water Quality Score Breakout
Water Quality Scores
100
90
80
70
60
50
40
30
20
10
0
WBOT01000000000
WBONFK00000000
WBO00000000800
WBO00000004400
WBO00000007100
WBO00000010200
West Bouldin Water Quality Reaches
WQ Future Score
WQ Current Score
0 - 20 Very Low
20 - 40 Low
40 - 60 Moderate
60 - 80 High
80 - 100 Very High

Figure A - 48



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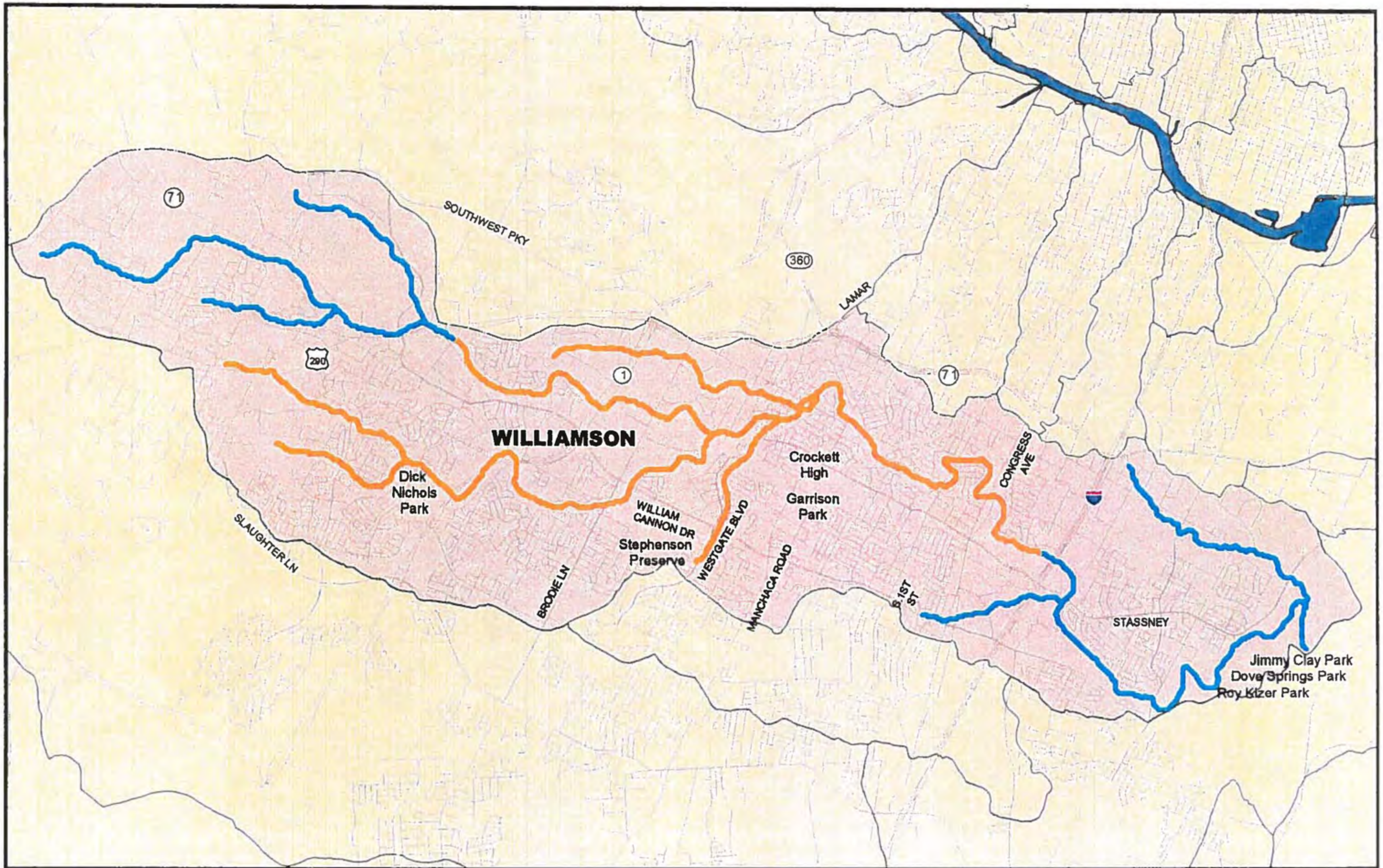
Williamson Creek Watershed
Current Erosion Problem Rating

1 0 1 2 Miles

N

Figure A - 49

Current Erosion Problem Rating
- Very Low
- Low
- Moderate
- High
- Very High
- Lakes and Rivers
- Roads
- Phase 1 Watershed
- Austin Area Watersheds



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Williamson Creek Watershed
Current Water Quality Problem Rating

1 0 1 2 Miles

N

Figure A - 50

Water Quality Rating
- Very Low
- Low
- Moderate
- High
- Very High
- Roads
- Lakes & Rivers
- Phase 1 Watersheds
- Austin Area Watersheds

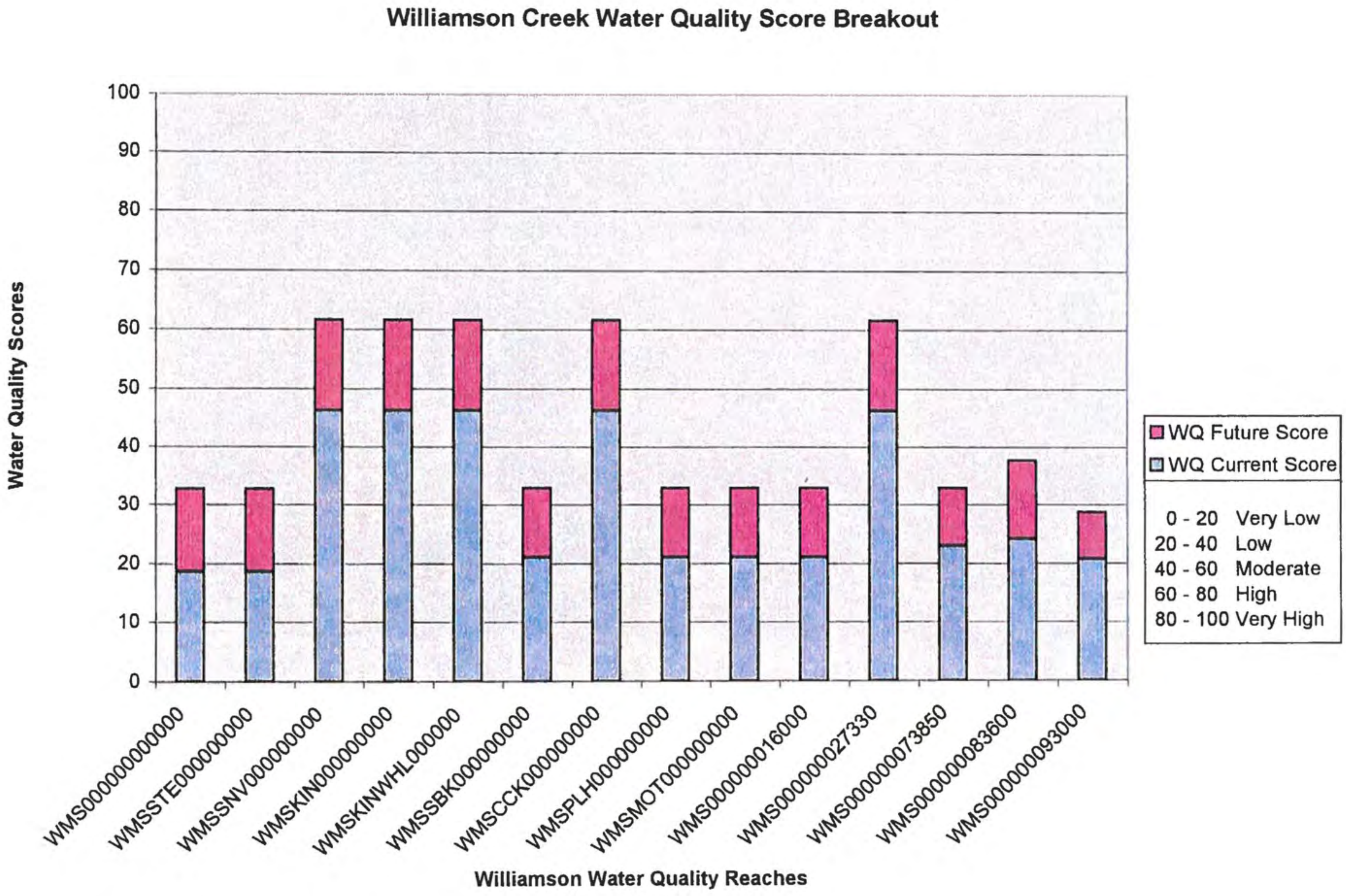
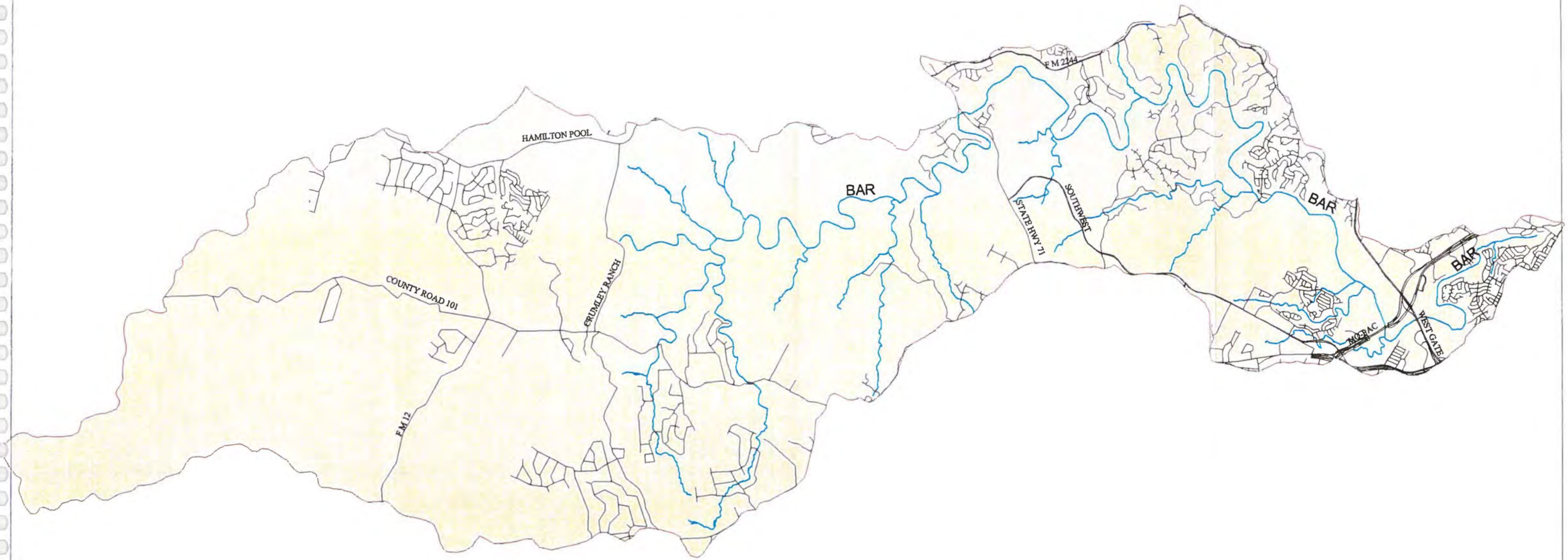

Williamson Creek Water Quality Score Breakout
Water Quality Scores
100
90
80
70
60
50
40
30
20
10
0
WMS00000000000
WMSSTE00000000
WMSSNV00000000
WMSKIN00000000
WMSKINWHL000000
WMSSBK00000000
WMSCCK00000000
WMSPLH00000000
WMSMOT00000000
WMS000000016000
WMS000000027330
WMS000000073850
WMS000000083600
WMS000000093000
Williamson Water Quality Reaches
WQ Future Score
WQ Current Score
0 - 20 Very Low
20 - 40 Low
40 - 60 Moderate
60 - 80 High
80 - 100 Very High

Figure A - 51

Barton Creek Watershed



BAR Barton Main Branch

Watershed Protection Department

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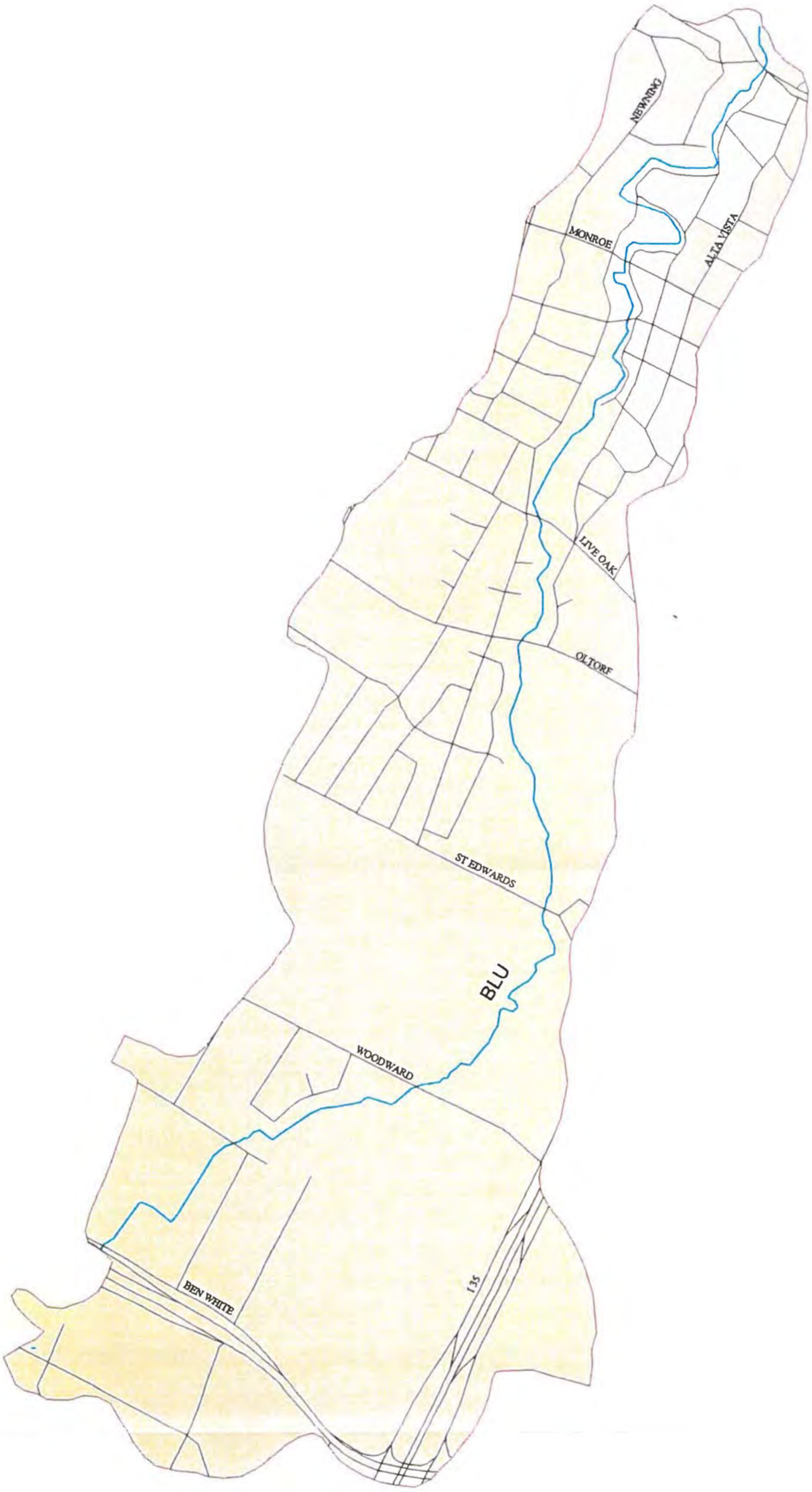
N

Figure A - 52

0 1 2 3 4 5 6 7 8 Miles

Roads
Creeks & Tributaries
Watershed Boundary

Blunn Creek Watershed



BLU Blunn Main Branch

Watershed Protection Department

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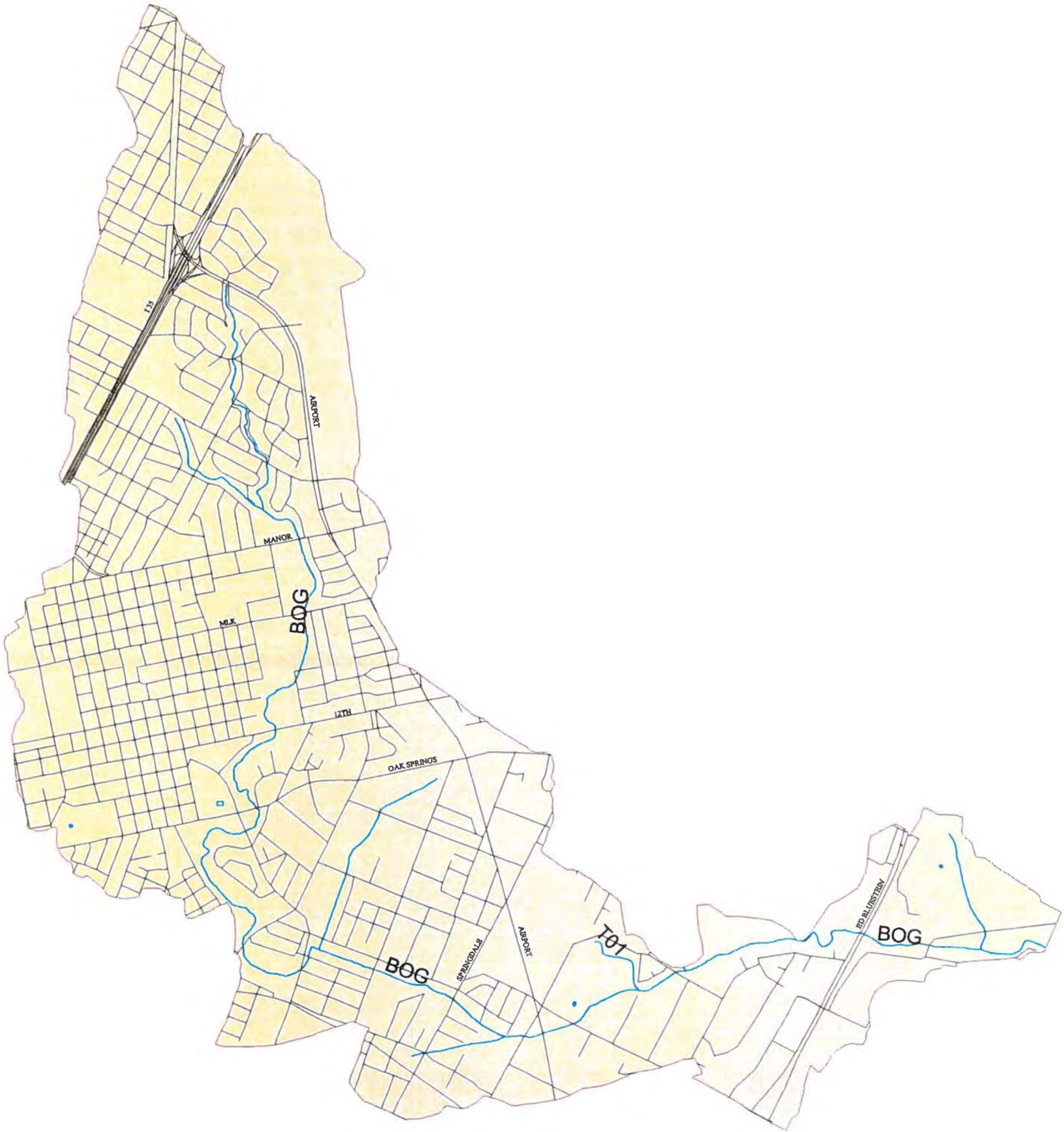
N

Figure A - 53

0 0.25 Miles

Roads
Creeks & Tributaries
Watershed Boundary

Boggy Creek Watershed



BOG Boggy Main Branch
T Tributary

Watershed Protection Department

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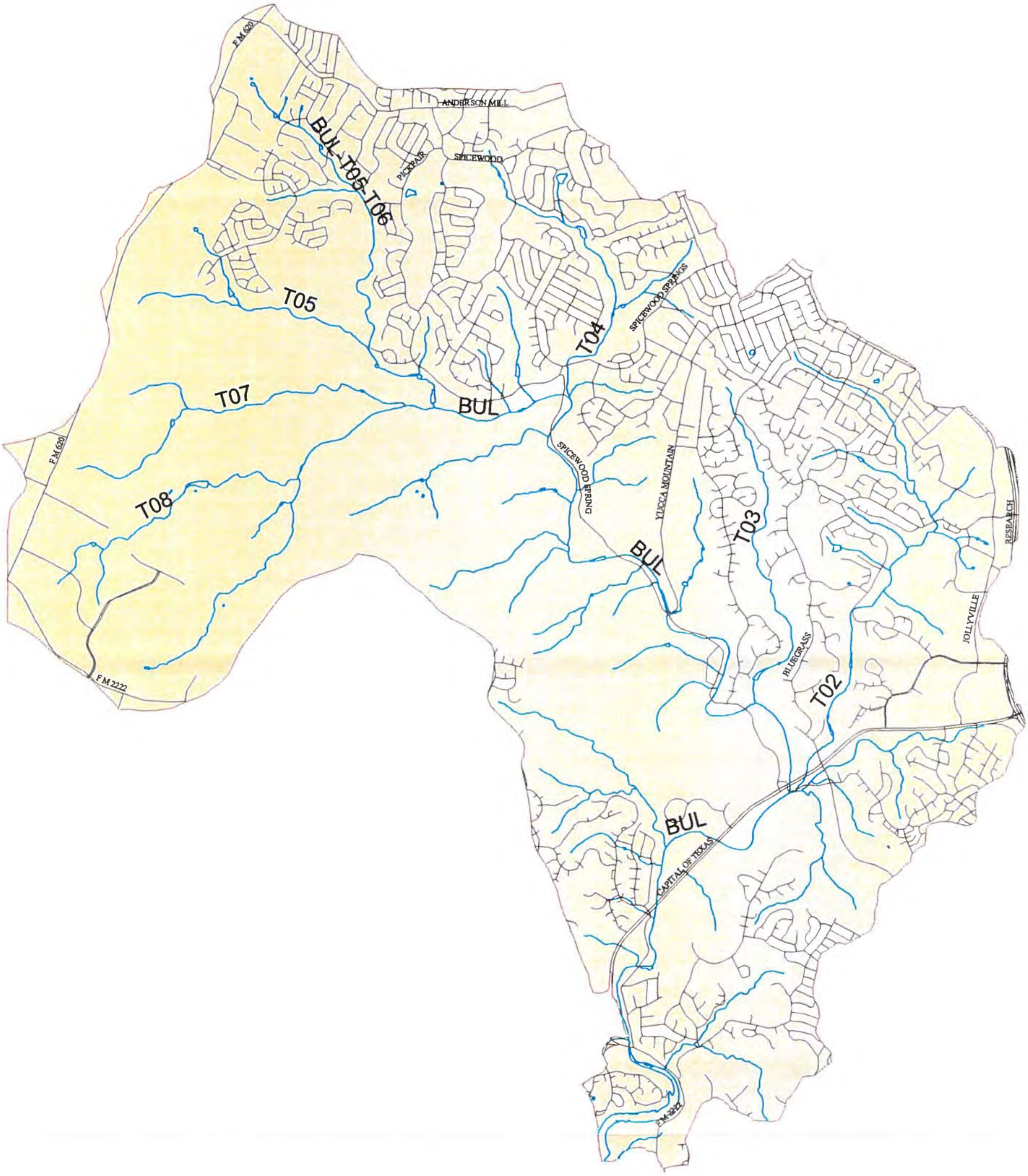
N

0 0.5 1 Miles

Roads
Creeks & Tributaries
Watershed Boundary

Figure A - 54

Bull Creek Watershed



BUL Bull Creek Main Branch
T Tributary

Watershed Protection Department

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N

0 0.5 1 1.5 Miles

Roads
Creeks & Tributaries
Watershed Boundary

Figure A -55

Buttermilk Creek Watershed

BMK Buttermilk Main Branch

Watershed Protection Department

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N

Figure A - 56

0 0.25 0.5 Miles

Roads
Creeks & Tributaries
Watershed Boundary

Country Club Creek Watershed

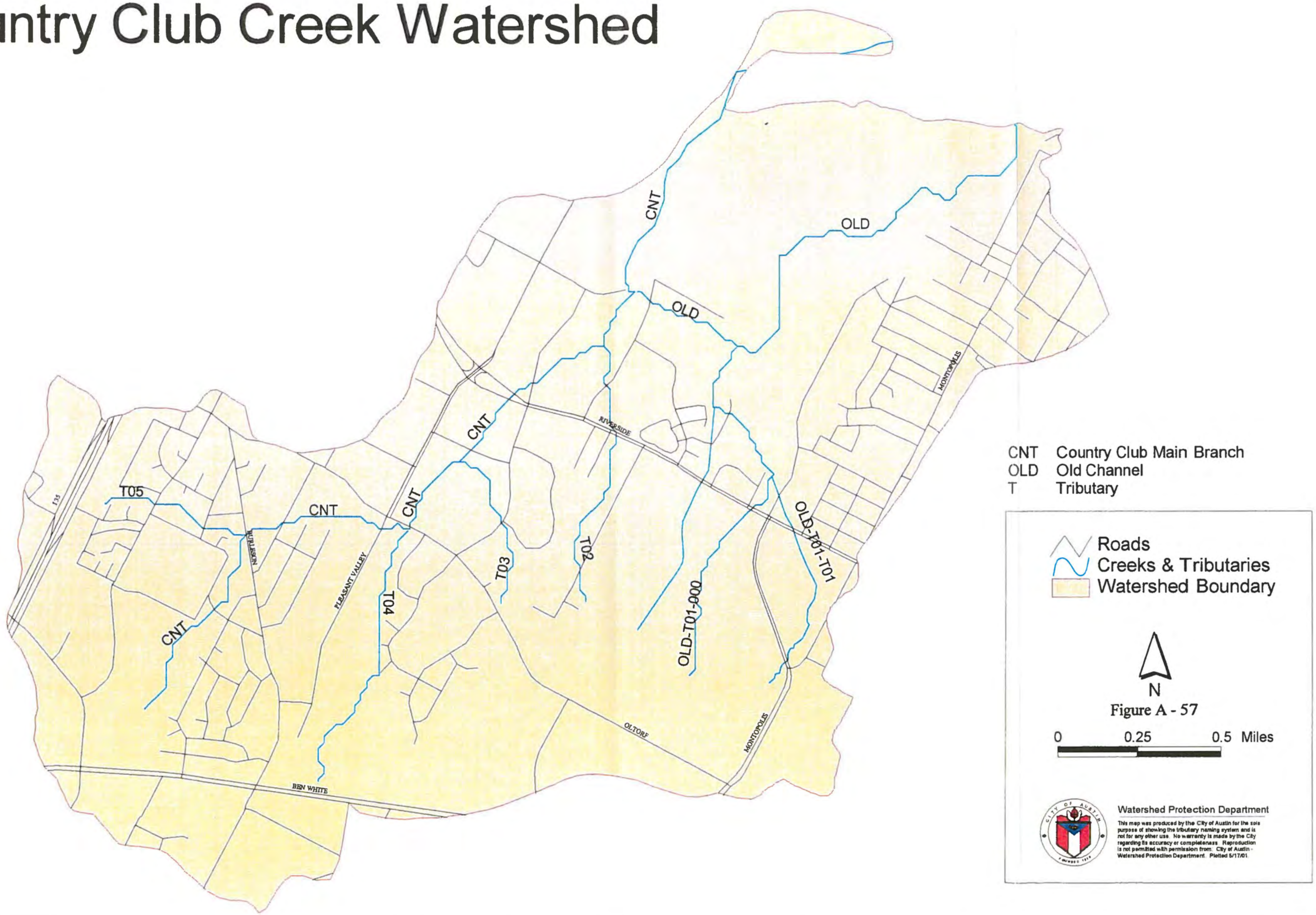

Figure A - 57

Watershed Protection Department

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East Bouldin Creek Watershed

EBO East Bouldin Main Branch
STE St Edward's Branch

Watershed Protection Department

N

0 0.25 0.5 Miles

Roads
Creeks & Tributaries
Watershed Boundary

Figure A - 58

Fort Branch Watershed

FOR Fort Branch Main Branch
T01 Tributary 1

Watershed Protection Department

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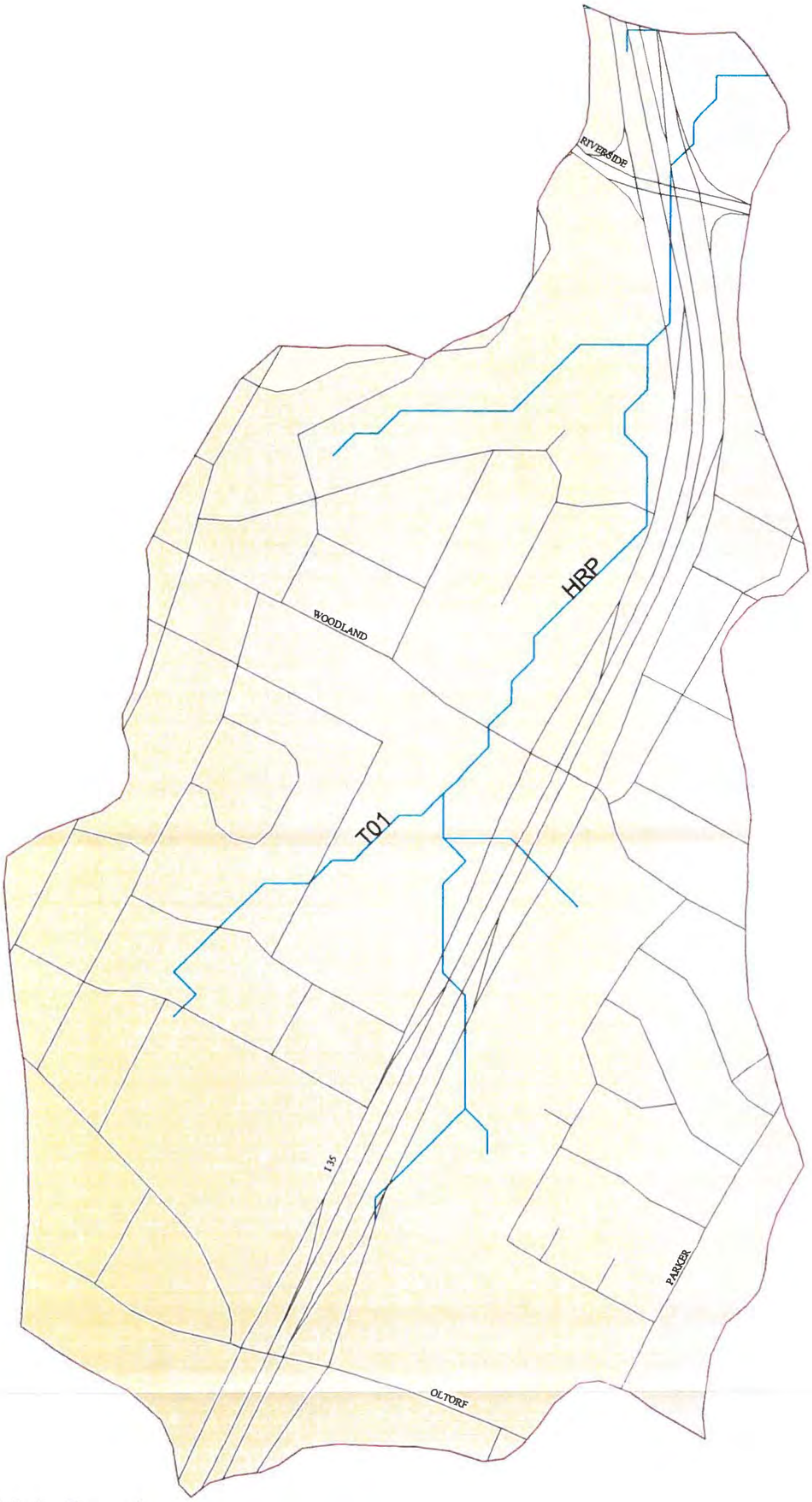
N

0 0.5 1 Miles

Roads
Creeks & Tributaries
Watershed Boundary

Figure A - 59

Harper's Branch Watershed



HRP Harper's Main Branch
T01 Tributary 1

Watershed Protection Department

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N

Figure A - 60

0 0.1 0.2 0.3 Miles

Roads
Creeks & Tributaries
Watershed Boundary

Johnson Creek Watershed

POS Possum Trot Branch
JOH Johnson Main Branch

Watershed Protection Department

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N

0 0.25 0.5 Miles

Roads
Creeks & Tributaries
Watershed Boundary

Figure A - 61

Little Walnut Creek Watershed

LWA Little Walnut Main Branch
QCB Quail Creek Branch
T Tributary

Watershed Protection Department

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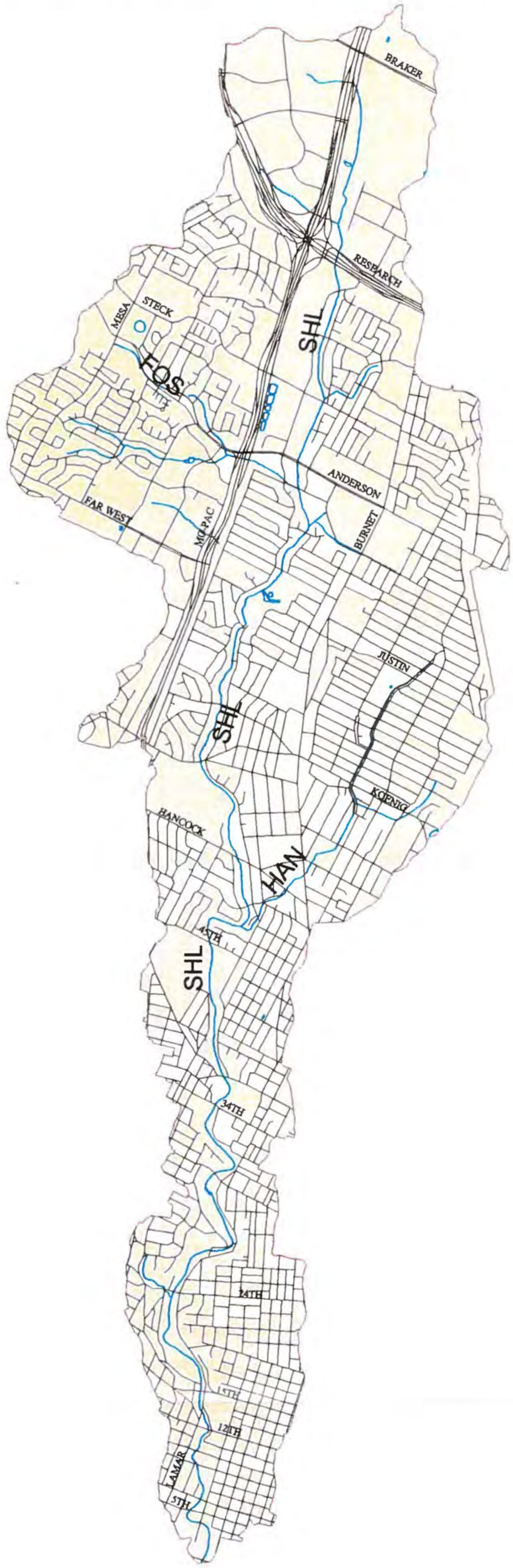
N

0 0.5 1 Miles

Roads
Creeks & Tributaries
Watershed Boundary

Figure A - 62

Shoal Creek Watershed



FOS Foster Branch
HAN Hancock Branch
SHL Shoal Main Branch

Watershed Protection Department

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N

0 0.5 1 1.5 Miles

Roads
Creeks & Tributaries
Watershed Boundary

Figure A - 63

Tannehill Watershed

GP Givens Park Trib
TAN Tannehill Main Branch
WT West Trib

Watershed Protection Department

N

Figure A - 64

0 0.5 1 Miles

Roads
Creeks & Tributaries
Watershed Boundary

Waller Creek Watershed

HMP Hemphill Branch
WLR Waller Main Branch

Watershed Protection Department

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N

Figure A - 65

0 0.5 1 Miles

Roads
Creeks & Tributaries
Watershed Boundary

Walnut Creek Watershed

KMR Kramer Ln
TAR Tar Branch
T Tributary
WEL Wells Branch
WLN Walnut Main Branch

Watershed Protection Department

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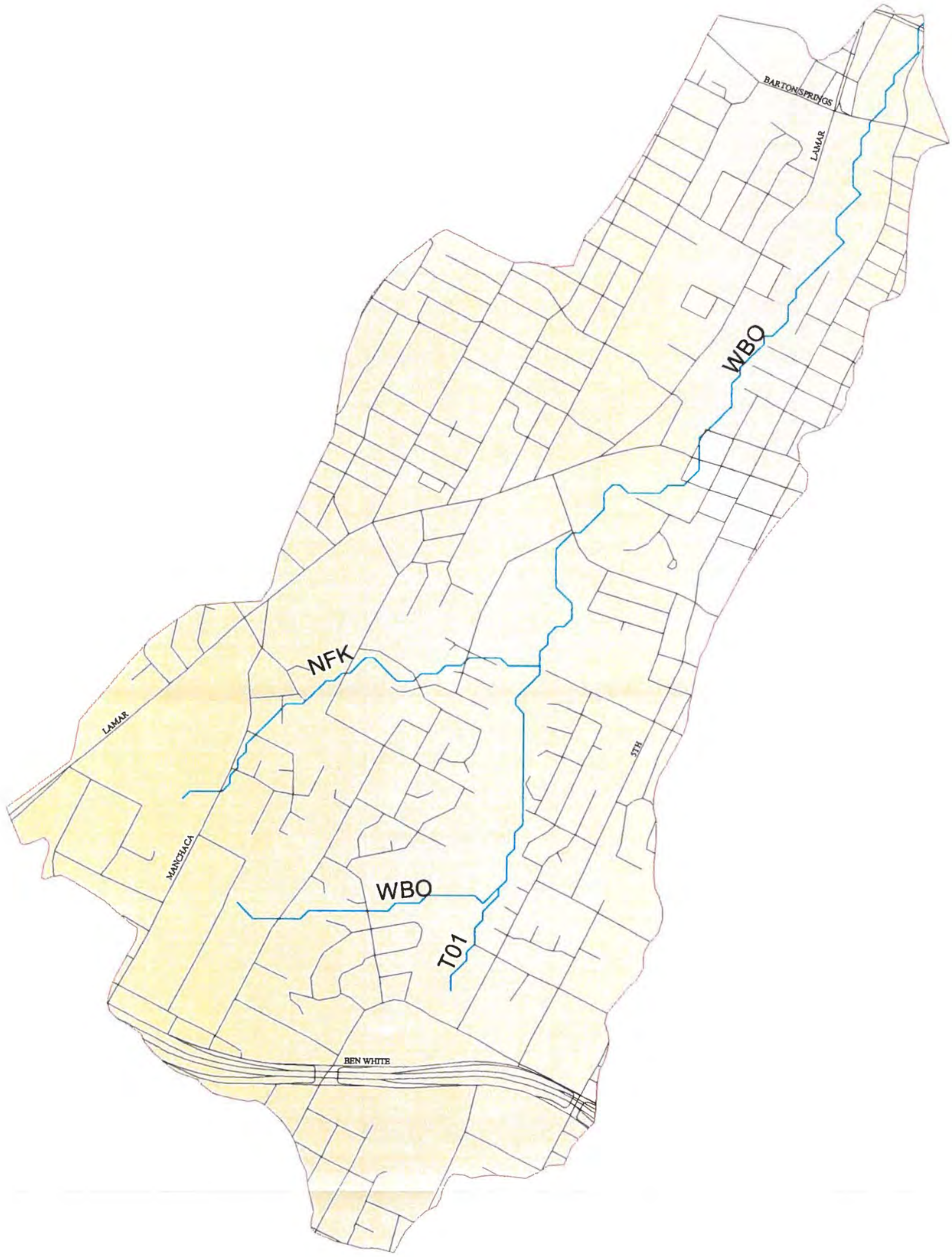
N

0 1 2 3 Miles

Roads
Creeks & Tributaries
Watershed Boundary

Figure A - 66

West Bouldin Creek Watershed



NFK North Fork
WBO West Bouldin Main Branch

Watershed Protection Department

N

Figure A - 67

0 0.25 0.5 Miles

Roads
Creeks & Tributaries
Watershed Boundary

Williamson Creek Watershed

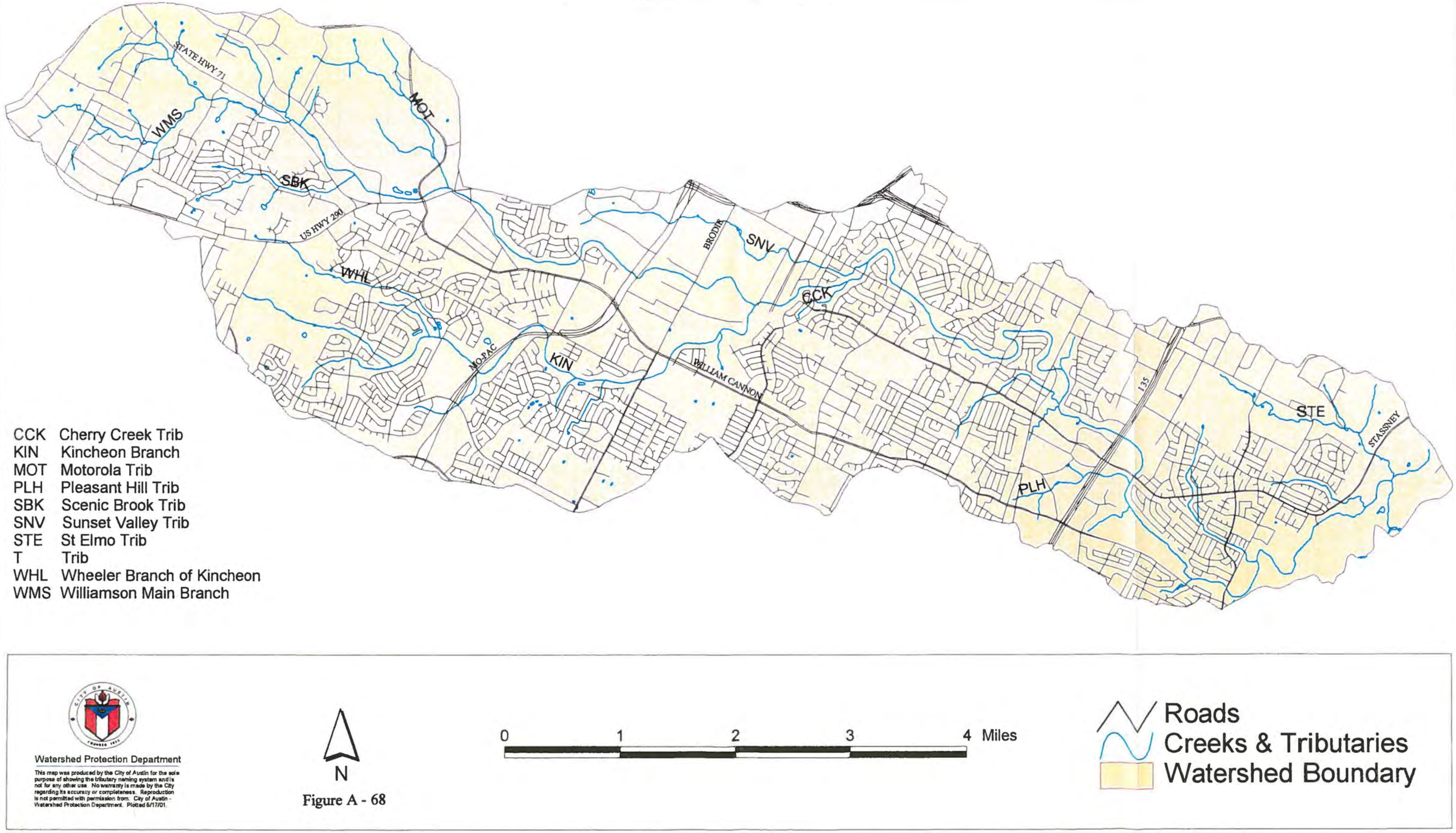


Figure A - 68

APPENDIX B

Problem Area Assessment Scores

Table B - 1
Master Plan Problem Area Assessment Flood Control Scores

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	Exist Public Safety Score	Exist Property Protection Score	Future Public Safety Score	Future Property Protection Score	PSE Normalized	PPE Normalized	PSF Normalized	PPF Normalized	Flag	FC Reach ID	FC Final Score
BAR	000	000	0	999999	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	EST	BAR000000000000	0.00
BLU	000	000	0	1875	5.00	5.00	5.00	5.00	0.04	0.22	0.02	0.14	CALC	BLU000000000000	0.08
BLU	000	000	1875	3900	1520.00	124.00	1520.00	124.00	11.23	5.43	6.01	3.46	CALC	BLU000000001875	4.70
BLU	000	000	3900	6325	63.00	11.00	46.00	6.00	0.47	0.48	0.18	0.17	CALC	BLU000000003900	0.17
BLU	000	000	6325	7715	868.00	69.00	868.00	69.00	6.41	3.02	3.43	1.93	CALC	BLU000000006325	2.68
BLU	000	000	7715	10280	0.00	3.00	0.00	3.00	0.00	0.13	0.00	0.08	CALC	BLU000000007715	0.04
BLU	000	000	10280	12600	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BLU000000010280	0.00
BMK	000	000	0	2050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BMK000000000000	0.00
BMK	000	000	2050	4020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BMK000000002050	0.00
BMK	000	000	4020	5990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BMK000000004020	0.00
BMK	000	000	5990	7971	6.00	8.00	13.00	11.00	0.04	0.35	0.05	0.31	CALC	BMK000000005990	0.17
BMK	000	000	7971	10024	10.00	1.00	33.00	4.00	0.07	0.04	0.13	0.11	CALC	BMK000000007971	0.12
BOG	000	000	0	2080	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BOG000000000000	0.00
BOG	000	000	2080	4565	2225.00	287.00	2225.00	287.00	16.43	12.57	8.79	8.01	CALC	BOG000000002080	8.39
BOG	000	000	4565	6500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BOG000000004565	0.00
BOG	000	000	6500	8386	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BOG000000006500	0.00
BOG	000	000	8386	10775	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BOG000000008386	0.00
BOG	000	000	10775	12260	5.00	0.00	5.00	0.00	0.04	0.00	0.02	0.00	CALC	BOG000000010775	0.01
BOG	000	000	12260	14003	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BOG000000012260	0.00
BOG	000	000	14003	16610	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BOG000000014003	0.00
BOG	000	000	16610	17935	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BOG000000016610	0.00
BOG	000	000	17935	20050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BOG000000017935	0.00
BOG	000	000	20050	21380	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BOG000000020050	0.00
BOG	000	000	21380	24350	426.00	97.00	426.00	97.00	3.15	4.25	1.68	2.71	CALC	BOG000000021380	2.20
BOG	000	000	24350	27080	781.00	520.00	781.00	520.00	5.77	22.78	3.09	14.52	CALC	BOG000000024350	8.81
BOG	000	000	27080	28360	729.00	182.00	729.00	182.00	5.38	7.97	2.88	5.08	CALC	BOG000000027080	3.98
BOG	000	000	28360	29967	1091.00	271.00	1091.00	271.00	8.06	11.87	4.31	7.57	CALC	BOG000000028360	5.94
BOG	000	000	29967	32000	3142.00	657.00	3142.00	657.00	23.21	28.78	12.41	18.34	CALC	BOG000000029967	15.38
BOG	000	000	32000	34500	313.00	80.00	313.00	80.00	2.31	3.50	1.24	2.23	CALC	BOG000000032000	1.74
BOG	000	000	34500	35770	37.00	6.00	37.00	6.00	0.27	0.26	0.15	0.17	CALC	BOG000000034500	0.16
BUL	000	000	0	1755	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BUL000000000000	0.00
BUL	000	000	1755	4060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BUL000000001755	0.00
BUL	000	000	4060	6100	0.00	0.00	7.00	2.00	0.00	0.00	0.03	0.06	CALC	BUL000000004060	0.05
BUL	000	000	6100	8200	4252.00	547.00	7414.00	882.00	31.40	23.96	29.29	24.62	CALC	BUL000000006100	26.96
BUL	000	000	8200	10350	42.00	2.00	257.00	16.00	0.31	0.09	1.02	0.45	CALC	BUL000000008200	0.74
BUL	000	000	10350	12125	178.00	14.00	419.00	30.00	1.31	0.61	1.66	0.84	CALC	BUL000000010350	1.25
BUL	000	000	12125	14075	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BUL000000012125	0.00
BUL	000	000	14075	16300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BUL000000014075	0.00
BUL	000	000	16300	18055	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BUL000000016300	0.00
BUL	000	000	18055	19900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BUL000000018055	0.00
BUL	000	000	19900	22175	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BUL000000019900	0.00
BUL	000	000	22175	24270	0.00	0.00	3.00	2.00	0.00	0.00	0.01	0.06	CALC	BUL000000022175	0.04
BUL	000	000	24270	26350	1188.00	197.00	1810.00	267.00	8.77	8.63	7.15	7.45	CALC	BUL000000024270	7.30
BUL	000	000	26350	28500	438.00	53.00	998.00	112.00	3.23	2.32	3.94	3.13	CALC	BUL000000026350	3.54
BUL	000	000	28500	30300	1721.00	204.00	2345.00	261.00	12.71	8.94	9.27	7.29	CALC	BUL000000028500	8.28
BUL	000	000	30300	32050	2387.00	345.00	4296.00	606.00	17.63	15.11	16.97	16.92	CALC	BUL000000030300	16.95
BUL	000	000	32050	34250	38.00	3.00	214.00	16.00	0.28	0.13	0.85	0.45	CALC	BUL000000032050	0.65
BUL	000	000	34250	35900	1395.00	224.00	2004.00	291.00	10.30	9.81	7.92	8.12	CALC	BUL000000034250	8.02
BUL	000	000	35900	38040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BUL000000035900	0.00

Table B - 1

Master Plan Problem Area Assessment Flood Control Scores

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	Exist Public Safety Score	Exist Property Protection Score	Future Public Safety Score	Future Property Protection Score	PSE Normalized	PPE Normalized	PSF Normalized	PPF Normalized	Flag	FC Reach ID	FC Final Score
BUL	000	000	38040	40100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BUL000000038040	0.00
BUL	000	000	40100	42200	1801.00	196.00	2608.00	267.00	13.30	8.59	10.30	7.45	CALC	BUL000000040100	8.88
BUL	000	000	42200	44575	387.00	34.00	581.00	47.00	2.86	1.49	2.30	1.31	CALC	BUL000000042200	1.81
BUL	000	000	44575	46180	13.00	1.00	155.00	11.00	0.10	0.04	0.61	0.31	CALC	BUL000000044575	0.46
BUL	000	000	46180	47860	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BUL000000046180	0.00
BUL	000	000	47860	49950	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BUL000000047860	0.00
BUL	000	000	49950	51790	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BUL000000049950	0.00
BUL	000	000	51790	54240	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BUL000000051790	0.00
BUL	000	000	54240	56345	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BUL000000054240	0.00
BUL	000	000	56345	58345	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BUL000000056345	0.00
BUL	000	000	58345	59735	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BUL000000058345	0.00
BUL	T02	000	0	2090	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT02000000000	0.00
BUL	T02	000	2090	4040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT02000002090	0.00
BUL	T02	000	4040	5840	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT02000004040	0.00
BUL	T02	000	5840	7840	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT02000005840	0.00
BUL	T02	000	7840	10150	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT02000007840	0.00
BUL	T02	000	10150	12250	3.00	1.00	3.00	1.00	0.02	0.04	0.01	0.03	CALC	BULT02000010150	0.02
BUL	T02	000	12250	14250	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT02000012250	0.00
BUL	T02	000	14250	16285	16.00	4.00	16.00	4.00	0.12	0.18	0.06	0.11	CALC	BULT02000014250	0.09
BUL	T02	000	16285	18580	176.00	26.00	176.00	26.00	1.30	1.14	0.70	0.73	CALC	BULT02000016285	0.72
BUL	T03	000	0	2070	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT03000000000	0.00
BUL	T03	000	2070	4170	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT03000002070	0.00
BUL	T03	000	4170	6290	434.00	47.00	246.00	30.00	3.21	2.06	0.98	0.84	CALC	BULT03000004170	0.91
BUL	T03	000	6290	8350	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT03000006290	0.00
BUL	T03	000	8350	10070	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT03000008350	0.00
BUL	T03	000	10070	11660	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT03000010070	0.00
BUL	T04	000	0	2010	354.00	34.00	398.00	37.00	2.61	1.49	1.57	1.03	CALC	BULT04000000000	1.30
BUL	T04	000	2010	4040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT04000002010	0.00
BUL	T04	000	4040	5930	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT04000004040	0.00
BUL	T04	000	5930	7380	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT04000005930	0.00
BUL	T05	000	0	2130	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT05000000000	0.00
BUL	T05	000	2130	4430	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT05000002130	0.00
BUL	T05	000	4430	6490	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT05000004430	0.00
BUL	T05	000	6490	8310	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT05000006490	0.00
BUL	T05	000	8310	9940	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT05000008310	0.00
BUL	T05	T06	0	2060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT05T06000000	0.00
BUL	T05	T06	2060	4140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT05T06002060	0.00
BUL	T05	T06	4140	5750	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT05T06004140	0.00
BUL	T07	000	0	1845	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT07000000000	0.00
BUL	T07	000	1845	4015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT07000001845	0.00
BUL	T07	000	4015	5590	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT07000004015	0.00
BUL	T07	000	5590	7610	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	BULT07000005590	0.00
BUL	T08	000	0	999999	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	EST	BULT08000000000	0.00
CNT	000	000	0	2150	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	CNT000000000000	0.00
CNT	000	000	2150	4100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	CNT000000002150	0.00
CNT	000	000	4100	6200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	CNT000000004100	0.00
CNT	000	000	6200	8075	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	CNT000000006200	0.00
CNT	000	000	8075	10073	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	CNT000000008075	0.00
CNT	000	000	10073	11975	2.00	0.00	6.00	1.00	0.01	0.00	0.02	0.03	CALC	CNT000000010073	0.03

Table B - 1
Master Plan Problem Area Assessment Flood Control Scores

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	Exist Public Safety Score	Exist Property Protection Score	Future Public Safety Score	Future Property Protection Score	PSE Normalized	PPE Normalized	PSF Normalized	PPF Normalized	Flag	FC Reach ID	FC Final Score
CNT	000	000	11975	14010	6.00	1.00	25.00	7.00	0.04	0.04	0.10	0.20	CALC	CNT000000011975	0.15
CNT	000	000	14010	16050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	CNT000000014010	0.00
CNT	000	000	16050	18860	6.00	1.00	9.00	2.00	0.04	0.04	0.04	0.08	CALC	CNT000000016050	0.05
CNT	OLD	000	0	2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	CNTOLD000000000	0.00
CNT	OLD	000	2000	4100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	CNTOLD000002000	0.00
CNT	OLD	000	4100	8290	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	CNTOLD000004100	0.00
CNT	OLD	000	6290	9220	14.00	10.00	35.00	18.00	0.10	0.44	0.14	0.50	CALC	CNTOLD000006290	0.33
CNT	OLD	T01	0	2090	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	CALC	CNTOLDT01000000	0.00
CNT	OLD	T01	2090	4187	145.00	40.00	244.00	52.00	1.07	1.75	0.96	1.45	CALC	CNTOLDT01002090	1.22
CNT	OLD	T01	4187	6144	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	CNTOLDT01004187	0.00
CNT	T02	000	0	2000	175.00	36.00	347.00	60.00	1.29	1.58	1.37	1.68	CALC	CNTT02000000000	1.54
CNT	T02	000	2000	4200	1093.00	206.00	1774.00	282.00	8.07	9.02	7.01	7.87	CALC	CNTT02000002000	7.47
CNT	T03	000	0	2725	1801.00	884.00	2610.00	280.00	13.30	38.72	10.31	7.82	staff	CNTT03000000000	8.98
CNT	T04	000	0	2275	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	CNTT04000000000	0.00
CNT	T04	000	2275	4500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	CNTT04000002275	0.00
CNT	T05	000	0	2421	3.00	1.00	5.00	1.00	0.02	0.04	0.02	0.03	CALC	CNTT05000000000	0.03
EBO	000	000	0	2015	6.00	1.00	8.00	1.00	0.04	0.04	0.02	0.03	CALC	EBO000000000000	0.03
EBO	000	000	2015	3907	135.00	42.00	135.00	42.00	1.00	1.84	0.53	1.17	CALC	EBO000000002015	0.88
EBO	000	000	3907	5822	825.00	145.00	825.00	145.00	6.09	6.35	3.26	4.05	CALC	EBO000000003907	3.69
EBO	000	000	5822	7609	19.00	4.00	19.00	4.00	0.14	0.18	0.08	0.11	CALC	EBO000000005822	0.10
EBO	000	000	7609	9943	1139.00	165.00	993.00	133.00	8.41	7.23	3.92	3.71	CALC	EBO000000007609	3.81
EBO	000	000	9943	12059	288.00	75.00	288.00	75.00	2.13	3.29	1.14	2.09	CALC	EBO000000009943	1.65
EBO	000	000	12059	13931	436.00	88.00	436.00	88.00	3.22	3.85	1.72	2.46	CALC	EBO000000012059	2.09
EBO	000	000	13931	15985	1060.00	110.00	1060.00	110.00	7.83	4.82	4.19	3.07	CALC	EBO000000013931	3.63
EBO	000	000	15985	17957	1.00	0.00	1.00	0.00	0.01	0.00	0.00	0.00	CALC	EBO000000015985	0.00
FOR	000	000	0	4713	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	FOR000000000000	0.00
FOR	000	000	4713	6946	7987.00	1441.00	7987.00	1441.00	58.99	63.12	31.58	40.23	CALC	FOR000000004713	36.17
FOR	000	000	6946	7878	1843.00	325.00	1843.00	325.00	13.61	14.24	7.28	9.07	CALC	FOR000000006946	8.23
FOR	000	000	7878	10040	778.00	141.00	778.00	141.00	5.75	6.18	3.07	3.94	CALC	FOR000000007878	3.53
FOR	000	000	10040	12241	491.00	69.00	491.00	69.00	3.63	3.02	1.94	1.93	CALC	FOR000000010040	1.93
FOR	000	000	12241	14628	10.00	2.00	10.00	2.00	0.07	0.09	0.04	0.06	CALC	FOR000000012241	0.05
FOR	000	000	14626	17345	67.00	8.00	67.00	8.00	0.49	0.35	0.26	0.22	CALC	FOR000000014628	0.24
FOR	000	000	17345	20951	1481.00	374.00	1481.00	374.00	10.94	16.38	5.85	10.44	CALC	FOR000000017345	8.29
FOR	000	000	20951	25760	1481.00	374.00	1481.00	374.00	10.94	16.38	5.85	10.44	EST	FOR000000020951	8.29
FOR	000	000	25760	999999	2.00	1.00	2.00	1.00	0.01	0.04	0.01	0.03	EST	FOR000000025760	0.02
FOR	T01	000	0	999999	2.00	1.00	2.00	1.00	0.01	0.04	0.01	0.03	EST	FORT01000000000	0.02
HRP	000	000	0	999999	2.00	1.00	2.00	1.00	0.01	0.04	0.01	0.03	EST	HRP000000000000	0.02
HRP	T01	000	0	999999	2.00	1.00	2.00	1.00	0.01	0.04	0.01	0.03	EST	HRPT01000000000	0.02
JOH	000	000	0	1900	23.00	6.00	23.00	6.00	0.17	0.26	0.09	0.17	CALC	JOH000000000000	0.13
JOH	000	000	1900	3975	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	JOH000000001900	0.00
JOH	000	000	3975	5950	2.00	0.00	2.00	0.00	0.01	0.00	0.01	0.00	CALC	JOH000000003975	0.00
JOH	000	000	5950	8000	0.00	13.00	0.00	13.00	0.00	0.57	0.00	0.36	CALC	JOH000000005950	0.18
JOH	000	000	8000	10200	15.00	2.00	15.00	2.00	0.11	0.09	0.06	0.06	CALC	JOH000000008000	0.06
JOH	000	000	10200	12650	26.00	4.00	26.00	4.00	0.19	0.18	0.10	0.11	CALC	JOH000000010200	0.11
JOH	POS	000	0	2105	51.00	25.00	51.00	25.00	0.38	1.10	0.20	0.70	CALC	JOHPOS000000000	0.46
JOH	POS	000	2105	4245	27.00	8.00	27.00	8.00	0.20	0.35	0.11	0.22	CALC	JOHPOS000002105	0.17
LWA	000	000	0	2040	224.00	28.00	224.00	28.00	1.65	1.23	0.89	0.78	CALC	LWA000000000000	0.84
LWA	000	000	2040	4280	486.00	63.00	512.00	66.00	3.59	2.76	2.02	1.84	CALC	LWA000000002040	1.93
LWA	000	000	4280	6200	1903.00	211.00	2553.00	287.00	14.05	9.24	10.09	7.45	CALC	LWA000000004280	8.77

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Master Plan Problem Area Assessment Flood Control Scores

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	Exist Public Safety Score	Exist Property Protection Score	Future Public Safety Score	Future Property Protection Score	PSE Normalized	PPE Normalized	PSF Normalized	PPF Normalized	Flag	FC Reach ID	FC Final Score
LWA	000	000	6200	8300	209.00	26.00	225.00	27.00	1.54	1.14	0.89	0.75	CALC	LWA000000006200	0.82
LWA	000	000	8300	10140	8.00	2.00	27.00	3.00	0.06	0.09	0.11	0.08	CALC	LWA000000008300	0.10
LWA	000	000	10140	12100	360.00	44.00	502.00	60.00	2.66	1.93	1.98	1.68	CALC	LWA000000010140	1.83
LWA	000	000	12100	14000	430.00	56.00	507.00	64.00	3.18	2.45	2.00	1.79	CALC	LWA000000012100	1.90
LWA	000	000	14000	15850	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	LWA000000014000	0.00
LWA	000	000	15850	18000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	LWA000000015850	0.00
LWA	000	000	18000	20060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	LWA000000018000	0.00
LWA	000	000	20060	21950	42.00	5.00	42.00	5.00	0.31	0.22	0.17	0.14	CALC	LWA000000020060	0.16
LWA	000	000	21950	23920	1685.00	178.00	2436.00	259.00	12.44	7.80	9.63	7.23	CALC	LWA000000021950	8.46
LWA	000	000	23920	25860	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	LWA000000023920	0.00
LWA	000	000	25860	28000	607.00	67.00	764.00	88.00	4.48	2.93	3.02	2.46	CALC	LWA000000025860	2.75
LWA	000	000	28000	30155	1367.00	114.00	1223.00	105.00	10.10	4.99	4.83	2.93	CALC	LWA000000028000	3.90
LWA	000	000	30155	32020	411.00	71.00	509.00	89.00	3.04	3.11	2.01	2.48	CALC	LWA000000030155	2.24
LWA	000	000	32020	34075	4.00	117.00	8.00	152.00	0.03	5.12	0.03	4.24	CALC	LWA000000032020	2.23
LWA	000	000	34075	36040	8.00	3.00	50.00	12.00	0.06	0.13	0.20	0.34	CALC	LWA000000034075	0.27
LWA	000	000	36040	38040	37.00	7.00	131.00	27.00	0.27	0.31	0.52	0.75	CALC	LWA000000036040	0.64
LWA	000	000	38040	40020	12410.00	1468.00	7268.00	954.00	91.65	64.30	28.72	26.63	CALC	LWA000000038040	27.63
LWA	000	000	40020	42050	9638.00	1387.00	7058.00	1009.00	71.18	60.75	27.89	28.17	CALC	LWA000000040020	28.04
LWA	000	000	42050	44070	1277.00	183.00	1697.00	249.00	9.43	8.02	6.71	6.95	CALC	LWA000000042050	6.84
LWA	000	000	44070	47210	86.00	22.00	80.00	22.00	0.64	0.96	0.32	0.61	CALC	LWA000000044070	0.47
LWA	QCB	000	0	2040	1268.00	112.00	1489.00	131.00	9.36	4.91	5.88	3.66	CALC	LWAQCB000000000	4.72
LWA	QCB	000	2040	4175	836.00	147.00	1288.00	190.00	6.17	6.44	5.09	5.30	CALC	LWAQCB000002040	5.20
LWA	QCB	000	4175	7070	36.00	2.00	73.00	5.00	0.27	0.09	0.29	0.14	CALC	LWAQCB000004175	0.21
LWA	T02	000	0	1550	434.00	155.00	430.00	155.00	3.21	6.79	1.70	4.33	CALC	LWAT02T01000000	2.98
LWA	T02	000	1550	2800	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	LWAT02T01001550	0.00
LWA	T02	T01	0	2030	1793.00	336.00	1831.00	343.00	13.24	14.72	7.23	9.58	CALC	LWAT02000000000	8.38
LWA	T02	T01	2030	4060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	LWAT02000002030	0.00
LWA	T02	T01	4060	6060	700.00	111.00	744.00	122.00	5.17	4.86	2.94	3.41	CALC	LWAT02000004060	3.17
LWA	T02	T01	6060	8110	222.00	97.00	336.00	135.00	1.64	4.25	1.33	3.77	CALC	LWAT02000006060	2.52
LWA	T02	T01	8110	10030	272.00	55.00	261.00	52.00	2.01	2.41	1.03	1.45	CALC	LWAT02000008110	1.23
LWA	T02	T01	10030	11700	8.00	2.00	8.00	2.00	0.06	0.09	0.03	0.06	CALC	LWAT02000010030	0.04
LWA	T02	T04	0	1790	0.00	1.00	1.00	1.00	0.00	0.04	0.00	0.03	CALC	LWAT04000000000	0.01
LWA	T02	T04	1790	3240	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	LWAT04000001790	0.00
LWA	T02	T05	0	2095	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	LWAT05000000000	0.00
LWA	T02	T05	2095	4820	8.00	4.00	8.00	4.00	0.06	0.18	0.03	0.11	CALC	LWAT05000002095	0.07
LWA	T06	000	0	2050	122.00	24.00	121.00	24.00	0.90	1.05	0.48	0.67	CALC	LWAT06000000000	0.58
LWA	T06	000	2050	4180	0.00	15.00	0.00	15.00	0.00	0.66	0.00	0.42	CALC	LWAT06000002050	0.22
LWA	T07	000	0	1875	114.00	14.00	176.00	21.00	0.84	0.61	0.70	0.59	CALC	LWAT07000000000	0.64
LWA	T07	000	1875	3485	2.00	1.00	2.00	1.00	0.01	0.04	0.01	0.03	CALC	LWAT07000001875	0.02
SHL	000	000	0	2030	258.00	107.00	252.00	105.00	1.91	4.69	1.00	2.93	CALC	SHL000000000000	2.01
SHL	000	000	2030	4160	4549.00	2068.00	4355.00	1993.00	33.60	90.58	17.21	55.64	CALC	SHL000000002030	37.39
SHL	000	000	4160	6160	4759.00	1300.00	4786.00	1334.00	35.15	56.94	18.91	37.24	CALC	SHL000000004160	28.53
SHL	000	000	6160	8305	10.00	1.00	10.00	1.00	0.07	0.04	0.04	0.03	CALC	SHL000000006160	0.03
SHL	000	000	8305	9850	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	SHL000000008305	0.00
SHL	000	000	9850	11900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	SHL000000009850	0.00
SHL	000	000	11900	13850	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	SHL000000011900	0.00
SHL	000	000	13850	15982	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	SHL000000013850	0.00
SHL	000	000	15982	17950	7.00	0.00	7.00	0.00	0.05	0.00	0.03	0.00	CALC	SHL000000015982	0.01
SHL	000	000	17950	20000	10.00	4.00	10.00	4.00	0.07	0.18	0.04	0.11	CALC	SHL000000017950	0.08

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Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	Exist Public Safety Score	Exist Property Protection Score	Future Public Safety Score	Future Property Protection Score	PSE Normalized	PPE Normalized	PSF Normalized	PPF Normalized	Flag	FC Reach ID	FC Final Score
SHL	000	000	20000	21959	84.00	14.00	78.00	12.00	0.82	0.81	0.31	0.34	CALC	SHL000000020000	0.33
SHL	000	000	21959	24060	808.00	91.00	776.00	88.00	5.97	3.99	3.07	2.48	CALC	SHL000000021959	2.77
SHL	000	000	24060	28200	397.00	47.00	372.00	43.00	2.93	2.06	1.47	1.20	CALC	SHL000000024080	1.34
SHL	000	000	28200	28041	1.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	CALC	SHL000000026200	0.00
SHL	000	000	28041	30545	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	SHL000000028041	0.00
SHL	000	000	30545	32063	2.00	0.00	2.00	0.00	0.01	0.00	0.01	0.00	CALC	SHL000000030545	0.01
SHL	000	000	32063	33960	23.00	1.00	21.00	1.00	0.17	0.04	0.08	0.03	CALC	SHL000000032083	0.06
SHL	000	000	33980	38020	16.00	0.00	13.00	0.00	0.12	0.00	0.05	0.00	CALC	SHL000000033960	0.03
SHL	000	000	36020	37985	56.00	3.00	50.00	2.00	0.41	0.13	0.20	0.06	CALC	SHL000000036020	0.13
SHL	000	000	37985	40000	38.00	3.00	35.00	2.00	0.28	0.13	0.14	0.06	CALC	SHL000000037985	0.10
SHL	000	000	40000	41915	3.00	0.00	2.00	0.00	0.02	0.00	0.01	0.00	CALC	SHL000000040000	0.01
SHL	000	000	41915	43930	24.00	2.00	14.00	0.00	0.18	0.09	0.06	0.00	CALC	SHL000000041915	0.03
SHL	000	000	43930	46005	1717.00	355.00	1175.00	280.00	12.66	15.55	4.64	7.26	staff	SHL000000043930	6.01
SHL	000	000	46005	48239	6.00	0.00	4.00	0.00	0.04	0.00	0.02	0.00	CALC	SHL000000046005	0.01
SHL	000	000	48239	52360	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	SHL000000048239	0.00
SHL	FOS	000	0	461	380.00	37.00	402.00	40.00	2.81	1.82	1.59	1.12	CALC	SHLFOS000000000	1.34
SHL	HAN	000	0	2130	2462.00	275.00	2478.00	277.00	18.18	12.05	9.79	7.73	CALC	SHLHAN000000000	8.76
SHL	HAN	000	2130	4320	53.00	20.00	54.00	20.00	0.39	0.88	0.21	0.58	CALC	SHLHAN000002130	0.39
SHL	HAN	000	4320	6260	382.00	88.00	371.00	65.00	2.82	2.98	1.47	1.81	CALC	SHLHAN000004320	1.64
SHL	HAN	000	6260	8125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	SHLHAN000006260	0.00
SHL	HAN	000	8125	9870	27.00	12.00	27.00	12.00	0.20	0.53	0.11	0.34	CALC	SHLHAN000008125	0.23
SHL	HAN	000	9870	11220	4.00	0.00	4.00	0.00	0.03	0.00	0.02	0.00	CALC	SHLHAN000009870	0.01
TAN	000	000	0	1660	0.00	0.00	5895.00	628.00	0.00	0.00	22.50	17.53	staff	TAN000000000000	20.02
TAN	000	000	1660	3970	0.00	0.00	5895.00	628.00	0.00	0.00	22.50	17.53	staff	TAN000000001660	20.02
TAN	000	000	3970	5860	223.00	13.00	223.00	13.00	1.65	0.57	0.88	0.36	CALC	TAN000000003970	0.62
TAN	000	000	5860	7937	42.00	10.00	42.00	10.00	0.31	0.44	0.17	0.28	CALC	TAN000000005880	0.23
TAN	000	000	7937	10000	1247.00	314.00	1247.00	314.00	9.21	13.75	4.93	8.77	CALC	TAN000000007937	6.85
TAN	000	000	10000	12160	680.00	142.00	680.00	142.00	5.02	6.22	2.69	3.98	CALC	TAN000000010000	3.33
TAN	000	000	12160	14150	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	TAN000000012160	0.00
TAN	000	000	14150	18250	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	TAN000000014150	0.00
TAN	000	000	16250	18170	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	TAN000000018250	0.00
TAN	000	000	16170	21840	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	TAN000000018170	0.00
TAN	000	000	21840	24290	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	TAN000000021840	0.00
TAN	000	000	24290	26270	22.00	8.00	22.00	8.00	0.16	0.35	0.09	0.22	CALC	TAN000000024290	0.16
TAN	000	000	26270	27933	56.00	21.00	56.00	21.00	0.41	0.92	0.22	0.59	CALC	TAN000000026270	0.41
TAN	000	000	27933	34687	40.00	6.00	40.00	6.00	0.30	0.28	0.16	0.17	CALC	TAN000000027933	0.17
TAN	GP1	000	0	2070	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	TANGP1000000000	0.00
TAN	GP1	000	2070	4187	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	TANGP1000002070	0.00
TAN	GP1	000	4187	6527	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	TANGP1000004187	0.00
TAN	GP1	GP2	0	1935	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	TANGP1GP2000000	0.00
TAN	GP1	GP2	1935	3715	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	TANGP1GP2001935	0.00
TAN	GP1	GP2	3715	4965	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	TANGP1GP2003715	0.00
TAN	T01	000	0	800	2.00	1.00	2.00	1.00	0.01	0.04	0.01	0.03	EST	TANT01000000000	0.02
TAN	T02	000	0	375	2.00	1.00	2.00	1.00	0.01	0.04	0.01	0.03	EST	TANT02000000000	0.02
TAN	WT3	000	0	1980	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	TANWT3000000000	0.00
TAN	WT3	000	1980	2770	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	TANWT3000001980	0.00
WBO	000	000	0	1997	3864.61	1050.63	3248.34	929.17	28.54	46.02	12.83	25.94	CALC	WBO000000000000	19.39
WBO	000	000	1997	4209	380.22	76.94	380.22	76.94	2.81	3.37	1.50	2.15	CALC	WBO000000001997	1.83
WBO	000	000	4209	6009	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WBO000000004209	0.00

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	Exist Public Safety Score	Exist Property Protection Score	Future Public Safety Score	Future Property Protection Score	PSE Normalized	PPE Normalized	PSF Normalized	PPF Normalized	Flag	FC Reach ID	FC Final Score
WBO	000	000	6009	8049	4.42	1.89	4.42	1.89	0.03	0.08	0.02	0.05	CALC	WBO000000006009	0.04
WBO	000	000	8049	9885	10.46	8.65	3300.00	980.00	0.08	0.38	13.04	27.36	staff	WBO000000008049	20.20
WBO	000	000	9885	12030	244.87	32.60	3290.00	980.00	1.81	1.43	13.00	27.36	staff	WBO000000009885	20.01
WBO	000	000	12030	14080	140.05	30.66	140.05	30.66	1.03	1.34	0.55	0.86	CALC	WBO000000012030	0.70
WBO	000	000	14080	15880	760.53	405.13	760.53	405.13	5.62	17.75	3.00	11.31	CALC	WBO000000014080	7.06
WBO	000	000	15880	17516	231.57	36.99	184.45	30.04	1.71	1.62	0.73	0.84	CALC	WBO000000015880	0.78
WBO	NFK	000	0	1925	52.51	30.14	52.51	30.14	0.39	1.32	0.21	0.84	CALC	WBONFK000000000	0.52
WBO	NFK	000	1925	4175	60.23	11.95	54.10	10.20	0.44	0.52	0.21	0.28	CALC	WBONFK000001925	0.24
WBO	T01	000	0	999999	2.00	1.00	2.00	1.00	0.01	0.04	0.01	0.03	EST	WBOT01000000000	0.02
WLN	000	000	0	3370	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000000000	0.00
WLN	000	000	3370	4130	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000003370	0.00
WLN	000	000	4130	6225	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000004130	0.00
WLN	000	000	6225	8180	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000006225	0.00
WLN	000	000	8180	10050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000008180	0.00
WLN	000	000	10050	11980	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000010050	0.00
WLN	000	000	11980	14275	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000011980	0.00
WLN	000	000	14275	16300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000014275	0.00
WLN	000	000	16300	18029	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000016300	0.00
WLN	000	000	18029	20380	0.00	219.00	0.00	277.00	0.00	9.59	0.00	7.73	CALC	WLN000000018029	3.87
WLN	000	000	20380	22225	49.00	29.00	5360.00	745.00	0.36	1.27	21.18	20.80	staff	WLN000000020380	20.99
WLN	000	000	22225	24400	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000022225	0.00
WLN	000	000	24400	26290	1678.00	425.00	1946.00	495.00	12.39	18.62	7.69	13.82	CALC	WLN000000024400	10.76
WLN	000	000	26290	27430	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000026290	0.00
WLN	000	000	27430	30087	1132.00	607.00	1521.00	763.00	8.36	26.59	6.01	21.30	CALC	WLN000000027430	13.66
WLN	000	000	30087	32125	1712.00	617.00	3210.00	931.00	12.64	27.03	12.68	25.99	CALC	WLN000000030087	19.34
WLN	000	000	32125	34245	11724.00	1774.00	25309.00	3582.00	86.59	77.70	100.00	100.00	CALC	WLN000000032125	100.00
WLN	000	000	34245	36205	309.00	71.00	1205.00	281.00	2.28	3.11	4.76	7.84	CALC	WLN000000034245	6.30
WLN	000	000	36205	37945	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000036205	0.00
WLN	000	000	37945	40120	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000037945	0.00
WLN	000	000	40120	42115	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000040120	0.00
WLN	000	000	42115	43800	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000042115	0.00
WLN	000	000	43800	46010	289.00	53.00	1089.00	195.00	2.13	2.32	4.30	5.44	CALC	WLN000000043800	4.87
WLN	000	000	46010	48240	396.00	61.00	1130.00	181.00	2.92	2.67	4.46	5.05	CALC	WLN000000046010	4.76
WLN	000	000	48240	49750	58.00	42.00	248.00	94.00	0.43	1.84	0.98	2.62	CALC	WLN000000048240	1.80
WLN	000	000	49750	51730	8.00	2.00	29.00	7.00	0.06	0.09	0.11	0.20	CALC	WLN000000049750	0.16
WLN	000	000	51730	54100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000051730	0.00
WLN	000	000	54100	56330	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000054100	0.00
WLN	000	000	56330	58000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000056330	0.00
WLN	000	000	58000	60400	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000058000	0.00
WLN	000	000	60400	62230	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000060400	0.00
WLN	000	000	62230	64600	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000062230	0.00
WLN	000	000	64600	66650	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000064600	0.00
WLN	000	000	66650	69900	363.00	34.00	852.00	78.00	2.68	1.49	3.37	2.18	CALC	WLN000000066650	2.73
WLN	000	000	69900	72000	1639.00	142.00	4153.00	357.00	12.10	6.22	16.41	9.97	CALC	WLN000000069900	12.97
WLN	000	000	72000	74090	141.00	36.00	609.00	149.00	1.04	1.58	2.41	4.16	CALC	WLN000000072000	3.35
WLN	000	000	74090	76000	0.00	0.00	5.00	1.00	0.00	0.00	0.02	0.03	CALC	WLN000000074090	0.03
WLN	000	000	76000	78170	145.00	14.00	496.00	48.00	1.07	0.61	1.96	1.34	CALC	WLN000000076000	1.63
WLN	000	000	78170	80230	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000078170	0.00
WLN	000	000	80230	82250	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.03	CALC	WLN000000080230	0.02

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Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	Exist Public Safety Score	Exist Property Protection Score	Future Public Safety Score	Future Property Protection Score	PSE Normalized	PPE Normalized	PSF Normalized	PPF Normalized	Flag	FC Reach ID	FC Final Score
WLN	000	000	82250	84250	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000082250	0.00
WLN	000	000	84250	85900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000084250	0.00
WLN	000	000	85900	88210	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000085900	0.00
WLN	000	000	88210	90240	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000088210	0.00
WLN	000	000	90240	91940	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000090240	0.00
WLN	000	000	91940	93625	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000091940	0.00
WLN	000	000	93625	95350	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000093625	0.00
WLN	000	000	95350	97990	8.00	1.00	44.00	12.00	0.04	0.04	0.17	0.34	CALC	WLN000000095350	0.26
WLN	000	000	97990	100080	2.00	0.00	40.00	6.00	0.01	0.00	0.16	0.17	CALC	WLN000000097990	0.17
WLN	000	000	100080	101780	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000100080	0.00
WLN	000	000	101780	103880	0.00	0.00	282.00	32.50	0.00	0.00	1.11	0.91	staff	WLN000000101780	1.01
WLN	000	000	103880	105890	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000103880	0.00
WLN	000	000	105890	107800	8.00	0.00	137.00	14.00	0.06	0.00	0.54	0.39	CALC	WLN000000105890	0.47
WLN	000	000	107800	110019	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000107800	0.00
WLN	000	000	110019	111900	0.00	0.00	10.00	2.00	0.00	0.00	0.04	0.06	CALC	WLN000000110019	0.05
WLN	000	000	111900	113960	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000111900	0.00
WLN	000	000	113960	116000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000113960	0.00
WLN	000	000	116000	117795	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLN000000116000	0.00
WLN	000	000	117795	120165	758.00	94.00	1090.00	197.00	5.60	4.12	4.31	5.50	staff	WLN000000117795	4.91
WLN	KMR	000	0	1940	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNKMR000000000	0.00
WLN	KMR	000	1940	4070	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNKMR000001940	0.00
WLN	KMR	000	4070	4550	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNKMR000004070	0.00
WLN	T01	000	0	2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT01000000000	0.00
WLN	T01	000	2000	4175	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT01000002000	0.00
WLN	T01	000	4175	6300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT01000004175	0.00
WLN	T01	000	6300	8370	256.00	78.00	444.00	118.00	1.89	3.42	1.75	3.29	CALC	WLNT01000006300	2.52
WLN	T01	000	8370	10895	86.00	67.00	153.00	123.00	0.64	2.93	0.60	3.43	CALC	WLNT01000008370	2.02
WLN	T01	000	10895	12430	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT01000010895	0.00
WLN	T01	000	12430	14205	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT01000012430	0.00
WLN	T01	000	14205	16040	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT01000014205	0.00
WLN	T01	000	16040	17690	1.00	0.00	3.00	1.00	0.01	0.00	0.01	0.03	CALC	WLNT01000016040	0.02
WLN	T01	T01	0	2070	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT01T01000000	0.00
WLN	T01	T01	2070	2690	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT01T01002070	0.00
WLN	T03	000	0	999999	2.00	1.00	2.00	1.00	0.01	0.04	0.01	0.03	EST	WLNT03000000000	0.02
WLN	T04	000	0	2300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT04000000000	0.00
WLN	T04	000	2300	4350	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT04000002300	0.00
WLN	T04	000	4350	6140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT04000004350	0.00
WLN	T04	000	6140	8420	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT04000006140	0.00
WLN	T05	000	0	1830	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT05000000000	0.00
WLN	T05	000	1830	3950	43.00	7.00	156.00	22.00	0.32	0.31	0.62	0.61	CALC	WLNT05000001830	0.62
WLN	T05	000	3950	6100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT05000003950	0.00
WLN	T05	000	6100	8320	0.00	0.00	4.00	1.00	0.00	0.00	0.02	0.03	CALC	WLNT05000006100	0.03
WLN	T05	000	8320	10800	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.03	CALC	WLNT05000008320	0.02
WLN	T05	T01	0	2400	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT05T01000000	0.00
WLN	T06	000	0	1930	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT06000000000	0.00
WLN	T06	000	1930	4050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT06000001930	0.00
WLN	T06	000	4050	6010	0.00	0.00	4.00	1.00	0.00	0.00	0.02	0.03	CALC	WLNT06000004050	0.03
WLN	T06	000	6010	8070	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT06000006010	0.00
WLN	T06	000	8070	9960	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT06000008070	0.00

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Master Plan Problem Area Assessment Flood Control Scores

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	Exist Public Safety Score	Exist Property Protection Score	Future Public Safety Score	Future Property Protection Score	PSE Normalized	PPE Normalized	PSF Normalized	PPF Normalized	Flag	FC Reach ID	FC Final Score
WLN	T06	000	9960	11740	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT06000009960	0.00
WLN	T07	000	0	2080	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT07000000000	0.00
WLN	T07	000	2080	4080	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT07000002080	0.00
WLN	T07	000	4080	5980	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT07000004080	0.00
WLN	T07	000	5980	8140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT07000005980	0.00
WLN	T07	000	8140	10123	27.00	6.00	29.00	6.00	0.20	0.26	0.11	0.17	CALC	WLNT07000008140	0.14
WLN	T07	000	10123	12180	5073.00	776.00	151.00	122.00	37.47	33.99	0.60	3.41	staff	WLNT07000010123	2.01
WLN	T07	000	12180	13430	22.00	1.00	38.00	3.00	0.16	0.04	0.15	0.08	CALC	WLNT07000012180	0.12
WLN	T07	T01	0	2050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT07T01000000	0.00
WLN	T07	T01	2050	3440	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT07T01002050	0.00
WLN	T08	000	0	2020	78.00	11.00	101.00	13.00	0.58	0.48	0.40	0.36	CALC	WLNT08000000000	0.38
WLN	T08	000	2020	4090	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT08000002020	0.00
WLN	T08	000	4090	5860	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT08000004090	0.00
WLN	T08	000	5860	7979	1.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	staff	WLNT08000005860	0.00
WLN	T08	000	7979	9910	4265.00	931.00	0.00	0.00	31.50	40.78	0.00	0.00	staff	WLNT08000007979	0.00
WLN	T08	000	9910	11900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT08000009910	0.00
WLN	T09	000	0	2005	6.00	1.00	27.00	4.00	0.04	0.04	0.11	0.11	CALC	WLNT09000000000	0.11
WLN	T09	000	2005	3960	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT09000002005	0.00
WLN	T09	000	3960	6010	122.00	17.00	346.00	40.00	0.90	0.74	1.37	1.12	CALC	WLNT09000003960	1.25
WLN	T09	000	6010	7990	56.00	11.00	101.00	18.00	0.41	0.48	0.40	0.50	CALC	WLNT09000006010	0.45
WLN	T09	000	7990	10000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT09000007990	0.00
WLN	T09	000	10000	11950	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT09000010000	0.00
WLN	T09	000	11950	13400	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT09000011950	0.00
WLN	T10	000	0	2040	5.00	1.00	49.00	10.00	0.04	0.04	0.19	0.28	CALC	WLNT10000000000	0.24
WLN	T10	000	2040	4040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT10000002040	0.00
WLN	T10	000	4040	4710	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNT10000004040	0.00
WLN	TAR	000	0	1800	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNTAR000000000	0.00
WLN	TAR	000	1800	4070	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNTAR000001800	0.00
WLN	TAR	000	4070	5950	7.00	2.00	19.00	4.00	0.05	0.09	0.08	0.11	CALC	WLNTAR000004070	0.10
WLN	TAR	000	5950	7940	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNTAR000005950	0.00
WLN	TAR	000	7940	9430	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNTAR000007940	0.00
WLN	WEL	000	0	2000	261.00	53.00	335.00	68.00	1.93	2.32	1.32	1.90	CALC	WLNWEL000000000	1.61
WLN	WEL	000	2000	4040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNWEL000002000	0.00
WLN	WEL	000	4040	5975	861.00	121.00	2073.00	264.00	6.36	5.30	8.19	7.37	CALC	WLNWEL000004040	7.78
WLN	WEL	000	5975	7975	442.00	55.00	1196.00	146.00	3.26	2.41	4.73	4.08	CALC	WLNWEL000005975	4.41
WLN	WEL	000	7975	9850	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNWEL000007975	0.00
WLN	WEL	000	9850	11875	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNWEL000009850	0.00
WLN	WEL	000	11875	14050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNWEL000011875	0.00
WLN	WEL	000	14050	16080	8.00	1.00	63.00	14.00	0.06	0.04	0.25	0.39	CALC	WLNWEL000014050	0.32
WLN	WEL	000	16080	18000	1.00	0.00	11.00	2.00	0.01	0.00	0.04	0.06	CALC	WLNWEL000016080	0.05
WLN	WEL	000	18000	19850	117.00	23.00	364.00	68.00	0.86	1.01	1.44	1.90	CALC	WLNWEL000018000	1.67
WLN	WEL	000	19850	21975	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNWEL000019850	0.00
WLN	WEL	000	21975	24075	0.00	0.00	2.00	1.00	0.00	0.00	0.01	0.03	CALC	WLNWEL000021975	0.02
WLN	WEL	000	24075	25625	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNWEL000024075	0.00
WLN	WEL	T01	0	2030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNWELT01000000	0.00
WLN	WEL	T01	2030	4120	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNWELT01002030	0.00
WLN	WEL	T01	4120	6070	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNWELT01004120	0.00
WLN	WEL	T01	6070	8310	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNWELT01006070	0.00
WLN	WEL	T02	0	1920	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNWELT02000000	0.00

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Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	Exist Public Safety Score	Exist Property Protection Score	Future Public Safety Score	Future Property Protection Score	PSE Normalized	PPE Normalized	PSF Normalized	PPF Normalized	Flag	FC Reach ID	FC Final Score
WLN	WEL	T02	1920	3400	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNWELT02001920	0.00
WLN	WEL	T03	0	600	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WLNWELT03000000	0.00
WLR	000	000	0	1994	251.00	85.00	251.00	85.00	1.85	3.72	0.99	2.37	CALC	WLR000000000000	1.70
WLR	000	000	1994	3972	1166.00	501.00	1166.00	501.00	8.61	21.94	4.61	13.99	CALC	WLR000000001994	9.40
WLR	000	000	3972	6018	758.00	614.00	758.00	614.00	5.60	26.89	2.89	17.14	CALC	WLR000000003972	10.22
WLR	000	000	6018	8136	32.00	8.00	32.00	8.00	0.24	0.35	0.13	0.22	CALC	WLR000000006018	0.18
WLR	000	000	8136	10117	15.00	2.00	15.00	2.00	0.11	0.09	0.06	0.06	CALC	WLR000000008136	0.06
WLR	000	000	10117	11933	23.00	6.00	23.00	6.00	0.17	0.26	0.09	0.17	CALC	WLR000000010117	0.13
WLR	000	000	11933	14100	272.00	79.00	272.00	79.00	2.01	3.46	1.07	2.21	CALC	WLR000000011933	1.65
WLR	000	000	14100	16062	310.00	113.00	310.00	113.00	2.29	4.95	1.22	3.15	CALC	WLR000000014100	2.21
WLR	000	000	16062	17965	6.00	2.00	6.00	2.00	0.04	0.09	0.02	0.06	CALC	WLR000000016062	0.04
WLR	000	000	17965	20006	253.00	26.00	253.00	26.00	1.87	1.14	1.00	0.73	CALC	WLR000000017965	0.86
WLR	000	000	20006	22048	304.00	105.00	1095.00	272.00	2.25	4.60	4.33	7.59	staff	WLR000000020006	6.00
WLR	000	000	22048	24095	453.00	139.00	1095.00	272.00	3.35	6.09	4.33	7.59	staff	WLR000000022048	6.00
WLR	000	000	24095	26023	66.00	34.00	66.00	34.00	0.49	1.49	0.26	0.95	CALC	WLR000000024095	0.61
WLR	000	000	26023	28041	286.00	95.00	1090.00	274.00	2.11	4.16	4.31	7.65	staff	WLR000000026023	6.02
WLR	000	000	28041	30157	546.00	75.00	1090.00	274.00	4.03	3.29	4.31	7.65	staff	WLR000000028041	6.02
WLR	000	000	30157	32093	1.00	0.00	1.00	0.00	0.01	0.00	0.00	0.00	CALC	WLR000000030157	0.00
WLR	HMP	000	0	1994	2.00	1.00	2.00	1.00	0.01	0.04	0.01	0.03	CALC	WLRHMP000000000	0.02
WLR	HMP	000	1994	3980	56.00	16.00	56.00	16.00	0.41	0.70	0.22	0.45	CALC	WLRHMP000001994	0.34
WLR	HMP	000	3980	4854	51.00	9.00	51.00	9.00	0.38	0.39	0.20	0.25	CALC	WLRHMP000003980	0.23
WMS	000	000	0	2380	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMS000000000000	0.00
WMS	000	000	2380	4400	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMS000000002380	0.00
WMS	000	000	4400	6040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMS000000004400	0.00
WMS	000	000	6040	8240	0.00	33.00	0.00	40.00	0.00	1.45	0.00	1.12	CALC	WMS000000006040	0.56
WMS	000	000	8240	9800	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMS000000008240	0.00
WMS	000	000	9800	11800	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMS000000009800	0.00
WMS	000	000	11800	13950	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMS000000011800	0.00
WMS	000	000	13950	15900	26.00	1.00	63.00	2.00	0.19	0.04	0.25	0.06	CALC	WMS000000013950	0.16
WMS	000	000	15900	18430	2887.00	335.00	5712.00	650.00	21.32	14.67	22.57	18.15	CALC	WMS000000015900	20.36
WMS	000	000	18430	20350	93.00	12.00	238.00	31.00	0.69	0.53	0.94	0.87	CALC	WMS000000018430	0.91
WMS	000	000	20350	21870	0.00	0.00	2.00	0.00	0.00	0.00	0.01	0.00	CALC	WMS000000020350	0.01
WMS	000	000	21870	23950	24.00	1.00	94.00	7.00	0.18	0.04	0.37	0.20	CALC	WMS000000021870	0.29
WMS	000	000	23950	25900	1.00	0.00	3.00	0.00	0.01	0.00	0.01	0.00	CALC	WMS000000023950	0.01
WMS	000	000	25900	28230	22.00	4.00	88.00	13.00	0.16	0.18	0.35	0.36	CALC	WMS000000025900	0.36
WMS	000	000	28230	30140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMS000000028230	0.00
WMS	000	000	30140	32360	798.00	81.00	1514.00	151.00	5.89	3.55	5.98	4.22	CALC	WMS000000030140	5.10
WMS	000	000	32360	34210	139.00	64.00	361.00	104.00	1.03	2.80	1.43	2.90	CALC	WMS000000032360	2.17
WMS	000	000	34210	36350	425.00	48.00	1174.00	131.00	3.14	2.10	4.64	3.66	CALC	WMS000000034210	4.15
WMS	000	000	36350	38325	332.00	27.00	669.00	54.00	2.45	1.18	2.64	1.51	CALC	WMS000000036350	2.08
WMS	000	000	38325	40375	19.00	4.00	58.00	11.00	0.14	0.18	0.23	0.31	CALC	WMS000000038325	0.27
WMS	000	000	40375	42220	125.00	14.00	272.00	29.00	0.92	0.61	1.07	0.81	CALC	WMS000000040375	0.94
WMS	000	000	42220	44230	1226.00	158.00	2615.00	344.00	9.05	6.92	10.33	9.60	CALC	WMS000000042220	9.97
WMS	000	000	44230	46090	129.00	18.00	280.00	33.00	0.95	0.79	1.11	0.92	CALC	WMS000000044230	1.02
WMS	000	000	46090	48090	583.00	100.00	1371.00	230.00	4.31	4.38	5.42	6.42	CALC	WMS000000046090	5.92
WMS	000	000	48090	50250	1360.00	219.00	3349.00	548.00	10.04	9.59	13.23	15.30	CALC	WMS000000048090	14.27
WMS	000	000	50250	52150	489.00	122.00	924.00	231.00	3.61	5.34	3.65	6.45	CALC	WMS000000050250	5.05
WMS	000	000	52150	54160	3485.00	532.00	5370.00	911.00	25.74	23.30	21.22	25.43	CALC	WMS000000052150	23.33
WMS	000	000	54160	56210	79.00	15.00	245.00	46.00	0.58	0.66	0.97	1.28	CALC	WMS000000054160	1.12

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Master Plan Problem Area Assessment Flood Control Scores

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	Exist Public Safety Score	Exist Property Protection Score	Future Public Safety Score	Future Property Protection Score	PSE Normalized	PPE Normalized	PSF Normalized	PPF Normalized	Flag	FC Reach ID	FC Final Score
WMS	000	000	56210	58220	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMS000000056210	0.00
WMS	000	000	58220	60182	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMS000000058220	0.00
WMS	000	000	60182	62130	15.00	3.00	39.00	6.00	0.11	0.13	0.15	0.17	CALC	WMS000000060182	0.16
WMS	000	000	62130	64120	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMS000000062130	0.00
WMS	000	000	64120	65900	6.00	0.00	35.00	0.00	0.04	0.00	0.14	0.00	CALC	WMS000000064120	0.07
WMS	000	000	65900	68150	65.00	5.00	237.00	23.00	0.48	0.22	0.94	0.64	CALC	WMS000000065900	0.79
WMS	000	000	68150	70070	114.00	17.00	287.00	42.00	0.84	0.74	1.13	1.17	CALC	WMS000000068150	1.15
WMS	000	000	70070	71740	80.00	12.00	222.00	33.00	0.59	0.53	0.88	0.92	CALC	WMS000000070070	0.90
WMS	000	000	71740	73990	1766.00	379.00	2784.00	610.00	13.04	16.60	11.00	17.03	CALC	WMS000000071740	13.95
WMS	000	000	73980	76000	467.00	301.00	971.00	588.00	3.45	13.18	3.84	15.86	CALC	WMS000000073990	9.98
WMS	000	000	76000	77950	560.00	258.00	1005.00	516.00	4.14	11.30	3.97	14.41	CALC	WMS000000076000	9.31
WMS	000	000	77950	79690	128.00	68.00	230.00	132.00	0.95	2.98	0.91	3.69	CALC	WMS000000077950	2.33
WMS	000	000	79690	82030	1.00	1.00	6.00	2.00	0.01	0.04	0.02	0.06	CALC	WMS000000079690	0.04
WMS	000	000	82030	83790	16.00	7.00	61.00	24.00	0.12	0.31	0.24	0.67	CALC	WMS000000082030	0.46
WMS	000	000	83790	85850	51.00	27.00	133.00	67.00	0.38	1.18	0.53	1.87	CALC	WMS000000083790	1.21
WMS	000	000	85850	88090	30.00	8.00	85.00	22.00	0.22	0.35	0.34	0.61	CALC	WMS000000085850	0.48
WMS	000	000	88090	90100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMS000000088090	0.00
WMS	000	000	90100	92570	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMS000000090100	0.00
WMS	CCK	000	0	1982	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMSCCK000000000	0.00
WMS	CCK	000	1982	4053	163.00	18.00	174.00	20.00	1.20	0.79	0.69	0.56	CALC	WMSCCK000001982	0.63
WMS	CCK	000	4053	6041	265.00	30.00	277.00	31.00	1.96	1.31	1.09	0.87	CALC	WMSCCK000004053	0.98
WMS	CCK	000	6041	8001	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	CALC	WMSCCK000006041	0.00
WMS	CCK	000	8001	10531	22.00	3.00	23.00	4.00	0.16	0.13	0.09	0.11	CALC	WMSCCK000008001	0.10
WMS	KIN	000	0	2100	17.00	2.00	62.00	7.00	0.13	0.09	0.24	0.20	CALC	WMSKIN000000000	0.22
WMS	KIN	000	2100	3990	504.00	71.00	900.00	125.00	3.72	3.11	3.56	3.49	CALC	WMSKIN000002100	3.53
WMS	KIN	000	3990	6060	520.00	56.00	1474.00	169.00	3.84	2.45	5.82	4.72	CALC	WMSKIN000003990	5.28
WMS	KIN	000	6060	7875	8.00	6.00	27.00	18.00	0.06	0.26	0.11	0.50	CALC	WMSKIN000006060	0.30
WMS	KIN	000	7875	9395	33.00	7.00	175.00	35.00	0.24	0.31	0.69	0.98	CALC	WMSKIN000007875	0.83
WMS	KIN	000	9395	12285	4295.00	988.00	2609.00	272.00	31.72	43.28	10.31	7.59	staff	WMSKIN000009395	8.98
WMS	KIN	000	12285	14055	13540.00	2283.00	2609.00	273.00	100.00	100.00	10.31	7.62	CALC	WMSKIN000012285	8.99
WMS	KIN	000	14055	16115	565.00	150.00	1091.00	259.00	4.17	6.57	4.31	7.23	CALC	WMSKIN000014055	5.74
WMS	KIN	000	16115	17905	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMSKIN000016115	0.00
WMS	KIN	000	17905	19870	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMSKIN000017905	0.00
WMS	KIN	000	19870	21940	222.00	42.00	645.00	119.00	1.64	1.84	2.55	3.32	CALC	WMSKIN000019870	2.93
WMS	KIN	000	21940	23940	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMSKIN000021940	0.00
WMS	KIN	000	23940	25950	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMSKIN000023940	0.00
WMS	KIN	000	25950	27770	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMSKIN000025950	0.00
WMS	KIN	WHL	0	1950	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMSKINWHL000000	0.00
WMS	KIN	WHL	1950	3505	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMSKINWHL001950	0.00
WMS	KIN	WHL	3505	4762	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMSKINWHL003505	0.00
WMS	MOT	000	0	2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMSMOT000000000	0.00
WMS	MOT	000	2000	4050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMSMOT000002000	0.00
WMS	MOT	000	4050	5295	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMSMOT000004050	0.00
WMS	PLH	000	0	2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMSPLH000000000	0.00
WMS	PLH	000	2000	4220	1.00	0.00	6.00	1.00	0.01	0.00	0.02	0.03	CALC	WMSPLH000002000	0.03
WMS	SBK	000	0	2048	254.00	57.00	463.00	103.00	1.88	2.50	1.83	2.88	CALC	WMSSBK000000000	2.37
WMS	SBK	000	2048	4000	480.00	71.00	959.00	147.00	3.55	3.11	3.79	4.10	CALC	WMSSBK000002048	3.95
WMS	SBK	000	4000	6014	43.00	8.00	104.00	18.00	0.32	0.35	0.41	0.50	CALC	WMSSBK000004000	0.46
WMS	SBK	000	6014	6880	2.00	1.00	4.00	1.00	0.01	0.04	0.02	0.03	CALC	WMSSBK000006014	0.03

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Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	Exist Public Safety Score	Exist Property Protection Score	Future Public Safety Score	Future Property Protection Score	PSE Normalized	PPE Normalized	PSF Normalized	PPF Normalized	Flag	FC Reach ID	FC Final Score
WMS	SNV	000	0	2260	1099.00	289.00	2633.00	722.00	8.12	12.66	10.40	20.18	CALC	WMSSNV000000000	15.28
WMS	SNV	000	2260	4060	961.00	327.00	1514.00	560.00	7.10	14.32	5.98	15.63	CALC	WMSSNV000002260	10.91
WMS	SNV	000	4060	5950	340.00	80.00	747.00	165.00	2.51	3.50	2.95	4.61	CALC	WMSSNV000004060	3.80
WMS	SNV	000	5950	7940	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMSSNV000005950	0.00
WMS	SNV	000	7940	8790	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMSSNV000007940	0.00
WMS	STE	000	0	2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMSSTE000000000	0.00
WMS	STE	000	2000	4040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMSSTE000002000	0.00
WMS	STE	000	4040	6065	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMSSTE000004040	0.00
WMS	STE	000	6065	8075	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMSSTE000006065	0.00
WMS	STE	000	8075	10125	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	CALC	WMSSTE000008075	0.00

Table B-2
Master Plan Problem Area Assessment Erosion Control Scores

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	Type1 Score Normalized	Type2 Score Normalized	Type3 Score Normalized	FRS Score Normalized	Final EC Problem Score	EC Narrative Rating	EC Rank Score	Flag	EC Reach ID
BAR	000	000	0	2780	50.00	4.59	0.00	9.55	3.10	Very Low	1	CALC	BAR000000000000
BAR	000	000	2780	3664	0.00	2.76	1.26	9.31	2.80	Very Low	1	CALC	BAR000000002780
BAR	000	000	3664	9060	0.00	4.52	0.00	9.98	3.10	Very Low	1	CALC	BAR000000003664
BAR	000	000	9060	11620	0.00	2.19	0.00	4.94	1.50	Very Low	1	CALC	BAR000000009060
BAR	000	000	11620	32120	0.00	13.76	2.36	17.39	7.40	Very Low	1	CALC	BAR000000011620
BAR	000	000	32120	49000	0.00	4.24	1.76	6.51	2.70	Very Low	1	CALC	BAR000000032120
BAR	000	000	49000	70920	0.00	1.00	0.00	5.23	1.30	Very Low	1	CALC	BAR000000049000
BAR	000	000	70920	82600	0.00	0.70	0.00	10.21	2.20	Very Low	1	CALC	BAR000000070920
BAR	000	000	82600	101460	0.00	0.00	7.78	10.42	3.60	Very Low	1	CALC	BAR000000082600
BAR	000	000	101460	111450	0.00	0.34	0.00	5.40	1.20	Very Low	1	CALC	BAR000000101460
BLU	000	000	386	2680	0.00	5.36	27.82	42.75	15.50	Low	3	CALC	BLU000000000386
BLU	000	000	2680	4330	0.00	0.00	27.93	34.18	12.40	Low	3	CALC	BLU000000002680
BLU	000	000	4330	7600	0.00	54.38	11.49	47.13	25.30	Moderate	5	CALC	BLU000000004330
BLU	000	000	7600	10350	0.00	36.84	0.00	42.10	17.60	Low	3	CALC	BLU000000007600
BLU	000	000	10350	12850	0.00	0.00	28.16	43.54	14.30	Low	3	CALC	BLU000000010350
BMK	000	000	0	4880	0.00	61.21	35.48	24.71	27.30	Moderate	5	CALC	BMK000000000000
BMK	000	000	4880	5990	0.00	16.79	4.65	19.07	8.90	Very Low	1	CALC	BMK000000004880
BMK	000	000	5990	8870	0.00	0.00	7.49	9.88	3.50	Very Low	1	CALC	BMK000000005990
BMK	000	000	8870	10535	0.00	17.10	2.95	12.12	7.30	Very Low	1	CALC	BMK000000008870
BMK	000	000	10535	12265	0.00	3.44	1.67	12.34	3.70	Very Low	1	CALC	BMK000000010535
BOG	000	000	0	4800	0.00	56.21	32.18	23.46	25.20	Moderate	5	CALC	BOG000000000000
BOG	000	000	4800	6150	0.00	0.00	0.00	20.54	4.10	Very Low	1	CALC	BOG000000004800
BOG	000	000	6150	8140	0.00	0.00	0.00	15.18	3.00	Very Low	1	CALC	BOG000000006150
BOG	000	000	8140	19600	0.00	0.00	0.00	4.15	0.80	Very Low	1	CALC	BOG000000008140
BOG	000	000	19600	26900	0.00	75.70	100.00	29.38	44.80	Very High	9	CALC	BOG000000019600
BOG	000	000	26900	32700	0.00	20.65	39.38	4.39	13.90	Low	3	CALC	BOG000000026900
BOG	000	000	32700	36660	88.57	31.52	11.07	14.86	44.10	Very High	9	CALC	BOG000000032700
BUL	000	000	290	7630	0.00	0.00	0.00	8.48	1.70	Very Low	1	CALC	BUL000000000290
BUL	000	000	7630	11630	0.00	7.22	7.38	17.08	6.70	Very Low	1	CALC	BUL000000007630
BUL	000	000	11630	13655	0.00	0.00	5.55	12.84	3.70	Very Low	1	CALC	BUL000000011630
BUL	000	000	13655	15410	0.00	0.00	1.42	13.58	3.00	Very Low	1	CALC	BUL000000013655
BUL	000	000	15410	21280	0.00	0.00	7.58	17.55	5.00	Very Low	1	CALC	BUL000000015410
BUL	000	000	21280	24880	0.00	0.00	1.80	17.30	3.80	Very Low	1	CALC	BUL000000021280
BUL	000	000	24880	34200	100.00	0.00	24.47	35.43	47.00	Very High	9	CALC	BUL000000024880
BUL	000	000	34200	37910	0.00	0.00	22.00	37.92	12.00	Low	3	CALC	BUL000000034200
BUL	000	000	37910	42880	0.00	0.00	10.75	20.26	6.20	Very Low	1	CALC	BUL000000037910
BUL	000	000	42880	47860	0.00	7.17	2.00	17.56	5.70	Very Low	1	CALC	BUL000000042880
BUL	000	000	47860	53420	0.00	0.00	3.70	35.50	7.80	Very Low	1	CALC	BUL000000047860
BUL	000	000	53420	57300	0.00	0.00	1.49	11.01	2.50	Very Low	1	CALC	BUL000000053420
BUL	T02	000	100	12150	0.00	57.29	100.00	62.31	46.80	Very High	9	CALC	BULT02000000100
BUL	T02	000	12150	14560	0.00	6.57	18.77	41.13	13.60	Low	3	CALC	BULT02000012150
BUL	T03	000	1000	2900	0.00	8.00	3.46	33.18	9.30	Very Low	1	CALC	BULT03000001000
BUL	T03	000	2900	5100	0.00	4.00	9.11	21.09	7.00	Very Low	1	CALC	BULT03000002900
BUL	T04	000	100	3960	0.00	24.18	35.66	60.77	25.30	Moderate	5	CALC	BULT04000000100

Master Plan Problem Area Assessment Erosion Control Scores

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	Type1 Score Normalized	Type2 Score Normalized	Type3 Score Normalized	FRS Score Normalized	Final EC Problem Score	EC Narrative Rating	EC Rank Score	Flag	EC Reach ID
BUL	T04	000	3960	6530	0.00	0.00	14.92	37.09	10.40	Low	3	CALC	BULT04000003960
BUL	T05	000	100	3440	0.00	0.00	3.77	16.66	4.10	Very Low	1	CALC	BULT05000000100
BUL	T05	T06	1000	7350	0.00	0.00	12.00	13.94	5.20	Very Low	1	CALC	BULT05T06001000
BUL	T07	000	0	999999	0.00	0.00	0.00	0.00	7.80	Very Low	1	EST	BULT07000000000
BUL	T08	000	0	3600	0.00	6.65	5.75	46.92	12.20	Low	3	CALC	BULT08000000000
CNT	000	000	0	850	0.00	26.03	17.74	72.78	24.60	Moderate	5	CALC	CNT000000000000
CNT	000	000	850	7090	0.00	0.00	27.27	67.33	18.90	Low	3	CALC	CNT000000000850
CNT	000	000	7090	12680	100.00	10.83	0.00	67.17	51.40	Very High	9	CALC	CNT000000007090
CNT	000	000	12680	15165	0.00	60.72	77.32	61.96	43.10	Very High	9	CALC	CNT000000012680
CNT	000	000	15165	16710	0.00	17.36	20.59	43.92	17.20	Low	3	CALC	CNT000000015165
CNT	OLD	000	0	2850	0.00	32.73	17.32	58.01	23.30	Moderate	5	CALC	CNTOLD000000000
CNT	OLD	000	2850	4700	0.00	7.71	16.67	55.65	16.40	Low	3	CALC	CNTOLD000002850
CNT	OLD	000	4700	7650	0.00	5.17	31.96	68.99	21.50	Moderate	5	CALC	CNTOLD000004700
CNT	OLD	T01	0	999999	0.00	0.00	0.00	0.00	21.80	Moderate	5	EST	CNTOLDT01000000
CNT	T02	000	0	999999	0.00	0.00	0.00	0.00	51.40	Very High	9	EST	CNTT02000000000
CNT	T03	000	0	999999	0.00	0.00	0.00	0.00	51.40	Very High	9	EST	CNTT03000000000
CNT	T04	000	0	999999	0.00	0.00	0.00	0.00	43.60	Very High	9	EST	CNTT04000000000
CNT	T05	000	0	999999	0.00	0.00	0.00	0.00	43.60	Very High	9	EST	CNTT05000000000
EBO	000	000	0	6040	0.00	37.80	100.00	13.82	32.20	High	7	CALC	EBO000000000000
EBO	000	000	6040	7260	0.00	0.00	3.10	12.70	3.20	Very Low	1	CALC	EBO000000006040
EBO	000	000	7260	9400	100.00	20.93	10.00	12.33	9.70	Very Low	1	CALC	EBO000000007260
EBO	000	000	9400	16692	0.00	81.72	58.10	36.59	39.40	High	7	CALC	EBO000000009400
FOR	000	000	0	1100	0.00	12.87	25.41	43.94	17.10	Low	3	CALC	FOR000000000000
FOR	000	000	1100	9820	0.00	100.00	100.00	45.75	54.20	Very High	9	CALC	FOR000000001100
FOR	000	000	9820	14800	0.00	43.46	48.33	24.33	25.40	Moderate	5	CALC	FOR000000009820
FOR	000	000	14800	19750	0.00	5.58	16.81	9.55	6.70	Very Low	1	CALC	FOR000000014800
FOR	000	000	19750	22250	100.00	28.58	3.74	11.50	45.20	Very High	9	CALC	FOR000000019750
FOR	000	000	22250	24210	0.00	0.00	0.00	8.71	1.70	Very Low	1	CALC	FOR000000022250
FOR	000	000	24210	25760	0.00	0.00	3.43	16.90	4.10	Very Low	1	CALC	FOR000000024210
FOR	000	000	25760	27960	0.00	0.00	1.32	10.83	2.40	Very Low	1	CALC	FOR000000025760
FOR	000	000	27960	29310	0.00	3.18	3.57	11.00	3.70	Very Low	1	CALC	FOR000000027960
FOR	T01	000	0	3850	0.00	15.85	16.17	30.60	12.00	Low	3	CALC	FORT01000000000
HRP	000	000	0	1100	0.00	0.00	0.00	0.00	0.00	Very Low	1	CALC	HRP000000000000
HRP	000	000	1100	1850	0.00	18.08	20.70	4.11	9.50	Very Low	1	CALC	HRP000000001100
HRP	000	000	1850	2450	0.00	0.00	0.04	0.36	0.10	Very Low	1	CALC	HRP000000001850
HRP	000	000	2450	3330	0.00	1.36	0.00	6.67	1.70	Very Low	1	CALC	HRP000000002450
HRP	000	000	3330	3800	0.00	0.00	0.00	0.00	0.00	Very Low	1	CALC	HRP000000003330
HRP	000	000	3800	4100	0.00	13.47	0.00	22.34	7.80	Very Low	1	CALC	HRP000000003800
HRP	T01	000	0	450	0.00	13.47	0.00	22.34	7.80	Very Low	1	CALC	HRPT01000000000
JOH	000	000	0	4120	0.00	54.53	16.48	12.26	19.40	Low	3	CALC	JOH000000000000
JOH	000	000	4120	5900	0.00	0.00	0.00	0.00	0.00	Very Low	1	CALC	JOH000000004120
JOH	000	000	5900	6800	0.00	5.65	1.55	10.41	3.80	Very Low	1	CALC	JOH000000005900
JOH	000	000	6800	7800	0.00	0.00	0.00	0.00	0.00	Very Low	1	CALC	JOH000000006800
JOH	000	000	7800	9660	0.00	13.22	1.83	8.98	5.50	Very Low	1	CALC	JOH000000007800

Table B-2
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Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	Type1 Score Normalized	Type2 Score Normalized	Type3 Score Normalized	FRS Score Normalized	Final EC Problem Score	EC Narrative Rating	EC Rank Score	Flag	EC Reach ID
JOH	000	000	9660	11045	0.00	8.75	0.39	3.19	2.90	Very Low	1	CALC	JOH000000009660
JOH	000	000	11045	12650	0.00	1.03	3.25	6.98	2.30	Very Low	1	CALC	JOH000000011045
JOH	POS	000	0	680	0.00	0.00	0.00	1.79	0.40	Very Low	1	CALC	JOHPOS000000000
JOH	POS	000	680	2795	0.00	5.41	2.25	5.03	2.80	Very Low	1	CALC	JOHPOS000000680
JOH	POS	000	2795	3790	0.00	0.00	0.00	1.39	0.30	Very Low	1	CALC	JOHPOS000002795
LWA	000	000	0	3260	0.00	27.51	18.71	45.31	19.70	Low	3	CALC	LWA000000000000
LWA	000	000	3260	6950	0.00	37.45	20.36	29.45	15.30	Low	3	CALC	LWA000000003260
LWA	000	000	6950	10440	0.00	17.64	5.24	21.51	7.60	Very Low	1	CALC	LWA000000006950
LWA	000	000	10440	13530	0.00	0.00	4.68	24.32	5.80	Very Low	1	CALC	LWA000000010440
LWA	000	000	13530	15985	0.00	0.00	0.00	23.44	4.70	Very Low	1	CALC	LWA000000013530
LWA	000	000	15985	21580	0.00	10.03	5.80	17.85	7.20	Very Low	1	CALC	LWA000000015985
LWA	000	000	21580	32880	0.00	14.74	18.45	14.44	10.30	Low	3	CALC	LWA000000021580
LWA	000	000	32880	36000	0.00	0.00	5.02	12.37	3.50	Very Low	1	CALC	LWA000000032880
LWA	000	000	36000	41760	100.00	18.08	0.00	13.09	42.10	Very High	9	CALC	LWA000000036000
LWA	000	000	41760	44835	0.00	0.00	0.00	13.74	2.70	Very Low	1	CALC	LWA000000041760
LWA	QCB	000	0	945	0.00	0.00	0.00	19.91	4.00	Very Low	1	CALC	LWAQCB000000000
LWA	QCB	000	945	2260	0.00	2.37	9.65	21.58	6.80	Very Low	1	CALC	LWAQCB000000945
LWA	QCB	000	2260	4215	0.00	0.00	0.00	20.28	4.10	Very Low	1	CALC	LWAQCB000002260
LWA	QCB	000	4215	6840	0.00	0.00	0.00	26.07	5.20	Very Low	1	CALC	LWAQCB000004215
LWA	T02	000	0	999999	0.00	0.00	0.00	0.00	2.20	Very Low	1	EST	LWAT02T01000000
LWA	T02	T01	0	1650	0.00	7.12	0.00	13.08	4.40	Very Low	1	CALC	LWAT02000000000
LWA	T02	T01	1650	4100	0.00	3.49	7.90	10.73	4.60	Very Low	1	CALC	LWAT02000001650
LWA	T02	T01	4100	6130	0.00	0.00	0.00	11.06	2.20	Very Low	1	CALC	LWAT02000004100
LWA	T02	T04	0	999999	0.00	0.00	0.00	0.00	4.40	Very Low	1	EST	LWAT04000000000
LWA	T02	T05	0	999999	0.00	0.00	0.00	0.00	4.40	Very Low	1	EST	LWAT05000000000
LWA	T06	000	0	999999	0.00	0.00	0.00	0.00	3.50	Very Low	1	EST	LWAT06000000000
LWA	T07	000	0	999999	0.00	0.00	0.00	0.00	42.10	Very High	9	EST	LWAT07000000000
SHL	000	000	0	5	0.00	9.10	3.34	9.41	4.80	Very Low	1	CALC	SHL000000000000
SHL	000	000	5	587	0.00	1.85	4.94	9.11	3.30	Very Low	1	CALC	SHL000000000005
SHL	000	000	587	7622	100.00	45.35	84.70	15.33	25.70	Moderate	5	CALC	SHL000000000587
SHL	000	000	7622	9820	0.00	21.55	7.85	8.97	8.80	Very Low	1	CALC	SHL000000007622
SHL	000	000	9820	14670	0.00	20.61	17.73	13.93	10.30	Low	3	CALC	SHL000000009820
SHL	000	000	14670	17462	0.00	3.01	4.92	9.09	3.60	Very Low	1	CALC	SHL000000014670
SHL	000	000	17462	24385	0.00	44.21	26.10	16.87	19.60	Low	3	CALC	SHL000000017462
SHL	000	000	24385	25960	0.00	5.71	1.16	11.11	3.90	Very Low	1	CALC	SHL000000024385
SHL	000	000	25960	29900	0.00	0.00	0.00	6.21	1.20	Very Low	1	CALC	SHL000000025960
SHL	000	000	29900	33130	0.00	21.66	5.43	14.84	9.50	Very Low	1	CALC	SHL000000029900
SHL	000	000	33130	35870	0.00	0.00	0.00	11.19	2.20	Very Low	1	CALC	SHL000000033130
SHL	000	000	35870	38875	0.00	13.05	2.24	9.20	5.60	Very Low	1	CALC	SHL000000035870
SHL	000	000	38875	41695	0.00	6.41	14.61	20.37	8.60	Very Low	1	CALC	SHL000000038875
SHL	000	000	41695	44640	0.00	0.00	5.40	35.32	8.10	Very Low	1	CALC	SHL000000041695
SHL	000	000	44640	49575	0.00	0.00	16.43	44.93	12.30	Low	3	CALC	SHL000000044640
SHL	FOS	000	0	999999	0.00	0.00	0.00	0.00	8.60	Very Low	1	EST	SHLFOS000000000
SHL	HAN	000	0	2300	0.00	0.00	0.00	13.45	2.70	Very Low	1	CALC	SHLHAN000000000

Master Plan Problem Area Assessment Erosion Control Scores

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	Type1 Score Normalized	Type2 Score Normalized	Type3 Score Normalized	FRS Score Normalized	Final EC Problem Score	EC Narrative Rating	EC Rank Score	Flag	EC Reach ID
SHL	HAN	000	2300	4050	0.00	0.00	16.69	15.72	6.50	Very Low	1	CALC	SHLHAN000002300
SHL	HAN	000	4050	6970	0.00	0.00	0.00	19.56	3.90	Very Low	1	CALC	SHLHAN000004050
TAN	000	000	0	1250	0.00	3.73	4.56	18.69	5.60	Very Low	1	CALC	TAN000000000000
TAN	000	000	1250	5300	0.00	0.00	0.00	4.34	0.90	Very Low	1	CALC	TAN000000001250
TAN	000	000	5300	6290	0.00	24.91	0.00	15.77	9.40	Very Low	1	CALC	TAN000000005300
TAN	000	000	6290	10775	0.00	2.59	14.21	2.63	3.40	Very Low	1	CALC	TAN000000006290
TAN	000	000	10775	17275	100.00	78.58	19.76	17.80	62.20	Very High	9	CALC	TAN000000010775
TAN	000	000	17275	23330	0.00	2.91	21.94	5.71	6.30	Very Low	1	CALC	TAN000000017275
TAN	000	000	23330	27680	100.00	7.96	0.43	3.18	37.70	High	7	CALC	TAN000000023330
TAN	000	000	27680	29020	0.00	3.18	1.16	9.50	2.90	Very Low	1	CALC	TAN000000027680
TAN	GP1	000	0	999999	0.00	0.00	0.00	0.00	9.40	Very Low	1	EST	TANGP1000000000
TAN	GP1	GP2	0	999999	0.00	0.00	0.00	0.00	9.40	Very Low	1	EST	TANGP1GP2000000
TAN	T01	000	0	800	0.00	3.18	1.16	9.50	2.90	Very Low	1	CALC	TANT01000000000
TAN	T02	000	0	375	0.00	0.00	0.00	0.00	2.90	Very Low	1	EST	TANT02000000000
TAN	WT3	000	0	999999	0.00	0.00	0.00	0.00	4.00	Very Low	1	EST	TANWT3000000000
WBO	000	000	0	4900	0.00	13.35	36.45	7.47	7.40	Very Low	1	CALC	WBO000000000000
WBO	000	000	4900	7270	100.00	16.59	14.90	4.59	43.00	Very High	9	CALC	WBO000000004900
WBO	000	000	7270	8050	0.00	0.00	0.00	5.64	1.10	Very Low	1	CALC	WBO000000007270
WBO	000	000	8050	14570	0.00	0.00	11.32	6.08	3.50	Very Low	1	CALC	WBO000000008050
WBO	NFK	000	0	999999	0.00	0.00	0.00	0.00	3.50	Very Low	1	EST	WBONFK000000000
WBO	T01	000	0	970	0.00	2.92	0.00	17.81	4.30	Very Low	1	CALC	WBOT01000000000
WLN	000	000	0	4440	0.00	51.65	20.04	100.00	36.90	High	7	CALC	WLN000000000000
WLN	000	000	4440	25120	0.00	100.00	100.00	100.00	65.00	Very High	9	CALC	WLN000000004440
WLN	000	000	25120	35040	0.00	100.00	100.00	100.00	65.00	Very High	9	CALC	WLN000000025120
WLN	000	000	35040	49700	100.00	100.00	100.00	100.00	100.00	Very High	9	CALC	WLN000000035040
WLN	000	000	49700	55500	0.00	100.00	27.41	100.00	50.50	Very High	9	CALC	WLN000000049700
WLN	000	000	55500	58700	0.00	17.13	23.40	77.81	24.50	Moderate	5	CALC	WLN000000055500
WLN	000	000	58700	63000	0.00	8.09	15.40	84.50	22.00	Moderate	5	CALC	WLN000000058700
WLN	000	000	63000	78200	0.00	36.15	100.00	77.46	44.50	Very High	9	CALC	WLN000000063000
WLN	000	000	78200	81070	0.00	32.43	24.47	74.65	27.90	Moderate	5	CALC	WLN000000078200
WLN	000	000	81070	85230	0.00	26.39	23.57	66.86	24.70	Moderate	5	CALC	WLN000000081070
WLN	000	000	85230	88760	0.00	38.92	80.42	100.00	45.80	Very High	9	CALC	WLN000000085230
WLN	000	000	88760	90720	0.00	14.69	26.46	75.69	24.10	Moderate	5	CALC	WLN000000088760
WLN	000	000	90720	98410	0.00	99.61	67.67	100.00	58.40	Very High	9	CALC	WLN000000090720
WLN	000	000	98410	103950	0.00	4.77	18.58	79.89	20.90	Moderate	5	CALC	WLN000000098410
WLN	000	000	103950	108530	0.00	4.03	19.52	83.29	21.60	Moderate	5	CALC	WLN000000103950
WLN	000	000	108530	114240	0.00	4.57	11.40	100.00	23.40	Moderate	5	CALC	WLN000000108530
WLN	KMR	000	0	999999	0.00	0.00	0.00	0.00	58.40	Very High	9	EST	WLNKMR000000000
WLN	T01	000	0	15780	0.00	4.11	51.74	41.07	19.60	Low	3	CALC	WLNT01000000000
WLN	T01	T01	0	300	0.00	4.11	51.74	41.07	19.60	Low	3	CALC	WLNT01T01000000
WLN	T01	T01	300	999999	0.00	0.00	0.00	0.00	19.60	Low	3	EST	WLNT01T01000300
WLN	T03	000	0	10250	0.00	58.99	33.92	100.00	41.50	Very High	9	CALC	WLNT03000000000
WLN	T03	000	10250	14500	0.00	53.77	19.31	100.00	37.30	High	7	CALC	WLNT03000010250
WLN	T03	000	14500	19000	0.00	39.27	16.77	100.00	33.20	High	7	CALC	WLNT03000014500

Table B-2
Master Plan Problem Area Assessment Erosion Control Scores

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	Type1 Score Normalized	Type2 Score Normalized	Type3 Score Normalized	FRS Score Normalized	Final EC Problem Score	EC Narrative Rating	EC Rank Score	Flag	EC Reach ID
WLN	T04	000	0	999999	0.00	0.00	0.00	0.00	65.00	Very High	9	EST	WLNT04000000000
WLN	T05	000	0	999999	0.00	0.00	0.00	0.00	100.00	Very High	9	EST	WLNT05000000000
WLN	T05	T01	0	999999	0.00	0.00	0.00	0.00	100.00	Very High	9	EST	WLNT05T01000000
WLN	T06	000	0	999999	0.00	0.00	0.00	0.00	28.00	Moderate	5	EST	WLNT06000000000
WLN	T07	000	0	5000	0.00	10.43	21.13	50.69	17.00	Low	3	CALC	WLNT07000000000
WLN	T07	000	5000	8550	0.00	11.40	5.74	51.75	14.30	Low	3	CALC	WLNT07000005000
WLN	T07	000	8550	12970	0.00	0.00	0.00	41.97	8.40	Very Low	1	CALC	WLNT07000008550
WLN	T07	T01	0	5840	0.00	3.08	5.07	40.42	9.90	Very Low	1	CALC	WLNT07T01000000
WLN	T08	000	0	1370	0.00	12.97	24.25	62.76	20.60	Moderate	5	CALC	WLNT08000000000
WLN	T08	000	1370	2470	0.00	4.04	5.55	53.25	12.80	Low	3	CALC	WLNT08000001370
WLN	T08	000	2470	10390	0.00	7.76	23.13	57.55	18.10	Low	3	CALC	WLNT08000002470
WLN	T09	000	0	13500	0.00	0.00	52.32	100.00	30.50	High	7	CALC	WLNT09000000000
WLN	T10	000	0	999999	0.00	0.00	0.00	0.00	23.40	Moderate	5	EST	WLNT10000000000
WLN	TAR	000	0	999999	0.00	0.00	0.00	0.00	24.70	Moderate	5	EST	WLNTAR000000000
WLN	WEL	000	0	3240	0.00	5.32	11.25	98.05	23.20	Moderate	5	CALC	WLNWEL000000000
WLN	WEL	000	3240	5570	100.00	52.56	53.38	100.00	78.80	Very High	9	CALC	WLNWEL000003240
WLN	WEL	000	5570	9650	0.00	6.88	66.18	79.39	30.80	High	7	CALC	WLNWEL000005570
WLN	WEL	000	9650	18150	0.00	20.51	100.00	100.00	45.10	Very High	9	CALC	WLNWEL000009650
WLN	WEL	000	18150	19720	0.00	0.00	27.74	100.00	25.50	Moderate	5	CALC	WLNWEL000018150
WLN	WEL	000	19720	27260	0.00	17.72	16.87	100.00	27.80	Moderate	5	CALC	WLNWEL000019720
WLN	WEL	T01	0	999999	0.00	0.00	0.00	0.00	30.90	High	7	EST	WLNWELT01000000
WLN	WEL	T02	0	999999	0.00	0.00	0.00	0.00	27.80	Moderate	5	EST	WLNWELT02000000
WLN	WEL	T03	0	999999	0.00	0.00	0.00	0.00	27.80	Moderate	5	EST	WLNWELT03000000
WLR	000	000	0	3000	0.00	39.60	14.11	16.40	16.00	Low	3	CALC	WLR000000000000
WLR	000	000	3000	6620	0.00	1.37	2.50	8.39	2.50	Very Low	1	CALC	WLR000000003000
WLR	000	000	6620	12300	0.00	44.40	3.08	5.98	12.90	Low	3	CALC	WLR000000006620
WLR	000	000	12300	22300	0.00	11.55	1.55	12.70	5.70	Very Low	1	CALC	WLR000000012300
WLR	000	000	22300	26240	0.00	21.38	1.95	15.97	8.90	Very Low	1	CALC	WLR000000022300
WLR	000	000	26240	26690	0.00	0.00	0.00	12.15	2.40	Very Low	1	CALC	WLR000000026240
WLR	000	000	26690	28465	0.00	0.00	0.00	7.84	1.60	Very Low	1	CALC	WLR000000026690
WLR	000	000	28465	31811	0.00	6.94	0.00	19.97	5.70	Very Low	1	CALC	WLR000000028465
WLR	000	000	31811	34730	0.00	0.00	3.16	21.20	4.90	Very Low	1	CALC	WLR000000031811
WLR	HMP	000	0	865	0.00	10.30	1.15	2.13	3.20	Very Low	1	CALC	WLRHMP000000000
WLR	HMP	000	865	3290	0.00	49.15	0.00	2.48	12.80	Low	3	CALC	WLRHMP000000865
WLR	HMP	000	3290	4854	0.00	2.00	0.55	2.24	1.10	Very Low	1	CALC	WLRHMP000003290
WMS	000	000	0	2380	0.00	17.57	18.88	23.65	12.90	Low	3	CALC	WMS000000000000
WMS	000	000	2380	3280	0.00	24.40	18.33	22.43	14.30	Low	3	CALC	WMS000000002380
WMS	000	000	3280	15700	0.00	94.02	40.15	34.27	38.40	High	7	CALC	WMS000000003280
WMS	000	000	15700	17900	0.00	21.24	21.80	22.41	14.20	Low	3	CALC	WMS000000015700
WMS	000	000	17900	30140	0.00	39.51	26.31	22.94	19.70	Low	3	CALC	WMS000000017900
WMS	000	000	30140	32160	0.00	2.80	5.18	11.57	4.10	Very Low	1	CALC	WMS000000030140
WMS	000	000	32160	36000	0.00	22.30	11.03	25.42	12.90	Low	3	CALC	WMS000000032160
WMS	000	000	36000	46000	0.00	23.54	20.38	14.36	12.80	Low	3	CALC	WMS000000036000
WMS	000	000	46000	49660	0.00	17.08	12.82	30.06	12.80	Low	3	CALC	WMS000000046000

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	Type1 Score Normalized	Type2 Score Normalized	Type3 Score Normalized	FRS Score Normalized	Final EC Problem Score	EC Narrative Rating	EC Rank Score	Flag	EC Reach ID
WMS	000	000	49660	55560	0.00	37.29	79.49	40.59	33.30	High	7	CALC	WMS000000049660
WMS	000	000	55560	75020	0.00	5.20	4.94	13.50	5.00	Very Low	1	CALC	WMS000000055560
WMS	000	000	75020	82030	0.00	13.07	7.45	20.92	8.90	Very Low	1	CALC	WMS000000075020
WMS	000	000	82030	86950	0.00	16.99	17.31	28.03	13.30	Low	3	CALC	WMS000000082030
WMS	CCK	000	0	8980	0.00	17.69	44.84	14.01	16.20	Low	3	CALC	WMSCCK000000000
WMS	KIN	000	0	13400	0.00	0.82	14.17	4.06	3.90	Very Low	1	CALC	WMSKIN000000000
WMS	KIN	000	13400	21200	0.00	3.27	0.00	6.67	2.20	Very Low	1	CALC	WMSKIN000013400
WMS	KIN	WHL	0	999999	0.00	0.00	0.00	0.00	2.20	Very Low	1	EST	WMSKINWHL000000
WMS	MOT	000	0	1760	0.00	0.00	0.00	8.97	1.80	Very Low	1	CALC	WMSMOT000000000
WMS	PLH	000	0	999999	0.00	0.00	0.00	0.00	19.80	Low	3	EST	WMSPLH000000000
WMS	SBK	000	0	999999	0.00	0.00	0.00	0.00	13.30	Low	3	EST	WMSSBK000000000
WMS	SNV	000	0	9000	0.00	0.00	0.00	56.14	11.20	Low	3	CALC	WMSSNV000000000
WMS	STE	000	0	7200	0.00	67.54	84.06	100.00	53.70	Very High	9	CALC	WMSSTE000000000

Table B - 3
Master Plan Problem Area Assessment Water Quality Scores

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	Current WQ Problem Score	Future WQ Problem Score	Final WQ Problem Score	WQ Narrative Rating	WQ Rank Score	Flag	WQ Reach ID	EII Site
BAR	000	000	3750	46600	49.60	26.90	59.10	Moderate	5	CALC	BAR000000003750	53
BAR	000	000	46600	59600	14.70	24.60	30.40	Low	3	CALC	BAR000000046600	88
BAR	000	000	59600	111950	29.40	29.80	45.80	Moderate	5	CALC	BAR000000059600	82
BAR	000	000	111950	112450	20.40	33.60	41.70	Moderate	5	CALC	BAR000000111950	48
BAR	000	000	112450	264275	29.40	100.00	100.00	Very High	9	CALC	BAR000000112450	78
BLU	000	000	550	5700	31.60	12.80	34.30	Low	3	CALC	BLU000000000550	180
BLU	000	000	5700	8400	31.00	18.90	38.60	Low	3	CALC	BLU000000005700	364
BLU	000	000	8400	12600	2.80	15.40	14.10	Very Low	1	CALC	BLU000000008400	362
BLU	000	000	12600	12850	35.30	18.80	41.90	Moderate	5	CALC	BLU000000012600	363
BMK	000	000	75	3600	22.70	10.20	25.40	Low	3	CALC	BMK000000000075	851
BMK	000	000	3600	7150	6.50	9.50	12.40	Very Low	1	CALC	BMK000000003600	783
BMK	000	000	7150	11650	34.00	7.60	32.20	Low	3	CALC	BMK000000007150	782
BMK	000	000	11650	12265	74.50	5.70	62.00	High	7	CALC	BMK000000011650	852
BOG	000	000	2900	20150	35.70	11.10	36.10	Low	3	CALC	BOG000000002900	493
BOG	000	000	20150	30800	32.60	5.20	29.20	Low	3	CALC	BOG000000020150	837
BOG	000	000	30800	35800	30.10	3.80	26.20	Low	3	CALC	BOG000000030800	853
BOG	000	000	35800	36660	39.20	5.60	34.70	Low	3	CALC	BOG000000035800	784
BUL	000	000	7650	13210	14.60	24.70	30.30	Low	3	CALC	BUL000000007650	347
BUL	000	000	13210	36500	54.90	53.40	83.70	Very High	9	CALC	BUL000000013210	350
BUL	000	000	36500	59735	51.20	65.80	90.40	Very High	9	CALC	BUL000000036500	920
BUL	T02	000	0	999999	0.00	0.00	83.70	Very High	9	EST	BULT02000000000	0
BUL	T03	000	0	999999	0.00	0.00	83.70	Very High	9	EST	BULT03000000000	0
BUL	T04	000	0	999999	0.00	0.00	90.40	Very High	9	EST	BULT04000000000	0
BUL	T05	000	0	999999	0.00	0.00	90.40	Very High	9	EST	BULT05000000000	0
BUL	T05	T06	450	5750	31.80	32.20	49.50	Moderate	5	CALC	BULT05T06000450	151
BUL	T07	000	0	999999	0.00	0.00	90.40	Very High	9	EST	BULT07000000000	0
BUL	T08	000	0	999999	0.00	0.00	90.40	Very High	9	EST	BULT08000000000	0
CNT	000	000	12650	16710	13.30	11.10	18.80	Very Low	1	CALC	CNT000000012650	850
CNT	OLD	000	450	8075	96.00	21.10	90.50	Very High	9	CALC	CNTOLD000000450	848
CNT	OLD	000	8075	9220	71.50	15.10	66.90	High	7	CALC	CNTOLD000008075	849
CNT	OLD	T01	0	999999	0.00	0.00	90.50	Very High	9	EST	CNTOLDT01000000	0
CNT	T02	000	0	999999	0.00	0.00	18.80	Very Low	1	EST	CNTT02000000000	0
CNT	T03	000	0	999999	0.00	0.00	18.80	Very Low	1	EST	CNTT03000000000	0
CNT	T04	000	0	999999	0.00	0.00	18.80	Very Low	1	EST	CNTT04000000000	0
CNT	T05	000	0	999999	0.00	0.00	18.80	Very Low	1	EST	CNTT05000000000	0
EBO	000	000	200	7750	45.40	6.20	39.90	Low	3	CALC	EBO000000000200	115
EBO	000	000	7750	12600	28.50	7.50	27.90	Low	3	CALC	EBO000000007750	119
EBO	000	000	12600	16600	97.50	10.20	83.20	Very High	9	CALC	EBO000000012600	120

Master Plan Problem Area Assessment Water Quality Scores

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	Current WQ Problem Score	Future WQ Problem Score	Final WQ Problem Score	WQ Narrative Rating	WQ Rank Score	Flag	WQ Reach ID	Eii Site
EBO	000	000	16600	17957	46.30	12.50	45.40	Moderate	5	CALC	EBO000000016600	121
FOR	000	000	250	13800	33.20	12.10	35.00	Low	3	CALC	FOR000000000250	123
FOR	000	000	13800	20975	20.30	6.60	20.70	Low	3	CALC	FOR000000013800	898
FOR	000	000	20975	28635	30.40	7.10	29.00	Low	3	CALC	FOR000000020975	125
FOR	000	000	28635	29310	51.80	12.90	50.00	Moderate	5	CALC	FOR000000028635	126
FOR	T01	000	0	999999	0.00	0.00	29.00	Low	3	EST	FORT01000000000	0
HRP	000	000	300	3200	40.20	4.50	34.50	Low	3	CALC	HRP000000000300	484
HRP	000	000	3200	4700	61.60	4.20	50.90	Moderate	5	CALC	HRP000000003200	844
HRP	000	000	4700	5700	2.80	5.10	6.10	Very Low	1	CALC	HRP000000004700	877
HRP	T01	000	0	999999	0.00	0.00	50.90	Moderate	5	EST	HRPT01000000000	844
JOH	000	000	350	5600	100.00	1.70	78.50	High	7	CALC	JOH000000000350	489
JOH	000	000	5600	8050	79.10	1.30	62.10	High	7	CALC	JOH000000005600	857
JOH	000	000	8050	11040	77.60	1.40	61.00	High	7	CALC	JOH000000008050	897
JOH	000	000	11040	12650	33.20	1.50	26.80	Low	3	CALC	JOH000000011040	847
JOH	POS	000	0	999999	0.00	0.00	78.50	High	7	EST	JOHPOS000000000	0
LWA	000	000	1400	15130	29.40	15.10	34.40	Low	3	CALC	LWA000000001400	634
LWA	000	000	15130	25680	2.10	10.10	9.40	Very Low	1	CALC	LWA000000015130	840
LWA	000	000	25680	43570	26.90	8.80	27.60	Low	3	CALC	LWA000000025680	839
LWA	000	000	43570	47210	24.90	8.00	25.40	Low	3	CALC	LWA000000043570	838
LWA	QCB	000	0	999999	0.00	0.00	27.60	Low	3	EST	LWAQCB000000000	0
LWA	T02	000	0	999999	0.00	0.00	9.40	Very Low	1	EST	LWAT02T01000000	0
LWA	T02	T01	0	999999	0.00	0.00	9.40	Very Low	1	EST	LWAT02000000000	0
LWA	T02	T04	0	999999	0.00	0.00	9.40	Very Low	1	EST	LWAT04000000000	0
LWA	T02	T05	0	999999	0.00	0.00	9.40	Very Low	1	EST	LWAT05000000000	0
LWA	T06	000	0	999999	0.00	0.00	27.60	Low	3	EST	LWAT06000000000	0
LWA	T07	000	0	999999	0.00	0.00	27.60	Low	3	EST	LWAT07000000000	0
SHL	000	000	150	9000	67.20	5.30	56.10	Moderate	5	CALC	SHL000000000150	122
SHL	000	000	9000	30700	26.80	6.10	25.50	Low	3	CALC	SHL000000009000	116
SHL	000	000	30700	46800	18.70	10.50	22.60	Low	3	CALC	SHL000000030700	117
SHL	000	000	46800	52360	30.30	12.70	33.10	Low	3	CALC	SHL000000046800	118
SHL	FOS	000	0	999999	0.00	0.00	22.60	Low	3	EST	SHLFOS000000000	0
SHL	HAN	000	0	999999	0.00	0.00	25.50	Low	3	EST	SHLHAN000000000	0
TAN	000	000	0	13600	5.90	6.50	9.60	Very Low	1	CALC	TAN000000000000	854
TAN	000	000	13600	18170	41.20	7.30	37.50	Low	3	CALC	TAN000000013600	843
TAN	000	000	18170	30200	37.80	5.00	33.10	Low	3	CALC	TAN000000018170	842
TAN	000	000	30200	34687	37.80	5.00	33.10	Low	3	CALC	TAN000000018170	842
TAN	GP1	000	0	999999	0.00	0.00	9.60	Very Low	1	EST	TANGP1000000000	0
TAN	GP1	GP2	0	999999	0.00	0.00	9.60	Very Low	1	EST	TANGP1GP2000000	0

Table B - 3
Master Plan Problem Area Assessment Water Quality Scores

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	Current WQ Problem Score	Future WQ Problem Score	Final WQ Problem Score	WQ Narrative Rating	WQ Rank Score	Flag	WQ Reach ID	EII Site
TAN	T01	000	0	800	0.00	0.00	33.10	Low	3	EST	TANT01000000000	842
TAN	T02	000	0	375	0.00	0.00	45.00	Moderate	5	EST	TANT02000000000	841
TAN	WT3	000	0	999999	0.00	0.00	9.60	Very Low	1	EST	TANWT3000000000	0
WBO	000	000	800	4400	76.00	5.60	63.10	High	7	CALC	WBO000000000800	486
WBO	000	000	4400	7100	0.40	5.60	4.70	Very Low	1	CALC	WBO000000004400	878
WBO	000	000	7100	10200	77.10	5.90	64.10	High	7	CALC	WBO000000007100	845
WBO	000	000	10200	17516	46.50	5.90	40.40	Moderate	5	CALC	WBO000000010200	846
WBO	NFK	000	0	999999	0.00	0.00	64.10	High	7	EST	WBONFK000000000	0
WBO	T01	000	0	999999	0.00	0.00	40.40	Moderate	5	EST	WBOT01000000000	0
WLN	000	000	9370	30000	35.50	29.60	50.20	Moderate	5	CALC	WLN000000009370	503
WLN	000	000	30000	49270	41.60	37.10	60.80	High	7	CALC	WLN000000030000	465
WLN	000	000	49270	75300	39.20	32.80	55.60	Moderate	5	CALC	WLN000000049270	500
WLN	000	000	75300	80880	36.90	28.70	50.70	Moderate	5	CALC	WLN000000075300	464
WLN	000	000	80880	120165	11.10	29.80	31.60	Low	3	CALC	WLN000000080880	659
WLN	KMR	000	0	999999	0.00	0.00	31.60	Low	3	EST	WLNKMR000000000	0
WLN	T01	000	0	999999	0.00	0.00	50.20	Moderate	5	EST	WLNT01000000000	0
WLN	T01	T01	0	999999	0.00	0.00	50.20	Moderate	5	EST	WLNT01T01000000	0
WLN	T03	000	0	999999	0.00	0.00	60.80	High	7	EST	WLNT03000000000	0
WLN	T04	000	0	999999	0.00	0.00	60.80	High	7	EST	WLNT04000000000	0
WLN	T05	000	0	999999	0.00	0.00	60.80	High	7	EST	WLNT05000000000	0
WLN	T05	T01	0	999999	0.00	0.00	60.80	High	7	EST	WLNT05T01000000	0
WLN	T06	000	0	999999	0.00	0.00	50.70	Moderate	5	EST	WLNT06000000000	0
WLN	T07	000	0	999999	0.00	0.00	31.60	Low	3	EST	WLNT07000000000	0
WLN	T07	T01	0	999999	0.00	0.00	31.60	Low	3	EST	WLNT07T01000000	0
WLN	T08	000	0	999999	0.00	0.00	31.60	Low	3	EST	WLNT08000000000	0
WLN	T09	000	0	999999	0.00	0.00	31.60	Low	3	EST	WLNT09000000000	0
WLN	T10	000	0	999999	0.00	0.00	31.60	Low	3	EST	WLNT10000000000	0
WLN	TAR	000	0	999999	0.00	0.00	31.60	Low	3	EST	WLNTAR000000000	0
WLN	WEL	000	0	999999	0.00	0.00	31.60	Low	3	EST	WLNWEL000000000	0
WLN	WEL	T01	0	999999	0.00	0.00	31.60	Low	3	EST	WLNWELT01000000	0
WLN	WEL	T02	0	999999	0.00	0.00	31.60	Low	3	EST	WLNWELT02000000	0
WLN	WEL	T03	0	999999	0.00	0.00	31.60	Low	3	EST	WLNWELT03000000	0
WLR	000	000	850	11865	54.10	3.90	44.80	Moderate	5	CALC	WLR000000000850	38
WLR	000	000	11865	21900	16.50	3.90	15.80	Very Low	1	CALC	WLR000000011865	624
WLR	000	000	21900	26150	13.20	4.40	13.60	Very Low	1	CALC	WLR000000021900	781
WLR	000	000	26150	31811	40.70	6.80	36.70	Low	3	CALC	WLR000000026150	780
WLR	HMP	000	0	999999	0.00	0.00	15.80	Very Low	1	EST	WLRHMP000000000	0
WMS	000	000	0	16000	23.90	18.30	32.70	Low	3	CALC	WMS000000000000	223

Master Plan Problem Area Assessment Water Quality Scores

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	Current WQ Problem Score	Future WQ Problem Score	Final WQ Problem Score	WQ Narrative Rating	WQ Rank Score	Flag	WQ Reach ID	EII Site
WMS	000	000	16000	27330	27.10	15.50	32.90	Low	3	CALC	WMS000000016000	492
WMS	000	000	27330	73850	60.20	19.60	61.60	High	7	CALC	WMS000000027330	491
WMS	000	000	73850	83600	29.70	12.90	32.90	Low	3	CALC	WMS000000073850	344
WMS	000	000	83600	93000	31.10	17.70	37.70	Low	3	CALC	WMS000000083600	490
WMS	000	000	93000	98000	27.00	10.30	28.80	Low	3	CALC	WMS000000093000	300
WMS	CCK	000	0	999999	0.00	0.00	61.60	High	7	EST	WMSCCK000000000	0
WMS	KIN	000	0	999999	0.00	0.00	61.60	High	7	EST	WMSKIN000000000	0
WMS	KIN	WHL	0	999999	0.00	0.00	61.60	High	7	EST	WMSKINWHL000000	0
WMS	MOT	000	0	999999	0.00	0.00	32.90	Low	3	EST	WMSMOT000000000	0
WMS	PLH	000	0	999999	0.00	0.00	32.90	Low	3	EST	WMSPLH000000000	0
WMS	SBK	000	0	999999	0.00	0.00	32.90	Low	3	EST	WMSSBK000000000	0
WMS	SNV	000	0	999999	0.00	0.00	61.60	High	7	EST	WMSSNV000000000	0
WMS	STE	000	0	999999	0.00	0.00	32.70	Low	3	EST	WMSSTE000000000	0

Table B - 4
Master Plan Problem Area Assessment Integrated Scores (98 Methodology)

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	FC Final Wt	EC Final Wt	WQ Final Wt	IS Reach ID	Final FC Problem Score	FC Narrative Rating	FC Rank Score	Final EC Problem Score	EC Narrative Rating	EC Rank Score	Final WQ Problem Score	WQ Narrative Rating	WQ Rank Score	Integrated Score	IS Narrative Rating
BAR	000	000	0	2780	0.2750	0.3094	0.4156	BAR000000000000	0.00	Very Low	1	3.10	Very Low	1	59.10	Moderate	5	2.66	Low
BAR	000	000	2780	3664	0.2750	0.3094	0.4156	BAR000000002780	0.00	Very Low	1	2.80	Very Low	1	59.10	Moderate	5	2.66	Low
BAR	000	000	3664	3750	0.2750	0.3094	0.4156	BAR000000003664	0.00	Very Low	1	3.10	Very Low	1	59.10	Moderate	5	2.66	Low
BAR	000	000	3750	9060	0.2750	0.3094	0.4156	BAR000000003750	0.00	Very Low	1	3.10	Very Low	1	59.10	Moderate	5	2.66	Low
BAR	000	000	9060	11620	0.2750	0.3094	0.4156	BAR000000009060	0.00	Very Low	1	1.50	Very Low	1	59.10	Moderate	5	2.66	Low
BAR	000	000	11620	23600	0.2750	0.3094	0.4156	BAR000000011620	0.00	Very Low	1	7.40	Very Low	1	59.10	Moderate	5	2.66	Low
BAR	000	000	23600	32120	0.2869	0.3029	0.4103	BAR000000023600	0.00	Very Low	1	7.40	Very Low	1	59.10	Moderate	5	2.64	Low
BAR	000	000	32120	46600	0.2869	0.3029	0.4103	BAR000000032120	0.00	Very Low	1	2.70	Very Low	1	59.10	Moderate	5	2.64	Low
BAR	000	000	46600	49000	0.2869	0.3029	0.4103	BAR000000046600	0.00	Very Low	1	2.70	Very Low	1	30.40	Low	3	1.82	Very Low
BAR	000	000	49000	59600	0.2869	0.3029	0.4103	BAR000000049000	0.00	Very Low	1	1.30	Very Low	1	30.40	Low	3	1.82	Very Low
BAR	000	000	59600	70920	0.2869	0.3029	0.4103	BAR000000059600	0.00	Very Low	1	1.30	Very Low	1	45.80	Moderate	5	2.64	Low
BAR	000	000	70920	82600	0.2869	0.3029	0.4103	BAR000000070920	0.00	Very Low	1	2.20	Very Low	1	45.80	Moderate	5	2.64	Low
BAR	000	000	82600	101460	0.2869	0.3029	0.4103	BAR000000082600	0.00	Very Low	1	3.60	Very Low	1	45.80	Moderate	5	2.64	Low
BAR	000	000	101460	111450	0.2869	0.3029	0.4103	BAR000000101460	0.00	Very Low	1	1.20	Very Low	1	45.80	Moderate	5	2.64	Low
BAR	000	000	111450	111950	0.2869	0.3029	0.4103	BAR000000111450	0.00	Very Low	1	1.20	Very Low	1	45.80	Moderate	5	2.64	Low
BAR	000	000	111950	112450	0.2869	0.3029	0.4103	BAR000000111950	0.00	Very Low	1	1.20	Very Low	1	41.70	Moderate	5	2.64	Low
BAR	000	000	112450	264275	0.2869	0.3029	0.4103	BAR000000112450	0.00	Very Low	1	1.20	Very Low	1	100.00	Very High	9	4.28	Moderate
BLU	000	000	0	386	0.2599	0.3359	0.4043	BLU000000000000	0.08	Low	3	15.50	Low	3	34.30	Low	3	3.00	Low
BLU	000	000	386	550	0.2599	0.3359	0.4043	BLU000000000386	0.08	Low	3	15.50	Low	3	34.30	Low	3	3.00	Low
BLU	000	000	550	1875	0.2599	0.3359	0.4043	BLU000000000550	0.08	Low	3	15.50	Low	3	34.30	Low	3	3.00	Low
BLU	000	000	1875	2680	0.2599	0.3359	0.4043	BLU000000001875	4.70	Low	3	15.50	Low	3	34.30	Low	3	3.00	Low
BLU	000	000	2680	3900	0.2599	0.3359	0.4043	BLU000000002680	4.70	Low	3	12.40	Low	3	34.30	Low	3	3.00	Low
BLU	000	000	3900	4330	0.2599	0.3359	0.4043	BLU000000003900	0.17	Low	3	12.40	Low	3	34.30	Low	3	3.00	Low
BLU	000	000	4330	5700	0.2599	0.3359	0.4043	BLU000000004330	0.17	Low	3	25.30	Moderate	5	34.30	Low	3	3.67	Low
BLU	000	000	5700	6325	0.2599	0.3359	0.4043	BLU000000005700	0.17	Low	3	25.30	Moderate	5	38.60	Low	3	3.67	Low
BLU	000	000	6325	7600	0.2599	0.3359	0.4043	BLU000000006325	2.66	Low	3	25.30	Moderate	5	38.60	Low	3	3.67	Low
BLU	000	000	7600	7640	0.2599	0.3359	0.4043	BLU000000007600	2.66	Low	3	17.60	Low	3	38.60	Low	3	3.00	Low
BLU	000	000	7640	7715	0.2750	0.3188	0.4063	BLU000000007640	2.68	Low	3	17.60	Low	3	38.60	Low	3	3.00	Low
BLU	000	000	7715	8400	0.2750	0.3188	0.4063	BLU000000007715	0.04	Low	3	17.60	Low	3	38.60	Low	3	3.00	Low
BLU	000	000	8400	10280	0.2750	0.3188	0.4063	BLU000000008400	0.04	Low	3	17.60	Low	3	14.10	Very Low	1	2.19	Low
BLU	000	000	10280	10350	0.2750	0.3188	0.4063	BLU000000010280	0.00	Very Low	1	17.60	Low	3	14.10	Very Low	1	1.64	Very Low
BLU	000	000	10350	12600	0.2750	0.3188	0.4063	BLU000000010350	0.00	Very Low	1	14.30	Low	3	14.10	Very Low	1	1.64	Very Low
BLU	000	000	12800	12850	0.2750	0.3188	0.4063	BLU000000012600	0.00	Very Low	1	14.30	Low	3	41.90	Moderate	5	3.26	Low
BMK	000	000	0	75	0.3052	0.2976	0.3972	BMK000000000000	0.00	Very Low	1	27.30	Moderate	5	25.40	Low	3	2.98	Low
BMK	000	000	75	2050	0.3052	0.2976	0.3972	BMK000000000075	0.00	Very Low	1	27.30	Moderate	5	25.40	Low	3	2.98	Low
BMK	000	000	2050	3600	0.3052	0.2976	0.3972	BMK000000002050	0.00	Very Low	1	27.30	Moderate	5	25.40	Low	3	2.98	Low
BMK	000	000	3600	4020	0.3052	0.2976	0.3972	BMK000000003600	0.00	Very Low	1	27.30	Moderate	5	12.40	Very Low	1	2.19	Low
BMK	000	000	4020	4880	0.3052	0.2976	0.3972	BMK000000004020	0.00	Very Low	1	27.30	Moderate	5	12.40	Very Low	1	2.19	Low
BMK	000	000	4880	5990	0.3052	0.2976	0.3972	BMK000000004880	0.00	Very Low	1	8.90	Very Low	1	12.40	Very Low	1	1.00	Very Low
BMK	000	000	5990	7150	0.3052	0.2976	0.3972	BMK000000005990	0.17	Low	3	3.50	Very Low	1	12.40	Very Low	1	1.61	Very Low
BMK	000	000	7150	7971	0.3052	0.2976	0.3972	BMK000000007150	0.17	Low	3	3.50	Very Low	1	32.20	Low	3	2.40	Low
BMK	000	000	7971	8870	0.3052	0.2976	0.3972	BMK000000007971	0.12	Low	3	3.50	Very Low	1	32.20	Low	3	2.40	Low
BMK	000	000	8870	10024	0.3052	0.2976	0.3972	BMK000000008870	0.12	Low	3	7.30	Very Low	1	32.20	Low	3	2.40	Low
BMK	000	000	10024	10535	0.3052	0.2976	0.3972	BMK000000010024	0.12	Low	3	7.30	Very Low	1	32.20	Low	3	2.40	Low
BMK	000	000	10535	11650	0.3052	0.2976	0.3972	BMK000000010535	0.12	Low	3	3.70	Very Low	1	32.20	Low	3	2.40	Low
BMK	000	000	11650	12265	0.3052	0.2976	0.3972	BMK000000011650	0.12	Low	3	3.70	Very Low	1	62.00	High	7	3.99	Low
BOG	000	000	0	2080	0.2929	0.3425	0.3645	BOG000000000000	0.00	Very Low	1	25.20	Moderate	5	36.10	Low	3	3.10	Low
BOG	000	000	2080	2900	0.2929	0.3425	0.3646	BOG000000002080	8.39	Moderate	5	25.20	Moderate	5	36.10	Low	3	4.27	Moderate
BOG	000	000	2900	4565	0.2929	0.3425	0.3646	BOG000000002900	8.39	Moderate	5	25.20	Moderate	5	36.10	Low	3	4.27	Moderate
BOG	000	000	4565	4800	0.2929	0.3425	0.3646	BOG000000004565	0.00	Very Low	1	25.20	Moderate	5	36.10	Low	3	3.10	Low
BOG	000	000	4800	6150	0.2929	0.3425	0.3646	BOG000000004800	0.00	Very Low	1	4.10	Very Low	1	36.10	Low	3	1.73	Very Low
BOG	000	000	6150	6500	0.2929	0.3425	0.3646	BOG000000006150	0.00	Very Low	1	3.00	Very Low	1	36.10	Low	3	1.73	Very Low
BOG	000	000	6500	8140	0.2929	0.3425	0.3646	BOG000000006500	0.00	Very Low	1	3.00	Very Low	1	36.10	Low	3	1.73	Very Low
BOG	000	000	8140	8386	0.2929	0.3425	0.3646	BOG000000008140	0.00	Very Low	1	0.80	Very Low	1	36.10	Low	3	1.73	Very Low

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	FC Final Wt	EC Final Wt	WQ Final Wt	IS Reach ID	Final FC Problem Score	FC Narrative Rating	FC Rank Score	Final EC Problem Score	EC Narrative Rating	EC Rank Score	Final WQ Problem Score	WQ Narrative Rating	WQ Rank Score	Integrated Score	IS Narrative Rating
BOG	000	000	8386	10775	0.2929	0.3425	0.3646	BOG000000008386	0.00	Very Low	1	0.80	Very Low	1	36.10	Low	3	1.73	Very Low
BOG	000	000	10775	11400	0.2929	0.3425	0.3646	BOG000000010775	0.01	Low	3	0.80	Very Low	1	36.10	Low	3	2.31	Low
BOG	000	000	11400	12260	0.2990	0.2962	0.4048	BOG000000011400	0.01	Low	3	0.80	Very Low	1	36.10	Low	3	2.41	Low
BOG	000	000	12260	14003	0.2990	0.2962	0.4048	BOG000000012260	0.00	Very Low	1	0.80	Very Low	1	36.10	Low	3	1.81	Very Low
BOG	000	000	14003	16610	0.2990	0.2962	0.4048	BOG000000014003	0.00	Very Low	1	0.80	Very Low	1	36.10	Low	3	1.81	Very Low
BOG	000	000	16610	17935	0.2990	0.2962	0.4048	BOG000000016610	0.00	Very Low	1	0.80	Very Low	1	36.10	Low	3	1.81	Very Low
BOG	000	000	17935	19600	0.2990	0.2962	0.4048	BOG000000017935	0.00	Very Low	1	0.80	Very Low	1	36.10	Low	3	1.81	Very Low
BOG	000	000	19600	20050	0.2990	0.2962	0.4048	BOG000000019600	0.00	Very Low	1	44.80	Very High	9	36.10	Low	3	4.18	Moderate
BOG	000	000	20050	20150	0.2990	0.2962	0.4048	BOG000000020050	0.00	Very Low	1	44.80	Very High	9	36.10	Low	3	4.18	Moderate
BOG	000	000	20150	21380	0.2990	0.2962	0.4048	BOG000000020150	0.00	Very Low	1	44.80	Very High	9	29.20	Low	3	4.18	Moderate
BOG	000	000	21380	24350	0.2990	0.2962	0.4048	BOG000000021380	2.20	Low	3	44.80	Very High	9	29.20	Low	3	4.78	Moderate
BOG	000	000	24350	26900	0.2990	0.2962	0.4048	BOG000000024350	8.81	Moderate	5	44.80	Very High	9	29.20	Low	3	5.37	Moderate
BOG	000	000	26900	27080	0.2990	0.2962	0.4048	BOG000000026900	8.81	Moderate	5	13.90	Low	3	29.20	Low	3	3.60	Low
BOG	000	000	27080	28360	0.2990	0.2962	0.4048	BOG000000027080	3.98	Low	3	13.90	Low	3	29.20	Low	3	3.00	Low
BOG	000	000	28360	29900	0.2990	0.2962	0.4048	BOG000000028360	5.94	Moderate	5	13.90	Low	3	29.20	Low	3	3.60	Low
BOG	000	000	29900	29967	0.2964	0.2839	0.4198	BOG000000029900	5.94	Moderate	5	13.90	Low	3	29.20	Low	3	3.59	Low
BOG	000	000	29967	30800	0.2964	0.2839	0.4198	BOG000000029967	15.38	High	7	13.90	Low	3	29.20	Low	3	4.19	Moderate
BOG	000	000	30800	32000	0.2964	0.2839	0.4198	BOG000000030800	15.38	High	7	13.90	Low	3	26.20	Low	3	4.19	Moderate
BOG	000	000	32000	32700	0.2964	0.2839	0.4198	BOG000000032000	1.74	Low	3	13.90	Low	3	26.20	Low	3	3.00	Low
BOG	000	000	32700	34500	0.2964	0.2839	0.4198	BOG000000032700	1.74	Low	3	44.10	Very High	9	28.20	Low	3	4.70	Moderate
BOG	000	000	34500	35770	0.2964	0.2839	0.4198	BOG000000034500	0.16	Low	3	44.10	Very High	9	26.20	Low	3	4.70	Moderate
BOG	000	000	35770	35800	0.2964	0.2839	0.4198	BOG000000035770	0.16	Low	3	44.10	Very High	9	26.20	Low	3	4.70	Moderate
BOG	000	000	35800	36660	0.2964	0.2839	0.4198	BOG000000035800	0.16	Low	3	44.10	Very High	9	34.70	Low	3	4.70	Moderate
BUL	000	000	0	290	0.2990	0.2769	0.4240	BUL000000000000	0.00	Very Low	1	1.70	Very Low	1	30.30	Low	3	1.85	Very Low
BUL	000	000	290	1755	0.2990	0.2769	0.4240	BUL000000000290	0.00	Very Low	1	1.70	Very Low	1	30.30	Low	3	1.85	Very Low
BUL	000	000	1755	4060	0.2990	0.2769	0.4240	BUL000000001755	0.00	Very Low	1	1.70	Very Low	1	30.30	Low	3	1.85	Very Low
BUL	000	000	4060	6100	0.2990	0.2769	0.4240	BUL000000004060	0.05	Low	3	1.70	Very Low	1	30.30	Low	3	2.45	Low
BUL	000	000	6100	7630	0.2990	0.2769	0.4240	BUL000000006100	26.96	Very High	9	1.70	Very Low	1	30.30	Low	3	4.24	Moderate
BUL	000	000	7630	7650	0.2990	0.2769	0.4240	BUL000000007630	26.96	Very High	9	6.70	Very Low	1	30.30	Low	3	4.24	Moderate
BUL	000	000	7650	8200	0.2990	0.2769	0.4240	BUL000000007650	26.96	Very High	9	6.70	Very Low	1	30.30	Low	3	4.24	Moderate
BUL	000	000	8200	10350	0.2990	0.2769	0.4240	BUL000000008200	0.74	Low	3	6.70	Very Low	1	30.30	Low	3	2.45	Low
BUL	000	000	10350	11630	0.2990	0.2769	0.4240	BUL000000010350	1.25	Low	3	6.70	Very Low	1	30.30	Low	3	2.45	Low
BUL	000	000	11630	12125	0.2990	0.2769	0.4240	BUL000000011630	1.25	Low	3	3.70	Very Low	1	30.30	Low	3	2.45	Low
BUL	000	000	12125	13210	0.2990	0.2769	0.4240	BUL000000012125	0.00	Very Low	1	3.70	Very Low	1	30.30	Low	3	1.85	Very Low
BUL	000	000	13210	13655	0.2990	0.2769	0.4240	BUL000000013210	0.00	Very Low	1	3.70	Very Low	1	83.70	Very High	9	4.39	Moderate
BUL	000	000	13655	14075	0.2990	0.2769	0.4240	BUL000000013655	0.00	Very Low	1	3.00	Very Low	1	83.70	Very High	9	4.39	Moderate
BUL	000	000	14075	15410	0.2990	0.2769	0.4240	BUL000000014075	0.00	Very Low	1	3.00	Very Low	1	83.70	Very High	9	4.39	Moderate
BUL	000	000	15410	16300	0.2990	0.2769	0.4240	BUL000000015410	0.00	Very Low	1	5.00	Very Low	1	83.70	Very High	9	4.39	Moderate
BUL	000	000	16300	18055	0.2990	0.2769	0.4240	BUL000000016300	0.00	Very Low	1	5.00	Very Low	1	83.70	Very High	9	4.39	Moderate
BUL	000	000	18055	19900	0.2990	0.2769	0.4240	BUL000000018055	0.00	Very Low	1	5.00	Very Low	1	83.70	Very High	9	4.39	Moderate
BUL	000	000	19900	21280	0.2990	0.2769	0.4240	BUL000000019900	0.00	Very Low	1	5.00	Very Low	1	83.70	Very High	9	4.39	Moderate
BUL	000	000	21280	22175	0.2990	0.2769	0.4240	BUL000000021280	0.00	Very Low	1	3.80	Very Low	1	83.70	Very High	9	4.39	Moderate
BUL	000	000	22175	24270	0.2990	0.2769	0.4240	BUL000000022175	0.04	Low	3	3.80	Very Low	1	83.70	Very High	9	4.99	Moderate
BUL	000	000	24270	24880	0.2990	0.2769	0.4240	BUL000000024270	7.30	Moderate	5	3.80	Very Low	1	83.70	Very High	9	5.59	Moderate
BUL	000	000	24880	26350	0.2990	0.2769	0.4240	BUL000000024880	7.30	Moderate	5	47.00	Very High	9	83.70	Very High	9	7.80	High
BUL	000	000	26350	28500	0.2990	0.2769	0.4240	BUL000000026350	3.54	Low	3	47.00	Very High	9	83.70	Very High	9	7.21	High
BUL	000	000	28500	30300	0.2990	0.2769	0.4240	BUL000000028500	8.28	Moderate	5	47.00	Very High	9	83.70	Very High	9	7.80	High
BUL	000	000	30300	32050	0.2990	0.2769	0.4240	BUL000000030300	16.95	High	7	47.00	Very High	9	83.70	Very High	9	8.40	Very High
BUL	000	000	32050	34200	0.2990	0.2769	0.4240	BUL000000032050	0.65	Low	3	47.00	Very High	9	83.70	Very High	9	7.21	High
BUL	000	000	34200	34250	0.2990	0.2769	0.4240	BUL000000034200	0.65	Low	3	12.00	Low	3	83.70	Very High	9	5.54	Moderate
BUL	000	000	34250	35900	0.2990	0.2769	0.4240	BUL000000034250	8.02	Moderate	5	12.00	Low	3	83.70	Very High	9	6.14	High
BUL	000	000	35900	36500	0.2990	0.2769	0.4240	BUL000000035900	0.00	Very Low	1	12.00	Low	3	83.70	Very High	9	4.95	Moderate
BUL	000	000	36500	37910	0.2990	0.2769	0.4240	BUL000000036500	0.00	Very Low	1	12.00	Low	3	90.40	Very High	9	4.95	Moderate
BUL	000	000	37910	38040	0.2990	0.2769	0.4240	BUL000000037910	0.00	Very Low	1	6.20	Very Low	1	90.40	Very High	9	4.39	Moderate

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Master Plan Problem Area Assessment Integrated Scores (98 Methodology)

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	FC Final Wt	EC Final Wt	WQ Final Wt	IS Reach ID	Final FC Problem Score	FC Narrative Rating	FC Rank Score	Final EC Problem Score	EC Narrative Rating	EC Rank Score	Final WQ Problem Score	WQ Narrative Rating	WQ Rank Score	Integrated Score	IS Narrative Rating
BUL	000	000	38040	40100	0.2990	0.2769	0.4240	BUL000000038040	0.00	Very Low	1	6.20	Very Low	1	90.40	Very High	9	4.39	Moderate
BUL	000	000	40100	42200	0.2990	0.2769	0.4240	BUL000000040100	8.88	Moderate	5	6.20	Very Low	1	90.40	Very High	9	5.59	Moderate
BUL	000	000	42200	42880	0.2990	0.2769	0.4240	BUL000000042200	1.81	Low	3	6.20	Very Low	1	90.40	Very High	9	4.99	Moderate
BUL	000	000	42880	44575	0.2990	0.2769	0.4240	BUL000000042880	1.81	Low	3	5.70	Very Low	1	90.40	Very High	9	4.99	Moderate
BUL	000	000	44575	46180	0.3243	0.2921	0.3836	BUL000000044575	0.46	Low	3	5.70	Very Low	1	90.40	Very High	9	4.72	Moderate
BUL	000	000	46180	47860	0.3243	0.2921	0.3836	BUL000000046180	0.00	Very Low	1	5.70	Very Low	1	90.40	Very High	9	4.07	Moderate
BUL	000	000	47860	49950	0.3243	0.2921	0.3836	BUL000000047860	0.00	Very Low	1	7.80	Very Low	1	90.40	Very High	9	4.07	Moderate
BUL	000	000	49950	51790	0.3243	0.2921	0.3836	BUL000000049950	0.00	Very Low	1	7.80	Very Low	1	90.40	Very High	9	4.07	Moderate
BUL	000	000	51790	53420	0.3243	0.2921	0.3836	BUL000000051790	0.00	Very Low	1	7.80	Very Low	1	90.40	Very High	9	4.07	Moderate
BUL	000	000	53420	54240	0.3243	0.2921	0.3836	BUL000000053420	0.00	Very Low	1	2.50	Very Low	1	90.40	Very High	9	4.07	Moderate
BUL	000	000	54240	56345	0.3243	0.2921	0.3836	BUL000000054240	0.00	Very Low	1	2.50	Very Low	1	90.40	Very High	9	4.07	Moderate
BUL	000	000	56345	57300	0.3243	0.2921	0.3836	BUL000000056345	0.00	Very Low	1	2.50	Very Low	1	90.40	Very High	9	4.07	Moderate
BUL	000	000	57300	58345	0.3243	0.2921	0.3836	BUL000000057300	0.00	Very Low	1	2.50	Very Low	1	90.40	Very High	9	4.07	Moderate
BUL	000	000	58345	59735	0.3243	0.2921	0.3836	BUL000000058345	0.00	Very Low	1	2.50	Very Low	1	90.40	Very High	9	4.07	Moderate
BUL	T02	000	0	100	0.2990	0.2769	0.4240	BULT02000000000	0.00	Very Low	1	46.80	Very High	9	83.70	Very High	9	6.61	High
BUL	T02	000	100	2090	0.2990	0.2769	0.4240	BULT02000000100	0.00	Very Low	1	46.80	Very High	9	83.70	Very High	9	6.61	High
BUL	T02	000	2090	4040	0.2990	0.2769	0.4240	BULT02000002090	0.00	Very Low	1	46.80	Very High	9	83.70	Very High	9	6.61	High
BUL	T02	000	4040	5840	0.2990	0.2769	0.4240	BULT02000004040	0.00	Very Low	1	46.80	Very High	9	83.70	Very High	9	6.61	High
BUL	T02	000	5840	7840	0.2990	0.2769	0.4240	BULT02000005840	0.00	Very Low	1	46.80	Very High	9	83.70	Very High	9	6.61	High
BUL	T02	000	7840	10150	0.2990	0.2769	0.4240	BULT02000007840	0.00	Very Low	1	46.80	Very High	9	83.70	Very High	9	6.61	High
BUL	T02	000	10150	12150	0.2990	0.2769	0.4240	BULT02000010150	0.02	Low	3	46.80	Very High	9	83.70	Very High	9	7.21	High
BUL	T02	000	12150	12250	0.2990	0.2769	0.4240	BULT02000012150	0.02	Low	3	13.60	Low	3	83.70	Very High	9	5.54	Moderate
BUL	T02	000	12250	14250	0.2990	0.2769	0.4240	BULT02000012250	0.00	Very Low	1	13.60	Low	3	83.70	Very High	9	4.95	Moderate
BUL	T02	000	14250	14560	0.2990	0.2769	0.4240	BULT02000014250	0.09	Low	3	13.60	Low	3	83.70	Very High	9	5.54	Moderate
BUL	T02	000	14560	16285	0.2990	0.2769	0.4240	BULT02000014560	0.09	Low	3	13.60	Low	3	83.70	Very High	9	5.54	Moderate
BUL	T02	000	16285	18580	0.2990	0.2769	0.4240	BULT02000016285	0.72	Low	3	13.60	Low	3	83.70	Very High	9	5.54	Moderate
BUL	T03	000	0	1000	0.2990	0.2769	0.4240	BULT03000000000	0.00	Very Low	1	9.30	Very Low	1	83.70	Very High	9	4.39	Moderate
BUL	T03	000	1000	2070	0.2990	0.2769	0.4240	BULT03000001000	0.00	Very Low	1	9.30	Very Low	1	83.70	Very High	9	4.39	Moderate
BUL	T03	000	2070	2900	0.2990	0.2769	0.4240	BULT03000002070	0.00	Very Low	1	9.30	Very Low	1	83.70	Very High	9	4.39	Moderate
BUL	T03	000	2900	4170	0.2990	0.2769	0.4240	BULT03000002900	0.00	Very Low	1	7.00	Very Low	1	83.70	Very High	9	4.39	Moderate
BUL	T03	000	4170	5100	0.2990	0.2769	0.4240	BULT03000004170	0.91	Low	3	7.00	Very Low	1	83.70	Very High	9	4.99	Moderate
BUL	T03	000	5100	6290	0.2990	0.2769	0.4240	BULT03000005100	0.91	Low	3	7.00	Very Low	1	83.70	Very High	9	4.99	Moderate
BUL	T03	000	6290	8350	0.2990	0.2769	0.4240	BULT03000006290	0.00	Very Low	1	7.00	Very Low	1	83.70	Very High	9	4.39	Moderate
BUL	T03	000	8350	10070	0.2990	0.2769	0.4240	BULT03000008350	0.00	Very Low	1	7.00	Very Low	1	83.70	Very High	9	4.39	Moderate
BUL	T03	000	10070	11660	0.2990	0.2769	0.4240	BULT03000010070	0.00	Very Low	1	7.00	Very Low	1	83.70	Very High	9	4.39	Moderate
BUL	T04	000	0	100	0.3243	0.2921	0.3836	BULT04000000000	1.30	Low	3	25.30	Moderate	5	90.40	Very High	9	5.89	Moderate
BUL	T04	000	100	2010	0.3243	0.2921	0.3836	BULT04000000100	1.30	Low	3	25.30	Moderate	5	90.40	Very High	9	5.89	Moderate
BUL	T04	000	2010	3960	0.3243	0.2921	0.3836	BULT04000002010	0.00	Very Low	1	25.30	Moderate	5	90.40	Very High	9	5.24	Moderate
BUL	T04	000	3960	4040	0.3243	0.2921	0.3836	BULT04000003960	0.00	Very Low	1	10.40	Low	3	90.40	Very High	9	4.65	Moderate
BUL	T04	000	4040	5930	0.3243	0.2921	0.3836	BULT04000004040	0.00	Very Low	1	10.40	Low	3	90.40	Very High	9	4.65	Moderate
BUL	T04	000	5930	6530	0.3243	0.2921	0.3836	BULT04000005930	0.00	Very Low	1	10.40	Low	3	90.40	Very High	9	4.65	Moderate
BUL	T04	000	6530	7380	0.3243	0.2921	0.3836	BULT04000006530	0.00	Very Low	1	10.40	Low	3	90.40	Very High	9	4.65	Moderate
BUL	T05	000	0	100	0.3243	0.2921	0.3836	BULT05000000000	0.00	Very Low	1	4.10	Very Low	1	90.40	Very High	9	4.07	Moderate
BUL	T05	000	100	2130	0.3243	0.2921	0.3836	BULT05000000100	0.00	Very Low	1	4.10	Very Low	1	90.40	Very High	9	4.07	Moderate
BUL	T05	000	2130	3440	0.3243	0.2921	0.3836	BULT05000002130	0.00	Very Low	1	4.10	Very Low	1	90.40	Very High	9	4.07	Moderate
BUL	T05	000	3440	4430	0.3243	0.2921	0.3836	BULT05000003440	0.00	Very Low	1	4.10	Very Low	1	90.40	Very High	9	4.07	Moderate
BUL	T05	000	4430	6490	0.3243	0.2921	0.3836	BULT05000004430	0.00	Very Low	1	4.10	Very Low	1	90.40	Very High	9	4.07	Moderate
BUL	T05	000	6490	8310	0.3243	0.2921	0.3836	BULT05000006490	0.00	Very Low	1	4.10	Very Low	1	90.40	Very High	9	4.07	Moderate
BUL	T05	000	8310	9940	0.3243	0.2921	0.3836	BULT05000008310	0.00	Very Low	1	4.10	Very Low	1	90.40	Very High	9	4.07	Moderate
BUL	T05	T06	0	450	0.3243	0.2921	0.3836	BULT05T06000000	0.00	Very Low	1	5.20	Very Low	1	49.50	Moderate	5	2.53	Low
BUL	T05	T06	450	1000	0.3243	0.2921	0.3836	BULT05T06000450	0.00	Very Low	1	5.20	Very Low	1	49.50	Moderate	5	2.53	Low
BUL	T05	T06	1000	2060	0.3243	0.2921	0.3836	BULT05T06001000	0.00	Very Low	1	5.20	Very Low	1	49.50	Moderate	5	2.53	Low
BUL	T05	T06	2060	4140	0.3243	0.2921	0.3836	BULT05T06002060	0.00	Very Low	1	5.20	Very Low	1	49.50	Moderate	5	2.53	Low
BUL	T05	T06	4140	5750	0.3243	0.2921	0.3836	BULT05T06004140	0.00	Very Low	1	5.20	Very Low	1	49.50	Moderate	5	2.53	Low

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	FC Final Wt	EC Final Wt	WQ Final Wt	IS Reach ID	Final FC Problem Score	FC Narrative Rating	FC Rank Score	Final EC Problem Score	EC Narrative Rating	EC Rank Score	Final WQ Problem Score	WQ Narrative Rating	WQ Rank Score	Integrated Score	IS Narrative Rating
BUL	T05	T06	5750	7350	0.3243	0.2921	0.3836	BULT05T06005750	0.00	Very Low	1	5.20	Very Low	1	49.50	Moderate	5	2.53	Low
BUL	T07	000	0	1845	0.3243	0.2921	0.3836	BULT07000000000	0.00	Very Low	1	7.80	Very Low	1	90.40	Very High	9	4.07	Moderate
BUL	T07	000	1845	4015	0.3243	0.2921	0.3836	BULT07000001845	0.00	Very Low	1	7.80	Very Low	1	90.40	Very High	9	4.07	Moderate
BUL	T07	000	4015	5590	0.3243	0.2921	0.3836	BULT07000004015	0.00	Very Low	1	7.80	Very Low	1	90.40	Very High	9	4.07	Moderate
BUL	T07	000	5590	7610	0.3243	0.2921	0.3836	BULT07000005590	0.00	Very Low	1	7.80	Very Low	1	90.40	Very High	9	4.07	Moderate
BUL	T08	000	0	3600	0.3243	0.2921	0.3836	BULT08000000000	0.00	Very Low	1	12.20	Low	3	90.40	Very High	9	4.65	Moderate
CNT	000	000	0	850	0.3115	0.2893	0.3992	CNT000000000000	0.00	Very Low	1	24.60	Moderate	5	18.80	Very Low	1	2.16	Low
CNT	000	000	850	2150	0.3115	0.2893	0.3992	CNT000000000850	0.00	Very Low	1	18.90	Low	3	18.80	Very Low	1	1.58	Very Low
CNT	000	000	2150	4100	0.3115	0.2893	0.3992	CNT000000002150	0.00	Very Low	1	18.90	Low	3	18.80	Very Low	1	1.58	Very Low
CNT	000	000	4100	6200	0.3115	0.2893	0.3992	CNT000000004100	0.00	Very Low	1	18.90	Low	3	18.80	Very Low	1	1.58	Very Low
CNT	000	000	6200	7090	0.3115	0.2893	0.3992	CNT000000006200	0.00	Very Low	1	18.90	Low	3	18.80	Very Low	1	1.58	Very Low
CNT	000	000	7090	8075	0.3115	0.2893	0.3992	CNT000000007090	0.00	Very Low	1	51.40	Very High	9	18.80	Very Low	1	3.31	Low
CNT	000	000	8075	9700	0.3115	0.2893	0.3992	CNT000000008075	0.00	Very Low	1	51.40	Very High	9	18.80	Very Low	1	3.31	Low
CNT	000	000	9700	10073	0.2956	0.2782	0.4262	CNT000000009700	0.00	Very Low	1	51.40	Very High	9	18.80	Very Low	1	3.23	Low
CNT	000	000	10073	11975	0.2956	0.2782	0.4262	CNT000000010073	0.03	Low	3	51.40	Very High	9	18.80	Very Low	1	3.82	Low
CNT	000	000	11975	12650	0.2956	0.2782	0.4262	CNT000000011975	0.15	Low	3	51.40	Very High	9	18.80	Very Low	1	3.82	Low
CNT	000	000	12650	12680	0.2956	0.2782	0.4262	CNT000000012650	0.15	Low	3	51.40	Very High	9	18.80	Very Low	1	3.82	Low
CNT	000	000	12680	14010	0.2956	0.2782	0.4262	CNT000000012680	0.15	Low	3	43.10	Very High	9	18.80	Very Low	1	3.82	Low
CNT	000	000	14010	15165	0.2956	0.2782	0.4262	CNT000000014010	0.00	Very Low	1	43.10	Very High	9	18.80	Very Low	1	3.23	Low
CNT	000	000	15165	16050	0.2956	0.2782	0.4262	CNT000000015165	0.00	Very Low	1	17.20	Low	3	18.80	Very Low	1	1.56	Very Low
CNT	000	000	16050	16710	0.2956	0.2782	0.4262	CNT000000016050	0.05	Low	3	17.20	Low	3	18.80	Very Low	1	2.15	Low
CNT	000	000	16710	18860	0.2956	0.2782	0.4262	CNT000000016710	0.05	Low	3	17.20	Low	3	18.80	Very Low	1	2.15	Low
CNT	OLD	000	0	450	0.3115	0.2893	0.3992	CNTOLD000000000	0.00	Very Low	1	23.30	Moderate	5	90.50	Very High	9	5.35	Moderate
CNT	OLD	000	450	2000	0.3115	0.2893	0.3992	CNTOLD000000450	0.00	Very Low	1	23.30	Moderate	5	90.50	Very High	9	5.35	Moderate
CNT	OLD	000	2000	2850	0.3115	0.2893	0.3992	CNTOLD000002000	0.00	Very Low	1	23.30	Moderate	5	90.50	Very High	9	5.35	Moderate
CNT	OLD	000	2850	4100	0.3115	0.2893	0.3992	CNTOLD000002850	0.00	Very Low	1	16.40	Low	3	90.50	Very High	9	4.77	Moderate
CNT	OLD	000	4100	4700	0.3115	0.2893	0.3992	CNTOLD000004100	0.00	Very Low	1	16.40	Low	3	90.50	Very High	9	4.77	Moderate
CNT	OLD	000	4700	6290	0.3115	0.2893	0.3992	CNTOLD000004700	0.00	Very Low	1	21.50	Moderate	5	90.50	Very High	9	5.35	Moderate
CNT	OLD	000	6290	7850	0.3115	0.2893	0.3992	CNTOLD000006290	0.33	Low	3	21.50	Moderate	5	90.50	Very High	9	5.97	Moderate
CNT	OLD	000	7650	8075	0.3115	0.2893	0.3992	CNTOLD000007650	0.33	Low	3	21.50	Moderate	5	90.50	Very High	9	5.97	Moderate
CNT	OLD	000	8075	9220	0.3115	0.2893	0.3992	CNTOLD000008075	0.33	Low	3	21.50	Moderate	5	66.90	High	7	5.18	Moderate
CNT	OLD	T01	0	2090	0.3115	0.2893	0.3992	CNTOLDT01000000	0.00	Very Low	1	21.80	Moderate	5	90.50	Very High	9	5.35	Moderate
CNT	OLD	T01	2090	3100	0.3115	0.2893	0.3992	CNTOLDT01002090	1.22	Low	3	21.80	Moderate	5	90.50	Very High	9	5.97	Moderate
CNT	OLD	T01	3100	4187	0.2956	0.2782	0.4262	CNTOLDT01003100	1.22	Low	3	21.80	Moderate	5	90.50	Very High	9	6.11	High
CNT	OLD	T01	4187	6144	0.2956	0.2782	0.4262	CNTOLDT01004187	0.00	Very Low	1	21.80	Moderate	5	90.50	Very High	9	5.52	Moderate
CNT	T02	000	0	1280	0.3115	0.2893	0.3992	CNTT02000000000	1.53	Low	3	51.40	Very High	9	18.80	Very Low	1	3.94	Low
CNT	T02	000	1280	2000	0.2956	0.2782	0.4262	CNTT02000001280	1.54	Low	3	51.40	Very High	9	18.80	Very Low	1	3.82	Low
CNT	T02	000	2000	4200	0.2956	0.2782	0.4262	CNTT02000002000	7.47	Moderate	5	51.40	Very High	9	18.80	Very Low	1	4.41	Moderate
CNT	T03	000	0	2725	0.2956	0.2782	0.4262	CNTT03000000000	8.98	Moderate	5	51.40	Very High	9	18.80	Very Low	1	4.41	Moderate
CNT	T04	000	0	2275	0.2956	0.2782	0.4262	CNTT04000000000	0.00	Very Low	1	43.60	Very High	9	18.80	Very Low	1	3.23	Low
CNT	T04	000	2275	4500	0.2956	0.2782	0.4262	CNTT04000002275	0.00	Very Low	1	43.60	Very High	9	18.80	Very Low	1	3.23	Low
CNT	T05	000	0	2421	0.2956	0.2782	0.4262	CNTT05000000000	0.03	Low	3	43.60	Very High	9	18.80	Very Low	1	3.82	Low
EBO	000	000	0	200	0.2599	0.3079	0.4322	EBO000000000000	0.03	Low	3	32.20	High	7	39.90	Low	3	4.23	Moderate
EBO	000	000	200	2015	0.2599	0.3079	0.4322	EBO000000000200	0.03	Low	3	32.20	High	7	39.90	Low	3	4.23	Moderate
EBO	000	000	2015	3907	0.2599	0.3079	0.4322	EBO000000002015	0.88	Low	3	32.20	High	7	39.90	Low	3	4.23	Moderate
EBO	000	000	3907	5822	0.2599	0.3079	0.4322	EBO000000003907	3.69	Low	3	32.20	High	7	39.90	Low	3	4.23	Moderate
EBO	000	000	5822	6040	0.2599	0.3079	0.4322	EBO000000005822	0.10	Low	3	32.20	High	7	39.90	Low	3	4.23	Moderate
EBO	000	000	6040	7260	0.2599	0.3079	0.4322	EBO000000006040	0.10	Low	3	3.20	Very Low	1	39.90	Low	3	2.38	Low
EBO	000	000	7260	7609	0.2599	0.3079	0.4322	EBO000000007260	0.10	Low	3	9.70	Very Low	1	39.90	Low	3	2.38	Low
EBO	000	000	7609	7750	0.2599	0.3079	0.4322	EBO000000007609	3.81	Low	3	9.70	Very Low	1	39.90	Low	3	2.38	Low
EBO	000	000	7750	9400	0.2599	0.3079	0.4322	EBO000000007750	3.81	Low	3	9.70	Very Low	1	27.90	Low	3	2.38	Low
EBO	000	000	9400	9943	0.2599	0.3079	0.4322	EBO000000009400	3.81	Low	3	39.40	High	7	27.90	Low	3	4.23	Moderate
EBO	000	000	9943	10131	0.2599	0.3079	0.4322	EBO000000009943	1.65	Low	3	39.40	High	7	27.90	Low	3	4.23	Moderate
EBO	000	000	10131	11350	0.2599	0.3079	0.4322	EBO000000010131	1.65	Low	3	39.40	High	7	27.90	Low	3	4.23	Moderate

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Master Plan Problem Area Assessment Integrated Scores (98 Methodology)

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	FC Final Wt	EC Final Wt	WQ Final Wt	IS Reach ID	Final FC Problem Score	FC Narrative Rating	FC Rank Score	Final EC Problem Score	EC Narrative Rating	EC Rank Score	Final WQ Problem Score	WQ Narrative Rating	WQ Rank Score	Integrated Score	IS Narrative Rating
EBO	000	000	11350	12059	0.3115	0.3283	0.3602	EBO000000011350	1.62	Low	3	39.40	High	7	27.90	Low	3	4.31	Moderate
EBO	000	000	12059	12600	0.3115	0.3283	0.3602	EBO000000012059	2.09	Low	3	39.40	High	7	27.90	Low	3	4.31	Moderate
EBO	000	000	12600	13931	0.3115	0.3283	0.3602	EBO000000012600	2.09	Low	3	39.40	High	7	83.20	Very High	9	6.47	High
EBO	000	000	13931	15965	0.3115	0.3283	0.3602	EBO000000013931	3.63	Low	3	39.40	High	7	83.20	Very High	9	6.47	High
EBO	000	000	15965	16600	0.3115	0.3283	0.3602	EBO000000015965	0.00	Very Low	1	39.40	High	7	83.20	Very High	9	5.85	Moderate
EBO	000	000	16600	16692	0.3115	0.3283	0.3602	EBO000000016600	0.00	Very Low	1	39.40	High	7	45.40	Moderate	5	4.41	Moderate
EBO	000	000	16692	17957	0.3115	0.3283	0.3602	EBO000000016692	0.00	Very Low	1	39.40	High	7	45.40	Moderate	5	4.41	Moderate
FOR	000	000	0	250	0.3179	0.3299	0.3522	FOR000000000000	0.00	Very Low	1	17.10	Low	3	35.00	Low	3	2.36	Low
FOR	000	000	250	1100	0.3179	0.3299	0.3522	FOR000000000250	0.00	Very Low	1	17.10	Low	3	35.00	Low	3	2.36	Low
FOR	000	000	1100	4713	0.3179	0.3299	0.3522	FOR000000001100	0.00	Very Low	1	54.20	Very High	9	35.00	Low	3	4.34	Moderate
FOR	000	000	4713	6946	0.3179	0.3299	0.3522	FOR000000004713	36.17	Very High	9	54.20	Very High	9	35.00	Low	3	6.89	High
FOR	000	000	6946	7878	0.3179	0.3299	0.3522	FOR000000006946	8.23	Moderate	5	54.20	Very High	9	35.00	Low	3	5.62	Moderate
FOR	000	000	7878	9820	0.3179	0.3299	0.3522	FOR000000007878	3.53	Low	3	54.20	Very High	9	35.00	Low	3	4.98	Moderate
FOR	000	000	9820	10040	0.3179	0.3299	0.3522	FOR000000009820	3.53	Low	3	25.40	Moderate	5	35.00	Low	3	3.66	Low
FOR	000	000	10040	12241	0.3179	0.3299	0.3522	FOR000000010040	1.93	Low	3	25.40	Moderate	5	35.00	Low	3	3.66	Low
FOR	000	000	12241	13800	0.3179	0.3299	0.3522	FOR000000012241	0.05	Low	3	25.40	Moderate	5	35.00	Low	3	3.66	Low
FOR	000	000	13800	14800	0.3179	0.3299	0.3522	FOR000000013800	0.05	Low	3	25.40	Moderate	5	20.70	Low	3	3.66	Low
FOR	000	000	14800	14826	0.3179	0.3299	0.3522	FOR000000014800	0.05	Low	3	6.70	Very Low	1	20.70	Low	3	2.34	Low
FOR	000	000	14826	17345	0.3179	0.3299	0.3522	FOR000000014826	0.24	Low	3	6.70	Very Low	1	20.70	Low	3	2.34	Low
FOR	000	000	17345	19750	0.3179	0.3299	0.3522	FOR000000017345	8.29	Moderate	5	6.70	Very Low	1	20.70	Low	3	2.98	Low
FOR	000	000	19750	20951	0.3179	0.3299	0.3522	FOR000000019750	8.29	Moderate	5	45.20	Very High	9	20.70	Low	3	5.62	Moderate
FOR	000	000	20951	20975	0.3179	0.3299	0.3522	FOR000000020951	8.29	Moderate	5	45.20	Very High	9	20.70	Low	3	5.62	Moderate
FOR	000	000	20975	22250	0.3179	0.3299	0.3522	FOR000000020975	8.29	Moderate	5	45.20	Very High	9	29.00	Low	3	5.62	Moderate
FOR	000	000	22250	24210	0.3179	0.3299	0.3522	FOR000000022250	8.29	Moderate	5	1.70	Very Low	1	29.00	Low	3	2.98	Low
FOR	000	000	24210	25760	0.3179	0.3299	0.3522	FOR000000024210	8.29	Moderate	5	4.10	Very Low	1	29.00	Low	3	2.98	Low
FOR	000	000	25760	27960	0.3179	0.3299	0.3522	FOR000000025760	0.02	Low	3	2.40	Very Low	1	29.00	Low	3	2.34	Low
FOR	000	000	27960	28635	0.3179	0.3299	0.3522	FOR000000027960	0.02	Low	3	3.70	Very Low	1	29.00	Low	3	2.34	Low
FOR	000	000	28635	29310	0.3179	0.3299	0.3522	FOR000000028635	0.02	Low	3	3.70	Very Low	1	50.00	Moderate	5	3.04	Low
FOR	T01	000	0	3850	0.3179	0.3299	0.3522	FORT01000000000	0.02	Low	3	12.00	Low	3	29.00	Low	3	3.00	Low
HRP	000	000	0	300	0.2869	0.3218	0.3913	HRP000000000000	0.02	Low	3	0.00	Very Low	1	34.50	Low	3	2.36	Low
HRP	000	000	300	1100	0.2869	0.3218	0.3913	HRP000000000300	0.02	Low	3	0.00	Very Low	1	34.50	Low	3	2.36	Low
HRP	000	000	1100	1850	0.2869	0.3218	0.3913	HRP000000001100	0.02	Low	3	9.50	Very Low	1	34.50	Low	3	2.36	Low
HRP	000	000	1850	2450	0.2869	0.3218	0.3913	HRP000000001850	0.02	Low	3	0.10	Very Low	1	34.50	Low	3	2.36	Low
HRP	000	000	2450	3200	0.2869	0.3218	0.3913	HRP000000002450	0.02	Low	3	1.70	Very Low	1	34.50	Low	3	2.36	Low
HRP	000	000	3200	3330	0.2869	0.3218	0.3913	HRP000000003200	0.02	Low	3	1.70	Very Low	1	50.90	Moderate	5	3.14	Low
HRP	000	000	3330	3800	0.2869	0.3218	0.3913	HRP000000003330	0.02	Low	3	0.00	Very Low	1	50.90	Moderate	5	3.14	Low
HRP	000	000	3800	4100	0.2869	0.3218	0.3913	HRP000000003800	0.02	Low	3	7.80	Very Low	1	50.90	Moderate	5	3.14	Low
HRP	000	000	4100	4700	0.2869	0.3218	0.3913	HRP000000004100	0.02	Low	3	7.80	Very Low	1	50.90	Moderate	5	3.14	Low
HRP	000	000	4700	5700	0.2869	0.3218	0.3913	HRP000000004700	0.02	Low	3	7.80	Very Low	1	6.10	Very Low	1	1.57	Very Low
HRP	T01	000	0	450	0.2869	0.3218	0.3913	HRPT01000000000	0.02	Low	3	7.80	Very Low	1	50.90	Moderate	5	3.14	Low
JOH	000	000	0	350	0.3025	0.3043	0.3932	JOH000000000000	0.13	Low	3	19.40	Low	3	78.50	High	7	4.57	Moderate
JOH	000	000	350	1900	0.3025	0.3043	0.3932	JOH000000000350	0.13	Low	3	19.40	Low	3	78.50	High	7	4.57	Moderate
JOH	000	000	1900	3975	0.3025	0.3043	0.3932	JOH000000001900	0.00	Very Low	1	19.40	Low	3	78.50	High	7	3.97	Low
JOH	000	000	3975	4120	0.3025	0.3043	0.3932	JOH000000003975	0.00	Low	3	19.40	Low	3	78.50	High	7	4.57	Moderate
JOH	000	000	4120	5600	0.3025	0.3043	0.3932	JOH000000004120	0.00	Low	3	0.00	Very Low	1	78.50	High	7	3.96	Low
JOH	000	000	5600	5900	0.3025	0.3043	0.3932	JOH000000005600	0.00	Low	3	0.00	Very Low	1	62.10	High	7	3.96	Low
JOH	000	000	5900	5950	0.3025	0.3043	0.3932	JOH000000005900	0.00	Low	3	3.80	Very Low	1	62.10	High	7	3.96	Low
JOH	000	000	5950	6800	0.3025	0.3043	0.3932	JOH000000005950	0.18	Low	3	3.80	Very Low	1	62.10	High	7	3.96	Low
JOH	000	000	6800	7800	0.3025	0.3043	0.3932	JOH000000006800	0.18	Low	3	0.00	Very Low	1	62.10	High	7	3.96	Low
JOH	000	000	7800	8000	0.3025	0.3043	0.3932	JOH000000007800	0.18	Low	3	5.50	Very Low	1	62.10	High	7	3.96	Low
JOH	000	000	8000	8050	0.3025	0.3043	0.3932	JOH000000008000	0.06	Low	3	5.50	Very Low	1	62.10	High	7	3.96	Low
JOH	000	000	8050	9660	0.3025	0.3043	0.3932	JOH000000008050	0.06	Low	3	5.50	Very Low	1	61.00	High	7	3.96	Low
JOH	000	000	9660	10200	0.3025	0.3043	0.3932	JOH000000009660	0.06	Low	3	2.90	Very Low	1	61.00	High	7	3.96	Low
JOH	000	000	10200	11040	0.3025	0.3043	0.3932	JOH000000010200	0.11	Low	3	2.90	Very Low	1	61.00	High	7	3.96	Low

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	FC Final Wt	EC Final Wt	WQ Final Wt	IS Reach ID	Final FC Problem Score	FC Narrative Rating	FC Rank Score	Final EC Problem Score	EC Narrative Rating	EC Rank Score	Final WQ Problem Score	WQ Narrative Rating	WQ Rank Score	Integrated Score	IS Narrative Rating
JOH	000	000	11040	11045	0.3025	0.3043	0.3932	JOH000000011040	0.11	Low	3	2.90	Very Low	1	26.80	Low	3	2.39	Low
JOH	000	000	11045	12650	0.3025	0.3043	0.3932	JOH000000011045	0.11	Low	3	2.30	Very Low	1	26.80	Low	3	2.39	Low
JOH	POS	000	0	680	0.3025	0.3043	0.3932	JOHPOS000000000	0.46	Low	3	0.40	Very Low	1	78.50	High	7	3.96	Low
JOH	POS	000	680	2105	0.3025	0.3043	0.3932	JOHPOS000000680	0.46	Low	3	2.80	Very Low	1	78.50	High	7	3.96	Low
JOH	POS	000	2105	2795	0.3025	0.3043	0.3932	JOHPOS000002105	0.17	Low	3	2.80	Very Low	1	78.50	High	7	3.96	Low
JOH	POS	000	2795	3790	0.3025	0.3043	0.3932	JOHPOS000002795	0.17	Low	3	0.30	Very Low	1	78.50	High	7	3.96	Low
JOH	POS	000	3790	4245	0.3025	0.3043	0.3932	JOHPOS000003790	0.17	Low	3	0.30	Very Low	1	78.50	High	7	3.96	Low
LWA	000	000	0	1400	0.2990	0.3154	0.3856	LWA000000000000	0.84	Low	3	19.70	Low	3	34.40	Low	3	3.00	Low
LWA	000	000	1400	2040	0.2990	0.3154	0.3856	LWA000000001400	0.84	Low	3	19.70	Low	3	34.40	Low	3	3.00	Low
LWA	000	000	2040	3260	0.2990	0.3154	0.3856	LWA000000002040	1.93	Low	3	19.70	Low	3	34.40	Low	3	3.00	Low
LWA	000	000	3260	4280	0.2990	0.3154	0.3856	LWA000000003260	1.93	Low	3	15.30	Low	3	34.40	Low	3	3.00	Low
LWA	000	000	4280	6200	0.2990	0.3154	0.3856	LWA000000004280	8.77	Moderate	5	15.30	Low	3	34.40	Low	3	3.60	Low
LWA	000	000	6200	6950	0.2990	0.3154	0.3856	LWA000000006200	0.82	Low	3	15.30	Low	3	34.40	Low	3	3.00	Low
LWA	000	000	6950	8300	0.2990	0.3154	0.3856	LWA000000006950	0.82	Low	3	7.60	Very Low	1	34.40	Low	3	2.37	Low
LWA	000	000	8300	10140	0.2990	0.3154	0.3856	LWA000000008300	0.10	Low	3	7.60	Very Low	1	34.40	Low	3	2.37	Low
LWA	000	000	10140	10440	0.2990	0.3154	0.3856	LWA000000010140	1.83	Low	3	7.60	Very Low	1	34.40	Low	3	2.37	Low
LWA	000	000	10440	12100	0.2990	0.3154	0.3856	LWA000000010440	1.83	Low	3	5.80	Very Low	1	34.40	Low	3	2.37	Low
LWA	000	000	12100	13530	0.2990	0.3154	0.3856	LWA000000012100	1.90	Low	3	5.80	Very Low	1	34.40	Low	3	2.37	Low
LWA	000	000	13530	14000	0.2990	0.3154	0.3856	LWA000000013530	1.90	Low	3	4.70	Very Low	1	34.40	Low	3	2.37	Low
LWA	000	000	14000	14700	0.2990	0.3154	0.3856	LWA000000014000	0.00	Very Low	1	4.70	Very Low	1	34.40	Low	3	1.77	Very Low
LWA	000	000	14700	15130	0.2809	0.3014	0.4177	LWA000000014700	0.00	Very Low	1	4.70	Very Low	1	34.40	Low	3	1.84	Very Low
LWA	000	000	15130	15850	0.2809	0.3014	0.4177	LWA000000015130	0.00	Very Low	1	4.70	Very Low	1	9.40	Very Low	1	1.00	Very Low
LWA	000	000	15850	15985	0.2809	0.3014	0.4177	LWA000000015850	0.00	Very Low	1	4.70	Very Low	1	9.40	Very Low	1	1.00	Very Low
LWA	000	000	15985	18000	0.2809	0.3014	0.4177	LWA000000015985	0.00	Very Low	1	7.20	Very Low	1	9.40	Very Low	1	1.00	Very Low
LWA	000	000	18000	20060	0.2809	0.3014	0.4177	LWA000000018000	0.00	Very Low	1	7.20	Very Low	1	9.40	Very Low	1	1.00	Very Low
LWA	000	000	20060	21580	0.2809	0.3014	0.4177	LWA000000020060	0.16	Low	3	7.20	Very Low	1	9.40	Very Low	1	1.56	Very Low
LWA	000	000	21580	21950	0.2809	0.3014	0.4177	LWA000000021580	0.16	Low	3	10.30	Low	3	9.40	Very Low	1	2.16	Low
LWA	000	000	21950	23920	0.2809	0.3014	0.4177	LWA000000021950	8.46	Moderate	5	10.30	Low	3	9.40	Very Low	1	2.73	Low
LWA	000	000	23920	25680	0.2809	0.3014	0.4177	LWA000000023920	0.00	Very Low	1	10.30	Low	3	9.40	Very Low	1	1.60	Very Low
LWA	000	000	25680	25860	0.2809	0.3014	0.4177	LWA000000025680	0.00	Very Low	1	10.30	Low	3	27.60	Low	3	2.44	Low
LWA	000	000	25860	28000	0.2809	0.3014	0.4177	LWA000000025860	2.75	Low	3	10.30	Low	3	27.60	Low	3	3.00	Low
LWA	000	000	28000	30155	0.2809	0.3014	0.4177	LWA000000028000	3.90	Low	3	10.30	Low	3	27.60	Low	3	3.00	Low
LWA	000	000	30155	32020	0.2809	0.3014	0.4177	LWA000000030155	2.24	Low	3	10.30	Low	3	27.60	Low	3	3.00	Low
LWA	000	000	32020	32600	0.2809	0.3014	0.4177	LWA000000032020	2.08	Low	3	10.30	Low	3	27.60	Low	3	3.00	Low
LWA	000	000	32600	32680	0.3115	0.2990	0.3895	LWA000000032600	2.23	Low	3	10.30	Low	3	27.60	Low	3	3.00	Low
LWA	000	000	32680	32880	0.3115	0.2990	0.3895	LWA000000032680	2.23	Low	3	10.30	Low	3	27.60	Low	3	3.00	Low
LWA	000	000	32880	34075	0.3115	0.2990	0.3895	LWA000000032880	2.23	Low	3	3.50	Very Low	1	27.60	Low	3	2.40	Low
LWA	000	000	34075	36000	0.3115	0.2990	0.3895	LWA000000034075	0.27	Low	3	3.50	Very Low	1	27.60	Low	3	2.40	Low
LWA	000	000	36000	36040	0.3115	0.2990	0.3895	LWA000000036000	0.27	Low	3	42.10	Very High	9	27.60	Low	3	4.79	Moderate
LWA	000	000	36040	38040	0.3115	0.2990	0.3895	LWA000000036040	0.64	Low	3	42.10	Very High	9	27.60	Low	3	4.79	Moderate
LWA	000	000	38040	40020	0.3115	0.2990	0.3895	LWA000000038040	27.63	Very High	9	42.10	Very High	9	27.60	Low	3	6.66	High
LWA	000	000	40020	41760	0.3115	0.2990	0.3895	LWA000000040020	28.04	Very High	9	42.10	Very High	9	27.60	Low	3	6.66	High
LWA	000	000	41760	42050	0.3115	0.2990	0.3895	LWA000000041760	28.04	Very High	9	2.70	Very Low	1	27.60	Low	3	4.27	Moderate
LWA	000	000	42050	43570	0.3115	0.2990	0.3895	LWA000000042050	6.84	Moderate	5	2.70	Very Low	1	27.60	Low	3	3.03	Low
LWA	000	000	43570	44070	0.3115	0.2990	0.3895	LWA000000043570	6.84	Moderate	5	2.70	Very Low	1	25.40	Low	3	3.03	Low
LWA	000	000	44070	44835	0.3115	0.2990	0.3895	LWA000000044070	0.47	Low	3	2.70	Very Low	1	25.40	Low	3	2.40	Low
LWA	000	000	44835	47210	0.3115	0.2990	0.3895	LWA000000044835	0.47	Low	3	2.70	Very Low	1	25.40	Low	3	2.40	Low
LWA	QCB	000	0	945	0.3115	0.2990	0.3895	LWAQCB000000000	4.72	Low	3	4.00	Very Low	1	27.60	Low	3	2.40	Low
LWA	QCB	000	945	2040	0.3115	0.2990	0.3895	LWAQCB000000945	4.72	Low	3	6.80	Very Low	1	27.60	Low	3	2.40	Low
LWA	QCB	000	2040	2260	0.3115	0.2990	0.3895	LWAQCB000002040	5.20	Moderate	5	6.80	Very Low	1	27.60	Low	3	3.03	Low
LWA	QCB	000	2260	4175	0.3115	0.2990	0.3895	LWAQCB000002260	5.20	Moderate	5	4.10	Very Low	1	27.60	Low	3	3.03	Low
LWA	QCB	000	4175	4215	0.3115	0.2990	0.3895	LWAQCB000004175	0.21	Low	3	4.10	Very Low	1	27.60	Low	3	2.40	Low
LWA	QCB	000	4215	6840	0.3115	0.2990	0.3895	LWAQCB000004215	0.21	Low	3	5.20	Very Low	1	27.60	Low	3	2.40	Low
LWA	QCB	000	6840	7070	0.3115	0.2990	0.3895	LWAQCB000006840	0.21	Low	3	5.20	Very Low	1	27.60	Low	3	2.40	Low

Table B - 4
Master Plan Problem Area Assessment Integrated Scores (98 Methodology)

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	FC Final Wt	EC Final Wt	WQ Final Wt	IS Reach ID	Final FC Problem Score	FC Narrative Rating	FC Rank Score	Final EC Problem Score	EC Narrative Rating	EC Rank Score	Final WQ Problem Score	WQ Narrative Rating	WQ Rank Score	Integrated Score	IS Narrative Rating
LWA	T02	000	0	1550	0.2809	0.3014	0.4177	LWAT02T01000000	2.98	Low	3	2.20	Very Low	1	9.40	Very Low	1	1.56	Very Low
LWA	T02	000	1550	2600	0.2809	0.3014	0.4177	LWAT02T01001550	0.00	Very Low	1	2.20	Very Low	1	9.40	Very Low	1	1.00	Very Low
LWA	T02	T01	0	1650	0.2809	0.3014	0.4177	LWAT02000000000	8.38	Moderate	5	4.40	Very Low	1	9.40	Very Low	1	2.12	Low
LWA	T02	T01	1650	2030	0.2809	0.3014	0.4177	LWAT02000001650	8.38	Moderate	5	4.60	Very Low	1	9.40	Very Low	1	2.12	Low
LWA	T02	T01	2030	4060	0.2809	0.3014	0.4177	LWAT02000002030	0.00	Very Low	1	4.60	Very Low	1	9.40	Very Low	1	1.00	Very Low
LWA	T02	T01	4060	4100	0.2809	0.3014	0.4177	LWAT02000004060	3.17	Low	3	4.60	Very Low	1	9.40	Very Low	1	1.56	Very Low
LWA	T02	T01	4100	6060	0.2809	0.3014	0.4177	LWAT02000004100	3.17	Low	3	2.20	Very Low	1	9.40	Very Low	1	1.56	Very Low
LWA	T02	T01	6060	6130	0.2809	0.3014	0.4177	LWAT02000006060	2.52	Low	3	2.20	Very Low	1	9.40	Very Low	1	1.56	Very Low
LWA	T02	T01	6130	8110	0.2809	0.3014	0.4177	LWAT02000006130	2.52	Low	3	2.20	Very Low	1	9.40	Very Low	1	1.56	Very Low
LWA	T02	T01	8110	10030	0.2809	0.3014	0.4177	LWAT02000008110	1.23	Low	3	2.20	Very Low	1	9.40	Very Low	1	1.56	Very Low
LWA	T02	T01	10030	11700	0.2809	0.3014	0.4177	LWAT02000010030	0.04	Low	3	2.20	Very Low	1	9.40	Very Low	1	1.56	Very Low
LWA	T02	T04	0	1790	0.2809	0.3014	0.4177	LWAT04000000000	0.01	Low	3	4.40	Very Low	1	9.40	Very Low	1	1.56	Very Low
LWA	T02	T04	1790	3240	0.2809	0.3014	0.4177	LWAT04000001790	0.00	Very Low	1	4.40	Very Low	1	9.40	Very Low	1	1.00	Very Low
LWA	T02	T05	0	2095	0.2809	0.3014	0.4177	LWAT05000000000	0.00	Very Low	1	4.40	Very Low	1	9.40	Very Low	1	1.00	Very Low
LWA	T02	T05	2095	4820	0.2809	0.3014	0.4177	LWAT05000002095	0.07	Low	3	4.40	Very Low	1	9.40	Very Low	1	1.56	Very Low
LWA	T06	000	0	2050	0.3115	0.2990	0.3895	LWAT06000000000	0.58	Low	3	3.50	Very Low	1	27.60	Low	3	2.40	Low
LWA	T06	000	2050	4180	0.3115	0.2990	0.3895	LWAT06000002050	0.22	Low	3	3.50	Very Low	1	27.60	Low	3	2.40	Low
LWA	T07	000	0	1875	0.3115	0.2990	0.3895	LWAT07000000000	0.64	Low	3	42.10	Very High	9	27.60	Low	3	4.79	Moderate
LWA	T07	000	1875	3485	0.3115	0.2990	0.3895	LWAT07000001875	0.02	Low	3	42.10	Very High	9	27.60	Low	3	4.79	Moderate
SHL	000	000	0	5	0.2750	0.3188	0.4063	SHL000000000000	2.01	Low	3	4.80	Very Low	1	56.10	Moderate	5	3.17	Low
SHL	000	000	5	150	0.2750	0.3188	0.4063	SHL000000000005	2.01	Low	3	3.30	Very Low	1	56.10	Moderate	5	3.17	Low
SHL	000	000	150	587	0.2750	0.3188	0.4063	SHL000000000150	2.01	Low	3	3.30	Very Low	1	56.10	Moderate	5	3.17	Low
SHL	000	000	587	2030	0.2750	0.3188	0.4063	SHL000000000587	2.01	Low	3	25.70	Moderate	5	56.10	Moderate	5	4.45	Moderate
SHL	000	000	2030	4160	0.2750	0.3188	0.4063	SHL000000002030	37.39	Very High	9	25.70	Moderate	5	56.10	Moderate	5	6.10	High
SHL	000	000	4160	6160	0.2750	0.3188	0.4063	SHL000000004160	28.53	Very High	9	25.70	Moderate	5	56.10	Moderate	5	6.10	High
SHL	000	000	6160	7622	0.2750	0.3188	0.4063	SHL000000006160	0.03	Low	3	25.70	Moderate	5	56.10	Moderate	5	4.45	Moderate
SHL	000	000	7622	8305	0.2750	0.3188	0.4063	SHL000000007622	0.03	Low	3	8.80	Very Low	1	56.10	Moderate	5	3.17	Low
SHL	000	000	8305	9000	0.2750	0.3188	0.4063	SHL000000008305	0.00	Very Low	1	8.80	Very Low	1	56.10	Moderate	5	2.63	Low
SHL	000	000	9000	9820	0.2750	0.3188	0.4063	SHL000000009000	0.00	Very Low	1	8.80	Very Low	1	25.50	Low	3	1.81	Very Low
SHL	000	000	9820	9850	0.2750	0.3188	0.4063	SHL000000009820	0.00	Very Low	1	10.30	Low	3	25.50	Low	3	2.45	Low
SHL	000	000	9850	11900	0.2750	0.3188	0.4063	SHL000000009850	0.00	Very Low	1	10.30	Low	3	25.50	Low	3	2.45	Low
SHL	000	000	11900	13850	0.2750	0.3188	0.4063	SHL000000011900	0.00	Very Low	1	10.30	Low	3	25.50	Low	3	2.45	Low
SHL	000	000	13850	14670	0.2750	0.3188	0.4063	SHL000000013850	0.00	Very Low	1	10.30	Low	3	25.50	Low	3	2.45	Low
SHL	000	000	14670	15982	0.2750	0.3188	0.4063	SHL000000014670	0.00	Very Low	1	3.60	Very Low	1	25.50	Low	3	1.81	Very Low
SHL	000	000	15982	17462	0.2750	0.3188	0.4063	SHL000000015982	0.01	Low	3	3.60	Very Low	1	25.50	Low	3	2.36	Low
SHL	000	000	17462	17950	0.2750	0.3188	0.4063	SHL000000017462	0.01	Low	3	19.60	Low	3	25.50	Low	3	3.00	Low
SHL	000	000	17950	19275	0.2750	0.3188	0.4063	SHL000000017950	0.08	Low	3	19.60	Low	3	25.50	Low	3	3.00	Low
SHL	000	000	19275	20000	0.3115	0.3088	0.3797	SHL000000019275	0.08	Low	3	19.60	Low	3	25.50	Low	3	3.00	Low
SHL	000	000	20000	21959	0.3115	0.3088	0.3797	SHL000000020000	0.33	Low	3	19.60	Low	3	25.50	Low	3	3.00	Low
SHL	000	000	21959	24060	0.3115	0.3088	0.3797	SHL000000021959	2.77	Low	3	19.60	Low	3	25.50	Low	3	3.00	Low
SHL	000	000	24060	24385	0.3115	0.3088	0.3797	SHL000000024060	1.34	Low	3	19.60	Low	3	25.50	Low	3	3.00	Low
SHL	000	000	24385	25960	0.3115	0.3088	0.3797	SHL000000024385	1.34	Low	3	3.90	Very Low	1	25.50	Low	3	2.38	Low
SHL	000	000	25960	26200	0.3115	0.3088	0.3797	SHL000000025960	1.34	Low	3	1.20	Very Low	1	25.50	Low	3	2.38	Low
SHL	000	000	26200	28041	0.3115	0.3088	0.3797	SHL000000026200	0.00	Very Low	1	1.20	Very Low	1	25.50	Low	3	1.76	Very Low
SHL	000	000	28041	29900	0.3115	0.3088	0.3797	SHL000000028041	0.00	Very Low	1	1.20	Very Low	1	25.50	Low	3	1.76	Very Low
SHL	000	000	29900	30545	0.3115	0.3088	0.3797	SHL000000029900	0.00	Very Low	1	9.50	Very Low	1	25.50	Low	3	1.76	Very Low
SHL	000	000	30545	30700	0.3115	0.3088	0.3797	SHL000000030545	0.01	Low	3	9.50	Very Low	1	25.50	Low	3	2.38	Low
SHL	000	000	30700	32063	0.3115	0.3088	0.3797	SHL000000030700	0.01	Low	3	9.50	Very Low	1	22.60	Low	3	2.38	Low
SHL	000	000	32063	33130	0.3115	0.3088	0.3797	SHL000000032063	0.06	Low	3	9.50	Very Low	1	22.60	Low	3	2.38	Low
SHL	000	000	33130	33960	0.3115	0.3088	0.3797	SHL000000033130	0.06	Low	3	2.20	Very Low	1	22.60	Low	3	2.38	Low
SHL	000	000	33960	35870	0.3115	0.3088	0.3797	SHL000000033960	0.03	Low	3	2.20	Very Low	1	22.60	Low	3	2.38	Low
SHL	000	000	35870	36020	0.3115	0.3088	0.3797	SHL000000035870	0.03	Low	3	5.60	Very Low	1	22.60	Low	3	2.38	Low
SHL	000	000	36020	37985	0.3115	0.3088	0.3797	SHL000000036020	0.13	Low	3	5.60	Very Low	1	22.60	Low	3	2.38	Low
SHL	000	000	37985	38875	0.3115	0.3088	0.3797	SHL000000037985	0.10	Low	3	5.60	Very Low	1	22.60	Low	3	2.38	Low

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	FC Final Wt	EC Final Wt	WQ Final Wt	IS Reach ID	Final FC Problem Score	FC Narrative Rating	FC Rank Score	Final EC Problem Score	EC Narrative Rating	EC Rank Score	Final WQ Problem Score	WQ Narrative Rating	WQ Rank Score	Integrated Score	IS Narrative Rating
SHL	000	000	38875	40000	0.3115	0.3088	0.3797	SHL000000038875	0.10	Low	3	8.60	Very Low	1	22.60	Low	3	2.38	Low
SHL	000	000	40000	41695	0.3115	0.3088	0.3797	SHL000000040000	0.01	Low	3	8.60	Very Low	1	22.60	Low	3	2.38	Low
SHL	000	000	41695	41915	0.3115	0.3088	0.3797	SHL000000041695	0.01	Low	3	8.10	Very Low	1	22.60	Low	3	2.38	Low
SHL	000	000	41915	42580	0.3115	0.3088	0.3797	SHL000000041915	0.03	Low	3	8.10	Very Low	1	22.60	Low	3	2.38	Low
SHL	000	000	42580	43930	0.3087	0.2962	0.3952	SHL000000042580	0.03	Low	3	8.10	Very Low	1	22.60	Low	3	2.41	Low
SHL	000	000	43930	44640	0.3087	0.2962	0.3952	SHL000000043930	6.01	Moderate	5	8.10	Very Low	1	22.60	Low	3	3.02	Low
SHL	000	000	44640	46005	0.3087	0.2962	0.3952	SHL000000044640	6.01	Moderate	5	12.30	Low	3	22.60	Low	3	3.62	Low
SHL	000	000	46005	46800	0.3087	0.2962	0.3952	SHL000000046005	0.01	Low	3	12.30	Low	3	22.60	Low	3	3.00	Low
SHL	000	000	46800	48239	0.3087	0.2962	0.3952	SHL000000046800	0.01	Low	3	12.30	Low	3	33.10	Low	3	3.00	Low
SHL	000	000	48239	49575	0.3087	0.2962	0.3952	SHL000000048239	0.00	Very Low	1	12.30	Low	3	33.10	Low	3	2.38	Low
SHL	000	000	49575	52360	0.3087	0.2962	0.3952	SHL000000049575	0.00	Very Low	1	12.30	Low	3	33.10	Low	3	2.38	Low
SHL	FOS	000	0	461	0.3087	0.2962	0.3952	SHLFOS000000000	1.34	Low	3	8.60	Very Low	1	22.60	Low	3	2.41	Low
SHL	HAN	000	0	2130	0.3115	0.3088	0.3797	SHLHAN000000000	8.76	Moderate	5	2.70	Very Low	1	25.50	Low	3	3.01	Low
SHL	HAN	000	2130	2300	0.3115	0.3088	0.3797	SHLHAN000002130	0.39	Low	3	2.70	Very Low	1	25.50	Low	3	2.38	Low
SHL	HAN	000	2300	4050	0.3115	0.3088	0.3797	SHLHAN000002300	0.39	Low	3	6.50	Very Low	1	25.50	Low	3	2.38	Low
SHL	HAN	000	4050	4320	0.3115	0.3088	0.3797	SHLHAN000004050	0.39	Low	3	3.90	Very Low	1	25.50	Low	3	2.38	Low
SHL	HAN	000	4320	6260	0.3115	0.3088	0.3797	SHLHAN000004320	1.64	Low	3	3.90	Very Low	1	25.50	Low	3	2.38	Low
SHL	HAN	000	6260	6970	0.3115	0.3088	0.3797	SHLHAN000006260	0.00	Very Low	1	3.90	Very Low	1	25.50	Low	3	1.76	Very Low
SHL	HAN	000	6970	8125	0.3115	0.3088	0.3797	SHLHAN000006970	0.00	Very Low	1	3.90	Very Low	1	25.50	Low	3	1.76	Very Low
SHL	HAN	000	8125	9870	0.3115	0.3088	0.3797	SHLHAN000008125	0.23	Low	3	3.90	Very Low	1	25.50	Low	3	2.38	Low
SHL	HAN	000	9870	11220	0.3115	0.3088	0.3797	SHLHAN000009870	0.01	Low	3	3.90	Very Low	1	25.50	Low	3	2.38	Low
TAN	000	000	0	1250	0.3375	0.3050	0.3575	TAN000000000000	20.02	Very High	9	5.60	Very Low	1	9.60	Very Low	1	3.70	Low
TAN	000	000	1250	1660	0.3375	0.3050	0.3575	TAN000000001250	20.02	Very High	9	0.90	Very Low	1	9.60	Very Low	1	3.70	Low
TAN	000	000	1660	3970	0.3375	0.3050	0.3575	TAN000000001660	20.02	Very High	9	0.90	Very Low	1	9.60	Very Low	1	3.70	Low
TAN	000	000	3970	5300	0.3375	0.3050	0.3575	TAN000000003970	0.62	Low	3	0.90	Very Low	1	9.60	Very Low	1	1.68	Very Low
TAN	000	000	5300	5860	0.3375	0.3050	0.3575	TAN000000005300	0.62	Low	3	9.40	Very Low	1	9.60	Very Low	1	1.68	Very Low
TAN	000	000	5860	6290	0.3375	0.3050	0.3575	TAN000000005860	0.23	Low	3	9.40	Very Low	1	9.60	Very Low	1	1.68	Very Low
TAN	000	000	6290	7937	0.3375	0.3050	0.3575	TAN000000006290	0.23	Low	3	3.40	Very Low	1	9.60	Very Low	1	1.68	Very Low
TAN	000	000	7937	10000	0.3375	0.3050	0.3575	TAN000000007937	6.85	Moderate	5	3.40	Very Low	1	9.60	Very Low	1	2.35	Low
TAN	000	000	10000	10775	0.3375	0.3050	0.3575	TAN000000010000	3.33	Low	3	3.40	Very Low	1	9.60	Very Low	1	1.68	Very Low
TAN	000	000	10775	12180	0.3375	0.3050	0.3575	TAN000000010775	3.33	Low	3	62.20	Very High	9	9.60	Very Low	1	4.12	Moderate
TAN	000	000	12180	13600	0.3375	0.3050	0.3575	TAN000000012180	0.00	Very Low	1	62.20	Very High	9	9.60	Very Low	1	3.44	Low
TAN	000	000	13600	14150	0.3375	0.3050	0.3575	TAN000000013600	0.00	Very Low	1	62.20	Very High	9	37.50	Low	3	4.16	Moderate
TAN	000	000	14150	15700	0.3375	0.3050	0.3575	TAN000000014150	0.00	Very Low	1	62.20	Very High	9	37.50	Low	3	4.16	Moderate
TAN	000	000	15700	16250	0.3149	0.2976	0.3875	TAN000000015700	0.00	Very Low	1	62.20	Very High	9	37.50	Low	3	4.16	Moderate
TAN	000	000	16250	17275	0.3149	0.2976	0.3875	TAN000000016250	0.00	Very Low	1	62.20	Very High	9	37.50	Low	3	4.16	Moderate
TAN	000	000	17275	18170	0.3149	0.2976	0.3875	TAN000000017275	0.00	Very Low	1	6.30	Very Low	1	37.50	Low	3	1.78	Very Low
TAN	000	000	18170	21840	0.3149	0.2976	0.3875	TAN000000018170	0.00	Very Low	1	6.30	Very Low	1	33.10	Low	3	1.78	Very Low
TAN	000	000	21840	23330	0.3149	0.2976	0.3875	TAN000000021840	0.00	Very Low	1	6.30	Very Low	1	33.10	Low	3	1.78	Very Low
TAN	000	000	23330	24290	0.3149	0.2976	0.3875	TAN000000023330	0.00	Very Low	1	37.70	High	7	33.10	Low	3	3.56	Low
TAN	000	000	24290	26270	0.3149	0.2976	0.3875	TAN000000024290	0.16	Low	3	37.70	High	7	33.10	Low	3	4.19	Moderate
TAN	000	000	26270	27680	0.3149	0.2976	0.3875	TAN000000026270	0.41	Low	3	37.70	High	7	33.10	Low	3	4.19	Moderate
TAN	000	000	27680	27933	0.3149	0.2976	0.3875	TAN000000027680	0.41	Low	3	2.90	Very Low	1	33.10	Low	3	2.40	Low
TAN	000	000	27933	29020	0.3149	0.2976	0.3875	TAN000000027933	0.17	Low	3	2.90	Very Low	1	33.10	Low	3	2.40	Low
TAN	000	000	29020	30200	0.3149	0.2976	0.3875	TAN000000029020	0.17	Low	3	2.90	Very Low	1	33.10	Low	3	2.40	Low
TAN	000	000	30200	34687	0.3149	0.2976	0.3875	TAN000000030200	0.17	Low	3	2.90	Very Low	1	33.10	Low	3	2.40	Low
TAN	GP1	000	0	2070	0.3375	0.3050	0.3575	TANGP1000000000	0.00	Very Low	1	9.40	Very Low	1	9.60	Very Low	1	1.00	Very Low
TAN	GP1	000	2070	4187	0.3375	0.3050	0.3575	TANGP1000002070	0.00	Very Low	1	9.40	Very Low	1	9.60	Very Low	1	1.00	Very Low
TAN	GP1	000	4187	6527	0.3375	0.3050	0.3575	TANGP1000004187	0.00	Very Low	1	9.40	Very Low	1	9.60	Very Low	1	1.00	Very Low
TAN	GP1	GP2	0	1935	0.3375	0.3050	0.3575	TANGP1GP2000000	0.00	Very Low	1	9.40	Very Low	1	9.60	Very Low	1	1.00	Very Low
TAN	GP1	GP2	1935	3715	0.3375	0.3050	0.3575	TANGP1GP2001935	0.00	Very Low	1	9.40	Very Low	1	9.60	Very Low	1	1.00	Very Low
TAN	GP1	GP2	3715	4965	0.3375	0.3050	0.3575	TANGP1GP2003715	0.00	Very Low	1	9.40	Very Low	1	9.60	Very Low	1	1.00	Very Low
TAN	T01	000	0	800	0.3149	0.2976	0.3875	TANT01000000000	0.02	Low	3	2.90	Very Low	1	33.10	Low	3	2.40	Low
TAN	T02	000	0	375	0.3149	0.2976	0.3875	TANT02000000000	0.02	Low	3	2.90	Very Low	1	45.00	Moderate	5	3.18	Low

Table B - 4
Master Plan Problem Area Assessment Integrated Scores (98 Methodology)

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	FC Final Wt	EC Final Wt	WQ Final Wt	IS Reach ID	Final FC Problem Score	FC Narrative Rating	FC Rank Score	Final EC Problem Score	EC Narrative Rating	EC Rank Score	Final WQ Problem Score	WQ Narrative Rating	WQ Rank Score	Integrated Score	IS Narrative Rating
TAN	WT3	000	0	1980	0.3375	0.3050	0.3575	TANWT3000000000	0.00	Very Low	1	4.00	Very Low	1	9.60	Very Low	1	1.00	Very Low
TAN	WT3	000	1980	2770	0.3375	0.3050	0.3575	TANWT3000001980	0.00	Very Low	1	4.00	Very Low	1	9.60	Very Low	1	1.00	Very Low
WBO	000	000	0	800	0.2750	0.2906	0.4344	WBO000000000000	19.39	High	7	7.40	Very Low	1	63.10	High	7	5.26	Moderate
WBO	000	000	800	1997	0.2750	0.2906	0.4344	WBO000000000800	19.39	High	7	7.40	Very Low	1	63.10	High	7	5.26	Moderate
WBO	000	000	1997	4209	0.2750	0.2906	0.4344	WBO000000001997	1.83	Low	3	7.40	Very Low	1	63.10	High	7	4.16	Moderate
WBO	000	000	4209	4400	0.2750	0.2906	0.4344	WBO000000004209	0.00	Very Low	1	7.40	Very Low	1	63.10	High	7	3.61	Low
WBO	000	000	4400	4700	0.2750	0.2906	0.4344	WBO000000004400	0.00	Very Low	1	7.40	Very Low	1	4.70	Very Low	1	1.00	Very Low
WBO	000	000	4700	4900	0.2750	0.2906	0.4344	WBO000000004700	0.00	Very Low	1	7.40	Very Low	1	4.70	Very Low	1	1.00	Very Low
WBO	000	000	4900	6009	0.2750	0.2906	0.4344	WBO000000004900	0.00	Very Low	1	43.00	Very High	9	4.70	Very Low	1	3.32	Low
WBO	000	000	6009	7100	0.2750	0.2906	0.4344	WBO000000006009	0.04	Low	3	43.00	Very High	9	4.70	Very Low	1	3.87	Low
WBO	000	000	7100	7270	0.2750	0.2906	0.4344	WBO000000007100	0.04	Low	3	43.00	Very High	9	64.10	High	7	6.48	High
WBO	000	000	7270	8049	0.2750	0.2906	0.4344	WBO000000007270	0.04	Low	3	1.10	Very Low	1	64.10	High	7	4.16	Moderate
WBO	000	000	8049	8050	0.2750	0.2906	0.4344	WBO000000008049	20.20	Very High	9	1.10	Very Low	1	64.10	High	7	5.81	Moderate
WBO	000	000	8050	9240	0.2750	0.2906	0.4344	WBO000000008050	20.20	Very High	9	3.50	Very Low	1	64.10	High	7	5.81	Moderate
WBO	000	000	9240	9885	0.2903	0.3014	0.4083	WBO000000009240	20.03	Very High	9	3.50	Very Low	1	64.10	High	7	5.77	Moderate
WBO	000	000	9885	10200	0.2903	0.3014	0.4083	WBO000000009885	20.01	Very High	9	3.50	Very Low	1	64.10	High	7	5.77	Moderate
WBO	000	000	10200	12030	0.2903	0.3014	0.4083	WBO000000010200	20.01	Very High	9	3.50	Very Low	1	40.40	Moderate	5	4.96	Moderate
WBO	000	000	12030	14080	0.2903	0.3014	0.4083	WBO000000012030	0.70	Low	3	3.50	Very Low	1	40.40	Moderate	5	3.21	Low
WBO	000	000	14080	14570	0.2903	0.3014	0.4083	WBO000000014080	7.06	Moderate	5	3.50	Very Low	1	40.40	Moderate	5	3.79	Low
WBO	000	000	14570	15880	0.2903	0.3014	0.4083	WBO000000014570	7.06	Moderate	5	3.50	Very Low	1	40.40	Moderate	5	3.79	Low
WBO	000	000	15880	17516	0.2903	0.3014	0.4083	WBO000000015880	0.78	Low	3	3.50	Very Low	1	40.40	Moderate	5	3.21	Low
WBO	NFK	000	0	1925	0.2903	0.3014	0.4083	WBONFK000000000	0.52	Low	3	3.50	Very Low	1	64.10	High	7	4.03	Moderate
WBO	NFK	000	1925	4175	0.2903	0.3014	0.4083	WBONFK000001925	0.24	Low	3	3.50	Very Low	1	64.10	High	7	4.03	Moderate
WBO	T01	000	0	970	0.2903	0.3014	0.4083	WBOT01000000000	0.02	Low	3	4.30	Very Low	1	40.40	Moderate	5	3.21	Low
WLN	000	000	0	3370	0.3115	0.3088	0.3797	WLN000000000000	0.00	Very Low	1	36.90	High	7	50.20	Moderate	5	4.37	Moderate
WLN	000	000	3370	4130	0.3115	0.3088	0.3797	WLN000000003370	0.00	Very Low	1	36.90	High	7	50.20	Moderate	5	4.37	Moderate
WLN	000	000	4130	4440	0.3115	0.3088	0.3797	WLN000000004130	0.00	Very Low	1	36.90	High	7	50.20	Moderate	5	4.37	Moderate
WLN	000	000	4440	6225	0.3115	0.3088	0.3797	WLN000000004440	0.00	Very Low	1	65.00	Very High	9	50.20	Moderate	5	4.99	Moderate
WLN	000	000	6225	8180	0.3115	0.3088	0.3797	WLN000000006225	0.00	Very Low	1	65.00	Very High	9	50.20	Moderate	5	4.99	Moderate
WLN	000	000	8180	9370	0.3115	0.3088	0.3797	WLN000000008180	0.00	Very Low	1	65.00	Very High	9	50.20	Moderate	5	4.99	Moderate
WLN	000	000	9370	10050	0.3115	0.3088	0.3797	WLN000000009370	0.00	Very Low	1	65.00	Very High	9	50.20	Moderate	5	4.99	Moderate
WLN	000	000	10050	11980	0.3115	0.3088	0.3797	WLN000000010050	0.00	Very Low	1	65.00	Very High	9	50.20	Moderate	5	4.99	Moderate
WLN	000	000	11980	14275	0.3115	0.3088	0.3797	WLN000000011980	0.00	Very Low	1	65.00	Very High	9	50.20	Moderate	5	4.99	Moderate
WLN	000	000	14275	16300	0.3115	0.3088	0.3797	WLN000000014275	0.00	Very Low	1	65.00	Very High	9	50.20	Moderate	5	4.99	Moderate
WLN	000	000	16300	18029	0.3115	0.3088	0.3797	WLN000000016300	0.00	Very Low	1	65.00	Very High	9	50.20	Moderate	5	4.99	Moderate
WLN	000	000	18029	20380	0.3115	0.3088	0.3797	WLN000000018029	3.87	Low	3	65.00	Very High	9	50.20	Moderate	5	5.61	Moderate
WLN	000	000	20380	22225	0.3115	0.3088	0.3797	WLN000000020380	20.99	Very High	9	65.00	Very High	9	50.20	Moderate	5	7.48	High
WLN	000	000	22225	24400	0.3115	0.3088	0.3797	WLN000000022225	0.00	Very Low	1	65.00	Very High	9	50.20	Moderate	5	4.99	Moderate
WLN	000	000	24400	25120	0.3115	0.3088	0.3797	WLN000000024400	10.76	High	7	65.00	Very High	9	50.20	Moderate	5	6.86	High
WLN	000	000	25120	26290	0.3115	0.3088	0.3797	WLN000000025120	10.76	High	7	65.00	Very High	9	50.20	Moderate	5	6.86	High
WLN	000	000	26290	27430	0.3115	0.3088	0.3797	WLN000000026290	0.00	Very Low	1	65.00	Very High	9	50.20	Moderate	5	4.99	Moderate
WLN	000	000	27430	30000	0.3115	0.3088	0.3797	WLN000000027430	13.66	High	7	65.00	Very High	9	50.20	Moderate	5	6.86	High
WLN	000	000	30000	30087	0.3115	0.3088	0.3797	WLN000000030000	13.66	High	7	65.00	Very High	9	60.80	High	7	7.62	High
WLN	000	000	30087	32125	0.3115	0.3088	0.3797	WLN000000030087	19.34	High	7	65.00	Very High	9	60.80	High	7	7.62	High
WLN	000	000	32125	34245	0.3115	0.3088	0.3797	WLN000000032125	100.00	Very High	9	65.00	Very High	9	60.80	High	7	8.24	Very High
WLN	000	000	34245	35040	0.3115	0.3088	0.3797	WLN000000034245	6.30	Moderate	5	65.00	Very High	9	60.80	High	7	6.99	High
WLN	000	000	35040	36205	0.3115	0.3088	0.3797	WLN000000035040	6.30	Moderate	5	100.00	Very High	9	60.80	High	7	6.99	High
WLN	000	000	36205	37945	0.3115	0.3088	0.3797	WLN000000036205	0.00	Very Low	1	100.00	Very High	9	60.80	High	7	5.75	Moderate
WLN	000	000	37945	40120	0.3115	0.3088	0.3797	WLN000000037945	0.00	Very Low	1	100.00	Very High	9	60.80	High	7	5.75	Moderate
WLN	000	000	40120	42115	0.3115	0.3088	0.3797	WLN000000040120	0.00	Very Low	1	100.00	Very High	9	60.80	High	7	5.75	Moderate
WLN	000	000	42115	43800	0.3115	0.3088	0.3797	WLN000000042115	0.00	Very Low	1	100.00	Very High	9	60.80	High	7	5.75	Moderate
WLN	000	000	43800	46010	0.3115	0.3088	0.3797	WLN000000043800	4.87	Low	3	100.00	Very High	9	60.80	High	7	6.37	High
WLN	000	000	46010	48240	0.3115	0.3088	0.3797	WLN000000046010	4.76	Low	3	100.00	Very High	9	60.80	High	7	6.37	High
WLN	000	000	48240	49270	0.3115	0.3088	0.3797	WLN000000048240	1.80	Low	3	100.00	Very High	9	60.80	High	7	6.37	High

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	FC Final Wt	EC Final Wt	WQ Final Wt	IS Reach ID	Final FC Problem Score	FC Narrative Rating	FC Rank Score	Final EC Problem Score	EC Narrative Rating	EC Rank Score	Final WQ Problem Score	WQ Narrative Rating	WQ Rank Score	Integrated Score	IS Narrative Rating
WLN	000	000	49270	49700	0.3115	0.3088	0.3797	WLN000000049270	1.80	Low	3	100.00	Very High	9	55.60	Moderate	5	5.61	Moderate
WLN	000	000	49700	49750	0.3115	0.3088	0.3797	WLN000000049700	1.80	Low	3	50.50	Very High	9	55.60	Moderate	5	5.61	Moderate
WLN	000	000	49750	51730	0.3115	0.3088	0.3797	WLN000000049750	0.16	Low	3	50.50	Very High	9	55.60	Moderate	5	5.61	Moderate
WLN	000	000	51730	54100	0.3115	0.3088	0.3797	WLN000000051730	0.00	Very Low	1	50.50	Very High	9	55.60	Moderate	5	4.99	Moderate
WLN	000	000	54100	55500	0.3115	0.3088	0.3797	WLN000000054100	0.00	Very Low	1	50.50	Very High	9	55.60	Moderate	5	4.99	Moderate
WLN	000	000	55500	56330	0.3115	0.3088	0.3797	WLN000000055500	0.00	Very Low	1	24.50	Moderate	5	55.60	Moderate	5	3.75	Low
WLN	000	000	56330	56740	0.3115	0.3088	0.3797	WLN000000056330	0.00	Very Low	1	24.50	Moderate	5	55.60	Moderate	5	3.75	Low
WLN	000	000	56740	58000	0.2929	0.2948	0.4123	WLN000000056740	0.00	Very Low	1	24.50	Moderate	5	55.60	Moderate	5	3.83	Low
WLN	000	000	58000	58700	0.2929	0.2948	0.4123	WLN000000058000	0.00	Very Low	1	24.50	Moderate	5	55.60	Moderate	5	3.83	Low
WLN	000	000	58700	60400	0.2929	0.2948	0.4123	WLN000000058700	0.00	Very Low	1	22.00	Moderate	5	55.60	Moderate	5	3.83	Low
WLN	000	000	60400	62230	0.2929	0.2948	0.4123	WLN000000060400	0.00	Very Low	1	22.00	Moderate	5	55.60	Moderate	5	3.83	Low
WLN	000	000	62230	63000	0.2929	0.2948	0.4123	WLN000000062230	0.00	Very Low	1	22.00	Moderate	5	55.60	Moderate	5	3.83	Low
WLN	000	000	63000	64600	0.2929	0.2948	0.4123	WLN000000063000	0.00	Very Low	1	44.50	Very High	9	55.60	Moderate	5	5.01	Moderate
WLN	000	000	64600	66650	0.2929	0.2948	0.4123	WLN000000064600	0.00	Very Low	1	44.50	Very High	9	55.60	Moderate	5	5.01	Moderate
WLN	000	000	66650	69900	0.2929	0.2948	0.4123	WLN000000066650	2.73	Low	3	44.50	Very High	9	55.60	Moderate	5	5.59	Moderate
WLN	000	000	69900	72000	0.2929	0.2948	0.4123	WLN000000069900	12.97	High	7	44.50	Very High	9	55.60	Moderate	5	6.76	High
WLN	000	000	72000	74090	0.2929	0.2948	0.4123	WLN000000072000	3.35	Low	3	44.50	Very High	9	55.60	Moderate	5	5.59	Moderate
WLN	000	000	74090	75300	0.2929	0.2948	0.4123	WLN000000074090	0.03	Low	3	44.50	Very High	9	55.60	Moderate	5	5.59	Moderate
WLN	000	000	75300	76000	0.2929	0.2948	0.4123	WLN000000075300	0.03	Low	3	44.50	Very High	9	50.70	Moderate	5	5.59	Moderate
WLN	000	000	76000	78170	0.2929	0.2948	0.4123	WLN000000076000	1.63	Low	3	44.50	Very High	9	50.70	Moderate	5	5.59	Moderate
WLN	000	000	78170	78200	0.2929	0.2948	0.4123	WLN000000078170	0.00	Very Low	1	44.50	Very High	9	50.70	Moderate	5	5.01	Moderate
WLN	000	000	78200	80230	0.2929	0.2948	0.4123	WLN000000078200	0.00	Very Low	1	27.90	Moderate	5	50.70	Moderate	5	3.83	Low
WLN	000	000	80230	80740	0.2929	0.2948	0.4123	WLN000000080230	0.02	Low	3	27.90	Moderate	5	50.70	Moderate	5	4.41	Moderate
WLN	000	000	80740	80810	0.3115	0.3088	0.3797	WLN000000080740	0.02	Low	3	27.90	Moderate	5	50.70	Moderate	5	4.38	Moderate
WLN	000	000	80810	80880	0.3115	0.3088	0.3797	WLN000000080810	0.02	Low	3	27.90	Moderate	5	50.70	Moderate	5	4.38	Moderate
WLN	000	000	80880	81070	0.3115	0.3088	0.3797	WLN000000080880	0.02	Low	3	27.90	Moderate	5	31.60	Low	3	3.62	Low
WLN	000	000	81070	82250	0.3115	0.3088	0.3797	WLN000000081070	0.02	Low	3	24.70	Moderate	5	31.60	Low	3	3.62	Low
WLN	000	000	82250	84250	0.3115	0.3088	0.3797	WLN000000082250	0.00	Very Low	1	24.70	Moderate	5	31.60	Low	3	2.99	Low
WLN	000	000	84250	85230	0.3115	0.3088	0.3797	WLN000000084250	0.00	Very Low	1	24.70	Moderate	5	31.60	Low	3	2.99	Low
WLN	000	000	85230	85900	0.3115	0.3088	0.3797	WLN000000085230	0.00	Very Low	1	45.80	Very High	9	31.60	Low	3	4.23	Moderate
WLN	000	000	85900	88210	0.3115	0.3088	0.3797	WLN000000085900	0.00	Very Low	1	45.80	Very High	9	31.60	Low	3	4.23	Moderate
WLN	000	000	88210	88760	0.3115	0.3088	0.3797	WLN000000088210	0.00	Very Low	1	45.80	Very High	9	31.60	Low	3	4.23	Moderate
WLN	000	000	88760	90240	0.3115	0.3088	0.3797	WLN000000088760	0.00	Very Low	1	24.10	Moderate	5	31.60	Low	3	2.99	Low
WLN	000	000	90240	90720	0.3115	0.3088	0.3797	WLN000000090240	0.00	Very Low	1	24.10	Moderate	5	31.60	Low	3	2.99	Low
WLN	000	000	90720	91940	0.3115	0.3088	0.3797	WLN000000090720	0.00	Very Low	1	58.40	Very High	9	31.60	Low	3	4.23	Moderate
WLN	000	000	91940	93625	0.3115	0.3088	0.3797	WLN000000091940	0.00	Very Low	1	58.40	Very High	9	31.60	Low	3	4.23	Moderate
WLN	000	000	93625	95350	0.3115	0.3088	0.3797	WLN000000093625	0.00	Very Low	1	58.40	Very High	9	31.60	Low	3	4.23	Moderate
WLN	000	000	95350	97990	0.3115	0.3088	0.3797	WLN000000095350	0.26	Low	3	58.40	Very High	9	31.60	Low	3	4.85	Moderate
WLN	000	000	97990	98410	0.3115	0.3088	0.3797	WLN000000097990	0.17	Low	3	58.40	Very High	9	31.60	Low	3	4.85	Moderate
WLN	000	000	98410	100080	0.3115	0.3088	0.3797	WLN000000098410	0.17	Low	3	20.90	Moderate	5	31.60	Low	3	3.62	Low
WLN	000	000	100080	101780	0.3115	0.3088	0.3797	WLN000000100080	0.00	Very Low	1	20.90	Moderate	5	31.60	Low	3	2.99	Low
WLN	000	000	101780	103880	0.3115	0.3088	0.3797	WLN000000101780	1.01	Low	3	20.90	Moderate	5	31.60	Low	3	3.62	Low
WLN	000	000	103880	103950	0.3115	0.3088	0.3797	WLN000000103880	0.00	Very Low	1	20.90	Moderate	5	31.60	Low	3	2.99	Low
WLN	000	000	103950	105890	0.3115	0.3088	0.3797	WLN000000103950	0.00	Very Low	1	21.60	Moderate	5	31.60	Low	3	2.99	Low
WLN	000	000	105890	107800	0.3115	0.3088	0.3797	WLN000000105890	0.47	Low	3	21.60	Moderate	5	31.60	Low	3	3.62	Low
WLN	000	000	107800	108530	0.3115	0.3088	0.3797	WLN000000107800	0.00	Very Low	1	21.60	Moderate	5	31.60	Low	3	2.99	Low
WLN	000	000	108530	110019	0.3115	0.3088	0.3797	WLN000000108530	0.00	Very Low	1	23.40	Moderate	5	31.60	Low	3	2.99	Low
WLN	000	000	110019	111900	0.3115	0.3088	0.3797	WLN000000110019	0.05	Low	3	23.40	Moderate	5	31.60	Low	3	3.62	Low
WLN	000	000	111900	113960	0.3115	0.3088	0.3797	WLN000000111900	0.00	Very Low	1	23.40	Moderate	5	31.60	Low	3	2.99	Low
WLN	000	000	113960	114240	0.3115	0.3088	0.3797	WLN000000113960	0.00	Very Low	1	23.40	Moderate	5	31.60	Low	3	2.99	Low
WLN	000	000	114240	116000	0.3115	0.3088	0.3797	WLN000000114240	0.00	Very Low	1	23.40	Moderate	5	31.60	Low	3	2.99	Low
WLN	000	000	116000	117795	0.3115	0.3088	0.3797	WLN000000116000	0.00	Very Low	1	23.40	Moderate	5	31.60	Low	3	2.99	Low
WLN	000	000	117795	120165	0.3115	0.3088	0.3797	WLN000000117795	4.91	Low	3	23.40	Moderate	5	31.60	Low	3	3.62	Low
WLN	KMR	000	0	1940	0.3115	0.3088	0.3797	WLNKMR000000000	0.00	Very Low	1	58.40	Very High	9	31.60	Low	3	4.23	Moderate

Table B - 4
Master Plan Problem Area Assessment Integrated Scores (98 Methodology)

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	FC Final Wt	EC Final Wt	WQ Final Wt	IS Reach ID	Final FC Problem Score	FC Narrative Rating	FC Rank Score	Final EC Problem Score	EC Narrative Rating	EC Rank Score	Final WQ Problem Score	WQ Narrative Rating	WQ Rank Score	Integrated Score	IS Narrative Rating
WLN	KMR	000	1940	4070	0.3115	0.3088	0.3797	WLNKMR000001940	0.00	Very Low	1	58.40	Very High	9	31.60	Low	3	4.23	Moderate
WLN	KMR	000	4070	4550	0.3115	0.3088	0.3797	WLNKMR000004070	0.00	Very Low	1	58.40	Very High	9	31.60	Low	3	4.23	Moderate
WLN	T01	000	0	2000	0.3115	0.3088	0.3797	WLNT01000000000	0.00	Very Low	1	19.60	Low	3	50.20	Moderate	5	3.14	Low
WLN	T01	000	2000	4175	0.3115	0.3088	0.3797	WLNT01000002000	0.00	Very Low	1	19.60	Low	3	50.20	Moderate	5	3.14	Low
WLN	T01	000	4175	6300	0.3115	0.3088	0.3797	WLNT01000004175	0.00	Very Low	1	19.60	Low	3	50.20	Moderate	5	3.14	Low
WLN	T01	000	6300	8370	0.3115	0.3088	0.3797	WLNT01000006300	2.52	Low	3	19.60	Low	3	50.20	Moderate	5	3.76	Low
WLN	T01	000	8370	10895	0.3115	0.3088	0.3797	WLNT01000008370	2.02	Low	3	19.60	Low	3	50.20	Moderate	5	3.76	Low
WLN	T01	000	10895	12430	0.3115	0.3088	0.3797	WLNT01000010895	0.00	Very Low	1	19.60	Low	3	50.20	Moderate	5	3.14	Low
WLN	T01	000	12430	14205	0.3115	0.3088	0.3797	WLNT01000012430	0.00	Very Low	1	19.60	Low	3	50.20	Moderate	5	3.14	Low
WLN	T01	000	14205	15780	0.3115	0.3088	0.3797	WLNT01000014205	0.00	Very Low	1	19.60	Low	3	50.20	Moderate	5	3.14	Low
WLN	T01	000	15780	16040	0.3115	0.3088	0.3797	WLNT01000015780	0.00	Very Low	1	19.60	Low	3	50.20	Moderate	5	3.14	Low
WLN	T01	000	16040	17690	0.3115	0.3088	0.3797	WLNT01000016040	0.02	Low	3	19.60	Low	3	50.20	Moderate	5	3.76	Low
WLN	T01	T01	0	300	0.3115	0.3088	0.3797	WLNT01T01000000	0.00	Very Low	1	19.60	Low	3	50.20	Moderate	5	3.14	Low
WLN	T01	T01	300	2070	0.3115	0.3088	0.3797	WLNT01T01000300	0.00	Very Low	1	19.60	Low	3	50.20	Moderate	5	3.14	Low
WLN	T01	T01	2070	2690	0.3115	0.3088	0.3797	WLNT01T01002070	0.00	Very Low	1	19.60	Low	3	50.20	Moderate	5	3.14	Low
WLN	T03	000	0	10250	0.3115	0.3088	0.3797	WLNT03000000000	0.02	Low	3	41.50	Very High	9	60.80	High	7	6.37	High
WLN	T03	000	10250	14500	0.3115	0.3088	0.3797	WLNT03000010250	0.02	Low	3	37.30	High	7	60.80	High	7	5.75	Moderate
WLN	T03	000	14500	19000	0.3115	0.3088	0.3797	WLNT03000014500	0.02	Low	3	33.20	High	7	60.80	High	7	5.75	Moderate
WLN	T04	000	0	2300	0.3115	0.3088	0.3797	WLNT04000000000	0.00	Very Low	1	65.00	Very High	9	60.80	High	7	5.75	Moderate
WLN	T04	000	2300	4350	0.3115	0.3088	0.3797	WLNT04000002300	0.00	Very Low	1	65.00	Very High	9	60.80	High	7	5.75	Moderate
WLN	T04	000	4350	6140	0.3115	0.3088	0.3797	WLNT04000004350	0.00	Very Low	1	65.00	Very High	9	60.80	High	7	5.75	Moderate
WLN	T04	000	6140	8420	0.3115	0.3088	0.3797	WLNT04000006140	0.00	Very Low	1	65.00	Very High	9	60.80	High	7	5.75	Moderate
WLN	T05	000	0	1830	0.3115	0.3088	0.3797	WLNT05000000000	0.00	Very Low	1	100.00	Very High	9	60.80	High	7	5.75	Moderate
WLN	T05	000	1830	3950	0.3115	0.3088	0.3797	WLNT05000001830	0.62	Low	3	100.00	Very High	9	60.80	High	7	6.37	High
WLN	T05	000	3950	6100	0.3115	0.3088	0.3797	WLNT05000003950	0.00	Very Low	1	100.00	Very High	9	60.80	High	7	5.75	Moderate
WLN	T05	000	6100	8320	0.3115	0.3088	0.3797	WLNT05000006100	0.03	Low	3	100.00	Very High	9	60.80	High	7	6.37	High
WLN	T05	000	8320	10800	0.3115	0.3088	0.3797	WLNT05000008320	0.02	Low	3	100.00	Very High	9	60.80	High	7	6.37	High
WLN	T05	T01	0	2400	0.3115	0.3088	0.3797	WLNT05T01000000	0.00	Very Low	1	100.00	Very High	9	60.80	High	7	5.75	Moderate
WLN	T06	000	0	1930	0.2929	0.2948	0.4123	WLNT06000000000	0.00	Very Low	1	28.00	Moderate	5	50.70	Moderate	5	3.83	Low
WLN	T06	000	1930	4050	0.2929	0.2948	0.4123	WLNT06000001930	0.00	Very Low	1	28.00	Moderate	5	50.70	Moderate	5	3.83	Low
WLN	T06	000	4050	6010	0.2929	0.2948	0.4123	WLNT06000004050	0.03	Low	3	28.00	Moderate	5	50.70	Moderate	5	4.41	Moderate
WLN	T06	000	6010	8070	0.2929	0.2948	0.4123	WLNT06000006010	0.00	Very Low	1	28.00	Moderate	5	50.70	Moderate	5	3.83	Low
WLN	T06	000	8070	9960	0.2929	0.2948	0.4123	WLNT06000008070	0.00	Very Low	1	28.00	Moderate	5	50.70	Moderate	5	3.83	Low
WLN	T06	000	9960	11740	0.2929	0.2948	0.4123	WLNT06000009960	0.00	Very Low	1	28.00	Moderate	5	50.70	Moderate	5	3.83	Low
WLN	T07	000	0	2080	0.3115	0.3088	0.3797	WLNT07000000000	0.00	Very Low	1	17.00	Low	3	31.60	Low	3	2.38	Low
WLN	T07	000	2080	4080	0.3115	0.3088	0.3797	WLNT07000002080	0.00	Very Low	1	17.00	Low	3	31.60	Low	3	2.38	Low
WLN	T07	000	4080	5000	0.3115	0.3088	0.3797	WLNT07000004080	0.00	Very Low	1	17.00	Low	3	31.60	Low	3	2.38	Low
WLN	T07	000	5000	5980	0.3115	0.3088	0.3797	WLNT07000005000	0.00	Very Low	1	14.30	Low	3	31.60	Low	3	2.38	Low
WLN	T07	000	5980	8140	0.3115	0.3088	0.3797	WLNT07000005980	0.00	Very Low	1	14.30	Low	3	31.60	Low	3	2.38	Low
WLN	T07	000	8140	8550	0.3115	0.3088	0.3797	WLNT07000008140	0.14	Low	3	14.30	Low	3	31.60	Low	3	3.00	Low
WLN	T07	000	8550	10123	0.3115	0.3088	0.3797	WLNT07000008550	0.14	Low	3	8.40	Very Low	1	31.60	Low	3	2.38	Low
WLN	T07	000	10123	12180	0.3115	0.3088	0.3797	WLNT07000010123	2.01	Low	3	8.40	Very Low	1	31.60	Low	3	2.38	Low
WLN	T07	000	12180	12970	0.3115	0.3088	0.3797	WLNT07000012180	0.12	Low	3	8.40	Very Low	1	31.60	Low	3	2.38	Low
WLN	T07	000	12970	13430	0.3115	0.3088	0.3797	WLNT07000012970	0.12	Low	3	8.40	Very Low	1	31.60	Low	3	2.38	Low
WLN	T07	T01	0	2050	0.3115	0.3088	0.3797	WLNT07T01000000	0.00	Very Low	1	9.90	Very Low	1	31.60	Low	3	1.76	Very Low
WLN	T07	T01	2050	3440	0.3115	0.3088	0.3797	WLNT07T01002050	0.00	Very Low	1	9.90	Very Low	1	31.60	Low	3	1.76	Very Low
WLN	T07	T01	3440	5840	0.3115	0.3088	0.3797	WLNT07T01003440	0.00	Very Low	1	9.90	Very Low	1	31.60	Low	3	1.76	Very Low
WLN	T08	000	0	1370	0.3115	0.3088	0.3797	WLNT08000000000	0.38	Low	3	20.60	Moderate	5	31.60	Low	3	3.62	Low
WLN	T08	000	1370	2020	0.3115	0.3088	0.3797	WLNT08000001370	0.38	Low	3	12.80	Low	3	31.60	Low	3	3.00	Low
WLN	T08	000	2020	2470	0.3115	0.3088	0.3797	WLNT08000002020	0.00	Very Low	1	12.80	Low	3	31.60	Low	3	2.38	Low
WLN	T08	000	2470	4090	0.3115	0.3088	0.3797	WLNT08000002470	0.00	Very Low	1	18.10	Low	3	31.60	Low	3	2.38	Low
WLN	T08	000	4090	5860	0.3115	0.3088	0.3797	WLNT08000004090	0.00	Very Low	1	18.10	Low	3	31.60	Low	3	2.38	Low
WLN	T08	000	5860	7979	0.3115	0.3088	0.3797	WLNT08000005860	0.00	Very Low	1	18.10	Low	3	31.60	Low	3	2.38	Low
WLN	T08	000	7979	9910	0.3115	0.3088	0.3797	WLNT08000007979	0.00	Very Low	1	18.10	Low	3	31.60	Low	3	2.38	Low

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	FC Final Wt	EC Final Wt	WQ Final Wt	IS Reach ID	Final FC Problem Score	FC Narrative Rating	FC Rank Score	Final EC Problem Score	EC Narrative Rating	EC Rank Score	Final WQ Problem Score	WQ Narrative Rating	WQ Rank Score	Integrated Score	IS Narrative Rating
WLN	T08	000	9910	10390	0.3115	0.3088	0.3797	WLNT08000009910	0.00	Very Low	1	18.10	Low	3	31.60	Low	3	2.38	Low
WLN	T08	000	10390	11900	0.3115	0.3088	0.3797	WLNT08000010390	0.00	Very Low	1	18.10	Low	3	31.60	Low	3	2.38	Low
WLN	T09	000	0	2005	0.3115	0.3088	0.3797	WLNT09000000000	0.11	Low	3	30.50	High	7	31.60	Low	3	4.24	Moderate
WLN	T09	000	2005	3960	0.3115	0.3088	0.3797	WLNT09000002005	0.00	Very Low	1	30.50	High	7	31.60	Low	3	3.61	Low
WLN	T09	000	3960	6010	0.3115	0.3088	0.3797	WLNT09000003960	1.25	Low	3	30.50	High	7	31.60	Low	3	4.24	Moderate
WLN	T09	000	6010	7990	0.3115	0.3088	0.3797	WLNT09000006010	0.45	Low	3	30.50	High	7	31.60	Low	3	4.24	Moderate
WLN	T09	000	7990	10000	0.3115	0.3088	0.3797	WLNT09000007990	0.00	Very Low	1	30.50	High	7	31.60	Low	3	3.61	Low
WLN	T09	000	10000	11950	0.3115	0.3088	0.3797	WLNT09000010000	0.00	Very Low	1	30.50	High	7	31.60	Low	3	3.61	Low
WLN	T09	000	11950	13400	0.3115	0.3088	0.3797	WLNT09000011950	0.00	Very Low	1	30.50	High	7	31.60	Low	3	3.61	Low
WLN	T09	000	13400	13500	0.3115	0.3088	0.3797	WLNT09000013400	0.00	Very Low	1	30.50	High	7	31.60	Low	3	3.61	Low
WLN	T10	000	0	2040	0.3115	0.3088	0.3797	WLNT10000000000	0.24	Low	3	23.40	Moderate	5	31.60	Low	3	3.62	Low
WLN	T10	000	2040	4040	0.3115	0.3088	0.3797	WLNT10000002040	0.00	Very Low	1	23.40	Moderate	5	31.60	Low	3	2.99	Low
WLN	T10	000	4040	4710	0.3115	0.3088	0.3797	WLNT10000004040	0.00	Very Low	1	23.40	Moderate	5	31.60	Low	3	2.99	Low
WLN	TAR	000	0	1800	0.3115	0.3088	0.3797	WLNTAR000000000	0.00	Very Low	1	24.70	Moderate	5	31.60	Low	3	2.99	Low
WLN	TAR	000	1800	4070	0.3115	0.3088	0.3797	WLNTAR000001800	0.00	Very Low	1	24.70	Moderate	5	31.60	Low	3	2.99	Low
WLN	TAR	000	4070	5950	0.3115	0.3088	0.3797	WLNTAR000004070	0.10	Low	3	24.70	Moderate	5	31.60	Low	3	3.62	Low
WLN	TAR	000	5950	7940	0.3115	0.3088	0.3797	WLNTAR000005950	0.00	Very Low	1	24.70	Moderate	5	31.60	Low	3	2.99	Low
WLN	TAR	000	7940	8430	0.3115	0.3088	0.3797	WLNTAR000007940	0.00	Very Low	1	24.70	Moderate	5	31.60	Low	3	2.99	Low
WLN	WEL	000	0	2000	0.3115	0.3088	0.3797	WLNWEL000000000	1.61	Low	3	23.20	Moderate	5	31.60	Low	3	3.62	Low
WLN	WEL	000	2000	3240	0.3115	0.3088	0.3797	WLNWEL000002000	0.00	Very Low	1	23.20	Moderate	5	31.60	Low	3	2.99	Low
WLN	WEL	000	3240	4040	0.3115	0.3088	0.3797	WLNWEL000003240	0.00	Very Low	1	78.80	Very High	9	31.60	Low	3	4.23	Moderate
WLN	WEL	000	4040	5570	0.3115	0.3088	0.3797	WLNWEL000004040	7.78	Moderate	5	78.80	Very High	9	31.60	Low	3	5.48	Moderate
WLN	WEL	000	5570	5975	0.3115	0.3088	0.3797	WLNWEL000005570	7.78	Moderate	5	30.80	High	7	31.60	Low	3	4.86	Moderate
WLN	WEL	000	5975	7975	0.3115	0.3088	0.3797	WLNWEL000005975	4.41	Low	3	30.80	High	7	31.60	Low	3	4.24	Moderate
WLN	WEL	000	7975	9650	0.3115	0.3088	0.3797	WLNWEL000007975	0.00	Very Low	1	30.80	High	7	31.60	Low	3	3.61	Low
WLN	WEL	000	9650	9850	0.3115	0.3088	0.3797	WLNWEL000009650	0.00	Very Low	1	45.10	Very High	9	31.60	Low	3	4.23	Moderate
WLN	WEL	000	9850	11875	0.3115	0.3088	0.3797	WLNWEL000009850	0.00	Very Low	1	45.10	Very High	9	31.60	Low	3	4.23	Moderate
WLN	WEL	000	11875	14050	0.3115	0.3088	0.3797	WLNWEL000011875	0.00	Very Low	1	45.10	Very High	9	31.60	Low	3	4.23	Moderate
WLN	WEL	000	14050	16080	0.3115	0.3088	0.3797	WLNWEL000014050	0.32	Low	3	45.10	Very High	9	31.60	Low	3	4.85	Moderate
WLN	WEL	000	16080	18000	0.3115	0.3088	0.3797	WLNWEL000016080	0.05	Low	3	45.10	Very High	9	31.60	Low	3	4.85	Moderate
WLN	WEL	000	18000	18150	0.3115	0.3088	0.3797	WLNWEL000018000	1.67	Low	3	45.10	Very High	9	31.60	Low	3	4.85	Moderate
WLN	WEL	000	18150	19720	0.3115	0.3088	0.3797	WLNWEL000018150	1.67	Low	3	25.50	Moderate	5	31.60	Low	3	3.62	Low
WLN	WEL	000	19720	19850	0.3115	0.3088	0.3797	WLNWEL000019720	1.67	Low	3	27.80	Moderate	5	31.60	Low	3	3.62	Low
WLN	WEL	000	19850	21975	0.3115	0.3088	0.3797	WLNWEL000019850	0.00	Very Low	1	27.80	Moderate	5	31.60	Low	3	2.99	Low
WLN	WEL	000	21975	24075	0.3115	0.3088	0.3797	WLNWEL000021975	0.02	Low	3	27.80	Moderate	5	31.60	Low	3	3.62	Low
WLN	WEL	000	24075	25625	0.3115	0.3088	0.3797	WLNWEL000024075	0.00	Very Low	1	27.80	Moderate	5	31.60	Low	3	2.99	Low
WLN	WEL	000	25625	27260	0.3115	0.3088	0.3797	WLNWEL000025625	0.00	Very Low	1	27.80	Moderate	5	31.60	Low	3	2.99	Low
WLN	WEL	T01	0	2030	0.3115	0.3088	0.3797	WLNWELT01000000	0.00	Very Low	1	30.90	High	7	31.60	Low	3	3.61	Low
WLN	WEL	T01	2030	4120	0.3115	0.3088	0.3797	WLNWELT01002030	0.00	Very Low	1	30.90	High	7	31.60	Low	3	3.61	Low
WLN	WEL	T01	4120	6070	0.3115	0.3088	0.3797	WLNWELT01004120	0.00	Very Low	1	30.90	High	7	31.60	Low	3	3.61	Low
WLN	WEL	T01	6070	8310	0.3115	0.3088	0.3797	WLNWELT01006070	0.00	Very Low	1	30.90	High	7	31.60	Low	3	3.61	Low
WLN	WEL	T02	0	1920	0.3115	0.3088	0.3797	WLNWELT02000000	0.00	Very Low	1	27.80	Moderate	5	31.60	Low	3	2.99	Low
WLN	WEL	T02	1920	3400	0.3115	0.3088	0.3797	WLNWELT02001920	0.00	Very Low	1	27.80	Moderate	5	31.60	Low	3	2.99	Low
WLN	WEL	T03	0	600	0.3115	0.3088	0.3797	WLNWELT03000000	0.00	Very Low	1	27.80	Moderate	5	31.60	Low	3	2.99	Low
WLR	000	000	0	850	0.3052	0.2782	0.4165	WLR000000000000	1.70	Low	3	16.00	Low	3	44.80	Moderate	5	3.83	Low
WLR	000	000	850	1994	0.3052	0.2782	0.4165	WLR000000000850	1.70	Low	3	16.00	Low	3	44.80	Moderate	5	3.83	Low
WLR	000	000	1994	3000	0.3052	0.2782	0.4165	WLR000000001994	9.40	Moderate	5	16.00	Low	3	44.80	Moderate	5	4.44	Moderate
WLR	000	000	3000	3972	0.3052	0.2782	0.4165	WLR000000003000	9.40	Moderate	5	2.50	Very Low	1	44.80	Moderate	5	3.89	Low
WLR	000	000	3972	6018	0.3052	0.2782	0.4165	WLR000000003972	10.22	High	7	2.50	Very Low	1	44.80	Moderate	5	4.50	Moderate
WLR	000	000	6018	6620	0.3052	0.2782	0.4165	WLR000000006018	0.18	Low	3	2.50	Very Low	1	44.80	Moderate	5	3.28	Low
WLR	000	000	6620	8136	0.3052	0.2782	0.4165	WLR000000006620	0.18	Low	3	12.90	Low	3	44.80	Moderate	5	3.83	Low
WLR	000	000	8136	8900	0.3052	0.2782	0.4165	WLR000000008136	0.06	Low	3	12.90	Low	3	44.80	Moderate	5	3.83	Low
WLR	000	000	8900	10117	0.2929	0.2852	0.4219	WLR000000008900	0.06	Low	3	12.90	Low	3	44.80	Moderate	5	3.84	Low
WLR	000	000	10117	11865	0.2929	0.2852	0.4219	WLR000000010117	0.13	Low	3	12.90	Low	3	44.80	Moderate	5	3.84	Low

Table B - 4
Master Plan Problem Area Assessment Integrated Scores (98 Methodology)

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	FC Final Wt	EC Final Wt	WQ Final Wt	IS Reach ID	Final FC Problem Score	FC Narrative Rating	FC Rank Score	Final EC Problem Score	EC Narrative Rating	EC Rank Score	Final WQ Problem Score	WQ Narrative Rating	WQ Rank Score	Integrated Score	IS Narrative Rating
WLR	000	000	11865	11933	0.2929	0.2852	0.4219	WLR000000011865	0.13	Low	3	12.90	Low	3	15.80	Very Low	1	2.16	Low
WLR	000	000	11933	12300	0.2929	0.2852	0.4219	WLR000000011933	1.65	Low	3	12.90	Low	3	15.80	Very Low	1	2.16	Low
WLR	000	000	12300	14100	0.2929	0.2852	0.4219	WLR000000012300	1.65	Low	3	5.70	Very Low	1	15.80	Very Low	1	1.59	Very Low
WLR	000	000	14100	16062	0.2929	0.2852	0.4219	WLR000000014100	2.21	Low	3	5.70	Very Low	1	15.80	Very Low	1	1.59	Very Low
WLR	000	000	16062	17965	0.2929	0.2852	0.4219	WLR000000016062	0.04	Low	3	5.70	Very Low	1	15.80	Very Low	1	1.59	Very Low
WLR	000	000	17965	20006	0.2929	0.2852	0.4219	WLR000000017965	0.86	Low	3	5.70	Very Low	1	15.80	Very Low	1	1.59	Very Low
WLR	000	000	20006	21900	0.2929	0.2852	0.4219	WLR000000020006	6.00	Moderate	5	5.70	Very Low	1	15.80	Very Low	1	2.17	Low
WLR	000	000	21900	22048	0.2929	0.2852	0.4219	WLR000000021900	6.00	Moderate	5	5.70	Very Low	1	13.60	Very Low	1	2.17	Low
WLR	000	000	22048	22300	0.2929	0.2852	0.4219	WLR000000022048	6.00	Moderate	5	5.70	Very Low	1	13.60	Very Low	1	2.17	Low
WLR	000	000	22300	24095	0.2929	0.2852	0.4219	WLR000000022300	6.00	Moderate	5	8.90	Very Low	1	13.60	Very Low	1	2.17	Low
WLR	000	000	24095	25740	0.2929	0.2852	0.4219	WLR000000024095	0.61	Low	3	8.90	Very Low	1	13.60	Very Low	1	1.59	Very Low
WLR	000	000	25740	26023	0.2929	0.2852	0.4219	WLR000000025740	0.61	Low	3	8.90	Very Low	1	13.60	Very Low	1	1.59	Very Low
WLR	000	000	26023	26150	0.2929	0.2852	0.4219	WLR000000026023	6.02	Moderate	5	8.90	Very Low	1	13.60	Very Low	1	2.17	Low
WLR	000	000	26150	26240	0.2929	0.2852	0.4219	WLR000000026150	6.02	Moderate	5	8.90	Very Low	1	36.70	Low	3	3.02	Low
WLR	000	000	26240	26690	0.2929	0.2852	0.4219	WLR000000026240	6.02	Moderate	5	2.40	Very Low	1	36.70	Low	3	3.02	Low
WLR	000	000	26690	28041	0.2929	0.2852	0.4219	WLR000000026690	6.02	Moderate	5	1.60	Very Low	1	36.70	Low	3	3.02	Low
WLR	000	000	28041	28465	0.2929	0.2852	0.4219	WLR000000028041	6.02	Moderate	5	1.60	Very Low	1	36.70	Low	3	3.02	Low
WLR	000	000	28465	28780	0.2929	0.2852	0.4219	WLR000000028465	6.02	Moderate	5	5.70	Very Low	1	36.70	Low	3	3.02	Low
WLR	000	000	28780	30157	0.3052	0.2782	0.4165	WLR000000028780	6.02	Moderate	5	5.70	Very Low	1	36.70	Low	3	3.05	Low
WLR	000	000	30157	31811	0.3052	0.2782	0.4165	WLR000000030157	0.00	Very Low	1	5.70	Very Low	1	36.70	Low	3	1.83	Very Low
WLR	000	000	31811	32093	0.3052	0.2782	0.4165	WLR000000031811	0.00	Very Low	1	4.90	Very Low	1	36.70	Low	3	1.83	Very Low
WLR	000	000	32093	34730	0.3052	0.2782	0.4165	WLR000000032093	0.00	Very Low	1	4.90	Very Low	1	36.70	Low	3	1.83	Very Low
WLR	HMP	000	0	865	0.2929	0.2852	0.4219	WLRHMP000000000	0.02	Low	3	3.20	Very Low	1	15.80	Very Low	1	1.59	Very Low
WLR	HMP	000	865	1994	0.2929	0.2852	0.4219	WLRHMP000000865	0.02	Low	3	12.80	Low	3	15.80	Very Low	1	2.16	Low
WLR	HMP	000	1994	3290	0.2929	0.2852	0.4219	WLRHMP000001994	0.34	Low	3	12.80	Low	3	15.80	Very Low	1	2.16	Low
WLR	HMP	000	3290	3980	0.2929	0.2852	0.4219	WLRHMP000003290	0.34	Low	3	1.10	Very Low	1	15.80	Very Low	1	1.59	Very Low
WLR	HMP	000	3980	4854	0.2929	0.2852	0.4219	WLRHMP000003980	0.23	Low	3	1.10	Very Low	1	15.80	Very Low	1	1.59	Very Low
WMS	000	000	0	2380	0.2894	0.2962	0.4144	WMS000000000000	0.00	Very Low	1	12.90	Low	3	32.70	Low	3	2.42	Low
WMS	000	000	2380	3280	0.2894	0.2962	0.4144	WMS000000002380	0.00	Very Low	1	14.30	Low	3	32.70	Low	3	2.42	Low
WMS	000	000	3280	4400	0.2894	0.2962	0.4144	WMS000000003280	0.00	Very Low	1	38.40	High	7	32.70	Low	3	3.61	Low
WMS	000	000	4400	6040	0.2894	0.2962	0.4144	WMS000000004400	0.00	Very Low	1	38.40	High	7	32.70	Low	3	3.61	Low
WMS	000	000	6040	8240	0.2894	0.2962	0.4144	WMS000000006040	0.56	Low	3	38.40	High	7	32.70	Low	3	4.18	Moderate
WMS	000	000	8240	9800	0.2894	0.2962	0.4144	WMS000000008240	0.00	Very Low	1	38.40	High	7	32.70	Low	3	3.61	Low
WMS	000	000	9800	11800	0.2894	0.2962	0.4144	WMS000000009800	0.00	Very Low	1	38.40	High	7	32.70	Low	3	3.61	Low
WMS	000	000	11800	13950	0.2894	0.2962	0.4144	WMS000000011800	0.00	Very Low	1	38.40	High	7	32.70	Low	3	3.61	Low
WMS	000	000	13950	15700	0.2894	0.2962	0.4144	WMS000000013950	0.16	Low	3	38.40	High	7	32.70	Low	3	4.18	Moderate
WMS	000	000	15700	15900	0.2894	0.2962	0.4144	WMS000000015700	0.16	Low	3	14.20	Low	3	32.70	Low	3	3.00	Low
WMS	000	000	15900	16000	0.2894	0.2962	0.4144	WMS000000015900	20.36	Very High	9	14.20	Low	3	32.70	Low	3	4.74	Moderate
WMS	000	000	16000	17900	0.2894	0.2962	0.4144	WMS000000016000	20.36	Very High	9	14.20	Low	3	32.90	Low	3	4.74	Moderate
WMS	000	000	17900	18430	0.2894	0.2962	0.4144	WMS000000017900	20.36	Very High	9	19.70	Low	3	32.90	Low	3	4.74	Moderate
WMS	000	000	18430	20350	0.2894	0.2962	0.4144	WMS000000018430	0.91	Low	3	19.70	Low	3	32.90	Low	3	3.00	Low
WMS	000	000	20350	21870	0.2894	0.2962	0.4144	WMS000000020350	0.01	Low	3	19.70	Low	3	32.90	Low	3	3.00	Low
WMS	000	000	21870	23950	0.2894	0.2962	0.4144	WMS000000021870	0.29	Low	3	19.70	Low	3	32.90	Low	3	3.00	Low
WMS	000	000	23950	25900	0.2894	0.2962	0.4144	WMS000000023950	0.01	Low	3	19.70	Low	3	32.90	Low	3	3.00	Low
WMS	000	000	25900	27330	0.2894	0.2962	0.4144	WMS000000025900	0.36	Low	3	19.70	Low	3	32.90	Low	3	3.00	Low
WMS	000	000	27330	28230	0.2894	0.2962	0.4144	WMS000000027330	0.36	Low	3	19.70	Low	3	61.60	High	7	4.66	Moderate
WMS	000	000	28230	30140	0.2894	0.2962	0.4144	WMS000000028230	0.00	Very Low	1	19.70	Low	3	61.60	High	7	4.08	Moderate
WMS	000	000	30140	32160	0.2894	0.2962	0.4144	WMS000000030140	5.10	Moderate	5	4.10	Very Low	1	61.60	High	7	4.64	Moderate
WMS	000	000	32160	32360	0.2894	0.2962	0.4144	WMS000000032160	5.10	Moderate	5	12.90	Low	3	61.60	High	7	5.24	Moderate
WMS	000	000	32360	34210	0.2894	0.2962	0.4144	WMS000000032360	2.17	Low	3	12.90	Low	3	61.60	High	7	4.66	Moderate
WMS	000	000	34210	36000	0.2894	0.2962	0.4144	WMS000000034210	4.15	Low	3	12.90	Low	3	61.60	High	7	4.66	Moderate
WMS	000	000	36000	36350	0.2894	0.2962	0.4144	WMS000000036000	4.15	Low	3	12.80	Low	3	61.60	High	7	4.66	Moderate
WMS	000	000	36350	38325	0.2894	0.2962	0.4144	WMS000000036350	2.08	Low	3	12.80	Low	3	61.60	High	7	4.66	Moderate
WMS	000	000	38325	40375	0.2894	0.2962	0.4144	WMS000000038325	0.27	Low	3	12.80	Low	3	61.60	High	7	4.66	Moderate

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	FC Final Wt	EC Final Wt	WQ Final Wt	IS Reach ID	Final FC Problem Score	FC Narrative Rating	FC Rank Score	Final EC Problem Score	EC Narrative Rating	EC Rank Score	Final WQ Problem Score	WQ Narrative Rating	WQ Rank Score	Integrated Score	IS Narrative Rating
WMS	000	000	40375	42220	0.2894	0.2962	0.4144	WMS000000040375	0.94	Low	3	12.80	Low	3	61.60	High	7	4.66	Moderate
WMS	000	000	42220	44230	0.2894	0.2962	0.4144	WMS000000042220	9.97	Moderate	5	12.80	Low	3	61.60	High	7	5.24	Moderate
WMS	000	000	44230	46000	0.2894	0.2962	0.4144	WMS000000044230	1.02	Low	3	12.80	Low	3	61.60	High	7	4.66	Moderate
WMS	000	000	46000	46090	0.2894	0.2962	0.4144	WMS000000046000	1.02	Low	3	12.80	Low	3	61.60	High	7	4.66	Moderate
WMS	000	000	46090	48090	0.2894	0.2962	0.4144	WMS000000046090	5.92	Moderate	5	12.80	Low	3	61.60	High	7	5.24	Moderate
WMS	000	000	48090	49660	0.2894	0.2962	0.4144	WMS000000048090	14.27	High	7	12.80	Low	3	61.60	High	7	5.82	Moderate
WMS	000	000	49660	50250	0.2894	0.2962	0.4144	WMS000000049660	14.27	High	7	33.30	High	7	61.60	High	7	7.00	High
WMS	000	000	50250	52150	0.2894	0.2962	0.4144	WMS000000050250	5.05	Moderate	5	33.30	High	7	61.60	High	7	6.42	High
WMS	000	000	52150	52740	0.2894	0.2962	0.4144	WMS000000052150	23.33	Very High	9	33.30	High	7	61.60	High	7	7.58	High
WMS	000	000	52740	54160	0.3052	0.2879	0.4069	WMS000000052740	23.28	Very High	9	33.30	High	7	61.60	High	7	7.61	High
WMS	000	000	54160	55560	0.3052	0.2879	0.4069	WMS000000054160	1.12	Low	3	33.30	High	7	61.60	High	7	5.78	Moderate
WMS	000	000	55560	56210	0.3052	0.2879	0.4069	WMS000000055560	1.12	Low	3	5.00	Very Low	1	61.60	High	7	4.05	Moderate
WMS	000	000	56210	58220	0.3052	0.2879	0.4069	WMS000000056210	0.00	Very Low	1	5.00	Very Low	1	61.60	High	7	3.44	Low
WMS	000	000	58220	60182	0.3052	0.2879	0.4069	WMS000000058220	0.00	Very Low	1	5.00	Very Low	1	61.60	High	7	3.44	Low
WMS	000	000	60182	62130	0.3052	0.2879	0.4069	WMS000000060182	0.16	Low	3	5.00	Very Low	1	61.60	High	7	4.05	Moderate
WMS	000	000	62130	64120	0.3052	0.2879	0.4069	WMS000000062130	0.00	Very Low	1	5.00	Very Low	1	61.60	High	7	3.44	Low
WMS	000	000	64120	65900	0.3052	0.2879	0.4069	WMS000000064120	0.07	Low	3	5.00	Very Low	1	61.60	High	7	4.05	Moderate
WMS	000	000	65900	68150	0.3052	0.2879	0.4069	WMS000000065900	0.79	Low	3	5.00	Very Low	1	61.60	High	7	4.05	Moderate
WMS	000	000	68150	70070	0.3052	0.2879	0.4069	WMS000000068150	1.15	Low	3	5.00	Very Low	1	61.60	High	7	4.05	Moderate
WMS	000	000	70070	71740	0.3052	0.2879	0.4069	WMS000000070070	0.90	Low	3	5.00	Very Low	1	61.60	High	7	4.05	Moderate
WMS	000	000	71740	73850	0.3052	0.2879	0.4069	WMS000000071740	13.95	High	7	5.00	Very Low	1	61.60	High	7	5.27	Moderate
WMS	000	000	73850	73990	0.3052	0.2879	0.4069	WMS000000073850	13.95	High	7	5.00	Very Low	1	32.90	Low	3	3.65	Low
WMS	000	000	73990	74770	0.3052	0.2879	0.4069	WMS000000073990	9.72	Moderate	5	5.00	Very Low	1	32.90	Low	3	3.03	Low
WMS	000	000	74770	75020	0.3081	0.2809	0.4110	WMS000000074770	9.98	Moderate	5	5.00	Very Low	1	32.90	Low	3	3.05	Low
WMS	000	000	75020	76000	0.3081	0.2809	0.4110	WMS000000075020	9.98	Moderate	5	8.90	Very Low	1	32.90	Low	3	3.05	Low
WMS	000	000	76000	77950	0.3081	0.2809	0.4110	WMS000000076000	9.31	Moderate	5	8.90	Very Low	1	32.90	Low	3	3.05	Low
WMS	000	000	77950	79690	0.3081	0.2809	0.4110	WMS000000077950	2.33	Low	3	8.90	Very Low	1	32.90	Low	3	2.44	Low
WMS	000	000	79690	82030	0.3081	0.2809	0.4110	WMS000000079690	0.04	Low	3	8.90	Very Low	1	32.90	Low	3	2.44	Low
WMS	000	000	82030	83600	0.3081	0.2809	0.4110	WMS000000082030	0.46	Low	3	13.30	Low	3	32.90	Low	3	3.00	Low
WMS	000	000	83600	83790	0.3081	0.2809	0.4110	WMS000000083600	0.46	Low	3	13.30	Low	3	37.70	Low	3	3.00	Low
WMS	000	000	83790	85850	0.3081	0.2809	0.4110	WMS000000083790	1.21	Low	3	13.30	Low	3	37.70	Low	3	3.00	Low
WMS	000	000	85850	86950	0.3081	0.2809	0.4110	WMS000000085850	0.48	Low	3	13.30	Low	3	37.70	Low	3	3.00	Low
WMS	000	000	86950	88090	0.3081	0.2809	0.4110	WMS000000086950	0.48	Low	3	13.30	Low	3	37.70	Low	3	3.00	Low
WMS	000	000	88090	90100	0.3081	0.2809	0.4110	WMS000000088090	0.00	Very Low	1	13.30	Low	3	37.70	Low	3	2.38	Low
WMS	000	000	90100	92570	0.3081	0.2809	0.4110	WMS000000090100	0.00	Very Low	1	13.30	Low	3	37.70	Low	3	2.38	Low
WMS	000	000	92570	93000	0.3081	0.2809	0.4110	WMS000000092570	0.00	Very Low	1	13.30	Low	3	37.70	Low	3	2.38	Low
WMS	000	000	93000	98000	0.3081	0.2809	0.4110	WMS000000093000	0.00	Very Low	1	13.30	Low	3	28.80	Low	3	2.38	Low
WMS	CCK	000	0	1982	0.2894	0.2962	0.4144	WMSCCK000000000	0.00	Very Low	1	16.20	Low	3	61.60	High	7	4.08	Moderate
WMS	CCK	000	1982	4053	0.2894	0.2962	0.4144	WMSCCK000001982	0.63	Low	3	16.20	Low	3	61.60	High	7	4.66	Moderate
WMS	CCK	000	4053	6041	0.2894	0.2962	0.4144	WMSCCK000004053	0.98	Low	3	16.20	Low	3	61.60	High	7	4.66	Moderate
WMS	CCK	000	6041	8001	0.2894	0.2962	0.4144	WMSCCK000006041	0.00	Very Low	1	16.20	Low	3	61.60	High	7	4.08	Moderate
WMS	CCK	000	8001	8980	0.2894	0.2962	0.4144	WMSCCK000008001	0.10	Low	3	16.20	Low	3	61.60	High	7	4.66	Moderate
WMS	CCK	000	8980	10531	0.2894	0.2962	0.4144	WMSCCK000008980	0.10	Low	3	16.20	Low	3	61.60	High	7	4.66	Moderate
WMS	KIN	000	0	2100	0.3052	0.2879	0.4069	WMSKIN000000000	0.22	Low	3	3.90	Very Low	1	61.60	High	7	4.05	Moderate
WMS	KIN	000	2100	3990	0.3052	0.2879	0.4069	WMSKIN000002100	3.53	Low	3	3.90	Very Low	1	61.60	High	7	4.05	Moderate
WMS	KIN	000	3990	6060	0.3052	0.2879	0.4069	WMSKIN000003990	5.28	Moderate	5	3.90	Very Low	1	61.60	High	7	4.66	Moderate
WMS	KIN	000	6060	7875	0.3052	0.2879	0.4069	WMSKIN000006060	0.30	Low	3	3.90	Very Low	1	61.60	High	7	4.05	Moderate
WMS	KIN	000	7875	9395	0.3052	0.2879	0.4069	WMSKIN000007875	0.83	Low	3	3.90	Very Low	1	61.60	High	7	4.05	Moderate
WMS	KIN	000	9395	12285	0.3052	0.2879	0.4069	WMSKIN000009395	8.98	Moderate	5	3.90	Very Low	1	61.60	High	7	4.66	Moderate
WMS	KIN	000	12285	13400	0.3052	0.2879	0.4069	WMSKIN000012285	8.99	Moderate	5	3.90	Very Low	1	61.60	High	7	4.66	Moderate
WMS	KIN	000	13400	14055	0.3052	0.2879	0.4069	WMSKIN000013400	8.99	Moderate	5	2.20	Very Low	1	61.60	High	7	4.66	Moderate
WMS	KIN	000	14055	16115	0.3052	0.2879	0.4069	WMSKIN000014055	5.74	Moderate	5	2.20	Very Low	1	61.60	High	7	4.66	Moderate
WMS	KIN	000	16115	17905	0.3052	0.2879	0.4069	WMSKIN000016115	0.00	Very Low	1	2.20	Very Low	1	61.60	High	7	3.44	Low
WMS	KIN	000	17905	19870	0.3052	0.2879	0.4069	WMSKIN000017905	0.00	Very Low	1	2.20	Very Low	1	61.60	High	7	3.44	Low

Table B - 4
Master Plan Problem Area Assessment Integrated Scores (98 Methodology)

Watershed	Level 1 Trib	Level 2 Trib	Station ID	Reach End	FC Final Wt	EC Final Wt	WQ Final Wt	IS Reach ID	Final FC Problem Score	FC Narrative Rating	FC Rank Score	Final EC Problem Score	EC Narrative Rating	EC Rank Score	Final WQ Problem Score	WQ Narrative Rating	WQ Rank Score	Integrated Score	IS Narrative Rating
WMS	KIN	000	19870	21200	0.3052	0.2879	0.4069	WMSKIN000019870	2.93	Low	3	2.20	Very Low	1	61.60	High	7	4.05	Moderate
WMS	KIN	000	21200	21940	0.3052	0.2879	0.4069	WMSKIN000021200	2.93	Low	3	2.20	Very Low	1	61.60	High	7	4.05	Moderate
WMS	KIN	000	21940	23940	0.3052	0.2879	0.4069	WMSKIN000021940	0.00	Very Low	1	2.20	Very Low	1	61.60	High	7	3.44	Low
WMS	KIN	000	23940	25950	0.3052	0.2879	0.4069	WMSKIN000023940	0.00	Very Low	1	2.20	Very Low	1	61.60	High	7	3.44	Low
WMS	KIN	000	25950	27770	0.3052	0.2879	0.4069	WMSKIN000025950	0.00	Very Low	1	2.20	Very Low	1	61.60	High	7	3.44	Low
WMS	KIN	WHL	0	1950	0.3081	0.2809	0.4110	WMSKINWHL000000	0.00	Very Low	1	2.20	Very Low	1	61.60	High	7	3.47	Low
WMS	KIN	WHL	1950	3505	0.3081	0.2809	0.4110	WMSKINWHL001950	0.00	Very Low	1	2.20	Very Low	1	61.60	High	7	3.47	Low
WMS	KIN	WHL	3505	4762	0.3081	0.2809	0.4110	WMSKINWHL003505	0.00	Very Low	1	2.20	Very Low	1	61.60	High	7	3.47	Low
WMS	MOT	000	0	1760	0.3081	0.2809	0.4110	WMSMOT000000000	0.00	Very Low	1	1.80	Very Low	1	32.90	Low	3	1.82	Very Low
WMS	MOT	000	1760	2000	0.3081	0.2809	0.4110	WMSMOT000001760	0.00	Very Low	1	1.80	Very Low	1	32.90	Low	3	1.82	Very Low
WMS	MOT	000	2000	4050	0.3081	0.2809	0.4110	WMSMOT000002000	0.00	Very Low	1	1.80	Very Low	1	32.90	Low	3	1.82	Very Low
WMS	MOT	000	4050	5295	0.3081	0.2809	0.4110	WMSMOT000004050	0.00	Very Low	1	1.80	Very Low	1	32.90	Low	3	1.82	Very Low
WMS	PLH	000	0	2000	0.2894	0.2962	0.4144	WMSPLH000000000	0.00	Very Low	1	19.80	Low	3	32.90	Low	3	2.42	Low
WMS	PLH	000	2000	4220	0.2894	0.2962	0.4144	WMSPLH000002000	0.03	Low	3	19.80	Low	3	32.90	Low	3	3.00	Low
WMS	SBK	000	0	2048	0.3081	0.2809	0.4110	WMSSBK000000000	2.37	Low	3	13.30	Low	3	32.90	Low	3	3.00	Low
WMS	SBK	000	2048	4000	0.3081	0.2809	0.4110	WMSSBK000002048	3.95	Low	3	13.30	Low	3	32.90	Low	3	3.00	Low
WMS	SBK	000	4000	6014	0.3081	0.2809	0.4110	WMSSBK000004000	0.46	Low	3	13.30	Low	3	32.90	Low	3	3.00	Low
WMS	SBK	000	6014	6880	0.3081	0.2809	0.4110	WMSSBK000006014	0.03	Low	3	13.30	Low	3	32.90	Low	3	3.00	Low
WMS	SNV	000	0	2260	0.2894	0.2962	0.4144	WMSSNV000000000	15.28	High	7	11.20	Low	3	61.60	High	7	5.82	Moderate
WMS	SNV	000	2260	4060	0.3081	0.2809	0.4110	WMSSNV000002260	10.91	High	7	11.20	Low	3	61.60	High	7	5.88	Moderate
WMS	SNV	000	4060	5950	0.3081	0.2809	0.4110	WMSSNV000004060	3.80	Low	3	11.20	Low	3	61.60	High	7	4.64	Moderate
WMS	SNV	000	5950	7940	0.3081	0.2809	0.4110	WMSSNV000005950	0.00	Very Low	1	11.20	Low	3	61.60	High	7	4.03	Moderate
WMS	SNV	000	7940	8790	0.3081	0.2809	0.4110	WMSSNV000007940	0.00	Very Low	1	11.20	Low	3	61.60	High	7	4.03	Moderate
WMS	SNV	000	8790	9000	0.3081	0.2809	0.4110	WMSSNV000008790	0.00	Very Low	1	11.20	Low	3	61.60	High	7	4.03	Moderate
WMS	STE	000	0	2000	0.2894	0.2962	0.4144	WMSSTE000000000	0.00	Very Low	1	53.70	Very High	9	32.70	Low	3	4.20	Moderate

APPENDIX C

Board and Commission Actions

Master Plan Citizen's Advisory Group Recommendations

Environmental Board Motion

Parks and Recreation Department Board Meeting Minutes

Planning Commission Annotated Agenda

Master Plan Citizen's Advisory Group

The Watershed Protection Department Master Plan Citizens Advisory Group highly commends the City staff and consultants for their hard work in compiling data, evaluating project solutions and procedures, and making recommendations. The WPD Master Plan speaks for itself -- the City is in great need of this plan to help prioritize our various needs. The Plan clearly shows that the City must aggressively pursue funding, and implement a timeframe to handle the highest priority sites. The longer problem areas remain uncorrected, the higher the eventual cost and the greater the negative impact to the natural character of the 'Creeks.

We have reviewed the Executive Summary and have discussed it with staff, especially the findings and recommendations. We have also heard the comments and concerns of citizens at the public hearing and have included them in our considerations. The Citizens Advisory Group supports the staff findings and recommendations. Because we want the Master Plan to be a living document, we would like to emphasize the importance of pursuing an integrated and aggressive implementation plan. It is in this context that we propose additional recommendations. ***With the inclusion of these additional recommendations the Citizens Advisory Group strongly urges that the City Council adopt the Watershed Protection Master Plan and that the City Manager be instructed that pursuit of its implementation is a high Council priority.***

1. Implementation:
   - 1.1. Identify an initial 5 -year (of the total projected) implementation program in the areas of capital solutions, program enhancements, and regulatory modification.
   - 1.2. Present a preliminary 5-year implementation timetable to the Environmental Board. Report biannually on the status of implementation per the 5-year plan to the Environmental Board.
   - 1.3. Continue to incorporate new data and modify the program of implementation appropriately.
   - 1.4. Continue to refine our land use projections.
   - 1.5. Aggressively pursue retrofits for water quality.
   - 1.6. Expand master planning efforts beyond the Phase I watersheds as soon as possible. Begin developing and identifying priority areas considering what is already known from existing problems and expected development.

2. Funding:
   - 2.1. Develop short and long-range funding proposals to support solution implementation.
   - 2.2. Continue to evaluate the Drainage Utility fee to see if it is adequate for full program funding,
   - 2.3. Actively pursue funding with multiple governmental agencies.
   - 2.4. Characterize past and potential future watershed protection funding sources. List funding options.
   - 2.5. Aggressively pursue funding to upgrade infrastructure storm sewer systems.

3. Advocacy:
   - 3.1. Encourage the Environmental Board to act as an advocate to get projects funded and implemented.
   - 3.2. Develop a plan to seek community leaders who have been educated about the plan and funding issues who will act as advocates and educate citizenry.
   - 3.3. Continue support for the Citizens' Advisory Group to monitor the implementation of Phase I and the development of Phase II.
   - 3.4. Since the Environmental Officer is, by ordinance, strongly dedicated to the goals of protecting the environment, the Environmental Officer should have additional duties related to the better implementation of the Master Plan:

3.4.1. Develop a plan to optimize City departmental relationships by cooperating to protect the environment (i.e., Public utilities, Water/Wastewater and Tree Protection staff)
3.4.2. Continue to enforce strict compliance with preventive regulatory approaches.
3.4.3. Aggressively pursue the proposed regulatory modifications (Executive Summary, pages 46 and 47).

4. Public Information:
   4.1. Develop a community education program for all Drainage Utility customers so that they know they have been heard.
   4.2. Provide the Master Plan Executive Summary to all appropriate City boards and commissions, other City departments, other governmental agencies, neighborhood associations, and neighborhood master planning groups so that they can incorporate Master Planning concepts in making decisions that affect the watersheds.

Mary Arnold, Chair	L.G. "Skip" Cameron	Hong Guo, P.E.
Dr. Sterling Lands	Craig Smith	Michael Barrett, P.E.
Joyce Conner	Tim Jones	Tom Shefelman, AIA

Michael Barrett, Ph.D., P.E. phone (512) 471-0935
Center for Research in Water Resources fax (512) 471-0072
PRC Building 119
The University of Texas at Austin
Austin, TX 78712

I am generally supportive of the overall goals and objectives described in the Watershed Master Plan; however, I do have a couple of concerns.

1. The overall budget for the effort may be too large. If I had an additional $800M to spend to improve the quality of life in Austin, I might prefer that a significant portion be dedicated to improved mobility (not just roads, but sidewalks and bike paths as well) or to parks for instance.

2. I have a long-term vision of turning the urban creeks into greenbelts, which could provide alternative transportation corridors (for pedestrians and bicyclists) as well as recreational opportunities. Unfortunately, much of the property adjacent to the creeks is in private hands. Many of these property owners deny access to the creeks by the public, yet they are more than happy to request public money to protect their property from erosion. Consequently, I believe the City should obtain an easement along the creek from property owners in exchange for using taxpayers dollars to stabilize their backyards.

-

Michael Wilson

Mr. Wilson suggested several changes to the recommendations. Of the ones he suggested, the following recommendations were not made because the original language had already been approved by the majority of the Advisory Group and because the language changed the meaning of what already been approved.

"We have also heard the comments and concerns of citizens at the public bearing and have included them in [our considerations - **delete) (insert** - the following recommendations).

***With the inclusion of these additional recommendations the Advisory Group strongly urge that the City Council adopt the Watershed Protection Master Plan land that the City Manager be instructed that pursuit of its implementation is a high Council priority* - delete].**

1.2 [Present preliminary 5-year implementation timetable to the Environmental Board. Report biannually on the status of implementation per the 5-year plan to the Environmental Board - **delete].**

2.4 [List funding options - **delete].**

3.1 [Encourage the Environmental Board to act as an advocate to get projects funded and implemented **-delete].**

3.2 [Develop a plan to - delete] **(insert** - The city Council of Austin should actively) seek community leaders who have been educated about the plan and funding issues who will act as advocates and educate citizenry.

3.3 [Continue support for the Citizens' Advisory Group to monitor the implementation of Phase I and the development of Phase II - **delete].**

3.4 [Since the Environmental Officer is, by ordinance, strongly dedicated to the goals of protecting the environment, the Environmental Officer should have additional duties related to the better implementation of the Master Plan: - **delete]**
- 3.4.1 [Develop a plan to optimize City departmental relationships by cooperating to protect the environment (i.e., Public utilities, Water/Wastewater and Tree Protection staff) - **delete]**
- 3.4.2 [Continue to enforce strict compliance with preventive regulatory approaches - **delete].**
- 3.4.3 [Aggressively pursue the proposed regulatory modifications (Executive Summary, paces 46 and 47)- **delete].**

4.2 Provide **(insert -** Make available,) the Master Plan to all City boards and commissions, other City departments, other governmental agencies, neighborhood associations, and neighborhood master planning groups so that **they** [can - **delete] (insert -** have the opportunity to) incorporate Master Planning concepts in making decisions that **(insert -** may) affect the watersheds.

ENVIRONMENTAL BOARD MOTION 022101-B1

Date: February 21, 2001

Subject: Watershed Protection Department Master Plan Recommendations
Motioned By: Joyce Conner Seconded By: Phil Moncada

The Environmental Board strongly recommends adoption of the Watershed Protection Master Plan with the inclusion of additional recommendations developed jointly by the Watershed Protection Department Citizens Advisory Group and the Environmental Board Master Plan subcommittee. Further, the Environmental Board urges Council to instruct the City Manager that pursuit of the Master Plan implementation is a high Council priority.

The Board also wishes to recognize the years of effort on the part of the WPD Master Plan Citizens Advisory Group and to highly commend the City staff and consultants for their ongoing hard work compiling data, evaluating project solutions and procedures, and making recommendations. The Board and the Citizens Advisory Group held a public hearing on the plan on February 7, 2001. The concerns voiced by citizens at this hearing were also given consideration in developing the recommendation of the Citizens Advisory Group to the Board.

The Watershed Protection Master Plan clearly shows that the City is in great need of this plan to help prioritize our various needs, and that the City should aggressively pursue funding to correct the highest priority watershed problems on a timely basis. The longer problem areas remain uncorrected, the higher the eventual cost and the greater the adverse impact on the natural character of the creeks.

The recommendations of the Citizens Advisory Group and the Environmental Board subcommittee that have been endorsed by the Environmental Board follow. Because we want the Master Plan to be a living document, we would like to emphasize the importance of pursuing an integrated and aggressive implementation plan.

1. Implementation:
   1.1. Identify an initial 5-year (of the total projected) implementation program in the areas of capital solutions, program enhancements, and regulatory modification.
   1.2. Present a preliminary 5-year implementation timetable to the Environmental Board. Report biannually on the status of implementation per the 5-year plan to the Environmental Board.

1.3. Continue to incorporate new data and modify the program of implementation appropriately.
1.4. Continue to refine our land use projections.
1.5. Aggressively pursue retrofits for water quality.
1.6. Expand master planning efforts beyond the Phase I watersheds as soon as possible. Begin developing and identifying priority areas considering what is already known from existing problems and expected development.

2. Funding:
   2.1. Develop short and long-range funding proposals to support solution implementation.
   2.2. Continue to evaluate the Drainage Utility fee to see if it is adequate for full program funding.
   2.3. Actively pursue funding with multiple governmental agencies.
   2.4. Characterize past and potential future watershed protection funding sources. List funding options.
   2.5. Aggressively pursue funding to upgrade infrastructure storm sewer systems.

3. Advocacy:
   3.1. Encourage the Environmental Board to act as an advocate to get projects funded and implemented.
   3.2. Develop a plan to seek community leaders who have been educated about the plan and funding issues who will act as advocates and educate citizenry.
   3.3. Continue support for the Citizens' Advisory Group to monitor the implementation of Phase I and the development of Phase II.
   3.4. Since the Environmental Officer is, by ordinance, strongly dedicated to the goals of protecting the environment, the Environmental Officer should have additional duties related to the better implementation of the Master Plan:
      3.4.1. Develop a plan to optimize City' departmental relationships by cooperating to protect the environment (i.e., Public utilities, Water/Wastewater and Tree Protection staff).
      3.4.2. Continue to enforce strict compliance with preventive regulatory Approaches.
      3.4.3. Aggressively pursue the proposed regulatory modifications (Executive Summary, pg 46 & 47).

4. Public Information:
   4.1. Develop a community education program for all Drainage Utility customers so' that they know they have been heard.
   4.2. Provide the Master Plan Executive Summary to all appropriate City boards and commissions, other City departments, other governmental agencies, neighborhood associations, and neighborhood master planning groups so that they can incorporate Master Planning concepts in making decisions that affect the watersheds.

Citizens Advisory Group Supporting Recommendations:

Mary Arnold, Chair	L.G. "Skip" Cameron	Hong Guo, P.E.
Tim Jones	Craig Smith	Tom Shefelman, AIA
Michael Barrett, P.E.	Dr. Sterling Lands	Joyce Conner

Vote: 7-0-0-1

For: Alvarez, Conner, Jones, Leffingwell, Moncada, Williams

Against: None

Abstain: None

Absent: Avery

Approved By:

Lee Leffingwell, Chair

Parks and Recreation Department Board
Minutes

March 13,2001
Regular Meeting

A regularly scheduled meeting of the Parks and Recreation Department Board was held on Tuesday, March 13, 2001 in the Board Room of the Parks and Recreation Department Main Office located at 200 South Lamar Blvd., Austin, Texas.

Board Members Present: Rosemary Castleberry, Mary Ruth Holder, Rocky Medrano, Clint Small, Jeff Francell, and Carol Kim.

Board Members Absent: Rhonda Taylor and Amy Babich

Staff Members Present: Stuart Strong, Juan Valera-Lema, Don Koehler, Cappy Manly, Kimberley Mitchell, Randy Scott and Dina Haines.

A. **MEETING CALLED TO ORDER** The meeting was called to order at 6:32 p.m. by Rosemary Castleberry, Chair.

B. **APPROVAL OF THE MINUTES**, February 27, 2001 meetings. **Board Member Francell** made the motion to approve the minutes as written. **Board Member Small** second the motion. **The Board was in favor 6-0-0.**

C. **PRESENTATIONS**
Dolores Duran, City of Austin Public Works Department spoke in regards to the Land Use Agreement and Permanent Slope Easement Related to Phase II and Phase III of the Loyola Lane Right of Way.
Jean Drew, City of Austin Watershed Protection Department gave a presentation to the board regarding the Watershed Protection Master Plan. (see attachment)

D. **CITIZEN COMMUNICATION**
John Nyfeler, Architect, Aquirre/Nyfeler spoke on his request to have the Lamar hike and bike pedestrian bridge named after James D. Pfluger, FAIA. Mr. James D. Pfluger, was the principal designer who worked with Lady Bird Johnson in the original creation of Town Lake Park. Mr. Pfluger was one of the architects who did the layout of the Town Lake hike and bike trail. Mr. Nyfeler said he has support from various associations and provided copies of letters of support.

Tom Evans spoke to the board regarding his concern of a developer's improper clearing of the Balcones Canyonland Preserves. The developer allegedly cut the locks on a city-installed gate on Kollimeyer Road and entered the property with a number of trucks, a bulldozer, a shredder and several chainsaws and cut a 700 foot long, 25 foot wide swath of land on BCP property. Mr. Evans stated his support for preserving the tract of land for the Golden-cheeked Warbler habitats.

Don Koehler, BCP Manager was present to answer questions. Mr. Koehler stated that although the developer has permission to enter upon proper circumstances, such as surveying, but not to clear property without proper pen-nits required by Watershed Protection Department.

Pam Murfin also spoke to the board with her concerns of the clearing through the BCP property. Ms. Murfin lives between Medway Ranch and Reicher Ranch. She informed the board of her intent to try to locate outside conservation buyers to purchase more land to secure for the Golden-cheek Warbler. She also encouraged the Parks Board to seek City Council support for more funding to purchase land.

Board Member Small left the meeting 6:58 p.m.

E. ITEMS FOR ACTION

1. Make a Recommendation to City Council regarding a Parkland Use Agreement and Permanent Slope Easement Related to Phase 11 and Phase III of the Loyola Lane Right of Way.

Dolores Duran, Project Manager with the Public Works Department gave a presentation to the board. The project consist of a land use agreement to construct a 20 to 30 foot wide slope easement along the full length of the Northeast Park southern boundary adjacent to Loyola Lane near Hwy 183. The Loyola Lane project from Hwy 183 to Decker Lane will improve the roadway from two lanes to four lanes, including bike lanes, sidewalks and drainage improvements. In the Colony Park and Northeast Park, the Public Works Department is also asking for temporary staging area permission to store materials for the project while under construction. **Board Member Holder** informed the board this item had been brought to the Land and Facilities committee meeting and would recommend to City Council the Parkland Use Agreement, Permanent Slope Easement and temporary staging area related to Phase II and Phase III of the Loyola Lane Right of Way improvements. **Board Member Medrano** seconded the motion. **The motion passed in favor 5-0-0.**

2. Make Recommendation to City Council Regarding the Watershed Protection Department Master Plan, Phase I Report.

Jean Drew, Master Plan Program Coordinator from the Watershed Protection Department gave a slide show presentation of the Watershed Protection Master Plan. The

Master Plan findings can be summarized generally as watershed problems are wide spread and are expectant to worsen if solutions are not implemented. To address these problems over 800 millions of capitol improvements have been identified and are needed to construct integrated watershed protection facilities including detention ponds, channel stabilization projects, flood, erosion and water quality controls. (Presentation Attached)

Board Member Holder stated this item was also brought to Land and Facilities committee meeting. Ms. Holder stated that in the Board Member's packet was the Environmental Board's Recommendation, which incorporated the citizen advisory group's recommendations. Ms. Holder felt the Parks Board should support these recommendations with the following addition: On page 2, in the Environmental Board Recommendation, Item 3, 3.4.1. entitled "develop a plan to optimize City departmental relationship by cooperation to protect the environment" (i.e. Public Utilities, Water/Wastewater and Tree Protection staff) the Parks and Recreation Department should be added to the list of departments. Ms. Holder also stated she believes Board members should be cautious about allowing the use of parklands and preserves as locations for city flood control and water quality projects because private development created the need for such projects and public lands should not have to bear all the burden of the effects of private development.

Board Member Francell made the motion to recommend to City Council the recommendations in the Environmental Board's recommendation with the addition of Parks and Recreation Department in item 3, 3.4. 1. **Board Member Medrano** seconded the motion. **The motion passed in favor 5-0-0.**

3 <u>Make Recommendation to City Council Regarding a Parkland Use for an ICG Communication Line to cross parkland near Drake Bridge</u>.

Stuart Strong stated the ICG Communications Company requested a license agreement to place an underground telecommunication line on parkland near the intersection of Cesar Chavez and the South First Street bridge. Telecommunications are permitted to place lines in rights of way without local approval.

The hike and bike trail would remain open and that the work will be completed within two evenings.

Board Member Holder made motion to recommend to City Council a Parkland Use Agreement for ICG Communication Line to cross parkland near Drake Bridge. **Board Member Kim** seconded the motion. The motion passed in favor 5-0-0,

4. <u>Make Recommendation to the Director Regarding the Dino Pit Exhibit at the Austin Nature and Science Center</u>.

CITY PLANNING COMMISSION
May 1, *2001* [ANNOTATED]
One Texas Center
505 Barton Springs Road
3rd Floor Conference Room

CALL TO ORDER - 6:00 P.M.
START. 6.OO P.M. ADJOURN. 11:25 PM

__A__ Jim Robertson
______ Dr. Sterling Lands
______ Robin Cravey Assist. Secretary
______ Silver Garza Chair
______ Jean Mather Secretary
______ Ben Heimsath
__A__ Lydia Ortiz Vice-Chair
______ Betty Baker Parliamentarian
______ Ray Vrudhula

ORDER OF PROCEDURE

1. Chair announces request.
2. Staff presents a summary of the case.
3. Chair calls on those FAVORING the request.
   a. Applicant's presentation (5 minutes).
   b. Others favoring the request (3 minutes).
4. Chair calls on those OPPOSING the request.
   a. Primary presentation (5 minutes).
   b. Others opposing the request (3 minutes).
5. Applicant is given opportunity to answer objections stated. (3 minutes)
6. Staff summation and questions from the Commission.
7. The public hearing on a zoning case may be closed and no further testimony is taken from the public.
8. If the public hearing is closed, the Commission shall make a recommendation to the City Council within 14 days or the case will be forwarded to the City Council without a recommendation. (Section 25-2-282)

All of the following items may be acted upon by one motion. The Commission does not consider items earlier than the time stated on the agenda; "Other Business" items can be taken at any time. After the posted time, the Commission Chairperson may announce the item and, if there is no opposition, the item may be taken "by consent" for approval without discussion.

CITIZENS WISHING TO SPEAK BEFORE THE COMMISSION MUST REGISTER BY SIGNING A LIST A T THE ENTRANCE.

Any interested party aggrieved by a decision of the Planning Commission on a Hill Country Site Plan Conditional Use Permit, Replacement Site Plan, or a Preliminary Subdivision Plan with an environmental variance may only appeal the Commission's decision to the City Council. The notice of appeal must be submitted in writing on a form **provided** by the Director of Watershed Protection and Development Review Department within fourteen (14) days following the decision of the Planning Commission.

POSTED: April 27, 2001 @: 4:00 P.M. FACILITATOR: David Wahlgren
PLANNING COMMISSION May 1, 2001 6:00P.M.

A. REGULAR AGENDA

EXECUTIVE SESSION (No public discussion)

The Planning Commission will announce it will go into Executive Session, if necessary, pursuant to Chapter 551 of the Texas Government Code, to receive advice from Legal Counsel on matters specifically listed on this agenda. The Planning Commission may also announce it will go into Executive Session, if necessary, to receive advice from Legal Counsel regarding any other item on this agenda.

Private Consultation with Attorney - Section 551.071

CITIZEN COMMUNICATION:

1. The first four (4) speakers signed up to speak will each be allowed a three-minute allotment to address their concerns.

SUSANA ALMANZA - OZONE DAYS
RAMON MALDONADO - SPANISH TRANSLATION FOR P. C MEETINGS

APPROVAL OF MINUTES

2. Approve Planning Commission minutes from April 17, 2001.

APPROVED BY CONSENT
[R.V, R.C 2nd] (7-0) L.O, J.R - ABSENT

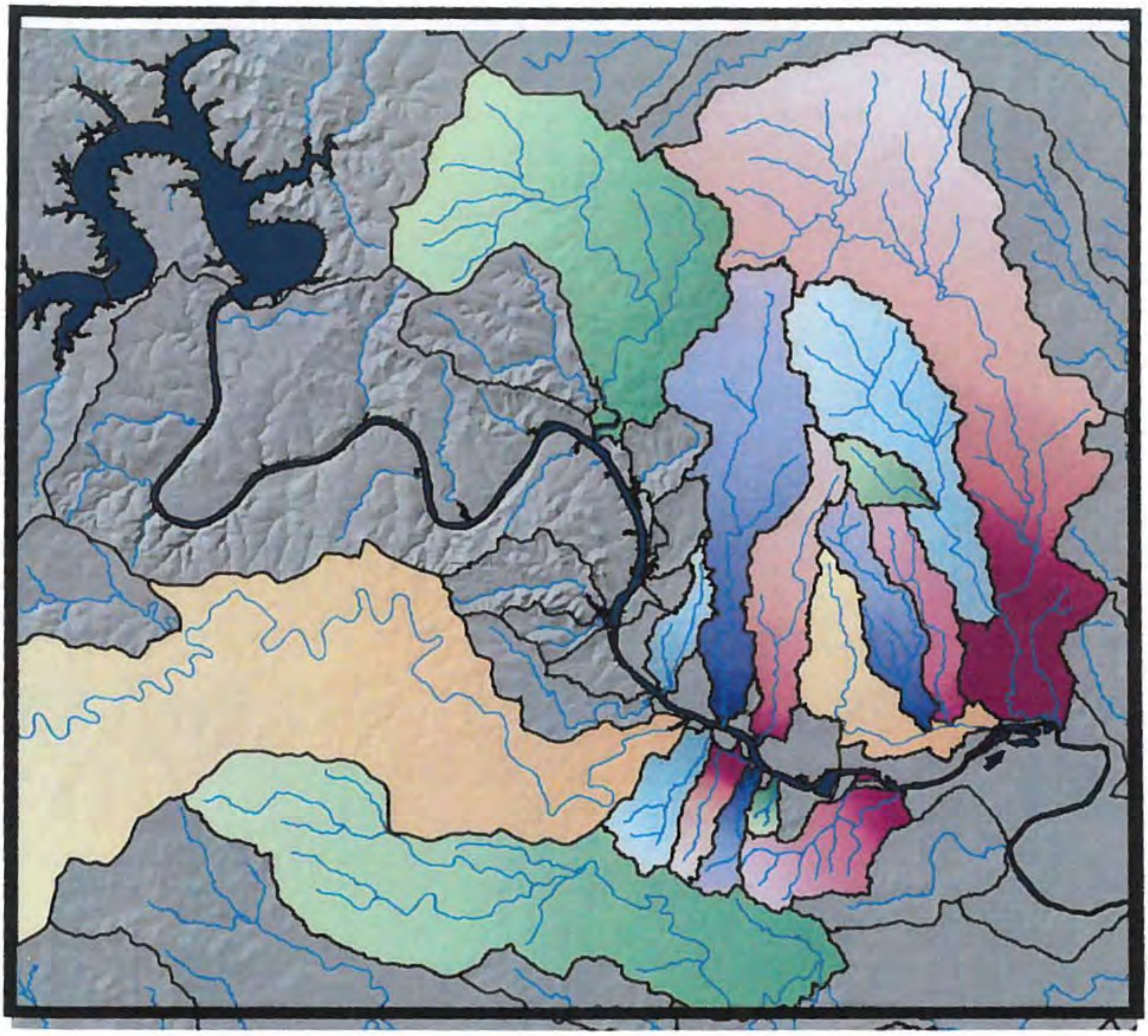
DISCUSSION AND ACTION

3. Discussion and action regarding the Watershed Protection Master Plan. **City Staff. Jean Drew, Watershed Protection and Development Review Department, 499-2272.**

   MOTION MADE TO ENDORSE THE WATERSHED MASTER PLAN TO THE COUNCIL, THAT IT BE ADOPTED AND CONSIDERED A STARTING POINT FOR MORE AGGRESSIVE EFFORT IN PROTECTING AND MANAGING THE CITY'S WATERSHEDS. ALSO TO ENDORSE AND INCLUDE ENVIRONMENTAL BOARD'S RECOMMENDATION DATED FEBRUARY 21, 2001.
   [R., J.M 2nd] (7- 0) L.0, J.R - ABSENT

WATERSHED PROTECTION MASTER PLAN

Phase I Watersheds Report



FLOOD • EROSION • WATER QUALITY

City of Austin
Watershed Protection Department

Watershed Protection

Watershed Protection Report Series
COA-WPD 2001-02

June 2001

Volume One

WATERSHED PROTECTION MASTER PLAN

Phase I Watersheds Report

Prepared by

City of Austin
Watershed Protection Department

Department Director

Michael J. Heitz, AIA

Assistant City Manager

Lisa Gordon

City Manager

Jesus Garza

Watershed Protection

City of Austin
Watershed Protection Department

Watershed Protection Report Series
COA-WPD 2001-02

June 2001

ACKNOWLEDGEMENTS

This report was prepared by the Watershed Protection Department under the general supervision of Michael J. Heitz, AIA, Department Director, and Jody Hamilton, Assistant to the Director. The information contained herein was developed through a coordinated effort of City staff, professional engineering consultant teams, and academic researchers.

The authors wish to especially recognize the valuable contributions of the following members of the Master Plan Citizens Advisory Group who patiently volunteered their time and expertise during the course of this effort.

Mary Arnold	Dorothy Limon
Michael Barrett, P.E.	Melinda Luna, P.E.
L.G. "Skip" Cameron	Letesia Cantu McGarrahan
Joyce Conner	Andy Rooke, P.E.
Lee Dawson	Tom Shefelman, AIA
Donald Dodson	Raymond Slade
Hong Guo, P.E.	Craig Smith
Tim Jones	Emmit Spears, Jr.
Anjali Kaul	Michael Wilson
Dr. Sterling Lands	

The authors also wish to thank the numerous current and former Watershed Protection Department staff members who, in addition to performing their regular work responsibilities, dedicated significant amounts of time and energy to this project. This includes staff from the Office of the Director, Environmental Resources Management Division, Environmental Review and Inspection Division, and Watershed Engineering Division and Field Operations Division.

ACKNOWLEDGEMENTS

Master Plan Contributor*	**Product/ Service**
Camp Dresser & McKee, Inc.	– Flood Prioritization GIS Application – General Technical Assistance
Carter & Burgess, Inc.	– Flooded Structure Database, Surveying
Center for Research In Water Resources (Univ. of Texas at Austin)	– Pollutant Load GIS Model
City of Austin Infrastructure Support Services	– Structure Flooding GIS Application
Loomis Austin, Inc.	– Flood Model Conversions – Integrated Solutions Development
Raymond Chan & Associates	– Erosion Technical Assessments

*Project team leaders only are shown.

Other City Departments provided data or input including Parks and Recreation Department, Public Works Department, Transportation Planning and Design Department, Law Department, Public Information Office, Neighborhood Planning and Zoning Department, and the Office of Neighborhood Services.

Due to the magnitude of this project, some Master Plan contributors may inadvertently not be acknowledged herein. The authors apologize for and will correct any omissions in subsequent Master Plan documents.

Contents

Tables

Figures

Executive Summary

Overview

The mission of the Watershed Protection Department (WPD) is to reduce the impact of flooding, erosion and water pollution on our community in order to protect lives, property and the environment. To accomplish this mission, WPD completed Phase I of a Watershed Protection Master Plan to better prioritize service needs and refine program direction.

The Master Plan inventories existing watershed problems and gauges the impact of future urbanization in seventeen (17) watersheds – including all of the urban watersheds and five surrounding non-urban watersheds:

Urban		NonUrban
Blunn (BLU)	Johnson (JOH)	Barton (BAR)
Boggy (BOG)	Little Walnut (LWA)	Bull (BUL)
Buttermilk (BMK)	Shoal (SHL)	Country Club (CNT)
East Bouldin (EBO)	Tannehill (TAN)	Walnut (WLN)
Fort Branch (FOR)	Waller (WLR)	Williamson (WMS)
Harper's Branch (HRP)	West Bouldin (WBO)	

Phase I studies helped to locate and prioritize problem areas where watershed protection goals and objectives are not currently being met or are not expected to be met in the future. These studies are categorized by mission as creek flooding, localized flooding, streambank erosion and water quality degradation. Integrated problem areas were determined by overlaying the results of the individual mission studies to identify areas of concurrent flooding, erosion and water quality problems. Integrated problem areas demonstrate an increased need for multi-purpose solutions.

These studies determined that watershed problems are widespread and will worsen if corrective action is not taken. Creek flooding poses a recurring citywide risk to public safety and property. For example, a relatively small 2-year storm creates structure flooding in 14 of the 17 Phase I watersheds. Localized flooding also threatens property across the City due to undersized, deteriorated, clogged or inadequate storm drain systems. Over 4000 localized flooding complaints have been logged over the last ten years. New erosion data identifies numerous existing threats to property with nearly 500 sites currently threatened. Increased stormflows from urban development have accelerated streambank erosion, leading to enlarged and unstable creek channels. Water quality studies document the fact that urbanization has led to the degradation of our urban creeks and receiving waters. Future development is predicted to continue the trend of degrading habitat and creek biology and increasing pollutant levels in local surface waters.

The Master Plan identifies opportunities for optimizing existing resources through improved prioritization, mission integration and a renewed commitment to the use of environmentally responsible, cost-effective and sustainable solutions. Problem priorities were established based on the severity of the identified problem at each location and the number and type of affected community resources (such as homes, roadways and receiving waters).

To address the problems characterized by the watershed studies, the Master Plan identifies the need to implement a combination of watershed solutions including:

Capital Infrastructure Projects – Over $800 million in capital funds are required to construct integrated watershed protection facilities including detention ponds, channel stabilization projects and other flood, erosion and water quality controls.

Operating Program Enhancements – Additional funding of $2 – 5 million per year is needed to provide essential levels of service for several City programs and activities including infrastructure maintenance, development review and inspection, public education and design support.

Regulatory Modifications – Various code and criteria changes are required to improve service to the public, provide developer incentives, reduce long-term maintenance needs and prevent the creation of new watershed problems in the future.

As detailed above, additional resources and funding will be necessary to achieve watershed protection goals. While attainment of erosion and flood goals may be possible given sufficient funding, water quality goals are not attainable through implementation of solutions evaluated in Phase I. Limited regional retrofit opportunities in urban watersheds and inadequate regulatory controls in areas outside the City's jurisdiction are examples of the various physical and institutional constraints that currently exist. Given these considerations, Phase I Master Plan recommendations are to:

1) Develop longrange funding proposals to support solution implementation.
2) Integrate watershed solutions to the extent possible to effectively promote watershed protection goals attainment.
3) Implement integrated capital projects using a needs-based, watershed management area approach as funding becomes available.
4) Develop collaborative multi-agency partnerships (that include federal, state, and local entities along with other City Departments, community groups and concerned citizens) to achieve watershed protection goals.
5) Use Master Plan results to assist in the development of proposed WPD budget increases to fund priority program enhancements.
6) Involve stake holders in the comment and review process for proposed regulatory modifications before Council consideration as final language is developed.
7) Refine watershed protection goals based on continued public involvement and additional studies.
8) Continue development and evaluation of innovative water quality solutions to attain water quality goals. Refine water quality goals to reflect additional evaluation and feasibility of solution implementation.
9) Update Phase I Master Plan information as better data becomes available and solutions are implemented.
10) Expand master planning efforts beyond the Phase I watersheds as funding allows.

Introduction

The mission of the Watershed Protection Department (WPD) is to reduce the impact of flooding, erosion, and water pollution on our community in order to protect lives, property and the environment. To accomplish this mission, WPD completed Phase I of a Watershed Protection Master Plan to better prioritize service needs and refine program direction. The Master Plan inventories existing watershed problems and gauges the impact of future urbanization over the next 40 years. Based on the magnitude of problems found in the seventeen (17) Phase I watersheds, the Master Plan identifies the need to implement an array of watershed solutions including:

> **Capital Infrastructure Projects** – Over $800 million in capital funds are required to construct new or improved integrated watershed protection facilities including detention ponds, channel stabilization projects and other flood, erosion and water quality controls.
>
> **Operating Program Enhancements** – Additional funding of $2 – 5 million per year is needed to provide essential levels of service for several City programs and activities including infrastructure maintenance, development review and inspection, public education and design support.
>
> **Regulatory Modifications** – Various code and criteria changes are required to improve public service, provide developer incentives, reduce long-term maintenance needs and prevent the creation of new watershed problems in the future.

In addition to the solutions listed above, the Master Plan identifies opportunities for optimizing existing resources through improved prioritization, mission integration and a renewed commitment to the use of environmentally responsible, cost-effective and sustainable solutions. However, additional resources and funding will be necessary to achieve watershed protection goals.

As the findings and recommendations are presented in this report, it is useful to gain a better understanding of the history and past issues that have led to the creation of this Master Plan.

For more than two decades, the City of Austin has been recognized as a national leader in addressing watershed protection issues. Beginning in the 1970's, Austin began to place an emphasis on creek protection and the prevention of future problems through regulation. In 1974, the Waterway Development Ordinance (a.k.a., the Creek Ordinance) required a development permit and site plan, limited development in the 25-year floodplain, required developments to identify appropriate sedimentation and erosion controls, and brought a new focus to protecting the "natural and traditional character" of local creeks. Since that time, the City has enacted additional watershed regulations and established design criteria manuals aimed at mitigating increased runoff rates and pollutant loadings from new land development.

Probably the single most important event that helped shape the City's current watershed protection program is the Memorial Day Flood of 1981. In response to the storm's devastating effects, the City implemented a new drainage fee to provide funding for an expanded stormwater management program. Between 1981 and 1984, strong public support for flood and erosion bond packages became evident as voters authorized more than $75 million for capital improvement projects. From the mid 1980's to today, the City's erosion and water quality efforts have matured as a result of drainage fee fund increases and the passage of notable water quality ordinances (e.g., CWO, UWO and SOS ordinances).

Due to the passage of these existing City regulations, much of the City's current watershed protection efforts are targeted at fixing problems caused by existing development that predated these regulations.

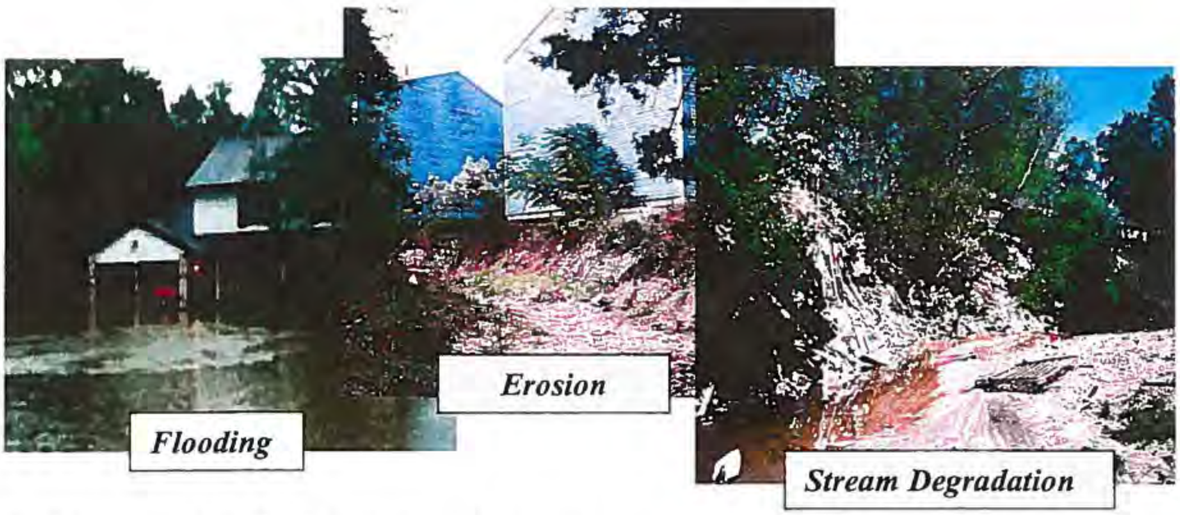
The Watershed Protection Department was created in 1996 with the merging of the flood and erosion programs of Public Works with the water quality protection programs of the Environmental and Conservation Services Department. With the creation of this unified department, a new emphasis was placed on:

1) improving the prioritization of future watershed protection efforts,
2) determining the adequacy of existing funding levels, and
3) integrating the three missions of the new department to more cost-effectively achieve flood control, erosion control and watershed protection goals.

Shortly thereafter, this Master Plan was initiated.

Protecting Lives, Property and the Environment

Protecting lives, property and the environment. From this multi-objective mission statement, specific management goals for flood control, erosion control and water quality protection are derived that incorporate the vision and values of the community.



Building on the WPD mission statement, seven (7) specific management goals and 27 corresponding objectives were developed to guide the Master Plan. The long-term goals and objectives (shown in Table 1) reflect target levels of public safety, property protection and environmental protection within the Phase I watersheds (Figure 1). These goals are considered "interim" pending public consideration of the goal attainment opportunities and costs identified by this first WPD Master Planning effort.

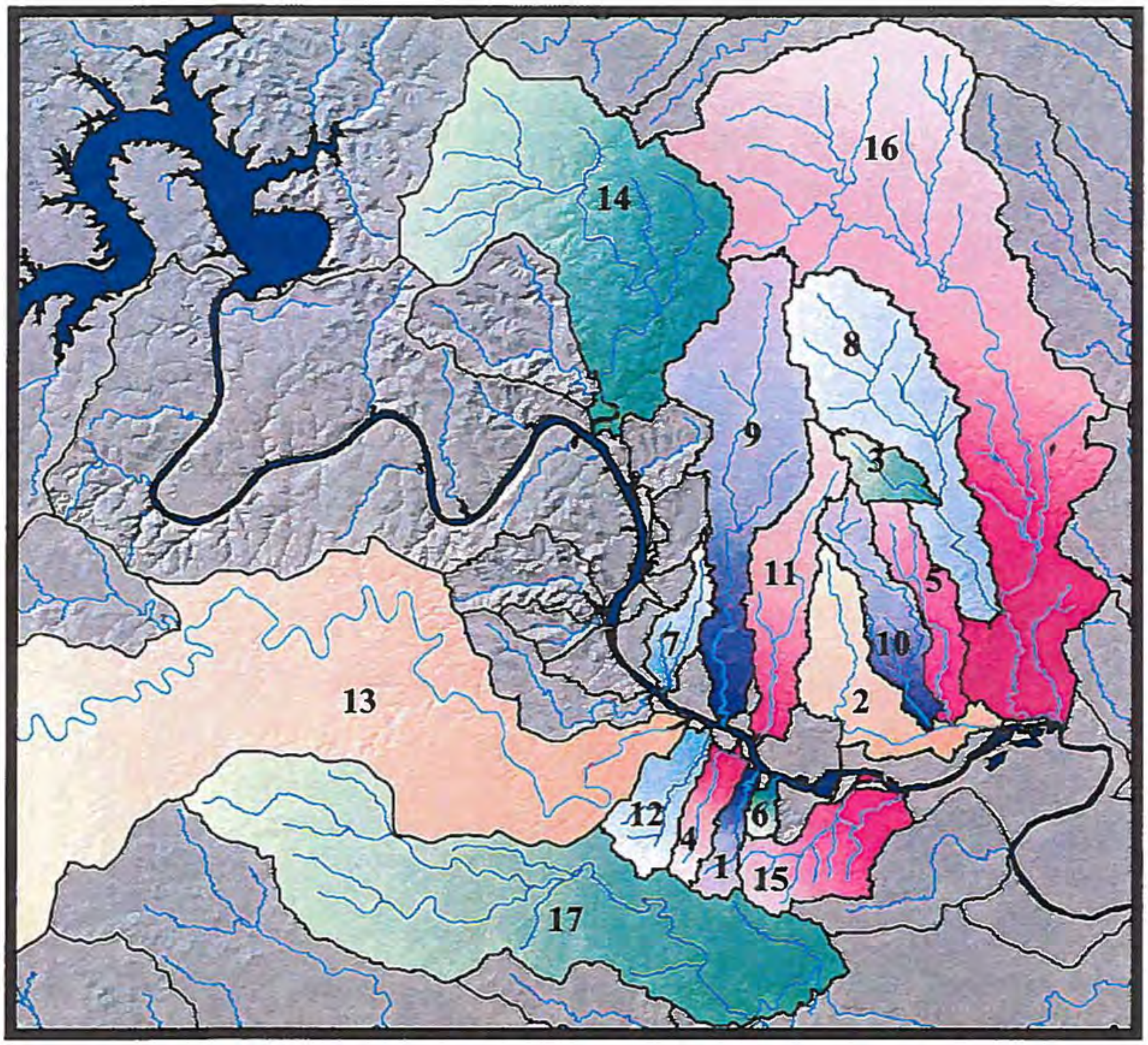
WPD utilized several means to involve the community in the goal setting process. In the fall of 1996, three public meetings of the Master Plan Citizen Advisory Group (MPCAG) were dedicated to refinement of the Department mission statement, management goals and objectives. These goals were also reviewed in the three public meetings held during the spring of 1998 to inform the public about the results of the technical assessment portion of the Master Plan. This type of results-oriented, inclusive planning was a guiding principle for the Master Plan. In addition, watershed protection goals have been and will continue to be published for review in the City's annual budget and business plan documents.

Table 1
Watershed Protection Master Plan Interim Goals and Objectives

Goals	Objectives
Protect lives and property by reducing the impact of flood events.	FC1. Reduce the depth and frequency of flooding for all structures in the 100-year floodplain. FC2. Reduce the depth and frequency of flooding on all roads in the 100-year floodplain. FC3. Reduce the danger at road crossings subject to any flooding by the 100-year flood (includes the provision of adequate warning). FC4. Provide mitigation for flood damage. FC5. Prevent the creation of future flood hazards to human life and property. FC6.. Reduce the depth and frequency of localized flooding for buildings. FC7. Reduce the depth and frequency of localized flooding for yards. FC8. Reduce the danger of street flooding associated with old storm drains. FC9. Reduce standing water in public rights-of-way and drainage easements outside the100-year floodplain.
Protect channel integrity and prevent property damage resulting from erosion.	EC1. Repair current erosion that threatens habitable structures and roadways. (Type 1 sites) EC2. Repair current erosion that threatens properties, trees, fences, drainage infrastructure, parks, hike and bike trails (Type 2 sites). EC3. Minimize the future enlargement of channels that would threaten public and private property. (Type 3 sites) EC4. Achieve stable stream systems.
Protect and improve Austin's waterways and aquifers for citizen use and the support of aquatic life.	WQ1. In local creeks, achieve or exceed Good Environmental Integrity Index (EII) scores. WQ2. In Urban creeks, restore baseflow quantity and quality to the maximum extent possible. WQ3. In Non-Urban creeks, preserve the existing baseflow quantity and quality to the maximum extent possible. WQ4. In all creeks, reduce existing and future pollutant loads to the maximum extent possible. WQ5. In the Edward's Aquifer, maintain or enhance the existing rate of recharge to the maximum extent possible. WQ6. Maintain or enhance high quality environmental features (springs, seeps, wetlands, swimming holes, threatened or endangered species habitat) to the maximum extent possible.
Improve the urban environment by fostering additional beneficial uses of waterways and drainage facilities.	CG1. Maximize the use of waterways and drainage facilities for public recreation. CG2. Maximize areas for public use within floodplains. CG3. Maintain natural and traditional character of floodplains to the maximum extent possible.
Meet or exceed all local, state, and federal permit and regulatory requirements.	CG4. For all state designated stream segments, including Lake Travis, Lake Austin, Town Lake, the Colorado River below Austin, Barton and Onion creeks, maintain or improve the Designated Use Support status. CG5. Comply with Stormwater NPDES permit requirements & Endangered Species 10 (a) permit. CG6. Minimize the risk to structures in the 100-year floodplain as required by the National Flood Insurance program.
Maintain the integrity and function of Utility Assets.	CG7. Provide for adequate maintenance of the watershed protection infrastructure system and minimize maintenance requirements for system improvements.
Optimize City resources by integrating erosion, flood and water quality control measures.	CG8. Maximize flood control, pollution removal and streambank protection for all solutions including CIP projects.

FC = Flood Control; EC = Erosion Control; WQ = Water Quality; CG = Common Goal

Figure 1 Phase 1 Watersheds Study Area Map



URBAN WATERSHEDS	
1. Blunn (BLU)	7. Johnson (JOH)
2. Boggy (BOG)	8. Little Walnut (LWA)
3. Buttermilk (BMK)	9. Shoal (SHL)
4. East Bouldin (EBO)	10. Tannehill (TAN)
5. Fort Branch (FOR)	11. Waller (WLR)
6. Harper's Branch (HRP)	12. West Bouldin (WBO)

NON URBAN WATERSHEDS
13. Barton (BAR)
14. Bull (BUL)
15. Country Club (CNT)
16. Walnut (WLN)
17. Williamson (WMS)

Assessment of Current and Future Problems

A series of technical studies characterizing flood, erosion and water quality conditions in the Phase I watersheds determined that watershed problems are pervasive and will worsen if corrective action is not taken.

Phase I of this Master Plan included seventeen (17) watersheds including all of the urban watersheds and five surrounding non-urban watersheds:

Urban		Non-urban
Blunn (BLU)	Johnson (JOH)	Barton (BAR)
Boggy (BOG)	Little Walnut (LWA)	Bull (BUL)
Buttermilk (BMK)	Shoal (SHL)	Country Club (CNT)
East Bouldin (EBO)	Tannehill (TAN)	Walnut (WLN)
Fort Branch (FOR)	Waller (WLR)	Williamson (WMS)
Harper's Branch (HRP)	West Bouldin (WBO)	

Additional watersheds will be studied in subsequent phases of the Master Plan.

Phase I studies helped to locate and prioritize problem areas where watershed protection goals and objectives are not currently being met or are not expected to be met in the future. The problem area studies are categorized by mission as follows:

Creek Flooding	Stream Erosion
Localized Flooding	Water Quality Degradation

Integrated problem areas were determined by overlaying the results of the individual mission studies to identify areas of concurrent flooding, erosion and water quality problems. Integrated problem areas demonstrate an increased need for multi-purpose solutions.

Creek Flooding

Most people who live in Austin have witnessed firsthand or seen reports of flooded homes, businesses and roadways. The Memorial Day Flood of 1981 and the recent storms of 1997 and 1998 are reminders of the public safety and property hazards created by heavy rains. Even in the midst of an extended drought, the risks associated with these destructive storms are always present.

Source: Austin-American Statesman, 1997, 1998

Hydrologists classify or "size" storms based upon how often they are likely to occur in a specific region. In Austin, for example, there is a 1% probability in any given year that 6.9 inches of rainfall will occur in a three-hour period. This is called a 100-year, 3-hour storm event. Similarly, a 2-year storm (2.6 inches of rainfall over 3 hours) has a 50% chance of occurring in any given year.

Flood models are used to estimate the depth of flow in local creeks for storms of various sizes. These flow depths are then compared to bridge heights and adjacent property elevations to predict where floodwaters may pose a public safety or property threat. The results of the creek modeling for each of the Phase I watersheds are shown in Table 2. Based on the findings of the creek flooding assessments, the majority of the Phase I watersheds are prone to creek flooding that creates public hazards. In fact, the 2-year storm is predicted to cause structure and road flooding in 14 of the 17 Phase I watersheds.

Table 2
Estimates of Flooded Structures and Roadways

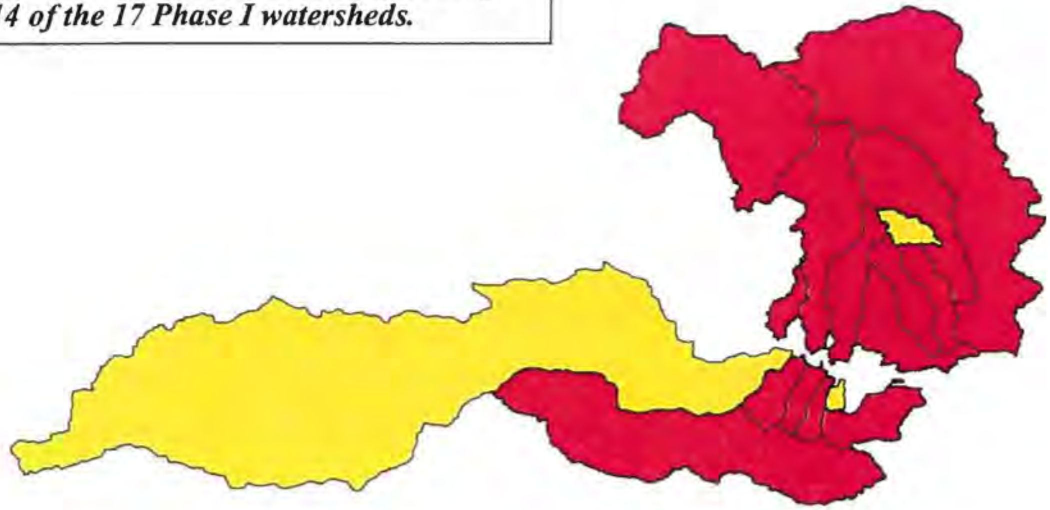
Watershed	No. of Flooded Structures*				No. of Flooded Roadways			
	2-Year	10-Year	25-Year	100-Year	2-Year	10-Year	25-Year	100-Year
Barton Creek**	–	–	–	–	–	–	–	–
Blunn Creek	1	4	6	14	0	6	8	8
Buttermilk Creek	0	1	1	1	0	0	0	0
Boggy Creek	42	61	70	81	5	6	6	6
Bull Creek	3	14	26	40	14	14	15	15
Country Club Creek	11	12	13	17	1	2	4	7
East Bouldin Creek	10	33	47	64	0	13	18	19
Fort Branch	32	60	84	110	5	5	7	7
Harper's Branch**	–	–	–	–	–	–	–	–
Johnson Creek	3	4	8	13	2	5	11	13
Little Walnut Creek	85	213	313	401	6	15	22	26
Shoal Creek	32	89	132	245	0	5	10	11
Tannehill Branch	2	40	55	69	0	0	0	0
West Bouldin Creek	7	19	31	116	0	6	8	8
Walnut Creek	92	238	306	350	10	20	25	30
Waller Creek	1	43	76	127	13	26	31	36
Williamson Creek	58	199	295	454	9	14	17	18
Totals	379	1,030	1,463	2,102	65	137	182	204

* Primary structures only; buildings such as unattached garages, etc. not included.

** Flood models not available

Source: City of Austin, 1998; L Loomis Austin, Inc., 2000

A 2-year storm creates structure flooding in 14 of the 17 Phase I watersheds.

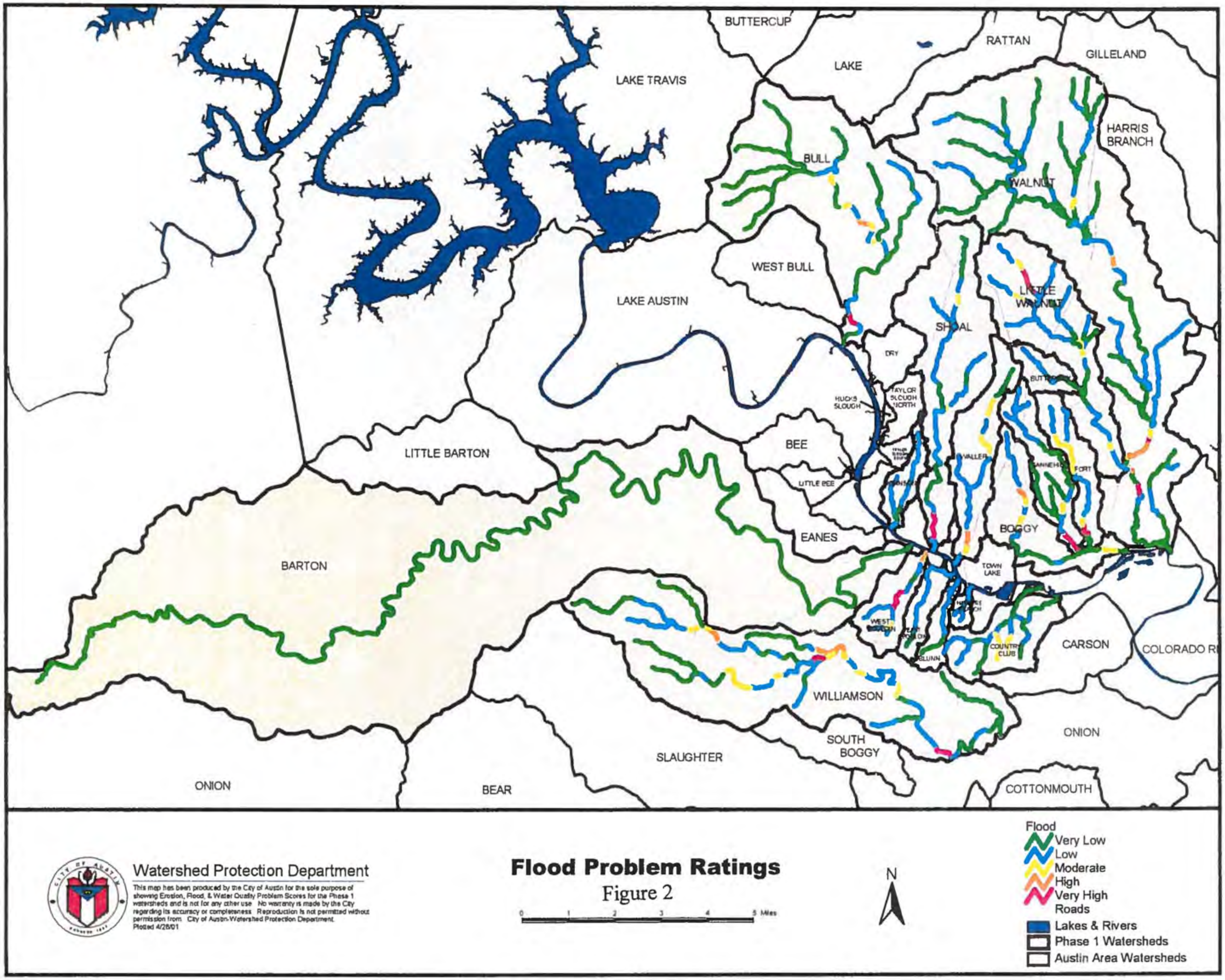


Historically, WPD has prioritized flood problem areas by focusing on the number of homes and businesses in the 100-year floodplain in a particular location. Where the information was available, the number of structures in the 2-, 10-, and 25-year floodplains was also considered. However, this additional information was rarely available. The calculation of structure and road crossing flooding estimates for the 2-, 10-, 25-, and 100-year storms enabled the use of a refined prioritization process during the Master Plan. The improved prioritization process gives higher priority to those community resources that are flooded more frequently and at greater depths.

Figure 2 depicts the results of the problem area prioritization for creek flooding by reach. Severe flood problem areas are found in the Walnut, Williamson, Shoal, Fort Branch, Little Walnut, and Bull Creek watersheds. The Crystal Brook neighborhood and the Austin Hills Mobile Home Estates in Walnut Creek are areas at risk of flooding for relatively small storm events. In the Williamson Creek watershed, flooding problems are prevalent – especially in the Creek Bend neighborhood and along middle Williamson Creek from Bayton Loop to Heartwood Drive.

Williamson Creek Flooding

As demonstrated during the 1981 Memorial Day Flood, lower Shoal Creek (south of 15th Street) is prone to flooding from a 100-year storm event. The Eleanor Drive area along Fort Branch also is predicted to flood during the 100-year storm event. In the Little Walnut Creek watershed, the Mearns Meadow Boulevard area north of Rutland Drive is ranked as a very high problem area.



Flood Problem Ratings

Figure 2

In the Bull Creek watershed, severe flooding of low water crossings, including FM 2222 at Lakewood Drive, are reflected in the flooding problem results. Other less severe flooding areas are scattered throughout the Phase I watersheds.

Even though Master Plan results have improved the basis for estimating flooding risks, the number of inhabited structures subject to flooding by the 100-year flood within the City of Austin is difficult to determine. Phase I Master Plan results have led to a reduction in previous Citywide estimates from 12,000 to approximately 7,000 to 8,000 structures. Structures may lie within the horizontal extent of the 100-year floodplain, but their first floor elevation may be above the base flood elevation or they may not be inhabited structures. For the Phase I watersheds, better data was collected regarding the type and vertical elevation of structures within the 100-year floodplain. However, much work remains to improve this data and to improve the comparison of structure elevations to the base flood elevations for all watersheds in the Austin area.

Even with the reduced estimate of 7,000 to 8,000 structures, the risk to human life and property is high. As many as 20,000 people could be threatened by floodwaters should the 100-year storm occur. In addition, flooded creeks commonly overtop roadways, posing a recurring threat to motorists and public safety personnel deployed in storm emergencies. There are over 200 roadway crossings subject to inundation during the 100-year storm event. Historically, the large majority of flood event related deaths in Austin have occurred at roadway crossings.

Localized Flooding

"Localized flooding" is the term used for flooding that occurs in the secondary drainage system. The secondary drainage system (the local storm drain system) is composed of storm drainpipes, curb inlets, manholes, minor channels, roadside ditches, and culverts. WPD maintains approximately 400 miles of storm drainpipe, ranging in diameter from six inches to eight feet. In addition to minor channels and ditches, the system includes over 18,000 curb inlets. This system is intended to efficiently convey storm flows to the primary drainage system in our community – our creeks. When the secondary drainage system is outdated, localized flooding may occur.

The identification and prioritization of localized flooding problem areas in the Phase I watersheds was based on customer complaint data from two sources: 1) the drainage complaint database maintained by WPD, and 2) the results of a customer flood survey that was conducted by WPD in 1996. Unlike the creek flooding studies, the prioritization of localized flooding areas was not based on hydrologic and hydraulic models. Flooding simulation models are not available for the extensive storm drain system due to incomplete information on the location, size and condition of the system.

Since 1988, WPD has tracked customer drainage complaints through a computer database. With the help of database and geographical information system (GIS) technology, over 6,000 customer complaints (Table 3) were analyzed to locate problem areas for the localized drainage system. The drainage complaint database was queried to identify localized flooding complaints. The drainage complaint database and 1996 flood survey results were geocoded (mapped) using the street address provided by each utility customer who contacted the City's complaint hotline or responded to the flood survey. Reported complaints were then characterized by complaint density – the number of complaints mapped per square mile. The results are shown in Figure 3.

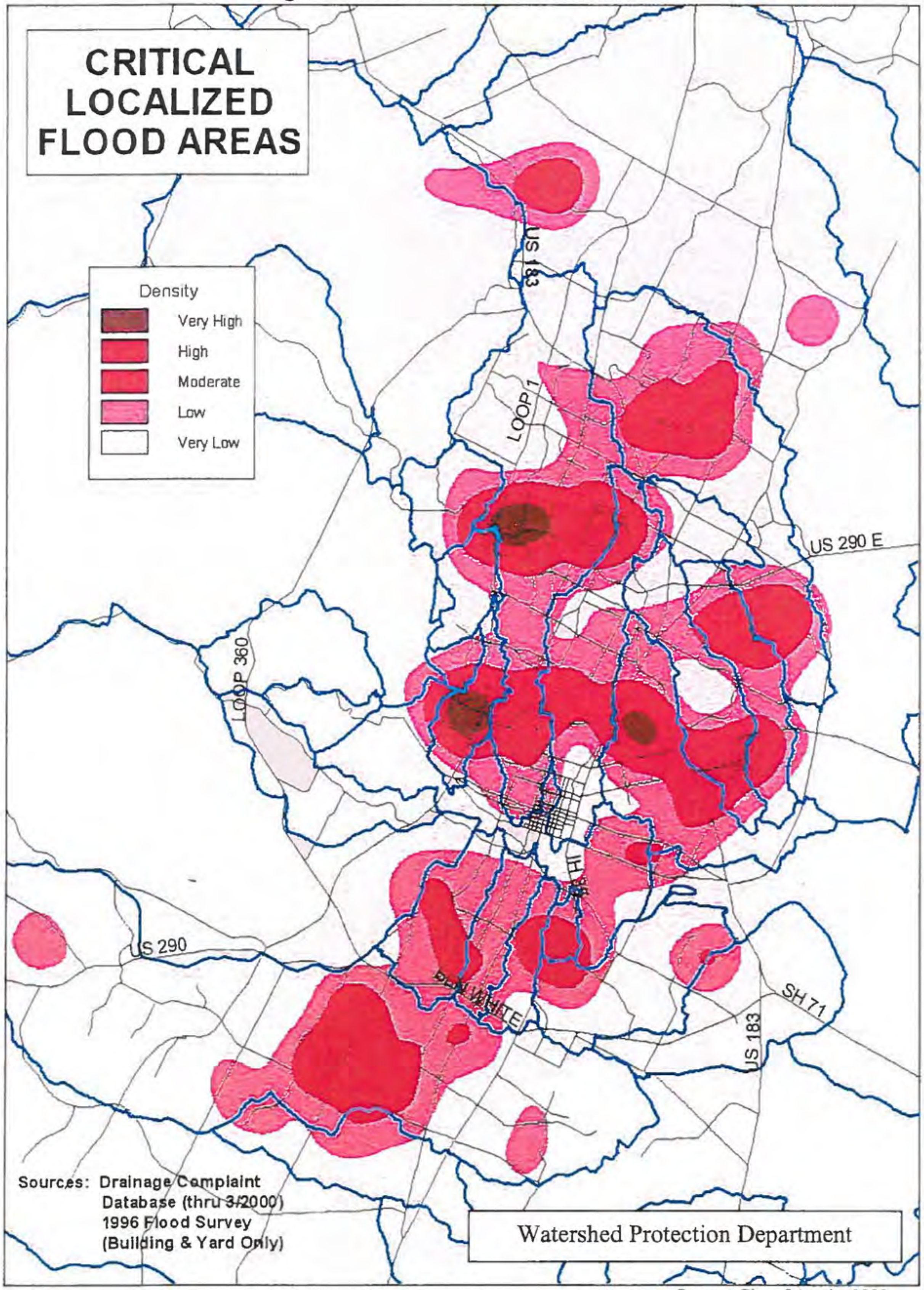
Table 3

Customer Drainage Complaint Database Results (Through March, 2000)

Flood Complaint Type	No. of each
Building Flooding	551
Yard Flooding	1,459
Street Flooding	687
Standing water	851
Miscellaneous Flooding	1,762
Unrelated to Localized Flooding	1,005
Total	6,315

In general, the highest complaint densities for localized flooding occur in the urban core of the City. As shown in Figure 3, there are several local storm drain systems that will likely require upgrades. A significant number of drainage complaints originate from the Boggy, Fort Branch, Johnson, Little Walnut, Tannehill, Walnut, and Williamson Creek watersheds.

Figure 3 Critical Localized Flood Areas



Source: City of Austin, 2000

In the urban core, older storm drainage systems often fall into one of four conditions:

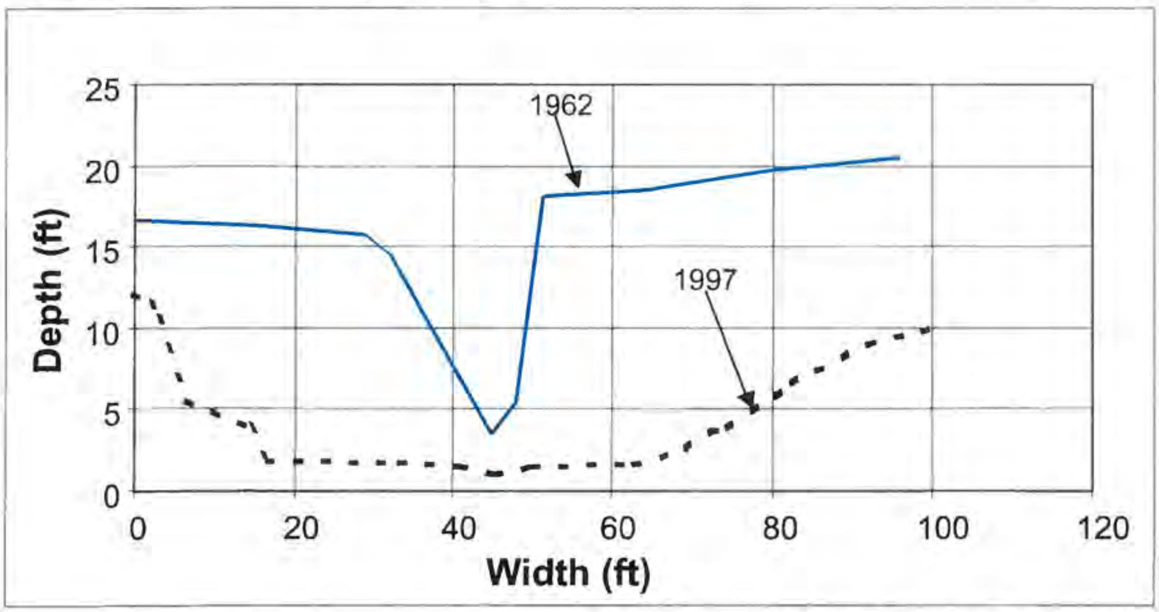
1) Existing storm drains become outdated through changes in design criteria;
2) Existing storm drains have exceeded their anticipated service life (disjointed segments, damaged or deteriorated pipe);
3) Existing storm drains are partially or completely clogged (debris, sediment, and utility conflicts); or
4) Storm drains do not exist.

There are certain limitations to using customer data to prioritize problem areas. First, complaint data may not reflect all areas since customers living in areas served by old storm drain systems may not have experienced flooding (i.e., their area has not been subjected to a large storm since the inception of the flood complaint database in 1988). It should also be assumed that not all customers report localized flooding in their area. Until flooding models are available for the secondary drainage system, WPD must rely on customer complaint data to help identify study areas. More detailed analyses are required in priority areas where improvements are needed in the local drainage system.

Stream Erosion

Most of Austin's watersheds (including both urban and suburban watersheds) are drained by creeks that exhibit Stream Erosion problems. Erosion problems primarily result from changing land use conditions (i.e., urbanization) that modify watershed hydrology – significantly increasing stormflows in creeks for even small rainfall events. The change in watershed hydrology (and sedimentology) greatly increases the frequency, magnitude and duration of "erosive" flows. These changes in streamflow have resulted in changes in local creek characteristics. For example, past survey data shows that a typical section of Little Walnut Creek (Figure 4) has expanded by 60 feet over the last 35 years. A 20-foot wide section of creek in 1962 is now 80-feet wide today.

Figure 4 Past Channel Expansion in Little Walnut Creek



Source: Raymond Chan & Associates, October 1997

As stream channels react to changes in watershed hydrology, several concerns arise regarding future creek bank failures, long-term channel degradation, and the resulting impacts to creekside residents, their property, and water quality.

Detailed erosion assessments conducted during the Master Plan process characterized general creek conditions, identified current erosion problems along the major creek system and furthered understanding of where future problems may occur. An inventory of problem sites identified locations along the creeks where erosion poses an existing or future threat to buildings and roadways, stream stability, water quality, and drainage infrastructure. Property threats of interest include houses, buildings, parking lots, bridges, retaining walls, trees, utility poles, and utilities crossing the creek, and fences.

When an erosion problem was encountered, a priority was assigned to each site as shown in Table 4.

Table 4
Erosion Problem Types

Priority	Description
Type 1	House, building, or road currently threatened by channel bank erosion
Type 2	Other resources (walls, fences, trees, trails, utility lines, yards, recreational amenities) currently threatened by channel bank erosion.
Type 3	Resources not currently threatened but may be threatened in the future.

Source: Raymond Chan & Associates, 1997

In the Phase I watersheds, approximately 975 erosion problems were identified. Thirteen (13) are Type 1 problems. The remaining problem sites are split almost evenly between Type 2 and Type 3 problems. Table 5 shows the distribution of the identified erosion problems.

Type 1 Erosion Example

Table 5
Erosion Problem Site Summary

Watershed	Number of Sites Identified			
	Type 1	Type 2	Type 3	Total
Barton	0	18	6	24
Blunn	0	11	8	19
Boggy	1	24	30	55
Bull	1	15	36	52
Buttermilk	0	22	16	38
Country Club	1	17	16	34
East Bouldin	1	27	27	55
Fort	1	27	26	54
Harper's Branch	0	8	5	13
Johnson	0	18	11	29
Little Walnut	1	23	21	45
Shoal	1	29	59	89
Tannehill	2	23	20	45
Waller	0	33	10	43
Walnut	2	125	98	225
West Bouldin	2	7	18	27
Williamson	0	62	66	128
Total	13	489	473	975

In addition to erosion hazard identification, a rapid geomorphic assessment (RGA) of each creek segment (or reach) determined the relative stability of the creek channel system. By observing the presence of various physical features within a reach, field teams characterized channel stability based on visual evidence of ongoing erosional processes (such as widening or downcutting). Reaches were categorized into one of three stability classes (Table 6).

Table 6
Channel Stability Classes

Stability Class	Description
Stable	Little to no evidence of channel instability or enlargement. The stream channel is conveying water and sediment loads without substantial erosion or deposition.
Transition	Frequent evidence of instability leading to channel enlargement. Increased runoff is exceeding the ability of the natural channel to maintain its form.
In-Adjustment	Widespread evidence of channel instability and channel enlargement. Channel has been significantly destabilized and is attempting to adapt to large, rapid changes in the water and sediment loads delivered to the stream system.

Source: Raymond Chan & Associates, 1997

Channel stability rating results (Table 7) for each of the Phase I watersheds demonstrate that the majority of creek segments studied are unstable. The majority of stable channels are located in rock controlled or structurally-controlled (concrete or gabion-lined) reaches. Over three-fourths of the identified creek reaches were determined to be in-transition or in-adjustment, demonstrating significant evidence of channel instability and enlargement.

Table 7
Channel Stability Ratings by Watershed

Watershed	Channel Stability Rating Frequency*		
	Stable	Transition	In Adjustment
Barton	9	1	0
Blunn	0	2	3
Boggy	1	3	3
Bull	2	14	5
Buttermilk	0	4	1
Country Club	1	1	6
E Bouldin	1	3	0
Fort	1	4	5
Harper's	4	2	0
Johnson	6	4	1
Little Walnut	0	15	1
Shoal	3	10	5
Tannehill	2	5	1
Waller	4	6	2
Walnut	6	21	7
W Bouldin	1	2	2
Williamson	4	8	7
Total	45	105	49

*Figures represent number of creek segments in each stability class by watershed.

Source: Raymond Chan & Associates, May-Oct. 1997

A major accomplishment of the Master Plan was the development and application of a procedure to estimate historic and future channel enlargement in Austin creeks as a function of watershed impervious cover. Estimates of past and future channel enlargement for the Phase I watersheds are illustrated in Figures 5 and 6 respectively.

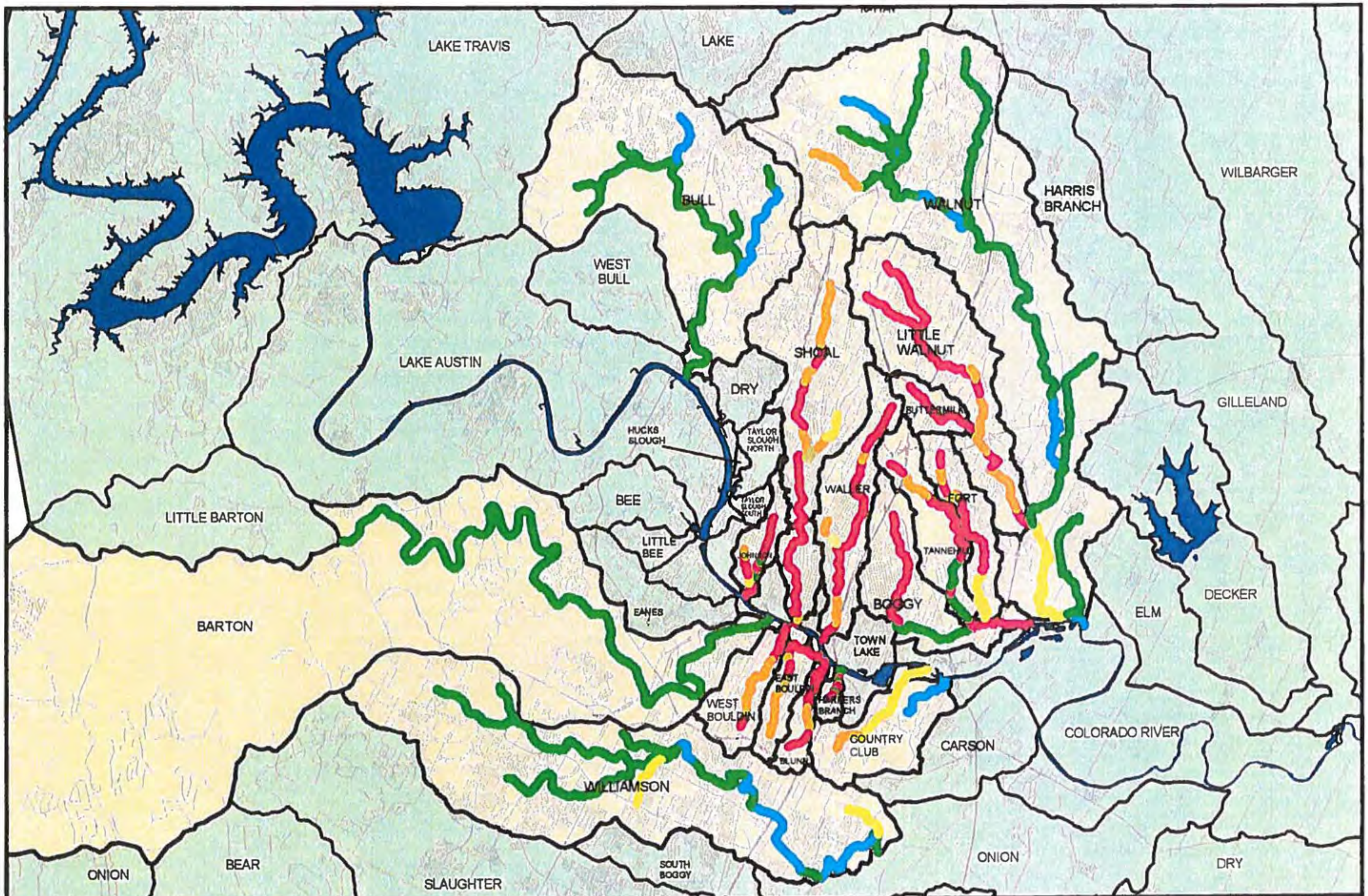
The most significant channel enlargements have occurred in the urban watersheds (Figure 5). Channel enlargements of over ten times historic conditions were documented for some Austin creeks. The majority of the creek reaches in the urban watersheds have more than doubled in channel size due to significantly higher stormflows generated by urban development. The Little Walnut Creek example (Figure 4 from page 15) is representative of the past channel expansion experienced in the urban watersheds.

Based on expected future development levels, substantial increases in channel area are predicted for many of the suburban watersheds, especially Walnut Creek (Figure 6).
High levels of future channel enlargement are predicted in areas where:

1) creeks and tributary channels are composed of alluvial materials, and
2) contributing watershed areas are expected to experience substantial increases in urban development.

It should be noted that future predicted increases in channel area are not solely a response to future development in the watershed. Erosion occurs over a period of many years (50 years is not uncommon). A portion of the predicted future channel erosion is a delayed response to increases in storm flows from existing development.

Erosion problem ratings were assigned to the Phase I watersheds, based on the inventory of the number and types of erosion problems identified during each stream investigation and the results of a future reach stability analysis. The results are shown in Figure 7 and indicate both current problems (Type 1 & 2) and future problems (Type 3 and Future Reach Stability). As demonstrated in Figures 5 and 6, the City's eastern watersheds (and especially the Walnut Creek watershed) merit significant attention given the high priority ratings assigned to this area.



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Past Channel Expansion

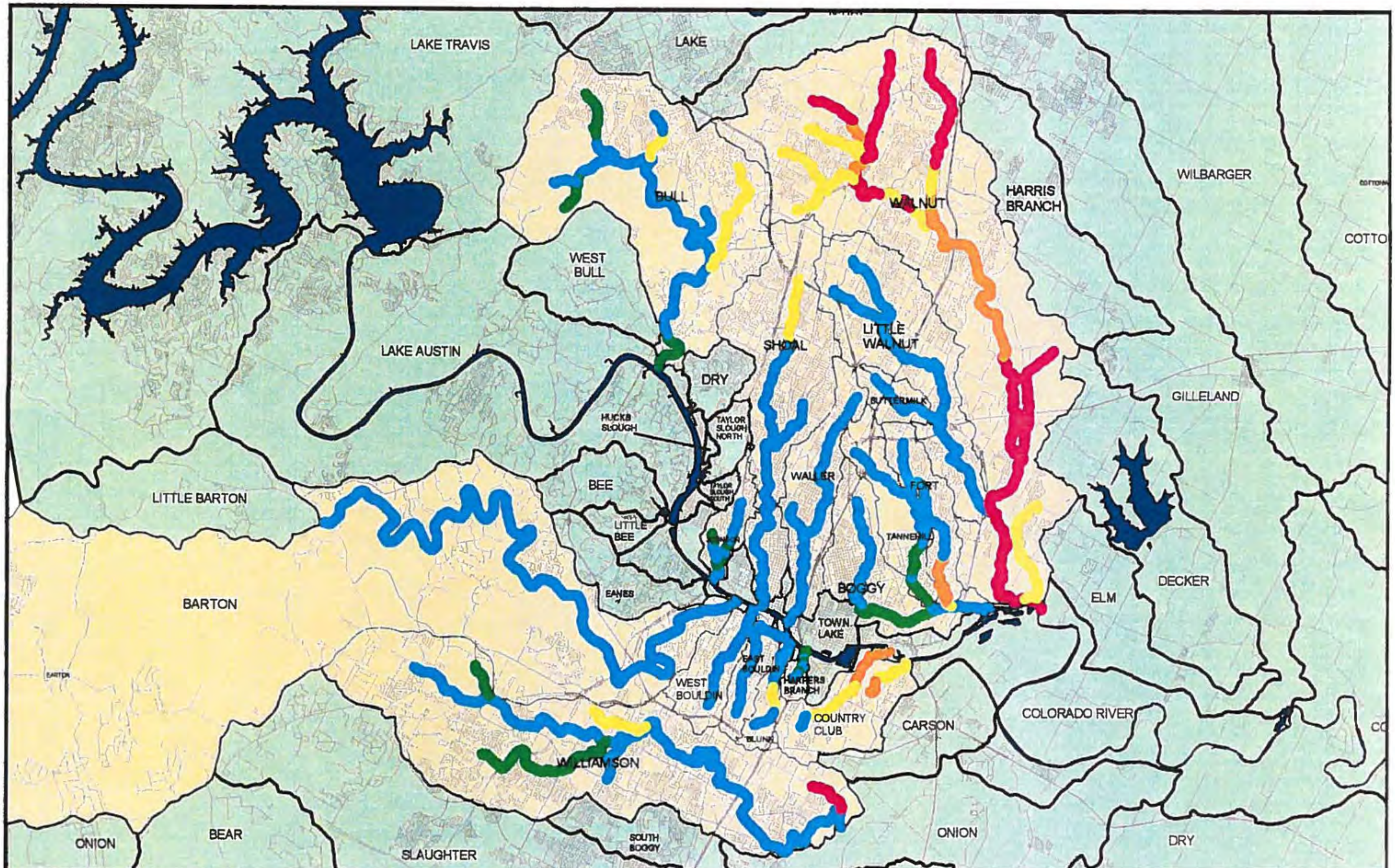
Figure 5

0 2 4 6 8 Miles

N

Percent Increase in Channel Area

- Very Low (0%)
- Low (0-40%)
- Medium (40-120%)
- High (120-300%)
- Very High (300 or more)
- Streets
- Austin Area Watersheds
- Phase 1 Watersheds
- Lakes and Rivers



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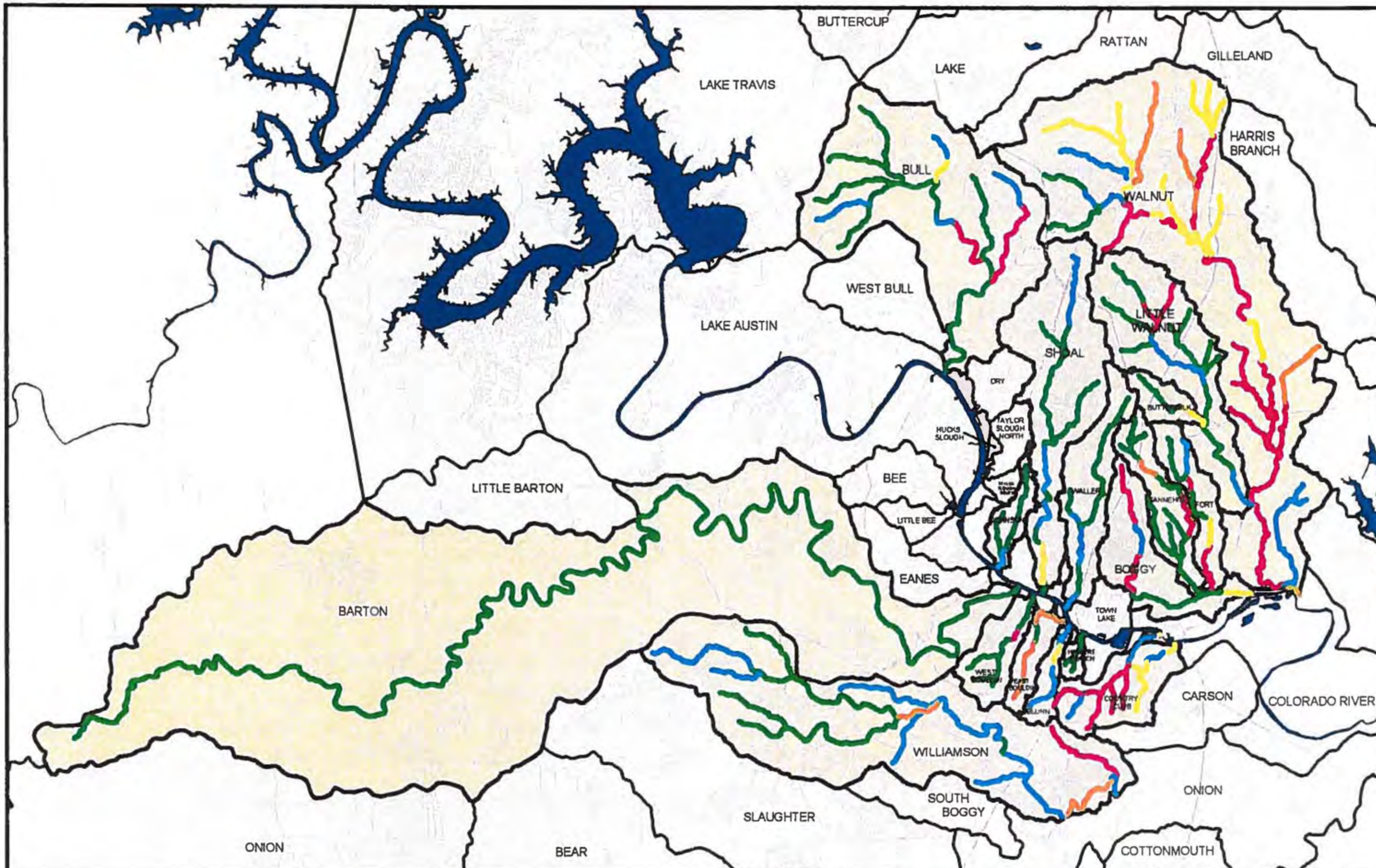
Predicted Future Channel Expansion

0 2 4 6 8 Miles

N

Percent Increase in Channel Area
- Very Low (0%)
- Low (0-40%)
- Medium (40-100%)
- High (100-160%)
- Very High (160+)
- Streets
- Lakes and Rivers
- Phase 1 Watersheds
- Austin Area Watersheds

Figure 6



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Erosion Problem Ratings

Figure 7

0 1 2 3 4 5 Miles

N

Erosion Problem Rating
- Very Low
- Low
- Moderate
- High
- Very High
- Roads
- Lakes & Rivers
- Phase 1 Watersheds
- Austin Area Watersheds

Water Quality Degradation

Austin's quality of life is closely linked to the environmental integrity of its local water resources. As with flooding and erosion, water quality problems primarily stem from changing land use conditions (i.e., urbanization) that modify watershed hydrology and the level of pollutants in local waterways. A water quality assessment was completed for each of the Phase I watershed creeks and several receiving waters including Lake Austin, Town Lake, the Colorado River below Town Lake, the Southern Edwards Aquifer, Barton Springs Pool, and McKinney Falls. The water quality assessments evaluated existing and future problem areas based on field monitoring results, and modeling and evaluation. Water quality priorities are established based on the resource value of the receiving water and the severity of identified current and future water quality problems.

The main sources of information used for characterizing water quality problems are:

1) Environmental Integrity Index (EII) scores (developed by WPD).
2) Flow volumes, including baseflow for creeks and spring flow for Barton Springs - calculated or extrapolated from the University of Texas Center for Research in Water Resources GIS Loading model (the CRWR model, Dartiguenave, 1997).
3) Annual average pollutant loads (from the CRWR model). The following parameters are considered:
   - Sediment -Total Suspended Solids (TSS)
   - Nutrients - Total Nitrogen (TN), Total Phosphorus (TP)
   - Toxicity - Total Organic Carbon (TOC), Chemical Oxygen Demand (COD), Copper (Cu), Lead (Pb), Zinc (Zn)
4) Spills Risk (from Spills Risk Index developed by WPD).
5) Construction Runoff Loads (provided by CRWR).
6) Future Reach Stability (from erosion assessments).

Also used to a limited extent were State water quality assessment data and reports, data analyzed from WPD's water quality and spills database and the Visual Index of Pollution for Town Lake.

To consider water quality problems at a local level as well as at a larger scale, the creeks within each watershed were broken up into segments known as Environmental Integrity Index (EII) reaches. The EII is a tool developed by WPD to monitor and assess the ecological integrity and the degree of impairment of Austin creeks (City of Austin, 1997).

To formulate the EII, the designated water uses specified in the Clean Water Act that are applicable to Austin area creeks were identified and condensed into six protection categories. The EII score is calculated as the average of these six sub-indices. The six major categories (sub-indices) are:

1) Contact recreation (swimming and wading)
2) Non-contact recreation and aesthetics
3) Water quality
4) Sediment quality
5) Physical integrity and channel stability
6) Aquatic life support

A primary motivation for developing the EII was to address the concern that water chemistry data alone does not adequately describe the health of water resources. Measuring a range of chemical, physical, and biological conditions (Table 8) results in a more accurate and comprehensive assessment of stream health. The results of the EII ratings are shown in Figure 8.

The EII provides a more accurate and comprehensive assessment of stream health.

Table 8

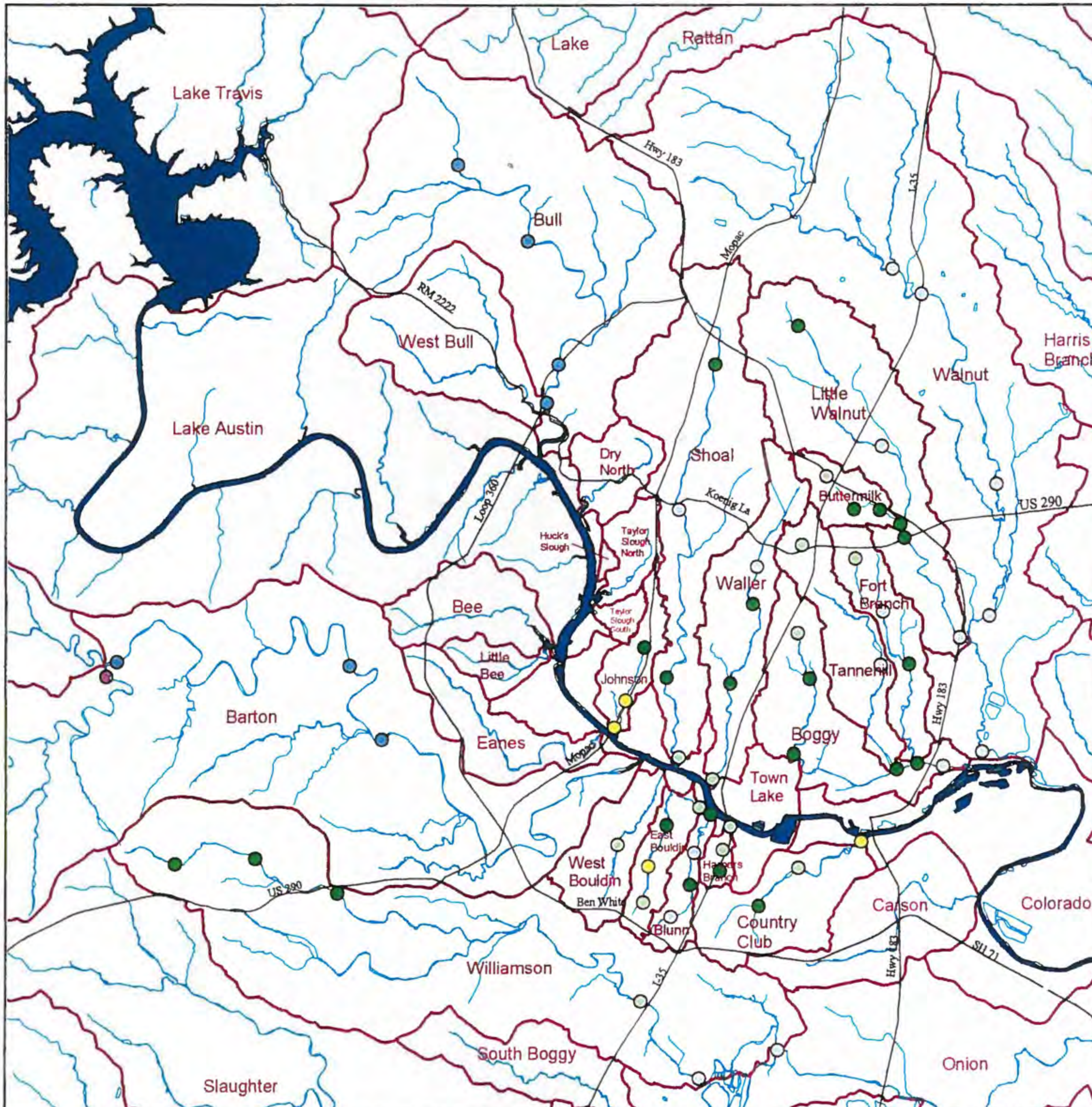
Summary of EII Components

Contact Recreation Swimming & Wading	**Physical Integrity & Channel Stability**	**Water Quality**
Fecal Coliform	Channel Alteration Sediment Deposition Embeddedness Channel Flow Status Condition of Banks Bank Vegetation Protection Disruptive Pressure Riparian Zone Width	Fecal Coliform Total Suspended Solids Total Dissolved Solids Nitrate-Nitrogen Orthophosphorus Ammonia-Nitrogen
Sediment Quality Metals Polycyclicaromatichydrocarbons (PAH), Organochlorides, Pesticides, & Polychlorinatedbiphenyls (PCB)	***Channel Stability***	**Aquatic Life Support**
Non-Contact Recreation/Aesthetics Surface Appearance Litter Odor Clarity Percent Algae Cover	Landform Slope Mass Wasting Debris Jam Potential Entrenchment Ratio Bank Rock Content Cutting & Deposition Scouring Rock Angularity Brightness (Clean Rock) Attached Aquatic Vegetation Obstructions Consolidation Percent Stable Material	Macroinvertebrate Community Structure Diatom Community Structure Algae Percent Cover Chlorophyll a Fish (presence/absence)

Source: City of Austin, 1997

Problem severity is assessed based on the difference between a receiving water's water quality goal and the *current* measured or predicted *future* condition. Water Quality Problem Scores depicting existing conditions are shown in Figure 9.

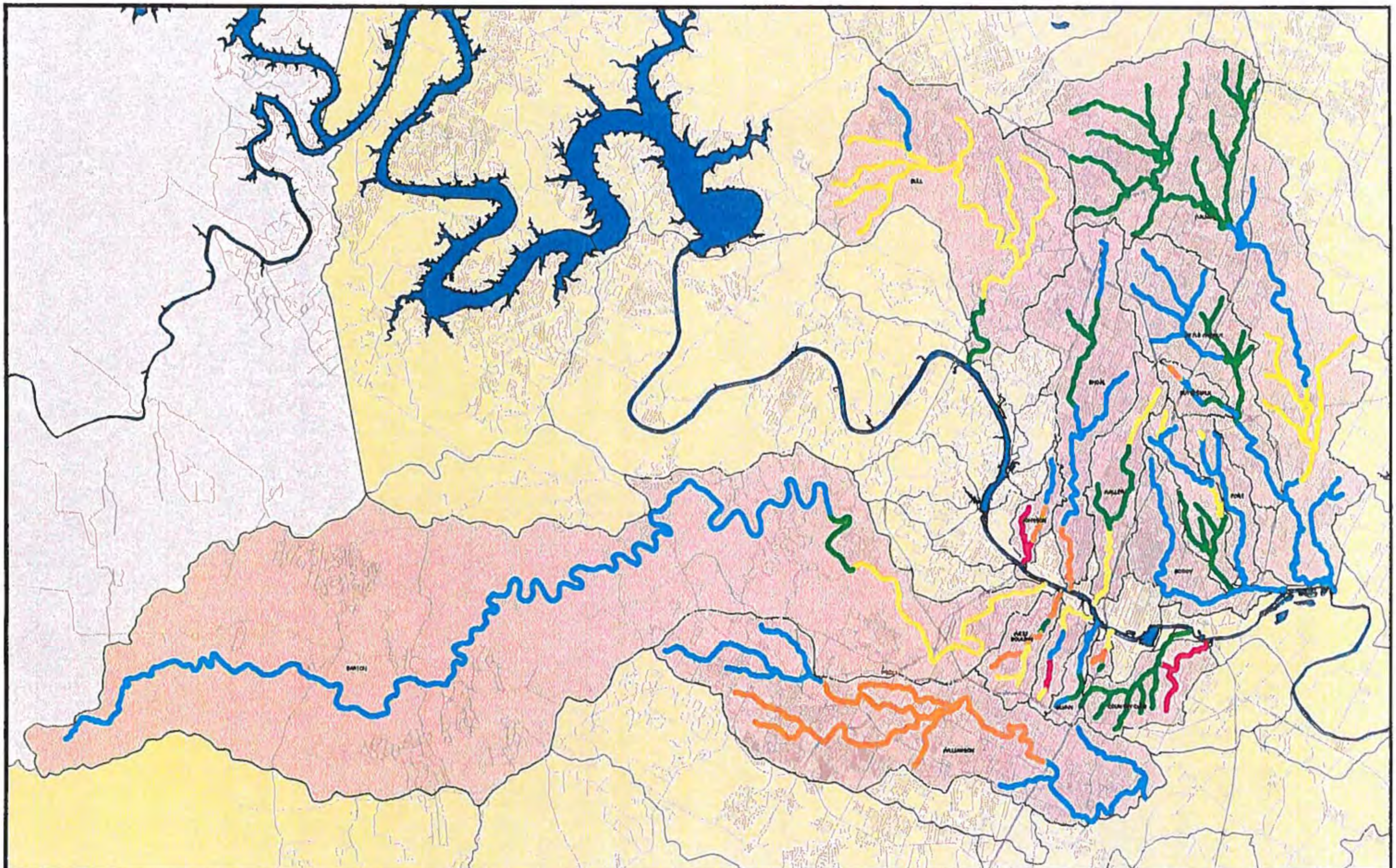
Current problem determination for each EII creek reach is based on how far apart the current water quality condition (measured as an EII score) is from the desired water quality condition. Current problem determinations for each of the nine major receiving waters (lakes, pools and rivers) were developed based upon available data. Examples of data used include State water quality reports, current spills risks data, and data collection and analyses performed by WPD (toxic sediments, major algae blooms, sediment loads, aquatic life use, and aesthetics).



Current Condition of Austin Creeks as Measured by EII

Figure 8

Watershed Protection Department



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Water Quality Problem Ratings
For Existing Conditions

2 0 2 4 Miles

Figure 9

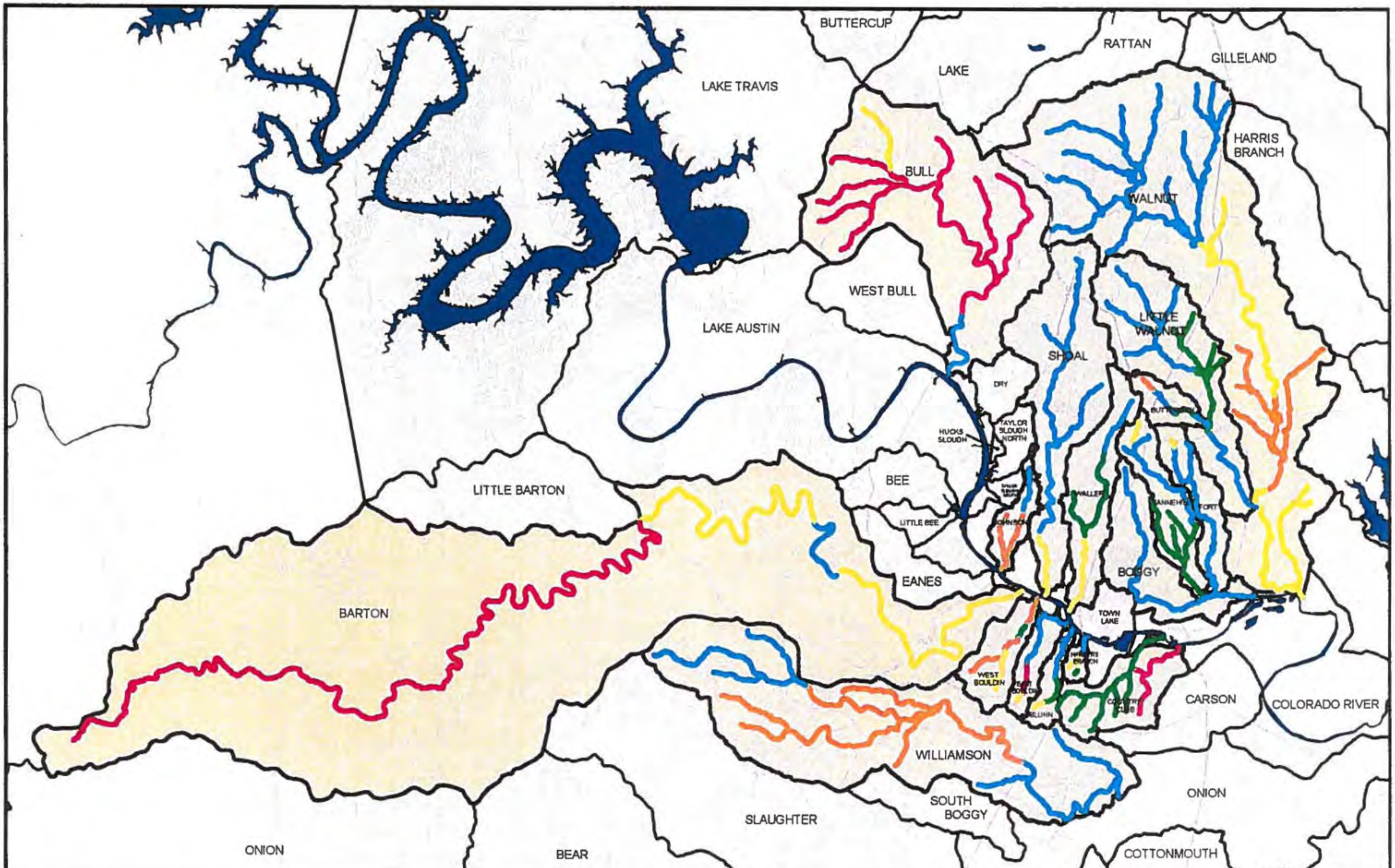
N

Water Quality Ratings
- Very Low
- Low
- Moderate
- High
- Very High
- Roads
- Lakes & Rivers
- Phase 1 Watersheds
- Austin Area Watersheds

Future problem determinations are based on the difference between current conditions and projected future conditions. For example, the water quality in an urban creek may not be meeting its water quality goal (e.g., it has a low EII score); however, the watershed may be almost fully developed, so future changes in the pollutant loads are projected to be small. In this case, the EII reach would have a high current problem rating and a low future problem rating.

The basic procedure for developing water quality problem priorities is to consider both the receiving water's resource value and problem severity. Resource values reflect the number and quality of designated uses (e.g., contact recreation, and aquatic life support) supported by the receiving water. The more designated uses supported by the receiving water, the higher the resulting resource value assigned. For example, Lake Austin was assigned the highest resource value since it is designated as supporting public water supply, contact recreation, noncontact recreation and aquatic life uses. Water quality problem ratings are shown in Figure 10 and depict both the current and future problem information.

Overall, the results indicate that water quality problems are geographically distributed. Not surprisingly, urban creeks are the most degraded currently while future threats are of most concern in the non-urban creeks. Urbanized creeks, especially the downstream segments of East Bouldin, Johnson, West Bouldin and Country Club creeks, demonstrate low aquatic life levels and poor water/habitat quality. Rapidly developing watersheds, such as Walnut and Bull, still retain good water quality conditions but are susceptible to impacts from future development. In the Bull Creek watershed, localized water quality impacts to springs have been documented (City of Austin, 1999). Model results also indicate that while the current condition of the nine studied receiving waters (e.g., Town Lake) is good, degradation may occur in the future due to increases in pollutant loads (Figure 11), changes in flow regime and other factors.



Watershed Protection Department

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Water Quality Problem Ratings

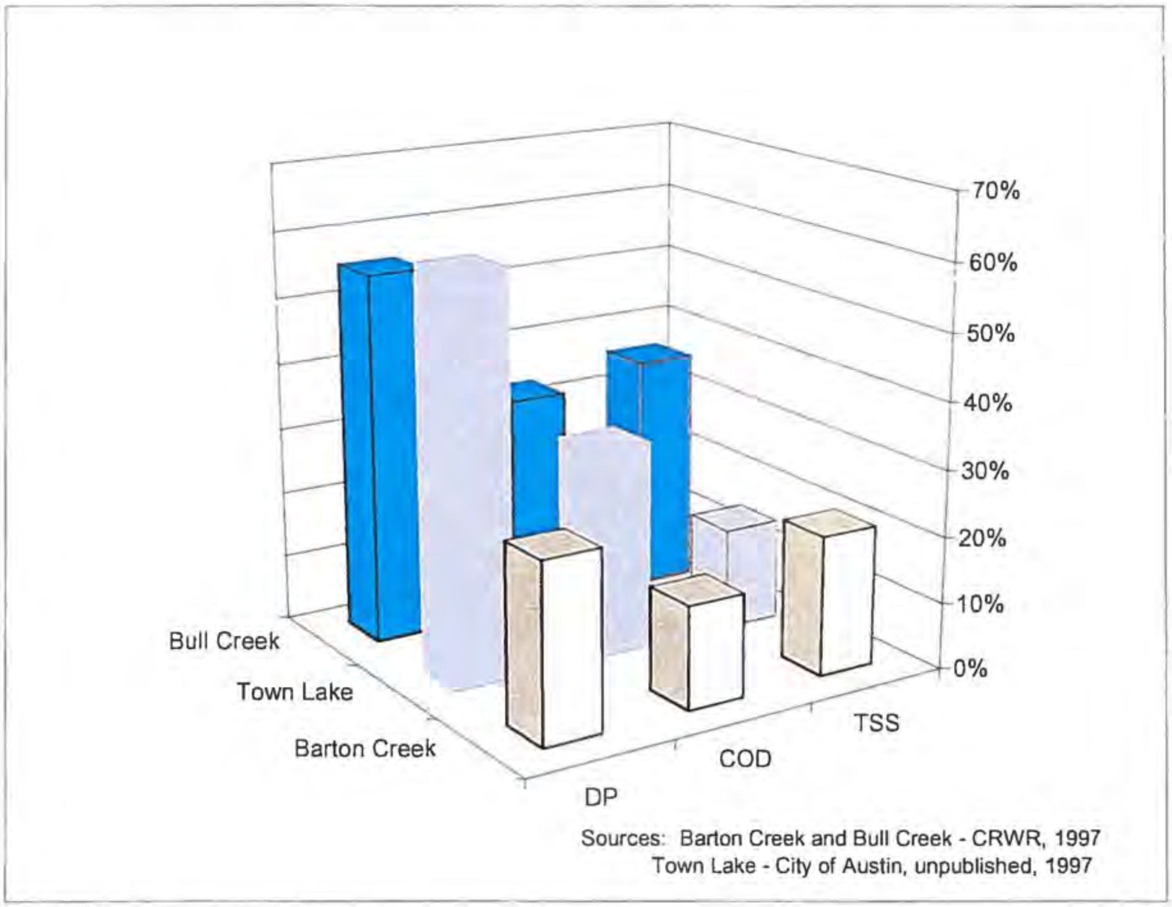
0 1 2 3 4 5 6 Miles

N

Figure 10

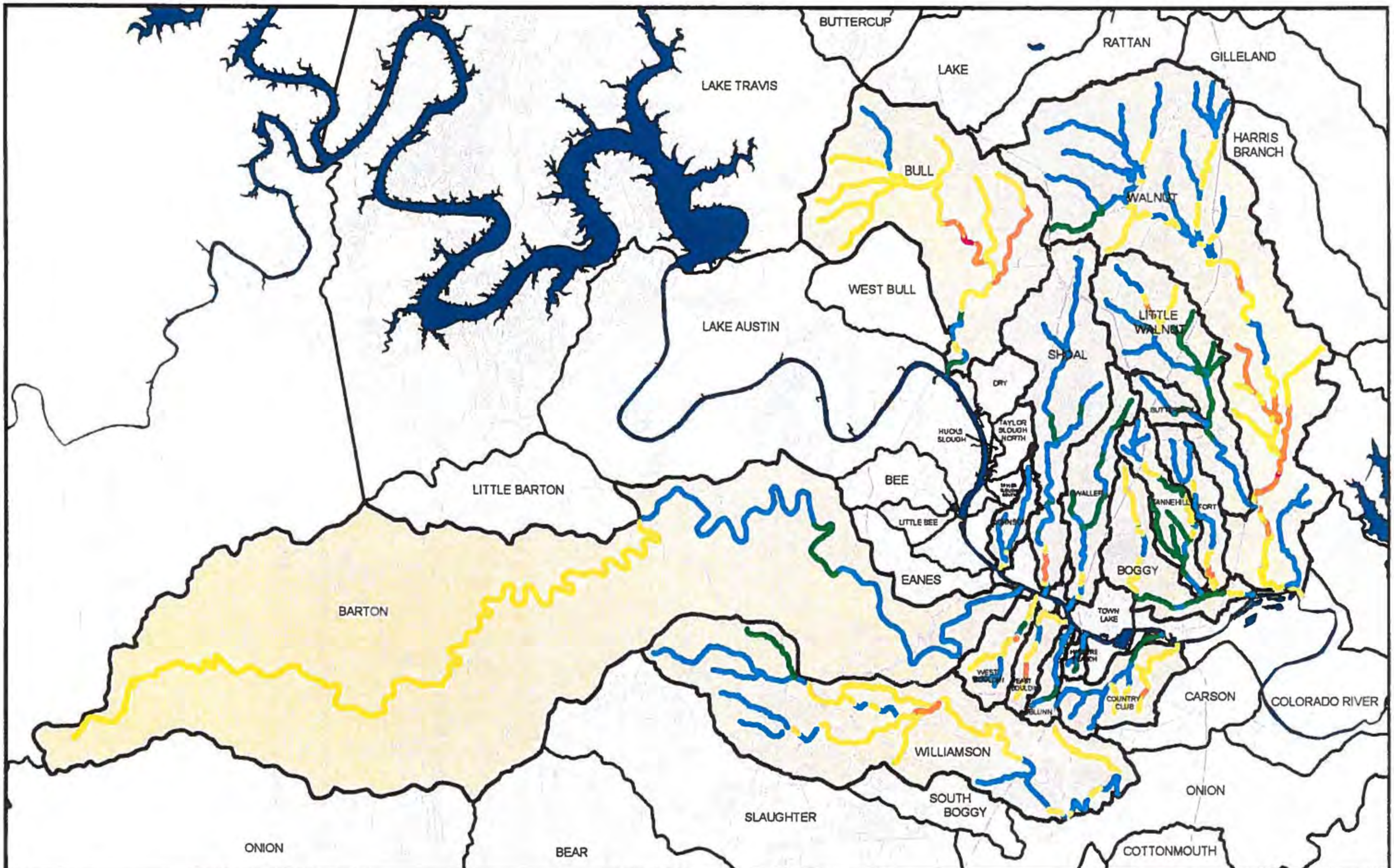
Water Qualtiy Problem Rating
- Very Low
- Low
- Moderate
- High
- Very High
- Roads
- Lakes & Rivers
- Phase 1 Watersheds
- Austin Area Watersheds

Figure 11 Predicted Pollutant Load Increases for 1995 – 2040



Integrated Problem Areas

A ranking of integrated problem areas was developed by averaging the flood, erosion and water quality problem area results for each creek. These composite (or integrated) scores (Figure 12) help to identify areas that are most appropriate for an integrated solution - a solution that simultaneously addresses the flood, erosion and water quality needs of an area. Based on this integrated assessment, sections of Bull Creek and the Crystal Brook area of the Walnut Creek watershed demonstrated the highest integrated problem ratings due to the extent of flooding, erosion and water quality concerns in these areas.



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Integrated Problem Ratings

Figure 12

0 1 2 3 4 5 Miles

N

Integrated Problem Rating
- Very Low
- Low
- Moderate
- High
- Very High
- Roads
- Lakes & Rivers
- Phase 1 Watersheds
- Austin Area Watersheds

Developing Integrated Solutions

After the Phase I problem assessments were completed, the master planning effort then focused on the task of developing integrated solutions for identified flood, erosion and water quality problem areas. An "integrated" solution refers to the ideal situation where a proposed solution would effectively promote the attainment of each of the watershed protection goals for a targeted location.

An integrated solutions development process was developed which entails various steps for evaluating the appropriateness and effectiveness of solution alternatives. For the Master Plan, the process is broken down into these general steps:

- <u>Inventorying Solution Types</u> – documenting the range of available solution types and their general levels of effectiveness, cost and other implementation considerations.
- <u>Identifying Preferred Solutions</u> – procedures for identifying the "preferred" solution type for a given problem area. Also includes planning level estimates of the general benefits and costs for site-specific preliminary solutions for each of the Phase I watersheds.
- <u>Estimating Goal Attainment</u> – comparing the benefits provided by proposed solutions to WPD goals and objectives.
- <u>Planning Implementation Activities</u> – describing the steps to implement capital projects, programs and regulations.

Findings and Recommendations were developed based on the results of the solution development process, and are discussed on page ES-61.

Inventory of Solution Types

To facilitate the solution development process, available watershed protection techniques were characterized along with their corresponding levels of effectiveness, cost and other implementation considerations. The complete inventory of watershed protection techniques contains over 130 different solution types (Loomis Austin, Inc., 2000). Information on flood, erosion and water quality controls was taken from a variety of sources including the City of Austin, Lower Colorado River Authority and other local, state and national resources (including the Center for Watershed Protection in Maryland).

From a municipal perspective, watershed protection solutions are grouped into three broad categories: *capital projects, operating programs*, and *regulations*.

- **Capital Projects** most commonly involve the construction or improvement of drainage infrastructure such as detention ponds, channels or storm drains. Floodplain structure buyouts and open lands acquisition is also considered. The term "capital" implies the method by which most of these large projects are funded – through the City's capital improvement program.
- **Operating Programs** are watershed protection activities implemented by City staff and funded through the WPD operating budget. Examples of operating programs include infrastructure maintenance, emergency spills and complaints response, design review and inspection of new development.
- **Regulations** are solutions implemented through application and enforcement of City of Austin codes and rules. Examples of regulations include impervious cover limits for new development, drainage design criteria, and industrial storm sewer discharge permitting.

Table 9 lists the solutions included in the inventory by the categories listed above.

Table 9
Inventory of Watershed Protection Solutions

Capital Projects		
Flood Control	**Erosion Control**	**Water Quality Control**
Property Acquisition through Condemnation Property Acquisition through Voluntary Buyout Flood Detention Channelization Structure Raising Storm Drain System Upgrades Flow Diversion-Channels and Tunnels Removal of Structural Restrictions Levees and Floodwalls	Property Acquisition Side Slope Treatments - Reinforced Earth - Vegetative Bioengineering - Vegetative Reinforcement Techniques - Placed Rock Rip Rap - Big Rock Toe Treatments - Gabions - Concrete Rip Rap - Mortared Rock Geomorphically Referenced River Engineering Storm Water Detention for Erosion Control Flow Attenuation Check Dams Measures for Localized Erosion Problems - Outlet Protection at Storm Drain outfalls - Flow Deflectors	Source Controls - Inlet Filters - Trash and Debris Booms - Retrofit for Existing Development - Impervious Cover Removal - Impervious Cover Disconnection - Bioretention - Infiltration Basins - Infiltration Trenches - Porous Pavement - Rainwater Harvesting - Hazardous Materials Traps Rangeland Management Strategies - Native Grassland Establishment - Livestock Control in Riparian Areas - Specialized Grazing Systems Stormwater Treatment Measures - Retention-Irrigation - Wet Ponds - Constructed Stormwater Wetlands - Urban Forestry

Existing WPD Programs		
Flood Control	**Erosion Control**	**Water Quality Protection**
- Watershed Hydraulic and Hydrologic Modeling - Flood Plain Office - Watershed Management and Facilities Planning (RSMP) - Flood Hazard Public Information - Flood Early Warning System - Channel Vegetation Control - Pond Vegetation Control - Open Waterway Maintenance - Bridge and Culvert Clearing - Storm Drain System Repair and Rehabilitation - Storm Drain System Cleaning - Flood Project Planning. Implementation & Field Engineering	- Erosion Project Planning -Implementation and Field Engineering -Erosion Control Crew **Integrated Programs** -Detention & Water Quality Pond Maintenance and Rehabilitation -Review & Inspection of Development -Watershed Master Planning Database Management and Geographic Information Systems (GIS)	-Federal Permit Compliance -Water Quality Assessments -Land Use Water Quality and Structural Controls Monitoring -Environmental Impact Assessments -Water Quality Planning and Implementation -Storm Sewer Discharge Permits -Emergency Spills and Complaints -Contaminated Site Cleanup -Pond Operating Permits Program -Commercial Pond Inspection -Underground Storage Tank Permits -Town Lake Cleanup -Water Quality Public Education

Table 9 continued
Inventory of Watershed Protection Solutions

New Proposed Programs		
Flood Control	**Water Quality Control**	**Integrated Programs**
- Dam Safety Inspection	- Small Scale Urban Water Quality Retrofit - Small Scale Urban Retrofits for Baseflow Enhancement - Grow Green Landscaping - Street sweeping for Toxics - Trash and Debris Control Team - Dry Weather Flow Screening	- Ongoing Voluntary Buyout of Floodplain - Land & Conservation Easement Acquisition - Rural Watershed Restoration - Programs Integration - Watershed Steward Program

Regulations		
Flood Control	**Water Quality Protection**	**Integrated**
- Prohibitions on Obstructions to Waterways & Easements - Peak Flow Limits - Floodplain Alteration Guidelines - Drainage Study, Floodplain & Easement Delineation Standards - Return Interval Standards - Contributing Area Assumptions - Drainage Easement Maintenance Criteria **Erosion Control** - Shoreline Modifications & Dredging - Construction Phase Controls - Revegatation Requirements - Cut & Fill Limits - Design Storm Runoff Detention - Drainage Design Criteria	- Pollution Prohibition - Litter Laws - Animal Regulations - Municipal Solid Waste - Fertilizer & Pest Management Standards - Stormwater & Nonstormwater Discharge Permits - Industrial Storm Discharge Permits - Hazardous Material Storage & Spill Control - Hazardous Material Traps - Remediation Cleanup Standards - Wastewater Line Construction - On-site Sewage Facility Requirements - Effluent Irrigation Standards - Phosphorus Controls - Water Quality Controls - Capture Volume - Treatment Standards - Maintenance of WQ Controls	- Comprehensive Planning - Natural Channel Conveyance - Impervious Cover Limits - Impervious Cover Reductions via Development Regulations - Flow Volume Limits - Disconnected Impervious Cover - Steep Slope Restrictions - Stream Setbacks - Headwater Buffer Zone Protection - Wetlands Protection - Critical Environmental Feature Protection - Landscape Regulations - Tree Protection Standards

Incentives and Enforcement	
Adoption of Rules Regulatory Incentives Land Acquisition & Conservation Easements Variance Procedures Operation & Maintenance Permits Environmental Assessments	Application of Standards to Platted Single Residential Lots Application of Standards to Subdivision of Illegal Lots Redevelopment Standards Fee In Lieu Alternatives Legal Enforcement

Source: (Loomis Austin, Inc., 2000)

Identifying Preferred Solutions

Preferred solutions for a given problem area were chosen from the solutions inventory based on the nature of the watershed problem and the effectiveness and limitations of the solution being considered.

General protocols (or "ground rules") were developed to assist with the selection of alternative capital project, programmatic and regulatory solutions for further evaluation. These protocols are best described as establishing a hierarchy of preferred solutions based on each solution's capacity to simultaneously achieve WPD's goals under various land use and geographic conditions. In other words, the preferred solution(s) should reflect a cost-effective and sustainable strategy to:

1) meet flood, erosion and water quality objectives;
2) maintain or improve the natural character of the creek;
3) maintain or reduce required maintenance needs;
4) ensure compliance with applicable local, state, federal permit and regulatory requirements;
5) foster additional beneficial uses of waterways and drainage facilities where possible.

The solution protocols are applied to identify specific solutions for each of the Phase I watersheds. Depending on site constraints and preliminary constructability considerations, one or more preferred alternative solutions were proposed to address each problem area. Finally, the benefits and costs of the preferred solutions are estimated to facilitate comparisons to watershed goals and available funding resources.

Capital Projects

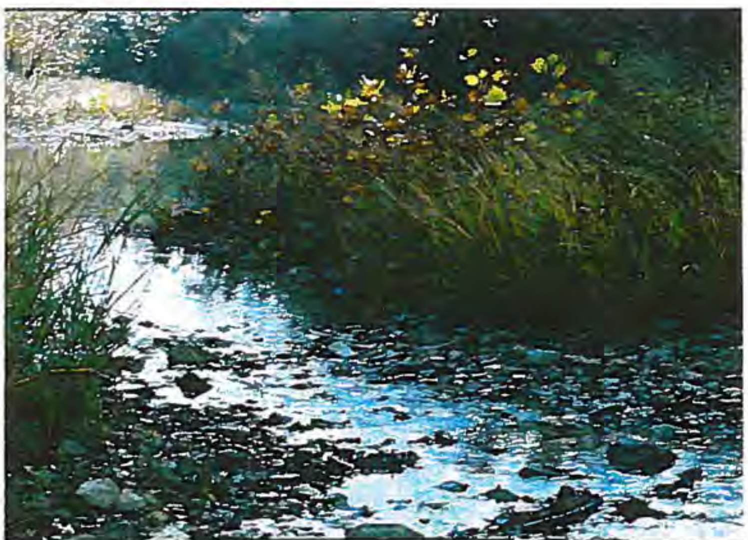
Selecting the most appropriate capital solution alternative(s) for a specific problem area is heavily influenced by the development conditions of the watershed in which the target problem area is located. In Table 10, three watershed development categories are identified – *rural, developing* and *urbanized.*

Table 10
Solution Preferences by Watershed Type

RURAL WATERSHEDS	DEVELOPING WATERSHEDS	URBANIZED WATERSHEDS
1. Barton Creek	1. Blunn Creek 2. Bull Creek 3. Country Club Creek 4. Walnut Creek 5. Williamson Creek	1. Buttermilk Creek 2. Boggy Creek 3. East Bouldin 4. Fort Branch 5. Harper's Branch 6. Johnson Creek 7. Little Walnut Creek 8. Shoal Creek 9. Tannehill Branch 10. West Bouldin Creek 11. Waller Creek
Rural Watershed Characteristics	**Developing Watershed Characteristics**	**Urbanized Watershed Characteristics**
Future Impervious Cover <15%	Existing Impervious Cover >15% Net Future Impervious Cover Increase >5%	Existing Impervious cover >50% Net Future Impervious Cover Increase <5%
Solution Options for Flood Control	**Solution Options for Flood Control**	**Solution Options for Flood Control**
- No flooding problems in Barton Creek	- Property Acquisition (Buyouts) for Flood Control - Flood Detention - Channelization - Flow Diversion: Channels and Tunnels - Replacement of Structural Constrictions - Levees and Floodwalls	- Property Acquisition (Buyouts) for Flood Control - Flood Detention - Channelization - Flow Diversion: Channels and Tunnels - Replacement of Structural Constrictions - Levees and Floodwalls
Solution Options for Erosion and Water Quality	**Solution Options for Erosion and Water Quality**	**Solution Options for Erosion and Water Quality**
- Geomorphically-Referenced River Engineering (GRRE) - Wet Pond/Wetlands - Retention-Irrigation Ponds	- Reinforced Earth [erosion side slope projects] - Gabions/Concrete Riprap [erosion side slope proj.] - Geomorphically-Referenced River Engineering (GRRE) - Erosion Detention - Erosion Detention + Wet Ponds - Erosion Detention + Wet Ponds + Baseflow Extended Detention - Retention-Irrigation Ponds *[Bull; Williamson in BSZ]*	- Reinforced Earth [erosion side slope projects] - Gabions/Concrete Riprap [erosion side slope proj.] - Geomorphically-Referenced River Engineering (GRRE) - Erosion Detention *[Little Wal. & Shoal headwaters]* - Wet Ponds/Wetlands - Wet Ponds + Baseflow Extended Detention

Source: Loomis Austin, Inc., 2000

In *rural* watersheds, the impacts of urbanization on creek flooding, erosion and water quality are limited and isolated when compared to urbanized watersheds. Creeks draining rural watersheds (e.g., Barton Creek) have mostly stable channels with minimal amounts of past channel enlargement. In lieu of capital projects, preventive regulatory approaches (including restrictions for developing in the floodplain, creek setbacks and onsite water quality and erosion controls) are more effective since much of the land is yet to be developed. Water quality retrofits are more appropriate in pockets of more intense existing development. Due to limited flooding (and natural character concerns), regional on-line flood detention ponds are not expected to be an integral part of the watershed protection strategy for rural watersheds.



Barton Creek

Developing watersheds (Blunn, Bull, Country Club, Walnut, and Williamson) generally have moderate levels of existing impervious cover (between 5% and 50%), and a relatively high potential for future impervious cover increases (greater than 5% increase). Creeks in developing watersheds experience accelerated creek erosion, show signs of instability and are predicted to increase in channel size by greater than 25% in most cases. Priority flood solutions include property buyouts and detention due to their limited impact on riparian areas relative to channel improvements. Bridge or culvert replacement, channel improvements and floodwalls are also considered viable options. The availability of open space makes detention a more likely alternative for developing watersheds as opposed to urbanized watersheds.

In developing watersheds, construction of regional detention facilities to provide erosion control is given a high priority since the potential for future stream degradation due to erosion is high. Priority is also given to the integration of large-scale regional facilities to address flood and water quality concerns. Sideslope stabilization measures are recommended to protect existing property threatened by creek erosion, but these measures will not be effective over the long-term if watershed-scale measures (such as erosion detention ponds and stream corridor restoration) are not implemented.

Regional water quality controls (e.g., wet ponds) that do not provide detention are given a lower priority since they do not effectively address the adverse hydrologic impacts of development. Retention-irrigation ponds were considered for the Bull and Williamson Creeks watersheds to facilitate a higher level of water quality treatment for these watersheds located in the City's designated Drinking Water Protection Zone.

Urbanized watersheds typically have high existing impervious cover levels (greater than 50%) and thus, a lower potential for future development when compared to rural and developing watersheds. Infill and redevelopment are the most likely sources of future increases in impervious cover. Urban creeks commonly have experienced significant channel enlargement in the past. Therefore, estimates of future enlargement are predictably low (less than 25%). In addition, undeveloped land for siting new erosion, flood or water quality detention ponds is severely limited in urbanized watersheds. In urbanized watersheds, large-scale erosion detention ponds are generally not considered effective solutions because most of the preventable creek enlargement has already occurred. Efforts in these watersheds should focus on channel restoration including localized sideslope stabilization and property buyouts together with retrofits of existing ponds for water quality and erosion benefits. Flood solutions are likely to include property buyouts, bridge replacement or channel improvements. However, flood detention is a preferred alternative where sufficient open space is available. In addition to reducing pollutant loads, water quality ponds should be designed to augment baseflow and improve stream habitat quality and stability.

Urbanized Fort Branch Watershed

The City's Desired Development Zone includes several Phase I watersheds that are developing or urbanized. In support of the City's Smart Growth initiative, the Master Plan emphasizes the use of engineered strategies in the Desired Development Zone to minimize the need for additional regulations that may restrict development in that area.

Once the capital solution preferences in Table 10 were established, specific locations in the Phase I watersheds were identified where preferred erosion, flood and water quality solutions could potentially be constructed given apparent site constraints. In all, over 300 sites for potential projects were identified. These conceptual projects were then evaluated to estimate construction costs (discussed below) and benefits (see page ES-51).

Once the initial solution development effort was completed, WPD continued to refine the project identification process by conducting additional investigations of specific projects, screening out less feasible projects and identifying additional capital solution alternatives to further promote goal attainment for each WPD mission. Table 11 presents the results of the cost analysis for each of the Phase I watersheds. As shown, a total of $875,030,000 in capital solutions were identified.

The flood project cost total of $444,980,000 is based on the selection of the alternative solution judged most desirable for each problem area using the initial project cost data from Loomis-Austin, Inc. As discussed earlier, most locations for potential watershed solutions had more than one type of technology identified as a potential solution for any given location. In most cases, the highest cost flood control alternative per site (purchase of floodplain property) generally yields the highest integrated benefits. Final costs could range from $300-500 million.

Additional erosion sideslope projects (approximately 50 new projects) were added by WPD to address problem areas not considered in the initial effort. Costs for the added erosion sideslope projects were based on averaged costs from past projects. The $166,810,000 shown in Table 11 reflects the implementation cost of approximately 110 total sideslope projects.

Table 11
Primary Drainage System Cost by Watershed (rounded)

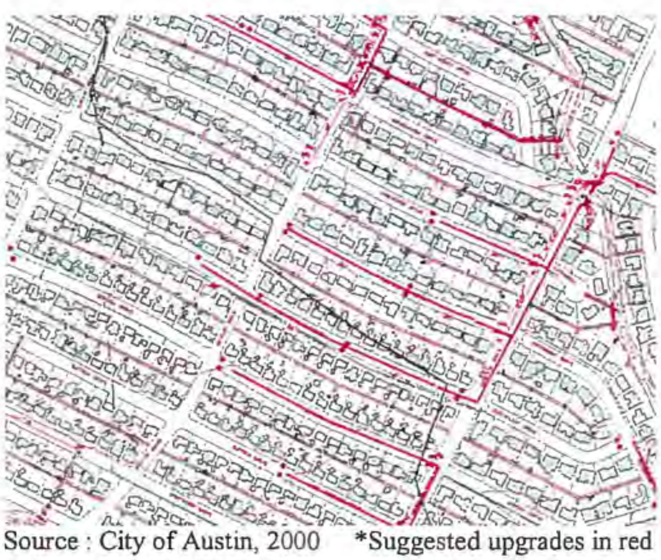
Watershed	Flood	Erosion Sideslope	Water Quality/ Erosion Ponds	Total
Barton	–	$2,640,000	$11,340,000	$13,980,000
Blunn	$4,820,000	$2,230,000	$2,230,000	$9,280,000
Buttermilk	–	$4,880,000	$2,660,000	$7,540,000
Boggy	$8,000,000	$8,710,000	$6,440,000	$23,150,000
Bull	$24,420,000	$10,850,000	$43,420,000	$78,690,000
Country Club	$15,810,000	$6,390,000	$7,950,000	$30,150,000
East Bouldin	$24,980,000	$5,740,000	$7,090,000	$37,810,000
Fort Branch	$7,820,000	$9,930,000	$3,240,000	$20,990,000
Harper's Branch	–	$260,000	$1,680,000	$1,940,000
Johnson	$4,300,000	$5,610,000	$1,010,000	$10,920,000
Little Walnut	$98,190,000	$13,440,000	$12,900,000	$124,530,000
Shoal	$69,690,000	$21,360,000	$29,450,000	$120,500,000
Tannehill	$2,120,000	$8,520,000	$3,210,000	$13,850,000
West Bouldin	$7,790,000	$3,140,000	$13,680,000	$24,610,000
Walnut	$54,380,000	$36,890,000	$55,910,000	$147,180,000
Waller	$21,620,000	$7,260,000	$10,770,000	$39,650,000
Williamson	$101,040,000	$18,960,000	$50,260,000	$170,240,000
Total	$444,980,000	$166,810,000	$263,240,000	$875,030,000

Source: City of Austin, 2000; Loomis Austin, Inc., 2000 ENR construction cost index (1999) = 6060

Proposed erosion and water quality pond projects total $263,240,000 and include varying configurations of wetpond, baseflow enhancement and erosion detention features. Fourteen regional erosion detention ponds are proposed – including four ponds identified by a more detailed study of the Walnut Creek Watershed (COA, 1999). Water quality solutions include 38 regional water quality pond facilities. Many of the initial water quality controls were deleted from consideration due to their location along the main creek channel, prompting concerns for channel erosion and natural character impacts resulting from project implementation. Due to the limited number of feasible water quality control opportunities, other retrofit alternatives were subsequently identified. The cost of retrofitting additional regional stormwater management ponds and existing residential and commercial ponds was evaluated. The water quality costs shown in Table 11 include all project costs. The combined cost for erosion and water quality controls (sideslope and ponds) for the urban and non-urban watersheds are approximately $185,440,000 and $244,610,000 respectively. Urban and non-urban watershed costs for flood controls are $249,330,000 and $195,650,000 respectively.

To address localized flooding problems, a preliminary study of several local storm drainpipe networks was completed to determine if current system capacity and pipe sizes are adequate. Each watershed sub-basin area was analyzed to compute excess runoff and size the main storm drain system (Figure 13).

Figure 13
Localized Drainage System Study Example*



Source : City of Austin, 2000 *Suggested upgrades in red

Preliminary cost estimates were prepared for each storm drain system in order to obtain an estimate of the magnitude of required infrastructure needs. Table 12 summarizes the estimated project costs for each watershed. Final costs could range from $100 - $300 million. Ultimately, construction costs will depend on the results of final design configurations and the length of time required for implementation and the ability to coordinate projects with other City infrastructure improvements.

Table 12
Localized Drainage System Upgrade Estimates

Entire Watershed Studies (based on previous complaints received through December 1998):

Watershed	Prelim. Project Cost (Millions)	Suggested # of System Upgrades
Boggy	$ 17.5	36
Blunn	$ 5.2	24
Buttermilk	$ 0	0
Carson	$ 0	0
Country Club	$13.3	21
East Bouldin	$12.6	30
Fort Branch	$19.3	48
Harper's Branch	$ 2.6	5
Johnson	$15.2	34
Little Walnut	$10.4	27
Shoal	$43.3	47
Tannehill	$ 8.4	24
Town Lake 1	$ 2.1	4
Town Lake 2	$ 6.2	4
Town Lake 3	$19.4	3
Waller	$39.4	24
West Bouldin	$23.0	50
Partial Watershed studies:		
Barton	$ 0	0
Bull	$ 0.8	2
Eanes	$ 0.04	1
Walnut	$ 0.35	2
Williamson	$18.4	37
Total:	$257.5 Million	423

Source: City of Austin, March, 2000
ENR construction cost index = 6127, December 1999

It should be noted that the initial feasibility determination for identified potential capital projects is based on very preliminary site investigations. Therefore, the estimation of benefits and costs should also be considered preliminary in nature. Additional study of these project concepts will be necessary during the preliminary engineering phases of the CIP implementation process to define proposed project budgets and objectives. Based on current estimates, capital project needs for watershed protection exceed $800 million.

Capital Project needs exceed $800 million	
Creek Flooding Buyouts, Detention Ponds, Channel Modifications	$300 - 500 million
Storm Drains Storm Drain Installation, Repair, Replacement	$100 - 300 million
Bank Stabilization Projects Biorevetment, Gabions	$150+ million
Integrated Ponds Water Quality, Erosion and Multi-objective	$250+ million

Operating Programs

In conjunction with the solution inventory, program data was collected to estimate existing operational program service levels. Service levels are measured differently for different programs (e.g., miles of pipe replaced, number of plans reviewed). After determining the service levels provided by current WPD programs, proposed operational program enhancements were recommended to improve service levels (Loomis & Moore, 1999a). These enhancements included improvements to existing programs and the provision of additional services not currently provided by WPD.

Program activities were also related to the WPD goals and objectives they support. For instance, the maintenance programs (such as storm drain or detention pond maintenance) not only ensure the proper operation of the drainage infrastructure to achieve desired levels of erosion, flood and water quality protection but also help maintain asset values. Programs that provide guidance or support (such as modeling, design, and database management) to other WPD programs were also evaluated based on the recommended enhancements of the supported programs.

Program recommendations were derived from comparisons of current versus alternative levels of service and the identification of service gaps for existing programs. Three alternative levels of service were determined through a combination of targeted benchmarking of other cities and consultant recommendations. The levels of service are defined as follows:

- **Essential** - Level of service provided by a program that only addresses immediate program needs but does not function at an optimum level due to resource constraints.
- **Optimum** - The target level of service for each program where each program's minimum objectives are achieved.
- **Maximum** - The maximum level of service that should be considered by WPD for each program.

Consultant recommendations were made for each program to achieve each of these levels of service. After review, priority enhancements were identified.

From Table 13, program enhancements are recommended for various programs including maintenance, review and inspection, public education and design/modeling support.

Maintenance

Public Education

Review and Inspection

Table 13
Proposed Program Enhancements

Program Name	Program Enhancement
Channel Vegetation Control	Program expansion including increased contractuals, required to meet demand and customer requests.
Detention and Water Quality Pond Maintenance and Rehabilitation	Additional staff to help with completion of short term, priority pond remediations in a timely manner, and provide for annual inspection and maintenance of City-maintained ponds once the short term work is completed. Currently 150 out of 450 ponds are maintained on a regular basis.
Emergency Spills and Complaints	Additional staff to address increased workload. Upgrade and improve design of database.
Environmental Impact Assessments	Additional staff to expand hydrogeological review to support growing WPAP review needs, cave management plan review/coordination, and karst feature protection and mitigation reviews.
Erosion Control Crew	Additional staff to help reduce the significant backlog of necessary erosion repairs within a reasonable timeframe.
Erosion Project Planning, Implementation and Field Engineering	Additional staff to plan, design and manage construction projects performed by Erosion Control Crew and to provide Utility contact for CIP projects.
Flood Early Warning System	Additional staff to enhance emergency preparedness planning, decision support and response tools.
Flood Hazard Public Information	Additional staff to improve current customer service levels.
Flood Plain Office	Additional staff to create Digital Flood Insurance Rate Maps, to provide public notification of changes in floodplain status (flood insurance requirements), to review development in the floodplain.

Table 13 continued
Proposed Program Enhancements

Program Name	Program Enhancement
Flood Project Planning, Implementation and Field Engineering	Additional staff to meet essential performance levels. Services need to be completed within a reasonable amount of time, and an inventory of existing storm drain locations is needed.
GIS and Database Management	Additional staff for the design and maintenance of database systems, and to provide GIS support for the maintenance activities of the department.
Pond Vegetation Control	Contractual increase to provide increased frequency in maintenance. Other enhancements include evaluation of vegetation removal frequencies and methods.
Residential and Commercial Pond Inspections	Additional staff to increase ability to complete inspections of 429 Residential Ponds, 3243 Commercial Ponds, and 852 FEMA Creek Crossings.
Review and Inspection of Development	Additional staff to upgrade inspection and enforcement capabilities, improve customer assistance, and provide assistance with consultation on legal issues.
Storm Drain System Repair and Rehabilitation	Additional staff to provide an improved level of service. Currently, approximately one-tenth of needed repairs are performed each year.
Storm Sewer Discharge Permits	Additional staff to address increased workload.
Water Quality Assessments	Additional staff to integrate water quality monitoring database with GIS, and to design and implement more effective monitoring of onsite wastewater treatment/disposal system impacts in cooperation with W&WW department ongoing studies, and evaluate impact of leaking sewers on surface and groundwater quality.
Water Quality Control Planning and Implementation	Additional staff to implement expanded WQ retrofit program.
Water Quality Public Education	Additional staff for graphic design, printing, and representation at environmental fairs, and to conduct surveys regarding the effectiveness of the public education initiative.
Watershed Hydrologic and Hydraulic Modeling and Flood Plain Mapping	Additional staff and contractual funding is needed for implementation of a systematic model maintenance and upgrade procedure updating of the existing watershed models; and for development of an efficient digital model storage and retrieval system.
Watershed Management and Facilities Planning	Additional staff to perform engineering assessments and preliminary engineering, provide project planning and design for large-scale projects.
Watershed Master Planning	Phase 2 funding necessary for watershed assessment and solution development.
Program Name	**New Program Description**
Conservation Easement and Land Acquisition	Proposed new program to identify, facilitate acquisition of, and maintain strategic land in the Master Plan watersheds. Application of this program for riparian buffer acquisition could be coordinated with flood and erosion hazard property acquisition, which would deal with similarly located properties.
Dry Weather Field Screening	New program required by federal permit. Dry weather field screening and inspection of storm drain outlets must be performed to locate and eliminate illicit non-storm discharges. Work to be performed by existing City staff.
Flood and Erosion Hazard Property Acquisition	Proposed new program would coordinate the acquisition of properties at risk of flooding and/or erosion on a voluntary basis.
Rural Watershed Restoration	Proposed new program to encourage and provide assistance to local landowners willing to restore degraded rangeland areas.
Small Scale Retrofits for Water Quality and Baseflow Enhancement	Proposed new program to implement small-scale CIP projects that intercept and retain pollutants from non-point sources and which promote enhancement of stormwater infiltration and baseflow. Includes widespread implementation of smaller-scale BMPs (usually retrofits) in areas where larger CIP projects are infeasible.
Trash and Debris Control Team	Proposed new program to target cleanup of trash dumped in City waterways which often results in citizen complaints and aesthetic problems in creeks and lakes.

Regulations

After a review of the City's watershed protection regulations, approximately 50 potential changes were recommended for further evaluation (Loomis & Moore, 1999a). The proposed changes were subsequently screened by WPD based on the expected benefit, availability of data to support the need, and requirements to implement and enforce the proposed change. After the screening process, the remaining regulatory changes were grouped into the following benefit categories:

- **Incentives** – modifications to the City's current regulations that provide incentives to improve watershed protection through the use of alternative methods to achieve compliance.
- **Public Service** – providing flexible and consistent criteria and tools for developers and other members of the public.
- **Infrastructure Management** – implementing changes to fees and criteria to improve the integrity of drainage infrastructure and reduce long-term maintenance demands.
- **Problem Prevention** – changes in regulations to avoid the creation of new problems in the future.

Table 14 summarizes the proposed regulatory changes for each of the categories listed above. Incentives are proposed to promote the use of low impact development techniques, improve construction site management, and protect more sensitive watershed areas through development transfers. The public is expected to benefit from efforts to simplify the permitting process through the provision of new design criteria for alternative water quality controls and more closely aligning City and federal NPDES pollution prevention plan requirements. Infrastructure management recommendations include proposed clarifications of maintenance criteria along open waterways and a review of developer participation fees. The problem prevention category includes proposals to establish erosion control-based stream setbacks and to modify current drainage channel and detention pond requirements to reduce the threat of future erosion.

Table 14
Proposed Regulatory Modifications

Incentives	
Landscape-Low Impact Development	Allow for landscape credit to be given to developers who choose to use low-impact development techniques located within landscaped areas to receive runoff from their site. Water Quality credit could be offered for such low-impact design alternatives. See alternative WQ Design criteria under customer service/assistance below.
Erosion Control - Site Management	Update the Environmental Criteria Manual to incorporate improvements in materials and design standards to coordinate with the COA Standards Manual. Incentives such as reduction or early release of fiscal could be offered for those using improved site management techniques such as storing and reusing native topsoil, minimizing time between grading and revegetation, use of native or xeriscape plant material and seed mixes, and wash racks to control mud tracking.
Development Mitigation Policy	Mitigation Policies can benefit both the City and landowners when transfer of development rights are allowed between different properties through mitigation that includes concepts such as: 1) the transfers result in less impervious cover than otherwise allowed, 2) transfers move development from more environmentally sensitive land to less sensitive land, 3) transfers move development to areas that can be served using existing public infrastructure, and 4) transfers are structured to preserve open space and natural areas within each watershed.

Public Service/Assistance	
WQ Design Criteria	Revise and expand the Environmental Criteria Manual to include standard design criteria and assessment methods for alternative water quality controls based on average annual pollutant load reductions.
Erosion Control - NPDES Permit Provisions	Update City of Austin erosion control criteria to include or reference Federal NPDES construction permit requirements creating a consistent set of criteria for local developers to follow.
Uniform Relocation Assistance	Address relocation assistance in instances where residential or commercial property threatened by flooding or creek erosion is acquired by the City on a voluntary basis.

Table 14 continued
Proposed Regulatory Modifications

Infrastructure Management	
Revise RSMP and Urban WQ Control Fees	Fee amounts have not been evaluated since program origin in 1980's for RSMP and 1990 for WQ fee. Fees are currently being reviewed to determine if they adequately address increases in land and construction cost while still remaining low enough to encourage participation. Establish participation criteria for WQ fee-in-lieu-of.
Drainage System and Waterway Maintenance Criteria	Regulation to allow the maintenance of drainage easements in the original permitted design configuration and to define conditions warranting vegetation removal in order to adequately convey stormwater flows. Set standards for maintenance performed within waterways, including soil stabilization and replanting.
Drainage Study, Floodplain and Easement Delineation Standards	Require drainage easements to be designed using an assumption of infrequent maintenance.
WQ Control Registration	Current requirements exist for operating and maintenance permits for the Barton Springs Zone. Expand registration of WQ controls City wide as a prerequisite for getting reductions in drainage fee to help track location and ownership of controls. Actively publicize fee reduction/registration program.

Problem Prevention	
Stream Setbacks	Establish erosion control based stream setbacks to provide property protection from the threat of erosion. Maintain vegetation in the critical water quality zone using native plants without managed turf grass, pesticides or unapproved fertilizers.
Design Storm Runoff Detention for Stream Bank Erosion	Require developments to capture and detain the runoff volume greater than that released from the undeveloped site for those small and relatively frequent storms that control the channel size and shape. The smaller storms should be detained for an optimum detention period to prevent erosion damage to property and the stream system.
Effluent Irrigation Standards	Require additional soil depth for effluent irrigation, to specify maximum nitrogen loading, to require additional wet weather storage, to require setbacks from watercourses and Critical Environmental Features, and to require monitoring for effluent constituents.
Golf Course Management Plan	Require a management plan for all golf courses to include components for water balance, fertilizer loadings and monitoring, and would limit activities in the critical water quality zone.
Drainage Design Criteria	Revise the Drainage Criteria Manual to ensure that new or altered channels are properly designed to minimize future erosion. Potential modification would include adding permissible shear stress criteria for both the bottom and side slopes for the 1-, 2-, 10-, 25- & 100-year storm events.
Tree Protection Standards	Expand tree protection requirements to allow for specific circumference regulations for different tree species, to require a percent of site be left in a natural area, to protect significant groves of trees, to evaluate establishing a minimum percent canopy cover for a site, and to establish a mitigation fee system for tree replacement.

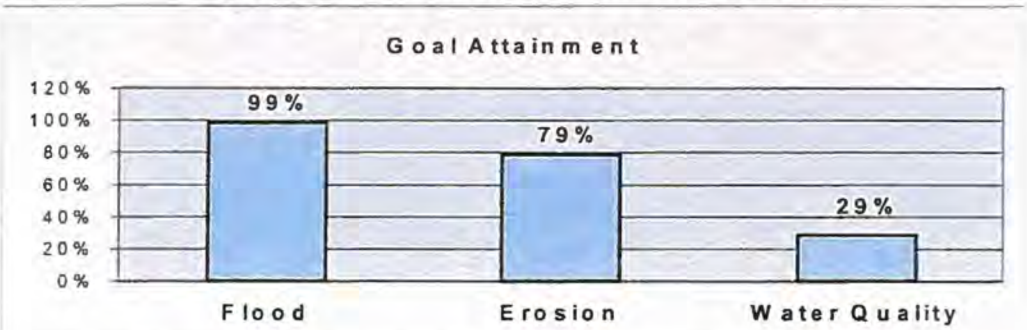
Estimating Goal Attainment

In an effort to gauge the cumulative benefits of proposed solutions, preliminary estimates of watershed goal attainment for erosion, flood and water quality objectives were developed. As explained on page ES-44, these estimates are considered preliminary due to the conceptual nature of the defined solutions and the estimation process used to determine cumulative benefits.

Goal attainment was defined according to the erosion, flood and water quality objectives listed in Table 1. For each proposed capital project concept, a benefits estimate was calculated based on the specific characteristics of each project such as potential pond detention volumes, number of homes in the 100-year floodplain, contributing drainage area, etc. The benefits of certain programs and regulations were also included where estimating benefits was deemed reasonable based in part on the availability of data quantifying their effectiveness.

Assuming that the most effective solution is feasible at each project site, a best-case scenario goal attainment value was calculated (Loomis-Moore, 1999b). The results are generalized for each mission and are shown in Figure 14. The majority of flood problems are addressed by the best-case scenario (99% goal attainment) since project concepts were estimated to fully alleviate 100-year flooding at most problem sites. The same is true for erosion (79% goal achievement) with the exception of those erosion sites where a conceptual project was not originally proposed or where future reach stability is difficult to achieve due to site constraints.

Figure 14 Generalized Goal Attainment Results



Source: Loomis & Moore, 1999b

From Figure 14, of most concern is the predicted goal attainment for water quality (29%), which reflects several factors including limited opportunities to: 1) mitigate the impact of past development in the City's urban watersheds, and 2) address the impacts from new development in areas outside the City's jurisdiction. It should also be noted that the estimated goal attainment values above represent an ambitious best case scenario that all of the identified project concepts are feasible and implemented.

With the benefits of additional sideslope stabilization projects and alternative water quality strategies proposed by WPD staff, relative goal attainment for erosion and water quality should be enhanced over the estimates given above. However, the revised estimates for water quality goal attainment are still low (25 - 50 %). Additional work is needed to investigate alternative control opportunities, including less effective and more costly onsite retrofits. For each mission, achieving watershed protection goals is dependent on the final feasibility of the project concepts identified in this Master Plan and the availability of funding to support their implementation.

Implementation Planning

Successful implementation of proposed watershed protection solutions relies heavily on additional public input and support. Additional meetings are proposed to further educate the public on Master Plan findings and recommendations. In the future, capital projects and program enhancements will be implemented as funding is approved through the annual budgeting process, special bond elections or other funding allocations. Regulatory changes will proceed through the appropriate public review and adoption process.

Capital Projects

Assuming that funding is available, policy decisions must be made regarding the implementation of capital projects. Different prioritization processes were reviewed during the course of this Master Plan. Several included ranking factors such as cost-benefit, sustainability and neighborhood impacts. Ultimately, a "needs-based" approach was selected (with support of the Citizen's Advisory Group) to prioritize WPD recommendations for future project funding. A needs-based approach simply means that the worst problem areas [where the needs (risks) are greatest] will be considered first for project implementation. The problem area results shown in Figures 2, 7, 10 and 12 for flood, erosion, water quality and integrated problem areas form the basis for priority designations. It should be noted though that projects that fix the worst problem areas in the City are generally the most expensive projects. Therefore, actual implementation of these priority projects may be delayed until funding is available. In addition, projects may be selected for implementation due to criteria placed on the use of targeted funds (e.g., RSMP funds) or other opportunity based considerations (e.g., land availability, joint projects with other entities).

A major tenet of this Master Plan is a commitment to implement sustainable watershed protection strategies that integrate WPD missions. Past project experience has shown that "single mission" project planning strategies are more costly than multipurpose, integrated project strategies. Single mission planning and implementation commonly creates unanticipated impacts on other missions. Ideally, multiple integrated projects are designed concurrently to avoid project conflicts and enhance watershed benefits.

Determining the cumulative impact of implementing several multi-objective projects in the same watershed is very complex. An understanding of stream dynamics is necessary to optimize project benefits. For this reason, a watershed management area (WMA) approach for solution implementation is also recommended. The WMA approach provides an improved basis for the development of comprehensive, coordinated watershed management plans.

This system is based on the classification of creek segments or reaches into three categories (Table 15) based on the predictions of how the creek will respond to given drainage improvements (Chan, 1997). Watershed management areas were designated by WPD to encompass given reaches of a creek based on the creek segment characteristics described in Table 15. The needs-based prioritization system (described previously) was applied to these larger watershed management areas. The results are shown in Figures

15, 16, 17 and 18. By following a systematic procedure to group similar reaches of the creek, WPD can combine and better integrate potential CIP solutions – designing and implementing them concurrently as a comprehensive strategy, rather than individually.

Table 15
Watershed Management Area Approach

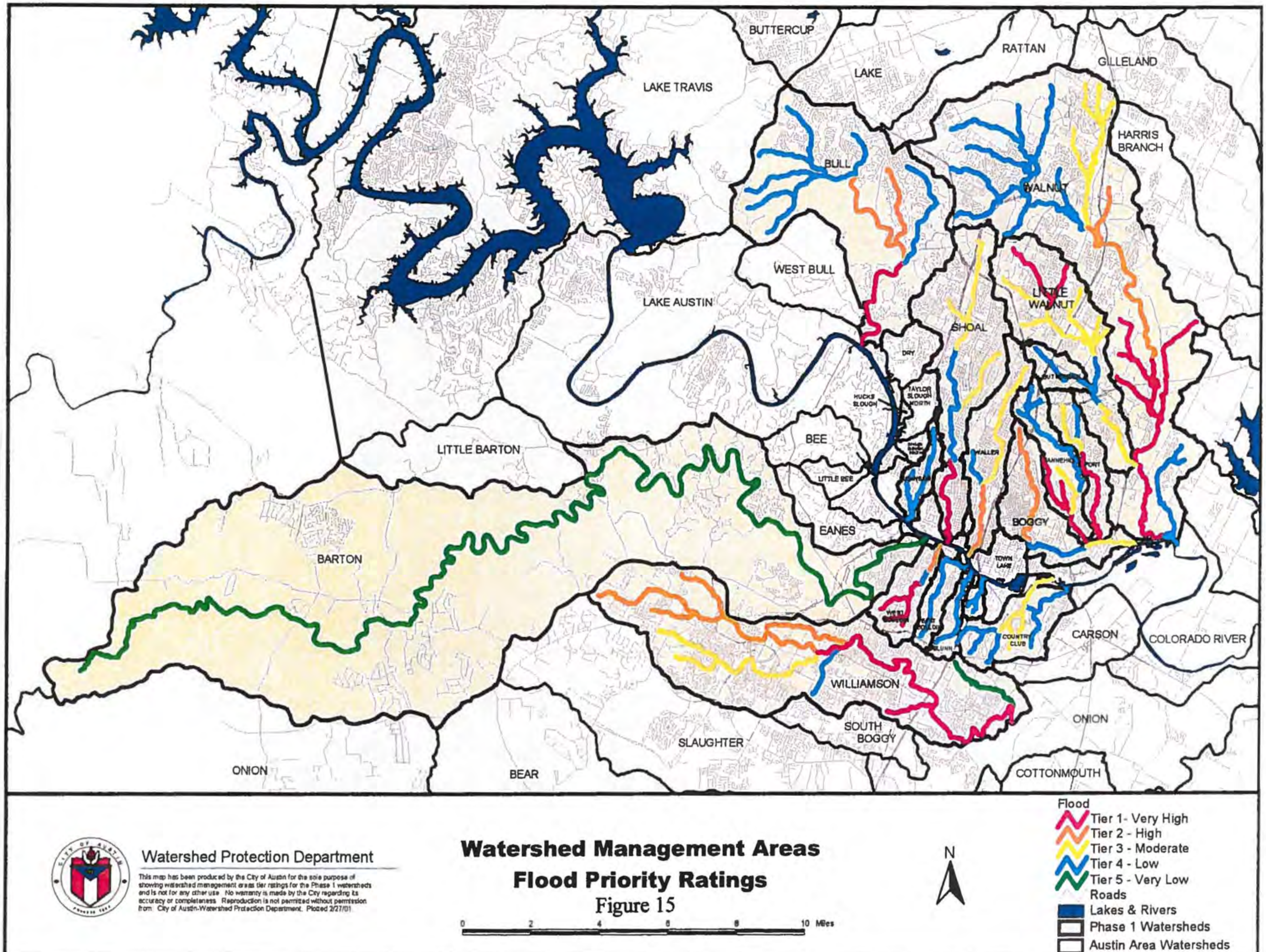
Classification	Approach
Type A	Type A restoration involves specific reaches or lengths of the creek wherein the stabilization work for these reaches can be undertaken in isolation of upstream or downstream creek morphology; in other words, work done in one reach does not impact other reaches.
Type B	Type B restoration programs involve two or more reaches of the creek wherein work done in one reach affects or impact other reaches of the creek.
Type C	Type C restoration programs involve watershed wide stabilization schemes because work done in any reach has watershed wide impacts.

Source: Raymond Chan & Associates, 1997

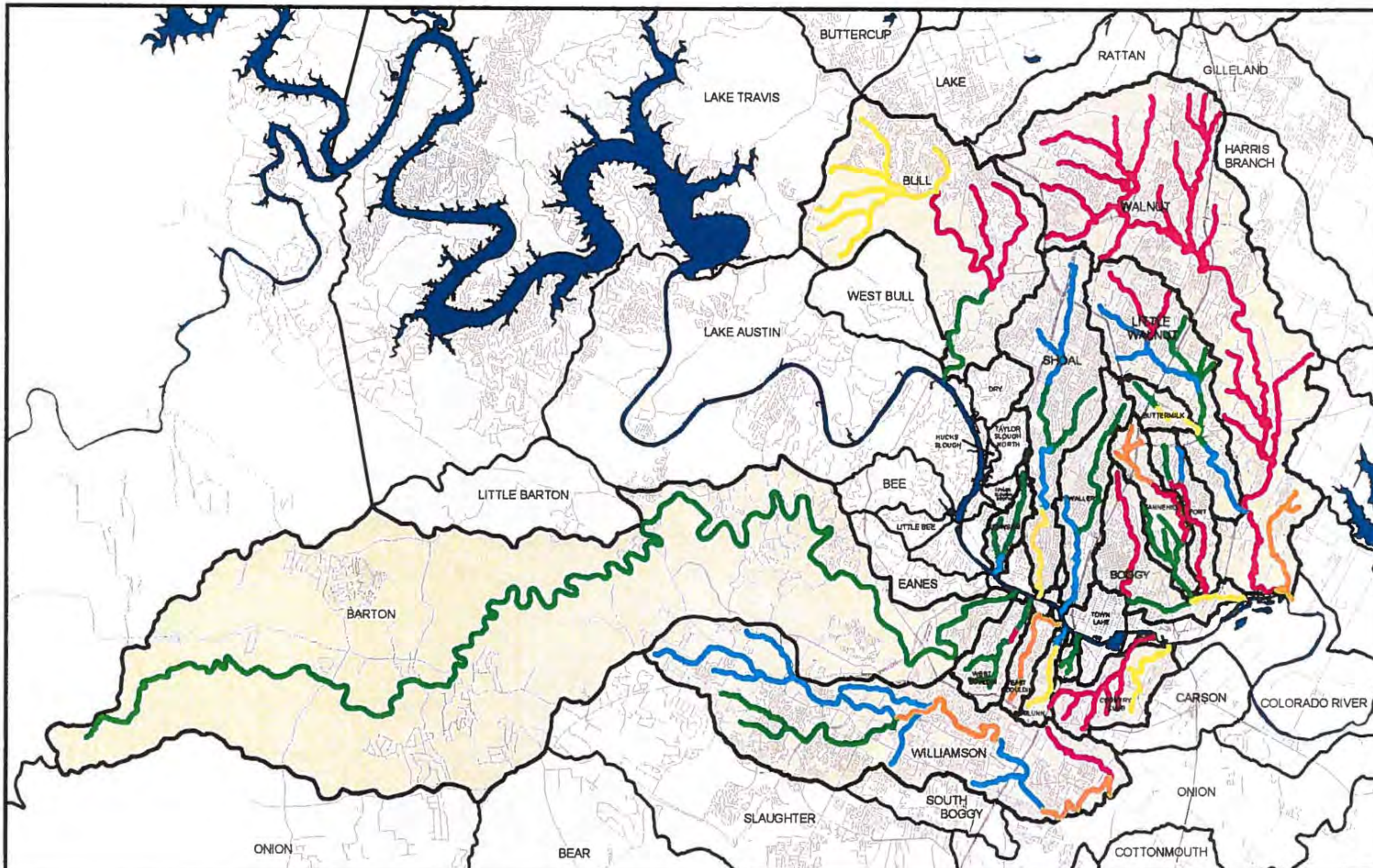
Storm drain improvements will not be dictated by the WMA process since the majority of localized flooding occurs in areas beyond the boundaries of creek corridors. There will be a greater demand for adequate drainage as in-fill and redevelopment occurs in the urban core. As of spring 2000, WPD identified more than 420 areas in the Phase I watersheds needing upgrades due to existing capacity. Each localized flooding area requires further study to better determine potential integration opportunities.

Operating Programs

As discussed on page ES-45, program enhancements were defined based on a level of service analysis. This analysis resulted in the identification and initial prioritization of needed WPD program enhancements. While some identified program enhancements do not require funding to implement, most will require additional funding approval through the City's annual budgeting process. WPD will propose budget enhancements incrementally as Council approves proposed increases in the drainage fee.



Watershed Management Areas
Flood Priority Ratings
Figure 15



Watershed Protection Department

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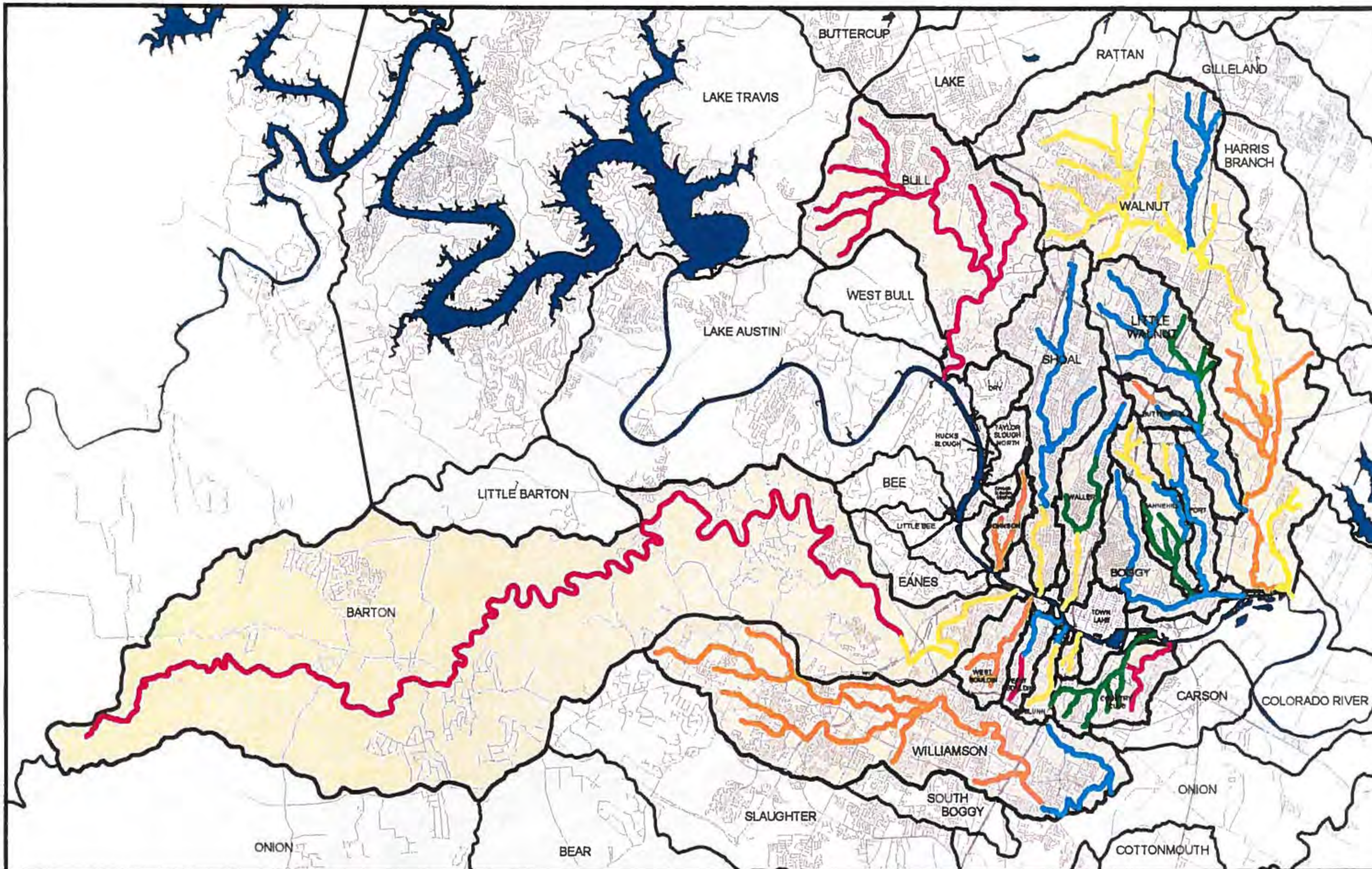
Watershed Management Areas
Erosion Priority Ratings
Figure 16

0 2 4 6 8 10 Miles

N

Erosion
- Tier 1 - Very High
- Tier 2 - High
- Tier 3 - Moderate
- Tier 4 - Low
- Tier 5 - Very Low
- Roads
- Lakes & Rivers
- Phase 1 Watersheds
- Austin Area Watersheds



Watershed Protection Department

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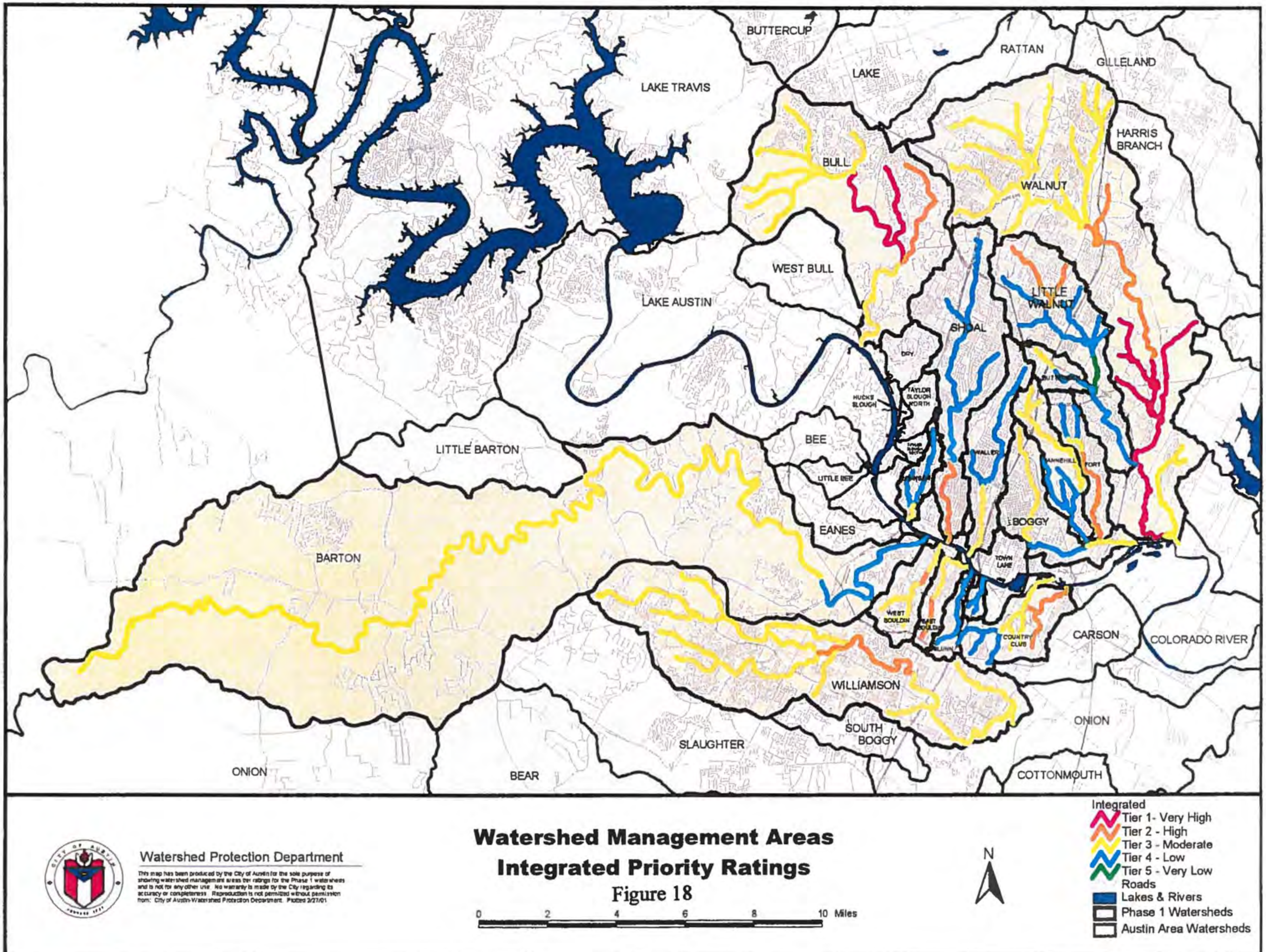
Watershed Management Areas
Water Quality Priority Ratings
Figure 17

0 2 4 6 8 10 Miles

N

Water Quality
- Tier 1- Very High
- Tier 2 - High
- Tier 3 - Moderate
- Tier 4 - Low
- Tier 5 - Very Low
- Roads
- Lakes & Rivers
- Phase 1 Watersheds
- Austin Area Watersheds



Watershed Management Areas
Integrated Priority Ratings
Figure 18

Regulations

Proposed regulatory enhancements require changes in the Land Development Code and the Environmental and Drainage Criteria manuals (Table 16). The regulatory changes proposed do not at this time have final language drafted. Instead, they represent planning level recommendations. In order for regulatory changes to be implemented, final language containing specific rules and criteria based on additional studies must be prepared for public review.

Table 16
Location for Proposed Regulatory Modification

Regulation	Location in Code/Criteria
Reassess RSMP fees	Annual Fee Ordinance. Drainage Criteria Manual (DCM)
Reassess Urban Fees	Annual Fee Ordinance. Environmental Criteria Manual
Drainage System and Waterway Maintenance Criteria	Environmental/Drainage Criteria Manuals
Drainage Study, Floodplain and Easement Delineation Standards	Land Development Code (LDC) and Drainage Criteria Manual
Registration for WQ Controls	Land Development Code (LDC) and Drainage Criteria Manual
WQ Design Criteria	Environmental Criteria Manual
Erosion Control/NPDES	Land Development Code (LDC) and Environmental Criteria Manual
Uniform Relocation Assistance	Land Development Code
Landscape-Low Impact Development	Land Development Code (LDC) and Environmental Criteria Manual
Erosion Control-Site Management	Land Development Code (LDC) and Environmental Criteria Manual
Development Mitigation Policy	Land Development Code
Stream Setbacks	Land Development Code
Design Storm Runoff Detention for Stream Bank Erosion	Land Development Code and Environmental/Drainage Criteria Manuals
Effluent Irrigation Standards	Land Development Code
Drainage Design Criteria	Drainage Criteria Manual (DCM)
Golf Course Management Plan	Land Development Code (LDC) and Environmental Criteria Manual
Tree Protection Requirements	Land Development Code (LDC) and Environmental Criteria Manual

Changes to the City Code (including the Land Development Code) must be approved by City Council. Proposed changes would be reviewed by the City boards and commissions which are relevant to the subject of the proposed code change (e.g., Environmental Board, Planning Commission). These meetings would be advertised through the standard posting process for public meetings, and would include a public hearing to obtain input from interested parties prior to the final Council hearing where action is taken.

Rule changes (including Criteria Manual revisions) are subject to an administrative process that includes stakeholder review and a public review period. Stakeholders are made up of other City departments affected by the rules, as well as environmental, neighborhood, and business and professional organizations. After stakeholder review, the rule is then posted for public comment prior to final adoption.

Little Walnut Creek

Appropriate stream setbacks can prevent the creation of new watershed problems due to erosion.

As shown in Table 14, relatively few regulations are proposed for modification. The majority of existing regulations are effective in minimizing the impact of new development that is subject to current City rules and regulations. Many existing watershed problems were caused by older development that occurred prior to the passage of watershed regulations. Similarly, many future problems are predicted due to development in areas outside Austin's ETJ, or from future development within Austin not subject to current requirements by virtue of exceptions allowed by State law.

Findings and Recommendations

Findings

1) In the Phase I watersheds, flood, erosion and water quality problems are widespread and are expected to worsen if corrective action is not taken.

2) Over the next 40 years, more than $800 million in capital funds are required to construct new or improved integrated watershed protection facilities including detention ponds, channel stabilization projects and other flood, erosion and water quality controls. This funding level is equivalent to approximately twice the historical capital spending rate.

3) Additional funding of $2 – 5 million per year is needed to provide essential levels of service for several City programs including infrastructure maintenance, environmental development review and inspection, public education and design support.

4) Various code and criteria changes are required to improve public service, provide developer incentives, reduce long-term maintenance demands, and prevent the creation of new watershed problems in the future.

5) Attainment of erosion and flood goals may be possible given sufficient funding.

6) Water quality goals are not attainable through implementation of solutions evaluated in the Master Plan. Limited regional retrofit opportunities in urban watersheds and inadequate regulatory controls in areas outside the City's jurisdiction are significant constraints.

Recommendations

1) Develop long–range funding proposals to support solution implementation.

2) Integrate watershed solutions to the extent possible to effectively promote watershed protection goals attainment.

3) Implement integrated capital projects using a needs-based, watershed management area approach as funding becomes available.

4) Develop collaborative multi-agency partnerships (that include federal, state, and local entities along with other City Departments, community groups and concerned citizens) to achieve watershed protection goals.

5) Use Master Plan results to assist in the development of proposed WPD budget increases to fund priority program enhancements.

6) Involve stakeholders in the comment and review process for proposed regulatory modifications before Council consideration as final language is developed.

7) Refine watershed protection goals based on continued public involvement and additional studies.

8) Continue development and evaluation of innovative water quality solutions to attain water quality goals. Refine water quality goals to reflect additional evaluation and feasibility of solution implementation.

9) Update Phase I Master Plan information as better data becomes available and solutions are implemented.

10) Expand master planning efforts beyond the Phase I watersheds as funding allows.

Section 1

Introduction

1.1 Background

For more than two decades, the City of Austin has been recognized as a national leader in addressing watershed protection issues. Beginning in the 1970's, Austin began to place an emphasis on creek protection and the prevention of future problems through regulation. In 1974, the Waterway Development Ordinance (a.k.a., the Creek Ordinance) limited development in the 25-year floodplain, required developments to identify appropriate sedimentation and erosion controls and brought a new focus to protecting the "natural and traditional character" of local creeks. Since that time, the City has enacted additional watershed regulations and established design criteria manuals aimed at mitigating increased runoff rates and pollutant loadings from new land development.

Probably the single most important event that helped shape the City's current watershed protection program is the Memorial Day Flood of 1981. In response to the storm's devastating effects, the City implemented a new drainage fee to provide funding for an expanded stormwater management program. Between 1981 and 1984, strong public support for flood and erosion bond packages became evident as voters authorized more than $75 million for capital improvement projects. The first creek ordinance that limited development in the 100-year floodplain was passed in 1983. Erosion controls were first required for new construction in 1978 with the Lake Austin ordinance. From the mid 1980's to today, the City's erosion and water quality efforts have matured as a result of drainage fee fund increases and the passage of notable water quality ordinances (e.g., Comprehensive Watershed Ordinance, Urban Watershed Ordinance and the Save Our Springs Ordinance).

Due to the passage of these existing City regulations, much of the City's current watershed protection efforts are targeted at fixing problems caused by existing development that predated these regulations.

Today, the City's watershed management program has three primary missions, flood control, stream erosion control, and water quality management. The programs that comprise these missions are described below:

- **Flood Control** – The City's flood control program is founded on regulations that prohibit an increase in peak storm water runoff that results in increase flooding impacts from development, maintenance programs to ensure that waterways are free of flow-blocking debris and vegetation, construction projects to improve the ability of creeks and streams to carry water, and finally, a system of regional detention facilities. Regional detention ponds can help reduce storm water runoff from large watershed areas, and are much easier to construct in some areas than many smaller facilities.

- **Stream Erosion Control**– The City's current erosion control program was formally adopted in 1991, during the formation of the Drainage Utility. Prior to that time, the City had a limited budget for erosion control projects. Occasionally, projects intended to reduce flooding also helped control stream bank erosion but, by and large, no specific erosion control projects were built (even though complaints by property owners indicated that there was a strong need for such projects). Once the erosion control program was started, City staff found that they faced a daunting task — erosion problems along several creeks were so severe and widespread that short-term and small-scale solutions would have been ineffective. Little Walnut Creek, Tannehill Branch, and Fort Branch were some of the creeks that fell into this category.

- **Water Quality Protection** – Austin has developed a multi-faceted storm water quality program to control pollution from urban areas. The City's control strategy relies on source control and treatment facilities to remove pollution. Source control measures include land use zoning, impervious cover limits, creek set backs and buffer requirements for new development, and the control of illegal discharges, public education, a spill and environmental complaint response program, and drainage facility maintenance. Despite the above efforts, treatment structures are also needed to protect water quality. The City pioneered the use of sand filtration systems to reduce pollution in storm water runoff. Today, the types of treatment technologies used for this purpose have expanded to include wet ponds, retention/irrigation systems, extended detention ponds, and alternative filtration systems.

1.2 Need for a Master Plan

In 1991, the City established a Drainage Utility to oversee storm water management programs. Between 1982 and 1991, any monies raised by the fee could be used for storm water management, but were not dedicated exclusively to storm water projects. The creation of the Drainage Utility in 1991 ensured that funds raised by the fee would be used only for storm water management and watershed protection programs.

The Watershed Protection Department was created in 1996 with the merging of the flood and erosion programs from Public Works with the water quality protection programs of the Environmental and Conservation Services Department. With the creation of this unified department, a new emphasis was placed on:

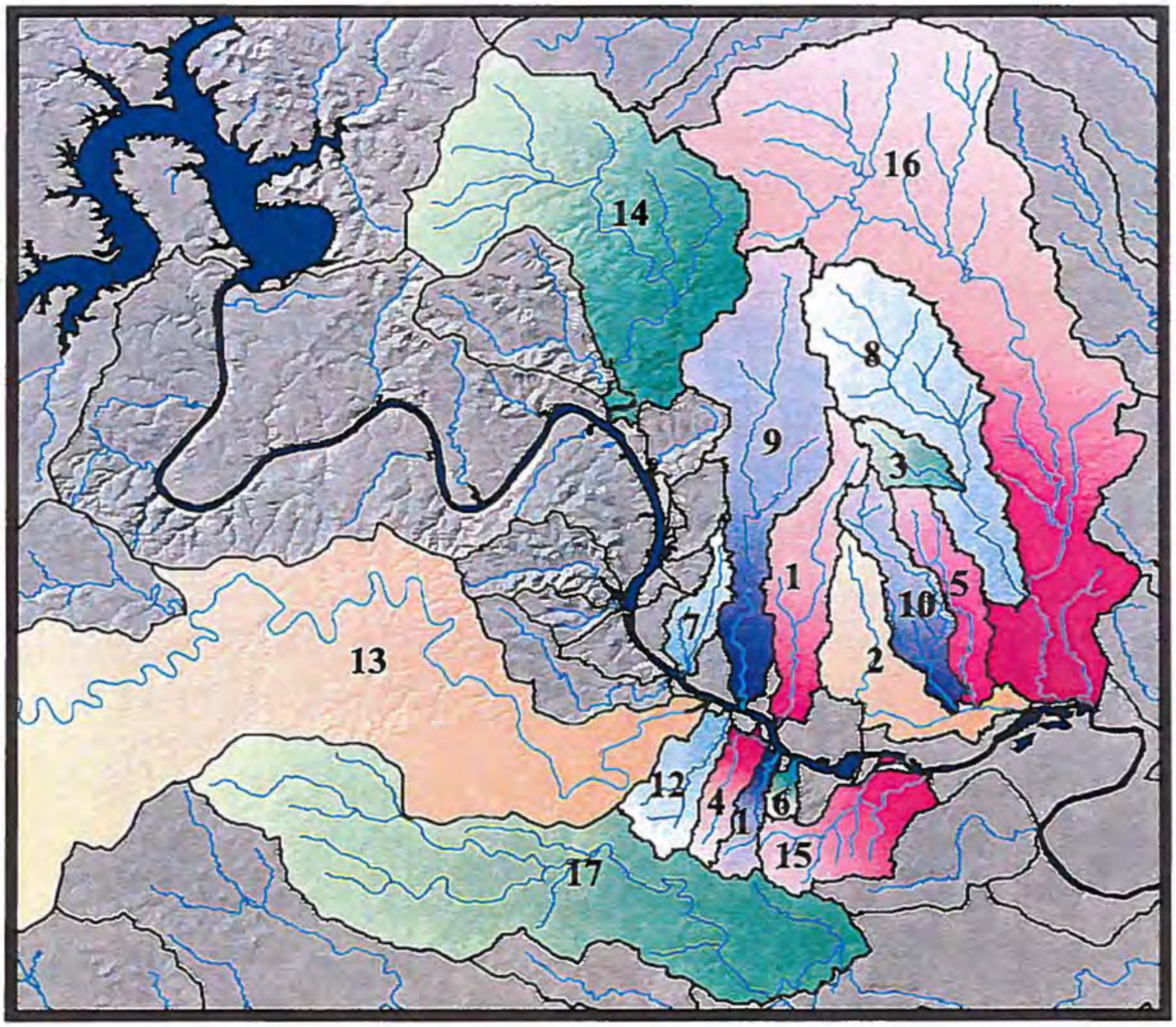
1) improving the prioritization of future watershed protection efforts,
2) determining the adequacy of existing funding levels, and
3) integrating the three missions of the new department to more cost-effectively achieve flood control, erosion control and watershed protection goals.

Shortly after this the Watershed Protection Phase I Master Plan was initiated to obtain city-wide technical data on the flood erosion and water quality missions that is needed to prioritize watershed protection efforts. As solutions were developed and evaluated, they were analyzed to determine the most effective solution types for each problem area, as well as to determine the location where integrated solutions were needed.

1.3 Master Plan Approach

This Master Plan sets forth a plan to protect watersheds, people and property. Phase I watersheds include all twelve urban watersheds, and five surrounding suburban and water supply watersheds: Barton, Blunn, Boggy, Buttermilk, Bull, Country Club, East Bouldin, Harper's Branch, Johnson, Little Walnut, Shoal, Tannehill, Waller, Walnut, West Bouldin, and Williamson Creek Watersheds. Figure 1 – 1 shows the Phase I watersheds. The Master Plan Phase I watersheds represent 64% of the area within the City's limited purpose annexation area, and represent 32% of the area within the City's 5-mile extra-territorial jurisdiction (ETJ).

Figure 1 – 1
Phase 1 Watersheds Study Area Map

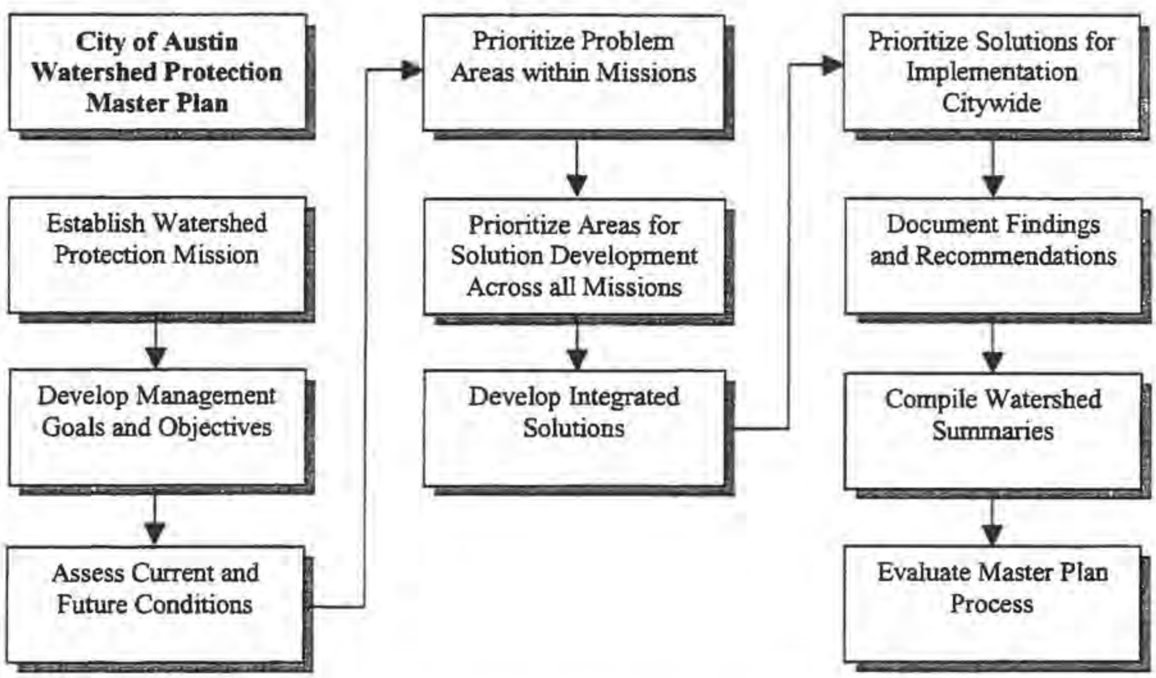


URBAN WATERSHEDS		NON URBAN
1. BLUNN (BLU)	7. JOHNSON (JOH)	13. BARTON (BAR)
2. BOGGY (BOG)	8. LITTLE WALNUT (LWA)	14. BULL (BUL)
3. BUTTERMILK (BMK)	9. SHOAL (SHL)	15. COUNTRY CLUB (CNT)
4. EAST BOULDIN (EBO)	10. TANNEHILL (TAN)	16. WALNUT (WLN)
5. FORT BRANCH (FOR)	11. WALLER (WLR)	17. WILLIAMSON (WMS)
6. HARPER'S BRANCH (HRP)	12. WEST BOULDIN (WBO)	

The first step in developing a Master Plan was to establish the Utility mission and the management goals. Section 2 of this report provides details on the goal setting process. Next, technical assessments were performed to identify flood, erosion and water quality problems within the Phase I watersheds. The technical assessments assessed current conditions as well as future conditions to the year 2040. After the problem areas were identified, a prioritization process was developed for each mission. An overview of the problem summary and prioritization process is provided in Section 3 of this report. Problem summary information for each mission is provided in Sections 4-7, and a summary of integrated problems is located in Section 8. Integrated problem areas are defined by overlaying individual mission problem areas together to see where problems exist in a common area. These "common" or integrated problem areas represent a need for multi-mission solutions that incorporate elements for flood, erosion, and water quality into a single solution strategy. Figure 1 – 2 describes the Master Plan process.

Figure 1 – 2

Master Plan Process



After the technical assessments were completed, solution development began, as described in Section 10 of this report. Solutions that were analyzed included Capital projects, WPD operating programs, and regulations. After the potential solutions were identified, recommendations were developed based on implementation through a needs based priority system. Section 11 describes the recommendations and the priority implementation process.

1.4 Master Plan Public Input Process

In order to receive citizen input during all stages of the Master Plan process, three major strategies were developed.

- Citizens Advisory Group
- Public Input Survey
- Master Plan Public Meetings

1.4.1 Citizens Advisory Group

The Citizens Advisory Group was formed early in the Master Plan process and consisted of members from varying interest groups and geographical areas throughout the city, representing neighborhood interests, water quality action groups, the academic community, as well as business and development interests. They provided advice on the process, made recommendations on various forms of public input and promoted the Master Plan efforts among fellow citizens.

1.4.2 Public Input Survey

The Watershed Protection Department commissioned an independent telephone survey in July 1997 to provide citizen input on drainage issues in their watershed. The seventeen Phase I watersheds were divided into 39 polling areas based on the size of the watershed. In the larger watersheds, for example, the watershed was divided into three segments so that variances from the headwater areas, mid-watershed and lower watershed could be measured. In the mid-sized creeks, two polling areas were used and in the smallest watersheds, only one was deemed necessary.

Citizens were asked their level of concern about flooding, erosion and water quality problems in their immediate neighborhood and in the City in general. They were also given the opportunity to describe any specific problem areas with which they were familiar. On the watershed level, results varied based on watershed specific concerns. The city-wide survey results showed a nearly equal concern level for each of the missions:

Mission	% of Respondents Expressing Concern
Flood	35%
Erosion	30%
Water Quality	35%

1.4.3 Master Plan Public Meetings

Three Master Plan public meetings took place in April and May of 1998 to allow citizens to comment on the findings of the Master Plan problem assessments as well as potential solution types.

Publicity for these meetings included the distribution of doorhangers in each of the seventeen watersheds, newspaper advertisements in the Austin American-Statesman and the Austin Chronicle, informational articles in the Statesman and various neighborhood papers, letters from the Director to community organization leaders and letters from Citizen Advisory Group members inviting targeted citizens.

The meetings included information on Department activities, followed by individual presentations by staff members on findings of technical assessments for each of the Phase I watersheds. Presentation materials included maps that illustrated problem severity in the creek (flood control, stream erosion control, and water quality, and integrated problems). Information on potential capital, programmatic and regulatory solutions were provided. Individual watershed Fact Sheets were also developed to summarize relevant population, land use, and technical assessment data.

Following the presentations, there was a question and answer periods where citizens commented on the information presented. Citizens were also asked to fill out a survey on issues covering the meeting content, the Master Plan process, and Utility funding.

One additional meeting was held February 7, 2001 to present the findings and solution recommendations of the Phase I Master Plan. The public meeting was co-sponsored by the Environmental Board and the Citizen's Advisory Group.

1.5 Master Plan Participants

The City of Austin managed the Watershed Protection Master Plan, utilizing consultants and researchers as needed to gather technical data on the problem areas and potential solution concepts. Table 1 – 1 outlines the efforts of the team members used on this project.

Table 1 – 1
Master Plan Participants

Element	Participant
Erosion Assessments	Raymond Chan & Associates
Flood Problem Assessment - Hydrologic & Hydraulic model conversion	Loomis Austin, Inc.
Flooded Structure Survey data	Carter & Burgess
Flooded Structure GIS application	City of Austin
Problem Area Prioritization System	City of Austin
Prioritization System Automation	Camp Dresser & McKee (CDM)
Water Quality Assessments	City of Austin
Pollutant Load GIS Modeling	University of Texas at Austin Center for Research in Water Resources (CRWR)
Stream Erosion Solutions Development	Raymond Chan & Associates Loomis Austin, Inc.
Regulatory Solutions Development	Glenrose & Associates Loomis Austin, Inc. Raymond Chan & Associates
WPD Program Level of Service and Benchmarking	Loomis Austin, Inc. and Crespo Consulting
Initial Capital Solution Evaluation	Loomis Austin, Inc.
Findings and Recommendations	City of Austin
General Technical Assistance and Report Reproduction	Camp Dresser & McKee

Section 2

Watershed Protection Goals

Watershed protection goals define program direction, facilitate accountability and thereby enhance public trust. A set of clearly defined and comprehensive watershed management goals is necessary to focus the Master Planning process. By including the public in the goal development process, consensus building and public trust are fostered as proposed management strategies are developed and measured against the desired outcome. This type of results-oriented, inclusive planning was a guiding principle for the Master Plan.

The following section provides an overview of the Watershed Protection Department (WPD) mission statement, management goals and objectives. The goals and objectives were key factors in determining the type of data to be collected during the Master Plan to locate and describe watershed problem areas. Thus, they are reflected in the design of the technical assessments (field work and modeling) described later in Sections 3 through 8 of this Master Plan. In Section 10, the City's ability to achieve these goals is discussed.

2.1 Challenges of Watershed Protection

Changes to the landscape from urbanization can profoundly affect stream character. Urbanization in the form of impervious cover (rooftops, streets, sidewalks, driveways and parking lots) represents that change. Increased impervious cover can alter the watershed's hydrology, increasing the risk of flooding and causing erosion. It also affects the quality of stormwater runoff, and initiates a chain of events that can degrade water quality.

2.1.1 Watershed Hydrology

Urbanization increases the amount of water that "runs off" into streams and causes flooding. Development sets in motion a series of hydrologic changes that:

- Increases peak discharges

- Increases stormwater runoff volume
- Reduces time needed for runoff to reach a stream, and
- Increases runoff velocity

These changes can lead to expansion of the floodplain and increased flood risks to people and property.

To reduce the threat from flooding, the stream system is often modified to direct and convey runoff away from urbanized areas. Stream diversion, channelization, damming and piping, which have been traditional responses to flooding and the altered hydrology of the stream, may destroy stream beds and related aquatic habitats like wetlands. Conversely, the altered hydrology of the stream may reduce streamflow during prolonged periods of dry weather.

Stream channels change shape, or adjust, in response to more severe flooding caused by increases in impervious cover or urbanization. Higher flows may increase the size of a stream by widening stream banks, downcutting stream beds or sometimes both. Stream channel instability, in turns, triggers a cycle of stream erosion. Property loss is a major expression of channel instability. Other consequences of stream erosion include the loss of aquatic habitat, such as a pool and riffle sequence, increased sediment deposition, and the loss of overhead protection and shading from the tree canopy.

2.1.2 Water Quality

Pollutant export increases dramatically both during and after construction. Site preparation practices such as clearing and grading leaves soils exposed and unprotected. Unless adequate erosion controls are installed and maintained at the site, sediment can be delivered to the stream channel, along with attached soil nutrients and organic matter.

Urban pollutant loads are directly related to watershed imperviousness. Impervious surfaces collect and accumulate non-point source pollutants deposited from the atmosphere, leaked from vehicles or derived from other sources. During storms, accumulated pollutants are quickly washed off and carried into local streams.

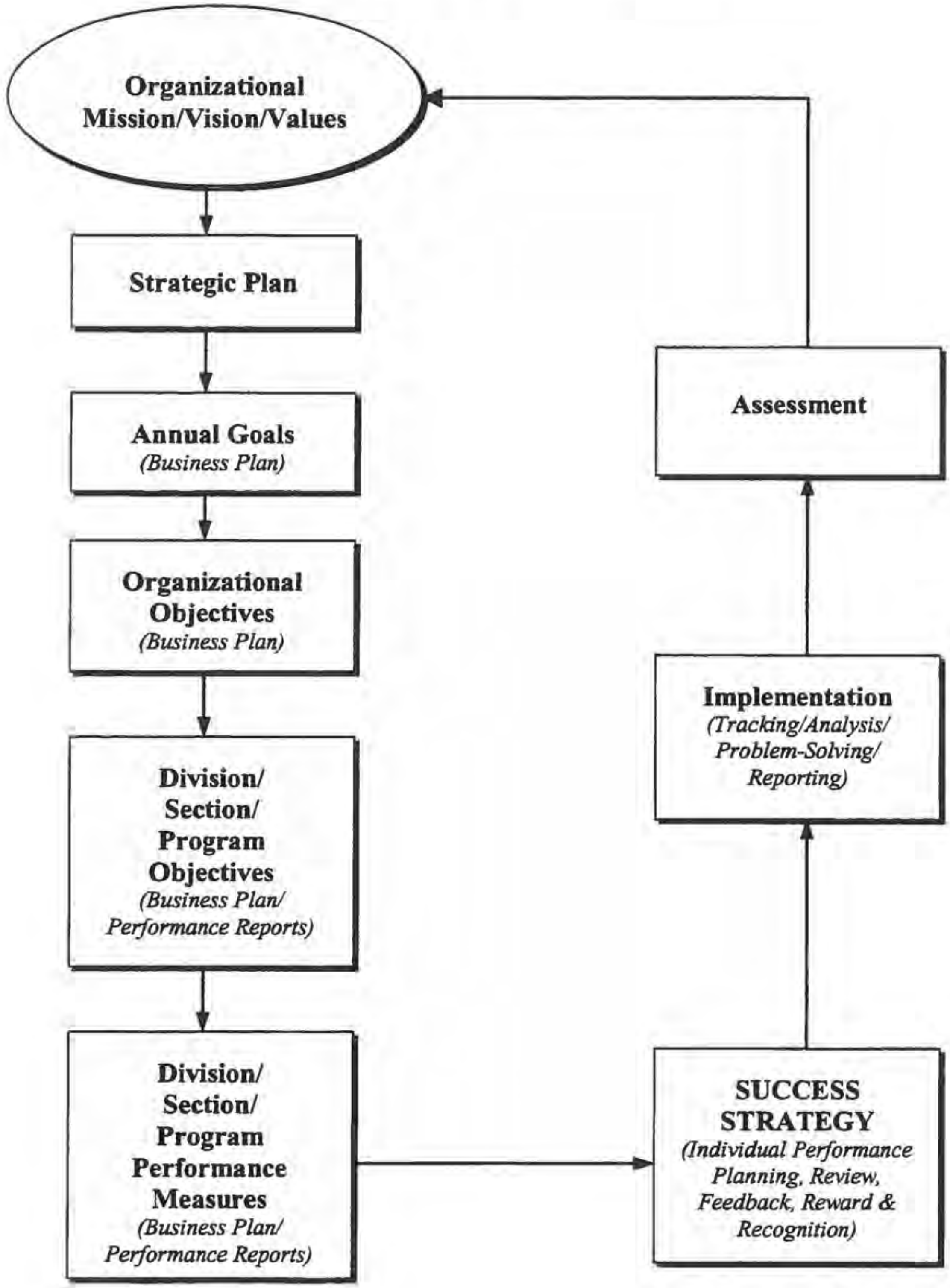
Major non-point source pollutants include certain types of bacteria, nutrients, toxic contaminants, debris and sediment. Bacterial contamination indicates a possible health hazard and can affect drinking water and close recreational areas to swimming. Nutrients such as nitrogen and phosphorus "enrich" stream water leading to algae blooms that, when they subside, rob the water of oxygen, which fish and aquatic insects rely on. Toxic contaminants like heavy metals and pesticides threaten the health of aquatic organisms, which can also harm their human consumers. Furthermore, these contaminants may persist for a very long time. Debris is unsightly and in some cases harms animals and humans. Sediment, another non-point source pollutant, is a major concern because of its negative impacts to aquatic species and their habitats, and also because other pollutants can adhere to eroded soil particles.

2.2 Goal Setting Process

In early 1996, the newly formed Watershed Protection Department had its first opportunity to formulate integrated watershed protection goals. The "Planning for Performance" approach (Figure 2 – 1) adopted by the City heavily influenced the goal setting process. The first step in this planning process was to establish a mission statement for the WPD. The *mission statement* describes the purpose of the functional services performed by the WPD. This mission statement then leads to management goals that convey the vision and values of the community.

The *goals* that are established under a performance-based system should be a concise statement of the desired results of the City's watershed protection efforts. In other words, stated goals should convey long-term purpose and direction for the WPD. Typically, these goals do not change from year to year and are not quantifiable. For quantification purposes, *objectives* are developed that describe in specific, measurable terms the results

Figure 2 – 1
Planning for Performance Approach



Source: Nancy Noble, Ph.D., 1/18/95

a program is expected to achieve toward a certain goal. Objectives are commonly synonymous with the desired *level of service*. The stated objectives should be attainable within a certain timeframe and may change annually in an attempt to achieve the desired goal.

Example:

Goal = To meet or exceed all state and federal permits and regulations.

Objective = For FY 99-00, comply with 137 activities specified in federal storm water permit.

After establishing long-term goals and objectives, a strategic plan (e.g., this Master Plan) is developed to determine how best to achieve the stated goals. Long-term goals and objectives are translated into annual goals that are included in the WPD's business plans. Eventually, these annual goals help define the performance measures for the department's work groups and individual staff members through a performance review process. Finally, annual performance measures are tracked to relate the success of the strategic plan back to the original goals and objectives.

To promote consensus building and public understanding, WPD staff utilized several means for involving the community in the goal setting process. In the fall of 1996, three public meetings of the Master Plan Citizen Advisory Group (MPCAG) were dedicated to review and comment on the mission statement, management goals and objectives. These goals were also reviewed in the three public meetings held during the spring of 1998 at local high schools to inform the public about the results of the technical assessment portion of the Master Plan. Goals are also presented in the WPD's business plan and annual budgets.

2.3 Mission Statement

As contained in the FY1999-2000 business plan, the current mission statement for the Watershed Protection Department is as follows:

The purpose of the Watershed Protection Department is to reduce the impact of flooding, erosion, and water pollution on our community in order to protect lives, property and the environment.

Although the City has long realized that flood control, erosion control and water quality protection are integrally linked, an integrated mission statement for Austin's watershed protection efforts was created relatively recently in 1995. Previous City budget documents and regulatory initiatives (e.g., 1974 Creek Ordinance) conveyed multi-objective goals, but none contained a concise mission statement that incorporated flood, erosion and water quality concerns.

The origin of WPD's mission statement coincides with the inception of the primary funding mechanism for the City's current watershed protection activities – the drainage fee. Created in 1982, the fee helped fund program activities of the Watershed Management Division (WMD) of the Department of Public Works and Engineering until 1986. At the time, WMD's established drainage program was complemented by a growing water quality section that provided monitoring, modeling, and design criteria/review support. Although WMD did not have a single integrated mission statement, annual budgets included references to flood, erosion and water quality objectives through 1986.

In FY 1986-87, the Water Quality Section of WMD was transferred to the newly created Department of Environmental Protection (DEP), thus separating the erosion and flood control activities from the water quality activities on an organizational basis. Not until 1990, when the City established a dedicated Drainage Fund, did the semblance of an integrated mission statement appear. In the enacting ordinance and amendments that followed, the declarations of purpose referenced a multi-objective theme:

> *"....in order to protect the citizenry from the degradation of water quality and loss of life and property caused by surface water runoff, overflows, and stagnation......it is necessary and in the best interest of public health and safety to a establish a drainage fee....(Ordinance No. 900913-Q)"*

In December 1993, a Drainage Utility Strategic Planning Team was formed that included City staff representatives of the erosion and flood control mission groups (from the Public Works and Transportation Department) and the water quality management mission group (from the Environmental and Conservation Services Department, formerly DEP).

The team's January 1995 final report contained the first integrated mission statement for the City's watershed protection efforts:

> *"The Mission of the Drainage Utility is to use environmentally-responsible and cost effective approaches to protect lives, property and the quality of life by managing the movement of water to reduce flooding, erosion and pollution."*

Based on staff review and public input, variations of this mission statement were created for the Master Plan and the WPD's annual business planning efforts. From 1995 until today, each version specifically addresses the three primary missions of the Watershed Protection Department:

Flood Control **Erosion Control** **Water Quality**

Ultimately, these missions reflect the City's commitment to improve public safety, property protection and the quality of life in Austin.

For the most part, the information presented in this Master Plan is organized by these three missions. However, because the integration of these missions is a primary goal of this Master Plan, problem areas and solutions that address more than one mission are also presented.

2.4 WPD Goals and Objectives

Building on the department's mission statement, WPD staff developed seven (7) specific management goals to guide the Master Plan in 1996. The long-term goals listed below reflect public input received during the goal setting process. The goals are further defined by multiple objectives as show in Table 2 – 1.

Table 2 – 1
Watershed Protection Department Master Plan
Goals and Objectives

GOALS	OBJECTIVES
Protect lives and property by reducing the impact of flood events	FC1. Reduce the depth and frequency of flooding for all 100-year floodplain structures. FC2. Reduce the depth and frequency of flooding on all roads in the 100-year floodplain. FC3. Reduce the danger at road crossings subject to any flooding by the 100-year flood. (including "Provide adequate warning at dangerous crossing") FC4. Provide mitigation for flood damage. FC5. Prevent the creation of future flood hazards to human life and property. FC6. Reduce the depth and frequency of localized flooding for buildings. FC7. Reduce the depth and frequency of localized flooding for yards. FC8. Reduce the danger of street flooding created by substandard storm drains. FC9. Reduce standing water in public rights-of-way and drainage easements outside the 100-year floodplain.
Protect channel integrity and prevent property damage resulting from erosion.	EC1. Repair current erosion that threatens habitable structures and roadways (referred to as Type 1 sites). EC2. Repair current erosion that threatens properties, trees, fences, drainage infrastructure, parks, hike and bike trails (Type 2 sites). EC3. Minimize the future enlargement of channels that would threaten public and private property (Type 3 sites). EC4. Achieve stable stream systems.
Protect and improve Austin's waterways and aquifers for citizen use and the support of aquatic life.	WQ1. In local creeks, achieve or exceed Good (>=62.6) Environmental Integrity Index (EII) scores. WQ2. In Urban creeks, restore baseflow quantity and quality to the maximum extent possible. WQ3. In Nonurban creeks, preserve the existing baseflow quantity and quality to the maximum extent possible. WQ4. In all creeks, reduce existing and future pollutant loads to the maximum extent possible. WQ5. In the Edward's Aquifer, maintain or enhance the existing rate of recharge to the maximum extent possible. WQ6. Maintain or enhance high quality environmental features (e.g., springs, seeps, wetlands, swimming holes, threatened or endangered species habitat) to the maximum extent possible.
Improve the urban environment by fostering additional beneficial uses of waterways and drainage facilities.	CG1. Maximize the use of waterways and drainage facilities for public recreation. CG2. Maximize areas for public use within floodplains. CG3. Maintain natural and traditional character of floodplains to the maximum extent possible.
Meet or exceed all local, state, and federal permit and regulatory requirements.	CG4. For all state designated stream segments, including Lake Travis, Lake Austin, Town Lake, the Colorado River below Austin, Barton and Onion creeks, maintain or improve the Designated Use Support status. CG5. Comply with Storm Water NPDES permit requirements. CG6. Minimize the risk to structures in the 100-year floodplain as required by the National Flood Insurance program.
Maintain the integrity and function of Utility Assets	CG7. Provide for adequate maintenance of the watershed protection infrastructure system and minimize maintenance requirements for system improvements.
Optimize City resources by integrating flood, erosion and water quality control measures.	CG8. Maximize flood control, pollution removal and streambank protection for all solutions including CIP projects.

Primary Mission: FC = Flood Control, EC = Erosion Control, WQ = Water Quality, CG = Common Goal

2.4.1 Flood Control

The management goal of the flood control mission is to protect lives and property by reducing the impact of flood events. This goal is further defined by the following objectives:

FC1. Reduce the depth and frequency of flooding for all 100-year floodplain structures.

FC2. Reduce the depth and frequency of flooding on all roads in the 100-year floodplain.

FC3. Reduce the danger at road crossings subject to flooding by the 100-year flood.

FC4. Provide mitigation for flood damage.

FC5. Prevent the creation of future flood hazards to human life and property.

FC6. Reduce the depth and frequency of localized flooding for buildings.

FC7. Reduce the depth and frequency of localized flooding for yards.

FC8. Reduce the danger of street flooding associated with old storm drains.

FC9. Reduce standing water in public rights-of-way and drainage easements outside the 100-year floodplain.

Even in the midst of drought conditions, flash flooding poses a continuous threat to Central Texans. The heavy downpours common to this area combine with the steep slopes of the Balcones Escarpment to present an often times dangerous combination for local motorists and creekside residents. These dangers are mostly present along flooded creeks, especially where bridges and low water crossing have been inundated with floodwaters. The allure of flooded streams can also be dangerous as spectators standing on soft and muddy banks can venture too close to the fast moving flows. In locations where old storm drain systems do not meet current criteria, rising waters can cause severe property damage even for those residents who do not live near flooded creeks.

The primary purpose of the flood control mission is to reduce the existing and future impacts of flooding on local roadways and structures. This is true for both the primary creek system (creekside flooding) and the local storm drain network (localized flooding).

Creekside flooding commonly poses the greatest threat to public safety. For this reason, an important activity of the flood control mission is to issue flood warnings during heavy storms. Low water crossings are closed, and the public is encouraged to be attentive to any imminent flood danger. Flood insurance and floodplain information is also distributed on a routine basis to help mitigate property damage from floods and save lives.

Because heavy downpours occur infrequently, there is a tendency for the public to lose interest in flood management initiatives as past floods fade from memory. However, WPD's floodplain managers are actively planning and implementing solutions to improve the drainage system and reduce the creation of new flood hazards.

Localized flooding is the term given to flooding areas that result from the secondary drainage system (storm drains), not necessarily as a result of creekside flooding. Storm drains begin with inlets and include drain pipes, culverts, and open ditches. Localized flood complaints occur more frequently than creekside flood complaints because they most often arise from smaller storm events. Localized flooding problems can be categorized as building flooding, yard flooding, street flooding, or nuisance standing water.

Building or yard flooding can damage real property if storm water runoff is not contained in the secondary drainage system. Often, the secondary drainage systems in the urban watersheds are outdated. Old or outdated storm drains mean storm drains designed and/or installed under drainage criteria in effect before January 1977. This is due to changes in design requirements over time. In fact, storm drains (namely, inlets and drain pipes) constructed before the 1970's appear to be sized for the 10-year (or less frequent) storm event. In certain areas where inlets and storm drains are outdated, the ponding of runoff along streets can result in undesirable driving hazards for motorists. The City has adopted stricter drainage requirements since the 1970's.

In addition to driving hazards, standing water in public rights-of-way and drainage easements poses a general nuisance related to diminished aesthetic value, mosquito breeding, soggy mud, pedestrian and vehicular inconvenience, and commonly foul odors.

Standing water often appears as puddles or "bird baths" along minor ditches or deteriorated roadway infrastructure systems (curbs and gutters). Standing water can usually be attributed to poor design, poor construction or poor maintenance. Sometimes, in flat or low areas, standing water cannot be completely eliminated by draining due to topographical constraints.

2.4.2 Erosion Control

The management goal of the erosion control mission is to prevent property damage resulting from erosion and protect channel integrity. This goal is further defined by the following objectives:

EC1. Repair current erosion that threatens habitable structures and roadways.

EC2. Repair current erosion that threatens properties, trees, fences, drainage infrastructure, parks, hike and bike trails.

EC3. Minimize the future enlargement of channels that would threaten public and private property.

EC4. Achieve stable stream systems.

As discussed in Section 1, urbanization alters the hydrologic response of a watershed to rainfall. Development increases the total volume, peak discharge rate and frequency of runoff from rainfall events. Consequently, the capacity of urban streams and channels to withstand erosive flows is exceeded more frequently. The steep slopes in West Austin and the deep soils in East Austin exacerbate the erosive conditions caused by these higher runoff volumes and more frequent flow events leading to unstable stream channels. Often, the result is severe channel erosion in the form of degradation and widening. Where structures have been constructed near stream banks, channel widening can pose a serious threat to property. Stream bank erosion also creates a significant sediment load to local creeks and lakes, resulting in increased turbidity and adverse impacts to aquatic ecosystems.

Historically, much of the City's erosion control program has been aimed at mitigating areas where stream bank erosion has posed an immediate threat to property (mostly homes and businesses) on a complaint basis. Without comprehensive erosion assessments that provide insight into the geomorphic characteristics of a creek (e.g., channel type, bank stability and future enlargement potential), the preventive capabilities of the erosion program were severely limited. In 1997, erosion assessments for each of the Phase I watersheds were completed. These assessments were designed to evaluate the erosion conditions of each watershed compared to the erosion control goals and objectives described above. Therefore, each assessment includes an inventory of community resources threatened by erosion and an analysis of existing and future channel stability. This new erosion assessment data has enabled the Watershed Protection Department to proactively plan for erosion mitigation and prevention and to promote geomorphically stable creek systems. This represents a tremendous advancement in the understanding of erosion control issues in our local creek systems. Please refer to Section 6 of this Master Plan for a detailed summary of the erosion assessment methods and results.

2.4.3 Water Quality Protection

The management goal of the water quality protection mission is to protect and improve Austin's waterways and aquifers for citizen use and the support of aquatic life. This goal is further defined by the following objectives:

- WQ1. In local creeks, achieve or exceed Good Environmental Integrity Index (EII) scores.
- WQ2. In Urban creeks, restore baseflow quantity and quality to the maximum extent possible.
- WQ3. In Nonurban creeks, preserve the existing baseflow quantity and quality to the maximum extent possible.
- WQ4. In all creeks, reduce existing and future pollutant loads to the maximum extent possible.
- WQ5. In the Edward's Aquifer, maintain or enhance the existing rate of recharge to the maximum extent possible.

WQ6. Maintain or enhance high quality environmental features (e.g., springs, seeps, wetlands, swimming holes, threatened or endangered species habitat) to the maximum extent possible.

As natural lands are transformed into urban land uses, the increase in impervious area, traffic, and other human activity results in dramatic changes to our local waterways. By altering the flow regime of creeks and increasing pollutant loads, urbanization can lead to adverse impacts to aquatic ecosystems and riparian areas. Some of these changes can be readily apparent as spills, trash and debris create noticeable environmental problems. In other cases, changes in a waterway's environmental integrity occur very slowly in response to development. This is especially true of long-term erosive processes and gradual increases in pollutant loadings in slow developing watersheds.

A common approach to water quality management is to focus on the reduction of non-point source pollution. While this has proven to be a valuable approach to storm water quality management, this single measure does not adequately reflect the range of urban impacts on the beneficial uses of our waterways. For example, reducing stormwater pollutants in runoff does not address the acceleration of stream band erosion and resulting loss of habitat quality due to increased storm flows.

One of the major objectives of the Water Quality mission is to achieve or exceed Good Environmental Integrity Index (EII) scores for local creeks. The EII was developed by WPD as a tool to monitor and assess the ecological integrity and degree of impairment of local creeks and streams as they relate to beneficial uses. It represents a compilation of various sampling results that reflect the chemical, physical and biological health of a stream system. The narrative results (discussed in Section 7) are reported in one of eight categories - Very Bad, Bad, Poor, Marginal, Fair, Good, Very Good and Excellent. For creeks that exceed the desired minimum score of "Good", a revised goal is established to attain a narrative score one level higher than the existing score in an effort to improve water quality Citywide. Where creeks are found to be at the highest rating of Excellent, the goal is to maintain this rating.

As a result of urbanization, much of the rainfall that once infiltrated into the ground and reappeared days later as creek baseflow now falls on rooftops and parking lots to be quickly conveyed to a ditch or storm drain. In addition to reductions in baseflow volumes, reduced infiltration of rainfall results in increased stormflows and a deficit of rainfall that is recharged to aquifers. Therefore, the water quality mission strives to restore baseflow quantity and quality in urban creeks where the impacts of development are most prominent. In nonurban creeks, preservation of a watershed's baseflow characteristics is a high priority. Maintaining or enhancing recharge rates to the Edward's Aquifer helps promote baseflow and springflow volumes, protects aquatic ecosystems and replenishes drinking water supplies. Likewise, the City promotes the protection of sensitive environmental features.

2.4.4 Common Goals

Many of the goals of the Watershed Protection Department are common to each of the three missions described above. These shared goals cover a range of initiatives that strive to make the best use of City resources and maintain compliance with applicable State and Federal regulations. As the Master Plan commenced, three shared goals were formulated to encompass a variety of objectives as follows:

<u>Goal:</u> Improve the urban environment by fostering additional beneficial uses of waterways and drainage facilities. This goal is further defined by the following objectives:

- CG1. Maximize the use of waterways and drainage facilities for public recreation.
- CG2. Maximize areas for public use within floodplains.
- CG3. Maintain natural and traditional character of floodplains to the maximum extent possible.

The City of Austin has a long history of promoting the public enjoyment of local waterways and constructed drainage facilities. Miles of greenbelts and hike and bike trails parallel Austin's creeks and lakes. Working closely with the City's Parks and Recreation Department, soccer fields and park areas are commonly integrated into the design of many Austin storm water management facilities (e.g., Northwest Park and Dick Nichols Park). The effort to promote the public use of City drainage facilities and floodplains (while promoting the natural and traditional character of local creeks) will continue as new solutions are implemented in the future.

Goal: Meet or exceed all local, state, and federal permit and regulatory requirements. This goal is further defined by the following objectives:

CG4. For all state designated stream segments, including Lake Travis, Lake Austin, Town Lake, the Colorado River below Austin, Barton and Onion creeks, maintain or improve the Designated Use Support status (see Table 2 – 2).

CG5. Comply with Storm Water NPDES permit requirements.

CG6. Minimize the risk to structures in the 100-year floodplain as required by the National Flood Insurance program.

Table 2 – 2
Designated Use of Local Receiving Waters

Receiving Water	Designated Use			
	PWS	CR	NCR	ALS
Lake Austin	√	√	√	H
Lower Town Lake	√	√[1]	√	H
Colorado River below Longhorn Dam (to E edge of Austin ETJ)	√	√	√	E
Barton Creek (all)	√	√	√	AP[2]
Blunn		√[3]	√	L
Boggy		√[3]	√	L
Bull Creek		√[3]	√	H
Country Club		√[3]	√	L
East Bouldin		√[3]	√	L
Fort Branch		√[3]	√	L
Harper's Branch		√[3]	√	L
Johnson		√[3]	√	L
Little Walnut		√[3]	√	L
Shoal		√[3]	√	L
Tannehill		√[3]	√	L
Waller		√[3]	√	H
Walnut		√[3]	√	H
West Bouldin		√[3]	√	L
Williamson		√[3]	√	L

Source: 30 TAC §307.10(1) Appendix A

PWS - Public Water Supply CR - Contact Recreation NCR - Non Contact Recreation
ALS - Aquatic Life Support H - High E - Exceptional L - Limited AP - Aquifer Protection
[1]While Segment 1429 may exhibit quality characteristics which would make it suitable for contact recreation, the use is prohibited by local regulation for reasons unrelated to water quality.
[2]The aquifer protection use applies to the contributing, recharge, and transition zones of the Edwards Aquifer.
[3] Unclassified segment, but assume this is the correct presumption based on 30 TAC §307.4(j)

The City of Austin is obligated to comply with all applicable local, state and federal permit and regulatory requirements. The objectives listed above are the three most prominent regulatory issues affecting the Watershed Protection Department. It should be noted that the WPD must comply with any state and federal permit or regulation that may be applicable to the daily operations of the WPD. In addition to the regulations addressed by the three objectives listed above, other applicable regulations commonly include the Texas Water Code, Local Government Code and Federal Endangered Species Act.

Mandated programs usually align with the City's designated goals. For example, the National Flood Insurance Program requires the City to minimize flood threats to structures in the 100-year floodplain, which is a stated goal of WPD's flood control mission. In other cases, new permits and regulations create the need for new City initiatives. Routine dry weather screening is an example of a new water quality monitoring activity that is federally mandated through the City's NPDES storm water permit. In most cases, noncompliance with state and federal regulatory requirements can lead to stiff penalties and fines. Therefore, it is in the City's best interest to ensure compliance is maintained on a continual basis.

<u>Goal:</u> Maintain the integrity and function of Drainage Utility assets. This goal is further defined by the following objective:

CG7. Provide for adequate maintenance of the watershed protection infrastructure system.

The City's drainage infrastructure system consists of hundreds of miles of creeks, improved channels, ditches, and storm drains. In addition, the system includes over 18,000 curb inlets and over 400 detention and water quality ponds. This extensive drainage network services over 200 square miles of the City. Providing adequate maintenance of the drainage infrastructure system is a high priority because:

1) the initial construction and improvements of this system represents a tremendous financial investment of both public and private resources, and
2) in order to achieve WPD goals, the drainage system must function as designed.

Because the WPD operates as a public utility under the Texas Municipal Drainage Utility Systems Act, the components of the drainage system network are dedicated drainage utility assets. Therefore, from a financial perspective, it is the City's responsibility to maintain the value of its drainage utility assets through a proper inspection, maintenance and repair program.

From a goal attainment standpoint, maintaining the efficiency and effectiveness of the drainage system is imperative for the City to achieve its watershed protection goals. For example, the benefits of flood and water quality ponds can only be realized if these facilities are maintained properly. If debris is not cleared from clogged bridges after storms, subsequent storms could easily overtop the bridge, flood the immediate vicinity and erode adjacent streambanks. Each component of the drainage system must be operating as designed for the entire system to be effective.

Goal: Optimize City resources by integrating flood, erosion and water quality control measures. This goal is further defined by the following objective:

CG8. Maximize flood control, pollution removal and streambank protection for all solutions including CIP projects.

From the outset of the Master Plan, a high priority has been assigned to integrating the three missions of the Watershed Protection Department. The need for integration in erosion control, flood control and water quality management issues are integrally connected. The ability to reduce erosion and protect aquatic ecosystems is directly related to managing stormflow regimes. Water quality strategies must address streambank erosion concerns, and not inadvertently worsen flooding.

Through integration, resulting watershed protection strategies should ideally make the best use of drainage funds by simultaneously addressing flood, erosion and water quality problems. While the opportunity to integrate missions is heavily influenced by site-specific factors (especially for capital projects), the selected approach should strive to improve the status quo for each mission. In some cases, maintaining the existing flood conditions may have to suffice for an erosion or water quality project. Likewise, a flooding project may not always incorporate water quality enhancement features. However, it should be noted that any new capital project should be designed to promote a sustainable and stable stream channel.

An integrated approach usually requires more thoughtful planning and sophisticated designs. When compared to a single mission project, planning and design costs tend to be higher and project implementation periods tend to be lengthened as a greater variety of skilled planners and designers are involved in the process. However, when compared to the independent planning and design of separate flood, erosion and water quality projects, the overall benefits of integration are tremendous.

Public opinion and desires for capital projects can also impact the nature of a project design. Public sentiment regarding mission integration can vary widely based on the particular needs of a neighborhood and available funding.

It is the intent of this Master Plan to promote integrated planning, and thus the implementation of integrated solutions, in an effort to optimize the limited resources available for the attainment of WPD's diverse watershed protection goals.

Section 3

Problem Area Identification

The Watershed Protection Department (WPD) performed technical studies to characterize flood control, erosion control and water quality problem areas within the Phase I watersheds. These studies helped to define watershed characteristics and locate areas within each watershed where watershed protection goals are not being achieved. With a variety of technical professionals working on this aspect of the Master Plan, special attention was given to the manner in which problem identification was performed. Methods used to identify watershed problem areas were developed that maximized the use of existing information, allowed direct comparisons between watersheds, and promoted consistency among the three missions.

This section presents the methods used for data collection and evaluation to determine both current and projected future problems on a mission-by-mission basis. The problem area results are then detailed for the Phase I watersheds. An "integrated problem area" concept is presented later in this section. This concept provides additional insight into potential watershed management strategies by combining the results of the three individual mission studies to identify areas of concurrent flood, erosion and water quality problems, thus suggesting an increased need for multi-purpose solutions.

3.1 Data Collection and Evaluation

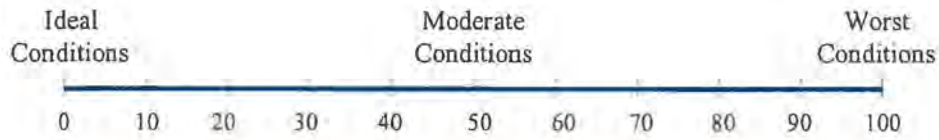
This Master Plan represents the City's first effort to develop and implement an integrated planning process for watershed protection. This integrated planning approach encourages the joint development of flood, erosion and water quality management strategies. Given the ambitious scope of this study, it became readily apparent that the success of the Master Plan relied heavily on the WPD's ability to coordinate data collection and evaluation methods within and across the three missions of the WPD.

Since the City and several consultants performed data collection and evaluation, a concerted effort was made to identify common data needs among the different project teams. Before the Master Plan began, few of the Phase I watersheds had water quality management plans and none had ever been studied for erosion control management. Therefore, the erosion and water quality assessments were largely consistent in their use of common data sources since these studies included initial model development and implementation. On the other hand, the flood control assessments relied on watershed data already contained in existing hydrologic and hydraulic (H+H) models to support analysis of problem areas. As part of this Master Plan, the various H+H models were converted to the same suite of software programs developed by the U.S. Army Corps of Engineers Hydrologic Engineering Center. This effort greatly improved WPD's ability to compare converted flood model results among watersheds. However, updating the raw data contained in the existing flood models and calibrating the updated models was determined to be cost-prohibitive during Phase I of the Master Plan.

The data necessary to characterize watershed problems is described in the following sections. In addition, detailed watershed data is contained in each of the specific reports generated by the various project teams.

3.2 The "Problem Score" Approach

A common principle was established for the approach used to characterize and prioritize problem areas for each mission [flood control (FC), erosion control (EC), and water quality (WQ)]. This principle relies on the calculation of a **"problem score"** for each segment, or **"reach"** of a creek. Problem scores range from 0 to 100 with a score of 0 reflecting ideal watershed conditions and a score of 100 representing the worst identified problem area within the Phase I watersheds. These scores are initially developed on a mission specific basis for each creek reach. Later, the individual EC, FC, and WQ mission scores are combined (based on public input) to develop integrated problem scores (See Section 8).



Problem Scores Range from
0 to 100

The determination of a problem score for a given reach of a creek is a function of 1) problem severity, 2) the number of resources impacted, and 3) the type of community resources impacted by the problem (reflected by the "resource value").

3.2.1 Problem Severity

The technical studies for each mission determined the severity of existing and potential future problems in each studied creek reach. Public safety and property protection needs associated with flood control (see Section 4) were evaluated by determining the flooding depth and velocity at each impacted resource (e.g., a residence). Erosion problems focused on property protection and stream bank stability issues. The erosion assessments identified community resources (homes, businesses, etc.) along creeks that were (or will be) threatened by eroding banks. Areas were also identified where future streambank stability is a concern (see Section 6). The methods used to characterize severity of water quality problems varied depending on the affected water body considered and its designated uses (see Section 7). Water quality sampling results for biological, chemical and physical parameters were considered along with predicted pollutant loadings, baseflow volumes and spills risk for existing and future conditions.

3.2.2 Resource Values

WPD assigned numerical values to the various community resources that might be threatened by flooding, erosion, or impaired water quality. These values were established with input from the Master Plan Citizens Advisory Group. The resources affected and the values placed on each resource are different for each mission. For example, resources threatened by flooding or erosion include homes and businesses, while resources impacted by poor water quality are receiving waters and individual creek segments (including the recreational value and aquatic life they support). Again, using a score between 0 and 100, high priority resources (e.g., a school) may be given a resource value of 90 – 100, with lower values given to resources of lesser priority. Resource values established for each mission are presented in the discussions of mission-specific study methods later in Sections 4.3, 6.3, and 7.2.

3.2.3 Problem Score Calculations

The general concept for calculating the problem score for a creek reach is represented by:

> Reach Problem Score = f(# of resources located in the creek reach, their resource value and the severity of the watershed problem at each resource)

Reach problem scores account for both existing conditions and future development conditions. Combining the existing and future problem data then produces an overall reach score. Since each mission defines problem severity and resource values in different manners, the specific formulas vary by mission. However, this general concept is followed for all three missions.

3.3 Reach Naming System

Another important part of the problem scoring process was the development of a standard method for identifying locations along a creek or major tributary. An understanding of this naming convention is helpful as many of the detailed Master Plan results are referenced to creek segments using this system. Creek segments (reaches) are bounded by a downstream point and upstream point on the creek. For reporting purposes, reaches were identified by their downstream point. Each mission project team segmented the creeks according to their individual study needs (see Table 3 – 1) but used the same nomenclature for identifying reach beginning and end points.

Table 3 – 1

Stream Segmentation

Mission	Creek Reach Segmentation Based on:	Number of Reaches	Average Reach Length (ft)
Flood	FEMA Stations	500(1)	2,000
Erosion	Like reaches	199	4,540
Water Quality	EII Sites	70	12,015(2)

(1) This value reflects 489 reaches for which there was a flood model and 11 reaches that were estimated based on best available flood information

(2) The median water quality reach length is 5570 feet.

The alphanumeric naming system is composed of four fields:

Creek Tributary — Station

WWW - FFF - SSS - 999999

WWW	FFF	SSS	999999
Watershed	First Level Tributary	Second Level Tributary	Distance from Mouth (ft.)

The first three fields (having three characters each) describe the creek tributary name. For instance, WMS-KIN-WHL represents the tributary identifier for Wheeler Branch. Wheeler Branch (WHL) discharges to Kincheon Branch (KIN) which ultimately flows into Williamson Creek (WMS). A placeholder ("000") is used in the second and third fields to represent the main stem of major creeks. For example, the reach designation for the main stem of Williamson Creek is WMS-000-000 and its major tributary Kincheon Branch is designated as WMS-KIN-000. Standard three-letter code designations for major creeks are taken from Section 1.0 of the City of Austin Drainage Criteria Manual.

The fourth field (999999) represents the "station" or point of interest on the creek. Stations are measured (in feet) from the creek's confluence (also known as the mouth of the creek) with another creek or major receiving water. For instance, the point at which East Bouldin Creek flows into Town Lake is considered the mouth of the creek and is represented as 000000. A point located 250 feet upstream on East Bouldin Creek is designated as 000250.

Figure 3 – 1 illustrates how the reach naming system is applied to Bull Creek. This figure shows a small section of the creek where Tributary 1 and Tributary 2 join the main stem. The main stem reach between station 12500 and 25000 begins 12500 feet from the mouth of Bull Creek and is designated as BUL 000 000 012500. Similarly, the reach shown for Tributary 1 begins at the confluence of the main stem and the tributary and is designated as BUL T01 000 000000. A site along Tributary 1 located 2100 feet from the confluence of the tributary and the main stem is designated as BUL T01 000 002100. These reach designators appear in many of the tables and maps contained in this Master Plan. The specific reach designation system for each watershed can be found in Appendix A (the Watershed Summaries section of this Master Plan).

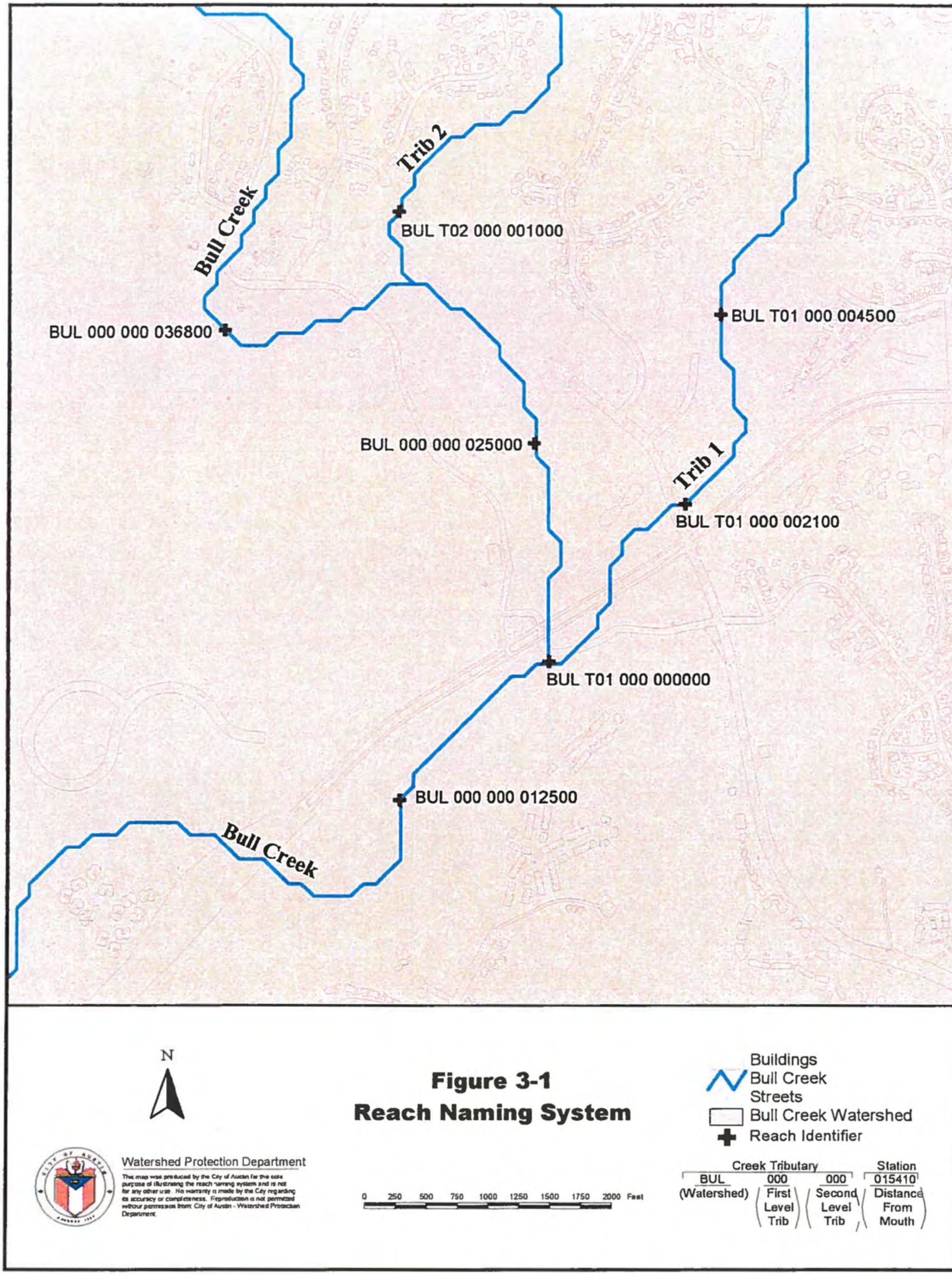


Figure 3-1
Reach Naming System

Section 4

Creek Flooding Assessment

4.1 Background

Shoal Creek, 1981

Most people who live in Austin have witnessed firsthand or seen reports of flooding of homes, roads, or other property. The "big" storms of 1998, 1991 and the Memorial Day flood of 1981 are reminders of the public safety and property hazards associated with flooding. Hydrologists classify or "size" storms based upon how often they are likely to occur. For example, a very large storm that has a 1% probability of occurring in any given year is termed a 100-year storm event. The Memorial Day flood of 1981 that killed 13 people and resulted in over $35 million in property damage was estimated to be a 100-year storm for Shoal, Walnut, and Little Walnut (lesser frequency for other watersheds). For this Master Plan, models were used to estimate flooding resulting from the 2-, 10-, 25-, and 100-year storm events.

4.2 Study Methods for Creek Systems

Flooding problems may occur in the both the primary and secondary drainage systems. This section describes the methods used to investigate problems associated with the primary system only (major creeks and their tributaries). Methods used to investigate localized flooding associated with the secondary drainage system (storm drains and minor channels) are reviewed in Section 5 of this report.

Flooding problems in major creek systems were identified with the aid of hydrologic and hydraulic (H+H) models. Hydrologic models use data describing watershed and channel characteristics to compute storm water runoff quantities for storms of various sizes. Using flow rates computed by the hydrologic models, hydraulic models are then employed to predict the depth and velocity of flow in creek channels. The predicted depths help determine when creek levels will be high enough to overflow creek banks and flood nearby structures (e.g., homes and businesses). This analysis is performed for existing and projected future development conditions.

Over the last twenty years, the City has studied many of the Phase I watersheds as part of its storm water management efforts. The City, local engineering consultants and the U.S. Army Corps of Engineers (USACOE) have been the primary developers and users of flood models for the major creek systems in Austin. As discussed in Section 3.1, the flood control assessments relied on watershed data already contained in existing hydrologic and hydraulic (H+H) models to support analysis of problem areas. As part of the Master Plan, the various H+H models were converted to the same suite of software programs developed by the USACOE Hydrologic Engineering Center (HEC). This effort greatly improved WPD's ability to compare converted flood model results among watersheds. However, updating the raw data contained in the existing flood models was determined to be cost-prohibitive during Phase I of the Master Plan.

In the past, local hydrology was modeled using various methods including the Austin Standard Method, TR-20, NUDALLAS and HEC-1. For the Master Plan, available models were converted to the HEC-1 model for 14 Phase I watersheds that had originally been modeled using other formats as shown in Table 4 – 1. (Note that Tannehill was already in HEC-1 format and Barton and Harper's did not have flood models completed.)

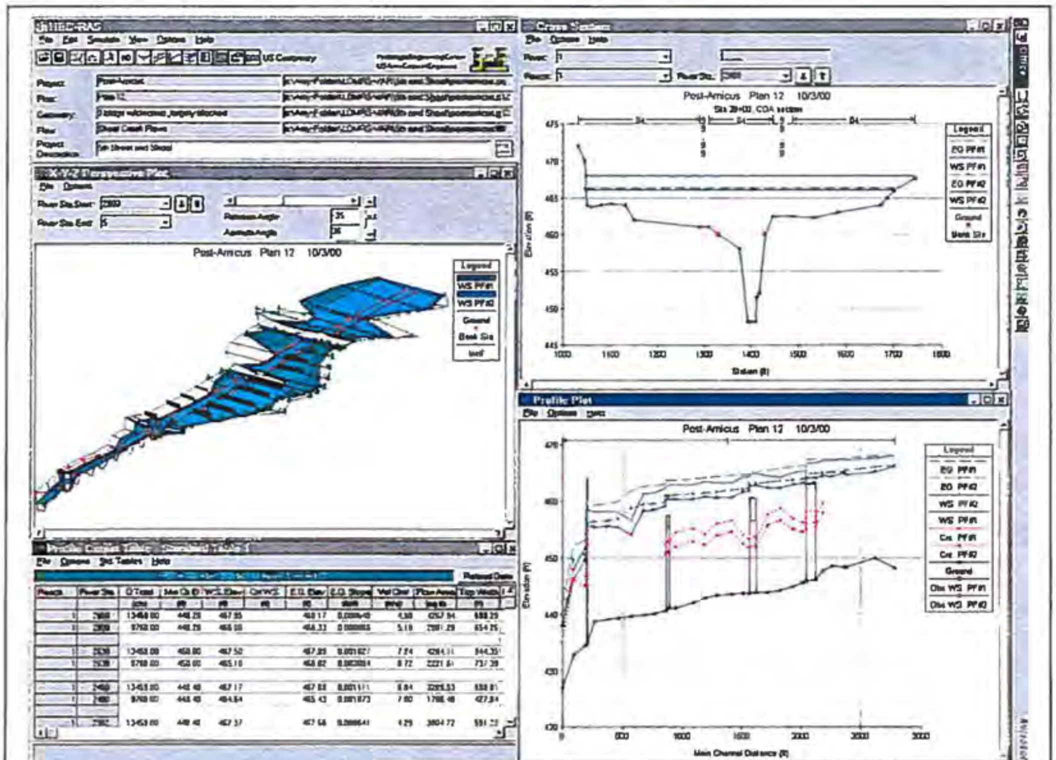
The hydraulic model previously used to assess most watersheds in Austin, HEC-2, was replaced with a newer version, HEC-RAS. HEC-RAS was released in 1995 by the Corps of Engineers and offers graphical bridge modeling and analysis routines not offered in its HEC-2 predecessor, as well as enhanced application routines. Existing HEC-2 models for 15 Phase I watersheds were translated into the newer HEC-RAS format.

Table 4 – 1

Hydrologic Model History

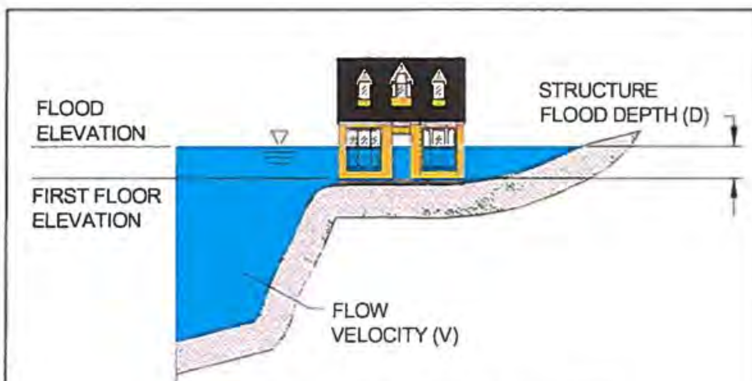
Watershed	Subwatershed	Model History		
		Author	Method	Date
Blunn		City of Austin	TR-20	Mid 90's
Boggy		USACOE	NUDALLAS	1989
Bull		City of Austin	TR-20	1991
Buttermilk		Murfee Engineering Company, Inc.	TR-20	1992
Country Club	Old Main Channel New Bypass Channel	Espey Huston & Associates, Inc. Crespo Consulting Service, Inc.	TR-20 TR-20	1992 1996
East Bouldin		Dannenbaum Engineering Corp.	Austin Standard Method	1984
Fort		USACOE	NUDALLAS	1989
Johnson		City of Austin	Austin Standard Method	1984
Little Walnut		Murfee Engineering Company, Inc.	TR-20	1992
Shoal	Upper Lower	Espey Huston & Associates, Inc. Unknowns	HEC-1 Austin Standard Method	1997 80's
Tannehill		Camp Dresser & McKee, Inc./ Raymond Chan & Associates, Inc.	HEC-1	1997
Waller		Raymond Chan & Associates, Inc.	TR-20	1994
Walnut		Gebhard Sarma Group, Inc.	TR-20	1996
West Bouldin		Dannenbaum Engineering Corp.	Austin Standard Method	1984
Williamson		City of Austin	TR-20	1990

Two watersheds, Barton Creek and Harper's Branch, do not have existing hydraulic models. To date, flooding problems along these creeks have not warranted intensive flood studies or H+H model development.



HEC-RAS Program

The model conversion efforts described above resulted in a set of standardized H+H model results that can be more confidently compared across the Phase I watersheds. The results predicted the depth of stormflow and flood elevations in the primary drainage system (major creeks and tributaries) for the Phase I watersheds.



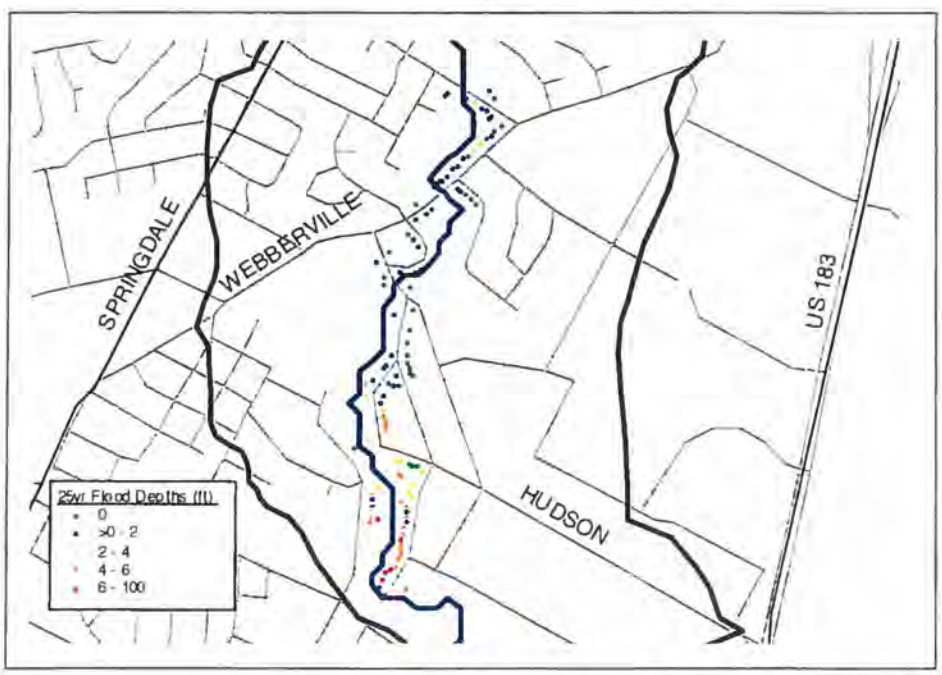
Flooded Structure Parameters

The next step in the flood assessment methodology is to determine the resulting depth and velocity of flooding at specific points of interest for both existing and future development conditions. These points include residential and commercial buildings, low water crossings and bridges. In order to accomplish this task, additional information regarding structure location and first floor (or roadway) elevation was needed. First floor elevations of flooded structures were surveyed in some of the Phase I watersheds as funding allowed (approximately 8,000 structures). For the remaining Phase I watersheds, finished floor elevation data was estimated using City of Austin 2' topographic maps. The first floor (and roadway) elevations were input into a "flooded structure" database.

A GIS-based procedure was then applied to define structure flooding depths using the H+H models results and first floor elevation data. When the elevation data is combined with a structure location map and the H+H model results, a GIS computer application estimates the depths of flooding at each structure for the 2-, 10-, 25-, and 100-year storm event. This data is then used to calculate flood problem scores as discussed later in Section 4.5. Figure 4 – 1 shows an example of the flooded structure analysis for a 25-year storm in a portion of the Fort Branch watershed.

Figure 4 – 1

Flooded Structure Analysis for Fort Branch



Source: Camp Dresser & McKee, 2000

While the previously described method appears quite simple, the amount of interrelated data is voluminous. By restricting the modeling analysis to only the primary drainage system, H+H models were utilized to reflect flooding conditions in 72 major creeks and tributaries within the Phase I watershed area.

4.3 Resource Values

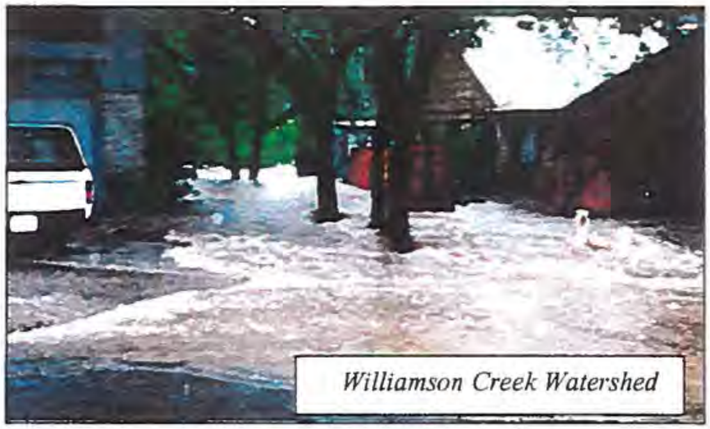
Flooding impacts several types of community resources. These include different types of residential and commercial structures and roadways. Flood management strategies aim to reduce the risks posed by flooding to a level acceptable to the public.

When flooding occurs, public safety and property protection are the two immediate concerns to be addressed. For the purposes of prioritizing flood problem areas, resource values were assigned for both public safety and property protection concerns with input from the Master Plan Citizens Advisory Group. These values are shown in Table 4 – 2. These values are used in the development of problem area scores as discussed later in Section 4.5.

Table 4 – 2
Flood Control Resource Values

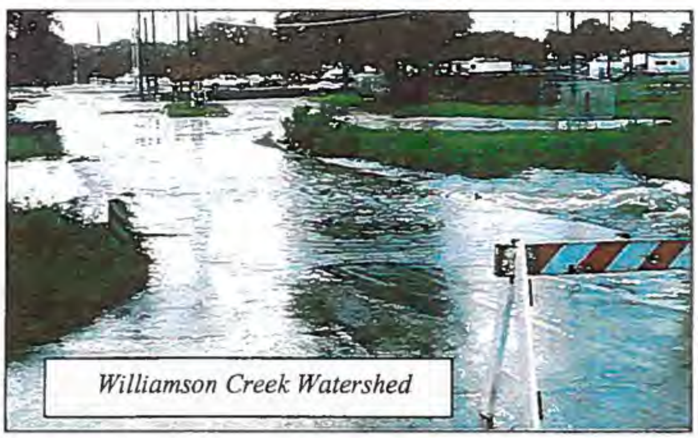
Resource Type	Public Safety Resource Value	Property Protection Resource Value
Structures		
Public Care Facilities (school, hospital)	100	100
Residential - Multi-Family	80	60
Residential - Single-Family	60	40
Non Residential	40	80
Roadways		
Highway	100	100
Arterial Road	80	70
Single Access Road	60	30
Collector Road	40	20
Local Road	20	10

4.4 Problem Severity


Williamson Creek Watershed

Historically, WPD has prioritized flood problem areas by focusing on the number of homes and businesses in the 100-year floodplain in a particular location. Where the information was available, the number of structures in the 2-, 10- and 25-year floodplains was also considered. However, this additional information was rarely available. During the course of this Master Plan, this additional information was obtained for the Phase I watersheds. The use of database and GIS applications facilitated the analysis necessary to compile this wealth of information.

Like resource values, threats to both property protection and public safety were considered during the calculation of problem severity values. Flood threats to *property* are directly measured by the depth and frequency of flooding that occur at the property.


Williamson Creek Watershed

Flood threats to *public safety* also correspond to the depth and frequency of flooding. However, the velocity or speed of floodwaters also plays a role in determining the relative threat to public safety. For example, fast moving floodwaters pose a greater danger to vehicles and pedestrians crossing flooded low water crossings and bridges than slower moving waters. It should be noted though that drownings have occurred along major Austin creeks where the public has underestimated the force of even slow moving floodwaters.

A flood threat was calculated for individual resources listed in the City's flooded structure database. Flood threats to property protection and public safety are based on the following equations:

$$FT_{Property} = \tfrac{1}{2}*D_2 + 1/10*D_{10} + 1/25*D_{25} + 1/100*D_{100}$$

$$FT_{Safety} = \tfrac{1}{2}*D_2*V_2 + 1/10*D_{10}*V_{10} + 1/25*D_{25}*V_{25} + 1/100*D_{100}*V_{100}$$

Where:

$FT_{Property}$ = Flood threat (problem severity) to property

FT_{Safety} = Flood threat (problem severity) to public safety

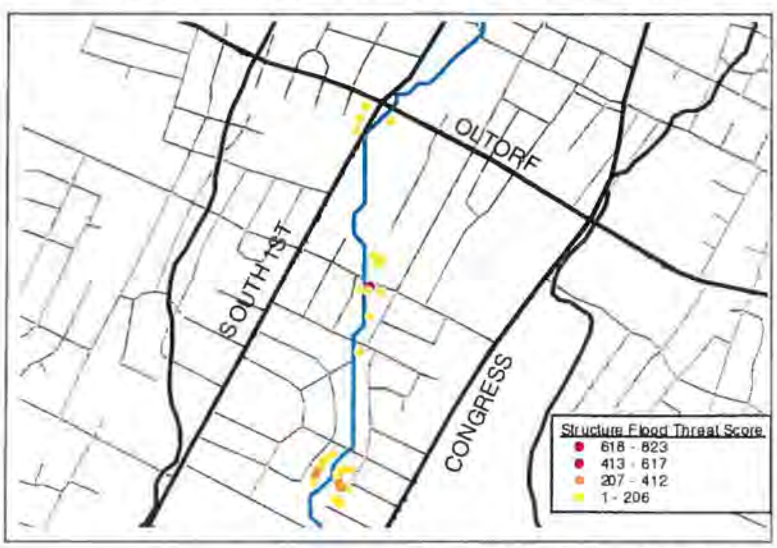
D_2 = Flood depth for the 2-year flood, etc.

V_2 = Flow velocity for the 2-year flood, etc.

Structure flooding depths were calculated as the difference between first floor elevations and creek flood stages predicted by HEC-RAS. An example of structure flood threat scores for East Bouldin is shown in Figure 4 – 2. Velocities were also taken from the HEC-RAS model output. From the equations above, community resources that are flooded more frequently and at greater depths merit a higher threat score. In other words, a home or business that floods every two years (i.e., flooded by the 2-year storm) is assigned a higher threat value than a home that is flooded every 25 years.

Figure 4 – 2

Flooded Structure Threat Scores for East Bouldin



Source: Camp Dresser & McKee, 2000.

4.5 Calculating Problem Scores

Flood problem scores are calculated for each creek reach using the flood threat value at each flooded structure within the reach. Each modeled creek and tributary was segmented into multiple reaches of approximately 2,000 feet long. A flood problem score for any given reach was based on: 1) the number and type of structures located along its 2,000 foot length, and 2) the severity of flooding along the segment. Similar to the flood threats calculated for each structure, a property protection and public safety problem score is calculated for each creek reach. Flood problem scores are computed using the following equations:

$$PP = \sum_{i=1}^{n} (RV_{property} * FT_{property})_i$$

$$PS = \sum_{i=1}^{n} (RV_{safety} * FT_{safety})_i$$

Where:

PP	= Property protection problem score
PS	= Public safety problem score
$RV_{property}$	= Resource value for property protection
RV_{safety}	= Resource value for public safety
$FT_{property}$	= Flood threat (problem severity) for property protection
FT_{safety}	= Flood threat (problem severity) for public safety
n	= Number of flooded structures

An existing and future reach flood problem score is then determined for each reach by weighting the two composite scores based on the relative concerns of the public with respect to public safety and property protection as shown below:

$$FC_{E,F} = W_{property} * PP + W_{safety} * PS$$

Where:

FC	= Flood problem score (existing or future conditions)
$W_{property}$	= Weighting factor for property protection (see below)
W_{safety}	= Weighting factor for public safety (see below)
PP	= Reach problem score for property protection
PS	= Reach problem score for public safety

Existing and future flood control scores were normalized to a maximum score of 100. Although current and future conditions were evaluated, the final reach problem score is based on the future flooding conditions only. It should be noted that $W_{property}$ and W_{safety} varied by watershed, and for larger watersheds these weights varied within the watershed. Based on the public input process, a relative weight was determined for public safety and property protection for each watershed or subwatershed.

This new prioritization system takes advantage of the additional information regarding 2-, 10- and 25-year storm event flooding and represents a significant improvement in WPD's ability to prioritize flood control needs across the City.

4.6 Results

Based on the findings of the creek flooding assessments, the majority of the Phase I watersheds are prone to creek flooding that creates public hazards. The results of the creek modeling for each of the Phase I watersheds is shown in Table 4 – 3. From Table 4 – 3, the 2-year storm is predicted to cause structure and road flooding in 14 of the 17 Phase I watersheds.

Table 4 - 3
Estimates of Flooded Structures and Roadways

Watershed	No. of Flooded Structures*				No. of Flooded Roadways			
	2-Year	10-Year	25-Year	100-Year	2-Year	10-Year	25-Year	100-Year
Barton Creek**	–	–	–	–	–	–	–	–
Blunn Creek	1	4	6	14	0	6	8	8
Buttermilk Creek	0	1	1	1	0	0	0	0
Boggy Creek	42	61	70	81	5	6	6	6
Bull Creek	3	14	26	40	14	14	15	15
Country Club Creek	11	12	13	17	1	2	4	7
East Bouldin Creek	10	33	47	64	0	13	18	19
Fort Branch	32	60	84	110	5	5	7	7
Harper's Branch**	–	–	–	–	–	–	–	–
Johnson Creek	3	4	8	13	2	5	11	13
Little Walnut Creek	85	213	313	401	6	15	22	26
Shoal Creek	32	89	132	245	0	5	10	11
Tannehill Branch	2	40	55	69	0	0	0	0
West Bouldin Creek	7	19	31	116	0	6	8	8
Walnut Creek	92	238	306	350	10	20	25	30
Waller Creek	1	43	76	127	13	26	31	36
Williamson Creek	58	199	295	454	9	14	17	18
Totals	379	1,030	1,463	2,102	65	137	182	204

* Primary structures only; buildings such as unattached garages, etc. not included.

** Flood models not available

Source: City of Austin, 1998; Loomis Austin, Inc. 2000

While determining the exact number of structures that will be subject to flooding by the 100-year storm event is very difficult, various studies have allowed WPD to develop order of magnitude estimates. Initial estimates predicted that there were approximately 12,000 homes citywide that would be flooded in the 100-year storm event. Results from the H+H models and the GIS flood application estimate that about 2,500 primary structures (e.g., homes and businesses) in the Phase I watersheds are predicted to flood in the 100-year storm event. This data has been extrapolated to a citywide estimate of approximately 7,000 to 8,000 primary structures with predicted flooding under the 100-year storm event, down from initial estimates of 12,000.

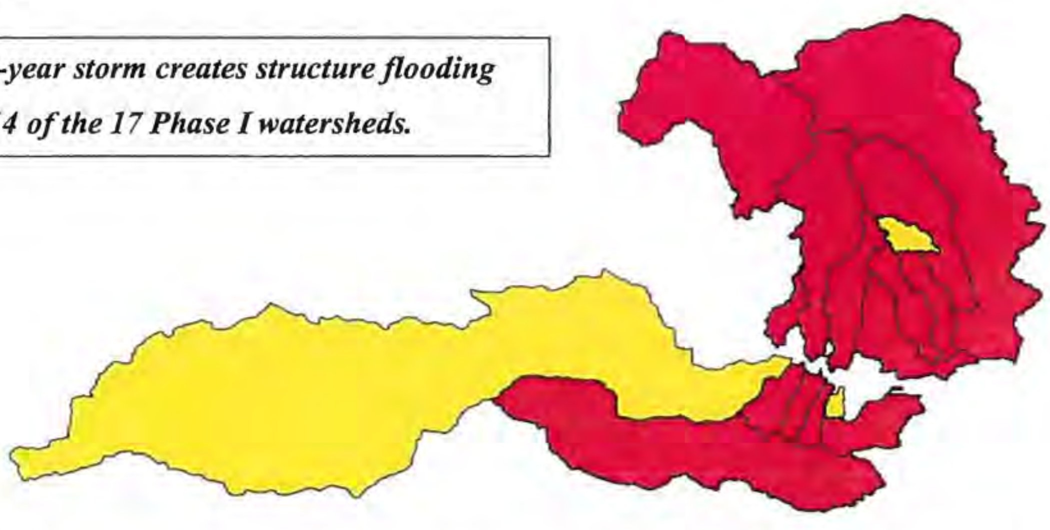
Structures may lie within the horizontal extent of the 100-year floodplain, but their first floor elevation may be above the base flood elevation or they may not be inhabited structures. For the Phase I watersheds, better data was collected regarding the type and vertical elevation of structures within the 100-year floodplain. However, much work remains to improve this data and to improve the comparison of structure elevations to the base flood elevations for all watersheds in the Austin area.

Even with the reduced estimate of 7,000 to 8,000 structures, the risk to human life and property is high. As many as 20,000 people could be threatened by floodwaters should the 100-year storm occur. In addition, flooded creeks commonly overtop roadways, posing a recurring threat to motorists and public safety personnel deployed in storm emergencies.

There are over 200 roadway crossings subject to inundation during the 100-year event. Historically, the large majority of flood event related deaths in Austin have occurred at roadway crossings. Public safety personnel routinely perform rescue missions during flood events for vehicles stalled on roadway crossings or swept into waterways.

Flood problem scores are used to identify relative flooding concerns for creeks and their major tributaries in the Phase I watersheds. Based on the modeling results shown in Table 4 – 3 and the scoring methodology described in Section 4.5, flood scores were calculated for 500 creek reaches, reflecting one million feet, or nearly 190 miles, of creek channel.

A 2-year storm creates structure flooding in 14 of the 17 Phase I watersheds.



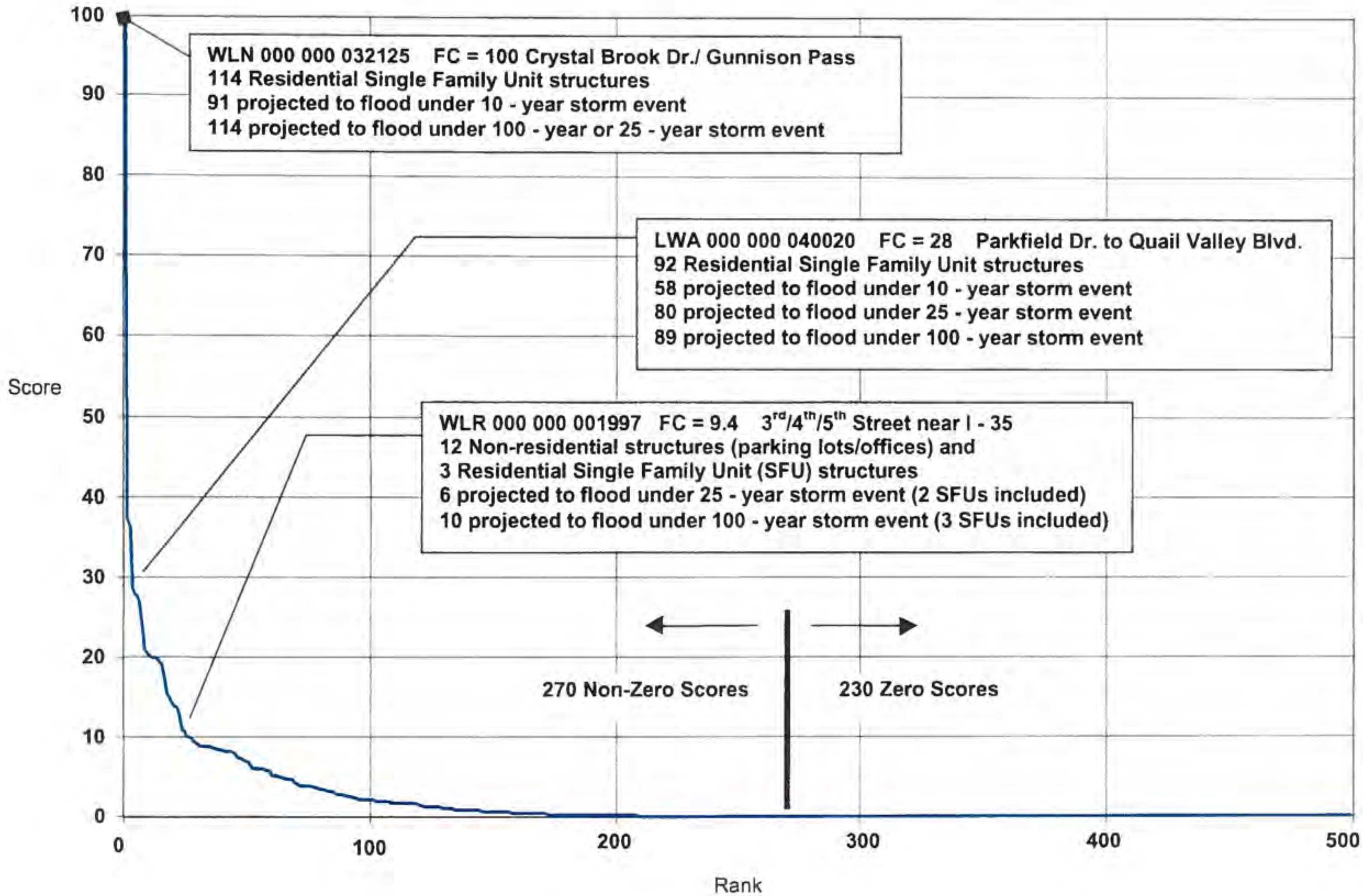
Flood problem scores are listed in Table B-1 of Appendix B. Figure 4 – 3 presents the distribution of flood control scores. As shown, more than one-half of the flood reaches (approximately 270) have a non-zero flood control score, indicating that flooding of a community resource is predicted within the reach. The y-axis in Figure 4 – 3 represents the flood control problem score. Each mission (FC, EC, and WQ) divided problem scores into ranges that represented one of five categories. The division and categories for flood control scores are as follows:

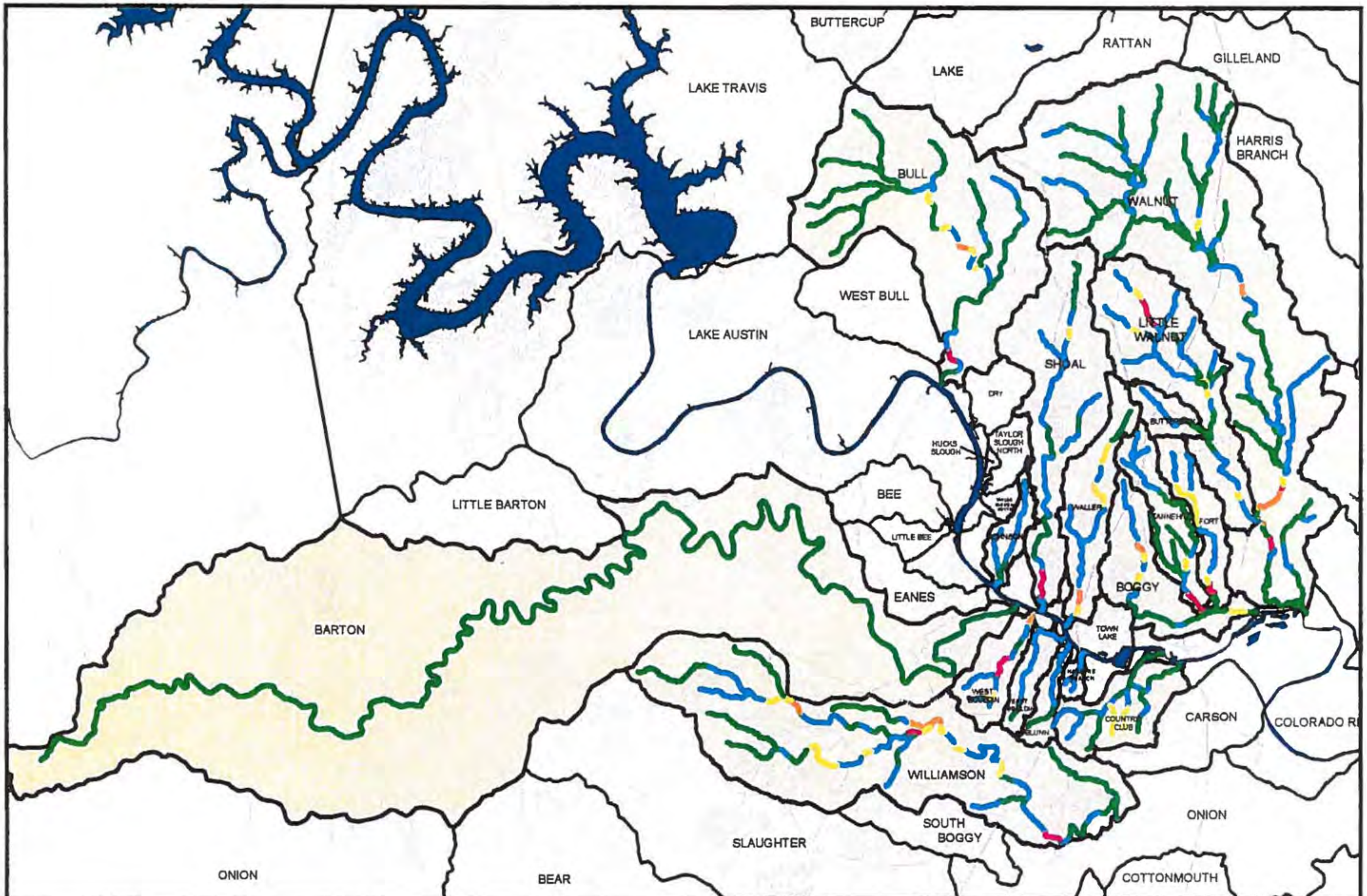
Problem Score	Narrative Rating
0	Very Low
0-5	Low
5-10	Moderate
10-20	High
20-100	Very High

Figure 4 – 4 depicts the results of the problem area prioritization for creek flooding. Severe flood problem areas are found in the Fort Branch, Walnut, Williamson, Shoal, Little Walnut, and Bull Creek watersheds. The Crystal Brook neighborhood and the Austin Hills Mobile Home Estates in Walnut Creek are areas at risk of flooding for relatively small storm events. Ten out of the eleven reaches in Fort Branch have flooding problems. Most notably, the Eleanor Drive area along Fort Branch also is predicted to flood during the 100-year storm event. In the Williamson Creek Watershed, flooding problems are prevalent - especially in the Creek Bend neighborhood and along middle Williamson Creek from Bayton Loop to Heartwood Drive.

Williamson Creek Flooding

Figure 4 – 3
Flood Control Score Distribution





Watershed Protection Department

This map has been produced by the City of Austin for the sole purpose of showing Erosion, Flood, & Water Quality Problem Scores for the Phase 1 watersheds and is not for any other use. No warranty is made by the City regarding its accuracy or completeness. Reproduction is not permitted without permission from: City of Austin-Watershed Protection Department. Plotted 4/26/01.

Flood Problem Ratings

0 1 2 3 4 5 Miles

N

Flood
- Very Low
- Low
- Moderate
- High
- Very High
- Roads
- Lakes & Rivers
- Phase 1 Watersheds
- Austin Area Watersheds

Figure 4 – 4

As demonstrated during the 1981 Memorial Day Flood, lower Shoal Creek (south of 15th Street is prone to flooding from a 100-year storm event. In the Little Walnut Creek watershed, the Mearns Meadow Boulevard area north of Rutland Drive is ranked as a very high problem area. In the Bull Creek watershed, severe flooding of low water crossings, including FM 2222 at Lakewood Drive, are reflected in the flooding problem results. Other less severe flooding areas are scattered throughout the Phase I watersheds. The top ten flood control problem reaches listed alphabetically are as follows:

Reach	**Rating**	**Location**
BUL000000006100	Very High	Near the intersection of FM 2222 and Lakewood Dr.
FOR000000004713	Very High	Near the intersection of Lott Ave. and Ledesma Rd.
LWA000000038040	Very High	From Mearns Meadow Blvd. to Parkfield Dr.
LWA000000040020	Very High	From Parkfield Dr. to Quail Valley Blvd.
SHL000000002030	Very High	From 6th Street to 11th Street
SHL000000004160	Very High	From 11th Street to Kingsbury Street
WLN000000020380	Very High	Near the intersection of Martin Luther King Blvd. and Johnny Morris Rd.
WLN000000032125	Very High	About 2300 feet upstream of the crossing at Loyola Lane in the vicinity of Crystal Brook Dr.
WMS000000052150	Very High	From the confluence with Cherry Creek to West Gate Blvd.
WMS000000015900	Very High	From West Gate Blvd. to Reese Dr. (Creek Bend Area)

Section 5

Localized Flooding Assessment

5.1 Introduction

The secondary drainage system (collectively known as the localized storm drain system) is composed of storm drainpipes, curb inlets, manholes, minor channels, roadside ditches, and culverts. WPD operates approximately 400 miles of storm drainpipe, ranging in diameter from six inches to eight feet. In addition to minor channels and borrow ditches, the system includes over 18,000 curb inlets as well. This system is intended to efficiently concentrate and convey stormflows to the primary drainage system (creeks). "Old" or "outdated" storm drains means storm drains designed and/or installed under drainage criteria in effect before January 1977. When the secondary drainage system is old, localized flooding may occur.

As used in this Master Plan, "localized flooding" is the term given to areas where flooding occurs due to the secondary drainage system, not necessarily as a result of creekside flooding. Creekside flooding is commonly associated with the 100-year floodplain area of a given creek. On the other hand, localized flooding typically occurs outside of the 100-year floodplain with one exception. The exception is where there is a transition area along floodplains. If the creek does not rise enough to back up water into the local storm drains, there may still be a possibility of localized flooding for smaller storms inside the 100-year flood plain.

A study of past drainage complaints revealed that more customers outside the 100-year floodplain complain about the secondary system through the drainage complaint hotline than do customers within the 100-year floodplain. To date, WPD has responded to customer complaints regarding localized flooding on a case-by-case basis. This means that traditionally WPD has been reactive in response to customer needs regarding localized flooding. However, with the advent and the growing availability of geographical information system (GIS) technology, WPD is proactively moving towards understanding the magnitude and causes of localized flooding. With a better understanding of the issues, WPD can better develop solution strategies, inform decision-makers and the public, define reasonable levels of service, address customer expectations, and plan future improvements.

This study concludes that in the urban core, the localized storm drains often fall into one of four conditions:

1) Storm drains do not exist;
2) Existing storm drains become old through changes in design criteria;
3) Existing storm drains have exceeded their anticipated service life (disjointed segments, damaged or deteriorated pipe); or
4) Existing storm drains are partially or completely clogged (debris, sediment, and utility conflicts).

5.2 History

The earliest recorded flood in Austin occurred in 1832 when, the Bicentennial record states, the Colorado River rose far more than 46 feet. This occurrence predates Austin being chartered as the capital of the Republic of Texas in 1839 and the Civil War. In nearly every decade since, there is record of significant flood events. Only since late 1988 has WPD tracked customer drainage complaints through a computer database. It was not until the late 1990's, with the help of GIS as an information management tool, that WPD was able to plot the customer complaints and begin to analyze the localized drainage system.

To better understand how the localized drainage system evolved to its present condition, it is necessary to explore past design practices. Borrowing from agricultural experience, the earliest urban drainage systems were designed and constructed as a series of open ditches. Later, storm drainpipes were designed to carry runoff underground ("out-of-sight, out-of-mind"). The integrity of these storm drainpipe systems is heavily dependent on two factors - material selection and design criteria.

5.2.1 Material Selection

Historically, the predominant drainpipe materials used in Austin are vitrified clay, non-reinforced concrete, and reinforced concrete. The first material used for enclosed storm drains was vitrified clay pipe. This material, while resistant to corrosion, is fragile when disturbed by construction or soil movement. In Austin, vitrified clay pipe was probably installed around the 1890's- early 1900's and is still present in parts of downtown, the Enfield area, and the Hyde Park neighborhood. Non-reinforced concrete pipe is a cylindrical concrete pipe without steel reinforcement. This material was used predominantly in the 1930's to early 1960's. Non-reinforced concrete pipe is commonly found in the older parts of the City, which were developed during this time period. Experience has shown that in Austin, non-reinforced concrete pipe has a service life of about 40 years. Unfortunately, with out the steel reinforcement, it has a reduced service life and is subject to collapse requiring routine replacement. Reinforced concrete pipe (RCP) was developed in the 1950's but was not cost-effective for common use until the early 1960's. It has a design life of more than 50 years and, under ideal conditions, it can exceed 75 years or more.

5.2.2 Design Criteria

City drainage design criteria have had significant changes in the past as well. The earliest criteria for designing storm drains can be found in the 1954 City Code. It set the minimum requirement of computing total runoff to be not less than 2.6 cubic feet per second (cfs) per acre. The Rational Method was developed in mid-1800's and is commonly used to size storm drains, but this method was not formally introduced as part of City criteria until the first edition of the City's Drainage Criteria Manual in 1977. It is not clear what methods were accepted for determining excess runoff prior to 1977. As a comparison, the 1954 minimum criteria of 2.6 cfs per acre would more likely be about 5 to 7 cfs per acre, on average, for most fully-developed residential areas under the City's current criteria. This means that the older storm drain capacities are undersized by a factor of 2 to 3 times under today's standards. Curb inlets are used to get the water off the streets and into the storm drainage system. There are old curb inlets scattered throughout the City. Some of the smallest are only 18 inches in length. Five (5) foot curb inlets are prevalent throughout the inner city. Today's minimum curb inlet length is 10 feet. Lastly, in various parts of town, there are no storm drains at all. The excess runoff was apparently designed to flow along city streets and in minor channels, sometimes between houses or businesses.

5.3 Available Database Information

Two vital information sources were available for this localized drainage study. One is WPD's drainage complaint database and the other is a customer flood survey that was conducted in 1996. These two information sources allowed WPD staff to begin to gain an understanding of the localized drainage system needs and priorities.

5.3.1 Drainage Complaint Database

There are several 'truisms' that need to be stated regarding flood complaints.

- Not everyone is aware of the threat of localized flooding in their area. WPD only has records of complaints since 1988; this is too short a period to compare with large storm events (such as the 25- to 100-year storms) that are of greater concern. A common misconception is seen in the Memorial Day flood of 1981, well publicized as a 100-year storm event (i.e., an event that has a 1 in 100 or 1% chance of occurring in any given year). Most people don't realize that it predominantly affected the flood plain in the Shoal Creek watershed. This event was not a good benchmark for the 100-yr storm in most areas of Austin. There may be a false sense of security in comparing the 1981 Memorial Day flood damage in the Shoal Creek area to the lack of damage in other parts of the City. In addition, people moving to Austin who are new to Central Texas may not be aware of the threat of flash flooding.
- Not everyone who has experienced localized flooding calls in a complaint. Some people either choose not to complain or don't know where or how to file a complaint.
- WPD is only aware of those localized flood prone areas where the department has record of a complaint. There is not enough detailed data (such as finished floor elevations and land survey information) to accurately model the entire City to a level of detail necessary to identify projected areas of localized flooding. The City is taking steps to acquire a better understanding of these localized problems - see below.
- Not all of the complaints filed are the responsibility of the City of Austin. In some cases, the complaints are a result of actions taken by others such as

neighbors, businesses or property owners without the City's involvement. Such cases become civil matters between property owners.

- Areas where yard-flooding complaints have been filed may be indicative of potential future structural flooding. This statement is supported by the fact that not every part of Austin has experienced the 100-year storm event in recent years. To date, flooded yards may have only experienced structural flooding "near misses" in the brief complaint record history.

In the spring of 1999, the drainage complaint database was queried, searching for key words like flood, flooded, house, garage, structure, foundation, and building. There were 5,793 responses out of nearly 16,000 complaints. This was the first set of data to support a long held belief by WPD staff that the local drainage system was outdated.

A simple complaint density for each of the Phase I watersheds was developed by dividing the number of complaints in a watershed by the area of that watershed in square miles, as shown in Figure 5 – 1. Table 5 – 1 *Drainage Complaint Densities,* provides the numbers used to develop the complaint density for each watershed using 5,793-flood complaint records.

Figure 5 - 1
Drainage Complaint Densities

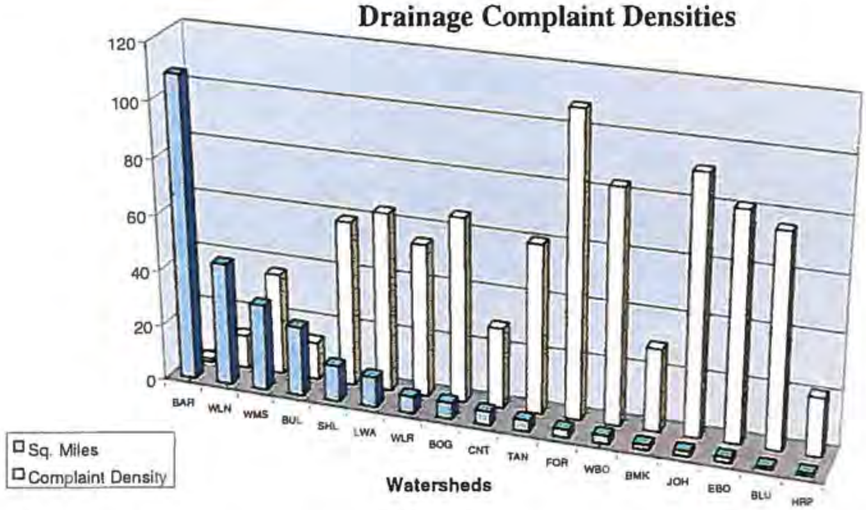


Table 5 – 1

Drainage Complaint Densities

Watershed	Sq. Miles	# of Complaints	Complaint Density
BAR	109	134	1
BLU	1	76	76
BMK	2	59	30
BOG	6	397	66
BUL	25	336	13
CNT	5	144	29
EBO	2	163	82
FOR	3	325	108
HRP	1	21	21
JOH	2	184	92
LWA	11	706	64
SHL	13	770	59
TAN	4	242	61
WBO	3	251	84
WLN	44	524	12
WLR	6	329	55
WMS	31	1132	37

As illustrated in Figure 5 – 1 and Table 5 – 1, the following observations are made:

- The complaint densities are neither directly or inversely proportional to the size of the watershed. Inverse proportionality (the smallest watershed has the highest complaint density) might have indicated the densities were skewed by watershed area (i.e., dividing by a smaller drainage area renders a large complaint density or vice versa). There is a disproportionate distribution of complaint densities varying from watershed to watershed.
- For their size, Fort, Johnson, West Bouldin, East Bouldin and Blunn Creeks have the highest complaint densities. This information might play a part in prioritizing the implementation of solutions, as funding becomes available, but it does not specifically address the severity of the complaints.
- The highest complaint densities occur in the urban core. This supports the conclusions of this study that the older urban drainage systems are outdated.

In the spring of 2000, the drainage complaint database was again queried to identify localized flooding complaints (versus creekside flooding). A total of 6,315 customer complaints were identified with verifiable street addresses. Each customer complaint was individually reviewed for content and sorted with one of six flood codes per the following descriptions [*keywords are italicized*]:

Flood Codes for the Localized Flood Study

BLD (building reported to have flooded from storm water runoff)
House, home, garage, business, office, inside door, basement

YRD (yards or water around buildings; possible near misses)
Yard, front yard, back yard, foundation, driveway, property, parking lot

STR (old street storm drainage systems)
Street, curb and gutter, inlet, bar ditch, barrow ditch

STN (standing; poor drainage)
Standing water, stagnant, not draining, pooling (but not if a designated pond)

OTH (other with flood/drainage complaints associated; drainage complaint without specific key words fitting in above categories.)

DEL (delete; not applicable)
Dead animal, snakes, erosion, vegetation, rats, weeds, trash debris without any indication of a flood complaint

The flood codes are listed in hierarchical order, BLD (building) being of the highest concern. Any notes that had multiple keywords were categorized using the highest-ranking flood code. Table 5 – 2 illustrates the new codes with the respective complaint totals per each type.

Table 5 – 2

Drainage Complaint Database

Flood Code	Flood Complaint Type		Number[1]
BLD	Building Flooding		551
YRD	Yard Flooding		1,459
STR	Street Flooding		687
STN	Standing water		851
OTH	Other Flooding		1,762
DEL	Deleted		1,005
		Total	6,315

Note: (1) Database Results through March 2000

As mentioned earlier, this localized drainage study must rely largely on customer complaint data to identify study areas in the absence of detailed models. Therefore, it is important to capture as many drainage complaints as possible, as reported by WPD customers, to get the clearest view of the big picture.

5.3.2 1996 Flood Survey

In addition to the complaint database, WPD conducted a public flood survey mail-out in 1996 to gather additional information related to customer drainage concerns. While the survey was intended to survey all drainage utility customers (approximately 250,000), the survey effort was curtailed after 180,000 mail-outs due to the response level and the resulting phone bank workload. Approximately 1,600 responses acknowledged some degree of structure, yard or street flooding. Table 5 – 3 summarizes the results of the 1996 flood survey.

Table 5 – 3

Flood Survey (1996)

Flood Complaint Type	Number
Building Flooding	524
Yard Flooding	723
Street Flooding	221
Other Flooding	169*
Total Complaints	1,627

*Flooding reported for neighbors or neighborhoods

5.3.3 Comparative Review of Data Sources

The drainage complaint database and the 1996 flood survey were compared to identify any overlaps. As of March 2000, there were only five addresses that appeared in both data sources. The results of this comparison infer several things. First, the two data sources are distinct and valuable information pools. Second, a significant number of customers do not know where to call to report a drainage concern. Third, the incomplete flood survey may have garnered additional addresses had it been carried to fruition.

The combination of the Flood Survey (1996) and the drainage complaint database (1991-2000) yields the following results:

Table 5 – 4

Combined Results of 1996 Flood Survey and 1991 – 2000 Complaints

Flood Complaint Type	Number
Building Flooding	>1,000
Yard Flooding	>2,000
Street Flooding	> 900
Standing Water	> 800
Other Flooding	>1,700
	>6,400

5.4 Localized Flood Study

Characterizing and prioritizing localized flooding is a monumental task. In the past, WPD has relied on outdated maps and complaints to help focus storm drain improvements. Without intensive system investigations to determine the location of collapsed or clogged pipes, the true cause of reported complaints is not readily apparent. Because comprehensive data on the location, size and condition of the storm drain system does not currently exist, incorporating the same methods used for the primary drainage system is not possible at this time.

Although the methods used to identify flooding concerns along major creeks could not be applied to storm drains, WPD recognized that flooding caused by damaged, clogged, or outdated storm drains is a significant issue in Austin. In an attempt to better define the extent of localized flooding, WPD conducted additional analysis of the available information.

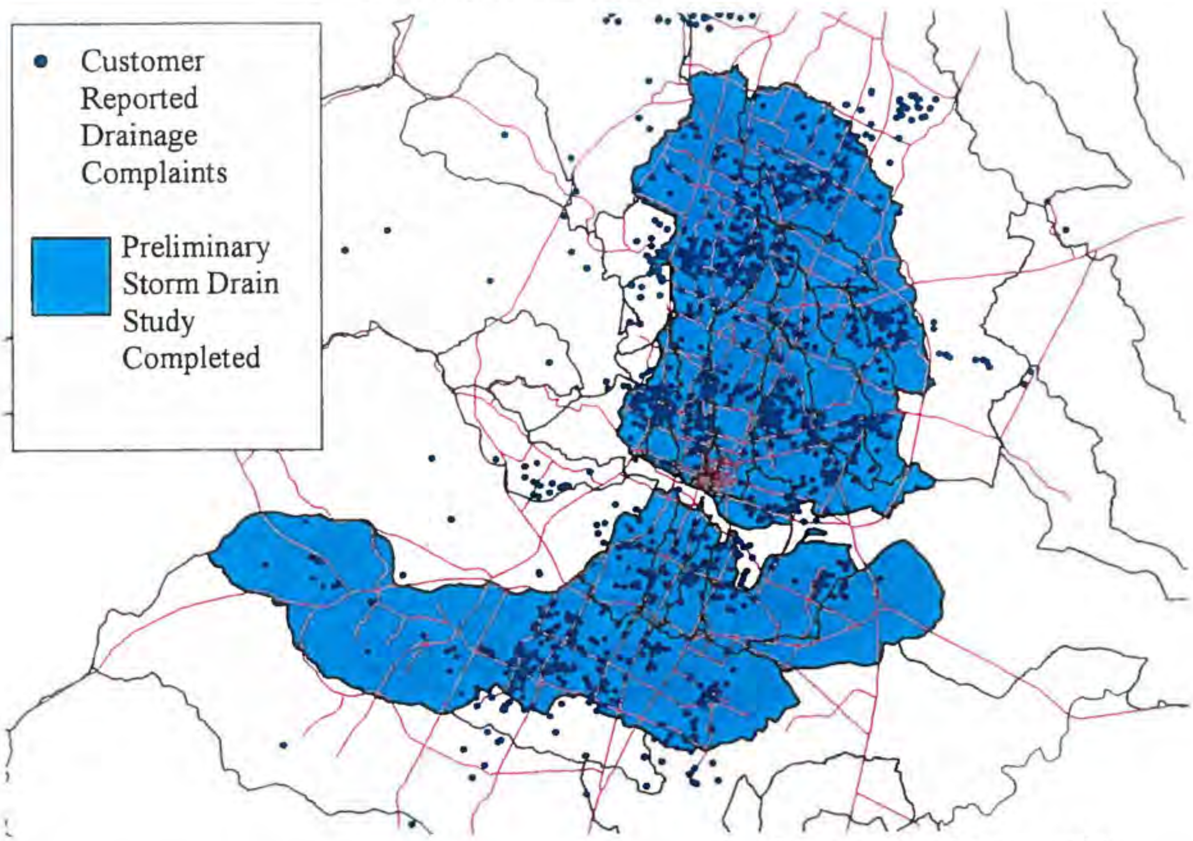
With the advent and growing availability of geographical information system (GIS) technology, the task of studying localized flooding over a large area has become much more manageable. WPD staff, working with local consultants, has utilized GIS to develop a much better understanding of the secondary drainage system and localized flood areas.

5.4.1 Flood Complaints Mapping

Using the analysis results described above, the locations of customer reported flood complaints were mapped on a GIS computer system. The drainage complaint database and flood survey results were geocoded (mapped) using the street address provided by each utility customer that contacted the City's complaint hotline or responded to the 1996 flood survey. The results are shown in Figure 5 – 2. The concentrations of flood complaints in various watersheds are possibly reflective of old storm drain systems in those areas. During the course of the master plan, WPD has completed preliminary study of several local storm drainpipe networks (see Figure 5 – 2) to determine if current system capacity and pipe sizes are up to current criteria.

Figure 5 – 2

Drainage Complaints – Citywide



Source: City of Austin, 2000.

As part of the mapping effort, the 100-year floodplain boundaries were geographically mapped in relation to the customer complaint data. Figure 5 – 3 shows an example taken from upper middle Shoal Creek watershed where the locations of the 100-year flood plain and customer complaints have been mapped. By mapping the creek floodplain boundaries, certain observations can be made regarding creek flooding, localized flooding and the customer reported complaint areas. First, most flood complaints that WPD has received through the 1996 Flood Survey and Drainage Complaint Database (1990 to 1999) occur outside of the 100-year flood plain. From Section 4.2 of this Master Plan, it is estimated that roughly 8,000 structures are located in the 100-year flood plain. When compared to the 6,400 total local flood complaints received between 1988 to 2000, it is apparent that customers in the 100-year flood plain don't necessarily utilize the drainage complaint hotline. Second, the distribution of local flood complaints provides some insight into the possible location of outdated storm drains. The concentrated patterning of complaints over time further verifies the outdated nature of the local storm drainage system in certain areas. Third, some dots are located on the borderline of the flood plain. In these areas, it is likely that old storm drains still require upgrading to accommodate smaller storm events other than the 100-year. This fringe area is a mix between structures that may experience both localized flooding and large scale flooding. Due to the probability of storm events, the occurrence of localized flooding is likely to be more frequent.

Figure 5 – 3

Drainage Complaints – Localized vs. Flood Plain

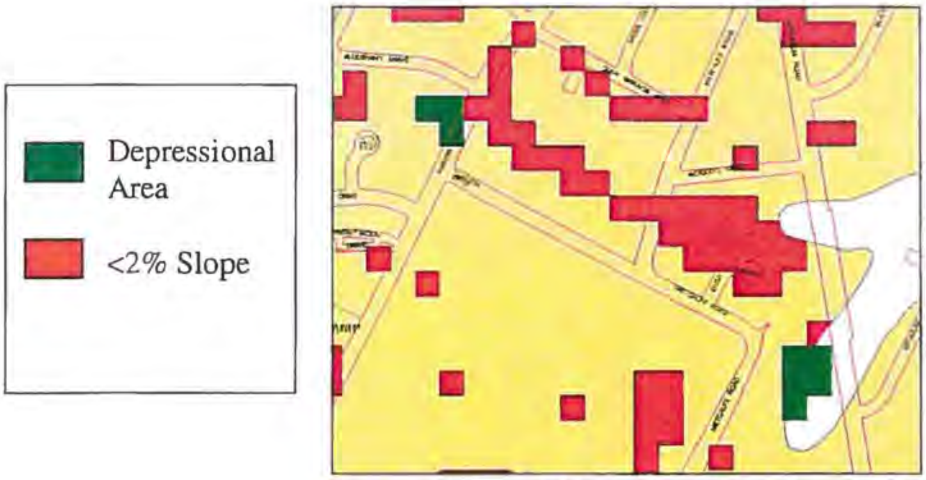
Source: City of Austin, 2000.

5.4.2 Identification of Flat Slopes and Possible Depressions

Another valuable GIS application involved the analysis of elevation and contour data to determine areas that may be prone to localized flooding due to relatively flat topography. Using GIS, local consultants Baker Aicklen, Inc. performed a three-dimensional assessment of a City of Austin elevation model to identify areas with relatively flat slopes (<2%) or depressions. The results are based on a 100' by 100' grid map system- an example of which is illustrated in Figure 5 – 4. Depressional areas were identified where a grid cell had an elevation lower than each of its neighboring grid cells – analogous to the bottom of a bowl. Also, the grid cells with 2% slope or less were also highlighted.

Figure 5 – 4

2% Slope and Depressions



Source: Baker-Aicklen & Associates, Inc., 1999

5.4.3 Storm Drain Study

In order to tie the drainage complaints to the localized storm drainage system, WPD began an intensive preliminary engineering study of all the storm drains in the urban core. The limits of this Storm Drain Study includes the entirety of 15 watersheds and portions of 5 others. These correlate to watersheds with the highest density of flood complaints during the 10-year complaint record. The 15 completed watersheds are: Boggy, Blunn, Buttermilk, Carson, Country Club, East Bouldin, Fort Branch, Harpers Branch, Johnson, Little Walnut, Shoal, Tannehill, Town Lake, Waller and West Bouldin. The 5 partial watersheds include Barton, Bull, Eanes, Walnut and Williamson. Each watershed was broken down into sub-basin drainage areas. Each sub-basin area was analyzed using the Rational Method to compute excess runoff and preliminarily size the main storm drain system. When the required pipe sizes were determined, in many cases, the storm drains were found to be either non-existent or outdated. An inventory of the actual condition of the existing storm drains is necessary to identify infrastructure with reduced service. A prospective field inventory should also include the location and condition of existing open channels and culverts, to allow for the modeling of the complete secondary drainage system.

WPD also prepared preliminary cost estimates for each storm drain system in order to obtain an estimate of the magnitude of required infrastructure needs. Table 5 – 5 summarizes the estimated project costs for each watershed in December 1999 dollars (ENR Construction cost index = 6127). The actual costs will vary depending on further engineering study and length of time to implement based on fund availability.

Table 5 – 5

Localized Drainage System Suggested Upgrades

	Watershed	Prelim. Project Cost (Millions)	Suggested # of System Upgrades
Completed Watershed studies[1]:			
	Boggy	$ 17.5	36
	Blunn	$ 5.2	24
	Buttermilk	$ 0	0
	Carson	$ 0	0
	Country Club	$13.3	21
	East Bouldin	$12.6	30
	Fort Branch	$19.3	48
	Harper's Branch	$ 2.6	5
	Johnson	$15.2	34
	Little Walnut	$10.4	27
	Shoal	$43.3	47
	Tannehill	$ 8.4	24
	Town Lake 1	$ 2.1	4
	Town Lake 2	$ 6.2	4
	Town Lake 3	$19.4	3
	Waller	$39.4	24
	West Bouldin	$23.0	50
Incomplete Watershed studies:			
	Barton	$ 0	0
	Bull	$ 0.8	2
	Eanes	$ 0.04	1
	Walnut	$ 0.35	2
	Williamson	$18.4	37
	Total:	$257.5 Million	423

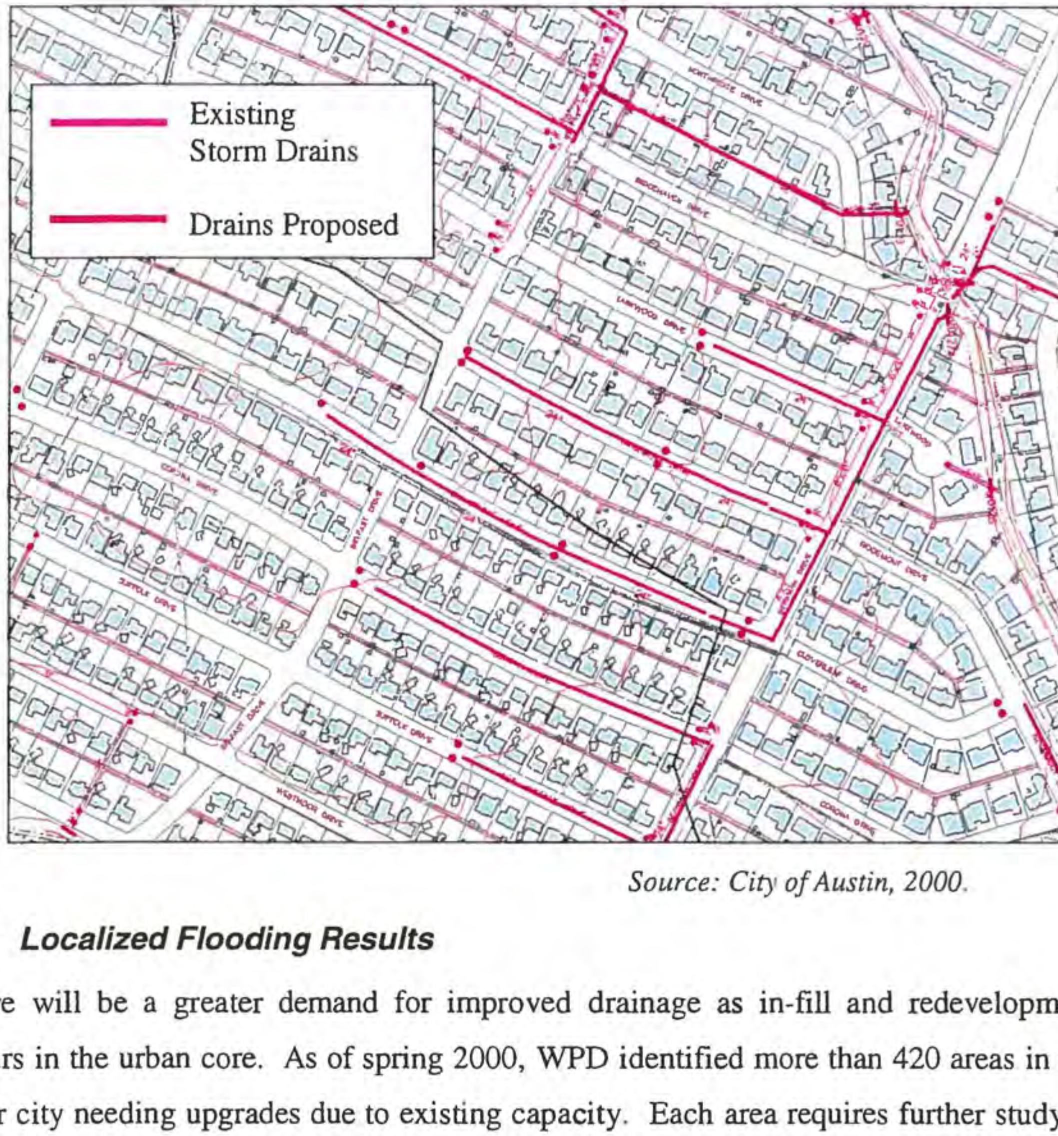
Notes: (1) Based on previous complaints received through December 1998
Source: City of Austin, March 2000

Figure 5 – 5 shows both existing and proposed storm drains. Shown in **red** are the suggested storm drain upgrades. Existing storm drains are shown in **magenta.** The dots

represent curb inlets. The area shown is located in the Fort Branch watershed. This is a good illustration of an outdated localized drainage system under current City standards. WPD records indicate a combination of building, yard and street flooding in this area.

Figure 5 – 5

Suggested Localized Drainage System Upgrades



Source: City of Austin, 2000.

5.5 Localized Flooding Results

There will be a greater demand for improved drainage as in-fill and redevelopment occurs in the urban core. As of spring 2000, WPD identified more than 420 areas in the inner city needing upgrades due to existing capacity. Each area requires further study to determine possible solutions and costs. The implementation of solutions to the areas is directly dependent on funding availability. As funding becomes available, implementation of the solutions will proceed in priority order.

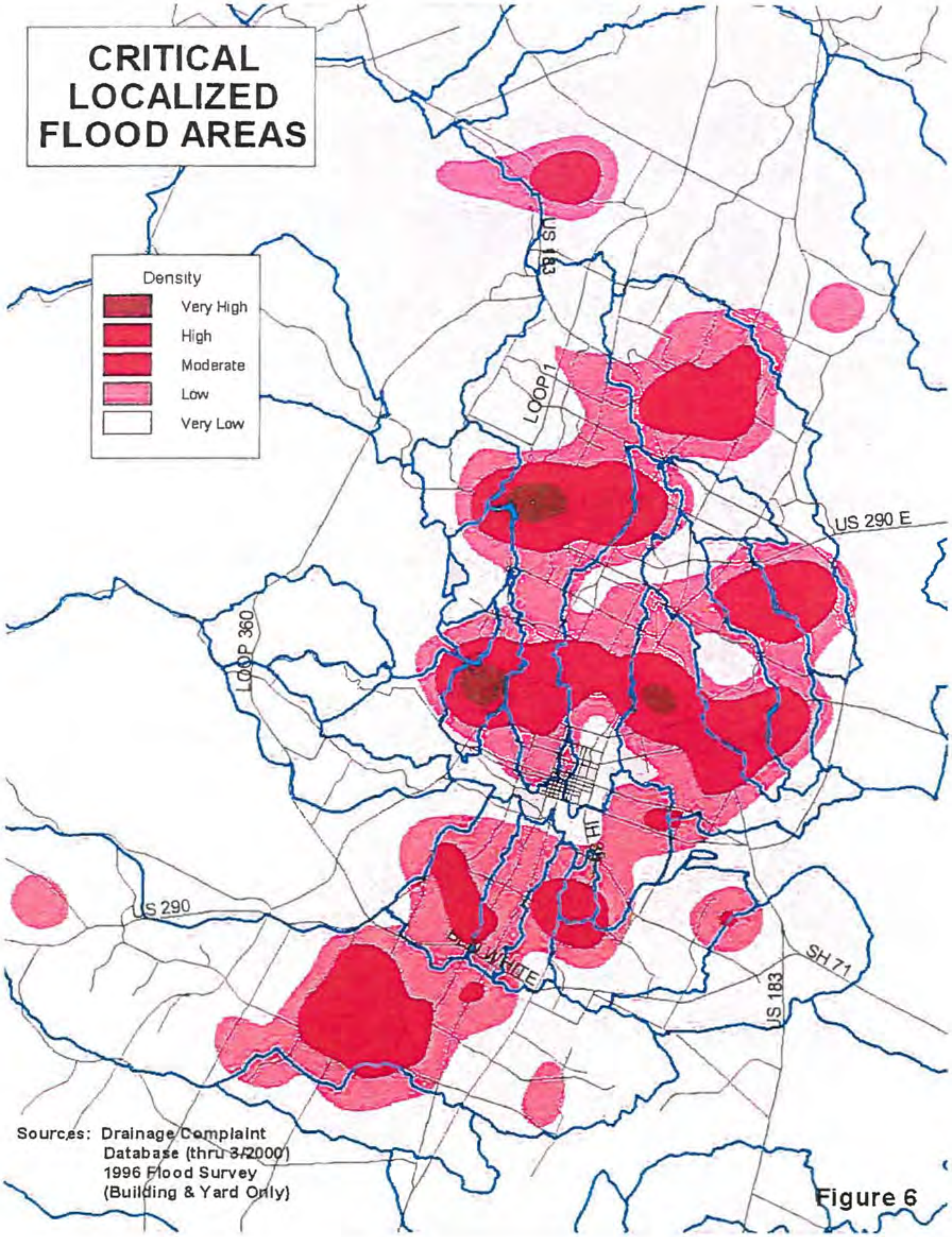
5.5.1 System Upgrades: Where to Start?

Finding a starting point to initialize improvements requires prioritization. Prioritization involves considering a combination of levels of service (see Goals, Section 2), critical localized flood area classification (Very High to Very Low), and studying case by case single complaints. Further engineering study will help determine the more detailed solutions and priorities, and identify storm drains needing replacement due to age or condition. This process will help move WPD away from totally reactive and toward proactive results in meeting customer needs.

Using a combination of several layers of information, it is possible to identify the most critical areas of need to address localized flooding. Buildings with reported flooding receive the highest priority. Plotting building and yard flooding locations reveal that there is not a uniform area distribution, but a coincidental patterning. By zeroing in the tightest densities of the building and yard flooding, and utilizing the GIS spatial analyst, the critical localized flood areas were identified. Figure 5 – 6 illustrates the results of this process of identifying critical localized flood areas from very high to very low. The very high critical flood areas are shown in **dark red**. In addition, a multiplicity of other flood types can be included in a solution to thwart future complaints. Concurrent with buildings and yards, reports of street, standing and/or other flood types may be addressed as well. Where possible, it makes sense to fix as many drainage issues as feasible at one time.

Figure 5 – 6

Critical Localized Flood Areas



As is apparent in Figure 5 – 6, there are several areas that seem to indicate the need for system upgrades. The "Very High" and "High" critical areas occur in portions of Boggy, Fort Branch, Johnson Creek, Little Walnut, Tannehill, Walnut, and Williamson Creek watersheds. This is an improved understanding of the localized flooding beyond the drainage complaint densities (Figure 5 – 1) because it considers the spatial distribution of localized flood complaints across watershed boundaries. There are widespread areas of localized flooding concerns throughout all urban watersheds except Buttermilk Creek. Figure 5 – 6 is anticipated to be a dynamic graphic for two reasons. First, as more storm events are encountered and more complaints received, the densities will probably shift. Second, as problem areas are improved, the density areas will most certainly change. The goal of localized flooding should be to normalize the city to "low" and "very low" critical areas.

5.5.2 Single Address Complaints

Figure 5 – 6 will be valuable for zeroing in on detailed study areas and developing future Capital Improvement Projects, but there still exists the necessity to look at each complaint on a case by case basis. Two main considerations for prioritizing improvements are inundation depths and frequency of flooding. A comprehensive hydraulic computer model requires a thorough inventory and physical survey of the entire drainage system. Such a model would provide analysis of the entire list of complaints to the level of knowing how deep and how often a structure or property is flooded. It is anticipated that this kind of model will not be available for several years. For now, customer reports are the best source of available information.

5.5.3 Anticipated Effects to Watersheds

The overall effect of selectively adding storm drains to a watershed or even to a sub-basin area is anticipated to be negligible, particularly in highly urbanized areas. The timing of peak flows and the connectivity of impervious cover should not change significantly.

First, the suggested system upgrades are site specific and not considered large enough to dramatically affect hydrologic change on the macro-scale. The existing stream reaches in many urban watersheds have already enlarged significantly due to near maximum development build-out. The primary goal of a localized storm drainage system upgrade is to more efficiently move the storm water from point A to point B. It is important to achieve this goal while reducing the threat of localized flooding without adverse drainage impact to upstream or downstream properties.

Second, the storm water volume remains constant for a given intensity-duration-frequency storm even with system upsizing. Whether or not the storm water runoff is being carried by pipes, streets, or concentrated overland flow, it is still primarily open channel hydraulics with negligible changes in storage or detention. The key then is to capture and convey excess runoff in a manner which minimizes the threat of localized flooding. Again, each system upgrade should be studied to ensure no adverse affects to surrounding properties.

5.6 Localized Flooding Future Efforts

WPD has initiated a pilot program to inventory and analyze the existing drainage system in Waller Creek. This is being referred to as the Drainage Infrastructure GIS (DIG) effort. It is anticipated that once complete, WPD will know the location, elevation, dimensions, age and condition of the existing drainage infrastructure in portions of the Waller Creek watershed. In addition, the Waller Creek drainage system will analyze the existing storm drains, channels, and culverts. After expansion to its full potential, inventory and modeling of existing drainage infrastructure will become the next generation of information in concert with the previous Storm Drain Study toward understanding the localized flooding.

More study and analysis will be necessary for several departmental functions to be realized. These include modeling, marking, maintaining, and improving the existing drainage infrastructure system. As the system operator, WPD needs to know where and how the Municipal drainage system functions. This will provide the Field Operation staff with information, which fosters systematic inspection and maintenance. Some portions of the drainage system are subject to structural failure or chronic clogging. A plan needs to be established to systematically inspect and routinely replace deteriorated pipe when it exceeds the service life or does not meet operating tolerances. In addition, WPD is responsible for providing utility locations ahead of new construction to avoid conflicts and prevent possible damage. With a better understanding of the existing system, WPD can better predict needs for improvements and the priority order for implementation.

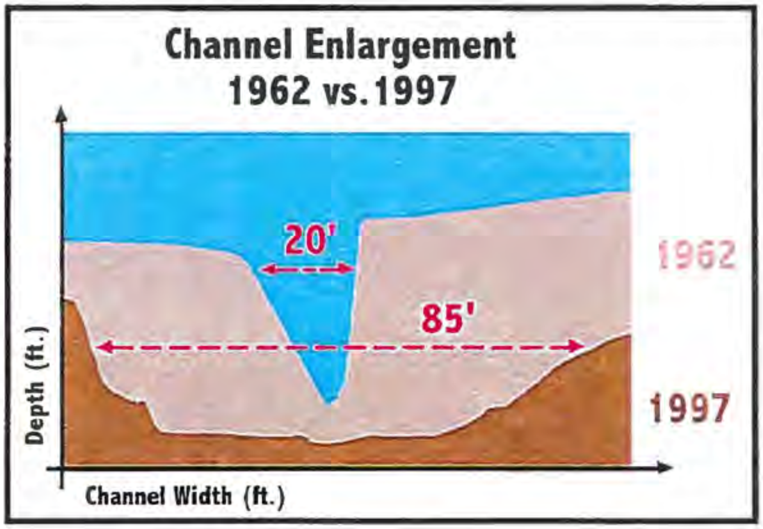
Coordination with other departments is ongoing to align construction of multi-departmental projects and to effectively reduce public inconvenience.

Section 6

Erosion Assessment

6.1 Background

Most of Austin's watersheds (including both urban and suburban watersheds) are drained by streams that exhibit stream erosion problems. Erosion problems primarily stem from changing land use conditions (i.e., urbanization) that modify watershed hydrology – significantly increasing stormflows in creeks for even small rainfall events. These changes in streamflow have resulted in changes in local creek characteristics. For example, past survey data shows that a typical section of Little Walnut Creek has expanded by 65 feet over the last 35 years. A 20-foot wide section of creek in 1962 is now 85 feet wide today. As stream channels react to changes in watershed hydrology, several concerns arise regarding future creek bank failures, long-term channel degradation, and the resulting impacts to creekside residents, their property, and water quality. To address these concerns, detailed erosion assessments were conducted for each of the major creeks in the Phase I watersheds.



6.2 Study Methods

The study methods used to conduct the erosion assessments for the Phase I watersheds are described in a report entitled Technical Procedures for the Watershed Erosion Assessments (Raymond Chan and Associates, 1997). This report was developed by Raymond Chan and Associates (RCA) to serve as a guide for the performance of individual watershed studies. The report helped document and standardize the procedures to be used to assess and describe watershed conditions, the types of data to be collected and the subsequent evaluations to be performed

The goal of each watershed erosion assessment was to characterize general creek conditions, identify current erosion problems along the major creek system and to garner a better understanding of where future problems may occur. An inventory of problem sites was produced identifying locations along the creeks where erosion posed an existing or future threat to property, stream stability, water quality, utilities and drainage infrastructure. The field investigations addressed main branches of creeks and tributaries up to a contributing drainage area of 640 acres (one square mile). This resulted in an inventory of over 170 miles of stream channels. Numerous photographs and stream cross-section measurements were taken, generating a photographic log that will serve as a stream benchmark – allowing future comparisons to be made with 1997 stream conditions. To facilitate the master planning process, the RCA project team also prioritized problem areas using the problem score concept (see Section 3) and offered erosion management recommendations. The following text provides more detail on key components of the erosion assessment studies.

Source: City of Austin

6.2.1 Erosion Problem Identification

During the field surveys, existing erosion problems were noted where physical structures or other community resources were threatened or had the potential to be threatened in the future. Structures of interest included houses, buildings, parking lots, bridges, retaining walls, trees, utility poles and utilities crossing the creek, and fences. Field teams also noted areas where a significant loss of land may occur as a result of a bank failure or where steep creek banks within park areas posed a safety threat to the public.

When an erosion problem was encountered, a priority was assigned to each site as shown in Table 6 – 1:

Table 6 – 1
Erosion Problem Priority

Priority	Description
Type 1	House, building, or road currently threatened by channel bank erosion
Type 2	Other resources (walls, fences, trees, trails, utility lines, yards, recreational amenities) currently threatened by channel bank erosion.
Type 3	Resources not currently threatened by may be threatened in the future.

Type 1 Erosion Example

Source: Raymond Chan & Associates, 1997.

In the Phase I watersheds, approximately 975 erosion problems were identified. Thirteen (less than 2% of the problems) were Type 1 problems. The remaining problem sites were split almost evenly between Type 2 and Type 3 problems. Walnut Creek had the most erosion problems identified of all the studied watersheds. Table 6 – 2 shows the distribution of the identified erosion problems. Note that this table does not reflect erosion problems that have been corrected by ongoing City work completed since the original study.

The resulting inventory of the number and types of erosion problems identified during each stream investigation is used later to help prioritize erosion problem areas (see Section 6.5, Calculating Problem Scores).

Table 6 – 2

Erosion Problem Site Summary

Watershed	Number of Sites Identified				
	Type 1	Type 2	Type 3	Total	# of Problem Sites/ Mile of Reach
Barton	0	18	6	24	1
Blunn	0	11	8	19	8
Boggy	1	24	30	55	8
Bull	1	15	36	52	3
Buttermilk	0	22	16	38	16
Country Club	1	17	16	34	7
East Bouldin	1	27	27	55	17
Fort	1	27	26	54	9
Harper's Branch	0	8	5	13	15
Johnson	0	18	11	29	9
Little Walnut	1	23	21	45	4
Shoal	1	29	59	89	8
Tannehill	2	23	20	45	8
Waller	0	33	10	43	6
Walnut	2	125	98	225	5
West Bouldin	2	7	18	27	9
Williamson	0	62	66	128	5
Total	13	489	473	975	6

Source: Raymond Chan & Associates, 1997.

6.2.2 Stream Reach Classification System

A stream reach classification system was developed and applied to classify "geomorphically similar" or "like" reaches. In simple terms, field investigation crews determined where continuous lengths of creeks demonstrated similar channel characteristics based on channel type. Channel types are categorized in Table 6 – 3.

Table 6 – 3

Stream Reach Classifications

Channel Type	Typical Channel Description	Relative Susceptibility to Erosion
Alluvial	Formed in alluvium (loose gravel, sand or silt) or unconsolidated overburden deposits - susceptible to scour.	High
Rock Bed	Channel is worn into massive bedrock materials or well armored with scour resistant materials. One or both banks are formed in alluvial or unconsolidated soils - susceptible to erosion.	Moderate
Rock Controlled	Channels are commonly formed in bedrock materials with the banks being relatively resistant to erosion scour.	Low
Structurally Controlled	Channel has been modified and armored with concrete rip rap, rock gabions, stone, etc.	Varies

Source: Raymond Chan & Associates, 1997.

6.2.3 Stream Stability Ratings

After the identification of "like" reaches based on the channel types listed above, field teams completed a rapid geomorphic assessment (RGA) of each reach to determine the relative stability of the creek channel system. By observing the presence of various physical features within a reach, field crews characterized channel stability based on visual evidence of ongoing erosional processes (widening, downcutting, degradation, aggradation). Reaches were then categorized into one of three stability classes:

Stability Class	Description
Stable	Little to no evidence of channel instability or enlargement. The stream channel is conveying water and sediment loads without substantial erosion or deposition.
In-Transition	Frequent evidence of instability leading to channel enlargement. Increased runoff is exceeding the ability of the natural channel to maintain its form.
In-Adjustment	Widespread evidence of channel instability and channel enlargement. Channel has been significantly destabilized and is attempting to adapt to large, rapid changes in the water and sediment loads delivered to the stream system.

Figure 6 – 1 shows an example of a channel stability map for Bull Creek watershed. Channel stability rating results for each of the Phase I watersheds are shown in Table 6 – 4. The majority of the stable channels are located in rock controlled or structurally controlled reaches. Barton Creek has the highest percentage of its like reaches (90%) in "stable" condition. Just over half of the reaches are considered to be "in transition", demonstrating the effects of urbanization on stream channels. Little Walnut Creek has the highest percentage of its like reaches (nearly 94%) "in transition".

Nearly one-fourth of the identified creek reaches were determined to be in adjustment, demonstrating significant evidence of channel instability and enlargement. It is not surprising that many of the reaches that are in adjustment are located in alluvial channels where the upstream contributing drainage area has experienced significant urbanization.

The stability rating summarizes channel stability features to indicate the current condition of the channel and the past erosion features observed in the field. The stability rating is also used to determine the expected processes that may cause or accelerate channel enlargement in the future.

6.2.4 Channel Enlargement Estimates

A major accomplishment of the RCA project team was the development and application of a procedure to estimate historic and predicted future channel enlargement in Austin creeks as a function of watershed impervious cover. Determining the enlargement potential for each like reach provides an estimate of the expected channel enlargement, corresponding sediment load to the creek and the identification of erosion hazard areas. Channel enlargement occurs primarily through ***downcutting*** (the channel bottom is progressively washed away) and ***widening*** (the channel side slopes are progressively washed away). The primary cause of stream channel erosion is increased storm water runoff. Simply stated, as runoff volumes increase due to urbanization, the channel's resistance to erosion is surpassed. The rate at which erosion is accelerated is dependent on the channel type (e.g., alluvial channels tend to erode faster than rock channels).

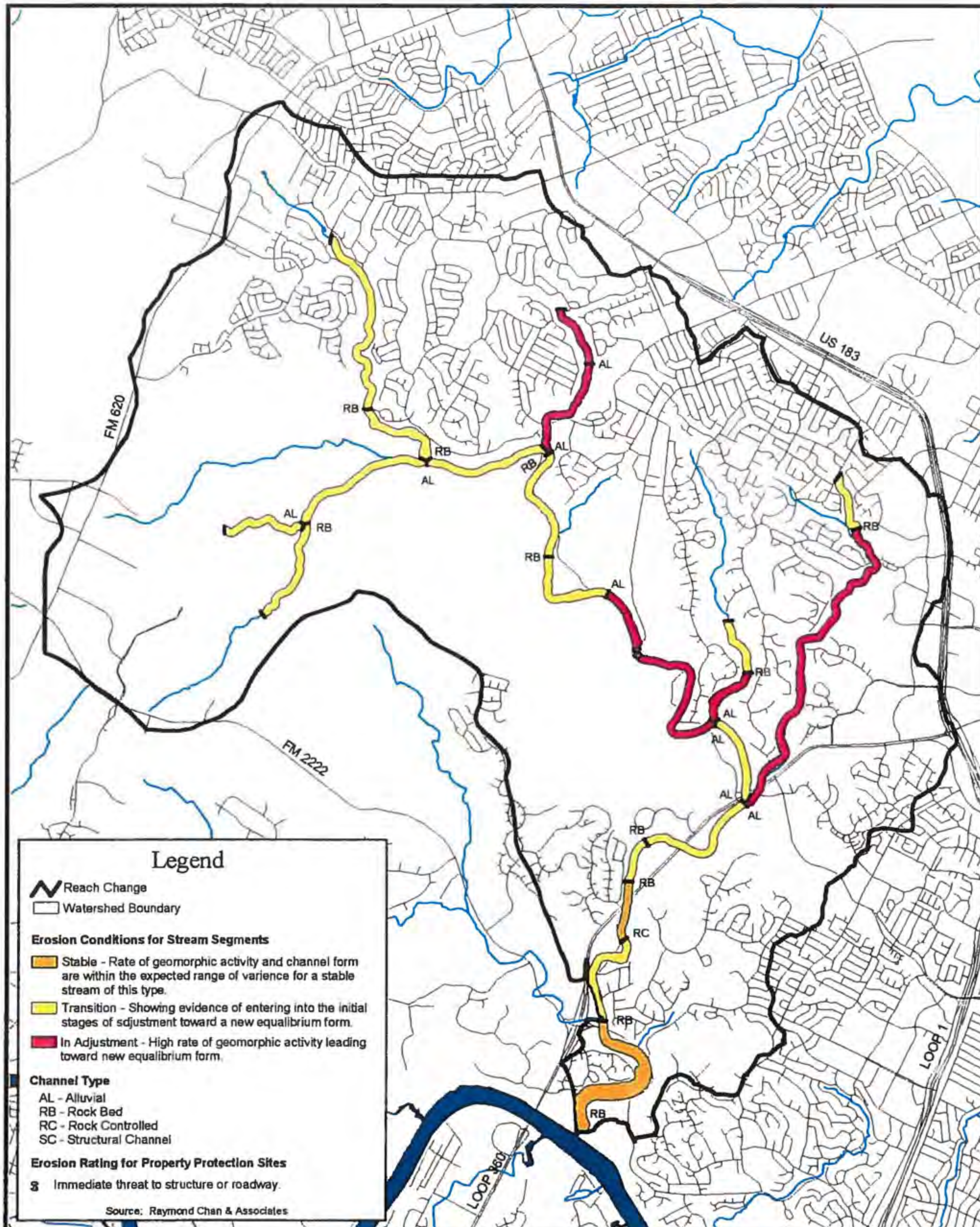


Figure 6 - 1
Bull Creek Watershed Erosion Assessment

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Source: Chan 1997

Table 6 – 4

Channel Stability Ratings by Watershed

Watershed	Channel Stability Rating Frequency		
	Stable	Transition	In Adjustment
Barton	9	1	0
Blunn	0	2	3
Boggy	1	3	3
Bull	2	14	5
Buttermilk	0	4	1
Country Club	1	1	6
E Bouldin	1	3	0
Fort	1	4	5
Harper's	4	2	0
Johnson	6	4	1
Little Walnut	0	15	1
Shoal	3	10	5
Tannehill	2	5	1
Waller	4	6	2
Walnut	6	21	7
W Bouldin	1	2	2
Williamson	4	8	7
Total	45	105	49

*Figures represent number of creek segments in each stability class by watershed.

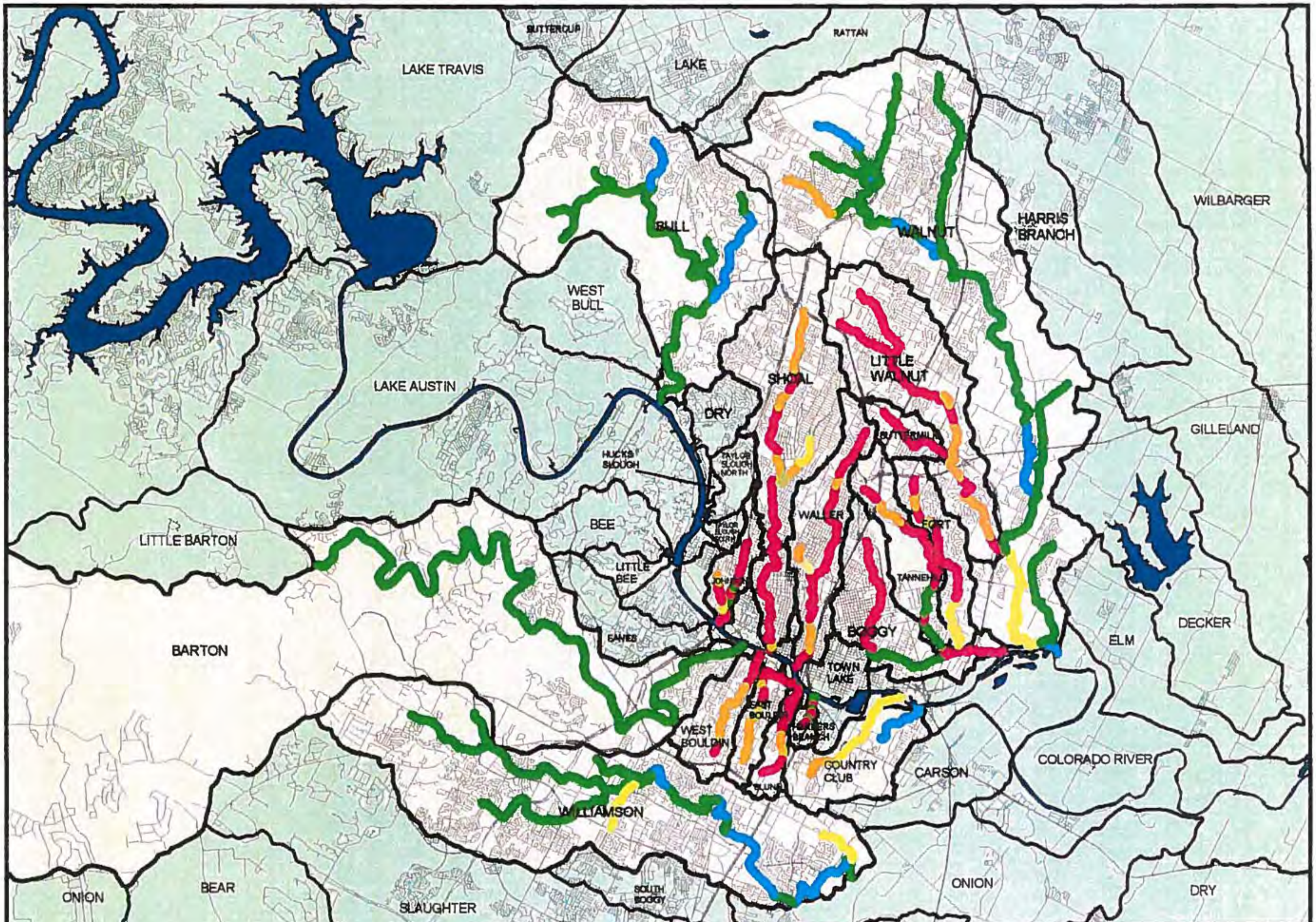
Source: Raymond Chan & Associates, May - Oct. 1997.

To predict channel enlargement, "channel enlargement curves" were developed that relate increases in channel size (as a ratio of future size to existing size) to increases in impervious cover for three channel types – alluvial, rock bed, and rock-controlled. An empirical approach was applied based on the development and calibration of channel enlargement curves using local creek data. These methods are patterned after similar studies across the United States (Morisawa and Laflure, 1979, Allen and Narramore, 1985, MacRae et al., 1994) that use changes in impervious cover within a watershed as an indicator to reflect changes in stream erosion potential. The mechanics of the approach are described in detail in Technical Procedures for the Watershed Erosion Assessments (RCA, 1997).

A detailed study of 60 sites was used to develop the enlargement curves. Estimates of current and future (year 2040) impervious cover used in this analysis were developed on a watershed basis (CRWR, 1997). Based on a follow-up analysis on the Walnut Creek Watershed (RCA, January 1999), initial estimates of predicted future channel enlargement were modified to reflect the beneficial effect of sedimentation-filtration ponds anticipated to be constructed for new development. The City's Land Development Code requires structural water quality controls of all new development. The runoff volumes detained in these structures help reduce instream stormflow volumes, thereby reducing future enlargement potentials. Sedimentation-filtration ponds projected for constructed in the Walnut Creek watershed are predicted to reduce future enlargement potentials by 40 – 60% of the original estimates.

Estimates of past and predicted future channel enlargement for the Phase I watersheds are illustrated in Figures 6 – 2 and 6 – 3 respectively. From Figure 6 – 2, it is clearly evident that the most significant channel enlargements have occurred in the urban watersheds. Channel enlargements of over ten times historic conditions were documented for some Austin creeks. The majority of the creek reaches in the urban watersheds have more than doubled in channel size due to significantly higher stormflows generated by urban development practices. The Little Walnut Creek example given in Section 6.1 is representative of the past channel expansion experienced in the urban watersheds.

Urban development increases the frequency of bankfull flows over the course of an average year. This effectively increases the erosion potential for the stream system. This phenomenon is reflected in the high number of Type 1 and 2 erosion problems identified in the most heavily urbanized watersheds as shown in Table 6 – 2.



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Past Channel Expansion

0 2 4 6 8 10 Miles

N

Percent increase in Channel Area
- Very Low (0%)
- Low (0-40%)
- Medium (40-120%)
- High (120-300%)
- Very High (300 or more)
- Streets
- Austin Area Watersheds
- Phase 1 Watersheds
- Lakes and Rivers

Source: Chan 1997, COA 1999

Figure 6 - 2

One of the most significant findings of this Master Plan is shown in Figure 6 – 3. Based on predicted development levels and resulting increases in impervious cover, substantial increases in channel area are predicted for many of the suburban watersheds (especially Walnut Creek). The predicted channel enlargements take into account the benefits expected from sedimentation-filtration basins constructed for new development as discussed earlier for only the Nonurban watersheds (Barton, Bull, Country Club, Walnut and Williamson Creek watersheds). These benefits were not applied to the Urban watersheds due to the fact that the majority of the Urban watersheds are already developed.

From the future channel enlargement data shown in Figure 6 – 3, the following creeks and tributaries are of most concern:

Creek/Tributary	Predicted Channel Enlargement (rounded)
Walnut Creek (all)	40 - 380%
Lower Fort Branch	10 - 110%
Country Club Creek (all)	40 - 130%
Tributaries 2 and 4 of Bull Creek	30 - 60%
St. Elmo Tributary of Williamson Creek	230%

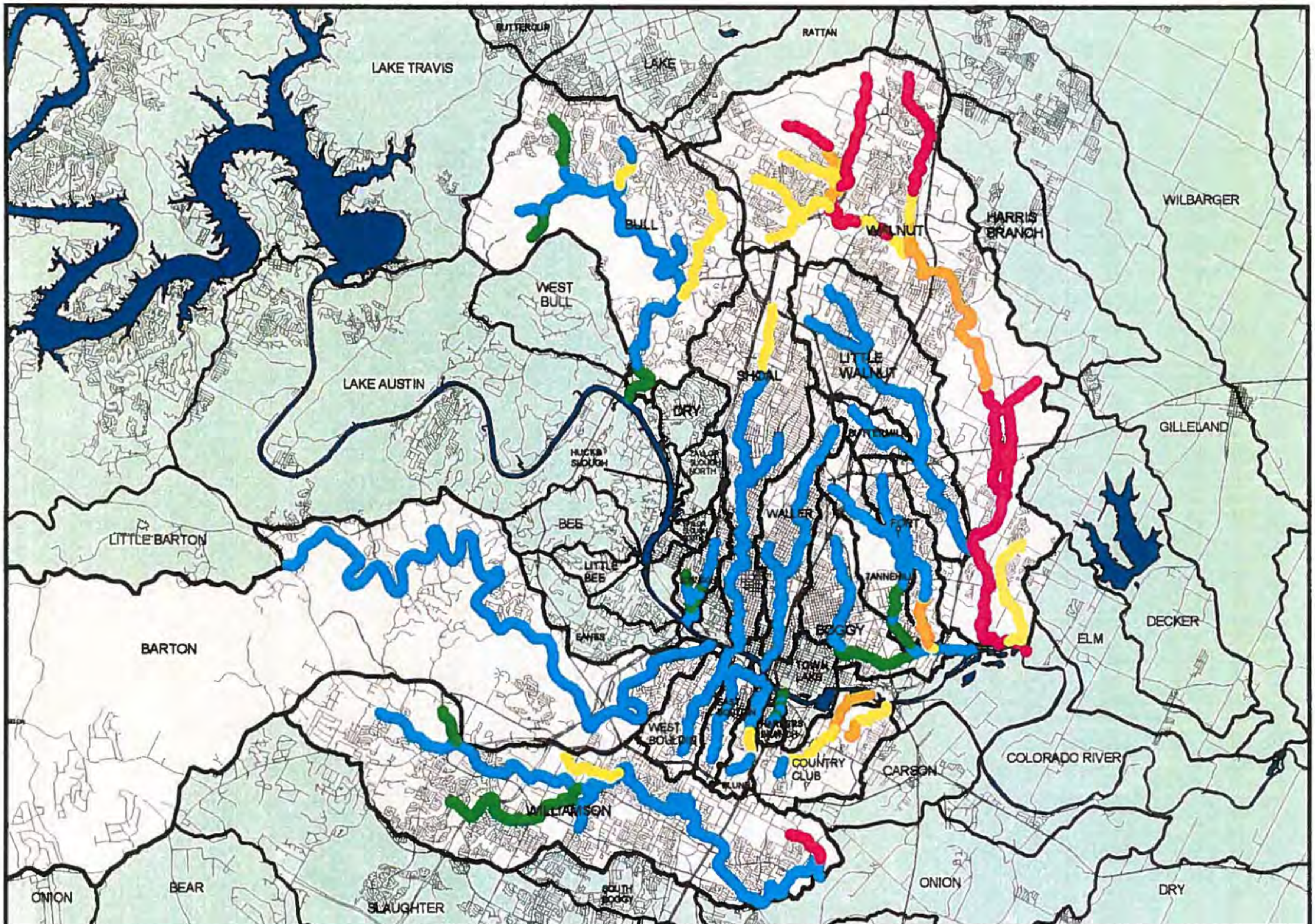
Source: Chan, 1997

In many cases, high levels of predicted channel enlargement are found in areas where:

1) creeks and tributary channels are composed of alluvial materials, and
2) their contributing watershed areas are expected to experience substantial increases urban development.

It should be noted though that future predicted increases in channel area are not solely a response to future development in the watershed. Erosion occurs over a period of many years (over 50 years for example). Much of the predicted future channel erosion is a delayed response to increases in stormflows from existing development.

As a result of this analysis, WPD is currently developing detailed erosion management strategies for the Walnut Creek watershed. Additional erosion studies are also planned



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Predicted Future Channel Expansion

0 2 4 6 8 10 Miles

N

Percent Increase in Channel Area

- Very Low (0%)
- Low (0-40%)
- Medium (40-100%)
- High (100-160%)
- Very High (160+)
- Streets
- Lakes and Rivers
- Phase 1 Watersheds
- Austin Area Watersheds

Figure 6 - 3

Source: Chan 1997, COA 1999

for the Bull Creek watershed as a supplement to the Water Supply Suburban Watersheds Report (WPD, 1999) presented to the Austin City Council in December 1999.

6.3 Resource Values

Stream Erosion affects several types of community resources. As discussed in Section 3.2, the prioritization methods used for each WPD mission rely, in part, on the assignment of "values" to each community resource threatened by erosion, flooding and water quality degradation. During the stream field inventory, all existing and potential erosion threats to property were documented. With input from the Citizens Advisory Group, erosion control resource values were assigned to each identified resource as shown in Table 6 – 5, based on the following categories:

Table 6 – 5
Erosion Control Resource Values

Resource Type	Resource Value
Major Road	100
House/Building	90
Minor Road	75
Priority Woodland (public)	60
Public Recreational Amenity*	50
Public Parkland > = 500 ft	50
Fixed Storage Building	50
Retaining Wall	45
Protected Tree	45
Pipeline	45
Public Parkland < 500 ft	40
Priority Woodland (private)	35
Yard (major loss)	35
Fence	30

*Includes swimming pools, tennis courts, playscapes, hike-n-bike trails, and other tangible assets
Source: COA, 1997

The resource values shown above are used in the development of problem area scores as discussed later in Section 6.5.

6.4 Problem Severity

A problem severity scoring system was developed and applied for each threatened resource and stream reach. Erosion severity (ES) scores were calculated for each threatened resource site based on its priority rating - Type 1, 2 or 3. Type 2 and Type 3 problem sites were further broken down by land use (park/woodland resource versus non-park/woodland resource). A separate ES score was also calculated for each reach that reflects future reach stability (FRS) concerns. Scores were calculated for both current and future conditions.

Erosion severity scores for each priority category are based on the factors shown in Table 6 – 6. The scoring system incorporated much of the data collected during the creek field inventories that described watershed development conditions and the geomorphic characteristics of the stream.

As shown in Table 6 – 6, Type 1 problem severity scores were based on geotechnical, imminent threat, site geomorphology, and reach stability factors. Geotechnical factors include vegetative coverage, bank soils strength, substrate type, bank height, and bank slope. Imminent threat factors consider the distance from the creekbank to the foundation of a threatened structure and indications of structure stability/foundation integrity. For the remaining problem sites (Type 2, 3, and FRS), erosion severity scores are reflective of channel characteristics and bank stability factors.

Table 6 – 6

Erosion Problem Severity Factors

Category	Weights		Scoring Factors (weights)	
	Current	Future	Current Conditions	Future Conditions
Type 1	75	25	Geotechnical (20%) Imminent Threat (50%) Site Geomorphology (10%) Current Reach Stability (20%)	Future Reach Stability (100%)
Type 2	75	25	For Park and Woodland Resources: Magnitude of Loss (20%) Excessive Meanders (10%) Bend Location (20%) Current Reach Stability (50%) For Non-Park/Woodland Resources: Site Geomorphology (50%) Reach Stability (50%)	Future Reach Stability (100%)
Type 3	0	100		For Park and Woodland Resources: Excessive Meanders (30%) Bend Location (15%) Future Reach Stability (55%) For Non-Park/Woodland Resources: Site Geomorphology (50%) Future Reach Stability (50%)
Future Reach Stability	0	100		Future Reach Stability (100%)

Source: Raymond Chan & Associates, 1997.

Future problem severity scores were based primarily on the future reach stability analysis. This comprehensive analysis considered a variety of factors that could affect the potential for change in the shape and size of the reach channel. Future reach stability is important because it helps predict which structures on or near stream banks might be threatened by erosion. A critical component of this analysis is the prediction of channel enlargement described in Section 6.2. Other factors considered in the future stability analysis include: current reach stability (whether it is stable, in-transition, or in-adjustment), potential increases in small stormflows from development, how much the creek meanders, how many "knickpoints" (abrupt changes in the creek's longitudinal profile) are present, and how much sediment is expected to be generated by stream bank erosion.

6.5 Calculating Problem Scores

Following the problem score concept described in Section 3.2, an erosion problem score is calculated for each stream reach along the major drainage system of each watershed. Each reach score was calculated as a composite of: 1) the problem scores associated with each Type 1, 2 and 3 problem site located within the reach, and 2) the particular reach's future stability score.

6.5.1 Type 1, 2, 3 and FRS Problem Scores

As described in Section 3.2, the general concept for calculating problem scores is represented by:

Problem Score = *f* (# of resources located in the creek reach, their resource value and the severity of the watershed problem at each resource)

Before a composite reach score is calculated, an individual problem score is calculated for the Type 1, 2, 3 and FRS problem categories. A problem score for each Type 1, 2 and 3 site is computed using the resource value for the threatened structure from Table 6 – 5 and the erosion problem severity (ES) score referenced in Section 6.4. For calculating erosion control problem scores, the function listed above is generally applied by the following equation:

$$EC_{\text{Type 1, 2, 3}} = \sum_{i=1}^{n} (RV*ES_{\text{Type 1, 2, 3}})_i$$

For Type 1 and 2 sites, erosion problem severity scores are calculated for both existing and future conditions. Therefore, a composite score is calculated by weighting the scores as shown in Table 6 – 6. By definition, Type 3 problems sites reflect those resources that may be threatened in the future. Therefore, Type 3 and future reach stability scores are characterized by a single score representative of future conditions.

6.5.2 Reach Problem Scores

Composite reach erosion scores were computed using the following formula:

$$EC = (W_1 * EC_{\text{Type 1}}) + (W_2 * EC_{\text{Type 2}}) + (W_3 * EC_{\text{Type 3}}) + (W_4 * EC_{\text{Future Stability}})$$

Where:

EC	= Erosion problem score
$W_{1,2,3,4}$	= Weighting factors (from Table 6-6)
$EC_{\text{Type 1}}$	= Erosion score for Type 1 problems
$EC_{\text{Type 2}}$	= Erosion score for Type 2 problems
$EC_{\text{Type 3}}$	= Erosion score for Type 3 problems
$EC_{\text{Future Stability}}$	= Erosion score for future reach stability

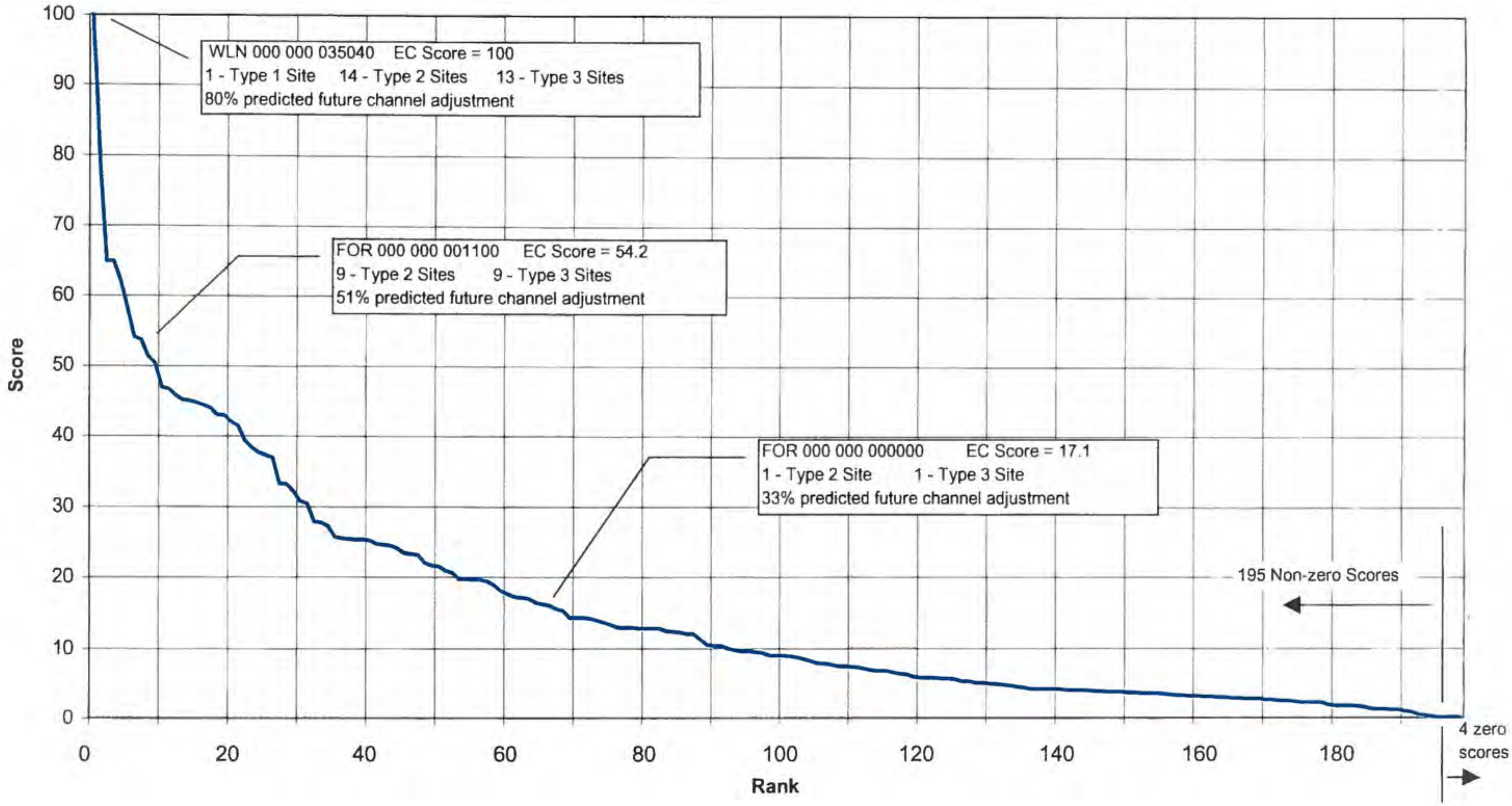
6.6 Results

An erosion problem score was calculated for each of the 199 like reaches identified in the stream assessments. The resulting scores (Table B – 2, found in Appendix B) were used to identify relative erosion concerns along the primary drainage systems of the Phase I watersheds. Figure 6 – 4 presents the distribution of erosion control scores.

Problem Score	Narrative Rating
0-10	Very Low
10-20	Low
20-30	Moderate
30-40	High
40-100	Very High

Based on average erosion control scores for a given watershed, the Walnut Creek watershed demonstrates the highest erosion control problems. Figure 6 – 5 depicts the

Figure 6 - 4
Erosion Control Problem Score Distribution



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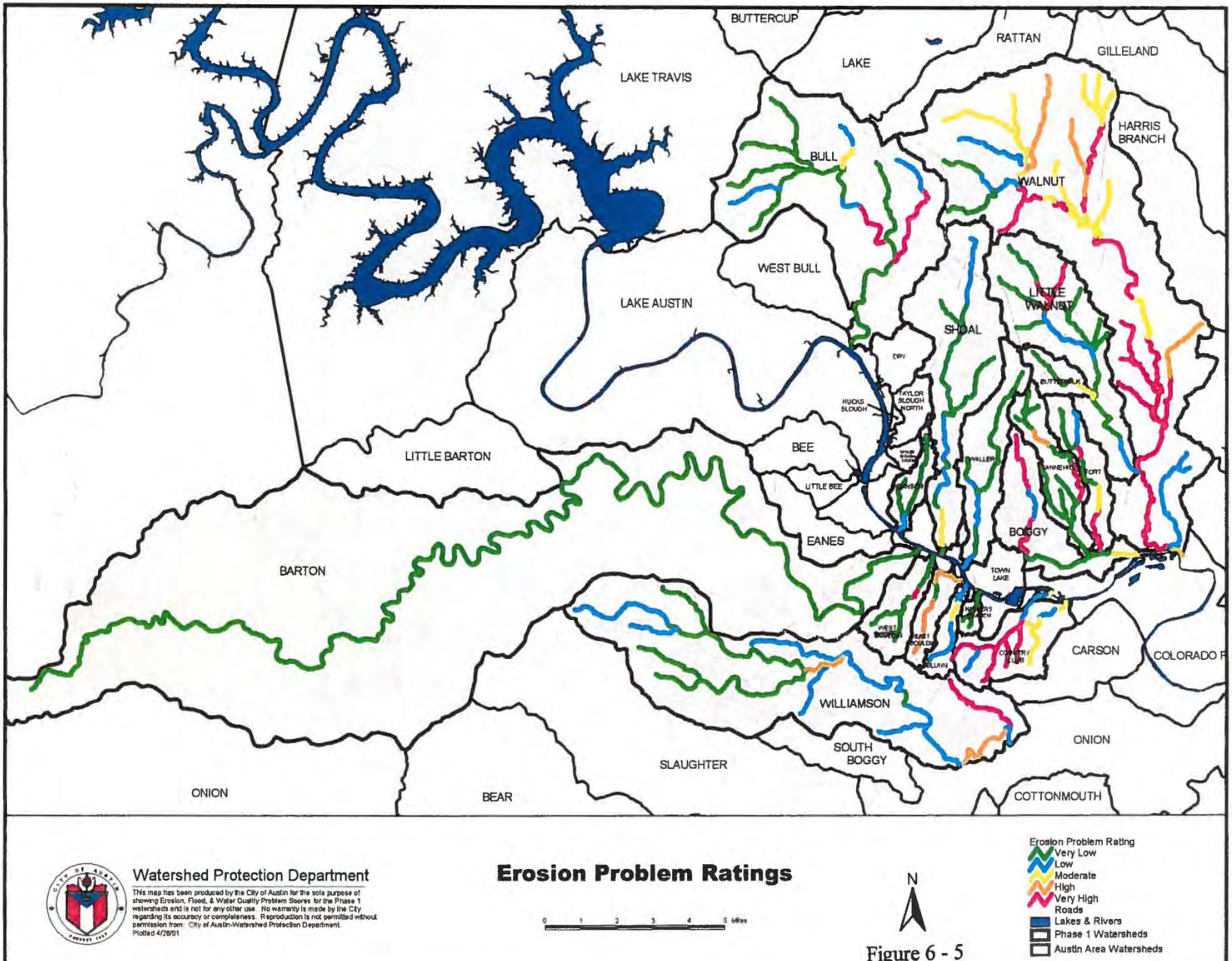

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Plotted 4/26/01

Erosion Problem Ratings

Figure 6 - 5

results of the problem area prioritization for creek erosion. This watershed's average erosion score is 33.8, and it includes 6 of the top 10 highest erosion problem scores. All six of these reaches were rated Very High problem areas. Walnut Creek includes the four top erosion problem scores of 100, 78.8 65, and 65. These reaches in Walnut Creek are in the vicinity of Springdale Rd., Wells Branch upstream of Walnut Creek Park Rd., Walnut Creek from the confluence with Tributary 1 to the confluence with Little Walnut Creek, and Walnut Creek from the confluence with Little Walnut Creek to the confluence with Tributary 3, respectively. The two top problem score reaches include Type 1 erosion problems. Walnut Creek near Springdale Rd. has a threatened minor road (resource value of 75) and the Wells Branch reach has a threatened house (resource value of 90). Walnut Creek near Springdale Rd. has 14 Type 2 problems (mostly trees with a resource value of 45) and 13 Type 3 problems (again, mostly trees). Wells Branch upstream of Walnut Creek Park Rd. has 4 Type 2 problems (trees and a wall, all with resource values of 45) and 3 Type 3 problems (two trees and a fence with a resource value of 30). The next two highest erosion problem scores of 65 (both in Walnut Creek) do not have any Type 1 erosion problems. The jump down in score emphasizes the priority in addressing Type 1 problems. Walnut Creek from the Confluence with Tributary 1 to the confluence with Little Walnut Creek has 19 Type 2 problems (all trees) and 2 Type 3 problems (one major road with a resource value of 100 and one minor road with a resource value of 75). Walnut Creek from the confluence with Little Walnut Creek to the confluence with Tributary 3 has 11 Type 2 problems (trees, pipelines, and a utility all with resource values of 45) and 8 Type 3 problems (all trees). Erosion problem scores depicting current conditions only are shown in Appendix B. Watershed summaries for each of the Phase I watersheds are also provided in Appendix A. These summaries discuss both current and overall problem score results for each watershed.

Country Club Creek is the next most vulnerable watershed with an average score of 27.05. Country Club's top problem area, from Elmont Dr. to Oltorf St., has an erosion problem score of 51.4, one Type 1 problem (a threatened bridge with a resource value of 100) and one Type 2 problem (a pipeline with a resource value of 45). Five of its eight reaches had scores above 20, indicating Moderate or more severe problem areas.

Other high scoring reaches are found in Tannehill Branch, from just north of MLK Blvd. to Old Manor Rd.; Fort Branch, between Webberville Rd. and the Austin-Northwestern railroad tracks; and the St. Elmo Branch of Williamson Creek. The Tannehill reach has 1 Type 1 problem (a threatened bridge, resource value of 90); 7 type 2 problems (trees, a pipeline and a wall); and 8 Type 3 Problems (tree/wall/pipeline, a pedestrian bridge with a resource value of 50, and a building with a resource value of 90). The Fort Branch reach has no Type 1 problems; 9 Type 2 problems (trees, fences, and a yard with a resource value of 35); and 9 type 3 problems (trees, houses, a building, and a minor road). The St. Elmo Branch has 4 Type 2 problems (trees and a yard); and 2 Type 3 problems (trees).

Barton Creek appears to be the least troubled of the Phase I watersheds. This watershed has a very low average score of 2.9. The entire watershed has no Type 1 problems; 12 Type 2 problems (trees, pipelines, and a wall); and 6 Type 3 problems (3 dams with a resource value of 50, one recreational amenity with a resource value of 50, a minor road, and a pipeline). Of the 199 erosion reaches, only 4 have an erosion control score of zero, indicating no erosion problem sites. Two of these reaches were located in the Harper's Branch watershed and two more are in the Johnson Creek watershed. The top ten erosion control problem reaches listed alphabetically are as follows:

Reach	**Rating**	**Location**
CNT000000007090	Very High	Elmont Dr. to Oltorf St.
FOR000000001100	Very High	Between Webberville Rd. and MKT railroad tracks
TAN000000010775	Very High	Martin Luther King Blvd. to Old Manor Rd.
WLN000000004440	Very High	Confluence with Tributary 1 (near the mouth) to confluence with Little Walnut Creek
WLN000000025120	Very High	Confluence with Little Walnut Creek to confluence with Tributary 3 (in Walnut Creek Nature Preserve)
WLN000000035040	Very High	Confluence with Tributary 3 to Springdale Rd.
WLN000000049700	Very High	From Springdale Rd. to Sprinkle Rd.
WLN000000090720	Very High	From Metric Blvd. to upstream of Hwy 183
WLNWEL000003240	Very High	Well's Branch upstream of Walnut Creek Park Rd.
WMSSTE000000000	Very High	St. Elmo Branch of Williamson Creek

Section 7

Water Quality Assessment

To compare the relative magnitude of water quality problems in the Phase I watersheds, a problem area point scoring system was developed. The scoring system was developed by ERM staff, with significant guidance provided by two EPA documents, Urban Targeting and BMP Selection: An Information and Guidance Manual for State NPS Program Staff Engineers and Managers (US EPA, 1990) and Geographic Targeting: Selected State Examples (US EPA Office of Water, EPA-841-B-93-001, February, 1993). Like the point systems for flood control and erosion control, the scoring system ranges from 0 to 100 (with higher scores indicating the more severe water quality problems) and is based on problem severity and the resource value of the receiving waters. Receiving waters include Lake Austin, upper and lower segments of Town Lake, Colorado River below Town Lake, Southern Edwards Aquifer, Barton Springs Pool, Barton Creek, Bull Creek above Loop 360, McKinney Falls, and individual creek segments within the watersheds. The individual creek segments are referred to as Environmental Integrity Index (EII) reaches, which are discussed below. The other receiving waters were identified because they are either major water bodies or resources (i.e., Lake Austin, Colorado River, Town Lake, and Southern Edwards Aquifer) or because they support high quality designated uses, especially contact recreation (i.e., Barton Springs Pool, Barton Creek, Bull Creek above Loop 360, and McKinney Falls).

7.1 Environmental Integrity Index (EII) and EII Reaches

To consider water quality problems at a local level as well as at a larger scale, the creeks within each watershed were broken up in to segments known as Environmental Integrity Index (EII) reaches. This approach is similar to that used for the flood control and erosion control missions, where creeks were divided into segments. A total of 70 EII reaches were identified in the 17 Phase I watersheds.

The EII is a tool developed by the City of Austin's Environmental Resource Management Division to monitor and assess the ecological integrity and the degree of impairment o

Austin creeks (*Environmental Integrity Index Water Quality Technical Assessment Methodology*, City of Austin, Watershed Protection Department, August 1997). A primary motivation for developing the EII was to address the concern that water chemistry data alone does not adequately describe the health of water resources. By measuring a range of chemical, physical, and biological conditions, a more accurate assessment of stream health results.

To formulate the EII, the designated water uses specified in the Clean Water Act Section 303 [c](2)(A) that are applicable to Austin area creeks were identified and condensed into six protection categories. These categories are aquatic life protection, non-contact recreation, contact recreation, habitat quality, water quality, and sediment quality. Specific parameters under each of these categories were selected after careful review of other state and federal water quality monitoring and assessment protocols, and professional judgement. In particular, the US Environmental Protection Agency (USEPA) Rapid Bioassessment Protocols (Plafkin, et al. 1989) and the Texas Natural Resource Conservation Commission, (TNRCC) Use Attainability Assessment and Physical Characteristic Assessment (TNRCC, 1988) were useful references. However, some of the EII procedures are new or modified from existing state or federal protocols to better reflect Central Texas ecoregions and local conditions. The six major categories (sub-indices) are summarized in Table 7 – 1 and are as follows:

1. Contact recreation swimming and wading
2. Non-contact recreation and aesthetics
3. Water quality
4. Sediment quality
5. Physical integrity and channel stability
6. Aquatic life support

The EII score is calculated as the average of these six sub-indices, i.e., each sub-index is equally weighted. Typically sediment quality is sampled at only one site per watershed (the most downstream site) and the resulting score is assigned to all upstream reaches.

Table 7 – 1

Summary of EII Categorical Components

Contact Recreation Swimming/Wading	Non-Contact Recreation/Aesthetics	Water Quality	Sediment Quality	Physical Integrity & Channel Stability	Aquatic Life Support
Fecal Coliform	Surface Appearance Litter Odor Clarity Percent Algae Cover *Greenbelt/Buffer* *Trail/Access*	Fecal Coliform Total Suspended Solids Total Dissolved Solids Nitrate-Nitrogen Orthophosphorus Ammonia-Nitrogen	Metals PAHs Organochlorides, Pesticides, & PCBs *Grain Size* *Acid Volatile Sulfides* *Total Hardness*	Channel Alteration Sediment Deposition Embeddedness Channel Flow Status Condition of Banks Bank Vegetation Protection Disruptive Pressure Riparian Zone Width *Lateral Stability* *Vertical Stability* *Bed Material Size Distribution* Channel Stability	Macroinvertebrate Community Structure Diatom Community Structure Algae Percent Cover Chlorophylla Fish (presence/absence) *Instream Cover* *Channel Flow Status* *Embeddedness* *Frequency of Riffles* *Anaerobic Conditions* *Riparian Zone Width* *Riparian Vegetation Type*
				Landform Slope Mass Wasting Debris Jam Potential Entrenchment Ratio Bank Rock Content Cutting & Deposition Scouring Rock Angularity Brightness(Clean Rock) Attached Aquatic Vegetation Obstructions Consolidation Bank Vegetation Protection Percent Stable Material	

Note: Italicized Parameters are Not Used in Scoring EII

The EII reaches were delineated based on the locations of sampling sites for the water quality and aquatic life support sub-indices (see Figure 7 – 1). The location of these sampling sites were selected based primarily on (1) presence of riffles (necessary for aquatic life support sampling), (2) access to creek, and (3) approximately equal number of reaches per watershed. Some changes have been made to this criteria for future Master Plan assessments, primarily that the number or sites/reaches per watershed is now a function of watershed drainage area.

7.2 Resource Values

Resource values were determined for each receiving water, which are the EII reaches and the nine major receiving waters mentioned previously. Resource values are based on a 0 to 100 scale, with a score of 100 representing the highest possible resource value.

The resource values for the nine major receiving waters reflect the number and quality of designated uses (e.g., contact recreation swimming and aquatic life support) supported by the receiving water as well as the relative importance placed on the receiving water by the Citizens Advisory Group. The resource values for the nine major receiving waters are listed in Table 7 – 2.

Table 7 – 2

Resource Values for Receiving Waters

Receiving Water	Resource Value
Lake Austin	100
Upper Town Lake	85/35*
Lower Town Lake	35
Colorado River below Longhorn Dam (to E edge of Austin ETJ)	30
Southern Edwards Aquifer	95
Barton Springs Pool	45
Barton Creek (all)	35
Bull Creek above Loop 360 (EII 350)	30
McKinney Falls (east of BSZ)	30

** 85/35 represents Current/Future Resource Values for Upper Town Lake; future condition assumes Green Water Treatment Plant no longer in service.*

Current Condition of Austin Creeks as Measured by EII

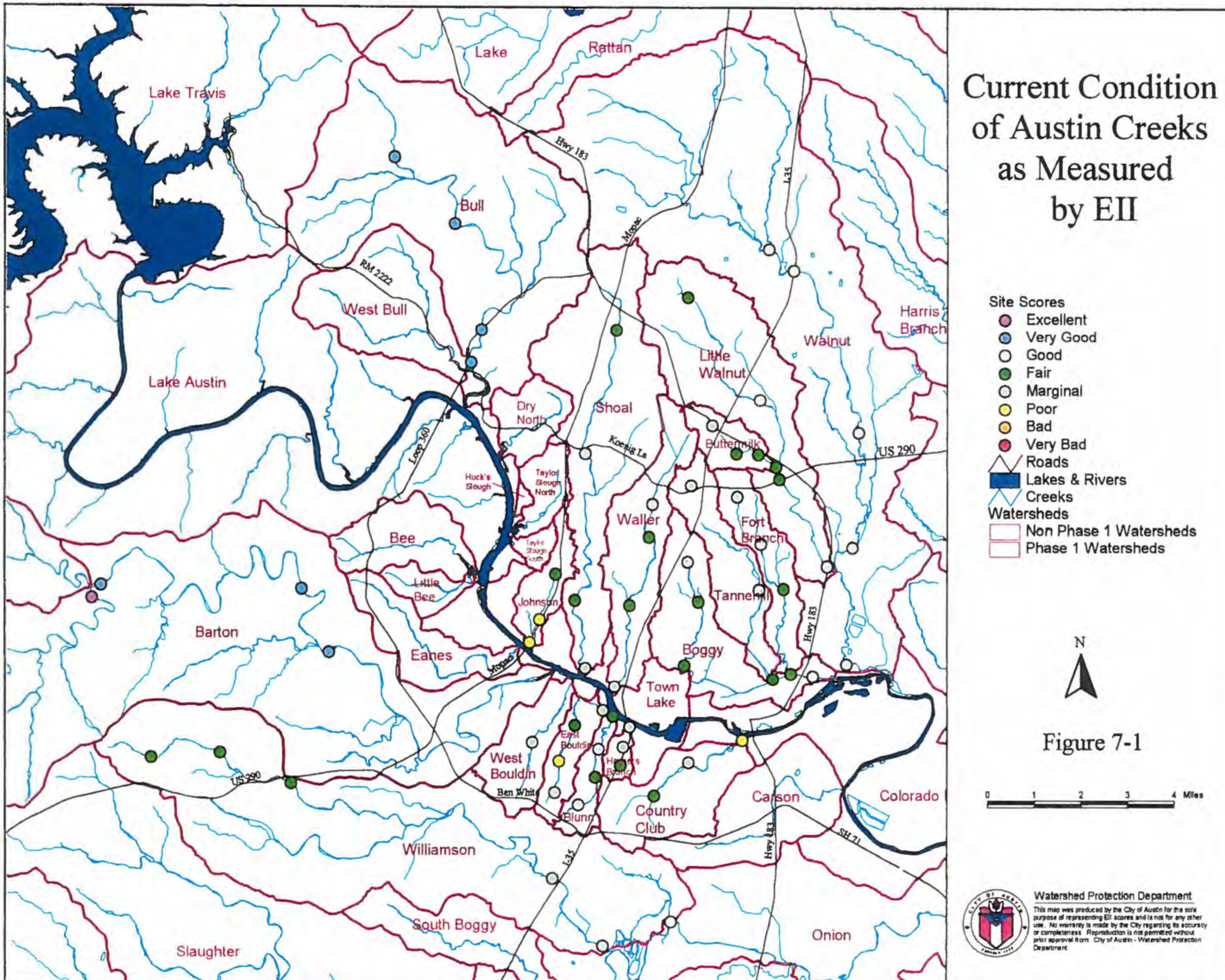


Figure 7-1

Resource values for the EII reaches were developed differently than those for the nine major receiving waters. For EII reaches, each EII score was categorized with a narrative rating based upon the ranges shown in Table 7 – 3. The current narrative rating determined the rating goal which in turn determined the resource value for the segment as described below and reflected in Table 7 – 3.

Table 7 – 3

EII Narrative Rating Score Ranges

Current Narrative Score	Current Numeric EII Score	Target Narrative Score*	Minimum Goal Score	Resource Value Score
Very Bad	0.0 – 12.5	Good	62.6	15
Bad	12.6 – 25.0	Good	62.6	15
Poor	25.1 – 37.5	Good	62.6	15
Marginal	37.6 – 50.0	Good	62.6	15
Fair	50.1 – 62.5	Good	62.6	15
Good	62.6 – 75.0	Very Good	75.1	20
Very Good	75.1 – 87.5	Excellent	87.6	25
Excellent	87.6 - 100	Excellent	87.6	25

*One level above current score with a minimum goal of "Good."

From these ratings, water quality objectives were established based on the following EII goals:

- If the current EII score is "Excellent", the goal is to maintain an "Excellent" score;
- If the current EII score is "Very Good", the minimum goal is to achieve a score of "Excellent";
- If the current EII score is "Good", the minimum goal is to achieve a score of "Very Good"; and,
- If the current EII score is less than "Good", the minimum goal is to achieve a score of "Good".

7.3 Problem Severity

Problem severity scores were developed for current and future conditions A "weighted factor" scoring system was used whereby either direct or surrogate measures of water quality conditions were assigned relative importance ("weights"), and the magnitude of problems calculated on a 0 to 100 point scale, with 100 being the most severe problem.

The current problem severity score for each EII reach is based on how far apart the current water quality condition (measured as an EII score) is from the desired water quality condition (the lowest EII score within the range for it's stated goal category; e.g.lowest numerical value that would achieve "Very Good"). The current problem severity score for each EII reach was computed in several steps. First the ratio of EII score to EII goal was calculated, e.g., if the EII Score = 52 (= "Fair") and the EII Goal = 62.6 (= "Good"), the ratio is 52/62.6 = 0.83. This value can be interpreted as the degree of EII goal achievement, e.g., the reach is achieving 83% of its EII goal. As it is necessary for problem severity scores to increase in ascending order, the EII score:EII goal ratio is subtracted from 1, e.g., 1 – 0.83 = 0.17. The higher this value, the further the EII reach is from achieving its EII goal, and the worse the problem severity. Finally, the scores are converted to a 100 point scale by setting the worst individual reach to a score of 100, e.g., if the worst reach has a 1-EII score:EII goal value of 0.52, then a Problem Severity Score for the example reach would be 100 * (0.17/0.52) = 32.7.

Current problem severity scores for each of the nine major receiving waters were developed based upon available information. The type of data information for each varied considerably, as did water quality goals, thus the data and procedures used to calculate problem severity scores varied with receiving water. As an example of the difference between goals, a "non-degradation" goal exists for the Southern Edwards Aquifer while the primary goal for the Colorado River below Longhorn Dam is the less restrictive "maintain existing designated uses." For Town Lake (upper and lower), Southern Edwards Aquifer, and Barton Springs Pool, recent studies and models from the City and CRWR were available for characterizing and predicting water quality and hydrologic conditions. For Lake Austin and the Colorado River below Longhorn Dam, assessment reports produced by TNRCC and monitoring data from the USGS were primary sources of information. For the three "contact recreation" receiving waters, i.e., Barton Creek, Bull Creek, and McKinney Falls, the EII data for creek reaches located within these was used to assess current conditions. Other factors selectively used included the City's spills database, the Visual Index of Pollution (Town Lake only), and analysis of monitoring data by ERM staff. Table 7 – 4 summarizes the factors used to calculate current problem severity scores for the nine major receiving waters. For each factor, a weight was assigned to represent a relative importance, and a problem severity score calculated based on either a numerical goal (e.g., "maintain existing pollutant loads") or as a normalized value (e.g., worst Spills Risk score assigned value of 100, with all others normalized against that score).

Table 7 – 4

Problem Severity Scoring Factors for Current Conditions for the

Nine Major Receiving Waters

Receiving Water	EII Scores	Pollutant Loads	1996 State 303(d) Priority Rating	1996 State 305 (b) Support Status	Spills Risk Index	ERM analysis of monitoring data	Visual Index of Pollution	Recharge Volume
Lake Austin			X	X	X	X		
Town Lake (Upper and Lower)		X			X		X	
Colorado River below Longhorn Dam			X	X	X	X		
Southern Edwards Aquifer		X			X			X
Barton Springs Pool		X			X			X
Barton Creek (all)	X							
Bull Creek above Loop 360	X							
McKinney Falls	X							

Future problem severity scores for the EII reaches and nine major receiving waters were calculated using a combination of factors, some of which were based on the *difference* between the current and projected future conditions, and others on the projected future condition alone (where current conditions scores were limited or not available, e.g., current construction loads). As an example of the case where the score is based on the difference between current and future conditions, the water quality in an urban EII reach may not be meeting the water quality goal (i.e., it has a low EII score). However, the watershed may be almost fully developed, so future changes in the pollutant loads and baseflow quantity are projected to be small. In this case, the EII reach would have a high current problem severity score and a low future problem severity score. Like the current problem severity scores, future problem severity scores are calculated differently for each of the nine major receiving waters and the EII reaches due to differing water quality goals and availability of models, studies and data.

The future problem severity scores for EII reaches were based on the change on seven scoring factors that may affect the six categories relating to water quality listed in Section 7.1. The seven scoring factors are shown below. Each factor was assigned a "weight" by ERM staff to reflect an assumed relative importance; with the sum of all weights = 1. Table 7 – 5 summarizes this information.

Table 7 – 5

Future Problem Severity Scoring Factors and Weights for EII Reaches

Scoring Factor	Weight
Change in TSS Loads	0.10
Change in Nutrient Loads (TN, TP, TOC)	0.10
Change in Toxic Loads (Cu, Pb, An, TOC, COD)	0.20
Construction Loads	0.10
Spills Risk	0.10
Change in Baseflow quantity	0.20
Reach stability/physical integrity	0.20

The use of these "surrogate" indicators was necessary because no numerical procedure was available for predicting EII scores. Post-assessment investigations conducted by ERM indicate that the selected indicators are appropriate, as statistically significant correlations have been found to exist between them and the EII sub-indices. The TSS load, nutrient load, toxic load, construction load, and baseflow quantity estimates were calculated using the GIS-based model developed jointly by ERM staff and the University of Texas Center for Research in Water Resources (CRWR). The reach stability/physical integrity score was estimated for the EII reaches using the Future Reach Stability scores from the Watershed Erosion Assessments.

The future problem severity scoring factors for the nine major receiving waters varied based on the goals of the receiving water and /or the availability of information. For all except the Colorado River below Longhorn Dam, the CRWR model was used to estimate future loads (including construction loads) and/or baseflow quantities. These estimates had to be extrapolated from the model for Lake Austin, and are only approximations. For the Colorado River below Longhorn Dam, future land and impervious cover could be estimated, and the latter was used as a surrogate indicator of future changes. Recognizing the limitations of modeled predictions for Lake Austin and the Colorado River below Longhorn Dam, trend analysis of monitoring data was added as a scoring factor. Spills risk scores were also projected, as a function of impervious cover, for all nine receiving waters. For the Southern Edwards Aquifer and Barton Springs Pool, the CRWR model was used in conjunction with the 1995 Santos and Loomis Barton Springs Zone Retrofit Master Plan Study and the CRWR "Parsimonious" model to predict future changes in pollutant loads and recharge volumes. Table 7 – 6 summarizes the factors used to calculate future problem severity scores for the nine major receiving waters. As with the current problem severity scoring system, a weight was assigned to each factor to represent its relative importance, and a problem severity score calculated based on either a numerical goal (e.g., "maintain existing pollutant loads") or as a normalized value (e.g., worst Spills Risk score assigned value of 100, with all others normalized against that score).

Table 7 – 6

Problem Severity Scoring Factors for Future Conditions for the Nine Major Receiving Waters

Receiving Water	Change in Pollutant Loads	Change in Baseflow Quantity	Future Reach Stability Score	Spills Risk Index	Construction Site Loads	ERM trend analysis of monitoring data	Visual Index of Pollution	Change in Impervious Cover	Change in Recharge Volume
Lake Austin	X			X	X	X			
Town Lake (Upper and Lower)	X			X	X		X		
Colorado river below Longhorn Dam				X		X		X	
Southern Edwards Aquifer	X			X	X				X
Barton Springs Pool	X			X	X				X
Barton Creek (all)	X	X	X	X	X				
Bull Creek above Loop 360	X	X	X	X	X				
McKinney Falls	X	X		X	X				

7.4 Water Quality Problem Area Scores

The basic procedure for calculating water quality problem scores is to multiply resource value times problem severity. Results were compiled by EII reach, incorporating the problem scores for the nine other receiving waters into the reach scores as shown in the following equation:

$$\text{Problem Score} = \sum_{i=1}^{n} \{W_{cur}*RV_{cur}*CPS*) + (W_{fut}*RV_{fut}*FPS*)$$

where n = number of receiving waters
W_{cur} = Weight assigned to Current problems
RV_{cur} = Resource Value for Current Conditions
CPS = Current Problem Severity Score
W_{fut} = Weight assigned to Future problems
RV_{fut} = Resource Value for Future Conditions
FPS = Future Problem Severity Score

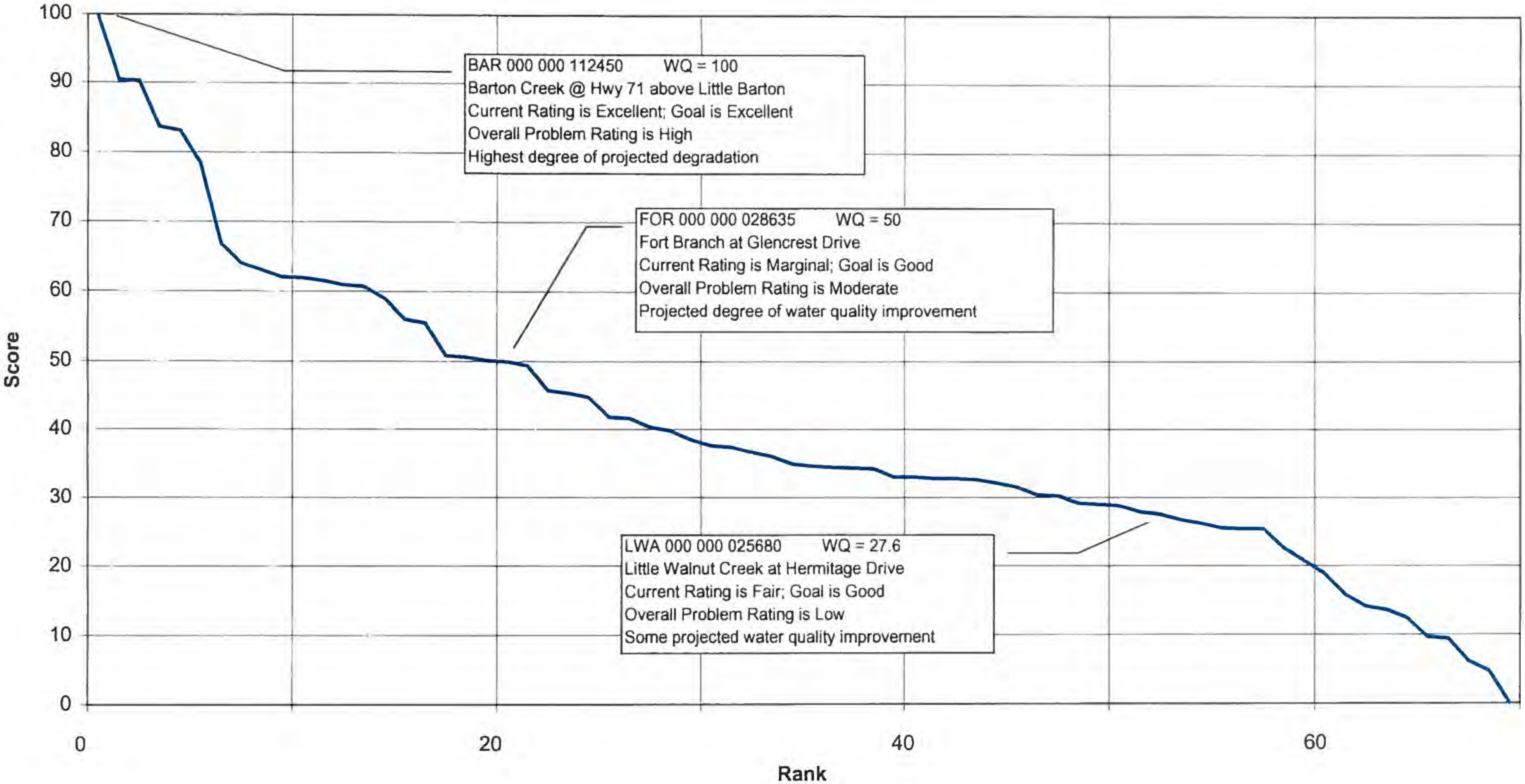
The method for compiling problem scores by EII reach was based simply on the ratio of EII reach drainage area and receiving water drainage area. This procedure was adopted from the EPA document Urban Targeting and BMP Selection: An Information and Guidance Manual for State NPS Program Staff Engineers and Managers, and results in the resource value of each receiving water being "allocated" to each EII reach. For example, for an EII reach with a drainage area of 200 acres that discharges to a receiving water with a resource value of 50 and a drainage area of 5000 acres, the "allocated" resource value for the EII reach would be 50* (200/5000) = 2.0. The drainage area used for Lake Austin was the area between Mansfield and Tom Miller Dams. For Town Lake it was the area between Tom Miller and Longhorn Dams. For the Colorado River below Longhorn Dam, the drainage area was based on the eastern edge of Austin's ETJ.

It was decided that present and future problems would be equally weighted, (i.e., $W_{cur} = W_{fut} = 0.5$). Once all of the total problem scores were calculated, they were scaled to a 0 to 100 scale by dividing each problem score by the highest (worst) problem score and multiplying by 100.

7.5 Results

The water quality problem scores (Table B – 3, found in Appendix B) were used to identify relative water quality concerns for creeks and their major tributaries in the Phase I watersheds. There were a total of 70 water quality monitoring points and associated reaches. Figure 7 – 2 presents the distribution of water quality problem scores. Figure 7-3 depicts the results of the problem area prioritization for water quality problems. The average water quality problem score is 40.26 and the median water quality problem score is 34.85. A narrative rating of Very Low was assigned to a problem score of 0-20, a narrative rating of Low for 20-40, a narrative rating of Moderate for 40-60, a narrative rating of High for 60-80 and a narrative rating of Very High for 80-100. Overall, the results indicate that water quality problems are widely distributed, spatially and temporally. Not surprisingly, urban creeks are the most degraded currently while future threats are of most concern in the non-urban creeks. Rapidly developing watersheds, such as Walnut and Bull still retain good water quality conditions but are showing signs of degradation. Closer inspection of the results shown in Appendix B also indicates that while the current condition of the other nine receiving waters (e.g., Town Lake, Southern Edwards Aquifer) is quite good, significant degradation may occur in the future.

Figure 7 - 2
Water Quality Problem Score Distribution



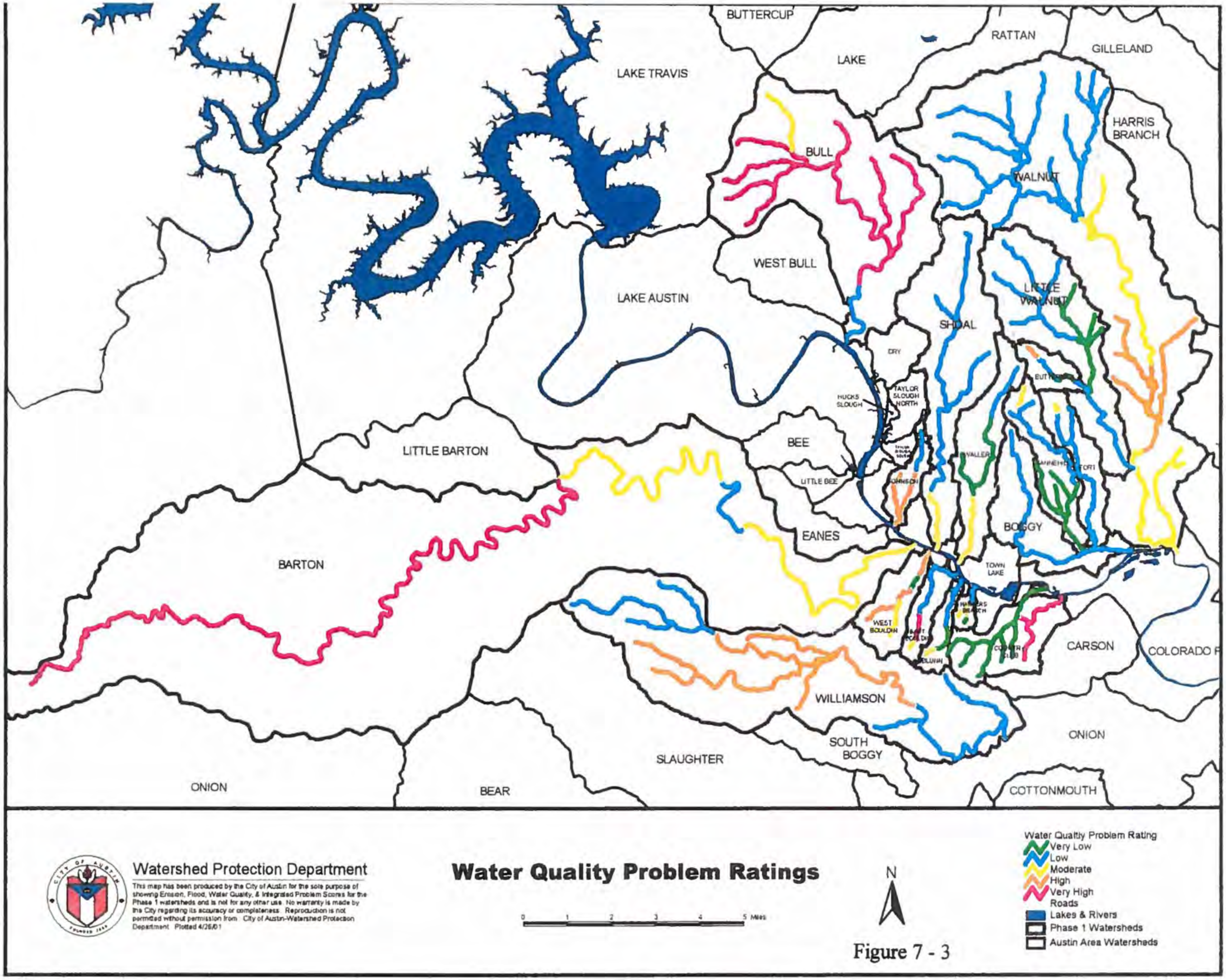

BUTTERCUP
RATTAN
GILLELAND
LAKE
LAKE TRAVIS
HARRIS BRANCH
BULL
WALNUT
WEST BULL
LAKE AUSTIN
LITTLE WALNUT
SHOAL
DRY
TAYLOR SLOUGH NORTH
HUCKS SLOUGH
BEE
LITTLE BARTON
WALLER
LITTLE BEE
JOHNSON
BOGGY
EANES
BARTON
TOWN LAKE
WEST BOULDIN
CARSON
COLORADO R
WILLIAMSON
ONION
SOUTH BOGGY
SLAUGHTER
ONION
BEAR
COTTONMOUTH
Watershed Protection Department
This map has been produced by the City of Austin for the sole purpose of showing Erosion, Flood, Water Quality, & Integrated Problem Scores for the Phase 1 watersheds and is not for any other use. No warranty is made by the City regarding its accuracy or completeness. Reproduction is not permitted without permission from City of Austin-Watershed Protection Department. Plotted 4/26/01
Water Quality Problem Ratings
0 1 2 3 4 5 Miles
N
Water Quality Problem Rating
Very Low
Low
Moderate
High
Very High
Roads
Lakes & Rivers
Phase 1 Watersheds
Austin Area Watersheds

Figure 7 - 3

Water Quality Problem scores depicting current conditions only are shown in Appendix B. Watershed Summaries for the Phase I watersheds are also provided in Appendix B. These summaries discuss both current and overall problem score results for each watershed.

Bull Creek watershed has the highest average score (63.48) of all Phase I watersheds, followed by Country Club Creek (with an average score of 58.73) and Johnson Creek (with an average score of 57.10). All three of these watersheds each include two of the top ten problem reaches.

While Barton Creek only ranks fourth based on average watershed score, it contains the reach with the worst water quality problem rating, as indicated by the score of 100. This reach is characterized by sampling taken at Hwy 71 above Little Barton (EII Site 78). The current EII rating for this site is "Excellent" and the EII goal is "Excellent." This problem score of 100 is driven largely by two factors, one being the receiving waters which this reach contributes to (e.g., Town Lake, Southern Edwards Aquifer) and the other being the predicted future conditions.

The top ten water quality problem areas listed alphabetically are as follows:

Reach ID	**Rating**	**Location**
BAR000000112450	Very High	Barton Creek at Hwy 71 above Little Barton
BUL000000013210	Very High	Bull Creek at Loop 360 First Crossing
BUL000000036500	Very High	Bull Creek at St. Edwards Park above dam
CNTOLD000000450	Very High	Country Club Creek below Grove Drive
CNTOLD000008075	High	Country Club Creek at Crossing Place Drive
EBO000000012600	Very High	East Bouldin Creek at South Austin Center
JOH000000000350	Very High	Johnson Creek at 1st Street
JOH000000005600	High	Johnson Creek at 11th Street
WBO000000000800	High	West Bouldin Creek at Riverside Drive
WBO000000007100	High	West Bouldin Creek at Guerrero Park

For an overview of water quality problem ratings for the Phase I watersheds as compared to erosion control, flood control, and integrated scores, please refer to Figures 8 – 6 through 8 – 22 found in Section 8. For information on specific scores for each watershed, please refer to the Watershed Summary section (Volume II) of the Master Plan.

Section 8

Integrated Assessment

8.1 Study Methods

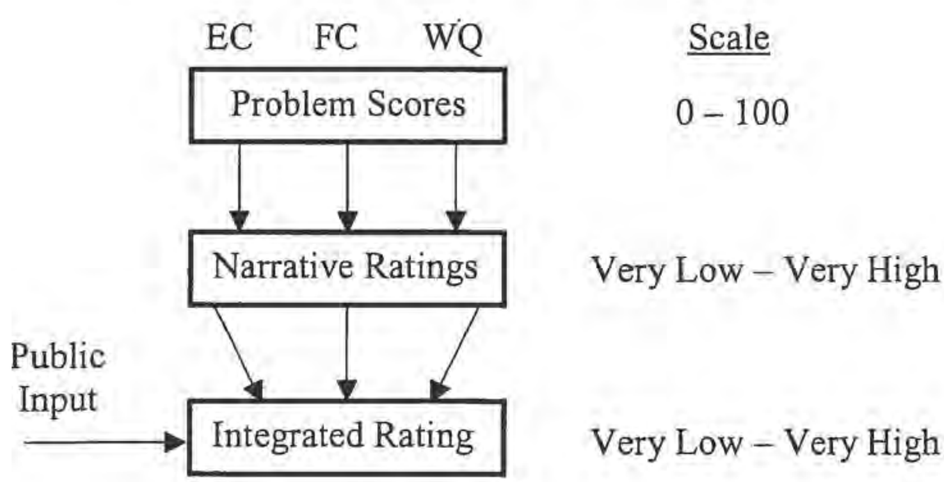
After problem area scores were developed for the flood, erosion and water quality missions, an "integrated" problem area score was developed. The integrated problem score provides additional insight into potential watershed management strategies by combining the results of the three individual mission studies to identify areas of concurrent flood, erosion, and water quality problems. While integrated solutions will be considered to the greatest extent possible for areas with single mission concerns, creek reaches with higher integrated problem scores demonstrate an increased need for multi-purpose solutions.

The process of combining the three individual mission scores, as shown in Figure 8 – 1, involved both:

1. Converting the numeric mission scores to narrative scores, and
2. Averaging the three narrative scores to create a single "integrated" narrative score.

Figure 8 – 1

Integrating Mission Scores



8.1.1 Converting Mission Scores

Because scoring systems and the resulting distribution of problem scores varied considerably between the flood, erosion, and water quality missions, an "integrated" score could not be generated by simply adding the results of each mission. For example, on a relative basis, a mission score of 35 would represent a ***High*** erosion problem rating, a ***Very High*** flood control rating and a ***Low*** water quality rating. Therefore, an average integrated score of 35 would provide little insight into the relative problems for each mission. In order to use the numeric mission scores to create a single integrated score, the numeric scores were standardized to a narrative rating range. Each mission identified the numeric scoring range that represented one of five narrative categories (Very Low, Low, Moderate, High and Very High). The numeric mission scores were then converted to a narrative score based on the range in which they fell. Table 8 – 1 summarizes the conversion basis for each of the three missions. Figures 8 – 2, 8 – 3, and 8 - 4 show graphic representation of these conversions applied to the histogram of each mission problem area score distribution (from Figures 4 – 3, 6 – 4, and 7 - 2).

Table 8 – 1

Problem Area Scores

Narrative Rating	Mission			Integrated Score	Narrative Rating Score
	Flood Control	Erosion Control	Water Quality		
Very Low	0 – 0	0 – 10	0 – 20	0 – 2	1
Low	0 – 5	100 – 20	20 – 40	2 – 4	3
Moderate	5 – 10	20 – 300	40 – 60	4 – 6	5
High	10 – 20	30 – 40	60 – 80	6 – 8	7
Very High	200 – 100	40 – 100	80 – 100	8 – 10	9

Figure 8 - 2
Flood Control Problem Score Distribution

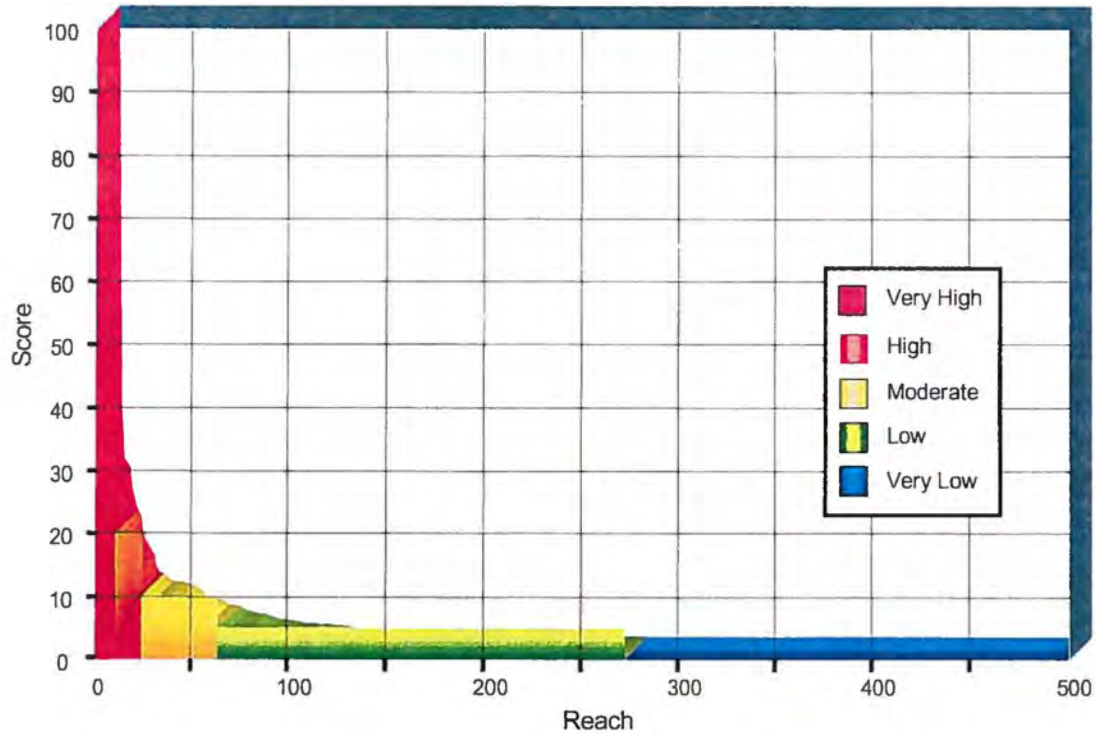


Figure 8 - 3
Erosion Control Problem Score Distribution

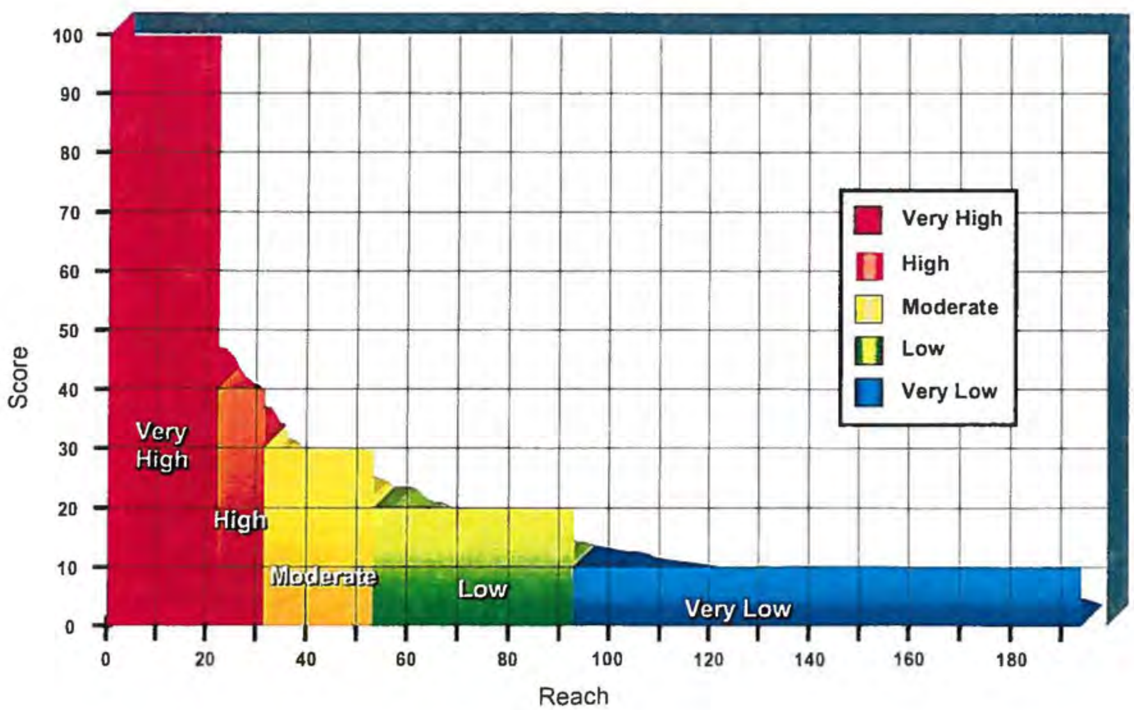
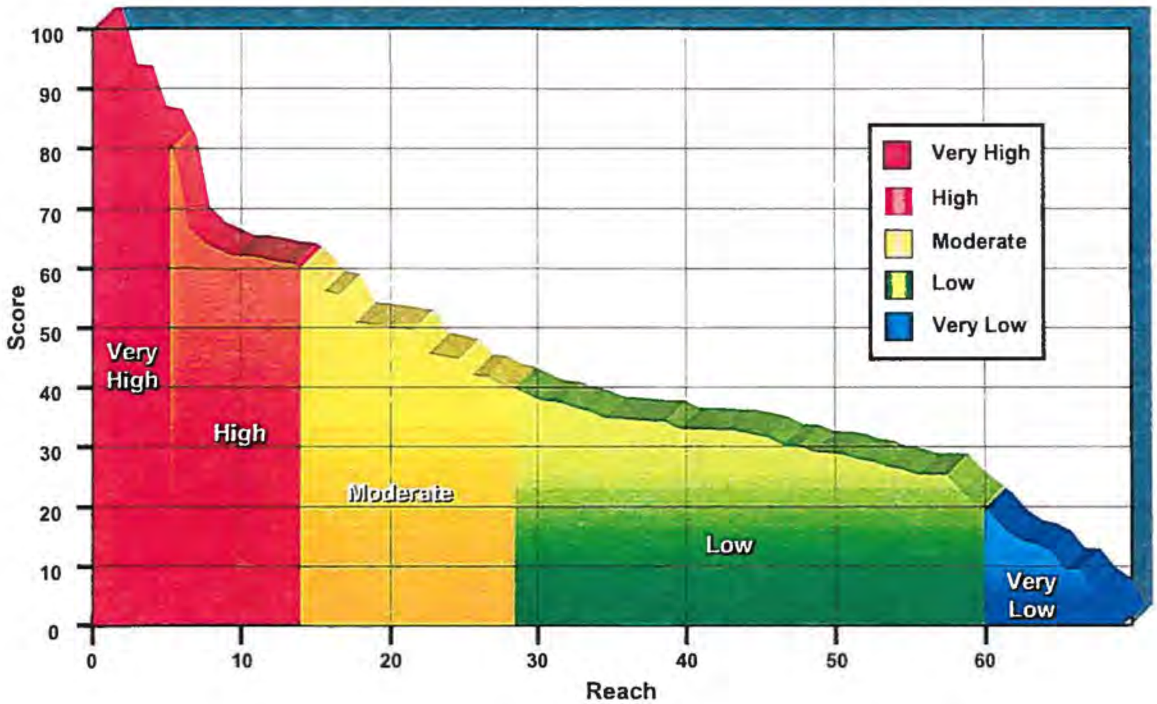


Figure 8 - 4
Water Quality Problem Score Distribution



8.1.2 Averaging Narrative Scores

Once the mission scores were converted to a narrative rating, an integrated score for each creek reach was produced by taking the weighted average of the narrative rating scores (shown in Table 8 – 1).

This calculation is described as follows:

$$IS = (W_E*EC_{NR}) + (W_F*FC_{NR}) + (W_W*WQ_{NR})$$

Where: IS = Integrated Score for each Creek Reach

$W_{E,F,W}$ = Weightings based on public input (see below)

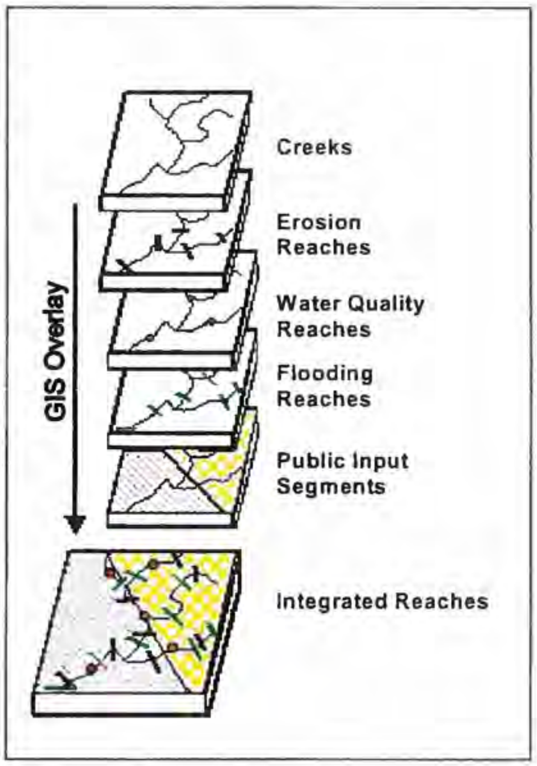
EC_{NR} = Erosion Control Narrative Rating Score

FC_{NR} = Flood Control Narrative Rating Score

WQ_{NR} = Water Quality Narrative Rating Score

Weights used in the above equation to combine the scores from the three missions were based on results of the telephone public survey described in Section 1 of this Master Plan. The telephone survey gauged the public's relative concerns regarding each of the missions on both a watershed-segment and City-wide basis. Survey results for both the watershed-based and City-wide responses were used to combine the mission scores. The final weights (W) were based on 75 percent of the watershed-segment (S) weight and 25 percent of the City-wide (C) weight. [Or $W = (0.75*S)+(0.25*C)$ for each mission.] Therefore, the final integrated score incorporated the public's perspective on relative watershed concerns on both a local and City-wide basis. *[Note: The watershed segment (S) survey results for flood control contained two factors – public safety and property protection. An average of these results was used to represent the flood control watershed segment (S) value.]*

Once the integrated score (IS) is calculated, a narrative score is assigned based on the ranges shown in Table 8 – 1. The process of calculating "integrated" scores was completed with the use of a GIS application. As discussed in Sec 3.3, each mission has a different method for defining the beginning and end of applicable reach segments. In order to integrate the three mission scores into a combined score, a reach segment network must be created that accounts for all break points across missions. The GIS application queries each mission for the associated mission scores for each integrated segment, applies the public input weighting factors, and calculates an integrated score.

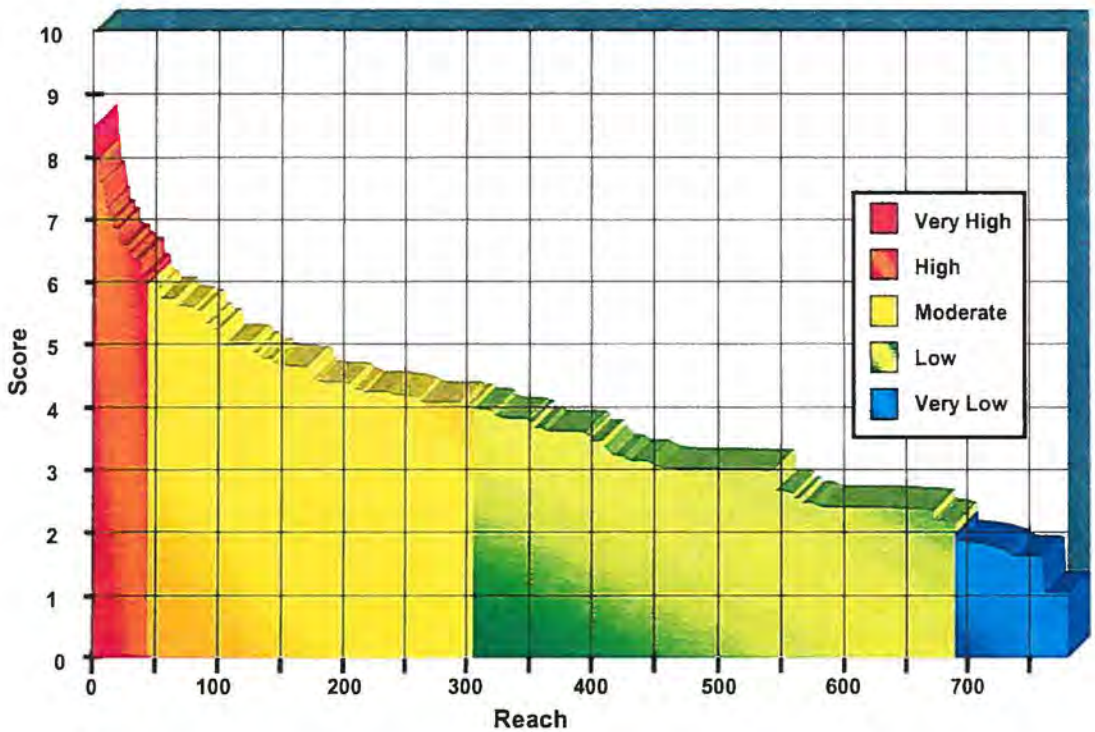


8.2 Integrated Results

As described in Section 8.1, averaging the flood, erosion and water quality problem scores for each segment or reach of a creek resulted in the assignment of integrated problem area ratings. These composite (integrated) scores help identify areas that are most appropriate for the implementation of an integrated solution – a solution that simultaneously addresses the flood, erosion and water quality needs of an area.

Figure 8 – 5 shows the distribution of Integrated Problem Scores in the Phase I watersheds.

Figure 8 - 5
Integrated Problem Score Distribution



This distribution is broken out by watershed in Table 8 – 2.

Table 8 – 2

Integrated Score Distribution by Watershed

Watershed	# Integrated Reaches	Narrative Rating				
		Very Low	Low	Moderate	High	Very High
BAR	17	2	14	1	0	0
BLU	16	2	14	0	0	0
BMK	13	2	10	1	0	0
BOG	31	9	9	13	0	0
BUL	91	4	10	64	12	1
CNT	36	5	16	14	1	0
EBO	18	0	4	12	2	0
FOR	22	0	15	6	1	0
HRP	11	1	10	0	0	0
JOH	21	0	19	2	0	0
LWA	65	21	37	5	2	0
SHL	56	7	45	2	2	0
TAN	36	18	11	7	0	0
WBO	21	1	9	10	1	0
WLN	181	3	94	67	16	1
WLR	36	11	23	2	0	0
WMS	111	4	46	57	4	0
Total	782	90	386	263	41	2

Of the 782 integrated problem reaches, nearly half of them have integrated score ratings of Low. Nearly a third of them are rated as Moderate problem areas and about a tenth of them are considered to be of Very Low problem concern. Less than ten percent of all Phase I integrated reaches are considered to be High or Very High problem concern areas. For a reach to receive an integrated rating of Very High, all three missions must have a High or Very High problem rating. Likewise, an integrated rating of Very Low requires that all three missions for that reach be rated Low or Very Low.

Figures 8 – 6 through 8 – 22 show the results of the integrated scoring process for each of the Phase I watersheds. Each figure shows the narrative ratings for flood, erosion, and water quality and the combined integrated score. Based on this integrated assessment, there are two reaches that have an integrated problem score rating of Very High as a result of the combined extent of erosion, flooding and water quality problems in the area. These two reaches are:

- the Crystal Brook area of the Walnut Creek watershed - this reach was rated Very High for flood and erosion problems and High for water quality problems.
- Bull Creek in the vicinity of the intersection of Spicewood Springs and Yucca Mountain Rd between the Bull Creek Greenbelt and St Edwards District Park –this reach was rated Very High for erosion and water quality problems and High for flood control problems.

Both of these reaches would likely benefit the most from an integrated solution.

Priority areas for potential integrated solution implementation are listed below:

<table>
<tr><th>Reach</th><th>Rating</th><th>Location</th></tr>
<tr><td>BUL000000024880
BUL000000026350
BUL000000028500
BUL000000030300
BUL000000032050</td><td>High
High
High
Very High
High</td><td>Collectively from the confluence with Tributary 3 (near the intersection of Spicewood Springs and Yaupon Dr.) to the entrance of the main stem into St Edwards District Park</td></tr>
<tr><td>BULT02000010150</td><td>High</td><td>The section of Tributary 2 that passes through Austin Hills Park (near Floral Park Dr.)</td></tr>
<tr><td>WLN000000020380</td><td>High</td><td>Just north of the intersection of Johnny Morris Rd and FM 969</td></tr>
<tr><td>WLN000000030000
WLN000000030087
WLN000000032125
WLN000000034245
WLN000000035040</td><td>High
High
Very High
High
High</td><td>Collectively from Loyola Ln to just upstream of the confluence with Tributary 3 (near Crystalbrook Subdivision)</td></tr>
<tr><td>WMS000000049660</td><td>High</td><td>Just upstream of Jones Rd.</td></tr>
<tr><td>WMS000000052150
WMS000000052740</td><td>High
High</td><td>Collectively from the confluence with Cherry Creek to the entrance of the main stem into Valley Creek Park (Reese Dr.)</td></tr>
</table>

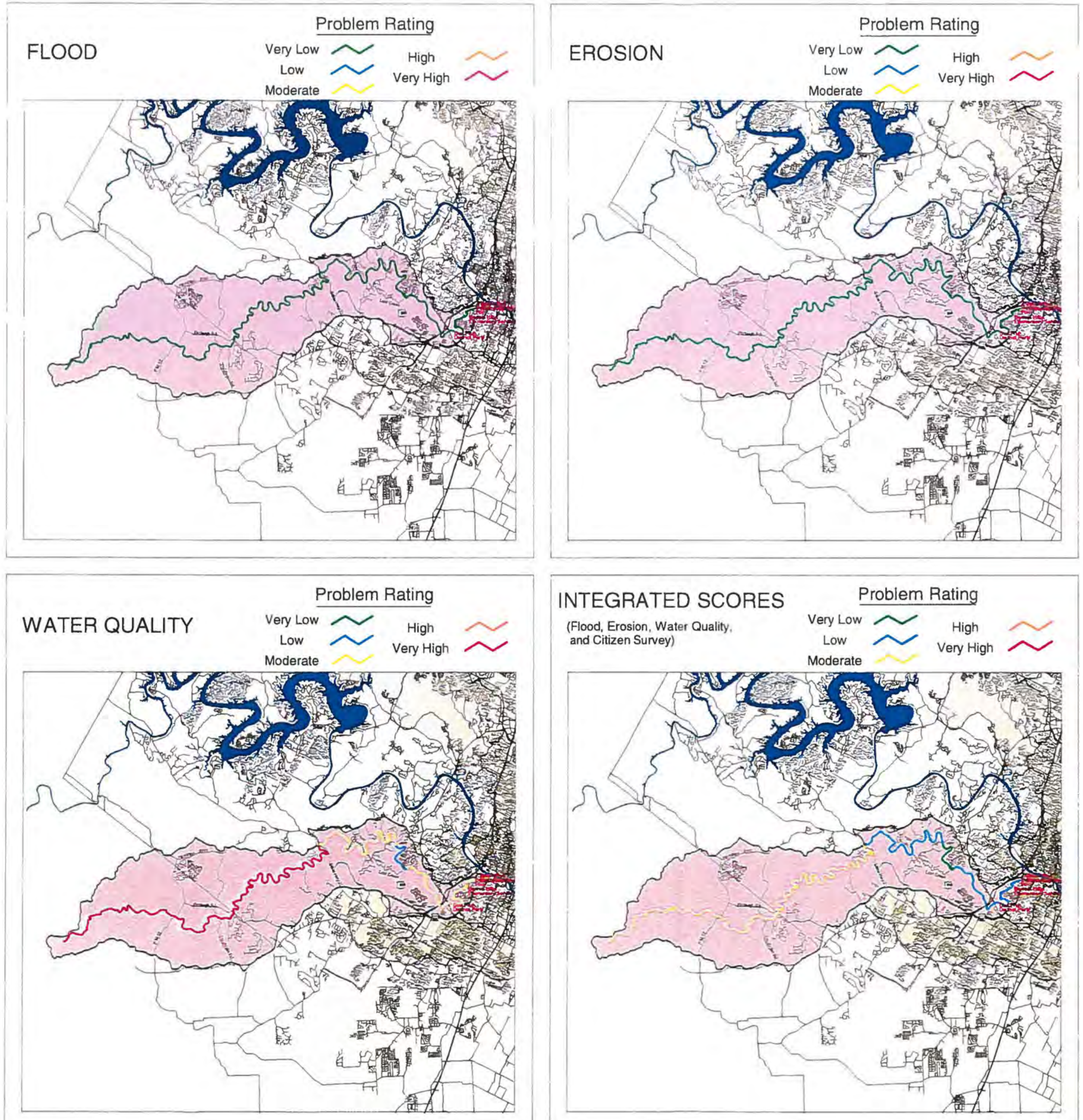
The process of determining integrated problem scores provides WPD with another means of prioritizing problem areas and developing management strategies. It should be noted that opportunities for developing integrated solutions were investigated for all problem areas and not just those with a relatively high integrated problem score. The initial feasibility of actually implementing a specific integrated or single mission solution for specific watershed problems throughout the Phase I watersheds is addressed in Section 10.

Figure 8 - 6

Watershed Protection Department

Master Plan
Problem Assessment

Barton



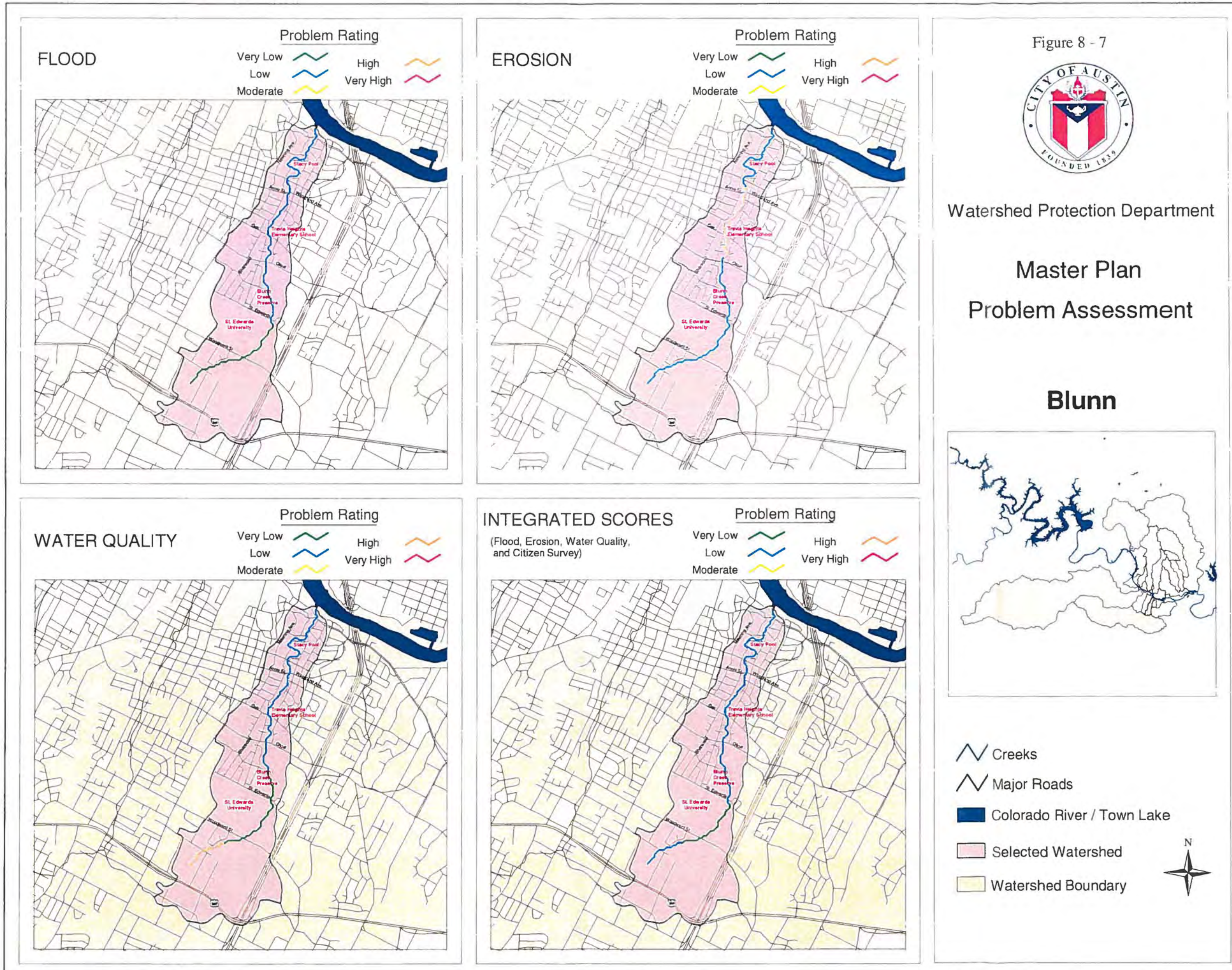
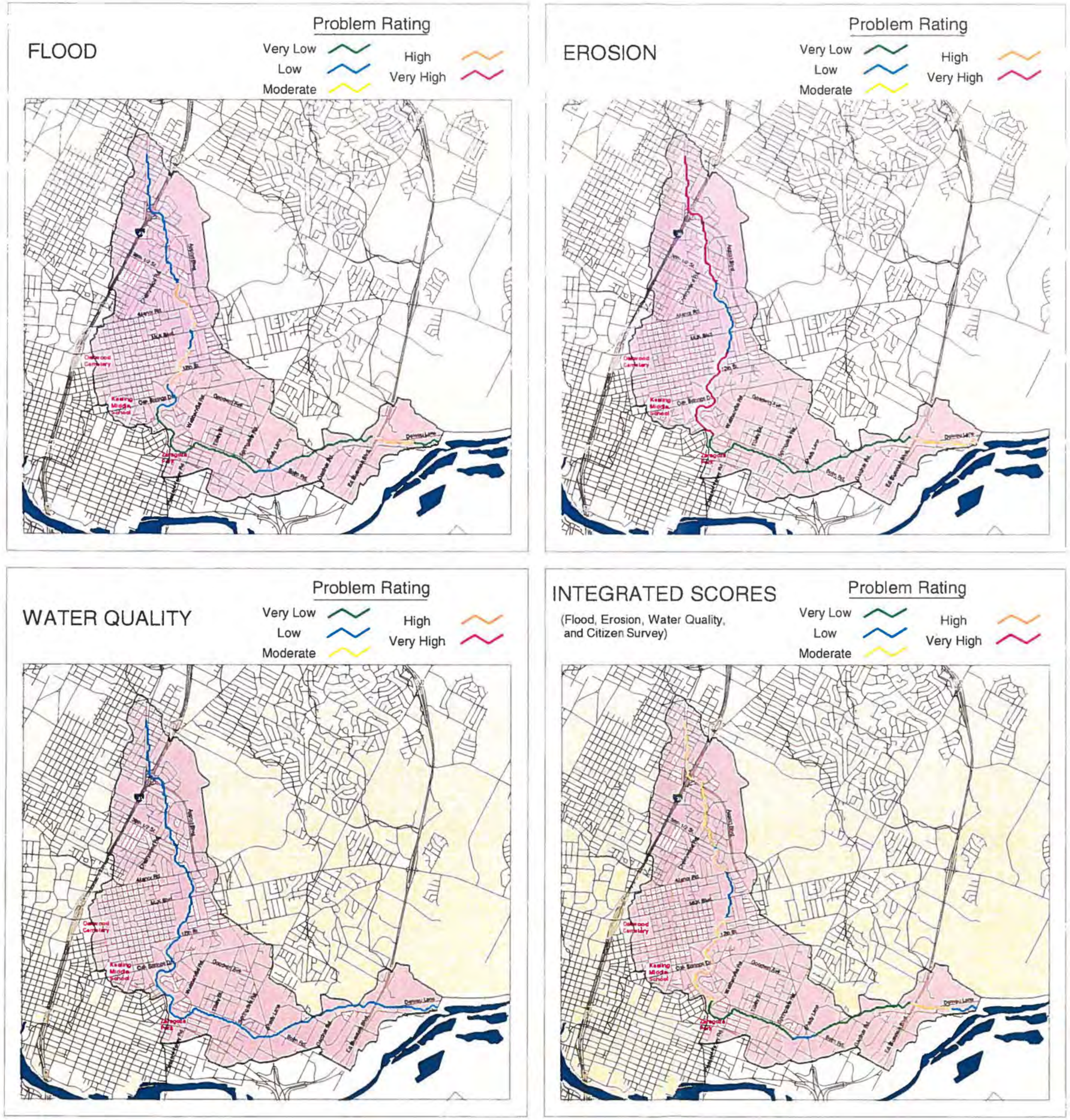

FLOOD
Problem Rating
Very Low
Low
Moderate
High
Very High
EROSION
Problem Rating
Very Low
Low
Moderate
High
Very High
WATER QUALITY
Problem Rating
Very Low
Low
Moderate
High
Very High
INTEGRATED SCORES
(Flood, Erosion, Water Quality, and Citizen Survey)
Problem Rating
Very Low
Low
Moderate
High
Very High
Figure 8 - 7
CITY OF AUSTIN
FOUNDED 1839
Watershed Protection Department
Master Plan
Problem Assessment
Blunn
Creeks
Major Roads
Colorado River / Town Lake
Selected Watershed
Watershed Boundary
N

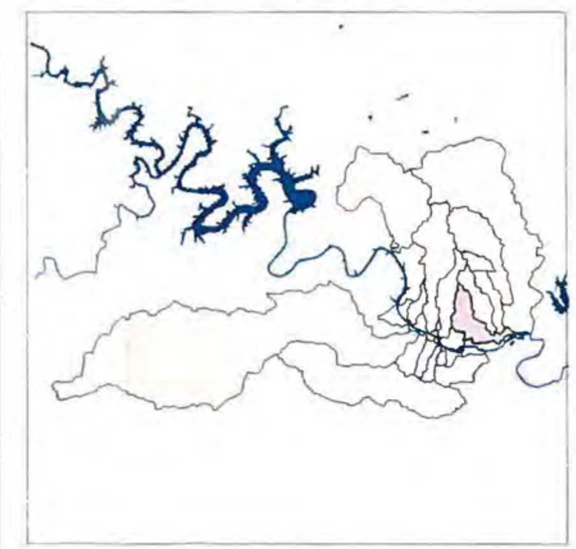
Figure 8 - 8

Watershed Protection Department

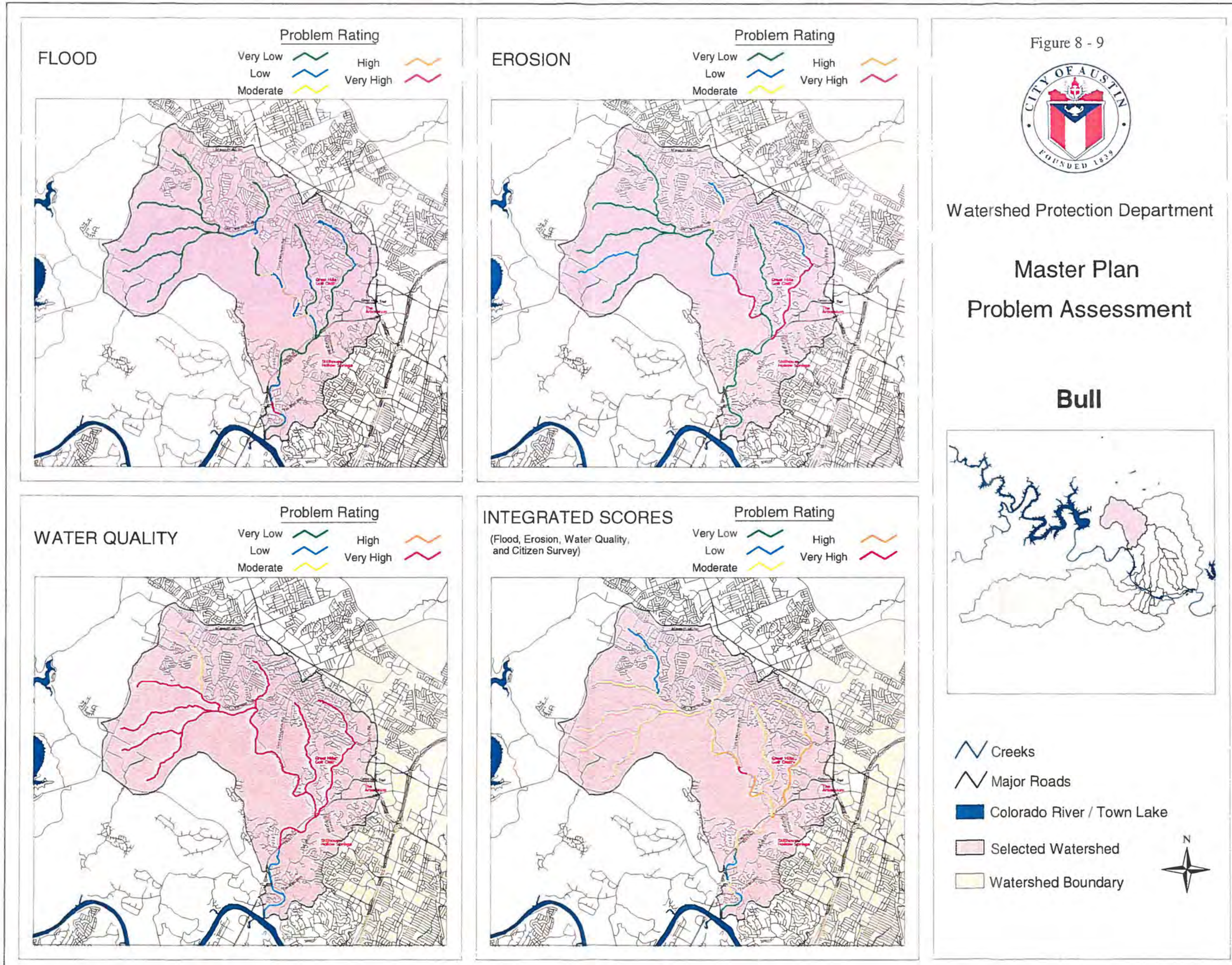
Master Plan
Problem Assessment

Boggy





Creeks
Major Roads
Colorado River / Town Lake
Selected Watershed
Watershed Boundary
N


FLOOD
EROSION
WATER QUALITY
INTEGRATED SCORES
(Flood, Erosion, Water Quality, and Citizen Survey)
Problem Rating
Very Low
Low
Moderate
High
Very High
Figure 8 - 9
CITY OF AUSTIN
FOUNDED 1839
Watershed Protection Department
Master Plan
Problem Assessment
Bull
Creeks
Major Roads
Colorado River / Town Lake
Selected Watershed
Watershed Boundary
N

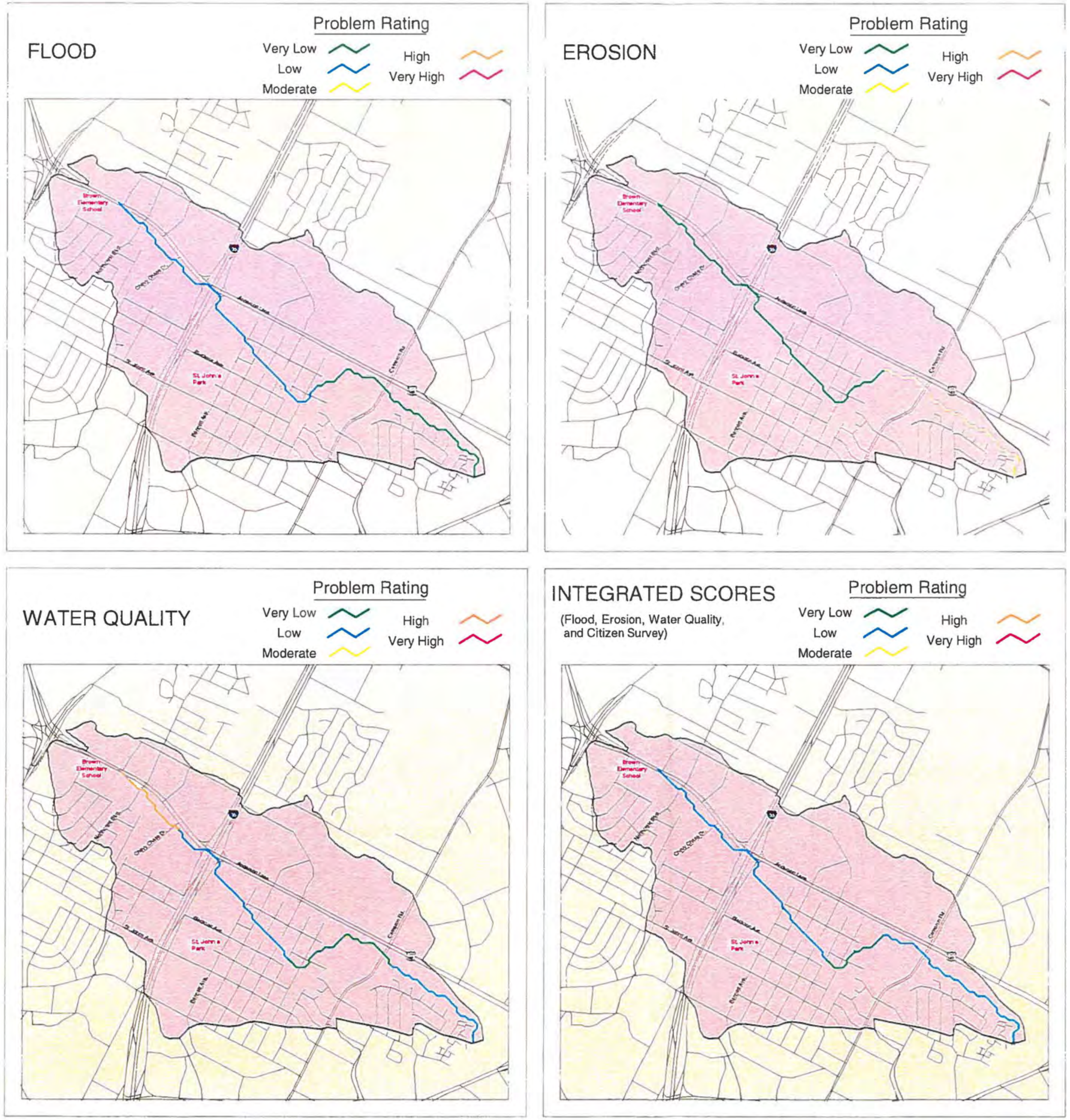
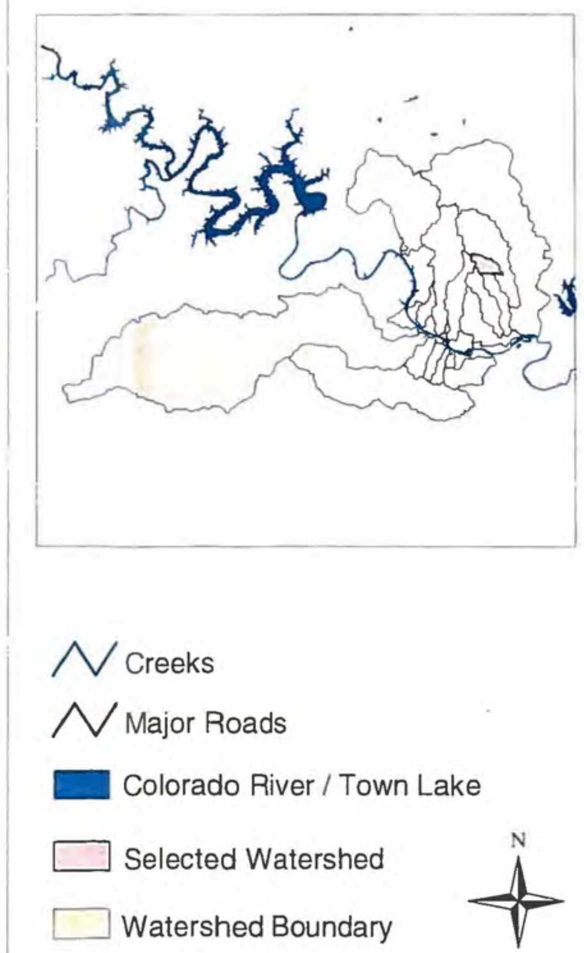


Figure 8 - 10

Watershed Protection Department

Master Plan
Problem Assessment

Buttermilk



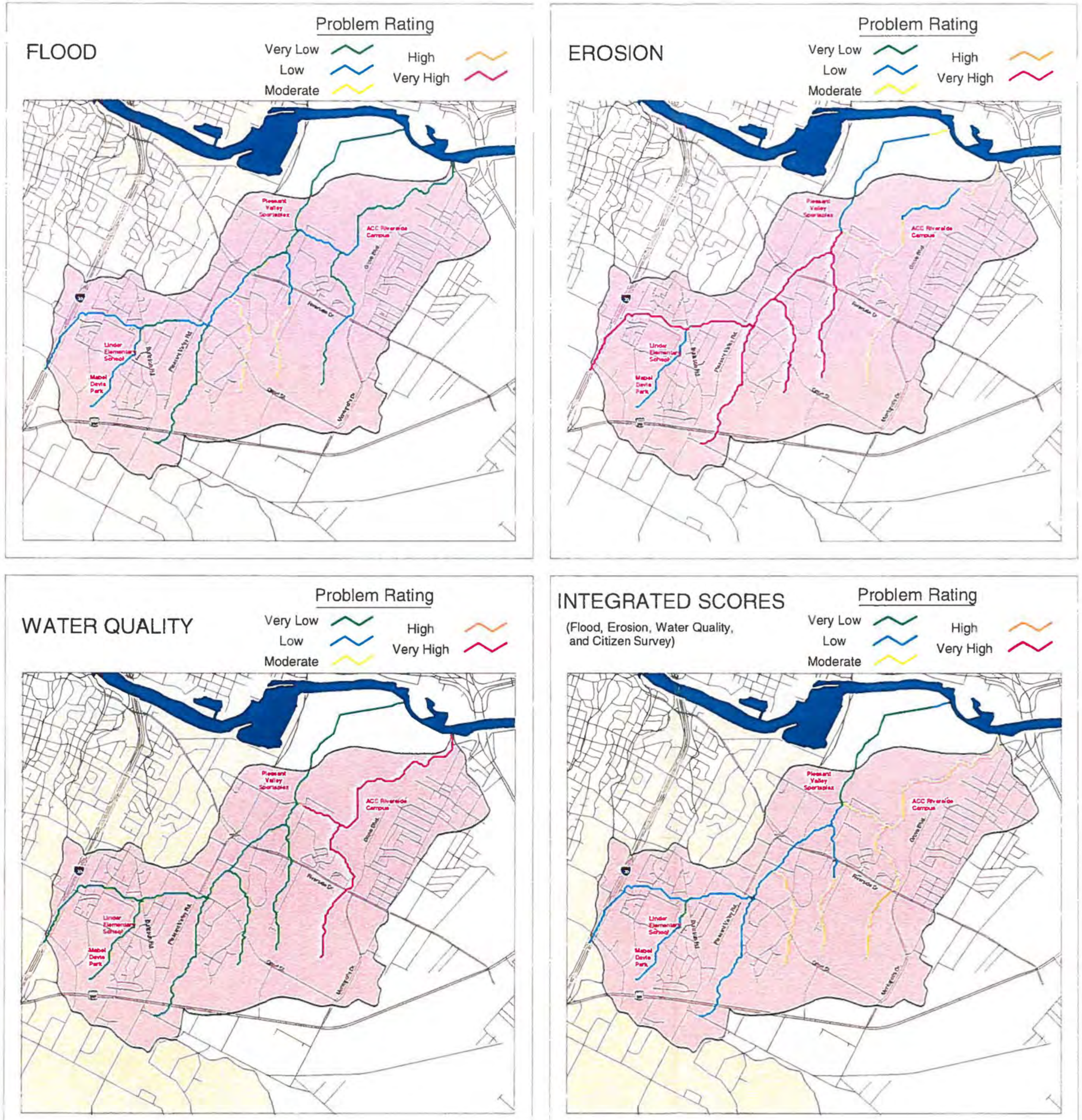
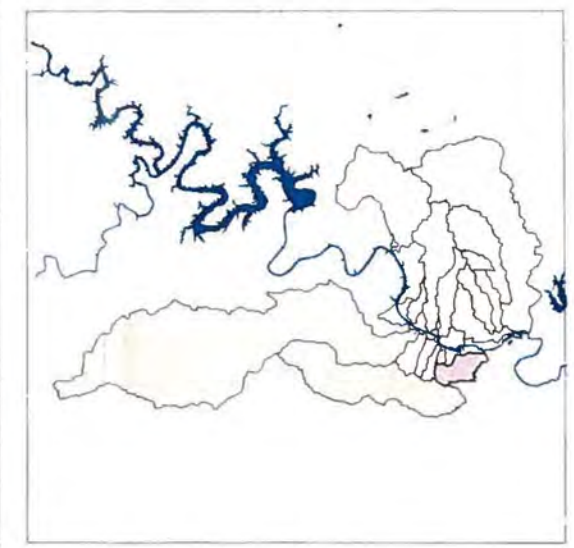


Figure 8 - 11

Watershed Protection Department

Master Plan
Problem Assessment

Country Club



Creeks

Major Roads

Colorado River / Town Lake

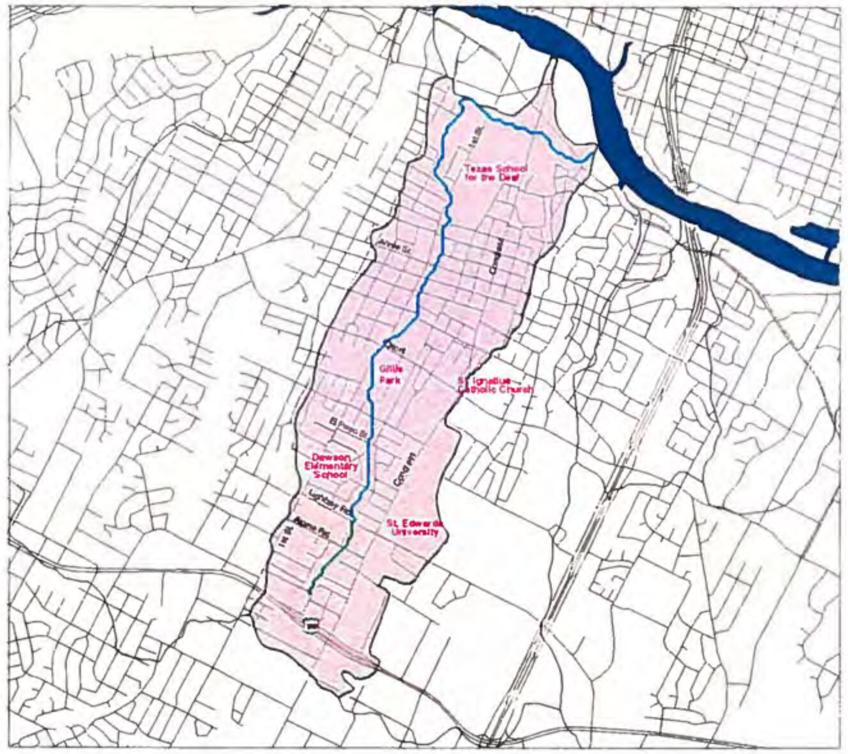
Selected Watershed

Watershed Boundary

N

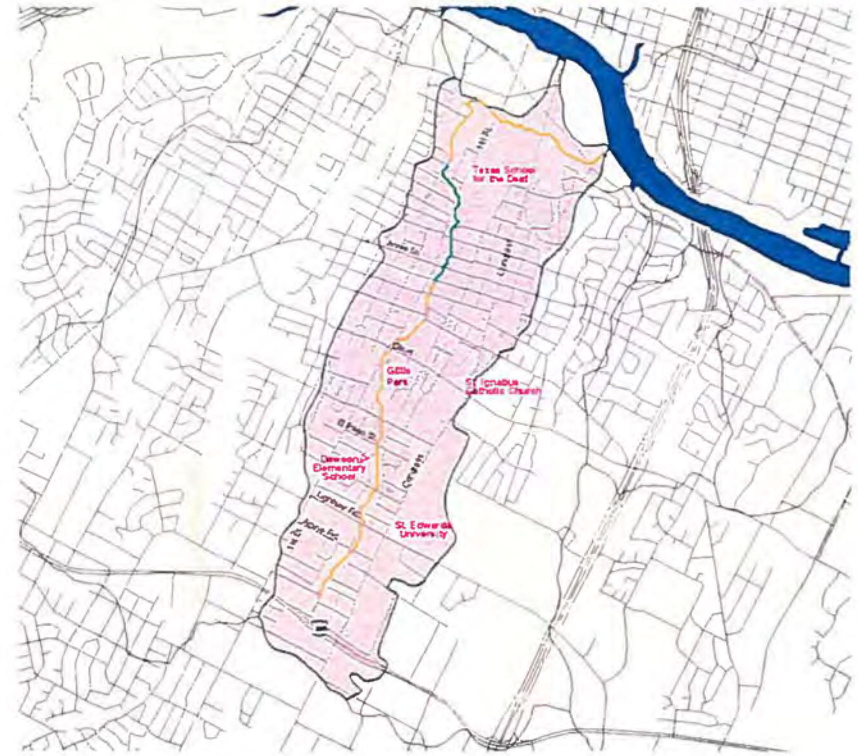
FLOOD

Problem Rating: Very Low, Low, Moderate, High, Very High



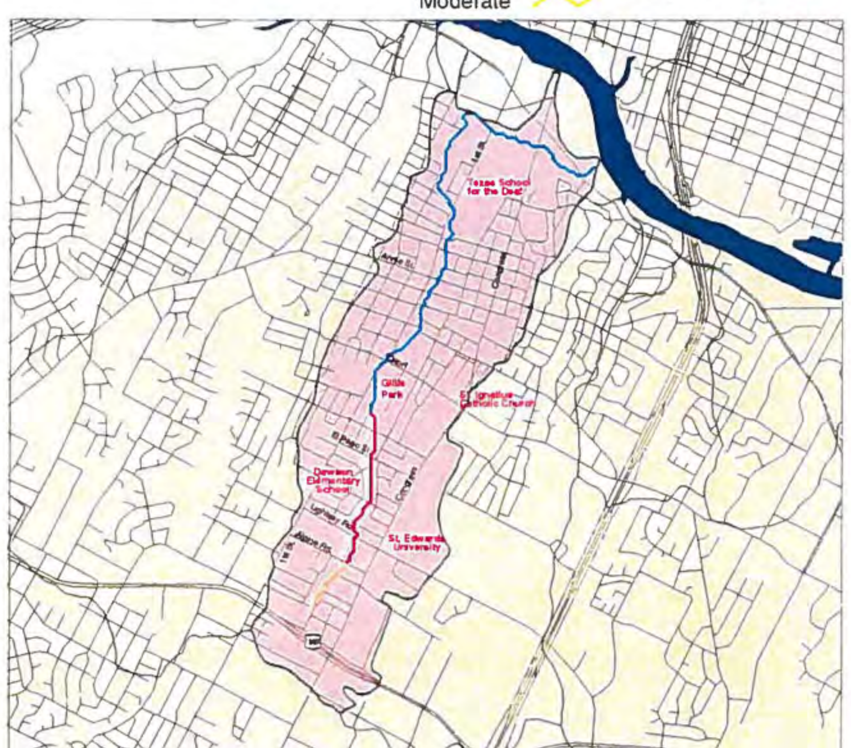
EROSION

Problem Rating: Very Low, Low, Moderate, High, Very High



WATER QUALITY

Problem Rating: Very Low, Low, Moderate, High, Very High



INTEGRATED SCORES

(Flood, Erosion, Water Quality, and Citizen Survey)

Problem Rating: Very Low, Low, Moderate, High, Very High

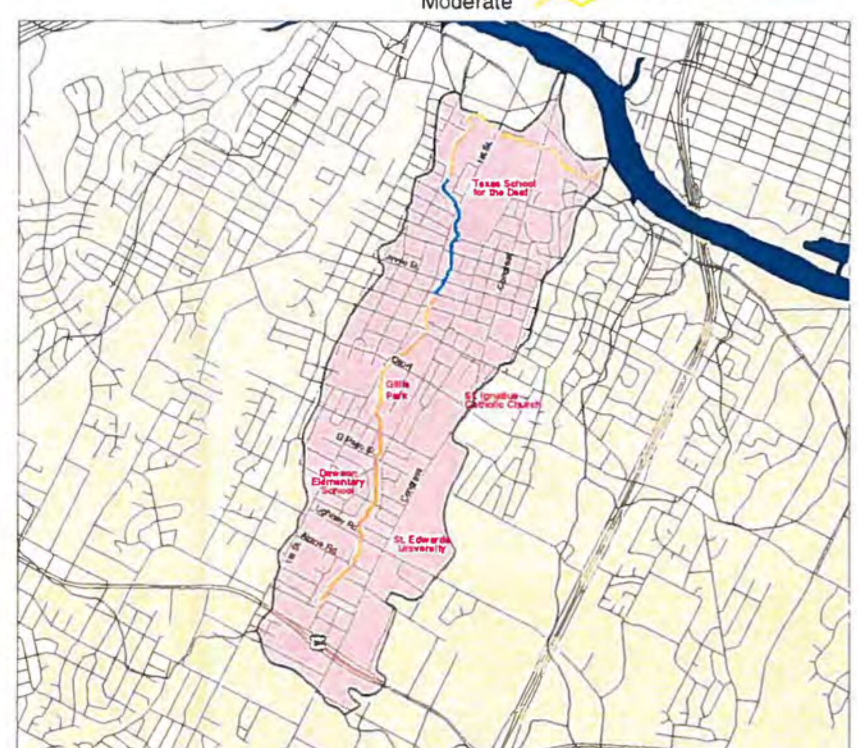
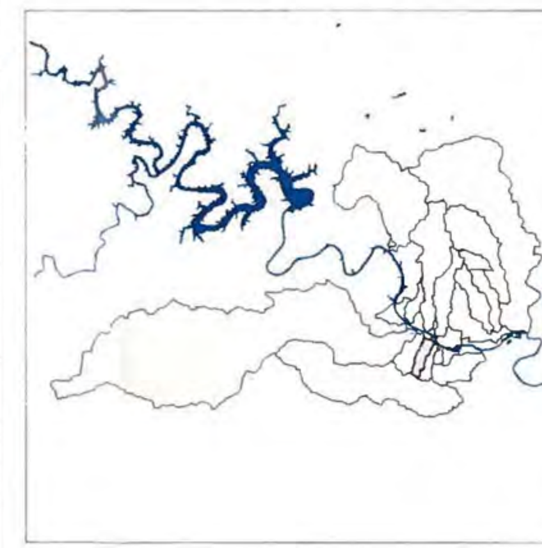


Figure 8 - 12

Watershed Protection Department

Master Plan
Problem Assessment

East Bouldin



Creeks

Major Roads

Colorado River / Town Lake

Selected Watershed

Watershed Boundary

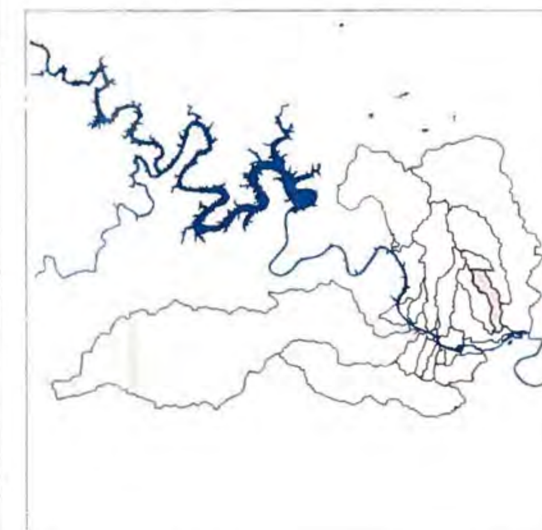
N

Figure 8 - 13

Watershed Protection Department

Master Plan
Problem Assessment

Fort



Creeks

Major Roads

Colorado River / Town Lake

Selected Watershed

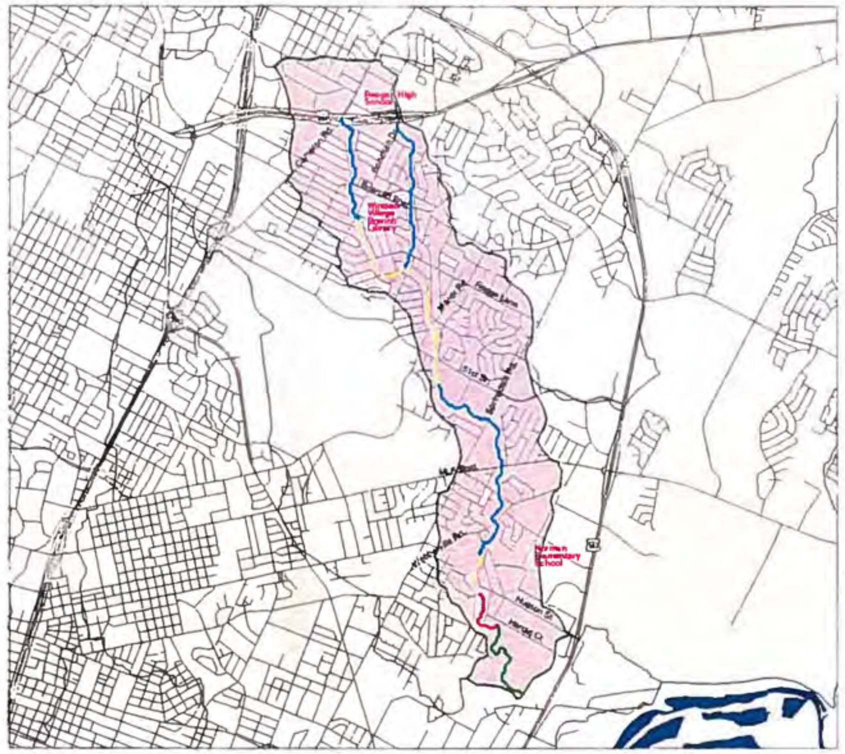
Watershed Boundary

N

FLOOD

Problem Rating

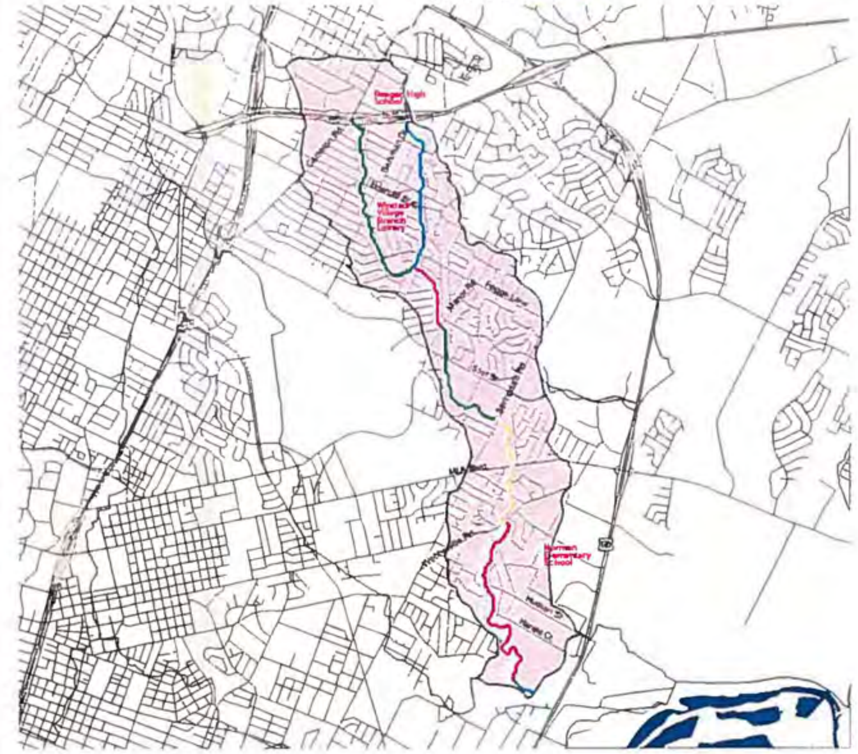
Very Low | Low | Moderate | High | Very High



EROSION

Problem Rating

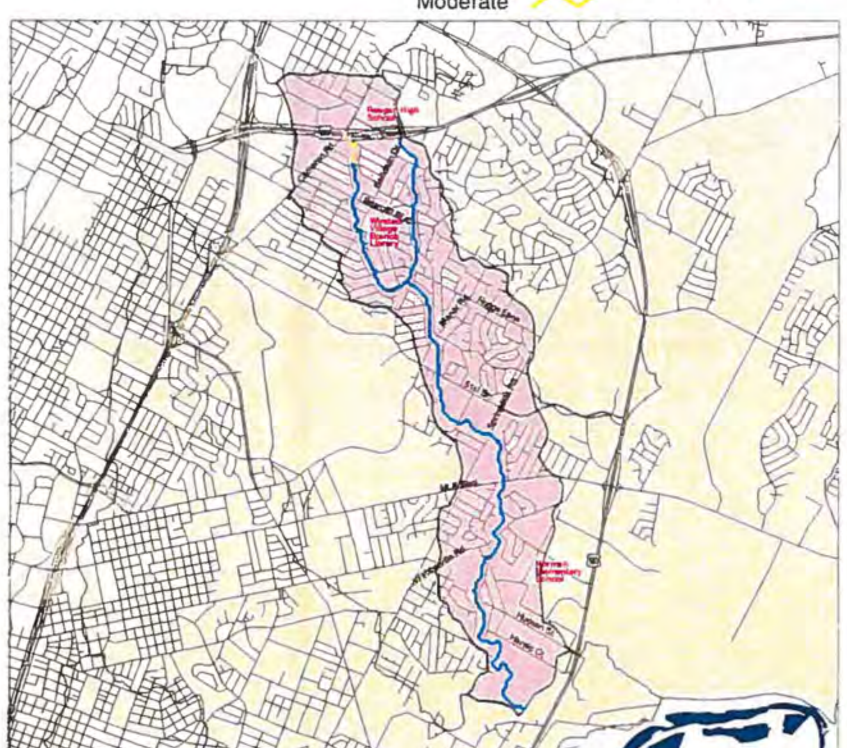
Very Low | Low | Moderate | High | Very High



WATER QUALITY

Problem Rating

Very Low | Low | Moderate | High | Very High

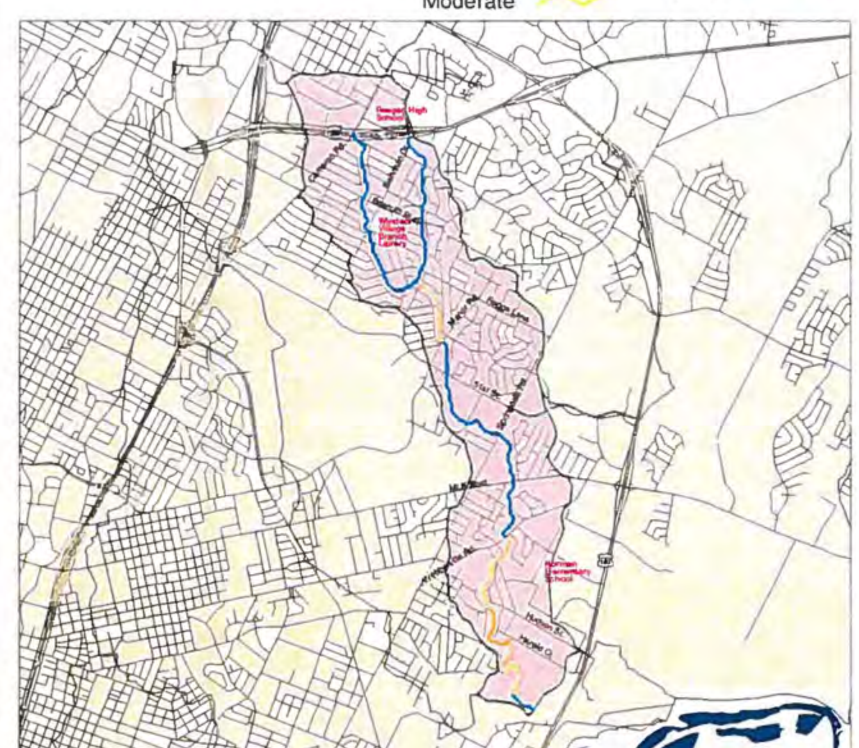


INTEGRATED SCORES

(Flood, Erosion, Water Quality, and Citizen Survey)

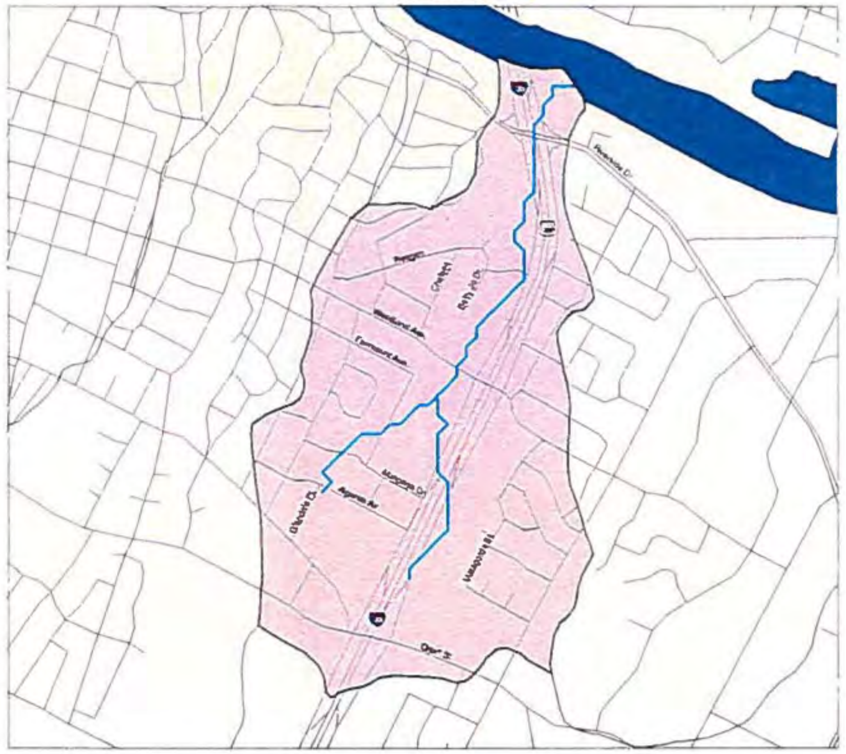
Problem Rating

Very Low | Low | Moderate | High | Very High



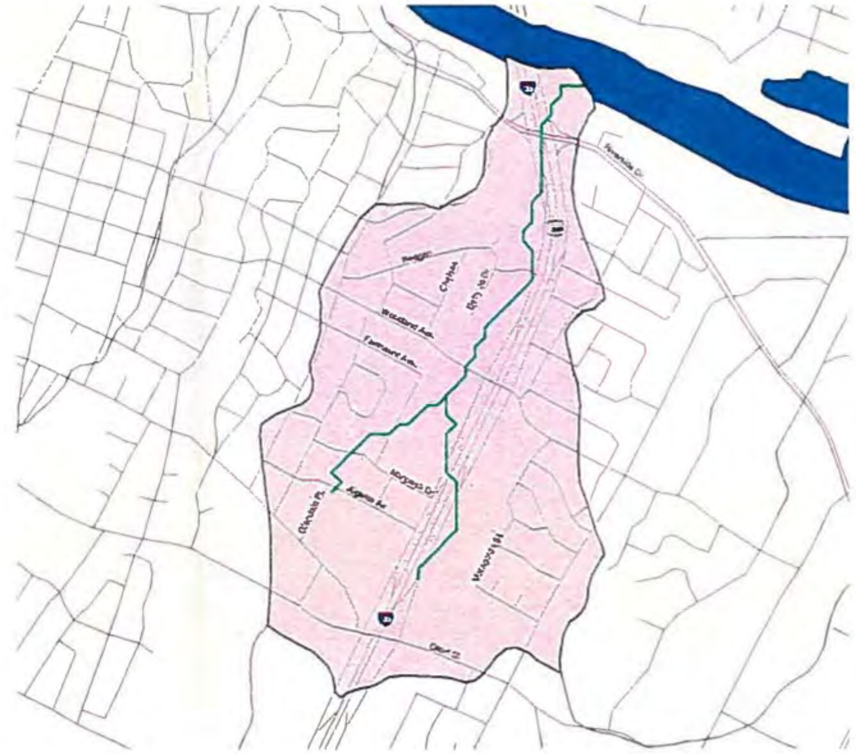
FLOOD

Problem Rating: Very Low, Low, Moderate, High, Very High



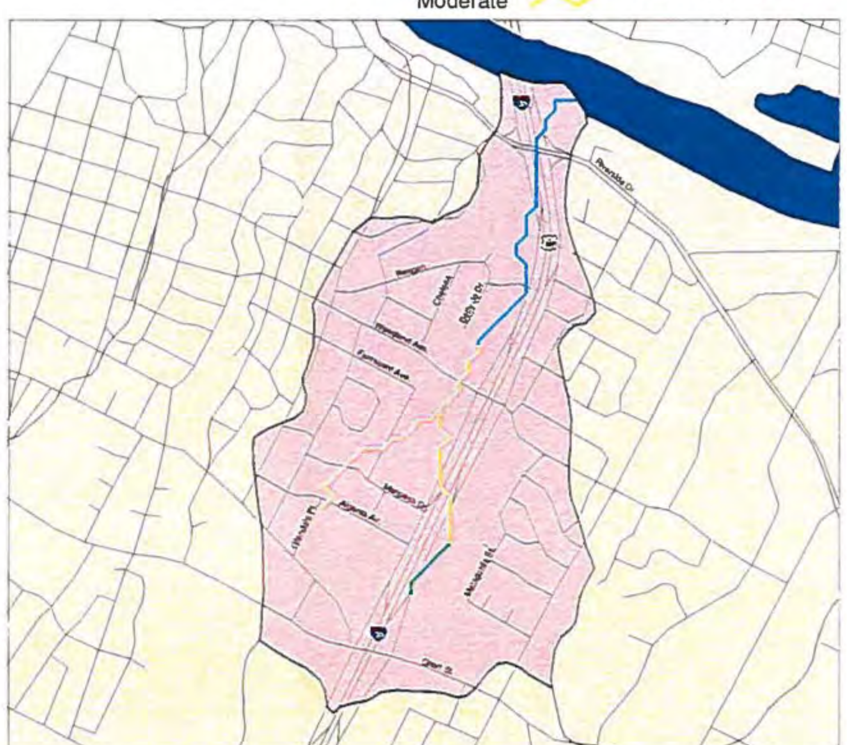
EROSION

Problem Rating: Very Low, Low, Moderate, High, Very High



WATER QUALITY

Problem Rating: Very Low, Low, Moderate, High, Very High



INTEGRATED SCORES

(Flood, Erosion, Water Quality, and Citizen Survey)

Problem Rating: Very Low, Low, Moderate, High, Very High

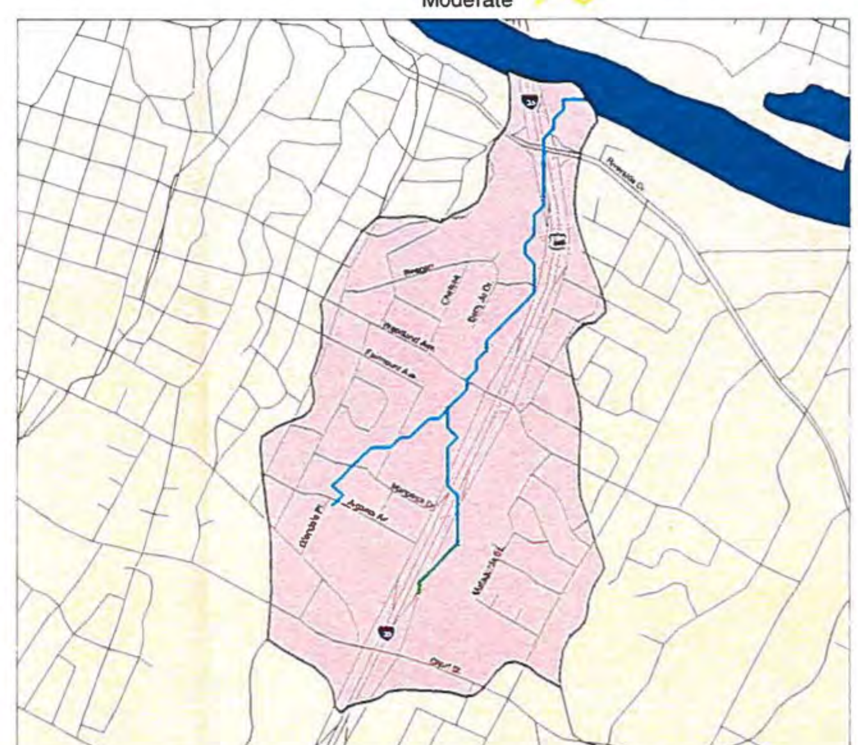
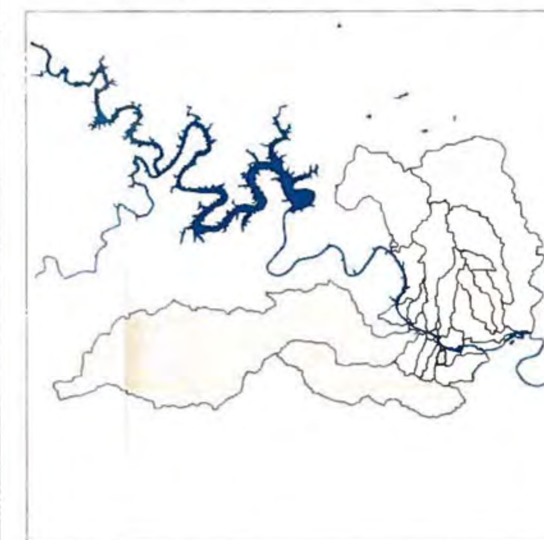


Figure 8 - 14

Watershed Protection Department

Master Plan Problem Assessment

Harper's Branch



Creeks

Major Roads

Colorado River / Town Lake

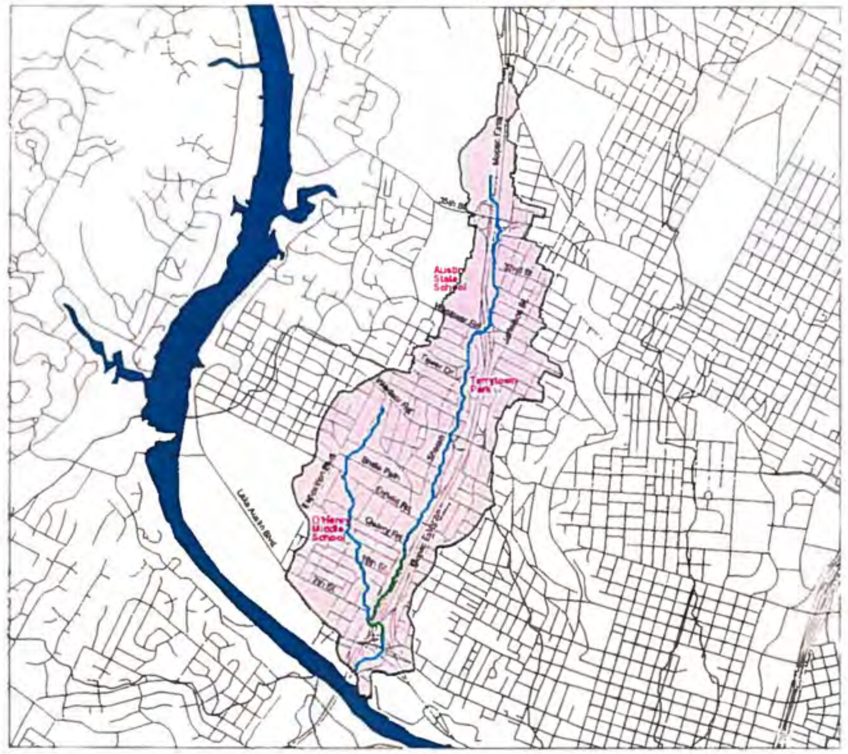
Selected Watershed

Watershed Boundary

N

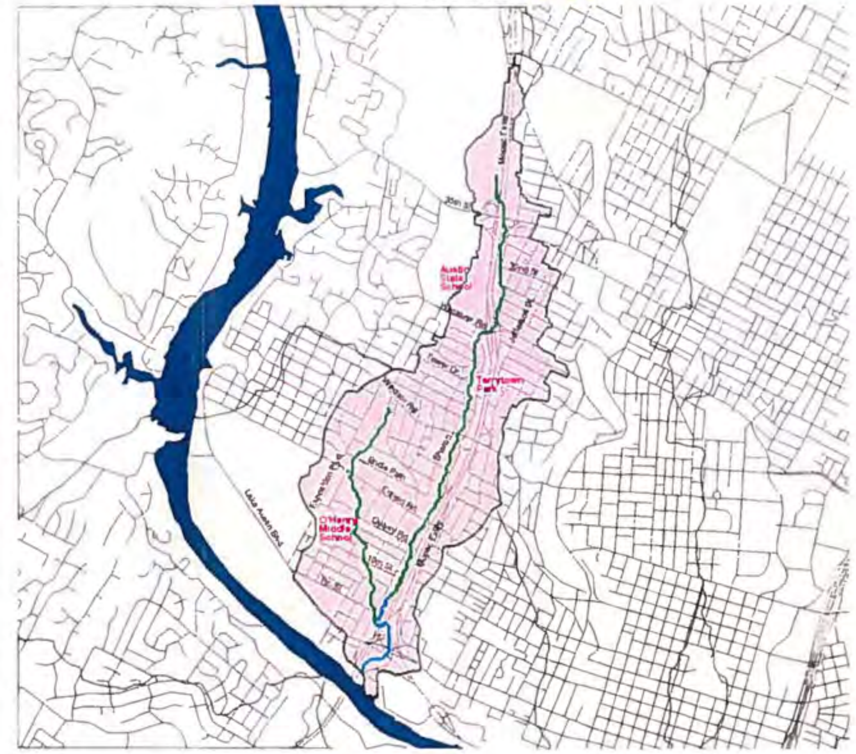
FLOOD

Problem Rating
Very Low
Low
Moderate
High
Very High



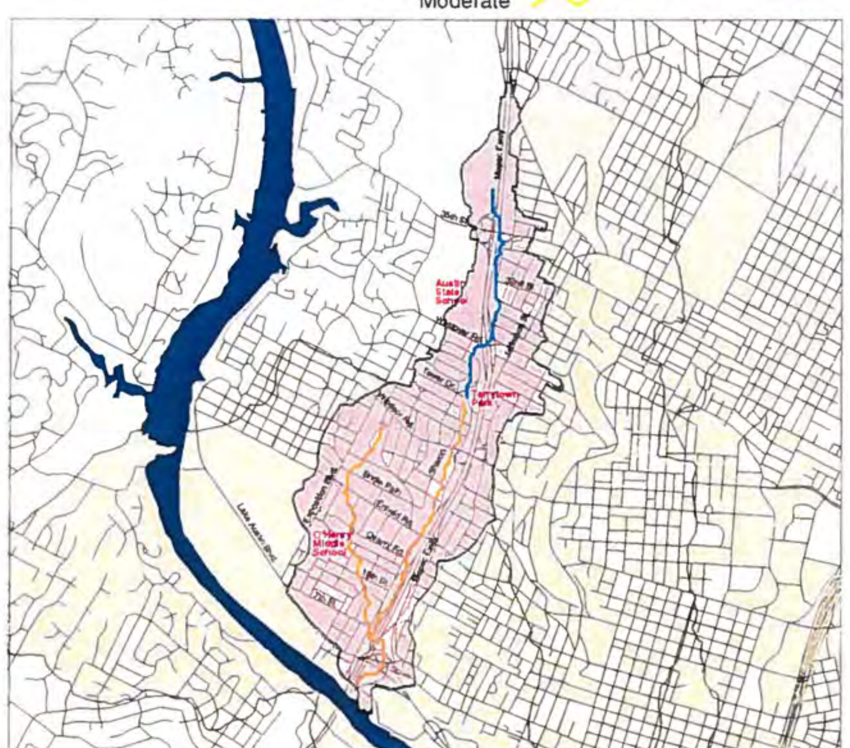
EROSION

Problem Rating
Very Low
Low
Moderate
High
Very High



WATER QUALITY

Problem Rating
Very Low
Low
Moderate
High
Very High



INTEGRATED SCORES
(Flood, Erosion, Water Quality, and Citizen Survey)

Problem Rating
Very Low
Low
Moderate
High
Very High

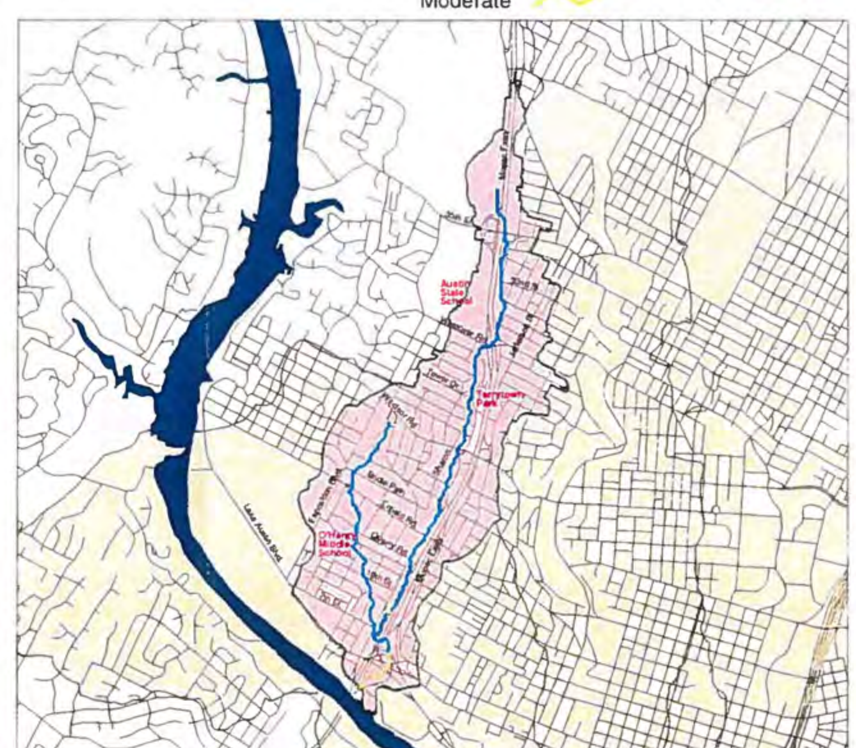
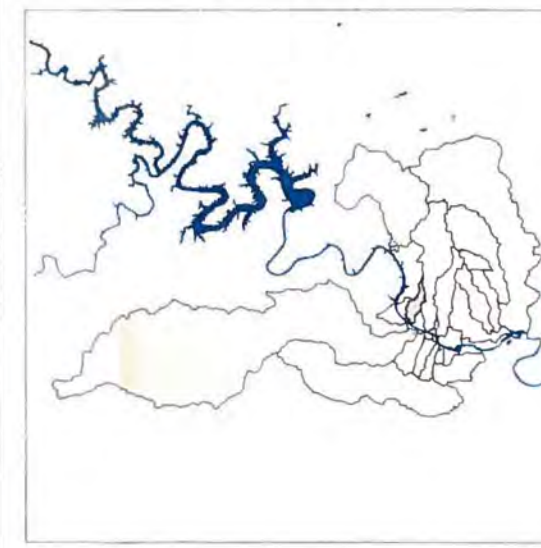


Figure 8 - 15

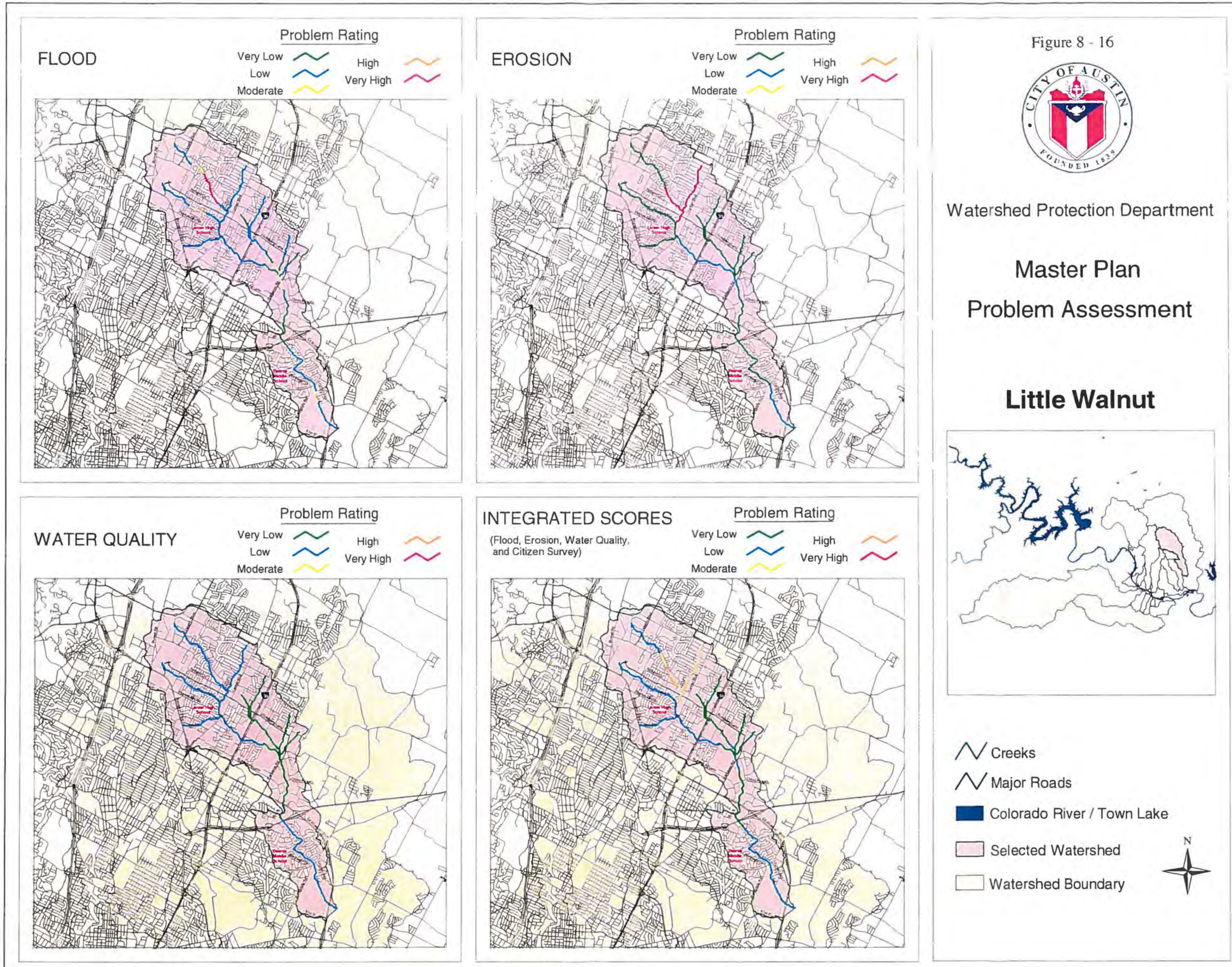
Watershed Protection Department

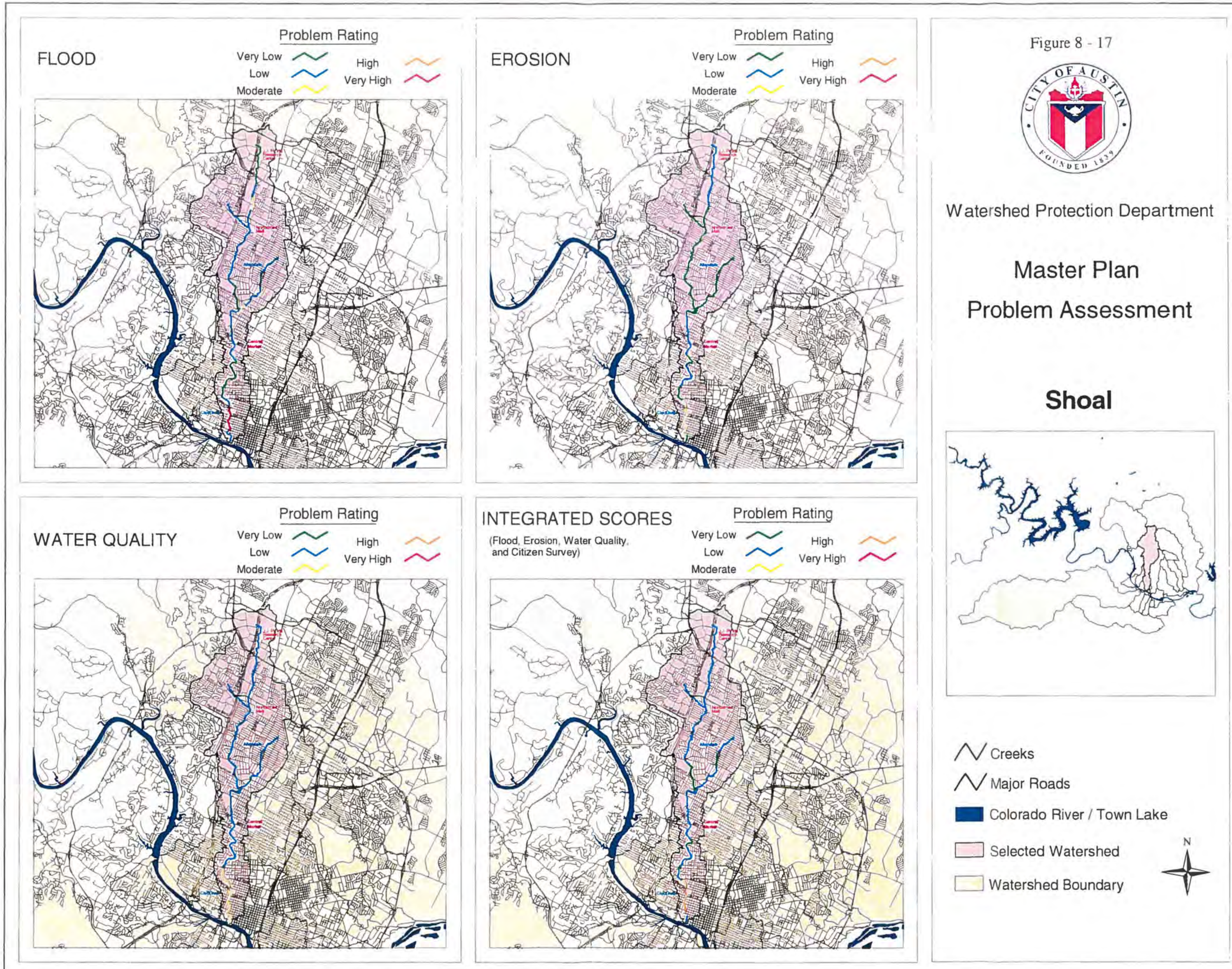
Master Plan
Problem Assessment

Johnson



Creeks
Major Roads
Colorado River / Town Lake
Selected Watershed
Watershed Boundary
N


FLOOD
Problem Rating
Very Low
Low
Moderate
High
Very High
EROSION
Problem Rating
Very Low
Low
Moderate
High
Very High
WATER QUALITY
Problem Rating
Very Low
Low
Moderate
High
Very High
INTEGRATED SCORES
(Flood, Erosion, Water Quality, and Citizen Survey)
Problem Rating
Very Low
Low
Moderate
High
Very High
Figure 8 - 16
CITY OF AUSTIN
FOUNDED 1839
Watershed Protection Department
Master Plan
Problem Assessment
Little Walnut
Creeks
Major Roads
Colorado River / Town Lake
Selected Watershed
Watershed Boundary
N

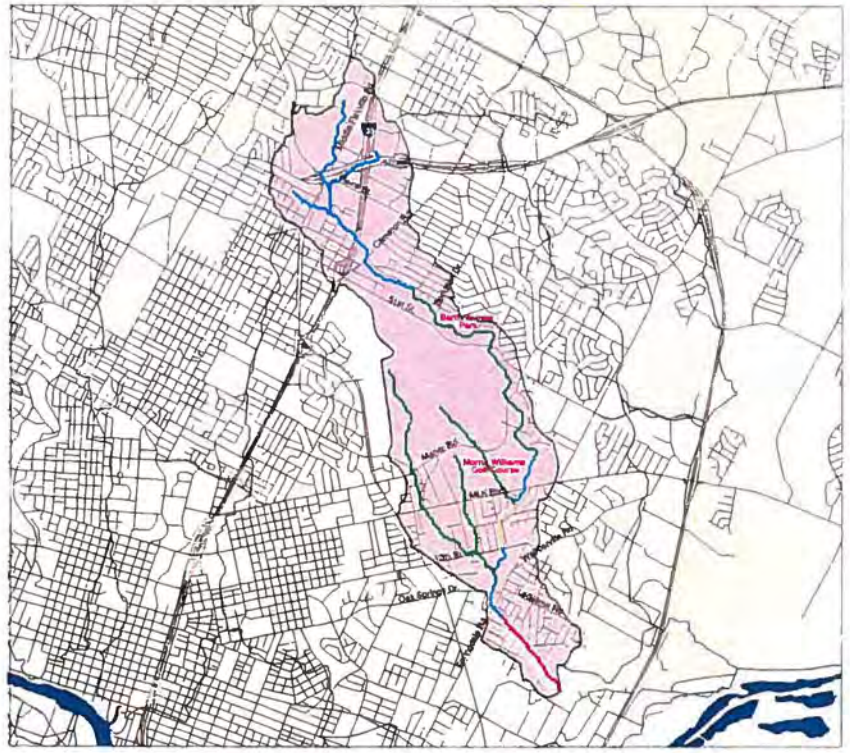


FLOOD
Problem Rating
Very Low
Low
Moderate
High
Very High
EROSION
Problem Rating
Very Low
Low
Moderate
High
Very High
WATER QUALITY
Problem Rating
Very Low
Low
Moderate
High
Very High
INTEGRATED SCORES
(Flood, Erosion, Water Quality, and Citizen Survey)
Problem Rating
Very Low
Low
Moderate
High
Very High
Figure 8 - 17
Watershed Protection Department
Master Plan
Problem Assessment
Shoal
Creeks
Major Roads
Colorado River / Town Lake
Selected Watershed
Watershed Boundary
N

FLOOD

Problem Rating

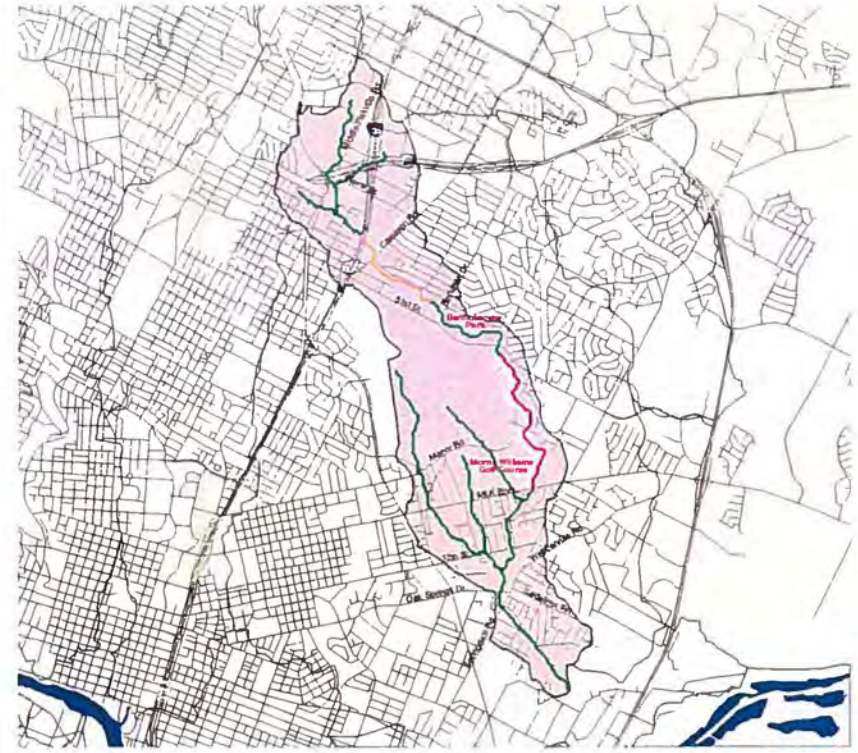
Very Low, Low, Moderate, High, Very High



EROSION

Problem Rating

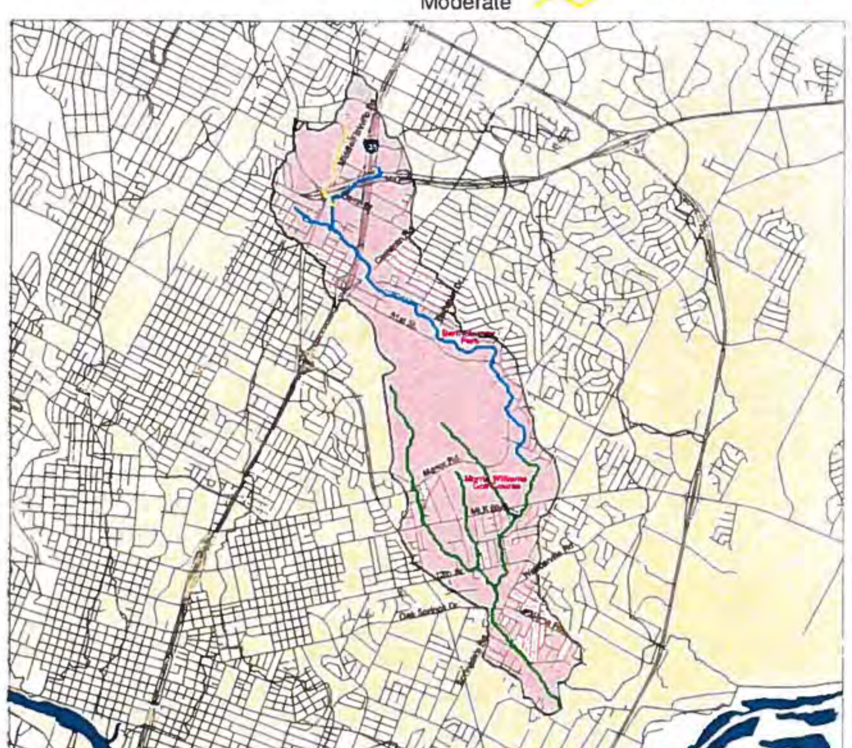
Very Low, Low, Moderate, High, Very High



WATER QUALITY

Problem Rating

Very Low, Low, Moderate, High, Very High



INTEGRATED SCORES

(Flood, Erosion, Water Quality, and Citizen Survey)

Problem Rating

Very Low, Low, Moderate, High, Very High

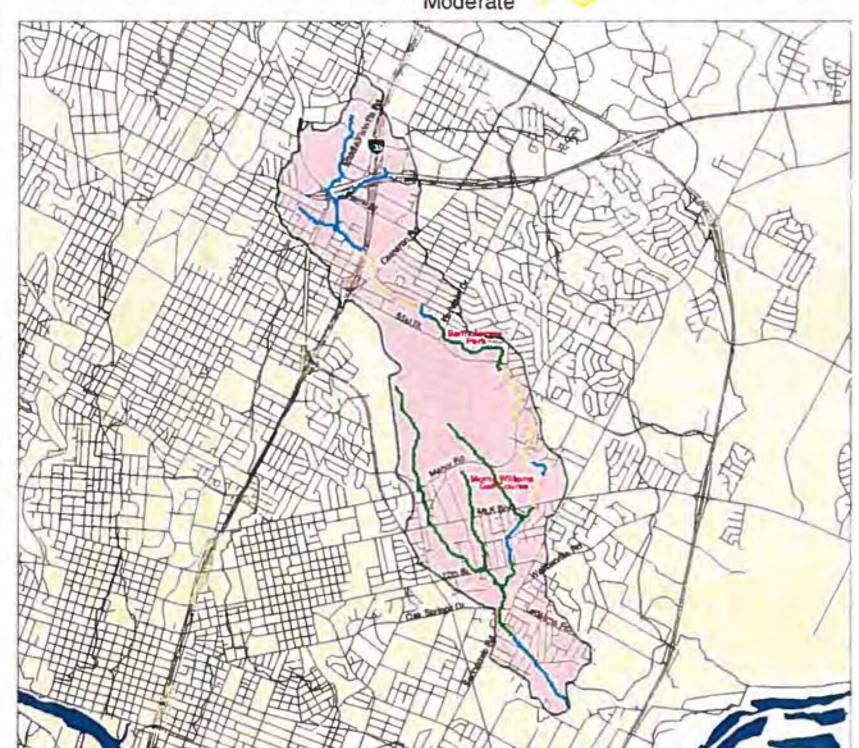
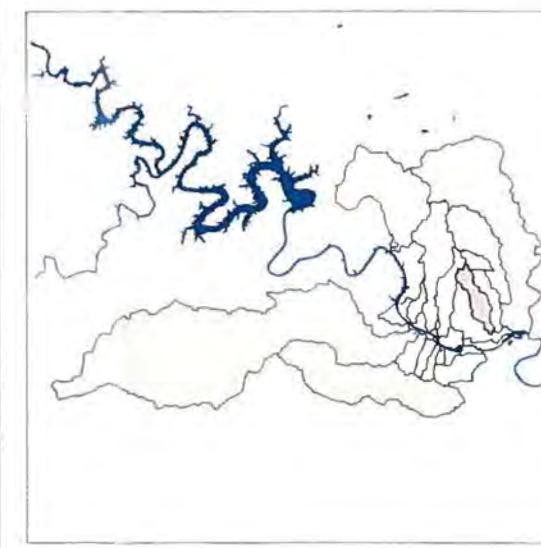


Figure 8 - 18

Watershed Protection Department

Master Plan Problem Assessment

Tannehill



Creeks

Major Roads

Colorado River / Town Lake

Selected Watershed

Watershed Boundary

N

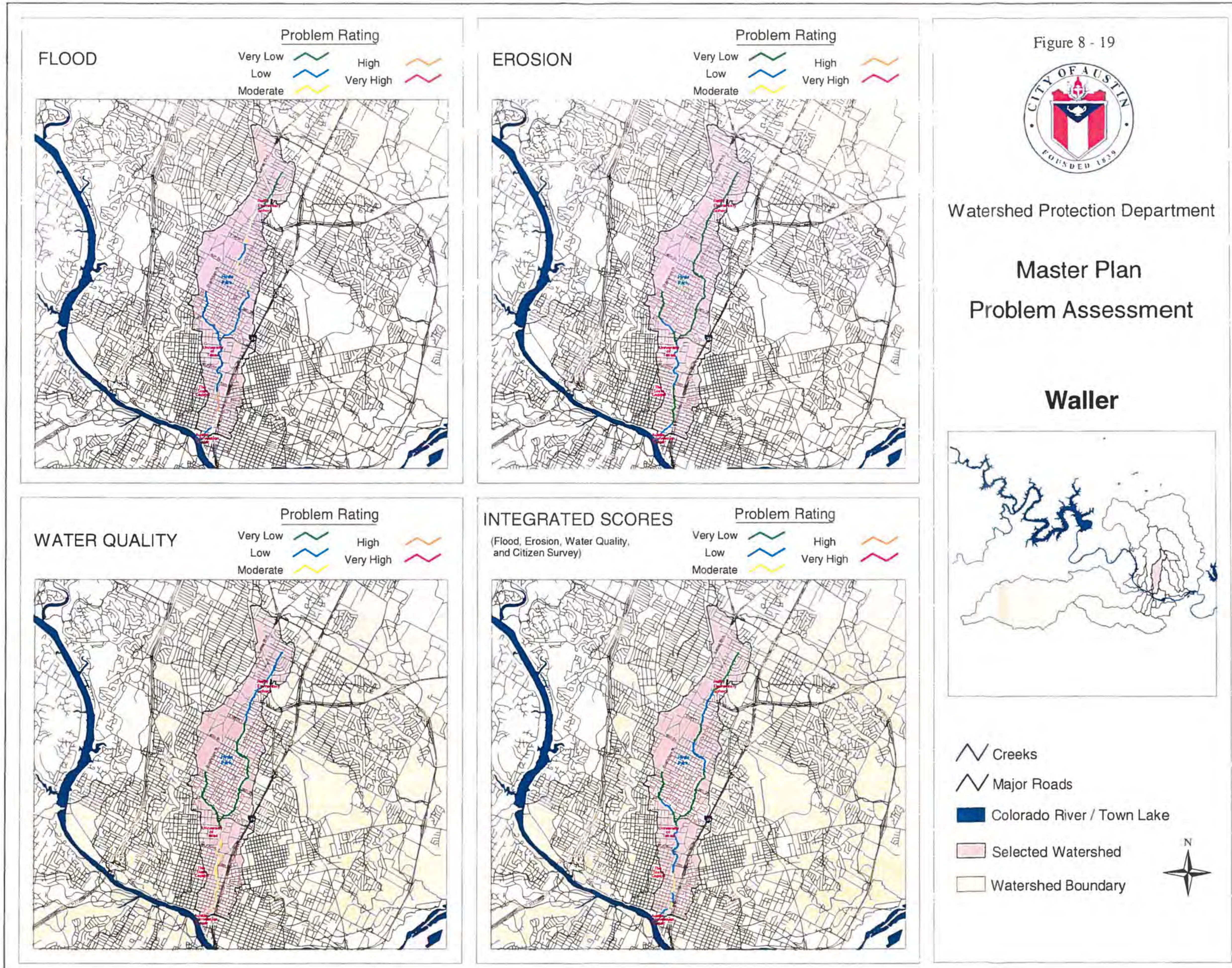
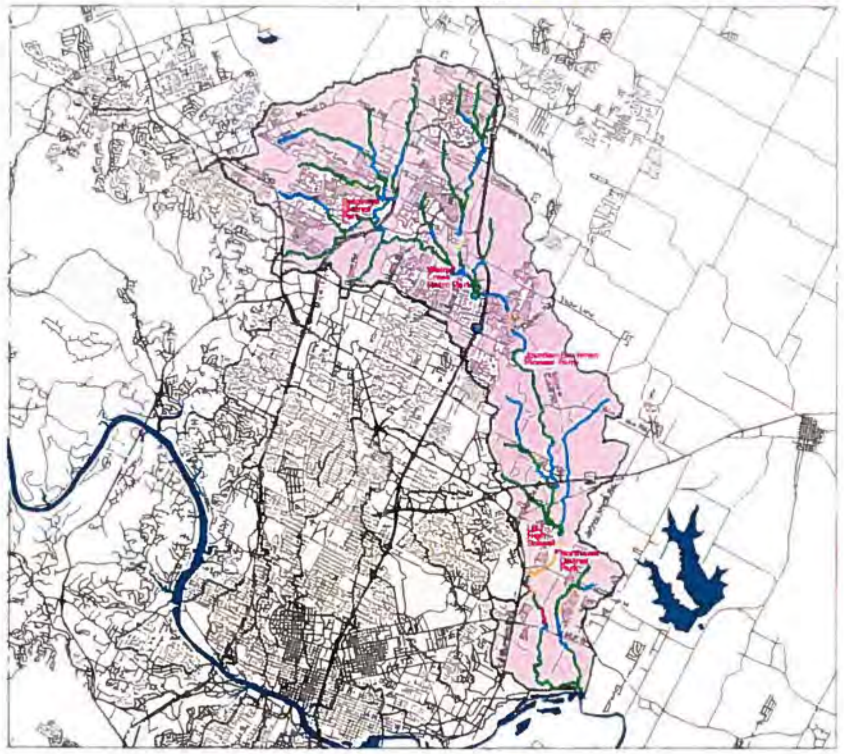


Figure 8 - 19
Watershed Protection Department
Master Plan
Problem Assessment
Waller
FLOOD
Problem Rating
Very Low
Low
Moderate
High
Very High
EROSION
Problem Rating
Very Low
Low
Moderate
High
Very High
WATER QUALITY
Problem Rating
Very Low
Low
Moderate
High
Very High
INTEGRATED SCORES
(Flood, Erosion, Water Quality, and Citizen Survey)
Problem Rating
Very Low
Low
Moderate
High
Very High
Creeks
Major Roads
Colorado River / Town Lake
Selected Watershed
Watershed Boundary
N

FLOOD

Problem Rating

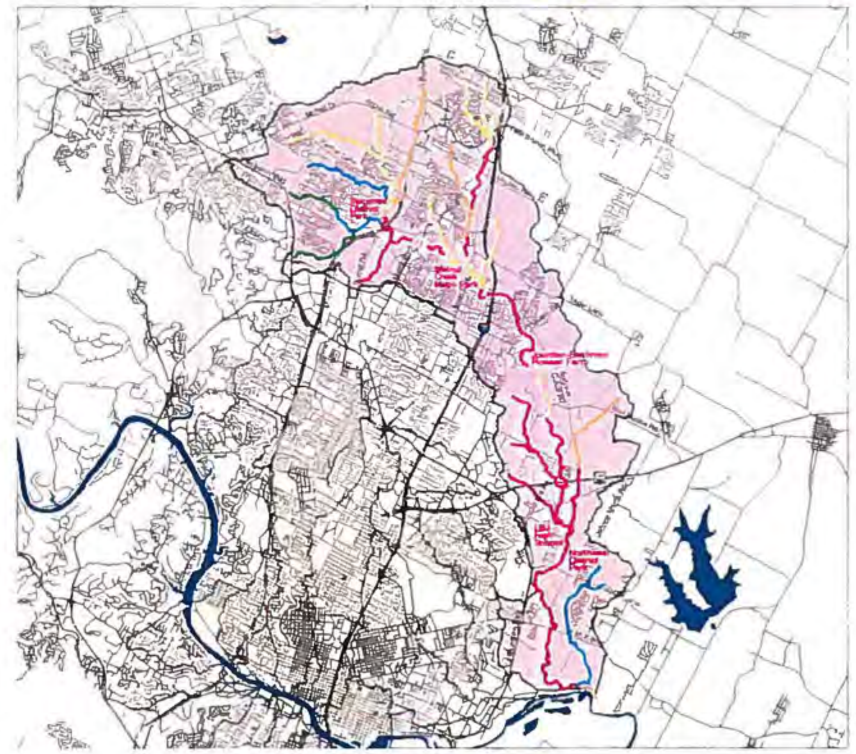
Very Low, Low, Moderate, High, Very High



EROSION

Problem Rating

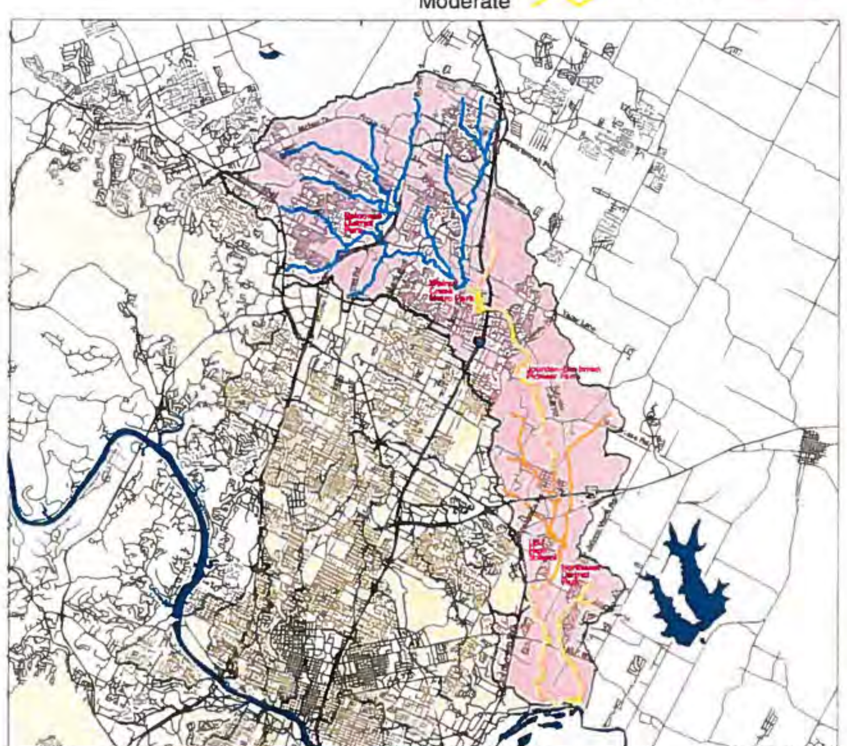
Very Low, Low, Moderate, High, Very High



WATER QUALITY

Problem Rating

Very Low, Low, Moderate, High, Very High



INTEGRATED SCORES

(Flood, Erosion, Water Quality, and Citizen Survey)

Problem Rating

Very Low, Low, Moderate, High, Very High

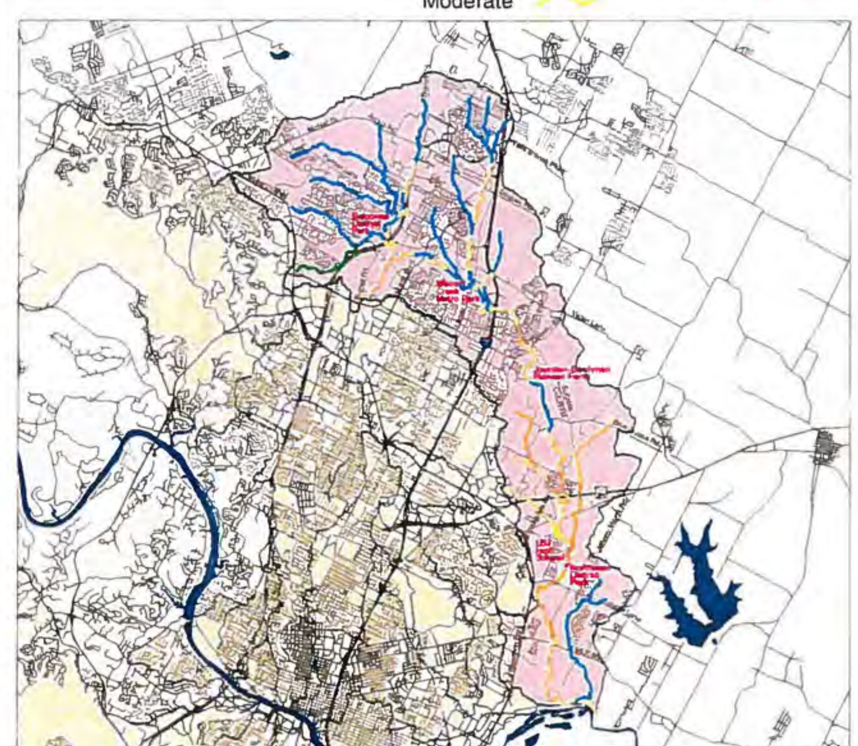
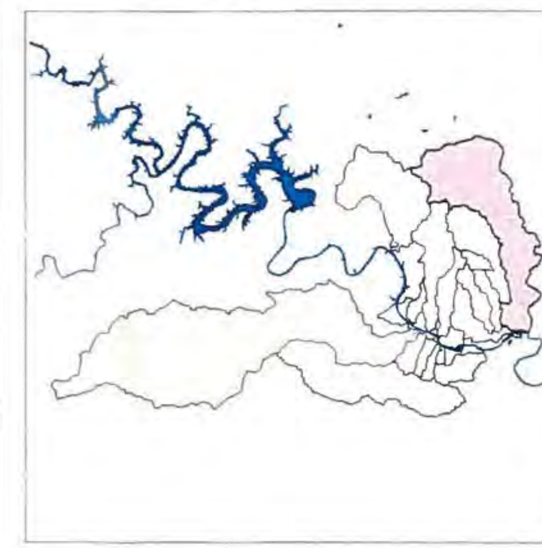


Figure 8 - 20

Watershed Protection Department

Master Plan Problem Assessment

Walnut



Creeks

Major Roads

Colorado River / Town Lake

Selected Watershed

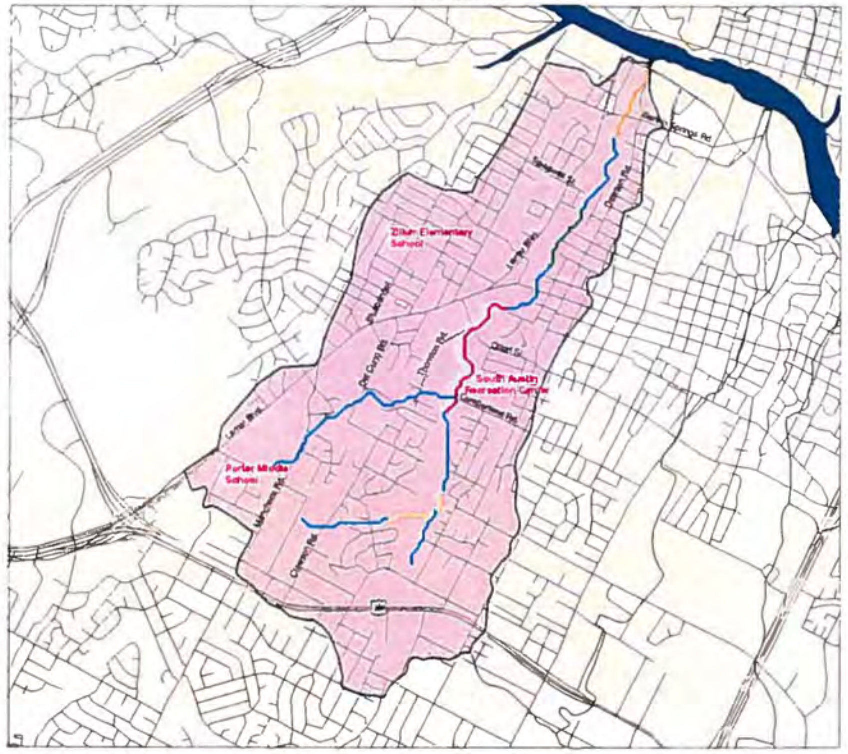
Watershed Boundary

N

FLOOD

Problem Rating

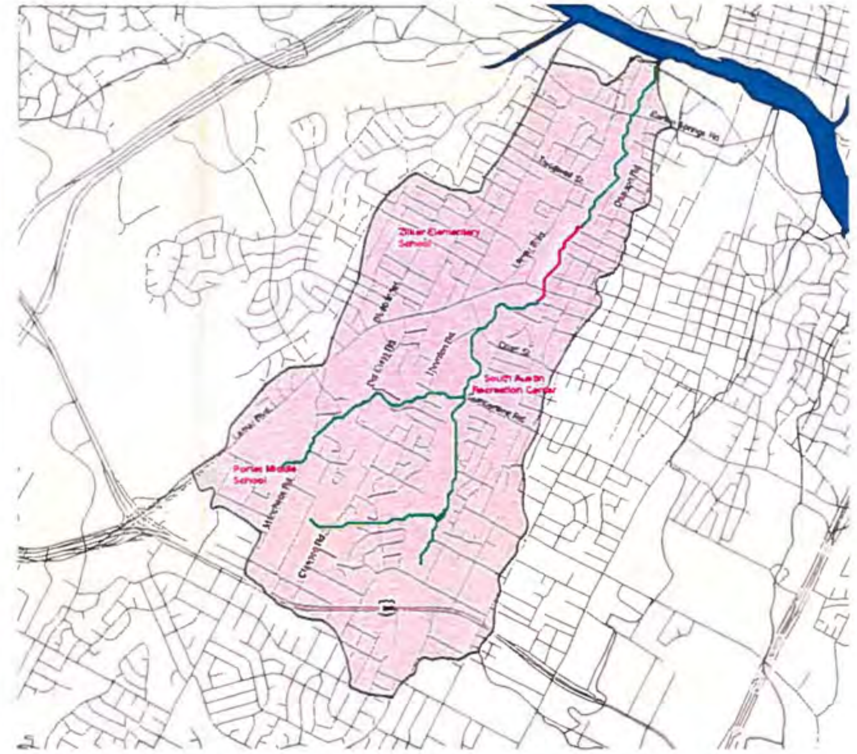
Very Low, Low, Moderate, High, Very High



EROSION

Problem Rating

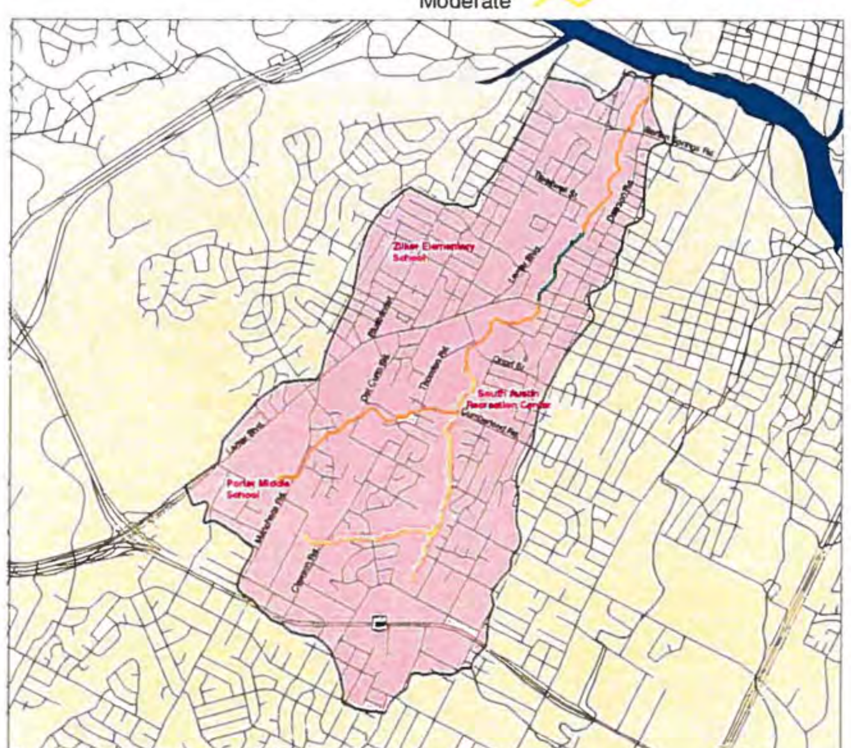
Very Low, Low, Moderate, High, Very High



WATER QUALITY

Problem Rating

Very Low, Low, Moderate, High, Very High



INTEGRATED SCORES

(Flood, Erosion, Water Quality, and Citizen Survey)

Problem Rating

Very Low, Low, Moderate, High, Very High

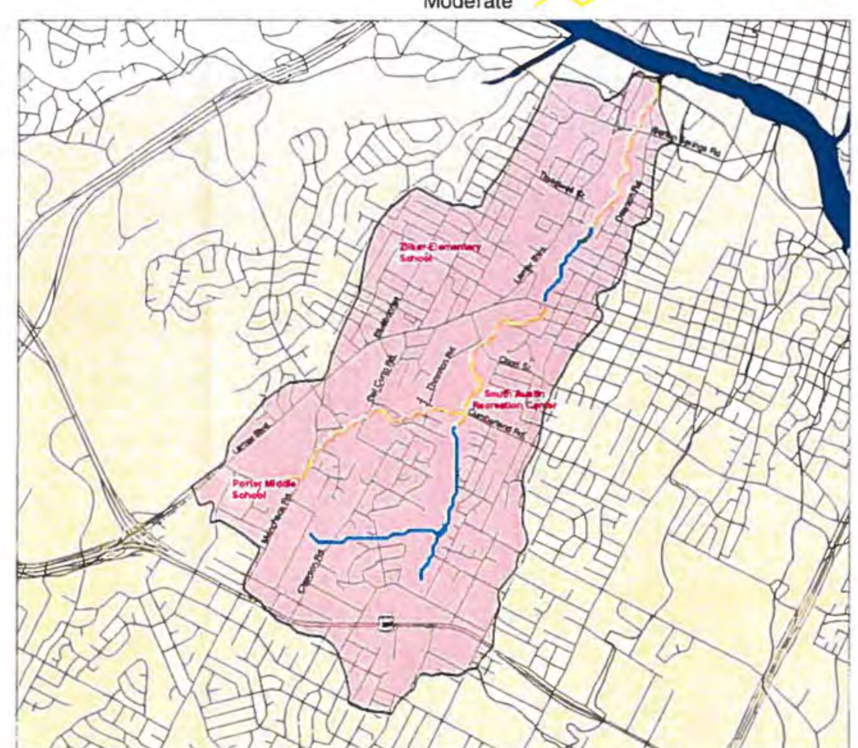
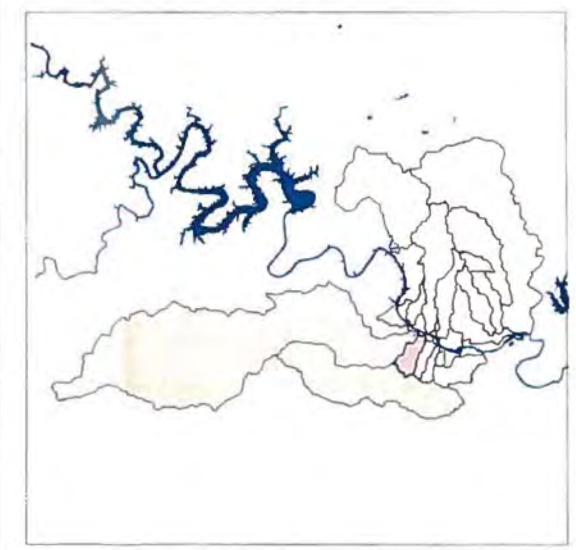


Figure 8 - 21

Watershed Protection Department

Master Plan
Problem Assessment

West Bouldin



Creeks

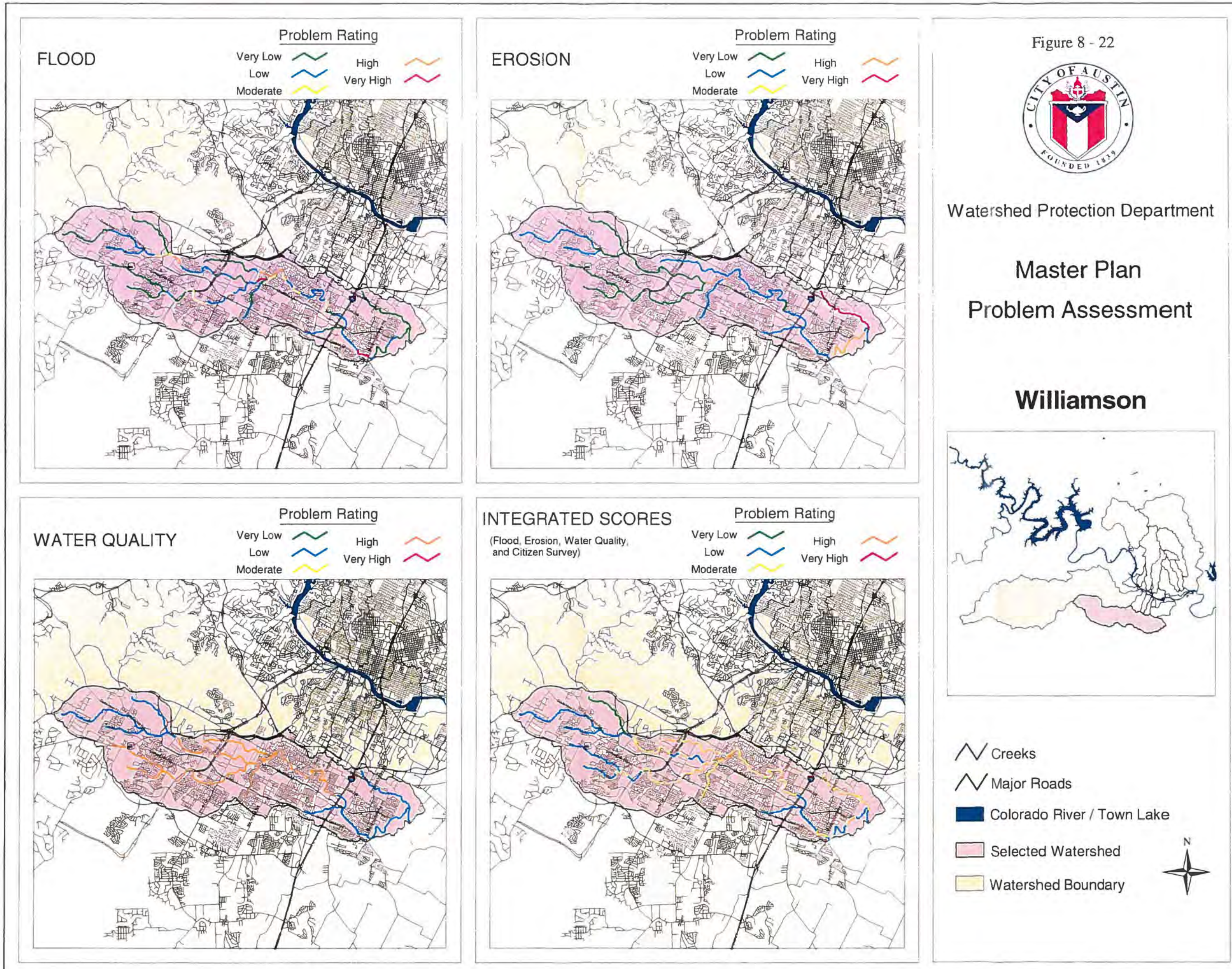
Major Roads

Colorado River / Town Lake

Selected Watershed

Watershed Boundary

N


FLOOD
Problem Rating
Very Low
Low
Moderate
High
Very High
EROSION
Problem Rating
Very Low
Low
Moderate
High
Very High
WATER QUALITY
Problem Rating
Very Low
Low
Moderate
High
Very High
INTEGRATED SCORES
(Flood, Erosion, Water Quality, and Citizen Survey)
Problem Rating
Very Low
Low
Moderate
High
Very High
Figure 8 - 22
CITY OF AUSTIN
FOUNDED 1839
Watershed Protection Department
Master Plan
Problem Assessment
Williamson
Creeks
Major Roads
Colorado River / Town Lake
Selected Watershed
Watershed Boundary
N