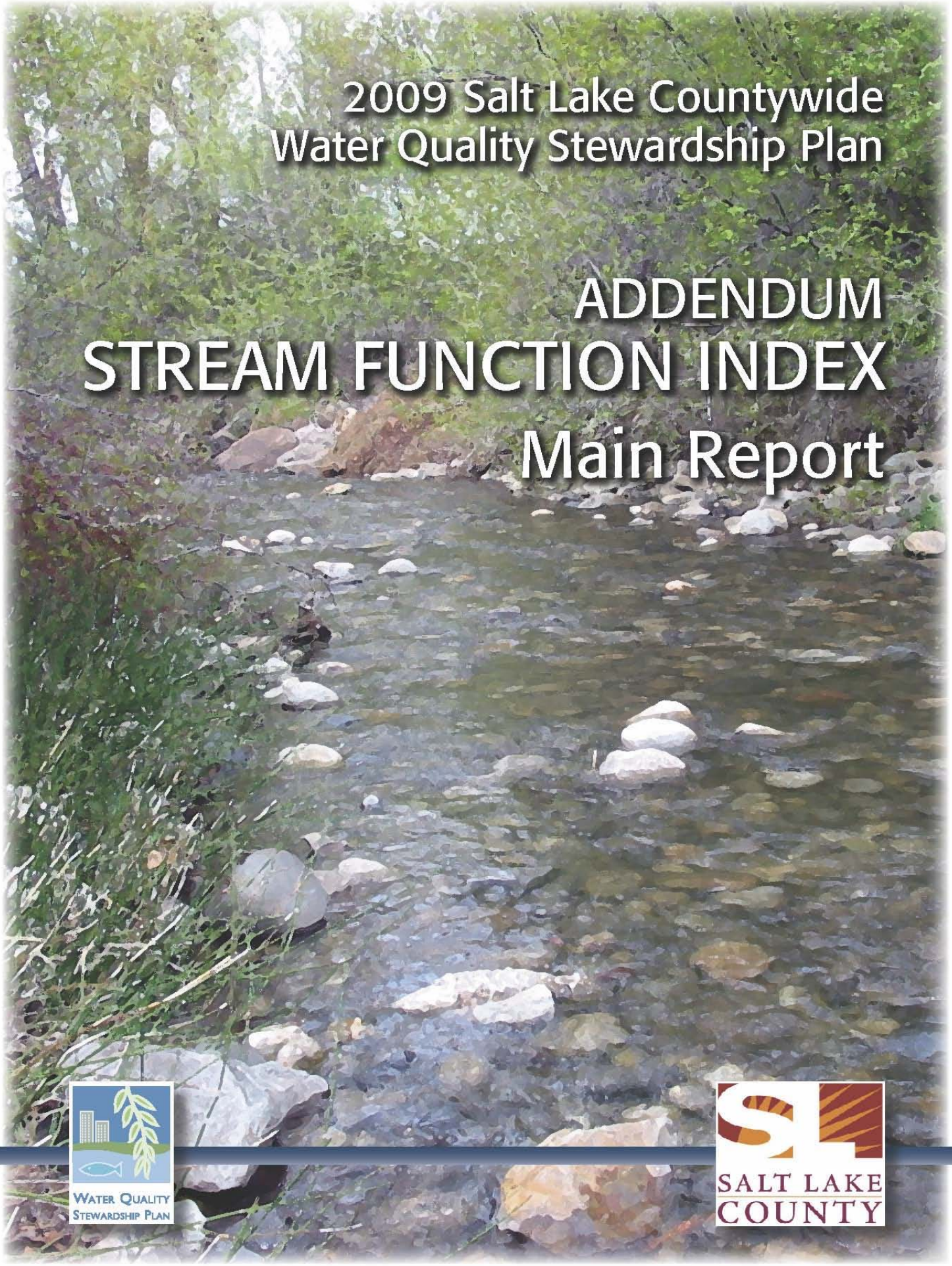

2009 Salt Lake Countywide Water Quality Stewardship Plan

ADDENDUM
STREAM FUNCTION INDEX
Main Report

WATER QUALITY STEWARDSHIP PLAN

SALT LAKE COUNTY

2009

SALT LAKE COUNTYWIDE
WATER QUALITY STEWARDSHIP PLAN

ADDENDUM
STREAM FUNCTION INDEX
MAIN REPORT

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April 2010

SALT LAKE COUNTY

WATER QUALITY STEWARDSHIP PLAN

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The SFI is a monitoring tool for the WaQSP and is unique for Utah and the Intermountain Region. While several rapid assessment protocols exist for western range and forest land streams, no examples are available for urban settings. In addition, entire perennial and intermittant stream systems, from their high mountain upper watershed to the urbanized valley, needed to be evaluated by the same protocol. This report represents over three years of coordination with the WaQSP team, planning and developing protocol, data collection and management, analysis, mapping, and document preparation. Many thanks go to the hard work and professional advice that allowed us to develop this essential monitoring tool needed for implementation of the WaQSP.

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ABSTRACT

The Stream Function Index (SFI) is a rapid assessment monitoring tool developed by Salt Lake County to help achieve the goals of the Salt Lake Countywide Water Quality Stewardship Plan (WaQSP) 2009. The SFI measures the general health and condition of major streams and the Jordan River in the County and provides the framework for further detailed studies and monitoring. The condition of the streams identifies water quality stressors along the waterways and within the watershed which then become candidates for improvements. The SFI contains two parts: the Ecosystem Health Index (EHI) that addresses the physical, chemical and biological elements of the waterways, and the Social Function that addresses the social factors that influence water quality and quality of life in Salt Lake County. The first complete dataset was collected during the 2007 and 2008 field seasons and is considered the baseline. The SFI will be repeated every 6 years in conjunction with the Water Quality Stewardship Plan Update.

GLOSSARY

303(d) List of Impaired Waters
The list of impaired and threatened waters (stream/river segments, lakes) that the Clean Water Act requires all states to submit for EPA approval every two years on even-numbered years. The states identify all waters where required pollution controls are not sufficient to attain or maintain applicable water quality standards, and establish priorities for development of TMDLs based on the severity of the pollution and the sensitivity of the uses to be made of the waters, among other factors (40C.F.R. §130.7(b)(4)). States then provide a long-term plan for completing TMDLs within 8 to 13 years from first listing.

Americans with Disabilities Act (ADA)
The Americans with Disabilities Act (ADA) was signed into law under President George H. W. Bush in 1990. It applies to all private and state-run businesses, employment agencies and unions with more than fifteen employees. The goal of the ADA is to make sure that no qualified person with any kind of disability is turned down for a job or promotion, or refused entry to a public-access area.

Aquatic
Living or growing in, or on, the water.

Area-wide Water Quality Management Agency
A regional planning organization established to develop area-wide management plans for the control of water quality pollution. These plans are required to identify waste treatment facilities, specify construction priorities and develop a regulatory program.

Beneficial Use (water quality) A desirable use that water quality should support. Beneficial uses include drinking water, primary contact recreation (such as swimming), and aquatic life support.

Benthic Invertebrate
Insects, mollusks, crustaceans, worms, and other organisms without a backbone that live in, on, or near the bottom of lakes, streams, or oceans.

Best Management Practices (BMPs)
Techniques that are determined to be currently effective, practical means of preventing or reducing pollutants from point and nonpoint sources, in order to protect water quality. BMPs include, but are not limited to: structural and nonstructural controls, operation and maintenance procedures, and other practices.

Dissolved Oxygen (DO)
The oxygen freely available in water, vital to fish and other aquatic life and for the prevention of odors. DO levels are considered a most important indicator of a water body's ability to support desirable aquatic life. Secondary and advanced waste treatment are generally designed to ensure adequate DO in waste-receiving waters.

E. coli
An enterobacterium (*Escherichia coli*) that is used in public health as an indicator of fecal pollution (as of water or food); may produce a toxin causing intestinal illness.

Ecosystem Health Index (EHI)
A score resulting from rapid assessment of physical chemical and biological conditions of waterways.

Emergent Bench
The land along a stream or river where the elevation is low enough to be saturated or flooded during yearly normal high flows. It supports emergent plants and other plants tolerant of a high water table such as cottonwood trees.

Emergent Plants
Emergent Plants are rooted plants often along the shoreline that stand above the surface of the water e.g., cattails. The stems of emergent plants are somewhat stiff or firm.

Entrenchment
The process of downward erosion so as to form a trench.

Eutrophication
The process by which water becomes enriched with plant nutrients, most commonly phosphorus and nitrogen.

Floodplain A floodplain is the area on the sides of a stream, river, or watercourse that is subject to periodic flooding. The extent of the floodplain is dependent on soil type, topography, and water flow characteristics.

Gabion
A basket or cage filled with earth or rocks and used in building a support or abutment. Often used to stabilize soils on a stream bank.

Gaging station
A particular site on a stream, canal, lake, or reservoir where systematic observations of hydrologic data are obtained.

Geographic Information System (GIS)
GIS is a system of hardware and software used for storage, retrieval, mapping, and analysis of geographic data.

Gradient (stream)
Change in elevation of the stream bed.

Habitat
The area or environment where an organism or ecological community normally lives or occurs.

Hotspot (erosion)
A location on a stream bank that is actively eroding.

Hydraulics
The physical science and technology of the static and dynamic behavior of fluids.

Hydrology
The science encompassing the behavior of water as it occurs in the atmosphere, on the surface of the ground, and underground.

Impervious
Incapable of being penetrated by water; non-porous.

Intermittent Stream
Streams that flow for a portion of the year or seasonally.

Interrupted Stream Flow
Flows that are completely dewatered for any time during the year as a result of diversions.

Macroinvertebrate
Animals large enough to be seen by the naked eye (macro) and lacking backbones (invertebrate).

Metric
Unit of measure.

Nonpoint Source
A source of water pollution generally associated with rainfall runoff or snowmelt. The quality and rate of runoff of NPS pollution is strongly dependent on the type of land cover and landuse from which the rainfall runoff flows. For example, rainfall runoff from forested lands will generally contain much less pollution and runoff more slowly than runoff from urban lands.

Perennial Stream
Streams that flow continuously throughout the year.

Pervious
Capable of being penetrated by water; porous.

Point source Pollution originating at a discrete source and conveyed through a discrete system.

Pool Riffle Ratio
The ratio of pools to riffles in a stream. The alternating sequence of deep pools and shallow riffles along the relatively straight course of a river.

Rapid Assessment
A quick scientific survey or count that helps measure local biodiversity to obtain knowledge of life in a selected ecosystem or area, ideally with minimum time and resources.

Reach
A continuous part of a stream between two specified points. The smallest unit of stream evaluated for the SFI.

Recreation Node
A managed public recreation facility such as a park or trailhead. Larger parks will have a variety of activity centers such as pavilions or ball fields.

Reduced Stream Flows
Instream flows are significantly reduced by diversions for irrigation or water supply.

Riffle
A rocky shoal or sandbar lying just below the surface of a waterway. A stretch of choppy water caused by such a shoal or sandbar.

Riparian
Relating to or living or located on the bank of a natural watercourse (as a river) or sometimes of a lake or a tidewater.

Riprap

Broken stones, rocks or boulders placed on embankments or used in river work for protecting earth surfaces against scour, and erosion.

Sediment
Particles, derived from rocks or biological materials, that have been transported by a fluid or other natural process, suspended or settled in water.

Segment
A collection of stream reaches that form a continuous part of a stream between two specified points.

Sinuosity
The ratio of the channel length between two points on a channel to the straight-line distance between the same two points; a measure of meandering.

STORET
The STORET (short for STOrage and RETrieval) Data Warehouse is a repository for water quality, biological, and physical data and is used by state environmental agencies, EPA and other federal agencies, universities, private citizens, and many others.

Streamflow
The discharge of water in a natural channel.

Stream Function Index (SFI)
A score resulting from rapid assessment of physical chemical and biological conditions (EHI) and social impacts and values of waterways.

Stream Type
Stream classification system developed by Rosgen (1996) on the basis of the form of the channel to aid in the understanding of stream condition and potential behavior under the influence of different types of changes.

Stressor
Any physical, chemical, or biological entity that can induce an adverse response.

Targets
A value that is used to measure against.

Terrestrial
Pertaining to, consisting of, or representing the Earth.

Total Maximum Daily Load (TMDL)
The amount, or load, of a specific pollutant that a water body can assimilate and still meet water quality standards for its designated use. For impaired waters, the TMDL allocates allowable pollutant loads from specific sources (i.e. point sources, nonpoint sources, background or natural loads, a margin of safety, and sometimes an allocation for future growth).

Total Dissolved Solids (TDS)
All material that passes through the standard glass river filter; now called total filtrable residue. Term is used to reflect salinity.

Total Phosphorus (TP)
A measure of the total concentration of all of the various forms of phosphorus found in a water sample.

Water Quality Standards
Standards that set the goals, pollution limits, and protection requirements for each waterbody. These standards are composed of designated (beneficial) uses, numeric and narrative criteria, and antidegradation policies and procedures.

Watershed
Land area that drains to a common waterway such as a stream, lake, or wetland.

Width to Depth Ratio
The ratio of the bankfull channel width to the bankfull channel depth. Bankfull is indentified by Rosgen (1996) as regular high flows reoccurring every 1.2 to 1.5 years.

Kayaker on the Jordan River.

1.0 INTRODUCTION

The Stream Function Index (SFI) is a rapid assessment monitoring tool developed by Salt Lake County to help achieve the goals of the Salt Lake Countywide Water Quality Stewardship Plan (WaQSP) 2009. The SFI measures the general health and condition of major streams and the Jordan River in the County and provides the framework for further detailed studies and monitoring. The SFI identifies water quality stressors along the waterways and the effectiveness of watershed management. Projects and policies that will improve stream and watershed conditions can then be identified and implemented.

The SFI monitors a broad spectrum of stream functions that define a healthy watershed, as outlined in Chapter 2 of the WaQSP. The SFI contains two parts: the Ecosystem Health Index (EHI) that addresses the physical, chemical and biological elements of the waterways, and the Social Function which addresses the social factors that influence water quality and quality of life in Salt Lake County.

Streams, as they travel through their watershed, are the recipients of the results of management and activities occurring on the stream itself and within the watershed. The consequences of poorly managed streams and watersheds particularly in desert urban area such as Salt Lake County, affect community economics and livability. Poor management also affects fish, birds and other wildlife that depend on the stream corridors for survival.

The SFI is the first comprehensive assessment of all major waterways in Salt Lake County and is considered the baseline. Twenty five streams totaling approximately 245 miles and 44 miles of the Jordan River were evaluated in Salt Lake County (Figure 1.1.) The SFI uses habitat, hydraulic and social data gathered during 2007 and 2008. The water quality data set was taken from 2001 to 2008 records. Another full set of data will be gathered for the next SFI in 2012 and 2013 and every 6 years thereafter when the WaQSP is updated.

The SFI is intended to give watershed and stream managers an overview of stream conditions in

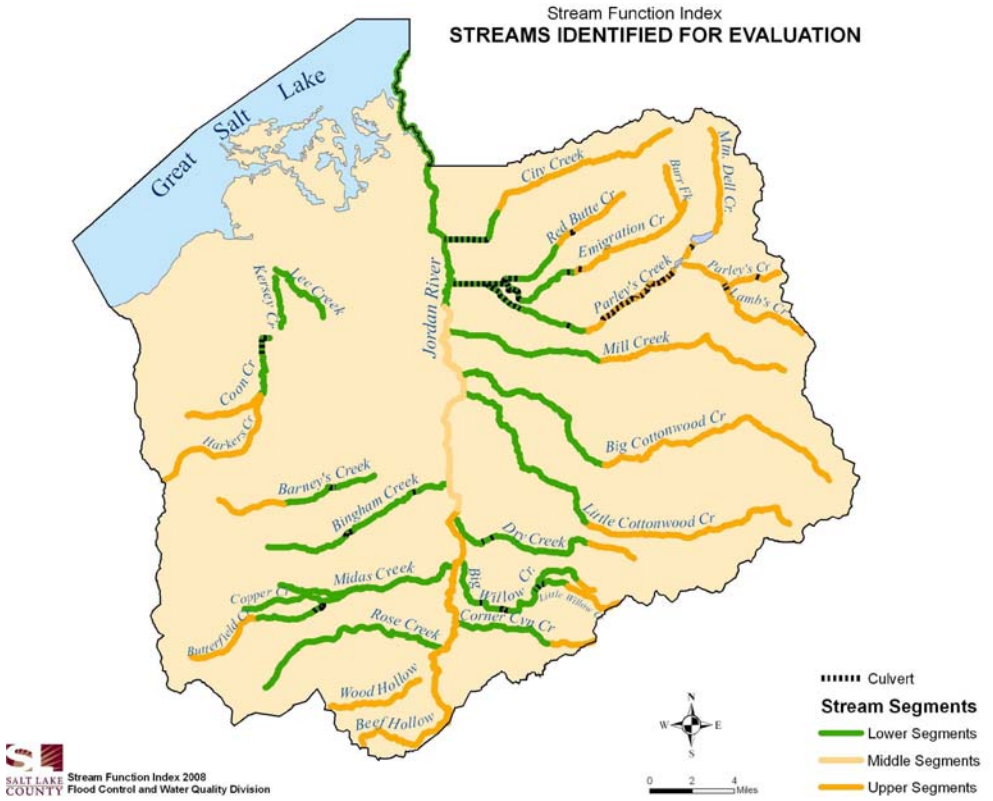


Figure 1.1 Map showing streams selected for evaluation. Streams were divided into upper and lower segments. The Jordan River was divided into upper, middle and lower segments.

order to identify steps to improve or preserve those conditions. As improvement projects are identified, more detailed studies may be required to fully assess the condition of the stream. All SFI results are intended to be shared with the public, cities and agencies. Salt Lake County will use the Index to guide its stewardship of waterways in the unincorporated areas and waterways throughout the County that function as the countywide stormwater and flood control network.

This document describes the overall SFI process with a summary of the methodology, targets, countywide index results and analysis. In addition, results specific to each of the 16 cities in Salt Lake County are written up as separate companion reports. Each City will receive a copy of the main report as well as several copies of their respective City-specific report. They will also receive electronic versions of the reports and Geographic Information System (GIS) shapefiles for their use. All reports will be available digitally on the Salt Lake County website under Watershed Planning.

1.1 SETTING

A variety of stream types and conditions exist in Salt Lake County making monitoring stream conditions a challenge. The County is divided east and west by a major river with its tributaries reaching from mountain wilderness to highly urbanized cityscapes and fast growing suburban areas. Streams in the northwest area of the county flow north to Great Salt Lake (Figure 1.2.) The river and tributaries all vary in character depending on size, water flows, geology, soils, elevation, and landuse.

The SFI protocol is designed to include an evaluation of natural stream channels as well as man-made conditions of Salt Lake County's urbanized areas. Most existing stream assessment protocols were originally designed for forest or

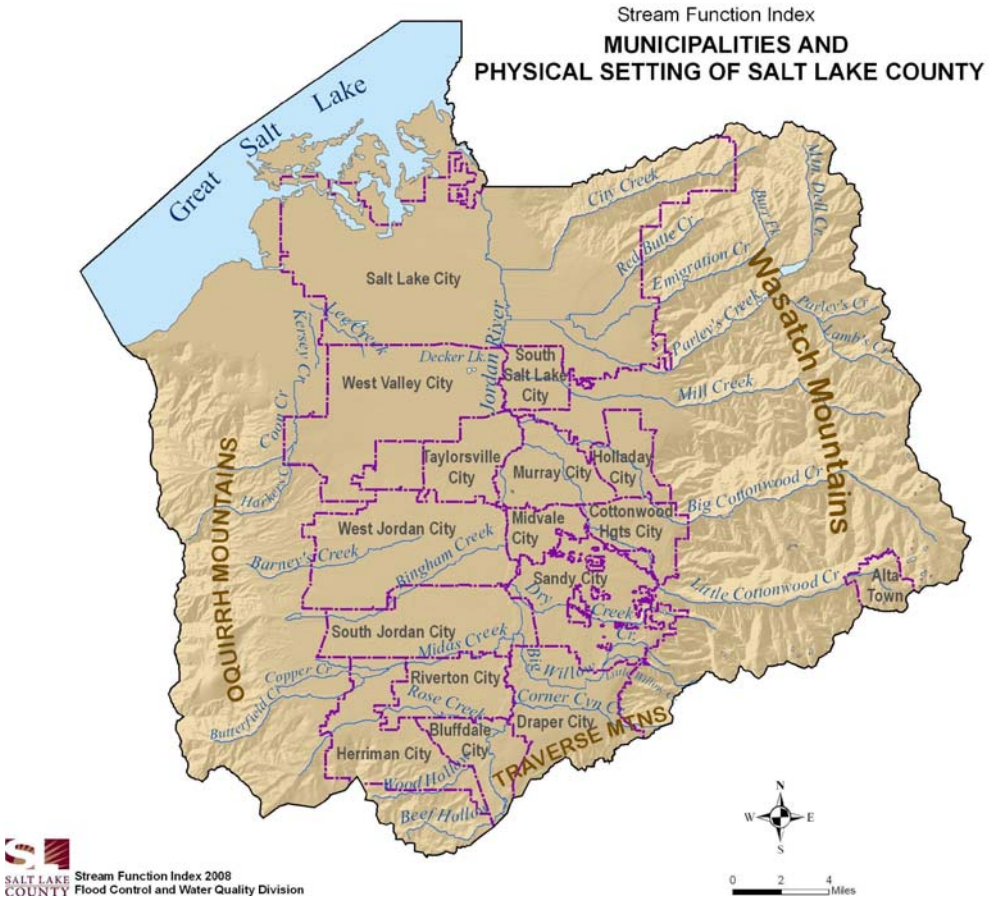


Figure 1.2 Map showing municipalities and physical setting of Salt Lake County

rangelands. Adding an urban element was a challenge that needed to be met in order to realistically characterize the conditions of both the upper non-urbanized and the lower urbanized stream segments in Salt Lake County. The urbanized sub-watersheds have more impervious surfaces and typically have altered and built upon natural floodplains. In addition, riparian vegetation is removed or extremely altered in domestic landscapes, and stabilization structures hold the bank in place rather than vegetation. Road crossings and buildings often define the limits of lateral stream movement. Sediment and debris are removed to keep channels open for flood conveyance. Stream channel characteristics are shaped by the altered water flows including surface diversions, ground water withdrawal, and stormwater conveyance. Streambeds continue to erode and downcut due to many of the factors described above, becoming more entrenched and difficult to stabilize.

1.2 STREAM TYPE

Each waterway in Salt Lake County has a unique character. No two streams are exactly alike nor are the upper mountain and lower valley portions of the same stream alike. Influences creating these differences include natural physical factors such as geology, soils, weather patterns, ground water flows, and precipitation. Disturbances caused by natural and human factors influence their character as well. An example of a natural disturbance is the hydrologic cycle which consists of both dry and wet years. One of the first human disturbance activities by settlers in Salt Lake Valley was water diversion for crop irrigation. Other human disturbances come from building road crossings and streamside development that defines stream alignments. Increased amounts of impervious surfaces with development has increased stormwater runoff into streams that otherwise would have been absorbed into the ground. To accommodate those flows and reduce flood damage to adjacent land, channels have been straightened and stabilized and debris and vegetation has been removed on a regular maintenance schedule, further altering the natural character of these waterways.

Stream management, including flood protection, flood control maintenance and bank stabilization policies, is now moving towards a more watershed -wide model. Studying the physical characteristics of the watershed and stream landforms relating to geology and water is a way of understanding how to manage and improve streams in concert with their natural character. Stream problems are looked at from a watershed point of view, taking into consideration historic conditions and upstream and downstream effects of proposed solutions. This approach emphasizes how sediment enters the stream and how scouring and deposition interact with various flow levels and timing of flows.

To help evaluate stream conditions, a stream type classification system was developed by Rosgen (1996.) Figure 1.3 shows the criteria that the system is based on: stream bed particle size, entrenchment (vertical containment), bankfull (normal high water) width to depth ratio, channel sinuosity, and stream slope. Detailed descriptions of the stream type criteria can be found in Appendix C Methodology Report.

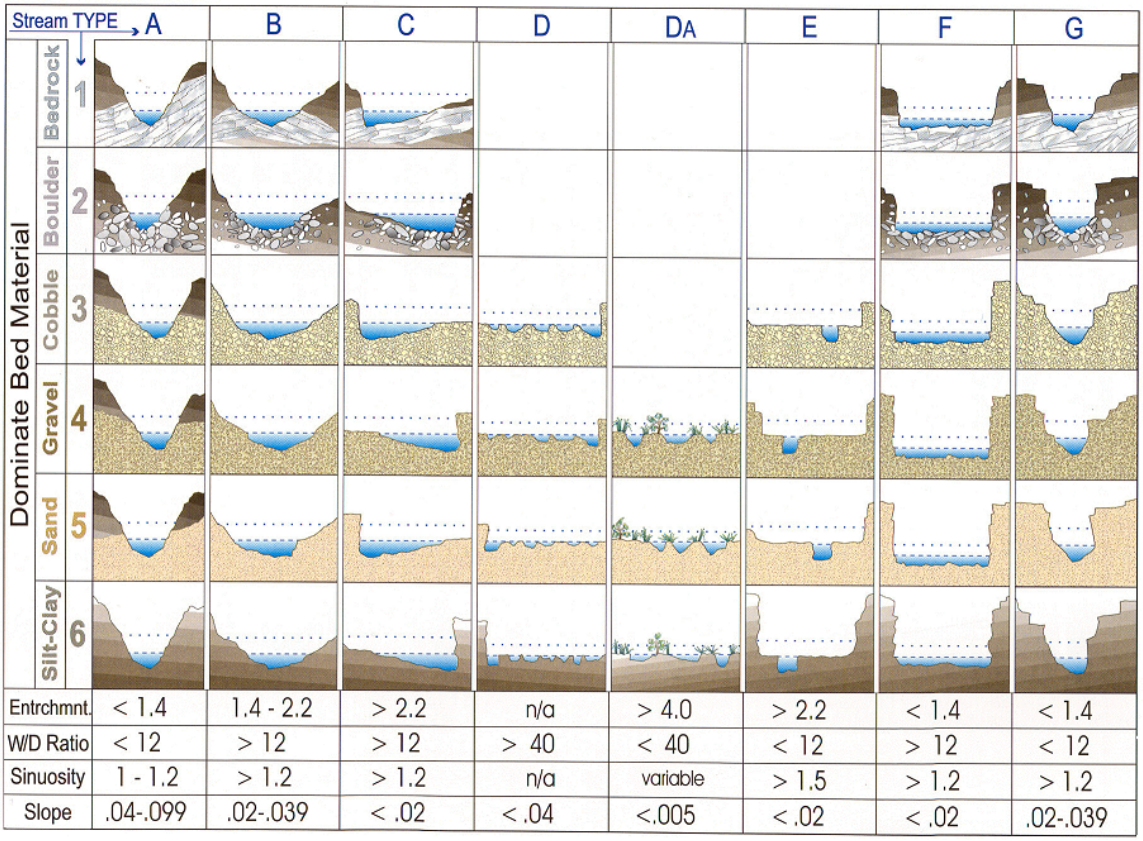
As part of the SFI, each stream in the County was evaluated according to the Rosgen criteria by field observations and computer aided analysis with GIS. Figure 1.4 shows streams types located in Salt Lake County. Figures 1.5 through 1.12 show photo examples of stream types found in the County.

Type A streams are distinguished by being very steep, between a 4 and 10 percent gradient, and deeply entrenched (major flood waters are contained within the channel.) In Salt Lake County, type A streams were found in the upper watersheds and in valley portions of Red Butte Creek, Big Willow and Little Willow Creeks.

Type B streams have a moderate gradient, 2 to 4 percent, are moderately entrenched and are generally very stable. Type B stream reaches were identified on most streams in both the valley and mountains of the County.

Type C streams have a low gradient, less than 2 percent, meandering alluvial channel with broad well defined floodplains. Valley segments of Big and Little Cottonwood Creeks, Dry Creek, Corner Canyon and Bingham Creeks were identified as type C stream reaches. In the mountains, type C stream reaches were identified in Emigration and Big and Little Cottonwood Canyons.

Type D streams are wide, braided channels with eroding banks and without a distinctive main channel. Dry Creek in the vicinity of 1000 E was the only type D stream reach identified in the County.



	A	B	C	D	DA	E	F	G
Entrchmnt.	< 1.4	1.4 - 2.2	> 2.2	n/a	> 4.0	> 2.2	< 1.4	< 1.4
W/D Ratio	< 12	> 12	> 12	> 40	< 40	< 12	> 12	< 12
Sinuosity	1 - 1.2	> 1.2	> 1.2	n/a	variable	> 1.5	> 1.2	> 1.2
Slope	.04-.099	.02-.039	< .02	< .04	<.005	< .02	< .02	.02-.039

Figure 1.3 Primary Delineative Criteria for the Major Stream Types, Rosgen (1996)

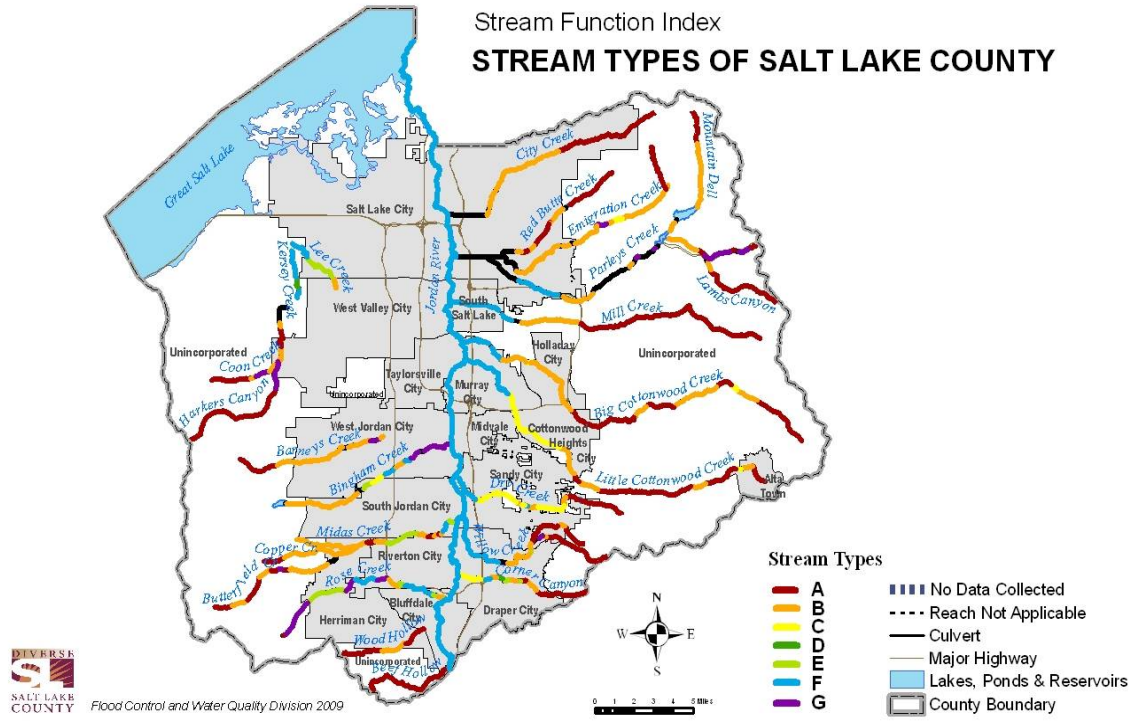


Figure 1.4 Map of Stream Types of Salt Lake County

Figure 1.5 Mountain A Type

Figure 1.6 Mountain B Type

Figure 1.7 Valley B Type

Figure 1.8 Valley C Type

Figure 1.9 Valley D Type

Figure 1.10 Valley E Type

Type E streams are a low gradient entrenched channel with little deposition and very stable. Type E stream channels were found on Midas Creek, Rose Creek, Bingham Creek and Lee Creek.

Type F streams have a low gradient similar to type C channels. However, unlike type C channels, type F channels have an eroded streambed and are entrenched, meaning they are cut-off from their floodplain. The banks are typically unstable with high bank erosion rates. The Jordan River and the lower reaches of the streams entering on the east side were identified as predominately type

Figure 1.11 Valley F Type

Figure 1.12 Valley G Type

F channels. On the west side of the valley, portions of Rose Creek, Bingham Creek, Lee Creek and Kersey Creek were identified as type F channels.

Type G streams have a moderate gradient similar to type B stream channels, 2 to 4 percent, but have downcut and are an entrenched gully. They are unstable with grade control problems and high bank erosion rates. Type G stream channels were identified in Emigration and Parleys Canyons and Little Willow, Rose, Butterfield, Bingham, Barneys, Coon and Harkers Creeks.

1.3 REFERENCE REACHES FOR STREAM TYPES

Identifying the type of each stream and understanding the historic stream character helps us understand the stream dynamics and how modifications will influence the future desired condition. The target for that desired condition is based on a functioning representation of the stream type within the same general setting called a reference reach. Reference reaches in Salt Lake County were identified to give managers a general idea of what their goal is when repairing an impaired stream in the County. Figure 1.13 shows

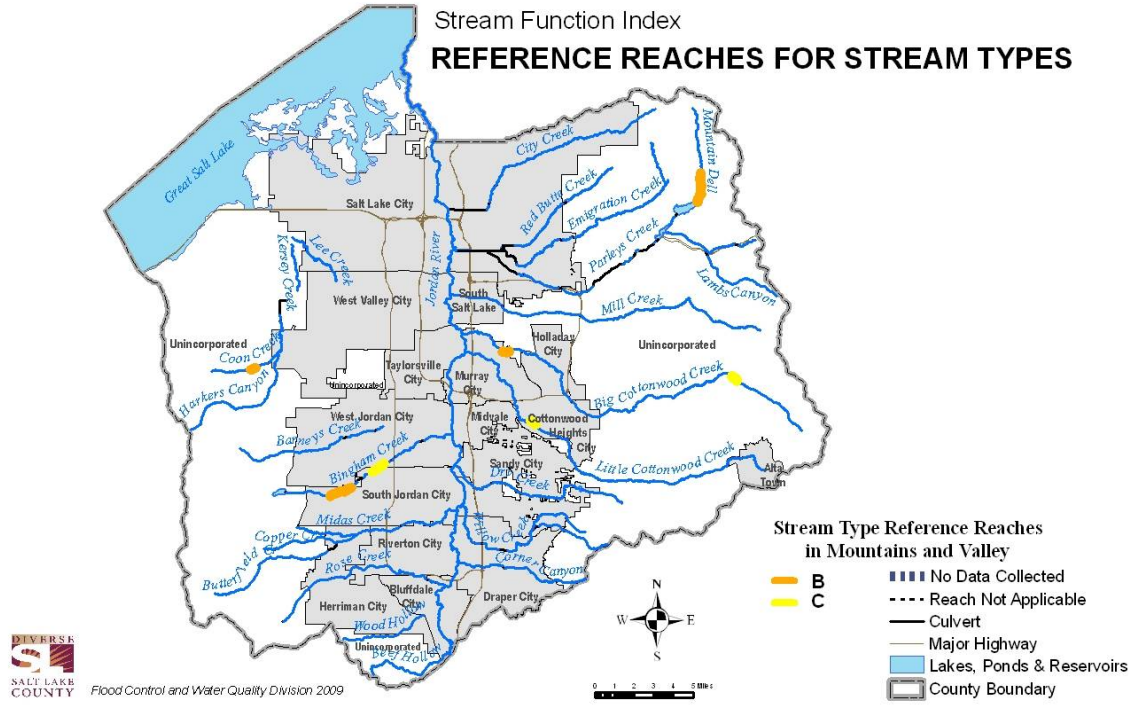


Figure 1.13 Map showing Reference Reaches for streams in Salt Lake County.

the locations of type B and C reference reaches. Figure 1.14 shows a view of the reference reach for a type B channel. Figure 1.15 shows a view of the reference reach for a type C channel.

Reference reaches were only selected for type B and C channels. The reason is that in Salt Lake Valley stream types F, G, and D can typically be treated as impaired versions of healthy type B and C channels. For example, the type C reference reach can be used for a type F channel since both have a stream gradient of less than 2 percent. The type B reference reach can be used for a type G channel since both have a stream gradient of 2 to 4 percent.

It may not be desirable or feasible to convert all type F or G channels to type C or B. Many factors are involved in the decision on what to do including upstream conditions, access, landuse, cost, and availability of lands adjacent to the channel for excavation. The decision will have to be made on a case by case basis. However, even a few changes based on the reference reaches can enhance stream function.

One example of changing a type F channel to a type C is along the Jordan River where over the last two decades Salt Lake County ecosystem restoration projects in select locations has focused on replacing shear eroding banks of an F type channel with floodplain benches and riparian vegetation of a more type C channel (Figure 1.16 and 1.17.) A diagram and further discussion of this method is found on page 4-4.

Figure 1.14 Type B reference reach on Big Cottonwood Creek below 900 East.

Figure 1.15 Type C reference reach on Little Cottonwood Creek near Crestwood Park.

Figure 1.16 (above) and 1.17 (below). Example of a type F channel on the Jordan River in Riverton with shear eroding banks (above). The bank was graded back, rock placed along toe of bank to prevent erosion and planted with riparian vegetation (below) creating a type C channel.

1.4 STREAM FLOW

Stream flows, duration and timing also help shape the character of stream channels. Natural flows and flow modification by diversion in the County are shown in Figure 1.18. Ground water extraction and diversion of natural springs are not shown.

The streams along the Wasatch Front are generally diverted above the valley for culinary or irrigation use. The exceptions are Red Butte and Mill Creeks which are not diverted. Parleys Creek below Mountain Dell Dam is fed by controlled releases. For dewatered streams, flows will naturally resume at some point downstream of the diversion fed by natural springs and ground water. Irrigation water from Utah Lake is returned to Big and Little Cottonwood Creeks and Mill Creek in the valley during irrigation season to provide enough water for downstream irrigation diversions.

Not shown in Fig 1.18, but an equally significant force that shapes stream channel character, is the increased volume and intensity of stormwater runoff into the streams as land development occurs. The reduced normal seasonal flows coupled with increased stormwater, restricted floodplains and eliminating lateral channel movement combine to alter the character of a stream. These conditions commonly exacerbate entrenchment, lower the groundwater table and compromise the health of riparian vegetation. Even intermittant streams such as Dry Creek are affected by lower groundwater flows that support riparian vegetation.

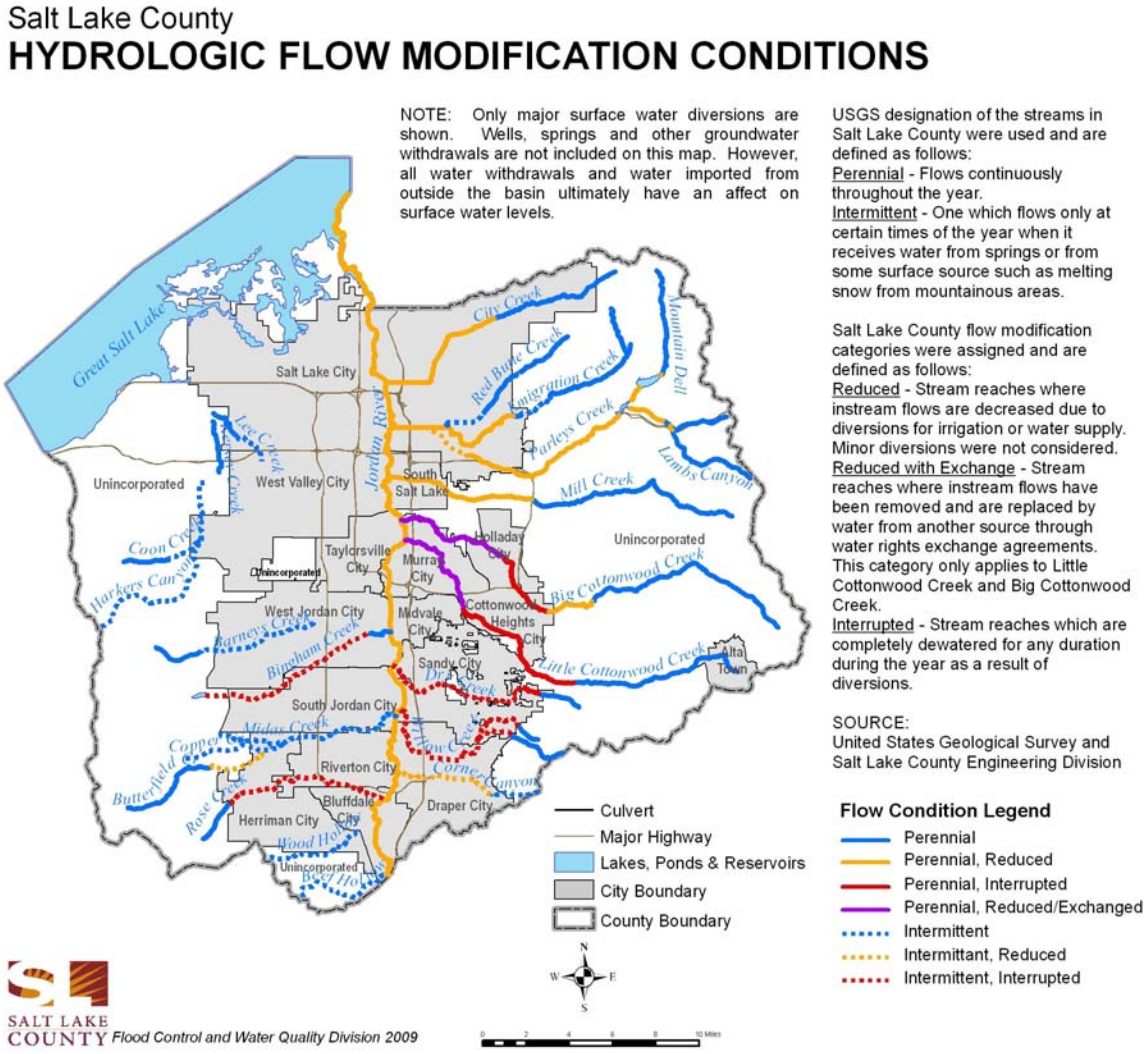


Figure 1.18 Map showing hydrologic modification of streams in Salt Lake County.

2.0 METHODS SUMMARY

This chapter summarizes the Stream Function Index (SFI) methodology. An in-depth report about the methodology used for the SFI can be found in Appendix C of this report as well as Appendix G in the Water Quality Stewardship Plan (WaQSP) Technical Appendices (2009).

The SFI is a useful and flexible tool for stream management. It calculates data scores to obtain an overall grade and the individual scores can be backtracked to a location of interest. The score helps prioritize specific areas that need improvement projects or special management. The data is also attached to a physical location through GIS, enabling a mapped visual display of data.

The SFI was developed by Salt Lake County to address its own unique stream system and its goals in the WaQSP. A rapid assessment, rather than an extensive data gathering effort, was chosen to represent Countywide conditions. The exception was water quality, where a rapid assessment was not possible so published water quality data was used. The methods for the rapid assessment of habitat and stream stability were adapted from other accepted methodologies and discussions with biologists and wildlife managers (see Acknowledgements.)

An important component of the SFI was the method of calculating the scores with targets. Targets are a measurable goal to achieve. The scores are how well the target, or desired condition, is met. An in-depth report about the targets used for the SFI can be found in the Appendix D of this report as well as Appendix G in the Water Quality Stewardship Plan (WaQSP) Technical Appendices (2008).

The following describes the criteria for the datasets that were selected for the SFI, a little about the process and the types of data involved, a brief description for each dataset, and how they were organized in the SFI.

The data collection effort had to meet the following criteria:

1) Accurately define progress towards goals and objectives of the WaQSP implementation.
2) Provide repeatable quantitative measurements and rapid assessments.
3) Be neither time nor cost prohibitive.
4) Can be collected by trained non-professional personnel within one or two field seasons.
5) Be able to capitalize upon existing datasets.

Data was applied to a stream in two ways: by reach and by segment. A stream reach was the smallest unit of stream distance that was measured during assessment. The location and length of a reach was determined by several factors as the observer moved downstream collecting data. A new reach began when the stream type changed, stream conditions dramatically changed, land use changed, or major road crossings were encountered. The reach needed to be long enough to expedite the data collection process and short enough to accurately characterize the stream in the scoring process. A stream segment divided the stream into its upper (mountain) watershed and its lower (valley) watershed. Tributaries such as Lamb's Canyon in upper Parley's Creek were also considered segments. Due to its length, the Jordan River included upper, middle, and lower segments. Countywide a total of 44 segments and 750 reaches were identified for the SFI.

After the data was gathered it was entered into a GIS geodatabase, mapped, analyzed, and prepared for the next phase. The data was then entered into a spreadsheet that included the targets. The spreadsheet calculated the final scores which were then entered back into GIS to map the results. Both the geodatabase and the spreadsheet were developed specifically for the County's unique needs. However, they could be used as templates and adjusted for application to other watersheds.

2.1 TYPES OF DATA

The Stream Function Index contains two sets of data: the first is the Ecosystem Health Index (EHI) that summarizes the physical, chemical and biological parameters through Habitat, Hydraulics and Water Quality metrics. The second is the Social Function which includes Aesthetics and Recreation metrics. Together, these create the SFI (Table 2.1.)

As previously mentioned, the use of targets was one of the key elements to providing a relevant SFI score. Data was evaluated against a target for a particular metric and stream segment. For instance, the valley and mountain segments of Big Cottonwood Creek had different targets for

recreation opportunities, given the different nature of these segments. Targets were used to establish what are reasonably accepted conditions based on stream type, water flows, scientific literature, knowledge of the project area, and management objectives. The targets may change over time based on a change in expectations or from any one of the sources mentioned above.

The metrics are the building blocks of the SFI (Table 2.1.) They were selected because they are 1) relevant indicators of stream health, 2) measurable and repeatable, and, 3) could be improved thus providing a potential to improve the index score. The 27 metrics selected provide a balanced approach to measuring stream conditions in Salt Lake County, regardless of its location in the upper watershed or lower urban landscape.

The metrics are organized into ten Sub-Groups which are then organized into four Functional Groups making up the final SFI score. The scores for each metric, Sub-Group and Functional Group can be used collectively to obtain the EHI and SFI scores or used separately to look more closely at different aspects of stream conditions.

If no data was collected or the data was not applicable to a particular stream reach, the metric score for that reach simply was not counted rather than being given a zero. This allowed only the metrics with data to be counted towards the score. Under these circumstances, using as complete a dataset as possible is important for the score to reflect conditions accurately. For instance, a few upper watershed stream reaches such as Big and Little Willow Creek and upper Mountain Dell Creek were too difficult or impossible to access to collect ground data. As a result, their Riparian Corridor scores include Riparian Width only, versus the combination of both Riparian Width and Density.

The following sections give a brief summary of each Metric's methodology and targets organized by the four Functional Groups and their Sub-

Metric	Sub-Group	Functional Group	Ecosystem Health Index	Stream Function Index
Pool/Riffle ratio	Stream Channel	Habitat	EHI	SFI
Water Depth				
Fish Passage				
Habitat Structures				
Flow Diversion				
Riparian Width	Riparian Corridor			
Riparian Density				
Floodplain Development	Flood Conveyance	Hydraulics		
Floodplain Connectivity				
Bank Stability	Stream Stability			
Hydraulic Alteration				
303(d) list	Regulatory	Water Quality		
Macroinvertebrate	Aquatic			
Total P	Monitoring			
Temperature				
TDS				
DO				
E. coli				
Management	Aesthetics	Social		
Visual Aesthetics				
Location	Amenities (Nodes)			
Accessibility (ADA Approved)				
Restrooms				
Resource Compatibility (Nodes)				
Trail Corridor	Amenities (Trails)			
Connectivity				
Resource Compatibility (Trails)				

Table 2.1 SFI Flow Chart of Metrics. Colors match the colored frames for maps in the Results section.

Groups. The Glossary on page vi is a quick reference for unfamiliar technical terms. The complete SFI Methodology and Target Reports are included in the Appendices of this report.

2.2 HABITAT FUNCTIONAL GROUP

The Habitat Functional Group addressed the condition of the aquatic habitat (Stream Channel Sub-Group) and the terrestrial habitat (Riparian Sub-Group) along the County's waterways.

2.2.1 Stream Channel Sub-Group

The Stream Channel Sub-Group included the Pool/Riffle Ratio, Water Depth, Fish Passage, Habitat Structures and Flow Diversion metrics. Intermittant streams (see Figure 1.18) were scored on Flow Diversion only.

- **Pool/Riffle Ratio Metric:** The number of mid-stream pools and riffles were counted for each reach while walking the stream during late summer low flow. Pools were only counted if they were at least 1 foot deep. High gradient riffles and step pools were not counted. The target for the pool/riffle ratio had two parts included in the score: 1) the total number of pools in a reach, and 2) the pool/riffle ratio target equals one. The number of pools expected to be found within a reach was based on stream types.

- **Water Depth Metric:** Water depth measurements were taken at a representative location within the reach while walking the stream during late summer low flow. The water depth target was based on minimum water depth requirements for trout and native sucker species according to the Utah Division of Wildlife.

- **Fish Passage Metric:** This metric measured the distance between barriers to fish passage. Fish barriers were tallied for each reach while walking the stream during late summer low flow. Barrier criteria included height of barrier, depth of plunge pool, water depth, and density of beaver dams. The target was ¼ mile during late summer low flow. The percent of the reach meeting the ¼ mile target was given a score of 100.

- **Habitat Structures Metric:** Habitat structures were in-stream natural or man-made objects that provided cover, resting and feeding areas for fish. The habitat structures were tallied for each reach while walking the stream during late summer low flow. Types of structures included imbedded logs, rootwads, boulders, undercut banks, beaver dams and man-made structures. The target was based on the number of habitat structures expected to be in a stream type.

- **Flow Diversion Metric:** Flow diversion indicates where streams were dewatered or had reduced flows that affected the quality of stream channels and riparian habitats. The reach was rated to include both the amount of time over a year and the length of the stream within a reach that maintains a natural flow. The target for stream flows was 100% natural flow for perennial and intermittent streams.

Figure 2.1 An example from Lower Big Cottonwood Creek that is channelized into a uniformly shallow streambed with no pool or riffle habitat diversity.

Figure 2.2 An example from Mountain Dell Creek of a riffle in the foreground and a pool above it.

Figure 2.3 An example of a culvert that serves as a barrier to fish movement during the low flow season.

2.2.2 Riparian Corridor Sub-Group

The Riparian Corridor Sub-Group included the Width and Community Type metrics.

- **Riparian Width Metric:** The riparian corridor width was measured 100 feet from the stream bank at the normal high flow line. Computer analysis with 2006 aerial photography was used to identify the tree canopy, shrub and riparian groundcover width. The score was derived from the average width of riparian vegetation within the 100 foot corridor on both banks for each reach. The target was 100 feet wide on both banks.

- **Riparian Density Metric:** Riparian density combined the percent coverage of the canopy, middle story, and understory vegetation of the riparian corridor within 100 feet of both banks. The density of each level was field evaluated for each reach and then recorded and averaged. The target was the highest possible score of 80% coverage for each vegetation level.

Figure 2.4 An example of good riparian habitat in Lower Emigration Creek.

2.3 HYDRAULICS FUNCTIONAL GROUP

The Hydraulics Functional Group addressed the condition of the floodplain (Floodplain Conveyance Sub-Group) and condition of the stream channel (Stream Stability Sub-Group) along the County's waterways.

2.3.1 Flood Conveyance Sub-Group

The Flood Conveyance Sub-Group included Floodplain Development and Floodplain Connectivity metrics.

- **Floodplain Development Metric:** Floodplain development evaluated the percent of pervious surface within the 100-year floodplain as defined by FEMA's Flood Insurance Maps. Computer analysis with 2006 aerial photography was used to identify the pervious areas within each reach. The target was 100% of the floodplain free from buildings and impervious surfaces such as roads, sidewalk, and parking lots. Where the 100-year floodplain has not been mapped by FEMA, a No Data Available (ND) was assigned.

- **Floodplain Connectivity Metric:** Floodplain connectivity measured the amount of stream entrenchment (or streambed erosion) where normal high flows cannot reach the floodplain. The entrenchment was calculated from field measurements at a representational location within each reach. The target was determined according to stream type. Any score falling within the normal entrenchment range for the stream type was given a score of 100.

2.3.2 Stream Stability Sub-Group

The Stream Stability Sub-Group included Hydraulic Alteration and Bank Stability metrics.

- **Hydraulic Alteration Metric:** Hydraulic alteration assessed the amount of bank stability structures (such as engineered gabions and concrete channels, and temporary fixes such as logs and concrete debris) located

Figure 2.5 An example of bank stabilization that is counted as hydraulic alteration.

in the reach based on visual observation by field personnel walking the streams. Boulder riprap was not counted primarily because it created a more natural bank cross-section and supported riparian vegetation growth. Ratings were recorded as a range. The target was based on the highest score obtainable based on the ranges.

- **Bank Stability Metric:** Bank stability of each reach was evaluated with a modified U.S. Forest Service protocol (Pfankuch, 1976) while walking the streams. Eighteen separate criteria were included in the final score. The rating for each reach indicated a condition of excellent, good, fair, or poor. The target for bank stability was excellent and good ratings. Although a score of "excellent" would be ideal, a "good" score is considered acceptable.

Figure 2.6 An Example of severe erosion on Lower Emigration Creek that is considered a "hotspot" on the Bank Stability Metric map.

2.4 WATER QUALITY FUNCTIONAL GROUP

The Water Quality Functional Group addresses the condition of the water in the County's waterways from three different approaches: using the current official status of stream water quality according to the State of Utah (Regulatory Sub-Group), using water quality indicators to monitor quality (Aquatic Sub-Group), and using direct water quality testing (Monitoring Sub-Group.)

2.4.1 Regulatory Sub-Group

The Regulatory Sub-Group includes only one metric which was the State of Utah's 303(d) list.

- **303(d) List Metric:** The State of Utah is required by the Clean Water Act to identify waters of the state that do not meet water quality standards. These waters are then put on the state's 303(d) List of Impaired Waters until the deficiencies are corrected. The Utah Division of Water Quality's 303(d) List of 2006 was used to identify the waterways in Salt Lake County that were water quality impaired. The target was to have the reach not listed on the 303(d) list.

2.4.2 Aquatic Sub-Group

The Aquatic Sub-Group included only one metric which was the Macroinvertebrate sampling metric.

- **Macroinvertebrate Metric:** Aquatic invertebrates live in the bottom parts of our waters. They are also called benthic macroinvertebrates (benthic = bottom, macro = large, invertebrate = animal without a backbone) and make good indicators of water quality based on their presence or absence. Macroinvertebrate sampling was not performed for the 2009 SFI. Future sampling will use the Rapid Bioassessment Protocol recommended by the EPA in partnership with the Utah Division of Water Quality. The target will be the expected results identified by the Utah Division of Water Quality for a particular stream.

2.4.3 Monitoring Sub-Group

The Monitoring Sub-Group included 2001 to 2008 published data from the Environmental Protection Agency's (EPA) STORET (a collective database for water quality sampling data) for **Total Phosphorus**, **Temperature**, **Total Dissolved**

Solids, **Dissolved Oxygen** and ***E. coli* Metrics**. The target was the criteria established by the Utah Division of Water Quality. All data was represented on a sub-watershed level.

2.5 ECOSYSTEM HEALTH INDEX (EHI)

The Ecosystem Health Index averages the scores of the three Functional Groups related to the physical, chemical and biological condition of the County's waterways and watershed—the Habitat, Hydraulics and Water Quality Functional Groups.

2.6 SOCIAL FUNCTIONAL GROUP

Because Salt Lake County is a fast growing urban county, another functional group was added to address the connection the population has with their waterways. The Social Functional Group includes three sub-groups—how the waterways are viewed by the public (Aesthetics Sub-Group), recreation in the setting of parks (Recreation Nodes Amenities Sub-Group), and linear recreation (Recreation Trails Amenities.)

2.6.1 Aesthetics Sub-Group

The Aesthetics Sub-Group score included two metrics designed to measure broad perspectives of how the public perceives natural areas such as streams and riparian areas, the Managed Open Space Metric and the Visual Aesthetics Metric.

- **Managed Open Space Metric:** The Managed Open Space Metric identified the amount of land under public management for open space that is located within the stream corridor up to 100 feet on each side. The target was determined according to the existing and projected future land uses along the stream corridors. The targets varied across the County with the target for the mountains at 100% of the 100-foot corridor on both sides of the waterway under managed open space, the valley was 25%, and the Jordan River Corridor was 100%.

Figure 2.7 Dimple Dell Regional Park along Dry Creek in Sandy City is an example of a managed open space.

- **Visual Aesthetics Metric:** The Visual Aesthetics Metric was not completed for this SFI but will be included for the next one. The conditions of the stream banks will be rated according to their natural or altered state as well as their level of maintenance. The target will be an acceptable level of appearance of stream banks.

Figure 2.8 Sugarhouse Park along Parleys Creek is an example of a recreation node.

2.6.2 Recreation Node Amenities Sub-Group

A recreation node was an area managed as a unit such as a park that may include several activity centers such as pavilions and ball fields. The Recreation Node Amenities Sub-Group addressed how many and how well the recreation nodes were dispersed along the waterways (Node Location Metric), how well they met the Standard for people with disabilities (Accessibility Metric), if sufficient restrooms were available (Restrooms Metric), and if the park facilities or visitor activities adversely affected the stream (Resource Compatibility Metric.)

- **Location Metric:** The location of recreation nodes within 100 feet of stream banks were

counted through computer mapping. The target for the number of nodes along the stream corridor was a one per mile minimum.

- **Accessibility Metric:** The Americans with Disabilities Act (ADA) compliance criteria was based on the ADA Standard language "usable by people with disabilities" criteria. The National Forest Service "Recreation Opportunity Spectrum" guided the decision on which recreation node was appropriate to rate. Appropriate recreation nodes were rated for ADA Standard compliance. The target for ADA compliance was 100% for appropriate nodes.

Figure 2.9 Recreation nodes were evaluated for usability by persons with disabilities.

- **Restrooms Metric:** Restrooms were tallied at recreation nodes. The buildings were tallied rather than individual stalls. The target for restrooms was based on appropriateness according to recreation node size and intended use.

- **Node Compatibility Metric:** Recreation nodes were rated for user impacts on stream resources. Each node was rated according to criteria including litter, tree damage, graffiti, facility maintenance, and human and animal waste. The target was the highest rating possible of 100.

2.6.3 Recreation Trails Amenities Sub-Group

For the purpose of this study, only trails dedicated to recreational use were evaluated. Bicycle lanes in roadways were not counted. The Recreation Trails Amenities Sub-Group addressed how many miles of streams had a trail along it (Trail Corridor Metric), the connection of trails throughout the watershed (Trail Connectivity Metric), and if the trail facilities or user activities adversely affected the stream (Trail Resource Compatibility Metric.)

- **Trail Corridor Metric:** The Trail Corridor Metric focused on the percentage of recreation trails along the County's waterways using computer mapping and analysis. The trail could be located on one or both sides of the waterway. The targets were based on current and projected future landuse and public land management objectives. The targets for the Wasatch Mountains and east side valley were 25%, the west side valley was 50%, and the Oquirrh Mountains and Jordan River were 100%.

- **Trail Connectivity Metric:** The Trail Connectivity Metric identified what percent of trails and trailheads along the waterways were connected to other trails and what percent were local trails. The target for connectivity was 85% connected trails which provided for both movement through the watershed as well as provided for shorter local trails.

Figure 2.10 Trails were evaluated for connection to other trails.

- **Trail Compatibility Metric:** The Trail Compatibility Metric rated user impacts on stream resources. Each section of trail was evaluated according to criteria including litter, tree damage, graffiti, facility maintenance, and human and animal waste. The target was the highest rating possible of 100.

2.7 STREAM FUNCTION INDEX

The Stream Function Index (SFI) score was the overall score resulting from averaging the EHI score with the Social Functional Group score.

This section included only a brief overview of the SFI methodology. A full description of the methodology can be found in Appendix C SFI Methodology and Appendix D SFI Targets found in this report. They can also be found in Appendix G in the Water Quality Stewardship Plan (WaQSP) Technical Appendices (2009). A more detailed description of field methods and computer analysis is available from Salt Lake County, Flood Control and Water Quality Division.

Upper Parleys Creek

3.0 RESULTS

This section reviews the resulting scores for all components of the Stream Function Index (SFI) in the same order as section 2.0 Methodology. Referring to Table 2.1 will be helpful for the reader's understanding. The score results are represented in map and text. In addition, the scores are shown in table and charts in the Appendices.

It is important to note that of all the different scores, the metric scores are the closest representative of specific stream conditions. The metric scores will also be the most sensitive to showing changes when the SFI is completed again. Once the metric scores are averaged for the Sub-Groups and then again for the Functional Groups and again for the Indexes, the scores will show less and less resolution. However, the Sub-Group, Functional Group and Index scores are very useful to paint the larger picture of stream conditions.

The reader will notice that the scores of the metric maps for Habitat and Hydraulics Functional Groups are represented in the smallest length of stream that was evaluated called stream reaches. The length of the reaches were dependent on similarities within the reach considering several factors: Stream type, stream condition, and landuse. Also, roads or railroad crossings often determined the beginning and end of reaches in the urban areas.

The scores of the metric maps for Water Quality and Social Functional Groups were represented in stream segments rather than reaches. Stream segments are defined by the location of the stream within its watershed such as upper and lower Mill Creek. The type of data used for both the Water Quality and Social metrics related more to the characteristics of the longer segment rather than to the shorter reaches. The rest of the maps for Sub-Groups, Functional Groups, EHI, and SFI are represented in segments.

All scores were based on a scale of 0 to 100 where zero is the lowest score and 100 is the highest. No Data (ND) indicates that the stream was a candidate for data collection but it was not collected due to inaccessibility or due to time and scheduling constraints. Not Applicable (NA) indicates that the data, for instance fish habitat structures data in intermittant streams, was not relevant to the stream being evaluated.

3.1 HABITAT FUNCTIONAL GROUP SCORES

The Habitat Functional Group scores represent the condition of the aquatic habitat (Stream Channel Sub-Group) and the terrestrial habitat (Riparian Sub-Group) along the County's waterways. The scores ranged from a high of 99 to a low of 18 for 44 segments. The average score was 65.

The map below shows that the mountain stream segments generally received higher scores than the valley segments. The lowest score for a mountain segment is Emigration Creek. Lower Little Cottonwood Creek and Lower City Creek scored below 50 which were the lowest for habitat of the perennial streams. Of the intermittant streams in the valley, Bingham, Copper, Rose, Willow and Dry Creeks scored below 50. The Jordan River scored moderately between 50 and 69.9.

Habitat Functional Group	
Average Segment Score	65
High Score	99
Low Score	18
Number of Segments	44

The following maps will break down the Habitat Functional Group scores by sub-group and metrics. Additionally, all scores are presented in table and chart forms in Appendix B.

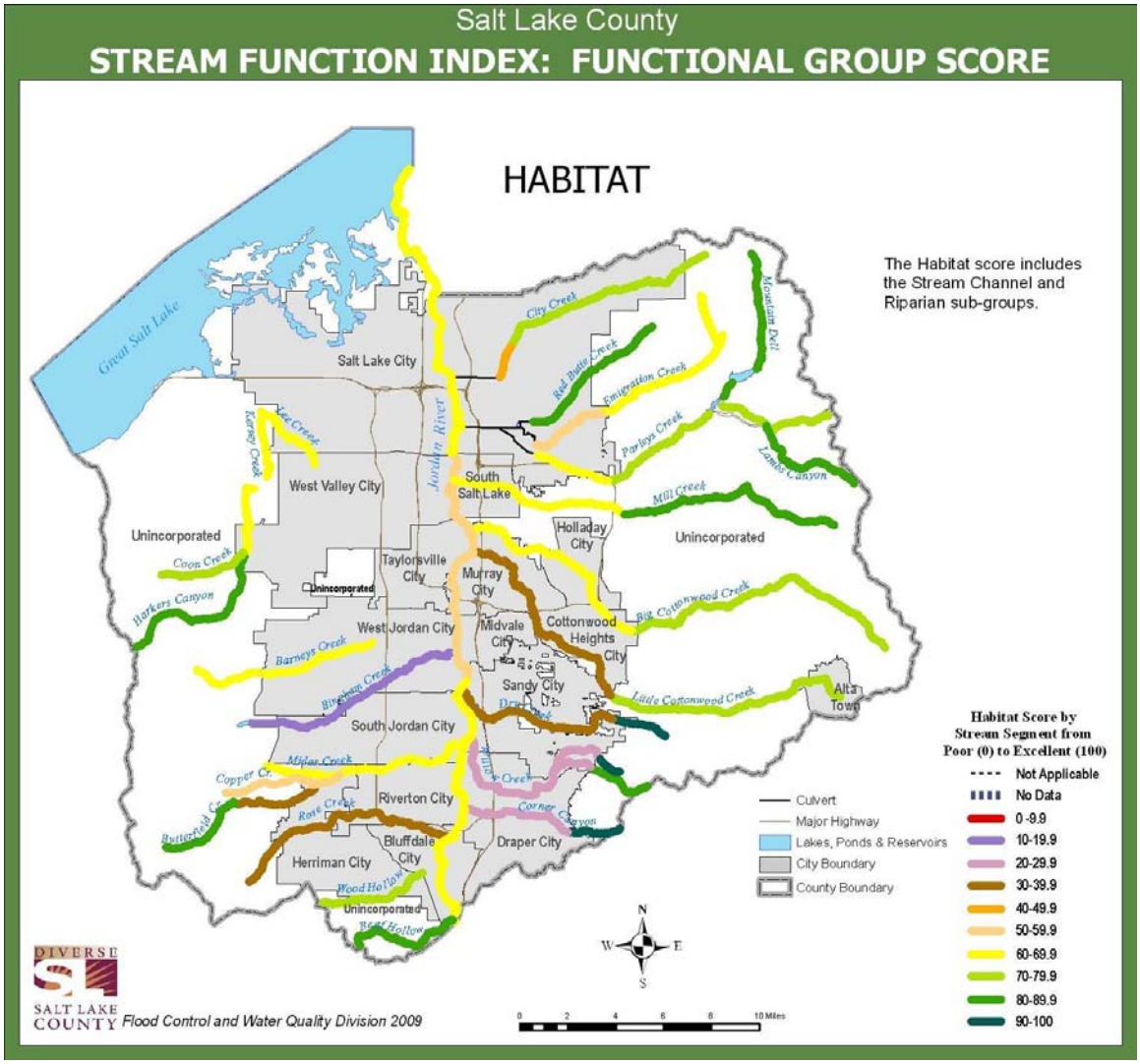


Figure 3.1 Habitat Functional Group Scores

3.1.1 Stream Channel Habitat Sub-Group

The Stream Channel Habitat Sub-Group includes the Pool/Riffle Ratio, Water Depth, Fish Passage, Habitat Structures, and Flow Diversion Metrics. Out of 44 stream segments rated, the average score was 68. The high score was 100 and the low score was 0.

Stream Channel Habitat Sub-Group	
Average Segment Score	68
High Score	100
Low Score	0
Number of Segments	44

The map below shows that the mountain segments generally rated high with the exception of City Creek, Emigration and Parleys Creek which were more moderately scored between 50 and 69.9. In the valley, Little Cottonwood, Dry Creek, Willow and Corner Canyon Creek scored extremely low below 10. In addition, Bingham Creek, Lower Butterfield Creek, Rose Creek and Lower Emigration and Lower City Creek scored below 50. The Upper and Lower Jordan River scored moderately ranging between 50 and 69.9 whereas the Middle Jordan River scored below 50 in the range between 40 and 49.9.

In the following maps, the Stream Channel Habitat scores will be broken down into metrics showing greater detail for each stream.

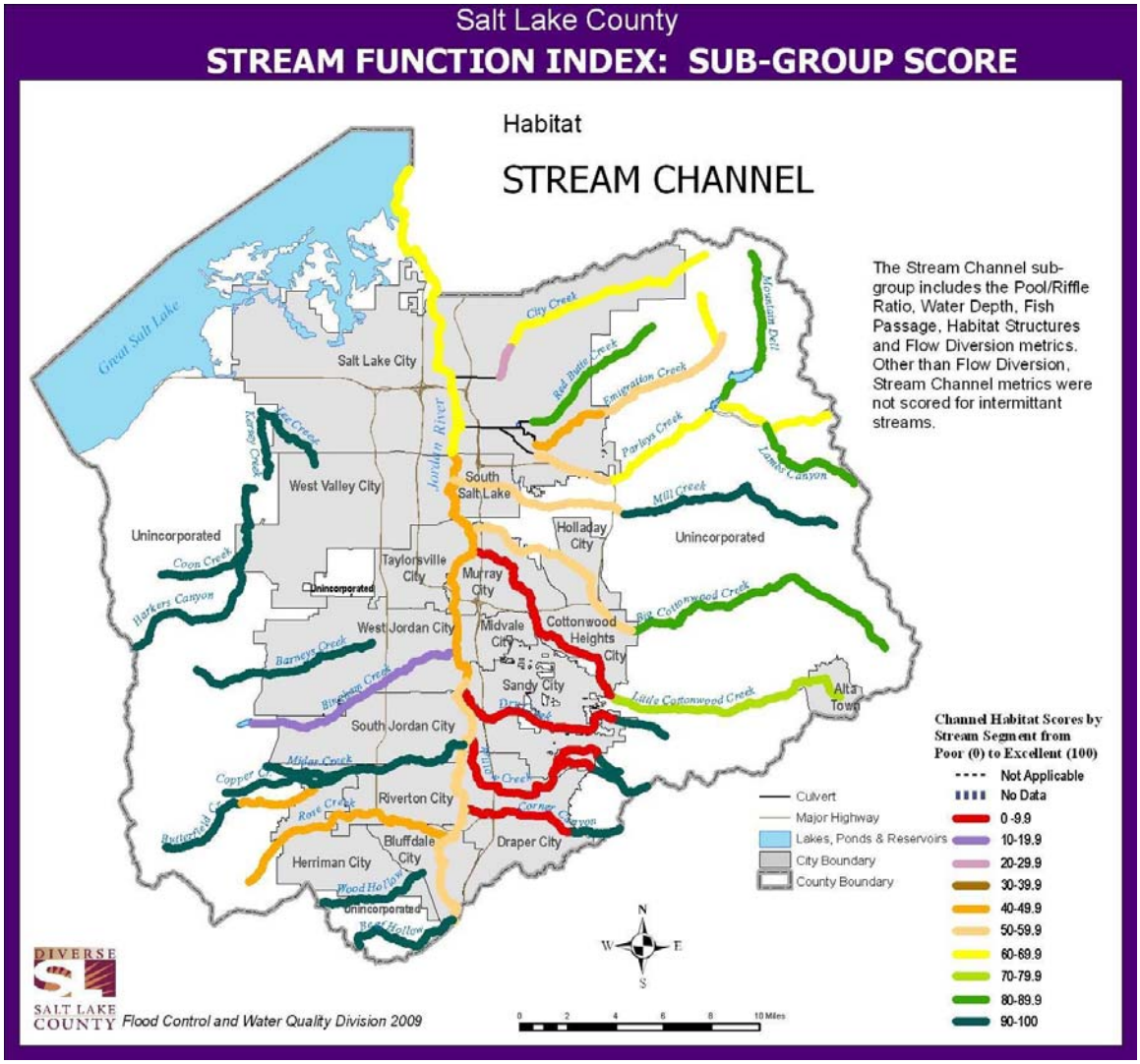


Figure 3.2 Stream Channel Habitat Sub-Group Scores

3.1.2 Pool/Riffle Ratio Metric

The Pool/Riffle Metric was based on the number of mid-stream pools at least one foot in depth and their relationship to the number of shallow turbulent flow areas per stream reach during low flow periods. The stream reach scores ranged from a high of 100 to a low of 0 with an average score of 47.

The map below show that low scores occurred in three major regions: near instream barriers, where stream channels had been modified, on reaches that exceed the suggested gradient for their stream type, and stream reaches that had been channelized thus no riffles were present (this was common in the stream reaches located in the Salt Lake Valley).

Pool Riffle Ratio Metric	
Average Reach Score	47
High Score	100
Low Score	0
Number of Reaches Evaluated	323

Low scores were found throughout the streams that were evaluated particularly in upper Big and Little Cottonwood Creeks, Parleys Creek, City Creek, Emigration Creek and the Jordan River. Moderate (51 to 75) to moderately high scores (76 to 100) predominated Mill Creek.

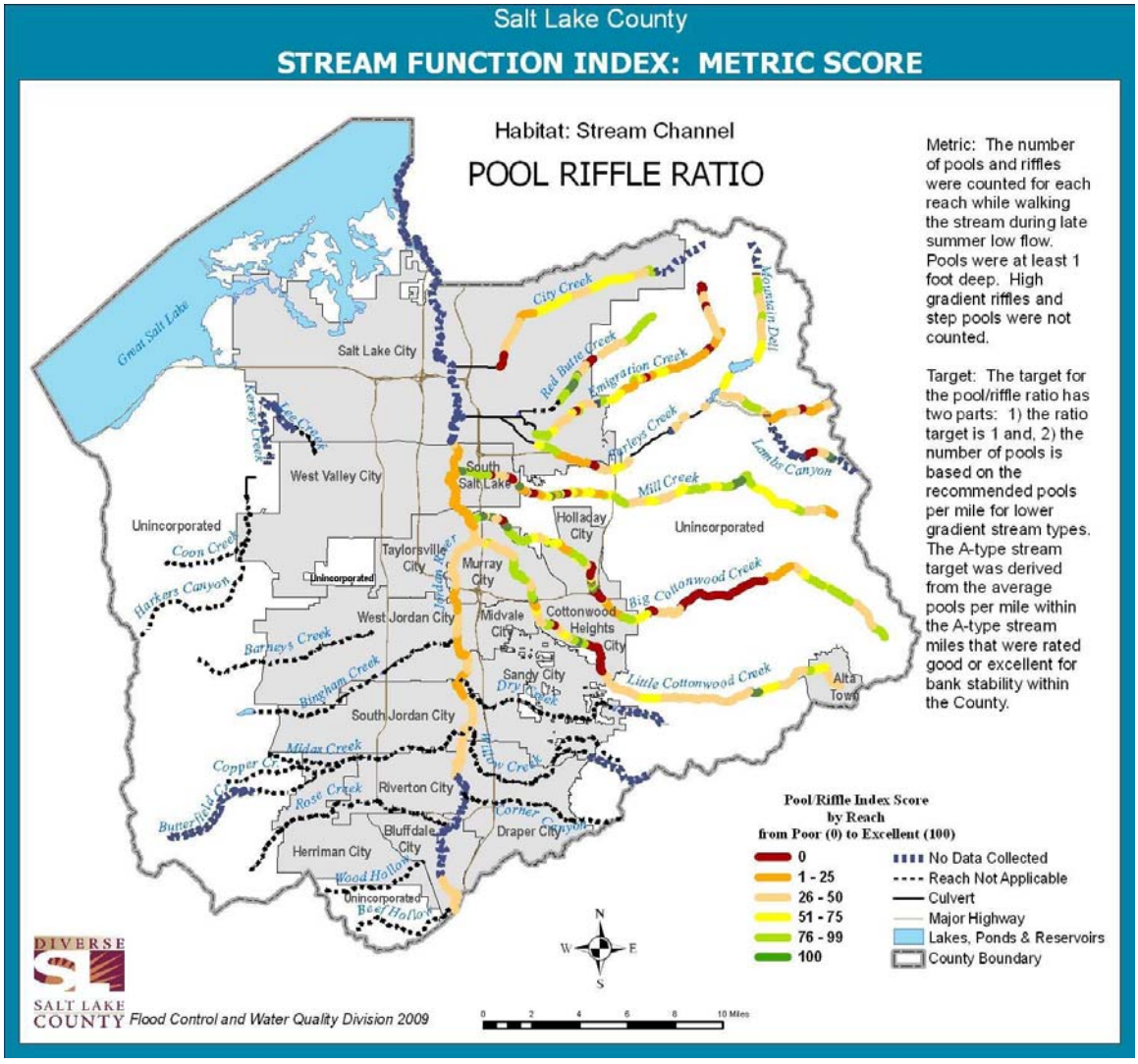


Figure 3.3 Pool Riffle Ratio Metric Scores

3.1.3 Minimum Water Depth Metric

The Minimum Water Depth Metric scores ranged from a high of 100 to a low of 0 with an average score of 83/100.

Water Depth Metric	
Average Reach Score	83
High Score	100
Low Score	0
Number of Reaches Evaluated	336

The map below shows that except for Emigration Canyon, the canyons scored well as did the Jordan River. Of the valley streams, Mill Creek and portions of the Cottonwood Creeks scored high. Water withdrawals from the upper Cottonwood Creeks reduce or remove instream flows until ground water, springs, and inflows of irrigation water from the Jordan River produce a flow. In addition to the amount of flow, streams with a wide flat bed cross-section had no middle channel or pools to concentrate water at a depth that fish could survive.

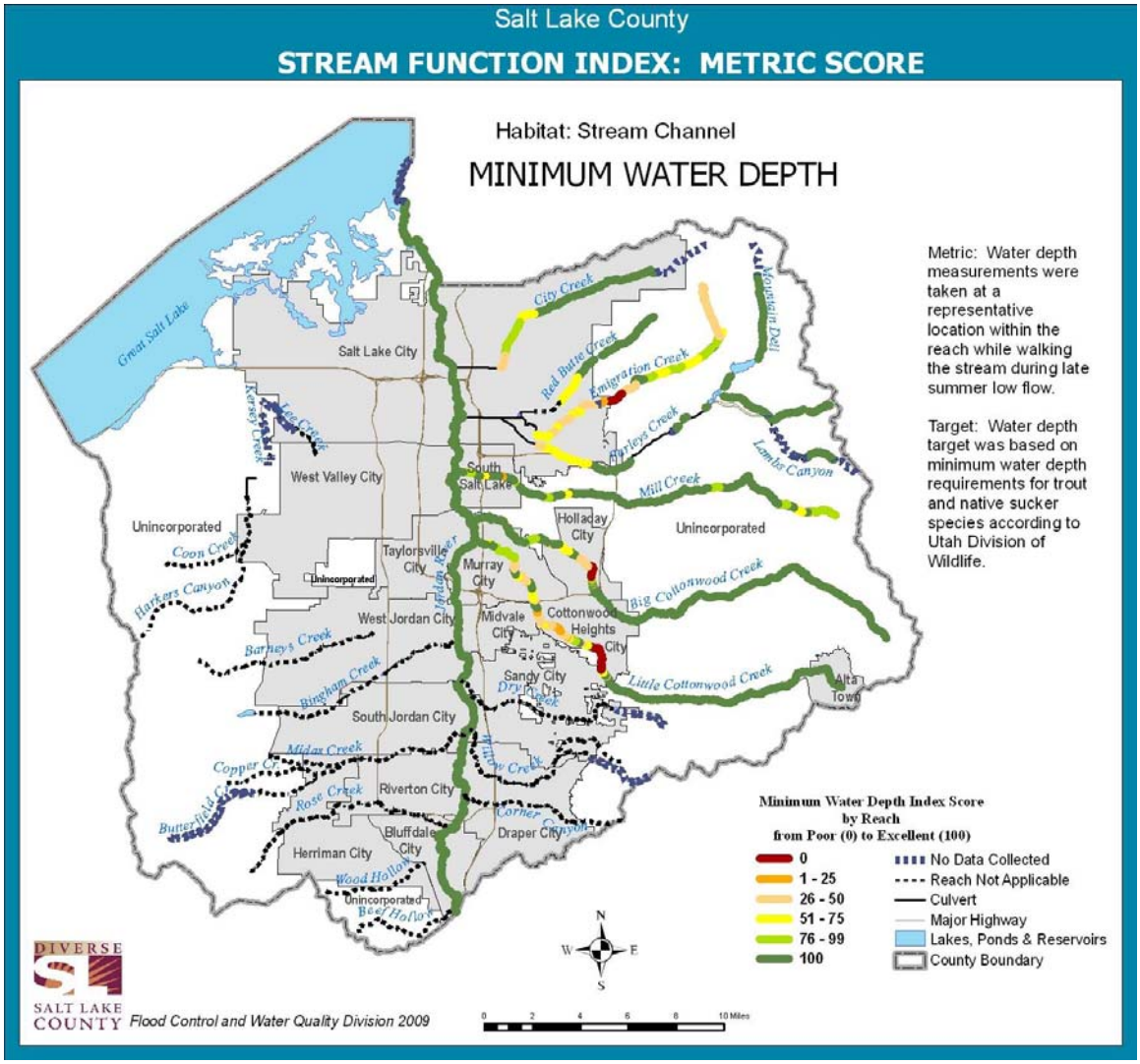


Figure 3.4 Water Depth Metric Scores

3.1.4 Fish Passage Metric

The Fish Passage Metric was based on the minimum distance needed for fish survival during late summer low flow periods between barriers to fish movements. For Salt Lake County, the minimum distance was defined as one-quarter mile between barriers. However, distances greater than one-quarter mile increase the potential of fish populations to survive and thrive. Fish Passage scores ranged from a high of 100 to a low of 0 with an average score of 81.

Low scores for fish passage typically occurred at road crossings with culverts and at natural barriers in the mountains. The map below shows that poor (0) to moderately low (26 to 50) scores were found in reaches of all valley streams. These scores were also found in upper City and Parleys Creeks, Mountain Dell Creek, and Big and Little Cottonwood Creek Canyons. The Jordan River scored high (100) along its entire length.

Fish Passage Metric	
Average Reach Score	81
High Score	100
Low Score	0
Number of Reaches Evaluated	336

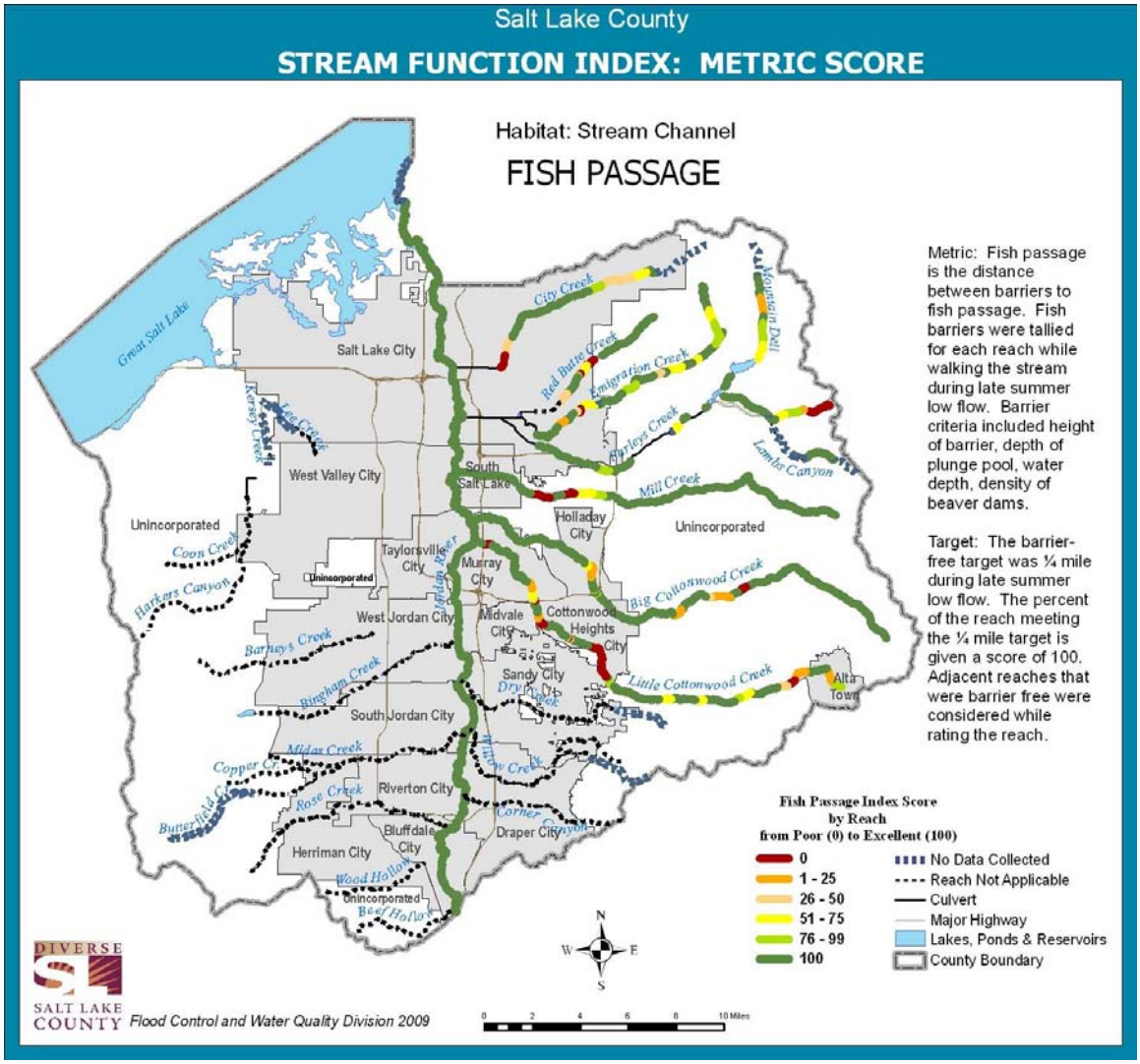


Figure 3.5 Fish Passage Metric Scores

3.1.5 Habitat Structure Metric

The Habitat Structure Metric was based on the number of structures that provided cover, feeding or resting areas for fish during low flow periods. Scores ranged from a high of 100 to a low of 0 with an average score of 47.

Habitat Structure Metric	
Average Reach Score	47
High Score	100
Low Score	0
Number of Reaches Evaluated	324

The map below shows that low scores (0 to 25) predominated the Jordan River and the valley streams except Red Butte Creek and the lower reaches of Mill Creek. Of the mountain streams, low to moderately low (0 to 50) scores were found on the lower portion of City Creek starting above the water treatment plant, Burr Fork and Emigration Canyon, Parleys Creek, and the lower few reaches of Little Cottonwood Canyon. High scores for habitat structure occurred in the upper reaches of City Creek Canyon, Red Butte Creek, Mountain Dell Creek, and upper Mill and the Cottonwoods.

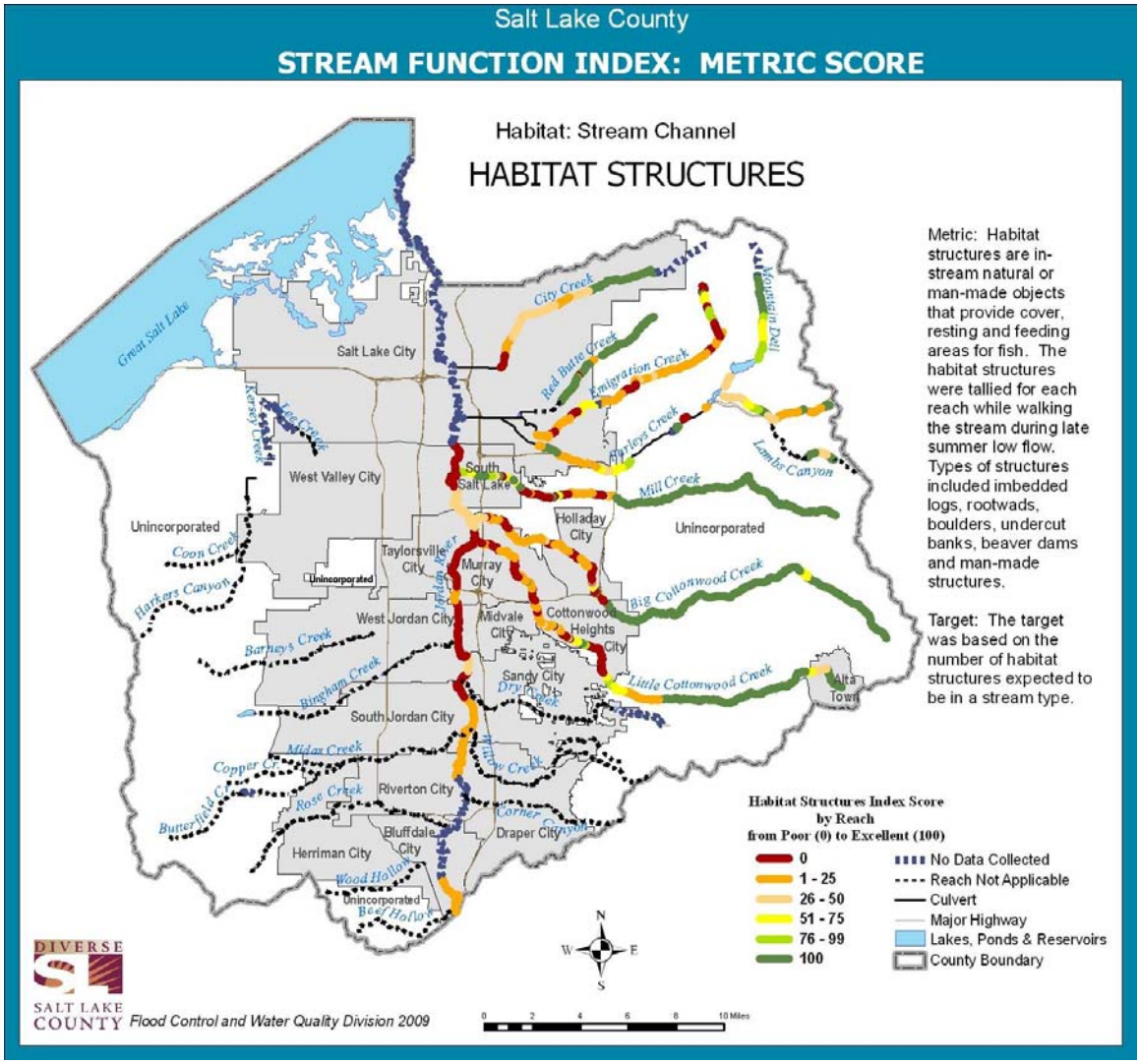


Figure 3.6 Habitat Structure Metric Scores

3.1.6 Flow Diversion Metric

The Flow Diversion Metric measured the degree to which natural surface stream flows had been reduced or disrupted and percent time of the year when that occurred. Low flow periods of the year are critical to fish survival and supporting other species using the riparian areas. Scores ranged from 0 to 100 and averaged 47.

Flow Diversion Metric	
Average Reach Score	47
High Score	100
Low Score	0
Number of Reaches Evaluated	570

The map below shows that the low scores occurred below the diversions that withdraw water all year for culinary purpose and on the Jordan River where not only irrigation water is withdrawn but flows are artificially controlled at the mouth of Utah Lake. Scores for lower Mill Creek, Rose Creek and Butterfield were slightly higher due to water withdrawals only occurring only during irrigation season approximately between mid-April to the first of October. High scores occurred generally in the upper watershed above water diversions for culinary and irrigation purposes.

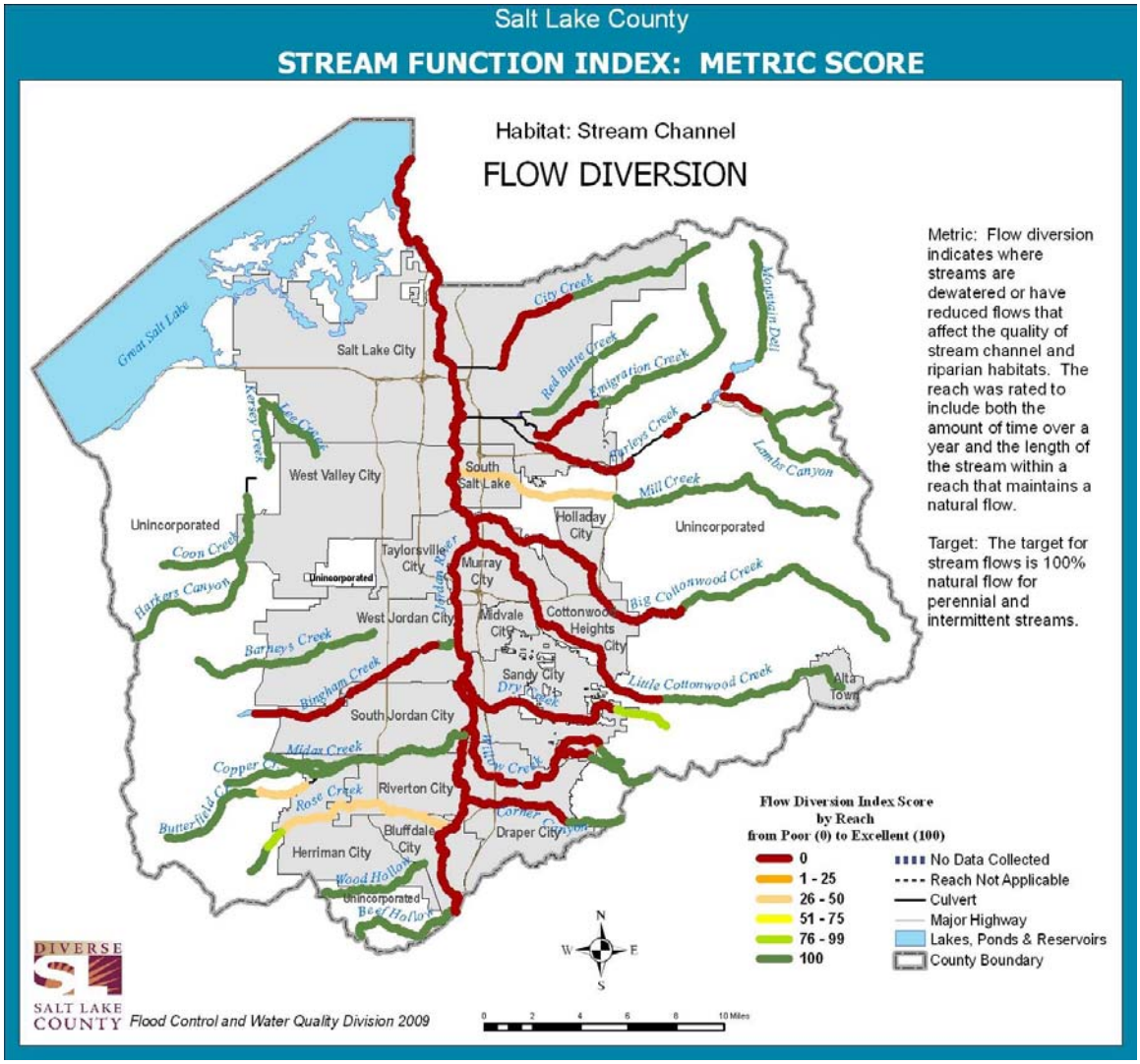


Figure 3.7 Flow Diversion Metric Scores

3.1.7 Riparian Habitat Sub-Group

Riparian Habitat Sub-Group includes the Riparian Width and Riparian Density Metrics. Out of 44 stream segments rated, the average score was 53. The high score was 100 and the low score was 10.

Riparian Habitat Sub-Group	
Average Segment Score	62
High Score	99
Low Score	10
Number of Segments	44

The map below shows that the mountain segments on the east side of the valley generally rated high. Most east side valley streams scored moderately between 50 to 69.9. Corner Canyon Creek scored lower between 40 and 49.9 whereas Big Cottonwood Creek scored higher between 70 and 79.9.

Of the west side mountain streams, Coon and Harkers Creeks, Butterfield Creek and Beef Hollow scored moderately between 50 and 69.9. Wood Hollow and upper Barney's Creek scored low between 30 and 40.9. The remaining valley streams all scored very low between 10 and 39.9. These scores reflect in part the natural difference between the drier west side of the county versus the wetter east side. However, as neighborhoods grow on the west side, more trees are being planted along streams by homeowners and for streamside parks.

The Jordan River scored moderately high between 60 and 79.9.

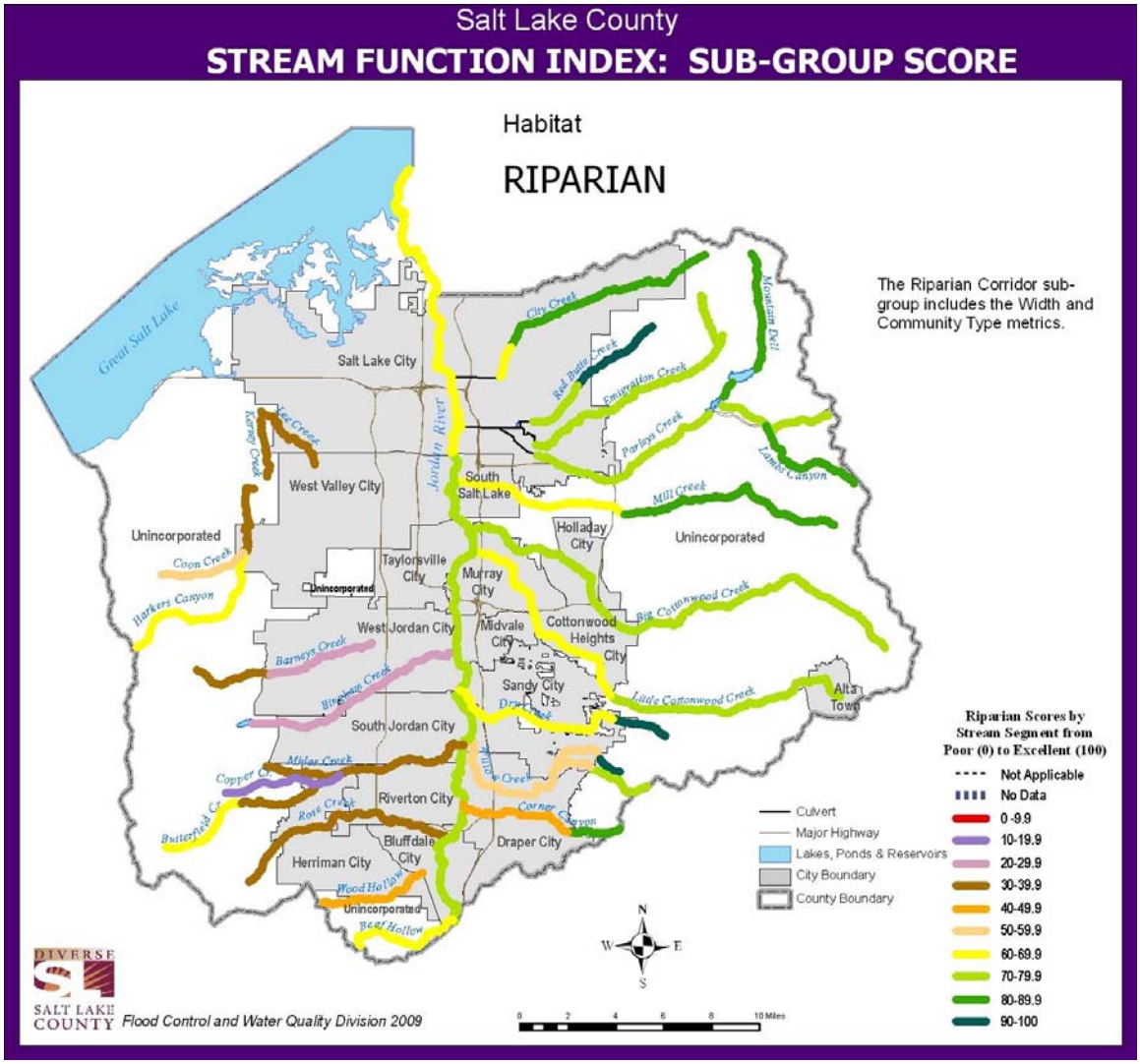


Figure 3.8 Riparian Habitat Sub-Group Scores

3.1.8 Riparian Width Metric

The Riparian Width Metric measured the area of continuous vegetation from both banks up to 100 feet. Isolated trees and shallow rooted cheatgrass were not counted. Scores ranged from 0 to 100 with an average score of 53.

Riparian Width Metric	
Average Reach Score	53
High Score	100
Low Score	0
Number of Reaches Evaluated	570

The map below shows that moderately high scores (76 to 99) were found in the upper reaches of the mountains on the east side where roadways were absent or were greater than 100 feet from the stream which includes upper City, Red Butte, Mountain Dell, Big Willow Dry, and Big and Little Cottonwood Creeks. Only portions of upper City Creek and Red Butte Creek were rated high (100.) Overall, the east side streams scored generally moderate (51-75) with moderately low to low (1 to 50) scores predominant on lower Corner Canyon Creek, Dry Creek, Mill Creek and Little Cottonwood Creek as well as occasionally found on the reaches of the other streams.

The west side mountain segments scored generally much lower than the east side valley. The valley stream segments all scored very low (0) to moderately low (26 to 50.)

The Jordan River scored high in a couple of reaches in the upper segment and a couple of reaches in the middle segment. Generally scores ranged from low (1 to 25) to moderately (51 to 75.)

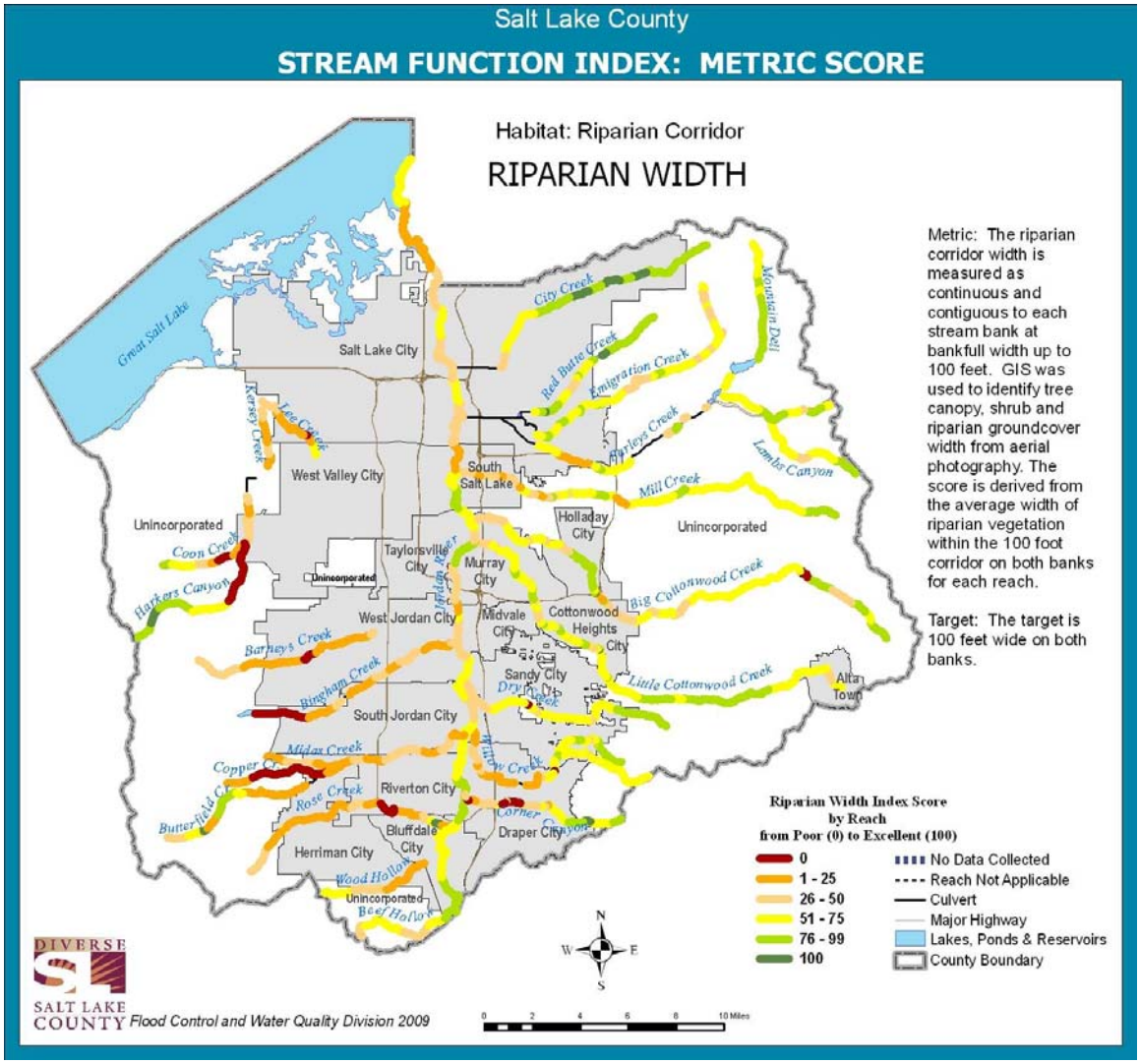


Figure 3.9 Riparian Width Metric Scores

3.1.9 Riparian Density Metric

The Riparian Density Metric measured the density the riparian vegetation identified in the Riparian Width Metric. Scores ranged from 0 to 100 with an average score of 74.

Riparian Density Metric	
Average Reach Score	74
High Score	100
Low Score	0
Number of Reaches Evaluated	563

The map below shows riparian density scores along the Jordan River, perennial streams on the east side of the valley, and on the mountain reaches on the west side of the valley were generally a mixture of moderate (51 to 75), moderately high (76 to 99) to high (100) scores with occasional low scoring reaches. Dry Creek, Corner Canyon Creek, and Willow Creeks in the valley were a mixture of low (1 to 25) to moderately high (76-99.) The west side valley creek scores were primarily low (1 to 25) and moderately low (26-50) with an occasional moderate score (51 to 75.)

The west side streams generally lacked the canopy typically found on the east side. However, as communities grow on the west side, more trees are being planted along waterways in residential areas that may contribute to higher scores in future SFIs.

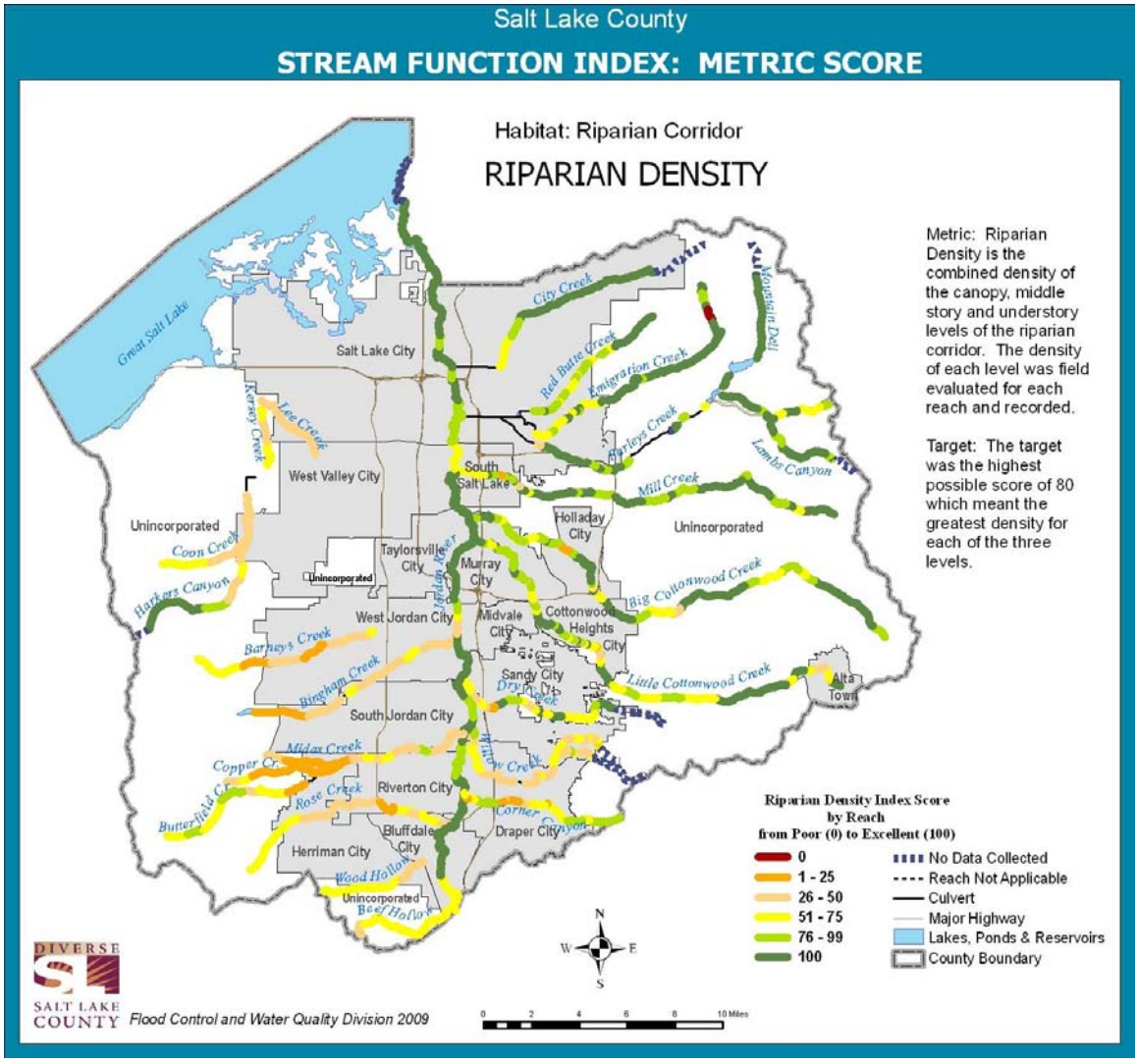


Figure 3.10 Riparian Density Metric Scores

3.2 HYDRAULICS FUNCTIONAL GROUP

The Hydraulics Functional Group scores represent the condition and relationship of the waterway to its floodplain (Flood Conveyance Sub-Group) and channel condition (Stream Stability Sub-Group.) The scores ranged from a high of 99 to a low of 43 for 41 segments. The average score was 72.

The map below shows that the lowest scoring streams in the 40 to 50 range were upper Red Butte and lower Big Willow Creek. The highest scores in the range of 90 to 100 were upper Little Cottonwood Creek and Mountain Dell. A short section of Killyons Canyon Creek also had the highest score. The rest of the streams stayed within the 50 to 90 range.

Hydraulics Functional Group	
Average Segment Score	72
High Score	99
Low Score	43
Number of Segments	41

The following maps will break down the Hydraulics Functional Group scores by sub-group and metrics. Additionally, all scores are presented in table and chart forms in Appendix B.

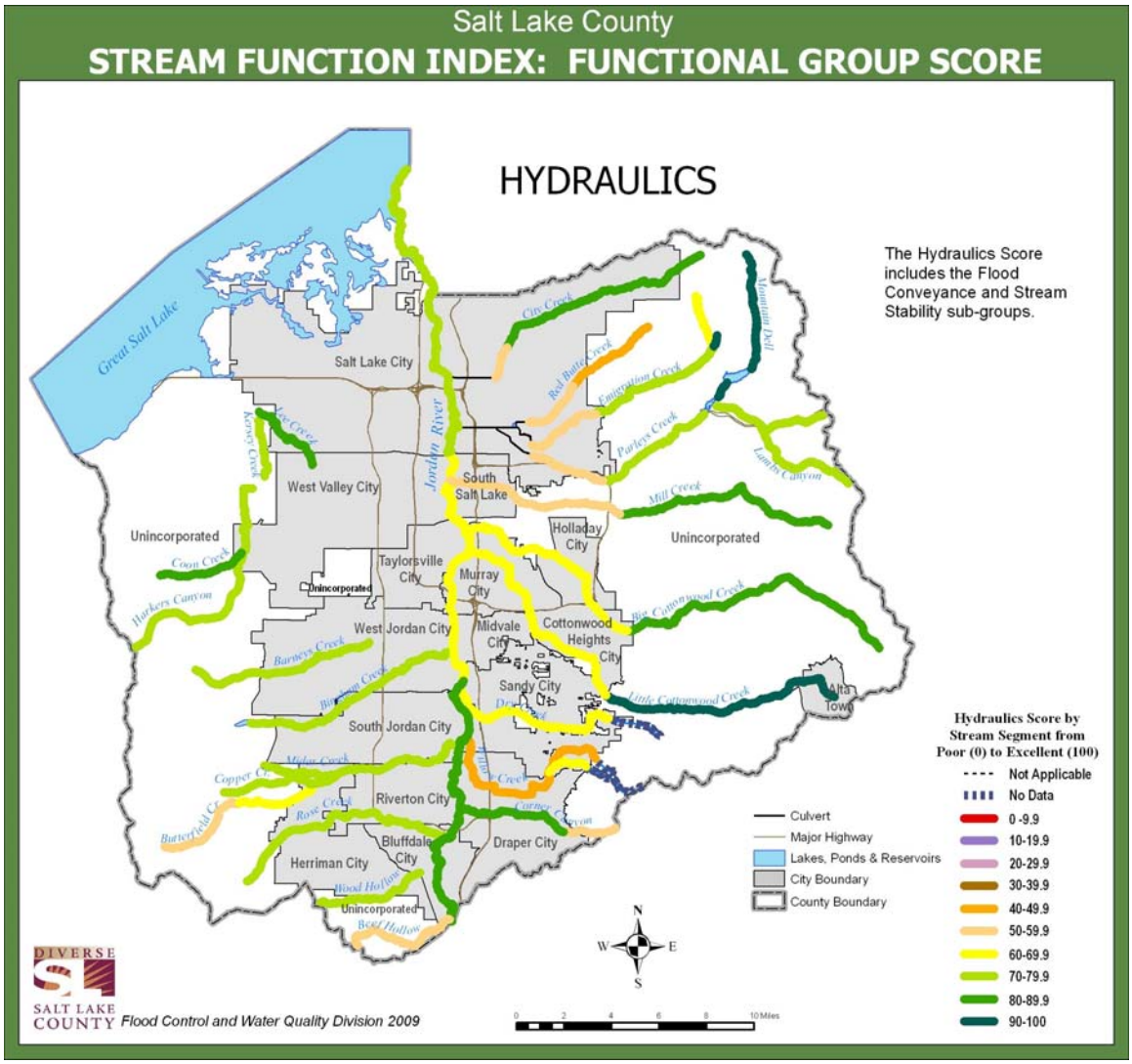


Figure 3.11 Hydraulics Functional Group Scores

3.2.1 Flood Conveyance Sub-Group

The Flood Conveyance Sub-Group includes the Floodplain Development and Floodplain Conveyance Metrics. Out of 41 stream segments rated, the average score was 63. The high score was 97 and the low score was 0.

The map below shows that the majority of stream segments scored above 50 which is moderate to high. The exceptions include lower City Creek, lower Big Cottonwood Creek, Kersey Creek, and Lambs Creek which scored moderately (40 to 49.9.) In addition, upper Red Butte, Corner Canyon and Butterfield Creeks, and Beef Hollow scored very low between 0 and 19.9. The Jordan River scored moderately high ranging between 70 and 89.9.

Flood Conveyance Sub-Group	
Average Segment Score	63
High Score	97
Low Score	0
Number of Segments	41

In the following maps, the Flood Conveyance Sub-Group scores will be broken down into metrics showing greater detail for each stream.

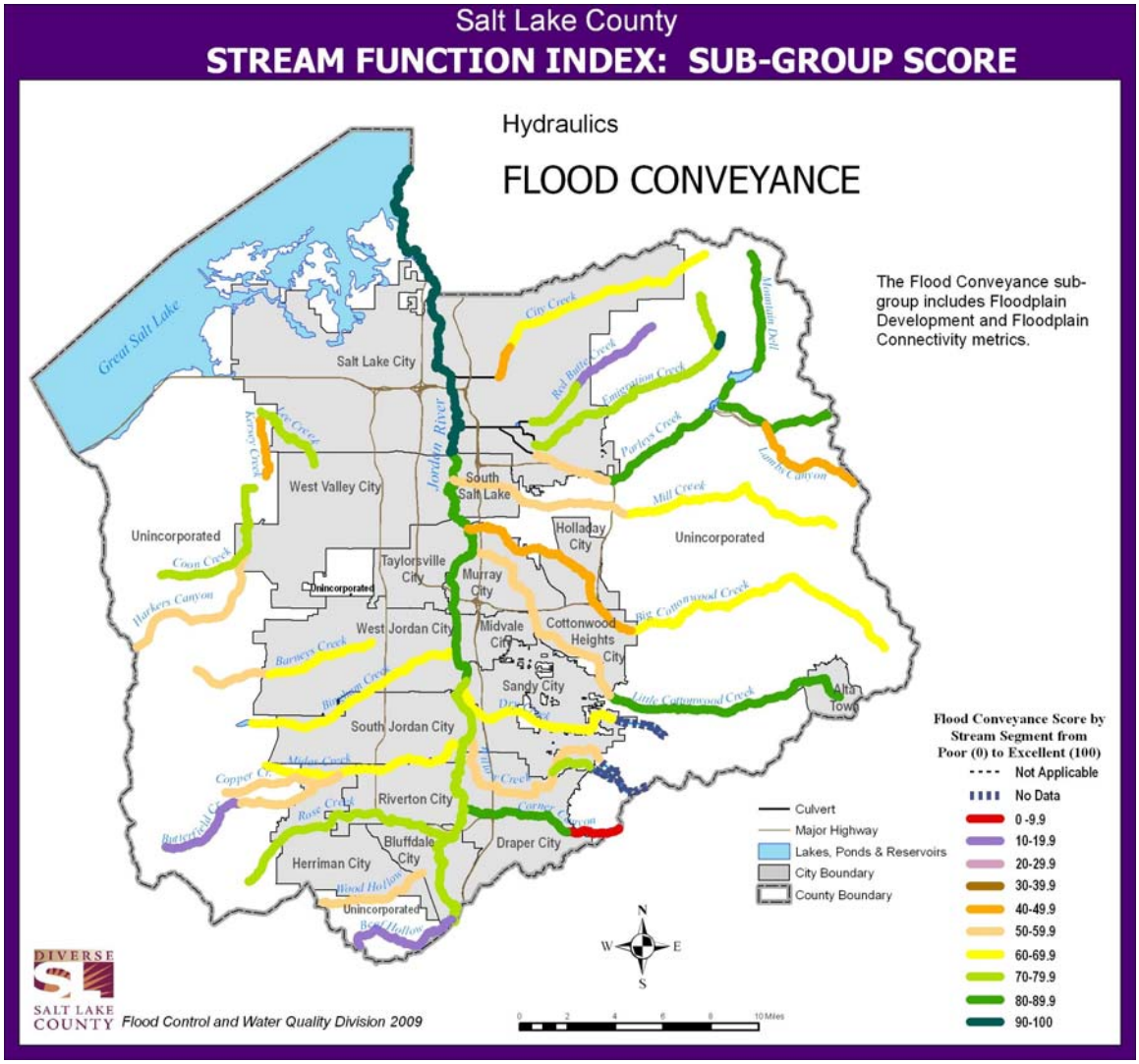


Figure 3.12 Flood Conveyance Sub-Group Scores

3.2.2 Floodplain Development Metric

The Floodplain Development Metric measured the percent of permeable surface within the 100-year floodplain as identified by the FEMA flood insurance maps. If the 100 year floodplain had not been studied and identified, a rating of No Data was applied. Undeveloped floodplains slow flood velocities, allow groundwater recharge and maintain riparian vegetation that stabilize banks. Scores ranged from 0 to 100 with a generally high average score of 87.

The map below shows that scores were generally moderately high (76 to 99.) Stream reaches with high scores (100) were found scattered on all streams. In addition, longer portions with high scores occur in Dry Creek in the Dimple Dell Regional Park as well as upper Little Cottonwood and the Jordan River through Bluffdale City.

Floodplain Development Metric	
Average Reach Score	87
High Score	100
Low Score	0
Number of Reaches Evaluated	459

The low to moderate (1 to 76) scores occur scattered throughout the north half of the County where it is more heavily urbanized.

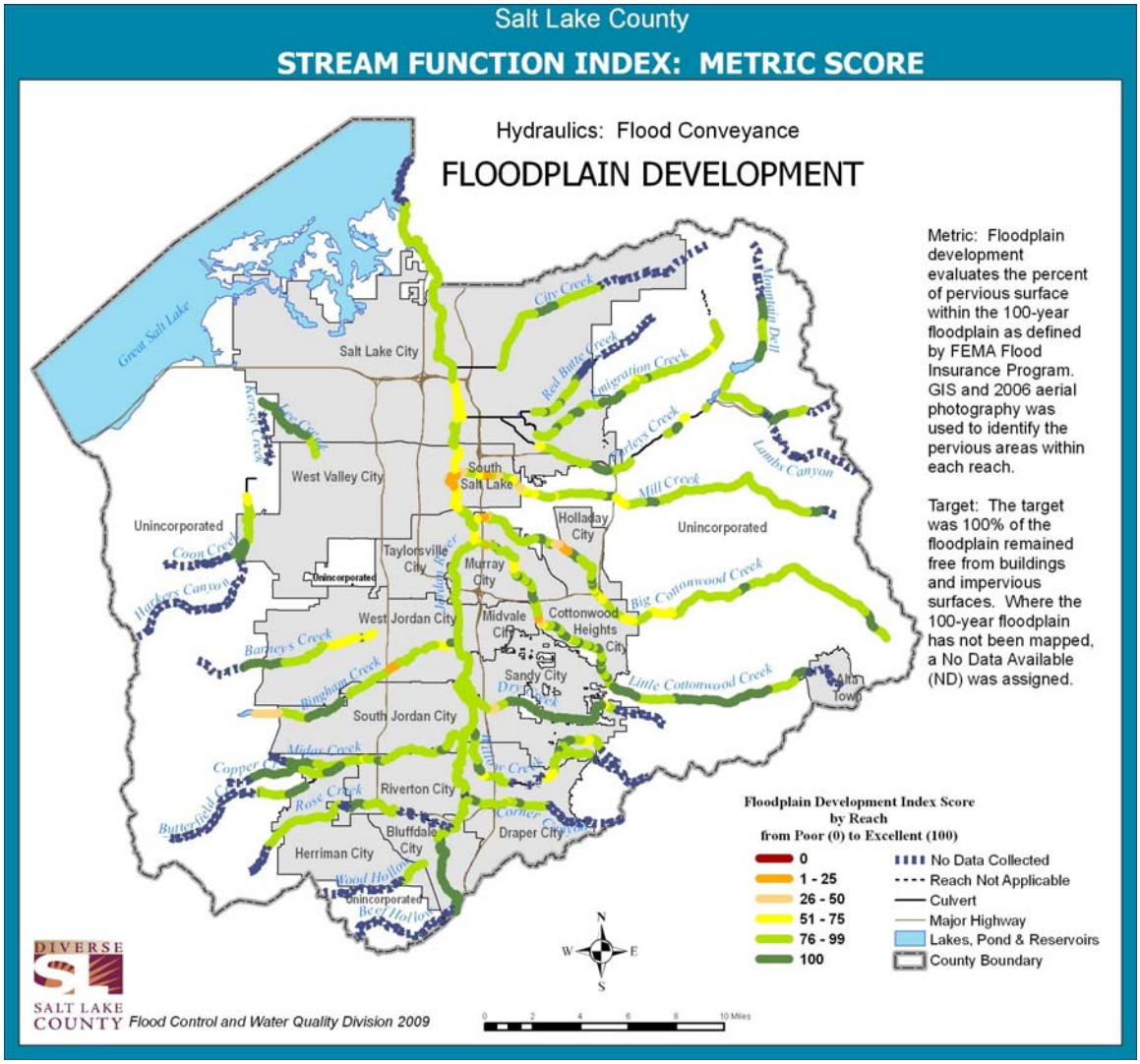


Figure 3.13 Floodplain Development Metric Scores

3.2.3 Floodplain Connectivity Metric

The Floodplain Connectivity Metric measured if normal seasonal high flows in a stream had access to its floodplain. Floodplain access from a stream channel can be impaired by building up to the bank edge, filling in the floodplain or lowering the stream bed. Scores ranged from 0 or 100 with an overall average score of 43.

Floodplain Connectivity Metric	
Average Reach Score	43
High Score	100
Low Score	0
Number of Reaches Evaluated	562

The map below shows the stream scores are generally mixed throughout the County. The Jordan River stands out with a score of 100 from near 7200 S all the way to Great Salt Lake.

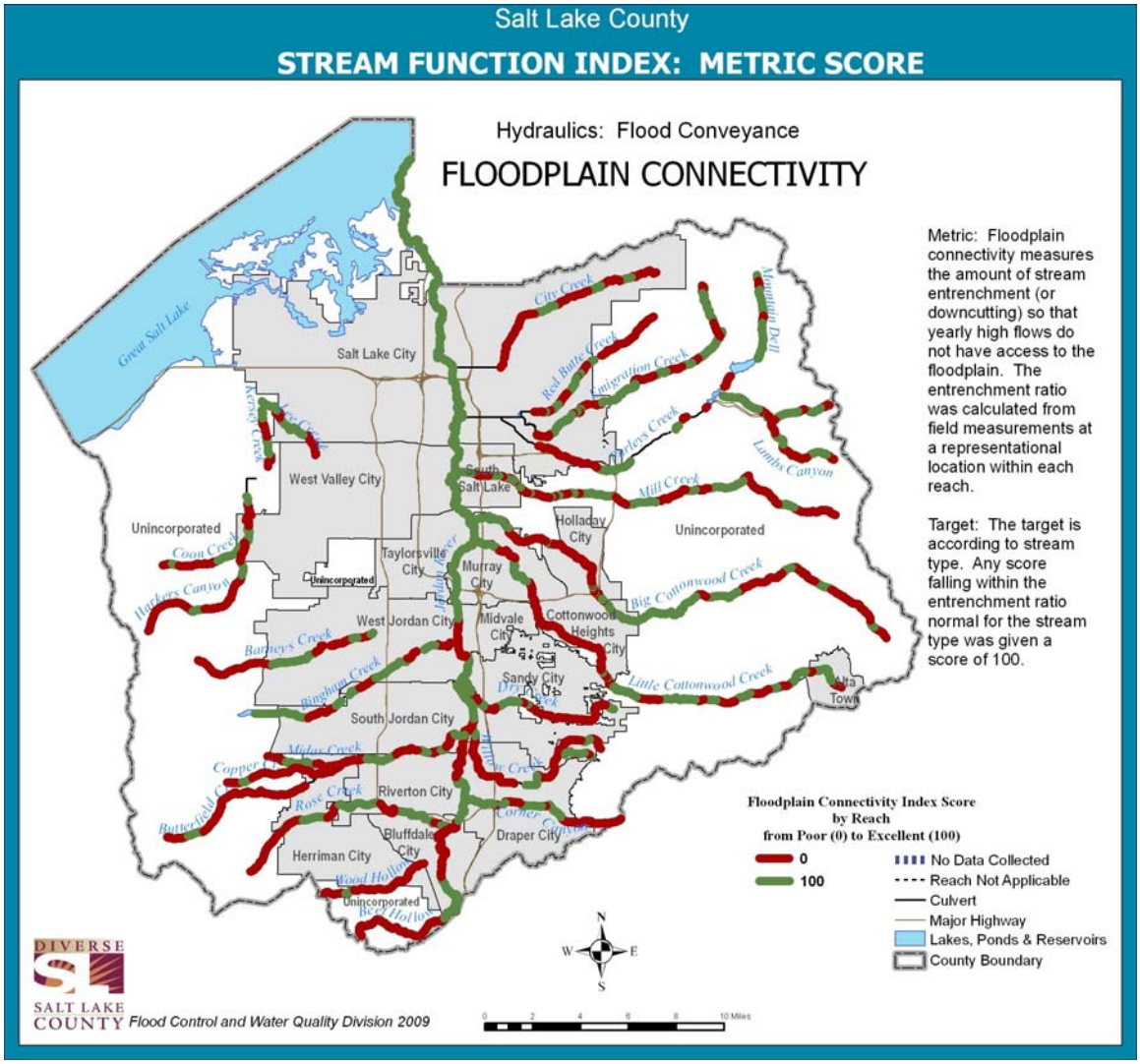


Figure 3.14 Floodplain Connectivity Metric Scores

3.2.4 Stream Stability Sub-Group

Stream Channel Stability Sub-Group includes what percentage of the stream channel has been modified with artificial stabilization techniques (Hydraulic Alteration Metric) and how resilient the stream channel is to disturbance (Bank Stability Metric.) Out of 41 stream segments rated, the average score was 81. The high score was 100 and the low score was 43.

Stream Stability Sub-Group	
Average Segment Score	81
High Score	100
Low Score	43
Number of Segments	41

The map below shows the overall highest scores occurred on the west side (80 to 100.) The east side streams that scored high were upper City Creek, Mountain Dell and Lambs Creeks, upper Mill and Little Cottonwood Creeks and all of Big Cottonwood and Corner Canyon Creeks. The only streams that dropped below a score of 50 include lower Red Butte, Emigration and Dry Creeks with scores of 40 to 49.9). The upper Jordan River scored high (90 to 100), the middle Jordan River scored moderately (50 to 59.9) and the lower Jordan slightly higher (60 to 69.9.)

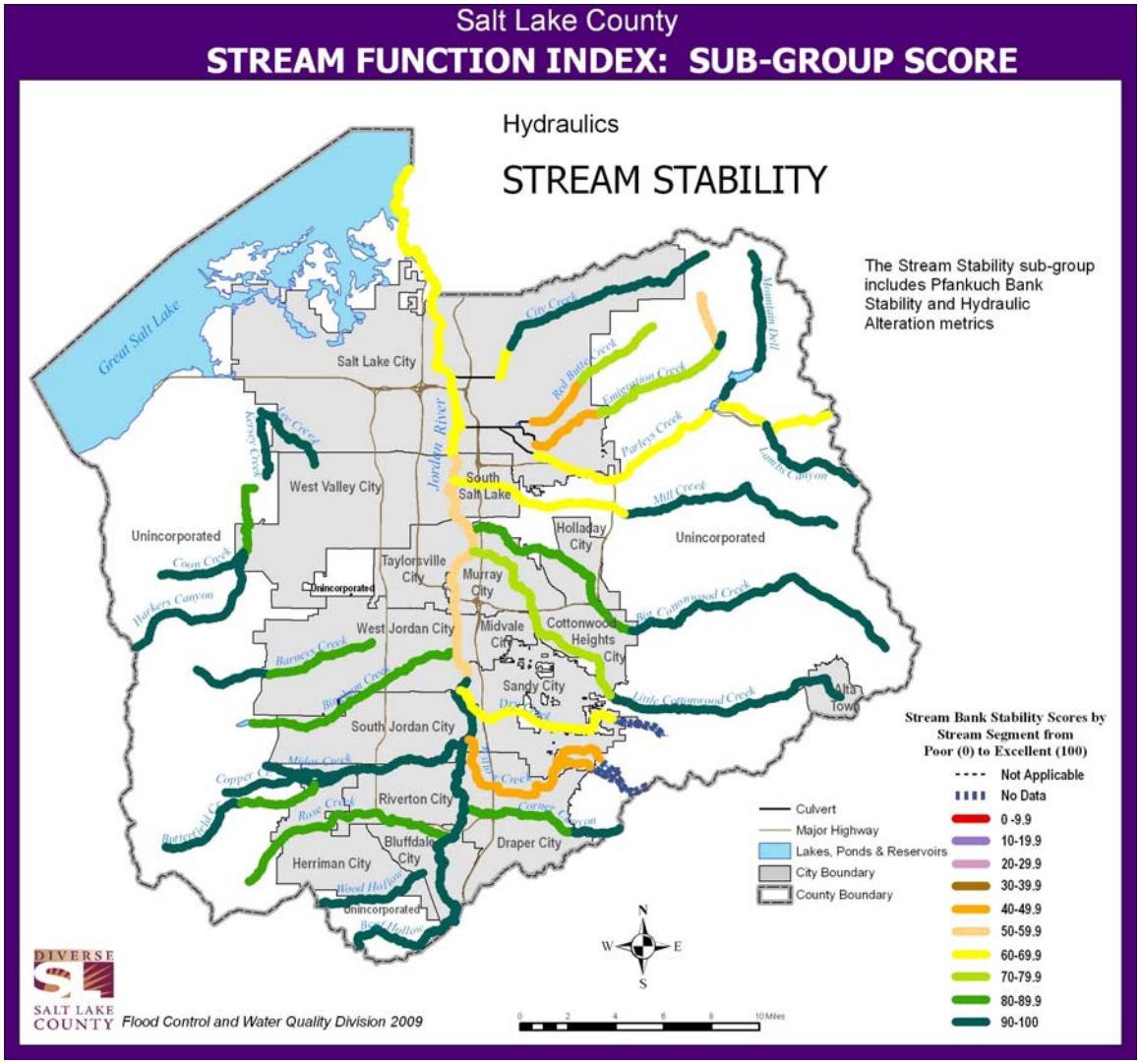


Figure 3.15 Stream Stability Sub-Group Scores

3.2.5 Hydraulic Alteration Metric

The Hydraulic Alteration Metric was a visual estimate of the percent of linear feet of bank stabilization structures such as engineered gabions and concrete channels, and temporary fixes such as piled logs, concrete slabs, or other improvised methods that were contained within a reach. Boulder riprap was not counted primarily because it creates a more natural bank cross-section and supports riparian vegetation growth that can help increase long term bank stability. The scores for this metric ranged from 0 to 100 with an average score of 80.

Hydraulic Modification Metric	
Average Reach Score	80
High Score	100
Low Score	1
Number of Reaches Evaluated	562

The map below shows that the east side mountains scored generally moderately high to high (76 to 100.) The exceptions included Parleys Creek that scored moderately low (26 to 50) and a couple reaches in each of City Creek, Emigration, Mill, and Big Cottonwood Creeks that scored moderately (51 to 75.) The east side valley stream reaches generally varied from high to low with Dry creek scoring a solid high through Dimple Dell Regional Park and Willow Creek scoring low (0 to 25) from 1100 E to the Jordan River.

The west side mountains scored moderately high to high (76 to 100.) The valley stream scores varied from high to low. The Jordan River scored consistently high (100.)

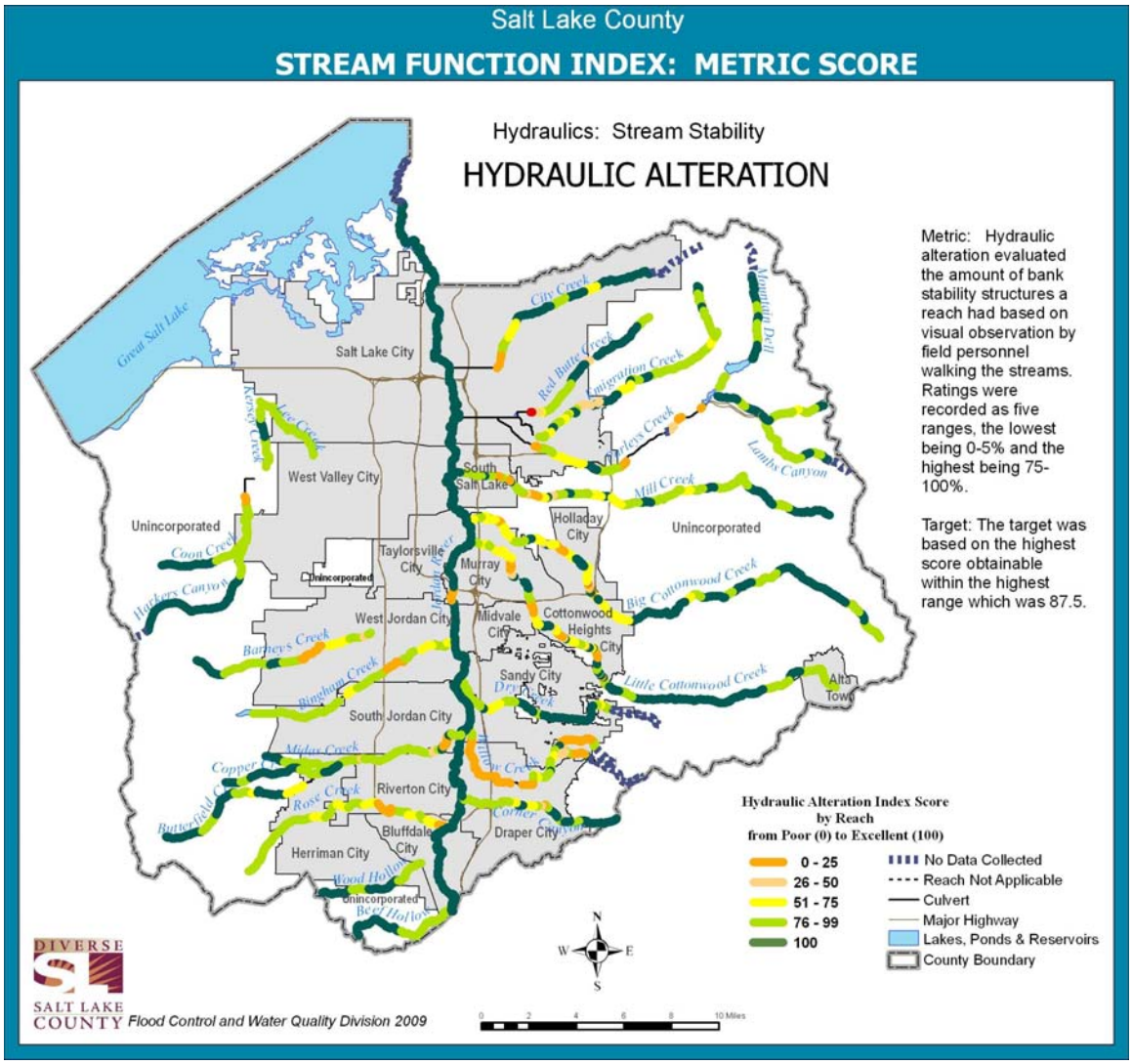


Figure 3.16 Hydraulic Alteration Metric Scores

3.2.6 Bank Stability Metric

The Bank Stability Metric used a protocol where observers examined stream channels at low flow looking for 18 specific criteria that indicated stream bank and bed stability. The scores for this metric ranged from 0 to 100 with an average score of 44.

Numerous 'hot spots', or actively eroding sites, were also identified and mapped. Although the presence of a hotspot did not contribute directly to the score, they provide a start at inventorying and prioritizing bank stabilization projects.

The map below shows most of the streams in the mountains on the east side were rated Good. The exceptions were portions of Emigration and Parleys Creeks which rated Fair. A score of Fair generally indicates that the stream has a high potential of going to Poor. The east side valley streams are mixed between Good and Fair. Several hotspot occur on Red Butte, Emigration, Mill, Dry, and Corner Canyon Creeks. Streams on the west side are generally in Good condition except for the high number of hotspots on Coon, Bingham, Butterfield and Rose Creeks. With exceptions in Salt Lake City, Murray City, and Bluffdale City, the Jordan River scored Fair with several hotspots from the Utah County boundary to 7200 S.

Stream Stability Metric	
Average Reach Score	44
High Score	100
Low Score	0
Number of Reaches Evaluated	560

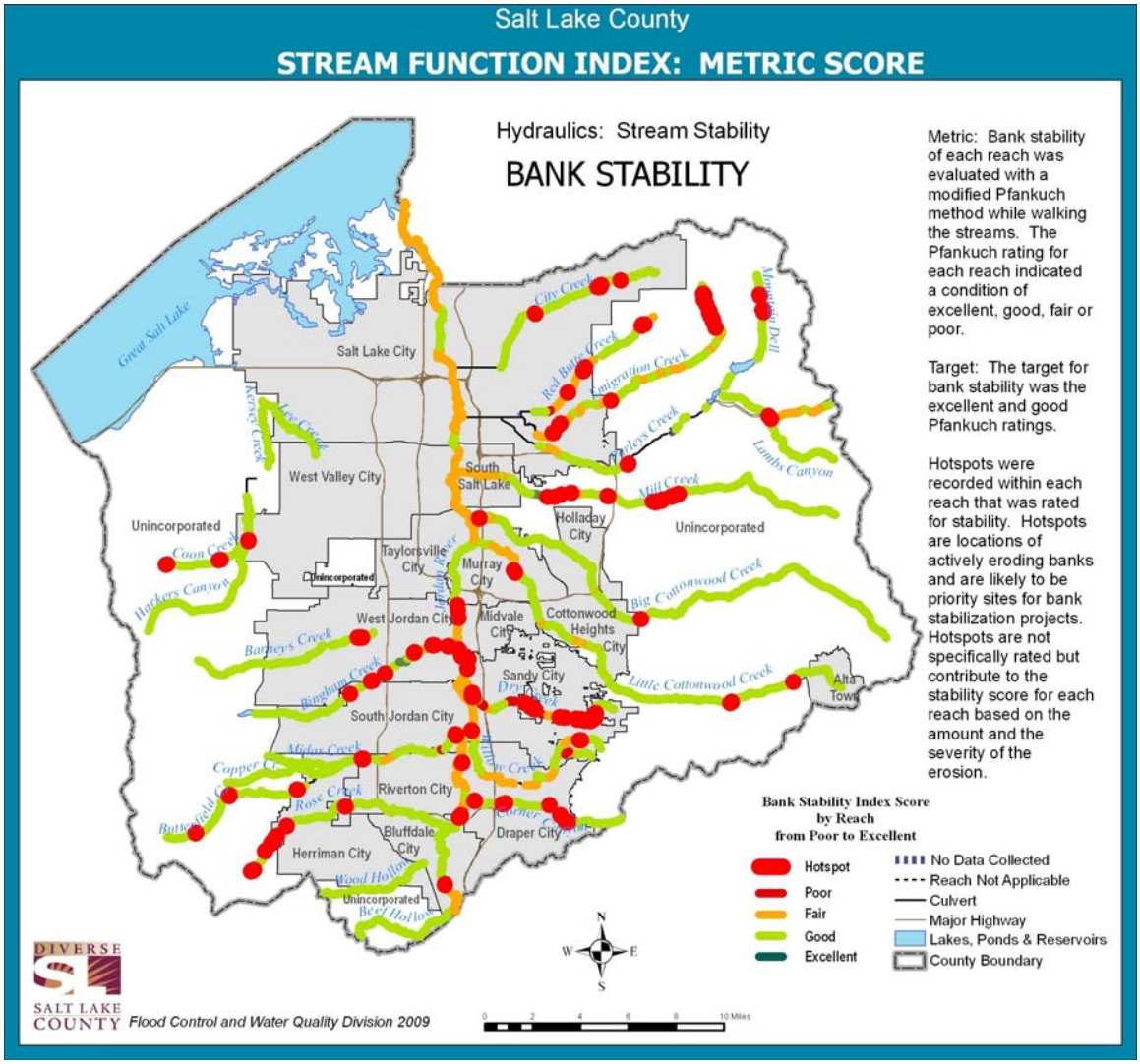


Figure 3.17 Bank Stability Metric Scores

3.3 WATER QUALITY FUNCTIONAL GROUP

The Water Quality Functional Group score assessed water quality in the County's waterways with three approaches: meeting State standards (Regulatory Sub-Group), biological monitoring (Aquatic Sub-Group), and water sampling (Monitoring Sub-Group.) All scores for water quality are based on the State of Utah's water quality standards. The scores ranged from a high of 100 to a low of 0 for 44 segments. The average score was 82.

The map below shows that the lowest scoring stream segments were the Upper and Lower Jordan River and lower Little Cottonwood Creek which scored between 30 and 39.9. Other low scoring streams on the east side were Emigration Canyon, Burr Fork, lower Big Cottonwood Creek and upper Little Cottonwood Creek which scored between 40 to 49.9. Lower Parleys Creek scored moderately between 50 and 59.9. The rest of the streams scored 70 and above.

Water Quality Functional Group	
Average Segment Score	82
High Score	100
Low Score	0
Number of Segments	44

The following maps will break down the Water Quality Functional Group scores by sub-group and metrics. Additionally, all scores are presented in table and chart forms in Appendix B.

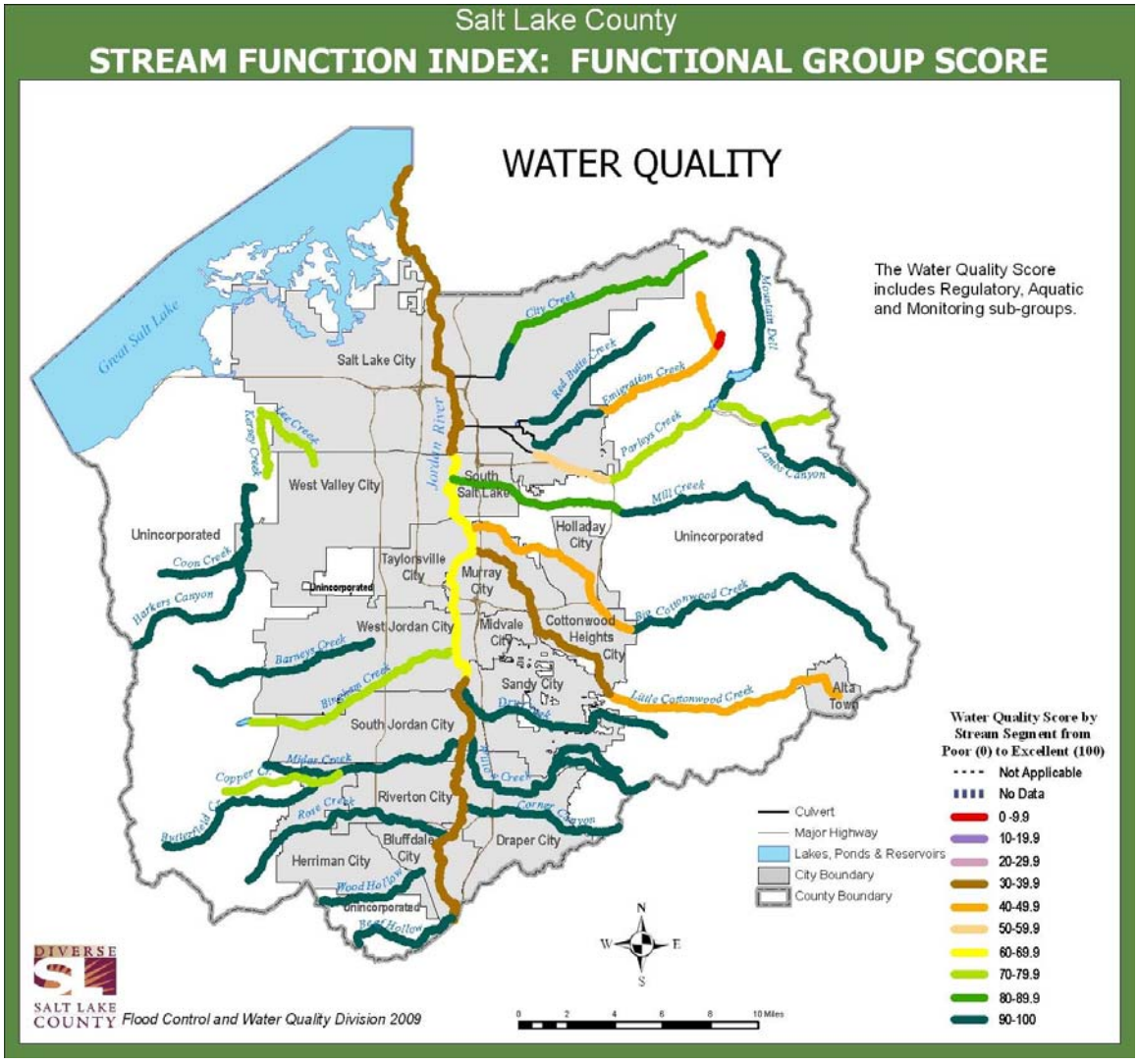


Figure 3.18 Water Quality Functional Group Scores

3.3.1 Water Quality Regulatory Sub-Group

Water Quality Regulatory Sub-Group includes only one metric that identified the streams in Salt Lake County that did not meet Utah State Water Quality Standards. These were listed by the State as the 303(d) List of Impaired Waters as required by the Clean Water Act as amended. Out of 44 stream segments rated, the average score was 78. The high score was 100 and the low score was 0.

The map below shows the score based on the percent of the length of stream segments that were listed as impaired by the State. The more impaired a segment was, the lower the score. The Jordan River, Emigration Canyon, Parleys Creek, lower Big Cottonwood Creek and all of Little Cottonwood Creek did not, in some part, meet water quality standards. The metric map on the next page identifies the specific reaches that were listed in the 303(d) List.

Water Quality Regulatory Sub-Group	
Average Segment Score	78
High Score	100
Low Score	0
Number of Segments Evaluated	44

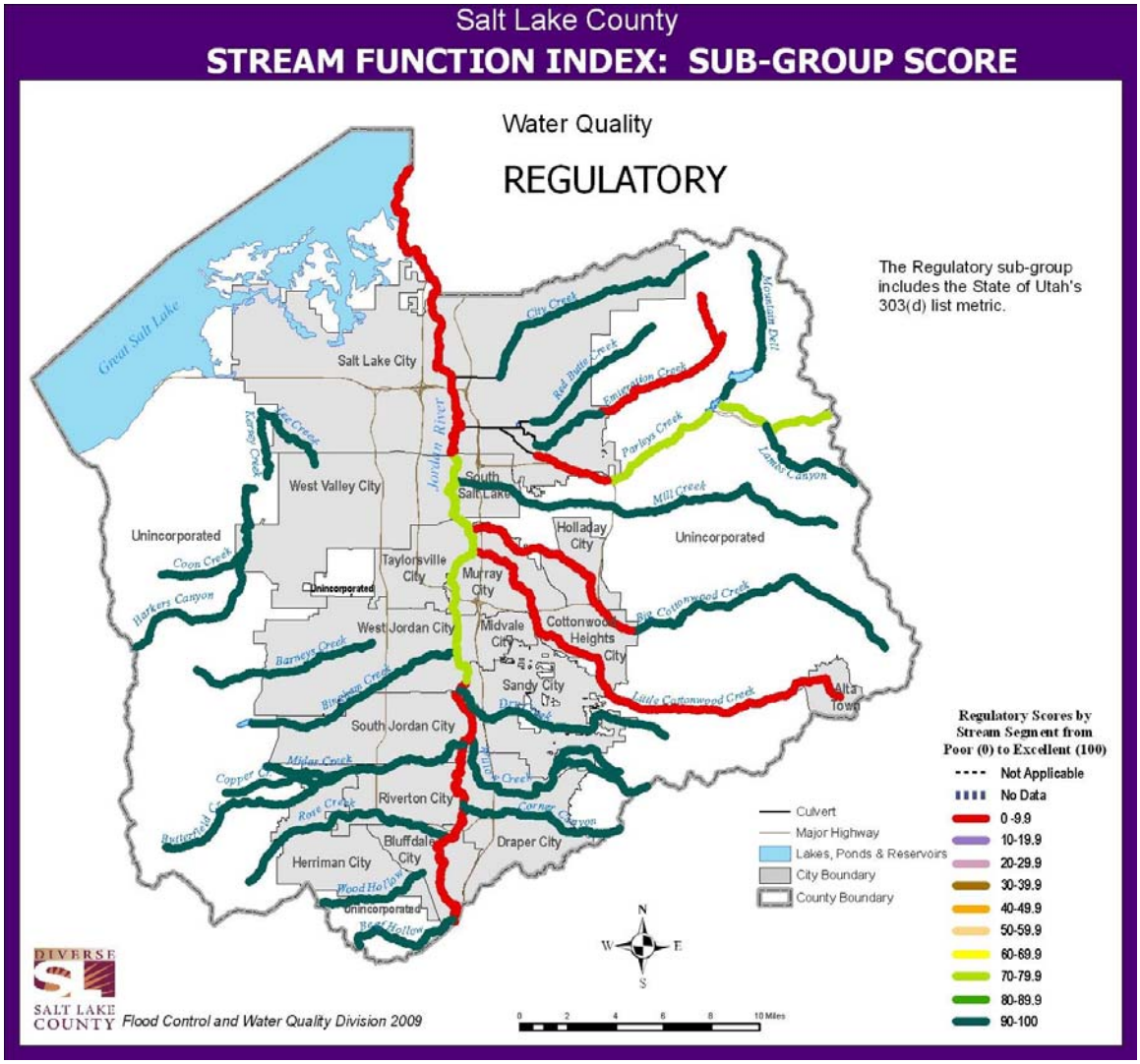


Figure 3.19 Water Quality Regulatory Sub-Group Scores

3.3.2 303(d) List Metric

The 303(d) List Metric measured if the State of Utah recognized water quality impairment in the County's waterways based on State Water Quality Standards called beneficial use. If a stream reach was listed for impairment by the State in the 303 (d) List of Impaired Waters it was given a 0 and, if it not listed, 100 was assigned. Once a stream is listed for impairment on the 303(d) List, certain regulatory actions may be required until water quality standards are met.

The map below shows a score of 0 for impaired waterways. These include the following:

- The Jordan River Total Maximum Daily Load (TMDL) study is in progress for Dissolved Oxygen (DO), *E. coli*, temperature and Total Dissolved Solids (TDS).

303(d) List Metric	
Average Reach Score	80
High Score	100
Low Score	0
Number of Reaches Evaluated	566

- Emigration Canyon TMDL is in progress for pathogens.
- Little Cottonwood Canyon TMDL for zinc is approved and currently in implementation phase.
- Lower Little Cottonwood Creek is listed as needing a TMDL for temperature and TDS.
- Lower Big Cottonwood Creek is listed as needing a TMDL for temperature.
- Parleys Canyon is listed as impaired by habitat alterations for which a TMDL is not required.

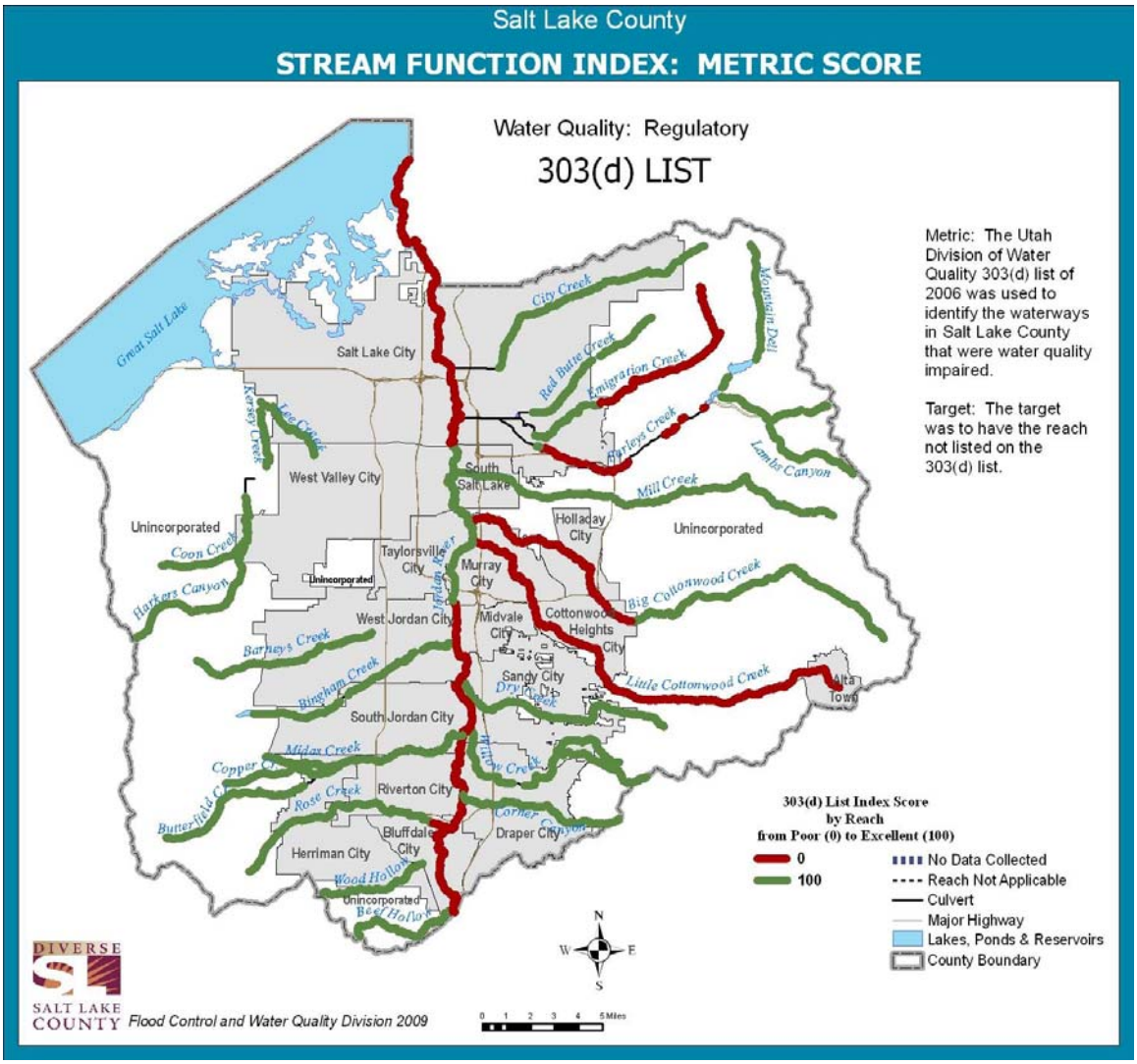


Figure 3.20 303(d) List Metric Scores

3.3.3 Water Quality Aquatic Sub-Group

The Water Quality Aquatic Sub-Group addressed the use of biological indicators to monitor water quality using one metric, Macroinvertebrate Metric. The collection and identification of stream bottom-dwelling macroinvertebrates (animals without backbones that are larger than 1/2 millimeter) indicate localized conditions over the period of time that the organism lived there. The poorer the water quality, the fewer macroinvertebrate species sensitive to pollutants will be found.

Macroinvertebrate data was not available for the 2009 SFI. However, a countywide macroinvertebrate sampling effort was begun in late 2009 working closely with the Utah Division of Water Quality (DWQ) and using their protocol. Sampling will continue and that data will be used for the next SFI.

The map below simply shows No Data for the Water Quality Aquatic Sub-Group.

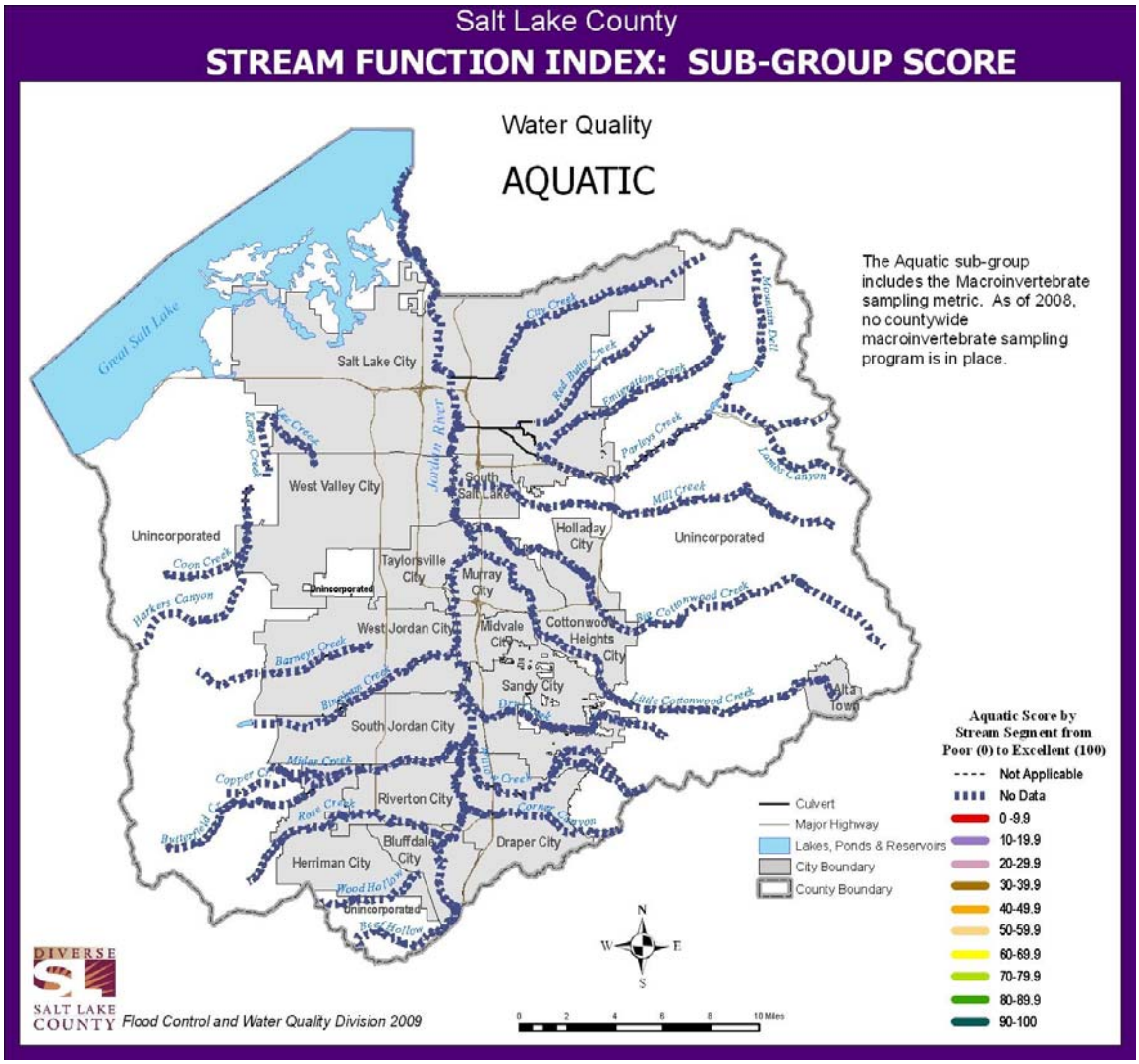


Figure 3.21 Water Quality Aquatic Sub-Group Scores

3.3.4 Water Quality Monitoring Sub-Group

The Water Quality Monitoring Sub-Group measured the quality of the water based on samples from the water column taken at selected sites between 2001 and 2008. This data was derived from the Environmental Protection Agency's (EPA) STORET database. Five water quality indicators were selected as metrics and included Total Phosphorus (TP), Temperature, Total Dissolved Solids (TDS), Dissolved Oxygen (DO) and *E. Coli*. Out of 22 stream segments where data was available, the average score was 76. The high score was 100 and the low score was 51.

Water Quality Monitoring Sub-Group	
Average Segment Score	76
High Score	100
Low Score	51
Number of Segments Evaluated	22

The map below shows that the east side perennial streams generally scored moderately high to high (70 to 100.) However, a few stream segments including City Creek, upper Parleys Creek and lower Mill Creek scored only moderately (50 to 69.9.) On the west side, Bingham Creek scored moderately low (40 to 49.9), Kersey, Lee and Copper Creeks scored moderately (50 to 59.9), and upper Butterfield scored high (80 to 89.9.) The upper Jordan River scored moderately high (70 to 79.9) whereas the lower Jordan scored lower at 60 to 69.9, and the middle Jordan River scored only moderately at 50 to 59.9.

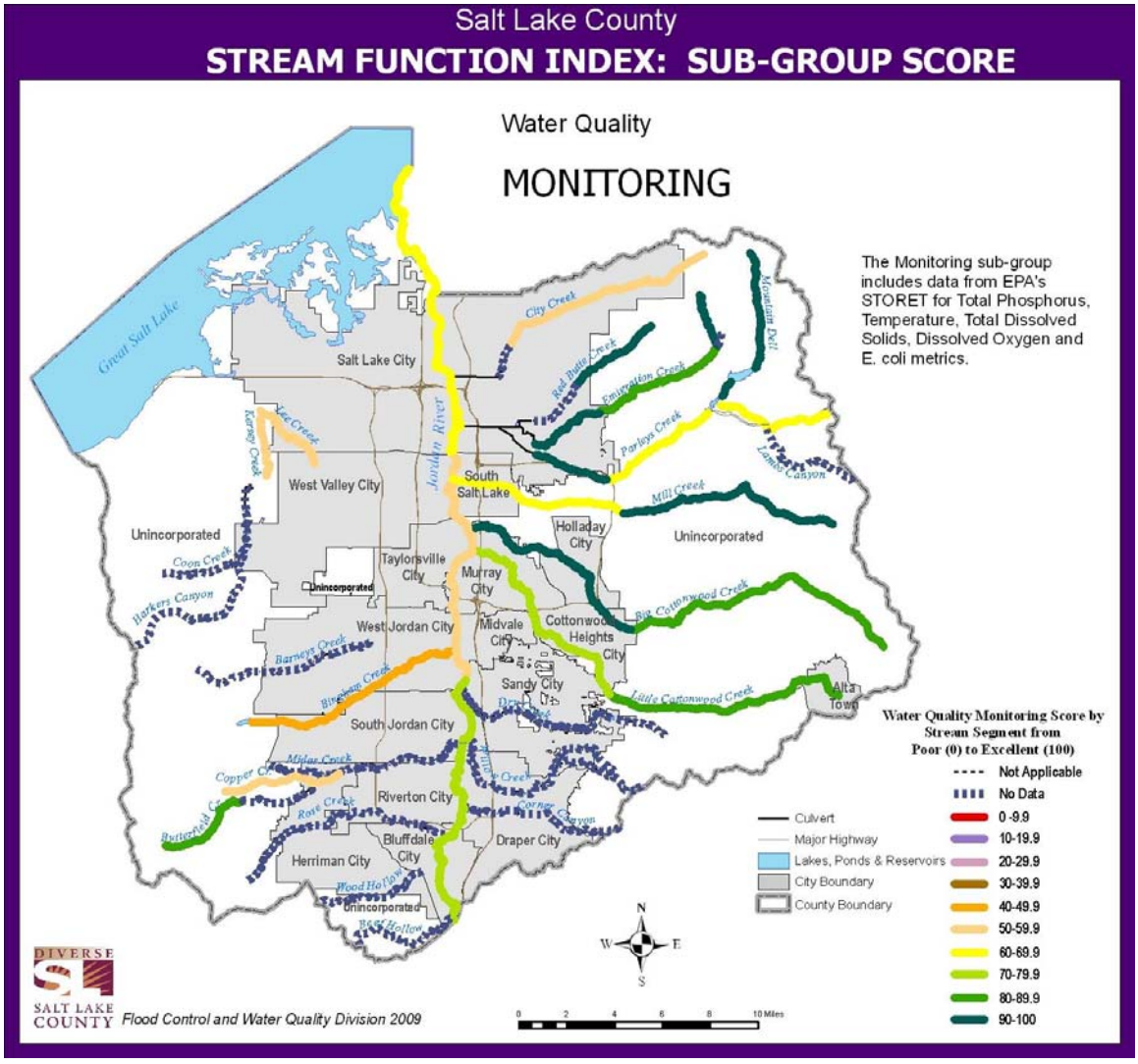


Figure 3.22 Water Quality Monitoring Sub-Group Scores

3.3.5 Total Phosphorus Metric

Total Phosphorus score ranged from 93 to 1 with an average score of 50.

The map below shows that of the streams with data, the lower Cottonwood Creeks, upper Mill Creek, upper Parleys Creek, Mountain Dell Creek, and upper Red Butte Creek scored moderately high (76 to 99.) Emigration Canyon, upper Big Cottonwood Creek and upper Butterfield Creek scored moderately (51 to 75.) Upper Little Cottonwood Creek, upper Jordan River and lower Mill Creek scored moderately low (26 to 50.) Upper City Creek, Kersey Creek and the Jordan River below 90th S scored very low (1 to 25.) Bingham Creek and Lee Creek received lowest scores for Total Phosphorus at 0. The remaining streams had no data to score.

Total Phosphorus Metric	
Average Segment Score	50
High Score	93
Low Score	1
Number of Segments Evaluated	19

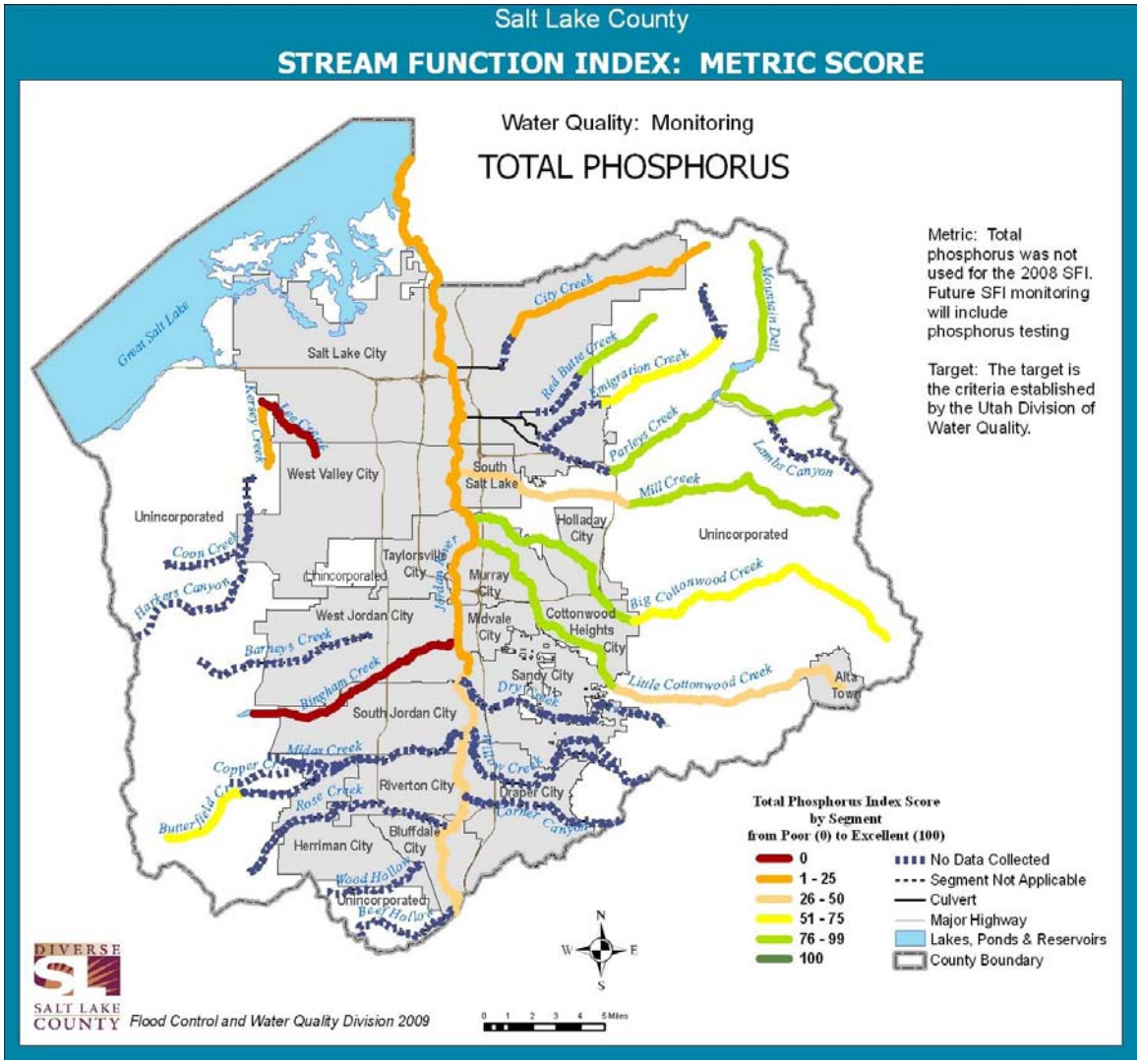


Figure 3.23 Total Phosphorus Metric Scores

3.3.6 Temperature Metric

The Temperature Metric showed generally high scores. The average score was 96 with a high score of 100 and the low score 78.

Temperature Metric	
Average Segment Score	96
High Score	100
Low Score	78
Number of Segments	22

The map below shows that all the waterways with data scored high for temperature. The mountain stream segments scored 100 except City Creek and Little Cottonwood Creek which score between 76 to 99. Lower Emigration and Parleys Creeks scored 100 whereas lower Mill Creek, lower Big and Little Cottonwood Creeks and Bingham Creek scored between 76 and 99. The Jordan River also scored between 76 and 99.

Although the Jordan River showed high scores, the river is currently in a TMDL study in part for being impaired by temperature. DWQ is also recommending that lower Little and Big Cottonwood Creeks are in need of TMDLs for temperature. The small amount and incomplete data used for the SFI is the likely the reason for the differences. Efforts are currently underway to gather more comprehensive data on all streams for a more accurate water quality assessment for the next SFI.

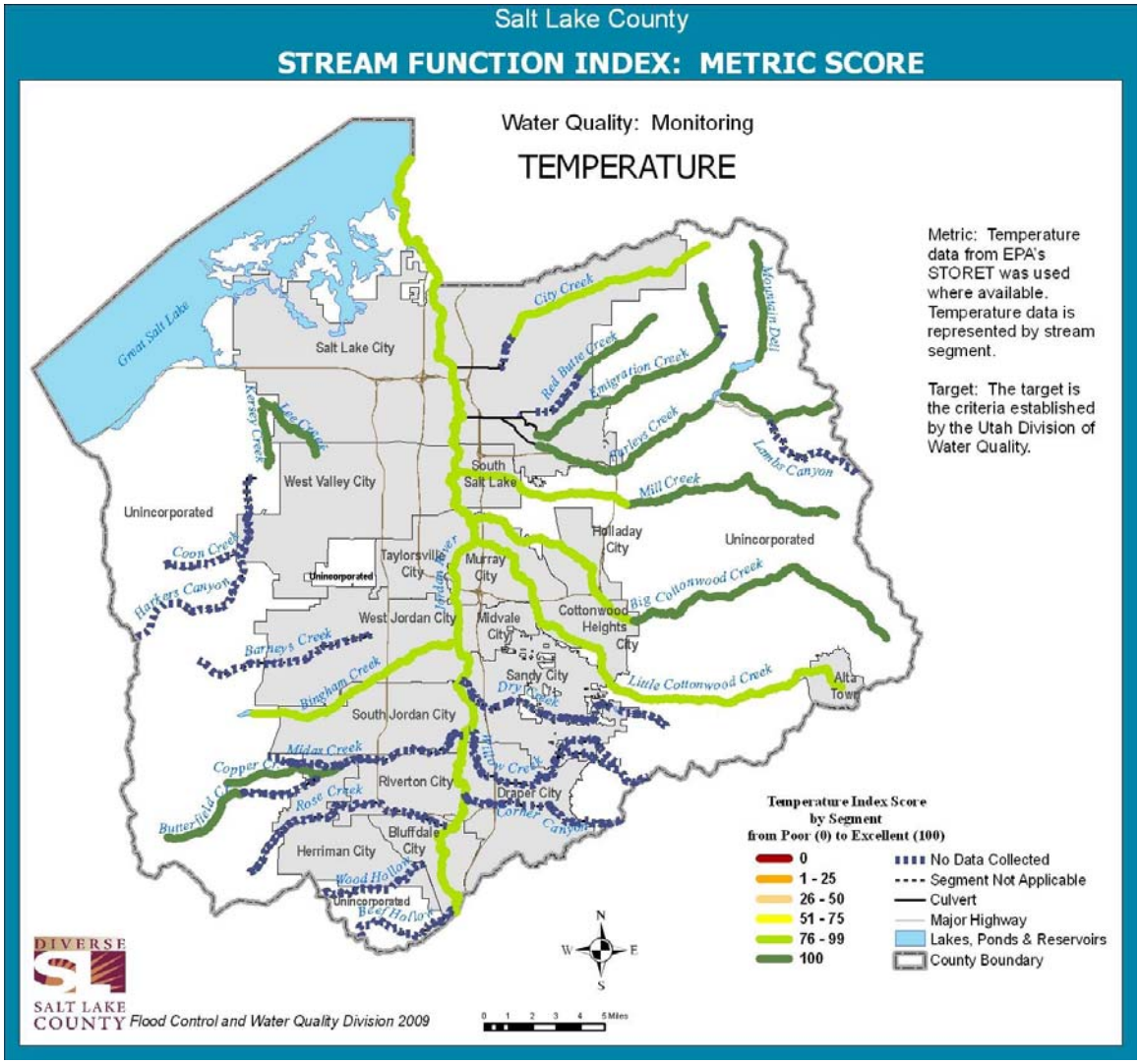


Figure 3.24 Temperature Metric Scores

3.3.7 Total Dissolved Solids Metric

The Total Dissolved Solids (TDS) Metric scores ranged from 0 to 100 with an average score of 70.

Total Dissolved Solids Metric	
Average Segment Score	76
High Score	100
Low Score	0
Number of Segments	21

The map below shows that, of the streams with data, the east side scored high (76 to 100) except for upper Parleys Creek which scored very low (1 to 25.) On the west side, Kersey Creek scored 0, Bingham Creek scored very low (1 to 25), Lee Creek scored low (26 to 50), upper Butterfield Creek scored moderately (51 to 75), and lower Butterfield Creek scored high (76 to 99.) The middle Jordan River scored moderately (51 to 75), the upper Jordan River scored high (75 to 99), and the lower Jordan River scored 100.

Although the Jordan River showed high scores, the river is currently in a TMDL study in part for being impaired by high TDS. The small amount and incomplete data used for the SFI is the likely the reason for the differences. Efforts are currently underway to gather more comprehensive data on all streams for a more accurate water quality assessment for the next SFI.

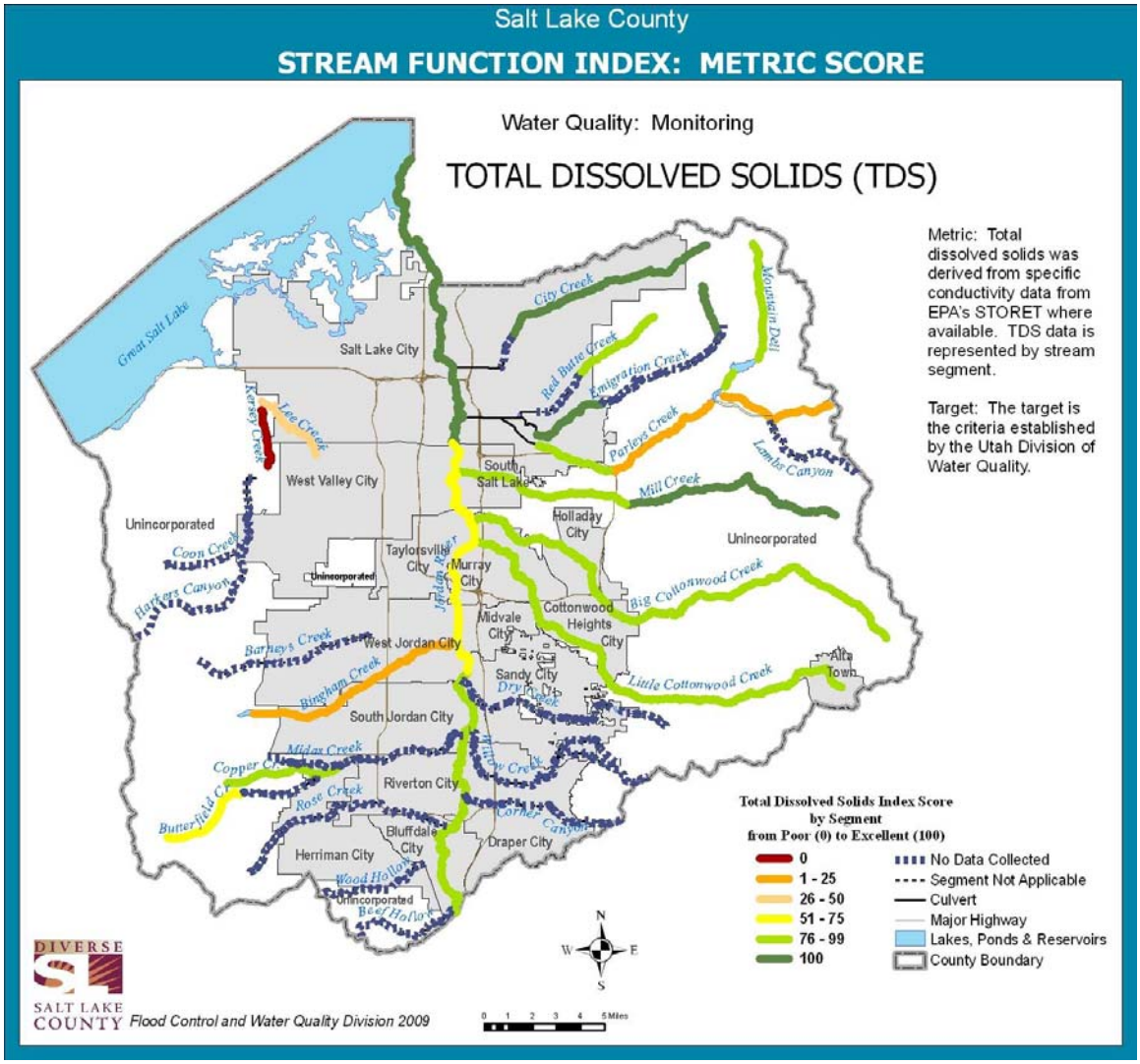


Figure 3.25 Total Dissolved Solids Metric Scores

3.3.8 Dissolved Oxygen Metric

The Dissolved Oxygen (DO) Metric scores ranged from 20 to 100 with an average score of 73.

The map below shows that, of the streams with data, only City Creek scored low (1 to 25.) Lower Mill Creek, lower Little Cottonwood Creek, and Copper Creek scored moderately (51-75.) The Jordan River, Burr Fork, upper Little Cottonwood and Butterfield Creeks, and Bingham and Kersey Creeks scored moderately high (76 to 99.) The high score of 100 was found on Lee Creek and lower Big Cottonwood Creek.

Although the Jordan River showed high scores, the river is currently in a TMDL study in part for being impaired by low DO. The small amount and incomplete data used for the SFI is the likely the reason for the differences. Efforts are currently underway to gather more comprehensive data on all streams for a more accurate water quality assessment for the next SFI.

Dissolved Oxygen Metric	
Average Segment Score	73
High Score	100
Low Score	20
Number of Segments	16

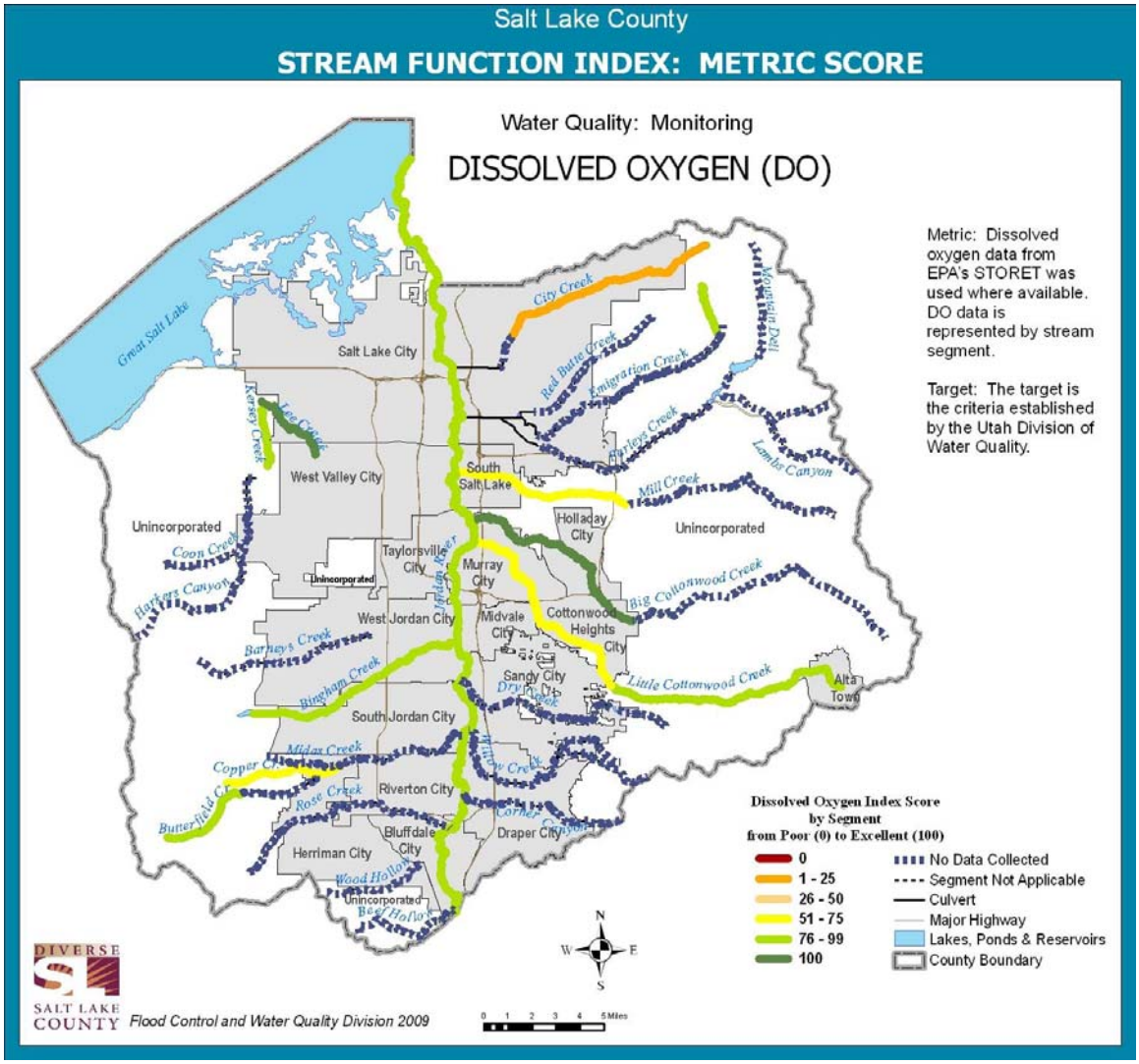


Figure 3.26 Dissolved Oxygen Metric Scores

3.3.9 *E. coli* Metric

The last water quality monitoring metric included in the SFI was the *E. coli* Metric. The three segments of *E.coli* Metric score data ranged from 24 to 56 with an average score of 41.

E. coli Metric	
Average Segment Score	41
High Score	56
Low Score	24
Number of Segments	3

Currently, EPA's STORET database was limited to *E. coli* data collected on the Jordan River between 2001 and 2008. Future SFI reports will incorporate new *E. coli* data now being collected along all perennial tributaries of the Jordan River.

As shown in the map below, the upper Jordan River scores were low (41/100 average) and decreased more (24/100) as the river flows north into Great Salt Lake. Although no tributary information was included in this data, it is likely that tributaries are contributing *E. coli* into the Jordan River.

Emigration Creek and the Jordan River are both listed as water quality impaired on the DWQ 303(d) list for high bacteria levels and as a result, a TMDL study is underway for both of these water bodies. Current sources of *E. coli* are still undetermined.

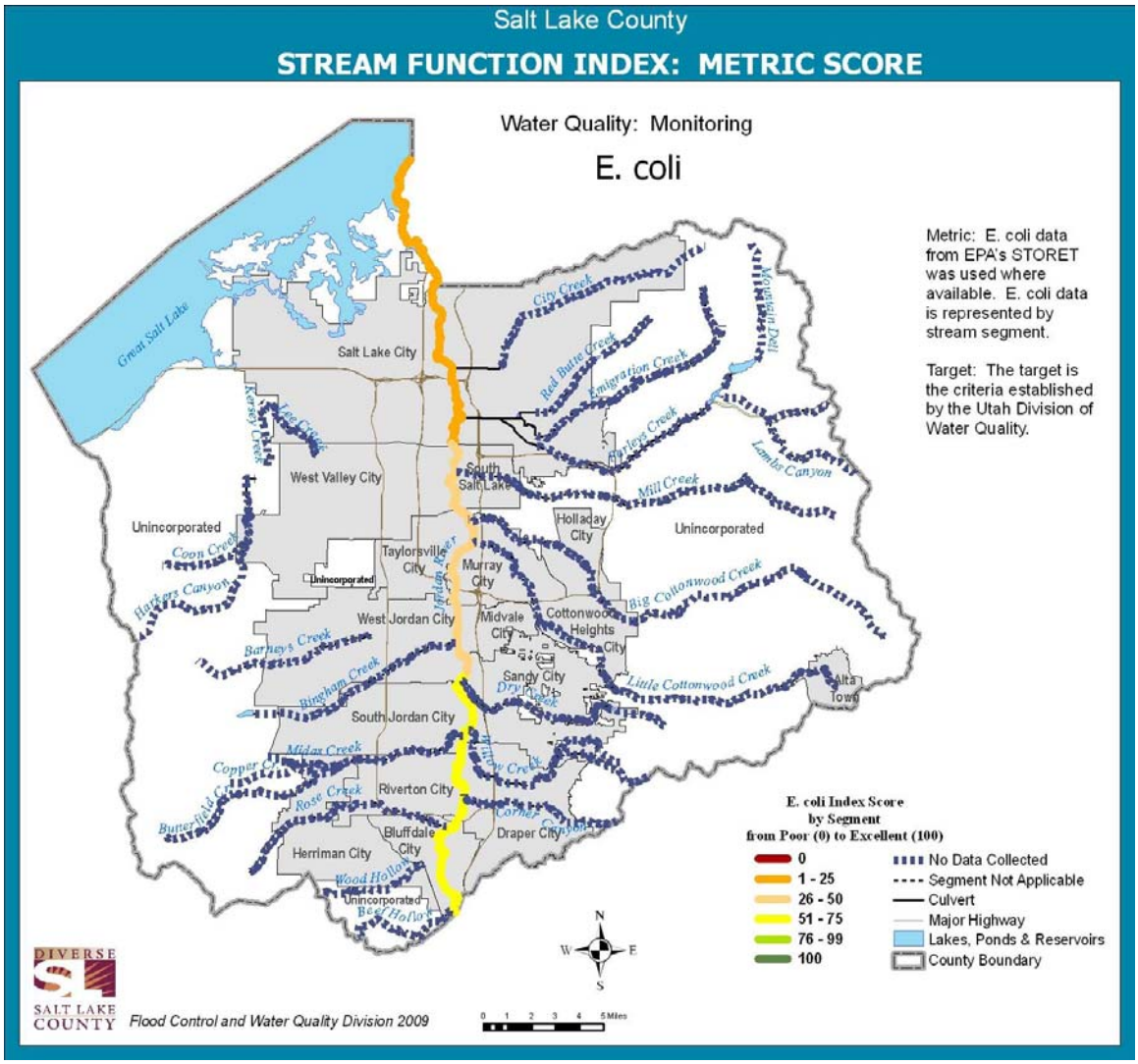


Figure 3.27 *E. coli* Metric Scores

3.4 ECOSYSTEM HEALTH INDEX

The Ecosystem Health Index (EHI) is the evaluation of physical, chemical and biological function of waterways in Salt Lake County. The functional groups whose results were reviewed in previous pages of this report were included: Habitat, Hydraulics, and Water Quality Functional Groups. The scores were averaged to obtain the EHI scores for the upper and lower segments of the streams. Out of 44 stream segments rated, the average score was 73. The high score was 100 and the low score was 52.

Ecosystem Health Index of Stream Segments	
Average Segment Score	73
High Score	100
Low Score	52
Number of Segments	44

The map below shows the mountain stream segments scored generally high. Little Cottonwood, Emigration Canyon and Burr Fork scored only moderately high between 60 and 69.9. Mountain Dell and upper Willow Creeks scored the highest (100.) And, the rest of the mountain streams scored moderately high between 70 and 89.9.

Most valley stream segments scored only moderately between 50 and 69.9 except for lower Emigration and Red Butte Creeks, Rose Creek, Barneys, Kersey and Lee Creeks which scored higher between 70 and 79.9. Lower Coon Creek and Brigham Creek both scored even higher between 80 and 89.9.

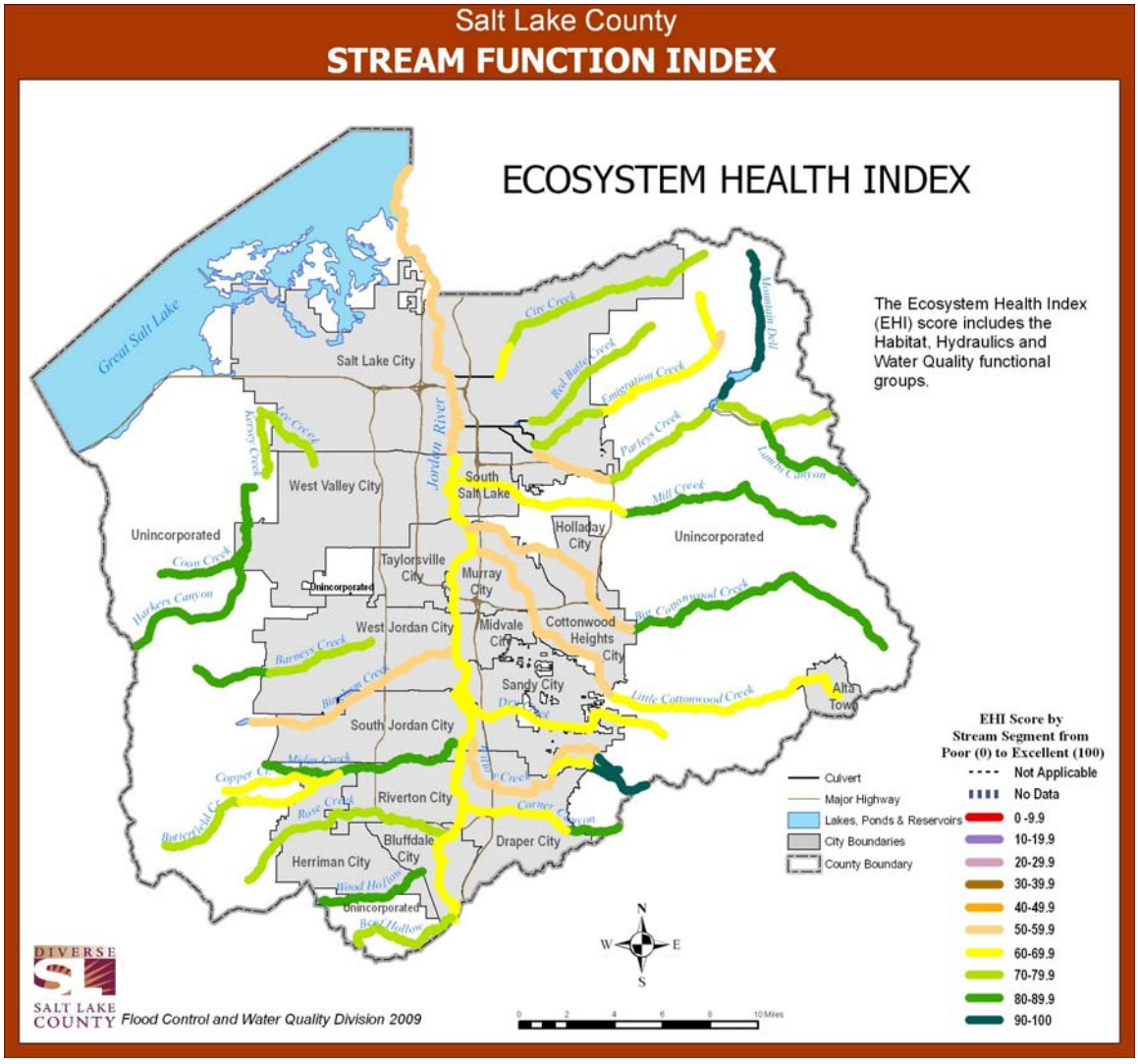


Figure 3.28 Ecosystem Health Index Scores by Stream Segment

3.5 SOCIAL FUNCTIONAL GROUP

The Social Functional Group score assessed the value of the County's waterways to the community as a visual amenity (Aesthetics Sub-Group) and as a recreation amenity including impacts of users on the waterways (Recreation Node Amenities and Trail Amenities.) Recreation Nodes were managed sites set aside for recreation including parks and trailheads. Each activity facility such as pavilions or playgrounds were rated as part of the node. Out of 44 stream segments rated, the average score was 42. The high score was 88 and the low score was 0.

The map below shows that along with the west side mountain streams, Butterfield and Copper Creeks, Kersey Creek, Emigration Canyon, Burr Fork, upper Red Butte Creek, and lower Mill and Big Cottonwood Creeks scored poor (0 to 29.9) primarily due to the lack of recreation sites. The high scoring stream segments between 70 to 100 included City Creek, lower Red Butte, Emigration and Parleys Creek, Mountain Dell Creek, upper Mill and Little Cottonwood Creek and lower Dry and Corner Canyon Creeks.

Social Functional Group	
Average Segment Score	42
High Score	88
Low Score	0
Number of Segments	44

The following maps will break down the Social Functional Group scores by sub-group and metrics. Additionally, all scores are presented in table and chart forms in Appendix B.

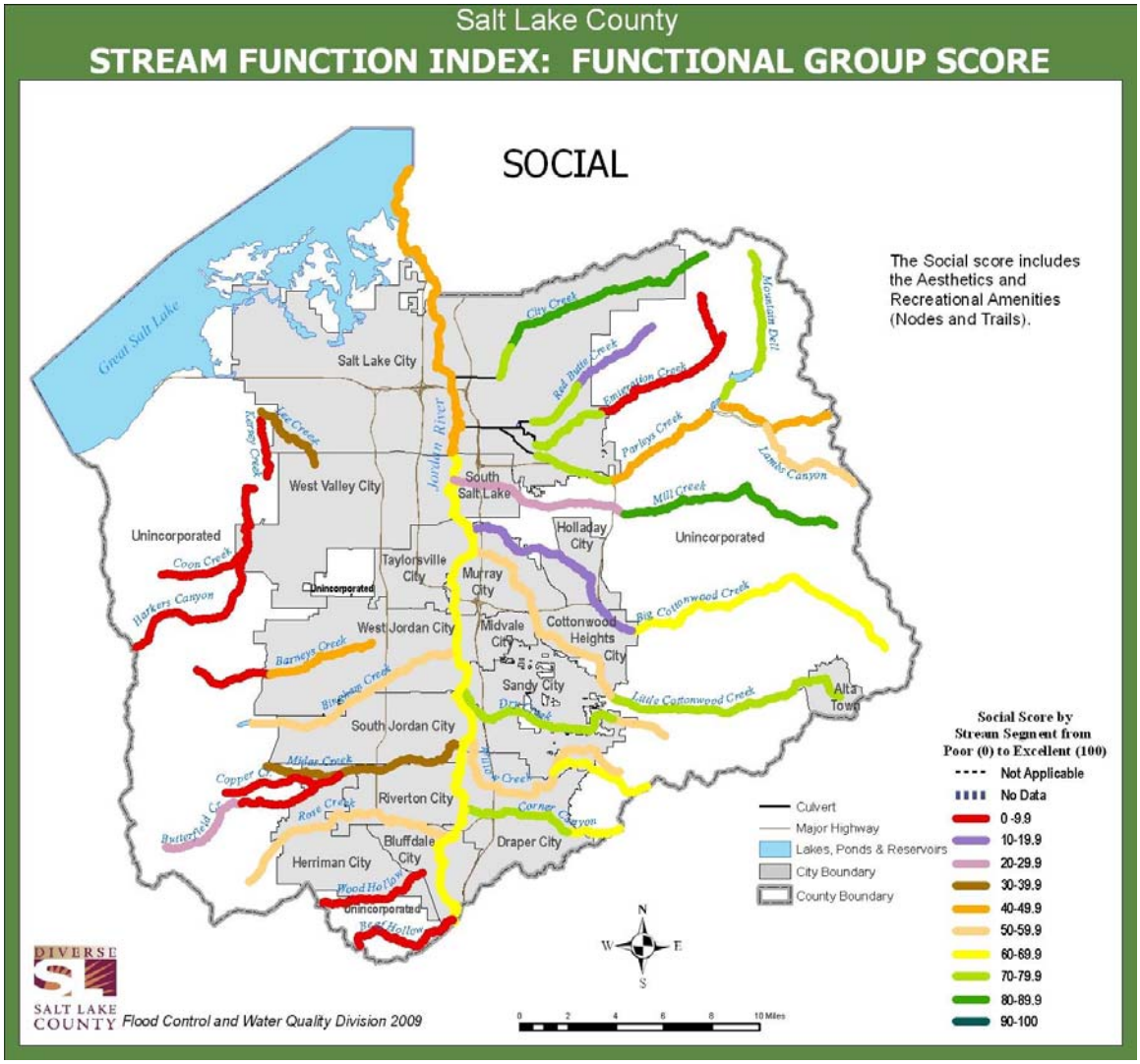


Figure 3.29 Social Functional Group Scores

3.5.1 Aesthetics Sub-Group

The Aesthetics Sub-Group included two metrics, Managed Open Space Metric and Visual Aesthetics Metric. The Visual Aesthetic Metric was not completed in time for the 2009 SFI. Thus, only the Managed Open Space Metric scores were reflected in the scores of this sub-group. Out of 44 stream segments rated for this sub-group, the average score was 61. The high score was 100 and the low score was 0.

Because there is only one metric in this sub-group, the map below shows the data represented in 10 categories whereas the Managed Open Space Metric map on the following page (Fig. 3-31.) represents the same data divided into 6 categories.

Aesthetics Sub-Group	
Average Segment Score	61
High Score	100
Low Score	0
Number of Segments	44

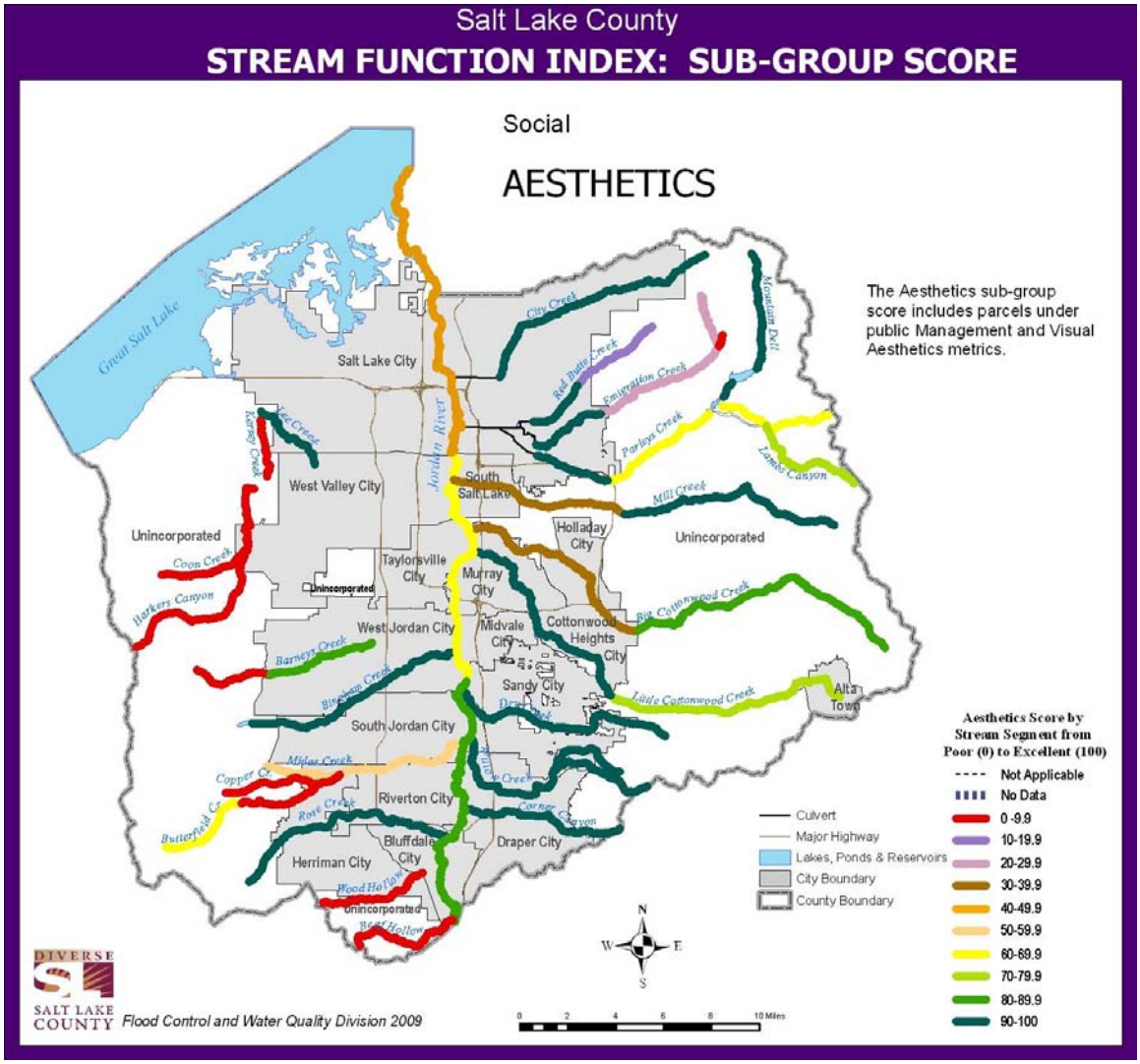


Figure 3.30 Aesthetics Sub-Group Scores

3.5.2 Managed Open Space Metric

The Managed Open Space Metric measured the amount of open space within 100 feet of a County waterway. Open land under management (rather than undeveloped land) was considered a visual amenity, a natural respite amidst urban landscapes. Out if 44 segments the scores ranged from 0 to 100 with an average score of 61.

Managed Open Space Metric	
Average Segment Score	61
High Score	100
Low Score	0
Number of Segments	44

The map below shows that generally the west side mountain streams had low scores primarily because of the large amount of private and military undeveloped land in the Oquirrh Mountains. Although these areas had low scores, future development has the potential to increase the score in these areas. Only Kersey Creek, Copper and lower Butterfield Creeks in the west side valley scored poor. All other streams scored above 50. The east side mountains scores were high except Emigration Canyon and Burr Fork, Red Butte and upper Parleys Creek. Red Butte Canyon scored low because recreation activity was restricted above the Red Butte Botanic Garden. Lower Mill and Big Cottonwood Creek rated moderately low as did lower Jordan River primarily because of the marsh conditions near Great Salt Lake. The middle and upper Jordan scored moderate (51 to 75) to moderately high (76 to 99) respectively.

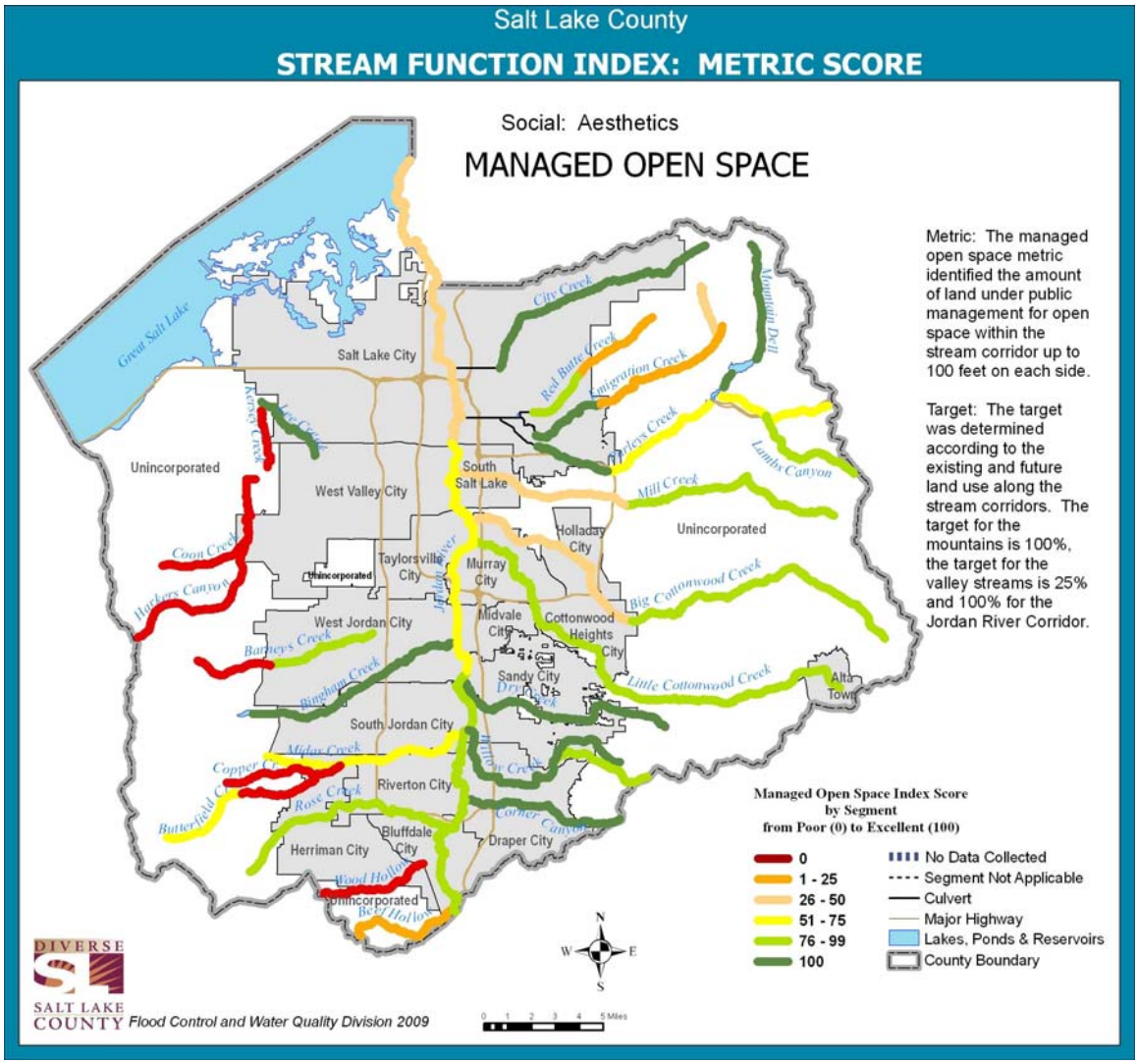


Figure 3.31 Managed Open Space Metric Scores

3.5.3 Recreation Node Amenity Sub-Group

The Recreation Node Amenities Sub-Group assessed waterways according to the social functions their current infrastructure provided (Recreation Node Location, Accessibility or ADA Standard, and Restroom Metrics), and environmental impacts that may occur from the use and presence of the facility (Recreation Node Resource Compatibility Metric.) Out of 44 stream segments rated, the average score was 31. The high score was 89 and the low score was 0.

Recreation Node Sub-Group	
Average Segment Score	31
High Score	89
Low Score	0
Number of Segments	44

The map below shows that the west side mountains scored very poorly (0) because of the large amount of private and military undeveloped land in the Oquirrh Mountains. In the west side valley Barney and Midas Creeks, Copper Creek and Kersey and Lee Creek scored low, where as Bingham and Rose Creeks scored moderate.

On the east side mountains, Red Butte Canyon, Emigration Canyon and Burr Fork, Bell's Canyon, Willow Creeks, and Corner Canyon Creek scored poor (0) primarily due to lack of facilities. Big and Little Cottonwood Canyons and Mill Creek Canyon scored high. The east side valley and Jordan River generally received moderate scores except lower Big Cottonwood Creek with a low score and Red Butte with a high score.

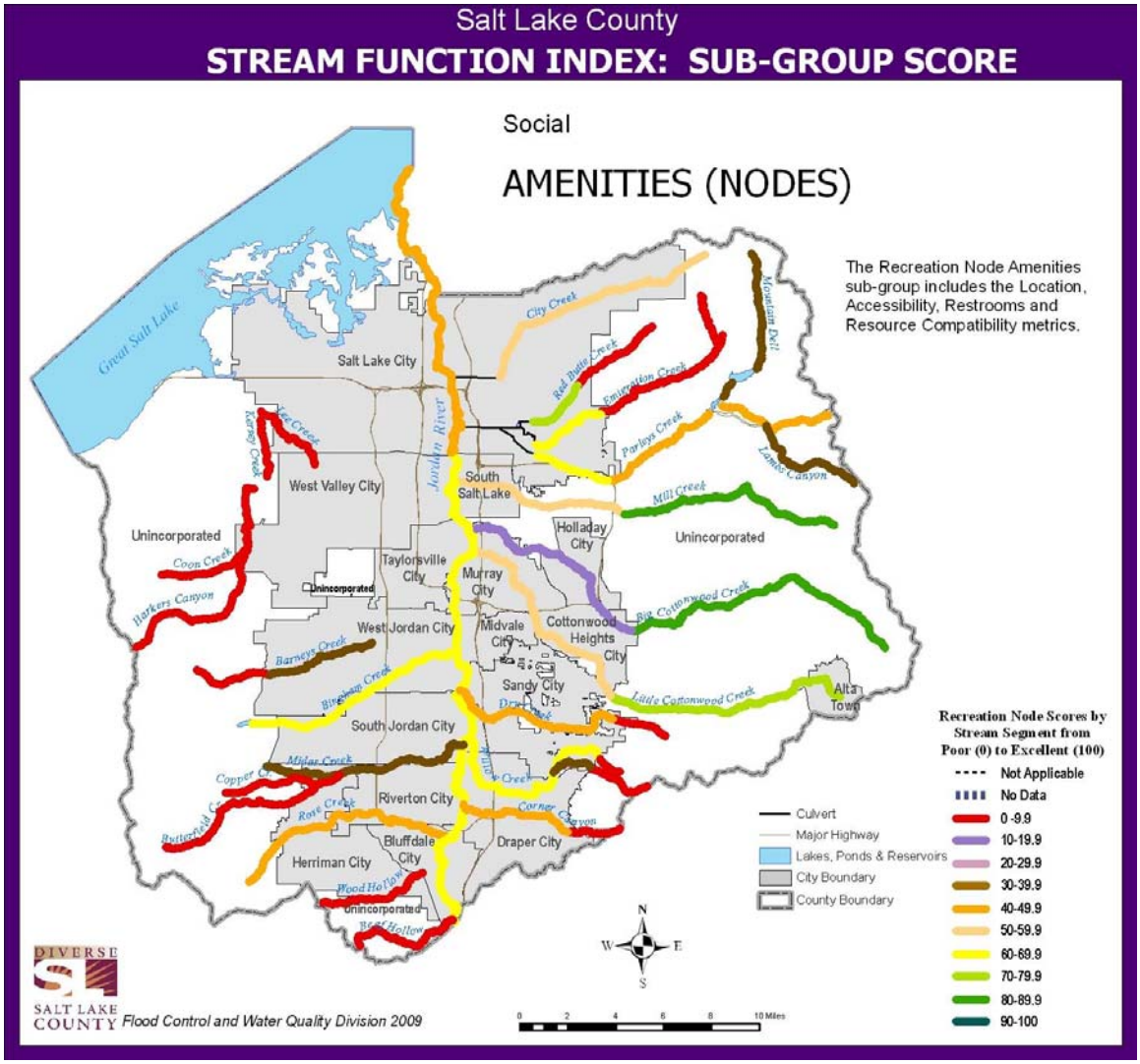


Figure 3.32 Recreation Node Amenity Sub-Group Scores

3.5.4 Recreation Node Location Metric

The Recreation Node Location measured the number of public parks, trailheads and campgrounds within 100 feet of streams. The target was one node per mile. The scores ranged from 0 to 100 with an average score of 31.

The map below shows that nodes were not present along the streams that scored 0 (symbolized in red.) Where nodes were present, the metric scored 100 for upper Mill and Big Cottonwood Creeks, lower City Creek, Red Butte, Emigration and Parleys Creeks and middle Jordan River. Bingham Creek and upper Jordan River scored moderately high (76 to 99) and Rose and Corner Canyon Creeks scored moderate (51 to 75.) The remaining segments scored low to moderately low.

Node Location Metric	
Average Segment Score	31
High Score	100
Low Score	0
Number of Segments	44

Two stream segment scores, upper City Creek and lower Dry Creek, deserve to be mentioned here as the exception to the low score values. The number of nodes counted in each segment is one. However, both creeks are excellent examples of large scale natural open parklands along a stream corridor in an urban setting. Both creeks are managed to provide stream protection and non-motorized trail access over a distance of several miles. However, these same stream segments scored high in the Managed Open Space Metric which tallies acres of managed open space within 100 feet of the bank.

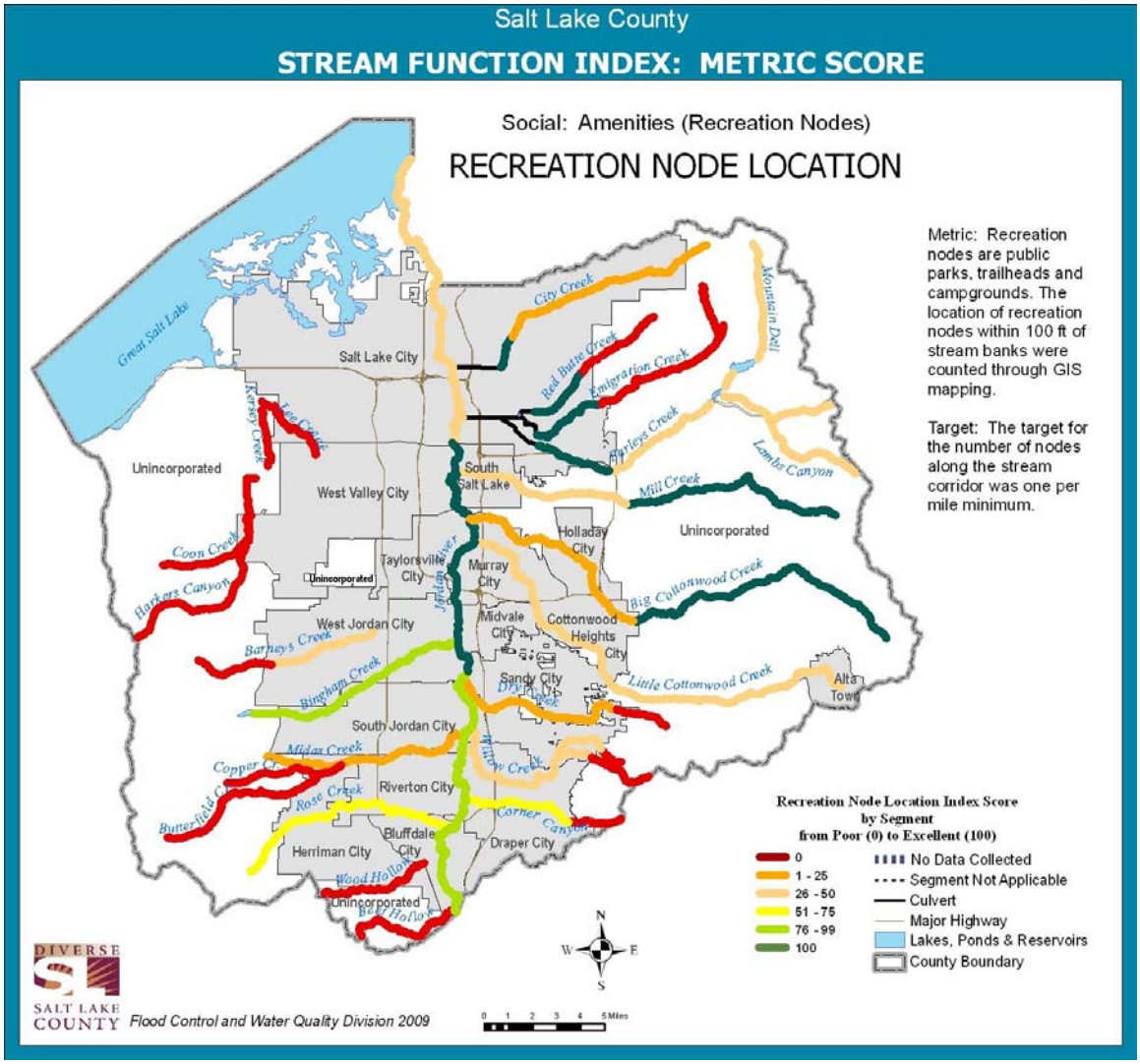


Figure 3.33 Recreation Node Location Metric Scores

3.5.5 Accessibility Metric

The Accessibility Metric measured the usability of nodes by people with disabilities. The target is 100% compliance with the Americans With Disabilities Act (ADA) for visibility and location of parking, walkway and activity access, and restroom and park furniture usability. Depending on the type of expected use, most urban recreation nodes needed to meet this target. A few wilderness trailheads were not evaluated. Out of 24 segments, the scores ranged from 0 to 93 and averaged 34.

The poor scores were lower Barneys, Midas and Rose Creeks, lower Corner Canyon and Willow Creeks, lower Big Cottonwood Creek and Parleys Creek upper watershed. Lower Emigration and Bingham Creeks scored only slightly better (1 to 25.) Lower Jordan River, lower City, Emigration, Mill and Big Cottonwood Creeks scored moderately low scores (26 to 50.) The upper Jordan River and lower Red Butte, Big Cottonwood and lower Dry Creek scored moderate (51 to 75.) The high scores went to upper City, Mill and Little Cottonwood Creeks and the middle Jordan River.

Node Accessibility Metric	
Average Segment Score	34
High Score	93
Low Score	0
Number of Segments	24

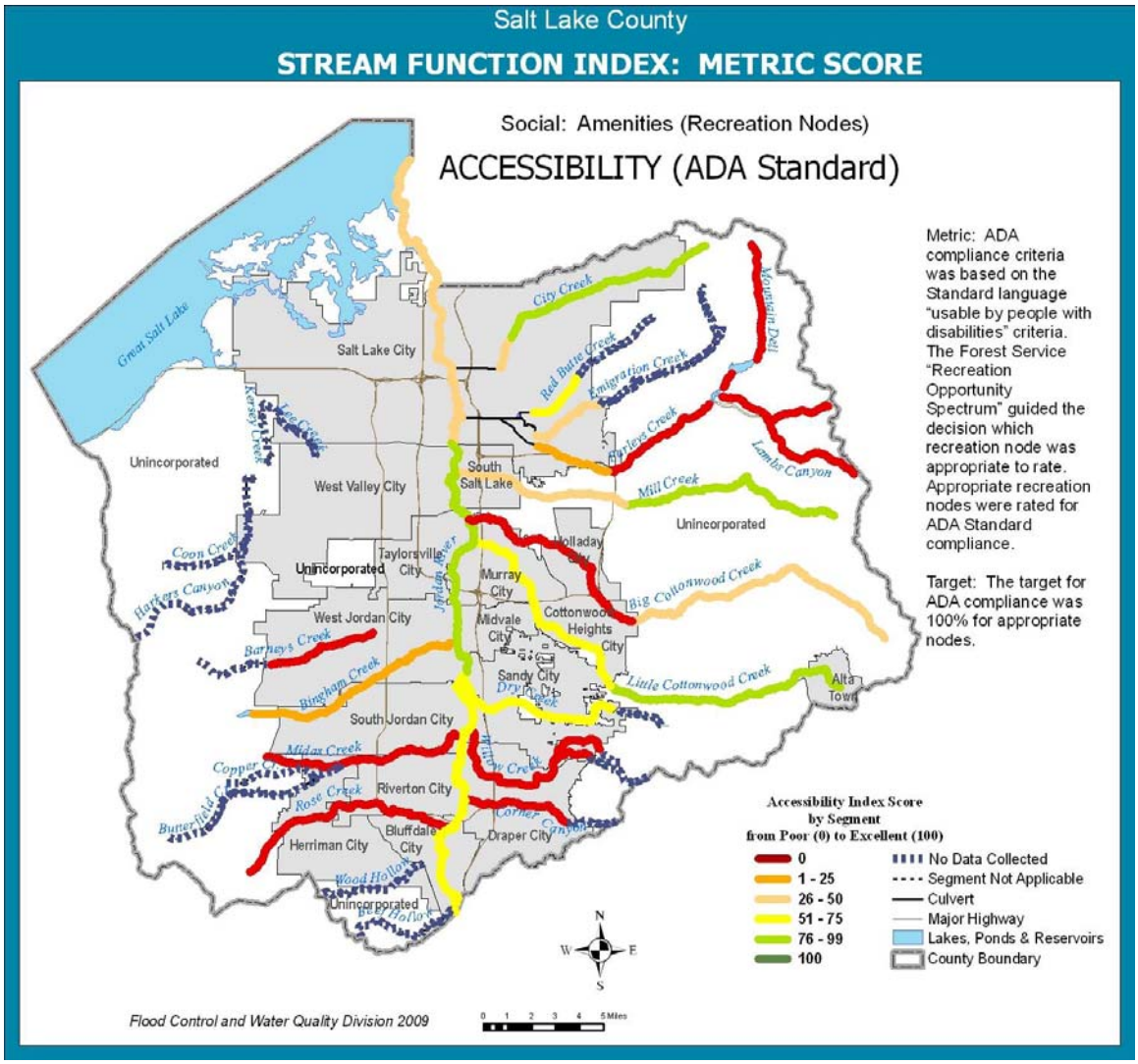


Figure 3.34 Recreation Node Accessibility Metric Scores

3.5.6 Restrooms Metric

The Restrooms Metric measured the number of restrooms per recreational node. The target was based on how many restrooms were thought to be reasonably appropriate for the specific node and use of the node. Evidence of overuse of a restroom facility or evidence of human waste in the recreation node could indicate that additional facilities may be required to protect water quality. Metric scores were generally high ranging from 0 to 100 with an average score of 89.

The map below shows that Midas and Barneys Creeks scored low due to lack of restrooms in the one recreation node found within each stream segment. Lower Big Cottonwood Creek scored moderately low (26-50) for its one recreation site and lower Corner Canyon Creek scored moderate (51 to 75.)

Node Restroom Metric	
Average Segment Score	89
High Score	100
Low Score	0
Number of Segments	22

Lower Jordan River, Rose Creek and lower Little Cottonwood Creek scored moderately high (76 to 99.) The east side mountain streams all scored 100 as well as lower Mill, Dry, and Willow Creeks, middle and upper Jordan River and Bingham Creek.

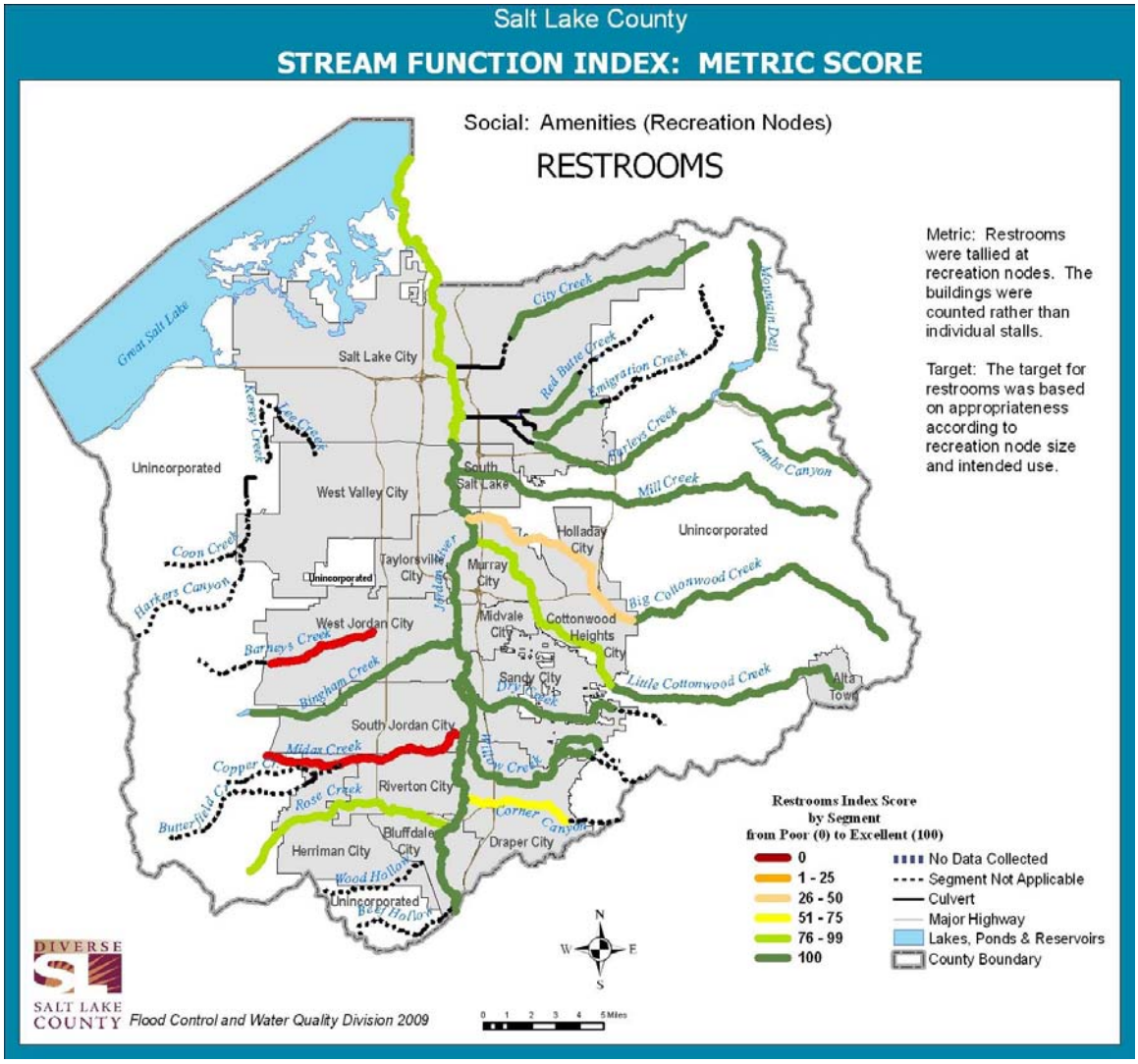


Figure 3.35 Recreation Node Restroom Metric Scores

3.5.7 Recreation Node Resource Compatibility Metric

The Recreation Node Resource Compatibility Metric measured the impacts on waterways from activities occurring at the nodes. Graffiti, litter, tree damage, vegetation trampling, presence of human or animal waste, and lack of facility maintenance were considered damaging to water quality and riparian vegetation, and undermine visitor's experience of the waterway. Scores ranged from 0 to 100 with an average score of 37.

Node Resource Compatibility Metric	
Average Segment Score	37
High Score	100
Low Score	0
Number of Segments	24

The map below shows that City Creek Canyon, Mountain Dell and Lambs Creeks, lower Big Cottonwood and Dry Creeks, lower Little Willow Creek and the middle Jordan River all scored poor (0.) Lower City Creek, Red Butte, Emigration and Parleys Creeks, lower Mill and Little Cottonwood Creeks scored low (1 to 25.) Upper Parleys Creek, upper Jordan River and Rose Creek score moderately low (26 to 50.) Upper Mill and Little Cottonwood Creeks, lower Big Willow and Corner Canyon Creeks and Bingham Creek score moderate (51 to 75.) Only upper Big Cottonwood, Midas and Barneys Creeks scored high (76 to 100.)

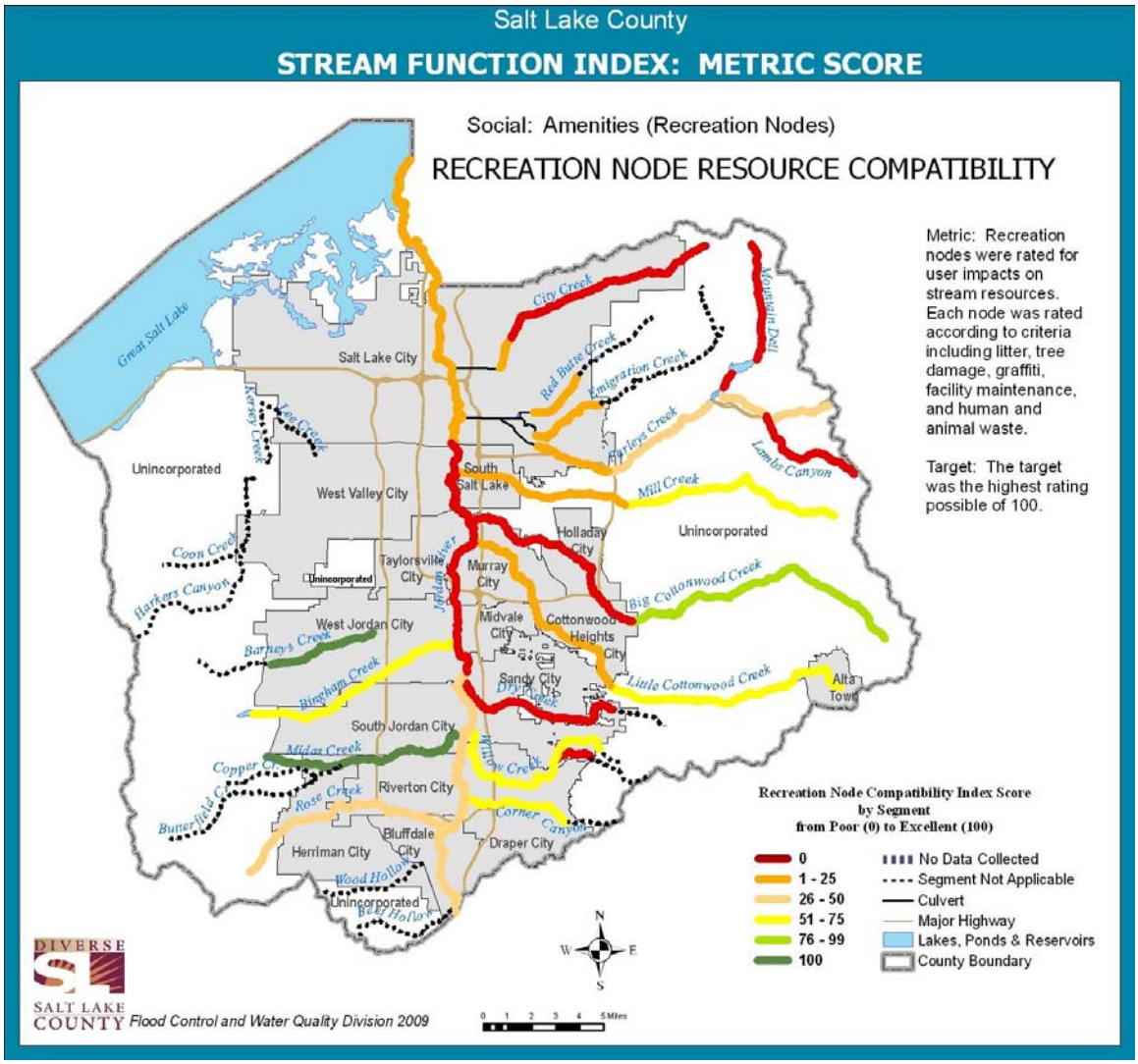


Figure 3.36 Recreation Node Resource Compatibility Metric Scores

3.5.8 Trails Amenity Sub-Group

The Trail Amenities Sub-Group included the presence of recreation trails along County waterways (Trail Corridor Metric), trail networks accessible from those trails (Trail Connectivity Metric), and environmental impacts that may occur from the use and presence of the facility (Resource Compatibility Metric.) Out of 44 stream segments rated, the average score was 33. The high score was 100 and the low score was 0.

The map below shows poor to low (0 to 10.9) scores for most of the west side except Rose Creek which scored moderately low (30 to 39.9.) The east side streams scored poor to low (0 to 29.9) in Emigration Canyon and lower Mill, Big Cottonwood and Big Willow Creeks. Lower Red Butte, Emigration, Parleys Creeks, upper Big Cottonwood Creek, Dry Creek and upper Big Willow Creeks all scored moderately (40 to 69.9.) City Creek, Mountain Dell Creek, upper Mill and Little Cottonwood Creeks, and Little Willow and Corner Canyon Creeks scored high (70 to 100.)

Recreation Trail Sub-Group	
Average Segment Score	33
High Score	100
Low Score	0
Number of Segments	44

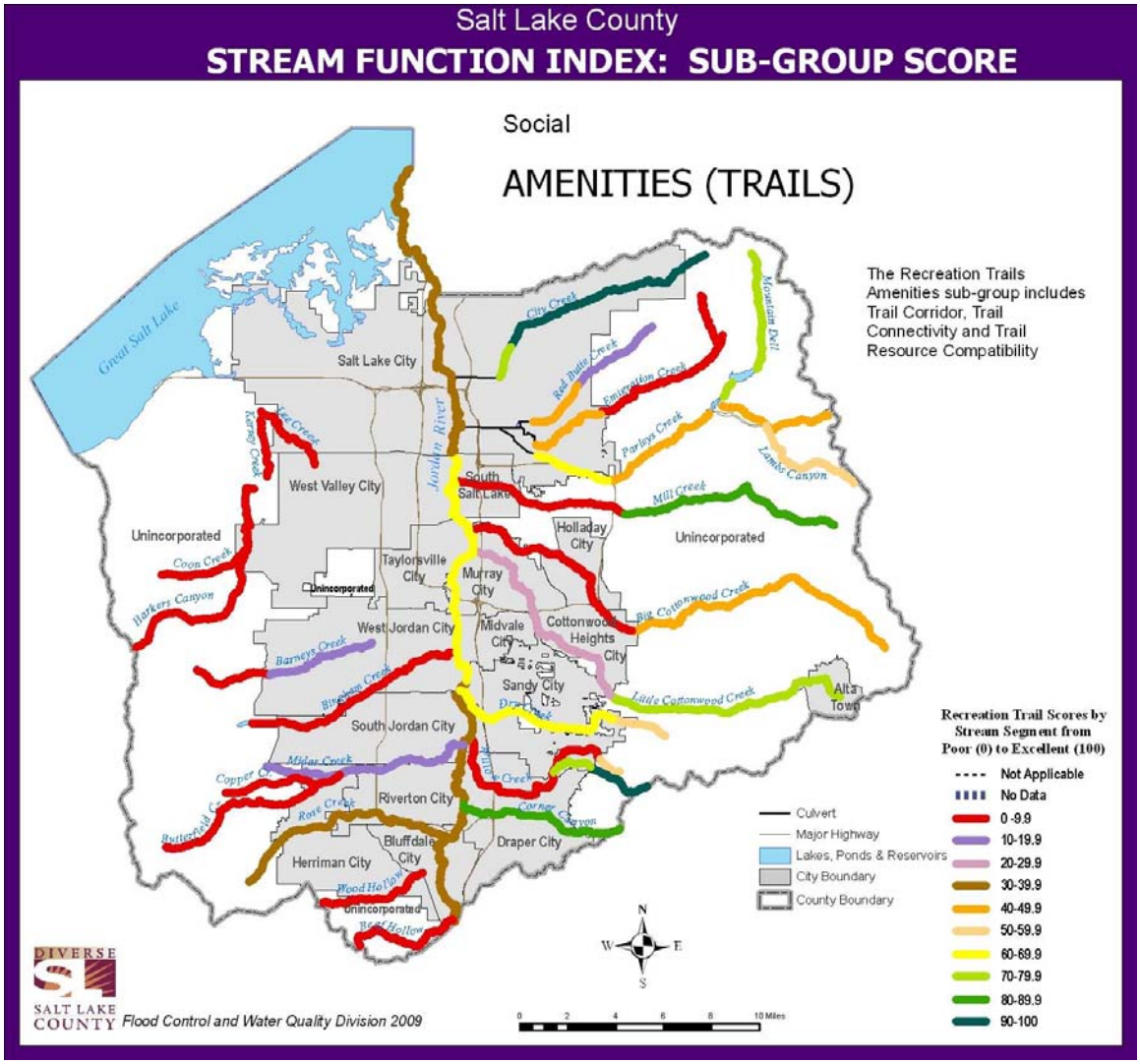


Figure 3.37 Trails Amenity Sub-Group Scores

3.5.9 Trail Corridor Metric

The Trail Corridor Metric measured the percent of each stream segment that had a recreation trail within the stream corridor. Roadway bicycle lanes were not counted. Out of 44 segments, the scores ranged from 0 to 100 and averaged 39.

Trail Corridor Metric	
Average Segment Score	39
High Score	100
Low Score	0
Number of Segments Evaluated	44

The map below shows that the west side mountains scored poor to low (0 to 25) which is primarily because the land is private or military and access is restricted. Kersey and Lee Creeks poor. Lower Barneys, Bingham and Midas Creeks scored moderately low (26 to 50) and Butterfield Creek scored moderately. On the east side streams Emigration Canyon, Burr Fork, Lambs and Big Willow Creeks scored poor (0.) Upper Red Butte, lower Mill and all of Big Cottonwood Creeks scored low (1 to 25.) Lower Emigration Creek scored moderately low (26 to 50.) Upper Parleys and Mill Creeks, lower Little Cottonwood and Little Willow Creeks, and upper Corner Canyon Creek scored moderate (51 to 75.) City Creek, Mountain Dell, Little Cottonwood Creeks, Dry Creek, and upper Little Willow and lower Corner Canyon Creeks score high to moderately high (76 to 100.)

The upper and lower Jordan scored moderate and the middle section scored moderately high (76 to 99.)

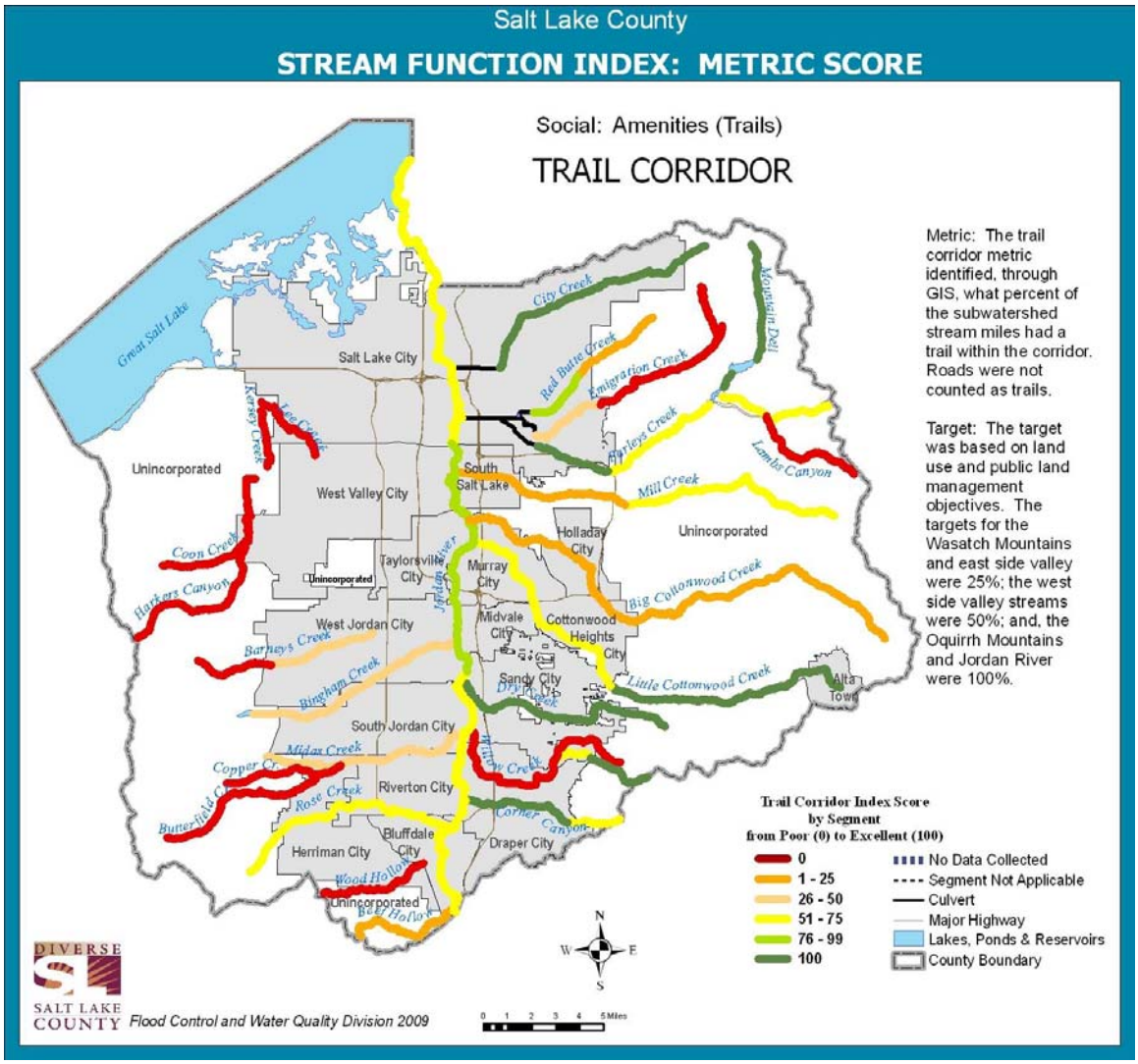


Figure 3.38 Trail Corridor Metric Scores

3.5.10 Trail Connectivity Metric

Trail Connectivity Metric measured the percent of trails and trailheads along the waterways that were connected to other trails and what percent were local trails. Of the 27 segments that were evaluated the scores ranged from 0 to 100 with an average score of 58.

Trail Connectivity Metric	
Average Segment Score	58
High Score	100
Low Score	0
Number of Segments Evaluated	27

The map below shows that several valley streams scored poor (0) including Barneys, Bingham and Midas Creeks on the west side and lower Mill, and Big and Little Cottonwood Creek on the east sides. In addition, Bells Canyon scored poor because it dead ends at the top. Rose Creek and upper Jordan River scored low (1 to 25) and lower Jordan River and lower Red Butte Creek scored moderately low (26 to 50.) Streams that scored moderate (51 to 75) included lower Emigration and Corner Canyon Creeks, upper Parleys Creek, and upper Little Cottonwood Creek. Lower Parleys Creek and upper Mill and Big Cottonwood Creeks scored moderately high (76 to 99.) City Creek, Mountain Dell and Lambs Creeks, Dry Creek, upper Willow and Corner Canyon Creeks, and the middle Jordan River scored 100.

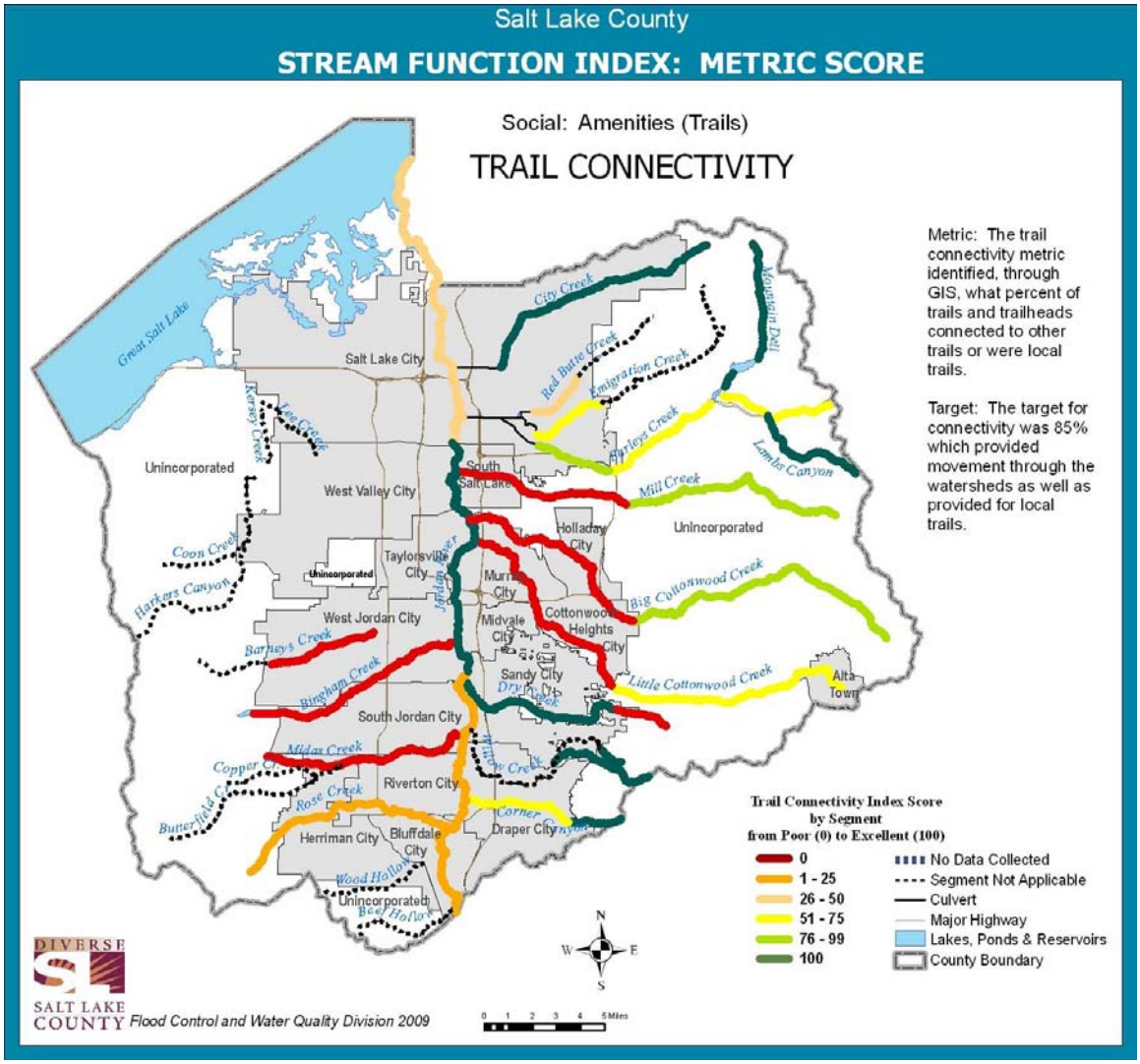


Figure 3.39 Trail Connectivity Metric Scores

3.5.11 Trails Resource Compatibility Metric

The Resource Compatibility of Trails Metric measured trail user impact on stream resources including litter, tree damage, graffiti, maintenance, and presence of animal and human waste. Of 16 segments, the scores ranged from 0 to 100 with an average score of 17.

Most stream segments that were evaluated received a poor to low (0 to 25) score. Rose Creek, lower City and Red Butte Creeks, and Mountain Dell Creek scored moderately low (26 to 50.) Lower Corner Canyon Creek was the only segment that received a high score. Several east side mountain streams were not evaluated due to lack of time and early snows. These segments will be evaluated for the next SFI.

Trail Resource Compatibility Metric	
Average Segment Score	17
High Score	100
Low Score	0
Number of Segments Evaluated	16

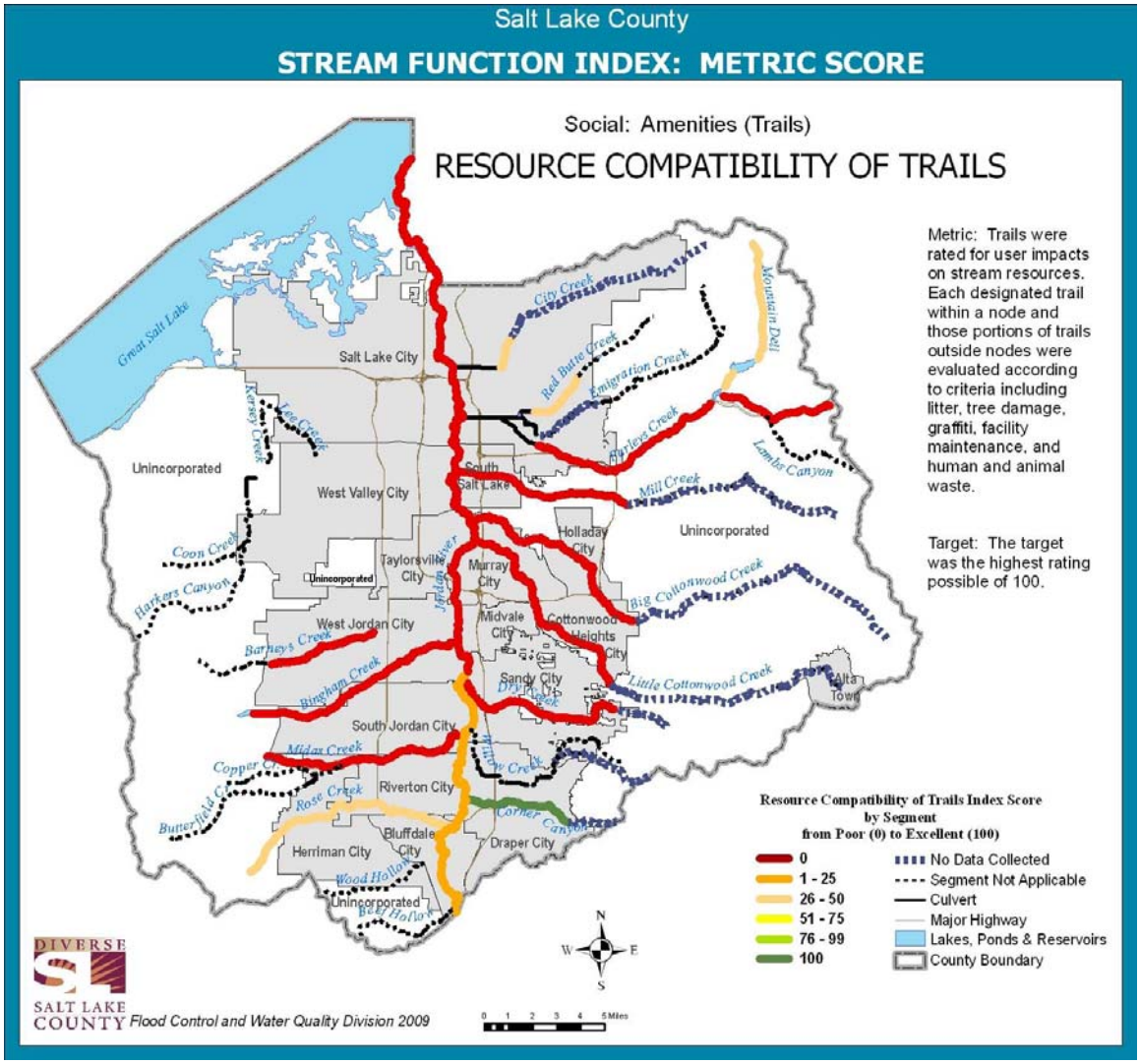


Figure 3.40 Trail Compatibility Metric Scores

3.6 STREAM FUNCTION INDEX

The Stream Function Index (SFI) measured overall stream health by averaging the Ecosystem Health Index score with the Social Functional Group. No weighting was applied. The resulting scores generally identified how well the stream was functioning. Out of 44 stream segments rated, the average score was 65. The high score was 89 and the low score was 41.

The map below shows that the lowest scoring stream segments were Emigration Canyon, Burr Fork, and lower Big Cottonwood Creek at 40 to 49.9. Most of the streams scored in the moderate range between 50 and 69.9. Upper City Creek, lower Red Butte and Emigration Creeks, Lambs Creek, upper Little Cottonwood Creek, and Corner Canyon Creek scored 70 to 79.9. The highest scores ranged from 80 to 89.9 and included Mountain Dell Creek, upper Mill Creek, Big Cottonwood Creek, and upper Willow Creek.

Stream Function Index of Stream Segments	
Average Segment Score	65
High Score	89
Low Score	41
Number of Segments	44

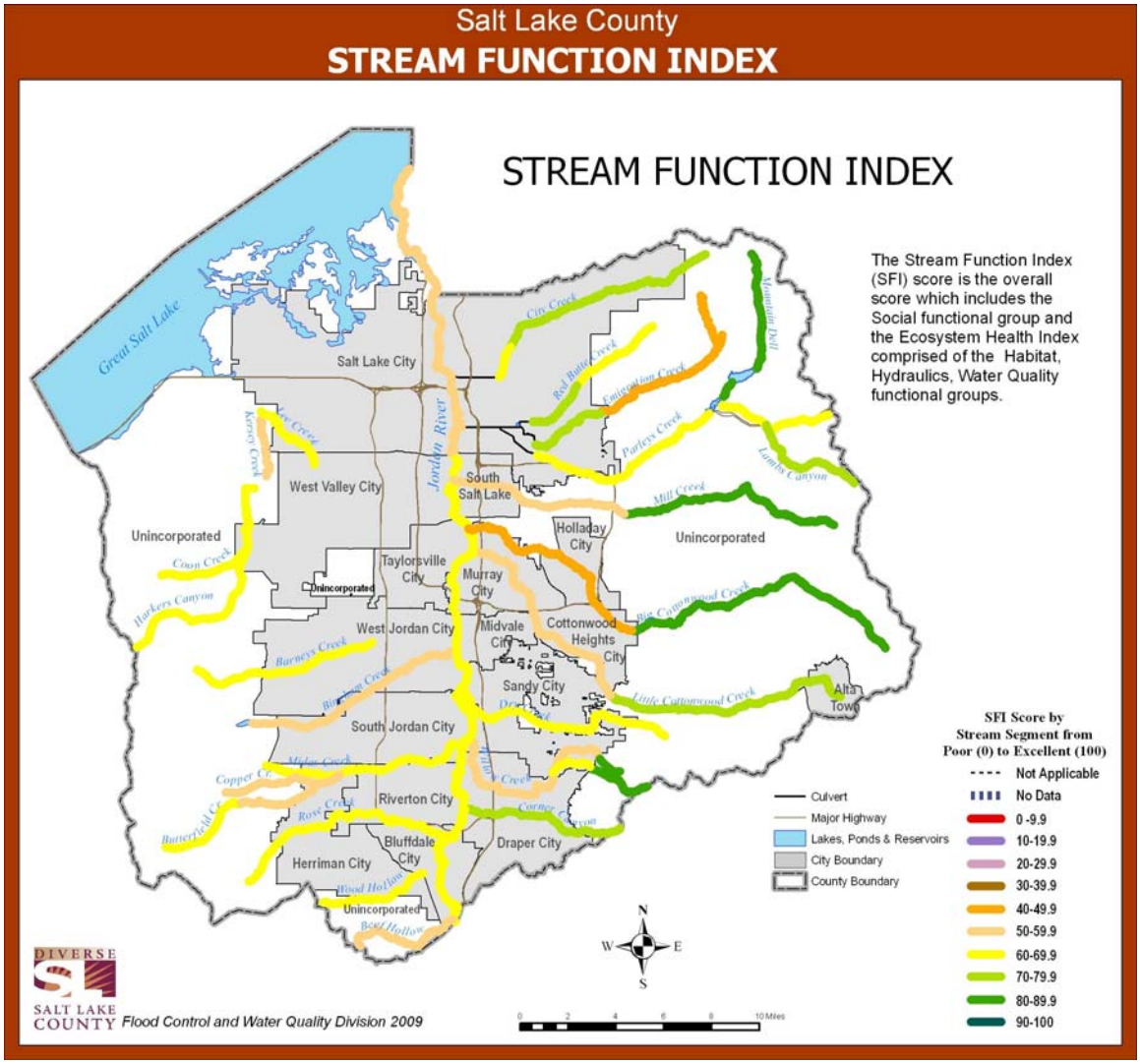


Figure 3.41 Stream Function Index Scores by Stream Segment

4.0 SFI DISCUSSION

Now that the Stream Function Index (SFI) methodology and results have been presented this chapter will review the process as a whole and discuss—

- the intent of the SFI
- how that was accomplished
- important characteristics for interpretation of results
- strengths and weaknesses
- data needs
- Best Management Practices (BMPs) implementation
- what is the next step?

4.1 WHAT WAS THE INTENT?

The SFI is designed to be the monitoring tool for the 2009 Salt Lake Countywide Water Quality Stewardship Plan (WaQSP.) The need to gain a comprehensive view of the chemical, physical and biological condition of the waterways in Salt Lake County has been long recognized. The effort began in the 1980's as a result of the 208 Area Wide Water Quality Management Plan (1978.) When discussions about doing the WaQSP began in 2006, a monitoring program was seen as a vital and necessary component of the ongoing process. Technology is available in the workplace to handle large amounts of data and mapping that previously was done by hand. The WaQSP and the SFI were conceived as working together and both would be completed in tandem in a 6-year cycle. Now that the first WaQSP and SFI are complete, the next WaQSP and SFI Updates are scheduled for completion in 2015.

4.2 HOW THAT WAS ACCOMPLISHED

As a monitoring program, the SFI is a *rapid assessment* and not a detailed study that would take excessive time or a large amount of funding. A rapid assessment provides a quick overview of the conditions of the County's waterways with only a few select parameters to represent the condition of each function, which streamlines the process. Gaps in knowledge are then identified for further study. The detailed studies can be prioritized by the Cities and County and accomplished over time as funding becomes available.

The 2009 SFI is the *baseline* for comparison against subsequent SFIs. Great effort was made to create a consistent process that would stand the test of time over several generations of WaQSP and SFI updates. However, the SFI is also a tool flexible enough to withstand inevitable adjustments here and there to fix minor issues and to make it more relevant to current conditions. In addition, other changes will naturally come from different personnel who work on the SFI and improved technology. The ability to make these changes will only make the SFI stronger and more reliable over time.

Figure 4.1 Measuring pool depth for habitat function.

4.3 IMPORTANT CHARACTERISTICS

Certain characteristics inherent in the design of the SFI are worth mentioning so there is a realistic expectation when interpreting the results and how this information is used. To begin with, the three functions in the Ecosystem Health Index (habitat, hydraulics, and water quality) and their targets are based on science thoroughly researched in scientific literature and from science-oriented professionals. In contrast, the Social Functional Group was developed by professionals knowledgeable in the fields of planning, recreation, and the Americans with Disabilities Act. Metrics and targets for the Social function are based on reasonable assumptions rather than guidelines from scientific research.

Another characteristic of the SFI is that the scores are calculated only from data that is available. This means that a lack of data does not affect the score by raising or lowering it. The downside to this method is that the score may be calculated from one piece of data and not be representative of actual conditions. The more data entered into the SFI, the greater the confidence in the score.

How SFI scores are calculated is another characteristic worth mentioning. The SFI is determined by only averaging the scores. In addition, the scores are not weighted for importance. This was considered appropriate for the type of data used and the purposes of the SFI. It was determined that more complicated statistical methods would not have produced a more accurate result.

The final characteristic worth noting is that the scores at the metric level are the closest representation of stream conditions versus the composite scores. The metric scores are also the most sensitive to showing changes and will be very useful for comparisons to future SFIs. On the other hand, composite scores are very useful to generally characterize a stream and give an overview of stream conditions.

Users of the SFI are encouraged to use all the score levels where they are appropriate. A simple SFI score carries a wealth of information that may not be apparent at first glance and may be misleading if it is not understood. The SFI process is a reasonable way of representing a quick assessment of stream conditions and is expected to be a great monitoring tool to accomplish the goals of the WaQSP and to implement stewardship of the watersheds of Salt Lake County.

4.4 STRENGTHS AND WEAKNESSES

Examining the strengths and weaknesses of the SFI process is important to identify areas that are working well and other areas that can be improved upon. Strengths are defined as accomplishing the purpose that was set for the SFI. After examining the results, the SFI has performed well and overall the scores appeared to reflect what could be expected on the ground if one keeps in mind the characteristics listed in the previous section.

Weaknesses of the SFI process point to what can be improved to accomplish the purpose that was set for the SFI. The lack of good comparable water quality data was identified as a primary weakness for the Water Quality Function.

As a rapid assessment, the SFI relies on existing water quality data to calculate scores. This is different than the Habitat and Hydraulic Functional Groups where data is collected quickly in the field over one or two years. Water quality sampling needs a more comprehensive approach, specific protocol, and often lab analysis. This is why the EPA's database, STORET, was used as the source for the SFI's water quality score.

STORET is a clearinghouse for data that is authenticated and can be used with a reasonable degree of confidence. The downside is that the authentication process is tedious and often data is never entered. Other data exists outside STORET but to locate, collect, and analyze scattered studies would be too time consuming for the SFI.

The County recognizes that STORET is a valuable vehicle to share and organize data. The County is making an effort to enter all water quality data that it collects. This will help future WaQSP and SFI updates as well as make County data available for others to use.

4.5 DATA NEEDS

Although the SFI, as published, is a comprehensive tool designed to describe stream function in Salt Lake County, there are data gaps that should be addressed. The most pressing data gaps relate to the Water Quality and Social Functional Groups.

4.5.1 Macroinvertebrate Sampling Program

In the Water Quality Functional Group, a Countywide macroinvertebrate study is required for the Aquatic Sub-Group data. Macroinvertebrates, aquatic insects that live in the streambed, are a well-known indicator of long-term water quality versus water sampling, which reveals the current condition of the water. Jordan River and stream managers will benefit from macroinvertebrate data

Figure 4.2 Macroinvertebrate sampling on Little Cottonwood Creek.

that will give a wider perspective of water quality issues in these waterways.

Beginning in 2009, Salt Lake County has been collecting macroinvertebrate data on the Jordan River and all perennial streams in the County. This will be considered baseline data and will be included in the next SFI. The County will continue work and partner with the Utah Division of Water Quality (DWQ) by using the state's protocol and the same lab they use for sample analysis. The state will also train the County's field personnel. The opportunity to work with the DWQ in this way will allow the County to use any local data the state collects for the SFI.

4.5.2 Stream Flow Gage and Water Sampling Stations

Consistent and comprehensive water quality monitoring for Total Phosphorus (TP), Dissolved Oxygen (DO), Total Dissolved Solids (TDS), and Temperature is vital to gaining knowledge of the condition of our waterways. Current data available for these metrics is sporadic and incomplete from year to year and for all waterways.

As part of the WaQSP implementation plan, 10 new flow and sampling stream gages will be installed over the next 2 years. The first 5 will be installed in 2010 and include TP, Temperature, TDS and DO. The stations will gather base flow level samples as well as samples during storm events.

4.5.3 *E. coli* Sampling Program

Figure 4.3 Stream flow gaging station on Big Cottonwood Creek.

Very little *E. coli* data was available for the 2009 SFI. DWQ conducted the first major sampling effort in 2009 for *E. coli* on east side perennial streams in Salt Lake County. Sampling for *E. coli* will continue to take place in 2010 in partnership with DWQ. Sampling will take place at the canyon mouths and the confluences with the Jordan River for City Creek, Red Butte Creek, Parleys Creek, Emigration Creek, Mill Creek and Big and Little Cottonwood Creeks. Salt Lake County is also implementing a program to sample other sites of concern throughout the county as the need arises to better understand local *E. coli* issues.

4.5.4 Visual Aesthetics

Figure 4.4 *E.coli* sampling on Big Cottonwood Creek.

The last dataset needed for the SFI is Visual Aesthetics Metric within the Social Functional Group. The appealing aesthetics of the waterways in Salt Lake County is considered an amenity to residents and visitors and is economically good for commerce. Field crews were unable to complete the survey for the first SFI due to time constraints. However, it is anticipated that it will be completed for the next SFI.

4.6 BEST MANAGEMENT PRACTICES (BMPS) IMPLEMENTATION

Because one of the primary BMPs recommendations to improve water quality is stream/river restoration, this section provides some general guidelines or suggestions for projects.

Data collected as part of the SFI effort can be used to identify appropriate restoration sites. However,

more detailed data and information will be required to develop plans and implement projects.

Streams and stream banks in Salt Lake County may come under several jurisdictions including municipal, county, state and federal governments. Research of all party interests and regulations are important up front especially to begin partnering agreements, easements, match funding for grants, and to identify any permits or authorizations that may be required.

Salt Lake County has used an "Emergent Bench" (Figure 4.5) design for restoration projects along the Jordan River. This design is appropriate for reaches with large easements/access. If easements are not available or the streams are deeply entrenched with little available access, other designs will need to be developed.

4.6.1 Funding

A typical major hurdle to stream/river restoration projects is funding. Some municipalities have elected to use stormwater utility fees or bond efforts to fund such projects. Fortunately, Federal, state, and private grants are available to support stream restoration efforts. The majority of projects that have been completed in Salt Lake County have relied heavily on grants. However, the cost of site identification and plan development usually falls to the sponsoring agency. A list of some grants that may be appropriate are provided in Appendix A: Grants for Stream and River Restoration Projects.

In addition to project development and construction, long-term stewardship of restoration sites needs to be addressed. Unfortunately little funding is available through grants for long-term maintenance activities. To address this critical need, innovative programs, as seen in other areas of the Country can be applied. For example, local stewardship groups can successfully take the lead on such efforts.

Although application deadlines and typical amounts awarded vary greatly, there are some common characteristics of successful grant applications:

- A clear, precise work plan
- Demonstrated involvement of many partners
- Inclusion of a monitoring effort
- Strong financial match

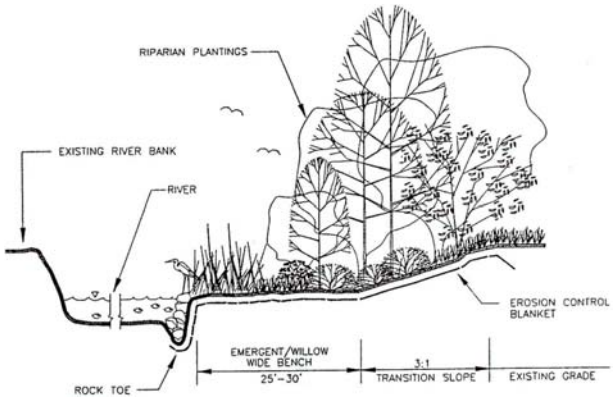


Figure 4.5 Diagram of emergent bench design used successfully along the Jordan River

Figure 4.6 In 2000 the Jordan River at 13000 South was severely eroding and disconnected from its yearly high water floodplain.

Figure 4.7 The same location on the Jordan River after restoring the floodplain with an emergent bench that floods in the spring.

4.6.2 Plan Implementation

With robust planning, established partnerships, and sufficient funding, stream and river restoration efforts may be highly successful. However, some pitfalls do exist. The following is a list of things to be aware of during a stream restoration effort:

Flow diversions may occur unexpectedly. Please assure that all permits (namely stream alteration and flood control permits) have been acquired and appropriate entities notified to avoid the unexpected destruction of restoration work.

Order plant and rock material early as many of these materials are in high demand. Notify and involve the public. Although stream and river restoration efforts are a great benefit to the local stream health, the process of restoration may at times appear destructive. Post notices explaining the project in order to prevent public misunderstanding.

Allow enough time. As with most projects, stream and river restoration projects may take longer than expected. Be sure to plan for unexpected delays in scheduling.

We're not the only ones that love trees. In many of the restoration efforts that Salt Lake County has overseen, beaver activity has been highly destructive. Be sure to consult local experts to prevent the destruction of newly planted trees.

Figure 4.8 A successful bank stabilization project in a heavily used recreation site in Mill Creek Canyon that included natural rock steps to access the creek and a boardwalk to prevent vegetation trampling and erosion.

4.6.3 Post Construction

One of the most important components of a successful stream or river restoration project is the long-term maintenance of the restoration site. Especially in the arid Salt Lake Valley, be sure to plan for irrigation and weed control to assure that the monies spent on the restoration project are used to their fullest extent.

Publicize your completed projects, especially if they are exceptionally successful, to gain interest and support from the public for future projects. Feedback about projects from the community is a valuable planning tool.

4.7 WHAT NEXT?

Now that the SFI is completed, this report and the individual SFI Reports prepared for each city in Salt Lake County provides the information to help prioritize stream corridor projects and opportunities to apply Best Management Practices (BMPs) as outlined in the WaQSP. The SFI provides a starting point to identify trouble spots that need attention as well as where streams are functioning well and need protection.

The County is currently using the SFI to identify potential ecosystem restoration projects along the Jordan River. Prioritization, identifying partners, right-of-way, and funding for these projects will continue on an on-going basis.

The County will also begin working with each municipality to locate and prioritize projects within their interest. The SFI City Reports go into greater detail about issues and potential opportunities to employ BMPs and implementation.

Citizens and organizations are also encouraged to work with their local government to implement BMPs along their stream corridors. Something as simple as getting the word out that dumping grass clippings and branches into the stream is not only illegal but is also detrimental to water quality and fish population, increases maintenance costs, and is unsightly to their neighbors. Greater awareness of the consequences of their actions will hopefully encourage people to take responsibility for their choices.