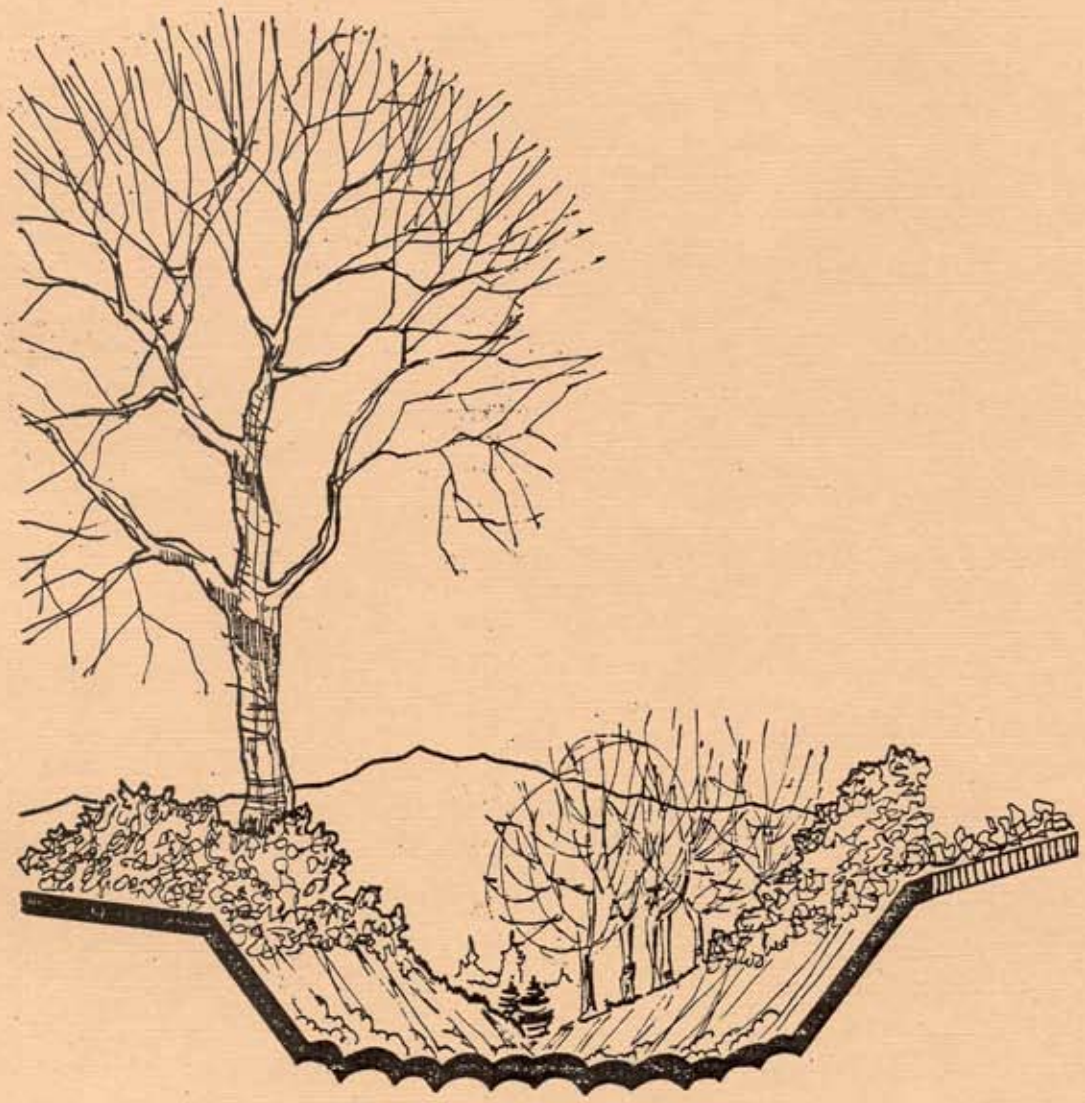

SALT LAKE CITY-COUNTY HEALTH DEPARTMENT
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Bureau of Water Quality

JORDAN RIVER
CHANNEL STABILITY EVALUATION

SALT LAKE CITY-COUNTY HEALTH DEPARTMENT

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BUREAU OF WATER QUALITY

STREAM REACH INVENTORY
AND
CHANNEL STABILITY EVALUATION
FOR
THE JORDAN RIVER IN SALT LAKE COUNTY, UTAH

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NOVEMBER, 1986.

Partially funded under Section 205j of the Federal Clean Water Act.

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I. INTRODUCTION

The United States Forest Service designed a bank stability inventory method for use in watershed streams in the State of Montana, that has been adapted by Salt Lake County for use along the Valley Tributaries. This method was employed along the Jordan River between the Jordan Narrows and 2100 South in order to determine relative conditions of bank erosion that hasoccurred over the past three years.

The method was utilized in support of an advance identification of wetlands adjacent to the Jordan River for which Section 404 permits could be issued by the U.S. Army Corps of Engineers. The Forest Service method is considered useful in identifying areas where sediment is trapped during flood periods, and where hydrologic conditions indicate that wetlands are performing important functions of nutrient retention, flood storage, and erosion control.

The Jordan River was surveyed utilizing the Bank Stability format and on-site photography in order to document conditions for review by Salt Lake County Flood Control, U.S. Corps of Engineers, U. S. Fish & Wildlife, U.S. Environmental Protection Agency, and the Salt Lake County and State Health Departments. The information is to be used for:

1. Determining locations where non-point sources of pollution are entering the Jordan River and where best management practices (erosion controls) should be implemented.
2. Prioritizing where Flood Control bank stabilization funds should be expended.
3. Identifying wetlands that perform important physical and biological functions for the support of beneficial uses of water in the Jordan River, such as fishing and other forms of recreation.

The general conclusion of the bank stability inventory is that:

1. Most bank erosion and degradation of the stream channel by hydraulicicutting falls within the upper reaches where gradient and flow velocities are greatest.
2. Land uses adjacent to the upper Jordan River that are impacting or are impacted by the river are primarily agricultural.
3. Oxbows or older meanders along the river are significant in protecting against bank erosion, maintenance of water quality, wildlife habitat, fishery habitat support, and support of high density and diversity of both plant and animal biota.

The bank stability inventory evaluates the Jordan River on the basis of homogeneous stream reaches that possess similar characteristics. It produces a score or qualitative point ranking for stream reaches on a relative basis, and enables decision-makers to refine detailed plans for the restoration of flood damage and river enhancment programs. The inventory will be factored into a wetland value process that will determine which wetlands are not suited to approval of 404 permits and should be set aside for public aquisition.

II. STUDY METHODOLOGY

The Northern Region Forest Service developed a stream reach inventory and channel stability evaluation in order to "systemize measurements and evaluations of the resistive capacity of mountain stream channels to the detachment of bed and bank materials and to provide informations about the capacity of streams to adjust and recover from potential changes in flow and/or increases in sediment production." (1)

Information may be gathered at point sites such as bridges or other crossings, or in larger analyses for fisheries, water balance or other multiple use inventories. Stream segments may be stratified by reach characteristics such as order or geologic type and sampled to meet survey requirements.

The Jordan River was divided into twelve stream segments, based largely on highway crossings and similar length (See Figure 1). Each stream segment was subdivided into stream reaches that were determined in the field to possess homogeneous characteristics. The stream segments are summarized below.

SEGMENT	DESCRIPTION	STREAM MILES
I.	Jordan Narrows to 14600 South Bridge in Bluffdale.	3.5
II.	Bluffdale Bridge to 12600 South in Riverton.	3.4
III.	Riverton Bridge to 10600 South Bridge in South Jordan.	2.7
IV.	South Jordan Bridge to 9000 South Bridge in Sandy.	2.3
V.	Sandy Bridge to 7800 South Bridge in Midvale.	1.8
VI.	Midvale Bridge to 6400 South Bridge in Murray.	1.5
VII.	Murray Bridge to 5300 South Bridge in Murray.	1.7
VIII.	5300 South Bridge to 4800 South Bridge in Murray.	1.3
IX.	4800 South Bridge to 4500 South Bridge in Taylorsville.	.57
X.	Taylorsville Bridge to 3900 South Bridge.	.93
XI.	3900 South Bridge to 3300 South Bridge in South Salt Lake.	1.0
XII.	South Salt Lake City Bridge to 2100 South Bridge.	1.0
	TOTAL	21.7

The approximate length of the Jordan River (22 stream miles) was field inventoried beginning July 2, 1986 and completed August 5, 1986. Approximately 15 man-days were spent on the field inventory, or an average of 1.5 man-miles per day. This time included field preparation time and post field recording time. The method of recording included the use of Inventory Data Sheets for each segment reach (Figures12-19), and on-site photography. Each segment description consists of individual reach descriptions, representative photographs, and narrative on any specific problems or unique observations.

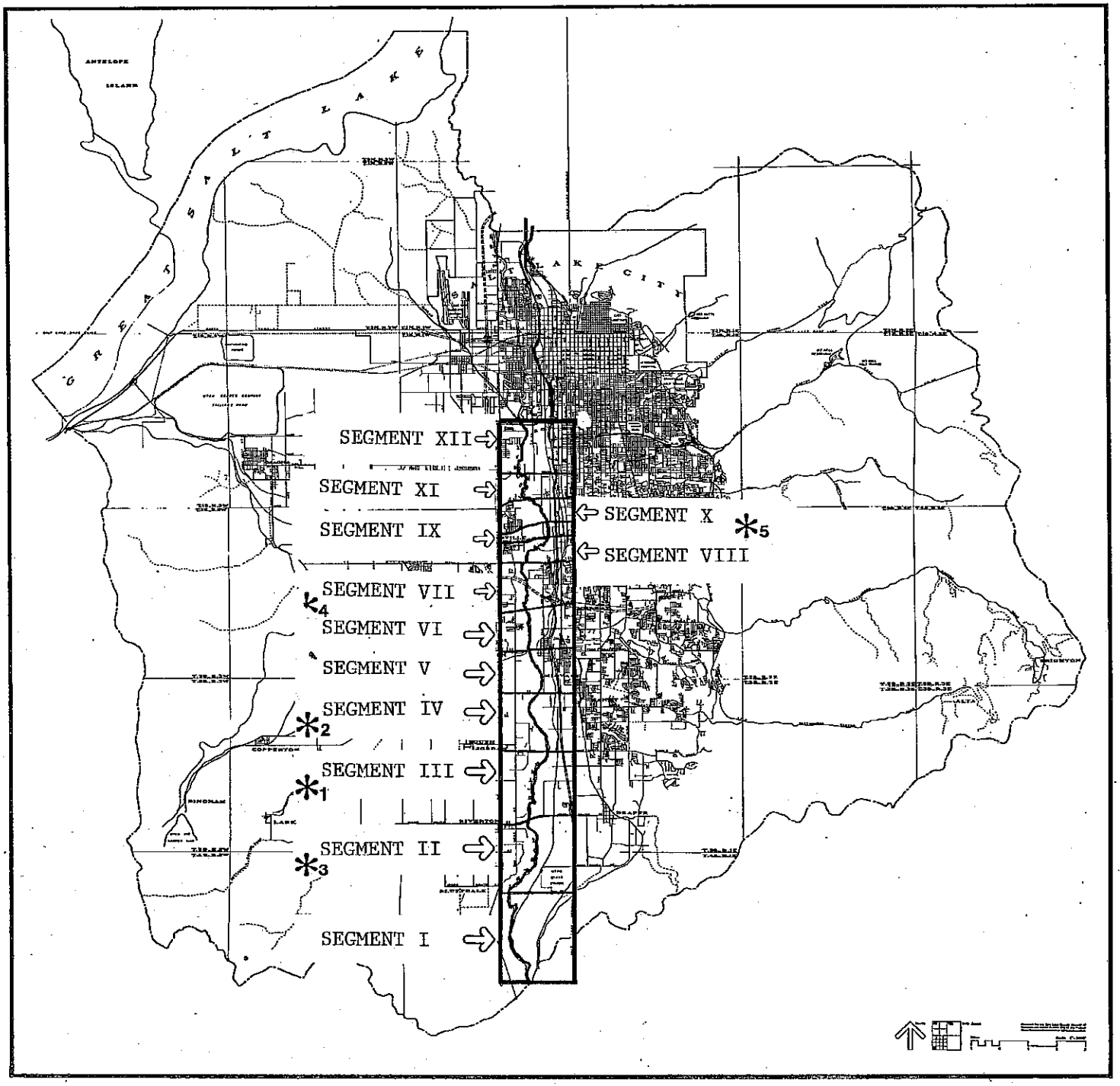
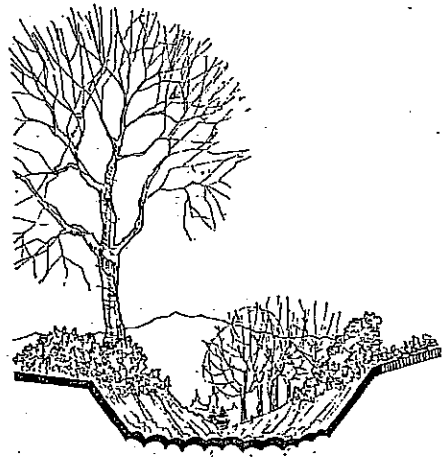


Figure 1

Study Area:
Stream Segments

* Priority



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JORDAN RIVER
CHANNEL STABILITY EVALUATION

A. STUDY METHODOLOGY: RATING FACTORS

The Stream Reach Inventory and Channel Stability Evaluation rates conditions for three major stream components: Upper Channel Banks, Lower Channel Banks, and Channel Bottom.

1. UPPER CHANNEL BANKS. For the immediate zone above the normal high water mark, the procedure rates the following factors:

A. Landform Slope. "The steepness of the land adjacent to the stream channel determines the lateral extent and ease to which banks can be eroded and the potential volume of slough which can enter the water....the steeper the land adjacent to the stream, the greater the potential volume of slough material."

1. Excellent: Side slopes less than 30% on both banks.
2. Good: Side slopes up to 40% on one or occasionally both banks.
3. Fair: Side slopes to 60% common on one or both banks.
4. Poor: Seep slopes over 60% on both banks.

B. Mass Wasting Hazard. Mass movement of banks by slumping or sliding introduces large volumes of soil and debris into the channel suddenly causing constrictions or complete damming, and grossly increasing sedimentation rates.

1. Excellent: No evidence that conditions does or could exist.
2. Good: Evidence of infrequent or small slumps.
3. Fair: Frequency & magnitude increasing; high water aggravates the condition with subsequent undercutting.
4. Poor: Potential slides from any increase in flow causes year-round sedimentation.

C. Debris Jam Potential. Tree trunks, limbs, and other debris cause deflection of flows.

1. Excellent: Debris on banks, but not situated to enable stream to entrain it into channel.
2. Good: Debris present offers bank protection but could float away forming only small jams.
3. Fair: Noticeable accumulation of all sizes and stream is enough to float it away.
4. Poor: Moderate to heavy accumulation present that, during high flows, could cause severe debris jams.

D. Vegetative Bank Protection. Soil is held in banks by plant roots. Root mats increase in density with proximity to the open channel. Trees and shrubs have deeper roots than grasses and forbs. The density of both understory and overstory vegetation, the more resistance to high-flow bank erosion. Damage from flow turbulence is greatest at the bank endge and diminishes with distance from the normal channel. Vegetal variety is more desireable than a monotypic plant community. Young plant, growing and reproducing vigorously, are better than old, decadent stands.

1. Excellent: 90% coverage by trees, shrubs, grass, and forbs. Variety present. Reproduction evident. Dense root mass.
2. Good: 70%-90% coverage, with shrubs prevalent. Deep root mass more pravalent than dense root mass.
3. Fair: 50%-70% coverage by any plant species. Reproduction is small or non-existent.

2. LOWER CHANNEL BANKS.

The lower channel zone is located between the normal high water and low water lines. Both aquatic and terrestrial plants grow but normally density is sparse. Lower channel banks define present stream width. Stability of channel banks is indicated under a given flow reginmen by minor, imperceptable changes in channel width from year to year. Erosion encroachment is nil.

Under conditions of increasing channel flow, banks weaken and both cutting and deposition begin, USUALLY AT BENDS AND POINTS OF CONSTRICTION. Cutting is evidenced by steepening of lower banks, which begin to undercut, crack, and slump.

A. Channel Capacity. Channel width, depth, gradient, and roughness determine the volume of water which can be transmitted. Some indicators of channel capacity are widening or deepening, which are expressions of the most recent flood event.

1. Excellent: Stream cross-section is ample for present peak volumes plus some additional. Over-bank floods are rare.
2. Good: Adequate cross-sections contain morst peak flows.
3. Fair: Channel barely contains peak runoff in average years.
4. Poor: Channel capacity inadequate, over-bank floods common.

B. Bank Rock Content. Where vegetation cannot grow, it is the size and shape of the rock component which determines resistance to flow.

1. Excellent: Rock comprises 65% or more of bank content. Angular 12" boulders are numerous.
2. Good: Rocks comprises 40%-65% of bank content, at 6"-12" sizes.
3. Fair: Rock comprises 20%-40% of bank volume at 3"-6" size.
4. Poor: Less than 20% rock fragments, mostly of gravel sizes 1"-3" in diameter.

C. Obstructions and Flow Deflectors. Embedded logs or boulders which change direction of flow and form sediment traps.

1. Excellent: Logs, rocks, and other flow obstructions are firmly embedded and produce non-erosive flow patterns. Pool riffle relationships are stable.
2. Good: Obstructions present which create some erosive cross-currents, and some sediment lis trapped in pools decreasing their capacity.
3. Fair: Moderate and unstable obstructions which cause noticeable erosion of the channel. Considerable sediment deposition behind obstructions.
4. Poor: Frequent unstable obstructions and traps, causing continuous seasonal shifts. Channel migration and widening.

D. Cutting. Loss of aquatic vegetation by scouring or uprooting. Beginning near the top, and later extending to the total depth, the lower channel bank becomes a near vertical wall.

1. Excellent: Very little or no cutting is evident. Raw, eroding banks are infrequent, short and less than 6" high.
2. Good: Intermittent cutting along channel outcurves and at constrictions. Vertical cuts less than 12" high.
3. Fair: Significant bank cutting occurs frequently along the reach. Vertical banks 12" to 24" high are prevalent as are root mat overhangs and sloughing.
4. Poor: Nearly continuous bank cutting. Vetical cut faces over 2' high with frequent overhangs and side failures.

E. Deposition. The appearance of sand & gravel bars where they did not previously exist may be one of the first signs of strema erosion.

1. Excellent: Very little or no deposition of fresh silt, sand or gravel in channel bars in straight reaches or point bars on the inside banks of curved reaches.
2. Good: Some fresh deposits behind obstructions. Coarse gravel size class.
3. Fair: Deposits of fresh, coase sands and gravels with bars enlarging and pools filling with riffles predominate.
4. Poor: Extensive deposits of fresh sand, silts, and small gravels. Rapid bar development common (no vegetation) Sediment storage full and moving during low flows.

3. CHANNEL BOTTOM.

The channel bottom is almost totally an aquatic environment, composed of inorganic rock constituents and a complex community of plant and animal life. Both components offer clues to stability of the stream bottom. Rock angularity, brightness, packing of bottom particles, distribution of bottom materials, scouring and depositional indicators, and aquatic vegetation are the factors to be rated.

A. Excellent to Poor ratings for angularity relate to the roundness exhibited and the smoothness or polish on the rock surface.

B. Brightness ratings relate to the lack of algae on the rocks, which, if present, produce a dulling of the rock surface;

1. Excellent: Less than 5% of the total bottom should be bright. Mostly covered by growths of film of organic stain.
2. Good: 5%-35% of the bottom appears brighter.
3. Fair: 50-50 mixture of bright and dull surfaces
4. Poor: Bright, freshly exposed rock surfaces predominate.

C. Consolidation of Bottom Materials. Under stable conditions, rock particles are packed together creating some overlap of larger materials like shingles. This creates high resistance to bottom scouring flows.

1. Excellent: Tightly packed array of rock sizes with overlapping sufficient to resist dislodge by kicking.
2. Good: Packing can be dislodged by higher than average flows.
3. Fair: Moderately loose with no overlap pattern and moveable by average high flows.
4. Poor: Loose array moved easily by average flows and move under foot. Similar size and assortment of mostly round rocks.

D. Bottom Size Distribution and Stable Materials. Large boulders and cobbles are considered more stable in average conditions.

1. Excellent: No noticeable change in rock size distribution, stable rock materials between 80%-100%.
2. Good: Slight shift in distribution. Stable rocks 50%-80%.
3. Fair: Moderate shift in size classes. Stable rocks 20%-50%.
4. Poor: Marked, pronounced shift in size distribution. Stable materials less than 20%.

E. Scouring and Deposition.

1. Excellent: Neither scouring nor deposition are evident. 5% may be present along the length of the reach.
2. Good: Affected reaches from 5%-30%.
3. Fair: 30%-50% of the bottom is in a state of flux.
4. Poor: 50% of more of the bottom is constantly moving.

F. Aquatic Vegetation. The existence of clinging moss and algae indicate bottom stability adequate to promote growth within a single season.

1. Excellent: Clinging plants are abundant throughout reach from bank to bank, and moss/algae are apparent in all directions.
2. Good: Plants common in slower portions but absent in swift water
3. Fair: Plants are found but occurrence is spotty. Absent from rocks in swift and even slow areas.
4. Poor: Plants rarely found anywhere in the reach.

The rating sheet used to record observations is shown in Figure 2. Each stream segment reach was rated, with reaches averaging 300'-800'.

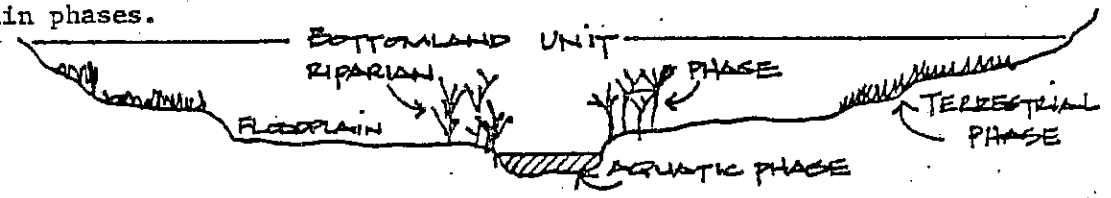
Figure 2

Major Drainage SALT LAKE SUB-BASIN _____ Date _____

Observer(s) _____ Stream Name JORDAN Reach Number _____

Elevation _____ to _____ feet Watershed # _____

A valley bottomland is that total area of land which includes the stream channel, the adjacent floodplain, benches or terraces, and other gentle terrain, and normally those valley toe slopes which may directly affect or be affected by the stream. Valley bottomlands may be stratified into aquatic, riparian, terrestrial, and floodplain phases.



Directions: Circle the appropriate response or fill in the blank as required.

Valley Shape: NOTCH V-SHAPED U-SHAPED BOX-SHAPED BROAD

Valley Width: narrow (100") moderately wide (100'-325') wide (325')

Side slope Gradient: low (30') moderately steep (30-60%) steep (60%)

Valley Gradient: low(4%) moderately steep (4-8%) steep (8%)

Channel Gradient: very low (2%) low (2-3%) moderately steep (3-6% steep (6%)

Channel Size: width _____ ft. Average depth _____ ft. Flow pattern _____

Geologic materials in bottom: _____

Landform/Type _____

	RIPARIAN PHASE	FLOODPLAIN	TERRESTRIAL PHASE
vegetative type:	_____	_____	_____
	_____	_____	_____
vegetative cover density:	_____	_____	_____
type of debris:	_____	_____	_____
sediment buffer potential:	_____	_____	_____

Number of debris jams &/or fish blocks/mile___. Upstream watershed impacts (Type)____.

Size Composition of Bottom Material (Total to 100%)

1. Exposed bedrock _____ %
2. Large boulders, 3' + Dia. ____ %
3. Small boulders, 1-3' _____ %
4. Large rubble, 6"-12" _____ %
5. Small rubble, 3"-6" _____ %
6. Coarse gravel, 1"-3" _____ %
7. Fine gravel, 0.1"-1" _____ %
8. Sand, silt, clay, muck ____ %

R-1 STREAM REACH INVENTORY and CHANNEL STABILITY EVALUATION

REACH LOCATION: Survey Date_____ Time_____ Obs._____

TS/R:_____ _____

Stream JORDAN RIVER Approx.Address:_____

Reath Description &
Other Identification_____

	Key #	Stability Indicators by Classes (Fair and Poor on reverse side) EXCELLENT		GOOD	
Upper Banks	1	Bank slope gradient <30%.	(2)	Bank slope gradient 30-40%.	(4)
	2	No evidence of past or any potential for future mass wasting into channel.	(3)	Infrequent and/or very small. Mostly healed over. Low future potential.	(6
	3	Essentially absent from immediate channel area.	(2)	Present but mostly small twigs and limbs.	(4)
	4	90%+ plant density. Vigor and variety suggests a deep, dense, soil binding, root mass.	(3)	70-90% density. Fewer plant species or lower vigor suggests a less dense or deep root mass.	(6)
Lower Banks	5	Ample for present plus some increases. Peak flows contained. W/D ratio <7.	(1)	Adequate. Overbank flows rare. Width to Depth (W/D) ratio 8 to 15.	(2)
	6	65%+ with large, angular boulders 12"+ numerous.	(2)	40 to 65%, mostly small boulders to cobbles 6-12".	(4)
	7	Rocks and old logs firmly embedded. Flow pattern without cutting or deposition. Pools and riffles stable.	(2)	Some present, causing erosive cross currents and minor pool filling. Obstructions and deflectors newer and less firm.	(4)
	8	Little or none evident. Infrequent raw banks less than 6" high generally.	(4)	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	(8)
	9	Little or no enlargement of channel or point bars.	(4)	Some new increase in bar formation, mostly from coarse gravels.	(8)
Bottom	10	Sharp edges and corners, plane surfaces roughened.	(1)	Rounded corners and edges, surfaces smooth and flat.	(2
	11	Surfaces dull, darkened, or stained, Gen. not "bright".	(1)	Mostly dull, but may have up to 35% bright surfaces.	(2,
	12	Assorted sizes tightly packed and/or overlapping.	(2)	Moderately packed with some overlapping.	(4)
	13	No change in sizes evident. Stable materials 80-100%.	(4)	Distribution shift slight. Stable materials 50-80%.	(8
	14	Less than 5% of the bottom affected by scouring and deposition.	(6)	5-30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	(12)
	15	Abundant. Growth largely moss-like, dark green, perennial. In swift water too.	(1)	Common. Algal forms in low velocity & pool areas. Moss here too and swifter waters.	(2)
		EXCELLENT COLUMN TOTAL →		GOOD COLUMN TOTAL →	

Add values in each column and record in spaces below. Add column scores.
E.__ + G.__ + F.__ + P.__ = _____ Total Reach Score.
Adjective ratings:<38=Excellent, 39-76=Good, 77-114=Fair, 115+=Poor*
*(Scores above may be locally adjusted by Forest Hydrologist)

R1-Form 2500-5A Rev.1-75 Side 1.

INVENTORY DATA: (observed or measured on this date)

Stream Width___ft.X Ave.Depth___ft.X Ave.Velocity___f/s=___Flow cfs
Reach Gradient___%, Stream Order___, Turbidity Level _____, Stream Stage_____, Sinuosity Ratio _____,
Temperature °F or °C of: Air___ Water___, Others_____

	Key #	Stability Indicators by Classes FAIR		POOR	
Upper Banks	1	Bank slope gradient 40-60%.	(6)	Bank slope gradient 60%+.	(8)
	2	Moderate frequency & size, with some raw spots eroded by water during high flows.	(9)	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	(12)
	3	Present, volume and size are both increasing.	(6)	Moderate to heavy amounts, predominantly larger sizes.	(8)
	4	50-70% density. Lower vigor and still fewer species form a somewhat shallow and discontinuous root mass.	(9)	<50% density plus fewer species & less vigor indicate poor, discontinuous, and shallow root mass.	(12)
Lower Banks	5	Barely contains present peaks. Occassional overbank floods. W/D ratio 15 to 25.	(3)	Inadequate. Overbank flows common. W/D ratio > 25.	(4)
	6	20 to 40%, with most in the 3-6" diameter class.	(6)	< 20% rock fragments of gravel sizes, 1-3" or less.	(8)
	7	Moderately frequent, moderately unstable obstructions & deflectors move with high water causing bank cutting and filling of pools.	(6)	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	(8)
	8	Significant. Cuts 12"-24" high. Root mat overhangs and sloughing evident.	(12)	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	(16,
	9	Moderate deposition of new gravel & coarse sand on old and some new bars.	(12)	Extensive deposits of predominantly fine particles. Accelerated bar development.	(16,
Bottom	10	Corners & edges well rounded in two dimensions.	(3)	Well rounded in all dimensions, surfaces smooth.	(4)
	11	Mixture, 50-50% dull and bright, ± 15% ie. 35-65%.	(3)	Predominantely bright, 65%+, exposed or scoured surfaces.	(4)
	12	Mostly a loose assortment with no apparent overlap.	(6)	No packing evident. Loose assortment, easily moved.	(8)
	13	Moderate change in sizes. Stable materials 20-50%.	(12)	Marked distribution change. Stable materials 0-20%.	(16,
	14	30-50% affected. Deposits & scour at obstructions, constrictions, and bends. Some filling of pools.	(18)	More than 50% of the bottom in a state of flux or change nearly yearlong.	(24)
	15	Present but spotty, mostly in backwater areas. Seasonal blooms make rocks slick.	(3)	Perennial types scarce or absent. Yellow-green, short term bloom may be present.	(4)
		FAIR COLUMN TOTAL →		POOR COLUMN TOTAL →	

Size Composition of Bottom Materials (Total to 100%)

1. Exposed bedrock.....___%	5. Small rubble, 3"-6".....___%
2. Large boulders, 3'+ Dia....___%	6. Coarse gravel, 1"-3"....___%
3. Small boulders, 1-3'.....___%	7. Fine gravel, 0.1-1".....___%
4. Large rubble, 6"-12".....___%	8. Sand, silt, clay, muck..___%

SUPPORTING MATERIALS

Since the Bank Stability Inventory was performed as part of the Jordan River Wetlands Advance Identification Study (WAIDS), it was necessary to assess functions related to adjacent wetlands and the river channel. The functions evaluated include the following factors verified by 1'/200' aerial interpretation and field survey:

1. GROUNDWATER RECHARGE AND DISCHARGE. Wetlands adjacent to the Jordan River are the site of extensive discharge of the Salt Lake Valley shallow aquifer to the river channel. They are the source of water for many wetlands within the floodplain or above high water inundation by the river. U.S Geological Survey Technical Publication 31, (Water Resources of Salt Lake County), was utilized to determine zones of shallow groundwater discharge to the Jordan River where wetlands could be anticipated. Any groundwater recharge zones could be discerned from this source (2). See Figure 3.

2. FLOOD STORAGE. Floodplain mapping prepared by Salt Lake County in coordination with the Federal Emergency Management Agency (FEMA) and the U.S Army Corps of Engineers was reviewed to determine the efficiency of wetlands in providing flood storage or flood flow attenuation (3). See Figure 4.

3. SHORELINE ANCHORING AND SEDIMENT TRAPPING. Soil Erosion potential was determined using the Salt Lake Soil Survey published by the U.S. Soil Conservation Service in 1974 (4). The low to high erosion potential along the Jordan River enables the anticipation of areas negatively affected by severe channel and bank erosion and helps to emphasize those wetlands adjacent to the river that provide valuable functions of shoreline anchoring and trapping of sediment generated from upstream. See Figure 5.

The National Wetland Inventory Maps produced by the U.S. Fish & Wildlife Service were used as base-map references for the inventory so that any potential wetland sites could be identified in proximity to stream reaches possessing excellent, good, fair, or poor channel stability conditions (4).

These wetland functions directly and indirectly impact nutrient production and retention, food chain support, fishery and wildlife habitat. Many answers needed to rank or prioritize wetlands performing complex natural stability functions were obtained as a result of the channel stability inventory. For example, continuous observations and ratings of channel stability from upstream to downstream reaches indicates that the presence of oxbow meanders that have been undamaged by diking, dredging, or other ineffective flood management activities, helped to reduce bank and channel erosion, store floodwater, reduce flow velocity, and maintain habitat conditions for both aquatic and terrestrial animals. Opportunities to have these functions performed downstream had, in many cases, been forgone by management practices that removed the oxbow from functioning as part of the river channel.

From these observations, it was possible to determine that oxbow meanders that support wetland vegetation provide a higher degree of benefit to river stability (both physical and biological) than wetlands not directly associated with seasonal flow fluctuations of the Jordan River. More discussion of these relationships will follow in the STUDY CONCLUSION.

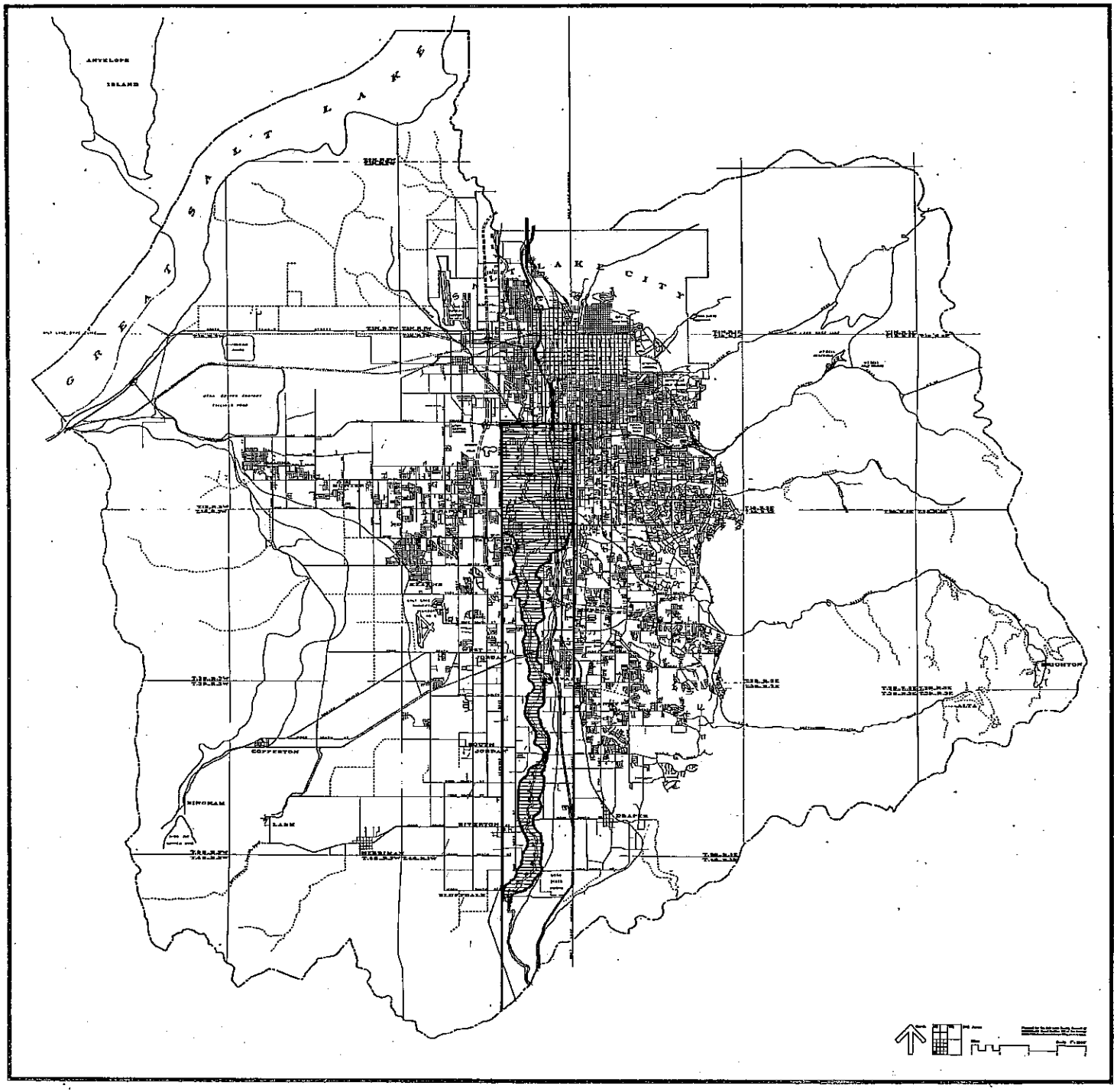
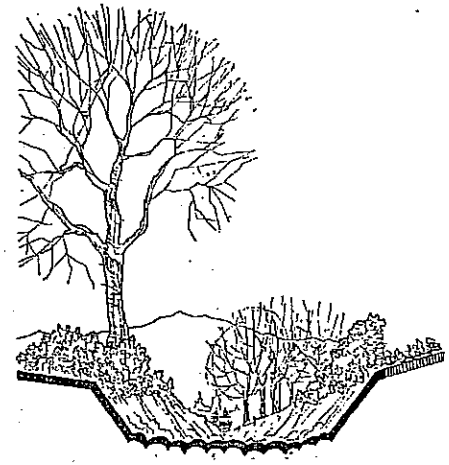


Figure 3
Area of Principal Groundwater Discharge



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CHANNEL STABILITY EVALUATION

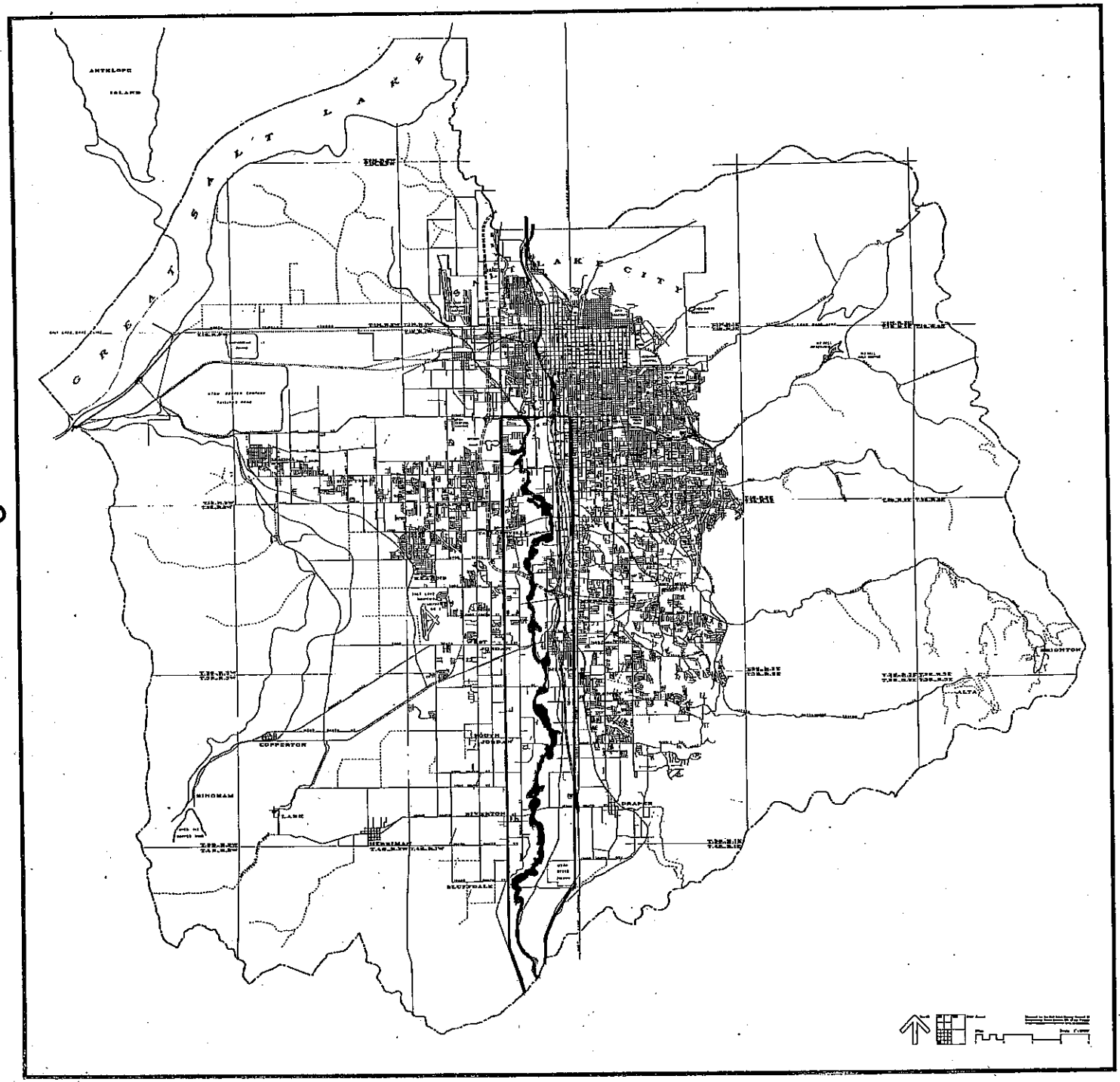
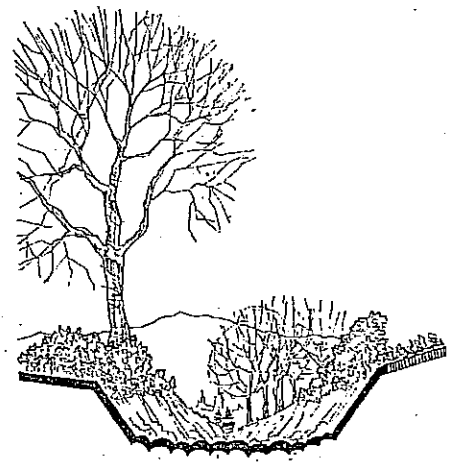


Figure 4
100 Year Frequency Floodplain



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CHANNEL STABILITY EVALUATION

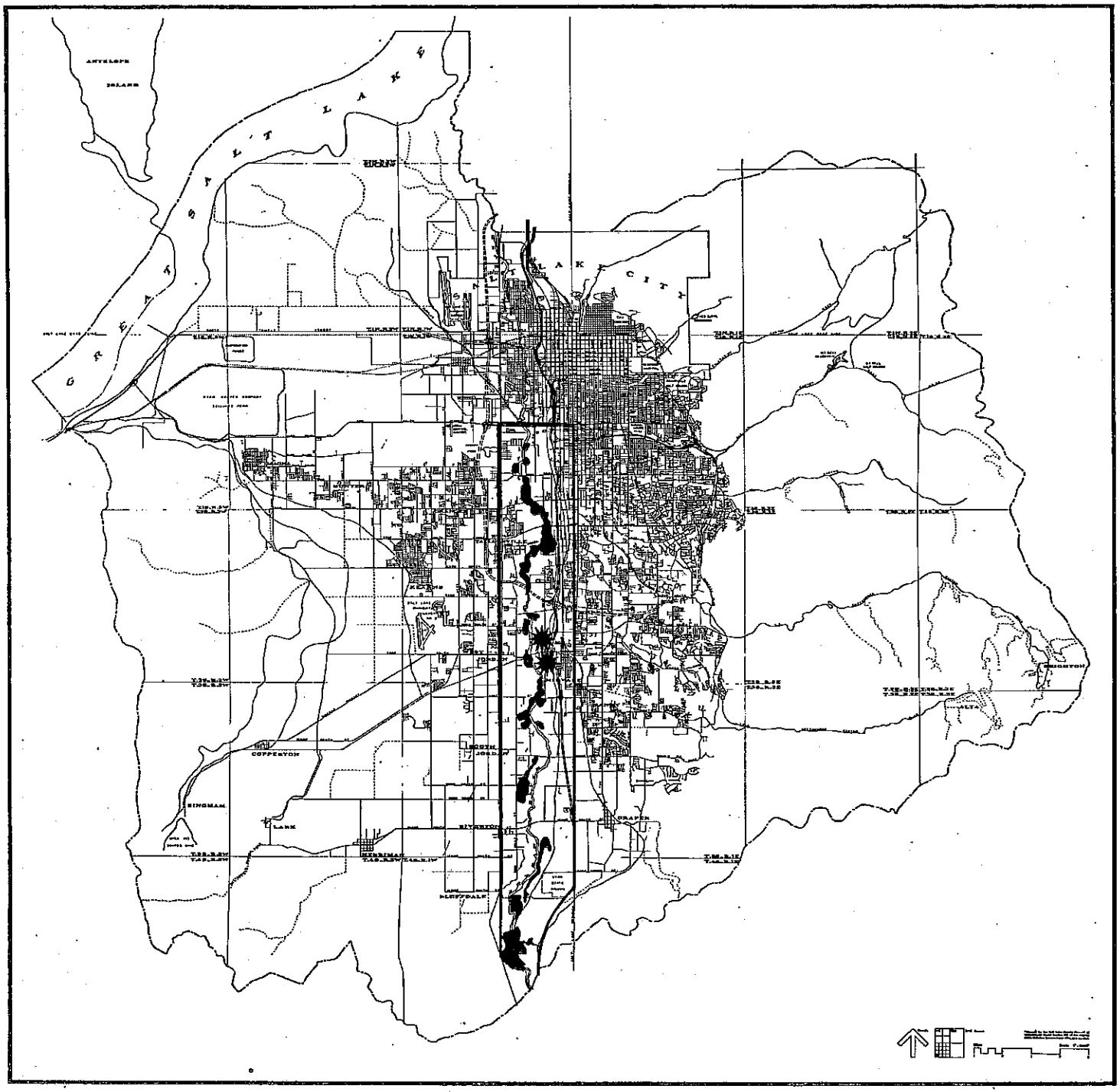
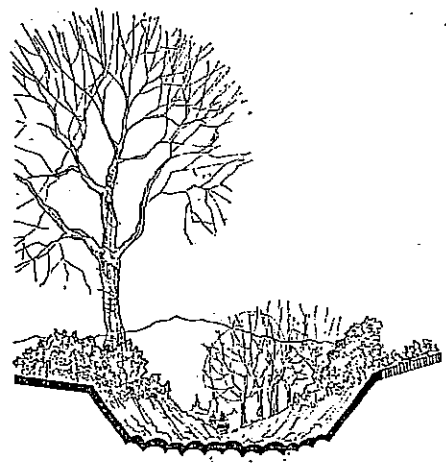


Figure 5
Areas of Moderate to Very High Erosion Hazard

✸ HAZARDOUS WASTE SITES



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CHANNEL STABILITY EVALUATION

III. STUDY ANALYSIS & DISCUSSION.

SUMMARY OF CONDITIONS.

Figure Six summarizes all channel stability rating factors together in a composite graph. All of the factors provide an index of general conditions within the study area. Total point ratings are plotted at each river reach and segment station. As indicated on the graph, the mean conditions appear to improve as the river flows downstream into the Midvale and Murray area. Some river reach conditions in the downstream section are fair to poor and produce some inconsistencies, but in general the conditions from 2100 South upstream to 5300 South are rated good, while those above 7800 South are fair to poor.

Within the total point distribution, 53% of the river reaches fell into the "fair" category, while only 8% were classified as "poor." None of the river reaches rated high enough to be "excellent," and 39% of the reaches rated "good." The largest distribution of "fair" ratings appears above or upstream of 5300 South, although the reach between 6400 and 7800 South scored very high or rated "good." This is an anomaly caused principally by the 6400 South Bridge which constricts the river flow and reduces velocities upstream, thus reducing bank and bed scouring.

It is concluded that river gradient is most responsible for the high incidence of "fair to poor" distribution (See Figure 7). As the Jordan loses gradient, there appears to be a close correllation with increase in bank stability conditions. This pattern is to be expected. However, some anomalies in bank stability appear within Segment X below 4500 South, Segment XI below 3900 South, and Segment XII below 3300 South. These anomalies are believed to be the result of recent and frequent in-stream dredging at these locations, which artificially increases stream velocity and bank/bed erosion. The same pattern occurs above 9000 South and 10600 South. The constriction at the 6400 South Bridge, while maintaining stability upstream, has produced severe (probably the worst observed on the lower Jordan) bank cutting downstream due to high velocities surging from the constriction. This pattern also seems evident below major bridge crossings.

The combination of bridge constrictions and dredging immediately upstream from the constrictions has produced the most obvious and severe bank/bed erosion conditions on the Jordan River. The second most apparent condition creating severe erosion is the occurence of mass-wasting at major bends or turns in the river. Mass-wasted, sheer banks of up to 30-40 feet in height have been documented in close proximity to bends where flow velocity is most extreme--particularly during flood season. A few mass-wasted sites have been documented on the lower river segments, but they are not as large and occur with much less frequency.

The presence of dense bank vegetation--especially that occurring within oxbow/meander flood channels--signaled the reaches with greatest stability. These reaches have been minimally affected over the last five years of extreme flooding, which attests to the durability and efficiency of natural riparian plant cover. This type of cover occurs most frequently along the lower reaches of the Jordan River. Upper reaches have been modified principally by agicultural removal, damage by stock animals, and poor management practices to maintain proper bank slope gradient. Although the Jordan meanders greatest on the upper reaches (Figure 8), little has been done in the past to arrest the rate of river meander through establishment of rhizomonous bank vegetation or other erosion control practices. Natural invasion of numerous overstory species, including cottonwood, tamarisk, Russian Olive, and willow, is occuring with extraordinary density and proliferation along the lower Jordan. Invasion along upper reaches is sparse and spotty at best, but could be improved with transplanting and artifical seed dispersion.

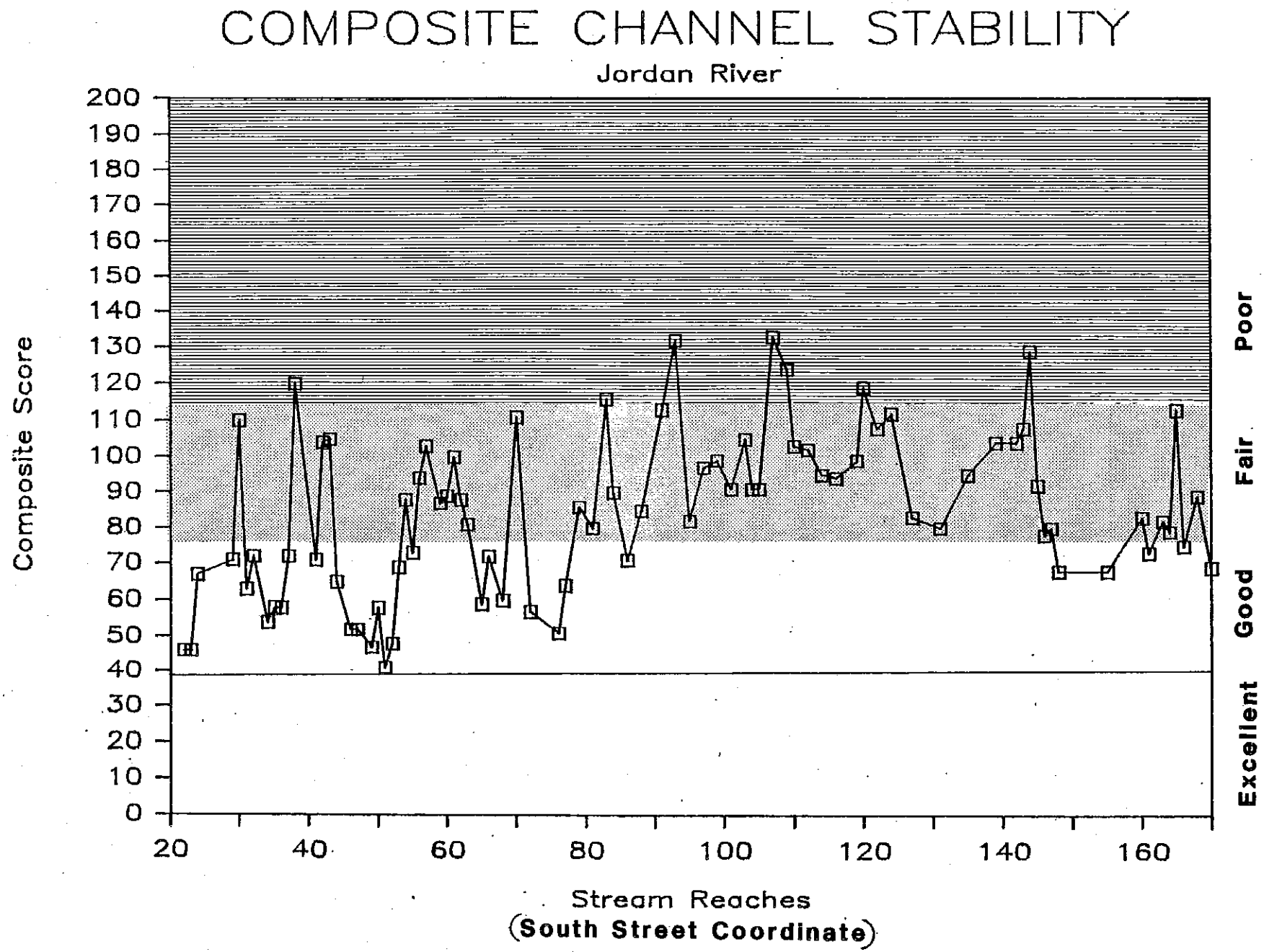

COMPOSITE CHANNEL STABILITY
Jordan River
Composite Score
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
20
40
60
80
100
120
140
160
Stream Reaches
(South Street Coordinate)
Poor
Fair
Good
Excellent

Figure 6

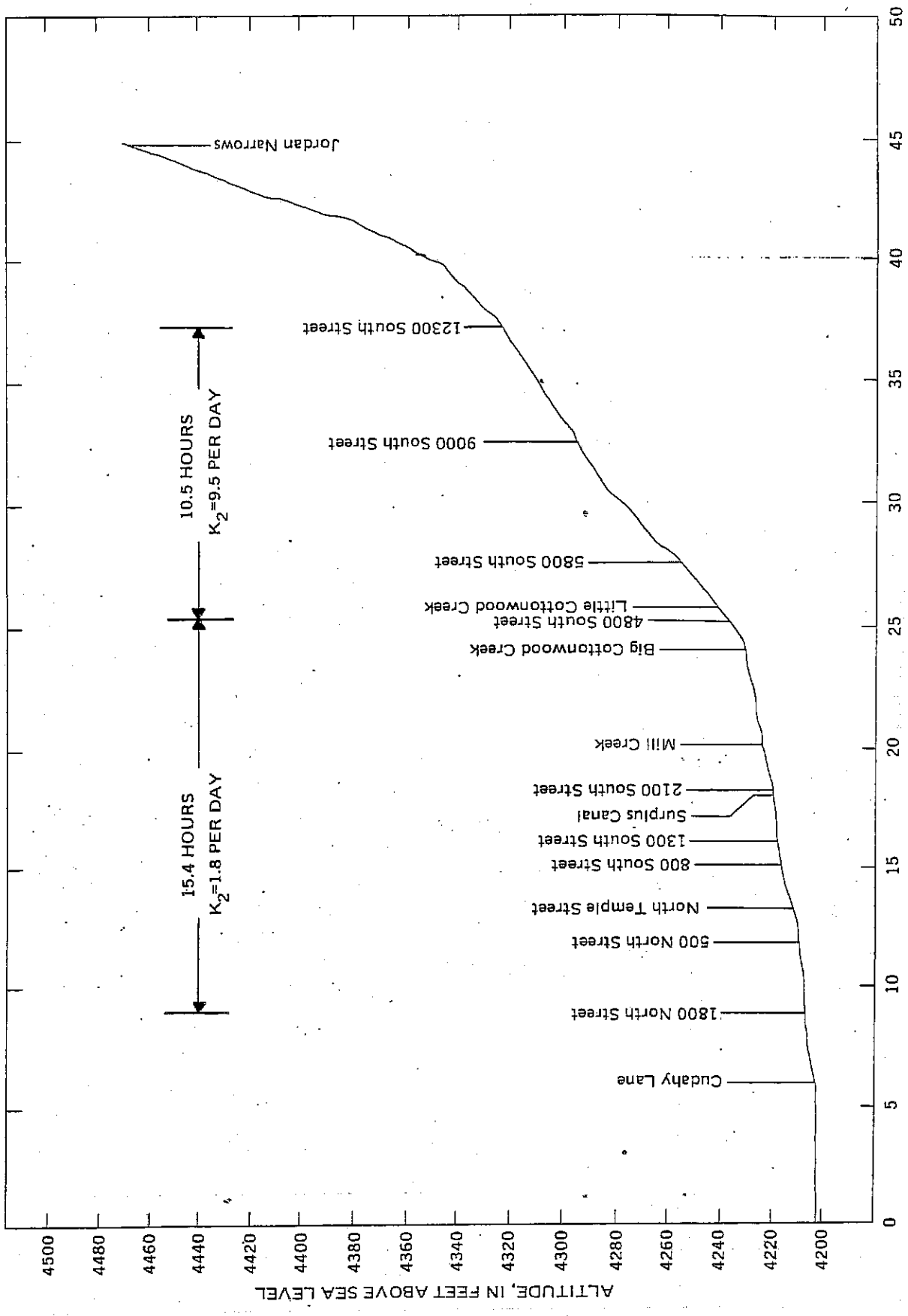


Figure 7.—Profile of the river channel with selected reference points, travel times, and reaeration rates (K_2). Modified from Stephens (1984).

ANALYSIS OF INDIVIDUAL STREAM REACHES : SELECTED STABILITY INDICATORS

Each major river segment was subdivided into shorter reaches which are generally homogeneous, i.e. having a number of similar characteristics. A rating sheet was completed for each reach, and representative photographs were taken. The following discussion summarizes selected factors for each reach, and Figures 8 through 11 graph results of selected indicators::

1. General riparian and wetland characteristics of the reach, such as dominant plant species cover and density, and random observations about the reach that may be of particular interest.
2. Occurrence, frequency and distribution of oxbow meanders and related wetland values.
3. Occurrence, frequency and distribution of groundwater discharge (springs) in proximity to the stream reach and adjacent wetlands. This factor includes discharges reaching river or wetlands through artificial and natural channels.
4. Upper bank slope gradient.
5. Upper bank mass-wasting hazard
6. Upper bank vegetative bank protection. This observation includes both overstory (trees/shrubs) and understory (grasses/forbs) vegetative cover, and includes discussion of observed wetland plant density where appropriate.
7. Lower bank cutting.
8. Lower bank depostion.

Factors NOT included in the analysis are:

1. Debris jam potential. This factor was rated the same for almost every stream reach. Little debris jamming potential exists along the Jordan River. There is not sufficient density of riparian overstory to create conditions that would create a hazard, especially on upper reaches where gradient is steep.
2. Channel Capacity. The figure showing the extent of the floodplain, together with observations about oxbow flood storage, are sufficient to describe this condition. Adequate channel capacity for normal seasonal flows is apparent for most river segments. New meanders or depositional features indicated where capacity was exceeded on the upper Jordan, while cutting indicated the same on the lower Jordan.
3. Obstructions and flow deflectors. These were not frequent enough to merit discussion.
4. Channel Bottom Data. The high dissolved solid content of the river made good observations of bottom conditions very difficult. Some effort was made to record bottom conditions, including size composition of bottom materials. These factors would be best addressed during an intensive bottom conditions survey, where sampling could substantiate observations.

Some conclusions from the information obtained are:

1. Most bottom material consists of small rubble (3"-6"), coarse and fine gravels, and sand & silts, except for the upper-most reaches where small boulders and large rubble were numerous.
2. Except for very new depositional areas downstream from recent cuts (Spring of 85 or 86), bottom materials are a 50-50% mixture of dull and bright.
3. Packing of bottom materials was principally a loose assortment to a moderate slightly overlapping assortment.
4. Stable materials distribution in the bottom was slight to moderate
5. Bottom scouring was evident in 30%-50% of all observations, with scour at constrictions, and deposition in pools and bends.
6. Aquatic vegetation was common in almost all reaches, but changes in density were apparent.

Figure 8

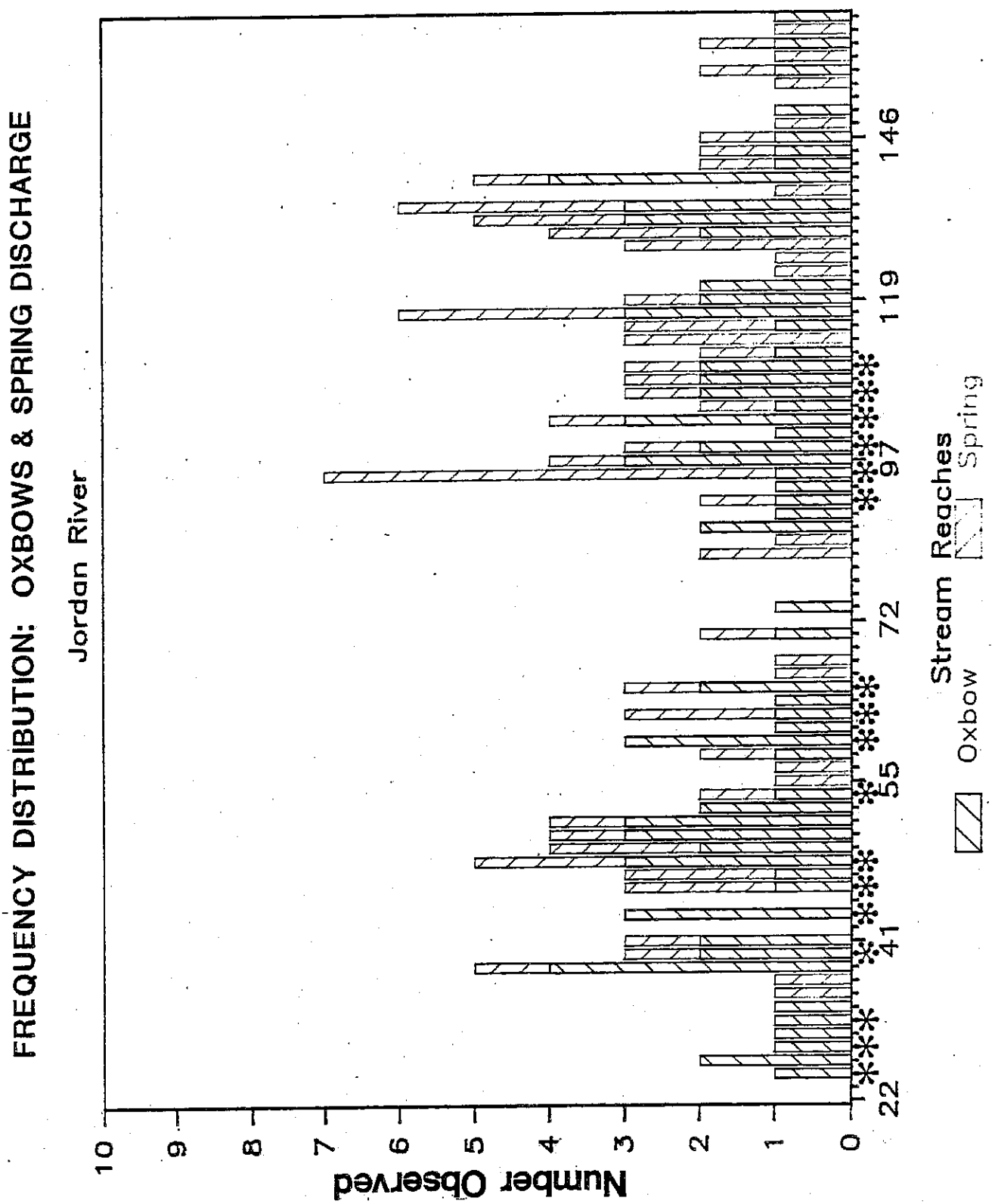

FREQUENCY DISTRIBUTION: OXBOWS & SPRING DISCHARGE
Jordan River
Number Observed
0
1
2
3
4
5
6
7
8
9
10
22
41
55
72
97
119
146
Stream Reaches
Oxbow
Spring
* oxbows cut-off

Figure 9

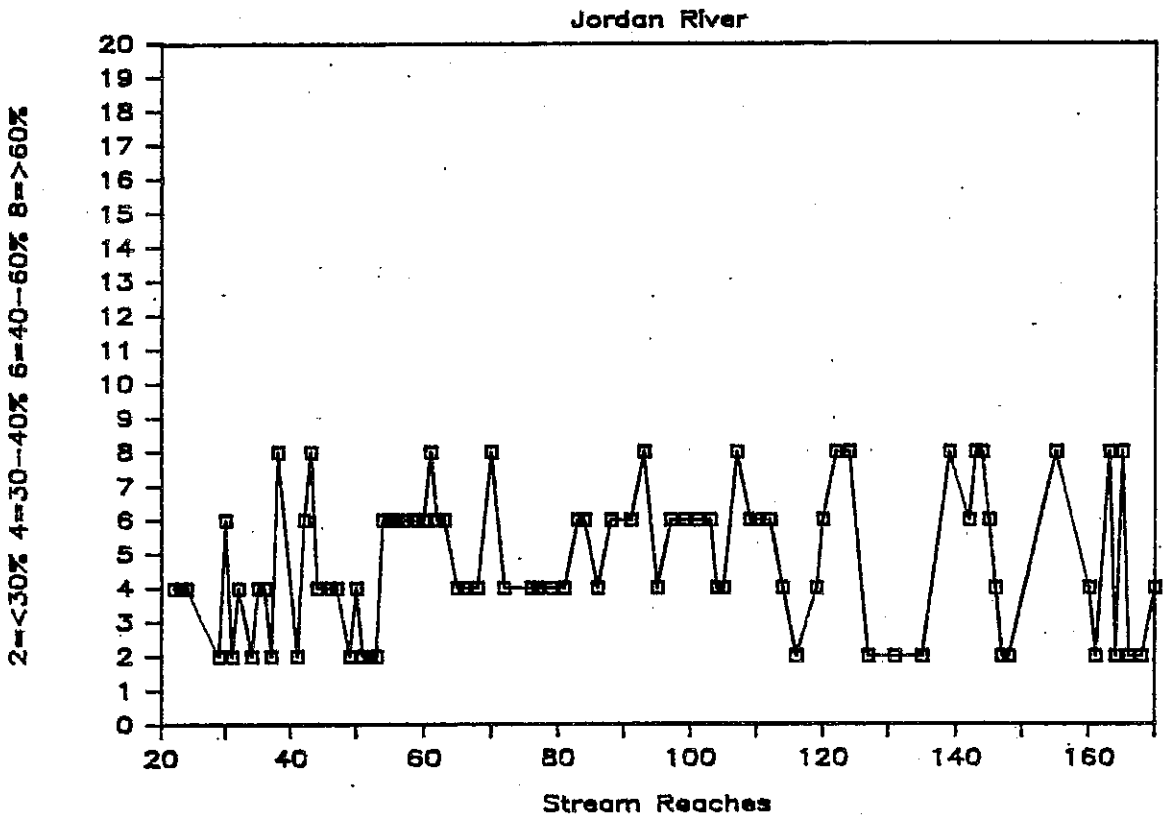
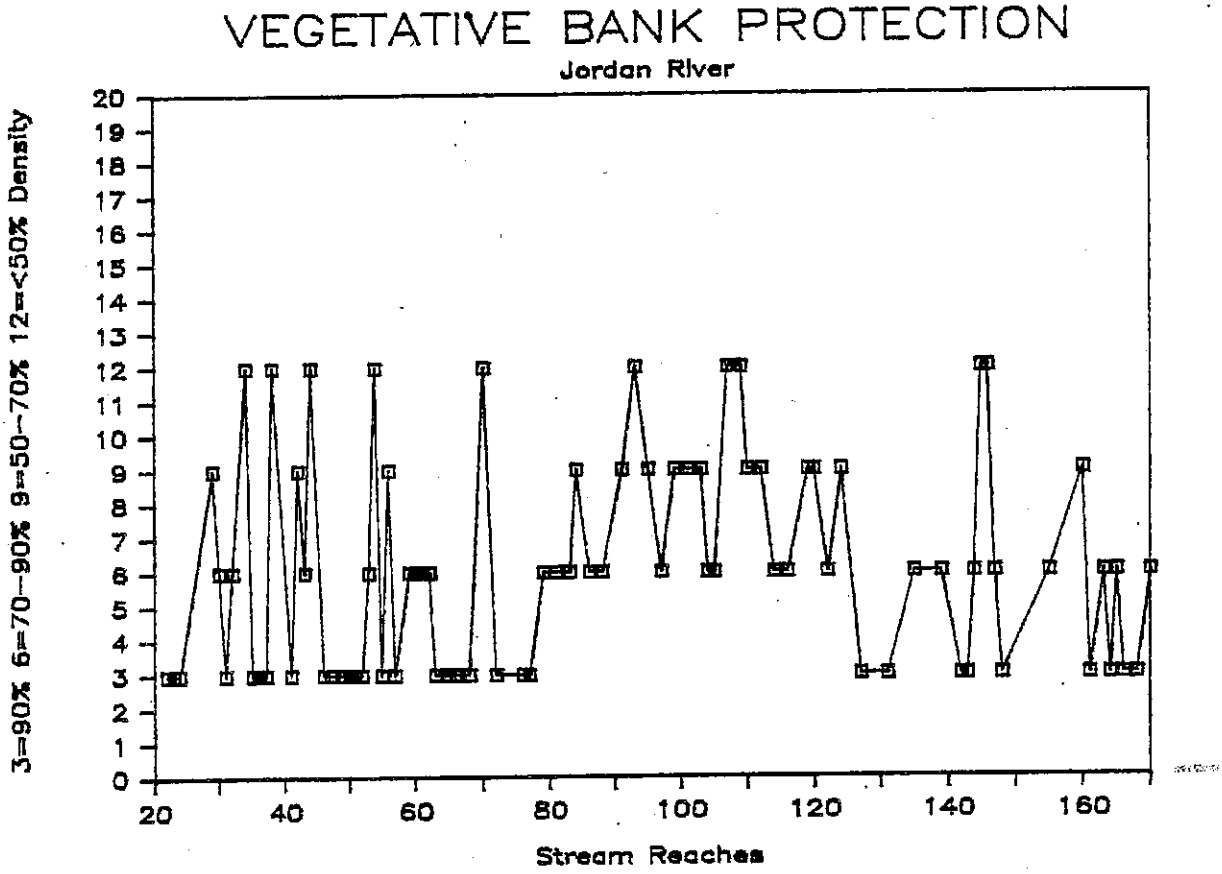

UPPER BANK SLOPE GRADIENT
Jordan River
2=<30% 4=30--40% 6=40--60% 8=>60%
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
20
40
60
80
100
120
140
160
Stream Reaches

Figure 10


VEGETATIVE BANK PROTECTION
Jordan River
3=90% 6=70-90% 9=50-70% 12=<50% Density
Stream Reaches

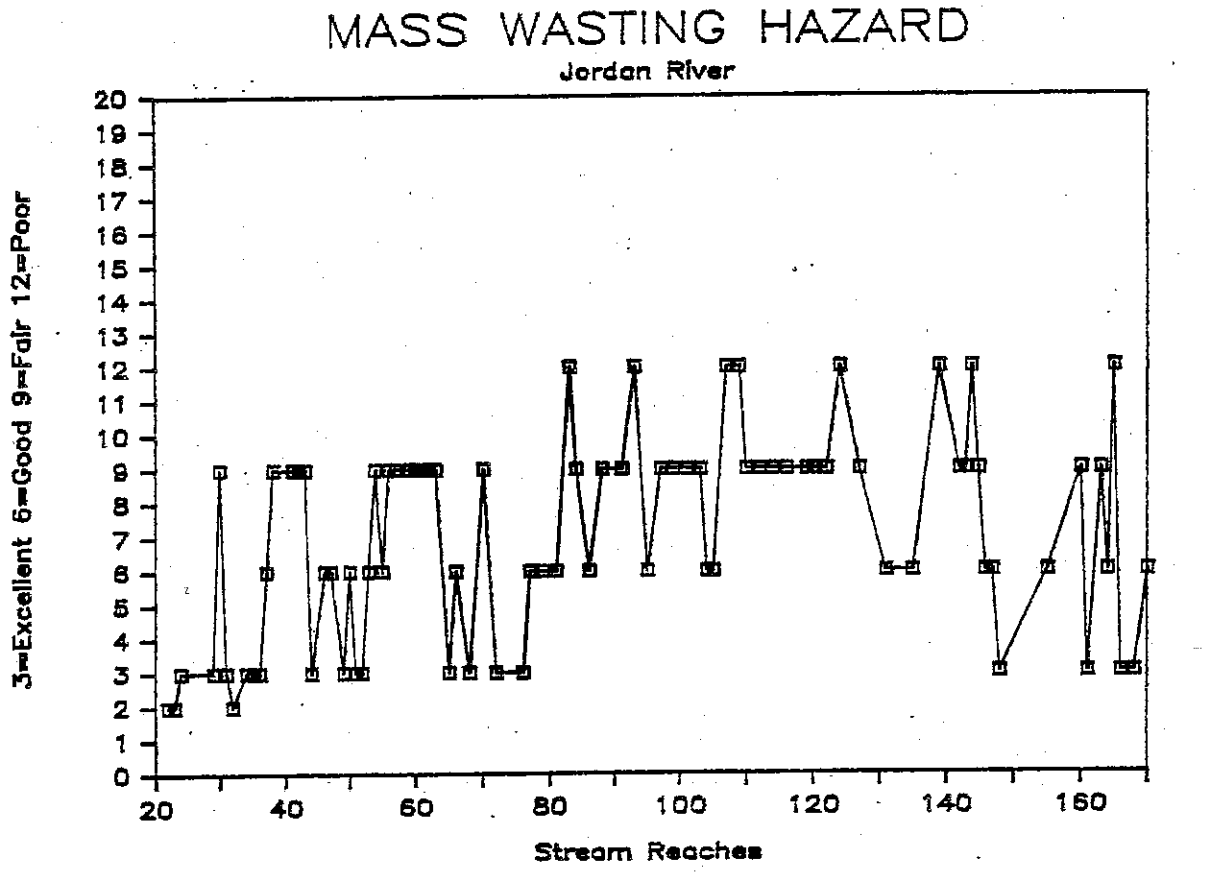
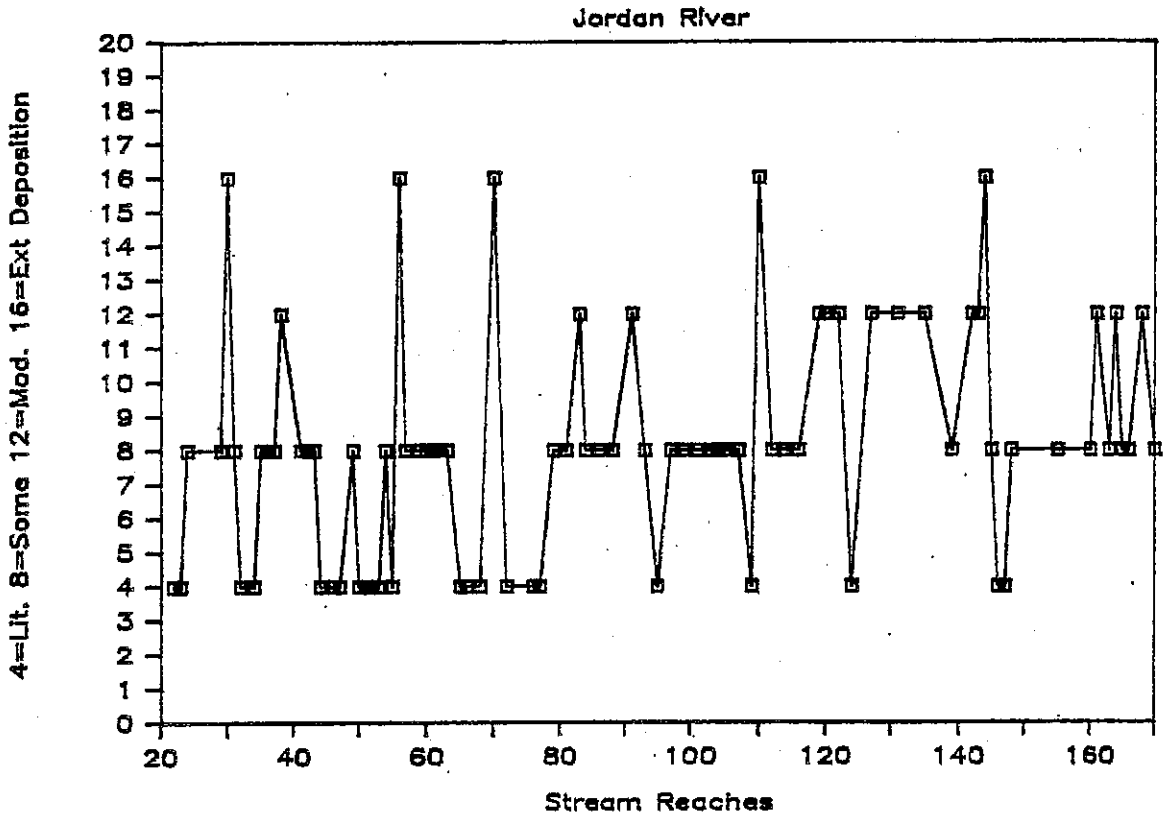
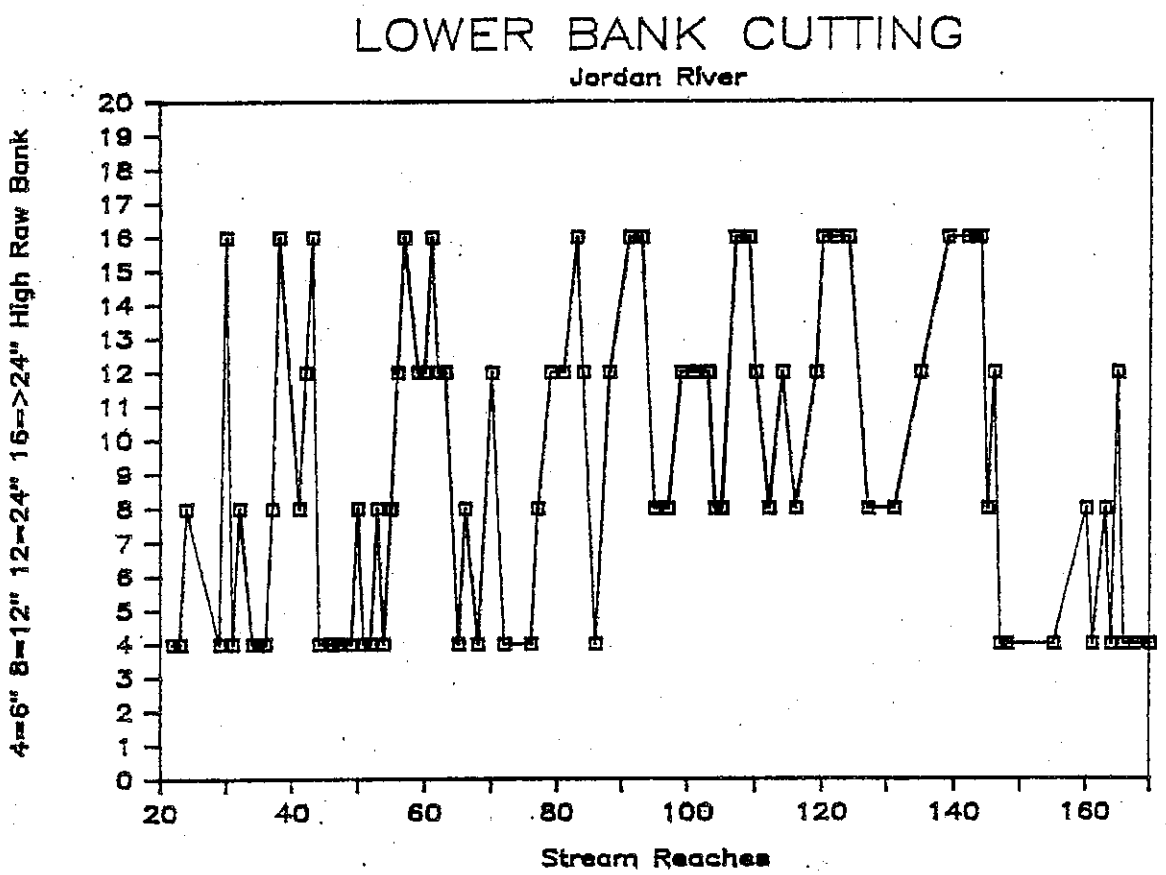

MASS WASTING HAZARD
Jordan River
3=Excellent 6=Good 9=Fair 12=Poor
Stream Reaches

Figure 11


LOWER BANK DEPOSITION
Jordan River
4=Lit. 8=Some 12=Mod. 16=Ext Deposition
Stream Reaches


LOWER BANK CUTTING
Jordan River
4=6" 8=12" 12=24" 16=>24" High Raw Bank
Stream Reaches

SEGMENT I. JORDAN NARROWS TO BLUFFDALE BRIDGE (14600 South).

SUMMARY/CONCLUSION. Segment I is among the highest rated six river segments on the Jordan, although it possesses the highest stream gradient. Five reaches score "good" with remainder "fair." The stability of this segment is due primarily to flood channels that store and attenuate high volumes and velocities.

REACH 1. From the Jordan Narrows downstream 1200' this portion has been channelled and rip-rapped. The riparian phase consists of less than 10% cottonwood, but adjacent floodplains exhibit more than 50% willow and cattail wetlands. No oxbows or springs were evident. Upper bank slopes average 30%-40%, but good vegetative bank protection rated the reach low for mass-wasting hazard. The reach displays excellent bank-rock content, due mainly to rip-rapping. Lower bank cutting and deposition were generally absent.

REACH 2. The river forks into a complex of braided flood channels. The riparian phase is almost 100% oak brush, tamarisk, and willow. Grass-Sage occupies upland terrestrial communities. We encountered a large four-point buck in this reach. A large oxbow flood channel was apparent, and spring flow was evident from the East banks. Bank slope gradient was less than 30%, with excellent vegetative coverage and no mass-waste hazard. Cutting and deposition were not observed. This reach has a high sediment buffer/trapping potential.

REACH 3. Another complex, heavily vegetated flood channel system, this reach is unique in its riparian phase consisting of box elder and cottonwood trees. Thick tamarisk, willow and olive shoots are emerging in the wetland and floodplain. Three large Does and a yearling Fawn were observed in this reach. The area is the site of a Boy Scouts of America Camp, and a possible Section 404 Violation seems apparent along the Northern edge of the reach. Both oxbow/meander flood channels and spring discharges were observed. Bank slope gradient was less than 30%, with excellent vegetative bank protection and low mass-wasting hazard. Bank rock composition was fair, but little cutting and deposition has occurred.

REACH 4. This short, straight reach has been constricted by an historic railroad trestle bridge. Bank slope gradient is in excess of 60%, with mass-wasting evident. Bank rock content is very poor. Extreme bank cutting is under way. A good candidate site for future rip-rapping.

REACH 5. The Jordan again forks into an extensive flood channel complex, creating a beautiful, isolated meander "valley" with heavy oak/box elder overstory, and thick stands of streamside willow, cattail, sedge, and hard-stem bullrush. This reach, together with reach 3 should be considered for public acquisition under the River Enhancement Program. The site harbors at least three pairs of nesting Night Herons. Numerous meander flood channels provide extensive flood storage and attenuation of flood velocities, and several indications of spring discharge were present. Low bank slopes and good vegetative bank growth render mass-wasting hazard low. Ratings for cutting and deposition are good to excellent.

REACH 6. Another short, constricted river reach with indications of a broken diversion or instream obstruction than has created head-cutting. Similar to Reach 4, the site has steep banks, high mass-wasting hazard, but still good conditions on the lower banks for cutting and deposition.

REACH 7. This long reach previously was a flood channel complex similar to Reaches 3 and 5. Construction of a new diversion dam has turned this area into a broad settling basin, with dense overstory and understory spring-fed growth. Cottonwood and Box Elder are mature and well distributed over the site, and several wetland complexes provide good opportunities to enjoy the quality of the resource. Substantial recreation, including camping, fishing, and canoeing occurs in the area. Flood inundation has killed many of the mature trees. Several springs discharge to the river, and an on-site pumphouse provides drinking water to the Camp Williams military facility. Bank slopes are slight with excellent vegetative bank protection. Fair bank rock condtions have helped keep cutting and deposition to a minimum.

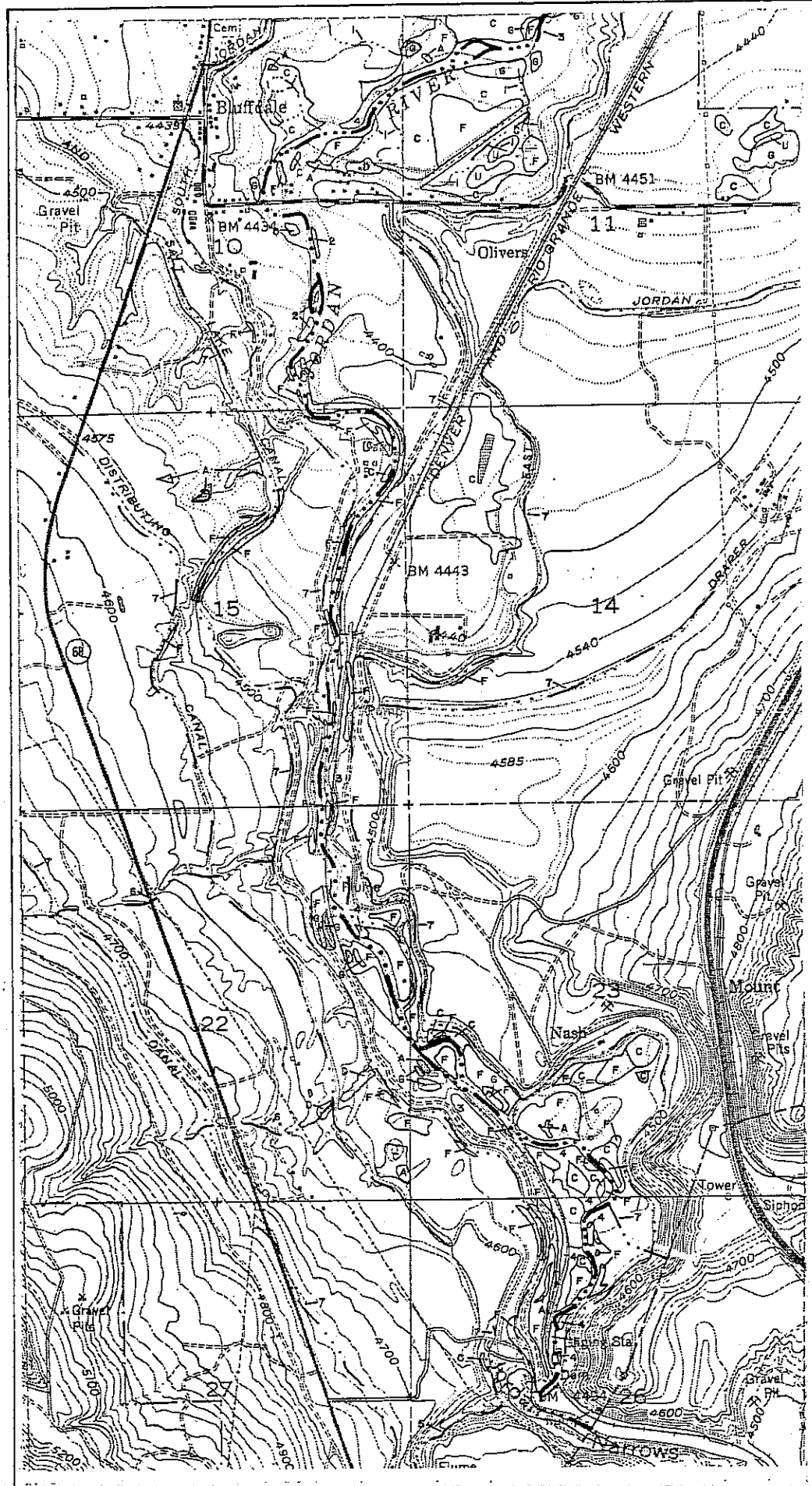
REACH 8. Constricted on both banks, this reach has been extensively stabilized with rip-rap at its upper end. Some spring discharge exists. Several fishermen were observed on three visits to the area. Mass wasting hazard exists on the lower reach where slope of banks increases and vegetative bank protection is only fair. No serious cutting or deposition.

REACH 9. This reach is well over a mile in length. It is a narrow, constricted channel that has been extensively stabilized by rip-rap. Railroad trestles on the East and TWO irrigation canals enclose the river along this steep, rapid stream portion. Some springs observed emerging from West banks of the river and canals, adjacent to bedrock outcrops. High bank slope gradient is off-set by good bank vegetation. Low future potential for mass-wasting, cutting, or deposition.

REACH 10. The Jordan River widely bends Westward at this reach, with drowned Olive and assorted shrubs (including HUGE growths of Poison Ivy) comprising the overstory, and good cattail growth in the understory. There has been an extensive fill with attendant bank stabilization on the West end of the reach. Spring discharge was observed. Banks generally less than 30% kept mass-wasting, cutting, and deposition low, together with thick vegeatative bank protection on both sides of the channel.

REACH 11. This reach is being modified by limited filling & bank stabilization. Russian Olive provides good bank protection, with some oxbow meanders and wetlands enhancing the condition. Good bank rock content and gradients have kept cutting, deposition, and mass-waste hazard low. Filling of East bank flood channel may create problems. Rip-rap downstream near bridge has eliminated any future concern for this reach.

Figure 12



Indicates Priority for Stabilization

SEGMENT I.

SEGMENT II. BLUFFDALE BRIDGE TO RIVERTON BRIDGE (12600 South).

SUMMARY/CONSLUSION. Segment II Reaches all ranked "fair" with exception of Reach 4 which ranked "poor." The reach contains fifteen oxbow meanders and at least sixteen spring discharges. Many bank slopes exceed 40% and cutting & deposition are common. Mass-wasting hazard is high, bank rock content fair to poor. Vegetative bank protection was best at oxbows and meander channels. The reach possesses very unique habitats and supports a diverse wildlife population. It is second only to Segment I in natural amenity and beauty.

REACH 1. Mostly grasses (90%) comprise the riparian phase, which has been drastically altered by rip-rap. Vegetative bank protection is absent, having been substituted by bank rock. Low potential for mass-wasting, but some significant bank cuts exist below the rip-rap. Deposition lacking. Springs discharging.

REACH 2. The Riparian phase is 15% Russian Olive, while the floodplain is 80% grasses and 20% trees. Moderate sediment trapping and deposition in West bank meander. Spring discharge evident. Fair bank slopes & mass-wasting hazard. Poor vegetative bank protection. Willow cuttings could be easily placed at this Reach.

REACH 3. Riparian & floodplain phase similar to Reach 2. No oxbows, meanders, or spring discharges evident. Average bank slopes above 60% with little or no vegetative bank protection and high mass-wasting hazard. Severe cutting and deposition occurring with extensive and hazardous bank undercutting.

REACH 4. Poorest rated Reach in Segment II. Possesses same characteristics as Reach 3 except WORSE. Severe bank cutting between 5'-7' high on East bank. Hazardous to stock and humans. Grading-back slopes with rip-rap tows and revegetated banks are recommended. Emergent wetland plants are initiating the bank stabilization process in the East bank meander. Numerous shore and wading birds.

REACH 5. This 3800' long reach is very unique in the extensive braided channel, bank cutting, and isolated meander ponds along the East banks. At least four oxbows and elevated meanders receive discharge from three springs. The Riparian Phase is dense and diverse with large Olives and other unidentified trees along the elevated banks. Five pairs of nesting Night Herons were observed in the quiet, isolated aquatic bedss of the East banks. A small flock of Black-faced Ibis were feeding in the pond area. A truly unique recreational experience, the elevated banks form a natural "nature trail" or path along the isolated ponds, rich in insects, wildlife, wetland plants, and wildflowers. Below, vegetative bank protection is excellent, but the river gradient and direction are producing extensive hazard of mass-wasting, cutting, and deposition.

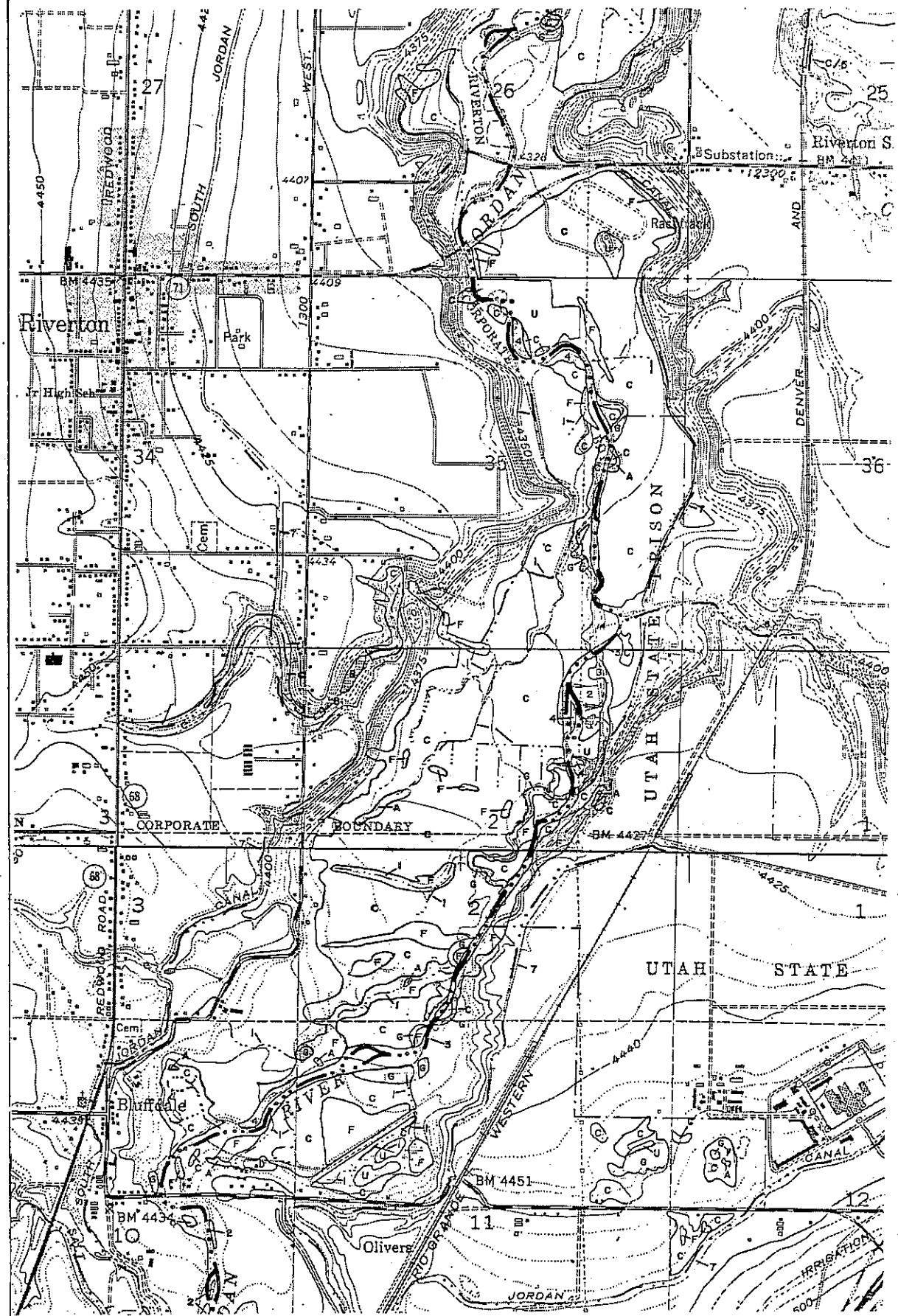
REACH 6. This 2000' long reach possesses much the same characteristics as reach 5, but length required division into a separate unit. A mass-wasted East bank 30'-40' high separates two hidden elevated aquatic beds. The erosion appears at a severe natural constriction of the river.

REACH 7. This expansive depositional reach is perhaps one mile in length. The widest flood channel is about 800' with little or no riparian vegetation. The Eastern banks and floodplains are heavily grazed. Three large oxbow meanders have recently formed and are fed by three discharging groundwater sources. The springs are used heavily by grazing stock, and are fast becoming polluted. Banks are generally less than 30% and vegetative bank replacement is beginning following the severe effects of past floods. This area is a good candidate for slope-regrading and vegetative replacement using species NOT desireable by cattle--if such a thing exists.

REACH 8. This reach contains three old oxbow meanders and at least three spring discharges. Riparian phase is mostly Olive, with large isolated pockets of hardstem bullrush wetlands occurring in the floodplain. Nesting Night Herons were observed, together with many sitings of Canadian Geese, Snowy Egrets, Great Blue Herons, and large flocks of Black-faced Ibis. Apparently the wetlands are used extensively by unique wildlife species. Bank slopes are less severe, and cutting/deposition are absent. This reach has approached natural equilibrium due mainly to oxbow and floodplain storage of high flows.

REACH 9. This reach is characterized by four major bends and associated cut/deposit zones. The Riparian phase is principally Russian Olive, and wetlands in the floodplain are very diverse and widely distributed. Although grazed, both East and West bank floodplains are rapidly emergent wetland communities with large numbers of interesting plant types. New meanders and oxbow vegetation will be maintained by both river and spring flow. Banks less than 30% predominate, but two large mass-waste cuts on the West bank require immediate attention. A fair amount of deposition below the cuts testifies to the severity of the isolated cutting.

Figure 13



SEGMENT II.

SEGMENT III. RIVERTON BRIDGE TO SOUTH JORDAN BRIDGE (10600 South).

SUMMARY/CONCLUSION. Of the ten Reaches within Segment III, seven are rated "fair" and three are rated "poor." This Segment has been somewhat manipulated by artificial flood control techniques, mainly dragline operations. Spoil piles have been left behind, some are revegetating, others eroding into the river. The Segment contains thirteen oxbows, some of which have been cut off by dragline operations. Where trees and vegetation have been undisturbed, they have been quite effective in reducing bank erosion. Like upstream reaches, the stability of this segment is due, for the most part, to oxbows and meanders that have stored floodwater and reduced stream velocities. The Segment supports flocks of diverse wading and shore birds, who enjoy large wetland areas adjacent to the river.

REACH 1. This reach is eroding badly. Riparian overstory is sparse except for a few streamside trees, mostly willow and cottonwood. Bank slopes exceed 60%, mass wasting hazard is high, bank rock content poor, and cutting producing 6'-7' high eroded banks. Bank re-grading, tow protection and overstory tree cuttings could effectively arrest the present condition.

REACH 2. Very sparse Riparian vegetation, mostly emergent tamarisks and olive. High bank slope gradients; good understory bank protection; poor bank rock content; poor cutting conditions; fair deposition. Sprig depositional areas with Tamarisk and grade-back Western banks.

REACH 3. Two oxbows and three spring discharges provide an increase in wetland diversity at this bending reach. Wide, 150' depositional areas have kept cutting on the East bank extreme and up to 20' high, placing a significant hazard before a valuable herd of dairy animals utilizing the East pastures. Mass wasting, cutting, deposition, bank rock content, and other factors are similar to those in Reach 2.

REACH 4. Of 15 rated factors, 9 scored "fair" to "poor." Minor oxbow benefits, but one emergent wetland oxbow does store and attenuate flood flows. Bank slopes are good with a 50% growth of bank vegetation. Rates "fair" in cutting and deposition. Flock of more than 100 Black-faced Ibis, 25 Canadian Geese, and a single Great Blue Heron observed in one afternoon, using mostly irrigated/inundated wetlands and pastures.

REACH 5. Three large oxbows with associated Spring inflow provide most bank protection in this reach. Depth of bank cuts are much less in this reach than in upstream reaches, with average bank slopes less than 30%. Vegetative bank protection is good, as is rating for cutting and deposition.

REACH 6. The Western grade of this reach has been raised. The Eastern grade is an oxbow. Little or no erosion on the East bank has occurred, but 3'-4' cuts are common on the opposite bank.

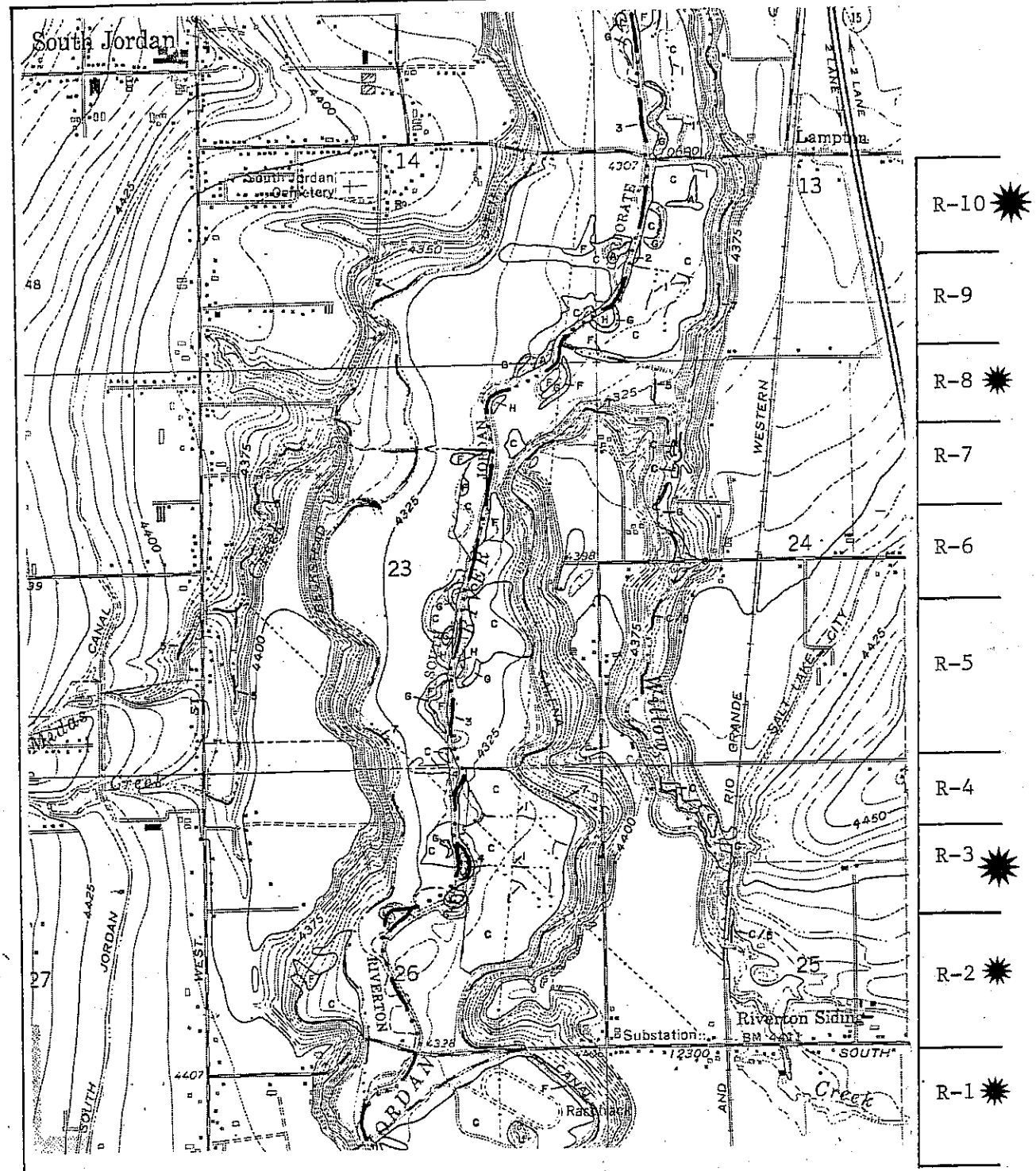
REACH 7. This Reach displays textbook erosion control measures on both banks. The 600' reach has been graded back at the extreme upstream end on the West bank. This bank is stable. The East bank is eroding. Further downstream, vegetative stabilization has been implemented on the East bank, while the West bank opposite is the site of a 10' bank cut.

REACH 8. Only a 5% Olive tree overstory and 50% grazed wetland comprise the riparian and floodplain phases of this reach. Three to four foot bank cuts are followed by moderate deposition. Significant bank cuts could be corrected partially by grading-back. Deposition appears to be accellerating on this reach, which is a good candidate for a model bank stabilization project, since the landowners appear to have had some epxerience with erosion control practices.

REACH 9. This reach is the beginning of extensive dredge spoil pile erosion back into the river. The West bank has been left with piles of unconsolidated, unvegetated bottom materials. Slope grades are between 40%-60%, with some mass-wasting happening on the spoil piles. Vegetative bank protection is poor on both sides. Some forb invasion is beginning on parts of the spoil piles, which are probably at least two years old. Significant bank cutting is occurring on this reach. One oxbow has been filled.

REACH 10. Conditions in Reach 9 are replicated here. Two Western oxbows have been cut off, and spoil mass-wasting and bank cutting is occurring at a rapid rate. Eastern flood channel meanders provide some storage and wetland benefit, but a dragline was busy on the day of observation moving toward the remaining wetland areas. Spring discharges are numerous, so both riparian and wetland vegetation could return with proper grading.

Figure 14



SEGMENT III.

SEGMENT IV. SOUTH JORDAN BRIDGE TO SANDY BRIDGE (9000 South)

SUMMARY/CONCLUSION. Nine stream reaches were selected for observation in Segment IV. Eight of nine scored in the "fair" category, while one scored "poor." Reach 8 scored 132 points, second to Reach 10 in upstream Segment III, which indicates serious problems relative to stability. This segment has been almost continuously dredged within the past three years. Riparian vegetation has been destroyed, increasing erosion. Habitat has been destroyed, decreasing wildlife values. Pool/Riffle ratios have been grossly modified by efforts to establish a trapezoidal channel, rendering the segment less productive as a fishery. Spoil piles have been left unstabilized, and many piles are mass-wasting and sloughing back into the river. Of the fourteen oxbows in the segment, it appears as though 12 have been cut off by either dredging or illegal filling activities. Flood storage capacity has been severely reduced in this segment. There is probably not one more negative action or effect that could be inflicted on this river segment, that has not already been executed.

This reach is an example of short-sighted river management, where neither short nor long-term effects were anticipated by the County. The damage and detrimental effects to downstream reaches of this segment will be documented during the Wetland Advance Identification Study, and it will take years for the downstream reaches to regain some level of natural equilibrium.

As is, the segment is a major non-point source of pollution to the Jordan River and will be targeted for extensive stabilization and revegetation efforts by federal, state, and local water quality regulatory agencies.

REACH 1 & 2. No question of homogeneity of these two reaches. A 20% density of Olive and shrubs provide very limited riparian benefit. Two small oxbows appear to provide some flood storage, and could be developed into excellent bass habitat. Spring and irrigation return flow discharge could help maintain new stands of overstory vegetation. The East banks possess tremendous potential for enhancement. Bank slope gradient is good, some bank cutting and deposition has occurred. The West banks are graded spoil piles and should be revegetated.

REACH 3. The three oxbows in Reach 3 have been cut off. Very sparse riparian vegetation and fair bank cover have combined with spoil piles to produce significant bank cutting. Coarse gravel deposition can be observed. Poor bank rock content and lack of spring discharge add to problems of this reach. The oxbow should be opened-up and reclaimed.

REACH 4 & 5. Both banks of Reach 4/5 are experiencing invasion of emergent overstory species, with a 50% density of olive, willow, and tamarisk. Bank slope gradients are in the range of 50%-60%, and significant cutting is taking place. Again, spoil piles seem to be causing the bulk of bank erosion. Of three oxbows between the reaches, one has been cut off. Substantial spring discharge was observed along this section, with at least seven individual flow channels. Dredge piles should have either been removed or stabilized as per requirements of the Corps of Engineers Nationwide Permit. Good conditions still exist on the East banks, with good flood storage and wetland values.

REACH 6. Three large oxbows in this reach have been filled. Both sides of the channel have been subjected to what appears to be unauthorized, illegal discharges of fill material into adjacent wetlands. Mass wasting is occurring during high flows, and spoil piles aggravate bank slopes in excess of 60%. Some increase in bar formation appears, but the reach is cutting more than depositing. Natural bank revegetation has begun and some recovery is evident.

REACH 7. This reach extends to a new irrigation diversion structure and displays evidence of widening with a dragline. One oxbow has been filled, and probably in response to protecting the diversion from flood wash-out. Banks do not exceed 40% on average, and mass wasting is infrequent with low future potential.

REACH 8. Reach 8 scored 132 points (poor conditions). It contains a single oxbow which is thick with diverse vegetation and harbors nesting Night Herons. It has been cut off by dredge piles. Very small spring discharge and stagnant conditions are being created. This site could be a high quality wetland park, with good access and diversity. If it were reclaimed and opened, bank slope gradients of more than 60% could be reduced, imminent mass-wasting hazard could be reduced, plant density on lower banks could be increased above 50%, continuous 24" cutting could be eliminated. This oxbow functioned as a regulating device for the Jordan, and with its demise, poor stability conditions have been created that will require expensive solutions by the taxpayers.

REACH 9. The river has been channeled on both banks. Natural revegetation is beginning to occur on the West, with continuous 3'-4' cuts on the East bank. Some emergent tamarisk was observed, but no riparian phase presently exists. Upper bank are in very poor condition. Some West banks have been graded back, and vegetative invasion has been strong. This practice could be replicated along the entire reach with good results. Spotty mass wasting could easily be arrested with the grade-back technique.

Even if grading back and vegetative sprigging is not considered a permanent solution, the question of cost and effectiveness in a specified time period should be addressed. If public resources are scarce, lower cost, affordable alternatives should be implemented.

SEGMENT V. SANDY BRIDGE TO MIDVALE BRIDGE (7800 South).

SUMMARY/CONCLUSION. Six reaches comprise Segment V. Four scored "fair" while one scored "good" and one "poor." It is an interesting segment for a number of reasons: It literally cuts through a large potential hazardous waste site; It contains a unique climax wetland community adjacent to the waste site; It was straightened many years ago, yet exhibits fair stability, with excellent sites for flood storage and wildlife habitat. Bank cutting on downstream reaches displays an almost symmetrical alternate fluvial pattern, with loss of a few large trees growing on the upper banks.

REACH 1. This is the most stable reach in the segment, owing to remaining oxbows and thick riparian vegetation consisting mostly of willows and emergent tamarisk. Groundwater discharge has maintained good wetland density and diversity along the reach. Some bank cutting has occurred on both banks, but not to the extent observed on upper reaches. Spotty vegetative bank protection is holding accellerated mass-wasting in check.

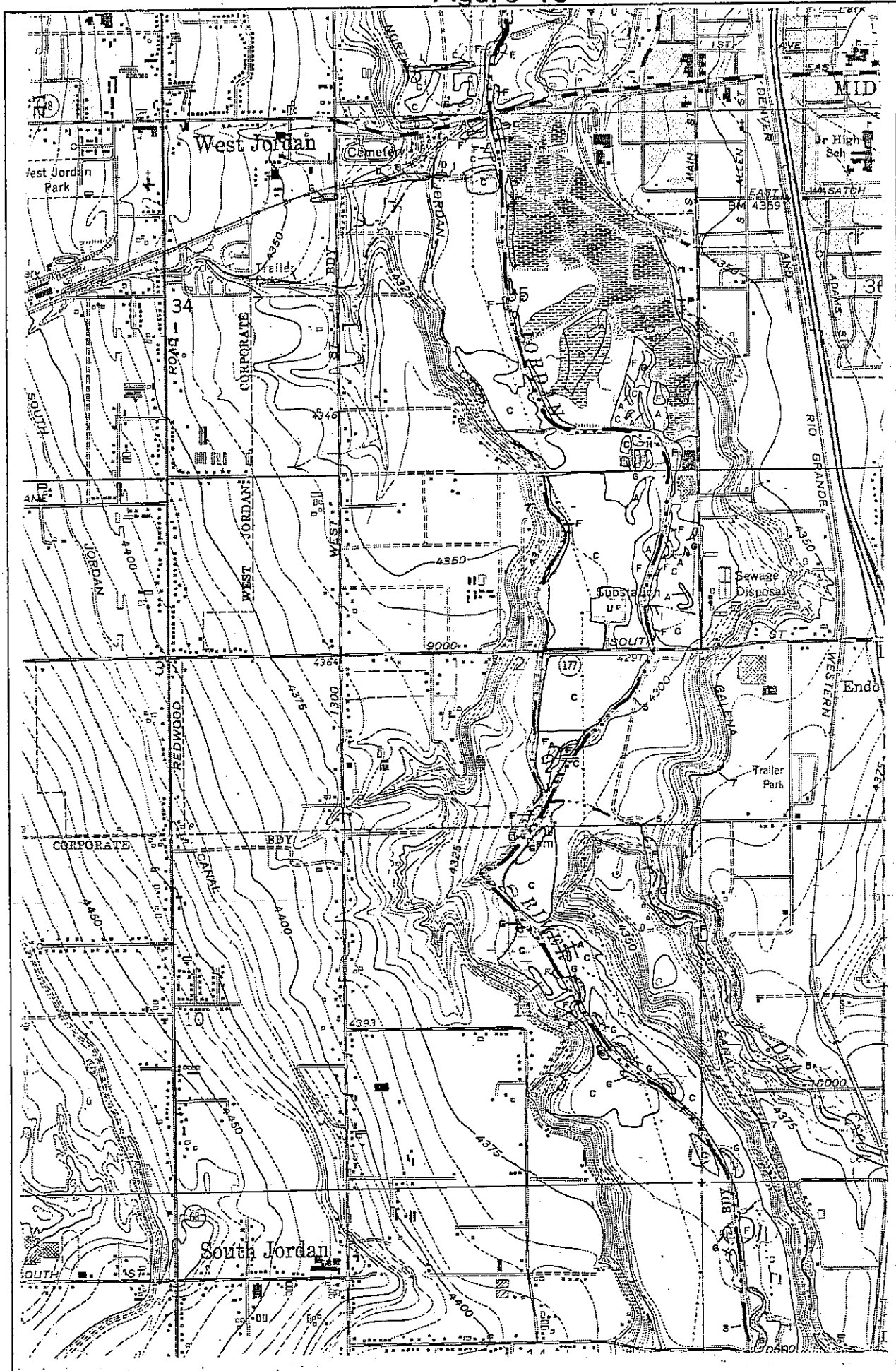
REACH 2. This is the most stable reach between 9000 South and 14600 South, and is directly owed to the existence of an undisturbed, climax wetland on the outside curve of the West-sweeping river. Flood storage in this wetland complex is extensive. A massive homogeneous community of hardstem bullrush occupies perhaps 8 acres, and provides good nesting, resting, feeding and breeding for large shore and wading birds. One of the single most important wetlands along the Jordan River, banks are at 30% with low potential for mass-wasting. Plant density of upper banks is between 70-90%, and little or no bank cutting was observed. Some increase in deposition was noted, mostly coarse gravels. This site is very high on the aquisition/conservation list.

REACH 3. No oxbow meanders or spring discharges were observed below this reach to 7800 South Bridge. Some irrigation return flow were noted, which may contain spring flow. This reach passes through a constriction which produces high velocities and high erosion rates, particularly downstream on outside bends where 5' undercutting banks pose special hazards to unsuspecting surveyors or grazing animals. Inside banks are well stabilized by Olive trees and cattails, which accounts for the 50% plant density rating.

REACH 4. The vegetative bank density averages between 70-90% where still standing. Alternate mass wasting of both banks has been occurring recently, and cutting appears almost continously. Deposition of new material was noted on opposite, vegetated banks. Very colorful tailings erosion is evident with cuts as high as 12'. No sediment or water quality samples were taken.

REACH 5 & 6. These reaches are quite similar, scoring within 4 points of each other. Both have 70-90% plant density in upper banks with significant cutting in spots. One severe mass-wasting site in the Sharon Mill Tailings is over 15' high. Western banks are generally stable and well vegetated.

Figure 15


West Jordan
Cemetery
Trailer
Park
Sewage
Disposal
Substation
South Jordan
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SEGMENT V.
SEGMENT IV.

SEGMENT VI. MIDVALE BRIDGE TO MURRAY PARKWAY GOLF COURSE BRIDGE (6400 S.)

SUMMARY/CONCLUSION. This stretch is among the most stable segments on the entire Jordan River. It passes by a potential hazardous waste site, an old municipal wastewater treatment plant, the new regional wastewater treatment plant, a dairy farm, and a mobile home park. It contains only two oxbows, both of which receive flood flows during heavy spring runoff. Four springs were observed discharging. The river channel in this area is one of the most stable of all the Jordan River segments, due mostly to the constriction caused by the 6400 South bridge which acts as a large drop structure. Flow velocities are greatly diminished, and grazing use on the West bank allows for temporary, seasonal flood inundation. Five of six reaches scored in the "good" category, with one "fair."

REACH 1 & 2. Both riparian and bank vegetative cover density are very high, comprised of willow, olive, tamarisk, and various wetland plants. Bank slopes average 30%, with some intermittent raw banks. Little or no deposition was noticed. The small oxbow on the West bank receives flood flows and a fairly large spring discharge. It is owned by the South Valley Water Reclamation Facility and has been set aside for the Jordan River Parkway as part of South Valley's Construction Grant.

REACH 3 & 3A. The Jordan is moving into the East banks where some erosion of steep slag banks is evident. Large concentrations of shiny, metallic sediment can be observed in the river. Aside from this condition, a good riparian and bank vegetative growth density exists on both sides. No mass wasting exists, and thick deposition was observed near the lower banks.

REACH 4. This long reach stretches to the old Midvale wastewater treatment plant. One oxbow and spring discharge on the East Bank provide flood storage and water quality improvment from surface runoff at the Valley Materials industrial site. Willow and wetlands plant provide 100% plant cover on both banks, gradient of which average 30%. Little or no bank cutting exists, and no deposition of sediment appeared.

REACH 5. The dense riparian growth on upper and lower banks is continued along this reach and downstream. Some minor cutting on the West bank exposes and interesting clay-loam substrate. Slope grades continue between 3-40%. Dense Olive and Tamarisk growth on the West banks adds to riparian values.

REACH 6. Willow comprises the dominant riparian species on both sides of 30% banks. Root mats appear thick and fibrous. No evidence of any mass wasting, little or no bank cutting, no enlargment of point bars. An extraordinarily stable segment.

SEGMENT VII. MURRAY PARKWAY BRIDGE TO 5300 SOUTH BRIDGE.

SUMMARY/CONSLUSION. Where the upstream segment was among the most stable, this segment is among the most unstable, due to increasing flow velocities below the 6400 South Bridge constriction. Six oxbows on the segment have either been filled or left elevated by eroding banks. During the survey, at least two Notice and Order Violations were served individuals illegally filling adjacent oxbows. At least six springs discharge to the river and oxbows. Six out of seven data points rate "fair." Good opportunity exists for grading-back eroding banks and planting with Cottonwood, willow, or tamarisk sprigging, since the land is being developed by persons and organizations interested in the Jordan River Parkway.

REACH 1. Only about 10% riparian cover remains on the flood-damaged upper banks, comprised mostly of Russian Olive. Average bank slopes are between 40-60%, and siginificant cutting has occurred. Some new increase in coarse gravel bar formation. Spotty but dense upper bank root masses are prviding deep soil binding. Two oxbows and two springs could be greatly improved to provide parkway benefit and fish-rearing opportunities.

REACH 2 & 2A. This long reach, adjacent to the Murray Parkway Golf Course, has very little riparian overstory, although lower banks do provide spotty but good vegetative coverage. The upper reach 2 has been graded back with concrete slab tow protection that is effective but not pretty. The remainder of the Golf Course reach should be dealt with similarly. Downstream banks are severely cut between 4' and 7'. The cuts and overhangs are dangerous. Little oxbow or spring benefits. Good candidate for overstory revegetation and bank re-grading.

REACH 3. One oxbow still appears in tact. Good vegetative bank cover at the oxbow, not so good downstream. Moderate frequency of mass wasting and significant cuts 12"-24" high. Some new increase in bar formation.

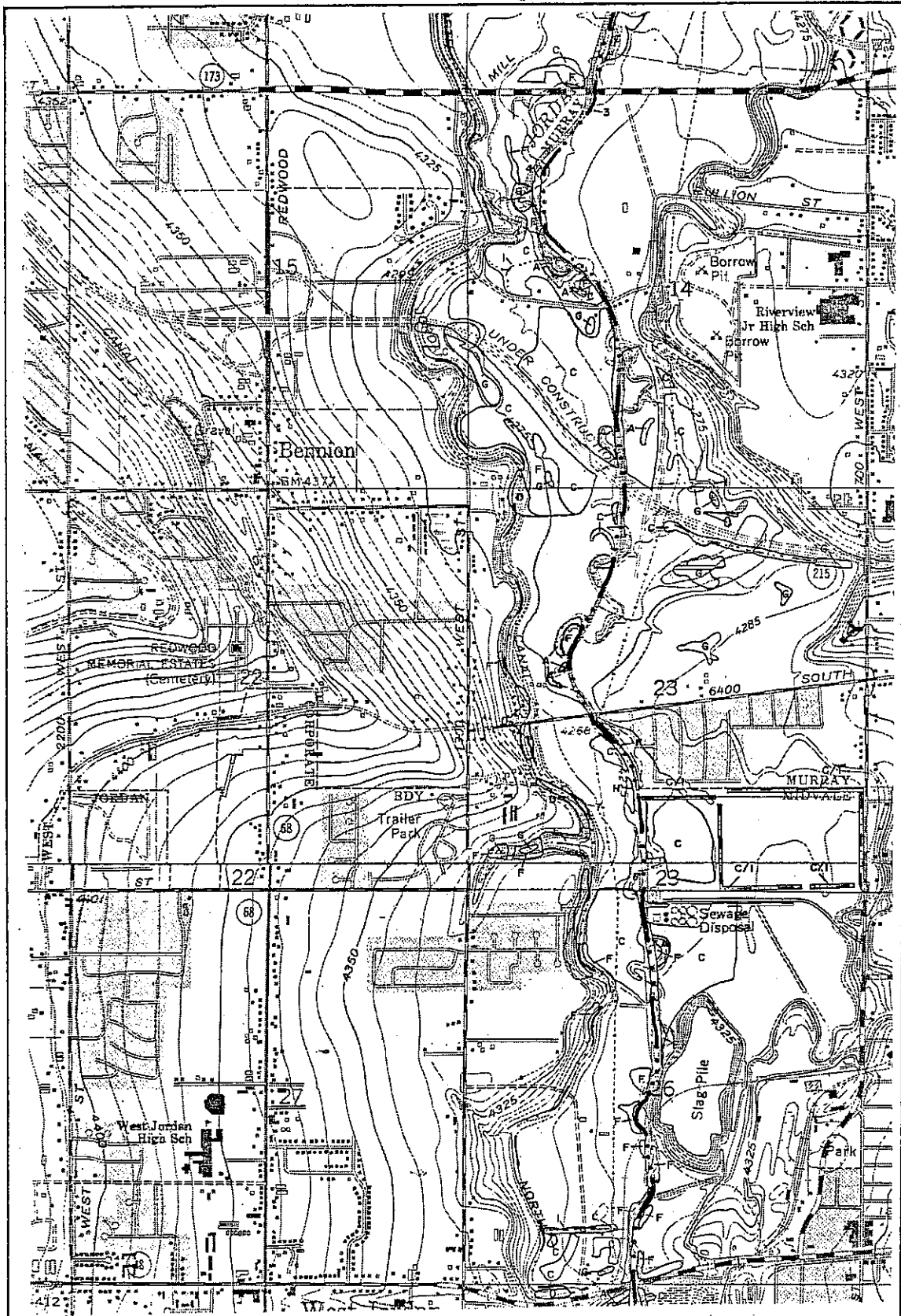
REACH 4. Russian Olive and Cottonwood riparian overstory at density of about 40%. Good 60% density wetlands adjacent to the river. Oxbows provide good bank protection and flood storage. Upper banks are steep and moderate mass wasting is noted. 70-90% plant density on upper banks is frequent. Some new bar development taking place.

REACH 5. Tamarisk, Elm, and Russian Olive comrise a 70% riparian density and 90% understory density on upper banks. Adjacent wetlands are interspersed 50/50 with grazing. Bank slopes at 40-60% exhibit some raw spots eroded during high flows, and concrete rip-rap appears on East banks, while the West banks are cut 3'-4' high. Oxbows have been filled-in illegally and regulatory actions have been initiated.

REACH 6. Riparian growth is diverse with Olive, Tamarisk, Willow, Elm and Cottonwood most common. There appears to be a pattern of increasing overstory diversity and density developing along the Jordan moving downstream, which indicates wider seed distribution. Bank slopes are 60% but an adjacent cut-off oxbow could be restored to facilitate stabilization, since some mass wasting is observed. Lower bank vegetative density (50%) has resulted in significant cutting and extensive deposits of eroded material in this reach.

REACH 7. East banks have excellent understory cover, while West bank exhibits 4'-5' cuts. Some mass wasting has been healed over. Little or no enlargement of channel or point bars.

Figure 16



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SEGMENT VII

SEGMENT VI

SEGMENT VIII. 5300 SOUTH BRIDGE TO 4800 SOUTH BRIDGE.

SUMMARY/CONCLUSION. This is the most stable segment on the entire Jordan River. Adjacent oxbows have been left open to function well for seasonal flood storage. Cost savings to Murray City residents from lack of dredging operations is probably significant. The City has made a wise investment in purchasing the majority of this river/oxbow corridor and leaving it in a natural state. Fourteen oxbows and ten springs discharges are found here, providing extraordinary wildlife and recreational benefits. Numerous vegetative transects, water quality and macroinvertebrate samples have been taken in this area, and opportunities exist for future stormwater management research sites. Of six reaches, five scored "good."

REACH 1. This reach scored "poor." 90% of the overstory riparian vegetation has been removed. Vegetative density on the banks is less than 50%, and some mass-wasting has occurred. Much of the reach has been rip-rapped for protection against increasing flow velocities below the 5300 South bridge. The mass-wasting has occurred next to a filled-in oxbow (shades of Segment III). Fortunately, this work has not been allowed to proceed North.

REACH 2. Two oxbows remain open providing flood storage and flow velocity attenuation. Riparian coverage is thick, 50%-50% Olive and Willow. Some increasing bank cutting of slopes generally less than 30%. Low potential for mass wasting, with some intermittent cutting at curves. Good vegetative plant density with good diversity of wetland plants. Noted nesting Night Heron.

REACH 3 & 4. Very similar reaches, with six oxbows and four springs between them. Very dense, diverse overstory and undertory vegetation. These are excellent examples of natural bank erosion control by oxbows, where flood storage and attenuation has kept raw banks infrequent. Excellent stormwater research site located in natural, hadstem bullrush oxbow.

REACH 5. Similar vegetation density & diversity with upstream reaches. One East bank mass wasting site noted, about 40' high. It occurs in an alluvial outcrop that is an obvious landform feature. Easily stabilized by revegetation. Enlarging oxbow opening upstream would reduce flow and velocity at this site. Some intermittent cutting of 12" banks downstream.

REACH 6. A broad, unique reach characterized by a wide floodplain and beautiful deepwater wetlands. Great diversity of both wading & passerine birds. Thick vegetative over/understory exhibits attractive parkway effect. Gentle bank slopes, no mass wasting, little bank cutting, some increase in bar formation, mostly coarse gravels.

SEGMENT IX. 4800 SOUTH BRIDGE TO 4500 SOUTH BRIDGE.

SUMMARY/CONSLUSION. A short segment with only two reaches, this area has been extensively rip-rapped. No overstory vegetation was replaced, making the upper reach a starkly naked benefit to parkway or recreational use. Willow sprigging is badly needed here. The lower reach is the first encounter with extensive emergent overstory seedlings that have invaded floodplains adjacent to the river and are reclaiming emergent wetlands on the West bank. The site is a good source of transplant material for other portions of the river that need upper bank improvement.

REACH 1 & 2. Well rip-rapped and very stable. Some mass wasting is present but small and healed over. No riparian overstrory, but high willow density on East lower banks.

SEGMENT X. 4500 SOUTH BRIDGE TO 4100 SOUTH BRIDGE.

SUMMARY/CONCLUSION. Two reaches rated "fair" and two rated "good." Contains five oxbows, two of which have been filled-in. Groundwater discharge evident. A tremendous amount of development and grading activity has aggravated erosion and increased mass-wasting. Bank stabilization projects are under way. Riparian values have been intentionally destroyed and should be replaced. Planting of downstream seedlings on upstream reaches would be cost-effective.

REACH 1 & 2. Interim bank protection with concrete has kept erosion problems in check, but lower banks require some increase in vegetative cover, which is presently less than 50%. Now a stark, damaged reach, no wonder the public is conveyed a negative image of the Jordan River.

REACH 3. 30% Willow coverage on upper banks is interspersed among more eroding dredge piles. 60% sloped banks indicate past mass wasting and significant bank cutting with new increases in downstream deposition.

REACH 4. Riparian overstory returns with 100% density of Willow, Cottonwood, Tamarisk, and Olive. Lower banks exhibit 90% vegetative density, and the reach conveys an attractive park-like environment. Some past moderate mass wasting has occured and some intermittent bank cutting evident, as is new bar deposition. None of these conditions are extreme. Overall a very stable reach.

SEGMENT XI. 4100 SOUTH BRIDGE TO 3500 SOUTH BRIDGE.

SUMMARY/CONCLUSION. Conditions are rated "good" in all but one reach. This is a very unique segment in that conditions begin to change radically for the better. Oddly, the river has been allowed to meander and maintains a high measure of natural equilibrium. Large expanses of invading, emergent tree seedlings are found at the base of old dredge piles and near river banks. Excellent flood storage and habitat benefits are found here. Evidence of water-dependant mammals was frequent. A flock of 12 Snowy Egrets was observed. Numerous fisherman were encountered catching White Bass 12" in length. Riparian vegetation is diverse, dense, and high. Interesting diversity in landscape. Relative quiet and solitude is possible. A high quality river segment with unique recreational opportunuties.

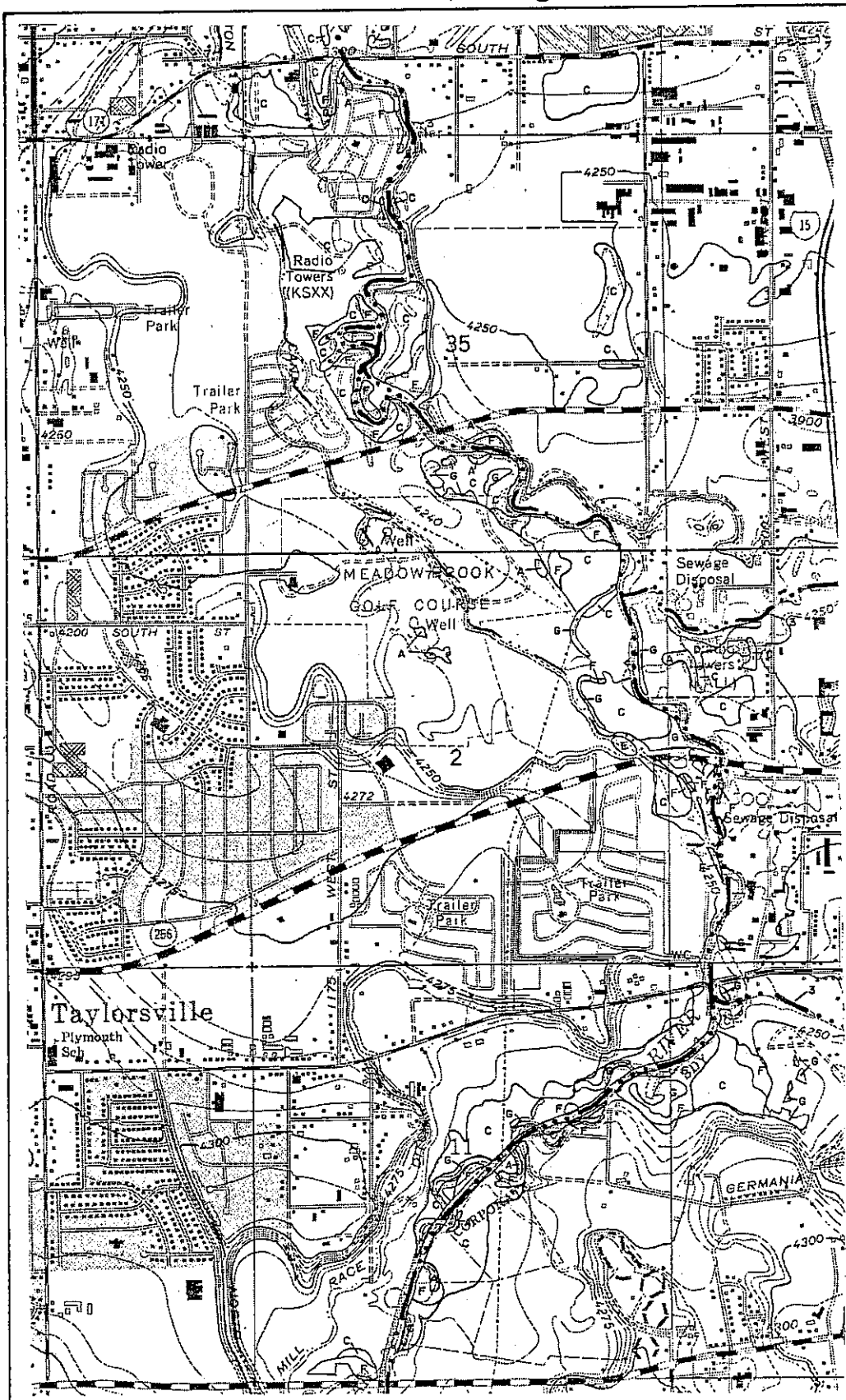
REACH 1. Below the bridge, 3'-4' cut banks are almost continuous and some mass wasting evident. Very poor vegetative density on upper and lower banks that range in gradient to 60% or greater. Moderate depostion of new gravel and coarse sand on old and some new bars.

REACH 2. This meandering reach has a 100% density invasion of assorted overstory species. Flood storage in oxbow meanders has reduced bank cutting significantly on slopes graded less than 30%. Lower bank plant density exceeds 90% and contains thick, diverse wetlands fed by springs and flood flows. Some intermittent cutting and deposition evident.

REACH 3 & 4. Overstory invasion continues. Good bank gradient. No evidence of mass wasting, few raw banks, some new deposition. 90% plant density on opper banks. Excellent wildlife and fish habitat. Outstanding parkway corridor along riverside access road. Bass, walleye, and catfish were among species being caught by six fishermen.

REACH 5. Rip-rapped Oxbow Park. Excellent bank condtions could use additional tree planting for shade. Very nice parkway addition.

Figure 18



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SEGMENT VIII. SEGMENT IX. SEGMENT X. SEGMENT XI.

SEGMENT XII. 3500 SOUTH BRIDGE TO 2100 SOUTH.

SUMMARY/CONCLUSIONS. This segment contains six oxbows that were filled within the past twenty years. It is very similar to Segment XI, with emergent trees and enjoyable meanders which have provided relative stability for upper and lower banks. Some bank stabilization is under way at outside bends. Another outstanding parkway opportunity for the community. Proceeding downstream toward 2100 South, dense willow growth dominates both banks, and fishery habitat conditions improve. Flow velocities decrease dramatically.

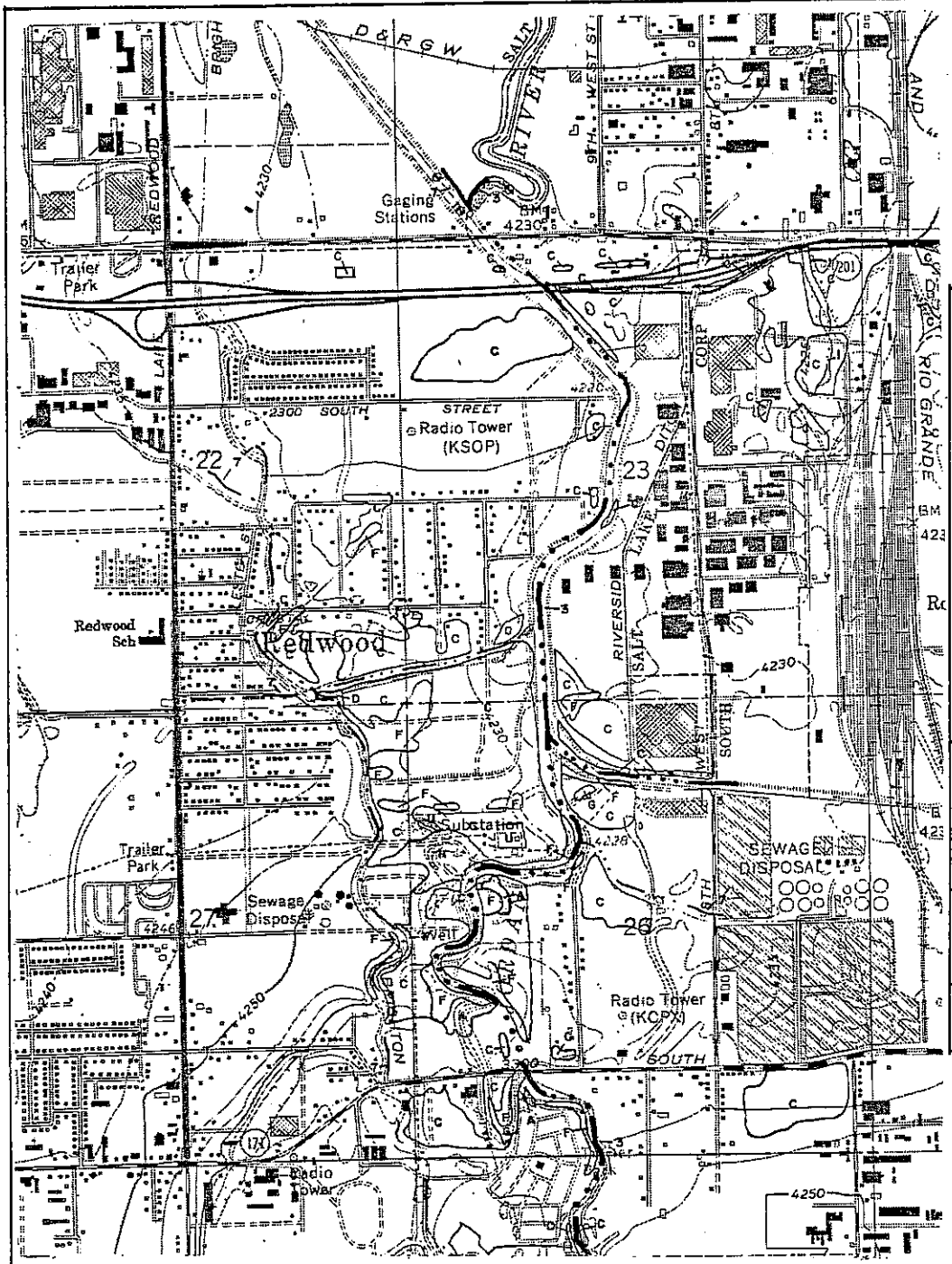
REACH 1. 90% density of willow upper and lower banks have kept mass wasting and bank cutting to a minimum. Little deposition. Good flood storage in Western oxbow.

REACH 2 & 2A. Cottonwood and Willow comprise 100% overstory plant density, and upper bank density provides deep root mass. Dredging has been extensive in the past and piles were never removed. Plant density decreases on lower reach with some attendant mass wasting and continuous bank cutting.

REACH 3 & 3A. Excellent bank coverage with thick willows. Good selective rip-rap jobs at problem corners. Gentle bank slopes with no evidence of mass wasting and very little cutting. Some new increase in bar formation, moslty coarse gravels but isolated sand accumulations. Numerous shore and wading birds, including Great Blue Heron standing almost 5' with 7' wingspan.

REACH 4 & 5. Again, 100% density overstory and 90% understory coverage primarily of willow, elm, and olive on both sides of bank to 2100 South. Stability second only to Reach 4 in Murray Segment VIII.

Figure 19



SEGMENT XII

IV. CONCLUSION: POLICY IMPLICATIONS & PRIORITIES FOR JORDAN RIVER MANAGEMENT.

The Jordan River in Salt Lake County has been identified in the State of Utah Water Quality "305b" report as the highest priority stream in Utah requiring pollution control effort. This report document serves as the tool for prioritizing problems requiring clean-up efforts under the federal Clean Water Act and local Water Quality Management Plans. (8)

The Water Quality Assessment summary for the Jordan River indicates that sediment is a principal pollutant in the Jordan River which impairs uses for which the River is protected. Flooding and dredging activity on the Jordan over the past four years have produced bank conditions that are generating disproportionate sediment loads the the River, and measures should be taken to stabilize these conditions. (9)

Habitat conditions have also been damaged as a result of past flow and management effects. Terrestrial and aquatic animals still survive under these conditions, but neglect for restoring habitat will result in long-term depletion of wildilife which in-turn will affect the attractiveness of the river for recreational uses for which it is protected. Water quality standards are also designed to protect aquatic biota and food chains dependant on river conditions.

Measures should be taken to restore eroded banks to a point where SIGNIFICANT sediment loads can be reduced, thereby promoting stability and natural equilibrium of instream biota. Measures that should be taken include both structural and non-structural stabilization, and these efforts should be implemented along those reaches identified as the most severe sediment sources.

This survey should provide a guideline for decision-makers to evaluate and prioritize those river segments which require further assessment to determine the extent and projected cost of stabilization procedures. Stream cross-sections with adequate survey controls should be established below those reaches having poorest stability. Erosional patterns and rates of fluvial aggradation and deposition should be further assessed to determine the effectiveness of various management strategies. Bottom sediment evaluation should be made to substantiate rates of movement in highly erodible reaches.

The following discussion summarizes priority stream reaches and recommends management practices that could be implemented to reduce high rates of existing erosion. It is not the objective of erosion control for the Jordan River to eliminate ALL erosion. Some natural sediment loading must be expected. Any water pollution control plan seeks to optimize pollution reduction between the cost of the measures and the benefits to be derived. What will be emphasized in the recommendations is lower-cost non-structural erosion control, with emphasis on revegetation and bank-grading as opposed to structural measures such as rip-rap, dredging, and other high cost alternatives.

PRIORITY STREAM SEGMENTS.

During a one month period, fifteen factors were rated at over 80 individual reaches on the Jordan River. A total of 1200 qualitative observations were made, which provides some basis for establishing a relative hierarchy of stream conditions:

PRIORITY SEGMENT I. The highest priority stream segment displaying poorest condtions and requiring most immediate erosion control is Segment III below the Riverton Bridge (12600 South) and directly above 10600 South. Reaches 9 and 10 nearest 10600 South are dredge spoil piles that are mass-wasting into the Jordan River. These piles should be either hauled away or graded back and stabilized using native grasses and tree sprigging. Because of the straightness of the channel, rip-rap is neither desireable nor cost-effective. Upstream bank conditions also require re-grading and revegetation, particularly Reaches 1,2, and 3.

PRIORITY SEGMENT II. Stream Segment IV just above 9000 South is the site of extensive dredging and construction that has simply been left unstabilized. Re-grading and revegetation is badly needed. Several dredge piles in this segment should be hauled away and oxbow meanders restored to provide natural flood storage and enhanced biological habitat. Several oxbows have been cut off by dredge spoil piles and illegally filled. The party or entity responsible should bear the cost of restoration.

PRIORITY SEGMENT III. Stream Segment II, (below the Bluffdale Bridge at 14600 South) especially those reaches near the natural gas line crossing, requires a combination rip-rap and bank re-grading/revegetation program. Severe cutting at bends is producing extensive downstream deposition and loss of property of adjacent farmers. Property owner interviews during the survey indicate a willingness to cooperate with such reclamation efforts.

PRIORITY SEGMENT IV. The segment of the Jordan between 6400 South and 5300 South (Segment VII) also requires bank re-grading and revegetation. Bends are probably not extreme enough to merit rip-rap, and some flood storage could be enhanced by oxbow restoration. Property owner interviews during the survey indicate a willingness to cooperate and participate in such efforts.

PRIORITY SEGMENT V. The upper middle reaches of Segment X below 4500 South may require selective rip-rapping at key bends. Small bank cuts can be graded-back and sprigged with locally available willow, cottonwood, and tamarisk cuttings.

Summarized, the Priority Segments are as follows

1. Segment III, extreme upper and lower reaches.
2. Segment IV, upper half and extreme lower reaches.
3. Segment II, middle reaches.
4. Segment VII, Upper middle reaches.
5. Segment X, upper middle reaches.

PRIORITY STREAM REACHES.

Table One summarizes specific stream reaches by priority requiring some method of bank stabilization. Priority reaches are selected on the basis of point values obtained in the ratings. Due to cost of rip-rapping, non-structural methods are recommended often over expensive structural methods. Priority Reaches are designated on Figures 12-19 with an ✸, with larger ones indicating higher priority, and smaller ones lower priority.

TABLE ONE. PRIORITY STREAM REACHES AND RECOMMENDED MANAGEMENT PRACTICES.

PRIORITY REACH	MANAGEMENT PRACTICE			
	Bank Re-Grading	Revegetation	Rip-Rap	Oxbow Restoration
*Rating Poor)				
1. R-10, Seg. III	X	X		X
2. R-8, Seg. IV	X	X		X
3. R-3, Seg. II	X	X	X	X
4. R-9, Seg. III	X	X		
5. R-1, Seg. XI	X	X	X	
6. R-3, Seg. III	X	X		
7. R-4, Seg. V	X	X	X	
*Rating Fair-60 Percentile or higher)				
8. R-4, Seg. I			X	
9. R-9, Seg. IV	X	X		
10.R-1, Seg.III	X	X		
11.R-4, Seg.VI	X	X	X	
12.R-3, Seg.XII	X	X	X	X
13.R-4, Seg.II	X	X	X	
14.R-2, Seg.III	X	X		
15.R-5/6, Seg.II	X	X	X	
16.R-3, Seg.IV	X	X		X
17.R-2/3, Seg. X	X	X	X	X
18.R-8, Seg.III	X	X		
19.R-6, Seg.VII	X	X	X	X
20.R-8, Seg.III	X	X	X	X

BANK RE-GRADING.

Bank re-grading can be accomplished on a mass scale, with revegetation implemented immediately after. Topsoiling may not be required if sprigging can be planted close to the water table. Native seed will require sprinkle irrigation for at least two weeks to insure germination, and is best done in the autumn when cooler weather and rains are common. Banks should be graded at a minimum 30% slope, and tows protected with a minimum 3' rip-rap corridor or 12" dimameter material or larger.

BANK REVEGETATION.

Revegetation can be accomplished with light topsoiling and planting native grass seed in the autumn Existing concrete can be lightly topsoiled and planted in areas of recreational or parkway sensitivity. Large stands of emergent overstory seedlings. mainly willow, cottonwood, olive. and tamarisk can be transplanted on upper/lower banks deep enough to surround the root zone by groundwater or saturated conditions. Volunteer groups can be effectively employed to carry out revegetation efforts. A demonstration project should be executed to insure effective planting procedures and survival

BANK RIP-RAP.

Rip-rap is the placement of large diameter rock material along the full expanse of the lower banks to protect against erosion at high flow. Material greater than 12" diameter should be used in accordance with proper engineering sizing procedures for design flows. Use minimally only at "hot spots" where high flows concentrate and cause extensive mass wasting and cutting. For the Jordan River, maximum slope gradient should be 40% for newly placed rip-rap.

OXBOW RESTORATION.

Oxbows have been found to provide significant benefits to the immediate river environs. They harbor extensive habitat for fish and wildlife and provide storage and attenuation of seasonal flood flows. They are typically wet and display great diversity and density of wetland plants. They are protected under Section 404 of the Clean Water Act, and many have been cut off or illegally filled.

Restoration consists of opening up the cut-off oxbows to enable them to function properly during floods. Acquisition of a meander corridor has been demonstrated to be extraordinarily effective on the lower Jordan River and should be replicated selectively on the upper Jordan, particularly in Segments IV, VII, XI, and XII.

Based on this inventory, the oxbow and wetland complexes functioning most effectively on the Jordan River are:

1. Segment I below the Jordan Narrows.
2. Segment II below the Bluffdale Bridge.
3 Segment III below the Riverton Bridge
4. Segment IV below the 10600 South Bridge
5. Segment VII below the 6400 South Bridge
6. Segment VIII below 5300 South.

Those oxbow meanders in Segments X, XI, and XII also provide important wetland functions, but are exposed to lower flow velocities.

Specific Riparian Zone Restoration projects should be implemented using funds allocated under the State River Enhancemnt Program to aquire and place these important resources back into service on the Jordan River. They are an essential part of any flood control, wetland, and habitat management program.

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