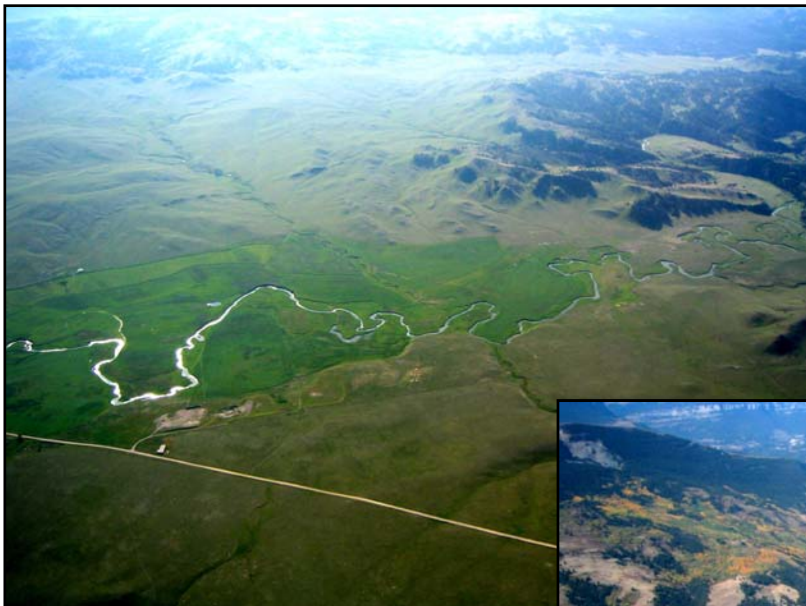
APPENDIX D: CHANNEL AND RIPARIAN AERIAL ASSESSMENT

DEARBORN TMDL PLANNING AREA

Channel and Riparian Aerial Assessment



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1.0 INTRODUCTION

An assessment of channel and riparian vegetation in the Dearborn River watershed was conducted using aerial methods to provide support for TMDL planning. The Dearborn River watershed is a tributary to the Missouri River in western central Montana, north of Helena. This assessment includes the Dearborn River, the Middle and South forks of the Dearborn, and Flat Creek.
The overall objectives of the aerial assessment were as follows:

- Provide information about surface physical stream corridor conditions as required to support determinations of impairment and beneficial use status.
- Identify potential causes and sources of natural resource concerns when feasible.
- Establish a baseline of current resource conditions and indicators along the stream corridor for future trend monitoring
- Support recommendations for natural resource restoration and protection strategies along the stream corridor and important uplands within the watershed.
- Serve as a source of background information and interpretations to support future requests for technical and financial assistance to carry out watershed planning efforts.

Assessment methods included interpretation of available aerial photographs and aerial reconnaissance. These are described in the following section.

2.0 METHODS

The aerial assessment included both photo interpretation and fixed-wing rapid aerial assessment. Photo interpretation was accomplished prior to the flights so interpretations could be confirmed during the flyovers. Aerial photos considered in the Dearborn assessment included flights from 1955, 1964, and 1995 (**Table 2-1**).

Table 2-1 ***Aerial Photo Sources***

Source	Date	Coverage
NRCS	1955	Central Dearborn Mainstem, portions of Flat Creek
NRCS	1964	Central Dearborn Mainstem, portions of Flat Creek
NRCS, Digital Orthoquads	1995	Complete Coverage of Watershed

Still photographs of the 2003 aerial reconnaissance are found in **Appendix C** (separate volume). Plots of the 1995 aerial photos with 2003 still photo inserts are found in **Appendix D**. These photo inserts were captured from continuous video coverage recorded in Hi-8 format and are a subset of photos found in **Appendix C**.

Specifically, the photo assessment included the following:

- Define Rosgen Level 1 classification and reach breaks,
- Stream length changes/meander cutoffs/sinuosity measurements,
- Channel bar/aggradation/incisement conditions and other indicators of vertical stability problems,

- Bank erosion and trend over time based on historic aerial photographs (channel width measured to evaluate movement of the stream and identify stream widening/narrowing),
- Riparian conditions and plant community characteristics (e.g. plant community, percent canopy cover/density),
- Location of major wetlands,
- Major sediment sources or mass wasting in the project area,
- Major land use changes,
- Potential reference condition metrics,
- Location of roads/culverts/channel intersections,
- Location of major water diversions,
- Areas that appear to be adversely impacted and require field investigations.

The aerial assessment involved two fixed-wing flights over the listed reaches and major tributaries. Video (Hi-8 format) and still photographs were recorded at an oblique angle (approx. 30 degrees ahead from vertical) from an elevation of 4500 ft and an average air speed of 90 mph. A second flight was made to confirm physical feature attribute data along the stream corridor. An aircraft with 2 crewmembers (a pilot, and a technician to record features) conducted the inventory.

Documentation of physical features was based on the visual observation and interpretation of the technician. Recorded features included:

Point Features

- Impoundments – Reservoirs on or immediately adjacent to the stream corridor,
- Instream Structures – Diversions, turnouts, pump sites,
- Headcuts – Active downcutting on side drainages,
- Potential Water Quality Point Sources - Corrals, feedlots, sewage discharge, irrigation return flows, dump sites, etc. along or adjacent to the stream corridor,
- Stream Crossings – Bridges, pipelines, culverts, ford crossings,
- Riparian Characteristics -
- Vegetation attributes (trees, shrub, mixed, grass sedge),
- Density (% Canopy Coverage),
- Point of reference characterized by apparent disturbance (low density, limited age class distribution, or species diversity, low vigor) by any source,
    - Point of reference characterized by apparent low levels of disturbance,
- Other – Car bodies, gravel pits, construction sites, etc. located along the stream.

Linear Features

- Bank Erosion – Accelerated, active erosion of stream banks,
- Mass Bank Sloughing – Natural sloughing of high terraces/banks,
- Rock Riprap – Round river stone, angular rock or other bank armor,
- Channelized Segment –artificial (human-induced) manipulation of the channel,
- Other (incised channel, etc.).

Data was marked on 1995 digital orthoquads (DOQ's). Variables measured are detailed in **Appendix A** and data tables are found in **Appendix B**.

3.0 RESULTS

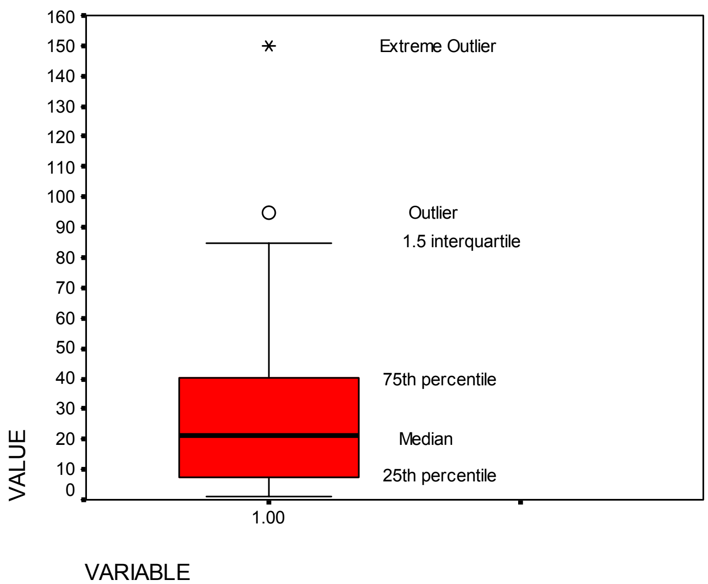
This section presents an analysis of channel and riparian condition for the Dearborn River Watershed. Analysis of results is grouped into stream reaches with identification as follows:

- DR: Dearborn Mainstem (6 Reaches, DR1, DR2, DR3, DR4, DR5, DR6).
- SF: South Fork of the Dearborn (2 reaches, SF1, SF2).
- MF: Middle Fork of the Dearborn (2 reaches, MF1, MF2).
- FC: Flat Creek (4 reaches, FC1, FC2, FC3, FC4).

Reach locations are depicted in **Figure 1** (pocket insert). Point observations for each variable were made at 10 to 70 locations within each reach depending on reach length and variability. This corresponded to a transect/point observation interval of approximately 1100 to 2500 feet within each delineated reach. Reference point numbers are found on the aerial photo sheets.

Results of analyses are presented as boxplots showing the central tendency (median) and distribution of data (**Figure 3-1**).

Figure 3-1. Example Boxplot



The central black bar is the median or 50th percentile value, which is equivalent to the average when data are normally distributed. The 25th and 75th percentiles are shown as the lower and upper extents of the box. The "whiskers" represent the value of 1.5 times the interquartile range. Circles represent outliers in the distribution of data, and asterisks represent extreme outliers. Normally distributed data would have a symmetrical form around the median value.

3.1 Channel Morphology and Condition

3.1.1 Background

Dearborn River
The mainstem of the Dearborn River is primarily an alluvial, gravel bed river (Rosgen Type C4) with a small to moderately extensive floodplain. Significant reaches of the channel are confined by deeply dissected terrain and canyon walls. Areas of lateral and vertical bedrock control are present, and this confinement has resulted in limited lateral floodplain development in some reaches. A short section of unstable braided channel is present in the transition from the headwaters near Falls Creek/Bean Lake (Reach DR6).

Middle Fork Dearborn
The Middle Fork of the Dearborn River is a C4 channel in the foothills/plains; however, a significant portion of the total stream length is a steeper gradient, headwaters B3/4 and A3 type channel. The channel makes this transition to B type morphology upstream of Highway 200 which then parallels the Middle Fork of the Dearborn to the headwaters. The extensive road fill slopes from Highway 200 do not encroach on the floodplain or result in geomorphic impacts to the perennial reaches of the Middle Fork. Lower reaches of the Middle Fork are predominately C4 type channel. Channel stability appeared to be closely related to riparian health. Increased channel width and bank instability were associated with loss of riparian vegetation.

South Fork Dearborn
The South Fork has characteristics similar to the Middle Fork, and much of the headwater zone is relatively undisturbed, steep forested terrain. Some land use (vegetation removal) impacts on channel morphology are apparent in the central reaches, and riparian vegetation is largely limited to willow and other shrub species. The river becomes an alluvial, gravel substrate channel (Rosgen C4) in the lower reaches. Channel stability appeared correlated to riparian vegetation health to some extent.

Flat Creek
Flat Creek is a low gradient, meandering channel with fine to very fine gravel bed materials (Rosgen C4/F4 channel type, tending towards C5/F5 in upper reaches). Flat Creek serves as a conveyance for irrigation water diverted from the mainstem of the Dearborn and channel morphology reflects this altered flow regime. Channel cross section is enlarged due to diverted irrigation flows and some channel erosion/instability is present in localized areas. Observed channel instability is likely the result of increased flows due to irrigation diversion and conversion of riparian vegetation to agricultural uses. Grazing and agricultural uses (pasture and cropland) were widespread in Flat Creek. Grazing appeared to be of higher intensity in the lower reaches.

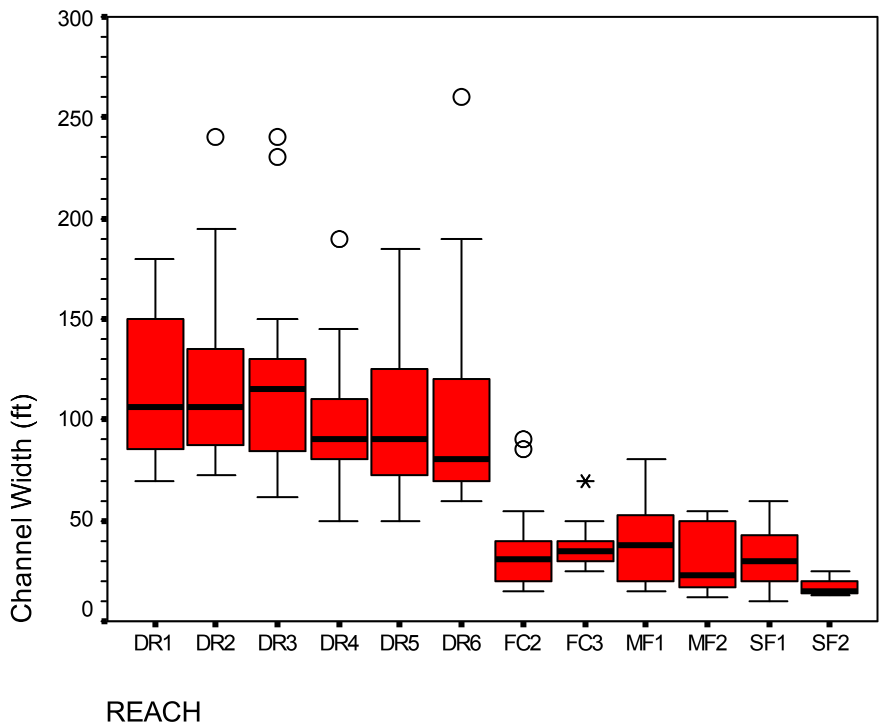
3.1.2 Channel Characteristics

Dearborn Mainstem

Six reaches were defined for the Dearborn mainstem (**Table 3-1**). Much of the mainstem channel was a Rosgen C4 channel type, although local inclusions of coarser substrate C3 or bedrock controlled channel appeared to be present in some areas.

Channel width ranged from 100 to 120 feet, generally increasing in the downstream direction. Channel width measures approximate bankfull width, but may be biased slightly high due to the tendency to include recently deposited gravel, or older un-vegetated gravel deposits near bankfull elevation in this measurement. The uppermost reach (DR6) had a short braided section that was a D4 channel type. Channel slope decreased from 0.008 in the upper reach (DR6) to 0.005 in the lower reach (DR1), and sinuosity ranged from 1.1 to 1.25 overall.

Figure 3-2 Channel Width in the Dearborn Watershed in 1995



Bank stability was assessed using 1995 aerial photos and video coverage. Stability scores were intended to approximate Rosgen Bank Erosion Hazard Index (BEHI) values. Banks rated "high" were generally vertical banks or high terraces with primarily herbaceous riparian vegetation. Moderate scores were assigned to banks that had sparse or patchy woody vegetation and steep to moderately sloped banks. Banks that had abundant woody vegetation and moderate to low angled banks were assigned a "low" score. This aerial assessment method was a coarse, screening level tool and could not evaluate for all the factors (e.g. bank height ratio, surface protection, etc) required to make a BEHI assessment. Nevertheless, it provided a simplified approach to rapid assessment of bank stability which was able to discern potential sediment source areas.

BEHI scores were similar for Dearborn mainstem reaches DR1, DR2, and DR4, with 8 to 12.3% of banks with “high” scores, and 87-92% in the moderate to low (i.e. stable) category. Reach DR3 had a higher proportion of banks in the high category (27%). Unlike downstream reaches DR1 and DR2, which are located in dissected “canyonland” topography, DR3 had an unconfined channel and active floodplain. Elevated width to depth ratios and meander cutoffs were therefore characteristic of this reach. BEHI ranking in reaches DR5 and DR6 indicated more instability than downstream reaches, with 21 to 47% of banks falling in the high (i.e. unstable) category. In particular, reach DR6 showed a significant proportion of unstable banks due to the braided (Rosgen D4) morphology. Aerial photos from 1955 and 1964 were not available to assess whether this braided character was related to flood damage in 1964. However, the location of reach DR6 in the transition from confined valley to unconfined plains is a common location for sediment adjustments to occur, and braided D or unstable C morphology is frequently observed.

Table 3-1 ***Stream Channel Characteristics – Dearborn Watershed, 1995***

Reach	Reach Length (mi)	Channel Type	Slope	Sinuosity	Channel Width (ft)	BEHI Rating (% of Reach)			Overall Channel Stability
						High	Mod	Low	
DR1	8.88	C4	0.005	1.15	115	8.1	38.3	53.6	Good
DR2	9.52	C4	0.006	1.25	117	12.3	42.1	45.6	Good
DR3	8.00	C4	0.007	1.13	120	27.4	35.3	37.3	Fair-Good
DR4	8.15	C4	0.007	1.22	100	11.8	41.2	47.1	Good
DR5	7.436	C4	0.008	1.04	100	21.2	28.8	50.0	Fair
DR6	6.53	D4	0.008	1.1	107	47.1	26.2	26.6	Poor
SF1	5.83	C4	0.012	1.22	34	8.3	25.0	65.7	Fair to Good
SF2	5.56	B4/A3	0.017	1.09	17	0.0	9.0	84.7	Good to Excellent
MF1	6.17	C4	0.015	1.25	39	10.6	35.3	54.1	Fair to Good
MF2	1.32	B4/A3	0.025	1.09	30	0.0	19.4	80.6	Good-Excellent
FC1	7.49	C4	0.007	1.6	49	11.2	17.7	71.1	Fair
FC2	4.43	C5/E5	0.006	1.55	36	13.1	36.9	50.0	Poor-Fair
FC3	4.35	C5/E5	0.006	1.28	38	14.0	30.8	55.2	Fair
FC4	11.64	C5/E5	0.006	1.3	19	8.4	33.3	58.3	Fair

A reference reach representative of unconfined C4 channel morphology was not readily apparent in the central reaches of the Dearborn. Review of aerial photography and 2003 aerial reconnaissance indicated that much of the C4 channel outside of the “canyon” or confined areas was laterally active with frequently high width to depth ratios and variable density of tree/woody shrub riparian vegetation.

Overall, BEHI scores were consistent with unimpacted bank conditions in reaches DR1, DR2, and DR4 for this channel type and geologic setting. Human impacts were not associated with “high” scores in these reaches and these banks were generally natural landscape features. Reach DR3 had a significant proportion of banks in the “high” category. Reach DR3 was an unconfined alluvial channel and BEHI scores would be expected to be higher for this reach. However, human impacts were apparent in portions of this reach and high BEHI rankings also appeared to be related to degraded riparian vegetation in some areas. The upper reaches DR5 and DR6 also had a large proportion of high BEHI scores. In particular, DR6 ranked poorly due to natural braided channel morphology. High BEHI scores were not related to human impacts and are likely related to natural processes rather than land use issues.

Dearborn South Fork

Two reaches were defined for the Dearborn South Fork (**Table 3-1**). Rosgen classification suggests that the lower reach (SF1) was a C4 channel type, and the upper reach (SF2) was a B4 to A3 channel. Analysis for the upper reach extended into the beginning of the forested headwaters.

Average channel width in SF1 was 34 feet, and the upstream reach SF2 averaged 17 feet. Channel slope decreased from 0.017 in the upper reach (SF2) to 0.012 in the lower reach (SF2), and sinuosity was 1.09 and 1.22, respectively.

Bank stability in the South Fork was generally good, with only 8.3% of banks in reach SF1 showing high BEHI scores, and <1% unstable banks in the upper reach SF2. Reach SF1 did show evidence of moderate instability with 25% of banks in this category. SF2 had significantly less bank in the moderate category (9%); the majority of the channel banks (85%) ranked good for stability (i.e. “low” BEHI ranking).

The relative differences in SF1 and SF2 bank stability are related primarily to channel type, and secondarily to vegetation and/or land use. SF2 is primarily forested A and B channel types in the headwaters, and has a relatively limited component of C channel in the lower part of the reach. SF2 is inherently more stable than SF1 because of this morphology.

Vegetation does appear to play a role in channel morphology and stability in the lower reach SF1. This is apparent from examination of aerial photography and visually comparing adjacent reaches with different vegetation densities. Hay/pasture and grazing in SF1 were associated with higher BEHI scores. The influence of riparian vegetation modification is more pronounced in the Middle Fork than the South Fork, however.

Dearborn Middle Fork

Two reaches were defined for the Dearborn Middle Fork (**Table 3-1**). The lower reach (MF1) was a Rosgen C4 channel type, and the upper reach (MF2) was a B4 at the lower end, and an A3 channel type in the headwaters. Analysis for the upper reach MF2 extended only partway into the forested headwaters because overhead canopy and small channel size limited quantitative measures. Average channel width in MF1 was 39 feet, and the upstream reach MF2 averaged 30 feet.

Bank stability assessment in the Middle Fork reach MF1 showed 11% of banks in reach MF1 with high BEHI scores and 35% with moderate scores. The upper reach MF2 had no banks with high BEHI scores. It should be noted that the aerial assessment did not cover detailed assessment of the uppermost reaches of MF2 due to dense canopy cover. Had this been feasible, the overall BEHI rating of reach MF2 would improve substantially due to more stable channel types/reaches in the headwaters.

Vegetation appeared to play a strong role in channel morphology and stability in the lower reach MF1. This is apparent from examination of aerial photography and visually comparing adjacent reaches with different vegetation densities. High and moderate BEHI scores were associated with loss of riparian vegetation and agricultural impacts.

Flat Creek

Four reaches were defined for Flat Creek (**Table 3-1**). The lower reach (FC1) was a Rosgen C4 channel type. Morphology suggested that substrate is predominately coarse gravel with bedrock control in some areas. Central reaches FC2 and FC3 appeared to be Rosgen types C5 or E5 channel types. The uppermost reach FC4 was also classified as a C5/E5 channel type. Average channel width in the lower reach of Flat Creek (FC1) was 49 feet, central reaches (FC2 and FC3) averaged 36 and 38 feet respectively. Flat Creek Reach FC4 had an average width of 19 feet.

Flat Creek appeared slightly incised in the central reaches. This suggested that Flat Creek has experienced downcutting (tending to F5 channel type) due to the diversion of irrigation water and is re-establishing equilibrium C or E morphology.

BEHI assessment indicated that 8.4 to 11.2% of bank length in Flat Creek scored “high”. Moderate bank erosion scores accounted for 18-37% of total bank length. Reaches FC1, FC2, FC3, and FC4 were similar in the distribution of bank stability. It should be noted that eroding banks originated both from human impacts and also areas where the active channel intersected natural terraces and hillsides. Eroding banks associated with topographic features can be related to human impacts; however, they can also be natural and unrelated to land use. In this case, the majority of eroding banks were associated with human impacts.

Flat Creek is a highly altered system with diverted irrigation water and extensive conversion of riparian areas to pasture or cropland. Loss of beaver from the system may also be a significant factor in modified channel morphology. Reference reaches were not apparent in Flat Creek. Prior to conversion to an irrigation conveyance, the channel of Flat Creek was certainly a narrower, more stable channel. Given the current flow regime and corresponding geomorphic adjustments, potential “reference” or “equilibrium” conditions and potential bank stability criteria would be best defined through field investigation.

3.2 Riparian Condition

Fully functioning, healthy riparian vegetation communities can reduce stream bank erosion, filter sediment, dissipate the energy of flood flows, and provide a healthy and contiguous environment for both terrestrial and aquatic biota.

The distribution and composition of the riparian vegetation community is a function of the physical and chemical properties of the soils, moisture, elevation, and aspect. Site characteristics can be altered by both natural and man-induced causes. For example, an extreme flood event in the Dearborn River drainage in 1964 significantly altered the physical characteristics of many stream floodplains as well as the character of the riparian vegetation communities. The effects from 1964 flooding are still evident in the riparian community (see **Section 3.3**). Man's actions can also have an effect on the riparian vegetation community. Riparian harvest, the presence of roads, stream crossings, agricultural encroachment, irrigation, and grazing can all have deleterious effects on riparian vegetation communities.

A potentially significant anthropogenic factor in riparian vegetation communities is grazing. Present-day grazing pressure is mainly related to cattle although at the turn of the century large bands of sheep were prevalent. Contemporary grazing pressure is not necessarily more intense than pre-settlement conditions. Lewis reported observing vast numbers of buffalo along the rivers in 1806 while traveling through the Dearborn-Sun area, including "not less than 10,000 buffalo" within a two-mile radius near the Sun River confluence with the Missouri. It should be recognized that interpretations of "unimpaired" riparian condition necessarily have a somewhat short-sighted perspective relative to historical "reference" conditions.

With this caveat, interpretation of "unimpaired" or reference riparian characteristics in the following discussion is generally a spatial comparison between "least impaired" reaches (i.e., maximum observed riparian coverage) vs. "impaired" reaches (i.e., areas that show evidence of conversion to agricultural uses or elevated grazing pressure). A description of selected features of the riparian corridor is presented on a stream-by-stream basis in the following sections.

The riparian buffer width was estimated by measurement from 1995 aerial photos and is reported for each of the study reaches. Riparian buffer width was measured as the distance that natural riparian vegetation extended from the streambank across the floodplain. Three classes of vegetation were delineated and the percent cover of each was reported for each of the study reaches. The vegetative community types included coniferous/deciduous tree, woody shrub, herbaceous, and bare ground.

Finally, a qualitative assessment of the integrity of the riparian buffer was conducted. For the purposes of this analysis, buffer integrity was ranked as good, fair, or poor. A "good" ranking represented a natural riparian vegetation community that extends uninterrupted from the edge of the active stream channel to the apparent topographic extent of the floodplain. A "fair" ranking represented a riparian buffer that showed evidence of possible vegetation alterations from grazing or other land use, but was generally intact along the stream channel. A "poor" ranking represents a natural riparian vegetation community that was restricted to the immediate proximity of channel margins, and/or a riparian buffer with obvious evidence of riparian harvest or conversion from a natural vegetation community to agriculture or impervious surfaces. In general, these rankings could be equated to "fully functioning, functioning at-risk, and non-functioning" type classification.

It should be noted that the aerial assessment techniques applied in this study are not adequately sensitive to detect all potential impacts to the riparian vegetative community. For example, the potential deleterious effects of low intensity or moderate grazing would not likely be detectable. Grazing impacts would likely only be noted in relatively extreme cases. Nonetheless, a "poor" ranking clearly raises a "red flag" that the condition of the riparian corridor may be limiting water quality and a "good" ranking likely eliminates the potential concern.

Dearborn Mainstem

Riparian vegetation was primarily open stands of deciduous cottonwood type (6 to 33% coverage), with extensive areas of herbaceous understory (30-64% coverage) and woody shrub components (19-39% coverage) (**Table 3-2**).

Table 3-2 ***Dearborn Mainstem Riparian Vegetation Features***

Reach	Riparian Buffer Width (ft)	Vegetation Type (% of reach)				
		Con/Dec (%)	Woody Shrub (%)	Grass/Sedge (%)	Total Woody (%)	Bare Ground/ Disturbed (%)
DR1	45	16	19	56	34	10
DR2	42	19	27	49	46	5
DR3	43	6	25	64	31	5
DR4	46	12	27	60	39	1
DR5	72	33	22	41	55	5
DR6	136	11	39	30	50	20

Although tree components were not the dominant vegetation component for the Dearborn mainstem, the overall coverage was good relative to the site potential. Riparian vegetation generally appeared to be in a seral state with multiple age classes of Cottonwood in active alluvial reaches (e.g. reach DR3). Upper reaches DR4, DR5, and DR6 had increasing amounts of coniferous overstory relative to deciduous Cottonwood.

Average riparian buffer width was fairly constant, ranging from 42 to 48 feet in reaches DR1 to DR4. Upper reaches DR5 and DR6 showed progressively greater riparian buffer widths (72 and 136 feet, respectively). This riparian buffer width appeared low relative to channel width (100 feet), but it should be noted that floodplain extents were limited by topographic features in many locations. Microsite factors (e.g. floodplain elevation, aspect, shading, etc.) also played an important role in vegetation distribution.

Representative photos for each Dearborn Mainstem Reach are found in **Figures 3-3 to 3-8**.

Figure 3-3. Dearborn Reach DR1

Figure 3-4. Dearborn Reach DR2

Figure 3-5. Dearborn Reach DR3

Figure 3-6. Dearborn Reach DR4

Figure 3-7. Dearborn Reach DR5

Figure 3-8. Dearborn Reach DR6

Shade provided by riparian vegetation to the stream channel was very limited on all reaches of the Dearborn mainstem. This resulted in part from low to moderate tree densities and canopy coverage, but also because tree heights and offset from the channel resulted in minimal shade projected to the water surface (e.g. **Figure 3-3**). Channel widths exceeding 100 feet limited effective shading potential from even mature Cottonwood stands adjacent to the river. The majority of shade to the Dearborn mainstem was related to topographic influences (see **Figures 3-3, 3-4, 3-7**).

Impervious/urban impacts on the mainstem of the Dearborn were infrequent and were limited to isolated road crossings and channel modifications. Bare ground or disturbed areas were present as gravel bar deposits or rock formations. Bare ground was largely unrelated to anthropogenic influences. Bare ground was especially characteristic of the braided reach in DR6 (20%).

Potential reference conditions for riparian vegetation in the Dearborn mainstem were difficult to establish based on clear delineation of pristine or un-impacted reach locations within the watershed. Review of historic aerial photographs and 2003 aerial reconnaissance did not suggest that reach-specific or localized grazing pressure had resulted in riparian impairment over most of the Dearborn. Upstream and downstream comparisons of adjoining reaches did not generally indicate any localized impairment to riparian condition or coverage related to human influence. Conversion of riparian communities to cropland or pasture was not characteristic of any reach of the Dearborn mainstem except for reach DR3. Reach DR3 showed some impacts from loss of riparian vegetation. Elsewhere in the Dearborn mainstem, human influence appeared minimal. Existing conditions likely represent relatively unimpacted vegetation characteristics. Much of the Dearborn mainstem is relatively inaccessible with a small, confined floodplain not well-suited to agricultural uses. This may account for the apparent low level of human impacts.

Dearborn Middle and South Fork

The distribution of riparian vegetation components in the Middle and South Forks is found in **Table 3-3** and is discussed in the subsequent sections separately for each stream reach.

Table 3-3 ***Riparian Vegetation Features***

Reach	Riparian Buffer Width (ft)	Vegetation Type (% of reach)				
		Con/Dec (%)	Woody Shrub (%)	Grass/Sedge (%)	Total Woody (%)	Bare Ground/ Disturbed (%)
SF1	28	3	49	46	52	2
SF2	61	18	31	51	49	<1
MF1	78	4	37	59	40	1
MF2	36	11	6	76	16	8

Dearborn South Fork

Riparian vegetation in lower Reach SF1 was characterized by isolated stands of deciduous cottonwood (3%) with extensive areas of herbaceous understory (46%) and woody shrub components (49%) (**Table 3-3**). Upper reach SF2 was mixed stands of deciduous cottonwood or conifers (18%) with extensive areas of herbaceous understory (51%) and woody shrub components (31%). Tree and woody shrub species increased towards the headwaters, and the upper portions of reach SF2 transitioned to a dominant coniferous overstory. Average riparian buffer width was 28 feet in reach SF1 and 61 feet in SF2.

Impervious/urban impacts on the South Fork of the Dearborn were infrequent, and were limited to isolated road crossings and channel modifications. Bare ground or disturbed areas were present as gravel bar deposits and were related to floodplain/land use in some cases.

Figures 3-9 and 3-10 contrast the ‘good’ and ‘poor’ riparian conditions for the South Fork of the Dearborn in the lower reach SF1. Woody species were predominately shrub/willow in ‘good’ reaches. Loss of riparian corridor due to conversion to agricultural uses resulted in reduced riparian buffer widths in many locations.

Figure 3-9. Central Portion of South Fork SF1 'Good'

Figure 3-10. Central Portion of South Fork SF1 'Poor'

The headwaters portion of the South Fork SF2 was primarily coniferous forest and did not show any significant influence from anthropogenic activities (**Figure 3-11**). Portions of the central and lower section of South Fork reach SF2 appeared to reflect the impacts of logging and riparian vegetation clearing (**Figure 3-12**). The aerial assessment could not determine whether grazing also impacted riparian coverage in this reach.

Figure 3-11. Upper Portion of South Fork SF2 'Good'

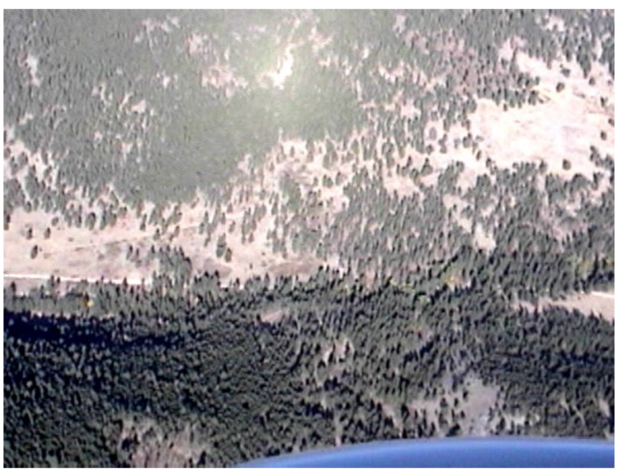


Figure 3-12. Lower Portion of South Fork SF2 'Poor'

Assessment of riparian vegetation impacts indicated that approximately 50% (20,593 feet) of riparian corridor was rated "poor" in lower reach SF1 (**Table 3-4**). An additional 29% (12,042 feet) was considered "fair", and 21% (8,725 feet) was in "good" condition. Cropland and conversion to pasture accounted for riparian impacts. Locations of reaches coded by impact are found in **Appendix E**.

Table 3-4. ***Riparian Vegetation Impact on the Dearborn South Fork (SF1)***

Impairment Status	Length	(%)
Good	8,725	21%
Fair	12,042	29%
Poor	20,593	50%
Total	41,361	100%

The upper reach of the South Fork SF2 showed post-1995 impacts from logging/riparian clearing along 5910 feet of channel. This resulted in a "poor" rating for this segment of the reach, although overall the headwaters were in "good" condition relative to site potential.

Vegetation assessment for the South Fork indicated that riparian coverage was sub-optimal in the lower reach SF1 and had significant conversion to herbaceous vegetation types. Riparian vegetation was lacking in woody shrub and tree components and was not in optimal condition relative to site potential. The upper reach SF2 had limited impacts from riparian clearing.

Dearborn Middle Fork

Riparian vegetation in lower reach MF1 was characterized by isolated stands of deciduous cottonwood (4%) with extensive areas of herbaceous understory (59%) and woody shrub components (37%) (**Table 3-3**). Upper reach MF2 was mixed stands of deciduous cottonwood or conifers (11%) with extensive areas of herbaceous understory (76%) and woody shrub components (6%). Tree and woody shrub species increased towards the headwaters, and the upper portions of reach MF2 transitioned to a dominant coniferous overstory. Vegetation coverage values were biased in reach MF2 because the aerial assessment focused on the lower end with more human impacts. Average riparian buffer width was 78 feet in reach MF1 and 36 feet in MF2.

Impervious/urban impacts on the Middle Fork of the Dearborn were generally limited to isolated road crossings. Bare ground or disturbed areas were present as gravel bar deposits and were related to land use/riparian vegetation loss in some locations.

Figures 3-13 to 3-15 contrast 'good' and 'poor' riparian conditions for the Middle Fork in the lower reach MF1. Woody species in the lower reach of the Middle Fork (MF1) were primarily woody shrubs. Tree components were not a significant part of the overall riparian coverage in 'good' reaches (**Figure 3-13**). Extensive clearing of riparian vegetation was apparent in the lower reach of the Middle Fork (**Figures 3-14 and 3-15**). The upper reach MF2 in the headwaters of the Middle Fork was mainly coniferous forest and was not significantly impacted by land use (**Figure 3-16**). Encroachment on riparian vegetation by Highway 200 was minimal except in a short section at the lower end of reach MF2.

Figure 3-13. Middle Fork Dearborn (MF1) 'Good' Reach

Figure 3-14. Middle Fork Dearborn (MF1) 'Fair' Reach

Figure 3-15. Middle Fork Dearborn (MF1) 'Poor' Reach

Figure 3-16. Middle Fork Dearborn (MF2) Reach

Assessment of riparian vegetation impacts indicated that approximately 65% (20,593 feet) of riparian corridor was rated "poor" in lower reach MF1 (**Table 3-5**). An additional 29% (12,042 feet) was considered "fair", and 21% (8,725 feet) was in "good" condition. Cropland and conversion to pasture accounted for riparian impacts. Locations of reaches coded by impact are found in **Appendix E**.

Table 3-5. ***Riparian Vegetation Impact on the Dearborn Middle Fork (MF1)***

Impairment Status	Length	(%)
Good	9,743	29%
Fair	1,837	7%
Poor	21,286	65%
Total	32,886	100%

Overall, riparian vegetation in MF1 was lacking in deciduous tree and woody shrub components and was not in optimal condition relative to site potential. The headwaters reach MF2 appeared to be in good condition with a full complement of conifer/deciduous overstory in most areas except for a short section in the lowermost portions near Highway 200.

Flat Creek

Vegetation metrics for Flat Creek indicated that riparian tree and woody shrub coverage was extremely low for most reaches. Tree components were less than 1% in all reaches except downstream reach FC1 (9%). Overall, woody shrubs comprised about 21% of the riparian corridor (**Table 3-6**), and herbaceous species averaged 77%.

Table 3-6 ***Riparian Vegetation Characteristics on Flat Creek***

Reach	Riparian Buffer Width (ft)	Vegetation Type (% of reach)				
		Con/Dec (%)	Woody Shrub (%)	Grass/Sedge (%)	Total Woody (%)	Bare Ground/ Disturbed (%)
FC1	47	9	12	79	21	0
FC2	61	<1	35	64	35	<1
FC3	78	<1	21	77	21	2
FC4	36	<1	4	93	4	2

The lowermost reach FC1 had the highest frequency of tree components, although herbaceous species were the dominant vegetation type (**Figure 3-17**). Average riparian buffer width was 47 feet in reach FC1 and was composed of about 79% herbaceous vegetation and 21% mixed conifer/deciduous and woody shrubs

Vegetation in the upstream reaches FC2, FC3, FC4 was largely herbaceous, with lesser amounts of remnant and decadent woody shrub species. Riparian buffer width (36 to 78 feet) was low in these upper reaches of Flat Creek relative to potential (**Figures 3-19 to 3-21**).

Impervious/urban impacts on Flat Creek were associated with road crossings and channel modifications. Bare ground or disturbed areas were relatively localized and had minor impacts to riparian vegetation.

Flat Creek would not be expected to support a significant Cottonwood overstory given the relatively arid plains location, channel type, and fine-grained floodplain substrate. Willow, snowberry and other shrubs would be expected to be the dominant riparian component in this geologic setting. It should be noted that less visible forms of woody species (e.g. sandbar willow) were not easily identified with aerial assessment. As a result, woody shrub components may be underestimated. Nevertheless, it is apparent that the high proportion of herbaceous vegetation likely does not represent optimal conditions for reaches FC2, FC3, and FC4. Flat Creek would potentially support a much more extensive woody shrub component especially given the augmented flow regime. The entire length of Flat Creek was considered to be in the “poor” category for riparian impacts.

Figure 3-17. Flat Creek Reach FC1 Unconfined Lower Reach

Figure 3-18. Flat Creek Reach FC1 Confined Lower Reach

Figure 3-19. Flat Creek Reach FC2 Reach

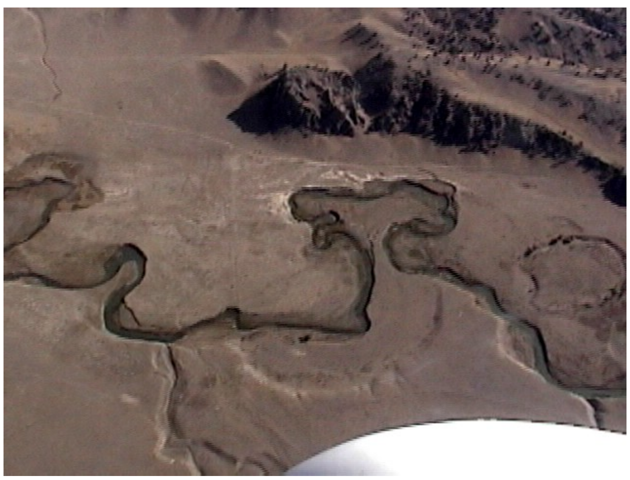


Figure 3-20. Flat Creek Reach FC3 Reach

Figure 3-21. Flat Creek Reach FC4 Reach

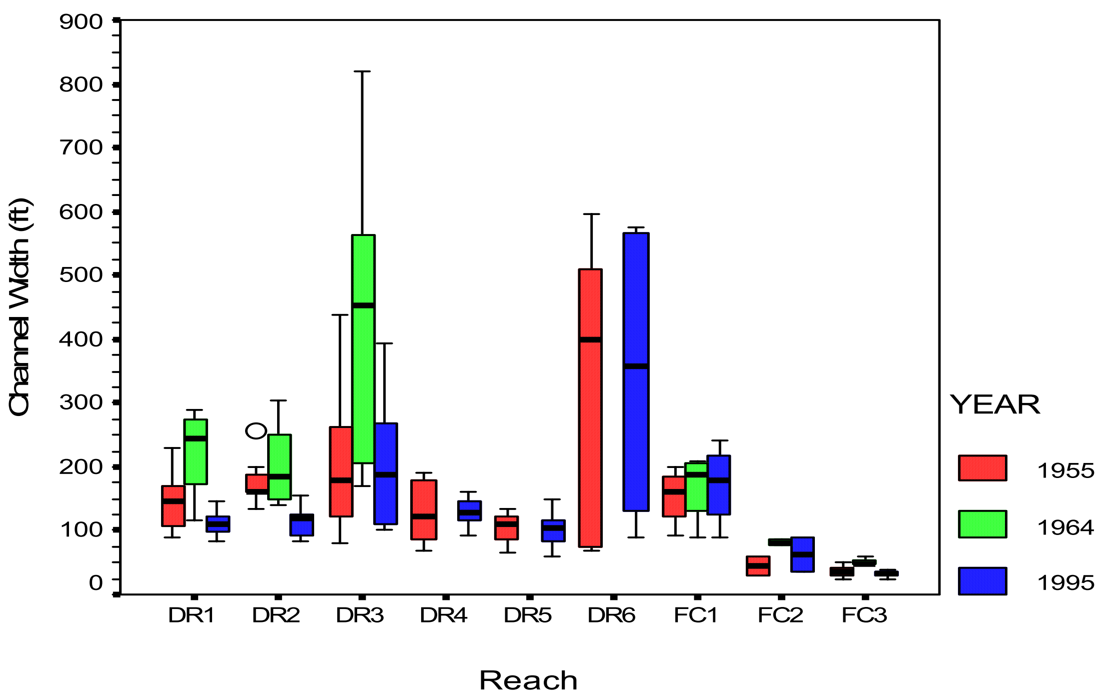
3.3 Temporal Changes in Channel Condition

A review of historic aerial photos was undertaken to evaluate changes in channel conditions over time. Aerial photo coverage for 1955, 1964, and 1995 was limited to the central portion of the study area on the mainstem of the Dearborn and portions of Flat Creek. Channel geometry including active channel width, stability, and riparian coverage were assessed and compared for those areas with coverage for the time period. The full set of coverage for the Dearborn reaches including 1955, 1964, and 1995 flights was available for reaches DR1, DR2, and DR3. The Flat Creek reaches FC1, FC2, FC3 also had coverage for these years. Dearborn Reaches DR4, DR5, and DR6 had coverage for 1955 and 1995 only, and no coverage was available for the Middle and South Forks of the Dearborn.

3.3.1 Channel Widths

Channel width was measured as the distance between the vegetative indicators that defined bank margins. In this analysis, topographic limits such as terraces, hillsides, and rock walls also helped define channel extents. Channel width approximates bankfull width in many cross sections but would exceed true bankfull measures especially for the 1964 measurements. For example, the measures of width in 1964 are larger than the geomorphic bankfull width because they include large expanses of gravel bar deposits and disturbed floodplain surfaces. Greatly increased width following the 1964 flood reflects loss of vegetation within the bankfull floodplain in addition to probable enlargement of channel cross section.

Figure 3-22. Estimated Channel Width in the Dearborn Planning Area in 1955, 1964, and 1995



In general, measurements showed that channel widths increased substantially following the 1964 flood, and that 1995 widths were comparable to pre-flood (1955) values (**Figure 3-22**).

Channel response to the 1964 flood resulted in significantly increased channel widths. In Dearborn reach DR1, channel width increased about 50%, from a 1955 value of 146 feet to 223 feet post-flood (**Table 3-7**). The Dearborn reach DR2 increased about 17% from a 1955 value of 176 feet to 205 feet post-flood, and reach DR3 nearly doubled in width to 429 feet. By 1995 these reaches had returned to pre-flood channel widths. DR1 and DR2 were narrower in 1995 compared to 1955. For reaches DR4 and DR5, 1964 data was not available. However, 1955 and 1995 measures show channel widths to be nearly identical.

Table 3-7. ***Temporal Changes in Channel Width***

Reach	Channel Width (ft)		
	1955	1964	1995
DR1	146	223	111
DR2	176	206	117
DR3	206	429	203
DR4	129	NA	130
DR5	104	NA	106
DR6	342	NA	346
FC1	153	169	172
FC2	45	81	62
FC3	37	52	33

Flat Creek reaches FC2 and FC3 also showed significant increases in channel width post-1964 flood. FC1 appeared relatively unaffected with channel widths increasing only slightly in 1964.

To state the obvious, a major decrease in channel stability occurred along with channel width increases after the 1964 flood. No metrics were calculated for bank erosion to demonstrate this point. Recovery of channel widths in 1995 to dimensions near (or less than) 1955 values indicates a strong trend for channel recovery following the 1964 flood. It is reasonable to assume that rebuilding of floodplain soils on exposed gravel deposits and re-establishment of climax floodplain vegetation communities is still continuing in the present day. Full recovery from the 1964 flood event has been gradual in many alluvial channels along the Rocky Mountain front. Exposed gravel floodplain surfaces are widespread in the portions of the Teton River, Birch Creek, and elsewhere in the area.

3.3.2 Temporal Changes in Canopy Coverage

A review of historic aerial photos was undertaken to evaluate changes in riparian vegetation over time. Conifer/deciduous tree, woody shrub, herbaceous, and bare ground classes were quantified. Aerial photo coverage for 1955, 1964, and 1995 was for the Dearborn, and portions of Flat Creek. The full set of coverage for the Dearborn reaches including 1955, 1964, and 1995 flights was available for reaches DR1, DR2, and DR3. The Flat Creek reaches FC2 and FC3 also had coverage for these years. Dearborn Reaches DR4, DR5, and DR6 had coverage for 1955 and 1995 only, and no coverage was available for the Middle and South Forks of the Dearborn.

Dearborn Mainstem

Changes in riparian coverage and composition were variable in the Dearborn mainstem (**Table 3-8**). The composite of conifer/deciduous trees and woody shrubs suggested that woody vegetation was unchanged in reach DR1 from 1955 to 1995. Dearborn reach DR2 decreased from 34% in 1955 to 27% in 1964, and increased to 46% in 1995. Reach DR3 also decreased from 1955 to 1964 (34% to 23%), and increased to 31% coverage in 1995. Reaches DR4 and DR5 both showed a 10-15% decrease in woody vegetation from 1955 to 1995. No data was available for 1964 in the upper reaches of the Dearborn.

Table 3-8. *Temporal Changes in Tree/Woody Shrub Canopy Coverage*

Reach	Canopy Coverage (%)		
	1955	1964	1995
DR1	33.6	34.7	34.1
DR2	33.9	26.8	46.4
DR3	34.0	22.5	30.5
DR4	49.6	NA	38.9
DR5	69.3	NA	54.6
DR6	NA	NA	49.5
SF1	NA	NA	51.8
SF2	NA	NA	48.7
MF1	NA	NA	40.4
MF2	NA	NA	16.3
FC1	NA	NA	20.9
FC2	30.5	30.5	35.0
FC3	19.9	18.3	21.4
FC4	NA	NA	4.3

Boxplots of individual riparian vegetation components are shown in (**Figures 3-23 to 3-26**). Conifer and deciduous tree coverage in reach DR1 was similar in 1955 and 1995, and was significantly higher in 1964 (**Figure 3-23**). Reach DR2 was similar in 1955 and 1964, and increased in 1995. Reach DR3 showed little change in tree coverage from 1955 to 1995. Reach DR4 decreased from 1955 to 1995, and reach DR5 increased tree coverage over the same time period. No historic data was available for reach DR6.

Overall, woody shrub coverage tended to increase in the upstream direction, with median values of 10-20% in the lower reaches, and values of 25-50% in the upper reaches. Shrub component was generally similar in 1955 and 1995 for most reaches, with the exception of reach DR5 that showed a decrease in woody shrub coverage. Trees increased in this reach over the same time period.

Figure 3-23. Conifer/Deciduous Coverage in the Dearborn Mainstem in 1955, 1964, and 1995

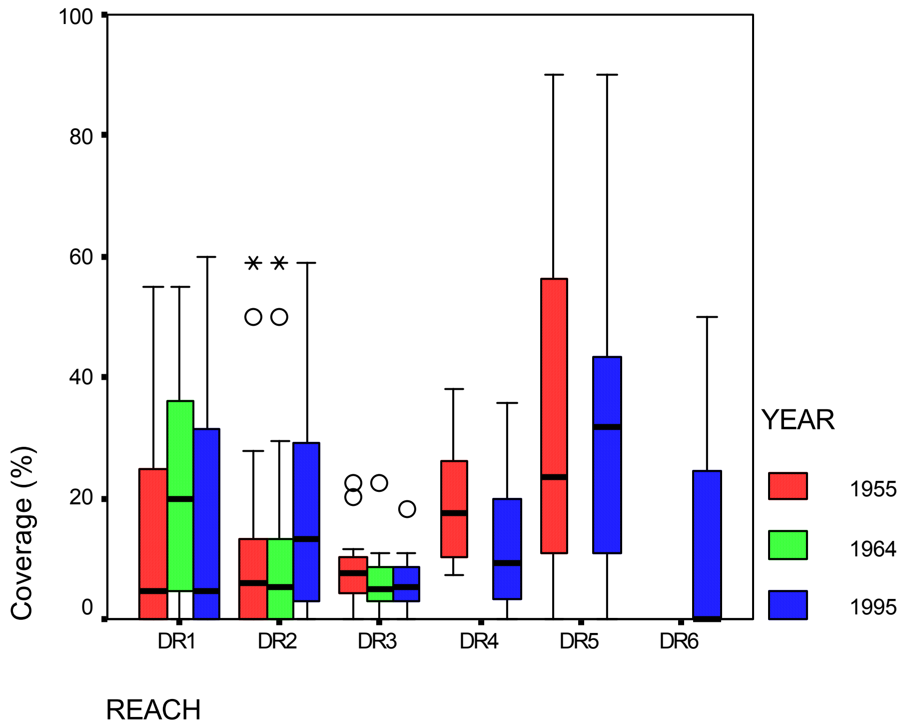
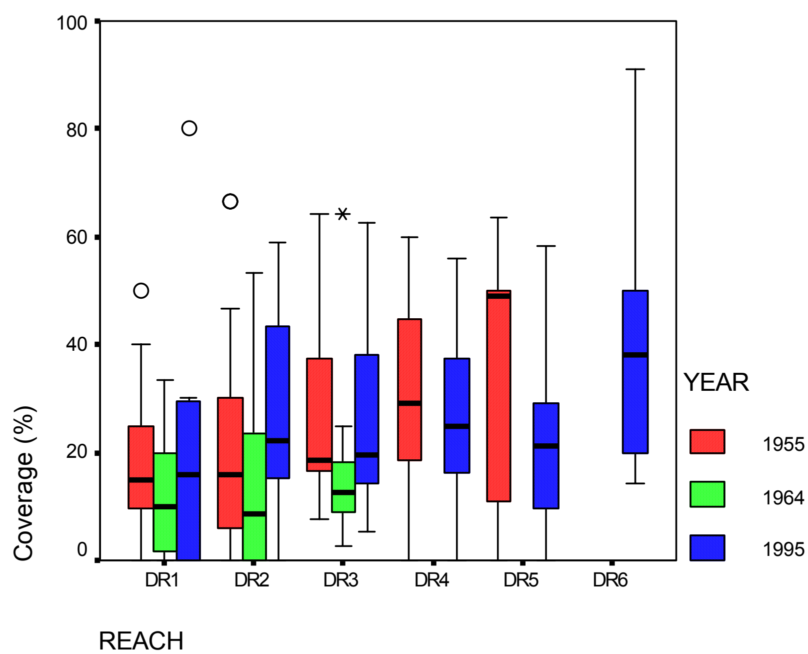
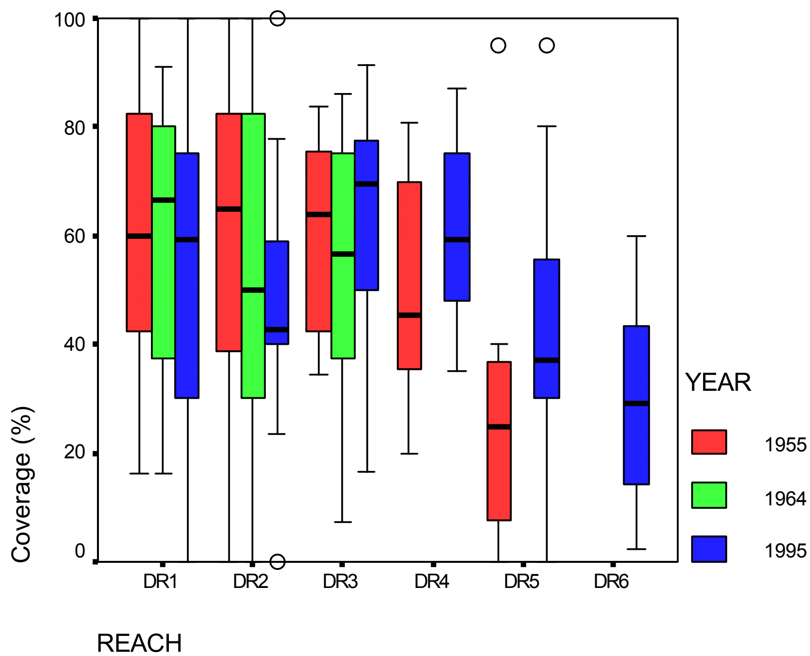


Figure 3-24. Woody Shrub Coverage in the Dearborn Mainstem in 1955, 1964, and 1995



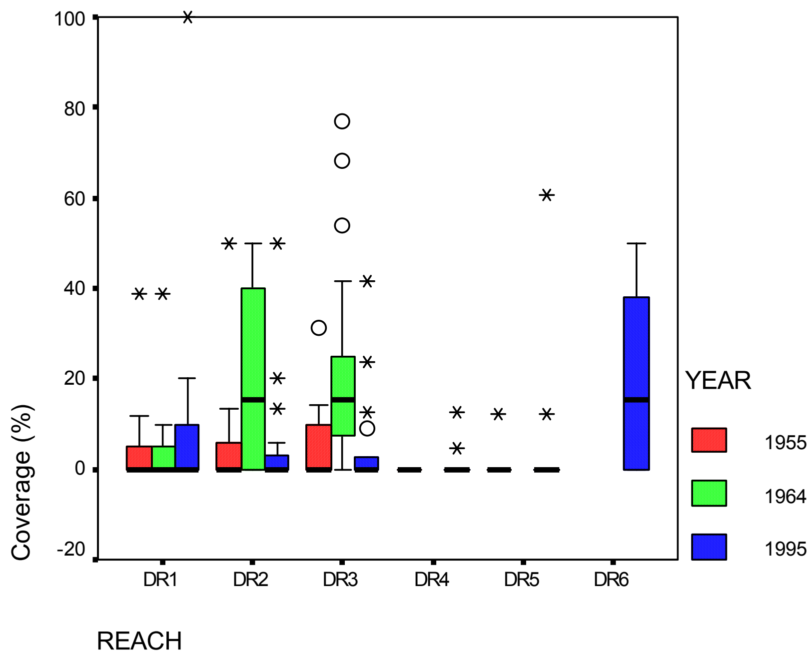
Overall, herbaceous coverage tended to increase in the downstream direction with median values of 60-70% in the lower reaches, and values of 20-40% in the upper reaches (**Figure 3-25**). Herbaceous coverage in reach DR1 was similar in 1955 and 1995, and showed a small increase in 1964. Reach DR2 herbaceous coverage decreased from 1955 to 1995, and showed corresponding increases in trees and shrubs. Reach DR3 showed a drop in herbaceous coverage in 1964, and was slightly higher in 1995 than 1955. Reaches DR4 and DR5 showed significant increases in herbaceous coverage from 1955 and 1995. Decreases in shrub coverage were also noted during this period. No 1955 or 1964 data was available for reach DR6.

Figure 3-25. Herbaceous Coverage in the Dearborn Mainstem in 1955, 1964, and 1995



Overall, bare ground was a minor component in riparian areas, generally less than 10% (**Figure 3-26**). Significant increases in disturbed, bare ground was observed following the 1964 flood in DR2 and DR3. This increase in disturbed ground returned to pre-flood levels in 1995.

Figure 3-26. Bare Ground in the Dearborn Mainstem in 1955, 1964, and 1995

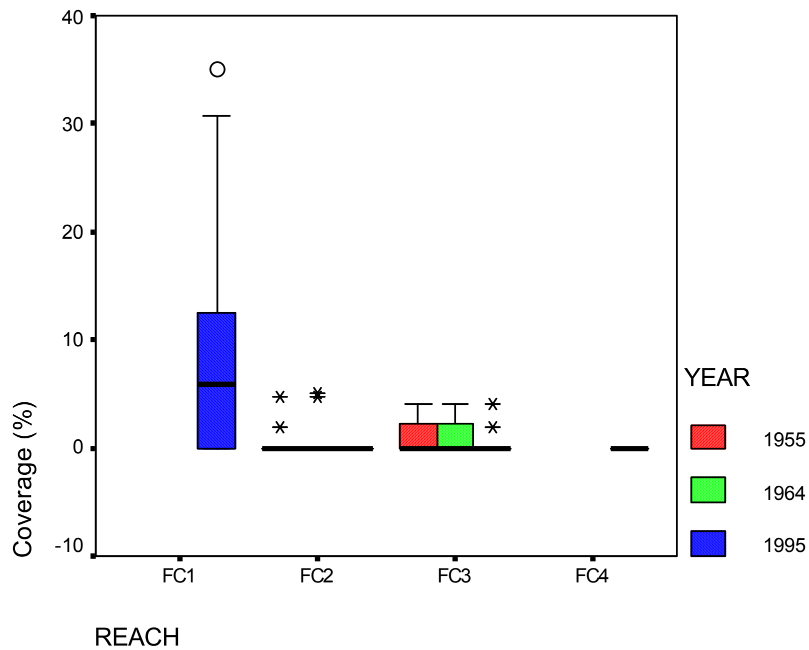


In summary, the lower three reaches of the Dearborn (DR1, DR2, and DR3) generally showed similar or greater tree and woody shrub coverage in 1995 as compared to 1955. With the exception of reach DR1, tree coverage as a proportion of total riparian vegetation did not change significantly as a result of the 1964 flood. Woody shrub coverage did tend to decrease in these reaches in 1964, but returned to pre-flood (1955) levels by 1995.

Flat Creek

Aerial coverage was available for 1955, 1964, and 1995 for Flat Creek reaches FC2 and FC3. Tree coverage in Flat Creek was generally minimal with the exception of FC1 (9%). No significant changes in tree coverage were apparent for Flat Creek reaches FC2 and FC3 from 1955 to 1995.

Figure 3-27. Conifer/Deciduous Coverage in Flat Creek in 1955, 1964, and 1995



The proportion of woody shrub coverage tended to increase in Flat Creek reach FC2 and FC3 from 1955 to 1995. The increase amounted to 5 to 10% greater woody coverage in 1995 relative to 1955 (**Figure 3-28**). Herbaceous coverage also tended to decrease over the same time period reaches FC2 and FC3 (**Figure 3-29)**. No historical coverage was available for reaches FC1 and FC4.

Figure 3-28. Woody Shrub Coverage in Flat Creek in 1955, 1964, and 1995

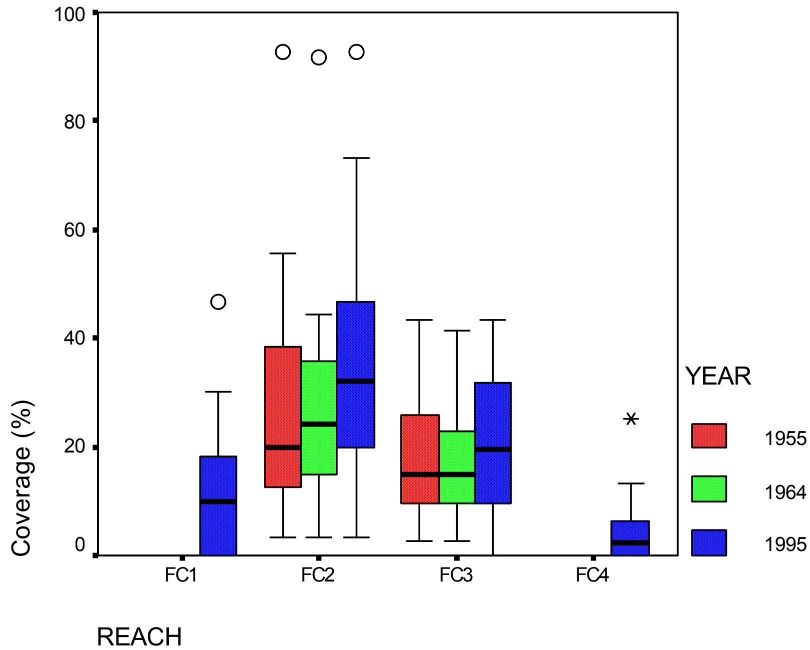
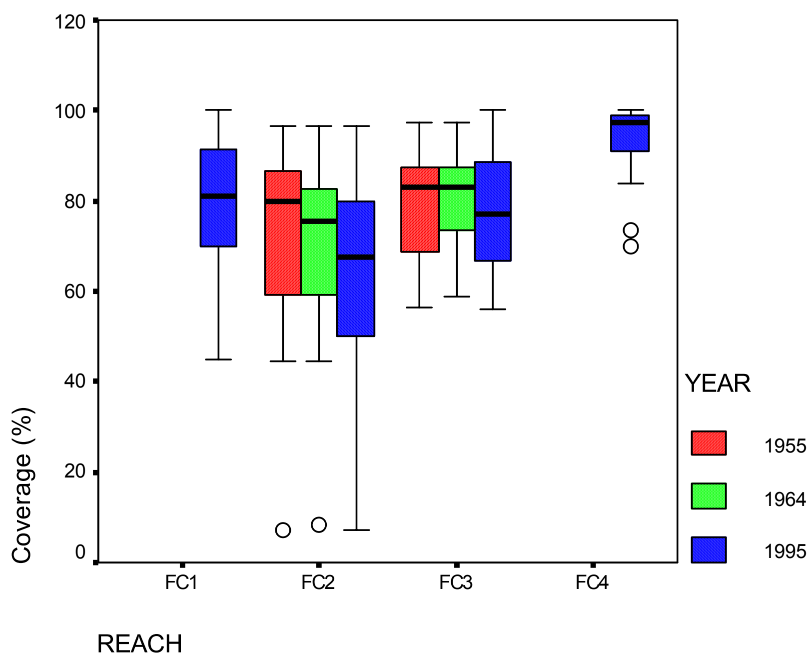
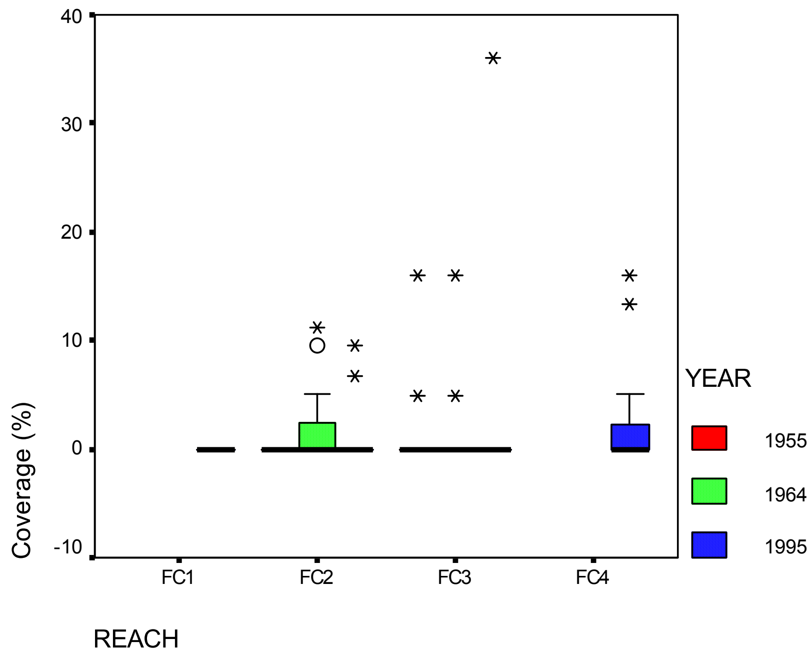


Figure 3-29. Herbaceous Coverage in Flat Creek in 1955, 1964, and 1995



Bare ground was infrequent in Flat Creek and amounted to less than 1% overall. A slight increase in bare ground was observed in 1964 in reach FC2, but was otherwise unchanged from 1955 to 1995.

Figure 3-30. Bare Ground in Flat Creek in 1955, 1964, and 1995



In summary, the central reaches of Flat Creek appeared to show an increase in woody shrub coverage and a decrease in herbaceous coverage from 1955-1995.

3.4 Sediment Source Areas

Potential sediment source areas were inventoried based on 1995 digital orthophotos and the results of 2003 aerial reconnaissance. Sediment sources inventoried included bank erosion, mass failure of terraces/slopes, headcutting from tributary drainages, incised reaches, and delivery from upland sources.

On the mainstem Dearborn and portions of Flat Creek an additional review of historic aerial photos was undertaken to evaluate changes in sediment sources over time and to help interpret trends. Aerial photo coverage for 1955, 1964, and 1995 was limited to these areas and was not conducted on other waterbodies in the project area.

3.4.1 In-Channel Sources

Overall, sediment sources in the Dearborn planning area were predominately derived from in-channel scour and fill processes. The bank stability (**Section 3.2.1**) assessment showed that significant sediment sources exist in portions of most stream segments. Eroding banks were classified as either “natural” or “anthropogenic” based on professional judgment considering factors such as adjoining land use, apparent channel modifications, vegetation alterations, and visual comparison to potential channel characteristics of up and downstream reaches. Length of eroding banks was quantified for the lower Middle Fork reach MF1 and Flat Creek (all reaches).

Dearborn Mainstem

Very little evidence of channel or riparian modification was apparent on the mainstem of the Dearborn based on aerial assessment. Much of the channel is located in deeply incised terrain with a confined floodplain. No cultivated farmland is present within the floodplain of the Dearborn mainstem except in reach DR3. Potential human impacts in most of the Dearborn would be largely limited to riparian vegetation alterations associated with grazing pressure and bank trampling. Review of aerial photographs and 2003 aerial reconnaissance did not indicate that any obvious grazing or land use conversion had impacted riparian or bank conditions in the Dearborn mainstem overall. Pre-1955 conditions are unknown, and the possibility exists that more intensive historical grazing (e.g. intensive sheep and cattle grazing) could have altered riparian communities to some extent. This issue cannot be addressed directly in this study.

Examination of historic photos as well as upstream-downstream comparisons did not show any strong localized riparian modification, associated bank instability, or grazing-related sediment sources with the exception of reach DR3. Conversion of riparian areas to hay/pasture may play a role in bank stability within portions of the upper 2.5 miles in this reach. Reach DR3 was an unconfined C4 channel which would be expected to have significant natural erosion and depositional processes. Sediment in the Dearborn mainstem appears to be derived almost entirely from natural alluvial channel processes.

Middle Fork

The Middle Fork of the Dearborn showed little influence of anthropogenic, in-channel sediment sources in the headwaters (MF2). This section of the channel is situated in deeply dissected, forested terrain and no significant channel or riparian modifications were present. Logging activity and road systems in the headwaters did not appear to contribute elevated quantities of sediment. Highway 200 has the potential to contribute sediment from cut/fill slopes and applied road sand. However, the aerial assessment did not show any apparent delivery of sediment from the road to the Middle Fork. Long delivery distance from the road to the channel is likely to limit sediment contribution in most locations. A possible pathway for road runoff was investigated on the ground but did not appear to be a source of significant sediment delivery to the channel. Spring snowmelt does have the potential to deliver road sand to the Middle Fork, but a comprehensive field investigation was beyond the scope of this study. Evaluating this potential source of sediment would require additional field work to determine if concentrated flow pathways are present.

The lower reach of the Middle Fork (MF1) showed evidence of channel instability related to land use/riparian modification for agriculture. In-channel sediment sources were present due to human-induced channel instability in some areas. An estimate of eroding bank lengths was made from the 1995 digital orthoquads and interpretation of the 2003 aerial video flight (**Table 3-9**). Bank erosion was classified into “high”, “moderate”, and “low” categories. These rankings are intended to correspond to probable Rosgen Bank Erosion Hazard Index (BEHI) values. Banks in the high and moderate categories were evaluated to determine if anthropogenic factors were a contributing factor to bank instability. Human land use impacts were assumed if riparian conversion to agriculture or grazing effects on streambanks appeared to be a significant factor in bank stability. An evaluation of bank stability in adjoining upstream and downstream reaches assisted in this interpretation.

Table 3-9 ***Bank Erosion, Middle Fork Reach MF1***

Category	Length (ft)	%	% Anthropogenic related
High	3486	10.6	45%
Moderate	11609	35.3	40%
Low	17791	54.1	NA
Total	32886	100.0	NA

Approximately 45% of eroding banks (1,569 feet) in the high category were associated with human related impacts. In several areas, eroding terraces were natural or not primarily related to human impacts. For example, a natural stream position along the valley margin can result in an eroding terrace feature that is mostly unrelated to adjoining land use.

Eroding banks in the moderate category associated with land use impacts totaled 4640 feet, accounting for 40% of eroding banks in this category. The remaining 60% of banks in the moderate category were not directly associated with land use impacts and represented natural, relatively unimpaired bank conditions for this channel type (Rosgen C4). The entire reach of the lower Middle Fork (MF1) has experienced some level of grazing pressure and conversion of riparian vegetation to agricultural uses. Drawing a clear distinction between human-impacted and natural banks from an aerial assessment was difficult. Additional challenges include the diffuse nature of possible grazing impacts and the potential for “response” reaches to reflect upstream impairment (e.g. increased sediment load) rather than immediate land use impacts. The value of 40% (4640) feet of streambank in the moderate category is intended to represent a conservative estimate of stream length directly impacted by land use activities.

South Fork

The headwaters of the South Fork (SF2) were steep, forested terrain and did not show evidence of anthropogenic sediment sources or accelerated bank erosion. The lower reach of SF2 had a 5900 foot segment of riparian area that was cleared/logged and some increases in sediment yield may be possible. Channel stability appeared to be impacted to some extent and additional investigation on the ground may be warranted.

The lower reach (SF1) of the South Fork had several miles where the riparian corridor had been converted to agricultural purposes (pasture and grazing). Some impacts to bank stability and channel shading were apparent but were generally of a diffuse nature. A BEHI assessment was not completed and additional field assessment may be required to evaluate these areas as potential sediment sources.

Flat Creek

Flat Creek has significant anthropogenic sources of sediment related to the altered flow regime and related channel adjustments. Diverted irrigation water greatly exceeds pre-development flow rates and results in an enlarged channel cross section and actively eroding banks. Grazing and conversion of riparian areas to pasture and cropland have also contributed to sediment impairments.

Flat Creek serves as an irrigation conveyance with flows exceeding 70 cfs diverted into the channel from the Dearborn mainstem. Prior to diversion of water the channel was likely a stable, meandering E type channel (transitioning to C) with a riparian zone composed predominately of willow-woody shrub species, and possibly lesser amounts of Cottonwood in the lower reaches. Sediment yield from eroding streambanks would have been relatively low compared to current conditions. Auchard Creek, a small tributary to the Dearborn (and parallel to Flat Creek), shows good channel stability and few actively eroding banks.

Present day channel morphology and channel adjustments have significantly increased sediment yield from Flat Creek. No pre-modification or reference data were available; however, it is likely that the majority of increased sediment yield from eroding banks on Flat Creek can be attributed to land use impacts. Loss of beaver from the system may also contribute to channel alterations including downcutting and bank erosion.

An estimate of eroding bank lengths was made from the 1995 digital orthoquads and interpretation of the 2003 aerial video flight (**Table 3-10**). Bank erosion was classified into "high", "moderate", and "low" categories. These rankings are intended to correspond to probable Rosgen Bank Erosion Hazard Index (BEHI) values.

Table 3-10 ***Bank Erosion, Flat Creek***

Reach/Category	Total Length (ft)	%	% Anthropogenic related
FC1			
High	4593	11.2	80%
Moderate	7259	17.7	60%
Low	29,158	71.1	
Total	41,010	100.0	
FC2			
High	3066	13.1	90%
Moderate	8635	36.9	90%
Low	11,701	50.0	
Total	23,401	100.0	
FC3			
High	3215	14.0	90%
Moderate	7074	30.8	90%
Low	12,678	55.2	
Total	22,967	100.0	
FC4			
High	7802	8.4	90%
Moderate	30,929	33.3	90%
Low	54,149	58.3	
Total	92,880	100.0	
Grand Total	32886	100.0	

In reach FC1, approximately 80% of eroding banks in the high category were associated with land use impacts totaling 3674 feet. Natural eroding terraces and hillsides not primarily related to land use accounted for 20% of eroding banks in the "high" category. Eroding banks in the moderate category associated with land use impacts totaled 4355 feet, accounting for 60% of eroding banks in this category. Approximately 40% of banks in the moderate category were not directly attributable to land use impacts and represented natural variability for this channel type (Rosgen C4).

Reaches FC2, FC3, and FC4 showed similar distributions of eroding banks in each category. Banks in the high category ranged from 8.4 to 14% of total reach length and 90% of these banks were related to human impacts. Total length of impacted banks in the high category was 2759, 2894, and 7022 feet in reaches FC2, FC3, and FC4, respectively.

Banks in the moderate category ranged from 31% to 37% of total reach length. Like banks in the "high" category, 90% of the banks in the moderate category were associated with agricultural impacts and alterations related to increased flow in Flat Creek. Total length of impacted banks in the moderate category was 7771, 6366, and 27,836 feet in reaches FC2, FC3, and FC4, respectively.

Although values of 80-90% human impacted banks may appear to be an extreme number, it should be noted that extensive riparian conversion to pasture and cropland as well as grazing impacts were widespread in Flat Creek. Sustained summer irrigation flow greatly exceeds the natural hydrograph of Flat Creek. This increased flow from irrigation diversion appeared to be a significant factor in bank stability. As a result of these considerations nearly all bank erosion in the "high" and "moderate" categories was attributed to human impacts.

3.4.2 Mass Failure

Mass failure was an uncommon source for sediment within the Dearborn and tributaries. A single location on the Dearborn mainstem showed evidence of active mass failure in Reach DR6, and was related to natural processes. Shallow-seated slumps were located on unconsolidated parent material, and contributed sediment directly to the Dearborn mainstem in this location (**Figure 3-31**). Limited areas of dry ravel/rilling were present but infrequent on steep slopes adjacent to the active channel in Reach DR4 (**Figure 3-32**). These natural sources of sediment would be expected to contribute fines to the channel during extreme rainfall events and also during peak flow events that erode the toe of the slope.

Figure 3-31. Slumps in Dearborn Mainstem Reach 6

Figure 3-32. Dry Ravel/Rilling in the Dearborn Mainstem Reach 4

No anthropogenic related sources of mass failure or delivery of sediment to the Dearborn mainstem were observed. No mass failure was observed in the Middle or South forks of the Dearborn.

A significant major source of mass failure was sloughing of high banks along Flat Creek. This was considered under the bank erosion category of sediment sources since it is primarily related to fluvial action and bank stability.

3.4.3 Headcutting/Incised Reaches

Active headcutting and sediment delivery to listed reaches was not characteristic of small channels draining upland areas. No active gully formation was observed in either ephemeral or perennial tributaries. Vertical stability in tributaries was good, and headcut formation in rangeland did not appear to be a significant source of sediment in the Dearborn Planning Area.

A series of three gullies were observed along reach DR5 in the Dearborn mainstem (**Figure 3-33**). These gullies appeared stable and may be a remnant of heavy precipitation/surface runoff in the spring of 1964 or other intense rainfall events.

The majority of smaller drainages and tributaries to the Dearborn mainstem appeared to be vertically stable, and were not a significant source of sediment to the Dearborn (**Figure 3-34**). The Middle and South forks of the Dearborn did not show any significant sources of sediment from influent tributaries.

Incised channel conditions were observed in portions of Flat Creek and were most probably related to the increased flow regime of diverted irrigation water. Loss of beaver from Flat Creek may also contribute to apparent localized changes in base level.

Figure 3-33. Gullies in the Dearborn Mainstem Reach 5

Figure 3-34. Typical Smaller Contributing Drainages to the Dearborn Mainstem

3.4.4 Upland Sources

Upland sources did not appear to contribute appreciable quantities of sediment to the Dearborn mainstem or tributaries. Perennial and intermittent tributaries appeared stable, and rangeland did not show evidence of surface erosion, rilling, or other signs of accelerated soil loss due to anthropogenic influences. Forested headwaters were largely pristine and unroaded in the mainstem and South Fork of the Dearborn. The Middle Fork of the Dearborn had minor impacts from Highway 200 in the upper headwaters (in the ephemeral portion). Sediment contribution from cut/fill slopes and road sand from Highway 200 appeared to be minimal due to the long delivery distance to the channel.

Hogan Creek (Tributary to Flat Creek, above the listed reach) showed pronounced turbidity during the 2003 aerial survey (**Figure 3-35**). Sediment sources appeared to originate from channel incisement, exposed soils and relatively poor vegetation coverage in this drainage. Soils appeared to be fine-textured and relatively arid. No obvious anthropogenic influence appeared to account for turbid water originating from Hogan Creek, although grazing may contribute to sparse vegetation coverage. Several small impoundments (presumably for stockwater) on Hogan Creek likely limit the potential delivery of sand/silt fractions to Flat Creek (**Figure 3-36**). In addition, the relative loading of sediment from Hogan Creek is likely to be low due to the low elevation and runoff volume.

Upland sources of sediment in Hogan Creek warrant additional field investigation to establish whether they are a significant contributor to impairment in Flat Creek.

Figure 3-35. Hogan Creek, Tributary to Flat Creek Reach 4.

Figure 3-36. Upper Hogan Creek, Tributary to Flat Creek Reach 4.

3.5 Cultural Features

An inventory of cultural, anthropogenic channel modifications was undertaken using 1995 aerial photos and aerial reconnaissance in 2003 (**Table 3-11**). Overall, the main cultural feature was stream crossings including bridges and fords. Stream crossings did not appear to have any significant up or downstream impacts on channel function other than minor localized effects. Very little bank stabilization/rip-rap or channelization was apparent in the reaches studied and did not account for any significant impacts to channel morphology.

No impoundments were observed in the primary reaches studied, although a number of small stockwater impoundments were present in smaller tributary streams to Flat Creek (e.g. Hogan Creek). These impoundments are unlikely to contribute significantly to either thermal or sediment impairments to Flat Creek and may help sustain summer baseflows in some cases. Small impoundments in Hogan Creek may reduce sediment loading to Flat Creek though this influence is likely to be minimal based on contributing area and water yield for the drainage.

Diversion structures were present in the Dearborn mainstem (Dearborn Canal), South Fork (Gibson Renning Ditch), Middle Fork (4 diversions), and Flat Creek (multiple locations). An assessment of diversion rates/capacity was beyond the scope of this study, and additional field investigation may be warranted to determine the influence of these diversions on flow and thermal impairments.

No major anthropogenic point sources for sediment or temperature impairment were noted. The Milford Colony has several lagoons/holding ponds located along the riparian corridor of Flat Creek (**Figures 3-37, 3-38**). Water quality in these lagoons is unknown and potential impacts to Flat Creek could not be determined in this study. The possible influence of these features on water quality may warrant additional investigation, although the potential to affect sediment or thermal impairments is likely to be minimal.

Figure 3-37. Milford Colony

Figure 3-38. Milford Colony

Table 3-11 ***Cultural Features – Dearborn River***

Reach	Rip-rap/other stabilization	Channelization	Impoundments	Instream Structures/ Diversions	Stream Crossings	Potential Water Quality Point Sources	Other (gravel pits, construction)
DR1	NA	NA	NA	NA	Train Bridge at Mouth Ford near pt. 3 Ford above pt. 5 Ford near pt. 11	NA	NA
DR2	NA	NA	NA	NA	NA	NA	NA
DR3	Minor rip-rap near bridge	NA	NA	Ditch near SF Mouth	Hwy 285 Bridge Small bridge nr pt. 2	NA	NA
DR4	NA	NA	NA	NA	Hwy 200 Bridge	NA	NA
DR5	NA	NA	NA		Bridge near pt. 16	NA	
DR6	250 ft at pt 13	NA	NA	Bean Ditch near pt 12 Dearborn Canal bl pt. 14	Bridge near pt. 8 Siphon out below pt. 6	NA	NA
SF1	NA	NA	NA	NA	Ford near mouth Bridge bl pt. 11 2 Bridges abv pt. 14 Bridge abv pt. 19	NA	NA
SF2	NA	NA	NA	Gibson-Renning ditch diversion nr pt 3	2 bridges nr pt 3 Bridge or ford blw pt 5? Bridge or ford abv SF-9 Bridge or ford between SF-10 and 11 Bridge or ford blw SF-10 Bridge nr SF-13	NA	NA
MF1	NA	NA	NA	2 Gillette ditch Borho Ditch diversion	Bridge nr pt 10 Bridge nr pt 17	NA	NA
MF2	Riprap by Hwy 200 blw MF-12 - 500ft	NA	NA	Nitch ditch Dueringer ditch	Hwy 200 bridge Bridge abv MF-10 Ford? Blw MF-14	NA	NA
FC1	NA	NA	NA	NA	NA	NA	NA
FC2	NA	NA	NA	NA	Ford nr pt. 15 Bridge-end of reach	NA	
FC3	Minor	NA	NA	Garino ditch Diversion Diversion a Hamilton ditch diversion between 11 and 12	Bridge and ford between pt 7 and 8 Ford between pt 21 and 22 Ford between pt 19 and 20	NA	NA
FC4	Minor	NA	Hogan Cr.	NA	NA	Milford Colony	NA

4.0 SUMMARY AND CONCLUSIONS

This study is based on an aerial reconnaissance conducted in October 2003 and the interpretation of historic aerial photographs from 1995, 1964, and 1995. Channel morphology, riparian condition, and source areas were evaluated to assess potential sources of impairment in the Dearborn planning area.

4.1 Potential Impairments

Dearborn Mainstem

The study indicated that anthropogenic influences have not substantially degraded the condition of riparian vegetation or channel function on most reaches of the Dearborn mainstem. No significant human impacts related to land use, conversion of riparian areas to pasture/cropland, or grazing were apparent except in reach DR3. Conversion of riparian areas to hay/pasture may play a role in bank stability within portions of the upper 2.5 miles in this reach. Most reaches of the mainstem had a small, confined floodplain that was relatively inaccessible and not well suited for agriculture. This probably explains the lack of human impacts to the channel and riparian community.

The 1964 flood had significant influence on channel stability and riparian vegetation in the Dearborn mainstem. Gravel bars, eroding banks and loss of riparian vegetation were apparent throughout much of the Dearborn in the post-flood aerial photos. Increased channel width and reduced riparian coverage were especially prevalent in alluvial reach DR3. Geologic structural constraints appeared to limit impacts from extreme flooding in other reaches. Riparian and channel conditions were generally comparable in 1955 and 1995, suggesting that the channel recovered from flood effects in the subsequent 41 years.

The deciduous cottonwood overstory in the Dearborn mainstem appeared to be in a seral state with multiple age classes of trees represented in many locations. This appeared to be related to natural fluvial processes rather than agricultural land use impacts with the exception of reach DR3. Shade provided by riparian vegetation did not appear to be substantial even in mature deciduous or coniferous riparian communities adjacent to the channel.

Sediment source areas were limited to natural processes including morphologically active channel segments, natural terraces and slopes, and natural bank erosion. Overall, land use and human impacts did not account for any significant increase in sediment sources or impairment. Reach DR3 had several locations with eroding banks that may be attributable to loss of riparian woody vegetation and impacts from agricultural uses.

Comparison of historic photos did not indicate any significant trend in human-related impacts to channel stability or riparian vegetation on the mainstem. Except for reach DR3, upstream and downstream comparisons also did not show any reach-specific impacts from human activities. In summary, the mainstem of the Dearborn appeared to be near full potential for riparian vegetation and channel/streambank stability given natural factors.

South Fork of the Dearborn

The South Fork of the Dearborn showed evidence of human impacts on riparian vegetation in both reaches studied. The upper reach SF2 was in good overall condition with a mature overstory of dominantly coniferous vegetation. A single 5910 foot segment of channel showed loss of riparian vegetation due to logging/riparian clearing that occurred after 1995. This resulted in loss of shade to the channel, but streambank stability appeared to be good overall.

The lower reach SF1 showed widespread impacts to riparian vegetation from agricultural activities. Approximately 50% of the total length ranked "poor" in terms of riparian condition. Eroding banks were associated with loss of riparian vegetation in several locations. Impairment to channel function did not appear to be severe in many instances, however.

Middle Fork of the Dearborn

The Middle Fork of the Dearborn is a steep, forested channel in the headwaters portion (reach MF2). Highway 200 and limited residential development are present along the riparian corridor. The Middle Fork showed minimal impacts to riparian vegetation and bank stability from human impacts in the upper reach MF2. No delivery of sediment from Highway 200 was apparent based on aerial reconnaissance and limited ground observation.

The lower reach of the Middle Fork (MF1) showed significant impacts to the riparian vegetation community. Approximately 65% of the riparian vegetation was ranked "poor" due to conversion of riparian vegetation to agricultural uses including grazing, pasture, and hay meadows. Bank stability and overall channel condition were sub-optimal; approximately 40-45% of the eroding banks were associated with human impacts.

Flat Creek

Flat Creek is a substantially altered system due to the diversion of irrigation water from the Dearborn mainstem. Sustained irrigation diversion and increased baseflow have resulted in impacts including enlarged channel cross section and probable channel downcutting. Flat Creek has adjusted to this altered flow regime to a large extent however eroding banks continue to contribute elevated sediment to the Dearborn mainstem. Grazing and conversion of riparian vegetation to pasture and agricultural use has significantly reduced woody species relative to site potential and contributed to sediment impairments. Almost no shade is provided by riparian overstory in most of Flat Creek except for the lower reach FC1.

Most of the increased sediment from eroding banks can be attributed to human impacts in Flat Creek. An estimated 80-90% of eroding banks in the "high" category were related to agricultural practices including increased flow, grazing, hay production, and cropping. Although woody species coverage increased from 1955-1995, riparian vegetation appeared to be sub-optimal relative to site potential.

4.2 Restoration Focus Areas

Dearborn Mainstem

The Dearborn mainstem had reaches with high channel instability (e.g. reach DR6), but these areas were related to natural channel process and do not appear to reflect existing or historical anthropogenic impacts. Evidence for this includes 1) the lack of human-related activity, 2) the lack of significant channel alterations, and 3) inherent instability related to geology and fluvial process. Therefore, no active restoration of riparian vegetation or channel planform/geometry is recommended for reaches of the Dearborn mainstem with the possible exception of reach DR3.

Reach DR3 was an unconfined Rosgen C4 type channel with channel instability in the upstream area. Conversion of riparian vegetation to hay/pasture has likely accelerated bank erosion in several areas. Recommended restoration activities include stabilization and revegetation of eroding banks with bioengineered geotextile treatments. Fencing and/or establishment of woody riparian buffer would help improve long-term stability.

Middle Fork of the Dearborn

No mitigation or restoration activities are recommended for the headwaters reach MF2 of the Middle Fork due to the relative lack of human impacts. Additional field investigation may be warranted to verify that no significant impacts from road sand occur on the Middle Fork.

Numerous areas of the lower reach of the Middle Fork have experienced some riparian impacts and channel instability mainly related to agricultural practices. Conversion of riparian corridors to pasture/agricultural uses has resulted in reduced riparian coverage. Approximately 4500 feet of channel showed a relatively high level of impacts to channel stability, and an additional 6600 feet had moderate impacts. Suggested restoration activities in the Middle Fork include improving woody riparian coverage and restoration of over-widened channel cross sections to reference conditions along impacted segments. Bank restoration can be accomplished with soft bioengineering methods (i.e. geotextile coir fabric wraps) and woody shrub/tree revegetation. Fencing or grazing rest-rotation in riparian areas would be beneficial to promote increased coverage of woody species. Offstream water sources may need to be developed.

South Fork of the Dearborn

The upper reach of the South Fork of the Dearborn is a steep, forested headwaters channel with minimal anthropogenic impacts. The headwaters are relatively undisturbed conifer forest in good condition and do not require any restoration or further assessment. The lower end of the upper reach (SF2) appears to have experienced some impacts from both logging/land clearing operations in the riparian area. Natural recovery from logging impacts would be expected to result in improving conditions in this reach. Some agricultural impacts (pasture/grazing/cropping) are present in reach SF2. Additional field assessment is recommended to determine if riparian clearing and agricultural impacts to the channel represent a significant impairment.

The lower reach SF1 experienced impacts from grazing and removal of riparian vegetation. Channel and riparian conditions were generally better than the lower reach of the Middle Fork. Additional field assessment in reach SF1 would be beneficial to establish whether any active restoration is required. Suggested restoration activities in the South Fork include improving land use practices and possibly riparian fencing to promote riparian vegetation recovery.

Flat Creek

Riparian vegetation appears to have been significantly degraded due to livestock grazing (see discussion of FC2, FC3 and FC4 above), and to a lesser extent, 1964 flood effects. There are extensive portions of Flat Creek that are most likely impaired due to reduced channel shading and poor habitat as a result of degraded riparian vegetation.

The flow regime in Flat Creek is largely artificial. Restoration to pristine conditions is therefore not a realistic objective at this time. There are, however, steps that can be taken to reduce water quality impacts and improve habitat conditions while continuing to accommodate the current flow regime. Suggested restoration activities include promoting recovery or enhancing riparian vegetation, and reducing sediment impacts through restoration of eroding banks. Restoration activities in Flat Creek to address thermal impairment should seek to increase shading through enhancement of woody riparian components. Establishment of mature tree stands could be expected to provide significant shading to the channel, although it should be recognized that extensive Cottonwood riparian communities would not be expected to be typical of this edaphic setting. Willow shrub communities would be more typical, though shading provided by willow would be modest. Strategies to reduce sediment yield would include sloping and revegetation of unstable terraces/banks with geotextile/revegetation treatments.