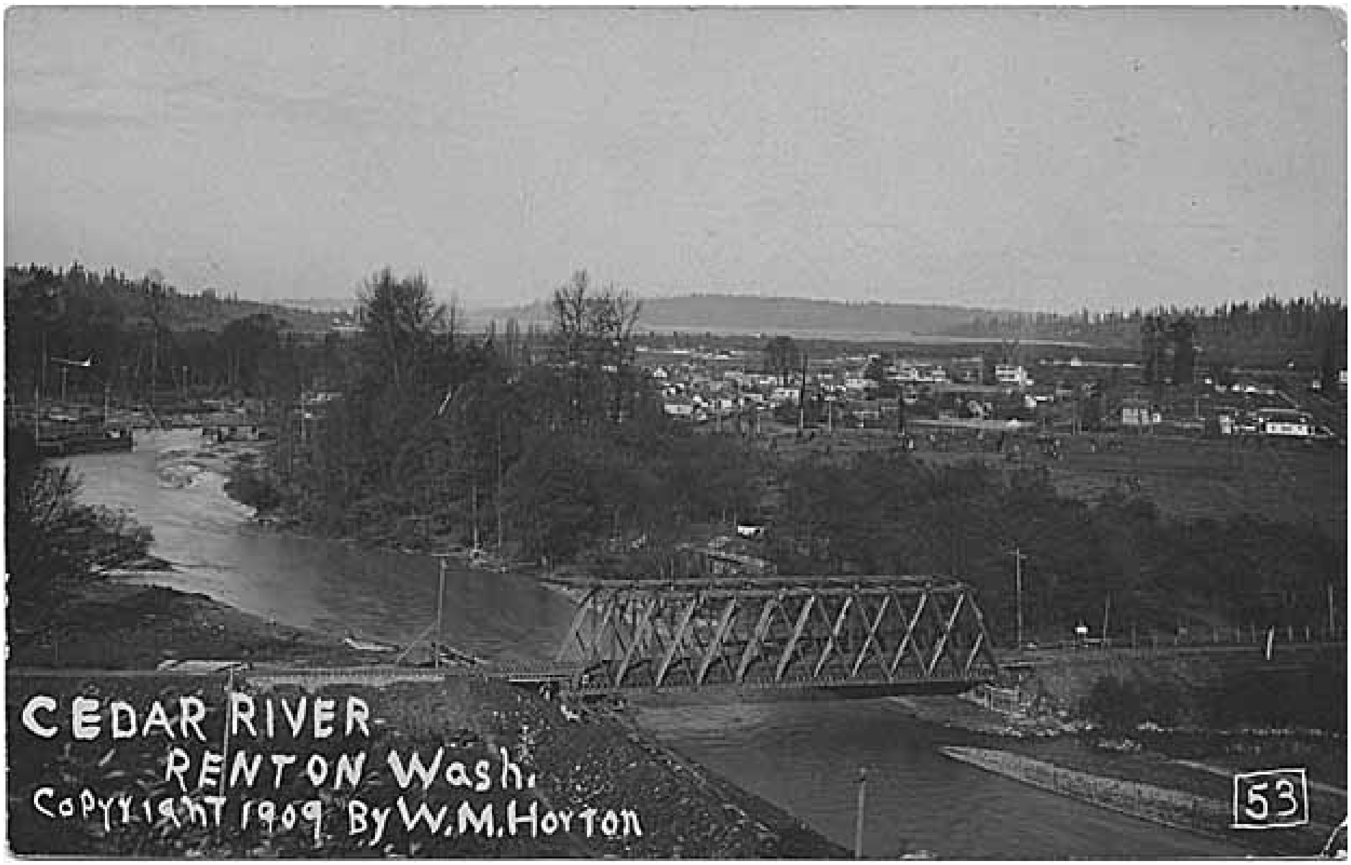
Historical River Channel Location Data for the Cedar River, RM 0 – RM 22, King County, Washington



Renton Historical Society

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INTRODUCTION

This report describes digital data created for King County Department of Natural Resources to support the County's development of a channel migration zone for the Cedar River downstream of Landsburg at RM 21.7. The data includes 11 sets of orthorectified aerial photos from 1936 through 2000, georeferenced General Land Office plat maps from 1865-1880, and GIS coverages of channel features digitized from these photos and maps. The report also includes a brief, general overview of historical channel conditions and channel change.

AERIAL PHOTO AND MAP SOURCES

We collected aerial photos for the study area, aiming for an average spacing between photo sets of about 5 years. We made use of 11 photo sets from 1936 to 2000 (Table 1), for an average of 5.3 years between sets. The maximum period between photo sets was 11 years (between 1948 and 1959), and the least was 4 years (between several sets). We borrowed photos from King County, University of Washington Libraries, and the King County Conservation District. DEM. We then mosaicked and tiled the orthorectified or georeferenced images.

The 2000 imagery was made available to us in georeferenced digital form. All other sets were paper prints, which we scanned at 600 ppi. Photo scale varied from 1:7,800 to 1:24,000, with one set at a much smaller scale (1980, 1:58,000). All were black and white excepting a 1980 infrared set and the color 2000 images. The 1944 images were a paper photomosaic, and all others were stereophoto contact prints. We georeferenced the 1944 photomosaic using points taken from USGS digital orthophoto quarter quads (DOQQs). We orthorectified all other photographs using ERDAS Imagine Orthobase, using the USGS DOQQs and the USGS 10-m

We tested our orthorectified photos using the National Standard for Spatial Data Accuracy (NSSDA) methodology (e.g., Minnesota Planning Land Management Information Center 1999) by acquiring at least 20 GPS points in the valley bottom that could be compared to the georeferenced, mosaicked, and tiled images, and determined the horizontal distance over which the user can be confident that the horizontal position of a feature on the image will be within its true location 95 percent of the time. The NSSDA 95% statistic varied between 5 m and 19 m (Table 2). Outliers generally concentrated in the upstream part of the study reach (see "comments" section of Table 2) indicating that accuracy is better in the middle and lower part of the study area and worse in the upstream-most part. The 1944 images, which we georeferenced rather than orthorectified, tested to a much lower accuracy (NSDDA 95% statistic of 30.2 m). This is probably because the original images were very grainy orthophoto maps with poor contrast, from photos mosaicked with methods current in 1944. Because the horizontal positional accuracy of imagery in Table 2 is a statistical characterization, we recommend that the user visually inspect the images to assess the local accuracy of digitized channel location and channel change between successive photo periods in using the GIS coverages digitized from the images to map channel locations and assess rates of channel migration.

King County tested the accuracy of the 2000 digital data using independent GPS points, and found that the CE90 (90% of the time the location on the image was within a certain distance of the actual location on the ground) for the imagery, was less than 4 m for the entire County, and generally less than 2.5 m in the southern two-thirds of the County, which includes the Cedar River.

We also made use of the earliest General Land Office plat maps. They were surveyed between 1865 and 1880. The downstream most of three plats (T23N R5E) was surveyed in 1865, the upstream most (T22N R6E) in 1880, and the middle (T23NR6E) in 1873. We georeferenced scanned original plat maps available from the Bureau of Land Management, using the current Public Land Survey System records for corners and quarter corners, then digitized channels from these georeferenced images. From our use of channels from plat maps elsewhere we have concluded that the mapped channel outline represents the active channel. Instructions given to surveyors in the region at the time (see White 1991) support this interpretation. Surveyors were instructed to survey along "both banks" at the "ordinary mean high water mark" which was defined in an early court case as "river bed which the river occupies long enough to wrest it from vegetation." Rivers were meandered (measured with bearings and distances) and thus should be positionally accurate, but our experience working with GLO plat maps is that the channel location is accurate where the river a section line crosses a river, and may be less accurate elsewhere. In North Puget Sound rivers, we found that surveyors drew channels on plat maps with varying fidelity to the field-measured widths, but on average widths were exaggerated on the plat maps by a few percent (Collins and Sheikh 2003).

DIGITIZING

We digitized channel features heads-up on screen in ESRI ArcGIS, generally at an approximate scale of 1:1,000. We mapped the active channel using the map units listed in Table 3. The wetted channel at the time of the photos was designated the "low flow channel" (LF). Areas mapped as "gravel bar" (GR) are generally unvegetated but can include small patches of vegetation. We mapped as "vegetation patch" (VP) areas of shrubs or immature trees on bars. We considered these three units to constitute the "active channel." We mapped a vegetation patch as a "forested island" (FI) if the patch included mature trees, particularly mature conifers, on the assumption that substrate having mature forest is likely to have accreted to the level of the floodplain; in other words, mapping mature forest is a surrogate for mapping floodplain. We also mapped the extent of the floodplain in which high-flow channels were visible ("FFHF"). In digitizing the General Land Office plat maps, we delineated the channel as a single unit that encompasses the low flow channel, gravel bars, and vegetation patches.

The accuracy with which the channel could be digitized varied with the scale and quality of aerial photos and with the presence or absence of streamside trees. For years from large-scale photography (1:12,000 scale or larger—1936, 1959, 1970, 1989, 1995) and for the 2000 digital images, the error in digitizing channel features not obscured by vegetation or by glare is small when averaged over a few tens of meters. However, in locations on the same photographs where the channel margin is overhung by vegetation or the photographs have sun glare, we estimate a typical potential error to be ± 3 m. On the smaller-scale photography (1:20,000-scale or smaller—1948, 1964, 1980, 1995), we estimate a typical error caused by vegetation cover or glare to be as much as ± 5 m. The 1944 photomosaics were a special case, because the image quality was poor; the potential maximum error in digitizing channel features locally could be as much as ± 7 m. Similar to the spatial data accuracy, this is a general assessment of the digitizing error, and we recommend the user consult the image (e.g. to determine the presence of overhanging vegetation or photo glare) to assess the local precision of digitizing.

OVERVIEW OF CHANNEL CHANGE THROUGH TIME

The General Land Office plat maps show the channel pattern at a time that is likely representative of conditions prior to later flow reductions, channelizing and revetment (Figure 1A). Large portions of the river at that time had a branching pattern—multiple channels having forested areas mapped between them. Most of the branching areas are between RM 5 and RM 14 and between RM 15 and RM 16 (Landsburg Diversion, the upper end of the study area, is at RM 21.7). Downstream of about RM 4, the river was primarily straight, with only a few meanders. Upstream of about RM 17 the river meandered in a valley that is narrower and confining, and tightly confined in the uppermost river mile.

The river segments showing the greatest amount of channel change between the General Land Office maps and the 1936 photos (Figure 1B) were generally in these historically branching areas; upstream and downstream, change was primarily associated with migration of individual meander bends. Between 1936 and 2000 (Figure 1C), channel change was less common, limited mostly to a few meander cut-offs. While for this report we have not quantified rates of channel migration, a qualitative assessment indicates that migration diminished through time overall in succeeding time periods bracketed by aerial photos. Most of the areas having channel migration in the early part of the 1936-2000 period have since been sites of revetment construction, so that channel change in the last few decades has been localized and generally confined to a small area.

The active channel has also narrowed substantially through time (Figure 2). Perkins (1994) ascribed this to the effects of flow reduction by water supply dams completed in 1904 and 1914, and later from the cumulatively narrowing effects of progressive revetment construction. Because of these influences, the channel area has diminished overall at a fairly uniform rate on average (Figure 2). Overall, the active channel area has diminished from about 300 ha in 1865-1880 (including the forested islands; excluding forest islands, the channel area was 244 ha) to 167 ha in 1936 to 111 ha in 2000. The 1936 channel is 56% that of the 1865-1864 channel, the 2000 channel area is 66% that of the 1936 channel area; hence, the 2000 channel area is only 37% that of the 1865-1864 channel.

ACKNOWLEDGMENTS

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Table 1. Aerial photos used. All photos were orthorectified except for 1944 Army Orthophoto map, which was georeferenced. Sources: 1 = King County; 2 = King County Conservation District; 3 = University of Washington Libraries.

YEAR	SCALE	PROJECT ID	PPI	TYPE	SOURCE
1936	1:10,500	-	600	BW	1
1944	1:20,000	Army Orthophoto Maps	600	BW	3
1948	1:21,000		600	BW	2
1959	1:7,800	KC-L-9	600	BW	1
1964	1:21,000	ENK	600	BW	2
1970	1:12,000	KP-70	600	BW	1
1980	1:58,000	HAP 80 (w/ small piece of HAP 83)	600	IR	3
1985	1:24,000	Sound Block 85	600	BW	3
1989	1:13,500	SP89	600	BW	1
1995	1:12,000	NW-95	600	BW	3
2000	-	Emerge Natural Color Derivative Aerial Photography	2 ft cell size	C	1

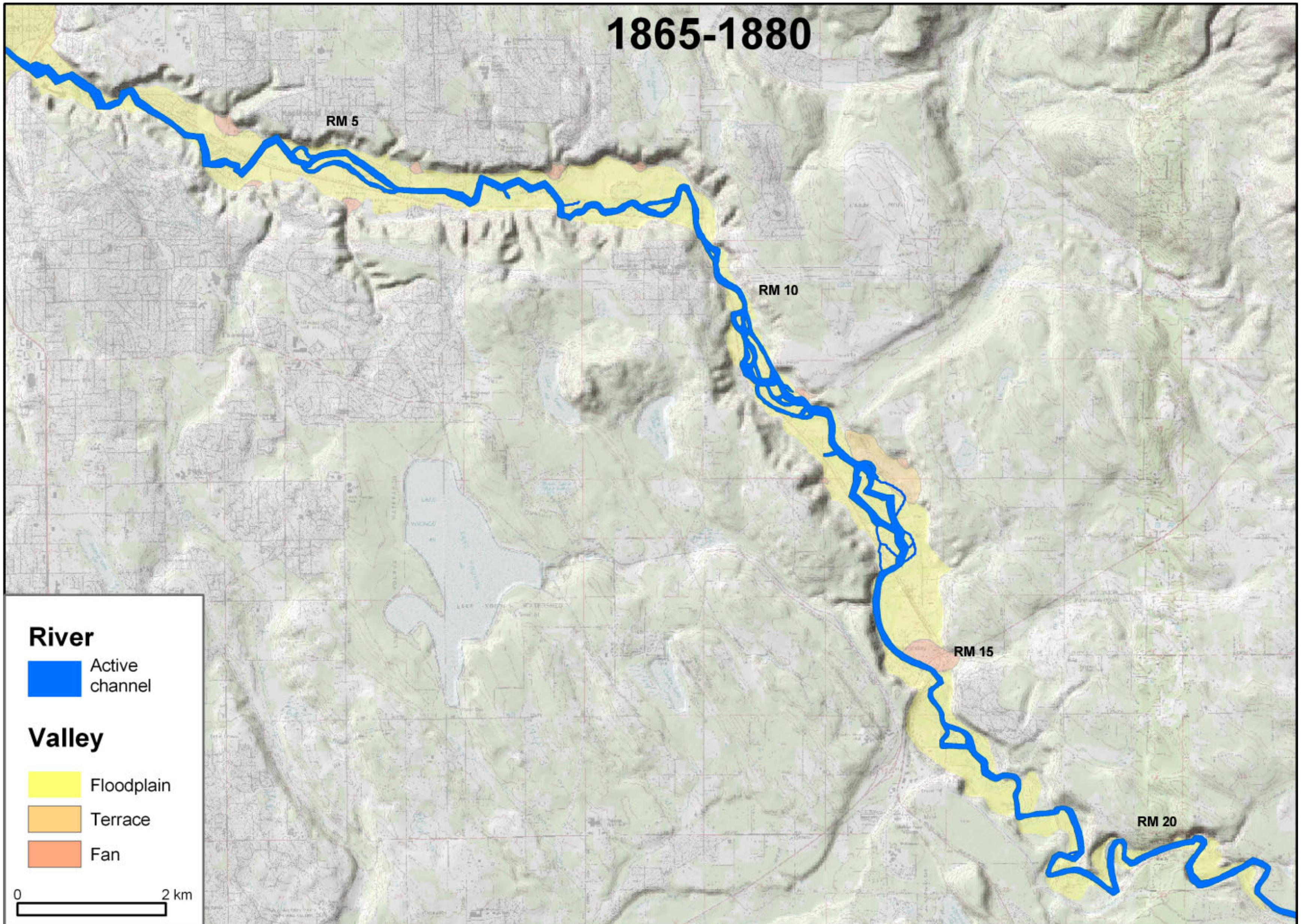
Table 2. Accuracy of digital imagery.

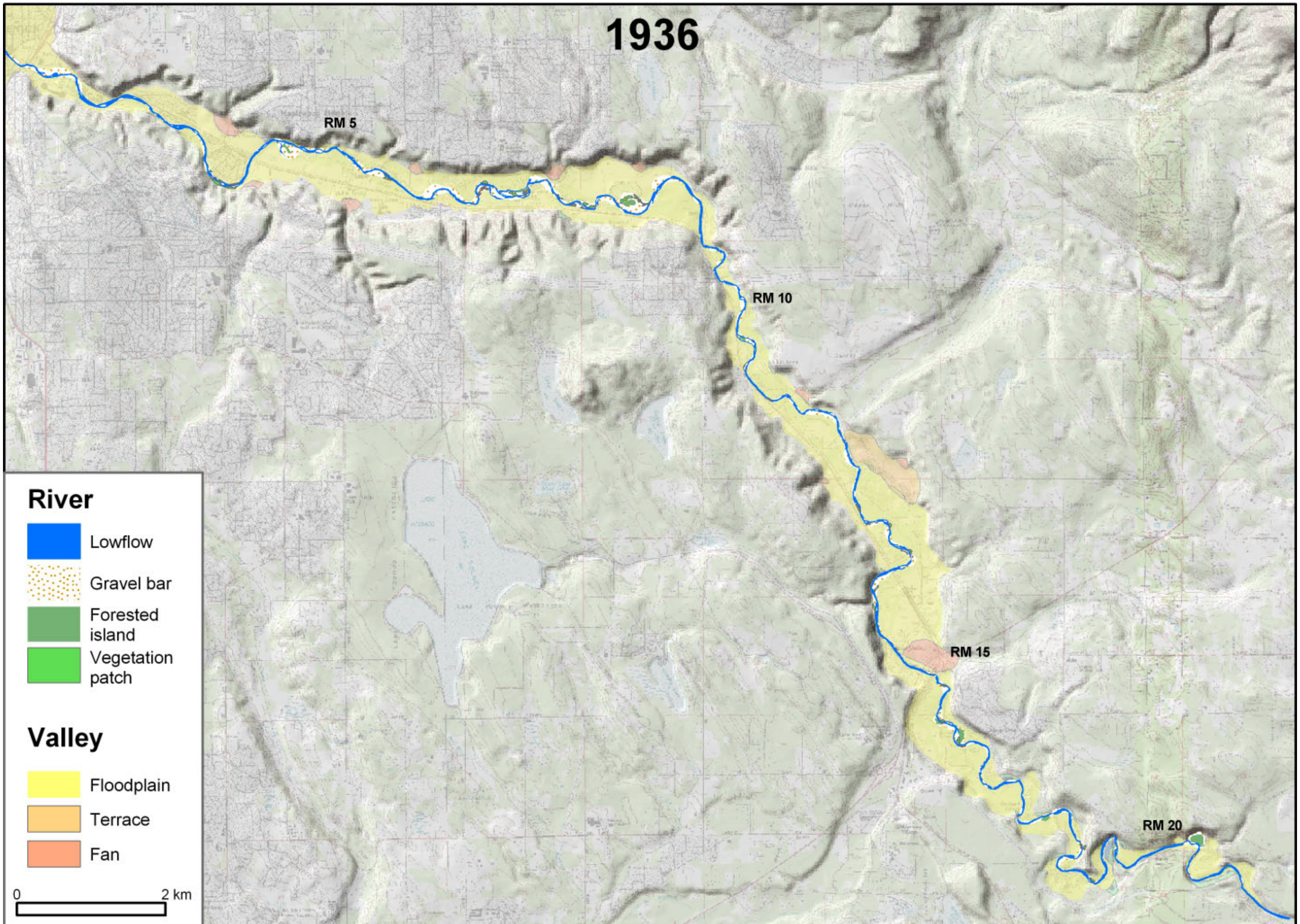
YEAR	SCALE	HORIZONTAL ACCURACY, METERS (NSSDA 95% STATISTIC)	COMMENTS
1936	1:10,500	10.3 m	Removing the tested points in the far SE (upstream) end of the photo set improves accuracy to 6.8 m
1944	1:20,000	30.2	Poor accuracy probably results from original images being very grainy orthophoto maps from photos mosaicked with methods current in 1944.
1948	1:21,000	16.3 m	Dropping three outliers, all in the SE and near the east edge of one photo, improves accuracy to 7.9 m. The local inaccuracy likely results from the photo that more directly covers the area being unavailable.
1959	1:7,800	-	Photo set does not encompass entire study area and only 10 GPS points fall within it; the NSSDA statistic requires a minimum of 20 points. Of the 10, the horizontal accuracy is 5.9 m at 95% confidence.
1964	1:21,000	9.0	Dropping three outliers, two of which are in the SE portion of the set, results in 6.9 m at 95% confidence.
1970	1:12,000	5.0	Dropping three outliers results in 3.9 m. The largest two outliers are in the upstream end of the study area.
1980	1:58,000	10.0	Dropping three outliers results in 8.1 m. Two of three outliers are in upstream end of the study area.
1985	1:24,000	18.7 m	
1989	1:13,500	7.2	
1995	1:12,000	6.0	

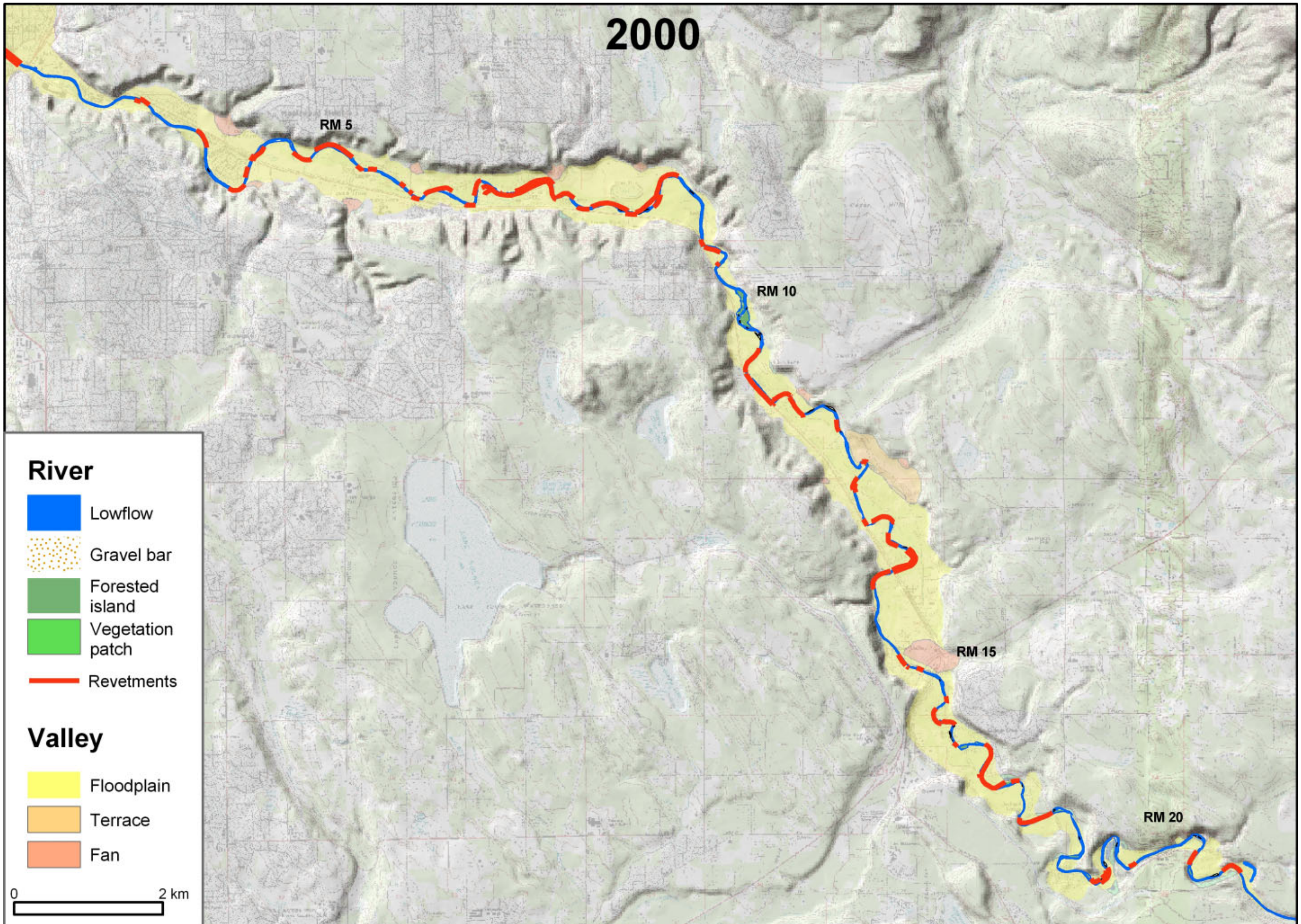
Table 3. Mapping categories used in digitizing channel features on aerial photographs and General Land Office plat maps.

LOCATION	TYPE	DESCRIPTION
Active Channel	LF	Low flow channel at the time of the aerial photograph.
	GR	Gravel bar. Includes small patches of vegetation.
	VP	Vegetation patch. Patch of vegetation on bar within active channel.
	AC	Active channel, undifferentiated. Includes LF, GR, and VP. Used for General Land Office plat maps.
Forested Floodplain	FFHF	Forested floodplain with high-flow channels. May include gravel patches.
	FI	Forested island. Patch of trees between branches of active channel.

Figure 1. (Following pages) A. Channel of the Cedar River in the study area from the General Land Office (1865-1880), B. from 1936 aerial photographs, and C. from 2000 photos. Revetments shown in 2000 image are from digital data provided by King County.


1865-1880
RM 5
RM 10
RM 15
RM 20
River
Active channel
Valley
Floodplain
Terrace
Fan
0
2 km


1936
RM 5
RM 10
RM 15
RM 20
River
Lowflow
Gravel bar
Forested island
Vegetation patch
Valley
Floodplain
Terrace
Fan
0
2 km


2000
RM 5
RM 10
RM 15
RM 20
River
Lowflow
Gravel bar
Forested island
Vegetation patch
Revetments
Valley
Floodplain
Terrace
Fan
0
2 km

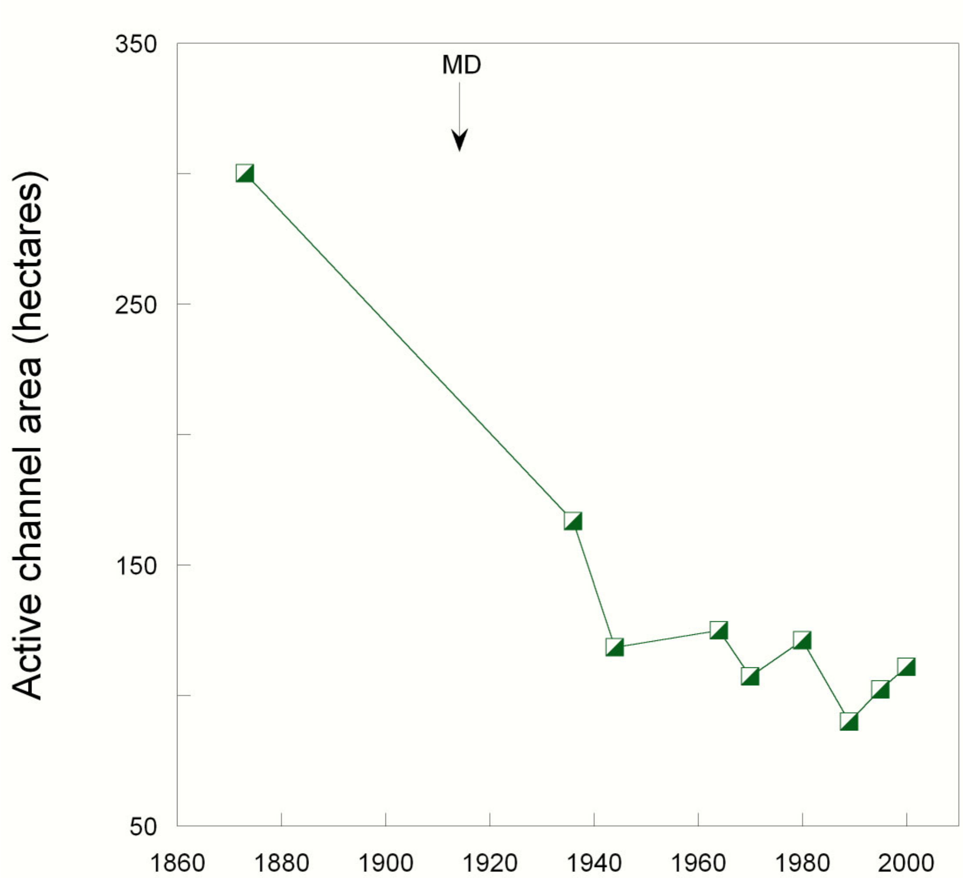


Figure 2. Active channel area through time. Active channel includes the low flow channel, gravel bars, immature vegetation patches on gravel bars, and forested islands. Data from 1948, 1959, and 1985 coverages are not included because they do not include the entire study area. The 1936 coverage includes an estimated 3 ha area for the uppermost 1.3 km, which was not mapped. "MD" represents the closing of Masonry Dam in 1914 at RM 36.