
Assessment of Bear Creek Watershed Wetlands



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King County

Department of Natural Resources and Parks
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Assessment of Bear Creek Watershed Wetlands

Prepared for:

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Submitted by:

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Natural Resources and Parks

Water and Land Resources Division

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EXECUTIVE SUMMARY

This technical report characterizes wetlands in the Bear Creek watershed study area and is intended to support the development of the Bear Creek Watershed-Scale Stormwater Management Plan as part of King and Snohomish Counties National Pollution Discharge Elimination System (NPDES) Phase I Municipal Stormwater Permit (2013–2018) compliance (S5.C.5.c) and the cities of Redmond and Woodinville NPDES Phase II (2013–2018) compliance (S5.C.4.g).

Development threatens the function of wetlands by removal and alteration, and loss and degradation of wetlands have major implications for watershed hydrology and fish and wildlife. A wetlands assessment and analysis was conducted to better understand current conditions of wetlands in the Bear Creek Watershed, examine how wetlands have changed over time, and gain perspective on how and when wetland regulations have evolved with respect to development.

Methods

Wetlands were mapped in the study area using seven different data sources from King County, Snohomish County, City of Woodinville, City of Redmond, and the National Wetland Inventory (NWI). Using all seven data sources, current conditions were analyzed by wetland type, rating, and rarity.

A subset of mapped wetlands was compared to wetland presence from approximately 35 years ago to see how they have changed over that time period. The King County Wetland Inventory (KCWI) wetlands were used to analyze wetland loss over the past 26–35 years because the KCWI wetlands cover most of the study area and the data was field verified. The KCWI was first published in 1983 with an update in 1991. KCWI contains 53 wetlands in the study area that were field verified in 1981 (45) and updated (4) or added (8) in 1990. Photos from the original 53 surveys were compared with current (2015) aerial imagery in order to determine the amount of apparent wetland loss to development. Anywhere development encroached into the previously drawn polygon, it was assumed that wetland experienced loss, and a new polygon was drawn to reflect the change.

Results

Current conditions: The final combined, merged wetland dataset from the seven available data sources show 326 wetland polygons in the Bear Creek watershed study area totaling 1793 acres.

Wetland type: Using the NWI dataset to aggregate the area of wetland types, forested wetlands are revealed as the most common wetland type in the Bear Creek watershed followed by scrub-shrub wetlands. The third most common type is emergent wetland. No single wetland type is rare; however, open-water ponds are the least common type present.

Wetland rating: Wetland rating systems are a category of tools used to understand the resource value of individual wetlands in order to protect them effectively. Two of the data sources used in this study included wetland rating information, which is used to indicate the functions and values of a wetland. KCWI included wetland ratings of 1, 2, or 3. The newer CAO wetland data included ratings as Category I, II, III, or IV.

Of the 53 KCWI wetlands in the study, the majority had the highest wetland ratings of 1 (25 percent) or 2 (70 percent). Only 3 wetlands (6 percent) had the lowest rating of 3. That so few wetlands were rated 3 is not surprising, because the wetlands in the KCWI tended to be larger, more noticeable wetlands, and wetlands rated as 3 are small (under an acre in size) and have only one or two wetland classifications present.

Of the 66 CAO wetlands delineated in the study area with wetland rating data, only 6 (9 percent) were rated as Category I, but they accounted for 29 percent of the wetland area (11.3 acres). The majority of CAO wetlands were category II or III; however, by far the most wetland area was covered by category II wetlands (26 wetlands covering 45 percent of the total wetland area). There is a fair amount of overlap of potential protective buffer sizes among category I, II, and III wetlands based on wetland type and habitat score. Therefore, wetland rating alone may not provide enough information to help decide on which wetlands provide greater levels of habitat value or other values.

Rarity: The King County Comprehensive Plan includes *Sphagnum*-dominated peat bogs as a habitat of local importance. Peat bogs are a habitat of local importance because they support a unique plant and animal community, they have declined as a result of development, and they are fragile ecosystems that can be easily destroyed but cannot be easily restored. In the study area there are seven known extant peat bogs and two peat bogs known to be extinct. Of the seven extant peat bogs in the study area, only three are currently in some form of protected land – one is in a TRACT parcel, one in a homeowner's association, and one in public ownership.

Wetland change: Of the 53 KCWI wetlands examined for loss over the past 35 years, 11 (21 percent) were visibly altered. The remaining 42 (79 percent) KCWI wetlands were visibly unchanged. The 11 wetlands that were obviously visibly changed since they were first inventoried vary in the amount of loss, ranging from 0.2 to 27.1 acres. The percent of each individual wetland that was lost ranges from 4.1 to 53.8 percent.

A total of 46 acres out of the original 1099 acres were developed; this change of 4.2 percent is relatively small. However, this exercise is crude at best and cannot account for loss of function or loss of wetlands that were not previously mapped. Furthermore, many of the wetlands mapped in the KCWI were larger, more obvious wetlands. Smaller wetlands and forested wetlands that were uncataloged or unprotected may have been more likely to be drained and filled.

Of the 11 wetlands that were visibly altered, 2 had a wetland rating of 1 and 9 had a rating of 2. Both in numbers and acreage, KCWI wetlands rated 2 were the most impacted during this time frame. By area, wetlands rated 2 were most heavily impacted by development;

however, wetlands rated 1 accounted for a higher percentage of wetland area in the watershed. It is unclear why these category 2 wetlands would be disproportionately affected by development.

Records of wetlands in the Bear Creek watershed do not exist prior to the KCWI. Without historic reference, it is impossible to know how many wetlands may have been drained or filled before the mapping exercises of the early 1980s.

Recommendations

The information presented in this report is to be used in the Bear Creek watershed plan, and any or all of the following recommendations could be conducted or implemented to improve and enhance knowledge of wetlands in the Bear Creek watershed and therefore contribute to any protection and restoration plans.

New Map Data: Snohomish County used a type of modeling that they felt relatively confident in. It is recommended that King County run the same modeling exercise to generate comparable data. It is also recommended that a subset of these newly modeled wetlands are field checked. If no new modeling takes place, it is recommended that a new update to the KCWI is undertaken using the same methods as when originally conducted. Once field checking commences, follow-up monitoring on a schedule of approximately every 5 years is recommended to continue to have the most up-to-date information available.

Mapping by King County Department of Permitting and Environmental Review: It is strongly recommended a new procedure be put in place to add wetlands to a spatial database (GIS) as they are submitted to the County for clearing and grading permits.

1.0 INTRODUCTION

Wetlands are those areas that are inundated by surface or ground water with a frequency sufficient to support plants and animals that depend on saturated or seasonally saturated soil conditions for growth and reproduction (Cowardin et al. 1979). Washington Department of Ecology (Michaud 2001) elucidates why wetlands are important to the health of natural ecosystems, and these functions and values specifically include:

- protecting water quality by trapping sediments and retaining excess nutrients and other pollutants such as heavy metals
- providing flood protection by holding the excess runoff after a storm, and then releasing it slowly, thereby maintaining streamflows
- recharging groundwater systems/aquifers, which, in turn, provide water for drinking, irrigation, and maintenance of streamflow and lake and reservoir levels.
- providing habitat for species of birds, fish, mammals, reptiles, and amphibians that rely on wetlands for breeding, foraging, and cover

All these functions and values contribute to the health of a watershed. And conversely, losing wetlands contributes to the decline of watershed health.

This wetlands analysis includes an inventory of wetlands currently mapped in the study area from seven different data sources. Wetlands are analyzed by category, classification, and rarity. A subset of currently mapped wetlands is compared to wetland presence from approximately 35 years ago to see how they have changed over that time period. This information may then be used to help prioritize specific areas for restoration or acquisition.

This technical report is intended to support the development of the Bear Creek Watershed-Scale Stormwater Management Plan as part of King and Snohomish Counties National Pollution Discharge Elimination System (NPDES) Phase I Municipal Stormwater Permit (2013–2018) compliance (S5.C.5.c) and the cities of Redmond and Woodinville NPDES Phase II (2013–2018) compliance (S5.C.4.g).

2.0 METHODS

The fastest and most efficient way to conduct a comprehensive watershed-wide wetlands analysis is by using GIS data. Available GIS data for the study area were used to report on current conditions, conduct a change analysis, and examine potential improvement opportunities. Field work for identifying or checking wetland presence was not included in the scope of work for this project.

2.1 Wetland Data Sources

Wetland datasets used for this analysis include (King County GIS file name in bold):

1. King County Wetland Inventory (KCWI; aka, “SAO wetlands”); 1981; 1990. **SAO_WETLAND_area**
2. King County permit application data (“CAO wetlands”); 2005–2013. **wetlands_area**
3. Snohomish County wetland data¹; ca. 2011.
4. City of Woodinville wetland data; 2006–2007. **cwo_wetland** and **cwo_wetland_potential**
5. City of Redmond wetland data²; 2015.
6. National Wetland Inventory; 1983–84. **nfw_nwiwetpy**
7. King County Bog Inventory; 1997.

No available wetland dataset is considered complete. First, for those datasets based on field verification, physical surveys of every potential wetland location in the study area were not conducted. Second, for those datasets based on remote sensing, some known wetlands were missed. However, these datasets, variable in how they were created, are each useful, especially in combination.

The rest of this section provides a summary of each of the datasets used for this analysis. A map of these datasets is presented in Figure 1.

¹ King County has a wetland file for Snohomish County wetlands (f61_wetlands). However, when the author contacted staff at Snohomish County to ask some questions about how the data was created, Snohomish County provided a completely different dataset, which was subsequently used for this analysis. The file name they sent is **snoco_car_wetland.shp**. The f61_wetlands data had originally come from Snohomish County, but the dataset was so old that no current staff were aware of its history.

² King County has a wetland file for City of Redmond wetlands (crm_wetlands). However, when the author contacted staff at City of Redmond to ask some questions about how the data was created, Redmond provided a completely different dataset, which was subsequently used for this analysis. The file name they sent is **RedmondWetlands.gdb**. The crm_wetlands data had originally come from the City of Redmond, but the dataset was so old that no current staff were aware of its history.

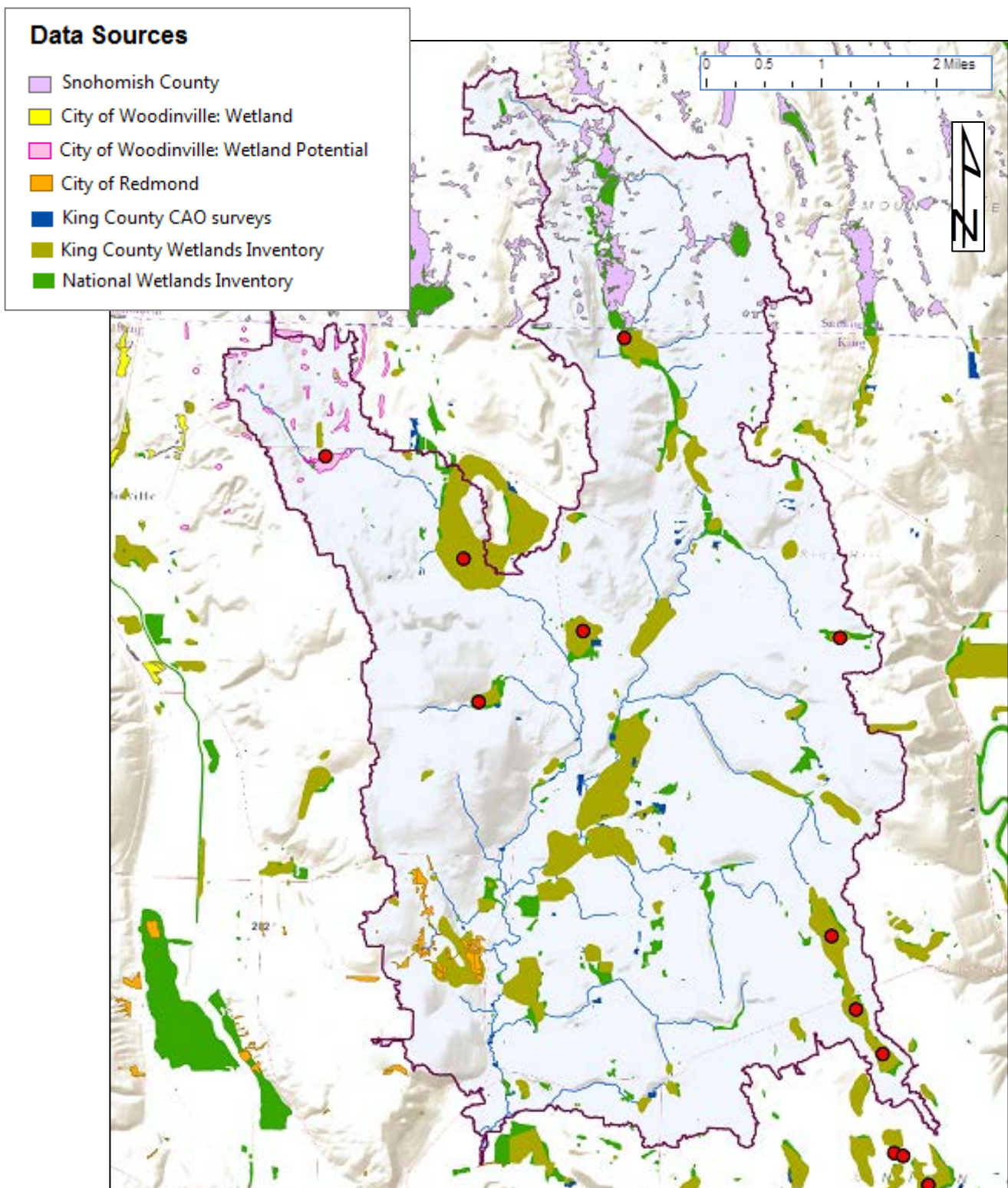


Figure 1. Wetland data sources available for the Bear Creek watershed analysis. The study area is indicated by the purple outline.

2.1.1 King County Wetlands Inventory³

The King County Wetland Inventory (KCWI) was first published in 1983. Typically, the KCWI identified and characterized wetlands only in the unincorporated parts of King County, so any areas that were incorporated at that time would not be included in the inventory (some areas that were incorporated more recently are included). Because some areas have been incorporated since the KCWI was first created, there are some KCWI wetlands in what is now City of Redmond's and City of Woodinville's jurisdictions. Because the KCWI is specific to King County, portions of the Bear Creek watershed in Snohomish County do not have this wetland data. Additionally, wetlands on federal lands and beyond the Forest Production District boundary were excluded.

The original KCWI included 868 wetlands, and the 1990 update added another 27 wetlands. A two-page hard copy data sheet was prepared for each wetland with documented information such as acreage, habitat types and features, water quality, hydrologic observations (including outlet condition), and plant and animal species observed during site visits. Each wetland was rated according to the criteria defined in the 1983 KCWI and subsequently adopted in the 1990 Sensitive Areas Ordinance; the wetland ratings are included on the data sheets. Wetland ratings used in the KCWI are described in Appendix A. All wetland classification types present at each wetland were listed on the data sheets. Each data sheet also included a hand-drawn approximation of the wetland boundary on black and white aerial photos from 1980. Scale and map orientation varied between wetlands. Because these wetlands were never delineated, drawn wetland boundaries should be considered approximate.

Data for a portion of the wetlands in the KCWI were updated in 1991 as part of the 1990 amendment to the King County Sensitive Areas Ordinance (SAO; Ord. 9614). For each reinventoried wetland, a new two-page data sheet was added to the original catalog of two-page data sheets. Subsequent to the 1991 update, wetlands have been inconsistently added to the KCWI as they were identified through development permits or field reconnaissance. Two such wetlands were added to the KCWI in approximately 1992, but no datasheets were included.

In the SAO update, the KCWI data were included in the Sensitive Areas Map Folio (King County 1987). Using the hard copy forms from the KCWI binders, E-size pen-and ink mylars were drafted at a scale of 1:24,000 for reduction and inclusion in the map folio, at a scale of 1 inch to 1 mile (1:63,360). The folio maps were cartographic products, and therefore legibility of the wetlands at the published scale was more important to the map design than precision of size or location. The wetland folio maps were designed to ensure all wetlands were readable on small printed maps, and in so doing the wetland areas for small wetlands were deliberately exaggerated. The placement of drawn wetlands was

³ This dataset and how it was created are described in great detail in part because how it was formed is relevant to this study, but also because no other written descriptions of the methods to create this GIS dataset could be found. Staff who worked on the creation of the dataset were interviewed in order to be able to present this documentation.

based on the context of road networks or other information, such as contours. Neither the original locations nor the extent of wetlands were very precise.

The mapping group in the Department of Development and Environmental Services (now Department of Permitting and Environmental Review, DPER) digitized the KCWI in a bulk process using the wetlands drawn in the SAO map folio work as the source (not the original KCWI maps). Their methods included scanning the mylars and using raster-to-vector software to convert the inked edges from pixels to a line feature. All files were transformed to the source projection, King County's standard datum/projection⁴. The GIS dataset is sometimes referred to as "SAO wetlands" because the GIS data were generated from the SAO folio and not the original KCWI.

Redrawing the wetlands from large scale to small scale back to large scale resulted in locations shifts of the wetland polygons⁵. Consequently, the outlines of the wetland drawings in GIS did not match those of the original hand-drawn maps in hard copy, and as a result, the digitized versions of the hard-copy drawings were typically very poor representations.

There are 55 KCWI wetlands in the study area. Two wetlands were added to the KCWI in 1992 and did not have hard copy drawings associated with them. The hard copy drawings for the remaining 53 wetlands were visually compared to the GIS polygons and redrawn in GIS when the SAO wetlands polygons did not match the original drawings. The redrawn polygons are better representations of the wetlands drawn in the original KCWI surveys than the "SAO wetlands" polygons. Ultimately, 47 (out of 53) wetland polygons were redrawn in the study area. KCWI wetlands used for analysis in this study reflect the newly redrawn polygons.

As part of the original digitization process, all hydrology, vegetation, and wildlife observation data from the original hard-copy catalog were put into three separate dBase tables⁶, which may then be joined to the appropriate wetland polygons in GIS. The names of the tables are `sao_wetland_hyd.dbf`, `sao_wetland_veg.dbf`, and `sao_wetland_wld.dbf`. Those tables have been archived and can be accessed via this GIS database search: <http://kcgisinternal/GISDataSearch/reports.aspx>⁷.

⁴ NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet.

⁵ Polygons are a GIS feature class used to represent areas. A polygon is defined by the arcs that make up its boundary and a point inside its boundary for identification. Polygons have attributes that describe the geographic feature they represent.

⁶ dBase is a data management program.

⁷ This database only works with Internet Explorer.

2.1.2 CAO Wetlands

“CAO wetlands” (data file **wetlands_area**) are wetlands that have been delineated under King County’s Critical Areas Ordinance regulations⁸. During the application process for clearing and grading permits, any wetlands located during a critical areas review are delineated, and maps are submitted as part of the permit application. Wetland maps submitted to DDES (King County Department of Development and Environmental Services) and subsequently DPER (King County Department of Permitting and Environmental Review) are not standardized and therefore come in a wide variety of formats.

In 2013, delineated wetland maps were converted into GIS data. The maps (in hard copy or electronic format such as Word or PDF) were obtained from DDES/DPER, and staff in King County’s GIS and Visual Communications Group replicated the delineations by hand into GIS polygons. The wetland boundaries were not obtained in the field using GPS, but rather they were visually estimated and hand drawn based on mapped field delineations. The majority of CAO wetlands digitized in 2013 were delineated between 2005 and 2009 (Table 1).

Table 1. All CAO wetlands in King County digitized in 2013.

Year	# of CAO wetlands delineated
2004	1
2005	132
2006	426
2007	449
2008	189
2009	71
2010	21
2011	8
2012	3
2013	3

The CAO wetlands are typically delineated only on the parcels for which permits have been applied. Therefore, in many instances, wetlands are only partially drawn because they cross parcel boundaries; an example of this is shown in Figure 2. The delineated CAO wetlands are the most accurate wetland data available, but the dataset is also incomplete because delineations were only made during clearing and grading permit applications. There were 68 delineated CAO wetlands in our study area as of 2013.

⁸ The Critical Areas Ordinance was actually composed of three ordinances and their associated code: K.C.C. 21A - zoning code (Ordinance 15051); K.C.C. 16.82 - clearing and grading (Ordinance 15053); and K.C.C. Title 9 - stormwater (Ordinance 15052). It was passed in 2004 and went into effect January 1, 2005.



Figure 2. Example of CAO wetland delineation stopping at parcel boundaries.

Each CAO wetland has been rated according to the criteria defined in the 2005 Critical Areas Ordinance. CAO wetland rating categories are described in Appendix B.

2.1.3 Snohomish County

Snohomish County provided wetland data for this analysis (snoco_car_wetland). Their data was created with a model using weighted probabilities of wetlands being present. This dataset was created in 2011 and includes 102 wetland polygons fully or partially in the Bear Creek watershed in Snohomish County.

King County has an old dataset (f61_wetlands), which shows 45 wetland polygons in the Snohomish County portion of the watershed. However, this dataset was not used for the analysis because the relatively new data provided by Snohomish County was considered by Snohomish County staff to be more accurate.

2.1.4 City of Woodinville

Wetland data from the City of Woodinville came from two sources. One dataset (**cwo_wetland**) appears to be based on permit-related delineations, and as with King County's CAO wetlands, some of the boundaries follow parcel lines instead of actual wetland boundaries. The remaining dataset (cwo_wetland_potential) is compiled primarily from studies conducted in 2006 by Cooke Scientific and 2007 by Jones and Stokes. Wetlands in those studies were not delineated (therefore boundaries were not verified) but were viewed in the field by wetland professionals and are likely as reliable as the wetlands visited in the KCWI. There are 8 wetlands in the City of Woodinville's "wetland" dataset and 28 in their "wetland potential" dataset within the study area.

2.1.5 City of Redmond

In 2015, the City of Redmond created two types of wetland GIS data: delineated wetlands and estimated wetlands. The delineated wetland data came from wetland reports from critical areas reviews. The estimated wetland data came from City of Redmond Natural Resources staff knowledge. Within the study area, there are 41 delineated wetland polygons

(cut by parcel boundaries, so representing far fewer wetlands) and 5 estimated wetland polygons (representing approximately 3 wetlands) in the 2015 dataset.

King County has an older dataset on file from 2006–2007 (crm_wetland), which shows 13 wetland polygons in the City of Redmond portion of the watershed. However, this dataset was not used for the analysis because the data provided by the City of Redmond was considered by their staff to be more accurate.

2.1.6 National Wetlands Inventory

In 1988 the U.S. Fish and Wildlife Service (USFWS), through the National Wetlands Inventory (NWI), completed wetland mapping for the State of Washington (Peters 1990). NWI data cover the entire study area. Current NWI data within the study area were derived from NWI wetland maps at a scale of 1:24,000 (U. S. Geological Survey 7.5 minute topographic map) that were prepared using color infrared aerial photographs (1:58,000 scale) taken in 1981. Photo-interpretation procedures combined with field review of a subsample of the wetland sites were used to complete the wetland mapping using the Classification of Wetlands and Deepwater Habitats of the United States (Cowardin et al. 1979). Because of the limitations of mapping primarily through the use of aerial photography, a small percentage of wetlands were likely not identified. There are approximately⁹ 186 NWI wetlands in this inventory in the Bear Creek Basin study area. Wetlands in the NWI are typically rendered in greater detail than in the KCWI. In the NWI, each wetland classification type is mapped within a single wetland complex. For example, a wetland with open water component, forest component, and emergent components are mapped into separate polygons and together they comprise a single wetland, whereas the same wetland in the KCWI would be a single polygon with several associated classifications.

2.1.7 King County Bog Inventory

The King County Bog Inventory (King County 1997) was conducted in 1997 and included all wetlands identified in the KCWI that have all or a portion of the vegetation community dominated by *Sphagnum* moss. The inventory includes both the original data sheets from the 1983 KCWI and the 1990 KCWI update as well as data sheets new in 1997 that include an expanded characterization of the bog portion of each wetland.

The bog inventory was created because wetlands containing *Sphagnum* moss are highly sensitive and easily disturbed, and this information may be used to help establish appropriate regulated wetland buffers. However, the data was not transferred to GIS as part of the inventory process. Subsequently, King County staff have created a point file that includes all the wetlands identified in the King County Bog Inventory as well as other bogs not included in the inventory.

⁹ Number is approximate because some mapped wetlands are close together and may in fact be the same wetland. Additionally, some wetlands that had obviously been a single wetland historically now have roads severing them and dividing them into two or more wetlands.

2.2 Current Conditions

A consolidated wetland file provides a map of where wetlands may be located and gives an idea of the total amount of wetland area in the watershed. A single, consolidated wetland file was created by first combining all the available wetland data described above in “Wetland Data Sources” into a single file. All overlapping and adjacent wetland polygons were merged, such that each resultant wetland polygon represents the outermost boundaries of each contributing polygon (Figure 3).

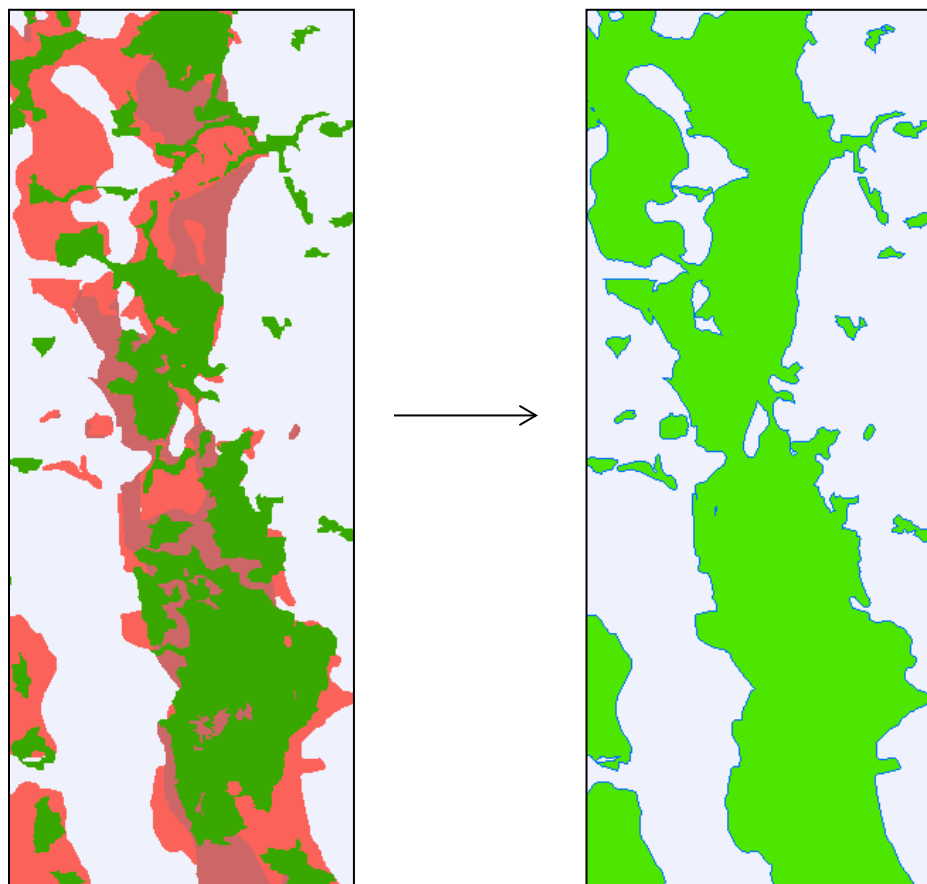


Figure 3. Detail to show result of taking all overlapping wetlands and merging them into a single dataset.

Wetland boundaries from the different data sources vary considerably from one another. Even boundaries of the same wetland rarely matched between different data sources. If one dataset were known to be highly reliable for its geographic range, wetlands from that dataset could be used for the comprehensive map; however, no single dataset is reliable to the degree that other wetland data in the same geographic area could be confidently ignored. Therefore, a map intended to represent all mapped wetlands in the Bear Creek watershed study area created from such widely varying sources is necessarily generalized.

In instances where wetland polygons crossed the watershed boundary, it is possible the boundary line was off or the wetland polygon was incorrect. It is also possible the wetlands

were saddle wetlands that straddled two catchments. Because the purpose of this map is to help identify areas in need of protection, improvement, and restoration, it is better to err on the side of inclusion. Therefore, if wetlands crossed the watershed boundaries, they were included on the map. The only exception is if almost the entire wetland was mapped outside the study area, those were excluded from the map.

2.2.1 Wetland Classification

In 1979, a comprehensive classification system of wetlands and deepwater habitats was developed for the U.S. Fish and Wildlife Service (Cowardin et al. 1979). This system is used to define wetland types ecologically. Under this system, wetlands are of two basic types, coastal and inland (palustrine). The Cowardin system is hierarchical and includes several layers of detail for wetland classification including water flow, substrate type, vegetation types and dominant species, and flooding regimes and salinity levels. This analysis examines only the main classification types including emergent, forested, scrub-shrub, and open-water.

Only two of the available wetland datasets include wetland classification information: KCWI and NWI. The KCWI wetlands are drawn as a single polygon with only a list of the different wetland types present. However, as mentioned in Section 2.1.6, each wetland classification type in the NWI has its own polygon. Therefore, the NWI data is best suited to provide an estimate of the proportion of area covered by different wetland types in the study area. Areas of each wetland type were aggregated to provide a total sum of area (acres) in each wetland type.

2.2.2 Wetland Ratings

All wetlands provide some functions and resources that are valued. These functions and resources may be ecological, economic, recreational, or aesthetic. Managers, planners, and citizens need tools to understand the resource value of individual wetlands in order to protect them effectively.

Wetland rating systems are a category of such tools. Rating systems are developed for different reasons, such as to differentiate between wetlands based on their sensitivity to disturbance, their significance, their rarity, our ability to replace them, and the functions they provide. The rating categories are intended to be used as the basis for developing standards for protecting and managing the wetlands to reduce further loss of their value as a resource. For example, rating systems are typically used to assign protective buffers.

These rating systems may vary both across time and depending on the agency doing the rating. When the KCWI wetlands were inventoried, each wetland was assigned a rating of 1, 2, or 3 (Appendix A). The rating system was based on wetland size, complexity, and presence of rare or listed species. More recently, the King County Critical Areas Ordinance has a rating system of four categories (Appendix B) based on Washington Department of Ecology's wetland rating system, which is based on wetland function. These ratings have been applied to the CAO wetlands. These rating "categories" are determined using an

extensive worksheet designed by the Washington Department of Ecology¹⁰ and based on wetland function.

KCWI wetlands were examined by rating number, and CAO wetlands were also grouped by wetland category to determine the presence in number and total area of the different wetland categories.

2.2.3 Bogs

The King County Comprehensive Plan includes *Sphagnum*-dominated peat bogs as a habitat of local importance. Peat bogs are a habitat of local importance because they support a unique plant and animal community, they have declined as a result of development, and they are fragile ecosystem that can be easily destroyed but cannot be easily restored.

The Cowardin (1979) wetland classification system described above allows for assigning subclasses and special modifiers, such that bog wetlands may be inferred. For example, a wetland classified as PSS3 would be a palustrine scrub-shrub wetland with broad-leaved evergreen plants. Although lacking further information it would not be a definitive way to identify bogs, broad-leaved evergreen species (locally these include Labrador tea and bog laurel) tend to be associated with bogs. However, the NWI GIS data does not include the subclass data that might suggest the presence of a bog wetland. And in fact, the original KCWI sometimes did not include the PSS3 classification, even when the broad-leaved evergreen species were present. Sometimes the classification for a bog in the KCWI is PSS1, palustrine scrub-shrub broad-leaved deciduous. That designation alone might indicate willow, or it might indicate “hardhack,” but willow are not known to be associated with *Sphagnum* moss at all, and hardhack, or *Spirea*, is a very common wetland species in this region and alone would not indicate the presence of *Sphagnum* moss. Finally, the original KCWI data generally did not include the PML1 classification, which is palustrine moss/lichen class with subclass of moss. Rarely was this classification applied to KCWI wetlands, even when *Sphagnum* moss was present.

In short, there is no way to reliably identify the presence of bogs with the use of GIS data alone. The data sheets associated with the original KCWI identify the presence of a bog component with a common name included along with the classification. As described in Section 2.1.7, all known bogs in the study area have been digitized into a point file. This point file was used to identify the locations of bogs within the watershed, as well as identify how many of them are in public versus private ownership.

2.3 Determining Change in Wetland Condition

Wetlands serve numerous purposes, or functions, including protecting water quality, providing flood protection, recharging groundwater, and providing habitat for wildlife. Changes in wetland condition can change function and therefore change ecosystem and

¹⁰ The Washington State Wetland Rating System for Western Washington is available at: <http://www.ecy.wa.gov/biblio/0406025.html>. Also see Appendix B.

habitat value. Wetlands can be impacted in many ways by development. The function of wetlands can be degraded and lost if they are filled or drained. Changes in land use adjacent to wetlands can impact water quality and chemistry, hydrology, and vegetation, which in turn may eliminate the wetland or change the wetland type or class by changing its functions.

The best method to assess wetland condition is to field investigate and record wetland features (soils, hydrology, vegetation communities, topography, etc.). Collecting field data in different years provides information to examine change in wetland condition over time. But with an absence of field-collected data, determining change in wetland condition or function is extremely limited.

However, aerial imagery may be used to remotely account for loss of wetland area to development. Historic and current information may be compared in order to determine change in wetland area over time. There are several reasons for conducting a wetland change analysis, including monitoring trends in habitat loss and monitoring changes in stormwater retention capacity. Specifically, determining how much wetland area and function has been lost since European settlement would provide an historic perspective to how much flood storage capacity, for example, has been lost. Unfortunately, this type of analysis would require historic data that does not exist and current data that would be very expensive and time-consuming to acquire. Another reason to conduct change analysis is to determine how much wetland area has been lost to development over a shorter time period, such as since protective regulations have been in place. Although this latter type of analysis is not as comprehensive as one that could look at the full time scale since pre-development, this level of analysis is feasible and provides valuable information.

The KCWI wetlands were a good candidate to analyze wetland loss because the data was field verified and the wetlands cover most of the study area. KCWI was therefore selected as the subset of the watershed's wetlands to analyze for loss over the past 26–35 years. The King County Wetland Inventory (KCWI) was first published in 1983 (data collected June through September 1981) with an update in 1991 (data collected June through August 1990). KCWI contains 53 wetlands in the study area that were field verified in 1981 (45) and updated (4) or added (8) in 1990.

Photos from the original 53 surveys were compared with current (2015) aerial imagery in order to determine the amount of apparent wetland loss to development. Anywhere development encroached into the previously drawn polygon, it was assumed that wetland experienced loss, and a new polygon was drawn to reflect the change (Figure 4). On some occasions, roads crossed the original KCWI wetlands; those areas of development were not included in the analysis (for example, see Figure 4).

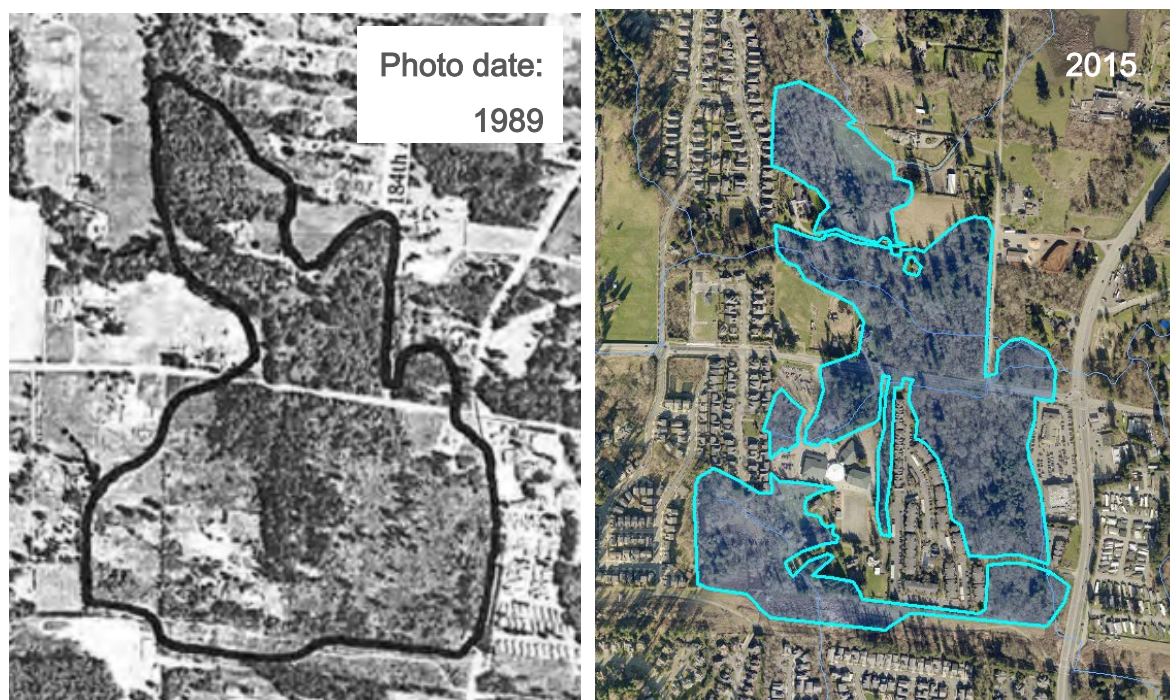


Figure 4. Example of KCWI wetland surveyed in 1990 (87 acres) compared to 2015 aerial (60.3 acres). Notice the road crossing the wetland; that area of development was included in the original polygon so was left intact in the 2015 analysis.

2.4 Wetland Regulations

Wetland regulations in King County have evolved over time to increasing levels of protection from development (Appendix C for detailed regulatory timeline). Although some wetland policies related to open space were established in the King County Comprehensive Plan by 1973, in addition to calling for the preservation of many wetlands, those policies also supported removal of “hazardous” wetlands or wetlands that created an “extreme nuisance” as well as policies supportive of peat mining. Wetland protections with respect to development permits first went into code in 1979. These first wetland protections in King County applied to the wetlands only and did not include any buffers. It was not until 1990 that wetland buffers were also protected in King County via the Sensitive Areas Ordinance and associated code. By 2005, wetland buffer sizes were increased when Critical Areas Ordinance went into effect.

The history of wetland regulations and protective measures is examined and discussed in relation to when development was occurring in the watershed.

3.0 RESULTS AND DISCUSSION

This section provides the results of the current conditions and change analyses. Each set of results is accompanied by a discussion of the findings.

3.1 Current Conditions

The final combined, merged wetland dataset from the available data sources described in Section 2.1 show 326 wetland polygons in the Bear Creek watershed study area totaling 1792.8 acres (including those wetlands that are only partially inside the study area). There are likely many more wetlands in the basin that are not mapped (errors of omission), and it is possible some mapped wetlands are not actually wetlands (errors of commission). The final map, which is used to identify known or potential wetland locations as well as generate the total area of wetland cover, is shown in Figure 5.

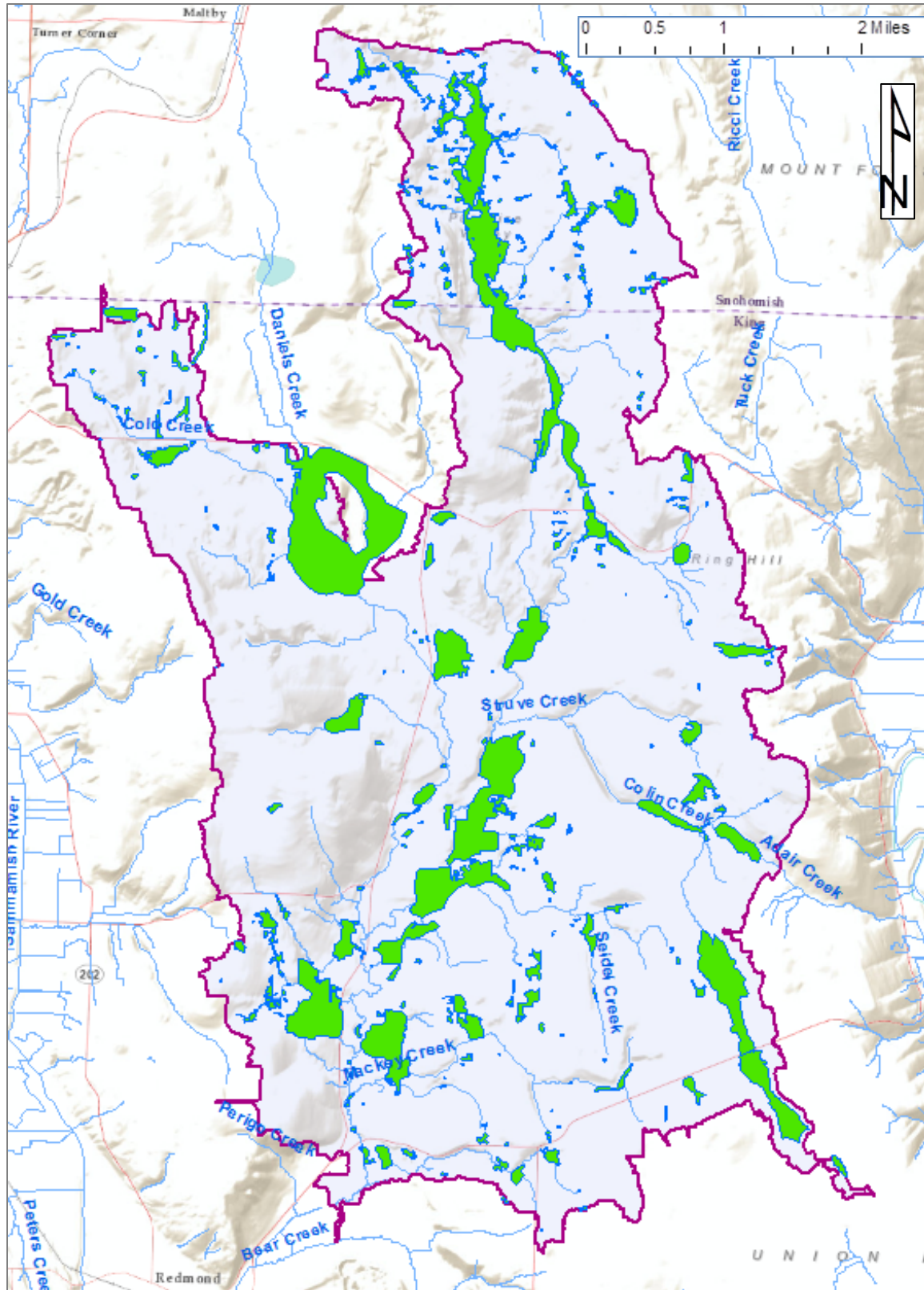


Figure 5. Mapped wetlands in the study area once all wetland data are merged. The study area is indicated by the purple outline.

3.1.1 Wetland Classification

The NWI dataset was used to aggregate the area of wetland types (Table 2). Forested wetlands are the most common wetland type in the Bear Creek watershed followed by scrub-shrub wetlands. No single wetland type is rare; however, open-water ponds are the least common type present.

Table 2. Area and proportion of each wetland classification type in the study area.

Wetland Type	Acres	Percent
Emergent	236.7	23.4
Forested	348.1	34.4
Scrub-Shrub	315.7	31.2
Open-water Pond	111.6	11.0

These data do not suggest one particular wetland classification type is at greater risk than the others or should be protected more than others.

3.1.2 Wetland Ratings

Of the 55 KCWI wetlands in the study area, the majority had a wetland rating of 1 (25 percent) or 2 (70 percent) (Table 3). Only 3 wetlands (6 percent) were rated 3. That so few wetlands were rated 3 is not surprising, because the wetlands in the KCWI tended to be larger, more noticeable wetlands, and wetlands rated as 3 are small (under an acre in size) and have only one or two wetland classifications present.

Table 3. The wetland rating of KCWI wetlands in entire inventory versus those in study area.

Wetland rating	All KCWI through 1990 update		KCWI wetlands in study area	
	Number (%)	Acres (%)	Number (%)	Acres (%)
1	188 (21.7)	10,167.9 (51.1)	13 (24.5)	604.8 (55)
2	572 (66.1)	9,607.4 (48.3)	37 (69.8)	493.1 (44.9)
3	106 (12.2)	118.2 (0.6)	3 (5.7)	1.4 (0.1)
total	866	19,893.5	53	1,099.3

Of the 68 CAO wetlands delineated in the study area, 2 were missing the rating data. Of the remaining 66, only 6 (9 percent) were rated as Category I, but they accounted for 29 percent of the wetland area (Table 4). The majority of CAO wetlands were category II or III; however, by far the most wetland area was covered by category II wetlands (26 wetlands covering 45 percent of the total wetland area).

The range of regulated buffers is included in Table 4 to give an idea of the implications of the wetland category. There is a fair amount of overlap of potential protective buffer sizes among category I, II, and III wetlands based on wetland type and habitat score. Therefore, wetland rating alone may not provide enough information to help decide on which wetlands provide greater levels of habitat value or other values.

Table 4. Wetland ratings of the CAO wetlands in the study area.

Wetland category	number	percent	acres	percent	Protective buffer size range (ft)*
I	6	9.1%	11.3	28.8%	50-300
II	26	39.4%	17.6	45.0%	50-300
III	26	39.4%	8.9	22.8%	40-150
IV	8	12.1%	1.3	3.3%	25-50
total	66		39.1		

*Range in protection depends on wetland type as well as intensity of impact of adjacent land use.

3.1.3 Bogs

In the study area there are seven known extant peat bogs and two peat bogs known to be extinct (Figure 6; Table 5). Of these bogs, only three of the extant bogs are currently in some form of protected land – one is in a TRACT parcel, one in a homeowner's association, and one in public ownership.

Table 5. Known extant (existing) and extinct bogs in the Bear Creek watershed study area.

KCWI number	Extant	ownership
0203	Yes	Private
0209	No	TRACT
0210	No	Public
0219	Yes	Private
0223	Yes	Private
0232	Yes	Private
0244	Yes	TRACT
0245	Yes	HOA
0252	Yes	Public

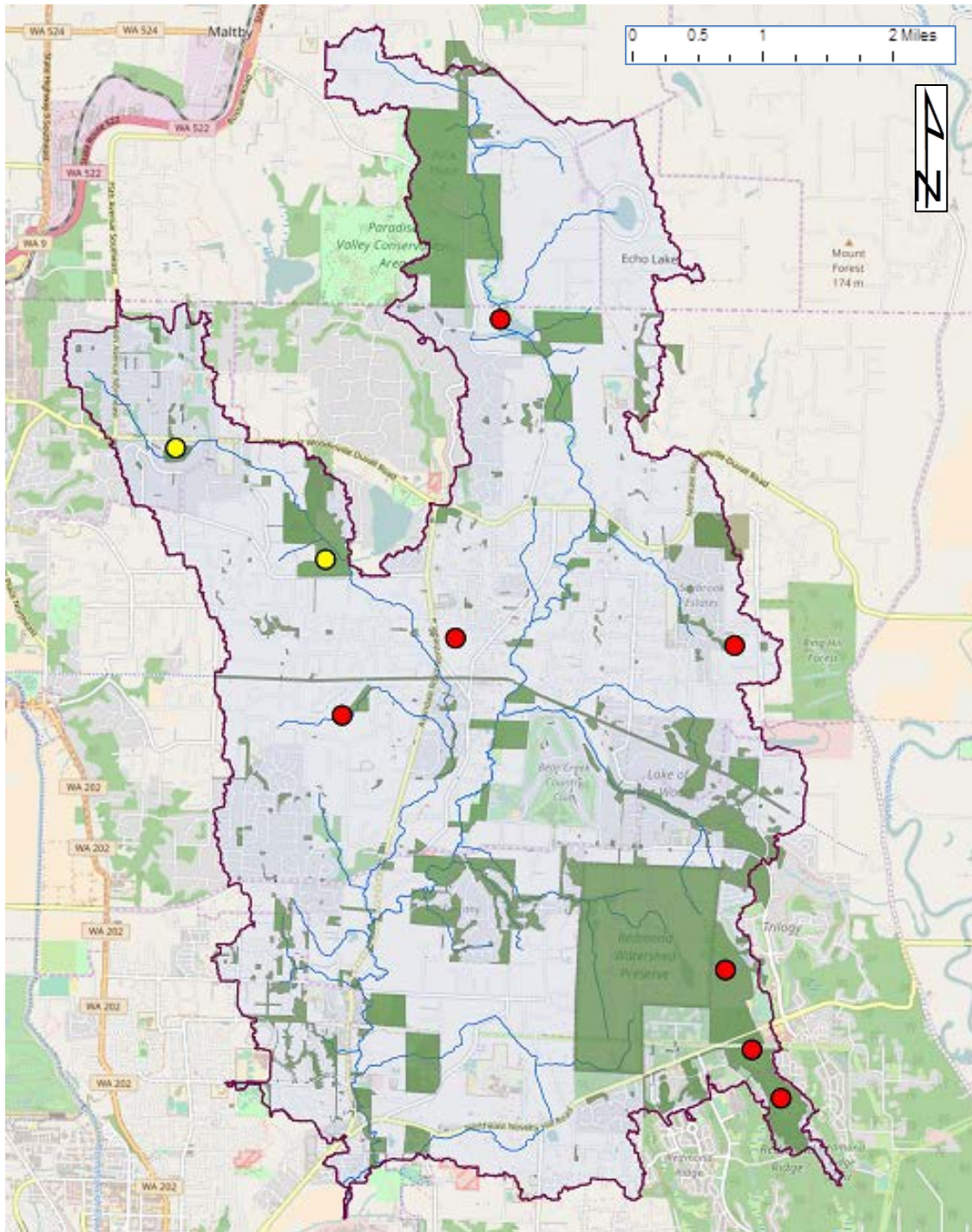


Figure 6. Location of extant and extinct bogs in the Bear Creek watershed study area. Extant bogs are indicated by red dots; extinct bogs are yellow dots. Public lands are shown in dark green.

3.2 Wetland Change

Using aerial photos, 53 KCWI wetlands were examined for loss to development. Of the 53 wetlands, 11 (21 percent) were visibly altered (Table 6). The remaining 42 (79 percent) KCWI wetlands were visibly unchanged.

Table 6. Change in the KCWI wetlands in the Bear Creek watershed study area.

Visual change in wetland area since 1981 / 1990?	# of wetlands	Approx. area of wetlands (acres)	
		1981 / 1990	2015
Yes	11	371	325
No	42	728	728
Total	53	1099	1053

The 11 wetlands that were obviously visibly changed since they were first inventoried vary in the amount of loss, ranging from 0.2 to 27.1 acres (Table 7). The percent of each individual wetland that was lost ranges from 4.1 to 53.8 percent.

Table 7. The 11 wetlands with development since they were put into the KCWI.

Wetland ID	Survey date	Original size in acres	2015 acres not developed	Change in wetland area to development	Percent of wetland area lost
0217	1981 0616	4.3	4.1	-0.2	4.7
0223	1981 0616	10.9	10.3	-0.6	5.5
0230	1990 0705	130.9	124.5	-6.4	4.9
0236	1981 0625	1.3	0.6	-0.7	53.8
0238	1990 0620	3	2.5	-0.5	16.7
0256	1981 0616	2.4	2.3	-0.1	4.2
0280	1990 0705	43.9	42.1	-1.8	4.1
0284	1990 0705	87.4	60.3	-27.1	31.0
0287	1990 0705	79.1	71.0	-8.1	10.2
0289	1990 0705	2.4	2.2	-0.2	8.3
0294	1990 0706	6	5.3	-0.7	11.7
Total:		371.4	325.1	-46.3	

This approach to determining wetland loss is assumed to be conservative, as development in the middle of a wetland is likely to significantly compromise the function of the remaining wetland fragments (see the example in Figure 4). A total of 46 acres out of the original 1099 were developed; this change of 4.2 percent is relatively small. However, this exercise is crude at best and cannot account for loss of function or loss of wetlands that were not previously mapped. Furthermore, many of the wetlands mapped in the KCWI were larger, more obvious wetlands. Smaller wetlands and forested wetlands that were uncataloged or unprotected may have been more likely to be drained and filled.

Of the 11 wetlands that were visibly altered, 2 had a wetland rating of 1 and 9 had a rating of 2 (Table 8). Both in numbers and acreage, KCWI wetlands rated 2 were the most impacted during this time frame. By area, wetlands rated 2 were most heavily impacted by development; however, wetlands rated 1 accounted for a higher percentage of wetland area in the watershed. It is unclear why these category 2 wetlands would be disproportionately affected by development.

Table 8. Comparison of the number and area of KCWI wetlands in the watershed versus in the entire inventory, and then of those in the watershed which ones were impacted by development.

Wetland rating	Total KCWI wetlands in study area				KCWI wetlands impacted		Loss of KCWI wetlands	
	number	percent	acres	percent	number	percent	acres	percent
1	13	25	605	55	2	15	7	1
2	37	70	493	45	9	24	39	8
3	3	6	1	0	0	-	0	0

All the analysis above was conducted using the KCWI. The CAO wetlands also provide clues as to how wetlands may have changed over time. There were 68 delineated CAO wetlands in the study area as of 2013. Approximately one-third (21) of these 68 wetlands overlap some portion of wetlands mapped in the King County Wetlands Inventory or National Wetlands Inventory. The other 47 are not in the immediate vicinity of NWI or KCWI wetlands. In some instances, they are in the proximity of larger mapped wetlands and may be a part of a larger wetland complex, but many are 500 ft or more from the nearest mapped wetland. The CAO wetlands were identified because the property owners had applied for a clearing and grading permit and the wetlands were found and mapped during their critical areas review as part of the application. That so many previously unmapped wetlands were discovered during the permitting process suggests that many wetlands remain undiscovered on properties where no one has applied for permits and conducted critical areas surveys. These previously unmapped wetlands tend to be small (less than 1.5 acres), forested, or both – reasons why the respective inventories might have missed or not included them. Assuming there are many others that have not yet been discovered, errors of omission are nearly certain.

Mapped wetlands that are errors of commission may have once been wetlands but are no longer because they were filled, developed, or because they were impacted in some other way that caused them to lose their wetland characteristics. It is also possible some mapped wetlands were not wetlands in the first place. This latter scenario is more likely when wetlands were modeled and not field verified.

Records of wetlands in the Bear Creek watershed do not exist prior to the KCWI. Without historic reference, it is impossible to know how many wetlands may have been drained or filled before the mapping exercises of the early 1980s.

3.3 Wetland Regulations

Wetland protection milestones in relation to when development was occurring in the Bear Creek watershed is illustrated in Figure 7 (for more details on Wetland Regulations, see Appendix C). The green bar in Figure 7 is when the KCWI wetlands were originally mapped. A lot of development was occurring in this time period. However, wetlands were already being protected when the KCWI wetlands were mapped in 1981, and by the time of the KCWI update in 1990, protections on the wetland buffers were going into effect via the adoption and implementat of the Sensitive Areas Ordinance (SAO). Therefore, any changes in this subset of wetlands over this timeframe would have occurred since the SAO and subsequent CAO (with even larger wetland buffers) were implemented. The protective regulations are likely a primary reason that a relatively small percentage of the wetlands in the change analysis shows loss to development.

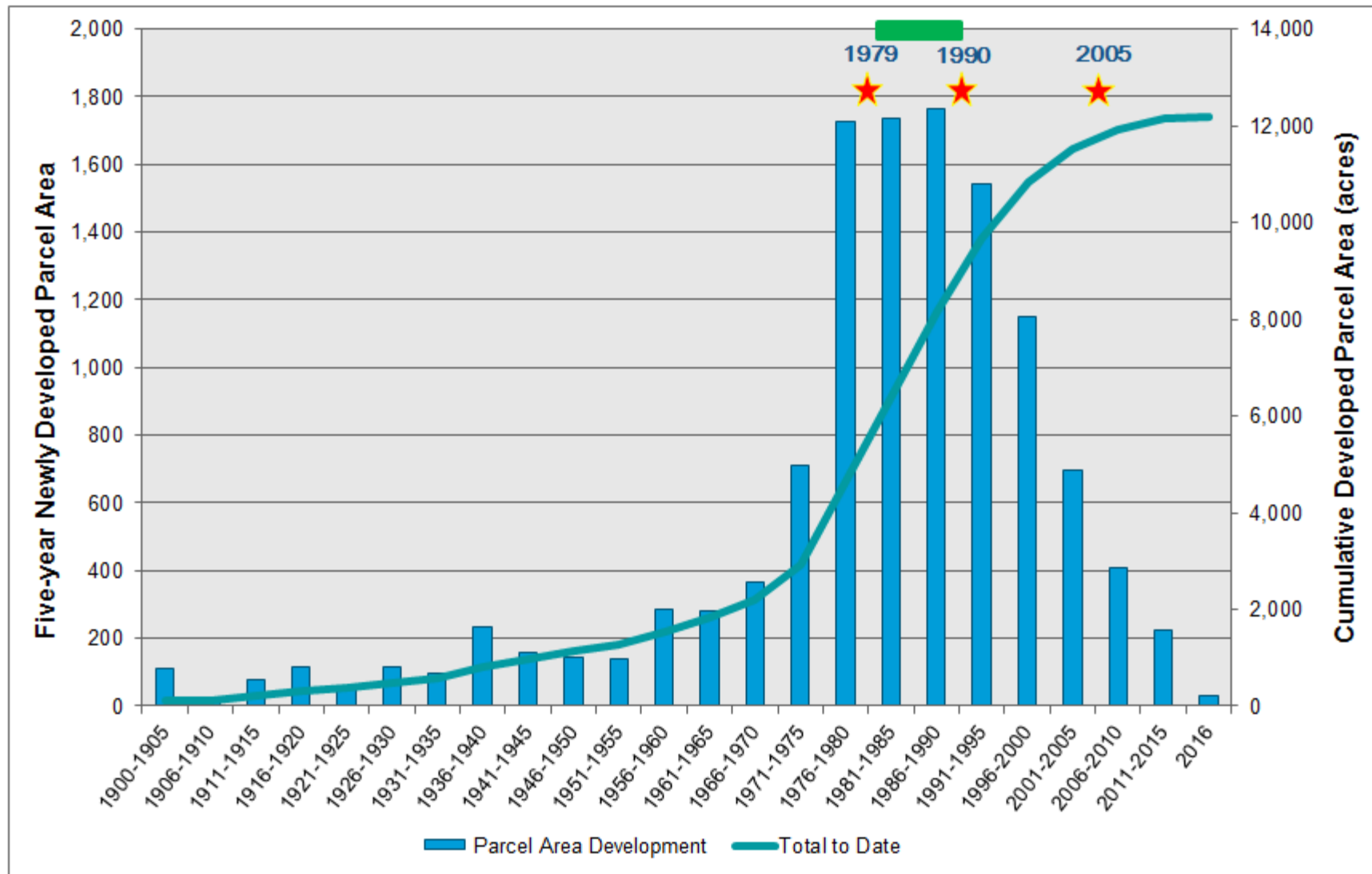


Figure 7. Urbanization over time in the study area. The three stars indicate when protective regulations were put into place in King County only; 1979 was when wetlands were first protected in King County code, 1990 was when protective buffers for wetlands were put into place via the Sensitive Areas Ordinance, and in 2005 wetland buffer sizes were increased when Critical Areas Ordinance went into effect. The green bar is the span of time over which the KCWI was created.

4.0 RECOMMENDATIONS

The following recommendations were generated after conducting the Bear Creek watershed wetland analysis. Any or all of the following recommendations could be conducted/implemented to improve and enhance our knowledge of wetlands in the Bear Creek watershed and therefore contribute to any protection and restoration plans.

New Map Data: The KCWI has not been updated since 1990, and the NWI hasn't been updated since the early 1980s. Yet these are two of the primary sources of data for reporting on current conditions. Snohomish County used a type of modeling that they felt relatively confident in. It is recommended that King County run the same modeling exercise to generate comparable data.

Field Checking: It is recommended that a subset of the newly modeled wetlands are field checked in the same manner as the KCWI and the City of Woodinville checked theirs. If no new modeling takes place, it is recommended that a new update to the KCWI is undertaken using the same methods as when originally conducted.

Monitoring: Once field checking commences, follow-up monitoring on a schedule of approximately every 5 years is recommended to continue to have the most up-to-date information available.

Mapping by King County DPER: Being able to track in real time the wetlands that are delineating during critical areas reviews for permit applications would greatly enhance our knowledge of current conditions. It is strongly recommended a new procedure be put in place to add wetlands to a spatial database (GIS) as they are submitted.

Functional Analysis: The analysis in this report assumes that loss to development is the primary source of wetland loss in the watershed. A functional analysis, yet to be determined, may help determine if that assumption is correct, and if it isn't, what the other contributions to wetland loss in the watershed are.

5.0 REFERENCES

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6.0 APPENDICES

Appendix A: King County Wetland Inventory Wetland Ratings

Appendix B: King County Critical Areas Ordinance Wetland Ratings

Appendix C: King County Wetland Regulations

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Appendix A: King County Wetland Inventory Wetland Ratings

When the KCWI wetlands were inventoried, each wetland was assigned a rating of 1, 2, or 3. The ratings were based on the following criteria, which were defined in the 1983 inventory and subsequently adopted in the King County Sensitive Areas Ordinance.

Criteria for wetland rating of 1, the highest rating:

- a. The presence of species listed by the federal government or the State of Washington as endangered or threatened, or the presence of critical or outstanding actual habitat for those species;
- b. Wetlands having 40 to 60 percent permanent open water in dispersed patches with two or more classes of vegetation;
- c. Wetlands equal to or greater than ten acres in size and having three or more wetland classes, one of which is open water; or
- d. The presence of plant associations of infrequent occurrence.

When a wetland is assigned a rating of 1, one to four letters (a, b, c, or d) will appear in parenthesis to the right. Each letter corresponds to one of the four criteria described above. This notation is intended to inform the user of the reasons for assigning the highest wetland rating.

Criteria for wetland rating of 2:

- a. Wetlands greater than one acre in size;
- b. Wetlands equal to or less than one acre in size and having three or more wetland classes;
- c. Wetlands equal to or less than one acre that have a forested wetland class;
- d. The presence of heron rookeries or raptor nesting trees.

Criteria for wetland rating of 3:

Any wetlands that are equal to or less than one acre in size and that have two or fewer wetland classes.

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Appendix B: King County Critical Areas Ordinance Wetland Ratings

King County, in its Critical Areas Ordinance, adopted the Department of Ecology's Wetland Rating methodology. The four wetland categories are described below. The scoring is based on the rating form found here:

<https://fortress.wa.gov/ecy/publications/parts/0406025part1.pdf>

Category I

Wetlands that represent a unique or rare wetland type, or are more sensitive to disturbance than most wetlands, or are relatively undisturbed and contain ecological attributes that are impossible to replace within a human lifetime, or provide a high level of functions, score of 70 points (out of 100) on the wetland rating form. Category 1 wetlands include estuarine, bogs, mature and old-growth forests, coastal lagoons, wetlands that perform many functions very well. Category 1 wetlands may be part of the "priority habitat" as defined by the Washington State Department of Fish and Wildlife (WDFW) <http://www.wdfw.wa.gov/hab/phspage.htm>, or be identified as a Natural Heritage wetland by the Washington Natural Heritage Program of the Department of Natural Resources (DNR) <http://www.dnr.wa.gov/nhp/index.html>.

Category II

Wetlands that are difficult, though not impossible to replace, and provide high levels of some functions. These wetlands occur more commonly than Category I wetlands but still need a relatively high level of protection. Category II wetlands include, but are not limited to, wetlands that perform functions well and score 51 to 69 points for habitat.

Category III

Wetlands with a moderate level of functions, scores between 30 to 50 points for habitat and generally have been disturbed in some ways, and are often less diverse or more isolated.

Category IV

Wetlands that have the lowest levels of functions (scores less than 30 points for habitat) and are often heavily disturbed. These are wetlands that we should be able to replace or improve. These wetlands may provide some important function and also need to be protected.

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Appendix C: King County Wetland Regulations

A brief summary of the timeline of King County wetland regulations:

- November 8, 1973. King County Ordinance 1838. The Council of King County declares it to be in the public interest to retain certain wetlands within a system of open space. Ordinance includes an addendum to the Comprehensive plan with policies that were intended to serve as one basis for evaluating the preservation, removal and/or incorporation of wetlands into development plans. In addition to calling for the preservation of many wetlands, there are also policies supporting removal of “hazardous” wetlands or wetlands that create an “extreme nuisance.” Additionally, there are policies supportive of peat mining.
- July 12, 1979. King County Ordinance 4365. Defines wetlands as a sensitive area. Wetlands located on the site of a proposed development requiring a permit shall not be disturbed or altered unless King County determines that either: (1) the wetland does not serve any of the valuable functions of wetlands identified in Ordinance 1838 and Army Corps of Engineers 33 CFR 320.4(b), including but not limited to wildlife habitat and natural drainage functions; or (2) the proposed development would preserve or enhance the wildlife habitat, natural drainage, and/or other valuable functions of wetlands as discussed in Ordinance 1030 or Army Corps of engineers 33 CFR 320.4(b) and would be consistent with the purposes of this ordinance.
- August 30, 1979. King County Code 21.54.160. First inclusion of wetlands as a Sensitive Area into code. Language mirrors that in King County Ordinance 4365.
- August 29, 1990. King County Ordinance 9614. Much expanded policy direction for wetlands protected from development as sensitive areas. Overall policy objective for wetlands is no net loss of wetlands functions and values. Includes alteration exceptions and mitigation guidance. Ordinance includes first policies for wetland minimum buffer requirements:
 - Class 1 wetlands shall have a 100 foot buffer.
 - Class 2 wetlands shall have a 50 foot buffer.
 - Class 3 wetlands shall have a 25 foot buffer.
- September 1990. King County Code 21.54.160-190. Puts into regulations the policies described in King County Ordinance 9614.
- October 29, 2004. Critical Areas Ordinance package—ordinances 15051, 15052, and 15053. Wetlands included as critical areas with expanded definitions, new alterations table, new wetlands classification system and new buffers, which range depending on wetland type as well as intensity of impact of adjacent land use. Buffer sizes for wetlands outside the urban growth area:
 - Class I: 50-300 ft.
 - Class II: 50-300 ft.
 - Class III: 40-150 ft.

- Class IV: 25-50 ft.
- January 1, 2005. Wetlands as critical areas codified in King County Code Chapter 21A.24. Puts into regulations the policies described in King County ordinances 15051, 15052, and 15053. Specific code sections are thus:
 - 21A.24.318 Wetlands — categories.
 - 21A.24.325 Wetlands — buffers.
 - 21A.24.335 Wetlands — development standards and alterations.
 - 21A.24.340 Wetlands — specific mitigation requirements.
 - 21A.24.342 Wetlands — agreement to modify mitigation ratios.
 - 21A.24.345 Specific mitigation requirements — wetland mitigation banking.