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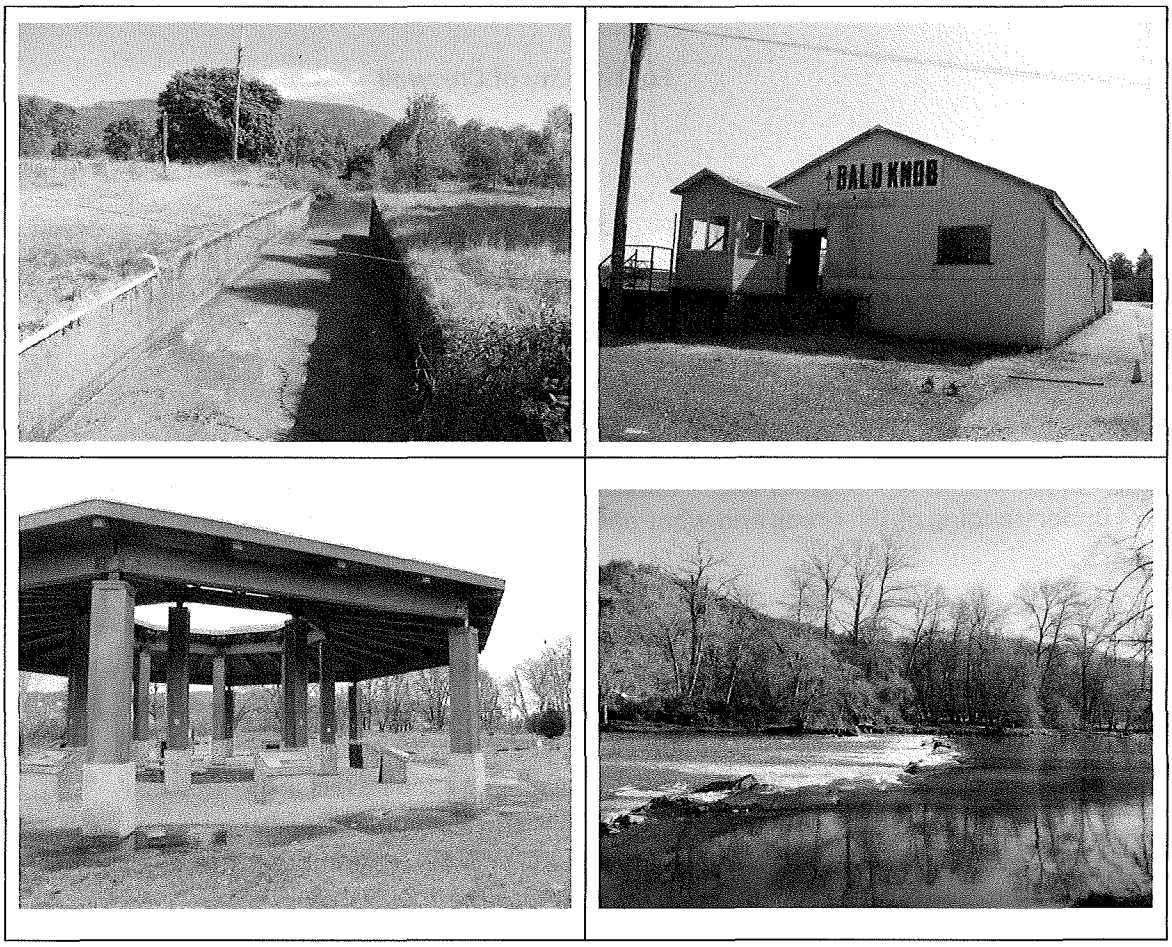
Coast Fork Willamette Watershed Council

City of Creswell

Hill Creek Management Plan



June 2015

Hill Creek Management Plan

By the
Coast Fork Willamette Watershed Council
Prepared by Pamela Reber
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For the City of Creswell

June 2015

Acknowledgements
Special thanks to the many individuals in the Creswell area who contributed to the collective understanding of Hill Creek and what needs to be done to enhance its function and condition.

Including:
Cliff Belew, City of Creswell
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Cover photos clockwise from top right: Bald Knob Mill Building, Coast Fork push up dam, Garden Lake Park Ron Petitti Memorial Pavilion, and the Hill Creek diversion structure where it meets the Coast Fork Willamette River.

TABLE OF CONTENTS

LIST OF FIGURES

Executive Summary

Hill Creek near Creswell, Oregon has complex water rights, property rights, and community relationships woven into its water resource issues. In this document, five different issue areas are discussed as focus areas for future action. Current conditions and the history of settlement, habitat, and stream flow as they relate to Hill Creek form the premise. Recommendations for future actions are preceded by an outline of process opportunities as many solutions fall outside of city limits and are inextricably linked to the voluntary cooperation of the affected landowners and water right holders meaning that specific projects must be driven forward by the needs and priorities of Creswell and the surrounding territory. Finally, agencies and organizations like the Coast Fork Willamette Watershed Council may have roles in future Hill Creek projects. Modern solutions for water resource issues exist that can meet the needs of Creswell and the surrounding Hill Creek community, but they will only achieve the proper goals if they are designed to do so. It may be prudent to contract technical assistance capable of assessing the feasibility, effectiveness, and cost of a proposed solution prior to investing significant staff time and resources in a potential solution.

The natural and anthropogenic channels, ponds, dams, diversions and wetlands and irrigation-related structures of Hill Creek form a complex system. Several different governing bodies with differing (and sometimes conflicting) goals share custodial responsibilities. While Hill Creek today is considered a creek by many residents who live along it, for others it is an irrigation canal. Each model carries with it management concepts, but Hill Creek does have a legacy of agricultural management, long family histories that have been engaged in that management, and physical structures that enjoin individual landowners in several different associations. As we consider the future of Hill Creek, let us honor this past as we assess future conditions and needs. Our agricultural heritage is at risk as much as our habitats and water resources are, and local food production should be supported as an important component of sustainability. But structures and channels change over time and as we give consideration to their maintenance and upgrade, let us also give consideration to future flow needs and modern water management techniques so that available water is used most efficiently.

Findings

- All channels of Hill Creek are very long and low-gradient.
- Hill Creek channels and ponds are wide and flat.
- Oregon water rights have stipulations for use
- Various regulations apply concurrently.
- Core services are important for water quality
- Temperature impairment is a high-priority water quality issue

Recommendations

- Outreach is a key strategy for addressing Hill Creek issues outside of city limits
- Prioritize Hill Creek actions within city limits
- Prioritize Hill Creek actions outside of city limits

Introduction

Hill Creek is a watershed of the Lower Coast Fork Willamette River with significant influence on the landscape of the rural city of Creswell, Oregon. Creswell is bordered by the Coast Fork Willamette River to the east, by Camas Swale Creek to the west and north and by Hill Creek to the south. Hill Creek is one of 6 modified 6th-field tributaries of the Lower Coast Fork (Figure 1).

In 2005, the Coast Fork Willamette Watershed Council completed a watershed assessment of the Lower Coast Fork Willamette River from the confluence with the Row River downstream to the confluence with the Middle Fork Willamette River. This study included the following tributaries (which are also called sixth field subbasins or watersheds): Gettings Creek, Hill Creek, Camas Swale Creek, Bear Creek, Papenfus Creek, and Wild Hog Creek. The assessment encompassed approximately 139 square miles or 88,970 acres of which Hill Creek comprises 17% of the entire Lower Coast Fork Watershed. It spans 23.8 square miles or 15,232 acres. [1]

Figure 1: Hill Creek as a 6th-field tributary of the Lower Coast Fork.*

The extensive wetlands, streams, and floodplains of the Coast Fork Willamette River around Creswell were altered between the 1850s and 1960s in order to create buildable and farmable lands. It is necessary to understand major historic features/issue areas of Hill Creek, as well as the original landscape and history of changes to the Willamette River, in order to understand modern Hill Creek.

Hill Creek originates southwest of the City of Creswell. Upper Hill Creek, known as Lynx Hollow, ends at the valley floor. At this juncture, the majority of the stream flow is directed into the mainstem Coast Fork Willamette River via a diversion structure. The stream itself makes a ninety degree turn and flows through a

[1] Lower Coast Fork Assessment

* The US Geological Survey defines streams in an order called HUCs (hydrologic unit codes). In some representations, Hill Creek is enjoined to Gettings Creek, but the modification made in the Lower Coast Fork Assessment separated the two.

small culvert into the Hill Creek channel. On its way north into Creswell, this channel collects some runoff from Creswell Butte and the nearby hills and wetlands. However, under most conditions, this western channel provides less than one-quarter of the total flow of Hill Creek. The balance of flow comes in from the east by a push up dam near river mile 16 on the mainstem Coast Fork Willamette River. This source begins at the river, to which it nearly returns twice, meandering through more than five miles of channel before joining the western channel at Bald Knob. Flow continues downstream to Garden Lake at Creswell's largest park (Garden Lake Park) and onto Emerald Valley where the creek skirts the sewage lagoons associated with this resort and housing development prior to joining the confluence with the mainstem Coast Fork Willamette River at RM 10. All of these valley-floor channels and features are referred to as comprising Hill Creek and are the focus of the issues considered.

Hill Creek Features/Issue Areas:

- Diversion
- Push Up Dam
- Bald Knob Dam
- Garden Lake
- Sewage Ponds

Figure 2: Blue herons thrive in the varied habitats and waterways of Hill Creek.

Since the early 2000s, the Creswell community has been coming together at Garden Lake Park to enjoy and improve this 33 acre site—one of two parks within city limits. However, in late summer, the volume of water necessary to fill the lake has become limited. Problems from the visual quality of the lake being impaired by algae to water quality and safety are being called into question by the public. Solutions are needed to ensure the Creswell community has safe and high quality park recreation experiences available.

Figure 3: CFWWC leads students in tree planting at an Earth Day event at Garden Lake Park.

Historically water at this site was supplied from the push up dam on the Coast Fork Willamette River as the summer irrigation season began. Changes in both the channel condition and its management have occurred and the result has been lower flows in Hill Creek and less water in Garden Lake. This site is important, as are the recreational opportunities provided by the City of Creswell at its parks. However it is important to understand all of Hill Creek in order to be able to predict what effect a particular action will have when source water is limited and the source is far from where it is needed. The intent of this Hill Creek background document is to provide a clear definition and presentation of the factors affecting flow and water quality throughout the system.

Lower Coast Fork - Hill Creek

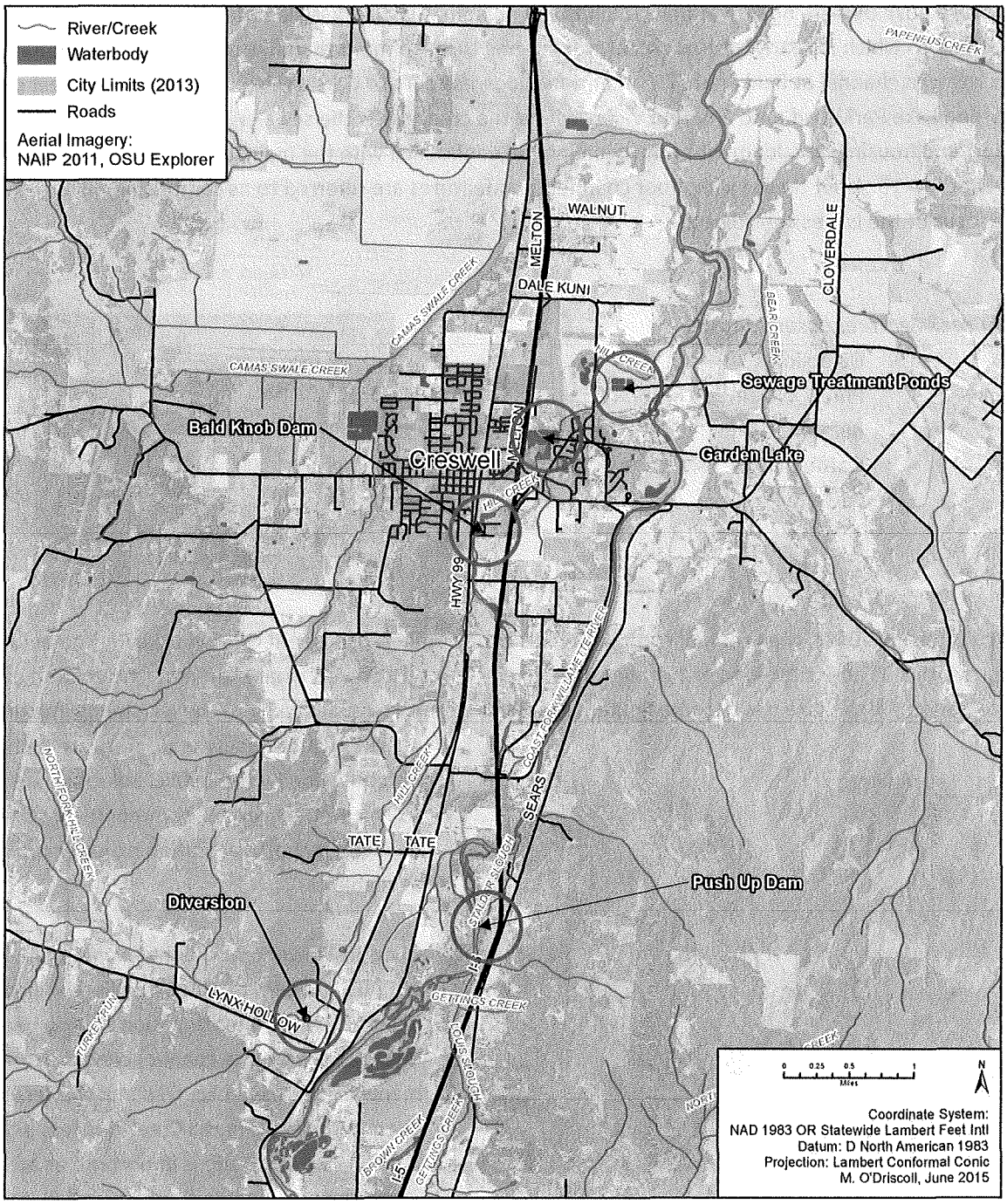

Figure 4: Hill Creek Overview Map

Background

The situation we are considering today in Creswell and its environs are the result of both natural history and environmental modifications by people; begun by Native Americans and continued by later-arriving immigrants. Both the Creswell Comprehensive Plan and the Lower Coast Fork Willamette Assessment acknowledge the influence of these factors in creating current conditions.

Founding of Creswell

Creswell Timeline

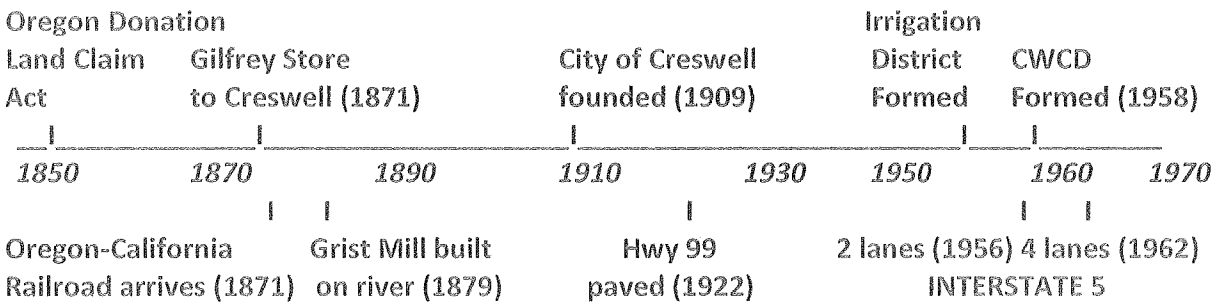

Figure 5: Creswell Timeline

When Europeans first arrived in the Lower Coast Fork Willamette River area, there were three distinct tribes of Kalapuya Indians living in the Creswell area and each had main camps on the river at what would become Enterprise, Cloverdale, and Cottage Grove. Records suggest the Native Americans existed primarily on game and produce (such as camas and acorns) which they cultivated using controlled burns. Extensive prairies and oak savannahs were created and maintained intentionally, but this landscape-scale management declined as the historic population of more than 15,000 people succumbed to first disease, and then intentional re-settlement until they were fewer than 1,000 when the community of Native Americans was replaced by Europeans by about 1850. Settlers successfully grew wheat in the wet and cool Oregon weather and three-story grist mill was erected on the river in 1878, one and one-half miles southeast of the Creswell we know today. In addition to growing wheat, by 1893, the area around Creswell was devoted to raising livestock. Then in 1910, the company of Minneapolis-based fruit magnet A.C Bohrnstedt planted out 1,000 acres of fruit trees in an effort of early, large-scale agriculture spurring migration to the area. By 1909, the population of the community was around 500 and the town was christened by Ben Holladay of the Oregon-California Railroad Company to be named Creswell after John Creswell, U.S. Postmaster General.

The ditch that supplied water to operate the flour mill eventually drove a turbine that supplied Creswell with its earliest electricity. The Creswell Volunteer Fire Department supported operation of the ditch until the formation of the Creswell Irrigation Association in 1957. Later, Bald Knob Land and Timber led maintenance of the channel and dam for nearly 30 years from the 1980s until a fire destroyed the facility in May 2008.[4][5][6]

[4] Benton County Historical Society

Historic Ecosystems

Prairies and wetlands defined the original conditions of Hill Creek. The extent of historic wetlands is evident from hydric soil distribution, historic vegetation, and detailed field notes of early explorers to the area. While a few of the species we find today are remnants of these historic ecosystems, the introduction of European grasses and the reduction of the use of fire caused a great change in these ecosystems across the Willamette Valley. Today, prairies and wetlands are rare; it is not obvious where they once were without reviewing maps of presettlement vegetation or hydric soils. In the map below, the tan areas indicate extensive prairie & wetlands that covered Hill Creek, orange shows shrublands near the river, streams are the turquoise lines, and the extensive expanse of yellow-green in the uplands indicate riparian and forested wetland.

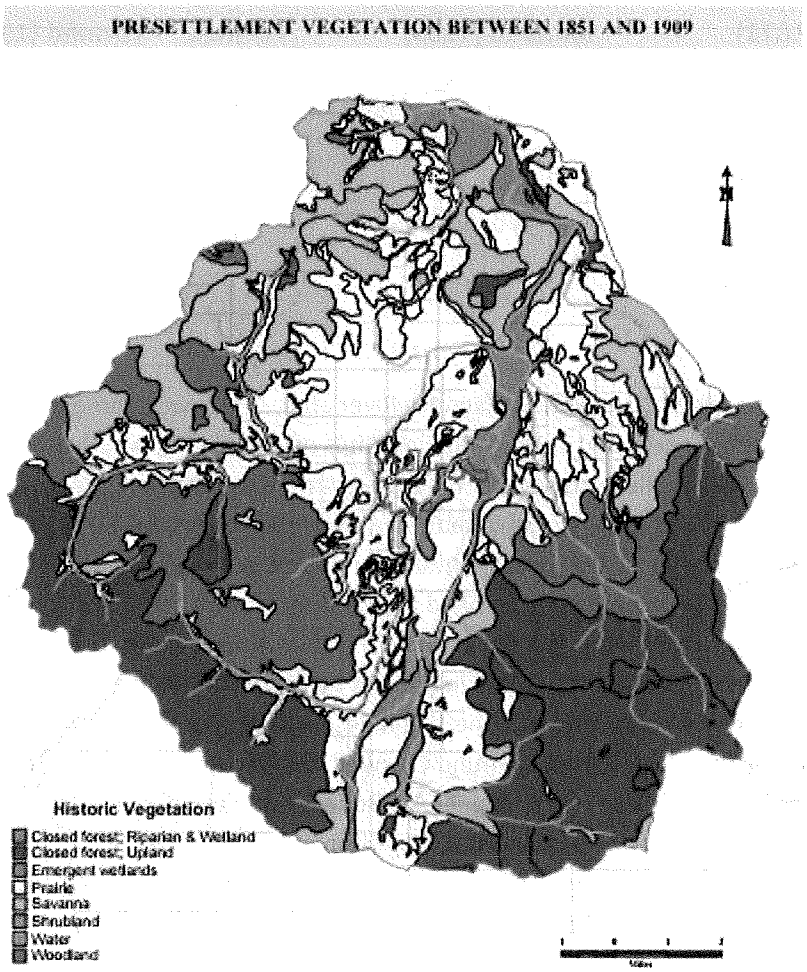

Figure 6: Presettlement Vegetation Map

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[5] Creswell Comprehensive Plan
[6] KVAL

Wetlands & Prairies

Historically, wetlands were a dominant habitat of the Lower Coast Fork Willamette Watershed. Willamette Valley native upland prairies, along with wetland prairies, now cover much less than 1% of their former area making them among the rarest of North American ecosystems. Prairies and wetlands are found in the similar areas and have habitat similarities but are different kinds of habitat. Wetlands form in the presence of two key factors: 1) a source of water and 2) hydric soils (i.e. soils that drain very slowly, like clays). The sources of water supplying wetlands vary. Most are in low lying areas that collect rain and runoff. Some are in places where the groundwater is at or near the surface and so are fed from below. Others are near rivers or other bodies of water that regularly overflow their boundaries. Beaver dams can also form wetlands by backing up streams and causing water to flood the land behind them. The combination of a water supply and hydric soils leads to saturated (i.e. water-logged) soils during part or all of the growing season. These conditions favor the growth of wetland plants, which have special adaptations that allow them to survive in soils that are saturated during portions of the growing season (e.g. Bradshaw's lomatium, tufted hairgrass).

Wetlands and wet prairies provided important services such as tempering the intensity of peak flows during floods, filtering sediments from these floodwaters, and providing thousands of acres of wildlife habitat. Groundwater recharge occurred from these wetlands, but more importantly, wetlands are able to hold water close to the surface until late in the summer. The dense structure of wetlands is a mix of clay and organic matter—and it functions very much like a sponge. Although wetlands are now understood to be important, they were generally viewed as a nuisance to travelers and homesteaders and a waste of potentially useful land. The effort to drain and convert these wetlands to farmland and urban areas was considerable—less than 5% of their original extent remains.

Emergent Wetland: Emergent wetland includes vernal pools and marshes that are inundated from several weeks of the year to permanently. Wetland plants include spike rush, pennyroyal, cattail, softstem bulrush and reed canary grass. Sites with permanent standing water often have floating aquatic plants.

Forested Wetlands: The hydrology of most forested wetlands is similar to the wet prairie. Oregon ash is the most common tree of the forested wetlands, though other species, including black cottonwood, Pacific willow, Oregon white oak and even ponderosa pine may be found.

Scrub-shrub: Scrub-shrub habitats are typically dominated by spirea, willows, rose, hawthorn and serviceberry. Historic scrub-shrub wetlands were often willow swamps caused by beaver dams.

Wet Prairie: Wet prairie is characterized by highly impermeable clay soils that cause seasonal ponding of water, but not significant inundation (i.e. deep standing water). Tufted hairgrass and camas are indicator species of these habitats.

Upland Prairies: Willamette Valley prairies are characterized by well-drained soils and no prolonged standing water. Species include Roemer's Fescue, Checkermallow, Mule's ears, Kincaid's lupine and Willamette daisy.

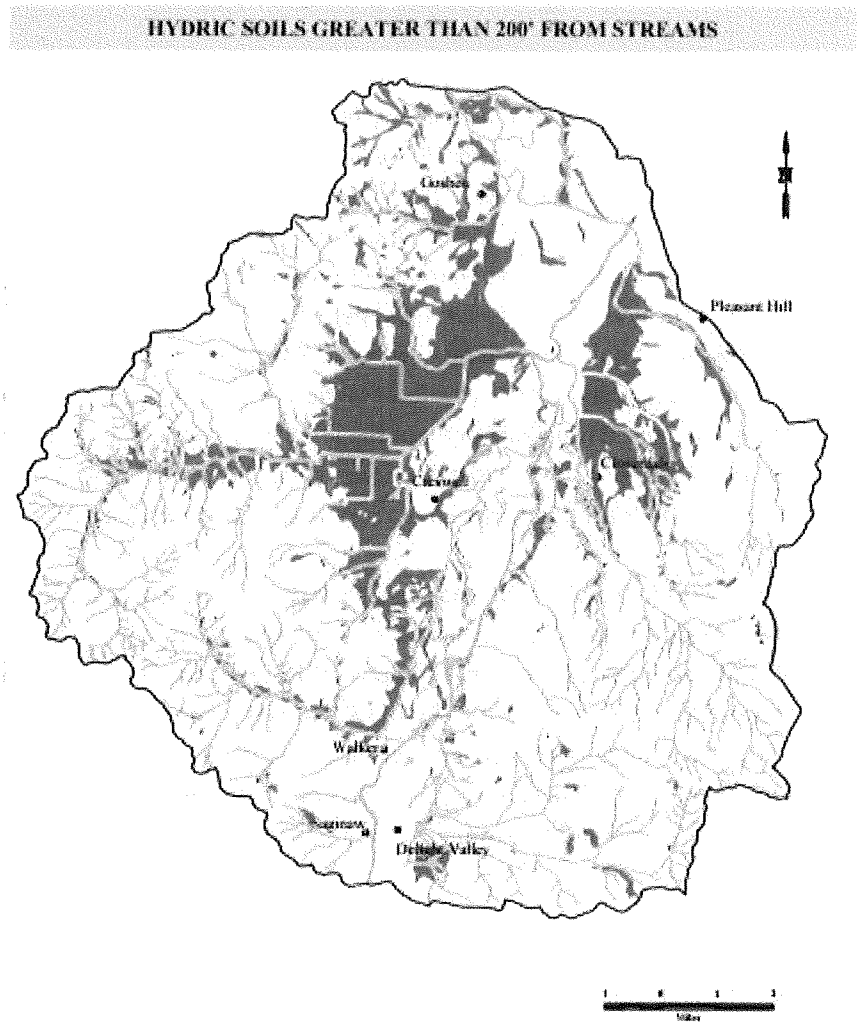


Figure 7: Hydric Soils Map

Streams and Rivers

George Emmons wrote of a grand panorama view he had in 1841, ". . . prairie to the south as far as the view extends, the streams being easily traced by a border of trees that grew up on either bank". Riparian zones are this area of vegetation defined by the stream or lake they border to which he was referring. Some riparian zones are broad and marshy, a result of seasonal floodwaters lingering during the winter. Other riparian zones consist of a small fringe along a steeply sided, fast moving mountain stream. Each kind of riparian zone has a characteristic assemblage of plants, which share a common ability to tolerate waterlogged roots for a period of time. Common riparian zone plants include Oregon ash, big leaf maple, willows, dogwood, vine maple, sedges, rushes and grasses. Other plants, like Douglas fir and western hemlock, are fairly intolerant of submerged roots and are found above the seasonal high water mark.

Riparian zones can provide a variety of benefits or "ecological functions". They are an important place for rearing fish, amphibians and birds because they have an abundance and diversity of food sources. Forested riparian zones provide shade, which prevents streams from heating due to direct sunlight. Trees and branches that fall into the water contribute large woody debris (LWD), which creates cover for fish and helps form pools and trap gravel important for spawning habitat. Leaf litter, seeds, fruit and insects that drop into the water from the riparian zone form the basis of the food chain for many streams. Vegetation in riparian zones also help to filter out sediment and pollutants during certain times of the year, which prevents them from entering waterways. The root structure of riparian vegetation contributes to stream bank stabilization and help to prevent erosion.

Over the past 150 years there have been significant changes to the physical structure and vegetation of riparian zones in the watershed. Stream channelization allows water from winter storms to move downstream more quickly and consequently has decreased floodplain width in some areas, resulting in a narrower strip of land that supports riparian and wetland vegetation. In some places riparian vegetation was removed in the process of rerouting channels. Past logging sometimes changed the size and type of trees in riparian zones from large conifers to smaller hardwoods. Roads, houses, lawns, urban development and livestock grazing have also changed riparian zones. The cumulative impact of all these activities has reduced the riparian zone's ability to provide habitat, shade, and woody material to the streams and thus results in degraded aquatic habitat.

The water quality of streams depends on riparian shade and the structure of wood falling in that allows scour to form deep places in the channel—these are the coldest locations in the summer, relied upon by native cold water fish like salmon and trout. Furthermore, cold water holds much more oxygen than warm water which is important for fish and overall water quality.

Figure 8: Native and Introduced Fish Species in the Lower Coast Fork Watershed Area

Native Species	
Common Name	**Scientific Name**
Pacific lamprey	Lampetra tridentata
western brook lamprey	Lampetra richardsoni
spring chinook salmon	Oncorhynchus tshawytscha
Winter steelhead	Oncorhynchus mykiss
rainbow trout	Oncorhynchus mykiss
coastal cutthroat trout	Oncorhynchus clarki clarki
mountain whitefish	Prosopium williamsoni
Oregon chub	Oregonichthys crameri
chiselmouth	Acrocheilus alutaceus
peamouth	Mylocheilus caurinus
northern pike minnow	Ptychocheilus oregonensis
longnose dace	Rhinichthys cataractae
speckled dace	Rhinichthys osculus
leopard dace	Rhinichthys falcatus
redside shiner	Richardsonius balteatus
largescale sucker	Catostomus macrocheilus
three-spine stickleback	Gasterosteus aculeatus

sand roller	Percopsis transmontana
torrent sculpin	Cottus rhotheus
shorthead sculpin	Cottus confusus
Introduced Species	
Common Name	**Scientific Name**
Fall chinook salmon	Oncorhynchus tshawytscha
common carp	Cyprinus carpio
brown bullhead	Ameiurus nebulosis
yellow bullhead	Ameiurus natalis
mosquitofish	Gambusia affinis
pumpkinseed	Lepomis gibbosus
warmouth	Lepomis gulosus
bluegill	Lepomis macrochirus
largemouth	Micopterus salmoides
smallmouth bass	Micopterus dolomieu
black crappie	Pomaxis nigromaculatus
white crappie	Pomaxis annularis
yellow perch	Perca flavescens

Flow & Hydrology

Roads and highways are one of the biggest influences on rivers and streams as they can direct or block the flow of water. This was certainly the case in Hill Creek with the settlement of Creswell. By 1871, the Oregon-California railroad came south from Eugene along the west side of the river to a point just north of what is now the City of Creswell. This prompted J. Gilfrey to move his store from Cloverdale to the Creswell area in 1872 which essentially founded the settlement where the current city exists. However, with the construction of the Southern Pacific Railroad line, Hill Creek was diverted to the north without a culvert resulting in the flooding of some 1,000 acres during periods of heavy rains. This is an example of how rail and road beds form *hydrologic barriers*. They function as a dam or revetment in the surface and subsurface flow of water because of the localized compaction. For the most part, water cannot flow through them, so the majority of flow moves along them. This creates a stream channel along the road or rail line until there is an opening like a bridge or culvert that allows it to pass to the other side. Consider how the Coast Fork Willamette Watershed is affected by that same railroad, Highway 99, and Interstate 5 that create 3 hydrologic barriers in a row as the creeks that drain the western hills flow east to the Coast Fork Willamette River.


Figure 9: Willamette River Snag Boat, ca. 1900

Another widespread change to water conveyance was the straightening and deepening of channels. This began with clearing large rivers of woody debris for navigation. Engineers noticed that if the strongest flow was allowed to move unimpeded, that its power would

grow enough to cut a channel. This practice evolved into the construction of revetments—streamside low-head dams comprised of large rock and covered in dirt that functioned very much like the rail and road beds. On a smaller scale, these practices were used in Hill Creek and Camas Swale. Creswell was rich in wetlands and small, dispersed streams that made it very difficult to farm until late in the summer. By cutting channels deeper than the surface flow at the edge of prairies, it was possible to lower the groundwater level in those fields, thus fostering earlier grazing and plowing. The practice of 'stream cleaning' followed these practices as early land managers somehow thought wood could prevent fish from migrating into streams—so they systematically had almost all of it removed. Today most all Willamette Valley rivers and streams are lacking in wood for habitat purposes.

These hydrologic changes likely caused even greater variation in flows in the summer dry period, and ultimately posed a problem for cities along the Willamette. Disposal of pollution and waste was most effective by dilution—but adequate flow was required in order to make this possible. By the 1950s, the Willamette River was being so abused with waste that pollution literally prevented development along its banks—and thus the availability of open space purchased later by the state forming the Willamette Greenway system. The solution to both water supply and pollution dilution was to create a system of dams that would provide a myriad of benefits from controlling flooding to augmenting summer water flow and supply.

Figure 10: Willamette Valley Projects (Dams) in the Coast Fork Willamette Watershed[10]

Watershed	Project (Dam)	River	Summer Reservoir Storage Capacity (Acre-ft.)
Coast Fork Willamette	Cottage Grove	Coast Fork Willamette	28,700
Coast Fork Willamette	Dorena	Row River	65,000

Three major tributaries contribute flow to the Coast Fork Willamette River upstream of Hill Creek. The Row River and Upper Coast Fork are both regulated by dams and Mosby Creek which is uncontrolled. Coast Fork water levels vary in response to the timing, intensity, and duration of rainfall (especially rain-on-snow events) and are also influenced by downstream water levels.

Flow in the Hill Creek channel is generally correlated to water levels in the mainstem Coast Fork. The amount of water in the river, its rate of flow, and how flows change over time can be visualized by graphing stream gauge data as seen here.

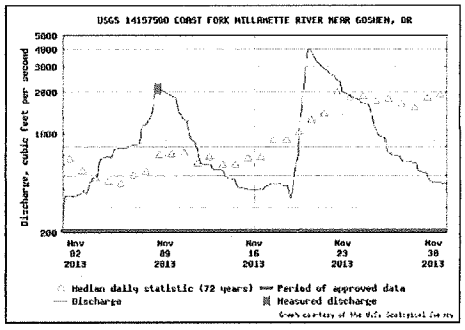


Figure 11: Graph of stream gauge data

There are five major features of Hill Creek: the diversion, the push up dam, bald knob dam, Garden Lake, and the sewage treatment ponds. Flow modification is the primary purpose of the majority of these structures. Whether it is the diversion that sends flood water to the Coast Fork or the

[10] U.S. Army Corps of Engineers, 2000; Oregon Water Resources Department, 2000.

push up dam that supplies irrigation water to Hill Creek or Bald Knob dam which held water back into a pond at the mill, flow is a determining factor of all of these structures. Today, flow is limited. In the past, many of these structures were constructed because of an excess of flow. Climate change and future drought conditions may necessitate the alteration of these structures in order to provide adequate water supply to the needed locations.

Another issue to consider is channel width. When the channel widens, the velocity of the water drops because it disperses over a wider area—constriction of flow can increase the rate of flow, but widening the channel path does just the opposite. In addition, when water slows it loses its power to carry sediment. Garden Lake and the Bald Knob ponds both function as settling basins for sediment for this reason. Along with sediment, particulates attach such as nitrogen and phosphorus from fertilizer or manure runoff that contributes to algae blooms, especially when temperatures rise. In this manner, channel structure affects water quality. If the channel receives inputs like sediment and pollutants but it does not have a riparian zone that would be able to contribute shade and wood, then the biological and physical processes that would normally occur to sequester or process these inputs will not function. Where the channel is very wide, Hill Creek is more like a series of ponds and water quality processes may resemble ecology similar to that in lakes such as seasonal algae blooms and turnover. This is simply the body of water responding to the conditions it has—lack of flow, increased temperatures, and presence of nutrients capable of supporting photosynthesis. Healthy ponds and lakes have a balance of organic matter, temperature, and nutrients but the processes are different than that of streams.

Coast Fork Willamette Watershed Council

The mission of the Coast Fork Willamette Watershed Council (CFWWC) is to enhance the Coast Fork Willamette Watershed through restoration, monitoring, education and stewardship. Our main restoration goals are to enhance and protect water quality, terrestrial habitat, and aquatic habitat. We seek to maintain, improve and conserve these resources through the voluntary action of watershed residents and public landowners. We research watershed issues, prioritize our actions and work with technical partners in order to leverage support for project implementation from diverse funding and in-kind sources.

Research into Hill Creek for CFWWC began with the Lower Coast Fork Assessment in 2002 (published 2005 and available at www.coastfork.org). It resumed in 2009 when we held a well-attended but somewhat controversial community meeting on the issue. The meeting considered the Hill Creek push up dam, issues affecting the condition of Hill Creek, as well as possible solutions and next steps. The following list of issues resulted from that meeting: fish passage barriers, unknown toxins, loss of historic wetland and floodplain habitats, temperature impairment of water quality, and fish and wildlife affected by flow, and flow management actions. Since that time our organization focused on the stewardship of habitat at Garden Lake Park. In addition, CFWWC conducted water quality monitoring from 2008-2010 at 13 locations in the watershed. In 2013 it became evident that people were coming to the table to understand the problem and search for specific solutions and starting at that time Coast Fork staff and technical partners conducted numerous site visits and discussions on our lengthy path of research and discovery in Hill Creek. CFWWC is

available to provide free site visits and support individuals and others in the watershed as the community moves forward on implementing water supply, quality, and habitat priorities.

Findings

- All channels of Hill Creek are very long and low-gradient.
- Hill Creek channels and ponds are wide and flat.
- Oregon water rights have stipulations for use
- Various regulations apply concurrently.
- Core services are important for water quality
- Temperature impairment is a high-priority water quality issue

All channels of Hill Creek are very long and low-gradient.

Hill Creek is a low-gradient channel (less than 1%); there is little elevation change across its length. This means that there is very little power to move water on elevation difference alone. Head (change in elevation) is needed to do the work of moving water and there is almost no change in elevation across the length of the channel. For example, LiDAR data analysis conducted by the CFWWC shows that it is 4.77 miles from Tate Road to the sewage ponds. Over this section, the average slope is 0.17% which is very low.

Hill Creek Elevations from LiDAR 2014[11]					
Location	Path Length (ft)	High Elevation (ft)	Low Elevation (ft)	Rise/Fall (feet)	Average Slope
Coast Fork at Tate Road to Sewage Ponds	25,196.93	561.50	518.00	43.50	0.17%
Hill Creek at Tate Road to Bald Knob Dam	13,947.20	574.00	540.00	34.00	0.24%
Hill Creek From Bald Knob Dam to Garden Lake	5,779.83	540.00	529.00	11.00	0.19%
Hill Creek From Garden Lake to Sewage Ponds	3,993.51	529.00	523.00	6.00	0.15%

Figure 12: Hill Creek Elevations from LiDAR 2014

Hill Creek channels and ponds are wide and flat.

In many places Hill Creek has been excavated into wide, flat channels and ponds with a lot of surface area and minimal aquatic habitat. This results in the pond areas of Hill Creek acting as settling basins for sediment and pollutants. It also means that a lot of water is required just to fill the channel in order to push it downstream. Narrowing the channel can result in conflicts with beavers as it provides them a place to pond the water.

Oregon Water Rights have stipulations for use.

[11] Lane County LiDAR

- Water rights are stated as both total volume and a rate per period.
- Water law includes stipulations that irrigation water be diverted only when the landowners with the right are 'ready and able' to irrigate.
- Moving a point of diversion for a water right cannot be injurious to downstream users that draw from the same location.[12]

Various regulations occur concurrently.

If a structure is permitted to exist or an activity is allowed to happen by one agency, this does not mean it is exempt from complying with the rules of other agencies. Furthermore, a permit or lack of regulation does not convey protection from legal liability.

Core services are important for water quality

It is important for citizens, staff and decision makers to understand just how much benefit core services can provide—providing clean drinking water and high quality sewage management is an important and expensive investment for a small city to make. Cities are one of the most regulated entities in Oregon and since the bar is especially high in Oregon, compliance with state and federal water quality requirements on the part of a small city is quite an accomplishment. Improving environmental resources is often a secondary activity for municipalities and other government entities because of the demand on general fund resources by other core services. However, sometimes efficiencies in existing services can alone provide the solution.

Temperature impairment is a high priority water quality issue

Temperature is one of the three parameters that have been included in all of the Willamette Basin DEQ water quality requirements (TMDLs), and therefore constitutes what is known as thermal pollution. Working with the Coast Fork Willamette Watershed Council to lower the temperature of water released from Garden Lake Park is specifically noted in the City of Creswell's Total Maximum Daily Load Implementation Plan. It could be perceived that cold water from the Coast Fork Willamette flows in at the pushup dam, follows over five miles of the irrigation channel before it reenters Hill Creek, at which point it would appear to reenter the Coast Fork Willamette River at lethal temperatures for fish (70—80 degrees F). While temperature is an issue for conditions within the channel, at summer low flows the actual pond levels drop down below the level necessary to flow out of Garden Lake—so they cannot discharge water into the mainstem Coast Fork. Thus the river is effectively protected from late summer warm temperatures of Hill Creek until the first fall storm at which point the temperatures start to lower.

Hill Creek Features

- Diversion
- Push Up Dam
- Bald Knob Dam
- Garden Lake
- Sewage Ponds

[12] Oregon Water Resources Department

Hill Creek Diversion

The Hill Creek diversion is a cement structure approximately 100 ft. wide and a quarter mile in length that directs water from the upper Lynx Hollow portion of Hill Creek to the Coast Fork Willamette River. A control structure (a culvert with a manually controlled gate) and a check dam directs a small portion of the creek flow out of the diversion at a right angle. This forms Hill Creek in its westernmost channel.

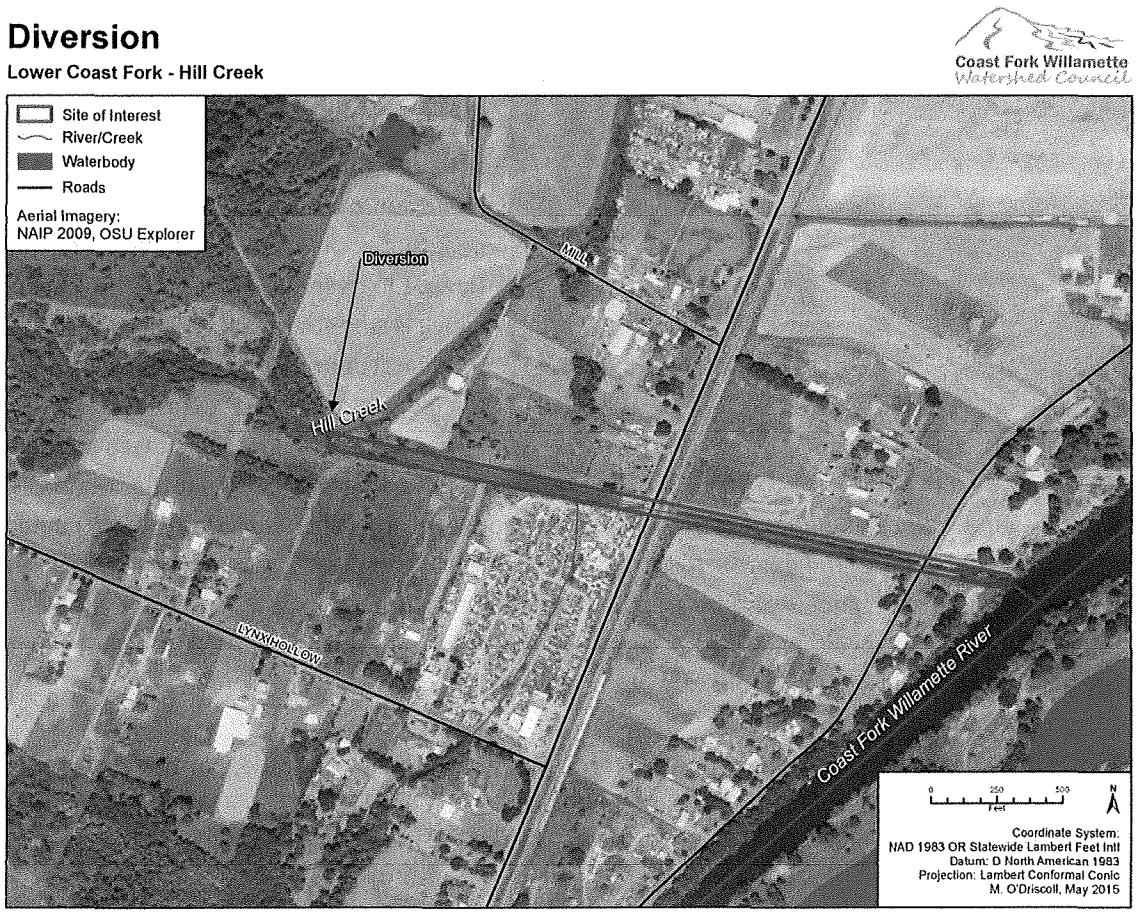


Figure 13: Diversion structure map

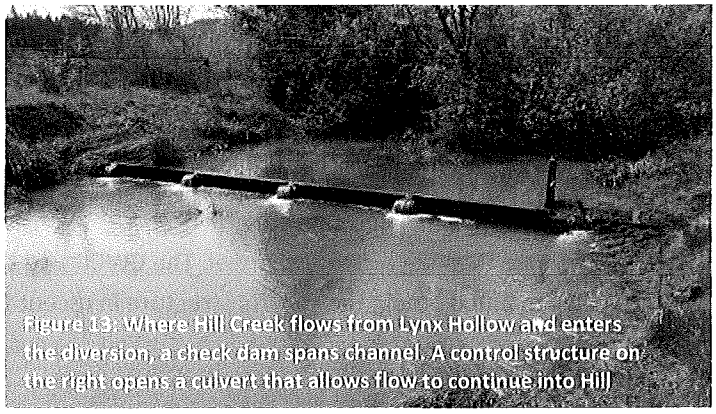
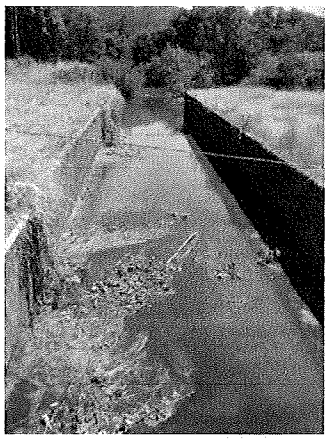


Figure 13: Where Hill Creek flows from Lynx Hollow and enters the diversion, a check dam spans channel. A control structure on the right opens a culvert that allows flow to continue into Hill

Figure 14: A CWCD member opens the control structure to allow flow into Hill Creek.

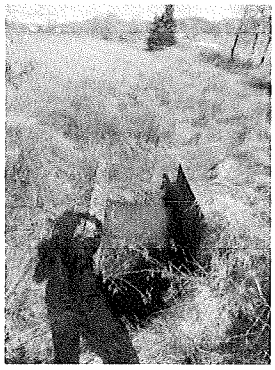
The Lynx Hollow portion of the Hill Creek flows east until it reaches the valley floor. Here, it is a natural channel shaded by willow: a meandering stream with a ~30 ft. wide active channel with a substrate of small gravels and fine sediments. Where the upper portion of the diversion begins it flows into a constructed channel with two distinct sections. The first 300 ft. length of the diversion canal features a 100 ft. wide flat stream channel with high earthen berms (20 ft. high). These berms and the channel are of solid construction and while there are a few trees, shrubs and blackberries growing on the berm, they do not pose a risk to the considerable structure. As the diversion passes under Highway 99 and continues towards the river, flow is conveyed in a channel with a cement base that is 30-50 ft. in width with sides approximately 5 ft. tall. As the flow reaches the river, the diversion structure simply ends with a sheer drop to the mainstem river. High flows have created a scour pool that is wide and moderately deep. In high flows, the river may back-flood the channel which is smooth except for moss or other incidental debris. At low flows water pours over the ledge at the end of the canal.



This structure has not been fitted with any form of fish passage structure at the river or in its length. However, it can be assumed that when flows are moderate and fish are migrating there could be strong individuals that enter the quarter-mile long diversion canal and push through to reach the natural Hill Creek channel. However, it should also be assumed that this structure is a migration barrier for juvenile fish of all species at all times of year and to adults in the summer and in peak and higher flow events due to the velocity barrier presented by such a long straight channel.

Finally, the diversion is likely not a benefit to water temperatures due to the wide, flat shape of the constructed structure. At low to moderate flows in the spring, summer and fall, the stream moves as sheet flow across the cement until it dries to a trickle allowing the cement to transfer heat to the water.

Creswell Water Control District



After contending with the seasonal challenge of flooding for 80 years, the Creswell Water Control District (CWCD) was formed in 1958. It was the CWCD who prompted the US Army Corps of Engineers to build a diversion channel to the river to correct this problem through the Federal Watershed Protection and Flood Prevention Act. The project incorporated flow control for diversion of flood waters to the river, with provision for flow to the north to support livestock needs. At the beginning of the diversion, there are footings for a check dam and a culvert with a manual control structure that can allow water to divert north along a grassy channel. The CWCD and the City of Creswell have coordinated on installing the check dam and opening the control structure in recent years (2013-2015).

The Creswell Water Control District (CWCD) was formed on October 25, 1957. Authorized under ORS Chapter 553, the CWCD consists of a five member board whose purpose under the statute is "to acquire, purchase, construct, improve, operate and maintain drainage, irrigation, flood and surface water control works in order to prevent damage and destruction of life and property by floods; to improve the agricultural and other uses of lands, and to improve the public health, welfare, and safety." The subdistrict extent is the mapped fee-assessment area and it appears the Special District comprises the legal extent of the CWCD. The CWCD does not levy taxes, instead Lane County Assessment & Taxation levies 'fees' for the special subdistrict properties, which totaled $2,491.50 in 2008-09, the most recent figures available.[13]

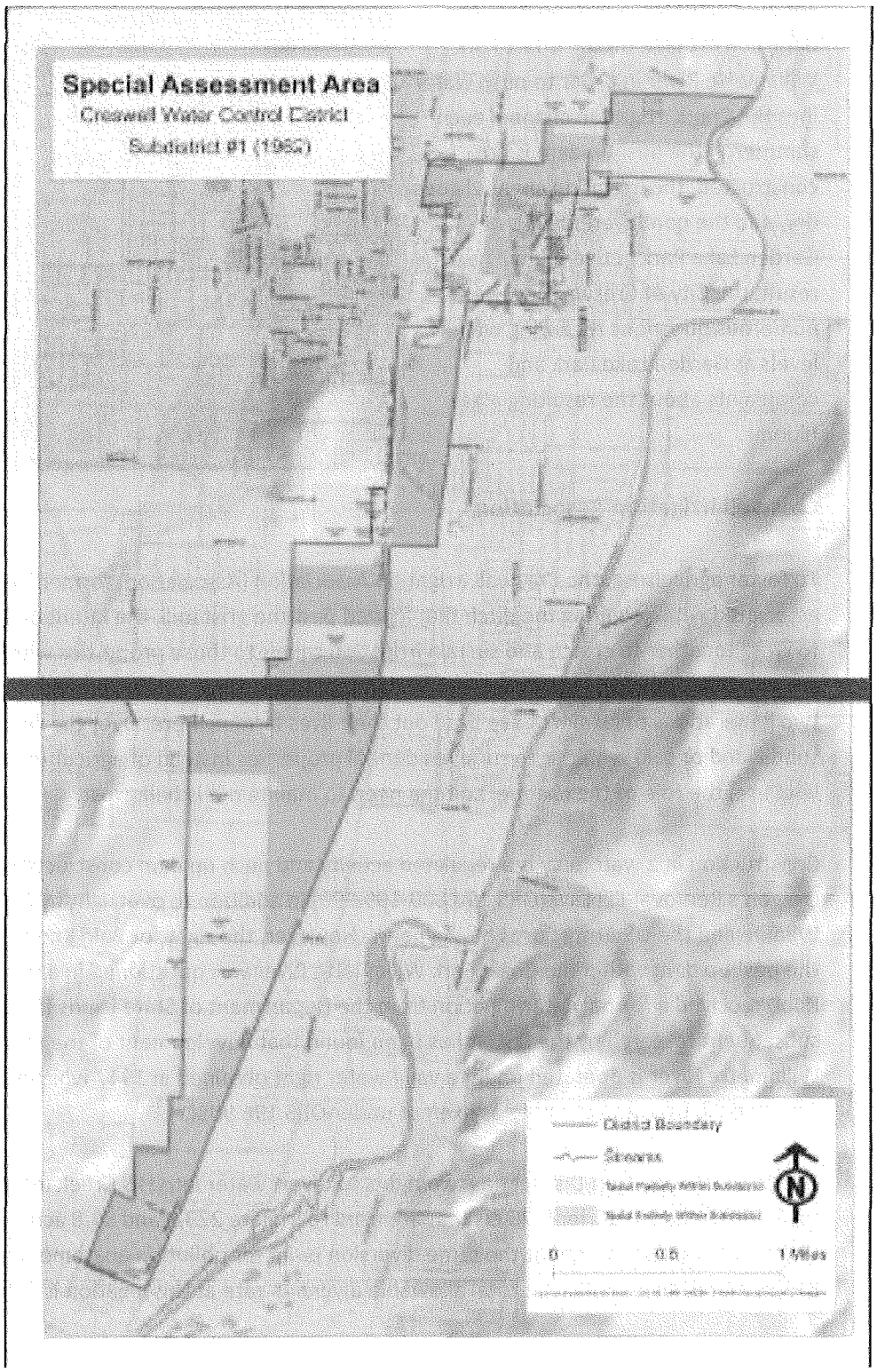


Figure 14: Creswell Water Control District Map

[13] Creswell Water Control District documents.

Push up Dam

For over 60 years, a pushup dam has been constructed on the Coast Fork Willamette River in order to push water into Hill Creek irrigation channel each summer. If the pushup dam is not constructed, the irrigation channel goes dry, and the pond water levels at Garden Lake Park get very low. As a result, the City of Creswell receives numerous questions regarding water levels at Garden Lake Park and complaints about the resulting algae blooms.


Figure 15: Push Up Dam August 24, 2012

Creswell Irrigation Association

To foster agriculture, the Creswell Irrigation Association (Association) formed on August 15, 1955. Historically associated with acquiring the ditch that flowed past the grist mill, the intent of the Association is for farmers to work together to create and sustain irrigation canals to those properties with water rights, most of which are in the floodplain of the Coast Fork Willamette River. Since establishment of the Association, more than two generations of farmers have lived out their lives farming here. Over the years, many farms have been subdivided or sold resulting in rural residential properties instead of agriculture lands. With this transition in land use, the role of the channel and the need to maintain it is being lost.

Construction in a waterway is a regulated activity and push up dam construction would typically be subject to Oregon's Removal-Fill Law (ORS 196.800-196.990) in addition to oversight by Oregon Department of Fish & Wildlife and the US Army Corps of Engineers. However, the right for Bald Knob Land and Timber to construct the pushup dam within the Coast Fork Willamette River was questioned in a late 1990s lawsuit. In 2003 Bald Knob received a formal determination from the Department of State Lands (DSL). After investigation and subsequent research by the DSL, it has been found that development of the pushup dam on the Coast Fork Willamette River is operated under a valid water right obtained in 1947 which pre-dates inception of the Removal-Fill Law, and qualifies as exempt under ORS 196.905(1).[14] [15]

The Creswell Irrigation District has two rights to divert water into Hill Creek for irrigation; Certificates 35348 for 2.79 cfs and 51019 for 0.75 cfs that are used to irrigate 223.3 and 59.8 acres respectively. Separately, the City of Creswell has a right at the same diversion point for pollution abatement and fire protection, certificate 81528 that is for 1.00cfs. The total allowable diversion rate at this location is 2,040 gallons per minute.[16]

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[14] Hill Creek Memo, Titus Tomlinson.
[15] DSL Letter July 3, 2003
[16] Hill Creek Memo

Historically, Bald Knob Land and Timber took primary responsibility to construct and maintain the pushup dam, ensuring that flow was maintained and the channel was clear of any diversions. On May 20, 2008 Bald Knob Veneer Company, a subsidiary branch of Bald Knob Land and Timber, experienced a severe fire, shutting the site down permanently. Since Bald Knob closed, the channel maintenance and push up dam construction has been in flux.[17] In recent years, this work has been done independently by a local contractor and also in contract with the City of Creswell's Public Works Department on an emergency basis to maintain water in Garden Lake. Creswell initiated the replacement of the push up dam and the clearing of blockages in the channel twice in spring 2014, and again in spring 2015.[18]

Maintaining flow through Hill Creek continues to be an unresolved issue. While it is likely that all landowners who hold water rights have a vested interest in maintaining flow in Hill Creek, the primary question is who shall be responsible for continued construction, operation, and maintenance of the pushup dam? While the bylaws of the association allows for an annual fee to be levied in order to fund improvements and maintenance of the irrigation system, Bald Knob subsidized a portion of the costs reducing the historic perceived burden to the many private water right holders in the Association. Assessment of this fee may resume if initiated by the Association, but it is not assessed by Lane County and may be unpopular or unpaid for the aforementioned reasons.

In 2013, the Coast Fork Willamette Watershed Council worked with Oregon Department of Fish and Wildlife (ODFW) Fish Screen Shop to begin to explore potential alternatives to the push up dam. In November 2013, the ODFW staff took a cross section of the irrigation canal at the push up dam in order to measure the amount of flow entering the channel. The flow was 6.99cfs, velocity was 0.3370 ft/s, and where the channel cross section was taken, the area was 20.77 sqft. (channel width 13.5 ft.) On that day, the USGS flow gauge at Goshen was reading approximately 550 cfs (the river flow at this location would be slightly less than this as it is upstream 10 miles), however, it was determined that it was not possible to establish a stage relationship with a flow gauge on the river likely due to the annual variability of channel shape due to scour and push up dam construction. This state agency is a potential future source of in-kind technical support for the design of a new diversion structure on the side of the river that would utilize a pump and a fish screen. It would be necessary to secure cooperative agreements from the affected property owners and water right holders first.

Figure 13: Push up dam (left), culvert at diversion channel (center), and ODFW at Hill Creek (right) in November 2013.

[17] Personal communication, Cindy Harrold.
[18] Personal communication, Cliff Belew.

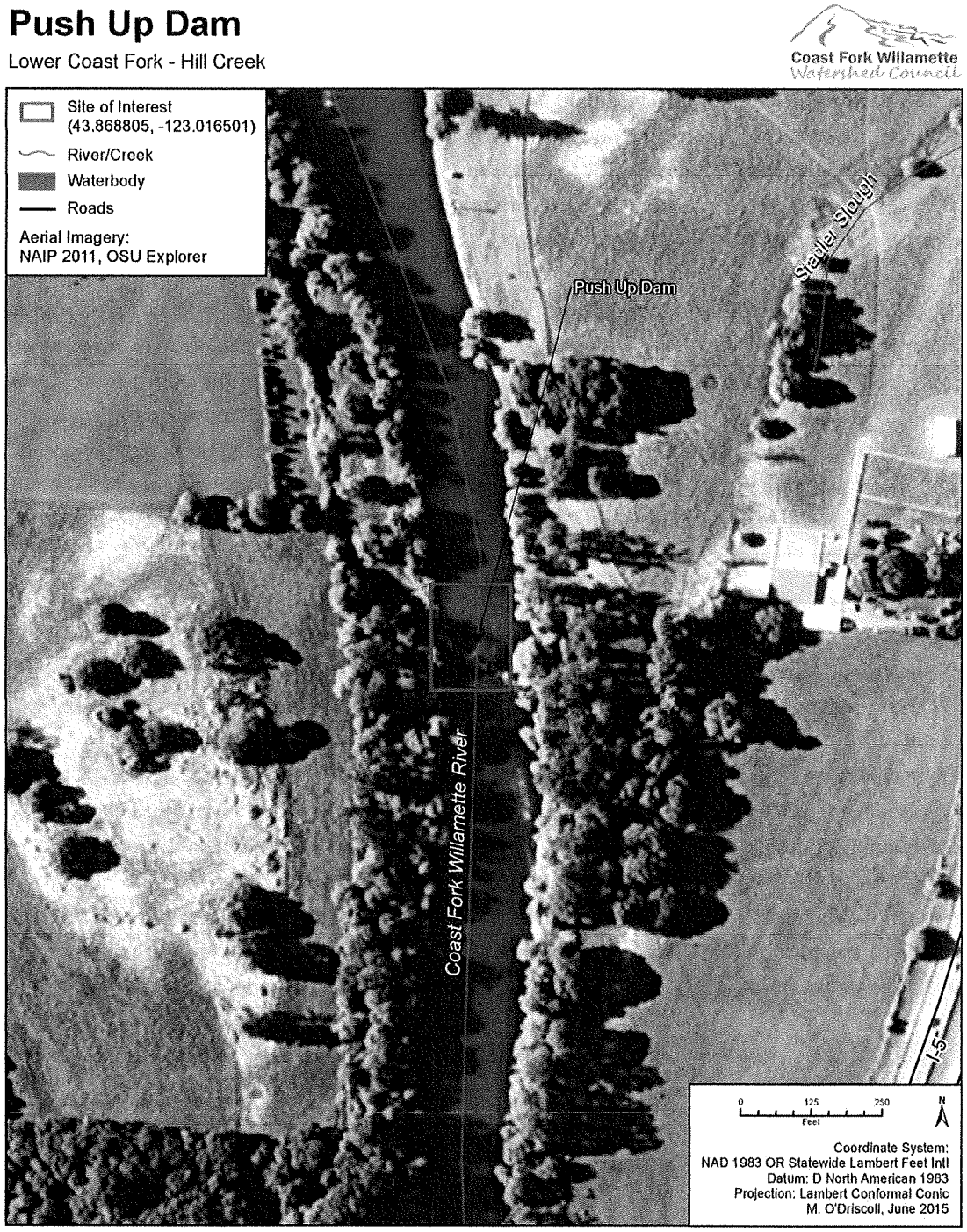


Figure 16: Push up dam map

Bald Knob Dam

As Hill Creek enters Creswell city limits, it flows through the former site of the Bald Knob Veneer Company, a subsidiary branch of Bald Knob Land and Timber now located in Springfield, Oregon. On May 20, 2008 the mill experienced a severe fire, shutting the site down permanently. Where Hill Creek flowed past the site it was excavated into a series of three large ponds, ostensibly to have a 'mill pond' for fire protection and possibly other industrial uses. At the lower end of the third pond there is a metal dam structure approximately 20 ft. wide and 15 ft. tall anchored into cement pilings. The mechanism for opening the dam is either broken or disconnected. Unless the gate is lifted open with a backhoe and propped open, it closes due to its weight.

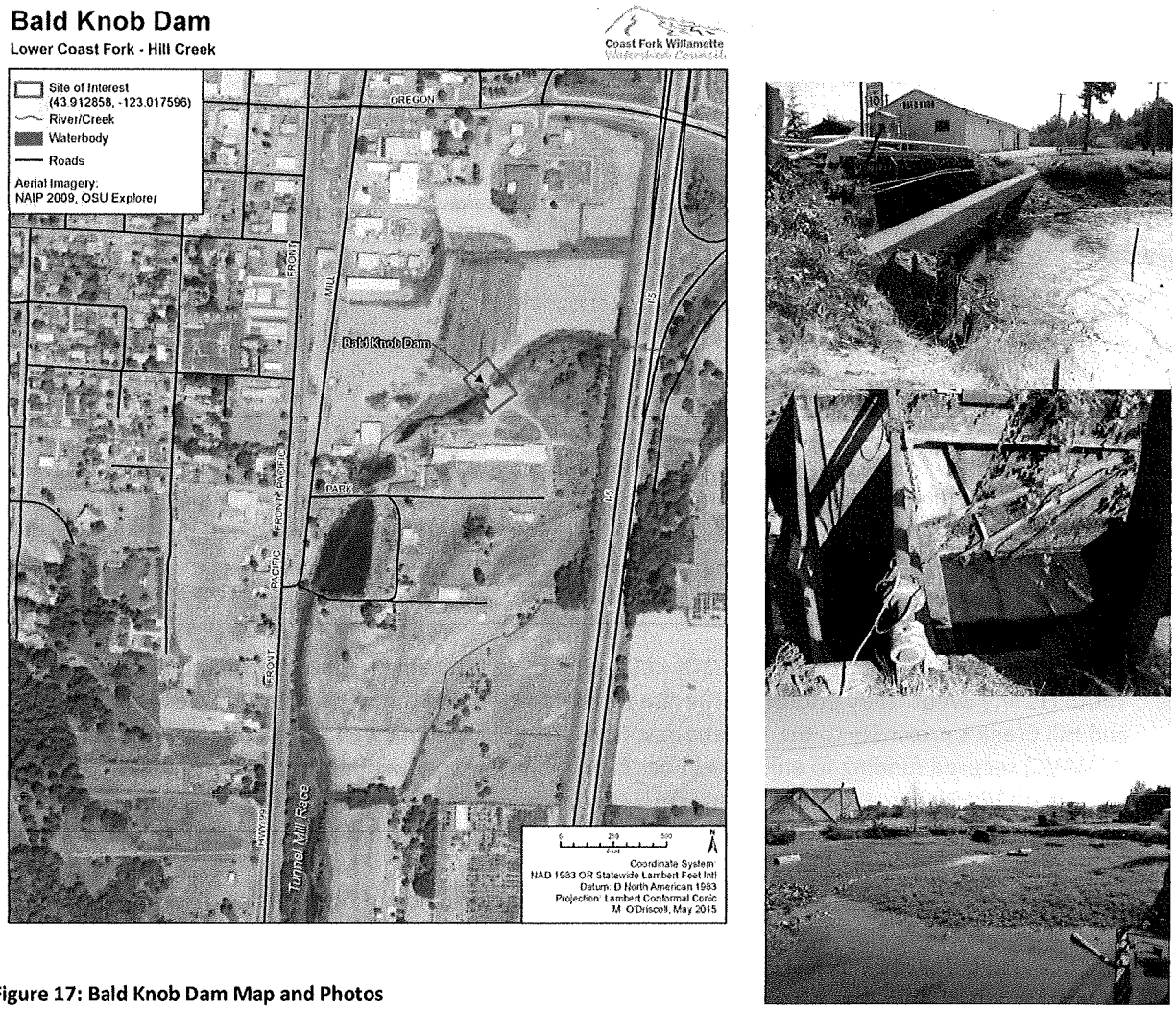
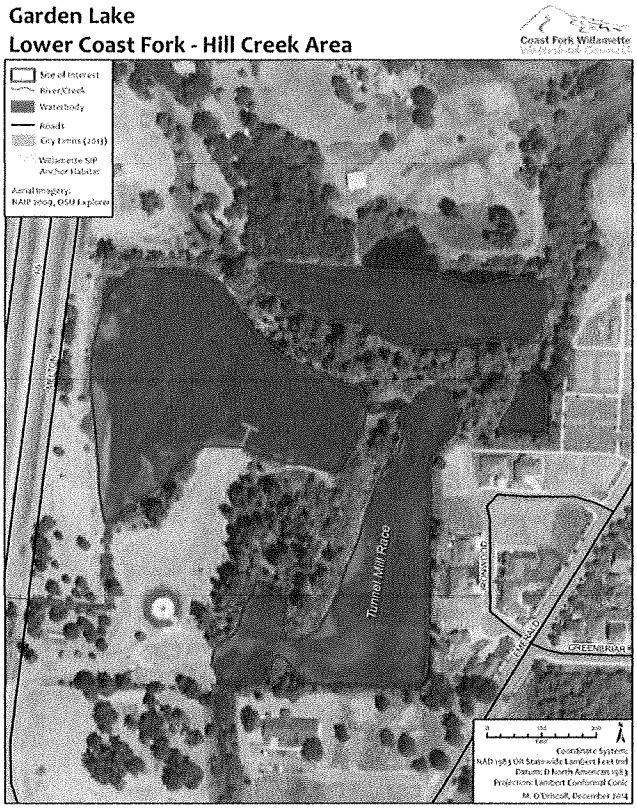


Figure 17: Bald Knob Dam Map and Photos

Garden Lake



The 33-acre Garden Lake Park is one of two parks within Creswell city limits. The park is 2 miles upstream from the Hill Creek confluence with the lower Coast Fork Willamette River. Interstate 5 forms the western boundary of the park and the Emerald Valley housing development forms the eastern park boundary. The northern boundary of the park is shared with two small farms. Hill Creek flows into one of five ponds from the south, flowing by the South Willamette Veterinary Clinic. On the map (left), a second source of flow is evident coming in from the west. This is a stormwater channel that carries surface flow under I-5 and into the western part of the largest pond.

Figure 19: Garden Lake Park Map

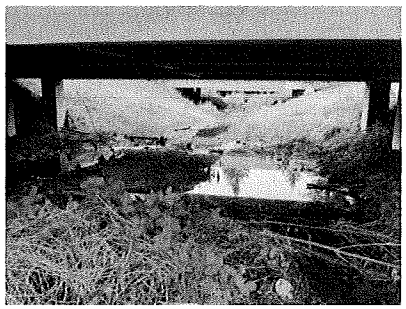


Figure 18: Stormwater flows into Garden Lake Park under I-5.

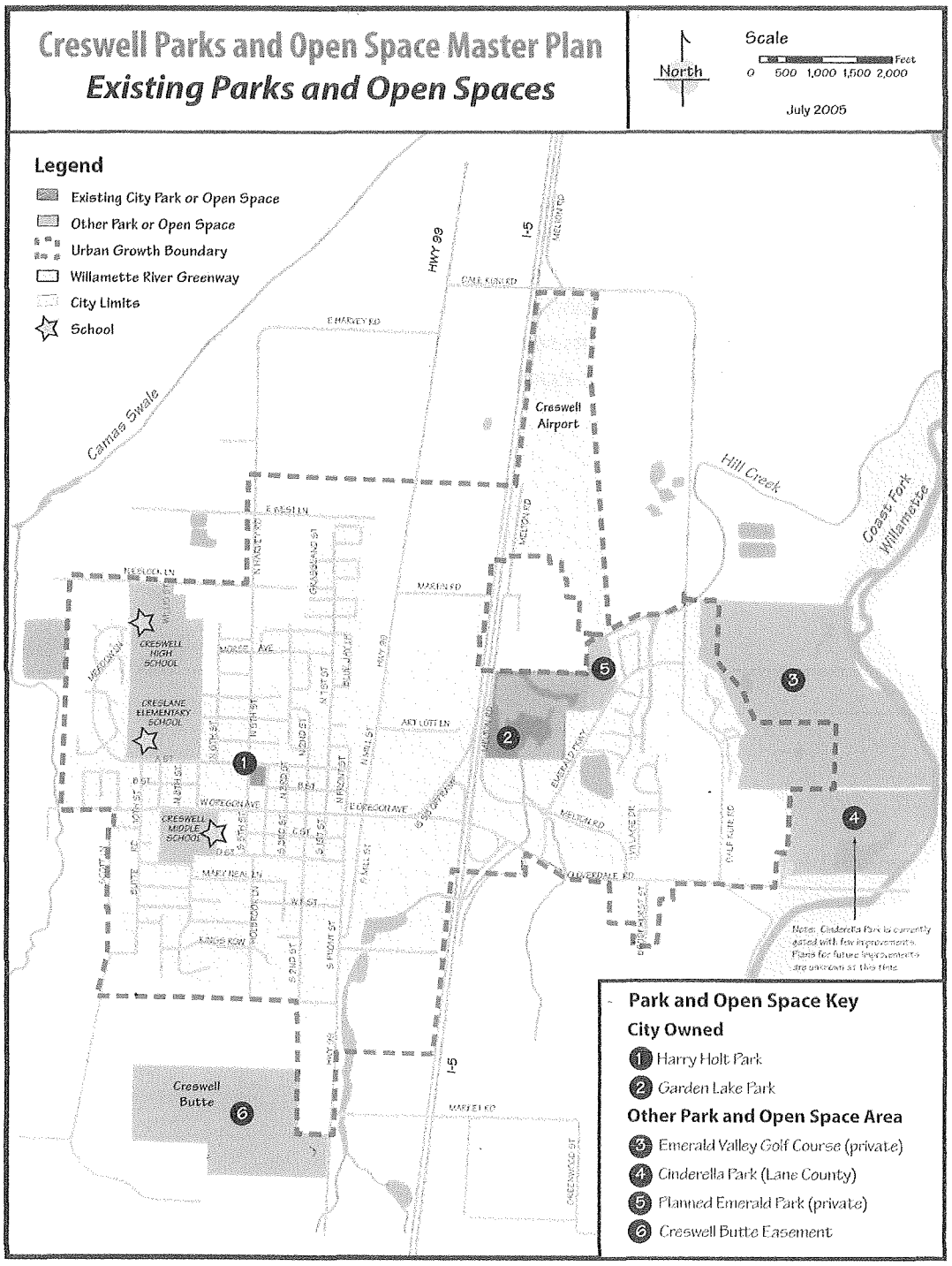
The ponds at Garden Lake Park are within the historic floodplain of the Coast Fork Willamette River as evidenced by the significant gravel deposits mined there for the construction of Interstate 5. This mining activity formed the borrow pits that are now ponds. Flooding, sediment deposits and vegetation growth have filled in the edges and naturalized the site so that it supports a robust array of bird life across wetlands, forested wetlands, open water, and scrub-shrub habitats. Beginning in the 1990s, community leaders and Key Club members began removing blackberries and reclaimed the site as a park.

ODFW installed a fishing dock in the early 2000s and began stocking rainbow trout and holding an annual Youth Fishing Event. They prioritized the site for restoration due to the presence of Western pond turtles and Hill Creek's proximity to the Lower Coast Fork. In 2005, the Coast Fork Willamette Watershed Council (CFWWC) secured funding to enhance 11 acres of habitat by conducting three years of invasive removal focused on blackberry, English ivy, and Scot's broom, followed by an extensive native planting. CFWWC conducted annual maintenance of the habitat areas and plantings from 2009 until 2013 on an in-kind basis.

Community efforts continued at Garden Lake with the construction of the Ron Petitti Memorial Pavilion, a kiosk, 28 educational signs (8 in pavilion, 20 along trails), and an Applegate Trail memorial. CFWWC, Creswell School District, and the City of Creswell collaborated on an annual Earth Day/Arbor Day event at the site from 2009-2014, as well as 1-3 annual work parties preceding Earth Day. In 2015, CFWWC and the City determined that both organization's limited resources would be best spent addressing the water issues in Hill Creek and thus moved into compiling this document.

While the force of the river may have been used in the past, it is important to realize that future flow solutions will likely require a pump as there is so little natural head or elevation difference across such a long expanse. Future river levels may be lower, unpredictable, or it may be impossible to move the water with only the volume associated with current water rights.

There are more modern methods of diverting water that do not block the entire stream channel and that screen fish from possible stranding in the irrigation channel. Unfortunately, head and/or electricity for a pump are required for these solutions to work. Proper design of a water intake structure on the side of the river would remedy the scour and the resulting loss of streambank and trees the upstream landowner currently experiences from the push up dam. It would be proactive and more affordable to update the point of diversion for the Association water rights now while there is funding available. This will protect fish, conserve water and protect existing water rights.



Creswell Parks and Open Space Master Plan *page 13*

Figure 20: Creswell Parks & Open Space Master Plan Map

Sewage Ponds

In the early 1980s three sewage treatment lagoons at Emerald Valley Golf Course were constructed in a 10-acre diked area as approved by the Creswell City Council. These ponds, owned by the McDougal Brothers Inc., serve to manage sewage from the Emerald Valley Resort and the associated housing development on the east side of Creswell. These ponds were permitted by the Department of Environmental Quality (permit no. 27115 dated 5/23/2000) in which they are defined as "sewage treatment lagoons with no discharge to surface waters". Permit 27115 is set to expire on 2/28/2017.[19]

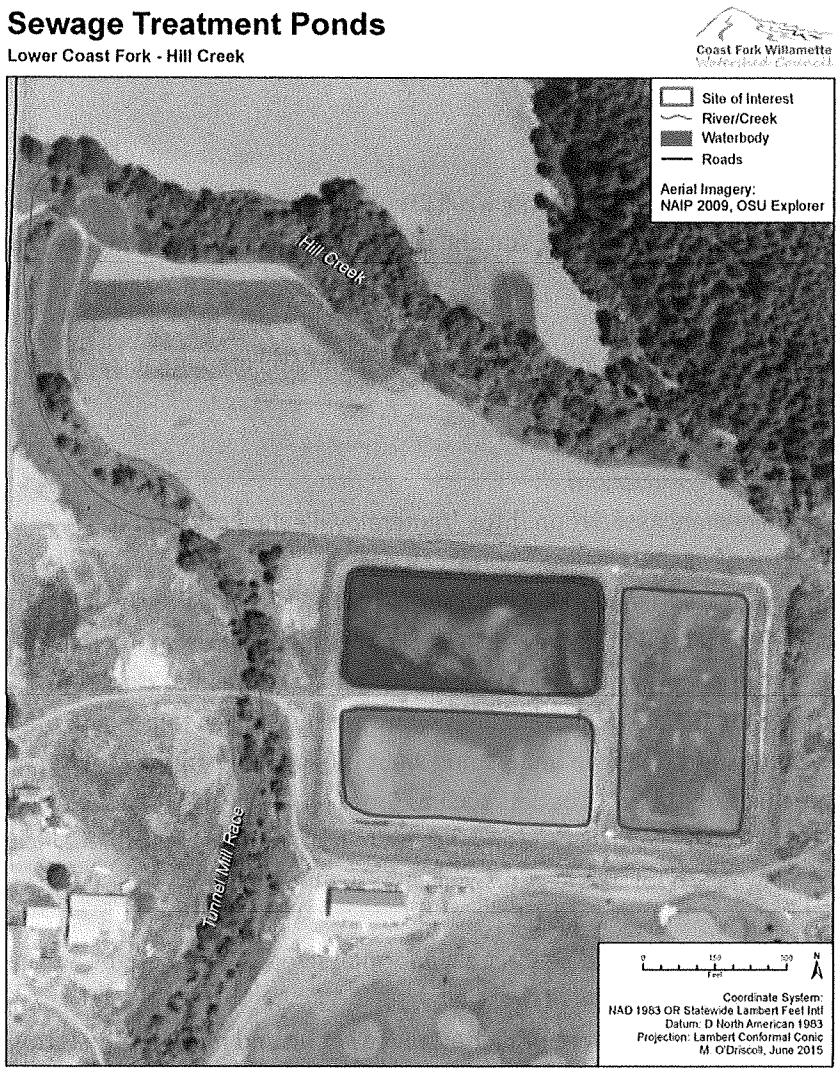


Figure 21: Sewage Ponds Map

As is evident on the map, Hill Creek surrounds the sewage ponds in that it flows along the west side to the north, then makes a 120 degree turn to the southeast to flow downstream to its confluence with the Lower Coast Fork Willamette River. While these ponds are designed not discharge to surface waters, there is a risk that under certain conditions or after a certain amount of time that leakage of untreated waste could occur. In particular, linings degrade over time. Or pond effluent goes above an existing liner. Or overflow occurs in rain events. In each scenario, it relatively simple for nutrient and bacteria pollution from human waste to migrate through the subsoil into the water table or directly flow into Hill Creek and then downstream into the Coast Fork Willamette River. Sewage ponds are not considered a best practice for municipal waste management. Furthermore, there are few public services more important than sanitation. Municipal entities do a great job implementing this human health priority.

[19] DEQ Facility Profiler

Process Opportunities

Complex problems provide many possible solutions. By using good process, it is possible to develop relationships and build consensus about what the problems are prior to determining a solution. A good faith effort to include people in the process (gathering all the relevant data and listening to the stories behind a problem) will make them feel heard and allow them to defer to decisions they would not choose themselves when they understand that their interests are being considered. This is an essential part of leadership and community building. However, process is time-consuming and can be expensive. It is important to choose a process that best fits the problem and consider how the process fits in with the department or staff who will lead the implementation of the solution. Below are a few process opportunities around the determining the priorities and solutions in Hill Creek.

Engage & Educate Residents Who Live Along Hill Creek

An annual outreach effort by the City of Creswell to the various Hill Creek stakeholders would open up lines of communication and provide the opportunity to educate stakeholders on key issues, requirements, and shared needs.

1. Begin annual plan of engagement and communication with interested and affiliated organizations including:
    - Creswell Water Control District (CWCD)
    - Creswell Irrigation Association (Association)
    - Emerald Valley West Homeowners Association (http://emeraldvalleyhoa.org/)

2. Convey the importance of water resources and working together to residents outside of city limits by creating an outreach strategy that educates on Hill Creek issues. Distribute educational materials ((such as best management practices for agriculture, rural living, water, and habitat), organize classes (OSU Extension Living on the Land workshops), host public meetings with speakers on key topics, and offer free site visits so city staff and partner organizations can understand what is happening on the ground.
    - Focus on direct engagement but use press outlets such as Creswell Chronicle where appropriate.
    - Don't forget to invite regular partners to review and distribute messages as appropriate including Creswell committees, Creswell School District, Creswell Library, Chamber, etc.

3. Through the use of a Memorandum of Understanding, request a formal, signed agreement be entered into by the CWCD and the Association with the City of Creswell.
    - Convene annual meetings with each of these organizations to set up and maintain the terms of the agreements.
    - Collaborate on the implementation of the actions specified within each MOU; as interest grows in additional actions, add them to the MOU and seek funding to conduct necessary and timely improvements (particularly the push up dam and diversion structure).

Partnerships for implementation

In order to enhance the capacity of Creswell Planning and Public Works staff and leverage future funding opportunities, formation of a project team should be considered once a goal has been identified. Potential project partners should have expertise in the particular focus area. Facilitating effective meetings with the invited staff of collaborating organizations presents the possibility of dividing roles within individual projects and collaborating on funding opportunities as they arise. Possible partners for Hill Creek include:

- Coast Fork Willamette Watershed Council (www.coastfork.org)
- State agencies who are both regulators and potential funders (OHA, DEQ, ODFW, OWRD)
- Entities who have adjacent/ overlapping areas of concern (Lane Co., OPRD, Cottage Grove)
- Agriculture-focused agencies (NRCS, ODA, FSA, UWSWCD)
- Downstream drinking water providers who have both resources and a vested interest.
- OSU Extension, LCC Watershed Science Technician Program, other UO and OSU departments.

Alternatives Analysis

An alternatives analysis process can be used to evaluate the risk and cost of a potential project and allow potential project partners, landowners, and water right holders to get involved.

Step 1: Fully develop potential alternatives

- Conduct the outreach necessary to ensure the correct partners are involved and interested in cooperating on a future project.
- Contracted conceptual designs and/or technical solutions must be developed at this stage in order to have rough cost estimates to inform the feasibility of the alternatives.

Step 2: Use a public process to select a preferred alternative

Step 3: Assess the feasibility of the preferred alternative

- Select a project manager and convene a project team with skills specific to the selected path.
- Proceed with 30% designs; manage relationships with landowners and water right holders associated with the project.
- Meet with permitting agencies and funders and review designs
- Compile a report that reviews risks and benefits of the project as proposed with a revised budget, timeline and recommendations.
- Secure agreements with willing landowners ensuring their cooperation.
- Facilitate a decision by public officials.

Creswell Public Works: Infrastructure is Relevant to Hill Creek

High quality, sustainable public infrastructure is an important goal for Hill Creek—and with the need to manage timelines, budgets, capacity, and communication; it is a process goal. Hill Creek is interwoven through Creswell. Providing the essential services of drinking water, waste water, parks and open space,

and Interstate 5. If the City of Creswell was to recover its own wastewater as part of a wastewater plant upgrade and resolve summer flow issues for Garden Lake many cost efficiencies could be realized.

Evaluate the City's future water supply needs and water rights. Conduct a SWOT analysis for water supply for all uses and sources.

Create an incentive program for water conservation and efficiency (drip irrigation, flow aerators, etc.) The benefits may be indirect but walking the talk and establishing a track record of best practices will educate the community and encourage support for City decision makers making prudent water decisions.

Reduce the water need at Garden Lake; explore the cost and feasibility of improving the ponds at Garden Lake by reducing their total surface area, deepening the fishing area, or creating wetlands in shallow areas. Creating wetlands will improve natural water filtration and help aggrade sediments that can fill in parts of the pond and reduce its extent and thus the summer water need. Excavation of the fishing dock area can reduce the extent of invasive plants and the fill could be used to build a wetland on the wide, flat western part of the largest pond. Wetland conservation values and opportunities include:

- Slowing the flow of runoff after storms which can reduce flooding downstream and improve water quality by giving time for suspended sediment to settle out.
- Wetlands provide winter habitat for fish, amphibians and invertebrates.
- Enhancing groundwater recharge by giving surface water more time to percolate down to aquifers.
- Enhancement and acquisition of parks and open space.

Develop a stormwater master plan that uses Low Impact Development tools to filter runoff into Hill Creek and enhance wetland and riparian habitats within city limits.

Assess the presence of toxins at Bald Knob; sequester or mitigate legacy toxins at the Bald Knob site. Historic industrial uses were not subject to the same laws regarding the use and disposal of toxic substances that exist today. The City of Creswell is conducting research, evaluations and outreach to the current owner of the Bald Knob property to potentially redevelop this site that is proximate to the business district of Creswell and across from a residential neighborhood. This is prudent as the majority of old industrial areas like this are also brownfield sites, making leadership by any other entity unlikely. It is likely that both the dam and the industrial site pose potential hazards from known and unknown conditions and should be managed accordingly. Due to the costs associated with these conditions, a feasibility study for any of the following ideas may be in order prior to selecting an action.

It is important to research historic industrial sites such as the Bald Knob site in order to assess the presence of pollution on them and if they pose a potential contamination risk. For example, it was not uncommon for petroleum and oil to be disposed of on the ground or in waterways prior to the establishment of regulations like the Clean Water Act. Toxins like heavy metals may bioaccumulate if allowed to enter the food chain. Bioaccumulation is the increase in toxicity by a factor of 10 at each stage of consumption like one fish eating another. For example, fishing for warm water predator fish like bass is popular in the Bald Knob ponds along Hill Creek and downstream at Garden Lake Park, so fish tissue could be pathway for contamination,

particularly of at-risk populations like youth and pregnant women. Oregon Health Authority and other state and federal agencies can assist with tissue sampling as well as precautionary signage that is an important educational tool.

Before any excavation in Hill Creek at the Bald Knob site is considered, level 1 and 2 site evaluations should be conducted in the ponds upstream of the dam. If there is pond contamination by toxics, then steps should be followed that evaluate the problem in accordance with the law and in order to prevent toxic sediments from mobilizing downstream. Ultimately if contamination is present, a determination will need to be made as to if any chemicals must be removed from the site, if established methods exist to treat the problem on site via remediation (using steam, mushrooms, plantings, etc.), or if a project designed to sequester problem in place will meet state and federal requirements. Brownfield remediation is extremely expensive but real or perceived contamination can have serious impacts on economic development and community vitality.

Remove Bald Knob dam

Remove Bald Knob dam in order to restore fish passage; restore Bald Knob ponds—sequester legacy toxins and restore aquatic habitat through plantings, wood placement, and grading pond edges. This important action item is broad in scope and potentially extremely expensive. An evaluation of how it fits into other City plans may result in cost savings.

Recommendation #3:
Prioritize Hill Creek actions outside of city limits

Here is a preliminary ranked list, prepared for the City from the perspective of the Coast Fork Willamette Watershed Council.

1. Address the problem of conveying water from the push up dam to Garden Lake Park.
2. Improve aquatic habitats by removing barriers to migration
3. Remove the push up dam and replace with a modern water intake structure
4. Restore the upper end of the Hill Creek diversion to naturally convey flow into Hill Creek
5. Improve wetland and riparian habitat along waterways

Address the problem of conveying water from the push up dam to Garden Lake Park. To continue to maintain flow during summer months into Garden Lake, annual channel maintenance and construction of the pushup dam that feeds water into Hill Creek must occur or an alternative to the current water needs for Garden Lake must be identified. Assess the feasibility of replacing the push up dam with a fish screened structure that has an electric pump capable of moving the City's water right through the canal (or a pipe) to Garden Lake. This feasibility assessment should include a water rights evaluation with recommendations by a professional water supply/flow consultant so that the City can both comply with and protect its water rights.

Improve aquatic habitats by removing barriers to migration. The Bald Knob dam and the Hill Creek Diversion create fish passage barriers for native fish. Native and non-native fish use Hill Creek and likely times for this use are when they need to get out of flood conditions into safer side channels and small tributaries. The current dam on the Bald Knob site is inoperable and requires a backhoe to lift them open. The Bald Knob dam forms a fish passage barrier and possibly a flow barrier. If removed it may allow increased flow to Garden

Lake ponds as well as upstream access to 3+ miles of degraded habitat of Hill Creek for native fish. Until access to Upper Hill Creek is remedied at the diversion structure or this degraded habitat improved, fish passage at this location is of moderate importance. However, the removal of the Bald Knob dam could be a simple and important place to start the process of restoration. Especially when done in conjunction with wetland restoration and brownfield redevelopment, removing outdated structures is a widely-recognized best practice and one that should be simple to fund once landowner permission is secured.

Remove the push up dam and replace with a modern water intake structure on the side of the river that has a fish screen and a pump and restore the floodplain of the mainstem Coast Fork Willamette River.

Restore the upper end of the Hill Creek diversion to naturally convey flow into Hill Creek; alternatively, retrofit the diversion for fish passage from the Coast Fork Willamette River to upper Hill Creek.

Improve wetland and riparian habitat along waterways in order to provide shade, reduce summer water temperatures, reduce evaporation, and provide aquatic habitat structure for fish. Consider the value of beaver in restoring streams and aquatic habitat. Install structures that allow beaver to build dams without blocking all flow ('beaver deceivers').

Appendices

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Acronyms

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Map Base Data:

The following data sources were used in constructing maps for this project.
Coast Fork Willamette Watershed Council.
Lane Council of Governments. Regional Land Information Database (RLID) Transportation Subcommittee.
Lane County.

State of Oregon. Oregon Department of Transportation (ODOT) Geographic Information Services Unit (GIS).
State of Oregon. Oregon State Service Center for GIS (SSCGIS).
State of Oregon. Oregon Water Resources Department.
U.S. Department of Agriculture. Farm Service Agency. National Agriculture Imagery Program.
U.S. Department of the Interior. Bureau of Land Management.
U.S. Geological Survey. National Hydrography Data Set.
U.S. Geological Survey. U.S. Board on Geographic Names. Geographic Names Information System.

Acronyms

BMP	Best Management Practice
CAFO	Confined Animal Feeding Operation
CFWWC	Coast Fork Willamette Watershed Council
CFS	Cubic Foot per Second
CWA	Clean Water Act
DEQ	Oregon Department of Environmental Quality
DO	Dissolved Oxygen
ft.	Foot (unit of measure)
GWMA	Groundwater Management Area
HUC	Hydrologic Unit Code
mi.	Miles (unit of measure)
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
ND	no data
NPDES	National Pollution Discharge Elimination System
NRCS	Natural Resources Conservation Service
OAR	Oregon Administrative Rules
ODA	Oregon Department of Agriculture
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
ODOT	Oregon Department of Transportation
OHA	Oregon Health Authority
ORS	Oregon Revised Statute
OWEB	Oregon Watershed Enhancement Board
RM	River Mile
TMDL	Total Maximum Daily Load
UWSWCD	Upper Willamette Soil & Water Conservation Service