A Field Trip Guide to Geological Hiking in Cougar Mountain Regional Wildland Park

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GENERAL HEALTH AND SAFETY NOTES

King County's Coal Creek Regional Wildland Park and the City of Bellevue's Coal Creek Natural Area are public gems worthy of our care. Using them, however, is not without risk. Coal mine gasses, unstable ground and steep slopes are significant hazards for those venturing off trail. Wet rocks in creek beds can pose significant slip hazards. Finally, COVID transmission risks have been increasing with the Delta variant, so please consider having a mask handy when you are in a close group – even if you are vaccinated!

Over the past year, there has been a spate of vehicle break-ins even at the most popular trailheads. To avoid becoming a victim of theft, we recommend leaving valuables at home or taking them with you on the trail. Please do not leave unattended valuables in your vehicle.

COUGAR MOUNTAIN GEOLOGIC OVERVIEW

Introduction

The Issaquah Quadrangle map of Booth and others (2006) provides a very good summary of the geology of Cougar Mountain, even though it only covers the eastern portion of the mountain. Cougar Mountain is part of a range of hills and low mountains within the Seattle Uplift. The range, which is informally-named the "Issaquah Alps", includes Somerset Hill and Hilltop, Cougar Mountain, Squak Mountain, and Tiger Mountain. Figure 1 presents the major rock units and structures, overlain on 2016 Puget Sound lidar hillshade imagery. Figure 2 presents a subsurface geologic cross section, after Booth and others (2006), with enhancements showing the Newcastle Hills Fault based on Pratt and Liberty (2008).

Stratigraphy

Major Units

Stratigraphically, Cougar Mountain has three main units. From south to north these are the Tukwila, Renton, and Blakeley Formations. The Tukwila Formation and the Renton Formation have also been known collectively as the Puget Group, with a cumulative thickness between 6,000 and 14,000 feet, regionally (Vine, 1952), and about 11,000 feet at Cougar and Squak Mountains (Booth and others, 2006). The mid- to late-Eocene Tukwila Formation consists of conglomeratic rocks derived from intermediate volcanic sources, as well as clastic sedimentary rocks and thin tuffaceous layers.

Overlying the Tukwila Formation is the late-Eocene Renton Formation, which consists of continental fluvial sandstones, siltstones and shales, with interbedded coal seams. Additionally, the Renton Formation crops out at the southern edge of Cougar Mountain, where it is steeply dipping and in fault contact with the Tukwila Formation.

Underlying the northern portion of Cougar Mountain is the Blakeley Formation, which consists of shallow marine sedimentary rocks of Oligocene age. Near its type sections on Bainbridge Island, Fulmer (1954) reports a thickness of about 5100 feet for the Blakeley Formation. Road cuts along Newport Way, west of Lakemont Boulevard, provide the best Blakeley exposures, including fossil-rich outcrops exhibiting abundant marine mollusk shells. Conformably overlying the Blakeley Formation are Miocene sedimentary rocks and tuffaceous materials, which crop out in a small area at the northern edge of Cougar Mountain, between I-90 and the Seattle Fault (Booth and others, 2006).

During the Pleistocene, continental glaciers inundated Cougar Mountain, depositing a veneer of glacial till across much of Cougar Mountain. Geomorphic evidence for this inundation can be seen in lidar (see Figure 1), particularly the north-south-oriented glacial fluting, which cross-cuts the west-northwest-oriented surface traces of the dipping bedrock strata.

Coal Stratigraphy

There were at least twelve named coal seams on Cougar Mountain, all within the Renton Formation (Figure 3). We discuss the details of the mining history in subsequent sections of this guide, but for the purposes of discussing the coal stratigraphy, it suffices to say that the first major underground mining occurred at Newcastle, on the west side of Cougar Mountain, in the mid-late 1800s. Mining operations began moving east toward Coal Creek after 1881, and by 1900 were focused almost entirely in the upper Coal Creek area.

Most of the coal seams in the Renton Formation were mined at one time or another, but our field trip will focus on four seams that produced the majority of the recovered coal (Figure 3). In stratigraphic order from oldest to youngest, the four seams are:

- The Muldoon seam, which was developed from Coal Creek after 1906.
- The Bagley seam, which also was developed from Coal Creek after about 1900.
- The N^{o} 3 seam, which was the focus of development at Newcastle before 1900. As a matter of unending confusion in the mine maps, mining at Newcastle prior to 1900 called this the N^{o} 2 seam.
- The N^{o} 4 seam, which was also was the focus of development in Newcastle before 1900.

A fifth coal seam worth mentioning is the Primrose seam. The Primrose was the youngest and stratigraphically highest seam. The last few years of major mining operations in the late 1920s expended considerable – and ultimately unrewarded – effort into developing this seam.

Structural Geology

Cougar Mountain Northern Boundary – The Seattle Fault

The Seattle Fault forms the northern boundary of the Issaquah Alps (see Figure 1). The fault brings Eocene to Miocene volcanic and sedimentary bedrock to the surface, in thrust contact with the younger Pleistocene glacial and non-glacial sediments that fill the Seattle Basin to the north. Based on seismic

reflection studies in and around the Issaquah Alps, the Blakeley Formation is found at depths of about 4 km (13,000 feet) north of the Seattle Fault, but lies at the ground surface south of the fault. Seismic reflection studies also indicate that the total thickness of Quaternary sediments (past 2.65 million years) is greater than 1.5 km (~3000 feet, Pratt and others, 2015).

The Seattle Fault is a relative newcomer to the geologic conceptual models of the Puget Sound region, having burst into the scientific literature in a special section of the December, 1992 issue of *Science* (Bucknam, and others, 1992, for example). Since then, the race has been on to define the crustal faults of the Puget Sound area and determine the frequency and magnitude of associated potential earthquakes. Given the relative youth of Seattle Fault studies, it is not surprising that there are multiple hypotheses about the nature of the fault movements, and about the geologic history of Cougar Mountain. Two leading hypotheses in the literature are that: 1) the Seattle Fault breaks through to the surface as a thrust fault, with a broad frontal deformation zone and back thrusts (Pratt and Liberty, 2008; Pratt and others, 2015); and 2) the Seattle fault is a deeply seated wedge whose deformation front is a monoclinal fold (Brocher and others, 2004). Analyses of these two hypotheses are nicely summarized in Figge's 2017 Geological Society of America Annual Meeting field trip guide to the Seattle Fault. Figure 4 shows a schematic of these hypotheses from Pratt and others (2015).

Cougar Mountain Southern Boundary – The Newcastle Hills Fault

This discussion also impacts the interpretation of the southern margin of Cougar Mountain, where the Newcastle Hills Fault juxtaposes near-vertically dipping Renton Formation rocks (to the south) against Tukwila Formation volcaniclastic rocks (to the north). Renton Formation rocks are exposed in small road cuts along May Valley Road in the old Coalfields neighborhood, where the May Creek mine unsuccessfully tried to exploit the steeply dipping coal seams. According to the seismic reflection interpretations of Liberty and Pratt (2008) this fault is a back-thrust associated with the larger Seattle Fault, as shown in Figure 2.

A kinematic analysis of the back-thrust fault model suggests that back thrusts such as the Newcastle Hills Fault may be capable of magnitude 5.5 to 6.0 earthquakes, assuming the Seattle Fault is capable of producing magnitude 6.5 to 6.7 earthquakes (Pratt and others, 2015).

The asymmetric Newcastle Hills anticline (see Figure 1) is a prominent feature of Cougar Mountain, with a steeply dipping south limb and a relatively gently dipping north limb. The anticlinal axis is also offset from the Cougar Mountain topographic high. Such asymmetry does not appear to conform to either of the Seattle Fault models depicted in Figure 4. Although bedding orientations on the south limb of the anticline can be difficult to measure in the field, due to the massive nature of many Tukwila Formation outcrops, dip slopes within the south limb of the anticline are clearly distinguishable in lidar hillshade imagery. Fold structures on the far northern side of Cougar Mountain, near the Seattle Fault, are similarly complex (Booth and others, 2006).

Cougar Mountain East and West Boundaries

Glacial paleo-drainages Tibbetts Creek and Lake Washington form the east and west margins of Cougar Mountain, respectively. Interestingly, based on a review of available seismic reflection data, Liberty and Pratt (2008) speculate whether there may be north-south fault zones aligned with the north-south oriented glacial lakes proximal to Cougar Mountain. Such a structural setting may explain the abrupt termination of the coal beds west of Cougar Mountain from the mines at Newcastle.

Structural Geology and Coal

From the standpoint of the coal, the remarkable feature of Cougar Mountain is its lack of structural complexity in the areas where coal is present. The bedding orientation will vary little among our stops (spoiler alert: 40 degrees to the NNE). The well-mapped coal seams in the major mines were largely free of faults, folds, or other structural complexity (Tim Walsh, personal communication). A greater concern was the pinching or splitting of seams due to the areal variations in the sedimentary depositional environments. In other words, the coal did not form in one big swamp, but in smaller swamps that were moving over time. Figure 5 shows the approximate locations of the major coal seams and the contact between the Renton and Tukwila Formations.

Surficial Geology – Reading the Lidar Imagery

Lidar imagery has revolutionized the study of geology in forested areas of the Pacific Northwest (Haugerud, and others, 2003). The 2016 lidar for the Puget Sound area provides spectacular imagery, especially on Cougar Mountain. This imagery beautifully highlights the local glacial geomorphology, bedrock stratigraphy, and structural geology, not to mention the topographic signature of the mining activities (e.g., cave holes from mine collapses, strip mines, exploration trenches, and other indicators of human activity). Old roads that are now completely obscured in undergrowth are resolvable in the lidar imagery, as is the extensive network of trails that criss-cross Cougar Mountain. The lidar data are publicly available through the DNR's lidar portal (https://lidarportal.dnr.wa.gov/).

With respect to glacial features, the largest-scale overview (Figure 1) shows the major waterways leading to Lake Sammamish traversing the gap between Cougar and Squak Mountains, as well as the currently underfit valley of May Creek to the south. The glacial sculpting of the bedrock surface in large-scale NNW to SSE striations is also apparent. Yet to be studied are some of the subtler hummocks and large ripple-like features that that may be associated with glacial meltwater processes.

The dipping beds of the Renton Formation are readily apparent in lidar, with a predominant NNW strike direction (Figure 5 andFigure 6). A particularly prominent ridge of resistant Tukwila Formation cuts across the Mountain (Figure 1Figure 5). The course of the main fork of Coal Creek, which starts flowing in a southward direction from its source in the former Klondike Reservoir (modern-day Klondike Swamp), takes a sharp turn to flow WNW at the base of this ridge, before turning again to flow NNW towards Lake Washington. The ridge makes prominent vees at the stream crossings to indicate its NNE dip direction. Across Tibbetts Creek to the east, on Squak Mountain, the ridge clearly defines a north-trending synclinal structure. The SSW dipping layers of the Newcastle Hills Anticline can be difficult to define in the massive, unbedded volcaniclastics of the Tukwila Formation. The lidar, however, shows very clear south-facing dip slopes in the southernmost parts of the mountain along May Creek Valley.

The most spectacular mining-related features of the lidar are the cave holes between Red Town and Sky Country trailheads (Figure 5). There are three distinct alignments which correspond from south to north with the Muldoon, Bagley, and N^{o} 3 coal-seam outcrops. Some smaller cave holes indicate excavated mine openings that reopened after failure of their seals, or that were never closed at all. Most of these were airways or secondary paths for emergency egress. The larger cave holes appear where excavation for coal extraction left an inadequate buffer below the surface, resulting in collapse. Mining during the less regulated times before 1900, and again after 1930, saw upward excavation extending as shallow as the rooting depth of trees. Additional mining features include the smaller strip mines, which removed

coal from surface excavations and trenches to confirm the locations of coals in advance of the eastward expansion of mining across Cougar Mountain.

Bellevue-based Mutual Materials operated a clay pit (Figure 5) on Cougar Mountain, starting in the late 1950s (Sally Lawrence, personal communication). The pit supplied material to its brick plant off Coal Creek Parkway in Newcastle up until the 2008 recession. The plant supplied bricks for both Red Square on the UW campus, and for T-Mobile Park (formerly Safeco Field). An older, now overgrown quarry known as the Victorian clay pit sits well off the trail network near the confluence of the main and east forks of Coal Creek. Besides the clay pits, the strongest evidence of clay activities in the lidar are a few long bulldozer trenches that run south from the clay pit to the contact of the Renton Formation with the Tukwila volcaniclastics. One of the trenches crosses the East Fork Trail, where the trench is heavily overgrown with vegetation. The clay exploration trenches may be clearly distinguished from the coal exploration trenches, which are shortened and confined to likely outcrops of the major seams.

COAL MINING OPERATIONS AND HISTORICAL OVERVIEW

The Newcastle Historical Society's book "The Coals of Newcastle" provides an excellent overview of the history of coal mining on Cougar Mountain from the 1850s to the present. The development of the coal industry depended on four things: the supply, the market, extraction technology, and transportation. These factors drove the development of the mines and ultimately led to their decline.

Mining Centers and Eras

Cougar Mountain was a major center of coal mining activity for over a century, spanning from the 1860s to the 1960s, with the main heyday occurring between 1890 and 1925. Over that time, there were several centers of mining activity (Figure 6). These centers were, in chronological order of development:

- **The Newcastle Mines (1869-1901)**. These were the initial focus of mining from 1869 to 1881, mining the **Nº 3 and 4 seams** before operations moved to Coal Creek.
- **The Issaquah Mines**. These tapped the same coal units, but along Issaquah Creek under Squak Mountain.
- **The Coal Creek Mines (1881-1929)**. The first major development after the railroad arrived was the **Coal Creek Mine,** which extended over 500 below sea level, tapping the **Nº 3 and 4 seams**. Fire destroyed the mine in 1894. Mining resumed in 1899 with the **Bagley Mine**, tapping the seam of the same name. The **Ford Mine** (1906-1926) worked the **Muldoon seam** and developed cross tunnels into portions of the **Nº 3 and 4 seams** that had not been previously mined. The **Primrose Tunnel** (or Mine) also started from Coal Creek in 1926.
- **Small-Scale Operations (1930-1962).** Some new mines were developed on the east side of Cougar Mountain in the **Queen Mine**, the **May Creek Mine** (which tapped near-vertical beds south of the Newcastle Hills Fault, with limited success), and the **Newcastle King Mine** (which mined the Primrose seam about a mile down Coal Creek from Red Town). The last mine to open and the last to close was the **Baima and Rubattino New Slope Mine** in the **Bagley** seam, which we will visit. Another operator, the Strain Company, continued to take coal from the existing mines mainly by taking out pillars, and they strip mined in the **Bagley** and **Nº 3 seams**.

Types of Coal Mines on Cougar Mountain

The mining methods had to adapt to the steep, 40-degree dip of the bedding on Cougar Mountain. There are three basic types of coal mines – water level mines, slope mines, and strip mines. Strip mines remove overburden and mine the coal at the surface, whereas water level mines and slope mines are underground mine types. The Newcastle Historical Society's 2020 book has an excellent illustration of the distinctions between water level and slope mines by Carla Trsek, reproduced by permission in Figure 7.

Water Level Mines

Water level mines start where a coal seam outcrops at relatively low elevation such as along Coal Creek. The main excavation for moving miners and coal, or gangway, runs at an upgrade angle that is just steep enough to assure water drainage. A second tunnel, or counter-gangway, runs parallel to the gangway for air circulation. The coal extraction starts at the gangways and proceeds up towards the surface with the coal falling by gravity toward the mine cars below. A buffer between the top of the mined gallery and the surface should have a thickness sufficient to assure the roof of the gallery does not collapse during mine operation (later collapse was another matter). Buffer distances should be greater than 50 feet, but in the earlier days of mining before 1900 and after the major mining operations ceased around 1930, these buffer restrictions were relaxed. Anecdotally, the upper mining limit mining was often tree roots or glacial till (Tim Walsh, personal communication). These galleries were liable to collapse, and they form the major portion of the sinkholes or cave holes on Cougar Mountain; such collapse holes are visible in lidar as dark pit-like features. Because the water level mines were following the seams upwards, their terminations near the surface follow the linear surface trace of the coal seam outcrops, as do the associated cave holes. The lidar makes it quite clear which seams are associated with which cave holes.

Water level mines were relatively low in cost to develop as they did not require pumps for water control, and the transportation of the loaded mine cars only had to overcome the friction of the rails, and not gravity. The primary drawback to water-level mines was that the amount of coal that could be extracted was limited by the elevation difference between the main gangway and the surface.

Slope Mines

Slope mines start at the surface outcrop of the coal seam, and descend into the subsurface following the downward dipping coal seam. At regular depth intervals along the main slope, gangways and counter gangways extend in either direction from the slope, and are identified on maps by level and seam name. Unlike the water-level mines, water had to be collected in sumps and pumped to the surface. Furthermore, the loaded mine cars had to be moved by hoist up the 40-degree slope of the bedding to the surface. Technological advances in machinery and electrification made slope mines economic, for a time.

Strip Mines

Strip mines were relatively uncommon or small, all operating in the 1930s and 1940s. In particular, the steeply dipping strata limited the extent to which strip mines could be developed without having to deal with large volumes of waste rock.

Brief History of Mining Activity

Again, this discussion is largely based on the Newcastle Historical Society's excellent book "The Coals and Newcastle, a Hundred Years of Hidden History (2nd edition, November 2020). It is also based on time spent with the Washington DNR's Geology Portal and their excellent database of coal mine maps (https://www.dnr.wa.gov/geologyportal).

For reasons of transportation access, the first major mining efforts began at the Newcastle townsite. Water-level mines started in coal seam outcrops at the base of ridge mentioned above and ran as far as two miles east of Red Town, beneath Cougar Mountain, following the N° 3 and N° 4 seams. Those mines operated from 1869 to 1881. Initially the coal moved by mule-drawn tramway to a bluff above Lake Washington, by barge across the lake, then overland by tram and later train to the waterfront on Puget Sound in Seattle. The direct train link to Seattle, which included spectacular trestles across May Creek Valley eliminated the over-lake portion of the journey in 1878.

A new slope mine at Coal Creek in 1881 continued the exploitation of the N° 3 and N° 4 seams from a portal that is now buried under the hairpin turn under present-day Lakemont Boulevard at Red Town. The move began the relocation of most of mine infrastructure and mining residences to the Coal Creek townsite. Although Newcastle was largely abandoned, it was not done with mining. The Coal Creek mine suffered several fire disasters in the 1890s, culminating in a blaze that shut down the mine for good. To keep up the supply of coal, a slope mine into the N° 3 and N° 4 seams opened at Newcastle and operated from 1895 to 1901.

The oldest mine maps in the DNR database date from 1894 to 1898, and these document surface facilities and exploration activities projecting the coal seams east beyond the Coal Creek townsite, and even further beyond a second set of Coal Creek outcrops near the source of Coal Creek at the Klondike reservoir[1]. The maps include the breast of the mining at the time (furthest development of excavation) and a line of cave holes that follows the N°3 seam's surface outcrop, though it is confusingly labeled N°2. These cave holes are well off the trail for the most part (we do see one along the Cave Hole Trail), and they were likely the product of water-level mining from Newcastle. Later maps from the first decade of the 1900s show the Coal Creek Mine's workings, but do not show details of the 19th century activity from Newcastle other than the mined-out areas in a gross sense. In the absence of regulatory controls, there was little incentive not to mine as close to the surface as possible and to tolerate sinkhole development.

The transition from Newcastle to Coal Creek was complete with the opening of the water-level Bagley Mine, which operated from 1899 to 1912 in the Bagley seam, and the Ford Mine (1906-1926), a slope mine focused on the Muldoon seam with cross cuts to access levels in the N°3, N°4, and Bagley seams. The Ford Slope Mine's entrance was the only one to be constructed in concrete, which accounts for its excellent state of preservation.

The era of major mining activity ended in the late 1920s. The highly productive Ford Slope Mine closed in 1926. Its successor was the Primrose Tunnel, whose now-obscured portal was a little north of the Red Town trailhead along Lakemont Boulevard. That tunnel would provide access to the yet untapped

[1] The mining company excavated a slope called the Klondyke Slope, which Harvey Manning in his 1984 50+ Trails book, notes was still open at the time and rather scary.

Primrose seam, the shallowest and most northerly outcropping of the major coal seams. The Primrose Tunnel would also provide access to the other seams further east from Coal Creek, improving both water drainage and ventilation. The grated opening at Hike #2, Stop 1 supported a fan for ventilating the network of openings connected to the Primrose Tunnel.

A series of misfortunes and economic turns doomed the continuation of major mining. The Primrose seam did not meet the optimistic expectations of coal quality, and clays along the tunnel alignment created serious maintenance problems. Then, in 1928, fire destroyed the bunkers at Coal Creek. The railroad trestles crossing May Creek were beginning to decay and the line ceased operation in 1930. In 1933 the tracks were pulled, and the remaining sound timbers of the trestles were repurposed, some even for construction of Grand Coulee Dam. Economically, besides the Great Depression, Washington coal was not only facing stiff competition from Wyoming coal, but oil was continuing to displace coal in key markets such as steamships.

1930 to 1962 was the era of small-scale mining, the so-called "gypo" operations, which drew both their miners and management from the Coal Creek mining community. They leased operations from the Pacific Coast Company, removing pillars from coal seams in existing mines at both Newcastle and Coal Creek, and starting new mines near the crest of Cougar Mountain at the B&R (Baima and Rubattino) New Slope Mine, (Hike #1, Stop 10), on the east side of Cougar Mountain (the Newcastle Queen Mine), and downstream of the Coal Creek townsite at the Newcastle King Mine in what is now Bellevue's Coal Creek Park. These small operations transported their coal by truck from the more distributed mine portals to markets that included government buildings and the University of Washington, whom the state mandated to use only local coal for heating. The closure of the New Slope Mine in 1962 ended almost a century of mining activity.

The mine maps of the Washington DNR data base provide insights to the development of mining on Cougar Mountain. Some of the best mine maps in the DNR data for understanding mining on Cougar Mountain are the K7A-J. Map K7D from 1929 has just the main gangways and airways without the mined rooms. Figure 8 shows Map K7D, superposed on the lidar image of the area we are visiting. The main workings are color coded by mine. Figure 9 is a cross-section of the Coal Creek and Ford Mines along the main slopes. This is an enhancement of a section in mine map K7J, which also has the surface openings identified and numbered.

The cross section in Figure 9 shows how each mine drove down a target coal seam. At regular intervals the miners dug a new level the extended laterally along strike into the coal seam. The Ford Mine had three levels in the Muldoon seam, while the Coal Creek Mine had five levels in the N^{o} 3 seam. The cross section also shows how tunnels could extend horizontally to intersect seams other than on host seam for the slope as the Coal Creek Mine deviates at the bottom to intersect the N^{o} 4 seam.

The maps of the gangways in Figure 8 show how the Ford Mine is sticking to its four sets of gangways in the Muldoon seam. This mine evidently stayed clear of the Coal Creek Mine, which may yet have been burning at the time. As the Ford Mine advanced east beyond where the Coal Creek Mine had stopped, the gangways become more numerous and complex as tunnels extend the connections of the Ford Mine to the N^{o} 3 seam, while maintaining a buffer from the Coal Creek Mine. Also shown are the water-level Bagley Mine, whose entrance we will visit (or at least stand above), and the New Slope Mine in the Bagley seam, which was the last to open and the last to close. We'll visit that mine's portal area, too.

Founding of the Cougar Mountain Wildland Park and Mine Remediation

Origins of the Park

Mining left Cougar Mountain a badly-damaged natural area on the edge of a burgeoning metropolitan area. Areas that were once too remote to evoke concern were now prime real estate for suburban residential development. The pressure of the growing Eastside also brought a recognition of the need for preserving wildlands for their recreational value, natural habitats, and historical significance. The creation of Cougar Mountain Wildland Park was the result of dedicated environmentalists and preservationists, notably Harvey Manning, the Issaquah Alps Trails Club (IATC), and the Newcastle Historical Society (NHS). From the late 1970s to through 1980s these lobbied for land purchases as they tirelessly blazed the trail system and created the recreational opportunities we enjoy today. The historical society collected the artifacts and documented the stories of the disappearing generations that lived and worked in Newcastle and Coal Creek.

Role of Federal Office of Surface Mining

The creation of the park would not have been possible without the Surface Mining Control and Reclamation Act which President Carter signed into law in 1977. This act established the funding for reclaiming lands damaged and abandoned by mining companies. Starting around 1984, the act began to fund the closure of mine openings that were dangerous both for their cave-in potential and the seepage of lethal gasses. The openings that have been remediated are mainly mine entrances – a few main portals and many smaller entrances that were used for ventilation and emergency egress. Many were still open in the early 1980s (see 50+ Trails of Cougar Mountain for contemporary trail descriptions). Others were sealed in the mining days using diverse, but impermanent, materials like tree stumps and rusted vehicle hulks. Hundreds of mine openings on Cougar Mountain have been remediated through the cooperative efforts of the federal Office of Surface Mining and King County. A key subcontractor for much of the geotechnical work has been Hart-Crowser. Although the level of activity has diminished over time, new openings continue to appear, such as the one at Hike #1, Stop 11, which reopened in 2018 and was filled in the 2019. Cave holes created by the collapse of mine rooms that ventured too close to the surface are generally not candidates for remediation.

Fire in Coal Mines

Fires are another continuing hazard of mining. Coal will spontaneously combust underground if there is a source of oxygen fed by incompletely closed mine openings. Fire in the N^{o} 3 seam destroyed the Coal Creek slope mine in 1894, and it is not clear that the fire has ever completely extinguished. The burning expresses itself occasionally through steam reaching the surface. Harvey Manning, in his 50+ Trails of Cougar Mountain, describes strip mining during WWII that let air into the Number 3 seam producing a plume visible from Seattle (Hike #2, Stop 2). An increase in steam activity in 2006 triggered the Office of Surface Mining to perform an aerial thermal imaging survey, which identified a surface temperature anomaly rough 100' wide by 200' long. According to retired park manager, Steve Williams, anomalies on the order of 100^{o}F or more continue to measurable on the surface**. <u>It must be noted that these thermal anomalies occur off the trails in some of the most hazardous portions of the part. They must be strictly avoided by the public.</u>**

HIKE NUMBER 1: SKY COUNTRY TO THE CLAY PIT AND BACK

Introduction

This hike covers the ground between the Sky Country trailhead and the Mutual Materials clay pit and back. The main highlights are the following:

- cave holes in the Muldoon, Bagley, and N^{o} 3 coal seams,
- coal seam exposures in the bed of Coal Creek
- dipping sedimentary layers in the clay pit and fractures in the beds of a dip slope exposure
- site of the last underground mine, the B&R New Slope Mine
- an air shaft to the Primrose Tunnel with remediation by grating
- The Klondike Reservoir site, formerly maintained as a water source by miners and now resurrected as a pond by beavers
- 2019 remediation of by cement filling of a mine opening whose original fill collapsed in 2018

As an important reminder, at all cave holes, stay behind the fence and don't approach the edges. Many of these holes daylight in glacial till or soil cover and the steep slopes are highly unstable. Furthermore, all mine openings may be transmitting methane and other potentially lethal gasses.

General Notes for Hikes

The hiking guide describes two hikes that start from the Sky Country Trailhead of Cougar Mountain Regional Wildland Park. The first focuses on the higher elevation areas between the Trailhead and the former Mutual Materials clay pit. It runs about 3 ½ miles with about 200 feet elevation gain. The second covers the terrain between Sky Country and the Red Town Trailheads with a focus on the area around the town and mining area of Coal Creek. It also has a side trip to a very curious exposure of the Tukwila Formation, the only place one encounters bedrock other than Renton Formation in this guide. Hike 2 can be shortened by starting from the Red Town Trailhead. It currently totals a little over 4 ½ miles with about 700 feet elevation gain – mostly on the return to Sky Country. The hike may be shortened by leaving out the last stop at the Tukwila Formation "quarry".

In addition to the figures bound with this document, Stephen Newman has prepared three oversized plates. One is an overview of both hikes, and the other two are smaller scale maps of each hike. A georeferenced pdf of these maps is available and may be downloaded to smart phones for use with Avenza, a powerful geographic imaging and mobile tracking app. The free version is adequate for these hikes. King County's trail map of Cougar Mountain Park is also available for free from Avenza's map store.

Please be safe taking these hikes. **Do not deviate off trail other than noted in the guide, and especially do not venture into the unstable areas around cave holes and other old mine openings. Take warning signs very seriously. Unstable ground and mine gases can be lethal!** Despite the efforts by the Office the Surface Mining and King County Parks to close or isolate old mine openings, many hazards remain, and more will appear in the future.

The trails are excellent but can be a bit rocky so good trail shoes or hiking boots are strongly recommended. Poles help especially on the few scrambles to exposures. Nettles and blackberry thorns abound, and Cougar Mountain is home to wildlife – including cougars and bears.

Hike 1, Stop 0: Nike Park, Hike 1 Start

The hike begins in the grassy area known as Nike Park for its prior function as a surface-to-air missile base through the 1960s. The concrete pads are part of the base's works, and the curved earthworks prominent in the lidar image served as a blast wall to protect servicemen during missile launches. It was formerly taller, but material was repurposed for the road to the clay pit. A large sinkhole opened in the middle of this field during base construction despite warnings from former miners. It is now filled. Head over to the split rail fence that bounds the west side of the park. On the other side of the fence is the Nike Horse Trail. You can also start this hike from the start of the Nike Horse Trail on the southwest side of the horse trailer parking lot.

Figure 10 provides overlays mine maps of the Ford Slope and B&R New Slope mines on the lidar and the trail tracks.

Hike 1, Stop 1: Cave Hole in the Muldoon Seam

Head south on the Nike Horse Trail about 0.25 miles to its intersection with the Cave Hole Trail. To your left is a cave hole which is fenced and signed. This collapse likely ties into late-era water-level mining in the Muldoon seam. Turn left onto the Cave Hole Trail.

Hike 1, Stops 2 and 3: Blackwater and Champion Cave Holes

Take a moment to look at the lines of cave holes on the lidar imagery. As the coal seams are dipping to the NNE, the deepest and oldest seams form the lines to the south and the younger seams are to the north. The trail here runs between the line of cave holes associated with the Muldoon seam and the lower Bagley seam (on the right), which is split into upper and lower seams on this part of the mountain. Short trails into the undergrowth provide paths to fenced cave holes on either side of the trail. **Stay outside the fencing!** Some are water-filled and others are dry, for reasons we can only speculate. The water-filled cave holes are not as distinct on the lidar because the lidar shows the water surface, but these are likely a tens to hundreds of feet deep.

The first of our cave hole stops on the right has been named the "Blackwater" cave hole in the Muldoon seam. Returning to the Cave Hole Trail, a side trail to the left leads to the "Champion" cave hole (named out of respect for its size). This cave hole collapsed into the Bagley seam. The timing of these cave holes requires some more research, but my speculation is that these formed from water level mining by the "gypo" operations in the 1930s. The N^{o} 3 seam cave holes which appear on the lidar north and west of here, on the other hand, were likely associated with water-level mining from the Newcastle Mine prior to the mid 1890s.

Hike 1, Stop 4: Lower Bagley Seam Outcrop in Coal Creek

Continue east on the Cave Hole Trail to a point where it takes a 90-degree turn. On the left is a cave hole, likely connecting to the lower Bagley seam. An informal trail leads to the right down the embankment to the bed of Coal Creek. This is steep and the soil is loose to take care with the descent. You may want to use poles or negotiate this with your rear end. At the bottom in the east wall of the creek bed is an excellent exposure of coal from the same seam that was mined to create the cave hole above. As a matter of safety, note that miners avoided excavating up into the creek beds for obvious reasons. A few yards upstream from the coal is an excellent exposure of sandstone. This is a good place

to reflect on the experiences of the original prospectors who were following Coal Creek up the mountain looking for exposures like these. You may spot some odd scraps of ore and short coils of steel wire lying around. These are wrappings for tarred, wooden pipes that once provided water conveyance from the upstream reservoir to the mining operations.

Hike 1, Stop 5: Dutch's Strip Mine and Site of the B&R New Slope Mine

Scramble back to the Cave Hole Trail and continue north. You will reach the intersection with the By-Pass Trail and turn right. Follow the trail across Coal Creek, through pleasant second-growth cedar groves until you reach Fred's Railroad Trail. Fred Rounds was a former miner who lived on the Mountain until the 1980s. He helped build a small railroad for logging along this alignment. In a short distance on the left, you will encounter Dutch's strip mine in the Bagley seam. This small surface excavation was perhaps the last mining of any kind occurring in 1982, according to Harvey Manning in his 1984 book, 50+ Trails of Cougar Mountain. The book also describes two major openings, one to the east and the other to the west. Both have undergone remediation since 1984, and the absence of any traces indicates the success of the work. The one to the west is an access to the Ford Slope mine, while the one to the east is access to the last underground mine on the mountain, the B&R New Slope Mine, which had its main operations at this site, including a bunker for processing the coal and the mine's main entrance and airway into the Bagley seam. The sites, as with all remediated openings, are marked with a monument consisting of pipe with a bronze marker indicating the Office of Surface Mining number, the date, and an identifying description such as the seam, the mine, or a nearby trail. Finding these nearby monuments requires a short but intense struggle with nettles and blackberries which we will forgo. To the west, you may note the last remnant of the mine operation, a wooden transformer tower.

Hike 1, Stop 6: Monument on Muldoon Mine Closure

Continue on Fred's Railroad Trail a little further. On the left will be some evidence of undergrowth removal which will lead us a short distance to a marker for the Muldoon seam in the Ford Slope Mine.

Turn back on Fred's Railroad trail and continue to the intersection with the Clay Pit Trail, which is the former road from the brick plant to the quarry. Continue up the hill, this is the steepest climb of our hike to the Mine Shaft Trail. Take a right turn and proceed a short distance to grated shaft with a bench and information kiosk.

Hike 1, Stop 7: Mine Shaft

This a one of the three well-preserved mine openings on Cougar Mountain. The other two are on Hike 2. This shaft (probably an incline) goes down about 1200 feet on the incline (600 feet vertically) to a mined area in the N^{o} 4 seam. This is a late 1920s excavation that complemented the digging of the Primrose Tunnel (or Mine). The hope, which was wildly optimistic in retrospect, was for the Primrose Tunnel to provide access to the last major untapped seam, the stratigraphically shallowest Primrose seam, with added functions of tapping into other seams and improving the water drainage and air circulation. A large ventilation fan once sat on top of this opening. As the section on coal mining in this field guide explains, the coal did not meet expected standards, the tunnel did not want to stay open, and the national economy along with the coal economy collapsed. Note the Office of Surface Mining Monument and an excellent example of a grated remediation.

Return to the Clay Pit Trail and continue up the slope to an overlook on the Mutual Materials Clay Pit. You can look past here to the Cascades, and this is our best long-distance view of the day! The clay pit is listed on the park map as closed, probably for liability reasons as Mutual Materials has a right to continue mining until 2040. However, 1) the brick plant is closed, 2) the brick-plant site was remade into condos and apartments, and 3) the clay pit floor has been revegetated. A return to excavation is unlikely. If you want to see where this material went, look no further than T-Mobile Park or UW's Red Square.

Hike 1, Stop 8: Dip-Slope Bedding Plane in Clay Pit

As you walk along the clay pit floor, take note of what nature thinks of the re-vegetation efforts. It is mostly working well, but the accumulation of water during the winter exceeds the infiltration capacity of the cover, and the excess water has been eroding through to the bedrock. The interplay of the sinuous gully and the dipping layers of sandstone, siltstones, and clay has a certain geologic aesthetic. Consider checking the strike and dip. Spoiler alert! It's dipping 40 degrees NNE just like everywhere else. Continue to the far end of the pit where you walk up a short slope to the last working benches that are not yet overgrown.

At the end of the easy access is a spectacular dip-slope bedding plane. Note from the talus how this is inclined close to the friction angle of the bedding planes. There are also three fracture sets in the exposure. Besides the discontinuous bedding plane, there is continuous vertical set with a strike in the direction of bedding dip, and a set perpendicular to the vertical set. There are several ways to get down the bench, going to the left is easier.

After enjoying this structural geology excursion, retrace your steps back to the Clay Pit Trail, and continue back the way you came from the Clay Pit Overlook. Continue past Fred's Railroad Trail to the crossing of Coal Creek on the Clay Pit Trail.

Hike 1, Stop 9: Klondike (or Klondyke) Reservoir (also called Klondike Swamp)

On our right is the site of the Klondike Reservoir, an impoundment on the main fork of Coal Creek, which supplied water for mining operations. After mining operations ceased, the dam fell into disrepair and the former reservoir floor returned to forest. In more recent years, the dam has been reconstructed by beavers, who have little regard for regulation. Their restoration of the dam has flooded the forest and destroyed many trees. In the past year, the Park has invested in this new structure under the trail, partly to make sure water flows are not entirely blocked and also to reduce the consequences of a beaver dam failure.

Hike 1, Stop 10: Wood Water Pipe

Continue on the Clay Pit Trail until it intersects with the Cave Hole Trail. Turn left. In a short distance, look on the left side the trail and you can spot a remnant of the piping that once conveyed water from Klondike Reservoir to the mine operations. Note the wire wrapping and the black, tarred surface. The wood appears at the ends of this large fragment. Recall that you may have seen this wire before, back at the coal seam exposure.

Hike 1, Stop 11: Mine Remediation

Continue on the Cave Hole Trail a short distance to the Old Man's Trail (not it's not named for this guide's author). Turn right and continue to a clearing which was formerly fenced but the wire is down. This mine opening (into the N^{o} 4 seam?) was probably closed during mining days. There was a cave hole here, hence the fencing, but in 2018-19 it re-opened. The surface dropped at least 20 feet and a few people brave (crazy?) enough to investigate the hole reported that it appeared bottomless. This is a good example of why the Office of Surface Mining's work at Cougar Mountain Park will likely never be done. Well over 100 openings have been closed and sealed, but many openings that were closed in the mining days, using at-hand materials like stumps and decrepit vehicles, fail over time. This is an excellent example of a concrete cap over a plug. Walk on this at your own risk!

Hike 1: End

Continue a short distance on Old Man's Trail back to the start. You will see Nike Park through a clearing. There is an unofficial short cut back to the start, or you may follow the trail to the Sky Country Kiosk and return either to the parking lot or the AEG event center.

HIKE NUMBER 2. COAL CREEK TOWNSITE AND MINING-INDUSTRIAL CENTER

This hike takes us from Sky Country Trailhead to Red Town Trailhead, the main area of mining activity from 1881 to ~1929. Red Town was one of several miner's neighborhoods at the Coal Creek Townsite. As mentioned in the introductory materials, Coal Creek took over from Newcastle, about 1 mile to the west, starting in 1881 with the opening of the Coal Creek mine, which worked the N^{o} 3 seam. After fire consumed the Coal Creek Mine in 1894, two new mines opened. These were the 1899 water Level Bagley Mine, working the Bagley seam, and the 1906 Ford Slope Mine, working the Muldoon Seam.

Hike 2, Stop 0

Hike 2 starts at the former Nike Park, a wide-open grassy area on the site of the former surface-to-air missile base intended to protect Seattle from air attack in the 1950s. The Nike Horse Trail lies on the other side of the split rail fence on the west side of the field. This hike can also start from the horse trailer parking lot. Hike down the Nike Horse trail about 0.3 miles to its intersection with the Cave Hole Trail.

Hike 2, Stop 1: Cave Hole in the Muldoon Seam

As we make the turn from the Nike Horse Trail to the Cave Hole Trail, note the large cave hole on the left. Look at the lidar image for Hike 2 and note there are three lines of cave holes. The lines of cave holes follow the surface outcrops of the coal seams. The most prominent of these lines is north of our current location following the N^{o} 3 seam. We will cross this line at Stop 2. The N^{o} 3 seam cave holes predate a geologic exploration map from 1895, which is the oldest map in the DNR coal mine database for this area. It was not until later that mining practices left 50-ft buffers.

Hike 2, Stop 2: Erratic and Mine Closure

A large granite erratic on the edge of trail marks Stop 2. As you approach the erratic, you may also see some sandstone in the roadbed of the trail. Also, as the erratic comes into view, note the small cave hole on the right side of the trail. Consider taking an orientation measurement for comparing to later stops. This fenced cave hole is part of the "Line of Cave Holes" that follows the N^{o} 3 seam and appears in the oldest mine map for the area in the DNR map database (K14A) from 1895. When that map was made, the mining from Newcastle and the Coal Creek Mine had advanced eastward well beyond this point. The maintenance of buffers between the mines and the surface was generally ignored prior to 1900 and after major operations ceased in ~1929. During those loosely regulated days, tree roots were sometimes taken as a sign that one should stop digging towards the surface. The Bagley and Muldoon cave holes may have formed from the "gypo" mining after 1930, while this line of cave holes in the N^{o} 3 seam mostly formed before 1895. The K14 map depicts surface features and geology with little information on the underground workings, other than a general indication of the "breast" or line of advance underground. The focus on surface geology may have reflected a need to find a new mine location after the catastrophic 1894 fire that ended the Coal Creek Mine's operations.

Just downhill of this stop, and clearly visible in the lidar, is one of the smaller attempts at strip mining from the 1940s, the only one in the N^{o} 3 seam, which ignited and continued to burn long after 1894. As recently as 2006, a flareup attracted attention from the Office of Surface Mining. The Office of Surface

Mining brought in aerial thermal imaging equipment to define the active burn[2] (Figure 11). According to Harvey Manning's 1984 50+ Trails of Cougar Mountain, the WWII era strip mining at this location enhanced air circulation to the already burning seams underground creating a steam and smoke plume visible from Seattle and misinterpreted by some as an enemy attack.

This is one of the Office of Surface Mining remediation sites (see the monument and marker). Besides stabilizing the ground, the closure efforts also reduced the airflow to the subsurface. Near surface soil temperatures, which may exceed 100°F, dropped after the repairs (Steven Williams, personal communication), though this continues to be a "hot" spot. For more information, please refer to the introductory material on mine fires.

The Line of Cave Holes in the N° 3 seam continues to be the most hazardous area of the park, and the admonition to remain on marked trails is particularly important. Not only is exploration of this area foolhardy, but there is no guarantee that a rescue can be undertaken in the event of an accident involving unstable underground openings.

Continue downhill along the Cave Hole Trail, which takes a right angle turn to the left at its junction with the Red Town Creek Trail. Take a right on the Red Town Creek Trail and continue to the next stop at the Red Town Dam site.

Hike 2, Stop 3: Red Town Dam Site

Red Town Dam was the main water supply for the town of Coal Creek. The creek bed here reveals sandstone overlain by glacial till. The timbers that made up the dam are long gone, but the concrete foundation is still visible. In typical autumns, like 2021, this creek is dry. During mining days, the water supply had to be supplemented by shipments from outside.

Hike 2, Stop 4: Exposure of the N° 3 ½ Seam

Continue on the Red Town Dam Trail to its "T" junction with Military Road Trail and turn left. Continue 0.2 miles (or follow your tracks on Avenza) to an unmarked, and currently decommissioned trail on the left. The trail itself is clear, and there is some gravel in the trail bed. There will be an AEG sign to help locate this. Follow the trail to where it runs above the creek and you can see a log crossing the channel. This will also be marked. Scramble down to the creek bed however you like, but I think it is easier on the left side of the log. Within a few tens of yards, there is well exposed contact of the N° 3 ½ seam with tan sandstone, and a coal seam continues up the creek bed along the strike of the seam. This is a relatively thin seam lying between the N° 3 and 4 seams that received little mining attention except for water-level mine entrance in the left bank of Coal Creek below Lakemont Boulevard.

Before you leave, consider taking a bedding orientation measurement if you have a Brunton compass or an appropriate app on your smart phone for comparison with other stops.

Back track to the trail and continue a short distance down to the Red Town Trailhead parking lot. From here, walk carefully in the parking lot to the entrance on Lakemont Boulevard. From there, carefully cross the street.

[2] https://blackdiamondhistory.wordpress.com/2019/02/01/burning-mines-creating-hazards-at-park/

NOTE THERE IS NO CROSS WALK AND TRAFFIC CAN BE MOVING RAPIDLY ON THIS STRETCH OF LAKEMONT BOULEVARD. BE CAREFUL!

Hike 2, Stop 5: Site of Hotel, General Store, and Railway Ticket Office

Once you have crossed the road, look at Figure 12, which is a superposition of a mine map from the late 1920s with the entire Newcastle Mine system. The map noted both underground and surface features, such as the hotel, store, and bunkers. Also note the location of the Coal Creek Mine entrance, which is now buried under the fill for present-day Lakemont Boulevard.

When we crossed the road, we left Cougar Mountain Wildland Park (King County) and entered Coal Creek Park (City of Bellevue), which also contains an excellent trail system with many informative displays. The portal of the Coal Creek Mine, which we now know was destroyed in 1984, was in the right bank of Coal Creek and is now buried under Lakemont Boulevard, which parallels the old county road of the mining days with a modern crossing a short distance downstream from the original crossing.

The open field we are now crossing was the site of the hotel and general store. A small portion of the hotel's foundation is still visible. This is park land, but just beyond the hotel on the former property of Milt Swanson, one of last of the miners, there are plans to develop over 30 new home sites. If you think a better use for this land would be to preserve it and perhaps upgrade visitor parking, please consider supporting the efforts to "Save Coal Creek".

The railway to Seattle terminated on the opposite side of Coal Creek at this location, and passengers used an elevated walkway to get to the station. We can ponder that while we descend on the Coal Creek Trail, arriving shortly at the next stop.

Hike 2, Stop 6: Airway to N^{o} 4 Seam

After a short distance, you will reach one of the three best preserved mine openings on Cougar Mountain. This is an airway to the N^{o} 4 seam. Note that the unlined opening is in glacial till. The Pleistocene glaciations overrode Cougar Mountain, filling the previously existent valleys and mantling the upland rock surfaces with till. Continue on the Coal Creek Trail to North Fork Falls on the right.

Hike 2, Stop 7: North Fork Falls

Here, the North Fork of Coal Creek descends over a near-vertical face of glacial till. The base of the falls is sandstone. This stream flows for most of the year and will likely be flowing at the time of our visit. The flow is sustained, in part, by drainage from the Primrose Tunnel which has a sealed but leaky portal about a quarter mile upstream. The water often runs red and stains the wall of glacial till, presumably from iron-loving bacteria in the discharge waters.

The Primrose Tunnel is so named for the Primrose coal seam, which is the highest seam stratigraphically and has the northern-most outcrops on the mountain. While not a water-level mine, the tunnel does have a slight upward grade to provide gravity water drainage. The Primrose Tunnel was excavated in the late 1920s with the multiple purposes of providing access to the Primrose seam as well as improved ventilation and drainage for accessing the other seams under the highest points of Cougar Mountain. As discussed in the introductory material, the effort was a bust as the quality of the coal from the Primrose seam did not meet expectations, and clays along the alignment made the tunnel's maintenance a nightmare. For those who have done Hike 1, the air shaft stop taps into the other end of this tunnel.

Note from Figure 12 that this location is across from the Coal Creek bunkers. We are close to the level of the train tracks. The station for passengers was not far above here. Coal-laden cars from the mines would run on tracks above here, on the opposite bank of the creek. They would drop their loads of coal in to the bunkers where coal pickers would grade and sort the coal as it dropped by gravity toward the waiting train cars below.

From here, return upstream along the interpretive loop.

Hike 2, Stop 8: Sandstone – Coal Seam Exposure

The interpretative trail has several highly informative displays on the mining days at Coal Creek. Geologically, the bank across from the trail has a good vertical exposure of sandstone and the N^{o} 3 ½ Coal seam, which we saw at Stop 4. Our thanks to Steve Williams, former park manager, for recently cleaning off the accumulated moss and algae! You can either follow the trail, or carefully follow the creek bed which exposes both sandstone and thin coal stringers.

From this stop, complete the interpretive loop trail, rejoining the Coal Creek Trail and back track to the Red Town Trailhead. Again, take great care while crossing Lakemont Boulevard.

Take note of the port-a-potties at the trailhead. They are the only facilities on this hike. The Red Town Trail heads up the slope, while the Wildside Trail is the level path to the right. Take this trail a short distance to the fork at the Bagley Seam Trail. Just before the fork, note the 15-foot vertical methane vent pipe. There is an OSM monument, which has lost its brass marker, either to vandals or the elements, but its number, OSM 60, is scratched into the paint on the remaining pipe of the monument. This vent marks the site of the Bagley Mine, which was a water-level mine in the Bagley seam. The Bagley seam was highly exploited from slope mines, water-level mines, and strip mines. The Bagley Seam Trail to the left follows small strip mine along the seam, which is also very clear in the lidar. A much larger strip mine operated along the Bagley seam to the west. This mine later became a landfill, which was later replaced by the Newcastle golf course. If you have time after the hike, consider a short drive up to its spectacular views of the Puget Sound area. The waste from the strip mines buried the Bradley Mine entrance, which is perhaps 10-20 feet below.

Proceed up the Bagley Seam Trail until you find the dipping bedrock exposures.

Hike 2, Stops 9 and 10: Bagley Mine Entrance and Bagley Seam Excavation

Although most of the coal is gone or still unexcavated underfoot, one can see nice dipping bedding surfaces of carbonaceous shale and some coal. This excavation and its continuation across the Red Town Trail to the north are clearly visible in the lidar. If you have a Brunton compass or smartphone app for taking orientation data, this is a good place to get a measurement to compare with other locations.

Retrace your steps to back down the Bagley Seam Trail. At the bottom, turn left back onto the Wildside Trail. Cross the footbridge over Coal Creek and climb past the unmarked site of the Wash House, where miners cleaned up after their shifts underground. The cuts along the trail here pass through coal mine wastes. This is a good place to find your souvenir lump. Never too early to start thinking about Christmas gifts for that deserving child!

At the junction of the Wildside and Rainbow Town trails, turn left and proceed to the portal of the Ford Slope Mine, which will be on your left. The Rainbow Town neighborhood allowed the house holder to choose their exterior colors unlike Red Town, where the company supplied one (and only one) color.

Hike 2, Stop 11: Ford Slope Mine

The Ford Slope operated from 1906 to 1926. The slope descends over 1700 feet on a 40-degree angle in the dip direction of the Muldoon seam, which was its main source of coal. The deepest levels are over 300 feet below sea level. The mine has four levels in the Muldoon, as well as cross cuts to levels in other seams. Each level has a short loop of track that allowed the coal cars to negotiate the 90-degree turn from the gangways to the main slope and to be hauled in or out of the mine. Figure 13 shows a detail of the lidar with the mine map superposed. The map shows the main workings of the Ford Mine (red) and Bagley Mine (water-level, green). Compare where the excavations end with the outcrop line of the Muldoon seam. The gap denotes the buffer from the surface, intended to avoid cave-ins.

The excellent state of preservation is owed to the use of concrete for the portal structure instead of timber. Compared to previously developed mines on Cougar Mountain, the Ford Slope took advantage of advances in mine machinery and electrification. Take a few moments to absorb the excellent materials on display in the information kiosk.

As you continue uphill along the Rainbow Town Trail, note the remains of the fan house foundation that supported the ventilation on one of the two airways parallel to the main Ford Slope. Note the date, which is gradually disappearing. At first glance it appears the fan house was swallowed in a sink hole, but the true story relates to an explosives company that tested product on Cougar Mountain in the 1960s. According to Steve Williams, retired park manager, the engineers underestimated the amount of steel in the concrete, and it took several tries to remove it. The final attempt moved the blocks considerably closer to the road.

Hike 2, Stop 12: OSM Monument 360, 2011 Foam Filling

On your left, we arrive at the Office of Surface Mining Monument 360. There are two remediation sites close to one another on the right side of the trail. The area to the left of the trail lies between the Muldoon seam (Ford Slope Mine) and Bagley Mine (Bagley seam), with an underlying outcrop of the May Creek seam, which lies between the two. This was not a major seam, though it was mined in several locations, including here. There are few cave holes into the May Creek seam, which appear clearly in the lidar as well as a few mine access openings. The opening underlying this monument was sealed in 2011 using an innovative application of high-density foam (Figure 14).

From here, continue up the Rainbow Town Trail to its junction with the Red Town Trail. Turn right and continue through Red Town on what was Third Avenue South and lined with miners' homes. Continue on this trail across a footbridge over Coal Creek and past the habitat restoration project on the right (on the site of the former baseball fields). Shortly before the bridge, you also walked across the contact between the sedimentary rocks of the Renton Formation and the volcanic rocks of the Tukwila Formation. Note on the lidar the prominent dip slope ridge in the Tukwila that controls the course of Coal Creek. As mentioned in the introductory notes, this ridge is useful for defining the structural geology of Cougar Mountain and Squak Mountain, where it defines a clear synclinal fold.

Turn left onto the Indian Trail, which crosses a gap in this ridge and defines a drainage divide between Coal Creek and tributaries of May Creek to the south. In a short distance on the left is a prominent outcrop of Tukwila Formation.

Hike 2, Stop 13: Tukwila Formation Rockfall

SAFETY NOTE: This outcrop invites rock scrambling especially for geologists. The Park recommends staying off the boulders, and any activity here must be undertaken at your own risk. Exercise caution!

Before reaching the Quarry Trail, a low outcrop of Tukwila Formation looks like a big jumble of rocks. This outcrop was interpreted as a quarry by Harvey Manning, the late and well-beloved leader of and the "Quarry Trail". The "Quarry Trail"splits off from the Indian Trail just south of here and refers to this site. That said, there are no records from the mining days that suggest this site was used for suppling rock.

Whether or not this is a human-made quarry is matter of interpretation, but I think there are at least three reasons to conclude that this was not a quarry. These reasons include:

- The displaced rock does not appear to have been removed
- The rock blocks are too big and varied in size for use as dimension stone
- There are no signs of drilling or blasting such as "half rounds" of blast holes surrounded by shattered rock.

The rock here is typical of the Tukwila Formation – a dominantly course andesitic volcaniclastic rock, which means to say that it consists of broken pieces of volcanic rock that have been transported by processes including mudflows such as lahars. The Tukwila also contains thin layers of tuff, including one in the back wall of this outcrop that provides a good indicator bedding. Minor amounts of other sedimentary rocks appear in the Tukwila Formation, along with occasional leaf fossils. Leaf fossils have been found here, and they also appear in Tukwila Formation exposures along Coal Creek Parkway on the southwest side of Cougar Mountain.

Another characteristic of the Tukwila Formation are cliffs and rockfalls. The Tukwila formation underlies the south portion of Cougar Mountain, and it can form glacially-plucked cliffs such as the De Leo Wall in the southwest corner of the Wildland Park and in the southeast along trails from the Jim Whittaker Wilderness Peak Trailhead. Below these cliffs, one can find prominent rockfalls, or boulder fields of car to small house-sized blocks of Tukwila Formation. In addition to these Cougar Mountain rockfalls, Tiger Mountain has talus caves, where the rock fall blocks, (Tukwila Formation), are the size of small buildings and the gaps between the blocks are large enough for a human to crawl through. The Tiger Mountain caves are reminiscent of the famous talus caves of Pinnacles National Park in California, where the rockfalls were caused by earthquakes on the adjacent San Andreas Fault.

There are three parts of this outcrop. One is the back wall, which is formed from a vertical fracture and where the rock is intact and in place. The second on the left (north) side of the outcrop exhibits several blocks in a diamond-shaped wedge that have displaced from the back

wall and one another, but are still in their original relative positions. The rest of the site consists of blocks that have displaced from the back wall and are mostly dislodged.

The quarry site we see here differs from the other rockfall sites. The slope here is not steep, nor is it particularly high. Some preliminary work on the fractures and bedding partings suggests that this rockfall, if we can call it that, did not fail due to gravity alone. It needed some help.

There have been no definitive studies at this site, but I can suggest three hypotheses to explain this jumble, having ruled out a simple gravity failure. One intriguing hypothesis is that this could have been seismically generated, perhaps by an earthquake on the Seattle Fault or the Newcastle Hills Fault. I think it is clear that non-gravitational accelerations are required to explain the apparent rock movements, and it is certainly possible, especially on a thrust fault, to generate vertical accelerations exceeding 1 g. Rockfalls are often associated with strong earthquakes in mountainous terrains.

A second hypothesis is that this could be the result of glacial plucking without complete removal from the site.

The third hypothesis, and perhaps most likely, is that this was an explosives test site. We know that there was an explosives company testing products on Cougar Mountain in the 1960s. They made arrangements with the Pacific Coast Company to use various sites and they had a field office in a trailer near Hike #1, Stop 5, Dutch's Strip Mine and the New Slope Mine site. The Newcastle Historical Society has copies of correspondence regarding the use of the Victorian Clay Pit, a now off-trail, overgrown site clearly visible in lidar near the confluence of Coal Creek's east and main forks. Correspondence also documents the explosives tests that made rubble of the fan house foundation by the Ford Slope Mine at Hike #2, Stop 11. There are, however, no records of explosives testing at this location.

Any thoughts are welcome. This outcrop could make a very interesting student project, especially if it could be established that there may be a seismic origin. Whether or not this site is earthquake-generated, other rockfalls on Cougar Mountain and in the Issaquah Alps could have seismic origins and would perhaps provide constraints on the accelerations of paleo-earthquakes. This is good topic for another geologic hiking trip!

Return to Sky Country Trailhead

This is the last stop on Hike #2. From here, retrace your steps back along the Indian Trail and return towards the Red Town Trailhead on the Red Town Trail. Pass both the Rainbow Town Trail, and the upper end of the Bagley Seam Trail, until you reach the intersection with the Cave Hole Trail. Turn right and take this uphill back to the Nike Horse Trail, and from there proceed to Nike Park and the Sky Country Trailhead.

End of Hike 2

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This guide grew out of over thirty years of hiking my neighborhood's trails and specifically out of a pandemic project to hike all the trails of Cougar Mountain. Although I am a professional engineering geologist, Cougar Mountain geology is a hobby and I make no claims to discovery in an academic sense, though I find every visit to Cougar Mountain is a discovery no matter how many times I hike these trails.

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Figure 1 – Simplified geologic map of Cougar Mountain.

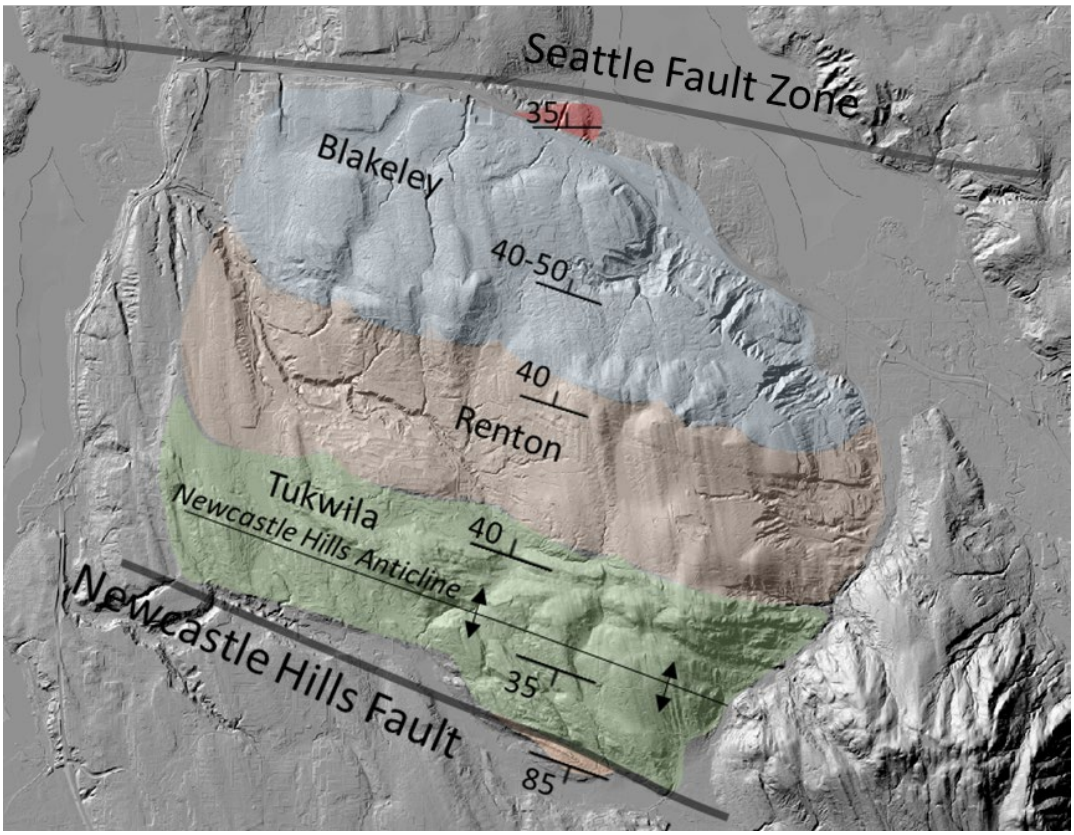


Figure 2 - Idealized Geologic Cross section of Cougar Mountain (after Booth and others, 2006).

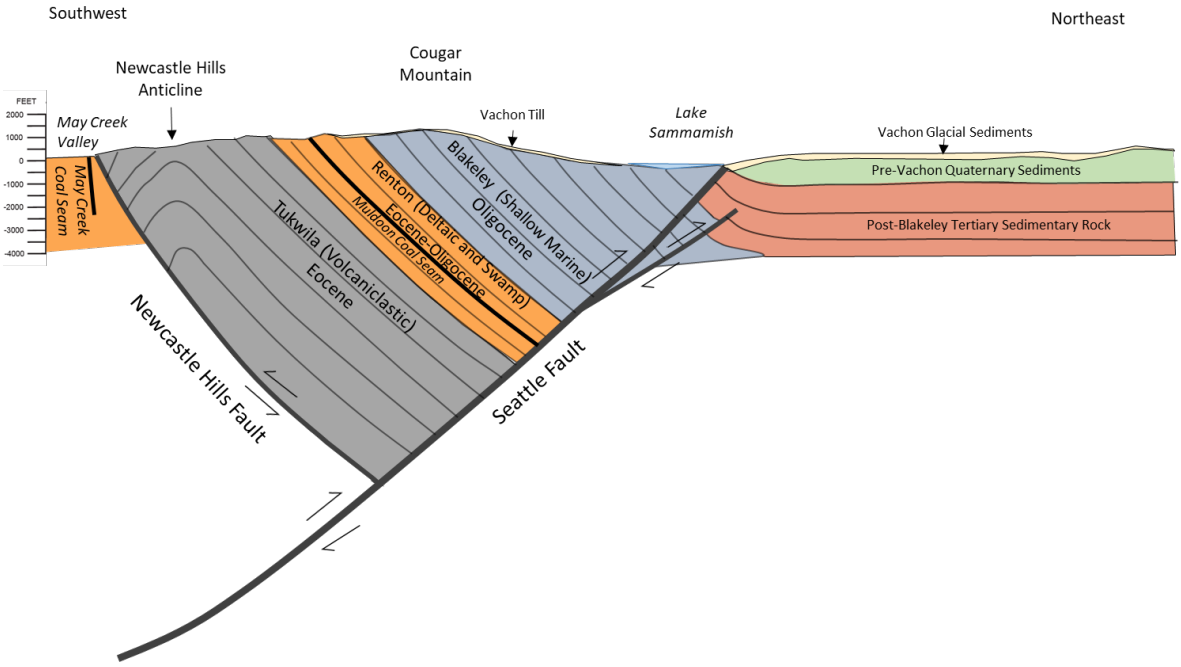
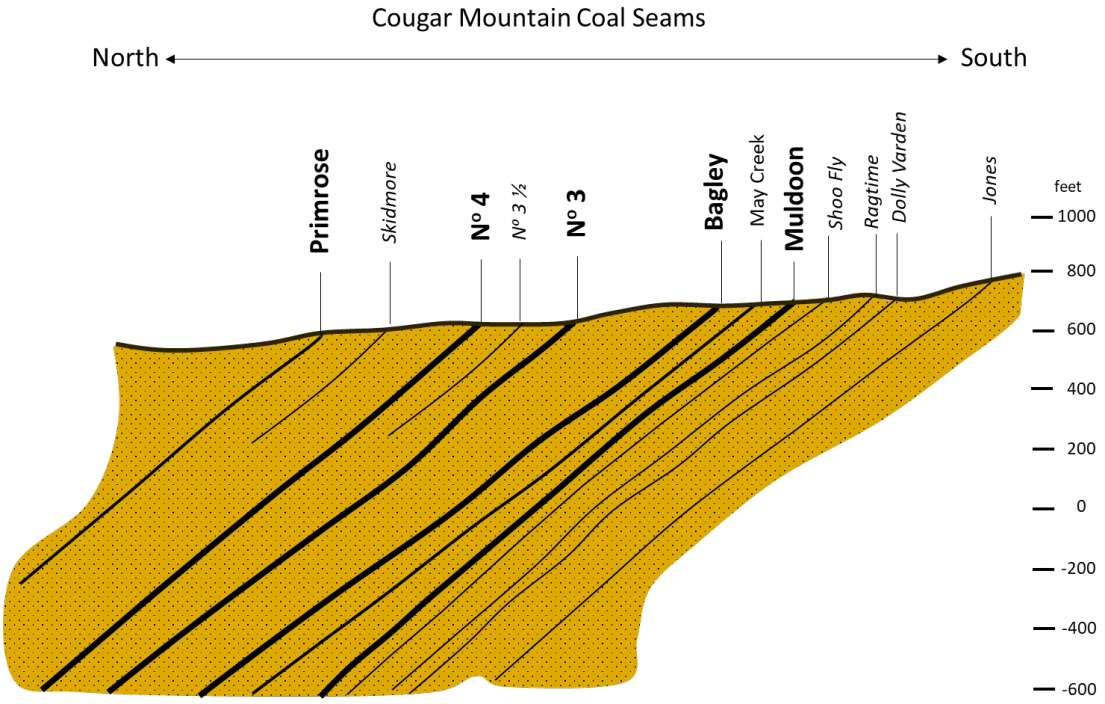


Figure 3 – Subsurface cross section showing Cougar Mountain coal strata.



After US Office of Surface Mining

Figure 4 – Two alternative mechanical models for the Seattle Fault (from Pratt and others, 2015). Left: thrust-backthrust model; Right: monocline over wedge model.

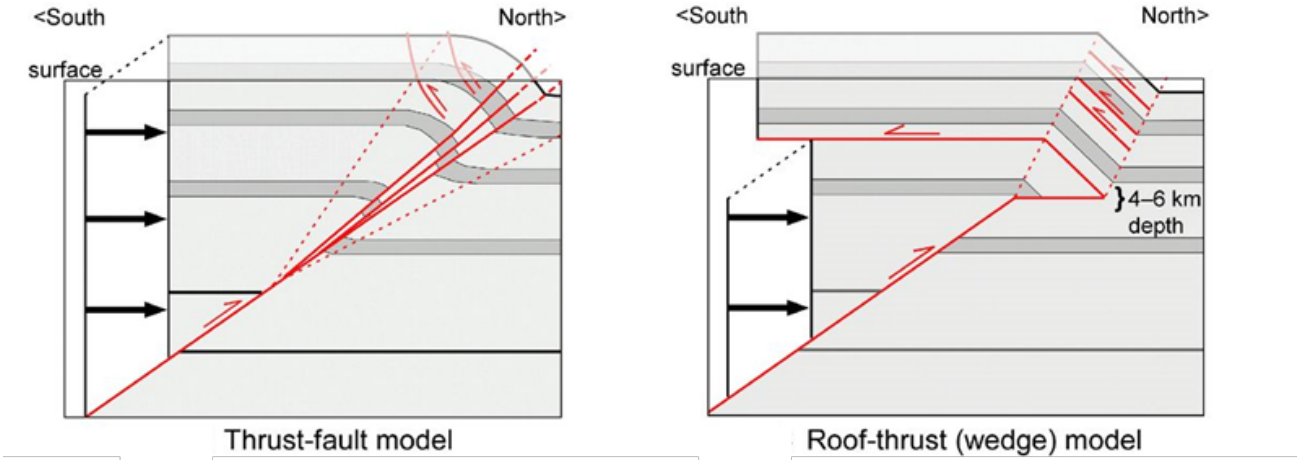


Figure 5 – Approximate surface traces of coal seams, overlain on Cougar Mountain lidar hillshade.

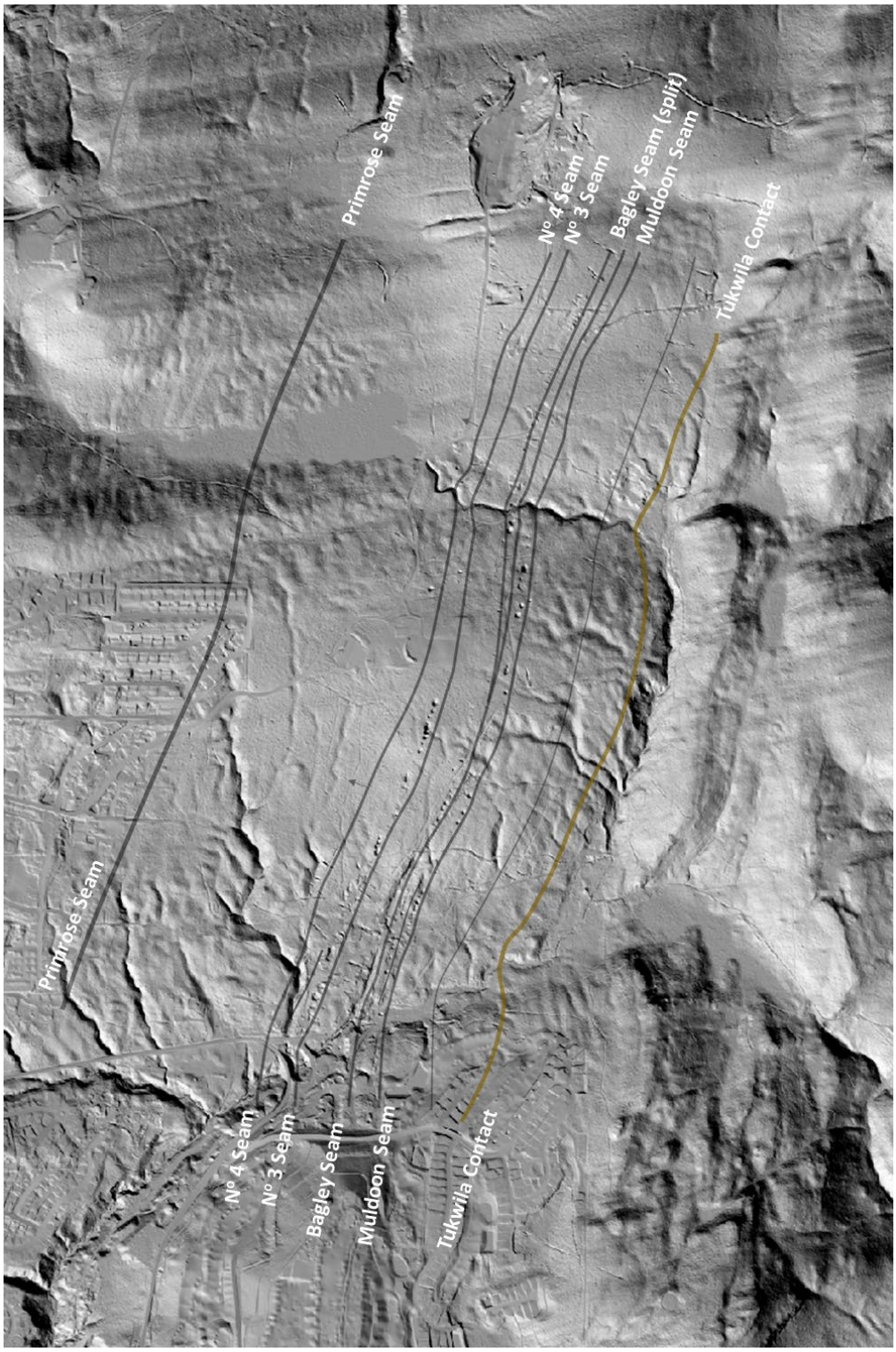


Figure 6 – Mines and mining areas of Cougar Mountain, overlain on lidar hillshade.

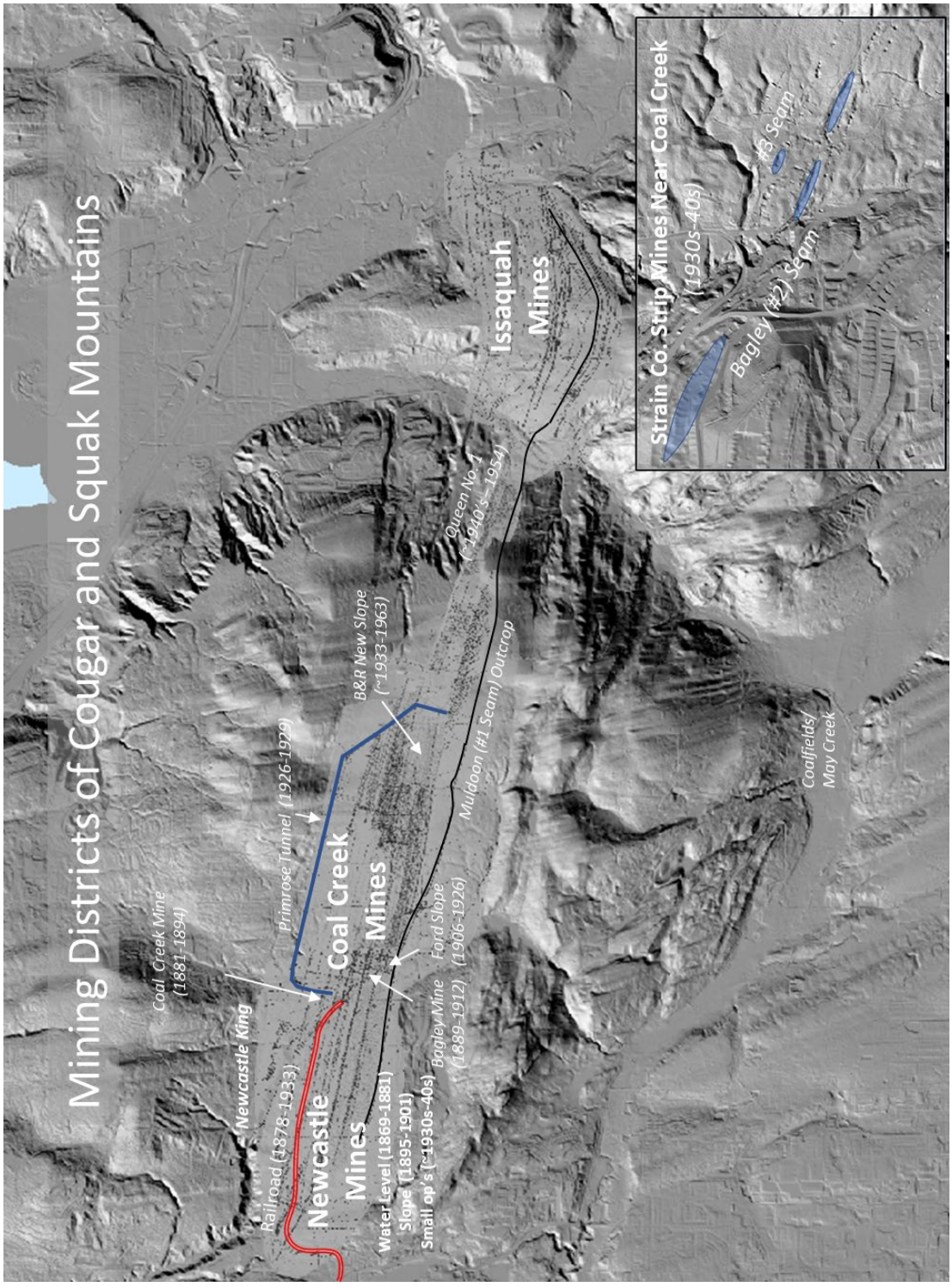


Figure 7 – Water-level mines and slope mines at Cougar Mountain.

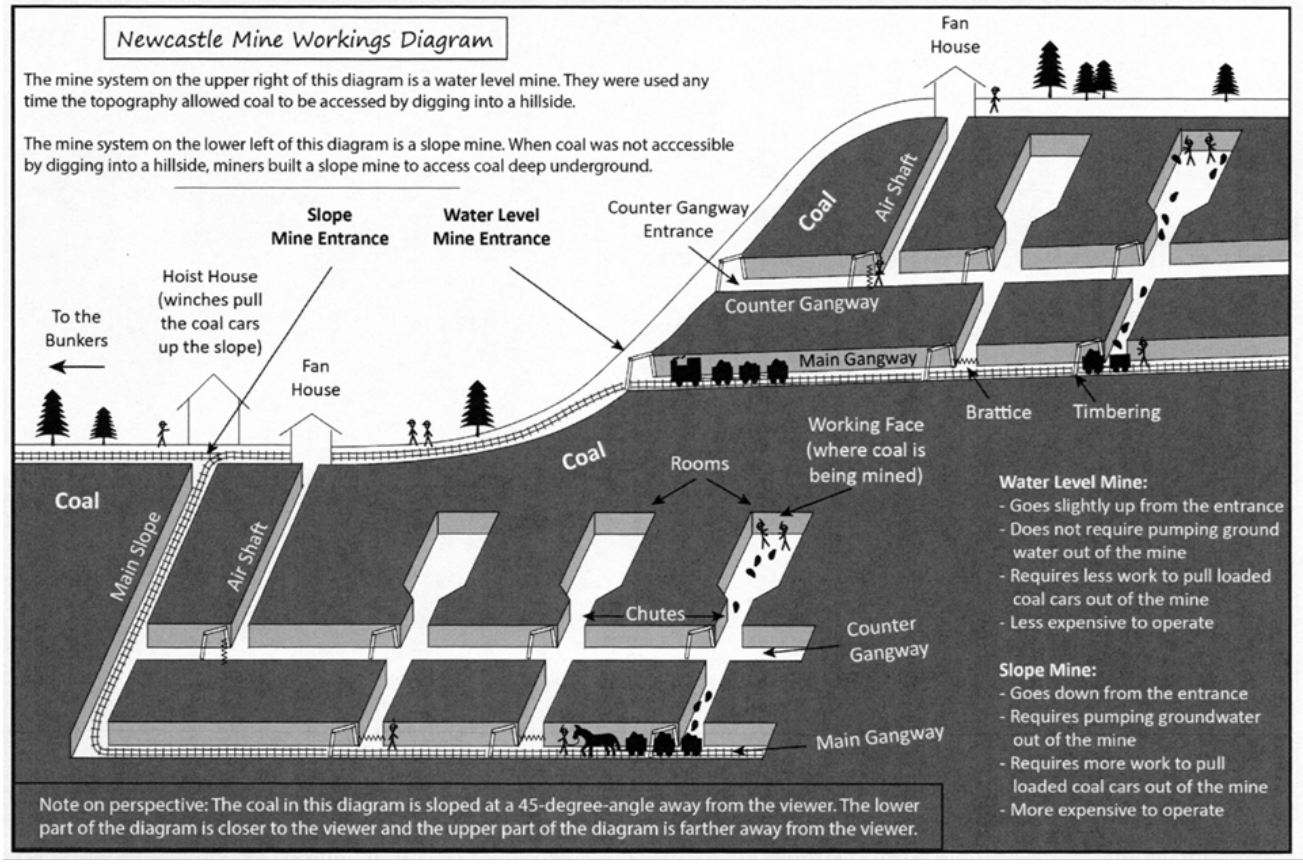


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Figure 8 – Main Gangways and Airways at Coal Creek and east of Coal Creek.

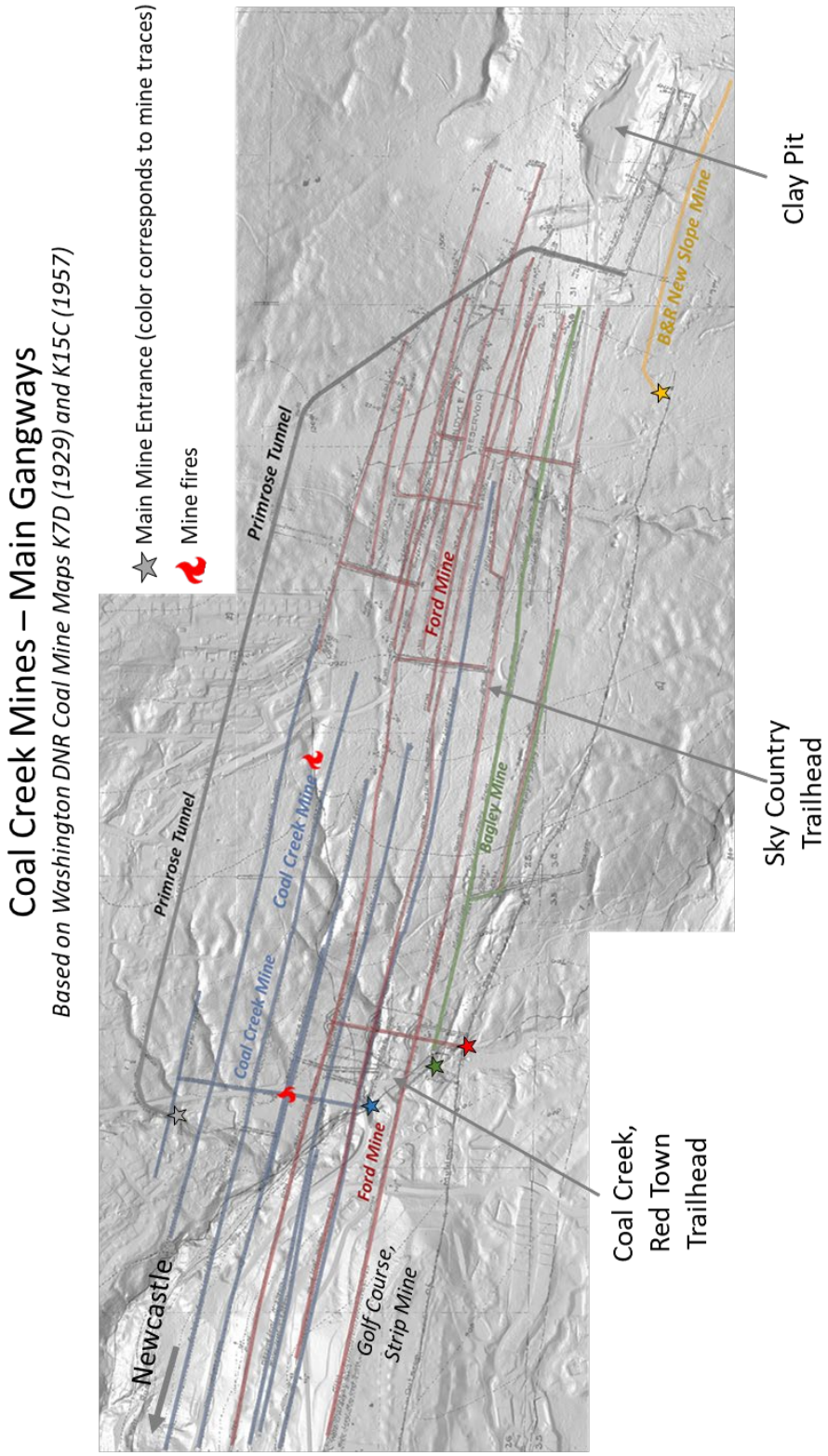
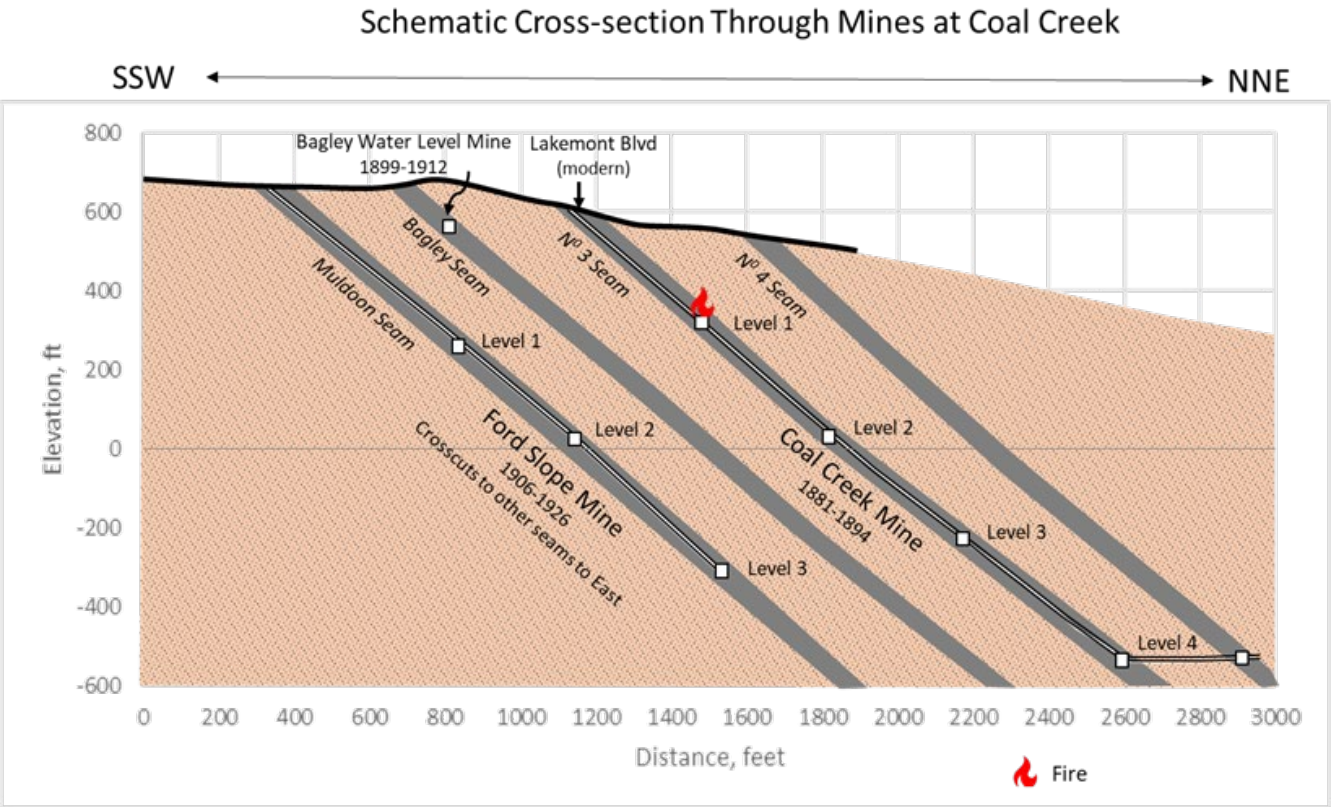


Figure 9 – Subsurface cross section through Coal Creek and Ford Mines.



Based on Washington DNR Mine Map K7J, ~1929
Bagley and No 4 Seams, Bagley Mine, and seam thicknesses approximate
For educational and illustration purposes only

Figure 10 – Detail of Hike #1, with mine maps K7J and K15A overlain on lidar hillshade. Openings of the Ford Mine appear in black, and openings of the B&R New Slope Mine (closed 1962) appear in red. Small black dots represent mine openings.

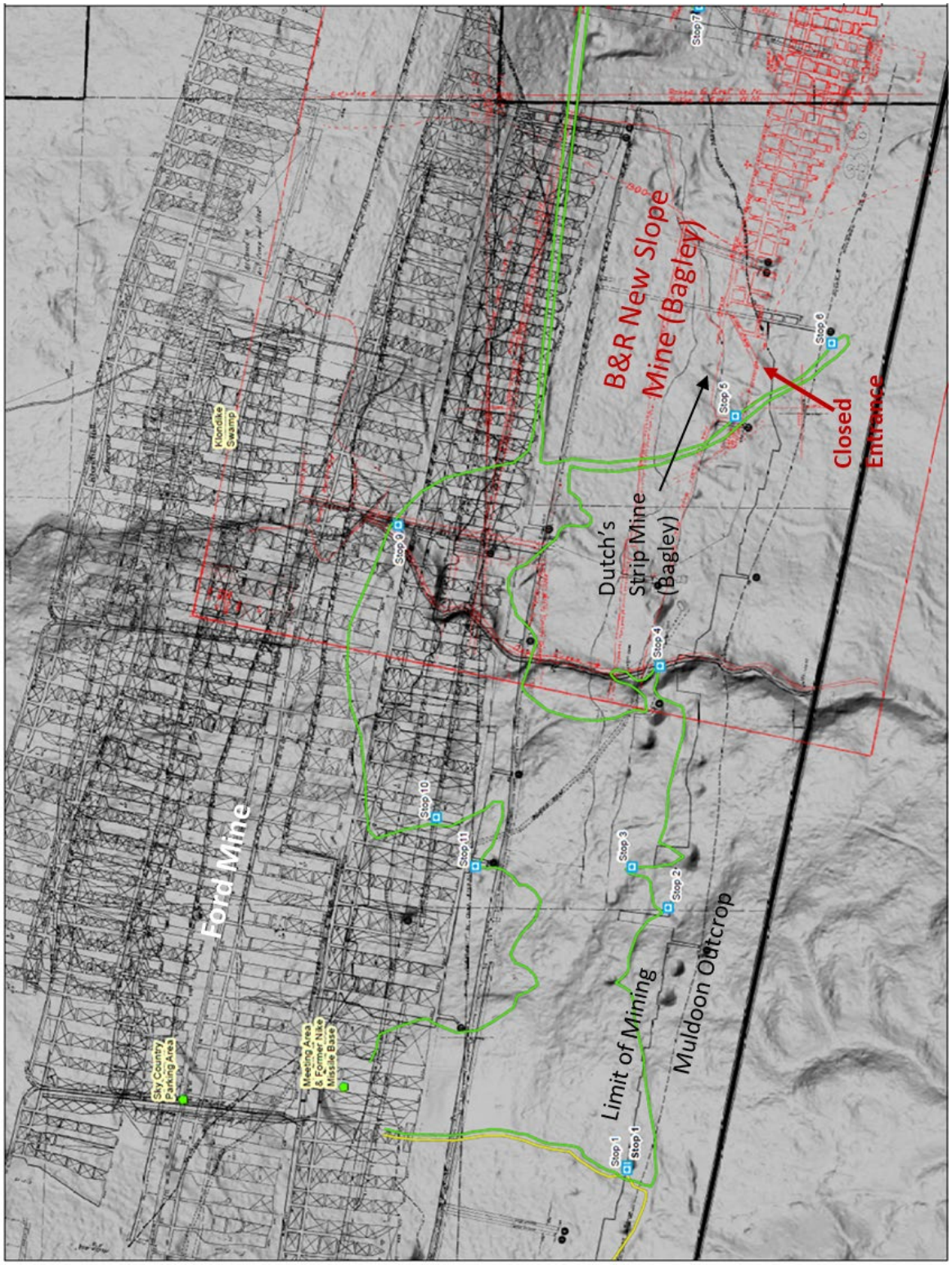


Figure 11 – Thermal imaging of surface above mine fire (courtesy Steve Williams)

Figure 12 – Detail of mines and surface facilities below Red Town Trailhead.

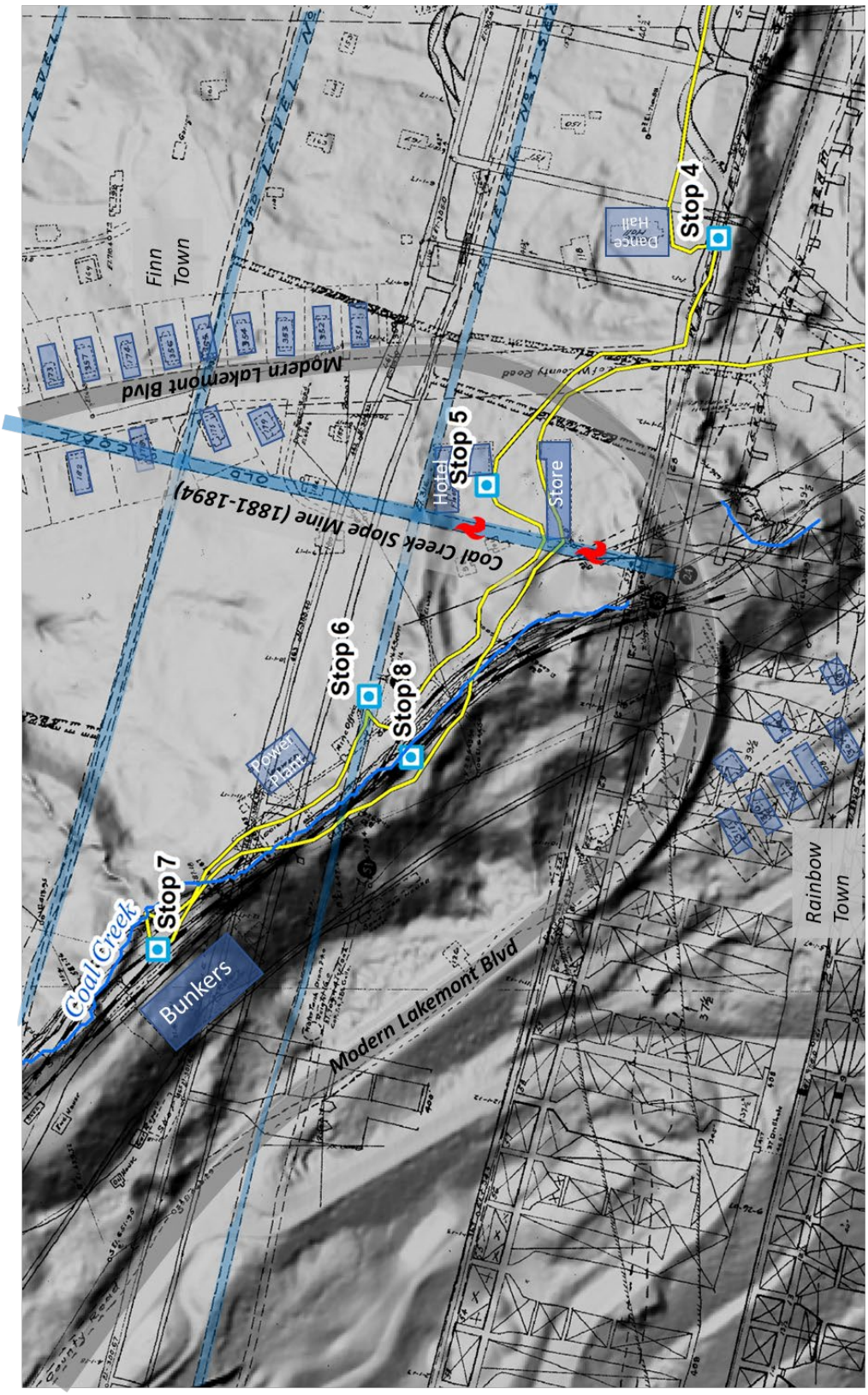


Figure 13 – Detail of mines and surface facilities around Ford Mine.

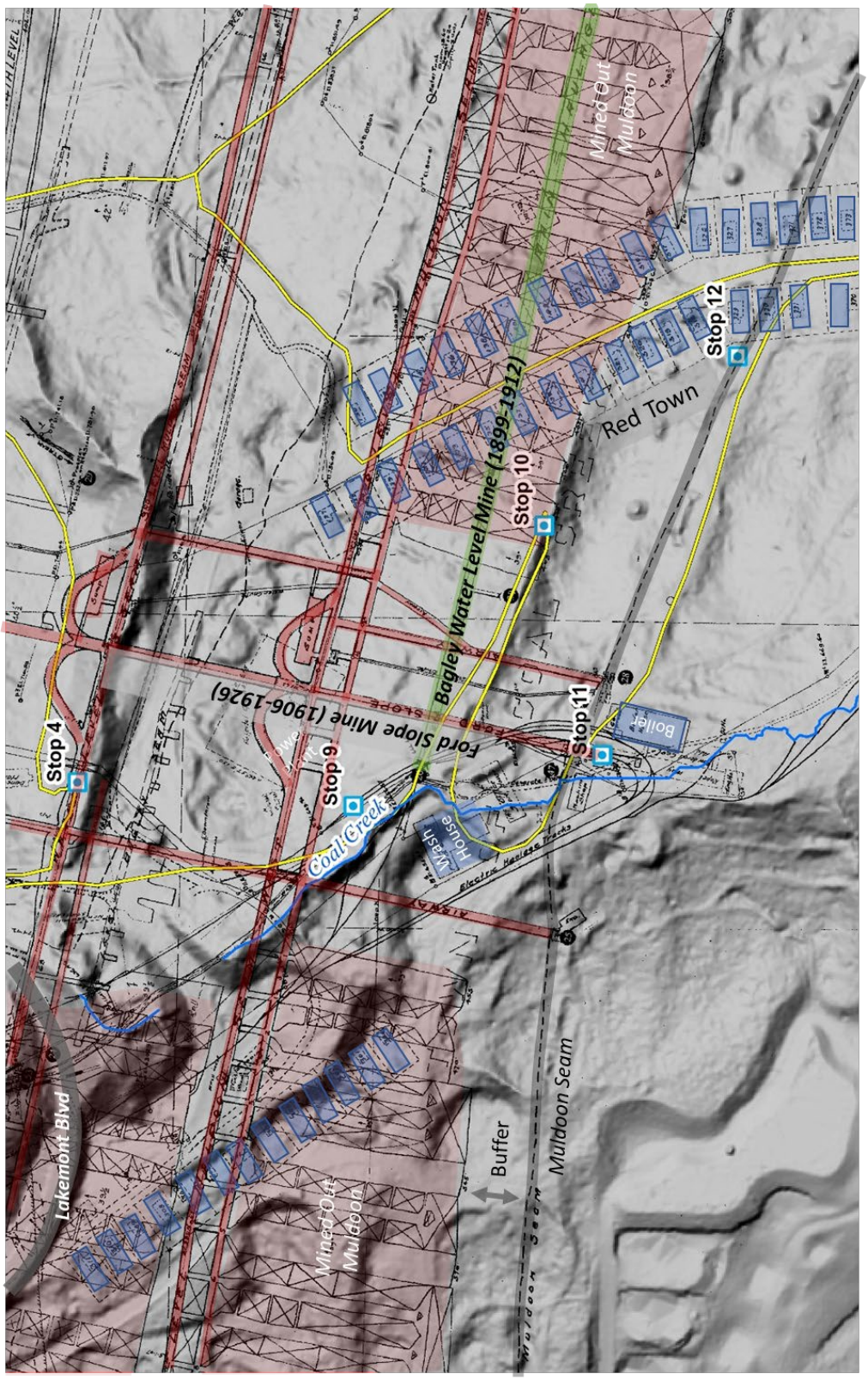


Figure 14 – Remediation by foam plug, OSM 360. (photo credit: Steve Williams).