Ski Hill Basin Flood Analysis

Chelan County Flood Control Zone District

Reference: 100-RCE-T39966

9 March 2023

SKI HILL BASIN FLOOD ANALYSIS

Project Number: 100-RCE-T39966
7 March 2023

PREPARED FOR

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EXECUTIVE SUMMARY[1]

Ski Hill Basin is located immediately north of the City of Leavenworth in Chelan County, Washington. Runoff from Ski Hill Basin originates mostly from federal land, over which the County and City do not manage. Runoff from Ski Hill Basin flows onto land managed by the County along E-W Titus Road[2], then flows approximately south-south-east into the City, then into the Wenatchee River. The basin has history of rain and/or snowmelt induced flooding that typically occurs in late winter and early spring and is exacerbated by shallow ground water-table. The runoff can overwhelm the county swales and culverts, causing flooding in the County, City, and private property, as well as impacting traffic.

Basin runoff within the county is managed by the Chelan County Flood Control Zone District (FCZD). In 2017, Tetra Tech developed a Comprehensive Flood Hazard Management Plan (Tetra Tech 2017), which identified Ski Hill as a top priority for flood mitigation efforts and called for an analysis of the basin to form an action plan for reducing flooding impacts to public and private property. The FCZD contracted Tetra Tech to perform a study to evaluate the flooding issues originating from Ski Hill Basin.

The work performed for this study included the following tasks: (1) a field and desktop-based site assessment, (2) a public outreach program, (3) a hydrologic analysis, (4) a hydraulic analysis, (5) develop mitigation alternatives, (6) develop cost-estimates for the 2 preferred alternatives, and (7) identify potential funding sources.

The field-based site assessment was held on September 12-13, 2019 and covered the area in a north-to-south direction from Ski Hill[3] to the Wenatchee River and west-to-east from the Ski Hill Drive to the Chumstick highway. The site assessment was performed to: (1) assess the topography, drainage network (e.g., culverts and swales) and potential flow paths, (2) characterize the Manning's *n* roughness values along the potential flow path; and (3) identify potential flooding mitigation measures. The desk-based assessment included review of aerial imagery, topographic mapping, soil mapping, and geologic mapping.

A public outreach program was developed to provide information about the study and to solicit feedback on the proposed alternatives using online surveys. The public outreach consisted of an ArcGIS StoryMap developed by Perteet. The FCZD performed additional public outreach which included press releases, mailed information to residents, and radio interviews. The StoryMap provided an online poll for residents to submit feedback on the proposed alternatives. Overall, the program was deemed a success by the project team.

A hydrologic analysis was performed to estimate the peak flows originating from the Ski Hill sub-basins for a range of rainfall/snowmelt frequency of events. The hydrologic modelling was performed using the Corps of Engineers Hydrologic Modelling System (HEC-HMS Version 4.8). A digital elevation model (DEM) was developed based on 2015 and 2018 LiDAR surveys. The Ski Hill Basin was sub-divided into seven sub-basins using the ArcHydro tools in ArcGIS. Elevations in the Ski Hill Basin range from about 3,094 ft northwest of Ski Hill to about 1,152 feet at Pine Street. Ski Hill Basin is 1.27 mi^2 and the sub-basins range in area from 0.03 to 0.41 mi^2. The sub-basin near the base of the Leavenworth Ski area has a peak discharge of 13 cfs for the 24-hour, 10-year rainfall/snowmelt event and 33 cfs for the 24-hour, 100-year rainfall/snowmelt event. The hydrologic model output was used to develop inflow hydrographs for the hydraulic model.

A 2-dimensional (2-D) hydraulic model was developed to simulate the existing conditions for the 24- hour, 10- and 100-year year rainfall/snowmelt events. The model was developed based on the DEM and structure geometry provided by the FCZD. Due to the absence of measured flow and water-surface elevation data, it was not possible to calibrate the hydraulic model. The model output was used to develop depth inundation

[1] This executive summary must be read in the context of the full report and the attached limitations.
[2] Titus Road runs in an east-west as well as in a north-south direction. For references purposes in this study, the road is referred to E-W and N-S Titus Road. This naming convention is not official street naming.
[3] The Leavenworth Winter Sports Club is located in the Ski Hill Basin

mapping. The existing conditions model was subsequently modified to size the channels, swales and culverts as part of the alternative's development.

The results of the field investigation and hydraulic modelling was used to develop 6 alternatives to mitigate flooding in the Ski Hill Basin project area. The six alternatives were selected in consultation with the FCZD and increase in complexity and construction costs, with Alternative 1 being the "do nothing" condition, and Alternative 6 being the most complex with realignment of the channels, detention storage facilities, and new culverts. The 6 alternatives were published in the StoryMap, and the public ranked the alternatives and submitted comments. Alternative 4 was the most popular and Alternative 3 was second. The FCZD and FCZD Board of Commissioners reviewed the alternatives and public comments and requested cost-estimates for the two preferred alternatives.

Alternatives 4 and 3 were developed to collect flow originating from Ski Hill Basin (land north of E-W Titus Road) and overland flow from between E-W Titus Road and Emig Drive, and the convey the flow along upgraded swales and culverts towards Chumstick Creek. Alternative 4 includes enlarging the swales upsizing 35 culverts, installing channel protection (riprap or erosion control fabric) along Titus Road, Emig Drive, Detillion Road and Sky View Lane. Alternative 3 includes enlarging the swales, upsizing 14 culverts and installing channel protection along portions of Titus Road and Detillion Road.

A Class 5 (order of magnitude) cost-estimate was performed for Alternatives 3 and 4 based on 2021 costs. According to the U.S. Department of Energy, a Class 5 cost-estimate is prepared based on limited information where the preliminary engineering is from 0 to 2 percent complete. The costs were estimated using RSMeans, corollary data from similar projects and vendor quotes. The costs were computed as the total cost of the contractor markup costs and the bid items.

A pond and underground gallery storage options were developed to regulate runoff from Ski Hill Basin. Due to the uncertainty about obtaining an agreement with Leavenworth Winter Sports Club and U.S Forest Service, the costs for the pond and gallery options were not included in Alternative 3 and 4. Also, the right-of-way costs are not included.

If determined by the County, construction of an alternative would likely be a few years aways and construction costs will higher. Therefore, the cost-estimates for Alternatives 4 and 3 based on 2021 costs are presented as a range. For Alternative 4, the cost is in the range of $1.3 million to $1.7 million. For Alternative 3, the cost is in the range of $500,000 to $750,000.

Implementation of the preferred alternative is anticipated to require grant funding. A review of the funding opportunities was performed, and the results summarized as fact sheets and include the following funding sources: (1) Washington State's Flood Control Assistance Account Program (FCAAP), (2) Federal Emergency Management Agency (FEMA) Building Resilient Infrastructure and Communities (BRIC) program, (3) FEMA's Hazard Mitigation Grant Program (HMPG), and (4) FEMA's Flood Mitigation Assistance (FMA) program.

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ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
ATI	Antecedent Temperature Index
CN	Curve Number
DEM	Digital Elevation Map
FCZD	(Chelan County) Flood Control Zone District
FEMA	Federal Emergency Management Agency
HEC-HMS	Hydrologic Engineering Centre Hydrologic Modelling System
HEC-RAS	Hydrologic Engineering Centre River Analysis System
HSG	Hydrologic Soil Group
LiDAR	Light Detection and Ranging
MSU	Map Soil Unit
NLCD	USGS National Land Cover Dataset
NRCS	National Resources Conservation Service
SWE	Snow-Water Equivalent
USACE	U.S Army Corps of Engineers
USGS	U.S. Geological Survey

1. INTRODUCTION

Ski Hill Basin is located immediately north of the City of Leavenworth in Chelan County, Washington (**Figure 1**). Runoff from Ski Hill Basin originates mostly from federal land north, then flows across land managed by the County and into the City, then into the Wenatchee River (Figure 2). The basin has history of rain and/or snowmelt induced flooding that typically occurs in late winter and early spring and is exacerbated by shallow ground water-table. Snowmelt runoff can overwhelm the county swales and culverts, causing flooding in the County, City, and private property, as well as impacting traffic. Runoff from rainfall during other times of the year, including from summer thunderstorms, can typically be conveyed by the stormwater system.

Basin runoff within the county is managed by the Chelan County Flood Control Zone District (FCZD). In 2017, Tetra Tech developed a Comprehensive Flood Hazard Management Plan (Tetra Tech 2017)[4], which identified Ski Hill Basin as a top priority for flood mitigation over other nearby basins due to: (1) the relatively large downstream population, (2) the largest number of county and City assets (roads, swales, culverts), and (3) the largest potential for future development. Comprehensive Flood Hazard Management Plan recommended further analysis of the basin to form an action plan for reducing flooding impacts to public and private property[5].

The FCZD contracted Tetra Tech in 2019 to perform a study to evaluate the flooding issues originating from Ski Hill Basin. The project study area extends south from E-W Titus Road to the City boundary, and east of Ski Hill Drive to N-S Titus Road (Figure 2).

1.1 SCOPE OF WORK

The work performed for this study included the following tasks:

- A site investigation and kick-off meeting were held on September 12, 2019, which included Mr. Detamore of the FCZD, Dr. Dai Thomas, and Mr. Stu Trabant from Tetra Tech, Mr. Ryan Walker of Grette Associates, LLC, and Ms. Jennifer Saugen of Perteet, Inc. Dr. Thomas and Mr. Trabant continued the site investigation on September 13.
- A public outreach program was initiated during the early phase of the project, which included the development of an ArcGIS StoryMap to provide online information about the study. The public outreach was expanded after the identification of the mitigation alternatives to provide information about the alternatives, to receive input, and to aid in the selection of a preferred alternative.
- A hydrologic analysis was performed that included an analysis of historic rainfall and snow measurements, and the development of a rainfall-runoff hydrologic (HEC-HMS) model to estimate the runoff from Ski Hill Basin for a combination of rainfall and snow events ranging from the 2- though 100-year rainfall events.
- A 2-dimensional (2-D) hydraulic (HEC-RAS) model was developed that extended north-to-south from the Ski Hill carpark to the Wenatchee River, and east-to-west from the base of the Tumwater Mountain foothills to the Chumstick Highway. The model was run for a series of flood frequency flows and the model output was used to: (1) predict the flow patterns downhill from Ski Hill Basin and develop flood inundation mapping, (2) to estimate the capacity of the existing culverts and drains, and (3) to develop the mitigation alternatives.

[4] http://www.co.chelan.wa.us/files/flood-control-zone-district/ChelanCoFloodPlan_Final_2017-11-17.pdf
[5] In addition, to Ski Hill Basin, two other basins were delineated and referred to as the West and East Basins (Figure 1). Runoff from the west basin flow mostly west of Ski Hill Drive and flow from the East basin is conveyed towards Chumstick Creek.

- Six mitigation alternatives were developed based on the results of the field investigation and hydraulic modeling. The alternatives ranged in complexity from “no-action” to significant upgrade of swales, drains and culverts. Following evaluation by the FCZD and input from the public outreach program, 2 alternatives were selected.
- Cost-estimates were developed for the 2 selected alternatives using the R.S. Means and local pricing information.
- Potential funding sources were identified and summarized in fact sheets. The fact sheets detail the funding agency, provide an overview, and list the requirements and limitations.

1.2 AUTHORIZATION

This study was carried out by Tetra Tech Inc. under a contract agreement with Chelan County Flood Control Zone District. The study included Perteet, an infrastructure consulting firm, and Grette and Associates, an environmental consulting firm. The Grette and Perteet staff were based in Wenatchee, WA. Mr. Jason Detamore is the project manager for the FCZD.

Technical staff who contributed to the study included:

- Dr. Dai Thomas, P.E. (CO), Project Manager, Senior Engineer and Geomorphologist
- Mr. Stuart Trabant, P.E. (CO), Senior Engineer
- Dr. Stephen Adams, EIT (CO), Staff Engineer
- Mr. Mike Brown, P.E (CO), Staff Engineer
- Mr. Rob Flanner, CFM, Hazard Mitigation Program Manager
- Mr. Kirk Homes (Perteet)
- Ms. Christina Wollman (Perteet)
- Ms. Jennifer Saugen (Perteet)
- Mr. Ryan Walker (Grette Associates)

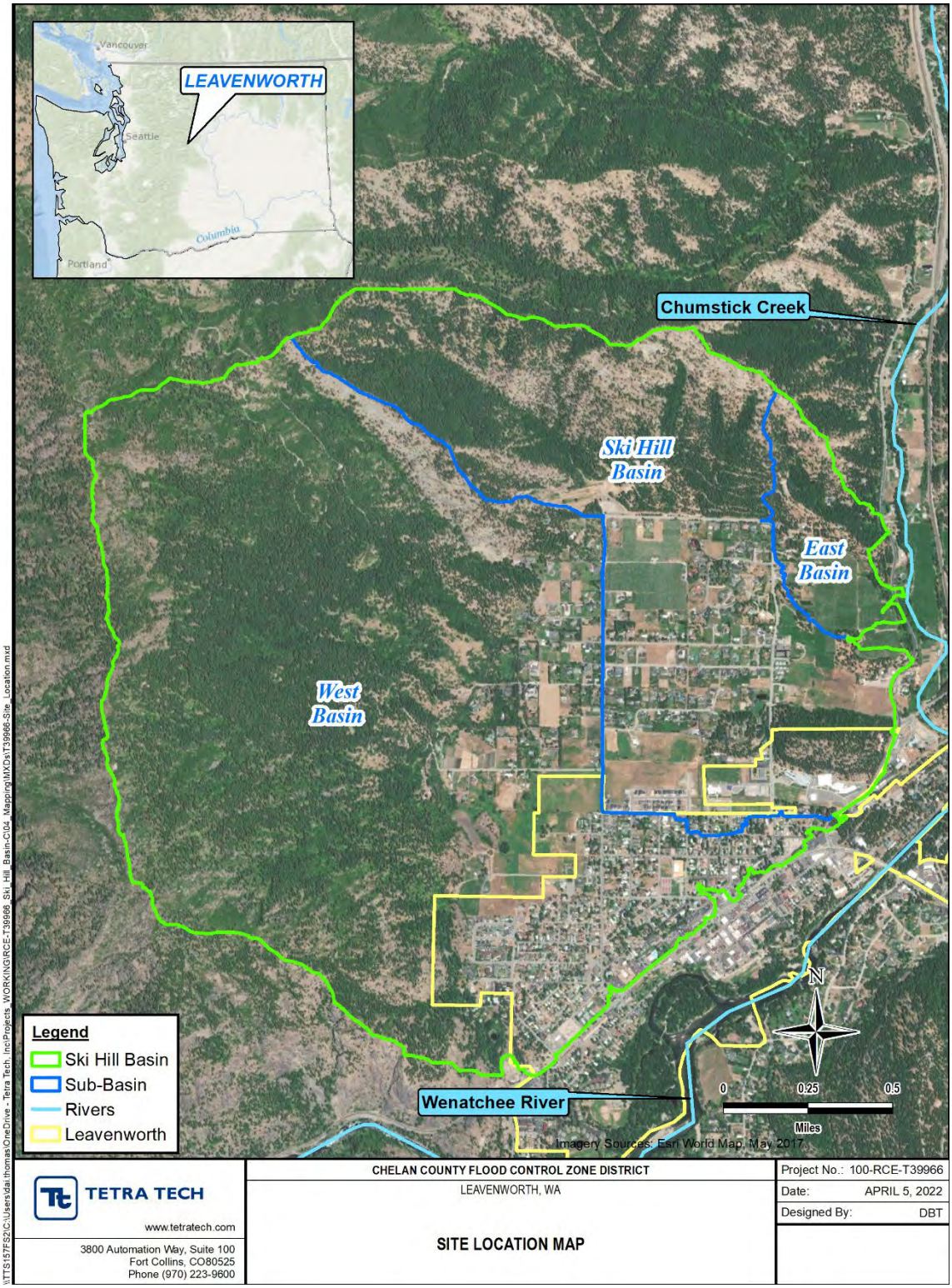


Figure 1. Site location map with Ski Hill Basin, West Basin and East Basin.

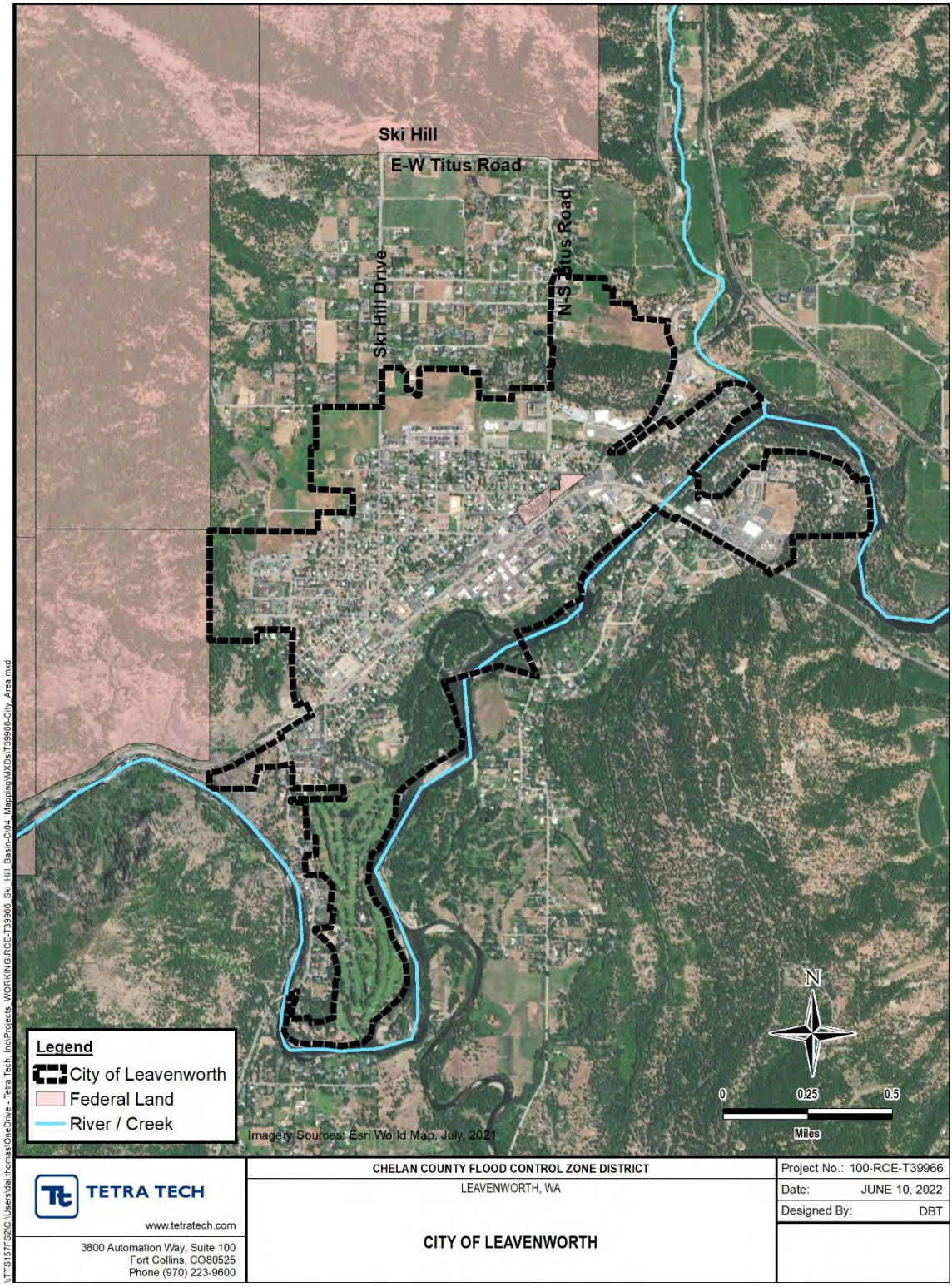


Figure 2. City of Leavenworth boundary.

2. SITE ASSESSMENT AND BACKGROUND INFORMATION

Field-based and desktop site assessments were performed to obtain information to develop the hydrology and hydraulic models, interpret the model results, and to develop mitigation measures.

2.1 BACKGROUND INFORMATION

Leavenworth is located on the southeast side of the North Cascade Mountains, near the confluence of Icicle Creek and the Wenatchee River (Figure 1). The city is approximately 1.4 square miles and located at an elevation of about 1,200 feet (**Figure 2**).

2.1.1 Climate

Leavenworth has a continental Mediterranean climate with summers characterized by hot, sunny days and chilly nights, and cold, snowy winters (Wikipedia). Due to the presence of the North Pacific anticyclone, the summer months are typically dry, with July being the hottest month with an average low temperature of 51°F, and average high temperature of 87°F. January is typically the coldest month, with an average low temperature of about 17°F, and an average high of 34°F. Leavenworth receives approximately 25 inches of precipitation per year with July being the driest with an average of 0.4 inches, and December being the wettest with an average of 4.8 inches. Annual snowfall is about 90 inches with December receiving the largest average monthly snowfall of about 30 inches.

2.1.2 Geology

The Ski Hill Basin located on the western edge of the Chiwaukum Graben, which a is down-dropped tectonic block. The western edge of the graben is a series of faults and includes the Leavenworth Fault that has a northwest-to-southeast alignment through the centre of Leavenworth, based on the generalized geology map (**)**. The northern portion of Ski Hill Basin is primarily composed of Tertiary age sedimentary rocks, known as the Chumstick formation which is a mix of conglomerates, sandstones, and shales. To the west of the Leavenworth fault, the rocks are part of the Ingalls Tectonic Complex, which are primarily pre-tertiary metamorphic rocks and include hornblende schist, amphibolite, and biotite schist. The majority of the area between the base of the hills and the Wenatchee River is mapped as quaternary alluvium, which was deposited by glacial processes during the Pleistocene Epoch. The region experienced a series of glacial advances that scoured Tumwater Canyon and Icicle Canyon and deposited glacial sediments near the confluence of the canyons and in the vicinity of Leavenworth.

2.1.3 Soils

Soil mapping was obtained from the Natural Resources Conservation Service (NRCS[6]) Web Soil Survey (WSS) website that contains complete coverage of the Leavenworth Watershed from two soil surveys which are reported as the Cashmere Mountain Area and the Chelan County Area (**Figure 4** and **Table 1**). For this study, the Leavenworth Watershed includes the Skill Hill Basin, West Basin and East Basin (Figure 1). The Soil Map Unit (MSU) symbols are reported as numbers for the Cashmere Mountain Area soil survey, and the SMUs are reported as letters for the Chelan County Area soil survey (Figure 4. NRCS Soil Map. Corresponding soil types are listed in Table 1.

[6] Web Soil Survey (usda.gov)

The area contains a variety of soil types but is dominated by loams and outcrop complexes. Burch fine sandy loam (17% of the study area), Peoh silt loam (12%), Cle Elum loam (12%), Nard sandy loam (10%), Varelum loam (19%), and Blag-Cle Elum-Rock outcrop complexes (23%) are the dominant soil types (Figure 4 and Table 1).

From a hydrologic perspective, 32% of the Leavenworth study area is characterized as Hydrologic Soil Group (HSG) B with moderately high infiltration potential, 32% is considered HSG C with moderately low infiltration potential, while 35% of the study area is characterized as having low infiltration potential in the form of HSG D soils (**Figure 5**). Bedrock outcropping comprises less than 1% of soil types. In general, soil types with lower infiltration potential (HSG C and D) exist in the hillslopes, and soils with higher infiltration potential (HSG B) are found at lower elevations.

2.1.4 Topographic Mapping

A digital elevation model (DEM) was developed based on Light Detection and Ranging (LiDAR) surveys performed by WSI Quantum Spatial in 2015 and 2018 for the State of Washington (WSI Quantum 2015, 2018). The 2015 LiDAR survey had a reported horizontal and vertical accuracies of 0.19 feet and 0.12 feet, respectively, and the 2018 survey had reported horizontal and vertical accuracies of 0.19 feet and 0.07 feet, respectively.

The 2015 and 2018 DEMs were merged to represent full coverage of the Leavenworth Watershed (**Figure 6**). The horizontal resolution of the LiDAR is 3 feet. The project mapping is the State Plane, Washington North, North American Datum of 1983 (NAD83), and the vertical projection is in the North American Vertical Datum of 1988 (NAVD88).

2.2 SITE ASSESSMENT

The field-based site assessment was held on September 12, 2019, which included Mr. Detamore of the FCZD, Dr. Dai Thomas, and Mr. Stu Trabant from Tetra Tech, Mr. Ryan Walker of Grette Associates, LLC, and Ms. Jennifer Saugen of Perteet, Inc. Dr. Thomas and Mr. Trabant continued the site investigation on September 13. The site assessment covered the area in a north-to-south direction from Ski Hill to the Wenatchee River and west-to-east from the Ski Hill Drive to the Chumstick highway.

The site assessment was performed to:

- Assess the topography, drainage network (e.g., culverts and swales) and potential flow paths, including identifying features that may affect the flow paths such as earthen berms, block walls, and drains.
- Characterize the Manning's *n* roughness values along the potential flow path.
- Identify potential flooding mitigation measures.

Information collected during the site inspection consisted of recorded field notes, mapping, and photos taken using a camera with a built-in GPS and compass. A review of aerial imagery, topographic mapping, and Google Earth Street View photography was performed. The information collected during the site inspection and the background information was used to develop the hydrologic and hydraulic model results to develop the mitigation alternatives.

Based on the field observations, topographic mapping and hydraulic analysis, a schematic figure was developed to show the approximate direction of flows originating from Ski Hill Basin (**Figure 7**). The yellow arrows shown on Figure 7 represent the general direction of the overland flow and the crimson arrows represent the flow direction in the channels/swales. The arrows are not scaled to size or positioned on the figure to represent the magnitude of the flow.

The following photos represent some of the observed conditions in the study area. The location of the photos is shown on **Figure 8**. The majority of the flow into the study area originates from Ski Hill Basin (**Figure 9**).

This basin is identified as “Hillslope West” in Section 4.2 and is approximately 0.41 square miles in area. The land north of E-W Titus Road and west of Ski Hill Drive is federal land (Figure 2).

Flow from the basin crosses the parking lot and flows into a swale along the north side of E-W Titus Road (**Figure 10, Figure 11** and **Figure 12**). There are two culverts that pass under E-W Titus Road near the south-east corner of the parking lot. Both culverts are partially blocked, and due to low capacity of the swale along the north side of Titus Road, it has been reported that water flows over Titus Road and into the orchard during moderate snow melt events (**Figure 13** and **Figure 14**). Based on field observations and the topographic mapping, the water in the orchard flows in an approximately south-south-east direction towards the City (Figure 7).

The swale along the north side of E-W Titus Road collects additional flow from the sub-basin located to the east of Ski Hill Basin. The flow is conveyed under E-W Titus Road and into another swale near the eastern end of the E-W Titus road, then flows along N-S Titus Road through a series of partially blocked culverts and under-sized swales (**Figure 15, Figure 16** and **Figure 17**).

The flow across the orchard as well as additional snow melt is partially intercepted by the drainage swales along Detillion Road and Emig Drive and conveyed east towards N-S Titus Road (**Figure 18, Figure 19** and **Figure 20**). The flow in the swales along N-S Titus Road is conveyed though a culvert near Hilltop Drive into an unnamed creek **(Figure 21)** then towards Chumstick Creek.

There is a large open field between Village View Drive and Pine Street (Figure 7 and **Figure 22**) which is located on City land. Runoff and snowmelt originating from the area south of West Emig Drive and including the open field flows towards Pine Street and is collected by the City stormwater system.

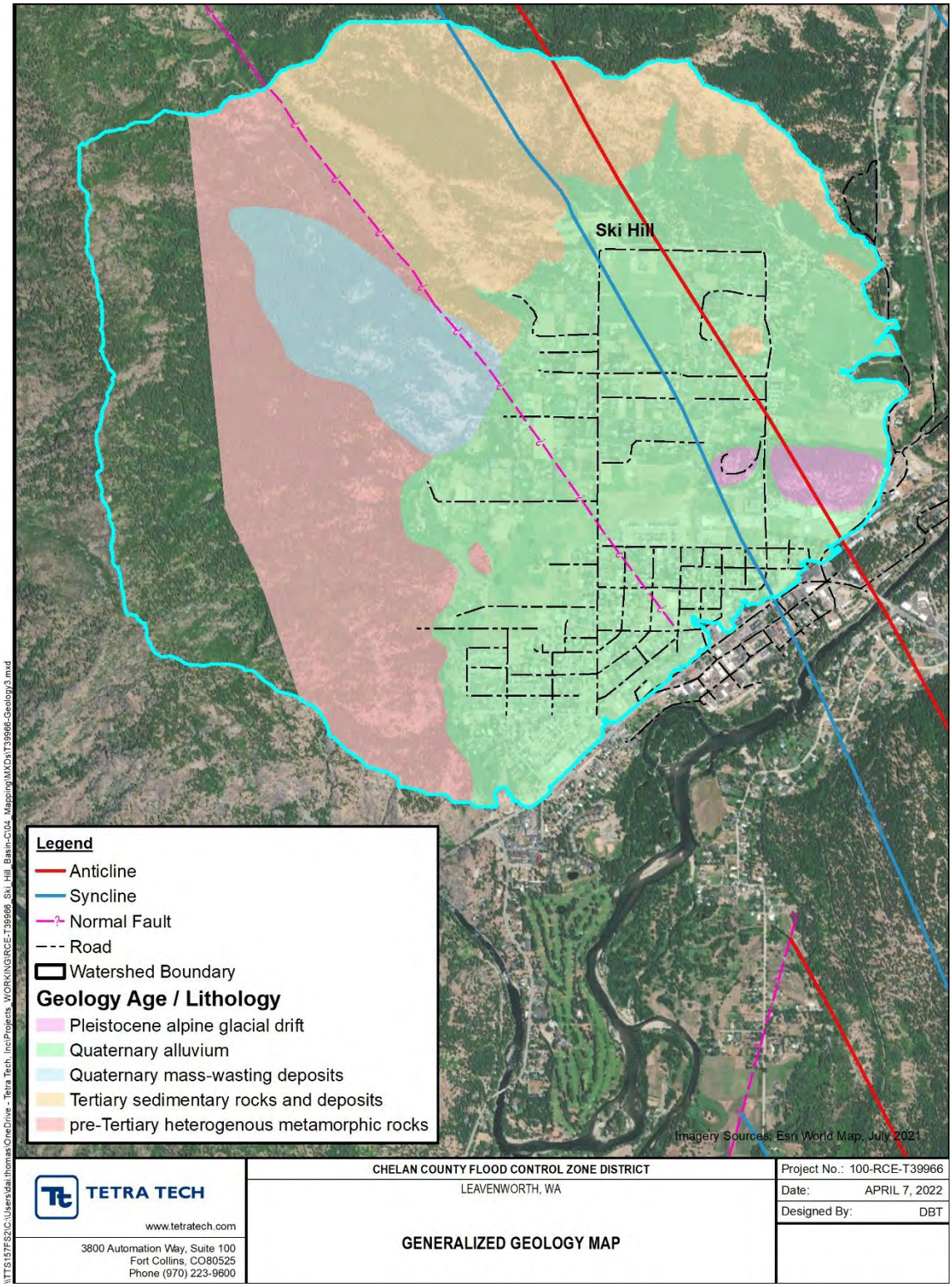


Figure 3. Generalized geology map.

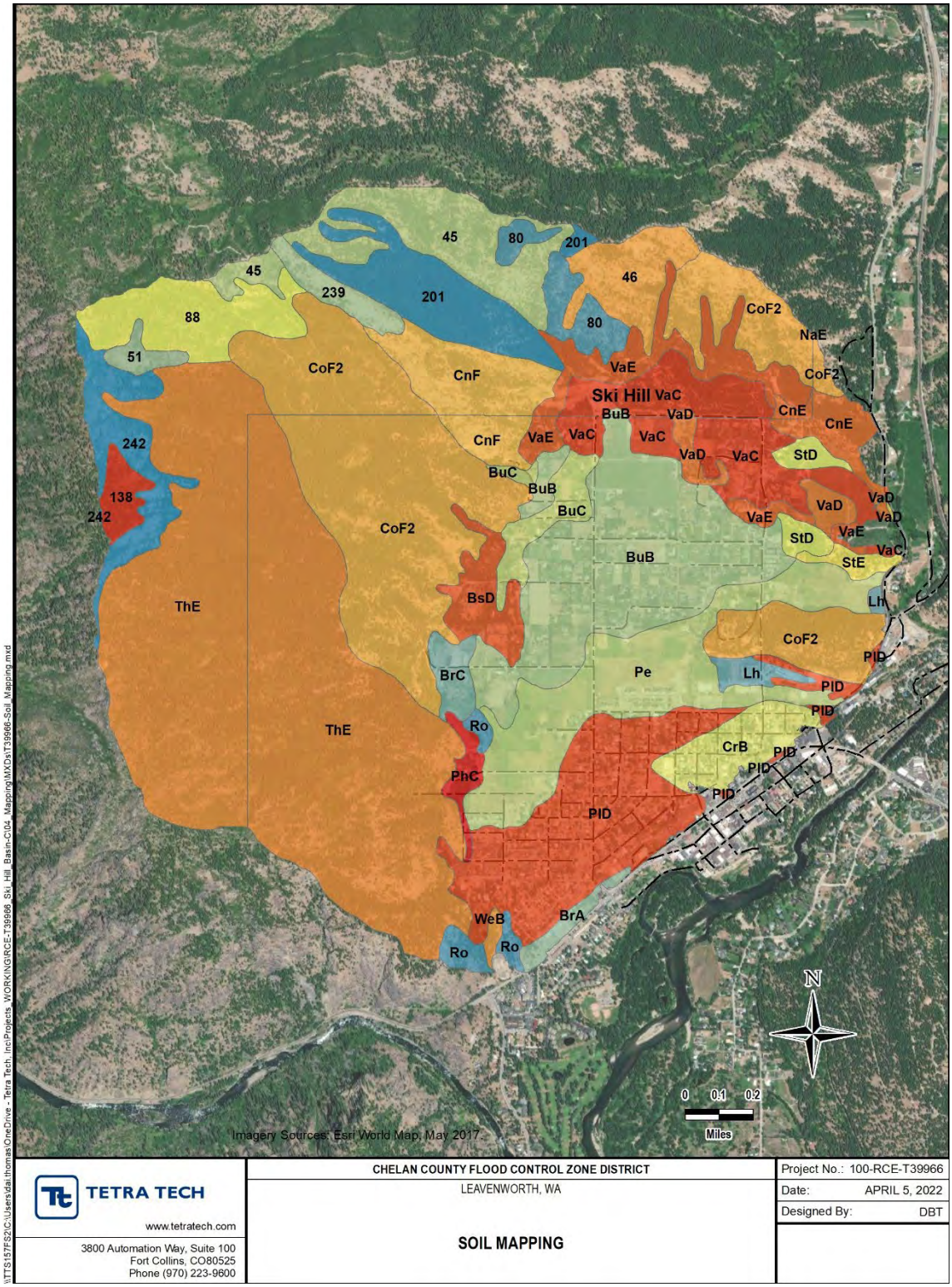


Figure 4. NRCS Soil Map. Corresponding soil types are listed in Table 1.

Table 1. Table 1 NRCS Soil Map Unit Legend

BrA	**Brief gravelly sandy loam, 0 to 3 percent slopes**
BrC	Brief gravelly sandy loam, 8 to 15 percent slopes
BsD	Brief stony sandy loam, 0 to 25 percent slopes
BuB	Burch fine sandy loam, 3 to 8 percent slopes
BuC	Burch fine sandy loam, 8 to 15 percent slopes
CnE	Cle Elum silt loam, 25 to 45 percent slopes
CnF	Cle Elum silt loam, 45 to 65 percent slopes
CoF2	Cle Elum-Rock outcrop complex, 25 to 65 percent slopes
CrB	Colockum silt loam, 3 to 8 percent slopes
Lh	Leavenworth fine sandy loam
NaE	Nard silt loam, 25 to 45 percent slopes
Pe	Peoh silt loam
PhC	Peshastin loam, 8 to 15 percent slopes
PlD	Peshastin stony loam, 0 to 25 percent slopes
Ro	Rock outcrop
StD	Stemilt silt loam, 0 to 25 percent slopes
StE	Stemilt silt loam, 25 to 45 percent slopes
ThE	Thow gravelly fine sandy loam, 25 to 45 percent slopes
VaC	Varelum silt loam, 3 to 15 percent slopes
VaD	Varelum silt loam, 15 to 25 percent slopes
VaE	Varelum silt loam, 25 to 45 percent slopes
WeB	Wenatchee silt loam, 3 to 8 percent slopes
Cashmere Mountain Area, Washington, Parts of Chelan and Okanogan Counties	
45	Blag-Cle Elum-Rock outcrop complex, 30 to 75 percent slopes
46	Blag-Rock outcrop complex, 30 to 80 percent slopes
51	Brisky-Rock outcrop complex, 30 to 60 percent slopes
52	Burch loam, 3 to 8 percent slopes
80	Cle Elum loam, 30 to 60 percent south slopes
88	Culving-Rock outcrop complex, 30 to 60 percent slopes
138	Icicle very bouldery sandy loam, 30 to 75 percent slopes
201	Nard sandy loam, 30 to 60 percent slopes
239	Rock outcrop
242	Rock outcrop-Chumstick-Icicle complex, 45 to 90 percent slopes

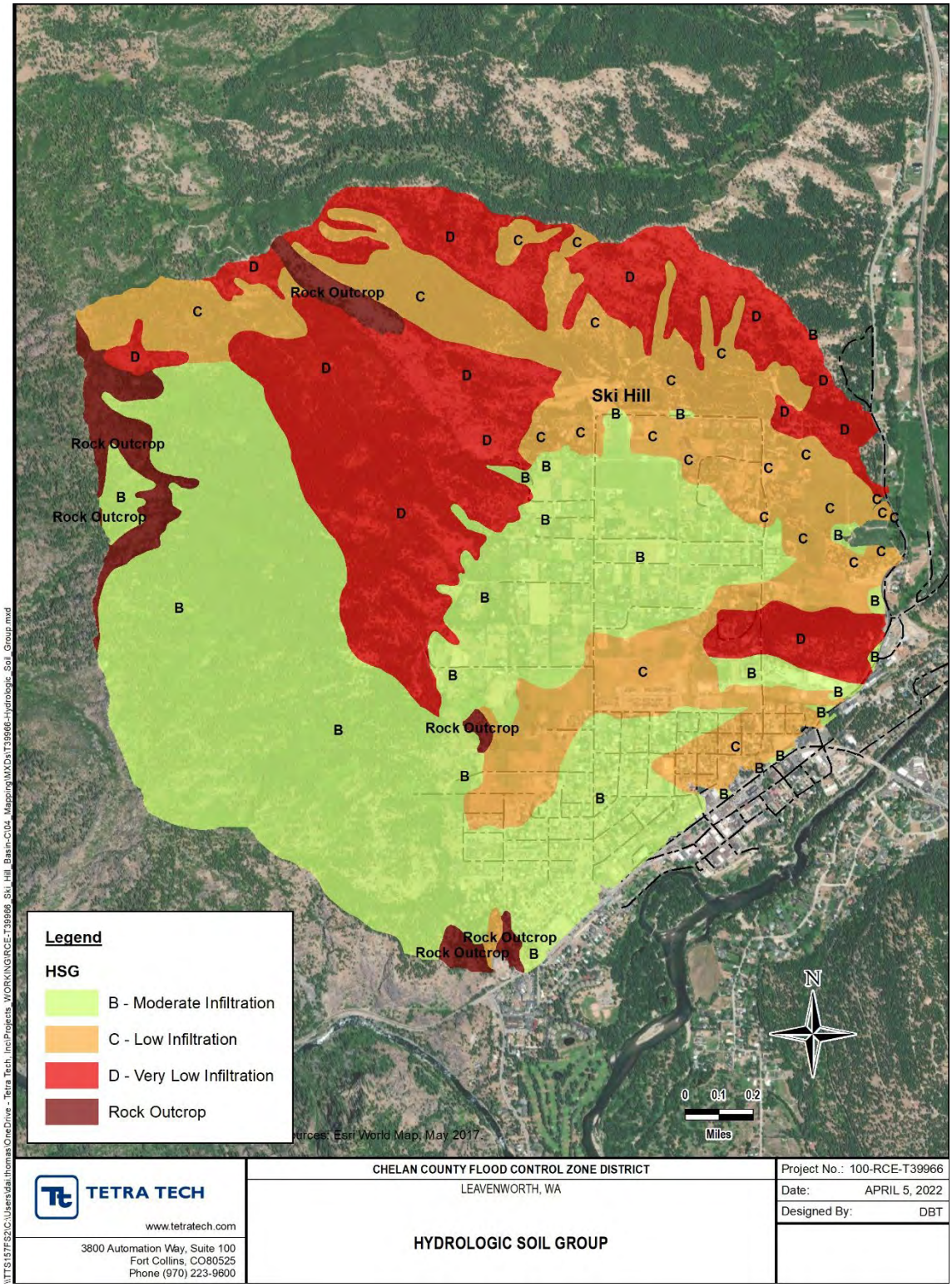


Figure 5. Hydrologic Soil Groups.

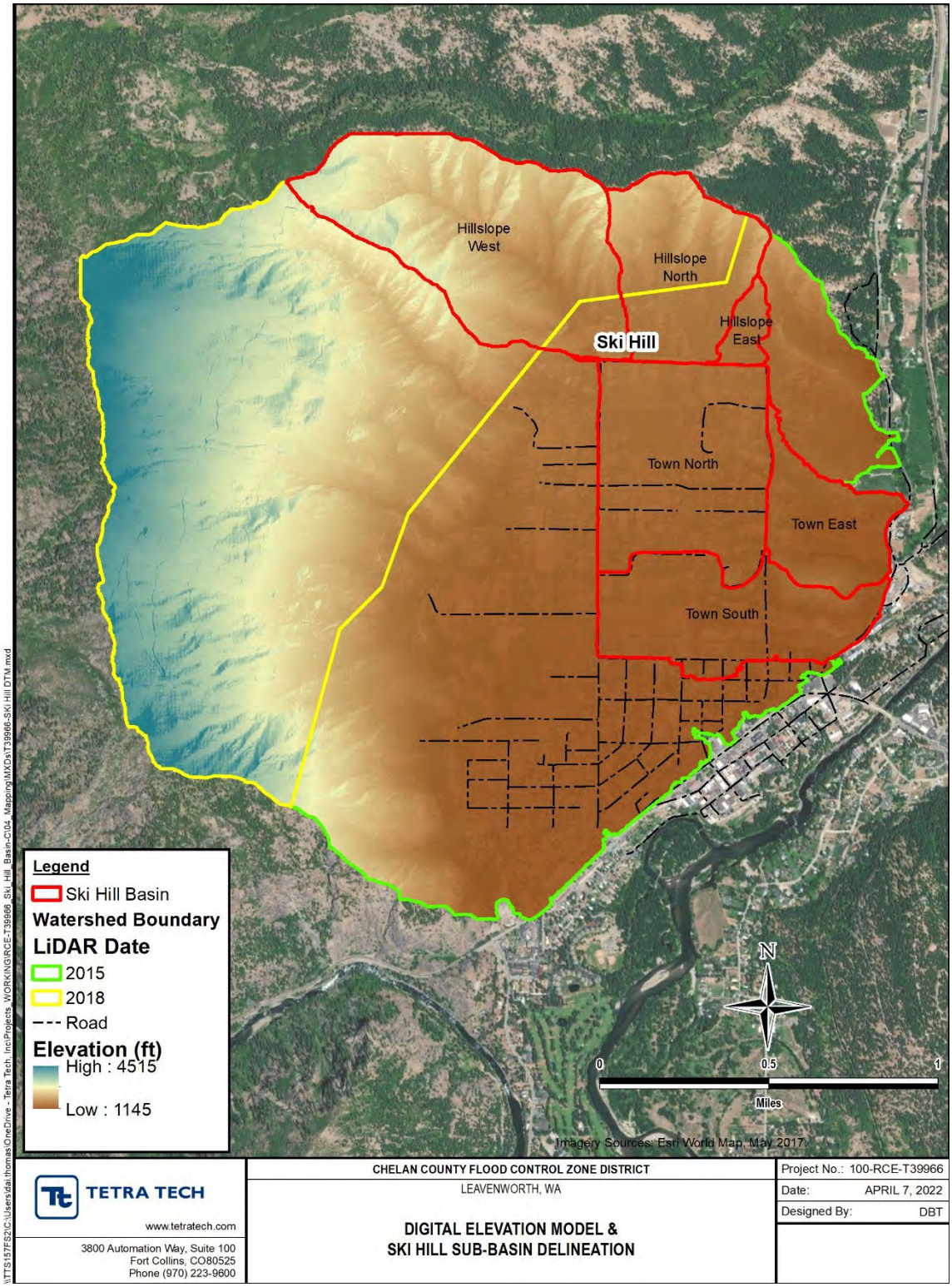


Figure 6. Digital elevation model and Ski Hill Basin sub-basin delineation.

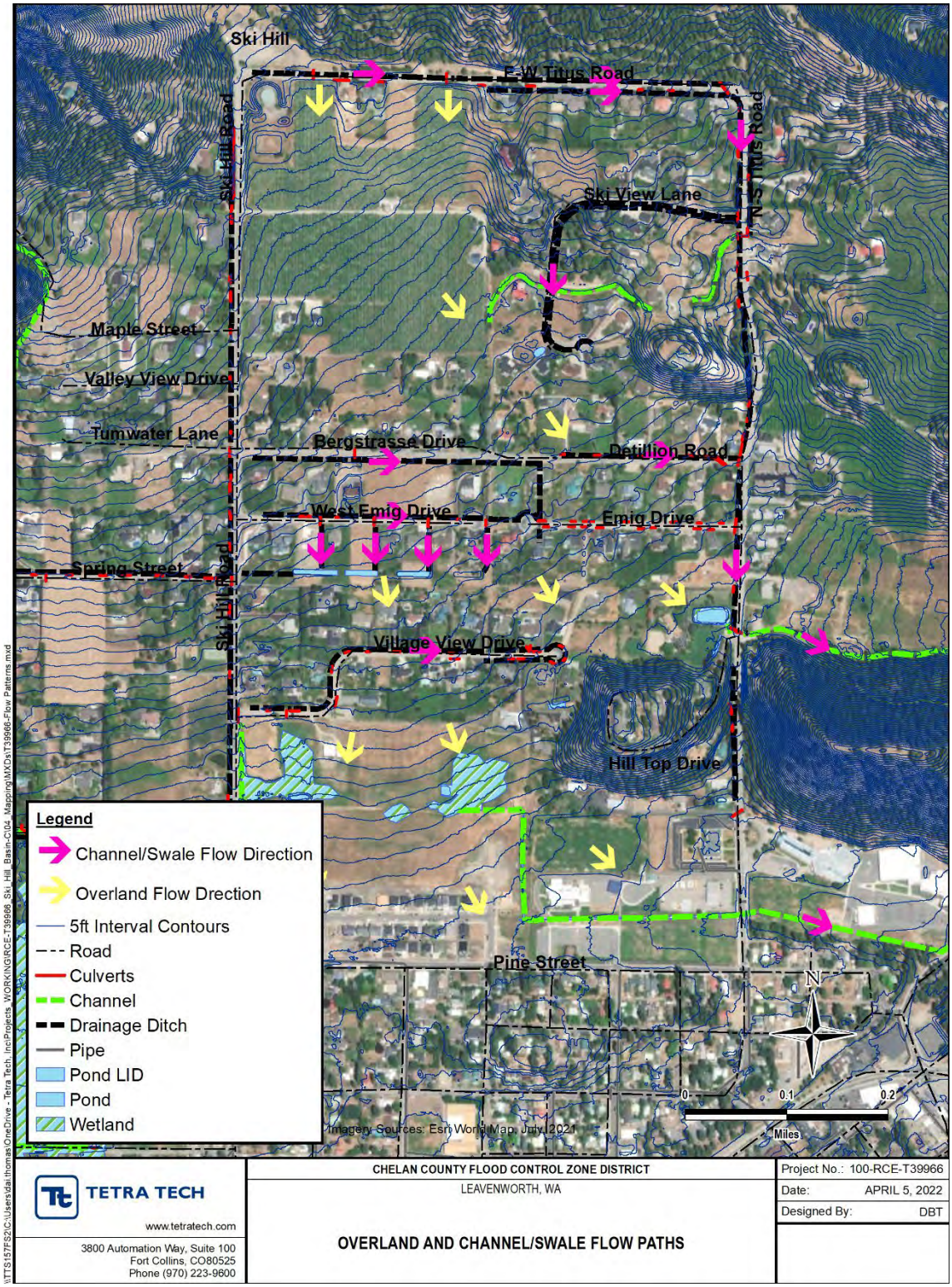


Figure 7. General overland flow path for flows originating from Ski Hill Basin.

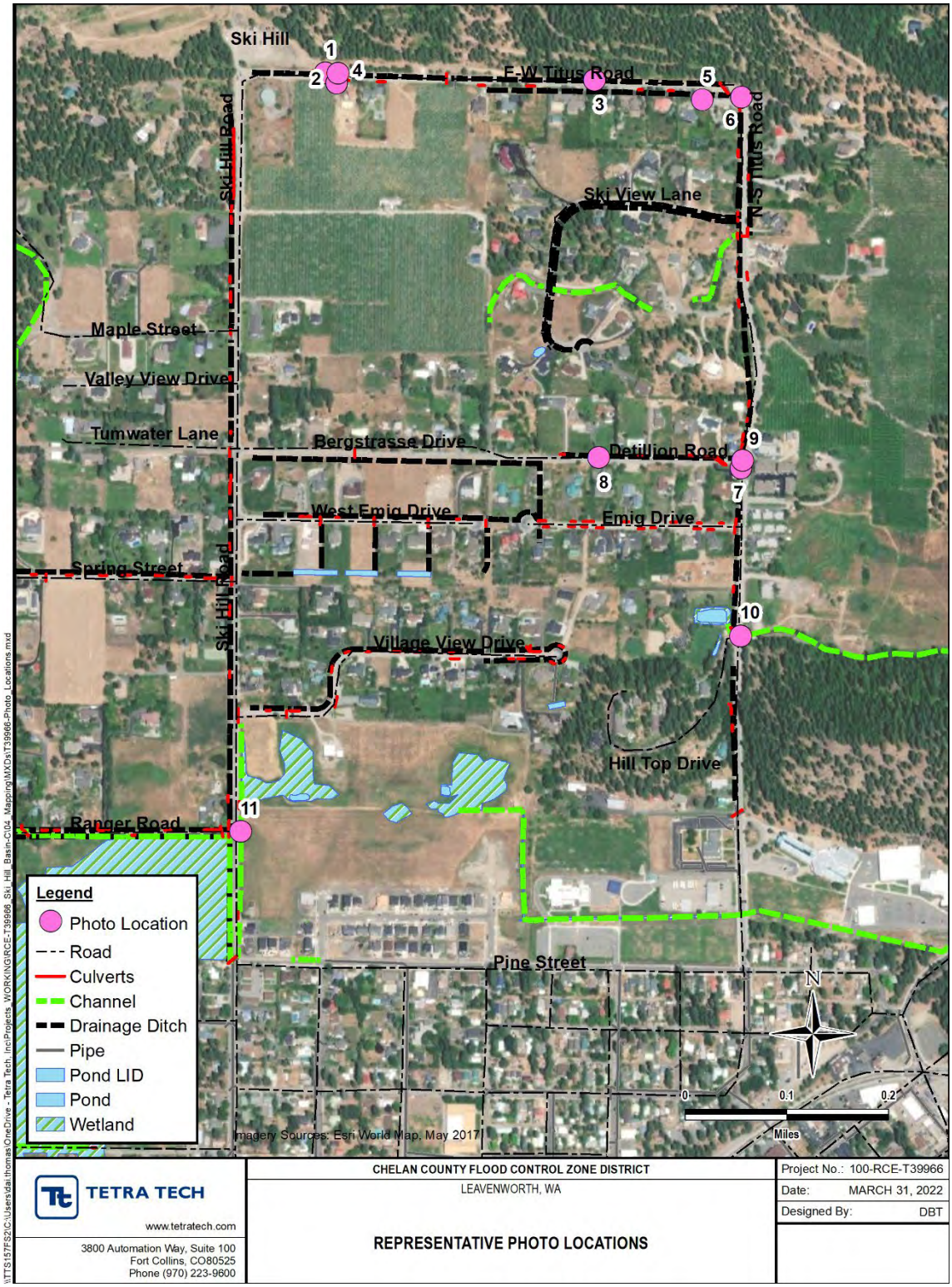


Figure 8. Representative photo locations.

Figure 9. View looking at the Ski Hill Basin. Photo is copied from Google Earth Street View. The photo is taken from Point 1 on Figure 8.

Figure 10. View looking east-to-west along Titus Road. The Ski Hill parking lot is seen in the upper right side of the photo. Mr. Walker of Grette Associates is standing beside a culvert that passes under Titus Road. The photo is taken from Point 4 on Figure 8.

Figure 11. View looking west-to-east along Titus Road from. Note the shallow swale along the left side of the road. The photo is taken from Point 4 on Figure 8.

Figure 12. View looking east-to-west along E-W Titus Road from point XX. Note the raise in road elevation approximately midway along E-W Titus Road. The photo is taken from Point 3 on Figure 8.

Figure 13. View looking south from E-W Titus Road. The photo is taken from Point 3 on Figure 8.

Figure 14. View looking south from E-W Titus Road during snow melt conditions. Photo taken from approximately same location as Figure 14. Photo provided by J. Detamore (FCZD).

Figure 15. View of the partially blocked culvert along E-W Titus Road. The photo is taken from Point 5 on Figure 8.

Figure 16. Partially blocked culvert along N-S Titus Road. The photo is taken from Point 6 on Figure 8.

Figure 17. Vegetated swale located near the corner of Detillion Road and N-S Titus Road. The photo is taken from Point 9 on Figure 8.

Figure 18. View looking west-to-east along Detillion Road. The photo is taken from Point 9 on Figure 8.

Figure 19. View looking west along Detillion Road from the corner of E-W Titus Road. The photo is taken from Point 8 on Figure 8.

Figure 20. View looking west along Detillion Road from the corner of E-W Titus Road. Photo provided by J. Detamore (FCZD) and taken from approximately same location as Figure 19.

Figure 21. View looking east along unnamed creek that conveys flow from N-S Titus Road to Chumstick Creek. The photo is taken from Point 10 on Figure 8.

Figure 22. View looking north across the open field. Note the slope from west-to-east towards the new homes along Pine Street seen along the right side of the photo. Portions of the field likely consist of wetlands. The photo is taken from Point 10 on Figure 8.

3. PUBLIC OUTREACH

A public outreach program was developed to provide information about the study and to solicit feedback on the proposed alternatives using online surveys.

The public outreach consisted of an ArcGIS StoryMap developed by Perteet (**Figure 23**), and the FCZD performed the following outreach:

- Provided online press releases.
- Mailed postcards with project information (Figure 24).
- Submitted a newspaper article.
- Individual meeting with homeowners.
- Posted on social media.
- City of Leavenworth newsletter
- Radio interview
- Held public meetings with both the City of Leavenworth City Council and the FCZD and FCZD Board of Supervisors

The StoryMap served as the primary public information source for the project. It was developed early in the study and updated as tasks were completed, including a significant update following development of the six alternatives. The StoryMap contained a description of the project, maps with narrative text and images, and provided the ability for the public to comment throughout the project timeline. A full copy of the StoryMap is provided in **Appendix A** and Perteet's summary report is provided in **Appendix B**.

Due to the Covid-19 pandemic, it was not possible to hold public meetings, but based on the many responses, the outreach program was deemed a success by Tetra Tech and the FCZD.

A discussion of the polling results for the alternatives is provided in Section 6.2.

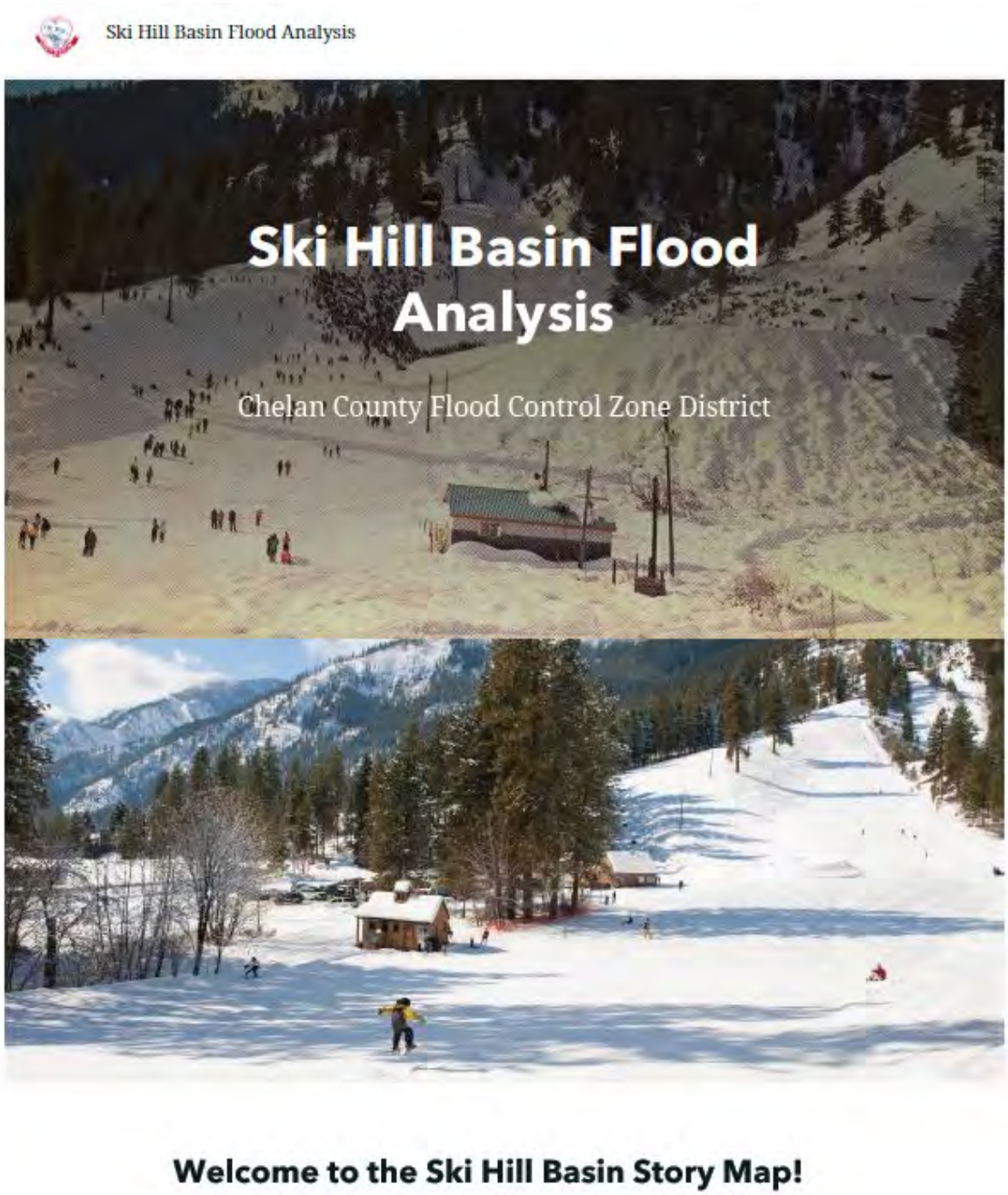


Figure 23. Cover page from the StoryMap.

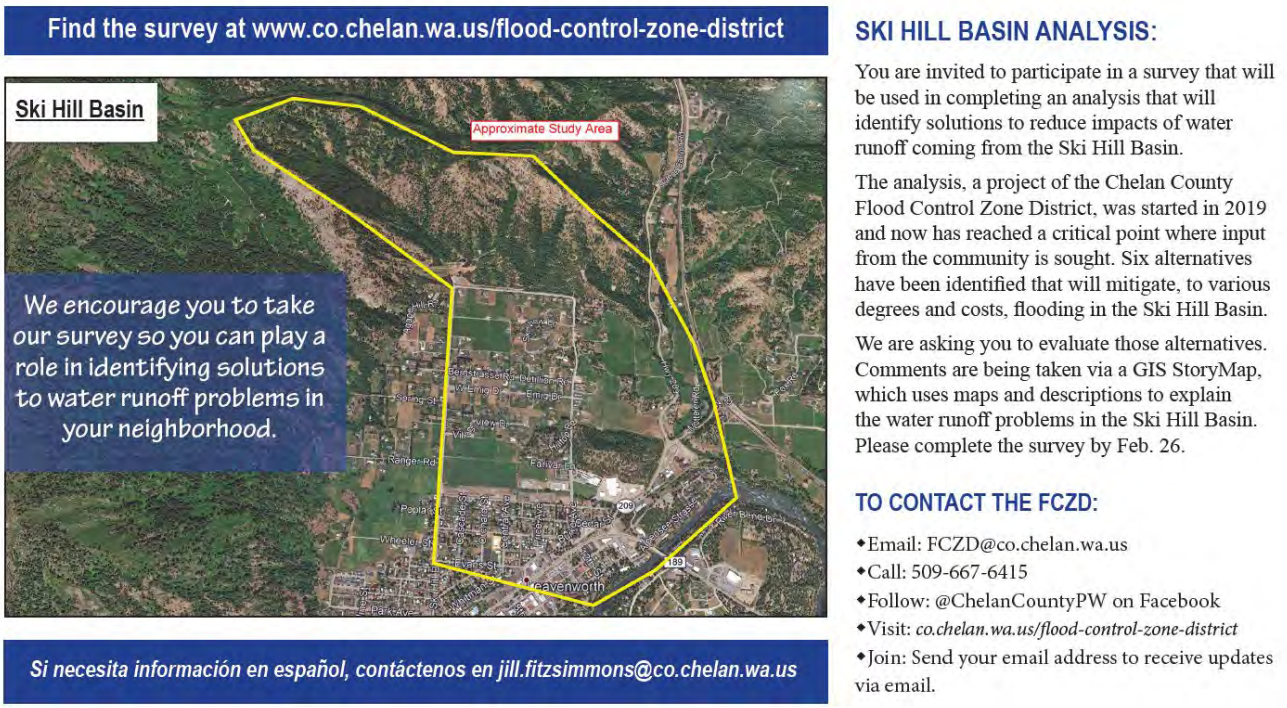


Figure 24. Post card sent to residents by Chelan County FCZD.

4. HYDROLOGY ANALYSIS

A hydrologic analysis was performed to estimate the peak flows originating from the Ski Hill sub-basins for a range of rainfall frequency events. The hydrologic modeling was performed using the Corps of Engineers Hydrologic Modeling System (HEC-HMS Version 4.8) computer software (USACE, 2021), which is considered an industry standard for hydrologic analyses.

HEC-HMS simulates surface runoff response of a river basin to precipitation by representing the basin as a system of interconnected hydrologic and hydraulic components. HEC-HMS simulates the precipitation-runoff response of the watershed by performing mathematical computations for four hydrologic and hydraulic processes:

- Precipitation
- Infiltration
- Transformation of precipitation excess to sub-basin outflow
- Channel routing

4.1 BASIN DESCRIPTION

Ski Hill Basin[7] was sub-divided into seven sub-basins using the ArcHydro tools in ArcGIS and the DEM. (Figure 6). There are three sub-basins north of E-W Titus Road that contribute the majority of the runoff and they are named in the HEC-HMS model from west-to-east as Hillslope West, Hillslope North and Hillslope East (Figure 6).

Elevations in the Ski Hill Basin range from about 3,094 ft northwest of Ski Hill to about 1,152 feet at Pine Street. Ski Hill Basin is 1.27 mi^2 and the sub-basins range in area from 0.03 to 0.41 mi^2 (**Table 2**). The basins include roughly the northern half of Leavenworth, agricultural fields north of Leavenworth, and the hills north and west of town, including the Leavenworth Ski Hill.

Table 2. Summary of basin and sub-basins areas and elevations

Basin	Sub-basin	Area (mi^2)	Max Elevation (ft)	Min Elevation (ft)
Ski Hill	Hillslope West	0.41	3,094	1,421
	Hillslope North	0.19	2,376	1,419
	Hillslope East	0.03	1,737	1,391
	Town North	0.30	1,540	1,235
	Town South	0.22	1,265	1,152
	Town East	0.12	1,359	1,159
	Total	1.27		

4.2 SNOW HYDROLOGY

Rain-on-snow events were modelled using the Temperature Index method in HEC-HMS. For hillslope subbasins, precipitation, snow-water equivalent (SWE) and temperature data were obtained from NRCS SNOTEL gage 352 Blewett Pass, which contains data from 1981 to the present. Blewett Pass is relatively close to the study site without major intervening topographic features and lies at a similar elevation as the maximum elevation of West basin (~4,200 ft). For town subbasins, precipitation, snow depths, and

[7] In engineering literature, the terms basin, catchment and watershed are commonly used interchangeably.

temperature data were obtained from NCDC gage (USC00454572 LEAVENWORTH 3 S, WA US) which contains data from 1970 to the present. For the town subbasins, SWE was computed from snow depths using Equation 1 from the Washington State Department of Transportation Hydraulics Manual (WSDOT 2019):

Equation 1

$$SWE\ (in) = \frac{Average\ snow\ depth\ (in)}{5}$$

SWE, precipitation, and temperature data for the singular Hillslope/Town subbasin were averaged from SNOTEL and NCDC gages. A summary of snow hydrology data is provided in **Figure 25** and **Figure 26.**

Parameters used within the Temperature Index method are discussed in detail below. The HEC-HMS manual was referenced to estimate default values for many parameters (USACE, 2018).

PX Temperature is a threshold determining if precipitation falls as rain or as snow. Snow occurs when air temperatures fall below the specified value. A value of 32 degrees was used.

The difference between the air temperature and the Base Temperature is multiplied by the melt rate to estimate the amount of snowmelt. The recommended value is 32 degrees.

Wet Meltrate represents the rate at which the snowpack melts during rain-on-snow events. This parameter was calibrated in HEC-HMS and is discussed in Section 4.4.

The default value of 0 for the Rain Rate Limit mandates the wet melt rate for all calculations. A non-zero value would apply a wet melt rate only for rainfall rates greater than the value specified. Otherwise, a dry melt rate would be applied.

The Antecedent Temperature Index (ATI) Melt Rate Function quantifies the increased tendency for snow melt at a higher altitude within a basin exhibiting greater exposure. An increase in the ATI Melt Rate Function results in an increase in snow melt contribution to the overall basin runoff hydrograph. This parameter was calibrated in HEC-HMS. Model calibration is described in Section 4.4.

A default value of 0.98 was entered for the ATI-Meltrate Coefficient. It controls calculation time intervals when the rain rate limit exceeds the rate of precipitation. The Rain Rate Limit was set to a default value of zero, rendering the ATI-Meltrate Coefficient unnecessary for calculations.

The Cold Limit accounts for rapid changes in temperature that snowpack undergoes during high precipitation rates. A default value of 0 was applied, such that any amount of snowfall would reset the cold content.

The ATI Coldrate Coefficient is used to update the antecedent cold content index from one time interval to the next. A default value of 0.5 was used.

The Water Capacity parameter specifies the amount of melted water that must accumulate within the snowpack prior to liquid water becoming available for infiltration or runoff. A value of 4 percent was assumed.

The Groundmelt Method specifies the melting of the snowpack due to contact with unfrozen ground. It may be entered as a constant value or as an annual pattern. For this model, a fixed value of 0.01 was selected.

For each of the subbasins described in Table 2, a single temperature band was located at the highest elevation of the longest flow path as measured in Google Earth. A typical Lapse Rate of -5 degrees F per 1,000 feet of elevation was assigned to each subbasin. This parameter defines temperature distribution moving vertically through the watershed.

Initial Snow Water Equivalent (SWE) was calculated from daily climate records as described above. Mean and median peak SWE values were modelled. More detail is provided in Section 4.4.

Initial Cold Content was set to 0 to simulate snowpack temperature as 32 degrees at all depths.

Initial Liquid Water was estimated as 0.5 based on limited guidance from the HEC-HMS User's Manual (USACE, 2018).

Similarly, Initial Cold Content ATI set to 32 degrees based on recommendation from the HEC-HMS manual.

Initial Melt ATI is the accumulation of degree-days since the last period of sustained air temperatures below freezing. Because these simulations begin melting peak SWE, a default value of 0 days was assumed.

4.3 LOSS METHOD AND BASIN PARAMETERS

The Natural Resources Conservation Service (NRCS) Curve Number (CN) method was applied to model the infiltration losses (USDA, 1986). For each basin, composite CN values were estimated using soil data, land use type and imperviousness data from aerial imagery and the National Land Cover Database (NLCD) 2016 (MRLC, 2019). CN values for each land use/HSG are provided in **Table 3.**

Table 3. Ski Hill Basin Curve Number Values

Land Use (Hydrologic Condition)	Hydrologic Soil Group	Curve Number	Subbasin
Oak-Aspen (Good)	B	30	Hillslope West Hillslope North Hillslope East
Oak-Aspen (Good)	C	41	Hillslope West Hillslope North Hillslope East Town East
Oak-Aspen (Good)	C/D	44.5	Town North
Oak-Aspen (Good)	D	48	Hillslope West Hillslope North Town North Town South Town East
Row crops SR (Good)	B	78	Town North Town South Town East
Row crops SR (Good)	C	85	Town North Town East
Row crops SR (Good)	C/D	87	Town North Town South Town East
Fallow CR (Good)	B	83	Town North Town East
Fallow CR (Good)	C	88	Town North
Fallow CR (Good)	C/D	89	Town North Town East
Residential 1 acre (20% impervious)	B	68	Town North Town South Town East
Residential 1 acre (20% impervious)	C	79	Town North Town East
Residential 1 acre (20% impervious)	C/D	81.5	Town North Town South Town East
Residential 1 acre (20% impervious)	D	84	Town North Town South
Residential 1/4 acre (38% impervious)	B	75	Town South Town East
Residential 1/4 acre (38% impervious)	C	84	Town South
Urban Districts Industrial (72% impervious)	B	88	Town South
Urban Districts Industrial (72% impervious)	C/D	92	Town South

Using the composite *CN* value for each subbasin, initial abstractions (I_a) (inches) were computed with Equation 2 which was obtained from the National Engineering Handbook (USDA 2010)

Equation 2

$$I_a = 0.2 \times \left[\left(\frac{1000}{CN}\right) - 10\right]$$

The Watershed Lag method (USDA, 2010) was used to compute the lag time (L) (hr) for each subbasin using Equation 3

Equation 3

$$L = \frac{l^{0.8}\,(S+1)^{0.7}}{1900Y^{0.5}}$$

Where,

S = the maximum potential retention (inches) calculated from $\left[\left(\frac{1000}{CN}\right) - 10\right]$

l = the length of the longest flow path (ft)

Y = the average watershed land slope (%)

The average watershed land slope was estimated from watershed delineations using the 3-ft DEM and Google Earth. The longest flow path was calculated using two different methods. First, an empirical formula from the National Engineering Handbook (USDA, 2010) was considered (Equation 4):

Equation 4

$$l = 209A^{0.6}$$

where, A = drainage area (acres).

For each subbasin, the longest flow path was also measuring manually using Google Earth. For all subbasins, this measured flow path was longer than the calculated flow path. To be conservative, the shorter, calculated lag time was used in HEC-HMS. A shorter lag time typically results in a larger peak discharge.

4.4 HEC-HMS MODEL AND CALIBRATION

Rain-on-snow hydrology was simulated for 2-, 5-, 10-, 25-, 50-, and 100-yr, 24-hr events using HEC-HMS 4.3 (USACE 2018). Rainfall-frequency data were obtained from NOAA Atlas 2 (Miller, et al., 1973). Models were simulated at a daily timestep with the goal of accurately simulating the timing and magnitude of peak snowpack melting over mean and median climatic conditions.

As mentioned above, the ATI Melt Rate Function and Wet Melt Rate were calibrated using both mean and median values of SWE, temperature, and precipitation. Under mean conditions, precipitation was non-zero for most days and calibration primarily involved the Wet Melt rate, while under median conditions, precipitation was zero for many days and calibration focused on the ATI-Melt Rate Function. A peak SWE value representative of the largest and highest elevation subbasins was used for calibration. This was done to fully capture melting of the largest (and slowest) snowpack. For Ski Hill Basin, this representative subbasin was

Hillslope West, and for West Basin, it was Hillslope 1. As a result, one Wet Melt Rate and ATI-Melt Rate Function were used for all Ski Hill Basin subbasins.

Model calibration involved adjusting the two parameters to minimize the magnitude of SWE percent bias while maximize Nash-Sutcliffe Efficiency (NSE) (Nash and Sutcliffe 1970). A SWE percent bias near 0 indicates neither over- nor under-predicting of snow melting, while an NSE near 1 suggests an accurate model with high predictive ability.

With calibrated snowmelt models for each subbasin, rain-on-snow flood scenarios were simulated using NOAA Atlas 2 precipitation concurrently with mean temperature and SWE data (Table 4. Rain-on-snow models were configured such that the timing of event precipitation coincided with snowmelt peaking. This approach produced a conservative estimate of rain-on-snow flood events to use as inputs for HEC-RAS hydraulic model.

Table 4. NOAA Atlas 2 Precipitation Values

Frequency Storm	Ski Hill & East Basin Precipitation (in)	West Basin Precipitation (in)
2-yr, 24-hr	1.5	1.65
5-yr, 24-hr	2.1	2.25
10-yr, 24-hr	2.35	2.5
25-yr, 24-hr	2.6	2.8
50-yr, 24-hr	3.1	3.25
100-yr, 24-hr	3.36	3.5

4.5 HEC-HMS MODEL RESULTS

A summary table of results for the 2-yr through 100-yr storm is displayed below for Hillslope West in Ski Hill Basin (Table 5). Peak discharges occur on April 28 and peak SWE volumes of 14.47 inches occur on March 11. Hydrographs of the 10-yr and 100-yr storms are provided in **Figure 27**.

Table 5. HEC-HMS Results for Hillslope West subbasin within Ski Hill Basin

Frequency Storm	Peak Discharge (cfs)	Discharge Volume (in)	Precipitation Volume (in)
2-yr, 24-hr	11.4	7.06	1.5
5-yr, 24-hr	15.4	7.52	2.1
10-yr, 24-hr	17.0	7.71	2.35
25-yr, 24-hr	18.7	7.90	2.6
50-yr, 24-hr	22.1	8.29	3.1
100-yr, 24-hr	23.8	8.50	3.36

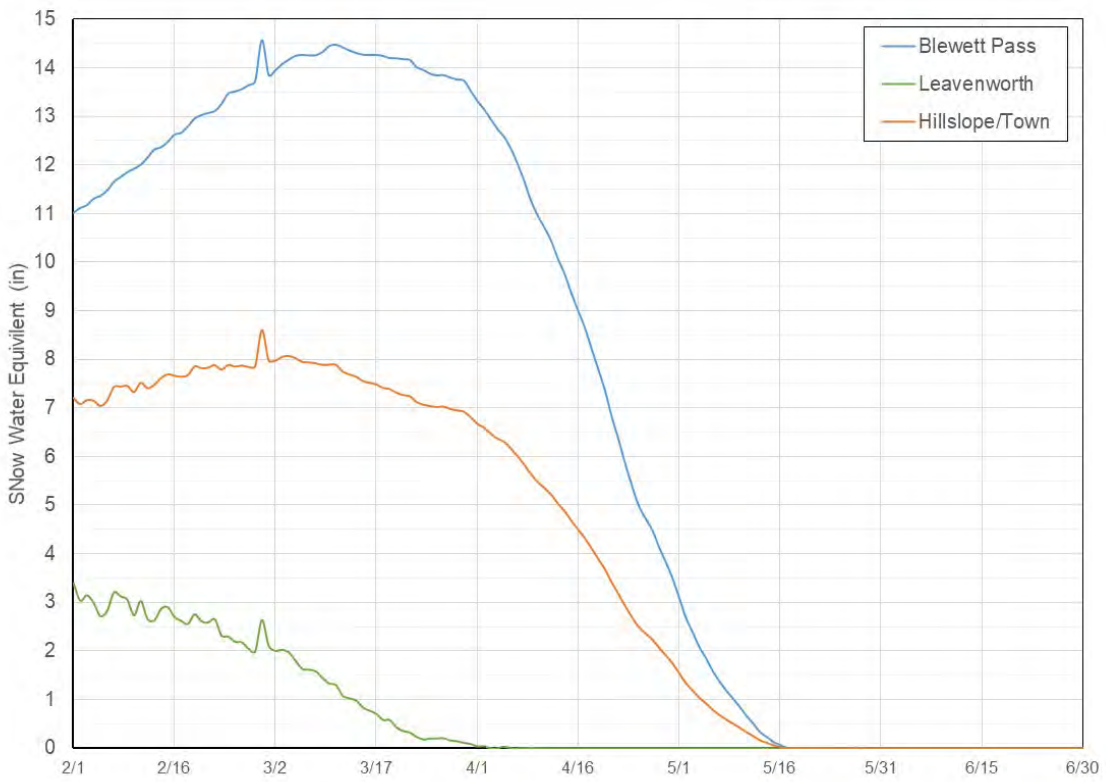


Figure 25. Snow-water equivalent data.

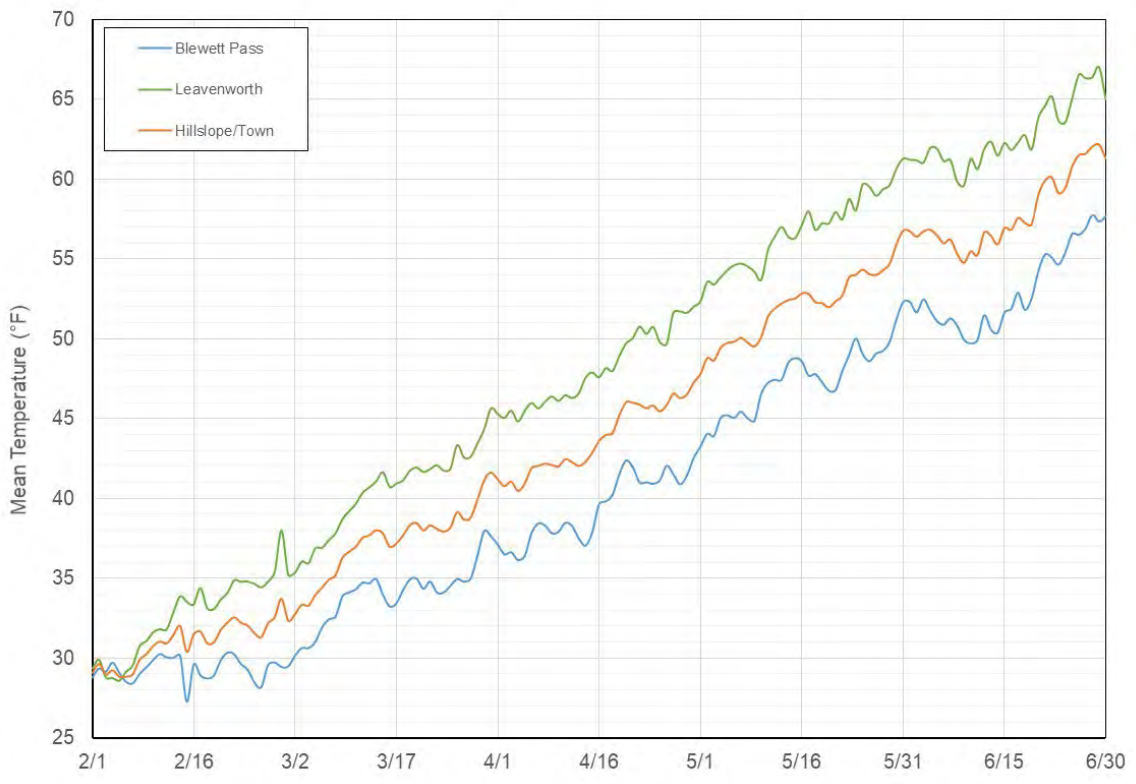


Figure 26. Mean Temperature data for Blewett Pass, Leavenworth and Hillslope/Town

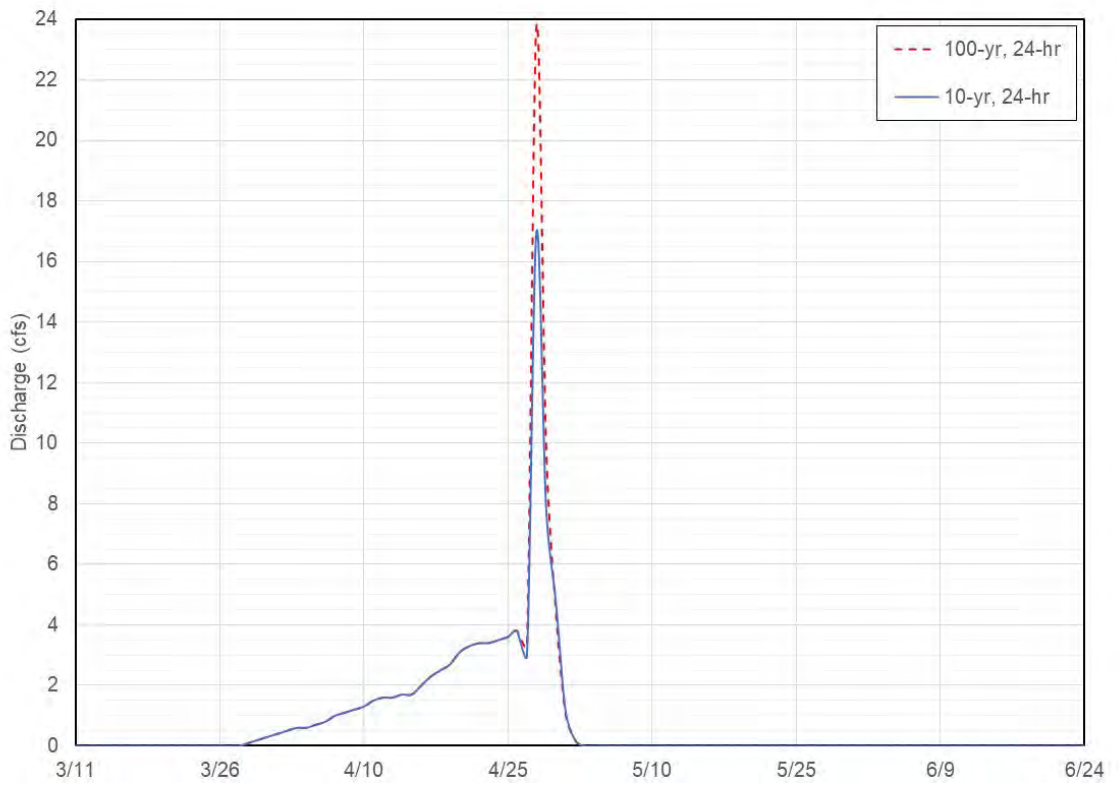


Figure 27. Mean Hydrograph of rain-on-snow events for the Hillslope West subbasin within Ski Hill Basin

5. HYDRAULIC ANALYSIS

A 2-dimensional (2-D) hydraulic model was developed to simulate the existing conditions for the 24- hour, 10-year rainfall/snowmelt event (which represents the return interval that municipalities commonly apply for stormwater design) and the 24-hour, 100-year event [that is commonly used for floodplain management such as by the Federal Emergency Management Agency (FEMA)].

The model was developed based on the DEM (Section 2.1.4) and culvert geometry provided by the FCZD. Due to the absence of measured flow and water-surface elevation data, it was not possible to calibrate the hydraulic model. The model was run over the 10- and 100-year events and the model output was used to develop depth inundation mapping.

The existing conditions model was subsequently modified to size the channels, swales, and culverts as part of the alternative's development.

5.1 EXISTING CONDITIONS MODEL DEVELOPMENT

The modelling was conducted using the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Centre–River Analysis System (HEC-RAS) version 6.1.0 software (USACE 2021). HEC-RAS is a modular hydraulic simulation program, capable of simulating both 1-D and 2-D depth-averaged hydraulics.

HEC-RAS is used to simulate the movement of a flow over a model mesh which is comprised of a system of 2-D grid cells (which are also referred in engineering literature as elements). The software can accommodate larger grid cell sizes than many other 2-D models using pre-processed hydraulic property tables. These tables represent the details of the underlying terrain for each grid cell, and thus retain the needed detail while using larger grid cells than most other 2-D hydraulic models (USACE 2014). The expected change in hydraulic grade line is considered when selecting the grid cell resolution. In areas of special interest or where steep water-surface slopes are expected (such as near hydraulic structures), smaller grid cell sizes are used to capture the changes in water surface. In contrast, areas where mild water surface slopes are expected, larger grid cell sizes can be used (USACE 2014). A denser grid resolution, however, can considerably increase computation time.

The 2-D model extended in a north-to-south direction from E-W Titus Road to U.S. 2/ Chumstick Highway, and from the west-to-east from the base of the hills to Chumstick Creek (Figure 28).

Many local agencies have recommendations that guide the design of their drainage systems to manage a specific flood, such as the 10-year event or the 25-year event. This helps ensure that flooding does not become worse for neighbouring properties. A 10-year flood is typically applied for a drainage design that includes roadside ditches and culverts because it provides a reasonable balance between risk management and cost-effectiveness. A 10-year flood is an event that has a 10% chance of occurring in any given year. Designing drainage systems to accommodate a 10-year flood event helps to reduce the risk of flooding to an acceptable level while also keeping the cost of construction and maintenance reasonable. If a drainage system was designed to accommodate a more severe flood, such as a 100-year flood (1% chance of occurring in any given year), the cost of construction and maintenance would be significantly higher, and the benefits may not justify the additional expense.

5.1.1 Topographic Data

The HEC-RAS hydraulic model requires an input "terrain" that represents the channel and overbank topography. The terrain is a 3-foot pixel resolution Digital Elevation Model (DEM) that consists of square pixels representing an area with a representative elevation (Figure 6). The model computes the hydraulic properties for each element in the terrain and uses the terrain to develop the flood inundation mapping.

5.1.2 Manning's *n* Roughness Values

The HEC-RAS model uses Manning's *n* roughness values to quantify energy losses. Manning's *n*-values were selected based on field observation of the floodplain characteristics and standard references. The overbank *n*-values were established based on the USGS National Land Cover Dataset (NLCD)[8] **(**

Figure 29**)**.

The NLCD maps 16 land use types within the model boundary. Manning *n*-values were assigned to each land use type based on field observations, similar experience with other rivers, and standard references (Chow 1959; Barnes 1967; Hicks and Mason 1991; Julien 1995) (Table 6). A Manning's *n*-value of 0.035 was applied to the channels/swales. Manning's *n*-values for the overbanks ranged from 0.035 for the open space areas to 0.15 for the heavily vegetated areas. Roads were assigned Manning's *n*-values of 0.023, and developed residential areas were assigned Manning's *n*-values ranging from 0.2 to 0.4.

Table 6. Manning's n-values assigned to the land use areas

Land Use	Manning's *n*-value
Roads	0.023
Channel/Swale	0.035
Developed, Open Space	0.035
Developed, Low Intensity	0.2
Developed, Medium Intensity	0.3
Developed, High Intensity	0.4
Barren Land Rock/Sand/Clay	0.03
Emergent Herbaceous Wetlands	0.055
Grassland/Herbaceous	0.04
Pasture/Hay	0.04
Shrub/Scrub	0.06
Woody Wetlands	0.08
Evergreen Forest	0.08
Mixed Forest	0.085
Cultivated Crops	0.04
Deciduous Forest	0.09

5.2 CULVERTS

Forty-one culverts are represented in the hydraulic model (Figure 28). The location and diameters of the culverts were obtained from mapping provided by the FCZD. Inlet and outlet elevations for the other culverts was estimated based on the DEM. Culvert lengths were measured based on the DEM and aerial photography.

[8] Multi-Resolution Land Characteristics (MRLC) Consortium

5.3 RESULTS

The hydraulic model was run for the 24-hour, 10- and 100-year peak rainfall/snowmelt conditions and the model output was used to develop depth inundation mapping and to assess the capacity of the channels. The depth mapping for the 10- and 100-year events and the maximum flows at the 3 inflow locations along the northern side of E-W Titus Road, are shown in **Figure 30** and **Figure 31**, respectively. It is important to remember, that the flows discussed in the following section represent the inflows from north of E-W Titus Road, and do not include the additional snowmelt from south of E-W Titus Road.

The following observations were made for the 10-year event:

- The peak flow from Ski Hill Basin is 17 cfs. At the culvert near Ski Hill parking lot, the model predicts the peak flow (combined flow over the road and through the culvert) into the orchard is 13 cfs and 1 cfs is conveyed in an easterly direction along E-W Titus Road.
- At the second culvert located near the label representing a peak flow of 6 cfs, the channel is under-sized and approximately 13 cfs passes through the culvert. The depth inundation mapping shows significant ponding along the upstream side of E-W Titus Road in the vicinity of the culvert (Figure 30), that is likely due to the flat slope of the swale.
- The peak flow along N-S Titus Road is about 1 cfs.
- The peak flow along N-S Titus Road downhill of the drainage is about 6 cfs.
- Based on conversation with the FCZD, there are no plans to increase the size of the culverts under E-W Titus Road, as the FCZD do not want to increase flow into the orchard. Instead, the FCZD prefers to increase the capacity of the existing channel/swales and convey flow to the east.

The following observations were made for the 100-year event:

- The peak flow from Ski Hill Basin is 34 cfs. At the culvert near Ski Hill parking lot, the model predicts the peak flow (combined flow over the road and through the culvert) into the orchard is 30 cfs and 4 cfs is conveyed in an easterly direction along E-W Titus Road.
- At the second culvert located near the label representing a peak flow of 13 cfs, the channel is under-sized and the peak flow through the culvert is about 12 cfs. The depth inundation mapping shows significant ponding along the upstream side of E-W Titus Road in the vicinity of the culvert (Figure 30), that is likely due to the flat slope of the swale.
- The flow along N-S Titus Road near the corner of Detillion Road is 13 cfs
- The peak flow along N-S Titus Road downhill of the drainage is about 38 cfs.

Many local agencies have recommendations that guide the design of their drainage systems to manage a specific flood, such as the 10-year event or the 25-year event. This helps ensure that flooding does not become worse for neighbouring properties. A 10-year flood is typically applied for a drainage design that includes roadside ditches and culverts because it provides a reasonable balance between risk management and cost-effectiveness. A 10-year flood is an event that has a 10% chance of occurring in any given year. Designing drainage systems to accommodate a 10-year flood event helps to reduce the risk of flooding to an acceptable level while also keeping the cost of construction and maintenance reasonable. If a drainage system was designed to accommodate a more severe flood, such as a 100-year flood (1% chance of occurring in any given year), the cost of construction and maintenance would be significantly higher, and the benefits may not justify the additional expense.

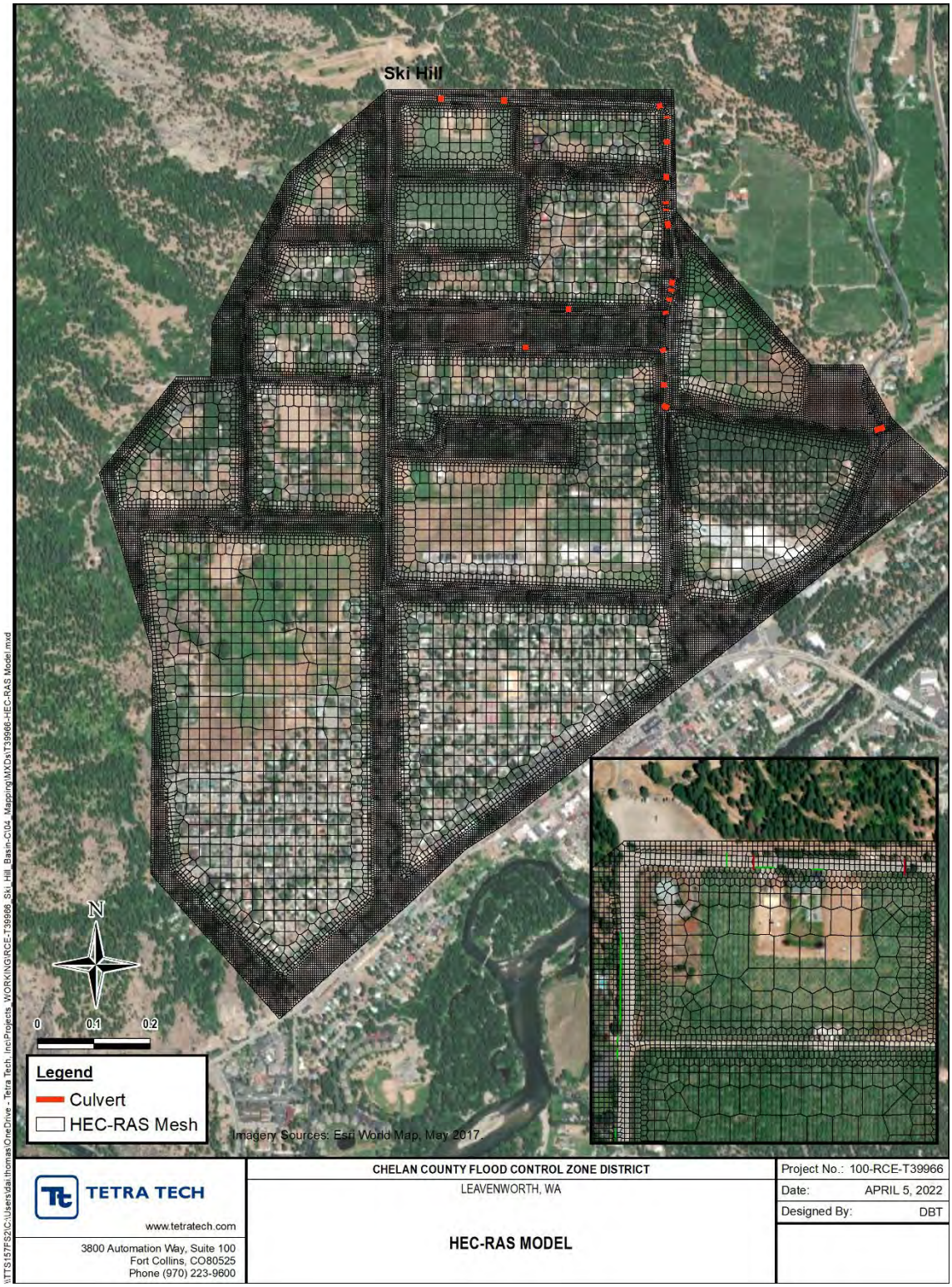


Figure 28. HEC-RAS model extents. Inset map shows the mesh resolution near the Ski Hill parking lots the mesh resolution near the Ski Hill parking lot.

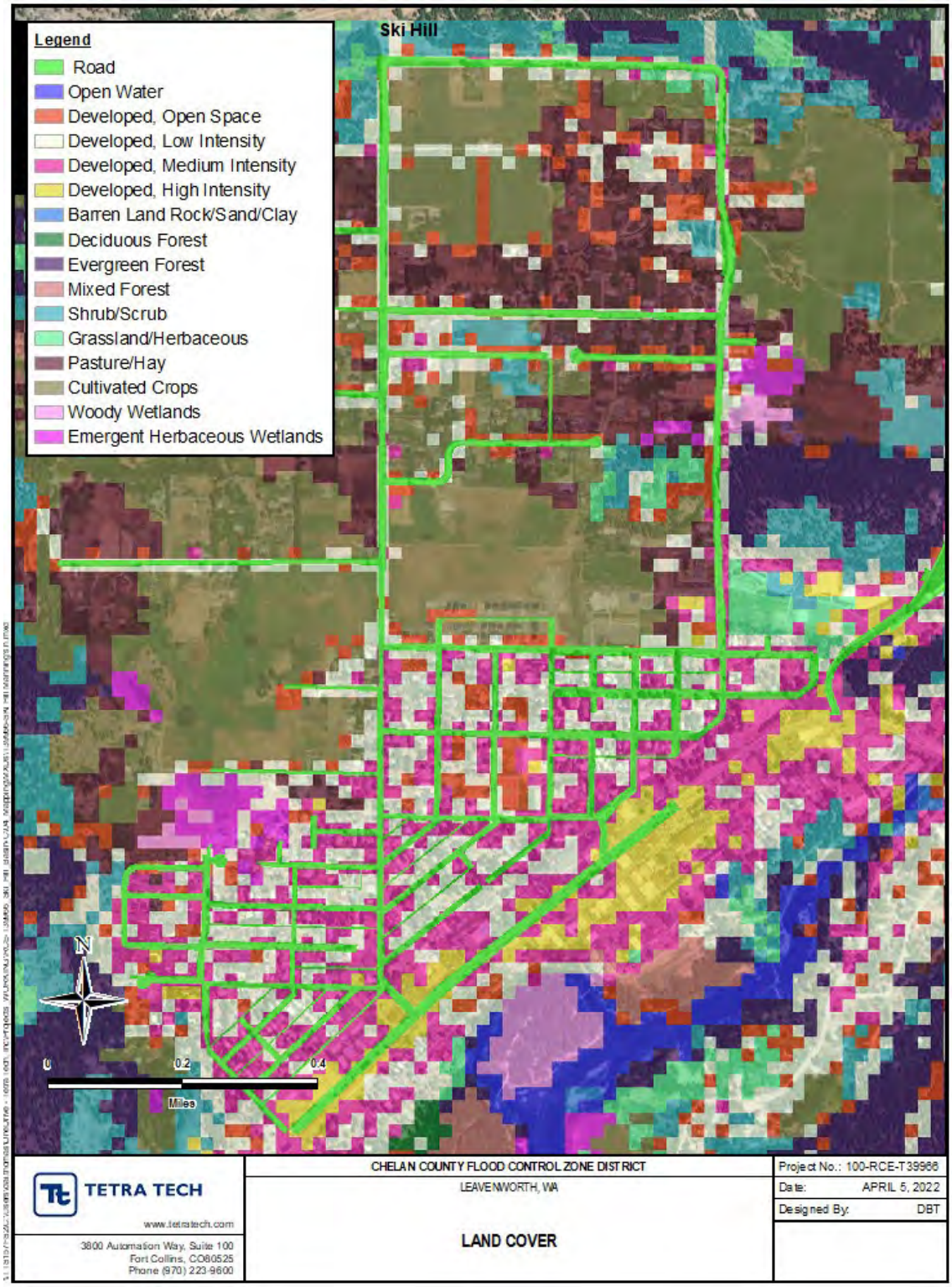


Figure 29. Land cover types obtained from the USGS National Land Cover Database.

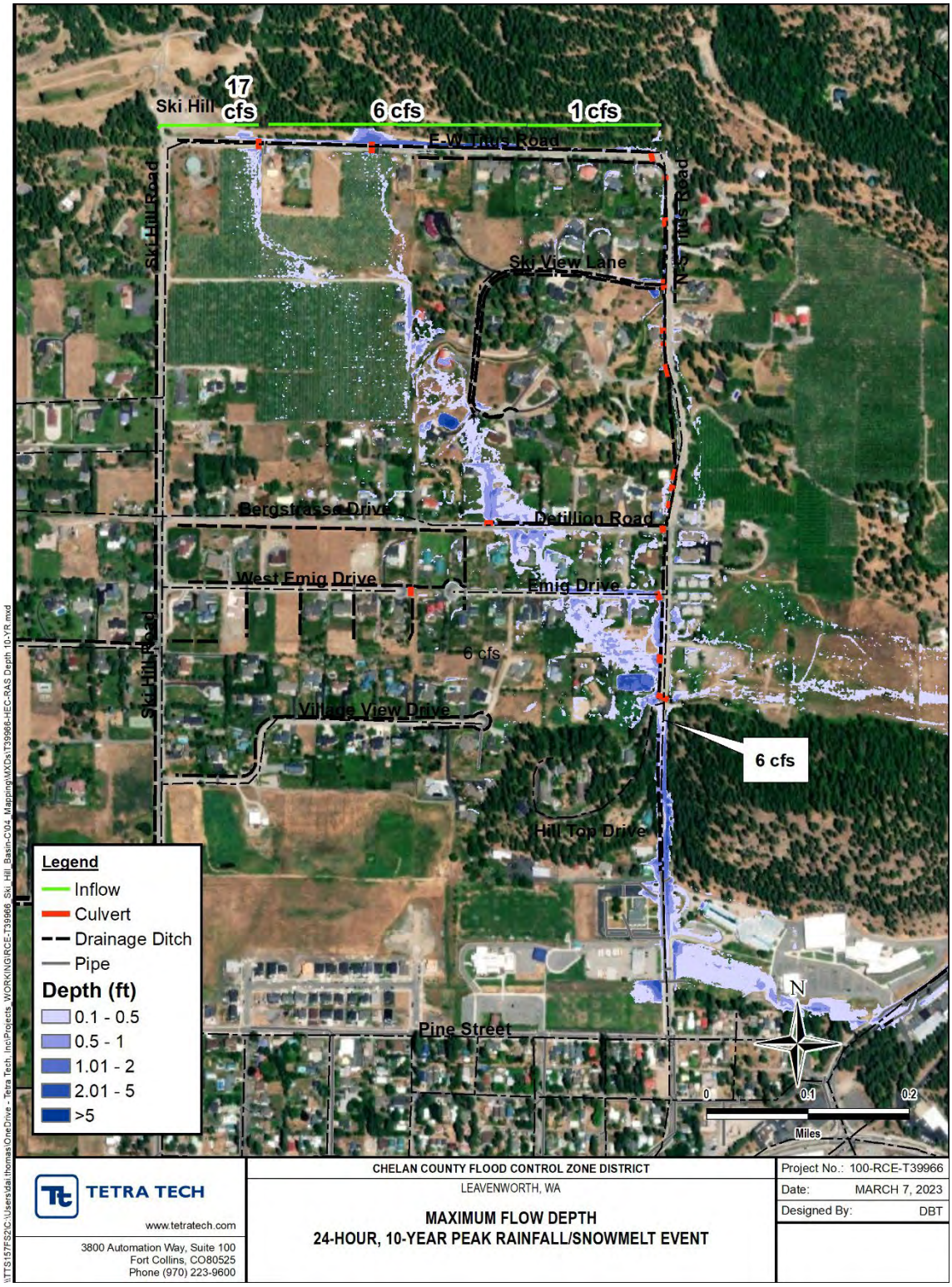


Figure 30. Predicted flow depth for the 10-year rainfall/snowmelt event.

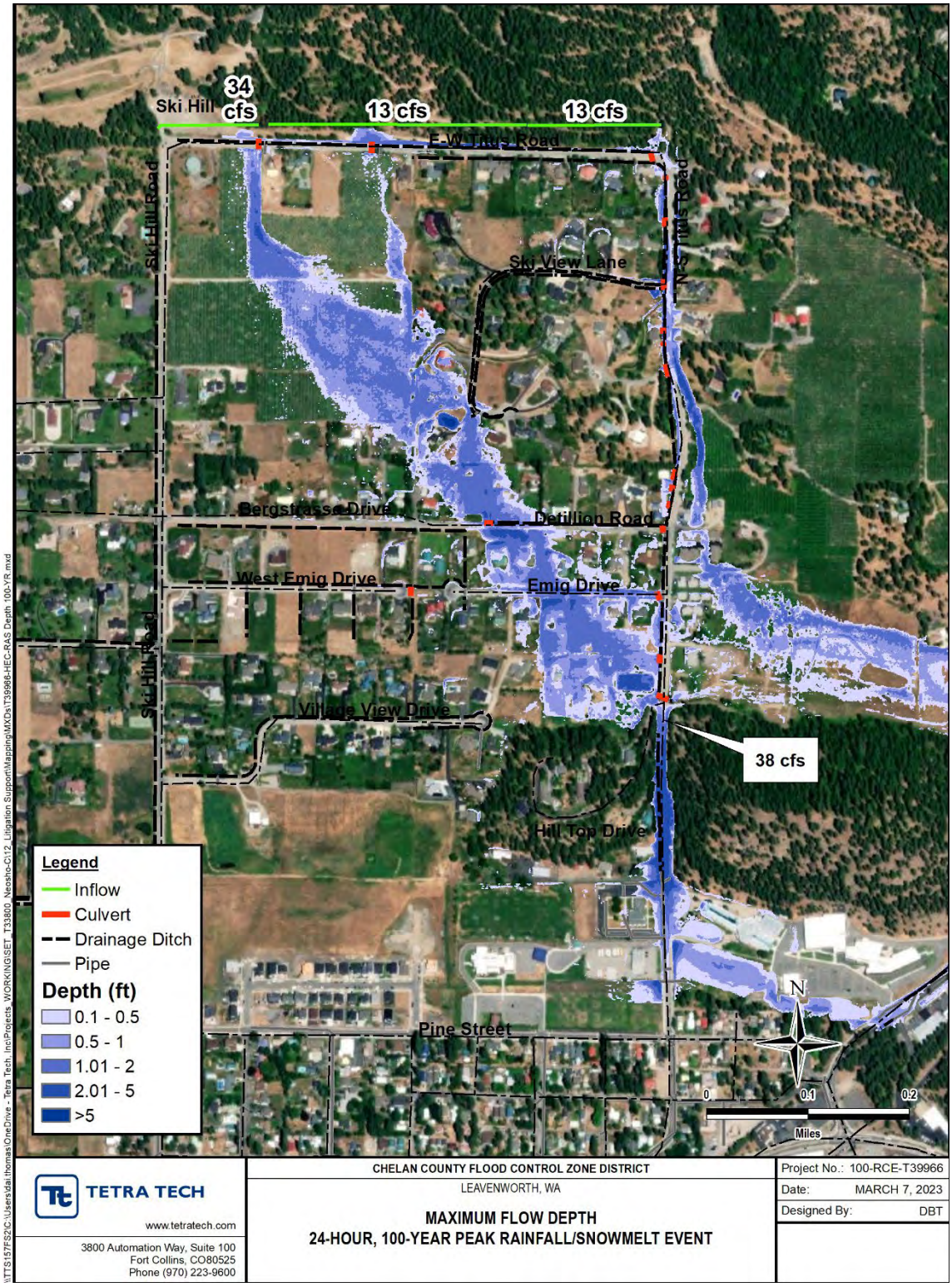


Figure 31. Predicted flow depth for the 100-year rainfall/snowmelt event.

6. ALTERNATIVE IDENTIFICATION AND EVALUATION

The results of the field investigation and hydraulic modelling was used to develop 6 alternatives to mitigate flooding in the Ski Hill Basin project area. The six alternatives were selected in consultation with the FCZD and increase in complexity and construction costs, with Alternative 1 being the “do nothing” condition, and Alternative 6 being the most complex with realignment of the channels, and construction of detention storage facilities and new culverts (**Table 7)**. The 6 alternatives were published in the StoryMap, and the public ranked the preferred alternatives and provided comments. The FCZD reviewed the alternatives and public comments and selected two preferred alternatives. Tetra Tech then developed cost-estimates for the two preferred alternatives.

The FZCD is keenly aware that any alternative should not cause adverse downstream impacts. The two following locations were identified for discussion.

There are two culverts located along the western end of E-W Titus Road that are closest to the Ski Hill outlet (Figure 10). Flow through the culverts passes across the orchard on private land (Figure 13); no changes were made to these culverts.

The construction of an alternative will increase the flow in the drainage swales including those located in the City of Leavenworth. As discussed later, there will likely be an increase in flow into the culvert located at Point 10 on Figure 8 that conveys flow at unnamed channel towards Chumstick Creek. The design of any alternative will need approval from the City of Leavenworth and will need to ensure that all upgraded and existing channels and swales have sufficient capacity and do not increase downstream flooding.

6.1 ALTERNATIVES DEVELOPMENT

The six alternatives include a combination of the following features and are summarized in Table 7 and shown in **Figure 32** through **Figure 37**:

- Improvement of existing channels/swales and culverts
- Construction of new channels/swales and culverts
- Construction of new detention structures
- Installation of new pipe

For all alternatives, it is recommended that continued maintenance of the culverts and channels/swales be performed to provide flow conveyance and minimize flooding.

Table 7. Summary of features in each alternative

Alternative	Improve Culverts	Improve Ditch	New Swale	New Detention	New Pipe
1					
2	✓	✓			
3	✓	✓	✓	✓	
4	✓	✓	✓	✓	✓
5	✓	✓	✓	✓	
6	✓	✓	✓	✓	✓

The following is a brief summary of each alternative.

Alternative 1 - This is the “No-Action” alternative, in which no new features will be constructed (Figure 32).

Alternative 2 - The intent of Alternative 2 is to capture more of the overland flow from the orchard area, and convey it along Detillion Road, then down N-S Titus Road into the un-named channel. The alternative features include improving the swale and culvert capacity along Detillion Road and along N-S Titus Road (Figure 33).

Alternative 3 - Includes the features of Alternative 2, as well as increasing the capacity of the swale near the Ski Hill parking **(**Figure 34). The two culverts under E-W Titus Road will remain the same as existing conditions.

Alternative 4 - Includes the following:

- Features of Alternative 3.
- Installing an underground pipe and improving the capacity of the swales along E-W Titus Road. The pipe is required to convey flow past the slight rise in the ground elevation approximately mid-way along E-W Titus Road.
- Improving the swale and culvert capacity along N-S Titus Road from between E-W Titus Road to Detillion Road (Figure 35).

Alternative 5 - Includes the features of Alternative 3, as well constructing flow detention and a new channel to convey flow from E-W Titus Road to Detillion Road (Figure 36).

The detention facility would be located near the south-east corner of the Ski Hill parking lot and will store a limited amount of runoff (depending on the size of structure) and regulate the flow into the swale along E-W Titus Road. The first detention method is a pond that would be excavated into the ground and the spoil material used to construct a berm to further increase the pond capacity. An outlet facility would be constructed to regulate flow into the swale along E-W Titus Road. The geology mapping indicates the area is composed of sedimentary rocks and deposits, however, the depth to bedrock (if any) is unknown. The detention would be most beneficial during the spring snowmelt period; however, temperatures will likely be below freezing, which may freeze water in the pond, leading to reduced storage and may affect the outflow.

The second detention method is underground gallery, likely constructed of large, corrugated metal pipes (CMPs) on the order of 8-feet in diameter. The CMP can be “designed for heavy loading[9]”, and therefore cars could park over the top without a loss of parking. Correspondence with Contech Engineered Solutions, a manufacturer of corrugated metal pipe (CMP) storage systems, indicated that a CMP system is suitable for the snowmelt runoff.

As part of Alternative 5, a new channel would be constructed in a north-to-south alignment between E-W Titus Road and Detillion Road. The parcel mapping indicated a 30-foot-wide right-of-way along the channel alignment. After development of the alternative, it was learned that the land is privately owned, and construction of the channel would require acquisition of land and/or easements.

Alternative 6 – Includes the following:

- Improving the swale along E-W Titus Road, installing pipe to convey flows the past the rise in the ground elevation approximately mid-way along E-W Titus Road (Figure 37).
- Constructing a new channel near the eastern end of E-W Titus Road to convey flow across the USFS land, then down an undefined flow path on private land to Chumstick Creek.

This alternative would require permission from USFS to construct the new channel, as well as land and or easement purchase from private landowners to construct the channel from the USFS land to Chumstick Creek.

[9] Detention-Infiltration-Overview.pdf (conteches.com)

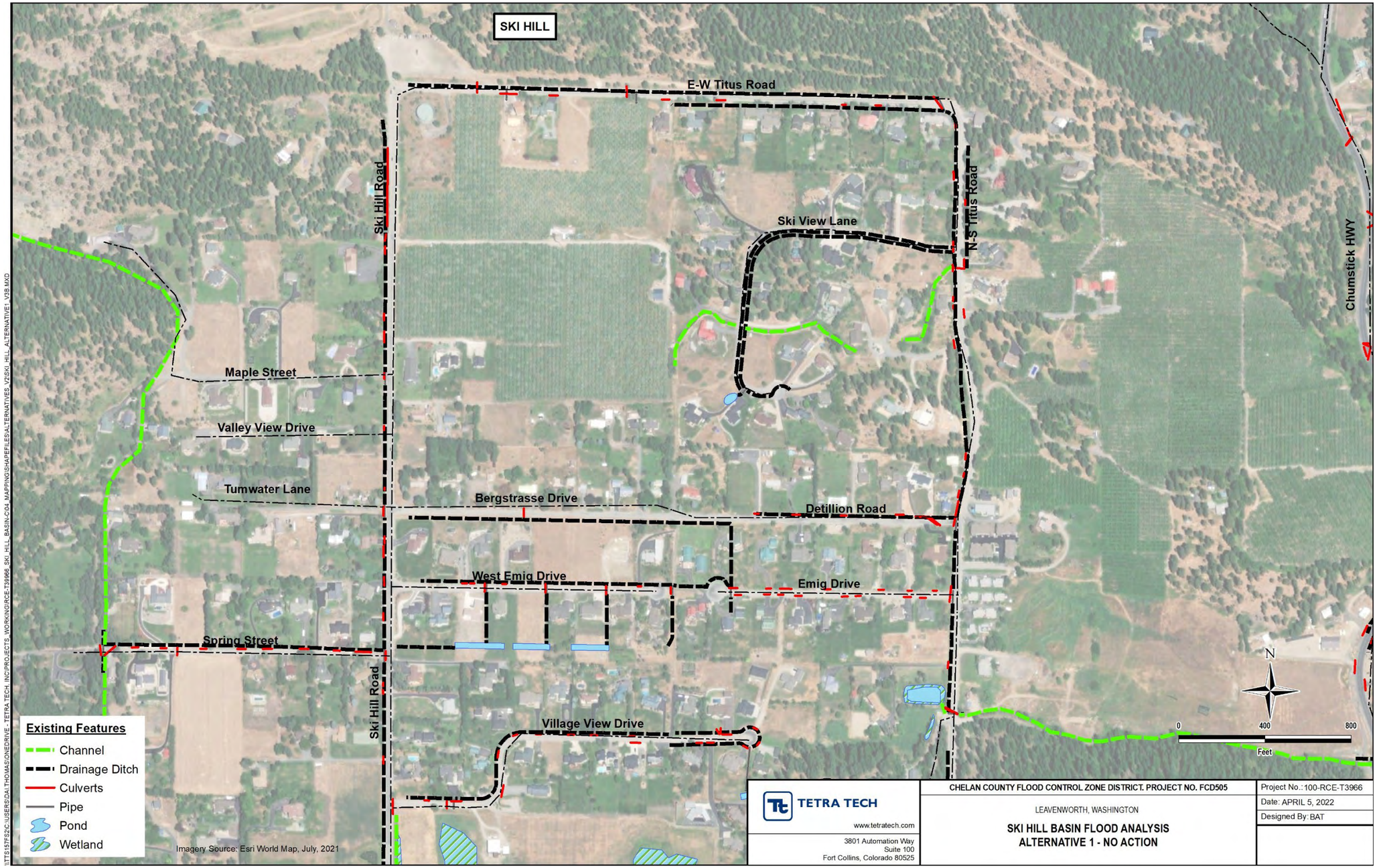


Figure 32. Design Alternative 1 (No Action)

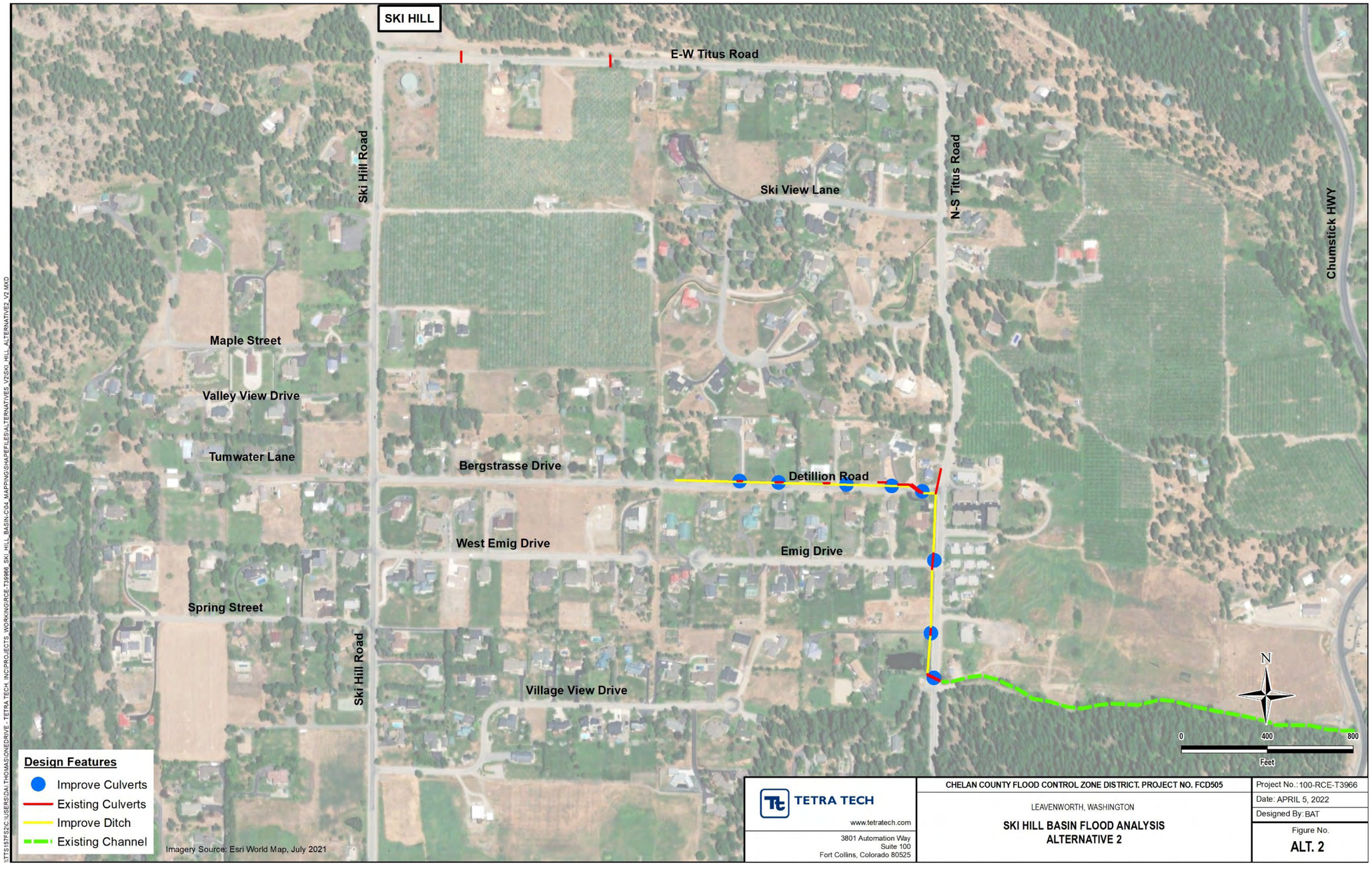


Figure 33. Design Alternative 2.

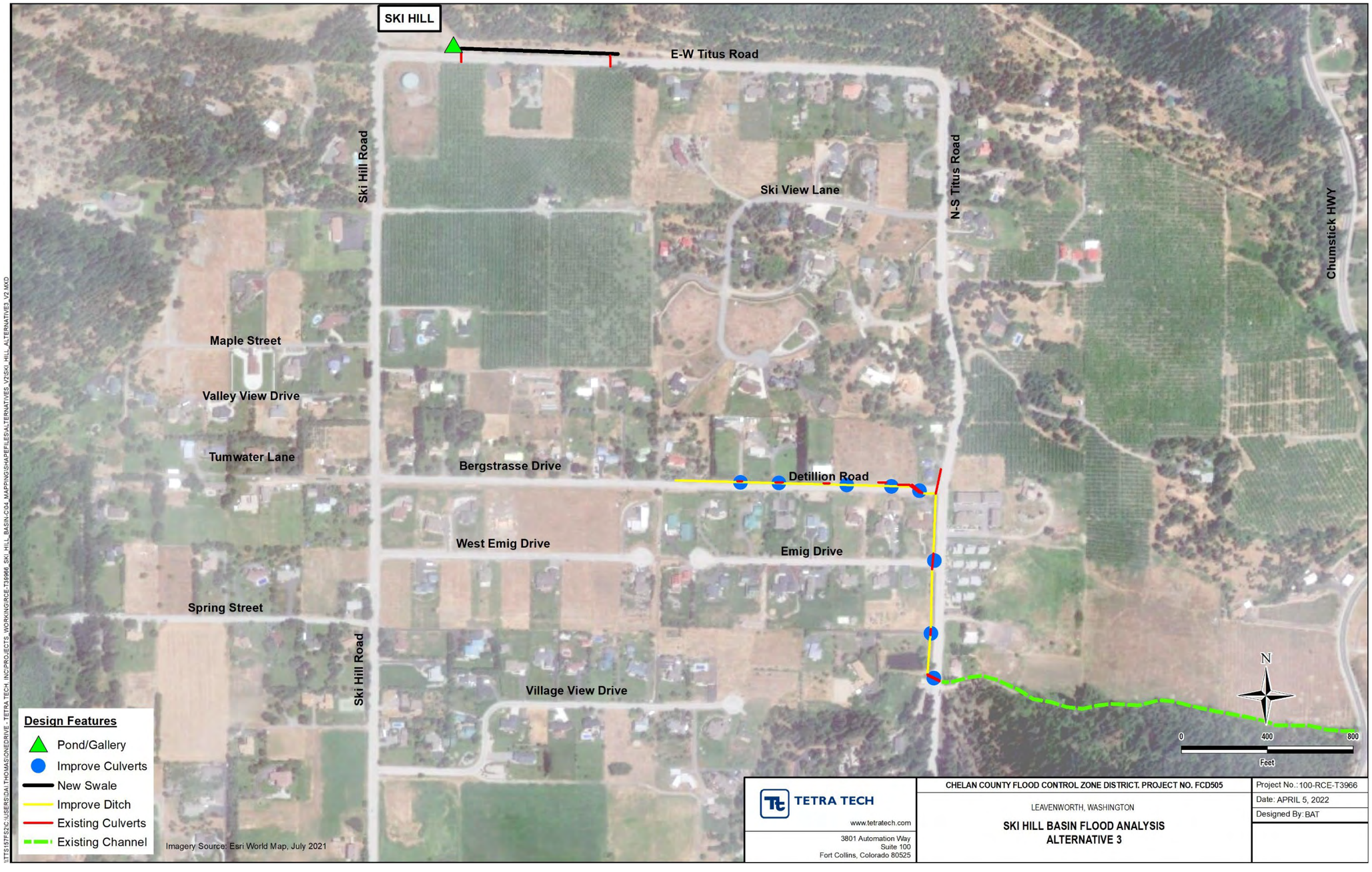


Figure 34. Design Alternative 3.

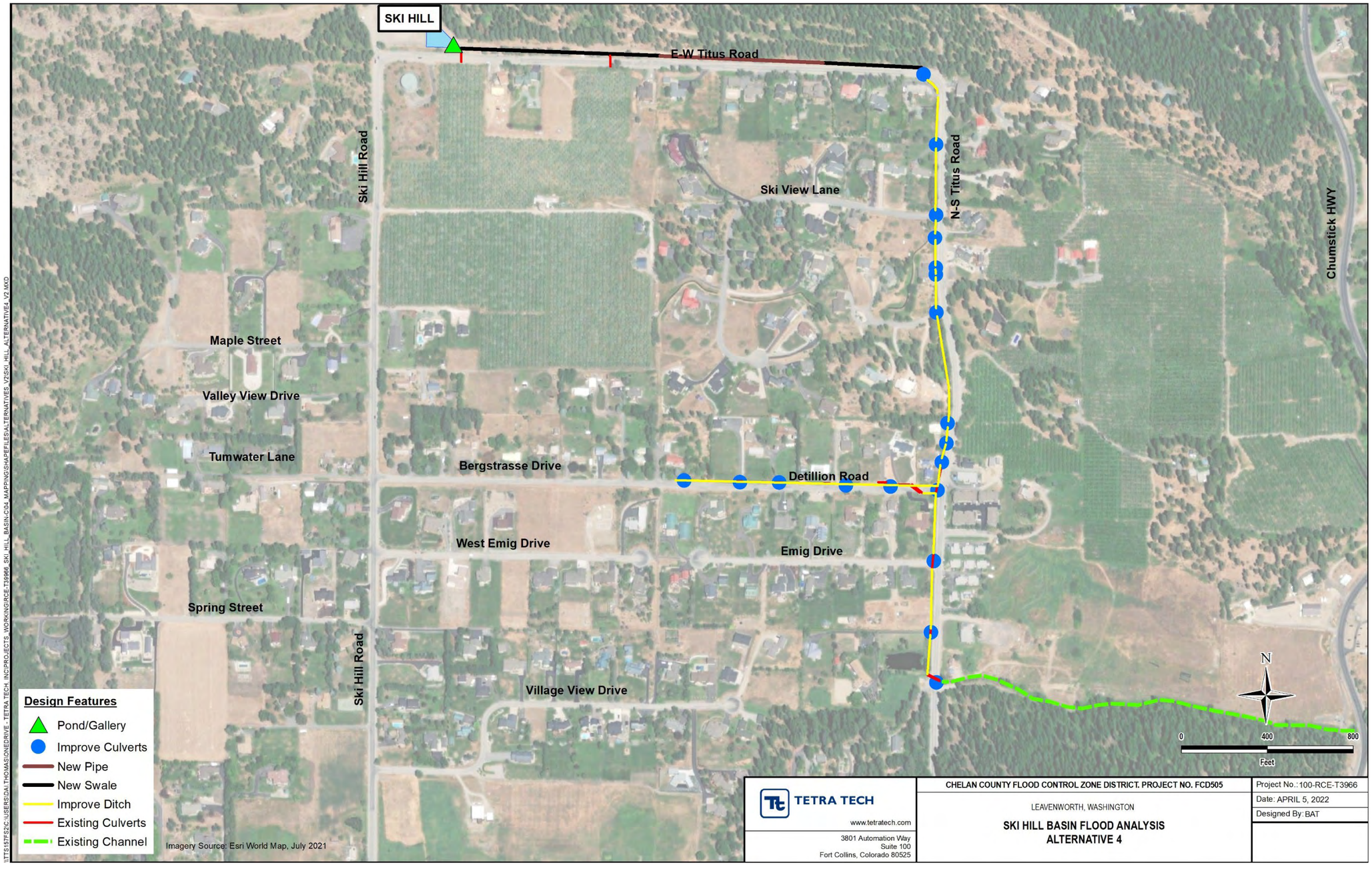


Figure 35. Design Alternative 4.

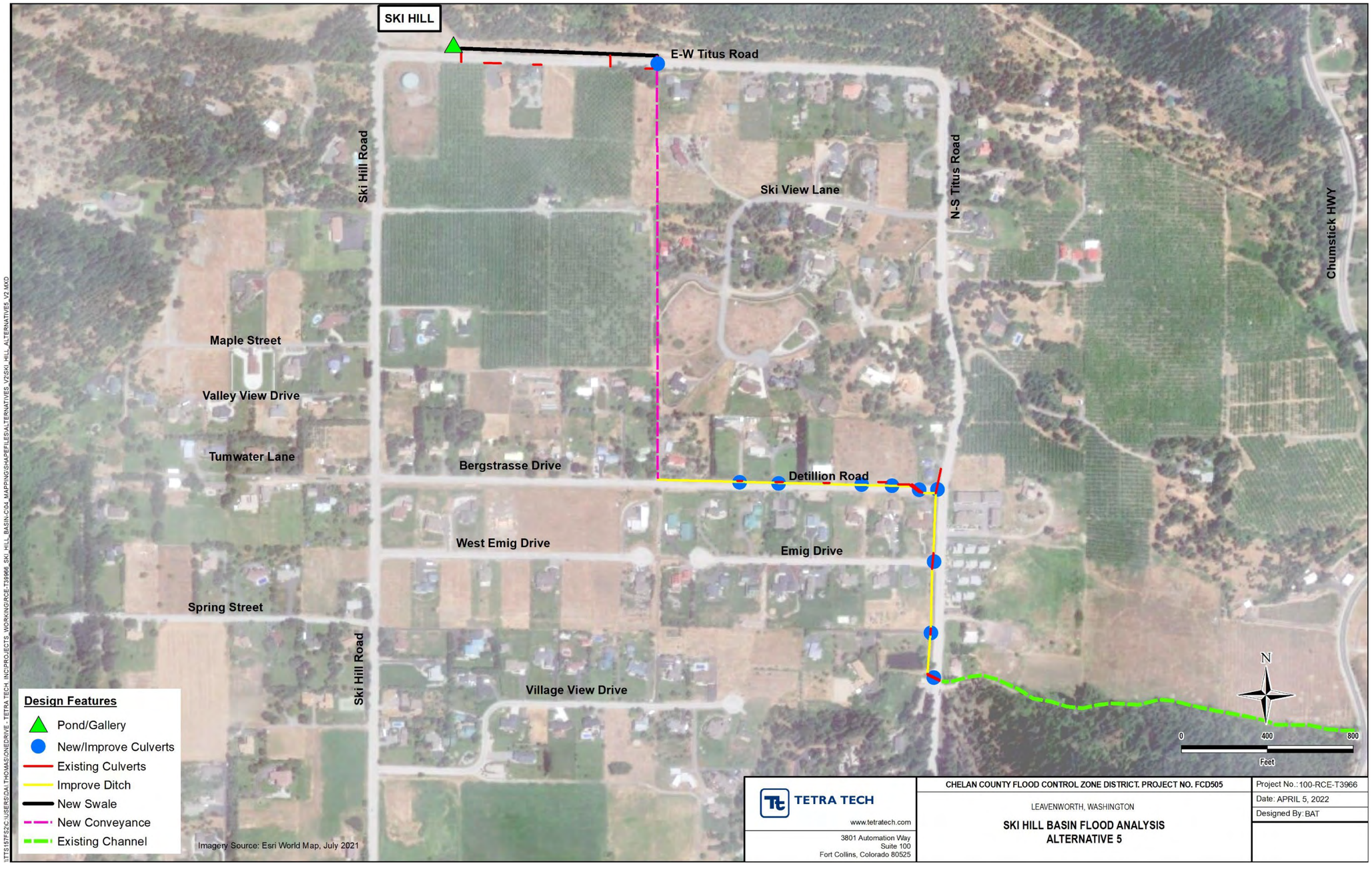


Figure 36. Design Alternative 5.

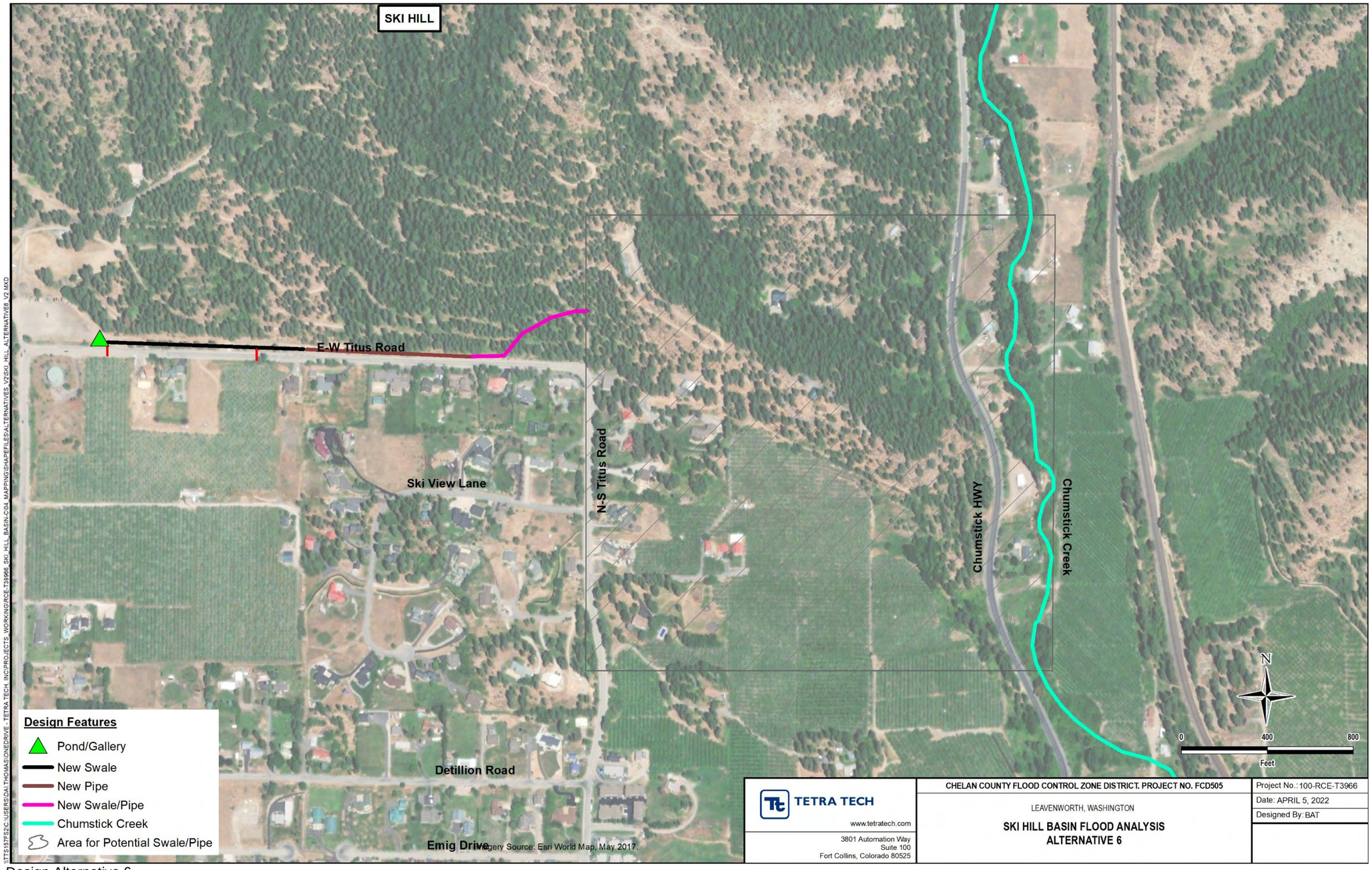


Figure 37. Design Alternative 6.

6.2 SELECTION OF PREFERRED ALTERNATIVES

The six alternatives were published on the StoryMap, and an online questionnaire was developed to obtain public feedback. Perteet's summary report is provided in **Appendix B**.

The first question asked was whether action should be taken to address flooding. There were 57 responses, of which 79% indicated something should be done, 12% indicated nothing should be done, and 9% were not sure.

The questionnaire then asked the same four questions about Alternatives 2 to 6 and whether they thought the alternative:

1. Improves drainage.
2. Reduces flooding.
3. Reduces damage to public infrastructure.
4. Reduces damage to private property.

For each question, the respondents were provided the following four options:

- Too little
- Just right
- Too much
- Not sure

Table 8 summarizes the responses for Alternatives 2 to 6. In general, the responses were answered the same way for each of the four questions. The average for each alternative was calculated and is summarized in **Table 9**. Based on the responses, Alternative 4 was the most popular with 47-percent responding it was "just right". Alternative 3 was the second most popular with 32-percent responding that it was "just right".

Following the public input, the results were provided to the FCZD that discussed them with the Chelan County Board of Supervisors, which supported the selection of Alternatives 3 and 4.

Table 8. Summary of responses to Alternatives 2 to 6

Alternative 2	**Too little**		**Just right**	**Too much**	**Not sure**	**Total Number of Response**
Improves drainage	59%		30%	6%	6%	54
Reduces flooding	58%		28%	4%	9%	53
Reduces damage to public infrastructure	55%		29%	4%	12%	51
Reduces damage to private property	60%		23%	4%	13%	52
Average	58%		28%	4%	10%	
Alternative 3	Too little		Just right	Too much	Not sure	Total Number of Response
Improves drainage	36%		38%	17%	9%	53
Reduces flooding	43%		32%	15%	9%	53
Reduces damage to public infrastructure	35%		33%	13%	19%	52
Reduces damage to private property	42%		27%	13%	17%	52
Average	39%		32%	15%	14%	
Alternative 4	Too little		Just right	Too much	Not sure	Total Number of Response
Improves drainage	15%		52%	27%	6%	48
Reduces flooding	**15%**		**54%**	**21%**	**10%**	48
Reduces damage to public infrastructure	19%		38%	21%	21%	47
Reduces damage to private property	19%		43%	19%	19%	47
Average	17%		47%	22%	14%	
Alternative 5	Too little		Just right	Too much	Not sure	Total Number of Response
Improves drainage	6%		33%	46%	15%	48
Reduces flooding	6%		31%	42%	21%	48
Reduces damage to public infrastructure	8%		25%	38%	29%	48
Reduces damage to private property	**17%**		**21%**	**38%**	**25%**	48
Average	9%		28%	41%	22%	
Alternative 6	Too little		Just right	Too much	Not sure	Total Number of Response
Improves drainage	**5%**		**18%**	**43%**	**34%**	44
Reduces flooding	5%		20%	39%	36%	44
Reduces damage to public infrastructure	7%		18%	34%	41%	44
Reduces damage to private property	7%		18%	36%	39%	44
Average	6%		19%	38%	38%	

Table 9. Average of the response of the four questions for Alternatives 2 to 6

Alternative	Too Little	Just Right	Too Much	Not Sure
2	58%	28%	4%	10%
3	39%	32%	15%	14%
4	17%	47%	22%	14%
5	9%	28%	41%	22%
6	6%	19%	38%	38%

6.3 ALTERNATIVE 4 MODEL RESULTS

The hydraulic model was modified to represent Alternative 4, which includes the culverts and increased swale capacity. The hydraulic model was run for the 24-hour, 10-year peak rainfall/snowmelt conditions, and the model output was used to develop depth inundation mapping (**Figure 38**). Comparison of the predicted flow depth for the Alternative 4 conditions with the existing conditions (Figure 30), shows a significant reduction in flooding in the following locations:

- across the orchard located downhill of Ski Hill
- between Detillion Road and Emig Drive
- between Emig Drive and N-S Titus Road.

Improvements to the roadside ditch, construction of a new swale, and culvert upgrades will result in a perceived increase in the flow within this new conveyance system, particularly along N-S Titus Road uphill of Hill Top Drive. This is because roadside ditches and culverts will be larger, therefore will have the ability to manage more water. Currently, the existing ditch/culvert system is easily overwhelmed during larger runoff events, leading to system failure where water is dispersed over public and private property. An important part of this project's design is to increase the capacity of the culvert under N-S Titus Road near Hill Top Drive that, similar to existing conditions, conveys flow into the irrigation overflow ditch. Development of the vacant land adjacent to this irrigation overflow ditch should take into account the future upsizing of this culvert under N-S Titus Road. While the Ski Hill Basin Analysis provides recommendations for sizing of roadside ditches, the swale, and culverts, these are conceptual and should be further analyzed during the design phase of the future improvement project(s).

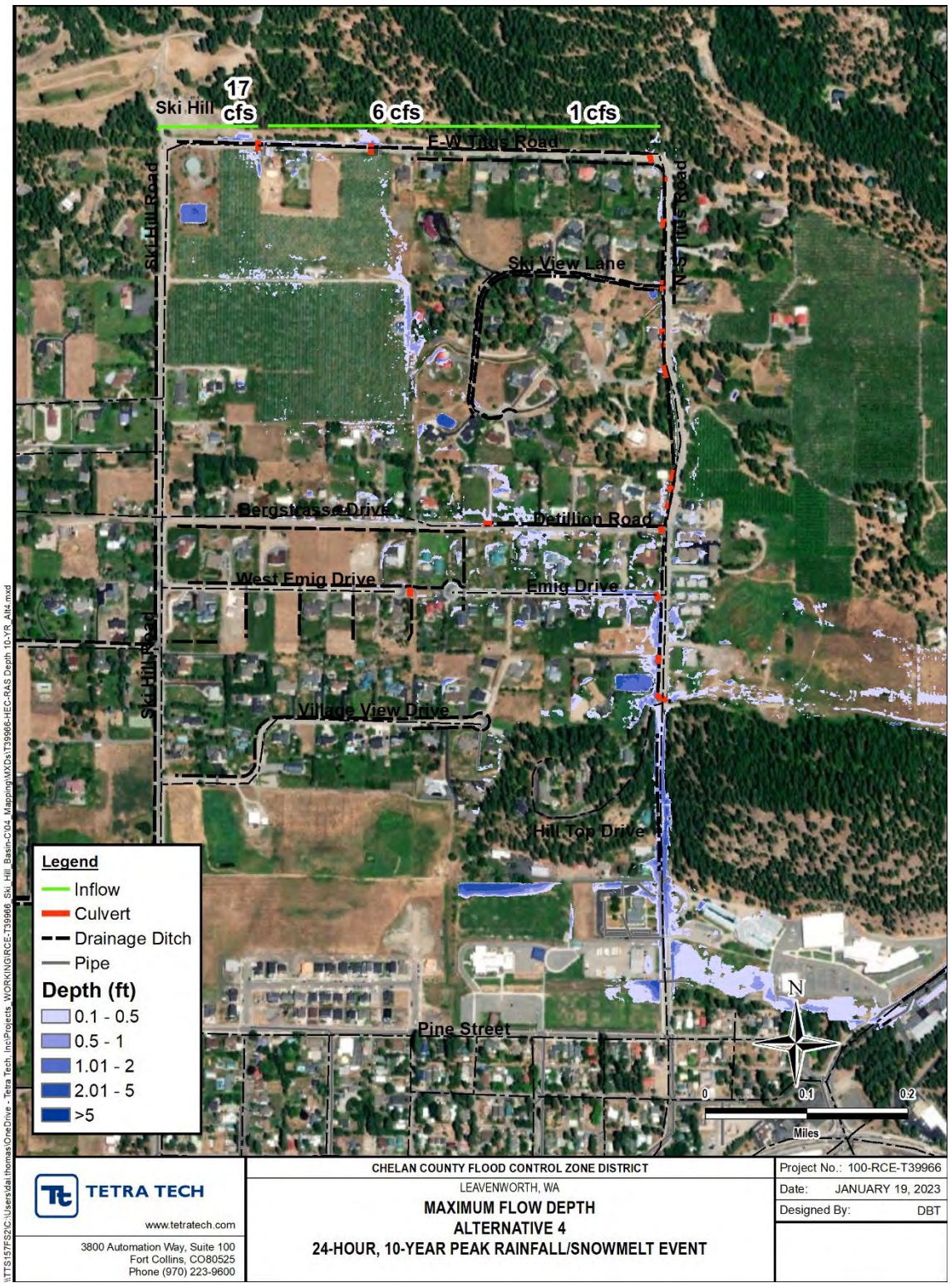


Figure 38. Predicted flow depth for the 10-year rainfall/snowmelt event under Alternative 4 conditions.

7. COST-ESTIMATE

A Class 5 (order of magnitude) cost-estimate was performed for Alternatives 3 and 4. According to the U.S. Department of Energy, a Class 5 cost-estimate is prepared based on limited information where the preliminary engineering is from 0 to 2 percent complete. The costs were estimated using RSMeans, corollary data from similar projects and vendor quotes based on costs in April/May 2021.

If the FCZD decides to proceed with an alternative, the design and construction phases would not occur for a few years. There have been considerable increases in construction costs over the last few years, and there is significant uncertainty what the costs will be when the design and construction phases begin. Due to this uncertainty a cost range is provided, which is intended to show the relative cost between alternatives.

7.1 RSMEANS COST ESTIMATE

The RSMeans cost-estimate included the materials purchase, construction costs and contractor markups. The contractor markups include: (1) Overhead, (2) Profit, (3) General Conditions, (4) Insurance, (5) Mobilization and Demobilization (Mob and Demob), (6) Bonds, and (7) General Allowance and (8) Contingency of 25-percent.

The cost-estimates do not include the right-of-way costs for construction.

7.2 POND AND GALLERY OPTIONS

The Pond and Gallery options are provided as options for both Alternative 3 and 4. Construction of these options would require agreement with the Leavenworth Winter Sports Club and the U.S. Forest Service. The pond and gallery options are intended to regulate the runoff from Ski Hill Basin into the drainage swales and prevent the swales from overflowing. Pond and gallery options are intended to function for small runoff events, and they are not designed to store the entire 10-year runoff volume. As discussed in the next sections, both the pond and gallery options store a small percentage of the 10-year runoff volume. Cost ranges for the pond and gallery options were developed, but the are not included in Alternative 3 or 4 discussions.

7.2.1 Detention Pond Cost

It was assumed that a triangular shaped pond would be located in the southeast corner of the parking lot and would be 10-feet deep, have surface area of 1,326 yd^2 (0.27 acres) and have a total volume of 4,420 yd^3 (about 2.74 acre-feet) (**Figure 39**). For references purposes, the total parking area is about 1.2 acres. The pond was located and sized to balance the parking area and storage needs. The parking area is used all year round and it was determined that a larger parking area would be poorly received by the community. The storage volume of the pond is about 0.4% of the total 10-year runoff volume.

It was assumed that the pond would be excavated, and the spoil material used to construct 3-foot high berms around the pond, except near the northwest corner which would remain open for runoff to flow into the pond. Remaining excavated soil would be hauled away. A culvert would be constructed in the southeast corner of the pond and regulate flows into the swale along the north side of E-W Titus Road. A layer of crusher fines would be placed on the bottom of the pond and overlain with a 40 mil HDPE liner. The liner would prevent infiltration into the ground. As previously discussed, a geotechnical investigation would be required to determine the depth of soil and depth to bedrock.

7.2.2 Gallery Cost

A gallery is an underground storage chamber (also referred to a vault) that is typically constructed from concrete or steel. The steel galleries can be made from corrugated metal pipe (CMP) in a circular, elliptical or arch shape.

The gallery would be in the southeast corner of the parking lot (Figure 38) and was sized to cover a similar area as the detention pond. The gallery could be sized to cover the entire parking lot; however, the cost was determined to be too expensive. It was assumed the storage chamber would be constructed from about 1,000 feet of 8-foot diameter circular CMP's (Figure 40), with a resulting storage volume of 1.15 acre-feet. The ground would be excavated to a depth of about 12 feet and 0.5 feet of crusher fines would be placed for bedding material. The CMP would be covered by about 3.5-feet of backfill material. As indicated, the geology mapping indicates the parking lot is formed on quaternary alluvium, however the depth to bedrock (if any) is unknown.

Like the pond option, an inlet drain would be constructed in the CMP to collect overland flow from the parking lot and the CMP would outlet into the swale along E-W Titus Road.

7.2.3 Comparison of Pond and Gallery options.

A benefit of the pond is that it is easy to construct and maintain, however, it would reduce the parking area.

A benefit of the gallery is that it would maintain the parking area, however, it is significantly more expensive than the pond option (**Table 10** and **Table** 12). Both options would require an agreement with the Leavenworth Winter Sports Club which operates the ski area. Also, both options provide about 1 acre-foot of storage, which is about 0.4% of the 10-year runoff. Both options could be made significantly larger; an enlarged pond would further reduce the parking area and enlarge gallery would greatly increase the cost beyond a similarly sized pond due to the higher costs for the CMP and backfill materials.

The cost for the pond is on the order of $250,000 and the gallery is on the order of $600,000 for similar sized storage. For a larger storage, the relative cost of the gallery increases at a faster rate compared to the pond, due to the increases in excavation, backfill and CMP.

Due to the required agreement with the Leavenworth Winter Sports Club, the costs for the pond and gallery options are not included in Alternative 3 and 4 discussions.

Table 10. Comparison of pond and gallery options.

Option	Benefit	Drawback
Pond	• Easy to construct and maintain	• Require agreement with Leavenworth Winter Sports Club and USFS • Reduced parking area • Uncertainty about depth of bedrock • Stores about 0.4-percent of total 10-year runoff
Gallery	• Underground and would continue to provide car parking	• Require agreement with Leavenworth Winter Sports Club and USFS • Uncertainty about operating in cold climate • Uncertainty about depth of bedrock • Stores about 0.4-percent of total 10-year runoff • More expensive

Table 11. Construction items for detention pond

Chelan County - Ski Hill Basin Flood Analysis

Ski Hill Basin

Items for Detention Pond Construction

Item	Description	Quantity	Unit
1.1	Excavate detention basin	2,700	CY
1.2	Construct Berms	900	CY
1.3	Haul Remaining Material	1,780	CY
1.4	Crusher-fines base (6-inch) for HDPE liner	1,340	CY
1.5	40 mil HDPE liner	2,670	SY

Table 12. Construction items for gallery

Chelan County - Ski Hill Basin Flood Analysis

Ski Hill Basin

Items for Gallery Construction

Item	Description	Quantity	Unit
2.1	Excavate gallery area	4,220	CY
2.2	Crusher-fines base (6-inch) for HDPE liner	135	CY
2.3	Gallery, 8-ft diam CMP	1,000	LF
2.4	Haul Remaining Material	2,000	CY

7.3 ALTERNATIVE 4 COST-ESTIMATE

Alternative 4 was most-popular alternative based on the public feedback and is presented first. The bid items are shown on **Figure 41** and in Table 13 include:

1. Excavation for the existing swale and new swale. The size of the swale was estimated based on hydraulic calculations, including the channel slope, Manning's *n* roughness values and a trapezoid channel geometry. Based on the calculations, the swale along E-W Titus Road is has a trapezoid shape and is 2 feet deep, has a 5-foot bottom width and 2H:1V side slopes. The swale along Detillion Road has a trapezoid shape, is 2 feet deep, a 5-foot bottom width and 2H:1V side slopes. The channels in Alternative 4 (and Alternative 3) were sized to convey the 10-year flood and additional capacity was added to account for additional overland runoff and snow in the channel and associated reduction in capacity, particularly along Detillion and Emig which have flatter slopes and prone to snowplows pushing snow into the swales.
2. The swale length is 1,385 feet with an excavation volume of 3,300 yd^3. The swale along N-S Titus Road has a trapezoid shape, is 2.5 feet deep, a 5-foot bottom width and 2H:1V side slopes.
3. Riprap would be installed along the steeper sections of the channel to prevent erosion. 9-inch riprap was sized based on the hydraulic calculations.
4. Culverts were sized to increase the flow capacity. One culvert is along E-W Titus Road, 28 along N-S Titus Road and 6 along Detillion Road. There are more culverts listed in the bid sheet than shown on the maps because many crossings require 2 culverts. Two culverts are used and not one, to reduce the amount of excavation, and to meet the County's culvert design criteria for the amount of cover between the top of the culvert and the road.
5. Re-seeding for disturbed areas such as channel excavation.
6. Sediment/Erosion Control and Storm Water Prevention Pollution Plan to prevent fugitive sediment entering the storm water system.
7. Construction layout for marking the location of proposed features to ensure a project is built according to engineering design plans.

The cost of construction based on May 2021 costs are in the range of $1.3 million to $1.7 million dollars.

7.4 ALTERNATIVE 3 COST-ESTIMATE

Alternative 3 was the second selected alternative. The bid items are similar to Alternative 4, but there are less features along E-W Titus Road and along the upper section of N-S Titus Road. For comparison, Alternatives 3 and 4 are shown in Figure 34 and Figure 35, respectively. The construction items are shown in Table 14.

There are 8 culverts along N-S Titus Road and 6 along Detillion Road.

The cost of construction based on May 2021 costs are in the range of $500,000 to $750,000.

Table 13. Table 10 Construction items for Alternative 4

Chelan County - Ski Hill Basin Flood Analysis

Ski Hill Basin

Items for Construction for Alternative 3

Location	Description	Quantity	Unit	Comment
E-W Titus Road	Re-seeding	1,022	SY	Only re-seed along culvert, remainder will be riprapped.
E-W Titus Road	Sediment/Erosion control and SWPPP	920	LF	
E-W Titus Road	Construction Layout	920	LF	
N-S Titus Road	2-foot diameter, 40-feet long CMP	2	EA	DetillionRd
N-S Titus Road	2-foot diameter, 70-feet long CMP	2	EA	EmigRd
N-S Titus Road	2-foot diameter, 50-feet long CMP	2	EA	Culvert10
N-S Titus Road	2-foot diameter, 70-feet long CMP	2	EA	TitusRds
N-S Titus Road	Turf reinforcement mat	1,000	SY	Ex. PYRAMAT-25-PDS.pdf (acfenvironmental.com
N-S Titus Road	Sediment/Erosion control and SWPPP	900	LF	
N-S Titus Road	Excavation for channel and culverts	470	CY	
N-S Titus Road	Sediment/Erosion control and SWPPP	900	LF	
N-S Titus Road	Construction Layout	900	LF	
Detillion Road	1-foot diameter, 50-feet long CMP	1	EA	Detillion1
Detillion Road	1-foot diameter, 60-feet long CMP	1	EA	Detillion2
Detillion Road	1-foot diameter, 50-feet long CMP	1	EA	Detillion3
Detillion Road	1-foot diameter, 40-feet long CMP	1	EA	Detillion4
Detillion Road	1-foot diameter, 60-feet long CMP	2	EA	Detillion5
Detillion Road	Excavation for channel and culverts	470	CY	
Detillion Road	Re-seeding	1,389	SY	
Detillion Road	Sediment/Erosion control and SWPPP	1,250	LF	
Detillion Road	Construction Layout	1,250	LF	

Table 14. Construction items Alternative 3

Chelan County - Ski Hill Basin Flood Analysis

Ski Hill Basin

Items for Construction for Alternative 4

Location	Description	Quantity	Unit	Comment
E-W Titus Road	Excavation for "New Swale"	3,300	CY	Includes new swale and new pipe
E-W Titus Road	Culvert 2-foot diameter	750	LF	750 feet long
E-W Titus Road	9-inch riprap (purchase and installation)	577	CY	For steep east section, west flat section will be bare
E-W Titus Road	Re-seeding	1,856	SY	Only re-seed along culvert, remainder will be riprapped.
E-W Titus Road	Sediment/Erosion control and SWPPP	2,200	LF	
E-W Titus Road	Construction Layout	2,200	LF	
N-S Titus Road	2-foot diameter, 55-feet long CMP	2	EA	TitusRdN
N-S Titus Road	2-foot diameter, 26-feet long CMP	2	EA	Culvert3
N-S Titus Road	2-foot diameter, 50-feet long CMP	2	EA	Culvert4
N-S Titus Road	2-foot diameter, 60-feet long CMP	2	EA	SkyViewLN
N-S Titus Road	2-foot diameter, 30-feet long CMP	2	EA	Culvert5
N-S Titus Road	2-foot diameter, 25-feet long CMP	2	EA	TitusPl
N-S Titus Road	2-foot diameter, 70-feet long CMP	2	EA	Culvert6
N-S Titus Road	2-foot diameter, 60-feet long CMP	2	EA	Culvert7
N-S Titus Road	2-foot diameter, 40-feet long CMP	2	EA	Culvert8
N-S Titus Road	2-foot diameter, 40-feet long CMP	2	EA	Culvert9
N-S Titus Road	2-foot diameter, 40-feet long CMP	2	EA	DetillionRd
N-S Titus Road	2-foot diameter, 70-feet long CMP	2	EA	EmigRd
N-S Titus Road	2-foot diameter, 50-feet long CMP	2	EA	Culvert10
N-S Titus Road	2-foot diameter, 70-feet long CMP	2	EA	TitusRds
N-S Titus Road	Turf reinforcement mat	3,167	SY	Ex. PYRAMAT-25-PDS.pdf (acfenvironmental.com)
N-S Titus Road	Sediment/Erosion control and SWPPP	2,850	LF	
N-S Titus Road	Excavation for channel and culverts	4,300	CY	
N-S Titus Road	Construction Layout	2,850	LF	
Detillion Road	1-foot diameter, 50-feet long CMP	1	EA	Detillion1
Detillion Road	1-foot diameter, 60-feet long CMP	1	EA	Detillion2
Detillion Road	1-foot diameter, 50-feet long CMP	1	EA	Detillion3
Detillion Road	1-foot diameter, 40-feet long CMP	1	EA	Detillion4
Detillion Road	1-foot diameter, 60-feet long CMP	2	EA	Detillion5
Detillion Road	Excavation for channel and culverts	470	CY	
Detillion Road	Re-seeding	1,389	SY	
Detillion Road	Sediment/Erosion control and SWPPP	1,250	LF	
Detillion Road	Construction Layout	1,250	LF	

Figure 39. Approximate location and size of the area for the conceptual pond and gallery used for cost-estimates.

Figure 40. Example of a CMP stormwater gallery. Copied from Contech Engineered Solutions.

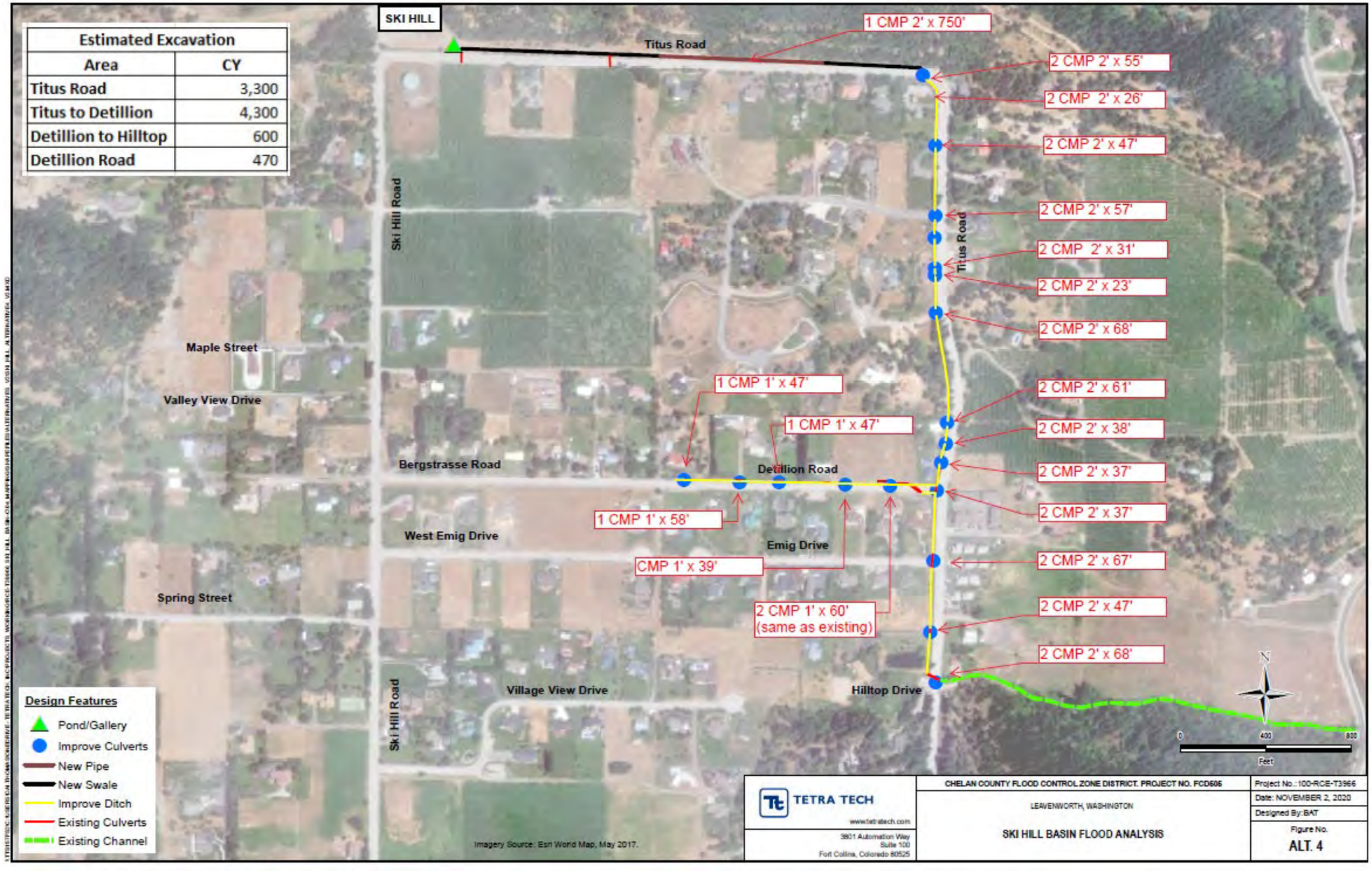


Figure 41. Schematic showing the diameter and length of improved culverts and estimated excavation quantities.

8. IDENTIFICATION OF FUNDING SOURCES

The implementation of the preferred alternative is anticipated to require grant funding. There are many funding sources available from state and federal agencies, and each one has limitations and/or requirements that may make them unsuitable for this project. Following discussion with the FCZD, a review of the funding opportunities was performed, and the results summarized as fact sheets. The review identified the following funding sources:

- Washington State's Flood Control Assistance Account Program (FCAAP)
- Federal Emergency Management Agency (FEMA) Building Resilient Infrastructure and Communities (BRIC) program
- FEMA's Hazard Mitigation Grant Program (HMPG)
- FEMA's Flood Mitigation Assistance (FMA) program

8.1 WASHINGTON STATE'S FLOOD CONTROL ASSISTANCE ACCOUNT PROGRAM (FCAAP)

Flood Control Account Assistance Program (FCAAP)

Program Overview

The Washington Legislature established the Flood Control Assistance Account Program (FCAAP) to assist local jurisdictions with comprehensive floodplain management planning and implementing actions to control flooding. Funding is determined every biennium by the state Legislature. The FCAAP program is administered by the WA Department of Ecology. The Legislature established the state Flood Control Assistance Account (FCAA) in 1986 to help local and tribal governments plan for and reduce their flood risks. State law requires $4 million be transferred every biennium from the state General Fund to FCAA for flood-risk reduction activities. Although the amount of available funding diminished for more than a decade, Governor Inslee has included full FCAA funding in his 2021-23 proposed biennial budget. Restoring FCAA funding will give Ecology and its local partners the ability to use FCAA to prepare for and avoid flood damages.

Eligible Applicants

Funding is available for the following entities:

Eligible planning project applicants: Cities, towns, counties, federally recognized Tribes, conservation districts, and special purpose districts, such as flood control districts.

Eligible emergency project applicants: Cities, towns, counties, federally recognized Tribes, conservation districts, and special purpose districts, such as flood control districts.

Eligible Projects

Eligible projects include:

- Comprehensive flood hazard management plans
- Feasibility studies
- Match for federal projects
- Flood control maintenance projects
- Emergency projects

Funding

For the 2021-2023 biennium, the Legislature appropriated approximately $1.5 million for floodplain planning projects. These projects are competitively evaluated and awarded. In addition to funding for planning projects, the Legislature also appropriated $150,000 for emergency flood response projects. These projects are not competitively evaluated or awarded. Funding is awarded on a first come, first served basis.

The grant application period for both planning and emergency projects opens on Tuesday, August 3, 2021 at 8:00 a.m. The application period for planning projects (SEAFCAAC-2123) closes on Thursday, September 30, 2021 at 5:00 p.m. The application period for emergency flood response projects (SEAFCAAP-2123) closes on Thursday, June 29, 2023 at 5:00 P.M.

Public Participation and Diversity, Equity, and Inclusion

Per Ecology's Comprehensive Planning for Flood Hazard Management Guidebook, flooding disproportionately affects vulnerable populations. Not only are lower income individuals more likely to live in neighbourhoods that are susceptible to flooding, they are also significantly disadvantaged in recovering from flood damage. Therefore, it is important to consider diversity, equity, and inclusion when developing a flood plan.

Evaluation and Scoring

Emergency projects are not competitively evaluated or awarded. Instead, funding decisions are based on a first come, first served basis, and available funds. Planning projects are competitively evaluated and awarded. Ecology staff, including technical experts, evaluate, score, and rank planning project proposals based on information provided in the grant application. Ecology finalizes the funding list and sends notifications to applicants whether or not their project has been chosen for funding.

TETRA TECH

Integrated Floodplain Management

Comprehensive floodplain planning efforts fundamentally intersect a variety of interests and require collaboration between departments, governmental agencies, Tribes, organizations, and the public. Applicants are encouraged to consider an integrated floodplain management approach to floodplain planning, and upload letters of support in the grant application.

Elements of Successful Proposals

- Show how the project solves or addresses a flooding problem by focusing on the cause of damage rather than treating the symptoms.
- Identify a **documented** flooding issue.
- Employ an integrated floodplain management approach that brings together multiple interests to find common agreement on local floodplain visions, strategies, and actions that achieves multiple benefits.
- Demonstrate how the project benefits salmon recovery.
- Describe how the project reconnects floodplains, protects channel migration zones, and/or restores habitat.
- Demonstrate how the project will **consider** climate change impacts.
- Explain the additional benefits of the project.
- Describe the collaboration, community support and stakeholder involvement, elements.
- Show that grant funds will be spent efficiently and on schedule.
- Illustrate that the project is ready to proceed.
- Is easy to read and understand.
- Include maps, diagrams, and pictures of the project area and display past projects (if any exist).
- Provide documentation to support answers, including citations.

8.2 FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA) BUILDING RESILIENT INFRASTRUCTURE AND COMMUNITIES (BRIC) PROGRAM

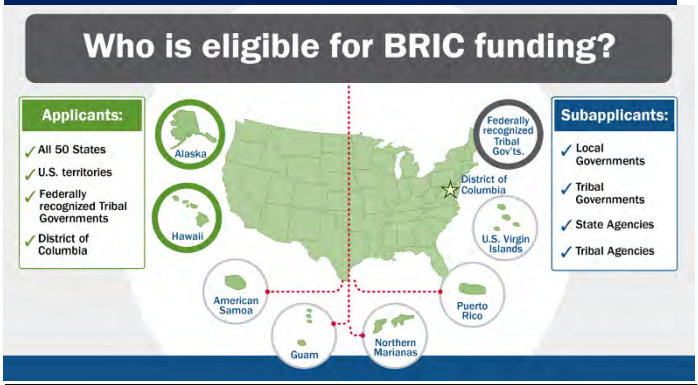
FEMA Building Resilient Infrastructure and Communities Program

Program Overview

Building Resilient Infrastructure and Communities (BRIC) will support states, local communities, tribes and territories as they undertake hazard mitigation projects, reducing the risks they face from disasters and natural hazards. BRIC is a new FEMA pre-disaster hazard mitigation program that replaces the existing Pre-Disaster Mitigation (PDM) program.

The BRIC program guiding principles are supporting communities through capability and capacity-building; encouraging and enabling innovation; promoting partnerships; enabling large projects; maintaining flexibility; and providing consistency.

Eligible



Who is not eligible?

Homeowners, business operators, and non-profit organizations cannot apply directly to FEMA, but can be included in a subapplication submitted by an eligible subapplicant.

BRIC Funding Eligible

Building Resilient Infrastructure and Communities (BRIC) funds may be used for:

- Capability- and Capacity-Building (C&CB) Activities
- Mitigation Projects
- Management Costs

All Projects must:

- Be Cost Effective
- Reduce or Eliminate Risk
- Meet either of the two latest International Building Codes (i.e. 2015 or 2018)
- Align with the applicable hazard mitigation plan
- Meet all environmental and historic preservation (EHP) requirements

Mitigation Projects

For Fiscal Year 2020, FEMA distributed up to $500 million through the BRIC program. Washington's 2020 funding was allocated to the following types of projects:

- Hazard Mitigation Planning
- Buyouts
- Vertical Evacuation shelters
- Seismic retrofits
- Project scoping
- Flood Control.
- Utility and Infrastructure Projects.

There are various avenues under which a community can apply for a grant. These include state-wide competition grants and national competition grants. As a majority of funding is allocated to national competition, the maximum award amounts for the two different grant types have different caps:

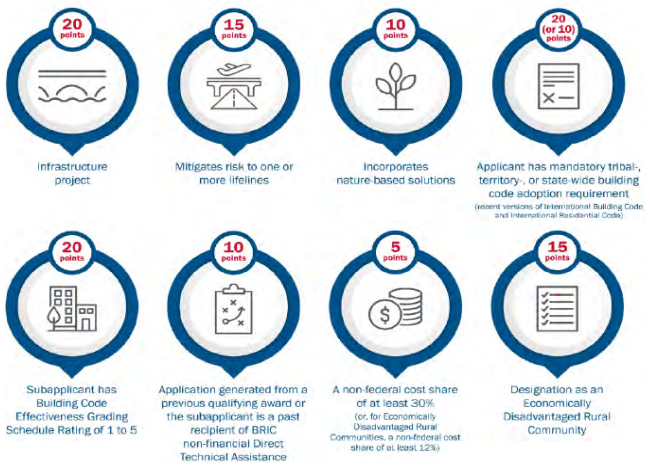
- State Maximum Allocation and Activity Cap: The maximum allocation for a state under this category is $1,000,000, covering all activities/projects.
- National Competition Cap: Applicants may submit an unlimited number of mitigation project subapplications each valued up to $50,000,000 federal share to the national competition.

NOTE: Any funds that are not awarded from the State/Territory Allocation or Tribal Set-Aside will be re-allocated to the national competition.

TETRA TECH

Technical Project Evaluation Criteria

There are eight technical evaluation criteria that are used in the Building Resilient Infrastructure and Communities (BRIC) national competition. The conditions that must be met to receive the point allotment for each criterion are shown below:



Each project must demonstrate *how it reduces risk to natural hazards how it protects designated lifelines; how it incorporates nature based solutions; whether the applicant has mandatory building code adoption requirement based on either the 2015 or 2018 versions of both the International Building Code (IBC) and the International Residential Code (IRC) model; if the subapplicant at the local level has a BCEGS rating between 1 and 5 during application submittal; whether the project was generated from a previous FEMA HMA Advance Assistance award and the award is directly related to the current proposal; indicate and incorporate at least a 25 percent sub-applicant cost share; and whether the community is a designated small impoverished community.*

Grant applications must provide strong justification as to how the project meets multiple program criteria.

Previous WA BRIC Awards

Project Name and Location	Award Amount	Description
North Shore Levee, Hoquiam, WA	$34.65 Million	West Segment, which is estimated to cost $40 million, will construct a levee (earthen, concrete and sheet pile) for 4.7 miles bordering the west side of Hoquiam. This levee will protect residents and build resiliency in the face of future flood events, as well as retain existing businesses, jobs and residents which have been on the decline in this community.
Waste Transfer Station Flood Mitigation Project, Kittitas County, WA	$12.65 Million	Annual flooding during significant rain and spring runoff events threatens public safety in Kittitas County because of the risk of the municipal solid waste, organic yard waste, recyclables, and moderate hazardous wastes handled by the waste transfer station spilling into the floodwater. This project will relocate the station out of the regulatory floodplain to avoid negative environmental resource impacts.

How to Apply and Application Timeline

Eligible applicants and subapplicants must apply for funding using the new grants management system: FEMA GO:

https://go.fema.gov/login?redirect=%2F

Many states have fixed subapplication deadlines that precede the application deadline. Contact your WA State Hazard Mitigation Officer (adjacent) to learn about potential state deadlines. The following is a general timeline for the grant submittal process:

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mil.wa.gov/emergency-management-division

8.3 FEMA'S HAZARD MITIGATION GRANT PROGRAM (HMPG)

FEMA Hazard Mitigation Grant Program (HMGP)

- Program Overview
- Eligible Communities
- Eligible Projects
- Guidelines in NY
- Relevant Mitigation Actions Awarded
- How to Apply

Program Overview

FEMA's Hazard Mitigation Grant Program provides funding to state, local, tribal and territorial governments so they can rebuild in a way that reduces, or mitigates, future disaster losses in their communities. This grant funding is available after a presidentially declared disaster.

In this program, homeowners and businesses cannot apply for a grant. However, a local community may apply for funding on their behalf.

Eligible

Who is not eligible?

Homeowners, business operators, and non-profit organizations cannot apply directly to FEMA, but can be included in a sub-application submitted by an eligible sub-applicant.

Eligible Projects

- Retrofitting existing buildings to make them less susceptible to damage from a variety of natural hazards.
- Purchasing hazard prone property to remove people and structures from harm's way.
- Utility and infrastructure retrofits to reduce risk of failure caused by natural hazards.
- Drainage improvement projects to reduce potential for flood damage.
- Slope stabilization projects to reduce risk to people and structures
- Developing and adopting hazard mitigation plans, which are required for state, local, tribal and territorial governments to receive funding for their hazard mitigation projects.
- Using aquifer storage and recovery, floodplain and stream restoration, flood diversion and storage, or green infrastructure methods to reduce the impacts of flood and drought.

Guidelines in Washington

In order to be eligible for Hazard Mitigation Grant Funding, each sub-applicant must meet Washington State Requirements.

Generally speaking, sub-applicants seeking project funds must be covered by a current all-hazards mitigation plan at the time of award.

Complete and are submitted, it is recommended that sub-applicants eligible applications will be scored based on priorities below. Recent award criteria include:

- Potential sub-applicants must submit a "pre-application" that can be submitted at any time at: https://mil.wa.gov/hmgp-dr-4481#documents
- EMD's evaluation and ranking process is inherently competitive.
- Tier 1: Declared Counties (Top Priority)
  - Previously submitted (but unfunded) HMGP applications
  - PA/HMGP Coordination (404/406 projects)
  - Hazard Mitigation Plans and Updates
  - Mitigating imminently threatened properties
  - Retrofitting critical infrastructure
- Tier 2: Non-Declared Counties
  - Previously submitted (but unfunded) HMGP applications
  - Hazard Mitigation Plans and Updates
  - Mitigating imminently threatened properties
  - Retrofitting critical infrastructure
- Mitigation of SRL/RL properties is a perennial priority of every HMGP funding round.

TETRA TECH

Relevant Mitigation Actions Awarded Mitigation Funding

- **Chelan County, WA:** Has had 16 MMGP grants funded totalling $3.3 million since 2009 in the following categories:
  - 2 planning grants
  - 5 Wildfire/Vegetation Management grants
  - 2 Generator grants
  - 1 Stormwater Management Grant
  - 4 property Acquisition grants
  - 2 property retrofit grants
- Washington State: has funded 421 HMGP grants since 1989, based 42 disaster declarations.
- The top 5 counties that have received HMGP grants within the State are: King County976), Pierce County (45), Snohomish County (26), Skagit County (21) and Whatcom County (18).
- Since 1989, $183.7 Million in funding has been awarded under HMGP in the State of WA, averaging $436,233 per grant award.

How to Apply and Application Timeline

Applicants may use the NEMIS, the grants management system to apply for and manage grants. Any additional questions should be directed to the adjacent individual.

Finally, contact the State Hazard Mitigation Officer (SHMO), or equivalent representative for additional information regarding additional application questions.

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8.4 FEMA'S FLOOD MITIGATION ASSISTANCE (FMA) PROGRAM

FEMA Flood Mitigation Assistance (FMA) Program

Program Overview

The Flood Mitigation Assistance Program is a competitive grant program that provides funding to states, local communities, federally recognized tribes and territories. Funds can be used for projects that reduce or eliminate the risk of repetitive flood damage to buildings insured by the National Flood Insurance Program.

FMA-funded grants will continue to reduce or eliminate claims under the National Flood Insurance Program (NFIP) with a focus on mitigating Severe Repetitive Loss and Repetitive Loss properties as well as projects that will reduce the risk profile in communities through mitigation of the largest number of NFIP-insured properties on a neighbourhood level.

Eligible

NOTE: Subapplicants must have a FEMA-approved Local or Tribal Hazard Mitigation Plan by the Application deadline and at the time of obligation of grant funds for project, Project Scoping, and Technical Assistance subapplications.

Structures identified in the subapplication must have an NFIP policy in effect at the FMA Application start date and must maintain it through completion of the mitigation activity and for the life of the structure.

Eligible Projects

The following non-exhaustive list represents some eligible FMA projects. Remember, projects must benefit NFIP insured properties in order to be deemed eligible under the FMA program. Example projects include, but are not limited to:

- Localized flood control
- Floodwater storage and diversion
- Floodplain and stream restoration
- Stormwater management
- Wetland restoration/creation

FMA Scoring Criteria

Supplications submitted to FMA will be reviewed and scored to determine grant eligibility. Projects must demonstrate cost effectiveness. The scoring is as follows:

NFIP Insured Multiple Loss Communities (up to 200 points): Communities with 50 or more Repetitive Loss (RL) or Severe Repetitive Loss (SRL) structures and have received NFIP claims in a county that has received an Individual Assistance declaration for flood in the past.

NFIP Policy Holder (5 points for each policy): Points will be assessed for every NFIP policy that is active as of the FMA application start date (Section D, Application and Submission Information, Key Dates and Times) and is verified within the benefitting area of the project.

Severe Repetitive Loss (SRL) and Repetitive Loss (RL) Properties: Points will be assessed for SRL or RL structure that is verified within the benefitting area of the project

Private-Partnership Cost Share: Cost share taken on by private organizations/businesses emphasizing community participation, collaboration, and investment. Points will be assigned based on percentage of private cost share invested

Community Rating System (CRS) Participation (10-100 pts. Based on grade scale)

Advance Assistance Generated Project (Projects Only) (20pts.)

Cooperating Technical Partners Program (CTP) Participation (30 pts for participating communities)

TETRA TECH

WA Flood Mitigation Projects Awarded FMA Funding

- **FY 2018: Chehalis Basin Strategy CFAR Early Focus projects** - $829,758
- **FY 2018: Thurston County 2018 Home Elevation Grant**-$ 334,999
- **FY 2017: 2017 Snohomish County, Stillaguamish Flood Mitigation**- $1,489,672
- **FY 2016: Clarks Creek Repetitive Loss Property Acquisition**- $680,211
- **FY 2015: Snohomish County, Elevation of Private Structures, Riverine**-$358,031
- **FY 2015: Pierce County, Acquisition of Private Real Property (Structures and Land), Riverine**- $265,150.00
- **FY 2014: Snohomish County, Acquisition of Private Real Property (Structures and Land), Riverine**- $273,740
- **FY 2015: Pierce County, Acquisition of Private Real Property (Structures and Land), Riverine**- $780,790

How to Apply and Application Timeline

Eligible Applicants must apply for funding using the new FEMA Grants Outcome (FEMA GO), which is now the management system for FMA. The development of FEMA GO was a multi-year effort to modernize and transform the way FEMA conducts grants management. FEMA GO will streamline the process to apply for, track, and manage FEMA grants. For any questions regarding your application, please contact Washington Emergency Management.

To apply, please visit https://go.fema.gov/

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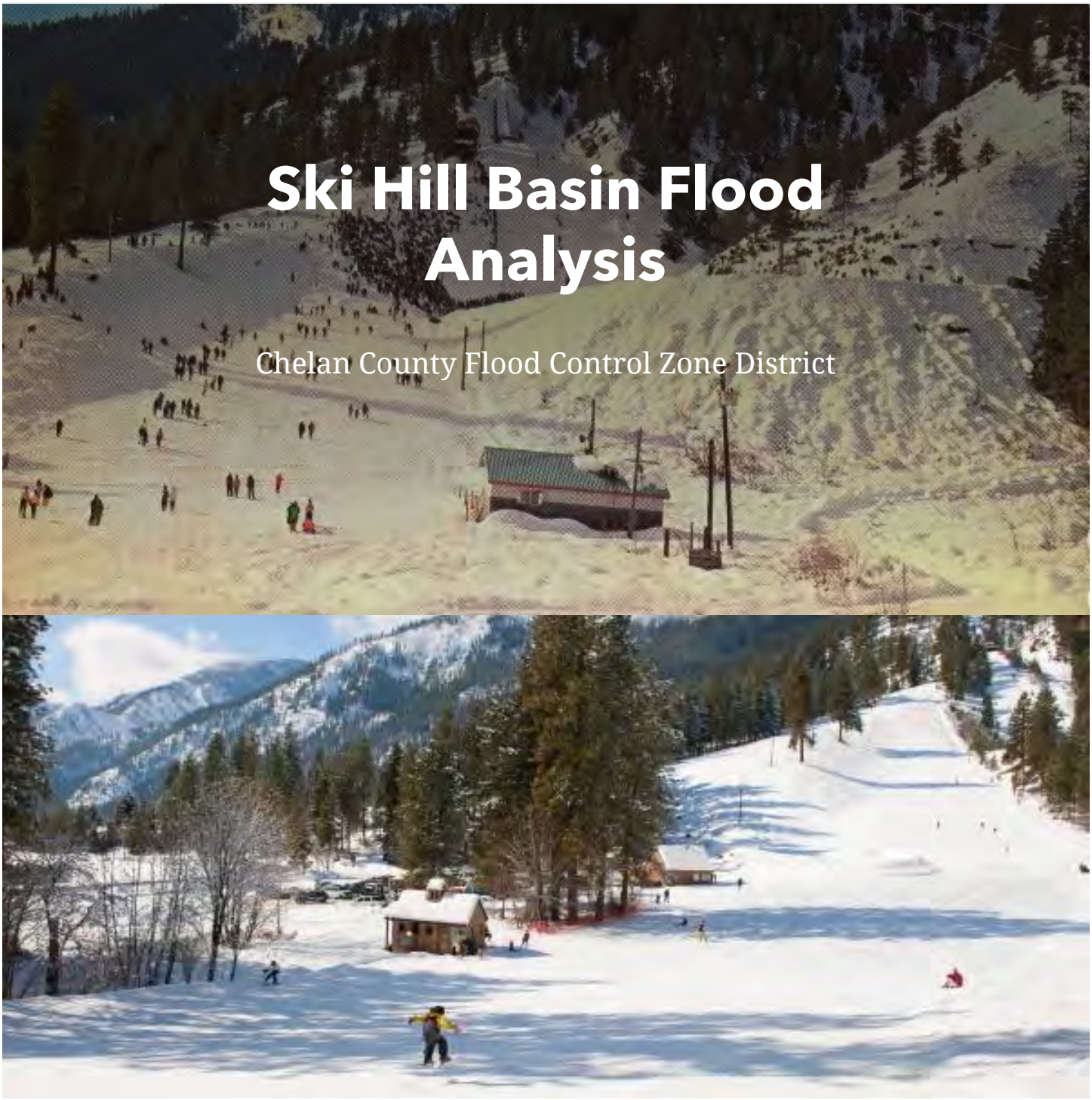
APPENDIX A: STORYMAP



Ski Hill Basin Flood Analysis

Chelan County Flood Control Zone District

Welcome to the Ski Hill Basin Story Map!

Purpose

The Chelan County Flood Control Zone District is performing a

study to identify solutions to reduce impacts of runoff coming from the Ski Hill basin.

The County's project team performed an engineering study to estimate how much runoff comes from the Ski Hill basin, and where that runoff goes. The results of the study were used to identify six potential alternatives that vary in complexity and cost to reduce the impacts of flooding.

Due to COVID-19 the project team is unable to hold a public open house as planned. The project team prepared this story map to help you learn about the project.

How to Use This Story Map

Keep scrolling down to learn more about the existing conditions, alternatives, and to take our survey. Use the links along the top to move quickly between sections.

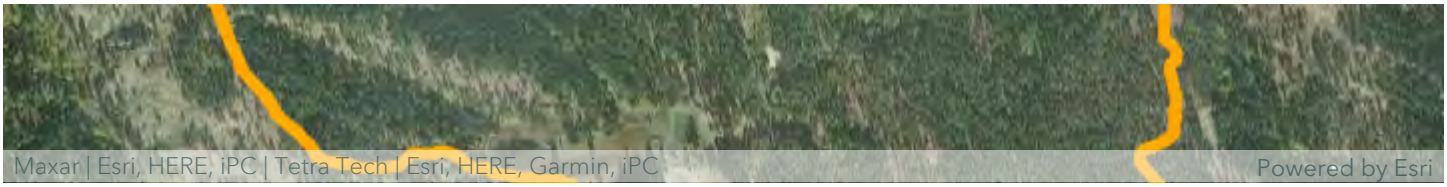
This story map includes several interactive features to help you learn about the project:

- **Interactive Maps.** All of the maps can be zoomed in and out to take a closer look at the proposed alternatives. If you're on a mobile phone, you can tap the map to make it full size for easier viewing. You can also click the white box with two arrows to make the map full screen.
- **PDF Downloads.** A PDF of each alternative is available for download.
- **Alternatives Survey.** Take a survey to provide feedback on the alternatives.

Background

Located just north of the City of Leavenworth, Ski Hill is a popular winter and summer recreation destination. Since 1928, Leavenworth Ski Hill has played an important role in the city's history, from hosting national ski jumping competitions and Special Olympics cross country skiing competitions, to providing local residents and visitors a place to learn winter sports and recreate.

Leavenworth Ski Hill is also known for runoff from rapid snow melt that floods and damages adjacent county roads and private property. Over the years, runoff has changed and appears to occur on a more frequent basis.



Current Conditions

Ski Hill Drainage Basin

A drainage basin (also referred to as a watershed) is an area of land where rainfall and snowmelt collect and drains to the same location, such as a creek or lake.

Runoff from the Ski Hill basin (shown in orange on the map) flows on to roads and into drainage ditches, and eventually makes its way to Chumstick Creek and the Wenatchee River.

In the winter and spring, runoff from Ski Hill basin frequently causes flooding on public and private property. Flooding is caused by a variety of conditions.

Flooding Conditions

Warm winter rains or rapid temperature increases

When the ground is frozen and covered in snow, rain causes a type of flooding called a “rain-on-snow” event. Flooding can also happen when temperatures quickly warm and cause rapid snowmelt. The frozen ground prevents runoff from infiltrating. When snow is in the road ditches and blocking culverts, runoff is forced onto roads and private property.

In this photo: The ditches are full of snow, causing the runoff to sheet flow across the road. Sheet flow is when runoff flows over a ground surface as a thin, even layer.

Shallow groundwater

When there is shallow groundwater, runoff does not infiltrate into the ground.

Undersized conveyance system

In the study area, the conveyance system includes roadside ditches, culverts, drainage ditches and ponds.

An undersized conveyance system means there is more water flowing in the system than it can carry. For example, during high flows, when the ditches and culverts are too small, the runoff overtops them and flows onto the roadway and over private property.

In this photo: The culvert is much smaller than the ditch and is partially blocked.

This survey is currently closed. Please contact the author of this survey for further assistance.

Do you feel there is a flooding problem in the Ski Hill basin?

If you're on a computer or tablet, click on the survey to activate it. If you're on a cell phone, click here to open the survey in a new window.

Project Steps

Chelan County Flood Control Zone District partnered with

TetraTech, Perteet and Grette Associates to complete the study. For the past several months, the project team has been gathering data and performing engineering studies to better understand the current conditions and identify potential solutions.

Step 1: Analysis

At the beginning of the study process, the project team performed a two-day site visit. During the site visit the project team made field observations to better understand the local topography and drainage patterns and to evaluate the existing stormwater infrastructure.

After the site visit, the project team performed a hydrology and hydraulic analysis. A hydrology analysis estimates **how much** water will run off the hills and out of the drainage basin, and a hydraulic analysis predicts **where** the water will flow.

The project team developed the hydrology model to estimate the peak flows and runoff volumes for the 2-year through 100-year return interval, rain-on-snow events. The hydraulic model was used to evaluate the flow paths, depths and velocity of the runoff and to evaluate the capacity of the existing drainage infrastructure.

Step 2: Identify Possible Alternatives

Using the results of the model, the project team identified several alternatives that might reduce flood impacts. The project team generated an initial list of alternatives and reduced the list to the six alternatives presented below.

Step 3: Evaluate Alternatives

Now the project team needs your input to help evaluate the alternatives. Keep scrolling to learn more about the six alternatives and to take a survey.

In addition to the survey results, the project team will use the following criteria to evaluate the alternatives:

- Improvement to drainage
- Reduction of flooding
- Reduction of damage to public infrastructure (roads, ditches, etc.) and private property
- Resiliency to flooding
- Construction costs
- Long-term maintenance costs

Step 4: Select Preferred Alternative(s)

After the survey closes, the project team will apply a ranking system to select the preferred alternative(s). The ranking system will compare the benefits and costs for the alternatives and then determine the most cost-effective alternatives. The results will be presented to the FCZD for final selection of the preferred alternative(s).

Following selection of the preferred alternative(s), the project team will finalize a report that details the analysis, public outreach process, and selection process, and provides conceptual level design drawings and cost estimates. The FCZD can use the report to support planning, permitting and applying for state and federal grants.

Step 5: Fund and Implement the Preferred Alternative(s)

To support implementation of the preferred alternative(s), the project team will assist the FCZD in identifying and pursuing state and federal grant opportunities.

Conveyance System Components

The proposed alternatives include a series of storm water features aimed to capture and convey the runoff more efficiently. The different features are described below:

Culvert – A tunnel that carries water under a structure such as road or railroad. They are commonly constructed out of concrete or corrugated metal pipe.

Channel – A path for flowing water that is confined by banks and a streambed (such as a creek).

Ditch – A narrow channel dug in the ground, typically used for drainage alongside a road or the edge of a field.

Gallery – An underground tank used to collect runoff, sediment and pollutants. The gallery has an outflow pipe that can be used to limit flow rates back into the existing stormwater network.

LID – Low Impact Development is a sustainable management strategy to protect water quality and associated aquatic habitat.

Pond – A small body of water formed in a natural depression, by excavating the ground or by constructing a dam.

Swale – A shallow channel with gently sloping sides that are often vegetated or lined with rocks. Swales are commonly constructed as an LID to collect runoff, filter pollutants and increase infiltration.

Wetland – Areas where water covers the soil or is present either at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season.

Alternatives

The six alternatives chosen for further evaluation are shown below. The alternatives increase in complexity and cost, with Alternative 1 being the least complex and least expensive and Alternatives 5 and 6 being the most complex and most expensive.

Each alternative includes a description of how the costs relate to the other alternatives.

$** - Least expensive, **$$** - Less expensive, **$$$** - More expensive, **$$$$ - Most expensive

After reviewing the alternatives, please take our survey.

Alternative #1

Alternative 1 is the “No Action” alternative. No new drainage features will be constructed, but on-going maintenance of the ditches and culverts will continue as necessary.

Relative Cost: **$**

Download PDF of Alt #1

Alternative #2

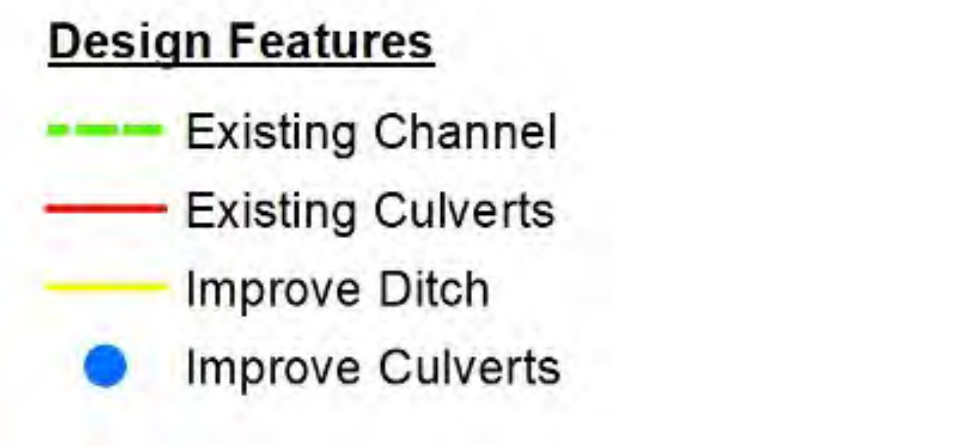
Alternative #2 is the most basic alternative.

It includes increasing the size of the roadside ditches and culverts along Detillion and Titus Roads. A field inspection indicated that many of the ditches and culverts are undersized. Increasing the size of the ditches and culverts will capture more runoff from uphill, particularly during spring runoff when the ditches may be partially blocked by snow.

The ditch adjacent to Titus Road may be improved to prevent erosion. All runoff would be directed to the channel shown as a green dashed line which drains into Chumstick Creek.

Relative Cost: **$$**

Download PDF of Alt #2



Alternative #3

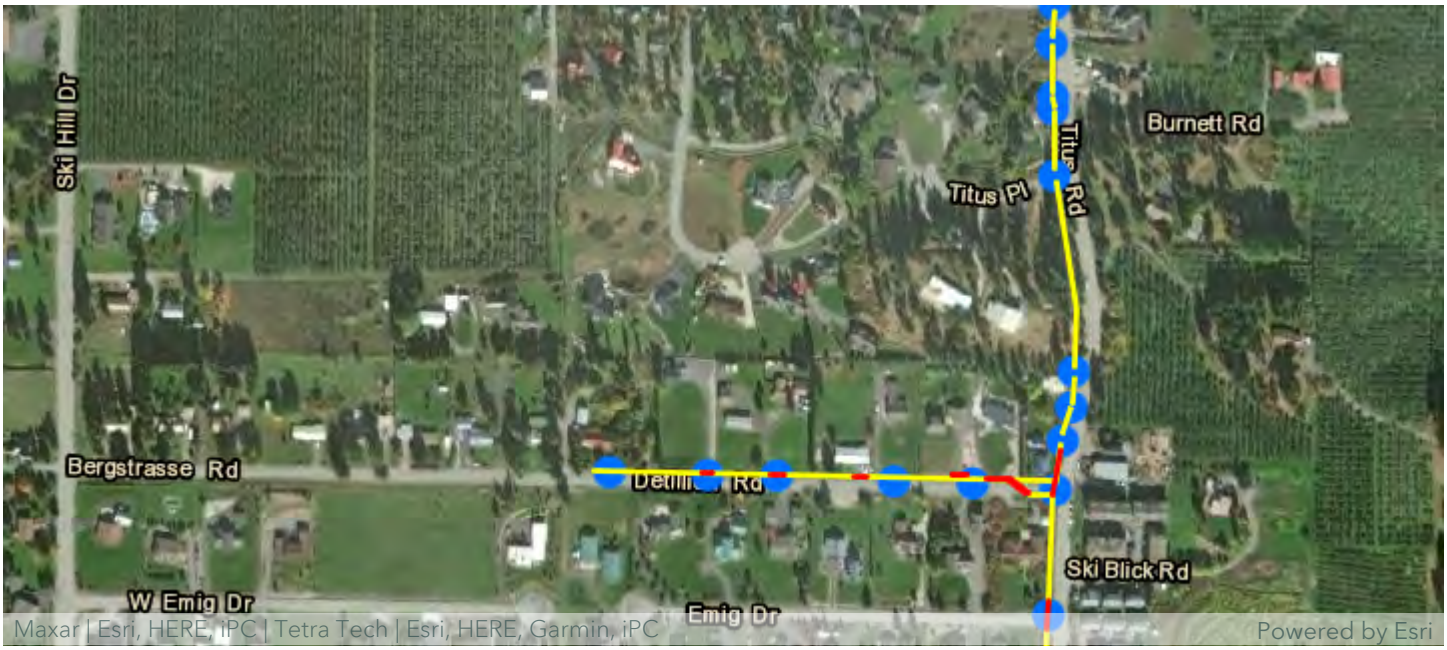
Alternative #3 includes all the features of Alternative #2 with the addition of:

- Construct a pond or install a gallery in the vicinity of the Ski Hill parking lot, and
- Construct larger swales along the north side of Titus Road between the existing culverts.

The intent of the pond or gallery at the Ski Hill parking lot is to store water and reduce the amount of runoff flowing along the north side and the overtopping of Titus Road. The features near the Ski Hill parking lot will also pass more flow through the culverts under Titus Road and reduce flow going over the road.

Relative Cost: **$$$**

Download PDF of Alt #3



Alternative #4

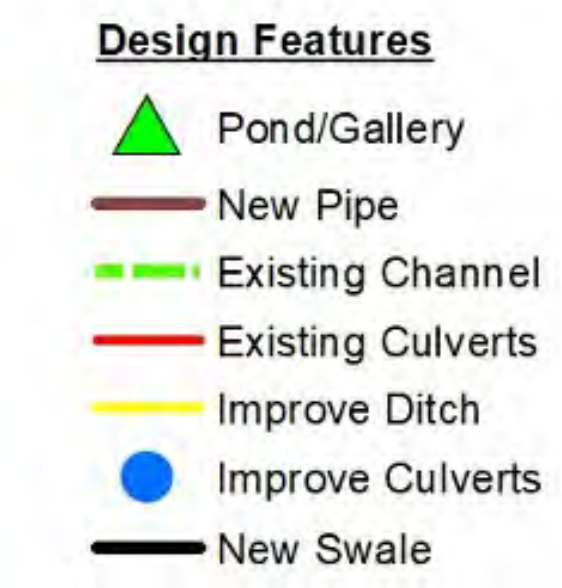
Alternative #4 includes all the features of Alternative #3 with the addition of:

- Construct a larger swale and install a culvert (pipe) to collect and convey water along Titus Road from west to east, and
- Improve the roadside ditches and culverts along Titus Road in the north-to-south direction.

The intent of Alternative 4 is to reduce the amount of flow into the orchard south of Ski Hill by conveying more flow along the north side of Titus Road to the existing ditch that starts where Titus Road turns south.

Relative Cost: **$$$$**

Download PDF of Alt #4



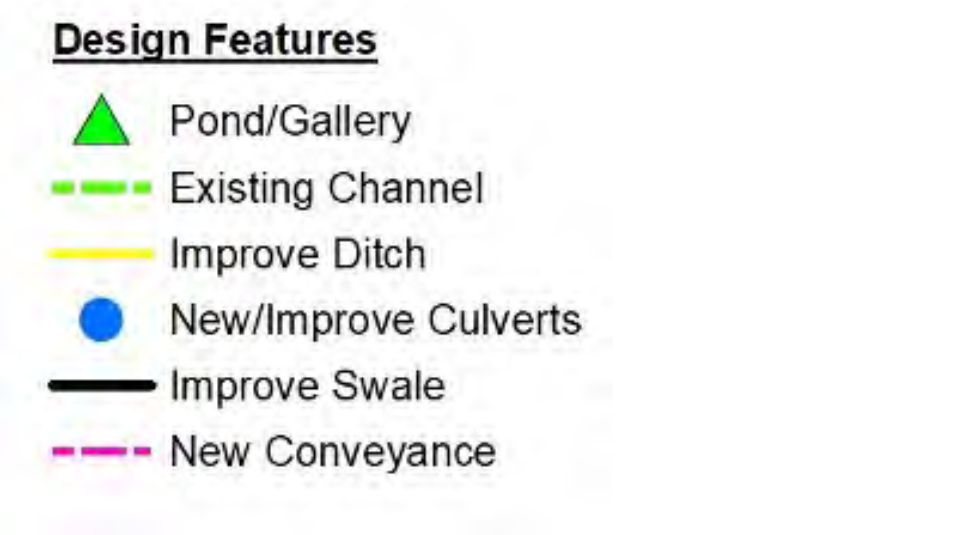
Alternative #5

Alternative #5 includes all the features of Alternative #3 with the addition of:

- Construct a new flow conveyance feature that flows in a north-south direction along a thin strip of land that extends from Titus Road to Detillion Road. The new conveyance feature, shown as a pink dashed line in the figure, may be a ditch, swale or a very long culvert or pipe. The type and alignment of the new conveyance feature will need to take into account the existing irrigation infrastructure.

Relative Cost: **$$$$**

Download PDF of Alt #5



Alternative #6

Alternative #6 is a ***conceptual idea***, with the intent being to collect and convey some of the runoff from Ski Hill basin more directly into Chumstick Creek. It will require construction of:

- A new swale and pipe along the north side of Titus Road,
- A new conveyance feature (such as a swale or pipe) across USFS land and private land,
- A new culvert under Chumsick Highway, and
- Construction of a pond or gallery at the Ski Hill parking lot to limit flows into the new conveyance system.

The project team did not identify at this time an exact location of this alternative. A potential section of the conveyance feature is shown as a magenta-colored line crossing US Forest Service land. The remainder of the conveyance feature would be constructed within the hatched area that is privately owned. Permission from multiple landowners will be required to construct the conveyance feature.

Relative Cost: **$$$$**

Download PDF of Alt #6

Alternatives Survey

If you are on a desktop computer or a tablet, click on the survey to activate it. If you are on a mobile device, click on the link to take the survey.

To view the survey in a new window, click on the white box with an arrow in the upper right corner, or click here https://www.surveymonkey.com/r/CK8HJKX.

This survey is currently closed.

For more information, please contact:

Jill FitzSimmons, Chelan County Flood Control Zone District

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Cover Photo	skisprungschanzen.com | Bill Pooley
Ski Hill Photos	Leavenworth Winter Sports Club Facebook Page
Site Visit Photos	Chelan County and Tetra Tech
Maps and Content	Tetra Tech and Perteet

APPENDIX B: STORYMAP SUMMARY REPORT

PUBLIC OUTREACH RESULTS

Chelan County Flood Control Zone District

June 7, 2021

Ski Hill Basin Analysis

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PROJECT BACKGROUND AND PURPOSE

The Skill Hill Basin is located north of the City of Leavenworth. Each spring, snow melt rapidly runs off the hillside causing flooding and damage to county roads and private property. The Chelan County Flood Control Zone District (FCZD) is sponsoring this analysis to better understand the causes and issues related to the runoff and to develop a preferred alternative that can be implemented to address the flooding. Because the runoff affects so many private property owners, the project team developed a robust public outreach program to gain public information and opinion, identify potential pitfalls of the alternatives, and determine which aspects of the alternatives are considered most favorable to property owners.

OUTREACH PROCESS

During late 2019, when the public outreach phase of the analysis was initially developed, the project team proposed an outreach plan that was a combination of online and in-person opportunities. The project team envisioned a process that began with an ArcGIS Online Story Map to provide information about the project and obtain feedback about the proposed alternatives. The next step was to be an in-person meeting to discuss the top three alternatives. During this meeting, the project team could discuss details of each alternative and engage the participants to gather information to help inform the selection of the preferred alternative.

However, during early 2020 when the project team began planning for the public outreach to begin, COVID-19 required a change to the plans. Due to the quarantine requirements from the "Stay Home, Stay Healthy" mandate, the project team changed the outreach plan to be all online opportunities. The primary focus of the outreach plan became the online story map supported with interactive maps and a survey to gather input from the public.

The project team worked throughout 2020 to develop and refine alternatives and a story map for presentation to the public. In January 2021, the story map was released to the public. The story map is provided in Appendix A and graphics of the six alternatives presented in the story map are in Appendix B.

The story map provided the public information about the project, including:

- Project background and purpose
- Current conditions and causes of flooding
- Project steps
- Description and maps of alternatives

To gather input from the public, the story map included two surveys. One was to gather general feelings about the project and the other to evaluate the proposed alternatives.

The story map was advertised by the FCZD using several methods:

- Flood Control Zone District Website: https://www.co.chelan.wa.us/flood-control-zone-district/pages/ski-hill-basin
- Press release sent to local media outlets and email lists. The press release was posted on the City of Leavenworth website and the Wenatchee World posted an article about the project. (Appendix C)
- Facebook posts on January 16 and February 16, 2020 (Figures 1 and 2)
- Postcard sent to 337 properties in the project area (Shown in Figure 2)
- Radio Interviews

Figure 1. Facebook Post – January 26

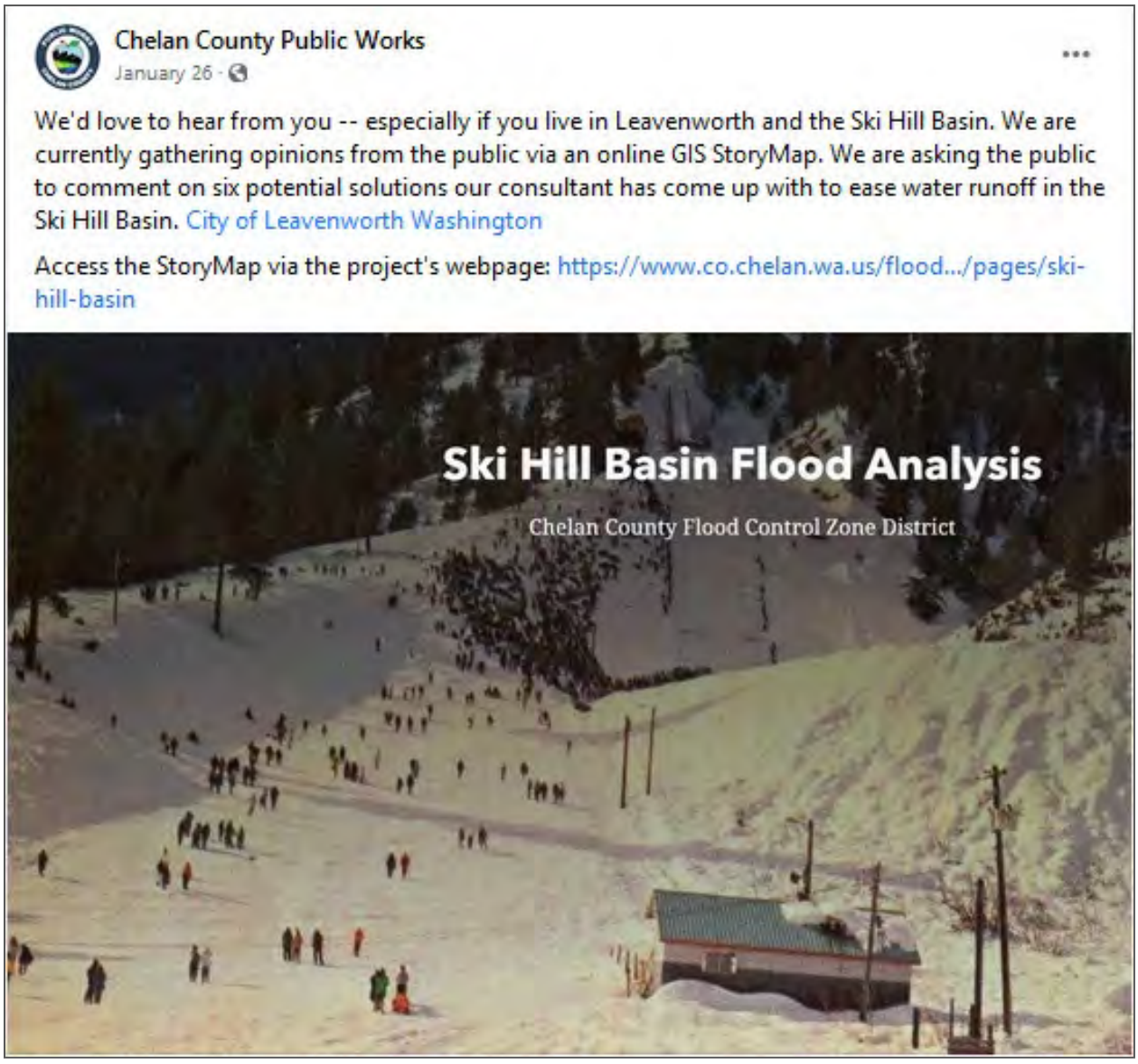


Figure 2. Facebook Post with Image of Postcard Sent to Study Area Landowners – February 16

PARTICIPATION

The robust advertising by the FCZD resulted in great participation by the public. During the time when the survey was open (January 26 to February 28, 2021), the story map had 247 users, with 67 of those users returning more than once for a total of 407 total page visits (Figures 3 and 4). While at the site, users stayed an average of 7 minutes 17 seconds on the page, indicating they took the time to read the information, review the proposed alternatives, and take the survey (Figure 5).

The story map included two surveys. The first survey asked two basic questions about flooding problems in the Ski Hill area. This survey had 77 responses. The second survey asked several questions about the proposed alternatives and had 66 responses. Both surveys asked open ended response questions that provided participants the opportunity to describe their flooding problems or the ideas or feelings about the proposed alternatives. Many survey participants took opportunity of the open-ended questions and provided long, detailed descriptions about their experiences with flooding and how they felt about the alternatives.

Figure 3. New and Returning Users

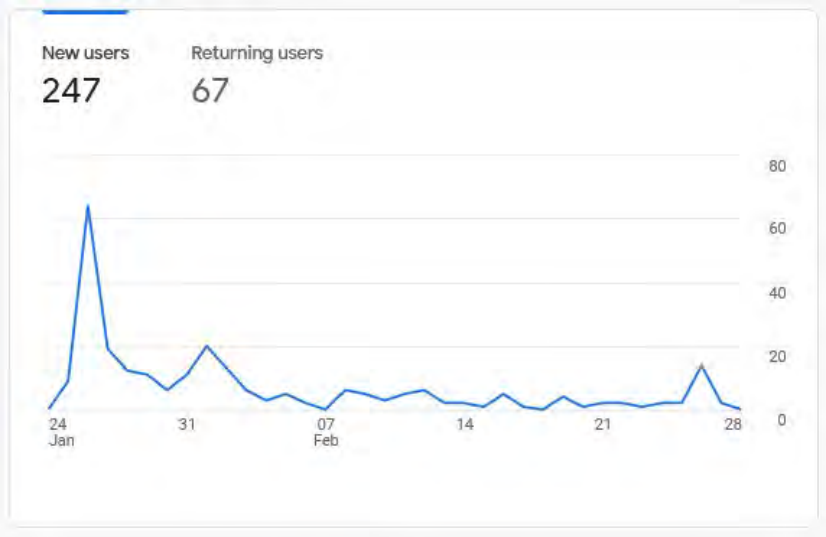


Figure 4. Total Page Views

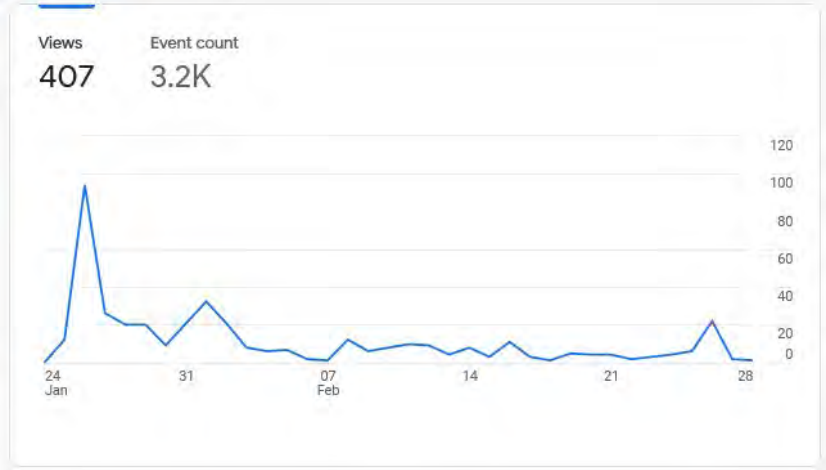
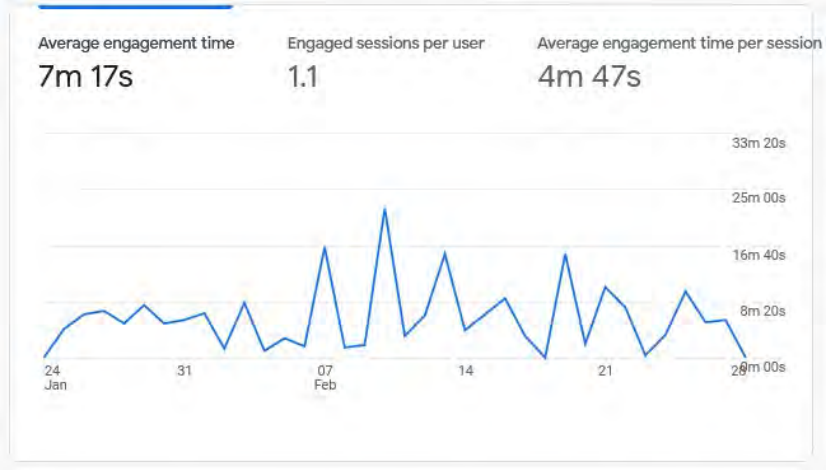


Figure 5. Average Engagement Time

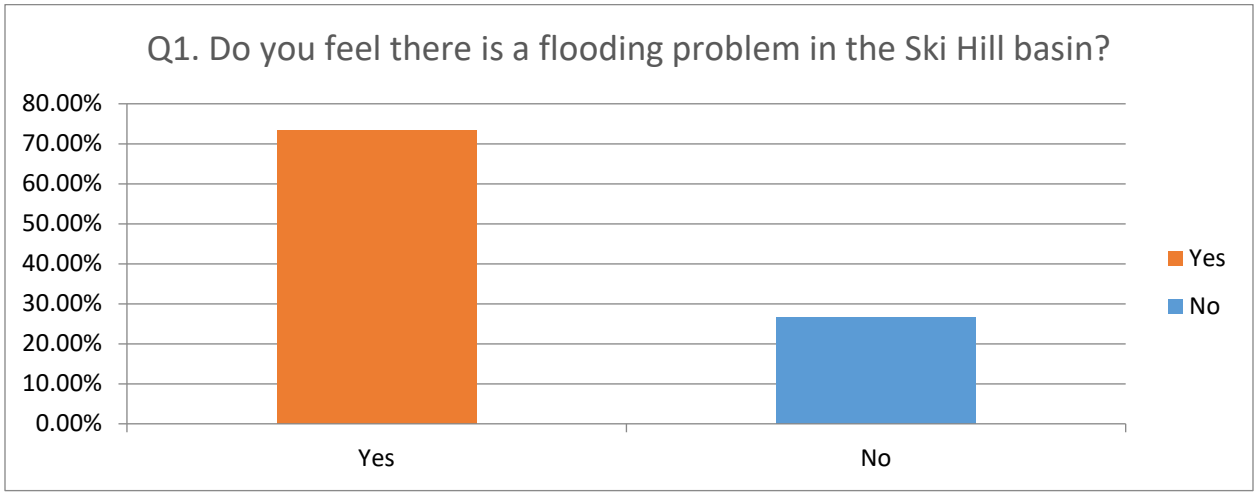


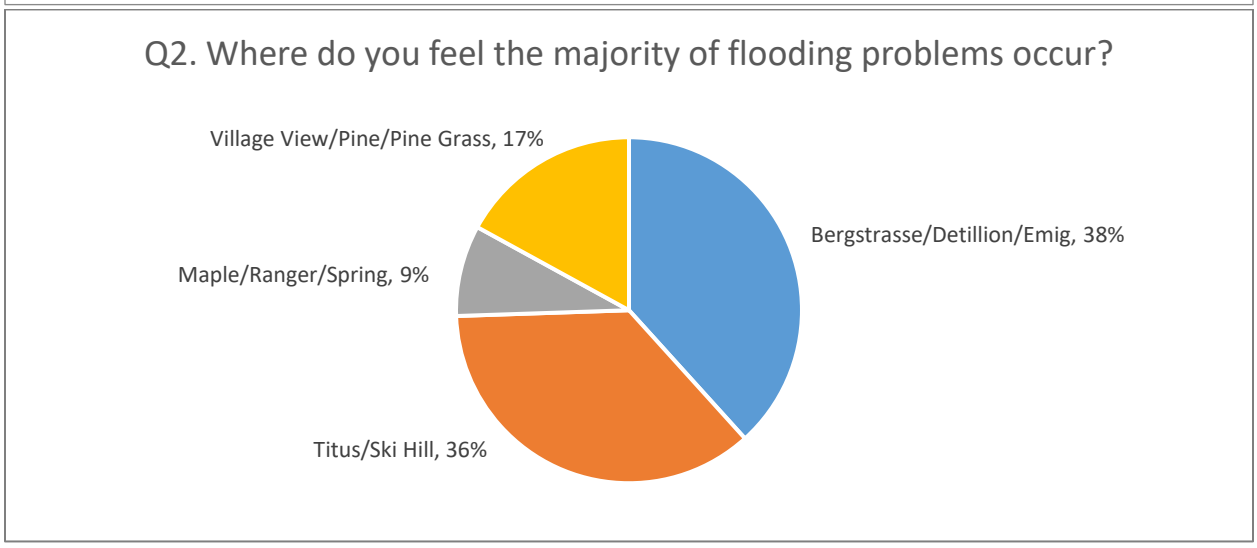
RESULTS

Flooding Problems Survey

The first survey asked two questions to gather general feelings about the flooding problem from the survey participants. Seventy-seven participants responded to this survey. Almost 75% of survey participants feel there is a flooding problem in the Ski Hill basin. Survey participants identified the greatest problems areas as the Bergstrasse/Detillion/Emig area and the Titus/Ski Hill area. Participants also described their experience with flooding in the area. Several identified new growth, lack of planning, and impacts to a wetland as an issue. Several participants were concerned with how projects may affect their property.

Figure 6. Flooding Problems Survey



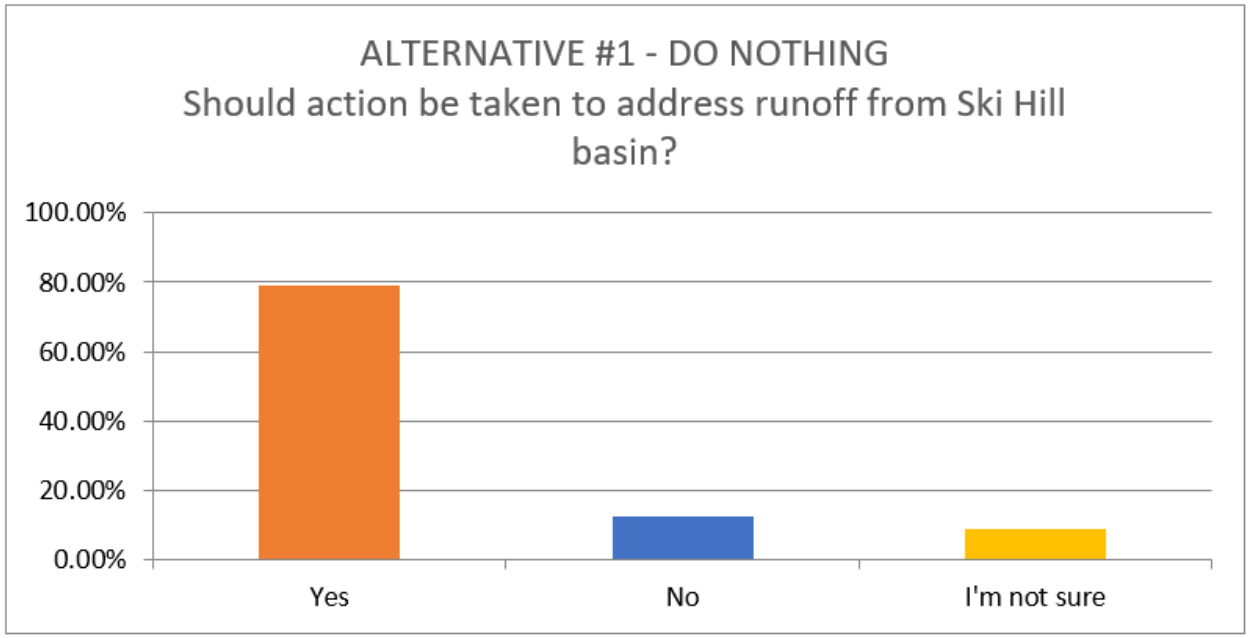


Alternatives Survey

The second survey asked questions about each alternative to determine the level of support from survey participants. Sixty-six participants responded to this survey. The project team presented six alternatives, including a do nothing alternative (#1) and a conceptual alternative (#6). Alternatives #2 through #5 built upon each other with the least action being taken in alternative #2 and the most action taken in alternative #5. See the story map in Appendix A and graphics in Appendix B for more information about each alternative.

For alternative #1, the survey asked participants a basic yes/no question to determine the level of support for taking action in the Ski Hill basin to address runoff. Almost 80% of survey participants answered yes, they support taking action, as shown in Figure 7.

Figure 7. Alternatives Survey - Alternative #1 Question



For alternatives #2 through #6, survey participants were asked a series of questions intended to evaluate how well they thought the alternative addressed certain issues. The survey asked participants to rate how well each alternative addressed the following priorities:

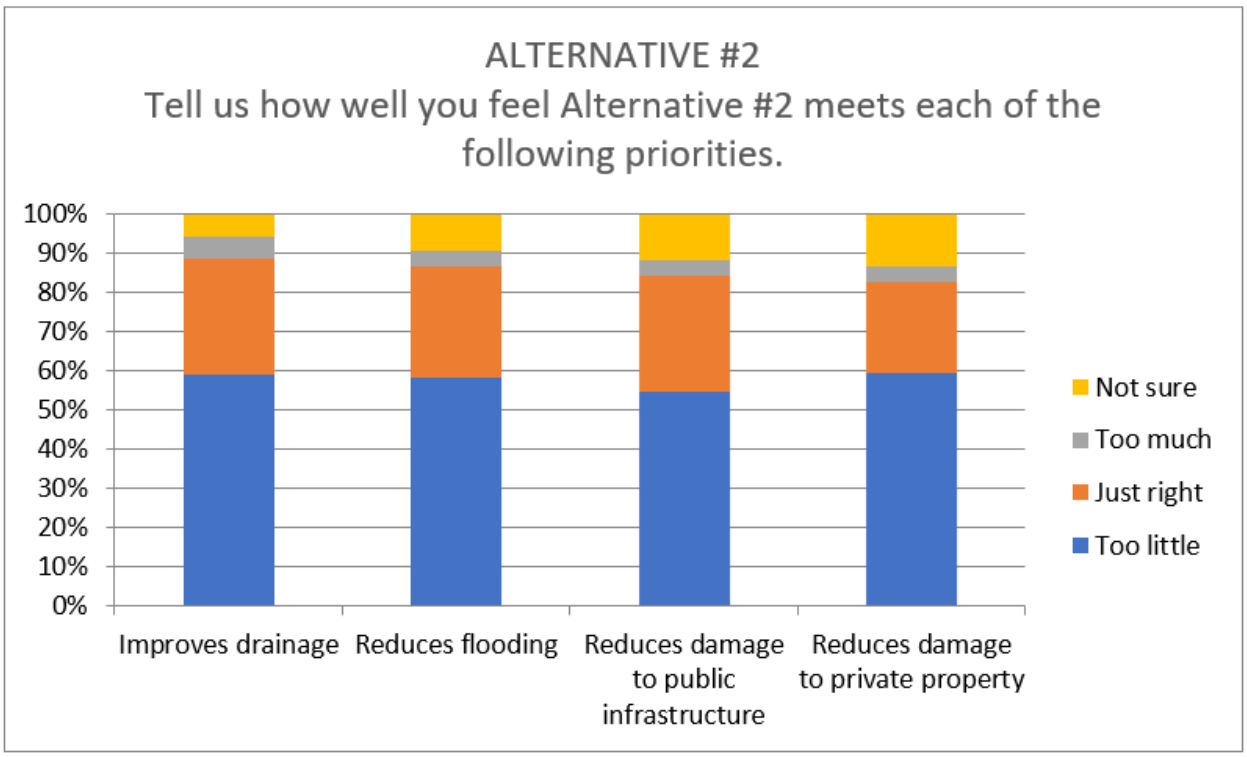
- Improves drainage
- Reduces flooding
- Reduces damage to public infrastructure
- Reduces damage to private property

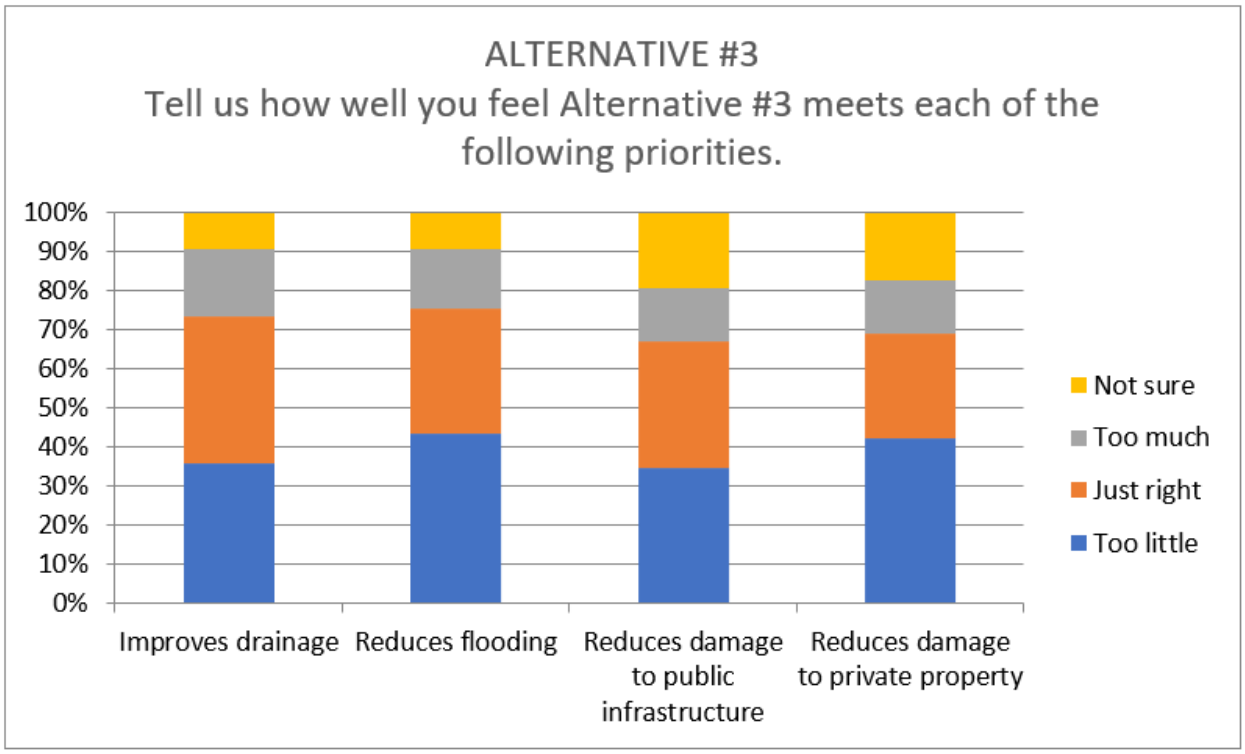
Survey participants were given the choices of:

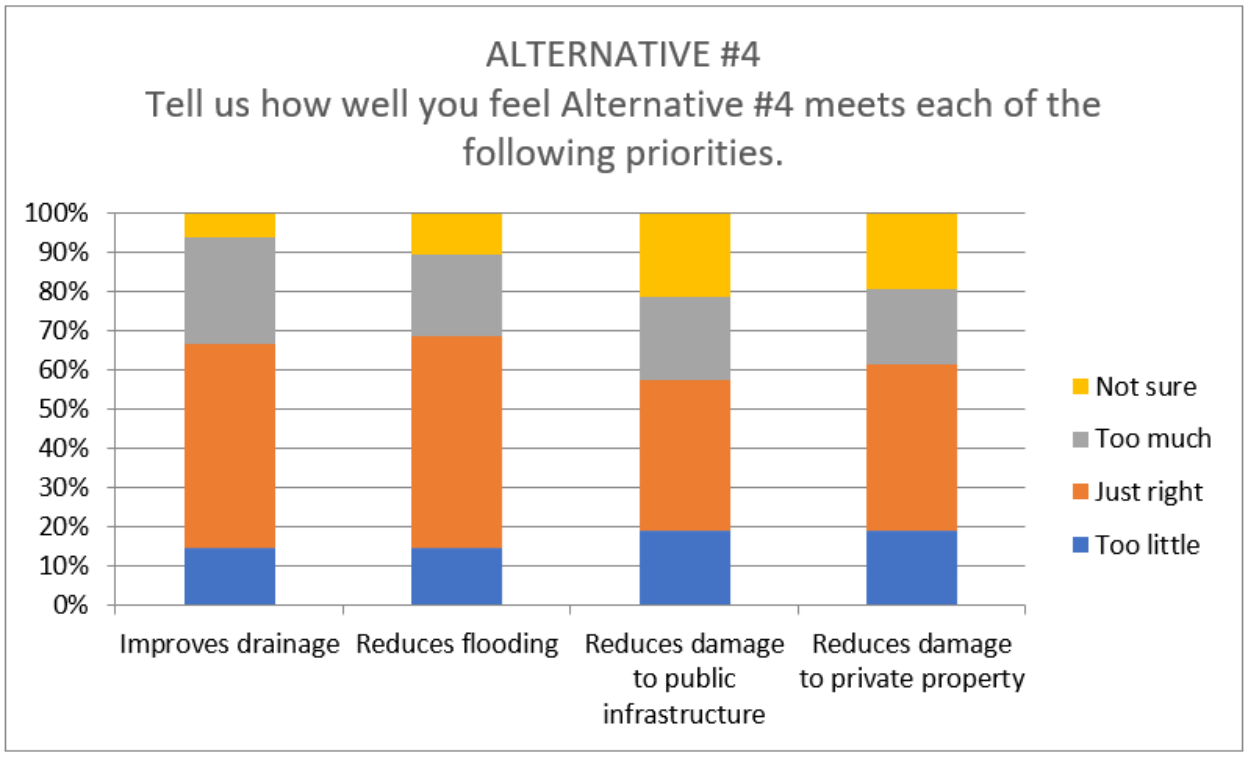
- Too little
- Just right
- Too much
- Not sure

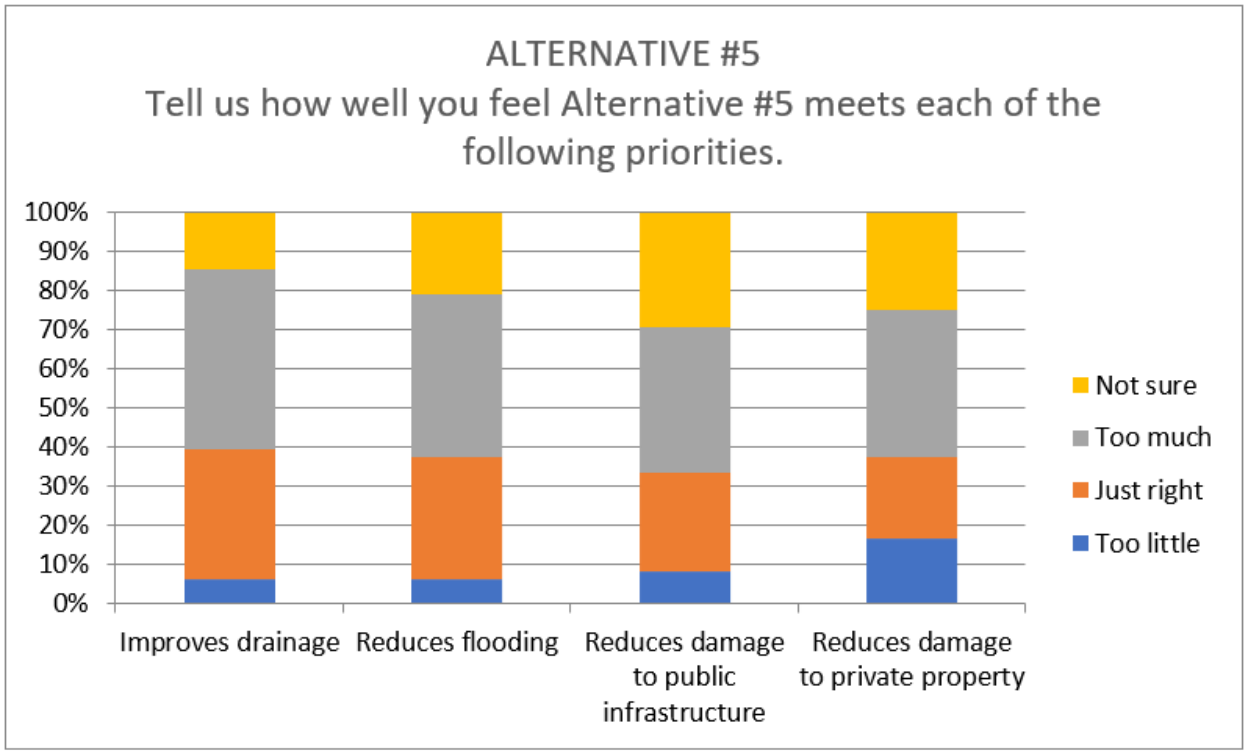
Figure 8 shows the survey response for alternatives #2 through #6.

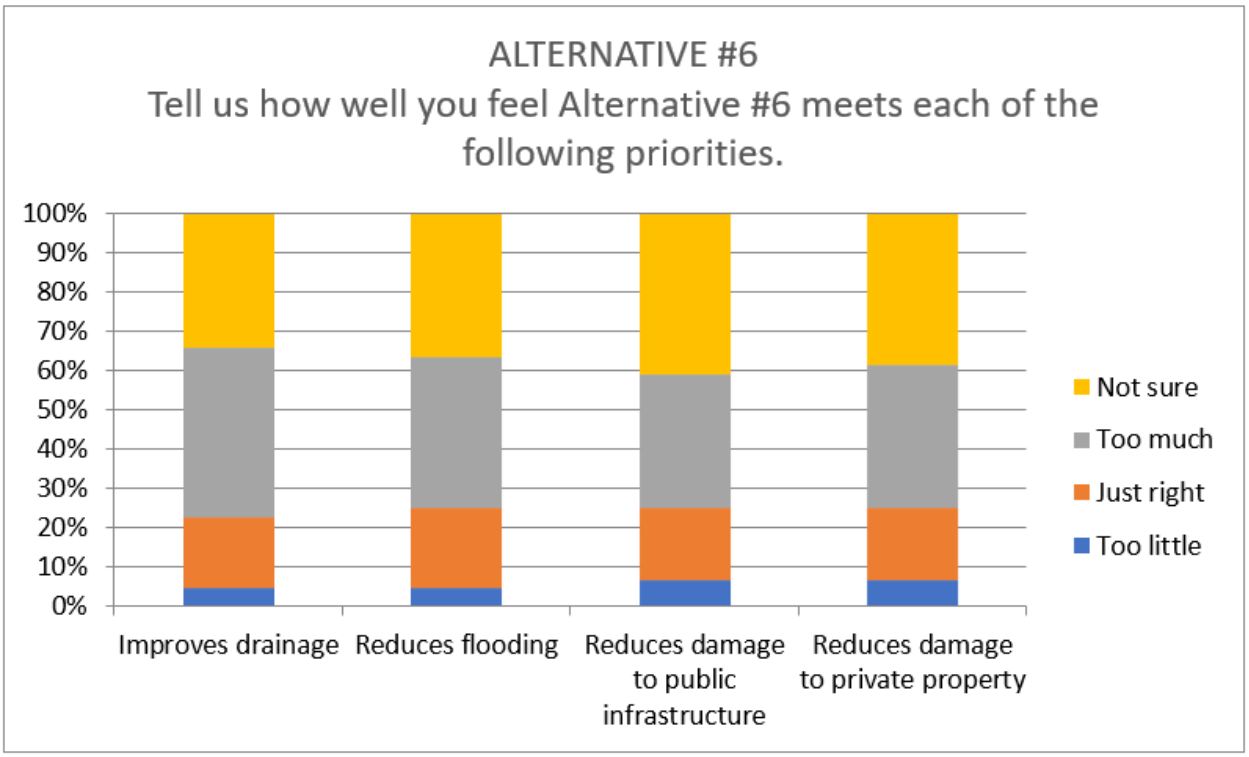
Figure 8. Alternatives Survey - Alternatives #2 Through #6 Questions




ALTERNATIVE #3
Tell us how well you feel Alternative #3 meets each of the following priorities.
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Improves drainage
Reduces flooding
Reduces damage to public infrastructure
Reduces damage to private property
Not sure
Too much
Just right
Too little

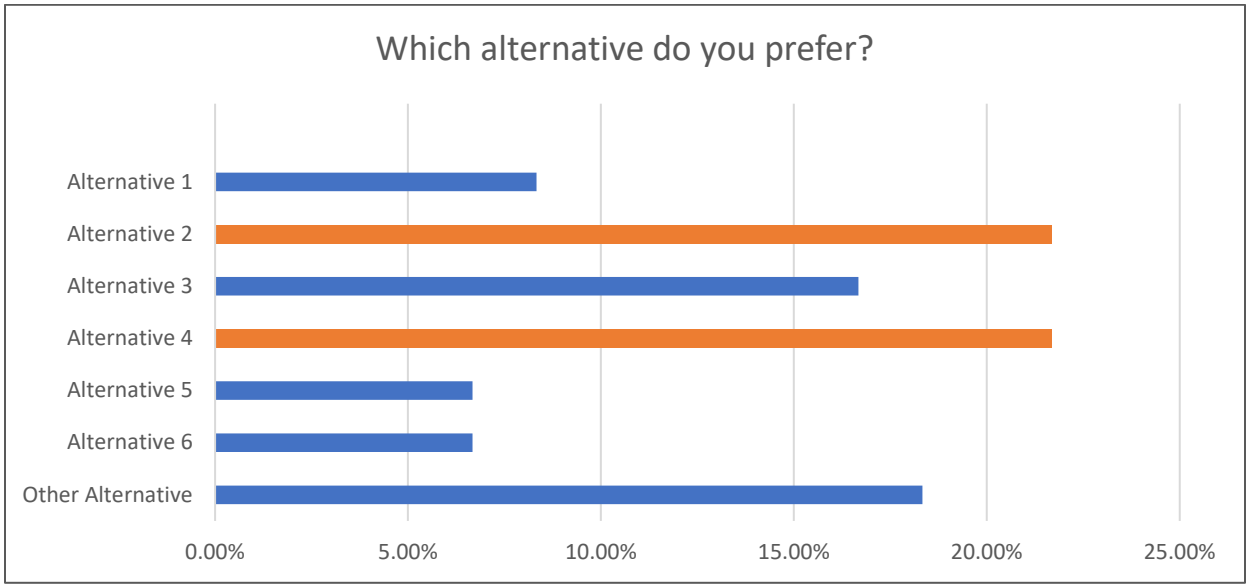

ALTERNATIVE #4
Tell us how well you feel Alternative #4 meets each of the following priorities.
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Improves drainage
Reduces flooding
Reduces damage to public infrastructure
Reduces damage to private property
Not sure
Too much
Just right
Too little





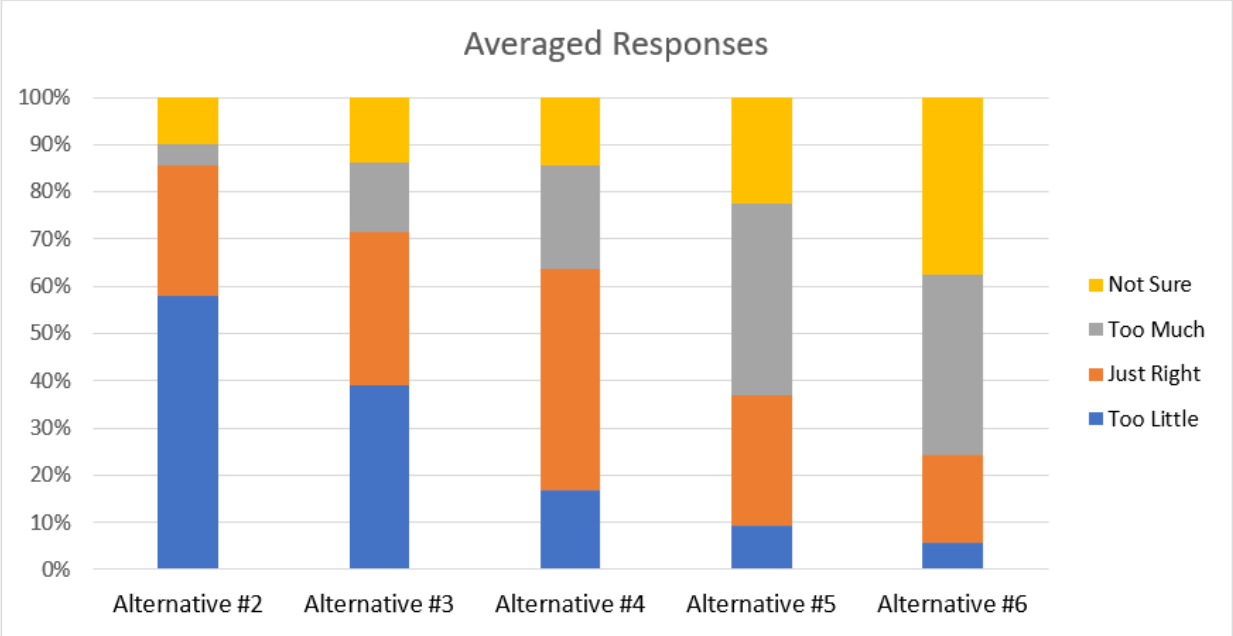
The final survey question asked participants to identify their preferred alternative. Most participants identified alternatives #2 and #4 as their preferred alternatives, as shown in Figure 9.

Figure 9. Alternatives Survey - Alternative Preference Question



To further evaluate the survey responses, the project team averaged the responses for each priority for alternatives #2 through #6. The results indicate that about half of the survey participants feel alternative #4 will provide just the right amount of benefit to address flooding in the Ski Hill basin, as shown in Figure 10.

Figure 10. Alternatives Survey - Averaged Priority Responses



TAKEAWAYS

Overall, survey participants are concerned about flooding in the Ski Hill basin. Several common themes emerged from reviewing the comments:

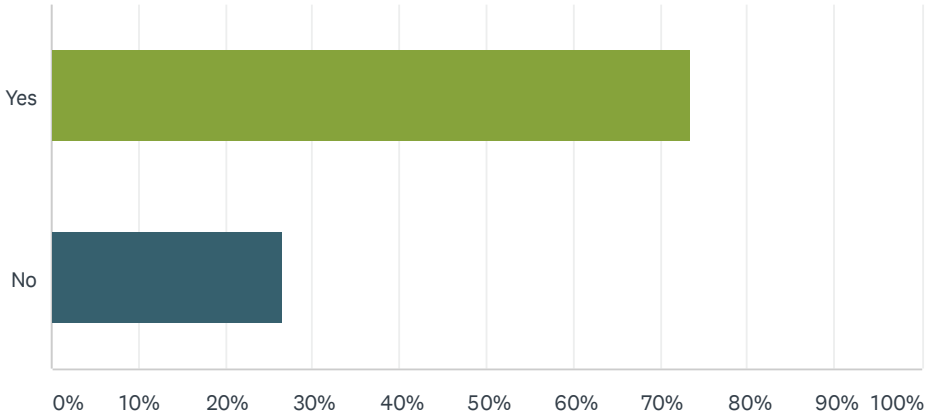
- Participants indicate flooding has increased or changed due to growth occurring in areas that used to pond and act as natural runoff retention. Many feel that lack of planning is contributing to the issue by allowing homes, infrastructure, and alterations to the wetlands in these areas without considering the runoff and requiring sufficient stormwater control.
- Several participants have constructed improvements or performed mitigation on their property to reduce flood damage and are concerned about whether their improvements will remain effective if an alternative is implemented.
- Many participants noted that road ditches have not been maintained and are full of silt which reduces their ability to convey runoff. They also noted that many culverts are too small.
- Several participants noted a desire for more natural features such as infiltration and ground water storage instead of conveying the runoff directly to the river.
- Many participants are concerned about flooding in areas adjacent to the study area.

APPENDIX A

Survey Results

Q1 Do you feel there is a flooding problem in the Ski Hill basin?

Answered: 75 Skipped: 1



ANSWER CHOICES	RESPONSES	
Yes	73.33%	55
No	26.67%	20
TOTAL		75

Q2 If so, where do you feel the majority of flooding problems occur? Please describe your concerns and experiences.

Answered: 56 Skipped: 20

#	RESPONSES	DATE
1	I live on Ranger and we experience following across Ranger annually.	2/27/2021 9:57 PM
2	Seasonal rain events in the spring on the snow pack is usually what it takes to cause these events	2/26/2021 5:01 PM
3	Mainly along the DeTillian road and accompanying ditches	2/26/2021 4:44 PM
4	Runoff from Ski Hill and wetland areas at the bottom of ski hill near Pine St.	2/26/2021 3:06 PM
5	It seems that the flooding is partly due to not maintaining culverts and ditches. It also appears the most threatened area is the orchard just below the ski hill, but that would be the case even if there were no road or other development. It appears that channelizing the run off has made flooding worse.	2/25/2021 11:27 AM
6	The flooding problems occur and originate on National Forest Service land and should be the responsibility of the National Forest Service and Chelan County government to contain the runoff in adequate ditching along both Titus Rd and Ski Hill Dr to storm water drainages leading to the Wenatchee River. In my opinion the runoff should not continue to be routed through private property for private property owners to combat.	2/24/2021 10:49 AM
7	In areas where water runnoff is poorly planned for, for example we bought a house at 10459 Titus. The forst winter we had a rapid thaw and our entie crawl space was filled. Come to find out the builder and the city and engineer redid the original engineerin pland for water runnoff because the condo associaiton didnt like the water running into the bi holding tank located beneath the condo's. Now we have extensive issues from water running off the hill and pts and orchards that surrounds us and we are the lowest point. There are no city or county plans to correct the water runnoff issues at this point.	2/20/2021 4:36 PM
8	West of Ski Hill Road and along Pine Street. Primary concern is increased housing development north of Pine Street that is and will continue to add more impervious surface and potentially worsen flooding lower in the basin. Other concerns include degraded water quality in Chumstick Creek and the Wenatchee River near outfalls of the basin's drainage system, ongoing loss of wetland functions in the basin, and the potential for solutions for flooding problems during peak flow to reduce water storage and availability during drier times of the year.	2/19/2021 4:47 PM
9	Right down the middle. Also, one of the holding ponds floods and a neighbor put a rain gutter to channel which makes it worse. East side of wheat field.	2/16/2021 12:31 AM
10	Titus road and cascade soccer fields run off over the road, water settles on the field and not enough drainage.	2/14/2021 7:16 PM
11	Top of Ski Hill, around Detillion and at the bottom of Ski Hill in the residential area around Pinegrass and Pine Streets	2/14/2021 6:18 PM
12	Along Titus Road, and the connecting roads.	2/12/2021 3:57 PM
13	It appears that the majority of the flooding happens as you get towards Pine Street. I have seen standing water in those folks' yards for many years. That water certainly needs to be diverted to perhaps a holding pond before it gets to Pine Street.	2/12/2021 9:48 AM
14	Definitely noticed inches of water on the surface in the area of Pine St and Ski Hill. Also in the front yards of newer houses on Pine Street - before development, they were mud holes. All lthat new pavement (roads , sidewalks, parking areas) doesn't allow the water to sink in they way it used to before that. Wasn't that area a wetland?? No wonder it is flooding now.	2/11/2021 3:44 PM
15	Starts from the Ski Hill and goes through the orchard then through private homes	2/11/2021 9:58 AM
16	Starts from the Ski Hill and goes through the orchard then through private homes	2/11/2021 9:58 AM
17	I manage an adult family home on the corner of Detillion Rd and Titus. We have seen first hand how the runoff has flowed over the street, filled the ditch to overflowing due to undersized culverts, and rushes down the hill between houses.	2/10/2021 11:17 AM
18	North Titus Rd	2/10/2021 9:57 AM
19	Stated very bluntly.... I have long looked at the building going on down stream from the Ski Hill and asked myself, 'Why would anybody build there?' because it is an obvious flood danger	2/6/2021 2:23 PM

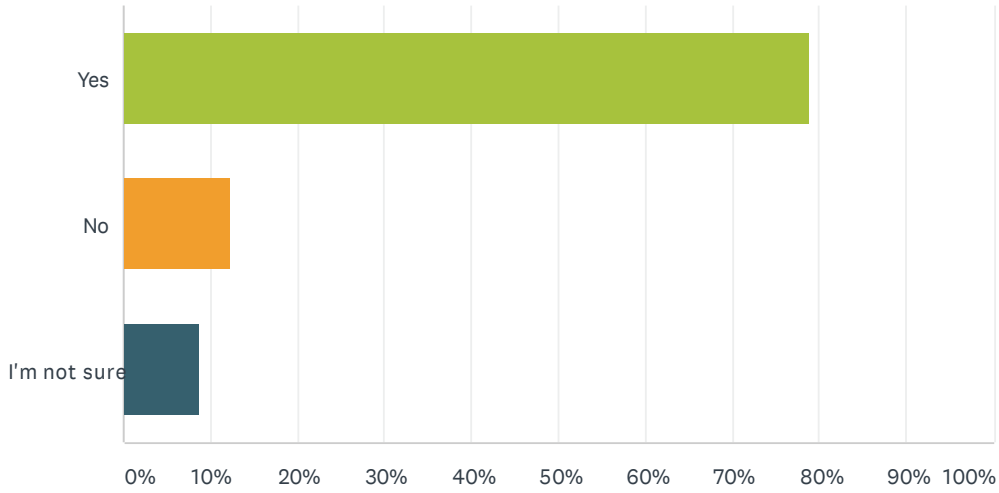
	area. Looking at the problem from an administrative point of view I would stop all new construction for which permits have been issued but no construction has started, and not issue any more construction permits until there is a flood mitigation plan. AND, any flood mitigation plan must include runoff from Tumwater Mountain from the entry into Tumwater Canyon to and including the whole of the Ski Hill Basin. AND, any flood mitigation plan for the area must consider not only sudden snow melt on frozen ground as in a 'January Thaw' but also the potential of a concentrated summer thunder shower that could put several inches of water into the Ski Hill basin and/or onto the east face of Tumwater Mountain. It is my opinion that IF there is to be flood control construction in the noted area North and West of Leavenworth it must be designed for a minimum of a three inch thunder shower dump in the Ski Hill basin which could put as much as 40 acre feet of water on the ground in an hour or less. My personal flood experience: *Columbia River and tributaries, including the Wenatchee River in 1948. *White River October 1949 flood (There are no records of this flood because it only affected the White River Valley and was absorbed by Lake Wenatchee as a mild level rise.) *Thunder Shower Flood in Summer of 1957 from #2 Canyon and more. *Many fall and spring floods in the Wenatchee River Valley *The 1970 flood of the Yukon River at Galena, AK. Flooding of the Missouri River west of the Fort Peck Dam and Reservoir *The June 1972 flood in East Wenatchee, several lesser floods in the same area. *And others that were not that memorable but still very messy. Thank you for the opportunity to comment; Paul K. Gray 545 N. Larch Avenue East Wenatchee, WA 98802-5047 Property owner: On South Wenatchee Avenue; East Wenatchee east of Kentucky Avenue; On Brown Road at Lake Wenatchee; And between the 3 and 4 mile markers on the White River Road.	
20	An endemic issue with SW in the Leavenworth area is the omission of the actual contributors to flooding. Having policies that ignore the impacts of snow accumulation followed by warmer rains creates a misrepresentation of water volumes. The impact of melting snow, especially as warm rains come following snow events, must be included in volume calculations within the county. As more impervious surfaces cover land, preventing the water infiltration, the greater the volume of SW flow accumulation.	2/6/2021 10:39 AM
21	First, there is an issue but it has been there for over 60 years with flooded orchards and the horse pastures in the middle of the Ski Hill/Titus road loop. The main issue is that the current 'conveyance system' is too small for the amount of water if you want to keep it in the conveyance system and off the old orchard/pasture land which is now houses. So the less expensive and affordable answer is to keep those channels, ditches and culverts cleaned out routinely in the winter and spring. That means the County needs to maintain and clean them all; in the past they have not even touched the channels and many of the culverts and ditches. The other practicable option is to enlarge the channels, ditches and culverts. Either of those two options is reasonably efficient and moderately affordable.	2/4/2021 3:04 PM
22	My only direct experience is when the water flows over Detillion	2/3/2021 10:45 AM
23	Down thru the orchard across the road from the ski area, and then the homes below. We live on Detillion, and have had to sandbag yet still had major amounts of water running through the yard, and major mud down the driveway. Was very worrisome.	2/3/2021 7:06 AM
24	We built a home on Titus RD a few years ago. We excavated an underground retention pond as dictated, and approved, by the City of Leavenworth. We inserted a drainage pipe in the drainage easement. The problem that caused flooding on our property was that the City of Leavenworth required us to cap our drainage pipe and not allow water to run (downhill) into the adjacent catch basin. What is the purpose of a drainage pipe if it is there only to stop the flow of water and back-up into an overflowing retention pond. In practical terms, this meant that we were responsible for stopping the entire Ski Hill runoff on our little property, i.e. stopping gravity. The City of Leavenworth needs to think through the consequences (and physics) of its regulations.	2/2/2021 9:28 AM
25	Emig, W. Emig, Berstrasse, Detillion all intercept water that should flow as shallow ground water or sheet flow. Infiltration galleries would help. The ditches are too small, but trapping the water and sending it directly to the river is not the answer.	2/1/2021 9:48 PM
26	The problem is building continues to occur in natural runoffs and wetlands. The homes off of pine are prime contributors to the growing problem.	2/1/2021 9:48 PM
27	I’m guessing pine street	2/1/2021 9:44 PM
28	It's a problem in several areas, including along Pine St, where new houses are bein built, which so happen to be in the places where an effort like this one, completed about 4 years ago by	2/1/2021 8:36 PM

	city, suggested some of those areas be set aside for water retention. Which followed the "Groundwater Problem Study" some of you today were involve in BACK IN THE LATE 90's! So I'm concerned this study will sit on a shelf and not lead to on the ground actions or policies addressing the problems.	
29	There has always been flooding on the inner loop of the Ski Hill roads - decades ago it was the orchards and the horse pasture that was flooded every spring. You put houses in there and now they get it. No pond at the parking lot or on the trails (biking and skiing and walking and such) That would ruin our recreation venue. If you get bigger culverts and clean out the ditches and channels (you ignore the channels right now and rarely clean out the culverts and ditches) it would take care of most if not all the problem But nothing at the Ski hill parking area or the trails. Clean out that ditch and put in more culverts might help up there but no ponds!!!!	1/31/2021 7:55 PM
30	Since water runs downhill, I worry about the new construction occurring on and above Pine St.	1/31/2021 6:41 PM
31	All across Titus road in the e-w direction and below	1/31/2021 4:46 PM
32	potential damage to homes and other structures by spring run off.	1/31/2021 4:30 PM
33	We live on Titus Rd at the intersection of Detillion and Titus Rd. We've had flooding in our crawl space when rain on snow events occur in late winter an early spring. Overflowing drainage ditches and culverts along Titus Rd may be contributing to some of the water draining onto our property.	1/30/2021 5:39 PM
34	On Titus and Detillion	1/30/2021 6:49 AM
35	Corner at Detillion/Titus. Sidewalks along north side of Pine. East section of Cedar. Curved section of Burke. BTW, why were houses built on Pine...so wet!!	1/29/2021 9:23 AM
36	Down from the ski hill to the city. From western hill side to the city. This is not a new problem, I have lived here for over 50 years and the orchards have absorbed most of the water. The addition of many houses toward the top of the basin has probably added to the problem, as they reduce the orchard coverage. Perhaps the number of nene homes and the smallness of building lots should be investigated	1/28/2021 7:25 PM
37	The flooding has been there for decades...those of us who were here in the 50s, 60s and 70s know the center area has always flooded. So what to do now that the County has opened that to houses? 1. Do better maintenance on the ditches, channels and culverts. I don't think any maintenance has been done to keep the channel on the Tumwater mountain side open, nor have the ditches been well maintained. 2. Install large enough culverts. So many of them are just too small for the water flow and they create flooding on the roads and on private property. Just go look at the size the County has at the end of Spring Street or the end of Maple - and compare those to the size of the channel that feeds the culverts. It's clear they are too small. 3. Do not put any ponds in the Ski Hill parking lot. We need that lot for parking for winter, spring, summer and fall recreation - plus a pond would interfere with the bike and ski trails. No to that option!!	1/28/2021 12:01 PM
38	In 16 years as a local property owner I have only seen one flood that over powered the ditches and drainae along Detillion.	1/27/2021 6:57 PM
39	Flooding is common at the east - west portion of Titus Road where the culvert takes water from the hillsides and draws under the road and into the orchard. As the photo illustrates, we've also seen occasional overtopping along Titus Road in the area around Emig Drive. The question for me is where did the water go before all of the development.	1/27/2021 11:45 AM
40	Last spring the vaults under the restroom at the parking lot was over flowing and leaking tank water onto the parking lot.	1/27/2021 11:20 AM
41	We live on Ranger Road and have experienced all the issues described in the analysis. A few years ago we experienced a pine apple express during winter time that flooded our crawl space. Our front yard turns into a swamp every spring. The channel that runs down through our property has at times carried so much water that the road gets flooded and washes out on its sides.	1/26/2021 4:30 PM
42	Ground water regularly flows across our property at 12285 Village View	1/26/2021 3:54 PM
43	The homes below the Ski Hill are at risk, some more than others, depending on the local geography.	1/26/2021 2:43 PM

44	Where there's development, of course. Why are we allowing folks to build in a wetland!?	1/26/2021 2:43 PM
45	Your picture of the street flooding is my concern and experience, all that water ran through my backyard! I almost lost my septic system and some of the foundation of my house. It cost me nearly $4,000 to mitigate the situation in my yard. The water still flows, but is contained in a stream bed. I feel you should not let the water flow under Titus and into the orchard. There should be a way for the water to run down Titus and into the creek without running through the orchard and private property. I know my neighbors have also spent a considerable amount to try and control the water and keep it out of their homes.	1/26/2021 2:35 PM
46	In the known and published flood zones. Mostly South of Detillion Rd, West of Titus Rd and East of Ski Hill Drive. This runoff goes to the natural low spot which is the field South of Village View, East of Ski Hill into the area that new homes are being built in off Pine St. This is a natural flood basin and should NOT be built in.	1/26/2021 1:37 PM
47	The big areas of concern are the areas where the County culverts and ditches are too small for the run off. We live in this area. It is clear that the current ditches need more routine clearing by the County. It is also apparent that many of the culverts are too small. For example: the end of Spring Street has one culvert on an angle and one straight across which carries water from a 'creek' or ditch that drains from all the way up top by Ron Anderson's canyon. Both of those on Spring Street need replacing with larger culverts...they overflow and flood private property. Same with the end of Maple Street. And along Titus. If there was more maintenance of the ditches and enlarging of the culverts we would be okay. As far as the Ski Hill parking area please DO NOT put a pond or anything that takes up space in the parking lot or on the lower trails!!! That is our recreation space and our trails for winter, spring, summer and fall. We need that space, those trails and all of that parking. IF something needs to happen up there, please consider cleaning out the ditch above Titus (and maintaining it) and putting in bigger culverts under Titus and drain the water toward the already-in-existence reservoir below the water tank on City property. Please - nothing in the Ski Hill parking lot or on our trails. More maintenance of the ditches (all of them!) and enlarging culverts. Thank you for the opportunity to comment.	1/26/2021 12:51 PM
48	Detillion Road	1/26/2021 11:54 AM
49	Rapid snow melt and inadequate drains or plugged drains.	1/26/2021 11:12 AM
50	The channel to the West, especially when crossing Maple Street is subject to flooding. Much more so over the last five years than before. Our previous neighbor used ecology blocks to protect his property but that now puts all of the flooding pressure on our property and eroding our driveway.	1/26/2021 10:02 AM
51	We have one of the channels on our property and we have replaced the culvert three times in the last doze years and still the channel is now eroding and damaging our driveway. We have also had the bottom of our property flooded three times in the last five years so that is new.	1/26/2021 9:57 AM
52	Winter	1/26/2021 9:47 AM
53	Unplanned growth and development. Not preserving some of the historic channels. Not preserving the wetlands along pine street.	1/26/2021 9:27 AM
54	Undersized culvert locations	1/26/2021 9:04 AM
55	My residence is adjacent to the orchard and I have a storm water collection basin on the property which typically fills and sends the overflow downstream via a neighbors dry stream bed and outbound to Bergstrase. I personally, prior to an $18K improvement, have had water in my residence. My concern is that any mitigation will adversely effect my improvement. I would therefore request a consultation prior to any work.	1/25/2021 4:22 PM
56	It won't be affecting all the new development in what used to be a wetland area as their built on high foundation. But that would be is where mitigation should of occurred. Stop allowing development in the last few wetland areas we have.	1/25/2021 2:10 PM

Q1 ALTERNATIVE #1 - DO NOTHINGShould action be taken to address runoff from Ski Hill basin?

Answered: 57 Skipped: 9



ANSWER CHOICES	RESPONSES	
Yes	78.95%	45
No	12.28%	7
I'm not sure	8.77%	5
TOTAL		57

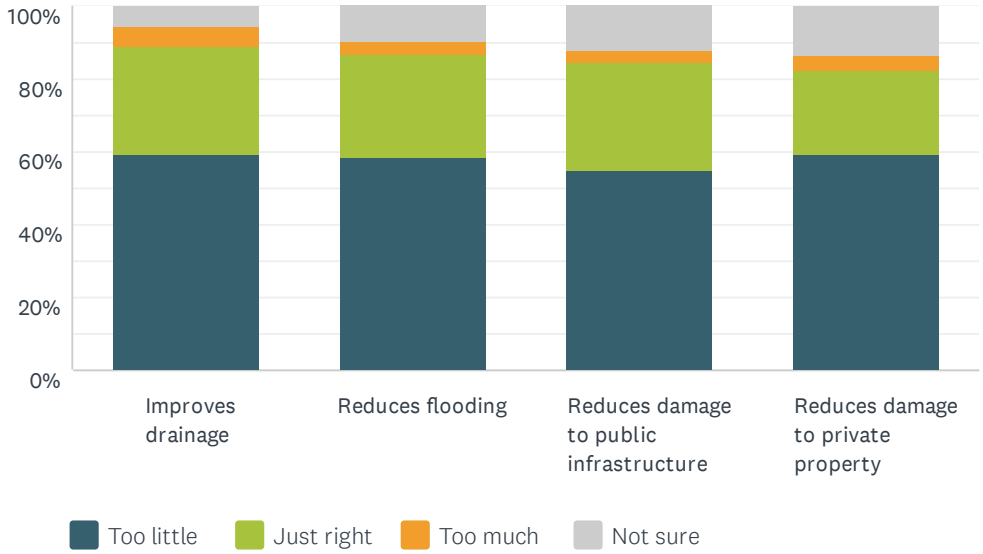
#	ARE YOU CONCERNED ABOUT THE RUNOFF FROM SKI HILL? PLEASE DESCRIBE YOUR CONCERNS AND EXPERIENCES.	DATE
1	Yes. It hasn't happened very often but when we get large rain events that melt snow we have seen flooding from Ski Hill through the orchard down and along Detillion Rd.	2/26/2021 3:17 PM
2	There are events that need some type of mitigation. I would prefer to see a minimal approach. It seems the orchard / future development below the county road should bear a large part of the mitigation when developed since it would have to deal with this even if the basin above had no development. The ski hill's channelizing bears some responsibility and the county road some responsibility for concentrating the runoffs. I cannot tell exactly what Alt 2 does, but it seems the ski hill parking lot and county ditch could provide a significant detention pond with a well maintained control structure/s and ditches to address these uncommon events. Improvements to ditches would be dependent upon effectiveness of the detention facility. I would stress nothing works if not maintained.	2/25/2021 11:55 AM
3	Yes, very concerned as a property owner located at 12254 Detillion Rd where nearly all the water leaving National Forest Service land eventually flows through to underwhelming ditches along Detillion Rd. We've experienced significant damages resulting in the runoff events in recent years since the Plat of Titus Estates directly to the north has been developing. The retention pond located on Lot 1, of Titus Estates Phase II has been altered and no longer is effective as it once seemed to be. We have sustained approximately $20,000 in damage repair in recent years due to the runoff.	2/24/2021 11:06 AM
4	I live on Ski View Ln and experience flooding across the back corner of my lot and my shed that is located in this area.	2/22/2021 2:43 PM
5	Very Much, our new house at 10459 Titus floods every year. NONE of these alternatives takes into account the land on this side, and run off on Titus Rd oppositite the existing culvert. The water FLOWS down from the top of titus, through the orchards, and collects here. So this is all wonderful for all the new houses being curretnly built. but as a 25 year resident of Chelan county we would like our concerns and issues dealt with as well.	2/20/2021 4:51 PM
6	Yes, I agree that flooding in the Ski Hill Basin should be addressed. But none of the proposed action alternatives provides a comprehensive, well integrated, interdisciplinary solution. The stated aim of the project is to capture and convey runoff more efficiently. This narrow objective seems to hark back to a past when engineering solutions focused on solving discrete environmental problems often created more new problems than they solved. The resulting set of alternatives is very constrained and does not address many associated issues. In particular, the criteria used to develop and evaluate alternatives do not include environmental impacts, visual impacts, and safety, among other factors that warrant consideration. After reviewing the alternatives, I came away with many critical questions. How will the proposed alternatives affect the function of existing wetlands in the basin? For example, will the proposed solutions to the flooding problem result in changes in the hydroperiod of the wetlands, or even draining them? How will these solutions affect peak flow in Chumstick Creek and the Wenatchee River? How will these solutions affect the potential for flooding downstream of the Ski Hill Basin? What effects on water quality in receiving waters will each alternative have? Why aren’t typical stormwater best practices like dispersion, detention, and infiltration more prominently featured in the preliminary designs? Why don’t the alternatives include construction of a relatively large detention pond with associated trails and interpretive signs which could be an amenity for residents and tourists, perhaps at a location like that of the formerly proposed Meadowlark development? During development of alternatives, how much coordination occurred with hydrology and engineering staff from key stakeholder entities like WSDOT, Chelan PUD, the USFS, and downstream municipalities, among others? What measures will be taken to manage further development in the Ski Hill Basin in a way that ensures proposed solutions are not overwhelmed in the near future? Until a broader perspective is brought to evaluating this issue, resulting in broader range of proposed solutions, I think the best course is the “no action” alternative.	2/19/2021 6:00 PM
7	I have friends that have build a home on ski view and they have had a number of flooding seasons and so have their neighbors the home that build right next to the drain pipe at the top of ski hill I can not feel sorry for he had to know how bad it gets this has gone on for years i have a home south of w emiG was told when I bought the there were years when the water would fan down to Bergstrasse this is nothing new	2/19/2021 12:05 PM
8	Each year there is flooding across the top of Ski Hill (Titus Road) onto and through the orchard. There is flooding at the corner of Titus and Detillion and along Titus near the old	2/15/2021 11:47 AM

	Autumn Pond Bed and Breakfast. Doing nothing will not solve this problem. In addition, we have growing concerns about the flooding along Pinegrass and Pine Streets. Recognizing this is Leavenworth City Limits and not wholely the responsibility of the County, runoff in the basin includes that area. Homes being built along those streets have had to build with substantial flood mitigation in the foundations during construction. The more homes that are build in the 35 acres between Village View Drive and Pinegrass, the more flooding issues we are going to experience. We live on Village View and walk in that 35 acres weekly. There is a 365 day a year spring releasing water year round in the middle of that acreage flowing toward the elementary school. It will continue to flow and flooding will continue to worsen as McDevitt Land Company sells off parcels and those parcels are built on. PLEASE plan for mitigating that water issue in the future.	
9	Yes, I am concerned. The flooding that has occurred is usually in the spring with surface water running off the hillside north or above of Ski Hill/Titus Road. The water/ice collects in the ditch then freezes not allowing it to pass through the convert in a timely fashion. It is mostly a maintenance issue and could be resolved with option #3 with the development of a expanded pond/gallery north of Ski Hill/Titus Rd, cleaning some of the storm water ditches and good proactive maintenance. More of a concern is the construction occurring in the City of Leavenworth along Pine and Pinegrass Streets. Ski Hill area has always had ground water flowing down the hill year-round. The houses being built have water flowing through or just below the concrete footings and sometimes create swimming pools in the foundations prior to flooring substructure application. Future water, sewer and road infrastructure is only going to compound the ground water issue, let along any flooding.	2/15/2021 6:50 AM
10	The following have not been addressed: 1) How climate change will affect snow pack in the Ski Hill area in the next 25 yr. and 50 yr. periods and the effect to ensuing runoff. 2) Frequency of $ damage due to sudden runoff during the past 25 yr. and 50 yr. periods. 3) Past $ damage that has occurred to each of the following : structures, roads and personal property. 4) If grants are not available, who pays and how much.	2/14/2021 1:58 PM
11	Stormwater runoff continues to cause an increase in damage to public and private property and structures.	2/12/2021 4:02 PM
12	Runoff after the orchard seems to pass through private property	2/11/2021 10:09 AM
13	Manage a home at the corner of Titus and Detillion and have seen first hand the problem with large water flows.	2/10/2021 11:26 AM
14	Yes, I live in the area. In recent years, the Titus Road ditches have been insufficient in containing the runoff.	2/3/2021 6:27 PM
15	Living on Detillion Road, at the last runoff event, we sandbagged, yet had major water running through our property and a big accumulation of mud on the property.	2/3/2021 7:23 AM
16	The 90s era Leavenworth Groundwater Problem Study was largely ignored. Too many impervious surfaces were built in areas upslope from previous development. A more recent study, commissioned by the city and paid for by Ecology in approximately 2016, was also mostly ignored when the houses and school were subsequently built along Pine St. Behind Club West, there are on-again, off-again efforts to manipulate the wetlands and remnants of old stream channels. For example some of it is now piped. That water should be daylighted. Putting water into pipes inhibits percolation and exacerbates flooding risks downstream in receiving areas. Enhance the wetland in the currently undeveloped area W of Aldea Village, and expand it onto portions of the MEND property and Agnew/ Hebert property between Titus Rd and Chumstick Hwy.	2/1/2021 8:55 PM
17	Yes - it flows through our property	2/1/2021 12:55 PM
18	I am concerned that the amount of development is creating more run-off to a poorly maintained conveyance system. Infrastructure should be in place prior to development and enhanced prior to more development that causes greater amounts of run-off. At a minimum, please clean out the existing culverts and ditches.	2/1/2021 10:56 AM
19	Now that nearly all available building lots are occupied, its pretty obvious that the existing stormwater drainage system is inadquate. The organic orchard bounded by Titus and Ski Hill will eventually turnover to housing. The runoff path is currently primarily through this orchard.	1/30/2021 1:55 PM
20	First, this water has been coming down in to the 'basin' orchards and horse pastures for decades upon decades. It is nothing new, what is new is the County allowed houses in the	1/28/2021 9:09 PM

	area. If better cleaning of the channels, ditches and culverts was taking place much of this could be handled, especially if you upgrade the size of some of the culverts. Those on Titus and Detillion and Emig plus the two at the end of Spring Street are too small. That's where I walk and there may be more but those overflow the street and private property from culverts that are too small for the channel or ditch. What we do not want is you taking our ski hill parking lot and trails that join the parking lot for a pond or whatever you call it. That is our space to bike and hike and ski - and we need the parking lot to do that. If there is too much water there how about you clean out the ditch along the upper side of Ski Hill Road/Titus and run culverts in to the city owned reservoir across the road????	
21	Definitely not a new problem. The orchards did reduce a lot of the problem that the many new homes built so close together may have aggravated	1/28/2021 7:54 PM
22	I haven't seen any problems but there must be one or this analysis would not have been done.	1/28/2021 4:26 PM
23	Routinely maintain the channels, ditches and culverts and that will help immensely. Next replace the too-small culverts with bigger ones that will handle the ditch and channel water flow. Specifically on Titus at Detillion and Emig, and at least two at the end of Spring Street. If you do both of those that is enough. And do not put a pond or gallery(whatever that is) on our ski hill parking lot or trails. That will mess with our winter and summer parking and recreation options.	1/28/2021 12:05 PM
24	But, the flood occurrence is so infrequent to not be a major problem. With the supposed global warming, less snow pack and drier climate this flooding becomes less of a problem over time. Major expense is probably not warranted.	1/27/2021 7:19 PM
25	I'm not overly concerned as most of the flooding appears to be minor, relative to the potential costs of the more expensive alternatives. Also, sometimes the solutions are worse than the problems when the intent is to occasionally move excess water. I think that slowing the water down is the best option, rather than just building faster flowing, more efficient ditches.	1/27/2021 12:05 PM
26	I think the answer to the above question depends on who's paying for it. The county and city agree to let folks build in these areas, and in turn they create revenue through permitting, and where possible, utility hook-ups.	1/26/2021 3:31 PM
27	I'm not affected by the runoff but understand the concern of people downstream that are. However, they were told they were building in a flood zone and either by manipulation and changes to the County code prohibiting construction or bad contractors building "flood safe" homes that weren't, were able to build in known flood zone. I agree that existing ditches and culverts could be improved to handle large runoff, but I would vigorously protest alternatives that would require a closed conveyance of the water, limiting the amount of water that is naturally returned to the ground water system. Results of that could take years to show how much of an error that would be but all the same an error.	1/26/2021 2:00 PM
28	I want to make sure the drainage issues to the West channel are also addressed.	1/26/2021 10:16 AM
29	This needs a long term vision/plan similar to what is occurring with the canyon drainage in and around the City of Wenatchee. That is to plan to keep canyon runoff separate from urban runoff.	1/26/2021 10:07 AM
30	I have plenty of experience with flood events in residential areas from previous 10+ years of living in North Bend, WA, so I'm not sure how to compare the runoff events from Ski Hill to more widespread flood zone type flooding when water tops river banks. Certainly, best to take advantage of natural fall-line topography when designing/implementing runoff drainage solutions. Also, I support use of natural features (on surface), like swales, berms, holding ponds, rather than culverts.	1/26/2021 9:45 AM
31	There is an issue and it seems to us (we live in the area) that if the County just put in larger culverts under the roads in many places (Titus, Ski Hill, Spring Street) and cleaned out the culverts and ditches and other run-off areas on a routine basis that would help immensely. Right now the culverts are not big enough. The end of Spring Street has two culverts (one on an angle and one straight across before the cul-de-sac) that are not large enough and overflow. That's an easy fix. How about simple and easier: put in bigger culverts then keep the ditches, culverts and such cleaned out on a regular routine basis.	1/25/2021 8:09 PM

Q2 ALTERNATIVE #2Tell us how well you feel Alternative #2 meets each of the following priorities.

Answered: 54 Skipped: 12

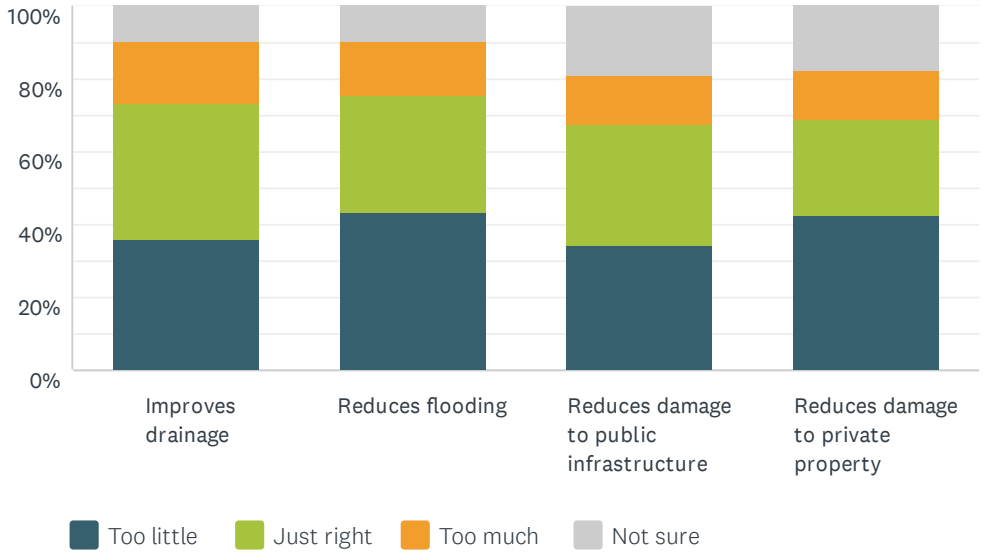


	TOO LITTLE	JUST RIGHT	TOO MUCH	NOT SURE	TOTAL
Improves drainage	59.26% 32	29.63% 16	5.56% 3	5.56% 3	54
Reduces flooding	58.49% 31	28.30% 15	3.77% 2	9.43% 5	53
Reduces damage to public infrastructure	54.90% 28	29.41% 15	3.92% 2	11.76% 6	51
Reduces damage to private property	59.62% 31	23.08% 12	3.85% 2	13.46% 7	52

#	DO YOU HAVE ANY OTHER COMMENTS ABOUT ALTERNATIVE #2 YOU'VE LIKE TO SHARE WITH THE PROJECT TEAM?	DATE
1	This isn't going to solve much. You'll still have issues with flood water through the orchards and newer houses in that area of Ski View Ln. More homes will be built in that area so the problem will just increase over time.	2/26/2021 3:17 PM
2	Alternative 2 does not address the problem of the water runoff coming down through the orchard. When the flood event happened 2-3 years ago in February it was the mass water flow through the orchard and into private housing property below. There's currently no clear path for the runoff water to flow through the orchard. What happens when the orchard is pulled and houses are built?? There needs to be a long term solution.	2/25/2021 8:09 PM
3	Continuing to allow the release of the runoff onto private property is not a long term solution. Private property owners should to continue to be responsible for the runoff originating on National Forest Service land. It should be the responsibility of government to contain and drain the water using public land and ditching.	2/24/2021 11:06 AM
4	Assuming the problem will only keep getting worse, this seems like a stopgap, not a solution. (With this in mind, I don't think any solution here can be "too much."	2/22/2021 4:43 PM
5	Maintaining the current infrastructure is prudent. The drainage system described in Alternative #2 has been in place for many years and has worked to handle run off. Unfortunately, the drainage ditches are often clogged with silt and cannot hold large flows of water. Digging them out and keeping them all maintained should be a first step.	2/15/2021 11:47 AM
6	As said before, additional pond/gallery north of Ski Hill/Titus road with some ditch cleaning and annual maintenance is the best. The flooding was due to a lack of awareness and good maintenance when necessary. No alternative will resolve the flooding if good maintenance and awareness is not in place. Also, clear out the ditches that have been filled in by the property owners.	2/15/2021 6:50 AM
7	It just makes sense to go with the path of least resistance at the most reasonable cost. Especially when there are a couple of other options that require this same step in them. If Alternative #2 is found to be less than expected, another Alternative could be implemented as the 2nd phase.	2/3/2021 6:27 PM
8	I doubt bigger ditches would handle the amount of water that has and can run off, as living on Detillion right at the base of the flow, we have seen how much water can and does run down.	2/3/2021 7:23 AM
9	Although I have not seen the city and county’s plan for future development in the Ski Hill area, I do know that the existing culverts need to be cleaned out and larger culverts and ditches installed at the culminating point of the conveyance system.	2/1/2021 10:56 AM
10	This alternative is fine so long as you pair it with more routine maintenance of all the channels and ditches and culverts.	1/28/2021 9:09 PM
11	Too much emphasis on simply moving the water faster.	1/27/2021 12:05 PM
12	This seems very reasonable.	1/26/2021 3:31 PM
13	While this alternative assists in reducing the damage from the occasional high runoff, it does not create the problem a closed conveyance system would by restricting the return of the water naturally to the water table.	1/26/2021 2:00 PM
14	I want to make sure the drainage issues to the West channel are also addressed.	1/26/2021 10:16 AM
15	This does not address runoff across the orchard to what will occur when the orchard develops. Need to look at both short term measures and long term. This is short term measure but doe not look to look term.	1/26/2021 10:07 AM
16	While doing #2 how about putting in larger culverts at the end of Spring Street and the end of Maple, and under Titus at the top of the loop? That would be a big help and not as large an undertaking as #3-#6.	1/25/2021 8:09 PM

Q3 ALTERNATIVE #3Tell us how well you feel Alternative #3 meets each of the following priorities.

Answered: 53 Skipped: 13



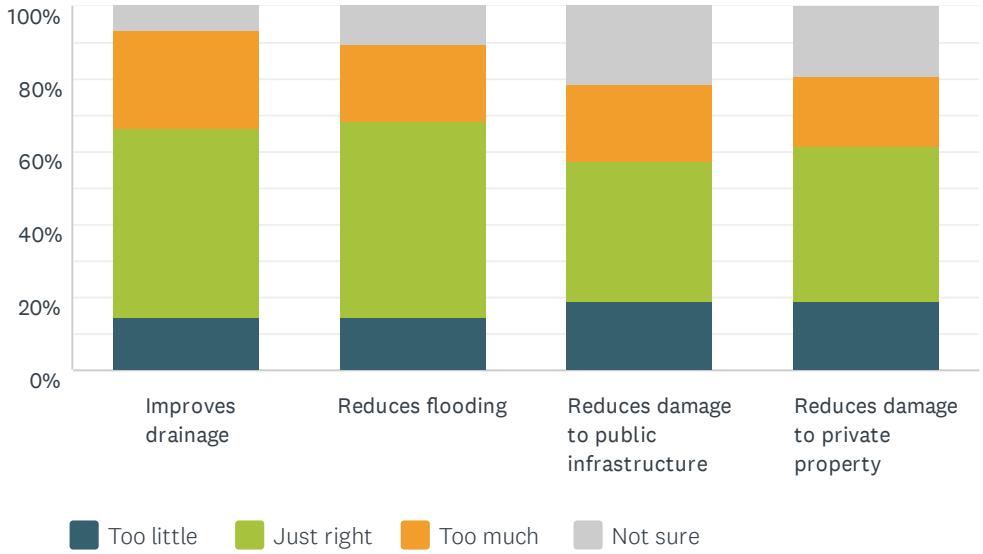
	TOO LITTLE	JUST RIGHT	TOO MUCH	NOT SURE	TOTAL
Improves drainage	35.85% 19	37.74% 20	16.98% 9	9.43% 5	53
Reduces flooding	43.40% 23	32.08% 17	15.09% 8	9.43% 5	53
Reduces damage to public infrastructure	34.62% 18	32.69% 17	13.46% 7	19.23% 10	52
Reduces damage to private property	42.31% 22	26.92% 14	13.46% 7	17.31% 9	52

#	DO YOU HAVE ANY OTHER COMMENTS ABOUT ALTERNATIVE #3 YOU'VE LIKE TO SHARE WITH THE PROJECT TEAM?	DATE
1	No pond at the Ski Hill parking lot. An underground storage tank could help.	2/26/2021 3:17 PM
2	Continuing to allow the release of the runoff onto private property is not a long term solution. Private property owners should to continue to be responsible for the runoff originating on National Forest Service land. It should be the responsibility of government to contain and drain the water using public land and ditching.	2/24/2021 11:06 AM
3	I like the pond idea, if it could be made large enough.	2/22/2021 4:43 PM
4	this maybe all that needs to be done and maintained	2/19/2021 12:05 PM
5	Holding water at the top of Ski Hill could provide a temporary flow reduction, however retention ponds are unsightly holes when not holding water and a safety risk for children, animals and overly inquisitive people. This is not the best option. We experienced flooding at the top of the HIll last year because of an ice dam and a poorly maintained culvert. If drainage swales and culverts are kept clean this is less of an issue.	2/15/2021 11:47 AM
6	seems like it might collect a lot of the water closest to the major source of run off and then limit the flow down stream at it's peak flows. This might be an infiltration pond that also helps it naturally infiltrate. Costs not as much as other alts	2/13/2021 12:26 PM
7	A pond at Ski Hill might be a hazard to youth who hang out at the ski hill area	2/3/2021 9:22 PM
8	I believe Alternative #3 is overkill until it has been determined if Alternative #2 is sufficient.	2/3/2021 6:27 PM
9	Either alternative 3 or 4 would be sufficient	2/3/2021 9:13 AM
10	Not knowing the amount of flooding that might occur, this alternative may not be enough to contain the water, as occurred recently…3 or 4 years ago. Much damage occurred at that time.	2/3/2021 7:23 AM
11	I don’t see anything in this plan, or any of the six, that deal with the increased run-off from the drainage area that is being developed adjacent to Pine Street. Probably because that is not in the county. Plan 3 does open up Chumstick Creek and improves they conveyance of water downstream but water mitigation uphill from the planned area still needs to be addressed.	2/1/2021 10:56 AM
12	what are the chances of the pond/gallery flooding across titus into the adjoining properties?	1/30/2021 4:47 PM
13	NOTHING in the parking lot at the ski hill. Please do not take our recreation site away.	1/28/2021 9:09 PM
14	The ski hill and the parking lot are a vital attribute for the community. Any plan that reduces the current parking are to be avoided. This is the access point for skiing, biking, walking, hiking and access to the forest	1/28/2021 7:54 PM
15	This could work if the pond at Ski area is large enough and metered to reduce high flows during flood events.	1/27/2021 7:19 PM
16	I'd recommend Alternative 3 due to the medium costs yet proactive in the actions that would be taken.	1/27/2021 3:07 PM
17	This seems to me to be the best option for slowing the water down without spending a ton of money.	1/27/2021 12:05 PM
18	Still reasonable.	1/26/2021 3:31 PM
19	This alternative is dangerous because it's not readily shown to improve the conceived problem of the homes that were built in an area that shouldn't have been and whether or not it would add flooding problems to the current orchard area which greatly reduces the flood by absorbing the runoff back into the ground water, which it should. However, the orchard may not be there in the future with it being replaced by more homes and now the "fix" will create a problem that will need to be addressed.	1/26/2021 2:00 PM
20	I want to make sure the drainage issues to the West channel are also addressed.	1/26/2021 10:16 AM
21	Doing more but again short plan with various measures to implement over time.	1/26/2021 10:07 AM
22	Pond/gallery at ski hill is good, but I support going one step further with Alt #5.	1/26/2021 9:45 AM
23	The Leavenworth Ski Hill is growing in popularity and the parking is in very short supply.	1/26/2021 9:36 AM

	Proposed retention pond looks to be built in the parking lot and nordic trail system.	
24	Please! NO pond/gallery/basin or anything in the Ski Hill parking lot that reduces the space to park, ski, tube, hike, use the trails or whatever. We NEED all of that space to enjoy the Ski Hill! If you put in a pond we will lose our cross country trails (and summer bike trails) as well as reduce the parking area. That is too important to our kids as a winter recreation area. Please don't!!!! If you need to drain from the lot area why don't you put culverts in from the parking lot under the road to the pond across the road by the City big water reservoir? That would not gut our skiing and trails and parking for recreation.	1/25/2021 8:09 PM
25	The lower parking lot area at ski hill is a mud pit anyways and needs improvement you would be helping the greater community out with this alternative.	1/25/2021 2:18 PM

Q4 ALTERNATIVE #4Tell us how well you feel Alternative #4 meets each of the following priorities.

Answered: 48 Skipped: 18



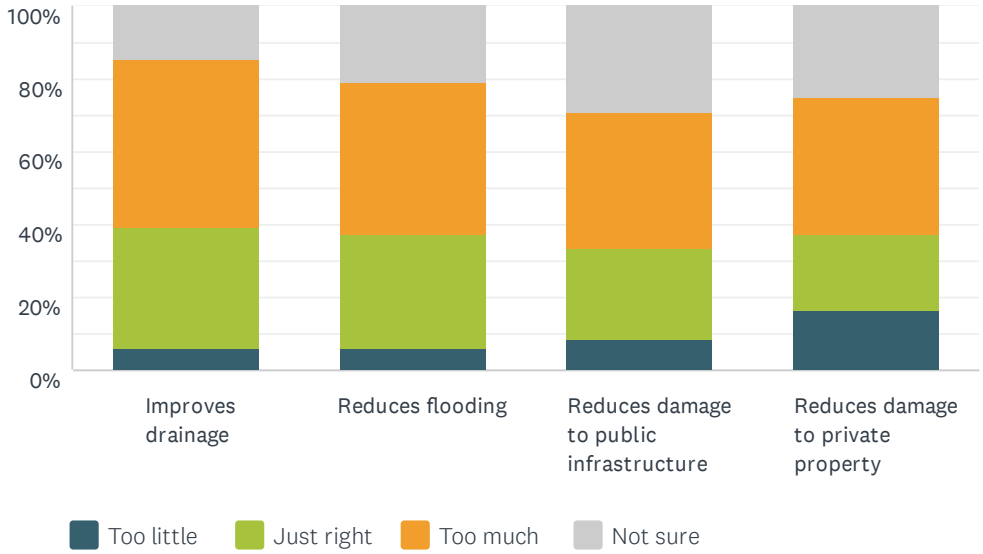
	TOO LITTLE	JUST RIGHT	TOO MUCH	NOT SURE	TOTAL
Improves drainage	14.58% 7	52.08% 25	27.08% 13	6.25% 3	48
Reduces flooding	14.58% 7	54.17% 26	20.83% 10	10.42% 5	48
Reduces damage to public infrastructure	19.15% 9	38.30% 18	21.28% 10	21.28% 10	47
Reduces damage to private property	19.15% 9	42.55% 20	19.15% 9	19.15% 9	47

#	DO YOU HAVE ANY OTHER COMMENTS ABOUT ALTERNATIVE #4 YOU'VE LIKE TO SHARE WITH THE PROJECT TEAM?	DATE
1	I think this is a good alternative because the storage underground will help slow the runoff and this option keeps floodwater within the public road right-of-way and not through private property. Seems like this is easiest for the County to manage long-term.	2/26/2021 3:17 PM
2	This is a possible good alternative to direct the runoff keeping it in county ditch property and sending it down the road. The speed of the water flowing down Titus could become a problem if the ditch banks are not reinforced. Instead of using an open ditch down Titus, a large pipe could be used to safely move the water down.	2/25/2021 8:09 PM
3	It would seem that alternative #4 is the "best" option in containing the runoff on National Forest Service land and routing the runoff in adequate and improved ditching along Titus Rd leading to the Wenatchee River. This appears to the "best" alternative in keeping the majority of runoff off of private property.	2/24/2021 11:06 AM
4	I like this one as well, although I realize we are getting into pricey territory.	2/22/2021 4:43 PM
5	PLEASE come WALK out property and let me give you a tour...	2/20/2021 4:51 PM
6	Routing the water flow eastward will run a huge amount of water down and around Titus--water that previously flowed through the orrchard.	2/15/2021 11:47 AM
7	I believe Alternative #4 is overkill until it has been determined if Alternative #2 is sufficient.	2/3/2021 6:27 PM
8	Either alternative 3 or 4 would be sufficient	2/3/2021 9:13 AM
9	This alternative seems to be the one that would protect homes and property downhill of the ski area.	2/3/2021 7:23 AM
10	The existing ditches and culverts in the Ski Hill drainage system need to be cleaned and repaired. The culvert in front of my house is 3/4 full of mostly mud. I clean the ends out with my shovel but a majority of the culvert is still full. Only a limited amount of water can pass through the culvert during heavy rains or run-off. The drain at the end of our street also needs to be cleaned. Opening a path for the run-off in Chumstick Creek is a good start. Increasing the diameter of the culverts to improve the flow of water from Ski Hill will allow water to flow into designed channels instead of flooding over roadways and private property. To curb some costs now, if more water mitigation is needed to the east of Titus, that drainage could be added to the system in a future project if the county installs culverts large enough to handle that addition. I have limited knowledge of that area. (The increased water into the system below is largely due to the development of the wetland area adjacent to Pine Street. Water from the hay fields used to slowly seep into the ground at the bottom of the fields that the city is now developing with houses minimally placed next to one another. I miss walking down Pine Street and seeing and hearing the frogs and birds that would frequent that wetland area. The standing water that attracted the birds and animals now runs off from the rooftops, driveways and roads placing heavier volumes of run-off into a poorly maintained conveyance system. I realize this is city property and planning.)	2/1/2021 10:56 AM
11	Options 3 and 4 are very good. 4 is more thorough than 3, so that is my first choice.	1/31/2021 4:43 PM
12	It is okay EXCEPT NOT the pond in the ski hill parking lot. Otherwise it's fine but may be way more than we need.	1/28/2021 9:09 PM
13	Some concerns over ski hill usage	1/28/2021 7:54 PM
14	Do not oversize the east-west pipe/swale and allow some extreme high flows to bleed off into the orchard.	1/27/2021 7:19 PM
15	I'm concerned about the cost of alternatives 4, 5 and don't know about 6 as there isn't much info. Alternative 3 is a middle of the road option. If there was a huge pot of money we could use with no increase in taxes or impacts to the environment, I'd select alternative 4, but that isn't realistic.	1/27/2021 3:07 PM
16	Somehow the flow has to be slowed down but this seems excessive.	1/27/2021 12:05 PM
17	Absolutely should not be done for basically the same reasons as stated above. Unfortunately, whether planned or not, the responses do not allow a clear statement of the problems with this alternative. Therefore, NO, this is NOT a good alternative.	1/26/2021 2:00 PM

18	This or alternative 5 appear to be the best options as they are more comprehensive.	1/26/2021 12:10 PM
19	Does this help the West channel flooding issues?	1/26/2021 10:16 AM
20	Too much "pipework" to force the water "around the corner" of Titus Road, rather than utilize natural slope and fall-line like Alt #5 does.	1/26/2021 9:45 AM
21	The Leavenworth Ski Hill is growing in popularity and the parking is in very short supply. Proposed retention pond looks to be built in the parking lot and nordic trail system.	1/26/2021 9:36 AM
22	Please! NO pond/gallery/basin or anything in the Ski Hill parking lot that reduces the space to park, ski, tube, hike, use the trails or whatever. We need all of that space to enjoy the Ski Hill! If you put in a pond we will lose our cross country trails as well as reduce the parking area. That is too important to our kids as a winter recreation area. If you need to drain from the lot area why don't you put culverts in from the parking lot under the road to the pond across the road by the City big water reservoir? That would not gut our skiing and trails and parking for tubing.	1/25/2021 8:09 PM
23	Doesn't seem necessary to solve the problem	1/25/2021 2:18 PM

Q5 ALTERNATIVE #5Tell us how well you feel Alternative #5 meets each of the following priorities.

Answered: 48 Skipped: 18

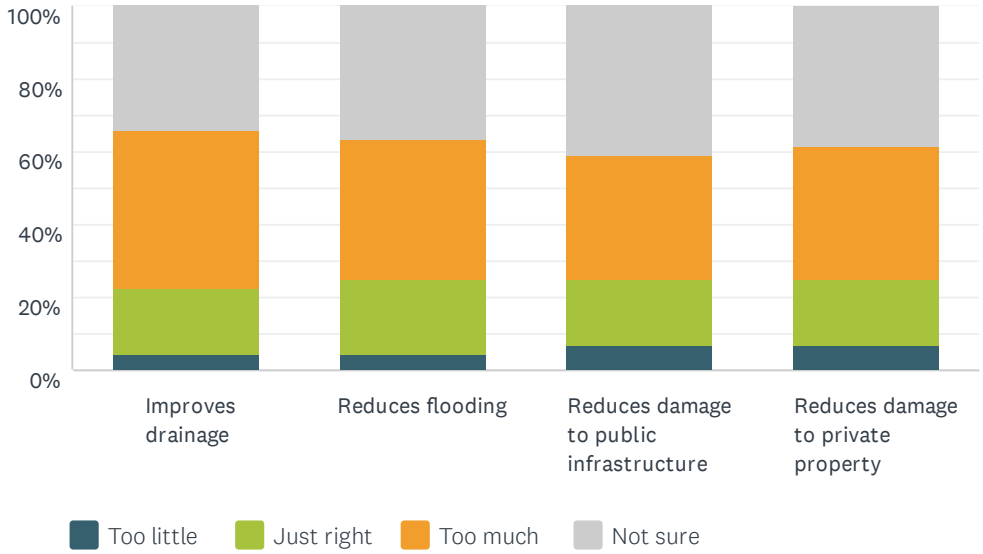


	TOO LITTLE	JUST RIGHT	TOO MUCH	NOT SURE	TOTAL
Improves drainage	6.25% 3	33.33% 16	45.83% 22	14.58% 7	48
Reduces flooding	6.25% 3	31.25% 15	41.67% 20	20.83% 10	48
Reduces damage to public infrastructure	8.33% 4	25.00% 12	37.50% 18	29.17% 14	48
Reduces damage to private property	16.67% 8	20.83% 10	37.50% 18	25.00% 12	48

#	DO YOU HAVE ANY OTHER COMMENTS ABOUT ALTERNATIVE #5 YOU'VE LIKE TO SHARE WITH THE PROJECT TEAM?	DATE
1	It seems risky to run that through a lot of private property, especially with expected growth in houses in that area. The orchard will all be houses someday. It also seems more difficult for the county to maintain and have to deal with private property owners.	2/26/2021 3:17 PM
2	This appears to funnel all the water down onto Detillion. Again when sending large quantities down along the road ditches, have large converts the length of the road been considered? It seems a larger open ditch along the road would be a potential safety hazard.	2/25/2021 8:09 PM
3	Not sure about getting a pipe or culvert through all that, but if I lived by that pink line I'm sure I wouldn't be as excited about this.	2/22/2021 4:43 PM
4	It seems that this option is set up to mitigate water away from the orchard--moving a flow pathway that has been there for decades. One might wonder, are we looking to mitigate this waterflow so the orchardist can eventually sell the land to build houses? The pink line as drawn will directly impact a hew home right on that pink line. While this could take some of the flow away from the upper end of Titus, it definitely will bring it all back in to Titus at Detillion. THAT corner would really need to be looked at with this option.	2/15/2021 11:47 AM
5	No.....do not do this option.	2/15/2021 6:50 AM
6	Acquiring easements on private property is not feasible.	2/10/2021 10:34 AM
7	We would rather not dry out the orchard area because it will just result in overdevelopment	2/3/2021 9:22 PM
8	I am NOT in favor of this option. Costs are too high and it routes right through several privately owned properties.	2/3/2021 6:27 PM
9	Would really help the properties below the ski hill area.	2/3/2021 7:23 AM
10	The map for Alternative 5 was not visible.	1/30/2021 1:55 PM
11	NOTHING in the ski hill parking lot or on our trails.	1/28/2021 9:09 PM
12	The cost is the issue and also the impacts to residents and users of this area. Don't use a sledge hammer where a small hammer will do...in other words, if a moderate amount of work will resolve the issue don't go for the very expensive alternative just because you can.	1/27/2021 3:07 PM
13	Not feasible to reconstruction the original drainage between upper Titus and Detillion road. Will need to be done with roadside drainage ditchees.	1/26/2021 3:28 PM
14	Same as Alternative #4. NO!	1/26/2021 2:00 PM
15	That seems to be the way the water wants to flow. But the culverts along Titus Rd need to be improved also.	1/26/2021 10:49 AM
16	I want to make sure this helps take pressure off of the West channel	1/26/2021 10:16 AM
17	This seem as good long term plan as it plan for long term measures and induvial sub-project could be developed to address overall basin deficiencies. It also plans for future development of the orchard land which will at sometime occur.	1/26/2021 10:07 AM
18	I prefer this option, only if the pink line is a surface swale, with mini-holding-ponds or water berms to retain/slow down the flow and create a natural channel, similar to the downstream green-dashed channel. Bonus would be environmental benefit for plants/animals. A culvert would lead to too much flow in high-melt or high-water events, in my mind, for downstream ditches to handle.	1/26/2021 9:45 AM
19	The Leavenworth Ski Hill is growing in popularity and the parking is in very short supply. Proposed retention pond looks to be built in the parking lot and nordic trail system.	1/26/2021 9:36 AM
20	Please! NO pond/gallery/basin or anything in the Ski Hill parking lot that reduces the space to park, ski, tube, hike, use the trails or whatever. We need all of that space to enjoy the Ski Hill! If you put in a pond we will lose our cross country trails as well as reduce the parking area. That is too important to our kids as a winter recreation area. If you need to drain from the lot area why don't you put culverts in from the parking lot under the road to the pond by the City big water reservoir? That would not gut our skiing and trails and parking for tubing.	1/25/2021 8:09 PM

Q6 ALTERNATIVE #6Tell us how well you feel Alternative #6 meets each of the following priorities.

Answered: 44 Skipped: 22

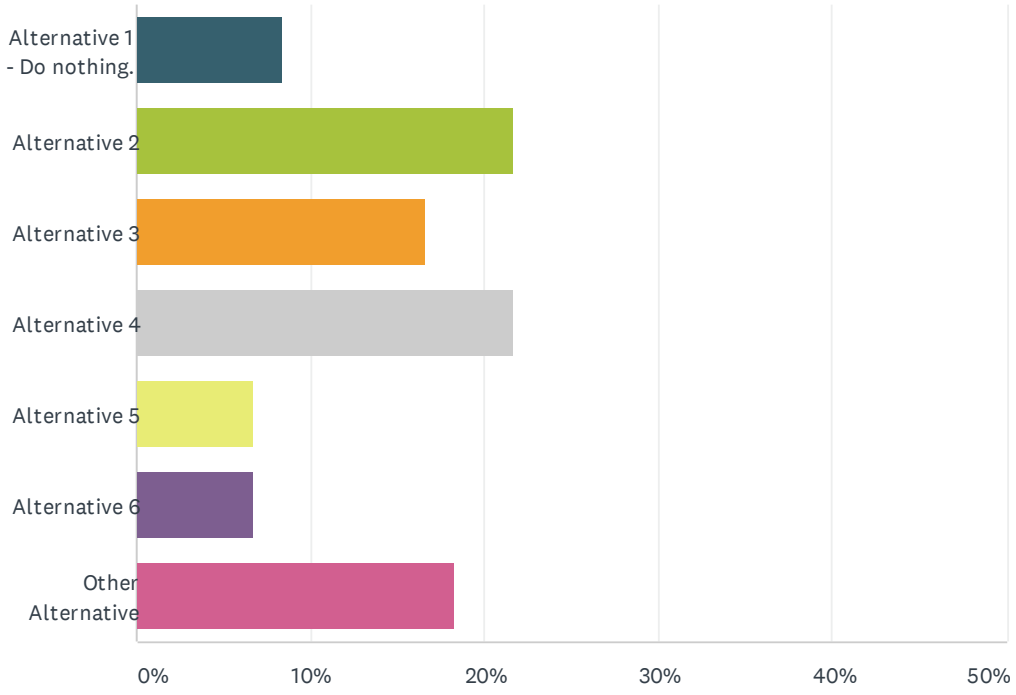


	TOO LITTLE	JUST RIGHT	TOO MUCH	NOT SURE	TOTAL
Improves drainage	4.55% 2	18.18% 8	43.18% 19	34.09% 15	44
Reduces flooding	4.55% 2	20.45% 9	38.64% 17	36.36% 16	44
Reduces damage to public infrastructure	6.82% 3	18.18% 8	34.09% 15	40.91% 18	44
Reduces damage to private property	6.82% 3	18.18% 8	36.36% 16	38.64% 17	44

#	DO YOU HAVE ANY OTHER COMMENTS ABOUT ALTERNATIVE #6 YOU'VE LIKE TO SHARE WITH THE PROJECT TEAM?	DATE
1	This could be a good solution if you can manage the runoff to get to Chumstick Creek without impacting too much private property. It would likely require more new infrastructure where there is already a mechanism to get water from Titus Rd to Chumstick Creek in the existing channel.	2/26/2021 3:17 PM
2	This seems like it would be very expensive for a flood problem that does happen vey often.	2/25/2021 8:09 PM
3	This seems more like a "wouldn't it be nice" rather than something that could realistically be done given the potential issues with forest service and homeowners.	2/22/2021 4:43 PM
4	Too much impact on private property and our local forest. Not a viable option. Moving the problem somewhere else does not solve it.	2/15/2021 11:47 AM
5	Problems ? To many unknowns.	2/10/2021 10:34 AM
6	This plan sounds expensive and difficult to implement	2/3/2021 9:22 PM
7	Alternative #6 may take care of the problem, but costs are likely a factor. It sounds expensive.	2/3/2021 6:27 PM
8	NOTHING in the ski hill parking lot or on our trails!!	1/28/2021 9:09 PM
9	Most expensive, but may be the best and cheapest in the long run.	1/28/2021 7:54 PM
10	Forces our flood event onto someone else. Major construction will be needed to protect Chumstick Highway.	1/27/2021 7:19 PM
11	Too vague, not enough info provided.	1/27/2021 3:07 PM
12	Not feasible.	1/26/2021 3:28 PM
13	NO!!	1/26/2021 2:00 PM
14	This would be a good option if it fully addresses the water issues at Detillion but with future development possible, option 4&5 would provide future development connections for stormwater overflow.	1/26/2021 12:10 PM
15	It looks too complex and cost prohibitive.	1/26/2021 10:49 AM
16	This would seem to open up all sort of problems and issues. It does plan to keep/direct canyon runoff separate from urban runoff which I think is the overall goal.	1/26/2021 10:07 AM
17	Too invasive, destructive to natural forest environment and is the "over-engineered" solution. Goes against the grain of natural topography and fall-lines. Too much $ and not worth the investment compared to the other options.	1/26/2021 9:45 AM
18	The Leavenworth Ski Hill is growing in popularity and the parking is in very short supply. Proposed retention pond looks to be built in the parking lot and nordic trail system.	1/26/2021 9:36 AM
19	Please! NO pond/gallery/basin or anything in the Ski Hill parking lot that reduces the space to park, ski, tube, hike, use the trails or whatever. We need all of that space to enjoy the Ski Hill! If you put in a pond we will lose our cross country trails as well as reduce the parking area. That is too important to our kids as a winter recreation area. If you need to drain from the lot area why don't you put culverts in from the parking lot under the road to the pond across the road by the City big water reservoir? That would not gut our skiing and trails and parking for tubing. Draining to Chumstick is fine, adding a pond or similar to the Ski Hill Parking lot is NOT okay - we lose too much by doing that.	1/25/2021 8:09 PM
20	way over the top	1/25/2021 2:18 PM

Q7 Which alternative do you prefer?

Answered: 60 Skipped: 6



ANSWER CHOICES	RESPONSES	
Alternative 1 - Do nothing.	8.33%	5
Alternative 2	21.67%	13
Alternative 3	16.67%	10
Alternative 4	21.67%	13
Alternative 5	6.67%	4
Alternative 6	6.67%	4
Other Alternative	18.33%	11
TOTAL		60

#	OTHER ALTERNATIVE. PLEASE DESCRIBE.	DATE
1	I like 2 & 3.	2/22/2021 4:43 PM
2	Please come up with a plan to also address the issues coming off of the area between Burnett Rd and Ski Blick, our porperty takes ALL THE WATER.	2/20/2021 4:51 PM
3	The aim of this project to hustle runoff water off the Ski Hill Basin is inappropriate. Even in flood, water is precious and needs to be conserved, especially in over-allocated, flow-limited basins and watersheds like the Chumstick and Wenatchee. Please design alternatives focused on retaining flood flows and getting them in the ground as much as possible. That approach will serve us better during our long, dry, fire-prone seasons that follow our brief floods.	2/20/2021 8:34 AM
4	Overall, these alternatives focus too much on engineering. Alt 5, if the long N-S feature was a swale (not a pipe), might be OK. Behind Club West, there are on-again, off-again efforts to manipulate the wetlands and remnants of old stream channels. For example some of it is now piped. That water should be daylighted once again. Putting water into pipes inhibits percolation and exacerbates flooding downstream. It'd be a better idea to enhance the wetland in the currently undeveloped area W of Aldea Village, and expand it onto portions of the MEND property (which has been for sale for years) and Agnew/ Hebert property between Titus Rd and Chumstick Hwy. This area could be an effective water retention location due to its location and topography, and it could be an attractive mitigation site for impacts to wetlands in the larger Ski Hill area as they are impaired due to activity along Pine St, on the former Brender property, near ALES, etc.	2/15/2021 7:53 PM
5	An improved pond/gallery north of Ski Hill/Titus road with a ditch cleaning and good annual maintenance.	2/15/2021 6:50 AM
6	Behind Club West, there are on-again, off-again efforts to manipulate the wetlands and remnants of old stream channels. For example some of it is now piped. That water should be daylighted once again. Putting water into pipes inhibits percolation and exacerbates flooding downstream. It'd be a better idea to enhance the wetland in the currently undeveloped area W of Aldea Village, and expand it onto portions of the MEND property (which has been for sale for years) and Agnew/ Hebert property between Titus Rd and Chumstick Hwy. This area could be an effective water retention location due to its location and topography, and it could be an attractive mitigation site for impacts to wetlands in the larger Ski Hill area as they are impaired due to activity along Pine St, on the former Brender property, near ALES, etc.	2/1/2021 8:55 PM
7	#1 or #2, but nothing in our ski hill parking lot or on our trails.	1/28/2021 9:09 PM
8	Alternative 4 with reduced east-west capacity and a bleed off to orchard.	1/27/2021 7:19 PM
9	It seems current planning is focused on flooding issues on the area on the eastside below ski hill. I am concerned that the flooding issues on the west side of Ski Hill Drive are not being addressed and might get worse if water is diverted or redirected on the eastside only. I would much appreciate more insight on this aspect.	1/26/2021 4:42 PM
10	Alternative #4 or #5 but I really want to understand how all of these alternatives impact the West Channel.	1/26/2021 10:16 AM
11	#1 if you do it regularly AND enlarge the culverts on upper Titus, end of Maple, end of Spring Street...or enlarge those culverts AND do #2.	1/25/2021 8:09 PM

Q8 Enter your email if you would like to receive an update when the report is completed.

Answered: 41 Skipped: 25

ANSWER CHOICES	RESPONSES	
Name	0.00%	0
Company	0.00%	0
Address	0.00%	0
Address 2	0.00%	0
City/Town	0.00%	0
State/Province	0.00%	0
ZIP/Postal Code	0.00%	0
Country	0.00%	0
Email Address	100.00%	41
Phone Number	0.00%	0

#	NAME	DATE
	There are no responses.	

#	COMPANY	DATE
	There are no responses.	

#	ADDRESS	DATE
	There are no responses.	

#	ADDRESS 2	DATE
	There are no responses.	

#	CITY/TOWN	DATE
	There are no responses.	

#	STATE/PROVINCE	DATE
	There are no responses.	

#	ZIP/POSTAL CODE	DATE
	There are no responses.	

#	COUNTRY	DATE
	There are no responses.	

#	EMAIL ADDRESS	DATE
1	dorothyjtn@gmail.com	2/27/2021 2:53 PM
2	birdrok@gmail.com	2/26/2021 3:18 PM
3	sanborn@nwi.net	2/26/2021 3:17 PM
4	dfullerwa@gmail.com	2/26/2021 10:22 AM
5	Pudforester2000@gmail.com	2/25/2021 8:09 PM
6	campfuller@yahoo.com	2/25/2021 11:55 AM
7	MKELLY@KELLYAPPRAISAL.COM	2/24/2021 11:06 AM
8	barbacovi@gmail.com	2/22/2021 4:43 PM
9	jayjay62@nwi.net	2/22/2021 2:43 PM
10	terimcintyre72@outlook.com	2/20/2021 4:51 PM
11	khalupka@frontier.com	2/19/2021 6:00 PM
12	clord46@charter.net	2/19/2021 12:05 PM
13	dnbbell@hotmail.com	2/16/2021 7:57 AM
14	pstroz13@gmail.com	2/15/2021 11:47 AM
15	sschimelfenig@yahoo.com	2/15/2021 6:50 AM
16	roslyndog@hotmail.com	2/14/2021 7:32 PM
17	wolfetj@frontier.com	2/14/2021 1:58 PM
18	tedtcc@gmail.com	2/13/2021 12:26 PM
19	mercyrome@gmail.com	2/12/2021 1:16 PM
20	cflorea@cityofleavenworth.com	2/10/2021 11:26 AM
21	gcpjday@aol.com	2/10/2021 10:34 AM
22	kinderranch@nwi.net	2/3/2021 6:27 PM
23	easy13b@netscape.net	2/3/2021 9:13 AM
24	ffj-ajf@nwi.net	2/3/2021 7:23 AM
25	davidmorgan29@hotmail.com	2/1/2021 8:55 PM
26	yorkbaur@hotmail.com	2/1/2021 12:55 PM
27	getintheAgame@gmail.com	2/1/2021 10:56 AM
28	levitsky52@aol.com	1/31/2021 4:43 PM
29	church.chris@gmail.com	1/30/2021 1:55 PM
30	bauer5503@genext.net	1/28/2021 7:54 PM
31	neimanken@comcast.net	1/27/2021 7:19 PM
32	robinodem@gmail.com	1/27/2021 3:07 PM
33	sibylle001@yahoo.com	1/26/2021 4:42 PM
34	keith@towerdesigns.com	1/26/2021 3:28 PM
35	dmorgan1242@fairpoint.net	1/26/2021 2:05 PM
36	streetspook@yahoo.com	1/26/2021 2:00 PM
37	dsmanager@cityofleavenworth.com	1/26/2021 12:10 PM

38	foyles@aol.com	1/26/2021 10:49 AM
39	lew_wagman@hotmail.com	1/26/2021 10:16 AM
40	mikepro3@gmail.com	1/26/2021 9:45 AM
41	fallonrob@gmail.com	1/26/2021 9:36 AM

#	PHONE NUMBER	DATE
	There are no responses.	

APPENDIX B

Press Release and News Articles

CHELAN COUNTY

FLOOD CONTROL ZONE DISTRICT
316 WASHINGTON STREET
SUITE 402
WENATCHEE, WASHINGTON 98801
TELEPHONE (509) 667-6415

ERIC PIERSON, PE
FCZD Administrator

FOR IMMEDIATE RELEASE
Date: 01/25/2021

Contact: Jill FitzSimmons, PIO
509-667-6415, jill.fizsimmons@co.chelan.wa.us

PRESS RELEASE

County seeks public input to help determine runoff relief measures in Ski Hill Basin area

LEAVENWORTH – The public is invited to participate in a survey that will be used in completing an analysis that will identify solutions to reduce the impacts of water runoff coming from the Ski Hill Basin in Leavenworth.

The analysis, paid for by the Chelan County Flood Control Zone District (FCZD), was started in 2019 and now has reached a critical point where input from the community is sought. Six alternatives have been identified that will mitigate, to various degrees and costs, flooding in the Ski Hill Basin. The public is asked to evaluate those alternatives.

Comments are being taken via a GIS StoryMap, which uses maps and descriptions to explain the water runoff problems in the Ski Hill Basin. It can be accessed online at the link below, or via the FCZD website (www.co.chelan.wa.us/flood-control-zone-district). **The FCZD asks people to complete the survey by Feb. 26.**

“We’re especially interested in hearing from those people living and working in the Ski Hill Basin and our partners in the Leavenworth community,” said Bob Bugert, Chelan County commissioner and FCZD supervisor. “Important mitigation efforts like these include gathering thoughts and opinions from the community.”

Located just north of the city of Leavenworth, the Ski Hill Basin stretches from the Cascade Range to the Wenatchee River. It includes national forest lands and the Ski Hill Lodge as well as residential and commercial areas. In most recent years, the area west of Titus Road has seen much residential development and growth.

In years past, basin homeowners have reported some flooding issues typically occurring during rapid snow melt in late winter and early spring. Water runoff in the basin also has overwhelmed county ditches and culverts, causing mud and debris to go across the road and impact traffic. The 2017 Comprehensive Flood Hazard Management Plan, also a project of the FCZD, identified Ski Hill as a top priority for flood mitigation efforts and called for an analysis of the basin to form an action plan for reducing flooding impacts to public and private property within Chelan County and the city limits of Leavenworth.

Resources:
Ski Hill Basin Analysis webpage
StoryMap

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June 05, 2021

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Bill Pay

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City Calendar

City Code

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Community Information

Community Pool

Employment Opportunities

GIS MAP/Permit Portal

Parks

Public Notices

Documents

- Open in a New Window or Tab -

County seeks public input to help determine runoff relief measures in Ski Hill Basin area

Filed under News, Press Releases, Public Notices, Uncategorized on January 26, 2021

Chelan County – Flood Control Zone District
1/25/2021

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StoryMap

FOR IMMEDIATE RELEASE Contact: Jill FitzSimmons, PIO Date: 01/25/2021
509-667-6415, jill.fitzsimmons@co.chelan.wa.us

Download full press release

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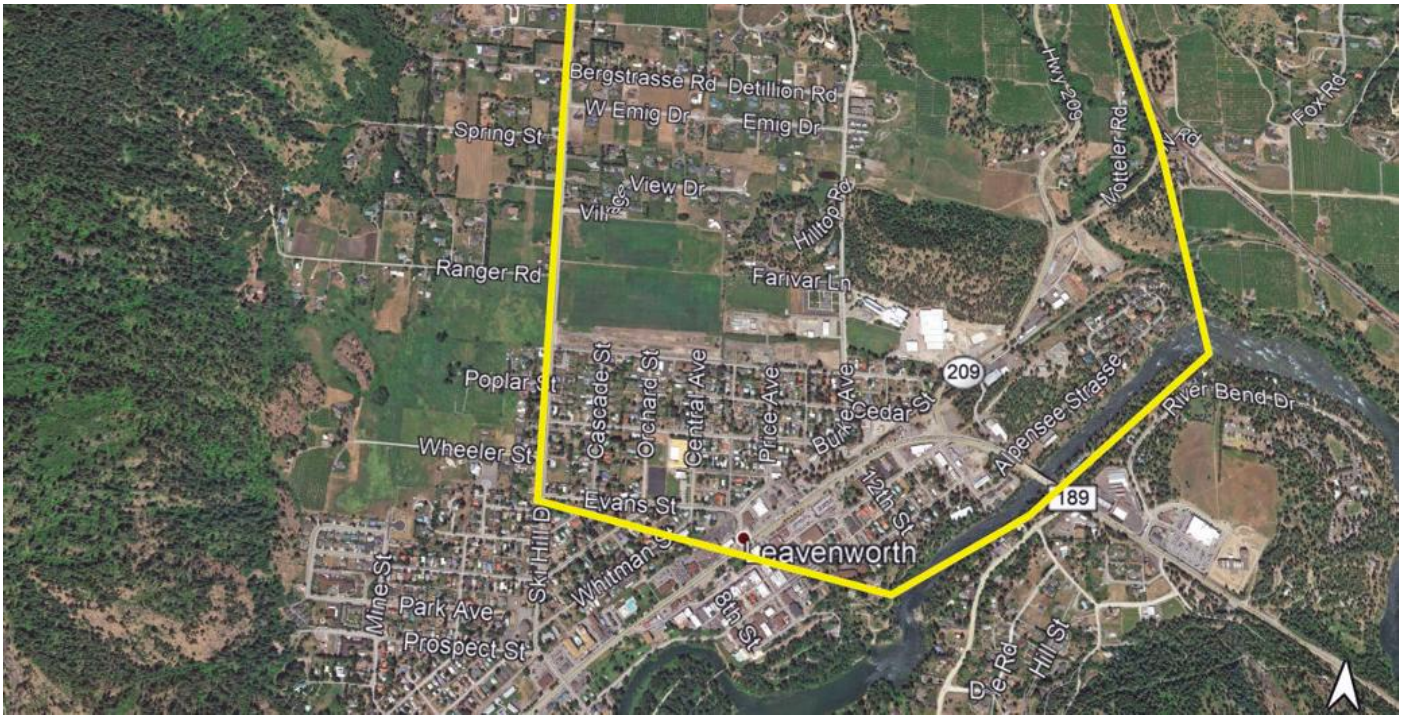
https://www.wenatcheeworld.com/news/where-will-the-ski-hill-runoff-water-go/article_65a94c8a-628e-11eb-97b6-2fdc39ebe1bf.html

Where will the Ski Hill runoff water go?

By Nevonne McDaniels
World staff writer
Jan 29, 2021



The Chelan County Flood Control Zone District is looking at a series of possible solutions for runoff from Ski Hill that has created issues for homeowners, especially during rapid snow melt in late winter and early spring. A survey asking for input is available at **wwrld.us/3j3kFl4**.

Provided map

LEAVENWORTH — Six options to prevent flooding in the Ski Hill Basin are being presented to the community in a survey form as part of a project being considered by the Chelan County Flood Control Zone District.

The alternatives, which range from doing nothing to piping water along Titus Road and across private and U.S. Forest Service land to a culvert under Chumstick Highway, are part of an analysis funded by the district aimed at reducing the impacts of water runoff from Ski Hill. Most of the proposed options address drainage issues along Titus and and Detillion roads.

Comments are being taken online through Feb. 26 at **wwrld.us/3j3kFl4**. The site includes maps and descriptions to explain the water runoff problems in the Ski Hill Basin.

“We’re especially interested in hearing from those people living and working in the Ski Hill Basin and our partners in the Leavenworth community,” said Bob Bugert, Chelan County commissioner and flood control district supervisor. “Important mitigation efforts like these include gathering thoughts and opinions from the community.”

The Ski Hill Basin, north of the Leavenworth city limits, stretches from the Cascade Range to the Wenatchee River. It includes national forest lands, the Ski Hill Lodge, residential and commercial areas. The area west of Titus Road has seen much residential development and growth in recent years.

Flooding has occurred during rapid snow melt in late winter and early spring, causing ditches to overflow, pushing mud and debris across the road.

The flood control district has studied the issue since 2019. Ski Hill was identified as a priority for flood mitigation in the 2017 Comprehensive Flood Hazard Management Plan, also a project of the flood control district.

Ski hill runoff options

Here is a summary of the alternatives being considered on the survey. The specific costs of each has not been determined.

Alternative 1: No action. No new drainage features added, but on-going maintenance of the ditches and culverts will continue as necessary.

Alternative 2: Increase the size of the roadside ditches and culverts along Detillion and Titus roads, which will capture more runoff from uphill, particularly during the spring when ditches may be partially blocked by snow.

The ditch adjacent to Titus Road also may be improved to prevent erosion. All runoff would be directed to the channel shown as a green dashed line which drains into Chumstick Creek.

Alternative 3: In addition to Alternative 2 actions, it would add a pond near the Ski Hill parking lot and build larger swales along the north side of Titus Road between the existing culverts.

The pond would help store water and reduce runoff flowing along the north side of Titus Road. The swales would direct more water through culverts under Titus Road, keeping water from going over the road.

Alternative 4: Alternative 2 and 3, expanding the swale along Titus Road and adding a culvert along Titus, traveling east/west. It also would improve the Titus ditches and culverts north-to-south. The idea is to reduce flow into the orchard south of Ski Hill by directing more water toward the Titus side.

Alternative 5: All the features of Alternative 3, plus a new ditch, swale or pipe, from about midway on the east/west stretch of Titus Road south to Detillion Road, connecting to the improved ditch there.

Alternative 6: Add a pond at the Ski Hill parking lot and direct runoff to a new swale or pipe along the north side of Titus Road that would then continue across private and USFS land to a new culvert under Chumstick Highway. Permission from multiple landowners would be required.

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