APPENDIX I

Water Resources

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JUNE 2025

Harvey Field Runway Improvement EA: Preliminary Water Resources Design Report

RS&H

Harvey Field Runway Improvement EA: Preliminary Water Resources Design Report

June 2025
Snohomish, WA
RS&H No.: 1047-0064-000

Prepared by RS&H, Inc. at the direction of Harvey Field, Inc.

RS&H

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CHAPTER 1

INTRODUCTION AND PURPOSE

1.1 INTRODUCTION

Harvey Field, Inc. (Client) contracted RS&H, Inc. to perform an Environmental Assessment (EA) for the Runway Improvement Project (Proposed Action) at Harvey Field (Airport). The Airport is privately owned and operated by Kandace Harvey (Airport Sponsor) and located in Snohomish County (County), Washington, approximately 25 miles northeast of the City of Seattle. The Proposed Action includes the construction of proposed Runway 15-33, a new parallel taxiway, and relocation of Airport Way, as well as associated development to support the new paved runway and parallel taxiway. Additional details on the Proposed Action can be found in **Section 1.5** of the EA narrative. The sections below describe the contents of this report as they apply to elements discussed in the EA narrative.

1.2 SURFACE WATER

RS&H has reviewed and documented existing surface water quality conditions in the Study Area. This report evaluates the hydrologic impact of the Proposed Action under the EA in order to meet requirements laid out by the National Environmental Policy Act (NEPA), Council on Environmental Quality (CEQ), Federal Aviation Administration (FAA), Endangered Species Act (ESA), and the Washington Department of Ecology. RS&H analyzed the changes in peak runoff flow rates and runoff volumes between existing and proposed conditions under the Proposed Action. Drainage analysis within this report was performed in accordance with the Snohomish County Drainage Manual (SCDM) Volume III – Hydrologic Analysis and Flow Control Best Management Practices (BMPs), dated July 2021. Currently, in the existing conditions, there are only water quality facilities at the Airport. In the absence of original design information, RS&H estimated the treatment capacities of these stormwater facilities by applying the water quality storm event to their respective contributing areas. It is assumed that the original design of these stormwater facilities was intended to treat these calculated water quality volumes.

1.3 GROUNDWATER

The Proposed Action and all cumulative development projects are required to comply with all applicable existing regulations that prevent exceedances in groundwater quality standards and maintain groundwater recharge. These groundwater regulations include the federal Safe Drinking Water Act (SDWA) and the Washington State Groundwater Quality Standards.

1.4 FLOODPLAINS

RS&H has reviewed and documented existing floodplains in the Study Area and evaluated potential impacts from encroachment or alterations of the floodplains. RS&H also evaluated Snohomish County Code (SCC) Density Fringe Requirements for maximum allowable density and maximum allowable obstruction. RS&H has also researched local adaptation activities to ascertain the extent of regional efforts, status, and data sharing opportunities associated with climate resiliency for the Proposed Action. These resources include an assessment prepared by Washington Coastal Resilience Project (WCRP) which analyzes localized sea level rise projections for varying climate scenarios that consider coastal inundation hazard composites including low-lying areas, areas affected by storm surge, and flood zones. This report defines the readily available data regarding sea level rise and evaluates potential hazards and impacts adjacent to the Proposed Action and on critical infrastructure associated with the Proposed Action.

CHAPTER 2
SURFACE WATERS

2.1 SITE HYDROLOGY

The Study Area is within the Snohomish River-Frontal Possession Sound watershed (Hydrologic Unit Code (HUC): 171100110203). The Study Area has two primary stormwater basins with distinct outlet points, designated the North Basin and South Basin. See **Figure 1.** Stormwater runoff from the North Basin generally flows off airfield pavements into vegetated infields and ditches. Stormwater runoff is then collected in underground storm sewer and discharged off-site from a culvert under State Route 9 to the west. Runoff generated from the airfield flows through a series of grass-lined drainage ditches and eventually discharges into the Snohomish River at a pump station several miles downstream of the Airport. A portion of the stormwater runoff generated from the northern portion of Airport Property is conveyed to water quality facilities which provide water quality treatment of stormwater runoff for frequent, low flow runoff-producing precipitation events. There are three water quality facilities located within or immediately adjacent to the Study Area, one (1) bioswale and two (2) sets of infiltration trenches. Descriptions of these water quality facilities are as follows:

- Bioswale – vegetated channel designed to convey stormwater while removing pollutants
- Infiltration Trench – a trench filled with stone that receives runoff from adjacent upstream surfaces and allows water to infiltrate into the ground prior to leaving the site

Stormwater runoff from the South Basin generally sheet flows off paved roads and into Hanson Slough, which is a low laying wetland area. Runoff is then discharged off-site to the southeast to Batt Slough through an existing 18” culvert with two 6” laterals. Runoff from the South Basin eventually discharges to the Snohomish River to the east. There are currently no existing water quality facilities in the southern portion of Airport Property.

Due to existing low topographic relief across the site, the existing Airport Way alignment would continue to serve as a drainage divide and the boundaries for the North and South basins in would be unaltered in proposed conditions. Drainage basin boundaries and outfalls will remain unchanged in proposed conditions. Proposed changes in hydrologic conditions and stormwater system under the Proposed Action can be seen in **Figure 2**.

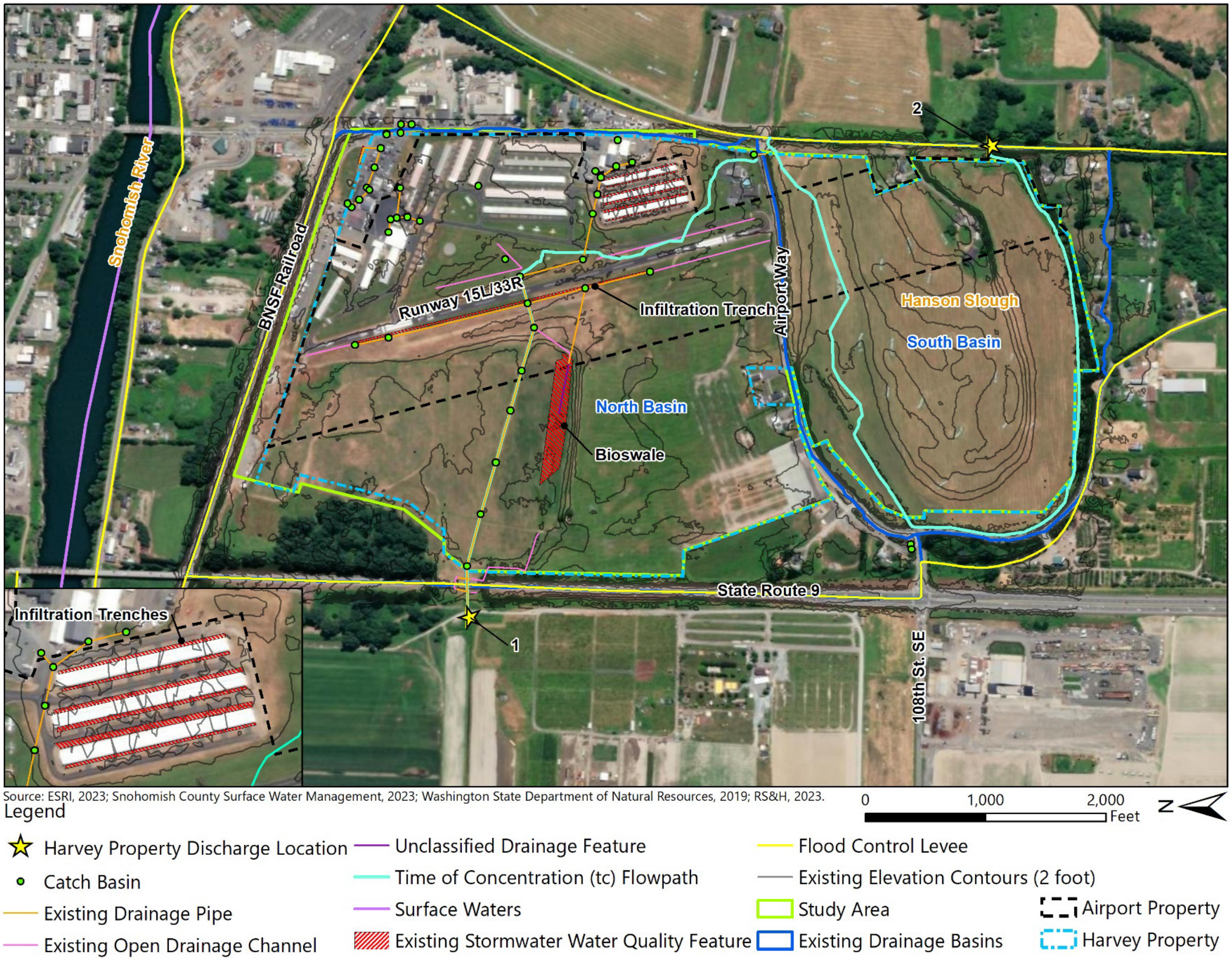


FIGURE 1: EXISTING HYDROLOGIC CONDITIONS

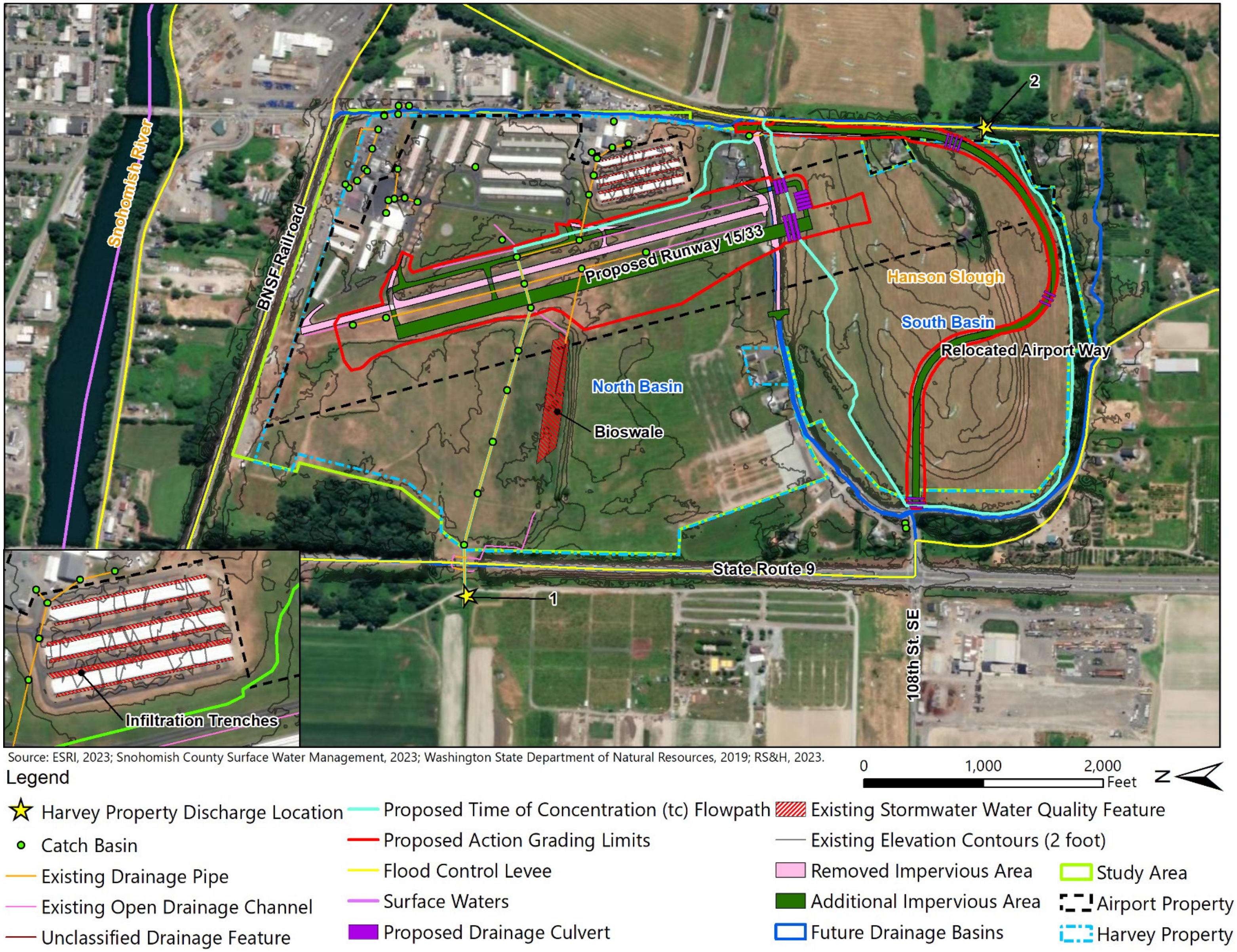


FIGURE 2: PROPOSED HYDROLOGIC CONDITIONS

2.2 COMPLIANCE WITH REGULATORY REQUIREMENTS

2.2.1 Snohomish County

Chapter 2 of the SCDM Volume I – Minimum Technical Requirements sets forth Nine Minimum Requirements (MRs) for new development and redevelopment projects. The Proposed Action could be categorized as a new development project because the site has less than 35% hard surface coverage in the existing condition. The nine MRs are as follows:

1. *Preparation of a stormwater site plan**
2. *Stormwater pollution prevention plan (SWPPP)^*
3. *Water pollution source control for new development activities*
4. *Preservation of natural drainage system or outfalls and provision of off-site mitigation*
5. *On-site stormwater management*
6. *Runoff treatment*
7. *Flow Control requirements for new development*
8. *Stormwater discharge to wetlands*
9. *Inspection, operation, and maintenance requirements**

*To be completed in the design phase
^To be completed by the contractor prior to construction phase

For the purposes of this analysis, the focus will be on MRs 3 through 8 as they impact the proposed stormwater improvements. The following sections briefly describe these requirements and their applicability to this project.

2.2.1.1 MR 3: Water Pollution Source Control for New Development Activities

MR 3 requires the implementation of source control best management practices (BMPs) during construction and on the developed site following construction. SCDM Volume IV provides specific guidance regarding which source control BMPs should be implemented. All known, available and reasonable source control BMPs are required:

- *Source control BMPs in accordance with SCDM Volume IV, Chapters 3 and 4 shall be applied during construction if any pollution-generating activities are performed on the site during construction; and,*

- *Source control BMPs in accordance with SCDM Volume IV, Chapter 5 shall be selected, designed, and constructed if any pollution-generating activities or uses are proposed for the developed site following construction.*

Both types of source control BMPs listed above would be implemented concurrently with the Proposed Action as soil disturbance would occur during construction, and aircraft maintenance and fueling would occur post-construction. Viable source control BMPs that could be implemented on site are as follows:

- *Design loading/unloading areas with berms, sloping, etc. to prevent run-on of stormwater*
- *Prepare a Spill Control Plan (SCP)*
- *Install Stabilized Construction Entrance/Exit*
- *Provide Temporary and Permanent Seeding/Sodding*

2.2.1.2 MR 4: Preservation of Natural Drainage System or Outfalls and Provision of Off-Site Mitigation

MR 4 dictates the preservation of natural drainage systems and outfalls and provision of off-site mitigation. The following elements dictate if this minimum requirement is met:

- *Natural drainage patterns occurring over the past 10 consecutive years shall be maintained*
- *Discharges from the project site shall occur at natural locations*
- *The manner by which runoff is discharged from the project site shall not cause off-site drainage impacts*

The Proposed Action would not modify drainage boundaries nor existing stormwater outfalls. Additionally, proposed conditions peak flow rates at stormwater outfalls would not exceed those of existing conditions which would minimize off-site drainage impacts. As a result, the Proposed Action would meet the requirements of MR 4.

2.2.1.3 MR 5: On-site Stormwater Management

MR 5 requires implementation of on-site permanent stormwater facilities to meet specific Low Impact Development (LID) performance standards. SCDM Volume I, Section 2.5.5 provides specific guidance regarding which permanent stormwater facilities should be implemented. MR 5 is applicable to all projects unless a project qualifies for an exception as defined by the SCC. Additionally, projects that are exempt from MR 7 do not have to achieve the LID performance standards, nor consider bioretention, rain gardens, permeable pavement, and full dispersion. RS&H determined that the Proposed Action is exempt from MR 7, thus the performance standards listed above would not be required for the Proposed Action. See **Section 2.2.1.5** of this document for additional information regarding the applicability of MR 7.

As the Proposed Action is exempt from MR 7, the following permanent stormwater facilities would be implemented, if feasible:

- *Post-Construction Soil Quality and Depth; and*
- *Concentrated Flow Dispersion or Sheet Flow Dispersion*

2.2.1.4 MR 6: Runoff Treatment

MR 6 dictates that stormwater treatment facilities shall be provided for each discharge area in which the following criteria are met:

- *The total of pollution-generating hard surface is 5,000 square feet or more; or*
- *The total of pollution-generating pervious surfaces is 0.75 acres or more.*

The Proposed Action would meet both criteria, so stormwater runoff from disturbed areas would be treated by future permanent stormwater facilities. The Airport is under the jurisdiction of the Snohomish County Phase 1 Municipal Separate Storm Sewer System (MS4) permit and is required to comply with standards of pollutant discharge set forth in the permit, including adherence to water quality criteria established in the SCDM. The procedures set forth in the SCDM Volume I, Chapter 4, Section 4.3 determines the specific type of stormwater treatment required for the project. SCDM Volume V, Chapter 4, Section 4.1 provides requirements for design storm volumes and flow rates.

2.2.1.5 MR 7: Flow Control Requirements for New Development

According to the SCDM Volume III, Section 2.2.2, flow control measures to reduce peak flow rates to pre-developed (that is, forested, uninhabited) conditions are required for most developments. However, flow control is not required for areas that discharge through a MS4 to a tidal waterway and where additional site-specific criteria are met. The Snohomish River, downstream of the confluence of the Snoqualmie River and the Skykomish River, is considered a tidal waterway. To be exempt from flow control requirements, a development must also meet all of the following criteria:

- *Not divert drainage from any waterbody with specific classification from the Washington State Department of Ecology;*
- *Have a contributing area that is drained by a conveyance system comprised of entirely manmade structures, such as pipes and ditches;*
- *Have sufficient hydraulic capacity to convey runoff from future build-out conditions; and,*
- *Have adequate stabilization of erodible manmade conveyance system elements.*

These criteria are all met for the Study Area, thus flow control to pre-developed runoff rates would not be required for the Proposed Action.

2.2.1.6 MR 8: Stormwater Discharge to Wetlands

Per MR 8, projects shall employ permanent stormwater facilities to reduce impacts of stormwater runoff to wetlands. The North Basin and South Basin both discharge to wetlands, which can be seen in **Figure 3** below, with detailed information found in the Wetlands Report.

The Level of Wetland Protection, including continuous simulation modeling, would be determined in the design phase of the Proposed Action. However, it is anticipated that the Proposed Action would be able to meet all requirements of the Level of Wetland Protection application package, including:

- *General protection of wetlands*
- *Protection from pollutants through the use of construction stormwater BMPs, source control BMPs, LID practices and principles, and water quality facilities*
- *Wetland Hydroperiod Protection*: required as Study Area is in a Critical Aquifer Recharge Area (CARA) with high sensitivity to contamination. See **Section 3.2** of this document for more detailed discussion.
- *No permanent stormwater facilities are proposed in wetlands or their associated buffer zones*

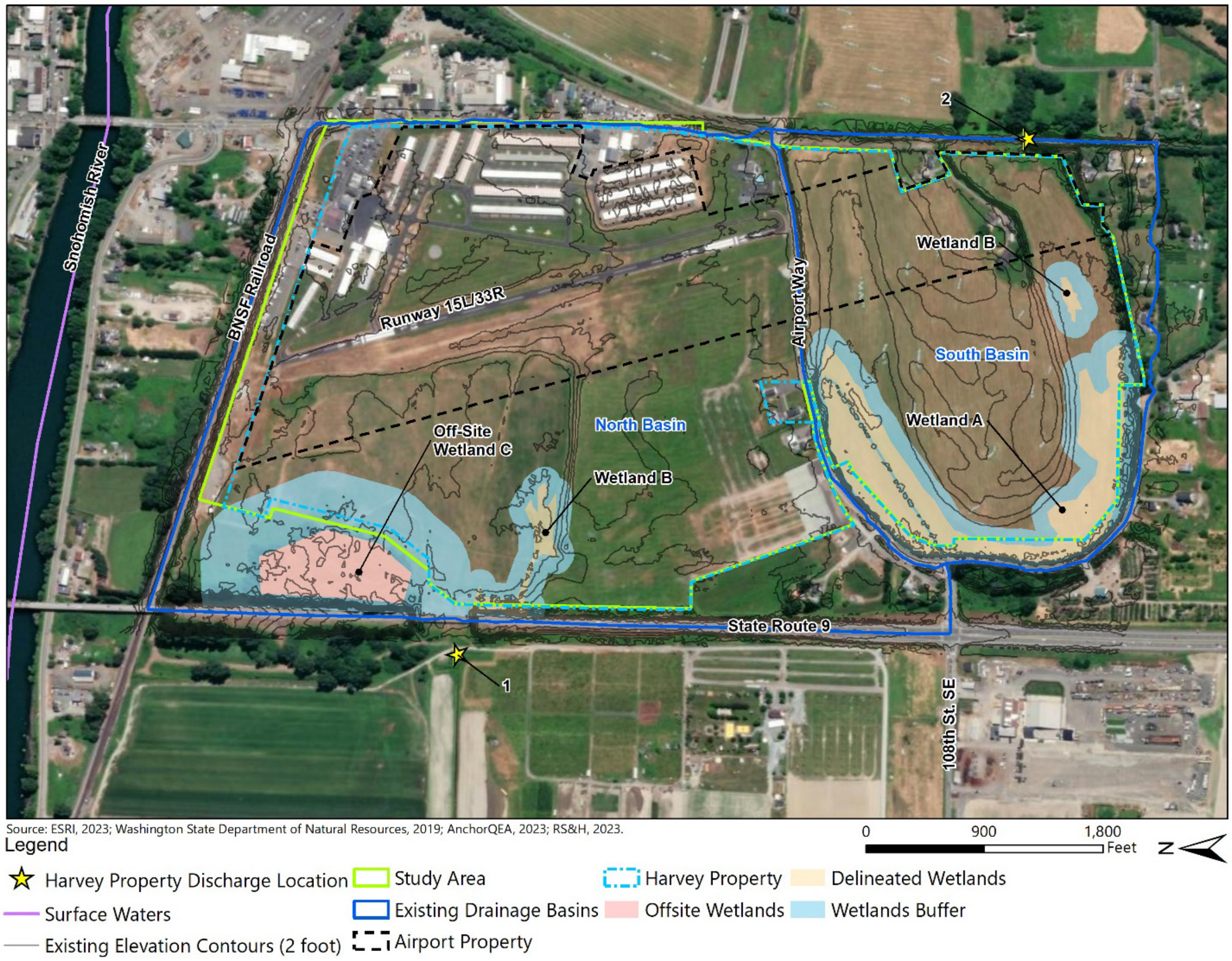


FIGURE 3: EXISTING DRAINAGE BASINS AND DELINEATED WETLANDS

2.2.2 Marshland Flood Control District

The off-site drainage ditches and pump station downstream from the project site are owned by the Marshland Flood Control District (FCD). See **Figure 4** for Marshland FCD boundaries. The Marshland FCD has the authority to engage in flood control activities necessary to prevent inundation or flooding from water bodies and take actions necessary to protect life and property from inundation or flow of flood waters, stormwaters, or surface waters. To minimize impacts to downstream properties and drainage infrastructure owned by the Marshland FCD, the stormwater improvements Proposed Action will ensure that peak flow rates from proposed conditions are less than or equal to those in existing conditions, regardless of the applicability of Snohomish County flow control requirements.

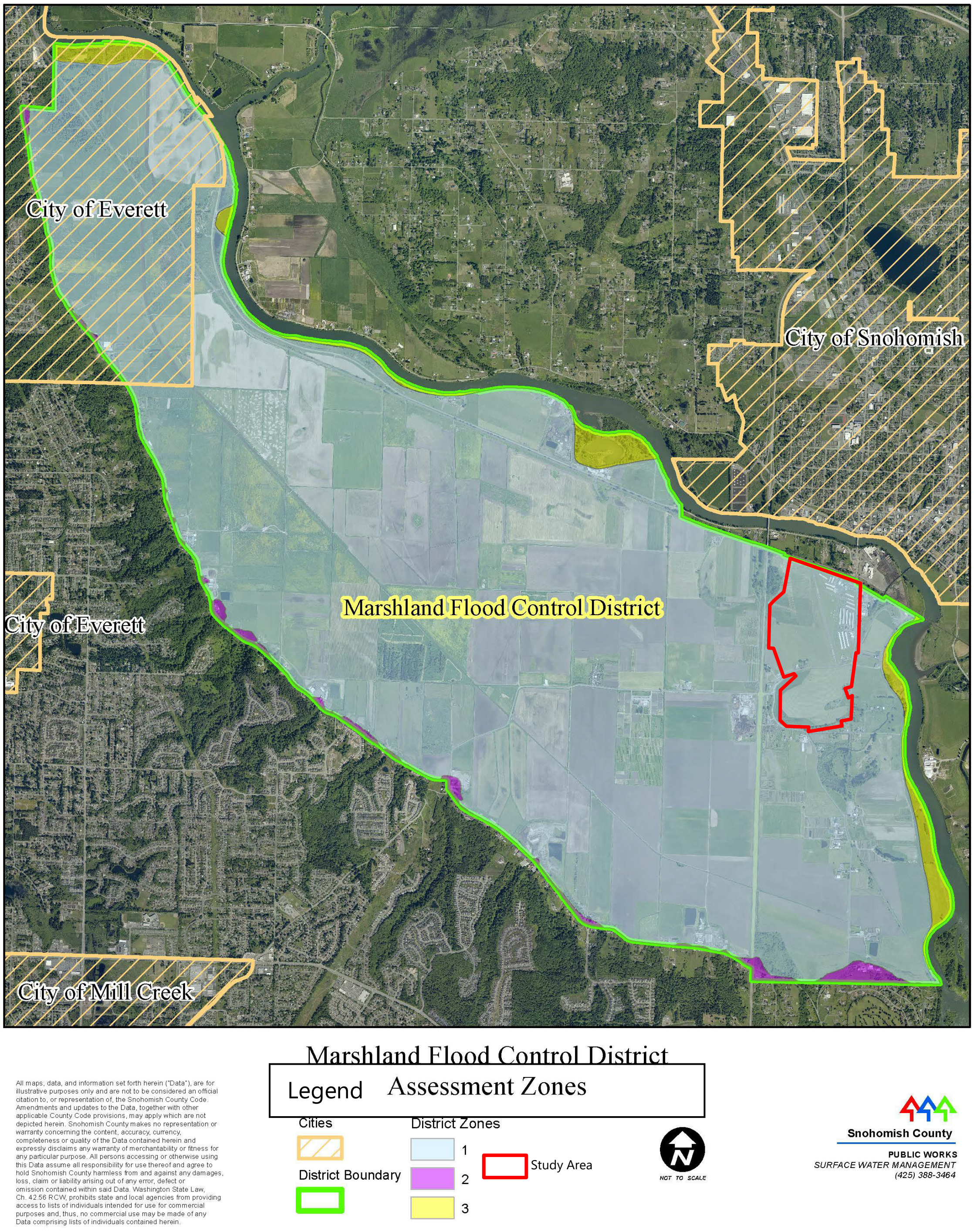


FIGURE 4: MARSHLAND FCD JURISDICTIONAL BOUNDARIES

2.2.3 Endangered Species

Projects that require federal permits and/or utilize federal funding are required to address the potential project impacts on federally listed threatened or endangered species and their designated or proposed critical habitat under Section 7 of the ESA and to address impacts to Essential Fish Habitat under the

Magnuson-Stevens Fisheries Management and Conservation Act. Multiple threatened or endangered fish species are documented in the Snohomish River. Due to the presence of endangered species in the Snohomish River, permanent stormwater improvements under the Proposed Action will be designed to have proposed conditions peak flow rates are less than those in existing conditions to assist in mitigate potential hazards to endangered species. A combination of flow control and permanent infiltration facilities would prevent an increase of pollutant discharge to surface waters which could adversely impact these species (Jviation, 2018).

2.3 WATER QUANTITY

RS&H utilized Technical Release 55 (TR-55) method, as described in the *Urban Hydrology for Small Watersheds TR-55 Manual,* to determine the difference in peak discharge rate resulting from the Proposed Action in the two drainage basins. The SCDM requires this runoff calculation method for projects over 25 acres. The TR-55 manual was developed by the Natural Resources Conservation Service (NRCS), a branch of the United States Department of Agriculture (USDA). The TR-55 method utilizes site topography, time of concentration (t_c), land cover, and soil type to delineate drainage basins and determine the site stormwater runoff.

2.3.1 Drainage Basins

RS&H delineated the existing drainage basins using existing LiDAR data from the Washington State Department of Natural Resources (DNR) and levee data provided by the Federal Emergency Management Agency (FEMA). Proposed drainage basins were unchanged from existing basins based on preliminary grading for the Proposed Action and lack of impact on existing levees. RS&H determined existing and proposed land covers for drainage basins utilizing aerial imagery (Maxar 2023) and the Proposed Action improvements. **Table 1** and **Table 2** summarize the land cover in existing and proposed drainage basins.

TABLE 1: NORTH DRAINAGE BASIN IMPERVIOUS COVER SUMMARY

Conditions	Discharge Location*	Area (acres)	Impervious Area (acres)	Percent Impervious
Existing	1	178.68	27.59	15.4%
Proposed	1	178.68	30.05	16.8%
Net Change			2.46	1.4%

*See **Figure 1** and **Figure 2** for existing and proposed hydrologic conditions, respectively.

TABLE 2: SOUTH DRAINAGE BASIN IMPERVIOUS COVER SUMMARY

Conditions	Discharge Location*	Area (acres)	Impervious Area (acres)	Percent Impervious
Existing	2	84.16	3.01	3.6%
Proposed	2	84.16	6.35	7.5%
Net Change			3.34	4.0%

*See **Figure 1** and **Figure 2** for existing and proposed hydrologic conditions, respectively.

2.3.2 Time of Concentration (t_c)

T_c is the time it takes runoff to travel from the hydraulically most distant point in the watershed or basin to the point of interest and is used in calculating the peak runoff rate. RS&H calculated the T_c for each existing and proposed drainage basin utilizing the NRCS Runoff Method. T_c flow paths for existing basins were determined using existing LiDAR elevation data and stormwater infrastructure data collected from the Snohomish County Drainage Inventory. The Snohomish County Drainage Inventory indicated that Corrugated Metal Pipe (CMP), High-density Polyethylene Pipe (HDPE), and Reinforced Concrete Pipe (RCP) are present on site. T_c for proposed conditions accounts for changes in hydrology based on preliminary proposed grading. The Manning's roughness coefficients (n) used in time of concentration calculations are shown in **Table 3** below. See **Attachment I-1** for T_c calculations.

TABLE 3: MANNING'S N VALUES

Material	Manning's n
Corrugated Metal Pipe (CMP)	0.024
High-density Polyethylene Pipe (HDPE)	0.012
Reinforced Concrete Pipe (RCP)	0.013

Source: Snohomish County Engineering Design and Development Standards, Table 5-2

2.3.3 Soils, Land Cover, and Curve Number

Soil type and land cover within the Study Area impact the amount of runoff produced by rainfall. These site characteristics can be used to determine runoff curve numbers (CN) for the site, which indicate the site's runoff potential. RS&H utilized NRCS resources to determine the types of soil found on site at the Airport. Soils on site consist of Puget Silty Clay Loam, Sultan Silt Loam, and Puyallup Fine Sandy Loam. Puget Silty Clay Loam and Puyallup Fine Sandy Loam are part of Hydrologic Soil Group (HSG) A and Sultan Silt Loam is part of HSG C. Soils in HSG A have high infiltration rates while soils in HSG C typically have moderately low infiltration rates. See **Attachment I-2** for NRCS Soils Report. **Table 4** below presents the soil types, land covers, and CN values for the site.

TABLE 4: LAND COVER AND CURVE NUMBER VALUES

Soil Type	Land Cover Description	Curve Number (CN)
Hydrologic Soil Group A	Good Condition (ground cover >75 percent and lightly or only occasionally grazed)	39
Hydrologic Soil Group C	Good Condition (ground cover >75 percent and lightly or only occasionally grazed)	74
Impervious	Paved Area, Roofs	98

Source: SCDM Volume III, Table 3-2.

2.3.4 Rainfall Depths

RS&H determined local rainfall depths using isopluvial maps from in the *SCDM Volume III, Appendix III-A and NOAA Atlas 2, Volume IX*. The SCDM requires analysis for runoff rates from the 2-, 10-, 50-, and 100-year, 24-hour storm events. Rainfall depths for these design storms are provided in **Table 5** below.

TABLE 5: RAINFALL DEPTH

Design Storm	Rainfall Depth (inches)
2-Year	1.9
10-Year	2.6
50-Year	3.3
100-Year	3.7

2.3.5 Peak Discharge

Using the TR-55 method with the variables as described in the above sections, RS&H determined peak discharge values across existing and proposed basins. Without permanent stormwater facilities for attenuation, the Proposed Action would increase stormwater runoff in both Airport drainage basins across each design storm analyzed. **Table 6** and **Table 7** below present the peak discharges and increases in peak discharge across each basin for the three design storms analyzed. See **Attachment I-3** for existing hydrologic conditions, CN and Peak Discharge calculations.

TABLE 6: NORTH BASIN PEAK DISCHARGE SUMMARY

Condition	Area (acres)	Time of Concentration (minutes)	Curve Number Value	2-Year Peak Discharge (cubic feet per second [cfs])*	10-Year Peak Discharge (cfs)*	50-Year Peak Discharge (cfs)*	100-Year Peak Discharge (cfs)*
Existing	178.68	55	72.55	3.49	9.30	21.18	31.02
Proposed	178.68	53.7	72.73	3.63	9.41	21.67	31.64
Net Change				+0.14	+0.11	+0.49	+0.62

*Peak Discharge Equation: $Q_p = q_u*A_m*Q*F_p$

q_u = Unit Peak Discharge (from TR-55 Manual), A_m = Drainage Area, Q = Runoff, F_p (Pond and Swamp Adjustment Factor) = 1

TABLE 7: SOUTH BASIN PEAK DISCHARGE SUMMARY

Condition	Area (acres)	Time of Concentration (minutes)	Curve Number Value	2-Year Peak Discharge (cubic feet per second [cfs])*	10-Year Peak Discharge (cfs)*	50-Year Peak Discharge (cfs)*	100-Year Peak Discharge (cfs)*
Existing	84.16	134.6	72.44	1.46	3.66	7.79	10.49
Proposed	84.16	143.4	73.43	1.61	3.99	8.34	11.16
Net Change				+0.15	+0.33	+0.55	+0.67

*Peak Discharge Equation: $Q_p = q_u*A_m*Q*F_p$

q_u = Unit Peak Discharge (from TR-55 Manual), A_m = Drainage Area, Q = Runoff, F_p (Pond and Swamp Adjustment Factor) = 1

2.3.6 Future Design Considerations

SCDM Volume III – Hydrologic Analysis and Flow Control BMPs, identifies the general requirements for stormwater quality facilities and may be used in final design to treat the volumes shown in **Table 8** below**.** Proposed permanent stormwater facilities should be designed to be less than or equal to the existing conditions flow rates discussed in **Section 2.3.5** of this document. Proposed permanent stormwater facilities may also be designed to provide some treatment, thus contributing to the necessary water quality volumes discussed in **Section 2.4.1** of this document. The increases in peak flow rates and required water quality volumes as a result of the Proposed Action are considered minor and could likely be mitigated through minor alterations of existing stormwater facilities or modifications to the existing stormwater system. Due high aquifer sensitivity in the Study Area, infiltration facilities utilizing perforated underdrains are prohibited in the Study Area (see discussion in Section 3.1). If new permanent stormwater facilities are necessary to be required in final design, the following permanent stormwater facilities are approved in SCDM Volume III to meet the flow control requirements:

- Detention Ponds
- Detention Pipes
- Detention Vaults

These permanent stormwater facilities should be designed to not interfere with known groundwater elevations and to limit standing water requirements to those outlined in FAA Advisory Circular (AC) 150/5200-33C, *Hazardous Wildlife Attractants on or Near Airports*. Additionally, in final design, detailed hydrologic modeling may show that the existing Hanson Slough, located in the South drainage basin, acts as a storage area for stormwater detention and assists in meeting flow control requirements for the South Basin.

2.4 WATER QUALITY

2.4.1 Calculations

SCDM Volume III, Section 2.3.1 identifies the design storm for volume-based treatment facility sizing is the 6-month, 24-hour rainfall depth, which can be calculated as 72% of the 2-year, 24-hour storm rainfall depth. Utilizing the runoff depth from the 6-month, 24-hour design storm applied across the drainage basin area yielded a water quality volume. RS&H used the TR-55 method to determine the runoff depth and total disturbed area for each basin to calculate the water quality volumes in each basin under proposed conditions. Note that some runoff from the airport is currently not treated and is not within the proposed grading limits. As this runoff is not treated in the existing condition, water quality volumes were calculated just for the disturbed area associated with the Proposed Action, inclusive of replaced impervious surfaces. Runoff generated from storm events greater than the water quality storm event would discharge through existing stormwater outfalls, shown in **Figure 1** and **Figure 2**. See **Attachment I-4** for water quality volume calculations.

The North Basin has three water quality facilities in place to treat stormwater runoff: a bioswale, an infiltration trench for the runway, and multiple infiltration trenches for a set of hangars towards the southeast corner of the Airport. These water quality facilities can be seen in **Figure 2,** with contributing areas for the existing water quality facilities shown in **Figure 5**. RS&H calculated treatment volumes for each water quality facility based on contributing area, land cover, and runoff (**Table 8** below) to estimate the current capacity of these permanent stormwater facilities. See **Attachment I-5** for water quality volume calculations and existing stormwater facility contributing areas. The Proposed Action would require removal of the existing infiltration trench that treats stormwater from a portion of the existing runway and the grass area adjacent to the west of the runway. This volume must be treated in the proposed conditions in addition to the treatment volumes provided in **Table 9** below**,** amounting to a necessary water quality volume of 0.24 acre-feet for the North Basin and 0.06 acre-feet for the South Basin. See **Figure 6** for proposed water quality treatment facility contributing areas. The functionality of other existing stormwater facilities should be confirmed in final design.

TABLE 8: EXISTING STORMWATER BMP WATER QUALITY VOLUMES

Existing Stormwater Facilities	Contributing Area (square feet)	Runoff, Q (inches)	Available Treatment Volume (cubic feet)	Available Treatment Volume (acre-feet)
Facility 1 – Bioswale	927,808	0.107	8,273	0.19
Facility 2 – Runway Infiltration Trench	373,600	0.073	2,273	0.05
Facility 3 – Hangar Infiltration Trenches	134,549	0.372	4,171	0.10

Note: V (cf) =A*Q/12

TABLE 9: REQUIRED WATER QUALITY VOLUMES FOR DISTURBED AREAS

Basin	Disturbed Area (acres)	Water Quality Volume (cubic feet)	Water Quality Volume (acre-feet)	Demolished Existing Water Quality Volume (acre-feet)	Total Required Water Quality Volume (acre-feet)
North	26.49	8,269	0.19	0.05	0.24
South	7.86	2,768	0.06	-	0.06

FIGURE 5: EXISTING WATER QUALITY TREATMENT CONTRIBUTING AREAS

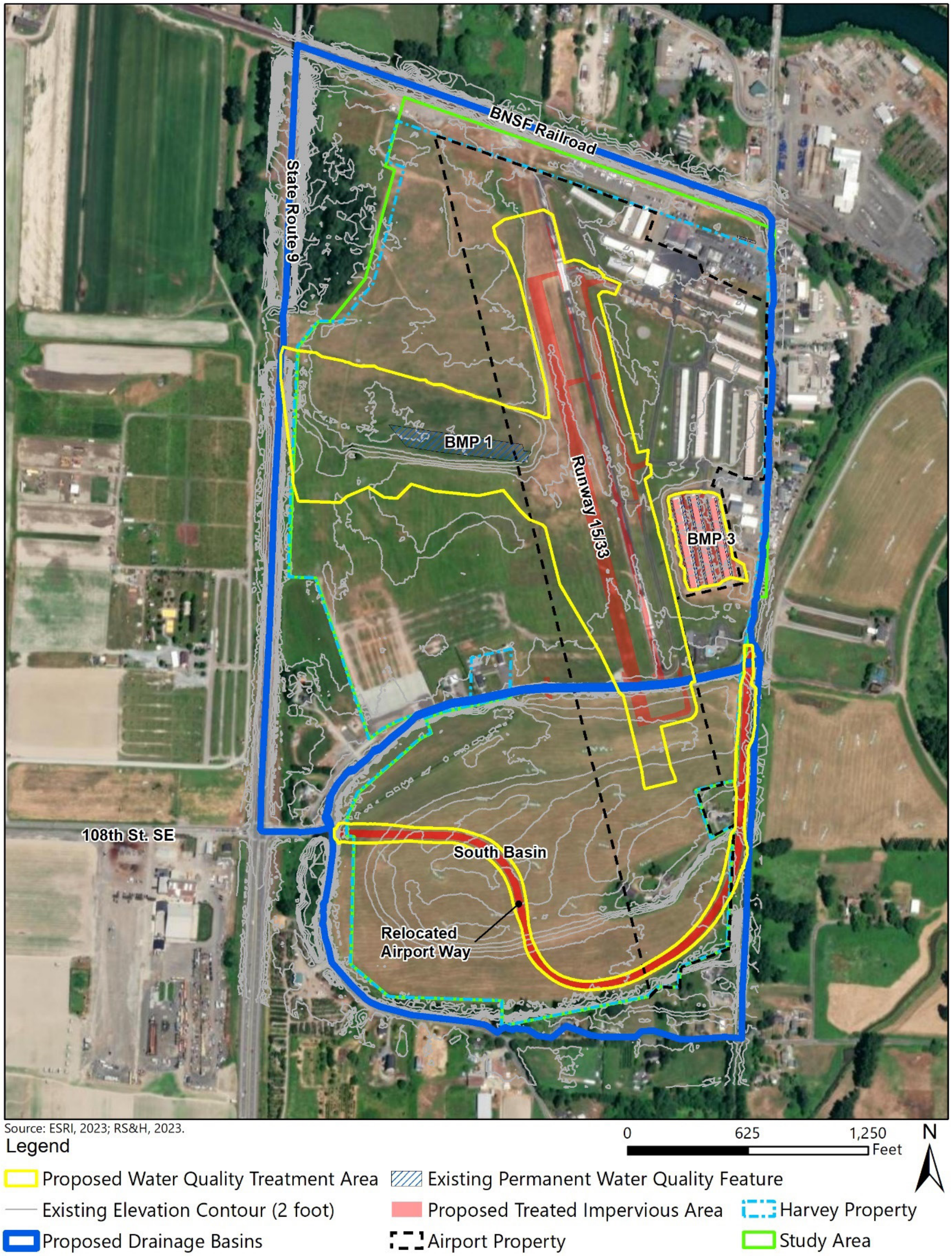


FIGURE 6: PROPOSED WATER QUALITY TREATMENT CONTRIBUTING AREAS

2.4.2 Future Design Considerations

SCDM Volume V – Runoff Control BMPs, dated July 2021 identifies the general requirements for stormwater quality facilities and may be used in final design to treat the volume provided in **Section 2.4.1** of this document. Existing stormwater facilities to remain would be expanded or new stormwater facilities would need to be installed. These facilities should be designed to accommodate the treatment volumes calculated in this section and can account for the treatment volume already provided by existing stormwater facilities that are not demolished. As discussed in Chapter 3 of the EA Narrative, surface water quality standards for temperature, Dissolved Oxygen (DO), pH, turbidity, and E. Coli apply to the site. Viable water quality facilities to remove pollutants and decrease overall turbidity are as follows:

- Biofiltration Swale
- Pretreatment settling basins
- Filtration
- Bioretention

These water quality facilities should be designed to limit standing water and to not interfere with known groundwater elevations.

CHAPTER 3
GROUNDWATER

3.1 REGULATORY REVIEW

Relevant local, state, and federal regulations and statues pertaining to groundwater include:

- Safe Water Drinking Act (SDWA)
- Chapter 173-200 Washington Administrative Code
- Chapter 90.48 RCW: Water Pollution Control
- Chapter 90.54 RCW: Water Resources Act of 1971

The Washington State Department of Ecology has developed Groundwater Quality Standards which protect both existing and future beneficial uses of groundwater resources in Washington State. These standards specifically identify potential groundwater contaminants and discharge criteria for each. An antidegradation policy is also enacted for non-permitted activities which have the potential to contaminate groundwater quality and is designed to ensure the protection of the State's groundwater resources and natural environment. Under this policy, groundwater resources should be protected as a potential source of drinking water which recognizes the future need of new potential drinking water sources. These measures prevent the degradation of groundwater resources beyond thresholds which are to not be exceeded as the result of proposed development. Additionally, groundwater which is hydraulically connected to a surface water body must abide by standards established in the Water Quality Standards for Surface Water of the State of Washington, which similarly have an antidegradation policy to restore and maintain the highest possible quality of surface waters of Washington.

3.2 GROUNDWATER RECHARGE

Under the Washington groundwater regulations, all groundwater resources should be protected as a potential source of drinking water, and thus measures must be taken to prevent the degradation of groundwater resources as a result of the Proposed Action. Soils on the site consist of HSG A soils and HSG C. Soils in HSG A have high infiltration rates while soils in HSG C typically have moderately low infiltration rates. See **Attachment I-2**. The amount of exposed HSG A soil increased by 0.2% of the total drainage area due to the Proposed Action because of demolition of impervious surfaces that were previously covering HSG A soils. The amount of exposed HSG C soil decreased by 1.8% of the total drainage area due to new impervious surfaces associated with the Proposed Action. As a result, groundwater infiltration and recharge rates are anticipated to be altered after project completion. However, per Snohomish County regulations for water quality (**Section 2.4** of this document), treatment must be provided for disturbed areas. Groundwater recharge rate would not be substantially affected due to additional stormwater runoff discharging to the Snohomish River, which is hydraulically connected to groundwater beneath the Study Area (Cardno, 2019).

The County has established CARAs to safeguard public health, safety, and welfare and protect groundwater resources. CARAs include sole source aquifers, Washington State Department of Health (WSDOH) wellhead protection areas, and areas that are sensitive to aquifer contamination as established by the U.S. Geological Survey (USGS). The Study Area is in an area with high aquifer sensitivity due to low depth to groundwater (see **Figure 7**). Aquifer sensitivity is defined by the relative ease with which a contaminant could hypothetically migrate to groundwater, accounting for parameters such as average annual groundwater recharge and depth to groundwater. Aquifer sensitivity does not account for the influence of human activities nor the actual vulnerability of an aquifer to contamination. As a result, aquifer sensitivity and aquifer vulnerability are not necessarily correlated. Proposed development in CARAs in the County has a sequential order of preference to avoid and minimize impacts, as shown below:

- Avoiding impacts altogether by not taking a certain action or parts of an action; or when avoidance is not possible;
- Minimizing impacts by limiting the degree or magnitude of the action and its implementation or by taking affirmative steps, such as project redesign, relocation, or timing, to avoid or reduce impacts; and
- Mitigation for the impacts to the CARA

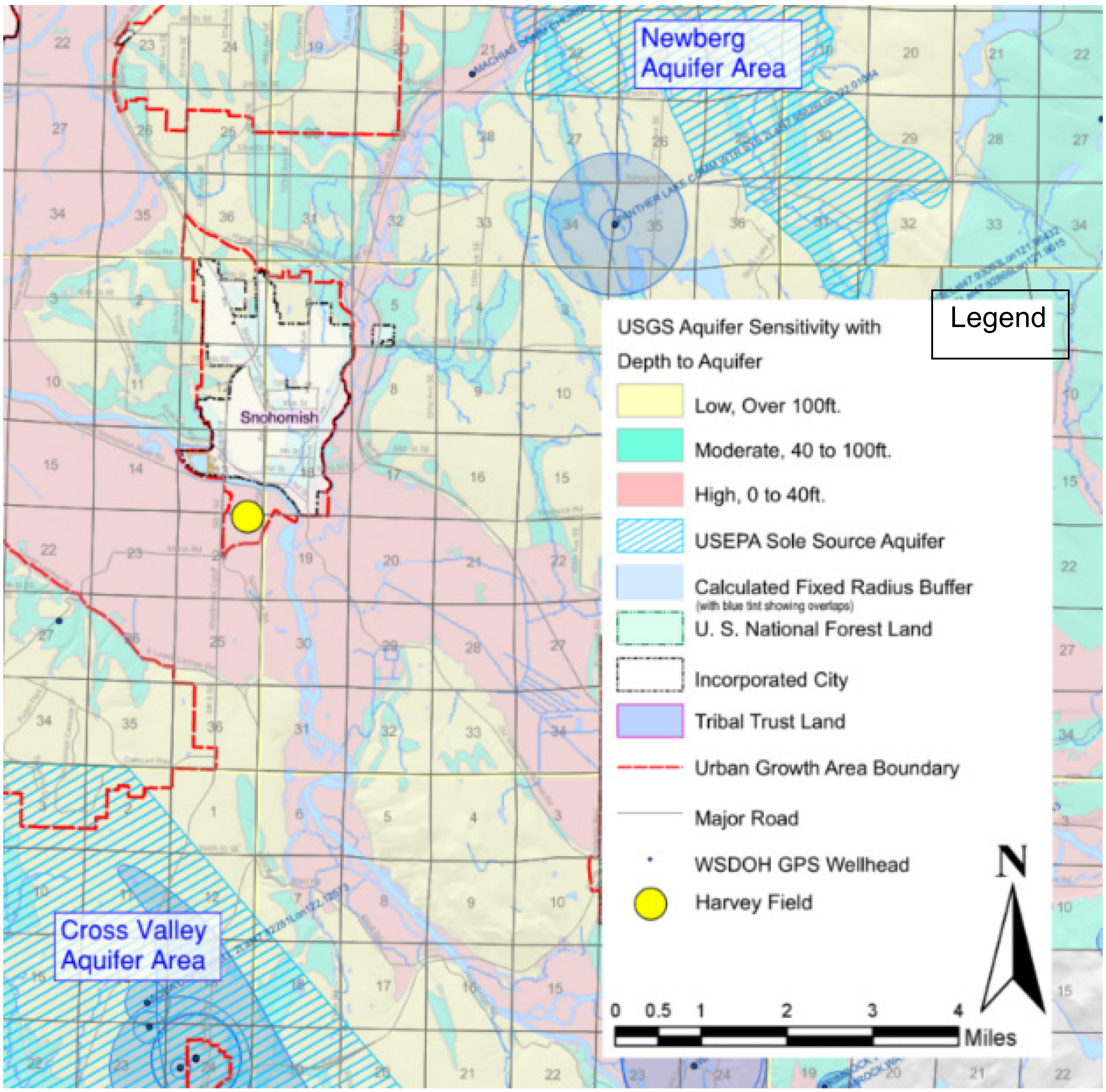


FIGURE 7: CRITICAL AQUIFER RECHARGE AREAS IN SNOHOMISH COUNTY

3.3 GROUNDWATER QUALITY

The Proposed Action and all cumulative development projects are required to comply with all applicable existing regulations that prevent exceedances in groundwater quality standards. As groundwater in the Study Area is hydraulically connected to the Snohomish River, the Surface Water Quality Standards for the waterway apply to the groundwater. As a result, as long as water quality facilities are installed to address surface water pollution concerns, the Proposed Action would be unlikely to cause or increase groundwater contamination and therefore would have no effect on groundwater.

CHAPTER 4
FLOODPLAINS

4.1 INTRODUCTION

Floodplains are delineated by the Federal Emergency Management Agency (FEMA) and are reported on Flood Insurance Rate Map (FIRM) panels. The Study Area is located in Snohomish County, FIRMs 1061G and 1065G (2020). The Proposed Action would encroach on FEMA-designated floodplains and Snohomish County-designated Density Fringe Area. The Density Fringe Area designation was established to regulate development in areas of high flood damage potential where conventional floodwater areas cannot be established. The Density Fringe Area is listed as having permitted development use of public works, limited to roads, bridges, docks, and port facilities (Snohomish County, 2015). The relocation of Airport Way is considered a public works project under these rules as the roadway will be deeded to Snohomish County upon completion. Additionally, per correspondence with Snohomish County, airfield improvements under the Proposed Action qualify as an approved land use and thus must meet the development criteria for the Density Fringe area.

Development within the Density Fringe areas must meet the following criteria in order to be permitted:

1. Maximum allowable density – land area occupied by any use or development that will displace floodwater shall not exceed two percent of the land area of that portion of the lot located in the density fringe area
2. Maximum allowable obstruction – The maximum width of all new construction shall not exceed 15 percent of the length of a line drawn perpendicular to the known floodwater flow direction at the point where the development is located. The length of said line shall not extend beyond the property boundary or edge of density fringe area, whichever is less.

The development criteria above are established by Snohomish County to prevent a cumulative increase in the BFE of the Density Fringe area of more than one foot.

Per the SCC, maximum allowable density and obstruction limitations shall not apply to public works projects that demonstrate that the floodwater displacement effects considered with the maximum floodwater displacement allowed per the SCC do not cause a cumulative increase in the BFE of more than one foot (Snohomish County, 2015). Thus, the relocation of Airport Way will not be considered during the evaluation of the maximum allowable density and maximum allowable obstruction for the Study Area.

The major factor contributing to the development of established BFEs at the Airport is the amount of water that would overtop existing levees in the Snohomish River in a flood event. As the Proposed Action would have no effect on water levels in the Snohomish River, during a flood event the amount of floodwater entering the Harvey Field flood storage area **(Figure 8)** as the result of overtopping levees would not change. Floodplain hydraulic modeling of the Proposed Action conducted as part of this EA demonstrates there would not be an increase in FEMA-established BFEs for the regulatory 100-year (1 percent-annual-chance) flood event. Based on comments received during the public review period, non-regulatory flood events that are less than the FEMA-regulatory 100-year (1-percent-chance) flood event were also analyzed for potential changes in flood elevations. See **Attachment I-6** for additional discussion of floodplain modeling.

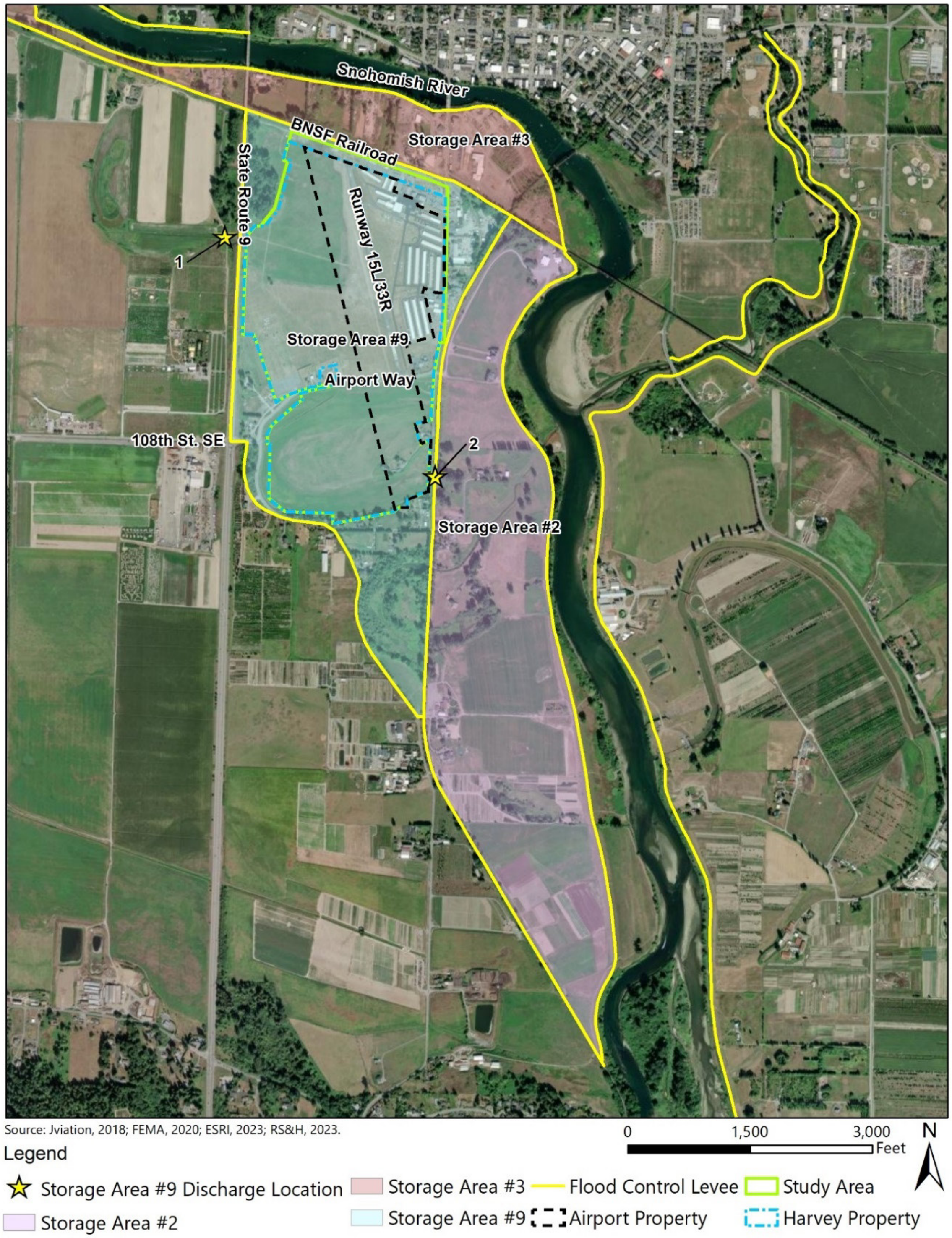


FIGURE 8: FLOOD STORAGE AREAS

4.2 MAXIMUM ALLOWABLE DENSITY CRITERIA

The maximum allowable density requirement for the Study Area must be evaluated as construction of the runway and the extension of the parallel taxiway qualify as permitted land use. The purpose of this criteria is to maintain the maximum amount of storage area in the Density Fringe area as possible, thus portions of the site that are currently located beneath the 100-year flood elevation were considered. The 100-year flood elevation at Harvey Field is 26.63 feet with a vertical datum of NAVD88. The Study Area is lower than this elevation, so the maximum allowable density criteria apply across the entire Harvey Property. This criterion is solely based on land area, so any cut volume associated with the site cannot work to offset the impacts of construction. The area that will displace floodwater, as mentioned in the criteria, is the fill footprint across the entire Harvey Property.

The maximum allowable density for the Harvey Property was evaluated based on the guidance outlined in SCC 30.65.250. The land area occupied by the Proposed Action that would displace floodwater, i.e. areas of fill, is equivalent to 3.29 acres. The entire Harvey Property is located in the Density Fringe area, which has an area of 204.48 acres. The area of fill makes up approximately 1.6% of the total Harvey Property area, thus the two percent allowable threshold would not be exceeded, and the criteria would be met **(Figure 9)**.

Legend Source: Jviation, 2018; ESRI, 2023; RS&H, 2023.

- Flood Control Levee
- Proposed Drainage Culvert
- Fill
- Cut
- Regulatory Floodway
- Proposed Airfield Pavement
- Removed Impervious Area
- Airport Property
- Harvey Property
- Study Area

0 500 1,000 Feet

N

Category	Area (acres)
Cut	24.07
Fill	3.29
Harvey Property	204.48

Note: The relocation of Airport Way is considered a public work in accordance with applicable sections of the Snohomish County Code. As a result, the roadway relocation is not subject to the allowable density and allowable obstruction requirements of the density fringe floodplain. The roadway relocation is not shown for clarity.

FIGURE 9: PROPOSED ACTION CUT/FILL AREAS

4.3 MAXIMUM ALLOWABLE OBSTRUCTION CRITERIA

The maximum allowable obstruction for the site was evaluated per the steps outlined in SCC 30.65.255. These steps are as follows:

1. Determine the general floodplain flow direction
2. Draw a line perpendicular to the flow direction
3. Draw the line where it intersects the largest width of new construction as a percentage of property width.
4. Sum of fill widths/total property width must be less than 15 percent.

Given that the Harvey Property is in an area with many surrounding levees, during a levee overtopping in a flood event the floodplain flow can be multidirectional and therefore cannot be defined into a single direction of floodplain flow. In order to ensure this criterion would be met, RS&H evaluated two possible general floodplain flow directions consistent with the 2018 MP. These floodplain flow directions are East to West and South to North. The execution of steps 1 through 3 as indicated above are presented in **Figure 10** and **Figure 11**. In order to meet obstruction limitations outlined in SCC 30.65.255, the Proposed Action would utilize concrete box culverts. As shown in **Figure 10** and **Figure 11** below, an array of 20-foot span concrete box culverts along the southern end of Proposed Runway 15-33 would allow the free flow of the floodwaters through the Study Area, and are not considered as fill areas for purposes of calculating the floodplain obstruction. The height of these culverts will be finalized in the design phase.

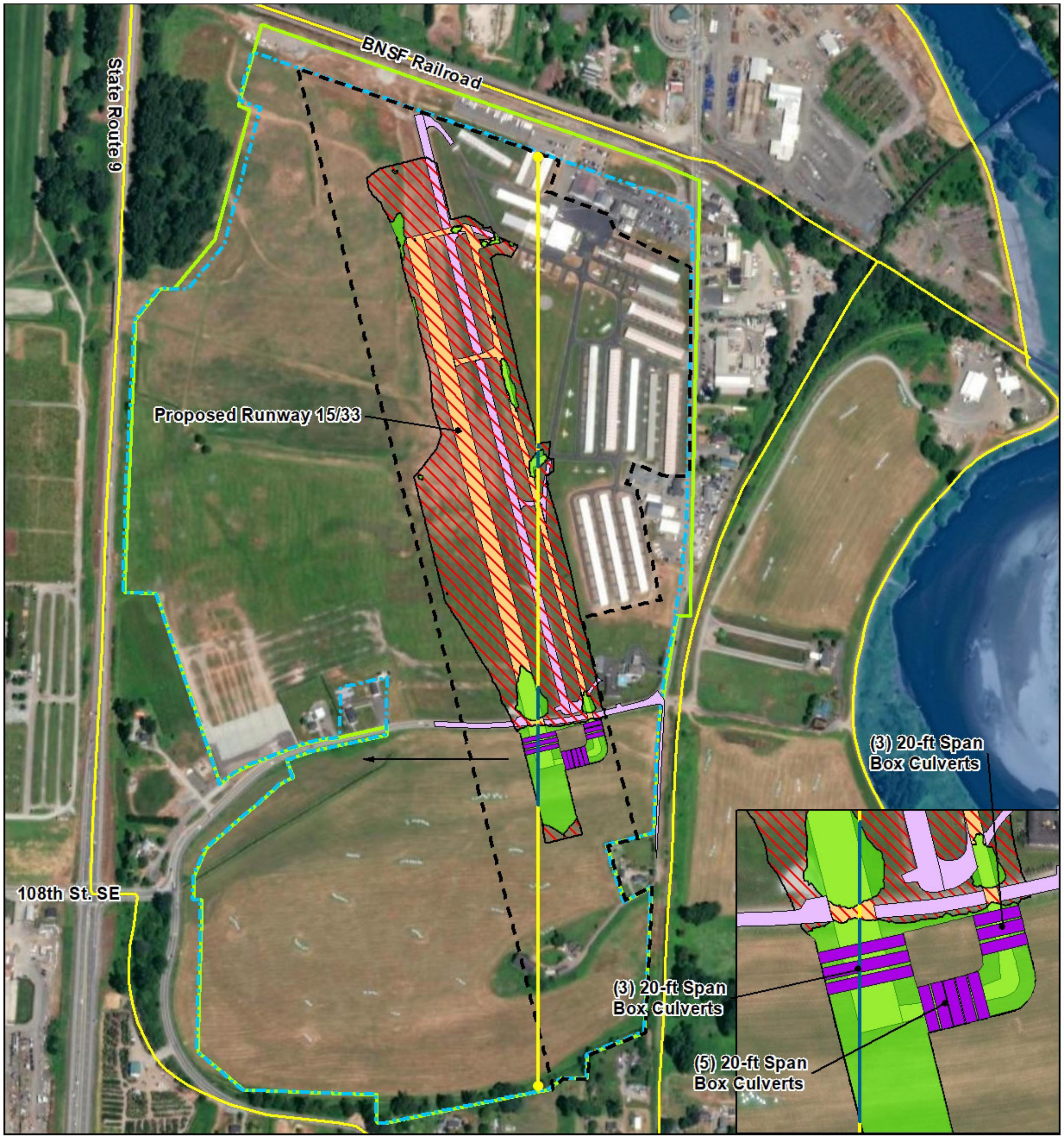
These culverts are consistent with a new runway design proposed in the 2018 MP and would result in a Proposed Action that does not exceed 15 percent obstruction limit for the lines perpendicular to the direction of flow. **Table 10** and **Table 11** below summarizes all relevant widths for each Scenario as well as the flow obstruction percentage.

TABLE 10: EAST TO WEST FLOW DIRECTION - OBSTRUCTION CALCULATION RESULTS

Feature	Width (feet)	Percent of Property Width
Property Width	1,846	--
New Fill	360	19.5%
Culvert Openings	100	5.4%
Fill – Culvert Openings	**260**	**14.1%**

TABLE 11: NORTH TO SOUTH FLOW DIRECTION - OBSTRUCTION CALCULATION RESULTS

Feature	Width (feet)	Percent of Property Width
Property Width	4,116	--
New Fill	564	13.7%
Culvert Openings	60	1.5%
Fill – Culvert Openings	**504**	**12.3%**



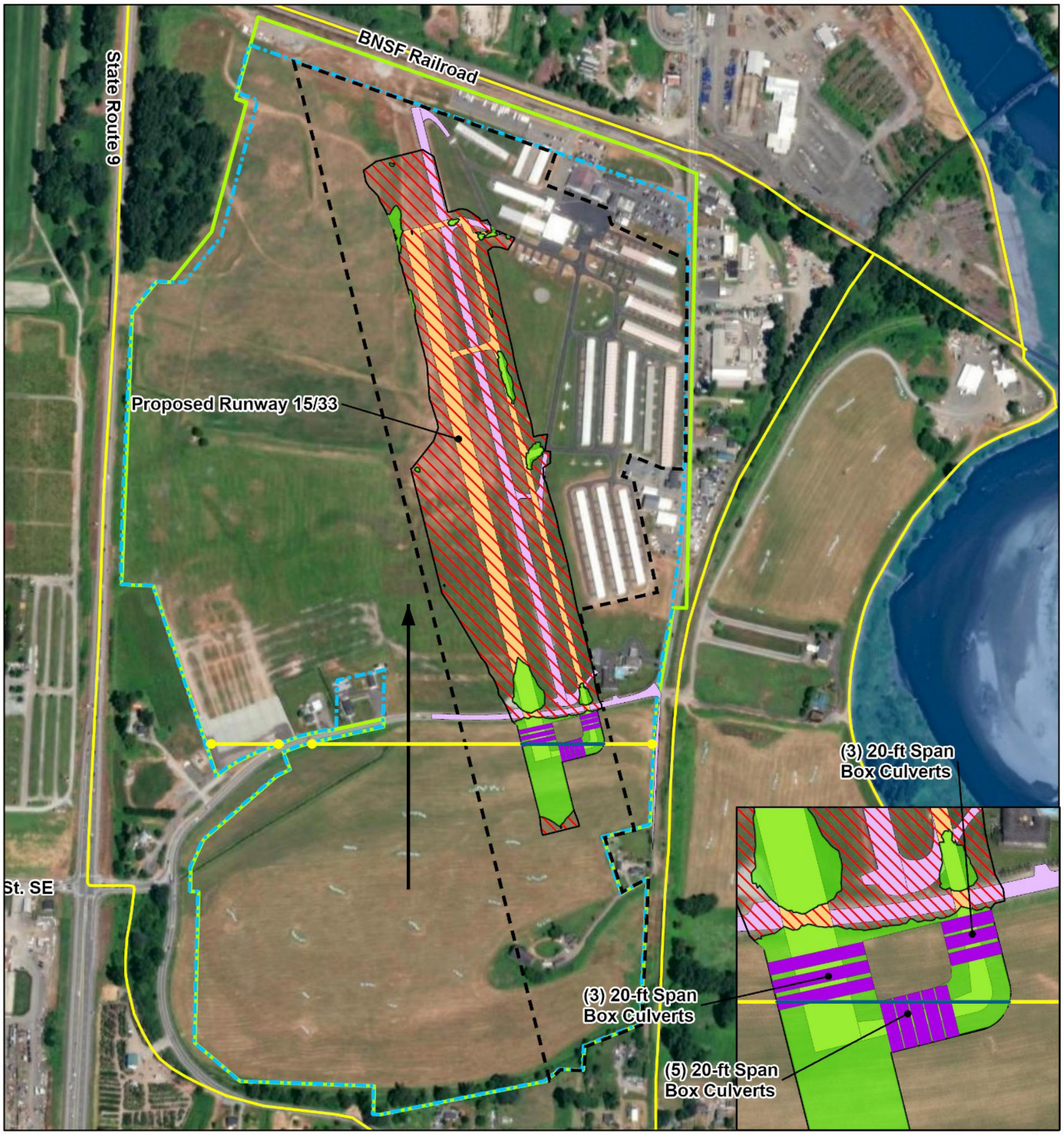
Legend Source: Jviation, 2018; ESRI, 2023; RS&H, 2023.

- Flood Control Levee
- Assumed Floodplain Flow Direction
- Proposed Drainage Culvert
- Fill
- Cross Section in Fill Area
- Regulatory Floodway
- Assumed Flow Cross Section
- Cut
- Proposed Airfield Pavement
- Removed Impervious Area
- Airport Property
- Harvey Property
- Study Area

Category	Measurement
Cut	24.07 ac
Fill	3.29 ac
Harvey Property	204.48 ac
Width of Cross Section in Fill Area	564 ft
Assumed Flow Cross Section Width	4116 ft

Note: The relocation of Airport Way is considered a public work in accordance with applicable sections of the Snohomish County Code. As a result, the roadway relocation is not subject to the allowable density and allowable obstruction requirements of the density fringe floodplain. The roadway relocation is not shown for clarity.

FIGURE 10: ALLOWABLE OBSTRUCTION - FLOW PERPENDICULAR TO FLOOD CONTROL LEVEES



Source: Jviation, 2018; ESRI, 2023; RS&H, 2023.

0 500 1,000 Feet

N

Legend

- Flood Control Levee
- Assumed Floodplain Flow Direction
- Cross Section in Fill Area
- Assumed Flow Cross Section
- Proposed Drainage Culvert
- Fill
- Regulatory Floodway
- Cut
- Proposed Airfield Pavement
- Removed Impervious Area
- Airport Property
- Harvey Property
- Study Area

Category	Measurement
Cut	24.07 ac
Fill	3.29 ac
Harvey Property	204.48 ac
Width of Cross Section in Fill Area	360 ft
Assumed Flow Cross Section Width	1846 ft

Note: The relocation of Airport Way is considered a public work in accordance with applicable sections of the Snohomish County Code. As a result, the roadway relocation is not subject to the allowable density and allowable obstruction requirements of the density fringe floodplain. The roadway relocation is not shown for clarity.

FIGURE 11: ALLOWABLE OBSTRUCTION - FLOW PARALLEL TO FLOOD CONTROL LEVEES

4.4 CLIMATE RESILIENCY

4.4.1 Sea Level Rise

FAA Order 1050.1F, Section 4-1, *Environmental Impact Categories*, does not identify sea level rise as a category nor provide significance thresholds, or factors to consider in its evaluation. However, information regarding the potential impacts from sea level rise on the Proposed Action is being provided for informational purposes only due to comments received on the Draft EA.

The Washington Coastal Resilience Project (WCRP) developed projections of relative sea level rise for multiple greenhouse gas (GHG) emissions scenarios. The study investigated relative sea level rise based on projected GHG scenarios Representative Concentration Pathway (RCP) 4.5 and RCP 8.5, scenarios developed by the Intergovernmental Panel on Climate Change (IPCC). RCP 4.5 is described as the intermediate scenario, where emissions peak around 2040 and then decline. RCP 8.5 assumes an increase in greenhouse gas emissions throughout the 21st century without effective climate change mitigation policies. WCRP also took probabilities of exceedance, based on the individual aspects of sea level rise, into account for each scenario. **Table 12** below presents the 1 percent probability of exceedance for the RCP 8.5 scenario, which will be the most conservative set of projected sea level rise for Snohomish County. The proposed runway is anticipated to have a full useful life of 30 years, which includes expected pavement reconstruction after 20 years to extend the useful life another 10 years. Considering this useful life, a 2060 projection and RCP 8.5 scenario will be considered in the analyses (FAA AC 150/5320-6G, Section 3.11.3.1.2.).

TABLE 12: 1 PERCENT EXCEEDANCE PROBABILITY SEA LEVEL RISE PROJECTIONS

Year	Projected Sea Level Rise (ft)
2040	1
2060	**1.9**
2080	3.3
2100	5

4.4.2 Extreme Coastal Water Level

WCRP developed additional guidance for assessing exposure to future coastal flooding during extreme weather events, including high tides, surge, and wave run-up. Many of these processes can occur concurrently, yielding an extremely elevated sea surface and higher likelihood that water while travel up the shoreline and further inland. These guidelines include projections of extreme still water level (SWL) and extreme total water level (TWL). SWL is the coastal water due to all processes except wave run-up on the shoreline while TWL is the maximum elevation that water reaches on the shoreline due to all processes. Extreme water levels during future events can be expressed as the following:

$$Future\ Extreme\ Water\ Level = \\ Relative\ SLR\ +\ Astronomical\ Tide\ Height\ +\ Storm\ Surge\ +\ Wave\ Run-up$$

To develop extreme SWL and TWL scenarios, the WCRP utilized a return frequency framework to estimate the likelihood that the various components contributing to extreme water level would coincide (WCRP, 2019). Unlike other areas in Washington State, TWL estimates for extreme events are not yet available for Puget Sound due to its geographic complexity. However, throughout most of the Puget Sound, waves are small enough that they are unlikely to dramatically change the expected pattern of extreme water level. To verify this, WCRP assessed the 100-year TWL using historical wave heights for a location near Tacoma, Washington and found that the TWL is 3.6 feet relative to the local mean higher high water tidal datum. The 100-year SWL for the Puget Sound is 3.2 feet relative to the MHHW, indicating that wave run-up has a small impact on the TWL in the area. Since this difference only amounts to a few inches, and the Study Area is approximately 8 miles inland, the SWL estimates are adequate to characterize the coastal flood risk. **Table 13** provides the WCRP estimates for the extreme SWL for the Puget Sound. **Table 14** provides the resulting SWL values for the projected sea level rise for Snohomish County.

TABLE 13: EXTREME STILL WATER LEVEL BY ANNUAL EXCEEDANCE PROBABILITY AND SEA LEVEL CHANGE

Sea Level Change (feet)	50% Annual Exceedance Probability (AEP) Still Water Level (SWL)	20% AEP SWL	5% AEP SWL	2% AEP SWL	1% AEP SWL
0	2.2	2.6	2.9	3.1	3.2
0.5	2.7	3.1	3.4	3.6	3.7
1.0	3.2	3.6	3.9	4.1	**4.2**
1.5	3.7	4.1	4.4	4.6	4.7
1.9*	4.1*	4.5*	4.8*	5.0*	**5.1***
2.0	4.2	4.6	4.9	5.1	5.2
2.5	4.7	5.1	5.4	5.6	5.7
3.0	5.2	5.6	5.9	6.1	6.2
3.3*	5.5*	5.9*	6.2*	6.4*	**6.5***
4.0	6.2	6.6	6.9	7.1	7.2
5.0	7.2	7.6	7.9	8.1	**8.2**

*Values were calculated by interpolating between established estimates

TABLE 14: 1 PERCENT EXCEEDANCE PROBABILITY SEA LEVEL RISE AND EXTREME STILL WATER LEVEL ESTIMATES

Year	Sea Level Rise (feet)	Extreme Still Water Level (feet)
2040	1	4.2
2060	**1.9**	**5.1**
2080	3.3	6.5
2100	5	8.2

4.4.3 Levee Overtopping

The National Oceanic and Atmospheric Administration (NOAA) Office for Coastal Management compiled existing surface data, mean higher high water (MHHW) tidal datum data, hydrological connectivity, tidal variations, and projections for sea level rise to map potential impacts of future flooding and inundation. The projections utilize the MHHW tidal datum as a baseline, to which sea level rise is combined with other factors to determine the extents of inundation. The Study Area also has existing levees, described in **Section 2.2.2** of this document, that NOAA mapped using best available elevation data. Inundation from coastal process would occur if the SWL is greater than the lowest height of the levees adjacent to the Study Area (NOAA, 2023). From the NOAA Office for Coastal Management tools, levee overtopping and permanent inundation would occur between 7 to 8 feet of sea level rise above the Mean Higher High-Water Level (MHHWL), considered as the highest daily tide level. Using 7-feet as a conservative assumption for the lowest levee elevation, the Proposed Action is not projected to be impacted by sea level rise nor extreme still water levels through the design life of 2060 as these elevations remain below the estimated levee elevation. Therefore, human safety, health, and welfare will not be impacted as a result of implementation of the Proposed Action as the result of climate change.

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ATTACHMENT I-1: TIME OF CONCENTRATION CALCULATIONS

Harvey Field Runway Improvement Project EA	Comp. By:	JKK
	Date:	8/30/2023
	Chk. By:	LMM
	Job No:	2470064.000

Time of Concentration Calculations

Sub-Basin Name: North
Condition: Existing

Sheet Flow [TR-55 equation 3-3]

	AB		BC							
Surface Description	Smooth surfaces		Dense grasses							
Manning's Roughness coeff., n	0.011		0.24							
Flow Length, L (should be <= 100 ft)	39	ft	61	ft		ft		ft		
Two-yr, 24-hr rainfall, P_2	1.90	in	1.90	in		in		in		
Elevation 1, E_1	24.86	ft	22.67	ft		ft		ft		
Elevation 2, E_2	22.67	ft	22.41	ft		ft		ft		
Land Slope, $s = (E_1 - E_2) / L$	0.06	ft/ft	0.00	ft/ft		ft/ft		ft/ft		
$Tt = 0.007 * (n * L)^{0.8} / (P_2^{0.5} * s^{0.4})$	0.01	hr	0.39	hr		hr		hr		
	0.5	+	23.1	+		+		=	23.6	min

Shallow Concentrated Flow [TR-55 figure 3-1]

	CD		DE		EF					
Surface Description	Unpaved		Paved		Unpaved					
Flow Length, L	49	ft	34	ft	1588	ft		ft		
Elevation 1, E_1	22.41	ft	22.29	ft	21.50	ft		ft		
Elevation 2, E_2	22.29	ft	21.50	ft	13.00	ft		ft		
Watercourse Slope, $s = (E_1 - E_2) / L$	0.002		0.023	ft/ft	0.005	ft/ft		ft/ft		
Velocity, V	0.80		3.10	ft/s	1.18	ft/s		ft/s		
$T_t = L / (3600 * V)$	0.02		0.00	hr	0.37	hr		hr		
	1.0	+	0.2	+	22.4	+		=	23.6	min

Open Channel Flow [TR-55 equation 3-4]

		FG		GH		HI					
		Pipe		Pipe		Pipe					
Open Channel	Front Slope, s_1		:1		:1		:1		:1		
	Bottom width, B		ft		ft		ft		ft		
	Back Slope, s_2		:1		:1		:1		:1		
	Depth, H		ft		ft		ft		ft		
Pipe	Diameter, D	4	in	24	in	30	in		in		
Cross Sectional Flow Area, a		0.09	sq ft	3.14	sq ft	4.91	sq ft		sq ft		
Wetted Perimeter, P_w		1.05	ft	6.28	ft	7.85	ft		ft		
Hydraulic radius, $r = a / P_w$		0.08	ft	0.50	ft	0.63	ft		ft		
Flow Length, L		156	ft	1522	ft	264	ft		ft		
Elevation 1, E_1		13.00	ft	12.31	ft	5.23	ft		ft		
Elevation 2, E_2		12.31	ft	5.23	ft	4.39	ft		ft		
Channel Slope, $s = (E_1 - E_2) / L$		0.004	ft/ft	0.005	ft/ft	0.003	ft/ft		ft/ft		
Manning's Roughness coeff., n		0.012		0.013		0.013					
Velocity, $V = 1.49 * r^{2/3} * s^{1/2} / n$		1.58	ft/s	4.92	ft/s	4.73	ft/s		ft/s		
$T_t = L / (3600 * V)$		0.03	ft/s	0.09	ft/s	0.02	ft/s		ft/s		
		1.7	+	5.2	+	0.9	+		=	7.7	min

Total Time of Concentration

Sub-Basin Tc = **55.0** **min**

Harvey Field Runway Improvement Project EA		
	Comp. By:	JKK
	Date:	8/30/2023
	Chk. By:	LMM
	Job No:	2470064.000

Time of Concentration Calculations

Sub-Basin Name: South
Condition: Existing

Sheet Flow [TR-55 equation 3-3]

	AB		BC								
Surface Description	Dense grasses		Smooth surfaces								
Manning's Roughness coeff., n	0.24		0.011								
Flow Length, L (should be <= 100 ft)	48	ft	52	ft		ft		ft			
Two-yr, 24-hr rainfall, P_2	1.90	in	1.90	in		in		in			
Elevation 1, E_1	26.62	ft	24.92	ft		ft		ft			
Elevation 2, E_2	24.91	ft	22.63	ft		ft		ft			
Land Slope, $s = (E_1 - E_2) / L$	0.04	ft/ft	0.04	ft/ft		ft/ft		ft/ft			
$Tt = 0.007 * (n * L)^{0.8} / (P_2^{0.5} * s^{0.4})$	0.14	hr	0.01	hr		hr		hr			
	8.2	+	0.7	+		+		=		8.9	min

Shallow Concentrated Flow [TR-55 figure 3-1]

	CD		DE								
Surface Description	Paved		Unpaved								
Flow Length, L	45	ft	5477	ft		ft		ft			
Elevation 1, E_1	22.63	ft	19.11	ft		ft		ft			
Elevation 2, E_2	19.11	ft	8.00	ft		ft		ft			
Watercourse Slope, $s = (E_1 - E_2) / L$	0.078		0.002	ft/ft		ft/ft		ft/ft			
Velocity, V	5.69		0.73	ft/s		ft/s		ft/s			
$T_t = L / (3600 * V)$	0.00		2.09	hr		hr		hr			
	0.1	+	125.6	+		+		=		125.7	min

Open Channel Flow [TR-55 equation 3-4] - None

Total Time of Concentration

Sub-Basin Tc = **134.6** **min**

Harvey Field Runway Improvement Project EA	Comp. By:	JKK
	Date:	8/30/2023
	Chk. By:	LMM
	Job No:	2470064.000

Time of Concentration Calculations

Sub-Basin Name: North
Condition: Proposed

Sheet Flow [TR-55 equation 3-3]

	AB		BC									
Surface Description	Smooth surfaces		Dense grasses									
Manning's Roughness coeff., n	0.011		0.24									
Flow Length, L (should be <= 100 ft)	39	ft	61	ft		ft		ft		ft		
Two-yr, 24-hr rainfall, P_2	1.90	in	1.90	in		in		in		in		
Elevation 1, E_1	24.86	ft	22.67	ft		ft		ft		ft		
Elevation 2, E_2	22.67	ft	22.41	ft		ft		ft		ft		
Land Slope, $s = (E_1 - E_2) / L$	0.06	ft/ft	0.00	ft/ft		ft/ft		ft/ft		ft/ft		
$Tt = 0.007 * (n * L)^{0.8} / (P_2^{0.5} * s^{0.4})$	0.01	hr	0.39	hr		hr		hr		hr		
	0.5	+	23.1	+		+		+		=	23.6	min

Shallow Concentrated Flow [TR-55 figure 3-1]

	CD		DE		EF		FG		GH			
Surface Description	Unpaved		Paved		Unpaved		Paved		Unpaved			
Flow Length, L	49	ft	34	ft	1091	ft	66	ft	349	ft		
Elevation 1, E_1	22.41	ft	22.29	ft	21.98	ft	14.55	ft	14.50	ft		
Elevation 2, E_2	22.29	ft	21.50	ft	14.55	ft	14.50	ft	13.00	ft		
Watercourse Slope, $s = (E_1 - E_2) / L$	0.002		0.023	ft/ft	0.007	ft/ft	0.001	ft/ft	0.004	ft/ft		
Velocity, V	0.80		3.10	ft/s	1.33	ft/s	0.56	ft/s	1.06	ft/s		
$T_t = L / (3600 * V)$	0.02		0.00	hr	0.23	hr	0.03	hr	0.09	hr		
	1.0	+	0.2	+	13.7	+	2.0	+	5.5	=	22.3	min

Open Channel Flow [TR-55 equation 3-4]

		HI		IJ		JK							
		Pipe		Pipe		Pipe							
Open Channel	Front Slope, s_1		:1		:1		:1		:1		:1		
	Bottom width, B		ft		ft		ft		ft		ft		
	Back Slope, s_2		:1		:1		:1		:1		:1		
	Depth, H		ft		ft		ft		ft		ft		
Pipe	Diameter, D	4	in	24	in	30	in		in		in		
Cross Sectional Flow Area, a		0.09	sq ft	3.14	sq ft	4.91	sq ft		sq ft		sq ft		
Wetted Perimeter, P_w		1.05	ft	6.28	ft	7.85	ft		ft		ft		
Hydraulic radius, $r = a / P_w$		0.08	ft	0.50	ft	0.63	ft		ft		ft		
Flow Length, L		156	ft	1522	ft	264	ft		ft		ft		
Elevation 1, E_1		13.00	ft	12.31	ft	5.23	ft		ft		ft		
Elevation 2, E_2		12.31	ft	5.23	ft	4.39	ft		ft		ft		
Channel Slope, $s = (E_1 - E_2) / L$		0.004	ft/ft	0.005	ft/ft	0.003	ft/ft		ft/ft		ft/ft		
Manning's Roughness coeff., n		0.012		0.013		0.013							
Velocity, $V = 1.49 * r^{2/3} * s^{1/2} / n$		1.58	ft/s	4.92	ft/s	4.73	ft/s		ft/s		ft/s		
$T_t = L / (3600 * V)$		0.03	ft/s	0.09	ft/s	0.02	ft/s		ft/s		ft/s		
		1.7	+	5.2	+	0.9	+		+		=	7.7	min

Total Time of Concentration

Sub-Basin Tc = 53.7 **min**

Harvey Field Runway Improvement Project EA	Comp. By:	JKK
	Date:	8/30/2023
	Chk. By:	LMM
	Job No:	2470064.000

Time of Concentration Calculations

Sub-Basin Name: South
Condition: Proposed

Sheet Flow [TR-55 equation 3-3]

	AB		BC							
Surface Description	Dense grasses		Smooth surfaces							
Manning's Roughness coeff., n	0.24		0.011							
Flow Length, L (should be <= 100 ft)	48	ft	52	ft		ft		ft		
Two-yr, 24-hr rainfall, P_2	1.90	in	1.90	in		in		in		
Elevation 1, E_1	26.62	ft	24.92	ft		ft		ft		
Elevation 2, E_2	24.91	ft	22.63	ft		ft		ft		
Land Slope, s = $(E_1 - E_2)$ / L	0.04	ft/ft	0.04	ft/ft		ft/ft		ft/ft		
Tt = 0.007 * $(n * L)^{0.8} / (P_2^{0.5} * s^{0.4})$	0.14	hr	0.01	hr		hr		hr		
	8.2	+	0.7	+		+			= 8.9	min

Shallow Concentrated Flow [TR-55 figure 3-1]

	CD		DE		EF		FG		GH		HI			
Surface Description	Unpaved		Unpaved		Paved		Unpaved		Paved		Unpaved			
Flow Length, L	45	ft	264	ft	81	ft	124	ft	151	ft	4819	ft		
Elevation 1, E_1	22.63	ft	19.11	ft	16.10	ft	15.81	ft	15.54	ft	15.29	ft		
Elevation 2, E_2	19.11	ft	16.10	ft	15.81	ft	15.54	ft	15.29	ft	8.00	ft		
Watercourse Slope, s = $(E_1 - E_2)$ / L	0.078		0.011	ft/ft	0.004	ft/ft	0.002	ft/ft	0.002	ft/ft	0.002	ft/ft		
Velocity, V	4.51		1.72	ft/s	1.22	ft/s	0.75	ft/s	0.83	ft/s	0.63	ft/s		
T_t = L / (3600 * V)	0.00		0.04	hr	0.02	hr	0.05	hr	0.05	hr	2.13	hr		
	0.2	+	2.6	+	1.1	+	2.7	+	3.0	+	128.0		= 134.6	min

Open Channel Flow [TR-55 equation 3-4] - None

Total Time of Concentration

Sub-Basin Tc = 143.4 min

ATTACHMENT I-2: NRCS SOILS SURVEY

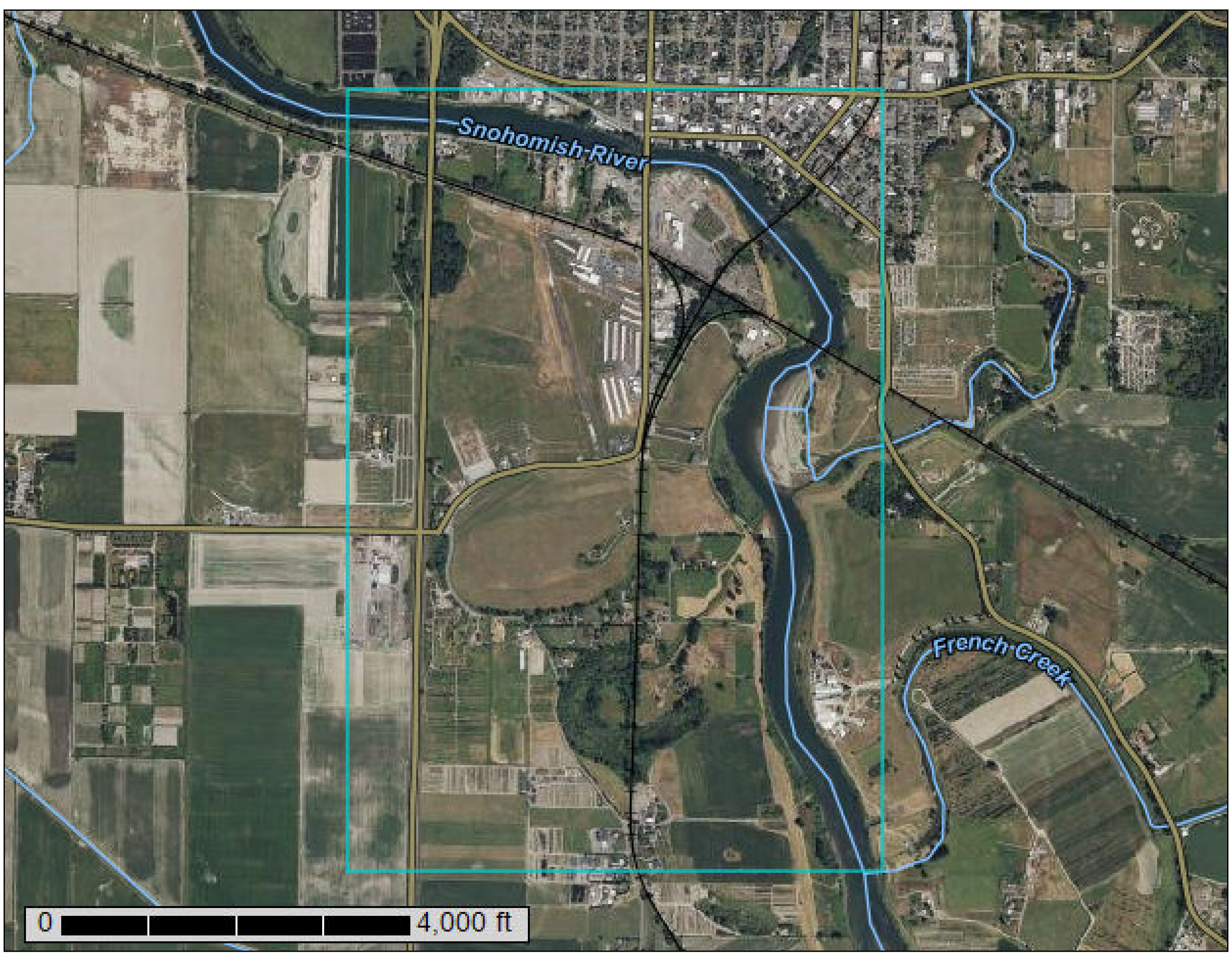
United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for
Snohomish County Area, Washington



July 14, 2023

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map

Map Scale: 1:16,000 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 200 400 800 1200

Feet: 0 500 1000 2000 3000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Snohomish County Area, Washington
Survey Area Data: Version 24, Sep 8, 2022

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 31, 2022—Aug 8, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
50	Pilchuck loamy sand	26.0	2.0%
55	Puget silty clay loam	463.6	36.4%
56	Puyallup fine sandy loam	261.2	20.5%
66	Sultan silt loam	302.9	23.8%
72	Tokul gravelly medial loam, 0 to 8 percent slopes	52.9	4.2%
73	Tokul gravelly medial loam, 8 to 15 percent slopes	20.9	1.6%
77	Tokul-Winston gravelly loams, 25 to 65 percent slopes	4.6	0.4%
82	Xerorthents, nearly level	4.0	0.3%
83	Water	137.8	10.8%
Totals for Area of Interest		**1,274.0**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Snohomish County Area, Washington

50—Pilchuck loamy sand

Map Unit Setting

National map unit symbol: 2hzb
Elevation: 0 to 980 feet
Mean annual precipitation: 35 to 60 inches
Mean annual air temperature: 48 to 52 degrees F
Frost-free period: 160 to 210 days
Farmland classification: Prime farmland if irrigated and either protected from flooding or not frequently flooded during the growing season

Map Unit Composition

Pilchuck and similar soils: 85 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Pilchuck

Setting

Landform: Flood plains
Parent material: Alluvium

Typical profile

H1 - 0 to 31 inches: loamy sand
H2 - 31 to 50 inches: fine sand
H3 - 50 to 60 inches: gravelly sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: About 24 to 48 inches
Frequency of flooding: FrequentNone
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: A
Ecological site: F002XA008WA - Puget Lowlands Riparian Forest
Forage suitability group: Droughty Soils (G002XN402WA)
Other vegetative classification: Droughty Soils (G002XN402WA)
Hydric soil rating: No

Minor Components

Puget, undrained

Percent of map unit: 5 percent
Landform: Flood plains
Other vegetative classification: Wet Soils (G002XN102WA)
Hydric soil rating: Yes

55—Puget silty clay loam

Map Unit Setting

National map unit symbol: 2hzh
Elevation: 10 to 650 feet
Mean annual precipitation: 35 to 55 inches
Mean annual air temperature: 48 to 50 degrees F
Frost-free period: 160 to 180 days
Farmland classification: Prime farmland if drained and either protected from flooding or not frequently flooded during the growing season

Map Unit Composition

Puget, drained, and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Puget, Drained

Setting

Landform: Flood plains
Parent material: Alluvium

Typical profile

H1 - 0 to 9 inches: silty clay loam
H2 - 9 to 38 inches: silty clay loam
H3 - 38 to 60 inches: silty clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.06 to 0.20 in/hr)
Depth to water table: About 24 to 47 inches
Frequency of flooding: NoneRare
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 12.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: C
Ecological site: F002XA007WA - Puget Lowlands Wet Forest
Forage suitability group: Soils with Few Limitations (G002XN502WA)
Other vegetative classification: Soils with Few Limitations (G002XN502WA)
Hydric soil rating: Yes

Minor Components

Puget, undrained

Percent of map unit: 5 percent
Other vegetative classification: Wet Soils (G002XN102WA)
Hydric soil rating: Yes

Sultan

Percent of map unit: 4 percent
Hydric soil rating: No

Snohomish, undrained

Percent of map unit: 3 percent
Landform: Flood plains
Other vegetative classification: Wet Soils (G002XN102WA)
Hydric soil rating: Yes

Sumas, undrained

Percent of map unit: 3 percent
Landform: Flood plains
Other vegetative classification: Wet Soils (G002XN102WA)
Hydric soil rating: Yes

56—Puyallup fine sandy loam

Map Unit Setting

National map unit symbol: 2hzj
Elevation: 0 to 660 feet
Mean annual precipitation: 35 to 60 inches
Mean annual air temperature: 50 degrees F
Frost-free period: 170 to 200 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Puyallup and similar soils: 85 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Puyallup

Setting

Landform: Terraces
Parent material: Alluvium

Typical profile

H1 - 0 to 10 inches: ashy fine sandy loam
H2 - 10 to 30 inches: fine sandy loam
H3 - 30 to 60 inches: sand

Properties and qualities

Slope: 0 to 3 percent

Depth to restrictive feature: 20 to 40 inches to strongly contrasting textural stratification
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: RareNone
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): 2w
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: A
Ecological site: F002XA005WA - Puget Lowlands Moist Forest
Forage suitability group: Droughty Soils (G002XN402WA)
Other vegetative classification: Droughty Soils (G002XN402WA)
Hydric soil rating: No

Minor Components

Sumas, undrained

Percent of map unit: 5 percent
Landform: Flood plains
Other vegetative classification: Wet Soils (G002XN102WA)
Hydric soil rating: Yes

Puget, undrained

Percent of map unit: 5 percent
Landform: Flood plains
Other vegetative classification: Wet Soils (G002XN102WA)
Hydric soil rating: Yes

66—Sultan silt loam

Map Unit Setting

National map unit symbol: 2hzw
Elevation: 0 to 820 feet
Mean annual precipitation: 35 to 55 inches
Mean annual air temperature: 50 degrees F
Frost-free period: 150 to 200 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Sultan and similar soils: 85 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Sultan

Setting

Landform: Flood plains
Parent material: Alluvium

Typical profile

H1 - 0 to 12 inches: ashy silt loam
H2 - 12 to 42 inches: silty clay loam
H3 - 42 to 60 inches: stratified sand to silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 24 to 48 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 10.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C
Ecological site: F002XA005WA - Puget Lowlands Moist Forest
Forage suitability group: Seasonally Wet Soils (G002XN202WA)
Other vegetative classification: Seasonally Wet Soils (G002XN202WA)
Hydric soil rating: No

Minor Components

Puget, undrained

Percent of map unit: 5 percent
Landform: Flood plains
Other vegetative classification: Wet Soils (G002XN102WA)
Hydric soil rating: Yes

72—Tokul gravelly medial loam, 0 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2t61k
Elevation: 160 to 1,150 feet
Mean annual precipitation: 45 to 70 inches
Mean annual air temperature: 46 to 52 degrees F
Frost-free period: 140 to 200 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Tokul and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tokul

Setting

Landform: Hillslopes, till plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Side slope, tread
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Volcanic ash mixed with loess over glacial till

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
Oa - 1 to 2 inches: highly decomposed plant material
A - 2 to 6 inches: gravelly medial loam
Bs1 - 6 to 9 inches: gravelly medial loam
Bs2 - 9 to 17 inches: gravelly medial loam
Bs3 - 17 to 24 inches: gravelly medial loam
BC - 24 to 33 inches: gravelly medial fine sandy loam
2Bsm - 33 to 62 inches: cemented material

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 20 to 39 inches to densic material; 20 to 39 inches to cemented horizon
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 8.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: B
Ecological site: F002XA005WA - Puget Lowlands Moist Forest
Forage suitability group: Limited Depth Soils (G002XN302WA), Limited Depth Soils (G002XF303WA)
Other vegetative classification: Limited Depth Soils (G002XN302WA), Limited Depth Soils (G002XF303WA)
Hydric soil rating: No

Minor Components

Pastik

Percent of map unit: 5 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear

Hydric soil rating: No

Barneston

Percent of map unit: 5 percent
Landform: Moraines, eskers, kames
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Crest, interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Norma

Percent of map unit: 3 percent
Landform: Drainageways, depressions
Landform position (three-dimensional): Dip
Down-slope shape: Linear, concave
Across-slope shape: Concave
Hydric soil rating: Yes

Mckenna

Percent of map unit: 2 percent
Landform: Drainageways, depressions
Landform position (three-dimensional): Dip
Down-slope shape: Linear, concave
Across-slope shape: Concave
Hydric soil rating: Yes

73—Tokul gravelly medial loam, 8 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2t61l
Elevation: 160 to 1,150 feet
Mean annual precipitation: 45 to 70 inches
Mean annual air temperature: 46 to 52 degrees F
Frost-free period: 140 to 200 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Tokul and similar soils: 70 percent
Minor components: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tokul

Setting

Landform: Till plains, hillslopes
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Side slope, tread
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Volcanic ash mixed with loess over glacial till

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
Oa - 1 to 2 inches: highly decomposed plant material
A - 2 to 6 inches: gravelly medial loam
Bs1 - 6 to 9 inches: gravelly medial loam
Bs2 - 9 to 17 inches: gravelly medial loam
Bs3 - 17 to 24 inches: gravelly medial loam
BC - 24 to 33 inches: gravelly medial fine sandy loam
2Bsm - 33 to 62 inches: cemented material

Properties and qualities

Slope: 8 to 15 percent
Depth to restrictive feature: 20 to 39 inches to densic material; 20 to 39 inches to cemented horizon
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 8.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: F002XA005WA - Puget Lowlands Moist Forest
Forage suitability group: Limited Depth Soils (G002XF303WA)
Other vegetative classification: Limited Depth Soils (G002XF303WA)
Hydric soil rating: No

Minor Components

Vanzandt

Percent of map unit: 10 percent
Landform: Hillslopes
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: No

Barneston

Percent of map unit: 5 percent
Landform: Moraines, eskers, kames
Landform position (two-dimensional): Shoulder, footslope
Landform position (three-dimensional): Crest, base slope
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Pastik

Percent of map unit: 5 percent
Landform: Terraces
Landform position (three-dimensional): Riser
Down-slope shape: Linear

Across-slope shape: Linear
Hydric soil rating: No

Rinker

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Crest
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Norma

Percent of map unit: 3 percent
Landform: Drainageways, depressions
Landform position (three-dimensional): Dip
Down-slope shape: Linear, concave
Across-slope shape: Concave
Hydric soil rating: Yes

Mckenna

Percent of map unit: 2 percent
Landform: Drainageways, depressions
Landform position (three-dimensional): Dip
Down-slope shape: Linear, concave
Across-slope shape: Concave
Hydric soil rating: Yes

77—Tokul-Winston gravelly loams, 25 to 65 percent slopes

Map Unit Setting

National map unit symbol: 2j08
Elevation: 150 to 1,900 feet
Mean annual precipitation: 40 to 80 inches
Mean annual air temperature: 46 to 50 degrees F
Frost-free period: 140 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

Tokul and similar soils: 60 percent
Winston and similar soils: 30 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Tokul

Setting

Landform: Escarpments, till plains
Parent material: Volcanic ash over basal till

Typical profile

H1 - 0 to 4 inches: gravelly medial loam

H2 - 4 to 22 inches: gravelly medial loam
H3 - 22 to 31 inches: gravelly medial fine sandy loam
H4 - 31 to 60 inches: gravelly sandy loam

Properties and qualities

Slope: 25 to 65 percent
Depth to restrictive feature: 20 to 40 inches to densic material
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.06 in/hr)
Depth to water table: About 18 to 36 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Low (about 5.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: C
Ecological site: F002XA005WA - Puget Lowlands Moist Forest
Hydric soil rating: No

Description of Winston

Setting

Landform: Escarpments
Parent material: Volcanic ash and glacial outwash

Typical profile

H1 - 0 to 3 inches: gravelly ashy loam
H2 - 3 to 25 inches: gravelly fine sandy loam
H3 - 25 to 60 inches: extremely gravelly coarse sand

Properties and qualities

Slope: 25 to 65 percent
Depth to restrictive feature: 20 to 40 inches to strongly contrasting textural stratification
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: Moderate (about 7.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: F002XA005WA - Puget Lowlands Moist Forest
Hydric soil rating: No

82—Xerorthents, nearly level

Map Unit Setting

National map unit symbol: 2j0g
Elevation: 2,620 to 4,100 feet
Mean annual precipitation: 40 to 60 inches
Mean annual air temperature: 50 degrees F
Frost-free period: 150 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

Xerorthents and similar soils: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Xerorthents

Setting

Landform: Till plains
Parent material: Disturbed areas replaced with mixed fill material

Typical profile

H1 - 0 to 6 inches: silty clay loam
H2 - 6 to 60 inches: silty clay loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.20 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water supply, 0 to 60 inches: High (about 10.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: B
Hydric soil rating: No

83—Water

Map Unit Composition

Water: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

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Glossary

Many of the terms relating to landforms, geology, and geomorphology are defined in more detail in the following National Soil Survey Handbook link: "National Soil Survey Handbook."

ABC soil

A soil having an A, a B, and a C horizon.

Ablation till

Loose, relatively permeable earthy material deposited during the downwasting of nearly static glacial ice, either contained within or accumulated on the surface of the glacier.

AC soil

A soil having only an A and a C horizon. Commonly, such soil formed in recent alluvium or on steep, rocky slopes.

Aeration, soil

The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil

Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alkali (sodic) soil

A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Alluvial cone

A semiconical type of alluvial fan having very steep slopes. It is higher, narrower, and steeper than a fan and is composed of coarser and thicker layers of material deposited by a combination of alluvial episodes and (to a much lesser degree) landslides (debris flow). The coarsest materials tend to be concentrated at the apex of the cone.

Alluvial fan

A low, outspread mass of loose materials and/or rock material, commonly with gentle slopes. It is shaped like an open fan or a segment of a cone. The material was deposited by a stream at the place where it issues from a narrow mountain valley or upland valley or where a tributary stream is near or at its junction with the main stream. The fan is steepest near its apex, which points upstream, and slopes gently and convexly outward (downstream) with a gradual decrease in gradient.

Alluvium

Unconsolidated material, such as gravel, sand, silt, clay, and various mixtures of these, deposited on land by running water.

Alpha,alpha-dipyridyl

A compound that when dissolved in ammonium acetate is used to detect the presence of reduced iron (Fe II) in the soil. A positive reaction implies reducing conditions and the likely presence of redoximorphic features.

Animal unit month (AUM)

The amount of forage required by one mature cow of approximately 1,000 pounds weight, with or without a calf, for 1 month.

Aquic conditions

Current soil wetness characterized by saturation, reduction, and redoximorphic features.

Argillic horizon

A subsoil horizon characterized by an accumulation of illuvial clay.

Arroyo

The flat-floored channel of an ephemeral stream, commonly with very steep to vertical banks cut in unconsolidated material. It is usually dry but can be transformed into a temporary watercourse or short-lived torrent after heavy rain within the watershed.

Aspect

The direction toward which a slope faces. Also called slope aspect.

Association, soil

A group of soils or miscellaneous areas geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

Available water capacity (available moisture capacity)

The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as:

Very low: 0 to 3
Low: 3 to 6
Moderate: 6 to 9
High: 9 to 12
Very high: More than 12

Backslope

The position that forms the steepest and generally linear, middle portion of a hillslope. In profile, backslopes are commonly bounded by a convex shoulder above and a concave footslope below.

Backswamp

A flood-plain landform. Extensive, marshy or swampy, depressed areas of flood plains between natural levees and valley sides or terraces.

Badland

A landscape that is intricately dissected and characterized by a very fine drainage network with high drainage densities and short, steep slopes and narrow interfluves. Badlands develop on surfaces that have little or no vegetative cover overlying unconsolidated or poorly cemented materials (clays, silts, or sandstones) with, in some cases, soluble minerals, such as gypsum or halite.

Bajada

A broad, gently inclined alluvial piedmont slope extending from the base of a mountain range out into a basin and formed by the lateral coalescence of a series of alluvial fans. Typically, it has a broadly undulating transverse profile, parallel to the mountain front, resulting from the convexities of component fans. The term is generally restricted to constructional slopes of intermontane basins.

Basal area

The area of a cross section of a tree, generally referring to the section at breast height and measured outside the bark. It is a measure of stand density, commonly expressed in square feet.

Base saturation

The degree to which material having cation-exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, and K), expressed as a percentage of the total cation-exchange capacity.

Base slope (geomorphology)

A geomorphic component of hills consisting of the concave to linear (perpendicular to the contour) slope that, regardless of the lateral shape, forms an apron or wedge at the bottom of a hillside dominated by colluvium and slope-wash sediments (for example, slope alluvium).

Bedding plane

A planar or nearly planar bedding surface that visibly separates each successive layer of stratified sediment or rock (of the same or different lithology) from the preceding or following layer; a plane of deposition. It commonly marks a change in the circumstances of deposition and may show a parting, a color difference, a change in particle size, or various combinations of these. The term is commonly applied to any bedding surface, even one that is conspicuously bent or deformed by folding.

Bedding system

A drainage system made by plowing, grading, or otherwise shaping the surface of a flat field. It consists of a series of low ridges separated by shallow, parallel dead furrows.

Bedrock

The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bedrock-controlled topography

A landscape where the configuration and relief of the landforms are determined or strongly influenced by the underlying bedrock.

Bench terrace

A raised, level or nearly level strip of earth constructed on or nearly on a contour, supported by a barrier of rocks or similar material, and designed to make the soil suitable for tillage and to prevent accelerated erosion.

Bisequum

Two sequences of soil horizons, each of which consists of an illuvial horizon and the overlying eluvial horizons.

Blowout (map symbol)

A saucer-, cup-, or trough-shaped depression formed by wind erosion on a preexisting dune or other sand deposit, especially in an area of shifting sand or loose soil or where protective vegetation is disturbed or destroyed. The adjoining accumulation of sand derived from the depression, where recognizable, is commonly included. Blowouts are commonly small.

Borrow pit (map symbol)

An open excavation from which soil and underlying material have been removed, usually for construction purposes.

Bottom land

An informal term loosely applied to various portions of a flood plain.

Boulders

Rock fragments larger than 2 feet (60 centimeters) in diameter.

Breaks

A landscape or tract of steep, rough or broken land dissected by ravines and gullies and marking a sudden change in topography.

Breast height

An average height of 4.5 feet above the ground surface; the point on a tree where diameter measurements are ordinarily taken.

Brush management

Use of mechanical, chemical, or biological methods to make conditions favorable for reseeding or to reduce or eliminate competition from woody vegetation and thus allow understory grasses and forbs to recover. Brush management increases forage production and thus reduces the hazard of erosion. It can improve the habitat for some species of wildlife.

Butte

An isolated, generally flat-topped hill or mountain with relatively steep slopes and talus or precipitous cliffs and characterized by summit width that is less than the height of bounding escarpments; commonly topped by a caprock of resistant material and representing an erosion remnant carved from flat-lying rocks.

Cable yarding

A method of moving felled trees to a nearby central area for transport to a processing facility. Most cable yarding systems involve use of a drum, a pole, and wire cables in an arrangement similar to that of a rod and reel used for fishing. To reduce friction and soil disturbance, felled trees generally are reeled in while one end is lifted or the entire log is suspended.

Calcareous soil

A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Caliche

A general term for a prominent zone of secondary carbonate accumulation in surficial materials in warm, subhumid to arid areas. Caliche is formed by both geologic and pedologic processes. Finely crystalline calcium carbonate forms a nearly continuous surface-coating and void-filling medium in geologic (parent) materials. Cementation ranges from weak in nonindurated forms to very strong in indurated forms. Other minerals (e.g., carbonates, silicate, and sulfate) may occur as accessory cements. Most petrocalcic horizons and some calcic horizons are caliche.

California bearing ratio (CBR)

The load-supporting capacity of a soil as compared to that of standard crushed limestone, expressed as a ratio. First standardized in California. A soil having a CBR of 16 supports 16 percent of the load that would be supported by standard crushed limestone, per unit area, with the same degree of distortion.

Canopy

The leafy crown of trees or shrubs. (See Crown.)

Canyon

A long, deep, narrow valley with high, precipitous walls in an area of high local relief.

Capillary water

Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Catena

A sequence, or “chain,” of soils on a landscape that formed in similar kinds of parent material and under similar climatic conditions but that have different characteristics as a result of differences in relief and drainage.

Cation

An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Cation-exchange capacity

The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity but is more precise in meaning.

Catsteps

See Terracettes.

Cement rock

Shaly limestone used in the manufacture of cement.

Channery soil material

Soil material that has, by volume, 15 to 35 percent thin, flat fragments of sandstone, shale, slate, limestone, or schist as much as 6 inches (15 centimeters) along the longest axis. A single piece is called a channer.

Chemical treatment

Control of unwanted vegetation through the use of chemicals.

Chiseling

Tillage with an implement having one or more soil-penetrating points that shatter or loosen hard, compacted layers to a depth below normal plow depth.

Cirque

A steep-walled, semicircular or crescent-shaped, half-bowl-like recess or hollow, commonly situated at the head of a glaciated mountain valley or high on the side of a mountain. It was produced by the erosive activity of a mountain glacier. It commonly contains a small round lake (tarn).

Clay

As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay depletions

See Redoximorphic features.

Clay film

A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Clay spot (map symbol)

A spot where the surface texture is silty clay or clay in areas where the surface layer of the soils in the surrounding map unit is sandy loam, loam, silt loam, or coarser.

Claypan

A dense, compact subsoil layer that contains much more clay than the overlying materials, from which it is separated by a sharply defined boundary. The layer restricts the downward movement of water through the soil. A claypan is commonly hard when dry and plastic and sticky when wet.

Climax plant community

The stabilized plant community on a particular site. The plant cover reproduces itself and does not change so long as the environment remains the same.

Coarse textured soil

Sand or loamy sand.

Cobble (or cobblestone)

A rounded or partly rounded fragment of rock 3 to 10 inches (7.6 to 25 centimeters) in diameter.

Cobbly soil material

Material that has 15 to 35 percent, by volume, rounded or partially rounded rock fragments 3 to 10 inches (7.6 to 25 centimeters) in diameter. Very cobbly soil material has 35 to 60 percent of these rock fragments, and extremely cobbly soil material has more than 60 percent.

COLE (coefficient of linear extensibility)

See Linear extensibility.

Colluvium

Unconsolidated, unsorted earth material being transported or deposited on side slopes and/or at the base of slopes by mass movement (e.g., direct gravitational action) and by local, unconcentrated runoff.

Complex slope

Irregular or variable slope. Planning or establishing terraces, diversions, and other water-control structures on a complex slope is difficult.

Complex, soil

A map unit of two or more kinds of soil or miscellaneous areas in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas.

Concretions

See Redoximorphic features.

Conglomerate

A coarse grained, clastic sedimentary rock composed of rounded or subangular rock fragments more than 2 millimeters in diameter. It commonly has a matrix of sand and finer textured material. Conglomerate is the consolidated equivalent of gravel.

Conservation cropping system

Growing crops in combination with needed cultural and management practices. In a good conservation cropping system, the soil-improving crops and practices more than offset the effects of the soil-depleting crops and practices. Cropping systems are needed on all tilled soils. Soil-improving practices in a conservation cropping system include the use of rotations that contain grasses and legumes and the return of crop residue to the soil. Other practices include the use of green manure crops of grasses and legumes, proper tillage, adequate fertilization, and weed and pest control.

Conservation tillage

A tillage system that does not invert the soil and that leaves a protective amount of crop residue on the surface throughout the year.

Consistence, soil

Refers to the degree of cohesion and adhesion of soil material and its resistance to deformation when ruptured. Consistence includes resistance of soil material to rupture and to penetration; plasticity, toughness, and stickiness of puddled soil material; and the manner in which the soil material behaves when subject to compression. Terms describing consistence are defined in the "Soil Survey Manual."

Contour stripcropping

Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Control section

The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches and 40 or 80 inches.

Coprogenous earth (sedimentary peat)

A type of limnic layer composed predominantly of fecal material derived from aquatic animals.

Corrosion (geomorphology)

A process of erosion whereby rocks and soil are removed or worn away by natural chemical processes, especially by the solvent action of running water, but also by other reactions, such as hydrolysis, hydration, carbonation, and oxidation.

Corrosion (soil survey interpretations)

Soil-induced electrochemical or chemical action that dissolves or weakens concrete or uncoated steel.

Cover crop

A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

Crop residue management

Returning crop residue to the soil, which helps to maintain soil structure, organic matter content, and fertility and helps to control erosion.

Cropping system

Growing crops according to a planned system of rotation and management practices.

Cross-slope farming

Deliberately conducting farming operations on sloping farmland in such a way that tillage is across the general slope.

Crown

The upper part of a tree or shrub, including the living branches and their foliage.

Cryoturbate

A mass of soil or other unconsolidated earthy material moved or disturbed by frost action. It is typically coarser than the underlying material.

Cuesta

An asymmetric ridge capped by resistant rock layers of slight or moderate dip (commonly less than 15 percent slopes); a type of homocline produced by differential erosion of interbedded resistant and weak rocks. A cuesta has a long, gentle slope on one side (dip slope) that roughly parallels the inclined beds; on the other side, it has a relatively short and steep or clifflike slope (scarp) that cuts through the tilted rocks.

Culmination of the mean annual increment (CMAI)

The average annual increase per acre in the volume of a stand. Computed by dividing the total volume of the stand by its age. As the stand increases in age, the mean annual increment continues to increase until mortality begins to reduce the rate of increase. The point where the stand reaches its maximum annual rate of growth is called the culmination of the mean annual increment.

Cutbanks cave

The walls of excavations tend to cave in or slough.

Decreasers

The most heavily grazed climax range plants. Because they are the most palatable, they are the first to be destroyed by overgrazing.

Deferred grazing

Postponing grazing or resting grazing land for a prescribed period.

Delta

A body of alluvium having a surface that is fan shaped and nearly flat; deposited at or near the mouth of a river or stream where it enters a body of relatively quiet water, generally a sea or lake.

Dense layer

A very firm, massive layer that has a bulk density of more than 1.8 grams per cubic centimeter. Such a layer affects the ease of digging and can affect filling and compacting.

Depression, closed (map symbol)

A shallow, saucer-shaped area that is slightly lower on the landscape than the surrounding area and that does not have a natural outlet for surface drainage.

Depth, soil

Generally, the thickness of the soil over bedrock. Very deep soils are more than 60 inches deep over bedrock; deep soils, 40 to 60 inches; moderately deep, 20 to 40 inches; shallow, 10 to 20 inches; and very shallow, less than 10 inches.

Desert pavement

A natural, residual concentration or layer of wind-polished, closely packed gravel, boulders, and other rock fragments mantling a desert surface. It forms where wind action and sheetwash have removed all smaller particles or where rock fragments have migrated upward through sediments to the surface. It typically protects the finer grained underlying material from further erosion.

Diatomaceous earth

A geologic deposit of fine, grayish siliceous material composed chiefly or entirely of the remains of diatoms.

Dip slope

A slope of the land surface, roughly determined by and approximately conforming to the dip of the underlying bedrock.

Diversion (or diversion terrace)

A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

Divided-slope farming

A form of field stripcropping in which crops are grown in a systematic arrangement of two strips, or bands, across the slope to reduce the hazard of water erosion. One strip is in a close-growing crop that provides protection from erosion, and the other strip is in a crop that provides less protection from erosion. This practice is used where slopes are not long enough to permit a full stripcropping pattern to be used.

Drainage class (natural)

Refers to the frequency and duration of wet periods under conditions similar to those under which the soil formed. Alterations of the water regime by human activities, either through drainage or irrigation, are not a consideration unless they have significantly changed the morphology of the soil. Seven classes of natural soil drainage are recognized—*excessively drained, somewhat excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained,* and *very poorly drained*. These classes are defined in the “Soil Survey Manual.”

Drainage, surface

Runoff, or surface flow of water, from an area.

Drainageway

A general term for a course or channel along which water moves in draining an area. A term restricted to relatively small, linear depressions that at some time move concentrated water and either do not have a defined channel or have only a small defined channel.

Draw

A small stream valley that generally is shallower and more open than a ravine or gulch and that has a broader bottom. The present stream channel may appear inadequate to have cut the drainageway that it occupies.

Drift

A general term applied to all mineral material (clay, silt, sand, gravel, and boulders) transported by a glacier and deposited directly by or from the ice or transported by running water emanating from a glacier. Drift includes unstratified material (till) that forms moraines and stratified deposits that form outwash plains, eskers, kames, varves, and glaciofluvial sediments. The term is generally applied to Pleistocene glacial deposits in areas that no longer contain glaciers.

Drumlin

A low, smooth, elongated oval hill, mound, or ridge of compact till that has a core of bedrock or drift. It commonly has a blunt nose facing the direction from which the ice approached and a gentler slope tapering in the other direction. The longer axis is parallel to the general direction of glacier flow. Drumlins are products of streamline (laminar) flow of glaciers, which molded the subglacial floor through a combination of erosion and deposition.

Duff

A generally firm organic layer on the surface of mineral soils. It consists of fallen plant material that is in the process of decomposition and includes everything from the litter on the surface to underlying pure humus.

Dune

A low mound, ridge, bank, or hill of loose, windblown granular material (generally sand), either barren and capable of movement from place to place or covered and stabilized with vegetation but retaining its characteristic shape.

Earthy fill

See Mine spoil.

Ecological site

An area where climate, soil, and relief are sufficiently uniform to produce a distinct natural plant community. An ecological site is the product of all the environmental factors responsible for its development. It is typified by an association of species that differ from those on other ecological sites in kind and/or proportion of species or in total production.

Eluviation

The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

Endosaturation

A type of saturation of the soil in which all horizons between the upper boundary of saturation and a depth of 2 meters are saturated.

Eolian deposit

Sand-, silt-, or clay-sized clastic material transported and deposited primarily by wind, commonly in the form of a dune or a sheet of sand or loess.

Ephemeral stream

A stream, or reach of a stream, that flows only in direct response to precipitation. It receives no long-continued supply from melting snow or other source, and its channel is above the water table at all times.

Episaturation

A type of saturation indicating a perched water table in a soil in which saturated layers are underlain by one or more unsaturated layers within 2 meters of the surface.

Erosion

The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (accelerated)

Erosion much more rapid than geologic erosion, mainly as a result of human or animal activities or of a catastrophe in nature, such as a fire, that exposes the surface.

Erosion (geologic)

Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion pavement

A surficial lag concentration or layer of gravel and other rock fragments that remains on the soil surface after sheet or rill erosion or wind has removed the finer soil particles and that tends to protect the underlying soil from further erosion.

Erosion surface

A land surface shaped by the action of erosion, especially by running water.

Escarpment

A relatively continuous and steep slope or cliff breaking the general continuity of more gently sloping land surfaces and resulting from erosion or faulting. Most commonly applied to cliffs produced by differential erosion. Synonym: scarp.

Escarpment, bedrock (map symbol)

A relatively continuous and steep slope or cliff, produced by erosion or faulting, that breaks the general continuity of more gently sloping land surfaces. Exposed material is hard or soft bedrock.

Escarpment, nonbedrock (map symbol)

A relatively continuous and steep slope or cliff, generally produced by erosion but in some places produced by faulting, that breaks the continuity of more gently sloping land surfaces. Exposed earthy material is nonsoil or very shallow soil.

Esker

A long, narrow, sinuous, steep-sided ridge of stratified sand and gravel deposited as the bed of a stream flowing in an ice tunnel within or below the ice (subglacial) or between ice walls on top of the ice of a wasting glacier and left behind as high ground when the ice melted. Eskers range in length from less than a kilometer to more than 160 kilometers and in height from 3 to 30 meters.

Extrusive rock

Igneous rock derived from deep-seated molten matter (magma) deposited and cooled on the earth's surface.

Fallow

Cropland left idle in order to restore productivity through accumulation of moisture. Summer fallow is common in regions of limited rainfall where cereal grain is grown. The soil is tilled for at least one growing season for weed control and decomposition of plant residue.

Fan remnant

A general term for landforms that are the remaining parts of older fan landforms, such as alluvial fans, that have been either dissected or partially buried.

Fertility, soil

The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Fibric soil material (peat)

The least decomposed of all organic soil material. Peat contains a large amount of well preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

Field moisture capacity

The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity*.

Fill slope

A sloping surface consisting of excavated soil material from a road cut. It commonly is on the downhill side of the road.

Fine textured soil

Sandy clay, silty clay, or clay.

Firebreak

An area cleared of flammable material to stop or help control creeping or running fires. It also serves as a line from which to work and to facilitate the movement of firefighters and equipment. Designated roads also serve as firebreaks.

First bottom

An obsolete, informal term loosely applied to the lowest flood-plain steps that are subject to regular flooding.

Flaggy soil material

Material that has, by volume, 15 to 35 percent flagstones. Very flaggy soil material has 35 to 60 percent flagstones, and extremely flaggy soil material has more than 60 percent flagstones.

Flagstone

A thin fragment of sandstone, limestone, slate, shale, or (rarely) schist 6 to 15 inches (15 to 38 centimeters) long.

Flood plain

The nearly level plain that borders a stream and is subject to flooding unless protected artificially.

Flood-plain landforms

A variety of constructional and erosional features produced by stream channel migration and flooding. Examples include backswamps, flood-plain splays, meanders, meander belts, meander scrolls, oxbow lakes, and natural levees.

Flood-plain splay

A fan-shaped deposit or other outspread deposit formed where an overloaded stream breaks through a levee (natural or artificial) and deposits its material (commonly coarse grained) on the flood plain.

Flood-plain step

An essentially flat, terrace-like alluvial surface within a valley that is frequently covered by floodwater from the present stream; any approximately horizontal surface still actively modified by fluvial scour and/or deposition. May occur individually or as a series of steps.

Fluvial

Of or pertaining to rivers or streams; produced by stream or river action.

Foothills

A region of steeply sloping hills that fringes a mountain range or high-plateau escarpment. The hills have relief of as much as 1,000 feet (300 meters).

Footslope

The concave surface at the base of a hillslope. A footslope is a transition zone between upslope sites of erosion and transport (shoulders and backslopes) and downslope sites of deposition (toeslopes).

Forb

Any herbaceous plant not a grass or a sedge.

Forest cover

All trees and other woody plants (underbrush) covering the ground in a forest.

Forest type

A stand of trees similar in composition and development because of given physical and biological factors by which it may be differentiated from other stands.

Fragipan

A loamy, brittle subsurface horizon low in porosity and content of organic matter and low or moderate in clay but high in silt or very fine sand. A fragipan appears cemented and restricts roots. When dry, it is hard or very hard and has a higher bulk density than the horizon or horizons above. When moist, it tends to rupture suddenly under pressure rather than to deform slowly.

Genesis, soil

The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Gilgai

Commonly, a succession of microbasins and microknolls in nearly level areas or of microvalleys and microridges parallel with the slope. Typically, the microrelief of clayey soils that shrink and swell considerably with changes in moisture content.

Glaciofluvial deposits

Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and occur in the form of outwash plains, valley trains, deltas, kames, eskers, and kame terraces.

Glaciolacustrine deposits

Material ranging from fine clay to sand derived from glaciers and deposited in glacial lakes mainly by glacial meltwater. Many deposits are bedded or laminated.

Gleyed soil

Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors.

Graded stripcropping

Growing crops in strips that grade toward a protected waterway.

Grassed waterway

A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel

Rounded or angular fragments of rock as much as 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

Gravel pit (map symbol)

An open excavation from which soil and underlying material have been removed and used, without crushing, as a source of sand or gravel.

Gravelly soil material

Material that has 15 to 35 percent, by volume, rounded or angular rock fragments, not prominently flattened, as much as 3 inches (7.6 centimeters) in diameter.

Gravelly spot (map symbol)

A spot where the surface layer has more than 35 percent, by volume, rock fragments that are mostly less than 3 inches in diameter in an area that has less than 15 percent rock fragments.

Green manure crop (agronomy)

A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

Ground water

Water filling all the unblocked pores of the material below the water table.

Gully (map symbol)

A small, steep-sided channel caused by erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage whereas a rill is of lesser depth and can be smoothed over by ordinary tillage.

Hard bedrock

Bedrock that cannot be excavated except by blasting or by the use of special equipment that is not commonly used in construction.

Hard to reclaim

Reclamation is difficult after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Hardpan

A hardened or cemented soil horizon, or layer. The soil material is sandy, loamy, or clayey and is cemented by iron oxide, silica, calcium carbonate, or other substance.

Head slope (geomorphology)

A geomorphic component of hills consisting of a laterally concave area of a hillside, especially at the head of a drainageway. The overland waterflow is converging.

Hemic soil material (mucky peat)

Organic soil material intermediate in degree of decomposition between the less decomposed fibric material and the more decomposed sapric material.

High-residue crops

Such crops as small grain and corn used for grain. If properly managed, residue from these crops can be used to control erosion until the next crop in the rotation is established. These crops return large amounts of organic matter to the soil.

Hill

A generic term for an elevated area of the land surface, rising as much as 1,000 feet above surrounding lowlands, commonly of limited summit area and having a well defined outline. Slopes are generally more than 15 percent. The distinction between a hill and a mountain is arbitrary and may depend on local usage.

Hillslope

A generic term for the steeper part of a hill between its summit and the drainage line, valley flat, or depression floor at the base of a hill.

Horizon, soil

A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the “Soil Survey Manual.” The major horizons of mineral soil are as follows:

O horizon: An organic layer of fresh and decaying plant residue.

L horizon: A layer of organic and mineral limnic materials, including coprogenous earth (sedimentary peat), diatomaceous earth, and marl.

A horizon: The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon, most of which was originally part of a B horizon.

E horizon: The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon: The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics, such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

C horizon: The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying soil material. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

Cr horizon: Soft, consolidated bedrock beneath the soil.

R layer: Consolidated bedrock beneath the soil. The bedrock commonly underlies a C horizon, but it can be directly below an A or a B horizon.

M layer: A root-limiting subsoil layer consisting of nearly continuous, horizontally oriented, human-manufactured materials.

W layer: A layer of water within or beneath the soil.

Humus

The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups

Refers to soils grouped according to their runoff potential. The soil properties that influence this potential are those that affect the minimum rate of water infiltration on a bare soil during periods after prolonged wetting when the soil is not frozen. These properties include depth to a seasonal high water table, the infiltration rate, and depth to a layer that significantly restricts the downward movement of water. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff.

Igneous rock

Rock that was formed by cooling and solidification of magma and that has not been changed appreciably by weathering since its formation. Major varieties include plutonic and volcanic rock (e.g., andesite, basalt, and granite).

Illuviation

The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Impervious soil

A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

Increasers

Species in the climax vegetation that increase in amount as the more desirable plants are reduced by close grazing. Increasers commonly are the shorter plants and the less palatable to livestock.

Infiltration

The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration capacity

The maximum rate at which water can infiltrate into a soil under a given set of conditions.

Infiltration rate

The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Intake rate

The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake, in inches per hour, is expressed as follows:

Very low: Less than 0.2
Low: 0.2 to 0.4
Moderately low: 0.4 to 0.75
Moderate: 0.75 to 1.25
Moderately high: 1.25 to 1.75
High: 1.75 to 2.5
Very high: More than 2.5

Interfluve

A landform composed of the relatively undissected upland or ridge between two adjacent valleys containing streams flowing in the same general direction. An elevated area between two drainageways that sheds water to those drainageways.

Interfluve (geomorphology)

A geomorphic component of hills consisting of the uppermost, comparatively level or gently sloping area of a hill; shoulders of backwearing hillslopes can narrow the upland or can merge, resulting in a strongly convex shape.

Intermittent stream

A stream, or reach of a stream, that does not flow year-round but that is commonly dry for 3 or more months out of 12 and whose channel is generally below the local water table. It flows only during wet periods or when it receives ground-water discharge or long, continued contributions from melting snow or other surface and shallow subsurface sources.

Invaders

On range, plants that encroach into an area and grow after the climax vegetation has been reduced by grazing. Generally, plants invade following disturbance of the surface.

Iron depletions

See Redoximorphic features.

Irrigation

Application of water to soils to assist in production of crops. Methods of irrigation are:

Basin: Water is applied rapidly to nearly level plains surrounded by levees or dikes.

Border: Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Controlled flooding: Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation: Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops or in orchards so that it flows in only one direction.

Drip (or trickle): Water is applied slowly and under low pressure to the surface of the soil or into the soil through such applicators as emitters, porous tubing, or perforated pipe.

Furrow: Water is applied in small ditches made by cultivation implements. Furrows are used for tree and row crops.

Sprinkler: Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Subirrigation: Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding: Water, released at high points, is allowed to flow onto an area without controlled distribution.

Kame

A low mound, knob, hummock, or short irregular ridge composed of stratified sand and gravel deposited by a subglacial stream as a fan or delta at the margin of a melting glacier; by a supraglacial stream in a low place or hole on the surface of the glacier; or as a ponded deposit on the surface or at the margin of stagnant ice.

Karst (topography)

A kind of topography that formed in limestone, gypsum, or other soluble rocks by dissolution and that is characterized by closed depressions, sinkholes, caves, and underground drainage.

Knoll

A small, low, rounded hill rising above adjacent landforms.

Ksat

See Saturated hydraulic conductivity.

Lacustrine deposit

Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Lake plain

A nearly level surface marking the floor of an extinct lake filled by well sorted, generally fine textured, stratified deposits, commonly containing varves.

Lake terrace

A narrow shelf, partly cut and partly built, produced along a lakeshore in front of a scarp line of low cliffs and later exposed when the water level falls.

Landfill (map symbol)

An area of accumulated waste products of human habitation, either above or below natural ground level.

Landslide

A general, encompassing term for most types of mass movement landforms and processes involving the downslope transport and outward deposition of soil and rock materials caused by gravitational forces; the movement may or may not involve saturated materials. The speed and distance of movement, as well as the amount of soil and rock material, vary greatly.

Large stones

Rock fragments 3 inches (7.6 centimeters) or more across. Large stones adversely affect the specified use of the soil.

Lava flow (map symbol)

A solidified, commonly lobate body of rock formed through lateral, surface outpouring of molten lava from a vent or fissure.

Leaching

The removal of soluble material from soil or other material by percolating water.

Levee (map symbol)

An embankment that confines or controls water, especially one built along the banks of a river to prevent overflow onto lowlands.

Linear extensibility

Refers to the change in length of an unconfined clod as moisture content is decreased from a moist to a dry state. Linear extensibility is used to determine the shrink-swell potential of soils. It is an expression of the volume change between the water content of the clod at $^{1}/_{3}$- or $^{1}/_{10}$-bar tension (33kPa or 10kPa tension) and oven dryness. Volume change is influenced by the amount and type of clay minerals in the soil. The volume change is the percent change for the whole soil. If it is expressed as a fraction, the resulting value is COLE, coefficient of linear extensibility.

Liquid limit

The moisture content at which the soil passes from a plastic to a liquid state.

Loam

Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess

Material transported and deposited by wind and consisting dominantly of silt-sized particles.

Low strength

The soil is not strong enough to support loads.

Low-residue crops

Such crops as corn used for silage, peas, beans, and potatoes. Residue from these crops is not adequate to control erosion until the next crop in the rotation is established. These crops return little organic matter to the soil.

Marl

An earthy, unconsolidated deposit consisting chiefly of calcium carbonate mixed with clay in approximately equal proportions; formed primarily under freshwater lacustrine conditions but also formed in more saline environments.

Marsh or swamp (map symbol)

A water-saturated, very poorly drained area that is intermittently or permanently covered by water. Sedges, cattails, and rushes are the dominant vegetation in marshes, and trees or shrubs are the dominant vegetation in swamps. Not used in map units where the named soils are poorly drained or very poorly drained.

Mass movement

A generic term for the dislodgment and downslope transport of soil and rock material as a unit under direct gravitational stress.

Masses

See Redoximorphic features.

Meander belt

The zone within which migration of a meandering channel occurs; the flood-plain area included between two imaginary lines drawn tangential to the outer bends of active channel loops.

Meander scar

A crescent-shaped, concave or linear mark on the face of a bluff or valley wall, produced by the lateral erosion of a meandering stream that impinged upon and undercut the bluff.

Meander scroll

One of a series of long, parallel, close-fitting, crescent-shaped ridges and troughs formed along the inner bank of a stream meander as the channel migrated laterally down-valley and toward the outer bank.

Mechanical treatment

Use of mechanical equipment for seeding, brush management, and other management practices.

Medium textured soil

Very fine sandy loam, loam, silt loam, or silt.

Mesa

A broad, nearly flat topped and commonly isolated landmass bounded by steep slopes or precipitous cliffs and capped by layers of resistant, nearly horizontal rocky material. The summit width is characteristically greater than the height of the bounding escarpments.

Metamorphic rock

Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement at depth in the earth’s crust. Nearly all such rocks are crystalline.

Mine or quarry (map symbol)

An open excavation from which soil and underlying material have been removed and in which bedrock is exposed. Also denotes surface openings to underground mines.

Mine spoil

An accumulation of displaced earthy material, rock, or other waste material removed during mining or excavation. Also called earthy fill.

Mineral soil

Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Minimum tillage

Only the tillage essential to crop production and prevention of soil damage.

Miscellaneous area

A kind of map unit that has little or no natural soil and supports little or no vegetation.

Miscellaneous water (map symbol)

Small, constructed bodies of water that are used for industrial, sanitary, or mining applications and that contain water most of the year.

Moderately coarse textured soil

Coarse sandy loam, sandy loam, or fine sandy loam.

Moderately fine textured soil

Clay loam, sandy clay loam, or silty clay loam.

Mollic epipedon

A thick, dark, humus-rich surface horizon (or horizons) that has high base saturation and pedogenic soil structure. It may include the upper part of the subsoil.

Moraine

In terms of glacial geology, a mound, ridge, or other topographically distinct accumulation of unsorted, unstratified drift, predominantly till, deposited primarily by the direct action of glacial ice in a variety of landforms. Also, a general term for a landform composed mainly of till (except for kame moraines, which are composed mainly of stratified outwash) that has been deposited by a glacier. Some types of moraines are disintegration, end, ground, kame, lateral, recessional, and terminal.

Morphology, soil

The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil

Irregular spots of different colors that vary in number and size. Descriptive terms are as follows: abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent*. The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium,* from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse,* more than 15 millimeters (about 0.6 inch).

Mountain

A generic term for an elevated area of the land surface, rising more than 1,000 feet (300 meters) above surrounding lowlands, commonly of restricted summit area (relative to a plateau) and generally having steep sides. A mountain can occur as a single, isolated mass or in a group forming a chain or range. Mountains are formed primarily by tectonic activity and/or volcanic action but can also be formed by differential erosion.

Muck

Dark, finely divided, well decomposed organic soil material. (See Sapric soil material.)

Mucky peat

See Hemic soil material.

Mudstone

A blocky or massive, fine grained sedimentary rock in which the proportions of clay and silt are approximately equal. Also, a general term for such material as clay, silt, claystone, siltstone, shale, and argillite and that should be used only when the amounts of clay and silt are not known or cannot be precisely identified.

Munsell notation

A designation of color by degrees of three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with hue of 10YR, value of 6, and chroma of 4.

Natric horizon

A special kind of argillic horizon that contains enough exchangeable sodium to have an adverse effect on the physical condition of the subsoil.

Neutral soil

A soil having a pH value of 6.6 to 7.3. (See Reaction, soil.)

Nodules

See Redoximorphic features.

Nose slope (geomorphology)

A geomorphic component of hills consisting of the projecting end (laterally convex area) of a hillside. The overland waterflow is predominantly divergent. Nose slopes consist dominantly of colluvium and slope-wash sediments (for example, slope alluvium).

Nutrient, plant

Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter

Plant and animal residue in the soil in various stages of decomposition. The content of organic matter in the surface layer is described as follows:

Very low: Less than 0.5 percent
Low: 0.5 to 1.0 percent
Moderately low: 1.0 to 2.0 percent
Moderate: 2.0 to 4.0 percent
High: 4.0 to 8.0 percent
Very high: More than 8.0 percent

Outwash

Stratified and sorted sediments (chiefly sand and gravel) removed or “washed out” from a glacier by meltwater streams and deposited in front of or beyond the end moraine or the margin of a glacier. The coarser material is deposited nearer to the ice.

Outwash plain

An extensive lowland area of coarse textured glaciofluvial material. An outwash plain is commonly smooth; where pitted, it generally is low in relief.

Paleoterrace

An erosional remnant of a terrace that retains the surface form and alluvial deposits of its origin but was not emplaced by, and commonly does not grade to, a present-day stream or drainage network.

Pan

A compact, dense layer in a soil that impedes the movement of water and the growth of roots. For example, *hardpan, fragipan, claypan, plowpan,* and *traffic pan*.

Parent material

The unconsolidated organic and mineral material in which soil forms.

Peat

Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture. (See Fibric soil material.)

Ped

An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedisediment

A layer of sediment, eroded from the shoulder and backslope of an erosional slope, that lies on and is being (or was) transported across a gently sloping erosional surface at the foot of a receding hill or mountain slope.

Pedon

The smallest volume that can be called “a soil.” A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation

The movement of water through the soil.

Perennial water (map symbol)

Small, natural or constructed lakes, ponds, or pits that contain water most of the year.

Permafrost

Ground, soil, or rock that remains at or below 0 degrees C for at least 2 years. It is defined on the basis of temperature and is not necessarily frozen.

pH value

A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Phase, soil

A subdivision of a soil series based on features that affect its use and management, such as slope, stoniness, and flooding.

Piping

Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

Pitting

Pits caused by melting around ice. They form on the soil after plant cover is removed.

Plastic limit

The moisture content at which a soil changes from semisolid to plastic.

Plasticity index

The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plateau (geomorphology)

A comparatively flat area of great extent and elevation; specifically, an extensive land region that is considerably elevated (more than 100 meters) above the adjacent lower lying terrain, is commonly limited on at least one side by an abrupt descent, and has a flat or nearly level surface. A comparatively large part of a plateau surface is near summit level.

Playa

The generally dry and nearly level lake plain that occupies the lowest parts of closed depressions, such as those on intermontane basin floors. Temporary flooding occurs primarily in response to precipitation and runoff. Playa deposits are fine grained and may or may not have a high water table and saline conditions.

Plinthite

The sesquioxide-rich, humus-poor, highly weathered mixture of clay with quartz and other diluents. It commonly appears as red mottles, usually in platy, polygonal, or reticulate patterns. Plinthite changes irreversibly to an ironstone hardpan or to irregular aggregates on repeated wetting and drying, especially if it is exposed also to heat from the sun. In a moist soil, plinthite can be cut with a spade. It is a form of laterite.

Plowpan

A compacted layer formed in the soil directly below the plowed layer.

Ponding

Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

Poorly graded

Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Pore linings

See Redoximorphic features.

Potential native plant community

See Climax plant community.

Potential rooting depth (effective rooting depth)

Depth to which roots could penetrate if the content of moisture in the soil were adequate. The soil has no properties restricting the penetration of roots to this depth.

Prescribed burning

Deliberately burning an area for specific management purposes, under the appropriate conditions of weather and soil moisture and at the proper time of day.

Productivity, soil

The capability of a soil for producing a specified plant or sequence of plants under specific management.

Profile, soil

A vertical section of the soil extending through all its horizons and into the parent material.

Proper grazing use

Grazing at an intensity that maintains enough cover to protect the soil and maintain or improve the quantity and quality of the desirable vegetation. This practice increases the vigor and reproduction capacity of the key plants and promotes the accumulation of litter and mulch necessary to conserve soil and water.

Rangeland

Land on which the potential natural vegetation is predominantly grasses, grasslike plants, forbs, or shrubs suitable for grazing or browsing. It includes natural grasslands, savannas, many wetlands, some deserts, tundras, and areas that support certain forb and shrub communities.

Reaction, soil

A measure of acidity or alkalinity of a soil, expressed as pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degrees of acidity or alkalinity, expressed as pH values, are:

Ultra acid: Less than 3.5
Extremely acid: 3.5 to 4.4
Very strongly acid: 4.5 to 5.0
Strongly acid: 5.1 to 5.5
Moderately acid: 5.6 to 6.0
Slightly acid: 6.1 to 6.5
Neutral: 6.6 to 7.3
Slightly alkaline: 7.4 to 7.8
Moderately alkaline: 7.9 to 8.4
Strongly alkaline: 8.5 to 9.0
Very strongly alkaline: 9.1 and higher

Red beds

Sedimentary strata that are mainly red and are made up largely of sandstone and shale.

Redoximorphic concentrations

See Redoximorphic features.

Redoximorphic depletions

See Redoximorphic features.

Redoximorphic features

Redoximorphic features are associated with wetness and result from alternating periods of reduction and oxidation of iron and manganese compounds in the soil. Reduction occurs during saturation with water, and oxidation occurs when the soil is not saturated. Characteristic color patterns are created by these processes. The reduced iron and manganese ions may be removed from a soil if vertical or lateral fluxes of water occur, in which case there is no iron or manganese precipitation in that soil. Wherever the iron and manganese are oxidized and precipitated, they form either soft masses or hard concretions or nodules. Movement of iron and manganese as a result of redoximorphic processes in a soil may result in redoximorphic features that are defined as follows:

1. Redoximorphic concentrations.—These are zones of apparent accumulation of iron-manganese oxides, including:
    A. Nodules and concretions, which are cemented bodies that can be removed from the soil intact. Concretions are distinguished from nodules on the basis of internal organization. A concretion typically has concentric layers that are visible to the naked eye. Nodules do not have visible organized internal structure; *and*
    B. Masses, which are noncemented concentrations of substances within the soil matrix; *and*
    C. Pore linings, i.e., zones of accumulation along pores that may be either coatings on pore surfaces or impregnations from the matrix adjacent to the pores.
2. Redoximorphic depletions.—These are zones of low chroma (chromas less than those in the matrix) where either iron-manganese oxides alone or both iron-manganese oxides and clay have been stripped out, including:
    A. Iron depletions, i.e., zones that contain low amounts of iron and manganese oxides but have a clay content similar to that of the adjacent matrix; *and*
    B. Clay depletions, i.e., zones that contain low amounts of iron, manganese, and clay (often referred to as silt coatings or skeletans).
3. Reduced matrix.—This is a soil matrix that has low chroma *in situ* but undergoes a change in hue or chroma within 30 minutes after the soil material has been exposed to air.

Reduced matrix

See Redoximorphic features.

Regolith

All unconsolidated earth materials above the solid bedrock. It includes material weathered in place from all kinds of bedrock and alluvial, glacial, eolian, lacustrine, and pyroclastic deposits.

Relief

The relative difference in elevation between the upland summits and the lowlands or valleys of a given region.

Residuum (residual soil material)

Unconsolidated, weathered or partly weathered mineral material that accumulated as bedrock disintegrated in place.

Rill

A very small, steep-sided channel resulting from erosion and cut in unconsolidated materials by concentrated but intermittent flow of water. A rill generally is not an obstacle to wheeled vehicles and is shallow enough to be smoothed over by ordinary tillage.

Riser

The vertical or steep side slope (e.g., escarpment) of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural, steplike landforms, such as successive stream terraces.

Road cut

A sloping surface produced by mechanical means during road construction. It is commonly on the uphill side of the road.

Rock fragments

Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Rock outcrop (map symbol)

An exposure of bedrock at the surface of the earth. Not used where the named soils of the surrounding map unit are shallow over bedrock or where “Rock outcrop” is a named component of the map unit.

Root zone

The part of the soil that can be penetrated by plant roots.

Runoff

The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Saline soil

A soil containing soluble salts in an amount that impairs growth of plants. A saline soil does not contain excess exchangeable sodium.

Saline spot (map symbol)

An area where the surface layer has an electrical conductivity of 8 mmhos/cm more than the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has an electrical conductivity of 2 mmhos/cm or less.

Sand

As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Sandstone

Sedimentary rock containing dominantly sand-sized particles.

Sandy spot (map symbol)

A spot where the surface layer is loamy fine sand or coarser in areas where the surface layer of the named soils in the surrounding map unit is very fine sandy loam or finer.

Sapric soil material (muck)

The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

Saturated hydraulic conductivity (Ksat)

The ease with which pores of a saturated soil transmit water. Formally, the proportionality coefficient that expresses the relationship of the rate of water movement to hydraulic gradient in Darcy's Law, a law that describes the rate of water movement through porous media. Commonly abbreviated as "Ksat." Terms describing saturated hydraulic conductivity are:

Very high: 100 or more micrometers per second (14.17 or more inches per hour)

High: 10 to 100 micrometers per second (1.417 to 14.17 inches per hour)

Moderately high: 1 to 10 micrometers per second (0.1417 inch to 1.417 inches per hour)

Moderately low: 0.1 to 1 micrometer per second (0.01417 to 0.1417 inch per hour)

Low: 0.01 to 0.1 micrometer per second (0.001417 to 0.01417 inch per hour)

Very low: Less than 0.01 micrometer per second (less than 0.001417 inch per hour).

To convert inches per hour to micrometers per second, multiply inches per hour by 7.0572. To convert micrometers per second to inches per hour, multiply micrometers per second by 0.1417.

Saturation

Wetness characterized by zero or positive pressure of the soil water. Under conditions of saturation, the water will flow from the soil matrix into an unlined auger hole.

Scarification

The act of abrading, scratching, loosening, crushing, or modifying the surface to increase water absorption or to provide a more tillable soil.

Sedimentary rock

A consolidated deposit of clastic particles, chemical precipitates, or organic remains accumulated at or near the surface of the earth under normal low temperature and pressure conditions. Sedimentary rocks include consolidated equivalents of alluvium, colluvium, drift, and eolian, lacustrine, and marine deposits. Examples are sandstone, siltstone, mudstone, claystone, shale, conglomerate, limestone, dolomite, and coal.

Sequum

A sequence consisting of an illuvial horizon and the overlying eluvial horizon. (See Eluviation.)

Series, soil

A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Severely eroded spot (map symbol)

An area where, on the average, 75 percent or more of the original surface layer has been lost because of accelerated erosion. Not used in map units in which “severely eroded,” “very severely eroded,” or “gullied” is part of the map unit name.

Shale

Sedimentary rock that formed by the hardening of a deposit of clay, silty clay, or silty clay loam and that has a tendency to split into thin layers.

Sheet erosion

The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Short, steep slope (map symbol)

A narrow area of soil having slopes that are at least two slope classes steeper than the slope class of the surrounding map unit.

Shoulder

The convex, erosional surface near the top of a hillslope. A shoulder is a transition from summit to backslope.

Shrink-swell

The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Shrub-coppice dune

A small, streamlined dune that forms around brush and clump vegetation.

Side slope (geomorphology)

A geomorphic component of hills consisting of a laterally planar area of a hillside. The overland waterflow is predominantly parallel. Side slopes are dominantly colluvium and slope-wash sediments.

Silica

A combination of silicon and oxygen. The mineral form is called quartz.

Silica-sesquioxide ratio

The ratio of the number of molecules of silica to the number of molecules of alumina and iron oxide. The more highly weathered soils or their clay fractions in warm-temperate, humid regions, and especially those in the tropics, generally have a low ratio.

Silt

As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Siltstone

An indurated silt having the texture and composition of shale but lacking its fine lamination or fissility; a massive mudstone in which silt predominates over clay.

Similar soils

Soils that share limits of diagnostic criteria, behave and perform in a similar manner, and have similar conservation needs or management requirements for the major land uses in the survey area.

Sinkhole (map symbol)

A closed, circular or elliptical depression, commonly funnel shaped, characterized by subsurface drainage and formed either by dissolution of the surface of underlying bedrock (e.g., limestone, gypsum, or salt) or by collapse of underlying caves within bedrock. Complexes of sinkholes in carbonate-rock terrain are the main components of karst topography.

Site index

A designation of the quality of a forest site based on the height of the dominant stand at an arbitrarily chosen age. For example, if the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years is 75 feet, the site index is 75.

Slickensides (pedogenic)

Grooved, striated, and/or glossy (shiny) slip faces on structural peds, such as wedges; produced by shrink-swell processes, most commonly in soils that have a high content of expansive clays.

Slide or slip (map symbol)

A prominent landform scar or ridge caused by fairly recent mass movement or descent of earthy material resulting from failure of earth or rock under shear stress along one or several surfaces.

Slope

The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Slope alluvium

Sediment gradually transported down the slopes of mountains or hills primarily by nonchannel alluvial processes (i.e., slope-wash processes) and characterized by particle sorting. Lateral particle sorting is evident on long slopes. In a profile sequence, sediments may be distinguished by differences in size and/or specific gravity of rock fragments and may be separated by stone lines. Burnished peds and sorting of rounded or subrounded pebbles or cobbles distinguish these materials from unsorted colluvial deposits.

Slow refill

The slow filling of ponds, resulting from restricted water transmission in the soil.

Slow water movement

Restricted downward movement of water through the soil. See Saturated hydraulic conductivity.

Sodic (alkali) soil

A soil having so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that plant growth is restricted.

Sodic spot (map symbol)

An area where the surface layer has a sodium adsorption ratio that is at least 10 more than that of the surface layer of the named soils in the surrounding map unit. The surface layer of the surrounding soils has a sodium adsorption ratio of 5 or less.

Sodicity

The degree to which a soil is affected by exchangeable sodium. Sodicity is expressed as a sodium adsorption ratio (SAR) of a saturation extract, or the ratio of Na^{+} to Ca^{++} + Mg^{++}. The degrees of sodicity and their respective ratios are:

Slight: Less than 13:1

Moderate: 13-30:1

Strong: More than 30:1

Sodium adsorption ratio (SAR)

A measure of the amount of sodium (Na) relative to calcium (Ca) and magnesium (Mg) in the water extract from saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration.

Soft bedrock

Bedrock that can be excavated with trenching machines, backhoes, small rippers, and other equipment commonly used in construction.

Soil

A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief and by the passage of time.

Soil separates

Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes, in millimeters, of separates recognized in the United States are as follows:

Very coarse sand: 2.0 to 1.0

Coarse sand: 1.0 to 0.5

Medium sand: 0.5 to 0.25

Fine sand: 0.25 to 0.10

Very fine sand: 0.10 to 0.05

Silt: 0.05 to 0.002

Clay: Less than 0.002

Solum

The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the material below the solum. The living roots and plant and animal activities are largely confined to the solum.

Spoil area (map symbol)

A pile of earthy materials, either smoothed or uneven, resulting from human activity.

Stone line

In a vertical cross section, a line formed by scattered fragments or a discrete layer of angular and subangular rock fragments (commonly a gravel- or cobble-sized lag concentration) that formerly was draped across a topographic surface and was later buried by additional sediments. A stone line generally caps material that was subject to weathering, soil formation, and erosion before burial. Many stone lines seem to be buried erosion pavements, originally formed by sheet and rill erosion across the land surface.

Stones

Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter if rounded or 15 to 24 inches (38 to 60 centimeters) in length if flat.

Stony

Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Stony spot (map symbol)

A spot where 0.01 to 0.1 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surrounding soil has no surface stones.

Strath terrace

A type of stream terrace; formed as an erosional surface cut on bedrock and thinly mantled with stream deposits (alluvium).

Stream terrace

One of a series of platforms in a stream valley, flanking and more or less parallel to the stream channel, originally formed near the level of the stream; represents the remnants of an abandoned flood plain, stream bed, or valley floor produced during a former state of fluvial erosion or deposition.

Stripcropping

Growing crops in a systematic arrangement of strips or bands that provide vegetative barriers to wind erosion and water erosion.

Structure, soil

The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are:

Platy: Flat and laminated
Prismatic: Vertically elongated and having flat tops
Columnar: Vertically elongated and having rounded tops
Angular blocky: Having faces that intersect at sharp angles (planes)
Subangular blocky: Having subrounded and planar faces (no sharp angles)
Granular: Small structural units with curved or very irregular faces

Structureless soil horizons are defined as follows:

Single grained: Entirely noncoherent (each grain by itself), as in loose sand
Massive: Occurring as a coherent mass

Stubble mulch

Stubble or other crop residue left on the soil or partly worked into the soil. It protects the soil from wind erosion and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

Subsoil

Technically, the B horizon; roughly, the part of the solum below plow depth.

Subsoiling

Tilling a soil below normal plow depth, ordinarily to shatter a hardpan or claypan.

Substratum

The part of the soil below the solum.

Subsurface layer

Any surface soil horizon (A, E, AB, or EB) below the surface layer.

Summer fallow

The tillage of uncropped land during the summer to control weeds and allow storage of moisture in the soil for the growth of a later crop. A practice common in semiarid regions, where annual precipitation is not enough to produce a crop every year. Summer fallow is frequently practiced before planting winter grain.

Summit

The topographically highest position of a hillslope. It has a nearly level (planar or only slightly convex) surface.

Surface layer

The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the “plow layer,” or the “Ap horizon.”

Surface soil

The A, E, AB, and EB horizons, considered collectively. It includes all subdivisions of these horizons.

Talus

Rock fragments of any size or shape (commonly coarse and angular) derived from and lying at the base of a cliff or very steep rock slope. The accumulated mass of such loose broken rock formed chiefly by falling, rolling, or sliding.

Taxadjuncts

Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior. Soils are recognized as taxadjuncts only when one or more of their characteristics are slightly outside the range defined for the family of the series for which the soils are named.

Terminal moraine

An end moraine that marks the farthest advance of a glacier. It typically has the form of a massive arcuate or concentric ridge, or complex of ridges, and is underlain by till and other types of drift.

Terrace (conservation)

An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet. A terrace in a field generally is built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Terrace (geomorphology)

A steplike surface, bordering a valley floor or shoreline, that represents the former position of a flood plain, lake, or seashore. The term is usually applied both to the relatively flat summit surface (tread) that was cut or built by stream or wave action and to the steeper descending slope (scarp or riser) that has graded to a lower base level of erosion.

Terracettes

Small, irregular steplike forms on steep hillslopes, especially in pasture, formed by creep or erosion of surficial materials that may be induced or enhanced by trampling of livestock, such as sheep or cattle.

Texture, soil

The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying “coarse,” “fine,” or “very fine.”

Thin layer

Otherwise suitable soil material that is too thin for the specified use.

Till

Dominantly unsorted and nonstratified drift, generally unconsolidated and deposited directly by a glacier without subsequent reworking by meltwater, and consisting of a heterogeneous mixture of clay, silt, sand, gravel, stones, and boulders; rock fragments of various lithologies are embedded within a finer matrix that can range from clay to sandy loam.

Till plain

An extensive area of level to gently undulating soils underlain predominantly by till and bounded at the distal end by subordinate recessional or end moraines.

Tilth, soil

The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Toeslope

The gently inclined surface at the base of a hillslope. Toeslopes in profile are commonly gentle and linear and are constructional surfaces forming the lower part of a hillslope continuum that grades to valley or closed-depression floors.

Topsoil

The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Trace elements

Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, in soils in extremely small amounts. They are essential to plant growth.

Tread

The flat to gently sloping, topmost, laterally extensive slope of terraces, flood-plain steps, or other stepped landforms; commonly a recurring part of a series of natural steplike landforms, such as successive stream terraces.

Tuff

A generic term for any consolidated or cemented deposit that is 50 percent or more volcanic ash.

Upland

An informal, general term for the higher ground of a region, in contrast with a low-lying adjacent area, such as a valley or plain, or for land at a higher elevation than the flood plain or low stream terrace; land above the footslope zone of the hillslope continuum.

Valley fill

The unconsolidated sediment deposited by any agent (water, wind, ice, or mass wasting) so as to fill or partly fill a valley.

Variegation

Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

Varve

A sedimentary layer or a lamina or sequence of laminae deposited in a body of still water within a year. Specifically, a thin pair of graded glaciolacustrine layers seasonally deposited, usually by meltwater streams, in a glacial lake or other body of still water in front of a glacier.

Very stony spot (map symbol)

A spot where 0.1 to 3.0 percent of the soil surface is covered by rock fragments that are more than 10 inches in diameter in areas where the surface of the surrounding soil is covered by less than 0.01 percent stones.

Water bars

Smooth, shallow ditches or depressional areas that are excavated at an angle across a sloping road. They are used to reduce the downward velocity of water and divert it off and away from the road surface. Water bars can easily be driven over if constructed properly.

Weathering

All physical disintegration, chemical decomposition, and biologically induced changes in rocks or other deposits at or near the earth's surface by atmospheric or biologic agents or by circulating surface waters but involving essentially no transport of the altered material.

Well graded

Refers to soil material consisting of coarse grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Wet spot (map symbol)

A somewhat poorly drained to very poorly drained area that is at least two drainage classes wetter than the named soils in the surrounding map unit.

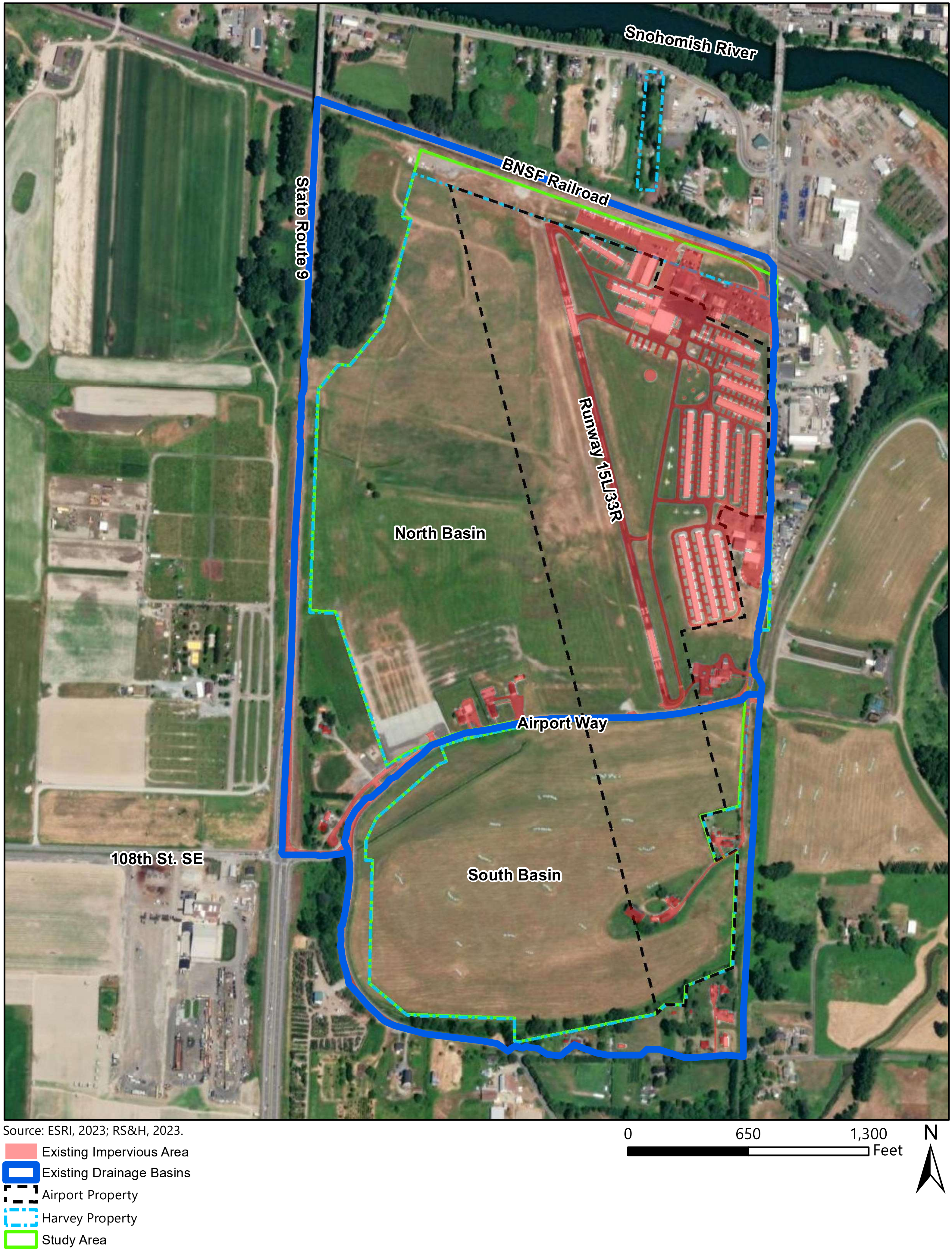
Wilting point (or permanent wilting point)

The moisture content of soil, on an ovendry basis, at which a plant (specifically a sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

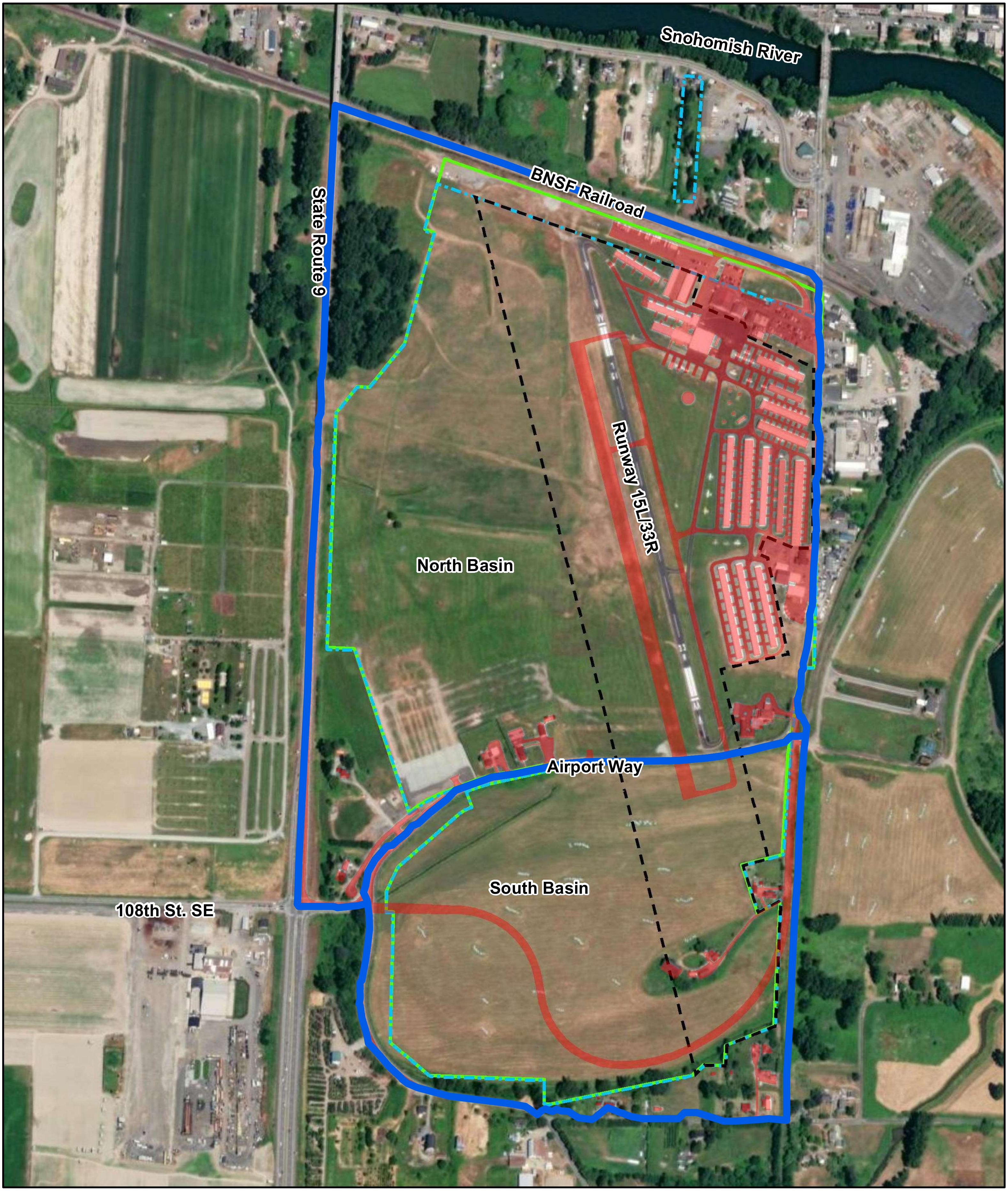
Windthrow

The uprooting and tipping over of trees by the wind.

ATTACHMENT I-3: SITE CURVE NUMBER AND PEAK FLOW CALCULATIONS



Snohomish River
BNSF Railroad
State Route 9
Runway 15L/33R
North Basin
Airport Way
108th St. SE
South Basin
Source: ESRI, 2023; RS&H, 2023.
Existing Impervious Area
Existing Drainage Basins
Airport Property
Harvey Property
Study Area
0
650
1,300
Feet
N



Source: ESRI, 2023; RS&H, 2023.

Future Impervious Area
Future Drainage Basins
Airport Property
Harvey Property
Study Area

Harvey Field Runway Improvement Project EA	Comp. By: JKK Date: 2/26/2024 Chk. By: Job No: 2470064.000

TR-55 Worksheet 2: Curve Number and Runoff

Subbasin Name: North
Condition: Existing

Curve Number (TR-55 Table 2-2)

Total Area:	7,783,373 sf	178.68	ac	0.28 mi^2
Pervious Area:	6,581,404 sf	151.09	ac	
Impervious Area:	1,201,969 sf	27.59	ac	

HSG	Description	CN	Area	CN*A
A	Good Condition (ground cover >75% and lightly or only occasionally grazed)	39	26.33	1026.9
C	Good Condition (ground cover >75% and lightly or only occasionally grazed)	74	124.76	9232.2
				0.0
				0.0
				0.0
				0.0
				0.0
				0.0
				0.0
Impervious	Paved Area, Roofs	98	27.59	2703.8
Totals:			178.68	12962.9
Composite Curve Number:				72.55

Runoff

			Recurrence Interval (yr)					
Frequency		yr	0.5*	2	5	10	50	100
Rainfall (NOAA Atlas 14, 24-hour)	P	in	1.37	1.90	2.30	2.60	3.30	3.70
Potential Maximum Retention (Use TR-55 Equation 2-4)	S	in	3.78	3.78	3.78	3.78	3.78	3.78
Runoff (Use TR-55 Equation 2-3)	Q	in	0.085	0.265	0.447	0.604	1.022	1.288

*72% of 2-year, 24-hour rainfall per SCDM Volume III Section 2.3.1

Harvey Field Runway Improvement Project EA	Comp. By: JKK Date: 2/26/2024 Chk. By: LMM Job No: 2470064.000

TR-55 Worksheet 2: Curve Number and Runoff

Subbasin Name: South
Condition: Existing

Curve Number (TR-55 Table 2-2)

Total Area:	3,666,195 sf	84.16	ac	0.13	mi^2
Pervious Area:	3,535,101 sf	81.15	ac		
Impervious Area:	131,091 sf	3.01	ac		

HSG	Description	CN	Area	CN*A
A	Good Condition (ground cover >75% and lightly or only occasionally grazed)	39	5.82	227.0
C	Good Condition (ground cover >75% and lightly or only occasionally grazed)	74	75.33	5574.4
				0.0
				0.0
				0.0
				0.0
				0.0
				0.0
Impervious	Paved Area, Roofs	98	3.01	294.9
Totals:			84.16	6096.3
Composite Curve Number:				72.44

Runoff

			Recurrence Interval (yr)					
Frequency		yr	0.5*	2	5	10	50	100
Rainfall (NOAA Atlas 14, 24-hour)	P	in	1.37	1.90	2.30	2.60	3.30	3.70
Potential Maximum Retention (Use TR-55 Equation 2-4)	S	in	3.80	3.80	3.80	3.80	3.80	3.80
Runoff (Use TR-55 Equation 2-3)	Q	in	0.084	0.262	0.443	0.599	1.016	1.281

*72% of 2-year, 24-hour rainfall per SCDM Volume III Section 2.3.1

Harvey Field Runway Improvement Project EA	Comp. By:	JKK
	Date:	2/26/2024
	Chk. By:	LMM
	Job No:	2470064.000

TR-55 Worksheet 2: Curve Number and Runoff

Subbasin Name: North
Condition: Proposed

Curve Number (TR-55 Table 2-2)

Total Area:	7,783,373	sf	178.68	ac	0.28	mi^2
Pervious Area:	6,474,380	sf	148.63	ac		
Impervious Area:	1,308,993	sf	30.05	ac		

HSG	Description	CN	Area	CN*A
A	Good Condition (ground cover >75% and lightly or only occasionally grazed)	39	27.11	1057.3
C	Good Condition (ground cover >75% and lightly or only occasionally grazed)	74	121.52	8992.6
				0.0
				0.0
				0.0
				0.0
				0.0
				0.0
				0.0
Impervious	Paved Area, Roofs	98	30.05	2944.9
Totals:			178.68	12994.8
Composite Curve Number:				72.73

Runoff

			Recurrence Interval (yr)					
Frequency		yr	0.5*	2	5	10	50	100
Rainfall (NOAA Atlas 14, 24-hour)	**P**	in	1.37	1.90	2.30	2.60	3.30	3.70
Potential Maximum Retention (Use TR-55 Equation 2-4)	**S**	in	3.75	3.75	3.75	3.75	3.75	3.75
Runoff (Use TR-55 Equation 2-3)	**Q**	in	0.087	0.270	0.453	0.611	1.032	1.299

*72% of 2-year, 24-hour rainfall per SCDM Volume III Section 2.3.1

Harvey Field Runway Improvement Project EA	Comp. By: JKK Date: 2/26/2024 Chk. By: LMM Job No: 2470064.000

TR-55 Worksheet 2: Curve Number and Runoff

Subbasin Name: South
Condition: Proposed

Curve Number (TR-55 Table 2-2)

Total Area:	3,666,195 sf	84.16	ac	0.13 mi^2
Pervious Area:	3,389,570 sf	77.81	ac	
Impervious Area:	276,625 sf	6.35	ac	

HSG	Description	CN	Area	CN*A
A	Good Condition (ground cover >75% and lightly or only occasionally grazed)	39	5.82	227.0
C	Good Condition (ground cover >75% and lightly or only occasionally grazed)	74	71.99	5327.5
				0.0
				0.0
				0.0
				0.0
				0.0
				0.0
Impervious	Paved Area, Roofs	98	6.35	622.3
Totals:			84.16	6176.9
Composite Curve Number:				73.39

Runoff

			Recurrence Interval (yr)					
Frequency		yr	0.5*	2	5	10	50	100
Rainfall (NOAA Atlas 14, 24-hour)	P	in	1.37	1.90	2.30	2.60	3.30	3.70
Potential Maximum Retention (Use TR-55 Equation 2-4)	S	in	3.63	3.63	3.63	3.63	3.63	3.63
Runoff (Use TR-55 Equation 2-3)	Q	in	0.097	0.288	0.477	0.639	1.069	1.341

*72% of 2-year, 24-hour rainfall per SCDM Volume III Section 2.3.1

Harvey Field Runway Improvement Project EA	Comp. By:	JKK
	Date:	2/26/2024
	Chk. By:	LMM
	Job No:	2470064.000

TR-55 Worksheet 3: Graphical Peak Discharge

Sub-Basin Name: North
Condition: Existing

Data

Drainage Area	A_m	=	0.28	mi^2
Runoff Curve Number (From TR-55 Worksheet 2)	CN	=	72.55	
Potential Maximum Retention (From TR-55 Worksheet 2)	S	=	3.78	
Time of Concentration (From TR-55 Worksheet 3)	T_C	=	0.92	hr
Rainfall Distribution		=	IA	
Pond and Swamp Area		=	--	% of A_m

Calculations

			Recurrence Interval				
Frequency		yr	2	5	10	50	100
Rainfall (IDF 24-hour)	P	in	1.90	2.30	2.60	3.30	3.70
Initial Abstraction (Use TR-55 Table 4-1)	I_a	in	0.756	0.756	0.756	0.756	0.756
Compute	I_a/P		0.40	0.33	0.29	0.23	0.20
Unit Peak Discharge (Use TR-55 Exhibit 4-IA)	q_u	csm/in	47	53	55	74	84
Runoff (From TR-55 Worksheet 2)	Q	in	0.265	0.447	0.604	1.022	1.288
Pond and Swamp Adjustment Factor (Use TR-55 Table 4-2)	F_p		1.0	1.0	1.0	1.0	1.0
Peak Discharge (Where $Q_p = q_u A_m Q F_p$)	Q_p	cfs	3.49	6.63	9.30	21.18	30.29

Harvey Field Runway Improvement Project EA	Comp. By:	JKK
	Date:	2/26/2024
	Chk. By:	LMM
	Job No:	2470064.000

TR-55 Worksheet 3: Graphical Peak Discharge

Sub-Basin Name: South
Condition: Existing

Data

Drainage Area	A_m	=	0.13	mi^2
Runoff Curve Number (From TR-55 Worksheet 2)	CN	=	72.44	
Potential Maximum Retention (From TR-55 Worksheet 2)	S	=	3.80	
Time of Concentration (From TR-55 Worksheet 3)	T_C	=	2.24	hr
Rainfall Distribution		=	IA	
Pond and Swamp Area		=	--	% of A_m

Calculations

			Recurrence Interval				
Frequency		yr	2	5	10	50	100
Rainfall (IDF 24-hour)	P	in	1.90	2.30	2.60	3.30	3.70
Initial Abstraction (Use TR-55 Table 4-1)	I_a	in	0.760	0.760	0.760	0.760	0.760
Compute	I_a/P		0.40	0.33	0.29	0.23	0.21
Unit Peak Discharge (Use TR-55 Exhibit 4-IA)	q_u	csm/in	43	45	47	59	63
Runoff (From TR-55 Worksheet 2)	Q	in	0.262	0.443	0.599	1.016	1.281
Pond and Swamp Adjustment Factor (Use TR-55 Table 4-2)	F_p		1.0	1.0	1.0	1.0	1.0
Peak Discharge (Where $Q_p = q_u A_m Q F_p$)	Q_p	cfs	1.46	2.59	3.66	7.79	10.49

Harvey Field Runway Improvement Project EA	Comp. By:	JKK
	Date:	2/26/2024
	Chk. By:	LMM
	Job No:	2470064.000

TR-55 Worksheet 3: Graphical Peak Discharge

Sub-Basin Name: North
Condition: Proposed

Data

Drainage Area	A_m	=	0.28	mi^2
Runoff Curve Number (From TR-55 Worksheet 2)	CN	=	72.73	
Potential Maximum Retention (From TR-55 Worksheet 2)	S	=	3.76	
Time of Concentration (From TR-55 Worksheet 3)	T_C	=	0.90	hr
Rainfall Distribution		=	IA	
Pond and Swamp Area		=	--	% of A_m

Calculations

			Recurrence Interval				
Frequency		yr	2	5	10	50	100
Rainfall (IDF 24-hour)	P	in	1.90	2.30	2.60	3.30	3.70
Initial Abstraction (Use TR-55 Table 4-1)	I_a	in	0.752	0.752	0.752	0.752	0.752
Compute	I_a/P		0.40	0.33	0.29	0.23	0.20
Unit Peak Discharge (Use TR-55 Exhibit 4-IA)	q_u	csm/in	48	53	55	75	84
Runoff (From TR-55 Worksheet 2)	Q	in	0.270	0.453	0.611	1.032	1.299
Pond and Swamp Adjustment Factor (Use TR-55 Table 4-2)	F_p		1.0	1.0	1.0	1.0	1.0
Peak Discharge (Where $Q_p = q_u A_m Q F_p$)	Q_p	cfs	3.63	6.72	9.41	21.67	30.55

Harvey Field Runway Improvement Project EA	Comp. By:	JKK
	Date:	2/26/2024
	Chk. By:	LMM
	Job No:	2470064.000

TR-55 Worksheet 3: Graphical Peak Discharge

Sub-Basin Name: South
Condition: Proposed

Data

Drainage Area	A_m	=	0.13	mi^2
Runoff Curve Number (From TR-55 Worksheet 2)	CN	=	73.39	
Potential Maximum Retention (From TR-55 Worksheet 2)	S	=	3.62	
Time of Concentration (From TR-55 Worksheet 3)	T_C	=	2.39	hr
Rainfall Distribution		=	IA	
Pond and Swamp Area		=	--	% of A_m

Calculations

			Recurrence Interval				
Frequency		yr	2	5	10	50	100
Rainfall (IDF 24-hour)	P	in	1.90	2.30	2.60	3.30	3.70
Initial Abstraction (Use TR-55 Table 4-1)	I_a	in	0.724	0.724	0.724	0.724	0.724
Compute	I_a/P		0.38	0.31	0.28	0.22	0.20
Unit Peak Discharge (Use TR-55 Exhibit 4-IA)	q_u	csm/in	43	45	48	60	64
Runoff (From TR-55 Worksheet 2)	Q	in	0.288	0.477	0.639	1.069	1.341
Pond and Swamp Adjustment Factor (Use TR-55 Table 4-2)	F_p		1.0	1.0	1.0	1.0	1.0
Peak Discharge (Where $Q_p = q_u A_m Q F_p$)	Q_p	cfs	1.61	2.79	3.99	8.34	11.16

ATTACHMENT I-4: DISTURBED AREA WATER QUALITY CALCULATIONS

Harvey Field Runway Improvement Project EA	Comp. By:	JKK
	Date:	8/30/2023
	Chk. By:	LMM
	Job No:	2470064.000

Water Quality

Sub-Basin Name: North
Condition: Existing

Data

Drainage Area A_m = 0.28 mi^2

			Recurrence Interval			
			0.5	2	5	10
Runoff (From TR-55 Worksheet 2)	Q	in	0.086	-	-	-

Calculations

		Recurrence Interval			
		0.5	2	5	10
V	cu. ft.	55943	-	-	-
	acre-ft	1.28	-	-	-

Harvey Field Runway Improvement Project EA	Comp. By:	JKK
	Date:	8/30/2023
	Chk. By:	LMM
	Job No:	2470064.000

Water Quality

Sub-Basin Name: South
Condition: Existing

Data

Drainage Area **A_m** = **0.13** mi^2

			Recurrence Interval			
			0.5	2	5	10
Runoff (From TR-55 Worksheet 2)	**Q**	in	**0.084**	**-**	**-**	**-**

Calculations

		Recurrence Interval			
		0.5	2	5	10
V	cu. ft.	**25369**	**-**	**-**	**-**
	acre-ft	0.58	-	-	-

Harvey Field Runway Improvement Project EA	Comp. By:	JKK
	Date:	9/27/2023
	Chk. By:	LMM
	Job No:	2470064.000

Water Quality

Sub-Basin Name: North
Condition: Proposed

Data

Disturbed Area A_m = 1153775 ft^2

			Recurrence Interval			
			0.5	2	5	10
Runoff (From TR-55 Worksheet 2)	**Q**	in	0.086	-	-	-

Calculations

		Recurrence Interval			
		0.5	2	5	10
V	cu. ft.	8269	-	-	-
	acre-ft	0.19	-	-	-

Harvey Field Runway Improvement Project EA	Comp. By:	JKK
	Date:	9/29/2023
	Chk. By:	LMM
	Job No:	2470064.000

Water Quality

Sub-Basin Name: South
Condition: Proposed

Data

Disturbed Area A_m = 342447 ft^2

			Recurrence Interval			
			0.5	2	5	10
Runoff (From TR-55 Worksheet 2)	Q	in	0.097	-	-	-

Calculations

		Recurrence Interval			
		0.5	2	5	10
V	cu. ft.	2768	-	-	-
	acre-ft	0.06	-	-	-

ATTACHMENT I-5: EXISTING STORMWATER FACILITY CURVE NUMBER AND PEAK FLOW CALCULATIONS

Harvey Field Runway Improvement Project EA	Comp. By: JKK Date: 2/7/2024 Chk. By: LMM Job No: 2470064.000

TR-55 Worksheet 2: Curve Number and Runoff

Subbasin Name: Facility 1 - Bioswale
Condition: Existing

Curve Number (TR-55 Table 2-2)

Total Area:	927,808 sf	21.30	ac	0.03 mi^2
Pervious Area:	924,366 sf	21.22	ac	
Impervious Area:	3,442 sf	0.08	ac	

HSG	Description	CN	Area	CN*A
A	Good Condition (ground cover >75% and lightly or only occasionally grazed)	39		0.0
C	Good Condition (ground cover >75% and lightly or only occasionally grazed)	74	21.22	1570.3
				0.0
				0.0
				0.0
				0.0
				0.0
				0.0
				0.0
Impervious	Paved Area, Roofs	98	0.08	7.7
Totals:			21.30	1578.1
Composite Curve Number:				74.09

Runoff

			Recurrence Interval		
Frequency		yr	0.5*	10	100
Rainfall (NOAA Atlas 14, 2-year, 24-hour)	**P**	in	1.90	-	-
Rainfall (6-month, 24-hour: Per Snohomish County Volume III)	**P**	in	1.37	N/A	N/A
Potential Maximum Retention (Use TR-55 Equation 2-4)	**S**	in	3.50	-	-
Runoff (Use TR-55 Equation 2-3)	**Q**	in	0.107	-	-

*72% of 2-year, 24-hour rainfall per SCDM Volume III Section 2.3.1

Harvey Field Runway Improvement Project EA	Comp. By:	JKK
	Date:	2/7/2024
	Chk. By:	LMM
	Job No:	2470064.000

TR-55 Worksheet 2: Curve Number and Runoff

Subbasin Name: **Facility 2 - Runway Infiltration Trench**
Condition: **Existing**

Curve Number (TR-55 Table 2-2)

Total Area:	**373,600**	sf	8.58	ac	0.01	mi^2
Pervious Area:	**323,179**	sf	7.42	ac		
Impervious Area:	**50,421**	sf	1.16	ac		

HSG	Description	CN	Area	CN*A
A	**Good Condition (ground cover >75% and lightly or only occasionally grazed)**	**39**	**1.38**	53.9
C	**Good Condition (ground cover >75% and lightly or only occasionally grazed)**	**74**	**6.04**	446.8
				0.0
				0.0
				0.0
				0.0
				0.0
				0.0
				0.0
Impervious	**Paved Area, Roofs**	**98**	**1.16**	113.4
Totals:			8.58	614.1
Composite Curve Number:				71.60

Runoff

			Recurrence Interval		
Frequency		yr	0.5*	10	100
Rainfall (NOAA Atlas 14, 2-year, 24-hour)	**P**	in	**1.90**	**-**	**-**
Rainfall (6-month, 24-hour: Per Snohomish County Volume III)	**P**	in	**1.37**	**N/A**	**N/A**
Potential Maximum Retention (Use TR-55 Equation 2-4)	**S**	in	3.97	-	-
Runoff (Use TR-55 Equation 2-3)	**Q**	in	0.073	-	-

*72% of 2-year, 24-hour rainfall per SCDM Volume III Section 2.3.1

Harvey Field Runway Improvement Project EA	Comp. By: JKK Date: 2/7/2024 Chk. By: LMM Job No: 2470064.000

TR-55 Worksheet 2: Curve Number and Runoff

Subbasin Name: **Facility 3 - Hangar Infiltration Trenches**
Condition: **Existing**

Curve Number (TR-55 Table 2-2)

Total Area:	**134,549** sf	3.09	ac	0.00	mi^2
Pervious Area:	**49,047** sf	1.13	ac		
Impervious Area:	**85,502** sf	1.96	ac		

HSG	Description	CN	Area	CN*A
A	Good Condition (ground cover >75% and lightly or only occasionally grazed)	39	0.37	14.5
C	Good Condition (ground cover >75% and lightly or only occasionally grazed)	74	0.75	55.8
				0.0
				0.0
				0.0
				0.0
				0.0
				0.0
				0.0
Impervious	Paved Area, Roofs	98	1.96	192.4
Totals:			3.09	262.7
Composite Curve Number:				85.04

Runoff

			Recurrence Interval		
Frequency		yr	0.5*	10	100
Rainfall (NOAA Atlas 14, 2-year, 24-hour)	**P**	in	1.90	-	-
Rainfall (6-month, 24-hour: Per Snohomish County Volume III)	**P**	in	1.37	N/A	N/A
Potential Maximum Retention (Use TR-55 Equation 2-4)	**S**	in	1.76	-	-
Runoff (Use TR-55 Equation 2-3)	**Q**	in	0.372	-	-

*72% of 2-year, 24-hour rainfall per SCDM Volume III Section 2.3.1

Harvey Field Runway Improvement Project EA	Comp. By:	JKK
	Date:	2/7/2024
	Chk. By:	LMM
	Job No:	2470064.000

Water Quality

Sub-Basin Name: Facility 1 - Bioswale
Condition: Existing

Data

Drainage Area A_m = 927808 ft^2

			Recurrence Interval		
			0.5	5	10
Runoff (From TR-55 Worksheet 2)	**Q**	in	0.107	-	-

Calculations

		Recurrence Interval		
		0.5	5	10
V	cu. ft.	8273	-	-
	acre-ft	0.19	-	-

Harvey Field Runway Improvement Project EA	Comp. By:	JKK
	Date:	2/7/2024
	Chk. By:	LMM
	Job No:	2470064.000

Water Quality

Sub-Basin Name: Facility 2 - Runway Infiltration Trench
Condition: Existing

Data

Drainage Area A_m = 373600 ft^2

			Recurrence Interval		
			0.5	5	10
Runoff (From TR-55 Worksheet 2)	Q	in	0.073	-	-

Calculations

		Recurrence Interval		
		0.5	5	10
V	cu. ft.	2273	-	-
	acre-ft	0.05	-	-

Harvey Field Runway Improvement Project EA	Comp. By:	JKK
	Date:	2/7/2024
	Chk. By:	LMM
	Job No:	2470064.000

Water Quality

Sub-Basin Name: Facility 3 - Hangar Infiltration Trenches
Condition: Existing

Data

Drainage Area A_m = 134549 ft^2

			Recurrence Interval		
			0.5	5	10
Runoff (From TR-55 Worksheet 2)	**Q**	in	0.372	-	-

Calculations

		Recurrence Interval		
		0.5	5	10
V	cu. ft.	4171	-	-
	acre-ft	0.10	-	-

ATTACHMENT I-6: FLOODPLAIN MODELING MEMORANDUM

WEST CONSULTANTS
WATER | ENVIRONMENTAL | SEDIMENTATION | TECHNOLOGY

TECHNICAL MEMORANDUM

WEST Consultants, Inc.
11400 SE 8th Street
Suite 410
Bellevue, WA 98004
(425) 646-8806
www.westconsultants.com

RAYMOND WALTON
STATE OF WASHINGTON
27111
REGISTERED PROFESSIONAL ENGINEER
EXPIRES 6/29/2026

To: Julie Barrow, RS&H, Inc.
Company: WEST Consultants Inc.
Date: June 26, 2025
From: Lars Berglund, P.E. and Raymond Walton, Ph.D., P.E.
Subject: No Rise Analysis of Harvey Field Preferred Alternative

1. Purpose and Background

This memorandum summarizes the results of a hydraulic model "no-rise" analysis conducted to support the proposed runway improvements project at Harvey Field, a public use general aviation (GA) reliver airport located in Snohomish County, Washington. The purpose of this analysis is to determine whether the grading associated with the proposed runway improvements project would impact flood behavior—specifically, whether it would cause an increase the water surface elevations (WSE) during the 1% (100-year) annual chance Flood event.

Harvey Field lies to the south of the Snohomish River and within the Density Fringe Floodway of the Snohomish River. The project site falls entirely within Storage Area 9 of the UNET hydraulic model of the Snohomish River used to develop the effective FEMA study of 2005. The 2005 study was later incorporated into the effective study of 2020 with only a datum conversion from NGVD1929 to NAVD1988. Because the proposed development introduces changes to the site's topography, a revised stage-storage curve was developed for Storage Area 9. The analysis was performed in compliance with Snohomish County regulations which require assurance that WSEs remain at or below existing condition elevations throughout the hydraulic model (or "no rise").

2. Regulatory Context

The proposed runway improvements project at Harvey Field is located entirely within a mapped FEMA floodplain and is thus subject to a combination of federal, state, and local floodplain regulations. These regulations are intended to preserve flood storage, protect public safety, and maintain the ecological functions of the floodplain.

The project site lies within the Zone AE floodplain of the Snohomish River, as shown on FEMA Flood Insurance Rate Map (FIRM) Panels 53061C1061G and 53061C1065G. Zone AE areas have Base Flood Elevations (BFEs) established for the 1% (100-year) annual chance flood. In the case of Storage Area 9 (which includes Harvey Field) and adjacent areas, the BFEs were developed under the worst-case condition of the left levees of the Snohomish River being removed.

Harvey Field is also entirely within a Density Fringe Floodway. In Density Fringe Floodways, development is controlled by density and obstruction criteria intended to preserve floodplain storage and allow floodwaters to pass through. Under Snohomish County Code (SCC) Chapter 30.65, the following key provisions apply:

- Maximum Allowable Density: Development may displace no more than 2% of the land area within the Density Fringe Area. This is measured as the total area occupied by fill or structures that displace floodwater and is not offset by excavation or cut elsewhere on site.
- Maximum Allowable Obstruction: New construction may obstruct no more than 15% of the width of the floodplain, as measured perpendicular to the flow of floodwater. For Harvey Field, the flow direction is difficult to define as the storage area acts like a pond, but one that is fully connected.

Because the site is within a Density Fringe Area, regulatory compliance is achieved by demonstrating no change in the existing BFE ("no rise").

3. Hydraulic Model Development

3.1. Overview of Hydraulic Model

To evaluate the hydraulic impacts of the proposed runway improvements project (see Figure 1), we used the effective FEMA UNET model of the Snohomish River. UNET simulates one-dimensional, unsteady flow conditions within the river and floodplain system. The model was developed by WEST Consultants, Inc. in coordination with Snohomish County and the Seattle District, U.S. Army Corps of Engineers, to support the FEMA Flood Insurance Study (FIS) for the lower Snohomish River. The model includes complex hydraulic features such as levees, lateral weirs, storage areas, and looped rating curves to simulate the tidal and overbank dynamics of the system.

Harvey Field is located adjacent to the Snohomish River (Figure 1) and lies entirely within Storage Area 9, one of several defined flood storage elements in the UNET model. Storage Area 9 is hydraulically connected to Storage Areas 2 and 3, and to the Marshlands conveyance area via lateral structures used to model levees and bridges. Storage areas are used in UNET to represent regions that do not convey flow in a defined channel but contribute to overbank floodwater storage. The original USACE study for the system is documented in the Technical Support Data Notebook (TSDN) for Snohomish County, Washington (WEST, 2001).

The lower Snohomish River is bounded by non-accredited levees. As part of the original analysis, multiple levee scenarios were evaluated to assess their effect on flood elevations. These included "with levees", "without left levee", and "without right levee" conditions. Of these, the "without left levee" scenario resulted in the highest modeled water surface elevations in Storage Area 9 and Marshlands. This scenario was used to evaluate the proposed development as a conservative assessment of potential impacts.

Figure 1. Proposed Project Plan and Grading Areas

3.2. Topographic Data and Storage Curve Development

Within the UNET model, each storage area is characterized by a stage-storage curve, which defines the cumulative volume of water that can be stored as a function of elevation (stage). This curve plays a central role in determining how the model balances overbank inflows and outflows during a flood.

In the original study, the stage-storage curve for Storage Area 9 was developed using topographic maps. For the proposed project, LiDAR (Light Detection and Ranging) flown in 2019 was used to develop more accurate site topography. Proposed topography for the runway improvements project grading was developed in CAD.

Using LiDAR-derived Digital Elevation Models (DEMs), WEST calculated stage-storage curves for existing and proposed conditions at five-foot elevation intervals, which is consistent with the original model. These curves quantify the cumulative volume of flood storage available below each elevation point, providing a basis for assessing how the proposed grading would alter the floodplain's ability to store water. Table 1 compares the existing UNET storage curve to the LiDAR derived storage curve for Storage Area 9. The original elevations were reported to the NGVD1929 datum. In Table 1 they are adjusted by 3.6 feet and reported to the NAVD1988 datum.

Two modeling approaches were evaluated:

<u>Method 1</u>

- Existing conditions: The original UNET Storage Area 9 stage storage curve was used.
- Proposed conditions: Modified the original Storage Are 9 curve by applying net differences between the existing and proposed LiDAR conditions at each elevation.

<u>Method 2</u>

- Existing conditions: Replaced the original UNET Storage Area 9 curve with LiDAR-derived storage area volumes.
- Proposed Conditions: Used the proposed conditions LiDAR derived storage area volumes.

Table 1. Storage Area 9 – Existing and Proposed Modeling Summary Table

Elevation (NAVD88)	Existing LiDAR SA9 Volume	Proposed LiDAR SA9 Volume	Change in Storage (Proposed LiDAR - Existing LiDAR)	Original UNET SA9 Volume	Method 2 – Proposed (Original UNET + Change)
ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
6.6	0.0	0.0	0.0	0.0	0.0
8.6	3.3	3.3	0.0	14.4	14.4
13.6	196.5	194.3	-2.3	336.7	334.4
18.6	890.8	896.6	5.8	1214.9	1220.7
23.6	2222.8	2218.7	-4.1	2596.4	2592.3
28.6	3799.9	3794.5	-5.4	4182.7	4177.3
33.6	5397.4	5392.0	-5.4	5782.7	5777.3

As seen in Table 1, the differences in storage volumes between existing LiDAR topography and proposed condition grading are small and generally within ±6 acre-feet across the range of analyzed stages. The most notable change occurs at 18.6 feet, where the proposed grading slightly increases available flood storage.

4. Hydraulic Model Results

The existing and proposed models, incorporating the updated stage-storage curves discussed in Section 3 (Method 1 and 2), were run using the same 100-year boundary conditions developed for the original FEMA study. The hydraulic analysis shows no increases in WSEs under proposed conditions during the 100-year event for either method. The results for Storage Area 9, which contains the project area, are shown in Table 2. The results for the adjacent Marshland overflow channel are shown in Table 3.

In addition to the 100-year flow analysis, storage area Method 1 was also evaluated for the 10- and 50-year events. As seen in Table 2 and Table 3, the proposed grading reduces water surface elevations slightly at the 10- and 50-year flood recurrence intervals in both Storage Area 9 as well as the Marshlands channel.

Table 2. Hydraulic Modeling Results – Storage Area 9

	Method 1 - Ex 100 Year	Method 1 - Pr 100 Year	Method 1 - Ex 50 Year	Method 1 - Pr 50 Year	Method 1 - Ex 10 Year	Method 1 - Pr 10 Year	Method 2 - Ex 100 Year	Method 2 - Pr 100 Year
Max Elevation (ft, NAVD88)	26.35	26.35	25.45	25.41	23.85	23.84	22.75	22.75

Table 3. Hydraulic Modeling Results – Marshlands Overflow Channel

	Method 1 - Ex 100 Year	Method 1 - Pr 100 Year	Method 1 - Ex 50 Year	Method 1 - Pr 50 Year	Method 1 - Ex 10 Year	Method 1 - Pr 10 Year	Method 2 - Ex 100 Year	Method 2 - PR 100 Year
River Mile	Elevation (ft - NAVD88)							
6.69	26.60	26.60	25.57	25.52	22.28	22.22	23.00	23.00
6.69	26.60	26.60	25.57	25.52	22.27	22.22	23.00	23.00
6.69	26.60	26.60	25.57	25.52	22.27	22.22	23.00	23.00
6.29	26.28	26.28	25.30	25.25	22.08	22.03	22.68	22.68
5.85	25.94	25.94	25.00	24.95	21.84	21.79	22.34	22.34
5.33	25.60	25.60	24.67	24.62	21.53	21.49	22.00	22.00
4.71	25.34	25.34	24.41	24.36	21.28	21.24	21.74	21.74
4.31	25.25	25.25	24.33	24.29	21.23	21.19	21.65	21.65
3.82	25.16	25.16	24.25	24.21	21.19	21.15	21.56	21.56
3.35	25.09	25.09	24.20	24.15	21.16	21.12	21.49	21.49
2.72	25.00	25.00	24.12	24.07	21.13	21.09	21.40	21.40
2.31	24.90	24.90	24.04	23.99	21.09	21.05	21.30	21.30
1.42	24.13	24.13	23.41	23.37	20.83	20.79	20.53	20.53
0.67	23.82	23.82	23.15	23.12	20.71	20.68	20.22	20.22
0.67	23.82	23.82	23.15	23.12	20.71	20.68	20.22	20.22
0.67	23.82	23.82	23.15	23.12	20.71	20.68	20.22	20.22

6. Conclusions

This hydraulic analysis shows that the proposed grading associated with the Harvey Field runway improvements project will not increase flood water surface elevations during the 100-year, 50-year, or 10-year flood events. The updated modeling, which incorporated LiDAR-based topography and revised stage-storage relationships for Storage Area 9, demonstrates that the site can accommodate the planned fill without changing system-wide flood behavior. Water surface elevations remain unchanged in both the Snohomish River-adjacent storage areas and in the Marshlands overflow channel, satisfying the “no-rise” criterion established under Snohomish County regulations.

By evaluating two methods of incorporating the revised topography—one that adjusts the existing model's stage-storage curve and one that fully replaces it—the analysis is a comprehensive approach to assessing the project’s hydraulic performance. These findings provide assurance that the proposed development is consistent with applicable floodplain management standards and will not increase flood elevations.

7. References

U.S. Army Corps of Engineers Hydrologic Engineering Center (HEC). (2001). *UNET: One-dimensional unsteady flow through a full network of open channels (User’s Manual, Version 3.2)* (CPD-66). U.S. Army Corps of Engineers

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