REPORT TO THE LEGISLATURE

DEPARTMENT OF ECOLOGY
State of Washington

Sprague Lake Hydrologic Study

Flood-risk reduction alternatives analysis

Background

Landowners in the city of Sprague (population 450) and around Sprague Lake in Lincoln and Adams counties have experienced high water in recent years that receded very slowly. This includes significant flooding in 2017 that caused damage to 12 properties along Sprague Lake and Negro Creek as well as to city infrastructure.

The level of Sprague Lake is adjudicated and has historically been managed by a water-control structure at the Cow Creek outlet. The constrictions in Cow Creek, both natural (sediment and vegetation) and manmade (bridges), could contribute to the slow release of floodwaters.

Landowners reported frustration with the high water and requested assistance from the state to manage the lake and reduce flooding risks. In Section 302 (52) of the 2022-2023 supplemental budget (ESSB 5693) the Legislature included the following appropriation for the Department of Ecology (Ecology) to study the issue:

> *$100,000 of the general fund—state appropriation for fiscal year 2023 is provided solely for a hydrologic analysis of the causes of flooding on and around Sprague Lake, including stream flows between Sprague Lake and Cow Creek during high water events. The department may contract with a third party to complete the analysis, and the department must collaborate with the department of fish and wildlife in overseeing the analysis. The department must report the results of the analysis to the appropriate committees of the legislature by June 30, 2023.*

Study Approach and Methodology

Ecology and Washington Department of Fish and Wildlife partnered to develop a request for proposals to analyze flooding and potential solutions for minimizing impacts to property using the funding appropriated by the legislature. The team selected Shannon & Wilson (S&W) to complete a hydrologic study by building a model that estimates lake conditions during storm events (Appendix B). The model was built using both existing and new data, including Light Detecting and Ranging (LiDAR), lake elevation levels, and land surveys.

Using this model, S&W analyzed downstream features suspected to cause flow constriction during flood events. The model was also used to assess options to manage flooding without impairing downstream water users, including the feasibility of a bypass channel, channel dredging and widening, and increasing the capacity under the Danekas Road bridge. The consulting team also evaluated multiple large-scale alternatives that combined flood-reducing strategies.

Results

Lake Inflow

Negro Creek is the main tributary of Sprague Lake. Negro Creek drains 215 square miles of lakes, pasture, woodlands, and open range directly east of the city of Sprague. It crosses State Route 23 and transitions into a concrete channel complex within the city. Two unnamed tributaries to the northeast and northwest that collectively drain 47 square miles are dry bed and only saturated during rain events.

As water moves through Negro Creek it switches between surface water and subsurface flow. The study suggests that upwards of 90% of the rainfall in the Negro Creek basin moves to subsurface flow, and only a small portion remains as surface water. The surface water path to Sprague Lake is significantly faster than the groundwater path but is slowed by snow accumulation in winter.

As a result, rainfall in the Negro Creek basin does not have a quick enough effect on lake levels to cause a high tailwater in the concrete drainage channel that runs through the city. It is more likely that long periods of multiple high rain events, or periods with large rates of snowmelt in the spring could cause high groundwater and high lake levels that can lead to flooding.

Lake Outflow Constriction Points

The outlet of Sprague Lake encompasses a relic water-control structure consisting of two concrete curbs positioned about 15 feet apart. These curbs retain a platform of earth and vegetation measuring approximately 1 foot in height that directs water flow into Cow Creek. A small concrete farm access crossing located within Cow Creek is 1,500 feet downstream. About 3,500 feet further downstream, Cow Creek intersects with Danekas Road. At this road crossing, a skewed pipe arch culvert measuring 15 by 6.6 feet has been securely embedded into the footings using mortar, featuring a natural channel bottom. Roughly 1,800 feet downstream from Danekas Road, a prominent bedrock outcrop forms a resilient natural constriction point within the channel.

Evaluation of Potential Structural Changes

Data from modeling runs that removed constriction points, such as the water control structure, and widened the creek channel, suggested little to no functional flood relief for lakeshore property owners. A scenario that widened the culvert under Danekas Road from 15 feet to 30 feet only reduced the estimated time to drain the lake to adjudicated levels from 25 to 23 days.

The hydrologic study also modeled two scenarios for large-scale combinations of various structural changes that consisted of:

- An 80-Foot-Wide Channel from the water control structure to 200-feet downstream of Danekas Road (see Figure 1).
- A Bypass Channel from the water control structure to Danekas Bridge, including the widened culvert from 15 feet to 30 feet (see Figure 2).

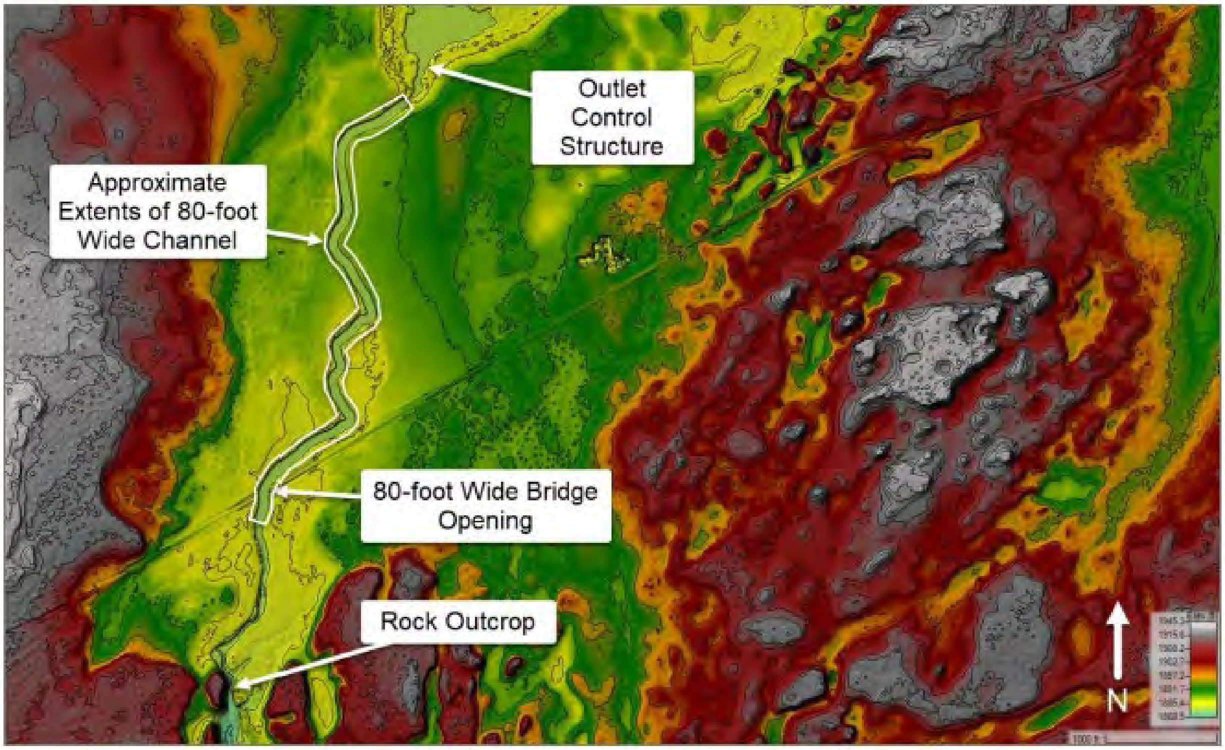

Figure 1 - Large Scale Widened Channel Alternative

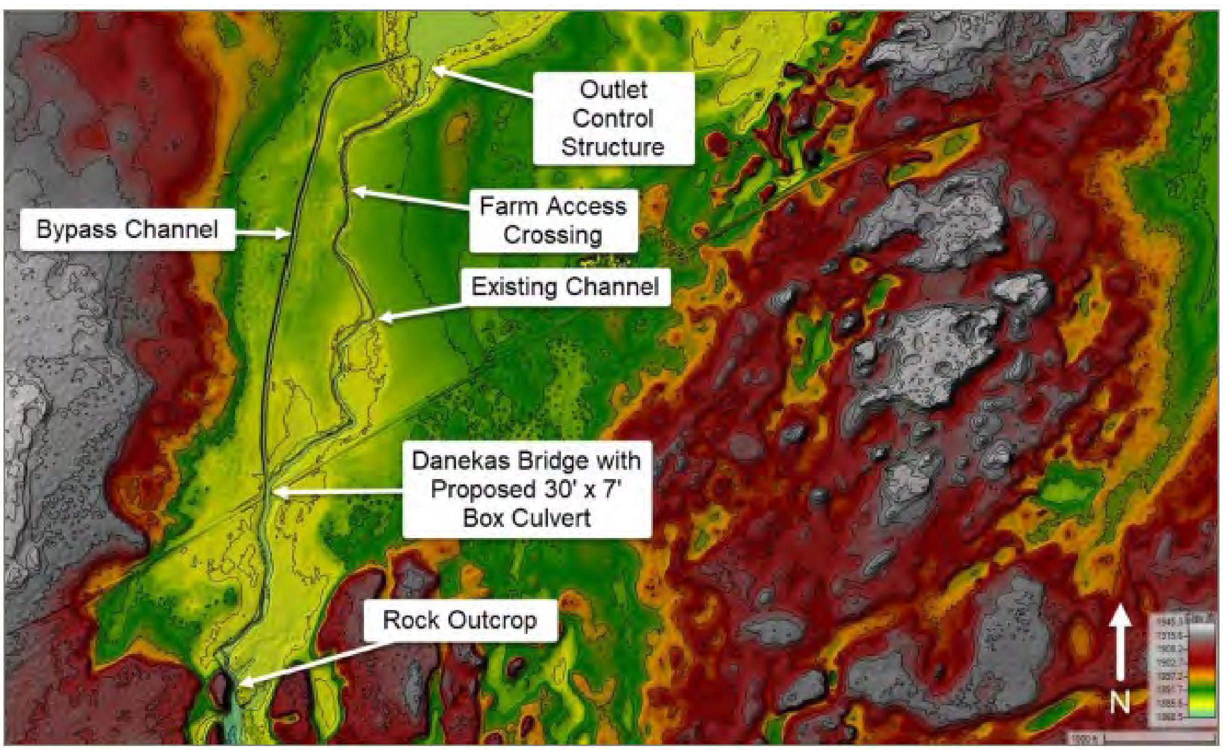

Figure 2 - Large Scale Bypass Channel Alternative

Although these alternatives showed a reduction in lake levels ranging from 1.5 to 2.8 feet within four days of peak levels, according to S&W they would require extensive permitting and environmental mitigation where costs may not outweigh the benefits.

According to the study, all outlet improvements evaluated have low flood risk reduction value for city residents and marginal value to lakeside properties. The long duration hydrology and influence of groundwater and snowmelt make it difficult to reduce flood risk, even with large-scale structural solutions. Additionally, these downstream solutions may impact surrounding wetlands and impair downstream water rights.

Recommendations

Ecology does not recommend altering the lake outlet or advancing a large-scale downstream solution at this time. If community leaders wish to continue to explore these or other structural solutions, further study would be needed including detailed cost-benefit analysis.

To better evaluate flooding within the city, we recommend installing water level loggers (gages) upstream and within the city drainage network to capture valuable data for future design and infrastructure improvements. For a better understanding of lake hydrology, long-term (7 to 10 years) gage installation upstream and downstream of the lake would inform a more detailed analysis of impacts to lakeside properties.

Ecology does encourage the city and counties to further the strategies identified in the U.S. Army Corp of Engineers 2020 report, *City of Sprague Nonstructural Flood Mitigation Assessment*. These include:

- Flood preparedness planning.
- Developing temporary flood fighting techniques.
- Developing and enforcing local zoning and building codes that reduce flood risk.
- Non-structural flood mitigation measures.

Next Steps

Ecology and Washington Department of Fish and Wildlife will host a community meeting to report the results and recommendations identified in the report.

We will also continue to support city and county efforts to plan for and mitigate flood risks.

Conclusion

The hydrologic analysis found that the long duration hydrology and influence of groundwater and snowmelt make it difficult to reduce flood risk around Sprague Lake, even with large-scale structural solutions.

Hydrologic modeling of options for removing individual constriction points for the lake discharge or widening the creek channel found little to no functional flood relief for lakeshore property owners. Two different alternatives that include large-scale structural changes were also analyzed. While these large-scale alternatives could reduce lake levels, they would require extensive permitting and environmental mitigation where costs may not outweigh the benefits.

Ecology does not recommend altering the lake outlet or advancing a large-scale downstream solution at this time. If community leaders want to continue to pursue structural solutions further evaluation would be needed, including a detailed cost-benefit analysis.

Ecology does recommend longer-term collection of additional data by installing water level gages to help inform better modeling of the flooding impacts and hydrology. We also recommend implementing strategies from the U.S. Army Corp of Engineers 2020 report.

Appendix A – Hydrology Analysis

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HYDROLOGY ANALYSIS

Sprague Lake

CITY OF SPRAGUE, WASHINGTON

October 2, 2023

Shannon & Wilson No: 109828-008

SHANNON & WILSON

Submitted To: Washington State Department of Ecology
4601 North Monroe
Spokane, WA 99205-1295
Attn: Karl Rains

Subject: HYDROLOGY ANALYSIS, SPRAGUE LAKE, CITY OF SPRAGUE, WASHINGTON

Shannon & Wilson prepared this report and participated in this project as a consultant to Washington State Department of Ecology. Our scope of services was specified in Agreement Number 109828-C230071, dated November 18, 2022. This report presents the hydrologic and hydraulic analysis for Sprague Lake in Sprague, Washington, and was prepared by the undersigned.

We appreciate the opportunity to be of service to you on this project. If you have questions concerning this report, or we may be of further service, please contact us.

Sincerely,

SHANNON & WILSON

GUS BRIAN KAYS
STATE OF WASHINGTON
45234
REGISTERED PROFESSIONAL ENGINEER
10/2/2023

Gus Kays, PE
Senior Associate

MDP:GBK:SRB/mdp

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ACRONYMS

AEP	Annual Exceedance Probability
ASCE	American Society of Civil Engineers
CEM	Coastal Engineering Manual (USACE, 2015)
cfs	cubic feet per second
CLOMR	Conditional Letter of Map Revision
CUP	Conditional Use Permit
EIS	Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FIS	flood insurance study
GIS	geographic information system
Ecology	Washington State Department of Ecology
HEC-RAS	Hydraulic Engineering Center's River Analysis System
HPA	Habitat Project Approval
LEDPA	Least Environmentally Damaging Practicable Alternative
LOMR	Letter of Map Revision
mph	miles per hour
NGS	National Geodetic Survey
NWP	Nationwide Permit
QA/QC	quality assurance/quality control
SEPA	State Environmental Policy Act
SR	State Route
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WDFW	Washington Department of Fish and Wildlife
WQC	Water Quality Certification

1 INTRODUCTION

This report presents the hydrologic and hydraulic analysis for Sprague Lake in Sprague, Washington (Figure 1). The Washington State Department of Ecology (Ecology) has indicated a need for the investigation into the recent flooding events in the City of Sprague (the City) and nearby areas, and recommendations of ways to reduce flood frequency and/or duration and improve the lakefront's resiliency during high rain and wind events.

A detailed hydrology analysis was conducted to determine alternatives that serve to mitigate flooding within Sprague Lake. Our results and findings are provided herein.

Sprague Lake is a 5-mile-long water body straddling Lincoln and Adams counties in eastern Washington. The nearby City is roughly 2.5 river miles upstream of the northeast lakeshore and roughly 35 miles southwest of Spokane, Washington. Flooding has been routinely reported in the City during high water lake events, in addition to flooding reports from landowners at the northeast shoreline, and the campground along the northwest shoreline adjacent to Bob Lee Road. Ecology and the Washington Department of Fish and Wildlife (WDFW) have formed a joint technical team to supervise this project investigating the causes and potential relief options for this flooding. Ecology is the lead agency administering this contract.

Shannon & Wilson has been engaged in a contractual agreement to conduct surveying, geographic information system (GIS) analysis, and hydrological and hydraulic investigations. The primary objective of these investigations is to discern areas of lake outlet flow constriction, be they artificially constructed or naturally occurring, and subsequently explore potential conceptual enhancements aimed at mitigating or improving conditions at these constrictions.

2 PROJECT SITE

The project site spans from the rock outcrop at the downstream extent to the northwest confluence of Negro Creek and Sprague city limits (Figure 2).

2.1 Hydrology

Ecology indicated that the flow inputs to Sprague Lake and their ratios of groundwater to surface water are not well understood. It is not the intent of this project to quantify or predict the hydrologic inputs to Sprague Lake. However, it should be understood how

Sprague Lake responds to rainfall and snowmelt, and whether surface water flood flows affecting the City are attenuated or driven by the surface level of Sprague Lake.

2.2 Tributaries and Outfall

The City surface water is drained by a series of concrete open channels and box culverts, which roughly follow West 2nd Street and North D Street. These channels collect stormwater throughout the City and discharge it under the BNSF railway to the north into a man-made vegetated channel. This vegetated channel meanders west and crosses the BNSF railway a second time, as well as I Street to the south. The vegetated channel then transitions into a natural streambed over the remaining 2 river miles as it winds through pastureland and eventually meets the shoreline of Sprague Lake (Exhibit 2-1).

Exhibit 2-1: City of Sprague Drainage Network

This watercourse through the City is fed by three distinct tributaries that directly affect flooding in the City. An unnamed tributary to the northwest, draining 44 square miles, crosses I-90 and joins the man-made vegetated channel north of the BNSF railway. A second unnamed tributary to the northeast follows State Route (SR) 23 south, draining 2.8 square miles, crosses I-90 and discharges into the upstream end of the concrete channels through City. Negro Creek is the main tributary of the lake and drains 215 square miles of lakes, pasture, woodlands, and open range directly east of the City. It crosses SR 23 and transitions into the concrete channel complex. The two unnamed tributaries (2.8-square-mile North Tributary East and 43.8-square-mile North Tributary West) are dry bed and only saturated during rain events. Negro Creek can clearly be seen in aerial photography switching between surface water and subsurface flow (Exhibit 2-2).

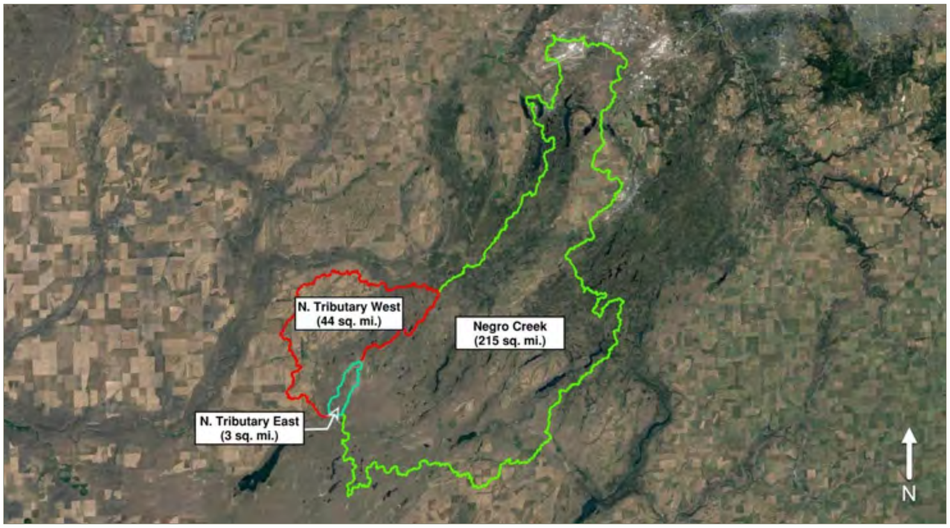

Exhibit 2-2: Tributaries Areas at Inflow Boundaries

Sprague Lake itself has several smaller lowland direct tributaries downstream of the City, amounting to an additional 23 square miles. These tributaries were considered negligible for the purpose of this analysis.

The outlet of Sprague Lake encompasses a relic control structure that consists of two concrete curbs positioned approximately 15 feet apart (Figure 2). These curbs retain a platform of earth and vegetation measuring approximately 1 foot in height. The flow from this control structure is directed into Cow Creek. There is a small concrete farm access crossing within Cow Creek, 1,500 feet downstream. Further downstream, approximately 3,500 feet from the farm access crossing, Cow Creek intersects with Danekas Road. At this road crossing, a skewed pipe arch culvert measuring 15 by 6.6 feet has been securely embedded into the footings using mortar, featuring a natural channel bottom. Roughly 1,800 feet downstream from Danekas Road, a prominent rock outcrop comprised of bedrock material forms a resilient natural constriction point within the channel.

2.3 Survey and Loggers

Shannon & Wilson was able to locate lidar, flown by NV5 Geospatial in 2018, for the entire lakeshore, downstream area, and the vicinity of the City. The lidar downstream of the lake was in an area known to be thick with vegetation, and accordingly, the returns through Cow Creek channel needed to be verified. Shannon & Wilson field staff surveyed the downstream area from the outlet structure to the rock outcrop, including the Danekas Road culvert, farm access crossing structures, and the outlet structure. Field loggers were deployed at the lake upstream of the control structure and upstream and downstream of the Danekas Road culvert. The channels in City were left consistent with the lidar surface and are expected to suffice for the level of detail needed for this study. Culvert inverts within the City were approximated based on field measurements relative to the road surface.

Water surface data loggers (SW-B, -C, and -D) were installed at three locations downstream of the lake to assess hydraulics related to the outlet to the lake and the outlet channel from the lake down to Danekas Road (Figure 2).

2.4 Survey Correction

The field survey was based on a U.S. Geological Survey (USGS) marker we believed to be SW1220, as detailed in the National Geodetic Survey (NGS) Database. This benchmark was occupied with our base station, which updates instruments with corrections based on satellite data throughout the day. This is standard practice for using Real-Time Kinematic survey systems. The system ran without any errors from 9:30 a.m. to 5:00 p.m. on the first day. At the end of the data collection day, the quality assurance/quality control (QA/QC) check of the data yielded a shift of 32 feet in the horizontal direction and approximately 8 feet in the vertical direction. Our Trimble survey representative verified there were no internal equipment errors, nor error messages, during the collection period. A second day of survey was needed to detail the Danekas culvert location. During this collection day, the base station was set up identically, but instead of manually locating via the NGS datasheet, field staff allowed the base station to collect data and continuously self-locate via satellite. The second day's QA/QC yielded accurate positioning of the base and topography data. This second day of data was submitted to the OPUS postprocessing online system, which confirmed the accuracy of the base station location. The first day of survey was also submitted to OPUS, which confirmed a translation of data by 32 feet in the horizontal and about 8 feet in the vertical. OPUS corrected the first day of survey and all survey data compares well with lidar for each area. It's possible that marker has been tampered with however our corrections and methodology have accounted for that possibility.

3 HYDROLOGIC AND HYDRAULIC ANALYSIS

3.1 Representative Hydrology

Two existing hydrologic data sources are available for the designated site. The hydrology data procured from the Federal Emergency Management Agency (FEMA) flood insurance study (FIS), conducted specifically for Lincoln County and the City, and the USGS StreamStats online hydrology tool are the notable sources. The two hydrologic data references exhibited concurrence concerning the occurrence of flood events with 10-year, 50-year, and 100-year return periods(as provided in the FIS). In the case of Negro Creek and the two smaller unnamed tributaries located to the north (designated as North Tributary

East and North Tributary West), the StreamStats data was employed to approximate flow rates. Exhibit 3-1 provides a comparison of peak discharges for 10-year, 50-year, and 100-year return periods between the FIS and StreamStats.

Exhibit 3-1: Peak Discharge Comparison Summary

Return Period	Negro Creek	North Tributary East	North Tributary West
2-year, FIS (cfs)	N/A	N/A	N/A
2-year, StreamStats (cfs)	654	24.9	192
10-year, FIS (cfs)	2,250	N/A	N/A
10-year, StreamStats (cfs)	2,240	111	738
50-year, FIS (cfs)	4,950	N/A	N/A
50-year, StreamStats (cfs)	4,750	278	1,960
100-year, FIS (cfs)	6,200	N/A	N/A
100-year, StreamStats (cfs)	6,180	385	2,260

cfs = cubic feet per second

The Soil Conservation Service TR-55 methodology was used to approximate the basin characteristics and times of concentration. Local rainfall data was used to compare logger lake levels with a predicted hydrograph.

3.2 Hydraulic Modeling

Shannon & Wilson employed the U.S. Army Corps of Engineers (USACE) Hydraulic Engineering Center's River Analysis System (HEC-RAS) Version 6.3.1 to conduct our analyses. This two-dimensional model enables the examination of flow in multiple directions. Note, a one-dimensional model would not suffice for this study. Such a model would fail to consider the dispersion of flow from the area of the City through the project culverts located centrally in the City. Additionally, it would overlook the attenuation of peak flows in Sprague Lake provided by constrictions located downstream at the flow control structure and Danekas Bridge. Furthermore, the HEC-RAS software operates on a conservation of volume and conservation of mass platform, eliminating the need for subjective modeling choices, as it inherently accounts for all volume and mass of water.

3.2.1 Terrain and Geometry Data

The acquisition of Lincoln and Adams counties' 2020 surface lidar was facilitated through the utilization of the Washington Department of Natural Resources (DNR) lidar portal. These lidar datasets were then integrated with our bathymetric and topographic survey conducted along Cow Creek, downstream of Sprague Lake, culminating in the creation of a

RAS Mapper Terrain. It is important to note that in densely vegetated areas, the resulting terrain may reflect the tops of bushes and or trees rather than bare earth.

The two-dimensional equivalent of floodplain cross sections is a mesh of grid points. This grid geometry was draped over the terrain with high resolution in the channels, ditches, and overtopping areas. The modeling mesh and associated RAS Mapper Terrain upstream and downstream of the lake are shown below in Exhibits 3-2 and 3-3 below.

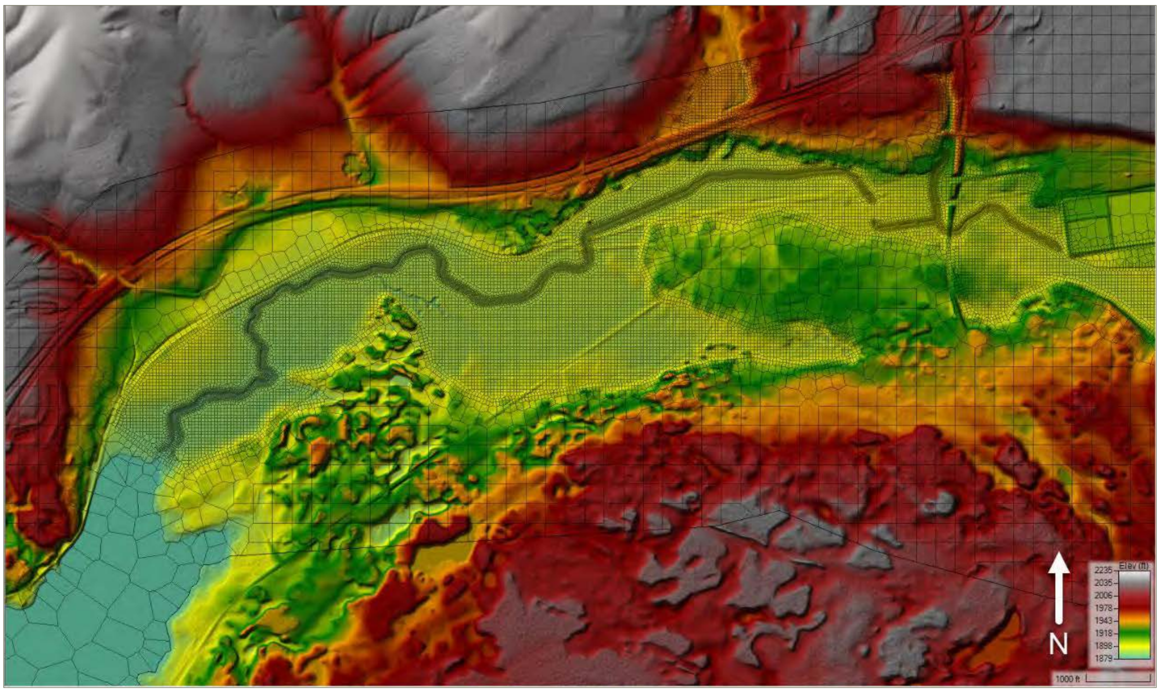

Exhibit 3-2: Modeling Mesh Upstream of Sprague Lake

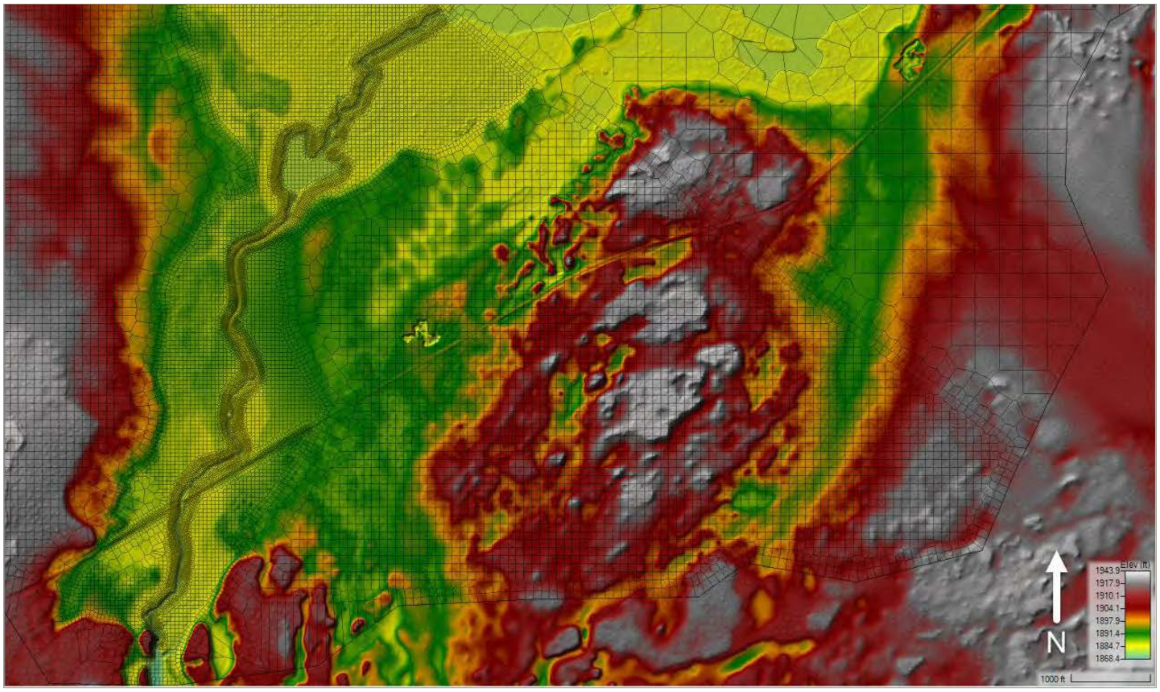

Exhibit 3-3: Modeling Mesh Downstream of Sprague Lake

3.2.2 Boundary Conditions

The City has expressed concerns regarding conditions that have led to previous flooding of Sprague. As Negro Creek, Sprague Lake, and Cow Creek are all in the FEMA Zone A Floodplain, the permitting/regulatory design storm would be the 100-year event for any infrastructure or fill planned to alleviate floodwater. To address stakeholder flood concerns, specific boundary conditions were established for modeling scenarios. The inflow boundary conditions were set at the approximate outlets of the three contributing drainage basins that feed directly into Sprague Lake (Exhibit 3-4).

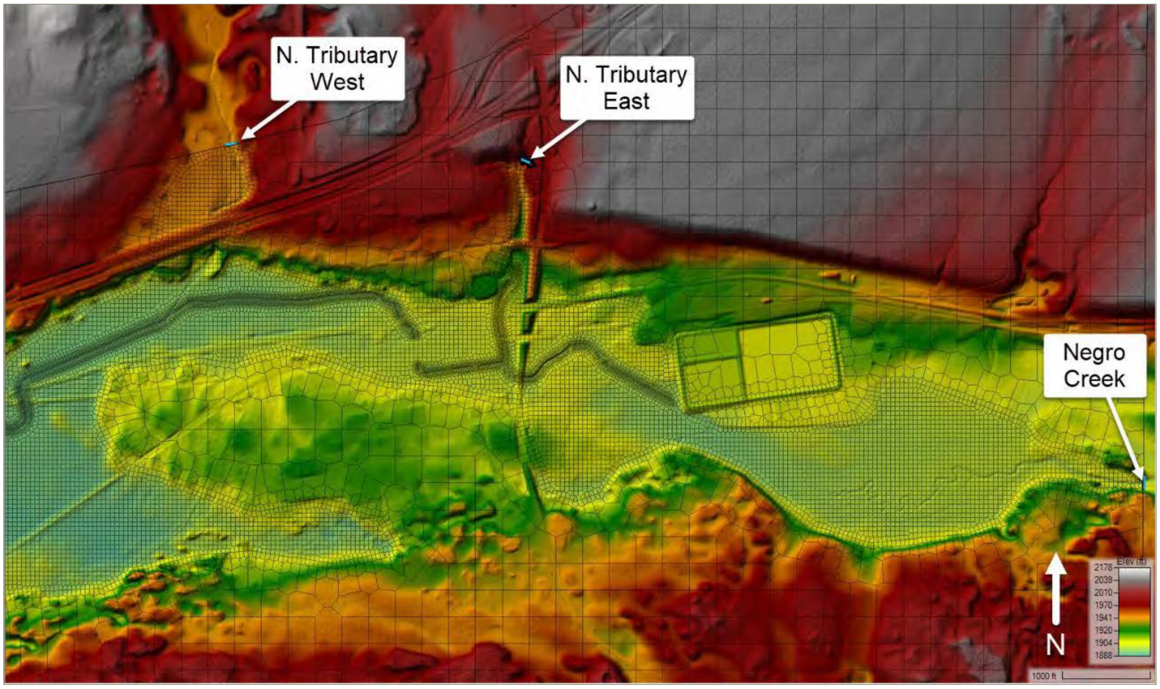

Exhibit 3-4: Upstream Modeling Boundary Conditions

In addition, a normal depth downstream boundary condition was added approximately 2 miles downstream of the Sprague Lake outlet. The normal depth was established based on the approximate channel gradient taken from the lidar.

3.2.3 Physical Calibration

Sprague Lake is equipped with an Ecology surface gage that has maintained an uninterrupted period of data recording since 2006. The gage not only facilitates the calibration of inflow parameters for the HEC-RAS model, but also enables the assessment of the lake's overall slope. While lakes are generally considered to have a flat surface, this particular system exhibits an elongated shape with a significantly greater length than width. Consequently, with inflows and outflows occurring at opposite ends of its elongated axis, this lake effectively functions as a gently sloping wide river segment.

Water surface data was recorded at the lake outlet throughout a period spanning from February to April 2023. Rainfall measurements obtained from the Fairfield, Washington, rain gauge during the aforementioned period were retrieved, and using HydroCAD, a runoff hydrograph was developed. The resulting hydrograph corresponded to a flood event characterized by a roughly 10-year return period, or a 10% exceedance probability, as ascertained from the StreamStats tool.

However, upon inputting the generated hydrograph into the HEC-RAS model, it became apparent that the resultant lake level exhibited an undesirably rapid and excessive rise, followed by an abrupt decline. This observation contradicted the expected behavior of the system. Subsequent sections of this report elaborate on the underlying reasons for this discrepancy. Specifically, the employed runoff model, tailored specifically for the parameters of this project, failed to accurately capture the hydrological dynamics associated with groundwater and snow melt-driven processes and exaggerated rainfall runoff. Given the nature of the approach adopted for evaluating the site, it is unlikely that developing a more intricate runoff model would significantly alter the findings or recommendations.

Nevertheless, it is crucial to emphasize the value of the logger data acquired during this investigation. These data provided corroboration that the runoff model wasn't properly capturing the hydrology. Furthermore, these logger data can be effectively utilized to compare the disparities in water stage measurements between loggers SW-B, -C, and -D against the disparities exhibited by the HEC-RAS model's water surfaces at each respective location. This comparative analysis was conducted and enabled us to calibrate the hydraulic properties governing water movement within the system. Exhibit 3-5 below provides a visual representation of our stage measurements for loggers SW-B, -C, and -D.

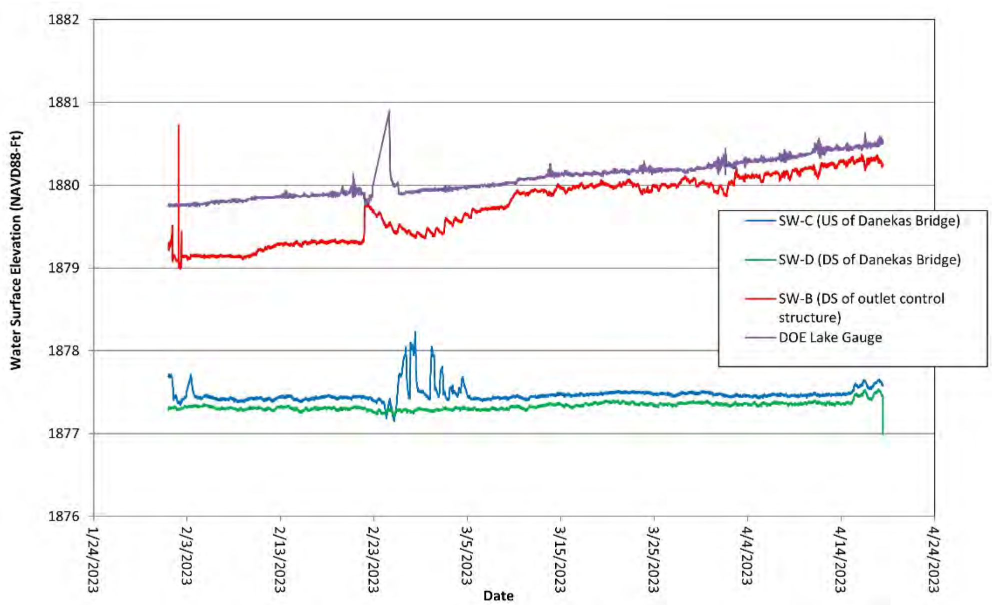

Exhibit 3-5: Stage Measurements for Shannon & Wilson Logger (February to April 2023)

3.2.4 Ecology Lake Gauge

As the predicted, modeled inflow hydrographs did not match well with logged elevations and were an order of magnitude above what could be expected by adjusting variables in the TR-55 methodology. Shannon & Wilson began to perform a gauge record analysis on the 17 years of data available for the Ecology lake gauge (SPRAD1). Gage data for each year's hydroperiod has a constant rise of lake level through summer, and a constant fall through winter, spring, and summer. Exhibit 3-6 below showcases the lake level trend during the 2016 water year (October 1, 2016, through September 30, 2017), including the maximum lake level for March 2017.

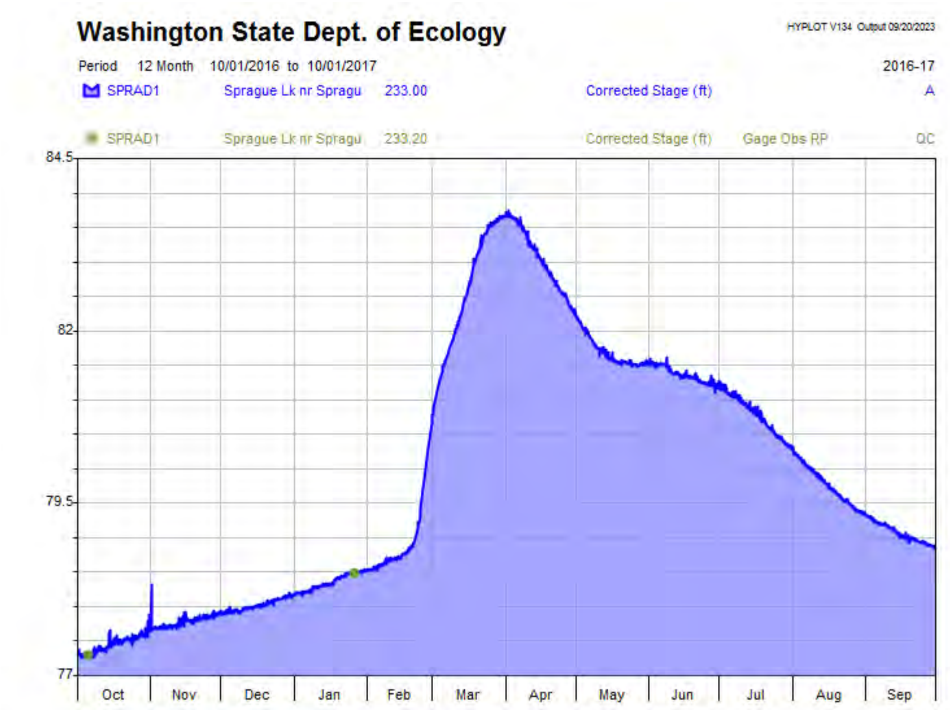

Exhibit 3-6: Sprague Lake Stage Hydrograph (Water Year 2016)

Evaluating rainfall data with the Sprague Lake water surface gaged data (shown in Exhibit 3-7 below) indicates that the response to rainfall is muted or attenuated given the high precipitation events mid-winter with nominal associated changes to lake levels.

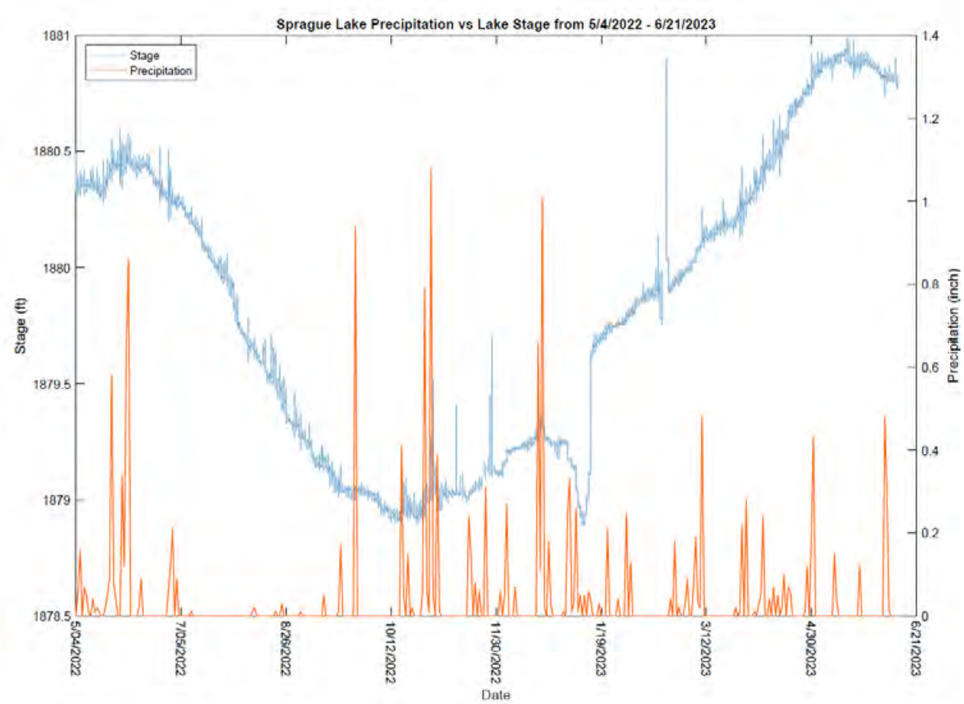

Exhibit 3-7: Sprague Lake Stage Hydrograph With Rainfall

Evaluating average daily temperature data with the Sprague Lake water surface gaged data (shown in Exhibit 3-8 below) does indicate a clear signal and response to lake levels related to air temperature. There is a temporal lag between the two data sets, but a clear relationship exists.

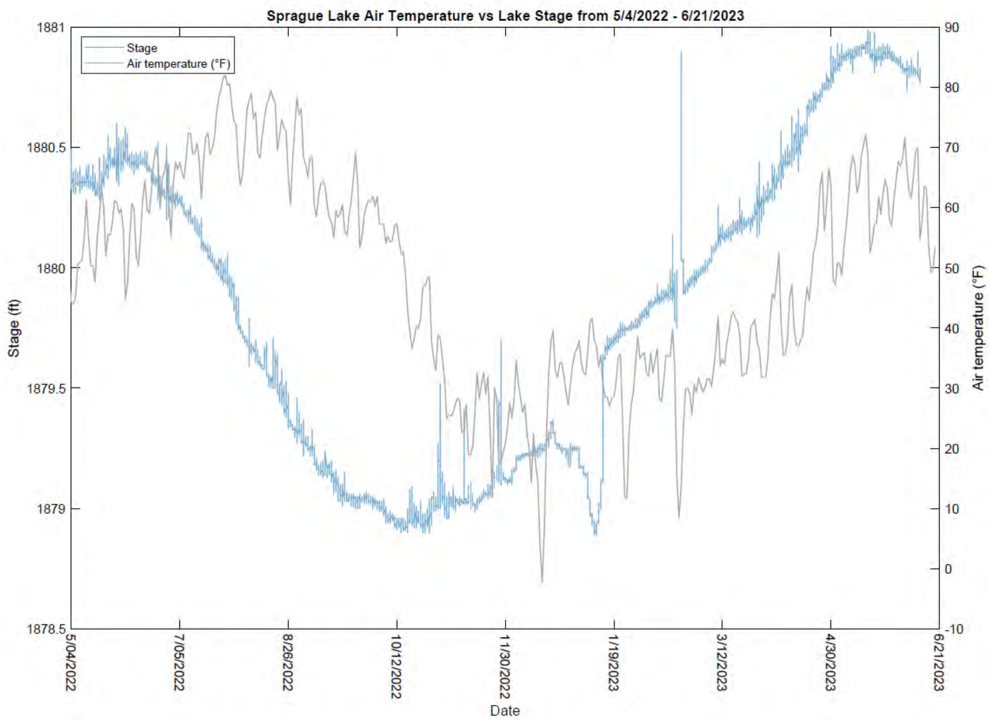

Exhibit 3-8: Sprague Lake Stage Hydrograph With Average Daily Temperature

We believe that these factors suggest that upwards of 90% of the rainfall in the Negro Creek basin moves to subsurface flow, and only a small portion remains as surface water. The surface water path to Sprague Lake is significantly faster than the groundwater path, which is drawn out and attenuated with snowmelt.

Accordingly, we can assume from the response in lake level of the Ecology gauge and our loggers for the period of record, that even significant rainfall in the Negro Creek basin does not have a quick enough effect on lake levels to cause a high tailwater on the concrete drainage channel through the City. It is more likely that long periods of multiple high rain events, or spring periods with large snowmelt numbers cause high groundwater and high lake levels. These same conditions are likely to be responsible for Negro Creek flowing at a higher proportion of surface flow than during low groundwater conditions.

The hydrological monitoring of the Sprague Lake drainage basin is currently limited, with no established gauging system in place, apart from the loggers specifically installed for this project. However, the adjacent Crab Creek basin, situated directly to the north of Sprague

Lake, possesses a comprehensive and long-term dataset encompassing both flow rates and water stage measurements. Leveraging the available Crab Creek gauge data served as a viable surrogate to evaluate local runoff characteristics, thereby facilitating the crosswalk of pertinent flood flow events between the adjacent gaged Crab Creek drainage and the ungaged Sprague Lake drainage.

Of particular significance is the 2017 flood event that occurred at Sprague Lake. This event holds merit due to its recency and the availability of corresponding datasets for both Sprague Lake and Crab Creek. Consequently, the 2017 flood event was used as a reference in describing the overall hydrology relevant to this study.

Upon review of the runoff data pertaining to Crab Creek, it is evident that the peak flow observed during the 2017 flood event at the Crab Creek Irby location approximately corresponds to a flood magnitude of a two-year return period, approximately 793 cubic feet per second (cfs), as recorded by the gauge. To provide visual context for this event, a graphical representation depicting the relative magnitude of this 2017 event (red line), in relation to more significant Crab Creek flood events during the 1990s, is presented below in Exhibit 3-9.

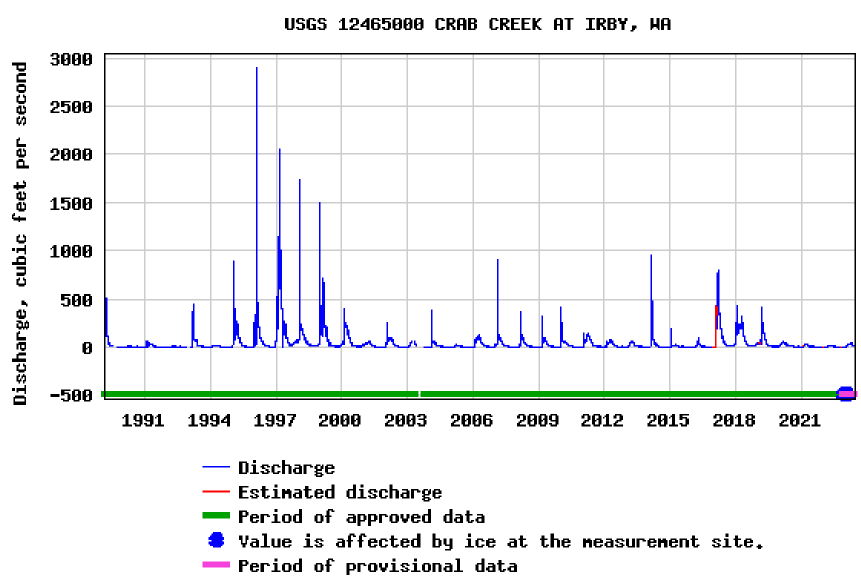

Exhibit 3-9: Crab Creek Flow Hydrograph (1990 to 2023)

Further analysis of the 2017 event, as illustrated in the Crab Creek 2016 Water Year graphic below (Exhibit 3-10), reveals a distinctive prolonged tail on the flood hydrograph. This extended duration indicates that the high runoff originating from the basin persisted over an extended period, spanning several months. Notably, this extended duration aligns well with the recorded data from Sprague Lake provided in Exhibit 3-5, suggesting a strong correlation between stream runoff and lake levels, both of which exhibit a dependence on the timing of groundwater and snowmelt driven processes, as opposed to being heavily influenced by intense and short-lived rainfall events.

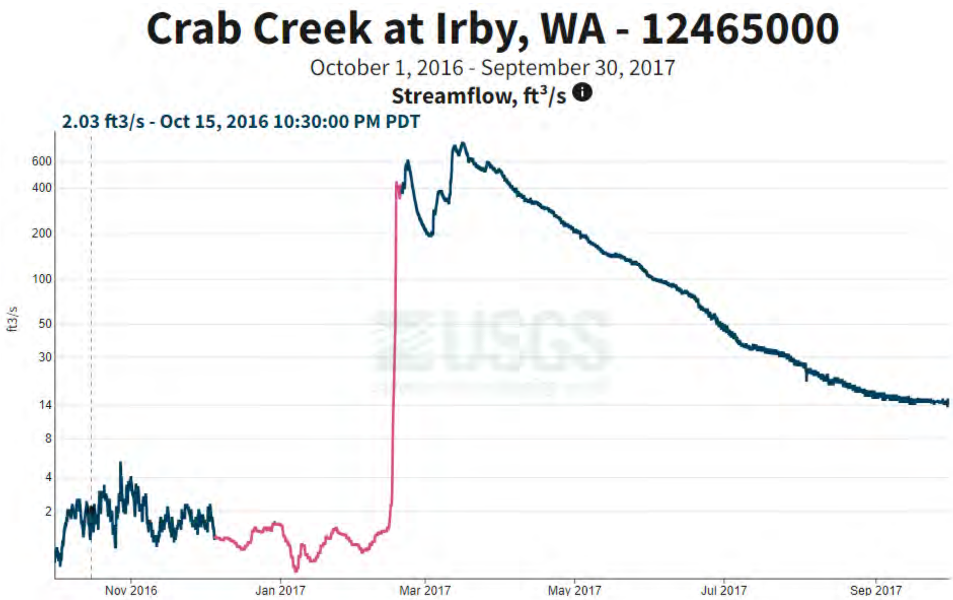

Exhibit 3-10: Crab Creek Hydrograph (Water Year 2016)

Due to the availability of gauge data pertaining to both Crab Creek and Sprague Lake during the 2017 flood event, this study focused on analyzing the aforementioned event with regard to two key parameters: lake stage and the inflow of the two-year return period to the tributaries of Sprague Lake.

Furthermore, upon inspection of the Crab Creek data, spanning March and April 2023 (Exhibit 3-11), which coincides with the duration for which data was collected using the loggers installed for the study, it becomes evident that utilizing the HydroCAD data for estimating Sprague Lake runoff leads to a substantial overestimation. As per the StreamStats tool, the projected HydroCAD flow in Negro creek would be the 10-year runoff, which for Crab Creek amounts to 3,380 cfs. However, during this rainfall event timeline, the Crab Creek gauge data exhibited minimal variability in runoff, and the actual recorded peak flow was considerably lower than the anticipated estimate if based on the rainfall event. This observation serves as a clear indication that the hydrology within the basin is primarily driven by the influence of groundwater and snowmelt, rather than by short-term and intense rainfall events.

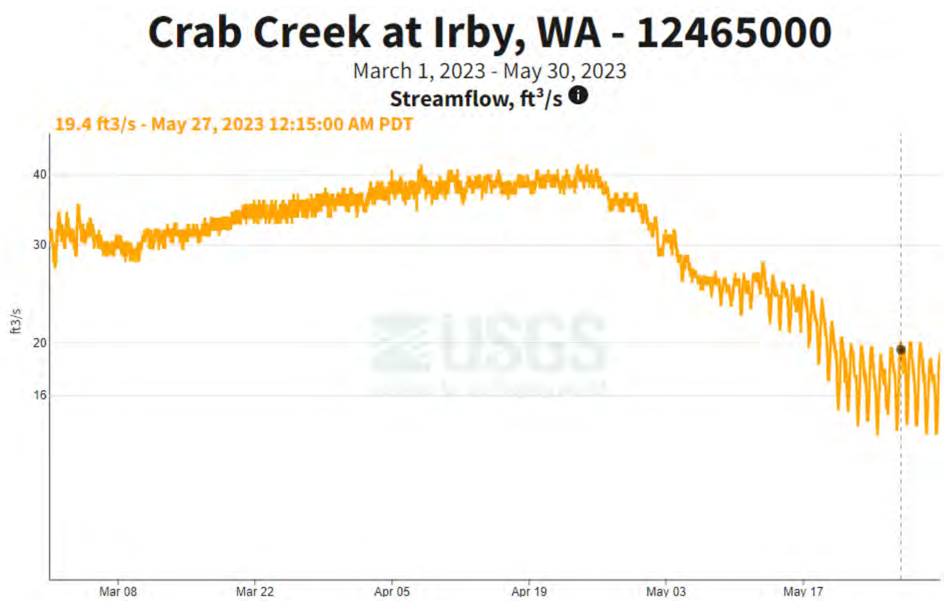

Exhibit 3-11: Crab Creek Hydrograph (Shannon & Wilson Recorded Period)

3.3 Constriction Analysis

Shannon & Wilson approached the lake outlet constriction analysis from the viewpoint of Sprague Lake at its 2017 peak flood level, as shown in the Ecology gauge. The HEC-RAS model was filled to this level using an empty to full flow rate of 121k cfs to expedite model run times. The lake was then allowed to drain. We ignored effects of inflow for the constriction analysis, as the high lake levels are results of long periods of high groundwater as previously mentioned, and having calibrated the physical response of lake slope and Cow Creek function in our hydraulic model to logger data. Water surface profiles for the constriction analysis can be found in Figures 3 and 4.

3.3.1 Channel Bypass / Control Structure

Inspection of the modeling results at the southwest edge of the lake (lake outlet), and from the field observations of the low height of the control structure, suggest that a bypass at the control structure, or removal of the concrete curbs would have little to no effect on the lake levels. The downstream channel of Cow Creek is a significantly tighter constriction than the area of the Control structure. The terrain modifications made to simulate a bypass channel at the control structure are shown in Exhibit 3-12 below.

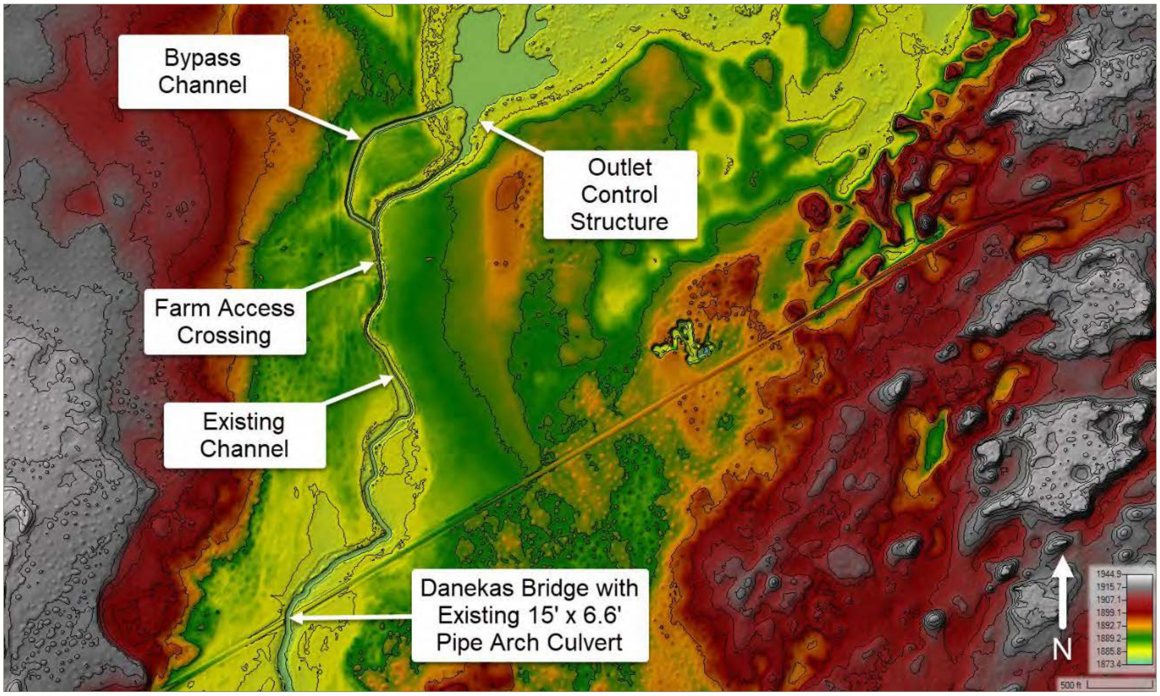

Exhibit 3-12: Modified Lake Outlet HEC-RAS Terrain (Proposed Bypass Channel)

3.3.2 Channel Dredging

The centerline of Cow Creek does have a high point in the vicinity of the farm access that disrupts the smooth continuity of the creek profile. This high point was removed, and the model was rerun with the 2017-year lake level. Dredging this area or simple cleaning of debris from the channel causes marginally faster draining of the lake, with increased water surfaces (and flow) downstream of the removed high point related to increased lake outflow. The terrain modifications made to represent a dredged channel along Cow Creek are shown in Exhibit 3-13 below.

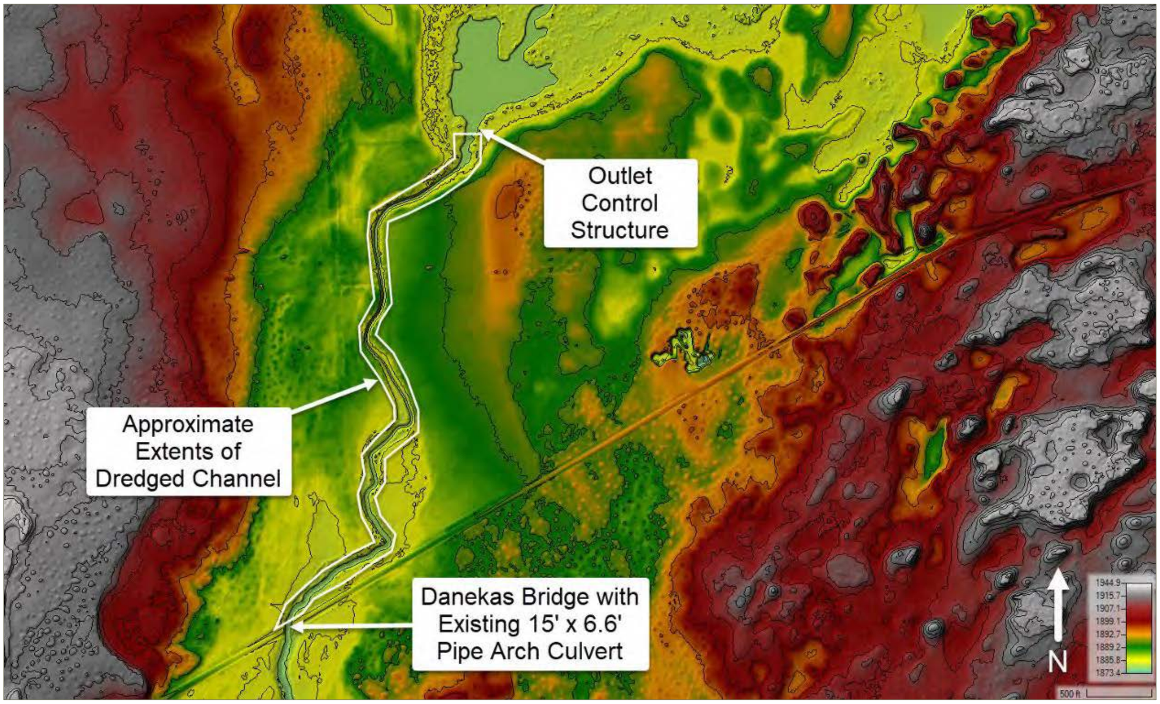

Exhibit 3-13: Modified Lake Outlet HEC-RAS Terrain (Proposed Dredged Channel)

3.3.3 Channel Widening

The existing channel of Cow Creek is approximately 40 feet wide from bank to bank and has a v-notch shape. In the vicinity of the farm crossing, the channel has a narrower cross section at 25 to 30 feet between banks. The entirety of Cow Creek was recut as a widened 40-foot channel with a rectangular cross section, effectively doubling the available channel area. Although this did result in an improvement in flow capacity and lake elevation, these improvements were on the order of 0.2 foot in reduced lake levels within the lake and an increase from 860 to 1,550 cfs of flow in the outlet channel, which is unlikely to provide functional flood relief for property owners on the shoreline. The terrain modifications made to represent a 40-foot-wide rectangular channel along Cow Creek are shown in Exhibit 3-14 below.

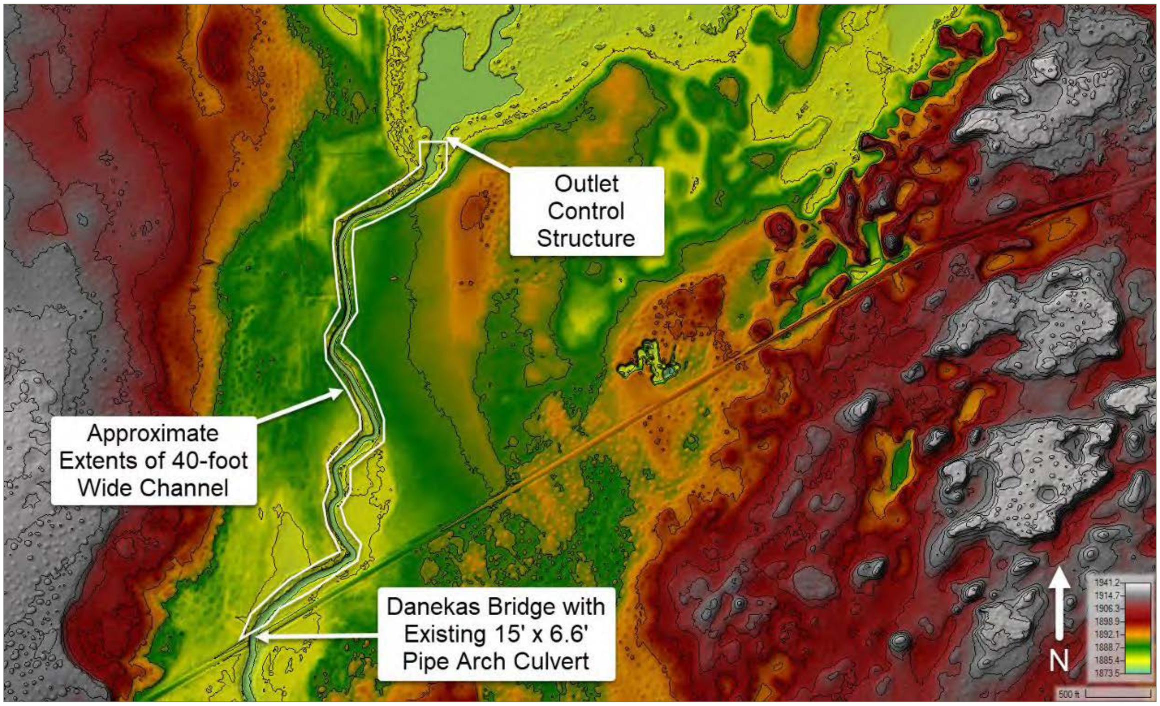

Exhibit 3-14: Modified Lake Outlet HEC-RAS Terrain (Proposed Widened Channel)

3.3.4 Danekas Road Bridge

The 15- by 6.6-foot pipe arch culvert at Danekas Road is the next constriction point upstream of the rock outcrop. This bridge was widened in the HEC-RAS model to a box culvert 30 feet wide by 7 feet tall (Exhibit 3-15). This widening did provide some improvement in draining of the lake, shortening the estimated time to drain from 25 days (2017 levels) to 23 days. However, as the lake drained at each time step, there was less than a foot of improvement in lake water surface elevation.

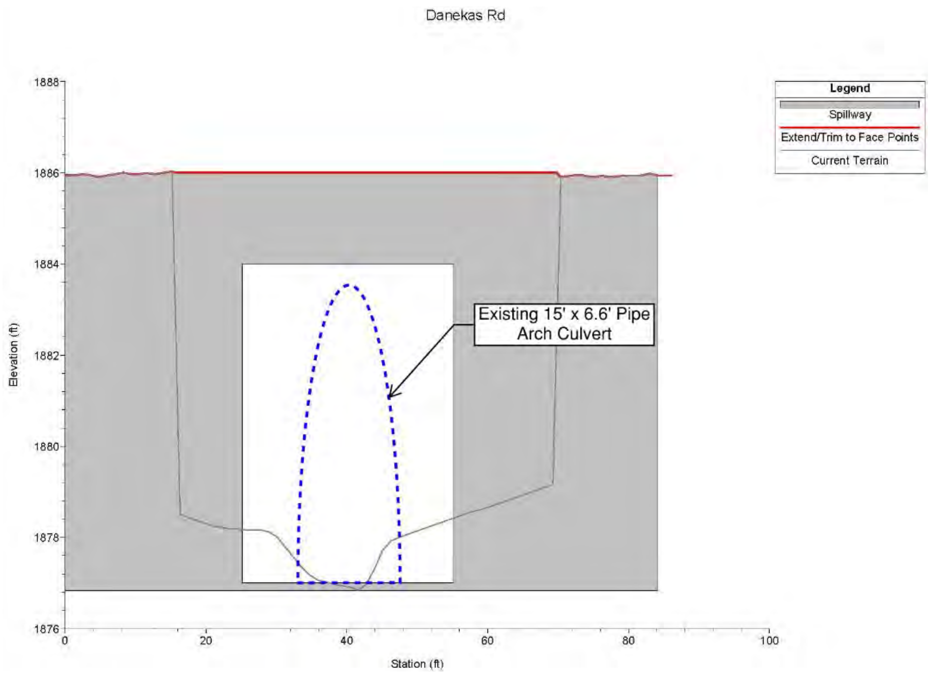

Exhibit 3-15: Modeled Danekas Road 30- by 7-Foot Box Culvert Schematic

A detailed study could be performed on how the long duration runoff east of SR 23 influences the flow and flooding in Negro Creek, including assessing improvements to stormwater conveyance through the City, and there are areas where a bypass channel could be constructed south of the existing concrete drainage structures. However, the bypass would likely come at extreme cost of earthwork and engineering, and analysis of a bypass and stormwater improvements are not part of the scope of this study.

3.4 Sensitivity Analysis – Large Scale Alternatives

As part of a sensitivity analysis, we have undertaken the development and execution of three additional larger scale outlet modification alternatives. To ensure the bedrock constriction downstream of Danekas Bridge did not influence the results, we extended our modeling grid in a southerly direction, effectively incorporating the rock outcrop as shown in Figure 2 and depicted in Exhibit 3-16 below. Modifications to the bedrock outcrop were not considered, but would not be expected to change the findings relative to flood lake levels. The ensuing sections provide detailed descriptions of the three large scale alternatives evaluated.

1. *Existing Conditions Model*: This model serves as the reference point, encapsulating the hydraulic dynamics under existing conditions.
2. *Alternative Model 1 – 80-Foot-Wide Channel*: The introduction of an 80-foot-wide channel, extending from the control structure to a location approximately 200 feet downstream of Danekas Bridge.

3. *Alternative Model 2 – Bypass Channel to Danekas Bridge*: The introduction of a bypass channel originating from the control structure and extending to Dankas Bridge with the inclusion of the previously proposed 30- by 7-foot box culvert as depicted in Exhibit 3-15.

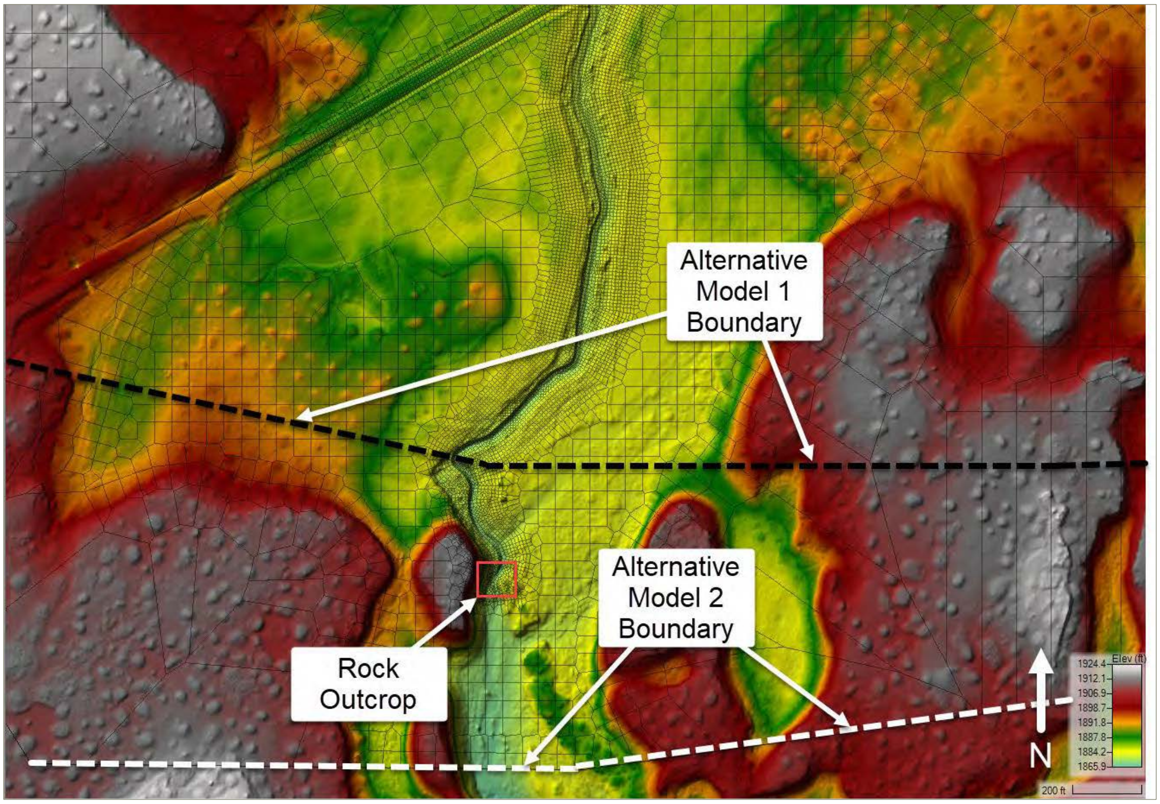

Exhibit 3-16: Large Scale Alternative Modeling Extents With Inclusion of Rock Outcrop

3.5 Large Scale Alternative 1 – 80-Foot-Wide Channel

For the first of two large scale alternatives, Cow Creek was recut as a widened 80-foot channel with a rectangular cross section. This channel excavation extended from the outlet control structure, reaching a point approximately 200 feet downstream of Danekas Road. The outcome of our modeling analysis revealed a reduction in peak lake levels, amounting to an approximate decrease of 0.2 foot at the peak. Furthermore, the post-peak lake levels indicated a reduction in lake levels of approximately 2.8 feet when considering a four-day drainage period after the peak levels.

Moreover, these alterations yielded a change in peak flow capacity within the Cow Creek channel, increasing from 860 to 2,900 cfs. It is worth noting that, similar to the proposed 40-foot wide channel alternative, this configuration is not deemed conducive to providing effective flood mitigation for landowners situated along the northeast shoreline of Sprague

Lake. A representation of the topographical modifications for the 80-foot-wide rectangular channel are provided in Exhibit 3-17 below.

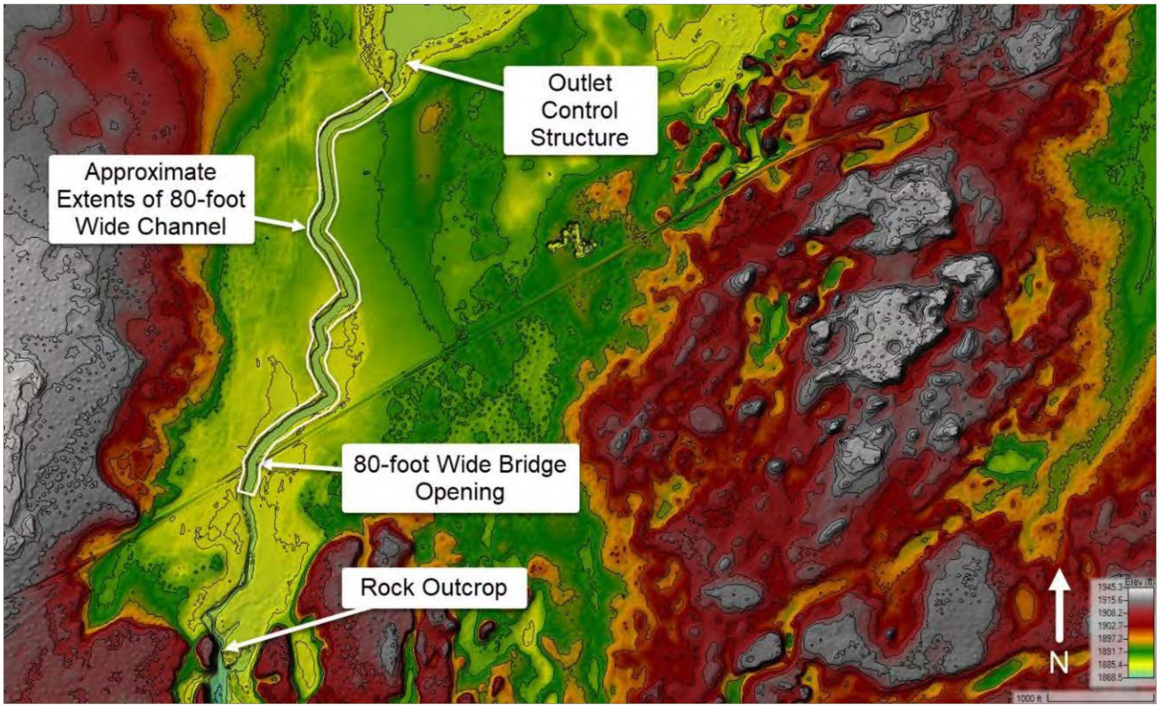

Exhibit 3-17: Modified Lake Outlet HEC-RAS Terrain (Proposed Large Scale Widened Channel)

3.6 Large Scale Alternative 2 – Bypass Channel to Danekas Bridge

For the second large scale alternative, a bypass channel was excavated, extending from the outlet control structure to a location immediately upstream of Danekas Road, situated to the west of Cow Creek. Additionally, the inclusion of a 30- by 7-foot box culvert along Danekas Road was proposed to facilitate enhanced drainage and conveyance efficiency within the system. A detailed representation of the topographical modifications required are provided in Exhibit 3-18 below.

Based on the modeling analysis, the peak lake levels exhibited a reduction of 0.1 foot compared to the existing conditions. Following a four-day drainage period, the lake levels demonstrated a decrease of approximately 1.5 feet when compared to existing conditions.

Moreover, the peak flow rates in Cow Creek experienced an increase in flow through Danekas Road from 860 to 1500 cfs.

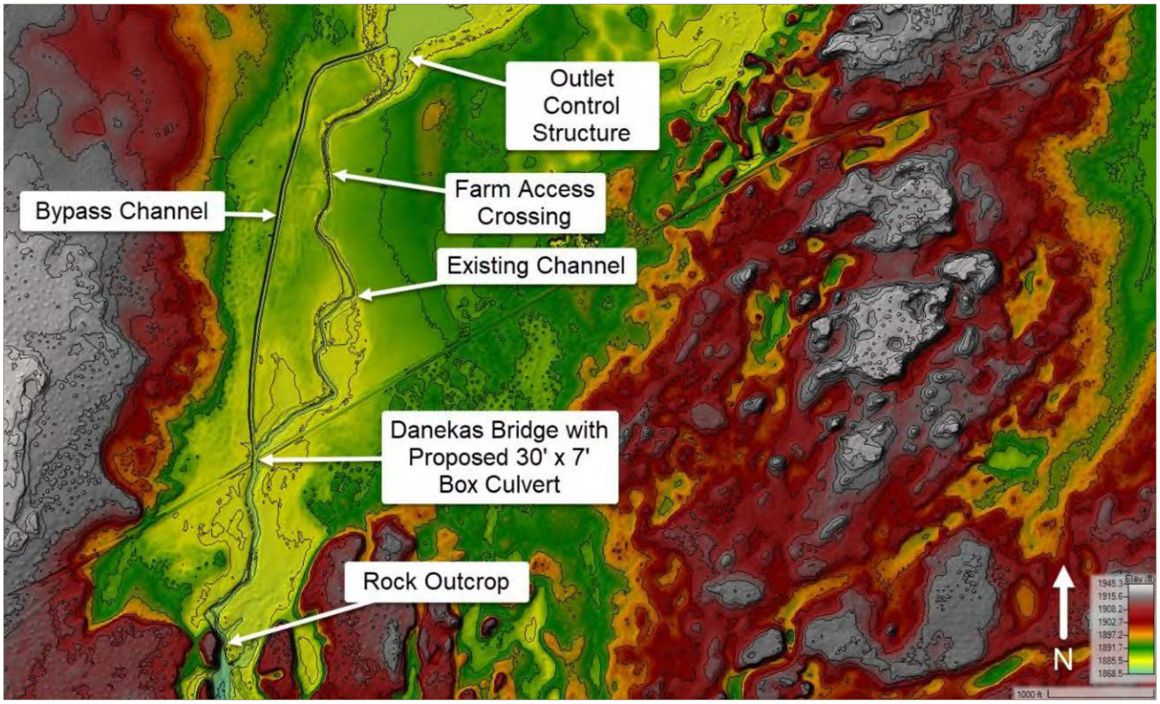

Exhibit 3-18: Modified Lake Outlet HEC-RAS Terrain (Large Scale Proposed Bypass Channel)

3.7 Flooding – City of Sprague

While it is outside the scope of this study to accurately predict surface water flows into the City, the infrastructure in the City has a consistent flow rate at which box culverts and concrete channels are overwhelmed and begin to flood. Looking at our representative hydrograph, which includes a rise and fall of flow, this overwhelming point occurs upstream in the system at roughly 370 cfs, and in the downstream of the system at roughly 450 cfs.

The relationship between City flooding, lake levels, and whether flooding is a symptom of overwhelmed culverts and drainage systems during high flow events was further evaluated. We ran a two-year, 654 cfs steady state flow through Negro Creek, 24.9 cfs North Tributary East, and 192 cfs North Tributary West into the City with a lake level held at the April 2023 logger lake level and at the extreme maximum 2017 lake level. This two-year simulation floods roughly 10 square blocks of the City in both the high lake level condition and the low lake level condition. The water surface profile provided (Figure 5) indicates that the upstream backwater effect from the two-year flood event with the 2017 maximum lake water surface versus the "lower" lake water surface from our logging interval is near the private road crossing, about 5,000 feet upstream of the lake. It is reasonable to conclude that flooding in the City is not from tailwater effects of the lake but likely from overwhelmed drainage systems within the City.

4 WAVE ANALYSIS

Sprague Lake is susceptible to wind-induced wave activity. To evaluate the potential impact of these waves on upstream flooding in the City, Shannon & Wilson employed methodologies outlined in the USACE Coastal Engineering Manual (2015) to compute wave parameters of relevance. The primary parameters of interest encompass wave height, wave period, and breaking wave height. By comparing these parameters with the hydraulically modeled flooding resulting from surface flow inputs, the analysis aims to discern the dominant factor contributing to problematic flood events.

In this assessment, wave runup (Exhibit 4-1) was excluded from consideration, given that the area under investigation for a wave runup analysis requires a steep embankment or shoreline. Specifically, the northeast shore of Sprague Lake, where Negro Creek converges with the lake, exhibits a gradient of less the 5%, indicating a shallow slope. Additionally, boat-generated waves were not factored into the analysis. While Sprague Lake hosts an active boating community, the vessels employed for recreational purposes are relatively small and unlikely to generate waves of sufficient magnitude to contribute to flooding extents.

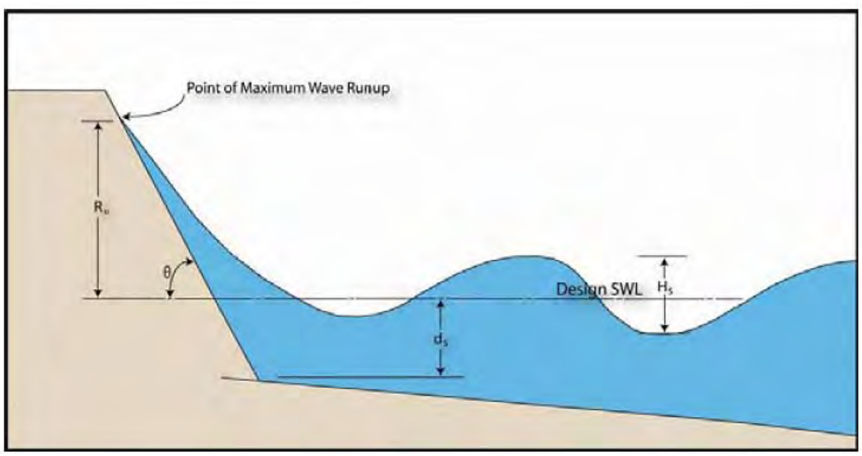

Exhibit 4-1: Wave Runup on a Steep Embankment (Figure 6.17 From the Federal Highway Administration's Hydraulic Engineering Circular No. 25 [Douglass, 2020])

4.1 Wind Waves

In accordance with the USACE Coastal Engineering Manual (CEM), we have determined the design wind and wave parameters by considering the specific site fetch and corresponding design wind speed and orientation. The fetch in the area of interest is influenced by Harper Island (Exhibit 4-2), situated near the southwest (outlet) end of the lake, as well as the curved shoreline at the northeast end (inlet). The calculated fetch length extends approximately 18,050 feet towards the northeast.

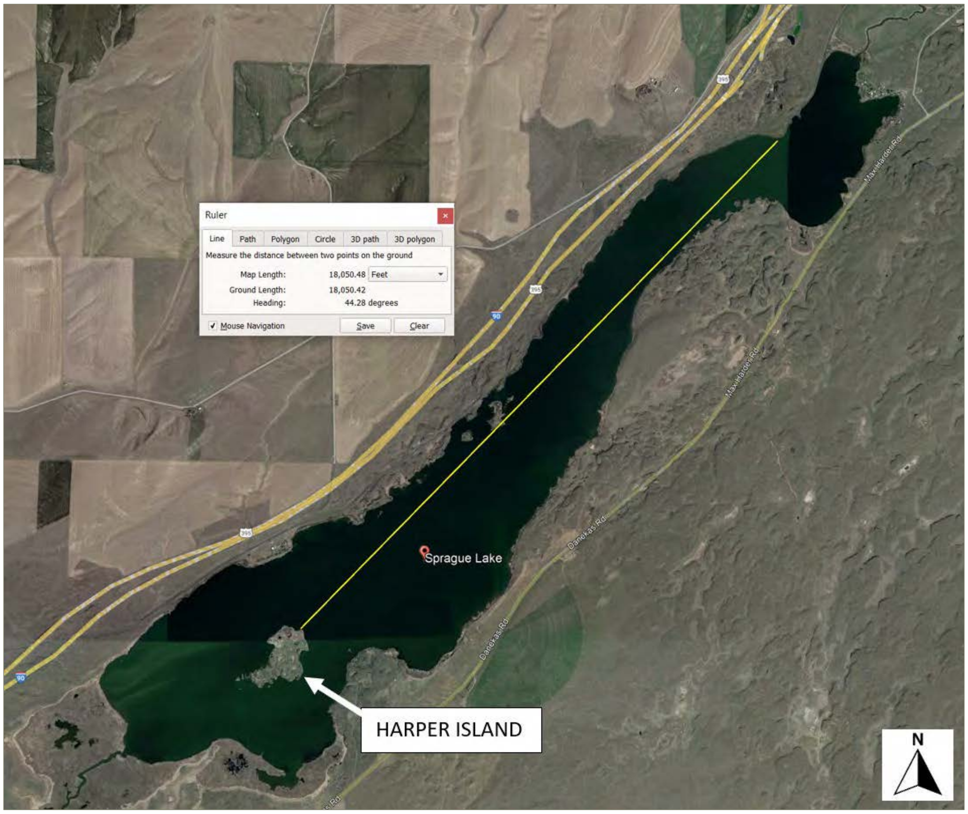

Exhibit 4-2: Fetch Measurement (Google Earth)

To establish the design wind speeds, we reference the American Society of Civil Engineers (ASCE) Standard 7-16 (ASCE, 2017). This standard offers estimates of three-second wind gust speeds for various recurrence intervals based on location. The estimated 1% Annual Exceedance Probability (AEP) three-second wind speed at the project location is determined to be 87 miles per hour (mph). However, it is important to note that a three-second wind gust does not generate a significant wave set. To fully generate fetch-limited waves for the given fetch length of 18,050 feet, a sustained wind duration of 15 minutes is necessary (EM-1110-2-110 P2, II-2-4 of the CEM).

The CEM provides an equation for converting wind speeds of one duration to an AEP-equivalent wind speed of a different duration. Utilizing this equation, we derive a 15-minute design wind speed of 60 mph. The resulting wave parameters are summarized in Exhibit 4-3 below.

Exhibit 4-3: Design Wave Parameters

Wave Height (feet)	Wave Period (seconds)	Break Wave Height (feet)
3.9	2.7	3.4

In addition, we reviewed the wind and lake level time series for the period of logger data; it can be seen that for the duration of the logger data, winds from the southwest (northeast direction) have very little impact (on the order of a few tenths of a foot) on lake water surface elevations at the Ecology Gage to the northeast (Exhibit 4-4).

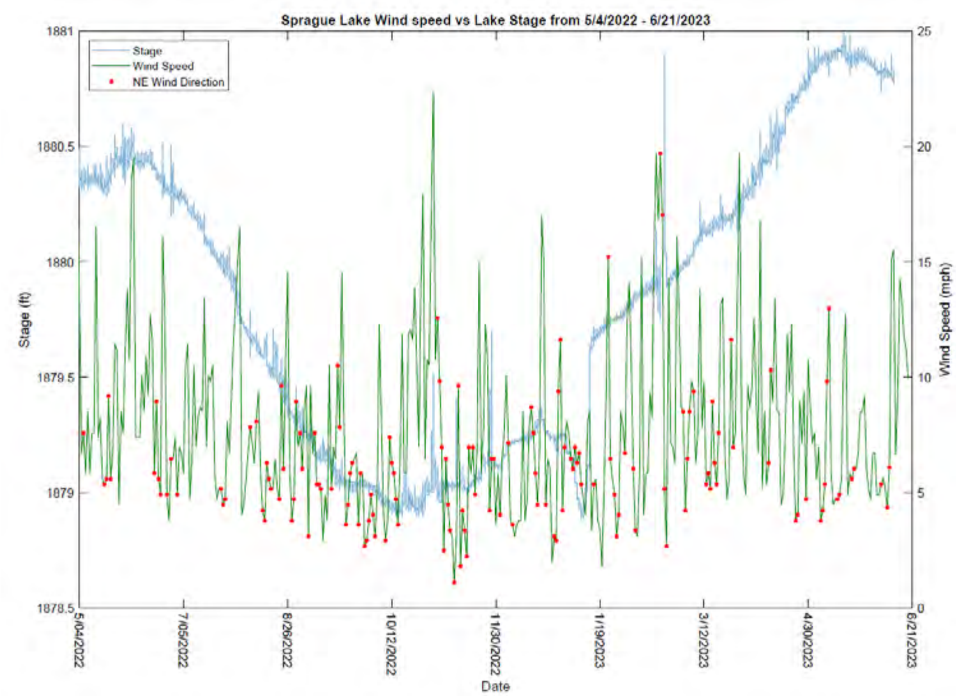

Exhibit 4-4: Correlation Between Lake Stage, Wind Speed, and Precipitation

4.2 Summary of Wave Analysis

The minimum elevation of structures within the City is estimated to be approximately 1,895 feet. During the peak months of April through June, the approximate elevation of the lake water surface reaches 1,880 feet. Considering a calculated wave height with a recurrence interval of 100 years, measuring 3.9 feet, it follows that the most vulnerable homes in the City would be situated approximately 11.1 feet above the wave height. Consequently, it is rational to assert that wave-induced flooding does not pose a threat to the City's infrastructure, but rather the Lakeside residents and the campground are likely the most impacted by waves.

5 SUMMARY OF PERMITTING REQUIREMENTS

Excavation of larger or new channels at the lake outlet would require extensive permitting. The permitting challenges are related to direct and indirect permanent and temporary impacts to lake, stream, wetlands, and/or buffers within the construction areas of the alternatives. The nature and extent of the direct impacts will depend on the design of selected alternative(s). The project would also likely lower the "low lake" water surface, with resulting indirect impacts to the wetlands (both area and conditions) and hydrology around the lake. These direct and indirect effects would require potentially substantial compensatory mitigation and may prove infeasible to permit if alternative flood risk reduction options exist. Based on the conceptual alternatives evaluated in this report, we have provided a list of likely permits and environmental reviews that would be required.

1. State Environmental Policy Act (SEPA): The project would require compliance with SEPA, and we assume that Ecology would act as the SEPA lead agency. A SEPA Checklist would be prepared first, potentially followed by an Environmental Impact Statement (EIS) if the Checklist review concludes with a Determination of Significance. Preparation of an EIS is a costly and time-consuming process. If federal funding is used or other federal nexus triggered, National Environmental Policy Act (NEPA) approval would also be required, which would likely further increase both cost and schedule of permitting.
2. County Shoreline Permit(s): Sprague Lake is a Shoreline of Statewide Significance and Cow Creek is a Shoreline of the State. Shoreline waterbodies are subject to the Shoreline Master Programs of Lincoln (creek only) and Adams counties (creek and lake). Dredging for flood management purposes in the aquatic environment may be allowed with a Substantial Development Permit, but other improvements or modifications in or adjacent to the water may require a Conditional Use Permit (CUP). Further, because Sprague Lake is a Shoreline of Statewide Significance, any project in or affecting the lake has to demonstrate consistency with a set of use preferences that emphasize statewide over local interests, preservation of the natural environment, and other criteria that may be difficult for a project of this type and in this setting. Depending on the design of the chosen alternatives and their location with respect to other critical areas, a Shoreline Variance may also be required. CUPs and Variances also have specific criteria that must be met and can be challenging and time-consuming to obtain.
3. WDFW Habitat Project Approval (HPA): Projects in lakes or streams that "use, divert, obstruct, or change the natural flow or bed of any of the salt or fresh waters of the state" (RCW 77.55.011(11)) will require an HPA.
4. USACE Section 404 Clean Water Act (CWA) Authorization: Per Section 404 of the CWA, a review process is required for projects involving discharges of dredge or fill materials into jurisdictional waters of the United States. Any proposed impact located within a jurisdictional wetland or stream would require either a Nationwide Permit (NWP) or an

Individual Permit from USACE. The potential projects being considered are unlikely to qualify for a NWP, so an Individual Permit would be required. Individual Permits require preparation of an Alternatives Analysis that shows that the proposed project is the Least Environmentally Damaging Practicable Alternative (LEDPA). USACE can only authorize the LEDPA. Projects that require or trigger a federal permit from USACE would also require approval under the Endangered Species Act (addressing yellow-billed cuckoo and monarch butterfly), Magnuson-Stevens Fishery Conservation and Management Act (addressing designated Chinook salmon essential fish habitat), and Section 106 of the National Historic Preservation Act (addressing effects on historic properties).

5. Ecology Section 401 CWA Individual Water Quality Certification (WQC): Ecology has been authorized to implement Section 401 of the CWA for WQC in Washington for most projects that require USACE permits under CWA Section 404. Typically, projects requiring a USACE Individual Permit also require an Individual WQC. The purpose of the certification process is to ensure that federally permitted activities comply with the federal CWA, state water quality laws, and any other applicable state laws. Some general requirements for Section 401, if it is required, include pollution spill prevention and response measures, disposal of excavated or dredged material in upland areas, use of fill material that does not compromise water quality, clear identification of construction boundaries, and provision for site access to the permitting agency for inspection. The project would require preparation and implementation of a formal Water Quality Monitoring and Protection Plan.
6. DNR: Once the project has been defined, DNR should be contacted to discuss whether any of the project falls into aquatic lands under their jurisdiction and to determine whether a right-of-entry or aquatic lands lease needs to be obtained. This process can be lengthy.
7. The alternatives studied fall within Adams County and are mapped FEMA Zone A. Zone A is a flood hazard area that has been mapped using approximate methods with no detailed studies (hydraulic modeling) or Base Flood Elevations being developed. Changes to the outlet by design would result in increased flows and would need to be modeled (potentially far downstream) and likely result in a re-mapping of the FEMA flood zone (CLOMR/LOMR) depending on the findings from the detailed modeling study and alternative considered. Regardless of FEMA requirements, a downstream flood risk study to understand risk to downstream stakeholders would be required.
8. Other local and state land use and environmental permits may also be required.

Special critical areas studies, including delineation of wetland boundaries, ordinary high water mark, and documentation of fish and wildlife habitat along with preparation of other technical reports will be necessary to support project design and permitting.

Depending on which alternative or combination of alternatives is chosen and the nature and extent of impacts, the planning level cost for permitting alone could range between $200k to $500k. Flood risk modeling would likely be between $100k to $300k, depending on the extent and remapping required. This cost does not include compensatory mitigation. Developing an appropriate mitigation strategy would be heavily dependent on the proposed design, further analysis of direct and indirect impacts to aquatic habitats and buffers, and may be subject to extensive negotiations with resource agencies and local tribes. Depending upon the type and extent of mitigation, additional property acquisition or easements may be required. Finally, downstream flood risk mitigation costs may be extensive. Environmental mitigation costs would likely far exceed the permitting costs if the low water elevation of the lake is lowered, likely resulting in extensive wetland impacts around the lake and not just at the project site.

6 CONCLUSIONS AND RECOMMENDATIONS

It is our opinion that outlet improvements explored for this study have low flood risk reduction value for City residents and likely marginal value to lakeside residences. The long duration hydrology and influence of groundwater and snowmelt on the runoff hydrographs and lake levels would likely require a major reconfiguration of the lake outlet with nominal improvements in flood risk reduction to residences surrounding the lake. Improving conveyance at the outlet would likely lower the dry season low water lake surface elevations and provide nominal relief from wind and wave damage; however, it would likely not significantly improve wet season lake levels when wind damage is most likely to occur. Additionally, lowering dry season lake levels would impact lakeside wetlands and may impact downstream water rights. This study looked at a broad range of outlet conveyance improvements to understand the lake outlet hydraulics; however, the alternatives evaluated were bounded by scope, budget, and what would be anticipated as reasonable modifications. Alternatives, such as improving local drainage infrastructure within the City and a detailed study of lakeside residential flooding was not conducted. Home elevations, property acquisition from willing sellers, and major civil works were not included in the study.

To better evaluate City flooding, we recommend installation of water level loggers (gages) upstream of the City and potentially within the City drainage network to better understand flooding and provide valuable data for future design and infrastructure improvements.

If more detailed understanding of lakeside residence flooding is needed, we would recommend a more detailed hydrologic study of the lake hydrology to better understand potential improvements to the outlet and their specific risk reduction impacts to lakeside individuals, both in duration and likelihood of flooding, with an associated alternatives and cost benefit analysis. In addition, long-term gage installation (7 to 10 years) upstream of the lake and downstream of the lake would further add detail and understanding to the lake hydrology and is recommended if further analysis is anticipated.

7 LIMITATIONS

This report was prepared for the exclusive use of Ecology and their representatives for specific application to the project. Our judgements, conclusions, and interpretations presented in the report should not be construed as a warranty of existing site conditions, nor future estimated conditions. It is in no way guaranteed that any regulatory agency will reach the same conclusions as Shannon & Wilson. Our assessment, conclusions, and recommendations are based on the limitation of our approved scope, schedule, and budget described in our contract.

Key limitations associated with this assessment include:

- Hydrologic and hydraulic analysis models predict flood water surface elevations based on limited data and numerical modeling techniques. Actual flood conditions may vary from the model predicted conditions.
- Rivers and floodplains are dynamic systems and will change compared to the modeled condition.
- The hydraulic model does not consider changes in future conditions due to changes in land use conditions, river and floodplain conditions, structure conditions, or climate change.

Site conditions may change due to natural forces or human activity under, at, or adjacent to the site. If changes occur, we should be retained to review the applicability of our conclusions and recommendations.

Shannon & Wilson has included a document, "Important Information About Your Geotechnical/Environmental Report," to assist you and others in understanding the use and limitations of this report.

8 REFERENCES

American Society of Civil Engineers, 2017, Minimum design loads and associated criteria for buildings and other structures: Reston, Va., American Society of Civil Engineers, ASCE Standard ASCE/SEI 7-16, 2 v.

United States Geological Survey (USGS), 2023, Crab Creek at Irby, WA – 12465000: Available: https://waterdata.usgs.gov/monitoring-location/12465000/#parameterCode=00060&period=P365D&showMedian=true&compare=true.

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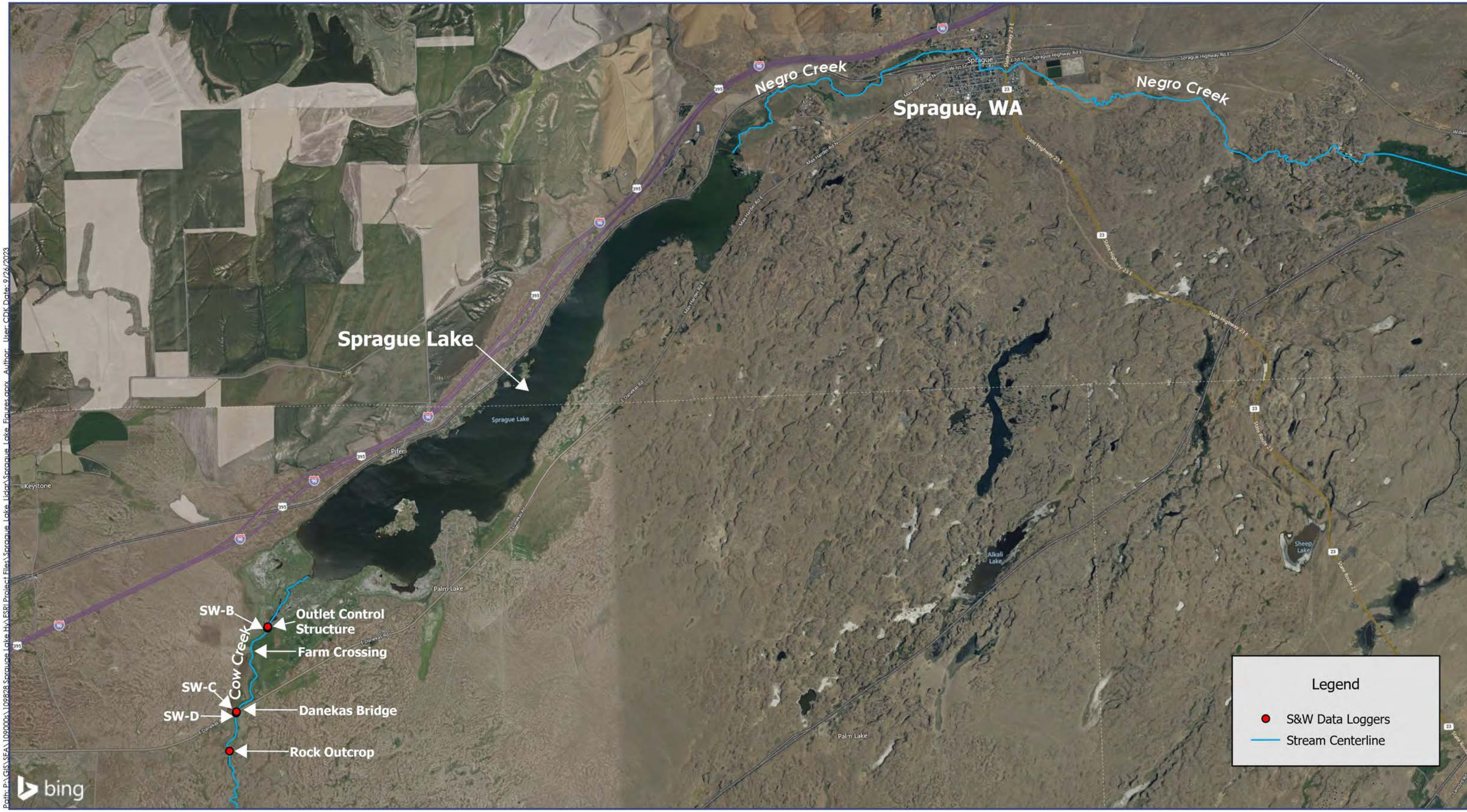
October 2023

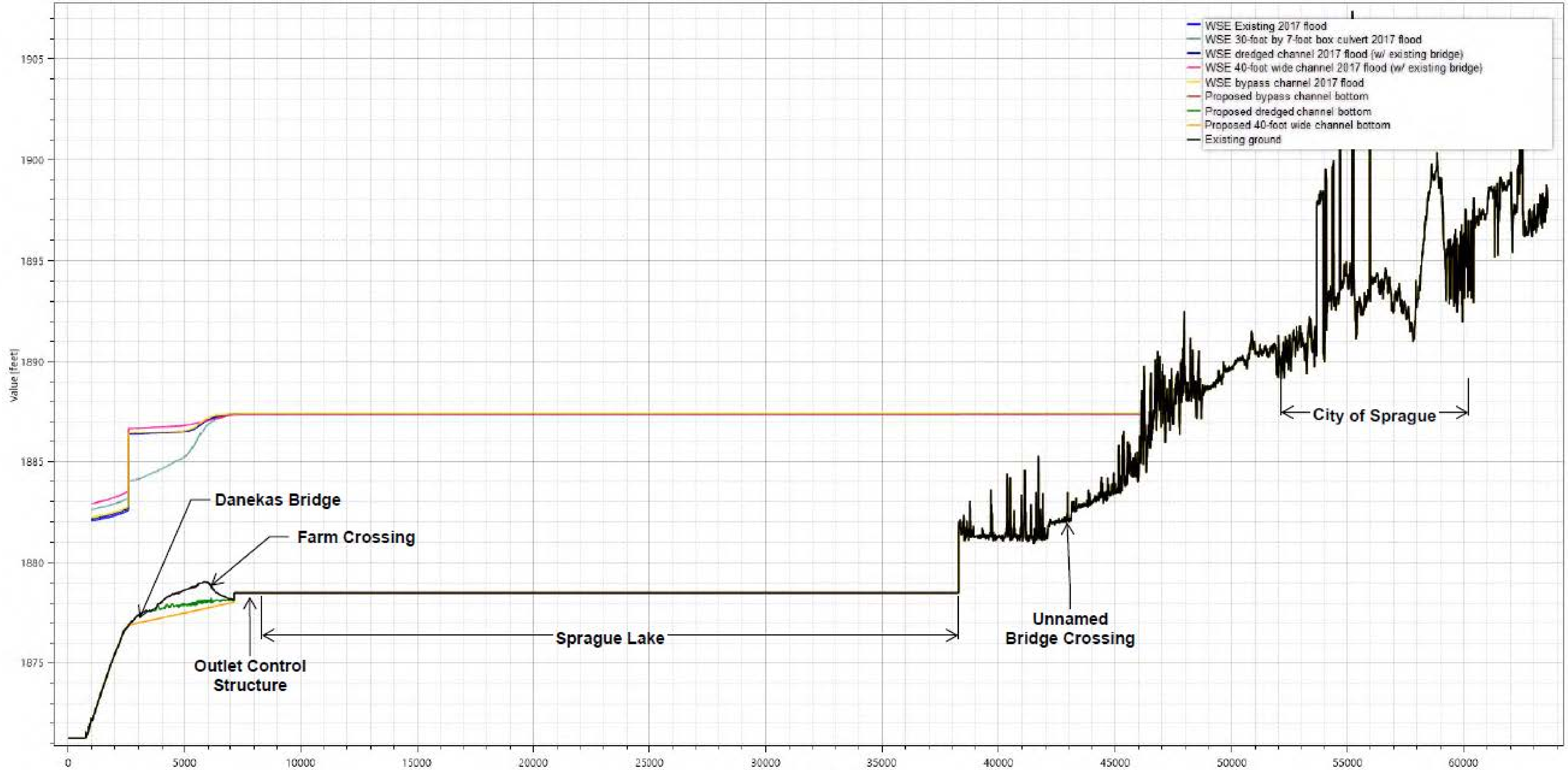
VICINITY MAP

Figure 1



SITE PLAN

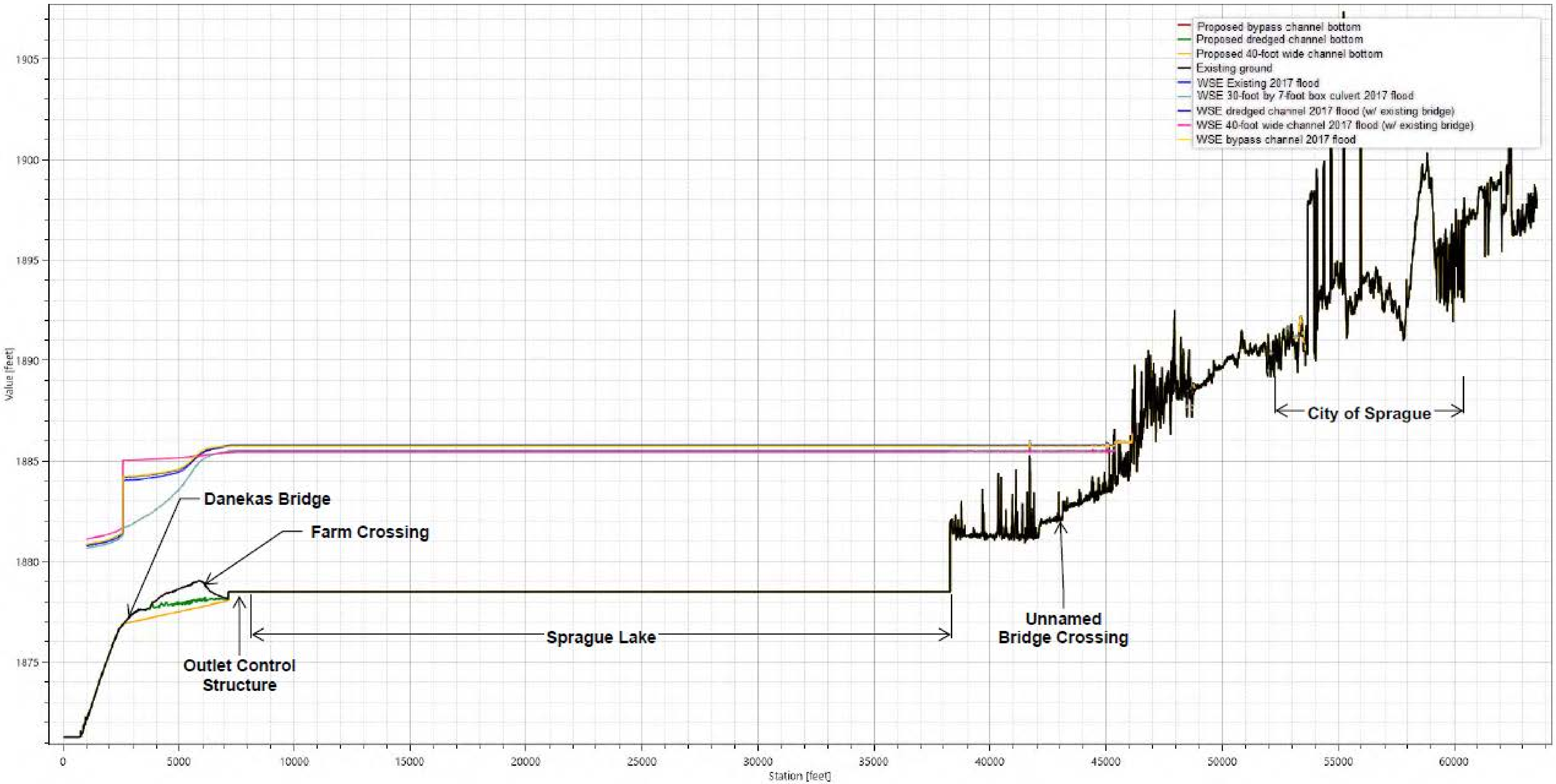
Figure 2



October 2023

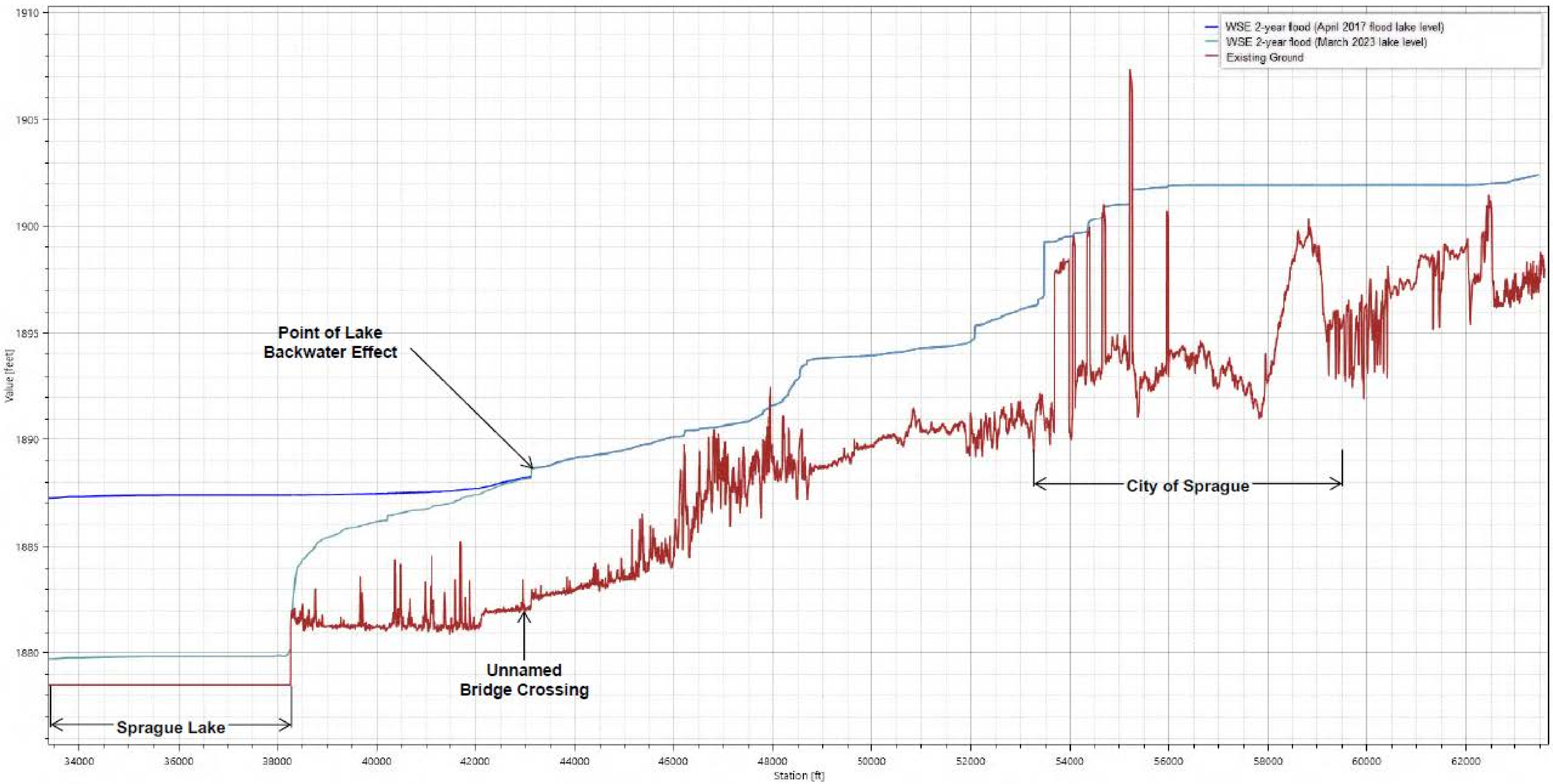
2017 Flood Profile - Peak Water Surface Elevations

Figure 3



2017 Flood Profile - 4 Days Following Peak Water Surface Elevations

Figure 4



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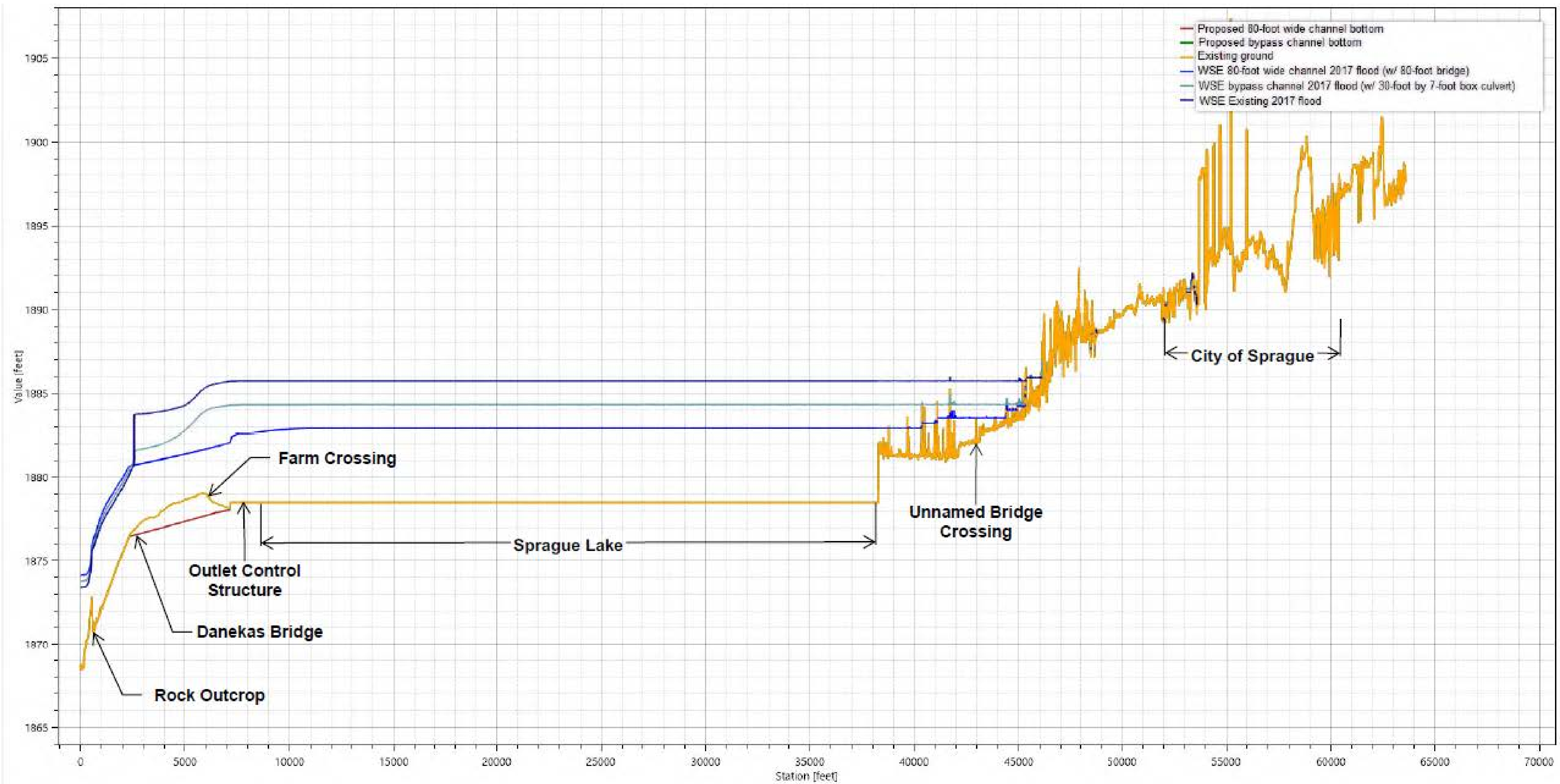
2017 Flood Profile - **Peak Water Surface Elevations Large Scale Alternatives**

Figure **6**



October 2023

2017 Flood Profile - **4 Days Following Peak Water Surface Elevations Large Scale Alternatives**

Figure **7**

IMPORTANT INFORMATION

Important Information

About Your Geotechnical/Environmental Report

IMPORTANT INFORMATION

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors that were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining

IMPORTANT INFORMATION

your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary, because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

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READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports, and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland.

Appendix B – Flood Report

City of Sprague, Washington
Nonstructural Flood Mitigation Assessment

January 2020

USACE Walla Walla District in support of the Washington Silver Jackets Program

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City of Sprague, Washington
Nonstructural Flood Mitigation Study

1.0 Introduction

This reconnaissance level nonstructural assessment was conducted in support of the U.S. Army Corps of Engineers (USACE) Seattle District and the Washington Silver Jackets team by the USACE Walla Walla District. The objective of the study was to assess the opportunity for nonstructural flood risk mitigation measures (NS measures) in the City of Sprague, Washington (Sprague). All 94 structures identified within the mapped 1-percent annual chance exceedance (1% ACE) floodplain were documented and qualitatively assessed. A location map of the study area is presented in Figure 1 and Figure 2.

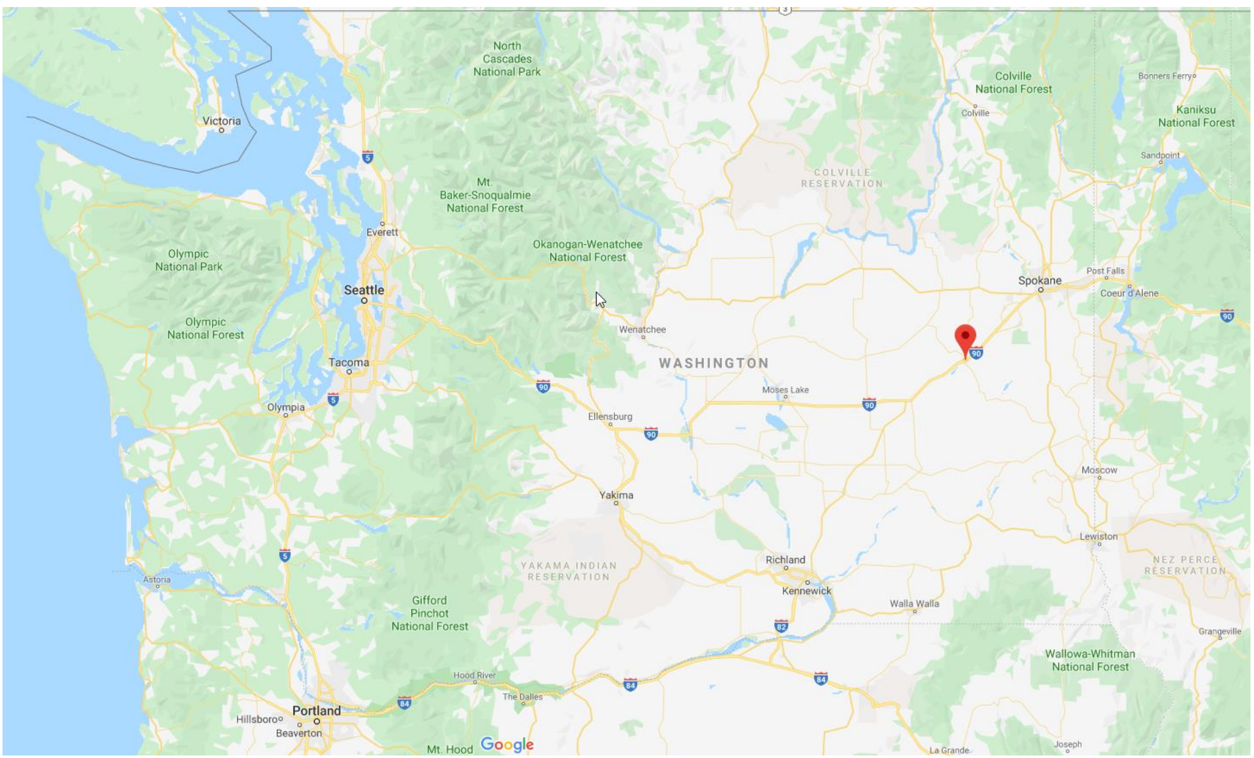


Figure 1. Sprague, Washington Vicinity Map.

In March 2017, significant rainfall on top of a melting snowpack caused significant flows in Negro Creek, which spilled over its banks and inundated homes, businesses and streets. The city mounted a significant flood fight effort with pumps and sandbags which helped to mitigate the impacts of flooding. However, damages still occurred throughout Sprague. The consequences of flooding will be very similar in future events in the absence of action taken in the floodplain.

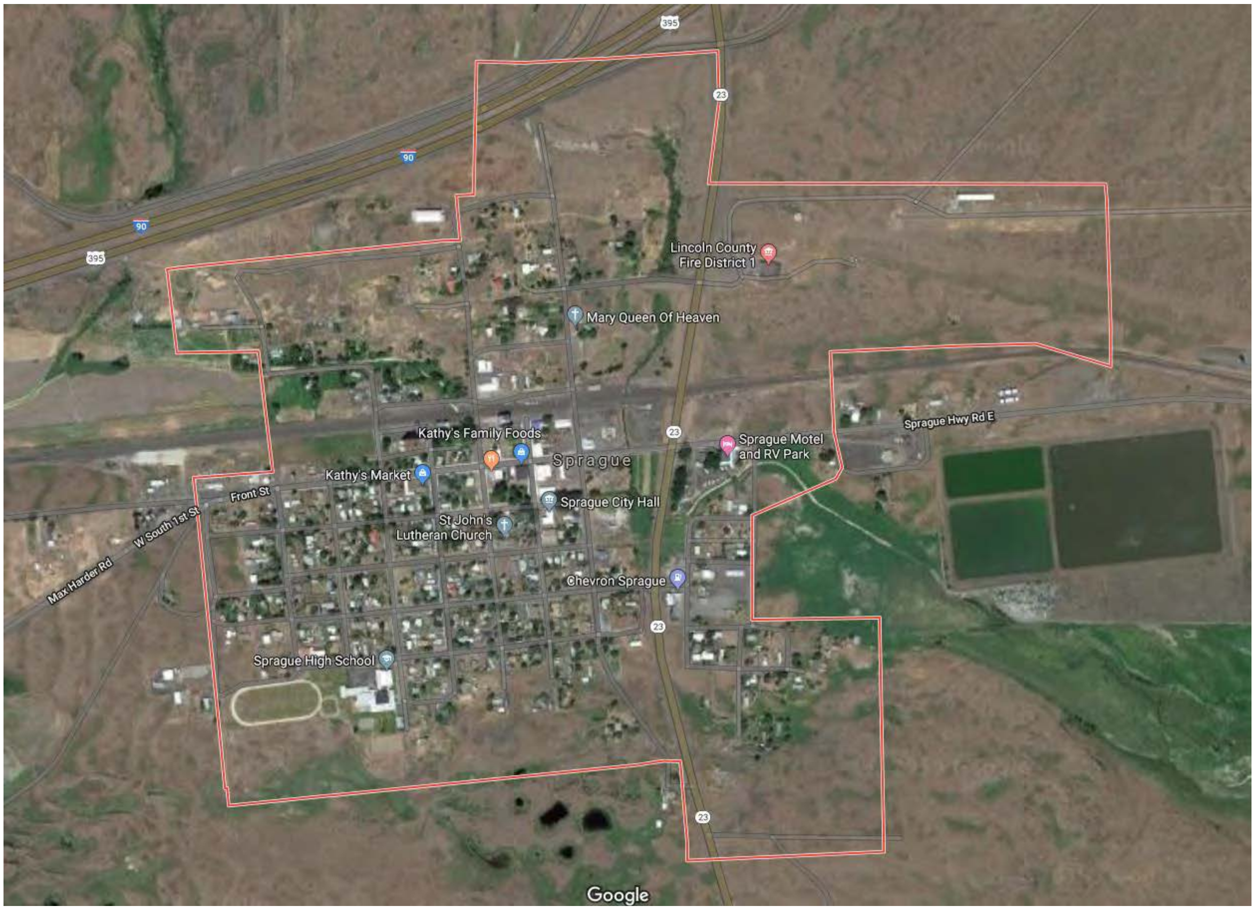


Figure 2. City of Sprague, Washington.

1.1 Floodplain and Flooding Characteristics

The primary flooding source in Sprague is from Negro Creek, which flows from east to west through the community and into Sprague Lake. Part of the flow path through town is underground. There is a substantial backwater effect from Sprague Lake downstream, causing extended periods of inundation.

The Negro Creek basin is characterized by relatively flat slopes and significant overbank storage, meaning that when floods occur, they will spread out fairly extensively in the basin. The overbank storage also provides attenuation for flood waters. The watershed lies over a fractured basalt formation, with significant exchange between surface water and groundwater.

Flooding in the Negro Creek drainage can occur from snowmelt, rain on snow, or prolonged widespread rain events in the basin. During large flood events, flood waters tend to arrive and recede slowly, often arriving in Sprague several days after whatever the source event may be. The Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) for Lincoln County, Washington, states that due to the amount of overbank storage and attenuation provided, quick moving large precipitation events like thunderstorms tend to result in minimal flooding in Sprague. Larger, more widespread sources of flooding like long rain events or rain-on-snow events tend to cause the worst flooding.

Sprague has experienced significant floods in 1918, May 1948, March 1954, January 1978, February and March of 1997, and as recently as March of 2017. Floodwaters typically have little velocity and carry little debris, so inundation is the primary damage driver.

1.2 Executive Order 11988 on Floodplain Management (EO 11988)

Executive Order 11988 (EO 11988) was issued by President Jimmy Carter on May 24, 1977. The order states "in order to avoid to the extent possible the long- and short-term impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative, it is hereby ordered that each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, floodplains in carrying out its responsibilities…". The NS measures assessment in this report was conducted in compliance with EO 11988, meaning any NS measures that are incorporated into alternatives recommended for implementation support the vision of EO 11988.

1.3 Addressing Flood Risk in Sprague

Flooding in and around Sprague requires the response and recovery efforts of local government, residents, and outside volunteers, as well as Lincoln County, state and federal agencies. When flooding occurs, the drain on human and financial resources is significant. Damage to residential, commercial and public facilities adversely impacts the entire community.

Whether hydrologic conditions remain the same or increase in the future, all structures located within the vicinity of the assessment area are at risk of flooding. This assessment focuses on at-risk structures and contains the qualitative technical assessment used for investigating the incorporation of NS measures within the assessment area. Without the incorporation of nonstructural mitigation or other structural measures such as levees, floodwalls, and channel modifications, these structures are at risk of being damaged or destroyed from flooding occurring in the future.

While NS measures are specific to the individual structure being investigated, when many measures are combined for mitigation of flood damages, the cumulative effect is to incorporate a full range of NS measures which are economically feasible, socially acceptable, environmentally adequate, and will reduce the cumulative risk of flooding for the community. Each individual structure assessed may require a different nonstructural technique. This assessment relies on data collected in the field for implementation and thus cannot be conclusive as to the ultimate feasibility of the alternative. Because of the limited nature of this investigation, this assessment was conducted as reconnaissance level detail and would require additional analyses to determine economic feasibility for implementation.

NS measures require different implementation methods than typical large-scale structural measures (for example, levees or floodwalls). Since each structure is owned and typically occupied, nonstructural implementation agreements must be entered into with each individual owner. NS measures are proven methods and techniques specifically directed at reducing flood risk and flood damages in floodplains. Numerous structures across the nation are subject to reduced risk and damage or no risk and no damage due to implementation of NS measures. These measures can be very effective for both short and long term flood risk and flood damage reduction and can be very cost effective when compared to other types of flood risk management (levee systems, detention, and channel modification) measures.

The ability of NS measures to be implemented in very small increments, with each increment producing flood risk reduction benefits, is an important characteristic of this form of flood risk management. Also important is the ability to implement measures over intermediate and long periods such that layering of measures, each one providing a higher degree of risk reduction, is possible and given both Federal and non-Federal funding constraints, may be probable.

2.0 The Nonstructural Assessment

This nonstructural assessment is meant to provide a qualitative assessment of all of the residential and commercial structures within the mapped 1-percent annual chance of exceedence (1% ACE) floodplain on the FEMA Flood Insurance Rate Map (FIRM) for Sprague. Outbuildings were typically not considered in the analysis.

2.1 Nonstructural Assessment Objectives

For a nonstructural assessment, each structure must be investigated for purposes of determining what type of NS measure is most appropriate for that particular structure given structure construction, structure and site conditions, location within the floodplain, and local flood characteristics (velocities, stages, and duration). The target flood for nonstructural flood proofing was the 1% ACE flood event. Basic structure information was collected in the field from public property and combined with other information obtained by USACE – Walla Walla and Seattle Districts with additional assistance from the community.

This assessment aims to provide a determination of the appropriate nonstructural technique for each structure. Due to the qualitative nature of field data collection, it was not possible to assess certain aspects of each structure that should be evaluated to determine if the NS measures considered would be appropriate for a given structure. In particular, a structure has to be in relatively good condition, meaning it has to be structurally sound in order to withstand elevation, relocation, or flood proofing. If a given structure is in poor condition, then only filling in the basement/crawlspace, if one exists, could be considered.

Filling in the basement/crawlspace includes relocating utilities, mechanical equipment (furnace, water heater, water softener, and appliances), electrical panels and circuits, as well as some storage to a new location above the Base Flood Elevation (BFE), which is the water surface elevation associated with the 1% ACE flood event. These measures were considered because they would both reduce future flood damages to the structure and reduce flood insurance premiums for the owner, which start at the lowest habitable elevation.

For dry flood proofing, the depth of flooding has to be limited to between three to four feet above ground elevation and the walls of the structure have to be of such structural integrity as to being able to withstand the lateral forces applied by the floodwaters.

Relocation is provided as an alternative to elevation for some structures. Typically, relocation is recommended where the depth of flooding is determined to be greater than 12-feet. In the case of Sprague, it may be feasible and desirable to relocate manufactured homes in an economic manner to remove them from the floodplain, rather than continue to face the threat of flooding.

The assessment of the project area indicated that there are a significant number of at-risk structures. While most of the commercial structures appear to have been constructed at ground or street level elevation, the residential structures vary in the first floor height off of the ground depending upon the style of the structure and whether a crawlspace or basement were contained within the structure. The size of structures also varied greatly from manufactured home to single story to multi-story for residential structures and from individual stand-alone to multi-bay commercial structures. Many of the commercial structures were constructed as slab-on-grade, with walls being constructed of masonry, metal, and wood.

2.2 Description of Nonstructural Structure Dataset

For this assessment, information was collected for every structure located within the mapped 1% ACE floodplain on the FEMA FIRM for Sprague. A total of 94 structures were assessed. USACE Walla Walla District personnel collected data and photographs in the field from public rights-of-way in late July of 2019. Additional information was gathered from Sprague records provided, aerial and street level imagery in Google Earth, and property information from Zillow.

The work began by digitizing the FEMA FIRM in the office and compiling information about Sprague, the floodplain, and the flood history of the area. USACE Walla Walla District personnel then performed a site visit to Sprague to photographically document conditions of each structure from public rights-of-way, gathering data about each structure (construction type, foundation, basements, mechanical equipment), and making a field estimate of potential flooding at each structure based on the Base Flood Elevation (the mapped 1% ACE flood elevation). The data was returned to the office, where assessments of each structure were made with both potential permanent nonstructural measures and also potential temporary protective measures. The caveats and cautions that were mentioned in the previous section apply to all of the recommendations.

Each structure was assessed using a similar format. The assessments and recommendations focused on mitigating structures utilizing elevation, dry flood proofing, wet flood proofing, and/or relocation/acquisition. The NS measures presented in this report are stand-alone mitigation techniques for individual structures or combination techniques to provide the most effective level of flood risk reduction.

The following assumptions were incorporated into the assessment because of the reconnaissance nature of the assessment:

1. Basement utilities, equipment, and storage are proposed to be relocated to an existing space or an addition to the existing structure and above the mitigation flood elevation. A more detailed investigation would be required to determine the specific area to accommodate these items on an individual structure basis.
2. Field observations were made as complete as possible, but there may be inaccurate or missing data in the assessment that could affect the appropriate recommendation for each structure.
3. Dry flood proofing was limited to four feet in height based upon typical best practice. Some structures may not have sufficient structural strength or integrity to handle four feet of dry flood proofing, and each structure will need to be analyzed in more detail prior to the application of any NS measure.
4. If the flood elevation is greater than the first floor elevation and a basement/crawlspace exists, the first floor cannot be dry flood proofed without eliminating the basement/crawlspace.

The assessment conducted was reconnaissance level in detail. If mitigation may occur on any individual structure, additional detailed data would be required. For the current level of assessment, the data is sufficient to identify potential NS measures, which could be effective in reducing future flood risk, life loss, and property damage.

3.0 Permanent Nonstructural Flood Risk Mitigation Measures

Nonstructural measures are used to reduce overall flood risk, decrease flood damages, and to potentially eliminate life-loss, while increasing the overall resilience of a community to the effects of flooding. NS measures reduce flood risk by modifying the characteristics of vulnerable structures that are subject to flooding. NS measures do not modify the characteristics of floods, nor should they encourage development or further development in a floodplain that is inconsistent with reducing flood risk. Instead, they modify the characteristics of structures or communities in the floodplain to make them more resistant to flooding. In essence, the purpose of NS measures is to reduce the impacts of flooding such that a community can be inundated during a flood event and survive it with a minimum of damage overall.

NS measures contrast with structural measures in that structural measures are meant to modify the characteristics of a flood. Examples of structural measures might include dams, which can change the timing, duration, or magnitude of a flood; levees, which may exclude flood waters from a portion of a floodplain; or even ring levees, which may exclude water from specific areas of a floodplain, such as critical facilities like power plants or utilities. While structural measures may decrease the frequency of flooding at a specific location, or protect a location from some specific level of flooding, they may actually increase flood risk overall if consequences of larger flood events are allowed to increase through additional floodplain development.

There are a number of NS measures that may be applicable to Sprague, which are as follows:

- Elevate existing structures in the floodplain to raise the finished floor above anticipated flood levels;
- Relocate at-risk structures with willing owners from the floodplain to a flood-free location;
- Acquire lands in the floodplain from willing sellers where structures have been relocated or removed and enforce deed restrictions to prevent any future uses that would be subject to flood risk;
- Acquire lands in the floodplain from willing sellers that is an existing open space and prevent future development that would be subject to flood risk;
- Acquire structures in the floodplain from willing sellers, demolish them, and enforce deed restrictions on the land to prevent future development that would be subject to flood risk;
- Dry floodproof structures (exclude all water from a structure through waterproofing);
- Wet floodproof structures (retrofit existing structures with water resistant materials to allow water to enter a structure with minimal damage);
- Develop public alert flood warning systems;
- Develop and implement emergency flood preparedness plans;
- Develop and implement a floodplain management plan;
- Develop evacuation procedures for flood-prone areas; and
- Employ educational and outreach programs aimed at reducing flood risk.

Each of the above NS measures can be applied as a single measure or combined with other NS measures or even structural measures to reduce or eliminate flood risk.

While all of these NS measures may be applicable and useful to all structures in Sprague, not all of them can be applied in a manner compliant with the National Flood Insurance Program (NFIP). Serious consideration should be given to the trade-offs between NFIP compliance, overall structure protection, and the safety and practicability in applying some of these NS measures to certain buildings. These NS measures will be discussed in more detail in a section below.

3.1 Common Nonstructural Flood Risk Mitigation Measures

There are a number of common NS measures that are commonly used for reducing flood risk and increasing community resilience to flooding, both in rural and urban areas. Some measures may be more applicable than others based on the specific structure characteristics and the nature of the flood risk at each specific location. Some of the NS measures may not be applicable at all, or may not lead to a solution that is compliant with the NFIP.

3.3.1 Elevation of a Structure. This NS measure entails the lifting of either the entire structure or the habitable portion of a structure to an elevation above a specific flood elevation, as shown in Figure 3. This measure is generally applicable to the entire study area, because no structure would be required to be lifted more than 12 feet above the adjacent grade. If a structure has a developed basement, and that basement could not continue to be a developed space post-elevation, the property owner would need to be compensated for the loss/removal of the basement. Typically, below grade space is valued less than above grade space. Velocity and hydrodynamic forces would need to be considered as part of a stable design of an elevated structure. All mechanical utilities would need to be elevated above the specified flood elevation. The space under an elevated structure could be used for storage or car parking, but not living space, in order to maintain NFIP compliance.

3.3.2 Relocation of a Structure. This NS measure involves physically moving a structure that is subject to a significant flood risk to an area outside of the floodplain. This measure also requires both the acquisition of new property to place the moved structure on, and acquisition of the existing flood-prone property to prevent future development that would incur flood risk. This measure provides a high level of flood risk mitigation as at-risk structures are moved to a location with no flood risk. Development of relocation sites where structures could be moved to allows a community to achieve both flood risk reduction and maintaining a community tax base, maintaining neighborhood cohesion, and maintaining cultural or historic values that exist in a community. This measure can be applicable across the study area.

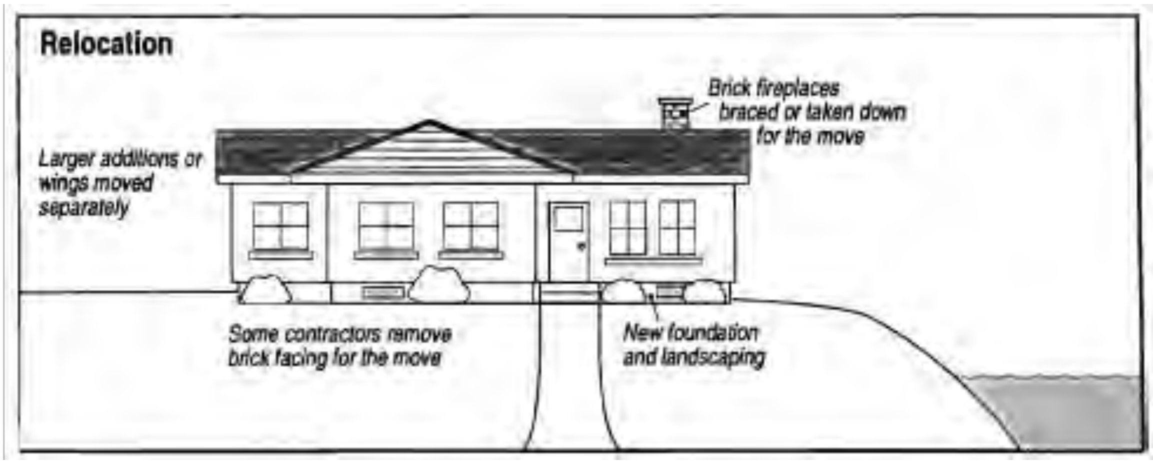


Figure 3. Relocation of a Structure (Diagrammatic Detail)

3.3.3 Removal of a Basement. In the case where a basement exists below the specified flood elevation, it is possible to move and replace all storage, utilities, mechanical equipment, electrical panels and circuits and fill the basement. If a structure's above-grade living space is already above the specified flood elevation, the basement can be filled without further elevating or modifying the rest of the structure, save for the required work to relocate storage space and all utilities and mechanical equipment. Building an addition onto the existing above-grade structure is possible to compensate for the loss of habitable basement space to the owner and to incorporate any mechanical equipment or utilities. It should be noted that if a property has an NFIP policy, an addition could trigger the substantial improvement clause, which may require additional modifications or upgrades to the structure to bring it fully into compliance with the NFIP. If an addition is not desired or cannot be accomplished on the existing property, partial compensation to the property owner for the lost basement space would be negotiable. Typically, basement space is not valued the same as above-ground finished space.

3.3.4 Acquisition with Demolition/Salvage of a Structure. This NS measure consists of purchasing an at-risk structure and the associated real property from a willing owner. The structure is either demolished or the structure is then sold to another party and relocated out of a floodplain. In some instances, communities are finding that some materials (wiring, plumbing, fixtures, etc.) can be salvaged instead of being landfilled to reduce waste. Redevelopment sites can be a consideration as part of project development in order to have locations where a community can construct new homes and businesses.

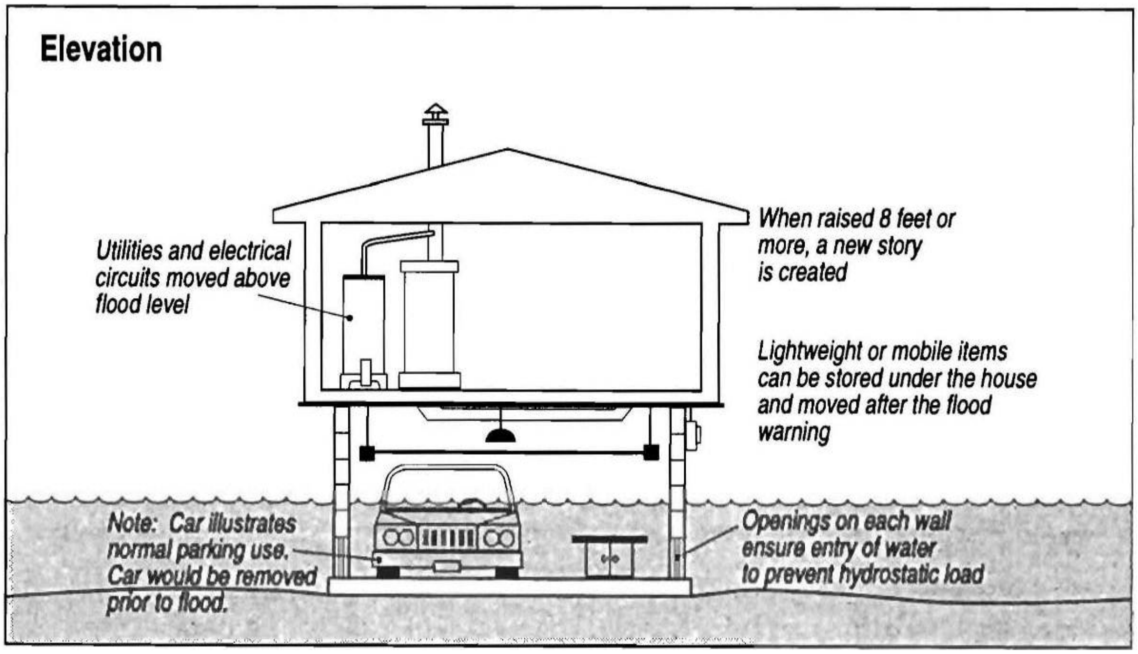


Figure 4. Elevation of a Structure (Diagrammatic Section).

3.3.5 Dry Floodproofing. Dry floodproofing is essentially waterproofing a structure, as shown in Figure 4. This NS measure is generally an acceptable approach to commercial structures, and can be applied to residential structures as well, but with some caution. While dry floodproofing achieves substantial flood risk reduction for all structures, it is not recognized by the NFIP for flood insurance premium rate reduction on residential structures. In addition, dry floodproofing a residential structure may lead to a false sense of security for a building's occupants, and may lead to belief that evacuating a structure that is or will be surrounded by flood waters is not necessary. This may lead to increase life-safety risk during a flood, as emergency services or later evacuation may not be possible for those who choose to stay in a floodproofed structure.

A general rule of thumb for the application of dry floodproofing to a structure is that it may be floodproofed up to between 3 and 4 feet on the exterior walls before hydrostatic and/or hydrodynamic forces may overcome the structural integrity of a building. A structural analysis of wall strength would be required in order determine the actual height that dry floodproofing may be effective. Additional features, such as a sump pump, a French drain system, and a one-way check valve on sewer connections may be required to account for seepage, interior drainage, and sewer backup. Closure panels would be required for all openings on the structure. Dry floodproofing does not work on structures with basements or crawl spaces due to the potential for water entry under the finished space during a long-duration flood. Filling and sealing of basements or crawl spaces may be required, or complex and expensive cut-off walls may be integrated into the design, in order to completely exclude water from the protected area and prevent the structural failure of the basement or crawl space (which would lead the failure of the overall structure).

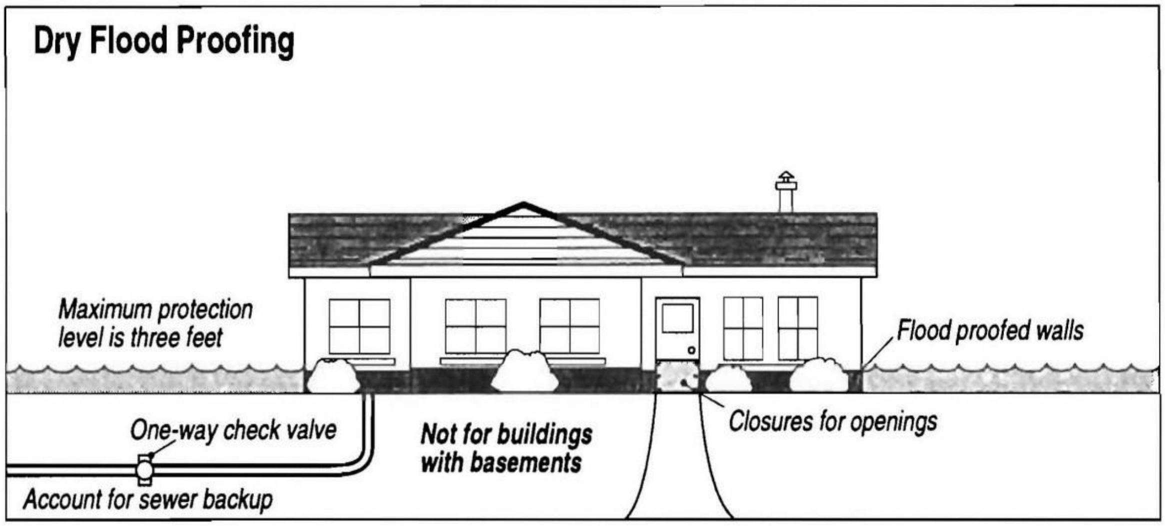


Figure 5. Dry Flood Proofing (Diagrammatic Detail).

3.3.6 Wet Floodproofing. Wet floodproofing is essentially making a structure resilient to flooding through the use of waterproof building materials up to the specified flood height, as shown in Figure 5. In wet floodproofing, water is allowed to enter and interact with a structure without damage. This NS measure can be a stand-alone measure, or combined with other measures such as elevation or dry floodproofing. All utilities and mechanical equipment must be elevated above the design flood elevation. Generally, wet floodproofing is not applicable to residential structures. It may, however, be able to provide commercial and industrial structures with a level of protection as long as the contents can be managed in such a way as to not be damaged during a flood. This measure is generally not applicable to large flood depths or high velocity flows due to the potential structure failure of walls.

Figure 6. Wet Flood Proofing (Diagrammatic Detail).

3.3.7 Berms, Levees, and Floodwalls. Although these items are structural in nature, and if considered for implementation by USACE, require standard USACE structural design criteria, they can sometimes be applied to individual structures without adversely impacting the floodplain by increasing stages, velocities, or durations. These measures are intended to reduce the frequency of flooding but not eliminate floodplain management and flood insurance requirements. An example is shown in Figure 6.

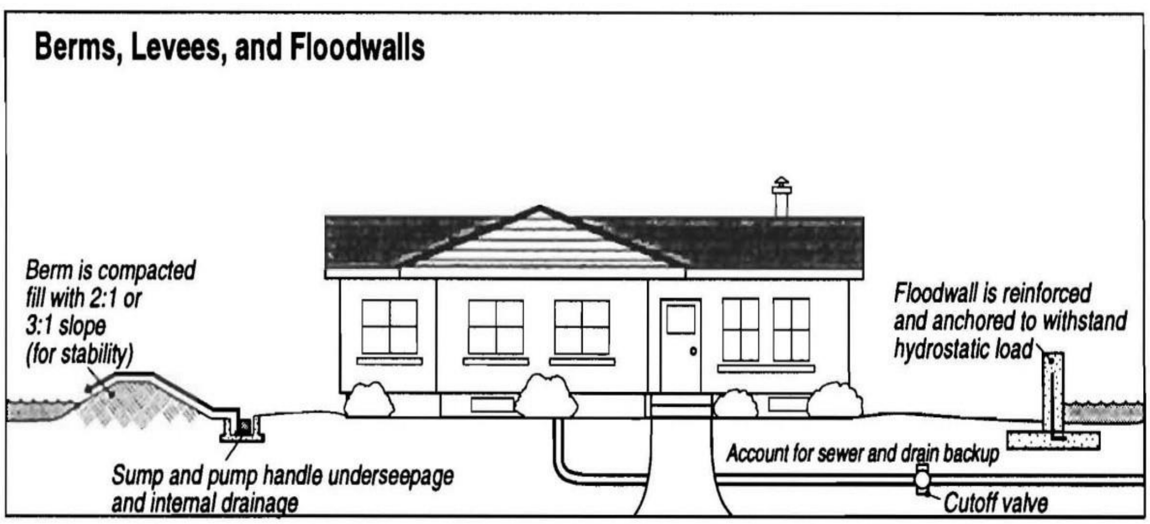


Figure 7. Berms, Levees, and Floodwalls (Diagrammatic Detail).

3.3.8 Land Acquisition. Land acquisition as a stand-alone measure applies to current open ground with minimal or no development. This measure can be in the form of either fee title or permanent easement with fee title. The purpose of land acquisition is to reserve open land for future flood conveyance. Lands acquired can be converted to new uses such as ecosystem restoration, parks, trails, or other recreational features. Conversion of previously developed lands to open space can also be accomplished in conjunction with the removal or relocation of any existing structures. Any infrastructure present on the lands, including roads, sidewalks, and power can potentially be removed as part of this measure. Economic feasibility of a buyout or relocation project can be enhanced due to the transfer of some flood risk management costs to ecosystem restoration and by adding the benefits and costs of recreation. This is typically referred to as "new uses of the permanently evacuated floodplains."

3.3.9 Floodplain Regulation and Floodplain Management. Floodplain regulation and floodplain management have proven to be very effective in reducing flood risk and flood damages when applied to new development. A community can develop a floodplain management plan and ordinances to direct development in a manner to reduce or avoid flood risk. It is much more difficult to apply retroactively to existing development at the time of the adoption of a management plan or new ordinances. The NFIP is a good source of minimum standards and principles for floodplain management. While the NFIP minimum standards provide some level of flood risk reduction, it is highly encouraged for a community to incorporate higher standards and more stringent building codes and zoning ordinances to meet community objectives to reduce or eliminate flood risk.

3.3.10 National Flood Insurance Program. The NFIP contains three main components: flood insurance, flood mitigation, and floodplain regulation. Floodplain regulation and flood risk mitigation are activities that can directly affect flood risk. Flood insurance is a tool to help make impacted parties whole again after a flood disaster. Insurance does not reduce flood risk, nor do FEMA FIRMs depict a community's flood risk with total accuracy. The NFIP provides mitigation programs that can be used by communities to address and reduce their flood risk. These are the Hazard Mitigation Grant Program (HMGP), Pre-Disaster Mitigation Grant Program (PDM), the Flood Mitigation Assistance Grant Program (FMA), and Severe Repetitive Loss Grant Program (SRL). Each of these is a cost-shared grant program. Floodplain regulation is also an effective NS measure, where a community adopts minimum floodplain management standards and participates in the NFIP.

4.0 Temporary Flood Proofing Measures

It is possible to reduce the impacts of flooding on a temporary basis, though it should be noted that permanent measures, whether structural or nonstructural, are much more reliable and effective. For the purposes of this report, this section will focus on temporary flood proofing techniques that can be employed to provide some level of protection to structures in the floodplain. It will also focus on the precautions that should be considered before implementing any particular strategy.

Effective temporary measures require significant planning ahead of an event. It is vital to understand the characteristics of flooding, such as likely depth of floodwaters, the areal extent of flooding, the potential duration of a flood, how much velocity a flood may have throughout the floodplain, and anticipated warning time of an event. Property owners and community officials alike need to consider these flood characteristics in making decisions about which temporary measures, if any, may be effective in reducing the impacts of a flood to the community and the properties within.

Temporary flood proofing measures must be deployed every time there is a risk of flooding in order to protect structures and their contents. The most effective, efficient, and reliable way to address flood risk is through permanent measures. Temporary measures should not be considered a long-term strategy, but may be useful as a stopgap until such time as permanent measures can be implemented. Each property owner or tenant should consider the costs and risk associated with repeatedly implementing temporary flood proofing measures versus the long-term security and confidence that can come with implementing permanent measures.

4.1 Common Temporary Flood Proofing Measures

Temporary flood proofing may be effective in short-duration flood events if applied properly and completely prior to the beginning of a flood. Potential temporary measures include: 1) polyethylene sheeting hung on the structure exterior (usually to a height of 3 feet above the first floor elevation and continued on the ground surface 4 feet from the structure exterior), in combination with door and window closures, 2) clear liquid sealant applied to the structure exterior, in combination with caulking of large cracks in the exterior and placement of door and window closures, 3) sandbag berms located around all or a portion of the structure, and 4) any of the barriers certified through the National Flood Barrier Testing and Certification Program [see http://nationalfloodbarrier.org/].

A key difference between these temporary measures is that hydrostatic forces are applied to the structure walls when using the polyethylene sheeting and clear liquid sealant measures, but not with sandbag berms or the certified barriers. The condition of the structure being protected must be considered when choosing a temporary measure.

4.2 Flood Characteristics and Selecting Temporary Measures

There are a number of factors that can affect the appropriate choice of a flood proofing measure, some of which may not be known or obvious to a property owner or tenant. The characteristics of the flooding itself, including the depth, velocity, and duration of a flood, can all dictate the type of temporary measure that can be used. It should be noted that velocities will be higher near the channel, although the nature of flooding along Negro Creek through Sprague is such that depth is the larger concern. The condition of the structure being protected is also an important consideration, including the condition of the foundation, crawlspace, basement, type of construction, and type and condition of the exterior walls can affect the effectiveness of any measure implemented. Finally, the surrounding site conditions are important to consider. Soils that are permeable or impermeable, the density of landscaping, and the location of utilities and other external features may all be part of the decision of which temporary measure to use.

4.3 Implementing Temporary Measures

The use of temporary measures can be successful in reducing or even preventing flood damages when conducted correctly. The scope of this Silver Jackets study does not allow the U.S. Army Corps of Engineers to evaluate the individual structures and their sites in sufficient detail to guarantee the success of temporary flood proofing, as there are several factors that the owner or tenant must consider when implementing temporary measures:

- Because of the serious nature of flooding and because of unknowns associated with the depth, velocity, and duration of flooding, as well as the precise structural condition of each structure, it is generally considered wise to allow no temporary flood proofing measures to be placed to a height which exceeds 3 feet above the elevation of the first floor of the structure. The hydrostatic forces of the floodwaters can cause a catastrophic collapse to the walls of a structure due to the lack of lateral resistance from the structure as the flood waters rise higher against the sides of the structure. And, since the characteristics of a flood (the depth, velocity and duration) may change during a flood event, it must be noted that it is possible for failure of foundations, walls, and closure panels to occur at a flood depth of less than 3 feet. Without a proper structural analysis of individual structures by a certified professional or contractor, failure of a structure can occur due to the hydrostatic and hydrodynamic pressures caused by water pooling up against or running into a structure. It is the highest recommendation of the team of engineers preparing this report that after the flood proofing measures have been implemented, all persons evacuate the structure to a predetermined location of safety.
- Though obvious, it must be stated that a structure could be exposed to a flood event of a depth greater than for which temporary flood proofing measures have been erected.
- Preparing a structure for a flood requires significant effort, and it is impossible to accurately predict even one day in advance the depth to which flood waters from an approaching storm may rise. Therefore, the owner or tenant cannot be certain that the projected flood event will actually occur. The owner or tenant must find his own comfort level and balance the risk of not having the structure properly flood proofed, versus the risk that the effort to flood proof was not necessary.
- In order to prevent unsanitary water from backing up into the structure during a flood, the owner should ensure that his sanitary drain line is fitted with an anti-backflow device.
- Downspouts and associated drainages must be considered. If a certified barrier or sandbag berm is erected, the downspouts need to be modified so they can be directed over the barrier; this would greatly reduce the amount of water to be pumped from within the protected area. Also, there may be drain lines that carry water from the downspout that pass under the certified barrier or sandbag berm, which must be plugged to prevent flood water from flowing through the line into the protected area.
- If the exterior construction is not structurally sufficient to withstand a significant water load the force of water at a depth of three feet (or perhaps less) could collapse walls. Therefore, it is recommended that when the temporary measures include placement of polyethylene sheeting on the exterior of a structure, a thick layer of plywood (up to 1 inch) be attached to the exterior surface of the structure up to the level of protection. The plywood could be attached to wall studs using countersunk threaded anchors with bolts, and sheeting would be placed over the plywood. Again, structural evaluation by a certified professional or contractor is recommended.

4.4 Planning and Preparation of Temporary Measures

The information provided in this report section is the basis for developing temporary mitigation measures to reduce the possibility of extensive flood damages. In order for flood proofing to be successful, a thorough plan for each individual structure needs to be developed and implemented. The plans will vary from structure to structure, depending upon structure type, projected depth of flooding, the velocity of floodwaters, the time available to implement the measures, and the availability of flood proofing materials. In some instances, due to the depth of flooding or the projected velocity of the floodwaters, rather than attempt to keep floodwater out of the structure, it may be more cost effective to remove or elevate to a higher interior location, those items (business records, electronics, computers, heirlooms, artwork, etc.) which contain a high value, intrinsic or monetary, so as to avoid exceptional loss.

For individuals wishing to implement temporary flood proofing measures, a plan should be developed to ensure that the measures can be employed as quickly as possible when the threat of flooding is imminent. Locations for storage of the materials and equipment should be designated far in advance of an event. Storage can occur on- or off-site; however, if materials and equipment are maintained off-site, arrangements should be made to transport these materials and equipment to the site for implementation. Because the limited time available to install temporary measures is a critical factor in the prevention of flood damages, site preparation, maintaining the proper inventory of flood proofing materials, and having a well prepared emergency response plan are crucial to a successful outcome. Early preparation can make the difference between minimal dollar damages and a catastrophic loss. While even the best laid plans may go awry, nationwide data indicate that the owners who pay attention to the details, establish a thorough step-by-step process for implementing their temporary flood proof measures, and prepare themselves and their structures prior to the start of the flood season, fare far better than those individuals who rush against time to install temporary measures which have not been thoroughly planned out.

It is imperative that the structure owner or tenant determine the type and amount of materials required to be on hand each year through the forecasted flood season. A checklist of these items or material requirements should be prepared, including the sequence of placement of materials in order to establish the most time-effective process for implementing the temporary measures. Each year prior to the start of the flood season, the owner or tenant should review the checklist, replace missing or damaged items, and prepare to implement the entire flood proofing measure during the first signs or indication of imminent flooding. In addition, the owner and/or tenant should develop a procedure for ensuring that all employees, residents and others who may have been in the structure prior to the flood event are accounted for after evacuation. This may be accomplished by planning to contact all personnel via cell phone and/or by arranging to meet at a designated location.

Once the owner or tenant has established a temporary protection plan for the structure, it may be beneficial to test the plan for efficiency and effectiveness in order to optimize the plan. The flood fight materials and equipment should be stored in such a manner that they will not be damaged and should be monitored on a regular basis to ensure that these materials will be effective when and if needed. For instance, blue plastic can become damaged with holes from animals or normal weathering and should be replaced if any damage occurs, and plywood should be stored such that it will not rot or be damaged by termites or storage in a wet or damp environment.

While protection of the structure and of the structure contents are of high importance, during any flood event there is a possibility of extensive damage to the structure. It is worth repeating that, in order to prevent extensive loss or damage to high value items, it is recommended that the emergency response plan also consider relocating away from the structure or to a higher elevation, those items which would be difficult or impossible to replace.

Again, it is imperative that each structure owner understand that the intent of these proposed measures is to provide only temporary protection from flooding. After the temporary measures have been implemented, after the sump pump(s) has been positioned and flooding appears to be imminent, the owner and all associated persons should evacuate the premises during the flood event. There is always a possibility that catastrophic failure of a structure or loss of life could occur during a flood event.

4.4.1 Site Preparation

The type and amount of site preparation will vary with each structure. For many structures, one of the recommendations is that, in order to prevent floodwaters from entering a structure and causing damage, the site surrounding the structure be prepped to a condition which allows relatively easy and quick installation of temporary flood proofing measures. For each structure, the owner or tenant should try to achieve at least 4 feet of leveled access area around all exposed sides of the structure. The placement of polyethylene (also known as polyurethane or plastic) sheeting and/or sandbags as a preventive barrier to flooding requires a leveled surface in order to resist seepage into the protected area.

While shrubs, flowers and trees provide character and add value to a property, it is important that they be removed from within the “leveled access area” in order to establish a preventive barrier to flooding. If the owner is unable to remove landscape items, it is important that a uniform barrier of protection be established by placing polyethylene sheeting or sandbags as close to the protruding plant as possible to develop a cohesive barrier between the ground and the employed flood proofing measures. Even a small weakness in the flood proofing measure could result in catastrophic failure and damage.

In certain circumstances, it will benefit the owner to identify appurtenances such as fence posts, gates, storage sheds and utility boxes which may prevent the establishment of a waterproof barrier. These items should be removed as much as possible from the “leveled access area.” Utilities and HVAC units must be considered. Where possible, vital utilities and HVAC units should be raised in height to a reasonable level. Otherwise, provisions in the flood proofing plan need to include the protection of these utilities and units. Also, these items are usually associated with wall openings through which flood waters may enter a structure. These openings must be sealed, along with any other holes or cracks in the exterior walls and foundation.

4.4.2 Removal of Interior Flood Water

The removal of flood waters from a structure to prevent inundation of the first floor can be one of the most important and critical ways to protect a structure from flooding. The use of sump pumps is one of the best and easiest methods to accomplish this. For most of the assessed structures, the Corps’ recommendation is to install one or more sump pumps. Loss of electricity during a flood event must also be considered; therefore, it is recommended that the owner provide pumps that can be powered with a battery power supply. In most cases, the installation of these pumps is relatively simple, and in some cases, the use of multiple pumps may be necessary.

4.4.3 Materials and Equipment Required for Temporary Measures

The owner should ensure that the materials recommended for protecting the structure have been obtained prior to the start of the flood season. Materials required for implementing a preventive barrier to flooding should be stockpiled in an accessible location. Materials remaining from the previous flood season should be inspected to determine condition for reuse. Some of the more frequent materials required for implementing successful temporary flood proofing measures includes:

- Polyethylene Sheeting. This sheeting material (known commercially as visqueen, polyethylene sheeting, LDPE sheeting, or plastic sheeting) is often recommended for use when employing a temporary waterproof barrier around a structure. The sheeting should be purchased in rolls, typically 5-6 mils thick, and will be cut long enough to extend from no more than 3 feet above the first floor of the structure to, at a minimum, 4 feet out from the structure. The further the "leveled access area" and polyethylene material extend beyond the exterior wall of the structure, the longer the flow path for floodwaters to enter a structure, including the crawlspace or basement, is extended, increasing the resistance to flooding. The shorter the flow path is to a foundation, the higher the risks of complete soil saturation around a foundation, resulting in complete inundation of the crawlspace or basement. Once the floodwaters have access to the crawlspace or basement, it becomes more difficult to remove the floodwaters and to prevent or limit damages.

- Connectors for Attaching Plastic Sheeting to Structure Exterior. The type of connector needed depends upon the type of exterior surface of the structure to which the sheeting is being fastened. Hooks, whether self-tapping or through drilled anchor connection, are normally recommended for use in fastening the polyethylene sheeting to the structure. Spacing of the hooks should be such that no span is greater than 2 feet. Hooks should be placed permanently for continuous use from one flood season to the next.

- Water Resistant Tape for Plastic Sheeting. For firm cohesiveness between the plastic sheeting and the exterior structure surface or between adjacent polyethylene sheets, this type tape is recommended for use. These tapes incorporate PVC adhesives and are ideal for use in outdoor situations. Consideration should be made for vinyl coated cloth tapes for effectiveness where product performance is critical; these tapes can sustain harsh weather conditions and can be used for repairs to many surface types. It is further recommended that tapes containing water resistant properties, all-weather properties, brittle resistance, and anti-aging properties be obtained.

- Closure panels (plywood and other material). A temporary closure system consisting of 1-inch thick plywood or OSB is often recommended for flood barrier construction at doorways and windows; no closure should have a horizontal or vertical span in excess of 3 feet without incorporating additional supports. Because 1-inch paneling may be expensive, a 1-inch closure can be pre-made by using a grid of screws to connect two boards of lesser thickness. Vent openings can usually be protected with a lesser thickness. Do not use materials that are not water resistant. The closure panel should be measured, cut, and identified for the specific location in the temporary flood barrier and should be available for use from one flood season to the next. The panels should be held in place with water resistant caulking, nails, screws and/or liquid nail. For doorways which open inwards, or for over the top of window glass, the closure panel should extend onto the exterior wall.

- Sand and Sandbags. Considered to be one of the most durable and easily employed flood-fight products on the market, sandbags are an integral component of many temporary barriers to flooding. Sandbags should be made of nylon or polyethylene. Generally, bags can be placed in a single row up to 3 bags high. Berms more than 3 bags high should be built in pyramid fashion; these berms should be as many bags wide at the base as they are bags high. Bags should be filled between half-way and two-thirds full, should not be tied and should be placed with the top of the bag tucked under the bag. After placement of each layer, the bags should be walked on to provide a better seal with adjacent bags. The bags in each course should be placed so that they cover to the maximum possible extent the joints in between the bags in the same course and also between the bags in the course below. Additional guidance on sandbagging is available from the Corps of Engineers. Sandbag closures at doorways and similar openings can work well but must be carefully sealed at the ends. The owner may prefer to use a plywood or other type closure panel.

- Caulk and Clear Sealant for Structure Exterior. If any portion of the structure to be protected consists of brick, stone, stucco, concrete, cinder block, or tile, a water resistant sealant may be recommended for use. It is best to use a clear liquid sealant which may be applied by brush, roller, or sprayer. The sealant should be applied to all porous surfaces, which have been thoroughly cleaned and dried to allow deep penetration and maximum resistance to the effects of water. The sealant should be extended above the area of proposed protection for best coverage. While at this time, no government testing programs have rated these commercial sealants, manufacturer's information indicate that commercial sealants may last up to 20 years without discoloration. In addition, if large cracks and voids in the structure exterior need to be filled; many products carried by local hardware companies are compatible with the materials on the exterior of the structures.

- Certified Temporary Flood Barriers. Preventing flood waters from entering a structure requires the use of temporary flood barriers. While there are many products marketed as flood barriers, very few have positively tested and been certified for preventing damages. The Association of State Flood Plain Managers (ASFPM) in collaboration with FM Approvals and the US Army Corps of Engineers National Nonstructural Committee (NNC) have implemented a national program of testing and certifying flood barrier products used for flood proofing and flood fighting. The purpose of this program is to provide an unbiased process of evaluating products in terms of resistance to water forces, material properties, and consistency of product manufacturing. This is accomplished by testing the product against water related forces in a laboratory setting, testing the product against material forces in a laboratory setting, and periodic inspection of the product manufacturing process for consistency of product relative to the particular product that received the original water and material testing. Upon products meeting the consistency of manufacturing criteria and meeting the established standards for the material and water testing, the certification part of the program becomes available to the product. Since the testing part of the program is conducted in a laboratory setting, not all forces and impacts to which the product could be subjected to during an actual flood event will be tested.

Certification will also reflect, in terms of flood proofing, the suitability of the product, the performance of the product based on the product deployment literature, the durability and reliability of the product, and the consistency of the product. All products will be examined and evaluated on a model by model, type by type, plant by plant, and manufacturer by manufacturer basis. For additional information on this program and a list of certified products, visit http://nationalfloodbarrier.org/.

- Interior Drainage Pump and Power Supply. In order to prevent flood damages due to seepage of floodwaters through the temporary flood barrier or resulting from a rising water table, it may be recommended that pumps be incorporated into the protection measures. Pumps will be needed inside the structure to collect seepage. At a minimum, one pump with a capacity of at least 20 gallons per minute should be considered for installation in the structure for every 2,000 square feet of floor space. 115-volt AC powered pumps can be used provided electricity is available throughout the flood event. The owner may consider installing a permanent sump pump with sump pit, or can bring in one or more pumps for temporary use. If loss of electrical power during a flood is a concern, the owner could employ a gasoline-powered electric generator to power the AC pump, or could use one or more battery-powered sump pumps. The user will have to be aware that the battery life is limited; therefore, a spare battery should be kept on-hand. The life of the battery recommended in the battery powered back-up sump pump 10 to 14.5 hours of pump use. Because it is impossible to know how much the pump will be operating, the user will need to monitor it often and be prepared to replace the battery. If there is no basement or crawl space, the owner may elect to use a floor-type pump that can maintain the depth of water on the floor to 1/8 inch. If the structure being protected does have a basement or crawlspace, the pump needs to be placed at the lowest elevation in order to work most efficiently. In some instances the owner may consider cutting a small hole through the floor of a closet space, for concealment purposes, and lowering the pump to the lower level. For a slab on grade structure, the pump should be placed in a location upon the floor where floodwaters may begin to collect. In all cases, the owner should consider placing the pump at a location where the discharge hose is easily positioned to extend beyond the limits of the protection measures.

  The discharge side of the pump should be sized to match a common 1-inch diameter garden hose or should be equipped with an adaptor to 1 inch. If there is a sandbag berm, a pump with significant capacity will be needed to collect rainfall, seepage and rising groundwater within the area of the berm.

5.0 Citywide Flood Risk Management

Recent flooding highlighted the flood risk that exists for Sprague. When flood events occur, they are often slow to rise and slow to recede, leaving many structures in the heart of the community vulnerable to damage from inundation.

From this assessment, it appears that managing the overall flood risk in Sprague will be complicated. Implementing NS measures may be effective for some areas of the city. Those nonstructural measures will need to be combined with flood response preparedness, managing development and redevelopment through local zoning and building codes, and flood insurance. These measures are discussed in more detail below.

5.1 Flood Preparedness Planning

Preparing for floods in Sprague should be a multifaceted effort. First, outreach and communication of the existing risk is vital in increasing awareness among residents. Increased awareness can lead to a better response time in the face of a flood event. The flooding that occurred in 2017 is still fresh in the memories of residents, so there is already some level of awareness within the community.

Second, Sprague should have and maintain a flood action plan and be prepared to respond to flood conditions. This may include developing plans for deploying a flood response, identifying roads that may be closed or areas that need to be evacuated, identifying any at-risk residents that need help getting out of their homes, and general tactics for a flood fight.

Last, stockpiling flood fight materials in an accessible location where they can be maintained in good order will allow Sprague to quickly deploy a flood fight. It may not be reasonable for Sprague to maintain its own stockpile of materials, but if a county or regional cache of materials could be developed with mutual aid agreements and maintenance agreements, the materials could be jointly acquired and then deployed as needed. The types of materials that could be stockpiled will be discussed in the next section.

5.2 Temporary Flood Fight Techniques

During the 2017 flood event in Sprague, a fairly sizeable flood fight was mounted to reduce the impacts of flooding through town. Sandbagging streets to direct the flow of water through the city around the piped portion of Negro Creek seemed to have some positive effect on the overall extent of the flooding. Pumps were used with some success as well to move water Citizens, resources from all levels of government, and even the Washington National Guard worked to place sandbags as the floodwaters rose. While the technique of channeling water through town does cut off portions of the city due to sandbag walls blocking roads, it may have some merit as a methodology to help contain floodwaters.

Given the relative success of this strategy, it may be worth considering the use of larger materials to accomplish similar results. Several common construction or material handling items can be used to create effective flood barriers. There are also proprietary flood barrier systems that can be used in place of sandbags that can be placed more quickly and reliably than sandbags.

For faster sandbagging, it may be worth considering the use of bulk bags or super sacks. These bags typically hold a cubic yard of sand and are relatively cube-like when filled. Although they will largely work like sandbags, the best results may occur when the stack is also wrapped in plastic sheeting. The bags are stackable and can be placed relatively quickly using a forklift, telehandler, excavator, loader, or even a backhoe. Filling the bags by hand would be impossible, but using a sandbag filler or even a winter sand spreader on the back of a dump truck can make the job approachable. Highway districts or the Washington Department of Transportation may have the equipment needed to fill and handle the bags, and the bags themselves are likely available from a retail construction supplier or bulk materials company.

Another option for creating a flood barrier would be to use Jersey barriers wrapped in plastic. These may also be obtained from a highway district, the Washington Department of Transportation, or another source. They can be transported on trucks and placed with a forklift or telehandler. Wrapping them in plastic as they are placed makes them fairly effective.

HESCO barriers can also be effective in forming long flood barriers relatively quickly, as shown in Figure 7. The barriers are fabric-lined wire baskets that are linked together and filled with sand. They can be placed and filled with small equipment, including a skid steer loader. If placed correctly, they do not need to be wrapped in plastic. These are a specialty product, however, and may not be readily available locally. However, if the city, the county, or the state desired to create a stockpile of HESCO barriers that could be readily accessed, they can be purchased. The U.S. Army Corps of Engineers also has HESCO barriers in the national flood materials stockpile, which may be accessible if a Direct Assistance mission is authorized. The lead time required for the Corps to deliver materials may be slower than the speed with which a flood develops in the Negro Creek drainage, however.

Figure 8. HESCO Barriers Deployed on the Boise River, Idaho, 2017.

Low-head, high-volume pumps may also be an important part of the flood fight to dewater areas or even to help move water through town via lay flat hoses or other means. Pumps can be used to dewater areas and discharge into the “channels” created in the streets with the flood barriers as well.

The U.S. Army Corps of Engineers Walla Walla District and Seattle District have access to dewatering pumps and dewatering expertise, though the response time may vary depending on where the pumps are located and how quickly the flooding and the associated request for assistance progresses.

There are a number of proprietary flood barrier products on the market that can be effective as well. Some can even be placed directly into moving water. While the Corps cannot recommend any one particular product over another, a general list and description is included here for further research and consideration. Water filled, linked flood control tubes such as Tiger Dams, AquaDams, or other similar products can be very effective at forming a temporary flood barrier and can be filled by the ready supply of water available during a flood. Harder barrier products, such as Muscle Walls, Aqua Fence, and others can also be highly effective when deployed. The Muscle Wall branded barriers are shown in Figure 8. Some of the harder barriers are water-filled and plastic-wrapped, and some are simply deployable walls that rely on water pressure on the wet side for stability.

Figure 9. Muscle Wall Flood Barrier Deployed on the Boise River, Idaho, 2017.

The key to effectively using any of the materials or strategies listed above is planning ahead and knowing where the materials are located and how to access them. The most effective method would be for Sprague to either own the materials themselves or have cooperative agreements in place that would allow for on-demand access to the materials. It is also important to work with the National Weather Service, the Washington Silver Jackets team, and other agencies and groups to develop both an implementation plan and strategy, and to develop thresholds or triggers to know when a deployment should begin. Getting materials on the ground quickly as the conditions for flooding are developing will have the best outcome.

5.3 Future Development

Local zoning and/or building codes may be used to reduce flood risk for new construction, redevelopment, and for community flood risk management required by the NFIP. Given the significant flood risk that exists in Sprague, it is highly recommended that the city strictly enforce its ordinances related to new development or redevelopment that require compliance with the NFIP and do not allow new construction or substantial improvements to occur in a manner that would be damaged by future floods. The ordinances could also encourage the preservation and development of open space to allow floodwaters a place to go. Finally, in any future development, the city could consider daylighting Negro Creek and do so in such a way that would allow more of a flood to pass through a channel with higher conveyance than the current capped channel allows. This last potential future development would require a significant engineering study and investment.

5.4 Risk Management through Flood Insurance

Sprague participates in the NFIP, so flood insurance is available for all structures in the community, regardless of their flood zone designation. Preferred risk flood policies, which are relatively inexpensive, may be available for structures located outside of the FEMA “Zone A” designated areas shown on the effective FIRM. A digitized depth map for the 1% ACE floodplain is included in Appendix A. Flood insurance is an important component of managing flood risk in Sprague because damage from flooding seems inevitable under current conditions. Insurance can help property owners and renters recover more quickly from flood damage.

6.0 Recommendation of Nonstructural Measures

Based upon the data collected for the 94 assessed structures, as well as the potential depth and extents of flooding for the 1% ACE flood event in Sprague, recommended mitigation measures are presented in Appendix B. Elevation appeared to be the most appropriate NS measure for the majority of the residential structures assessed in this study. Dry flood proofing was the primary NS measure identified for nonresidential structures.

It was beyond the scope of this study to determine the economic feasibility of implementing any of the recommended NS measures. The Washington State Risk MAP coordinator may be able to provide support, assistance, and guidance with understanding and planning how to address specific flood risk issues.

The temporary flood proofing measures can be considered as a potential stopgap strategy as more permanent NS measures are funded and implemented in Sprague. The use of flood fighting techniques may also present both a stopgap strategy, and potentially a more cost-effective and economically viable alternative to Sprague. Again, no economic feasibility was determined.

There are a number of federal and state programs, administered through the State of Washington that may be useful for Sprague in both the short- and long-term mitigation of flood risk. These programs are described in the following sections.

6.1 Flood Mitigation Assistance Program

The Flood Mitigation Assistance Program (FMA) is a FEMA program with cost-shared funds managed by the Washington State Emergency Management Division (EMD). The FMA program is available annually and is nationally competitive. Funds can be used for cost-effective projects that will reduce the risk of flood damage to structures that have flood insurance coverage. Funding for properties that meet the repetitive loss (RL) or severe repetitive loss (SRL) thresholds is available at a 90 percent or 100 percent federal cost share, respectively. Funding for all other grants is available at a 75 percent federal cost share. Cost-shared grants are also available for planning initiatives to update the flood hazard portion of an applicant's hazard mitigation plan. Applications to the Washington State EMD are typically due three months after the federal announcement, which generally happens in the spring of each year.

A RL property is any insurable building for which two or more claims of more than $1,000 were paid by the National Flood Insurance Program (NFIP) within any rolling ten-year period since 1978. A RL property may or may not be currently insured by the NFIP.

A SRL property is one that has either experienced four or more separate claim payments of $5,000 (building and contents) or more since 1978, or has had two or more separate claim payments (building only) where the total of the payments exceeds the current value of the property. In both cases, two of the claims have to have occurred in the last 10 years. The property does not need to have had the same owner throughout its damage history to qualify.

6.2 Pre-Disaster Mitigation Program

The Pre-Disaster Mitigation Program (PDM) is a FEMA program with cost-shared funds managed by the Washington State EMD. The PDM program is available annually and is nationally competitive. Funds can be used for hazard mitigation measures designed to reduce injuries, loss of life, and damage and destruction of property. Grants are available for mitigation planning as well as cost-effective mitigation projects. Small impoverished communities and tribes may be eligible for a 90 percent federal cost share. Applications to the Washington State EMD are typically due three months after the federal announcement, which generally happens in the spring of each year.

6.3 Washington State Floodplains by Design Program

The Washington State Floodplains by Design (FbD) program is a partnership of local, state, federal, and private organizations focused on coordinating investment in and strengthening the integrated management of floodplain areas throughout Washington State. The FbD grant program seeks to advance integrated floodplain strategies and projects that consider a broader variety of ecological functions, values, and benefits. Projects can have a higher likelihood of success when they improve ecological function, reduce flood risk, and meet other community needs because they are more likely to garner the necessary community support and public funding. Ideal projects are part of a strategy that is tailored to the specific reach of a river which reduces the flood risk, restores ecological function, and is a net gain for other community interests.

Funds are administered by the Washington Department of Ecology under a biennial funding cycle, with proposals due in even-numbered years. Funds, when appropriated by the state legislature, become available in odd-numbered years. There is a 20 percent non-federal cost share requirement. Qualified economically distressed communities or communities that have a Median Household Income less than 80 percent of the state Median Household Income may qualify for a zero percent non-federal cost share.

To explore qualifications and potential projects, community officials should work in coordination with Washington State Department of Ecology staff. More information and contacts can be found at https://ecology.wa.gov/About-us/How-we-operate/Grants-loans/Find-a-grant-or-loan/Floodplains-by-design.

6.4 Hazard Mitigation Grant Program

The Hazard Mitigation Grant Program (HMGP) is a FEMA program with cost-shared funds managed by the Washington State EMD, and is only available after a Presidential Declaration of Major Disaster. The program funds mitigation planning and cost-effective mitigation projects designed to reduce or eliminate the effects and costs of future disaster damage. This grant program requires a non-federal cost share of up to 25% of the total project cost. The cost share requirement may be reduced in the case of Governor and Legislature approving the state paying a portion of the non-federal cost share requirement. The HMGP program is a post-disaster program, and can be applied to communities that have suffered flooding. Competition for the funding is statewide with applications typically due to the state within 12 months of the declaration date.

More information is available by contacting the Washington EMD or visiting the state website at https://mil.wa.gov/emergency-management-division/grants/hazard-mitigation-grants

6.5 FEMA Small Impoverished Community Definition

Grants awarded to small impoverished communities may receive a Federal cost share of up to 90 percent of the total grant for use in an approved project. There are specific criteria that must be met to qualify:

- The community must have a population of 3,000 or fewer people and be identified by the state as a rural community that is not a remote area within corporate boundaries of a larger city;
- The community must be economically disadvantaged, with residents having an average per capita income of 80 percent or less of the national per capita income;
- The community must have an unemployment rate that is higher than the national unemployment rate by at least one percent; and,
- The community must meet any other requirements put in place by the state.

Applicants must certify and provide documentation of community status with an appropriate subapplication to qualify for the 90 percent federal cost share rate. If the documentation and certification is not submitted, any FEMA-funded project will be considered at the 75 percent non-federal cost share rate.

More information and assistance with applications can be obtained from the Washington EMD.

7.0 Flood Insurance Premium Reductions from Nonstructural Measures

Implementation of NS measures may result in reduced flood insurance premiums under the NFIP for certain structure type. Insurance premiums for structures located within the Special Flood Hazard Area are functions of the elevation of the first floor of the structure (which may be a basement or crawlspace, if either exists) with the respect to the BFE. The lowest habitable floor elevation will dictate the premium rate for flood insurance.

For residential structures, elevation of the structure on an extended foundation wall, on fill material, piers, posts, and columns has the effect of reducing the flood insurance premium because the structure is being moved away from the flood risk. It is important to note that the flood insurance is based upon a single flood event, the 1% ACE flood event and not a range of flood events. If the residential structure is elevated to be above the 1% flood elevation, there is still a possibility that a larger, more infrequent flood event could occur. Figure 9 illustrates the potential reduction in flood insurance premium for a sample residential structure elevated on extended foundation walls.

Currently, with regards to residential structures, no other physical NS measure, other than acquisition and relocation of the structure, provides a benefit by reducing the flood insurance premium. While wet flood proofing and dry flood proofing a residential structure have the potential to reduce property damages associated with flooding, neither technique results in a reduction in insurance premiums. As of the date of this report, FEMA had been directed by Congress, under the Homeowner Flood Insurance Affordability Act of 2014 (HIFAA), to produce guidelines for structure owners regarding alternative mitigation efforts, other than structure elevation, to reduce flood risk to residential structures that cannot be elevated due to structural characteristics. This request requires alternative forms of mitigation measures to be considered in the calculation of risk premium rates.

However, for nonstructural mitigation of commercial structures, a reduction in flood insurance premium may be obtainable if the flood risk for an individual structure can be reduced through mitigation such as elevation or dry flood proofing. As discussed in section 3.3.5, dry flood proofing is the prevention of flood waters from entering a commercial structure through implementation of engineered systems.

If dry flood proofing is a consideration for reducing flood risk, it is recommended that the structure owner employ closure barriers which have been certified through the National Flood Barrier Testing and Certification program. The purpose of the testing program is to provide a process for evaluating flood fight products in terms of their resistance to floodwaters, their material properties, and consistency of product manufacturing. Products are tested against water forces in the USACE Engineer Research and Development Center laboratory, tested against material forces in an FM Approval laboratory setting, and undergo periodic inspection of the manufacturing process for consistency of product.

Additional information regarding the certification program can be found at the following Association of State Floodplain Managers website: http://nationalfloodbarrier.org/

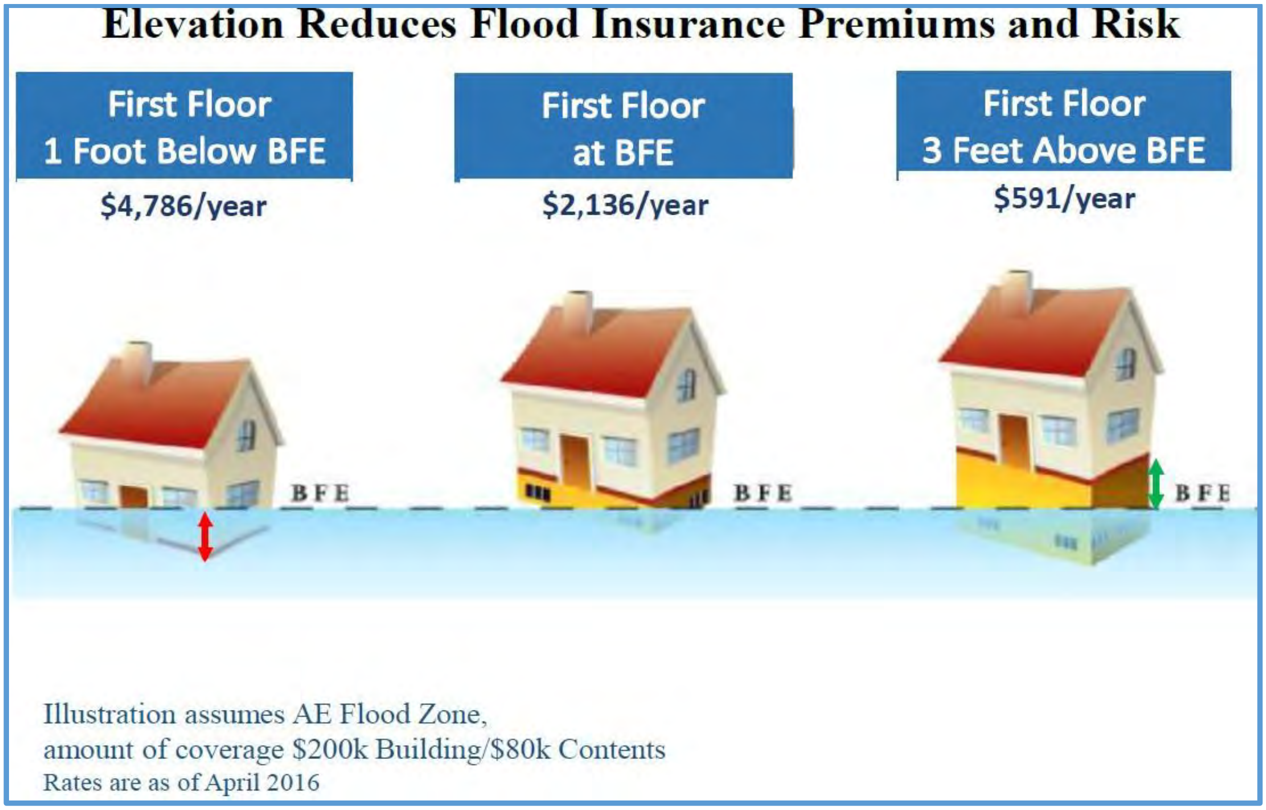


Figure 10. Example Flood Insurance Premium Reduction through Elevation.

8.0 Assessment Conclusions

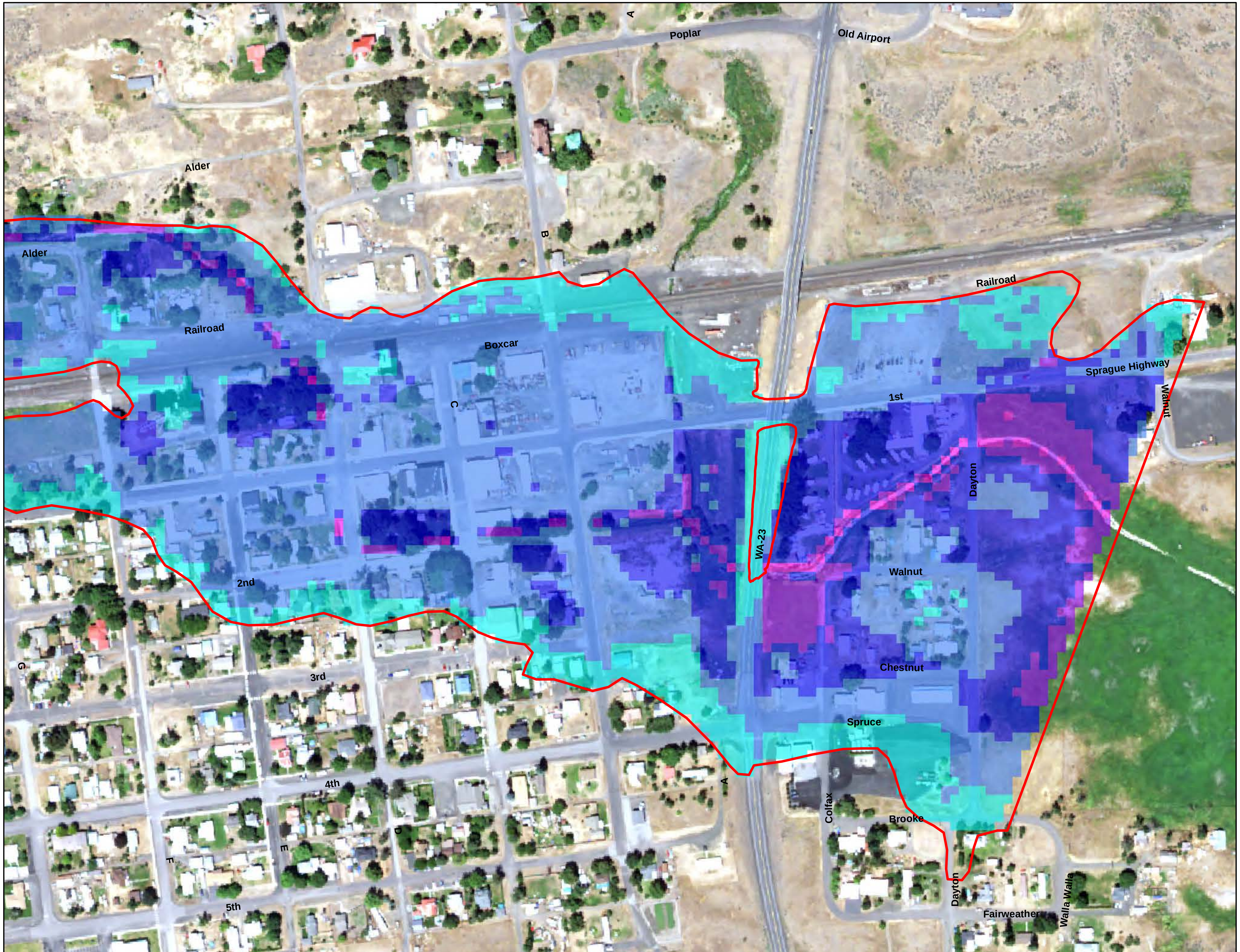
Sprague, Washington, is at substantial risk of flooding from Negro Creek, which flows through the middle of the community in a channel and underground in a pipe. There are numerous residential and nonresidential structures located within the 1% ACE floodplain. The USACE – Walla Walla District collaborated with the Washington Silver Jackets team and the City of Sprague on a nonstructural assessment sponsored through the USACE National Flood Risk Program, Floodplain Management Services, accessed through the national Silver Jackets Program to identify potential NS measures on a reconnaissance level for all 94 of the structures identified within the floodplain, as well as several properties adjacent to Sprague Lake. This assessment recommends potential NS measures for each structure, suggests potential temporary measures that could be implemented throughout the community, and recommended some larger flood fight strategies for the community to consider.

In this reconnaissance-level assessment, the depth of flooding and areal extent were combined with structure attributes of the 94 structures to determine the most appropriate potential course of action for each structure. As an example, if the 1% ACE flood depth were no greater than a foot or two above the first floor elevation of a structure, there would be no need to consider acquisition or relocation of the structure, when dry flood proofing the structure may significantly decrease the flood risk.

Since flooding within the city could occur at any given time prior to the community as a whole, or owners/tenants individually, implementing permanent NS measures, this assessment also provides practical information for the implementation of temporary measures. Materials and equipment needs are described in order to provide the owner/tenant with enough background information to develop a successful emergency flood response plan. Some recommendations for flood fight tactics were also presented.

Elevation appeared to be the most appropriate permanent NS measure for the majority of the residential structures assessed in this study. Dry flood proofing was the primary permanent NS measure identified for nonresidential structures.

Appendix A – Floodplain Maps



CITY OF SPRAGUE, WA.

Depth Grid Map

US Army Corps
of Engineers
Walla Walla District

Field Crew: Slack, Gabel
Drawn: Slack
Checked: Schwarz
Date: 26 July 2019

Legend

FEMA 1% Chance Exceedence Floodplain Boundary

Depth Grid
Feet

- 0 - 2
- 2 - 5
- 5 - 8
- 8 - 11
- 11 - 14.68

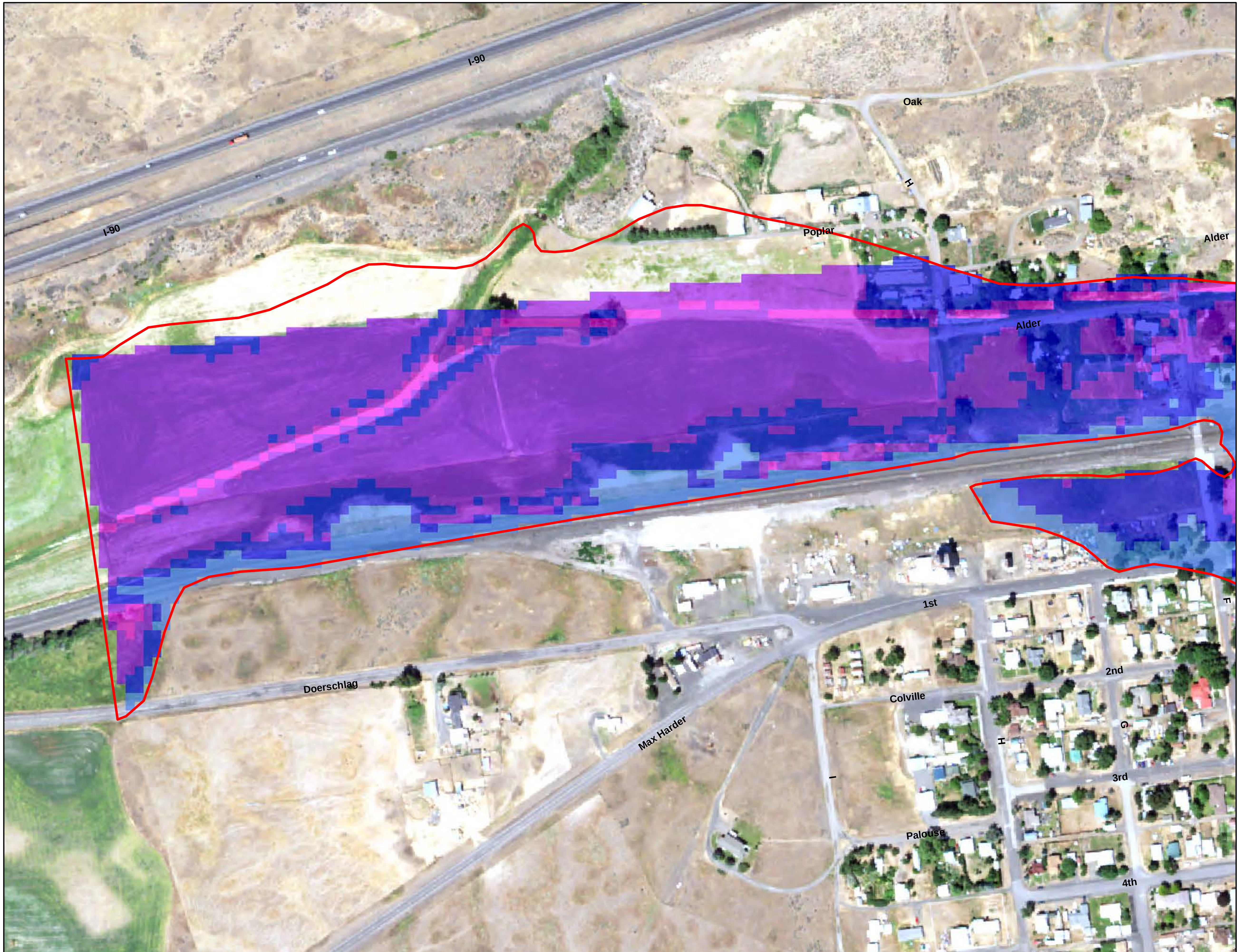
N

0.035 0 0.035 Miles

0.03 0 0.03 Kilometers

Map 1

Created By: G. Slack
Map ID: Map file name
Disclaimer



CITY OF SPRAGUE, WA.

Depth Grid Map

US Army Corps of Engineers
Walla Walla District

Field Crew: Slack, Gabel
Drawn: Slack
Checked: Schwarz
Date: 26 July 2019

Legend

FEMA 1% Chance Exceedence Floodplain Boundary

Depth Grid

Feet

- 0 - 2
- 2 - 5
- 5 - 8
- 8 - 11
- 11 - 14.68

N

0.035 0 0.035 Miles

0.03 0 0.03 Kilometers

Map 2

Created By: G. Slack
Map ID: Map file name
Disclaimer

This product was produced from geospatial information by the U.S. Army Corps of Engineers. Geospatial data and products may be developed from sources of differing accuracy, accurate only at certain scales, based on modeling or interpretation, incomplete while being created or revised, etc. Using this product for purposes other than those for which it was intended may yield inaccurate or misleading results. The U.S. Army Corps of Engineers assumes no liability for correctness or accuracy, and reserves the right to correct, update, or modify geospatial data and\or products without notification.

Appendix B – Property Recommendations

Property Address: 325 E Chestnut St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Piers	Unknown	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
4 ft	2 ft	2 ft

Property Recommendations

Permanent NS Measure: Elevation at least 2 ft.

Temporary Flood Measure: Sandbags and plastic sheeting; plywood over the skirting for structural reinforcement may be necessary.

Additional Comments: None.

Property Address: 313 E Chestnut St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on Grade	Unknown	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
5 ft	2 ft	3 ft

Property Recommendations

Permanent NS Measure: Elevation at least 3 ft using any foundation method.

Temporary Flood Measure: Sandbags and plastic sheeting; plywood closures over doors and windows up to 3 ft height on building.

Additional Comments: There may be some damage to exterior walls that suggests structural integrity is compromised. Use plywood to bridge significant exterior damage when setting up flood defenses.

Property Address: Chestnut Street Storage

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on Grade	Unknown	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
3 ft	0 ft	0 ft

Property Recommendations

Permanent NS Measure: Dry flood proofing with closures over doors.

Temporary Flood Measure: Sandbags and plastic sheeting; plywood closures over doors up to 3 ft height on building.

Additional Comments: None.

Property Address: Outbuilding on Chestnut Street

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on Grade	Unknown	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
6 ft	0 ft	6 ft

Property Recommendations

Permanent NS Measure: Relocation.

Temporary Flood Measure: Sandbags and plastic sheeting; plywood closures over doors up to 3 ft height on building.

Additional Comments: Be prepared to move contents to dry storage in event of significant flood. Garages are typically left to get inundated in nonstructural projects. This structure cannot be adequately flood proofed or elevated in its current location.

Property Address: 325 E Walnut St

Property Photos


Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Crawlspace	Unknown	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
5 ft	1 ft	4 ft

Property Recommendations

Permanent NS Measure: Elevation at least 4 ft using any foundation type; flood vents if extended foundation used.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures over doors and windows up to 3 ft. Water encroachment through floors is possible.

Additional Comments: None.

Property Address: 323 E Walnut St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Cinder block/piers	Window A/C	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
4 ft	3 ft	1 ft

Property Recommendations

Permanent NS Measure: Elevation at least 1 ft; flood vents in cinder block foundation.

Temporary Flood Measure: Sandbags and plastic sheeting.

Additional Comments: None.

Property Address: 322 E Walnut St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Basement	Unknown	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
3 ft	2 ft	1 ft

Property Recommendations

Permanent NS Measure: Basement must be filled to grade; home elevated at least 1 ft.

Temporary Flood Measure: Sandbags and plastic sheeting with cutoff trench and seepage pipe; water may enter basement and require pumping to minimize damages.

Additional Comments: Lost space from basement can be built as addition above the Base Flood Elevation.

Property Address: 316 E Walnut St

Property Photos


Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Piers and skirting	Window A/C	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
4 ft	3 ft	1 ft

Property Recommendations

Permanent NS Measure: Elevation at least 1 ft using any foundation type; flood vents required if extended foundation is used.

Temporary Flood Measure: Sandbags and plastic sheeting; water entry may occur from under the floor at 1% ACE flood.

Additional Comments: None.

Property Address: 315 E Walnut St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Crawlspace	Window A/C	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
4 ft	0.67 ft	3.33 ft

Property Recommendations

Permanent NS Measure: Elevation at least 4 ft using any method; flood vents required if extended foundation is used.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures over doors; cutoff trench and seepage pipe may be required. Water may encroach through floor.

Additional Comments: None.

Property Address: 304 E Walnut St

Property Photos


Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Crawlspace	Unknown	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
6 ft	3 ft	3 ft

Property Recommendations

Permanent NS Measure: Elevation at least 3 ft on extended foundation; flood vents will be required. Alternate elevation with piers and skirting.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures over doors; water may encroach through floor even with sheeting, cutoff trench, and seepage piping.

Additional Comments: None.

Property Address: 303 S Colfax St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Crawlspace	Window A/C	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
7 ft	2 ft	5 ft

Property Recommendations

Permanent NS Measure: Elevation at least 5 ft; flood vents required if extended foundation is used.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures over doors and windows up to 3 ft; cutoff trench and seepage pipe may be required. Water may encroach through floor.

Additional Comments: None.

Property Address: Corner of E Chestnut and S Colfax

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on Grade	Window A/C	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
4 ft	0.33 ft	3.33 ft

Property Recommendations

Permanent NS Measure: Dry flood proof; closures over doors and windows.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures over doors and windows up to 3 ft.

Additional Comments: Applying dry flood proofing beyond 3 ft in height may be possible, but a professional engineer will need to assess the structural strength.

Property Address: 209 E 4th St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on Grade	Window A/C	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
6 ft	0.5 ft	5.5 ft

Property Recommendations

Permanent NS Measure: Options include elevate 6 ft; Elevate 3 ft and dry flood proof additional 3 ft with closures over doors and windows; or relocate the business.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures over doors and windows up to 3 ft.

Additional Comments: Applying dry flood proofing beyond 3 ft in height may be possible, but a professional engineer will need to assess the structural strength. It is very unlikely that the building will be sound enough to flood proof to a height of 6 ft.

Property Address: 209 E 4th St Suite B

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Piers and skirting	Window A/C	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
4.5 ft	3 ft	1.5 ft

Property Recommendations

Permanent NS Measure: Elevate additional 2 ft and extend skirting and ramps/stairs.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures over doors and windows up to 3 ft. Water may encroach interior through the floor.

Additional Comments: This structure could potentially be moved to a site with less flood risk.

Property Address: 316 Colfax St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Elevated A/C above grade	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
1 ft	0 ft	1 ft

Property Recommendations

Permanent NS Measure: Dry flood proofing with closures for at-grade openings; may need to further elevate first floor A/C

Temporary Flood Measure: Sandbags and plastic sheeting around structure; plywood and caulking/sealant to provide closures on at-grade openings.

Additional Comments: Structural evaluation recommended before permanent NS measure applied.

Property Address: 312 E 1st St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Elevated A/C	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
6 ft	0.33 ft	5.67 ft

Property Recommendations

Permanent NS Measure: Dry flood proofing with closures for at-grade openings up to 3 ft will provide partial flood protection. May not be able to provide full nonstructural 1% ACE flood protection in location, so acquisition and/or relocation may be an appropriate option.

Temporary Flood Measure: Sandbags and plastic sheeting around structure; plywood and caulking/sealant to provide closures on at-grade openings up to 3 ft.

Additional Comments: Structural evaluation recommended to determine how high dry flood proofing can be applied – unlikely to withstand full height.

Property Address: Colfax St Mobile Park #1

Property Photos


Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Piers and skirting	Unknown	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
5 ft	3 ft	2 ft

Property Recommendations

Permanent NS Measure: This structure could be elevated an additional 2 ft or be relocated to another location.

Temporary Flood Measure: Water can occupy space under home up to floor level with no measures taken; plastic sheeting and plywood reinforcement may be ineffective.

Additional Comments: None.

Property Address: Colfax St Mobile Park #2

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Piers and skirting	Window A/C	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
6 ft	3 ft	6 ft

Property Recommendations

Permanent NS Measure: This structure could be elevated an additional 3 ft or be relocated to another location.

Temporary Flood Measure: Water can occupy space under home up to floor level with no measures taken; plastic sheeting and plywood reinforcement may be ineffective.

Additional Comments: None.

Property Address: Colfax St Mobile Park #3

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Piers and skirting	Window A/C	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
6 ft	3 ft	6 ft

Property Recommendations

Permanent NS Measure: This structure could be elevated an additional 3 ft or be relocated to another location.

Temporary Flood Measure: Water can occupy space under home up to floor level with no measures taken; plastic sheeting and plywood reinforcement may be ineffective.

Additional Comments: None.

Property Address: Colfax St Mobile Park #4

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Piers and skirting	Window A/C	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
6 ft	3 ft	6 ft

Property Recommendations

Permanent NS Measure: This structure could be elevated an additional 3 ft or be relocated to another location.

Temporary Flood Measure: Water can occupy space under home up to floor level with no measures taken; plastic sheeting and plywood reinforcement may be ineffective.

Additional Comments: None.

Property Address: Colfax St Mobile Park #5

Property Photos


Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Piers and skirting	Window A/C	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
6 ft	3 ft	6 ft

Property Recommendations

Permanent NS Measure: This structure could be elevated an additional 3 ft or be relocated to another location.

Temporary Flood Measure: Water can occupy space under home up to floor level with no measures taken; plastic sheeting and plywood reinforcement may be ineffective.

Additional Comments: None.

Property Address: Colfax St Mobile Park #6

Property Photos


Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Piers and skirting	Roof A/C	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
6 ft	3 ft	6 ft

Property Recommendations

Permanent NS Measure: This structure could be elevated an additional 3 ft or be relocated to another location.

Temporary Flood Measure: Water can occupy space under home up to floor level with no measures taken; plastic sheeting and plywood reinforcement may be ineffective.

Additional Comments: None.

Property Address: Historic Railroad Museum

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Crawlspace	A/C on grade	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
1 ft	2 ft	0 ft

Property Recommendations

Permanent NS Measure: Elevate mechanical 2 ft above surrounding grade; fill crawlspace or provide flood vents and waterproof subfloor.

Temporary Flood Measure: Sandbags and plastic sheeting as needed.

Additional Comments: None.

Property Address: 101 E 1st St

Property Photos


Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Unknown	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
3.5 ft	0 ft	3.5 ft

Property Recommendations

Permanent NS Measure: Dry flood proofing up to 3.5 or 4 ft may be possible. Closures will be required for all doors. Structural reinforcement will likely be required on east end of building.

Temporary Flood Measure: Sandbags and plastic sheeting as needed up to 3 ft. Use plywood closures across doors. Use plywood to span damaged walls. Do not span more than 3 ft horizontally without additional reinforcing behind plywood.

Additional Comments: None.

Property Address: 106 E 1st St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Roof A/C	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
3 ft	0 ft	3 ft

Property Recommendations

Permanent NS Measure: Dry flood proofing up to 3 ft. Closures will be required for all doors.

Temporary Flood Measure: Sandbags and plastic sheeting up to 3 ft. Use plywood closures across doors.

Additional Comments: A structural assessment is recommended prior to applying flood proofing.

Property Address: 3rd and S B St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Unknown	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure
1 ft	0 ft	1 ft

Property Recommendations

Permanent NS Measure: Dry flood proofing. Closures will be required for all doors.

Temporary Flood Measure: Sandbags and plastic sheeting up to 3 ft. Use plywood closures across doors.

Additional Comments: A structural assessment is recommended prior to applying flood proofing.

Property Address: 101 W 3rd St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Basement	Unknown	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
1 ft	3 ft	0 ft

Property Recommendations

Permanent NS Measure: Fill basement and build addition above grade to make up for lost space.

Temporary Flood Measure: Sandbags, plastic sheeting with cutoff trench and/or seepage pipe may not be effective to keep water out of basement. Pumping may be required.

Additional Comments: None.

Property Address: 109 W 3rd St

Property Photos


Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Piers and skirting	Window A/C	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
1 ft	3 ft	0 ft

Property Recommendations

Permanent NS Measure: None required – water should be able to occupy space under home.

Temporary Flood Measure: None.

Additional Comments: None.

Property Address: 214 S B St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Piers and skirting	Window A/C	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
5 ft	2 ft	3 ft

Property Recommendations

Permanent NS Measure: Elevate home additional 3 ft.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood reinforcement over skirting up to 3 ft.

Additional Comments: Garage/shop may already be resilient to flooding, but items that can be damaged by water should be prepared to be moved or stored above the flood level.

Property Address: 110 W 3rd St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Crawlspace	Unknown	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
1.5 ft	1 ft	0.5 ft

Property Recommendations

Permanent NS Measure: Consider filling crawlspace.

Temporary Flood Measure: Sandbags and plastic sheeting up to 1 ft as needed.

Additional Comments: None.

Property Address: 213 S C St – Chamber of Commerce

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Unknown	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
1 ft	0 ft	1 ft

Property Recommendations

Permanent NS Measure: Dry flood proof with closures across doors.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors.

Additional Comments: None.

Property Address: 204 S B St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Crawlspace	Unknown	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	0.33 ft	3.33 ft

Property Recommendations

Permanent NS Measure: Elevate structure by 4 ft.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3ft.

Additional Comments: None.

Property Address: 204 S B St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Crawlspace	Unknown	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	0.33 ft	3.33 ft

Property Recommendations

Permanent NS Measure: Elevate structure by 4 ft.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3ft.

Additional Comments: None.

Property Address: 117 W 2nd St

Property Photos


Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Unknown	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	0 ft	4 ft

Property Recommendations

Permanent NS Measure: Relocate structure.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3ft.

Additional Comments: Recommend a structural assessment, but unlikely that dry flood proofing can be applied up to 4 ft on structure.

Property Address: 119 W 2nd St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	A/C on grade	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	0.33 ft	3.67 ft

Property Recommendations

Permanent NS Measure: Dry floodproof up to 4 ft with closures across all doors. Elevate A/C above 1% ACE flood elevation.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3ft.

Additional Comments: Recommend a structural assessment prior to applying nonstructural measure.

Property Address: 201 W 2nd St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Basement	A/C on grade	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
3 ft	3 ft	0 ft

Property Recommendations

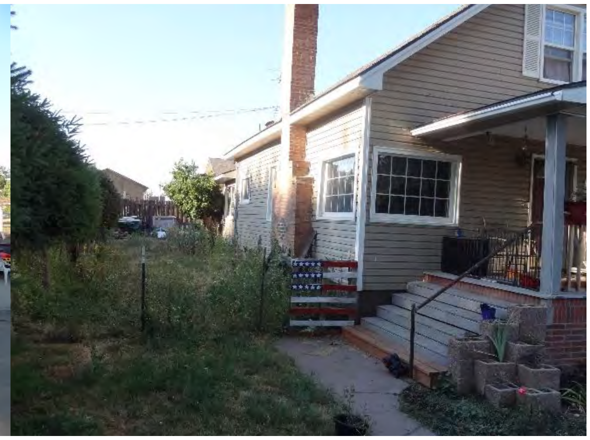
Permanent NS Measure: Fill basement and replace space with addition at grade plus 3 ft to stay above flood level. Elevate at-grade A/C unit.

Temporary Flood Measure: Sandbags and plastic sheeting, though measures may not keep water out of the basement. Active pumping may be required during a flood.

Additional Comments: None.

Property Address: 209 W 2nd St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Basement	A/C on grade	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
3 ft	3 ft	0 ft

Property Recommendations

Permanent NS Measure: Fill basement and replace space with addition at grade plus 3 ft to stay above flood level. Elevate at-grade A/C unit.

Temporary Flood Measure: Sandbags and plastic sheeting, though measures may not keep water out of the basement. Active pumping may be required during a flood.

Additional Comments: None.

Property Address: 219 W 2nd St

Property Photos


Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Basement	A/C on grade	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
2 ft	3 ft	0 ft

Property Recommendations

Permanent NS Measure: Fill basement and replace space with addition at grade plus 2 ft to stay above flood level. Elevate at-grade A/C unit.

Temporary Flood Measure: Sandbags and plastic sheeting, though measures may not keep water out of the basement. Active pumping may be required during a flood.

Additional Comments: None.

Property Address: 301 W 2nd St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Basement	A/C on grade	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
1 ft	3 ft	0 ft

Property Recommendations

Permanent NS Measure: Fill basement and replace space with addition at grade plus 1 ft to stay above flood level. Elevate at-grade A/C unit.

Temporary Flood Measure: Sandbags and plastic sheeting, though measures may not keep water out of the basement. Active pumping may be required during a flood.

Additional Comments: None.

Property Address: 305 W 2nd St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Basement	Unknown	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
1 ft	3 ft	0 ft

Property Recommendations

Permanent NS Measure: Fill basement and replace space with addition at grade plus 1 ft to stay above flood level. Elevate at-grade A/C unit, if present.

Temporary Flood Measure: Sandbags and plastic sheeting, though measures may not keep water out of the basement. Active pumping may be required during a flood.

Additional Comments: None.

Property Address: 311 W 2nd St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Basement	Window A/C	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
1 ft	2 ft	0 ft

Property Recommendations

Permanent NS Measure: Fill basement and replace space with addition at grade plus 1 ft to stay above flood level. Elevate at-grade A/C unit, if present.

Temporary Flood Measure: Sandbags and plastic sheeting, though measures may not keep water out of the basement. Active pumping may be required during a flood.

Additional Comments: None.

Property Address: 315 W 2nd St

Property Photos


Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Piers and skirting	Unknown	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
1 ft	2 ft	0 ft

Property Recommendations

Permanent NS Measure: Water may be able to safely be under home with minimal damage.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood reinforcement as need.

Additional Comments: None.

Property Address: 319 W 2nd St

Property Photos


Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Unknown	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
1 ft	1.5 ft	0 ft

Property Recommendations

Permanent NS Measure: Water may be able to safely be around home with minimal damage.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood reinforcement as need.

Additional Comments: None.

Property Address: 405 W 2nd St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Unknown	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
1 ft	1.5 ft	0 ft

Property Recommendations

Permanent NS Measure: Water may be able to safely be around home with minimal damage.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood reinforcement as needed.

Additional Comments: None.

Property Address: 410 W 2nd St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Basement	Window A/C	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
3 ft	0.67 ft	2.33 ft

Property Recommendations

Permanent NS Measure: Fill basement and replace space with addition at grade plus 3 ft to stay above flood level. Elevate home 3 ft above filled basement.

Temporary Flood Measure: Sandbags and plastic sheeting, though measures may not keep water out of the basement. Active pumping may be required during a flood.

Additional Comments: None.

Property Address: 408 W 2nd St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Basement	Window A/C	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	0.67 ft	3.33 ft

Property Recommendations

Permanent NS Measure: Fill basement and replace space with addition at grade plus 4 ft to stay above flood level. Elevate home 4 ft above filled basement.

Temporary Flood Measure: Sandbags and plastic sheeting, though measures may not keep water out of the basement. Active pumping may be required during a flood.

Additional Comments: None.

Property Address: 112 S E St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Window A/C	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
3 ft	1.5 ft	1.5 ft

Property Recommendations

Permanent NS Measure: Elevate structure by 2 ft.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures over door up to 2 ft.

Additional Comments: None.

Property Address: 318 W 2nd St

Property Photos


Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Crawlspace	Unknown	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	0.67 ft	3.33 ft

Property Recommendations

Permanent NS Measure: Elevate structure by 4 ft.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures over door up to 3 ft.

Additional Comments: None.

Property Address: 312 W 2nd St

Property Photos


Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Basement	Unknown	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
5 ft	0.67 ft	4.33 ft

Property Recommendations

Permanent NS Measure: Fill basement and replace space with addition at grade plus 5 ft to stay above flood level. Elevate home 5 ft above filled basement.

Temporary Flood Measure: Sandbags and plastic sheeting, though measures may not keep water out of the basement. Active pumping may be required during a flood.

Additional Comments: None.

Property Address: 118 W 1st St

Property Photos


Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Unknown	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	0.33 ft	3.67 ft

Property Recommendations

Permanent NS Measure: Dry floodproof up to 4 ft with closures across all doors.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3ft.

Additional Comments: Recommend a structural assessment prior to applying nonstructural measure.

Property Address: 107 W 1st St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Unknown	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	0.33 ft	3.67 ft

Property Recommendations

Permanent NS Measure: Dry floodproof up to 4 ft with closures across all doors.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3ft.

Additional Comments: Recommend a structural assessment prior to applying nonstructural measure.

Property Address: 113 S C St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Window A/C	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	0.33 ft	3.67 ft

Property Recommendations

Permanent NS Measure: Dry floodproof up to 4 ft with closures across all doors.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3ft.

Additional Comments: Recommend a structural assessment prior to applying nonstructural measure.

Property Address: 117 W 1st St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Window A/C	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	0.33 ft	3.67 ft

Property Recommendations

Permanent NS Measure: Dry floodproof up to 4 ft with closures across all doors.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3ft.

Additional Comments: Recommend a structural assessment prior to applying nonstructural measure.

Property Address: 201 W 1st St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Window A/C	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	0.33 ft	3.67 ft

Property Recommendations

Permanent NS Measure: Dry floodproof up to 4 ft with closures across all doors.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3ft.

Additional Comments: Recommend a structural assessment prior to applying nonstructural measure.

Property Address: 209 W 1st St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Unknown	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	0.33 ft	3.67 ft

Property Recommendations

Permanent NS Measure: Dry floodproof up to 4 ft with closures across all doors.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3ft.

Additional Comments: Recommend a structural assessment prior to applying nonstructural measure.

Property Address: 211 W 1st St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	A/C on grade	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	0.33 ft	3.67 ft

Property Recommendations

Permanent NS Measure: Dry floodproof up to 4 ft with closures across all doors. Elevate A/C above 1% ACE flood elevation.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3ft.

Additional Comments: Recommend a structural assessment prior to applying nonstructural measure.

Property Address: 213 W 1st St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Window A/C	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	0.33 ft	3.67 ft

Property Recommendations

Permanent NS Measure: Dry floodproof up to 4 ft with closures across all doors.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3ft.

Additional Comments: Recommend a structural assessment prior to applying nonstructural measure.

Property Address: 216 W 1st St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Window A/C	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	0.33 ft	3.67 ft

Property Recommendations

Permanent NS Measure: Dry floodproof up to 4 ft with closures across all doors.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3ft.

Additional Comments: Recommend a structural assessment prior to applying nonstructural measure.

Property Address: 305 W 1st St

Property Photos


Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	A/C on grade	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
3 ft	0.33 ft	2.67 ft

Property Recommendations

Permanent NS Measure: Dry floodproof up to 3 ft with closures across all doors. Elevate A/C above 1% ACE flood elevation.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3 ft.

Additional Comments: Recommend a structural assessment prior to applying nonstructural measure.

Property Address: 313 W 1st St

Property Photos


Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Unknown	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
3 ft	0.33 ft	2.67 ft

Property Recommendations

Permanent NS Measure: Dry floodproof up to 3 ft with closures across all doors.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3 ft.

Additional Comments: Recommend a structural assessment prior to applying nonstructural measure.

Property Address: 319 W 1st St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	A/C on grade	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
3 ft	0.33 ft	2.67 ft

Property Recommendations

Permanent NS Measure: Dry floodproof up to 3 ft with closures across all doors. Elevate A/C above 1% ACE flood elevation.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3 ft.

Additional Comments: Recommend a structural assessment prior to applying nonstructural measure.

Property Address: 109 S E St

Property Photos


Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Elevated A/C	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
3 ft	0.33 ft	2.67 ft

Property Recommendations

Permanent NS Measure: Elevate home 3 ft. Ensure A/C is above 1% ACE flood elevation.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3 ft.

Additional Comments: Recommend a structural assessment prior to applying nonstructural measure.

Property Address: 409 W 1st St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Wall A/C	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
3 ft	0.33 ft	2.67 ft

Property Recommendations

Permanent NS Measure: Dry floodproof up to 3 ft with closures across all doors. Ensure A/C elevated above 1% ACE flood elevation.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3 ft.

Additional Comments: Recommend a structural assessment prior to applying nonstructural measure.

Property Address: 419 W 1st St

Property Photos


Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Crawlspace	A/C on grade	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
2 ft	1.5 ft	0.5 ft

Property Recommendations

Permanent NS Measure: Elevate home 1 ft. Ensure A/C is above 1% ACE flood elevation.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3 ft.

Additional Comments: Recommend a structural assessment prior to applying nonstructural measure.

Property Address: 504 W 1st St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Basement	A/C on grade	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
1 ft	2 ft	0 ft

Property Recommendations

Permanent NS Measure: Fill basement and replace space with addition at grade plus 2 ft to stay above flood level.

Temporary Flood Measure: Sandbags and plastic sheeting, though measures may not keep water out of the basement. Active pumping may be required during a flood.

Additional Comments: None.

Property Address: 404 W 1st St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Unknown	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	0.33 ft	3.67 ft

Property Recommendations

Permanent NS Measure: Elevate home 4 ft.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3 ft.

Additional Comments: None.

Property Address: 318 W 1st St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	A/C on grade	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	0.33 ft	3.67 ft

Property Recommendations

Permanent NS Measure: Elevate home 4 ft. Elevate A/C above 1% ACE flood elevation.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3 ft.

Additional Comments: None.

Property Address: 314 W 1st St

Property Photos


Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Window A/C	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
3 ft	0.33 ft	2.67 ft

Property Recommendations

Permanent NS Measure: Elevate home 3 ft.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3 ft.

Additional Comments: None.

Property Address: 304 W 1st St

Property Photos


Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Piers and skirting	Unknown	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
3 ft	3 ft	0 ft

Property Recommendations

Permanent NS Measure: Water may be able to safely be under home with minimal damage.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood reinforcement as need.

Additional Comments: None.

Property Address: 113 N C St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Unknown	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	0.33 ft	3.67 ft

Property Recommendations

Permanent NS Measure: Dry floodproof up to 4 ft with closures across all doors. Elevate A/C above 1% ACE flood elevation.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3 ft.

Additional Comments: Recommend a structural assessment prior to applying nonstructural measure.

Property Address: 114 N C St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Unknown	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	0.33 ft	3.67 ft

Property Recommendations

Permanent NS Measure: Dry floodproof up to 4 ft with closures across all doors. Elevate A/C above 1% ACE flood elevation.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3 ft.

Additional Comments: Recommend a structural assessment prior to applying nonstructural measure.

Property Address: Shed on B Street

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Unknown	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	0 ft	4 ft

Property Recommendations

Permanent NS Measure: None.

Temporary Flood Measure: Remove items that may be damaged by a flood prior to flood arrival.

Additional Comments: None.

Property Address: BNSF Buildings on Railroad Ave

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Unknown	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	0 ft	4 ft

Property Recommendations

Permanent NS Measure: Ring levee/floodwall with closure.

Temporary Flood Measure: Remove items that may be damaged by a flood prior to flood arrival.

Additional Comments: None.

Property Address: Wood barn on S E St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Unknown	Non-Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	0 ft	4 ft

Property Recommendations

Permanent NS Measure: None.

Temporary Flood Measure: Remove items that may be damaged by a flood prior to flood arrival.

Additional Comments: None.

Property Address: 305 W Boxcar Ave

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Window A/C	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
6 ft	2 ft	4 ft

Property Recommendations

Permanent NS Measure: Elevate home 4 ft.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3 ft.

Additional Comments: None.

Property Address: 402 W Railroad Ave

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Window A/C	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
3 ft	0.33 ft	2.67 ft

Property Recommendations

Permanent NS Measure: Elevate home 3 ft.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood closures across doors up to 3 ft.

Additional Comments: None.

Property Address: 418 W Railroad Ave

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Window A/C	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
2 ft	2.5 ft	0 ft

Property Recommendations

Permanent NS Measure: Water may be able to safely be around home with minimal damage.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood reinforcement as needed.

Additional Comments: None.

Property Address: 209 N F St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Piers	Unknown	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	2 ft	2 ft

Property Recommendations

Permanent NS Measure: Elevate structure an additional 2 ft. If using an extended foundation, include flood vents.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood reinforcement up to 3 ft.

Additional Comments: None.

Property Address: 509 W Alder St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Piers and skirting	A/C on grade	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	3 ft	1 ft

Property Recommendations

Permanent NS Measure: Elevate structure an additional 1 ft. If using an extended foundation, include flood vents.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood reinforcement and closures up to 3 ft. Water may encroach on the structure through the floor.

Additional Comments: None.

Property Address: 504 W Alder St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Window A/C	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
4 ft	0.33 ft	3.67 ft

Property Recommendations

Permanent NS Measure: Elevate structure 4 ft. If using an extended foundation, include flood vents.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood reinforcement and closures up to 3 ft.

Additional Comments: None.

Property Address: 304 S H St

Property Photos


Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Piers and skirting	Unknown	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
3 ft	2 ft	1 ft

Property Recommendations

Permanent NS Measure: Elevate structure 1 ft. If using an extended foundation, include flood vents.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood reinforcement and closures up to 3 ft.

Additional Comments: Recommend structural analysis before applying nonstructural measure.

Property Address: 606 W Alder St

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Slab on grade	Unknown	Residential

Flood Characteristics (1% ACE Flood, all values are estimates)

Depth of Flooding at Structure	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure Above Grade
6 ft	0.67 ft	5.33 ft

Property Recommendations

Permanent NS Measure: Elevate structure 6 ft.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood reinforcement and closures up to 3 ft.

Additional Comments: Recommend structural analysis before applying nonstructural measure.

Property Address: 1999 Sprague Lake Resort Road

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Daylight basement	Unknown	Residential

Flood Characteristics

Depth of Flooding at Structure basement	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure basement
3 ft in recent high water	0 ft	3 ft

Property Recommendations

Permanent NS Measure: Consider dry or wet flood proofing for the walk out basement. Any utilities or mechanical equipment should be relocated to the upper floor.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood reinforcement and closures up to 3 ft on basement side.

Additional Comments: The main floor appears to be safe from lake flooding, but modifications to the basement portion seem warranted. Water can be excluded by watertight closures on the basement doors or the basement can be made resilient to water with stored items elevated within the basement.

Property Address: 1983 Sprague Lake Resort Road

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Basement	Unknown	Residential

Flood Characteristics

Depth of Flooding at Structure basement	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure basement
3 ft in recent high water	0 ft	3 ft

Property Recommendations

Permanent NS Measure: Consider dry or wet flood proofing for the basement. Any utilities or mechanical equipment should be relocated to the upper floor.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood reinforcement and closures up to 3 ft on basement side.

Additional Comments: The main floor appears to be safe from lake flooding, but modifications to the basement portion seem warranted. Water can be excluded by watertight closures on the basement doors or the basement can be made resilient to water with stored items elevated within the basement.

Property Address: 1873 Sprague Lake Resort Road

Property Photos

Structure Characteristics

Foundation Type	Mechanical Equipment	Type
Basement	Unknown	Residential

Flood Characteristics

Depth of Flooding at Structure basement	First Floor Elevation above Surrounding Grade	Net Flood Depth on Structure basement
3.5 ft in recent high water	0 ft	3.5 ft

Property Recommendations

Permanent NS Measure: Consider dry or wet flood proofing for the basement. Any utilities or mechanical equipment should be relocated to the upper floor.

Temporary Flood Measure: Sandbags and plastic sheeting with plywood reinforcement and closures up to 3 ft on basement side.

Additional Comments: The main floor appears to be safe from lake flooding, but modifications to the basement portion seem warranted. Water can be excluded by watertight closures on the basement doors or the basement can be made resilient to water with stored items elevated within the basement.

Publication information

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[1] www.ecology.wa.gov/contact