8.0 FLOOD:

8.1 Introduction

Parts of the area served by the Toledo School District may be subject to flooding from several different flood sources:

- Overbank flooding from rivers and streams,
- Local stormwater drainage flooding,
- Channel migration,
- Sheet flow flooding,
- Flooding from failures of dams, reservoirs or levees, and

Overbank flooding from rivers and stream occurs throughout Washington, most commonly from winter storms with heavy rainfall from November to February. Flood events with significant contributions from snowmelt may also occur during the spring snowmelt season for watersheds with high enough elevations to have significant snowfalls. Although it is less common, overbank flooding can also occur at any time of the year. The severity of overbank flooding depends primarily on flood depth. However, other factors such as flood duration, flow velocity, debris loads, and contamination with hazardous materials also significantly impact the severity of any given flood event. Overbank flooding can be very severe and affect broad geographic areas.

Storm water drainage flooding, sometimes referred to as urban flooding, occurs when inflows of storm water exceed the conveyance capacity of a local storm water drainage system. With this type of flooding, the drainage system overflows, resulting in water ponding in low lying areas. Storm water drainage flooding is generally localized, with flood depths that may range from a few inches to several feet.

Channel migration flooding occurs when ongoing erosion/deposition on the banks of a river result in the channel of the river or stream migrating (moving) to an extent that structures are affected by floods. Rivers or streams with low gradients (flat topography) and meandering patterns are prone to channel migration**.**

Sheet flow flooding occurs when stream flows are not confined to a channel but occur over a broad area. Sheet flows are common in areas within alluvial fans, which are sloping accumulations of sediments eroded from mountains or hills.

Failures of dams, reservoirs for potable water systems or levees results in flooding areas downstream of dams and reservoirs or behind levees. Toledo School District is located downstream of Mossyrock and Mayfield Dams. Failures of major dams operated and regulated by state or federal agencies are possible, but unlikely because these dams are generally well-designed, well-monitored and well-

maintained. However, failures of smaller dams maintained by local governments, special districts or private owners are more common.

Failures of reservoirs for potable water systems occur, especially from earthquakes. These reservoirs typically have much smaller storage volumes than dams, so flooding from failures is generally localized, but may be severe where flows are confined in narrow channels which contain structures or infrastructure. Similar flooding may occur from failures of large diameter water pipes.

Levee failures before overtopping may occur at any time, not only during high water events but also under normal non-flood conditions. There are numerous causes for such failures, including scour, foundation failures, under-seepage, through-seepage, animal burrows, and others.

Historically, flooding has occurred in Washington State throughout recorded history. The most severe, widespread flood events were:

- May/June 1948: widespread flooding in Eastern Washington and along the Columbia River from spring snowmelt.
- November 1990: widespread flooding on Western Washington rivers as well as on several Eastern Washington rivers. This event was the flood of record, the greatest recorded flood, on many rivers in Northwest Washington.
- February 1996: major flooding on many rivers in Western and Southeastern Washington. This event was the flood of record on many rivers in Southwest Washington.
- January 2012: major flood in Western Washington. This event was the flood of record on some rivers.

Every county in Washington is subject to flood risk and has experienced major flood events. However, Western Washington has experienced more major flood events than Eastern Washington.

8.2 Flood Hazard and Risk Assessments: Toledo School District

The potential impacts of future floods on the Toledo District are primarily damage to buildings and contents, disruption of educational services, and displacement costs for temporary quarters if some buildings have enough damage to require moving out while repairs are made. The likelihood of deaths or injuries is extremely low, because schools will be evacuated whenever flood warnings are issued and the district's facilities are very unlikely to be affected by flash flooding.

The vulnerability of the Toledo District's facilities to flooding varies markedly from campus to campus and from building to building on a given campus. The approximate levels of flood hazards and vulnerability are identified in the following sections at the campus-level and the building-level.

8.3 Flood Hazard and Risk Assessments: FEMA-Mapped Floodplains

FEMA Flood Insurance Rate Maps (FIRMs) delineate the regulatory (100-year) floodplain areas in Washington. Per FEMA regulations, there are limitations on new development within the 100-year floodplain.

The 100-year flood is defined probabilistically. A 100-year flood does not occur exactly every 100 years. Rather, the 100-year flood is the flood with a 1% chance of being exceeded in any given year. A 1% annual chance of flooding corresponds to about a 26% chance of flooding in a 30-year time period. A given location may have two or more 100-year (or greater) flood events within a few years or have none in several decades or longer.

FEMA's floodplain mapping provides a good starting point for flood hazard risk assessments. Facilities within FEMA mapped floodplains have at least some level of flood risk. However, determining the level of risk quantitatively requires additional flood hazard data, including the elevation of facilities relative to the elevation of a range of flood events. It is also important to recognize that some facilities not within FEMA-mapped floodplains also have high levels of flood risk.

FEMA floodplain maps represent the best available data at the time the maps were prepared. FEMA has an ongoing map modernization/update process, but many existing FIRM maps are old – some more than 30 years old. In many cases, flood risk in a given location increases with time because increasing development within the watershed increases runoff, and because development and fill within floodplains or sedimentation in a river channel may increase flood elevations. In some cases, flood elevations for a 100-year flood using current data may be up to several feet higher than outdated floodplain maps indicate.

Flood risk at a given location may also decrease over time if flood control structures such as levees or upstream dams for flood control are constructed or improved. Old floodplain maps are not necessarily incorrect. However, older maps should be interpreted carefully because the older a map is, the more likely it is to be significantly incorrect.

Recent and future FEMA floodplain maps are available in digital GIS-format and are known as DFIRMs. Older maps, which were originally prepared in paper format only, have been digitized, but contain less detailed information than DFIRMs. These maps are known as Q3 maps. For any given location, the most recent FEMA maps should be used for flood risk assessments.

FEMA floodplain maps identify several types of flood zones, with varying levels of flood hazard. The FEMA flood zone designations have evolved over time, with older maps using different nomenclature than recent maps. FEMA's current and historical flood zone designations are summarized below.

Table 8.1
FEMA Flood Zones
HIGH RISK AREAS

ZONE	DESCRIPTION
A	Areas with a 1% annual chance of flooding and a 26% chance of flooding over 30 years. Because detailed analyses are not performed for such areas; no depths or base flood elevations are shown within these zones.
AE, A1 – A30	The base floodplain where base flood elevations are provided. AE Zones are now used on new format FIRMs instead of A1-A30 Zones.
AH	Areas with a 1% annual chance of shallow flooding, usually in the form of a pond, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over 30 years. Base flood elevations derived from detailed analyses are shown at selected intervals within these zones.
AO	River or stream flood hazard areas and areas with a 1% or greater chance of shallow flooding each year, usually in the form of sheet flow, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over 30 years. Average flood depths derived from detailed analyses are shown within these zones.
AR	Areas with a temporarily increased flood risk due to the building or restoration of a flood control system (such as a levee or a dam).
A99	Areas with a 1% annual chance of flooding that will be protected by a Federal flood control system where construction has reached specified legal requirements. No depths or base flood elevations are shown within these zones.

MODERATE TO LOW RISK AREAS

ZONE	DESCRIPTION
B and X (shaded)	Area of moderate flood hazard, usually the area between the limits of the 100-year and 500-year floods. B Zones are also used to designate base floodplains of lesser hazards, such as areas protected by levees from 100-year flood, or shallow flooding areas with average depths of less than one foot or drainage areas less than 1 square mile.
C and X (unshaded)	Area of minimal flood hazard, usually depicted on FIRMs as above the 500-year flood level. Zone C may have ponding and local drainage problems that don't warrant a detailed study or designation as base floodplain. Zone X is the area determined to be outside the 500-year flood and protected by levee from 100-year flood.

UNDETERMINED RISK AREAS

ZONE	DESCRIPTION
D	Areas with possible but undetermined flood hazards. No flood hazard analysis has been conducted. Flood insurance rates are commensurate with the uncertainty of the flood risk.

FEMA Flood Insurance Rate Maps are always accompanied by Flood Insurance Studies. Flood Insurance Studies contain summaries of historical floods, details of the flood mapping and quantitative flood hazard data which is essential for quantitative flood risk assessments.

FEMA Flood Insurance Studies and Flood Insurance Rate Maps include a large number of terms of art and acronyms. A good summary of the terms used in flood hazard mapping is available from FEMA.[1]

The level of flood hazard (frequency and severity of flooding) for a given campus or building is not determined simply by whether the campus or building is or is not within the mapped 100-year floodplain. Rather, the level of flood hazard depends to a great extent on the elevation of buildings relative to the elevation of various flood events, such as the 10-year, 50-year or 100-year flood event.

For example, consider two schools both within the 100-year floodplain of a given river. The first school has a first floor elevation three feet above the 100-year flood elevation and the level of flood hazard is low (but not zero). The second school has a first floor elevation three feet below the 100-year flood elevation and the level of flood hazard is very high. In this example, the six foot difference in elevations of the two schools makes an enormous difference in the level of flood hazard.

For buildings within most FEMA mapped flood zones, quantitative flood data in the Flood Insurance Study allow calculation of the probability of flooding for any building, if the building's first floor elevation is known. The flood data used to make this calculation include stream discharges (volume of water flowing in a river) and flood elevations for floods of several different return periods (typically, the 10-, 50-, 100- and 500-year floods). For further details about flooding, see Chapter 10 in the Washington State K-12 Hazard Mitigation Plan. The OSPI Mitigation Planning Toolkit also has more detailed guidance and templates to gather and use the types of flood hazard data discussed above.

Examples of campus-level and building-level flood hazard and risk reports exported from the OSPI ICOS Pre-Disaster Mitigation database are shown on the following pages.

Table 8.2
TOLEDO School District Campus-Level Flood Hazard and Risk Report

Flood Campus-Level Hazard and Risk Report									Recommendation	
Campus	**Within FEMA Floodplain**	**FEMA Flood Zone**	**Local Flood Study°**	**Within 0.5 Mile of FEMA Flood Zone[1]**	**Number of Flood Events in 20 Years[2]**	**Other Flood Concerns[3]**	**Campus at Grade Elevation (NAVD 1988)‡**	**Preliminary Flood Risk Level†**	**Complete Building Level Flood Assessment (Yes/No)**	**Priority**
TOLEDO SCHOOL DISTRICT										
Cowlitz Prairie Academy	Yes	C	No	Yes	None	No	Far Above 500 Year Flood	Nil	No	N/A
District Offices	Yes	C	No	Yes	None	No	Above 500 Year Flood	Low or Very Low	TBD	TBD
Toledo Elementary School	Yes	A	No	In Zone	None	Yes	Between 100 and 500 Year	Moderate	Yes	Moderate
Toledo High School	Yes	C	No	No	None	No	Far Above 500 Year Flood	Nil	No	N/A
Toledo Middle School	Yes	C	No	Yes	None	No	Far Above 500 Year Flood	Nil	No	N/A

° With quantitative flood hazard data, similar to FEMA Flood Insurance Study.

[1] Applicable only if campus is not within a mapped flood zone.

[2] Severe enough to result in school closure and/or damage to at least on building.

[3] Local storm water drainage flooding, campus near stream/river without FEMA flood mapping, campus behind levee or downstream from a dam, campus on alluvial fan subject to sheet flows, campus near a migrating stream/river, or local flood study completed.

‡ Base on campus at grade elevation relative to flood elevations for 10, 50, 100 and 500 year flood elevations (if data entered on flood PDM screen) and/or on other district-entered data on the flood PDM screen.

† Preliminary estimate of flood risk, based on quantitative flood data (if entered on the Flood PDM Screen) and/or on the number of flood events in 20 years and expressed concerns about floods. More accurate risk assessments require building-level assessments: flood risk may vary markedly from building to building on a given campus, depending on a building's elevation and other factors.

DISCLAIMER: The information provided in this report is collected from various sources and may change over time without notice. The Office of Superintendent of Public Instruction (OSPI) and its officials and employees take no responsibility or legal liability for the accuracy, completeness, reliability, timeliness, or usefulness of any of the information provided.
The information has been developed and presented for the sole purpose of developing school district mitigation plans and to assist in determining where to focus resources for additional evaluations of natural hazard risks. The reports are not intended to constitute in-depth analysis or advice, nor are they to be used as a substitute for specific advice obtained from a licensed professional regarding the particular facts and circumstances of the natural hazard risks to a particular campus or building.

NOTE: The Middle School, Cowlitz Prairie Academy and High School are with FEMA's Zone C (Area of Minimal Flooding) but the flood risk is nil because these facilities are about 40 feet, 40 feet and 110 feet, respectively, above the 500 year flood elevation. The District Office is above the 500 year flood by a to be determined amount. The above table from OSPI's ICOS Database has been edited to reflect this information.

Table 8.3
Building Level Flood Risk Assessment – Campuses With Quantitative Flood Data (Discharges and Flood Elevations)

Building-Level Flood Report: With Quantitative Flood Hazard Data												
Building	**Basement (Yes/No)**	**First Floor Elevation (Feet) NAVD1988**	**Flood Elevations (Feet) (NAVD 1988)**					**Flood Return Period (Years)[1]**	**Flood Risk Level**	**Mitigation Desired (Yes/No)**	**Mitigation Type**	**Mitigation Completed (Yes/No)**
			Stream Bottom	**10-Year Flood**	**50-Year Flood**	**100-Year Flood**	**500-Year Flood**					
TOLEDO SCHOOL DISTRICT												
Cowlitz Prairie Academy		132	86.7	103.4	104.6	105.6	108.4	N/A	Nil	No		
District Offices		128	86.7	103.4	104.6	105.6	108.4	N/A	Nil	No		
Toledo Elementary School		105	87.6	102.3	103.5	104.5	106.8	N/A	Nil	No		
Concessions		105	87.6	102.3	103.5	104.5	106.8	124	Moderate	TBD	TBD	
Covered Play	No	105	87.6	102.3	103.5	104.5	106.8	124	Moderate	TBD	TBD	
ELF Building	No	105	87.6	102.3	103.5	104.5	106.8	124	Moderate	TBD	TBD	
Main Building	No	105	87.6	102.3	103.5	104.5	106.8	124	Moderate	TBD	TBD	
Portable	No	105	87.6	102.3	103.5	104.5	106.8	124	Moderate	TBD	TBD	
Toledo High School		225	94	109	110.4	111.4	114.4					
Concessions		225	94	109	110.4	111.4	114.4	N/A	Nil	No		
Greenhouse		225	94	109	110.4	111.4	114.4	N/A	Nil	No		
Main Building	No	225	94	109	110.4	111.4	114.4	N/A	Nil	No		
Stadium		225	94	109	110.4	111.4	114.4	N/A	Nil	No		
SW Outbuilding		225	94	109	110.4	111.4	114.4	N/A	Nil	No		
Toledo Middle School		148	86.7	103.4	104.6	105.6	108.4					
Classroom Bldg. (Bldg #2)	Yes	148	86.7	103.4	104.6	105.6	108.4	N/A	Nil	No		
District Garage/Shop		148	86.7	103.4	104.6	105.6	108.4	N/A	Nil	No		
District Storage										No		
Main Building (Bldg. #1)	Yes	148	86.7	103.4	104.6	105.6	108.4	N/A	Nil	No		
Playshed	No	148	86.7	103.4	104.6	105.6	108.4	N/A	Nil	No		
Wood Shop	No	148	86.7	103.4	104.6	105.6	108.4	2500	Nil	No		

[1] Flood return period is for flood reaching the first floor. Flood return period and flood risk level are calculated only if first floor elevation and either campus-level or building level flood elevations are entered. Building-level elevation data is used, if entered. If not, campus-level data is used. Building-level data provides more accurate flood risk assessment and are required for a FEMA mitigation grant application.

NOTE: The entries in Table 8.3 on the previous page have been edited from the values in the OSPI ICOS Database, ro incorporate more detailed district-specific information. The district has not experienced any damage at the campuses within FEMA-mapped floodplains in previous flood events.

8.4 Flood Hazard and Risk Assessments: Outside FEMA-Mapped Floodplains

Nationwide, more than 25% of flood damage occurs outside of FEMA-mapped floodplains. Campuses outside of FEMA-mapped floodplains may have significant flood risk if any of the following conditions apply:

- There is a history of floods from any source affecting or near a campus.
- Local storm water drainage flooding is common on or near a campus.
- Campus is near a river or stream not mapped by FEMA.
- Campus is on an alluvial fan subject to sheet flows.
- Campus is near a migrating river or stream.
- Campus is behind a levee or downstream of a dam or reservoir.
- A local flood hazard study is available for the campus and vicinity.

Guidance on evaluating flood hazards and risk for the above conditions is given in Chapter 10 in the Washington State K-12 Hazard Mitigation Plan and the OSPI Mitigation Planning Toolkit, and in the Hazard and Risk Assessments for School District Hazard Mitigation Plans: Technical Guidance Manual.

For flood-prone locations without quantitative flood hazard data, a different approach is required to evaluate flood hazards and flood risk than for locations where either a FEMA Flood Insurance Study or an equivalent local flood study provide the stream discharge and flood elevation data necessary for quantitative calculations. There are several possible options:

- For locations with a history of repetitive flooding, empirical estimates of the frequency (return period) of flooding can be made in two ways:
    - Using the FEMA Version 4.8 or Version 5.0 Benefit-Cost Analysis Damage-Frequency software, which is available for download on the FEMA website, along with guidance on using the software.
- For high value facilities where flood risk appears high, it may be worthwhile to have a local hydrologic and hydraulic study completed to obtain the types of quantitative flood hazard data contained in a FEMA Flood Insurance Study.

Such local studies may also be worthwhile when the FEMA Flood Insurance Study is old and there are reasons, such as increased development in the watershed, to suspect that flood hazards may have significantly increased.

- For locations subject to stormwater drainage flooding, engineers knowledgeable about the stormwater system may be able to provide quantitative data on the conveyance capacity of the system to supplement historical flood data. Stormwater systems are often designed to handle only 2-year or 5-year flood events, and are infrequently designed to handle rainfall events greater than 10-year or 15-year events.
- Estimating flood hazards and risks for locations behind levees or downstream from dams or reservoirs requires consultation with subject matter experts.

Evaluation of flood hazards and flood risk outside of mapped-floodplains necessarily requires more engineering experience and judgment than required to interpret the flood data in mapped riverine floodplains.

One important caveat is that the absence of a history of past flood events may indicate that flood risk is low, but this is not necessarily the case. Flood risk is inherently probabilistic. A campus that hasn't had a flood in 10, or 20 or 30 years may have just been "lucky" and flood damage might occur with floods of similar return periods. Or, the flood risk might have increased over time because of increasing development upstream in the watershed (which increases runoff) or because of channel changes. Or, a campus might not have frequent flooding, but the level of damages for a 50-year or 100-year event might be very severe.

Footnotes for Table 9.4:

[1]Estimate based on the number of flood events reported in the time period since flood records started. This value is calculated only if there are at least two flood events.

[2]Flood risk level is based on the estimated return period for flooding.

[3]Common mitigation measures for floods include: Elevation, Replacement, Flood Barriers or Minor Flood Proofing.

8.5 National Flood Insurance Program Insured Structures

The Toledo District has no NFIP insured structures.

8.6 Flood Mitigation Projects

For K-12 facilities with substantial levels of flood risk there are several types of potential flood mitigation measures available:

- Replacement of a facility at high risk from floods with a new facility located outside of flood hazard zones.
- Elevation of an existing building.
- Construction of levees, berms or flood walls to protect a facility.
- Installation of flood gates along with building water proofing measures.
- Minor floodproofing actions that address the most vulnerable elements in a facility; such projects include elevating at-grade utility infrastructure or relocating critical equipment or contents from basement levels of a building to higher levels.
- Local drainage improvements where stormwater drainage is a problem.

Replacing an at-risk facility with a new facility outside of flood hazards zones is essentially 100% effective in reducing future flood damages. A new replacement building also has other advantages such as energy efficiency and fully meeting current functionality requirements. Of course, the major impediment to widespread replacement is the cost.

The extent to which any of the above mitigation measures are warranted depends on the level of flood risk and on district priorities. For K-12 facilities at high flood risk, FEMA grant funding may be available for most of the flood mitigation measures noted above.

FEMA doesn't replace existing facilities, but does do acquisition/demolition projects in which the fair market value of a property is the total eligible project cost. FEMA-funded acquisition projects require demolition of the existing facility and deed restrictions to prevent future development of the area. Acceptable uses after demolition are limited to green space such as parks or sports fields with development limited to incidental structures such a restroom. With such projects, the FEMA funding, which is typically 75% of the total project costs, can be used towards building a replacement facility.

On a community or regional level, larger-scale flood control measures such as construction of upstream dams or detention basins and channel improvements may be effective in reducing flood risks. However, such larger-scale projects are outside the domain of responsibility for school districts.

The Toledo School Districts flood mitigation Action Items are shown in Table 8.5 on the following page.

Table 8.5
TOLEDO School District: Flood Mitigation Action Items

Hazard	Action Item	Timeline	Responsible Party	Plan Goals Addressed			
				Life Safety	Protect Facilities	Enhance Emergency Planning	Enhance Awareness and Education
Flood Mitigation Action Items							
Short-Term #1	Enhance emergency planning, including flood response measures such as sandbagging, for the Elementary School which has significant flood risk.	1-2 Years	Supt.	X	X	X	X
Short-Term #2	Evaluate the flood risk at the Elementary School to determine whether physical mitigation measures are desired and whether the District should have flood insurance for this school.	1-2 Years	Supt.	X	X	X	X
Short-Term #3	Obtain the dam failure inundation maps for the dams on the Cowlitz River impounding Mayfield and Riffe Lakes to evaluate the level of risk to the district's campuses and enhance evacuation planning as necessary.	1-2 Years	Supt.	X		X	X
Long-Term #1	Consider replacement of the Elementary School in lieu of future major remodeling or completing a major seismic retrofit, to locate a new school out of the floodplain.	1-2 Years	Supt.	X	X	X	X

8.7 References.

1. FEMA 480: National Flood Insurance Program, Floodplain Management Requirements, A Study Guide and Desk Reference for Local Officials. Available in hard copy and on CD from FEMA at: (800) 480-2520.