Sediment Maps Introduction

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This section presents a summary of the primary sedimentary units mapped during this part of the GWMA subsurface mapping effort.. This summary is subdivided into sections describing various Quaternary units, Plio-Pleistocene strata, and the Mio-Pliocene Ringold Formation. During the Quternary Period (approximately 2 million years ago to the present) the GWMA region experienced a variety of geologic events. These included the formation of the modern river drainages (commonly in pre-existing channels), cutting of the unique coulee landscape that characterizes so much of the region, formation of the caliche hardpan common to many upland areas (commonly superimposed on older caliche), accumulation of vast fields of wind-blown silt and sand (loess and sand dunes), and the continued slow uplift of the major east-west ridges that dominate the skylines of the western part of the GWMA. As one might surmise from this history, the strata formed in association with these events can have complex relationships, and in many cases are difficult to differentiate. Nevertheless, it is possible to reliably identify strata associated with these different events, group them into map units defined on the basis of unique physical characteristics, and use this information to interpret the subsurface distribution of these strata. Publicly available geologic literature provides the information needed to identify and map Quaternary units throughout the GWMA. Using this information, the two most widespread Quaternary units are the silt, sand, and gravel of the Pleistocene Cataclysmic Flood deposits and the silt and fine sand (loess) of the Palouse Formation. Largely uncemented, typically poorly indurated, well-stratified interbedded silt and sand, sand, gravelly sand, and pebble to boulder gravel is present across much of the region. Published geologic maps and reports show these materials form the uppermost geologic unit beneath many of the flat lowland areas common in the western part of the GWMA and they partially fill many of the coulees which cut across the eastern part of the GWMA. These strata have been interpreted as having been deposited by the Pleistocene Cataclysmic Floods that were released from glacial Lake Missoula periodically between approximately 1,000,000 and 12,000 years ago. Where present, Pleistocene Cataclysmic Flood deposits range from a few feet (<1 m) thick to more than 200 feet (+60 m) thick. Pleistocene Cataclysmic Flood deposits, also known informally as the Hanford formation in the southern part of the GWMA in the Pasco Basin, are commonly divided into three basic sediment types (facies) which commonly form the basis for subdividing the flood deposits into map units. Intercalated, well stratified silt and fine to coarse grained sand forming normally graded (fining upwards) beds that range from inches (few centimeters) to several feet (tens of centimeters) thick. This facies, also known as Touchet beds, is not widespread in the GWMA, being found predominantly on highland surfaces (ridges) and localized in small valleys tributary to the larger coulees. Laminated to massive, uncemented, felsic to basaltic, fine- to very coarse-grained sand. These sands can contain thin, lenticular silt to fine gravel interbeds. Where the silt content is low, a well sorted and open-framework texture is common. Where the basalt content in these deposits is high, they are often referred to as “black sands” because of the dark gray to black color caused by the high basalt content. This facies forms thick sheets beneath many of the broad, flat, lowland land surfaces in parts of Grant County (near Mattawa and the western Quincy Basin) and Franklin County (north of Pasco).Well-stratified to massive, uncemented, unweathered, mixed lithology (although basalt content is usually high) pebble to boulder gravel. Interstitial matrix in this facies generally ranges from absent to predominantly coarse sand and granules. Where these strata contain little or no matrix sand they commonly have an open framework texture where open intergranular pores are readily apparent to the unaided eye. This facies may be locally muddy, although such fine content does not appear to be widespread. Flood-deposited gravel commonly is referred to and mapped as the “Pasco gravel”. Flood gravel facies are found most commonly on the floors of Scabland coulees (including Cow Creek, Lind, Esquatzel, and Washtucna Coulees, and Crab Creek), the mouths of coulees (such as the Banks Coulee), comprising large terraces and flatlands (e.g., in the Mattawa, Quincy/Ephrata, Adams Dryland, and Moses Lake areas), and along the tracts of the Columbia and Snake Rivers. Also, this facies commonly is found interstratified with the sand facies. Another feature common to the flood deposits is clastic dikes. Clastic dikes usually consist of alternating vertical to subvertical layers of silt, sand, and granule gravel less than 0.5 in (~1 cm) up to 6 ft (2 m) thick. Clastic dikes typically cross cut bedding, although they do locally parallel bedding. Where dikes intersect the ground surface, a polygonal feature visible from the air and known as “patterned ground” is observed. Clastic dikes are generally best developed in the interstratified silt and sand facies and to a lesser extent in the sand-dominated facies. Palouse FormationsThe rolling hills adjacent to the coulees cross-cutting northern Grant County, eastern Franklin County, and the majority of Adams County are composed of a sequence of massive to poorly stratified, light colored, silt and very fine sand (Figure 9). These strata commonly are pedogenically altered (e.g., display evidence of soil forming processes, including animal burrow and root casts), in some areas contain air fall ash, and display evidence of multiple, stacked and superimposed soil horizons reflecting subtle changes in climate and erosion conditions in the region during the Quaternary. Caliche can be present in these strata. These strata, commonly referred to as loess, comprise the Palouse Formation or Palouse loess.The fine-grained material comprising the Palouse Formation generally is thought to consist of glacial “rock flour”. The source of this rock flour is thought to be the Cordilleran and Continental ice sheets. This rock flour was transported and deposited in the GWMA region by glacial melt waters (possibly including cataclysmic floods). Following deposition, the rock flour was reworked (transported) and deposited by wind across much of the GWMA region. Airfall ash found intermittently within the loess came from volcanic eruptions in the Cascade Range. Caliche, where found in the loess, suggests semi-arid conditions periodically occurred throughout the GWMA in the Quaternary. Across the GWMA, loess deposits generally are absent in scabland coulees and modern active river valleys. Because scabland coulees incise through the loess, and commonly into underlying basalt bedrock, much of the loess found in the Columbia Basin predates the later stages of the Pleistocene Cataclysmic Floods and resulting scabland erosion. Loess deposits adjacent to eroded scabland features may range from less than 1 ft (<0.3 m) to more than 225 feet (+75 m) thick in many of the dryland farming areas of the eastern GWMA. In the Columbia Basin, Baker and others (1991) identify multiple loess units

that range in age from more than 1 million years in age to less than 10,000 years in age. Other Quarternary Strata In addition to the two main Quaternary units summarized above, a variety of less widespread Quaternary units are found in the GWMA. These strata consist of a mix of silt, sand, and gravel deposited adjacent to slopes and on alluvial fans by debris flows, by fluvial processes along stream courses, and by wind before and after the Pleistocene Cataclysmic Floods. The main localized Quaternary units found within the GWMA are summarized below: Alluvium: This unit predominantly consists of (1) river deposited silt, sand, and gravel adjacent to modern streams including, but not limited to, the Columbia, Snake, and Palouse Rivers and (2) debris flow deposits on alluvial fans adjacent to topographic highlands like the Saddle Mountains. Alluvium commonly consists of basalt and reworked Pleistocene Cataclysmic Flood deposits which commonly are basaltic. Given this, alluvial deposits may be difficult to differentiate from cataclysmic flood deposits and they may have similar overall physical characteristics. Alluvium can range from matrix rich to matrix poor. Colluvium: This unit generally consists of rocky and blocky debris found at the base of slopes, including the steep sides of the large hill systems (Saddle Mountains, Beezely Hills, etc.) and coulee walls found in the GWMA. Colluvium generally is derived from weathering and mass wasting of the bedrock comprising the higher slopes of these landform features. Given that basalt forms the predominant bedrock of the region, colluvium in the GWMA is overwhelmingly composed of basalt debris. Except in outcrops where bedforms and its blocky nature can be readily identified, basalt colluvium may be very difficult to differentiate from basaltic cataclysmic flood deposits. Landslide deposits: Landscapes marked by hummocky topography are present locally along the slopes of the Saddle Mountains and Frenchman Hills and adjacent to the Columbia River. These landscapes are the products of large landslides off the adjacent uplands. Consequently, these deposits consist of a mix of material derived from the adjacent uplands, most commonly basalt debris mixed with loess and flood deposits.Quaternary sand dunes: This unit typically consists of unconsolidated and uncemented, Holocene-aged (post-Cataclysmic Flood), very fine- to medium-grained sand that forms both active and stabilized sand dunes. Quaternary dune sand generally is much coarser than Palouse Formation loess. Quaternary sand dunes are common around Moses Lake, Potholes Reservoir, and in east-central Franklin County. Small localized accumulations (covering a few acres) and thin (<3 feet) surface layers of dune sand (both active and inactive) can be found almost anywhere in the GWMA. The other Quaternary deposits typically are localized and generally thin, and except where outcrops are present they may be difficult to differentiate from the two predominant Quaternary units summarized previously. Plio-Pleistocene StrataPlio-Pleistocene strata consist of a range of lithologies similar to the younger Quaternary strata, but generally more cemented and indurated. Regionally, Plio-Pleistocene strata can be divided into four basic types (or facies): 1) calcium carbonate rich strata (also referred to as caliche), 2) basaltic alluvial deposits, 3) stratified silt, and 4) massive silt. Of these, the later three usually can be distinguished from younger deposits if outcrops are available for examination. However, without good maps or outcrop descriptions it is very difficult to identify these strata. For this report they are not identified. Only caliche was found to be easily recognizable in the primary source of information used for subsurface mapping for this project, water well drillers logs. Caliche, generally a pedogenic calcium carbonate deposit, is a common lithology found across many of the upland areas of the GWMA that were not deeply eroded by Pleistocene Cataclysmic Floods. However, caliche generally has not been mapped by previous investigators and it is not shown on existing geologic maps. For this project, caliche was mapped because it forms a generally easily recognized marker horizon on most water well drillers well logs.Caliche found in the GWMA usually consists of a thin, less than 10 foot (<3 m) thick, sequence of laterally discontinuous calcium carbonate (Figures 10 and 11) developed on, and incorporating material derived from, older fluvial, alluvial, eolian, colluvial, and lacustrine deposits and bedrock (basalt) units. Where present (e.g., where not removed by Pleistocene Cataclysmic Flood erosion) the unit is most commonly developed on either the Ringold Formation or Columbia River basalt. Individual horizons within the unit are laterally discontinuous, and alternating carbonate-rich and carbonate-poor intervals are common. The unit itself can be very widespread, being found across upland areas beneath thin veneers of wind blown sand and in some lowland areas where flood erosion has not deeply incised into underlying strata, most notably the Quincy Basin. Ringhold FormationA widespread sequence of indurated clay, silt, sand, and gravel (conglomerate) is found in the lowland areas common to the western and southern portion of the GWMA, especially in Franklin and Grant Counties. These indurated sediments are mainly found in the Pasco Basin south of the Saddle Mountains, between the Saddle Mountains and Frenchman Hills (in a structural low designated here the Othello Basin), and in the Quincy Basin between the Beezley Hills and Frenchman Hills (Figure 1). These sediments typically consist of well-stratified siltstone/claystone, pedogenically altered mudstone and sand, felsic fine to coarse grained sand, and multi lithologic, variably indurated granule to cobble. These strata are assigned to the approximately 10.5 to 3 million year old Ringold Formation.The Ringold Formation is divided into three informal members, or map units (Figure 2), each dominated by different facies associations. These members record the evolution of the ancestral Columbia River system in the GWMA region, and are referred to as the:Member of Savage Island: This member consists predominantly of planar-tabular, lacustrine sand and silt with diatomaceous intervals. This member records deposition in a series of lakes that formed near the end of Ringold deposition between 5 and 3 million years ago. The member of Savage Island is inferred to overlie both other Ringold members throughout the GWMA.Member of Taylor Flat: This member consists predominantly of sand found in elongated channel deposits intercalated with large silt paleosol intervals. It is interpreted to record deposition predominantly in sand-transporting river channels migrating across muddy flood plains. This member may be widespread across the GWMA region and it may be as old as 10 million years (or more) to as young as 3 to 4 million years old. Much of the Ringold Formation mapped in Grant County and Adams County probably belongs to this member.Member of Wooded Island: This member consists predominantly of gravelly strata with intercalated sand and silt paleosol intervals. The member is interpreted to reflect deposition in gravel-transporting river systems and adjacent flood plains and overbank areas. These rivers are thought to have formed broad, braided channels migrating across a gravelly plain. The member occurs in western Franklin and southern Grant Counties, forms the majority of the lower half of the Ringold Formation in Franklin

County, and comprises much of the oldest part of the Ringold, generally being more than approximately 5.5 million years old. Generally, Ringold Formation units thin and become more clay- and silt-rich to the northeast and east across the GWMA. This trend suggests the river system(s) that deposited the sand and gravel portions of the Ringold Formation become more common from the eastern to the western and central part of the GWMA region. Data Sources and MethodologyThe maps produced for this project were built from information found in data sources describing both surface and subsurface geologic conditions. Data sources used for the study include driller’s logs, field notes and borehole geologic logs compiled by geologists, borehole geophysical logs that have been collected for a number of municipal water supply wells and large private irrigation wells, and geologic maps compiled for the region and for specific areas. Specific entities and agencies from which these materials were collected include the following: Washington Department of Ecology (WADOE): The WADOE Eastern Region office in Spokane, Washington, is the primary source for drillers’ logs for the GWMA area. Electronic copies of the drillers’ logs were provided by WADOE as .jpg files on CD’s and compiled from Ecology’s online well log files. Franklin Conservation District (FCD) staff also provided paper copies for most drillers’ logs for wells in Franklin County and for all wells used as GWMA water quality sampling locations. U.S. Bureau of Reclamation (USBR): USBR records provided geologists’ logs for several hundred geotechnical borings and water wells drilled in the region. These records include copies of original interpreted logs maintained in USBR archives and records. Hanford project files: Kennedy/Jenks Consultants staff has access to personal files and records kept during previous work at the Hanford Site. These files and records include geologists’ well logs and outcrop logs for a number of locations in and near the GWMA. Published geologic maps and cross sections: Available geologic maps of the GWMA provided constraints on identification of geologic units, interpretation of geologic unit thicknesses and pinchouts, and determination of the presence and magnitude of faults and folds. The majority of the geologic maps used in this study are published by the U.S. Geological Survey or the Washington Department of Natural Resources, Division of Geology and Earth Resources. Dr. Lindsey’s post-doctoral research files: In addition to the data sources listed above, personal files, field notes, and knowledge were additional important sources of information. Dr. Lindsey, the project manager and technical lead for this project, compiled data on the Ringold Formation and equivalent units during post-doctoral research and provided this information.