

1.0 BASE LEVEL ENGINEERING GEODATABASE

1.1 OVERVIEW

The BLE geodatabase consists of three types of data: spatial data (feature classes), tabular data (database tables), and gridded data (rasters). Additionally, the spatial data is grouped into four themes (feature datasets) based on function and interconnectivity with other related FEMA datasets in this study, such as the Flood Risk Database (FRD) and the DFIRM Database, as well as the Coordinated Needs Management Strategy (CNMS) program.

The BLE Database does not represent a flood risk study, but is intended to serve as a data- and model-based foundation for future flood risk studies as well as to assist communities in better determining their flood risk by providing *estimated* base flood elevations (BFEs). The primary means of achieving this goal is through the *Estimated Base Flood Elevation Viewer* (<https://apps.fema.com/estbfe>).

Some of the data files in the geodatabase exactly match corresponding data files in other related FEMA datasets, while others are based on corresponding data files in other related FEMA datasets but have been modified for use with the *Estimated Base Flood Elevation Viewer*. These modifications are necessary since the automated processes create a foundational dataset for future studies, but do not meet minimum requirements themselves. For example, it is inappropriate to label a flood zone delineated by automated processes as Zone A, rather it can be described by its relative risk. These data files are described below.

1.2 BASE LAYERS

1.2.1. S_FRD_POL_AR

Flood Risk Database Political Areas: This polygon feature class is the combination of the S_Pol_Ar feature class from all FIRM databases in the project area. It shows political area boundaries and includes community-specific data. This feature class matches the S_FRD_Pol_Ar feature class in the FRD. For additional information, see the *Flood Risk Database (FRD) Technical Reference*.

1.2.2. S_HUC_AR

Hydrologic Unit Code Areas: This polygon feature class depicts the watersheds in and around the project area. It shows watershed boundaries and includes identifying information about these watersheds. This feature class matches the S_HUC_Ar feature class in the FRD. For additional information, see the *Flood Risk Database (FRD) Technical Reference*.

1.3 CNMS LAYERS

1.3.1. S_STUDIES_LN

Studies Lines: This polyline feature class depicts stream reaches recorded and assessed as part of the CNMS program. This feature class matches the S_Studies_Ln feature class in the CNMS database. For additional information, see the *Coordinated Needs Management Strategy (CNMS) Technical Reference*.

1.3.2. S_UNMAPPED_LN

Unmapped Lines: This polyline feature class depicts stream reaches known to FEMA but which have not been assessed or mapped on a FIRM. This feature class matches the S_Unmapped_Ln feature class in the CNMS database. For additional information, see the *Coordinated Needs Management Strategy (CNMS) Technical Reference*.

1.4 EBF LAYERS

1.4.1. DTL_STUD_AR

Detailed Studies Areas: This polygon feature class was created for the purposes of the *Estimated Base Flood Elevation Viewer*, and identifies areas that have detailed study depicted on the current effective Flood Insurance Rate Map (FIRMs) that may be available in portions of the study area. Additionally, it can also show areas of new detailed study that are currently in process and not yet effective, and which will be shown on updated FIRMs which may also be updated based on studies launched from the BLE dataset. It includes FIRM panel numbers where detailed studies are located, effective dates of the detailed study, the production stage of the detailed study (e.g. Preliminary, Effective, etc.), contact information for inquiries about the detailed study, and LOMR information for areas revised by Letters of Map Revision. Its purpose is to indicate to users of the *Estimated Base Flood Elevation Viewer* that flood data more detailed than the estimated base flood elevations produced by the automated processes are available.

1.4.2. DTL_STUD_LN

Detailed Studies Lines: This polyline feature class was created for the purposes of the *Estimated Base Flood Elevation Viewer*, and identifies stream reaches that have detailed study depicted on the current effective Flood Insurance Rate Map (FIRMs) that may be available in portions of the study area. Additionally, it can also show reaches of new detailed study that are currently in process and not yet effective, and which will be shown on updated FIRMs which may also be updated based on studies launched from the BLE dataset. It includes FIRM panel numbers where

detailed studies are located, effective dates of the detailed study, the production stage of the detailed study (*e.g.* Preliminary, Effective, *etc.*), contact information for inquiries about the detailed study, and LOMR information for areas revised by Letters of Map Revision. Its purpose is to indicate to users of the *Estimated Base Flood Elevation Viewer* that flood data more detailed than the estimated base flood elevations produced by the automated processes are available.

1.4.3. FLD_HAZ_AR

Flood Hazard Areas: This polygon feature class is based on the S_Fld_Haz_Ar feature class (*q.v.*) in the DFIRM database, but has been modified for use with the *Estimated Base Flood Elevation Viewer*. It contains information about flood risks in the study area and their geographic extents. This feature class includes an additional field EST_RISK (Estimated Risk) which substitutes in the *Estimated Base Flood Elevation Viewer* for the Flood Zone. Values in the EST_RISK field include:

- High, which corresponds to areas of 1 Percent Annual Chance Flood Hazard
- Moderate, which corresponds to areas of 0.2 Percent Annual Chance Flood Hazard; and
- Low, which corresponds to Areas of Minimal Flood Hazard.

Twelve fields, while populated in the database, are hidden in the *Estimated Base Flood Elevation Viewer*. For complete details on modifications to this feature class and which fields are visible to users, see the *Base Level Engineering, Region 6 Submittal Guidance*.

1.4.4. SUBBASINS

Subbasins: This polygon feature class is based on the S_Subbasins feature class (*q.v.*) in the DFIRM database, but has been modified for use with the *Estimated Base Flood Elevation Viewer*. It collects data and calculations used in the preparation of Base Level Engineering hydrology, which uses the Regional Regression Equations to calculate the flow volumes expected throughout study reaches. This feature class includes several additional fields:

- US_1 (Upstream Basin 1)
- US_2 (Upstream Basin 2)
- US_3 (Upstream Basin 3)
- US_4 (Upstream Basin 4)
- PRECIP_IN (Precipitation in Inches)
- MAINCHSL (Main Channel Slope)
- E_Q_10PCT (Estimated Discharge of the 10-percent-annual-chance Event)
- E_Q_04PCT (Estimated Discharge of the 4-percent-annual-chance Event)

- E_Q_02PCT (Estimated Discharge of the 2-percent-annual-chance Event)
- E_Q_01PCT (Estimated Discharge of the 1-percent-annual-chance Event)
- E_Q_01PLUS (Estimated Discharge of the 1-percent-plus-annual-chance Event)
- E_Q_01MIN (Estimated Discharge of the 1-percent-minus-annual-chance Event), and
- E_Q_0_2PCT (Estimated Discharge of the 0.2-percent-annual-chance Event).

Four fields, while populated in the database, are hidden in the *Estimated Base Flood Elevation Viewer*. For complete details on modifications to this feature class and which fields are visible to users, see the *Base Level Engineering, Region 6 Submittal Guidance*.

1.4.5. TENPCT_FP

Ten Percent Floodplain: This polygon feature class is based on the S_Fld_Haz_Ar feature class (*q.v.*) in the DFIRM database, but has been modified for use with the *Estimated Base Flood Elevation Viewer*. It contains information about the 10-percent-annual-chance-flood event flood risks in the study area and their geographic extents. This feature class includes an additional field EST_RISK (Estimated Risk) which substitutes in the *Estimated Base Flood Elevation Viewer* for the Flood Zone. Values in the EST_RISK field include:

- Extreme.

Thirteen fields, while populated in the database, are hidden in the *Estimated Base Flood Elevation Viewer*. However, since the 10-percent-annual-chance flood event is not reflected in any established flood zone, most fields are populated with null values. For complete details on modifications to this feature class and which fields are visible to users, see the *Base Level Engineering, Region 6 Submittal Guidance*.

1.4.6. WTR_AR

Water Areas: This polygon feature class is based on the S_Wtr_Ar feature class (*q.v.*) in the DFIRM database, but has been modified for use with the *Estimated Base Flood Elevation Viewer*. It contains information about and depicts the locations of waterbodies throughout the study area and/or those included in the automated hydrologic and hydraulic modeling. Two fields, while populated in the database, are hidden in the *Estimated Base Flood Elevation Viewer*.

1.4.7. WTR_LN

Water Lines: This polyline feature class is based on the S_Wtr_Ln feature class (q.v.) in the DFIRM database, but has been modified for use with the *Estimated Base Flood Elevation Viewer*. It contains information about and depicts the locations of streams and stream reaches throughout the study area and/or those included in the automated hydrologic and hydraulic modeling. Two fields, while populated in the database, are hidden in the *Estimated Base Flood Elevation Viewer*.

1.4.8. XS

Cross Sections: This polyline feature class is based on the S_XS feature class (q.v.) in the DFIRM database, but has been modified for use with the *Estimated Base Flood Elevation Viewer*. It contains information about and depicts the locations of streams and stream reaches throughout the study area and/or those included in the automated hydrologic and hydraulic modeling. Two fields, while populated in the database, are hidden in the *Estimated Base Flood Elevation Viewer*.

1.5 MITIGATION LAYERS

1.5.1. S_AOMI_PT

Areas of Mitigation Interest Points: This point feature class depicts the location of hydraulic structures (inline structures, dams, weirs, culverts, bridges, *etc.*) and other types of locations that may be used to refine future hydraulic models and mapping efforts. This feature class matches the S_FRD_Pol_Ar feature class in the FRD. For additional information, see the *Flood Risk Database (FRD) Technical Reference*.

1.5.2. S_CENBLK_AR

Census Block Areas: This polygon feature class contains the spatial location of census blocks intersecting the study area. It contains basic inventory and population data that is used as the basis for flood risk assessments in Hazus or similar software. This feature class matches the S_FRD_Pol_Ar feature class in the FRD. For additional information, see the *Flood Risk Database (FRD) Technical Reference*.

1.6 GRIDS

1.6.1. BLE_DEP01PCT

Depth 1 Percent: This raster dataset depicts the estimated flood water depth for the 1-percent-annual-chance flood event within the 1-percent-annual-chance floodplain as determined by the automated methods of the Base Level Engineering assessment.

1.6.2. BLE_DEP0_2PCT

Depth 0.2 Percent: This raster dataset depicts the estimated flood water depth for the 0.2-percent-annual-chance flood event within the 0.2-percent-annual-chance floodplain as determined by the automated methods of the Base Level Engineering assessment.

1.6.3. BLE_WSE01PCT

Water Surface Elevation 1 Percent: This raster dataset depicts the estimated water surface elevation (or *estimated base flood elevation*) for the 1-percent-annual-chance flood event within the 1-percent-annual-chance floodplain as determined by the automated methods of the Base Level Engineering assessment.

1.6.4. BLE_WSE0_2PCT

Water Surface Elevation 0.2 Percent: This raster dataset depicts the estimated water surface elevation (or *estimated base flood elevation*) for the 0.2-percent-annual-chance flood event within the 0.2-percent-annual-chance floodplain as determined by the automated methods of the Base Level Engineering assessment.

1.7 TABLES

1.7.1. L_RA_RESULTS

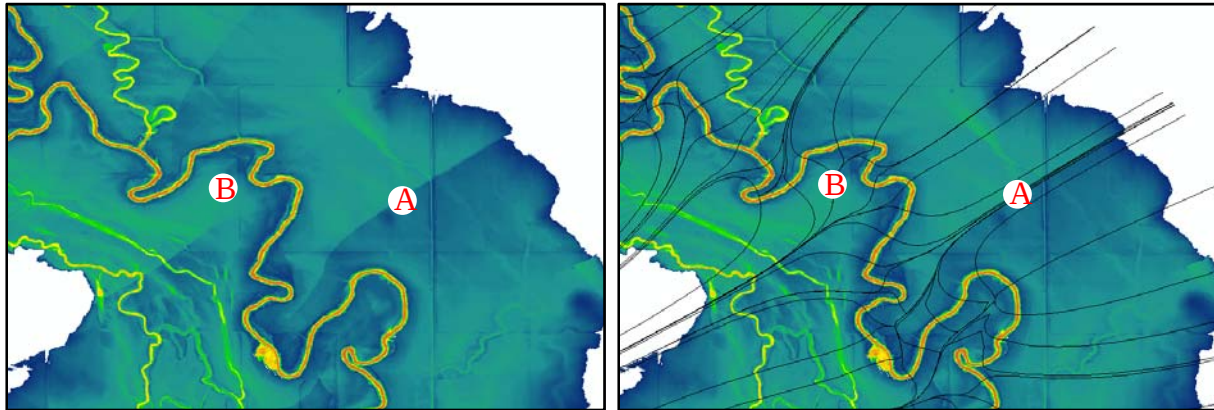
Risk Assessment Results: This table includes results from a flood risk assessment conducted in Hazus or similar software and are reported at the census block level. It is used in conjunction with the S_CenBlk_Ar feature class. This table matches the L_RA_Results table in the FRD. For additional information, see the *Flood Risk Database (FRD) Technical Reference*.

1.7.2. L_SOURCE_CIT

Source Citations: This table includes bibliographic data for references and data sources used in the compilation of the Base Level Engineering database. This table matches the L_Source_Cit table in the FIRM database and the FRD. For additional information, see the *Flood Insurance Rate Map (FIRM) Database Technical Reference* or the *Flood Risk Database (FRD) Technical Reference*.

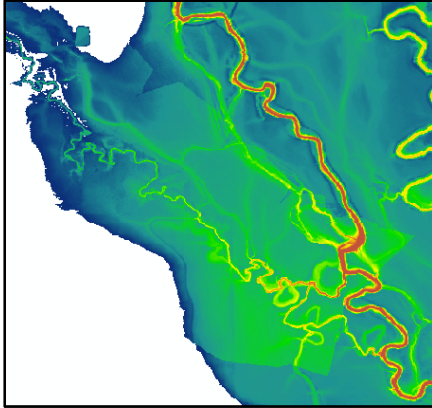
2.0 KNOWN ISSUES

Irregularities in depth values may appear in the depth grids due to parameters within the automated modeling. In most cases, these are caused by the orientation of cross sections as they were automatically created by the processing software. Per the rules of hydraulic modeling, cross sections must intersect the stream channel perpendicularly. And no irregularities are observed along or near the stream channel. However, in the overbank areas, which are sensitive to the orientation of cross sections, these irregularities appear. This is likely because in the overbank areas, flood waters are not flowing along the channel, but the cross sections are modeled as if they are. This becomes an issue in areas where the perpendicular requirement of cross sections along a highly meandering stream inside a wide floodplain causes cross sections to “bunch up” together. There are several possible ways to address this situation, but these may not be applicable for a low-level (base level) analysis and instead may be applicable for a full FIRM-level analysis or even a detailed analysis.



The image at left shows the depth grid without cross sections, so that these irregularities are easier to see. The image at right shows the depth grid with cross sections superimposed on it. Note that at Location A, the bunched up cross sections create an irregularity in the depth where the values change rather abruptly. Note that at Location B, where the cross sections near the channel and are no longer bunched up, these irregularities disappear.

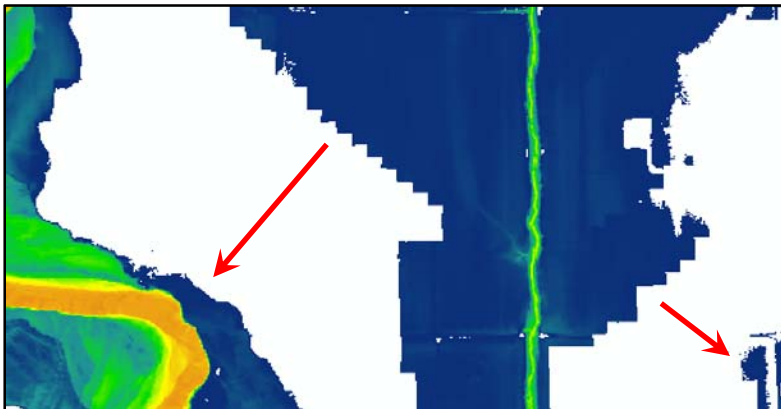
In other cases, irregularities appear at stream confluences. Generally, in hydraulic modeling, the main receiving stream has higher flows than tributary streams, and therefore exert backwater effects on these tributaries. However, in some portions of these watersheds, tributary streams have higher flows at their confluences with the main receiving stream than the main receiving stream itself. This is likely due to various factors such as geology, climate, contributing watershed area, floodplain geometry, and so on.



In this example, the tributary stream has a higher water surface elevation than the main receiving stream, and therefore backwater effects do not eliminate a “cliff” or “waterfall” in the water surface calculated by automated modeling. It appears here that this result may be influenced by the shared floodplain of the tributary and the main receiving streams.

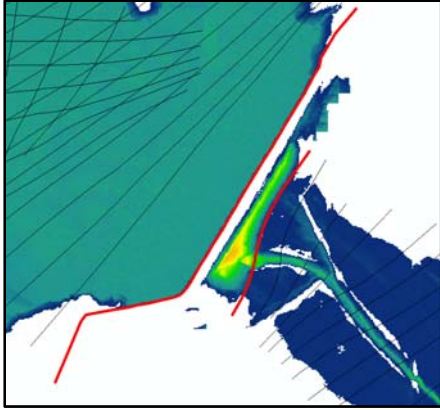
Efforts have been made to account for all manner backwater effects in the automated modeling, but the possibility still exists that this issue remains.

Next, in some areas, the automated modeling was unable to “close” a floodplain and determine a boundary. In most cases this appears to be the results of the limitations of automated 1D modeling that cannot account for split flows or areas of low topographic relief causing weir flow or sheet flow of water outside of a floodplain into another. These particular examples mentioned require 2D modeling to accurately determine flood prone areas subject to these conditions, which is usually reserved for detailed study areas, and is beyond the scope of low-level (base level) automated engineering methods. Other situations may also exist. In places where the model could not “close” a floodplain, usually because the water surface elevation did not intersect the ground on one side, the program eventually chose a location and stopped processing. This causes “stair step” boundaries to appear in the dataset, revealing which grid sectors were processed by the program and which were not.



“Stair step” boundaries caused by the program’s inability to “close” the floodplain. Note that the depths here are very shallow, usually less than six inches. It is possible that there may be weir flow or sheet flow into adjacent floodplains (indicated by red arrows), which is not included in basic 1D modeling.

Finally, values in the depth grids at dams are another irregularity. At some identified dam sites, automatically generated cross sections were not used, and instead an engineer manually added cross sections at the top and bottom of the dam structure. Depth values at dams between these two cross sections represent waterfall-type conditions and may show water depth deeper than it may actually occur. Again, at structures like dams, modeling the flow of water over or around dams and spillways is usually conducted for detailed studies and is beyond the scope of low-level (base level) analysis.



The cross sections at the top and bottom of this dam are indicated by heavy red lines. All others are indicated by thin black lines. Note that the water depths between the two dam cross sections, especially at the head of the channel at the foot of the dam, have higher depth values than elsewhere in the flood plain. These values may be erroneous. The cross sections do manage to pick up two tiny portions of the unmodeled spillway, located in the lower center portion of this image.

3.0 EXCEPTIONS AND SPECIAL CONSIDERATIONS

S FRD Pol Ar: Some fields, such as those relating to hazard declarations, flood policies, and hazard mitigation plans, are populated with null values since information for those fields is not available at this time.

S HUC Ar: No comments.

S Studies Ln: This feature class has no records since conducting a CNMS assessment is not included in the scope for this study.

S Unmapped Ln: This feature class has no records since conducting a CNMS assessment is not included in the scope for this study.

Dtl Stud Ar: Fields relating to point-of-contact information are populated with null values since this information is not available. Fields relating to LOMRs are populated with null values since no applicable LOMRs exist within the study area. Additionally, polygons covering the two HUC8 watersheds of the Canadian River and outside the BLE data area were added since this area is being studied separately by the United States Army Corps of Engineers. Their results are expected to be combined with the BLE assessment when the next map revision is made. Thus, to indicate this future detailed study, these polygons have been attributed with FIRM panel numbers with the next (future) suffix and a null value for the effective date.

Dtl Stud Ln: Fields relating to point-of-contact information are populated with null values since this information is not available. Fields relating to LOMRs are populated with null values since no applicable LOMRs exist within the study area. Additionally, polylines extracted from the National Hydrography Dataset and representing the Canadian River were added, since this area is being studied separately by the United States Army Corps of Engineers. Their results are expected to be combined with the BLE assessment when the next map revision is made. Thus, to indicate this future detailed study, these polylines have been attributed with FIRM panel numbers with the next (future) suffix and a null value for the effective date.

Fld Haz Ar: Automated processing usually produces “dirty” areas and “noise”, such as including small, low-lying areas adjacent to a flood zone as being in the flood zone even if they are not hydrologically connected to it. Additionally, it can generate polygons that are near-microscopic in size. To correct for these issues, to “clean” the dataset, and to conform to general FEMA mapping standards, polygons smaller than 1 acre in size (43,560 square feet) have been eliminated. Additionally, the largest polygon representing the area of “low” flood risk and analogous to “Area of Minimal Flood Hazard” could not be shown as a single polygon due to exceeding the vertex limit in ArcGIS. Thus, it has been divided into smaller polygons at HUC8 boundaries, and along major streams that divide the study area into approximate quadrants. Finally, the area within the Canadian River drainage and that is being studied by the United States Army Corps of Engineers is shown as *Zone D only for BLE database purposes*. However, in the *Estimated Base Flood Elevation Viewer*, flood zone designations are not shown and users will only see this area as “low” flood risk.

Subbasins: This feature class has no records since the automated processes used do not generate subbasins as part of its hydrologic modeling.

TenPct_FP: Automated processing usually produces “dirty” areas and “noise”, such as including small, low-lying areas adjacent to a flood zone as being in the flood zone even if they are not hydrologically connected to it. Additionally, it can generate polygons that are near-microscopic in size. To correct for these issues, to “clean” the dataset, and to conform to general FEMA mapping standards, polygons smaller than 1 acre in size (43,560 square feet) have been eliminated

Wtr_Ar: This feature class has no records since waterbodies with static elevations were not used in the hydraulic modeling.

Wtr_Ln: Water line features were taken directly from the profile base lines in the hydraulic modeling. These lines were previously refined to the terrain data as described in Section 2.3 above. However, for hydraulic modeling purposes it was necessary for these profile base lines to extend for some distance beyond the downstream confluence (mouth) of the stream. This creates overlapping features for most streams in the study area. For the Wtr_Ln feature class, these polylines were edited to remove these overlaps, and stream lines end at their downstream confluences. Stream names were taken from the National Hydrography Dataset or from published FIRMs. Name identifiers were not generated for unnamed streams. However, each stream, whether named or unnamed, has a unique Model ID, which is recorded in the corresponding XS file.

XS: Cross sections were extracted directly from the hydraulic modeling. Start ID points and cross sections letters were not identified for the Base Level Engineering database. Due to the density of the cross sections generated by the automated processes, not every cross section is attributed as “Mapped” (it will be visible in the *Estimated Base Flood Elevation Viewer*). Any cross section affected by backwater effects in the modeling (where the water surface elevation value in the cross section is different from the value in the water surface elevation grid at that location) is attributed as “Not Mapped” (it will not be visible in the *Estimated Base Flood Elevation Viewer*). Thereafter, every fourth cross section on a stream is shown as “Mapped” and the intervening three cross sections are shown as “Not Mapped”.

S_AOMI_Pt: Dam features within this feature class were obtained from the Oklahoma Water Resources Board. The source metadata indicates the spatial accuracy of the data “is low” and a reference scale value is not provided. Thus, the scale value for this reference is not populated in the L_Source_Cit table. Where possible the dam points were snapped to the water line at the top of the dam structure as it is visible in the terrain data. If a dam was located elsewhere not on a modeled stream, its location was placed at the top of the dam where the thalweg would otherwise intersect it. If a dam was not visible in the terrain data (e.g. dams located in the Canadian River drainage), it was refined in the same way using aerial photography. Road crossing locations were not generated within the Canadian River drainage basin because the extents of the Canadian River model being developed by the United States Army Corps of Engineers is unknown at this time.

S_CenBlk_Ar: No comments.

BLE_Dep01Pct: Per FEMA Region 6 guidance, the BLE database uses a geographic projection system, but grid data are to be in Universal Transverse Mercator projection. Grid data, therefore are in the UTM projection. The 1-percent-annual-chance event depth grid has been clipped to match the cleaned 1-percent-annual-chance event boundaries shown in the Fld_Haz_Ar feature class. Per FEMA guidance, cell values have been rounded to the nearest 0.1 foot. Cell values that rounded down to 0.0 feet were rounded up to 0.1 feet instead.

BLE_Dep0_2Pct: Per FEMA Region 6 guidance, the BLE database uses a geographic projection system, but grid data are to be in Universal Transverse Mercator projection. Grid data, therefore are in the UTM projection. The 0.2-percent-annual-chance event depth grid has been clipped to match the cleaned 0.2-percent-annual-chance event boundaries shown in the Fld_Haz_Ar feature class. Per FEMA guidance, cell values have been rounded to the nearest 0.1 foot. Cell values that rounded down to 0.0 feet were rounded up to 0.1 feet instead.

BLE_WSE01Pct: Per FEMA Region 6 guidance, the BLE database uses a geographic projection system, but grid data are to be in Universal Transverse Mercator projection. Grid data, therefore are in the UTM projection. The 1-percent-annual-chance event water surface elevation grid has been clipped to match the cleaned 1-percent-annual-chance event boundaries shown in the Fld_Haz_Ar feature class. Per FEMA guidance, cell values have been rounded to the nearest 0.1 foot. Cell values that rounded down to 0.0 feet were rounded up to 0.1 feet instead.

BLE_WSE0_2Pct: Per FEMA Region 6 guidance, the BLE database uses a geographic projection system, but grid data are to be in Universal Transverse Mercator projection. Grid data, therefore are in the UTM projection. The 0.2-percent-annual-chance event water surface elevation grid has been clipped to match the cleaned 0.2-percent-annual-chance event boundaries shown in the Fld_Haz_Ar feature class. Per FEMA guidance, cell values have been rounded to the nearest 0.1 foot. Cell values that rounded down to 0.0 feet were rounded up to 0.1 feet instead.

L_RA_Results: This table has no records since conducting a flood risk assessment is not included in the scope for this study. This assessment is scheduled to be conducted at a later time.

L_Source_Cit: No comments.

4.0 REFERENCES

Federal Emergency Management Agency; *Base Level Engineering, Region 6 Submittal Guidance*; Denton, TX; June 2017.

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Federal Emergency Management Agency; *Flood Insurance Rate Map (FIRM) Database Technical Reference*; Washington, DC; May 2016.

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United States Geological Survey; *Watershed Boundary Datasets*; Washington, DC; September 30, 2016.

United States Geological Survey, National Geospatial Program; *National Hydrography Dataset*; Reston, VA; September 1, 2017.