# Application of the Large Woody Debris Index: A Field User Manual

StreamMechanics

EPR Ecosystem Planning & Restoration

# Application of the Large Woody Debris Index:
# A Field User Manual
# Version 1

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# 1. Purpose and Background

Large Woody Debris (LWD) is defined as a dead piece of wood that is at least 10 cm in diameter and at least one-meter long. Wood of this size and larger can remain in the stream channel for years and plays an important role in shaping channel form and influencing function. Larger pieces that remain in place for long periods of time have a greater effect on channel morphology than smaller, transient pieces. Long lasting woody debris: 1) enhances bed form diversity by creating scour pools and increasing depth variability; 2) sorts sediments by altering localized water surface slopes; 3) increases variability in channel velocities; and 4) traps organic matter like leaves and sticks. These effects are essential in creating diverse in-stream habitats for macroinvertebrates and fish.

Although there are many LWD assessment methods, the Large Woody Debris Index (LWDI) has been included in the Stream Quantification Tool (Harman and Jones, 2017a). The LWDI is from the U.S. Forest Service (USFS) General Technical Report *Monitoring Wilderness Stream Ecosystems* (Davis et al., 2001). While the LWDI was developed for remote wilderness streams, the Stream Quantification Tool (SQT) applies the method to assess LWD as a function-based parameter of geomorphology in impacted and restored stream reaches. This method is appealing for use in stream assessments related to restoration because it is more robust than simply counting pieces per unit length. The additional detail provides a link between structural assessment and function. The LWDI requires only a moderate level of effort, is not overly complex, and is somewhat rapid. For instance, a 100-meter assessment takes about one hour or less for typical amounts of wood.

The instructions detailing the LWDI method in the original manual are brief and leave room for interpretation and subjectivity in scoring LWD. This manual will summarize the USFS methodology as described by Davis et al. (2001) and expand on the published methods to reduce subjectivity while collecting field data.

### 1.1 Overview of the LWDI

The USFS Forest Service, Rocky Mountain Research Station developed a methodology to assess the psychical, chemical, and biological aspects of stream ecosystems (Davis et al., 2001). The methodology was developed to evaluate wilderness streams in the remote backcountry where other methods may be difficult or prohibited. In this methodology, LWD within a stream reach is characterized according to how likely the LWD is to retain organic matter, provide fish habitat, and affect channel/substrate stability. The LWDI is calculated by scoring every piece of large wood and debris dam within a reach based on multiple characteristics that determine how well the piece or dam functions.

*"Large woody debris is described as the organic matter over 1 meter in length and at least 10 cm in diameter at one end (sticks to logs). When multiple pieces of debris accumulate in the stream channel and retard water flow, a debris dam is formed"* (Davis et al., 2001).

The ability of LWD to retain organic matter, provide fish habitat, and affect channel/substratum stability depends on the size of the wood (relative to stream size), where the wood is within the channel, and how secure it is. In the LWDI, characterization of each piece of LWD consists of 7 variables, while characterization of a debris dam (DD) consists of 5 variables. Each variable is scored on a scale of 1 to 5, indicating the relative importance of each piece of LWD and each DD.

Higher scores indicate greater function, or more influence on channel form. The variables used to score LWD pieces and debris dams are shown in Table 1 and each is described in more detail in the following chapter. The next section describes how the scores for pieces and debris dams are combined to calculate the LWDI.

*Table 1. Scores for LWD Pieces and Debris Dams*

| | Score | | | | |
|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** |
| **Pieces** | | | | | |
| **Length/Bankfull Width** | 0.0 to 0.4 | 0.4 to 0.6 | 0.6 to 0.8 | 0.8 to 1.0 | > 1.0 |
| **Diameter (cm)** | 10 to 20 | 20 to 30 | 30 to 40 | 40 to 50 | >50 |
| **Location** | **Zone 4** | | **Zone 3** | **Zone 2** | **Zone 1** |
| **Type** | Bridge | | Ramp | Submersed | Buried |
| **Structure** | Plain | Plain/Int | Intermediate | Int/Sticky | Sticky |
| **Stability** | Moveable | Mov/Int | Intermediate | Int/Sec | Secured |
| **Orientation (degrees)** | 0 to 20 | 20 to 40 | 40 to 60 | 60 to 80 | 80 to 90 |
| **Debris Dams** | | | | | |
| **Length (% of Bankfull Width)** | 0 to 20 | 20 to 40 | 40 to 60 | 60 to 80 | 80 to 100 |
| **Height (% of Bankfull Depth)** | 0 to 20 | 20 to 40 | 40 to 60 | 60 to 80 | 80 to 100 |
| **Structure** | Coarse | Coarse/Int | Intermediate | Int/Fine | Fine |
| **Location** | Partially high flow | In high flow | Partially low flow | Mid low flow | In low flow |
| **Stability** | Moveable | Mov/Int | Intermediate | Int/Sec | Secured |

### *1.1a Calculating the Large Woody Debris Index*

Once every piece of LWD and DD within the sampling reach is scored according to the variables in Table 1, the LWDI can be calculated. A sample score sheet is shown below in Table 2. The following steps outline how to calculate the LWDI:

1. Determine the total pieces in each score category, i.e. sum the tallies in each column (shown in red in Table 2).
2. Multiply the number of pieces (red) by the score for that column (green).
3. Sum the results from step 2 from each column to obtain the Piece Score (PS) for the sampling reach.

   PS = 8+10+6+12+15 = 51 in Table 2.

4. Repeat steps 1 - 3 for the debris dams to obtain the debris dam score (DDS)

   DDS = 1+6+9+4+10 = 30 in Table 2.

5. Calculate the LWDI as: $LWDI = PS + (DDS * 5)$

   LWDI = 51 + (30 * 5) = 201 for the example in Table 2.

To avoid errors in future calculations, it is important to keep track of the number of tallies in each row. The number of tallies in each row should be equal to the total number of pieces surveyed. The total number of pieces assessed in Table 2 equals 3; therefore, the sum of each row also equals 3.

*Table 2. LWD Sample Score Sheet with 3 Pieces and 2 Debris Dams.*

| | **Score** | | | | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | |
| | **Pieces** | | | | | |
| Length / Bankfull Width | II | | | I | | |
| Diameter | | I | I | I | | |
| Location | I | I | | | I | |
| Type | | II | | I | | |
| Structure | III | | | | | |
| Stability | II | | I | | | |
| Orientation | | I | | | II | |
| Piece Column Total | **8** | **5** | **2** | **3** | **3** | **PS** |
| **Piece Scores (PS)** | 8 x 1 = **8** | 5 x 2 = **10** | 2 x 3 = **6** | 3 x 4 = **12** | **3 x 5 = 15** | **51** |
| | **Debris Dams (DD)** | | | | | |
| Length | I | I | | | | |
| Height | | | II | | | |
| Structure | | I | I | | | |
| Location | | I | | I | | |
| Stability | | | | | II | |
| DD Column Total | **1** | **3** | **3** | **1** | **2** | **DDS** |
| **DD Scores (DDS)** | 1 x 1 = **1** | 3 x 2 = **6** | 3 x 3 = **9** | 1 x 4 = **4** | 2 x 5 = **10** | **30** |

An additional method for tallying is the dot-dash method. Each dot and dash represent one piece of LWD, or one debris dam. Figure 1 shows how to count using this method.

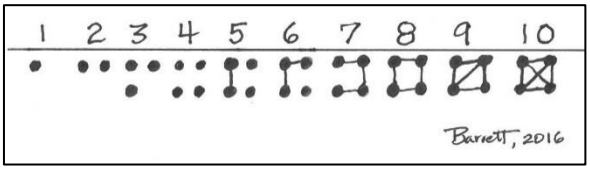


*Figure 1. Counting using the Dot-Dash Tally Method*

The rest of this manual expands on each variable used to characterize pieces of LWD and debris dams and provides picture references to facilitate consistency in the application of this method.

## 2. Field Manual

This chapter follows the LWDI field sheet that has been created for use with the SQT. This field sheet is provided in Appendix A and the Microsoft Excel version is available on the Stream Mechanics website[1] along with this manual. The top of the field sheet consists of background information about the data collection, stream catchment, riparian forest, and stream reach. A space for field notes is provided as well. Much of the field sheet consists of individual scoring sections for LWD pieces and debris dams. Each portion of the field sheet will be described in detail in the following sections.

Appendix B provides a quick visual field guide to accompany this manual and contains many photo examples and drawings to assist in scoring LWD pieces and debris dams.

### 2.1 LWD Data Collection Logistics

The top of the field sheet asks for the following project and stream information:

- Background Information: Name of investigators, data collection date, stream name, reach ID, state, county, and the latitude and longitude of the sampling reach.
- Catchment Information: Physiographic province, watershed name, and drainage area.
- Forest Information: Dominant species, forest type, and forest age.
- Stream Information: Survey length, flow classification (perennial, intermittent or ephemeral), stream condition (reference, degraded, or restored), bankfull width and depth, flood prone width, stream slope, bed material and Rosgen stream type.
- Field Notes.

As more data are collected, this information will help establish patterns and identify key factors that contribute to LWD scores. Prior to field work, the practitioner can fill in the Catchment Information and some of the background information listed above.

The Survey Length field in the field sheet is populated with 328 feet (or 100-meters). According to the USFS methodology, the LWDI is tabulated for the entire stream reach and then standardized by the reach length or area. The USFS methodology requires a minimum survey length of 100-meters. For the SQT, the sampling reach will consist of the 100-meters of stream

[1] https://stream-mechanics.com/stream-functions-pyramid-framework/

within the reach that will yield the **highest** score from visual observations. Regardless of stream reach length, the LWD assessment reach will be 100-meters long.

Multiple variables in the LWDI require that the bankfull width and depth be known for the sampling reach; therefore, the practitioner should identify and verify the bankfull stage and associated dimensions. Methods for identifying the bankfull stage and calculating the bankfull dimensions can be found in the *River Stability Field Guide* (Rosgen, 2014). Verifying bankfull is discussed in depth in the SQT Data Collection and Analysis Manual (Harman and Jones, 2017b) but generally consists of identifying bankfull features in the field and using regional curves to verify these values.

Some variables require the practitioner to identify base flow, therefore recent rain conditions play a role in characterizing LWD. Check the recent weather conditions before going in the field to anticipate whether water levels are likely to be higher or lower than base flow while the survey is being performed. Notes such as recent weather should be recorded in the field notes section.

Prior to heading out into the field to collect LWD data, the following steps must be completed:

**Office Task List**

1. Review the field sheet and data collection methods.
2. Determine the drainage area and physiographic province of your sampling area.
3. Calculate the drainage area in square miles.
4. Obtain the appropriate bankfull regional curves if available. Take these curves into the field.
5. Collect field equipment:
    - Required: 100-meter tape, ruler or tape[2] for measuring LWD diameter and length, two 100-foot tapes, pocket rod, and survey equipment to determine bankfull[3]
    - Optional: GPS, tree borer, 50 cm calipers
6. Check the weather, anticipate if conditions are likely to reflect base flow.

Once in the field, the practitioner should walk the entire stream reach and determine where to perform the LWD assessment. Recall the sampling reach will consist of the 100-meter of stream within the reach that will yield the **highest** score from visual observations.

During this initial site walk, the practitioner should also identify bankfull features and a typical riffle cross section for the reach. Bankfull features should be identified throughout the reach and the distance between bankfull and the water surface elevation measured. The typical riffle cross section will be used to verify bankfull at the site. For degraded stream systems, the typical riffle cross should be at a relatively stable cross section if available.

At the typical riffle cross section, identify bankfull features, then stretch a tape between them. The bankfull features at this cross section should be a similar height above water surface elevation as the bankfull features identified throughout the stream reach during the site walk. Either survey the channel cross section and calculate the cross-sectional area and mean depth, or take several depth measurements across the bankfull channel and average them to determine the bankfull mean depth. Then calculate the bankfull area by multiplying the width and the mean depth.

[2] A 25-ft tape with “Feet and Tenths/Metric”.
[3] Survey equipment could consist of a survey level and rod, or a hand or line level and a rod. Survey tapes for the reach length and cross section are also required.

Compare the bankfull width, mean depth and area to the values from the regional curve. The bankfull field data for the site should fall within the range of scatter of the regional curve for the site to be verified by the curve. If the field data are outside the range of scatter, the practitioner will need to determine if the wrong bankfull indicator was selected or if the regional curve represents a different hydro-physiographic region than the field site. Revise the bankfull calls if needed. Once the bankfull stage is verified, use survey equipment to determine the flood prone width.

Once all data is collected and recorded for the typical riffle cross section, collect all the equipment and relocate to the LWD sampling reach. Stretch a tape along the thalweg or top of bank of the sampling reach. Note that if the LWD survey is part of a larger data collection effort it is sufficient to note the beginning and ending station of the LWD survey along the reach profile.

In summary, while in the field but before you begin collecting LWD data, make sure you complete the following:

1. Determine bankfull using field indicators and verify using the regional curve data.
2. Determine the location of your sampling area along the stream reach. Select the reach that will yield the **highest** score.
3. Stretch a 100-meter tape along the thalweg or top of bank to be sampled.

The rest of this chapter describes in detail how to collect the LWD data. A presentation is included as Appendix B of this report that includes more photos and examples of scoring for both pieces and dams.

## 2.2 LWD Pieces

A LWD piece occurs within the within the channel, or touching the banks of the channel, and within the 100-meter sampling reach. A LWD pieces must also meet the following characteristics:

1. Non-living wood,
2. ≥ 1-meter in length,
3. ≥ 10-centimeters in diameter at its largest end,

Pieces of LWD are characterized by seven variables: length, diameter, location, type, structure, stability and orientation. Each variable is scored on a scale of 1 to 5 with a score of 1 indicating that the piece of LWD has little positive impact on the channel and a score of 5 indicating that the piece of LWD has a high degree of positive impact on the channel.

### *2.2a Measuring Length and Diameter of LWD Pieces*

*"The size of individual pieces is determined by measuring the length and diameter of the largest end. Longer, larger pieces should have a greater influence, are less likely to be moved, and are given a higher score"* (Davis et al., 2001).

First measure the length and the diameter of a potential LWD piece to see if it meets the criteria listed above. The diameter is measured at the larger end of the piece in centimeters. If the piece of wood is large enough and long enough to be considered LWD, then score the piece according the values in Table 3.

*Table 3. Length and Diameter Scoring for LWD Pieces*

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Length / Bankfull Width** | 0.0 to 0.4 | 0.4 to 0.6 | 0.6 to 0.8 | 0.8 to 1.0 | > 1.0 |
| **Diameter (cm)** | 10 to 20 | 20 to 30 | 30 to 40 | 40 to 50 | >50 |

The diameter measurement is scored directly while the length of the piece is scored as a ratio of the bankfull width. Measure the length of the piece of wood from end to end, if one or both ends are buried then the length must be estimated. Measure the bankfull width at the cross section where the piece of LWD is located. This may vary from the typical bankfull width at the surveyed riffle cross section but is indicative of the potential stability of that piece during large flow events. The measured height of bankfull above water surface elevation can assist in determining the local bankfull width. Divide the measured length of the piece of LWD by the local bankfull width and record a count on the field sheet for the appropriate ratio shown in Table 3.

### *2.2b Scoring the Location of LWD Pieces*

*"The location score is based on the portion of time a piece is likely to be in the active channel. Pieces that are in the active channel only at bankfull flows are given a lower score than pieces that will be in the channel at all times. Score is based on the predominant location in one of the four stream zones"* (Davis et al., 2001).

LWD can be located in one of four zones, as first described by Robison and Beschta (1990). Each zone location is described below and shown in Figures 2a and 2b and the score for each zone is shown in Table 4. **Note**: A piece score of 2 is not available for this variable.

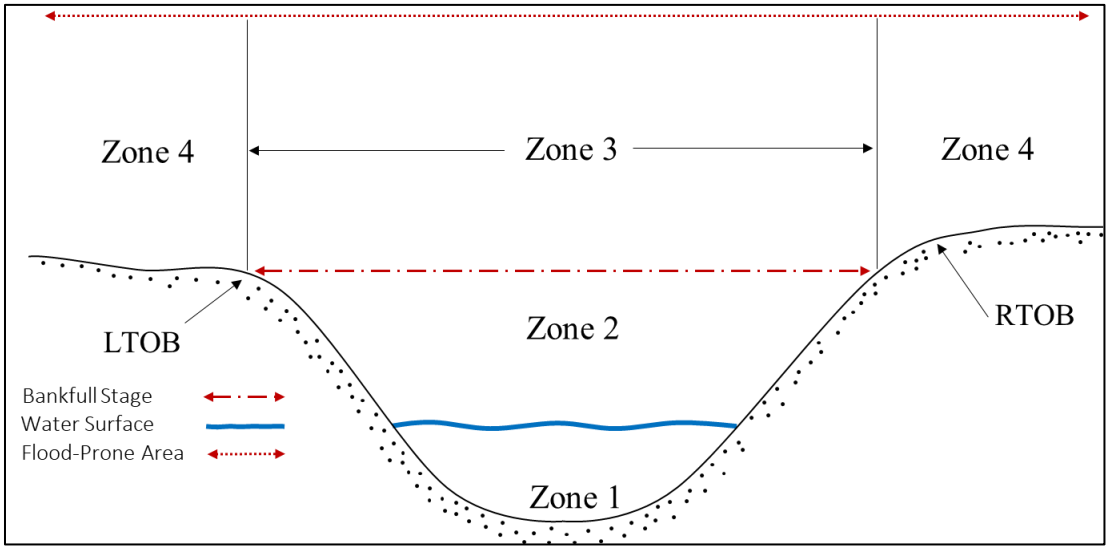


*Figure 2a. Location zones in a channel with a non-incised cross section.*

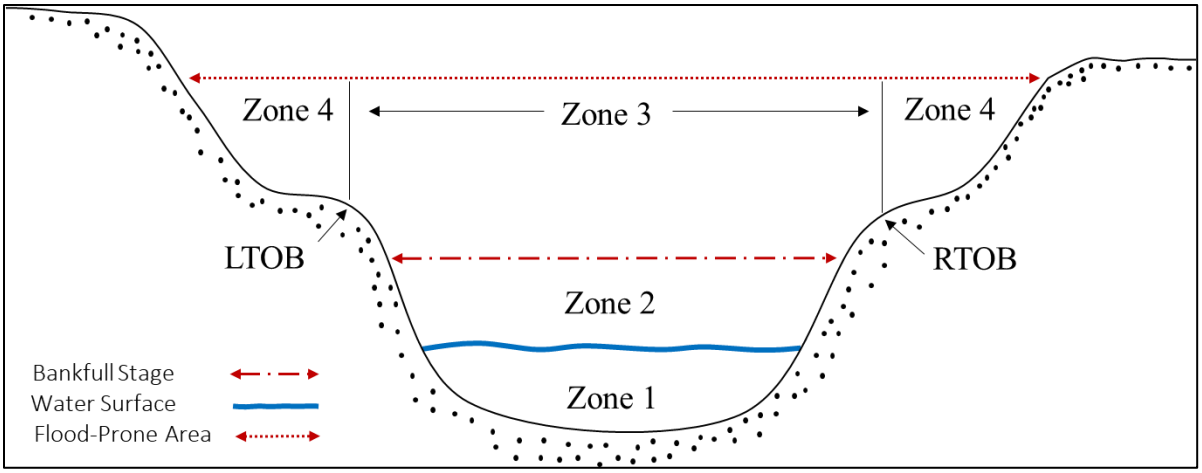


*Figure 2b. Location zones in a channel with incised cross section.*

## Description of Zones

**Zone 4** – The piece is located above bankfull, on a bankfull bench or touching the top of the streambank. The piece is barely in the active channel during a bankfull flow event. If there is not a bankfull bench, but the piece is touching the top of bank, it is counted. If the piece is on the terrace or floodplain and is NOT touching the top of bank, it is not counted. This is consistent with the zone method described by Robison and Beschta (1990) in which LWD was only measured if a portion of the piece was in zones 1, 2 or 3.

**Zone 3** – The majority of the piece is located above bankfull, but within the streambanks or between the bankfull benches. The piece is in the active channel only during a bankfull flow event. LWD in zones 3 and 4 are considered a potential source of LWD in the future (Robison and Beschta, 1990).

**Zone 2** – The majority of the piece is located below bankfull and above the base flow water surface. The piece is within the active channel during flows that are higher than base flow. LWD in zone 2 could influence stream roughness at high flow (Robison and Beschta, 1990).

**Zone 1** – The majority of the piece is located below the base flow water surface or is laying on the streambed. For small streams, the piece may be resting on the streambed while most of the wood is above the baseflow elevation. Since the piece is at the lowest possible elevation (the streambed) it is counted as zone 1 even though it isn't totally submerged. Pieces in zone 1 could influence fish habitat at low flow and affect stream roughness at high flow (Robison and Beschta, 1990).

Base flow can generally be assumed to be the water level on the day of the survey unless it has rained recently, is raining during the survey, or the area is undergoing drought conditions. It is important to check the recent weather conditions before going in the field to anticipate whether water levels are likely to be higher or lower than base flow while the survey is being performed.

*Table 4. Location scoring for LWD pieces.*

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Location** | **Zone 4** | | **Zone 3** | **Zone 2** | **Zone 1** |

Note: A Piece Score of 2 is not available for this variable.

If a piece of wood is between two different zones, it should be scored in the zone where the majority of the piece lies or the zone where it is primarily affecting flow in the active channel. If equal quantities are in 2 different zones, the higher scoring zone should be selected. In Figure 3, half of the LWD piece falls in zone 4 while the other half falls in zones 1 and 2. Classifying this piece as located in zone 4 would result in a score of 1 out of 5 even though the piece is significantly influencing bankfull flows. This piece was scored as predominantly being in zone 2, earning a score of 4.


*Figure 3. Example of a piece that starts in Zone 1 and ends in zone 4. Majority of LWD is in zone 2. (*Sal's Branch – Wake County, NC*).*

In an incised channel or a channel in a narrow valley, zone 4 may be difficult to determine. Zone 4 can shrink depending on the landscape, as shown in Figure 4. It is important to keep the flood prone area (twice the max bankfull depth) in mind in such cases. The flood prone area roughly corresponds to the 50-year flood event (Rosgen, 1996) which has geomorphic significance (Opperman et al., 2010). More photo examples of LWD pieces in the various zones are provided in Appendix B.

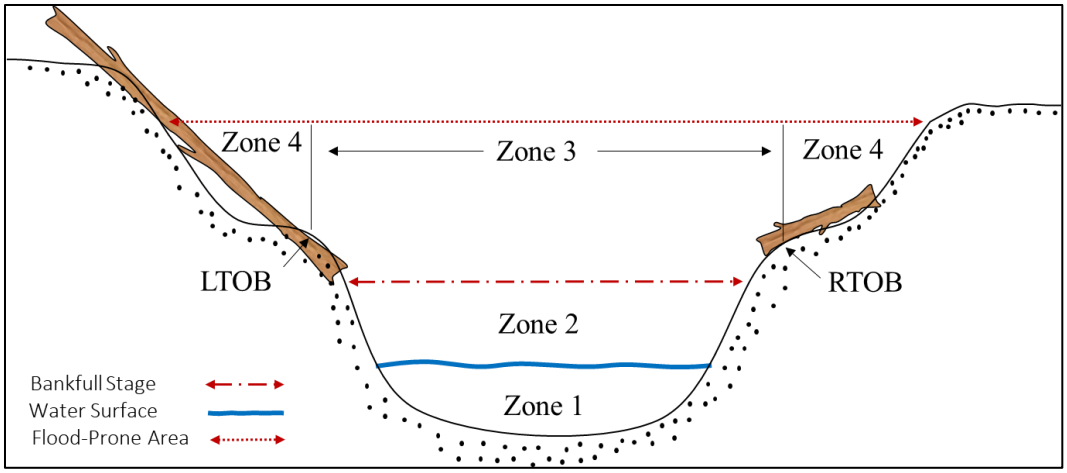


*Figure 4. LWD pieces located in zone 4 of an incised channel.*

### *2.2c Scoring the Type of LWD Pieces*

*"Scores for piece type are based on stability and their relative influence on morphology, flow, and organic matter retention"* (Davis et al., 2001).

A piece of LWD can be one of four types: bridge, ramp, submerged, or buried. Each type is shown in Figure 5 and described below. LWDI scoring by type is shown in Table 5. **Note**: A Piece Score of 2 is not available for this variable.

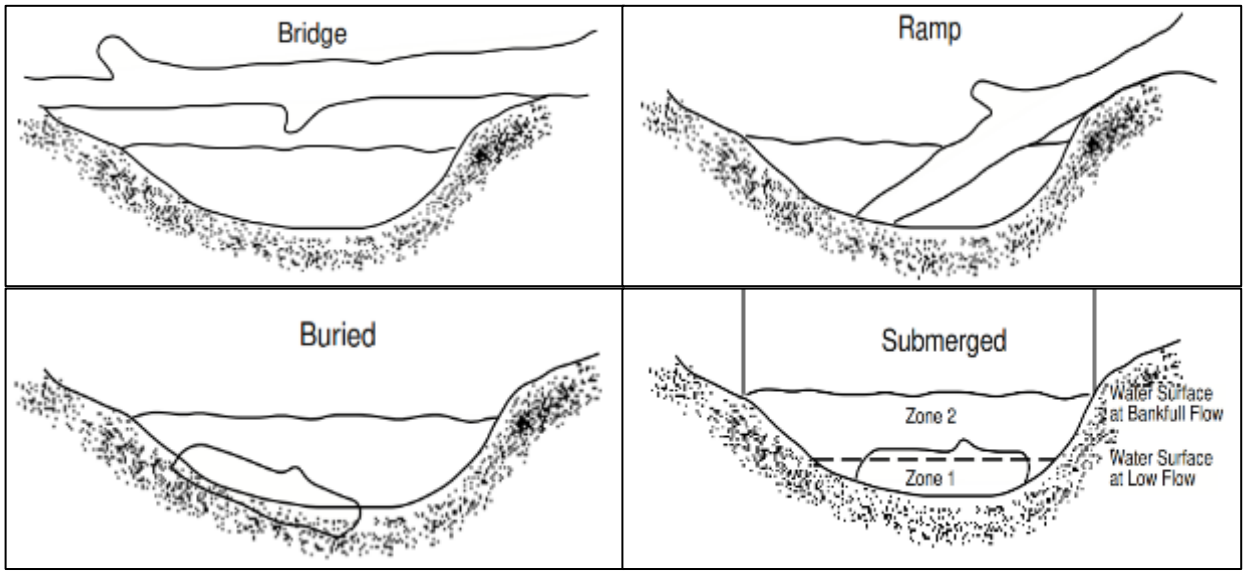


*Figure 5. Types of LWD piece as depicted by Davis et al. (2001).*

*Table 5. Type Scoring for pieces of LWD*

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Type** | Bridge | | Ramp | Submerged | Buried |

## ***Bridge***

A bridge is a LWD piece that spans the channel or protrudes over the stream and occurs above the base flow water surface. A bridge will typically be located in either zones 2, 3 or 4 as shown in Figures 6, 7 and 8. A bridge will not occur in zone 1 since it would be characterized as a "submerged" piece.

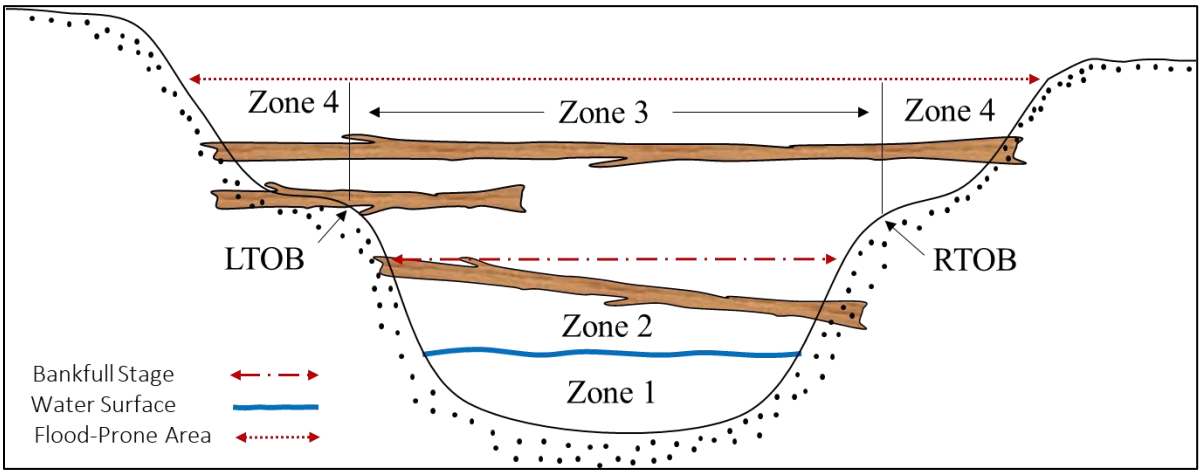


*Figure 6. Bridge examples of LWD pieces in an incised cross section.*

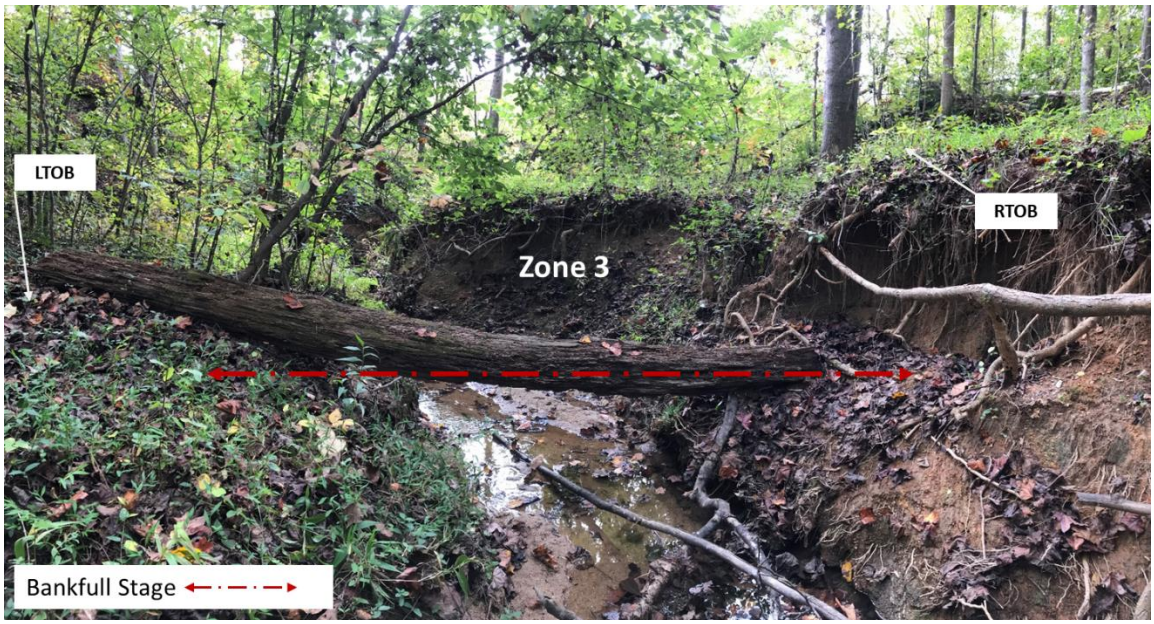


*Figure 7. Example of a bridge type LWD piece located in zone 3 (UT to Lowery Mill Creek – Forsyth County, NC).*

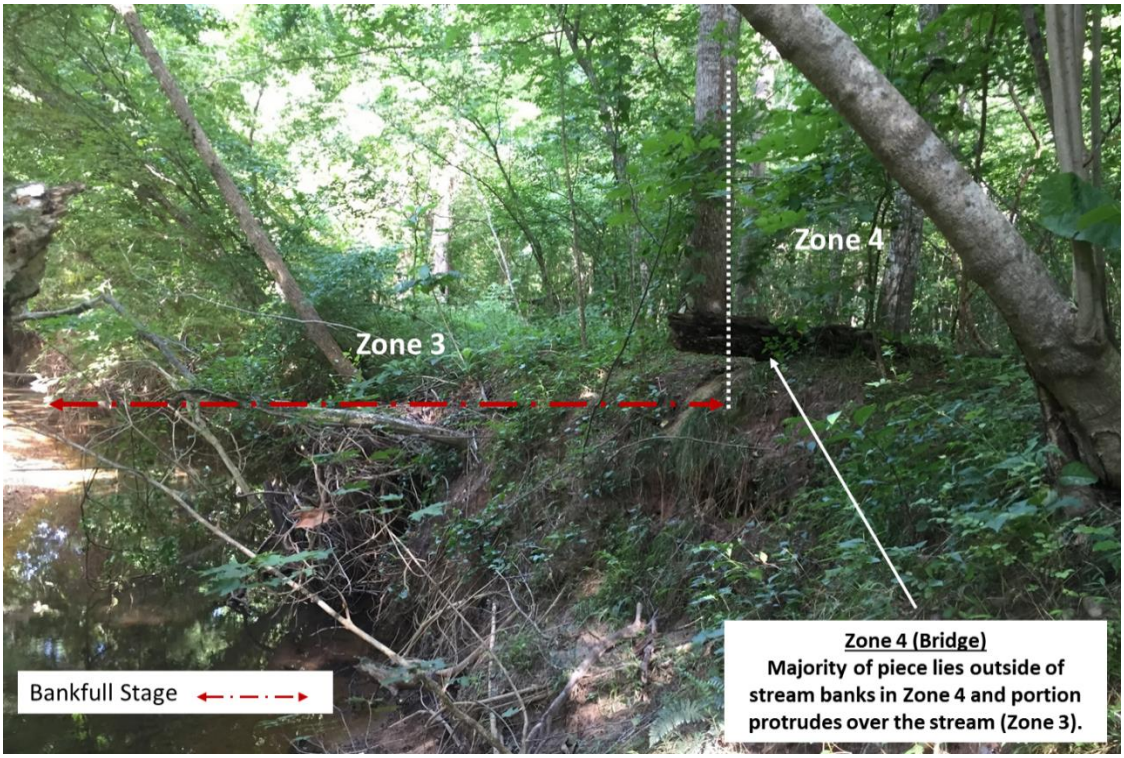


*Figure 8. Example of a bridge type LWD piece located in zone 4 (Swift Creek, Wake County, NC).*

***Ramp***

A ramp is an inclined piece of LWD that does not bridge the channel and is primarily above base flow as shown in Figure 9.

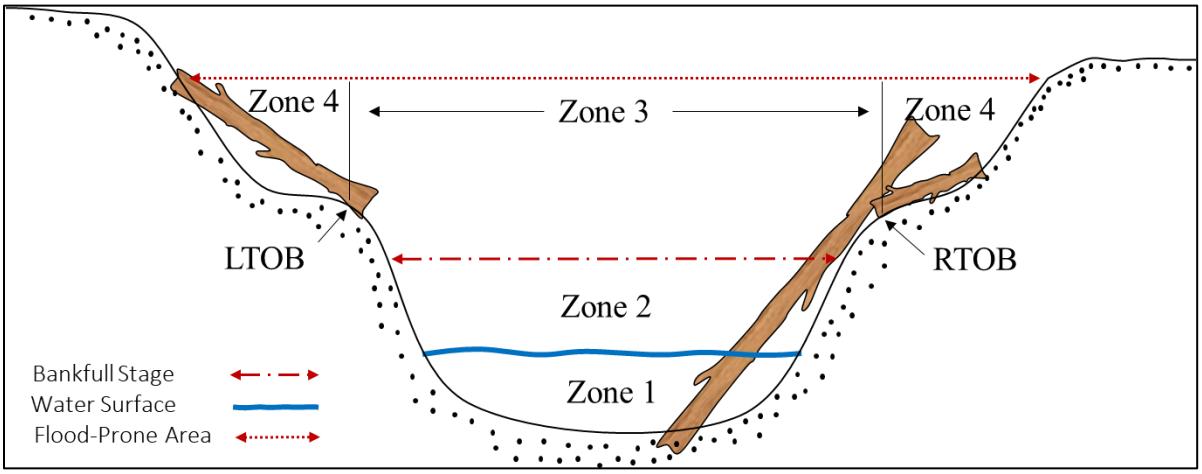


*Figure 9. Ramp examples of LWD pieces in an incised cross section.*

A ramp type LWD piece can span multiple location zones. Figures 3 and 10 show typical examples of a ramp type pieces of LWD. The ramp type is also a “catch-all” group that accepts any piece within the channel that is lying on the bank or depositional feature, e.g., point bar or mid-channel bar. Figure 11 shows a piece of LWD that is lying prone on a point bar. Even though the piece of LWD does not span multiple zones, it is within the bankfull channel and would not classify as a bridge.


*Figure 10. Ramp example of a LWD piece in zone 2. (Reedy Creek, Wake County, NC)*


*Figure 11. Ramp example of a LWD piece lying prone on a point bar (Little Fisher River – Surry County, NC).*

***Submersed***

Submersed pieces of LWD are those that would be submersed during a bankfull flow event and therefore, can only occur in zones 1 and 2 (Figure 12). A LWD piece is considered submersed if one of the following is true:

1) The majority of the piece length (underside) touches the water at base flow; or
2) The majority of the piece is lying on the bed, covered by water at base flow, but is not buried.

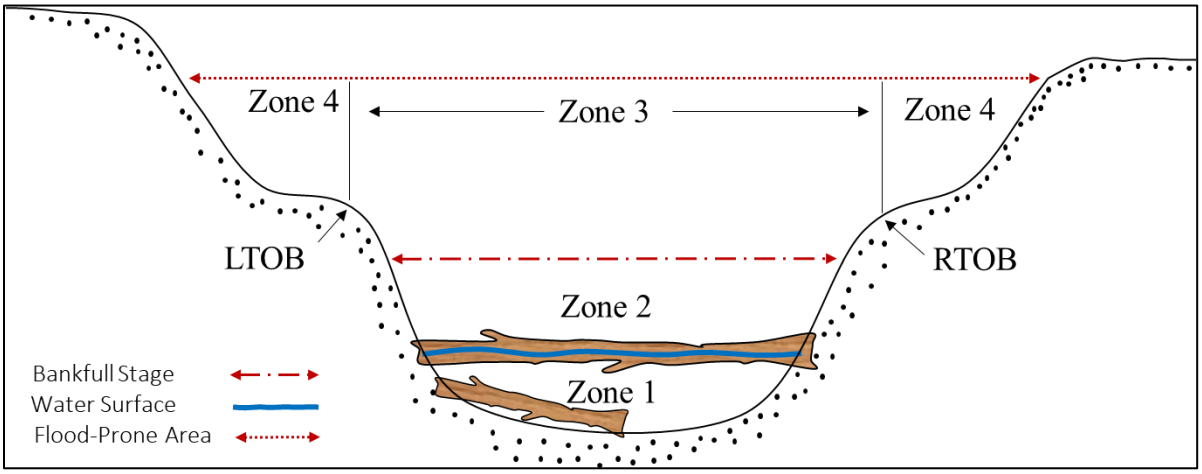


*Figure 12. Submersed examples of LWD pieces located in zone 1 of an incised stream cross section.*

*Figure 13. Submersed example of a LWD piece (Beaverdam Creek, Surry County, NC).*

***Buried***

A LWD piece is buried if the majority of the piece is covered by bed material or sediment. Buried pieces can occur in all zones but generally are found in zones 1 and 2 (Figure 14). Buried pieces can occur above base flow water surface and still influence the channel bed elevation (Figure 15).

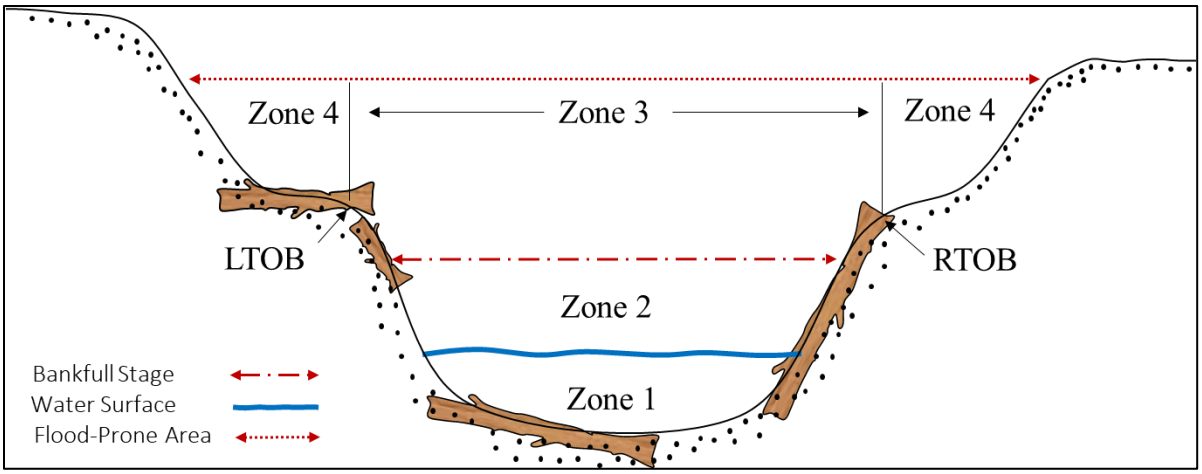


*Figure14. Buried examples of LWD pieces located in all zones of an incised stream cross section.*

*Figure 15. Buried example of a LWD piece located in zone 2. This piece is a part of the channel bed contributing to bed form diversity. (Reedy Creek – Wake County, NC).*

*Figure 16. Buried example of a LWD piece located in zone 1 (foreground). This piece is part of the channel bed contributing to bed form diversity. (Medium Creek – Mitchell County, GA).*

### *2.2d Scoring Structure of LWD Pieces*

*"Structure score is based on the potential to retain organic matter. LWD with a "sticky" structure has numerous branches or roots over its entire length"* (Davis et al., 2001).

LWD can be scored as plain, intermediate, or sticky. If the piece of wood does not fall into one of these main categories, it can be scored between plain and intermediate, as well as between intermediate and sticky. Below are descriptions of plain, intermediate, and sticky structures:

1. Plain – Essentially smooth. Does not contain sticks, limbs, or roots on the wood that could catch organic matter.
2. Intermediate – Contains low profile sticks, limbs, or roots that are visually obvious but do not capture organic matter easily.
3. Sticky – The majority of the wood is covered with sticks, limbs, or roots extending out such that they catch organic matter easily.

Figures 17 thru 20 show examples of the different structures of LWD pieces. LWDI structure scoring is shown in Table 6.

*Table 6. Structure Scoring for LWD pieces*

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Structure** | Plain | Plain/Int | Intermediate | Int/Sticky | Sticky |

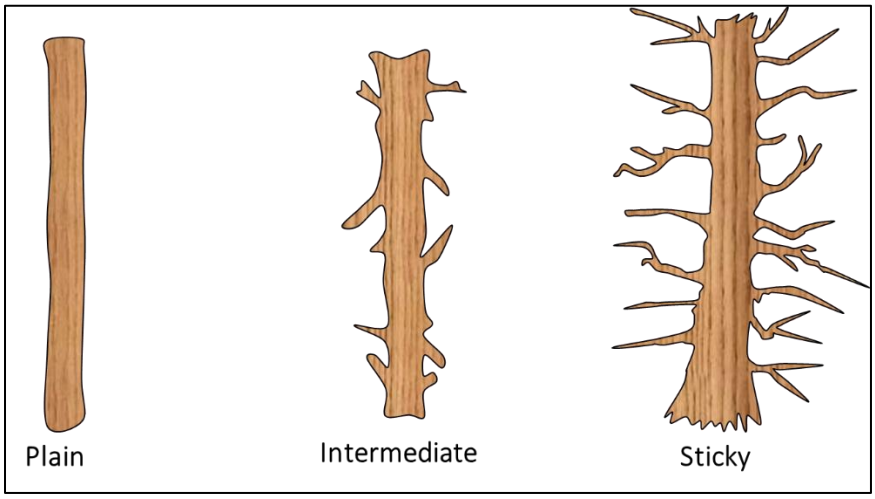


*Figure 17. Graphical examples of structure for LWD pieces.*

*Figure 18. Plain structure example for a LWD piece (Reedy Creek – Wake County, NC).*

*Figure 19. Intermediate structure example for a LWD piece (Boardman River – Grand Traverse County, MI).*

*Figure 20. Sticky structure example for a LWD piece (West Virginia).*

### *2.2e Scoring Stability and Orientation of LWD Pieces*

The last two variables used to assess LWD pieces are stability and orientation (Table 7). Each variable is described below.

*Table 7. Stability and Orientation Scoring for LWD pieces*

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Stability** | Moveable | Mov/Int | Intermediate | Int/Sec | Secured |
| **Orientation (degrees)** | 0 to 20 | 20 to 40 | 40 to 60 | 60 to 80 | 80 to 90 |

***Stability***

The stability variable assesses the mobility of the LWD piece. The stability of LWD can be considered as moveable, intermediate, or secured. If the piece of wood does not fall into one of these main categories, it can be scored between moveable and intermediate, as well as between intermediate and secured. Factors affecting stability include the following:

- How likely the log is to move during a bankfull flow event due to its size.
- How much of the piece is buried or anchored to the bed or bank.

Descriptions of the different types of stability are listed below:

1. Moveable – The piece is not anchored and can be easily transported during all types of flow events.
2. Moveable/Intermediate – Characteristics that fall between the moveable and intermediate categories. For example, a piece that is not secured but is located on a bar.
3. Intermediate – The piece is loosely anchored and would likely be moved by a bankfull event but remain in place during lower flow events.
4. Intermediate/Secured – Characteristics that fall between the intermediate and secured categories. For example, a piece that is not well secured but is at a higher elevation within the channel, e.g. on a bankfull bench.
5. Secured – The piece is securely anchored and is difficult to transport. Generally, portions of the piece or the entire piece itself is buried, rendering it immovable, except in very large flood events.

Figures 21 and 22 show pieces of LWD that are intermediate/secured. While they are not anchored, it is unlikely they will be moved by anything but a large flow event due to their size and location. Additionally, the pieces wouldn't make it very far before getting stuck on living trees. Figure 23 shows a piece of LWD that is moveable, as it is resting on a point bar and is not anchored to or entangled with anything else. LWDI scoring for stability is shown in Table 7.

*Figure 21. Intermediate/secured stability example for a LWD piece in zone 4 (Richland Creek - Wake County, NC).*

*Figure 22. Intermediate/Secured stability example for a LWD piece (Middle Creek - Wake County, NC)*

*Figure 23. Moveable stability example for a LWD piece on a point bar. (Reedy Creek - Wake County, NC)*

## ***Orientation***

*"LWD orientation is determined by the angle between the piece and the stream bank. Pieces perpendicular to the flow are more likely to create dam and plunge pools, increasing habitat complexity and organic matter retention. Pieces oriented 60 to 80$^{o}$ from the bank often divert flow and cause scour pools"* (Davis et al., 2001).

The orientation of LWD pieces affects how much the piece is influencing flow and bed forms within the channel. A piece that is perpendicular to flow has a larger hydraulic impact than a piece that is parallel to the bank. The angle at which the wood intersects the stream is scored for angles between 0 and 90 degrees. The angle should be measured from the closest streambank. LWDI scoring for orientation is shown in Table 8. Figures 24 and 25 show examples of orientation of LWD pieces. Figures 18 through 20 and 22, in previous sections show high angle (80 to 90 degrees) pieces.

*Table 8. Orientation Scoring for LWD pieces*

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Orientation (degrees)** | 0 to 20 | 20 to 40 | 40 to 60 | 60 to 80 | 80 to 90 |

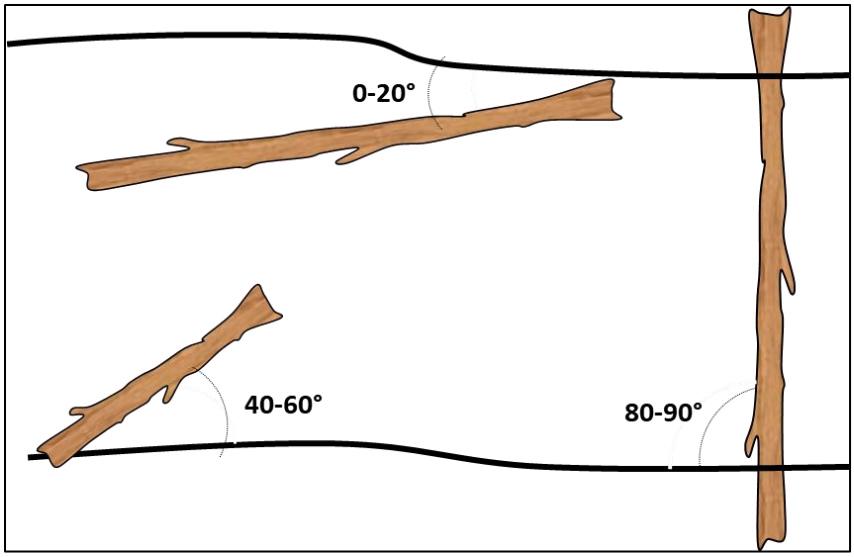


*Figure 24. Graphical depiction of LWD pieces oriented at various angles from the streambanks.*

*Figure 25. Low angle (0-20º) piece of LWD (West Virginia)*

### 2.3 Debris Dams (DD)

In the original methodology, a debris dam is classified as multiple pieces of LWD in the active channel that retard water flow. The debris dam score is weighted by 5 in the final calculation of

the LWDI, so DD can be quite important to the final reach score. A debris dam consists of at least 3 or more pieces of wood that would individually classify as LWD (≥ 10cm in diameter and ≥ 1m in length) that are touching (Figure 26).

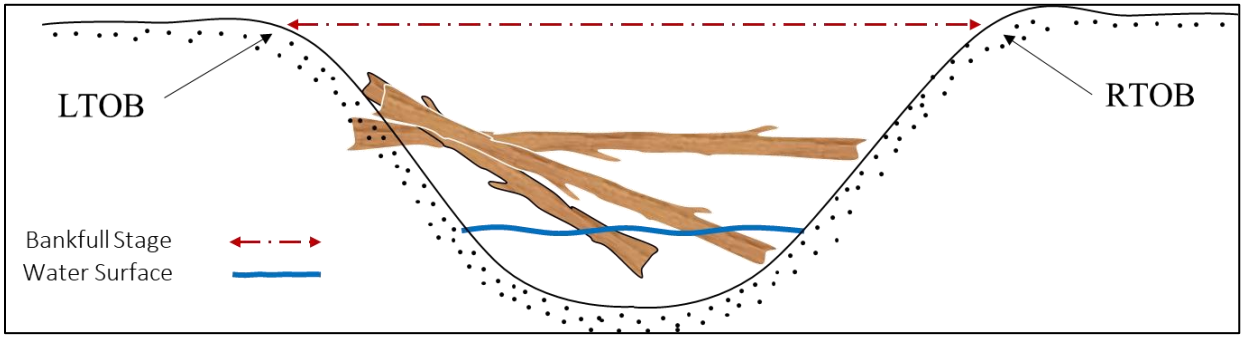


*Figure 26. Debris dam example.*

Debris dams are evaluated on 5 variables: length, height, structure, location, and stability. Each of these will be discussed in the following sections. Each variable is scored on a scale of 1 to 5 with a score of 1 indicating that the DD has little positive impact on the channel and a score of 5 indicating that the DD has a high degree of positive impact on the channel.

### *2.3a Measuring and Scoring the Length and Height of Debris Dams*

*"A debris dam extending all the way across a stream will have greater influence on morphology, hydrology, and organic matter retention than one that only partially disrupts flow. Debris dam height is relative to the bankfull depth and reflects the portion of the stream influenced"* (Davis et al., 2001).

For debris dams, the length is measured and scored as a percentage of the bankfull cross-sectional width of the channel. The height is measured and scored as a percentage of the bankfull cross-sectional depth of the channel. The length and height of the dam should be measured at the longest and tallest section of the obstruction. The bankfull cross-section width and depth should be estimated at the cross section where the debris dam is occurring rather than using the width and depth from the representative riffle cross-section.

#### ***Width***

The width of the DD should be measured as the widest part of the dam perpendicular to the channel flow (Figures 27 and 28). The width of the DD is then divided by the bankfull width to score the length on the field sheet. For example, if a DD is 3 feet long, and the bankfull width of the channel is 9 feet, then the dam is 33% of the bankfull width, which would receive a score of 2 for the length category (Table 9).

*Table 9. Length and Height Scoring for Debris Dams*

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Length (% of Bankfull Width)** | 0 to 20 | 20 to 40 | 40 to 60 | 60 to 80 | 80 to 100 |
| **Height (% of Bankfull Depth)** | 0 to 20 | 20 to 40 | 40 to 60 | 60 to 80 | 80 to 100 |

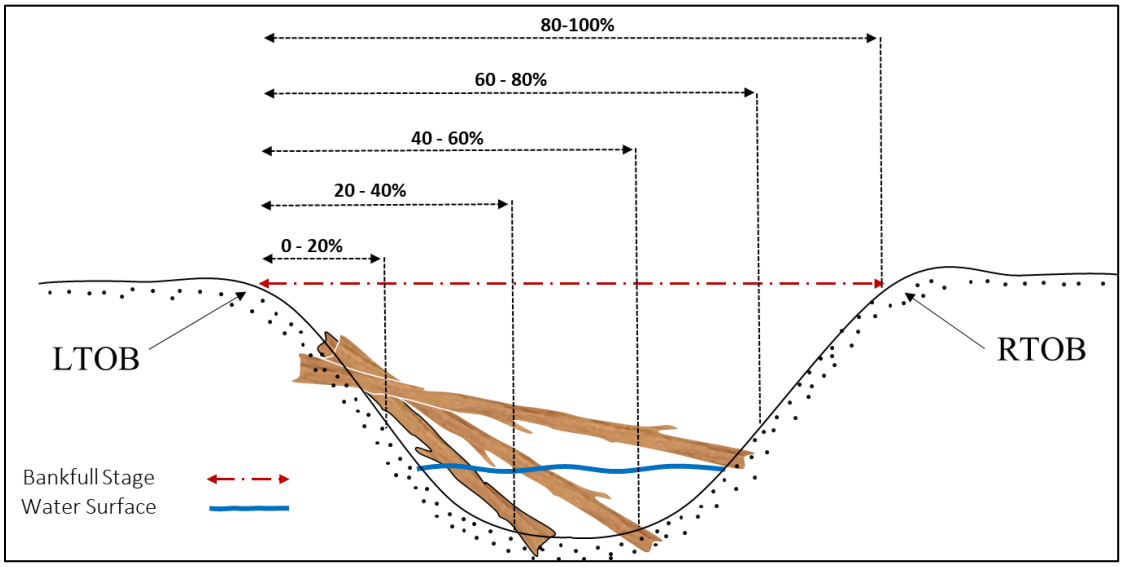


*Figure 27. Length of dam as a percentage of bankfull width in a non-incised stream cross section. The pictured dam is 60-80% of the bankfull width.*

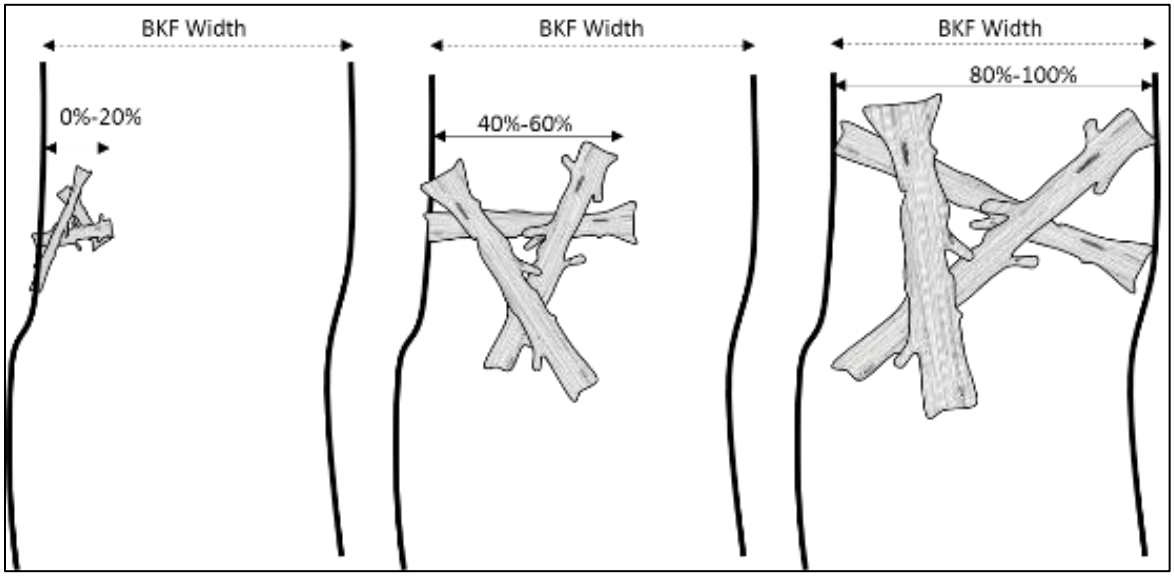


*Figure 28. Examples for measuring the length of debris dams, plan view.*

***Height***

The height of the dam should be measured from the lowest point of the debris dam within the bankfull cross section to the highest part of the debris dam within the bankfull cross section. If the bottom log in a debris dam is buried, then the height is measured starting at the channel bed; if a debris dam extends above the bankfull channel, only measure the height within the bankfull channel. The height is then divided by the bankfull height in order to score the height on the field sheet. For example, if a dam is 1 foot tall, and the bankfull height of the channel is 2 feet, then the dam is 50% of the bankfull depth and would receive a score of 3 (Figure 29 and Table 9). Figure 30 shows example of the debris dam occupying 40 – 60% of the bankfull width and 80 – 100% of the bankfull height.

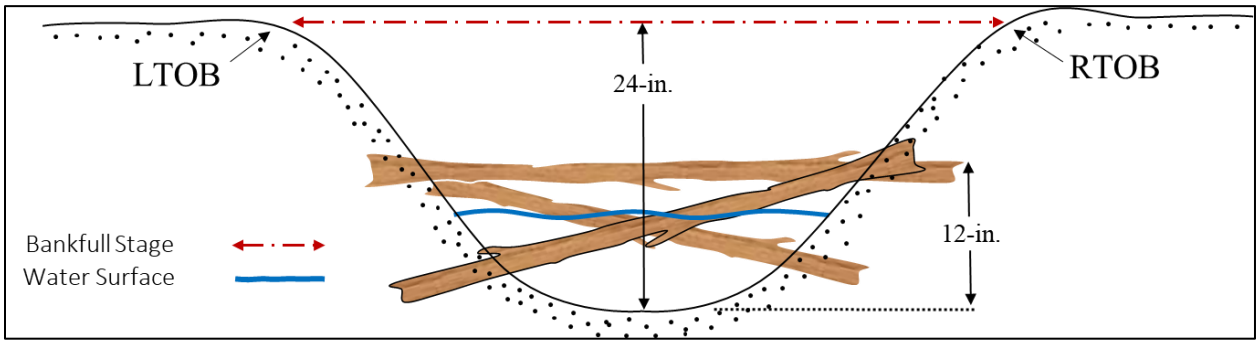


*Figure 29. Debris Dam occupying 50% of the bankfull height.*

*Figure 30. Debris Dam Occupying 40-60% of the bankfull width and 80-100% of the bankfull height. (Swift Creek, Wake County, NC)*

### *2.3b Scoring Structure of Debris Dams*

*"Structure relates to the retention capacity of the debris dam"* (Davis et al., 2001).

The dam structure characterizes the ability of the dam to retain organic matter including small woody debris, leaves and sediment. Structure is scored on a scale of 1 to 5 (Table 10), ranging from coarse (1) to fine (5). A coarse dam allows water to easily flow through it and only traps larger debris. A fine dam retains large and small debris, traps fine sediment, and impedes the flow of water. A fine structured dam is similar to a beaverdam and creates a backwater effect behind the dam. Figure 30, above, shows a coarse structure dam.

*Table 10. Structure Scoring for Debris Dams*

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Structure** | Coarse | Coarse/Int | Intermediate | Int/Fine | Fine |

### *2.3c Scoring Location of Debris Dams*

*"Location scores reflect the position of the debris dam in relation to the active channel at low flows"* (Davis et al., 2001).

A high scoring debris dam is located in the base flow of the channel while a low scoring debris dam would only influence higher, less frequent flows. The options for flow location are: partially in high flow, in high flow, partially in low flow, mid low flow, or in low flow (Figure 31). These descriptions have been interpreted to define low flow as base flow conditions and high flow is any flow higher than bankfull. LWDI scoring for debris dam location is shown in Table 11.

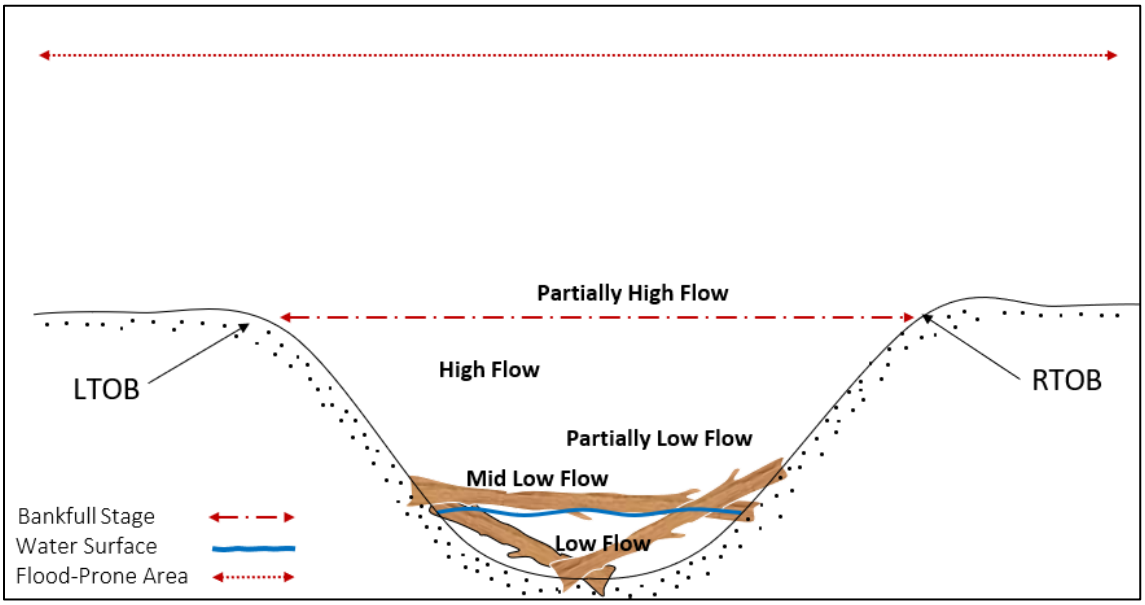


*Figure 31. Debris dam location zones. The dam shown in the figure is predominantly in mid low flow in a non-incised cross section since base flow can pass under the dam.*

*Table 11. Location Scoring for Debris Dams*

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Location** | Partially high flow | In high flow | Partially low flow | Mid low flow | In low flow |

To determine flow location for debris dams, consider where the bulk of the debris dam is.

1. Dams that are partially in high flow are located primarily above the bankfull flow and below the flood prone height, but some part of the dam sits in the bankfull flow.
2. Dams located in high flow do not affect the base flow but are situated in the bankfull flow.
3. Dams that are partially in low flow are located primarily above the base flow water surface but some part of the dam sits in base flow.
4. Dams that in mid low flow are situated in base flow but allow water to pass under the debris dam.
5. If the debris dam is in contact with the bed and does not allow flow underneath the structure, it is in low flow.

As in the location scoring for LWD pieces, it is recommended to keep the flood prone area depth (twice the max bankfull depth) in mind when assessing incised channels or channels in narrow valleys. The flood prone area roughly corresponds to the 50-year flood event. Any debris dam located above this depth would not be counted in the LWD assessment.

### *2.3d Scoring Stability of Debris Dams*

*"Stability scores are based on the likelihood that the dam will be retained over variable flows."* (Davis et al., 2001)

The stability variable assesses the longevity of the debris dam and its effects on the channel. The stability of debris dams is scored the same way in which the stability of LWD pieces is scored. Debris dams may be moveable, intermediate, or secured (Table 12). The stability may also be scored between moveable and intermediate, and between intermediate and secured.

*Table 12. Stability Scoring for Debris Dams*

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Stability** | Moveable | Mov/Int | Intermediate | Int/Sec | Secured |

Factors affecting stability include the following:

- How likely the dam is to move during a bankfull flow event due to its size;
- How much of the dam is buried; and
- Whether the dam is trapped by anything (i.e. live trees, rocks, etc.).

Figure 32 shows a debris dam with intermediate stability due to the size and anchoring of the dam.

*Figure 32. Debris dam in mid low flow and intermediate stability. Trees are not embedded in banks or bed but simply wedged in the channel. (Little Fisher River - Surry County, NC)*

# 3. Pictures/Examples

This section presents picture examples of LWD pieces and debris dams, scores them for every variable, and if necessary, explains the scores. Structures installed as a part of a stream restoration project are covered at the end of this section.

### 3.1 Pieces

**Example 1 (Pieces)**

Upper Stick Elliott Creek is a small stream, with a 0.42 square mile drainage area, in the foothills of North Carolina located in a 30 to 40-year old mixed pine hardwood forest. The following figure shows a LWD piece at this site.


*Figure 33. Example of bridge located in Zone 3 with intermediate structure (Upper Stick Elliott Creek – Cleveland County, NC).*

The complete scoring for the piece of LWD in Figure 33 is as follows (LWD Piece scores are in parentheses):

- Length/ Bankfull width: > 1.0 (Score = 5)
- Diameter: 10 – 20 cm measured at the larger end of the piece (Score = 1)
- Location: Zone 3 (Score = 3)
- Type: Bridge (Score = 1)
- Structure: Intermediate (Score = 3)
- Stability: Intermediate/Secured – due to its length and the thickness of the riparian vegetation (Score = 4)
- Orientation: 80 – 90 degrees (Score = 5)

**Total Piece Score = 22**

**Example 2 (Pieces)**

Sal's Branch is a small stream, with a 0.20 square mile drainage area, in the Piedmont of North Carolina located in an 80-year-old mixed hardwood forest. The following figure shows a LWD piece at this site.


*Figure 34. Ramp example with the majority of the piece located in Zone 2 (*Sal's Branch – Wake County, NC*).*

The complete scoring for the piece of LWD in Figure 34 is as follows (LWD Piece scores are in parentheses):

- Length/ Bankfull width: 0.4 - 0.6 (Score = 2)
- Diameter: 20 – 30 cm measured at the larger end of the piece (Score = 2)
- Location: Zone 2 (Score = 4)
- Type: Ramp (Score = 3)
- Structure: Plain (Score = 1)
- Stability: Between moveable and intermediate (Score = 2)
- Orientation: 0 – 20 degrees (Score = 1)

**Total Piece Score = 15**

## Example 3 (Pieces)

Middle Creek is a moderately sized stream, with a 5.6 square mile drainage area, in the Piedmont of North Carolina located in a 65-year-old hardwood forest. At first glance, it appears that there are two LWD pieces in the creek. The following figure shows one LWD piece and a living tree that has fallen across the creek.


*Figure 35. Ramp example of LWD piece located in Zone 2 (LWD Piece #1). Piece #2 is a living tree that has fallen and should not be counted as a LWD piece.*

The complete scoring for the LWD in Figure 35 is as follows (LWD Piece scores in parentheses):

Piece #1

- Length/Bankfull width: 0.4 – 0.6 (Score = 2)
- Diameter: 10 – 20 cm measured at the larger end of the piece (Score = 1)
- Location: Zone 2 (Score = 4)
- Type: Ramp (Score = 3)
- Structure: Plain (Score = 1)
- Stability: Intermediate (Score = 3)
- Orientation: 40 – 60 degrees (Score = 3)

**Total Piece Score = 17**

Piece #2 shown in Figure 35 is a living tree and is not counted as LWD.

**Example 4 (Pieces)**

Middle creek is a small sized stream, with a 5.6 square mile drainage area, in the Piedmont of North Carolina located in a 65-year-old hardwood forest. The following figure shows a LWD piece at this site.


*Figure 36. Example of a submersed LWD piece located in Zone 1 with an 80 - 90° orientation.*

The complete scoring for the piece of LWD in Figure 36 is as follows (LWD Piece scores in parentheses):

- Length/ Bankfull width: 0.0 – 0.4 (Score = 1)
- Diameter: 20 – 30 cm measured at the larger end of the piece (Score = 2)
- Location: Zone 1 (Score = 5)
- Type: Submersed (Score = 4), as it is not attached to the bed and forming bed features.
    - For comparison, see Figure 37, which shows a buried LWD type.
- Structure: Between plain and intermediate (Score = 2)
- Stability: Between intermediate and secured (Score = 4)
- Orientation: 80 – 90 degrees (Score = 5)

**Total Piece Score = 23**

**Example 5 (Pieces)**

Piney Branch is a small to medium sized stream, 0.53 square mile drainage area, in the Piedmont of North Carolina located in a 40 to 50-year-old red maple forest. The following figure shows a LWD piece at this site.


*Figure 37. Piece of LWD in Piney Branch, Yadkin County, NC.*

The complete scoring for the piece of LWD in Figure 37 is as follows (LWD Piece scores in parentheses):

- Length/ Bankfull width: 0.0 – 0.4 (Score = 1)
- Diameter: 20 – 30 cm measured at the larger end of the piece (Score = 2)
- Location: Zone 1 (Score = 5)
- Type: Buried (Score = 5).
    - For comparison, see Figure 36, which shows a submersed LWD piece.
- Structure: Plain (Score = 1)
- Stability: Between intermediate and secured (Score = 4)
- Orientation: 0 – 20 degrees (Score = 1)

**Total Piece Score = 19**

### 3.2 Debris Dams

**Example 1 (Debris Dams)**

Richland Creek runs through an NCSU experimental forest in Wake County. The creek is degraded and located within a 50 to 60-year old pine forest. The following debris dam occurred within the sampling reach.

*Figure 38. Debris dam in Richland Creek, Wake County, NC*

The complete scoring for the debris dam shown in Figure 38 is as follows (LWD Debris Dam scores are shown in parentheses):

- Length is 80-100% of bankfull (Score = 5)
- Height is 80-100% of bankfull (Score = 5)
- Structure is between fine and intermediate (Score = 4)
- Location: Partially in low flow (Score = 3); even though this dam is touching the base flow water surface, the dam is primarily functioning above base flow, but below bankfull.
- Stability: Secured (Score = 5)

Subtotal = 22

**Total Debris Dam Score = 22 x 5 = 110**

**Example 2 (Debris Dams)**

This sampling reach of Swift Creek is located in the Swift Creek Bluffs Nature Preserve in Wake County, NC. The creek is highly degraded due to concentrated flows from upstream development. The 70 to 85-old forest is primarily composed of hardwood species with scattered loblolly pines.

*Figure 39. Small but fine/Intermediate debris dam in Swift Creek.*

The center of this debris dam shown in Figure 39 is a living tree that has caught 3 or 4 pieces large enough to be considered LWD and a lot of smaller organic matter. The complete scoring for the debris dam shown in Figure 39 is as follows (LWDI score in parentheses):

- Length is 0-20% of bankfull (Score = 1)
- Height is 80-100% of bankfull (Score = 5)
- Structure is between fine and intermediate (Score = 4)
- Location: Partially low flow (Score = 3)
- Stability: Secured (Score = 5)

Subtotal = 18

**Total Debris Dam Score = 18 x 5 = 90**

**Example 3 (Debris Dams)**

The dam in Figure 40 is located between the bankfull height and the height of the flood prone area, therefore, it is located in high flow. The structure of the dam should be scored as intermediate because it would not completely block the flow of water if the water surface were to rise to the height of the dam.

*Figure 40. Debris dam of LWD, intermediate structure (Reedy Creek – Wake County, NC).*

The complete scoring for the debris dam shown in Figure 40 is as follows (LWDI score in parentheses):

- Length is 80-100% of bankfull (Score = 5)
- Height is 80-100% of bankfull (Score = 5)
- Structure is intermediate (Score = 3), as the dam would not completely block the flow of water if the water surface were to rise to the height of the dam.
- Location: High flow (Score = 2); located between the bankfull and flood prone area elevations.
- Stability: Secured (Score = 5)

Subtotal = 20

**Total Debris Dam Score = 20 x 5 = 100**

### 3.3 Stream Restoration Structures

Stream restoration practices that mimic natural conditions can include incorporating large woody debris as in-stream structures. As this methodology is being applied to impacted and restored stream reaches, there may be large woody debris in the channel that is placed rather than naturally occurring. Using LWD in stream restoration projects can provide substantial functional lift since many degraded streams are devoid of wood. However, it is unlikely that a stream restoration project will yield functioning scores since this could jeopardize channel stability when riparian vegetation is not established. It is more likely that stream restoration projects will increase scores from a not functioning condition to a functioning-at-risk condition. This will still provide functional benefits and the LWD scores will increase over time. Scoring in the NC SQT v3.0 is shown in Table 13.

*Table 13. LWDI Performance Standards in the NC SQT v3.0*

| Condition Description Compared to Reference Condition | **Not Functioning** | | **Functioning-At-Risk** | | **Functioning** | |
|---|---|---|---|---|---|---|
| **Index Score** | **0** | **0.29** | **0.3** | **0.69** | **0.7** | **1** |
| LWD Index (Dimensionless) | 0 | 199 | 200 | 299 | 300 | 700 |

Guidance is provided for scoring LWD pieces and Debris Dams in previous sections of this manual and a few examples of common in-stream structures are provided here. Each is discussed in more detail below, note that typical applications are discussed, and example scoring is provided where appropriate but the actual components of a structure can vary between providers and applications.

- Log vane – Counted as a LWD piece.
- Root wads – Not typically counted.
- Toe wood – Typically counted as a debris dam.
- Log sill – Counted as a LWD piece.
- Engineered log jam – Counted as a debris dam.
- Woody riffle – Each piece that meets the size requirements are counted as a LWD piece.
- Cover logs – Counted as individual pieces.

*Figure 41. Log vane structure after construction.*

Log vanes and any structure that implements a log as a vane arm, contribute to the LWDI. The complete scoring for a typical log vane as a piece of LWD is as follows (LWD Piece score in parentheses):

- Length/ Bankfull width is typically 0.8 – 1.0 or > 1.0 (Score = 4 or 5)
- Diameter: Typical minimum is 12” or 30cm (Score = 3)
- Location is typically Zone 1 and Zone 2 with the majority in Zone 2 (Score = 4).
- Type: Ramp (Score = 3)
- Structure: Plain (Score = 1)
- Stability: Secured (Score = 5)
- Orientation is typically around 20 degrees (Score = 1 or 2).

This scoring would total about 21 to 23 points for each log vane arm installed in the LWD sampling reach. In order for a channel to be considered functioning with respect to LWD in the SQT, the minimum score on the LWDI is 301. Log vanes alone are not going to generate a functioning score, nor should they.

Rootwads are useful structures that provide bank stability; they mimic the root mass in a bank that is provided by a living tree. As there is typically not a section of wood in the channel that is ≥1m in length, root wads are not counted as LWD. If cover logs are used between each root wad and meet the LWD size criteria, each piece can be counted as LWD. Note that in order for any structure to be counted in scoring the LWDI there must be pieces (or multiple pieces) of large wood observed (i.e. felt or seen) in the channel.

Toe wood includes multiple pieces of LWD as well as smaller organic material, where all the pieces are touching to comprise the lower portion of a streambank. However, typically many pieces protrude into the channel reducing near bank velocities, providing fish cover, and creating deep, undercut banks. Therefore, the pieces protruding into the channel can count as LWD and toe wood can be scored as a debris dam. An example is provided in Figure 42.

*Figure 42. Toe wood structure a few years after construction.*

The complete scoring for the tow wood structure shown in Figure 42 is as follows (LWDI score in parentheses):

- Length is <20% of bankfull (Score = 1)
- Height varies but typically is < 50% of bankfull (Score = 1 – 3)
- Structure is between intermediate and coarse (Score = 4)
- Location: In low flow (Score = 1)
- Stability: Secured (Score = 5)

Subtotal = 12 to 14

Therefore, a typical toe wood structure would add 60 to 70 points to the LWDI.

Log sills are usually installed in steeper systems as steps in a riffle-step-pool or step-pool stream. Log sills are likely to count as LWD pieces.

- Length/ Bankfull width is typically 0.8-1.0 or > 1.0 (4 or 5)
- Diameter: Typical minimum is 12” or 30cm (3)
- Location: Zone 1 (5)
- Type: Submersed or Buried (4 or 5)
- Structure: Plain (1)
- Stability: Secured (5)
- Orientation: 80 – 90 degrees (5)

While log vanes would score around 22 points, log sills can score 27 to 29 points as they are typically buried but at least submersed and a higher angle from the bank than log vanes.

Woody riffles implement multiple pieces of LWD to provide grade control along with the benefits of large and fine woody debris. An example of a woody riffle is shown in Figure 43.

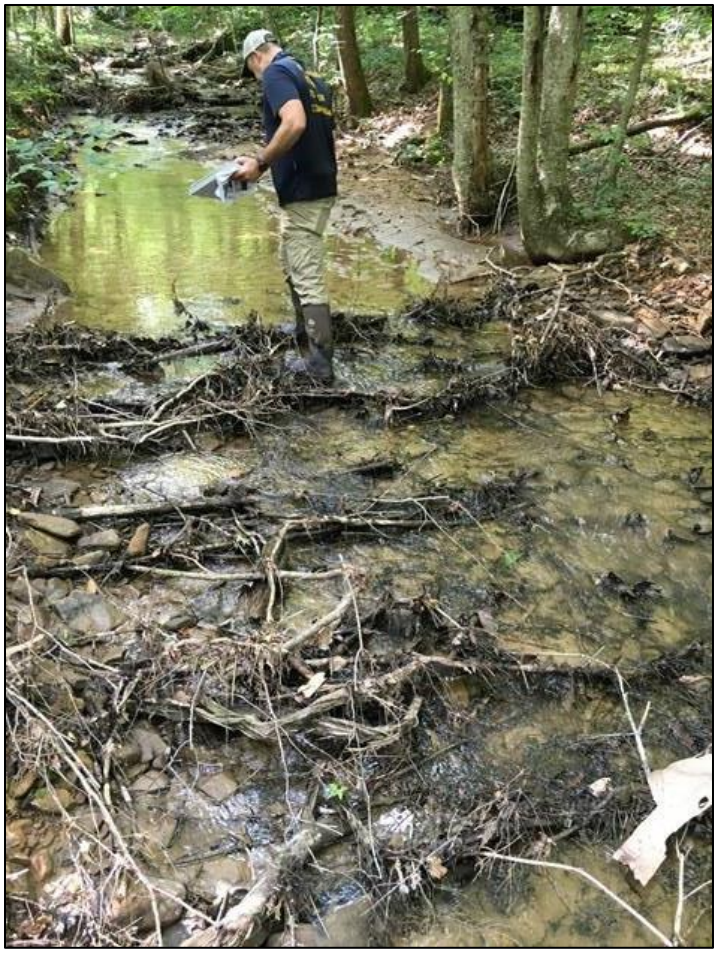

*Figure 43. Woody riffle structure.*

A woody riffle typically consists of primary logs, which are larger, and secondary logs that are smaller and used with sandy soil backfill in between the primary logs. If the primary logs meet the LWD size requirements, then the scoring is similar to the log sill scoring shown above and each primary log in the woody riffle may yield 27 to 29 points.

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# Appendix A

## LWDI Field Sheet

## LARGE WOODY DEBRIS FIELD FORM

*Date Revised: 10/19/2016*

| | | | | | |
|---|---|---|---|---|---|
| Investigator(s) | | State | | Forest Type | Deciduous Evergreen Mixed Other |
| Date | | County | | Forest Age (yrs) | |
| Stream Name | | Phys. Province | | Latitude (dd) | |
| Reach ID | | Drainage Area ($mi^2$) | | Longitude (dd) | |
| Watershed Name | | Dominant Species | | | |
| Survey Length (ft) | 328 Survey Length = 328 ft/100 m | BKF Width (ft) | | Slope (ft/ft) | |
| Stream Classification | Ephemeral Intermittent Perennial | BKF Mean Depth (ft) | | Bed material | |
| Stream Condition | Degraded Restored Reference Managed | Floodprone Width (ft) | | Rosgen Type | |
| Field Notes: | | | | | |

| SCORE | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 4 | | 5 | | |
| **CATEGORY** | *** PIECES *** | | | | | | | | | | **TOTAL PIECES** |
| Length/BKF Width | 0 to 0.4 | | 0.4 to 0.6 | | 0.6 to 0.8 | | 0.8 to 1.0 | | > 1.0 | | |
| Diameter (cm) | 10 to 20 | | 20 to 30 | | 30 to 40 | | 40 to 50 | | >50 | | |
| Location | **Zone 4** (Above BKF/Extending into Channel) | | | | **Zone 3** (Above BKF/Within Streambanks) | | **Zone 2** (Above WS/Below BKF) | | **Zone 1** (Below WS) | | |
| Type | Bridge | | | | Ramp | | Submersed | | Buried | | |
| Structure | Plain | | Plain/Int | | Intermediate | | Int/Sticky | | Sticky | | |
| Stability | Moveable | | Mov/Int | | Intermediate | | Int/Sec | | Secured | | |
| Orientation (deg) | 0 to 20 | | 20 to 40 | | 40 to 60 | | 60 to 80 | | 80 to 90 | | |
| **CATEGORY** | **** DEBRIS DAMS **** | | | | | | | | | | **TOTAL DAMS** |
| Length (% of BKF Width) | 0 to 20 | | 20 to 40 | | 40 to 60 | | 60 to 80 | | 80 to 100 | | |
| Height (% of BKF Depth) | 0 to 20 | | 20 to 40 | | 40 to 60 | | 60 to 80 | | 80 to 100 | | |
| Structure | Coarse | | Coarse/Int | | Intermediate | | Int/Fine | | Fine | | |
| Location | Partially high flow | | In high flow | | Partially low flow | | Mid low flow | | In low flow | | |
| Stability | Moveable | | Mov/Int | | Intermediate | | Int/Sec | | Secured | | |

* Pieces - Non-living wood that has a large end diameter ≥ 10 cm and has a length ≥ 1 m. ** Debris Dams - Three (3) or more pieces touching.

# Appendix B

## A Quick Field Guide to Measuring Large Woody Debris in Streams

# A Quick Field Guide to Measuring Large Woody Debris in Streams

**Tom Barrett**

**Will Harman**

**Cidney Jones**

**Updated on 11/17/2017**

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# Large Woody Debris in Streams

**Field Task List (Prior to conducting LWD Assessment)**

- Determine bankfull using field indicators and verify using the regional curve data.
- Measure bankfull dimensions. To be the most efficient, it is recommended that bankfull width (ft), bankfull mean depth (ft), and floodprone width (ft) be determined at the same time.
- Determine the location of your LWD sampling area along the channel.
  - The sampling reach will consist of the 100-meter of stream within the reach that will yield the **highest** score from visual observations.
- Stretch a 100-meter tape along the thalweg of the area to be sampled.

# Pieces

**Piece Definition**

1. **≥ 1-meter in length,**
2. **≥ 10-centimeters in diameter at its largest end,**
3. **Non-living wood,**
4. **Occurs within the specified locations (Zones), and**
5. **Within the 100-meter LWD assessment reach of the stream.**

- Determine if the wood meets the LWD definition
- Remember your measurements for Criteria 1 & 2.

# Piece Criteria

| | Score | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| **Pieces** | | | | | |
| **Length/Wbkf** | 0 to 0.4 | 0.4 to 0.6 | 0.6 to 0.8 | 0.8 to 1.0 | > 1.0 |
| **Diameter (cm)** | 10 to 20 | 20 to 30 | 30 to 40 | 40 to 50 | >50 |
| **Location** | Zone 4 | | Zone 3 | Zone 2 | Zone 1 |
| **Type** | Bridge | | Ramp | Submersed | Buried |
| **Structure** | Plain | Plain/Int | Intermediate | Int/Sticky | Sticky |
| **Stability** | Moveable | Mov/Int | Intermediate | Int/Sec | Secured |
| **Orientation (deg.)** | 0 to 20 | 20 to 40 | 40 to 60 | 60 to 80 | 80 to 90 |

- **Use your best judgement when assessing these criteria.**

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# Piece - Length/Bankfull Width

- **Measure the length of the piece**
- **Calculate or Estimate length/bankfull width ratio and record a tally in appropriate box**

**Reminder: Measure bankfull width at the cross section where the piece of wood is found**

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# Piece Diameter

- **Measure the diameter (cm) of the largest end of the LWD**
- **Record a tally in appropriate diameter range box (10-20, 20-30, etc.)**

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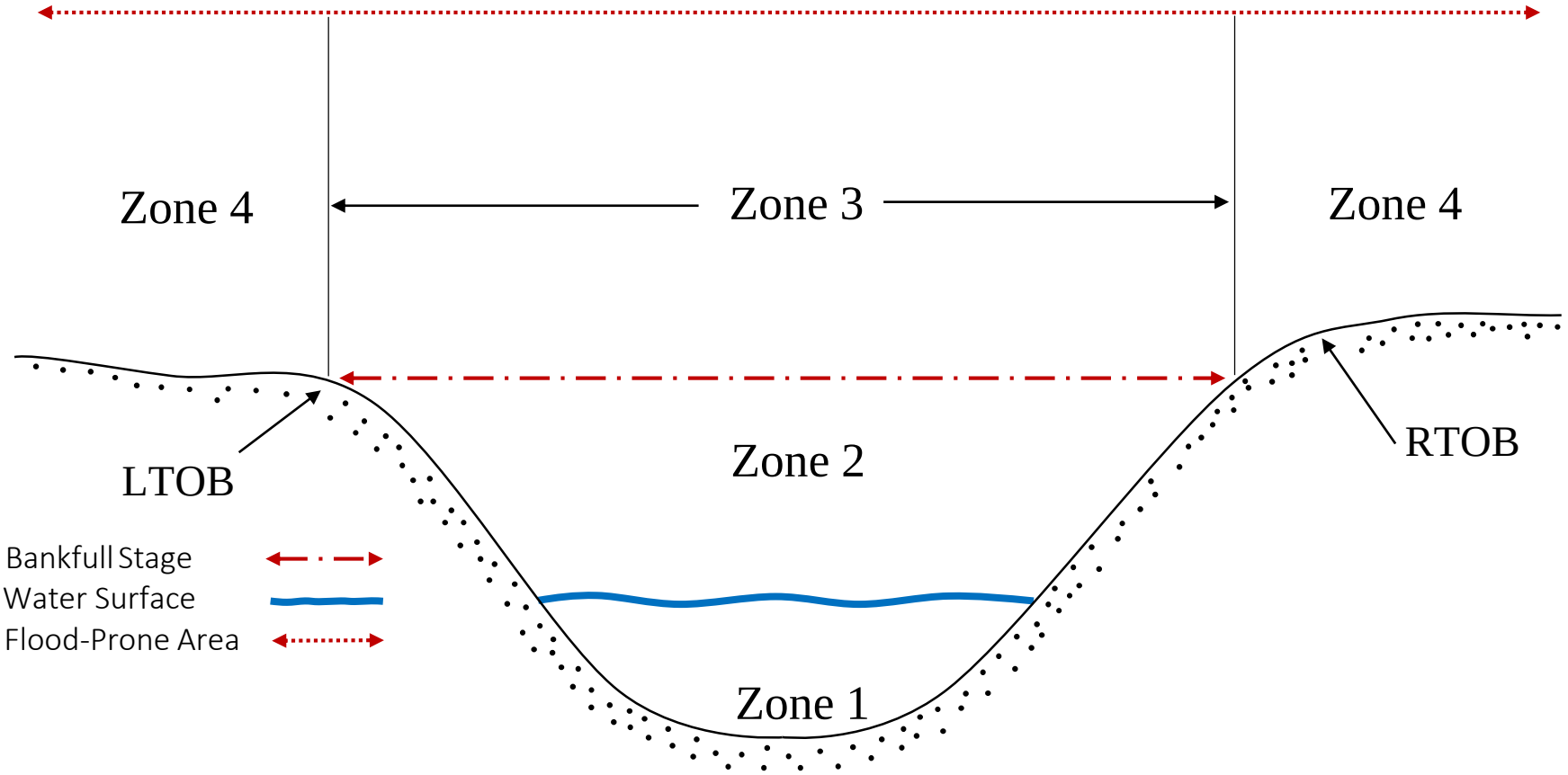
# Piece - Location (Zones)

## General Zone Overviews for

## Incised and Non-Incised Channels

# Zones
## (Non-Incised Channels)

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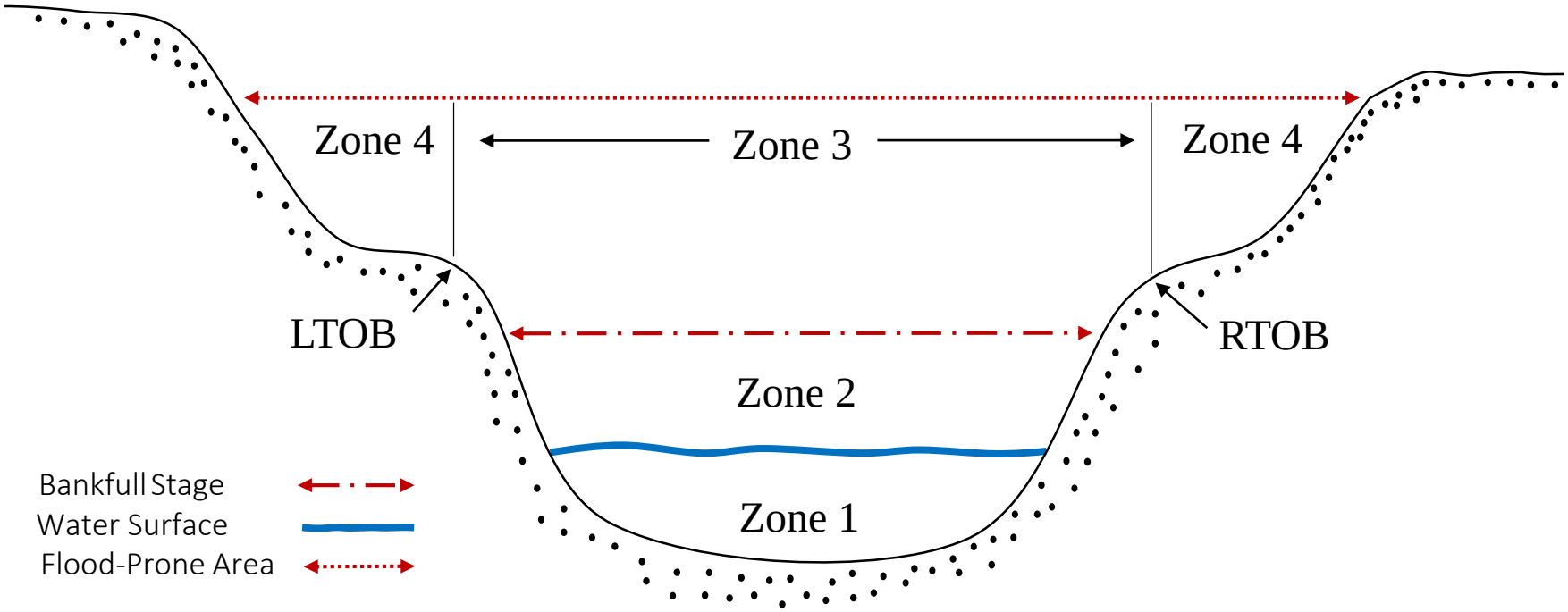
# Zones
## (Incised Channels)

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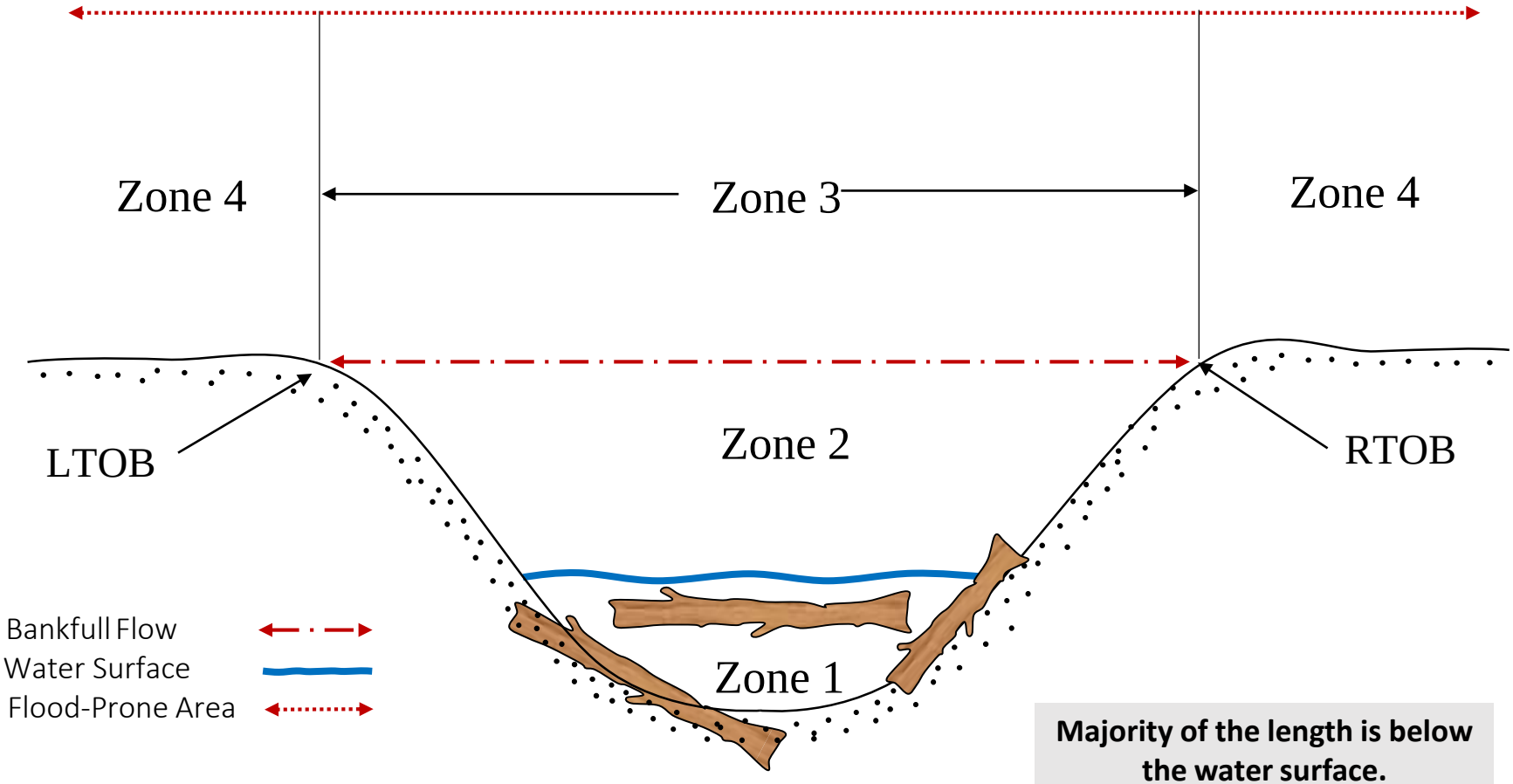
# Piece – Location Examples

**Zones for non-incised channels are presented first followed by incised channels**

# Zone 1




**Majority of the length is below the water surface.**

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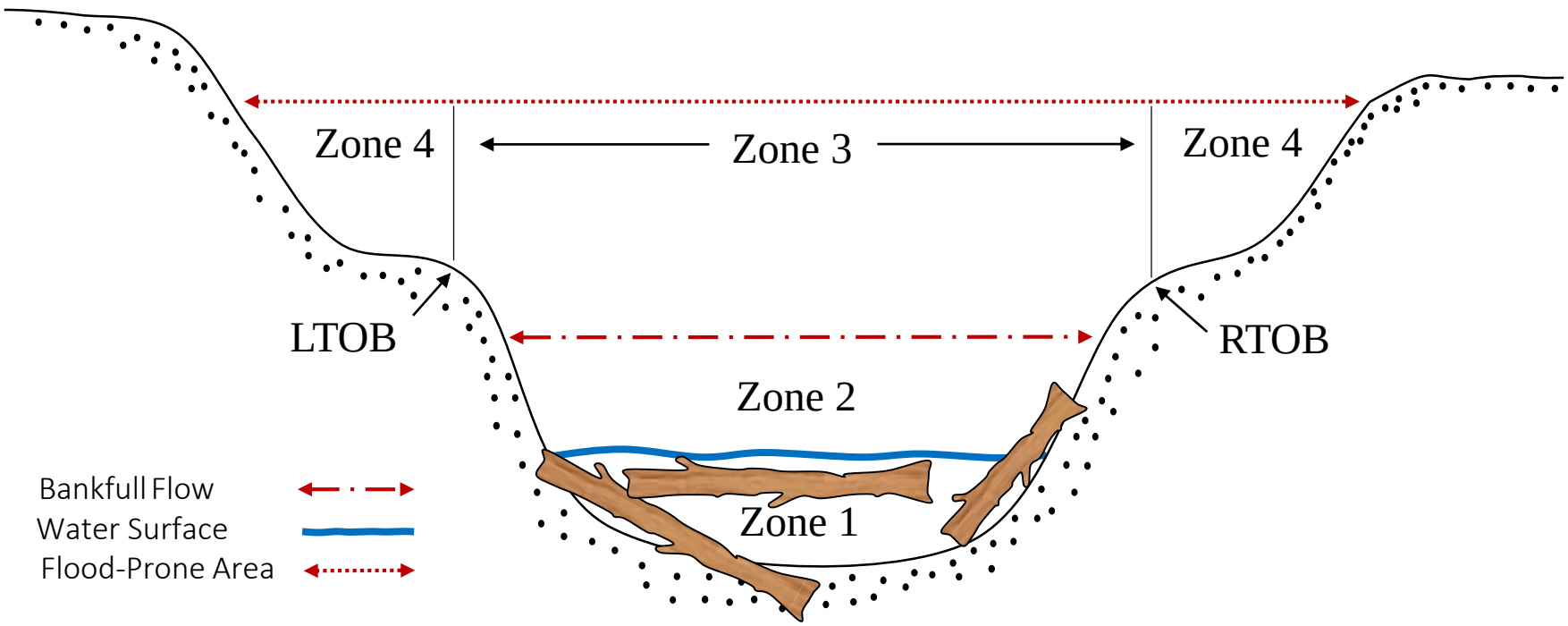
# Zone 1




**Majority of the length is below the water surface.**

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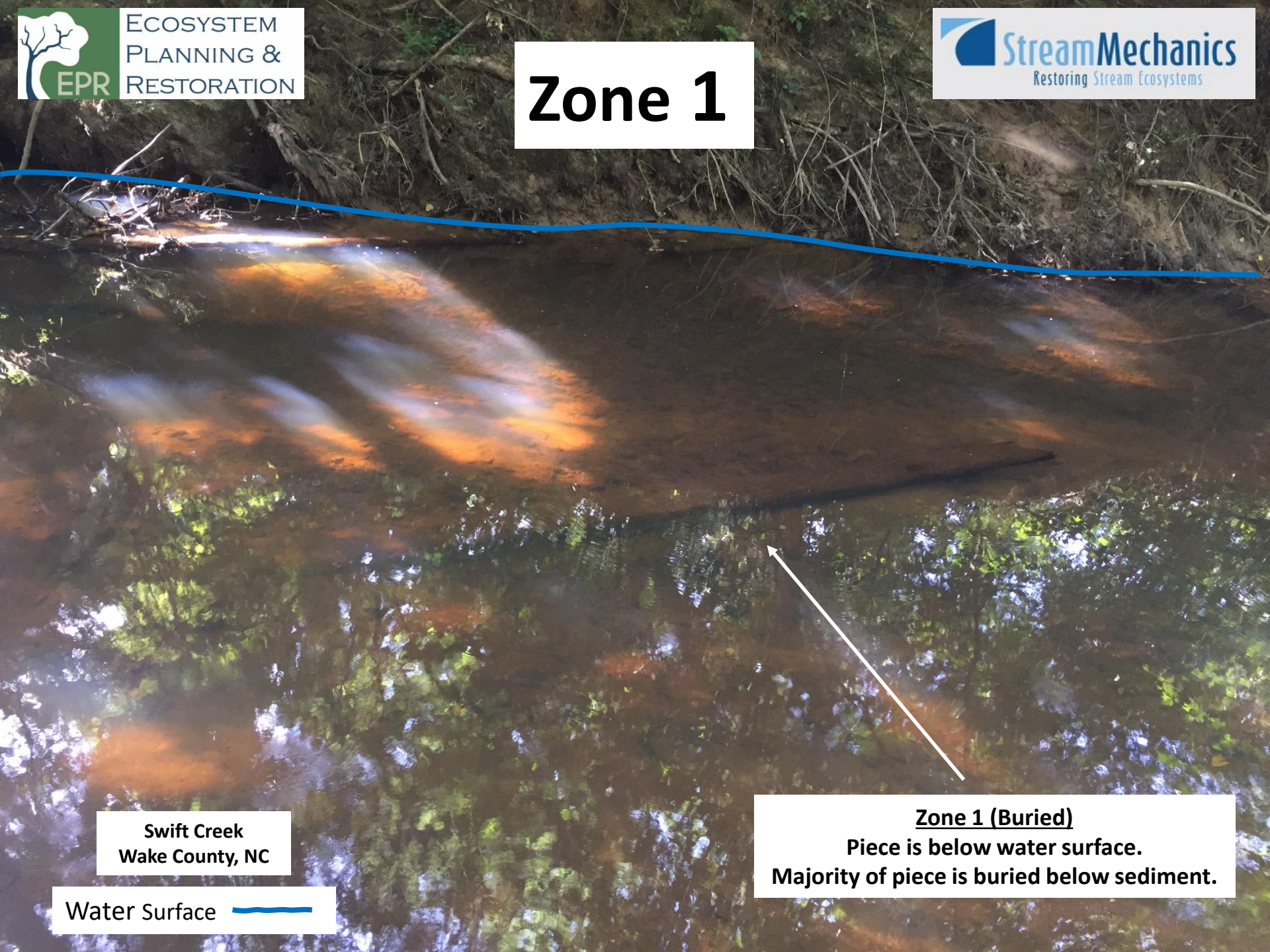
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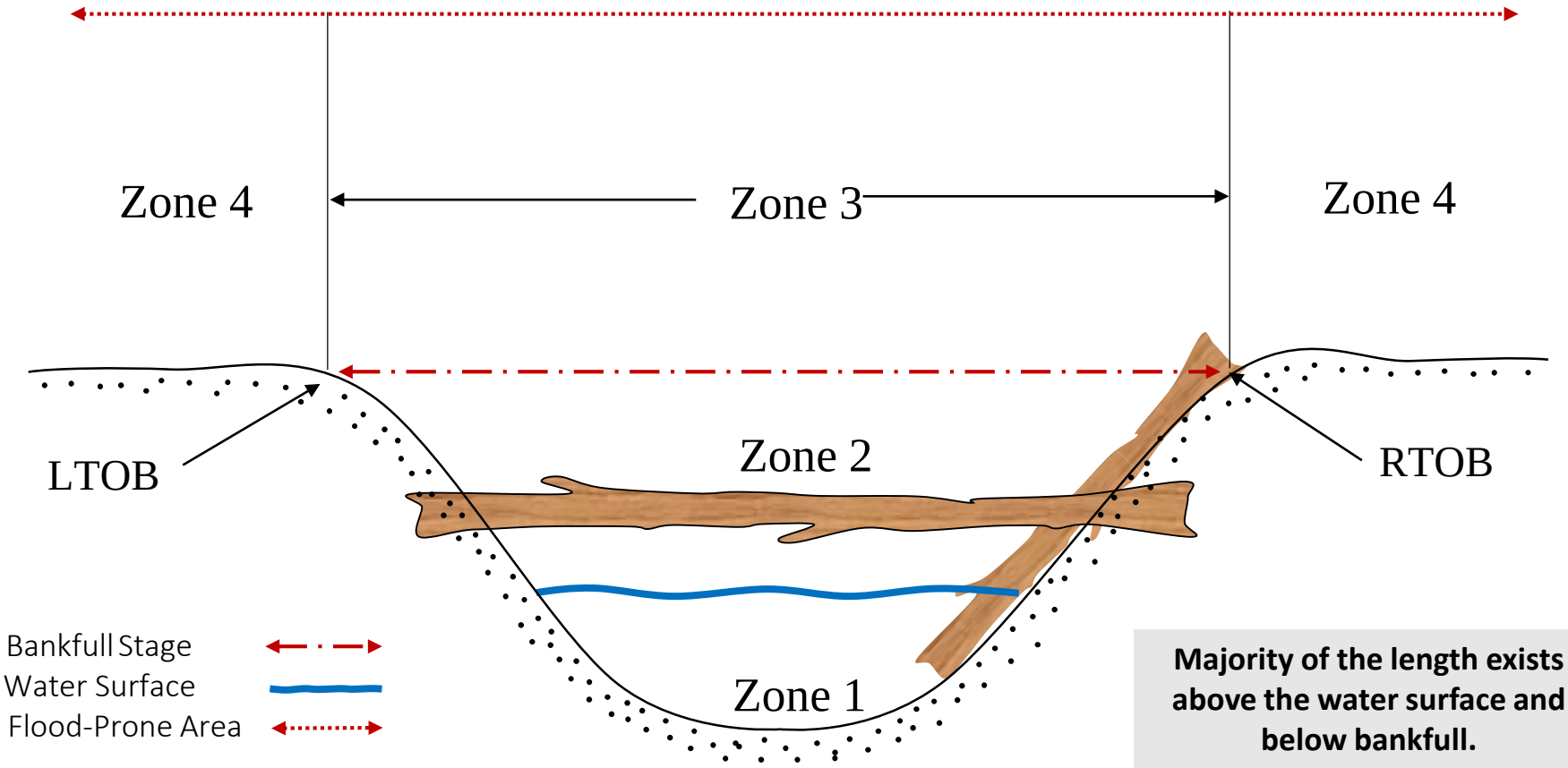
Zone 1
StreamMechanics
Restoring Stream Ecosystems
Swift Creek
Wake County, NC
Water Surface
Zone 1 (Buried)
Piece is below water surface.
Majority of piece is buried below sediment.

# Zone 2




**Majority of the length exists above the water surface and below bankfull.**

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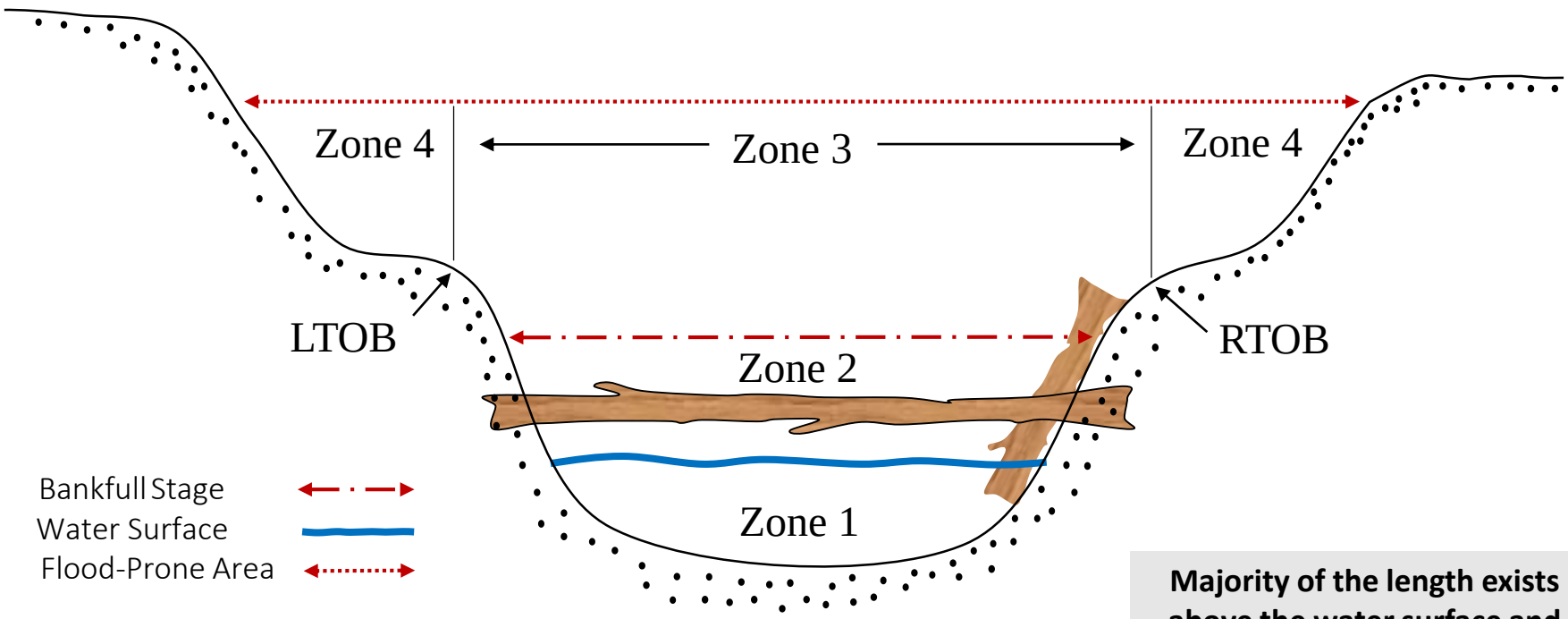
# Zone 2




**Majority of the length exists above the water surface and below bankfull.**

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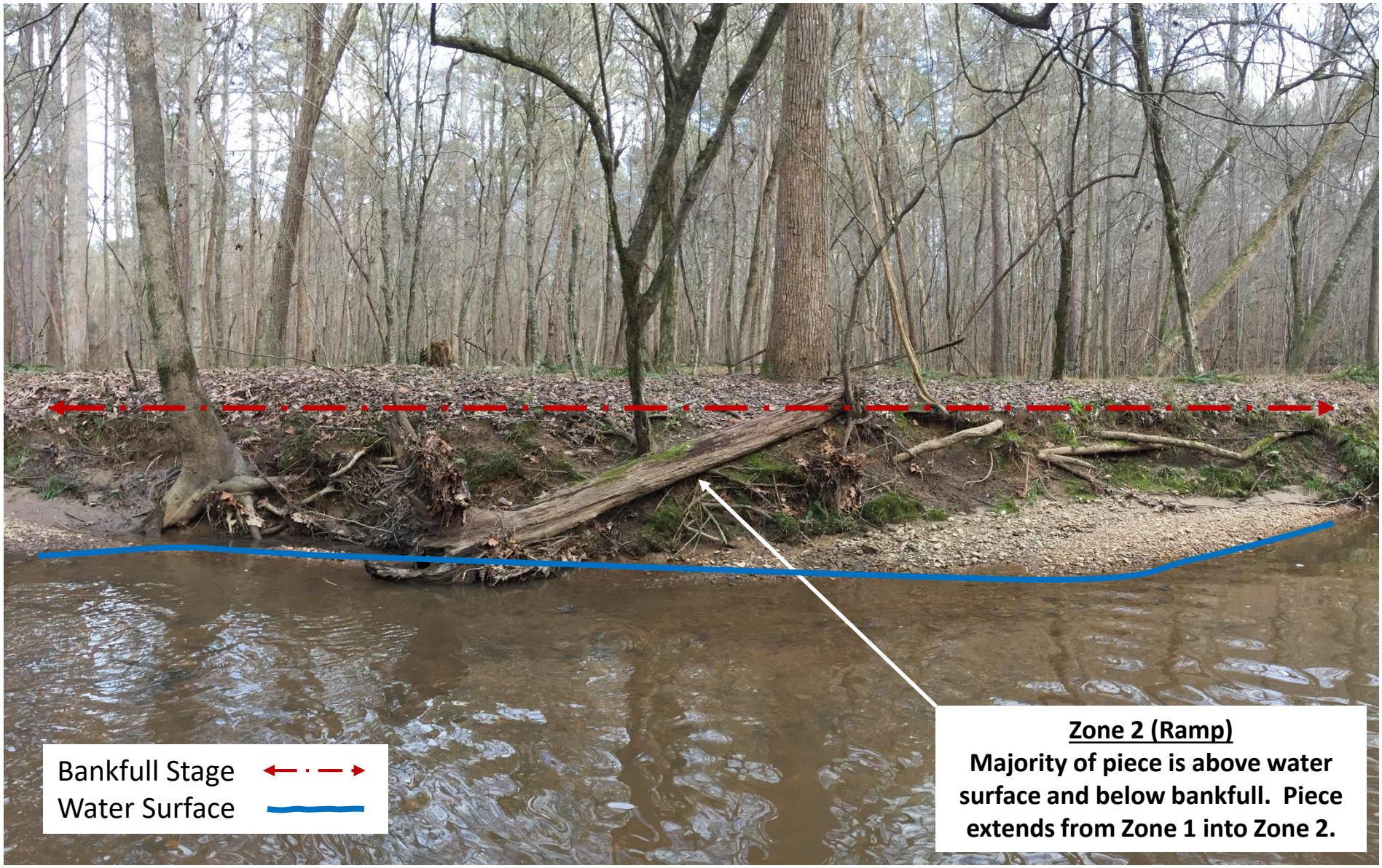


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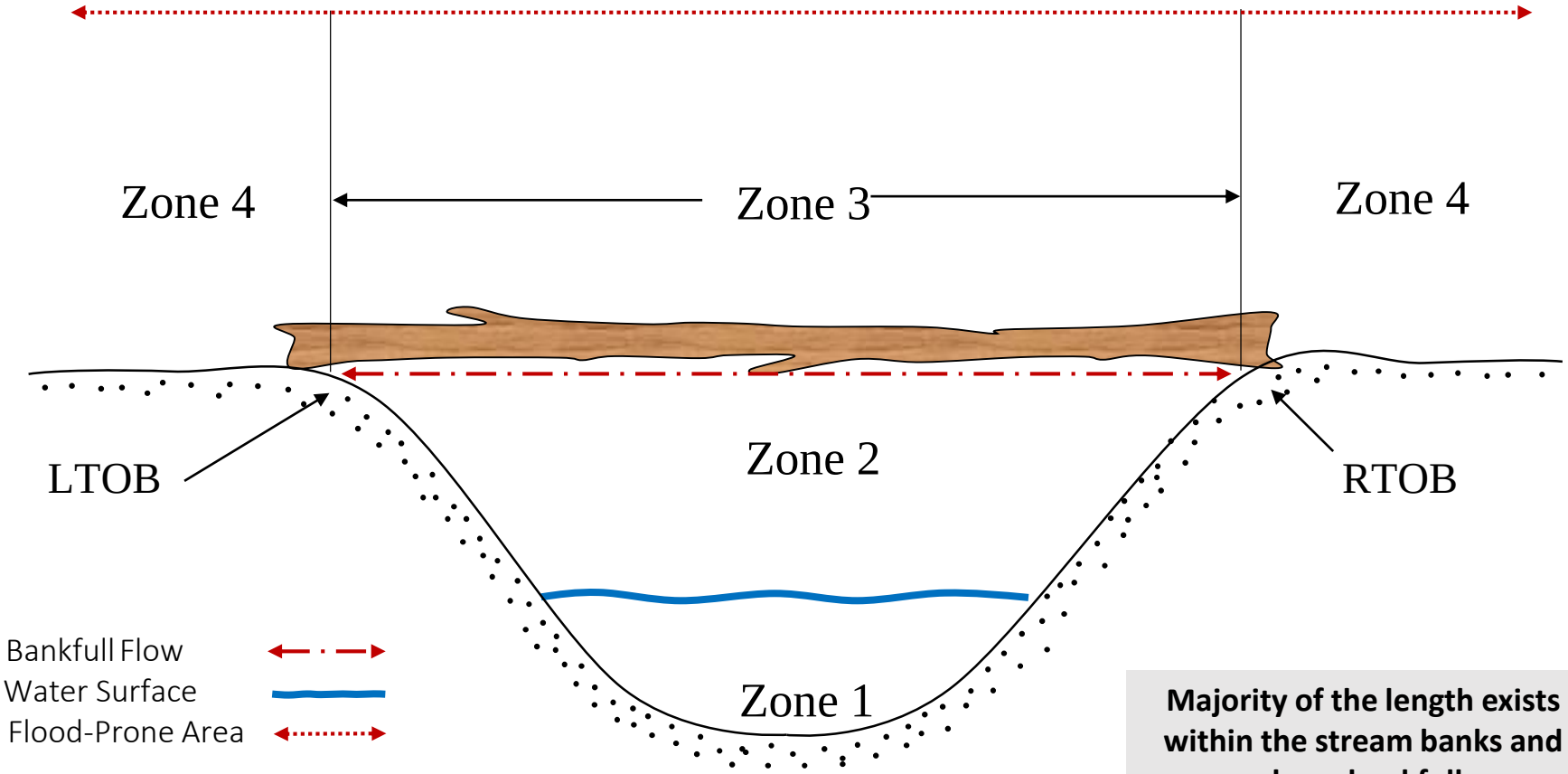
# Zone 3




**Majority of the length exists within the stream banks and above bankfull.**

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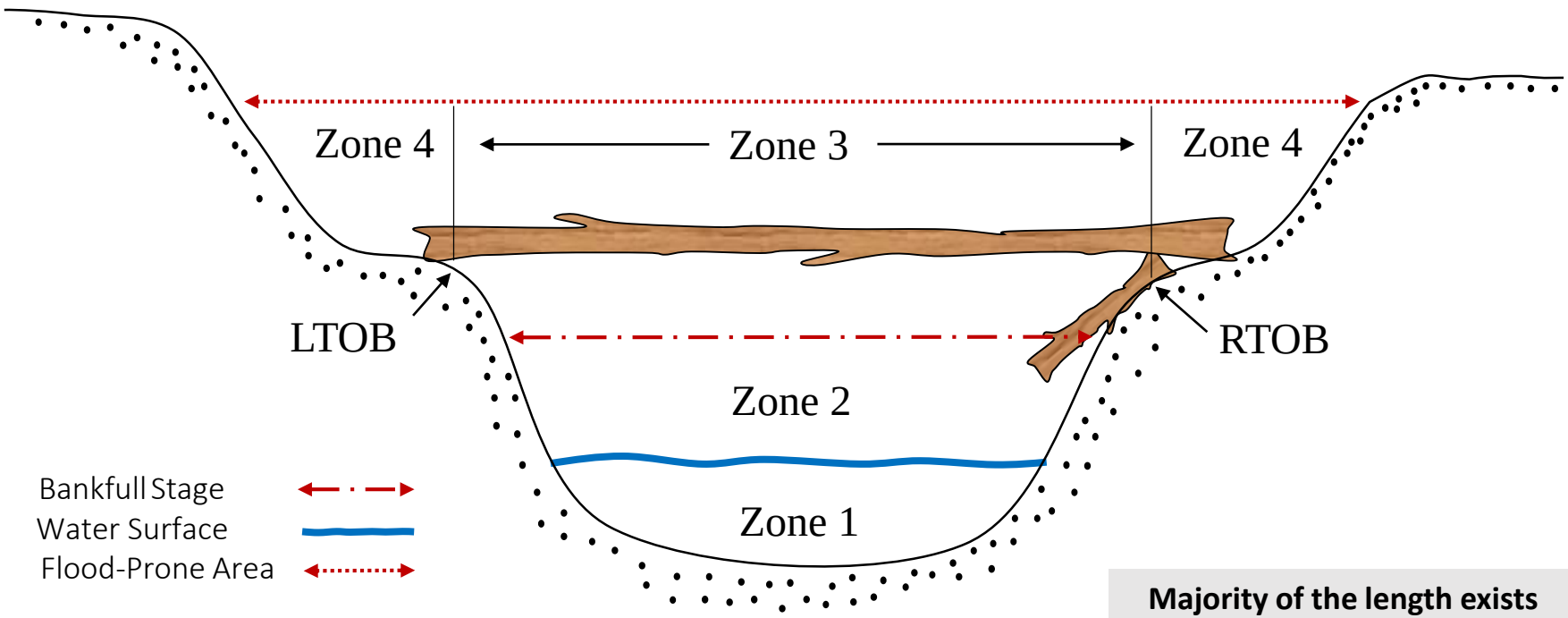
# Zone 3




**Majority of the length exists within the stream banks, above bankfull, and below the flood-prone depth.**

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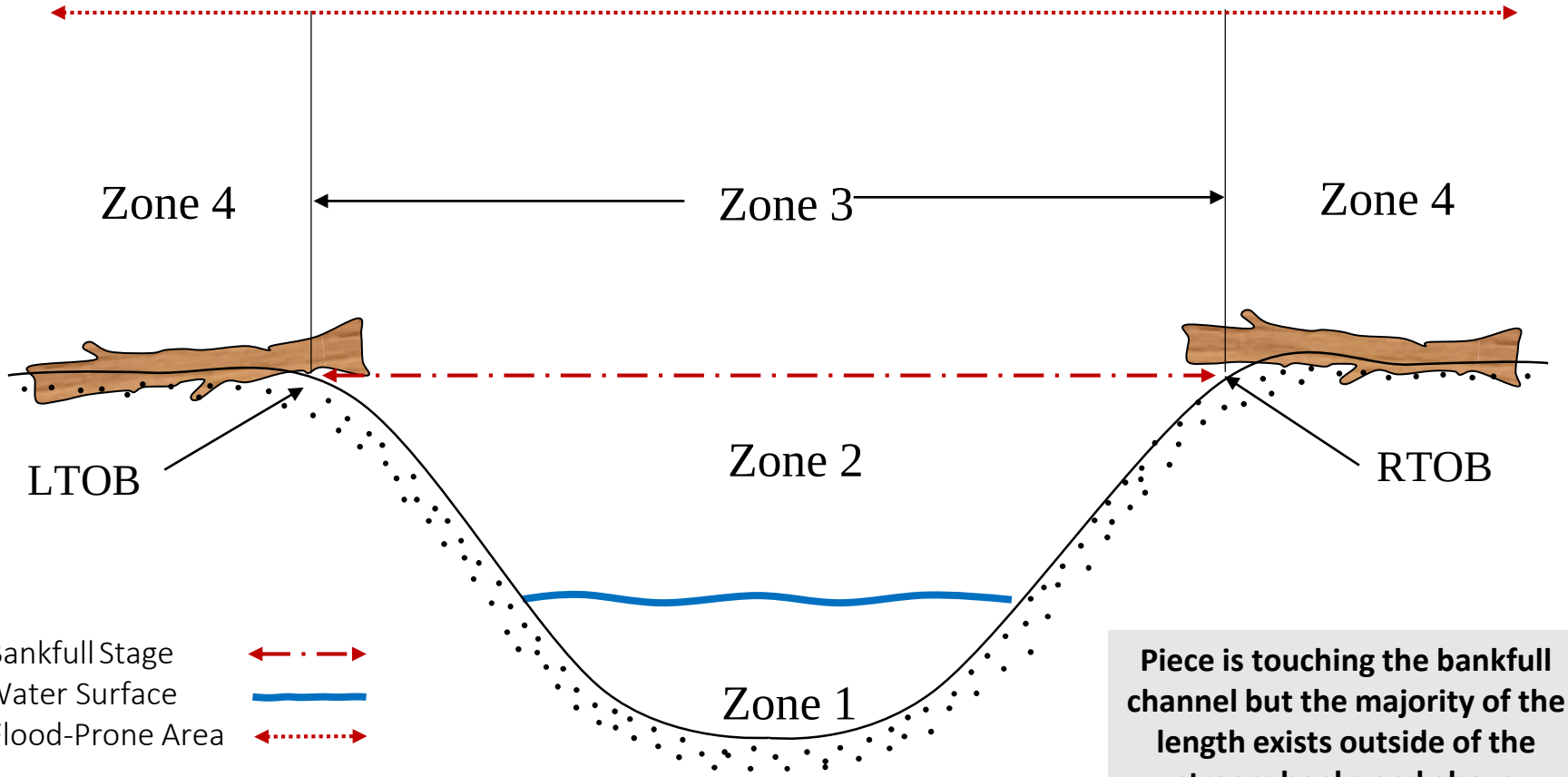
# Zone 4




**Piece is touching the bankfull channel but the majority of the length exists outside of the stream banks and above bankfull.**

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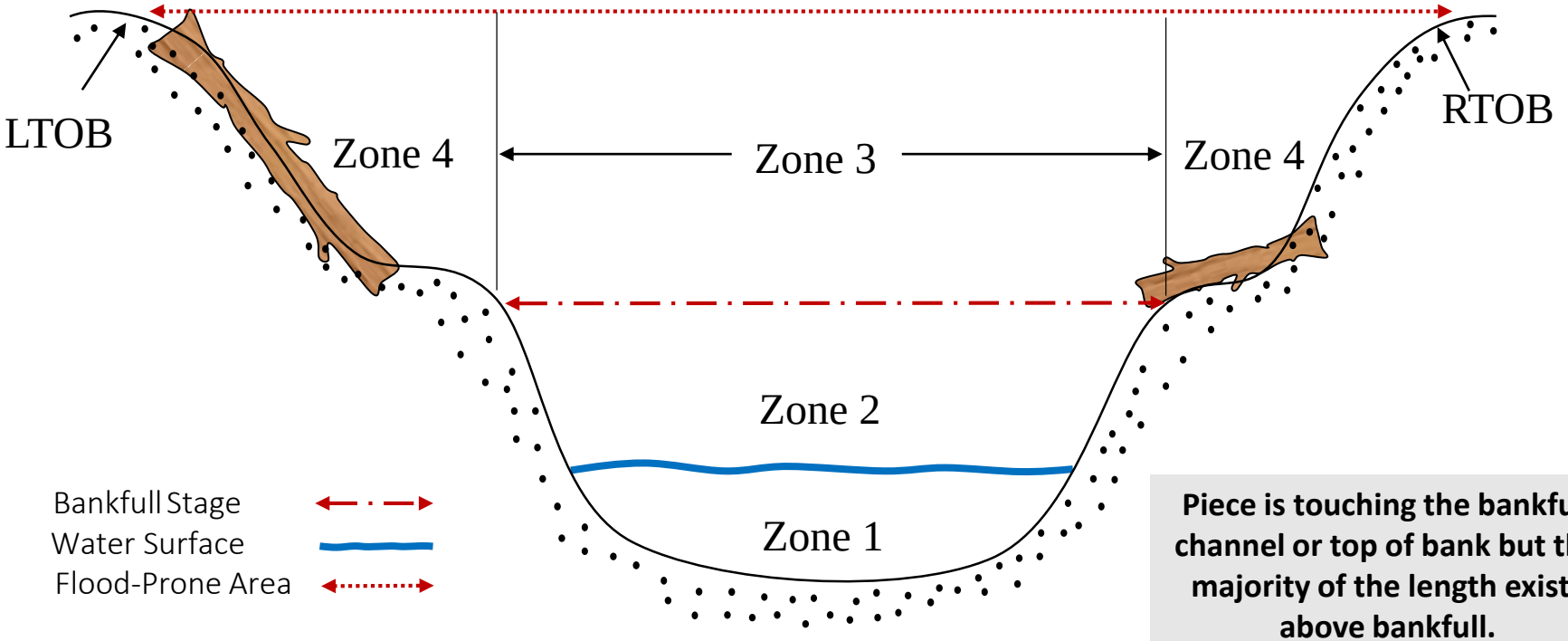
# Zone 4




**Piece is touching the bankfull channel or top of bank but the majority of the length exists above bankfull.**

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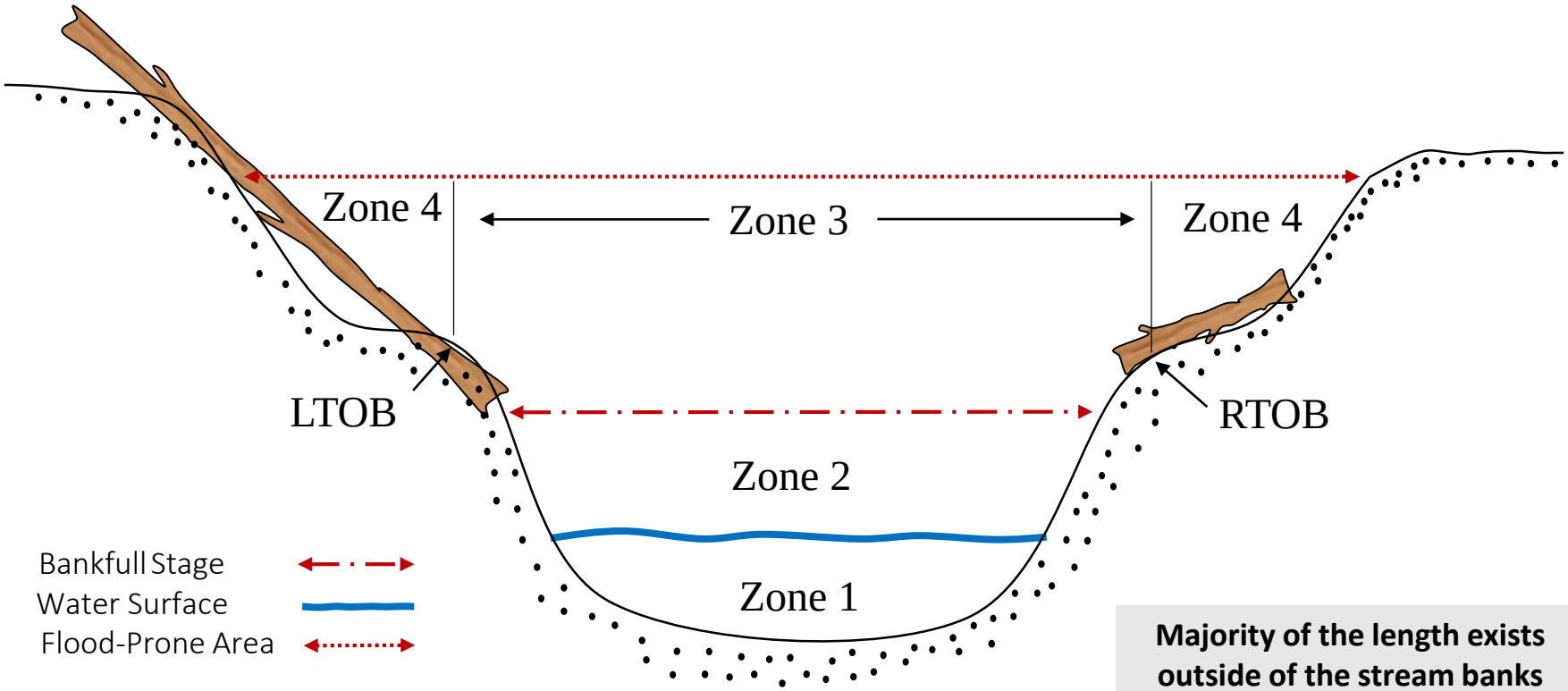
# Zone 4




**Majority of the length exists outside of the stream banks and above bankfull.**

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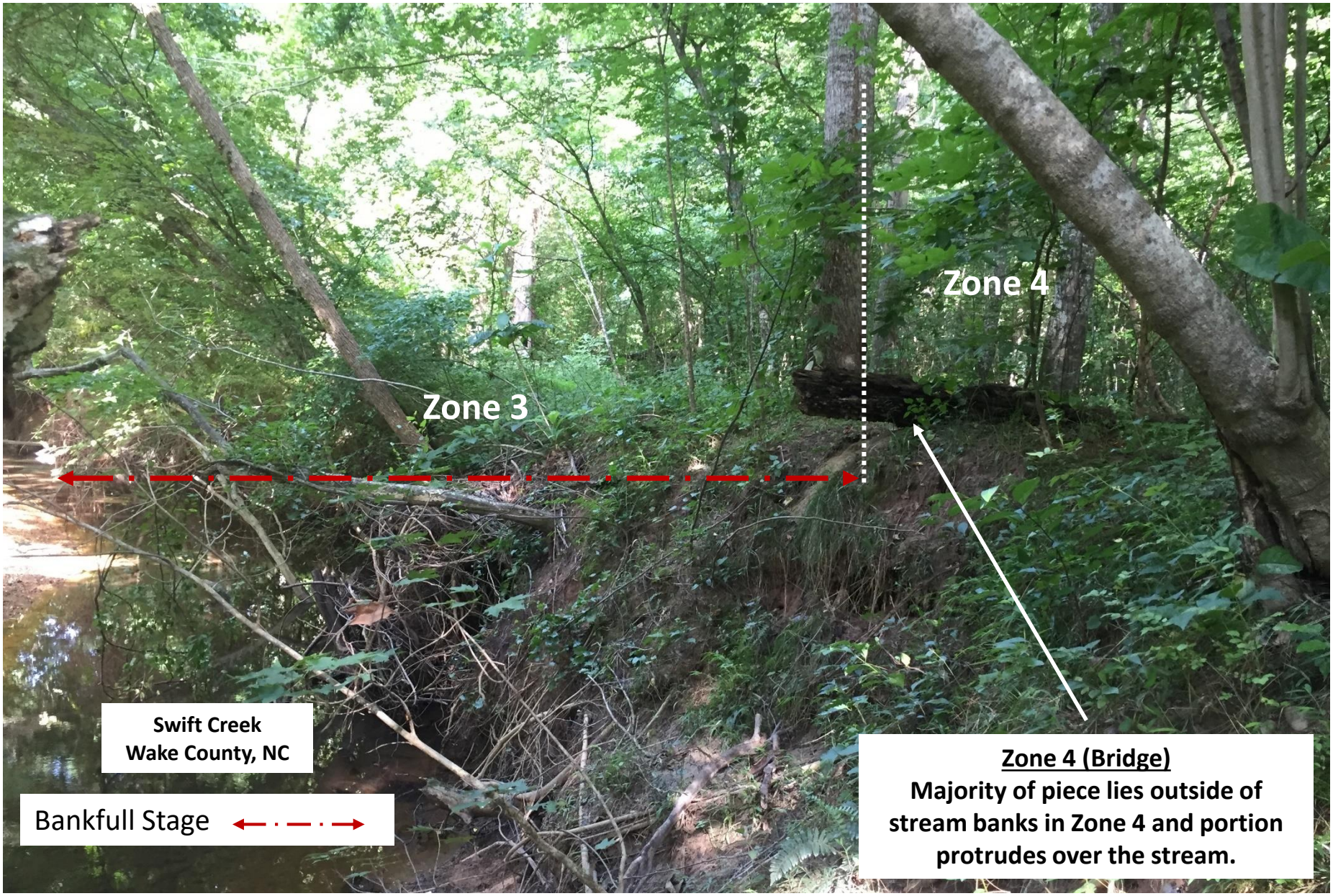


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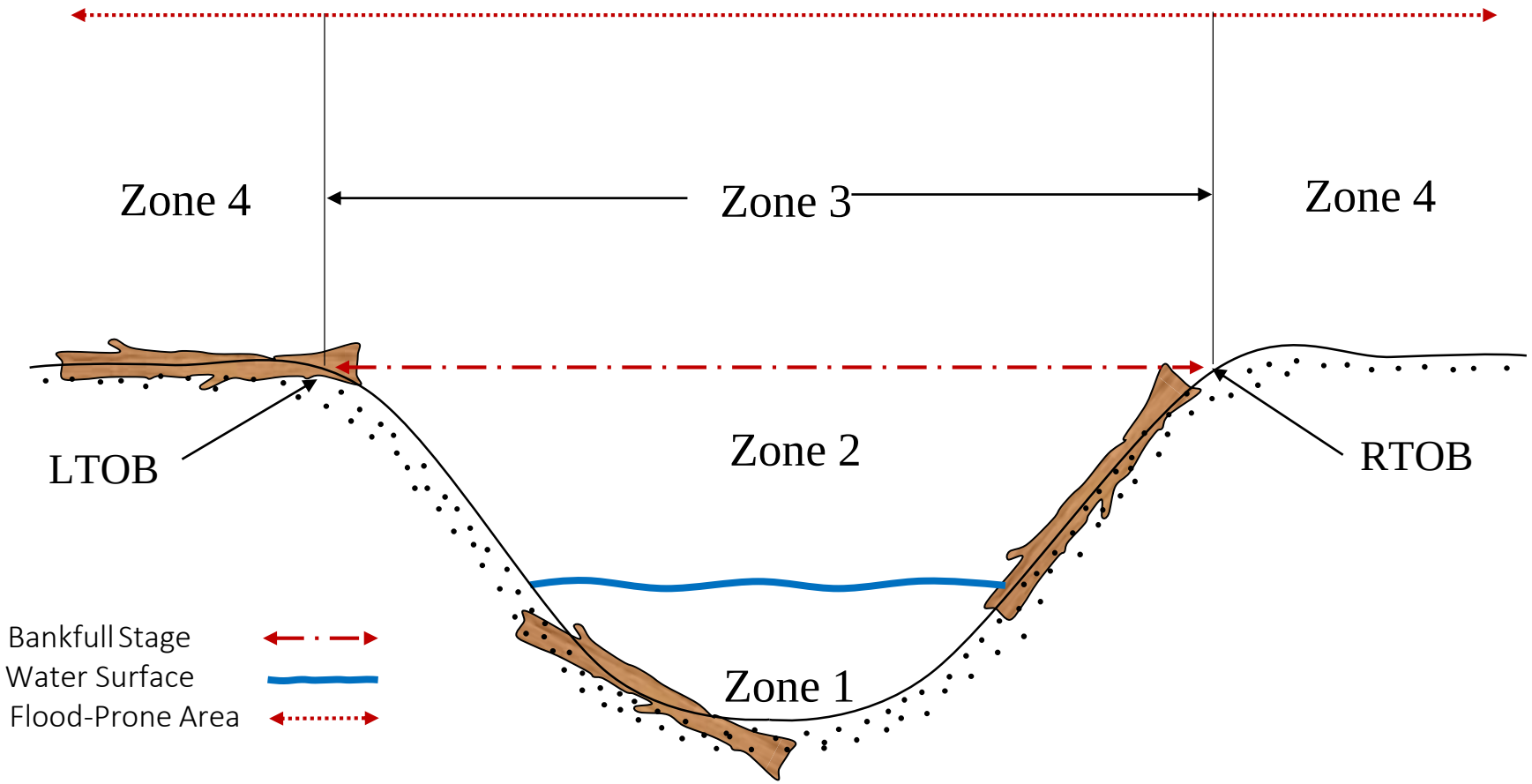
# Piece - Type

# Buried




**Majority of length is buried**

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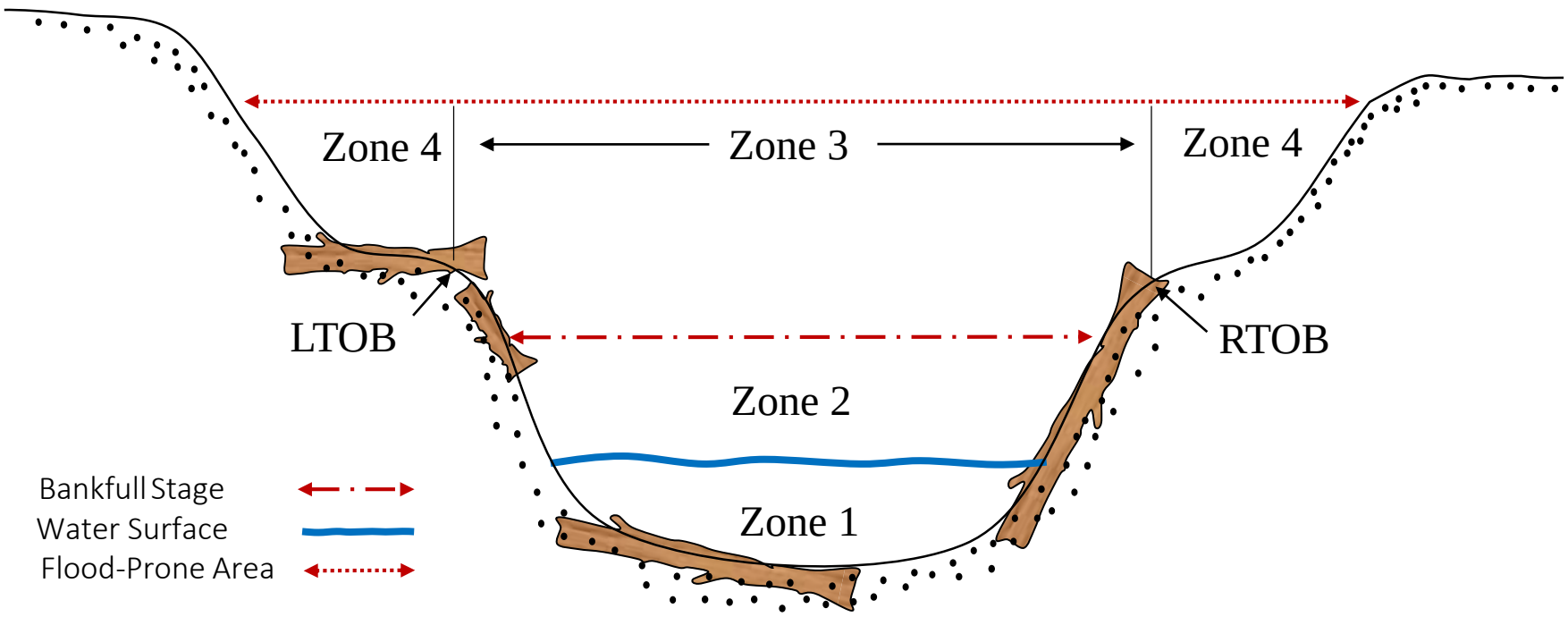
# Buried




**Majority of length is buried**

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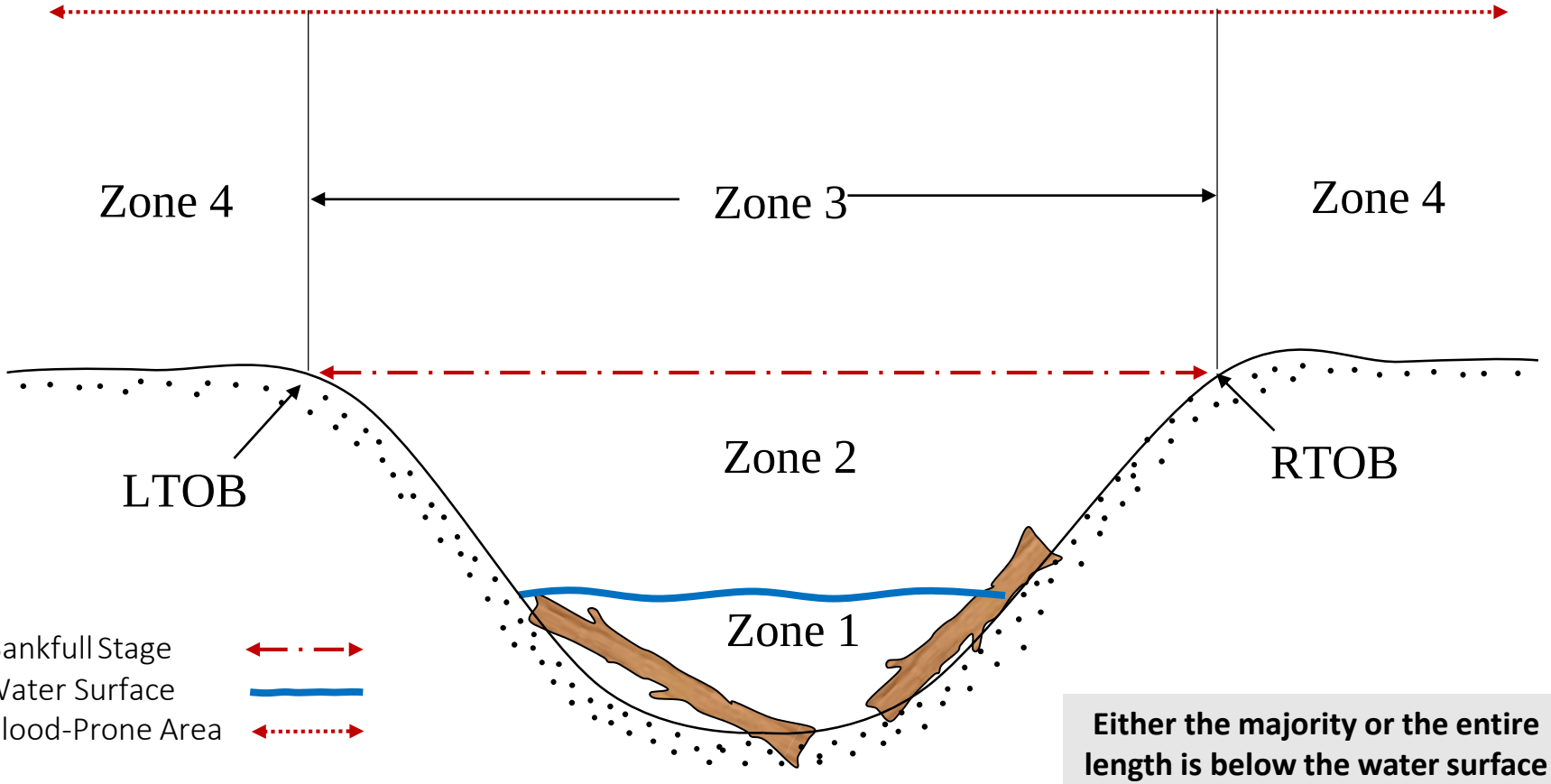
# Submersed




**Either the majority or the entire length is below the water surface**

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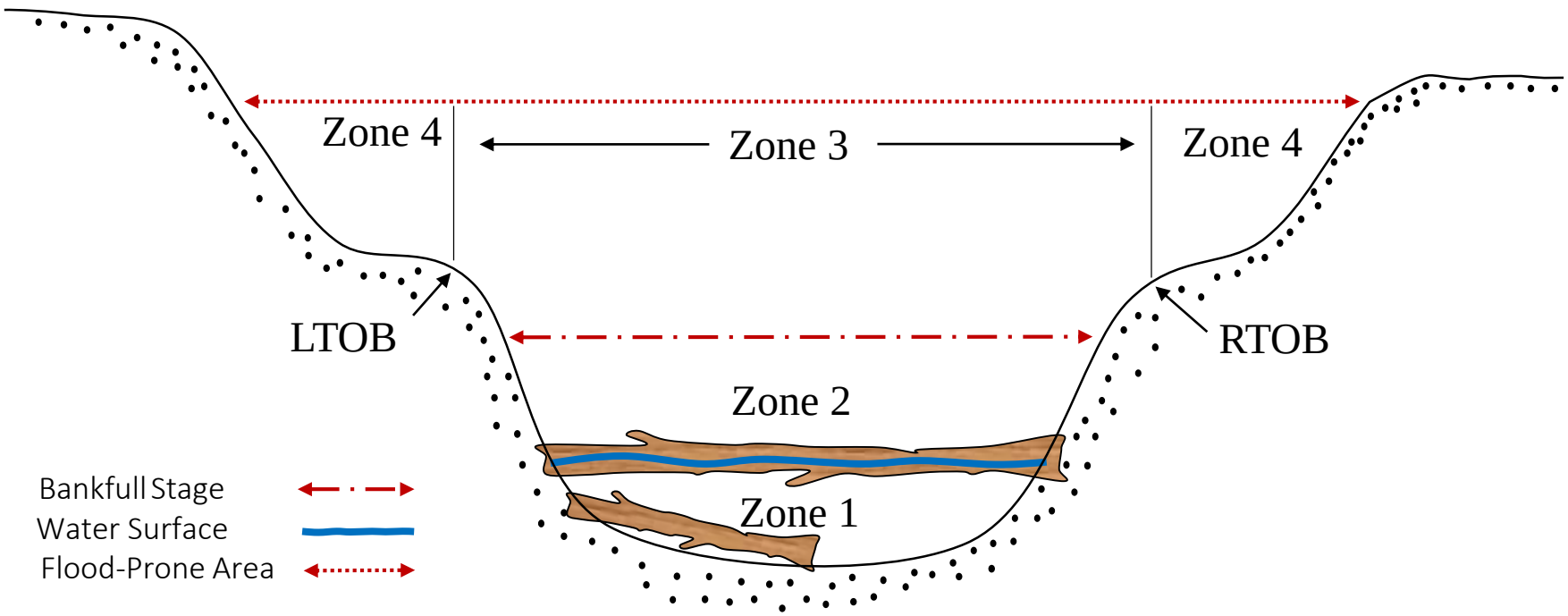
# Submersed




**Either the majority or the entire length is below the water surface**

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# Submersed

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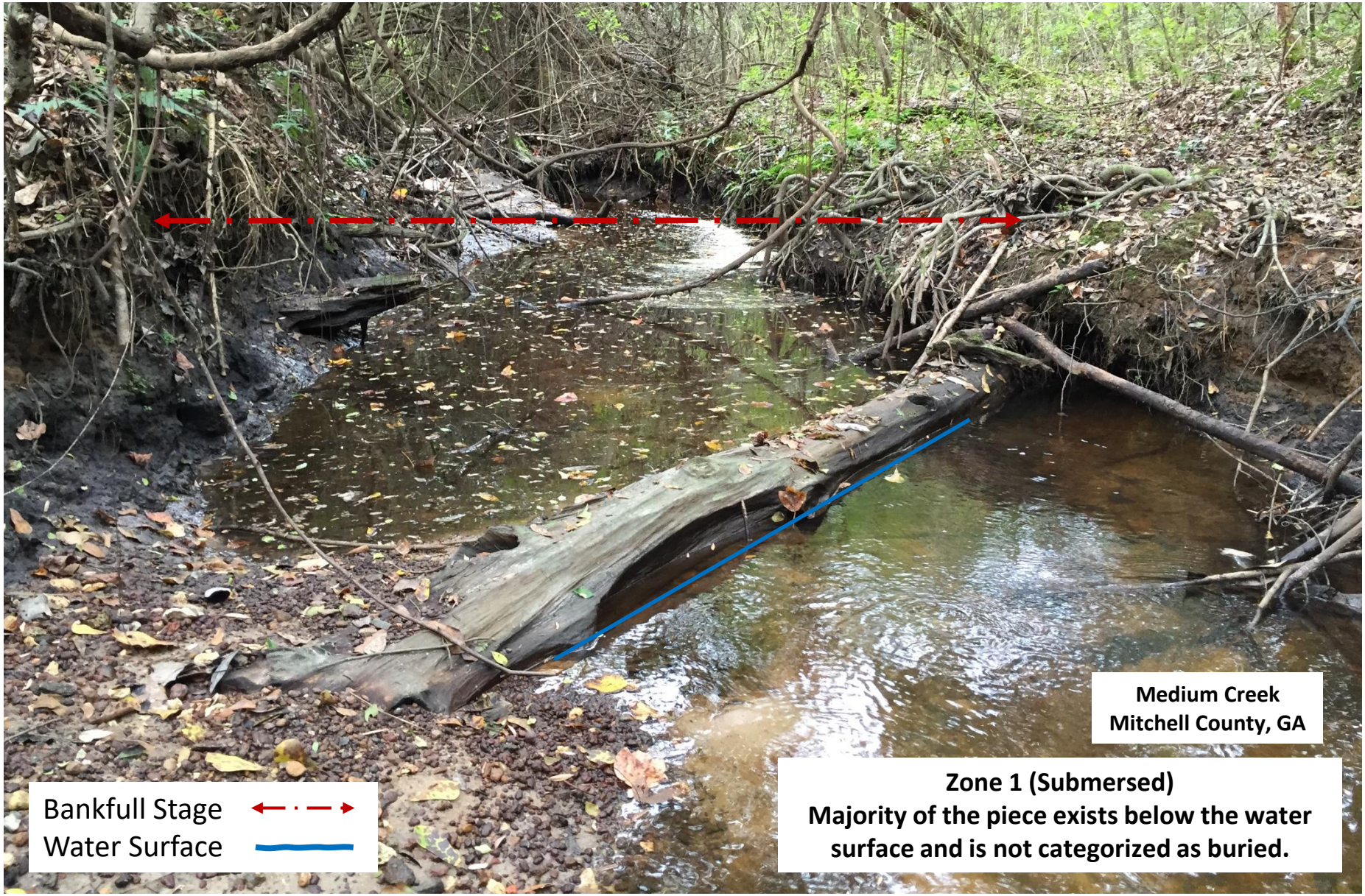


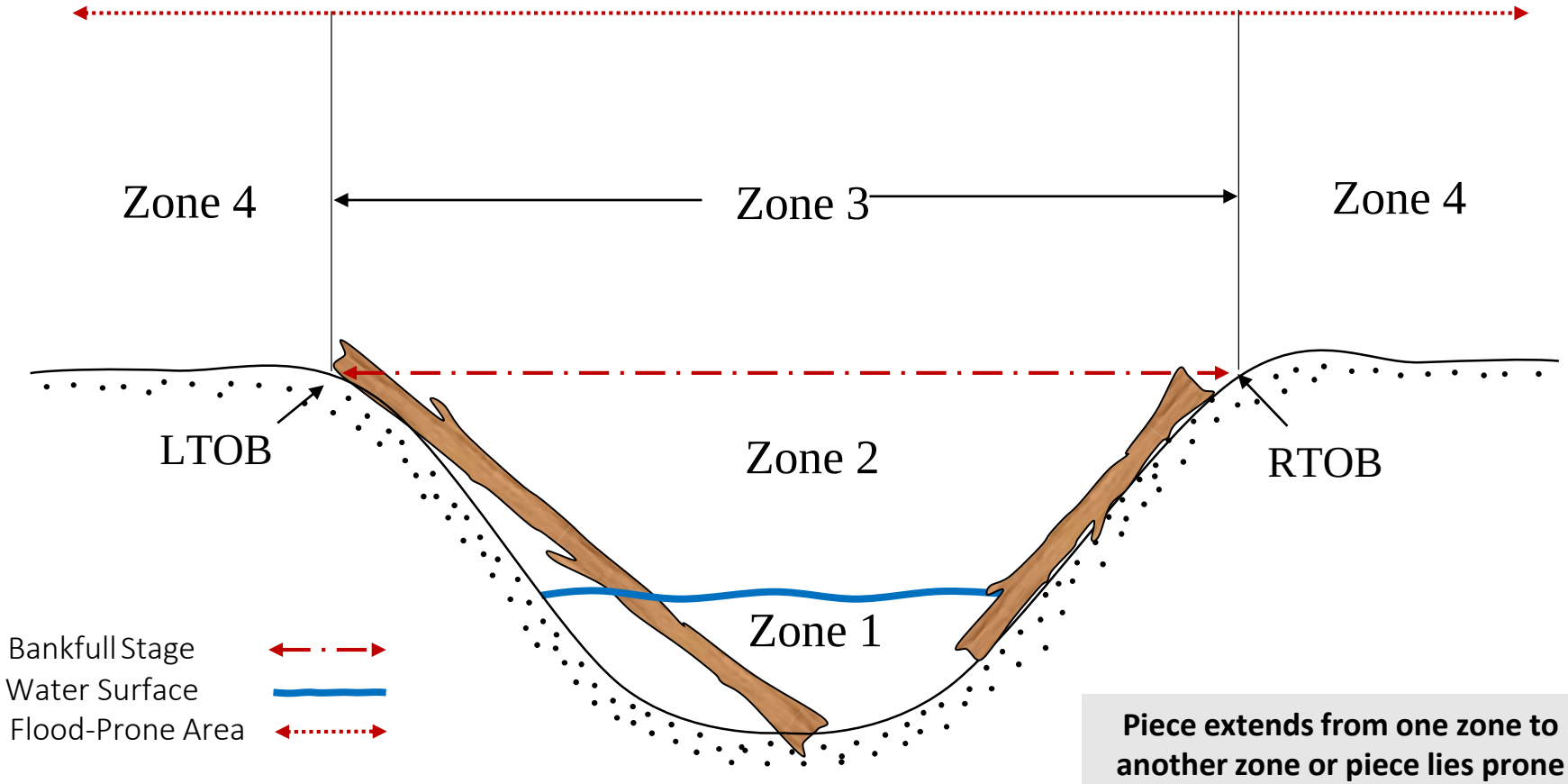
# Submersed

**Zone 1 (Submersed)**
**Majority of the piece exists below the water surface and is not categorized as buried.**

Bankfull Stage
Water Surface

**Medium Creek**
**Mitchell County, GA**

# Ramp




**Piece extends from one zone to another zone or piece lies prone within bankfull channel.**

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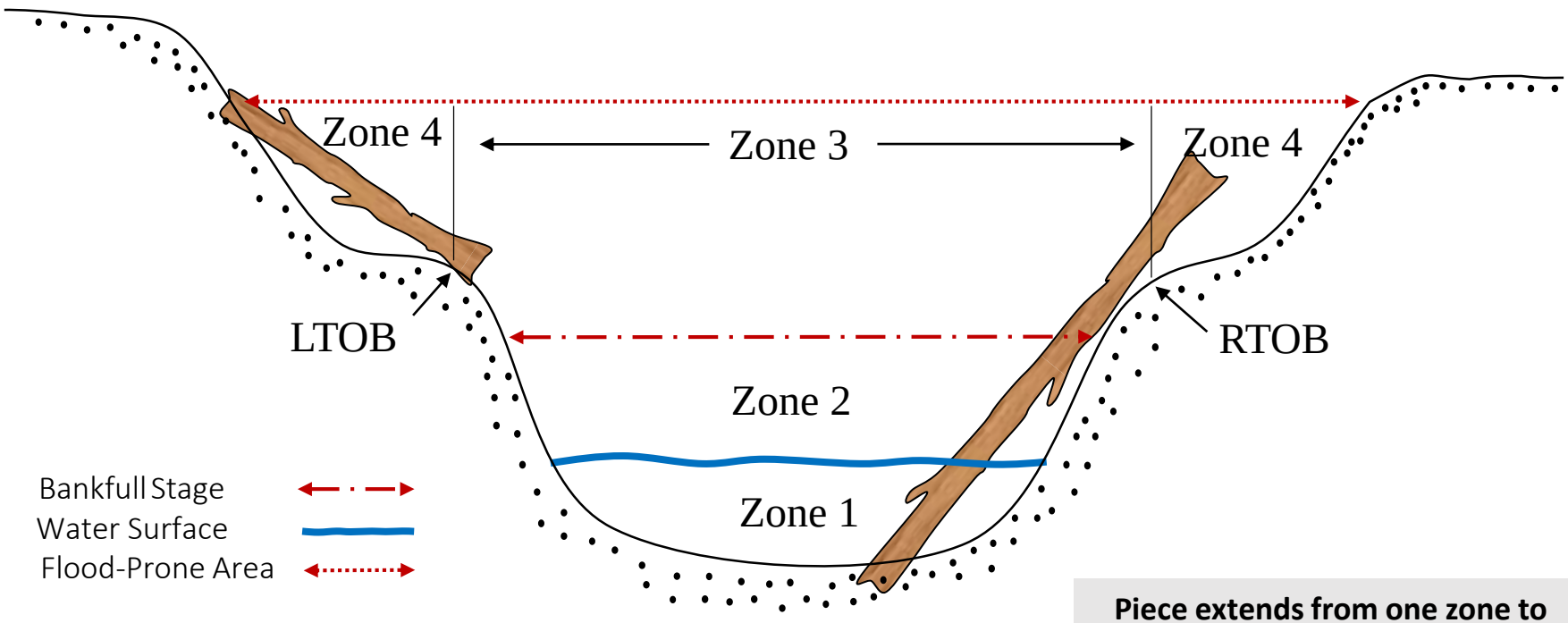
# Ramp




**Piece extends from one zone to another zone or piece lies prone within bankfull channel.**

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# Ramp


**Ramp (Zone 2)**

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# Ramp


**Little Fisher River,**
**Surry County, NC**

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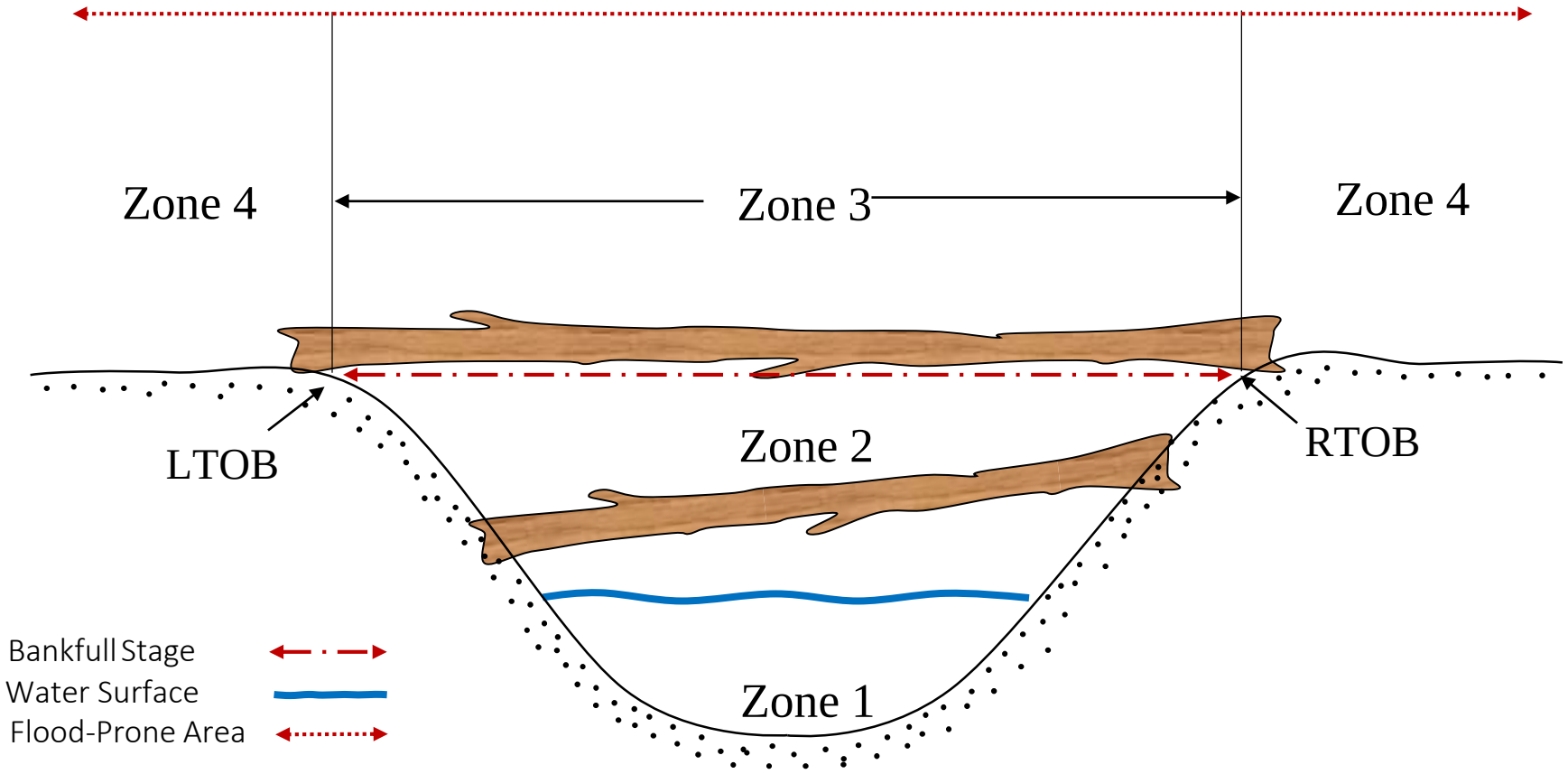
# Bridge




**Piece spans the channel.**

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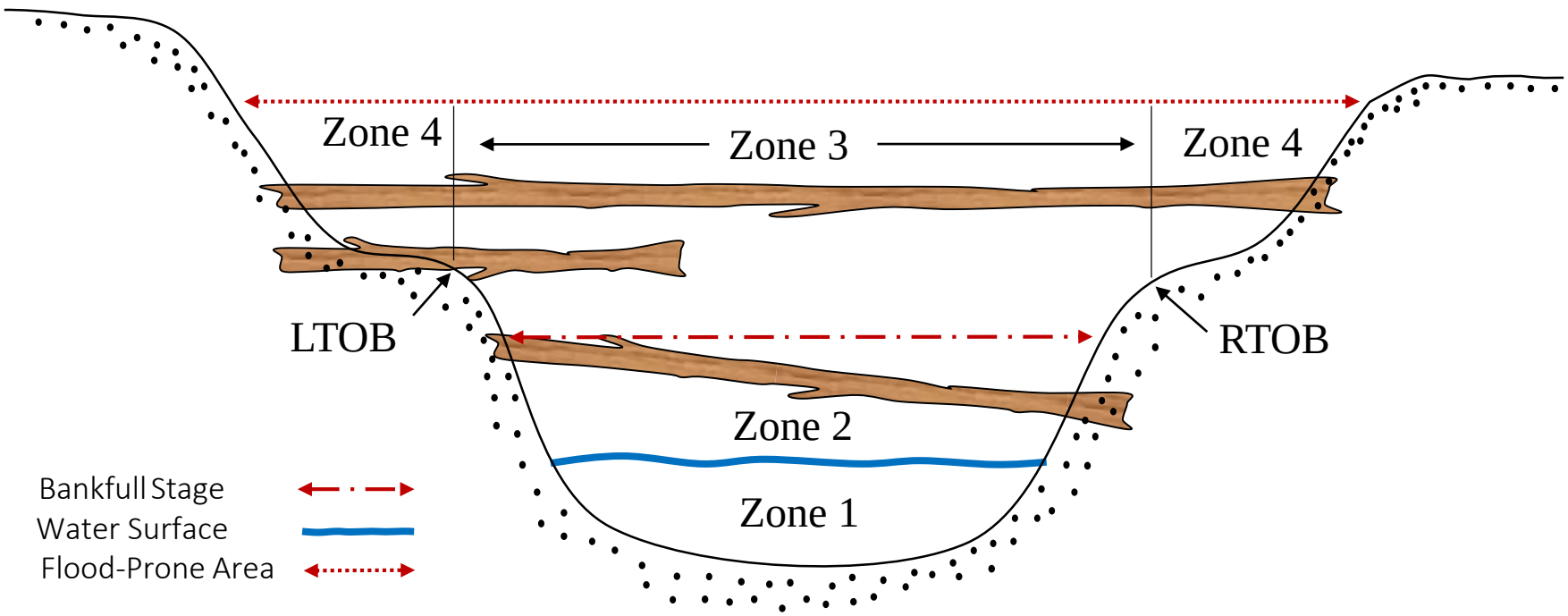
# Bridge




**Piece spans the channel or protrudes over the stream**

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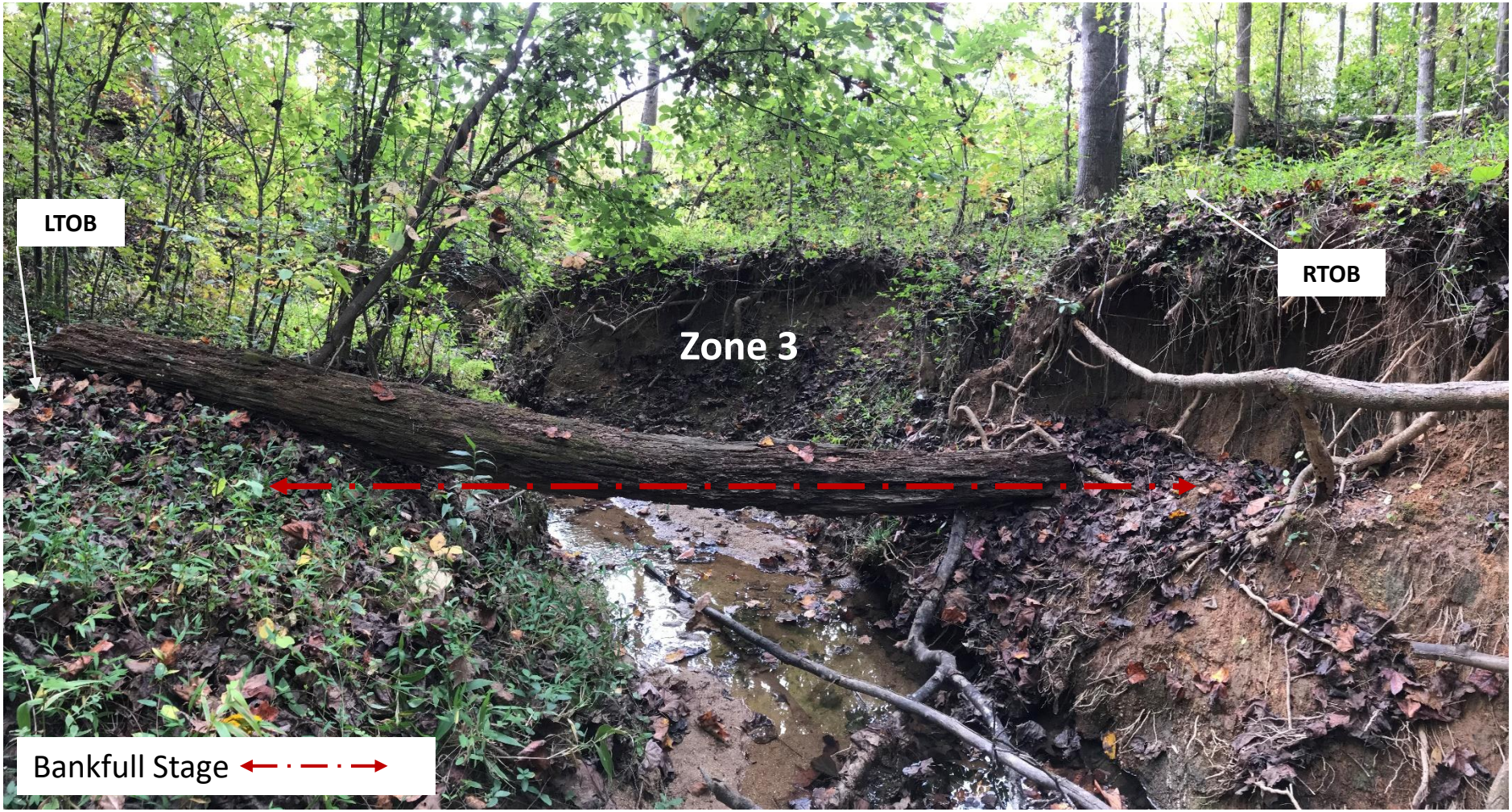
# Bridge

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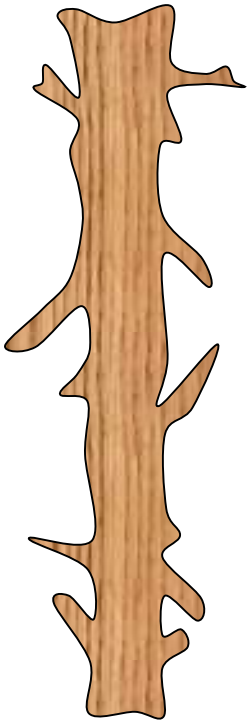
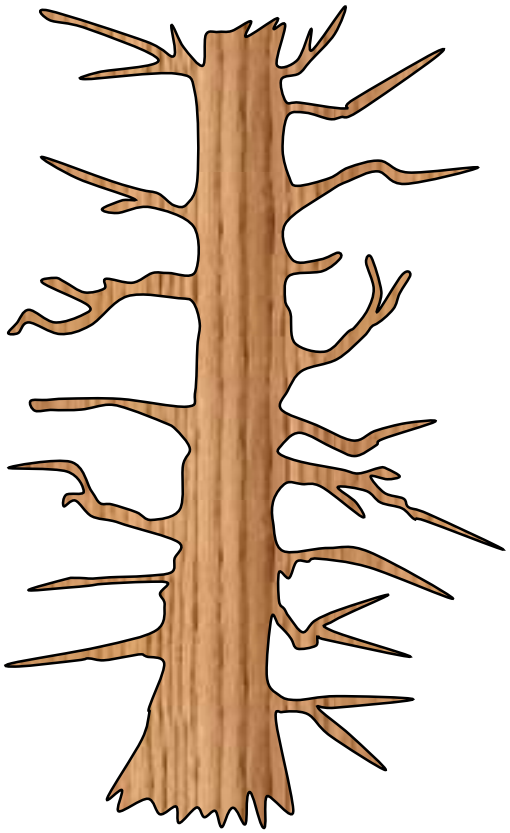
# Piece - Structure

# Structure

Plain



Intermediate



Sticky

- **How likely is the piece to trap organic matter?**
- **Record a tally in the correct box.**

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# Structure - Plain

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# Structure – Intermediate

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# Structure - Sticky

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# Structure

1. **Plain** – Essentially smooth. Does not contain sticks, limbs, or roots on the wood that could catch organic matter.

2. **Plain/Intermediate** – Characteristics that fall between the plain and intermediate categories.

3. **Intermediate** – Contains low profile sticks, limbs, or roots that are visually obvious but do not capture organic matter easily.

4. **Intermediate/Sticky** – Characteristics that fall between the intermediate and sticky categories.

5. **Sticky** – the majority of the wood is covered with sticks, limbs, or roots extending out such that they catch organic matter easily.

# Piece – Stability

# Stability

1. **Moveable** – The piece is not anchored and can be easily transported during all types of flow events.
2. **Moveable/Intermediate** – Characteristics that fall between the moveable and intermediate categories.
3. **Intermediate** – The piece is loosely anchored and would likely be moved by a bankfull event.
4. **Intermediate/Secured** – Characteristics that fall between the intermediate and secured categories.
5. **Secured** – The piece is securely anchored and is difficult to be transported. Generally, portions of the piece or the entire piece itself is buried, rendering it immovable, except in very large flood events.

# Stability - Moveable

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# Stability

**Some factors affecting stability include the following:**

- **How likely the log is to move during a bankfull flow event due to its size;**
- **How much of the piece is buried;**
- **Whether the piece is trapped by anything (i.e. live trees, rocks, etc.);**

# Stability - Secured

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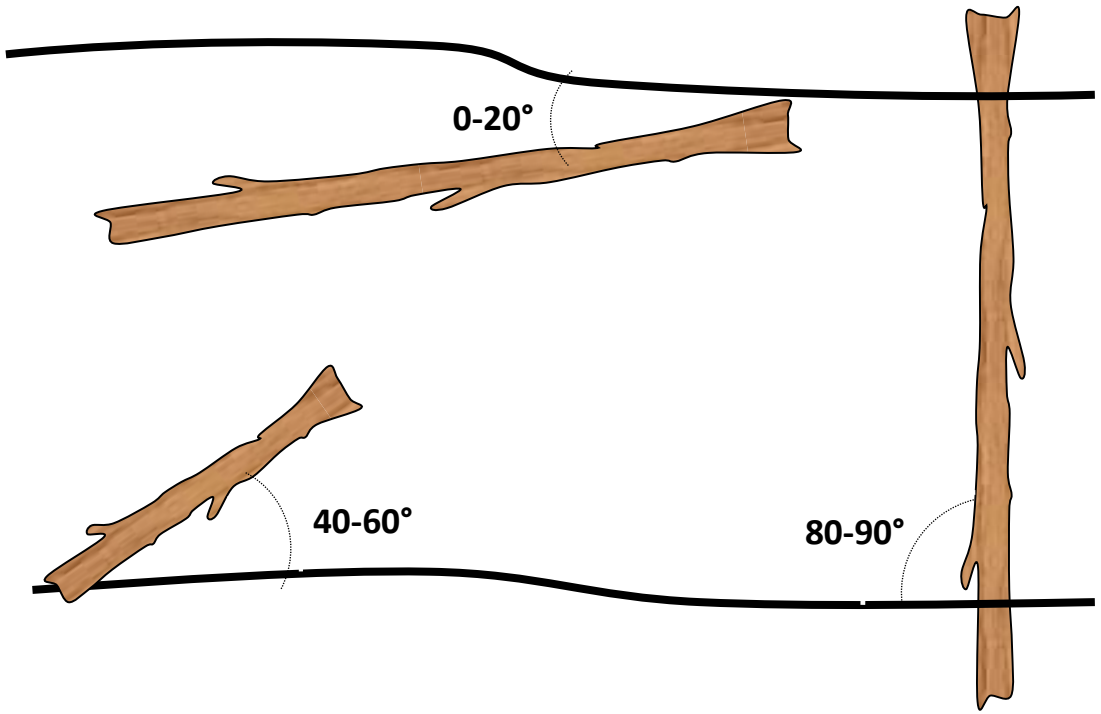
# Piece – Orientation

# Orientation

**The orientation of LWD piece affects how much the piece is influencing flow and bed forms within the channel.**

- **A piece that is perpendicular to flow has a larger hydraulic impact than a piece that is parallel to the bank.**
- **The angle at which the wood intersects the stream is scored for angles between 0 and 90 degrees.**
- **The angle should be measured from the closest streambank.**

# Orientation




- **Determine the piece orientation from the nearest streambank and record a tally in the correct box.**

# Orientation – 80 to 90 degrees

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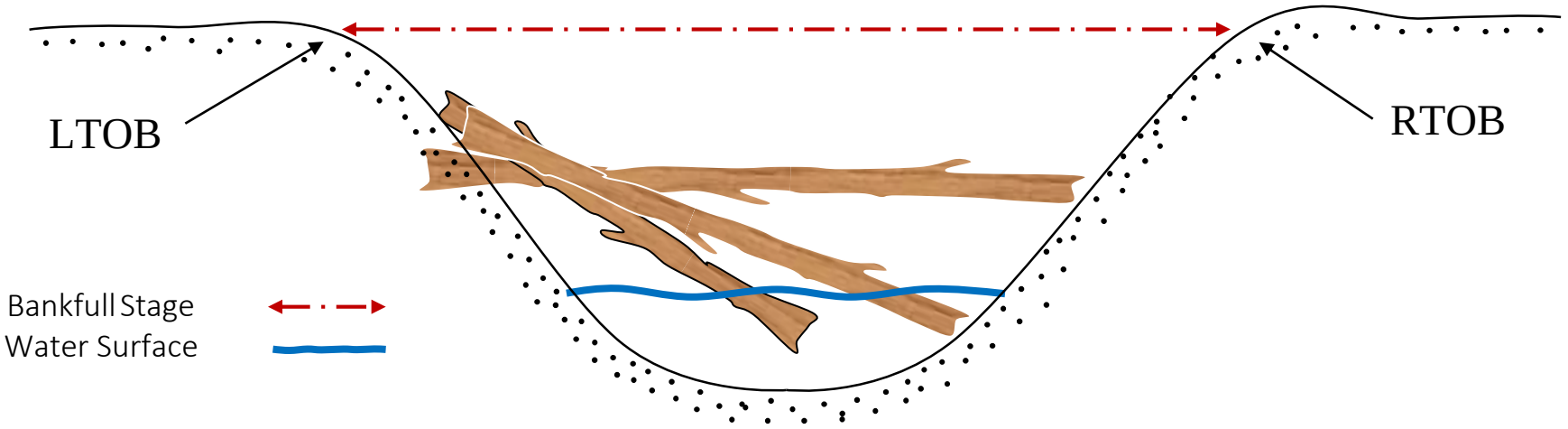
# Debris Dams

Debris Dams consist of at least 3 pieces of LWD that are
≥ 1-meter in length,
≥ 10-centimeters in diameter at its largest end,
Non-living wood,
Occurs within the specified locations (Zones), and
Within the 100-meter LWD assessment reach of the stream.

# Debris Dams

**A debris dam is formed when 3 or more "pieces" are touching.**




- **Make sure all components of the debris dam meet the definition of a LWD piece.**

# Debris Dam Criteria

| | Score | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| **Debris Dams** | | | | | |
| **Length (% of BKF Width)** | 0 to 20 | 20 to 40 | 40 to 60 | 60 to 80 | 80 to 100 |
| **Height (% of BKF Depth)** | 0 to 20 | 20 to 40 | 40 to 60 | 60 to 80 | 80 to 100 |
| **Structure** | Coarse | Coarse/Int | Intermediate | Int/Fine | Fine |
| **Location** | Partially high flow | In high flow | Partially low flow | Mid low flow | In low flow |
| **Stability** | Moveable | Mov/Int | Intermediate | Int/Sec | Secured |

- **Use your best judgement when assessing these criteria.**

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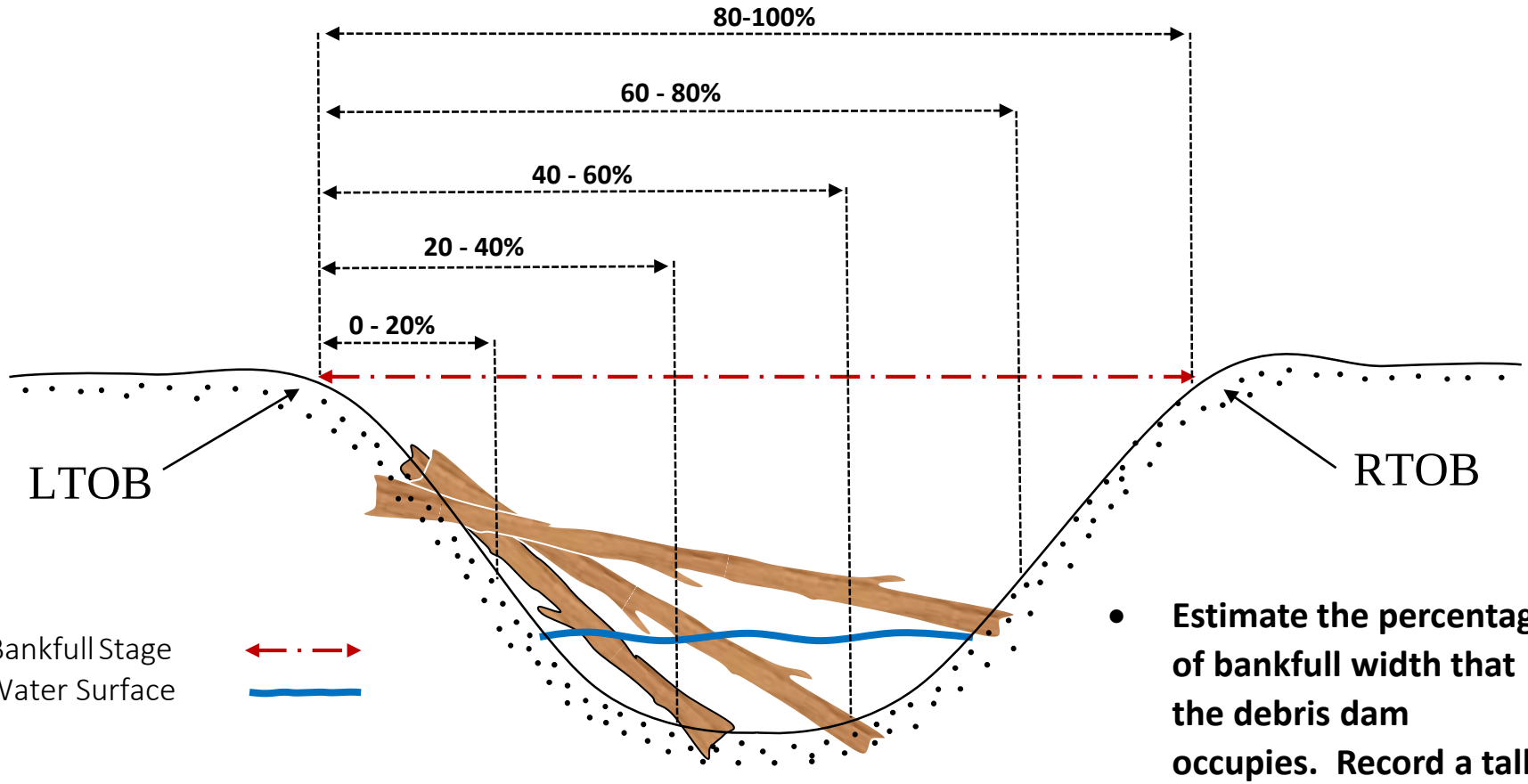
# Length - % of Bankfull Width




- **Estimate the percentage of bankfull width that the debris dam occupies. Record a tally in the correct box.**

**Reminder: Measure bankfull width at the cross section where the debris dam is found.**

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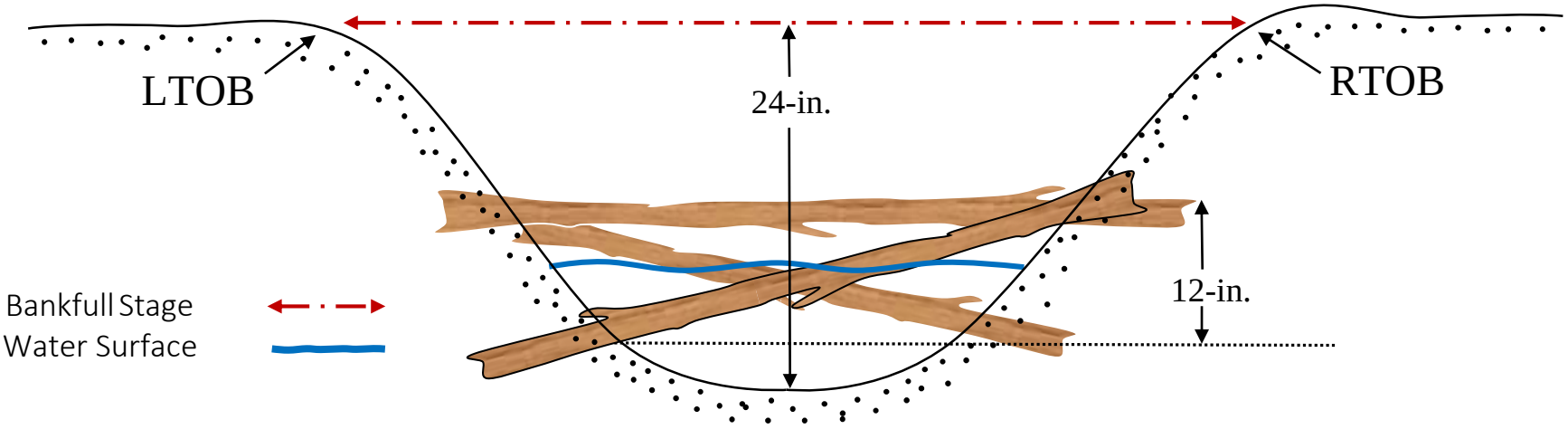
# Height - % of Bankfull Depth

- **Estimate the percentage of maximum bankfull depth that the debris dam actually occupies. Record a tally in the correct box.**

**(Example 1)**
**40% – 60%**




**Reminder: Measure bankfull depth at the cross section where the debris dam is found.**

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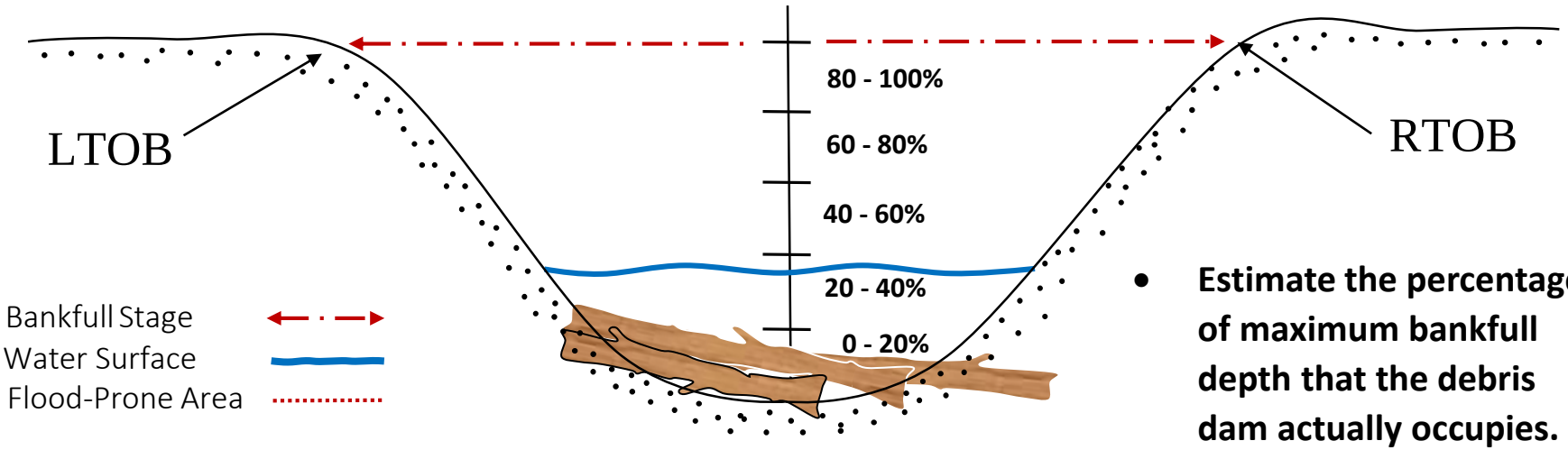
# Height - % of Bankfull Depth

**(Example 2)**
**0% - 20%**




- **Estimate the percentage of maximum bankfull depth that the debris dam actually occupies. Record a tally in the correct box.**

**Reminder: Measure bankfull depth at the cross section where the debris dam is found.**

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# Debris Dam

- **80 - 100% bankfull length and depth**

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# Structure

## Coarse

A coarse dam allows water to easily flow through it and only traps larger debris (West Virginia).

## Fine

A fine dam retains large and small debris, trapping fine sediment and impedes the flow of water (North Carolina)

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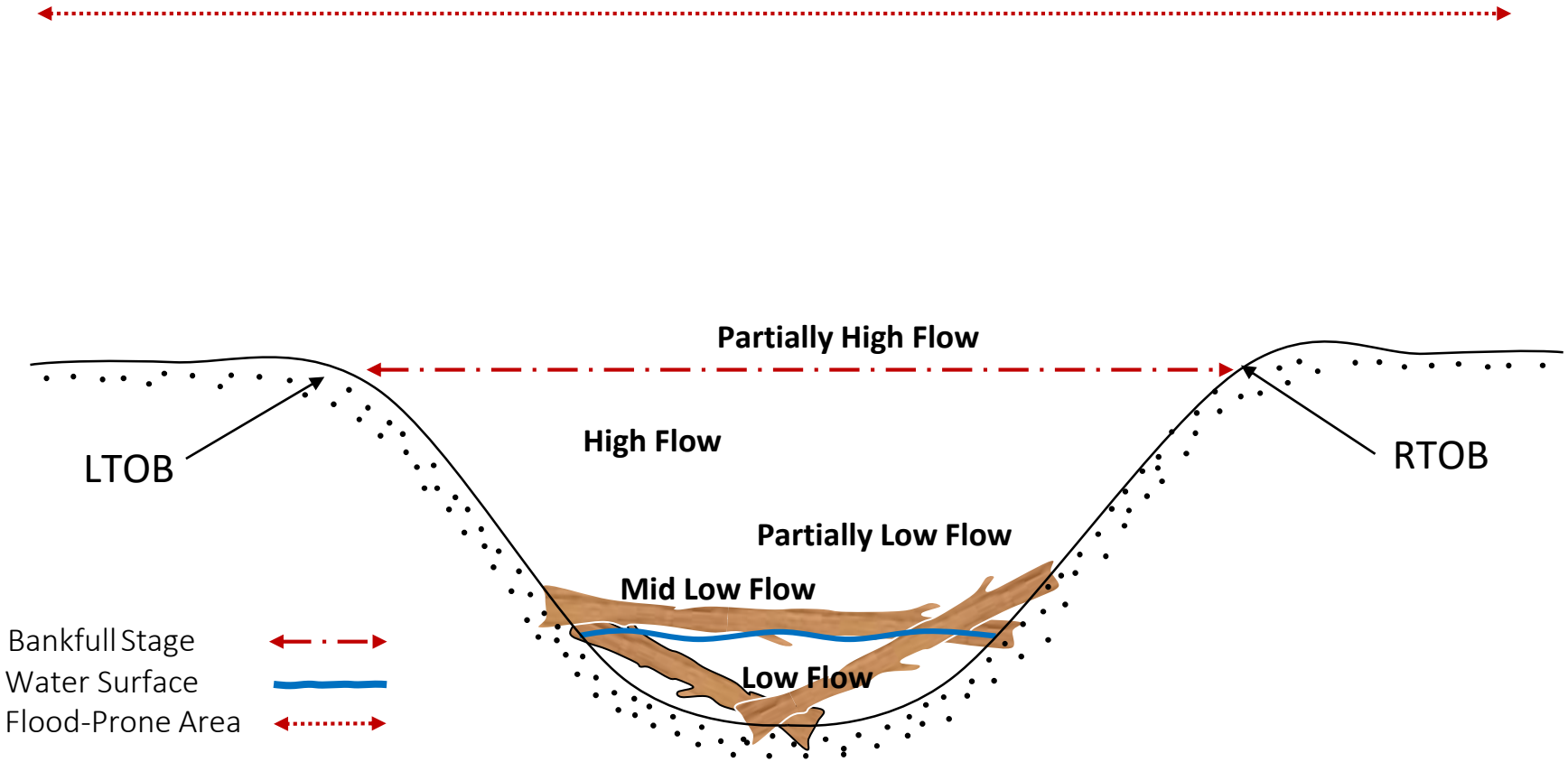
# Location

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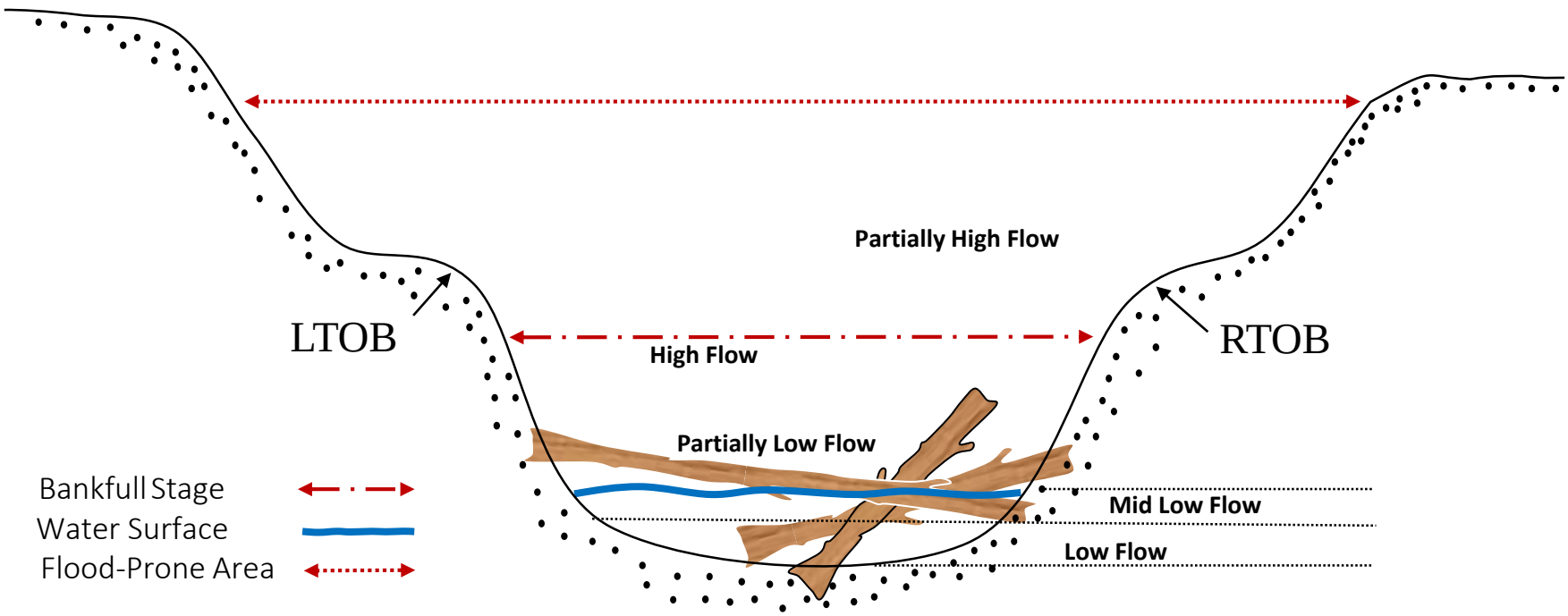
# Location

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# Debris Dam

- **Intermediate structure**

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# Stability

## “Stability scores are based on the likelihood that the dam will be retained over variable flows.”

Monitoring Wilderness Stream Ecosystems (Davis et al., 2001)

**Moveable** **Intermediate** **Secured**

Some Factors Influencing Stability

- How likely the dam is to move during a bankfull flow event due to its size;
- How much of the dam is buried;
- Is the dam is trapped by anything (i.e. live trees, rocks, etc.);

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# Debris Dam

- **Intermediate stability**

# Debris Dam

- 0-20% bankfull width
- 80 – 100% bankfull height
- Intermediate/Fine Structure
- Location: Mid low flow
- Intermediate stability

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# Debris Dam

- 20-40% bankfull width
- 80 – 100% bankfull height
- Coarse Structure
- Location: Partially low flow
- Secured

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