APPENDIX D - REFERENCE CONDITIONS AND TARGET VALUE RATIONALE

D1.0 REFERENCE CONDITIONS AND DATA SOURCES

MDEQ applies a reference condition to determine if narrative water quality standards are being achieved. The term "reference condition" is defined as the condition of a waterbody capable of supporting its present and future beneficial uses when all reasonable land, soil, and water conservation practices have been applied. In other words, reference condition reflects a waterbody's greatest potential for water quality given historic land use activities.

Waterbodies used to determine reference condition are not necessarily pristine or pre-settlement conditions, or display conditions that meet all possible beneficial uses. A reference condition is intended to differentiate between natural conditions and widespread or significant alterations of biology, chemistry or hydrogeomorphology due to human activity. Therefore, reference conditions should reflect minimum impacts from human activities. Reference conditions look to accommodate natural variations in biological communities, water chemistry, etc. due to climate, bedrock, soils, hydrology and other natural physiochemical differences. A reference condition attempts to identify the potential condition that could be attained (given historical land use) by the application of reasonable land, soil and water conservation practices. MDEQ realizes that pre-settlement water quality conditions usually are not attainable.

The following methods may be used to determine reference conditions:

Primary Approaches

- Regional Approach:
  Compare conditions in a waterbody to baseline data from reference waterbodies that are in a nearby watershed or in the same region having similar geology, hydrology, morphology, and/or riparian habitat.
- Historical Approach:
  Evaluate historical data relating to condition of the waterbody in the past.
- Internal Reference Approach:
  Compare conditions in a waterbody to conditions in another portion of the same waterbody, such as an unimpaired segment of the same stream.

Secondary Approaches

- Literature Approach:
  Review literature (e.g. review of studies of fish populations, etc. that were conducted on similar waterbodies.)
- Professional Judgment Approach:
  Seek expert opinion (e.g. expert opinion from a regional fisheries biologist who has a good understanding of the waterbody's fisheries health or capability).
- Modeling Approach:
  Apply quantitative modeling (e.g. applying sediment transport models to determine how much sediment is entering a stream based on land use information, etc.).

DEQ prefers to use the primary approach for determining reference condition, particularly where adequate regional reference data are available. Secondary approaches are often necessary to estimate reference condition when there is no regional reference data. DEQ often uses more than one approach to determine reference condition, especially when regional reference condition data are sparse or nonexistent. This is particularly true where the translation of a narrative standard may involve multiple target indicator parameters. Some parameters may have good regional or internal reference information; whereas regional or other primary reference information may be lacking for other parameters. Historical quantitative reference condition information is rarely available; however, historical information can supplement secondary approaches with qualitative data and best professional judgment.

Two main sources of data served as information to help identify reference conditions in the Flint TPA. Target values for the parameters of interest were based on unpublished data from USFS PIBO data collected throughout the Beaverhead Deerlodge National Forest, and from data collected during the 2009 DEQ Flint Creek sediment/habitat field study.

United States Forest Service Pacfish/Infish Biological Opinion (PIBO) data (2010) was reviewed for assistance in developing target values for width to depth ratios, percent fines less than 2mm and 6mm, residual pool depth, pool frequency, and large woody debris frequency. 63 PIBO sites were selected based on data specific to the Pintler Forest District, located in the Beaverhead Deerlodge National Forest, and occurring within or adjacent to the boundaries of the Flint Creek TPA.

PIBO classifies their study reaches as 'reference' or 'managed'. "Watersheds are considered reference if there had been no livestock grazing within the past 30 years, less than 10% of the watershed had undergone timber harvest, there was no evidence of mining in proximity to riparian areas, and road density was less than 0.5km/km2. Managed watersheds included a full complement of management activities, including timber harvest, road building and maintenance, livestock grazing, mining, and recreation" (Kershner, et al., 2004).

2009 DEQ field data was used for the development of all parameter values. Data from 24 sites from the DEQ field effort was collected on listed and non-listed streams throughout the Flint Creek watershed.

2009 DEQ data was categorized by reach results based on a stream stratification procedure. No reference reaches were identified through the stream stratification procedure; however, in the sampling analysis design for the 2009 field data study, sites were chosen to represent the variability among reach type categories and stratification parameters, and therefore include reaches that characterize the range from heavily impacted reaches to "near reference" condition. Although few if any of the reaches represent full application of all reasonable land, soil, and water conservation practices, several sampled reaches reflect the healthy conditions in the study area, with limited land use effects.

D2.0 Target Value Development

Target values are often presented for a range of conditions based on stream size, parent geology, or other significant factors that influence stream function and response. For instance, depending on the setting, sediment and habitat conditions in a 5th order stream may vary considerably from those in a 2nd order stream and therefore assessing the respective condition of each against the same target values would be inappropriate for some target parameters. In the Flint Creek TPA, data was sorted and analyzed based on reach type, level of impact (reference vs. non-reference), stream gradient and stream order; and target values were determined based on the best approach for analysis for a given parameter.

The use of median and percentiles in statistical analysis is often employed when data, such as water quality data, tend to have a non-normal distribution. Also, limited amounts of data can sometimes result in skewed results if using normal distribution statistics. For these reasons, it is more appropriate to use non-normal or non-parametric statistics for setting reference conditions and determining target values for most parameters.

If parameters are used where lower values represent better water quality conditions, then typically the 75th percentile of the reference data set is used as a potential target value. If higher values represent better water quality conditions then the 25th percentile would apply. If a dataset is known to represent a variety of conditions, and not just reference conditions, or where there is less confidence in the data to represent reference conditions, the median may be used. If a dataset is known to largely represent impacted conditions, then the opposite percentiles as mentioned above can be used. E.g. the 25th percentile of an impacted data set may be used to develop a percent fines target value (where lower values represent more desired conditions).

The use of a non-parametric statistical distribution for interpreting narrative water quality standards or developing numeric criteria is consistent with EPA guidance for determining 'water quality' criteria (U.S. Environmental Protection Agency, 1999). Therefore, the selection of the applicable statistics from a data set is consistent with ongoing development of MDEQ and EPA guidance for interpreting narrative water quality standards.

No reference sites were identified from the DEQ data set when developing target values. However the sites that were investigated represented a broad range of conditions, from heavily impacted by anthropogenic activity to desired or near-desired condition. Because of this, generally the median (50th percentile) of the total population of the DEQ data was the primary value of interest. The USFS PIBO data contains both reference and non-reference data. PIBO data sets were reviewed and a target value was determined based on a comparison between the median of total population and quartiles of the reference data sets. The statistics from both the DEQ and PIBO data were then compared and target values determined based on these comparisons, best professional judgment, and relation to commonly accepted literature values.

Information and rationale used to derive target values follow below. Target parameter description and rationale for inclusion is presented in **Section 5.4**.

D2.1 Width Depth Ratio

Width to depth ratios provide a metric by which we can assess the form, and therefore, relative function of a given reach. Lower values signify a narrow, deep channel, whereas larger values may indicate unnatural overwidening and shallowing of a reach. Criteria based on Rosgen stream type classification for width to depth ratios gives guidance of <12 for A, G and E stream types, and >12 for F, B and C stream types. While the upper limits are not provided for values >12, data from PIBO and DEQ can be reviewed to provide a range of targets that better represent desired conditions.

For the width/depth parameter, PIBO data was organized and reviewed according to reference sites, and all sites. The 75th percentile of the reference sites served as the focus for evaluating a target value. The median value for all site groupings was also reviewed, as it is assumed that these represent desired width/depths when investigating a variety of conditions encompassing a varying level of impacts to the stream.

Although fewer total reaches were examined in the DEQ study, the DEQ reaches did represent a wider range of stream size and power, and therefore, the width/depth data was broken out by stream order. This was done because it is assumed that as stream orders increase, width/depth ratios for F, B, C stream types will also show a gradual increase. PIBO data, on the other hand, was assumed to come from reaches predominantly 3rd order or less (based on a review of the bankfull widths), but actual stream order information did not accompany the data, and therefore was not segregated as such.

Upon review of the results (**Table D-1**), a width/depth ratio of ≤20 is the target value for 3rd order or less low gradient streams in the Flint Creek TPA. Due to the increasing size and stream power for streams that are 4th order or larger (essentially Flint Creek in the lower portion of the watershed), the width/depth target for these streams have a slightly larger target value of ≤28. As there were only 6 sites that were sampled which were 4th order or larger, best professional judgment and recognition that these sites have been affected by past anthropogenic activities was factored into the determination of ≤28 as a conservative target value. Values used as width to depth targets in prior TMDLs dealing with similarly sized streams (e.g., Prospect Creek, width/depth target of <30; St. Regis, width/depth target of <30) also suggest <28 is appropriate.

Table D-1. Width to Depth Values

	25th Percentile	**Median**	**75th Percentile**
USFS PIBO reference reaches(13)	16	20	21
USFS PIBO all reaches (33)	15	20	23
DEQ Reaches – Segregated by stream order			
2nd (9)	12	15	17
3rd (7)	16	20	24
4th (6)	26	28	29
Target Value	**Low Gradient Streams 3rd order or less***		**≤20**
		Low Gradient Streams 4th order or greater*	**≤28**

*Width to depth of <12 applies to low gradient E channels based on Rosgen stream classification criteria.

D2.2 ENTRENCHMENT

Criteria from Rosgen stream type classification for entrenchment gives guidance of <1.4 for A, F and G streams, 1.4-2.2 for B streams, and >2.2 for C, E streams. These literature values will serve as the target ranges for entrenchment in the Flint Creek TPA as well. Entrenchment values >2.2 are described by Rosgen as slightly entrenched to non-entrenchment as the values increase. The higher the entrenchment value the greater accessibility of streamflow to the floodplain at or greater than bankfull flow. While there is no upper limit to an entrenchment value, entrenchment values in the Flint Creek watershed is not generally expected to exceed 6.0, as observed in the data set (**Table D-2**).

Table D-2. Entrenchment Ratio Values (DEQ 2009 Data)

	High Gradient (>2%)	Low Gradient (<2%)	All Reaches
25th percentile	2.0	2.1	2.0
Median	2.3	3.5	3.1
75th percentile	4.2	6.1	5.5
Target Values	**Rosgen A: <1.4**	**Rosgen B: >1.4 - <2.2**	**Rosgen C,E >2.2**

D2.3 Percent Fines Analysis

In developing percent fines targets, differences in the data collection methodology between the PIBO and DEQ datasets does not always allow for direct comparison. DEQ collects percent fine data from both pool tails and riffles. As discussed in **Section 5.4.1.3**, pool tails are important spawning habitat for salmonids, and riffles also serve as spawning habitat for salmonids, as well as important habitat for macroinvertebrate communities. DEQ data is collected from pool tails using the grid toss method, and assesses for those particles less than 6mm. DEQ data is collected from riffles using the Wolman pebble count method, blindly selecting particles using a heel-to-toe process across the riffle, until at least 100 particles are obtained in a riffle, and 400 particles are collected from riffles in a reach.

PIBO data also collects percent fines using a grid toss method in pool tails. PIBO accounts for those particles less than 6mm and less than 2mm. However, PIBO data does not specifically target riffles for Wolman pebble count procedures. Instead, PIBO collects 5 particles from 20 evenly spaced cross sections throughout the reach. The sites where particles are collected may occur in riffles, or they may occur through pools or runs or other habitat features that may be prone to greater fine sediment deposition. Therefore, while PIBO and DEQ pool fines data are comparable, PIBO percent fines (using Wolman methods) provide an overview of conditions representative of the entire reach, where DEQ percent fines is targeted to riffles (and thereby a more focused look at the impact to aquatic life and fisheries). Because of this, the PIBO pebble count data is not comparable to DEQ riffle pebble count data.

It should also be noted that the percent fines targets described below are appropriate for those stream habitats and stream types that best show the effects of sediment accumulation in spawning areas. These targets may not apply to Rosgen E channels, which typically exhibit much higher natural values of percent surface fines. Percent fines in E channel reaches should be evaluated on a case by case basis. Percent fines evaluations should generally occur in ‘riffle and pool tails in Rosgen B and C Reach types as these often most clearly illustrate effects from percent fine accumulation.

D2.3 Percent Fines in Riffles (Wolman method) - <2mm

Percent fines data are sometimes reviewed in relation to the slope of the reach they are taken from. It is expected that in general, higher gradient reaches (slopes greater than 2 percent) act as transport reaches, and the velocity and turbulence within these reaches do not allow for much sediment accumulation in comparison to low gradient reaches. DEQ fines data by gradient is provided here to illustrate that this assumption is supported in the Flint Creek TPA data (**Table D-3**).

No PIBO reference data is available for percent fines <2mm in riffles. For this parameter, the median of the total DEQ data set is used to set the target at <7%. This value is below the minimum-effect sediment levels for sediment-sensitive species (13%) and aquatic macroinvertebrates (10%) as found by Bryce, Lomnicky, and Kaufmann (2010), and therefore will apply regardless of gradient. Based on the discussion above, it is expected that measured values in high gradient reaches would be lower than the target, and that values in high gradient reaches which are near or above the target value may indicate increased sediment input and potential impacts to low gradient reaches as well.

Table D-3. Wolman Pebble Count Percent Fines Values, <2mm (DEQ 2009 Data)

	25th percentile	**Median**	**75th percentile**
DEQ – High Gradient Reaches (7)	2	3	9
DEQ – Low Gradient Reaches (17)	6	8	12
DEQ - All	3	7	11
Target Value			**<7**

D2.4 Percent Fines in Riffles (Wolman method) - <6mm

Due to the differences in percent fines data collection between PIBO and DEQ, the DEQ dataset serves as the sole source of data for developing this target. In review of the data (**Table D-4**), the median values between the "low gradient reaches" and "all reaches" are very similar at 14 and 12, respectively. As expected, the high gradient reaches have percent fines values lower than low gradient reaches. The target value for percent fines <6mm in riffles is ≤14.

Table D-4. Wolman Pebble Count Percent Fines Values, <6mm (DEQ 2009 Data)

	25th Percentile	**Median**	**75th Percentile**
DEQ – High Gradient Reaches (7)	5	9	14
DEQ – Low Gradient Reaches (17)	12	14	20
DEQ – All (24)	8	12	19
Target Value			**<14**

As discussed in the target narrative for percent surface fines less than 2mm, percent fines data may be reviewed in relation to the slope of the reach they are taken from. It is expected that in general, higher gradient reaches (slopes greater than 2 percent) act as transport reaches, and the velocity and turbulence within these reaches do not allow for much sediment accumulation, in comparison to low gradient reaches. As with percent <2mm data, this assumption is illustrated with the data. Since a target of <15% fines less than 6mm is protective of beneficial uses regardless of the gradient, a single target value was chosen. Care should be taken in reviewing percent fine results in high gradient reaches when values approach the target. It is expected that measured values would be lower than the target, and that values in high gradient reaches which are near or above the target value may indicate increased sediment input and potential impacts to low gradient reaches as well.

D2.5 Percent Fines in Pool Tails (Grid Toss) - <6mm

In the case of percent fine data in pool tails, data exists for both DEQ and PIBO. As a result, a direct comparison between DEQ and PIBO data sets is possible. In general, the PIBO pool tail grid toss results shows consistency between the median values of the non-reference data sets and the 75th percentile of the reference reach data. In fact, the medians for all groupings are lower than the 75th percentile of the PIBO reference reaches. Overall, DEQ pool tail values are slightly lower than PIBO data; however, this may be attributed to subtle differences in identification and selection of which pool tails to measure. In addition, the DEQ results may be affected by the much smaller data set. Despite this, the overall consistency in statistical values between datasets allows for a reasonable target value of <15 percent surface fines less than 6mm (based on the 75th percentile of PIBO reference data) (**Table D-5**). This value is representative of what can be expected in this watershed under "good" conditions and is protective of beneficial uses.

Table D-5. Pool Tail Percent Fines (Grid Toss) Values, <6mm

	25th Percentile	**Median**	**75th Percentile**
PIBO – Reference Reaches (18)	6	10	15
PIBO – All Reaches (52)	6	11	24
DEQ – High Gradient Reaches (6)	3	4	11
DEQ – Low Gradient Reaches (15)	3	11	19
DEQ – All (21*)	3	10	16
* Some reaches did not have pool tails measurements taken.			
Target Value			**<15**

D2.5 Residual Pool Depth

A slightly different approach was taken when developing target values for residual pool depth. In this case, bankfull width information for the study reaches was available for both DEQ and PIBO data (**Table D-6**). Because pool depths are frequently a function of stream size and volume, it was deemed appropriate to segregate sampled reaches by bankfull width, which provides an indication of general stream dimension and power that affects pool size and quality.

For the PIBO data, two categories were broken out based on the sampled reaches; bankfull widths less than 20 feet and bankfull widths between 20-39 feet. DEQ data were split into three categories; bankfull widths less than 20 feet, bankfull widths between 20-39, and bankfull widths larger than 40. Although no statistical analysis was used to develop these breakouts, generally it was considered that <20 feet is the equivalent of 2nd order streams, 20-39 is the equivalent of 3rd order streams, and >39 feet is equivalent to 4th order (or greater) streams. No residual pool depth data existed for bankfull widths larger than 39 feet in the PIBO data.

In the 20-39 feet category of the PIBO data, generally, the reference sites exhibit deeper overall pools than non-reference sites. No reference sites were identified within the DEQ reaches. With this in mind, and presuming the differences between reference and non-reference sites are a constant within stream size, we can use the 20-39 feet category as a guide determine appropriate target values for other size categories.

Although the parameter is the same in the DEQ and PIBO datasets, it should be noted that subtle differences exist in the methodology between the DEQ and PIBO to classify pools. Although both methods identify a pool as having a maximum depth 1.5 times the pool tail depth, PIBO further selects those pools that fall within the path of the thalweg and are 50% or greater of the wetted channel width, whereas DEQ methodology includes all pools throughout the channel. As a result of this, PIBO data is likely to reflect slightly deeper average pool depths than the DEQ data. Targets will be set to apply to DEQ methods.

The DEQ data for residual pool depths in reaches with bankfull widths less than 20 feet exhibits a median value of 0.7 feet. As illustrated in the PIBO 20-39 feet dataset, we can expect something greater than the median under reference type conditions. The target for bankfull width less than 20 feet is therefore set at > 0.9 feet.

For bankfull widths 20-39 feet, the median of all reaches in the PIBO dataset (1.8 feet) and the 25th percentile of the PIBO reference data (1.8 feet) serve as the benchmarks for setting the target. In comparison, the median value of the DEQ 3rd order data is 1.2 feet. Because PIBO values are somewhat higher than DEQ results due to differing methodology, the target for this bankfull width category is set at 1.4 feet.

For bankfull widths >40 feet, there is no PIBO data available to review. Therefore the DEQ data is assessed with the same assumptions as the other categories and is applied with respect to a presumed difference in reference and non-reference datasets, and ever increasing pool depths as bankfull widths increase. As such, a target value of >1.7 is conservatively set for bankfull widths larger than 40. In the lower section of Flint Creek, where bankfull widths begin to exceed 50', it would be expected that residual pool depths should be somewhat greater than 1.7 feet, however no specific target for bankfull widths >50 is identified here due to the limited data for these sized reaches.

Table D-6. Residual Pool Depth Values

	25th Percentile	Median	75th Percentile
PIBO - All reaches: Bankfull width			
<20 (28)	0.7	0.9	1.0
20-39 (26)	1.2	1.8	2.2
PIBO - Reference: Bankfull width 20-39 (11)	1.8	1.9	2.1
DEQ – All Reaches – Segregated by bankfull widths			
<20 (10)	0.6	0.7	0.7
20-39 (7)	1.1	1.2	1.4
>40 (6)	1.1	1.3	1.7
			Target Value
<20			**>0.9**
20-39			**>1.4**
>40			**>1.7**

D2.6 Pool Frequency (per mile)

Pool frequency tends to be a function of stream size and power; although other factors also contribute to pool formation, such as geology, riparian condition (large woody debris input), and gradient. As streams increase in size, features such as riffles and pools also tend to increase in size, however those components such as boulders and large woody debris that influence pool development becomes less frequent, resulting in larger but fewer pools over a given distance.

Again, some differences in methodology between DEQ and PIBO do not allow for direct comparison of values. Both methods classify a pool as having a maximum pool depth > 1.5 times the pool tail depth. However, PIBO identifies those pools that fall within the path of the thalweg and that are 50% or greater of the wetted channel width; whereas DEQ methodology identifies *all* pools throughout the channel. As a result, PIBO methodology identifies fewer pools than noted according to DEQ methods. With this in mind, we can review the PIBO data in combination with the DEQ data to derive target values (**Table D-7**). (The targets below apply to DEQ pool quantification methods.)

For streams with a bankfull width <20 feet, the target is set at 95. The median of the DEQ data set is 95. The median of the PIBO data set is 78. It is expected that the PIBO pool numbers would be somewhat higher if DEQ protocols were applied in their data collection and therefore would be likely comparable to the DEQ median.

For streams with a bankfull width between 20 feet and 39 feet, PIBO data exists for both the total population, and for reference streams. The 25th percentile (49) of the PIBO reference data set appears to correspond well with the median (52) of all reaches of the same data set. The median (32) of DEQ data set is considerably less than the PIBO value, despite expectations that the PIBO values would be lower. However, this may be in part due to the limited sites within the DEQ data. In review of the specific reaches that make up the DEQ data set for bankfull widths 20-39, it was determined that 6 of the 7 sampled reaches represent impacted reaches. Because of this, and using the PIBO reference data as an indicator, the target is set at 70.

For streams with a bankfull width equal to or greater than 40 feet, the target is set at 50. No PIBO data is available in this stream size category for comparison. The median value of the DEQ data set (32) provides a reference, but again the limited number of reaches may mislead conclusions. Review of the individual reaches finds two reaches with limited human impact. The number of pools per mile in those two reaches are 79 and 100. Because of this, it appears the median value of the DEQ data set may be skewed lower than what might be expected under good conditions. With this in mind, a target somewhat greater than the median value, and in correspondence with the other bankfull width categories has been chosen.

Flint Creek becomes a 5th order stream toward the bottom of the watershed; however, only one reach of 5th order was sampled within the DEQ dataset. That reach resulted in 26 pools per mile. A conservative estimate therefore for pools per mile in 5th order streams is targeted at >30.

Table D-7. Pool Frequency Values (per mile)

	25th Percentile	**Median**	**75th Percentile**
DEQ - All Reaches – Segregated by bankfull width			
<20 (10)	69	95	116
20-39 (7)	24	32	37
>40 (6)	26	32	69
PIBO Reaches – Segregated by bankfull width			
<20 – All reaches (28)	61	78	116
20-39 – All reaches (26)	43	52	61
20-39 - Reference (11)	49	60	63
Bankfull Width			**Target Value**
<20			**95**
20-39			**70**
>40			**50**

D2.7 Greenline – Percent Shrub

Riparian green line is not used as a direct measurement of sediment itself in the Flint Creek TPA, however it is reviewed as supplemental information due to its relation to bank erosion and therefore an overall gage of stream health and potential sediment production. Shrub cover in particular provides stronger, more stable streamside woody vegetation, and it often provides an indicator of potential bank stability and temperature variability.

As mentioned in earlier target parameter discussions, there are a variety of conditions accounted for in the DEQ dataset, however few of them represent true desired or reference conditions. Although limited in the amount of available data, values were initially organized by their respective reach types to see if there were any obvious differences or similarities based on the physical characteristics of the stream (**Table D-8**). No true discernable variation in values could be determined based on the stream order, gradient, and confinement – but that is also expected since the riparian robustness is generally more a function of the activities on the land rather than the geologic constraints. As a result, the data shows that a target value can be set based on a review of the total dataset, rather than segregating it into specific categories. In reviewing these results, and knowing anthropogenic influence was common throughout the reaches, relying only on the median values in setting a target value may underestimate the potential quality that should be expected. Conversely, relying on the 75^{th} percentile may overestimate what should be expected, particularly in wide open agricultural valleys, where full riparian recovery may not be achievable even under all reasonable land, soil, and water conservation practices. Therefore the target is based on the midline between the median and 75^{th} percentile, and is set at >70.

Table D-8. Greenline Percent Shrub Cover by Reach Type

Reach Type	25^{th}	Median	75^{th}
MR-0-2-U (5)	10	58	75
MR-0-3-U (6)	3	25	75
MR-0-4-U (5)	1	65	91
MR-0-5-U (1)	0	0	10
MR-2-2-U (4)	30	63	93
MR-2-3-U (2)	0	46	98
MR-2-4-U (1)	64	80	85
Total	5	56	84
Target Value			**>70**

D2.8 Greenline – Percent Bare Ground

As described for the Greenline – Percent Shrub Cover, riparian green line is not used as direct target of sediment analysis in the Flint Creek TPA, however it is reviewed as supplemental information because of its relation to potential sediment production and overall gage of stream health. Bare ground along the riparian is the most unstable and most indicative display of streamside sediment sources. Similar to the percent shrub analysis, the statistics for percent bare ground are only used as a relative gage by which to select an appropriate value. In this case, lower percentages of percent bare ground are the expected and desired condition. Based on a review of the available information (**Table D-9**), the Flint Creek TPA would not expect to see any bare ground under most normal conditions. As such, the target for bare ground in conjunction with anthropogenic activities is 0%, however, it is acknowledged that some natural conditions such as talus slopes, recent landslide/avalanche chutes, and wildfire (although not witnessed in this data) may result in a small percentage of bare ground near the bank and therefore, this target is not absolute and will allow for some variance under specific natural conditions.

Table D-9. Greenline Percent Bare Ground by Reach Type

Reach Type	25th	Median	75th
MR-0-2-U (5)	0	0	0
MR-0-3-U (6)	0	0	0
MR-0-4-U (5)	0	0	0
MR-0-5-U (1)	0	0	8
MR-2-2-U (4)	0	0	0
MR-2-3-U (2)	0	0	0
MR-2-4-U (1)	0	0	0
Total	0	0	0
Target Value			**0**

D2.9 Large Woody Debris

Large woody debris is not a direct measure of sediment. However, the quantification of instream large wood is reviewed as supplemental information because of its relation to riparian condition and the associated sediment production that can occur in degraded riparian environments. Large woody debris also has affect on pool formation and habitat creation for both fish and macroinvertebrates and has been shown to be an indicator of overall stream health.

A mature and healthy streamside vegetative community plays a significant role in the numbers of large woody debris found in a stream. This is apparent in reviewing reference with non-reference PIBO data (**Table D-10**). As a result, we can presume that land management and impacts to the riparian community have a significant effect to the amount of large wood in the stream, and thereby the habitat complexity and overall health of the stream.

Large woody debris numbers also relate to stream size and power, in addition to the quality of the riparian condition. Therefore, smaller streams with good riparian health would be more likely to hold pieces of large wood that fall into the stream. As the stream sizes increase, the wider and deeper channels and associated flows mobilize more wood resulting in fewer identified pieces per reach.

Based on the PIBO and DEQ data for bankfull widths less than 20 feet, the target is set at >500 pieces per mile. Although numbers of reference sites in comparison to non-reference sites are few, the data does illustrate a significant difference between reference and non-reference conditions. In addition, the 25th percentile of the PIBO reference data does correspond well with the median of the DEQ data.

For bankfull widths 20-39 feet, the target for large wood per mile is set at >250. Again, there appears to be a good relationship between the 25th percentile of PIBO reference sites and the median of all DEQ sites.

For bankfull widths greater than 40 feet, the target value of >150 pieces per mile is based on the median of the DEQ data. Although there are few reaches within this category, and no reference data to compare to, the general trends in the other bankfull width categories indicate that using the median of the DEQ data is a reasonable approach.

Table D-10. Large Wood Values (per mile)

	25th Percentile	Median	75th Percentile
DEQ – All Reaches – Segregated by bankfull width			
<20 (10)	203	502	620
20-39 (7)	21	248	306
>40 (6)	81	156	183
PIBO Reaches – Segregated by bankfull width			
<20 (36)	9	91	241
<20 reference (6)	500	727	942
<20 managed (30)	0	55	98
20-39 (27)	74	178	283
20-39 reference (11)	274	293	740
20-39 managed (16)	28	99	163
			Target Value
<20			**>500**
20-39			**>250**
>40			**>150**

D3.0 References

Bryce, S. A., G. A. Lomnicky, and Philip R. Kaufmann. 2010. Protecting Sediment-Sensitive Aquatic Species in Mountain Streams Through the Application of Biologically Based Streambed Sediment Criteria. *North American Benthological Society.* 29(2): 657-672.

Kershner, Jeffrey, Brett Roper, Nicolaas Bouwes, Richard Henderson, and Eric Archer. 2004. An Analysis of Stream Habitat Conditions in Reference and Managed Watersheds on Some Federal Lands Within the Columbia River Basin. *North American Journal of Fisheries Management.* 24: 1363-1375.

U.S. Environmental Protection Agency. 1999. Protocol for Developing Sediment TMDLs. Washington, D.C.: U.S. Environmental Protection Agency. Report EPA 841-B-99-004.