

Appendix E

Hydraulic Structure Blockage Methodology & Results



APPENDIX E – HYDRAULIC STRUCTURE BLOCKAGE METHODOLOGY & RESULTS

1. BLOCKAGE OF HYDRAULIC STRUCTURES

For the P2N project, blockage of the culverts and bridge cross drainage structures is a risk that needs to be understood and managed or minimised through the design. Blockage is a random event but for the purposes of design it needs to be quantified.

ARR 2016 – Book 6, Chapter 6 includes advice and an approach for estimating blockage of bridges and culverts. This chapter concentrates specifically on blockage of cross drainage structures, in particular culverts and small bridges. The procedure has been developed to quantify the most likely blockage level and mechanism for a small bridge or culvert when impacted by sediment or debris laden floodwater.

The approach is both qualitative and quantitative and relies upon site and catchment specific information and engineering judgement. The intent of the approach is to estimate a numerical blockage factor that can be included in a hydraulic model.

2. ADOPTED APPROACH

The approach to the estimation of blockage has been adopted as per ARR2016. In applying this approach for P2N there are assumptions and interpretations of the guidance required and these are set out in the following sections.

2.1 FACTORS INFLUENCING BLOCKAGE

ARR2016 documents that the main factors influencing blockage include:

- Debris Type and Dimensions - Whether floating, non-floating or urban debris present in the source area and its size;
- Debris Availability - The volume of debris available in the source area;
- Debris Mobility - The ease with which available debris can be moved into the stream;
- Debris Transportability - The ease with which the mobilised debris is transported once it enters the stream;
- Structure Interaction - The resulting interaction between the transported debris and the bridge or culvert structure; and
- Random Chance - An unquantifiable but significant factor.

These various factors which impact debris movement and interaction with the structure are discussed further in the following sections.

2.2 PROJECT SPECIFIC FACTORS

2.2.1 DEBRIS TYPE AND DIMENSIONS

Experience has shown that there are three different types of debris typically that accumulated upstream of or within a blocked structure. This debris may be classified as:

- Floating (e.g. trees);
- Non-floating or depositional (e.g. sediment); and
- Urban (e.g. cars and other urban debris).

For the project it has been determined that floating and sediment/depositional types of debris are the most appropriate. There is a small potential for urban type debris where there are urban areas or farm houses and sheds upstream of the structure. These have been considered on a case by case basis.

FLOATING DEBRIS

There are a range of sizes for floating debris that can cause blockage of structures. Most of the creeks and drainage lines upstream of the project area are dry most of the time and not tree lined. Large floating debris such as tree branches would only be available from upper catchment areas. From a review of the aerial photographs and site photographs of the structures the dominant floating

APPENDIX E – HYDRAULIC STRUCTURE BLOCKAGE METHODOLOGY & RESULTS

debris will be grasses and small sticks, i.e small to medium size debris. It is noted that small floating debris tends to pass through structures due to their size compared to the structure size.

NON FLOATING/DEPOSITIONAL DEBRIS

Non floating debris generally related to sediment size. A review of regional soil maps (Australian Soil Resource Information System) (refer to Figure 2.1 below). for the upstream catchment has been undertaken. The soils are described as weathered bedrock with the upper layers consisting of alluvial sediments and sediments generated from wind erosion. The EIS (Table 14.1) described the top soil as clay consisting predominately of sand. The lower levels of soil from the EIS test pits includes silty clays with sand and gravels. ARR2016 classifies the sediment sizes as fine sediment, gravels and boulders.

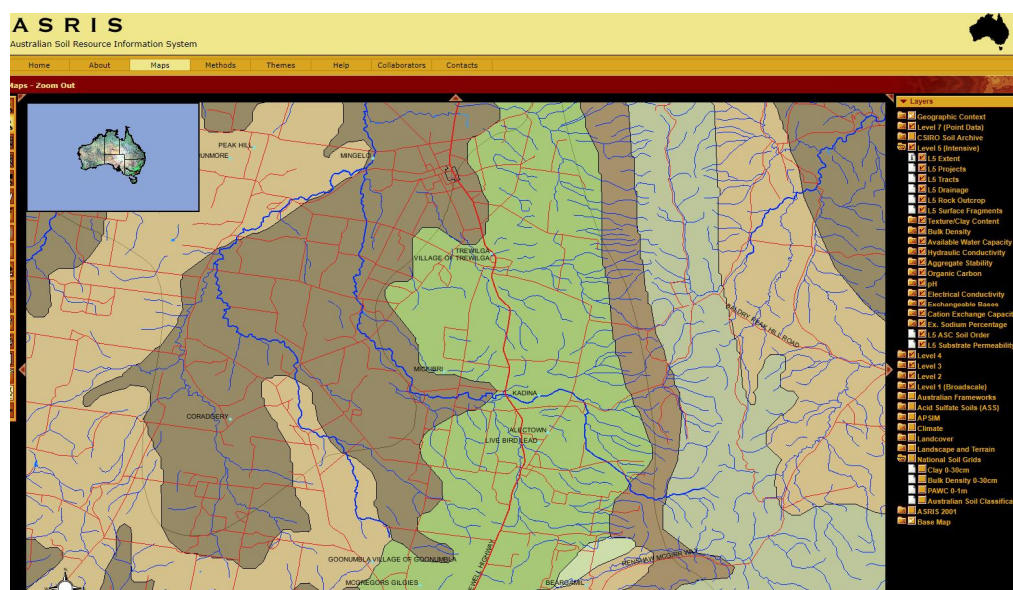


Figure 2.1 Soil Information (Australian Soil Information System), Accessed 3/10/2017

For the project area, the results of a series of boreholes have been assessed and d50 sediment size estimated at locations along the corridor. The results of the assessment indicate soil type of clays, sands and gravels are present along the corridor. Sediment size for the blockage assessment has been chosen based on the nearest borehole information.

2.2.2 DEBRIS AVAILABILITY

The availability of debris is determined by the area (source) that is upstream of the point of interest from which debris can come from. ARR2016 indicates that the availability is also dependent on the event, such that a small event is likely to only collect debris from a small area, and a larger event is likely to generate debris from a larger area simply by extent of inundation or volume of runoff.

The ARR2016 procedure is used to initially establish debris potential in a 1% Annual Exceedance Probability (AEP) event.

SOURCE AREA

The source area for the majority of the project can be described as gently undulating cleared farming land. The land is predominantly used for grazing of cattle and sheep with some areas of cropping. The cropping is seasonal and therefore this may have some impact on debris availability but only if immediately adjacent to the project alignment. A review of the aerial photographs of the catchment to the east (upstream) of the project alignment has been completed to help describe the source area. There are some patches of remnant vegetation at the top of local high points and there are some paddocks with contour banking that is assumed to control and reduce erosion during rainfall events.

APPENDIX E – HYDRAULIC STRUCTURE BLOCKAGE METHODOLOGY & RESULTS

Site photographs have also been reviewed to help establish an understanding of the source area. A selection of these photos are included below.

Chainage 449.765



Chainage 470.467 (cropped source area)



There are several mines in the catchment areas, Peak Hill (Gold) (currently closed Oct 2017), Tomingley (Gold) (open), North Parkes (Copper).

Debris availability for each culvert and bridge crossing has been classified on a case by case basis but in general the classification is low. ARR2016 describes the low classification as:

- Well maintained rural lands and paddocks with minimal outbuildings or stored materials in the source area.
- Streams with moderate to flat slopes and stable bed and banks.

APPENDIX E – HYDRAULIC STRUCTURE BLOCKAGE METHODOLOGY & RESULTS

3. IMPLEMENTATION OF THE PROCESS

In order to estimate a blockage factor for use in the hydraulic assessment a process has been developed that considers the qualitative factors above and site specific hydraulic factors that influence blockage. The inputs and process are described in detail below.

3.1 INPUTS

Fourteen parameters are used to assess the blockage risk on culvert structures. These include;

- **Approach Bed Slope**, this is extracted from the bed slope implemented in hydrological modelling of the catchment and provides an indicative upstream slope approaching the structure under investigation;
- **Stream Velocity**, this parameter is extracted from the maximum velocity result grid file from the latest iteration of the hydraulic models. Point sampling of hydraulic model results provides an indicative upstream maximum stream velocity across all modelled storm patterns and durations;
- **Peak Velocity**, obtained from hydraulic model results tabulated outputs of the storm pattern and duration deemed to be most representative of the project area. Specifically, the 1 dimensional tabulated structure output file is opened and the absolute maximum value of velocity through each structure is adopted in the process;
- **Stream Depth**, similar to Stream Velocity, this parameter is extracted by point sampling of maximum depth result grid results. Both Stream Velocity and Stream Depth are sampled at the same upstream location and are assumed to provide an indicative value. Again, the maximum depth value at the specified location across all modelled storm patterns and durations of the hydraulic model results is extracted and implemented;
- **Inlet Clear Width**, extracted from the hydraulic model input 1d Network layer, this parameter is the value of internal width of a single cell within a structure;
- **Inlet Clear Height**, extracted from the hydraulic model input 1d Network layer, this parameter is the value of internal height of a single cell within a structure;
- **Number of Cells**, provides the number of cells a structure is made up of;
- **Effective Stream Width**, defined as the effective material transporting width of an active stream at some distance upstream of a structure;
- **Temporal Variability in Max Stream Flows**, a parameter ranked High/Medium/Low. For a higher temporal variability, a High rating is applied;
- **L₁₀**, a parameter representing the average length of the longest 10% of the debris that could arrive at the site;
- **Debris Availability**, a parameter ranked High/Medium/Low.
- **Debris Mobility**, a parameter ranked High/Medium/Low.
- **AEP**, the Annual Exceedance Probability determined by the event under assessment;
- **Mean Sediment Present**, determined from geotechnical investigations close to a structures location.

3.2 PROCESS

The process implemented is based on guidance provided in Book 6, Chapter 6 of ARR2016 with key assumptions displayed clearly.

APPENDIX E – HYDRAULIC STRUCTURE BLOCKAGE METHODOLOGY & RESULTS

3.2.1 DEBRIS TRANSPORTABILITY

The site rating for each of the categories in Table 3.1 is a number, 3, 2 or 1 based on where each parameter falls in relation to the assessment conditions.

Table 3.1 Debris Transportability Assessment Table (modified from ARR2016, Book 6, Chapter 6, Table 6.6.3)

FACTOR	HIGH (3)	MEDIUM (2)	LOW (1)	SITE RATING
Slope (S) (%)	$S \geq 3$	$1 \leq S < 3$	$S < 1$	
Stream Velocity (Vs) (m/s)	$V_s \geq 2.5$	$1 \leq V_s < 2.5$	$V_s < 1$	
Stream Depth (ds) (m) relative to L10 (m)	$ds > 0.5 \times L_{10}$	$ds = 0.5 \times L_{10}$	$ds < 0.5 \times L_{10}$	
Effective Stream Width (Ws) (m)	$W_s > L_{10}$	$W_s = L_{10}$	$W_s < L_{10}$	
Temporal Variability in Maximum Stream Flows	Determined by assessor (3,2 or 1)			
				Debris Transportability Rating

Key Assumption

The overall Debris Transportability, as assessed in Table 3.1, receives either a High, Medium or Low rating. Each of the five assessment categories receives a score of 3, 2 or 1. The summation of these site ratings is used to determine the final Debris Transportability rating, High, Medium or Low. An approach based on the guidance for Debris Potential, Table 6.6.4 for Book 6, Chapter 6, of ARR2016, is adopted. Table 3.2 shows the process for determining the summation bounds that yield an end Debris Transportability rating of High, Medium or Low.

Table 3.2 Debris Transportability Assessment Final Rating Factors Table

FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	SUM	AVERAGE	H/M/L
3	3	3	3	3	15	3	H
3	3	3	3	2	14	2.8	H
3	3	3	2	2	13	2.6	H
3	3	3	3	1	13	2.6	H
3	3	2	2	2	12	2.4	M
3	2	2	2	2	11	2.2	M
3	3	3	1	1	11	2.2	M
2	2	2	2	2	10	2	M
3	3	1	1	1	9	1.8	M
2	2	2	2	1	9	1.8	M
2	2	2	1	1	8	1.6	M
3	1	1	1	1	7	1.4	L
2	2	1	1	1	7	1.4	L
2	1	1	1	1	6	1.2	L
1	1	1	1	1	5	1	L

APPENDIX E – HYDRAULIC STRUCTURE BLOCKAGE METHODOLOGY & RESULTS

The options 1 to 5 presented in Table 3.2 represent all possible final summation scenarios that impact the final site ranking. It is noted that the scenarios do not account for a specific category scoring a H (3), M (2) or L (1). By taking a simple average of the individual factor scores, and sorting from highest to lowest average value, a single number between 0 and 3 is achieved. Based on the factors average and the observed severity of each scenario, the following bounds for final Debris Transportability rating were established;

$$5 \leq \text{SUM} < 8 = \text{LOW} \quad 8 \leq \text{SUM} < 13 = \text{MEDIUM} \quad \text{SUM} \geq 13 = \text{HIGH}$$

3.2.2 DEBRIS POTENTIAL

Apart from Debris Transportability, the factors influencing the Debris Potential are directly drawn from the user inputs. Criteria used to determine Debris Mobility are detailed in Table 6.6.2 of ARR2016, Book 6, Chapter 6. Similarly, for Debris Availability, Table 6.6.1 of ARR2016, Book 6, Chapter 6. The site rating for each of the categories in Table 3.3 is a number, 3, 2 or 1 based on the score of the previously assessed factors.

Table 3.3 Debris Potential Assessment Table

FACTOR	HIGH (3)	MEDIUM (2)	LOW (1)	SITE RATING
Debris Availability	3	2	1	
Debris Mobility	3	2	1	
Debris Transportability	3	2	1	
Debris Potential Rating				

Table 3.4 Debris Potential Assessment Final Rating Table (modified from ARR2016, Book 6, Chapter 6, Table 6.6.4)

DEBRIS POTENTIAL RATING	COMBINATIONS
High	HHH (9), HHM (8)
Medium	MMM (6), HML (6), HMM (7), HLL (5)
Low	LLL (3), MML (5), MLL (4)

Where a score of 5 is determined, from the combinations in Table 3.4, the process will apply a condition such that if a score of 5 is achieved, and one of the values contributing to the score is, High (3), then the Debris Potential is Medium, otherwise it is Low.

The Debris Potential is then adjusted based on the Annual Exceedance Probability of the assessment. The adjustment conditions are shown in Table 3.5. Where the AEP does not satisfy an Event AEP condition, a site rating of zero is given. Therefore, the final site rating will be either 3, 2 or 1 corresponding directly to a High, Medium or Low site rating.

Table 3.5 Adjustment for Annual Exceedance Probability (modified from ARR2016, Book 6, Chapter 6, Table 6.6.5)

EVENT AEP	DEBRIS POTENTIAL AT STRUCTURE			SITE RATING
	HIGH (3)	MEDIUM (2)	LOW (1)	
AEP ≥ 5%	2	1	1	
0.5% ≤ AEP < 5%	3	2	1	
AEP < 0.5%	3	3	2	
Adjustment of Annual Exceedance Probability				

3.2.3 DESIGN BLOCKAGE LEVEL

The design blockage level for a structure is determined from Table 3.6. The table is used as a lookup with the two inputs; the condition relating Inlet Clear Width and L₁₀ and the Adjusted Debris Potential detailed in section 3.2.1.

APPENDIX E – HYDRAULIC STRUCTURE BLOCKAGE METHODOLOGY & RESULTS

Table 3.6 Most likely Inlet Blockage Levels (modified from ARR2016, Book 6, Chapter 6, Table 6.6.5)

CONTROL DIMENSIONS INLET CLEAR WIDTH (W) (m)	AEP ADJUSTED DEBRIS POTENTIAL AT STRUCTURE			SITE RATING
	HIGH	MEDIUM	LOW	
$W_i < L_{10}$	100%	50%	25%	
$L_{10} \leq W_i \leq 3 \times L_{10}$	20%	10%	0%	
$W_i > 3 \times L_{10}$	10%	0%	0%	
Inlet Blockage Level (%)				

3.2.4 SEDIMENT DEPOSITING IN BARREL/WATERWAY

By comparing the Peak Velocity through the structure with the Mean Sediment Size, Table 3.7 is utilised to determine the likelihood of sediment deposition in the barrel/waterway.

Table 3.7 Likelihood of Sediment Being Deposited in Barrel/Waterway (modified from ARR2016, Book 6, Chapter 6, Table 6.6.7)

PEAK VELOCITY THROUGH STRUCTURE (V_p) (m/s)	MEAN SEDIMENT SIZE PRESENT (mm)					SITE RATING
	Clay/Slit 0.001 – 0.04	Sand 0.04 - 2	Gravel 2 - 63	Cobbles 63 - 200	Boulders > 200	
$V_p \geq 3$	LOW	LOW	LOW	LOW	MEDIUM	
$1.0 \leq V_p < 3.0$	LOW	LOW	LOW	MEDIUM	MEDIUM	
$0.5 \leq V_p < 1.0$	LOW	LOW	LOW	MEDIUM	HIGH	
$0.1 \leq V_p < 0.5$	LOW	LOW	MEDIUM	HIGH	HIGH	
$V_p < 0.1$	LOW	MEDIUM	HIGH	HIGH	HIGH	
Likelihood of Sediment Being Deposited in Barrel/Waterway						

Table 3.7 is used as a lookup table. The user defines the Mean Sediment Size and together with the Peak Velocity the Likelihood of Sediment Deposition is determined.

The most likely depositional blockage level is then determined using the lookup Table 3.8 with the Likelihood of Sediment Deposition and the Adjusted AEP Debris Potential from Table 3.5.

Table 3.8 Most likely Depositional Blockage Levels (modified from ARR2016, Book 6, Chapter 6, Table 6.6.8)

LIKELIHOOD OF SEDIMENT DEPOSITION	AEP ADJUSTED NON FLOATING DEBRIS POTENTIAL (SEDIMENT) AT STRUCTURE			SITE RATING
	HIGH	MEDIUM	LOW	
HIGH	100%	60%	25%	
MEDIUM	60%	40%	15%	
LOW	25%	15%	0%	
Depositional Blockage Level (%)				

APPENDIX E – HYDRAULIC STRUCTURE BLOCKAGE METHODOLOGY & RESULTS

3.2.5 CELL HEIGHT AND L_{10} CONSIDERATIONS

Key Assumption

The implemented value of Inlet Clear Width, to the process described in previous sections, is defined based on the number of cells in the structure, the structure type, the Inlet Clear Height and the originally inputted value of Inlet Clear Width itself. The conditions are;

- If the number of cells is greater than one, the Inlet Clear Width is implemented as W_i ;
- If the number of cells is equal to one, and the Inlet Clear Height is zero, a pipe culvert, the Inlet Clear Width is implemented as W_i ;
- If the number of cells is equal to one, and the Inlet Clear Height is greater than zero, a box culvert, and the Inlet Clear Height is less than or equal to one third of the Inlet Clear Width, the Inlet Clear Height is implemented as W_i , otherwise the Inlet Clear Width is implemented as W_i .

Where the Inlet Clear Height is implemented as W_i , the value of L_{10} input is divided by two and takes the place of the original L_{10} value in the assessment.

3.2.6 FINAL DESIGN BLOCKAGE APPLIED

Key Assumption

The Final Design Blockage is the maximum of Shared Inlet Blockage Level and Shared Depositional Blockage Level. In line with ARR2016, Book 6, Chapter 6, Section 6.4.4.9, inlet and depositional shared blockage levels are assessed based on the structures width and the Effective Stream Width. The following conditions are applied;

- If the Active Stream Width is greater than or equal to the structure width, calculated as the product of Inlet Clear Width and Number of Cells, all cells are applied with a blockage equal to the Inlet/Depositional Blockage Level.
- If the Active Stream Width is less than the structure width the following conditions are applied;
 - Cells that are exposed to any flow from the active stream are applied with a blockage equal to the Inlet/Depositional Blockage Level.
 - Cells that are not exposed to any flow from the active stream are applied with a blockage equal to half of the Inlet/Depositional Blockage Level.
 - The shared blockage value is then derived by dividing the summation of each cell blockage level by the Number of Cells.

The Final Design Blockage Level is then adopted as the larger of the derived shared inlet and depositional blockage levels.

4. APPLICATION OF THE METHOD: WORKED EXAMPLE

Table 4.1 details the inputs used in this worked example.

Table 4.1 Worked Example Input Values

PARAMETER	UNIT	VALUE
Approach Bed Slope (S)	%	0.132
Stream Velocity (V_s)	m/s	4.03
Peak Velocity (V_p)	m/s	2.319
Stream Depth (d_s)	m	0.324
Inlet Clear Width (W_i)	m	3

APPENDIX E – HYDRAULIC STRUCTURE BLOCKAGE METHODOLOGY & RESULTS

PARAMETER	UNIT	VALUE
Inlet Clear Height (Hi)	m	2.4
Number of Cells (Ncells)		40
Active Stream Width (Ws)	m	20
Temporal Variability in Max Stream Flows	L/M/H (1,2,3)	2
L10	m	2
Debris Availability	L/M/H (1,2,3)	2
Debris Mobility	L/M/H (1,2,3)	1
AEP	%	1
Mean Sediment Present	mm	200

Intermediate Steps**L10 and Wi Implemented**

- The structure contains more than one cell, therefore the Wi implemented is equal to the Inlet Clear Width (3m);
- The structure contains more than one cell, therefore the L10 implemented is equal to L10 (2m).

Debris Transportability

- Slope (0.132%) < 1% therefore the site rating equals 1;
- Stream Velocity (4.03m/s) > 2.5m/s therefore the site rating equals 3;
- Stream Depth (0.324m) < 0.5 × L10 (2m) therefore the site rating equals 1;
- Active Stream Width (20m) > L10 (2m) therefore the site rating equals 3;
- Temporal Variability in Max Stream Flows is 2 therefore the site rating is 2;
- Final summation of the above site ratings is 10, $8 \leq 10 < 13$ therefore the Debris Transportability is **Medium**.

Debris Potential

- Debris Availability is 2 therefore the site rating equals 2;
- Debris Mobility is 1 therefore the site rating equals 1;
- Debris Transportability was determined as Medium therefore the site rating is 2;
- Final summation of the above site ratings is 5, as none of the site ratings are High (3) the Debris Potential is **Low**.

AEP Adjusted Debris Potential

- AEP (1%) is between 5% and 0.5% and previously determined Debris Potential is Low, therefore site rating is 1;
- Summation is also equal to 1 and therefore the Adjusted Debris Potential is **Low**.

Design Inlet Blockage Level

- $L10 (2m) \leq Wi (3m) \leq 3 \times L10 (2m)$ and the Adjusted Debris Potential is Low therefore the Design Inlet Blockage Level is **0%**.

APPENDIX E – HYDRAULIC STRUCTURE BLOCKAGE METHODOLOGY & RESULTS

Likelihood of Sediment Being Deposited in Barrel/Waterway

- Peak Velocity (2.319m/s) is between 1.0 and 3.0 and the Mean Sediment Present is 200mm, therefore the site rating is 2;
- Summation is also equal to 2 therefore the Likelihood of Sediment Begin Deposited in Barrel/Waterway is **Medium**.

Design Depositional Blockage Level

- The Likelihood of Sediment Begin Deposited in Barrel/Waterway is Medium and the Adjusted Debris Potential is Low therefore the Design Depositional Blockage Level is **15%**.

Final Output

- Debris Potential was determined as Low;
- AEP Adjusted Debris Potential was determined as Low;
- Design Inlet Blockage Level was determined as 0%;
- Likelihood of Sediment Begin Deposited in Barrel/Waterway was determined as Medium;
- Design Depositional Blockage Level was determined as 15%;
- The Effective Stream Width (20m) < Number of Cell (40) × Inlet Clear Width (3m) therefore the number of cells to apply full blockage values to is equal to the division of Effective Stream Width and Inlet Clear Width;

$$\frac{W_s}{W_i} = \frac{20}{3} \approx 7$$

- This value is rounded up to the nearest integer value. 7 cells are applied with full blockage values and 33 are applied with half blockage values;
- The maximum of the shared blockage values is taken;

$$\text{Shared Inlet Blockage} = \frac{7 \times 0\% + 33 \times 0.5 \times 0\%}{40} = 0\%$$

$$\text{Shared Depositional Blockage} = \frac{7 \times 15\% + 33 \times 0.5 \times 15\%}{40} = 8.8125\%$$

- Final Blockage Applied to the structure is **8.81%**.

5. RESULTS

The results of the blockage assessment at each structure for the design case are presented in the results sheets below.

APPENDIX E – HYDRAULIC STRUCTURE BLOCKAGE METHODOLOGY & RESULTS

Structure ID	Pipe Description	Approach Bed Slope (S)	Stream Velocity (Vs)	Peak Velocity (Vp)	Stream Depth (ds)	Inlet Clear Width (W)	Inlet Clear Height (H)	Number of Cells (Ncell)	Active Stream Width (Ws)	Temporal Variability in Max Stream Flows	L10	Debris Availability	Debris Mobility	AEP	Mean Sediment Present	Debris Potential	Adjustment for Annual Exceedance Probability	Design Inlet Blockage Level	Likelihood of Sediment Being Deposited in Barrel/Waterway	Depositional Blockage Level	Cells Applied with B _{DES}	Cells Applied with 0.5 x B _{DES}	Shared Inlet Blockage	Shared Depositional Blockage	Final Design Blockage	Comments	Warnings
																											H ≤ 1/3W
2A101	RCP Class 6	1.417	0.233	1.208	0.406	0.6	0	1	0	2	2	1	2	1	2.36	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		Yes
449.35	RCP Class 3	1.9556	0	0.6808	0	1.8	0.45	4	0	2	2	1	2	1	26.5	LOW	LOW	25%	LOW	0%	0 of 4	4 of 4	12.50%	0.00%	12.50%		Yes
449.765	Box Culverts	1.338	0.389	1.872	0.041	3	0.6	5	0	2	2	1	2	1	26.5	LOW	LOW	0%	LOW	0%	0 of 5	5 of 5	0.00%	0.00%	0.00%		Yes
449.852	Box Culverts	6.0243	0	0.8332	0.094	3	0.6	1	0	2	3	1	2	1	26.5	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		Yes
450.204	Box Culverts	2.8344	0.405	1.227	0.632	3	0.9	1	0	2	3.2	1	2	1	26.5	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		Yes
451.332	Box Culverts	0.696	0.559	2.729	1.312	2.4	1.2	9	0	2	2	1	2	1	2.36	LOW	LOW	0%	LOW	0%	0 of 9	9 of 9	0.00%	0.00%	0.00%		No
452.721	Box Culverts	1.4588	1.793	3.013	1.842	3	2.4	2	0	2	2	1	2	1	0.037	LOW	LOW	0%	LOW	0%	0 of 2	2 of 2	0.00%	0.00%	0.00%		No
453.403BR	Box Culverts	0.840	0.988	3.360	1.287	2.400	1.500	5.000	0	2	2	1	2	1	26.5	LOW	LOW	0%	LOW	0%	0 of 5	5 of 5	0.00%	0.00%	0.00%		No
453.642	Box Culverts	1.2043	0.193	2.432	0.992	1.8	0.9	1	20	2	2	1	2	1	0.037	LOW	LOW	25%	LOW	0%	1 of 1	0 of 1	25.00%	0.00%	25.00%		No
454.353	Box Culverts	1.1375	0.85	1.2604	0.654	1.8	0.9	4	0	2	2	1	2	1	26.5	LOW	LOW	25%	LOW	0%	0 of 4	4 of 4	12.50%	0.00%	12.50%		No
454.844BR	Box Culverts	1.0853	1.136	2.79	1.46	2.4	1.8	18	0	2	2	1	2	1	0.037	LOW	LOW	0%	LOW	0%	0 of 18	18 of 18	0.00%	0.00%	0.00%		No
455.228	Box Culverts	0.607	1.068	2.902	1.602	3.000	1.800	6.000	0	2	2	1	2	1	0.037	LOW	LOW	0%	LOW	0%	0 of 6	6 of 6	0.00%	0.00%	0.00%		No
456.184	Box Culverts	1.5284	0.644	2.335	0.526	3	1.2	2	0	2	2.5	1	2	1	0.037	LOW	LOW	0%	LOW	0%	0 of 2	2 of 2	0.00%	0.00%	0.00%		No
456.992a	Box Culverts	1.326	0.793	1.262	0.189	3	0.6	5	0	2	2	1	2	1	26.5	LOW	LOW	0%	LOW	0%	0 of 5	5 of 5	0.00%	0.00%	0.00%		Yes
457.486	Box Culverts	1.5896	0.741	2.757	0.934	2.4	1.2	1	0	2	2	1	2	1	0.037	LOW	LOW	0%	LOW	0%	0 of 1	1 of 1	0.00%	0.00%	0.00%		No
457.85	Box Culverts	1.326	0.849	2.901	0.878	0.6	0.45	5	0	2	2	1	2	1	26.5	LOW	LOW	25%	LOW	0%	0 of 5	5 of 5	12.50%	0.00%	12.50%		No
457.9	Box Culverts	1.5896	0.655	1.37	0.723	1.8	0.45	2	0	2	2.5	1	2	1	26.5	LOW	LOW	25%	LOW	0%	0 of 2	2 of 2	12.50%	0.00%	12.50%		Yes
458.07	Box Culverts	2.2042	0.371	1.051	0.505	1.8	0.45	5	0	2	2.2	1	2	1	26.5	LOW	LOW	25%	LOW	0%	0 of 5	5 of 5	12.50%	0.00%	12.50%		Yes
458.285	Box Culverts	2.204	0.747	1.945	0.387	1.800	0.600	1.000	0	2	2	1	2	1	0.037	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		Yes
458.323	Box Culverts	1.7679	0.798	4.422	0.827	1.8	0.9	2	0	2	2	1	2	1	26.5	LOW	LOW	25%	LOW	0%	0 of 2	2 of 2	12.50%	0.00%	12.50%		No
458.648	Box Culverts	3.0519	0.513	3.937	0.853	1.8	0.6	3	0	2	2	1	2	1	0.037	LOW	LOW	25%	LOW	0%	0 of 3	3 of 3	12.50%	0.00%	12.50%		Yes
459.676BR	Box Culverts	2.6256	0.545	1.425	0.699	1.8	0.6	1	0	2	2	1	2	1	0.037	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		Yes
460.127	Box Culverts	2.956	1.085	2.902	1.14	2.4	1.5	3	0	2	2	1	2	1	0.037	LOW	LOW	0%	LOW	0%	0 of 3	3 of 3	0.00%	0.00%	0.00%		No
460.698BR	Box Culverts	1.091	0.938	3.201	1.642	2.600	1.100	3.000	0	2	2	1	2	1	26.5	LOW	LOW	0%	LOW	0%	0 of 3	3 of 3	0.00%	0.00%	0.00%		No
460.698BRa	Box Culverts	1.091	0.743	2.832	1.87	3	1.5	4	0	2	2	1	2	1	26.5	LOW	LOW	0%	LOW	0%	0 of 4	4 of 4	0.00%	0.00%	0.00%		No
461.157BRa	Box Culverts	0.564	1.479	2.499	0.385	2.4	1.8	7	9	2	2.8	1	2	1	26.5	LOW	LOW	25%	LOW	0%	4 of 7	3 of 7	19.64%	0.00%	19.64%		No
461.244	Box Culverts	0.564	0.399	2.58	1.047	3	0.9	1	0	2	2.5	1	2	1	26.5	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		Yes
461.252	Box Culverts	0.564	0.477	2.314	0.914	3	0.9	1	0	2	2	1	2	1	0.037	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		Yes
461.980b	Box Culverts	0.3673	0	0.824	0.041	3	0.6	2	0	2	2.2	1	2	1	26.5	LOW	LOW	0%	LOW	0%	0 of 2	2 of 2	0.00%	0.00%	0.00%		Yes
462.814	Box Culverts	4.2237	0	1.071	0.036	3	0.9	3	0	2	2	1	2	1	26.5	LOW	LOW	0%	LOW	0%	0 of 3	3 of 3	0.00%	0.00%	0.00%		Yes
463.019	Box Culverts	5.8581	0	1.035	0.011	3	0.6	1	0	2	2	1	2	1	26.5	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		Yes
463.224	Box Culverts	5.128	1.250	0.919	0.152	1.800	0.450	2.000	0	2	2.2	1	2	1	0.037	LOW	LOW	25%	LOW	0%	0 of 2	2 of 2	12.50%	0.00%	12.50%		Yes
464.694	Box Culverts	1.0658	0.902	302%	1.631	300%	180%	4.00	0.00%	2	2	1	2	1	0.037	LOW	LOW	0%	LOW	0%	0 of 4	4 of 4	0.00%	0.00%	0.00%		No
464.746	Box Culverts	1.198	0.441	2.857	1.699	2.400	1.500	1.000	0	2	2.5	1	2	1	4.75	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		No
465.265	Box Culverts	1.168	0.904	1.655	0.232	1.800	0.600	1.000	0	2	2.5	1	2	1	2.36	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	13%		Yes
465.31	Box Culverts	0.537	0.725	2.998	0.593	1.800	0.600	1.000	0	2	2.5	1	2	1	4.75	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	13%		Yes
465.366	Box Culverts	0.020	0.367	0.914	0.579	1.800	0.600	1.000	0	2	3	1	2	1	4.75	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	13%		Yes
465.443	RCBC 0.45h	0.020	0	0	0.000	0.600	0.450	1.000	0	2	2.2	1	2	1	0.037	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	13%		No
465.859	Box Culverts	0.416	0	1.142	0.076	1.800	0.450	1.000	0	2	3	1	2	1	4.75	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	13%		Yes
NWL 2161a	RCP Class 3	5.772	0.981	0.5442	1.458	1.800	0.600	4.000	0	2	2	1	2	1	4.75	LOW	LOW	0.25	LOW	0	0 of 4	4 of 4	12.50%	0.00%	13%		Yes
NWL 250.000	Box Culverts	0.752	0.701	0.7849	0.588	3.000	0.600	20.000	0	2	2	1	2	1	4.75	LOW	LOW	0%	LOW	0%	0 of 20	20 of 20	0.00%	0.00%	0%		Yes
NWL 400.000	Box Culverts	0.752	0.747	1.6577	0.558	3.000	0.600	10.000	0	2	2	1	2	1	4.75	LOW	LOW	0%	LOW	0%	0 of 10	10 of 10	0.00%	0.00%	0%		Yes
NWL 700.000	Box Culverts	0.752	1.111	0.647	0.567	3.000	1.200	15.000	0	2	2	1	2	1	4.75	LOW	LOW	0%	LOW	0%	0 of 15	15 of 15	0.00%	0.00%	0%		No
NWL 800.000	Box Culverts	0.752	0.956	1.857	0.652	300%	0.9	100%	0%	2	2.00%	1	2	1	4.75	LOW	LOW	0%	LOW	0%	0 of 10	10 of 10	0.00%	0.00%	0%		Yes
NWL 1.380.000	Box Culverts	0.922	0.403	0.605	0.513	3.600	1.800	4.000	0	2	2	1	2	1	4.75	LOW	LOW	0%	LOW	0%	0 of 4	4 of 4	0.00%	0.00%	0%		No
NWL 1.640.000	Box Culverts	0.922	0.851	0.8773	0.533	3.000	1.200	12.000	0	2	2	1	2	1	4.75	LOW	LOW	0%	LOW	0%	0 of 12	12 of 12	0.00%	0.00%	0%		No
NWL 1.820a	Box Culverts	0.679	0.47	1.124	0.458	3.000	1.200	5.000	0	2	2	1	2	1	4.75	LOW	LOW	0%	LOW	0%	0 of 5	5 of 5	0.00%	0.00%	0%		

APPENDIX E – HYDRAULIC STRUCTURE BLOCKAGE METHODOLOGY & RESULTS

Structure ID	Pipe Description	Approach Bed Slope (S) (%)	Stream Velocity (Vs) m/s	Peak Velocity (Vp) m/s	Stream Depth (ds) m	Inlet Clear Width (Wl) m	Inlet Clear Height (Hi) m	Number of Cells (Ncell)	Active Stream Width (Ws) m	Temporal Variability in Max Stream Flows			L10 m	Debris Availability L/M/H (1,2,3)	Debris Mobility L/M/H (1,2,3)	AEP %	Mean Sediment Present mm	Debris Potential	Adjustment for Annual Exceedance Probability	Design Inlet Blockage Level B _{DES} %	Likelihood of Sediment Being Deposited in Barrel/Waterway (HML)	Depositional Blockage Level B _{DES} %	Cells Applied with B _{DES}	Cells Applied with 0.5 x B _{DES}	Shared Inlet Blockage %	Shared Depositional Blockage %	Final Design Blockage %	Comments	Warnings
										L/M/H (1,2,3)	L/M/H (1,2,3)	L/M/H (1,2,3)																	
1B101	RCBC 0.45h	0.6615	0	0	0.6	0.45	1	0	2	2	1	2	1	0.037	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		No			
478.174a	Box Culverts	0.214	0.805	1.663	1.700	2.400	1.500	6,000	0	2	2	1	2	1	0.037	LOW	LOW	0%	LOW	0%	0 of 6	6 of 6	0.00%	0.00%	0.00%		No		
478.174b	Box Culverts	0.21408	0.805	1.276	1.637	2.400	1.500	6,000	0.000	2	2,000	1	2	1,000	0.037	LOW	LOW	0%	LOW	0%	0 of 6	6 of 6	0.00%	0.00%	0.00%		No		
478.262a	Box Culverts	0.242	0.738	1.523	1.818	3	2.1	2	0	2	3	1	2	1	0.037	LOW	LOW	0%	LOW	0%	0 of 2	2 of 2	0.00%	0.00%	0.00%		No		
478.262b	Box Culverts	0.242	0.767	1.419	2.146	3,000	2,100	4,000	0	2	3	1	2	1	0.037	LOW	LOW	0%	LOW	0%	0 of 4	4 of 4	0.00%	0.00%	0.00%		No		
478.262c	Box Culverts	0.242	0.658	1.54	2.242	3,000	2,100	2,000	0	2	3	1	2	1	0.037	LOW	LOW	0%	LOW	0%	0 of 2	2 of 2	0.00%	0.00%	0%		No		
478.262d	Box Culverts	0.242	0.984	1.593	2.063	3,000	2,100	2,000	0	2	3	1	2	1	0.037	LOW	LOW	0%	LOW	0%	0 of 2	2 of 2	0.00%	0.00%	0%		No		
479.300c	Box Culverts	0.496	0.827	1.342	2.04	3.6	1.5	5	74	2	3	1	3	1	0.037	MEDIUM	MEDIUM	10%	LOW	15%	5 of 5	0 of 5	10.00%	15.00%	0%		No		
LX041.531	Box Culverts	0.92592	0.251	0.664	0.154	0.45	0	5	0	2	2	1	2	1	0.037	LOW	LOW	25%	LOW	0%	0 of 5	5 of 5	12.50%	0.00%	12.50%		Yes		
LX044.650	Box Culverts	0.3344	0.345	1.373	0.669	0.45	0	3	0	2	2	1	2	1	0.037	LOW	LOW	25%	LOW	0%	0 of 3	3 of 3	12.50%	0.00%	12.50%		Yes		
LX103.710	Box Culverts	0.716	0.414	1.805	0.767	0.750	0.000	9,000	0	2	2	1	2	1	0.02	LOW	LOW	25%	LOW	0%	0 of 9	9 of 9	12.50%	0.00%	12.50%		Yes		
LX114.000	Box Culverts	1.079	0.614	1.545	0.325	0.6	0	15	0	2	2.3	1	2	1	0.037	LOW	LOW	25%	LOW	0%	0 of 15	15 of 15	12.50%	0.00%	12.50%		Yes		
LX131.243	Box Culverts	0.461	0.426	0.551	0.934	0.450	0	1	0	2	2	1	2	1	13.2	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		Yes		
LX172.245	Box Culverts	0.594	0.390	1.434	0.581	0.450	0.000	1,000	0	2	2.6	1	2	1	0.037	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		Yes		
487.96	Box Culverts	0.01	0.172	2.046	0.296	1.8	0.9	1	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		No		
488	Box Culverts	0.01	1.747	2.267	0.392	2.1	0.9	1	0	2	2	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		No		
488.694	Box Culverts	0.688	0.853	2.039	0.193	1.8	0.9	1	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		No		
488.908	Box Culverts	0.452	0.549	2.248	0.165	1.8	0.9	2	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 2	2 of 2	12.50%	0.00%	12.50%		No		
489.7	Box Culverts	0.452	0.838	1.258	0.705	2.4	1.5	6	0	2	2	1	2	5	26.5	LOW	LOW	0%	LOW	0%	0 of 6	6 of 6	0.00%	0.00%	0.00%		No		
489.77	Box Culverts	0.452	0.692	2.816	1.538	2.4	1.8	5	0	2	2	1	2	5	26.5	LOW	LOW	0%	LOW	0%	0 of 5	5 of 5	0.00%	0.00%	0.00%		No		
489.844	Box Culverts	0.452	0.563	2.4	0.975	3	2.1	3	0	2	2	1	2	5	26.5	LOW	LOW	0%	LOW	0%	0 of 3	3 of 3	0.00%	0.00%	0.00%		No		
489.87	Box Culverts	0.452	0.77	3.012	1.238	3.6	1.8	3	0	2	2	1	2	5	26.5	LOW	LOW	0%	LOW	0%	0 of 3	3 of 3	0.00%	0.00%	0.00%		No		
489.92	Box Culverts	0.452	1.239	2.788	0.965	2.4	1.8	3	0	2	2	1	2	5	26.5	LOW	LOW	0%	LOW	0%	0 of 3	3 of 3	0.00%	0.00%	0.00%		No		
490.189	Box Culverts	0.452	0.536	2.978	0.506	2.4	1.2	4	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 4	4 of 4	12.50%	0.00%	12.50%		No		
490.553	Box Culverts	0.452	0.946	2.274	1.577	3	1.8	7	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 7	7 of 7	12.50%	0.00%	12.50%		No		
491.834	Box Culverts	0.01	1.074	0.99	0.316	2.4	1.8	5	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 5	5 of 5	12.50%	0.00%	12.50%		No		
492.079	Box Culverts	0.01	1.063	3.043	0.752	2.4	1.5	3	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 3	3 of 3	12.50%	0.00%	12.50%		No		
492.947	Box Culverts	0.01	1.028	1.107	0.643	1.8	0.9	10	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 10	10 of 10	12.50%	0.00%	12.50%		No		
493.293	Box Culverts	3.812	0.588	0.842	0.562	3	1.2	2	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 2	2 of 2	12.50%	0.00%	12.50%		No		
493.749	Box Culverts	2.261	0.333	1.78	0.301	2.4	0.9	1	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		No		
494.815	Box Culverts	2.261	0.801	2.272	0.093	1.8	0.9	2	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 2	2 of 2	12.50%	0.00%	12.50%		No		
495.535	Box Culverts	0.857	0.253	0.566	0.125	1.8	0.6	3	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 3	3 of 3	12.50%	0.00%	12.50%		Yes		
496.067	Box Culverts	1.035	0.965	2.106	0.727	1.8	0.6	1	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		Yes		
496.7	Box Culverts	0.167	0.422	2.372	0.775	1.8	0.9	2	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 2	2 of 2	12.50%	0.00%	12.50%		No		
496.885	Box Culverts	0.167	0.349	2.699	0.652	1.8	0.9	5	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 5	5 of 5	12.50%	0.00%	12.50%		No		
497.2	Box Culverts	0.167	1.37	1.609	0.022	2.4	0.9	3	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 3	3 of 3	12.50%	0.00%	12.50%		No		
497.613	Box Culverts	0.617	0.483	0.483	0.526	3	0.9	2	0	2	4	1	2	5	26.5	LOW	LOW	25%	MEDIUM	15%	0 of 2	2 of 2	12.50%	7.50%	12.50%		Yes		
497.613 B	Box Culverts	0.617	0.644	1.461	0.704	3	0.9	7	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 7	7 of 7	12.50%	0.00%	12.50%		Yes		
497.78	Box Culverts	0.312	1.38	2.194	0.659	1.8	0.6	4	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 4	4 of 4	12.50%	0.00%	12.50%		Yes		
498.061	Box Culverts	0.257	0.464	2.228	0.221	0.6	0.45	3	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 3	3 of 3	12.50%	0.00%	12.50%		No		
498.625	Box Culverts	0.921	0.426	1.513	0.452	1.8	0.6	2	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 2	2 of 2	12.50%	0.00%	12.50%		Yes		
498.7	Box Culverts	0.921	1.666	1.874	0.406	0.6	0.45	6	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 6	6 of 6	12.50%	0.00%	12.50%		No		
498.87	Box Culverts	0.408	1.272	1.029	0.079	0.6	0.45	7	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 7	7 of 7	12.50%	0.00%	12.50%		No		
499.054	Box Culverts	0.56	0.732	1.95	0.493	0.6	0.45	3	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 3	3 of 3	12.50%	0.00%	12.50%		No		
499.545	Box Culverts	0.56	1.164	2.92	0.75	0.6	0.45	3	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 3	3 of 3	12.50%	0.00%	12.50%		No		
499.577	Box Culverts	0.539	0.46	1.583	0.199	0.6	0.45	3	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 3	3 of 3	12.50%	0.00%	12.50%		No		
500.138	Box Culverts	0.275	0.833	1.046	0.281	0.6	0.45	3	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 3	3 of 3	12.50%	0.00%	12.50%		No		
500.482	Box Culverts	0.334	0.761	2.357	0.593	1.8	0.9	1	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		No		
500.598	Box Culverts	0.28	0.501	2.643	0.851	1.8	0.9	3	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 3	3 of 3	12.50%	0.00%	12.50%		No		
500.663	Box Culverts	0.3	0.459	0.809	0.7	2.4	1.2	2	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 2	2 of 2	12.50%	0.00%	12.50%		No		
501.167	Box Culverts	0.248	0.082	2.325	0.51	2.4	0.9	1	0	2	4	1	2	5	26.5	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		No		
502.456	Box Culverts	0.188	0.68	1.058	0.662	3	1.2	8	0	2	8	0	2	5	26.5	LOW	LOW	0%	LOW	0%	0 of 8	8 of 8	0.00%	0.00%	0.00%		No		
502.7	Box Culverts	0.188	1.083	1.717	0.671	3	1.2	10	0	2	10	1	2	5	26.5	LOW	LOW	0%	LOW	0%	0 of 10	10 of 10	0.00%	0.00%	0.00%		No		
502.974	Box Culverts	0.177	0.563	1.1																									

APPENDIX E – HYDRAULIC STRUCTURE BLOCKAGE METHODOLOGY & RESULTS

Structure ID	Pipe Description	Approach Bed Slope (S)	Stream Velocity (Vs)	Peak Velocity (Vp)	Stream Depth (ds)	Inlet Clear Width (Wi)	Inlet Clear Height (Hi)	Number of Cells (Ncell)	Active Stream Width (Ws)	Temporal Variability in Max Stream Flows	L10	Debris Availability	Debris Mobility	AEP	Mean Sediment Present	Debris Potential	Adjustment for Annual Exceedance Probability	Design Inlet Blockage Level	Likelihood of Sediment Being Deposited in Barrel/Waterway (HML)	Depositional Blockage Level	Cells Applied with B _{DES}	Cells Applied with 0.5 x B _{DES}	Shared Inlet Blockage	Shared Depositional Blockage	Final Design Blockage	Comments	Warnings	
		(%)	m/s	m/s	m	m	m		m	L/M/H (1,2,3)		L/M/H (1,2,3)	L/M/H (1,2,3)		L/M/H (1,2,3)			L/M/H (1,2,3)	L/M/H (1,2,3)	L/M/H (1,2,3)	L/M/H (1,2,3)	L/M/H (1,2,3)	L/M/H (1,2,3)	L/M/H (1,2,3)	L/M/H (1,2,3)			L/M/H (1,2,3)
517.428	Box Culverts	0.322	0.197	3.023	1.401	2.4	1.5	3	0	3	2	1	2	1	2.395	LOW	LOW	0%	LOW	0%	0 of 3	3 of 3	0.00%	0.00%	0.00%		No	
517.76	Box Culverts	0.322	0.274	2.891	1.366	2.4	1.5	2	0	3	2	1	2	1	2.19	LOW	LOW	0%	LOW	0%	0 of 2	2 of 2	0.00%	0.00%	0.00%		No	
518.556	Box Culverts	0.322	0.389	3.27	1.826	3	1.5	2	0	3	2	1	2	1	1.985	LOW	LOW	0%	LOW	0%	0 of 2	2 of 2	0.00%	0.00%	0.00%		No	
519.224	Box Culverts	0.231	0.867	4.823	1.919	3	1.1	4	20	3	3	1	2	1	1.78	LOW	LOW	0%	LOW	0%	4 of 4	0 of 4	0.00%	0.00%	0.00%		No	
519.25	Box Culverts	0.231	0.345	2.352	0.94	3	1.1	2	20	3	3	1	2	1	1.575	LOW	LOW	0%	LOW	0%	2 of 2	0 of 2	0.00%	0.00%	0.00%		No	
520.339	Box Culverts	0.301	0.517	2.623	0.843	2.4	1.2	7	0	3	2	1	2	1	1.37	LOW	LOW	0%	LOW	0%	0 of 7	7 of 7	0.00%	0.00%	0.00%		No	
520.555	Box Culverts	0.301	0.518	2.585	0.812	2.4	1.2	8	0	3	2	1	2	1	1.165	LOW	LOW	0%	LOW	0%	0 of 8	8 of 8	0.00%	0.00%	0.00%		No	
520.8	Box Culverts	0.301	0.612	1.274	0.519	2.4	1.2	7	0	3	2	1	2	1	0.96	LOW	LOW	0%	LOW	0%	0 of 7	7 of 7	0.00%	0.00%	0.00%		No	
521.6	Box Culverts	0.127	0.33	2.556	0.863	2.4	0.9	4	0	3	2	1	2	1	0.755	LOW	LOW	0%	LOW	0%	0 of 4	4 of 4	0.00%	0.00%	0.00%		No	
521.918	Box Culverts	0.127	0.251	2.782	0.879	2.4	1.2	1	0	3	2	1	2	1	0.55	LOW	LOW	0%	LOW	0%	0 of 1	1 of 1	0.00%	0.00%	0.00%		No	
523.223	Box Culverts	0.127	0.153	2.592	1	2.4	1.2	1	0	3	2	1	2	1	0.037	LOW	LOW	0%	LOW	0%	0 of 1	1 of 1	0.00%	0.00%	0.00%		No	
524.18	Box Culverts	0.247	0.352	2.916	0.667	3	0.6	1	0	3	2	1	2	1	2.337	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		Yes	
524.984	Box Culverts	0.364	0.388	3.166	0.631	1.8	0.6	1	0	3	2	1	2	1	4.637	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		Yes	
525.984	Box Culverts	0.273	0.457	2.436	0.8	1.8	0.9	2	0	3	2	1	2	1	6.937	LOW	LOW	25%	LOW	0%	0 of 2	2 of 2	12.50%	0.00%	12.50%		No	
528.371	Box Culverts	0.262	0.612	2.515	0.997	3	0.9	7	0	3	2	1	2	1	9.237	LOW	LOW	0%	LOW	0%	0 of 7	7 of 7	0.00%	0.00%	0.00%		Yes	
528.54	Box Culverts	0.401	0.755	1.111	0.951	2.4	1.2	17	0	3	2	1	2	1	11.537	LOW	LOW	0%	LOW	0%	0 of 17	17 of 17	0.00%	0.00%	0.00%		No	
528.668	Box Culverts	0.401	0.264	2.252	1.554	3	0.9	5	0	3	2	1	2	1	13.837	LOW	LOW	0%	LOW	0%	0 of 5	5 of 5	0.00%	0.00%	0.00%		Yes	
528.741	Box Culverts	0.447	0.244	2.971	1.151	2.4	1.2	3	0	3	2	1	2	1	16.137	LOW	LOW	0%	LOW	0%	0 of 3	3 of 3	0.00%	0.00%	0.00%		No	
529.274	Box Culverts	0.402	0.434	3.439	0.991	2.4	0.6	1	0	3	2	1	2	1	18.437	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		Yes	
529.768	Box Culverts	0.15	0.654	3.019	1.417	3	1.5	9	15	3	2	1	2	1	20.737	LOW	LOW	0%	LOW	0%	5 of 9	4 of 9	0.00%	0.00%	0.00%		No	
530.33	Box Culverts	0.15	0.583	2.507	1.302	3	1.2	7	0	3	2	1	2	1	23.037	LOW	LOW	0%	LOW	0%	0 of 7	7 of 7	0.00%	0.00%	0.00%		No	
530.705	Box Culverts	0.306	0.326	2.111	1.237	3	1.2	15	0	3	2	1	2	1	25.337	LOW	LOW	0%	LOW	0%	0 of 15	15 of 15	0.00%	0.00%	0.00%		No	
531.132	Box Culverts	0.306	0.603	3.265	1.641	2.4	1.8	10	0	3	2	1	2	1	26.5	LOW	LOW	0%	LOW	0%	0 of 10	10 of 10	0.00%	0.00%	0.00%		No	
531.543	Box Culverts	0.334	0.622	3.637	1.113	3	0.9	10	0	3	2	1	2	1	26.1	LOW	LOW	0%	LOW	0%	0 of 10	10 of 10	0.00%	0.00%	0.00%		Yes	
531.757	Box Culverts	0.278	0.615	2.668	1.145	1.8	0.9	10	0	3	2	1	2	1	25.7	LOW	LOW	25%	LOW	0%	0 of 10	10 of 10	12.50%	0.00%	12.50%		No	
531.906	Box Culverts	0.278	0.594	2.613	1.245	3	0.9	5	0	3	2	1	2	1	25.3	LOW	LOW	0%	LOW	0%	0 of 5	5 of 5	0.00%	0.00%	0.00%		Yes	
532.351	Box Culverts	0.184	0.43	2.468	1.005	3	0.9	2	0	3	2	1	2	1	24.9	LOW	LOW	0%	LOW	0%	0 of 2	2 of 2	0.00%	0.00%	0.00%		Yes	
533.149	Box Culverts	0.01	0.594	2.997	0.719	2.4	1.2	2	0	3	2	1	2	1	24.5	LOW	LOW	0%	LOW	0%	0 of 2	2 of 2	0.00%	0.00%	0.00%		No	
533.611	Box Culverts	0.01	0.853	2.923	1.282	3	1.2	3	0	3	2	1	2	1	24.1	LOW	LOW	0%	LOW	0%	0 of 3	3 of 3	0.00%	0.00%	0.00%		No	
534.776	Box Culverts	0.01	0.31	2.992	1.179	3	1.2	4	0	3	2	1	2	1	23.7	LOW	LOW	0%	LOW	0%	0 of 4	4 of 4	0.00%	0.00%	0.00%		No	
535.106	Box Culverts	0.01	0.093	1.059	0.71	2.4	1.2	1	0	3	2	1	2	1	23.3	LOW	LOW	0%	LOW	0%	0 of 1	1 of 1	0.00%	0.00%	0.00%		No	
536.243	Box Culverts	0.276	0.293	2.543	1.021	1.8	0.9	8	0	3	2	1	2	1	22.9	LOW	LOW	25%	LOW	0%	0 of 8	8 of 8	12.50%	0.00%	12.50%		No	
536.539	Box Culverts	0.561	0.285	1.699	1.183	2.4	1.5	6	0	3	2	1	2	1	22.5	LOW	LOW	0%	LOW	0%	0 of 6	6 of 6	0.00%	0.00%	0.00%		No	
536.891	Box Culverts	0.804	0.539	2.174	0.498	2.4	1.2	2	0	3	2	1	2	1	22.1	LOW	LOW	0%	LOW	0%	0 of 2	2 of 2	0.00%	0.00%	0.00%		No	
537.571	Box Culverts	0.292	0.463	1.478	0.782	3	0.9	2	0	3	2	1	2	1	21.7	LOW	LOW	0%	LOW	0%	0 of 2	2 of 2	0.00%	0.00%	0.00%		Yes	
537.993	Box Culverts	0.128	0.564	0.856	0.307	1.8	0.6	1	0	3	2	1	2	1	21.3	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		Yes	
538.563	Box Culverts	0.559	0.188	0	0.041	0.6	0.45	3	0	3	2	1	2	1	20.9	LOW	LOW	25%	HIGH	25%	0 of 3	3 of 3	12.50%	12.50%	12.50%		No	
539.013	Box Culverts	0.929	0.638	1.511	0.654	2.4	1.2	3	0	3	2	1	2	1	20.5	LOW	LOW	0%	LOW	0%	0 of 3	3 of 3	0.00%	0.00%	0.00%		No	
539.707	Box Culverts	0.765	0	0	0	1.8	0.6	1	0	3	2	1	2	1	20.1	LOW	LOW	25%	HIGH	25%	0 of 1	1 of 1	12.50%	12.50%	12.50%		Yes	
540.226	Box Culverts	0.769	0	0	0	1.8	0.6	1	0	3	2	1	2	1	19	LOW	LOW	25%	HIGH	25%	0 of 1	1 of 1	12.50%	12.50%	12.50%		Yes	
RD 515.785	Box Culverts	0.01	0.263	1.996	0.257	2.4	0.9	1	0	3	2	1	2	1	4	LOW	LOW	0%	LOW	0%	0 of 1	1 of 1	0.00%	0.00%	0.00%		No	
RD 524.99	Box Culverts	0.364	0.388	0.984	0.631	2.4	0.9	3	0	3	2	1	2	1	0.5	LOW	LOW	0%	LOW	0%	0 of 3	3 of 3	0.00%	0.00%	0.00%		No	
RD 537.960	Box Culverts	0.128	0.441	1.214	0.254	1.8	0.6	4	0	3	2	1	2	1	20	LOW	LOW	25%	LOW	0%	0 of 4	4 of 4	12.50%	0.00%	12.50%		Yes	
RD 538.860	Box Culverts	0.559	0.465	1.788	0.599	0.6	0.45	4	0	3	2	1	2	1	19	LOW	LOW	25%	LOW	0%	0 of 4	4 of 4	12.50%	0.00%	12.50%		No	
542.605	Box Culverts	0.392	0.459	0.982	0.184	1.8	0.6	2	0	2	3	1	1	5	19	LOW	LOW	25%	LOW	0%	0 of 2	2 of 2	12.50%	0.00%	12.50%		Yes	
543.766	Box Culverts	0.353	0.561	1.211	0.122	1.8	0.6	1	0	2	3	1	1	5	19	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		Yes	
544.452	Box Culverts	0.271	0.51	1.023	0.209	1.8	0.9	1	0	2	3	1	1	5	19	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		No	
545.968	Box Culverts	0.192	0.525	1.214	0.593	0.9	0	17	0	2	3	1	1	5	19	LOW	LOW	25%	LOW	0%	0 of 17	17 of 17	12.50%	0.00%	12.50%		Yes	
546.542	Box Culverts	0.029	0.613	1.849	1.272	3.3	1.2	8	0	2	3	1	1	8	5	19	LOW	LOW	0%	LOW	0%	0 of 8	8 of 8	0.00%	0.00%	0.00%		No
546.812	RCP Class 4	0.029	0.283	1.227	0.517	0.6	0	4	0	2	3	1	1	5	19	LOW	LOW	25%	LOW	0%	0 of 4	4 of 4	12.50%	0.00%	12.50%		Yes	
547.282	RCBC 0.9h	0.151	0.351	1.832	0.578	1.8	0.9	1	0	2	3	1	1	5	19	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		No	
547.559	Box Culverts	0.122	0.252	2.205	0.839	1.8	0.9	2	0	2	3	1	1	5	0.037	LOW	LOW	25%	LOW	0%	0 of 2	2 of 2	12.50%	0.00%	12.50%		No	
547.739	Box Culverts	0.305	0.289	1.457	0.839	1.8	0.9	1	0	2	3	1	1	5	0.037	LOW	LOW	25%	LOW	0%	0 of 1	1 of 1	12.50%	0.00%	12.50%		No	
547.841	Box Culverts	0.394	0.302	2.089	0.796	1.8	0.9</																					