Appendix D4

Technical Memorandum

Subject	TWA 20TW0002949 P274 Little Manatee River System MFLs Development Support Task 4.3 – Sediment and Detrital Transport Deliverable
Attention	Kym Holzwart, Southwest Florida Water Management District
From	Mike Wessel, Janicki Environmental, Inc.
Date	March 24th 2021
Through	James Greco, Jacobs Engineering Group

Dear Kym – On behalf of Janicki Environmental, Inc. (JEI) and Jacobs Engineering Group, we present this technical memorandum (TM) in fulfillment of Task 4.3 of Task Work Order Number 20TW0002949 describing the effects of the proposed minimum flows on the Sediment Loads and Transport of Detrital Material Water Resource Values (WRVs) in the Upper Little Manatee River. We hope that this will serve the Southwest Florida Water Management District (District) well in its efforts to develop minimum flows for the Little Manatee River System. Please feel free to contact us for any reason.

1. Background:

This TM describes analysis of sediment and detrital transport in the Upper Little Manatee River using output from the Hydrologic Engineering Centers River Analysis System (HEC-RAS) model originally developed for the river by ZFI (2010) as reported in Hood et al. (2011) and subsequently improved as reported in JEI (2018). The analyses were undertaken as part of the District's consideration of two WRVs, sediment loads and transfer of detrital material, in support of the development of minimum flows for the upper portion of the Little Manatee River (Upper Little Manatee River). These two WRVs are among the ten values identified in the State Water Resource Implementation Rule (62-40 F.A.C.) for consideration when establishing minimum flows or minimum water levels. This evaluation is not meant to support a primary criterion for establishing minimum flows but rather as a post-hoc evaluation of the potential effects of a considered minimum flow on these metrics as supplementary information.

Methods used for the analyses were previously documented as part of the development of minimum flows for the Silver River (SJRWMD 2017, ATM and JEI 2017). Portions of the text included in this memorandum, such as that associated with the identification of critical velocities for transport processes, was used or adapted, with permission, from the technical documents supporting the Silver River work.

Sediment loads were defined in the Silver River minimum flows reports as the transport of inorganic materials suspended in water, which may settle or rise depending on water depth and velocity (SJRWMD 2017, ATM and JEI 2017). Transport of sediment is a function of flows, sediment material composition, and supply. Specific indicators of sediment transport for the Silver River were defined as minimum current velocities required for sediment transport. In the Silver River report, a duration component (i.e., 7 and 30 continuous days above the critical velocity) was included to define a transport event, and this approach was adopted for the Upper Little Manatee River evaluation.

Transfer of detrital material was defined for the Silver River evaluation as the movement by water of loose organic material and debris and associated decomposing biota from the overbanks in the floodplain to the main channel, which is distinct from the transport of material (e.g., sediment) within the river channel (SJRWMD 2017, ATM and JEI 2017). Detrital material forms the basis for a detritus-based food web, where reduced carbon in dead plant, animal or microbial material is used by microbes, insects, and other animals. The floodplain was identified as the primary source of detritus in the Silver River, and critical elevations for floodplain inundation, along with the duration components identified for sediment transport, were used for evaluation of detrital transport in that system. These events were assumed to transfer detritus to the main channel, where it would be subsequently transferred downstream. These definitions and assumptions for the Silver River analyses were applied for use in the consideration of detrital transport in the Upper Little Manatee River.

2. Methods:

For the Little Manatee River analyses, a HEC-RAS model was used to identify flows at the U.S. Geological Survey (USGS) Little Manatee River at US Highway 301 near Wimauma, FL Gage (No. 02300500) that generate critical velocities and elevations expected to result in the transport of sediment and detritus. These “critical flows” were then used to evaluate the change in the frequency of occurrence of sediment transport “events” under Baseline and proposed minimum flows for the Upper Little Manatee River System. The proposed minimum flows are based on flows at USGS Gage No. 02300500 and defined as a reduction from a Baseline condition described in JEI (2018). The proposed minimum flows are as follows:

- 10% allowable flow reduction when flows are less than or equal to 35 cubic feet per second (cfs)
- 20% allowable flow reduction when flows are greater than 35 cfs and less than or equal to 72 cfs
- 13% allowable flow reduction when flows are greater than 72 cfs and less than or equal to 174 cfs
- 11% allowable flow reduction when flows are greater than 174 cfs

Similar to the Silver River report, sediment/bed material in the Upper Little Manatee River was characterized as “fine sand.” From the USGS Wentworth grain size chart (https://pubs.usgs.gov/of/2006/1195/htmldocs/images/chart.pdf), the d50 grain size of fine sand range is 0.125 mm to 0.25 mm. Using this d50 grain size range and the Hjulstrom Diagram in the Silver River report (SJRWMD 2017, ATM and JEI 2017), a maximum velocity of 0.56 feet per second (ft/sec) was identified as a critical velocity for sediment transport for the Upper Little Manatee River. To be consistent with the Silver River analyses, this value was rounded to a critical velocity of 0.6 ft/sec for analysis of sediment transport in the Upper Little Manatee River. As was done for the Silver River analyses, 7-day and 30-day duration components were used for the Little Manatee analyses. The extent to which the number of these events would be expected to change as a function of the proposed minimum flows for the Upper Little Manatee River was identified as a metric for the consideration of the potential effects of the proposed minimum flows on sediment transport.

For detrital transport, an event was identified as a flow above a critical elevation when flows first exceed the bank elevation on either side of the channel. The same duration components identified for sediment transport were used for assessment of detrital transport, consistent with the Silver River evaluation (SJRWMD 2017, ATM and JEI

2017). The extent to which the number of events changed as a function of potential flow reductions associated with proposed minimum flows was used as a metric for the consideration of the potential effects of flow reductions on detrital transport in the Upper Little Manatee River. The HEC-RAS model flow profiles (i.e., distributional percentiles between minimum and maximum flow in 1% increments) were updated using the USGS Gage No. 02300500 Baseline flow record for the period of record from April 1939 through December 2019. After consulting with the District, 13 HEC-RAS model cross-sections in 9 river reaches were selected for analysis (Figure 1). The selected cross-sections were determined based on the following process:

- Hydraulic grade line (HGL) review: an effort was taken to ensure that streambed and HGL factors such as high head loss, subcritical flow, and steep gradients were considered in the selection of the cross-sections.
- Distance from bridges: cross-sections immediately upstream/downstream of a bridge were actively avoided.
- Proximity to SEFA transect locations: an effort was made to have as much overlap as possible with existing SEFA transects.
- Distribution along the main branch: from conversations and review of the Silver River report, the analysis of velocities along the entire river was needed. Therefore, the distribution shown in Figure 1 was based on the distributing cross-section evaluations throughout the system.
- Cross-sections relevant to previous evaluations: cross-sections relevant to predetermined thresholds for fish passage and wetted perimeter from JEI (2018) were chosen.
- A cross-section in the most upstream reach: The District requested a cross-section from the most upstream reach be included.

These cross-sections were evaluated for this task as well as for a separate task (Task 4.4) considering navigation by canoe or kayak as a WRV in support of developing minimum flows for the Upper Little Manatee River.

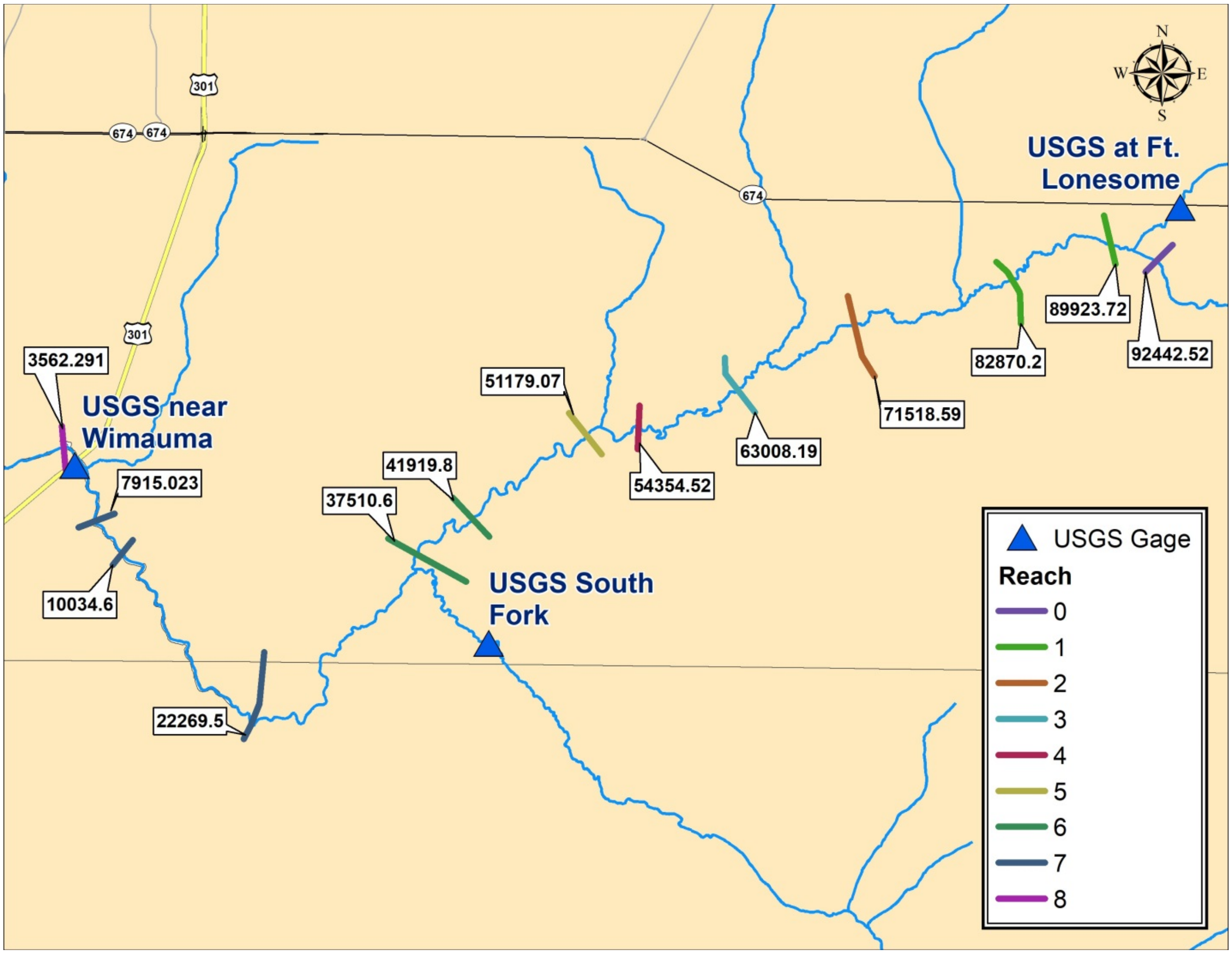

Figure 1. Location of cross-sections used in the evaluation of the Sediment Loads and Transfer of Detrital Material Water Resource Values for the Upper Little Manatee River.

The HEC-RAS model output for these cross-sections contained a velocity and elevation for each flow profile, and these profiles were used to identify the flows at USGS Gage No. 02300500 that resulted in the critical velocity in the channel (for sediment transport evaluation) or the critical elevation when flows first exceed the top-of-bank elevation (for detrital transport evaluation). In some cases, interpolation was required to identify the flow that would achieve the critical velocity (or elevation). In these cases, nonlinear interpolation using locally weighted (LOESS) regression between flow and velocity (or elevation) was used to identify these critical thresholds. In the Silver River evaluation, multiple critical elevations were identified for the assessment of detrital transport, including an elevation associated with the top-of-bank elevation and mean and maximum floodplain elevations (SJRWMD 2017, ATM and JEI 2017). Based on the morphology of the Upper Little Manatee River, evaluation of the Upper Little Manatee HEC-RAS model, and given that the District's proposed minimum flows for the river include a separate criterion based on floodplain inundation, we used only the elevation when flows first exceed the top-of-bank elevation for consideration of detrital transport.

To include the duration component, the 7-day and 30-day criteria were defined to be flows that were “continuously exceeded” exactly as defined for the Silver River analysis (SJRWMD 2017, ATM and JEI 2017). Therefore, the flow had to be above the critical threshold for 7 or 30 consecutive days to be considered an event. To be consistent with the Silver River analysis, only full water years were included, and each new water year would begin a new starting point for an event. The period of record for evaluation was thereby defined as October 1, 1939 through September 30, 2019. The results were expressed as the number of events in the Baseline and proposed minimum flows scenarios, as well as the difference and percent difference in events between the scenarios. Cross-sections are referred to as “stations” throughout the remainder of this document.

3. Results:

Sediment Transport Results:

The relationship between the velocity and flow profile is presented for each station in Figure 2. Velocities in Reach 0 (Station 92442.52) were above the critical velocities at all but the highest flow profiles and one station in Reach 1 (Station 82870.2) only exceeded the critical velocity at the highest recorded flow (Profile 100). Based on inspection of these curves, these stations were not further considered for sediment transport analysis. The remaining stations were evaluated for assessing sediment transport. Some curves were not monotonic due to a sudden drop in channel velocity. This was due to the quick increase in the flowing cross-sectional area during higher flow when main channel expands into adjacent side channels and floodplain. Despite this fact, these curves were considered for sediment transport analysis.

The velocity-flow profile curves were used to identify the critical flow associated with the critical velocity of 0.6 ft/sec, which are provided for each station in Table 1, along with flows, associated flow profiles, and velocities bracketing the critical velocity. The identified critical flows were rounded down to the nearest whole number for evaluation and used in the event duration assessment to identify the change in the number of events under the proposed minimum flows scenario relative the Baseline scenario.

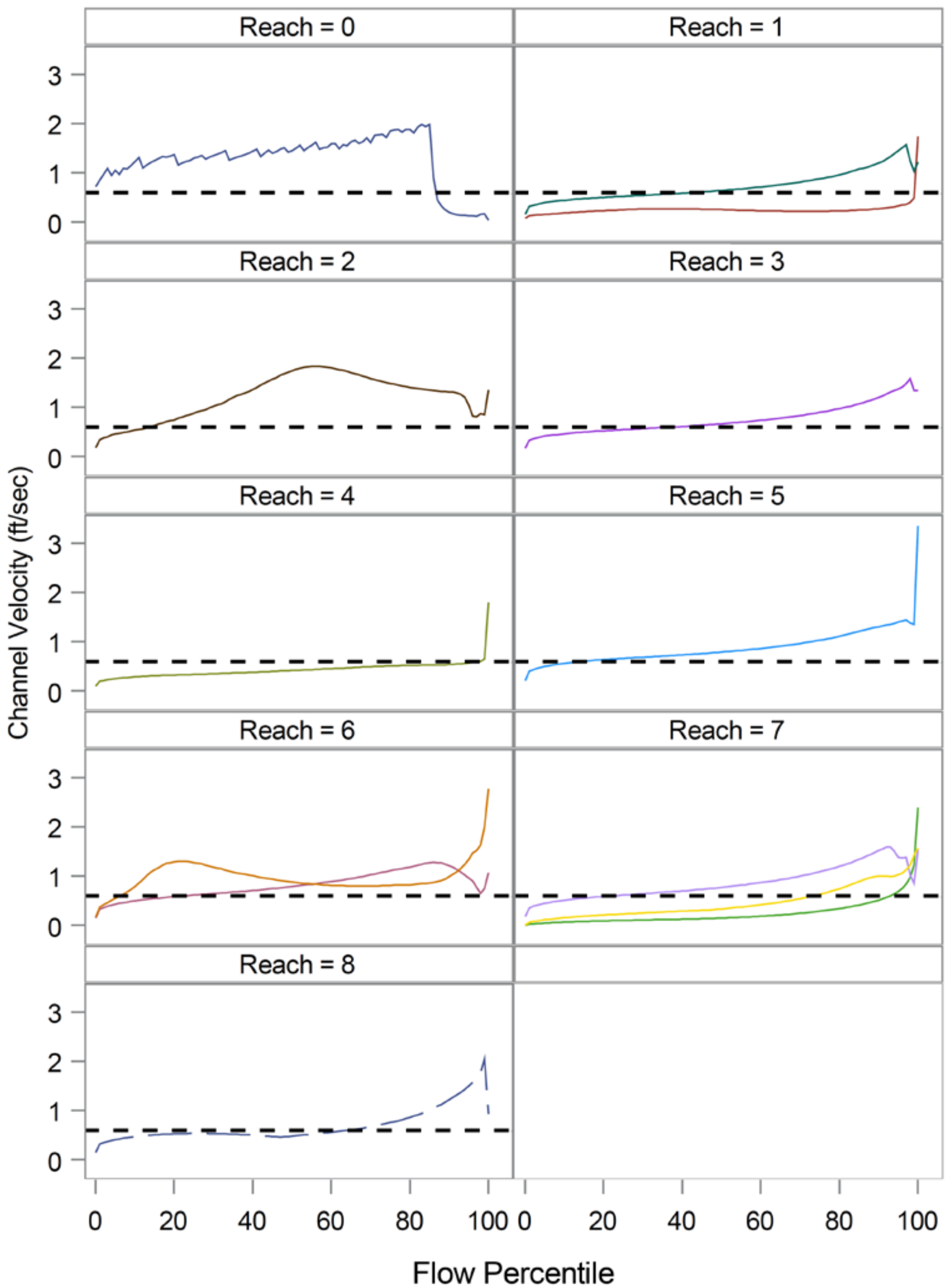

Figure 2. Cross-sectional average velocity as a function of flow profile under the Baseline condition for 9 reaches in the Upper Little Manatee River. Horizontal reference line for each reach indicates the critical velocity of 0.6 ft/sec. Multiple colored lines indicate stations within Reaches 1, 6, and 7.

Table 1. Critical flow associated with a critical velocity of 0.6 ft/sec, and flows and velocities bracketing the 0.6 ft/sec critical velocity for 13 stations (HEC-RAS model cross-sections) in the Upper Little Manatee River.

Reach	Station	Highest Flow Below Critical Velocity, cfs	Lowest Flow Above Critical Velocity, cfs	Profile Below	Profile Above	Velocity Below, ft/s	Velocity Above, ft/s	Critical Flow, cfs
0	92442.52	Na	Na	Na	Na	Na	Na	Na
1	82870.2	Na	Na	Na	Na	Na	Na	Na
1	89923.72	42.2	43.6	41	42	0.59	0.60	44
2	71518.59	20.0	20.9	13	14	0.58	0.61	21
3	63008.19	37.8	38.3	36	37	0.59	0.60	38
4	54354.52	760.0	918.0	96	97	0.58	0.60	918
5	51179.07	20.0	20.9	13	14	0.59	0.60	21
6	37510.6	26.0	26.8	21	22	0.59	0.60	27
6	41919.8	13.0	14.0	6	7	0.59	0.63	13
7	10034.6	459.0	513.0	92	93	0.57	0.60	513
7	22269.5	26.0	26.8	21	22	0.59	0.60	27
7	7915.023	121.0	127.7	72	73	0.58	0.60	128
8	3562.291	83.0	86.2	63	64	0.59	0.60	86

cfs = cubic feet per second; ft/s = feet per second
Na: not applicable; station considered to be exceeded too infrequently for assessing sediment transport.

The number of 7-day events under the Baseline scenario ranged from 17 to 3,809 over the 80-year period of record (Table 2). The proposed minimum flows scenario reduced the number of 7-day events at all locations. The expected differences ranged from 4 to 392 fewer events between Baseline and proposed minimum flows scenarios (Table 2). Expressed as a percent change from the Baseline scenario, the difference between scenarios ranged from 1.5% to 29.2%. Stations 10034.6 and 54354.52 had the highest percent change, but also exhibited the lowest number of events under the Baseline scenario.

Table 2. Number of 7-day events continuously exceeding the identified sediment transport critical flow at 13 stations in the Upper Little Manatee River under the Baseline and minimum flows scenarios evaluated based on flows at USGS Gage No. 02300500 between October 1, 1939 and September 30, 2019.

Reach	Station	Number of 7-Day Events, Baseline Scenario	Number of 7-Day Events, Minimum Flows Scenario	Difference in Number of 7-Day Events	Percent Difference in 7-Day Events
1	89923.72	2038	1689	349	17.1
2	71518.59	3393	3237	156	4.6
3	63008.19	2308	1916	392	17.0
4	54354.52	17	13	4	23.5
5	51179.07	3393	3237	156	4.6
6	37510.6	2981	2782	199	6.7
6	41919.8	3809	3751	58	1.5
7	10034.6	106	75	31	29.2
7	22269.5	2981	2782	199	6.7
7	7915.023	750	634	116	15.5
8	3562.291	1109	976	133	12.0

No 30-day events occurred at Station 54354.52 under the Baseline condition, so the station was excluded from analysis. The number of 30-day events under the Baseline condition for the remaining stations ranged from 1 to 832 over the 80-year period of record (Table 3). The number of 30-day events was reduced at 9 of 10 locations under the proposed minimum flows, with reductions for the period of record ranging from 15 to 92 30-day events. Expressed as a percent change from the Baseline condition, the difference between scenarios ranged from 0% to 28.5% with stations 89923.72 and 7915.023 exhibiting the highest percent change.

Table 3. Number of 30-day events continuously exceeding the identified sediment transport critical flow for each station under the Baseline and minimum flows scenarios evaluated based on flows at USGS Gage No. 02300500 between October 1, 1939 and September 30, 2019.

Reach	Station	Number of 30-Day Events, Baseline Scenario	Number of 30-Day Events, Minimum Flows Scenario	Difference in Number of 30-Day Events	Percent Difference in 30-Day Events
1	89923.72	312	223	89	28.5
2	71518.59	696	657	39	5.6
3	63008.19	373	281	92	24.7
5	51179.07	696	657	39	5.6
6	37510.6	577	508	69	12.0
6	41919.8	832	813	19	2.3
7	10034.6	1	1	0	0.0
7	22269.5	577	508	69	12.0
7	7915.023	61	45	16	26.2
8	3562.291	116	101	15	12.9

The expected difference in the number of events due to the proposed minimum flows expressed as difference per year ranged from less than 1 to about 5 fewer events per year for the 7-day evaluation. For the 30-day events, the differences ranged between 0 and 1 event per year.

Detrital Transport Results:

Out-of-bank flows were identified by the first occurrence of a velocity recorded at either the left or right top-of-bank elevation from the HEC-RAS model output (Table 4). These flows were deemed the critical flows for evaluating detrital transport events. Flows at four stations went out-of-bank at only the highest assessed flow values (shaded rows in Table 4) and were, therefore, excluded from the analysis. Four additional stations went out-of-bank at the 99% percentile of flow, indicating infrequent inundation of the floodplain at these locations, but were retained for analysis. Station 37510.6 in Reach 6 exhibited the most frequent flow that exceeded the top-of-bank elevation.

Table 4. Critical flow identified for detrital transport based on first occurrence of out-of-bank flows based on HEC-RAS model output for the Upper Little Manatee River. Shaded rows are stations where flows were out-of-bank only at the highest assessed flow values. Blank cells are a result of out-of-bank flows being identified by the occurrence of a velocity recorded at either the left or right top-of-bank elevation from the HEC-RAS model output.

Reach	Station	Flow Profile	Left Bank Velocity	Right Bank Velocity	Critical Flow
0	92442.52	99	0.01	0.01	1636
1	82870.2	100	0.32	1.02	11100
1	89923.72	98		0.26	1140
2	71518.59	99	0.2		1636
3	63008.19	99	0.46		1636
4	54354.52	97	0.05	0.03	918
5	51179.07	100	0.9	0.76	11100
6	37510.6	83	0.02	0.04	218.06
6	41919.8	91		0.01	413
7	10034.6	100	0.75	0.72	11100
7	22269.5	98	0.06	0.36	1140
7	7915.023	99	0.1	0.25	1636
8	3562.291	100	0.97	0.93	11100

The number of 7-day events under the Baseline condition ranged from 2 to 380 over the 80-year period of record (Table 5) and were reduced by between 2 to 56 events under the proposed minimum flows. The two stations in Reach 6 were the most reliable locations to estimate the effects of flow reductions on 7-day detrital transport events and the percent reduction from Baseline at those two stations suggested the proposed minimum flows may result in between a 14.7% and 18.8% reduction in events. Other stations had less than 18 events over the entire 80-year period of record. Likewise, the 30-day detrital transport assessment suggested that a 30-day continuously exceeded event only occurred at the stations in Reach 6, where 16 and 3 events occurred at stations 37510.6 and 41919.8, respectively (Table 6). The proposed minimum flows were associated with an expected reduction of 5 and 0 events at those stations, respectively.

Table 5. Number of 7-day events continuously exceeding the identified detrital transport critical flow at 9 stations in the Upper Little Manatee River under the Baseline and minimum flows scenarios evaluated based on flows at USGS Gage No. 02300500 between October 1, 1939 and September 30, 2019.

Reach	Station	Number of 7-Day Events, Baseline Scenario	Number of 7-Day Events, Minimum Flows Scenario	Difference in Number of 7-Day Events	Percent Difference in 7-Day Events
0	92442.52	2	0	2	
1	89923.72	8	4	4	50
2	71518.59	2	0	2	
3	63008.19	2	0	2	
4	54354.52	17	13	4	23.5
6	37510.6	380	324	56	14.7
6	41919.8	149	121	28	18.8
7	22269.5	8	4	4	50
7	7915.023	2	0	2	

Table 6. Number of 30-day events continuously exceeding the identified detrital transport critical flow for 2 stations in the Upper Little Manatee River under the Baseline and minimum flows scenarios evaluated based on flows at USGS Gage No. 02300500 between October 1, 1939 and September 30, 2019. 30-day events were not identified for other stations.

Reach	Station	Baseline Number of 30-Day Events	MFL Number of 30-Day Events	Difference in Number of 30-Day Events
6	37510.6	16	11	5
6	41919.8	3	3	0

4. Summary:

This memorandum used the existing methodology developed for the Silver River and adapted it to evaluate sediment and detrital transport in the Upper Little Manatee River. The evaluation provides evidence of the potential effects of the proposed minimum flows on the Sediment Loads and Transfer of Detrital Material WRVs for the Upper Little Manatee River.

The results of the evaluation suggests that reduced flows associated with a scenario based on proposed minimum flows for the river segment will reduce the frequency of both sediment and detrital transport events relative to Baseline (no flow reduction) conditions. The degree to which this occurs is dependent on location and duration of the event. The average percent change in events for sediment transport across stations was 12.6% and 13.0% for 7-day and 30-day events, respectively. For detrital transport, few out-of-bank events were identified. Stations in Reach 6 appeared most representative of effects of flow reductions on detrital transport from the floodplain, with results suggesting an average 16.8% reduction in 7-day events in that reach. Because there were few 30-day out-of-bank events during the period of record, the expression of percent change in those events is not included; however, based on the results, 4 fewer 30-day detrital transport events at Station 37510.6 in Reach 6 could be expected every 80 years.

5. References:

Applied Technology and Management, Inc. (ATM) and Janicki Environmental, Inc. (JEI) 2017. Evaluation of the Effects of Hypothetical Flow Reductions on Water Resource Values of Silver Springs and the Silver River, Marion County. Appendix E: Minimum flows determination for Silver Springs, Marion County, Florida. Prepared for the St. Johns River Water Management District, Palatka, Florida.

Hood, J., M. Kelly, J. Morales, and T. Hinkle. 2011. Proposed Minimum Flows and Levels for the Little Manatee River – Peer Review Draft. Southwest Florida Water Management District, Brooksville, Florida.

Janicki Environmental, Inc. (JEI). 2018. Reevaluation of the Proposed Minimum Flows for the Upper Segment of the Little Manatee River, Draft Report. Prepared for the Southwest Florida Water Management District, Brooksville, Florida.

St. Johns River Water Management District (SJRWMD). 2017. Minimum Flows Determination for Silver River, Marion County, Florida. Technical Publication SJ2017-02. St. Johns River Water Management District, Palatka, Florida.

ZFI. 2010. HEC-RAS Modeling of the Little Manatee River. Prepared for the Southwest Florida Water Management District, Brooksville, Florida.