Hydrology Model for Lower Waller Creek Created from a Less Impervious Watershed

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Abstract

The City of Austin constructed the Waller Creek Tunnel, a stormwater bypass tunnel, in lower Waller Creek in order to remove land from the floodplain. The hydrologic function of the Waller Creek watershed has been negatively impacted by urbanization prior to the existence of ordinances and regulations designed to decrease the impact of impervious cover. The City of Austin would like to manage the flow regime in lower Waller Creek so that it responds more like a less developed watershed via operational tools associated with the Waller Creek Tunnel. Average daily flow from nearby Bear Creek, (from 1995 through 2016) was used to create a surrogate flow regime for lower Waller Creek that slowly decreases after storm pulses, has reduced peak events, and maintains baseflow and low flow periods that mimic an undeveloped watershed. Implementation of this flow regime may require the use of a bypass channel around the Waller Creek Tunnel and storage capacity for large storm events in order to remain compliant with the current water contract with the Lower Colorado River Authority which allows for the recirculation of up to 7,240 ac-ft/yr from Lady Bird Lake.

Introduction

The City of Austin has constructed a stormwater bypass tunnel in lower Waller Creek to remove land from the Waller Creek floodplain (http://www.austintexas.gov/department/waller-creek). The Waller Creek Tunnel (WCT) will be operated in two recirculation modes during non-flood operation, one immediately following storm events and one during non-storm conditions. Immediately following storm events, water will be quickly pumped out of the WCT using high pump rates in order to extract any stormwater from the WCT. During non-storm conditions, water from Lady Bird Lake will be drawn into the Waller Creek Tunnel (WCT) via an outlet structure and flow north towards an inlet structure located in Waterloo Park (Figure 1) at a reduced pump rate in order to maintain dissolved oxygen (DO) concentrations in the tunnel. Herrington (2013) describes required recirculation rates and tunnel operation during non-storm events in order to keep the WCT from becoming anoxic. Actual operating range of the pumps is reported to be 3 to 28 ft^3/s.

The pumped recirculation water will join Waller Creek ambient flow after receiving oxygenation treatment via cascade aeration. A portion of this water will flow downstream to Lady Bird Lake, however; a portion will flow back into the WCT through side inlets located at 4th Street and 8th Street which connect laterally to the main WCT. Herrington (2013) proposed that some inflow through the side inlets during non-storm flow conditions may be necessary to maintain DO levels in these side connections of the WCT.

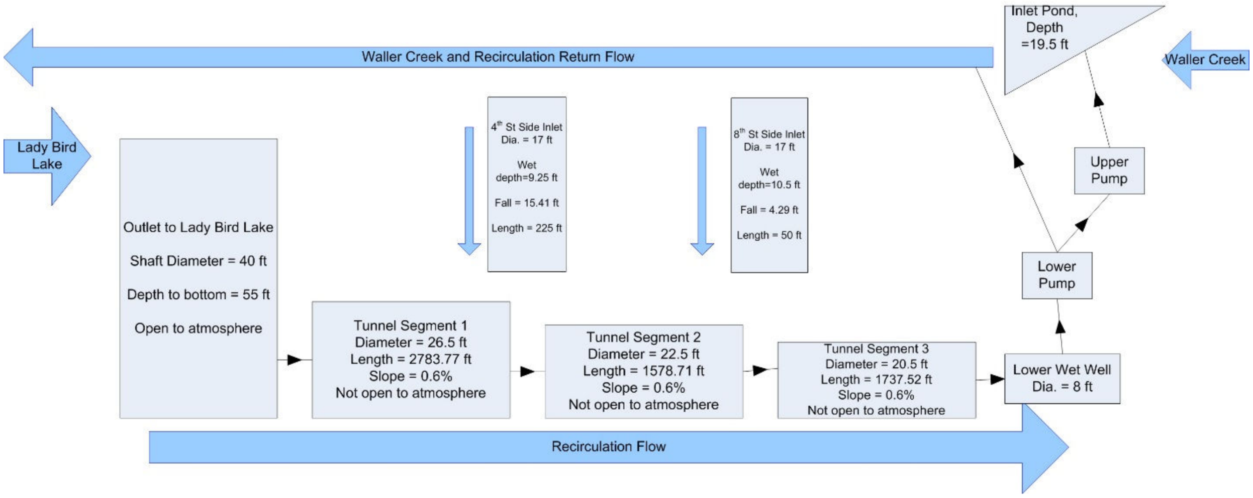

Figure 1. Conceptual model of Waller Creek Tunnel operations during non-storm flow conditions. Elements not to scale. Blue arrows indicate water flow direction through elements (Herrington 2013).

The Lower Colorado River Authority (LCRA) has entered a firm water contract with the City of Austin to provide recirculation water from Lady Bird Lake to the WCT that is currently limited to 7,240 ac-ft/year. Herrington (2013) reports that maintaining the DO while minimizing pump rates in the WCT should ensure that the LCRA firm water contract withdrawal amount is not exceeded, minimize the cost of running the pumps, and mimic existing hydrology on Waller Creek. However, a large proportion of the Waller Creek watershed was developed prior to the Waterways Ordinance of 1974 which restricted development in the 25 year floodplain and an even greater proportion was developed prior to the Urban Watersheds Ordinance of 1991 which established setbacks for streams and mandated use of water quality controls (https://www.austintexas.gov/sites/default/files/files/Watershed/MasterPlan/WatershedProfiles_NorthUrban.pdf). This has resulted in severe impacts to the hydrological function of Waller Creek related to the urban stream syndrome including erosion, loss of baseflow, water quality degradation, and flooding (Walsh et al. 2005, Chadwick et al. 2006, Hawley and Bledsoe 2011). For this reason, it is not appropriate to use the current degraded Waller Creek hydrology as a template for restoring hydrologic function downstream of the WCT.

The WCT is designed to prevent flooding in the lower portion of Waller Creek but the City of Austin Watershed Protection Department (WPD) sees this as an opportunity to try and restore other aspects of hydrologic function to the lower portion of Waller Creek by mimicking the hydrology of a watershed with a lower proportion of impervious cover. Impervious cover is often the cause of the loss of hydrological function in urban streams (Booth & Jackson, 1997; Konrad & Booth, 2005; Ogden, Raj Pradhan, Downer, & Zahner, 2011). The Waller Creek watershed is covered by 58% impervious cover of which only 11% is treated by water quality controls. In Austin, studies have shown water quality degradation responses at impervious cover levels in watersheds ranging from 5-30% (Scoggins 2000, Glick et al. 2010, Herrington 2010, Richter 2011, King et al. 2016). Thus, it would be ideal to mimic the hydrology from a creek with no impervious cover within its watershed. This report proposes to mimic the hydrology of a watershed of similar drainage area to Waller Creek with a minimal percentage of impervious cover. Following such a flow regime should lead to less severe shifts in flow after a storm, which would increase function of the aquatic ecosystems within the lower portion of Waller Creek (Scoggins 2000, Glick et al. 2010, Richter 2011).

Methods

Site Selection

The primary goal of this report is to generate an ecologically desirable flow regime for the lower portion of Waller Creek but the WPD would also like to ensure that the flow regime is realistic and sustainable, considering the known constraints. This would require that the flow regime be modeled at a location with a flow gage to check the validity of the flow regime and a location with background aquatic ecosystem data to verify how the system is responding to the new flow conditions. The WPD has been collecting water quality data, including data on aquatic communities, in the lower portion of Waller Creek at Cesar Chavez since 1996 through the Environmental Integrity Index (EII). This site is considered the mouth of Waller Creek and is located upstream of influence from Lady Bird Lake with a total drainage area of approximately 3,469 acres (approx. 14 km^2). The USGS installed a gage at this location in 2014 (USGS gage 08157560). Thus Waller Creek at Cesar Chavez was chosen as the location at which a modeled flow regime would be monitored.

The flow regime model was based on flow at a location with similar environmental conditions to Waller Creek at Cesar Chavez but with a lower impervious cover in the watershed. The drainage area was the first criteria used to obtain a possible site list for consideration as the drainage area should be a large factor in determining the flow within a creek at a particular site. There was a small list of sites that contained a comparable upstream drainage area where a flow gage was present. Most of the site locations were in the southwest portion of the Austin area where the geology, topography, and soils may not be similar to what is present in Waller Creek. Some of the sites were within the Edwards Aquifer Recharge Zone, which immediately eliminated them from the possible site list due to the fact that they would most likely be losing streams and would not represent flow that is likely present on a gaining stream of similar drainage area. The flow gage present on Bear Creek at Friendship Baptist Church was selected for the flow regime model as it is upstream of the recharge zone, has a drainage area of approx. 3,530 acres, flow records that date back to 1995, and impervious cover in the upstream portion of the watershed that increased from 0% to 8.2% to 19.4% in 1999, 2003, and 2013, respectively, which is relatively low compared to Waller Creek with over 50% impervious cover since the 1970's.

Daily flow data from the gage on Bear Creek at Friendship Baptist Church from 1995 through 2016 was used for further analysis. All local maxima in the time series were found programmatically using the DIF and SIGN functions in PROC IML in SAS v9.4. Specifically the SIGN function was used to assign a positive or negative one to a data point based on an increase or decrease from the previous data point in the time series. The DIF function found the difference between the SIGN function results for each data point. Local maxima are data points in the time step previous to a DIF function result of negative two. Each local maxima was considered to be the peak of a storm. A total of 293 storms were found using this method but 33 storms were removed due to short storm duration (only two data points in the storm) or the flow readings during the storm were odd and possibly bad readings resulting in 260 storms available for analysis.

Analysis focused on the difference in post-storm hydrographs between a watershed of high impervious cover and a watershed with minimal impervious cover. Bear Creek at Friendship Baptist Church was selected as the watershed with minimal impervious cover as stated above. While Waller Creek at Cesar Chavez is the site chosen for monitoring flow regimes in the future, there is not a great deal of historical flow data at this site for hydrograph comparison with the Bear Creek flow gage. Upstream in Waller

Creek there is another flow gage at 23rd Street which has been in place for a very long time and has a lot of historical data (1955 to present). The gage was initially run by the USGS (08157500) but the COA currently maintains the gage. The drainage area is much smaller at this location, 2,690 acres, but visualizing differences in hydrographs is all that is needed for comparison so the difference in drainage area should not be an issue. It can be seen that one major difference between the hydrograph for Bear Creek and the hydrograph for Waller Creek at 23rd Street is that after a rain event the flow in Bear Creek at Friendship Baptist Church slowly descends while the flow in Waller Creek at 23rd Street very rapidly descends to a minimal flow (Figure 2). This rapid drop in flow can have a detrimental effect on the benthic community (Richter 2011). It is also possible for the storm peak to be considerably larger in more impervious watersheds; however, the WCT will only allow a portion of flow to pass through or bypass the inlet pond during large storm events. This analysis thus focused on the flow rates after a storm and not a comparison of peak flows during a storm which should be mitigated by the presence of the WCT inlet pond.

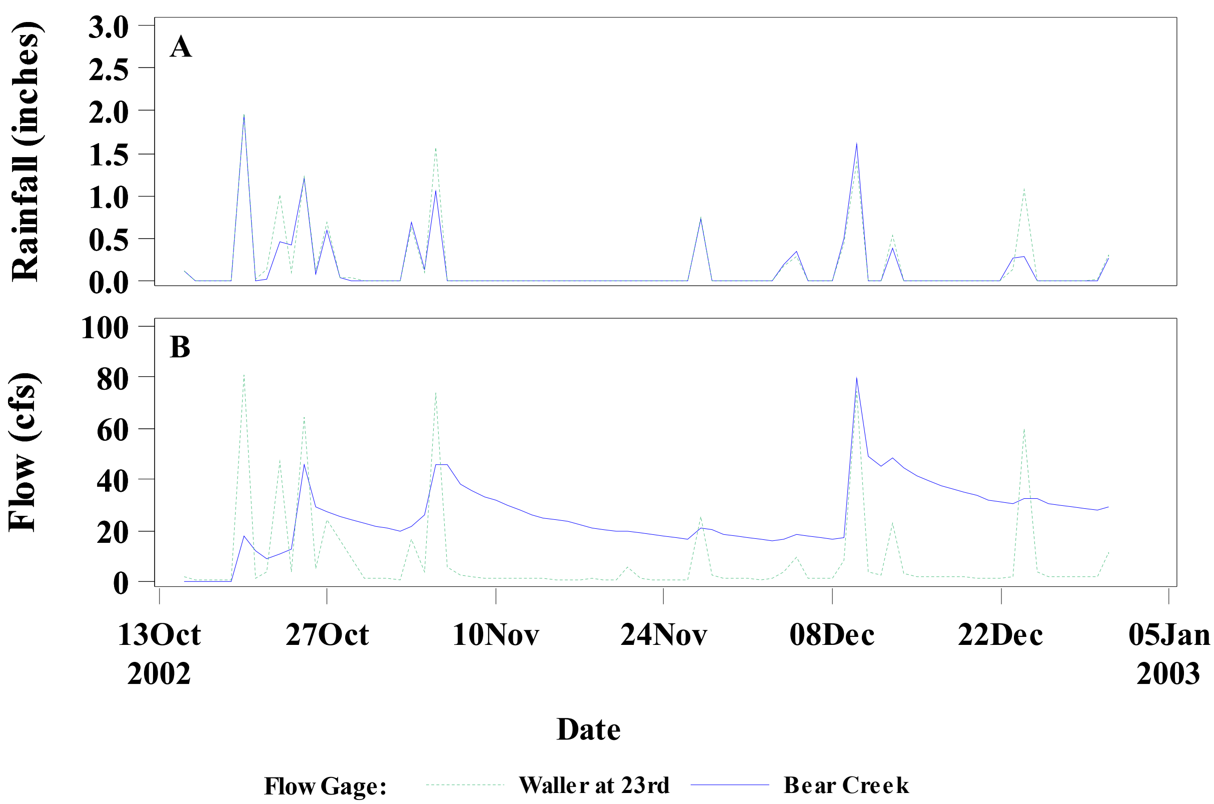

Figure 2: Rainfall (in.) and flow (ft^3/s) data from the gage on (A) Waller Creek at 23rd St. and (B) Bear Creek at Friendship Bapt. during the fall of 2002.

One noticeable aspect of the flow rates after a storm, is that they are influenced by the storm peak value. Larger storm events might drop in flow faster than smaller storm events. At this point it is worth noting that the impervious cover in Bear Creek increased over time, as noted above, and the amount of impervious cover within the watershed may be impacting the later portions of the Bear Creek time series data. Thus each storm was fit to an exponential growth (or decay) equation:

$$Flow = \frac{a}{1 + be^{-kt}}$$

The rate of change for the curve is related to the value of both *b* and *k,* while the magnitude of the storm peak value is related to *a* and *b*. Thus, *b* was set to negative one while *a* and *k* were allowed to vary for each individual storm. The value of *a* represented the magnitude of the storm peak value while *k* represented the rate of change in flow after a storm. Models were constructed to test if *k* changed in relation to the storm peak value or through time. Results indicated that the value of *k* was highly dependent on the storm peak value but did not increase over time as might be expected with the increasing impervious cover (not shown). Another way to examine if the *k* value shifted over time is to examine distributions of the *k* value in specific groups of time. Storms were grouped into years of differing impervious cover (0% IC: 1995-1999, 8.2% IC: 2000-2003, and 19.4% IC: 2004-2016). The distribution of the *k* values in each category do not differ greatly from one category to the next (Figure 3), adding more evidence that the *k* values did not shift over time for this set of flow data on Bear Creek.

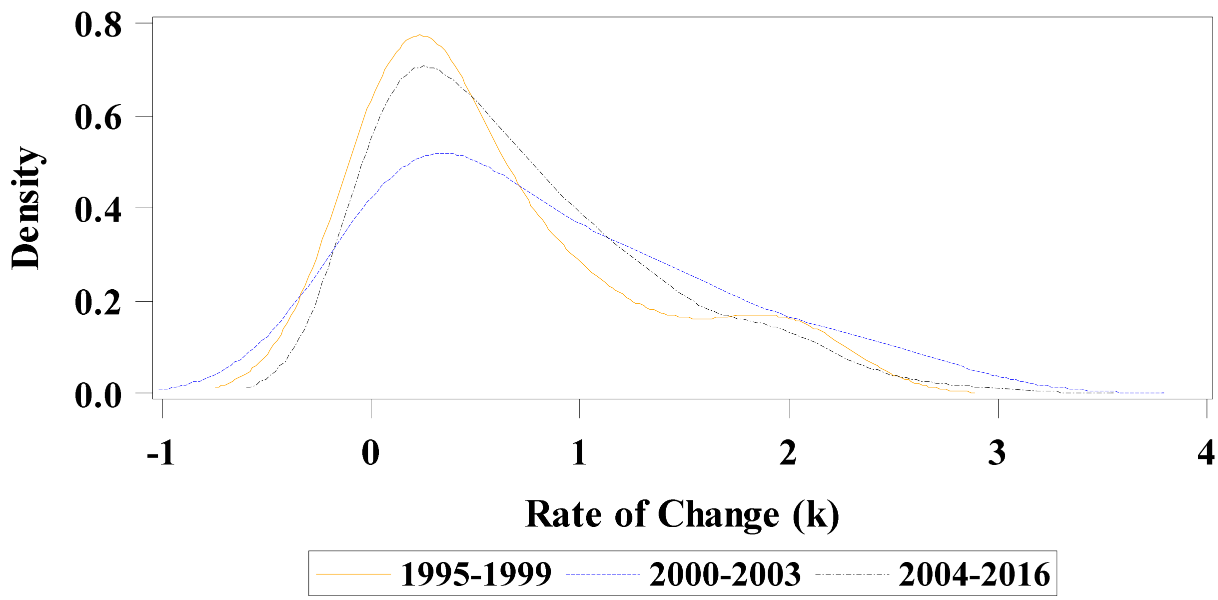

Figure 3: Distribution of the *k* (rate of change in flow after a storm event) values associated with individual storms. Storms were grouped into impervious cover categories (0% IC: 1995-1999, 8.2% IC: 2000-2003, and 19.4% IC: 2004-2016).

Examining the hydrograph for Bear Creek at Friendship Baptist Church led to an interesting pattern. After a certain number of days following a storm, the flow drops substantially if another storm event does not occur (Figure 4). This needs to be considered in creating the proposed flow regime. For a certain number of days after a storm, the flow regime should follow one function for decay and at some threshold day follow a different function.

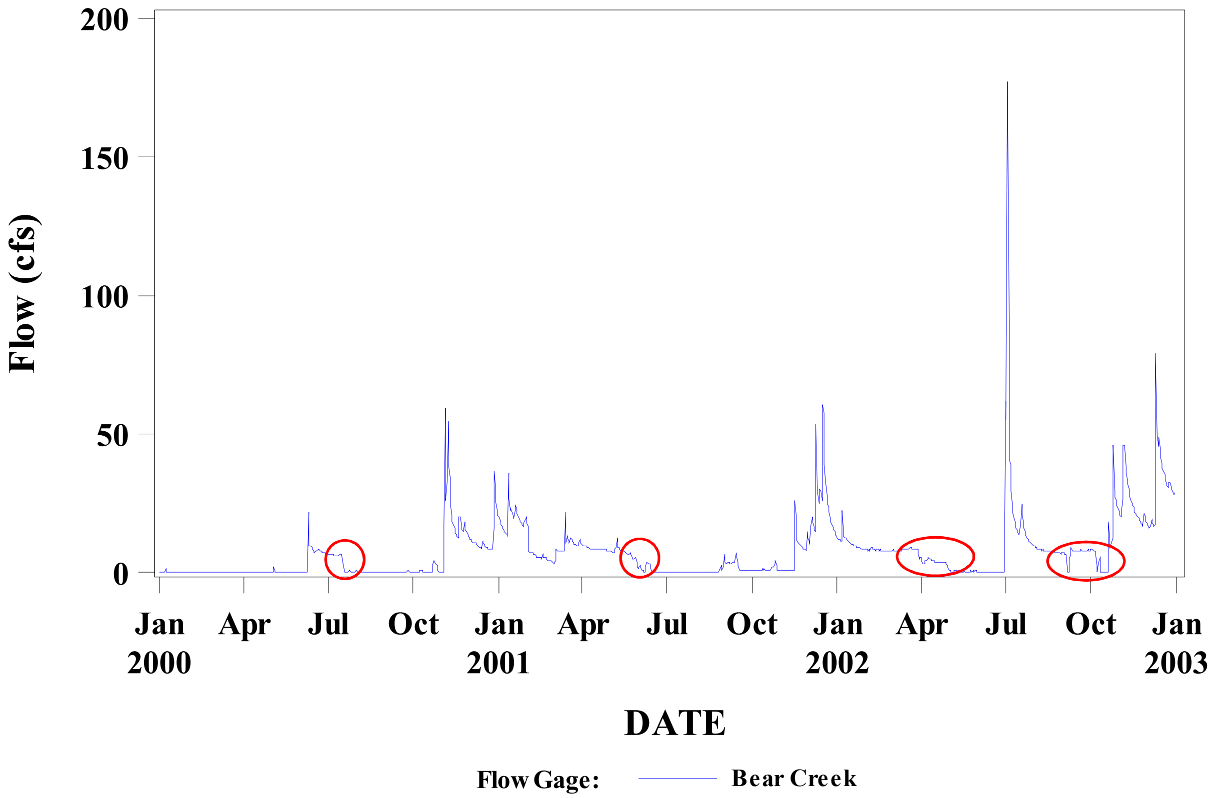

Figure 4: Flow (ft^3/s) from the gage on Bear Creek at Friendship Bapt. Church (2000 through 2002).

The full dataset from 1995 through 2016 was used to create the flow regime since the rate of change in discharge after a storm event did not change over the duration of the dataset. However, as the rate of change in flow after a storm was dependent on the storm peak value, multiple flow regimes were created that depended on the storm peak value using the following percentiles: 0.01, 0.05-0.95 (by 0.05 increments), and 0.99. Quantile regression was used to generate equations of flow following a storm for each percentile. The 0.01 and 0.05 percentiles followed a logarithmic equation as a logistic function could not successfully be fit to the data:

$$Flow = a + k * \ln(day)$$

where *a* represents the storm peak value and *k* is the rate of change in flow following the storm. All remaining percentiles followed a logistic function:

$$Flow = \frac{a}{1 + be^{-kt}}$$

The values of *a* and *b* are related to the storm peak value while the values of *b* and *k* are related to the rate of change in flow following the storm. All three values were allowed to vary to find the best fit for the data. Thresholds were incorporated into the model in order to account for the sudden drops in flow on Bear Creek after a certain number of days after a storm. Up to three threshold days were incorporated into each model in order to have the flow drop to a minimum value and improve the fit of the model. Markov Chain Monte Carlo (MCMC) methods were used to estimate all model parameters for each percentile using PROC MCMC in SAS v9.4 (Table 1).

Table 1: Description and labels of model parameters.

Label	Description
a, *b*, *k*	Parameters that will be filled into either a logarithmic equation (percentiles 1 and 5) or logistic equation
T1	Day when flow shifts from following a logarithmic or logistic equation to T1 Flow value
T2	Day when flow shifts from T1 Flow to T2 Flow
T3	Day when flow shifts from T2 Flow to T3 Flow
T1 Flow	Fixed value of flow between days T1 and T2
T2 Flow	Fixed value of flow between days T2 and T3
T3 Flow	Fixed value of flow following day T3

Results

The percentiles for the storm peak values in Bear Creek at Friendship Baptist Church can be seen in Table 2. These flows were used as maximum values for creating storm peak ranges. For example, storms within the 0.05 percentile will range from 1.27 to 4.01 ft^3/s. A flow regime was created for each of the storm peak ranges using the quantile regression results of the associated percentile (Table 3). Results of each flow regime can be visualized in Figure 5.

Table 2: Percentile of storm peak flow in Bear Creek at Friendship Baptist Church from 1995 through 2016.

Percentile	Flow (ft^3/s)
0.01	1.26
0.05	4.01
0.10	6.31
0.15	7.81
0.20	9.57
0.25	11.85
0.30	13.41
0.35	15.14
0.40	17.62
0.45	19.75
0.50	22.52
0.55	25.61
0.60	27.51
0.65	31.04
0.70	35.88
0.75	40.50
0.80	46.52
0.85	55.37
0.90	67.99
0.95	87.14
0.99	170.38

Table 3: Storm peak ranges (ft^3/s) in Bear Creek at Friendship Baptist Church and flow regime associated with each percentile. Prior to the T1 threshold the value of the flow regime will follow a logarithmic equation for the 0.01 and 0.05 percentiles but a logistic equation for the remaining percentiles.

Percentile	Storm Peak (ft^3/s)	Equation Parameters			T1 (day)	T1 Flow (ft^3/s)	T2 (day)	T2 Flow (ft^3/s)	T3 (day)	T3 Flow (ft^3/s)
		a	*b*	*k*						
0.01	0-1.26	1.40		-2.03	2	0.001				
0.05	1.27-4.01	3.55		-2.49	4	0.284	7	0.053	15	0.002
0.10	4.02-6.31	0.50	-0.95	0.03	11	0.343	23	0.014	42	0.002
0.15	6.32-7.81	0.52	-0.95	0.02	16	0.426	25	0.134	39	0.001
0.20	7.82-9.57	0.53	-0.95	0.01	18	0.520	27	0.136	50	0.003
0.25	9.58-11.85	0.58	-0.96	0.01	22	0.375	36	0.073	75	0.006
0.30	11.86-13.41	0.68	-0.96	0.01	25	0.407	38	0.143	75	0.014
0.35	13.42-15.14	0.75	-0.96	0.01	26	0.441	42	0.191	80	0.031
0.40	15.15-17.62	0.95	-0.95	0.01	27	0.527	42	0.235	80	0.054
0.45	17.63-19.75	1.60	-0.93	0.02	28	0.521	53	0.240	83	0.071
0.50	19.76-22.52	1.71	-0.93	0.02	38	0.458	58	0.258	87	0.084
0.55	22.53-25.61	4.56	-0.86	0.06	42	0.502	61	0.291	93	0.096
0.60	25.62-27.51	5.68	-0.84	0.07	46	0.482	82	0.217	158	0.086
0.65	27.52-31.04	6.10	-0.86	0.07	47	0.547	85	0.247	166	0.094
0.70	31.05-35.88	6.37	-0.87	0.06	49	0.808	82	0.339	170	0.103
0.75	35.89-40.50	6.35	-0.88	0.05	50	3.850	68	0.507	180	0.111
0.80	40.51-46.52	6.08	-0.90	0.04	60	3.905	81	0.537	203	0.114
0.85	46.53-55.37	6.20	-0.91	0.04	61	4.421	85	0.663	210	0.126
0.90	55.38-67.99	6.52	-0.92	0.04	85	2.131	105	0.714	217	0.144
0.95	68.00-87.14	6.79	-0.95	0.03	85	3.307	140	0.718	223	0.185
0.99	>87.15	9.46	-0.98	0.04	87	4.074	149	0.909	241	0.400

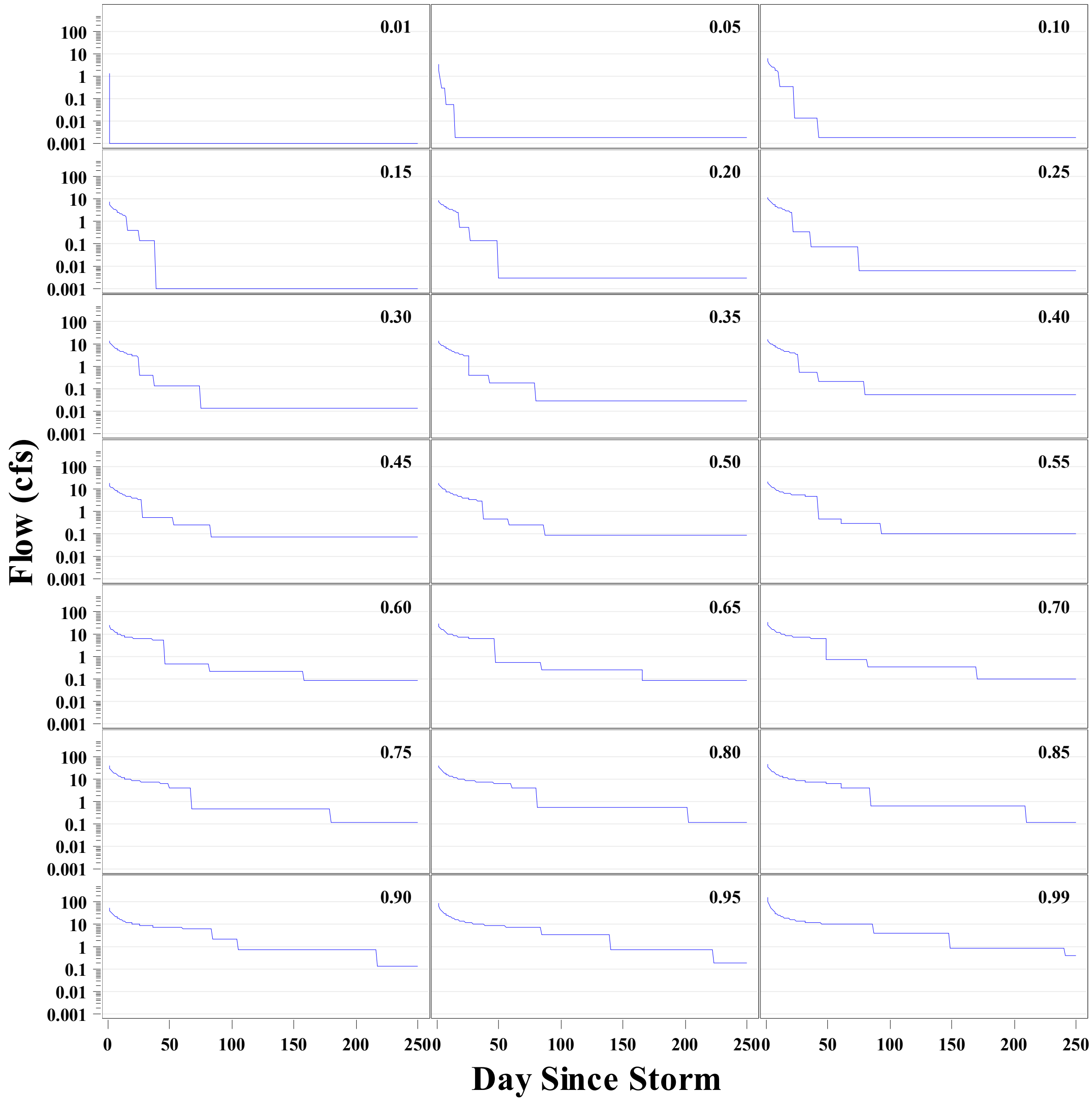

Figure 5: Model flow regime results for each storm peak percentile, 0.01-0.99, from Bear Creek at Friendship Baptist Church.

Conclusions

Flow in Bear Creek at Friendship Baptist Church after a storm reacts differently based on the magnitude of the storm peak value. During the initial days following a storm, flow decreases more quickly after a large storm peak value when compared to a small storm peak value. In addition, the number of days before the flow first substantially drops increases as the storm peak value increases. In the lower percentiles (0.01-0.70) the flow drops to below 1 ft^3/s at this initial drop. In the upper percentiles (0.75-0.99) the flow does not drop to below 1 ft^3/s until the second substantial drop which is approximately 70 days past the storm peak value or greater.

In order to have the lower portion of Waller Creek mimic the hydrology of a similar sized watershed with less impervious cover, it is recommended that the flow regime created in this report be implemented as measured in Waller Creek at the Cesar Chavez USGS gage. This would increase the amount of time that flow exists on Waller Creek at Cesar Chavez and decrease the substantial drops in flow directly following a rain event which would increase the ecosystem function of the benthic community at this location (Scoggins 2000, Glick et al. 2010, Richter 2011, King et al. 2016).

To implement the flow regime, daily flow from the USGS gage on Waller Creek at 23rd Street should be monitored as it is the closest upstream flow gage to the WCT inlet facility. The largest rainfall events do not always lead to the largest storm peak values on the Bear Creek flow gage. Because flow in Bear Creek at Friendship Baptist Church slowly decreases over a number of days or weeks, additional rainfall adds to the flow in Bear Creek creating higher storm peak values from smaller rainfall events. So this flow regime model should be applied to creek flow readings rather than rainfall events. Unfortunately, flow in a more impervious watershed decreases very quickly after a rainfall event and readings from a flow gage are more likely to represent only the most recent rainfall event.

If previous day flow readings from the gage on Waller Creek at 23rd Street indicate a rise in flow then the previous day should be considered a storm peak value and trigger the reset of the flow regime to match the flow level of the previous day. Roughly a 30 day period of time in January 2007 is used as an example of this flow regime (Appendix A). Beginning December 30, 2006, there is flow in Waller Creek at 23rd Street of 62.4 ft^3/s. After noticing this storm peak value on December 31, flow would be pushed through the WCT so that flow on Waller Creek at Cesar Chavez would be 43.3 ft^3/s based on the 0.90 percentile flow regime (55.38-67.99 ft^3/s). WCT operation would continue using the 0.90 percentile flow regime until January 5, when it would be noticed that there was a storm peak value of 18.6 ft^3/s on January 4. Operation would switch to using the 0.45 percentile flow regime (17.63-19.75 ft^3/s) and push water through the WCT so that flow on Waller Creek at Cesar Chavez would be 15 ft^3/s.

Implementation of this flow regime may be difficult due to all the considerations involved with maintaining flow in the WCT and the lower portion of Waller Creek. Dissolved oxygen must be maintained in the WCT at all times so that water pumped into lower Waller Creek is not anoxic (Herrington 2013). Side-inlets along Waller Creek at 8th Street and 4th Street draw water back into the tunnel, potentially changing downstream hydrology substantially. In addition, WCT currently has a maximum pump capacity of 28 ft^3/s which is far lower than the flow in the upper percentile flow regimes.

If the WCT was to pump flow equal to the proposed regime, as measured at Cesar Chavez, the annual maximum withdrawal volume from Lady Bird Lake has a good chance of being exceeded in any given year. Looking at the historical data from 1995 through 2016 on Waller Creek at 23rd Street, the maximum withdrawal of 7,240 ac-ft/year would have been exceeded in 13 of the 22 years (Appendix B). Following the recommended flow regime is also currently not possible because of constraints during both low and high flow conditions. During low flow conditions, the WCT may need to pump atleast 1ft^3/s during the winter months and approx 3 ft^3/s in the summer months to keep water in the tunnel from becoming anoxic, so low and no flow conditions are difficult. Since the current pump capacity is 28 ft^3/s, the recommended flow regime is bound on both sides by these limits if the WCT is the only source of water to lower Waller Creek. Under such constraints, the annual maximum withdrawal from Lady Bird Lake may still be exceeded. Running a similar analysis as above but using the constrained max flow from WCT, the maximum withdrawal would be exceeded 7 times from 1995 to 2016.

Recommendations

It is not practical that the WCT pumping options be the only tool used to help meet the criteria of the proposed flow regime for lower Waller Creek. The following strategies are suggested as additional componenets of flow management

- A portion of natural flow should be diverted around the inlet facility of the WCT so that during storms no flow is coming from the WCT. This change alone will reduce the number of years where the maxium annual withdrawal from Lady Bird Lake would be exceeded down to 3 from 1995 to 2016.
- A portion of the upper Waller Creek stormwater could also be captured and stored in the inlet facility, to be slowly released in days following the storm events. WCT would only provide a portion of the downstream flow. This would require that the WCT inlet facility maintain available storage capacity (detention volume).
- Implementation of the proposed flow regime should be flexible and adaptive. As more DO data within the tunnel becomes available, calibration of the DO model constructed by Herrington (2013) could be revisited to determine if lower flows or even stopping all flow from WCT during periods of low flow would be possible to reduce the potential for withdrawel exceedence.
- The analysis performed in this report was done using daily flow data because the current response time of WCT operations is likely daily. It is recommended that this analysis be redone using sub-daily data once operation at the WCT has the capability of using data at a shorter time interval. This would help avoid situations where WCT would have to pump during storm events and potentially make flow management more efficient and closer to the proposed regime.

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Appendix A: Daily flow values taken from the USGS gage on Waller Creek at 23rd Street from December 30, 2006, to January 31, 2007. Flow on Waller Creek at Cesar Chavez is recommended to match the flow regime during this time period based on the model generated in this report.

Date	Waller Creek Flow (ft^3/s)	Day After Storm	Storm Peak	Flow Regime (ft^3/s)	Storm Peak Value
30DEC2006	62.4	1	Yes	--	--
31DEC2006	23.1	2		43.3	62.4
01JAN2007	1.5	3		35.4	62.4
02JAN2007	1.4	4		30.2	62.4
03JAN2007	1.0	5		26.4	62.4
04JAN2007	18.6	6	Yes	23.6	62.4
05JAN2007	24.2	2	Yes	15.0	18.6
06JAN2007	1.5	2		19.2	24.2
07JAN2007	1.1	3		16.2	24.2
08JAN2007	0.9	4		14.1	24.2
09JAN2007	0.8	5		12.6	24.2
10JAN2007	1.0	6	Yes	11.4	24.2
11JAN2007	0.8	2		0.0	1.0
12JAN2007	0.7	3		0.0	1.0
13JAN2007	0.7	4		0.0	1.0
14JAN2007	301.2	5	Yes	0.0	1.0
15JAN2007	7.4	2		99.2	301.2
16JAN2007	19.8	3	Yes	72.3	301.2
17JAN2007	13.3	2		16.1	19.8
18JAN2007	10.5	3		13.8	19.8
19JAN2007	5.9	4		12.1	19.8
20JAN2007	4.1	5		10.8	19.8
21JAN2007	9.0	6	Yes	9.8	19.8
22JAN2007	4.0	2		7.7	9.0
23JAN2007	3.0	3		6.8	9.0
24JAN2007	3.4	4	Yes	6.1	9.0
25JAN2007	13.3	2	Yes	1.8	3.4
26JAN2007	2.2	2		11.5	13.3
27JAN2007	1.8	3		9.9	13.3
28JAN2007	1.5	4		8.8	13.3
29JAN2007	1.3	5		7.8	13.3
30JAN2007	1.3	6		7.1	13.3
31JAN2007	1.2	7		6.5	13.3

Appendix B: Volume of water that would be extracted from Lady Bird Lake through the Waller Creek Tunnel if the flow regime generated in this report were followed completely and once constraints of the pumping capacity (minimum of $1ft^3/s$ and maximum of $28ft^3/s$) are accounted for in the analysis. The annual maximum withdrawal from Lady Bird Lake is exceeded at a volume of 7,240 ac-ft.

Year	Volume (ac-ft.) under Flow Regime	Volume (ac-ft.) under Constrained Regime
1995	8724 (Exceed)	7215
1996	152	747
1997	6157	4581
1998	2295	2512
1999	6106	5301
2000	7504 (Exceed)	6812
2001	7904 (Exceed)	6418
2002	9118 (Exceed)	7057
2003	4603	4082
2004	12192 (Exceed)	8364 (Exceed)
2005	6586	6452
2006	8335 (Exceed)	6287
2007	14006 (Exceed)	9959 (Exceed)
2008	3733	3818
2009	9374 (Exceed)	7662 (Exceed)
2010	8047 (Exceed)	6739
2011	5497	4859
2012	12170 (Exceed)	8875 (Exceed)
2013	11207 (Exceed)	8347 (Exceed)
2014	9891 (Exceed)	7607 (Exceed)
2015	12352 (Exceed)	8133 (Exceed)
2016	310	928