

2020 Status Report: The Calculation of Trail Usage on The Legacy Trail and Venetian Waterway Park Trail

6/4/20

Stephen Martin, Ph.D.

1.0 Introduction

The monthly usage for The Legacy Trail and the Venetian Waterway Park are currently calculated using the Counter Graph Area (CGA) method documented in Reference [1]. A specific procedure for applying the method to these trails is documented in Reference [2]. This 2020 Status Report documents two recent improvements to the implementation of the CGA method and updates the Reference [2] method and documentation.

These improvements are:

1. The CGA method is now applied to each principal trail mode separately (i.e. cycle, walk, run, and skate), and the results from each mode are combined to give the total usage. In the previous method, the total usage for all modes was calculated in one step using an overall average distance-traveled parameter.
2. Virtual counters are used at four points on the Venetian Waterway Park and one additional point on The Legacy Trail. A virtual counter is a point on the trail where it has been determined that the traffic count there is a known fraction of the count on a nearby counter. This technique provides a more accurate estimate of the shape of the counter curve.

These improvements were made possible by additional data obtained from visual observations and counts from 12-hour time-lapse videos at new locations on the trails.

Notation: In the following, the The Legacy Trail will be abbreviated as LT and the Venetian Waterway Park trail will be denoted VWP. The western (island) segment of the VWP will be denoted as VWPW and the eastern (mainland) segment as VWPE. The single trail representing the contiguous LT and VWPE trails will be denoted LT+VWPE.

2.0 Calculating the Number of Users

In Reference [1] it is shown that a fundamental relation between counter readings and the number of trail users is expressed by the equation

$$N_u = \frac{A}{\mu} \quad (2.0)$$

where N_u is the number of usages, μ is the average distance traveled on the trail by trail users, and A is the area under the counter curve. The counter curve is the graph of counter values that would be obtained if there were a counter at every point on the trail. The area A is equal to the total distance traveled by all users in a given time period.

Although, Equation (2.0) is an exact relationship, the values of A and μ can only be approximated.

2.1 Calculation of Usage by Mode (Cycle, Walk, Run, and Skate)

When a counter is first installed, its accuracy is verified by a manual count over a 12-hour period. The manual count is then compared to the counter results to obtain a correction factor for the counter. In addition to the total count, the manual count also gives information about the fraction of each mode of trail usage (i.e. cyclists, walkers, runners, and skaters).

This information is useful because the mode fractions influence the value of μ , the average distance traveled on the trail by all trail users. Walkers do not travel as far as cyclists, and therefore, if there is an increased fraction of walkers, the average distance traveled by all trail users is decreased. A decrease in the average distance traveled results in an increase in predicted trail usage (for the same counts). Therefore, under-predicting the fraction of walkers results in an under-prediction of trail usage.

The fraction of trail users of a particular mode (e.g. walkers) cannot be determined from trail observations alone. For example, if there were equal numbers of walkers and cyclists on a trail, the traffic count would show fewer walkers than cyclists. The reason for this is that cyclists travel farther and are more likely to pass a given location.

The way around this problem is to calculate the usage for each mode separately. If we know the mode fraction at each counter, we know what the counter would have registered if it only counted users for that mode. For example, if we can know the count for walkers at each counter location, the total number of walkers can be calculated using the same method previously used to calculate total usage. In this calculation, in addition to using the counts for just walkers, we would also use the average distance traveled for walkers as the value for μ in Equation (2.0)

With this new method, the usages for cyclists, walkers, runners, and skaters are calculated separately according to the above procedure. These results are then summed to give the total trail usage for the month. The mode usage fractions can be obtained from these numbers. (Note that counters have mode count fractions, whereas the trail has mode usage fractions. It can get confusing.)

2.2 Using Virtual Counters to Supplement the Real Counters

A second improvement that has been made is the use of virtual counters. A virtual counter is a location on the trail where the traffic count can be estimated. The estimated count on the virtual counter is obtained by multiplying the count on a nearby real counter by a known factor. This factor is obtained by comparing a short-term measured count at the virtual location to the count on the reference real counter. For the present analysis, these short-term counts were obtained using manual counts from ~12-hour time-lapse video of the virtual counter location.

Two locations on the VWPE and two locations on the VWPW were chosen¹. These points are referred to the Hatchett Creek counter at mile 0.3 on The Legacy Trail. This is the nearest real counter to their location.

In addition to the above, traffic at one additional virtual counter location was measured at a point just north of Palmer Ranch Pkwy (mile 10.22) on the LT. This was done to determine how much of the traffic measured by the Palmer Ranch counter extends north to this short trail segment. It was found that the traffic there was only 60% of the traffic

¹ The points chosen were the two-point Gaussian quadrature points for each trail segment. See Reference [1] for a discussion of why these are the mathematically optimum sampling points.

at the Palmer Ranch Counter (mile 9.5).

3.0 Parameters Required for the Analysis

This model for calculating trail usage depends on a number of parameters. These can be divided into three groups: counter parameters, user parameters, and trail parameters.

3.1 Counter Parameters

Each counter has a location, a counter factor, and four mode fractions. For real counters the counter factor is the correction factor for that counter. For virtual counters, the counter factor is the multiplier of the corrected count on the reference counter. The counter factor and the mode fractions are obtained from manual counts of traffic passing the virtual counter location over an approximately 12-hour period.

The currently used values of the counter parameters are given in Table 3.1. These values may change in the future as updated data is obtained.

Table 3.1 - Counter Parameters						
Counter	Location	Count Factor	Mode Fractions			
			Cycle	Walk	Run	Skate
LT + VWPE						
VWPE-South*	-3.08	0.77	.761	.188	.046	.005
VWPE-North*	-0.82	0.81	.910	.066	.018	.006
Hatchett Creek	0.30	1.02	.885	.099	.014	.002
South Creek	5.39	1.02	.970	.012	.013	.005
Palmer Ranch	9.49	1.09	.800	.124	.057	.019
Culverhouse*	10.22	0.60	.747	.187	.040	.026
VWPW						
VWPW-South*	1.05	0.53	.827	.130	.027	.016
VWPW-North*	3.95	0.34	.826	.148	.021	.005
* Counter is a virtual counter						

3.2 User Parameters

The user parameters are the average distances traveled on the trail per trip for each of the four usage modes. These values are given in Table 3.2.

Table 3.2 – User Parameters				
Trail	Average Distance on the Trail Per Trip in Miles			
	Cycle	Walk	Run	Skate
LT+VWPE	16.1	3.62	6.72	7.83
VWPW	8.05	3.62	6.72	7.83

The mode distance data was obtained from both on-trail and online user surveys in 2016 and an online survey in 2018. Results from these surveys are documented in References [3] and [4]. The LT cycle distance is derived from the 2018 online survey because it more accurately represents behavior after Honore Avenue became available for loop rides with the LT. The availability of this loop option tended to decrease the average distance traveled by cyclist on the LT.

The walk, run and skate distances are derived from data in the 2016 survey because there was insufficient data for these modes in the 2018 survey. In addition, they would probably be much less affected by the opening of Honore Avenue.

The only difference between the two trails is that the cycle distance on VWPW is taken to be $\frac{1}{2}$ the distance on the LT+VWPE. The reason for this decrease is that VWPW is only 5 miles long, so it seems unlikely that the average cyclist would do 16 miles entirely on this trail. Also, VWPW has many connections to the urban Venice area and streets. This means that cycle usage is more likely to include casual cyclist and cyclist who use the trail for only part of their trip.

3.3 Trail Parameters

Table 3.3 gives the values of parameters that apply to the trail in general.

Table 3.3 – Trail Parameters				
	Start	End	Dfactor	Wfactor
LT+VWPE	-3.9	10.75	0.05	0.75
VWPW	0.0	5.0		

Start and End are the coordinates for the start and end of the trails. Dfactor is the fraction of users that are assumed to travel on both trails in a single trip. This parameter compensates for double counting if a user goes on both trails. Wfactor is used to reduce the measured counter walker mode fraction and correspondingly increase the cycle fraction. This factor is currently set to 0.75 to compensate for the fact that all of the walker fraction data has been obtained in cool weather in high season, and therefore probably results in a higher walker fraction than in summer.

4.0 Calculation of the Counter Graph Area and Trail Usage

For the present analysis, we will treat the LT and the VWPE as a single trail. VWPW will be treated as a separate trail. The analysis proceeds as described in Reference [2] with the following differences:

- The analysis is performed four times; once for each mode separately, and
- There are now six counters on the LT+VWPE, and two counters on the VWPW.

4.1 The LT+VWPE

Figure 4.1 shows the approximate current locations of the six counters on this trail. The x-coordinates on the graph represent locations on the trail in miles. The origin, or zero mile point, is taken to be the start of The Legacy Trail. This means that the south end of VWPE is at mile -3.9 in this coordinate system, and the north end of the LT is at mile 10.75. The mile locations of the counters are given in Table 3.1.

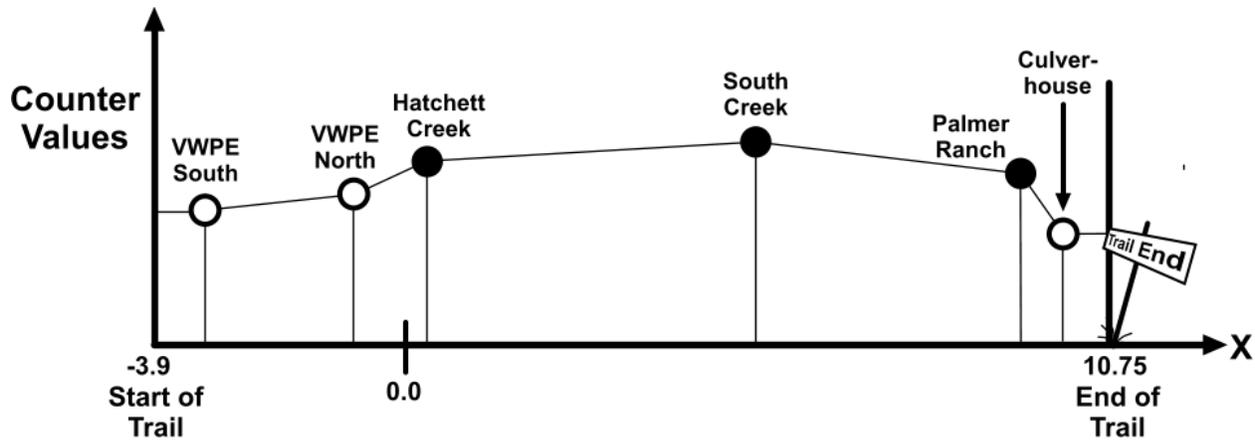


Figure 4.1 – The Locations of the Counters and the Assumed Counter Graph Shape

As discussed in Reference [2], for this trail we use a modified version of the trapezoidal method to estimate the area under the assumed counter curve. The x-value locations and counter values are denoted as shown in Table 4.1. The total usage is obtained by calculating the usage for each mode separately. The counter values in the equations below are the counts for each mode. These mode counts are obtained by multiplying the total count on each real or virtual counter by the mode fraction for that counter.

Table 4.1 – Symbols Used in Equations		
Location	Location	Mode Count
Beginning of Trail	x_0	-
VWPE-South	x_1	C_1
VWPE-North	x_2	C_2
Hatchett Creek	x_3	C_3
South Creek	x_4	C_4
Palmer Ranch	x_5	C_5
Culverhouse	x_6	C_6
North End of Trail	x_7	-

The area under the counter curve in Figure 4.1 is just the sum of the areas of the seven trapezoidal sections. Using the symbols in Table 4.1, the total area, A , is given by

$$A = W_1 C_1 + W_2 C_2 + W_3 C_3 + W_4 C_4 + W_5 C_5 + W_6 C_6 \quad (4.1)$$

where the W terms are weighting factors given by

$$W_1 = \left[-x_0 + \left(\frac{x_1 + x_2}{2} \right) \right] \quad (4.2)$$

$$W_2 = \left[\left(\frac{x_3 - x_1}{2} \right) \right] \quad (4.3)$$

$$W_3 = \left[\left(\frac{x_4 - x_2}{2} \right) \right] \quad (4.4)$$

$$W_4 = \left[\left(\frac{x_5 - x_3}{2} \right) \right] \quad (4.5)$$

$$W_5 = \left[\left(\frac{x_6 - x_4}{2} \right) \right] \quad (4.6)$$

$$W_6 = \left[x_7 - \left(\frac{x_6 + x_5}{2} \right) \right] \quad (4.7)$$

Using the coordinates given in Tables 3.1 and 3.3, the W_i terms evaluate to

$$\begin{aligned} W_1 &= 1.95, & W_2 &= 1.69, & W_3 &= 3.15, \\ W_4 &= 4.595, & W_5 &= 2.37, & W_6 &= 0.895 \end{aligned} \quad (4.8)$$

As derived in Reference [1], the usage for each mode is just this area divided by the average mode travel distance, μ . The total usage for the LT+VWPE is the sum of the usages calculated for each mode.

4.3 Island-Side Venetian Waterway Park

There are no automatic counters on the VWPW. However, in April 2020, 12-hour manual counts were taken at two locations. The two locations chosen were at mile markers 1.05 and 3.95 as shown in Figure 4.2.

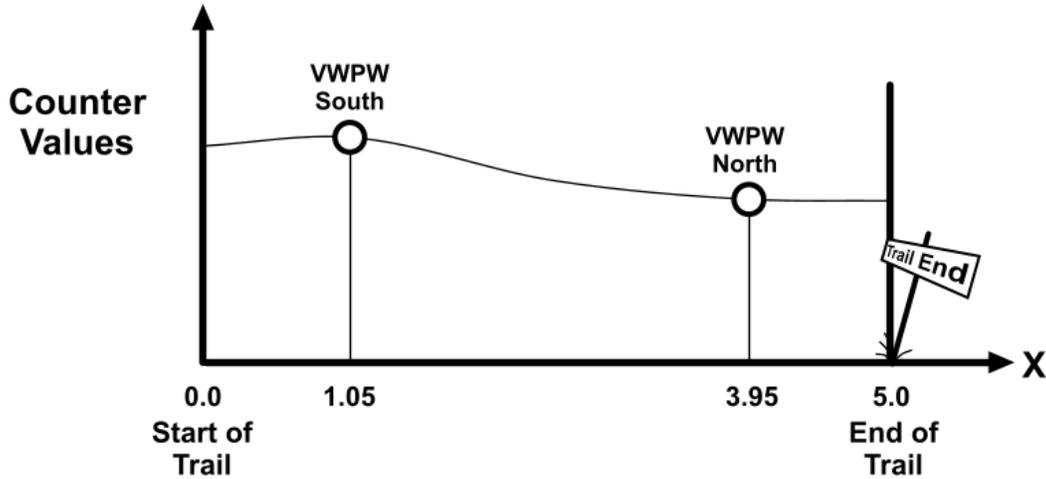


Figure 4.2 - Virtual Counter Locations and Approximate Shape of the Counter Curve² on the VWPW

These points are the two-point Gaussian quadrature points and are the optimum sampling locations. From the counts at these two points, the area under the counter curve is approximately

$$A = W_1 C_1 + W_2 C_2 \quad (4.9)$$

where C_1 and C_2 are the counts on these counters, and the weighting factors W_1 and W_2 are each equal to

$$W_1 = W_2 = 0.5L \quad (4.10)$$

where L is the length of the trail (= 5 miles in this case).

² Actually, the only assumption that is made is that the shape of the actual counter curve can be approximated by a cubic polynomial. There is no need to make a specific assumption about the curve's shape for Equation 4.9 to hold.

The total counts for these virtual counters are derived from the count on the Hatchett Creek counter. From the factors given in Table 3.1, the total counts are:

$$C_1 = 0.53C_H, \quad C_2 = 0.34C_H \quad (4.11)$$

where C_H is the corrected Hatchett Creek count.

Next, the usage for each mode is calculated. The mode counts are obtained by multiplying the total counts by the appropriate mode fraction at each counter. These fractions are given in Table 3.1. For example, from Table 3.1, for walkers the mode fraction for counter 1 (south VWPW) is 0.13 and the fraction for counter 2 is 0.148. Therefore, the walker counts are

$$C_{1W} = 0.13C_1, \quad C_{2W} = 0.148C_2 \quad (4.12)$$

The area under the walker counter curve is obtained by substituting Equations (4.12) and (4.10) into Equation (4.9). From Equation (2.0), the walker usage is obtained by dividing the area under the counter curve by the average distance traveled by walkers given in Table 3.2, i.e., 3.62 miles.

The same procedure is repeated for the other three modes. The total usage is obtained by summing the usage calculated for all four modes.

4.4 The Total Trail Usage

Once the usages for both the mainland and island trail sections are obtained, it might seem that we could just add them together to get the total usage. We will do this, but we need to make a small correction to account for the fact that some people travel on both trails in a single trip. These people would add one usage to both the mainland-side and island-side trail counts, and therefore be counted as two users. The total trail usage, N_T , is given by

$$N_T = N_E + N_W - N_{both} \quad (4.13)$$

where N_E is the number of users on the eastern (mainland) side, N_W is the number of users on the western (island) side, and N_{both} is the number of people who travel on both sides in a single trip.

Next, we assume that the number of people who travel on both trails is a fraction, r_b , of the total number of trail users, i.e., $N_{both} = r_b N_T$. Substituting this expression for N_{both} into Equation (4.13) gives the equation

$$N_T = N_E + N_W - r_b N_T \quad (4.14)$$

Since N_T appears on both sides of the equation, solving this equation for N_T gives the solution

$$N_T = \frac{N_E + N_W}{1 + r_b} \quad (4.15)$$

This equation gives the total usage for The Legacy Trail and VWP. (The parameter r_b is called Dfactor in Table 3.3.)

References

1. Martin, Stephen, (2019, March 18), "Calculating Trail Usage from Counter Data," <https://www.friendsofthelegacytrail.org/wp-content/uploads/2019/03/Calculating-Trail-Usage.pdf> , (Accessed June 2, 2020)
2. Martin, Stephen, (2019, March 18), "Using the Counter Graph Area Method to Estimate the Number of Users on The Legacy Trail and Venetian Waterway Park Trail" <https://www.friendsofthelegacytrail.org/wp-content/uploads/2019/08/CGA-Method-Legacy-Trail.pdf> , (Accessed June 2, 2020)
3. Martin, Stephen, et al., (2017, January 17), "Results and Analysis of a Survey of Users of The Legacy Trail and Venetian Waterway Park Performed During June and July of 2016," <https://www.friendsofthelegacytrail.org/wp-content/uploads/2020/06/Trail-Survey-Summer-2016.pdf> , (Accessed June 2, 2020)
4. Martin, Stephen, (2018, April 24), "2018 Online Trail Usage Survey," <https://www.friendsofthelegacytrail.org/trail-usage-survey-2018/> , (Accessed June 2, 2020)