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RESEARCH REPORT

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Measures to Alleviate Congestion at Rural Intersections

Case Study: Intersection of State Highway 55, Banks-Lowman Road, and Banks-Grade Way

By

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16. Abstract
Many rural highways experience a surge in traffic flow levels on certain "high-travel" days during national holidays. Due to the platooned nature of the high volume traffic on the main highway, vehicles on the minor approach attempting to turn to the major highway are subjected to excessive delays. Our research focuses on alternative intersection treatments to alleviate congestion at rural intersections during increased traffic volume on high-travel days. Specifically, the case study we investigated is the intersection of State Highway 55 (SH55), Banks-Lowman Road, and Banks-Grade Way. The high hourly traffic volume on SH55 during Memorial Day, Independence Day, and other summer weekends causes excessive delay for vehicles on the Banks-Lowman Road. Traffic flow trends for the intersection were obtained from data collected from several Automatic Traffic Recorders (ATR) continuously monitoring traffic near the intersection. In addition, field data was collected at the intersection during the 2014 Memorial Day and Independence Day weekends. The results of our study showed that signalization of the intersection along with some geometry alternation are the recommended treatments to alleviate the congestion and provide safe, efficient movement for both vehicular and pedestrian traffic at this intersection.

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		VOLUME					VOLUME		
fl oz	fluid ounces (US)	29.57	milliliters	mL	mL	milliliters	0.034	fluid ounces (US)	fl oz
gal	Gallons (liq)	3.785	liters	liters	liters	liters	0.264	Gallons (liq)	gal
ft^3	cubic feet	0.0283	meters cubed	m^3	m^3	meters cubed	35.315	cubic feet	ft^3
yd^3	cubic yards	0.765	meters cubed	m^3	m^3	meters cubed	1.308	cubic yards	yd^3
Note: Volumes greater than 1000 L shall be shown in m^3									
		TEMPERATURE (exact)					TEMPERATURE (exact)		
^oF	Fahrenheit temperature	5/9 (^oF-32)	Celsius temperature	^oC	^oC	Celsius temperature	9/5 ^oC+32	Fahrenheit temperature	^oF
		ILLUMINATION					ILLUMINATION		
fc	Foot-candles	10.76	lux	lx	lx	Lux	0.0929	foot-candles	fc
fl	foot-lamberts	3.426	candela/m^2	cd/cm^2	cd/cm^2	candela/m^2	0.2919	foot-lamberts	fl
		FORCE and PRESSURE or STRESS					FORCE and PRESSURE or STRESS		
lbf	pound-force	4.45	newtons	N	N	newtons	0.225	pound-force	lbf
psi	pound-force per square inch	6.89	kilopascals	kPa	kPa	kilopascals	0.145	pound-force per square inch	psi

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Each research project has an advisory committee appointed jointly by the ITD Research Manager and ITD Project Manager. The Technical Advisory Committee (TAC) is responsible for assisting the ITD Research Manager and Project Manager in the development of acceptable research problem statements, requests for proposals, review of research proposals, and oversight of the approved research project. ITD's Research Manager appreciates the dedication of the following TAC members in guiding this research study.

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Executive Summary

Many rural highways experience a surge in traffic flow levels on “high-travel” days during national holidays. Due to the platooned nature of the high volume traffic on the main highway, vehicles on the minor approach attempting to turn to the major highway are subjected to excessive delays. Our research focuses on alternative intersection treatments to alleviate congestion at rural intersections caused by increased traffic volume during high-travel days. The case study we investigated is the intersection of State Highway 55 (SH55), Banks-Lowman Road, and Banks-Grade Way. SH55 is a main North-South road to recreation areas from Boise. The high hourly traffic volume on SH55 during Memorial Day, Independence Day, holiday weekends, and many other summer weekends combined with high traffic volumes on the Banks-Lowman Road, causes excessive delays for vehicles on the Banks-Lowman Road.

Traffic flow trends for the intersection were obtained from data collected from several of the Automatic Traffic Recorder (ATR) continuously monitoring traffic near the intersection. In addition, field data was collected at the intersection during the 2014 Memorial Day and Independence Day (July 4th) weekends. From a trend analysis, three main sources that contribute to the excessive delay were identified as follows:

- The platooned nature of the traffic in the main highway reduces the number of gaps that are large enough to allow vehicles waiting in the minor road to turn onto the main road.
- Possible queue spillback from Horseshoe Bend, ID to the intersection is being studied.
- Conflicts arising from the one-lane bridge on the west approach in the intersection which prevents more than one movement from using the bridge at a time.

The results of our study showed that signalization of the intersection along with some geometry alterations are the recommended treatment to alleviate the congestion and provide safe and efficient movement for both vehicular and pedestrian traffic. Specifically, we recommend the following:

- An advanced warning sign “BE PREPARED TO STOP WHEN FLASHING” with the associated yellow flashing beacon should be installed in advance of the intersection on SH-55 and on the Banks-Lowman Road. This will alert drivers about the possibility of stopping at a red light at the intersection.
- This traffic signal should operate primarily in flashing mode and be activated only when traffic conditions warrant it. Specifically, signal actuation would occur when the queue on Banks-Lowman Road exceeds a certain length, when the traffic volume on SH55 reaches a set limit, or when activated by a pedestrian.
- Widening the bridge over the South Fork Payette River on SH55 and adding a lane will not only allow for future long-term development but can also fix issues with the bridge that has been identified as “Structurally Deficient” in the Idaho 55 Central Draft Corridor Plan.

- Widening the bridge over the North Fork Payette River is recommended to remove the conflict created by the one-lane bridge and to allow for future expansion to the west and to improve the safety of pedestrian movement on the bridge.

- A left-turn lane should be constructed on the Banks-Lowman Road. The added turn-lane will reduce delay time for vehicles turning right at the intersection.

- To eliminate the possibility of queue spill back from Horseshoe Bend, ITD should consider reviewing the 25 mph speed limit through Horseshoe Bend.

- To manage congestion at the intersection, ITD should continue to encourage drivers to avoid the intersection during the peak summer travel periods through public service messages in different media outlets.

- ITD should continue their flagging operations practice until intersection improvements can be made.

Chapter 1
Introduction

Many rural highways experience a surge in traffic flow levels on certain "high-travel" days during national holidays. Due to the platooned nature of the high volume traffic on the main highway, vehicles on the minor approach attempting to turn to the major highway are subjected to excessive delays. Our research focuses on alternative intersection treatments to alleviate congestion at rural Intersections due to increased traffic volume during high-travel days.

Banks-SH55 Intersection's Problem

The case study investigated is the intersection of State Highway 55 (SH55), Banks-Lowman Road, and Banks-Grade Way (hereafter, the intersection will be referred to as the "Banks-SH55 Intersection"). The high hourly traffic volume on SH55 during Memorial Day, and Independence Day combined with high traffic volumes on Banks-Lowman Road, causes excessive delay for vehicles on Banks-Lowman Road. To quote an Idaho Transportation Department (ITD) Foreman on how the holiday traffic affected the Banks-SH55 Intersection:

> *"Congestion at [the Banks-SH55] Intersection on summer holiday weekends forced law enforcement officers to control the traffic at the intersection and neglect other duties. The traffic backs up on SH55, all the way from [Horseshoe Bend, ID]… [and the resultant] backed up, stop and go traffic on SH55 prevented traffic on the Banks-Lowman Road from entering SH55 completely. People could sit for hours on the B/L road without moving. Engines would overheat, people needed to use a bathroom, etc. Drivers would get desperate and try to force their way into SH55 traffic, resulting in accidents and calls to law enforcement. Law enforcement would respond and try to unsnarl the mess, getting stuck at the location for hours."*[1]

> *"But if the weather is good and holiday traffic is heavy, the Intersection is just a bad place to be."*[1]

Study Area Description

Located about 41 miles north of Boise as shown in Figure 1, the SH55 Intersection is a four-legged intersection with each leg oriented roughly in the cardinal directions.[2] The north and south legs are SH55, while the east leg is the start of Banks-Lowman Road and the west leg is a one-lane bridge across the North Fork Payette River(NFPR) to provide access to Banks-Grade Way (Figure 2).

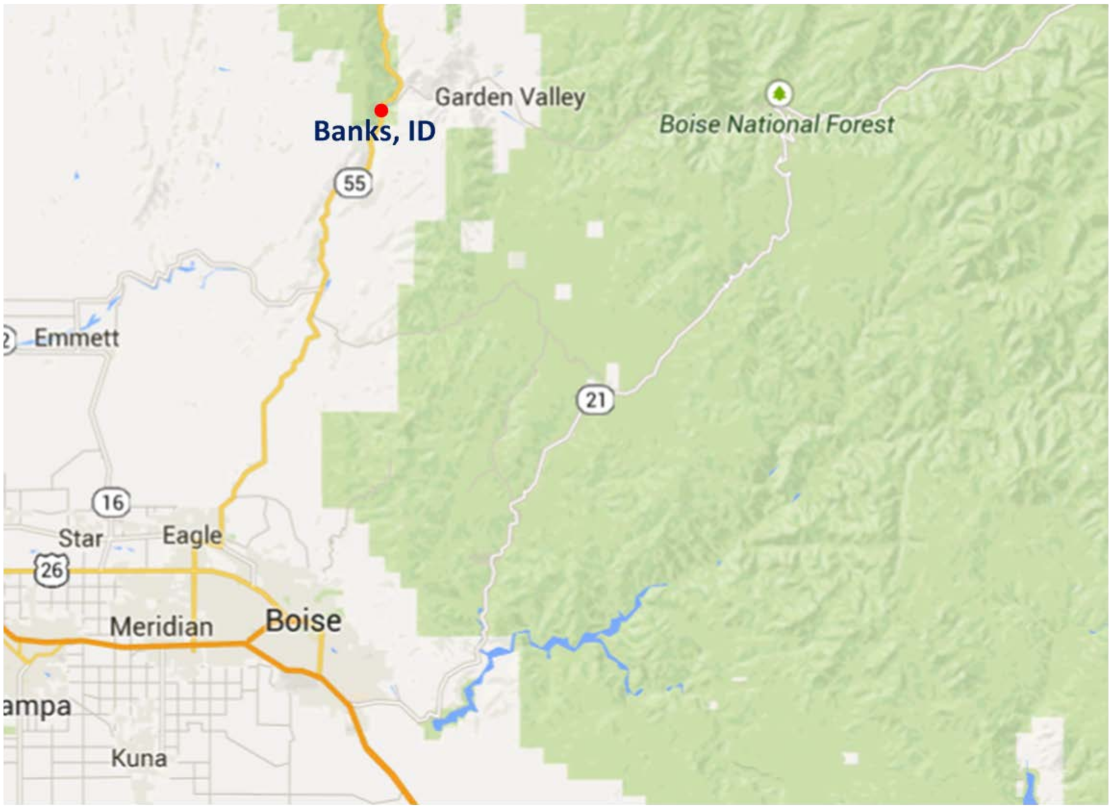

Figure 1. SH55 Reference Map

Classification and Conflict Management Method

According to Idaho's "*Statewide Transportation Systems Plan Technical Report 5: Highway System Classification*," the roads are classified as follows: [(3)]

1. SH55: Principle Arterial - Other (rural)
2. Banks-Lowman Road: Minor Arterial (rural)
3. Banks-Grade Way: Minor Collector (rural)

For most of the year, conflict between the four legs is controlled by a two-way stop intersection (TWSC). Stop signs control the minor east/west approach roads but are uncontrolled on the principal arterial, SH55.

The eastbound traffic, Banks-Lowman Road, approaches at 50 miles-per-hour (mph) and the westbound traffic, Banks-Grade Way, approaches at 25 mph prior to having to stop while uncontrolled SH55 has a speed limit of 55 mph. As noted by the ITD foreman, however, the current control method is insufficient during summer travel peaks: *"As a result of the situation, law enforcement requested that ITD manage the traffic… ITD usually puts out a media alert, asking drivers to avoid the intersection during the high congestion periods on these weekends and that has actually helped some. [Also,] message boards are put up well in advance of the flaggers…"*[(1)]

Geometric Description

The intersection is also nested in some very confining geographical boundaries (see Figure 2). Just southeast of the intersection, the NFPR and the South Fork Payette River (SFPR) join to create the Payette River. As a result, the Banks-Lowman Road is paralleled on the south side by the SFPR, limiting road expansion to the south. Similarly, the SH55’s south leg of the T-intersection has to cross the SFPR. Expansion of the southern leg of the intersection would require replacement of the existing bridge, which would have a significant cost. As for the NFPR, it hinders any westward expansion of the SH55. Finally, a slope [slightly less than a 1.5:1 (Vertical: Horizontal)] borders the east edge of SH55 and the north edge of Banks-Lowman Road.

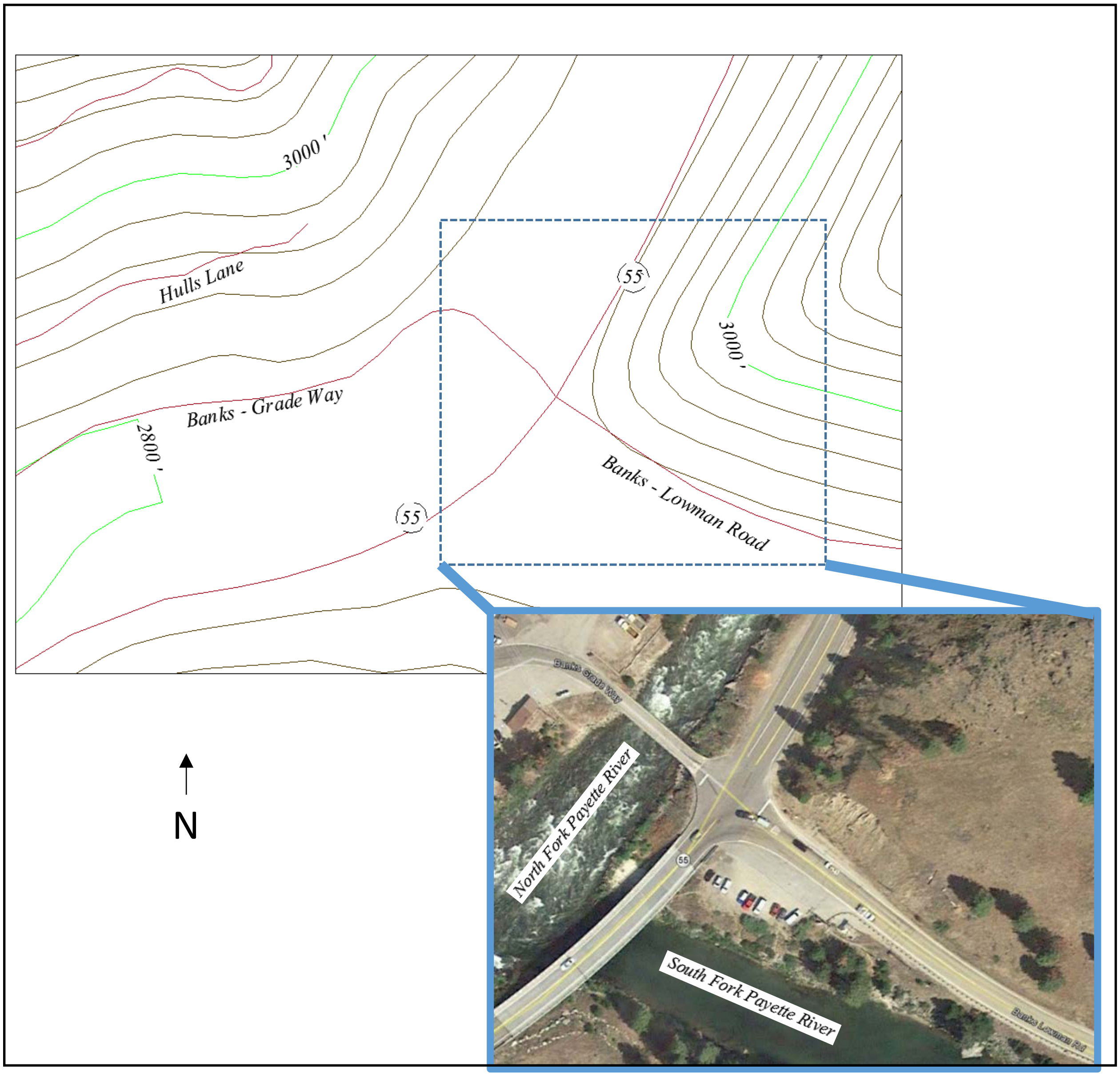

Figure 2. Simplistic Topography Map with 40 Foot Contour Intervals from the USGS Website[4]
Detail: Aerial Photo from Google Earth of the Banks-SH55 Intersection[2]

Chapter 2
Existing Traffic Conditions

Study Approach

Two types of data sources were used in this study:

- Previous years of counts from the Automatic Traffic Recorder (ATR) were provided by ITD.
- Field data collected specifically for this study.

Past ATR Count Data

Since late 2006, ITD has been reporting ATR data on 3 of the 4 legs in the Banks-SH55 Intersection. To facilitate that reporting, there is a permanent counter embedded in the north, south and east legs, and each counter is named and numbered as shown in Figure 3.

Figure 3. ATR Names and Numbers *U*sed for ITD's Reporting

Data was collected from ITD’s Average Daily Traffic (ADT) report for each ATR during the years of 2008 - 2013 to define what months were included in the Banks-SH55 Intersection’s peak season, and then ITD ATR Monthly Hourly Traffic Volume reports for those peak months were analyzed for trends.[5]

Field Studies

Over the 2014 Memorial Day and Independence Day weekends, traffic movements and queue build-up were recorded with video surveillance cameras. Post-processing was used to report turning movements and volumes for all of the approaches as well as identify queue length on the Banks-Lowman Road.

Summary of Findings

Traffic Volume

The Seasonal Peak

Table 1 shows the monthly average ADT volumes reported by ITD for each ATR at the Banks-SH55 Intersection. For emphasis, the July values in red are the peak ADT volumes and the December or January values in blue are the lowest ADT values for each year. For each year, the mean of the peak and low traffic volumes was used to define when the peak season started and ended (See Figure 4).

Table 1. Average Over 2008 to 2013 of ADT Reported for ATR #182 – 184[5]

ATR Number/ ATR Name	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
182 / S. Banks	2,515	2,647	2,343	2,272	3,285	4,497	6,154	5,323	4,026	3,376	2,619	2,272
183 / E. Banks	981	1,046	1,099	1,349	1,849	2,428	3,086	2,720	2,096	1,721	1,350	1,043
184 / N. Banks	3,421	3,578	3,351	3,402	4,991	6,787	8,817	7,889	5,837	4,884	3,727	3,261

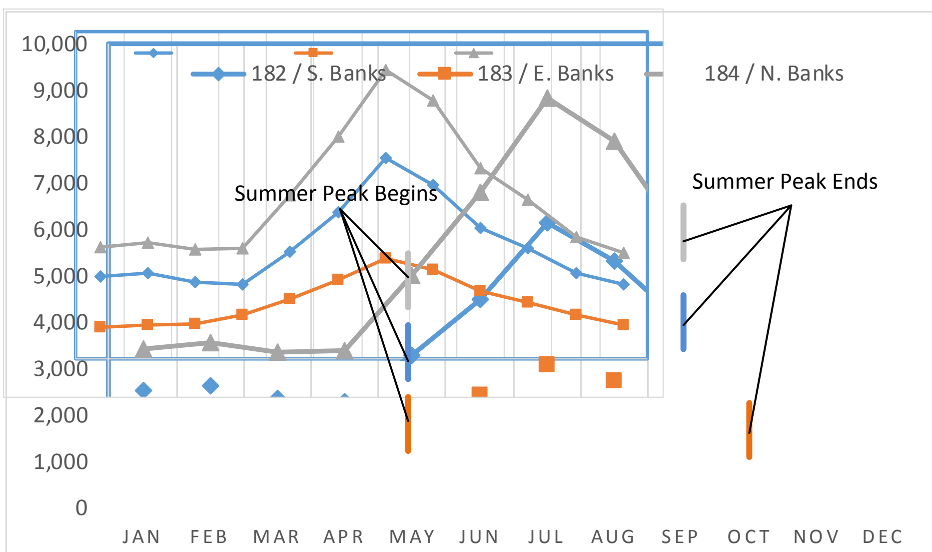

Figure 4. Graphical Representation of Table 1; Split by Peak and Off-Peak Periods

May was typically when the ADT rose above the mean value. Also, September was when the ADT typically dropped below the mean traffic volume. Therefore, the peak season was defined as the months of May through September, similar to the peak season defined in the *Idaho 55 Central Draft Corridor Plan*.[6]

Weekly Peaks within Each Season

As is shown in Figure 5, from the *Idaho 55 Central Draft Corridor Plan* which used data from ATR #184 (S. Banks), the average Sunday and Friday peaks are double the peaks of almost any other day of the week for SH55.[6] Because of this increase, Friday and Sunday peaks were further analyzed in this plan as shown in Figure 6 and Figure 7. Figure 6 shows that the majority of the vehicles traveling Sunday on SH55 are southbound. Conversely, Figure 7 of the same plan indicates that about the same majority of vehicles are northbound on Fridays. Similar figures to those shown for ATR #184 are found in analyzing ATR #182 and #183 (noting of course that since ATR #183 measures east to west flow, Friday is predominately eastbound and Sunday is predominately westbound). Appendix A presents Friday and Sunday trend graphs for peak seasons 2011 – 2013.

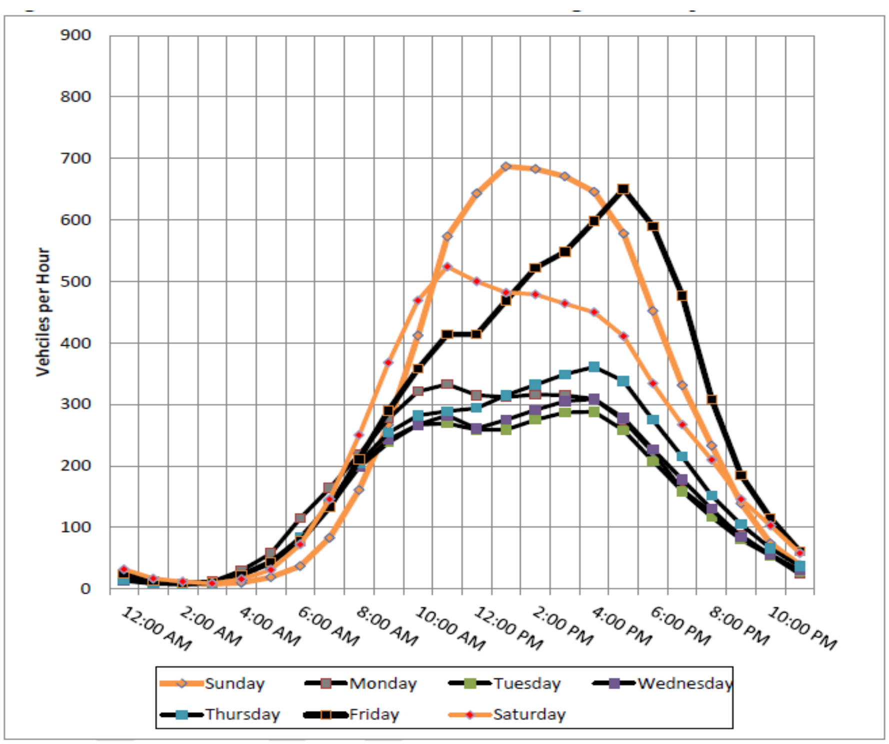

Figure 5. SH55 South of the Banks-Lowman Road Average Vehicles Per Hour for ATR #184[5]

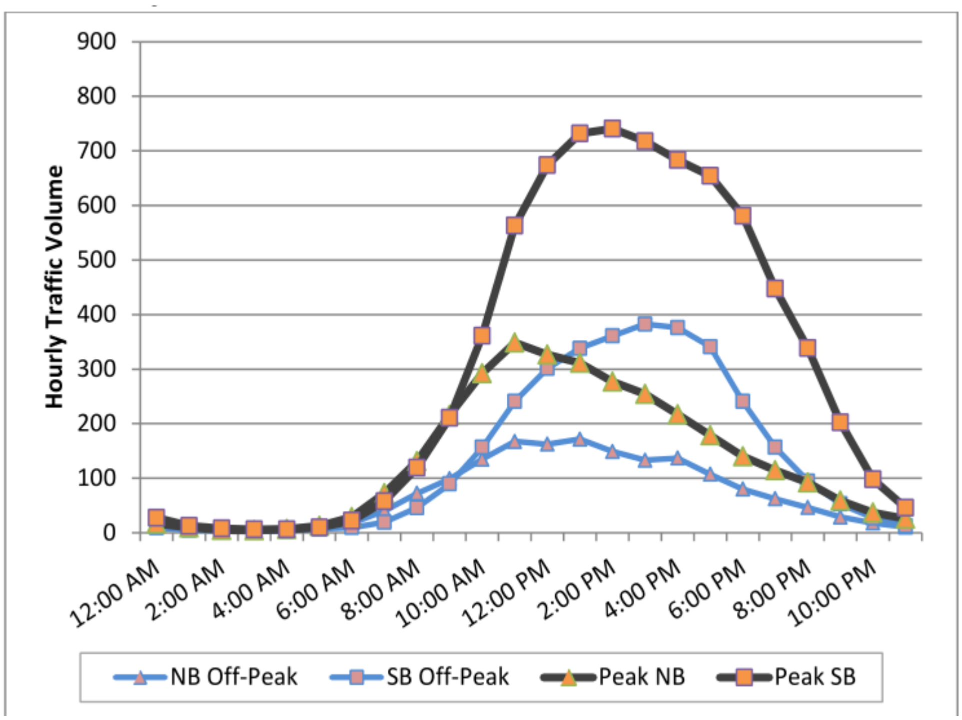

Figure 6. SH55 South of Banks-Lowman Road Average Sunday Traffic Volume by Direction by Hour[5]

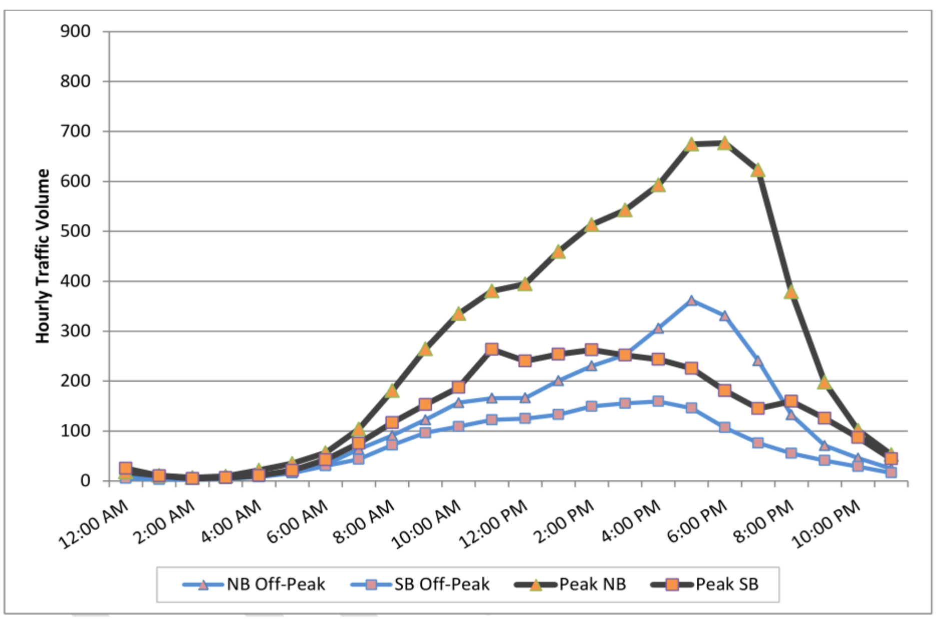

Figure 7. SH55 South of Banks-Lowman Road Average Friday Traffic Volume by Direction by Hour[5]

Although Sunday and Friday peaks are mentioned in the Corridor Plan, it is not the specific day of the week, but what it represents that is important.[6] The typical American work week is Monday through Friday with the majority of workers having Saturday and Sunday off. Therefore, the trend for increased traffic volume occurs on Friday, the last night of the work week when a high peak in the northbound and eastbound directions occurs. Similarly, on Sunday, the last day before work starts again, a high peak in the southbound and westbound directions occurs.

It logically follows that when holidays are on a Friday or Monday, the expected weekend peaks will not take place on Friday and Saturday. In the case of all Memorial Days and Labor Days, the last day before the work starts again is Monday and not Sunday so the southbound peak is shifted that week to Monday. As a result, our study focused on how holidays shift the expectations for when high peaks will occur during peak season.

Peak 15 Minute and Turning Movement Counts

Two field studies were performed during the 2014 peak season. The first study was conducted from May 23 to May 26, 2014 (Memorial Day Weekend) and the second took place over the Independence Day weekend (July 3 to July 6, 2014). From those studies, the northbound and southbound peak hours were identified and are listed in Table 2.

Table 2. Peak Hour Counts from Field Studies

Field Study Weekend	Primary Directions of Travel	Date of the Peak Hour	Peak Hour's Total Count for All Movements
Memorial Day Weekend 2014	Northbound	Friday, May 23rd 5:15 - 6:15 PM	1,398 vehicles
	Southbound	Monday, May 26th 11:45 - 12:45	1,367 vehicles
Independence Day Weekend 2014	Northbound	Thursday, July 3rd 4:49 - 5:49 PM	1,303 vehicles
	Southbound	Sunday, July 6th 4:19 - 5:19 PM	1,396 vehicles

The peak 15 minute volumes represent the most critical period for operations and were the focus of this study. Although the May 23rd's volume count is the highest, the slightly lower July 6th peak 15 minutes was used. Our study followed the protocols found in the *Highway Capacity Manual*, where every turning movement is placed in priority ranks with "left turn from minor road to major road" being the lowest priority.[(7)] Furthermore, the minimum acceptable gap required in the lane crossed over during the left turn movement is smaller than that which is required in the lane the left turn movement ends.

For the Banks-SH55 Intersection, the two minor roads left turns are off of Banks-Grade Way and Banks-Lowman Road. Banks-Grade Way's traffic is insignificant compared to Banks-Lowman Road's traffic so emphasis is put on the Banks-Lowman Road's left turn movement. Since Banks-Lowman Road's left turns end in the southbound lane of SH55, the time when the traffic experiences the largest volumes of left turns from the Banks-Lowman Road and southbound SH55 through movements produces the greatest delay for the minor roads. Because May 23rd is predominately northbound but July 6th is mostly southbound, the July 6th data's peak 15 minute volumes were used and are shown below in Figure 8.

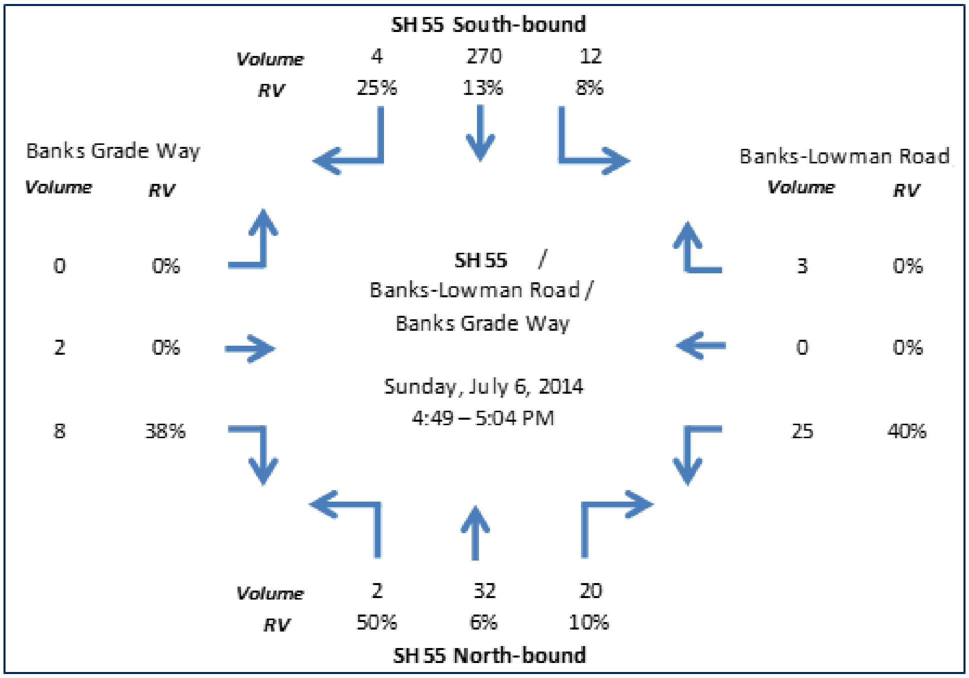

Figure 8. Independence Day Weekend's Southbound Peak 15 Minutes

Level of Service

During the peak hour on July 6, 2014, flaggers controlled the Banks-SH55 Intersection. For this report, McTrans' Highway Capacity Software was used to determine all of the levels of service (LOS) which meant adapting the "Streets" module in HCS 2010 to represent the flagging operation.[8] To do that, timestamps on the recorded video were used to calculate the percent service time for SH55, Banks-Grade Way, and Banks-Lowman Road shown in Table 3.

Using those values and the peak 15 minute volumes from Figure 7, the LOS E was calculated (see Table 4) based on the Highway Capacity Manual's classifications. LOS E corresponds to average delay per vehicle that ranges from 55 seconds to 80 seconds, indicating that the intersection is running at full capacity with long queues and delays.

Table 3. Breakdown of Cycle Length Inputs for Highway Capacity Manual 2010's Street Module

Approach	Percent of Time Given to the Approach by Flaggers	Seconds Allotted to Each Phase in HCS 2010 Street Module
SH55	68	82
Banks-Grade Way	9	11
Banks-Lowman Road	17	20
All-Red Time	6	7
Totals	100	120

Table 4. Level of Service Report from Highway Capacity Manual 2010 Streets Module for Existing Flagging Operation

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	3	8	18	7	4	14	1	6	16	5	2	12
Adjusted Flow Rate (*v*), veh/h		29			239			204			1045	
Adjusted Saturation Flow Rate (*s*), veh/h/ln		1374			1476			1590			1617	
Queue Service Time (g_s), s		2.6			14.9			0.0			43.6	
Cycle Queue Clearance Time (g_c), s		2.6			14.9			5.8			74.8	
Green Ratio (*g/C*)		0.03			0.12			0.66			0.66	
Capacity (*c*), veh/h		36			183			1077			1095	
Volume-to-Capacity Ratio (*X*)		0.821			1.307			0.190			0.954	
Available Capacity (c_a), veh/h		57			183			1077			1095	
Back of Queue (*Q*), veh/ln (95th percentile)		2.0			22.4			3.3			35.6	
Queue Storage Ratio (*RQ*) (95th percentile)		0.00			0.00			0.00			0.00	
Uniform Delay (d_1), s/veh		58.2			52.6			8.0			19.6	
Incremental Delay (d_2), s/veh		19.3			171.8			0.4			18.1	
Initial Queue Delay (d_3), s/veh		0.0			0.0			0.0			0.0	
Control Delay (*d*), s/veh		77.5			224.3			8.4			37.8	
Level of Service (LOS)		E			F			A			D	
Approach Delay, s/veh / LOS	77.5		E	224.3		F	8.4		A	37.8		D
Intersection Delay, s/veh / LOS				64.0						E		

In addition to computing the LOS for the existing flagging operation, the LOS for if the flagging operation didn't exist was also calculated using HCS 2010's TWSC module and shown in Table 5.

Table 5. Level of Service Report from HCS 2010 TWSC Module For the Existing Operations if No Flagging Were Performed

Delay, Queue Length, and Level of Service								
Approach	Northbound	Southbound	Westbound			Eastbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration	*LTR*	*LTR*		*LTR*			*LTR*	
v (veh/h)	*8*	*48*		*112*			*40*	
C (m) (veh/h)	*488*	*1328*		*70*			*192*	
v/c	*0.02*	*0.04*		*1.60*			*0.21*	
95% queue length	*0.05*	*0.11*		*9.62*			*0.76*	
Control Delay (s/veh)	*12.5*	*7.8*		*426.5*			*28.6*	
LOS	*B*	*A*		*F*			*D*	
Approach Delay (s/veh)	--	--		*426.5*			*28.6*	
Approach LOS	--	--		*F*			*D*	

Congestion from Horseshoe Bend to the Banks-SH55 Intersection

Method and Results

The "floating-car" method was used on July 6, 2014 (the peak day of the 2014 Peak Season if things followed previous year's trends) to track and evaluate the southbound traffic shockwave that some assume originated and propagates northerly from the point where Horseshoe Bend speed limit dropped to 25 mph..[9]

Therefore, a manned-vehicle was positioned just upstream of Horseshoe Bend's 35 MPH zone. The floating car reported the following observations:

- At the first monitoring location (see Figure 9) from about 9:30 AM Mountain Daylight Time until 4:45 PM and the traffic flow behavior was observed. When the shockwave's congestion reached the monitoring location, the time was recorded on a data collection form (see Appendix B).

- At 4:45, the driver then drove north, observing traffic conditions along the way. Several times along the drive, the southbound traffic would alternate between pockets of stand-still traffic and free-flowing traffic, with the largest (and also the last) stand-still group extending from the "Before Cascade Raft" location to somewhere past the "Gravel Bank at Cottonwood Creek" Location.

- Stopping at the 9th designated location (Figure 9) to record how long it took to reach that point, the floating car then followed the congestion, recording the times the shockwave reached a location and then driving to the next designated location. However, by 5:30 PM, the shockwave stopped advancing after traveling over 10.5 miles.

Reference Descriptions	Distance
Horseshoe Bend to Banks-SH55 Intersection	*15 Miles*
Boise to Horseshoe Bend	*27 Miles*
Boise to Banks-SH55 Intersection	*41 Miles*

Figure 9. Floating Car Method's Designated Location Reference

Discussion

Although the shockwave standstill traffic did not reach the Banks-SH55 Intersection, the data from the floating car observations suggests that it can and supports some of the observations by the Banks-SH55 Intersection ITD foreman's as stated in the quote below:

> "*The traffic backs up on SH55, all the way from Horseshoe Bend, due to several factors. The Banks Café is quite busy and traffic entering and leaving their parking area slows SH55 traffic. Whitewater enthusiasts crossing the North Fork of the Payette River bridge in front of our maintenance shed contribute, as do vehicles entering and leaving the numerous turnouts along SH55 south of Banks, particularly the little beach area about a half mile south of the café. Traffic may or may not have a short run at near highway speeds between the rafting takeout at Beehive Bend and the backed up traffic from the 25 MPH speed limit and turning traffic congestion in Horseshoe Bend, but usually traffic is backed up for several miles north of town, if not all the way to Banks.*"(1)

The ITD foreman assumed that it was through several factors including "vehicles entering and leaving the numerous turnouts along SH55 south of Banks, particularly the little beach area about a half mile south of the Banks Café." Applying this more generally, the data suggests that the main shockwave is primarily due to vehicles slowing down and bunching up. Since there is a reduction in the speed limit to 25 mph when entering Horseshoe Bend, that location is consistently forcing vehicles to slow down and this causes bunching. Combine that with the large platoons along SH55 the bunching-induced shockwave can propagate as long as the large platoons frequent enough. (See Figure 10) Since July 6, 2014 had lower volumes than usual for the end of Independence Day weekend (see Appendix C and Appendix D), it is assumed that the "pockets" of traffic near highway speeds seen by the floating car driver would disappear to match the ITD foreman's observations.

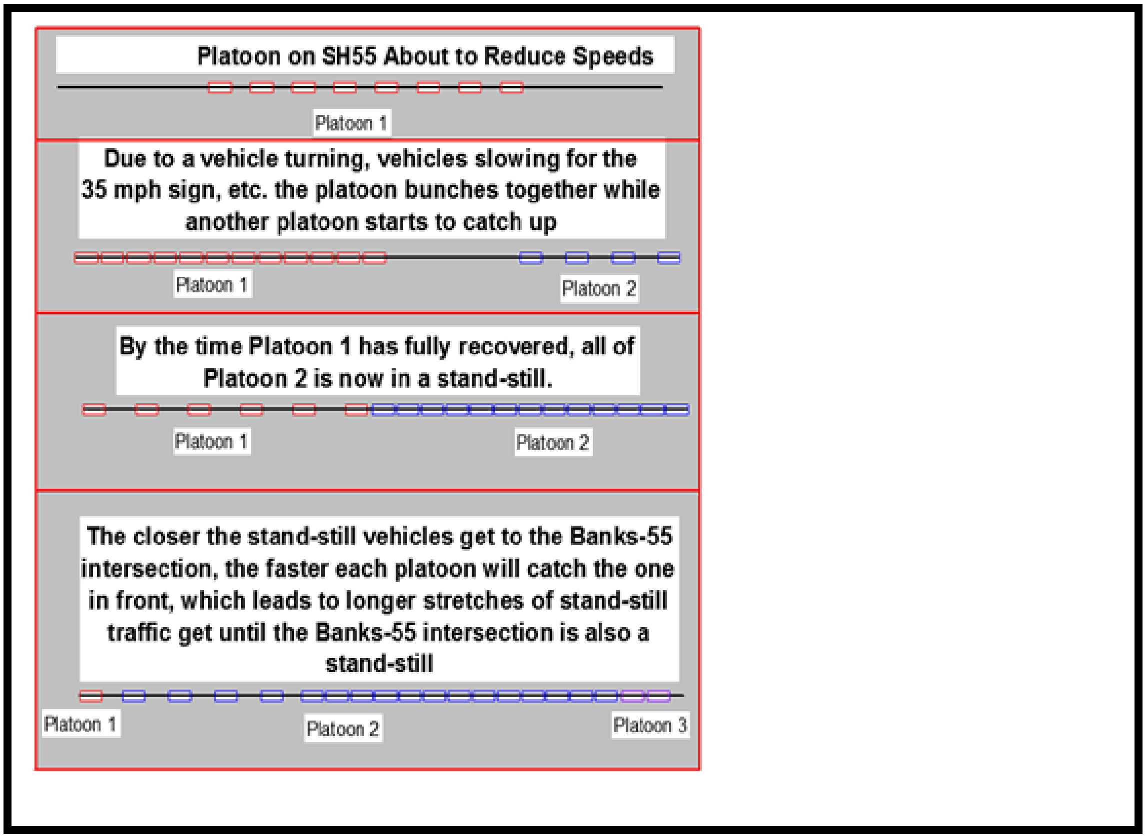

Figure 10. Graphical Representation of How a Shockwave Could Propagate the 15 Miles from Horseshoe Bend to the Banks-SH55 Intersection

Chapter 3
Conclusions and Recommendations

Three possible treatments are presented. With all of the proposed treatments, it is suggested that the expansion of the North Fork Payette River Bridge also be included. If done, it would remove the conflict on the existing one-lane bridge and would help mitigate future demands.

Signalize the Intersection and Add a Left Turn Pocket

Cost: $250,000 - $350,000

Pro: Signalized Intersections are one of the most well documented treatments available. So it makes sense to use this treatment to resolve traffic congestion. Since the timing of the signal forces the main line to stop at an optimized timing, there is a guaranteed time when a vehicle on Banks-Lowman Road will be served. Furthermore, the signal can be set to red and yellow flashing for most of the year (yellow serving SH55 and red for Banks-Lowman Road and Banks-Grade Way), but also have detectors on the approaches that will activate the actuated mode when the traffic volume reaches a set limit or the queue length in Banks-Lowman Road reaches a certain predefined limit. The signal can also be actuated through pedestrian push buttons. The LOS expected with after a traffic signal is installed is presented in Table 6. The conceptual intersection layout is presented in Figure 11.

Signal timings will also help pedestrians to cross SH55 safely by incorporating a pedestrian signal into the phase designs, and the transition time between phases can be decreased when compared to the existing flagging operation. Furthermore, as part of the signalization, the Banks-Grade Way bridge can be signalized so that when a pedestrian pushes a button to cross the bridge, signs turn on to prohibit turning into the bridge so as to protect the pedestrian without interfering with the signal timing. (i.e. The pedestrian pushing the button would act like a preempt signal from an on-coming train, similar to the system used in Folsom, California.)[10]

We recommend that a left turn pocket be added on the Banks-Lowman Road, so that the right turn and through movements can better perform their functions and reduce the queue length. Although right turns make up only 5 percent of the westbound vehicle movements, the lane can be achieved with relative low cost.

An advanced warning sign “BE PREPARED TO STOP WHEN FLASHING” with the associated yellow flashing beacon should be installed in advance of the intersection on SH-55 and on the Banks-Lowman Road. This will alert drivers about the possibility of stopping at red light at the intersection.

Con: Although angled crashes would decrease, the expected rear-end crashes would probably increase. Also, a formal signal warrant analysis is still needed, but that is not anticipated to be an issue.

Table 6. Level of Service Report for the Signalization Treatment

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	3	8	18	7	4	14	1	6	16	5	2	12
Adjusted Flow Rate (v), veh/h		29			239			204			1045	
Adjusted Saturation Flow Rate (s), veh/h/ln		1374			1476			1588			1617	
Queue Service Time (g_s), s		2.6			18.8			0.0			43.9	
Cycle Queue Clearance Time (g_c), s		2.6			18.8			5.8			75.0	
Green Ratio (g/C)		0.03			0.19			0.66			0.66	
Capacity (c), veh/h		36			283			1074			1093	
Volume-to-Capacity Ratio (X)		0.821			0.845			0.190			0.955	
Available Capacity (c_a), veh/h		366			443			1074			1093	
Back of Queue (Q), veh/ln (95th percentile)		1.9			11.3			3.3			35.9	
Queue Storage Ratio (RQ) (95th percentile)		0.00			0.00			0.00			0.00	
Uniform Delay (d_1), s/veh		58.2			46.8			8.1			19.8	
Incremental Delay (d_2), s/veh		15.5			5.0			0.4			18.4	
Initial Queue Delay (d_3), s/veh		0.0			0.0			0.0			0.0	
Control Delay (d), s/veh		73.7			51.8			8.4			38.2	
Level of Service (LOS)		E			D			A			D	
Approach Delay, s/veh / LOS	73.7		E	51.8		D	8.4		A	38.2		D
Intersection Delay, s/veh / LOS	37.0						D					

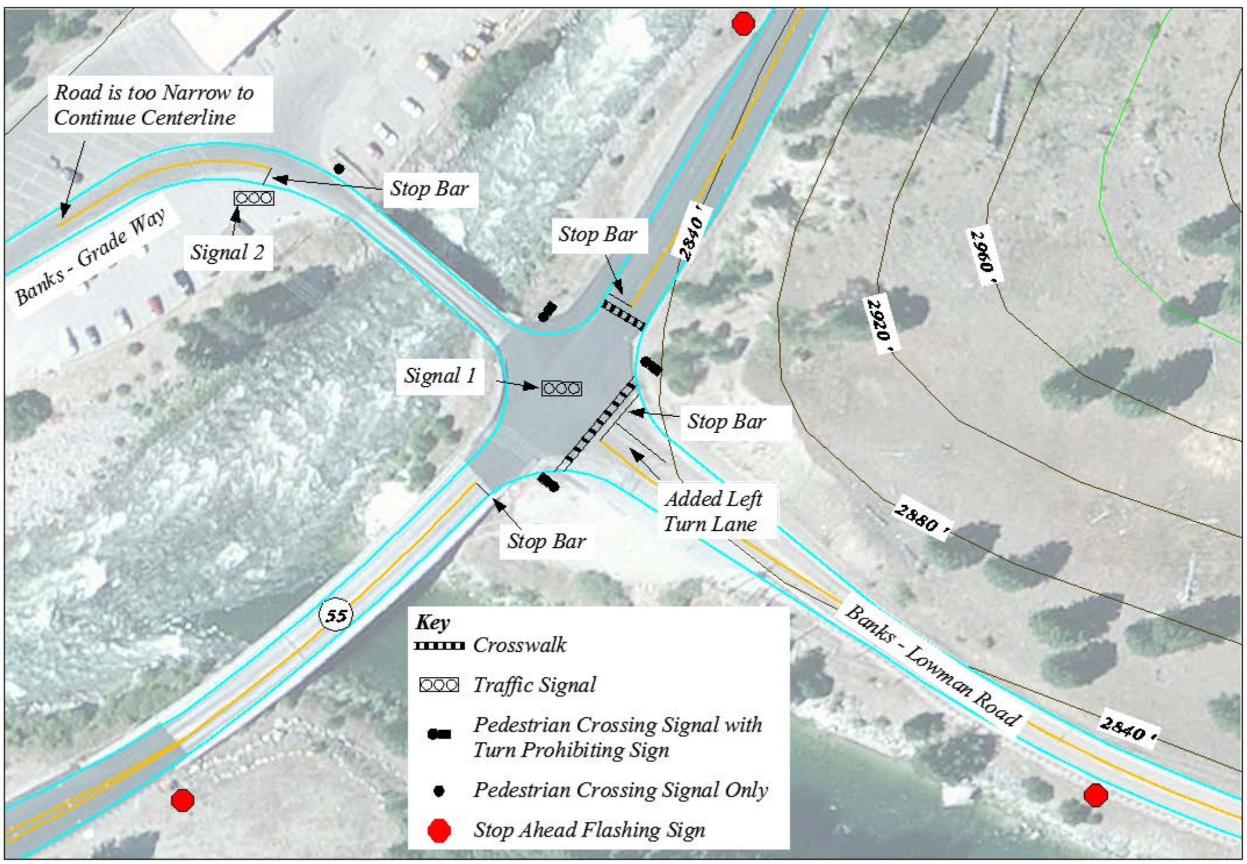

Figure 11. Conceptual Signalization Layout

Left-Turn Median Acceleration Lane

Pro: A Left-Turn Median Acceleration Lane (LTMAL) consists of a separate left turn lane on the mainline and an additional separate lane for left turns on to the mainline. Example of a left-turn median acceleration lane projected onto the Banks-SH55 intersection is presented in Figure 12. The LOS analysis for this treatment is presented in Table 7. Similar to a permitted left-turn through a median, westbound vehicles only interact with one direction at a time. The westbound-turning-southbound vehicle first crosses the northbound traffic into an added lane which allows the westbound-turning-southbound vehicle to sit protected in between the north and south bound traffic. Then, when there is a gap in the southbound traffic, the vehicle could enter the southbound lane.

Con: The greatest challenge to this treatment is that the bridge over SFPR is only a 220 feet south of the intersection. In order to avoid the cost of shifting the Banks-Lowman Road Intersection further north or widening the bridge, a truck and trailer must be able to drive across the northbound lane and get completely into the middle lane before they get too close to the bridge. That said, in the *Idaho 55 Central Draft Corridor Plan*, it identified the SFPR Bridge as being **"**Structurally Deficient."[(6)] Therefore, the cost to improve and widen the bridge may be connected to repairs to the bridge.

Table 7. Level of Service Report for the Left-Turn Median Acceleration Lane Treatment

Delay, Queue Length, and Level of Service								
Approach	Northbound	Southbound	Westbound			Eastbound		
Movement	1	4	7	8	9	10	11	12
Lane Configuration	*LTR*	*LTR*		*LTR*			*LTR*	
v (veh/h)	*8*	*48*		*112*			*40*	
C (m) (veh/h)	*488*	*1328*		*120*			*192*	
v/c	*0.02*	*0.04*		*0.93*			*0.21*	
95% queue length	*0.05*	*0.11*		*6.00*			*0.76*	
Control Delay (s/veh)	*12.5*	*7.8*		*133.2*			*28.6*	
LOS	*B*	*A*		*F*			*D*	
Approach Delay (s/veh)	--	--	*133.2*			*28.6*		
Approach LOS	--	--	*F*			*D*		

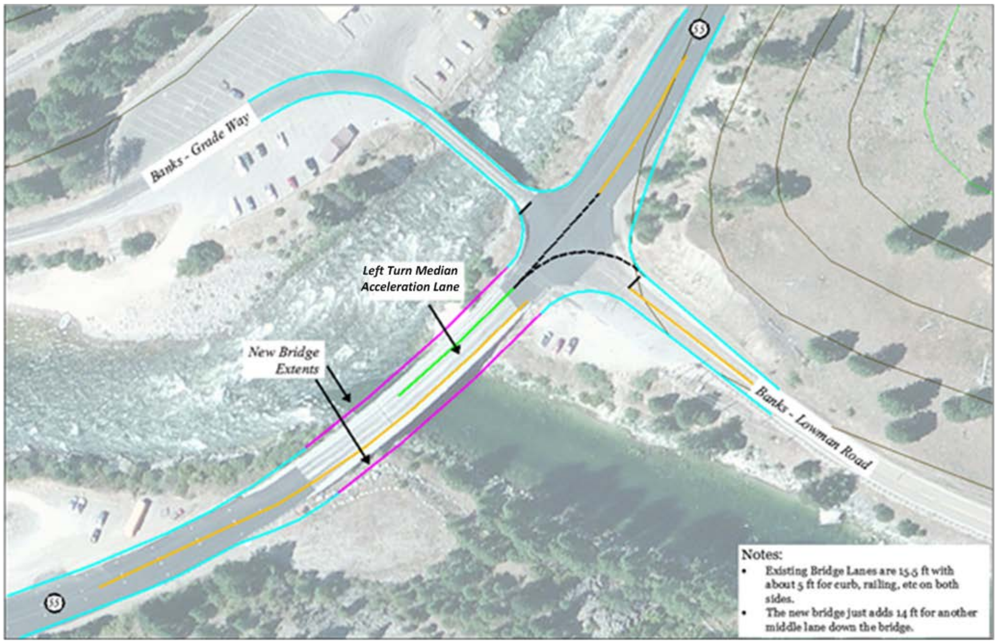

Figure 12. Example of a Left-Turn Median Acceleration Lane Projected Onto the Banks-SH55 Intersection

Roundabout

Pro: Since the Washington State Department of Transportation's roundabout on US Highway 2 (US2) and Rice Road has a similar approach speed, the applicability of that treatment is based on that case study. SH55's speed limit is 55 mph and US2's speed limit at the location is 50 mph, and their similarity suggests similar benefits such as relieved congestion, should be realized. However, the main difference between US2's implementation of the roundabout is that the goal wasn't to relieve congestion, but to reduce accidents. Congestion reduction was just an additional benefit for long-term planning, and the same could be realized at the Banks-SH55 Intersection. Using a roundabout, no approach would be subjected to more than a LOS C.[11] A preliminary design of a roundabout at the Banks-SH55 intersection is presented in Figure 13. The LOS analysis for the roundabout is presented in Table 8.

Con: Something to keep in mind when considering the roundabout is that the congestion on our case study road is limited to 3 months, but the effects from a roundabout would last year-round. To use the US2 example, where the speed limit shortly before and shortly after the roundabout is 50 mph, the major route is slowed to 40 mph prior to reaching the roundabout and then drivers are cautioned to slow to 20 mph while in the roundabout. That means that 8 to 9 months out of the year, drivers on SH55 would be unjustly forced to slow at the Banks-SH55 Intersection.

Furthermore, there would be an extensive costs associated with the roundabout option. As shown in Figure 13, not only would the bridge have to be remodeled, a significant amount of excavation would need to be done in order to accommodate the roundabout.

Table 8. Level of Service Report for the Roundabout Treatment

Delay and Level of Service												
	EB			WB			NB			SB		
	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass	Left	Right	Bypass
Lane Control Delay (d), s/veh		11.9			8.1			5.6		17.5	22.0	
Lane LOS		B			A			A		C	C	
Lane 95% Queue		0.3			1.3			0.8		5.2	7.0	
Approach Delay, s/veh	11.87			8.11			5.61			19.92		
Approach LOS, s/veh	B			A			A			C		
Intersection Delay, s/veh	15.98											
Intersection LOS	C											

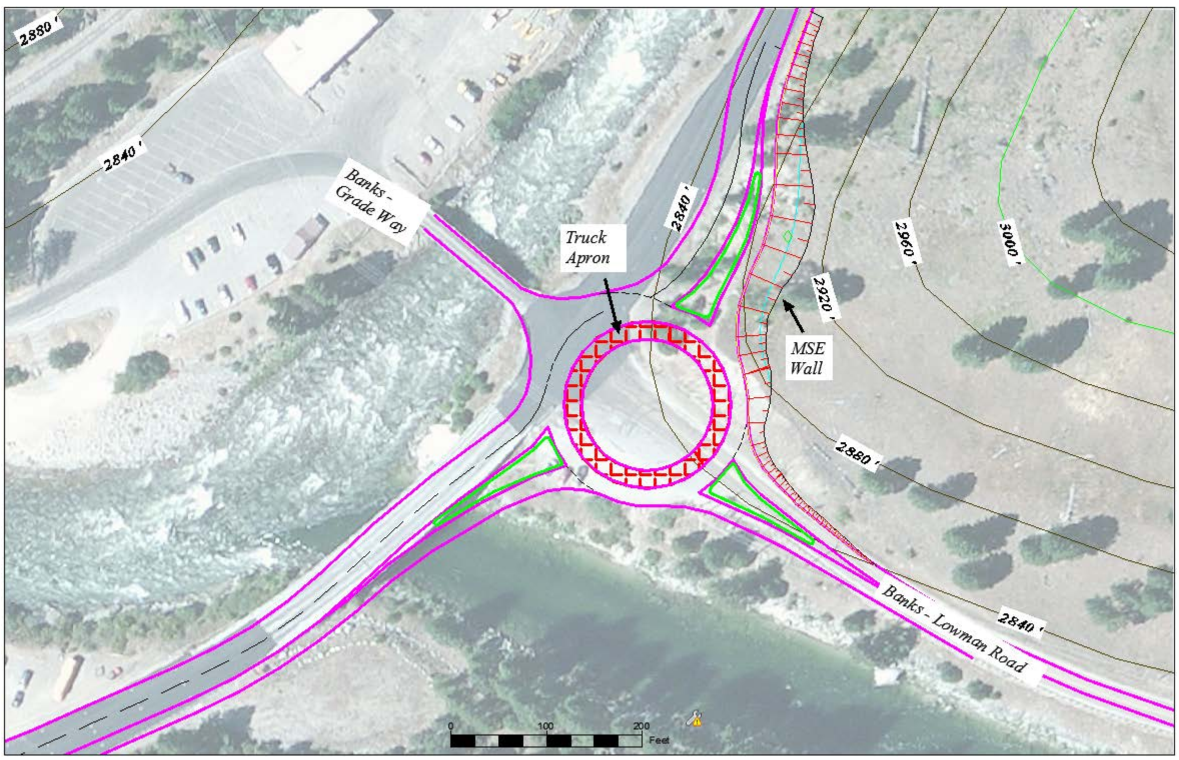

Figure 13. Preliminary Design of a Roundabout at the Banks-SH55 Intersection

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Appendix A
Friday and Sunday Trend Graphs For Peak Seasons 2011 – 2013

Friday Trends

Table 9. Key for Data in Figure 14, Figure 15, and Figure 16

Key for Friday Graphs						
Sunday #	2011		2012		2013	
	Month	*Day*	*Month*	*Day*	*Month*	*Day*
1	May	6	May	4	May	3
2	May	13	May	11	May	10
3	May	20	May	18	May	17
4	May	27	May	25	May	24
5	June	3	June	1	May	31
6	June	10	June	8	June	7
7	June	17	June	15	June	14
8	June	24	June	22	June	21
9	July	1	June	29	June	28
10	July	8	July	6	July	5
11	July	15	July	13	July	12
12	July	22	July	20	July	19
13	July	29	July	27	July	26
14	August	5	August	3	August	2
15	August	12	August	10	August	9
16	August	19	August	17	August	16
17	August	26	August	24	August	23
18	September	2	August	31	August	30
19	September	9	September	7	September	6
20	September	16	September	14	September	13
21	September	23	September	21	September	20
22	September	30	September	28	September	27

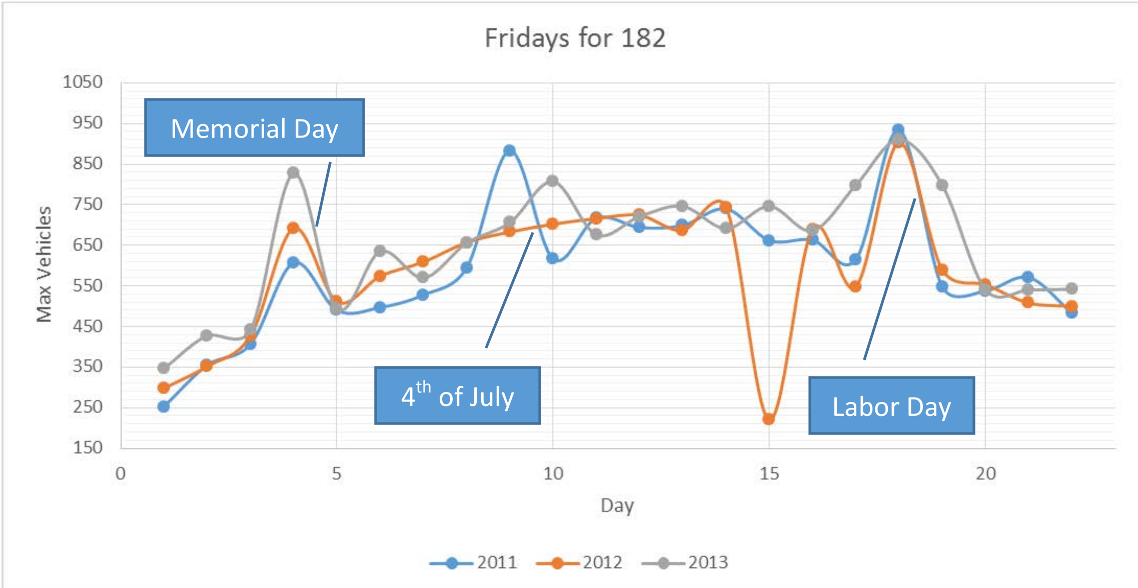

Figure 14. Fridays for ATR #182

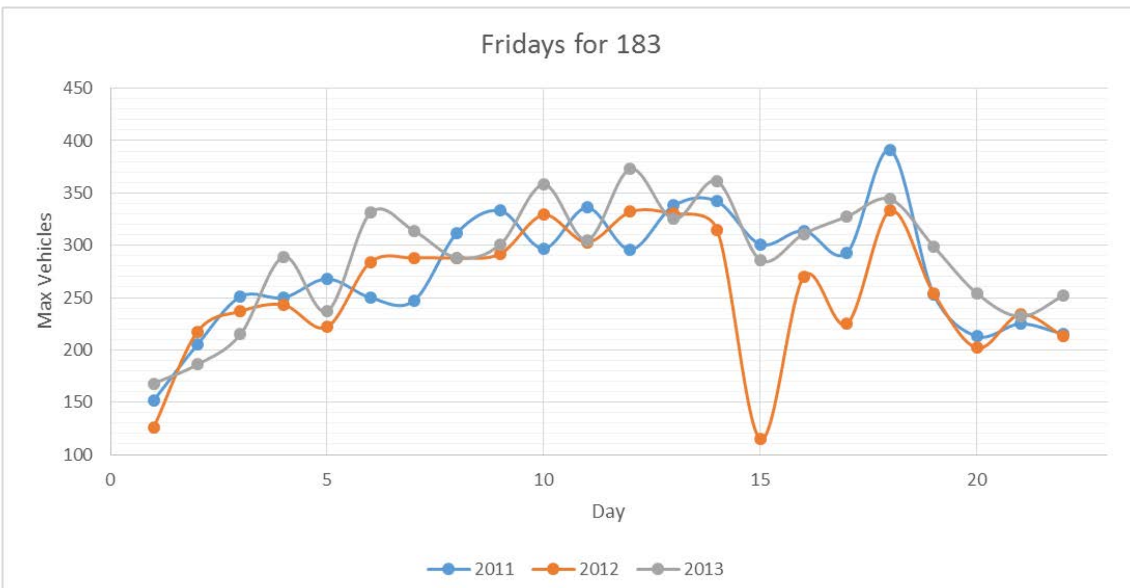

Figure 15. Fridays for ATR #183

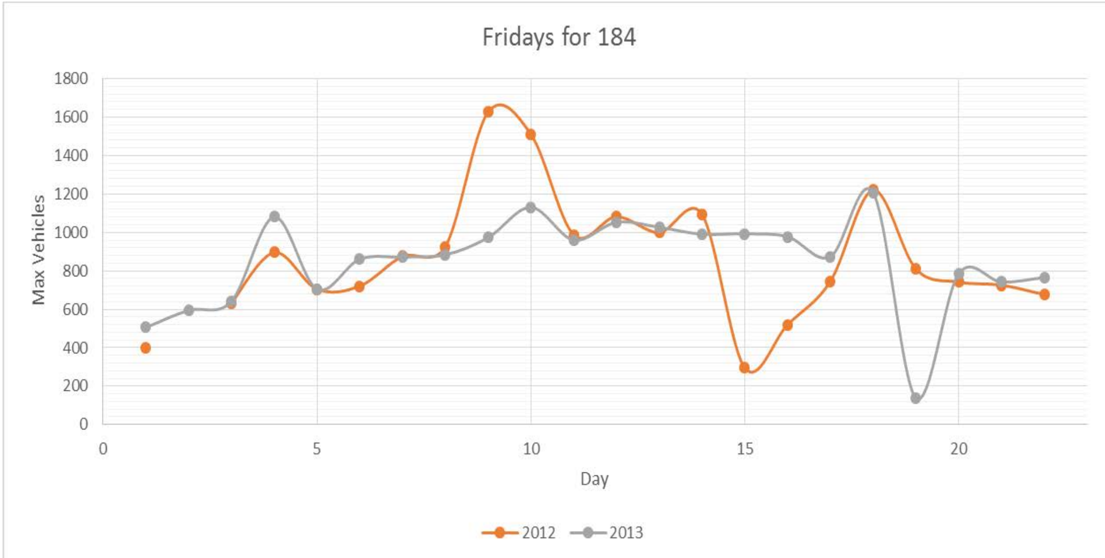

Figure 16. Fridays for ATR #184

Note: During the year 2011, ATR #184 was having problems accurately counting vehicles and was excluded from this chart (ITD assumes errors were due to construction in the area).

Sunday Trends

Table 10. Key for Data in Figure 17, Figure 18, and Figure 19

Key for Sunday Graphs						
Sunday #	2011		2012		2013	
	Month	*Day*	*Month*	*Day*	*Month*	*Day*
1	May	1	May	6	May	5
2	May	8	May	13	May	12
3	May	15	May	20	May	19
4	May	22	May	27	May	26
5	May	29	June	3	June	2
6	June	5	June	10	June	9
7	June	12	June	17	June	16
8	June	19	June	24	June	23
9	June	26	July	1	June	30
10	July	3	July	8	July	7
11	July	10	July	15	July	14
12	July	17	July	22	July	21
13	July	24	July	29	July	28
14	July	31	August	5	August	4
15	August	7	August	12	August	11
16	August	14	August	19	August	18
17	August	21	August	26	August	25
18	August	28	September	2	September	1
19	September	4	September	9	September	8
20	September	11	September	16	September	15
21	September	18	September	23	September	22
22	September	25	September	30	September	29

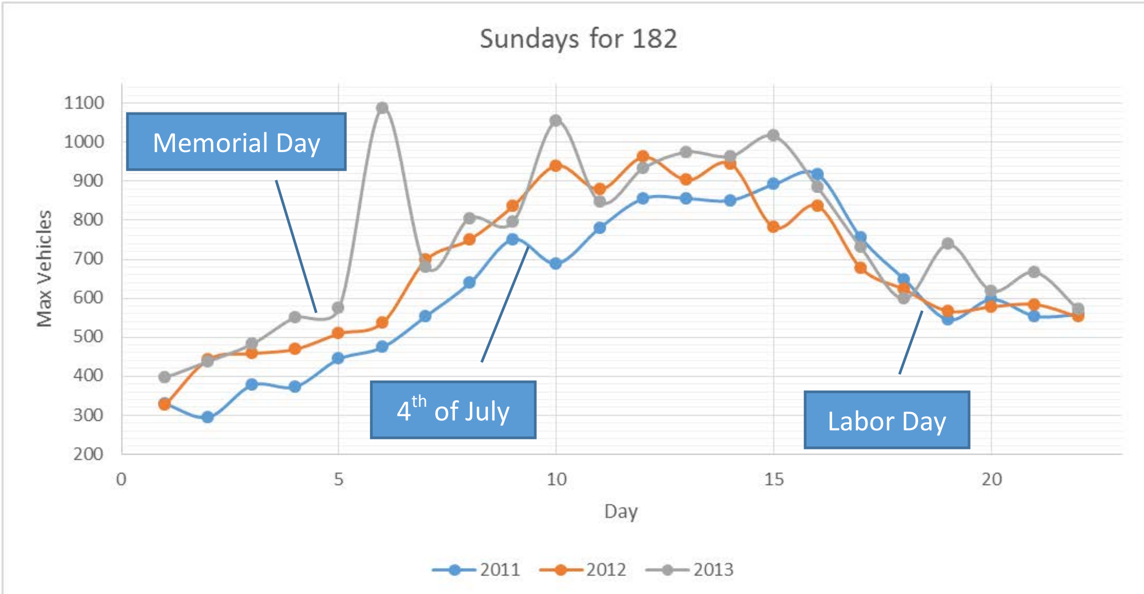

Figure 17. Sundays for ATR #182

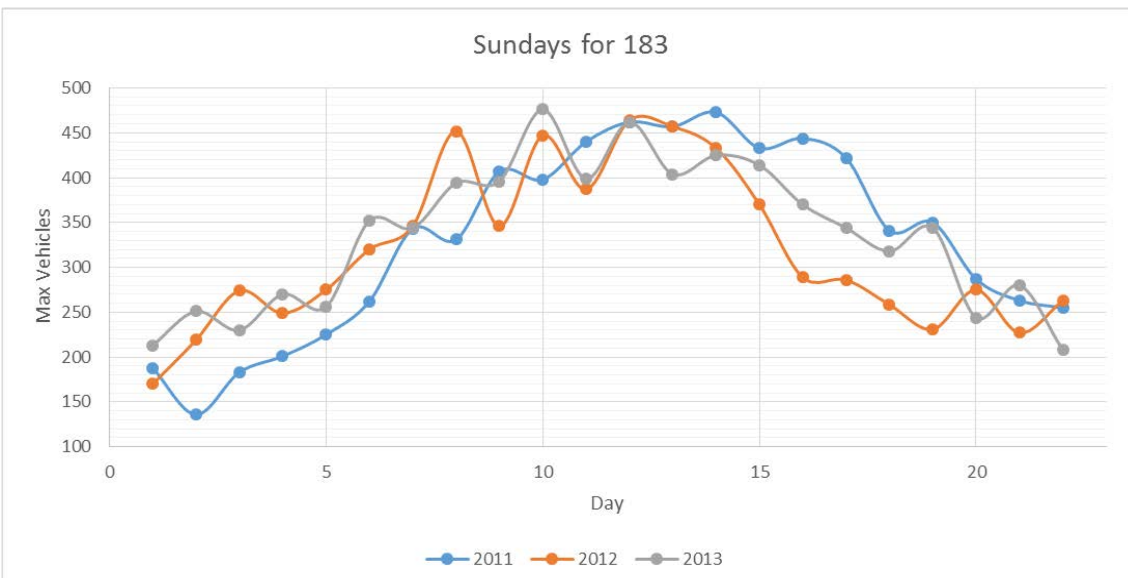

Figure 18. Sundays for ATR #183

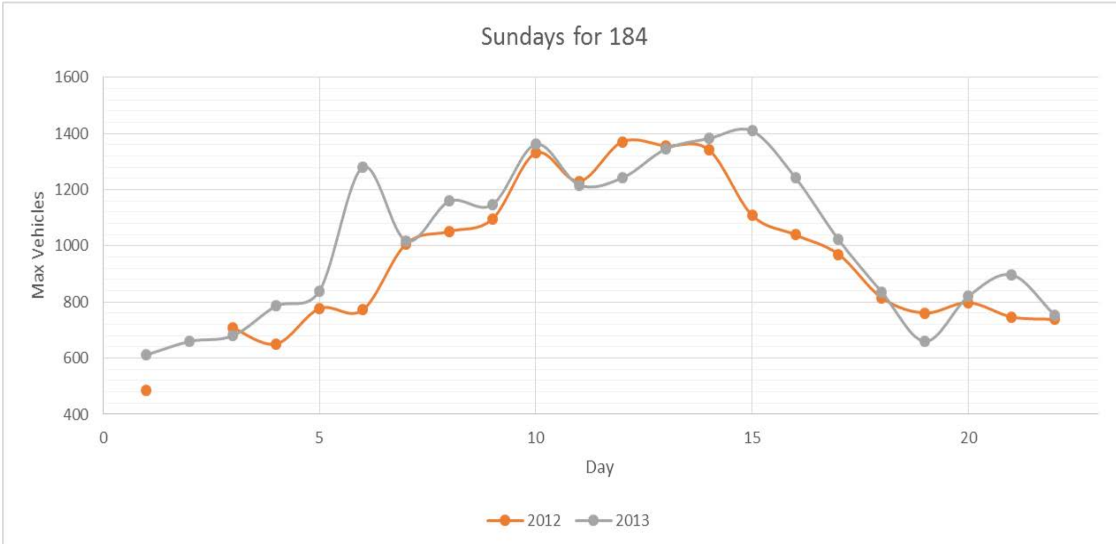

Figure 19. Sundays for ATR #184

Note: During the year 2011, ATR #184 was having problems accurately counting vehicles and was excluded from this chart (ITD assumes errors were due to construction in the area).

Appendix B
Mileage and Time Form for the Floating Car Method

Table 11. Blank Form

Floating Car Driver: ____________ **Observation Date:** **July 06, 2014** **Start Time:** ____________

Stop #	Name/Description	Distance	Distance Traveled	Expected Travel Time		Time Traveled
				Time	Time Traveled	
0	35 mph sign	0	0.0	0	0	N/A
1	Rocky Road	0.8	0.8	1	1	
2	Near Bridge	0.4	1.2	1	2	
3	Porter Creek Road	0.9	2.1	1	3	
4	Hill Creek Road	1.2	3.3	2	5	
5	Before Cascade Raft	1.9	5.2	3	8	
6	After Cascade Raft	0.8	6.0	1	9	
7	After Beartown	0.9	6.9	2	11	
8	Gravel Bank at Cottonwood Creek	1.1	8.0	1	12	
9	Residential Pullout	1.2	9.2	1	13	
10	Off-Roading Pullout	1.5	10.7	2	15	
11	shoulder Pullout	1.2	11.9	2	17	
12	Off-Roading Pullout	1.1	13.0	1	18	
13	Banks	0.7	13.7	0.87	18.87	

*All distances are in units of miles and time is in units of minutes.

Table 12. Completed Form

Floating Car Driver: Christopher Bacon **Observation Date: July 06, 2014** **Start Time: 11 AM**

Stop #	Name/Description	Distance	Distance Traveled	Expected Travel Time		Time Backup Reached Location
				Time	Time Traveled	
0	35 mph sign	0	0.0	0	0	Not Monitored
1	Rocky Road	0.8	0.8	1	1	14:30
2	Near Bridge	0.4	1.2	1	2	Arrived too Late
3	Porter Creek Road	0.9	2.1	1	3	Arrived too Late
4	Hill Creek Road	1.2	3.3	2	5	Arrived too Late
5	Before Cascade Raft	1.9	5.2	3	8	Arrived too Late
6	After Cascade Raft	0.8	6.0	1	9	Arrived too Late
7	After Beartown	0.9	6.9	2	11	Arrived too Late
8	Gravel Bank at Cottonwood Creek	1.1	8.0	1	12	Arrived too Late
9	Residential Pullout	1.2	9.2	1	13	17:07
10	Off-Roading Pullout	1.5	10.7	2	15	17:21
11	shoulder Pullout	1.2	11.9	2	17	N/A
12	Off-Roading Pullout	1.1	13.0	1	18	N/A
13	Banks	0.7	13.7	0.87	18.87	N/A

Note: All distances are in units of miles, Expected Travel Time is in units of minutes, and Time Backup Reached Location is in MDT.

Appendix C
15-Day Memorial Day Comparison: Field Values vs ATR Volumes

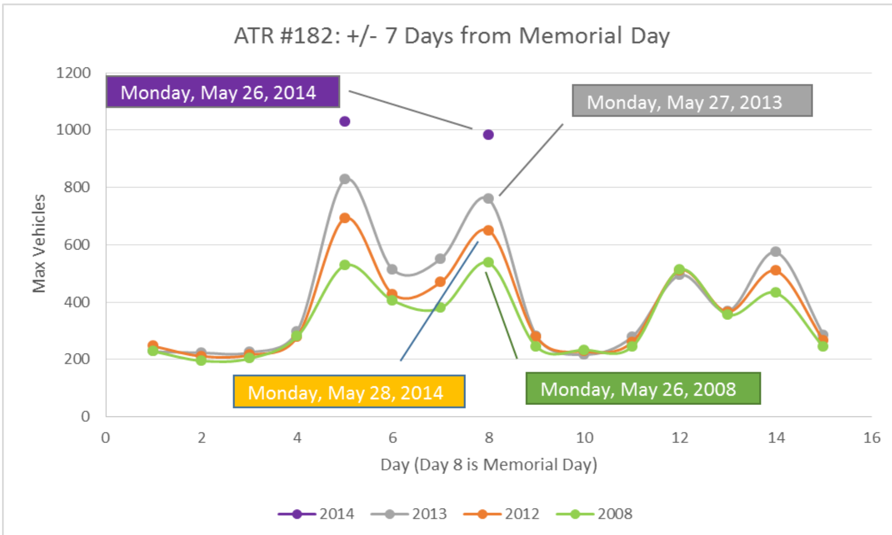

Figure 20. ATR #182's 15-Day Comparison with Field Test, Centered on Memorial Day

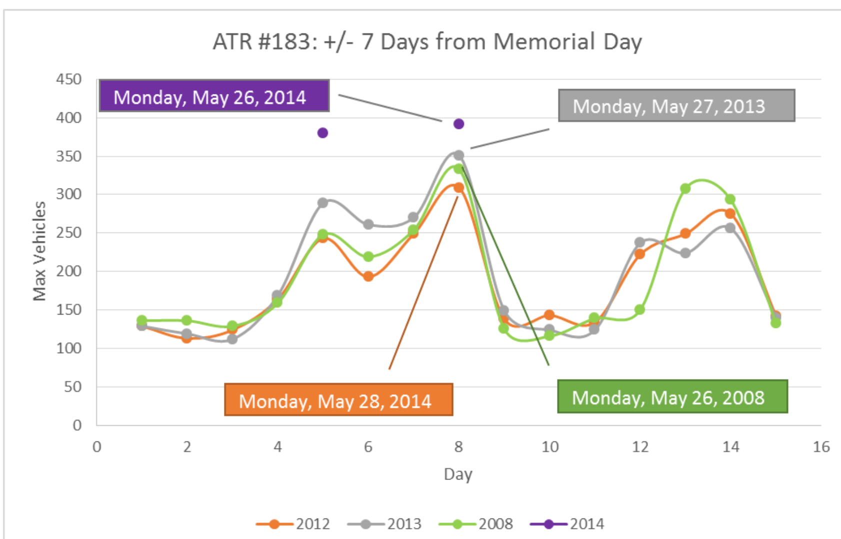

Figure 21. ATR #183's 15-Day Comparison with Field Test, Centered on Memorial Day

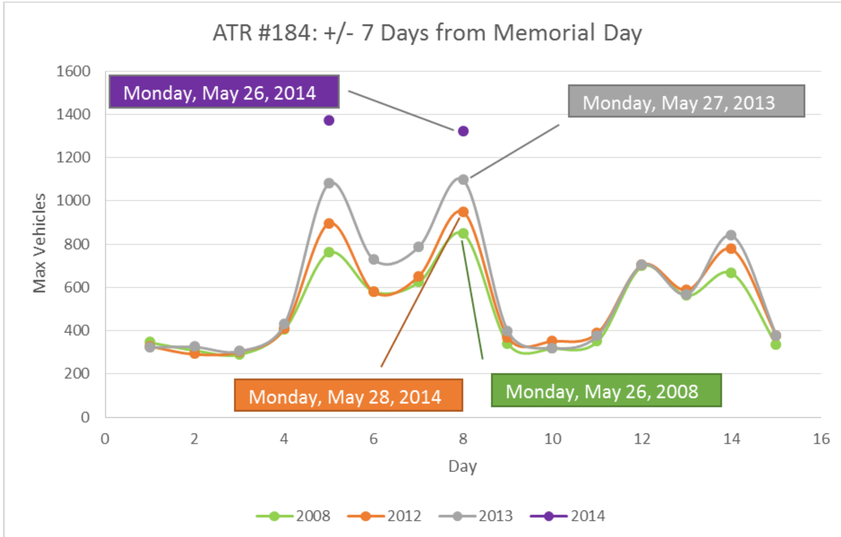

Figure 22. ATR #184's 15-Day Comparison with Field Test, Centered on Memorial Day

Appendix D
15-Day Independence Day Comparison: Field Values vs ATR Volumes

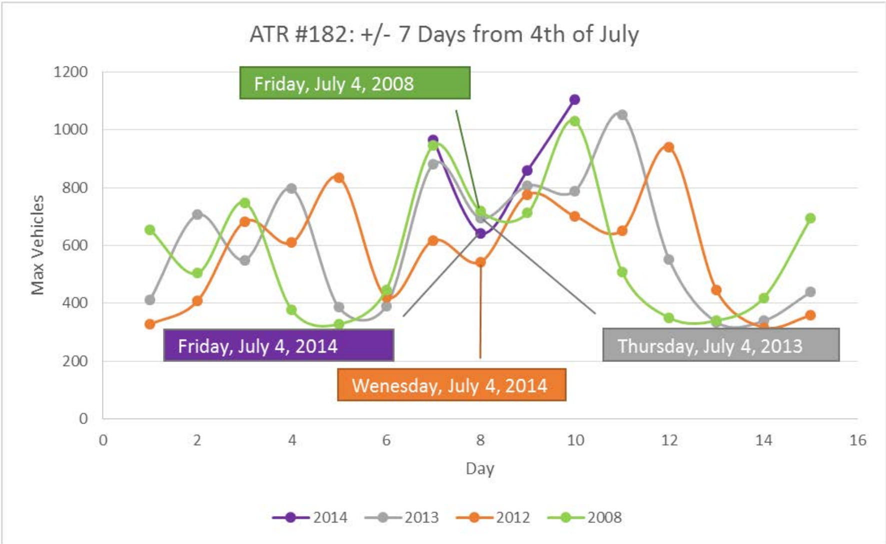

Figure 23. ATR #182's 15 Day Comparison with Field Test, Centered on Independence Day

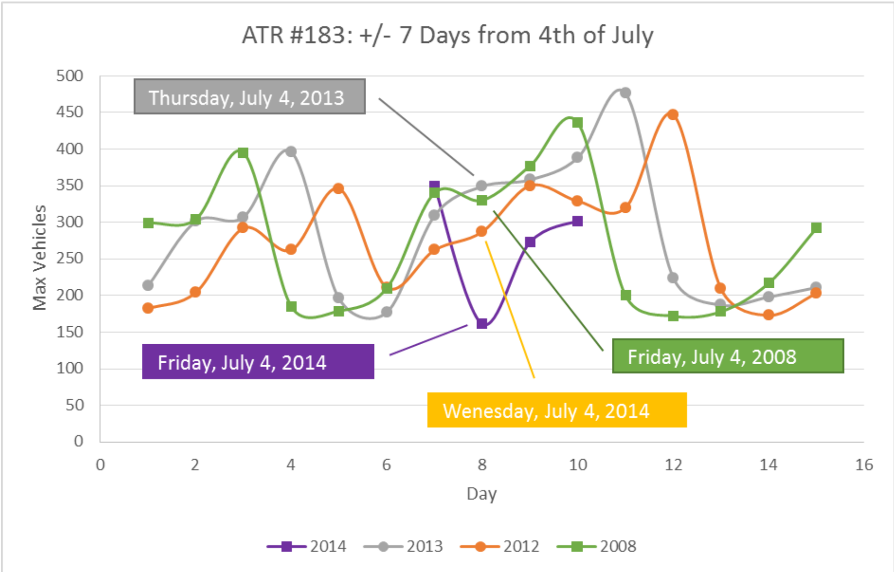

Figure 24. ATR #183's 15 Day Comparison with Field Test, Centered on Independence Day

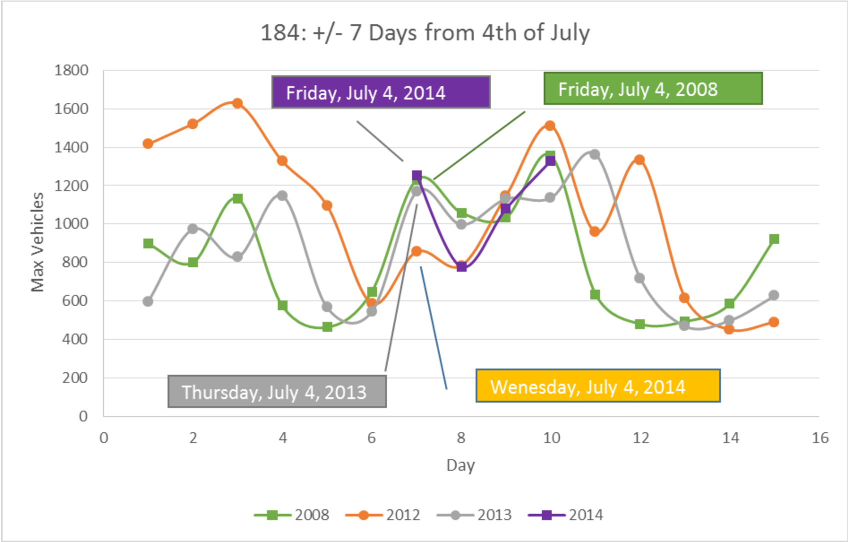

Figure 25. ATR #184's 15 Day Comparison with Field Test, Centered on Independence Day